1 CONCEPT OF ORGANISATION AND ENTERPRISE MANAGEMENT.

1.1 The word business is very broad in its meaning which includes varieties of activities. Hence business refers to some economic activities related to manufacturing, extracting, purchasing, selling, servicing etc of any goods and services by individuals or organisations, the purpose of which is to earn profit.

BUSINESS:

Business may be defined as "Those economic activities connected with manufacturing, assembling, extracting, collecting ~~and~~ purchasing, selling, servicing etc of any of any goods and services with the motive of earning revenue and profits"

Hence the term business may include varieties of activities needed for the purpose of manufacturing, assembling, collecting, extracting, constructing, grading, processing, packaging, purchasing, marketing, selling, transporting, advertising, trading, servicing. etc of any goods and services.

The term business contains a wide variety of ingredients in it. The person who carries on such activities of a business is business-man.

ex:- -The grocer, who is selling different grocery items is a businessman.

- The owner of a TV channel is a businessman.

The duties of each and every business man are to organise business and earn profit out of them.

Hence, the ultimate aim of each and every business is profit.

Features of Business:

The following are the essential features of business.

[1]. Plurality of persons:

There must be atleast two persons or organisations to carry on a business. There can't be any business where there is only one individual or organisation is involved. That means a person can't have business involving himself only. He needs at least one customer to have a business.

[2]. Purchase and sale:

There must be purchase and ~~sell~~. sale. That means, in a business, there must be a seller and a purchaser.

③ [3] Goods and services:

There must be some goods and services. There can be no business without involving any goods or services.

(Related to money /currency)

[4]. Monetary considerations:

There must be monetary consideration. In a business there must be transfer of goods or services from one person to another ~~from~~ for monetary consideration.

[5]. Repeatation of dealing:

There must be repeatation of dealing. Economic activities of purchase and sale of goods and services must be repeated. An isolated or single transaction is usually n't treated as business.

ex:- If a person purchase a flat and sold it at a profit, it is n't a business nor the person selling the flat is business.

But, If the individual purchases and sales flats repeatedly for gain, it is a case of business.

[6]. profit motive:

The ~~profit~~ motive behind such economic activityies must be to earn profit.

(If the motive is for any social, charitable, voluntary or mutual benefit or gain, it is n't a business)

① [7] Risk:

Business is always associated with risk and uncertainity. so risk is inseparable component of business. There can be no business without any risk. usually profit of a business depends on the risk involved in it. usually higher is the risk, higher the chances of profit and lower the risks, lower ~~the~~ is the chances of profit.

Component of Business:

Business has 2 major components..

[1] Industry.

[2] Commerce.

[1] Industry:

Industry is a place, where goods and services are produce.

such industry further devided into various catagories depending on size, nature, product, amount of investment etc.

Depending ~~upon~~ on the nature of industrial activities, industries can be classified into 5 catagories. such as:-

[1] Manufacturing industries.

[2]. Extractive Industries.

[3]. Genetic Industries.

[4]. construction Industries.

[5]. Service Industries.

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[1]. Manufacturing Industries:

under this type of industries, the economic activities concentrate around the making of a commodity or product either for final consumption

Manufacturing Industries are factories and mills where raw materials are introduced and finished product are found out.

Manufacturing industries are further classified into 4 types.

(1) Assembling Industries.
[2]. Processing Industries.
[3]. Analytical Industries.
[4]. Mixed type or synthetic type Industries.

[1] Assembing Industries:

This type of industries purchase different component, parts, assembling, accessories and assemble them into usable product.

Example:- Bicycle industries, automobile industries, watch industries., TV industries etc.

[2] Processing Industries:-

This type of industries purchase raw material and put into the processes. Raw material are introduced at a particular point and it travels from one process to another untill its completion as finish product.

6 under the arrangement, some type of processing, modifying, grinding, polishing, shaping, heating etc are done at different stages at different processes.

ex:- Furniture Making Industries,
Textile Industries,
paper making, Jute mills etc.

[3] <u>Analytical Industries:</u>

In this type of industries, raw material is introduced at one point and several product come out at the end of different processes by due seggregation, separation, analysis etc.

The other products ~~ma~~ are obtained from the basic raw materials. such product may be byproduct, joint products. etc.

example:- A milk product in which milk is introduced into the plant for processing and different product like ghee, cheese, butter, curd, condense milk come out at different processes.

[4] <u>Mixed type or synthetic type:</u>

under this type of industries, different raw material combined at different processes or stages and after further processing, finished products come out ~~en~~ at the end of the process.

ex:- Ayurvedic Medicine preparation industries, cosmetic industries,
Fertilizer industries

7

2. Extractive Industries:

This type of industries are ~~engaged~~ associated with the process of extraction of different materials from nature, like minning of ore and minerals, collection of forest product, etc. Such type of industries directly depend on nature.

3. Genetic Industries:

This type of industries are associated in the process of reproduction or multiplication of products which involves certain life. It takes time to complete and involves different stages of life.

example:- polutry.

4. Construction Industries:-

This type of industries are engaged in the construction of various infrastructure. like road, dam, bridge, canal, etc.

5. Service Industries:

This type of industries provides service of various type to the people, to the industries and other organisation.

Such type of industry don't produce any commodities but produce or create service for the needy.

ex:- garage for automobiles, cinemal halls, Tv channols, ~~hotels and~~ etc.

Commerce:

commerce includes all those economic activities of buying and selling.

The manufacturers produce good and services but commercial activities help the transfer of good and services from the point of manufacturing to the point of user.

It maintains the gap between the producer and user.

It includes:

(1) Trade

(2) Aid to trade.

Trade:

Trade refers to the actual transfer of ownership of goods and services from the producer to the consumers through various middlemen.

It includes the actual sale and purchase of goods and services.

The person purchasing from producers and selling them to the customers is a trader. His activities of buying and selling are trading activities.

so trade can be classified into

1. Retail trade and wholesale trade.
2. Local trade and Regional trade
3. National trade and international trade.
4. Import trade and export trade.

[1] Retail trade and wholesale trade:

Retail trade refer to the sale or transfer of goods and services directly to the consumers, and the person selling to the consumers in small quantities is known as retailer.

→ Retailers are usually spread over throughout the place whereever there is the conc. of consumers.

- Retailers are usually small business men or traders who deal in small quantities and remain in direct touch with the consumers.

Where as,

- Wholesale trade refers to the sale of good and services to a small scale trader. and the person selling to the small trader in large quantity is known as wholesaler (large scale trader)

- Wholesale trader are usually meant to cater to the need of specified area. town or locality.

- Wholesale traders deal in large quantities ~~and don't remai~~

[2] Local trade and regional trade:

When buying and selling of a commodity is confined (limited/restricted area) to a perticular locality, it is known as local trade.

- Here buying and selling activities of different comodity are carried out on in small quantities.

- local traders operate within locality and provides the needs of the people of locality.

(10) - They deal in small quantities of different commodities.

However,

- When buying and selling activities of goods and services are confined to a particular region, it is known as regional trade.

- There is free flow of goods and services among various localities of the region.

- Regional traders provides the need of the people ~~of the~~ of the regions.

- They deal in comparateively in more quantities.

National trade And International trade:

When goods and services are bought and sold within the country. it is known as national trade.
here exchange of goods and services takes place within the ~~country~~ boundry of the country.

- National ~~country~~ trade spread over through out the country.
- It is also known as internal trade.

However,

- When goods and services are bought and sold between the nations i.e outside the boundary of a country, it is known as international trade.

- International trade covers both the import and export of goods and services

- International trade spread through out the world.

Import trade And Export trade:

When goods are bought from other countries of the world to meet the demand of a country. It is known as import trade.

~~however~~ This happens because the country cannot produce all of its requirements of goods and services.

However, A country may supply ~~ist~~ its surplus goods and services to other countries where there are shortage is known as export trade.

- The sending of such goods and services is for economic gain.

Aid to Trade:

All those activities which facilitate trade are known as aid to trade. such activities help the process of buying and selling of goods and services.

ex:- such business activity of businessman includes - transportation of commodities, advertising, banking etc.

without such activities, it is difficult to carry on the process of buying and selling.

1.2 Different forms of Business organisation and their basic characteristics:

Different forms of business organisations are:-

(1) sole-proprietorship.
(2). Partnership firm.
(3). Joint Hindu family business.
(4). cooperative society.
(5). Joint stock company. (i.e pvt limited company, public limited company, public sector undertaking)

(12)

sole-proprietorship:

When a business is started by a single person, it is known as sole-proprietorship or single ownership or one man business.

Basic characteristics:

1. such a business is owned by a single individual.
2. such a business is control by the same individual.
3. The individual invest his own capital in the business.
4. The sole-proprietor derives the entire benefit of the business and all the profit go to his pocket.
5. No legal formalities are necessary to start such a business.
6. The sole-proprietor bears all the risk for the business.
7. sole-proprietor may take the help of some emplyoee who may get salary.

Advantages of sole-proprietorship:

1. Easy to start -
sole-proprietorship is easy to start as it doesn't require any agreement.

2. Profit -
All the profit is go to the pocket of sole proprietorship. There is nobody to share the profit of such business.

3. Business secrecy:
Some time it is very important to maintain the secrecy of a business. As sole - ~~pro~~ proprietorship

(13) is the only person in the business, it is quite easy to maintain business secrecy.

4. Prompt decision:

A sole-proprietor is the only individual in his business, he can take prompt decision whenever there is a need.

5. Flexibility:

The ~~a~~ sole-proprietor can enjoy the full freedom aswell as flexibility. he can do anything for the future business. He can close the business, expand it, change the nature of the business, change the name of the business etc.

(6). socially desirable:

This form of business organisation is socially desirable because it provides a lot of employement opportunities to unemplyoed individual. It solves the unemplyoment problem of a individuals aswell as country.

7. personal contact:-

As the sole-proprietor is the only individual in the business, he can maintain a personal contact with the customers, which is helpful to understand the mood, taste, requirement, habit, custom etc. of the customers and may design his business activities accordingly to suit the customers.

8. Easy Dissolution.

A sole proprietorship business can be dissolved at any time without any formalities. It can come to an end at the wish of sole proprietor.

Disadvantages

(1). Limited financial resources:

As the sole proprietorship is the only person in the business, he can contribute only limited amount of money for the purpose of business.

(2) Uncertain future: As sole proprietorship is only person in the business is purely uncertain and its continuity is always doubtful.

(3) Unlimited liability:

The liability of the sole-proprietor is always unlimited. He can be called upon to pay an unlimited amount of money in case of need.

(4) Limited managerial activity:-

A sole proprietor may not be expert in all the activities of his business.

[5]. Small business:

The sole-proprietor may n't start a big business and the production may n't be high.

(6). Lack of public faith and confidence:

As there is uncertainity on the continuance of this type of business, people may n't have faith and confidence

(7) No separate legal entity:

PARTNERSHIP:

When a group of persons combining together start a business, it may be a part~~tna~~nership business.

Partership business in India is governed by an Act in the parliament. so according to section 4 of Indian partnership Act, 1932, part~~ta~~nership is defined as a "relation between person who have agreed to share the profit of a business carried on by all (or any one acting for all) persons entering to the agreement are individually called partners and collectively a firm and the name under which business is carried out is called firm name".

Basic characteristics:

(1) The minimum number of ~~partners~~ members in case of partnership business is two and the maximum limit is twenty. However in case of banking and financial business the maximum membership is ten only.

(2). Part~~ta~~nership come into existence due to the agreement entered into ~~the~~ by the partners. Such an arrangement in writting is known as "partnership Deed".

(3): The motive of all the partners in the partnership must be to earn profit and share.

(4). All the partners can take active part in the management of partnership.

(5). Both the partners and firm are considered one unit in the eye of law.

(6) Partnership is the result of mutual understanding, faith and confidence among the partners: so all the partners should be just honest to one another and to the firm

(7). A partnership firm can't continue to carry
16 on its business for an ~~ott~~ unlimited period of time, If the partners have agreed to carry on business for limited period of time, it is known as "partnership for a fixed term."

If they have agreed to carry on partnership for the completion of a particular job and project, it is called "particular partnership."

If nothing is specified in the partnership agreement, such a partnership may be closed down at the wish of any partners and such a partnership is known as "partnership ~~with~~ at will"

Partnership Deed:

Deed means agreement. so partnership deed means the partnership agreement. Partnership is the result of an agreement between the partners. When the partnership agreement is in written form, it is known as partnership deed.

Partnership deed contains the rules & regulations for the internal management of the partnership. Also contains the terms and conditions of the partnership.

All the partners have to sign the partnership Deed. It contains the detail of the name of the firm, its adresses, names & addresses of each and every partners, nature of business, the profit sharing ratio, duration of partnership, power, duties and responsibilities of partners and all other rules regarding partnership.

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Types of partnership.

- general partnership
  - Partnership at will
  - Particular Partnership
  - Partnership for a specific time.
- Limited partnership.

General partnership:

Under this type of partnership the liabilities of all the partners are unlimited, their personal properties can be utilised to pay of business liabilities, if the properties of the firm are insufficient to meet business liabilities.

[a] partnership at will:

When all the partners come to an agreement and say nothing about the duration of partnership, such a partnership is end at the will of the partners.

[b] particular partnership:

If the partnership have entered into an agreement to complete a particular task, the partnership is automatically close down at the completion of such task, such partnership is known as particular partnership.

[c]. partnership for a specific time:

If ~~a~~ the partners have entered into an agreement to carry on business for a specific period of time i.e for 1 yr, 2yr etc. then on the completion of the prescribed time limit, the partnership is automatically close down, such a partnership is known as partnership for a specific time.

Limited partnership:

This type of partnership is usually n't found in India.

Under this type of partnership, there must be at least one general partner whose liability is unlimited and the rest of the partners may be limited partners, whose liabilities are unlimited to the extent of their share in partnership.

- A limited partner is allowed to transfer his share to another partner or to an outsider without the consent of all general partners.

Kinds of partners:

1. Active partners

This type of partner found in all the partnership. such partner not only contribute capital but also take active part in the management.

2. ~~see~~ sleeping partner:

This type of partner is also known as dormant partner. such a partner contributes capital to ~~the partner~~ but doesn't take any active part in the management of partnership.

3. Partners in profit only:

There are some partners who may be interested in the profit only, They aren't share the losses. They contribute capital but n't allowed to take active part. As because such partners share the profits only, their rights are also restricted.

4. Nominal partner:-

such partner neither contributes capital to the firm nor takes ~~pta~~ active part in the management. ~~of the partnership~~.

His name is only use as a partner.

19 This type of situation arises when the person is important and act as a strength to the partnership business to attract additional business. such a person is known as a partner to the outsiders but actually is not a partner.

5. Partner by estoppel:

sometimes it may so happen that a person may represent himself in a such a manner that other believe him to be a partner. Actually he is not a partner but behaves like a partner. such person neither contribute capital nor takes active part in the management. such a partner is known as partner by estoppel. In the other word, we can treat him to be a tout or cheat.

6. Minor partner:

Person who is below 18 years of age can't enter into an agreement / contract as per the Indian Contract Act. person below 18 years of age is treated as a minor. But the Indian partnership Act specifically provides that a minor person can enter into a partnership and becomes a partner.

Advantages of partnership:

1. Absence of legal formalities. — There is no need of obtaining any permission, licence or clearance from any authorities to start a partnership business No legal formalities are required to start a partnership firm. It can be started by any 2 or more individuals at any time or at any place.

2. Higher financial resources:—

As because the no of partnership is more, this business has more financial strength.

3. Bigger size of business— As compared to sole-proprietorship, a partnership business can start a comparatively big business with more capital.

4. Better management: In partnership, there are partners with varities of talent on various mattery. This brings more efficient management.

5. Reduced risk: As there are many person in a partnership the risk involved is shared among the partners.
   - Lighter risk enable the partners to take good business risk.

6. promt decision: As almost all the partners take active part ~~in the day~~, they can take promt and timely decision on many matters.

7. good public relation:

8.

9. Easy dissolution: The dissolution of a partnership is easy.

Disadvantages:

1. unlimited liability:
   The liabilities of each and every member in case of a partnership is unlimited.

2. Absence of continuity / uncertainty future:
   A partnership firm can't continue its business for a unlimited period of time. A partnership firm comes to an end on the event of death, insolvency, retirement etc. of a partner.

3. Higher risk:-

21 The personal properties of the partner are always at risk.

4. Absence of understanding Among partners:

As there are many partners in a partnership, there may be conflict of opinion which may give rise to misunderstanding among the partners on many matters. This is n't good for the business as well as partnership.

5. Business secrecy: sometimes business secrecy is very much important for the business. If there are many persons in a business, it is very difficult to maintain business secrecy.

6. Non-transferability of shares:

share of one partner can't be transferred to another partner.

Joint Hindu Family Business:

A large number of business in India is carried on by different families and such a business is called a "Joint Hindu Family business."

Joint Hindu Family business operates under the Hindu succession Act, 1956.

There are 2 division of the Hindu succession Act, such as. (1) Dayabhaga law.

(2) Mitakshyara law.

According to Dayabhaga Law (which is applicable ~~to~~ only to Bengal) only male members will inherit the property of the family only after the death of the father.

But according to Mitakshyara law (which
22 is applicable to the rest of India) three successive male generation can inherit the property of the family from the moment of their birth.

- Usually Joint Hindu family business is managed by the head of male members of the family. who is known as "Karta".
- The Karta is the manager of the business and is the senior-most male member of the family.
- He controls the income and expenditure of the business aswell as family. (other members of the family is known as co-parceners)
- ~~In the event of~~ After the death of Karta, the next senior most male member will become the Karta automatically.

Cooperative society:

When a group of persons belonging to a particular classes or catagory ~~or~~ of group associate themselves and start a business for their mutual benefits, it may be a "co-operative society."

The main aim of a co-operative society is not to earn profit but to give best possible service to its members.

Co-operative society is usually started by middle class or lower middle class ~~or the weaker~~ belonging to a particular area.

The main motto of a co-operative society is "all for each and each for all".

which can be achieved only by self help through mutual help.

Basic Features:

1. ~~If~~ When a co-operative society is register under the law, it can continue its operation for an unlimited period of time.

2. Any one can become a member of a cooperative society by purchasing the shares of the co-operative society and can withdraw his membership by simple application.

3. The objective of co-operative society is (not to make profits but to provide best possible services to its members.

4. President, vice president, secretary etc are elected ~~from~~ to manage the co-operative society

5. The minimum no of members in a co-operative society is 10 and the maximum is unlimited

Joint stock company:

Joint stock companies are most popular form of business organisation not only in India but also world wide.

The sole-proprietorship and partnership forms of business organisation couldnot meet the growing demand of business ~~and~~ hence Joint stock company form of business organisation became popular. So the joint stock company arises due to the growing demand for more and more big business.

Joint stock companies in India are governed & regulated by an Act in the parliament known as " The Indian companies Act, 1956.

According to this act, a joint stock company has been defined as "a company limited by shares, having a permanent paid up nominal share capital of fixed amout, devided into shares also of fixed amount, held and transferable as stock and formed on the principle of having in its members, only the holders of those shares and or stock and no other person."

Basic Features:

1. A joint stock company is treated as independent and separate body apart from its members.
2. Once a joint stock company is formed, it continues to carry on its activities for an unlimited period of time.
3. The liabilities of all the members of a joint stock company are limited to the extent of their share in the company.
4. The min. no of membership in case of public ~~sector~~ limited company is seven and maximum is unlimited. But for a private limited company, the minimum is 2 & Maximum is fifty.
5. The shareholders of the company are the members, who are the owners of that company. But the owner don't take active part in the management of the company.

They elect a group of persons among themselves who manage the company. The person elected are the Directors of the company. so a Board of Directors having several director & managing directors.

6. The shares can be purchased and sold at stock exchange.

7. While forming a joint stock company, the promoter have to mention the purpose of the company. for which the company is formed. The purpose of the company is known as its object, which defines the products on which the company wants to carry on business.

8. The finance of a joint stock company is ~~com~~ made by the contributions of each and every member of the joint stock company by purchasing shares of that company.

9. As because a joint stock company collects a large amount of money from the general public, the Government ~~pa~~ usually puts more control over the working of the joint stock company.

Public sector companies:

Public sector companies are those companies which are also Governed by the Indian companies Act 1956, But the only major difference is that, It is started, owned, managed and controlled by the government. The Government holds more than 50% of the shares of such companies. In some cases the govt. & Govt. agencies or organisation holds the entire shares of such ~~business~~. companies.

ex: of such companies are:-
Oil India ltd, steel Authority of India limited, BSNL, GAIL etc.

Management:

(Management is the term which finds a common application every where). Knowingly or unknowingly every individual applies the technique of management even in his daily life.) Management is a term which can be applied every where, i.e in kitchen, Government or in a large company. Now a days management has become a separate branch of study.

Defination:

"Management is an art of getting things done through other people"

→ J. L. Hayes

"Management is the multipurpose organ that manages a business and manages managers, and manages worker and work.

→ P. F. Drucker.

"To manage is to forecast, to plan, to organise, to command to co-ordinate and to control."

– Henry Fayol

Management is knowing exactly what you want men to do and then seeing that they do in the best and cheapest way.

Management   Administration.

Difference between Administration and management:

Administration	Management
1. It is a thinking function.	1. It is a doing function.
2. It involves the determination of plans and policies.	2. It involves the implement of plans and policies.
3. It takes major decision.	3. It takes decision within the framework of administration.
4. Administration is a top level function.	4. Management is a lower level function.
5. Generally, the term administration is used in non-business organisation ~~like school, college~~.	5. the term management is use in business organisation.
6. Its decision are generally influenced by external factors such as social, political & legal etc.	6. Its decision are generally influenced by internal factors such as values, beliefs and opi-,

Importance of Management:

Management is a technique or media through which goals or objectives can be achieved.

Management is a systematic and scientific approach to solve problem and get results.

Effective management is probably the main resource of developed countries and the most needed resources of developing ones.

Functions of Management:

All the activities performed by managers at various levels to get the desired results may be the functions of management. They are:-

(1). Forecasting.
(2). planning
(3) organising.
(4). staffing.
(5). Directing.
(6). motivation
(7) leadership.
(8) communication.
(9). co-ordinating
(10) controlling.

(1) Forecasting

Forecasting is the first thing in the management process basing on which plans are made and actions are taken. It is the base of the planning process. It is nothing but the prediction of future. Forecasting is based on the analysis of the past, study of the present and estimate the future. since future is uncertain, forecasting helps to add certain level of certainity to future.

Planning

Planning is the most important among all the managerial functions. It is considered as the foundation of the work. planning includes the selection of best alternative among all the alternative available. planning ~~bridg~~ makes a bridge between ~~the gap~~ where we are and where we want to be in a desired future. It involves, what to do? when to do? where to do? How to do? and Who is to do? The aim of planning is maximum results at minimum possible effort.

Organising:

Organising is the management process, which helps to carry out the plans. organising includes putting life to plans by bringing together the physical facilities, workers, capital, machines, material, other things, and services to carryout the plans. It is also a process which involves dividing and grouping the work into various jobs. organising also defines the relationship among persons and decides who will do what for the impementation of the plans and for the achievement of goals.

(4) staffing:

staffing is nothing but filling up the positions created in the organisation structure. staffing functions include reeruitment, selection, training, placement, transfer, promotion, etc.

The aim of staffing is optimum utilization of human resources of an organisation.

(5) Directing:

Appointment in different positions n't enough to get good results. They need direction. i.e the proper orders and instructions as per requirement. So directing also includes motivations, proper leadership and effective communication. A manager must make ~~the~~ use of his leadership and motivational qualities to direct and guide the subordinate. Directing helps the plans to be converted into performance.

Motivation:

Motivation is nothing but ~~the~~ creating an internal desire in the mind of a person to do something. In the management process motivation is a powerful tool to achieve the goal effectively. Motivation creats intrest in a person to work for ~~the~~ attending the common goal.

~~Co-ord.~~ Leadership:

Leadership is important in ~~to~~ management as b it gives direction to followers / subordinates.

Communication:

Communication is the management process which refer to the transmission of messages, news, informations, suggestion, instruction etc from one person to another. Through ~~Through~~ communication ~~can~~ ~~make~~ an effective link is created and maintained among all the individual of the organisation. communication may be also through speech, action, chart, graph, diagrams, figures, pictures, etc.

Co-ordination:

It is the duty of a manager to co-ordinate the activities of all the individuals to provide unity of action for the achievement of common goal. Co-ordination includes division of works and distribution of duties and responsibilities among various individuals and groups working in the organisation structure.

Control:

Control is the last phase of management process. Control is a continuous process. Control is essential because planning and performance are never perfect.

Scientific Management:

Frederick Winslow Taylor – Father of scientific management.

Controlling process involves:-

(1) Establishing standards to measure performance.

2. Measuring actual performance.

3. Comparing performance with standard.

4. Taking co-rrective action.

Scientific Management:

Earlier almost all the work were being performed based on convention, tradition, past exprience, imagination, intution, opinion etc and there were no scientific reasons and principle behind the performance of work. But scientific management principles advocate the use of scientific methods and techniques in the performance of each and every activities of an organisation. Hence scientific management can be called as scientific approach for the solution of different problems of an enterprise.

Scientific management is an art of management which involves knowing exactly what is to be done and the bestway of doing it.

Scientific management is connected with the finding out the solutions to managerial problems which includes scientific methods of studies and observation.

F.W. Taylor is known as Father of scientific management. According to him "scientific management is the substitution of exact scientific investigation and knowledge for the own individual judgement or opinion in all matter relating to the workdone in the shop."

Scientific management also called as "The process of directing human efforts which employs scientific methods for getting higest productivity"

Scientific Management includes:—

(1). Scientific study and analysis of work.

(2). Scientific selection, training and placement of workers.

(3) standardization of all other resources including raw materials, machines, equipments, tools etc & providing proper working condition.

(4). scientific way or manner of performing each and every work.

Aim of scientific Management:

- To ensure higher productivity.
- To ensure quality of work as well as finished product.
- Reduction in the cost of production.
- Ellimination of wastage at all the level of works.
- providing right people to right work to achieve high degree of excellence.

Principles of scientific management:

The principles advocated by F. W Tayor are as follows:—

1. Replacement of old rule of thumb.
2. scientific selection and training of workers.
3. cooperation between labour and management
4. Maximization of o/p.
5. Equal distribution of responsibilities.

(1) Replacement of old thumb rule:

Under this principle, business decision should n't be taken based on tradition, convention, opinion, intution or the rule of thumb. such old practices have to be discontinued and in place of that, methods based on scientific solution should be adopted. Decisions should be made on scientific lines after proper investigation, evaluation and study of facts and consequences.

(2) Scientific selection and training of Workers:

This principle involves the selection of right man for the right job and provide them proper training to handle their jobs. The selection procedures for these workers ~~best suited~~ ~~to~~ have to be made scientific and may be designed in such a manner that the workers are best suited to the job that they are selected.

(3) Co-operation between labour and Management:

This principle also emphasizes that there is the need of faith and mutual understanding in order to maintain, co-ordial relationship between workers and the management.

The workers should be disciplined, sincere, loyal, honest, where as Management should be co-operative, friendly and believable.

(4) Maximization of output:-

This principle advocate that the management and workers should try to increase productivity. Their aim should be to achieve maximum output at minimum possible cost. To achieve this, there is a need to perform each and every work on scientific methods by providing standard materials, qualitative tools and maintain better working condition and hence wastages can be reduced at all the level of works. Maximization of output also requires supply of right people to increase quality and quantity.

[5]. <u>Equal distribution of Responsibility:</u>

There must be proper division and distribution of responsibility among the managers and workers. The manager should be responsible for planning, organising, staffing, directing, controlling etc. whereas workers should be ~~made~~ responsible for execution of works.

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ENTREPRENEURSHIP

"Entrepreneurship" is considered as the combination of "entrepreneur" and "enterprise".

Enterprise is defined as a unit of economic activities or an economic organisation especially a business organisation.

Entrepreneur is a person who has already started an enterprise or in the process of starting an enterprise.

Entrepreneur is ~~considered as an~~ defined as someone who runs a business at his own risk.

Entrepreneur is also called as the risk taker.

Entrepreneur is also known as an opportunity seeker, who always remains in seach of right opportunities to convert them into projects and profits.

Characteristics of an entrepreneurship:-

37 Characteristics of an enterpreneur can be divided into 3 broad groups, such as:-

(1) Traits.
(2) qualities.
(3) abilities.

Traits (distinguished Features) of an enterpreneur:

(1) Initiative.
(2). concern for quality.
(3) Urge to take calculated risk.
(4). Urge for solving problems.
(5). planning.
(6). self-confidence.
(7). Efficiency orientation
(8). Risk taking.
(9) leadership.
(10). Result oriented.
(11) sense of responsibility.
(12). Time management.

Qualities of an Enterpreneur:

(1) self confidence.
(2). Risk taking.
(3) Decision making
(4) Independent thinking.
(5) Managerial skill.
(6). Intelligence.

(7) cooperative.
(8) Organising abilities.
(9). Budgeting abilities.
(10) observational abilities.
(11) Visualisation abilities.
(12). High motivation.
(13) competetive ~~spirite~~ spirit.
(14) Non conformist.
(15). popularity.
(16) Reality oriented.
(17) control capacity.
(18) Emotional tolerance.

Abilities of entrepreneur:

(1) controlling.
(2) planning
(3) Directing
(4) Managing
(5) self-executing.
(6) Deciding.
(7) co-ordinating.
(8) Demonstrating
(9) Evaluating.
(10) ~~cour~~ organising.
(11). motivating.
(12) Innovating.
(13) supervising.
(14) sensing problems.
(15) Risk taking
(16). Result oriented.
(17) Managerial skill.
(18) knowledge of accounting.
(19) Knowledge of income tax and sales-tax rules.
(20) Knowledge of labour laws.

Need of enterpreneurship:

- Enterpreneurship promotes small business in the society.
- plays an important role in the economic development of the country.
- It is a medium of employment opportunities in all societies. It is a vehicle for employment generation & wealth.
- Increases productivity.
- Reduces the need of import.
- helps in the developing of new products.

INVENTORY CONTROL:

Inventory means stock of any materials. In an organisation, inventory includes stock of raw materials, equipments, semi-processed materials, packeging materials.

It is essential to maintain stock of the materials in an organisation because without these there can't be smooth production.

It helps carreying out production activities and smooth functioning of an organisation.

An organisation can't survive on zero inventory, similarly excessive inventory is also equally harmful for an organisation. So there is need of control over the purchase, storing and usage of inventory in an organisation.

Inventory saves an organisation from being expensive and ineffective. Hence there is need of inventory of various items at perfect level.

Importance of Inventory control:

1. It helps in maintaining uninterrupted flow of production, which helps in increasing output and decreasing cost.

2. It helps to increase efficiency and helps to achieve production target in time.

3. It helps to avoid delay in delivery to coustomers, which is essential for maintaining good customer relation.

*4. It helps to avoid pilling of stocks or finished goods at different point.

5. It helps to avoid shortage of inventories in an organisation.

6. Inventory control is helpful to maintain perfect level investment in inventories.

7. It helps to achieve effective utilization of all the inventories.

8. It helps to regulate the cost of maintaining inventories by proper management of the inventories.

9. It helps to check the Loss of inventories during ~~receept~~, storage, i~~ssue~~ and usage.

10. It helps to achieve economy in productio and sales.

Purchase Management:

*. Purchase is a task usually performed by almost each and every individual. We depend on purchase because we can't produce everything that we need. Before making a purchase a person takes into account his requirement, his purchasing capacity, his willingness to purchase, price, quality, quantity etc.

Similarly ~~when a business~~ In business matter, it has to take into account many factors like its requirement, price, availability of funds, availability of storage space, quality, future availability of material etc. Then it has to decide what to buy, When to buy, how much to buy, at what price to buy, from where to buy. etc.

~~succe~~ Success of an organisation also depends upon the care with which the material and equipment are purchased.

To be successful in business one has to purchase right goods at the right price, at the right time and in right ~~quality~~. quantity

* If materials purchased are more than the requirement, there is unnecessary blockage of funds, loss of godown rent, loss of material due to carelessness, theft etc.

Hence every organisation should have a separate purchase department to perform all the purchase functions.

The purchase department has to prepare a purchase budget for smooth purchase function. The purchase department should make a purchase policy, & this policy should be evaluated every year.

Steps or procedures in making purchases:

[1]. Receiving the purchase requisition

[2] Exploring the sources of supply and choosing the supplier.

(3) placing purchase order.

[4]. Making follow up letters after placing the orders.

(5) Receiving, testing & inspecting the material.

(6) checking & passing the bill of payment

[1]. Receiving the purchase requisition: (Request)

Whenever any item is needed in the organisation, it is the storekeeper who knowns it first.

storekeeper is the person who keeps all the material needed in an organisation in his store. and issue it to different department as per their needs.

so the store keeper knows which materials are needed in an organisation. When he knows about need of a particular material, he informs the purchase department to purchase the material.

The store keeper preapares a "purchase requisition" for the material needed. & send it to purchase department.

~~original is sent~~

store keeper prepares 3 copies of purchase requisition

one copy — purchase department

2nd " — department requiring material

3rd copy kept by store keeper itself

purchase requisition is a (document/form proforma) ~~performa~~ to be filled by the store keeper, which contain the information like the date, purchase requisition No., name of the materials, code No, quantity, size, specification time within which it required.

(2) Exploring the sources of supply and selecting the supplier.

The purchase department usually maintains a list of all the materials needed in the organisation. It also maintain the list of of various supplier.

After receiving the purchase requisition from
45 the store keeper, the purchase department will be able to know about the materials required to be purchased.

~~The purchase departme~~

If the materials required urgent in nature, it may purchased from market, but for other materials, the purchase department invite quotation (formal statement) by issuing tender in the newspaper ~~and in the~~

Intrested suppliers may send their quotation mentioning their price and other terms and conditions on their offer. Then a best supplier is choosen, purchase should be made at best price.

Placing purchase order:

After selecting the supplier, the purchase department has to prepare purchase order. purchase order is sent by purchase department to supplier to supply their order as per the agreement. The no of copies of purchase order to be prepared depend upon the size and policy of the organisation.

Purchase order is usually a proforma, where all the details of the materials are filled in. It contains the name of the materials, its specification, size, quality, price, discount, quantity, date of delivery, terms & conding of payment.

Making follow-up letters:

After placing the order the purchase ~~department~~ manager shouldn't remain silent and wait for the arrival of the materials. He should ensure that the purchase order has reached the supplier or n't.

 Hence he may sent a follow-up letter for confirming the order.

Receiving, Testing and Inspecting the Materials:

In case of a receiving department, the receiving clerk will receive the materials. ~~an~~ He ensure that the order for that materials is actually made and supply is from that specific supplier only.

Then the packets may be opened and materials may be physically counted. If there is any shortage, breakage, it ~~may~~ will inform to the purchase department who will inform the supplier immediately.

If the materials are all right, an expert may be called upon to inspect the quality of the materials. ~~on the~~ After that he prepare a inspecting note basing on which the receiving department will prepare a Goods receiving note. (GRN)

Checking and passing the Bill for payment:

After the supply is over, the supplier will prepare a bill and send it to the purchaser. The purchase department on receiving the bill will compare it with the copy of purchase order, goods received Note, challan and Inspection note. If everything is satisfactory, the bill will sent to the accounting department.

Then the accounting department pass the bill to the cash section for payment.

BIN CARD:

Different types of materials are present at store but they are n't kept at one place. ~~but~~ They ~~are~~ kept at different places for easy identification. A particular place in the store is assigned to a particular material. Hence the ~~exit~~. entire room is ~~suitably~~ devided into many parts. The place or the space assigned to a particular material is called bin. So the store contains number of bin and ~~som~~ all the bins are numbered in ~~to~~. order. A card is attach to the bin known as "Bin card."

All the Bin cards have different nos, so that there is one Bin card for each particular material.

Bin cards helps is maintained by store keeper.

Bin card helps the store keeper to control the stack.

(bill) (supply/distribute) for use or sales.

Apart from receipt, issue and balance column, the bin cards provides information about maximum stock level, minimum stock level, ordering level, re-ordering level, danger level etc.

~~Store log~~ ledger:

The store keeper also maintains a big register for recording the receipt, issue and balance of different materials in the store. Such a register is known as "store ledger."

This register contains an account for all items of the store. It contains many pages and one page is meant for a particular material only, where receipt, issue and balance of the same material is recorded.

→ store ledger also helps the stock keeper to control the stock.

→ store ledger also ~~too~~ provides information about the maximum stock level, minimum stock level, ordering stock level, re-ordering stock level and danger level of different material.

Bin card is a record of quantity only, But store ledger is a record of quantities and values.
Bin card maintain by store keeper, store ledger is maintain by costing department.
Bin card is kept inside the store, & store ledger kept outside the store.

Goods Received Note:

After the receipt of the material from the supplier, ~~when~~ then it is counted, tested and verified. If it is satisfactory, a Goods Received Note is prepared and showing the details of the materials received. ~~It is also known as~~ In some organisation it is also known as Materials received ~~ntt~~ Note.

GRN is a proforma which contains the
49 details of materials received such as
quantity, specification, price, date of receipt, name of the supplier, purchase order No etc.
It ~~is~~ has 3 copy. one is sent to purchase department, one to accounting department and last copy is kept by store keeper.

*. Follow up – An action or thing that serves to increase the effectiveness of previous one, as second letter or subsequent letter, phone call or visit.

CH-6 PRODUCTION MANAGEMENT

Production management is that branch of management which ~~to~~ is related to the manufacturing of goods and services of an organisation.

The main aim of each and every production organisation is to use the best method of production to produce quality goods ~~at~~ ~~it~~ and maximize the profits.

Production:

Production is nothing but the conversion of raw material into finished products.

Planning:

Planning is nothing but forecasting and deciding in advance.

Production planning:

Production planning can be defined as the forecasting or deciding in advance as to when, by whom and how the raw materials shall be converted into finish product.

Control:

Control is the checking and ensuring that the plans are carried on as per expectations. Without control things mayn't happen as per wish.

Production control

Production controls guides the flow of production, so that products of desired quality are produced at the appropriate time.
Production control ensures checking & ~~ensuring~~ inspecting at various points, different works.

Production, planning and control:

Production planning and control may be defined as the " co-ordination of a series of functions according to the plan, which will regulate the orderly movement of goods through the entire manufacturing cycle from the procurement of all the material to the shipping of finished goods at a predetermined rate.

Importance of production, planning and control:—

(1). ~~Planning~~ production planning and control helps to increase productivity

(2) It also minimizes the cost of converting the raw material into finished goods.

(3) ~~Pro~~ It arranges the production process in sequence ~~so~~ that production target is achieved in time.

(4). It helps to achieve efficiency, economy and performance of work as per plans.

(5). production planning control helps in regulating production and maintain quality.

(6) It ~~bring~~ brings many benefits to many persons ~~like~~.

The manufacturers get increased production, higher productivity, delivery of goods to customers in time, low cost of production and higher profits.

The customers get quality product at low price and in time.

The workers get adequate wages, stable employment, job security and improved working condition, timely payment etc.

The investors get adequate rate of return ~~to~~ on their investment.

The society get the better utilisation of the wealth and creation of quality products.

<u>steps in production planning control:</u>

It includes:-

(1) Planning.
(2) Routing
(3) scheduling
(4) Loading.
(5) Despatching.
(6) Follow up.
(7) Inspection.

3. Planning:

It is the 1st step in production, planning and control programme. ~~In~~ under this the management has to prepare a broad plan for the production activities of the organisation. At this stage, the management decides the product to be produced. This also decides the resources required to carry on the production i.e. the requirement of men, machines, materials, methods, processes etc.

Routing:

Routing determines the way or the exact route through which all materials will flow from one process to another untill its completion as finish products. Before selecting the exact route through which raw materials will become finished goods, it is essential to study various routes and decide best route which is economical, efficient and less time consuming.

Scheduling:

After the exact route is decided, the next step to make a schedule. i.e. the time table for production activities. It involves fixation of time and date for starting and completion of ~~each~~ operation.

The whole operation is possible only when the entire work is divided into many parts, segments, bits or divisions and each portion ~~is~~ ~~ass~~ of work to a particular person

Loading:

It is associated with the quantity of works assigned to a machine or worker. Loading of works to different machines, sections and department or individual is essential for proper distribution of duties as per the capacity of the department / machines / individuals. There should neither be overload or underload to anyone.

Dispatching:

Dispatching is the actual execution of the plans. It includes

(1). Issue of necessary materials.

(2) Allocation of appropriate labour force and required machinery.

(3). Issuing necessary orders for inspections at various stage while the work is in progress.

(4) Maintenance of records for all orders issued from time to time.

Follow-up:

It involves the checking the progress of the work. It ensures the progress of work according to plans. If there is variation in any stages, then corrective measures should be taken to ensure smooth performance of work as per plans.

55

Inspection:

It is the last stage of production planning and control. It involves the checking of the quality of goods produced ~~and ensure that they~~.

If there is inspection at various points, where there are chances of mistakes or deviation, so that the final product is n't rejected and wasted.

Inspection includes the appointment of inspector at various points where the chances of deviation are very high.

Dispatching - procedure for assigning employees or vehicles to customers, courier, emergency services.

CH-7 Sales And Marketing Management.

56

Sales Management:

sales means actual exchange of goods and services between the buyer and seller. sale is the life of a business and it is the ultimate goal of each and every enterprise.

sale is the conversion of goods into cash. Without sale at resonable price, production has no meaning at all.

Marketing and selling are 2 different terms but are closely related.

selling is concerned with conversion of finished goods into cash, and its aim is to increase the sales volume.

But Marketing is concerned with the creation of demand and needs in the mind of the people to buy a product.

sale is one of the activities of Marketing. so marketing includes selling.

The main aim of an organisation should be to achieve good profits by increasing the sales volume.

Importance of sales Management:

1. sales Management is responsible for increase in sales volume and thereby increase profits, which is the ultimate goal of each and every business.

2. sales management helps to maintain an uninterrupted flow of goods and services.

3. It helps marketing management to achieve its by timely supply of goods and services to the customers.

4. Sales management helps to reduce the cost of selling thereby increasing the profits of the organisation.

5. Sales management is responsible for the delivery of goods and services to the customers.

*6. Sales management helps to avoid unnecessary pilling of stock of finished goods.

*7. Sales management is responsible for retaining the old customers by effective after sales service and thus create new customers and new demand.

*8. Sales management helps an enterprise to remain and succeed in business.

Marketing Management:

Market:- Market is the place or area where business activities such as buying and selling are carried on.

Meaning of Market is different for different people.

For a buyer → A market is a place where he can ~~meet~~ satisfy his wants / need by purchasing good & services.

For a seller → Market is a place, where he convert his goods into cash.

It is a place where the producers or sellers shows his talent to motivate the buyers to buy his products.

So Marketing involves flow of goods & services from the producer to the consumers through the process of exchange. It can also be defined as the process of exchange between buyer and seller.

Marketing – need of the buyer.
Selling – need of the seller.

* No body forces the buyer to go to the market, but goes to the market intentionally to satisfy his needs. They go to the market with money and intention of buying the goods and services.
Where as the seller goes to the market with goods and services only.

* According to Harry L Hansen, "Marketing is the process of discovering and translating consumer need and wants into products and services and then in turn expand their demands".

Marketing Management is the combination of Marketing and Management.

So Marketing management may be defined as the process of ascertaining consumer needs and wants and converting them into product and services and then moving the products and services

59 to the final consumers to satisfy their needs and wants.

Importance:

1. Marketing management helps to create demand and needs in the mind of the people for the goods and services of the organisation.

2. It helpful to create markets for the goods and services of an organisation.

3. Marketing management is responsible for increase in goods and services by the people.

4. Marketing management focuses on increased consumer's satisfaction ~~satisfaction~~ so that consumers creat consumers in large numbers.

5. It helps to study the markets and market conditions, to keep changing the market policies to stay in the market.

6. Marketing management helps the sales management to achieve its objective.

7.

Selling Methods:

The selection of an appropriate selling method depend upon type of product, policy of an organisation, number of consumers, location of concumers etc.

An organisation may select any one selling methods:-

(1) Hire-purchase or instalment.
(2). Self-servicing.
(3) Sale by sending travelling salesmen approaching door to door.

4. sale by offering quotation against tenders.
5. Mail order.
6. Retailing.
7. whole-selling.
8. Appointing agent at different cities and towns.
9. company's own show room.
10. Teleshopping.
11. E-commerce.
12. Autovending.
13. Auction sale.
14. counter sale.
15. Networking.

Hire-purchase or Instalment:

Under this method, the buyers don't pay the full price of the product. The entire price of the product is paid in montly or yearly instalment. The first instalment is known as 'Down payment'. The buyer take possession (owning) (controlling something) of the product and start using it. But the right over the product on the ownership lies with the seller till the last instalment is paid. If the buyer fails to pay even the last instalment, the seller can claim the possession of the product. This types of selling is usually done for costly items like car, scooter, refrigeratone, Tv, plots and readymade flats or houses etc

Self - Servicing

This type of selling is more popular in modern society, where people are more concerned about their prestige. under this system, goods are kept inside a large spacious shop, where customers move from one corner of the shop to the other, selecting commodities of their choice and put them into a trolley. ~~the~~ the trolley is pulled to the counter by the customer himself. The person in charge of the counter prepares a bill and then pack the commodities in a packet and hand over to the customer on payment of the money.

Sales by sending travelling salesmen Approaching door to door:

This method has ~~is~~ gone outdated. under this method the customers don't go to the market to buy product but the ~~sending~~ travelling seller takes the pain of. The salesmen demonstrate, convience the terms and conditions and collect money.

Sales by ~~approaching~~ offering quotation against Tenders:

When large organisation or business houses or Govt organisation make purchase, ~~d~~ they don't send people to the market to buy their requirement. They issue tenders which appear in the newspaper or in their notice board. There are some organisation who sell their product only through submission of quotations against such tenders. Intrested candidate submit their quoation against the tender giving the details of price, other terms and conditions.

Mail order:

When the customers of a product are spread over evenly throughout the country and the product is quite handy with moderate price., the mail order from selling is quite effection. under this the seller advertises in various medias like newspapers, T.V, Radio etc. regarding their product and also mentions that the product shall n't be available in shop. The seller sends the product by VPP (value payable by post)

Retailling:

under this system of sale, the manufacturer appoints a number of retailers throughout the country to provide the needs of all the people. Retailer collects products and directly sell the products to the customs in small quanties.

Retailers are usually placed at a place where customers can get their requirements easily without travelling a long destance. e.g. Petrol, diesel, cooking gas, Kerosene etc. There is no wholeseller.

wholesale:

under this method a manufacturer appoints a no of whole salers who sells the product in ~~b~~ large quantities to the retailers. This ~~happen~~ is found in case of consumer durable products or daily use and where the no of cusumer are unlimited.

whole salers are usually appointed at all the business centre. i.e cities and towns from where the retailers get their requirement in time.

ex:- wholesalers are appointed for soaps, matchbox, paper, clothes.

Appointing agents at different towns & cities:

Some producers don't have retailers or wholesalers but they appoint agents in different cities & town who sell their product ~~on~~.

They collect orders & supply the goods to the customers and paid commision for such sales.

This happens in case of product like air conditioners, medical equipment etc.

Company's own show room:

some companies directly sell to the customers through their own showrooms. producers ~~opens~~ usually opens show rooms at all important cities and towns and maintain stock of all varities of product produced by them. ~~The~~

The customers can directly go to the show room and get the product of their choice.

example– Bata products.

* Some times such company also have other retailers or dealers.

~~Tele~~

Tele-shopping:

Thereare some Business organisation, who telecast the programmes on Television & demonstrate different products, tell them about their uses, advantages, price etc. and convience the viewers. They also tell as to how such product can be purchased. Intrested viewer order such products.

The products are delevered at the door of the customers with in stipulated time and money is ~~called~~ collected on delivery.

* sometime some advance payment is also requested by the seller.

E-Commerce:

Now a day there is increased use of Personal computers by middle class and upper middle class. The easy availability of internet facilities at a cheaper cost has made the business of buying and selling very easy. This new concept was adopted by big companies for their own business but now general people are able to avail this facility with the help of modern communication network.

Autovending:

65 It is an innovative method of selling. In this method, an automatic vending machine is placed at for a particular product the busy market place where the customers can get that product from the machine by inserting the amount of money into the machine. Once the exact amount of money is inserted into the autovending machine, the desire product comes out automatically.

ex:— The products that are available throug autovending are:—

newspapers, magazines, cakes, icecreams, ~~pizzas~~ cold drinks ets.

Auction sales:

* It is a type of competition of the buyer ~~as~~ to purchase a particular good ~~and~~

This is usually organised by the seller or his agent. ~~as~~ In this method, selling is carried on through public auction. The auctioner invites the purchasers, who are called bidders to a particular place at a particular time.
The bidders are usually ask to deposit some amount of money with the auctioner as security money to be eligible for bidding in auction.

A minimum price (floor price) is usually fixed by the auctioner and the bidders are asked to quote their rates. When the bidding is in progress, one bidder can over-ride the other by announcing higher rate.

The bidder quoting or willing to pay the highest amount is sold the goods. The ~~sold~~ sale is complete on the fall of ~~by~~ the hammer.

6. The security deposits of the unsuccessful bidders are returned.

Counter sale:

Here the manufacturers opens counter at their factory itself or at different location at important places or different cities and towns.

Here the company or the manufacturers plan to sell their goods directly to the customers.

The manufacturers appoint their own manpower to manage the counter and goods. come directly to the counter from the factory.

Networking:

Under this type of selling, the seller creates a network of people and supply the product to those people through the network. This network is created by collecting membership or by having registration and the goods and services are supplied to them at the specified rates through the members of network. such goods are n't sold at open market but the members are to collect their requirements from the other senior members. At the end the commission or bonus is calculated on the basis of sale proceeds under each members. & the % of commission varies depending upon the seniority of members.

Ex:- Amway & Modicare.

* Manufacturer does n't spent much on adverting, storing etc & saves a lot of expenses. & saves the commission paybale to

middlemen. & the members in chain saves the
67 commission which is known as bonus.

PRODUCT Policy:

Product is the most important component in the marketing management. Product policy of an organisation includes the general rules and guidelines through which the product may made available to the customers ~~The management~~ should ~~formulo~~ made some guidelines ~~through which the product may~~ be ~~made available to the customers~~. of the ~~product~~

If a product ~~policy~~ fails to satisfy consumers expectation, no product policy shall be helpful to achieve the goal of the enterprise.

In the market varities of products available. ~~in the form of~~ Hence only good product which satify the consumers need can enjoy a longer stay in the market. So increase consumer ~~satisfication~~ Satisfaction and their desire to purchase are the key for the success of the product in the market. All other product may be available ~~plently~~ in large amount but don't have any buyers and fade away from the market very soon.

Hence product policy is very much important in the marketing management. So product policy should be designed very carefully.

Product policy can be 3 dimensional.

(1) Managerial dimension.
(2) Consumers dimension.
(3) Social dimension.

Types of products:

can be devided into many catagories such as:- agricultural goods, durable goods, non durable goods.

perishable goods and non perishable goods.

necessary goods and luxury goods

But, from marketing management point of view, it is of 3 types:—

(1) convenience goods.
(2) shopping goods.
(3) speciality goods.

(1)

These goods are products demanded by the customers very frequently and in small quanties.

ex:- match box, salt, soap, cin blade, tooth paste, agarbati.

(2) shopping goods:

shopping goods are the product which need search effort and special visit to certain market such products are n't urgently needed by customers.

ex:- furniture, domestic appliances, ornaments etc.

(3) speciality goods:-

These are the product having unique features.

They sold only in special shops meant for that purpose only. product are identified with their brand. Buyer can wait to get the particular brand of the product. ex:- car, scooter, TV, ...

69

BRANDING:

Branding is the naming of a product through which it is identified among similar product. A brandname is a symbol or a design or a combination of them which identify the goods and services of one seller from the other. Branding is use to differentiate the product of different manufactures. Brand is applied to almost all the products to have some identification make such as – trade mark, trade name, trade symbol, pictures, designs etc. It also includes distinctive lettering, colouring with or without slogan.

Branded products are easily identified and can easily recognised by the customers.

A good brandname is highly essential for success of a product in the market.

Principles of branding:

1. The brand name should indicate something about the products, its uses, benefits, quality, performance etc.

2. The brand name should be as short as possible, easy to remember, easy to spell.

3. It shouldn't be similar to any other brand name.

4. The brandname shouldn't be changed frequently

5. The brandname should be registered with the registar of Trade marks for legal protection of brand.

6. Brandname should create a pleasant association with the customers.

7. The brand should be unique & distinctive & attractive.

800

Packaging:

Packaging also plays an important role in marketing a product and creating its further demand. packaging is a marketing necessity. consumers n't only want the product, but also want a attractive and eye-catching appearance of the product, which can be made by packeging.

- Packing is used primarily to prevent leakage, maintain quality, ~~ensure~~ for safety and freshness of a product.

- Packing is also used to print the brand name, trade mark, symbol, price, composition, instruction etc. of the product.

- But the main idea of packaging is to protect the product against lose or damage in quality and quantity.

- so packeging performs three basic purposes such as protection of goods, enhancement of product value and advertisement of the product.

- A good packaging increases the value of the product.

- ~~la~~ However some product likes heavy machineries, car, scooter's and motor cycles, etc don't requires packing. only small products which need protection are ~~used~~ in use to need packeging.

Labelling:

Labelling is a part of packaging. There is need to provide the no. of information to the customers about the product like its price, its weight, its uses etc. on the packet. Label is usually a tag attached to the packet of the product, But now a days it is printed on the packet.

Labelling provide adequate information to the user about the product. It usually includes the name of the product, its weight, its composition, date of manufacturing, date of expiry etc.

Product-Mix:

A manufacturer may n't produce only one product. He may produce a number of product of different varieties.

So product-mix may be defined as the "Proportion of different products and their varieties manufactured by a producer."

Product Mix includes the depth and width of product policy of an organisation.

Example:-

A company may produce bicycle, scooter, motor cycle, fans, refrigerators, TVs etc which is known as product line of the company and is called the width of the product policy.

Similary the same company may be producing bicycle of different varieties such as baby bicycle, lady bicycle, gent's bicycle, racing bicycle and bicycles of different sizes and colours. This is known as depth of product policy.

*. The product mix has to be changed depending upon market condition and policy of the organisation.

Factors responsible for change in the product mix are:-

- consumer's behaviour.
- competetitions.
- financial conditions of the producer.
- producer image.
- *-change in the composition of population.
- change in the purchasing power of customers etc.

PRICING.

Pricing is the fixing the value of the product to be sold in the market.

There are different methods of pricing depending on costs, compitition, market etc. ~~These~~ most imp. methods are:-

(1) cost plus pricing:

Under this method, the producer calculate the total cost of the goods. Then a certain % of profit is added to the cost to findout the price of the product.

2. variable pricing policy:

2. Variable pricing policy:

Under this method, the producer charges different prices of the same product to different customers. So prices differ from buyer to buyer. Price is usually depend upon the volume of goods to be purchased, time of purchase, place and other related factors.

3. Base price discount:

Base price is the total cost of the product without any profit, when a product is sold below the base price, it is known as base price discount method. When a producer faces any problem, he may sell the product below the existing price so that he mayn't suffer from any financial hazard.

*. Discount:-

4. Market rate Method:-

This method of pricing depend upon the condition of the market such as demand and supply position, competition and consumer behaviour.

Market condition doesn't depend upon one seller or one product. So individual seller can't control the market condition.

Market price may be the price determined by the ~~Gover~~ Govt or market commitees.

A producer may sell his product at the market price, below the market price or above the market price & this decision depend upon his product, its quality, reputation, cost, bargaining power of the customers etc.

5. Skimming price ~~straegey~~ strategy:

Under this pricing policy, whenever a new product is introduced in the market, the producer fixes a very high price of his products in order to attract the attention of the buyers and this type of product is generally use by high class buyer. But common people cann't affort it. But later on the producer lowers the price gradually to win the Middleclass and lower middle class customers. & In this way it enlarges the market gradually.

*. A high ↑ initial price earns higher sales revenue higher profit & later on when price is reduced it achieves higher sales volume resulting higher profit.

ex:- ~~Thi~~ This type of pricing policy can be adopted in case of speciality goods and fashionable product.

6. Penetration strategy:

This policy is just opposite to skimming strategy. Under this policy, whenever a producer introduces a new product into the market, he fix a low price of the product to attract the attention of the customers and its sales

volume increases. Then producer establish its
75 brand and gradually the producer increases the price of his product depending upon the market condition.

sales promotion techniques:

sales promotion means increases the sales volume through different sales promotion techniques.

- Sales promotion motivate the ~~buyer~~ dealer to buy more, stock more and sell more.
- It encourages the sales force to increase the sell volume.
- It convience the buyer to buy more.

3 types of sales promotion techniques:

1. Dealer promotion
2. sales force promotion
3. consumers promotion.

[1] Dealer promotion:

Under dealer promotion scheme, the producer try to motivate the dealers to increase the sales by offering them some additional benefits. It includes giving discount, special treatment, prizes, gifts etc.

[2]. sales force promotion:

Under this, the producer try to motivate their own sales force to achieve higher sales volume. Different scheme are introduced to attract the sales force so that they can try their best to increase the sales volume and ~~it includes~~ the scheme includes promotions, bonus, organising contests among the sales force, conducting seminar, giving spacial gifts, honouring etc.

[3] consumer promotion:
76

Under consumer promotion scheme, consumer are centre of attraction. Some, schemes are introduced to attract the consumer to buy the products even if they are n't needed by them. such scheme includes giving free samples, ~~Soo~~ coupons, scratch card, bonous, discount, free demonstration etc.

ADVERTISING AND ITS MEDIA: It is n't enought to produce a product, But in addition to that producer has to inform the buyer about the product. Advertising is a method through which the producer informs the buyer about the product and tries to convience them to purchase.

- Advertsing is the method of creating demand in the mind of the people.

- Advertisement can be defined as the activities through which communication is sent to a target group of people for promotion of exchange of goods and services.

Now a days, advertising agencies are there who specialise in the job of advertising. They conduct ~~reas~~ research, studies innovative idea and thiugh to motivate the buyer.

Advertising Medias:

The message in the advertisement should reach the target or the buyer. There are several mediums through which such message may be communicated and such mediums are known as advertisement media.

Advertisement media can be devided into 4 types:-

1. Indoor Advertisement.
2. Outdoor Advertisement.
3. Direct Advertisement.
4. Display Advertisement.

[1] Indoor Advertisement:

Under this method of advertisement, the customer stay inside his home and message reach him through various mode ~~to~~ such as:-

1. Newspapers and magazines.
2. Televisions.
3. Radios
4. Films.
5. video
6. supplements and leaflets inserted inside the pages of newspapers etc.

[2] outdoor Advertisement:

Under this method of advertisement, when the customer go outside ~~th~~ of ~~the too~~ his home, he may get the message about the product. such methods includes:-

[1] posters.
[2] painted displays such as advertising board, wall advertisement.
[3]. Electric sign. (usually at night at busy centre like market place, railway station etc)

4. sky writting (~~Writing the~~

5. Travelling bus, taxies etc.

6. Banners across the roads.

[3] <u>Direct Advertisement</u>:

It includes direct contanct with the buyer, which includes,

[a] Promotional booklets.

[b]. Catelogues.

[c]. Gift like calenders, diaries, pen stand, ball pens, T-shirts, hand bags, hat etc.

[d] use of loudspeaker to announce.

[e] Affixing logos, ~~mon~~ symbols, names of products and company etc on the dresses, shoes, caps of sportsmen and players.

[f] ~~placing~~

[4] <u>Display Advertising</u>:

~~In~~ It includes :-

1. Window display.
2. Counter display.
3. showcase display.
4. show rooms.
5. Exhibitions.

CH-9 INDUSTRIAL SICKNESS

Industrial Sickness ~~of~~ is described as the overall illness of a business organisation due to financial weakness and continuous loss due to negative growth.

An industry is said to be sick, when it is n't able to function normally

In otherwoords, an industry becomes sick when it cann't fulfill the expectation of the owners, customers, workers, financers, government and the society.

Symptoms of sickness:

1. Increase in inventories.
2. Increase in quantities of slow or non moving item in the total inventories.
3. Low capacity utilisation.
4. Poor industrial relation.
5. Frequent industrial disputes.
6. Higher rejection of completed goods.
7. Delay in payment of taxes,
8. Faliure to make timely payment of electricity bill, telephone bills etc.
9. Inability to pay timely instalment of loans. and its intrest.
10. Increase in intrest burden.

2 Causes of Industrial Sickness:

Several factors are responsible for sickness of an industry. But some factors initiate the process of sickness and other factor extend good support to complete sickness:

These causes can be devided into 4 types:—

(1) Internal causes.
[2] External causes.
[3] Entrepreneurial causes.
[4] Other causes.

[1] Internal causes:

These cause usually takes ~~place~~ birth inside the organisation and become a reson for the sickness of the industry. such reasons may be:—

(i) obsolete technology:

Due to old and outdated technology, production mayn't be qualitative, speedy and economical and efficient.

[ii]. Non-flexibility:

The unit may lack flexibility which may be essential to adopt to any structural changes needed under the changing business environment.

(iii) Financial Mismanagement:

The finance of the organisation may be mismanaged. This may causes financial hardship and financial sickness.

[iv] Poor industrial relation:-

If the relation between the manage-ment and workers is n't good and there is no healthy working condition, then it hampers the industry.

[v]. Inefficient Management:

If all the facilities and provisions are available but there is lack of efficient management, every thing shall be fruitless. An efficient management n't only increases the profit but also convert the losses into profits where as an ~~a~~ inefficient management can easily convert the profit into heavy loss.

[vi] Inefficient sales and Marketing activities:-

Even if there is qualitative production, due to inefficient sales and marketing, other competitors will get the chance to win the heart of the consumers.

(vii) Higher cost:

If the cost of production is high, & the rate of return is n't high ~~a~~ then it will difficult to manage the business.

(viii) Poor quality control:-

If The ~~quality~~ control of quality is low or poor, then the business may be sick.

[ix] Higher wastage :-

If there is higher wastage or resources like time, energy, money, material manpower etc, it will lead to loss or reduction in profit.

[X] Increase Repair and Maintanance :-

Frequent stoppage or slowdown of activities for repair and maintainance will lead to lower productivity, which may result in sickness.

[XI] Over-capitalisation and under capitalisation

sometimes the entrepreneur can't calculate the exact amount of capital needed for the organisation.

so If the capital introduced is much more than the requirement, it will lead to over capitalisation, & the industry can't make full and effective utilisation of the capital. This will result in lower rate of return and profit & make a industry sick.

Similarly lower capitalisation is also a harmful thing. If capital invested is low or less than the requirement, it will cause under capitalisation and which may be a cause of industrial sick.

External causes :-

Apart from the internal causes, for industrial sickness, there are many external causes for sickness of industry.

[1] Non-acceptance of product by consumer:- 5

If the products produced by the organisation are n't accepted by the consumer due to any reason, the industry is bound to become sick.

[2]. Change in taste, fashion and custom of customers:

Many times there is change in taste, fashion and custom of customer which effects the demand of the product causing sickness of the unit.

[3] Shortage of raw material:-

If there is shortage of raw material in an industry, ~~&~~ then there will be less production and the industry become sick.

[4] Shortage of finance:-

If there is non-availability of finance at the appropriate time to meet the working capital needs, it will cause heavy damage to business organisation & leads to sick gradually.

[5] Sickness in customers Business:-

If there is sickness in the business of some of the customers on whom the organisation largely depends, it will also effect the business of the organisation.

(6) Competition:-

Some times ~~heavy~~ due to heavy competition producer usually sell their products even at reduced price to ~~as~~ elliminate the competitors. In such case, the industry having poor foundation or poor financial strength fail to perform and become sick.

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(7) Reduction in demand:-

If the demand of the product of the organisation goes down due to many reasons such as invention of new products, prices, alternative product, change in technology etc, the unit is become sick.

[8] change in Govt. policies:

Due to change in the Govt. policies on some products, some business become unprofitable & hence become sick.

example:- If the Govt. decides to import paper at low price, the domestic paper industries may become sick.

[9] When supply is more than demand:-

When supply is more than demand much goods remains unsold. Then under this some business organisation may become sick.

[C] Entrepreneurial Causes:-

Majority of the industries become sick due to the fault of the entrepreneurs.

Those are:-

(1) Improper planning:

Many ~~industries~~ industry fails and become sick due to improper planning by the entrepreneur.

(2) Lack of determination:

Lack of proper determination and lack of intrest may be the reason for the sickness of an industry. 7

[3] Lack of creativity, innovation and skill:

Starting an industry and running it successfully required a lot of innovation creativity and talent. Many people/entrepreneur don't have such talent and depend on others. Hence they make the industry sick.

[4]. Attitude of the entrepreneur:-

If the attitude of the entrepreneur is clear and is for the betterment of the organisation, his struggle will prove to be the reason for his success. But if the entrepreneur is lazy, dull it is difficult for him to run a business successfully. Such business usually becomes sick very soon.

[5] Intentional sickness:

If the entrepreneur has started the industry to make it sick by any means and divert its resources to other project, then nothing shall be helpful to avoid sickness.

[6] Lack of exprience:

If the entrepreneur doesnot have exprience, he maynot be able to solve many business problems and become a reason of sickness.

[7]. Sickness of entrepreneur:

If the entrepreneur becomes sick due to the personal health basis or there is ~~illness~~ prolonged illness, it will effect on the smooth running of the organisation. and industry becomes sick.

[8] Lack of entrepreneurial characteristics:

If the entrepreneur does posses all the characteristics, qualities, abilities, skill

8 and talent, there is a chance that the organisation will become sick.

[9] Excess dependance of Entrepreneur:–

During the initial period the entrepreneur do everything and get involved in almost all the activities to ensure success. But when they achieve success and become rich, gradually they start depending upon many persons and get things done through others. & other people try to take advantages of this independence. so excessive dependance may be the reason for the failure of an entrepreneur and the industry become sick.

[10] Improper selection of business Opportunity:

It is usually seen that entrepreneurs donot take sufficient care in selecting a business opportunity. As a result of which they may select improper business opportunity and ultimately leads to sickness.

Other causes:

There are some other causes which may make a industry sick.
some important causes are:–

[1] Natural causes:–

Sometimes natural activities such as flood, cyclone, drought, earthquake etc cause heavy damage to the industry and make it sick.

[2]. Social causes:–

[2] Social causes:-

Awareness among the people n't to use a particular product on the basis that it is harmful to health or environment and creats ~~opinion and~~ mass opinion and ~~movement against such~~ movements against such product and the industry become sick.

[3] Liberalisation and globalisation of economy:

Due to liberisation of economy, many foreign companies come and start their business in other countries. They bring up upto date technology, better products and better service and compete with the domestic indurstries. But many domestic indurstry cann't compete with them and become sick.

[4] Other causes:

(1) Improper location of unit.
(2) Increase in the cost of project due to delay.
(3) Increase in the cost of inputs making the business.

Remedial measures of sickness:

The following measures may be helpful for the entrepreneur in order to avoid sickness of industries.

(1). All the activities should be planned carefully.

(2). Financial ~~discipline~~ management should be there.

(3) A good industrial relation should be created and maintained.

[4] ~~Enter~~ Entrepreneur, workers and managers should keep them updated and should be aware of various techniques

[5] Excessive dependance on others should be avoided.

[6]. The management should be done efficiently.

[7]. Keep a watch on the competitors and their activities and prepare yourself accordingly.

[8]. Behaviour and the attitudes of the consumers may be studied carefully and one ~~should~~ should always in touch with the customers.

[9]. Remain in touch with the change in technology by visiting exhibitions, market.

[10]. Know your own faults, weakness, mistakes, ignorance and see that they don't bring problem to your organisation.

[11]. You should aware of various reasons or problems leading to sickness.

HUMAN RESOURCE MANAGEMENT

An organisation is run by individuals. Like any other resources such individuals are the resource of an organisation and is known as human resources.

and there is need of managing this resources, otherwise it will be directionless or it may be unutilised or mis utilised.

- Human resource is one of the resource, which take care of all the resources.
- Human resource is known as life line of an organisation.
- Managing the human resource in an organisation is known as human resource management.
- "HRM" is the process of employing people, training them, developing policies relating to them, developing strategies to retain them.

RECRUITMENTS AND ITS SOURCES:

Recruitment of manpower is considered to be the process of discovering the sources of manpower as per the job requirement and job specification.

Different sources of recruitment

It can be devided into 2 types. i.e.

- Internal sources
- External sources.

[1] Internal sources:

It includes

[A] Transfer:

Under this system, recruitment is made by transferring ~~employo~~ employees from one post to another, or new post and the process is called transfer.

- usually doesn't involves any extra financial benefits to an employee.
- Nature of duties, responsibilities, status etc donot change.

[B] promotion:

Under this system, post are filled up by offering promotion to higher post.

- Here the nature of duties, responsibility status, remuneration, privileges etc changes.
- It is the process of filling vacancies from lower post to higher post within the organisation.

[c] Own training centres:

A no. of organisation have opened their own training centre, where they take training on regular basis.

- They provide theory as well as practical skill for a period of time.
- some successful trainees are absorbed by the organisation itself and some find employment elsewhere.

External sources:-

[A] Advertisement:-

under this system, applications are invited for different post through advertisement in newspapers, magazines, radio, TV, etc.

- This type of advertisement reaches a large no of people over the large area.

[B]. campus interview:

Now a days recruiters go to different technical, professional, management institution for the purpose of selecting young and fresh talent for their requirement.

- They conduct test, interview etc. for final year students and just passed students and offer them placement in their organisation.

[c] Walk in interview:

Now a days it is a fashion for the employers/recruiters to organise walk-in interview at different town and cities to recruit man power.

[d] Employment Fair / Job Mela:-

It has become a fashion today to organise employment fair or job mela at the important places for the purpose of attracting large number of applicant for the purpose of recruitment.

[e] employment consulatant:

Employment consultant provide service to the employer by providing appropriate man-power as per their need.

- This type of recruitment is usually done for skilled personnel and for top managerial jobs.

[f] employment exchange:

This is a very old source of recruitment of manpower. Government employment exchanges are there throughout the country.

It act as a agent between the employers and the Jobseeker.

[g] Direct recruitment:-

under this system, the employer notifies the requirement of manpower in its notice board which is usually at the factory gate.

This is a old method of recruitment & usually adopted for the purpose of recruitment of non skilled casual worker.

[H]. unsolicited Applications:

Many candidates submit application for the different post at different times even if there is no vacancy in the organisation. There is a personnel department usually maintain record of such ~~organised~~ applications. such applicants can be called, for the purpose of recruitment whenever there is vacancy in the organisation.

[i] Recommendation:
some times appointments are made based on the recommendation made by commitees, important persons, friends & relatives.

[j] Labour contractor:
~~Labour~~ large scale industries usually require a large number of unskilled workers but don't appoint them rather they hire their services through labour contractor.

[K]

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Method of Recruitment:-

- Direct Method.
- Indirect method.
- Third party Method.

Direct Method:

Under this method, the employer does the entire process by himself and doesn't depend on other.

- Employer go to school, collages, universities, technical institution, management institutions for technicians, engineers, designers, specially skilled persons and professionals.

- They take help of such institutions to conduct test and interview.

Indirect Methods:

This is most widely adopted method ~~of~~ ~~to~~ of recruitment which includes mainly advertisement through newspapers, magazines, technical & professional journals etc.

- Now a days in big cities & town recruitment is done through 'walk in interview'

- under this the employer advertise in newspapers about the posts, its eligibility, the date & time of interview and the place of interview etc.

Any eligible candidate can go and attend the interview.

Third party Method:

Under this method, the recruitment is usually done through employment exchange, consultants services, employment agencies etc.

– Govt. employment exchanges are established throughout the country in each and every district as well as in town and cities and it is free of cost.

– While private employment agencies and consultant provide specialised consultancy and placement services for which they charge certain fee.

Selection:

Selection is the process of finding out the perfect match between the requirement of the jobs and the capabilities of the applicants. Selection is the process of selecting human resource based on skill, knowledge, qualification, exprience, abilities, talent etc.

The selection process includes:–

(1) Inviting applications.
(2). screening the applications received.
(3) conducting tests, interviews etc.
(4). conducting physical and medical fitness examination
(5). collecting the references and checking the antecedents.
(6) verifying the certificates.
(7) Issue of selection letter after final select

(1) Inviting Applications:

The first step in the selection process is to invite applications from the eligible candidates. The application proforma should be designed carefully. The format may be designed in such a way that, the applicants have to give the details of their education, training, exprience, age, family background, previous employment, previous salaries, reasons for leaving the previous job, extra curricular activities etc.

[2] screening the applications:

A number of applications may be received but all the applications may not be called for tests or interview. some of the applicantions may be rejected due to any reasons. Hence there is the need of screening the applications.

[3] conducting Tests / Interviews:

After the screening is over, the short-listed applicants may be called for employment test which may include a written examinations, group discussion etc to test the skill, intelligence, knowledge, aptitude, personality etc. usually the applicants found suitable in the written examinations are called for interviews.

[4] conducting physical and Medical fitness Test:

All the candidates qualified in the interview should be called for a physical fitness test. The physical tests may include running, swimming, jumping, driving, cycling etc.

Apart from the physical test, there may be a medical examination of the candidates to check the eye sight, ears, heart, kidney etc.

[5] collecting References and checking the Antecedents:

After the medical and physical test are over, there is need of ~~making~~ a collecting the information about the candidates. There is also the need of checking the past records of the applicants including the report of the local police stations.

[6] verifying the certificates:

After that, the applicants may be called once again with his/her original certificates for the purpose of verification.

[7]. Issue of selection letter after final selection:

All the successful candidates are to be ranked in order of their merit and final selection may depend upon the number of post. Appointment letter or selection letter may be issued to the successful applicants in order of their rank.

TRAINING:

Training is a learning process

- Training is also known as transfer of skill, knowledge etc. from the trainers to the trainees.
- It helps the employees to enhance their efficiencies.
- Training is a continuous process from the recruitment to the retirement.
- There is need of training to those new employees before assigning them any activities.
- Training is also essential for the old employees whenever, they are put to new assignment due to promotion, transfer, change in the nature of the job, change in technology, change in product, process, machines, change in business policy, change in working condition etc.
- The main purpose of training is knowledge.

Types of training:

1. Induction training:

Induction training is a type of training given to new employee. so that they shall be familiar to all the activities going on ~~the~~ in the organisation. This training is also known as "Orientation training".

→ This induction training provides the new employees information to the about the organisation, product, policies, plans, organisation structure, duties and responsibilities.

→ It also enables the new employee to learn about rules and regulation, discipline etc.

→ Induction training gives ~~the~~ knowledge to the new employee about the use of machineries, plants, equipments etc.

2. Apprenticeship Training:

Under this type of training fresh students are selected for training in an industry.

It is n't employment-oriented but it is practical knowledge oriented.

∴ such trainees are usually young persons who get a monthly stipend during the period of their training.

As per "Apprentices Act 1961", the passed out technicians, such as I.T.I certificate holders, vocational certificate holders, Diploma certificate holders in different branch of engineering are alloted apprentice training.

3. Refresher training

This type of training make existing employee to know about new methods, ~~lats~~ latest technology, new processes, new machineries and plants etc. to increase their efficiency and performance on their jobs.

- This type of training is organised to keep the work force upto date.
- such type of training are usually organised inside ~~th~~ or outside the organisation or both.
- such type of trainings are usually for a short period of time like 3 days, 5 days, one week, two week etc.
- The managers usually spend some money for the purpose of training.
- This type of training usually organised at distant places or even at industries or institutes.

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[4.] special training:

This type of training programm are organised for the existing employees to acquire knowledge, skill, talent etc relating to new development related to their jobs.

- This type of training required due to new product, technologies, processes, procedure etc.
- Here the best suited trainee is selected for this purpose.
- The management usually pays huge amount of money for ~~sending~~ this purpose.
- This type of training is usually organised at far off places or even at other countries.

[5] Training for new jobs:

These type of trainings are organised to make the employees capable to handle the new jobs.

- Management usually doesn't appoint separate persons for the new jobs. It may select some employees out of the present workforce and train them for the new jobs.
- such type of training is generally organised inside / outside the organisation.

[6] Internship training:

"This type of training is ~~essential~~ provided to the trainees with the joint efforts of the institutes and organisation.

The theoretical portion is taken care by the institutes and the practicals are done ~~by~~ in organisation.

Training Methods:

The methods of training depend on the nature of the training, types of trainees, cost of training, availability of quality trainers and training facilities. etc.

3 types of training.

- on-the-job training
  - under-studies
  - coaching by experts on the jobs.
  - Job rotation.
- off-the-job training
  - class room training.
  - conference
  - written instruction method.
  - institutional training.
  - on-line training.
- vestibule training.

On-the job training:

[1] Under studies:-

Under this method of training, the trainee placed under an expriened person as an assistant, who acquire skill, knowledge and exprience.

This process helps the trainee to develop himself as a capable person to handle the job independently.

[2] Coaching by experts on the jobs:-

Under this method the trainees are taken to the spots where the works are being performed. Different experts of different jobs trains the trainees. They demonstrate the jobs by performing them in front of trainees so that trainees get the chance of learning at the spot.

[3] Job rotation:-

Under this system, the traine get the chance of learning different jobs. They are not only trained for one job but also trained on various jobs on rotation basis so that they get knowledge on various jobs. This is known as job rotation in which trainees are periodically rotated from one job to another.

Off-the-job training:

(1) class room training:

Under this type of training, training are organised by for the employees either inside or outside the organisation. Lectures or instructor act as trainers traines and gives knowledge. he may use models, slides, overhead protection, video, audio, films, computer etc. This method is also known as lecture method

[2]. Conference:

Under this method of training, a small group of trainees are selected and they work together to train themsewes.

They learn together to come to conclusion ~~on~~ of different problems and develop new techniques, skill etc.

3. Written instruction method:-

Under this method, written or printed training ~~method~~ material are supplied to the trainee. The trainees from this material learn the techniques, skill etc for jobs.

It may contain all the instruction for operating different machines, plants equipment etc.

[4] Institutional training:

There are specific institutions for specific type of training. such training courses are conducted by them regularly. So persons requiring such type of training, go to such type of institution

They charge some fees for conducting such training.

ex:- Training nurses for hospitals.
training pilots for aeroplanes.

[5] on-line training:

Now a days since the use of computer and internet facilities is common practice, ~~so~~ therefore anyone can acess to knowledge with the use of it.

Any one can acquire knowledge, skill, talent etc to train himself in different field to perform different activities.

Vestibule training:

This type of training is neither on the job training nor off the job training. under this method a similar to the actual working condition is created and training is given to the trainees under such condition.

- Here as far as ~~possible~~ practicable actual machineries, actual materials, are used and actual working condition is created.

- This type of training is done without disrupting the actual activities of the organisation.

ex:- Firemen training for fire fighting.

Performance Appraisal:

Performance appraisal means execution of duties of an individual or group.

Appraisal may be the evaluation of a matter by an individual to give an expert opinion on it.

Performance appraisal is related to the measurement of performance of an individual on the job. in comparision to others or standard established.

Performance appraisal is also known as "merit rating", "Performance evaluation", "performance rating" etc.

Performance appraisal is always objective oriented.

It is used to measure the performance of the employees, using different technique to rank them in order of their merit.

under this an employee is analysed from different angles like creativity, Integrety, personality, honesty, initiative, attitude, contribution towards the organisation etc.

Performance appraisal includes:-

(1) collection of information about the performance of employees.

(2) Measurement of performance and result.

(3). Measurement of the resource utilised.

(4) Analysiss of those information, result and resource utilised.

(5) Interpretation of the analysiss.

(6) Framing of opinion and impartial judgement.

(7). Making a comparative analysiss for decision making.

Need of performance Appraisal:-

(1) It is useful to identify the Strength, weakness, merit, demerit of an employee.

(2). It is useful to identify the employee need for training and area of training.

(3) It is ~~also~~ needed to determine the salaries and wages on the basis of the performance.

[4]. It is needed to identify the employees eligible for promotion.

[5]. It is useful to locate the employees suitable for reward or punishment.

[6]. It helps the management to fix target, assign additional duties and responsibilities or reduce the work burden on employees etc.

[7] It also ~~act as a~~ helps in the self development of an employee.

[8] It helps to motivate an employee to put their best.

[9]. It is needed to decide the transfer of employees from one post to another or from one place to another.

[10]. It is needed for effective manpower planning.

CHAPTER-3
FINANCIAL ACCOUNTING AND COST CONTROL

Double entry system of book keeping:

An important aspect of financial management is the maintainance of financial records of a business. For good financial management all the financial events and transactions must be recorded. so the maintainance of records of the financial transaction is known as "Book keeping". Book means record and keeping is maintaining. so book keeping means, record keeping or record maintaining.

Every business has to maintain records of its financial activities to know the profits. The maintainance of such records is also compulsory in majority of the cases, because the business has to submit a number of reports and return to the Government.

so what ever may be the reasons, every business has to maintain records of its financial transactions in a systematic manner.

Book keeping is the maintainance of the accounts in a systematic manner. usually almost all the business organisation now a days maintain account under double-entry system of book keeping. under this system each and every business transaction is recorded twice.

under the double entry system of book keeping a business usually maintains a number of accounts such as cash A/c, salary A/c, Rent A/c, intrest A/c, Raw material A/c, machineries A/c, Bank A/c etc.

Accounts :-

All most all business organisation maintain their financial records under double entry system. To facilitate the maintenance of accounts under double entry system of book keep all the accounts have two sides each.

The left side of an account is known as the "debit side." shortly known as Dr. side. and the right side of an account is known as "credit side" shortly known as Cr. side.

All the accounts are devided vertically into 2 sides from the middle of the account. so an account has many column on both the side such as the date column, particular column, Journal folio column and the amount column.

specimen of An A/c.

Dr. Cr.

Date	Particulars	J.F	Amount	Date	Particulars	J.F	Amount

All the accounts maintained by a business are devided into three catagories.

Real A/c | Personal A/c | Nominal A/c.

Real A/c :- It refers to all the real things which are visible and tangible.
such as :- cash, machinaries, buildings, furniture, materials, finished goods, equipment etc.

Personal A/c - It refers to all the accounts of different individual or persons as well as all artificial persons. like, companies, bank like LIC, SBI etc.

Nominal A/c - It refers to all the accounts related to different incomes, expenses, losses and gains. These are not visible or tangible.
ex:- Rent, intrest, salary etc.

Real

Rule of Debit and credit:-

A business transaction is recorded under double entry system of book keeping. i.e. once the debit side of an account and once on the credit side of another account.

So every transaction have 2 effect. one is debit effect and another is credit effect.

The same transaction shall be recorded once on the debit side of one account and again on the credit side of another account reflecting the same amount.

So every transaction involves atleast 2 accounts.

ex:- purchased machine of Rs 10,000/- by paying cash.

Here in this transaction 2 accounts involved. one is cash account & another is machinery account.

But the main problem here is to decide as to in which account it shall be shown on the debit side and on which shall be credited.

To know this one should know the rule of debit and credit.

Real A/c { Debit what comes in.
credit what goes out.

Personal A/c { Debit the receiver.
credit the giver.

Nominal A/c { Debit all the expenses. & Losses
credit all incomes and gains.

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Real A/c - example:- Purchase machine of Rs. 10,000 by paying cash.

Machine and cash both are real things. Machine is coming in to the business and cash is going out of the business.

Purchase of Machine for cash shall be recorded on the debit side of Machinery a/c. & cash shall be recorded on the ~~cash~~ credit side of cash A/c.

Personal A/c - example:-

If any one is receiving something, it will be recorded on debit side of his account and if some one is giving something it would be recorded on the credit side of his account.

example:-

The business gives some goods to Mr, Ram on credit.

It would be recorded in the debit side of Mr. Ram.A/c. as Ram is the receiver of goods. & goods are going out of the business. so it would be recorded on credit side.

Nominal A/c:-

Salary is paid Rs 5000/-

All the salary is an expense.

* All the expense are written on the debit side. and all the gains are written /pr shall be recorded on the credit side of th account.

ex:- suppose salary is paid Rs 500/-.

Salary is an expense here, so it would be recorded on the debit side of Salary A/c.

cash is going out so it is recorded on the credit side of cash A/c.

Journal:-

Whenever a transaction takes place, it has to be recorded in the journal first, which is known as book of primary entry. Hence all the transactions are recorded in journal and all the entries made in the journal are known as journal entry.

Example:- Rent paid Rs 500/-.

Here in this transaction 2 accounts involved. These are:- Rent A/c, & cash A/c.

Rent is a nominal A/c,- and all the expenses have to be debited. So rent shall be dobidet. that means it would be written on the debit side of the rent A/c.

Similarly, cash is a Real A/c, which says debit what comes in, ~~debit~~ credit what ~~credit~~ goes out.

Here cash is going out. So cash A/c has to be credited.

So journal entry shall be,

Rent A/c Dr ------ Rs. 500

To cash A/c ------------ Rs 500

Q:- Make a journal entry: sold goods of Rs. 5,000 on cash.

Journal entry shall be,

cash A/c Dr ---- Rs 5,000

to goods A/c. ---- Rs 5,000

Date	Particulars	L.F	Debit Amount in Rs	Credit Amount in Rs

Ledgers:-

At the end of the day all the entries in the journal are transferred to the respective accounts i.e the ledgers.

The transfer of entries from journal to the ledgers or different accounts is known as posting.

ex:- All the cash entries are transferred to the cash A/c. i.e all the debits shall be transferred to the debit side and all the credit entries are transfer to the credit sides of respective account.

Cash Book:

For convenience, a separate cash book is maintained to record all cash transactions. It is just like a cash A/c. The cash book is a register which contains 2 sides divided vertically from the middle of the register.

- The left side is the debit side also called receipt side
- The right side is the credit side also payment side.
- All the cash receipts are recorded on the debit side/ receipt side, of the cash book.
- All the ~~cash~~ payment are recorded on the credit side/ payment side.
- The cashbook is balanced everyday to know the cash balance.

cash book can be of three types. such as:-

(1). cash book with cash column - single column cashbook.

(2) cash book with cash column and discount column. - Double column cashbook.

[3]. cash book with cash column, discount column and bank column. - Triple column cash book.

PETTY cashbook:-

In a Business there will always be a large number of cash transaction. All the cash transactions have to be recorded properly. In a business there may be small transaction as well as big transaction. That means there may be a transaction of Rs. 1,00,00,000 at the same time there may be another transaction of Rs. 1.50P. There may be the purchase of post card as well as machine of crores of rupees. so if all the big and small transaction are put together in one cash book it will be little inconvenient the cash book will be very much lengthy.

Hence it better to separate small transaction from the big transactions.

That's why all small or petty cash transactions are separately recorded in another cash book called as "Petty cash book.".

- petty cash maintain in a register known as petty cash book and the person maintaining the petty cash transactions and petty cash book is known as petty cashier.

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Trial balance:-

Preparation Trial balance is prepared before the ~~application~~ of final accounts and after all the accou are closed.

Trial balance is not an account.

Trial balance is a statement which contains summary of all the account.

- Trial balance is divided into 2 sides, the left side is the debit side and the right side is called credit side.

- All the debit balances of different accounts are put on the debit side of the trial balance and all the credit balances of different accounts are put on the credit side of the trial balance.

- The total of ~~the~~ both the side of the balance mustbe equal.

- If there is difference, that means there is a mistake or error in the preparation of accounts and it must be rectified.

Trading A/c:-

Preparation of trading account is the first step in the preparation of final accounts.

From the information provided by the Trial balance, one can prepare trading A/c, profit and Loss A/c. and the balance sheet.

For a manufacturing concern, Trading A/c is known as manufacturing A/c.

- Like any other account Trading A/c has 2 sides, the left side is the debit side and the right side is the credit side.
- On the debit side, all the expenses relating to trading or manufacturing are recorded. and on the credit side incomes from operation are recorded.
- Both the sides i.e debit sides and credit sides may not be equal.
- If the total of the credit side is more than the totals of the debit sides, the difference is known as "Gross profit".
- On the other hand, If the total of the debit side is more than the total of the credit side, the difference is known as "Gross Loss".
- Trading A/c or manufacturing A/c is the first statement of the final account.

Profit and Loss A/c:-

Profit and Loss A/c is prepared from the information provided by the Trial balance.

It can be prepared only after the preparation of Trading A/c or manufacturing A/c. Like Trading A/c, Profits & Loss A/c has 2 sides. The left side is the debit side and right side is the credit side.

- The gross profits or the gross loss of the trading manufacturing A/c is transferred to the profit & loss

- If there is gross profit, it is written in the cr side of the profit and loss A/c.

- on the other hand, If there is gross loss, it is written in the debi side of the profit and loss A/c.

- All other expenses, except these already shown on the debit side of the trading or manufacturing A/c, are written on the debit side of the profit & loss A/c.

- The items written on the debit side of the Profits and Loss A/c ; Gross Loss (If any), salaries, rent, Advertisement, intrest, telephone charges, electricity charges, printing and stationary, repair and maintainance of machine

- Similarly, All other incomes, except those already shown on the credit side of the Trading or manufacturing A/c, are written on the credit side of the profit & Loss A/c.

- The item written on the credit side are :- gross profits, intrest received, and any other incomes related to the business.

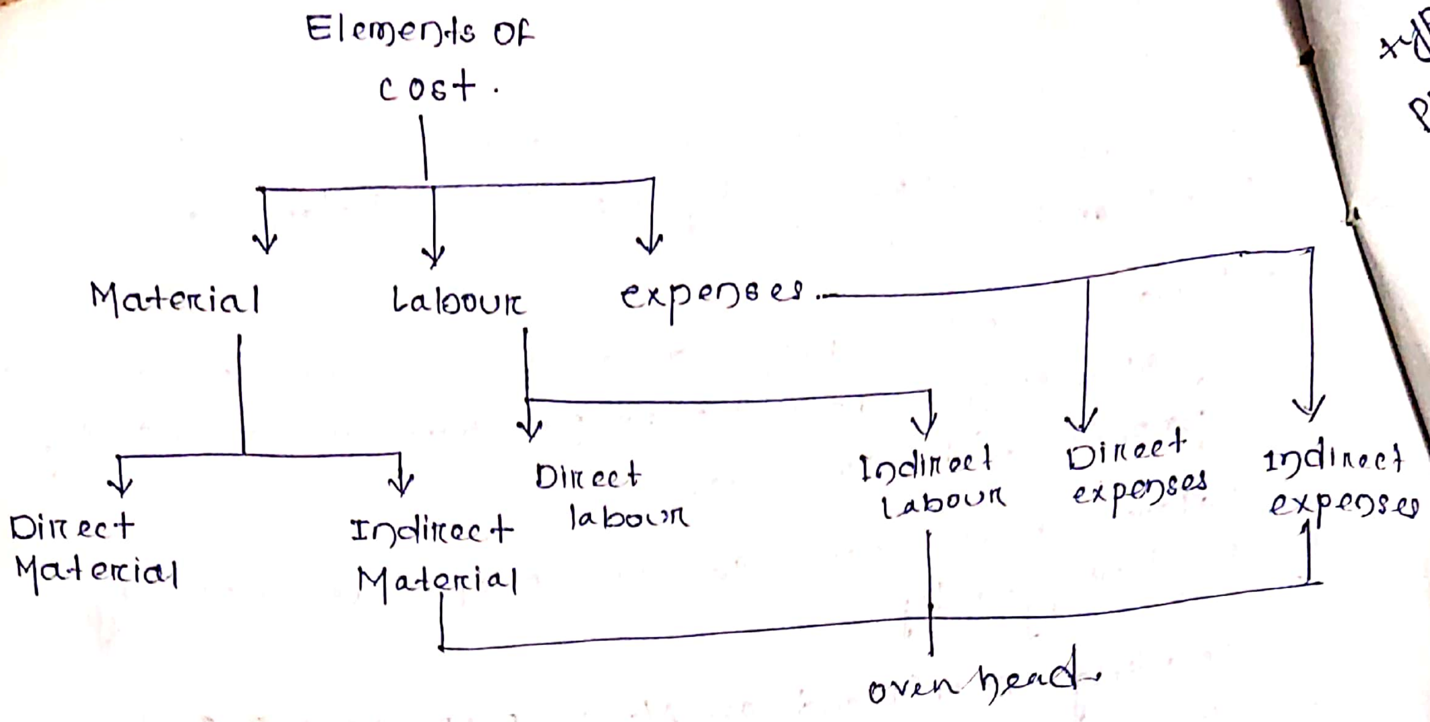
- If the total of the credit side is more than the total of the debit side, the difference is a "Net profit".

