University of Diyala -College of Engineering

Dept. of Power and Electrical Machines

Subject: Power System Protection

Oil Circuit Breaker

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Oil Circuit Breakers

Types of Oil Circuit Breakers:

(i) Bulk oil circuit breakers:

(a)Plain break oil circuit breakers

(b) Arc control oil circuit breakers

(i) Self-blast oil circuit breakers—in which arc control is provided by internal means i.e.the arc itself is employed for its own extinction efficiently.

We have to common types (a) Plain explosion pot.

(b) Cross jet explosion pot.

(c) Self-compensated explosion pot.

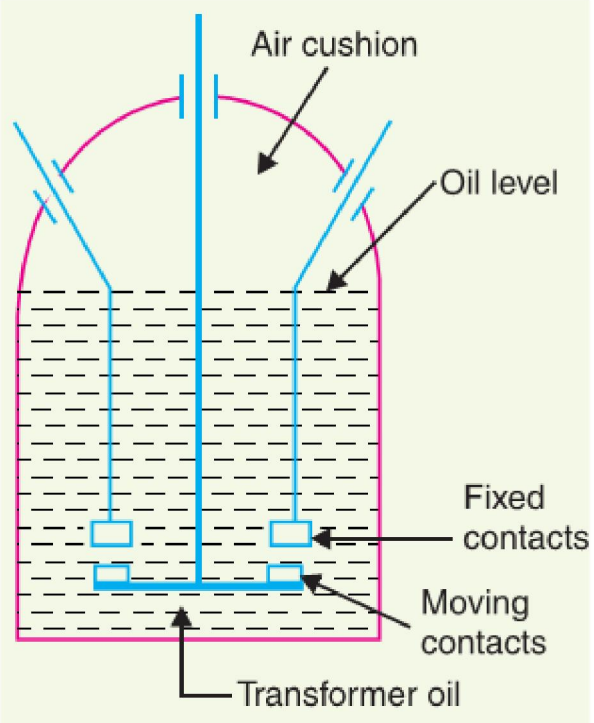
(ii) Forced-blast oil circuit breakers— in which arc control is provided by mechanical means external to the circuit breaker.

(ii) Low Oil Circuit Breakers


R19
115 kV BREAKER

Plain Break Oil Circuit Breakers

The plain-break oil circuit breaker is the earliest type from which all other circuit breakers have developed. **It has a very simple construction**. It consists of fixed and moving contacts enclosed in a strong weather-tight earthed tank containing oil up toa certain level and an air cushion above the oil level.
The air cushion provides sufficient room to allow for the reception of the arc gases without the generation of unsafe pressure in the dome of the circuit breaker.



Working principle:

(i) The hydrogen gas bubble generated around the arc cools the arc column and aids the deionisation of the medium between the contacts.
(ii) The gas sets up turbulence in the oil and helps in eliminating the arcing products from the arc path.
(iii) As the arc lengthens due to the separating contacts, the dielectric strength of the medium is increased.

Disadvantages

(i) There is no special control over the arc other than the increase in length by separating the moving contacts. Therefore, for successful interruption, long arc length is necessary.

(ii) These breakers have long and inconsistent arcing times.

(iii) These breakers do not permit high speed interruption.

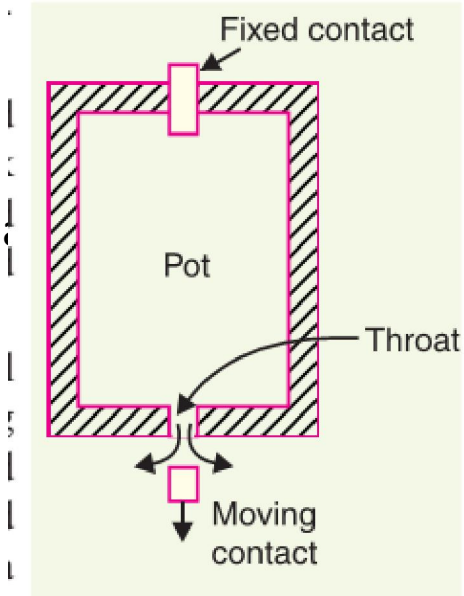
Due to these disadvantages, plain-break oil circuit breakers are used only for low-voltage applications where high breaking-capacities are not important. It is a usual practice to use such breakers for low capacity installations for voltages not exceeding 11 kV.

Arc Control Oil Circuit Breakers

- (i) Self-blast oil circuit breakers—in which arc control is provided by internal means i.e.the
- arc itself is employed for its own extinction efficiently.
- (ii) Forced-blast oil circuit breakers— in which arc control is provided by mechanical means
- external to the circuit breaker.

(i) Self-blast oil circuit breakers.

- In this type of circuit breaker, the gases produced during arcing are confined to a small volume by the use of an insulating rigid pressure chamber or pot surrounding the contacts. Since the space available for the arc gases is restricted by the chamber, a very high pressure is developed to force the oil and gas through or around the arc to extinguish it.
- **(a) Plain explosion pot.**
- It is a rigid cylinder of insulating material
- and encloses the fixed and moving contacts.
- The moving contact is a cylindrical rod passing through (called throat) at the bottom.
- When a fault occurs, the contacts get separated and
- an arc is struck between them.



The principal limitation of this type of pot is that it cannot be used for very low or for very high fault currents.

With low fault currents, the pressure developed is small, thereby increasing the arcing time.

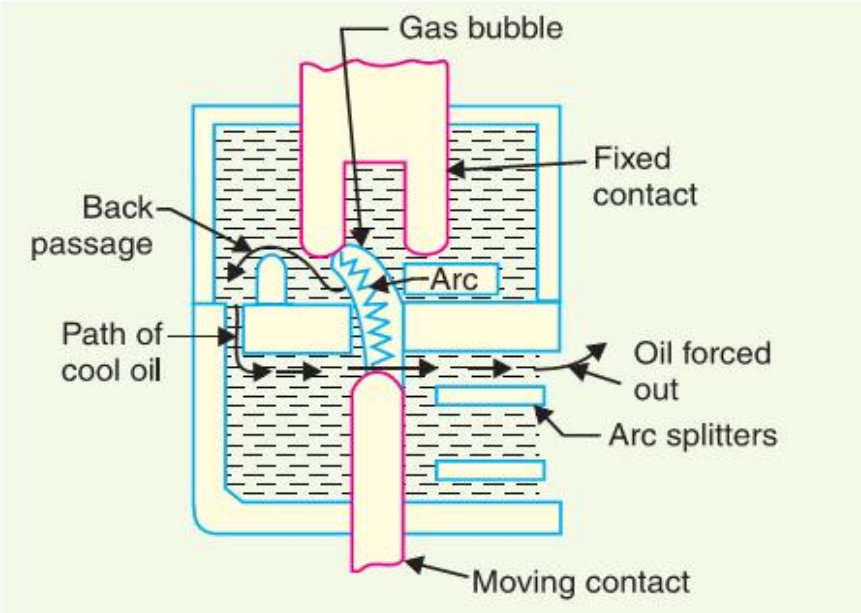
On the other hand, with high fault currents, the gas is produced so rapidly that explosion pot is liable to burst due to high pressure. For this reason, plain explosion pot operates well on moderate short-circuit currents only where the rate of gas evolution is moderate.

(b) Cross jet explosion pot:

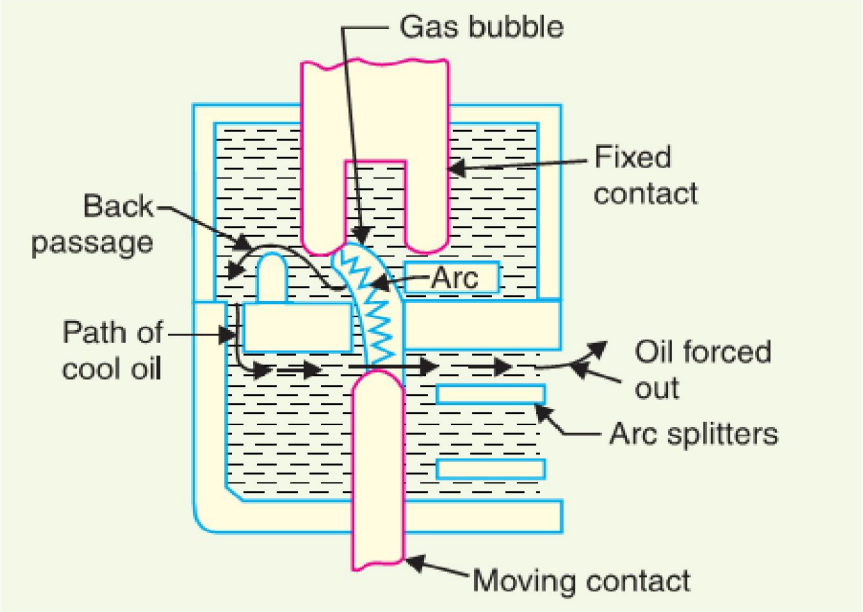
1- This type of pot is just a modification of plain explosion pot.

2- It is made of insulating material and has channel arc splitters.

3- The arc splitters help in increasing the arc length, thus facilitating arc extinction.



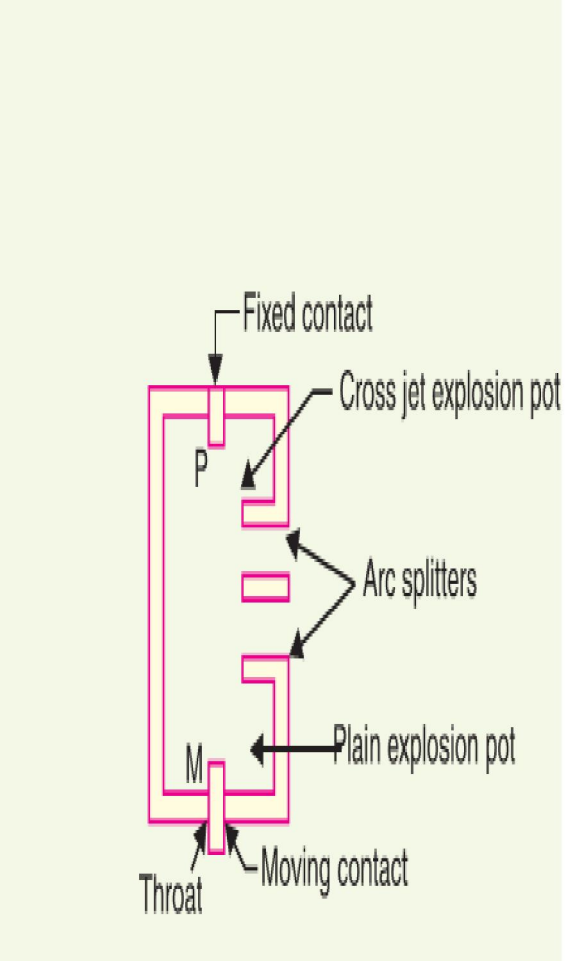
When
a fault occurs, the moving contact of the circuit breaker begins to separate. As the moving contact is withdrawn, the arc is initially struck in the top of the pot. The gas generated by the arc exerts pressure
on the oil in the back passage. When the moving contact uncovers the arc splitter ducts, fresh oil is forced *acrossthe arc path. The arc is, therefore, driven sideways into the “arc splitters” which increase the arc length, causing arc extinction.



The cross-jet explosion pot is quite efficient for interrupting heavy fault currents. However, for low fault currents, the gas pressure is small and consequently the pot does not give a satisfactory operation.

(c) Self-compensated explosion pot.

his type of pot is essentially a combination of plain explosion pot and cross jet explosion pot. Therefore, it can interrupt low as well as heavy short circuit currents with reasonable accuracy.