- on the other hand If the total of the debit side is more than the total of the credit side, the difference is a "Net Loss".

Balance sheet:

Balance sheet is prepared from the information provided by the trial balance and profit and loss A/c.

- Balance sheet is prepared at the end of the financial year, only after the preparation of the trading, profits and loss a/c.
- Balance sheet can also be prepared quaterly or half yearly.
- Trading, profit and loss A/c is prepared for a ~~day~~ ~~and not for a~~ year but balance sheet is prepared for a day. ~~not for a~~
- Balance sheet reflects ~~at~~ the exacts financial position of a business on a particular day.
- Balance sheet is a statement, not an account.
- Balance sheet has 2 sides. the left side is the liabilities side and the right side is the assets side.



Material:-

Materials are most important ingredients of a product. For cost accounting purpose. materials are devided into 2 catagories:- i.e Direct Material
Indirect Material.

(1) Direct Material:-

Direct material are those materials which are used in the manufacturing of finished

- It enters the production process as raw materials.
- such materials can be easily identified as a finished product.

ex:- wood use in the furniture making,
wool in sweater making.
cloth in dress making.

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INDIRECT MATERIAL:-

Apart from the direct materials, so many other type of materials are used in manufacturing a product.

They are not easily identified in a finished product.

- They donot enter into the production process directly.

ex:- Thread in dress making.
nails in furniture making. etc.

Labour:-

Material cann't automatically converted into finished goods. They require human efforts. i.e labour.

2 types:-

- Direct labour
- Indirect Labour.

Direct labour - Direct Labour is the labour, who is directly engaged in production, ~~maintenance~~, i.e converting the raw materials into finished goods.

ex:- labour ~~engage~~ directly engaded in production, supervision, maintenance, transportation OR material inside the factory etc.

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Indirect ~~Material~~ Labour:-

Labour engaged other than production is known as indirect labour.

ex:- clerical staff, instructor, security personnel etc. apprentice & trainee etc.

Expenses:-

Apart ~~from~~ from the material and labour to cost, there are so many other expenses without which there can't carry on production and without which there can't be any production.

Direct expenses | Indirect expenses.

Direct expenses:-

All the expenses other than direct material and direct labour, which are specifically spent for a particular product, job or process is known as direct expenses.

example:- Architech's fee, experimental expenses, hire charge of machine brough on hire, maintanance & repair of machineries. etc.

Indirect expenses:-

Besides the direct expenses some other expenses are there which are not specifically spent for a particular product, job or process. such expenses are general in nature.

example:- Rent, insurance, ~~in~~ Intrest, general manager's salary, telephone, telegrams & cast of training of new employees, advertisement, transportation etc.

Over head-

Overhead is ~~is~~ nothing but the combination of indirect material, indirect labour & indirect expenses.

For cost Accounting process, overhead may be classified into 4 catagories.

- Production overhead or Factory overhead.
- Office or administrative overhead.
- Selling over head
- distribution overhead.

Production overhead:-

Production overhead includes all the indirect costs (i.e indirect material, indirect Labour, indirect expenses) inside the factory for production purpose is known as production over head.

- Production overhead is also known as "Factory overhead" or "works overhead".

ex:- Repairs and maintainance of plant and Machinery, electricity changes, fuel, oil, lubricant, used in production department. & other expenseses made in production department

Administrative overhead:-

Administrative overhead includes all the expenses made in the office to carry on the administrative work. Also known as office overhead.

- Administrative overhead refers to all the indirect material, indirect labour & indirect expenses spent in the office ~~for~~ for the organisation day to day administration.

example :- general managers salary, salaries & wages paid to clerk and other office staff, telephone bill, office rent, repair and maintainance of office machineries, etc.

Selling overhead:-

selling overhead includes all the indirect materials, indirect labour and indirect expenses spent in selling the product.

ex:- sales ~~exp~~ office expenses, salesmen salaries, advertising, etc.

Distribution overhead:-

All the indirect material, indirect labour and indirect expenses spent to distribute the product ~~to~~ to various centres & customers is known as Distribution overhead.

ex:- ware house rent, warehouse insurance, warehouse staff salaries, expenses on delivery vans, payment to delivery staff, loading & unloading charges etc.

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BREAK-EVEN ANALYSIS:

The break-even analysis will be helpful to the management to know whether the business is running on profits. It also helpful to forecast the profits at various level of production.

For the purpose of break-even analysis, cost is devided into 2 catagories. such as.

[1] Fixed cost.

[2] Variable cost.

Fixed cost:-

Fixed cost are those cost which remain fixed in total and donot increase or decrease with increase or decrease in production.

Example:- Rent, Insurance premium, general manager's salary, Watchman salaries etc.

Variable cost:-

Variable cost are the costs/expenses which vary and not remain fixed.

Example:- cost of raw materials, manufacturing wages, royalty, excise duty etc.

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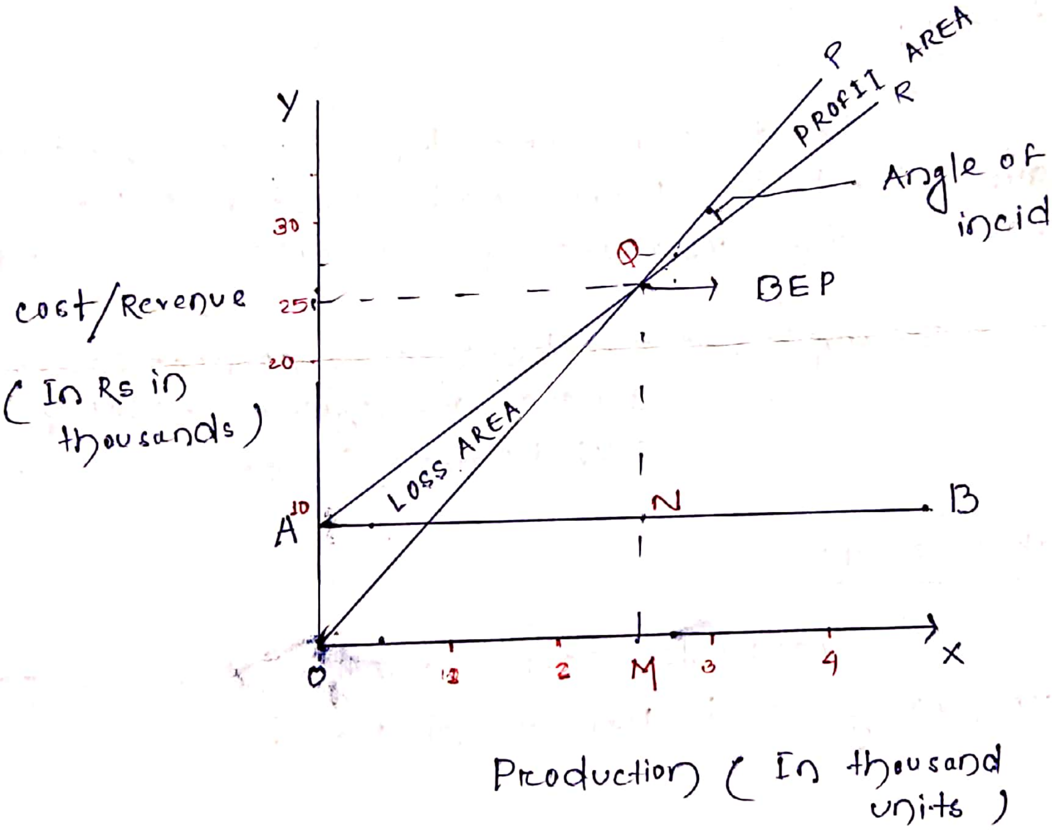
BREAK EVEN POINT:-

The break even point is the point where total cost is equal to total revenue.

Break-even point is also known as the point of no profit and no loss. At this point the total expenses is equal to the total incomes.

Break even analysis will ~~helpful~~ help the management to forecast the profit at various level of production activities.



[Graphical Representation of BEP]

In the above diagram OX axis represents production in units and OY axis represents cost/revenue in thousand rupees.

AB - Fixed cost curve, which is a horizontal line because fixed cost always remains constant at all the level of outputs.

AR - Total cost curve
(As the production increases, total cost also increases)

Total cost = Fixed cost + Variable cost.

OP - Total sales or revenue line.

OP curve crosses the AR curve at point Q.
At the point Q both sales and cost are same.

Q - Breakeven point.

QM - Total cost at ~~the~~ BEP.

QN - Variable cost at BEP.

MN - Fixed cost at BEP.

Production at this point 'Q' is known as breakeven production and sales at the point of Q is known as breakeven sales.

- Area at the right of the break even points represents the profit area and the area at the left of the Breakeven point is known as the loss area.

That means, If production increases beyond the BEP, there will be profit.

But If the production falls below the breakever point, there will be Loss.

The angle created at the right side of the BEP is known as the "Angle of incidence."

*. Assumption of Breakeven analysis:-

While calculating the breakeven point one has to assume the following conditions.

(1) All the cost can be separated into 2 catagories, i.e Fixed cost and variable cost.

(2). Fixed cost must remain constant at all the levels of output.

(3). Variable cost must vary in direct proportion to the volume of production.

[4]. All the goods produced are assumed to have been sold.

[5]. The selling price per unit of the finished goods must remain constant.

[6] There should not be any change in the operating efficiency of the organisation. Efficiency of men, machines and materials must remain unchanged.

[7] Breakeven analysiss is applicable only when the firm is producing one product.

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Advantages of Breakeven Analysis:-

[1] The information reveal by the breakeven analysis are more useful than the information obtained from the profit and loss A/c. and the balance sheet.

[2] It provides useful information to study the relationship between cost, volume and profit.

[3] This information is also necessary for taking managerial decisions.

[4]. This analysis is useful to forecast the profit as well as the cost at a given level of output.

[5]. Break-even analysis act as a tool to control the cost and regulate the expenses on each items.

[6]. B

Disadvantages:-

[1] The assumptions of breakeven analysis are not practicable.

[2] The information provided by breakeven analysis maynot be quite informative for taking important managerial decision.

[3] Increase in production maynot be accompanied by increase in profits, because it is a future event full of uncertainties.

CHAPTER-4 Financial Management.

Finance management is the branch of management which looks after the finance function of an organisation.

In a business organisation there is regular inflow and outflow of finance for which there is need of regulating these activities effectively and efficiently so that there is more inflow than the outflow.

Finance management is the activities performed for the planning, procurement, utilization and controlling of financial resources.

Financial management include management of cash, bank balances, capital, incomes, expenditures, borrowing, lending, investing, sale and purchase etc.

Importance

- Finance management is the most important component in a business and it is the root cause of all the business activities.
- Finance is needed to turn ideas into projects and profits.
- Finance is considered as the blood of the business & ~~and~~ without which it cann't survive.
- Finance is not only required to start a business but also require to run it successfully.
- Management of finance is not a one time affair but it is a continuous activity.
- The main aim of financial management is to increase the profit.
- Financial management is responsible for increasing the financial strength of a business
- Financial management is responsible for ~~per~~ proper use of fund.

Finance Functions:

Finance function of an organisation is usually managed by a separate department called the finance department. The head of the finance department is finance manager.

- The finance manager should be exprienced, skilled and capable enough to handle finance function independently.
- The finance manager has to make available sufficient finance to organize the business.
- All the decision taken in business ultimately becomes a financial decision. Hence the management should take decisions carefully in consultation with the finance department.
- All the department should co-ordinate the finance department for smooth performance of the finance function.

The finance department has to take 3 important decision:-

(1). Whether money shall be invested in the proposed project?

(2) If yes, decide the source of fund for the proposed project.

(3) Whether the proposed project will generate profit or not.

Capital :

The amount of money invested in a business is known as capital.

capital is invested to start a business and run it.

- capital is the blood of the business

Types of capital

capital

Fixed capital | Working capital

Fixed capital

Fixed capital is the amount of money invested in fixed assets like land, buildings, plant, machinery, equipment, tool, furniture etc to create physical ~~infrastructure to carry on business~~.

Usually a large amount of money is blocked for a long period of time in the form of fixed capital. There-fore fixed capital is also known as blocked capital.

Fixed capital depend upon the nature of industry, type of product, size of the unit, technique of production, volume of production etc.

heavier the size of the organisation → high will be the requirement of fixed capital

smaller the size of the organisation → lower will be requorement of fixed capital

Working Capital:

The amount of money invested in raw-materials, wages, salaries, electricity charges, transportation charges, advertising, insurance premium, telephone charges etc to run the business is known as "working capital".

The amount of working capital requirement depend upon the type of business, type of product, volume of production, stock policy of the organisation, time required in manufacturing etc.

Fixed capital	Working capital
1. Fixed capital is the amount of money invested in fixed assets like land, building, machinery etc.	1. Working capital is the amount of money invested in current assets like raw-materials, wages, salaries, advertising etc.
2. Fixed capital create an infrastructure for carrying on business.	2. Working capital is needed to ~~meet~~ run the business
3. Fixed capital is needed once only.	3. Working capital is needed all the time.
4. Fixed capital is also known as blocked capital	4. Working is also known as revolving or circulating capital.

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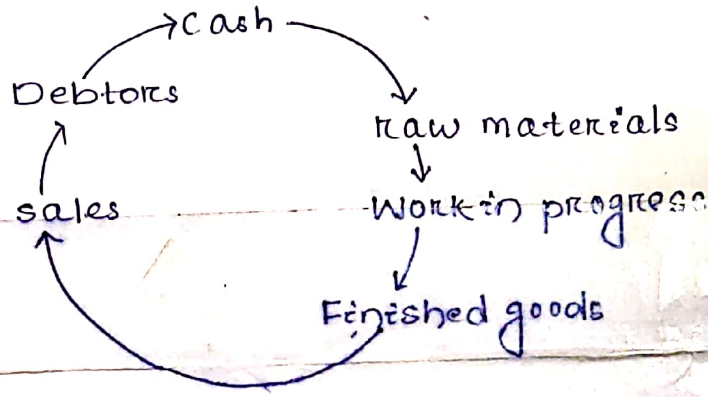
Working capital cycle: (operating cycle)

As production is continuous process, the need of working capital is also continuous. cash is not converted into cash instantly. cash is the most important element in working capital and all other element depend on this element.

— When cash is put into the business in the form of working capital it will go through various stages and take long time to converted into cash once again.



[Working capital cycle.]

In this process of business, cash is converted into the raw material, raw materials with the help of labour converted into semifinished good or work is in progress by processing, reprocessing, modifying refining etc. and after lots of activities it is converted into finished goods. After that finished goods are converted into sales and sales into debtor. The debtors pay cash ~~once~~'.

Hence the process of converting cash into cash once again is known as working capital cycle or operating cycle.

CHAPTER- 2 (Investment limits of MSME)

Industry:

- Micro Enterprise
  - Manufacturing (doesn't exceed Rs. 25,00,000)
  - Service (doesn't exceed 10,00,000)
- Small Enterprise
  - Manu-facturing (25,00,000 - 5crores)
  - Service (10,00,000 - 2 crores)
- Medium Enterprise
  - Manufacturing (5cr - 10cr)
  - service
- Large Enterprise
  - Manufacturing (More than ten crores)
  - service (More than 5cr)

After the selection of the industry and product, the entrepreneur should prepare the project report on his project. Project report is necessary as it is required for the purpose of registration, licence, permission and loans.

Project report is the mirror through which one can see the entire picture of an organisation in advance.

There is 2 types of project report:-

(1) Preliminary project report (PPR)

(2) Detailed project report (DPR)

PPR:

~~A~~ It is brief summary of project, which describes about the expected inputs and outputs like finance, manpower, materials, machinery, technology, production, profits, sales etc.

PPR:

Introduction

[1] [A] Information about the entrepreneur:

Name:

Address:

[B] Information about the proposed product

Product:

Location:

[2] Market potential:

- Area over which his product may be sold.

[3] Basis of presumption:

- The avg working hour per day, per month, per year
- when plant operates with full capacity.

[4] Impementation schedule:

- Time taken for completion of the project.

[5] production target:

- The production programme of the unit per annum.

[6] Technical details:

- Here entrepreneur has to mention all the technical details of his project including manufactoring process, quality & standards, pollution control measures etc.

[7] Financial details:

Fixed capital:

[A] Land and building

[B] Machinery and equipment.

[C] Miscellaneous fixed assests.

[D] preliminary and preparative expenses.

Working capital:

3

[a] Raw material

[b] salaries and wages

[c] utilities

[d] other expenses

[8] Total capital investment /cost of the project:

[9] cost of production per annum

[10] Turnover per annum:

[11] profit before Tax:

Turnover per annum − cost of production per annum

= Profit before tax.

[12] Break even point (BEP)

$$BEP = \frac{\text{Total fixed cost}}{\text{Total fixed cost} + \text{Profit}} \times 100$$

[13] Profitability ratio:

$$\text{Profitability} = \frac{\text{Profit}}{\text{Turnover}} \times 100$$

[14] Rate of return on investment:

$$R = \frac{\text{Profit}}{\text{Total investment}} \times 100$$

[15] [A] List of suppliers of plants and machines:

[B] List of suppliers of raw materials.

[c] Bank and branches having financial operation.

Date:-

sign. of the entrepreneur

Detailed project Report: (DPR) 4

DPR is the detailed elaboration of each and every information mentioned in PPR.

example:- Furniture is one item in the PPR but for preparation of DPR, all the information have to mention about the furniture in details like, size, specification, use, price, quality, name of the supplier, date of supply, date of payment, transportation expenses of such furniture.

Role of DIC, OSFC, OSIC, IDCO, SIDBI, IPICOL and Commercial bank in the context of MSME.

1. DIC - District industries centre.

- Provide assistance to the entrepreneurs
- conduct multiple training programs to encourage the entrepreneurs.
- provides the information on sources of machinery and equipment.
- Allots raw material to the concerned industries at district level.

2. OSFC - Odisha state Financial Corporation.

- Promote small and medium scale industries
- Empower micro, small and medium ~~enterpris~~ enterprises.

3. OSIC - odisha small industries corporation.

- Promote MSME in the state for their ~~ed~~ sustained growth and development.

4. IDCO - odisha industrial infrastructure development corporation.

- Helps in developing infrastructure facilities in the industrial area for rapid establishment and growth of industries

5. SIDBI - Small industries development bank of India.

- Helps for promoting, developing and financing MSME.

6. IPICOL - Industrial promotion and investment corporation of odisha.

- promote medium and large scale industry in the state.

7. Commercial Bank - Provide financial support and empower MSME.

CHAPTER-10

Industrial Legislation.

THE FACTORIES ACT, 1948:

The factories Act, 1948 is applicable to the whole of India. This Act came into force with effect from 1st April 1949. This act deals with the laws relating to employment of Labour in factories. The main aim of this act is to secure health, safety, welfare, proper working hours, leave and other benefits to worker.

Factory Inspector (Section 8)

The state Govt. may by notification in the official Gazette, apoint such persons as possess the qualification to be inspectors for the purpose of this Act and may assign to them some ~~limits~~. local limits.

Power of Factory Inspector (Section-9)

- Make examination of premises, plant, machinary and substances.
- Inquire into any accident or dangerous accurance, whether resulting in bodily injury, disability or n't
- Required the production of any register or any other document ~~as he may~~ relating to the factory
- Seize or take copies of any register, record or other document as he may consider necessary.
- make photograph and measurement and make such recording as he consider necessary for the purpose of any examination.
- The inspector may take possession of substance and detain it for so long as necessary for such examination.

HEALTH PROVISIONS:

A number of provisions have been made in the factories Act 1948 for the maintainance of the health of the employers.

Cleaniness

Every factory shall be kept clean accumulation of dirt shall be removed daily by sweeping

the floor of every workroom shall be cleaned at least once every week by washing.

Effective mean of drainage shall be there.

Disposal of wastes and Effluents:

*Effluent – liquid waste material that comes out of factories

Effective arrangement shall be made by every factory for the treatment of wastes and effluents due to manufacturing process.

Ventilation and Tempreture:

Effective and suitable provision shall be made for adequate ventilation by the circulation of fresh air.

Walls and roofs shall be of such materials and so designed that such tempreture shall not be exceeded but kept as low as practicable.

Dust and fumes:

In every factory due to the process of manufacturing dust or fume are produced which is dangerous. So effective measures should be taken to prevent its accumulation

Artificial humidification

The humidity of the air should artificially increased. Different method should be adopted for ventilation and cooling of the air and the workroom.

Overcrowding:

No rooms in any factory should be ~~overcrow~~ overcrowded to an extent injurious to the health of the workers.

Lighting:

In every part of a factory, where workers are working or passing there shall be provided and maintained sufficient and suitable lightning which may be natural or artificial or both.

Drinking Water:

In every factory effective arrangement shall be made and maintained at suitable points for all workers. for the drinking water.

latrines and urinals

In every factory sufficient latrines and urinals facility should be there and it should be maintained in a clean and sanitary condition.

spittoons: In every factory there should be provided a sufficient number of spittoons in convenient places and it should be maintained in a clean and hygienic condition.

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SAFETY PROVISIONS:

Fencing Of Machinery

In every factory, every moving part of a prime mover, fly wheel connected to a prime mover, every part of electric generator, motor, and every dangerous part of any other machinery should be fenced.

Work on or Near Machinery in Motion:

While the machinery is in motion, operation shall be made or carried out only by specially trained worker wearing tight fitting clothing.

No workman or young person shall be allowed to clean, lubricate or adjust any part of a prime mover or of any transmission machinery while the prime mover or transmission machinery is in motion.

Employment of young persons on Dangerous Machines:

No young person shall work at any machine ~~to which~~ unless he has been fully instructed.

Striking Gear and Devices for cutting off power:

In every factory suitable striking gear or other efficient mechanical appliances shall be provided and maintained

In every factory suitable devices for cutting off power in emergencies from running machinery shall be provided and maintained in every workroom.

Self-acting Machines:

No traversing part of a self-acting machine in any factory allowed to run on its outward or inward within a distance of eighteen inches from any fixed structure.

casing of New Machinery:

every set screw, bolt or key ~~or~~ on any revolving shaft, spindle, wheel shall be encased or otherwise effectively guarded as to prevent danger.

Prohibition of Employment of Women and children near cotton openers:

No women or child shall be employed in any part of a factory for pressing cotton in which a cotton opener is at work.

Hoist and lifts:

In every factory, every hoist and lift shall be of good mechanical construction, sound material and adequate strength.

Lifting Machines, chains, Ropes and lifting Tackles:

In every factory, other than a hoist or lift every lifting machine and every chain, rope should be of good materials.

Revolving Machinery: Effective measures shall be taken in every factory to ensure the safe working speed of every revolving vessel, cage, Fly wheel, disc, pulley driven by power is n't exceeded.

Pressure plant:

Effective measures shall be taken to ensure the safe working pressure.

Floors, stairs and Means of Acess:

All floors, steps and passage shall be of sound construction and should properly maintained.

Pits, sumps, opening in floors etc:

In every factory every tank, pits or opening in the ground or floor shall be either securely covered.

Excessive Weight

No person shall be employed in any factory to lift, carry or move any load as heavy as to be likely to cause him injury.

Protection of Eyes:

Risk of injury to the eyes from particles ~~or~~ thrown off in the course of the process and risk to the eyes by reason of exposures to excessive light should be taken care of.

Precaution against Dangerous Fumes:

No person in any factory shall enter or permitted to enter any chamber, tank, pit, pipe or confined space in which dangerous fumes are likely to be present.

Precaution Regarding the use of portable Electric light.

No portable electric light or any other electric appliance of voltage exceeding twenty four volts shall be permitted for use inside any chamber, tank, pit, pipe or other confined space.

Explosive or inflammable Dust, Gas etc:

Where in any factory any manufacturing process produces dust, gas, fume or vapour to such extent as to be likely to explode to ignition or practicable measures shall be taken to prevent any such explosion.

Precaution in case of fire:

In every factory there shall be provided such means of escape in case of fire

- In every factory the door affording exit from any room shall n't be locked.
- There shall be provided in every factory effective and clearly audible means of giving warning in case of fire;
- Effective measures shall be taken ~~to~~ ~~ensure that~~ where explosive or highly inflammable materials are used or stored.

Power to require specification of Defective parts or Test of stability:

If it appears to the Inspector that any building or part of a building or any part, machinery or factory is in such a condition that it may be dangerous to human life, he may give order in writting to furnish such particulars, which may be necessary.

Safety of building and Machinery:

If it appears to the inspector that any building or part of a building or factory is in such condition that it is dangerous to human life and safety, he may order the manager to take preventive measures

WELFARE PROVISIONS

Washing Facilities:

Suitable washing facilities for washing shall be provided and maintained.

Facilities for storing and drying clothes:

Suitable places should be there for keeping clothing not worn during working hours and for drying of ~~cloth~~ wet clothing.

Facilities for sitting:

In every factory suitable arrangement for sitting shall be provided and maintained. so that they can rest.

First Aid Appliances:

- First aid box should be provided and maintained
- First aid box shall be kept in the charge of a separate responsible person who hold a certificate in first aid treatment and he shall always be readily available during the working hour in factory.
- In every factory, where more than 500 workers are employed, there should ~~be~~ provided and maintained a special ambulance room.

Canteens:

In any specified factory where there is more than 250 workers are employed, a canteen shall be provided.

Shelters, rest rooms and lunchrooms:

In every factory, where more than 150 workers are employed, an adequate, suitable shelter or rest room and a suitable lunchrooms with the provision for drinking water, where workers can eat meals brought by them.

Creches:

In every factory, where more than 30 women workers are employed, there should be provided a suitable rooms for ~~fo~~ the use of ~~children~~ children under the age of six years.

- Such rooms shall provide with adequate ~~lightni~~ lighting and ventilation. It should be maintained in a clean and sanitary condition and shall be under the charge of women trained in the care of children.

Hours of Work

According to "section 51" of this act, no adult ~~works~~ workers shall be required or allowed to work in a factory for more than 48 hours in a week.

- Further According to "section 54" of this act the daily hours of work has been restricted to 9 hours.

*:- But daily maximum working hours can be exceeded with a view to facilitate the change of shift by approval of the chief inspector

- According to "section 55", the period of work shall be fixed that no adult worker is required to work for a period exceeding 5 hours without an interval of rest of at least half an hour.

- But according to "section 56" of this act, the period of work, including the such interval of rest, shall be so arranged that they shouldn't spread over more than 10 and half hours.

chapter-1 Introduction to Switchgear

→ The greatest demand of electrical energy is a notable feature of modern civilisation.

→ The importance of electric supply in everyday life has reached such a stage that it is needed to protect the power system from harm, during fault conditions and to ensure maximum continuity of supply.

→ For this purpose, switch ON or OFF generators, transmission lines, distributors and other equipment under both normal and abnormal conditions. This is achieved by an apparatus called switchgear.

→ SWITCHGEAR :- The apparatus used for switching, controlling and protecting the electrical circuits and equipment is known as switchgear.

→ A switchgear consists of ~~switchgear~~ switching & protecting devices such as:

(1) Switches
(2) Fuses
(3) circuit breakers
(4) Relays; etc.

→ The switchgear detects the fault and disconnects the unhealthy sections from the system.

→ Switchgear protects the system from damage and ensures continuity of supply.

→ Simplest form of switchgear

Tumbler switch + ordinary fuse.

→ Moderate form of switchgear (For high current rating)

switch + HRC (High Rupturing Capacity) fuse

→ In order to interrupt heavy fault currents, automatic circuit breakers are used.

→ ~~Cirb~~ Circuit Breaker

A circuit breaker is a switchgear which can open or close an electrical circuit under both normal and abnormal conditions.

1.1 ESSENTIAL FEATURES OF SWITCHGEAR

① Complete Reliability:

→ The switchgear is added to the power system to improve the reliability.

→ When fault occurs on any part of the power system, the switchgear must operate to isolate the faulty section from the remainder circuit.

(ii) Absolutely certain discrimination

→ When fault occurs on any part of the power system, the switchgear must be able to discriminate between the faulty section and the healthy section.

→ This will ensure continuity of supply.

(iii) Quick Operation

→ When fault occurs on any part of the power system, the switchgear must operate quickly so that no damage is done to generators, transformers and other equipment by the short-circuit currents.

→ If fault is not cleared by switchgear quickly, it is likely to spread into healthy parts, thus endangering complete shut down of the system.

(iv) Provision for manual control

→ A switchgear must have provision for manual control.

→ In case the electrical (or electronics) control fails, the necessary operation can be done through manual control.

(V) Provision for instruments

→ There must be provision for instruments which may be required.

→ These may be in the form of ammeter or voltmeter on the unit itself or the necessary voltage and current transformers for connecting to the main switchboard or a separate instrument panel.

(1.2) Switchgear Equipment

* Switchgear covers a wide range of equipment concerned with switching and interrupting currents under both normal and abnormal conditions.

It includes
(1) switches
(2) Fuses
(3) circuit breakers
(4) relays, and other equipments

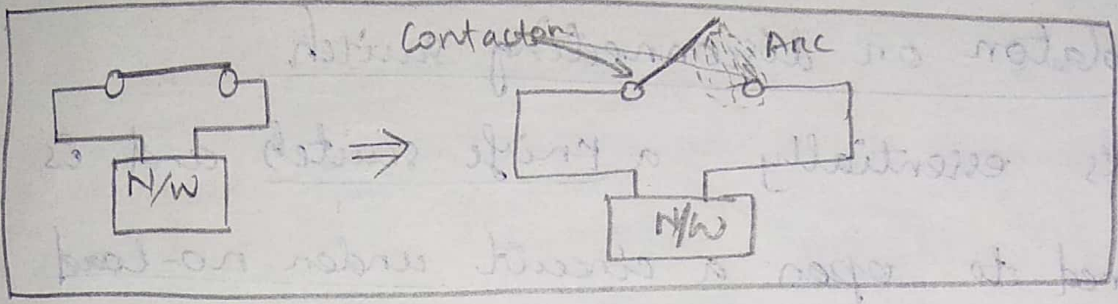
(1) SWITCHES

→ It is a device which is used to open or close an electrical circuit.

→ It can be ~~operated~~ used under full-load or no-load conditions.

→ It cannot interrupt the fault currents.

→ When the contacts of a switch are opened, an arc is produced in the air between the contacts. This is true for circuits of high voltage and current capacity.



→ Switches

air switches

Oil switches

(i) ~~Air switches~~ Air-break switch

Arcing horns → They are pieces of metals between which arc is formed during opening operation.

→ It is an air switch and is designed to open a circuit under load.

→ Special arcing horns are provided to quench the arc during opening the switch.

→ After open the switch, the arcing horns spreads the arc. ~~Then the ar~~ Gradually the arc is lengthened, cooled and interrupted.

→ Air break switches are generally used outdoor for circuits of medium capacity such as lines supplying an industrial load from a main transmission line or feeder.

(ii) Isolator or disconnecting switch

→ It is essentially a knife switch and is designed to open a circuit under no-load

→ Such switches are generally used on both sides of circuit breakers.

(iii) Oil switches

→ The contacts of such switches are opened under oil, usually transformer oil.

→ The effect of oil is to cool and quench the arc.

→ These switches are used for circuits of high voltage and large current carrying capacities.

(2) FUSES

→ A fuse is a short piece of wire or thin strip which ~~which~~ melts when excessive current flows through it for sufficient time.

→ It is connected in series with the circuit to be protected.

→ Under normal operating conditions, the fuse element is at a temperature below its melting point. When a short circuit or overload occurs, the current through the fuse element increases beyond its rated capacity. This raises the temperature and the fuse element melts, disconnecting the circuit protected by it.

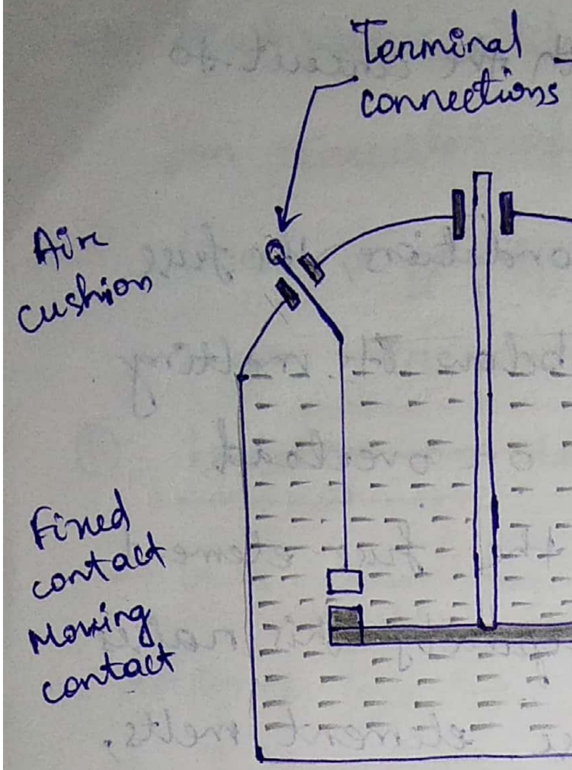
→ A fuse protects the machines and equipment from damage due to excessive currents.

NOTE
A fuse can detect/sense and break/interrupt the circuit under short-circuit or overload condition.

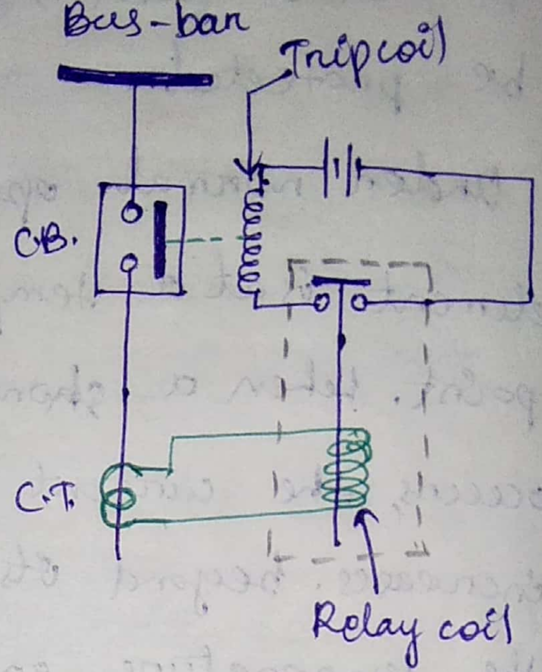
③ Circuit Breakers

→ It is an equipment which can open or close a circuit under all conditions (no-load, full-load and fault conditions)

→ It can be operated manually under normal conditions and automatically under fault conditions.



(Fig-1)



(Fig-II)

→ Fig-1 shows the parts of a typical oil circuit breaker.

→ The circuit breaker consists of moving and fixed contacts enclosed in strong metal tank and immersed in oil, known as transformer oil.

→ Fig-II shows circuit breaker control by a relay circuit.

→ Operation

→ Under normal operating conditions, the contacts remain closed and the circuit breaker carries the full load current continously.

→ In this condition, the emf in the secondary winding of of C.T. is insufficient to operate. the trip coil of the breaker but the contacts can be opened by manual or remote control.

→ When a fault occurs, the resulting overcurrent in the C.T. primary winding increases the secondary emf.

This energises the trip coil of the breaker and moving contacts are pulled down, thus opening the contacts. The arc produced during the opening operation is quenched by the oil.

NOTE Hence the circuit breaker does the actual circuit interruption.

(4) RELAYS

→ A relay is a device which detects (sense) the fault and supplies information to the breaker for circuit interruption.

→ Fig-11 shows a typical relay circuit. It can be divided into 3 parts

(i) The primary winding of a C.T. which is connected in series with the circuit to be protected. The primary winding often consists of the main conductor itself.

(2) The second circuit is the secondary winding of C.T. connected to the relay operating coil.

(3) The third ckt is the tripping circuit which consists of a source of supply, trip coil of ckt. breaker and the relay stationary contacts.

OPERATION

Under normal load conditions

→ secondary emf of CT is small.

→ Due to that, the relay coil is not energised or fully magnetised.

~~Under~~ When fault occurs

→ Primary current of CT increases, and secondary ~~of cu~~ voltage of CT increases. Then the relay coil is energised to close the trip ckt.

→ Then ~~as~~ the trip coil will energised by the battery voltage. and hence it opens the contacts of CB.

(1.3) Bus-Bar Arrangement

Busbars → It is a copper rod or thin walled tubes and operate at constant voltage.

→ When a number of generators or feeders operating at the same voltage have to be directly connected electrically, bus-bars are used as the common electrical component.

NOTE All the diagrams refer to 3-phase arrangement but are shown in single-phase for simplicity

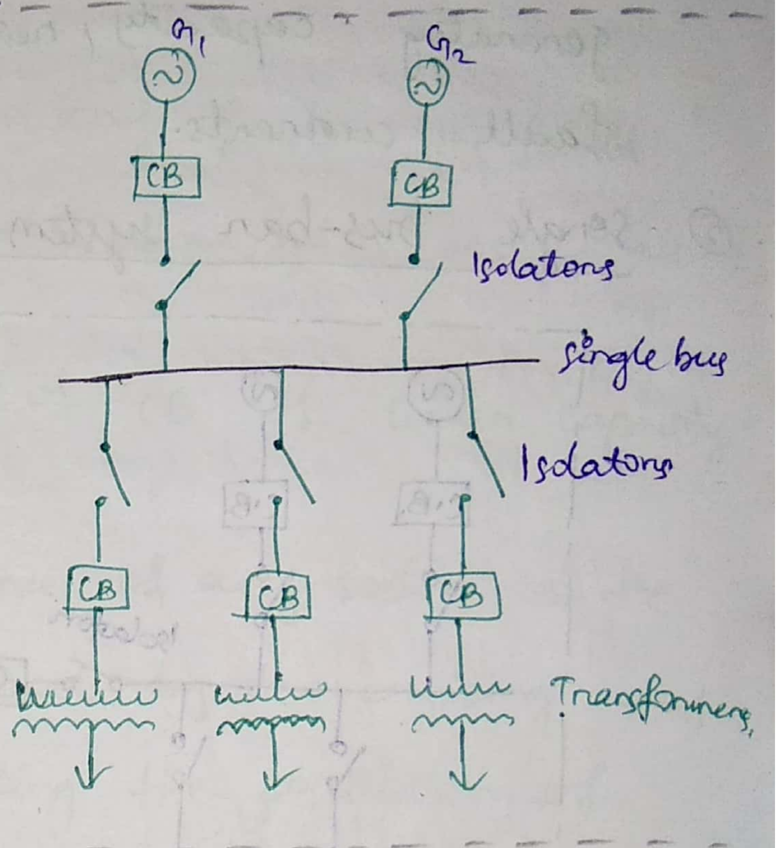
① Single Bus-bar System

→ It is used for power stations

→ It is also used in small outdoor stations having relatively few outgoing or incoming feeders and lines.

→ Fig (a) shows the single busbar system for a typical power station.

→ The Generators, outgoing lines and transformers are connected to the bus bar



(Fig-a)

→ Each generator and feeder is controlled by a CB.

→ The isolator allow to isolate ~~the~~ generators, feeders and CB from the bus-bar for maintenance.

Advantages

→ Low initial cost

→ Less maintenance

→ Simple operation.

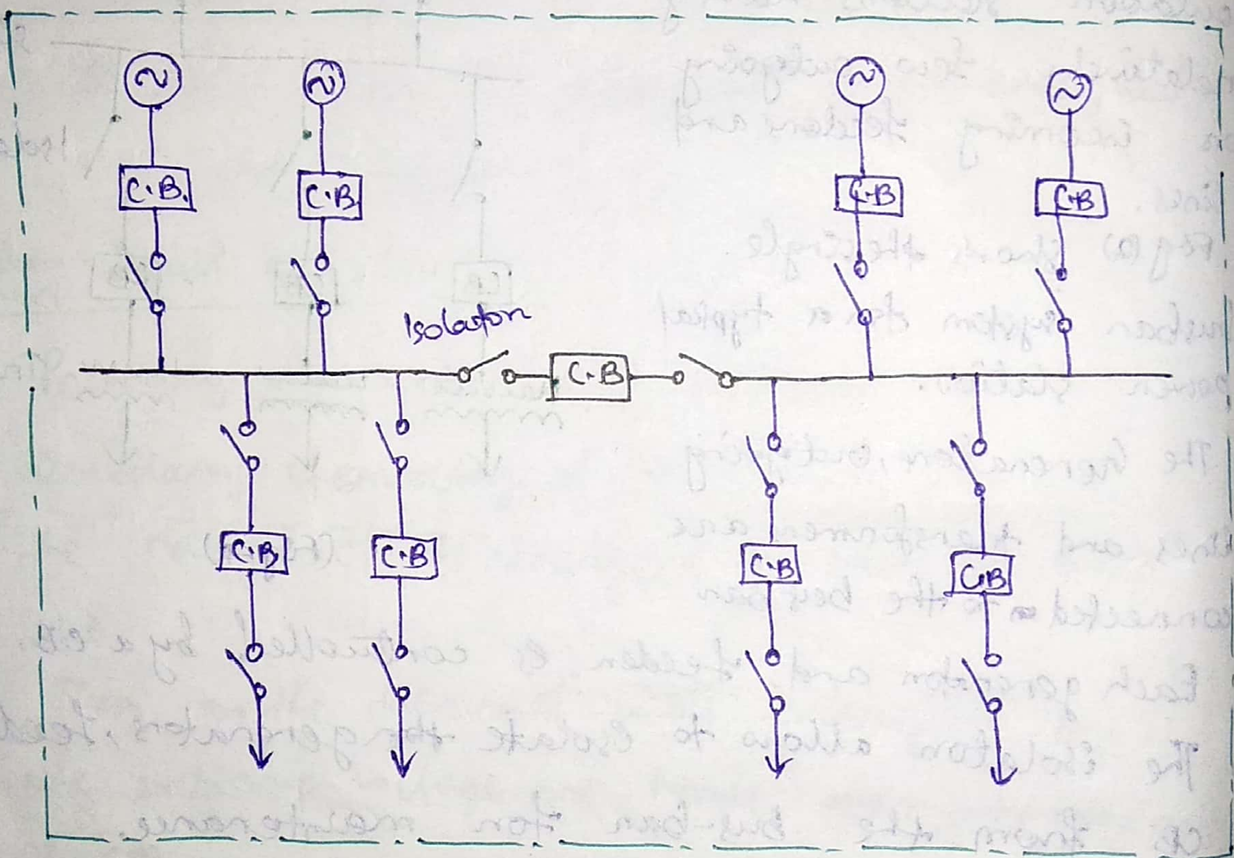
Disadvantages

→ The busbar cannot be cleaned, repaired or tested without de-energising the whole system.

→ If a fault occurs on the bus-bar itself, there is complete interruption of supply.

→ Any fault on the system is fed by all the generating capacity, resulting in very large fault currents.

② Single bus-bar system with sectionalisation



→ In large generating stations where several units are installed, it is a common practice to sectionalise the bus so that fault on any section of the bus-bar will not cause complete shut down.

→ The above fig. shows the bus-bars divided into two sections connected by a CB and isolators.

Advantages

(1) If a fault occurs on any section of the bus-bar, that section can be isolated without affecting the supply to other sections.

(2) If a fault occurs on any feeder, the fault current is much lower than with unsectionalised bus-bar.

This permits the use of CB of lower capacity in the feeders.

(3) Repairs and maintenance of any section of the bus-bar can be carried out by de-energising that section only, eliminating the possibility of complete shut-down.

(3) Duplicate Bus-bar system

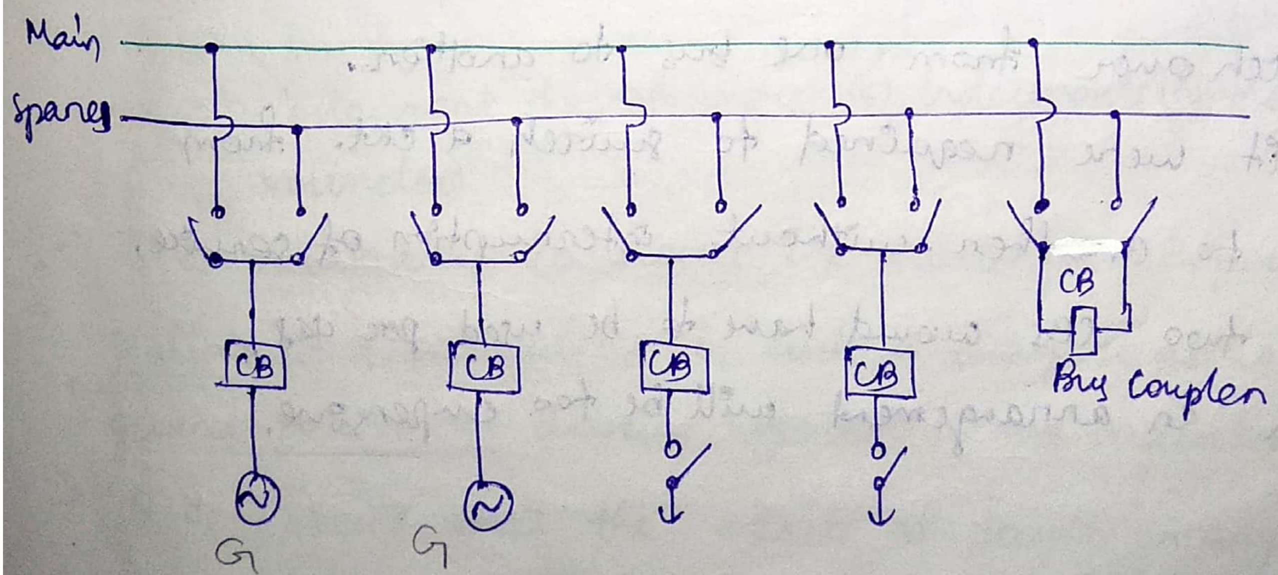


Fig (9)

→ Duplicate busbars is used to achieve the continuity of supply during breakdown & maintenance

→ It is used in important stations (Large stations)

→ This system consist of two bus-bars,

(1) Main bus-bar

(2) spare bus-bar.

→ Each generator and feeder may be connected to both main & spare bus-bar with the help of bus coupler.

→ The bus-coupler consist of circuit breaker & isolators.

→ The duplicate bus-bar system is shown in the fig (a).

→ In this scheme, service is interrupted during switch over from one bus to another.

→ If it were required to switch a ckt. from one to another without interruption of service, then two CBs would have to be used per ckt. Such an arrangement will be too expensive.

Advantages

→ If repair and maintenance is required on the main bus, then the entire load can be transferred to the spare bus. Hence the continuity of supply need not ~~be~~ be interrupted.

→ The testing of feeder ckt. breakers can be done by putting them on spare bus-bars, thus keeping the main bus-bar undisturbed.

→ If a fault occurs on the bus-bars, the continuity of supply to the circuit can be maintained by transferring it to the ~~main~~ other bus-bar.

1.4 SWITCHGEAR ACCOMODATION

The main ~~component~~ components of a switchgear are

(1) CB (2) Switches

(3) bus-bars

(4) Instrument transformers. (5) Instruments (Ammeter & Voltmeters)

→ It is necessary to house the switchgear in power stations and substations in such a way so as to safe-guard personnel during operation and maintenance.

→ It is ensure that the effects of fault on any section of the gear are occur to a limited region.

→ Depending upon the voltage to be handled, switchgear may be broadly classified into two types

(I) Outdoor type

(II) Indoor type.

(1) Outdoor type

→ For voltages more than 66KV, switchgear equipment is installed outdoor.

→ It is because for such voltages, the clearance between the conductors and the space required for switches, circuit breakers, transformers. & other equipment become so great that it is not economical to install all such equipment indoor.

(2) Indoor Type

→ For voltages below 66KV, switchgear is generally installed indoor because of economic considerations.

→ All live parts are completely enclosed in an earthed metal casing.

→ This switchgear is generally of metal-clad type.

1.5 SHORT CIRCUIT

→ Whenever a fault occurs on a network, if a large current flows in one or more phases, a short-circuit is said to have occurred.

→ When a short-circuit occurs, a heavy current called short circuit current flows through the circuit.

→ Ex:-

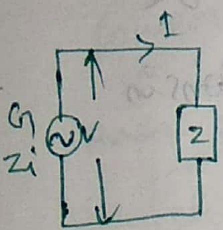


Fig (a)

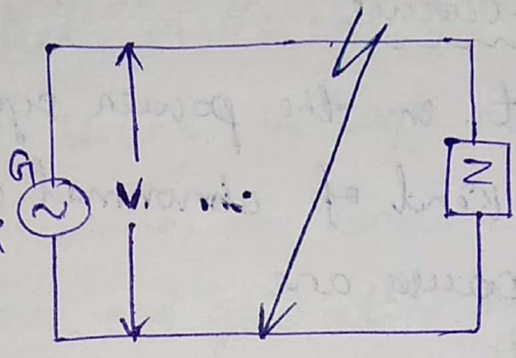


Fig (b)

The figure(a) shows a single phase generator of voltage V & internal impedance Z_i is supplying to a load Z.

Under normal conditions, the current in the ckt. is limited by load impedance Z.

If the load terminals get shorted due to any reason as illustrate in fig (b). The ckt. impedance is reduced to very low value.

Normal condition	Short-circuit condition
$I = \frac{V}{Z_i + Z}$	$I = \frac{V}{Z_i}$ = very high value because internal impedance is very low.

→ Therefore a large current flows through the circuit. This is called short-circuit current.

→ When a short circuit occurs, the voltage at fault point is reduced to zero. and the current is abnormally high, flows to the point of fault.

Causes of Short-circuit

A short circuit in the power system is the result of some kind of abnormal conditions in the system. The causes are

(i) Internal effects

→ Breakdown of equipment or transmission lines.

→ Defect of insulation in a generator, transformer, etc.

→ Ageing of insulation, inadequate design or improper installation.

(ii) External effects

~~When a short circuit occurs the current in the system increases to an abnormally high value while the system voltage decreases to a low value.~~

→ Insulation failure due to lightning surges.

→ Overloading of equipment causing excessive heating

→ Mechanical damage by public/human

* EFFECTS OF SHORT CIRCUIT

→ Fire or explosion due to excessive heat from over current

→ Considerable damage occurs to the system due to formation of arc

→ The voltage created by the fault has a very harmful effect on the service rendered by the power system. If the voltage remains low for even a few seconds, the consumers motors may be shut down and generators on the power system may become unstable.

1.6 SHORT-CIRCUIT CURRENTS

Most of the failures on the power system lead to short circuit fault and cause heavy current to flow in the system.

The calculations of these short-circuit currents are important for the following reasons.

(i) A short circuit on the power system is cleared by a circuit breaker or a fuse. It is necessary therefore, to know the maximum possible values of short circuit currents so that switchgear of suitable rating may be installed to interrupt them.

(ii) The magnitudes of short-circuit current determines the setting and sometimes the types and location of protective system.

(iii) The magnitudes of short-circuit current determines the size of the protective reactors which must be inserted in the system so that, the circuit breaker is able to withstand the fault current.

(iv) The calculation of short-circuit currents enables us to make proper selection of the associated apparatus (eg: bus-bars, CT, etc) so that they can withstand the forces that arise due to the occurrence of short circuits.

1.7 FAULTS IN A POWER SYSTEM

→ A fault occurs when two or more conductors that normally operate with a potential difference come in contact with each other.

→ These faults may be caused by sudden failure of a piece of equipment, accidental damage or short-circuit to overhead lines or by insulation failure resulting from ~~lighting~~ lightning surges.

→ Irrespective of the causes, the faults in a 3-phase system can be classified into two types.

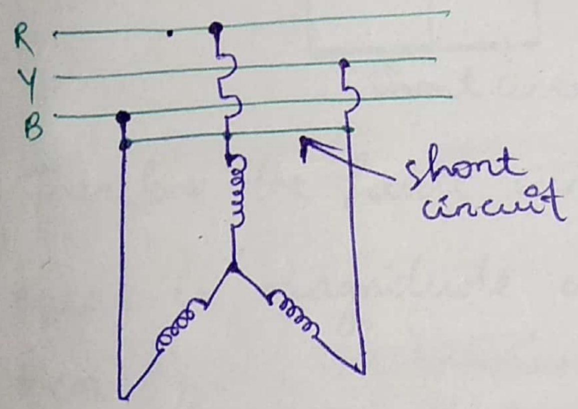
(i) Symmetrical faults

(ii) Unsymmetrical faults.

(i) Symmetrical faults

The fault which give rise to equal fault currents with 120° displacement is called a symmetrical fault.

EX:- When all the 3 conductors of a 3-phase line are brought together simultaneously into a short-circuit condition.



(ii) Unsymmetrical faults

The fault which give rise to unequal line currents with unequal displacement are called unsymmetrical faults.

The unsymmetrical faults are 3 types

① Single line to ground fault (L-G)

② Line to Line (L-L) fault

③ Double line to ground (L-L-G) fault.

→ Maximum occurring fault is unsymmetrical fault.

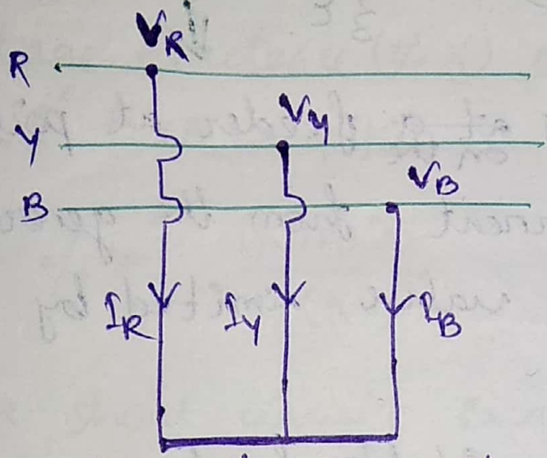
→ But the symmetrical fault is happen very rarely but very severe.

→ Most commonly single line to ground (L-G) fault occur.

FAULT CALCULATION

(2.1) Symmetrical faults on 3-phase system

→ The symmetrical fault occurs when all the three conductors of a 3-phase line are brought together simultaneously into a short-circuit condition.



Short circuit

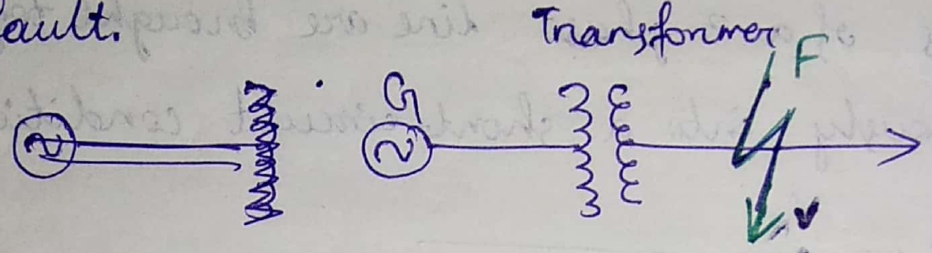
→ Therefore the fault currents I_R, I_Y, & I_B will be equal in magnitude with 120° displacement among them.

→ Because of balanced nature of fault, only one phase need be considered in calculations.

→ The symmetrical fault is the most severe and imposes more heavy duty on the circuit breaker.

(2.2) Limitation of Fault Current

→ When a short circuit occurs at any point in a system, the short circuit current is limited by the impedance of the system upto the point of fault.

→ 

If a fault occurs ~~at a~~ on the feeder at point F, then the short circuit current from the generating station will have a value limited by the impedance.

→ The impedance is available ~~from~~ in generator, transformer and the impedance of the line between the generator and the point of fault.

→ The impedances are limiting the fault current, are largely reactive.

(2.3) Percentage Reactance

→ The reactance of generator, transformers, reactors etc ~~is~~ expressed in percentage reactance to allow ~~easy &~~ quick short circuit calculations.

→ It is defined as the total phase voltage dropped in the circuit when full load current is flowing.

$$\% X = \frac{IX}{V} \times 100 \quad \text{———} (1)$$

where, I = full-load current

V = phase voltage

X = reactance in ohms per phase.

→ Percentage reactance (% X) can also be expressed in terms of KVA and KV

$$\% X = \frac{(KVA)X}{10(KV)^2} \quad \text{———} (2)$$

Now the short circuit current is

$$I_{sc} = \frac{V}{X} \quad \text{(If only reactance is present in the ckt)}$$

$$\% X = \frac{IX}{V} \times 100$$

$$X = \frac{(\% X) \times V}{100 \times I}$$

$$= \frac{(\% X) \times V \times V}{100 I \cdot \times V} \quad (\because \text{Multiply } V \text{ in both numerator \& denominator})$$

$$= \frac{(\% X) \times \frac{V}{1000} \times \frac{V}{1000}}{100 \times \frac{I}{1000} \times \frac{V}{1000}}$$

$$X = \frac{KV \times KV \times (\% X)}{\left(\frac{KVA}{10}\right)}$$

$$\Rightarrow \boxed{\% X = \frac{(KVA) X}{10(KV)^2}} \quad \text{proved.}$$

(*) Find short circuit current when 50 Amp current is flowing in the system, the percentage reactance of an element is 20%.

Sol^n^ $I = 50$ Amp.

$\% X = 20\%$.

$$I_{sc} = I \times \frac{100}{\% X} = \frac{50 \times 100}{20} = 250 \text{Amp}.$$

We know, $I_{sc} = \frac{V}{X}$, $V = \frac{I \times X}{\% X}$, $I_{sc} = \frac{I \times X}{X \times (\% X)} = \frac{I}{(\% X)} = \frac{50}{\frac{20}{100}}$

$= \frac{50 \times 100}{20} = 50 \times 5 = 250$ Amp.

~~2.4 Percentage Reactance & Base KVA~~

Advantage of Using % X ~~syste~~.

→ The advantage of using percentage reactance instead of ohmic reactance in short circuit calculations are.

(i) Percentage reactance values remain unchanged as they are referred through transformers, unlike ~~percentage~~ ohmic reactances which become multiplied or divided by the square of transformation ratio.

(ii) This makes the procedure simple and provide quick calculations.

2.4 Percentage Reactance & Base KVA

→ The equation ② shows that percentage reactance of an equipment depends upon its KVA rating

→ But the various equipments used in the power system have different KVA ratings, therefore it is necessary to find the percentage reactances of all elements on a common KVA rating.

→ This common KVA rating is known as base KVA

→ The value of base KVA may be

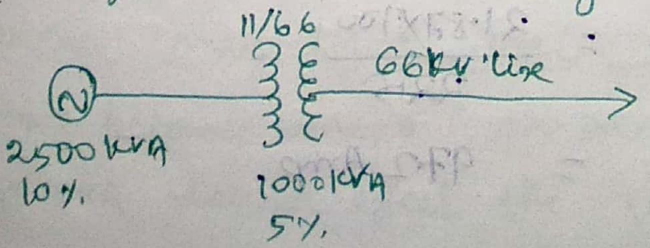
(i) Equal to that of largest plant

(ii) Equal to the total plant capacity

(iii) Any arbitrary value.

→ $\% X \text{ at base KVA} = \frac{\text{Base KVA}}{\text{Rated KVA}} \times (\% X \text{ at rated KVA})$

Ex:- ① Consider a 3-phase transmission line ~~good~~ operating at 66KV and connected through a 1000KVA transformer with 5% reactance to a generating station bus-bar. The generator is of 2500 KVA with 10% reactance. The single line diagram of the system is shown in fig below,



Sol^n ① ~~Suppose~~ Let we choose max^m KVA rating as the common base KVA.

Common base KVA = 2500 KVA

% reactance of t/f at 2500 KVA base

$$= \frac{2500}{1000} \times 5$$

$$= 12.5\%$$

%age reactance of generator at 2500 KVA base

$$= \frac{2500}{2500} \times 10$$

$$= 10\%$$

Total percentage reactance on the common base KVA is

$$\% X = 12.5 + 10 = 22.5\%$$

The FL current corresponding to 2500 KVA base at 66 KV is

$$I = \frac{\text{Base KVA}}{\sqrt{3} \times \text{Bus-bar voltage}} = \frac{2500 \times 1000}{\sqrt{3} \times 66 \times 1000} = 21.87\text{ Amp.}$$

∴ short circuit current

$$I_{sc} = \frac{I}{\%X} = \frac{21.87}{\frac{22.5}{100}}$$

$$= \frac{21.87 \times 100}{22.5}$$

$$= 972 \text{ Amp.}$$

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(ii) Now, suppose we choose 5000 KVA as the common base value.

$\% X$ of T/F at 5000 KVA base

$$= \frac{5000}{1000} \times 5 = 25\%$$

$\% X$ of Generator ~~common~~ 5000 KVA base value

$$= \frac{5000}{2500} \times 10 = 20\%$$

Total percentage reactance on the common base KVA value

$$\% X = 25 + 20 = 45\%$$

Full load current corresponding to 5000 KVA at 66 KV line

$$I = \frac{P}{\sqrt{3} \times V} = \frac{5000 \times 1000}{\sqrt{3} \times 66 \times 1000} = 43.74 \text{ Amp.}$$

Short circuit current,

$$I_{sc} = \frac{I}{\% X} = \frac{43.74}{\frac{45}{100}}$$

$$= \frac{43.74 \times 100}{45} = 97.2 \text{ Amp.}$$

From the above ~~example~~ it is clear that, whatever may be the value of base KVA, SC current ~~is the becomes same,~~ is the same. So the value of base KVA doesnot effect the short circuit current.

(2.5) Short-Circuit KVA

The product of normal system voltage and short-circuit current at the point of fault expressed in KVA is known as short-circuit KVA.

Short circuit current;

$$I_{sc} = I \times \left(\frac{100}{\% X}\right)$$

∴ Short-circuit KVA for 3-phase circuit

$$= \frac{3 V I_{sc}}{1000}$$

$$= \frac{3 V I}{1000} \times \frac{100}{\% X} \quad \left(\because I_{sc} = \frac{I \times 100}{\% X}\right)$$

$$\boxed{\text{Short-ckt KVA} = \text{Base KVA} \times \frac{100}{\% X}}$$

where, V = normal phase voltage in volts

I = FL current in amperes at base KVA

% X = percentage reactance of the system on the base KVA upto the fault point.

(2.8) Steps for Symmetrical fault Calculations

→ In symmetrical fault, we will calculate fault current ~~for~~ of one-phase. Because the fault currents in the 3-phases are are equal in magnitude but displaced in 120° electrically from one another.

→ The steps to solve the problem are ~~given~~ given below:

(1) Draw a single line diagram of the complete network indicating the rating, voltage and percentage reactance of each element of the network.

(2) Choose a numerically convenient value of base KVA and convert all percentage reactances to this base value.

(3) Draw the reactance diagram showing one phase of the system and the neutral. ~~similar~~ Indicate the % reactances on the base KVA in the reactance diagram. The transformer in the system should be represented by a reactance in series.

(4) Find the total % reactance of the network upto the point of fault. Let it be X%

(5) Find the FL current corresponding to the selected base KVA and the normal system voltage at the fault point. Let it be I

(6) Then the short circuit calculations are

$$\text{Short-circuit current}, I_{sc} = I \times \frac{100}{\%X}$$

$$\text{short-circuit KVA} = \text{Base KVA} \times \frac{100}{\%X}$$

আৰু

2.6 Reactor Control of Short-circuit Current

→ Generally, the reactance of the system under fault conditions is low and fault currents may rise to a dangerous high value.

→ If no steps are taken to limit the value of these short-circuit currents, then ~~the dunot~~ only the CB required excessive heavy duty but also damage ~~the~~ to lines and other equipment will almost certainly occur.

→ An additional reactances known as Reactors are connected in series with the system at suitable points in order to limit the short-circuit current. Then the value of short-ckt current can handle the circuit breaker.

→ A reactor is a coil having ~~no~~ number of turns

→ which is designed to have a large inductances as compared to its ~~oth~~ ohmic resistance.

→ The windings ~~of~~ of reactors must be solidly braced.

→ By adding the reactor, there is very little change in the efficiency of the system due to the reactor having very small resistance.

Advantages

(i) It limit the flow of short-circuit current

(ii) It protect the equipment from over heating as well as from failure due to destructive mechanical forces

(iii) Troubles are localised or isolated at the point at where they originate without communicating their disturbing effects to other parts of the power system. This increase the chances of continuity of supply.

(iv) They permit the installation of CB of lower rating.

2.7 Location of Reactors

Short circuit current limiting reactors may be connected in (i) series with ~~go~~ each generator

(ii) series with each feeder

(iii) bus-bars

(i) Generator Reactors

When the reactors are connected in series with each generator, they are known as generator reactors.

In this case, the reactor may be considered as a part of leakage reactance of the generator; hence its effect is to protect the generator in the case of any short-circuit beyond the reactors.

Disadvantages

(i) There is a constant voltage drop and power loss in the reactors even during normal operation.

(ii) If a bus-bar or feeder fault occurs close to the bus-bar, the voltage at the bus-bar will be reduced to a low value, thereby causing the generators to fall out of step.

(iii) If a fault occurs on any feeder, the continuity of supply to other is likely to be affected.

Due to these disadvantages and also since modern power station generators have sufficiently large leakage reactance to protect them against short-circuit, it is not a common practice to use separate reactors for the generators.

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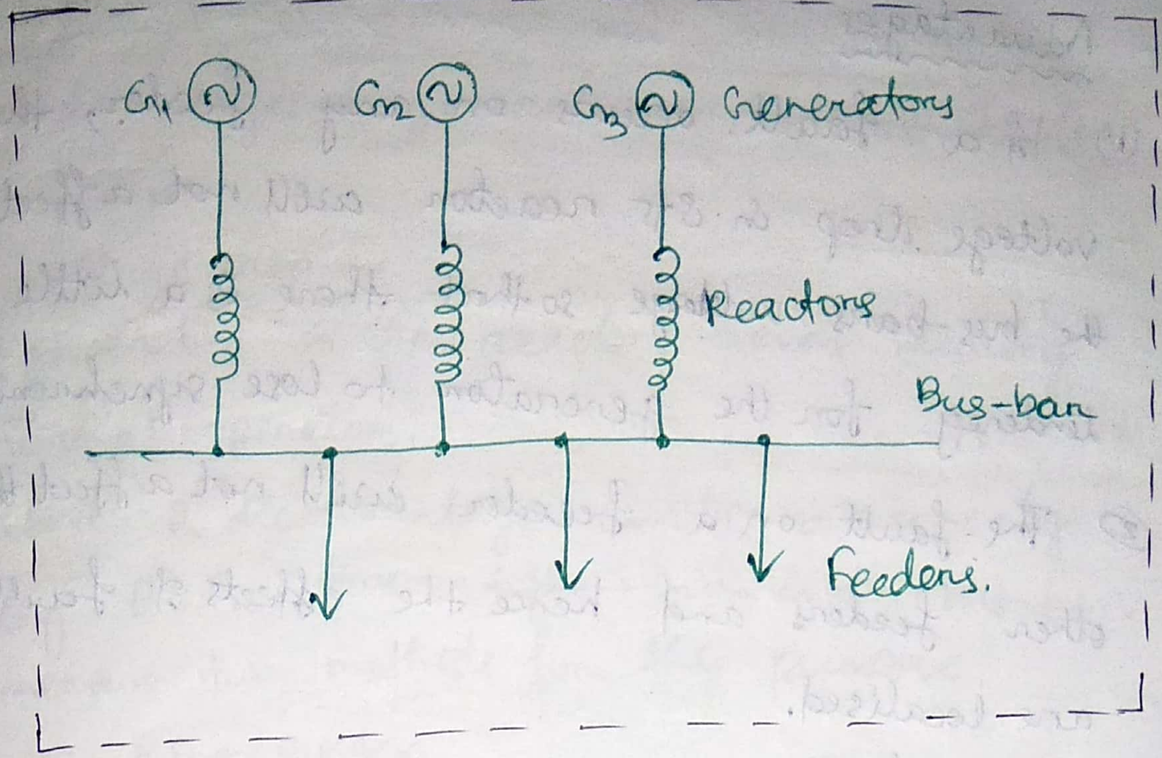
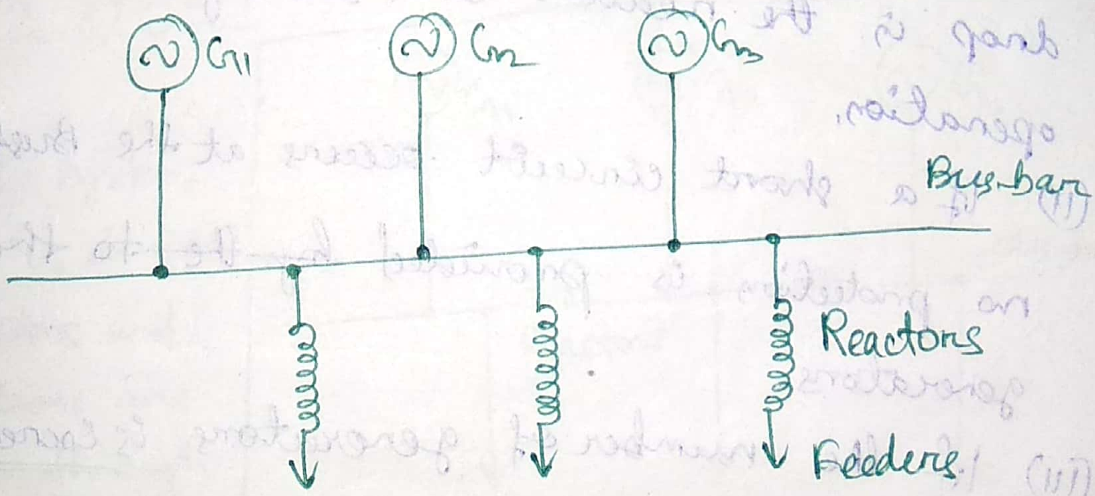


② FEEDER REACTORS



→ When the reactors are connected in series with each feeder, they are known as feeder reactors, which is shown in the above figure.

→ Most of the short-circuits occur on feeders, a large number of reactors are used for such circuits.

Advantages

(i) If a fault occurs on any feeder, the voltage drop in its reactor will not affect the bus-bars voltage so that there is a little tendency for the generator to lose synchronism.

(2) The fault on a feeder will not affect the other feeders and hence the effects of fault are localised.

Disadvantages

(i) There is a constant power loss and voltage drop in the reactors even during normal operation.

(ii) If a short circuit occurs at the Busbars, no protection is provided ~~by the~~ to the generators.

(iii) If the number of generators is increased, the size of feeder reactors will have to be increased to keep the short-circuit currents within the ratings of the feeder circuit breakers.

(iv)

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③ Bus-bar Reactors

→ Disadvantages of generator reactors & feeder reactors are

① voltage drop

② power loss in the reactors even during normal operation.

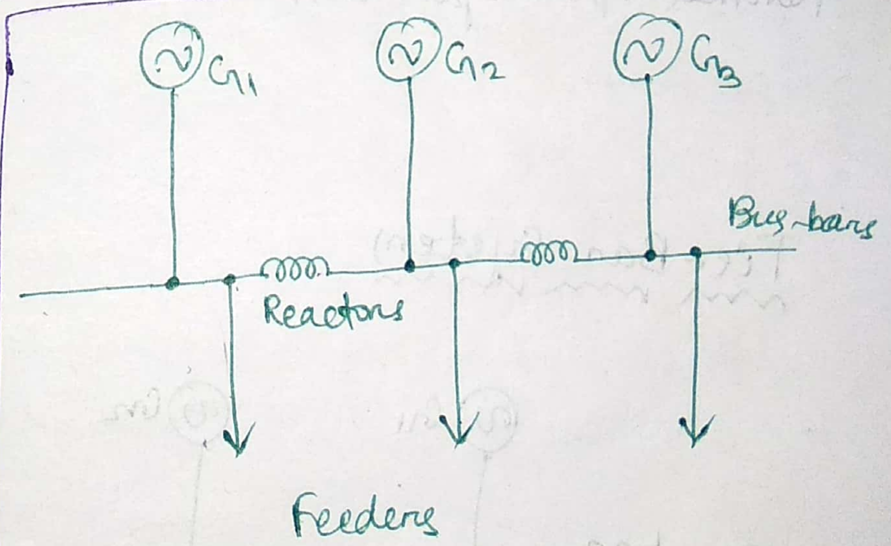
→ The above 2 disadvantages can be overcome by locating the reactors ~~in the bus~~ in the bus-bars.

→ There are two methods for this purpose.

(1) Ring system

② Tie-Bar system

① RING SYSTEM



→ In this system, bus-bar is divided into sections and these sections are connected through reactors.

→ One feeder is fed from one generator only.

→ Under normal operating conditions, each generator will supply its own section of the load and very little power will ~~be~~ fed by ~~the~~ other generators.

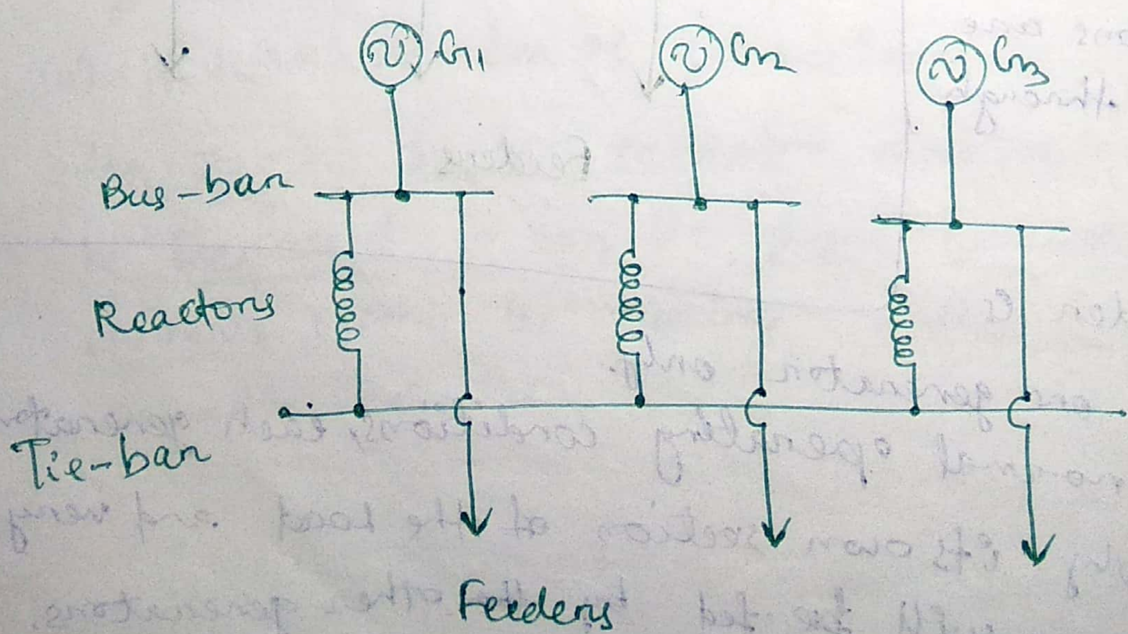
→ This results in low power loss and voltage drop in the reactors.

Advantages

① If a fault occurs on any feeder, only one generator mainly feeds the fault current while the current fed from other generators is small due to the presence of reactors.

② Therefore only ~~that~~ fault sectn of the busbar is affected to which the feeder is connected, the other sectn being able to continue in normal ~~operal~~ operation.

Tie-Bar System



In tie-bar system, there are effectively two reactors in series between sections so that reactors must have approximately half the reactance of those used in a comparable ring system.

Advantages

→ The additional generators may ~~not~~ be connected to the system without requiring changes in the existing reactors.

Disadvantages

→ It requires an additional bus-bar. that is tie-bar.

CHAPTER-3

FUSES

A fuse is a short piece of metal, inserted in the circuit, which melts when excessive current flows through it and thus breaks the ckt.

Features of fuse element

① Low melting point
② High conductivity
③ Least deterioration due to oxidation.

3.1 Desirable Characteristics of Fuse Element

• The function of a fuse is to carry the normal current without overheating but when the current exceeds its normal value, it rapidly heats up to melting point and disconnects the ckt. protected by it.

The fuse element should have the following desirable characteristics:

(i) Low melting point (Ex:- tin, lead)
(ii) High conductivity (Ex :- silver, copper)
(iii) free from deterioration due to oxidation (silver)
(iv) Low cost (Ex:- lead, tin, copper.

The above point reveals that no material possesses all the characteristics. Therefore, a compromise is made in the selection of material for a fuse.

3.2 Fuse Element Materials

→ The most commonly used materials for fuse element are lead, tin, copper, zinc and silver.

→ For small currents (upto 10Amp)

~~upto 10A.~~

tin or an alloy of lead & tin (lead 37%, tin 63%) is used for making the fuse element

→ For larger currents

Copper or silver is employed. Because copper protect it ~~for~~ from oxidation.

→ Zinc is good but it takes more time to melt. as compared to other ~~elem~~ fuse element

The present trend is to use silver despite its high cost due to the following reasons.

(i) It is comparatively free from oxidation.

(ii) It doesnot deteriorate when used in dry air

(iii) The coefficient of expansion of silver is so small that no critical fatigue occurs, Therefore the fuse element can carry the rated current continuously for a long time.

(iv) The conductivity of silver is very high.

(v) Due to comparatively low specific heat, silver fusible elements can be raised from normal temperature to vapourisation quicker than other fusible elements. Hence, operation becomes very much faster at higher currents.

(vi) Silver vapourises at very low temperature at which its vapour will readily ionise. Therefore an arc is formed through the vapourised portion of the element, ~~baying~~ having high resistance. As a result, S.C current is quickly/ ~~rapidly~~ interrupted.

3.3 Important terms used for fuses

① Current rating of fuse element

→ It is the current at which the fuse element can normally carry without overheating/melting.

② Fusing current

→ It is ~~the~~ minimum current at which the fuse elements melts and thus disconnects the ckt ~~pro~~ and protect the ckt elements, ~~and~~ and devices.

→ Its value will be more than the current rating of the fuse elements.

→ It depends ~~on~~ upon the temperature rise of the contacts of the fuse holder, fuse material and the surroundings of the fuse.

→ ~~For~~ For a round wire, the approximate relationship betn fusing current I & the diameter d of of the wire is

$$I = K d^{3/2} = \cancel{Kd}$$

$$= K d^{1.5}$$

where, K = constant, called fuse constant. Its value depends upon the metal of which the fuse element is made.

→ Sir W.H. Preece found the value of K for different materials.

Material	value of K: d in cm	d in mm
Copper	2530	80
Aluminium	1873	59
Tin	405.5	12.8
Lead	340.6	10.8

The fusing current depends upon:

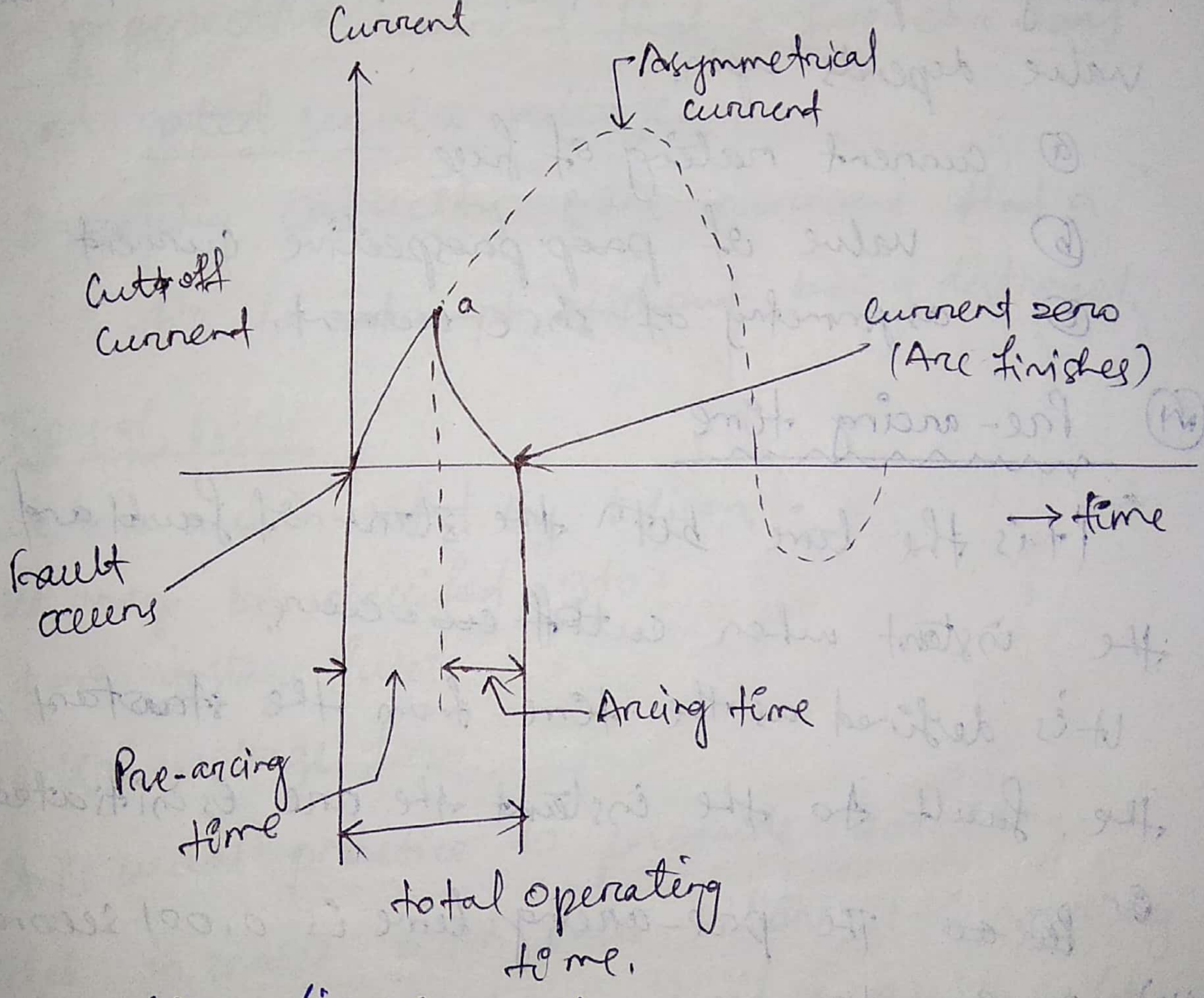
(a) Material of fuse element
(b) length.
(c) diameter
(d) size & location of terminals
(e) Previous history
(f) type of enclosure used.

③ Fusing factor

It is defined as the ratio of minimum fusing current to the current rating of the fuse element.

$$\text{Fusing factor} = \frac{\text{Min}^{m}\ \text{fusing current}}{\text{Current rating of fuse.}}$$

→ Its value is always more than one.



④ Prospective ~~time~~ Current

The rms value of the 1st loop of fault current is known as prospective current.

It is the rms value of the 1st loop of the fault current obtained if the fuse is replaced by an ordinary conductor of negligible resistance

(v) Cut-off current

It is the max^m value of fault current actually reached before the fuse melts. The current corresponding to point 'a' is the cut-off current. The cut-off value depends upon.

(a) current rating of fuse

(b) value of ~~prop~~ prospective current

(c) asymmetry of ~~s~~ ~~c~~ current.

(vi) Pre-arcing time

It is the time betn the start of fault and the instant when cutoff ~~cu~~ occurs.

It is defined as the time from the ~~sta~~ start of the fault to the instant the arc is initiated.

Q. ~~Ko~~ ~~ee~~ The pre-arcing time is 0.001 second.

(VII) Arcing time.

This is the ~~ti~~ time betn the end of pre-arcing time and the instant when the arc is extinguished.

(VIII) Total operating time

It is the sum of pre-arcing time & arcing times.
The operating time of a fuse is quite low (0.002sec) as compared to a CB (0.2sec).

(IX) Breaking Capacity

It is the rms value of ac component of max^m prospective current that a fuse can deal with at rated service voltage.

Breaking capacity is the current that a fuse is able to interrupt without being destroyed.

Types of fuses

Fuse ~~wire~~ was invented by Edison.
Fuses may be classified into:
(I) Low voltage fuses
(II) High voltage fuses.

→ It is usual practice to provide isolating switches in series with fuses where it is necessary to permit fuses to be replaced ~~___~~ with safety.
→ If isolations are not available the fuses must be shielded to protect the user.

3.4 Low voltage fuse & High voltage fuse

1. Low voltage fuse

(a) Semi enclosed rewirable fuse

(b) High rupturing capacity (HRC) Catridge fuse.

(a) Semi-enclosed rewirable fuse

→ It is also called as Kit-Kat type fuse.

→ The Kit-Kat fuse is used where low value of fault current are to be interrupted.

→ It consists of (i) base &
(ii) ~~Carrier~~ fuse carrier.

→ The base is made up of ~~pro~~ porcelain and having a fixed contact to which the incoming & outgoing phase wires are connected.

→ The fuse carrier is also of ~~pro~~ porcelain and holds the fuse element between its terminals.

→ The fuse carrier can be inserted in or taken out of the base when desired.

Operation

→ When a fault occurs, the fuse element is blown out and the circuit is interrupted.

→ The fuse carrier is taken out and the blown out fuse element is replaced by the new one.

→ The fuse carrier is then re-inserted in the base to restore the supply.

* Advantages

→ The replacement of fuse element without any danger ~~co~~ of coming in contact with live parts.

→ The cost of replacement is negligible.

Disadvantages

→ There is a possibility of renewal of fuse element of wrong size or improper material.

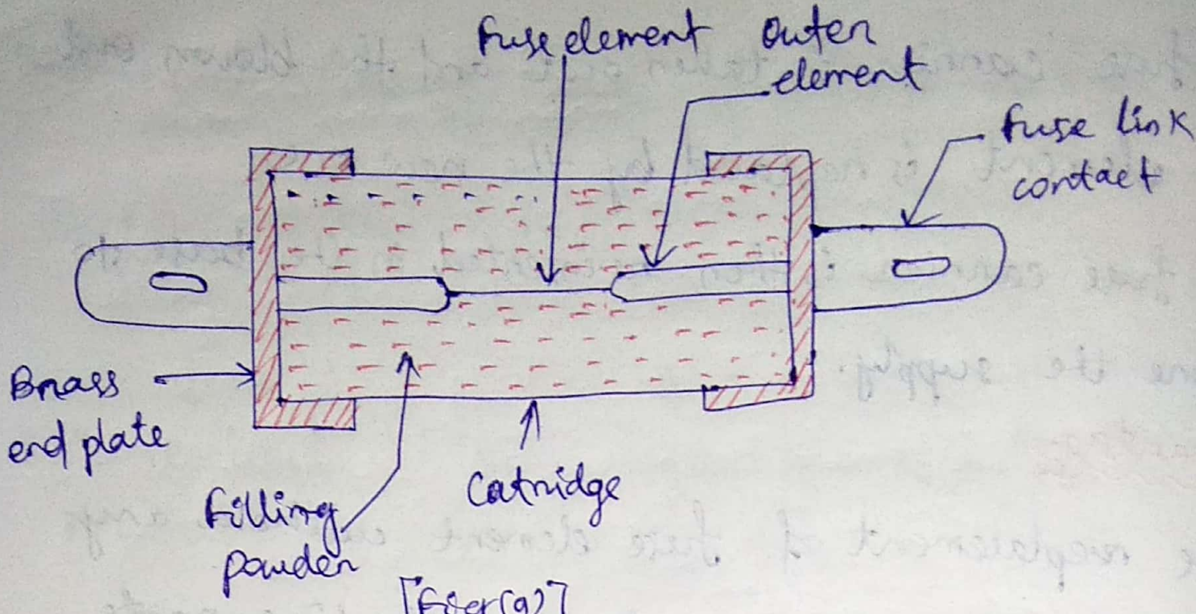
→ It cannot be used in ckts of high fault level because it has low breaking capacity.

→ Deterioration due to oxygen through the ~~co~~ continous heating up ~~it~~ of the element. Therefore the current rating of the fuse is decreased.

→ The ~~reliability of~~ protective capacity of this fuse is uncertain or may be low ~~as it~~ due to it is affected by the ambient conditions.

(b) High-Rupturing Capacity (HRC) catridge fuse

Rupturing → breaking



[Fig(a)]

→ This fuse overcome the ~~problem of~~ disadvantage low and uncertain breaking capacity of semienclosed reweirable fuse.

→ Fig (a) shows the parts of a typical HRC catridge fuse.

→ It consists of a heat resisting ceramic body having metal end caps to which is welded silver current carrying element.

→ The surrounding of fuse element is filled by powder (chalk, plaster of paris, quartz or marble dust), which act as an arc quenching and cooling medium.

- Therefore, it carries the normal current without overheating.

→ Working or operation

→ When a fault occurs, the current increases and the fuse element melts before the fault current reaches its ~~1st~~ 1st peak.

→ Then the fuse element melts and then vapourises the melted silver element. The chemical reaction betn the silver vapour and the filling powder ~~result~~ results in the formation of a high resistance substance which helps in quenching the arc.

Advantages

① They are capable of clearing high as well as low fault currents.

② They ~~donot~~ do not deteriorate with age.

③ They have high speed of operation

~~④ They provide reliable discrimination.~~

~~⑤ They require no maintenance~~

④ Complete reliability

⑤ No maintenance is reqd.

⑥ Low cost

⑦ They ~~permit~~ provide consistent performance.

Disadvantages

① They have to be replaced after each operation

* ② Heat produced by the arc may affect the associated switches

(2) High Voltage Fuses

→ The low voltage fuse have low normal current rating and breaking capacity. ~~Th~~Hence, they cannot be successfully used on high voltage ckts.

→ The high voltage fuse is of two types

(a) High voltage fuse

- Catridge type
- Liquid type.

(i) Catridge type

→ ~~This fuse is~~ The construction of this fuse is similar to LV catridge type except that special design features are ~~pra~~ included.

→ Some designs employ fuse element wound in the form of a helix. so as to avoid corona effects at higher voltages.

→ ~~On~~ Some designs provided two fuse elements in parallel; one of low resistance (silver wire) and the other of high resistance (tungsten wire).

Operation

Under normal load condition, the low resistance element is blown out. and the high resistance element reduces the short ckt current and finally breaks the ckt.

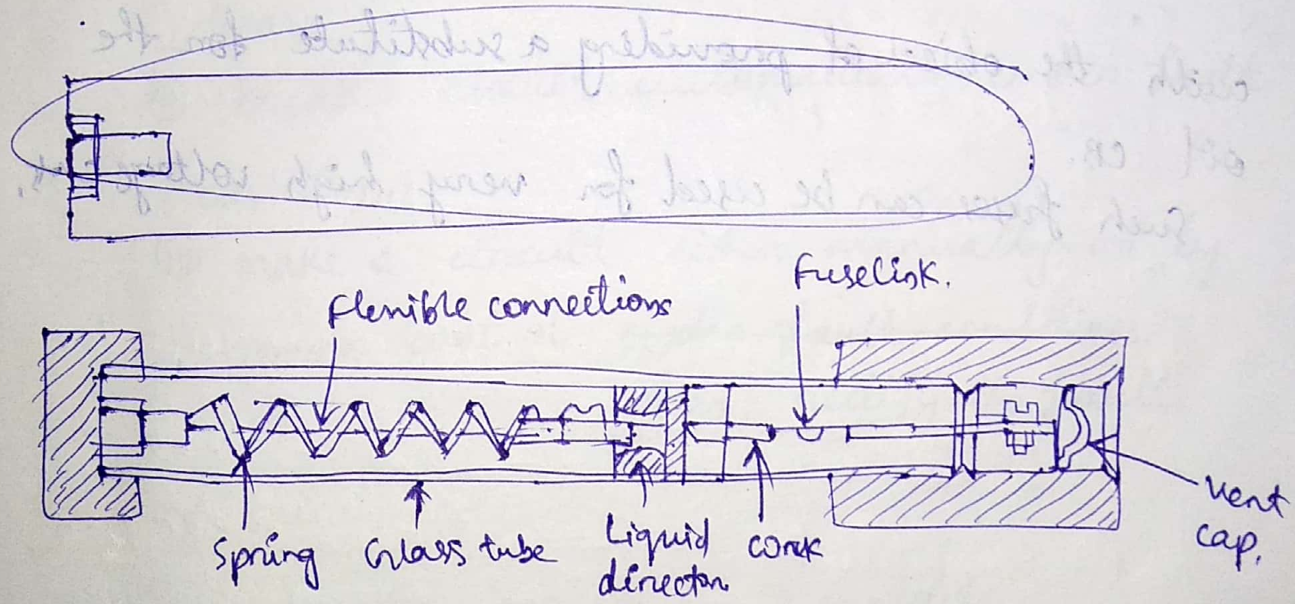
→ The HV catridge fuses are used upto 33 KV with breaking capacity of about 8700 A at that voltage.

→ Rating of the order of 200 A at 6.6 KV & 11 KV, & 50 A at 33 KV are also available.

② Carb Liquid type

→ These fuses are filled with carbon tetrachloride and have the widest range of application to h.v. systems.

→ They may be used for ckts upto about 100 A rated current on systems upto 132 KV and have breaking capacities of the order of 6100 A.



→ It consists of a glass tube filled with carbon tetrachloride solution and sealed at both ends with brass caps.

→ The fuse wire is sealed at one end of the tube and the other end of the wire is held by a strong phosphor bronze spiral spring.

Operation

→ When fault occurs the fuse element is blown out and the liquid director moves towards the liquid.

→ The small quantity of gas produced during fusion forces some part of the liquid into the passage through baffle and can effectively extinguish the arc.

$\boxed{\text{Baffle} \rightarrow \text{obstacle}}$

③ Metal clad fuses

Metal clad oil-immersed fuses have been developed with the object of providing a substitute for the oil CB.

Such fuses can be used for very high voltage ckts.

CIRCUIT BREAKERS

(4.1) Definition & Principle of Circuit breakers

Definition:- A circuit breaker can make or break a circuit either manually or automatically under all conditions (like:- no-load, full-load and short-circuit conditions)

or

A circuit breaker is a piece of equipment which can (i) make or break a circuit either manually or by remote control under normal conditions.

(ii) break a circuit automatically under fault conditions.

(iii) make a circuit either manually or by remote control ~~under fault conditions~~. after rectify the fault.

Operating Principle:-

→ A ckt. breaker consists of 2 contacts
(i) Fixed contact & (ii) Moving contacts.
these contacts are called electrode.

→ Under normal operating conditions, these contacts remain closed.

→ The contacts can be opened manually or by remote control whenever desired/required/needed.

→ When a fault occurs on any part of the system, the trip coils of the circuit breaker get energised and the moving contacts are pulled apart by some mechanism, thus opening the ckt.

→ When the contacts of a CB are separated under fault conditions, an arc is struck betn them. The current is thus able to continue until the discharge finishes.

→ The production of arc not only delays the current interruption process but also generates ~~enomo~~ enormous heat which may damage the CB.

NOTE ✱ The main problem in a CB is to extinguish the arc. ~~within the shortest~~ within very short period of time so that heat generated by it may not reach a dangerous value.

4.2 Arc phenomenon & principle of arc extinction

Arc Phenomenon

→ When a short circuit occurs, a heavy current flows through the contacts of the CB.

→ When the contacts begin to separate, the contact area decreases rapidly and large fault current causes increased current density and hence rise in temperature.

→ The heat produced in the medium betn the contacts (oil or air medium) is sufficient to ionise the air or oil. The ionised air or oil acts as conductor and arc is struck betn the contacts.

→ The PD betn the contacts is quite small and it is sufficient to maintain the arc.

→ The arc provides a low resistance path and hence the current in the ckt remains uninterrupted as long as the arc persists.

→ During the arcing period, the current flowing between the contacts depends upon the arc resistance. The greater the arc resistance, the smaller the current that flows between the contacts.

→ The arc resistance depends upon 3 factors
- (i) Degree of ionisation
- (ii) Length of the arc
- (iii) cross-section of the arc.

(i) Degree of Ionisation :- the arc resistance increases with the decrease in the number of ionised particles between the contacts.

(ii) Length of the arc :- the arc resistance increases with the increase in length of the arc.

(iii) Cross-section of the arc :- the arc resistance increases with the decrease in area of X-section of the arc.

⊛ Principle of arc extinction

The factors responsible for the maintenance of arc between the contacts are

1. P.d. betn the contacts
2. ionised particles betn contacts.

→ When the contacts have a small separation, the PD between them is sufficient to maintain the arc. One way to extinguish the arc is to separate the contacts to such a distance that p.d. becomes insufficient to maintain the arc. But this method is impractible in high voltage system where a separation of many metres may be required.

→ The ionised particles between the contacts tend to maintain the arc.

If the arc path is deionised, then the arc extinction will be facilitated.

→ This may be achieved by cooling the arc or removing the ionised particles from the space between the contacts.

4.3 Methods of arc extinction

There are two methods of extinguishing the arc in the CB.

① High resistance method

② Low resistance method (current zero method)

① High resistance method

→ In this method, arc resistance is made to increase with time so that current is reduced to a value insufficient to maintain the arc.

→ Consequently, the current is interrupted ~~on the due~~ to arc is extinguished.

→ The disadvantages of this method is that enormous energy is dissipated in the arc. Therefore it is employed only in d.c. ckt. breakers and low capacity a.c. CB.

The resistance of the arc may be increased by:

① Lengthening the arc :-

~~The length of the arc can be increased by increasing the gap~~ The resistance of the arc is directly proportional to its length. ($R \propto l$). The length of the arc can be increased by increasing the gap between contacts

(ii) Cooling the arc.

Cooling helps in the deionisation of the medium between the contacts. This increase the arc resistance.

(iii) Reducing X-section of the arc :-

If the area of X-section of the arc is reduced, ($\uparrow R \propto \frac{1}{A\downarrow}$), the voltage necessary to maintain the arc is increased. and the resistance of the arc path is increased.

(iv) Splitting the arc

The resistance of the arc can be increased by splitting the arc into a number of smaller arcs.

② Low resistance or Current zero method

→ This method is employed for ~~ac~~ arc extinction in a.c. ckt. only.

→ In this method, arc resistance is kept low untill current is zero where the arc extinguishes naturally.

→ All modern high power a.c. circuit breakers employ this method for arc extinction.

→ In an a.c. system, current drops to zero after every half cycle. At every current zero, the arc extinguishes for a brief moment.

→ Now the medium between the contacts contains ions and electrons so that it has small dielectric strength and can be easily broken down by the rising contact voltage.

→ If such a breakdown ~~does~~ occur, the arc will persist for another half-cycle.

→ If immediately after current zero, the dielectric strength of the medium between contacts is built up more rapidly, then the arc fails to restrike and the current will be interrupted.

→ The rapid increase of dielectric strength of the medium near ~~zero~~ current zero can be ~~ach~~ obtained by:

(a) Causing the ionised particles in the space between contacts to recombine into neutral molecules.

(b) Sweeping the ionised particles away and replacing them by un-ionised particles.

The de-ionisation of the medium can be achieved by :
1. Lengthening of the gap
2. High pressure
3. cooling
4. blast effect.

(2) High pressure

If the pressure in the vicinity of the arc is increased, the density of the particles constituting the discharge also increases. The increased density of particles causes higher rate of de-ionisation and the dielectric medium between the contacts is increased.

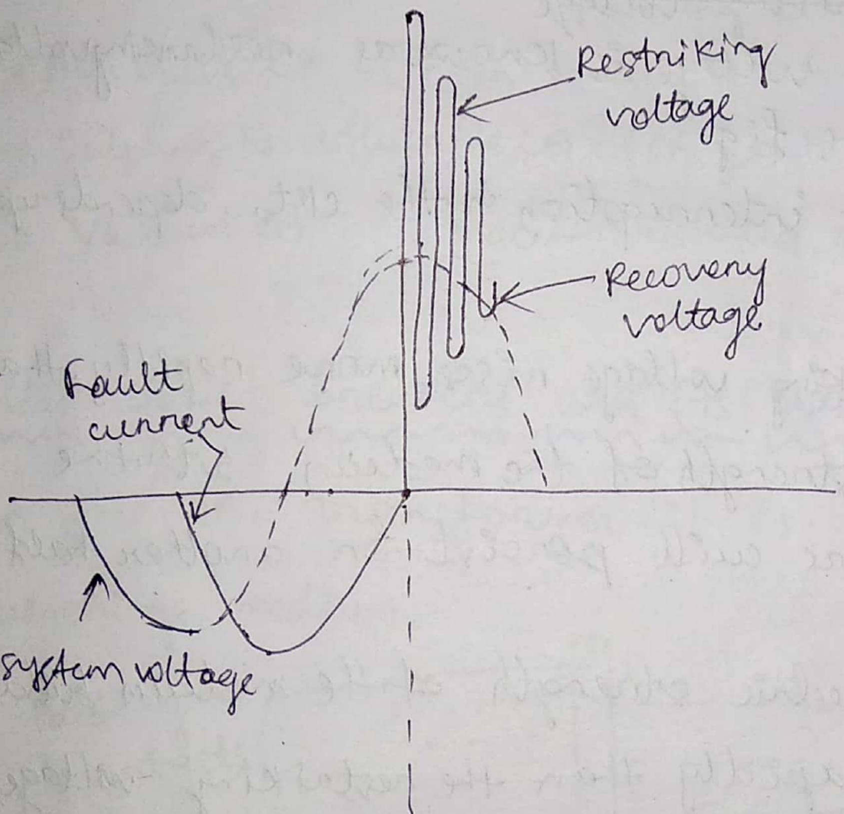
(4) Blast effect

If the ionised particles between the contacts are swept away and replaced by un-ionised particles, the dielectric strength of the medium can be increased. This may be achieved by forcing oil into the contact space or by a gas blast directed along the discharge.

4.4 Definitions of arc voltage, Re-striking voltage and recovery voltage

① Arc voltage

It is the voltage that appears across the contacts of the circuit breaker during the arcing period.



When the contacts of the circuit breaker separate, an arc is formed. The voltage that appears across the contacts during arcing period is called arc voltage.

→ ~~when~~ The ~~volt~~ arc voltage is low when current max^m.

~~But the arcing current is high or max^m when the current is at zero,~~ voltage

At current zero, the arc voltage rises rapidly to peak value and this peak voltage tends to maintain the current flow in the form of arc.

(ii) Restriking voltage

It is the transient voltage that appears across the contacts at or near current zero during arcing period.

~~If the restriking voltage~~

The transient voltage is known as restriking voltage.

→ as shown in the fig.

→ The current interruption in the ckt. depends upon this voltage.

→ If the restriking voltage rises more rapidly than the dielectric strength of the medium betn the contacts, the arc will persist for another half cycle.

→ If the dielectric strength of the medium builds up more rapidly than the restriking voltage, the arc fails to restrike and the current will be interrupted.

(iii) Recovery voltage

It is the normal frequency (50Hz) rms ~~vol~~ voltage that appears across the contacts of the circuit breaker after final arc extinction.

It is approximately equal to the system voltage.

4.5 Classification of circuit breaker.

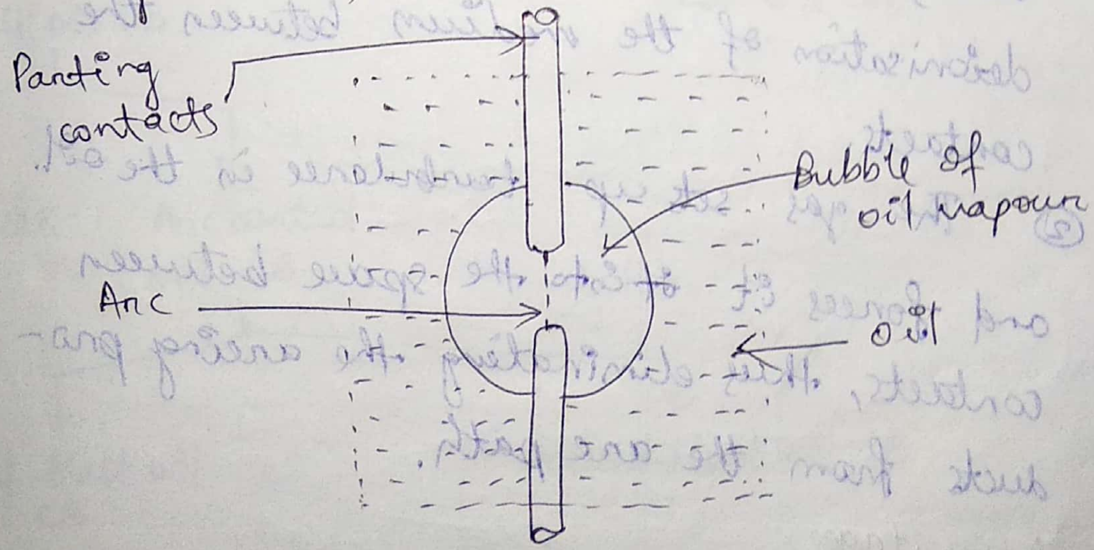
The most general way of classification of is on the basis of medium used for arc extinction. The medium used for arc extinction is usually air, oil, sulphur hexafluoride (SF_6) or vacuum.

CB

- Oil ckt Breaker [(which employs some insulating oil) on T/f oil for arc extinction)
- Air blast CB (high pressure air blast is used)
- Sulphur hexafluoride CB (SF_6 gas is used)
- Vacuum CB [Vacuum is used for arc extinction]

4.6 Oil circuit breakers and its classification

→ In this CB, transformer oil is used as an arc quenching medium.



The contacts are opened under oil and an arc is struck between them.

→ Then the heat of the arc evaporates the surrounding oil and dissociates it into a substantial volume of gaseous hydrogen gas at high pressure.

The hydrogen gas occupies a volume about one thousand times that of the oil decomposed.

Then the oil is pushed away from the arc and an expanding hydrogen gas bubble surrounds the arc region and adjacent portions of the contacts as shown in the fig.

The arc extinction is facilitated mainly by two processes.

1. The hydrogen gas has high heat conductivity and cools the arc, thus helping the deionisation of the medium between the contacts.
2. The gas sets up turbulence in the oil. and forces it ~~it~~ into the space between contacts, thus eliminating the arcing products from the arc path.

Advantages

1. It absorbs the arc energy to decompose the oil into gases which have excellent cooling properties.

② It acts as an insulator and permits smaller clearance betn live conductors.

③ The surrounding oil presents cooling surface in close near to the arc.

Disadvantages

① It is inflammable and there is a risk of a fire.

② It may form an explosive mixture with air

③ The arcing products (EX: carbon) remain in the oil ~~and~~ and its quality deteriorates with successive operations. ~~That why~~ This necessitates periodic checking and replacement of oil.

Classification of oil circuit Breakers

- oil CB
  - Bulk oil CB
    - Plain break oil CB
    - Arc control oil CB
      - Self-blast oil CB
      - Forced-blast oil CB
  - Low oil CB

① Bulk oil CB

→ This CB use a large quantity of oil. The oil has to serve two purposes.

① It extinguishes the arc during opening of contacts.

⑪ It insulates the current conducting parts from one another and from the earthed tank.

→ This CB is classified into two types:

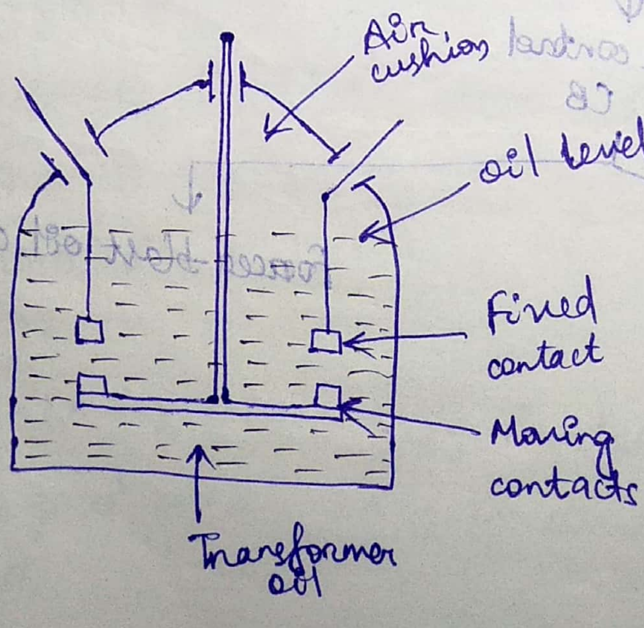
(a.) Plain break oil CB.

(b) Arc control oil CB.

② Low oil circuit breakers

This CB use minimum amount of oil. Oil is used for arc extinction; the current conducting parts are insulated by air or insulating material.

4.7 Plain Break Oil Circuit Breakers



→ There is no special system for arc control. ~~other than the~~

→ The arc extinction occurs when a certain gap critical gap betn the contacts is reached.

→ It has a very simple construction.

→ It consists of two contacts
① fixed contact & ② Moving contacts.

→ These two contacts enclosed in a ~~stro~~ tank con containing oil upto a certain level and an air cushion above the oil level.

→ The air cushion provides sufficient space to allow for the reception of the arc gases.

→ It also absorbs the mechanical shock of the upward oil movement.

→ Fig(a) shows a double break plain oil CB. It is called a double break because it provides two breaks in series.

Operation

→ Under normal operating conditions, the fixed & moving contacts remain closed and the breaker carries the normal ckt current.

→ When a fault occurs, the moving contacts are pulled down by the protective system and an arc is struck betn them, which vapourises the oil mainly into hydrogen gas.

→ The arc extinction is facilitated by the following processes:

① The hydrogen gas bubble generated around the arc and cools the arc.

② The gas sets up turbulence in the oil and helps in eliminating the arcing product from the arc path.

③ As the arc lengthens due to the separating contacts, the dielectric strength of the medium is increased.

The result of these actions is that at some critical gap length, the arc is extinguished and the circuit current is interrupted.

Disadvantages

→ There is no special control over the arc. Therefore, for successful interruption, long arc length is necessary.

→ These breakers have long & inconsistent arcing times.

→

→ These breakers do not permit high speed ~~operation~~ interruption.

Note: Due to these disadvantages, plain-break oil CBs are used only for low voltage applications. Its capacity for voltages not exceeding 11 KV.

4.8 Arc control Oil Circuit Breakers

It is of two types

1. Self-blast oil CB
2. Forced-blast oil CB

~~1. Self-blast oil CB~~

~~In this type of breakers, the~~

The circuit breakers provided the arc control is known as arc control CB.

1. Self-Blast oil CB

In such CB, movements of oil into contact space is increased by the use of pressure developed by arc itself.

The high pressure produced by the arc causes an immediate flow of oil into space betn contacts. After the arc current goes to zero.

→ In this CB, the gases produced during arcing are limited to a small volume by the use of an insulating rigid pressure chamber surrounding the contacts.

→ The space available for the arc gases is restricted by the chamber, a very high pressure is developed to force the oil and gas around the arc to extinguish it.

→ The magnitude of pressure developed depends upon the value of fault to be interrupted.

→ As the pressure is generated by arc itself, such breakers are ~~sometimes~~ called self-generated pressure oil circuit breakers.

→ The pressure chamber is cheap to make and gives less arcing time as compared to plain break oil CB.

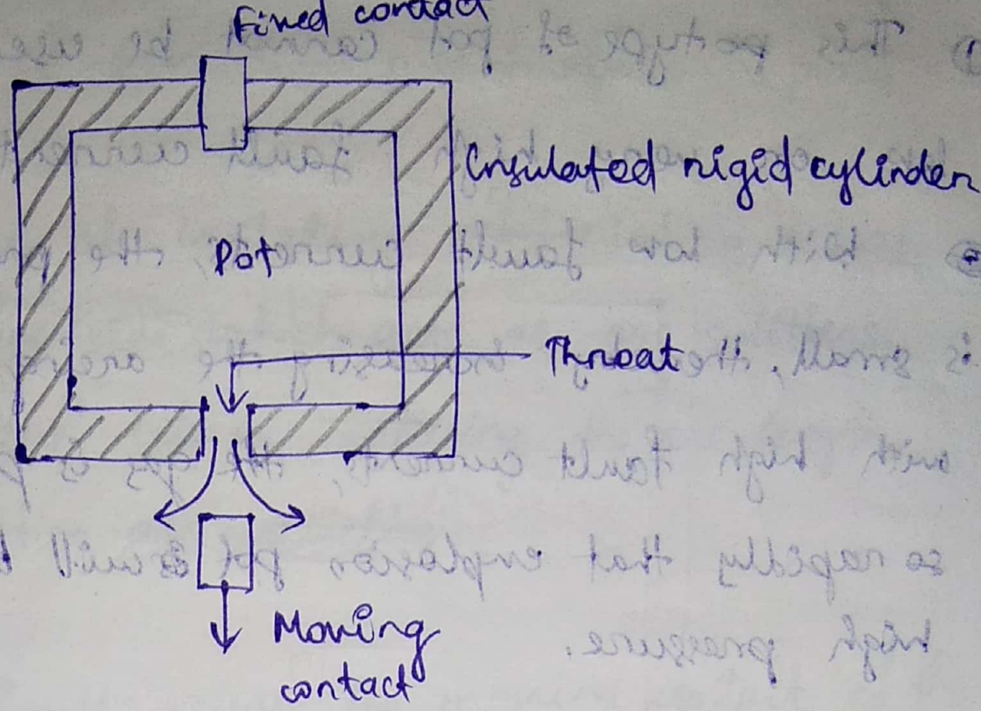
• The designs of pressure chamber are

(a) Plain explosion pot

(b) Cross jet explosion pot

(c) Self-compensated explosion pot.

(a) Plain explosion pot



→ ~~It is a~~ The plain explosion pot is shown in the figure,
→ which shows a rigid cylinder of insulating material and encloses the fixed and moving contacts. The
→ The moving contact is a cylindrical rod passing through a throat at the bottom.

Operation

→ when a fault occurs, the contacts get separated and an arc is struck between them.

→ Then the heat of the arc decomposes oil into a gas at very high pressure in the pot.

→ This ~~pres~~ high pressure forces the oil and ~~gas~~ around the arc to extinguish it.

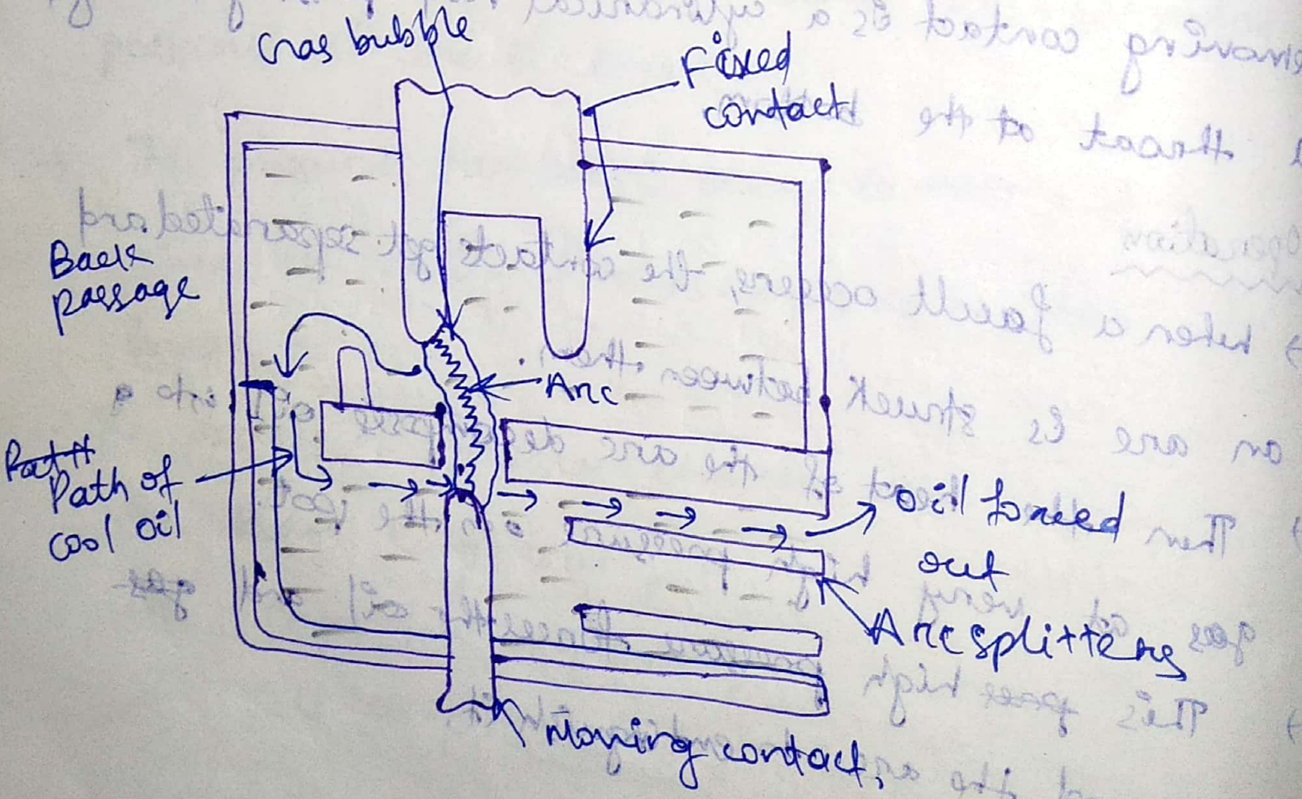
Limitation

① This ~~po~~type of pot cannot be used for very low or very high fault currents.

② With low fault currents, the pressure developed is small, thereby increasing the arcing time. Then with high fault currents, the gas is produced so so rapidly that explosion pot will burst due to high pressure.

Note Plain explosion pot operates well on moderate short-ckt. currents only where the rate of gas evolution is moderate.

ⓑ Cross jet explosion pot



→ The cross jet explosion pot is shown in the fig.

→ This ~~p~~ type of pot is a modification of plain explosion pot.

→ It is made of insulating material and has channels on one side which acts as arc splitters.

→ The arc splitters help in increasing the arc length, thus facilitating arc extinction.

→ Operation

→ When a fault occurs, the moving contact of the circuit breaker begins to separate.

→ As the moving contact is pulled down, the arc is initially struck both the contact.

→ The gas generated by the arc exert pressure on the oil in the back passage.

→ Then the arc is driven sideways into the arc splitters which increase the arc length, causing arc extinction.

Application

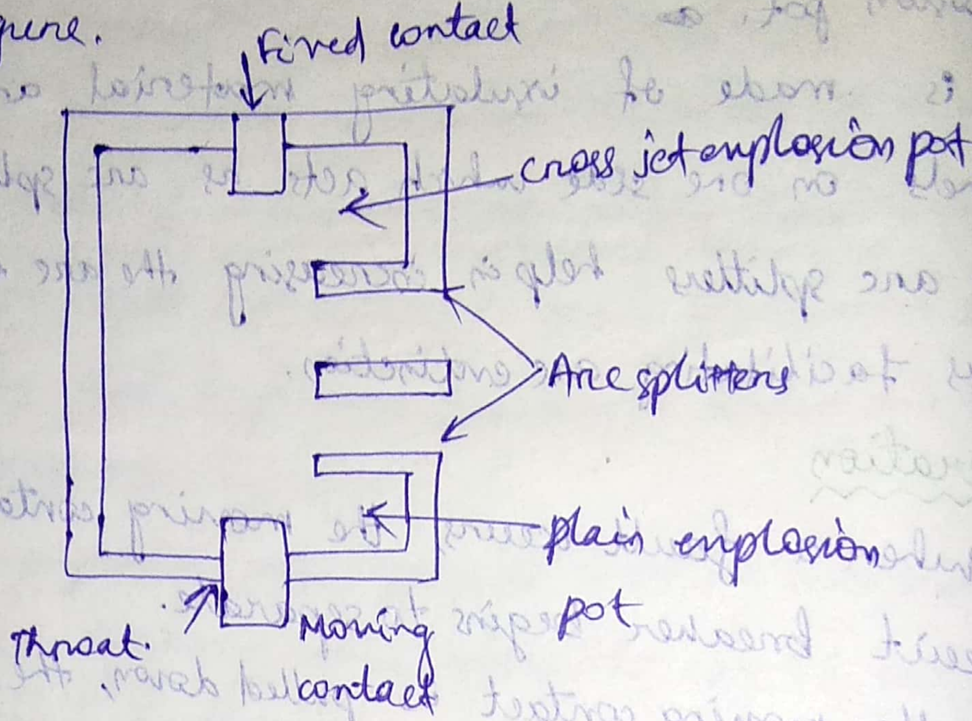
The cross-jet explosion pot is quite efficient for interrupting heavy fault currents.

Limitation

It cannot used for low fault current. Because, the gas pressure is small and the pot doesnot give a satisfactory operation.

© Self-compensated explosion pot

→ The self-compensated explosion pot is shown in the figure.



→ This pot is a combination of plain explosion pot and cross jet explosion pot. Therefore, it can interrupt ~~to~~ moderate as well as heavy short circuit currents. ~~which~~

→ It consists of two chambers, the upper chamber and lower chamber. The upper chamber is the cross-jet explosion pot with two arc splitters ~~darct~~ while the lower one is the plain ~~explion~~ explosion pot.

→ Operation

→ When the short-circuit current is heavy, the rate of generation of gas is very high and the device behaves as a cross-jet explosion pot.

→ The arc extinction takes place, when the moving contact opens the arc splitter duct.

→ However, on moderate SC-currents, the rate of gas generation is moderate and very little pressure leakage through the arc splitters and

→ when the moving contact comes out of the throat, the arc is extinguished by plain explosion pot action.

(11) Forced-blast oil circuit breakers

→ In forced blast oil circuit breaker, oil pressure is created by the piston-cylinder arrangement.

→ The movement of the piston is mechanically coupled to the moving contact.

Operation → When a fault occurs, the contacts get separated by the protective system and an arc is struck between the contacts.

→ The piston forces a stream of oil towards the contact gap to extinguish the arc.

Advantages

(a) Since oil pressure developed is independent of the fault current to be interrupted, the performance at low currents is more consistent than with self blast oil CB.

→ The quantity of oil required is reduced than self oil CB.

4.9 Low oil Circuit Breakers

Bulk oil CB performs 2 function

(1) It acts as an arc quenching medium

(2) It act as a insulator.

→ But it has been found that only a small % of oil is actually used for arc extinction.

→ Large amount of oil in bulk oil CB increases the expenses, tank size and weight of the breaker but it also increases the fire risk and maintenance problems. So low oil ckt. breaker is developed.

→ A low oil ckt breaker uses solid materials for insulation purpose and uses a small quantity of oil, which is just sufficient for arc extinction.

Construction

→ There are 2 compartments separated from each other but both filled with oil.

→ Upper chamber is ckt. breaker chamber,
lower " " " supporting chamber.

2 chamber are separated by partition (Division) & oil from one chamber is prevented from mixing with the other chamber.

This arrangement permits 2 advantages

① The MOCB chamber requires a small volume of oil which is just sufficient for arc extinction.

② The amount of oil to be replaced is reduced as the oil in the supporting chamber doesnot contaminated by the arc.

① Supporting chamber

→ It is a porcelain chamber mounted on a metal chamber. It is filled with oil which is physically separated from the oil in the circuit breaking compartment.

→ It is filled with oil for insulation purpose.

(ii) Circuit breaking chamber

It is a porcelain enclosure mounted on the top of the supporting compartment. It is filled with oil and has following parts.

ⓐ Upper & lower fixed contacts
ⓑ Moving contacts
ⓒ turbulator.

→ The moving contact is hollow and includes a cylinder which moves down over a fixed piston. (Vent-gate)

→ The turbulater is an arc control device and has both axial & radial vents.

→ The axial venting interrupts low currents & radial ventings interrupt heavy currents.

(11) Top chamber

→ It is a metal chamber and is mounted on the ckt-breaking chamber.

→ It provides expansion space for the oil in the circuit-breaking compartments.

* Operations

→ Under normal operating conditions, the moving contact remains closed with the upper fixed contact.

→ When a fault occurs, the moving contact is pulled down by the tripping arrangement ~~springs~~ and an arc is struck betn the contacts

→ The heat of the arc vapourises the oil & produces gases under high pressure.

→ This a high pressure forces the oil through turbulator to quench the arc.

Advantages

→ It requires less quantity of oil

→ It requires smaller space

→ There is reduced risk of fire

→ Maintenance problems are reduced.

Disadvantages

→ Due to smaller quantity of oil, the degree of carbonisation is increased.

→ Dielectric strength of the oil deteriorates rapidly due to high degree of carbonisation.

→ There is a difficulty of removing the gases from the contact space in time.

Anita

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4.10 Maintenance of oil circuit breaker

→ The maintenance of oil CB is generally concerned with the checking of contacts and dielectric strength of oil.

→ It is a good practice to inspect the CB at regular intervals of 3 or 6 months.

→ During inspection of the CB, the following points should be kept in view:

(i) Check the current carrying parts and arcing contacts. If the burning is severe, the contacts should be replaced.

(ii) Check the dielectric strength of the oil. If the oil is badly discoloured, it should be changed or reconditioned. The oil in good condition should withstand 30kV for one minute in a standard oil testing cup with 4mm gap betn electrodes.

(iii) Check the insulation for possible damage. Clean the ~~oil~~ surface and remove carbon deposits with a strong and dry fabric (cloth)

(iv) Check the oil level

(v) Check closing and tripping mechanism.

4.11 Air-Blast Circuit breaker & its classification

Air-blast Circuit Breakers

→ These breakers employ a high pressure air-blast as an arc quenching medium.

→ The contacts are opened in a flow of air-blast. ~~established by the opening of blast valve.~~

→ The air-blast ~~also~~ cools the arc and sweeps away the arcing products to the atmosphere.

→ This rapidly increases the dielectric strength of the medium between contacts and prevents from re-establishing the arc.

→ Then the arc is extinguished & flow of current is interrupted.

Advantages

→ Risk of fire is eliminated.

→ The arcing products are completely removed by the blast.

→ The growth of dielectric strength is so rapid that final contact gap needed for arc extinction is very small.

→ The arcing time is very small due to the rapid build up of dielectric strength betn contacts.

→ Due to lesser arc energy, air-blast CBs are very suitable where frequent ~~&~~ operation is required.

→ Disadvantages

→ The air has relatively low arc extinguishing properties.

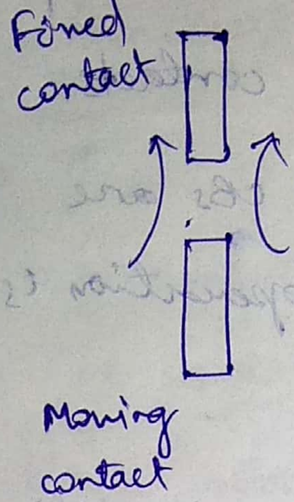
→ The air-blast CBs are very sensitive to the variation in the rate of rise of restriking voltage.

Types of Air-Blast Circuit Breakers

Depending upon the direction of ~~arc~~, air-blast in relation to the arc, air-blast CBs are classified into

1. Axial-blast type.
2. Cross-blast type
3. Radial-blast type.

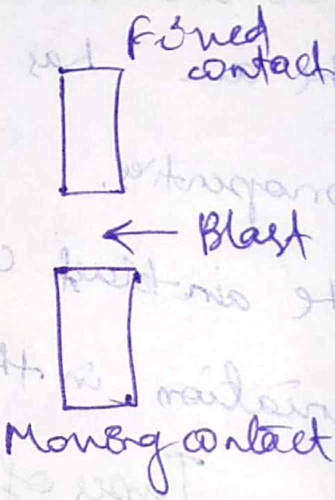
(i) Axial-blast type



Axial-blast type in which the air-blast is directed along the arc path as shown in the fig.

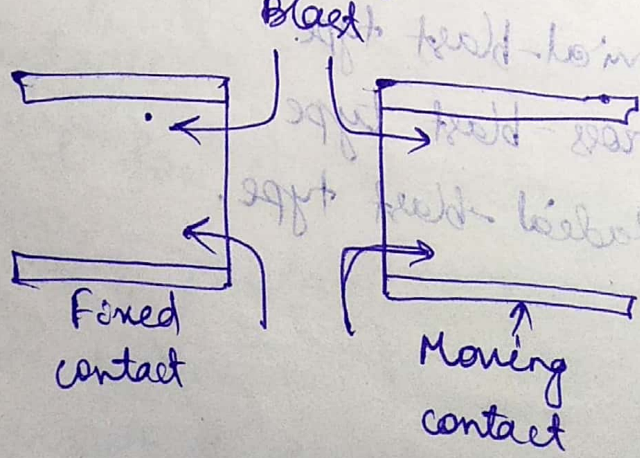
(ii) Cross-blast type

The air blast is directed at right angles to the arc path as shown in the fig.

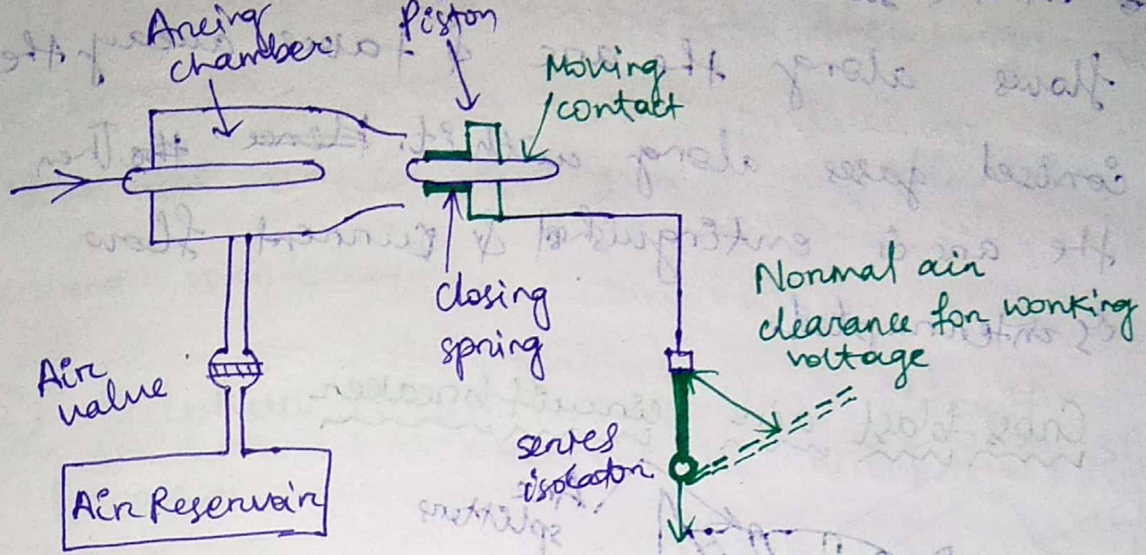


(iii) Radial blast type

The air blast is directed radially as shown in the figure.



① Axial ~~Air~~-blast air circuit breaker



→ The fixed and moving contacts are held in the closed position by spring pressure under normal conditions.

→ The air reservoir is connected to the arcing chamber through an air valve.

→ This valve remains closed under normal conditions but opens automatically by the tripping impulse when a fault occurs on the system.

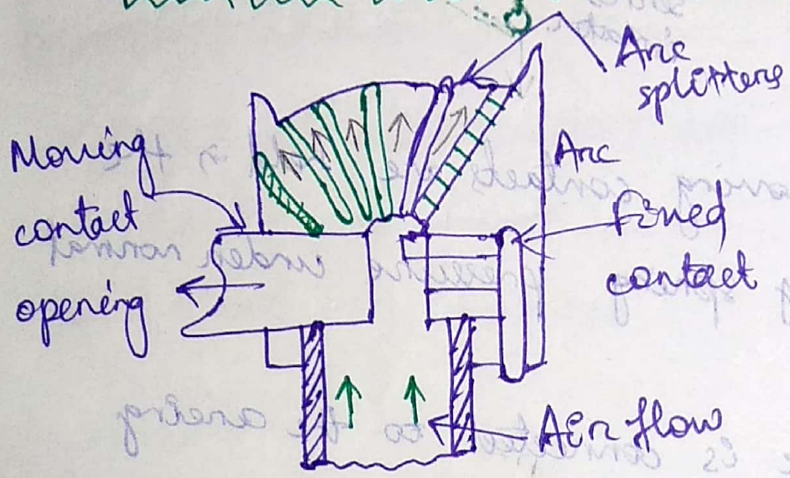
→ When a fault occurs, the tripping impulse causes opening of the air valve which connects the CB reservoir to the arcing chamber.

→ Then the high pressure air entering the arcing chamber pushes away the moving contact against spring pressure.

→ Now the moving contact is separated & arc is struck betn them.

→ At the same time high pressure air blast flows along the arc & takes away the ionised gases along with it. ~~Hence~~ ~~the~~ Then the arc is extinguished & current flow is interrupted.

(11) Cross-blast air circuit breaker



→ In this type of CB, an air-blast is directed at right angles to the arc.

→ The cross-blast lengthens and forces the arc into a suitable shield for arc extinction.

→ The typical cross blast air CB is shown in the fig.

→ Function

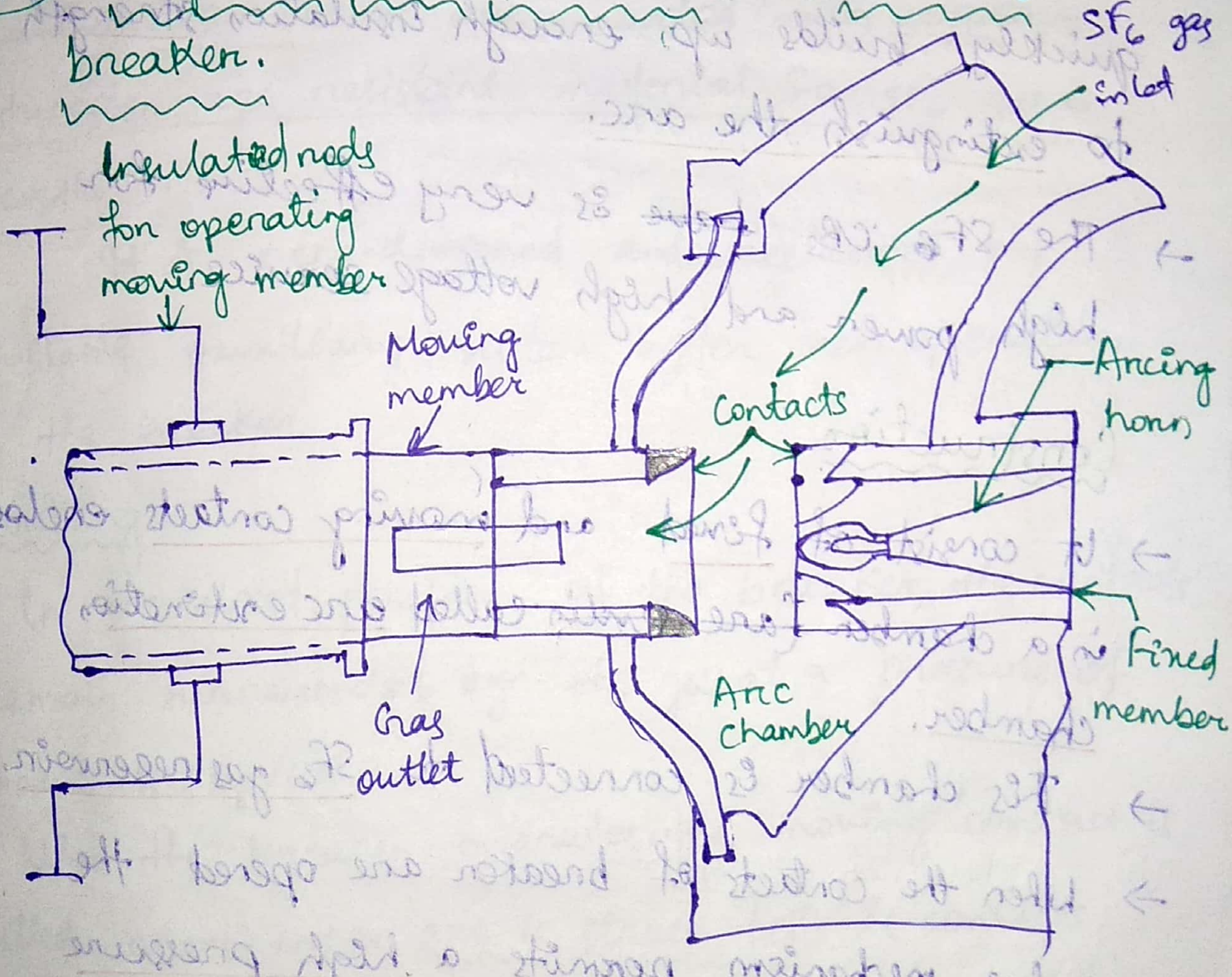
→ When the moving contact is withdrawn, an arc is struck betn the fixed and moving contacts.

→ The high pressure crossblast forces the arc into a shield consisting of arc splitters. ~~and baffles~~.

→ The splitters ~~serve~~ help to increase the length of the arc.

→ Then the arc is extinguished and flow of current is interrupted.

(4.12) Sulphur Hexa-fluoride (SF6) circuit breaker.



→ Sulphur hexafluoride (SF_6) gas is used as the arc quenching medium.

→ The SF_6 is an electro-negative gas & has a strong tendency to absorb free electrons.

→ The contacts of the breaker are opened in a high pressure flow of SF_6 gas and an arc is struck between them.

→ The conducting free electrons in the arc are rapidly captured by the gas to form relatively immobile negative ions.

This loss of conducting electrons in the arc quickly builds up enough insulation strength to extinguish the arc.

→ The SF_6 CBs ~~have~~ is very effective for high power and high voltage service.

Construction:

→ It consist of fixed and moving contacts enclosed in a chamber ~~(arc. ext.)~~ called arc extinction chamber.

→ This chamber is connected to SF_6 gas reservoir.

→ When the contacts of breaker are opened the valve mechanism permits a high pressure SF_6 gas from the reservoir to flow towards the arc interruption chamber.

→ The fixed contact is a hollow cylindrical current carrying contact fitted with an arc horn.

→ The moving contact is also a hollow cylinder with rectangular holes in the sides to permit the SF_6 gas to let out through these holes after flowing along ~~or~~ and across the arc.

→ The tips of fixed contact & moving contact and arcing horns are coated with copper-tungsten arc resistant material. So SF_6 gas is costly.

It is reconditioned and reclaimed by suitable auxiliary system after each operation of the breaker.

Working

→ In the closed position of the breaker, the contacts remain surrounded by SF_6 gas at a pressure of about 2.8 Kg/cm².

→ When the breaker operates, the moving contact is pulled apart and an arc is struck both the contacts.

→ The movement of the moving contact is synchronised with the opening of a valve which permits SF_6 gas at 14 Kg/cm² pressure from the reservoir to the arc interruption chamber.

→ The high pressure flow of SF_6 rapidly absorbs the free electrons in the arc path.

→ Then the medium between the contacts quickly builds up high dielectric strength and causes the extinction of the arc.

Advantages

→ The SF_6 CBs have many advantages over oil or air circuit breakers are.

(i) SF_6 CBs have very short arcing time.

(ii) It can interrupt much larger currents.

(iii) There is no moisture problem

(iv) There is no risk of fire in such breakers.

(v) Low maintenance cost, ~~Light fo~~

~~(vi)~~

Disadvantages

(i) SF_6 breakers are costly due to high cost of SF_6.

(ii) Additional equipment is required for reconditioned after every operation of breaker.

115kV to 230kV, power rating 10MVA to 20MVA.

4.13 Vacuum Circuit Breakers:

* In such breakers, vacuum is used as the arc quenching medium.

Principle

~~→ When the production of arc is~~

→ When the a/c contacts of the breaker are opened in vacuum (10^{-7} to 10^{-5} torr), an arc is produced between the contacts by the ionisation of metal vapours of contacts.

→ However, the arc is quickly extinguished because the metallic vapours, electrons and ions produced during arc rapidly condense on the surfaces of the circuit breaker contacts, resulting in quick recovery of dielectric strength.

Construction

→ It consists of fixed contact, moving contact & arc shield mounted inside a vacuum chamber.

→ The movable member is connected to the control mechanism by stainless steel bellows.

→ This enables the permanent sealing of the vacuum chamber so as to eliminate the possibility of leak.

→ A glass vessel or ceramic vessel is used as the outer insulating body.

→ The arc shield prevents the deterioration of the internal dielectric strength by preventing metallic vapours falling on the inside surface of the outer insulating cover.

Working

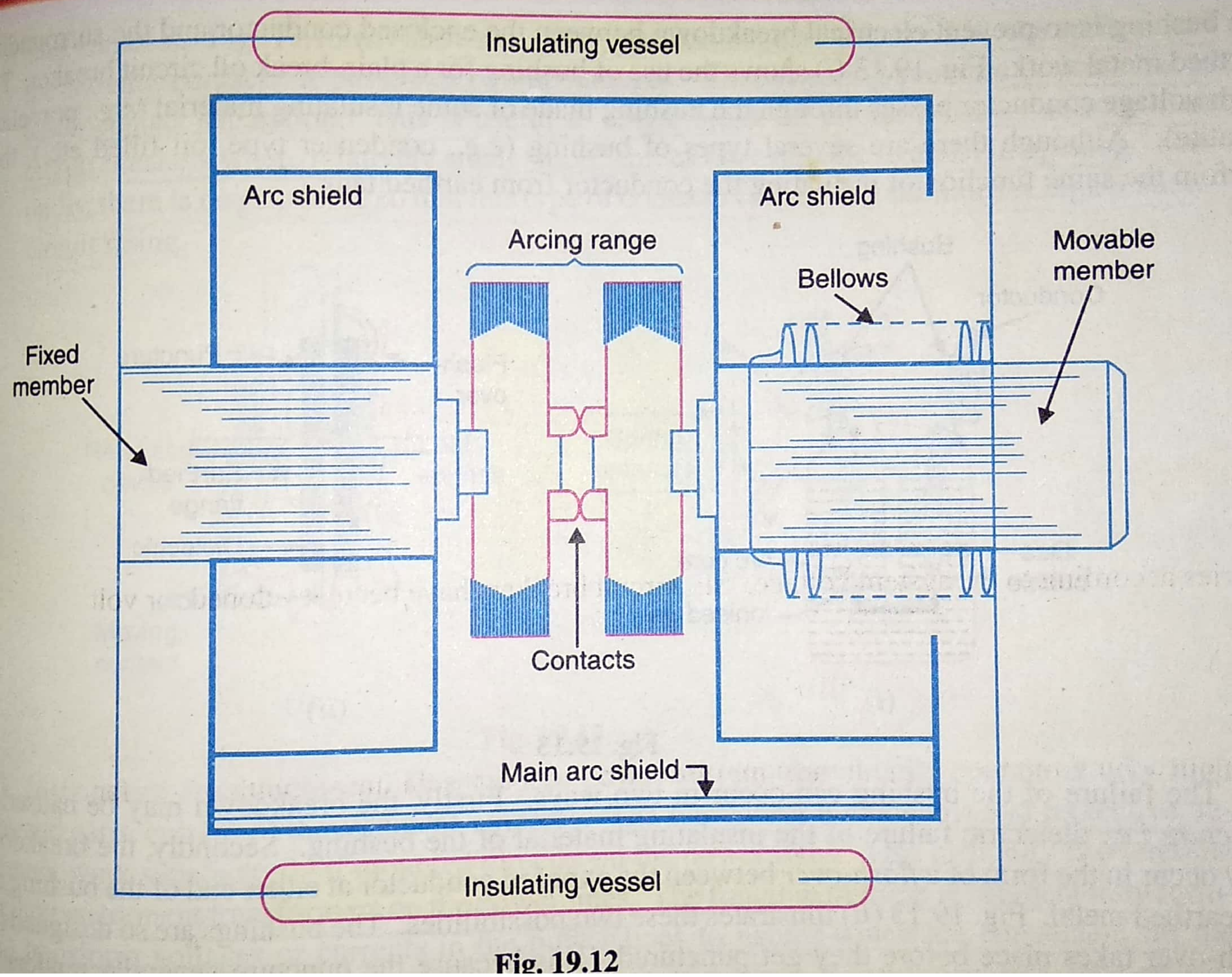
→ When the breaker operates, the moving contact separates from the fixed contact and an arc is struck between the contacts.

→ The production of arc is due to the ionisation of metal ions and depends upon the material of contacts.

→ The arc is quickly extinguished because the metallic vapours, electrons & ions produced during arc are diffused in a short time.

→ Vacuum has very fast rate of recovery of dielectric strength.

→ The arc extinction in a vacuum breaker occurs with a short contact separation (0.625 cm)



Insulating vessel
Arc shield
Arc shield
Arcing range
Movable
member
Bellows
Fixed
member
Contacts
Main arc shield
Insulating vessel

Fig. 19.12

Advantages

1. They are compact, reliable and ~~have~~ have longer life.
2. There are no fire hazards
3. There is no generation of gas during & after operation
4. They can interrupt any fault current
5. ~~It~~ they require little maintenance.

Application

→ NCBs are being employed for outdoor applications ranging from (22 kV to 66 kV) (60 to 100 MVA)

4.14 Switchgear Component

Some important components common to most of the circuit breakers are :-

1. Bushings
2. Circuit breaker contacts
3. Instrument transformers
4. Bus-bars and conductors

1. Bushings

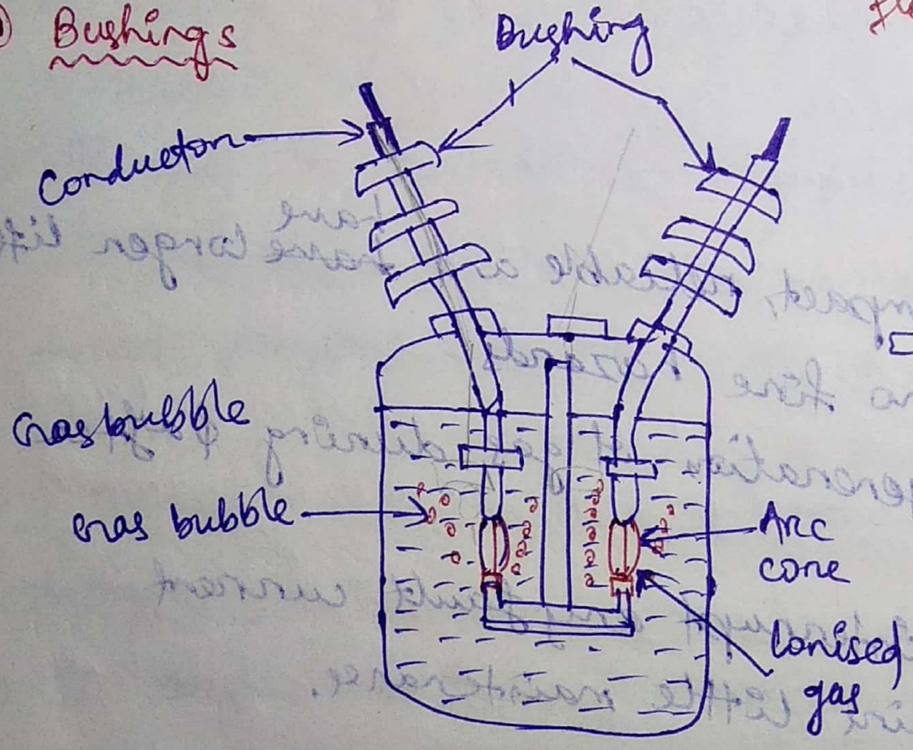


fig 1

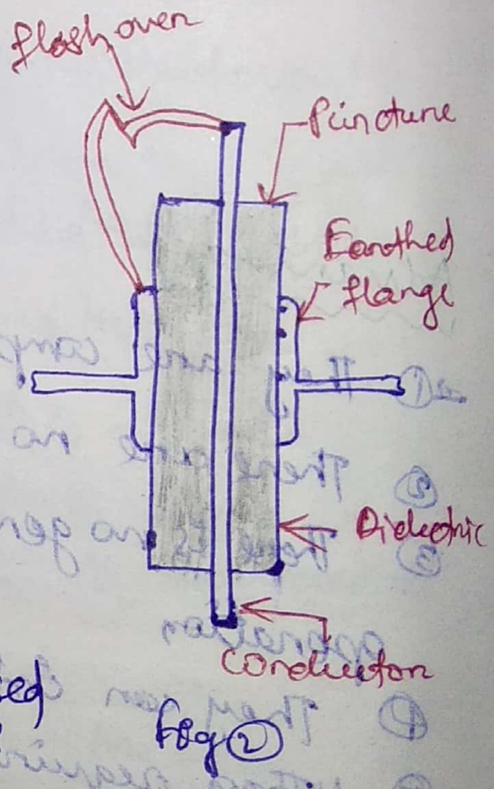


fig 2

→ When a high voltage conductor passes through a metal sheet ~~sub~~ which is at earth potential, the necessary insulation is provided in the form of bushing.

→ The primary function of bushing is to prevent electrical breakdown between the enclosed conductor and the surrounding earthed metal work.

→ High voltage conductor passes through the bushing made of some insulating material (porcelain).

→ Failure of the bushing can occur in 2 ways

① The breakdown may caused by puncture. (dielectric failure of the insulating materials)

② Breakdown may occur in the form of flash-over between the exposed conductor at either end of the bushing and the earthed material.

→ Fig ② shows these two possibilities.

② Circuit breaker contacts

The circuit breaker contacts are required to carry normal as well as short-circuit current. There are 3 types of CB contacts:

ⓐ Tulip type contact

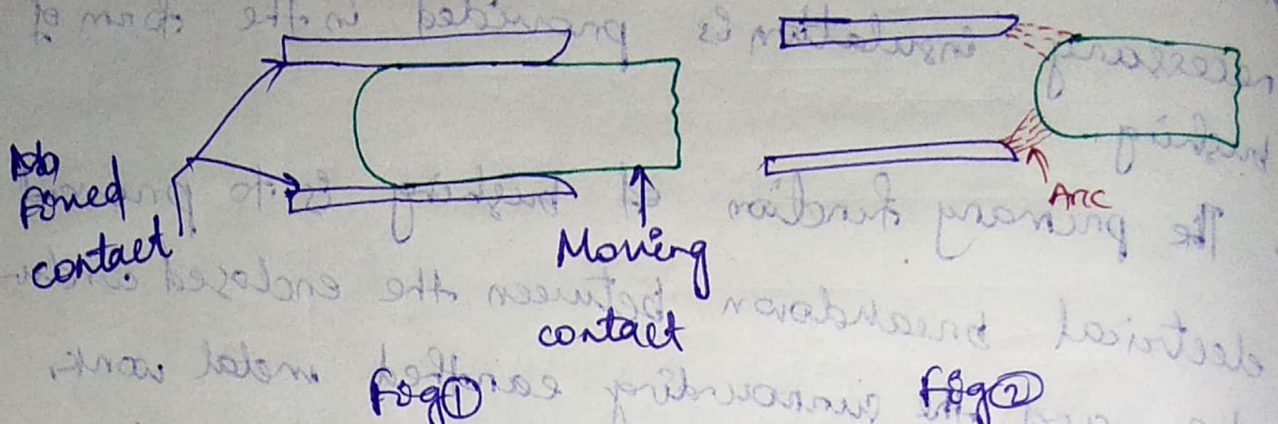
ⓑ Finger and wedge contacts

ⓒ Butt contacts.

Butt → hold

wedge →

→ ① Tulip type Contacts



→ fig① shows the tulip type contact.

→ It consists of moving contact which moves inside the fixed contacts.

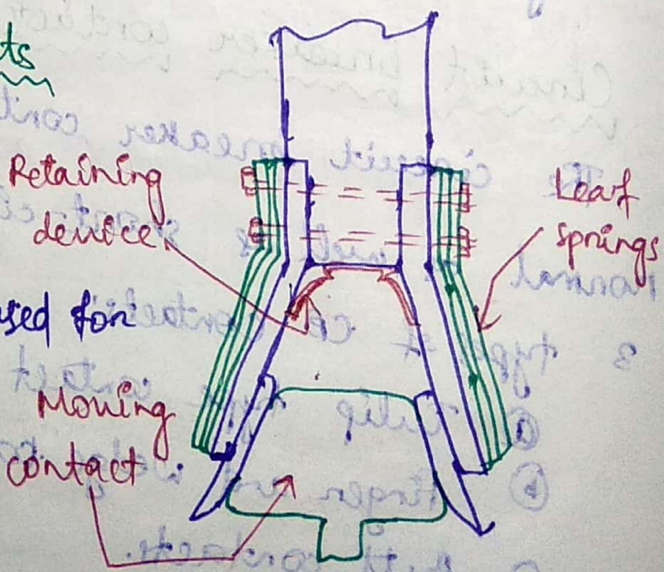
→ At contact separation, the arc is established betn the tips of fixed & moving contacts as shown in fig②.

→ The advantage of this type of contact is that arc is limited to the tip of the contact & not spread to whole portions of the contacts.

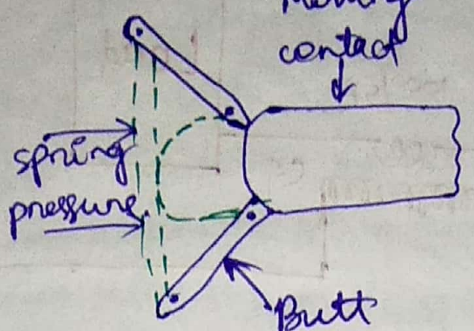
② Finger & Wedge contacts

→ Finger & wedge type contact is shown in the figure

→ This type of contact is largely used for low voltage oil CB.



(c) Butt contacts



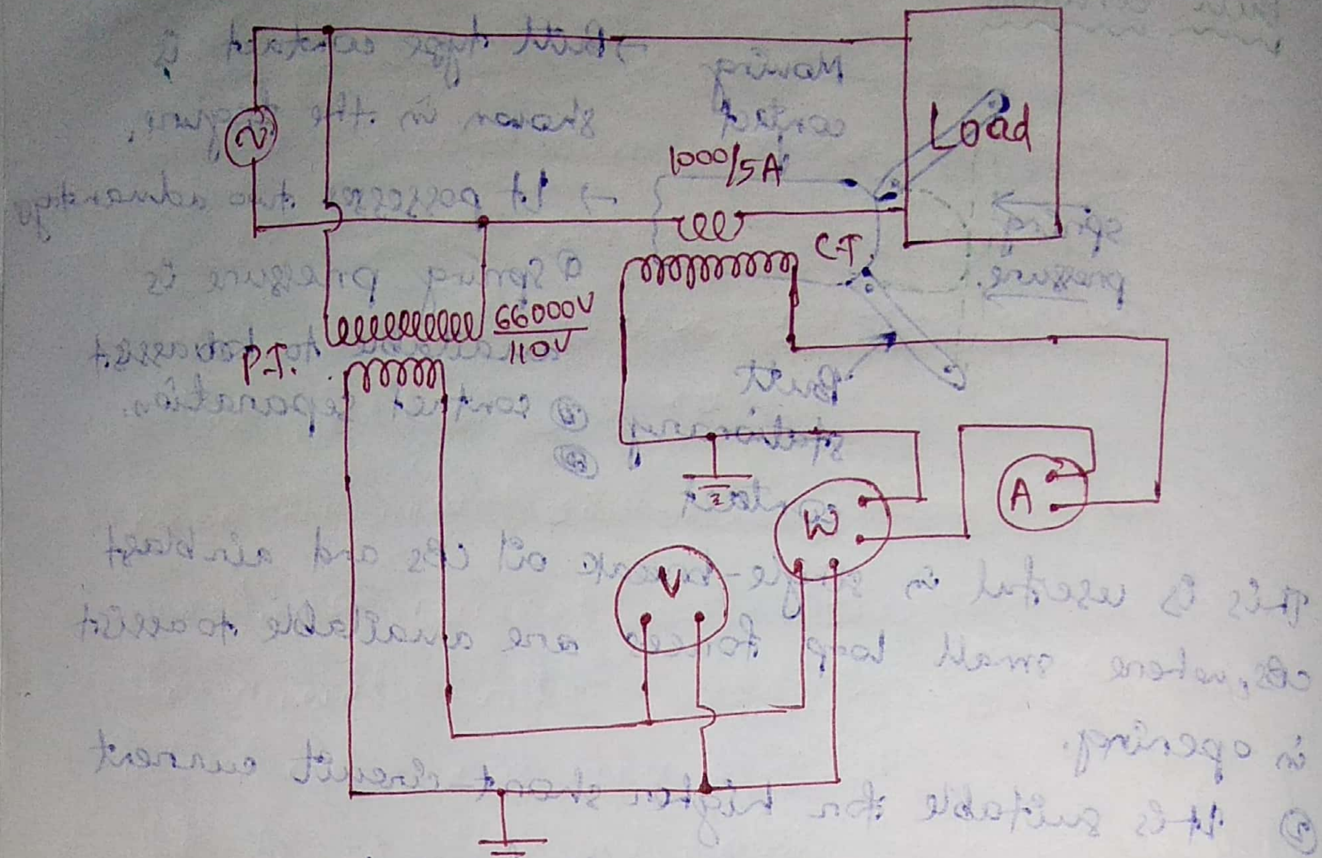
→ Butt type contact is shown in the figure.
→ It possesses two advantag
(i) spring pressure is available to assist
(ii) contact separation.
(iii)

This is useful in single-break oil CBs and air blast CBs, where small loop forces are available to assist in opening.

(2) It is suitable for higher short-circuit current rating because it has no grip force.

(iii) Instrument transformers

→ The measuring instruments and protective devices cannot work satisfactorily if connected directly on the power lines.
→ This difficulty is overcome by installing instrument transformers on the power lines.
→ The function of these instrument t/fs is to transform voltages or currents in the power lines to low voltage or current lines for the operation of measuring instruments & relays.
→ Instrument transformers are of 2 types.
(1) Current transformer (C.T.)
(2) Potential transformer (P.T)



→ The primary ~~& seco~~ of CT & PT are connected in the power Line.

→ The secondary of CT & PT provides low values of current & voltage (constant fraction) to be measured in ~~voltmeter~~ measuring instruments (Voltmeter, Ammeter & wattmeter).

→ The above fig. shows the use of instrument transformers.

	Primary	Secondary
C.T. ~~rating~~ :	1000A	5A
PT rating	66,000V	110V

→ The primary voltage of PT & primary current of CT can be found out by ~~applying~~ the ~~help~~ use of transformation ratio. But the secondary reading should require for calculation,

(IV) Bus-bars & conductors

→ The current carrying members in a CB consist of fixed and moving contacts and the conductors connecting these to the points external to the breaker.

→ If the switchgear is of outdoor type, these connections are connected directly to the overhead lines. In case of indoor switchgear, the incoming conductors to the CB are connected to the bus-bars.

4.15 Problems of Circuit Interruption

→ When a fault occurs, the energy stored in the system can be considerable. ~~Interr~~ Then Interruption of fault current by a circuit breaker ~~and~~ will result in most of the stored energy dissipated within the CB.

→ Therefore, the CB must be designed to dissipate as much of the stored energy as possible.

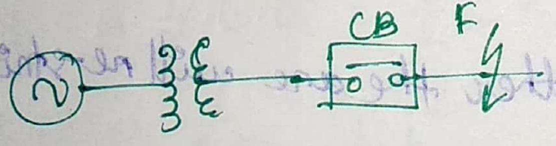


Fig ①

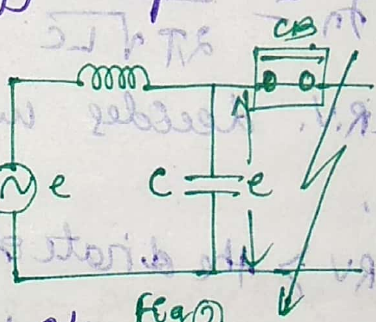


Fig ②

→ Fig ① shows a short-circuit occurring on the transmission line.

→ Fig ② shows the equivalent ckt, where L & C are the per phase inductance & capacitance of the system.

→ The resistance of the system is neglected as it is small.

① Rate of rise of re-striking voltage.

→ It is denoted by/abbreviated by R.R.R.V.

→ It is the rate of increase of re-striking voltage. Usually the voltage is in KV & time in microseconds so that R.R.R.V. is in KV/μsec.

→ When the contacts are opened and the arc is formed, when current reaches zero at π radian, the generator voltage suddenly applied to the inductance & capacitance in series.

→ This L-C combination forms an oscillatory circuit and produces a transient of frequency.

$$f_n = \frac{1}{2\pi\sqrt{LC}}$$

→ The R.R.R.V. decides whether the arc will re-strike or not.

If RRRV > the rate of rise of dielectric strength between the contacts, the arc will re-strike.

If RRRV < rate of rise of dielectric strength, then the arc will fail to re-strike.

→ The value of RRRV depends upon:

ⓐ Recovery voltage

ⓑ natural frequency of oscillations.

→ For a sc occurring near the power station bus-bars, C being small, the f_n will be high, Hence, RRRV will attain a large value.

(ii) Current Chopping:-

→ It is the phenomenon of current interruption before the natural current zero is reached.

→ Current chopping mainly occurs in air-blast CBs. Because they retain the same extinguishing power irrespective of the magnitude of the current to be interrupted.

→ As the chop occurs at current i, therefore, the energy stored in inductance is $\frac{1}{2}Li^2$. This energy will be transferred to the capacitance C.

$$\cancel{\tfrac{1}{2}} L i^2 = \cancel{\tfrac{1}{2}} C e^2$$

$$e^2 = \frac{L i^2}{C}$$

$$e = i\sqrt{\frac{L}{C}} \text{ volts} = \text{prospective voltage}$$

Ex:- If L & C are 4 mH & 0.001 μF. A current chop of magnitude 50A. would induce a voltage of

$$e = i\sqrt{\frac{L}{C}} = 50\sqrt{\frac{4\times10^{-3}}{0.001\times10^{-6}}}$$

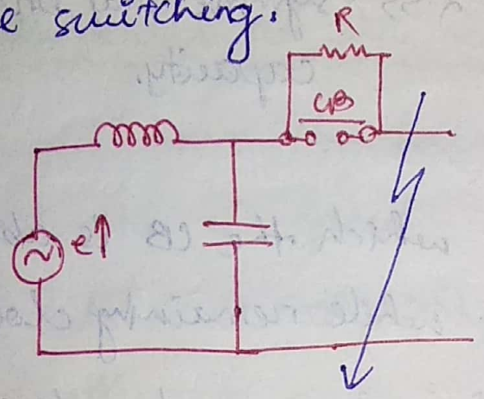
$$= 100\times10^{3} \text{ Volts} = 100 \text{ kV}.$$

* Excessive voltage surges due to current chopping are prevented by shunting the contacts of the breaker with a resistor (Resistance switching)

4.16 Resistance Switching

→ The current chopping, capacitive current breaking etc give rise to severe voltage oscillations.

→ These ~~excessive~~ voltage surges during circuit interruption can be prevented by the use of shunt resistance R connected across the circuit breaker contacts as shown in the fig (a). This is known as resistance switching.



→ The shunt resistor also helps in limiting the oscillatory growth of re-striking voltage.

→ The shunt resistor reduce the voltage surges due to current chopping and capacitive current breaking.

4.17 Circuit Breaker Rating

→ The CBs have three ratings

1. Breaking capacity
2. making capacity
3. short-time capacity.

1. Breaking capacity

It is the rms ~~cur~~ value of current that a CB is capable of breaking at given recovery voltage and RRR voltage.

→ If I is the rated breaking current in amperes and V is the rated service line voltage in volts, then

$$\text{Breaking capacity} = \sqrt{3} \times V \times I \times 10^{-6} \text{ MVA}$$

(ii) Making capacity

The peak value of current during the 1st cycle of current wave after the closure of CB is known as making capacity.

Making capacity = 2.55 × symmetrical breaking capacity.

(iii) Short-time rating

→ It is the period for which the CB is able to carry fault current while remaining closed.

→ The short time rating of a CB depends upon its ability to withstand

(a) the electromagnetic force effects

(b) temperature rise.

chapter-05 Protective Relays

(5.1) Definition of Protective Relays

→ A protective relay is a device that detects the fault and initiates the operation of the circuit breaker to isolate the defective element from the rest of the system.

(5.2) Fundamental requirement of protective relay.

It should have the following qualities:

① selectivity ② speed ③ sensitivity

④ reliability ⑤ simplicity ⑥ economy

① Selectivity

It is the ability of the protective system to select correctly that part of the system in trouble and disconnect the faulty part without disturbing the rest of the system.

② Speed

The relay system should disconnect the faulty section as fast as possible for the following reasons.

① Electrical apparatus may be damaged if they are made to carry the fault currents for a long time.

②

(ii) A failure in the system leads to a great reduction in the system voltage. If the faulty section is not disconnected quickly, then the low voltage created by the fault may shut down consumer's motors and generators on the system may become unstable.

(iii) The high speed relay system decreases the possibility of development of one type of fault into the other more severe type.

③ **Sensitivity**

It is the ability of the relay system to operate with low value of actuating quantity.

Ex:- A 1VA relay is more sensitive than a 3VA relay.

④ **Reliability**

→ It is the ability of the relay system to operate under the pre-determined conditions.

→ Without reliability, the protection would be ineffective.

⑤ **Simplicity**

→ The relaying system should be simple so that it can be easily maintained.

→ The simpler the protection scheme, the greater will be its reliability.

⑥ Economy

. The protective system should ~~to~~ not cost more than 5% of total cost. So the most importante factor is the choice of a particular protection system is the economic aspects.

(5.3) Basic Relay operation

→ Most of the relays in service on electric power system today are of electro-mechanical type.

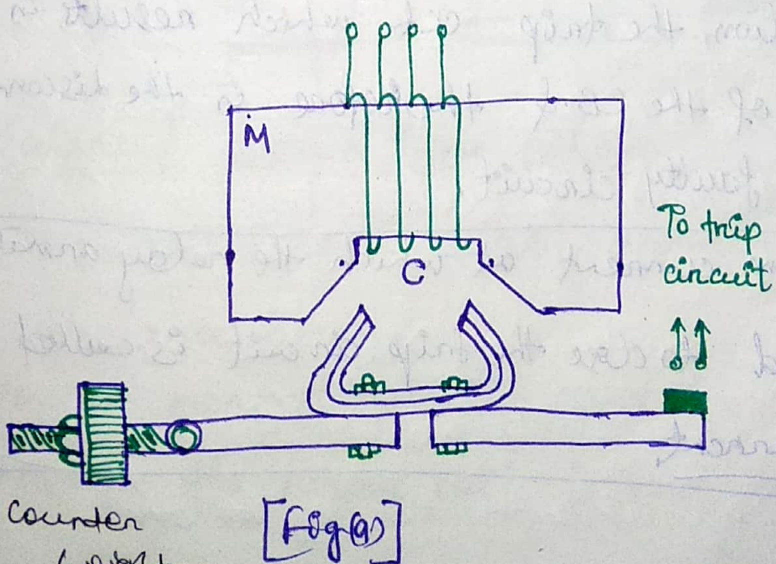
→ They work on the following operating principles:

① Electromagnetic attraction

② Electromagnetic induction.

(a) Electromagnetic Attraction type

① Attracted armature type relay



[Fig (a)]

→ Fig (a) shows the schematic arrangement of an attracted armature type relay.

→ It consists of a laminated electromagnet M carrying a coil C and a pivoted laminated armature.

→ The armature is balanced by a counterweight and carries a pair of spring contact fingers at its free end.

Operation

→ Under normal operating conditions, the current through the relay coil C is ~~so~~ such that counterweight holds the armature in the initial position.

→ When a short-circuit occurs, the current through the relay coil increases sufficiently and the relay armature bridge a pair of stationary contacts attached to the relay.

→ This completion the trip ckt. which results in the opening of the CB. & therefore in the disconnection of the faulty circuit.

→ The minimum current at which the relay armature is attracted to close the trip circuit is called pickup current.

(ii) Solenoid type relay

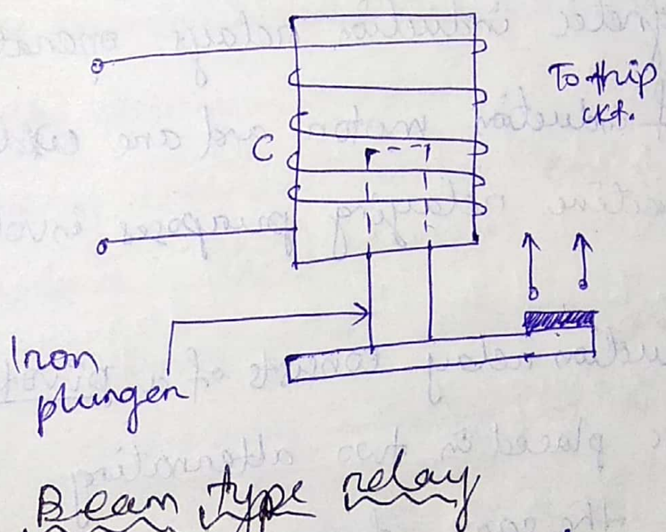
→ It consists of a solenoid and movable iron plunger arranged with trip circuit.

→ Under normal operating conditions, the current through the relay coil 'C' is such that it holds the plunger by spring in the initial position.

Operation

→ On the occurrance of a fault, the current through the relay coil becomes more than the pick-up value, then the plunger to be attracted to the solenoid.

→ The upward movement of the plunger closes the trip circuit, thus opening the CB & disconnecting the faulty circuit.



(iii) Balanced Beam type relay

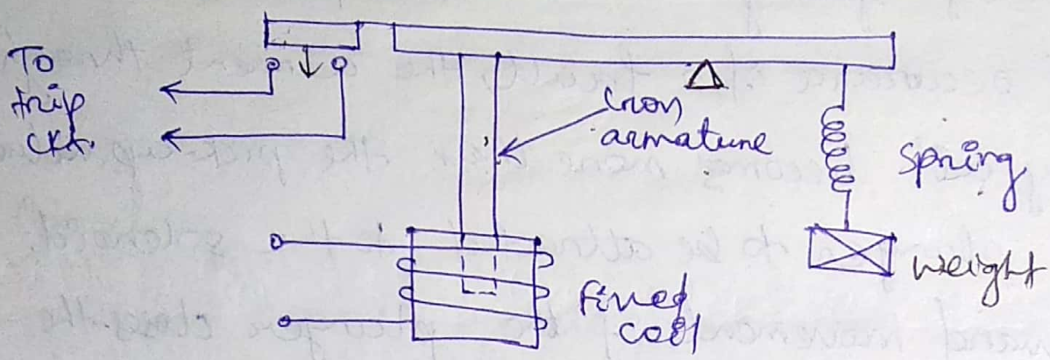
→ It consisted of an iron armature connected to a balance beam.

→ Under normal operating conditions, the current through the relay coil is such that the beam is held in the horizontal position by the spring.

Operation

→ When a fault occurs, the current through the relay coil becomes greater than the pickup value and beam is attracted to close the trip ckt.

→ This causes the opening of the CB to isolate the faulty ~~ckt~~. circuit.



(11) Induction Relays

→ Electromagnetic induction relays operate on the principle of induction motor and are widely used for protective relaying purposes involving ac quantities.

→ An induction relay consists of a pivoted aluminium disc placed in two alternating magnetic fields of the same frequency but displaced in time & space.

→ The torque is produced in the disc by the interaction of one of the magnetic fields with the currents induced in the disc by the other,

→ Three types of structures are commonly used for the operating torque in induction relays.

① shaded pole structure

② watthour-meter or double winding structure

③ induction cup structure.

* Watt Hour-meter structure

→ It is used in watthour meters.

→ It consists of a pivoted aluminium disc arranged to rotate freely between the poles of two electromagnets.

→ The upper electromagnets carries two windings; the primary and the secondary

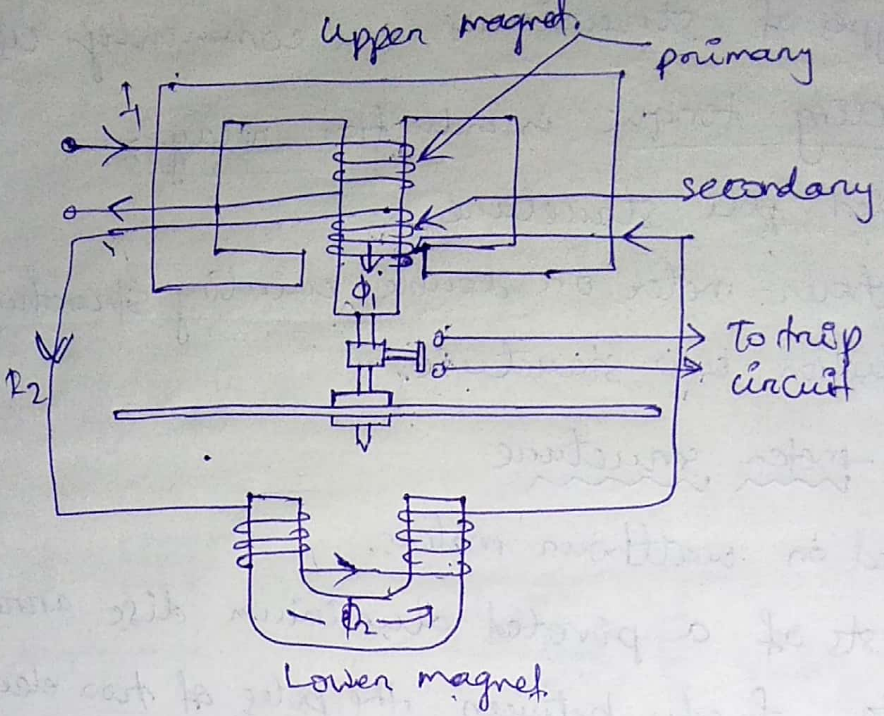
→ The primary winding carries the relay current I_1 while the secondary winding is connected to the winding of the ~~lo~~ lower magnet.

→ The primary current induces emf in the secondary and circulates a current I_2 in it.

→ The flux ϕ_2 induced in the lower magnet by the current in the secondary winding of the ~~cup~~ upper magnet will lag behind ϕ_1 by an angle α.

→ The two fluxes ϕ_1 & ϕ_2 differs in phase by α will produce a driving torque on the disc proportional to $\phi_1\phi_2 \sin\alpha$.

$$\boxed{T \propto \phi_1\phi_2 \sin\alpha.}$$



5.4 Definition of following important terms

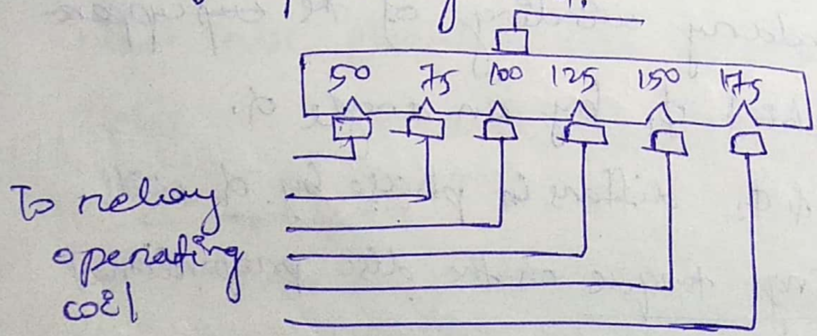
(a) **Pick-up current :-**

It is the minimum current in the relay coil at which the relay starts to operate.

(b) **Current setting**

→ The adjustment of pickup current to any required value is called current setting.

→ This is achieved by the use of tappings on the relay operating coil.



(c) Plug setting multiplier (P.S.M).

It is the ratio of fault current in relay coil to the pick-up current.

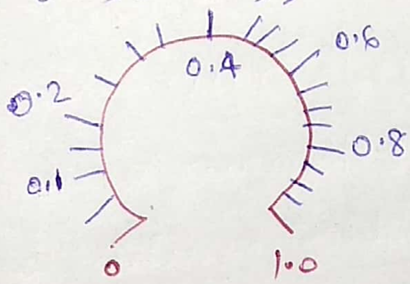
$$P.S.M = \frac{\text{fault current in relay coil}}{\text{pick-up current}}$$

Pickup current = Rated secondary current of C.T. × current setting.

(d) Time-setting multiplier

→ A relay is generally provided with control to adjust the time of operation. This adjustment is known as time-setting multiplier.

→ The time setting dial is calibrated from 0 to 1 in steps of 0.05 sec. as shown in the fig.



→ If time setting is 0.1 & time obtained from the time/P.S.M curve is 3 seconds,

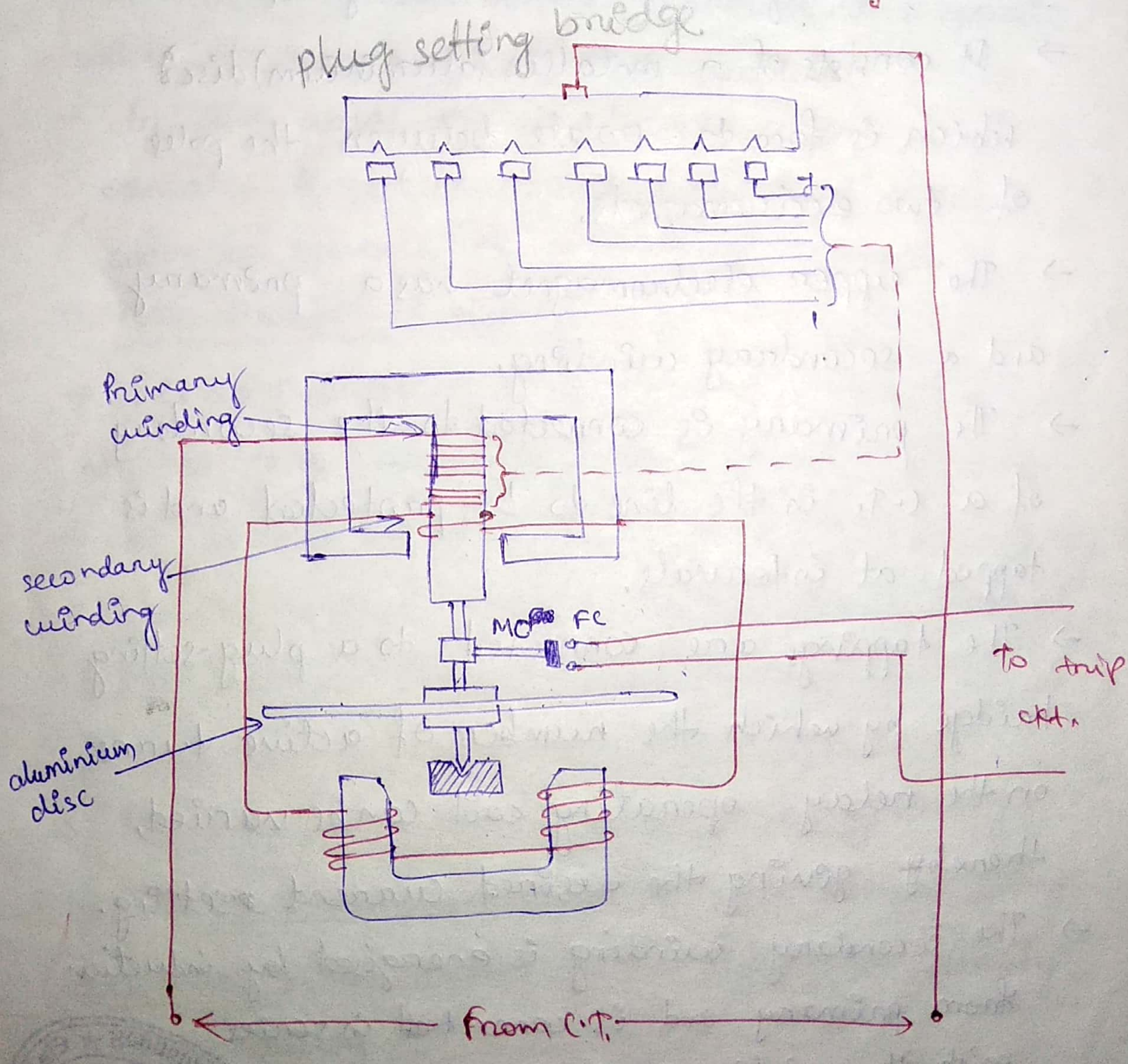
Actual relay operating time is $= 3 \times 0.1 = 0.3$ second.

5.6 Classification of functional Relays

→ There are several types of special function relays, the important types of relays are

1. Induction type overcurrent relays
2. Induction type power relays
3. Distance relays
4. Differential relays
5. Translay scheme.

5.7 Induction type over current relay (Non-directional)



→ A relay which recognises over current in a circuit and initiates corrective measures could be termed as an overcurrent relay.

→ These relays are used on A.C. circuits only & can operate for fault current flow in either direction.

Construction

→ The typical non-directional induction type over-current relay is shown in the figure.