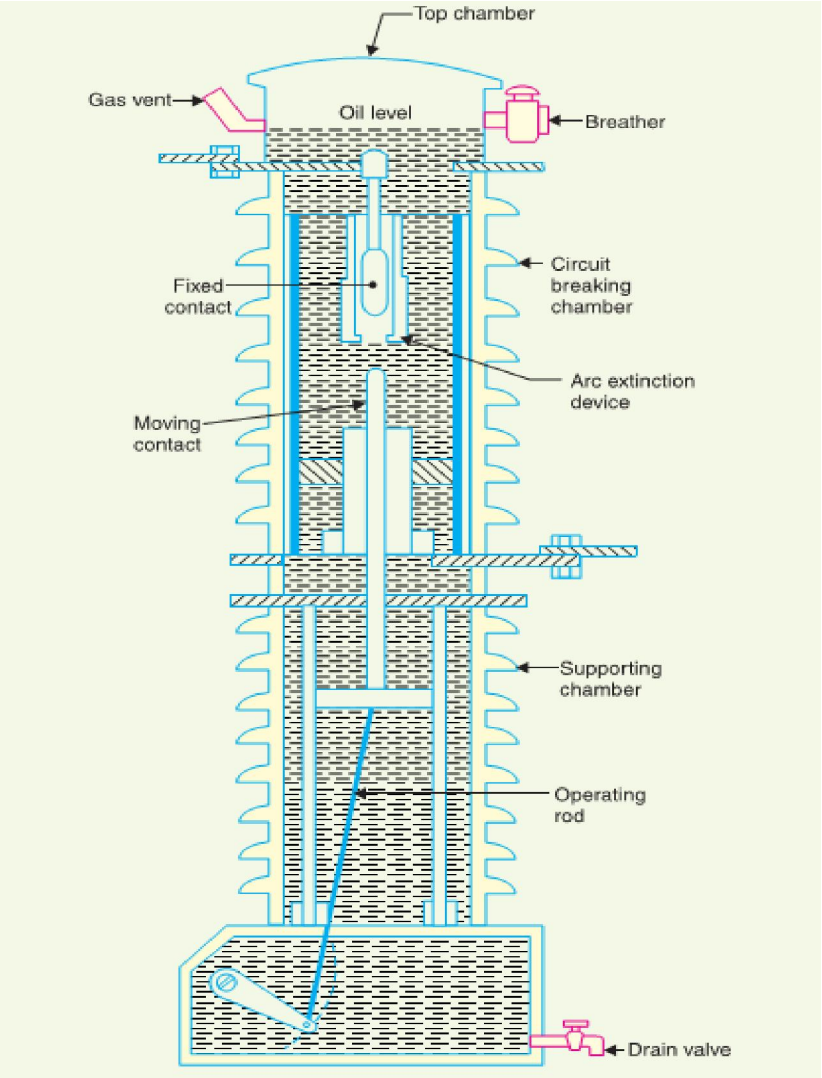


(ii) Forced-blast oil circuit breakers.

- In a 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. When a fault occurs, the contacts get separated by the protective system and an arc is struck between the contacts. The piston forces a jet of oil towards the contact gap to extinguish the arc.
- It may be noted that necessary oil pressure produced does not in any way depend upon the fault current to be broken.
- **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 circuit breakers.**
- **(b) The quantity of oil required is reduced considerably.**

Low Oil Circuit Breakers

- It has been found that only a smallpercentage of oil is actually used for arc extinction while the major part is utilised for insulation purposes.
- For this reason, the quantity of oil in bulk oil circuit breakers reaches a very high figure as the system voltage increases. This not only increases the expenses, tank size and weight of the breaker but it also increases the fire risk and maintenance problems.


Top chamber
Gas vent
Oil level
Breather
Fixed contact
Circuit breaking chamber
Arc extinction device
Moving contact
Supporting chamber
Operating rod
Drain valve

Advantages.

A low oil circuit breaker has the following advantages over a bulk oil circuit breaker:

(i) It requires lesser quantity of oil.

(ii) It requires smaller space.

(iii) There is reduced risk of fire.

(iv) Maintenance problems are reduced.

Disadvantages

.A low oil circuit breaker has the following disadvantages as compared to a bulk oil circuit breaker :

(i) Due to smaller quantity of oil, the degree of carbonisation is increased.

(ii) There is a difficulty of removing the gases from the contact space in time.

(iii) The dielectric strength of the oil deteriorates rapidly due to high degree of carbonisation.