→ It consists of a metallic (aluminium) disc which is free to rotate between the poles of two electromagnets.

→ The upper electromagnet has a primary and a secondary winding.

→ The primary is connected to the secondary of a C.T. in the line to be protected and is tapped at intervals.

→ The tappings are connected to a plug-setting bridge by which the number of active turns on the relay operating coil can be varied, thereby giving the desired current setting.

→ The secondary winding is energised by induction from primary and is connected in series with the winding on the lower magnet.

→ The controlling torque is provided by a spiral spring.

→ The spindle of the disc carries a moving contact which bridges two fixed contacts (connected to trip circuit) when the disc rotates through a pre-set angle.

→ This angle can be adjusted to any value between 0° to 360°.

→ By adjusting this angle, the travel of the moving contact can be adjusted and hence the relay can be given any desired time setting.

Operation

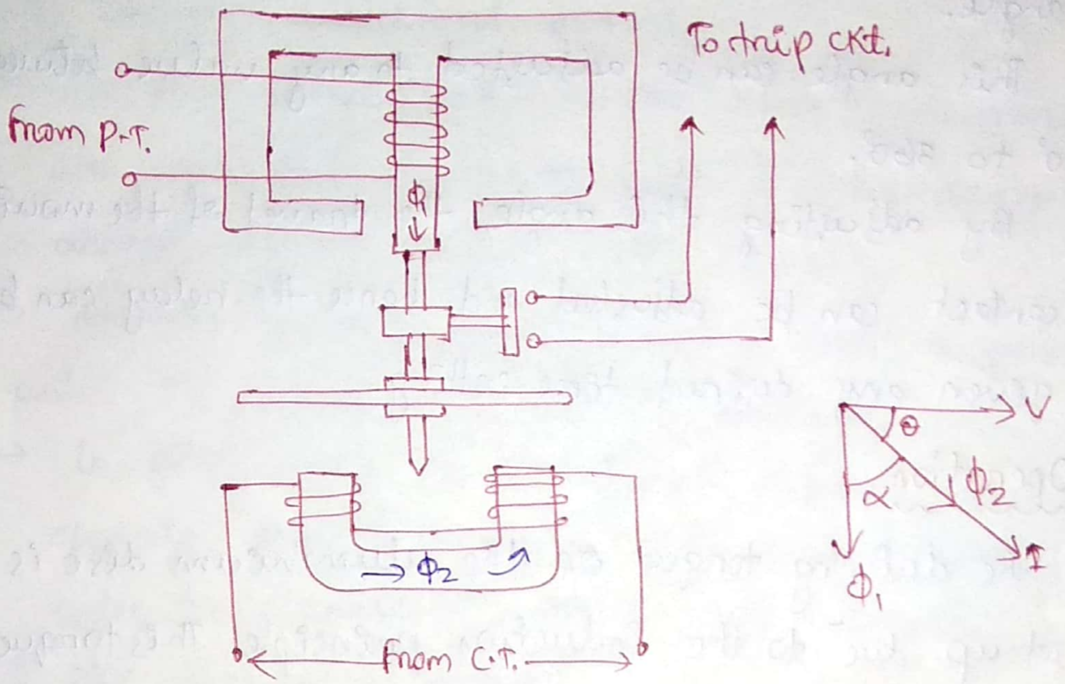
→ The driving torque on the aluminium disc is set up due to the induction principle. This torque is opposed by the ~~restrai~~ restraining torque provided by the spring.

→ Under normal operating conditions, restraining torque is greater than the driving torque produced by the relay coil current. Therefore the aluminium disc remains stationary.

→ When fault occurs, the current in the protected circuit exceeds the pre-set value, the driving torque becomes greater than the restraining torque.

→ Then aluminium disc rotates and the moving contact bridges the fixed contacts when the disc has rotated through a pre-set angle. Then the trip circuit operates the circuit breaker which isolates the faulty section.

5.8 Induction type directional power relay



→ It operates when power in the circuit flows in a specific direction.

Construction

→ The above figure shows the parts of a typical induction type directional power relay.

→ It consists of an aluminium disc is free to rotate in between the poles of two electromagnets.

→ The upper electromagnet carries a winding is called potential coil on the central limb which is connected through a potential transformer (P.T.) to the ~~the~~ circuit voltage source.

→ The lower electromagnet has a separate winding (called current coil) connected to the secondary of C.T. in the line to be protected.

→ The current coil is provided with a number of tappings connected to the plug-setting bridge.

→ This permits to have any desired current setting.

→ The restraining torque is provided by a spiral spring.

Operation

→ The flux ϕ_1 due to current in the potential coil will be nearly 90° lagging behind the applied voltage V,

→ The flux ϕ_2 due to current coil will be nearly in phase with the operating current I.

→ The interaction of fluxes ϕ_1 & ϕ_2 with the eddy currents induced in the disc produces a driving torque ~~as~~ is:

$$T \propto \phi_1 \phi_2 \sin\alpha$$

$$\phi_1 \propto V, \quad \phi_2 \propto I$$

$$\alpha = 90 - \theta$$

$$T \propto VI \sin(90-\theta)$$

$$\propto VI\cos\theta$$

$\propto$ power in the circuit.

→ Therefore, the direction of driving torque on the disc depends upon the direction of power flow in the circuit to which the relay is associated.

→ When the power in the circuit flows in the normal direction, the driving torque and the restraining torque help each other to run away the moving contact from the fixed contacts.

→ The reversal of current in the circuit reverses the direction of driving torque on the disc.

→ When the reversed driving torque is large enough, the disc rotates in the reverse direction and the moving contact closes the trip circuit. Then the circuit breaker operates and disconnects the faulty section.

5.9 Induction type directional overcurrent Relay

Construction

→ It consists of 2 relay elements mounted on a common case:-

1. directional element
2. Non-directional element

1. Directional element

→ It is a directional power relay which operates when power flows in a specific direction.

→ The potential coil of the element is connected through a potential transformer (P.T.) to the system voltage.

→ The current coil of the element is energised through a C.T. by the circuit ~~breaker~~ current.

→ This winding is carried over the upper magnet of the non-directional element.

→ The trip contacts (1 & 2) of the directional element are connected in series with the secondary circuit of the overcurrent element.

→ Therefore, the later element cannot start to operate until its secondary circuit is completed.

→ In other words, the directional element must operate first (i.e., contacts 1 & 2 should close) in order to operate the overcurrent element.

② Non-directional element

→ It is an overcurrent element similar in all respects to a non-directional over-current relay.

→ The spindle of the disc of this element carries a moving contact which closes the fixed contact (trip circuit contact) after the operation of directional element.

→ It may be noted that plug setting bridge is also provided in the relay for current setting but has been omitted in the figure for clarity and simplicity.

→ The tappings are provided on the upper magnet of overcurrent element and are connected to the bridge.

Operation

→ Under normal operating conditions, power flows in the normal direction in the circuit protected by the relay.

→ Therefore, directional power relay (upper element) doesnot operate, thereby keeping the overcurrent element (lower element) unenergised.

→ When a short circuit occurs, there is a tendency for the current or power to flows in the reverse direction.

→ ~~When the~~ Then the disc of the upper magnet rotates to bridge the fixed contacts 1 & 2.

→ This completes the circuit for overcurrent element

→ The disc of this element rotates and the moving contact attached to it closes the trip circuit.

→ This operates the circuit breaker which isolates the faulty section.

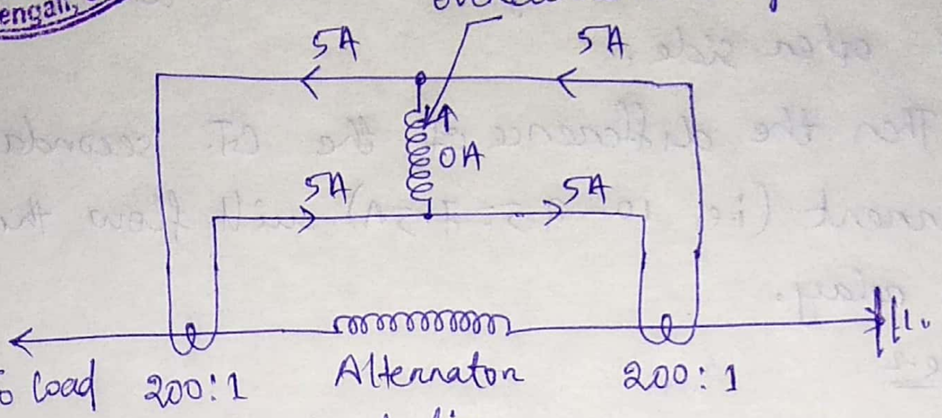
5.10 Differential Relay

A differential relay is one that operates when the phasor difference of two or more similar electrical quantities exceeds a pre-determined value.

There are two fundamental systems of differential or balanced protection.

1. Current differential relay
2. Voltage balance differential

(a) Current Differential Relay



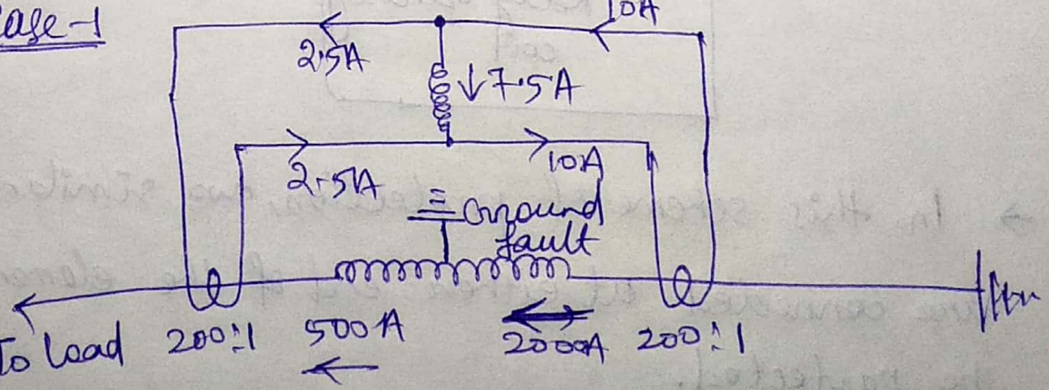
→ Overcurrent relay operates as a differential relay.

→ During normal operating condition; there is no fault currents in the two C.T.s secondaries are equal & relay operating coil therefore does not carry any current.

→ During fault conditions, there will be a differential current flows through the differential relay operating coil.

→ If this current exceeds the pick-up value, the relay will operate.

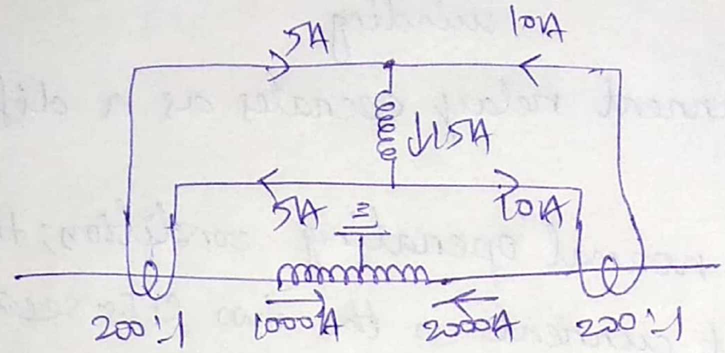
→ Case-1



→ If some current 500A flows out of one side while a larger current 2000A enters the other side.

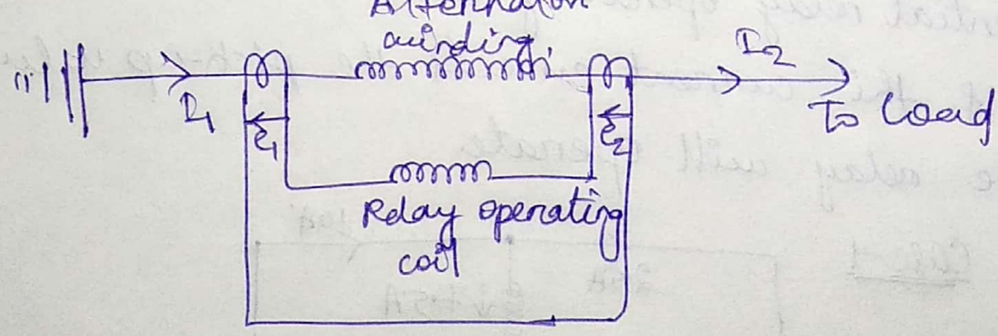
→ Then the difference of the C.T. secondary current (i.e. 10 − 2.5 = 7.5A) will flow through the relay.

Case-2



→ If current flows to the fault from both sides, then sum of C.T. secondary currents (i.e. 10 + 5 = 15A) will flow through the relay.

ⓑ Voltage Balance Differential Relay



→ In this scheme of protection, two similar CTs are connected at either end of the element to be protected.

→ The secondaries of CTs are connected in series with a relay in such a way that under normal conditions, their induced emfs are in opposition.

→ Under healthy conditions, equal currents ($I_1 = I_2$) flows in both primary windings.

→ Therefore, the secondary voltages of the two CTs are balanced against each other and no current will flow through the relay operating coil.

→ When a fault occurs in the protected zone, the currents in the two primaries will differ from one another ($I_1 \neq I_2$) and their secondary voltages will no longer be in balance.

→ This voltage difference will cause a current to flow through the operating coil of the relay which closes the trip circuit.

5.11 Types of protection

→ When a fault occurs on any part of electric power system, it must be cleared quickly in order to avoid damage with the rest of the system.

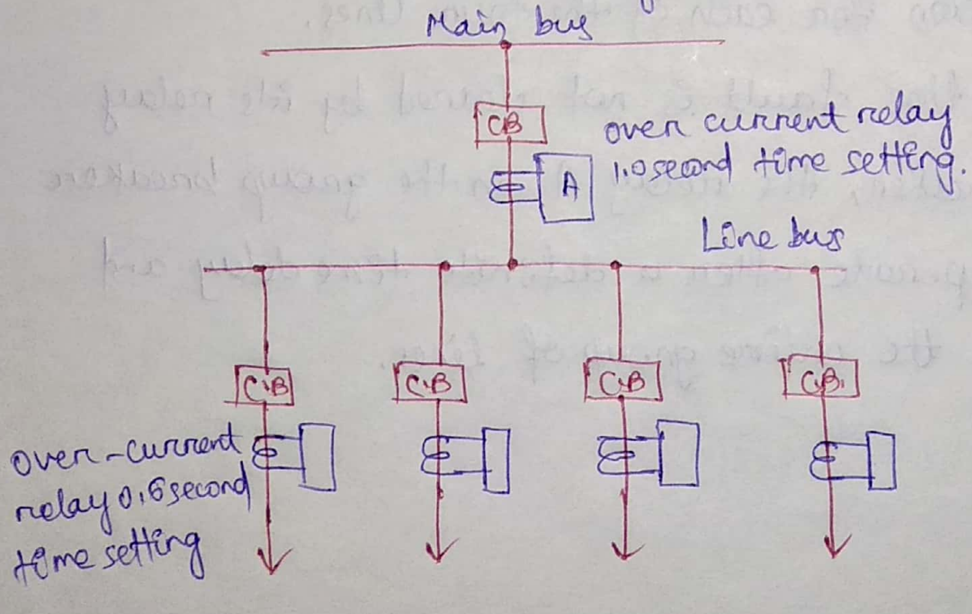
→ The protection scheme is divided into 2 classes

1. Primary protection
2. Back-up Protection.

① Primary Protection

→ It is designed to protect the component parts of the power system.

→ Each line has an overcurrent relay that protects the line as shown in the fig.



→ If a fault occurs on any line, it will be cleared by its relay & circuit breaker.

→ This forms the primary protection

→ Sometimes faults are not cleared by primary relay system because of trouble within the relay, wiring system. or breaker.

→ Under such conditions, back-up protection performs the required job.

(ii) Back-up Protection

→ It is the second line of defence in case of failure of the primary protection.

→ It is designed to operate with sufficient time delay, so that the primary relaying will have enough time to operate, if possible.

→ In the above figure, relay A provides back-up protection for each of the four lines.

→ If a line fault is not cleared by its relay and breaker, the relay A on the group breaker will operate after a definite time delay and clear the entire group of lines.

Chapter-06

Protection of Electrical Power Equipments & Lines

(6.1) Protection of Alternators

The generating unit, especially the larger ones, are relatively few in number and higher in individual cost than most other equipments. Therefore, it is necessary to provide protection to cover the wide range of faults which may occur in the modern generating plant.

Some of the important faults which may occur on an alternator are:

① Failure of prime-mover.

→ When input to the prime-mover fails, the alternator runs as a synchronous motor and draws some current from the supply system. This motoring conditions is known as "inverted running".

(a)→ In case of turbo-alternator sets, failure of steam supply may cause inverted running.

→ If the steam supply is gradually restored, the alternator will pick-up load without disturbing the system.

→ If the steam failure is likely to be prolonged, the machine can be safely isolated by the control room attendant since this condition is relatively harmless. Therefore, automatic protection is not required.

(b) In case of hydro-generator sets, protection against inverted running is achieved by providing mechanical devices on the water-wheel.

→ When the water flow drops to an insufficient rate to maintain the electrical output, the alternator is disconnected from the system. Therefore in this case also electrical protection is not necessary.

(c) Diesel engine driven alternators, when running inverted, draw a considerable amount of power from the supply system and it is a usual practice to provide protection against motoring in order to avoid damage due to possible mechanical seizure.

→ This is achieved by applying reverse power relays to the alternators which isolate the latter during their motoring action.

(2) Failure of field

→ The chances of field failure of alternators are undoubtedly very rare. Even if it does occur, no immediate damage will be caused by permitting the alternator to run without a field for a short period.

→ It is sufficient to rely on the control room attendant to disconnect the faulty alternator manually from the system bus-bars.

→ Therefore, an automatic protection is not necessary.

③ Overcurrent:

→ It occurs mainly due to partial breakdown of winding insulation or due to overload on the supply system.

→ Overcurrent protection for alternators is not necessary because the modern tendency is to design alternators with very high values of internal impedance so that they will stand a complete short-circuit at their terminals for sufficient time without serious overheating.

→ On the occurance of an overload, the alternators can be disconnected manually.

④ Overspeed:-

→ The main cause of overspeed is the sudden loss of major part of load on the alternator.

→ Modern alternators are usually provided with mechanical centrifugal devices mounted on their driving shafts to trip the main valve of the prime-mover when a dangerous overspeed occurs.

⑤ Over-voltage:

→ The field excitation system of modern alternators is so designed that over voltage conditions at normal running speeds cannot occur. However, overvoltage in an alternator occurs when speed of the prime-mover increases due to sudden loss of alternator load.

→ The over-voltage relays are operated from a voltage supply derived from the generator terminals.

→ The relays are so arranged that when the generated voltage rises 20% above the normal value, they operate to

ⓐ trip the main CB to disconnect the faulty alternator from the system.

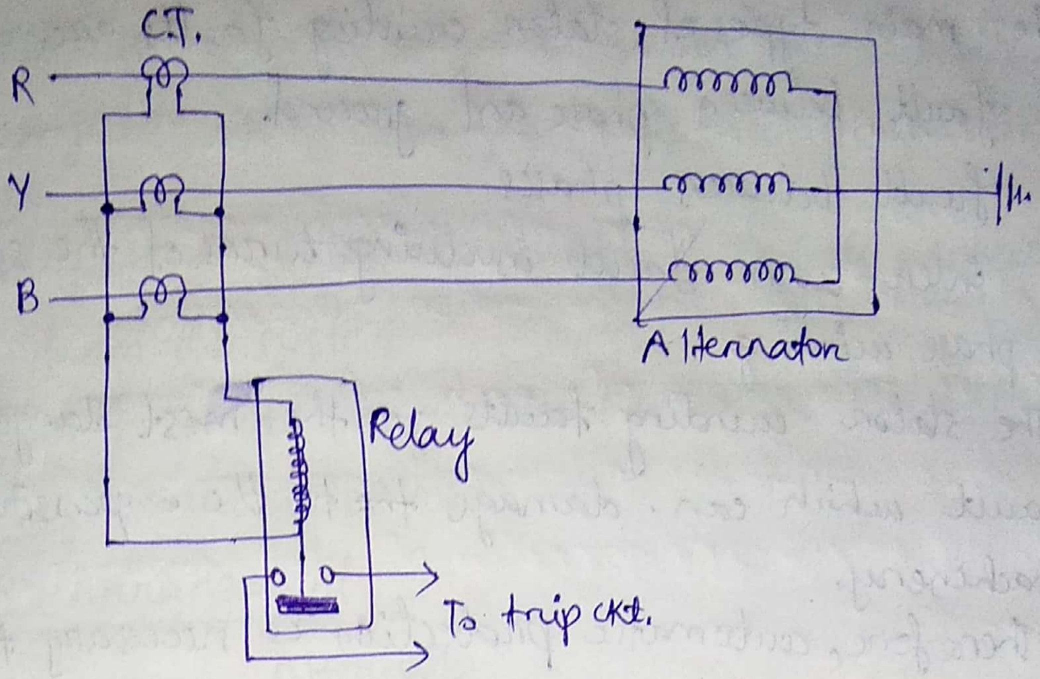
ⓑ disconnect the alternator field circuit.

⑥ Unbalanced Loading →

→ Unbalanced loading means there are different phase currents in the alternator.

→ Unbalanced loading arises from faults to earth or faults between phases on the ckt. external to the alternator.

→ The unbalanced currents, if allowed to persist, may damage the field winding.



→ The above figure shows the arrangement for the protection of alternator against unbalanced loading.

→ Under normal operating conditions, equal currents flow through the different phases of the alternator and their algebraic sum is zero.

→ Therefore, the sum of the currents flowing in the secondaries is also zero and no current flows through the operating coil of the relay.

→ If unbalancing occurs, the currents induced in the secondaries will be different and the resultant of these currents will flow through the relay. Then the operation of the relay will trip the CB to disconnect the alternator from the system.

⑦ Stator winding faults:-

These faults occur mainly due to the insulation failure of the stator windings.

The main types of stator winding faults are

(a) fault between phase and ground.

(b) fault between phases

(c) inter-turn fault involving turns of the same phase winding.

→ The stator winding faults are the most dangerous fault which can damage ~~the~~ to the expensive machinery.

→ Therefore, automatic protection is necessary to clear such faults.

→ For protection of Alternators against such faults, differential method of protection (also known as Merz-Price system) is most commonly employed due to its greater sensitivity and reliability.

6.2 Differential Protection of Alternators

→ The most common system used for the protection of stator winding faults employs circulating-current principle.

→ In this scheme of protection, currents at the two ends of the protected section are compared.

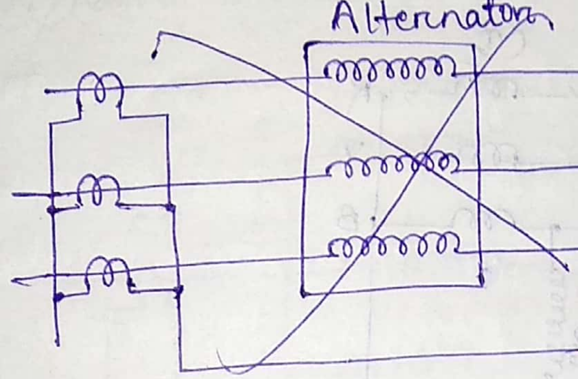
→ Under normal operating conditions, these currents are equal but may become unequal on the occurrence of a fault in the protected section.

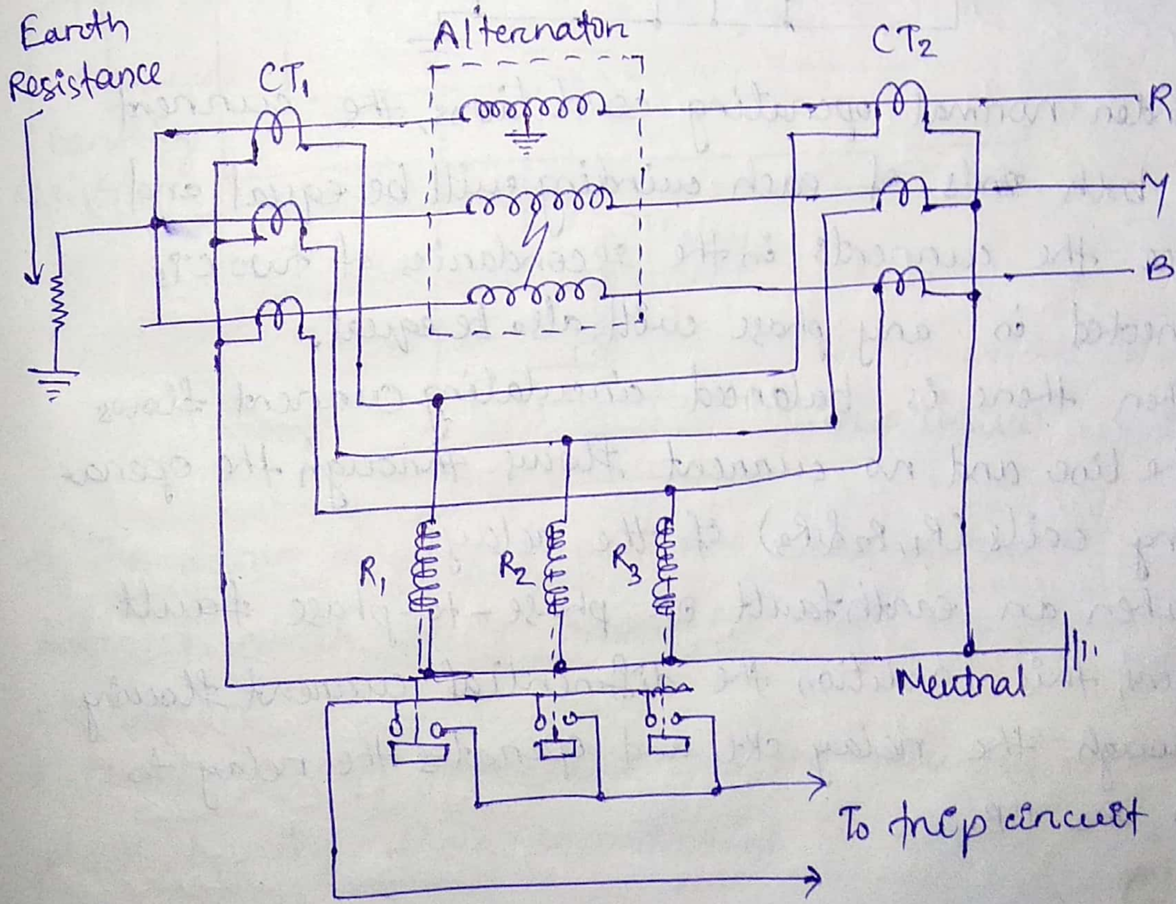
→ The difference of the currents under fault conditions is arranged to pass through the operating coil of the relay.

→ The relay then closes its contacts to isolate protected section from the system.

→ This form of protection is also known as Merz-Price circulating current scheme.

Schematic Arrangement





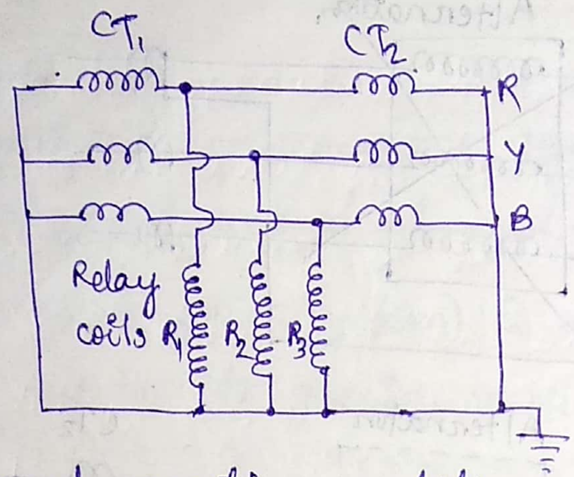
→ The above figure shows the arrangement of current differential protection for a 3-phase alternator.

→ Identical CT pairs are placed on either side of each phase of the stator windings.

→ The secondaries of each set of CTs are connected in star & the relay coils are connected in star.

→ The relays are generally of electromagnetic type.

Operation



→ Under normal operating conditions, the current at both ends of each winding will be equal and hence the currents in the secondaries of two CTs connected in any phase will also be equal.

→ Then there is balanced circulating current flows the line and no current flows through the operating coils (R_1, R_2 & R_3) of the relays.

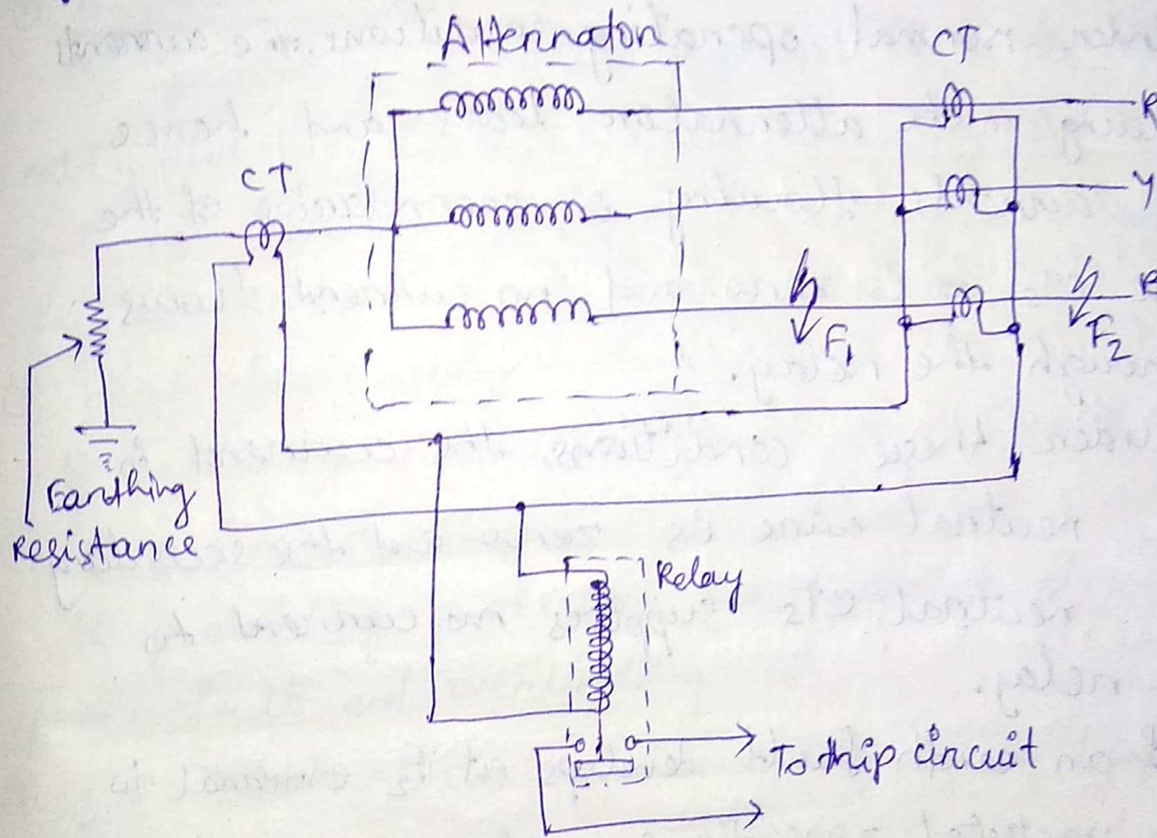
→ When an earth fault or phase-to-phase fault occurs, this condition the differential current flowing through the relay ckt. and operates the relay to trip the CB.

(6.3) Balanced Earth-fault Protection

→ It is necessary to provide protection against earth-faults only by the use of balanced earth-fault protection scheme.

→ This scheme provides no protection against phase-phase faults, until they develop into earth-faults.

Schematic Arrangement



→ The above figure shows the arrangement of a balanced earth-fault protection for a 3-phase alternator.

→ It consists of three line CTs, one mounted in each phase, having their secondaries connected in parallel with that of a single current transformer in the conductor joining the star point of the alternator to earth.

→ A relay is connected across the transformers secondaries.

→ The protection against earth faults is limited to the region betn the neutral & the line CTs.

Operation

→ Under normal operating conditions, the currents flowing in the alternator leads and hence the currents flowing in secondaries of the line CTs is zero. and no current flows through the relay.

→ Under these conditions, the current in the neutral wire is zero and the secondary of neutral CTs supplies no current to the relay.

→ If an earth-fault develops at F_2 external to the protected zone, the sum of the currents at the terminals of the alternator is exactly equal to the current in the neutral connection and hence no current flows through the relay.

→ When an earth fault occurs at F_1, these currents are no longer equal and the differential current flows through the operating coil of the relay. Then the relay closes its contacts to disconnect the alternator from the system.

6.4 Protection Systems for Transformers

→ The principal relays and systems used for transformer protection are:

① Buchholz devices
② Earth-fault relays
③ Over current relays
④ Differential system.

① Buchholz devices

It providing protection against all kinds of incipient (initiatory) faults, i.e. slow developing faults such as insulation failure of windings, core heating, fall of oil level due to leaky joints etc.

② Earth-fault relays

It providing protection against earth-faults only.

③ Overcurrent relay

It providing protection mainly against phase-to-phase faults and overloading.

④ Differential system (or circulating current system)

It providing protection against both earth and phase faults.

→ The complete protection of transformer usually requires the combination of these systems.

→ Choice of a particular combination of systems may depend upon several factors. such as:

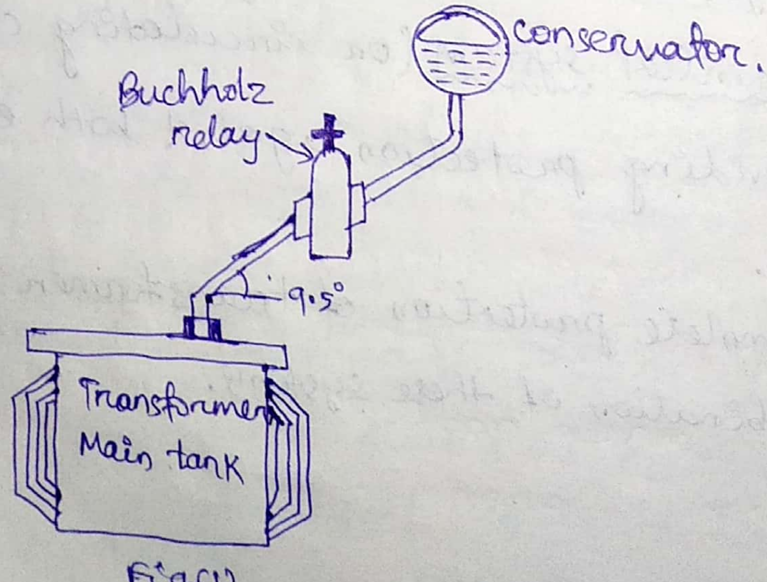
ⓐ size of transformer
ⓑ type of cooling
ⓒ location of transformer in the network.
ⓓ nature of load supplied and
ⓔ importance of service for which transformer is required.

6.5 Buchholz Relay

→ Buchholz relay is a gas actuated relay installed in oil immersed transformers for protection against all kinds of faults.

→ It is used to give an alarm in case of incipient (slow developing) faults in the transformer and to disconnect the transformer from the supply in the event of severe internal faults.

→ It is installed in the pipe connecting the conservator to the main tank as shown in the fig ①



Fig(1)

→ It is used in all such oil immersed transformers having ratings of in excess of 750KVA.

Construction

→ Fig② shows the constructional details of a Buchholz relay.

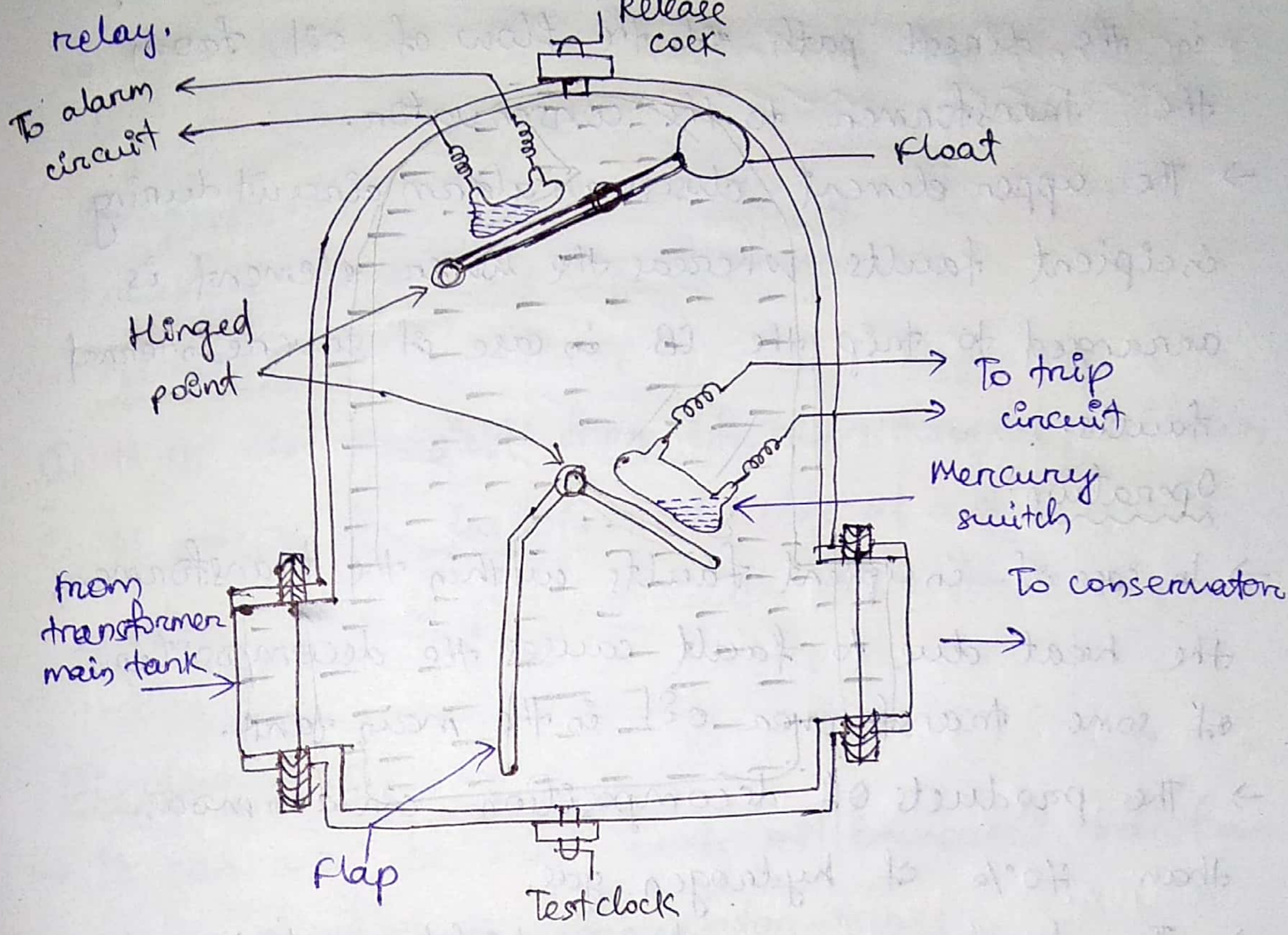


Fig.②

→ It forms of a domed vessel placed in the connecting pipe between the main tank and the conservator.

→ The device has two elements

① The upper element &

② The lower element.

→ The upper element consists of a mercury type switch attached to a float.

→ The lower element contains a mercury switch mounted on a hinged type flap located in the direct path of the flow of oil from the transformer to the conservator.

→ The upper element closes an alarm circuit during incipient faults whereas the lower element is arranged to trip the CB in case of severe internal faults.

Operation:

→ In case of incipient faults within the transformer, the heat due to fault causes the decomposition of some transformer oil in the main tank.

→ The products of decomposition contain more than 70% of hydrogen gas.

→ The hydrogen gas being light and tries to go into the conservator.

→ When a pre-determined amount of gas gets accumulated, it exerts sufficient pressure on the float to cause it to bend and close the contacts of mercury switch attached to it. This completes the alarm circuit to sound an alarm.

→ If a serious fault occurs in the transformer, an enormous amount of gas is generated in the main tank.

→ The oil in the main tank rushes towards the conservator via the Buchholz relay and the flap to close the contacts of mercury switch. This completes the trip circuit to open the circuit breaker controlling the transformer.

Advantages

① It is the simplest form of transformer protection.

② It detects the incipient faults at a stage much earlier than is possible with other forms of protection.

Disadvantages

1→ It can only be used with oil immersed transformers equipped with conservator tanks.

6.6 Protection of Busbar

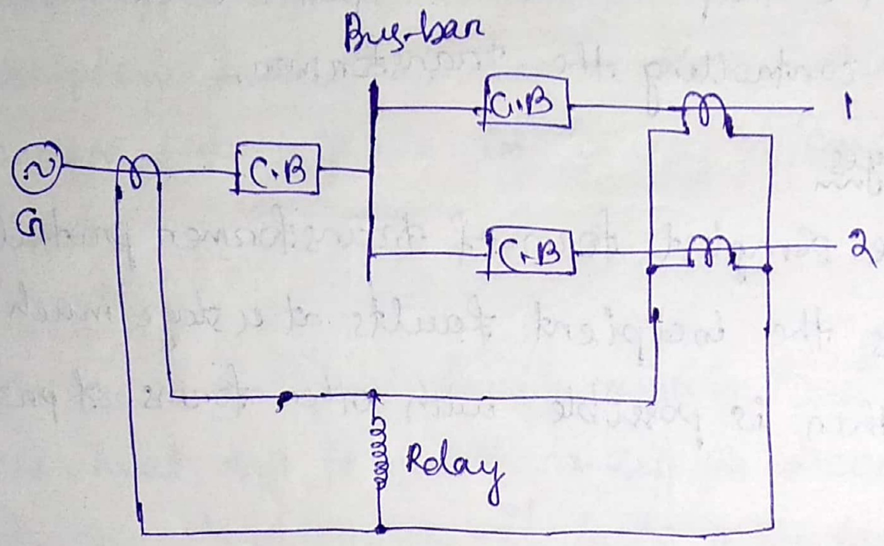
→ If a fault occurs on a bus bar, considerable damage and disruption of supply will occur unless some form of quick-acting automatic protectn is provided to isolate the faulty busbar.

→ The two most commonly used schemes for busbar protection are

① Differential protection

② Fault bus protection.

① Differential protection



→ This is the basic method for busbar protection.

→ The differential protection scheme is shown in the above fig.

→ The busbar is feed by a generator and supplies load to two lines.

→ The secondaries of CTs in the generator lead, in line 1 & in line 2, are all connected in parallel.

→ The protective relay is connected across this parallel connection.

→ All CTs must be of the same ratio.

→ under normal load conditions, the sum of the currents entering the bus is equal to those leaving it and no current flows through the relay.

→ If a fault occurs within the protected zone, the current entering the bus will no longer be equal to those leaving it.

→ The difference of these currents will flow through the relay and then the circuit breaker operates.

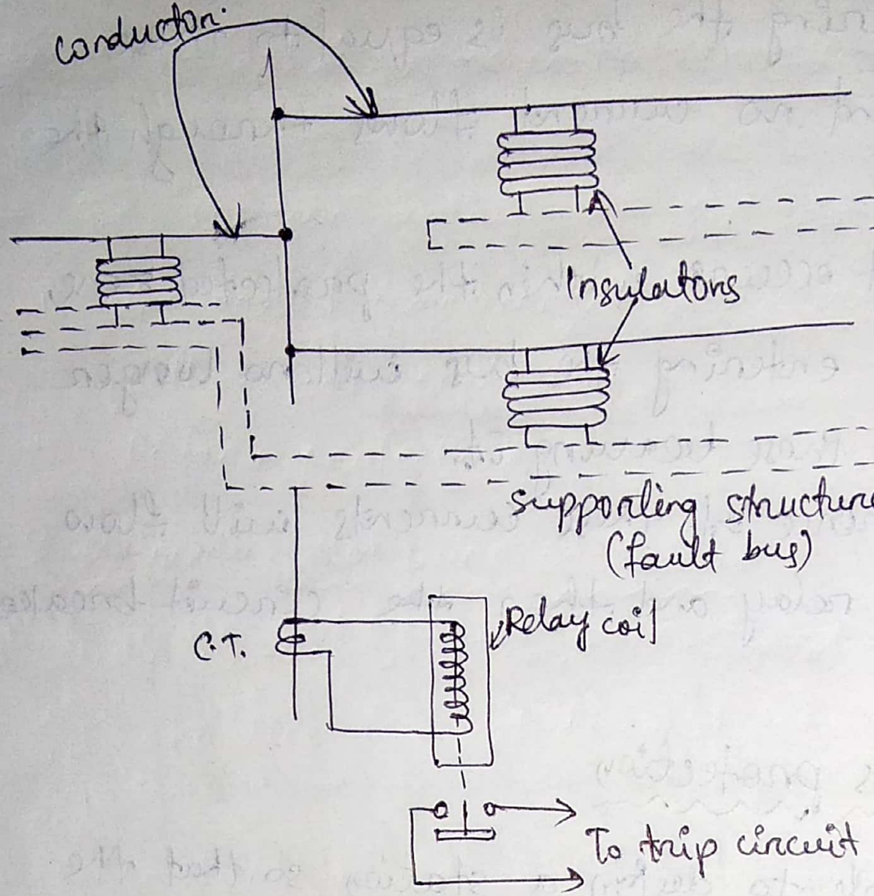
② Fault Bus protection

→ It is possible to design a station so that the faults that develop are mostly earth faults. This can be achieved by providing earthed metal barrier (known as fault bus) surrounding each conductor throughout its entire length in the bus structure.

→ In this arrangement, every fault that might occur must involve a connection betn a conductor and an earthed metal part.

→ By directing the flow of earth fault current, it is possible to detect the faults and determine their location.

→ This type of protection is known as fault bus protection.



→ The above fig. shows the schematic arrangement of fault bus protection.

→ The metal supporting structure or fault bus is earthed through a current transformer.

→ A relay is connected across the secondary of this CT.

→ Operation

→ Under normal operating conditions, there is no current flow from fault bus to ground and the relay remains inoperative.

→ When a fault involving a connection between a conductor and earthed supporting structure will result in current flow to ground through the fault bus, causing the relay to operate.

→ The operation of relay will trip all breakers connecting equipment to the bus.

6.7 Protection of Transmission Line

→ The probability of faults occuring on the lines is much more due to their greater length and exposure to atmospheric conditions.

→ The requirements of line protection are:

(i) In the event of a short-circuit, the circuit breaker closest to the fault should open, all other circuit breakers remaining in a closed position.

(ii) In case the nearest breaker to the fault fails to open, back-up protection should be provided by the adjacent circuit breakers.

(iii) The relay operating time should be just as short as possible in order to preserve system stability, without unnecessary tripping of circuits.

→ ~~While~~ Differential protection is ideal method for lines, it is much more expensive to use.

→ The two ends of a line may be several kilometers apart and to compare the two currents a costly pilot-wire circuit is required. This expense may be justified but in general less costly methods are used.

→ The common methods of line protection are

(i) Time-graded overcurrent protection

(ii) Differential protection

(iii) Distance protection.

6.8 Different pilot wire protection

→ Under normal conditions, the current entering one end of a line is equal to that leaving the other end.

→ When fault occurs betn the two ends, this condition no longer holds and the difference of incoming incoming and outgoing currents is arranged to flow through a relay which operates the circuit breaker to isolate the faulty line.

(i) Merz-Price voltage balance system

→ Fig(a) shows the single line diagram of Merz-Price voltage balance system for the protection of a 3-phase line.

→ Identical current transformers are placed in each phase at both ends of the line.

151

→ The pair of CTs in each line is connected in series with a relay. ~~in such a way that~~

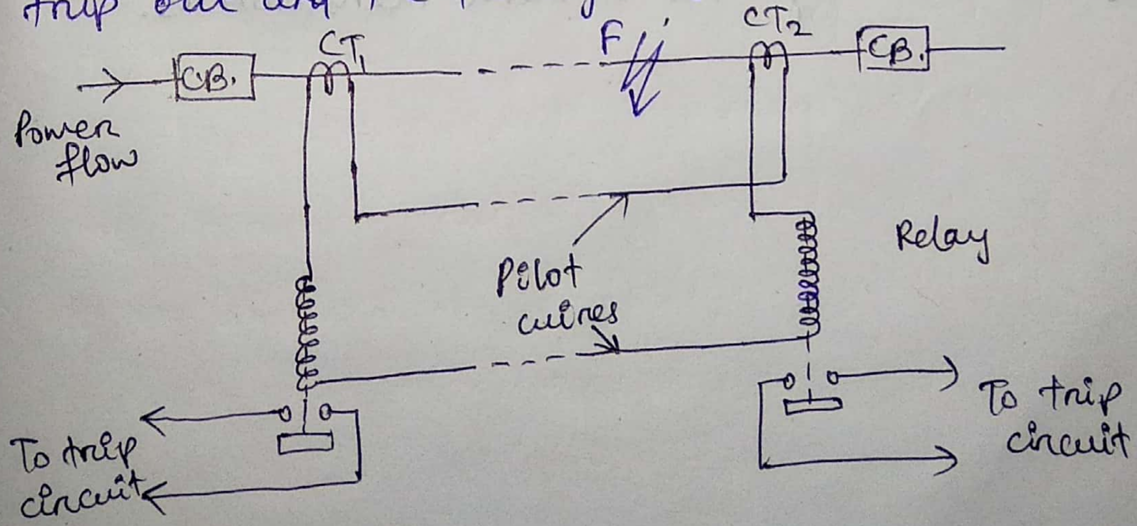
→ Under normal operating conditions, their secondary voltages are equal and in opposition i.e. they balance each other.

→ Under healthy conditions, current entering the line at one-end is equal to that leaving it at the other end.

→ Therefore, equal and opposite voltages are induced in the secondaries of the CTs at the two ends of the line. The result is that no current flows through the relays.

→ When a fault occurs at point F on the line, then a greater current to flow through CT_1 than through CT_2.

→ Consequently, their secondary voltages become unequal and circulating current flows through the pilot wires and relays. Then the CB at both ends of the line will trip out and the faulty line will be isolated.



Advantages

(i) This system can be used for ring mains as well as parallel feeders.

(ii) This system provides instantaneous protection for ground faults. This decrease the possibility of these faults involving other phases.

(iii) This system provides instantaneous relaying which reduces the amount of damage to overhead conductors resulting from arcing faults.

Disadvantages

(i) Accurate matching of current transformers is very essential.

(ii) If there is a break in the pilot-wire circuit, the system will not operate.

(iii) This system is very expensive due to the greater length of pilot wires required.

(iv) This system cannot be used for line voltages beyond 33KV because of constructional difficulties in matching the current transformers.

Chapter-07

Protection against overvoltage & Lightning

(7.1) Voltage surge & causes of over voltage

Voltage surge

A sudden rise in voltage for a very short duration on the power system is known as a voltage surge or transient voltage.

Causes of over voltage

The causes of overvoltage are due to switching surge or transients and lightning ~~surge~~/strike.

Causes of overvoltages

- Internal causes
  - Switching surges
  - Insulation failure
  - Arcing ground
  - Resonance.
- External causes (Lightning)

(7.2) Internal cause of over voltage

- Internal cause of overvoltages on the power system are primarily due to oscillations set up by the sudden changes in the circuit conditions.

① Switching surges

The overvoltages produced on the power system due to switching operations are known as switching surges.

② Insulation failure

The most common case of insulation failure in a power system is the grounding of conductor. (i.e. insulation failure betn line and earth)

③ Arcing ground

→ The phenomenon of intermittent arc taking place in line to ground fault of a 3-ϕ system with consequent production of transients is known as arcing ground.

→ The arcing ground produces severe oscillations of 3 to 4 times the normal voltage.

→ The transient produced due to arcing ground are cumulative and may cause serious damage to the equipment in the power system, by causing breakdown of insulation.

④ Resonance

→ Resonance occurs when inductive reactance of the circuit becomes equal to capacitive reactance.

→ Under resonance, the impedance of the circuit is equal to resistance of the circuit and the p.f is unity.

→ Resonance causes high voltages in the electrical system.

→ In small or medium transmission lines, the capacitance is very small so that resonance rarely occurs at the fundamental supply frequency.

→ If generator emf. wave is ~~distoned~~ distorted, the trouble of resonance may occur due to 5th or higher order harmonics and in case of underground cables too.

(7.3) External cause of over voltage (lightning)

→ Surges due to lightning are very severe and may increase the system voltage to several times the normal value.

→ If the equipment in the power system is not protected against lightning surges, these surges may cause considerable damage.

(7.4) Mechanism of lightning discharge.

An electric discharge between cloud and earth, between clouds or between the charge centres of the same cloud is known as lightning.

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→ Lightning is a huge spark and takes place when clouds are charged to such a high potential (+ve or -ve) with respect to earth or a neighbouring cloud. that the dielectric strength of neighbouring medium is destroyed.

→ The uprush of warm moist air from earth, the friction between the air and the tiny particles of water causes the building up of charges.

→ when drops of water are formed, the larger drops become positively charged and the smaller drops become negatively charged.

→ when the drops of water accumulate, they form clouds, and hence cloud may possess either a positive or a negative charge, depending upon the charge of drops of water they contain.

→ The charge on a cloud may become so great that it may discharge to another cloud or to earth and we call this discharge as lightning

→ As the charge acquired by the cloud increases, the potential between cloud and earth increases. and therefore, gradient in the air increases.

→ when the potential gradient is sufficient (5KV/cm to 10KV/cm) to break down the surrounding air, the lightning stroke starts.

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The stroke mechanism are:

① As soon as the air near the cloud breaks down, a streamer called leader streamer or pilot streamer starts from the cloud towards the earth and carries charge with it as shown in fig (1).

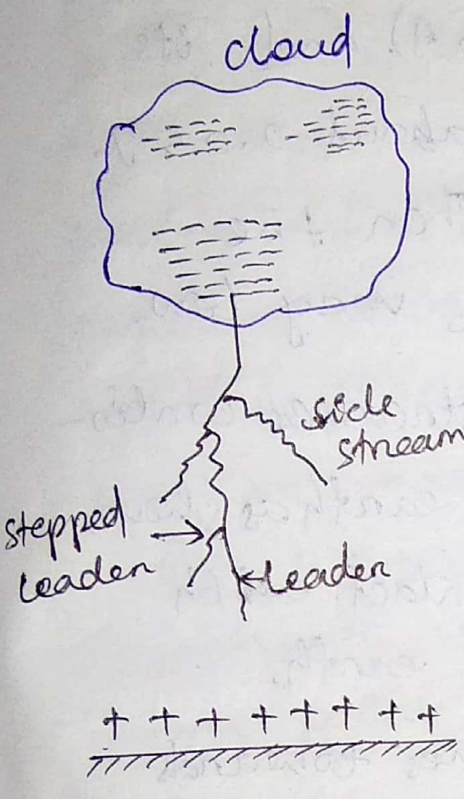


Fig ①

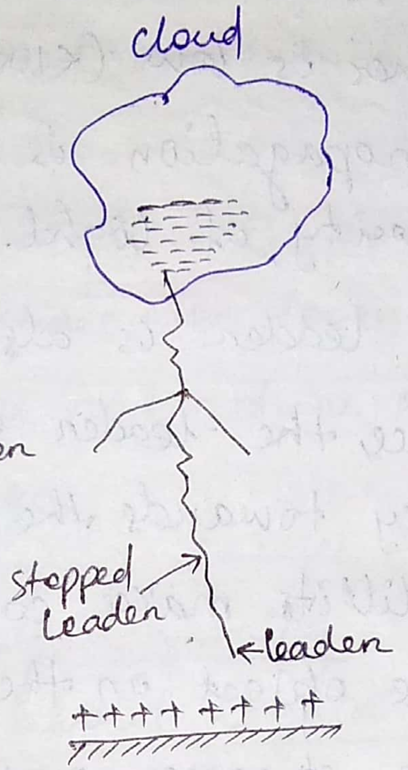


Fig (II)

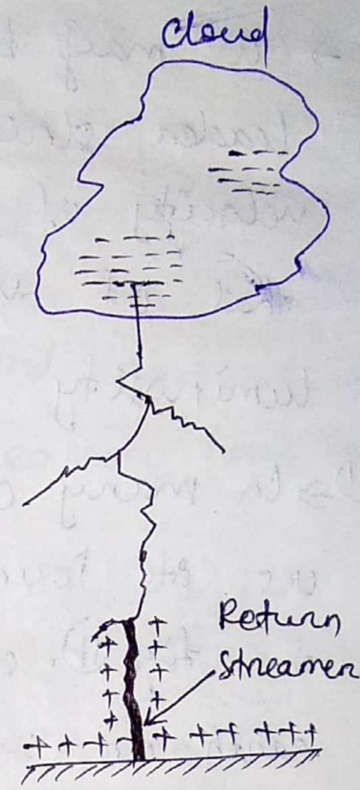


Fig (III)

→ The leader streamer will continue its journey towards earth as long as the cloud, from which it produces enough charge to maintain gradient at the top of the leader streamer above the strength of air.

→ If this gradient is not maintained, the leader streamer stops and the charge is dissipated without the formation of a complete stroke. In other words the leader streamer will not reach the earth.

~~→ In other words~~

→ The fig(I) shows the leader streamer being unable to reach the earth as gradient at its end could not be maintained.

→ It may be noted that current in the leader streamer is low (<100 A) and its velocity of propagation is about 0.05 % that of velocity of light. Then the luminosity of leader is also very low.

(II) → In many cases, the leader streamer continues its journey towards the earth as shown in fig (II). until its makes contact with earth or some object on the earth.

→ As the leader streamer moves towards earth, it is accompained by points of luminescence which travel in jumps giving rise to stepped leaders.

→ The velocity of stepped leaders exceeds one-sixth of that light and distance travelled in one step is about 50m.

→ Here the stepped leaders have sufficient luminosity and give rise to first visual phenomenon of discharge.

→ (iii) → The path of leader streamer is a path of ionisation and, therefore, of complete breakdown of insulation.

→ As the leader streamer reaches near the earth, a return streamer shoots up from the earth to the cloud as shown in fig (iii).

→ The sudden action can be compared with the closing of a switch between the positive and negative terminals; the downward leader having negative charge and return streamer having positive charge.

→ This phenomenon causes a sudden spark which we call <u>lightning</u>.

→ Some <u>points about lightning discharge</u>

(a) → A lightning discharge which usually appears to the eye as a single flash is in reality made up of a number of separate strokes that travel down the same path.

→ The interval between them varies from 0.0005 to 0.5 second.

→ Each separate strokes stands as a downward leader from the cloud.

(b) It has been found that 87% of all lightning strokes result from negatively charged clouds and only 13% originate from positively charged clouds.

(c) It has been estimated that, throughout the world, there occur about 100 lightning strokes per second.

(d) Lightning discharge may have currents in the range of 10KA to 90KA.

(7.5) Types of Lightning strokes

It is of two types

Lightning strokes

- Direct stroke
- Indirect stroke.

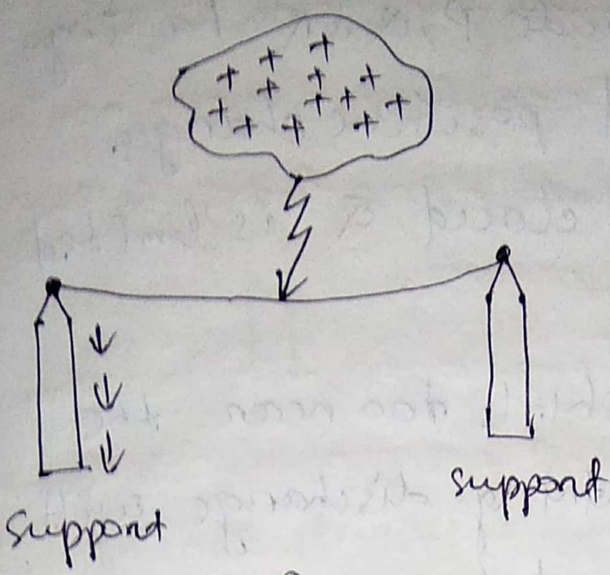
(1) Direct stroke

→ In direct stroke, the lightning discharge is directly from the cloud to the over-head line (ex). From the line, the current path may be over the insulators down the pole to the ground.

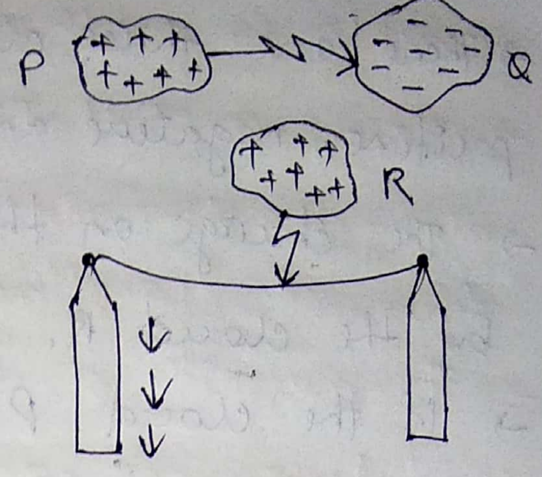
→ The overvoltages set up due to the stroke may be large enough to flashover this path directly to the ground.

→ The direct strokes can be of two types

(1) stroke (A) · (2) stroke B.



Fig(i)



Fig(ii)

(1) In stroke A, the lightning discharge is from the cloud to the subject equipment. i.e. an overhead line ~~as sho~~ as shown in fig(i).

→ The cloud will induce a charge of opposite sign on the tall object (eg. an overhead line in this case).

→ when the potential between the cloud and line exceeds the breakdown value of air, the lightning discharge occurs betn the cloud and the line.

→ In stroke B, the lightning discharge occurs on the overhead line as a result of stroke A between the clouds as shown in fig(ii).

→ There are three clouds P, Q & R having positive, negative and positive charges.

→ The charge on the cloud Q is limited by the cloud R.

→ If the cloud P shifts too near the clouds Q, then lightning discharge will occur betn them and charges on both these clouds disappears quickly.

→ Then the charge on cloud R suddenly becomes free and it then discharges rapidly to earth.

→ Direct strokes on the power system are very rare.

→ Stroke A will always occur on high voltage transmission lines and hence protection can be provided against it.

→ Stroke B completely ignores the height of the object and can even strike the ground.

→ Therefore it is not possible ~~to~~ to provide protection against stroke B.

② Indirect stroke

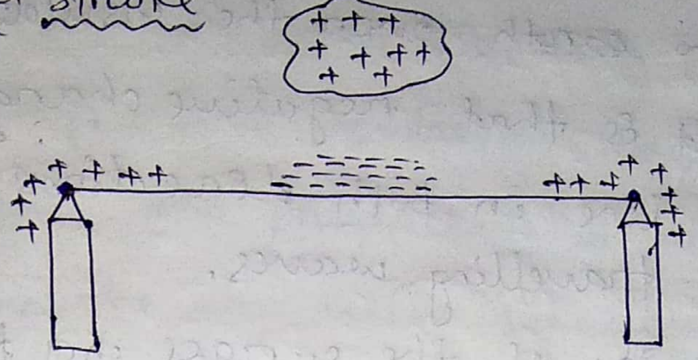


Fig ⓐ

→ Indirect strokes result from the electrostatically induced charges on the conductors due to the presence of charged clouds as shown in fig (a).

→ A positively charged cloud is above the line and induces a -ve charge on the line by electrostatic induction.

→ This -ve charge, however will be only on that portion of the line right under the cloud and the portions of the line away from it will be positively charged as shown in fig (a).

→ The induced positive charge leaks slowly to earth via the insulators.

→ When the cloud discharges to earth or to another cloud, the -ve charge on the wire is isolated as it cannot flow quickly to earth over the insulators.

→ The result is that negative charge rushes along the line in both directions in the form of travelling waves.

→ The majority of the surges in a transmission lines are caused by indirect lightning strokes.

(7.6) Harmful effect of lightning

→ The harmful effects of lightning are

(i) The travelling waves produced due to lightning surges will ~~sha~~ break the insulators and may even wreck poles.

(ii) → If the travelling waves produced due to lightning hit the windings of a transformer or generator, it may cause considerable damage.

→ The inductance of the winding opposes any sudden passage of electric charge through it. Therefore, the electric charges "piles up" against the transformer or generator.

This induces such an excessive pressure both the windings that insulation may breakdown, resulting in the production of arc.

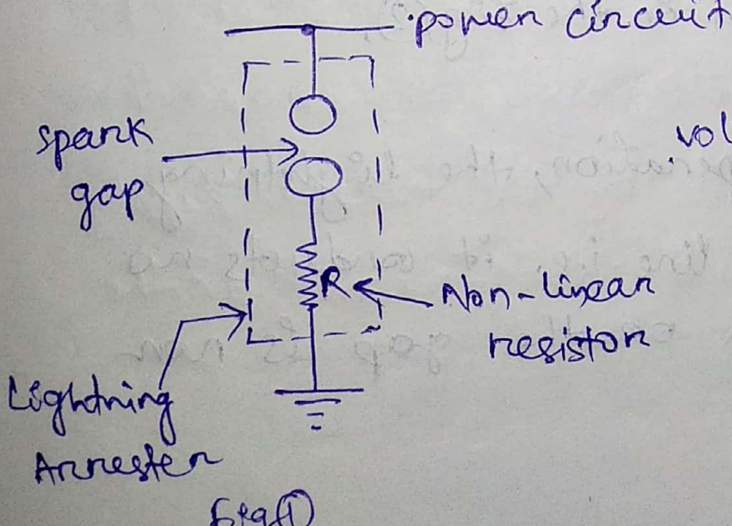
→ Therefore the arc will severely damage the ~~damage~~ machine.

(iii) If the arc ~~will~~ is initiated in any part of the power system by the lightning stroke, this arc will set up very disturbing oscillations in the line.

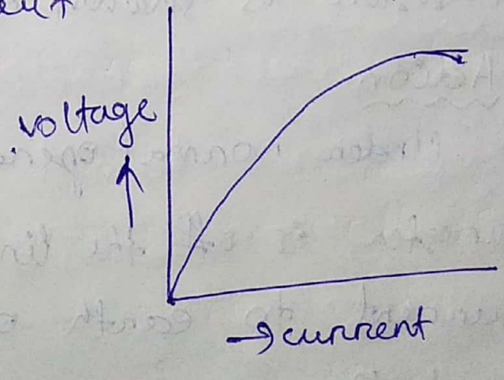
This may damage other equipment connected to the line.

(7.7) Lightning Arresters

A lightning arrester or a surge diverter is a protective device which conducts the high voltage surges on the power system to the ground.



Fig①



Fig②

→ The fig① shows the basic form of a surge diverter.

→ It consists of a spark gap in series with a non-linear resistor.

→ One end of the diverter is connected to the terminal of the equipment to be protected and the other end is effectively grounded.

→ The length of the ~~line~~ gap is so set that normal line voltage is not enough to cause an arc across the gap but a dangerously high voltage will break down the air insulation and form an arc.

→ The property of the non-linear resistance is that its resistance decreases as the voltage (or current) increases and vice-versa.

→ The volt/Ampere characteristic of the resistor is shown in the fig②.

Action

→ Under normal operation, the lightning arrester is off the line i.e. it conducts no current to earth or the gap is non conducting.

→ On the occurance of over voltage, the sp insulation gap breaks down and an arc is formed providing a low resistance path for the surge to the ground.

→

(7.8) Types of Lightning Arresters

Lightning Arresters

- Rod gap Arrester
- Horn gap Arrester
- Multigap Arrester
- Expulsion type Arrester
- Valve type Arrester.

(a) Rod-gap Lightning Arresters

→ It is a very simple type of diverter and consists of two 1.5cm rods which are bent at right angles with a gap in betn as shown in fig (i).

→ One rod is connected to the line circuit and the other rod is connected to earth.

→ The distance betn gap and insulator (i.e. distance P) must not be less than one-third of the gap length so that the arc may not reach the insulator and damage it.

→ The string of insulators for an overhead line on the bushing of transformer has frequently a rod gap across it.

→ Under normal operating conditions, the gap remains non-conducting.

→ On the occurrence of a high voltage surge on the line, the gap sparks over and the surge current is conducted to earth. Then excess charge on the line due to the surge is harmlessly conducted to earth.

Limitations

① After the surge is over, the arc in the gap is maintained by the normal supply voltage, leading to a short-circuit on the system.

② The rod may melts or get damaged due to excessive heat produced by the arc.

③ The climatic conditions affect the performance of rod gap arrester.

④ Due to these limitations, the rod gap arrester is only used as a back-up protection in case of main arresters.

ⓑ ~~Horn-gap arresters~~

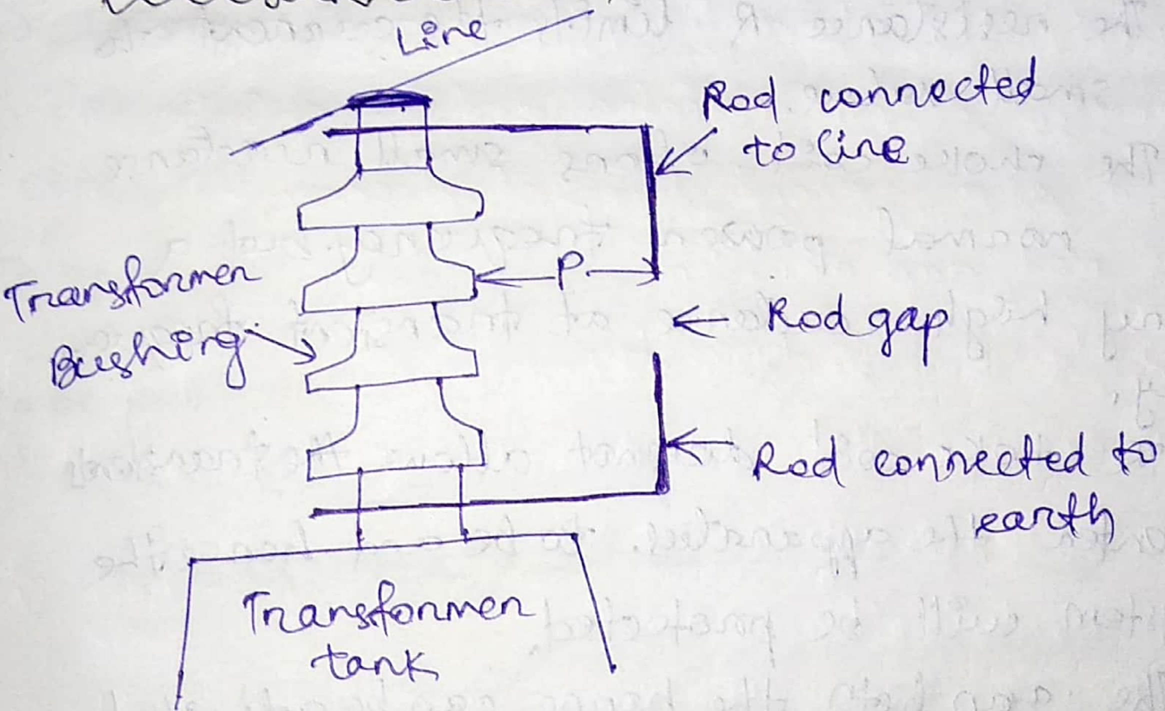


Fig ⓘ Rod-gap Arrester

ⓑ Horn-gap Arrester·

→ It ~~consi~~ consists of a two horn shaped metal rods A & B separated by a small air gap,

→ The horns are constructed that, distance between them gradually increases towards the top as shown in fig 2.11.

→ The horns are mounted on porcelain insulators.

→ One end of horn is connected to the line through a resistance R and choke coil L while the other end is effectively grounded.

→ The resistance R limits the current to a small value.

→ The choke coil offers small reactance at normal power frequency. but a very high reactance at transient frequency.

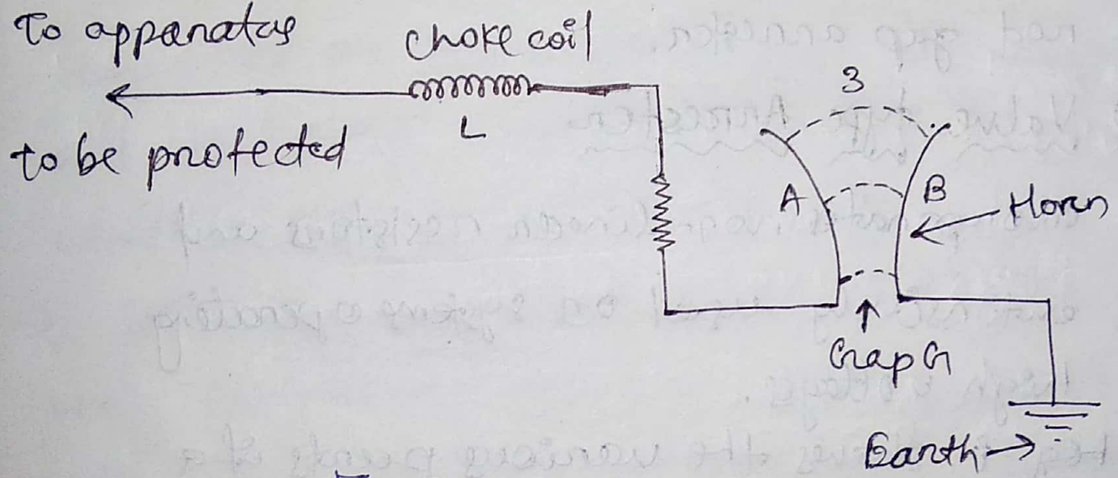
→ The choke coil doesnot allow the transients to enter the apparatus. ~~to be~~ and hence the system will be protected.

→ The gap betn the horns can be adjusted to release the arc or split the arc

Operations

→ Under normal conditions, the gap is non-conducting. ~~i.e. no~~

→ On the occurrance of an overvoltage, spark go-over takes place across the small gap G.
→ The heated air around the arc and the magnetic effect of the arc cause the arc to travel up the gap.
→ The arc moves progressively into positions 1, 2 & 3.
→ At position 3, the distance may be too great for the voltage to maintain the arc.
→ Consequently, the arc is extinguished.
Then the excess charge on the line is thus conducted through the arrester to the ground.



[Fig ① Horn-gap Arrester]

Advantages

① The arc is self clearing. ~~Hence~~

② Series resistance helps in ~~maintaining~~ limiting the flow of current to a small value.

Limitations

(i) The bridging of gap by some external agency (e.g. birds) can render the device useless.

(ii) The setting of horn gap is likely to change due to corrosion or pitting. This adversely affect the performance of the arrester.

(iii) The time of operation is long, say about 3 seconds.

Due to the above limitations, this type of arrester is not reliable and can only be used as a second line of defence like the rod gap arrester.

(c) Valve type Arrester

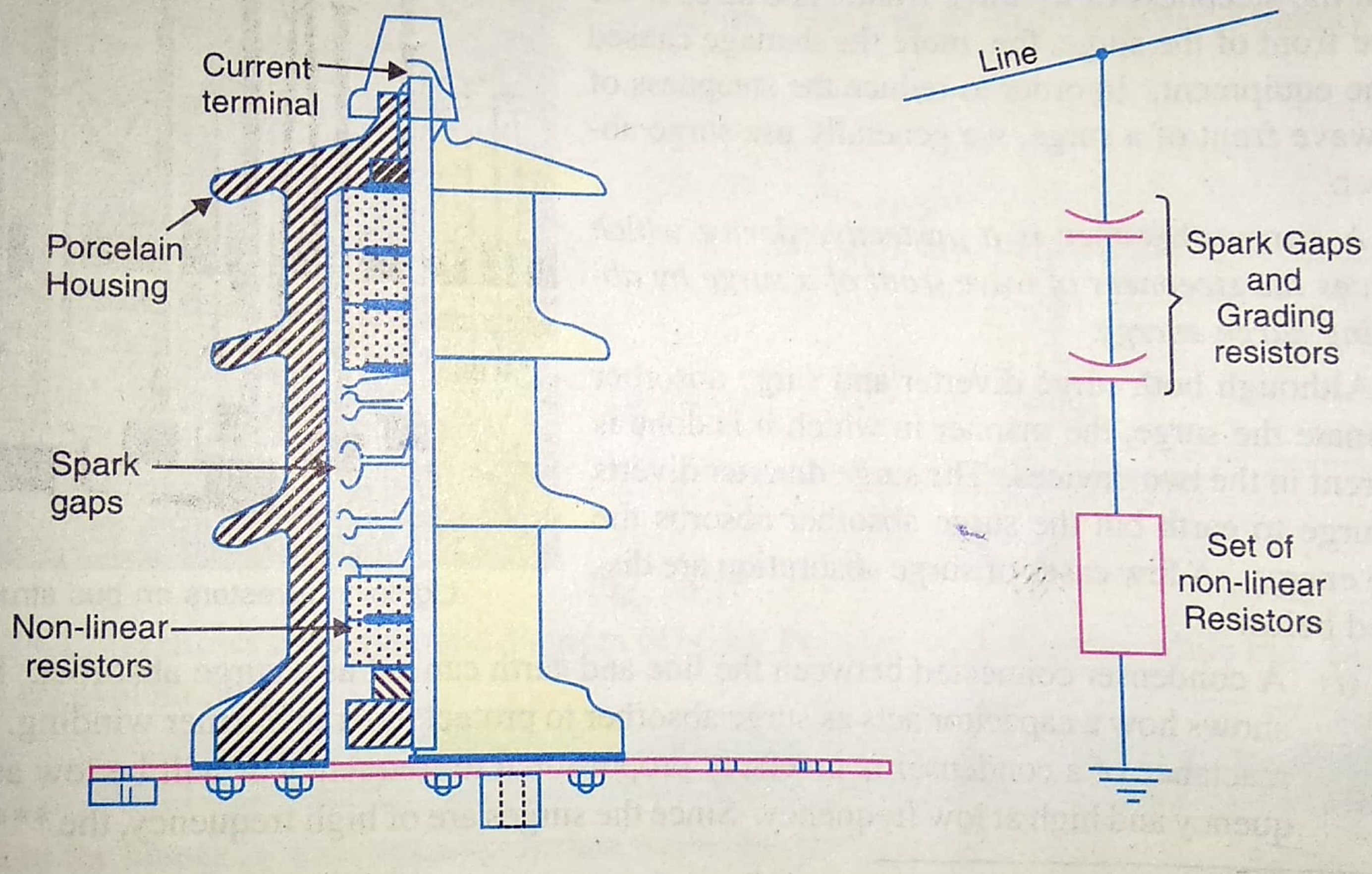
→ It incorporates non-linear resistors and are extensively used on systems operating at high voltages.

→ Fig. ? shows the various parts of a valve type arrester.

→ It consists of two assemblies

(i) series spark gaps

(ii) non-linear resistor disc. in series.


Current terminal
Porcelain Housing
Spark gaps
Non-linear resistors
Line
Spark Gaps and Grading resistors
Set of non-linear Resistors

(i) (ii)

→ Both the assemblies are accommodated in tight porcelain container.

→ Each spark gap consists of 2 electrodes with a fixed gap spacing.

→ The voltage distribution across the gaps is linearised by means of additional resistance elements across the gaps.

Operation

→ Under normal conditions, the normal system voltage is insufficient to cause the break down of air gap assembly.

→ On the occurrence of an overvoltage, the break down of the series spark gap takes place and the surge current is conducted to earth via the non-linear resistors.

→ Since the magnitude of surge current is very large, the non-linear elements will offer a very low resistance to the passage of surge.

→ Then the surge will rapidly go to earth instead of being sent back over the line.

→ When the surge is over, the non-linear resistors assume high resistance to stop the flow of current.

Advantages

(i) They provide very effective protection for transformer and cables against surges.

(ii) They operate very rapidly taking less than a second.

(iii) The impulse ratio is practically unity.

Limitations

(i) Their performance is adversely affected by the entry of moisture into the enclosure. This necessitates effective ~~sea~~ sealing of the enclosure at all times.

~~* Valve~~

* Valve type arresters are 2 types
(1) station type [upto 220KV or >>220KV] (2) Line type [upto 66KV]

(7.9) Surge Absorber

A surge absorber is a protective device which reduces the steepness of wave front of a surge by absorbing ~~the~~ surge energy.

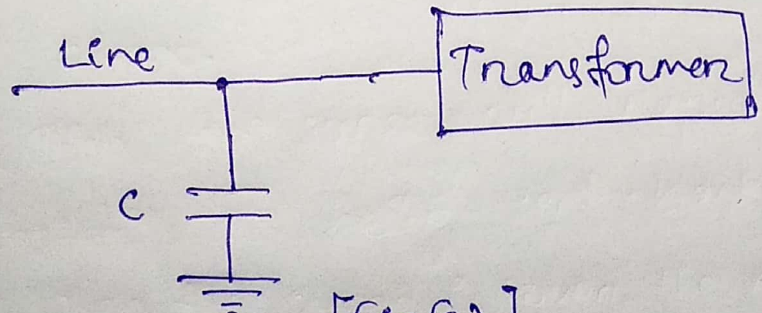
→ The surge diverter diverts the surge to earth but the surge absorber absorbs the surge energy.

→ A condenser connected betn the line and earth can act as a surge absorber.

→ ~~Fig~~ Fig ⓐ shows how a capacitor acts as surge absorber to protect the transformer winding. Since the reactance of a condenser is inversely proportional to frequency, it will be low at high frequency and high at low frequency.

→ Since the surges are of high frequency, the capacitor acts as a short circuit and passes them directly to earth.

→ However, for power frequency, the reactance of the capacitor is very high and practically no current flows to the ground.



[Fig(a)]

Chapter-08 Static Relay

The relay which doesnot contain any moving parts is known as the static relay. In such types of relays, the output is obtained by the static components like magnetic and electronic circuit, etc..

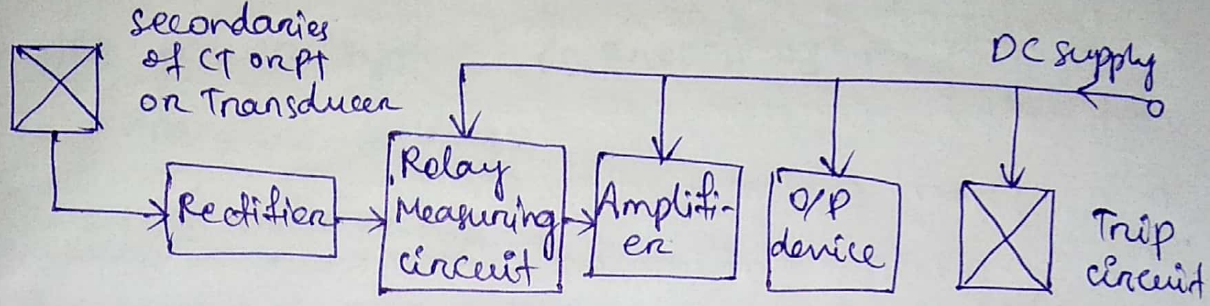


Fig. [Block diagram of static relay]

(8.1) Advantages of Static Relay

① It consumes very less power

② It gives quick response, long life, high reliability and accuracy and it is shockproof.

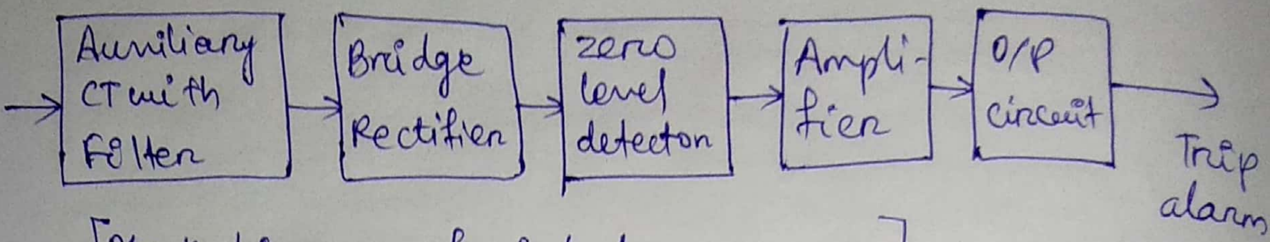
③ The reset time of the relay is very less.

④ The relay amplifies the input signal which increases their sensitivity.

⑤ The chance of unwanted tripping is less in this relay.

⑥ The static relay can easily operate in earth-quake-prone areas because they have high resistance to shock.

(8.2) Instantaneous overcurrent relay



[Block diagram of instantaneous over current relay]

→ The output of CT is rectified, smoothened and supplied to the measuring unit (level detector)

→ This measuring unit determines whether the quantity has attained the threshold value (set value) or not. When the input to measuring unit is less than the threshold value, the O/P of the level detector is zero.

→ For an over current relay,

For Input < ~~thresold~~ threshold, $I_{o/p} = 0$

~~For Input >>~~

For input $\geq$ threshold, $I_{o/p}$ = present

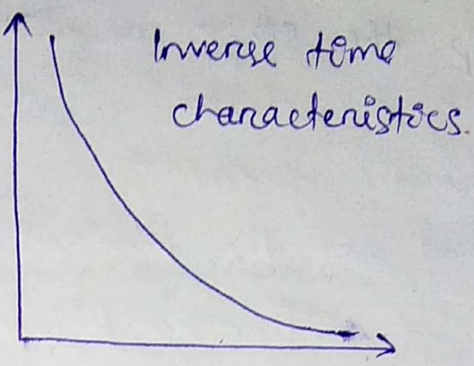
→ After the operation of measuring unit, the O/P is amplified by amplifier. The ampified O/P is given to the O/P circuit to cause trip.

→ If time delay is desired, a timing circuit is introduced before the level detector.

→ Smoothing circuit and filters are introduced in the O/P of the bridge rectifier.

→ The general equation for time characteristics is given by,

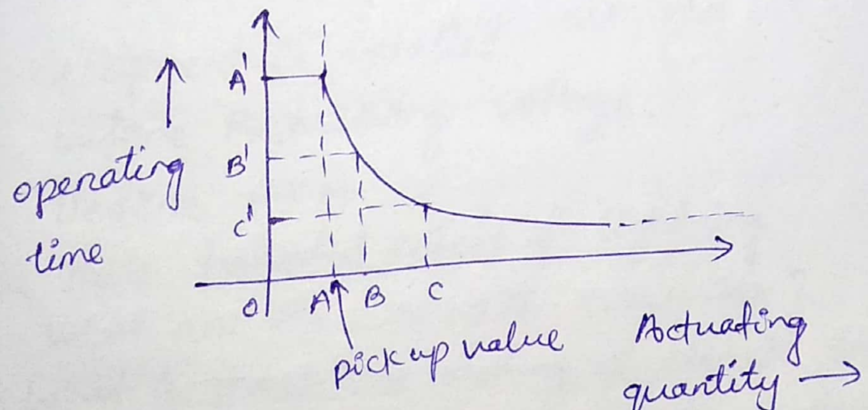
$$I^n t = K$$



The static instantaneous over current 'I' relay can have operating time 't' of as small as 10 or 20 msec.
(conventional electromagnetic relay - operating time 0.1 sec or 100ms)

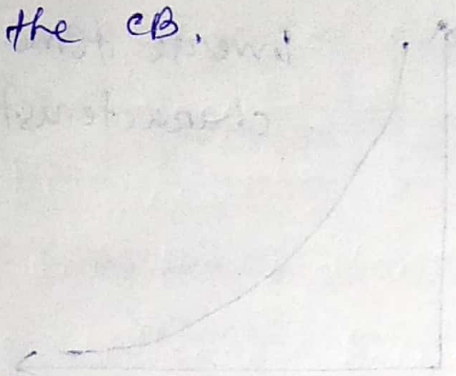
(8.3) Principles of IDMT Relay

IDMT stands for Inverse Definite Minimum Time



→ They are used on transmission lines to see to that the line current doesnot exceed safe values.
→ If it does, the CB operates.
→ As the current keeps increases, the relay takes minimum time to trip the circuit.

→ Higher the current value, lesser the time taken for the relay to ~~trip~~ operate and trip the CB.

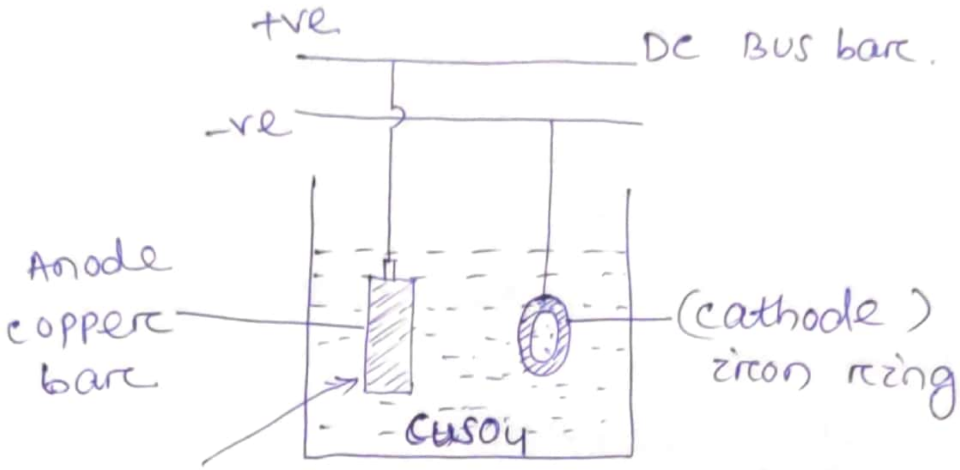


1st chapter.

Electrolytic process :-

The process of depositing metal on the surface of some other metal by electrolysis is called electro plating.

Basic principle of electro deposition :-



$CuSO_4 \rightarrow Cu^{++} + SO_4^{--}$
(cation) (Anion)

(i) when two electrodes are dipped in an electrolyte, an electrical potential is applied across them, the molecules of the substance dissolved are dissociated into two ions. that is +ve ions and -ve ions.

(ii) Here copper bar is taken as anode and iron ring as cathode. The electrolyte solution is copper sulphat ($CuSO_4$)

(iii) when supply from DC busbar is given

$CuSO_4$ breaks into Cu^{++} (cations) and SO_4^{--} (Anion)

(iv) The cations move towards cathode and the anion towards anode.

(v) Thus at anode $CuSO_4$ molecule is formed and at cathode Cu^{++} receives two electron ($2e^-$) from cathode. and get deposited in metalic form on iron ring.

(vi) In this way the copper is deposited on the iron ring.

<u>chemical</u> <u>equation</u> :-

$$CuSO_4 \longrightarrow Cu^{++} + SO_4^{--}$$

At anode $\rightarrow$ $SO_4^{--} + Cu^{++} \longrightarrow CuSO_4$

At cathode $\longrightarrow$ $Cu^{++} + 2e^- \longrightarrow Cu$ (metal).

Faraday's laws of electrolysis.

1st law :-

The weight of a substance liberated from an electrolyte in a given time is proportional to the total quantity of electricity passed on it.

$$W \propto Q$$
$$W \propto IT$$
$$W = ZIT \quad (Z = \text{constant}).$$

where,

W = The weight of the substance liberated.