Air-Blast Circuit Breakers

These breakers employ a high pressure *air-blast as an arc quenching medium. The contacts areopened in a flow of air-blast established by the opening of blast valve. The air-blast cools the arc and sweeps away the arcing products to the atomsphere. This rapidly increases the dielectric strength of the medium between contacts and prevents from re-establishing the arc. Consequently, the arc is extinguished and flow of current is interrupted.

Advantages.

An air-blast circuit breaker has the following advantages over an oil circuit breaker:

(i) The risk of fire is eliminated.

(ii) The arcing products are completely removed by the blast whereas the oil deteriorates with successive operations; the expense of regular oil replacement is avoided.

(iii) The growth of dielectric strength is so rapid that final contact gap needed for arc extinction is very small. This reduces the size of the device.

(iv) The arcing time is very small due to the rapid build up of dielectric strength between contacts. Therefore, the arc energy is only a fraction of that in oil circuit breakers, thus resulting in less burning of contacts.

(v) Due to lesser arc energy, air-blast circuit breakers are very suitable for conditions where frequent operation is required.

(vi) The energy supplied for arc extinction is obtained from high pressure air and is independent of the current to be interrupted.

Disadvantages.

The use of air as the arc quenching medium offers the following disadvantges :

(i) The air has relatively inferior arc extinguishing properties.

(ii) The air-blast circuit breakers are very sensitive to the variations in the rate of rise of restriking voltage.

(iii) Considerable maintenance is required for the compressor plant which supplies the air-blast.

The air blast circuit breakers are finding wide applications in high voltage installations. Majority of the circuit breakers for voltages beyond 110 kV are of this type.

Types of Air-Blast Circuit Breakers

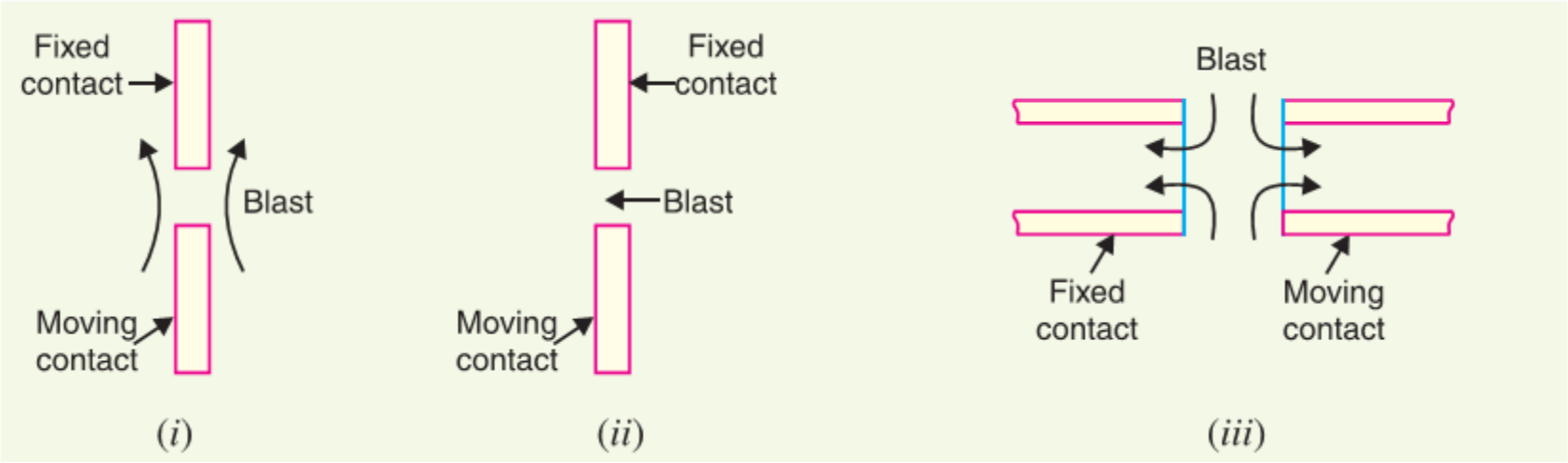
Depending upon the direction of air-blast in relation to the arc, air-blast circuit breakers are

classified into :

(i) Axial-blast typein which the air-blast is directed along the arc path as shown in Fig. (ii) Cross-blast typein which the air-blast is directed at right angles to the arc path as shown in

Fig. 19.8 (ii).

(iii) Radial-blast typein which the air-blast is directed radially as shown in Fig. 19.8 (iii).



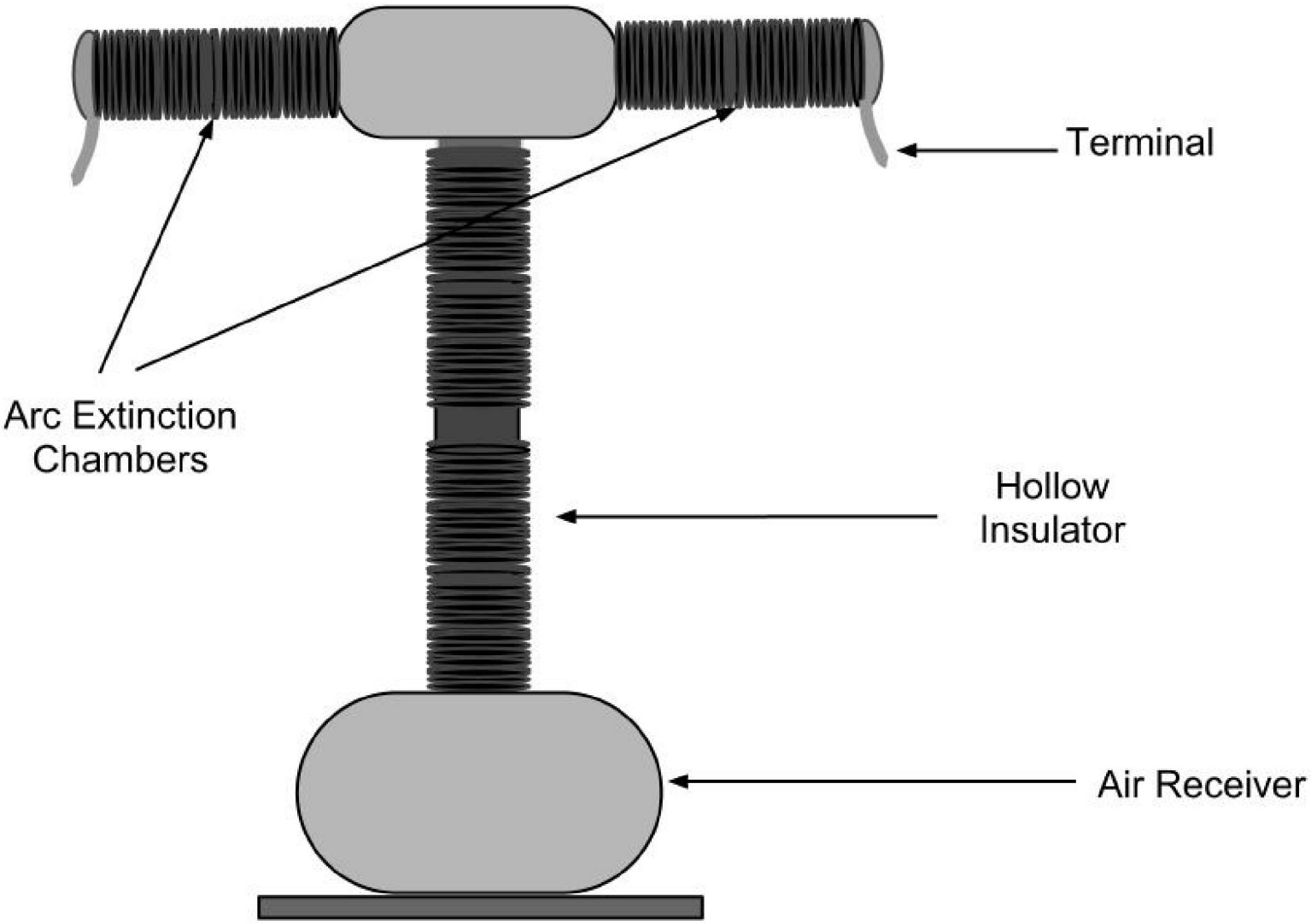
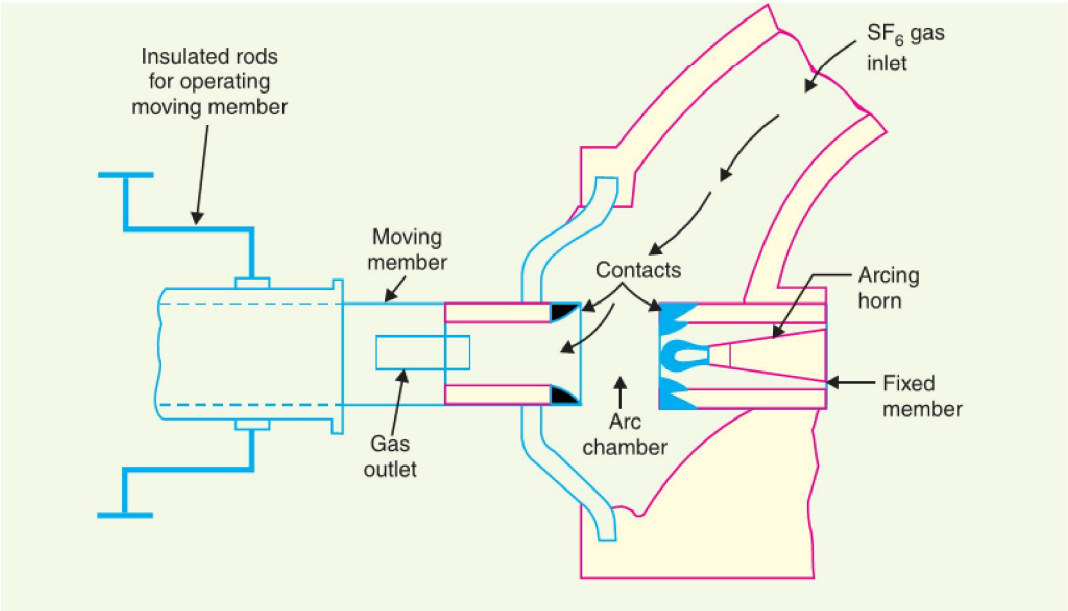