I = current in Ampere.

T = Time in second.

Q = charge in coulomb.

when $I = 1$ Amp. , $T = 1$ sec

then,

$$\boxed{W = Z}$$

Z = electrochemical equivalent.

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2nd law :-

If the same current flows for a given time through several electrolytes, the weight of substance liberated are proportional to the chemical equivalent.

$$\boxed{\text{chemical equivalent} = \frac{\text{Atomic weight of a substance}}{\text{Valency}}}$$

According to this law, if we take the two electrolyte of $CuSO_4$ and Nickel sulphate in which same current flows for the same time.

$$\frac{\text{weight of cu deposited by given quantity of electricity}}{\text{weight of Nickel deposited by the same quantity of electricity}}$$

$$= \frac{\text{chemical equivalent of Cu}}{\text{chemical equivalent of Ni}}$$

(1) Electrolyte :-

The solution of a salt when used for electrolytic process is called an electrolyte.

(2) Electrodes :-

The plates or rods immersed in an electrolyte and connected to dc supply are called electrodes.

(3) Anode :-

The electrode connected to the +ve terminal of the supply is called Anode.

(4) cathode :-

The electrode connected to the -ve terminal of the supply is called cathode.

(5) Ions. :-

when a direct current is passed through an electrolyte, it gets chemically decomposed into two parts known as +ve and -ve ions.

(6) cations :-

These are the +ve charged ions and they move towards the cathode.

(7) Anions :-

These are negatively charged ions and they move towards the anode

(8) chemical equivalent weight :-

Chemical equivalent weight of a substance may be defined as the ratio of its atomic weight and valency.

i.e chemical Equivalent = $\frac{\text{Atomic weight}}{\text{Valency}}$

(9) Electro chemical Equivalent (ECE) :-

ECE of a substance is the amount deposited on passing a steady current of one ampere for one second through its solution.

(10) Atomic weight :-

The atomic weight of an element is a number which is the average of the masses of its various isotopes weight - relative to their abundance or the atomic weight is the ratio of the weight of an atom of the element to the weight of an atom of hydrogen.

(ii) Valency :-

The valency of an atom or a group of atoms is the number of Hydrogen-atoms which it will react chemically. Valency is always an integer (1, 2, 3 etc) but for a given atoms or radical, it can have different value in different chemical reactions.

Current efficiency :-

Due to impurities which cause secondary reaction, the quantity of the substance liberated is less than that calculated from Faraday's law.

$$\text{Current efficiency} = \frac{\text{Actual quantity of substance liberated}}{\text{Theoretical quantity.}}$$

Energy efficiency :-

In actual practice, the actual voltage required for the deposition or liberation of metal highere than the theoritical value. As a result actual energy required is increased.

$$\text{Energy efficiency} = \frac{\text{Theoritical Energy}}{\text{Actual Energy}}.$$

factors affecting the amount of electro deposition

(i) Time :-

The quantity of electro deposition is directly proportional to time.

(ii) efficiency :-

With high value of efficiency the amount of electrodeposition is also high.

(iii) current :-

(i) The amount of electrodeposition is directly proportional to current flowing through it.

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(ii) But after certain limit colour such blackish will be appeared which is known as burent metal.

(4) Strength of solution :-

If the strength of solution is more, then the mass of metal deposited will be more.

Factors Governing the better electrodeposition :

(1) current density :-

(i) for low value of current density the ions are released at slow rate and the deposits are crystaline in nature.

(ii) for high value of current density the deposits are of uniform. and fine ground.

(iii) If the current density is too high exceeding the limit the deposits are of spongy. and porous. in nature

(2) Electrolytic concentration :-

(i) Increase in concentration of electrolyte tends to give better deposit and it is generally recommended to use concentrated electrolyte.

(3) Temperature :-

(i) The temperature of the electrolyte is different for different metals. for better deposition.

(4) Addition of agents :-

(i) The quality of deposit can be increased by adding some organic compound like Jums, rubber, Alkali and sugar.

(5) Nature of the electrolyte :-

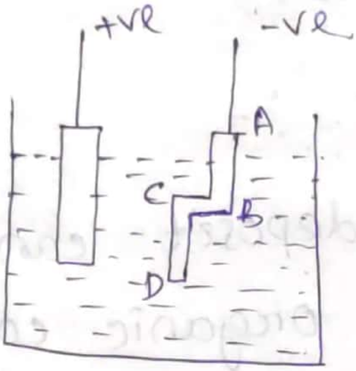
(i) The Nature of the electrolyte greatly affects the smoothness of electro-deposition.

Example :- silver from silver nitrate solution forms rough deposite, but silver from cyanide forms a smooth deposite.

(6) Nature of the metal ~~open~~ upon which deposite is to made :-

(7) Throwing power :-

(i) The throwing power of an electrolyte is defined as the quantity which produces a uniform deposite on a cathode having an irregular shape.



$R = \rho \frac{l}{A}$

(ii) The distance between anode and 'AB' is more. so resistance is high and current is less. As a result the deposition is less in 'AB' as compared to 'CD'.

(iii) The throwing power can be improved in two ways.

(a) By increasing the distance between cathode and anode

(b) By using some colloidal particle

which increased the current density.

e.g → cyanide of metals increase the throwing power

Application of electrolysis :-

(1) extraction of metals from their ores.

(i) The ore is first treated with acid to obtained a salt and the solution of the salt is electrolised to liberate the metal.

(ii) when the ore is in molten state, it is electrolised in the furnance.

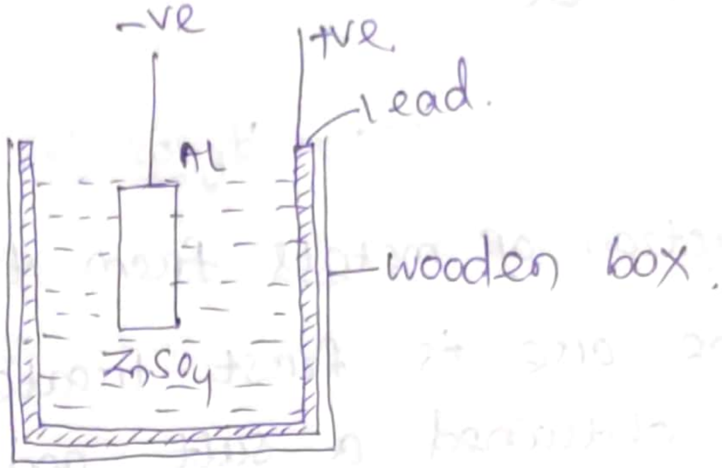
(2) extraction of zinc :-

(i) The zinc oxide (zinc ore) is treated with concentreated sulphuric acid and passed through various chemical process to get rid of impurities like cadmium, copper etc by precipitation.

(ii) Then electrolysis process is carried out in wooden box with inner lining of lead.

(iii) Here anode is lead and cathode is

Alumininum. In this process zinc is deposited on the cathode.



(3) extraction of Alumininum :-

(i) the aluminium ore (cryolite, barurite) is treated chemically and reduced to aluminium oxide and then electrolytic process is started.

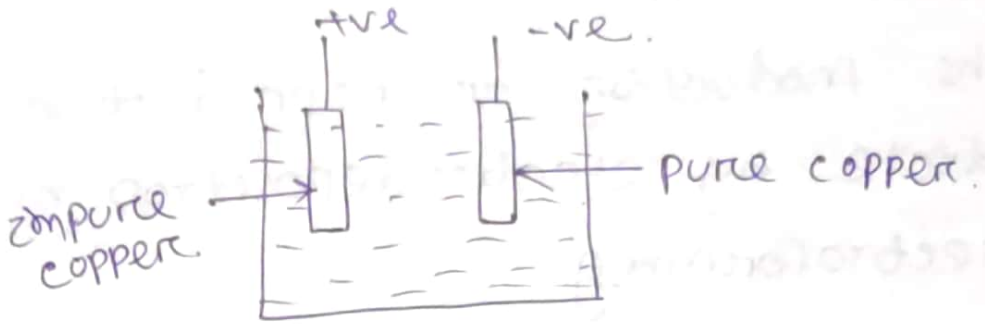
(ii) Then aluminium metals get deposited at the cathode.

(4) Refining of metals:-

(i) The metal extracted are not much pure, so using electrolysis the purity is increased to 99.95 %.

(ii) copper sulphite is taken as electrolyte and impure copper is as anode.

(iii) Through electrolyte process the pure copper get deposited on the cathode.



(5) Production of chemicals like caustic soda, chlorine gas, Amonium sulphate, hydrogen and oxygen.

(6) Separating metals, like aluminium from its compound of aluminium oxide, silica and iron oxide.

(7) Electroforming :-

(i) The Production or reproduction of an article by electrodeposition is known as Electroforming.

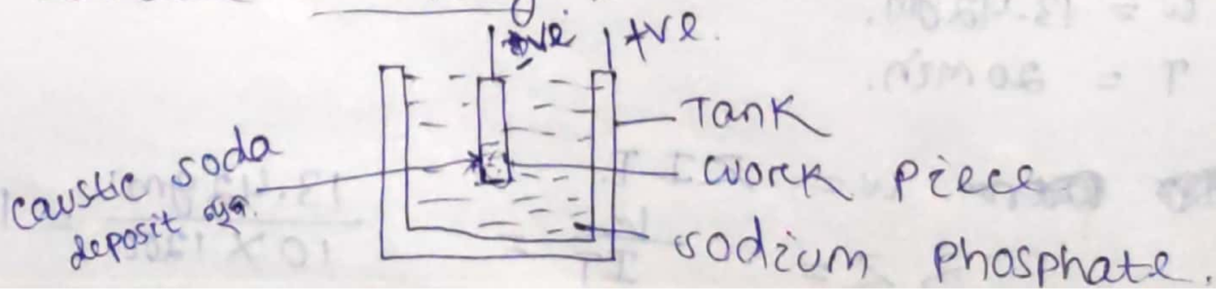
(ii) first of fall an impression of Point is made in wax surface. Then it is coated with graphite powder in order to make it conducting.

(iii) Then it is dipped in an electroforming cell as a cathode. After the given ~~the~~ metal is coated on the mould, the wax is melted out of the metal shell.

(8) Electrodeposition :-

(i) Electro deposition is carried out for deposition of one metal over another.

(9) Electro cleaning :-



caustic soda → oil remove

Hydrogen (H) → remove grease

(i) Before electroplating process the article is need to be free from grease and oil through electrocleaning process.

(ii) In this process sodium phosphate is taken as electrolyte solution.

(iii) +ve supply is given to the inner lining of tank.

(iv) The workpiece to be cleaned is used as cathode

(v) In this process of electrolysis, caustic soda is deposited on the cathode surface which removes oil from the workpiece

(vi) In the ~~mean~~ mean time hydrogen gas is involved which helps in removes grease from the work piece.

This cleaning process is known as cathodic cleaning.

2nd chapter

Electrical heating :-

(i) Electrical heating is based on the principle that when the electric current passes through a medium (solid, liquid, gas) heat is produced.

(ii) There are three modes transmission of heat.

conduction – solid
convection – liquid.
Radiation – gas.

Domestic application of electrical heating :-

(i) Room heater. for heating building.
(ii) immersion heater. for heating water.
(iii) Gyser
(iv) Electrical iron.
(v) Hot air driers.
(vi) electrical oven.
(vii) electrical toaster.

Industrial application of electrical heating:-

(i) melting of metal.
(ii) electric welding.
(iii) moduling plastic components.

(iv) Enamelling of copper conductors.

Electrical heating

- Frequency heating
  - Resistance heating
    - Direct resistance heating.
    - Indirect resistance heating
  - Arc heating
    - Direct
    - In-direct
- High frequency heating
  - Induction heating
    - Direct core type.
    - Coreless type.
    - Vertical core type.
    - Indirect core type.
  - Dielectric heating

Advantages :-

(i) Clean and neat atmosphere.

(ii) No pollution.

(iii) Temperature control.

(iv) Automatic switching control is possible.

(v) The heating is uniform through out the process.

(vi) No extra construction is required

(vii) High efficiency as compare to other heating process.

(viii) Portable in nature.

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Methods of heat transfer :-

(1) conduction
(2) convection
(3) radiation.

conduction :-

(i) The flow of heat along a substance or object depends upon the temperature variance.

(ii) Each molecules of the substance get heated and transfer the heat to the adjacent one., thus making heat travel from one point to another.

convection :-

(i) most common example of heat transfer by this method is heating of water by an immersion heater, where convection are set up and water gets heated by this.

Radiation :-

(i) heat reaches the object from the source without heating the medium in between them.

Stephan's law (Stephan-Boltzman's Law):-

Heat dissipated $= 5.72 \times 10^4 \, ke \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4 \right] \text{watt}/m^2$

T_1 = Temperature of the source in ° absolute

T_2 = Temperature of the object obserbing the heat in ° absolute.

K = constant (depending on radiating frequency).

e = emissivity $\begin{bmatrix} 1 = \text{black body.} \\ 0.9 = \text{resistance heating element.} \end{bmatrix}$

Stephan's law states that, energy radiated per second per unit area by a perfect body varies directly as the 4th power of its absolute temperature.

mathematically $E \propto T^4$

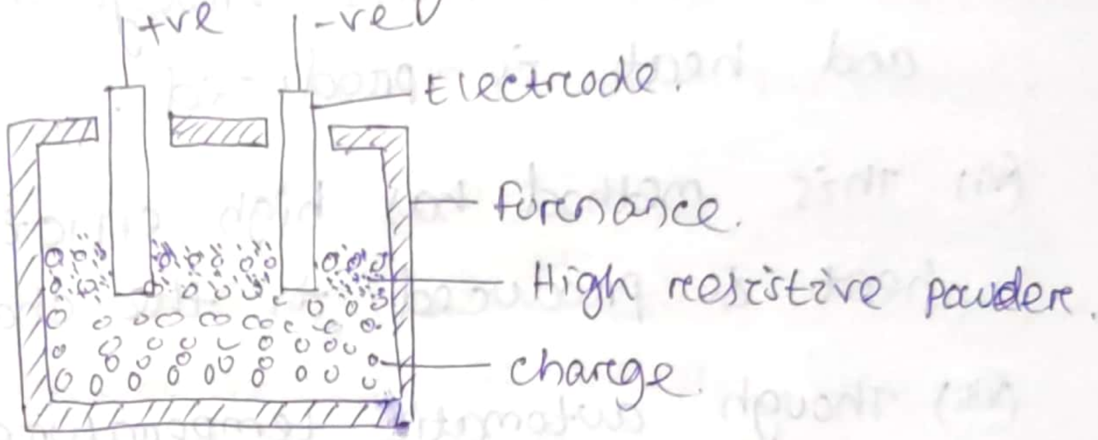
Resistance heating :-

(i) This method is based upon the I^2R loss, whenever current is passed through a resistive material, heat is produced because of I^2R loss. There are two methods of resistance heating.

(i) Direct resistance heating.

(ii) Indirect resistance heating.

Direct resistance heating :-



(i) In this method of heating the material or charge to be heated is taken as a resistance and current is passed through it.

(ii) The charge may be in the form of powder piece or liquid.

(iii) The two electrodes are immersed in the charge and connected to the supply.

(iv) In case of DC or single phase AC, two electrodes are required, but there will be three electrodes in case of three phase supply.

(v) when metal pieces are to be heated a powder of high resistivity material is sprinkiled over the surface of the charge to avoid direct short circuit

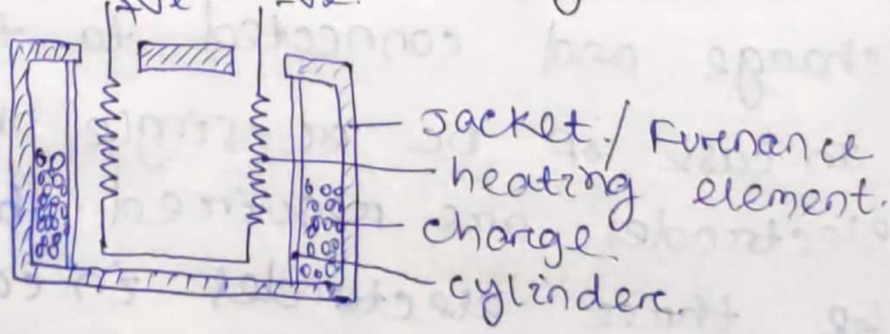
(vi) The current flows through the charge and heat is produced.

(vii) This method has high efficiency, since heat is produced in the charge itself

(viii) Though automatic temperature control is not possible in this method, it gives uniform heat and high temperature.

(ix) one of the major application of this process is ~~saalt~~ salt bath. It's operating temperature ranges between (500°c – 1400°c.)

Indirect resistance heating :-



(i) In this method the current passed through a highly resistive element which is either placed above or below the oven depending upon the nature of the job to be performed.

(ii) heat proportional to the I^2R losses produced in heating element delivered to the charged either by radiation or by convection.

(iii) In industrial heating the resistance is placed in a cylinder which is surrounded by the charge placed in the jacket as shown in the figure.

(iv) The arrangement provides an uniform temperature.

(v) Here automatic temperature control can be provided.

(vi) common example of this type of heating is electrical oven.

<u>Arc Furnace</u> :-

(i) The furnace used for melting/extraction of ferrous and non ferrous metals need a high temperature operation.

(ii) Arc is the flow of current through

an air gap between the two conducting bodies.

(iii) Two types of arc furnance is there

(1) Direct arc furnance.

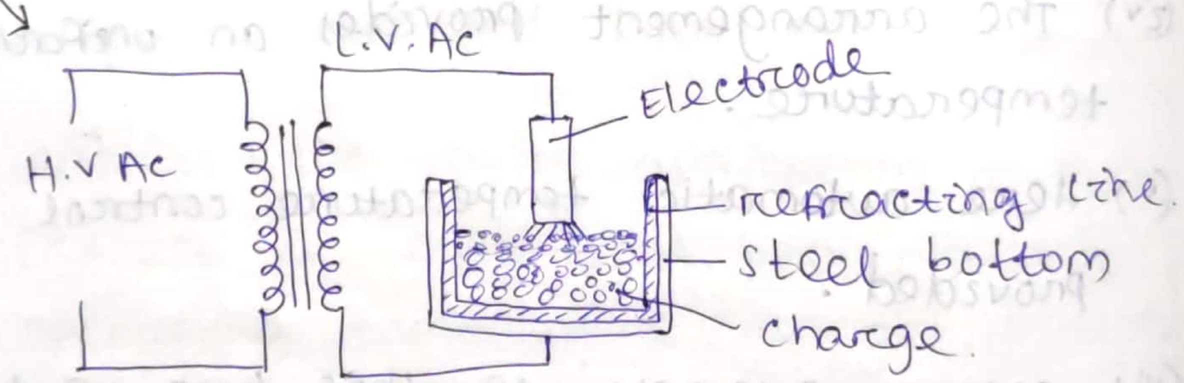
(2) Indirect arc furnance.

Direct Arc furnace :—

(i) These furnace can be further subdivide into two categories i.e.

(1) conducting bottom type

(2) Non-conducting bottom type.



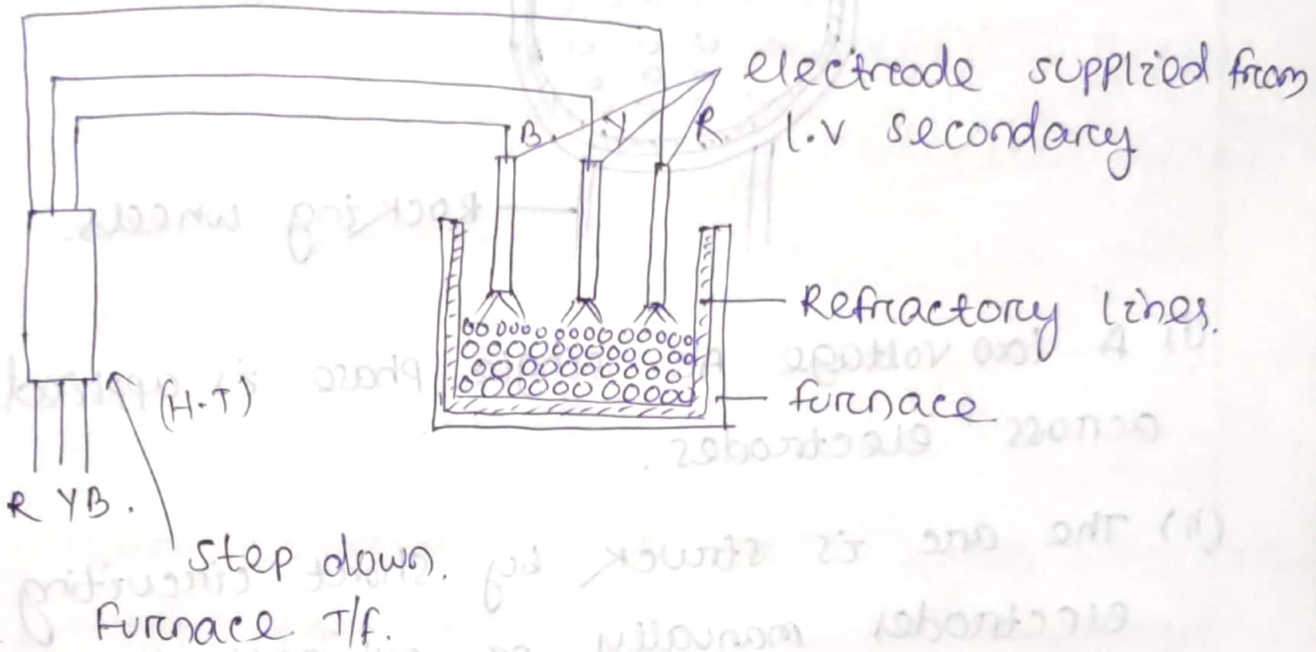
(i) In the conducting ~~to~~ bottom type arc furnace, ~~the conducting~~ steel used as the conducting surface of the furnace to make the electrical ckt complete.

(ii) when the apply a 1-ϕ supply to the electrode through a step down T/F.

high current will flow through the air gap between electrode and charge.

(iii) As a result arc will be produced and the heat is transfered to the charged directly.

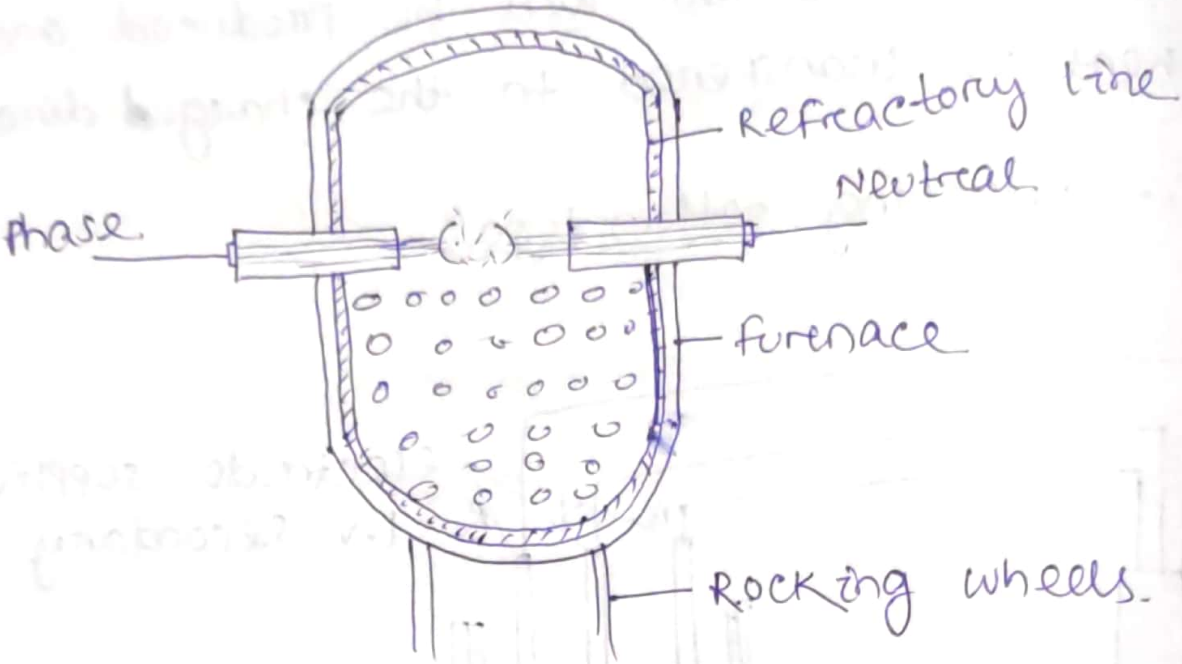
Non-conducting bottom type:-



(i) Here no current flows through the body of the furnace.

(ii) most of the furnace used are non-conducting bottom type due to insulation problem faced in case of conducting bottom.

Indirect arc furnace :-



(i) A low voltage AC single phase is applied across electrodes.

(ii) The arc is struck by short circuiting the electrodes manually or automatically for a moment.

(iii) The heat from the arc is transfered to the charge top layer and refractory line through radiation. and from top layer to the bottom through conduction process.

(iv) To distribute the heat properly, the furnace has to be rocked continuously exposing further layer not only from the arc but from the exposed lining.

(v) Since the unit is working on a 1-ϕ a great unbalanced will ~~resolved~~ result, if a furnace transformer without 3-ϕ is not used.

(vi) The furnace are not supposed to handle melting beyond one tonne for the same reason.

(vii) The unit works quite efficiently.

(viii) Special motores with reduction gears with reversing direction are used for rocking.

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Principle of induction heating :-

→ Eddy current which provides the basis for induction heating are used for melting of metals.

→ The induced emf is depended upon the rate of change of flux '$\frac{d\phi}{dt}$'. Therefore magnitude of eddy current is proportional to frequency of supply.

→ Heat produced is thus proportional to I^2, the eddy current heating effect is proportional to f^2.

→ The flux density is produced is proportional to relative permeability.

$$B = \mu_0 \mu_r H.$$

where,

$$H = \frac{NI}{l}$$

$\mu_r \rightarrow$ Relative permeability

$H \rightarrow$ magnetic intensity.

$l \rightarrow$ length of magnetic ckt

→ Greater is the no. of turns of the coil greater will be the magnitude of the flux. Thus eddy current heating is a function of 'N'.

$$W_e = K B_m^2 f^2$$

eddycurrent loss.

Hysteresis :-

(i) The losses occuring in any electromagnetic device are name as hysteresis loss.

(ii) The energy lost is converted into heat.

(iii) Greater is the frequency of supply Larger will be the no. of such loops ~~traced~~ traced / second. , and more will be the heat produced.

$$W_h = K B_m^{1.6} f.$$

Different types of induction furnace :-

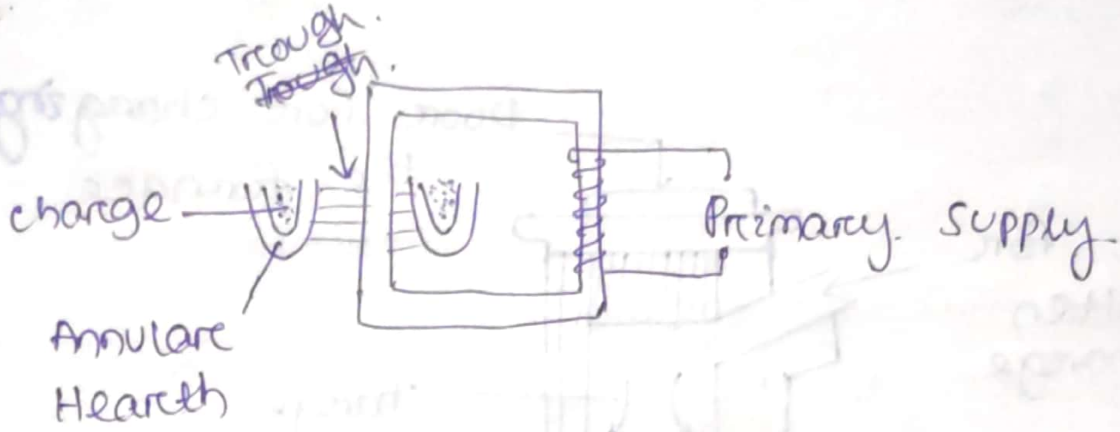
(1) Direct core type

(2) Vertical core type

(3) Indirect core type.

(4) core-less type induction furenace

Direct core type :-



(i) It is like a T/F, the charge forms the secondary winding and consist of one turn only formed by the metal to be melted.

(ii) The charge is magnetically coupled to the primary winding.

(iii) When there is no molten metal, no current will flow in the secondary

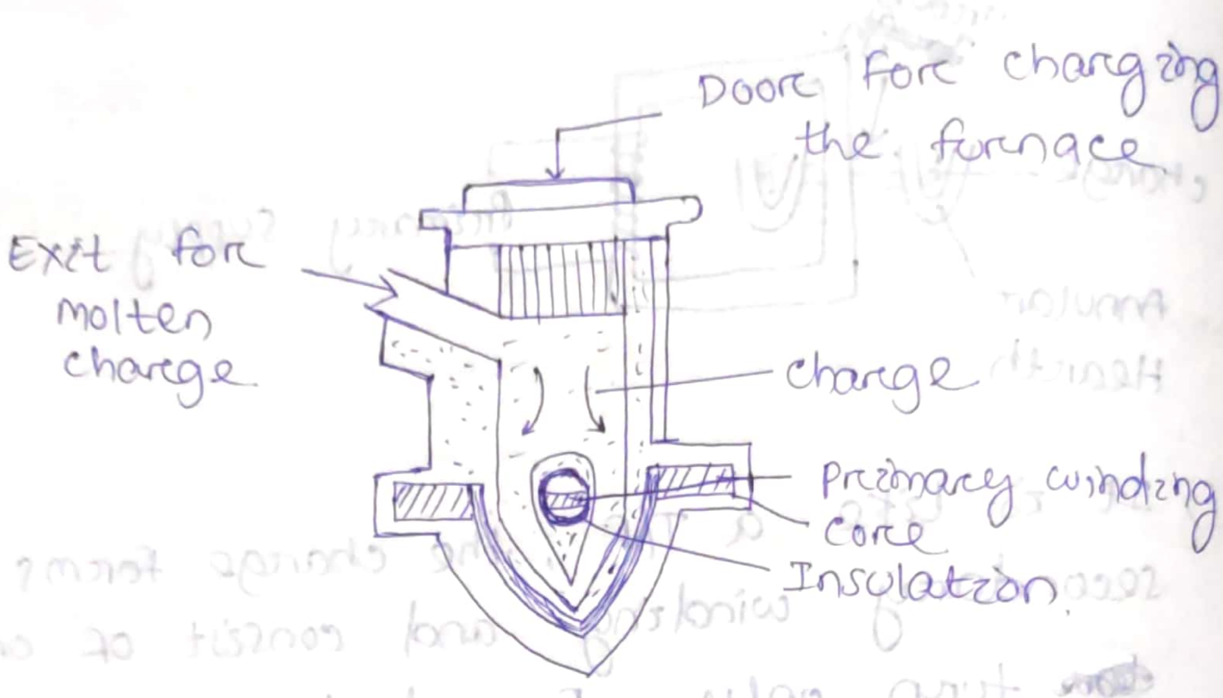
Drawbacks :-

(i) leakage reactance is high.

(ii) P.F is low due to poor magnetic coupling

(iii) Pinch effect causes interruption of secondary.

Vertical core type :-



(Ajax - wyatt vertical core type)

(i) This furnace is an improved covered core type furnace.

(ii) It has vertical channel for the charge. It is also known as Ajax-wyatt vertical core type.

(iii) Here the magnetic coupling is better than core type.

(iv) leakage reactance is low, power factor is high.

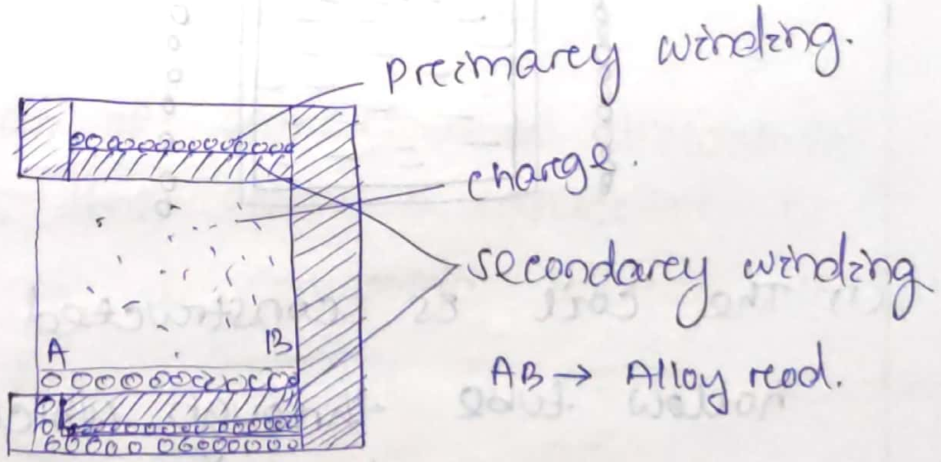
(v) It can be operated from normal frequency supply.

(vi) The circulation of molten metal is kept up round in the V-portion by convection currents as indicated in the figure.

(vii) The furnace is suitable for continuous operation. The ~~trough~~ top is covered with insulated cover which can be removed for charging.

(viii) It is very widely used in industries for melting and refining brass and other non-ferrous metals.

Indirect core type :-



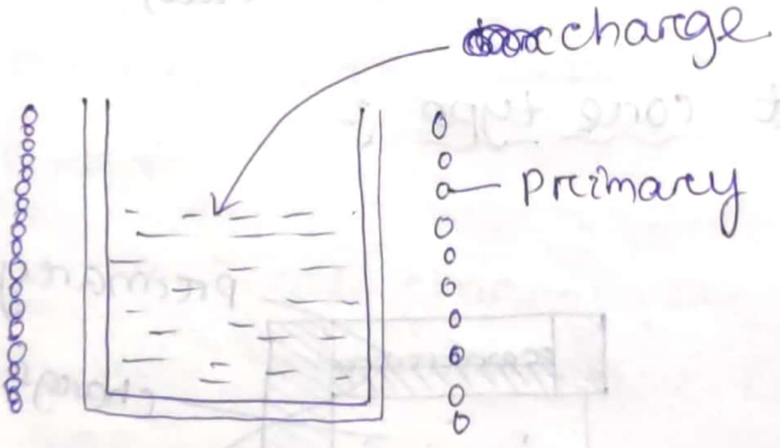
(i) The induction principle can also be used for general heat treatment through radiation process.

(ii) Here secondary windings forms the wall of metal container. and the iron core links the primary as well as secondary winding.

(iii) Here the temperature control is possible

(iv) The 'AB' portion indicated in the figure is a special alloy which losses it's magnetic property beyond a certain temperature we can easily detached the 'AB' rod for temperature control.

Core less Induction furnace :-



(i) The coil is constructed in the form of hollow tube through which cold water is circulated.

Advantage :-

(i) Time taken to reach the melting temp. is less than other.

(ii) Presize control of heat on to the charged can be employed.

(iii) charging and pouring is simple.

(iv) There is no dust, smoke, noise etc.

(v) cost effective.

Dielectric Heating principle :-

(i) This is called high frequency capacitive heating.

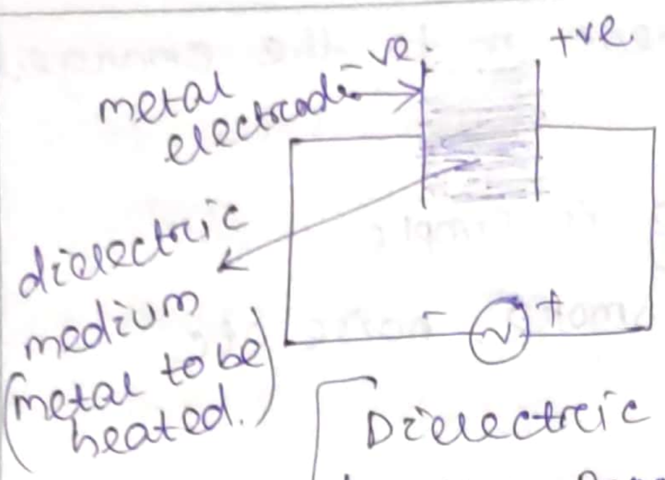
(ii) It is employed for heating of insulating material like wood, plastic and ceramic. etc.

(iii) supply frequency of 10-30 m cycle/sec (MHz) with voltage of 20 KV is required for this process.

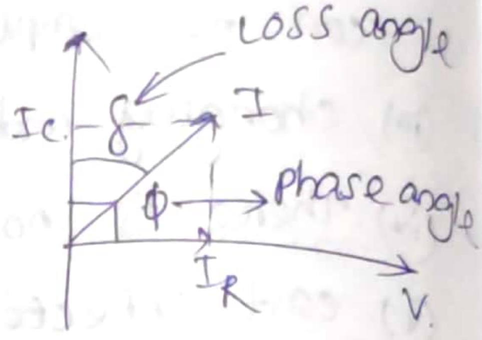
(iv) A principle of operation of dielectric heating is that other a capacitor is subjected to a sinusoidal voltage, the current drawn by, it is never leading the voltage exactly by 90°.

(v) Here the resistance (R) is very high so that current flowing it is very small. so that

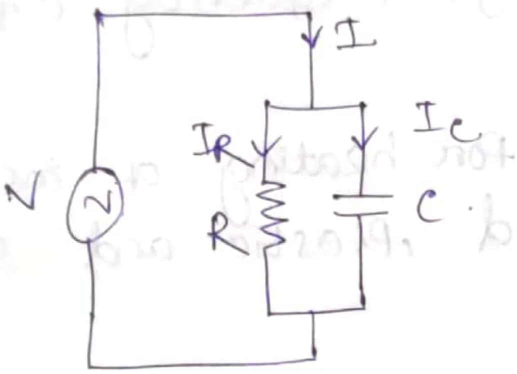
$$\boxed{I \simeq I_c}$$



[Dielectric heating Process]



(Phasor diagram)



(Equipment electrical circuit)

Power consume (P) = VI $\cos\phi$.

$$I_c = \frac{V}{X_c} = \frac{V}{\frac{1}{2\pi f C}} = 2\pi V f C.$$

$$\boxed{I_c = 2\pi V f C}$$

$\Rightarrow P = V I_c \cos\phi.$

$\Rightarrow P = V\, 2\pi V f C \cos\phi.$

$\Rightarrow P = V^2 2\pi f C \cos\phi.$

$\phi = 90^\circ - \delta$

$\cos\phi = \cos(90° - \delta)$

$= \sin\delta$

$P = 2\pi V^2 f C \sin\delta$.

As the loss angle is very very small

$\sin\delta = \tan\delta = \delta$.

$\Rightarrow \boxed{P = 2\pi V^2 f C \delta}$ watt.

$C = K K_0 A/d$. K_0 = Permittivity.

where.

$K_0 = 8.854 \times 10^{-12}$ f/m.

A = surface area of the metal to be heated

d = Thickness of the material to be heated.

Here capacitance c and loss angle δ are constant. so the heat generated is directly proportional V^2 & f.

$P = 2\pi V^2 f C$

So,

$\boxed{P \propto V^2 f}$

Here,

$[2\pi C = \text{constant}]$

Microwave heating :-

(i) In this system the electrical wave is converted in to electromagnetic waves which generates heat energy used cook the food.

(ii) These waves are high frequency radio-waves. also known as microwaves.

(iii) when a microwave energy comes into contact with some substance, it is reflected, transmitted or absoreb.

(iv) These waves are reflected by metals transmitted through paper, glass, plastic etc. and absorbed by water or moisture present in the food.

(v) when this energy is absorbed, heat is produced and coocking takes place.

(vi) The microwaves are attracted to water, fat and sugar molecules. They cause these molecules to vibrate at 2400 MHz. leading to friction with in the food. which generates heat.

(vii) The microwave heating is used in the microwave oven for baking purpose.

(viii) The frequency is used is from 900-2400 MHz.

Application :-

(i) Baking and manufacture of bread, toaste, etc.

(ii) drying of paper and textiles.

(iii) food processing and kitchen work.

(iv) Treatment of diseases like cancer.

(v) manufacture of plastic.

(vi) processing of cement.

Advantage :-

(i) It has neat and clean system.

(ii) It provides uniform heating to the ~~syst~~ substance.

(iii) The system provides quick heating.

(iv) The depth of penetration of heat in to the material is much more.

3rd chapter:-

Arc welding :-

T = 3000°C.

V = 100 V.

I = 75-600 Amp.

Types of arc welding :-

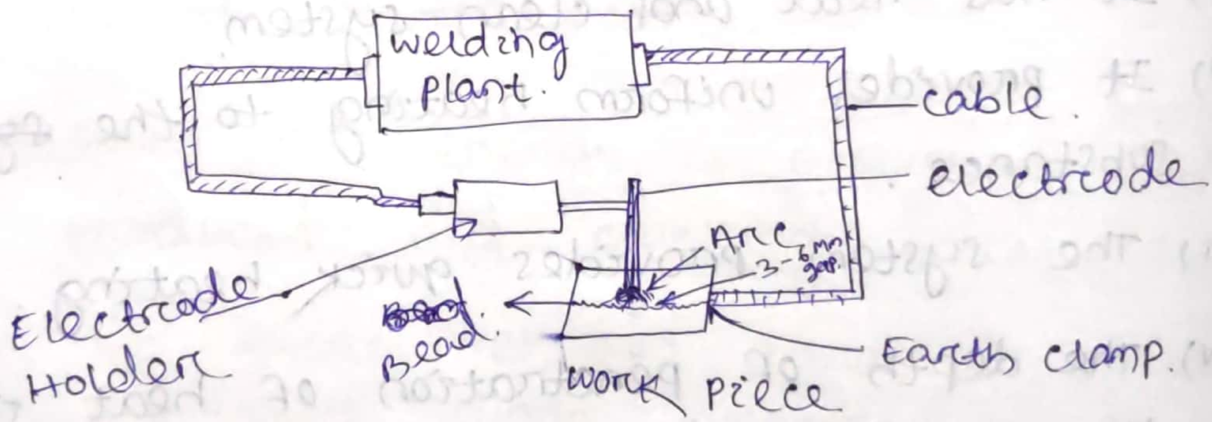
(1) carbon arc welding.

(2) metal Arc welding.

(3) Atomic hydrogen Arc welding.

(4) Helium or Argon Arc welding.

Principle of Arc welding :-



(i) current from an AC or DC source is applied, one terminal is connected to the electrode and the other to the work piece.

(ii) The arc gap of 3mm - 6mm is maintain to Produce the arc. due to the interruption of arc heat is produced with the range of 3700° – 4000°c .

Necessary condition for Arc welding :-

(i) Aluminium and certain alloys can only be welded with DC.

(ii) High striking voltage to maintain the Arc.

(iii) Relatively low supply voltage to enable the earth

(iv) A limited current value to melt the electrode and parent metal without burning

Sparking/striking voltage → 80-100V AC
60 – 80 V DC.

Arc voltage → 20-35 V.

current → 15-600 A.

Types of welding equipment :-

(1) DC welding equipment :-

→ A motor generator set is present in the welding plant . Here 1-φ squirrel cage induction motor and differential compound DC generator are used.

(ii) Due to drooping characteristics of differential compound generator, with increase of load current the terminal voltage will be low.

(iii) A ~~balanced~~ ballast resistance is ~~closed~~ put in series to control current.

(iv) for multioperation separate ballast is used.

AC welding equipment :-

(i) A step down T/F is present in the welding plant a resistance with reactance is used for well operation below saturation point to avoid harmonics and prevents cooling of Arc.

Advantage of DC welding :-

(i) Direct current Electrode positive (DCEP) is used for deeper penetration welds.

(ii) DC electrode negative (DCEN) deposits more metal in the joint.

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Disadvantage of DC welding :-

(i) It is more costly as compare to AC welding.

Uses of AC welding equipment :-

(i) For moderate operation this type of welding is required.

(ii) more diameter is required to half more AC current.

(iii) The cost is very low.

Resistance welding :-

(i) It may be defined as the method in which a sufficiently strong electric current is sent through the two metals in contact to be welded, bringing the two pieces to the molten state and thus applying mechanical pressure at this time to complete the joint.

The heat generated $H = I^2RT$.

(ii) The amount of current required is 4400 – 5000 A/m^2.

(iii) pressure varies around 565 kg/m^2.

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Advantage :-

(i) It is a quick method of joining two pieces

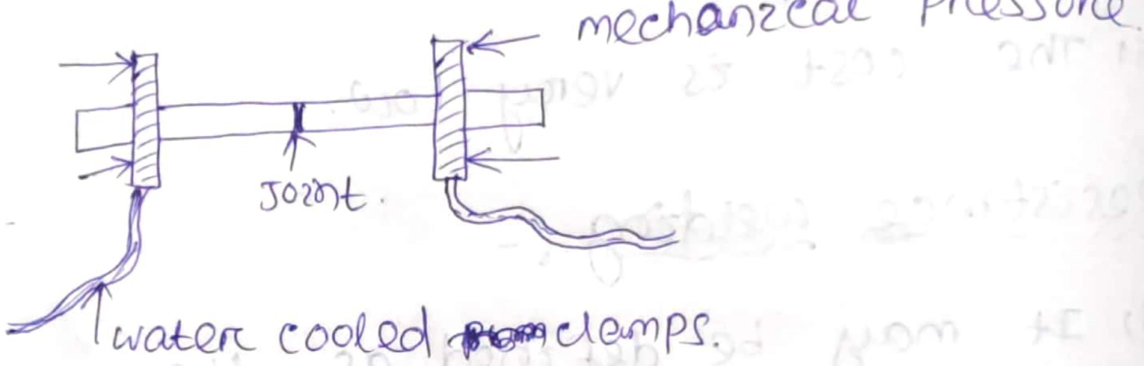
(ii) There is a very little wastage of metal.

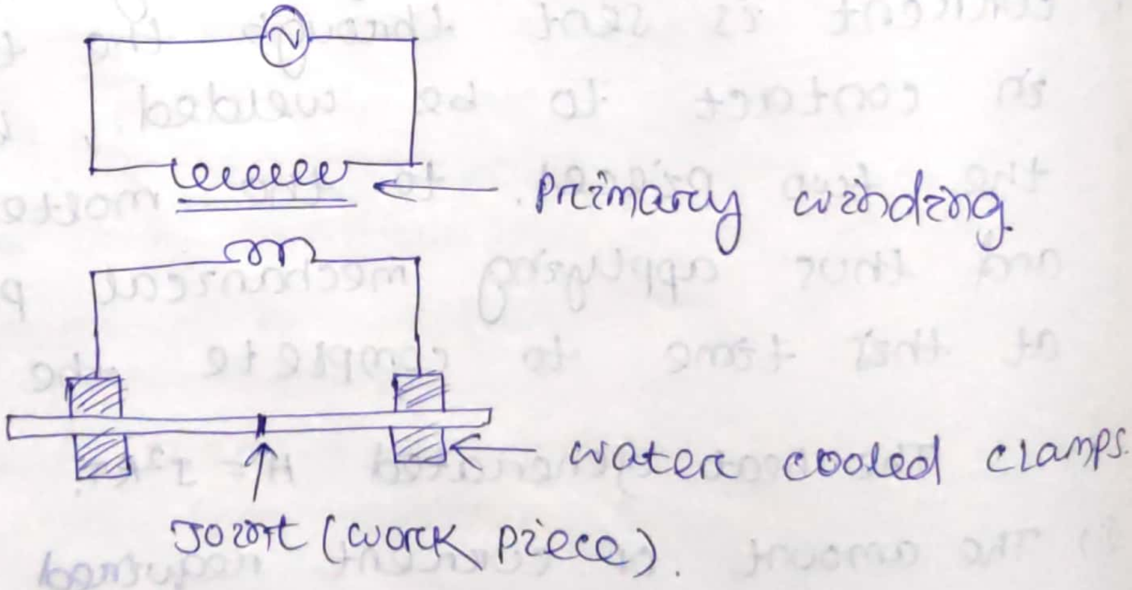
(iii) Process can be accurately controlled.

(iv) The wells are consistantly uniform.

Types of resistance welding :-

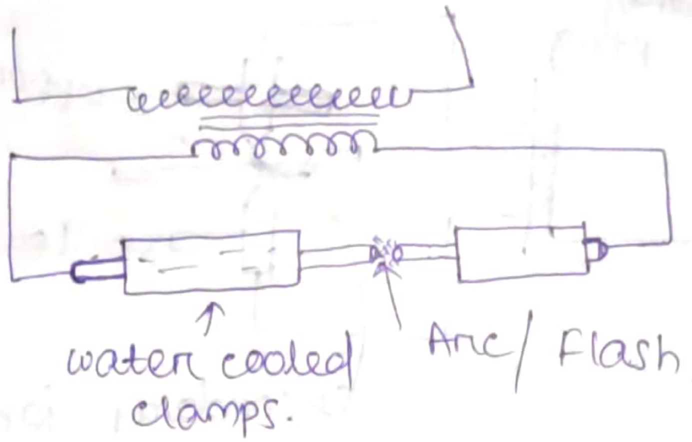
1. Butt welding :-





[Electrical Equivalent]

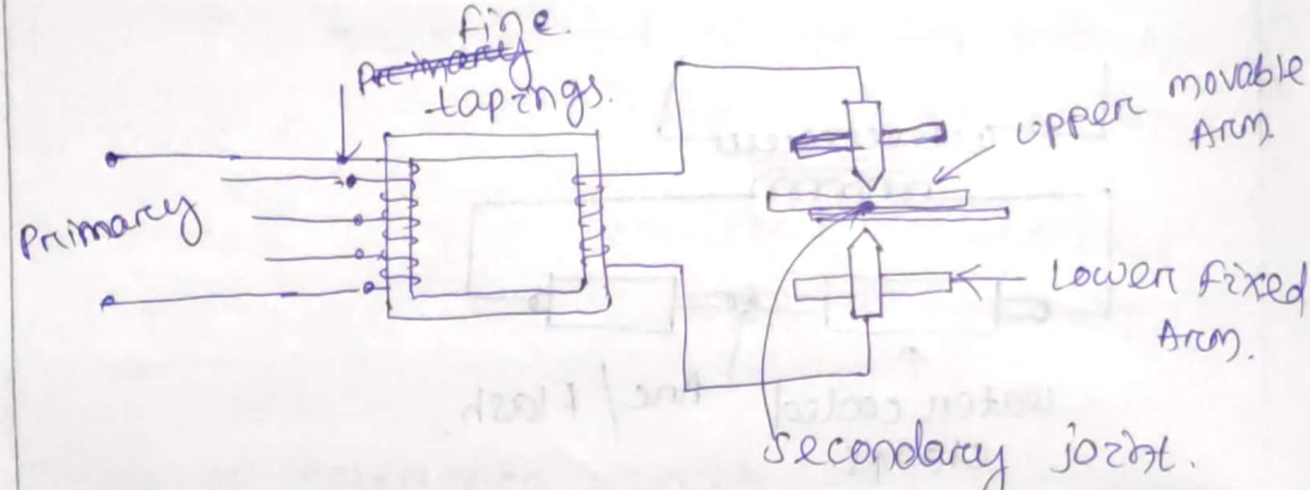
2. Flash welding :-



(i) This is similar to butt welding.
(ii) Before welding separation between two metal is kept. by the application of secondary supply voltage, a high current pass through the gap and formation of Arc/Flash takes place.
(iii) In this process the two surface of the metal get heated and through the mechanical spring action the two metal faces are brought together.

Application :-
(i) Pipes and rods.

• Spot welding :-



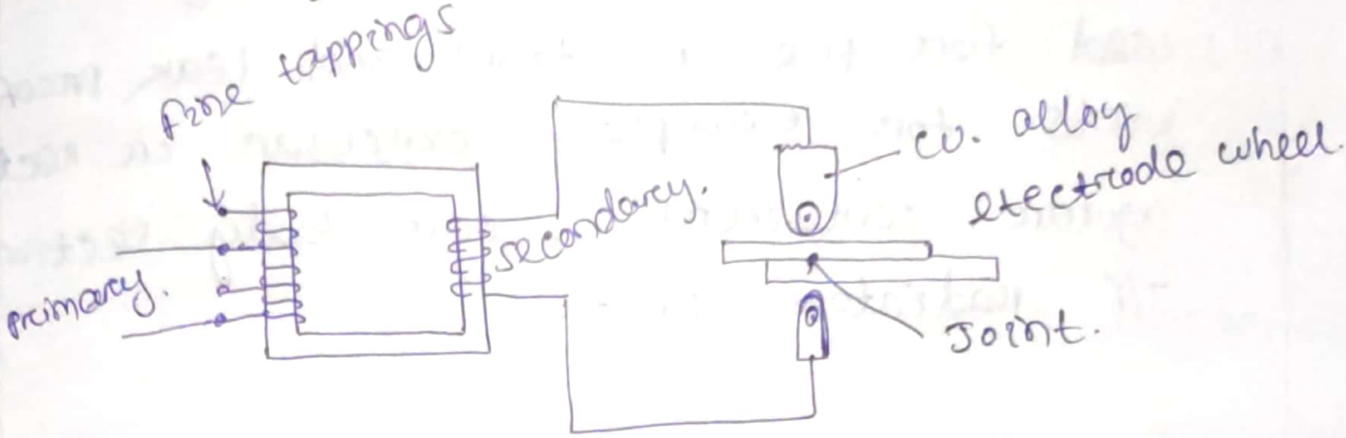
(i) This is the simplest and most universally adopted method of making lap welds in thin sheets up to a maximum thickness of 12.7mm.

(ii) In it's simplest form the spot welding machine consist of a transformer to produce high current at low voltage electrodes are connected to the ends ~~to the work~~ of the secondary winding for leading the current to the work and to apply the necessary mechanical pressure

Application :-

(i) It is applied to welding of sheets.
(ii) It may be applied to all types of boxes, cores and enclosing cases etc.
(iii) It is used for fabricating all types of sheet metal structure.

4. Seam welding :-



(i) This similar to spot welding, but series of spot are produced due to roller mechanism.

(ii) As the roller passes over the overlapped metals under pressure, current passing between them produced it.

(iii) The main objective is to produce gas and liquid leak proof lap joints.

(a) When current turns off regularly a overlapped spot produced.

(b) An uninterrupted flow of current to the electrodes will ~~flow~~ form a continuous seam.

Application :-

(i) used for making lap joints. and butt joints

(ii) It is quicker than spot welding.

(iii) used for pressure tight and leak proof joints. for example. circular or rectangular containers, car body section, T/F radiator unit.

Automatic hydrogen Arc welding :-

The essentials of automatic hydrogen welding process are.

(i) Electrode energy is supplied to an Arc between two tungsten electrode where it is transferred into heat.

(ii) moleculare hydrogen is blown through this arc and transferred into automatic form due to high temperature of 6000°c.

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(iii) The heat recombination process arround the vicinity of arc produced.

(iv) To strike and maintain the arc an open ckt voltage of 300V. is necessary and for hand welding 50A current is required. In this type of welding the arc is struck between two tungsten electrodes and hydrogen is passed through the arc.

(v) Due to high temperature hydrogen changes to its automatic form when the automatic hydrogen travels to coolere reason in the vicinity of the arc. It regains its moleculare form by given of heat energy

(vi) Thus a very intense heat is produced which is used it additional metal is needed for making a joint.

(vii) This method is successfully used for welding stainless steel and moist non- ferous metal.

Illumination :-

Nature of radiation :-

corpuscles Theorem :-

Light consist of a stream of extreemely minuee particale called corpuscles which were shoot from a hot body, when impinged on human eye produced some sensation.

wave Theory :-

The wave theory states that There is a need of medium to transmit the Light.

Later a principle theory known as quantum theory was introduced. Energy is emitted and absorb only in descreate quanta of magnitude hf.

h = plank's constant.
$= 6.547 \times 10^{-27}$ erg sec.

The descreate bundles ~~and~~ or quanta of energy is known as photon.

→ The electron from lower orbit transmitted to the higher orbit by absorbing photons after 10 nsec, they come to the normal state by emitting energy.

→ Each photons may be considered as a wave. So it is associated with frequency, wave length and velocity.

$$v = \lambda f.$$

→ The light spectrum consist of 7 colour, ~~consist of~~ 'VIBGYOR'.

→ unit of wavelength → Angstrom. 1. → $= 10^{-10}$ m.

1 micron $= 10^{-6}$ m.

Wavelength.	Name	frequency
10^{-14}	cosmic	3×10^{22}
10^{-12}	γ	
10^{-10}	x	
10^{-8}	ultraviolet	
10^{-6}	$\boxed{\text{Visible}}$	
10^{-4}	infrared.	
10^{-2}	Short wave	
10^{2}	long wave	3×10^{12}

Radio wave.

4000 — V I B G Y O R — 7000

Angstrom.

Terms used in illumination :-

Luminous Intensity :-

(i) Luminous intensity in any particular direction is the luminous flux emitted by per unit solid angle by a point source and is denoted by 'I'.

$$I = \frac{F}{\omega} = \frac{\phi}{\omega} \text{ lumens/steradian or candla.}$$

(ii) It is the ratio of brightness of a source of light to that of standard candle. One candle gives out luminous flux of 4π lumen in space. Thus lumens emitted by one candle source of light is one lumen / steradian.

(iii) In scientific terms candla is defined as the luminous intensity in the perpendicular direction of a surface of 1/600,000 sq. metre of a full radiator at the temperature of freezing Plantinum under a pressure of 101,325 N/sq. metre.

Illumination :-

(i) When the light falls upon any surface, the phenomenon is called illumination. It is defined as the number of lumens falling on the surface per unit area.

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(ii) It is denoted by symbol E and is measured in Lumens per square metre or lux or metre candle.

(iii) If a flux of ϕ Lumens falls on a surface of area A, then the illumination of that surface is $E = \phi/A$ Lumens/m^2 or lux or metre-candle.

Bigger unit of illumination is phot.
one phot = 10^4 Lux.

MHCP (mean Horizontal candle power) :-
(i) It is average of all the candle powers in all directions in the horizontal plane containing the source of light.

MSCP (mean spherical candle power) :-
It is defined as the average of candle powers in all directions ~~above or~~ and in all plans from ~~through~~ the source of light

MHSCP (mean hemi-spherical candle power) :-
It is defined as the average of candle powers in all directions above or below the horizontal plane passing

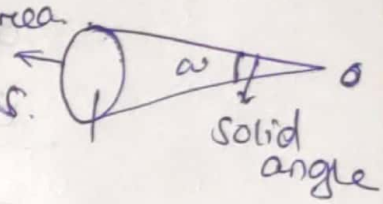
through the source of light.

Solid angle :-

(i) Solid angle is the angle generated by the line passing through the point in space and the periphery of the area or A solid angle enclose a volume by an infinite number of lines lying on a surface and meeting at a point.

(ii) It is measured in steradians and is denoted by ω and

$$\omega = \frac{\text{Area}}{(\text{Radius})^2} \text{ steradians.}$$



(iii) where one steradian is the angle subtended at the centre of a sphere by an area on the surface of the sphere which is numerically to the square of the radious.

(iv) The total plane angle subtended by circumference of a circle at the centre of circle is 2π radians.

(v) Similarly total solid angle subended at a point in space is obtained by considering point at the centre of sphere and the surface area of the sphere.

Luminous efficiency :-

It is defined as the output in lumens per watt of the power consumed by the source of light. It is measured in lumens per wattage.

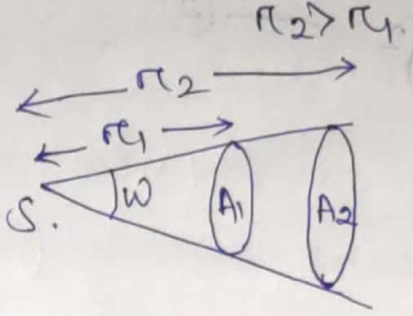
If,
 E = Energy radiated at wave length λ.
 h = The relative sensitivity of eye at wave length λ.
 K = maximum possible efficiency if whole of the electrical input were transformed into radiating energy at 5550 A.U
 = 620 lumens/watt.

$\boxed{\text{Efficiency at wave length}, \lambda = hK}$

Laws of illumination :-

1. Inverse square law :-

This law states that the illumination of a surface is inversely proportional to the square of the distance between the source and surface, provided that the distance between the surface and the source is sufficiently large. So that the source can be regarded as a point source.



→ consider a point source 's' having an intensity I lumens / steradian.

→ let two surface having area A_1, A_2 be placed at distance r_1 and r_2 respectively from the source.

→ The two surface are enclosed in the same solid angle 'w'.

<u>for surface A_1</u>

Total luminous flux (ϕ) = Iw. $\left[I = \frac{\phi}{w} \right]$.

solid angle $(w) = \frac{\text{Area}}{(\text{distance})^2} = \frac{A_1}{(r_1)^2}$

Total flux $(\phi) = Iw$.

$= I \times \frac{A_1}{(r_1)^2}$ ①

illumination $(E_1) = \frac{\phi}{A_1} = \frac{I A_1}{r_1^2} \times \frac{1}{A_1} = \frac{I}{(r_1)^2}$

Similarly we can find

$$E_2 = \frac{I}{(r_2)^2} \quad \text{---} \; (2)$$

$$\frac{E_1}{E_2} = \frac{(r_2)^2}{(r_1)^2}$$

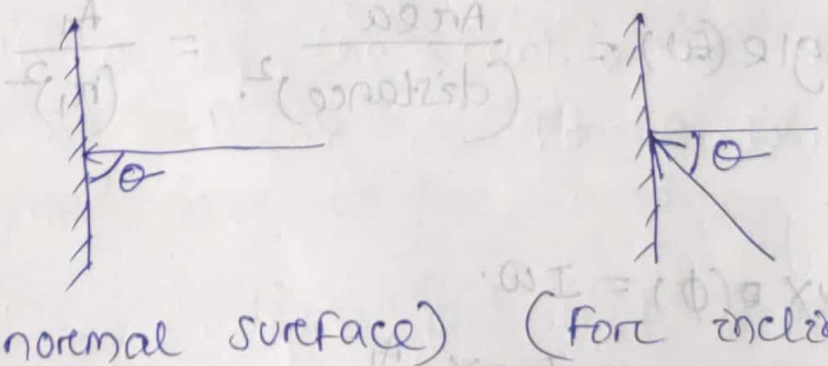
2. <u>Lambert's cosine law</u> :-

This law states that illumination of a surface varies directly as the cosine of the angle between the normal to the surface and direction of incident light.

$$E \propto \cos\theta$$

(i) For normal surface, $E = \frac{\phi}{\text{Area}}$

(ii) For inclined surface, $E = \frac{\phi}{\text{Area}} \cos\theta$



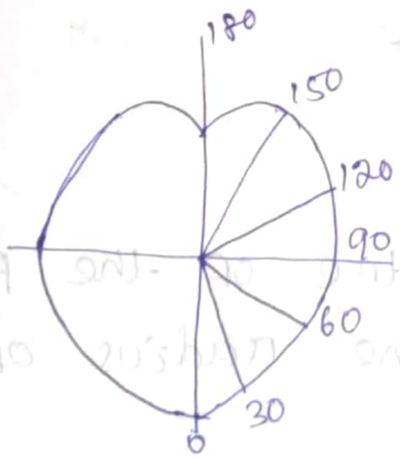
(For normal surface) (For inclined surface)

Polar curves :-

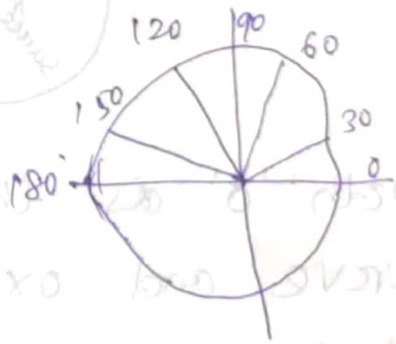
→ The curve representing the unequal distribution of luminous intensity or candle power in any direction due to its unsymmetrical shape is known as polar curve.

→ A radial ordinate in any particular direction on a polar curves represents the luminous intensity of this source when viewed from that direction.

→ Horizontal ~~power~~ polar curves is obtained between candle power and angular position in a horizontal plane



(Vertical polar curves)



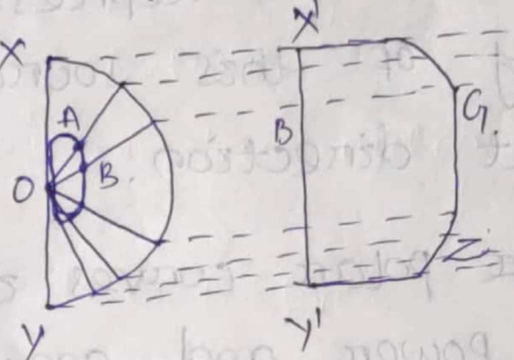
(Horizontal polar curves)

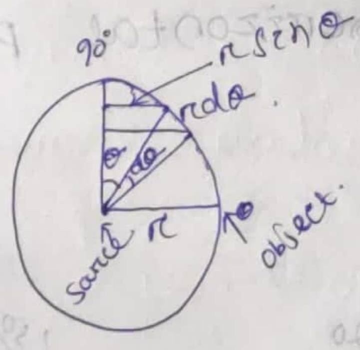
→ Similarly the luminous intensity measured in vertical plane about a horizontal axis gives vertical polar curves

→ The polar curves are used to find the mean horizontal candle power (MHCP) and mean spherical candle power (MSCP).

→ The polar curves are also used to find the actual illumination of a surface by employing the candle power in that specific direction.

Rousseau's construction :-



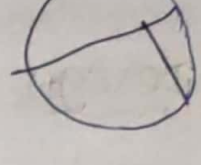


→ With 'O' as the centre of the polar curve and OX is the radius of semi-circle.

→ X'Y' is drawn parallel with XY. the ordinates are set equal to the corresponding radius on the polar curve.

Mean ordinate of the curve

$$= \frac{\text{Area of } X'GZY'}{\text{Length } X'Y'}$$



Luminous intensity $I = \lim_{\delta\omega \to 0} \frac{\delta F}{\delta \omega}$.

$$I_\theta = \frac{dF}{d\omega}$$

$$d\omega = \frac{r d\theta \cdot 2\pi r \sin\theta}{r^2}$$

$$= 2\pi \sin\theta \, d\theta$$

$$\Rightarrow dF = I_\theta d\omega$$

$$F_{\theta_1, \theta_2} = \int_{\theta_1}^{\theta_2} I_\theta d\omega$$

$F \to$ Total flux.

$\omega \to$ solid angle

$$= \int_0^{90^\circ} I_\theta 2\pi \sin\theta \, d\theta.$$

$$= I_\theta 2\pi \int_0^{90^\circ} \sin\theta \, d\theta.$$

$$= I_\theta 2\pi.$$

$$\boxed{F = I_\theta 2\pi}$$

$$I_\theta = \frac{F_{0,90^\circ}}{2\pi} = \frac{\text{Total flux in upper horizontal}}{2\pi}.$$

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$I_\theta \rightarrow$ upper mean Hemispherical candle power.

Design of lighting schemes :-

(1) Space height ratio :-

$$\frac{\text{Horizontal distance between the lamps}}{\text{mounting height of lamp.}}$$

→ The mounting distance of a lamp should be in between 2.2 – 2.45 metre. and the value of this ratio lies between 1 to 2.

(2) Utilization factor :-

$$\frac{\text{Total utilised on working plane}}{\text{Total lumens radiated by lamp.}}$$

→ This value depends upon

(i) The area to be illuminated

(ii) height at which the lamps are fitted.

(iii) The colour of surrounding walls ceiling or fittings.

(iv) The type of lights (direct or indirect)

The range of direct light → 0.25 to 0.5.

" " " In " " → 0.1 to 0.3

(3) Depreciation factor :-

$$\frac{\text{illumination under normal working condition}}{\text{illumination when everything is clean.}}$$

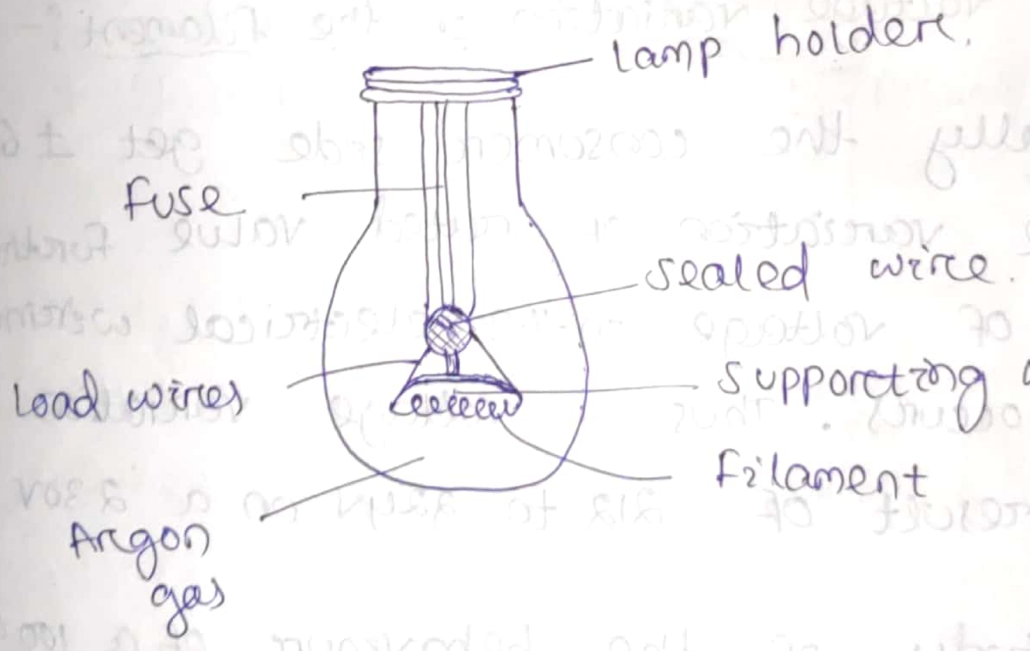
$\simeq 0.8$.

(4) Maintenance factor :-

(1) The ratio of illumination on a area given after a period of time to the initial illumination on the same area.

Electrical source of Light :-

(1) Incandescent Lamp :-



(i) The space within the lamp is replaced with inert gas like argon which can reach a temperature of 2400K without evaporation.

(ii) To prevent heat loss coiled coil / spiral filaments are used.

(iii) Howevere gradual evaporation makes a ~~large~~ dark deposit on the wall of the bulb.

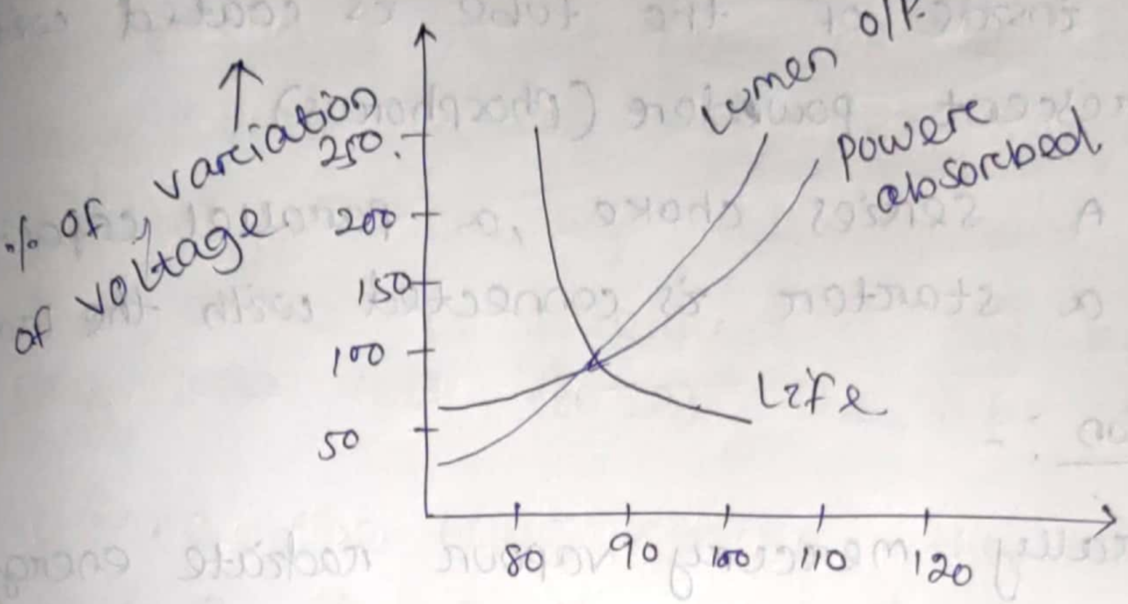
(iv) with flowing of current in the filament initially, a red colour appearance occurs in the filament tube. with the increase of heat a white spot appears across the filament.

<u>Effect of voltage variation on the filament</u>:-

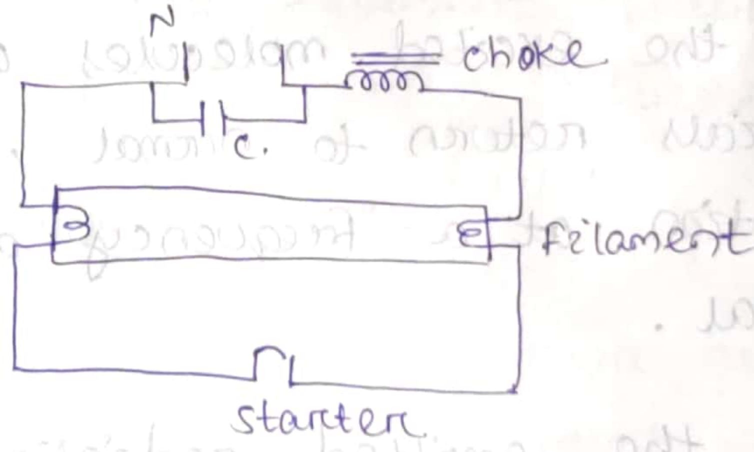
(i) Generally the consumer side get ±6% voltage variation of rated value. further drop of voltage in the electrical wiring may occurs. Thus a voltage variation may result of 212 to 224V on a 230V.

(ii) A study of the behaviour of a 100 watt filament gives the characteristics curve for its life lumen o/p.

and power absorbed.



Constructional features of fluorescent lamp:-



(1) The fluoroscent lamp is in the form of a tube 3 to 5 cm in diameter and 0.5 m to 1.5 m Long.

(ii) with an electrode at each end which are in the form of coil filaments coated with an electron emmiting material.

(oxide of berium or strontium).

(iii) The inside of the tube is coated with fluorescent powdere (phosphorus).

(iv) A series choke, a parallel capacitor and a starter is connected with the lamp

<u>operation</u> :-

(i) Generally mercury vapour radiate energy which comes under ultraviolet reagion. so they are of no use as a sourse of light. However these radiation are used in exciting certain materials.

(ii) when the excited molecules of these materials return to normal, they emit a readiation at a frequency different from original.

(iii) Now the emitted radiation comes under visible region. materials which poses this property is known as fluorescent and the process is known as fluorescence

(iv) when the supply is switched on, the current flows through the choke, starter and electrodes, the starter raises the temperature of the bimetal contacts and they get closed. After flow of the steady current they cooled down and get separated suddenly. there by the current through the choke is interrupted and approximately 1000 volt causes the tube to strike.

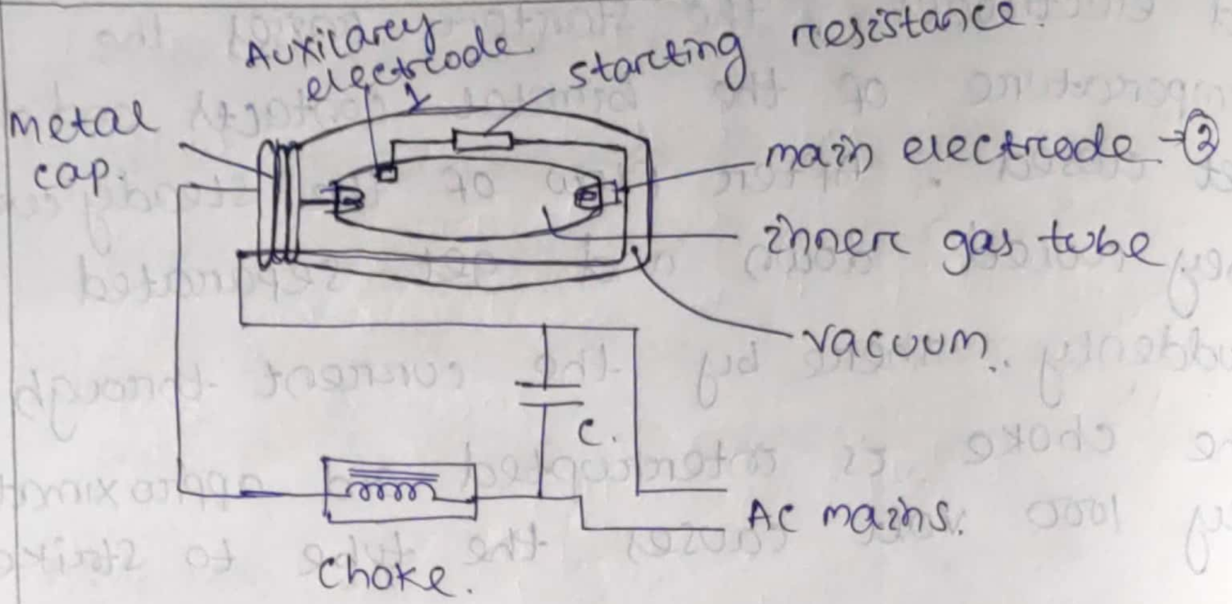
(v) once the tube strike, the tube current flows throw the ionised molecules inside the tube and the bimetal contacts remain open.

(vi) The gas inside the starter is Argon or Neon, and the filament coating contains oxide of barium or strontium.

Mercury vapour lamp :-

(i) In case of mercury vapour atoms, the excitation to different level is possible some of the important wave length radiated are 2537 AU, 5561 AU, 4358 AU, 4047 AU. (Austronomical unit - AU)

(ii) The first one i.e 2537 AU fall in the ultraviolet range and the last three are in the visible range.



construction :-

(i) The tube containing mercury vapoure is made up hard glass.

(ii) the outer glass cover protects the inner tube from coming into direct contact with atmospheric temperature variation. It also absorbs the ultraviolet radiation emitted from the lamp during the work.

(iii) There are two main electrodes made up tungsten wire and a starting electrode which is spaced ~~wide~~ white closed to main electrode (1) through a high series resistance along with the main electrode (-2).

(iv) The phase comes to the main electrode through a series choke and a capacitor is parallel.

Working principle :-

(i) When ckt is energised the supply voltage appears between the main electrode (1) and the starting or auxiliary electrode.

(ii) The argon or neon coming between these two electron is immediately ionised because distance between these two electrode is very small and a glow appears betn the said electrodes.

(iii) A small current starts flowing through the starting resistor in series with the auxiliary electrode.

(iv) This results in building of pressure due to heating of mercury which is originally in the condensed form.

(v) Ultimately medium between the main electrodes is ionised and the current starts flowing between the two electrodes due to the negative temperature coefficient.

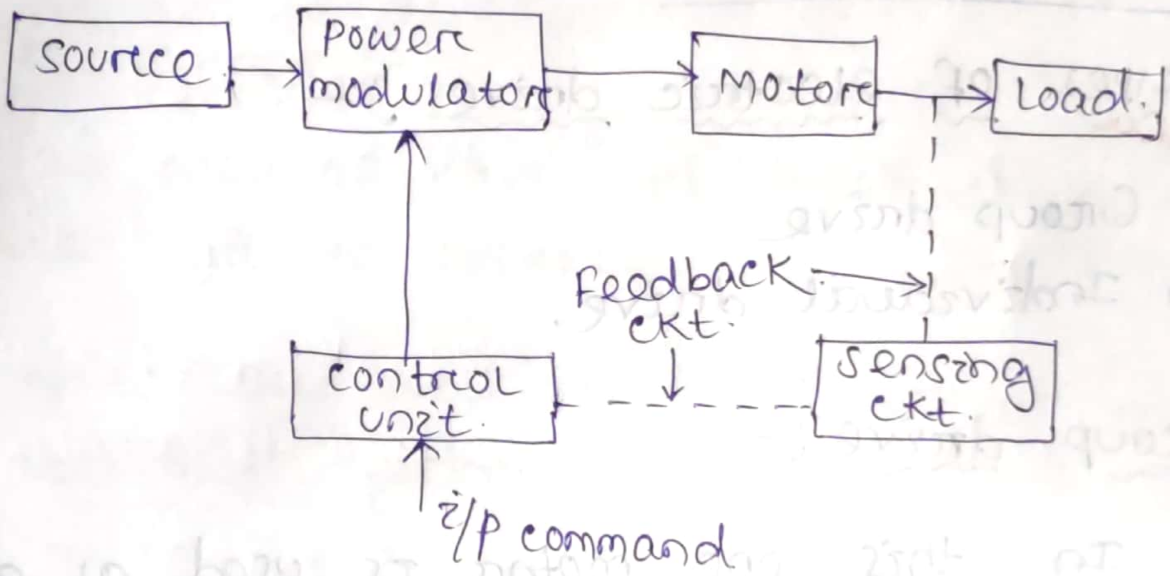
(vi) Now it is controlled by the choke to limit the current so as to counter at the low resistance of the path between the two electrodes.

Chapter-5:

Industrial drive :

Electric drive :-

(i) An electric drive is defined as a form of machine equipment design to convert electrical energy in to mechanical energy and provide electrical control of these process.



Source :-

It is may be of AC or DC.

Power modulator → It converts AC to DC or DC to AC. It limits the current during starting, breaking and reversing motion.

→ It also selects the modes i.e motoring and breaking.

<u>Load</u> :→

for example fans, machine tools.

<u>motor</u> :

sensing unit.

control unit

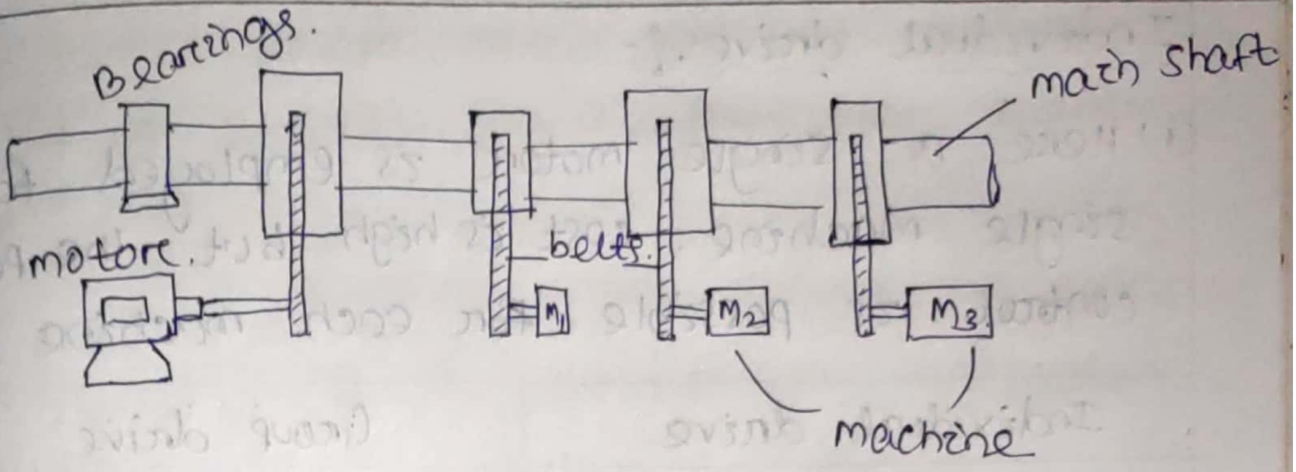
Types of electric drive :-

(1) Group drive

(2) Individual drive.

Group drive :-

(i) In this one motor is used as a drive for two or more than two machines. The motor is connected to a long shaft on which other machines are mounted through belts.



Advantage :-

(i) The effective cost is less as compare to individual drive.

Disadvantage :-

(i) In case of fault all the machines mounted are fail to operate.

(ii) Efficiency will be low when all machine are not working.

(iii) It is not possible to install a new machine at a far away distance.

(iv) This drive is heavy and difficult to control.

Individual drive :-

(i) Here a single motor is employed for a single machine. cost is high but the personal control is possible for each machine.

Individual drive	Group drive
(i) Initial cost is more	(i) initial cost is less.
(ii) It works at good power factor.	(ii) It works at low power factor.
(iii) It has high efficiency	(iii) It has low efficiency (light load).
(iv) It has high reliability.	(iv) It has less reliability
(v) It can be fitted anywhere.	(v) such arrangement is not possible.
(vi) use less, where sequence of operation is required.	(vi) useful, because all the operation stopped simultaneously.
(vii) space can be fully utilized.	(vii) more space is required.
(viii) This must for driving heavy machines e.g cranes, lifts. etc.	(viii) This system not employed such cases.

Explain the factors which you will consider while selecting a motor for a particular industrial drive.

The factors which should be consider while selecting a motor for a particular industrial drives are :-

(i) nature of electricity :-

whether AC or DC supply is to be used for the drive.

(ii) nature of drive :-

whether the particular motor is going to drive individual machines or a group of machine

(iii) capital cost and running cost of the drive :-

(iv) maintenance required for the drive.

(v) Types of insulation.

(vi) space and weight restriction ~~if~~ any.

(vii) Ambient temperature

(viii) efficiency of the machine.

(ix) surrounding environment and location.

(x) nature of load whether the load requires light ~~and~~ or heavy starting torque, or the load torque increases with speed and remains constant.

(xi) Electrical characteristics such as starting characteristics, running characteristics, speed control and breaking characteristics.

(xii) Mechanical characteristics such as, types of enclosure, bearings, noise level, heating and cooling arrangement.

As the above all condition are not achievable at all time the main important points, we need to consider are

mark

(i) nature of mechanical load drive
(ii) Suitable speed - torque characteristics
(iii) Starting and running condition.

Application of DC motor (shunt motor) :-

The characteristics of a shunt motor revals that it is a constant speed motor. It is therefore used

(i) where the speed is required to remain almost constant from no load to full load.

(ii) where the load has to be driven a no. of speed at any one of which is required to be remain constant.

Application :-

(i) Lathe machine.

(ii) Drills.

(iii) Boring mills.

(iv) Spinning & weaving machine.

Series motor :-

→ It is a variable speed motor i.e speed is low at high torque. However at light loads the motor tends to attend dangerously high speed.

→ There force it is used to a high starting torque is used.

Application :-

(i) Electric Traction

(ii) Trains.

(iii) Elevators.

(iv) air compressor, vacuum cleaner, haire dreiore or

(3) compound motor :-

Differential compound motors are rarely used because of their poor torque characteristics however cummulative compound motors are used where a fairely constant speed is required with irregular loads or suddenly applied heavy loads.

Application :-

~~Electric traction, crane, elivators, air compressor, vacuum cleaner, hair drier, sewing machine, etc.~~

Presses, shears, machine, Respirocating machine etc.

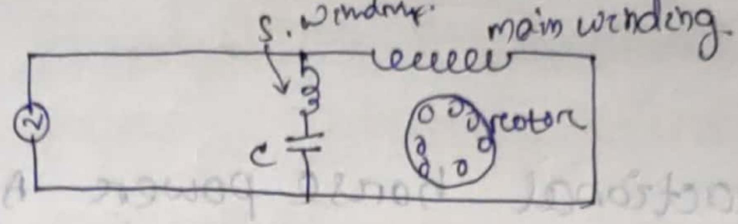
Application of 1ϕ IM :-

01. Split phase induction motor (IM) :-

These motors have suitable when a moderate starting torque is required.

e.g → fan's, washing machine, oil burners, small machine tools (low to 250W.

02. capacitore start motore :-



Those are used where with stationary torque is required and where the starting may be long.

uses :- compressore, Large fan, pump, high inertia loss, Here the equipments are of high rating i.e 120 watt to 7.5 KW.

03. capacitore start capacitore run motore :-

(i) Because of constant torque the motore is vibration free and can be used in hospital, studios and other places where silence is important.

Shaded pole induction motore :-

(i) The salient features of this motores are extremely simple construction and absense of centrifugal switch

(ii) since starting torque, efficiency and power factore are very low. These motores are only suitable for low power application.
e.g → small Fans, Toys, hair driers, desk fans

Application of series motor and universal motor :-

(i) The fractional horse power AC series motor have high speed and large starting torque. They can be therefore used to drive high speed vacuum cleaners, sewing machine, electric shavers, drills

Repulsion motor (application) :-

(i) Due to their high starting torque repulsion motor's ~~wherefore~~ are used to operate device such refrigerators, pumps compressors etc.

Application of synchronous motor :-

(i) over excited synchronous motors can be used to improve power factor of a plant while carrying their rated speed.

(ii) They are used to improve the voltage regulation of transmission line.

(iii) High power electronic converters generating very low frequencies enable us to run synchronous motors at ultra low speed. (Thus huge motors 10 MW range drive crushers, rotatory kilns, variable speed ball machine).

Application of 3 phase induction motors :-

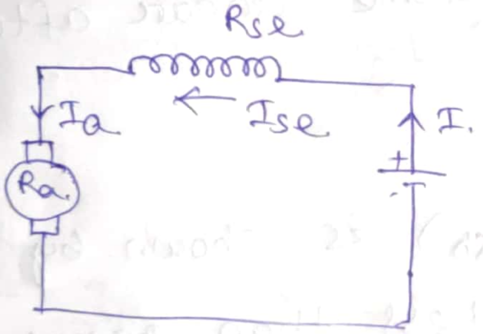
(i) This motor is nearly constant speed motor with a poor starting torque. It has high overload capacity and operates always at lagging p.f from 0.7 to 0.9.

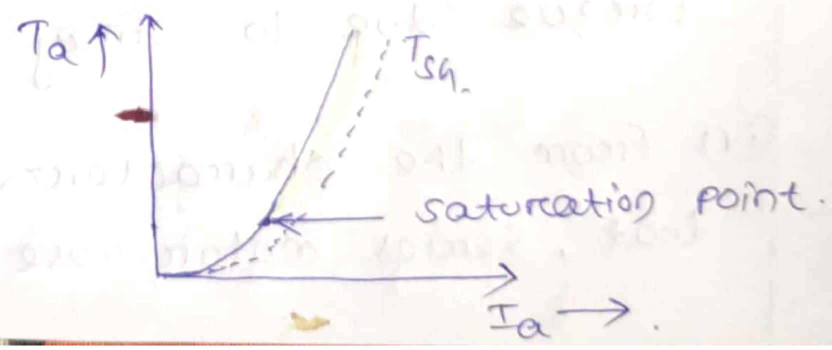
(ii) The squirrel cage IM can be used for driving low and medium power drives, where speed control is not required.

(iii) Tubewells, lathe machine, drilling machine, saws machine, grinders etc.

characteristics of DC series motor.