Fig-C: Sketch of Air Blast Circuit Breaker (ABCB)

Sulphur Hexaflouride (SF6) Circuit Breakers

In such circuit breakers, sulphur hexaflouride (SF6) gas is used as the arc quenching medium. TheSF6 is an electro-negative gas and has a strong tendency to absorb free electrons. The contacts of the breaker are opened in a high pressure flow of SF6 gas and an arc is struck between them.



Advantages.

Due to the superior arc quenching properties of SF6 gas, the SF6 circuit breakers have many advantages over oil or air circuit breakers. Some of them are listed below :

(i) Due to the superior arc quenching property of SF6, such circuit breakers have very shortarcing time.

(ii) Since the dielectric strength of SF6 gas is 2 to 3 times that of air, such breakers can interrupt much larger currents.

(iii) The SF6 circuit breaker gives noiselss operation due to its closed gas circuit and no exhaust to atmosphere unlike the air blast circuit breaker.

(iv) The closed gas enclosure keeps the interior dry so that there is no moisture problem.

(v) There is no risk of fire in such breakers because SF6 gas is non-inflammable.

(vi) There are no carbon deposits so that tracking and insulation problems are eliminated.

(vii) The SF6breakers have low maintenance cost, light foundation requirements and minimum auxiliary equipment.

(viii) Since SF6breakers are totally enclosed and sealed from atmosphere, they are particularly suitable where explosion hazard exists e.g.,coal mines.

Disadvantages

(i) SF6 breakers are costly due to the high cost of SF6

.

(ii) Since SF6 gas has to be reconditioned after every operation of the breaker, additional equipment is requried for this purpose.

Applications.