(1) T_a Vs. I_a :-





$T \propto \phi I_a$

$\phi \propto I_{se}$.

$\phi \propto I_a$.

$\Rightarrow \boxed{T \propto I_a^2}$ ← before saturation.

$\boxed{T \propto I_a}$ ← After saturation.

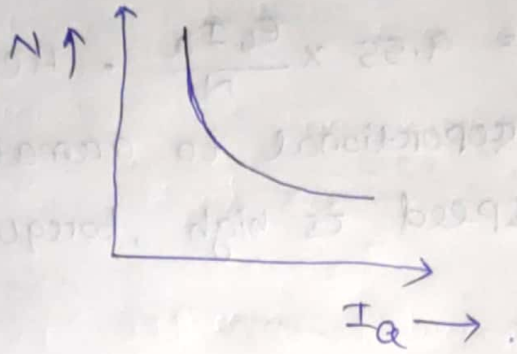
(i) Before saturation torque $\propto I_a^2$. At light load I_a is small, hence flux is small. As I_a increases, armature torque T_a also increases as square of the armature current.

(ii) Hence, initially the torque is parabolic but after saturation the flux is almost independent of I_a, hence torque $(T_a) \propto I_a$. So, the characteristics become linear after saturation.

(iii) The shaft torque (T_{sh}) is shown by the doted line. It is less than armature torque due to stray loss.

(iv) From the characteristics we can conclude that, series motor use where huge starting torque is required for accelerating heavy masses like electric train.

(2). N Vs. I_a :-



$E_b \propto \phi N$

$\downarrow N \propto \frac{E_b \downarrow}{\phi \uparrow\uparrow}$

$E_b = V - I_a R_a$

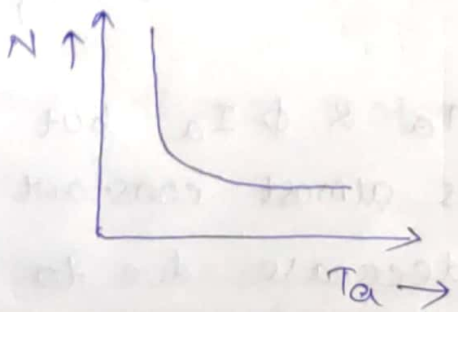
(i) variation of speed can obtain from the formula $N \propto \frac{E_b}{\phi}$.

(ii) As load increase I_a increase, with increases the flux. Here change in E_b for various load current is very small.

(iii) Hence the speed varies inversely as the armature current. when load is heavy, I_a is large and speed will be low.

(iv) when load is small I_a falls to a very small value. As a result speed become very high.

(3) N Vs. T_a characteristics :-



$T_a \propto \frac{1}{N}$

$$T_a = 9.55 \times \frac{E_b I_a}{N}$$

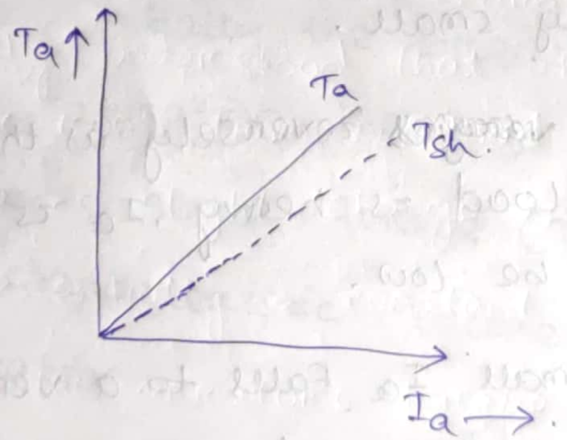
$N \propto \frac{E_b}{T_a}$ because $\phi \propto I_a$.

→ we know that $T_a = 9.55 \times \frac{E_b I_a}{N}$. Here speed is inversely proportional to armature torque. so, when speed is high, torque is low.

→ when speed is low, torque is high.

Shunt Motor.

T_a Vs I_a characteristics :-



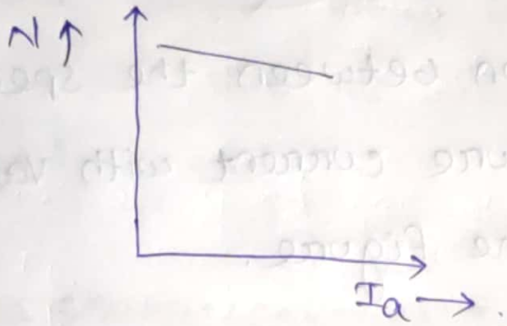
$T_a \propto \phi I_a$

$\boxed{T_a \propto I_a}$ {because ϕ is constant}

(i) we know that $T_a \propto \phi I_a$ but in shunt motor the flux is almost constant only of heavy load. ϕ decrease due to increase in armature reaction.

(ii) There force, In a shunt motor $T_a \propto I_a$. So the characteristics is a straight line passing through the origin (Linear).

N vs I_a characteristics :-



$$N \propto \frac{E_b}{\phi} \leftarrow \text{constant.}$$

$$N \propto V - I_a R_a$$

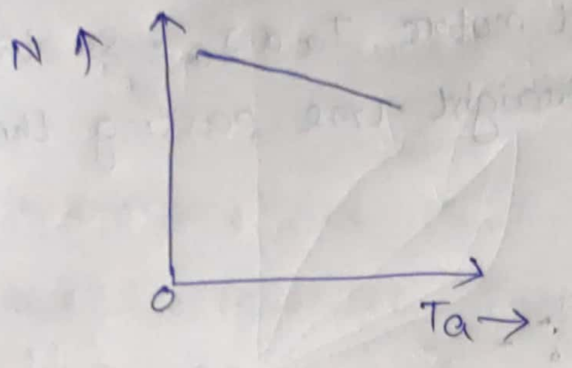
(i) In a shunt motor, flux is almost constant, therefore $N \propto E_b$. But practically both E_b and flux decreases with increase in load

(ii) However, decrease in E_b is more than the flux, as a result there is some decrease in speed.

(iii) From the characteristics we can notice that there is no appreciable change in the speed of DC shunt motor from no load to full load.

(iv) Therefore these motor are used where sudden change in the load takes place like wood cutting Lathe machine, etc.

N Vs Ta characteristics :-



(i) This curve is drawn between the speed of the motor and armature current with various amps. as shown in the figure.

(ii) From the curve it is understood that the speed reduces when the load torque increases.

(iii) with the above three characteristics, it is clearly understood that when the shunt motor runs from no load to full load there is slight change in speed. Thus, it is essentially a constant speed motor. Since the armature torque is directly proportional to the armature current, the starting torque is not high.

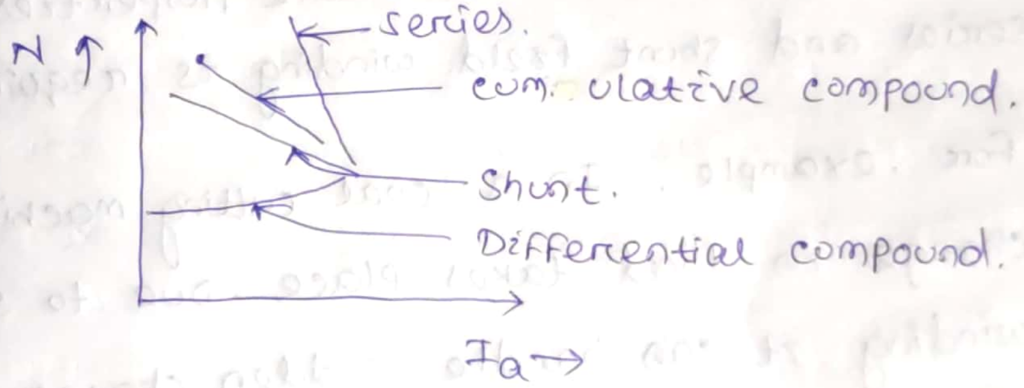
Compound Motor :-

(i) These motors have both series and shunt winding

(ii) If series field flux is in the same direction with shunt field flux, then motor is said to be cumulative compound motor.

(iii) If the series field opposes the shunt field, then the motor is said to be differential compound motor.

N vs Ia characteristics :-



Cumulative compound.

$$\phi_t = \phi_{sh} + \phi_{se}.$$

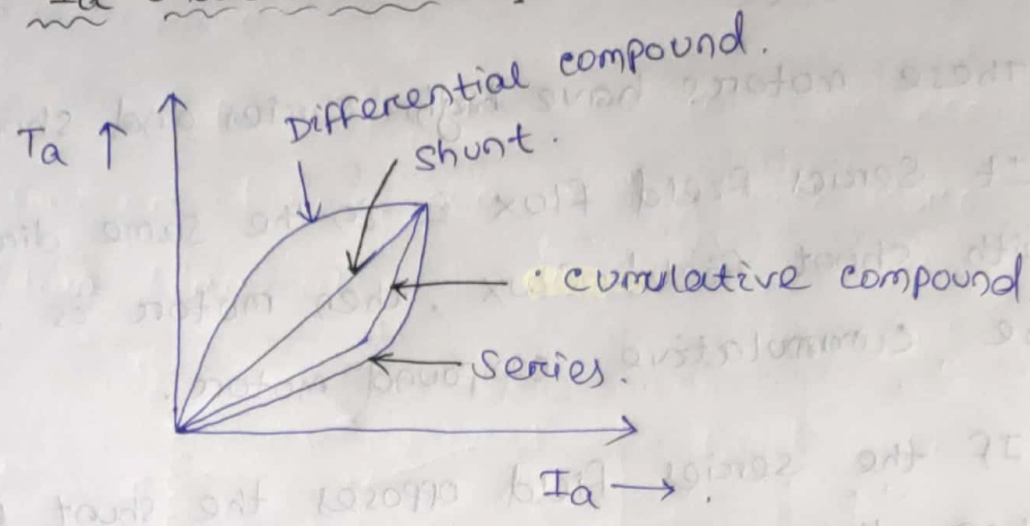
Load ↑ I_a ↑ ϕ_{se} ↑ ϕ_t ↑ N ↓.

Differential compound

$$\phi_t = \phi_{sh} - \phi_{se}$$

Load ↑ I_a ↑ ϕ_{se} ↑ ϕ_t ↓ N ↑

Ta Vs Ia characteristics :-



cumulative compound Motor :-

(i) These motor are used where properties of both series and shunt field winding is required.

(ii) For, example. In a coal cutting machine sudden change in load takes place. Due to shunt winding it can handle sudden change in load and due to series field it will be able to take heavy load.

(iii) cumulative compound motor are used where high starting torque is required with pulsating loads.

Differential compound Motor :-

(i) As series field opposes the shunt field, if load is increased, total flux will decrease.

(ii) Therefore speed of differential compound motor is constant when Load is less, but speed increases with increase in Load.

(iii) Therefore, these motors are not commonly used.

Chapt-6 Electric Traction.

Explain DC and AC Traction Motor :-

(i) Dc traction motors are generally used for dc traction purposes, dc locomotives and drives.

(ii) The speed can be changed by the variation of the field winding taps.

(iii) By using the rheostat taps the resistance is varied and accordingly the speed will be varied. Also for the control in a dc drive, dc traction motor (series type) can be changed.

(iv) These traction motors may be opted in series or parallel. For the higher speed requirement, the motors are operated in parallel and for lesser speeds series connected motors are essential.

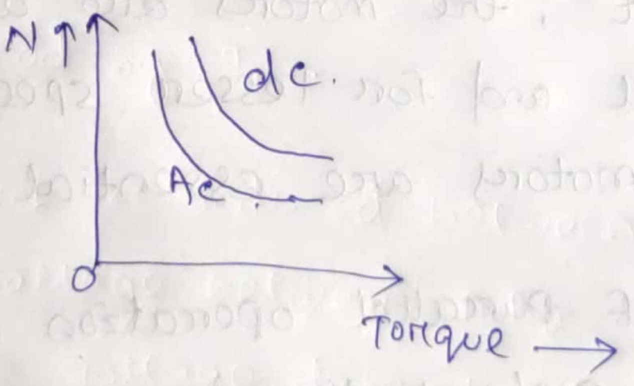
(v) In case of parallel operation of two traction motors the dc supply voltage available will be constant (high) and as speed $\propto$ 'V' $\Rightarrow$ speed increases.

(vi) Also Ac series traction motors may be operated in Ac drive system i.e in Railways AC traction motors are preferred.

(vii) The single phase compensated series motors have been built for traction work upto sizes of several hundred HP.

(viii) They have low PF at starting and therefore starting torque is low. The AC series motor is not well suited to sub-urban services and stops are frequent.

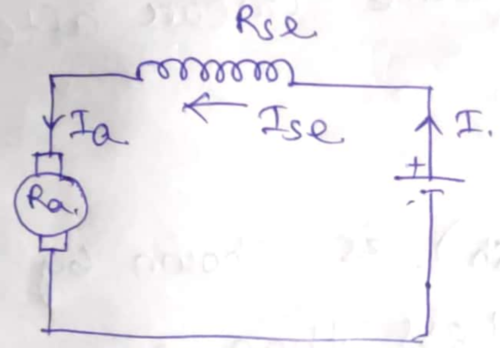
(ix) The speed-torque characteristics is similar to that of a dc series traction motor and is drawn below.

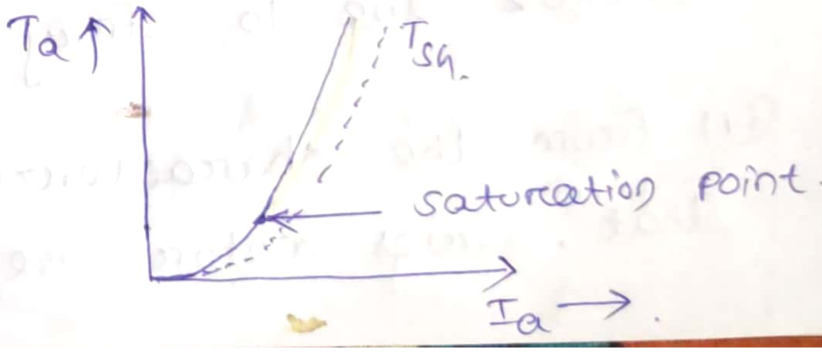


(x) Also 3ϕ induction motor can be used for the traction purpose but with lesser extent. It has been used in the Kando system.

characteristics of DC series motor.

(1) T_a Vs. I_a :-





$T \propto \phi I_a$

$\phi \propto I_{se}$.

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$\Rightarrow \boxed{T \propto I_a^2} \leftarrow$ before saturation.

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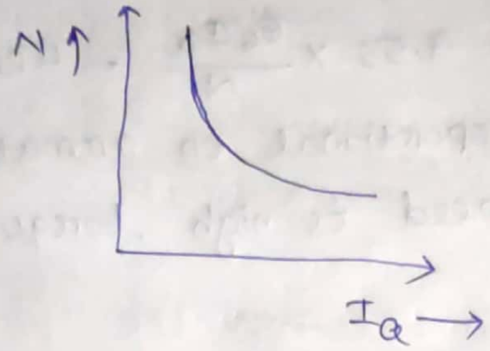

$$\left\{\begin{array}{l} E_b \propto \phi N \\ \downarrow N \propto \dfrac{E_b \downarrow}{\phi \uparrow\uparrow} \\ E_b = V - I_a R_a \end{array}\right.$$

(i) variation of speed can obtain from the formula $N \propto \dfrac{E_b}{\phi}$.

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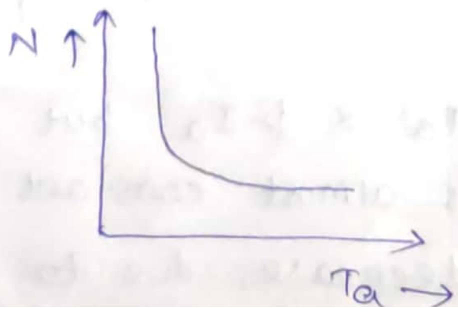

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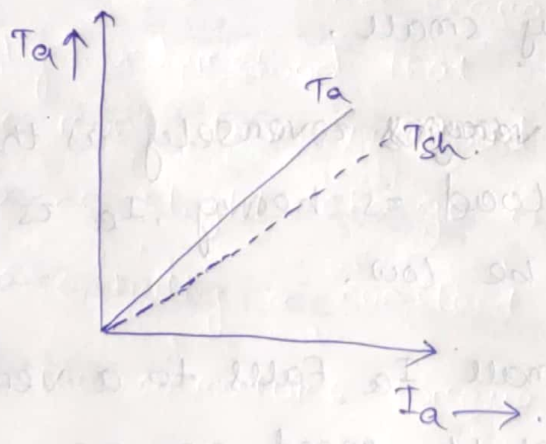

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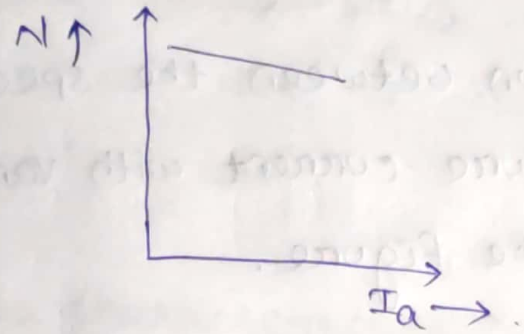

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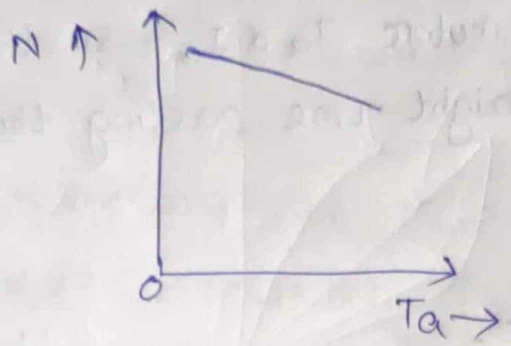

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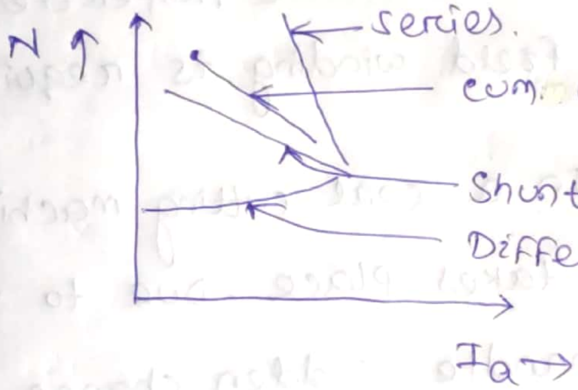

Cumulative compound.

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Load ↑ I_a ↑ ϕ_{se} ↑ ϕ_t ↑ N ↓.

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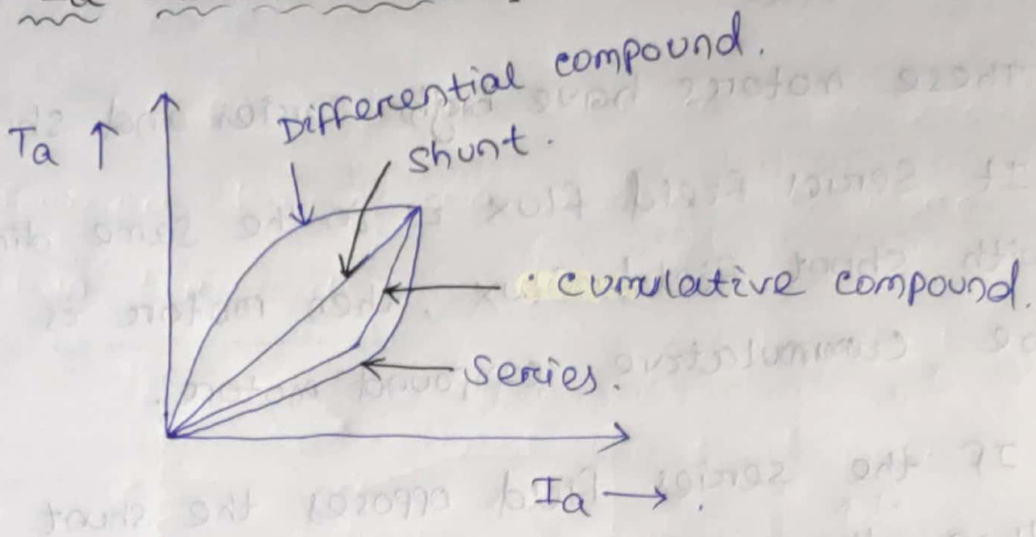
T_a Vs I_a characteristics :-



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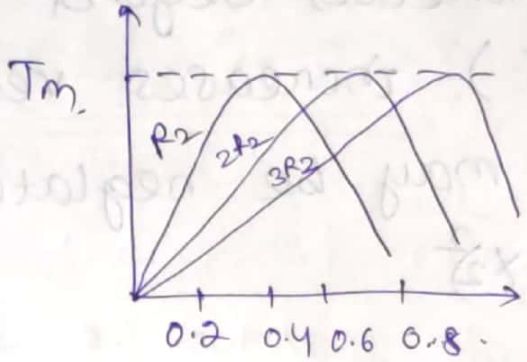
Torque-slip characteristics of induction motor.



→ As we know $T = \dfrac{K_2 S R_2}{R_2^2 + (S X_2)^2}$

(i) as $S = 0$, $T = 0$ so the curve starts from origin.

(ii) At normal speed the slip is more, so that SX_2 is negligible as compared to R_2. Hence $T \propto \frac{S}{R_2}$ as R_2 is constant $\boxed{T \propto S}$. Hence torque-slip curve is a straight line from zero slip to a slip that corresponds to full load

→ as slip increases beyond full load slip the torque increases and becomes maximum at $S = \frac{R_2}{X_2}$. The maximum torque in a induction motor is called pulled out torque or break down torque

→ when slip increases beyond that, the term $(S^2 \cdot X_2^2)$ increases very rapidly so that R_2^2 may be neglated as compare to $(SX_2)^2$.

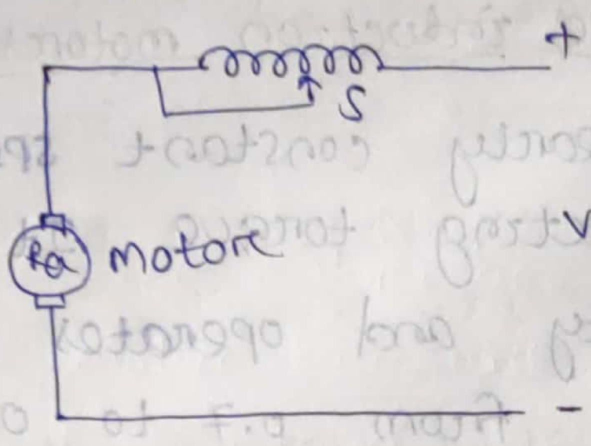
$$T \propto \frac{S}{S^2 X_2^2}$$

$$T \propto \frac{1}{S}$$

Thus the torque is inversely proportional to slip

Control of motors

(i) Tapped field control of motor :-



(i) Here traction motors have run upto a speed and increase the speed limit by 15% to 30% by weakening the field strength.

(ii) Since, speed is inversely proportional to flux by reducing the field strength the speed is increased. For this purpose a tapping arrangement is provided at the series field of DC motor.

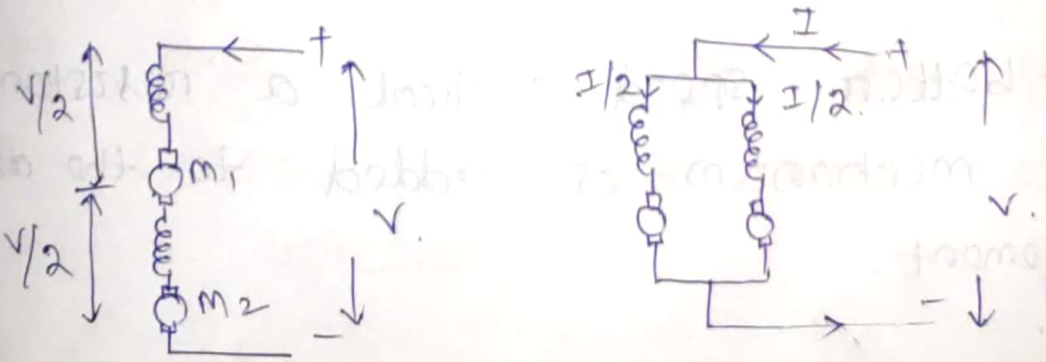
(iii) The advantage of field control is that it makes the equipment very flexible. As for instances in frequently stopped station the speed is low, but between inter urban station the speed require is high. At that time tapped field control arrangement comes fruitfull.

(iv) In this method flux is reduced by decreasing the number of turns of the series field winding. The switch 'S' can short ckt any part of the field winding thus decreasing the flux and raising the speeds.

(v) with full turns of the field winding the motor runs at normal speed and as the field turns are cut out speeds higher than the normal speed are achieved.

Series-parallel control :-

(i) In this system two or more than two similar DC series motor are mechanically coupled to the same load.



$$N \propto \frac{E_b}{\phi} = \frac{V/2}{I} = \frac{V}{2I} \text{ (series)}$$

$$\frac{1}{2}\left(\frac{V}{I}\right).$$

$$\frac{V}{I/2} = \frac{2V}{I} \text{ (parallel.)}$$

$$2\left(\frac{V}{I}\right)$$ [4 times greater than series]

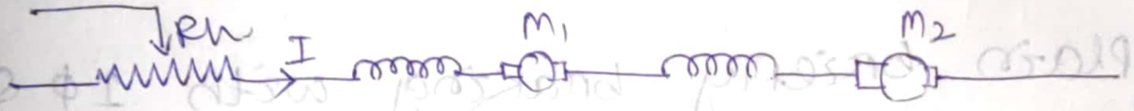
(ii) when the motors are connected in series each motor armature will receive $\frac{1}{2}$ of the normal voltage. Therefore the speed will be low

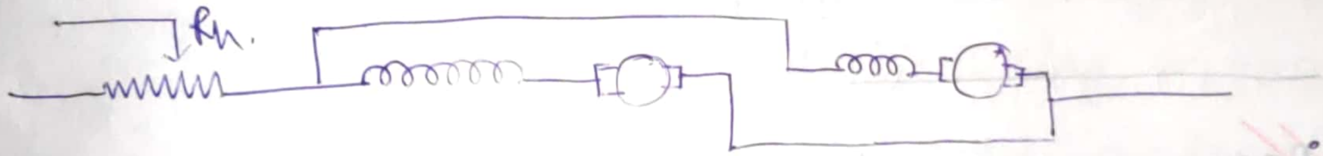
(iii) when the motors are connected in parallel each motor armature receive the normal voltage and half of the supply current. Thus the speed is high.

(iv) thus we can obtained two speed in the above figure. the speed obtained in parallel connection is four times that of in series connection.

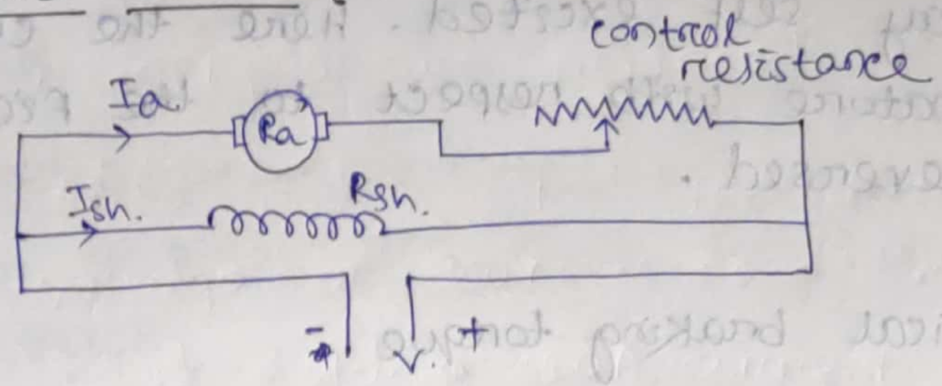
(v) For better speed control a resistance control mechanism is added to the above arrangement.

(vi) At standstill the motors are connected in series via a ~~static~~ starting rheostat and in the process the resistance are cut out to attain the increase speed.





Rheostatic control :-



This method consist of obtaining reduce speed by the insertion of external series resistance in the armature circuit it can be used with series, shunt and compound motors.

Advantage :-

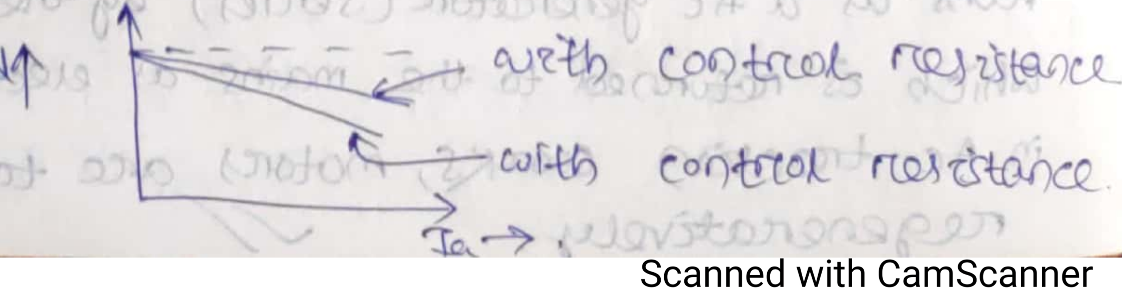
(i) The ability to achive speeds below the normal rated speed.

(ii) Simplycity and easy of connection.

Disadvantage :-

(i) Relatively high cost of Large continuously rated variable resistore capable of dissipating Large amount of power.

(ii) Poor speed regulation.



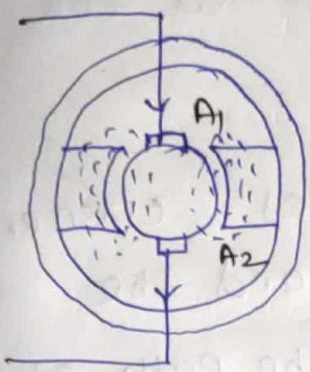
- In armature or rheostatic control method of speed the voltage across the armature is varied by inserting variable rheostat fault control resistance in series with armature

- As the controller resistance is increased the P.D across the armature is decreased, ~~there~~ there by decreasing the armature speed.

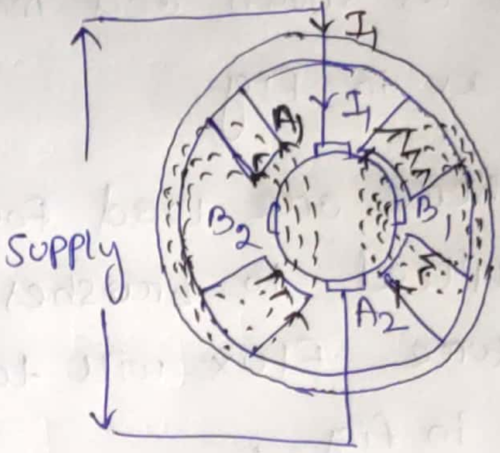
- For a load of constant torque speed is proportional to the P.D across the armature

- From the speed armature point characteristics it is seen that greater the resistance in armature greater in the fall in speed.

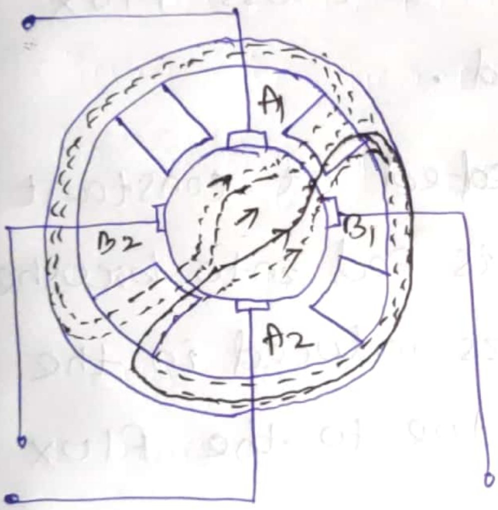
Metadyne control of motore :-



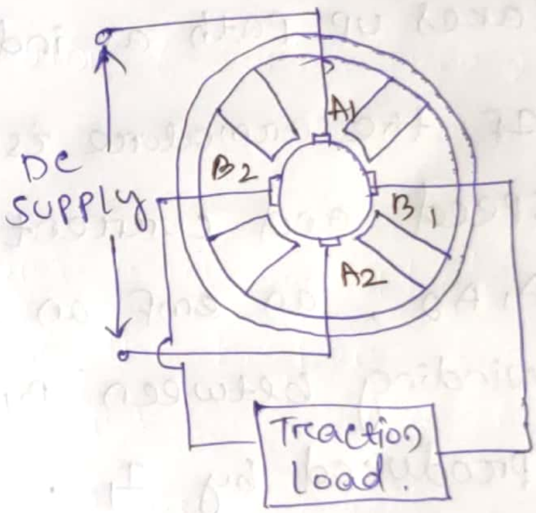
(fig - 1a)



(fig 1-b.)



(fig 1-c.)



(fig 1-d.)

(i) The metadyne system of speed control estimates the energy loss and achieves a very smooth control during the acceleration period.

(ii) Considere a dc armature with two brushes and two poles. If current is supplied to the brushes A_1, A_2, the armature flux will be as shown and mainly confined the poles as in Fig.

(iii) If there are load four brushes, current is supplied to brushes A_1, A_2 and the armature flux will take up the path as shown in fig.

(iv) If now the current supply to brushes B_1, B_2 as in fig, the armature cross flux takes up path as indicated.

(v) If the armature is rotated at constant speed and current 'I_1' is fed into brushes A_1 A_2, an emf an emf is induced in the winding between B_1 B_2 due to the flux produced by I_1.

(vi) No emf is induced between A_1 A_2 and the voltage between A_1 A_2 is on account of the voltage drop due to I_1.

(vii) Since an emf is induced across B_1, B_2 a current I_2 will flow in a load connected between them.

(viii) The rotation of the armature in ϕ_2 induces emf E_1 between A_1 and A_2 which opposes the supply voltage. since the current is to kept at its original value of the supply voltage must be induced to over come E_2. under stedy state condition.

$$E_1 \propto \phi_2 = KI_2, \quad E_2 \propto \phi_1 = KI_1$$

$$E_1 I_1 = E_2 I_2 = KI_1 I_2$$

(ix) This shows that the m/c behave like a dc Transformer only the rotational losses of m/c need be supplied by the driving motor.

Regenerating braking :-

(1) Reduce

(2) Field excitation ↑ ϕ ↑ E_b ↑ $E_b = \frac{P\phi ZN}{60A}$.

(3) Speed suddenly increased.

Regenerating braking apply to DC shunt motor :-

(i) Regenerative braking can be applied easily to DC shunt motors with out any change of connection.

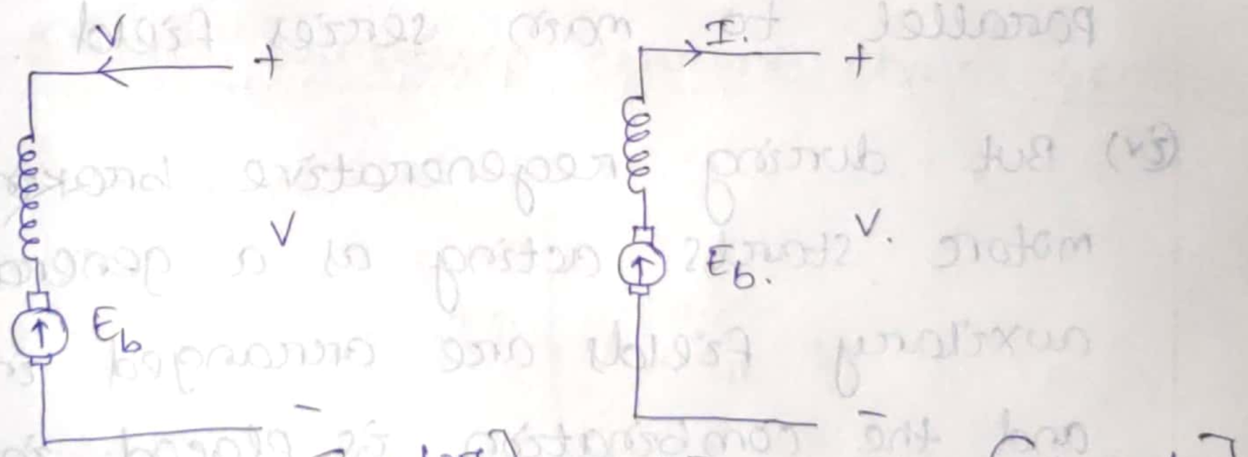
(ii) In normal working of DC shunt motor supply voltage 'V' is greater than the induced EMF 'E_b'. and motor is drawing current from the supply.

(iii) If due to the overhauling load,

the speed of the motor becomes greater than 'v' and as a result direction of armature current get reversed. This feeds back the power to supply and produces opposing torque. due to which the speed of the motore comes down.

(iv) Regenerative braking can be easily apply to DC shunt motores, particularlly in case where it is required to hold a load at a certain speed for instanse lowering the hoists.

Regenerative braking applied to DC series motor.



$E_b < V$. [motor]. $E_b > V$. [generator]

(i) ~~For DC~~ series ~~motor~~ regenerating braking can't be applied to DC series motor as such because as the direction of current is revered in the armature, for regenerative purpose, the direction of field current also get reversed. Thus series field connection must be reversed. If the series field connection are not reversed the torque applying on the motor will same as previous.

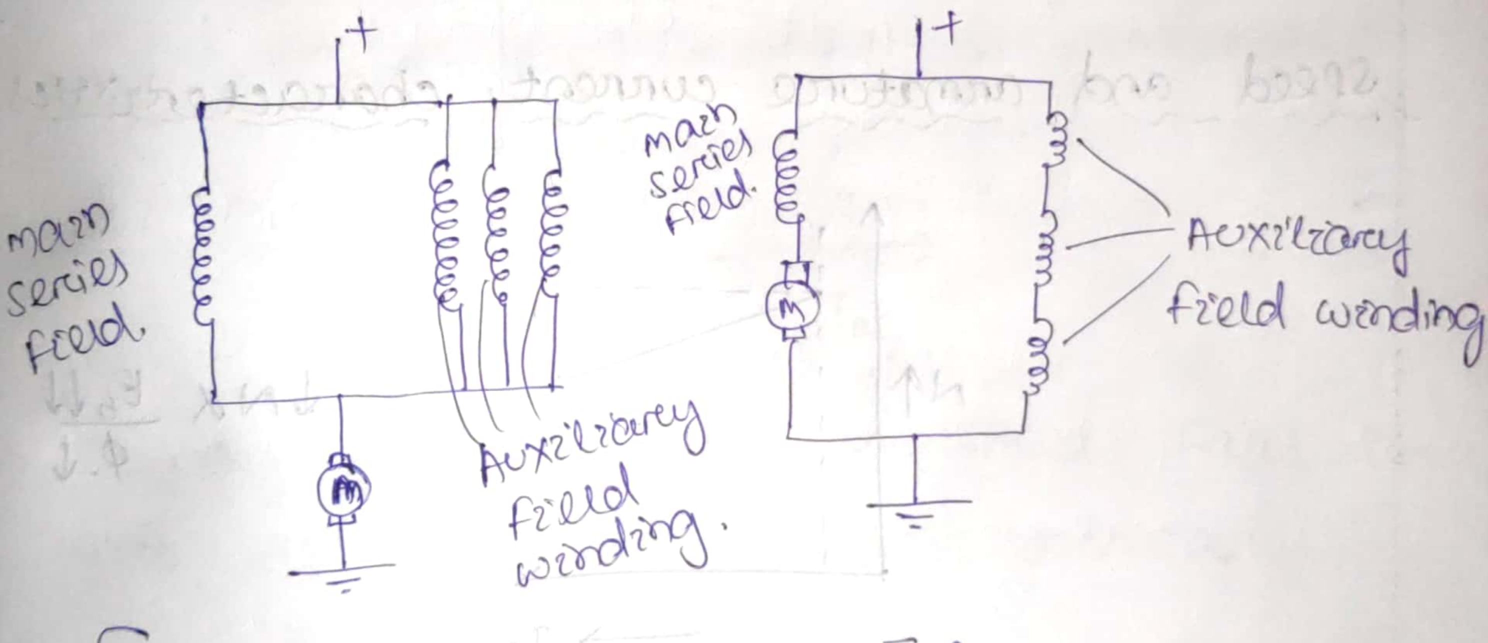
(ii) So we need to have some special arrangement in field connection of DC series motor.

(iii) During motoring the auxilary field winding are bunched together in parallel and the whole bunch is connected in parallel to main series field.

(iv) But during regenerative braking, the motor starts acting as a generator. The auxilary fields are arranged in series and the combination is placed in parallel across the main series field. Thus making the machine to behave as a differentially compound generator.

(v) If there is slight change in line voltage the shunt field will immediately

cause increase in the generated emf. Thus the arrangement will be self compensating.
This method is known as french method.



[Motoring action] [Generating action].

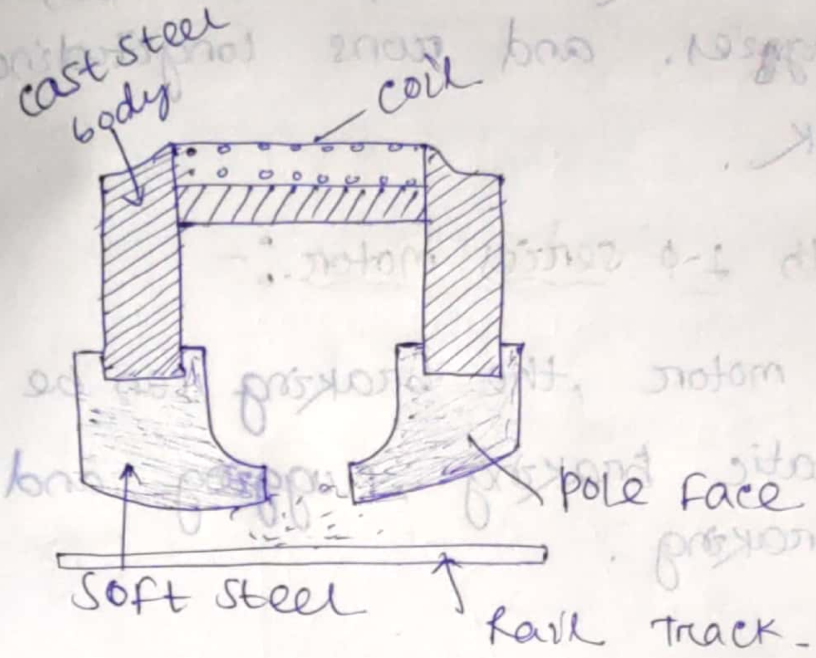
Scanned with CamScanner

Magnetic braking :-

(i) The magnetic brake consist of bipolar electromagnet with employed pole faces a short distance apart and along with rails.

Scanned with CamScanner

(ii) It's body is madeup cast steel and pole faces of soft steel. Pole faces are parallel to the rail.



(iii) Passage of current to exciting coil produces magnetism which passes perpendicular to the rail face. as shown by doted lines. This produces force of attraction between magnetic pole faces and rail which is given by the equation

$$F = \frac{B^2 a}{2\mu_0} \text{ Newton}$$

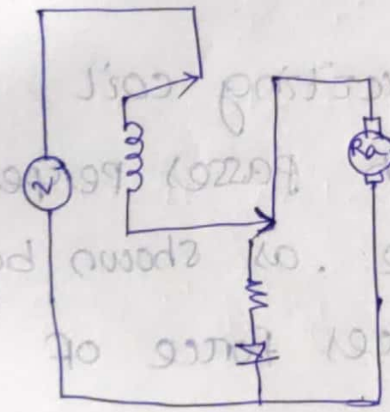
$$= \frac{B^2 a}{8\pi \times 10^{-7}} \cdot N$$

This magnetic force increases the weight on braking wheel with the result that the braking force of magnitude $\mu a F$ is produced.

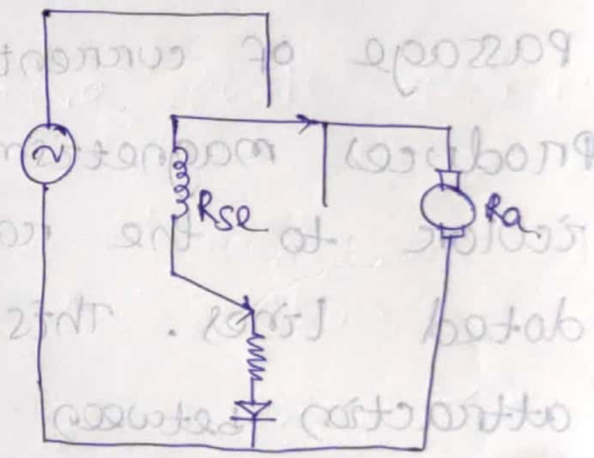
(iv) magnetic break is fitted in between wheels of the boggies. and runs longitudinal along the track.

Braking with 1-ϕ series motor.:-

(i) In this motor, the braking can be done by rheostatic braking, plugging and regenerative braking.



(normal working condn.)



(braking action).

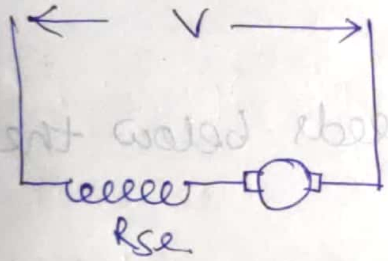
(i) In the rheostatic braking the armature is disconnected from the supply and work as an AC series generator. For this it is necessary that the total resistance in the motor ckt should be less than the critical resistance, so that the generator may self excited. Here the connection of armature with respect to the field is also reversed.

Electrical braking torque :

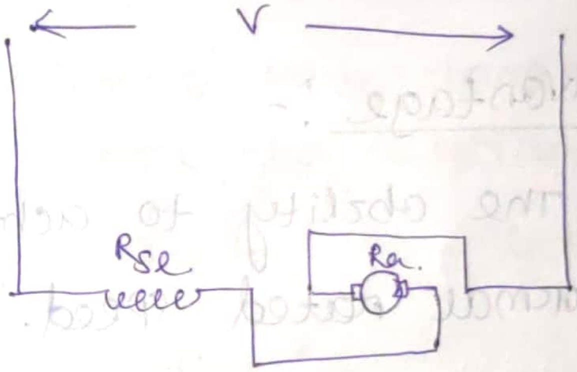
$= K\phi I_a$

$= K\phi \frac{E_b}{(R+R_a+R_{se})}$

plugging :-



(normal working)



(braking condition).

(i) In plugging the armature connection is reversed so that a reverse ~~protecting~~ rotating torque is applied which provides necessary breaking torque.

→ In a regenerative braking the AC series motor runs as a AC generator (series) by the K.E of the load which is returned to the mains as electric energy. mainly in AC traction works, motors are to be braked regeneratively.

ELECTRICAL INSTALLATION

WIRE:- single core strand may be bare or cover with insulations known as wire.
CABLE:-Several wire stranded together is known as cable. (Cover with insulation)

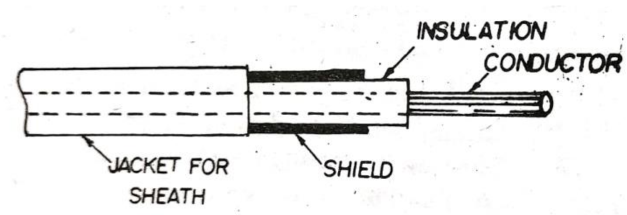
NECESSITY IN A CONDUCTOR/WIRE/CORE:

- Good conductor of electricity (low resistivity)
- Cheaper in cost.
- Safety (not provide leakage current)
- Easily available.
- High mechanical strength, durable.
- Melting point should be high.
- High resistivity to corrosion, oxidation, withstand dampness.
- High resistivity towards chemical reaction.

PARTS OF CABLE:

Cable consists of three parts

a) Conductor/Wire/Core
b) Insulation/Dielectric
c) Cable jacket



a) Conductor/core:-It carries current.
b) Insulation/Dielectric:-covering part is used to avoid leakage current from the conductor.
c) Cable jacket;-The protective covering for protection of insulation from mechanical damage.

CONDUCTOR MATERIAL USED IN CABLES:-

1. COPPER
2. ALUMINIUM
3. SILVER
4. GOLD
5. LEAD & TIN
6. STEEL
7. GALVANISED STEEL

1.COPPER:-

- It has high conductivity.
- Less resistivity, durable and ductile.
- Mechanically strong, hard
- High resistivity to corrosion, oxidation, high temperature.
- Welded easily, soldered.
- Cheaper in cost.

2.ALUMINIUM

- Cheaper in cost
- Long distance power distribution (use in place of copper for bare electric cable)

Aluminium	copper
1. Less conductivity than copper (60% of copper). 2. required Aluminium is 1.61times that of copper in volume.	1. More conductivity than aluminium.

INSULATING MATERIALS:- It is used to prevent the leakage current from conductor.

Properties of insulating material:-

- High resistivity.
- High flexibility.
- High dielectric strength.
- Non-inflammable (not catching fire easily/not inflammable).
- Non-hygroscopic (it does not absorb water and moisture from atmosphere).
- High resistive to moisture, acid, or alkalis.
- Capabilities to withstand high rupturing voltage and high temperature.
- Capability withstand wind, force, Iceland.

TYPES OF INSULATING MATERIALS:-

1.RUBBER

Advantages:-

- It has good dielectric strength(30KV/MM)
- It has high insulating properties.
- High relative permittivity.

Disadvantages:-

- It absorbed moisture.
- Often when heated to a temperature of 60 to 70°C
- Ages when expose to light.
- Deform when warm and brittle when cold.
- It is sticky in nature.
- So, hat pure rubber is not used for insulation.

2. VIR (VULCANISED INDIAN RUBBER)

Advantages:-

- It has great mechanical strength.
- It has good dielectric strength (60KV/MM)
- It has good insulating properties.
- It does not absorb moisture from atmosphere.
- It is Durable

VULCANISATION

- It is a chemical process for converting natural rubber to more durable material by adding of sulphur.

- Sulphur reacts with copper and corroded the copper surface. So this can be avoided by providing a tinned layers over the copper surface.
- It may be used in internal wiring and other low voltage insulation. (decoration)

3. SILK& COTTON:-

- This is used in low voltage cable.
- Conductors may have a single layer or double layer covering depending upon the requirements of service.
- Silk of cotton covered wires are usually used for instruments and motor windings

4. IMPREGNATED PAPER

Advantages:-

- It has high dielectric strength. (30 kv/ mm)
- It has good insulation resistance.
- It has low cost.

Disadvantages:-

- It absorbed moisture (hygroscopic in nature).So that it always provided with some protective covering and never left unshield.
- To make it noninflammable paper, impregnated with some compound like paraffin, napthenic and resin.

5. POLYVINYLE CHLORIDE (PVC)

- It has good dielectric strength.
- It has good insulating properties.
- Good mechanical strength.
- It does not absorb moisture.
- It does not reacts with acid & alkali (used in house wiring ,cable factories)
- It is used for low & medium voltage domestic & industrial light and power installation.
- It is low cost.

MECHANICAL PROTECTION

- Insulating materials are mechanically weak so protection against mechanical injury is required.
- Protection is provided by steel, aluminium on PVC covering.
- **Protection against damage & moisture.**

TYPES OF CABLES USED IN INTERNAL WIRING

The wire employed for internal wiring of building may be divided into different groups according to:-

1. Conductors used (according to the conductors material used in cable:-

a) Copper conductor
b) Aluminium conductor

2. According to the numbers of core in cables:-

a) Single core cable
b) Twin core cable
c) Three core cable
d) Four core cable

3. According to voltage grading, the cables are 2 types:-

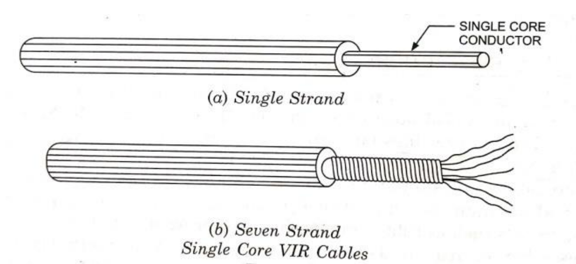
a) 250/500 volt cable
b) 660/1100 volt cable

4. According to types of insulation the cables are:-

a) VIR insulated cables
b) TRS/CTS cables — TRS-Tough rubber sheath
c) Lead sheath cable — CTS-Cab tyre sheath
d) PVC Cable
e) Waterproof cable/weather proof
f) Flexible cord & cables

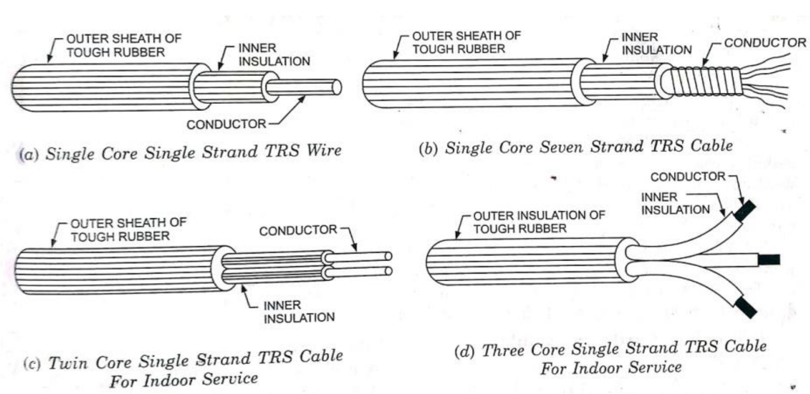
1. VIR INSULATED CABLE

- The cables are available in 250/500 volt and 660/1100 volt.
- It consists of tin & copper conductor covered with a layer of VIR Insulation.
- Over the rubber insulation cotton tap sheath covering with moisture resistance compound bitumen wax to make the cable moisture proof.
- Conductor reacts with VIR insulation therefore to prevent the reaction a tin layer is given in the conductor.
- VIR is used to protect the conductor from mechanical injury.
- Bitumen & cotton tap are used to protect the insulation from weather & moisture.



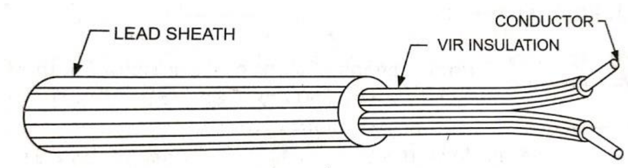
2. TRS/CTS CABLE

- These cables are available in 250/500 volt and 660/1100.
- TRS/CTS cable is vulcanized rubber, insulated conductor with an outer protective covering of tough rubber which provides additional insulation and protection against wear & tear.
- These cables are water proof and hence can be used in wet condition.
- This cable is available in single core, twin core, three cores etc.
- The cores are insulated from each other and covered with a common sheathing.



3. LEAD SHEATH CABLE

- This cable is available in 250/500 volt.
- It consists of vulcanized rubber insulated conductors cover with a sheath of lead.
- The lead sheath provides a very good protection against the moisture and mechanical injury. So this can be used without casing or conduit system.
- This cable is available in single core, twin core, three cores etc.



2-Core Lead Sheathed Cable

4. POLYVINYL CABLE (PVC)

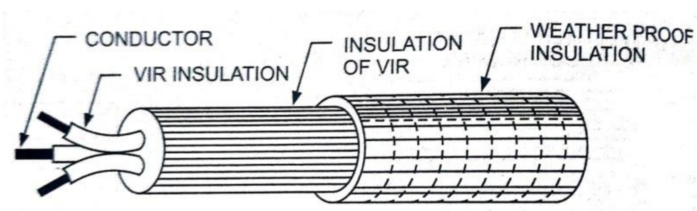
- These cables are available in 250/500 volt & 660/1100 volt grade.
- It is used incasing-capping, batten& conduit wiring system.
- Since PVC is harder than rubber it does not require cotton tapping over it for mechanical and moisture protection.
- These type cable conductors are insulated with PVC insulation.

ADVANTAGES

- Better insulating properties.
- Low cost
- Better flexibilities.
- No chemical effect on metal of the wire.

5. WEATHER PROOF CABLE

- These cables are available in 250/600 volt and 660/1100 volt grade.
- These cables are either PVC or VIR insulated conductors and then compounded with weather resisting material.
- These cables are not affected by heat, sunlight, rain.
- It is used for outdoor wiring, power supply or industrial supply.



3-Core Weather Proof Cable

6. FLEXIBLE CORD & CABLE

- It consist of wire silk, cotton, plastic covering.
- Flexible cord have tin-copper conductor.
- Flexibilities and strength is obtained by using conductors having large no. of strand.
- This wire or cable are used as connecting wires for such purpose as from ceiling rose to lamp holder ,socket outlet to portable apparatus such as fan ,lamp, heater ,etc.

MULTISTRAND CABLE

- Advantages of multi strand cables w.r.t single solid conductors.
- Multi strand cables are more flexible and durable and therefore can be handle conveniently.
- The surface area of multi strand cable is more as compare to the surface area of equivalent single solid conductor .so heat radiating capacity is more in multi strand cable because of its large area.
- Skin effect is better as conductors are tubular, specially in case of high frequency.
- The no. of strand is stranded cable must be 3,7, 19, 37, 61, 91 etc.

VOLTAGE GRADING OF CABLES:-

- This specifies the safe voltage which the insulation of the cable can withstand.
- The cables employed for domestic wiring are graded as 250/500 volt & 660/1100 volt grade.

GENERAL SPECIFICATION OF CABLES:-

1. SIZE OF CABLE:
   19/24
   19-No. of strand in cable 24-diameter of each strand in mm
2. Types of conductors used in cable (co & Al)
3. The no.of core that cable consists of (single core, twin core ,three core ,four core)
4. Voltage grading (250/500 volt & 660/1100 volt grade)
5. Types of cable with clear description regarding insulation, shielding etc.(PVC etc.)

LIGHTING ACCESSORIES AND FITTINGS

1. SWITCH
2. CEILING ROSE
3. SOCKET OUTLET
4. PLUGS
5. LAMP HOLDER

1. SWITCHES

- A switch is used in an electric circuit as a device for making or breaking the electric ckt in a convenient i.eis by the simple motion of handle or knob to connect together or disconnect two terminal to switch cables or wires are connected.

2. TYPES OF SWITCH:-

a) ACCORDING TO THE TYPE OF BASE MATERIAL:-

- Porcelain switch(high rating)
- Bakelite switch(low rating)

b) ACCORDING TO THE COLOUR

- black
- white
- Brown

c) ACCORDING TO OPERATION

- One way switch
- 2 way switch
- 2 way centre off switch
- Double pole main switch
- Single pole single throw

- Single pole double throw
- Double pole double throw
- Double pole main switch
- Single pole main switch

1. **ONE WAY SWITCH**

- 6 amp,250 volt --------light load (fan, tube light)
- 16 amp,250 volt -------heavy load(washing machine, heater, AC etc)

2. **TWO WAY SWITCH**

- The switch of this type consist of 3 or 4 terminals
- The switch of this type is usually used for staircase wiring orckt where one point is to be controlled from two different places.
- 6 amp, 250volt -------(light load)

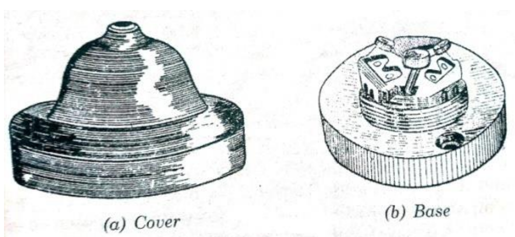
Connection diagram of 2 way switch

3. **2 WAY CENTRE OFF SWITCH**

- 6 amp ,250 volt

4. **SINGLE POLE MAIN SWITCH**
5. **DOUBLE POLE MAIN SWITCH**
6. **SINGLE POLE SINGLE THROW**
7. **SINGLE POLE DOUBLE THROW**
8. **DOUBLE POLE DOUBLE THROW**

<u>CEILING ROSE</u>



- The ceiling rose is used to connect the pendent lamp, fan and fluorescent tube to install through flexible wire.
- It consists of 2 parts

1. Base   2.cover

It is made of bakelite, porcelain

TYPES OF CEILING ROSES

1. 2-way ceiling rose:-
   It is fitted with two terminal plate.
2. 3-way ceiling rose:-
   It is fitted with 3 terminal plates. Rating 6A, 250 volt

SOCKET OUTLET:-

The socket outlet are used to supply outlet connection when ever required for electrical appliances such as TV, iron table fan.

TYPES OF SOCKETS

1 PIN SOCKETS

3 PINSOCKETS

5 PIN SOCKETS

Three-Pin Socket 6 A, 250 V   Five-Pin Socket 6 A, 250 V, AC

LAMP HOLDER:-

- It is used to support the lamp and also to connect of electricity.
- These are design for quick removal,replacement. Of the lamp.
- It is made of Bakelite with porcelain interiar.

TYPES OF LAMP HOLDER:-

1. Pandent holder
2. Angle holder
3. Slanting holder

Fantum   Royal

PLUG:- Plugs are use to connect the supply from the socket outletfor electrical appliances such as TV, Iron

2pin plug   3pin plug

PARALLEL OPERATION ADVANTAGES

- The supply voltage is uniform in each load.
- In case the light or same other equivalent goes out of order, it will not affect the supply of current to other light etc as each one of them is individually connected to line.
- The voltage in the ckt will be uniform and every will glow with full brightness.

SERIES CONNECTION

- The ckt useful for decorative lighting for marriage and other places where groups of lamps are tobe control by switch instead of placing separate switch for each light.
- The major disadvantages areof one light goes out of order , light and other equipments in that ckt will go off . As the flowof current from one point to other is stop.

SERIESPARALLEL CONNECTION

2 way centre off switch

Series parallel ckt are used either to provide deam light or full bright light through the same lamp by using special switch such as two way centre off switch .

To operate either both lamp in series or parallel by wing two pole double throw switch

FUSE

It is a simple and cheapest device used for interupturing and electrical ckt under short ckt or over load condition.

- The action of a fuse is based upon the heating effect of the electric current.

ADVANTAGES

- It is cheaper form of protection available.
- It needs no maintenance.
- Its operation is completely automatic.
- It interrupt huge short ckt current without noise, gas, smoke.

DISADVANTAGE

- Considerable time is lost in running or replacing a fuse after operation.

FUNCTION OF WIRE

- To carry the current working current flow without heating.
- To break the ckt when the current exceed the limiting current.

FUSE ELEMENT MATERIAL

- The material used fuse elements must be of low rating point ,high conductivity , low cost and from deterioration.
- The material commonly use for fuse elements are tin, lead ,copper, zinc, aluminium and alloy of lead and tin(60+40)
- Fuse element is a low melting point material such as tin, lead and zinc.
- The alloy of lead and tin is used for small current for fuse (up to 15 amp)

Metals	Melting point
silver	980
tin	240
zinc	419
lead	328

copper	1090
aluminium	665

- Beyond 15 amp rating ckt copper wire fuse are used.
- Either copper or lead tin alloy is mostly used as an ordinary use wire.

TYPES OF FUSE:-

- Supply main fuse

This fuse is provided by the supplier and is fixed just before the service meter .The rating of supply main fuse will be as from bad current of the consumers.

- Consumers main fuse

  This is another fuse of rating slightly less than that of supply main fuse and placed after the consumers main switch.

3.SUB CKT:-

The total wiring system is divided in to no. of sub ckt or branch. A separate fuse is provided for each branch ckt and is known as sub. Ckt or branch ckt fuse.

POINT FUSE :-

In good quality indoor wiring in building light and plug point is provided with its individual fuse known as point fuse.

IMPORTANT DEFINATION (2 MARK)

FUSE:-

Fuse is a current interrupting device which break or open the ckt by fusing the elements when the current in the ckt exceed a certain voltage.

FUSE ELEMENTS OR FUSE WIRE:-

It is that point of the fuse which actually melt when an excessive current flow in the cktr and thus isolate the faulty device from the supply.

CURRENT RATING:-

It is define as the rms value of current which the fuse wire can carry continuously without deterioration and with temperature rise with in specific limit.

FUSING CURRENT;-

It is define as the minimum value of current at which the fused elements or fuse wire melt. Its value will be more than current rating of the fuse element for a round wire the appropriate value of fusing is given by

$$I=Kd^{\frac{3}{2}}$$

Where k= fuse constant, depend upon the metal of the fuse elements

d =diameter of the wire

The fusing current depends upon various factor such as

1. Types of metal used.
2. The cross sectional area i.e whether round or regular section
3. Diameter of the wire
4. Types enclose employed
5. Type of surface (stranded)

The fusing current for stranded fuse will be less than the product of the fusing current one strand and the no. of strand.

DETERMINATION OF SIZE OF FUSE WIRE

1. Factors responsible for deteriorating the size of the fuse wire in an installation are:-
    - Maximum current rating of the circuit.
    - Current rating of the smallest cable in the ckt protect by the fuse.

EARTHING CONDUCTOR:-

- Earthing conductor is of v high conductivity material specially we i. E copper & G.I wire.
- I should be protect against mechanical injuries in corrosion.

WHAT IS EARTHING;-

Connection of non-current carrying part of electrical apparatus such as metallic frame, metallic covering of cables, earth terminals of sockets outlet, stay wire etc to the general mass of earth in such a manner that at all time an immediate discharge of electric energy taken place without danger.

EARTHING IS PROVIDED

- To avoid electric shock to the human beings
- To avoid risk of fire due to earth leakage current through unwanted path.

IS SPECIFICATION REGARDING EARTHHING OF ELETRIC INSTALLATION:-

Distance of earth from building

An earthing electrode shall not situated with in a distance of 1.5 mt from the based where installation system is being earthed.

SIZE OF EARTH CONTINUITY CONDUCTOR (ECC)

The conductor which is used to connect the body of an equivalent or connected to the earth is known as earth continuity conductor. It should not be less than 2.9 mm2 or half of installation conductor size.

RESISTANCE OF EARTH:-

- The earth resistance should be low enough to cause flow of current.
- The value of earth resistance does not remain constant but change with the weather at its depend upon the moisture contain of the soil and is maximum during dry season.
  For large power station =0.5 Ω
  Major power station=1.0 Ω
  Small substation=2.0 Ω
  In all other cases=5 Ω maximum
- The earth wire and earth electrode shall be of same material:-
  The earth wire shall be taken through G.I pipe of 13mm diameter for at least 30 cm length below ground surface to the earth electrode to protect it against mechanical damage.
- The earth electrode shall always be placed in vertical position inside earth or pit so that it may be in contact with all the different earth layers.

It is made of bakellite , porcelain

SOCKET OUTLET:-

The socket outlet are used to supply outlet connection when ever required for electrical appliances such as TV, iron table fan.

LAMP HOLDER:-

- It is used to support the lamp and also to connect of electricity.

- These are design for quick removal, replacement. Of the lamp.
- It is made of Bakelite with porcelain interiar.

TYPES OF LAMP HOLDER:-

4. Pandent holder
5. Angle holder
6. Slanting holder

CONNECTION

1. PARALLEL CONNECTION:-

NO. OF WIRE	1	2	3	4	7
FUSING CURRENT	1	1.667	1.25	2.75	4

FUSING FACTORS:-

It is the ratio between minimum fusing current to the current rating of fusing elements is known as fusing factor and it is always greater than unity.

$$\text{Fusing factor}=\frac{minimum\ fusing\ current}{current\ rating\ of\ fusing\ element}$$

DETERMINATION OF SIZE OF FUSE WIRE:-

Factor responsible for determining the size of fuse wire in an installation are

1. Maximum current rating of the circuit.
2. Current rating of the smallest cable in the circuit protected by the fuse.

EARTHING CONDUCTOR:-

- Earthing conductor is of high conductivity material specially we use copper and G.I wire.
- It should be protected against mechanical injury and corrosion.

EARTHING:-

Connection of non-current carrying part of electrical apparatus such as metallic frame ,metallic covering of cables ,earth terminals of socket outlet, stay wire etc to the general mass of earth in such a manner that at all times an immediate discharge of electric energy takes place without danger.

Earthing is provided

- To provide electric shock to the human beings.
- To avoid risk of fire due to earth leakage current through unwanted path.

IS SPECIFICATION REGARDING EARTHING OF ELECTRICAL INSTALLATION

1. Distance of earth from Building

An earth electrode shall not be situated within a distance of1.5m from the building whose installation is being earthed.

2. Size of earthed continuity conductor
    - The conductor which is used to connect the metal body of an equipments or appliances to the earth is known as earth continuity conductors (ECC).
    - It should not be less than 2.9mm^2 or half of installation conductor size.
3. Resistance of earth
    - The earth resistance should be low enough to cause flow of current.

- The value of earth resistance does not remain constant but change with the weather as it depends upon the moisture contents of the soil and is maximum during dry season.
  Large power station =0.5Ω
  Major power station=1Ω
  Small sub-station=2Ω
  In other all cases=5Ωmaximum
- The earth wire and earth electrode shall be of same material.
- The earth wire shall be taken through G.I pipe of 13 mm diameter for atleast30 cm length below ground surface to the earth electrode to protect it against mechanical damage.
- The earth electrode shall always be placed in vertical position inside the earth or pit so that it may be in contact with all the different earth layer.
- All the earth wire run along the various sub circuit shall be terminated and looped firmly at the main board and from main board, the main earth shall be taken to the electrode.

POINT TO BE EARTH

- Earth pin of 3- pin& 5- pin socket should be permanently and efficiently earth.
- All metallic covering containing or protecting any electric supply line or apparatus such as iron clad switches ,iron clad distribution fuse board, G.I pipes and conduit enclosing VIR or PVC cable etc should be connected to earth.
- The frame of energy generator, stationary motor ,portable motor and the metallic part of all transformer and any other apparatus used for regulating and controlling energy and all medium voltage energy consuming apparatus should be a earth by two separate different connection with earth.
- Fabricating steel ,transformer line tower, tubular steel or rail poles carrying overhead conductor should be earthed.
- Stay wire provide for overhead lines should be connected to earth buy connecting at least one strand of the earth wire .
- The neutral conductor of a 3phase, 4 wire system and the middle conductor of a 2pjase ,3 wire system should be earthed by two separate and different connection in earth at the generating station and at the substation.

DETRMINATION OF SIZE OF EARTH WIRE AND EARTH PLATE FOR DOMESTIC OF MOTOR INSTALLATION

CONDUITS ACCESSORIES& FITTINGS

1. CONDUIT COUPLER
   It is used to joint two length of conduit. The length of screw conduits are always threated at both end on outer side.
2. GRIP COUPLER

In grip coupler, no extra labour is required for making threads. The ends of conduits are placed in the grip coupler and screw it tightly.
It is covered above two conductor and the screw is used to make it tight.

2. FLEXIBLE CONDUIT COUPLER

For coupling a flexible conduit to the rigid conduit a combine coupling is used.

3. BENDS ,ELBOW, & TEES

BEND:- Bends are usually used for change in direction of conduit.

ELBOW:

Elbows are of shorter radius, are only used where sudden right turn is required.`

TEES

CONDUIT BUSHINGS

This are used when the rigid conduit enter the conduit box or a hole which is not threaded.

This are used to prevent cable from being cut by the edges.

It is up two types.

a) Male -outer threads
b) Female-inner threads

CONDUIT REDUCER

Conduit reducers are used when the size of conduit change.

Conduit reducer have both male & female threads.

FIXING OF CONDUIT

It is used to fix the conduit over the wall.

CLIP:- Clip are used for fixing the conduit on rough brick walls and in concealed wiring.

SADDLE:

Saddle are used for fixing the conduit where clips cannot provide a firm enough hold or a single screw cannot be dependent upon for fixing.

LOCKNUTS/CHECK NUTS:

This are used when rigid conduit enter a conduit box.

CONDUIT NIPPLES

This serve the same purpose as conduit bushing.

This are rarely used due to their higher cost.

CONDUIT BOXES

The conduit boxes are used in surface conduit wiring as well as concealed conduit wiring. It serve the following purpose.

It is used to provide connection to rigid fan and other point.

For pulling of cable into the conduit. Boxes serving this purpose are known as inspection box . this are provided after every 30 cm length straight run.

For housing junction of cables, the conduit boxes serving this purpose are known as junction box.

WIRING SYSTEM

A network of wires connecting various accessories for distribution of electrical energy from the supply meter board to the numerous electrical energy consuming device such as lamps & fan and other domestic appliances through controlling & safety device is known as wiring system.

TYPICAL HOUSE WIRING SYSTEM

SYSTEM OF DISTRIBUTION OF ELCTRICAL ENERGY

As per recommendation of Indian standard, the maximum number of points of light, fan and 5A sockets outlet that can be connected in one circuit is 10and the maximum load that can be connected in such circuit is 800 watt, in case more load or points are required to be connected to the supply, then it is to be done by having more than one circuit.

The system of distribution of electrical energy is two types

1. Distribution board system
2. Tee system

DISTRIBUTION BOARD SYSTEM

TEE SYSTEM

METHODS OF WIRING

Therearetwo methods of wirings known as joints box system (tee system)and loop in system wiring.

JOINTS BOX/ TEE SYSTEM

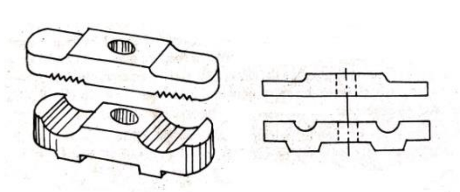
CHAPTER-3 INTERNAL WIRING

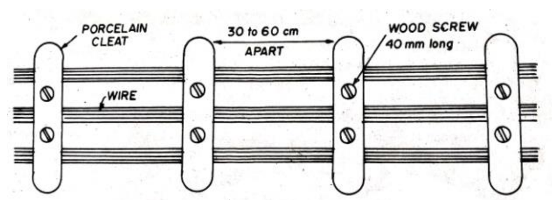
TYPES OFINTERBNAL WIRING

Following are the type of internal wiring usually employed in industries and house wiring;-

1. Cleat wiring
2. Wooden casing & capping wiring
3. C.T.S/T.R.S or batten wiring
4. Lead sheathed or metal sheathed wiring
5. Conduit wiring

1. CLEAT WIRIG





Wires laid in three groove cleats.

- In this type of internal wiring the cable used are either VIR or PVC.
- The cables are held by porcelain, cleat above wall or ceiling.
- The cleats are made in two halves one is base and other is cap.
- The base is groove to accommodate the cable and the cap is put over it and a whole of it then screwed on wooden plug (guttis) over the wall or ceiling.
- The cleat are up three types
    - One groove-one cable
    - Two groove-two cable
    - Three groove-three cable

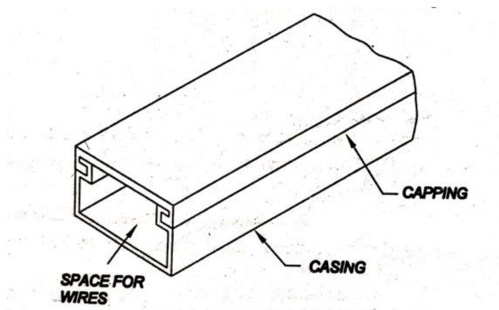
- The cleat should be usually used at interval of 30 cm and in no case at more than 60 cm.

ADVANTAGES
- It is cheapest system of internal wiring.
- It’s installation and dismantlement is easy and quick.
- Inspection, alternation and addition can be easily made.
- Skill required is little.

DISADVANTAGES
- It is not good looking.
- It is quite temporary & destroy quickly.
- The insulation dampness from the atmosphere hence this system of wiring can be used in damp place.
- Oil& smoke are injurious to VIR insulation.

FIELD APPLICATION
- The wiring of this type is very suitable for temporary installation in dry places, where appearance is not so important and cost is the main consideration.

2. WOODEN CASING & CAPING WIRING



Assembly of Casing and Capping.

- This is one of the earliest systems of wiring.
- The cables used in this type of wirings are either VIR or PVC.
- It has two halves, one is casing and another is capping.
- The casing consist of V – shaped grooves and is covered at the top buy means of rectangular strip of wood known as capping.
- The varnished is used to protect wood from white ants.

ADVANTAGES
- Cheaper in cost as compare to lead sheath wiring.
- Easy to install and rewire.
- It provides good insulation as conductors are at a good distance apart.
- Easy to inspect by opening the capping.

DISADVANTAGES
- This type of wiring is also coated with pain to varnish to protect from dampness. So it can be used in damp place.
- Since there is a risk of fire. It cannot be used where there is a possibility of fire hazard.
- This type of wiring can be used only on surface and can be concealed in plaster.
- Since it require better work skills, the labour cost is higher.

FIELD APPLICATION
- This type of wiring is suitable for low voltage domestic installation in dry places and where there is no risk of fire.

PVC CASING & CAPING WIRING

- Due to increased cost of teak wood, the wooden casing & capping are becoming absolute and PVC casing &capping are being used.
- This type of wiring is achieved by using hollow channel made of PVC plastic.

3. C.T.S/ T.R.S OR BATTEN WIRING

T.R.S-Tough rubber sheathed wiring
C.T.S-Cab Tyre sheathed wiring

- In this type of wiring the cables used may be single core, twin core or three core T.R.S cable with a circular shape.
- T.R.S cables are sufficiently chemical proof, water proof, steam proof but are slightly affected by lubricating oil.
- T.R.S cables are run on perfectly straight and well varnished teak wood batten.
- The width of batten depends upon number and size of cables to be carried by it.
- The wood battens are screw to wood by plugs at an interval not exceeding 75 cm.
- The cables are held on the wood batten by means of tin-brass links clips at an interval of 10 cm or 15cm.

ADVANTAGES

- Its installation is easy and quick.
- Its life is sufficiently long.
- Within certain limits it is fire proof.
- It can withstand the action of most chemical such as acids &alkalis.
- It is cheaper than other types of wiring excepts cleat wiring.
- If the job is carried out with a care it gives a nice appearance.

DISADVANTAGES

- Good workmanships is required forth is type of wiring.
- This type of wiring cannot be recommended for use in situation open to sun & rain

FIELD APPLICATION

- The T.R.S wiring is suitable for low voltage installation in domestic & commercial building.
- It cannot be used in damp places.

4 .LEADSHEATHED / METAL SHEATHED WIRING

- In this type of wiring the cables used are T.R.S or P.V.C with an outer covering of sheath of lead aluminium alloy containing about 95% of lead.
- This metal sheath protection to the cables from mechanical injuries, dampness and atmospheric corrosion.
- The whole lead covering is made electrically continuous and is connected to earth at the point of entry to protect against leakage current.

ADVANTAGES

- It provides protection against mechanical injuries better than that of T.R.S wiring.
- It is easy to fix and look nice.
- Its life is long if proper earth continuity is maintain throughout.
- It can be used in damp situation provided protection against moisture.
- It can be used in situation exposed to rain & sun.

DISADVANTAGES

- It is costlier than T.R.S wiring.
- In case of damage of insulation the metal sheath becomes alive and gives shock.

- Skilled labour & proper supervision is required.

5.CONDUIT WIRING

- In this system of wiring al wires are enclosed in steel pipe known as conduit (PVC or VIR).
- There are3types of conduit wiring
  1. Concealed conduit wiring.
  2. Surface conduit wiring
  3. Flexible conduit wiring

1. CONCEALED CONDUIT WIRING

- The conduit are embedded along wall or ceiling in plaster at the time of construction.
- The conduit should be electrically& mechanically continuous and connected to earth at suitable place through earth wire.
- The conduit used for this purposes is up two types.
  1. Light gauge conduit
  2. Heavy gauge conduit
- PVC conduit pipes are also available now and are increasing being employed in place of steel conduit.
- PVC. Conduits are cheaper in cost. It required less time to install. Such conduits are resist to acids, alkalis, oil & moisture.

2.SURFACED CONDUIT WIRING

- The conduit in surface conduit wiring is placed on the surface of the wall and hold with the of conduit saddle.
- This system of wiring is applied in the industrial wiring.

3.FLEXIBLE CONDUIT WIRING

- The flexible conduit pipe is a pipe which can bend or twist without the change in its diameter.
- The flexible conduits are not used for general electrical wiring system. it is used for connecting rigid conduit with machine terminal box in case of motor wiring, energy meter and main switch in case industrial & domestic wiring system.

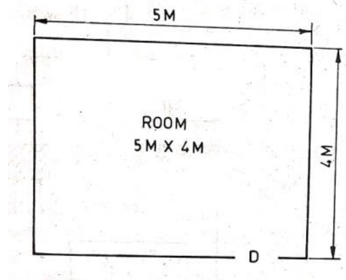
ADVANTAGES

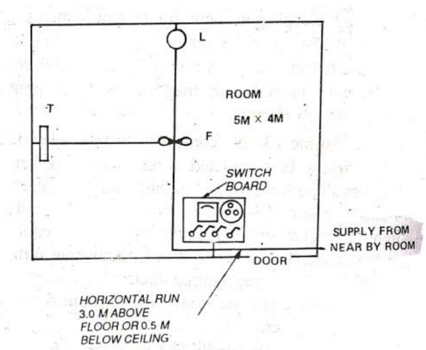
- It provides protection against mechanical damage.
- The whole system is water proof.
- Replacement and alternation of defective wiring is easy.
- Its life is long if the work is properly executed.
- It is shock proof if earthing &bonding is properly done.

DISADVANTAGES

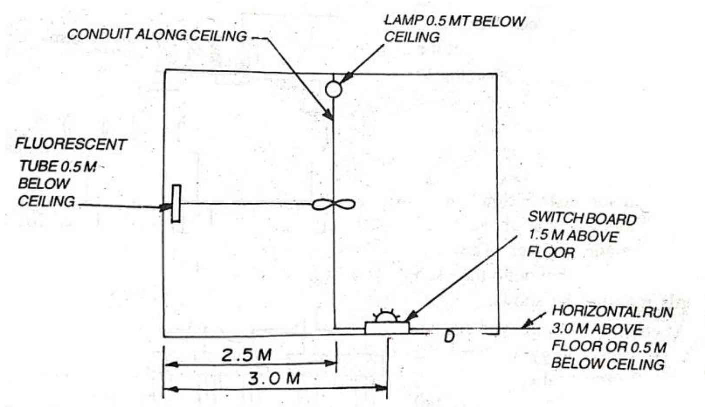
- It is a very costly system of wiring.
- Experience & highly skilled labour needed for carrying out the job.

Q.1 The plan of a single room of size 5mtsX4mts is given below .The room is required to be provided with one lamp, one fan, fluorescent tube and one 5 Amp socket –outlet. Each of the points is controlled by its individual switch. Mark the location of the electrical points suitably and draw the installation plan. Also draw the wiring diagram. Calculate the total length of wire and other materials and prepare complete list of materials required for wiring the room in concealed steel conduit system of wiring .No main switch is to be provided as the entry of the sub-circuit is from adjoining room.





Solution



Installation plan

Assume

a) Total height from floor to ceiling=3.5 mts
b) Height of H.R from floor=3.0 mts
c) Height of switch board from floor=1.5mts
d) Light and tube points from ceiling=0.5 mts

Calculation for length of conduits pipe of 20 mm diameter

from SB to HR=1.5 mts
from entry of circuit into room upto take off points=2.0+0.5=2.5mts
from HR to lamp point=0.5mt+4+0.5=5mts
from fan to tube points=2.5+0.5=3 mts
total length of conduit pipe=(1.5+2.5+5+3)mts=12mts
taking 10% for wastage=1.2 mts
total length of conduit pipe required for wiring the room=13.2 mts

Calculation for length of phase wire

from point of entry of circuit into room upto SB= 2(HR)+1.5(VR)=3.5 mts
from SB to fan =1.5(VR)+0.5(HR)+0.5+2=4.5mts

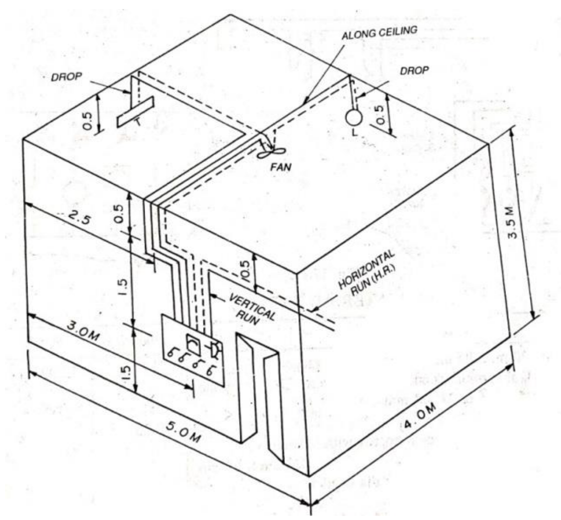
from SB to lamp=4.5+2+0.5=7 mts
from SB to tube point=4.5+2.5+0.5=7.5 mts
total length of phase wire=(3.5+4.5+7+7.5)mts=22.5mts
taking 15% for wastage=3.37mts
total length of phase wire required for wiring the room=22.5+3.37=25.075mts

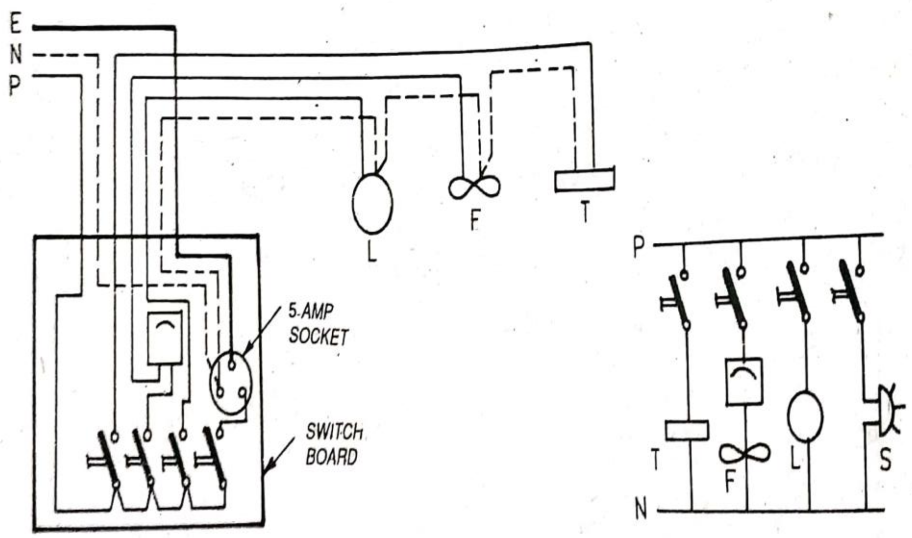
Calculation for length of neutral wire

from point of entry of circuit into room up to SB= 2(HR)+1.5(VR)=3.5 mts
from SB to fan =1.5(VR)+0.5(HR)+0.5+2=4.5mts
from fan to lamp points=2+0.5=2.5mts
from fan to tube point=2.5+0.5=3mts
total length of neutral wire=(3.5+4.5+2.5+3)mts=13.5mts
taking 15% for wastage=2.02
total length of neutral wire required for wiring the room=13.5 +2.02=15.52mts

calculation for length of earth wire (14 SWG)

length of earth wire=0.25 mt.

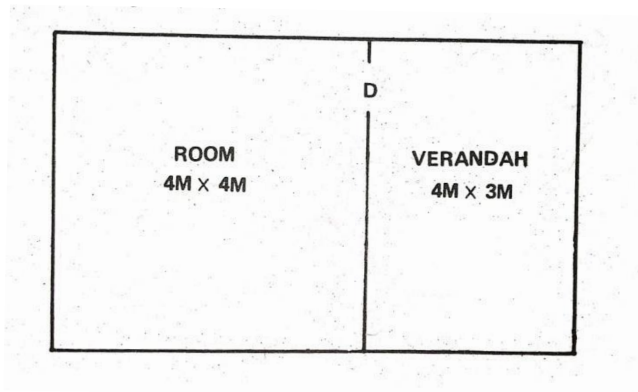




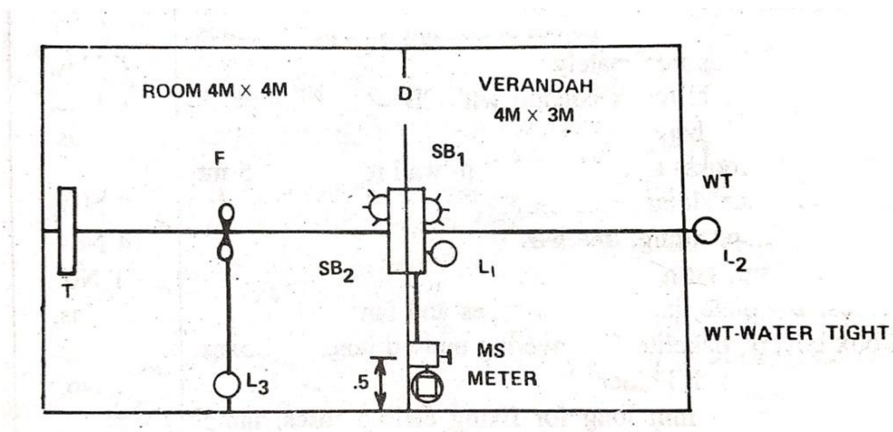
Material Table

Si no.	description of materials with specifications	Quantity
1	total length of conduit pipe (20 mm dia)	13.2 mts
2	total length of phase wire (1 mm^2)	25.075mts
3	total length of neutral wire(0.5 mm^2)	15.52mts
4	total length of earth wire(14 SWG ,G.I)	0.25 mt.
5	Conduit pipe accessories for 20 mm dia a. 1-way junction box b. 2-way junction box c. 3-way junction box d. Conduit bends	 2 nos 1no. 2nos. 3nos.
6	One way switch,5 amp ,rating	4nos.
7	Socket,5 amp rating, 3 pin	1nos.
8	Ceiling rose, 2-plate,bakelite	2nos.
9	Lamp brass bracket with holder	1nos.

Q.2 A room and a verandah ,the plan of which is given below is required to be provided with electrical wiring. Mark the location of energy meter, main switch and switch board and electrical points suitably and draw the installation plan showing supply path to each points and wiring diagram .calculate the total length of wire required for wiring the room and verandah in batten system of wiring. Prepare a list of materials with complete specification of each item with approximate cost.



Solution



Installation plan.