A typical SF6 circuit breaker consists of interrupter units each capable of dealing with currents upto 60 kA and voltages in the range of 50—80 kV. A number of units are connected in series according to the system voltage. SF6circuit breakers have been developed for voltages 115 kV to 230 kV, power ratings 10 MVA to 20 MVA and interrupting time less than 3 cycles.

In an electric power system, **switchgear** is the combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment.

Switchgear Components

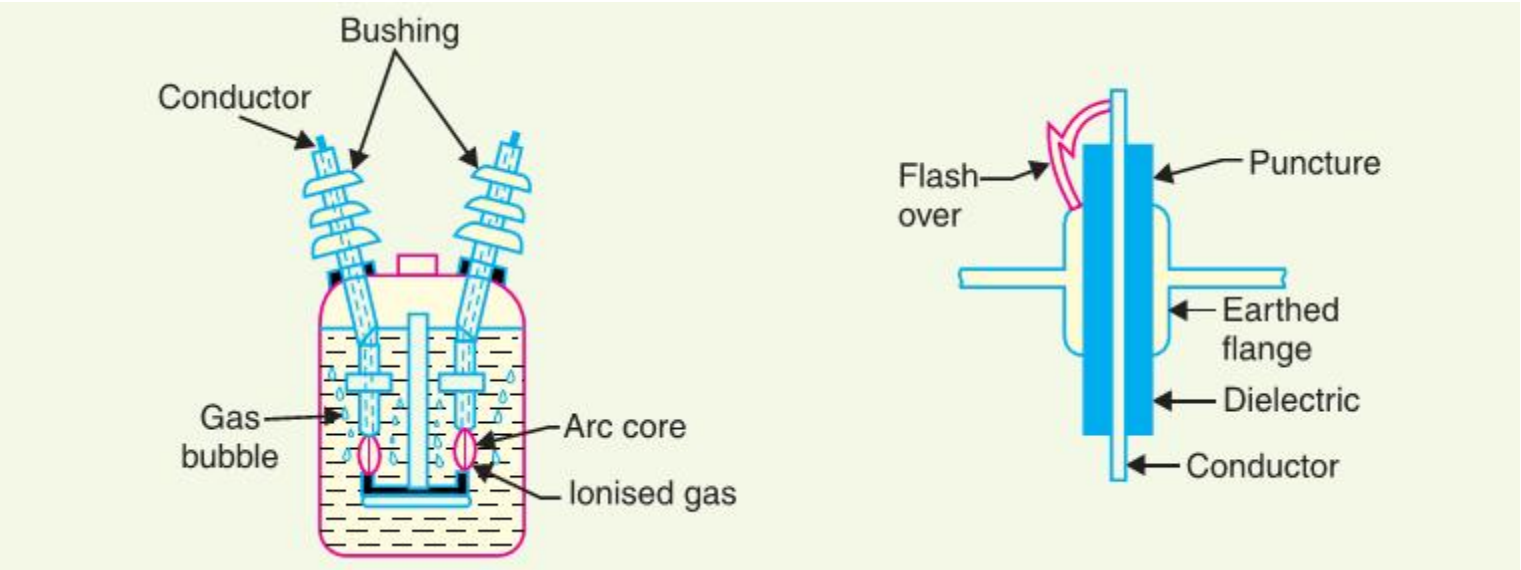
The following are some important components common to most of the circuit breakers :

(i) Bushings.

(ii) (ii)Circuit breaker contacts.

(iii) Instrument transformers.

(iv)Bus-bars and conductors.



(iii) Instrument transformers. In a modern power system, the circuits operate at very highvoltages and carry current of thousands of amperes. The measuring instruments and protective devices cannot work satisfactorily if mounted directly on the power lines.

This difficulty is overcome by installing instrument transformers on the power lines. The function of these instrument transformers is to transform voltages or currents in the power lines to values which are convenient for the operation of measuring instruments and relays. There are two types of instrument transformers viz.

(a) Current transformer (C.T.)

(b) Potential transformer (P.T.)

The primary of current transformer is connected in the power line. The secondary winding provides for the instruments and relays a current which is a constant fraction of the current in the line.