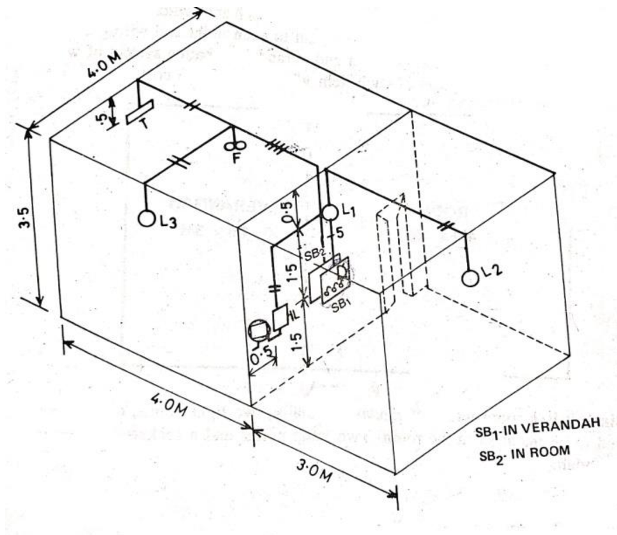
Assume

a) Total height from floor to ceiling=3.5 mts
b) Height of H.R from floor=3.0 mts
c) Height of switch board from floor=1.5mts
d) Light and tube points from ceiling=0.5 mts

e) Location of energy meter and main switch board=0.5 mt. inside verandah on room wall

Calculation of load

Lamps= 3X60 W=180W
Fan=1X60W=60W
Socket outlet 5 amp.=2X100W=200W
Fluorescent tube=1X40W=40W
Total connected load=480W
Load in ampere=480W/230V=2.1 amp



Selection and rating of main switch

Rating of DPIC , Main switch =5 ampere ,250 volt grade

Selection and rating of Distribution board

There are only seven light/fan/socket points, hence no distribution board will be used

Calculation for length of batten

from main board to HR=1.5 mts =13mm X13mm (2 wire)
from SB_1 to HR =1.5mts=31mm X13mm (5wire)
from SB_2 to HR=1.5mts=25mm X13mm (4wire)
from HR above main board to L_1=1.5mts=13mm X13mm (2 wire)
from L_1 to L_2=0.5+3+0.5=4mt=13mm X13mm (2 wire)
from HR above SB_2 to fan =0.5+2=2.5 mts=25mm X13mm (4wire)
from fan to L_3=2+0.5=2.5mt=13mm X13mm (2 wire)
from fan to tube point=2+0.5=2.5mt=13mm X13mm (2 wire)

total length of batten of size
13mm X13mm=1.5+1.5+4+2.5+2.5=12mt
25mm X13mm=1.5+2.5=4mt
31mm X13mm=1.5mt

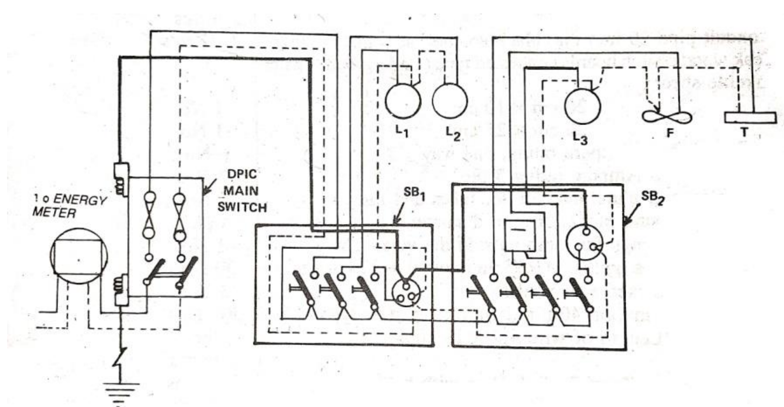
taking 10% for wastage which is required for wiring the room
13mm X13mm=12mt +1.2=13.2 say 13mt
25mm X13mm=4mt+0.4=4.4mt say 4.5 mt
31mm X13mm=1.5mt+0.15=1.65 mt say 2mt

Calculation for length of aluminium conductor VIR wire of size 1.5 mm^2

13mm X13mm=12mtX 2 wire=24 mts
25mm X13mm=4mt X 4 wire=16 mts
31mm X13mm=1.5mt X 5 wire=7.5 mts

total length of wire on batten=47.5mts
taking 15% for wastage=7.2mts
total length of phase wire required for wiring the room=47.5+7.2=55.7mts say 56mts

calculation for length of earth wire (14 SWG)
from MS to SB_2 through SB_1=1.5+1.5+1.5+0.25(thickness of wall)=4.75mts
taking 15% for wastage=0.47mt
taking 10% for wastage which is required for wiring the room=4.75+0.47=5.2 mts say 5.5 mts



Material Table

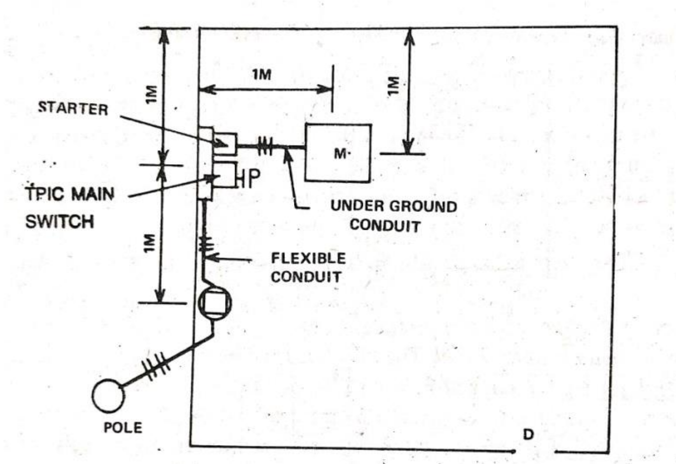
Si no.	description of materials with specifications	Quantity
	DPIC main switch 5 amp rating,250 volt grade with fuse and NL	1no.
1	total length of Different size of Batten 13mm X13mm 25mm X13mm	 13mt 4.5 mt

	31mm X13mm	2mt
2	total length of phase & neutral wire (1.5 mm^2)	56mt
4	total length of earth wire(14 SWG ,G.I)	5.5 mts
5	Conduit pipe accessories for 20 mm dia a. 1-way junction box b. 2-way junction box c. 3-way junction box d. Conduit bends	 2 nos 1no. 2nos. 3nos.
6	One way switch,5 amp ,rating	6nos.
7	Socket,5 amp rating, 3 pin	2nos.
8	Ceiling rose, 2-plate,bakelite	2nos.
9	Lamp brass bracket with holder	2nos.
9	Link clip,aluminium 40 mm long (10 cm apart)	300 nos
9	Black enamel nails to fix clips with batten	100 gms
9	Teak wood plugs (guttis) at 0.75 mt interval	30nos.
9	Earthing thimbles 5 amp rating for fixing earth wire to main switch	2nos.
9	Earthing set complete with pipe,earth wire,charcoal,salt,thimbles,nuts & bolts etc	1 set.

Q.3 It is proposed to install a power connection of 3 phase 5 HP induction motor for an agriculture tube-well in the room of size 3MX3MX3M high. The motor is one metre away from two nearest walls. Prepare the estimate in the following order.

a) Draw installation plan showing location of MB and motor etc. Also mark path of wiring by a thick line.
b) Single line diagram. Showing earth wires also.
c) Wiring diagram.
d) Decide the rating and specification of important materials and calculate of wire ,conduits,earth wire etc. and prepare a complete list of materials required for wiring the room with complte specification of each item. Also calculate the approximate cost for the power wiring.

Solution



Installation Plan.

Assumption

a) Total height of main board from floor =1.5 mts
b) Two earth wires enclosed in their respective 15 mm dia. G.I pipe installed side by side for earthing the motor.
c) The Motor with pumping set is installed 0.25 mt above floor on a suitable foundation

Calculation of load

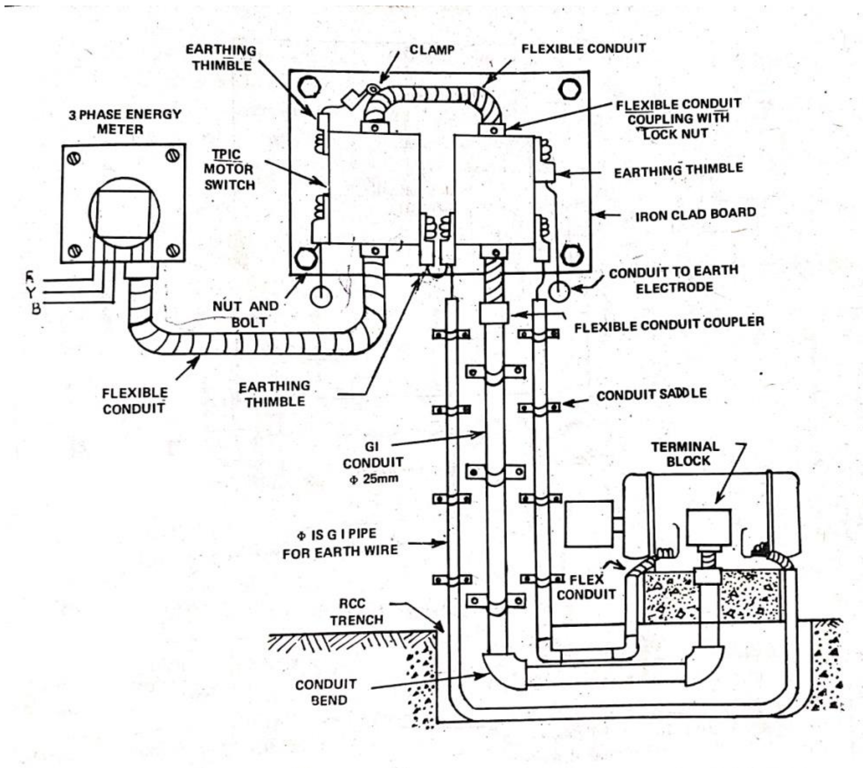
Running current =$\frac{5\times 746}{\sqrt{3}\times 400\times 0.85\times 0.8}$ = 9.1 amp say 8 amp
Starting current=1.5$\times 8 = 12$ amp

Selection and rating of MS

It is suggested that a TPIC, Main switch=32 amp,500 volt grade

Selection and rating of wire

It is suggested that a PVC Insulated aluminium conductor, single core ,660 volts grade of size 6 mm^2 or 1/2.80 mm diameter, should be used for power wiring



Calculation for length of heavy gauge conduits of 25 mm diameter

From TPIC to motor foundation=1.5+0.25+1+o.25+0.25=3.25 mts
Taking 10% wastage=0.325mt
Total length of conduit required for wiring the motor =3.25+0.325=3.57 mts say 4 mts

Calculation for length of heavy gauge conduits of 15 mm diameter

From starter to motor foundation=(1.5+0.25+1+o.25+0.25)X2=3.25 mts X 2=6.5 mts
Taking 10% wastage=0.65mt
Total length of conduit required for wiring the motor =6.5+0.65=7.1 mts say 7.5 mts

Calculation for length of flexible conduits of 25 mm diameter

From energy meter to main board=1.0 mt
From main switch to starter=0.5 mt
From starter to conduit mouth=0.25mt
From motor foundation to motor terminal block=0.25mt
Total length of conduit=(1.0+0.5+0.25+0.25)mt=2mt
Taking 10% wastage=0.2mt
Total length of flexible conduit required for wiring the motor =2+0.2=2.2mts say 3.25 mts

Calculation for length of phase wire of 6 mm^2 or 1/2/80 mm dia

From TPIC to motor foundation=(rigid conduit +flexible conduit)X3

=(3.25+2)mts X 3

=15.75 mts

Taking 15% wastage=2.5mt

Total length of phase wire required for wiring the motor=(15.75+2.5)mts=18.25 mt=18.5 mts

Calculation for length of 8 SWG , G.I , earth wire

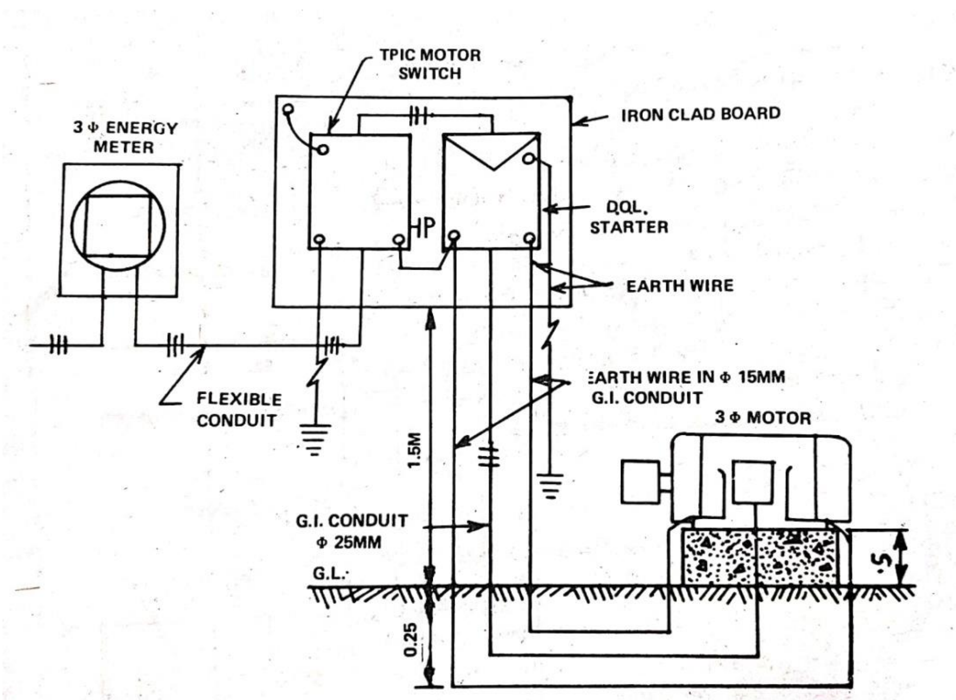
From starter to motor foundation = length of conduit X 2 earth wires

=3.25 X 2 Wires

=6.5 mts

Taking 10% wastage=0.65mt

So total earth wire required for wiring the motor=6.5 +0.65=7.15mt say 7.5 mts



Material Table

Si no.	description of materials with specifications	Quantity
1	TPIC main switch 32 amp rating,500 volt	1no.

2	Total length of rigid conduit (25mm dia)	4 mt
3	Total length of flexible conduit (25 mm dia)	2.5 mt
4	Total length of rigid conduit (15mm dia)	7.5
5	Total length of phase wire(6 mm^2)	19 mt.
6	Earth wire (14 SWG)	8 mt
7	Saddle	1 pkt
8	Nuts & bolts	1 pkt
9	Wooden screw 20 mm long	30 nos.
10	PVC tape	1 pkt.
11	Bend	30 gms
12	Earthing thimbles 5 amp rating for fixing earth wire to main switch	2nos.
13	Earthing set complete with pipe,earth wire,charcoal,salt,thimbles,nuts & bolts etc	1 set.

CHAPTER-4 OVERHEAD INSTALLATION

Q.1 In a city locality, an overhead distribution line of 400 volts, 3 phase ,50 cycle/sec. is to be erected along a straight route on steel tubular poles. The length of the line is 500 metres and the line terminates at the ends. The span between adjacent poles is 50 mts. The street light conductors are also supported on the same poles.Make a neat sketch of the last 2-3 poles and estimate the quantity of material required for installing the distribution line with full specification of each items. Other details of the line are suggested as under.

ACSR conductors are phase lines, neutral and street light conductor of size 6/1$\times$ 2.11 (squirrel conductor). Earth wire 8 SWG , Galvanised iron

Solution

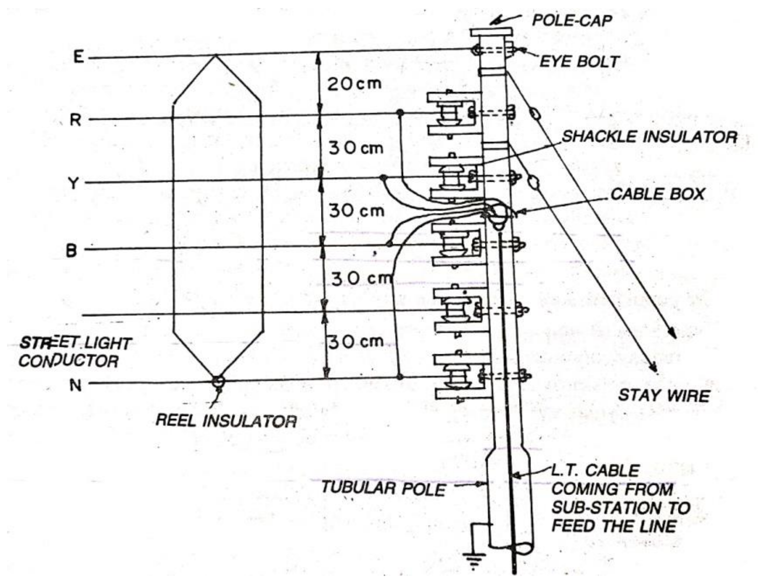
Assuming that the connection is taken for the line from an existing sub-station of 11/0.4 KV.
Length of line =500 metres
Average span=50 mts.
No. of tubular poles required=$\frac{500}{50}$+1=11 nos.
Length of squirrel ACSR conductor of size(6/1$\times$ 2.11 mm)=(500 mts$\times$ 5)+2% for sag
=2500+50
=2550 mts

In weight=85 kg/km=216.75 kg say 217kg

Length of 8 SWG, galvanized iron= 500+2% for sag

=510 mts

In weight =10 mts/kg=51 kg

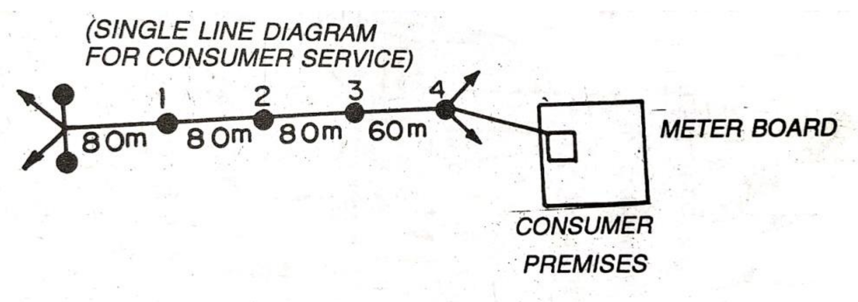


Material Table

Si no.	description of materials with specifications	Quantity
1	Steel tubular poles (9 mts long)	11 nos
2	ACSR squirrel conductors of size(6/1× 2.11 mm)	2550 mts(218 kg)
3	E arth conductors 8 SWG GI	510 mts (51kg)
4	shackle Insulators with ‘D’ straps i.e 5 on each pole	55 nos.
5	Nuts and Bolts 15 mm dia ,200 mm long with washers for fixing ‘D’ straps with pole,one for each straps	55 nos.
6	Nuts and Bolts 15 mm dia ,125 mm long with washers for fixing insulators with ‘D’ straps	55 nos.
7	Earth wire pole clamp one on each end pole	2nos.
8	Eye bolts,15 mm dia ,200 mm long for holding earth wire on intermediate pole	9 nos.
9	Guard wire of size 7/16 SWG ,for guarding at approximate 15 places	45 mts
10	Reel insulator	15 nos.
11	Pole caps for steel tubular poles	11 nos.

12	Stay wire set complete i.e 2 sets on each terminals poles	2+2=4 nos
13	Earthing sets complete for earting(one at each terminal pole and one central pole)	3 sets
14	Street light fitting complete with tube and clamps	11nos.
15	Number plates with clamps	11nos.
16	Pole foundation for each pole	11nos.
17	To complete the job miscellaneous items such as cement ,sand, concrete etc	-
18	14 SWG ,galvanized steel wire as binding wire	5kg

Q.2 A tube well owner wants 3 phase,4 wire power connection to his 10 BHP motor from an over head double pole structure having of 25 KVA ,11/0.4 KV . The double pole structure is 300 metres away from tube well. Estimate the quantity of materials required for erecting a line and for giving a service connection to the tube well motor. Also draw neat sketch of the same.



Solution

Total connected load =10BHP

Starting current=$\frac{10\times746}{\sqrt{3}\times400\times0.85\times0.9}$ = 14.07 amp

Starting current=1.5$\times$ $14.07 = 21.10$ amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% $\times$ 21.10)+21.10=31.65 amp

It is therefore suggested that

- L.T 4 core ,aluminium conductor weather proof cable of size =6 mm^2 (from distribution transformer to pole and from last pole to the meter box)
- A.A.C of minimum size =3/3.00 mm mantis stranded conductor (from fifst pole to last pole)

Average span=50 mts.

No. of Concrete pole required(9 mt. long) =$\frac{300}{50}$=6 nos.

Length of mantis AAC conductor of size(3/3.00 mm)=(300 mts$\times$ 4)+2% for sag

=1200+24

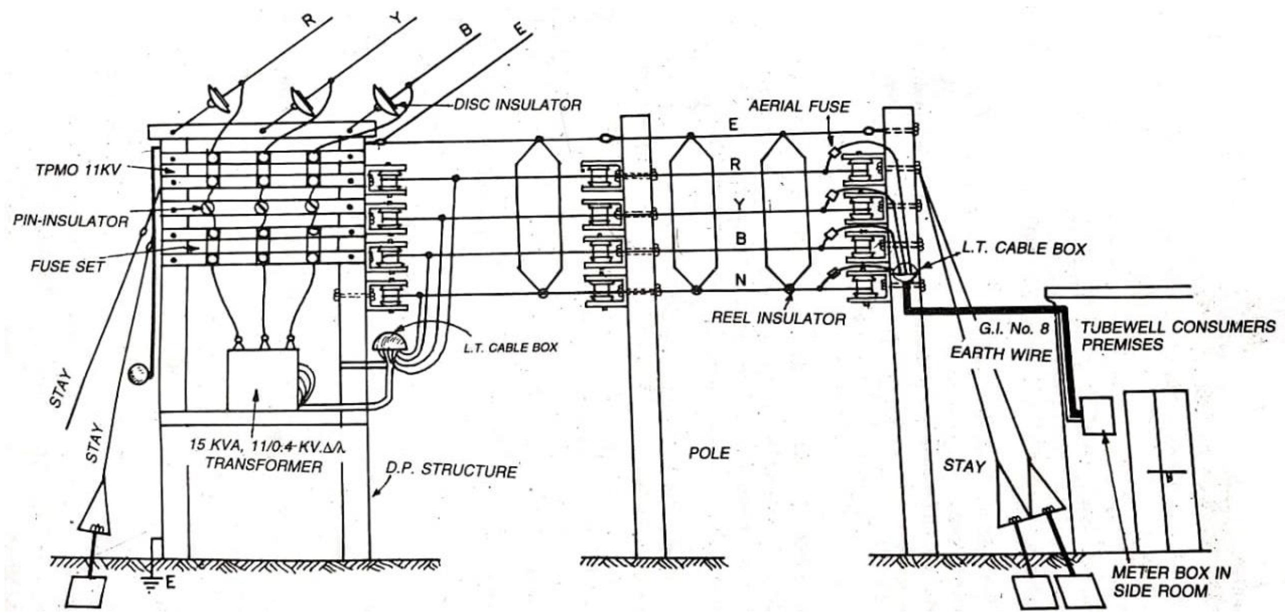
=1224 mts

In weight=58 kg/km=70 kg

Length of 8 SWG, galvanized iron= 300+2% for sag

=306mts

In weight =10 mts/kg=30.6kg



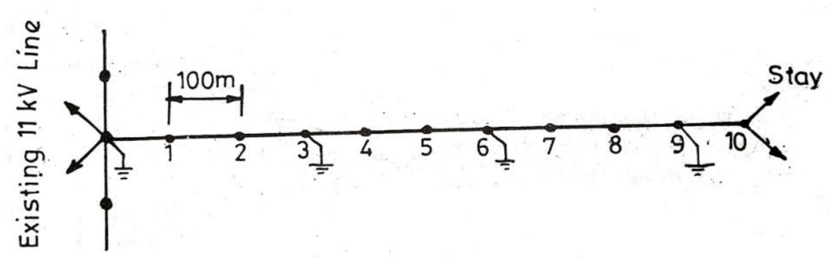
Material Table

Si no.	description of materials with specifications	Quantity
1	RCC poles (9 mts long)	6 nos
2	AAC, mantis conductors of size(3/3.00mm)	1224 mts(70kg)
3	E arth conductors 8 SWG GI	306 mts (30.6kg)
4	Shackle Insulators with ‘D’ straps i.e 4 on each pole	24+4=28 nos
5	Nuts and Bolts 15 mm dia ,200 mm long with washers for fixing ‘D’ straps with pole,one for each straps	28nos.
6	Nuts and Bolts 15 mm dia ,125 mm long with washers for fixing insulators with ‘D’ straps	28 nos.
7	Eye bolts,15 mm dia ,200 mm long for holding earth wire on intermediate pole	4 nos.
8	Earth wire pole clamp one on each end pole	2 nos.
9	Guard wire of size 7/16 SWG ,for guarding at	30 mts

	approximate 15 places	
10	Aerial fuse,32 amp rating on last pole	3 nos.
11	L.T outdoor cable box, complete with clamps	2 nos.
12	Reel insulator	10 nos.
13	Pole caps for steel tubular poles	6 nos.
14	Stay wire set complete i.e 2 sets on each terminals poles	2+2=4 nos
15	Earthing sets complete for earting(one at each terminal pole and one central pole)	1 sets
16	Number plates with clamps	6 nos.
17	Pole foundation for each pole	6 nos.
18	To complete the job miscellaneous items such as cement ,sand, concrete etc	-
19	14 SWG ,galvanized steel wire as binding wire	2kg

Q.3 Estimate the quantity of material required for the construction of 1 kilometre overhead line. The line is tapped from the existing 11 KV line to feed a particular locality. The particulars of the important materials to be used for the line to be erected are as follows.

a) Size of conductor : ACSR 6/1× 2.59 mm
b) Tubular pole or supports of 11 metres length
c) Size of earth wire : G.S (galvanized steel) 8 SWG
d) Average span length=100 mts.
e) No. of earthing sets to be installed:3 nos.



Single line diagram of the line

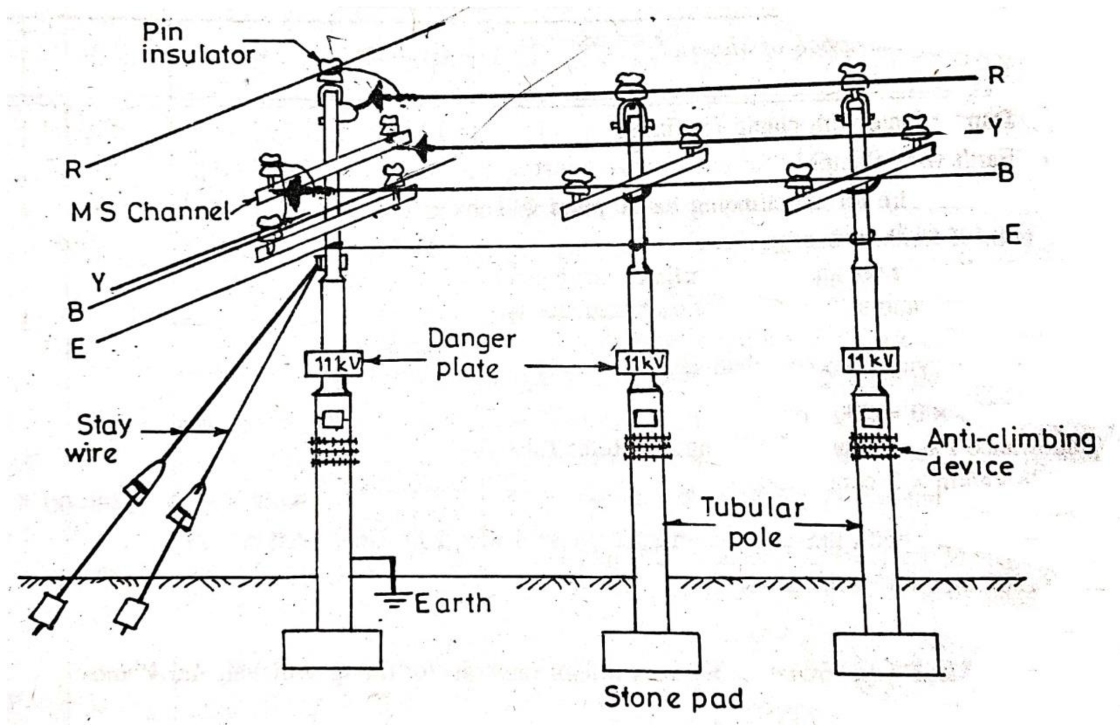
Solution

Total Length of conductors (ACSR weasel conductor 6/1 X 2.59 mm)= (1000X3)+2% for sag

=3000+60=3060 mts

Total length of G.I. earth wire of size 8 SWG =1000+2% for sag

=1000+20=1020 mts



Material Table

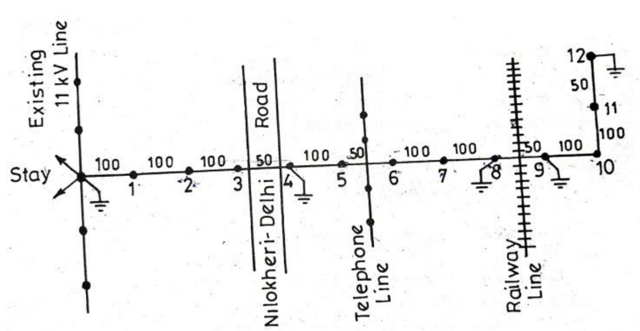
Si no.	description of materials with specifications	Quantity
1	Tubular line supports (11 mts long)	10 nos
2	Material required for connection with existing line of 11 KV line 1. M.S channel for cross arm (10 cmX5 cmX1.5mts) 2. H.T ,11 KV Disc insulator with complete fittings 3. H.T ,11 KV ,pin type insulators with nuts and bolts 4. Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates) 5. Earth wire clamp 6. Binding wires 7. Clamps for M.S channel 8. Concreting for stay rod	 1no. 3nos. 2 nos. 2nos. 1no. 1 kg 1 no. 2nos.

3	Fitting for new line supports 1. Stone pads for poles 2. Angle iron cross arms, 1 for each pole 3. clamps for fixing cross arm with poles 4. 11 KV ,pin type insulators with nuts and bolts 5. No. plates with clamps for fixing 6. Danger plates with clamps for fixing 7. Earth wire clamp 8. Barbed wire for anti climbing for 10 poles @ 1 kg for each pole 9. Binding wires (for fixing conductors over insulators)	 10 nos. 10 nos. 10 nos. 30 nos. 10 nos. 10 nos. 10 nos. 10kg 6kg
4	ACSR weasel conductors of size 6/1 X 2.59 mm	3060 mts
5	G.I earth wire of size 8 SWG	1020 mts.
6	Earthing complete sets (G.I pipe, charcoal ,salt etc)	3 nos.
7	Painting for poles	10 nos.

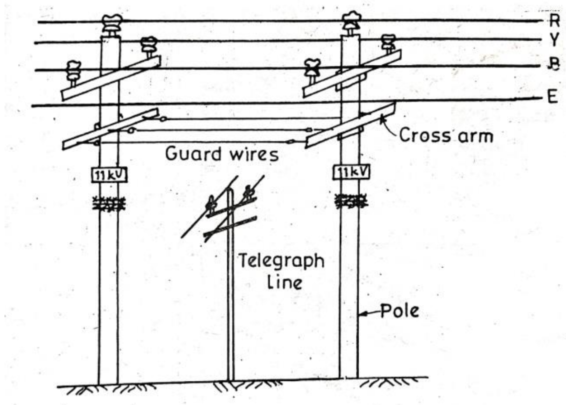
Q.4 Estimate the material and cost for the construction of 1 kilometre overhead line. The line is tapped from the existing 11 KV overhead line. Assuming that the line is passing over the main road, telegraph line and railway line. Given data:

a) Size of conductor : ACSR 6/1× 2.36 mm gopher
b) Type of pole : R.S (Rolled steel) joist 10 mts and 11.5 metres long.
c) Size of earth wire : G.S (galvanized steel) 8 SWG
d) Type of cross arm : mode of angle iron
e) No. of earthing : plate eathing

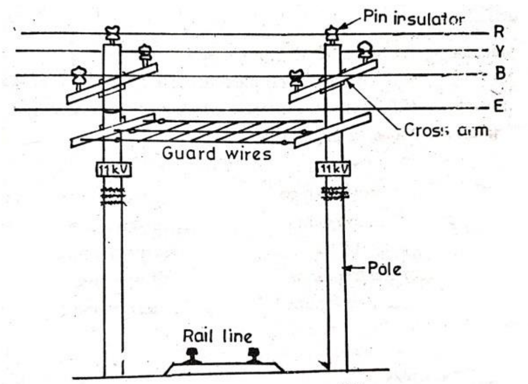
Solution



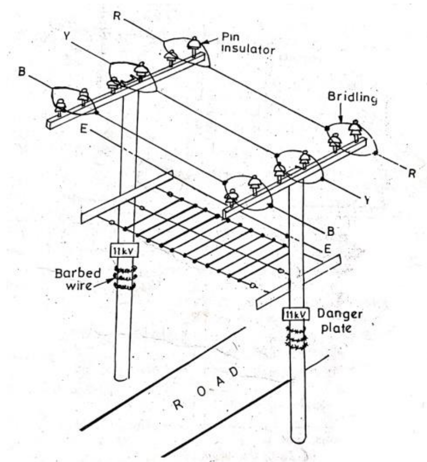
Layout Plan of 11 kV line.



Guarding for telegraph line.



Guarding for rail line



Bridling on road crossing.

Total Length of conductors (ACSR gopher conductor 6/1 X 2.36 mm)= (1000X3)+2% for sag

=3000+60=3060 mts

Total length of G.I. earth wire of size 8 SWG =1000+2% for sag

=1000+20=1020 mts

Material Table

Si no.	description of materials with specifications	Quantity
1	a) R.S joist poles 15cm diameter 10 mt long b) R.S joist poles 15cm diameter 11.5 mt long	6 nos. 6 nos.

2	Material required for connection with existing line of 11 KV a) M.S channel for cross arm (10 cmX5 cmX1.5mts) b) H.T ,11 KV Disc insulator with complete fittings c) H.T ,11 KV ,pin type insulators with nuts and bolts d) Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates) e) Earth wire clamp f) Binding wires g) Clamps for M.S channel h) Concreting for stay rod	 1no. 3nos. 2 nos. 2nos. 1no. 1 kg 1no. 2nos.
3	Fittings for new line supports a) Stone pads for poles b) Angle iron cross arms, 1 for each pole c) clamps for fixing cross arm with poles d) 11 KV ,pin type insulators with nuts and bolts e) No. plates with clamps for fixing f) Danger plates with clamps for fixing g) Earth wire clamp h) Barbed wire for anti climbing for 10 poles @ 1 kg for each pole i)Binding wires (for fixing conductors over insulators)	 12 nos. 12 nos. 12nos. 42 nos. 12 nos. 12 nos. 12 nos. 12 kg 8 kg
4	Extra material for poles at road crossing a) Brindling cross arm b) Cross arm clamps c) Guard wire	 2 nos. 2nos. 10 kg
5	Extra material for telegraph line crossing a) Cross arm b) Clamps for cross arm c) Guard wire d) Eye bolts for holding guard wire	 2nos. 2 nos. 20 kg. 6 nos
6	Extra material for rail way line crossing a) Cross arm b) Clamps for cross arm c) Guard wire d) Eye bolts for holding guard wire	 2nos. 2 nos. 20 kg. 6 nos
7	ACSR gopher conductors of size 6/1 X 2.36 mm	3060 mts
8	G.I earth wire of size 8 SWG	1020 mts.
9	Earthing complete sets (G.I pipe, charcoal ,salt etc)	4 nos.
10	Painting for poles	12 nos.

CHAPTER -5 OVERHEAD SERVICE LINE

PREPARE AND ESTIMATE FOR PROVIDING SINGLE PHASE SUPPLY LOAD OF 5KW (LIGHT,FAN,SOCKET) TO A SINGLE STORED RESIDENTIAL BUILDING

Q.1 A newly constructed single storeyed house is to be provided with single phase 230 volts,50 HZ having a load of 5 KW(light,fan,socket). The supply is to be given from overhead line 20 mt. away from the building. Prepare a list of the material,for giving sevice connection and also estimate the cost of the service connection. A G.I pipe is to be raised along the roof to receive bare conductor on its cross arm fitted with insulators. Also draw sketch of service connection.

<u>Solution</u>

<u>Assumptions</u>

1. Height of ground floor=3.5 mts.
2. Service connection received at the height of 6 mts. from ground.

<u>Selection and rating of weatherproof ,twin core, aluminium conductor cable and line conductor</u>

Total connected load=5 KW

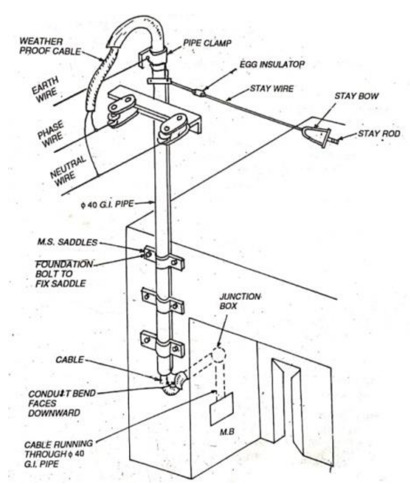
Total load in ampere=5000/230=21.7 amp

Diversity factor=60%X21.7=13 amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% X13)+13=19.5 amp

It is therefore suggested that

- Rating of weatherproof cable =6 mm^2 or 1/2.80 mm ,twin core, PVC insulated cable to carry a load current of 27 amp.
- Rating of bare conductor for installation between distribution pole upto insulators=10 mm^2 ,AAC
- Rating of earth wire=8 SWG



<u>Material Table</u>

Si no.	Specification	Quantity

1	PVC weatherproof cable of size $6mm^2$ or 1/2.80 mm twin core including wastage	10mts
2	AAC for phase and neutral connection (10 mm^2)	42 mts
3	8 SWG GI earth wire(from pole to meter board)	20+1+10=31 mts
4	G I pipe (50 mm diameter)	8mt.
5	Conduit bends	3 nos
6	GI pipe Saddles	10 nos.
7	Earthing Thimble (to fix earth wire and stay wire)	2 nos.
8	LT shackle insulators	4 nos.
9	Angle iron bracket insulator of size(50mmX50mmx6mmx60mm) long	2 nos.
10	Stay insulator	1no.
11	Stay wire	7mt.
12	Stay bow	1 nos
13	Stay rod	1 nos
14	Cement	1 bag
15	Sand	3 bag
16	Concrete	2 bag
17	2 Way junction box	2 nos.
18	Nuts & bolts	2 pkt

Q.2 A newly constructed single storeyed house is to be provided with single phase 230 volts,50 HZ having a load of 4 KW. The supply is to be given from overhead line 30 mt. away from the building.

Prepare a list of the material,for giving sevice connection and also estimate the cost of the service connection.

<u>Solution</u>

<u>Assumptions</u>

3. Height of ground floor=3.5 mts.
4. Service connection received at the height of 6 mts. from ground.

<u>Selection and rating of weatherproof ,twin core, aluminium conductor cable</u>

Total connected load=4 KW

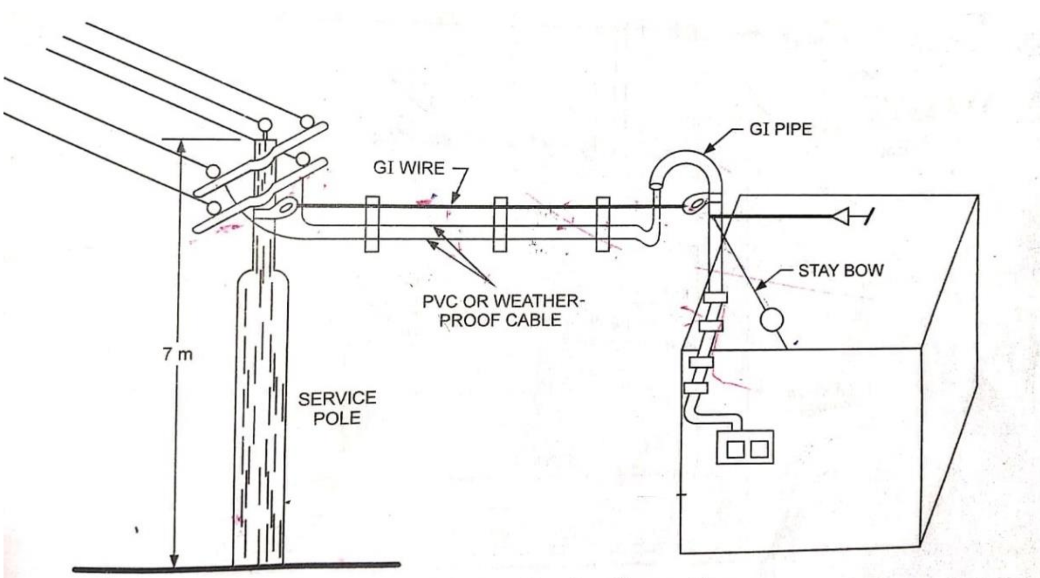
Total load in ampere=4000/230=17.29 amp

Diversity factor=60%X17.29=10.43 amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% X10.43)+10.43=15.21 amp

It is therefore suggested that

- Rating of weatherproof cable =4 mm^2 or 1/2.24 mm ,twin core, PVC insulated cable
- Rating of G.I wire=8 SWG



PVC/Weatherproof Cable Service Connection

Material Table

Si no.	specification	quantity
1	PVC weatherproof cable(from pole to EM with wastage)	30+2+15=47 mt
2	8 SWG GI wire	32 mt.
3	G I pipe (50 mm diameter)	8mt.
4	Conduit bends	3 nos
5	GI pipe Saddles	10 nos.
6	Earthing Thimble	2 nos.
7	Stay wire	7mt.
8	Stay insulator	1 nos
9	Stay bow	1 nos
10	Stay rod	1 nos
11	Cement	1 bag
12	Sand	3 bag
13	Concrete	2 bag
14	2 Way junction box	2 nos.
15	Nuts & bolts	2 pkt
16	Binding wire	2 mts

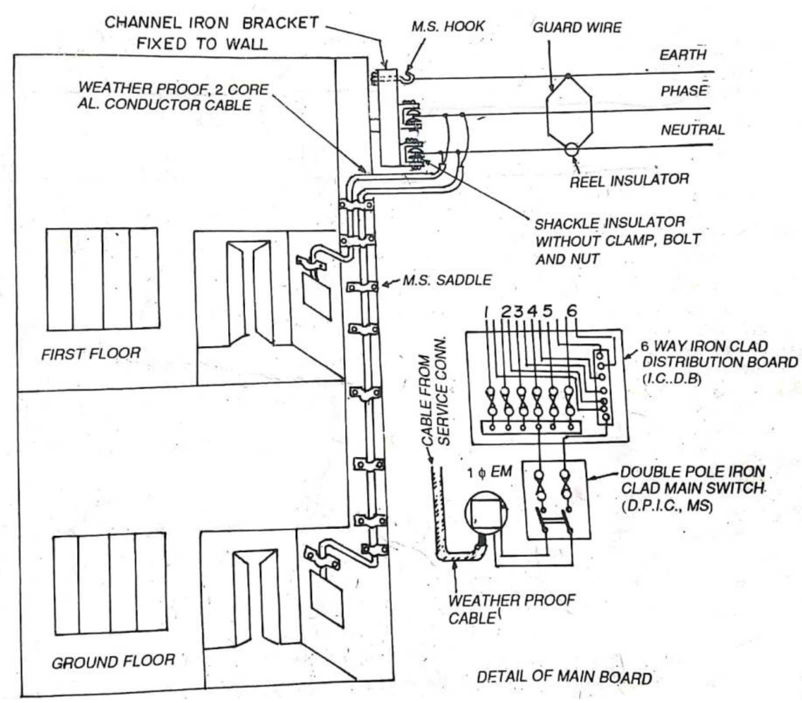
PREPARE AND ESTIMATE FOR PROVIDING SINGLE PHASE SUPPLY LOAD OF 3KW TO EACH FLOOR OF A TO DOUBLE STORED RESIDENTIAL BUILDING HAVING SEPARATE ENERGY METER

Q.3 Prepare a list of material and estimate the cost for giving service connection to a double storeyed building having two energy meters.The supply is to be given at 230 volt single phase having a load of 4 sub-cicuit (light,fan)and two 15 amp socket points on each floor .The supply is to be given from overhead line 20 metres away from the building .Also draw diagram of service connection.

Solution

Assumptions

1. Height of ground floor=3.5 mts.
2. Total height of first floor from ground=7mts.
3. Service connection received at the height of 6 mt. from ground.
4. Height of ground floor meter board from floor=1.5mts.



Selection and rating of weatherproof ,twin core, aluminium conductor cable and Line conductor

Total connected load for 4 sub-circuit=4X800=3200 watts

2-15 amp sockets=2X1000=2000watts

So total load of a single building storeyed=3200+2000=5200 watt

Total load in ampere=5200/230=22.6amp (for single storeyed)

Total connected load for both floor=22.6+22.6=45.2 amp

Diversity factor=60%X45.2=27.12amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building .It is therefore a better suggestion that a weather proof cable of higher rating may be used=(50% X27.12)+27.12=40.68amp

It is therefore suggested that

- Rating of weatherproof cable =16 mm^2 or 7/1.70 mm ,twin core, PVC insulated cable
- Rating of bare conductor for installation between distribution pole upto insulators=16 mm^2 ACSR Conductor
- Rating of G.I wire=8 SWG

Material Table

Si no.	Specification	Quantity
1	Shackle insulators with U clamps,nuts & bolts	2+2=4 nos.
2	Mild steel channel or hook	2 nos.
3	ACSR conductor for phase and neutral connection ($16mm^2$) including wastage	20+20+2=42mts
4	8 SWG GI earth wire(from pole to meter boa)	20+1+15=36mts
5	MS angle iron bracket of sze(50mmX50mmx6mmx1mt) long	2 nos.
6	PVC Weather proof cable	15 mt
7	MS Saddles	15 nos.
8	Earthing Thimble (to fix earth wire)	2 nos.
9	Reel insulator	1no.
10	Guard wire	7mt.
11	Cement	1 bag
12	Sand	3 bag
13	2 Way junction box	2 nos.
14	Nuts & bolts	2 pkt

<u>PREPARE ONE ESTIMATE OF MATERIAL REQUIRED FOR SERVICE CONNECTION TO A FACTORY BUILDING WITH LOAD WITHIN 15KW USING INSULATED WIRE</u>

Q.1 A workshop required to connect a 3-phase 15 KW ,415 V ,50 HZ motor to a 3-phase ,4-wire,415/240 volt ,50 HZ overhead line .The distance of the service line from the workshop structure having motor is 15 mt. The motor has an efficiency of 85% and a power factor of 0.8 . Estimate the quantity and cost of material required.

<u>Solution</u>

<u>Assumptions</u>

1. Height of ground floor=6 mts.
2. Service connection received at the height of 7 mts. from ground.

<u>Selection and rating of weatherproof ,twin core, aluminium conductor cable</u>

Total connected load =15KW

Running current=$\frac{15\times1000}{\sqrt{3}\times415\times0.85\times0.8}$ =30 amp

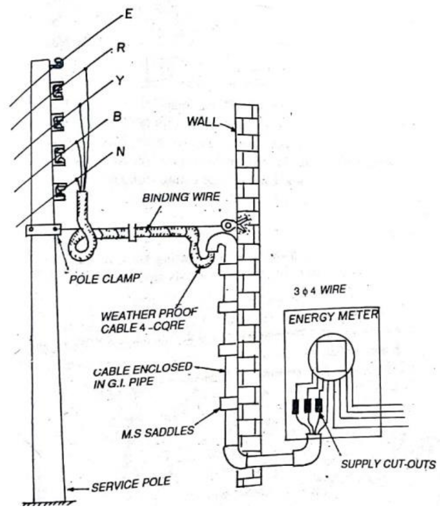
Starting current=1.5$\times 30 = 45$ amp

Diversity factor =60%$\times 45 = 27$

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% $\times 27$)+27=40.5 amp

It is therefore suggested that

- Rating of weatherproof cable =10mm^2 or 1/3.55 mm ,4 core, PVC insulated aluminium conductor
- Rating of G.I wire=8 SWG



Material Table

Si no.	specification	quantity
1	PVC weatherproof cable(from pole to EM with wastage)	15+2+5+10=32 mt
2	8 SWG GI wire	17 mt.
3	G I pipe (50 mm diameter)	7mt.
4	Conduit bends	3 nos
5	GI pipe Saddles	15 nos.
6	Pole clamp	1 nos
7	Cement	1 bag
8	Sand	3 bag
9	Concrete	2 bag
10	2 Way junction box	2 nos.
11	Nuts & bolts	2 pkt
12	Binding wire	2 mts
13	M S hook	1 no.

Q.2 A workshop owner wants 3-phase ,4 wire power connection to his 10 HP motor from the pole of 400v ,3 phase 50 HZ overhead line at a distance of 200mt. from the workshop. Make a sketch showing the arrangement of supply and estimate the quantity and cost of the material required.

-

Solution

Assumptions

1. Height of ground floor=6 mts.
2. Service connection received at the height of 7 mts. from ground.

Selection and rating of weatherproof ,twin core, aluminium conductor cable

Total connected load =10HP

Running current $=\frac{10\times746}{\sqrt{3}\times400\times0.85\times0.8}$ = 15.8 amp

Starting current=$1.5\times 15.8 = 23.7$amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% $\times$ 23.7)+23.7=35.55 amp

It is therefore suggested that

- Rating of weatherproof cable =6 mm^2 or 1/2.80 mm ,4 core, PVC insulated aluminium conductor
- Rating of bare conductor for installation between distribution pole upto insulators=10 mm^2 ACSR Conductor
- Rating of G.I wire=8 SWG

Material Table

Si no.	specification	quantity
1	PVC weatherproof cable	15 mts
2	Bare conductors	808 mts
3	Shackle insulator	8 nos.
4	8 SWG GI wire	202 mt.
5	G I pipe (50 mm diameter)	6 mt.
6	Conduit bends	3 nos
7	GI pipe Saddles	15 nos.
8	Earthing Thimble	2 nos.
9	Cement	1 bag
10	Stay insulator	1no.
11	Stay wire	7mt.

12	Stay rod	1 nos
13	Stay bow	1 nos
14	Reel insulator	2no.
15	Guard wire	8mt.
16	Sand	3 bag
17	Concrete	2 bag
18	2 Way junction box	2 nos.
19	Nuts & bolts	2 pkt
20	Binding wire	2 mts

CHAPTER -6 ESTIMATING FOR DISTRIBUTION SUBSTATION

Q.1 Estimate the cost of a pole mounted sub-station of capacity 50 KVA transformer of rating 11/0.5 KV. The H.T line is available about 50 metres from the proposed site.Also make a neat sketch of the pole mounted sub-station.

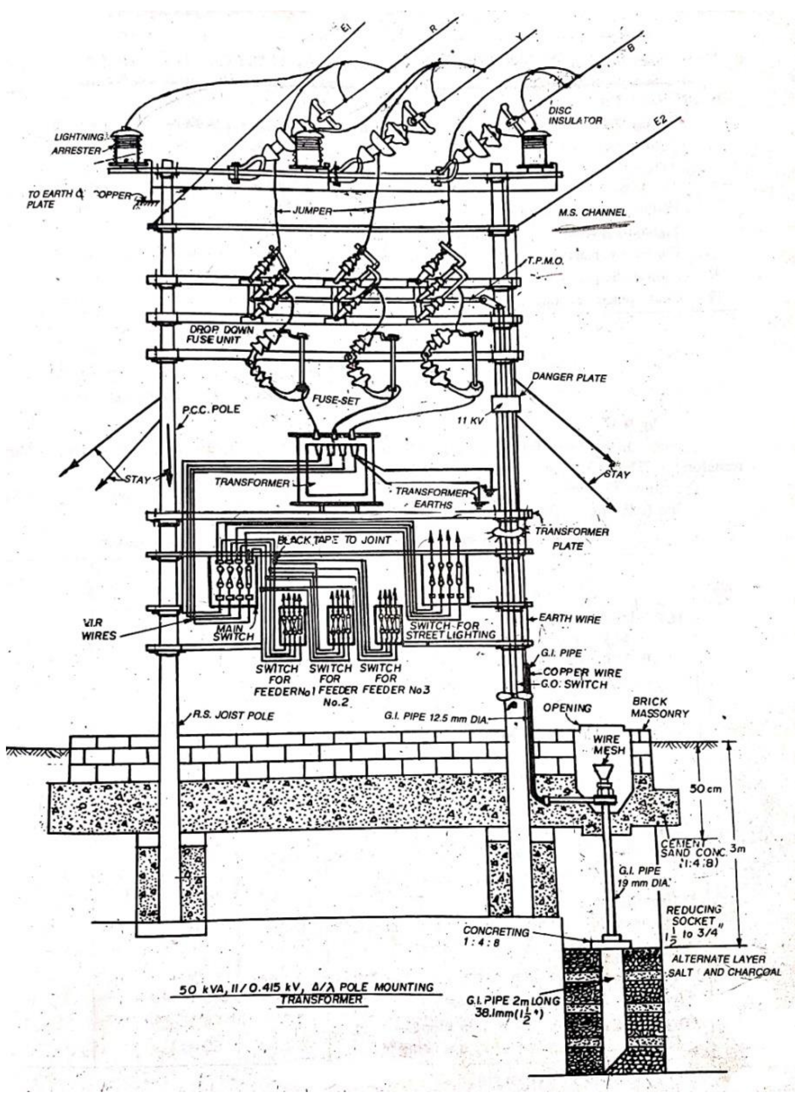
Solution

Total Length of conductors (ACSR gopher conductor 6/1 X 2.36 mm)= (50X3)+2% for sag

=150+3=153 mts

Total length of G.I. earth wire of size 8 SWG =50+2% for sag

=50+1=51 mts.



Material Table

Si no.	description of materials with specifications	Quantity
1	Material for H.T connection with main line	
	1. M.S channel cross arm 10 cm$\times$ 5cm $\times$1.5 mt long	1no.
	2. H.T H.T ,11 KV Disc insulator with complete fittings	3nos.
	3. Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates)	2 nos.
	4. Earth wire clamp	2nos.
	5. Binding wires	500 gms
	6. Clamps for M.S channel	1 no.
	7. Concreting for stay rod	2nos.
2	Conductor ACSR gopher 6/1$\times$2.36 mm diameter	153 mts.
3	Earth conductors 8 SWG GI	51 mts.
4	R .S joist 175 mm$\times$ 100mm $\times$2 mt long	2 nos.
5	Fittings on H.T double pole structure for pole mounted sub-station.	
	1. Stone pad	2 nos.
	2. Sub-station plate	1 no.
	3. M.S channel cross arm 100 mm$\times$ 50mm $\times$ 8mm $\times$2.65mt long	1no.
	4. Eye bolt	3 nos.
	5. Dropper angle iron 75 mm$\times$ 75mm $\times$ 8mm $\times$2mt long	1no.
	6. Stay complete sets	2 nos.
	7. 11 KV ,Disc type insulators with nuts and bolts	3nos.
	8. 11 KV ,pin type insulators with nuts and bolts	3nos.
	9. Binding wires	500 gms
	10. No. plates with clamps for fixing	1no.
	11. Danger plates with clamps for fixing	1no.
	12. Earth wire clamp	1no.
	13. Barbed wire for anti climbing for 10 poles @ 1 kg for each pole	5kg.
	14. Earthing complete	1set
	15. Jumper wire for jumping	11mts
	16. Nuts and bolts of size as required.	18nos.
	17. Concreting poles	2 nos
	18. T.P.M.O switch	1no.
	19. Painting of pole and other attachments	2 litres
	20. Fuse sets	1set
6	Transformer 50 KVA ,11/0.4 KV	1no.
7	TPICN(triple pole iron clad with neutral) main switch 100 ampere rating	1no.
8	Earthing for transformer	1no.
9	Lighting arresters one set of three	1set

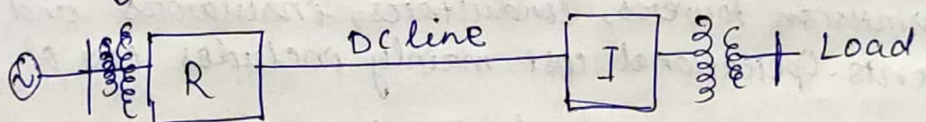
① DC POWER TRANSMISSION TECHNOLOGY

Introduction:-

1.1 The industrial and economical growth of countries has increased consumption of electrical energy. To meet the increased consumption generation and transmission facilities are increasing.

Normaly generating stations are at distance of hundreds of kilometers from load centres. System interconnections also required for effective power transmission. There are many problems of AC transmission particularly in long distance transmission. To overcome these problems, development of DC transmission has started.

DC transmission requires conversion at two ends, from AC to DC at the sending end DC to AC at the receiving end. Conversion is done by rectifier at sending end and inverter at receiving end.



Initially mercury arc valves were used in rectifiers and inverters. But now-a-days high power semiconductor devices like thyristors and IGBTs are used. As a result transmission voltage and power has increased. Highest transmission voltage and power reached to ±600KV and 75000 MW.

1.2 COMPARISION OF AC AND DC TRANSMISSION

The major feature of a power system is that it can expand easily when power demand increases. So once we decide to establish a transmission system, we have to consider that it is the part of a long-term system (power system). Before deciding the mode of transmission between AC and DC the system planner must compare the following factors.

1) Economics of power transmission
2) Technical Performance.
3) Reliability.

1.2.1 Economics of Power Transmission

⇒ Cost of a transmission line includes investment and operational cost.

$$\text{Total cost} = \text{Investment cost} + \text{operational cost.}$$

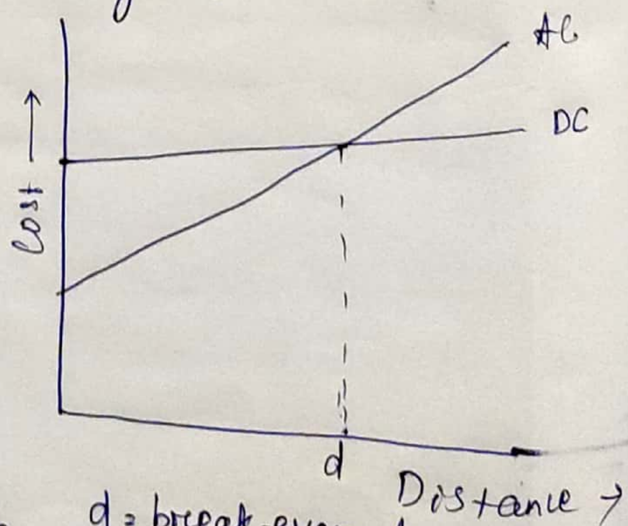
⇒ Investment cost includes cost of Right of way (ROW), transmission towers, conductors, insulators and terminal equipments. Operational cost mainly includes cost of losses.

⇒ But for a given power level, DC line requires less RoW, simpler and cheaper towers and ~~reduced~~ less no of conductors and insulator;

⇒ Power losses are also reduced with DC as there are only two conductors.. As skin effect is absent in DC, corona loss is less in DC as compare to AC.

⇒ But cost of terminal equipments are very high in DC transmission.

⇒ The figure shows the variation of cost with distance for both AC and DC transmission.



d = break-even distance

⇒ Here we can notice that upto a certain distance (d = break-even) AC transmission is econonomical. But after break-even distance DC transmission is economical.
Break-even distance may vary from 500 to 800 km.

1.2.2 Technical Performance.

In technical performance DC transmission has some positive features as ~~co~~ which are absent in AC transmission. Those positive features of DC transmission are.

1) Controllability.

⇒ In DC transmission power can be controlled continuously by ~~con~~ different converter control methods.

⇒ It can limit the fault current by fast control. Therefore we can ~~ah~~ avoid DC breakers in two terminal DC links.

⇒ It has ability to enhance transient and small signal stability in associated AC networks.

2) Stability limits.

⇒ Power transfer in AC lines depend upon the angle diff between the voltage phasors at the two ends. For a given power level, this angle increases with distance.

⇒ So power carrying capacity of AC line depends upon the distance of transmission. But power carrying capacity of DC is unaffected by distance. Power capacity of DC is only affected by current carrying capacity of the conductors.

3) Voltage Control.

⇒ Voltage along the line of a AC transmission is same (flat) if it is connected to surge impedance loading. But if the load is greater than surge impedance loading, mid point voltage will reduced. And if load is less than SIL, mid point voltage is increased.

⇒ So to maintain constant voltage along the transmission line (AC), we require reactive power control.

⇒ But in DC transmission, Reactive power sources are not required for the line.

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4) Line Compensation

⇒ To control the voltage, shunt and series compensators are used in AC transmission lines in regular intervals. But in DC transmission line we don't required.

5) Problems of AC interconnection

⇒ If two power systems are connected through AC tie lines,
(i) transmission of disturbance can be done from one system to other.
(ii) Presence of large power oscillation can lead to frequent tripping.
(iii) Can increase fault level.

⇒ Therefore for interconnection between two system dc ties are prefered over AC.
⇒ If we want to connect two systems with different frequency, then it is only possible by dc tie line.

6) Ground Impedance:

⇒ Ground offers high impedance to AC transmission. But ground impedance is negligible for DC current.
⇒ Therefore a dc link can operate with one conductor and ground return.

But in technical performance DC transmission has some limitations- Those are.

1) Cost of DC breakers.

⇒ It is very difficult to break a d.c current as compare to a.c. Because a.c current has a zero crossing. But DC does not have zero crossing. Therefore cost of the DC breaker is more as compare to AC breaker.

2) Voltage level can not changed.

⇒ In DC transmission voltage level can not be changed by using transformers. But in AC transmission we can easily change the voltage level by transformers.

③ High cost of conversion equipments.

→ Cost of converter and stations (rectifier and inverter) is very high.

→ It includes cost of semiconductor devices, it's cooling arrangements, firing circuits, protection circuits, control circuits etc.

④ Complexity of control.

→ We know that controllability is a major advantage of DC transmission. But it is a very complex process.

⑤

1.2.3 Reliability.

Reliability of DC transmission is quite good and comparable to that of AC systems.

With continuous development in HVDC system, it's reliability has been increasing day by day. ~~Thus~~ For example thyristor value is much more reliable than mercury arc valves. Further ~~the~~ development of light triggering thyristors can improve reliability because here high voltage pulse transformers and auxiliary supplies for turning on the valves are not required.

There are two measures of overall system reliability.

① Energy availability.

It is the measure of how many time power supply is available.

$$\text{Energy availability} = \left(1 - \frac{\text{equivalent outage time}}{\text{total time}}\right) \times 100\,\%$$

System capacity is reduced due to equivalent outage time.

Transient reliability.

This is the factor which specify the performance of HVDC systems during recordable faults on the associated AC system.

$$\text{Transient reliability} = \frac{\text{No of times HVDC system performed as designed.}}{\text{No of recordable AC faults}} \times 100$$

1.3 APPLICATION OF DC TRANSMISSION.

From the detailed comparission of AC and DC transmission interms of economics and technical performance, we can conclude that dc transmission can be used in the following areas.

① long distance bulk power transmission

⇒ If transmission distance is more than break-even distance, then DC transmission is more economical than AC transmission. Because cost of tower, conductors, ROW, insulator is less in DC. I^2R loss and Corona loss is also less as compare to AC transmission.

⇒ For distance less than break-even distance, total cost of DC transmission line will be greater than AC transmission due to it's high converter station cost.

⇒ Further uses of phase shifters, static Var systems, series capacitors, etc are eliminated in dc transmission.

② Underground and underwater cables

⇒ As ground impedance offered ~~by~~ to DC current is negligible, ground or sea can be used as return path.

⇒ But in AC transmission ground or ~~sea~~ sea can not be used as return path.

⇒ It is economical to use ground or sea as return path.

③ Interconnection of AC systems operating at different frequency.

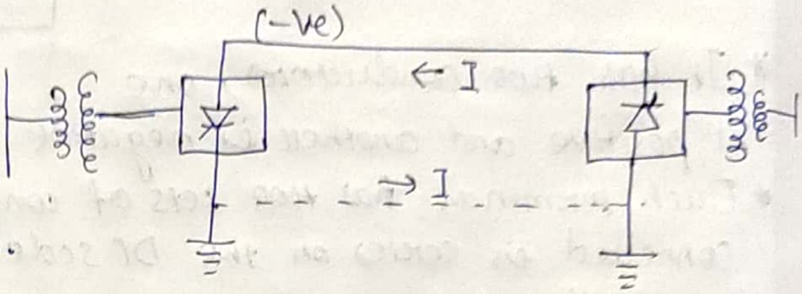
⇒ Technical performance of a DC inter-connection link. ~~So~~ like is better than ac inter-connection link. Again we can not connect two different frequency system by A.C. line. So DC alternative is preffered.

④ Control and stabilisation of power flow in AC tie lines in an integrated power system.

1.4.1 TYPES OF DC LINKS

DC link is the conductor which connect the rectifier station and inverter station. For connecting two networks or systems, various types of HVDC links are used. HVDC links are classified into three types :

(1) Monopolar link

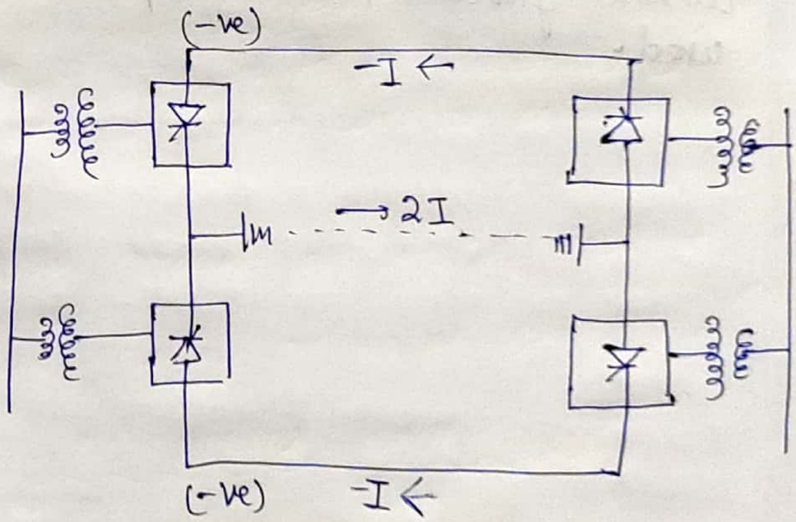


⇒ Monopolar link has one conductor usually of negative polarity and use ground or sea return.

⇒ Sometimes metallic return is also used.

⇒ Mainly negative polarity link is used because corona loss in -ve conductor is less as compare to +ve conductor.

(2) Homopolar link



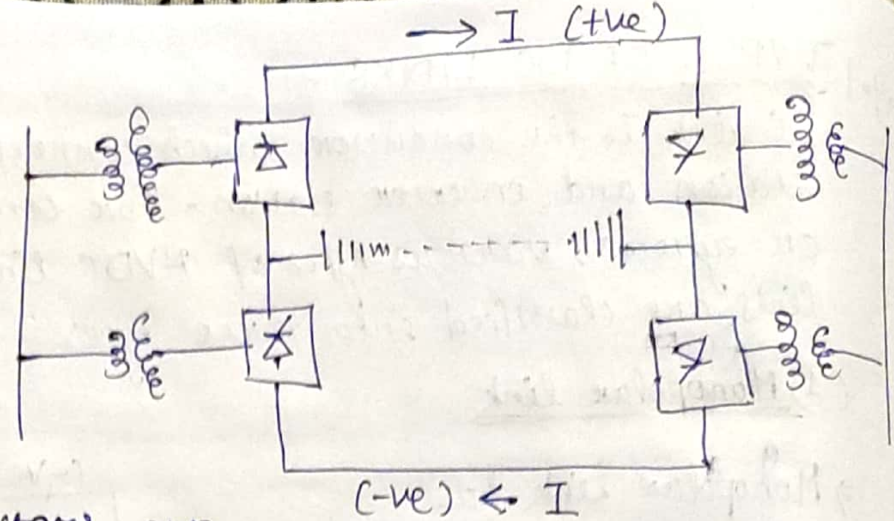
⇒ A homopolar link has two conductors, having same polarity.

⇒ Usually the conductors are -ve and always operated with ground or metallic return.

⇒ The disadvantages of the homopolar link is that the ground current is two times higher than rated currents.

⇒ But in homopolar link, if one converter unit or one line fails to operate, then another converter unit can take the continuity of supply.

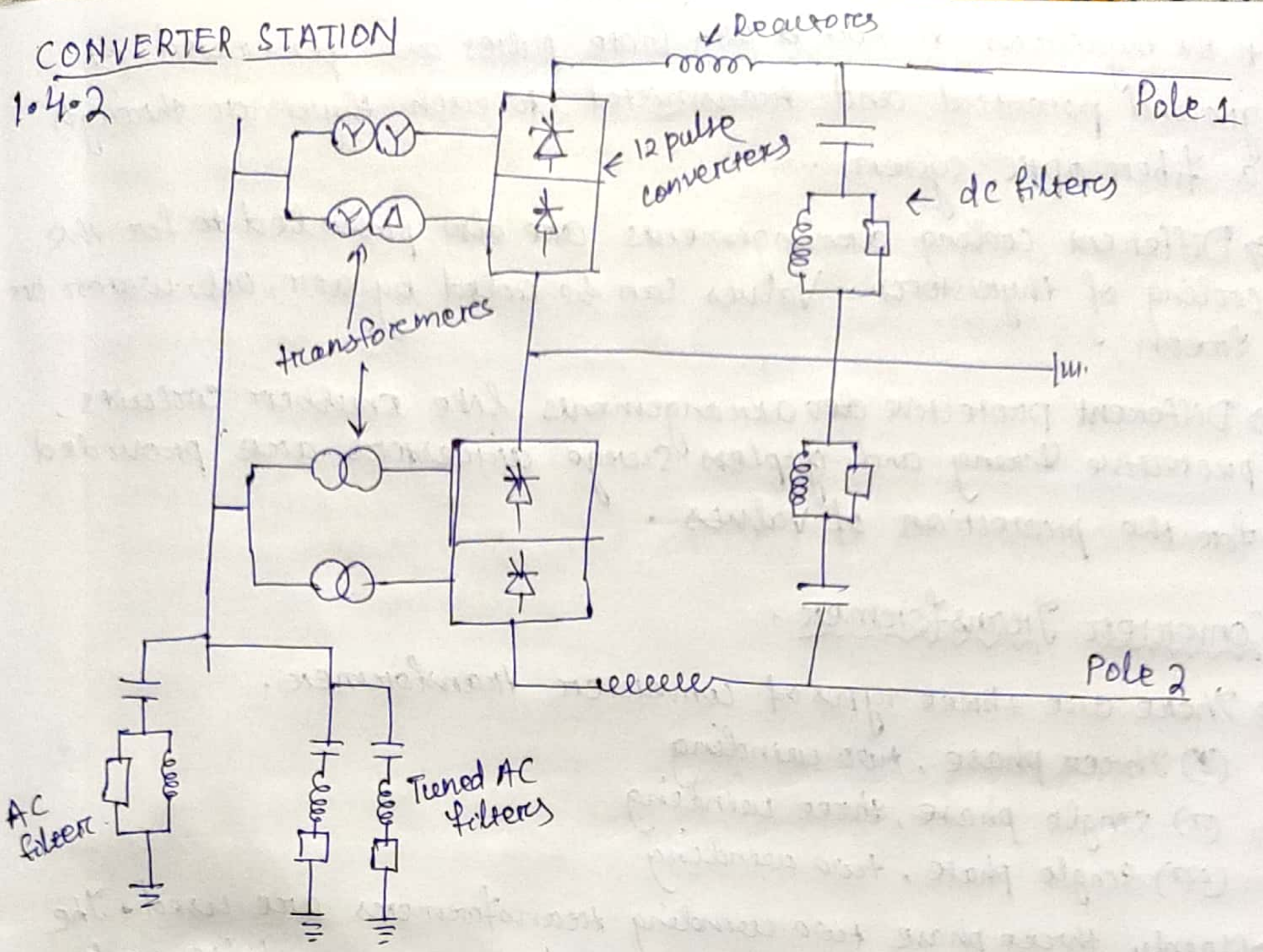
Bipolar link



* It has two conductors, one is positive and another is negative.
* Each terminal has two sets of converter of identical rating, connected in series on the DC side.
* Normally, both poles operate at equal currents and hence there is zero ground current flowing under these conditions.
* Because of the desirability of operating a DC link without ground return, bipolar links are ~~not~~ commonly used.

CONVERTER STATION

1.4.2



The major components of a HVDC transmission system are converter stations. One is rectifier station where AC is converted into DC and other is Inverter station where DC is converted into AC.

Main parts of a converter station are:

1) 12 pulse converter unit
2) Converter Transformer.
3) Filters
4) Reactive power sources
5) Smoothing Reactor.
6) DC switchgear.

12 pulse Converter unit.

⇒ A 12 pulse converter consist of two three phase converter bridges connected in series. Total number of thyristor valves in such a unit are twelve.

⇒ Thyristor valve is a series and parallel combination of more than one thyristor. Rating of a valve is fixed by considering maximum possible short circuit current. ~~and~~

⇒ Firing circuits are provided which generate and deliver gate to the thyristors to turn it ON. Gate pulses are generated at ground potential and transmitted to each thyristor through a fiber optic system.

⇒ Different cooling arrangements are also provided ~~to~~ for the cooling of thyristors. Valves can be cooled by air, oil, water or freon.

⇒ Different protective ~~dev~~ arrangements like snubber circuits, protective firing and gapless surge arrestors are provided for the protection of valves.

② Converter Transformer.

⇒ There are three types of converter transformer.

(i) Three phase, two winding
(ii) single phase, three winding
(iii) single phase, two winding

⇒ Mainly three phase two winding transformers are used. The valve side windings are connected in star or delta with neutral grounded. On the AC side, the transformers are connected in parallel with neutral grounded.

⇒ Leakage reactance of the transformer is chosen to limit the short circuit currents through valve, to withstand DC voltage stress and eddy current losses due to harmonic currents.

③ Filters

Mainly three types of filters are used in HVDC transmission system.

1) AC filters:⇒ These are passive circuits used to provide low impedance, shunt paths for AC harmonics currents. Both tuned and damped filters arrangements are used.

2) DC filters⇒ These are similar to AC filters and are used for filtering of DC harmonics.

3) High frequency filters⇒ These are connected between the converter transformer and the station AC bus to suppress high frequency currents.

(4) Reactive Power Source ⇒

⇒ Current drawn by a line commutated converter can lag the supply voltage. Therefore reactive power stations require reactive power supply.

⇒ Different types of reactive power sources like AC filters, shunt capacitors, static Var compensator (SVC), STATCOM, synchronous condensers are used.

(5) Smoothing Reactor.

Smoothing reactor is used on DC side to smooth DC current and also for protection.

(6) DC switchgear.

This is usually a modified AC equipment used to interrupt DC current. Switching equipments like DC breakers are used.

1.6 MODERN TRENDS IN HVDC TECHNOLOGY.

The continuing technological developments in the areas of power semiconductor devices, digital electronics, control system, protection system etc have increased the pace of application of DC transmission. Due to continuous development cost of the converter station has reduced and reliability has increased.

Power semiconductors and values:

⇒ Cost of the converters can decrease, if no of devices connected in series and parallel can be decreased. ~~W~~ And we can reduce no of devices by increasing their current and voltage ratting.

⇒ Development of Light triggering thyristors has improved the reliability.

⇒ Cost of the value is also reduced by the application of zinc oxide gapless arrestors, protective firing methods and better cooling arrangements.

⇒ Development GTOs also reduces the cost of converter. Because commutation circuit is not required. But GTOs required large gate current to turn off and switching speed is low.

⇒ Therefore now-a-days IGBTs are used in converters. It requires less power to turn off and has high switching speed.

Converter Control.

⇒ Development of microcomputer based converter control equipments help direct control of the system automatically incase of fault.

⇒ Control and protection requires the measurement of direct current. Traditionally the direct current ~~was~~ is measured using transducers which are bulkey.

⇒ Now hybrid-optical measuring instruments are developed. ~~It is~~ Measured signal is transmitted through optical link. Development of this system has improved the control system of ~~con~~ HVDC system.

DC breakers.

⇒ By development and testing of DC breakers, it will be possible to develope Multi terminal DC systems.

⇒ The DC breaker rating should not exceed the full load rating of the system.

Conversion of existing AC lines

For same power transfer RoW (Right of Way) required is larger for AC transmission as compare to DC transmission. It is economical to convert a double circuit AC line to a bipolar HVDC line with increased power.

Active DC filter.

⇒ In nineties, a hybrid filter made up of an active filter in series with passive filter has been developed to improve the filtering of harmonic currents flowing in HVDC lines.

⇒ Active filter can eliminate both characteristics and low frequency non-characteristics harmonics.

Capacitor Commutated Converters.

⇒ In a capacitor commutated converters a commutation capacitor is connected in series with the value side windings of the converter transformer. The capacitor is used for forced commutation purpose.

⇒ The advantages of capacitor commutated converters are.

⇒ Reduce risks of commutation failures.

⇒ Less load rejection overvoltages

⇒ Act as a reactive power source.

⇒ Improve voltage stability when operating with weak AC link.

UHV DC Transmission.

Voltage level above ±800kV is known as UHV DC (ultra high voltage DC). If the generating stations are at far distance from the load area and huge amount of power is to be transfered, then UHVDC transmission should be used.

Operation with weak AC systems

Strength of AC systems connected to the terminals of a DC link is measured in terms of short circuit ratio (SCR) which is defined as

$$SCR = \frac{\text{Short circuit level at the bus converter}}{\text{Rated DC power}}.$$

If SCR is less than 3, the AC system is said to be weak. Conventional constant extinction angle control may not be satisfactory with weak AC system. So constant reactive power control or AC voltage control are used to overcome problems.

1.5 Planning for HVDC Transmission

⇒ A system planner must consider the following factors before finalize that which type of transmission is to be choosen, EHV-AC or HVDC transmission. Factors are.

i) Cost
ii) technical performance.
iii) Reliability.

⇒ If technical performance and Reliability is perfect, then cost of which alternative (EHV-AC or HVDC) is minimum, that is choosen.

⇒ For Planning of HVDC transmission system planners also have to consider the application. Applications are.

i) Long distance bulk power transmission.
ii) Interconnection between two adjacent systems.

⇒ For the first application, if system security and reliability ~~are~~ of both AC and DC alternatives are same, then selection is done on the basis of cost comparison.

⇒ For second application, AC interconnection can create several problems. Therefore most of the time DC alternative is choosen over AC. Advantage of DC interconnection are.

i) Small fluctuations in the voltage and frequency can not affect the power flow.
ii) System security can be improve by fast control of DC power.

⇒ There are three possible configuration of inter connection.

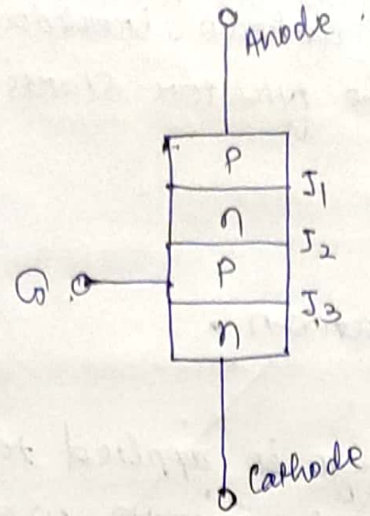
(i) A two terminal DC transmission where each terminal is located at a suitable place somewhere within the network and connected by a DC over head line.

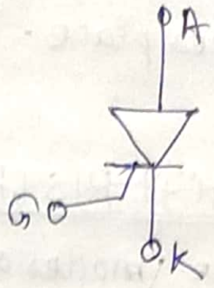
(ii) A back to back HVDC converter station located somewhere within one of the system and connected by an AC overhead line to another system.

(iii) A back to back station located closed to the boundary between the two system.

* Between the first and second configuration converter cost is less for common coupling station i.e. second configuration. But AC line cost is greater than DC line cost.
* So if distance is less than 200 km second configuration is to be performed.
* If the distance is large, than the third alternatate is most economical.

(2) THYRISTOR DEVICE.





⇒ Thyristor is a four-layered, three junction semiconductor switching device. It has three terminals i.e. anode, cathode and gate.

⇒ It is also a unidirectional device like diode i.e current flows in one direction only.

⇒ It is a controlled device, because it's output voltage can be vary.

⇒ Gate terminal is used to trigger the SCR by providing small voltage to this terminal.

2.1.1. Principle of operation.

A Thyristor acts like a diode. A thyristor has two ~~p~~ layer of p-type semiconductor and two layer of n-type semiconductor. Anode is connected to outer p-layer, cathode is connected to outer n-layer and gat is connected to inner P-layer.

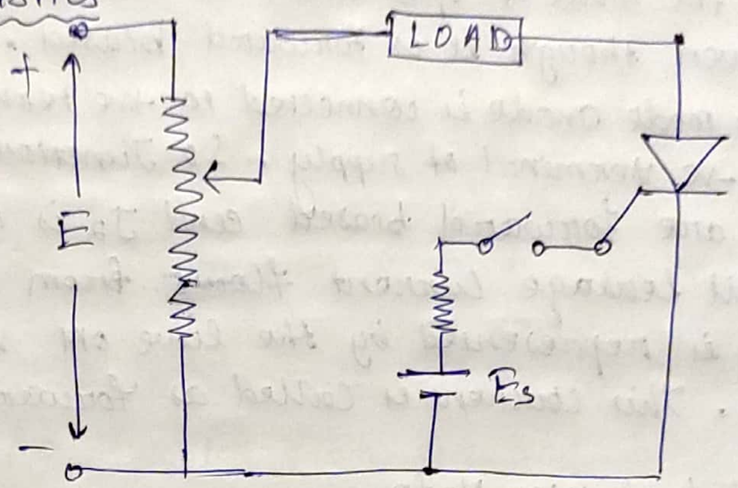
When the anode ~~po~~ is a positive potential w.r.t cathode and no voltage is applied to the gate, junction J_1, J_3 is forward biased and J_2 is reversed biased. So no conduction takes place.

But when the applied voltage is increased beyond the breakdown voltage, breakdown of junction J_2 takes place and it starts conducting.

Without increasing the applied voltage we can also start the thyristor. When a positive potential is applied at the gate terminal with respect to cathode, breakdown of junction J_2 takes place. As a result the thyristor starts to conduct.

2.1.2 DEVICE CHARACTERISTICS

① VI characteristics



⇒ VI characteristics is the plot between anode to cathode voltage Va and current through the thyristor Ia.

⇒ To obtain VI characteristics, it's anode and cathode are connected to a variable source E. Gate and cathode terminals are again connected to a separate voltage source Es.

⇒ We know that a thyristor has three modes of operation.

① Reverse Blocking mode.
② Forward Blocking mode.
③ Forward Conduction mode.

Reverse Blocking Mode.

* It is the mode of operation in which thyristor offers high impedance for current flow. In this mode thyristor behaves as an open switch.
* If anode is connected to −ve terminal and cathode is connected to +ve terminal of supply E, Junction J_1 and J_3 are reversed biased while J_2 is forward biased.
A small leakage current of order milli or micro ampere flows which is represented by line OP in characteristic curve.

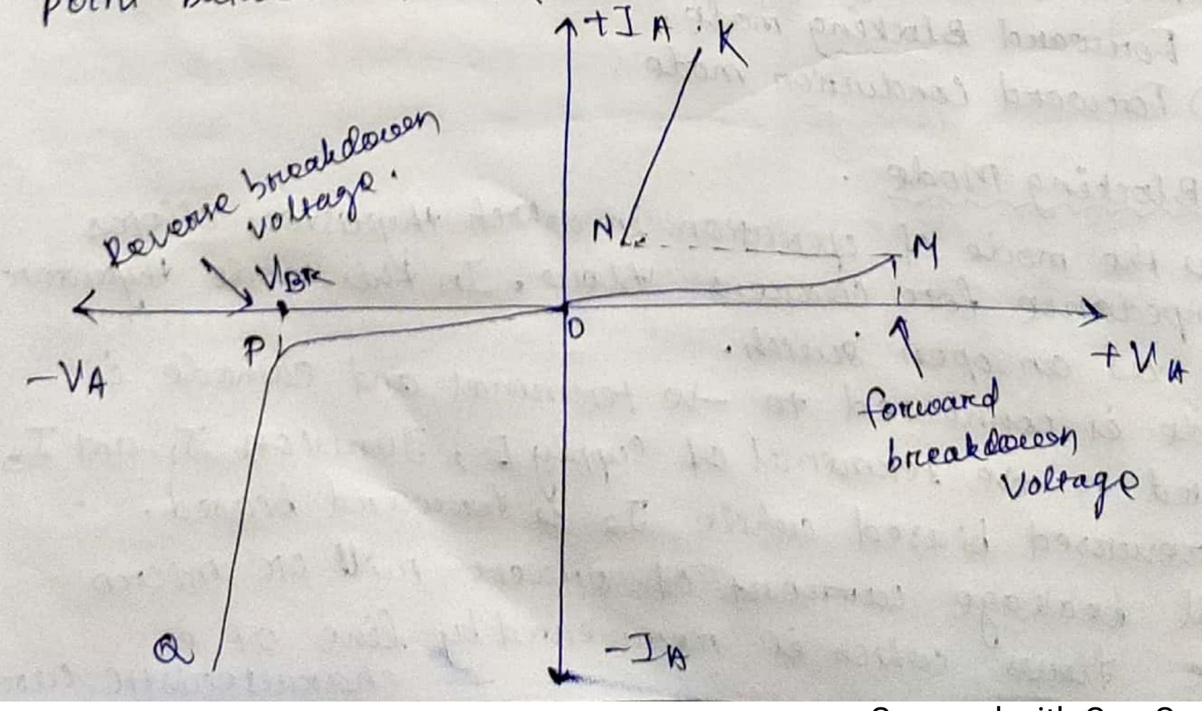
* If the reverse voltage is increased, at a certain Voltage (Reverse Breakdown voltage), V_{BR} Junction J_1 and J_3 breakdown and a sudden increase in current takes place. This increased current is ~~given by~~ represented by PQ in the characteristic.

Forward Blocking Mode.

* ~~B~~ It is the mode of operation in which it does not conduct ~~even~~ even though it is forward biased.
* In this mode anode is connected to the terminal and cathod to the -ve terminal of supply. So Junctions J_1 and J_3 ~~revers~~ are forward biased and J_2 is reverse biased.
* A small leakage current flows from anode to cathode which is represented by the line OM in characteristic graph. This current is called as forward leakage current.

Forward Conduction Mode.

* In forward blocking mode the thyristor can not conduct. To start the thyristor, the applied voltage is increased.
* When this positive anode to cathode voltage increased to forward breakdown voltage, depletion layer of Junction J_2 decreases and the thyristor start to conduct. Ia starts to increase.
* Now the characteristics shift from point M to any point between N and K.



SWITCHING CHARACTERISTICS (Dyanamic Characteristics)

Switching characteristics shows the variation of anode to cathode voltage (V_a) of thyristore and current through the thyristore with respect to time during turn-on and turn-off of thyristore. It is also knows the Dynamic characteristics of thyristor.

Characteristics during turn ON.

* When the thyristore is in off condition, voltage across it (V_a) is maximum and current through it (I_a) is zero.
* In forward blocking mode a small amout of current flows. When mode of operation shift to forward conduction mode current I_a can not immediately increase from minimum value to maximum value. The time required to change state of a thyristor from forward blocking mode to forward conduction mode is know as turn on time.

* Turn on time is devided into three time intervals.

  Turn on time = Delay time + Rise time + Spread time

* ~~In~~ Delay time.

  In this time interval anode current reaches to $0.1 I_a$ and gate current reaches to $0.9 I_g$. It is also defined as the time during which anode voltage falls from V_a to $0.9 V_a$.

* Rise time

  It is defined as the time taken by the anode current to rise from $0.1 I_a$ to $0.9 I_a$. During this time ~~Voltage~~ Voltage V_a falls from $0.9 V_a$ to $0.1 V_a$.

* Spread time.

  Spread time of thyristor is the time taken by ando anode current to reach from $0.9 I_a$ to I_a. After spread time, anode current attains a steady state valve.

Characteristics during turn-off.

* Switching characteristics of SCR during turn off is the transition of SCR from forward conduction state to blocking state.
* This transition period involves decrease of anode current Ia below holding current, sweeping out of charges from the outer junction J_1 and J_3 and recombination of holes and electrons at the inner junction.
* This whole process takes some time, which is known as turn off time of SCR (tq). This turn off time may be divided into two part, i.e. reverse recovery time and gate recovery time.

$$t_q = t_{rr} + t_{gr}$$

* where t_q = turn off time.
  t_{rr} = reverse recovery time.
  t_{gr} = gate recovery time.

* In reverse recovery time excess charge carriers are removed from the outer p and n layer.
* In gate recovery time, charge ~~carriers~~ carriers in the inner junction recombine with each other. Thus the thyristor is not free of charge carriers and can gain blocking mode.
* At time t_1, the anode current becomes zero. Now the charge carriers will move in opposite direction. So current flows in opposite direction which sweep out free charge carriers form outer layer.
* At time t_2, this ~~carrier~~ current becomes maximum; Then it start to decrease.

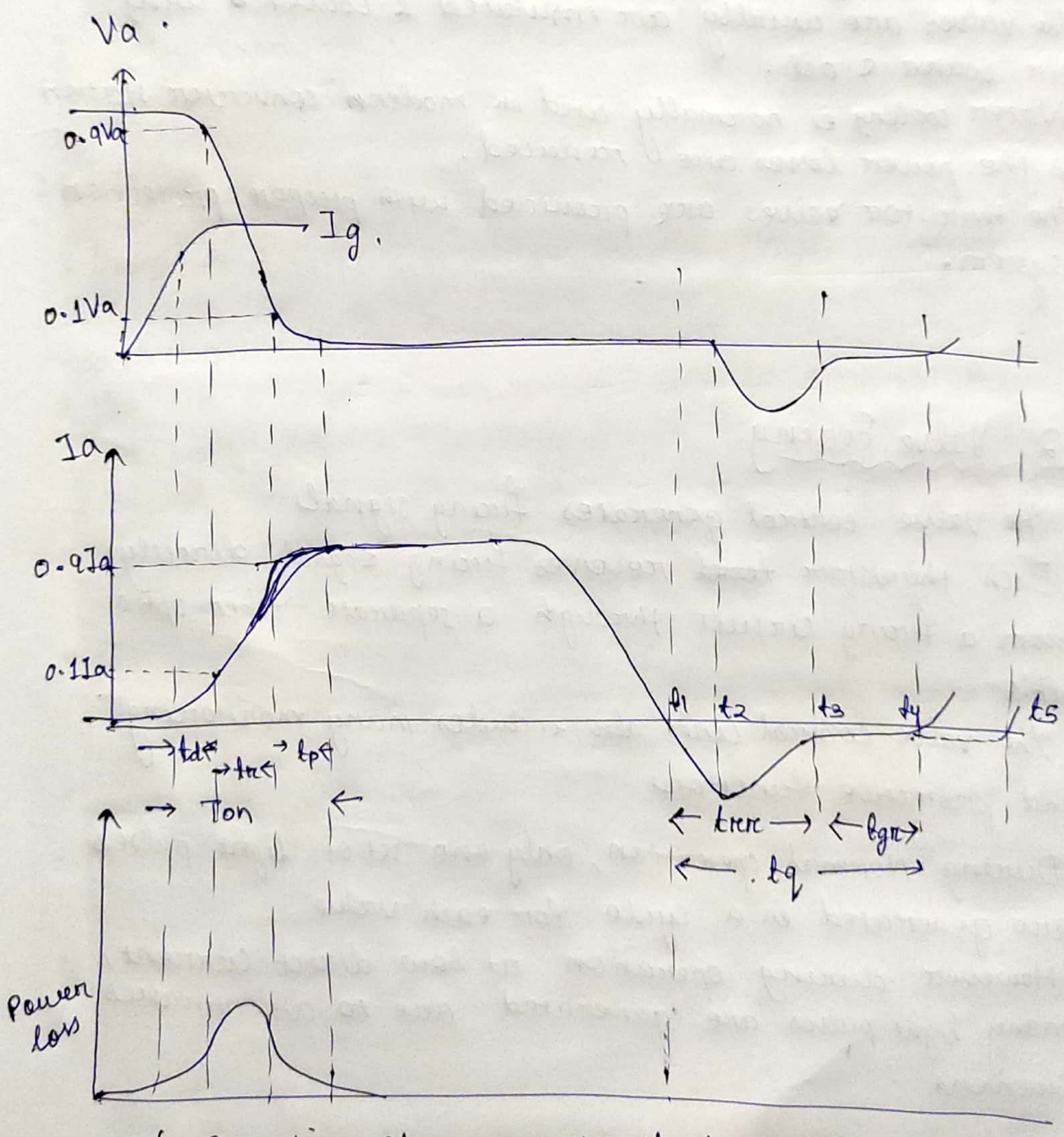
2.1.3 Gate - Drive

* A Thyristor - Gate - drive unit is primarily a current source, supplying current pulse to gate.

OR

Gate Drive is a circuit which provide gate pulses (short or long pulses) to the thyristor to turn it on.

*



(Switching Characteristics of thyristor)

2.2 THYRISTOR VALVE

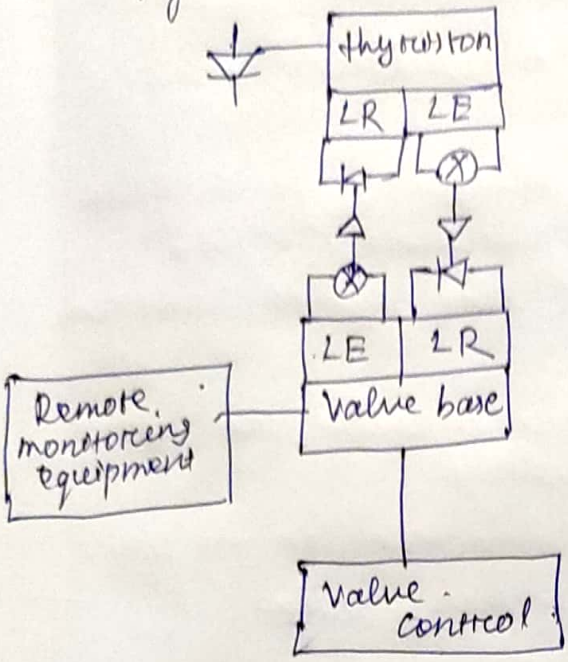
2.2.1 General Introduction to thyristor valve.

* A thyristor valve is made up of a number of devices connected in series and parallel to provide required voltage and current ratting.
* A number of devices are connected in parallel to provide the required current rating.
* The number of series connected thyristor, increases the voltage ratting.
* The valves are usually air insulated & cooled by using air, water & oil.
* Water cooling is normally used in modern converter station as the power losses are reduced.
* The thyristor valves are provided with proper protection system.

2.2.2. Valve Firing

* The valve control generates firing signals.
* Each thyristor ~~level~~ receives firing signal directly from a firing circuit through a separate fiber-optic cable.
* The valve control unit also includes many monitoring and protective functions.
* During Normal operation, only one set of light pulses are generated in a cycle for each valve.
* However during operation at low direct current, many light pulses are generated due to discontinuous current

* The basic valve firing scheme is shown in the figure



2.3.3 Valve Design Consideration.

* Design of a valve must consider the voltage & current stresses that occur during normal and abnormal condition.
* The over voltages across a valve may be generated internally during switching action or the result of external causes such as short-circuit on AC or DC system.
* The over current in a valve arise from short-circuits across a valve on a converter bridge.
* The surge current rating of a valve is limited by transformer leakage reactance and system impedance.
* The overload rating of a valve is a function of the size of the device as well as ambient temperature and the cooling system.
* The losses in a valve include
  (i) The losses during on-state and switching losses.
  (ii) grading circuit losses
  (iii) losses due to auxiliary power required for cooling.

2.2.4 Valve Protection.

Over voltage Protection.

* A HVDC valve must be designed to withstand internal and external over voltages.
* The external sources of over voltages across a valve can be due to lightning ~~or~~ and switching surges.
and Injection of AC voltage on the DC line due to converter fault.
* Gapless DC surge arresters across a valve can protect the valve against transient over voltage.
* The over voltage in the forward direction can be controlled by protective firing of the thyristors in a valve.

Over temperature Protection.

* With the increase in the temperature of the junction, insulation may get failed. So we have to take proper measures to limit temperature rise.
* We can achive temp. protection by mounting thyristors on heat sink which is mainly made by high thermal conducting metals like aluminium or copper etc.

Over current Protection.

* ~~Reacto~~ Smoothing reactors are used to protect the circuit from over current.
* If the fault is severe, then the dc link is need to be discharged so the arc in the dc line becomes zero

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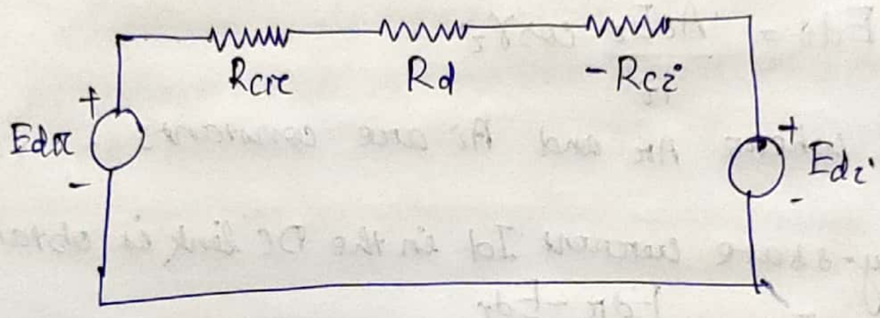
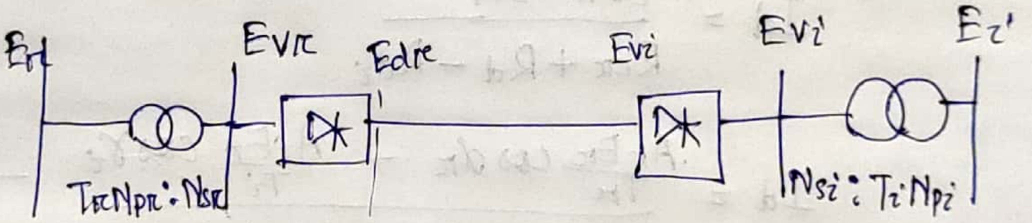
3 CONVERTER AND HVDC SYSTEM CONTROL.

3.1 Principle of DC link Control.

The control of power in a DC link can be achieved through the control of current or voltage. From minimum of loss consideration, it is important to maintain constant voltage in the link. So current is adjusted to meet the required power. As a result voltage regulation is improved and optimal utilization of the insulation takes place.

Consider the steady state equivalent circuit of a two terminal DC link as shown in the fig below.





Here E_r = AC Voltage on Rectifier side Bus-bar.
E_i = AC Voltage on Inverter side Bus-bar
T_r = turns ratio of rectifier side transformer.
T_i = turns ratio of ~~rectifier~~ inverter side transformer.
E_{vr} = AC input to the Rectifier.
E_{vi} = AC output of the inverter.
E_{dr} = DC output of Rectifier
E_{vi} = DC input to Inverter.
R_{cr} = Resistance of Rectifier.
R_{ci} = Resistance of Inverter.
R_d = Resistance of dc line.

If N_{pr} is primary no of turns and N_{sr} is secondary no of turns of rectifier transformer, E_{vr} is given by

$$E_{vr} = \frac{N_{sr} E_r}{N_{pr} T_r}$$

Semenalare at inverter side

$$E_{vi} = \frac{N_{si} E_i}{N_{pi} T_i}$$

We know that output voltage of rectifier and inverter are given by:

$$E_{dr} = \left(\frac{3\sqrt{2}}{\pi}\right) n_b E_{vr} \cos\alpha_r \quad \text{--- (1)}$$

$$E_{di} = \left(\frac{3\sqrt{3}}{\pi}\right) n_b E_{vi} \cos\gamma_i \quad \text{--- (2)}$$

By putting the value of E_{vr} in equation (1), we get.

$$E_{dr} = \frac{A_r E_r}{T_r} \cos\alpha_r$$

Similarly $E_{di} = \dfrac{A_i E_i}{T_i} \cos\gamma_i$

where A_r and A_i are constants.

The steady-state current I_d in the DC link is obtained as

$$I_d = \frac{E_{dr} - E_{di}}{R_{cr} + R_d - R_{ci}}$$

$$I_d = \frac{\frac{A_r E_r}{T_r}\cos\alpha_r - \frac{A_i E_i}{T_i}\cos\gamma_i}{R_{cr} + R_d - R_{ci}} \quad \text{--- (3)}$$

from eq^n (3) it is clear that control variables are $T_r, T_i, \alpha_r, \gamma_i$. As denominator of this equation is very small, even a small changes in the voltage magnitudes E_r or E_i can result in large change in the DC current. But it is desirable to control current not voltage. Power control in the DC link can be done by the ~~Current in~~ following ways:

(i) The increase of power in the link is achieved by reducing α_r which improves the power factor at the rectifier. Also minimize the reactive power consumption.

(ii) The inverter can now be operated at minimum γ. So minimum reactive power consumption takes place at inverter.

(iii) The operation at minimum extinction angle at the inverter and current control at the rectifier results in better voltage regulation.

(iv) The currents during the line faults are automatically limited with rectifier station in current control.

(v) It is important to maintain a minimum extinction angle of the inverter to avoid commutation failure. So it is economical to operate the inverter at constant extinction angle.

(vi) Under normal condition, the rectifier operates at constant current (CC) control and inverter operates at current extinction angle (CEA) control.

(vii) If AC voltage is reduced at the rectifier, it is necessary to shift the current control to the

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3.2 CONVERTER CONTROL CHARACTERISTICS

3.2.1 Basic Characteristics.

* Basic characteristics gives the relation between dc line Voltage and current and mode of op control at converter station. Characteristics of each station is divided into three parts.

Station-I	Station-II	Type
ab	hg	minimum (α)
bc	gf	constant current control
cd	fe	minimum (γ) or constant extinction angle control

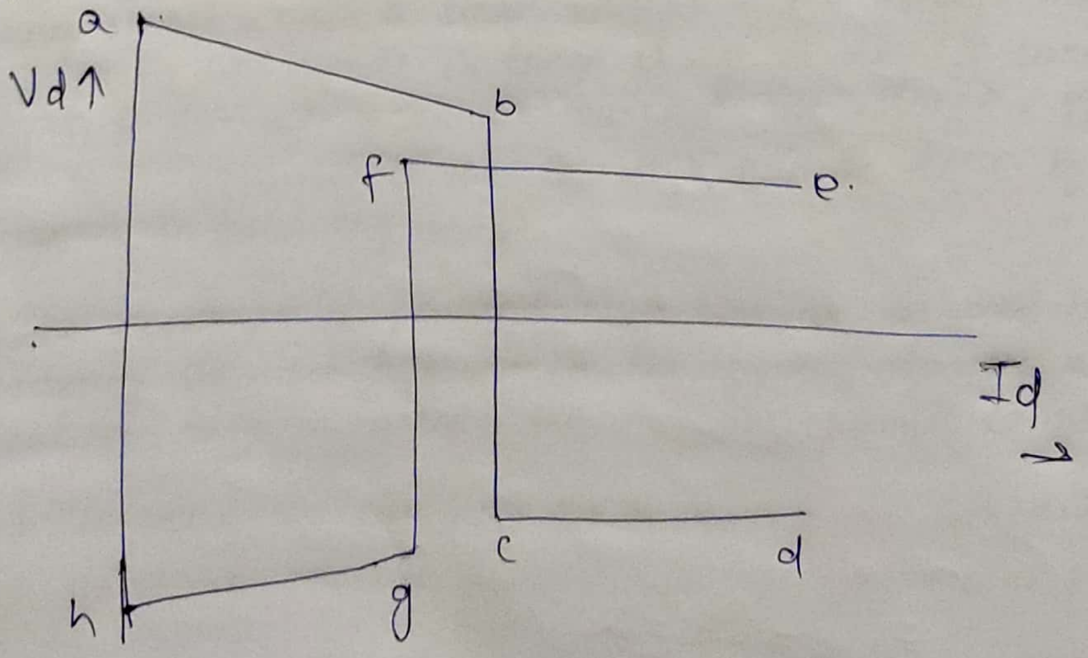
* The intersection point of characteristics of two stations determine the mode of operation of the convertation station.

* There are three modes of operation of the link. For the same direction of power flow:

(1) At normal condition rectifier operates at constant current (CC) control and inverter operates at constant extinction angle

(2) With slight decrease in AC voltage, the point of intersection shifts to point C which indicate minimum α at rectifier and minimum γ at the inverter (constant extinction angle).

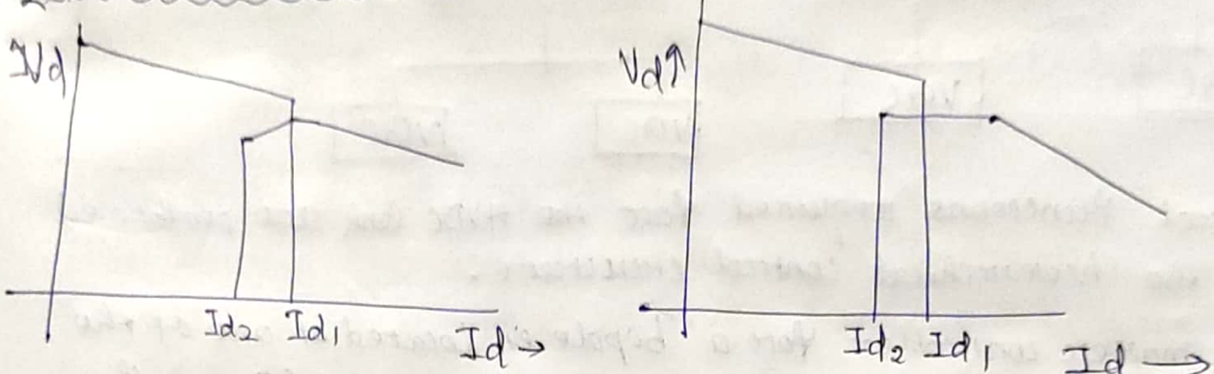
(3) With more decrease in AC voltage at the rectifier, the mode of operation shifts to point B which implies constant current at inverter and minimum α at the rectifier.



* Characteristics ab has generally more negative slop than characteristics fe. ~~for simulat~~ Because slop of ab is due to the combination of line resistance and rectifier resistance and slop of fe is due to inverted resistance.

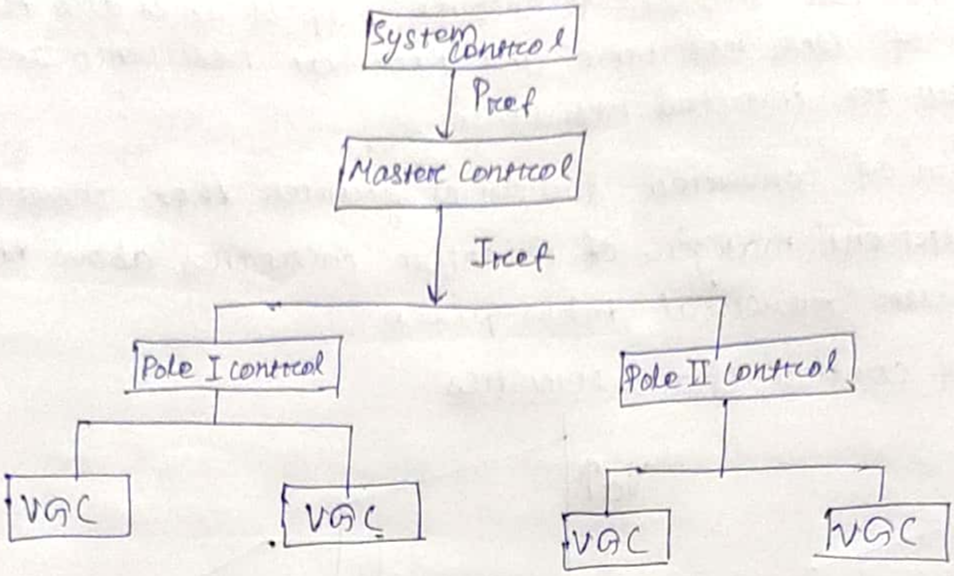
* Current margin of converter station is greater than inverter station. If current margin of inverter increases above the rectifier, power reversal takes place.

3.2.2 Modification of control characteristics



* If slop of fe exceeds ab, there will be three possible operating points A, A' and A''.
* As a result instability of the control takes place.
* To eliminate this problem, the inverter characteristics are modified.
* First modification is done by providing a positive slop between Id_1 and Id_2. This is achived by current error dependent γ control.
* 2 Second modification is to maintain a constant DC voltage at inverter.

3.3 SYSTEM CONTROL HIERARCHY



* Control functions required for the HVDC link are performed using the hierarchical control structure.

* The master controller for a bipole is located at one of the terminals. It provided with the power order (Pref) from the system controller. It has also other information such as AC voltage at the converter bus, DC voltage etc.

* The master controller transmits the current order (Iref) to the pole units. ~~which~~

* Pole units provide firing angle order to the individual valve group control. The valve group or converter control also control valve monitoring and ~~fi~~ firing circuit. It also includes commutation failure protection, tap changer control, valve protection circuits.

* Pole control also includes pole protection, DC line protection, converter paralleling and deparalleling sequences.

* Master control also ~~control~~ includes the function of frequency control, power modulation, reactive power control etc.

3.4 FIRING ANGLE CONTROL.

There are mainly two basic schemes of firing.

(1) Individual phase control (IPC)

(2) Equidistance phase control (EPC)

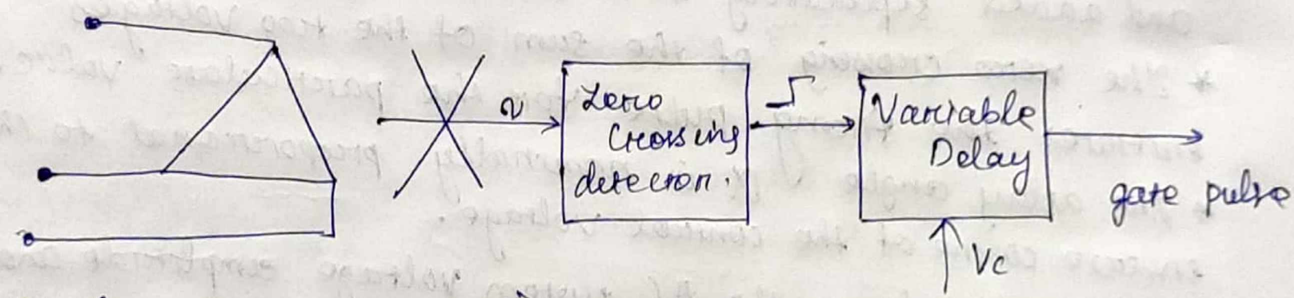
If firing circuit is provided for each thyristor value separately, then the system is called individual phase control system. But if a single firing circuit is provided to all values of a converter, then it is called as Equidistance phase control (EPC).

Individual phase control.

This schemen was used in early HVDC projects. The main feature of this scheme is that the firing pulse generator for each value is independent of each other. This control can be achived by two methods.

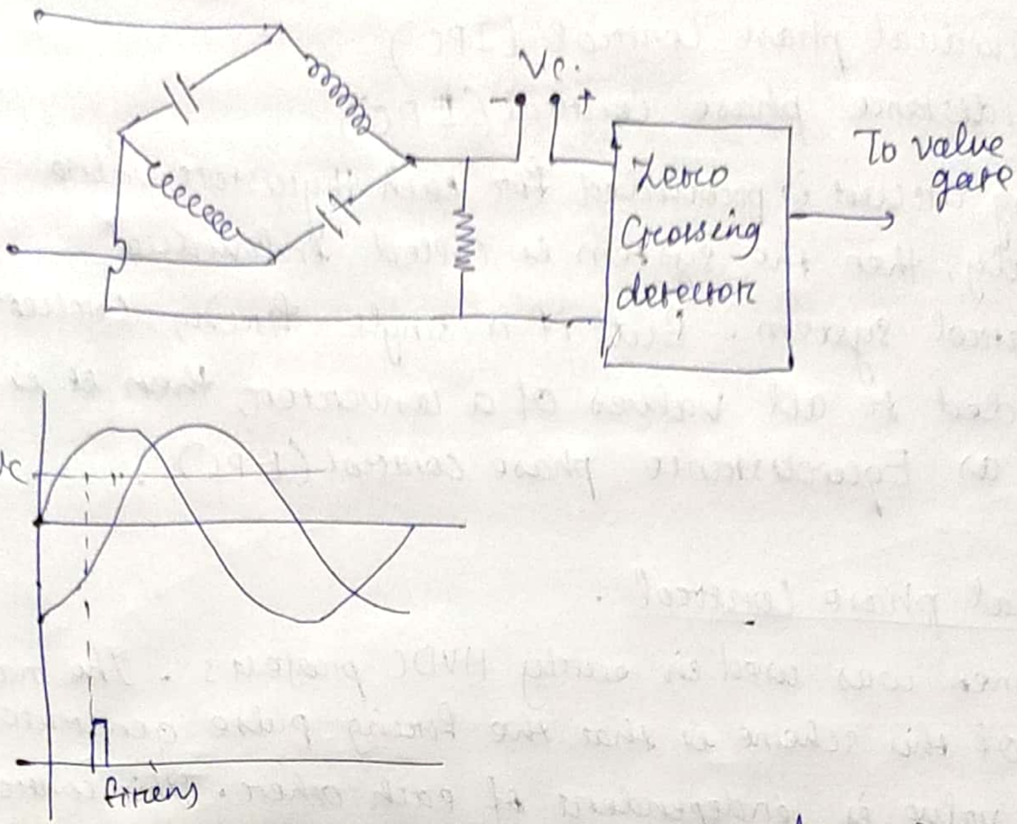
(1) Constant α control (2) inverse cosine control.

Constant α control.



* In this scheme six timing (commutation) voltages are derived from the converter AC bus via voltage transformers and the six gate pulses are generated at identical delay times subsequent to the respective voltage zero crossing.
* The instant of zero-crossing of a particular commutation voltage corresponding to $\alpha = 0$ for that value. The delays are produced by independent delay circuits and controlled by a common control voltage V_c derived for the current / extinction angle controller.

③ ~~Re~~ Inverse cosine control.



* The six timing voltages are produced, ~~six~~ in the similar process as that of constant α control.
* ~~They are shifted by 90°~~
Phase shift of 90° is created ~~by~~ between the voltage pulses and added separately to a common voltage Vc.
* The zero crossing of the sum of the two voltages initiates the firing pulse for the particular value.
* The delay angle α is nominally proportional to the inverse cosine of the control voltage.
* It also depends on the AC system voltage amplitude and shape.
* The main advantage of this scheme is that the average DC voltage across the bridge varies linearly with the control voltage Vc.

Disadvantages of IPC scheme.

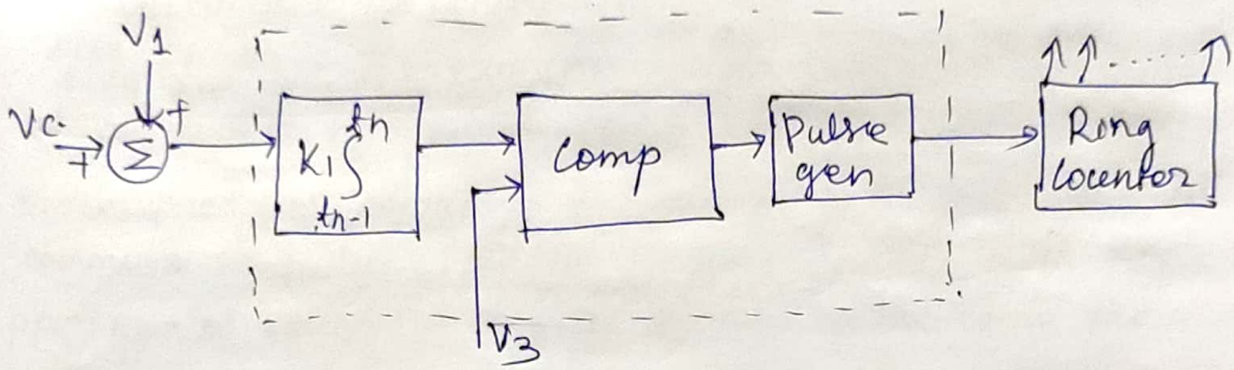
① Wrong detection of zero crossing causes ~~harmo~~ non-characteristics harmonics.

Equidistant Pulse Control (EPC).

In this scheme, the firing pulses are generated in steady state at equal intervals of $1/pf$, through a ring counter. There are three types of EPC scheme

1. Pulse frequency control (PFC)
2. Pulse Period control.
3. Pulse phase control (PPC).

Pulse frequency control (PFC)



* In this scheme, a voltage controlled oscillator (VCO) is used, the frequency of which is determined by the control voltage V_c which is related to the error in the control quantity like current, extinction angle or DC voltage which is regulated.
* Frequency in steady-state operation is equal to Pf_0 where f_0 is the nominal frequency of the AC system.
* The above figure shows a simplified block diagram of the PFC system. The voltage controlled oscillator (VCO) consists of an integrator, comparator and a pulse generator.
* Output pulses of the ~~the~~ pulse generator drive the ring counter and also reset the integrator. The instant (t_n) of the firing pulse is determined from the following equation.

$$\int_{t_{n-1}}^{t_n} K_1 (V_c + V_1)\, dt = V_3$$

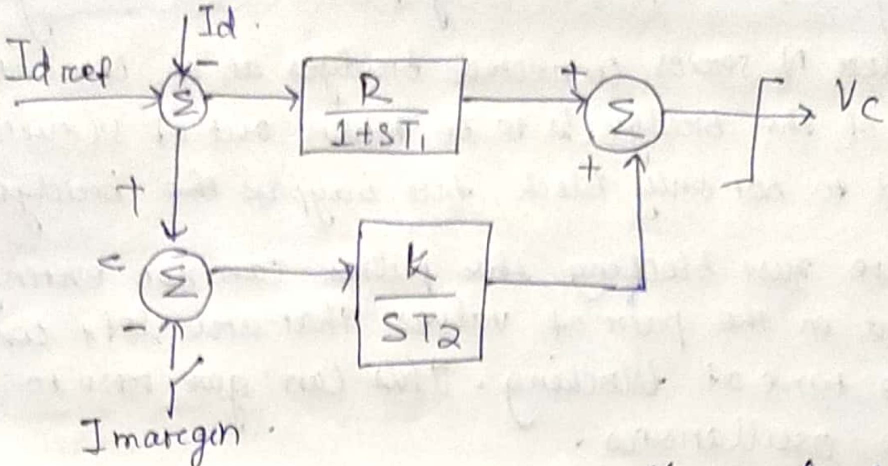
Pulse Period Control.

* This method is similar with PFC, except the way in which the control voltage V_C is handled.
* The structure of the controller is same as PFC. However, V_C is now summed with V_3 instead of V_1. Thus, the instant t_n of the pulse generation is given by

$$\int_{t_{n-1}}^{t_n} k_1 V_1 \, dt = V_3 + V_C$$

from $k_1 V_1 (t_n - t_{n-1}) = V_3 + V_C$.

3.5 CURRENT AND EXTINCTION ANGLE CONTROL.



* The current ~~to~~ controller is generally a feedback type system. The extinction angle controller can be of predictive type or feedback type with EPC control.
* The predictive controller is considered to be less prone to commutation failure. ~~and~~ The feedback control with ~~PEC~~ PFC type of equidistance pulse control ~~to~~ overcome the problems associated with IPC.
* The extinction angle, as opposed to current, is a discrete variable and it was felt that feedback control of gamma is slower than the predictive type. In one of the predictive schemes ~~p~~, the firing pulse generation is based on the following equation.

$$0 = \int_{-\pi+\delta_{n-1}}^{\omega t_n} e_{cj}\, d(\omega t) + 2X_c I_d.$$

where C_{cj} = commutation voltage across value j.

t_n = instant of firing.

* In general, the prediction of firing angle is based on the equation $\beta_j = \gamma_{ref} + u_j$

where u_j = overlap angle of value j

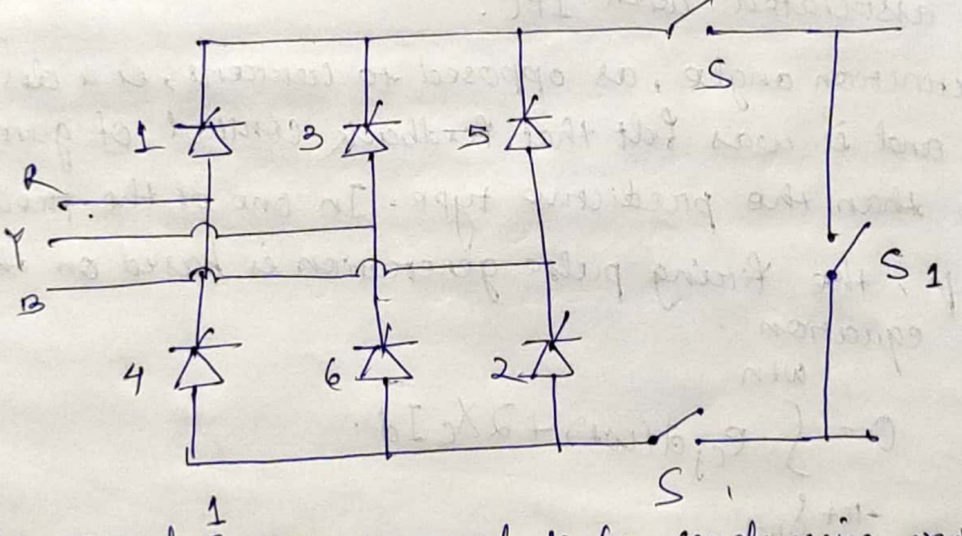
3.6 Energization and Deenergization of a Bridge.

* Consider N series connected bridges at a converter station. If one of the bridge is to be taken out of service, there is need to not only block, but baypass the bridge.

* Because just blocking the pulses can not extinguish the current in the pair of valves that are left conducting at the time of blocking. This can give rise to current and voltage oscillations.

* Bypassing of bridge can be done with the help of a separate bypass valve or by activating a bypass pair in the bridge.

* Bypass valve was used in mercury arc valves where the possibility of arc backs makes it impractical to use bypass pair.



* Valve 2 and 1 are assumed to be conducting initially when the blocking command is given. Let Value 1 and 4 are selected as bypass pair.

* Commutation from valve 2 to 4 is in usual manner, but Commutation from value 1 to 3 is prevented.

* Now current from the by pass pair is shunted to a mechanical switch S_1 with the help of isolators. So now the bridge is isolated

* The time between blocking command and current transfer to the by pass path can vary from 60° to 180° for a rectifier.

Energization of a blocked Bridge.

* Energization of a blocked bridge is done in two stages.

(i) Current is first diverted from S_1 to the by pass pair. AC breakers with sufficient arc voltage with reduced breaking capacity are used as switch (S_1).

(ii) In the second stage of energization current is diverted from the by pass pair. For the rectifier this process takes place instantaneously but for inverter it requires more time.

3.6 START-UP OF DC Link

There are two different start-up procedures depending upon whether the converter firing controller provide a short gate pulse or a long gate pulse.

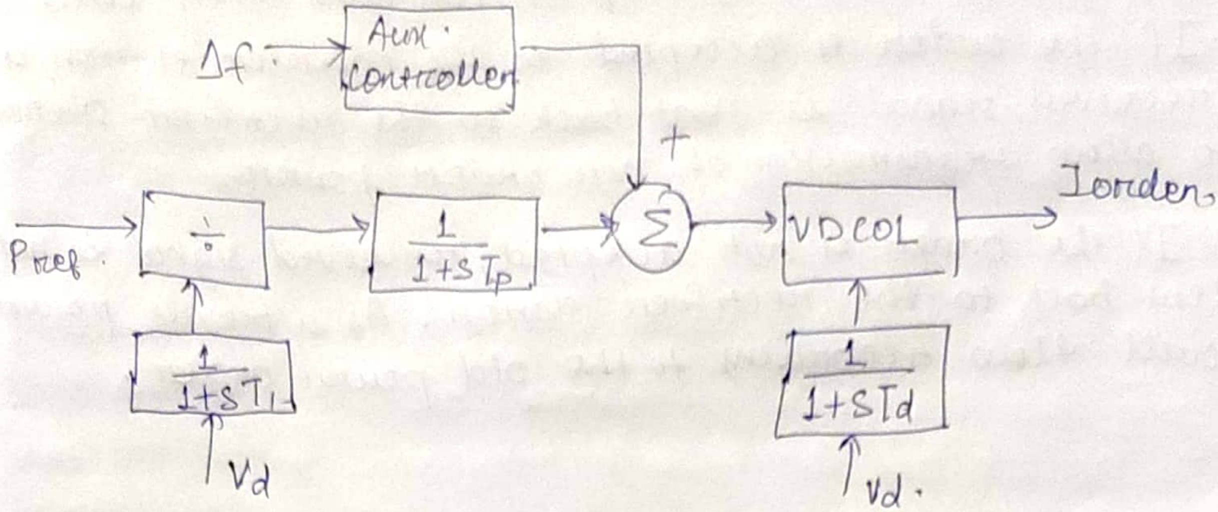
Start-up with long-pulse firing

1) Deblock inverter at about $\gamma = 90°$
2) Deblock rectifier at $\alpha = 85°$ to establish low direct current.
3) Ramp up voltage by inverter control and the current by rectifier control.

Start-up with short pulse firing

1) Open bypass switch at one terminal
2) Deblock that terminal and load to minimum current in rectifier mode.
3) Open bypass switch at the second terminal and commutate current to the bypass pair.
4) Start the second terminal also in the rectifier mode.
5) The inverter terminal is put into the inversion mode.
6) Ramp up Voltage and current.

3.7 POWER CONTROL



The above diagram indicate circuit of a basic power and auxiliary controller used.

* The current order is obtained as the quantity derived from the power order by dividing it by the direct voltage.
* The limits on the current order are modified by the voltage dependent current order limiter (VDCOL). The objective of VDCOL is to prevent individual thyristor from carrying full current for long periods during commutation failures.
* By providing both converter station with power control circuit, fastest response is obtained.
* In this case to get equal calculated current orders in two stations, the DC voltage must be measured from a same point.(middle of the DC link).
* But when length of the DC link is large and exposed to large temperature variation, the DC line voltage drop may not be equal for both station. As a result magnitude of 'Vd' and current order will be different for both station.
* This problem can be solved by using a current order calculator in one station only and transmitting the data to the other station.

* The current order set in one station is transmitted to the other with the help of communication link.

* If the order is accepted in the inverter station, a received signal is sent back to the rectifier station to allow transmission of new order power.

* If the order is not accepted, received signal is not sent back to the rectifier station. As a result power will flow according to the old power order.

3.8 HIGHER LEVEL CONTROLLERS.

3.8.1 ① Frequency and Power/Frequency control.

* Power in a DC link can also be controlled in response to the system frequency to improve security of overall system.

* Frequency control can be used in the case of
  (i) isolated load (ii) isolated generation.

* The nuclear power stations are very sensitive to output power and frequency fluctuation. By proper control of the power carried on the DC link in a hybrid transmission system consisting of both HVDC and UHV lines, frequency variation can be minimized.

* When the DC link is used as a tie between two power systems, the frequency bias can be used to adjust the power flow over the tie to assist the system in difficulty.

* We know that an HVDC link has no inherent sensitivity to system frequency. If it is introduced to the system, then it can sense it.

② Stabilization of AC ties.

* If a DC tie line is connected between two weak AC systems, DC line power can be varied quickly and automatically to balance the load flows and maintain stability of

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3.8.2
(2) Stabilization of AC Ties.

* When two AC systems are connected through a DC tie line and weak AC tie lines, DC link power can be varied quickly and automatically to balance the load flows and a maintain stability if one of the AC tie trips.
* A DC tie used in parallel with an AC tie can be used to damp low frequency interarea oscillation in the AC tie.
* The DC tie can also provide frequency control for one end of the AC tie becomes disconnected and can thus permit resynchronization of the AC tie.

3.8.3
(3) Emergency Control.

* In an AC tie line, the power flow is determined by conditions in the systems which it connects. If one of the system suffers by disturbance the fault may transmit to another system or the tie line may trip.
* But in a HVDC tie line, with power control ~~the~~ fault in one system can not transmit to other.
* With suitable control, a disturbance originating in either system can be shared ~~by~~ in a predetermined manner and the oscillations occurring in the two systems can be damped simultaneously.

3.8.4
(4) Reactive Power Control.

* Reactive power control is important, particularly in weak AC systems, in reducing the dynamic over voltages.

* Also in inverters, the fast reactive power control can help in allowing the injection of increased power at times of need to improve the stability of the receiving end AC system.

* The converter controls can be coordinated with the discrete control of the reactive power sources to provide voltage stability and eliminate voltage flicker.

3.9 TELECOMMUNICATION REQUIREMENTS

* To control power of a HVDC link, power controller is placed at one end of the link (Rectifier or inverter).
* Current order is calculated at one end and transmitted to the other end or station.
* Manual power order setting with voice communication is possible. But this process is very slow.
* Therefore telecommunication lines are used to transfer signal from one station to other.
* Fiber optic cables are used for this purpose.
* For the used of stabilization control, a 1200 baud channel is required for power flow control. This gives a sampling interval of 20 ms with a resolution of 0.05 percent of the maximum current order, which should be adequate for most cases.
* The primary objective of telecommunication line is to provide proper current margin. ~~It~~ To increase the current order of the link, first current order of the rectifier should be increased. And to ~~d~~ reduce current order, inverter current is reduced before rectifier.

(4) CONVERTER FAULTS.

In HVDC system fault can be caused by malfunctioning of equipments, controllers, failure of insulation caused by external sources such as lightning.

Due to fault regular power supply is interrupted and causes stress on the equipments due to overcurrent and over voltages.

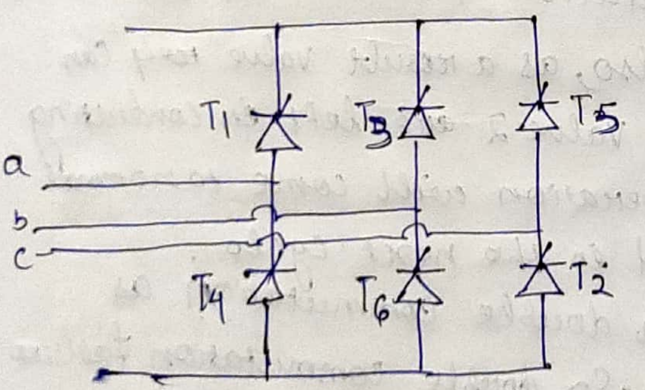
Faults have to be detected using control system and ~~protected~~ Protection has to be provided.

4.1.1 General faults.

There are mainly three types of faults in a converter station.

(1) Commutation failure in inverters.
(2) Short circuits in a converter station
(3) Faults due to malfunctions of valves and controllers.
This type of fault is also classified into ~~three~~ four types.
(i) Arc back
(ii) Arc through
(iii) Misfire.
(iv) Current Extinction or Quenching

4.1.2. Commutation failure.



→ If a conducting thyristor fails to turn-off in time. it leads to a fault known as Commutation failure.

We know that some time is required to turn-off a ~~ty~~ thyristor. which is called turn-off time. Therefore it is required to maintain a minimum value of extinction angle.

Reduction in voltage or increase in current or both can result in reduction in extinction angle. This gives rise to commutation failure.

Let Value 1 and Value 2 are conducting. After value 1 value 3 is going to conduct. If the incoming value 3 can not turn on and value 1 continue to conduct the full load current, commutation failure occurs.

After value 2, value 4 is going to conduct. If value 4 is fired ~~with Value 1~~ short circuit will occur. Because two values on a same same arm is left conducting. This state continues untill value 6 is fired.

Firing of value 5 before value 6 is unsuccessful, because value 5 is reversed biased at the time of firing. Because voltage across Value 5 is $(e_c - e_a)$ instead of normal commutation voltage $(e_c - e_b)$.

If commutation from Value 4 to Value 6 is successful, the conduction pattern returns to normal. If causes which results in commutation failure is cleared, the bridge operation returns to normal state ~~at~~ in the next cycle. So a single commutation failure is said to be self clearing.

Failure of two successive commutation in the same cycle is called double commutation failure. If commutation failure occurs to value 2 also, as a result value 4 can not turn on. So Value 1 and Value 2 are left in conducting state. The converter ~~will~~ operation will come to normal stage when value 3 is fired in the next cycle.

Fault time is greater in double commutation as compare to single commutation. So double commutation failure is more severe than the single commutation failure.

<u>effects of commutation failure.</u>

i) The bridge voltage remains zero for a period exceeding 1/3 of a cycle. During this time DC current is high.

ii) There is no AC current for the period in which the two valves in an arm are left conducting.

* The commutation failure in a bridge can lead to commutation failures in the series connected other bridges. If rate of rise of current is limited by the smoothing reactor, then it can be prevented.

Arc Through.

Arc Back.

⇒ If a valve fails to block in the reverse direction, then this type of fault is called Arc Back. Due to Arc back fault, the valve looses rectifying property temporarily due to conduction in the reverse direction.

⇒ This fault mainly occurs in mercury arc valves. But thyristors don't suffer from this fault. Therefore now thyristors are used to form valve.

⇒ This is not a self clearing fault like commutation failure. It causes sever stresses on transformer windings.

4.1.3 ARC THROUGH

⇒ This fault mainly occures in inverter station. If a false pulse force a valve which is not supposed to conduct but it is forward biased, then this type of fault is called Arc through.

⇒ This fault occurs due to malfunction in gate pulse generator or control system.

⇒ For example in a converter, let valve 1 and 2 are conducting. After successful commutation of valve 1, valve 3 is going to fired a conduct.

⇒ But if a false pulse can not turn on Valved 3, but it turn on valve 1 again, then Arc through fault occurs.

⇒ Effects of an arc through are similar to that of commutation failure. In this fault also short circuit occurs in the bridge as valve 1 and Valve 4 will conduct at a time. As a result voltage across the bridge falls to zero and AC current also goes to zero.

⇒ The converter returns to it's normal operation when valve 6 is fired. So a single arc through is self clearing, if cause of this fault is cleared.

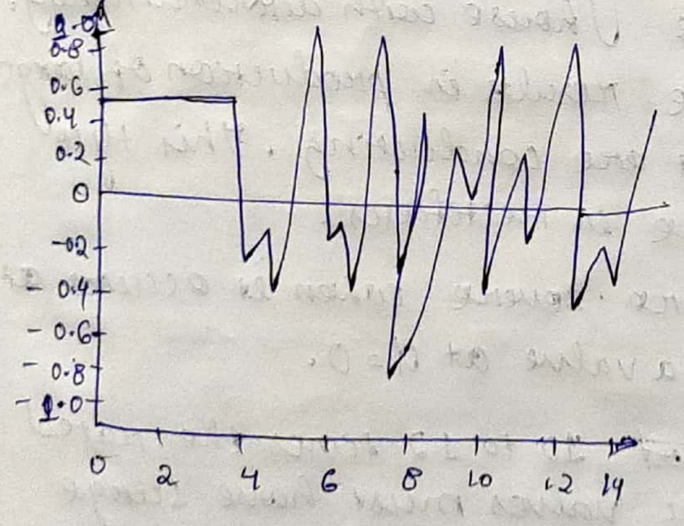
4.1.4 MISFIRE

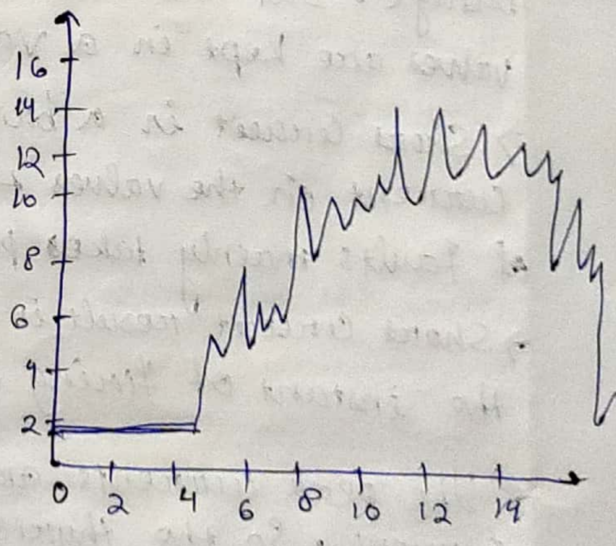
→ If the required gate pulse is missing and the incoming valve is unable to fire, then this fault is called misfire.

→ Probability of this fault is very small in modern converter stations because of advanced converter controls, monitoring and protective firing of valves.

→ This fault can occurs in both rectifier and inverter station. But effect of the fault is more severe in inverter station. Misfire in inverter leads to large voltage oscillation in DC link. and inverter voltage becomes zero.

→ The effect of a single misfire are similar to commutation failure and arc through. Let valve 1 and valve 2 are conducting. After valve 1, valve 3 is going to fired. But let firing of valve 3 is missed, then valve 1 will continue to conduct. As a result with firing of valve 4 after 2 valve 2, short circuit occurs in the converter. Waveforms of DC voltage and current for persistent misfire is given below.





4.1.5. Current Extinction

⇒ Current extinction of a valve takes place when current through it falls below the holding current.

⇒ When transient condition arise due to any reason, current can falls to a very low value. This may cause current extinction.

⇒ Current extinction can result over voltages across the valve.

⇒ Problem of current extinction is more severe in case of short pulse ~~fire~~ firing method.

⇒ When current extinction occurs, increased (build up) voltage across the thyristor is measured by valve group control and it may generate a no of firing pulses. ~~when~~

4.1.6. Short Circuit in a Bridge.

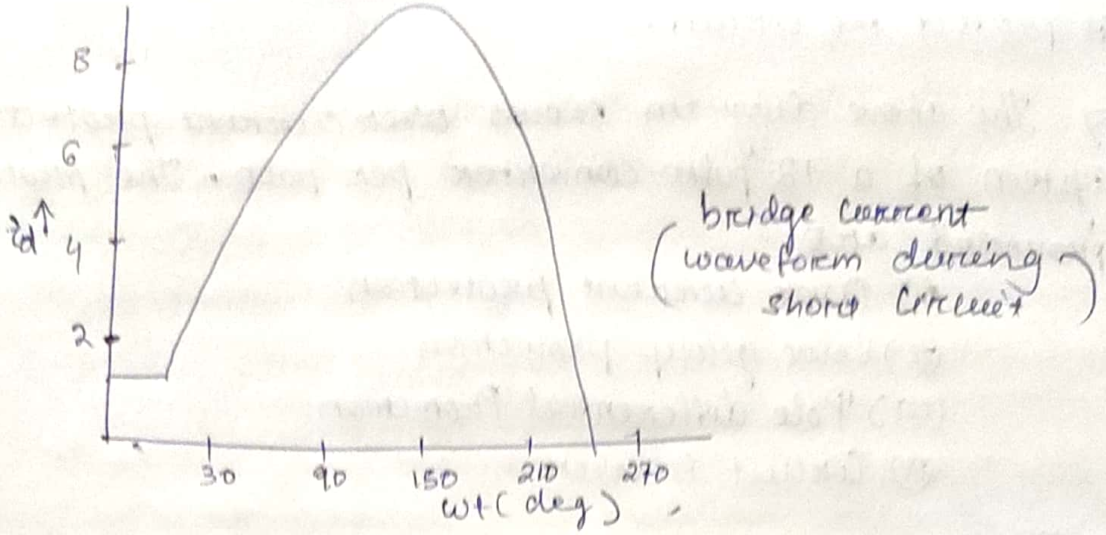
⇒ Bushing flashover can lead to short circuit across the bridge. But this fault has very low probability, because valves are kept in a valve house with air conditioning.

⇒ Short circuit in a bridge results in production of large current in the valves that are conducting. This type of faults mainly takes place in rectifiers.

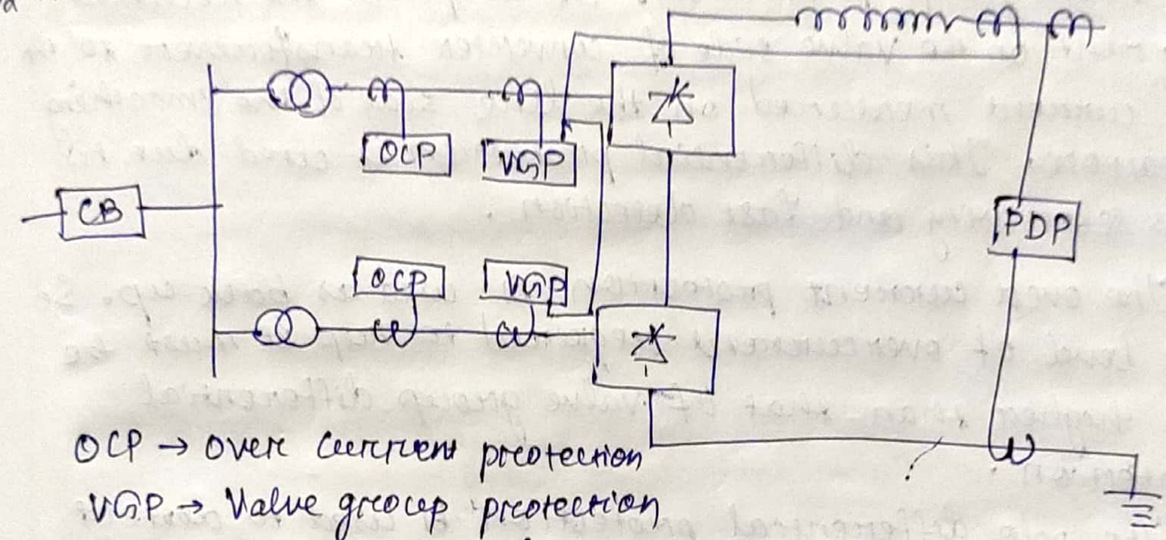
⇒ Short circuit result is more severe when it occurs at the instant of firing of a valve at $\alpha = 0$.

⇒ The peak currents are ~~of~~ 10 to 12 times the rated current. So the thyristor valves must have surge current rating above this value.

⇒ Fault clearing is performed by blocking the firing pulses. If the valve is unable to block the forward voltage; the fault is cleared by tripping the AC breaker.



4.2. PROTECTION AGAINST OVERCURRENTS



OCP → Over current protection
VGP → Valve group protection
PDP → Pole Differential protection
CB → Circuit Breaker.

→ The following factors must be considered in designing a protection system for converter.

(i) Selectivity ⇒ The protection system should correctly identify the faulty section and only disconnect this faulty section.

(ii) Sensitivity ⇒ Main feature of converter protection is sensitivity. It should be capable to clear the fault as fast as possible (in less than 20 msec).

(iii) Reliability ⇒ The protection system should be reliable so that it operate properly and clear the fault at right time.

(iv) Back up ⇒ Protection system should have back up. If any one system can not operate, the back up must work to protect the circuit.

⇒ The above diagram shows over current protection system of a 12 pulse converter per pole. The protection provided are.

(i) Over current protection
(ii) Valve group protection
(iii) Pole differential Protection
(iv) Circuit Breaker.

⇒ The basic protection against converter faults is provided by valve group protection. It compares the rectified current on the valve side of converter transformer to the DC current measured on the line side of the smoothing reactor. This differential protection is used due to it's selectivity and fast detection.

⇒ The over current protection is used as back-up. So the level of overcurrent required to trip it must be set higher than that of valve group differential protection.

⇒ The pole differential protection is used to detect ground fault which ~~may not be~~ is can not detect by other protection system.

⇒ Fault clearing action of these protection circuits is to block valves. and trip the AC breaker.

⇒ The faults producing overcurrent can be classified into three types

(i) Internal fault which cause overcurrent, but are very infrequent. ~~The thyri~~

(ii) Line fault which can cause overcurrent. There are limited by current control.

(iii) Commutation failure at inverters. This fault is quite frequent but magnitude of over current is small as compare to other.

4.3 Over Voltage in a Converter Station.

4.3.1 Types of overvoltages, in a AC system, can be classified into three categories.

(i) Switching overvoltages
(ii) Temporary overvoltages
(iii) Steep front overvoltages.

4.3.1 Disturbance on the AC side.

⇒ Lightening strokes in the AC network cause steep-fronted ~~with~~ high voltages. This voltage can be reduced by AC filters.

⇒ The initiation and clearing or (by switching action) of the faults in the AC system results in switching surges and temporary over voltages.

⇒ Energization of a converter transformer can cause high over voltage due to the inrush magnetizing currents. This type of temporary over voltage can cause severe stresses on the surge arrestors.

⇒ Overvoltage can occurs in converter station connected to weak AC system due to load rejection.

4.3.2 Disturbance on the DC side.

⇒ Steep front ~~to~~ overvoltage ~~to~~ in DC overhead lines are produced by lightening strokes. This is limited by smoothing reactor.

⇒ The switching surges at the converter are also caused by ground faults on a pole of bipolar DC link.

⇒ The switching of DC filter branches, parallel connection of poles can cause transient current and overvoltages.

⇒ Overvoltages can also be caused by oscillation of voltage and current in the line due to commutation failure and other converter fault.

4.3.3 Over voltages Caused by Internal Converter Disturbance.

⇒ The series connection of thyristor and spread in the delay times of the thyristor turn-on result in overvoltages across the device. These overvoltages are repetitive.

⇒ So valve must be design considering these overvoltages. Snubber circuits are used to limit it.

⇒ Spread in reverse recovery charges and commutation overshoot also result in repetitive overvoltages.

⇒ A ground fault at the valve side of the smoothing reactor may cause overvoltages at converter.

⇒ A ground fault between the valve bridge and the converter transformer may also cause overvoltage.

⇒ Forcing of bypass pairs or closing of bypass switch across one converter generates overvoltages across the remaining converters.

⇒

4.4 SURGE ARRESTERS.

⇒ It is a protective device used to protect the circuit from over voltage.

⇒ It provide a path to ground, when the system voltage is above a certain value.

⇒ Stop the flow of current to ground, as soon as the system voltage drops below that value (predetermined). And restore insulating properties between line and ground.

⇒ It should not damaged by the discharge and be capable of automatically repeat the discharge process frequently.

⇒ It should not allow current to flow to the ground as when the system voltage is normal.

• Working Principle.

When over voltage travels along the conductor and reaches the point at which the lightning arrester is installed, it breaks down the insulation of arrester momentarily and allow the voltage surge to discharge. When the system voltage drops; insulation between the conductor and ground is restored and further current flow to ground stops.

CONSTRUCTION

Initially, DC surge arresters were not available. So valves were protected by the spark gaps connected across them. Later active spark gaps were used. Then DC arresters were made.

A DC arrester is made up of nonlinear resistors in series with a active spark gaps. But with development of metal oxide resistor with high nonlinearity the need of a series gap has disappeared. So Now DC arresters are gapless arresters. (DC arrester is made up of only non-linear resistor)

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Non linear resistor is mainly made up of Zinc oxide. But some other metal oxide like MnO_2, Cr_2O_3, Bi_2O_3 etc are used as additives. This resistor disk i.e conducts less than a milliampere of current at normal operating voltage and can carry thousands of amperes at twice the normal operating voltage.

Temperature co-efficient of the material is slightly negative at low current, but becomes positive at high current. Due to this property Zinc Oxide is used as arrestor.

Arresters are designed considering one more factor i.e it's energy dissipation capacity. In many DC applications, if energy dissipation capacity of a single column of discs is not sufficient, multiple columns are used.

4.5 PROTECTION AGAINST OVERVOLTAGE:

Basic Principle of overvoltage Protection are:

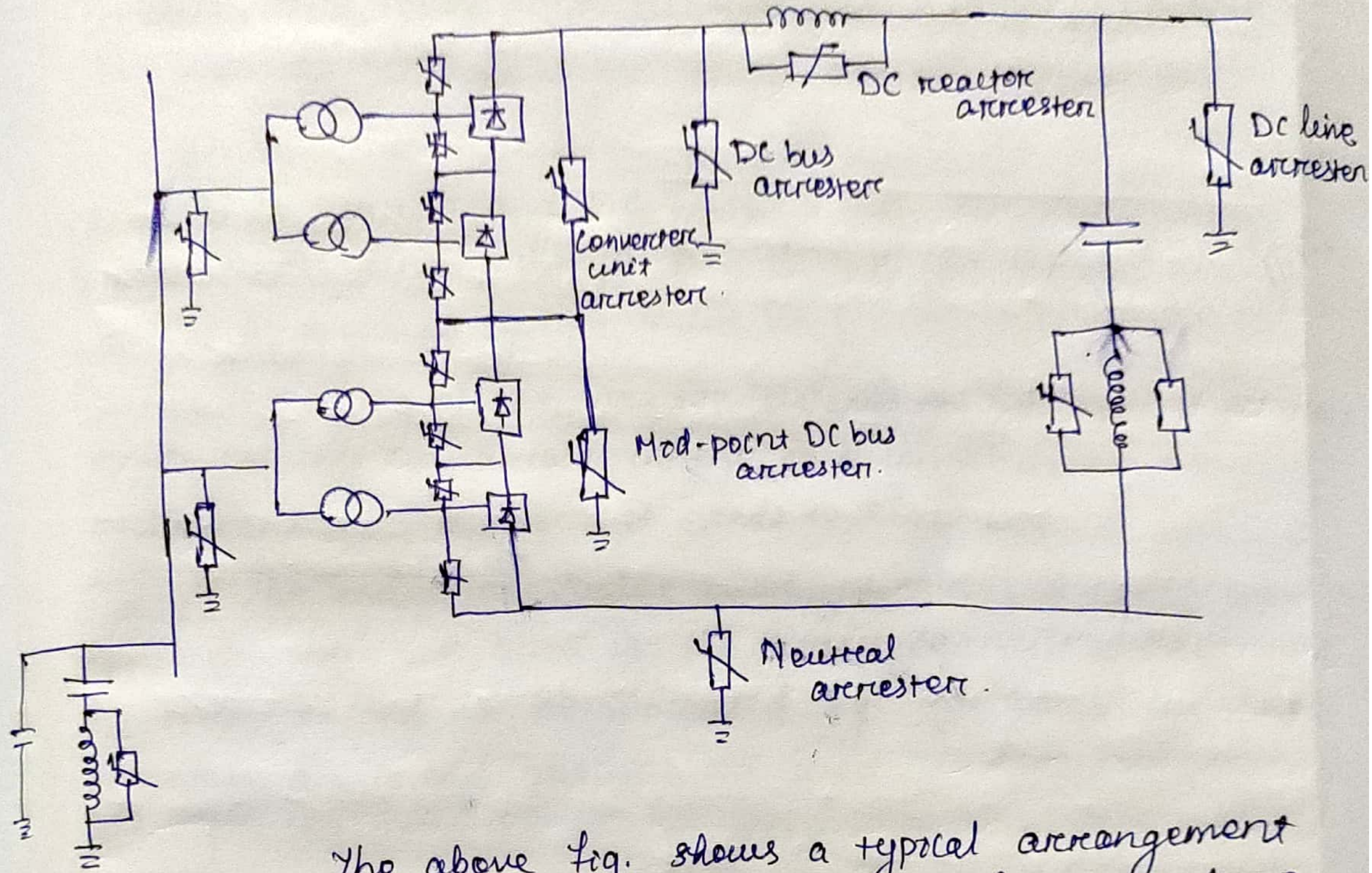
1) The overvoltage stresses in equipment with non ~~self-clearing~~ self-restoring insulation must be limited at all time by providing surge arresters. The protection level of the arresters must be lower than the breakdown voltage of the insulation.

2) Self restoring insulation such as air may be allowed to breakdown where there is no danger to the safety of the personnel.

3) The operation of surge arresters or flashover of air insulation should not be frequent. Frequent discharge of arresters may damage them.

4) There must be proper co-ordination of the insulation and overvoltage protection in different parts of the system.

overvoltage generated on the AC side should be limited by arresters on AC side. Overvoltages generated on the DC side must be limited by DC side arresters. Critical components such as valves are directly protected by arresters connected close to the components.



The above fig. shows a typical arrangement of surge arresters in a converter station for over voltage protection. For a system with two 12-pulse converters per pole, there are about 40 arresters per pole. These arresters are of different energy dissipation capabilities. It depends on where it is used. For example converter unit arresters should have high energy dissipating ~~ca~~ capacity as compare to neutral arrester.

5 SMOOTHING REACTOR AND DC LINE.

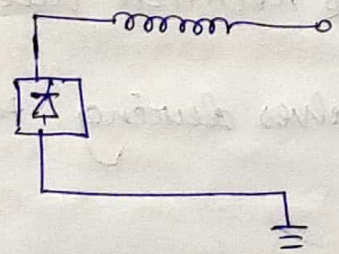
5.1 REACTOR (Smoothing Reactor)

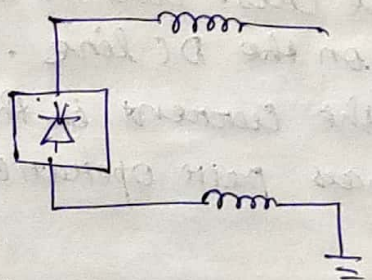
A smoothing Reactor is an static electromagnetic device (inductor) which is connected in series with a circuit. It's inductance reduce the harmonics (ripple) in current.

In HVDC transmission smoothing Reactor is connected between converters and DC filter. For normal DC transmission line value of reactor vary from 0.27 H to 1.5H. ~~or~~ For back to back system value vary from 12mH to 200mH.

The sizing of the reactor depends on how much (maximum) ripple current may arise where it is connected and how much harmonics current it needs to eliminate.

The inductance value must remain practically constant with variation in the direct current. The reactor should not be saturated by high ~~gro~~ DC current. Therefore air-cored reactors are used.





Location of smoothing reactor · can be at high voltage terminal or at ground terminal. The advantages of having the reactor at the ground side is that it allows the converter ground faults to be cleared by converter control.

Choice of optimum size of a DC smoothing reactor based on S_i factor.

$$S_i = \frac{L V_{dn}}{I_{dn}}$$

where V_{dn} = rated direct voltage in KV

I_{dn} = rated direct current in KA.

L = DC line ~~re~~ inductance (includes transformer leakage reactance)

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Higher the factor, higher the rate of rise of fault current.

Other two factors also play an important role in sizing of reactor.

① Highest value of ripple current,

② Peak direct current during the bypass pair operation caused by commutation failures.

Function of smoothing Reactor -

① They reduce the incidence of commutation failure in inverters caused by dip in AC voltage at the converter bus.

② They prevent consequent commutation failures in inverters by reducing the rate of rise of direct current in the bridge.

③ They smooth the ripple in the direct current in order to prevent the current becoming discontinuous at light loads.

④ They decrease harmonic voltage and current in the DC line.

⑤ They limit the crest current in the rectifier due to short circuit on the DC line.

⑥ They limit the current in the valves during the converter bypass pair operation.

5.2 CORONA EFFECTS

Corona is defined as a luminous discharge due to ionization of air surrounding a conductor caused by a voltage gradient exceeding a certain value.

Process

Within a very thin circumferential layer (not more than 2 (cm) surrounding the conductor surface corona effect occurs. In this zone when the field strength exceeds a certain (high) value, ionization of air surrounding this conductor takes place. Electrons are removed from the atoms of the air molecules and accelerate towards the positive conductor and away from the negative conductor. These high velocity electrons collide with other air molecules ~~releasing a~~ and release additional electrons. The ions carrying the same charge as the adjacent conductor are repelled from the ionization zone.

This moving ions go accumulate in the region between pole to pole or pole to ground. These ions then recombine with the oppositely charged ions or neutral molecules. To maintain the net charge in this region, a corona current flows from the conductor by the movement of electrons in the ionization zone and by ions beyond this zone.

Corona has the following effects.

1. Corona loss
2. Radio and television interference.
3. Audible noise.
4. Space charge field.

The first three effects occurs in AC lines also. Last effect occurs on only DC lines.

① Corona loss.

A power loss occur due to corona - The power losses is given by

$$P_{loss} = \left[2V(k+1)K_c\, n r\, 2^{0.25(g-g_0)}\right] \times 10^{-3}\ \mathrm{KW/circuit-km}$$

where V = pole to ground voltage in KV

n = number of sub conductors

r = radius of each

g = maximum conductor surface gradient at operating voltage.

$g_0 = 22\,\delta$ KV/cm, where δ = relative air density

K_c = conductor surface co-efficient which varies from less than 0.15 for smooth, clean conductor to more than 0.35 for conductor with imperfections.

H = mean height of conductors.

S = pole spacing.

T = temperature in centigrade

② Radio interference

Radio interference ~~means~~ occurs when unwanted frequency signal disturb the radio ~~television or~~ signal transmitting through the communication line. These lines are supported by electrical ~~substat~~ transmission and distribution towers. This interference may cause temporary loss of a signal or may affect the quality of the sound.

In HVDC transmission RI is mainly due to the positive conductor. Because corona discharge in negative conductor is uniform throughout it's surface but in +ve conductor corona discharge is non uniform.

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$$RI = 25 + 10\log n + 20\log r + 1.5(g - g_0)$$

This is due to positive conductor.

* RI due to negative conductor is about 20 dB lower than positive conductor..
* RI in DC lines decrease by rain and wet snow. ~~which~~ This ~~is~~ phenomenon is opposite to that in AC conductors.
* RI increased by wind.

Audible noise (AN).

The corona discharges from the conductor produce ~~compression and to~~ acoustical energy. The portion of the acoustical energy spectrum that lies ~~below~~ within the sonic range is audible noise.

The sound level is expressed in decibels and is defined as

$$dB = 20\log(P/P_R)$$

where P = measured sound pressure
P_R = reference pressure level

For example ±600KV DC line would produce an audible noise of 45 dB to 55 dB measured at 30 meters from the ROW centre line. Positive polarity conductor is the primary source of Audio noise. Rain causes a very slight reduction of Audio Noise.

Space charge field.

Ions produced by the corona on overhead DC lines accumulate in the region between conductors or conductor to neutral due to the action of electric field and wind.

In AC lines, the problem of space charge is not present because ions created during one half cycle are recaptured during the second half cycle.

5.3 PROTECTION OF DC LINE

⇒ To clear DC line fault, line current and voltage made zero which reduces the Arc produced due to fault.

⇒ To achieve this condition, the rectifier is put into inverter mode by sudden increase in the delay angle to it's maximum limit. The inverter operates as inverter. As a result energy stored in the DC line is discharged and delived to the AC line. So current and voltage in the DC line fall to zero and help in deionizing the arc path.

⇒ After some time (0.2 to 0.5 sec), the line is automatically energized by restarting the converters in usual manner.

⇒ If the restart is unsuccessful due to persistent fault, the protective action will deenergize the line again. Normally three attempts are made to re-start it automatically.

⇒ But after three attempts ~~still~~ if the restart is unsuccessful then it is required to shut down the link and clear the fault.

Detection of line fault:

First detection of fault is done, then deenergization of link process takes place. Detection of fault is based on the following condutions:

(i) a sudden drop in the DC voltage measured on the line side of the reactor: ($V_d < K_1$ and $\frac{dV_d}{dt} < -A$ for $t > t_1$)

(ii) Sustained low direct voltage ($V_d < K_2$ for a duration $t > t_2$)

where K_1, K_2 and A are positive parameters.

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The criterial for selecting these parameters are.

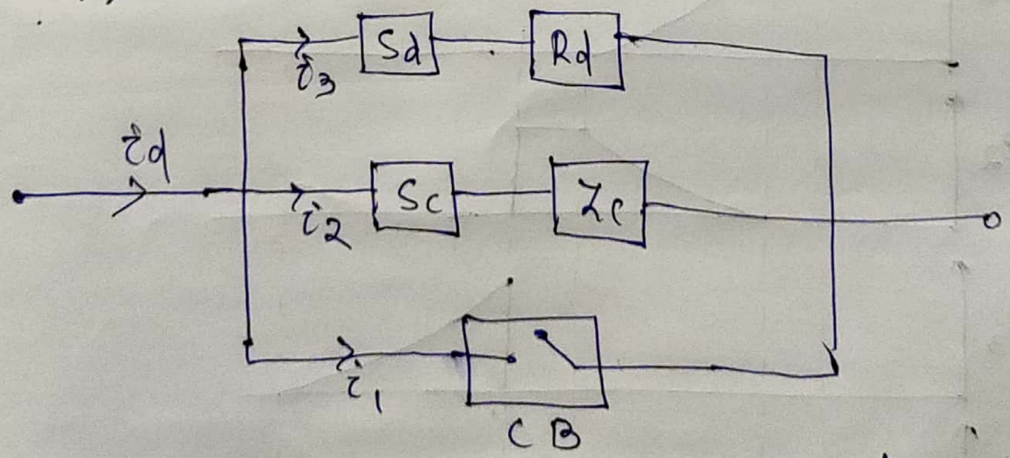
1) Selectivity.
2) Sensitivity
3) Reliability.

⇒ It is very difficult to perform de energization of DC line in fault with voltage source converter. Because voltage in VSC based links can not be reversed and DC capacitors at the converter station & discharge or feed current to fault. So in case of VSC based link once fault is detected dc line has to be disconnected from the AC line by circuit breaker.

5.4 DC BREAKERS

(i) The major problem in the current interruption in DC circuit is that there is no natural current zero as in the case of AC circuits.

(ii) The current can be brought to zero only by applying a counter voltage higher than the system voltage. The second ~~proprte~~ problem is the dissipation of large energy stored in the circuit.



The general arrangement of a HVDC circuit breaker is shown above.

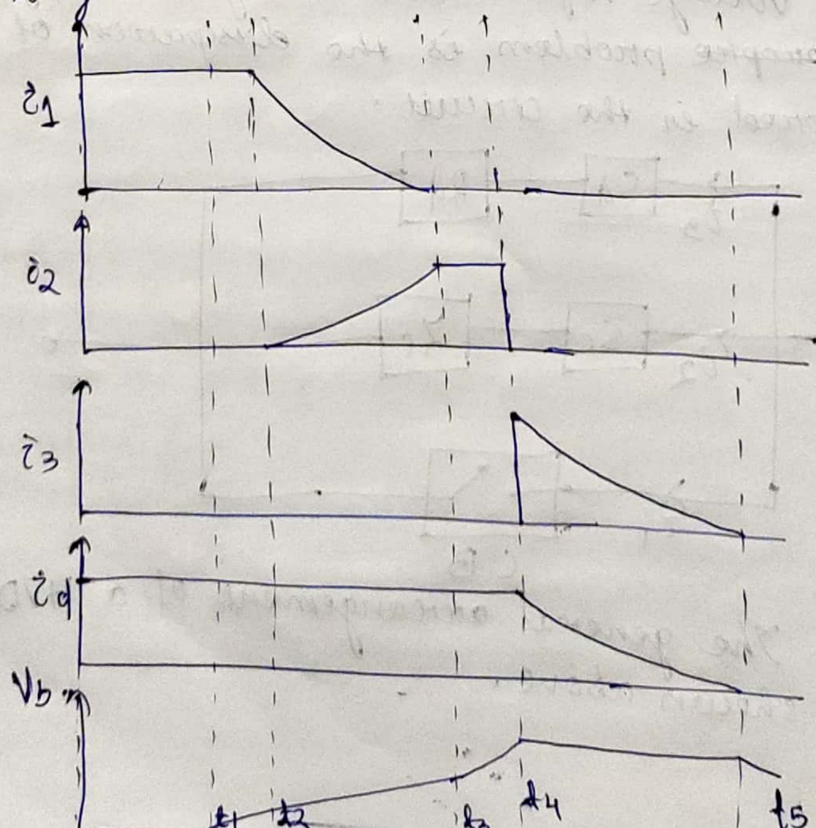
(iii) The current in the breaker in normal conditions is carried through CB. ~~with~~ moving circuit breaker may be vaccum, oil, airblast or SF_6 device.

(iv) When a trip signal is given to the breaker, the breaker contacts open and arc is produced. This is indicated at time t_1. After a short time t_2, the commutation circuit is inserted through the insertion device Sc. The commutation circuit is made up of a series L-C circuit. The main purpose of commutation circuit is to creat current zero in Circuit Breaker and transfore the current to Z_c.

(v) This current transfer is completed by time t_3. DC current Id flowing through the Z_c, build up a high voltage Vb across the breaker.

(vi) At t_4, energy absorber Rd is inserted through the device Sd. The direct current now decays to zero by discharging it's energy to Rd at time t_5. So the breaker operation complete at t_5.

DC Current Id and Voltage Vb (across the CB) waveforms with respect to time during the switching operation of CB is given below:



Applications of DC Breakers.

→ Application of DC breakers is required mainly for fault clearing in MTDC systems.

→ When the converters feed two parallel DC lines.

→ When parallel connected converters feed the same line.

→ When current needs to be transferred from the ground return to the metallic return during monopolar operation.

(6) REACTIVE POWER CONTROL

6.1 Requirement of Reactive power.

→ In HVDC system both the terminals have converter bridges. These bridges are made up of ~~to~~ semiconductor devices.

→ The semiconductor devices like Thyristors, IGBTs are turned on in a controlled manner. After ~~to~~ forward biasing of the device, it turns on when firing pulse is given to the gate. Angle at which firing pulse is given is called firing angle or delay angle.

→ This delay in firing ~~can~~ causes lagging current through the switch or device. Therefore bridges needs reactive power.

→ Now, when the converter bridges are connected to the AC grids, they will ~~start~~ drawing reactive power from the grid and the ~~the~~ grid voltage will start to collapse.

→ So it is required to compensate the reactive power demand of the converters at both the rectifier and inverter terminal.

→ Fixed capacitors, AC filters, synchronous condenser, SVC, STATCOMs are used as reactive power sources at the converter station.

6.2 Sources of Reactive Power.

* Adjustable reactive power sources are provided in HVDC system to improve power factor and for better voltage regulation.
* Improved voltage regulation of power factor help to minimize losses and improve stability of the system

* Following sources are used to provide reactive power requirement of the converter.

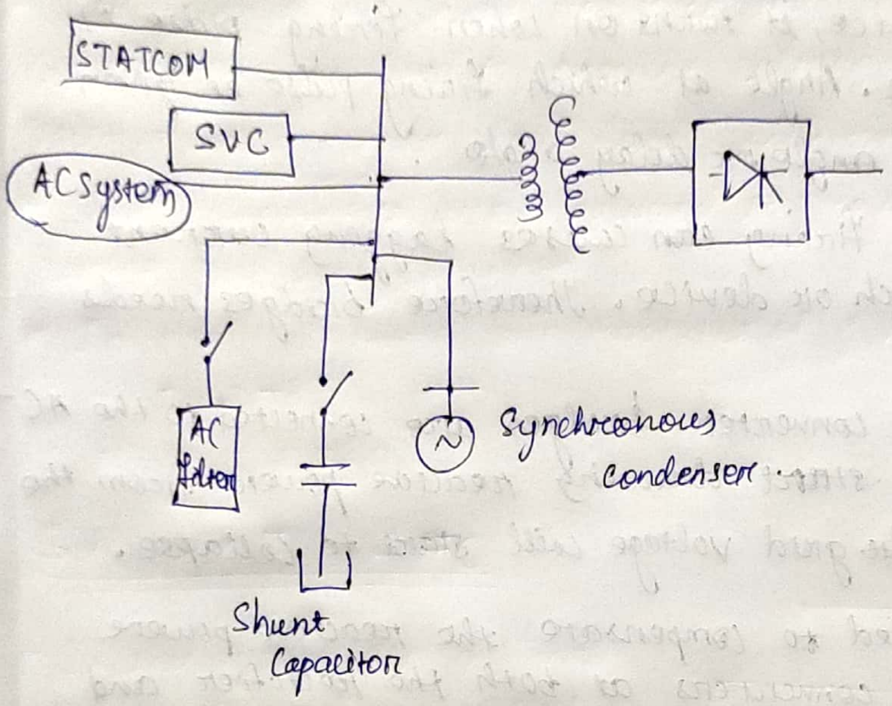
(i) AC filters

(ii) Shunt Capacitor

(iii) Synchronous condenser

(iv) Static VAR compensator (SVC)

(v) Static Synchronous Compensator (STATCOM)



* For slow variation in load shunt capacitors and AC filters are used. But this is a discreet type of control because they are mechanically switched.

* But Synchronous condenser, SVC and STATCOM provide continuous control of reactive power. So they can be used for fast variation in load.

* Shunt capacitors and AC filters results in Voltage fluctuation if the operating voltage is large. It can cause low order harmonics.

* Synchronous condenser are synchronous motor operating at no load with an excitation control to maintain terminal voltage. Advantages of synchronous condensers are: (i) Better voltage regulation during transient period.

(ii) It can provide voltage source for commutation at the inverter, if the connection to AC system is temporarily disconnected.

* But cost of synchronous condenser are high and required high maintenance. Also possibility of instability due to machine going out of synchronism increases.

* Static VAR compensators provide fast response and it's output reactive power can vary easily. In SVC there is no synchronism problem.

* SVC is generally of two types:
(i) Fixed capacitor connected parallely with a thyristor controlled reactor (FC & TCR)
(ii) Thyristor switched capacitor in parallel with thyristor controlled reactor (TSC & TCR).

* Static synchronous compensator or STATCOM is an advanced voltage source converter. It has fast response, less maintenance requirement and free from the problem of loss of synchronism.

~~6.3~~

6.3 STATIC VAR COMPENSATOR (SVC):-

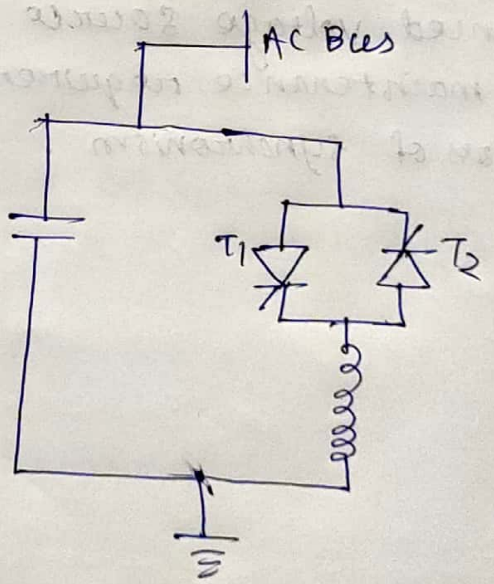
* SVC are used in high voltage power system. The advantages of using SVC are :-
  (i) To maintain voltage variation within limit.
  (ii) To improve power factor.
  (iii) To reduce line losses

* SVC consist of shunt reactors and capacitors. Shunt reactors ~~capacitors~~ are used to prevent voltage fluctuation and voltage rise under low load condition.

* Shunt ~~reactors~~ capacitors are required to prevent voltage drop during pick load condition.

* In practical there are two types of SVC.
  (i) FC & TCR
  (ii) TCS & TCR.

SVC with TCR & FC.



* In this type of SVC a fixed capacitor is used in parallel with a thyristor control reactor.

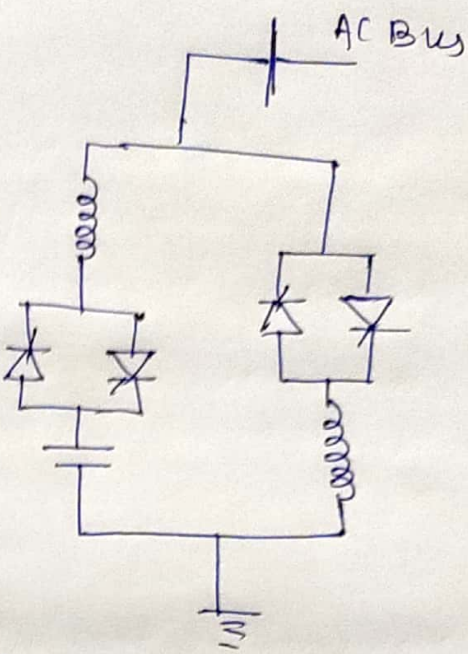
* TCR is made up of two thyristors (T_1 & T_2) connected in antiparallel and connected in series with the reactor.

* The capacitor has a constant value, so it supplies constant leading power.

* By changing firing angle of T_1 & T_2 lagging power supplied by the reactor can be changed. As a result total output power of the SVC can be vary with different load.

SVC with TSC and TCR:

* Thyristor switched capacitor consist of a capacitor and a small inductor connected in series with the anti-parallely connected thyristor.



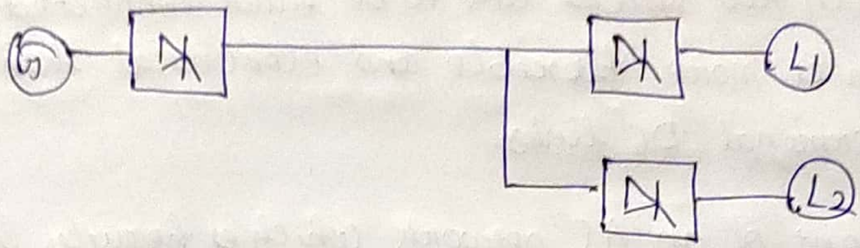
* Here TSC provides leading power and Thyristor switched reactor provides lagging power without affecting each other.

* Lagging power of TCR controlled continuously by changing the firing angle of the thyristor.
* Leading power of the TSC can also be controlled by changing the firing angle of 2 thyristor connected in series with it.

(7) MULTI-TERMINAL DC SYSTEM.

(i) A multi-terminal DC system has more than two converter stations. Some of them operated as rectifiers and other as inverters.

(ii) The simplex way of building a MTDC system from a two terminal system is by introducing tappings in the main DC link.



7.1 Application of MTDC system.

. There are several applications, where MTDC system can be used in place of conventional two terminal due to it's several advantages.

(1) Bulk power transmission from several generating Station to several load

* In MTDC system tapping of power from existing two terminal system can be done. As a result power can be transmitted from more than one generating Station to more than one load station.

* For interconnection of several stations, MTDC system has many advantages over two terminal system.

* Let consider two generating station and two load station. In figure-1 they are connected to each other by two terminal system and in fig-2 they are connected to each other by a MTDC system.

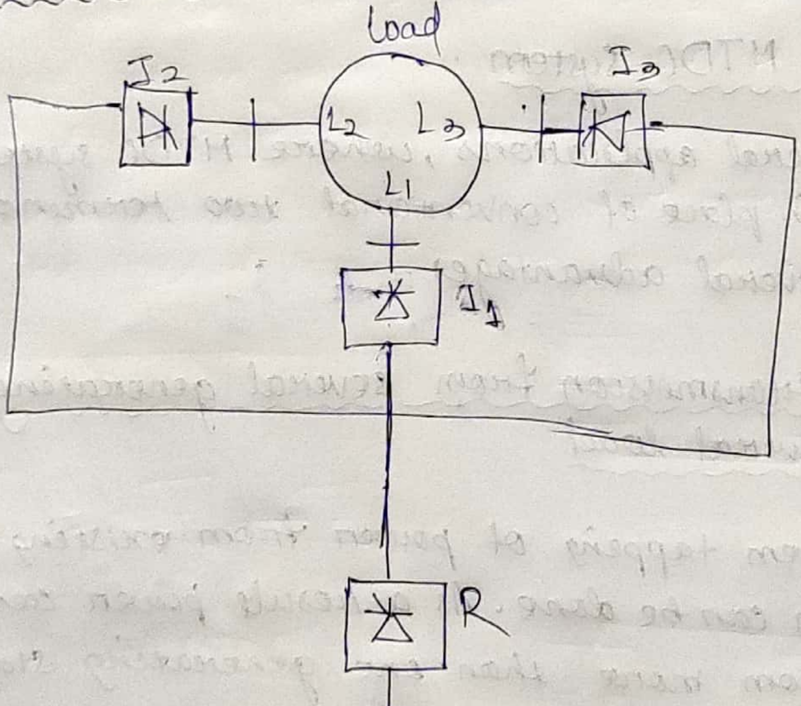
* From the above figure we can see that to two generating station with load station, three two-terminal DC links and two extra converter stations are required in two terminal system.

* This would result in extra cost for converter station and additional power losses in extra dc link.

② Asynchronous interconnection between adjacent Power system.

* When more than two systems are to be inter connected a MTDC system is more flexible and economical than using several two terminal DC links.

③ Reinforcement of an AC network which is heavily loaded



* Consider an urban power station which is fed by a generating station. If the load station is large, power injection to the load system should be at more than one point. So that the AC network is not over loaded.
* This is easily achieved by using MTDC system with one rectifier station and several inverter station.

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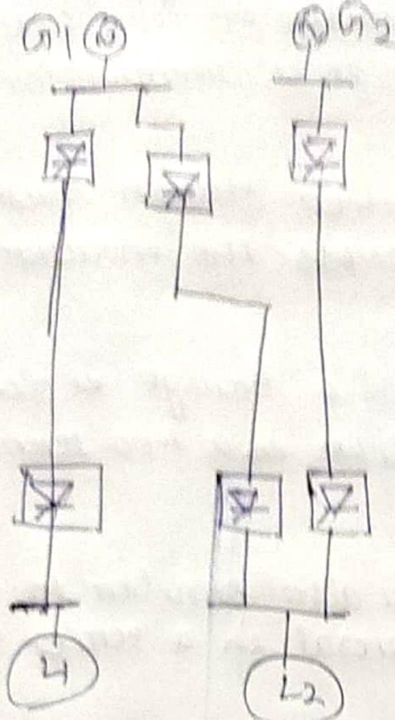


fig-1

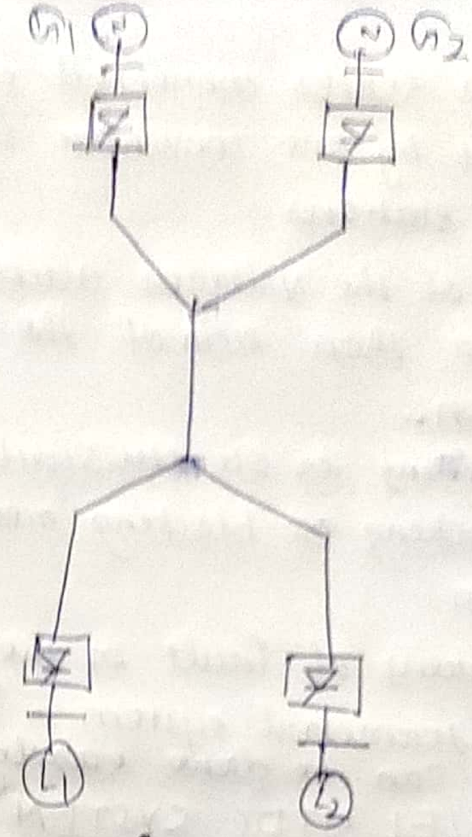


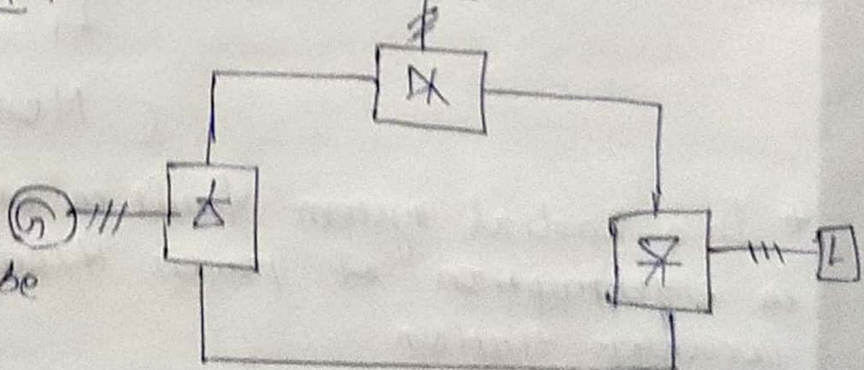
fig-2.

7.2 TYPES OF MTDC SYSTEM.

* There are two types of MTDC system
  (1) Series
  (2) Parallel
* Again Parallel MTDC system can be classified into two types. (i) Radial
  (ii) Mesh

SERIES MTDC SYSTEM.

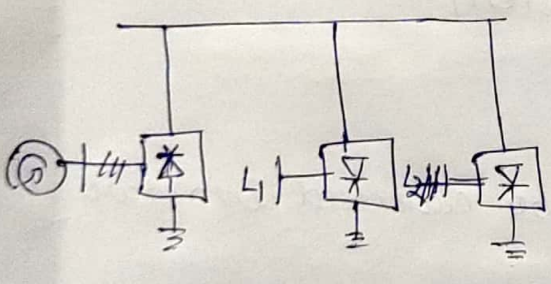
* This is a natural extension of two terminal system.
  This system can ~~help~~ be both monopolar or homopolar.



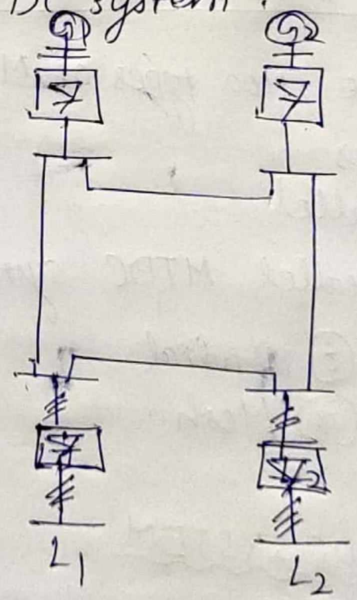
* In a series connected system the value of line current is set by one converter station and it is common for all other stations.
* Sum of the voltages across the rectifier station must be larger than sum of the voltage across the inverter station..
* Switching in or ~~sti.~~ switching out of a bridge is done by D-blocking or blocking method just like in a two-terminal system.
* Clearing of fault in the DC line is also similar to two-terminal system. Power reversal in a series system can be done easily.

PARALLEL MTDC SYSTEM.

* One of the converter station operates as a voltage setting terminal and in other station current is adjusted to control the power requirement.
* It can be monopolar or homopolar arrangement. There are two types of parallel MTDC system.
*



Radial MTDC



(Mesh MTDC)

* In a Radial system fault in one DC link can result in interruption of power flow to one or more converter station.
* But in a mesh system the removal of one link can not interrupt the power supply. Because the

remaining links are capable of carrying the required power.

* Therefore a mesh system is more reliable than a radial system.