UNIT V CIRCUIT BREAKERS

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- With this method a breaker capacity (MVA) of five time of that of the capacity of the test plant can be

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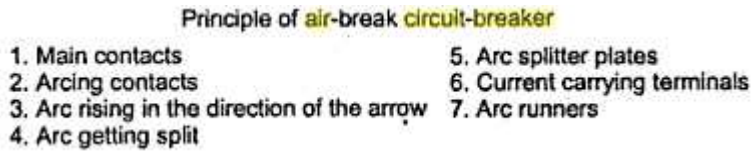
Air Blast Circuit Breaker

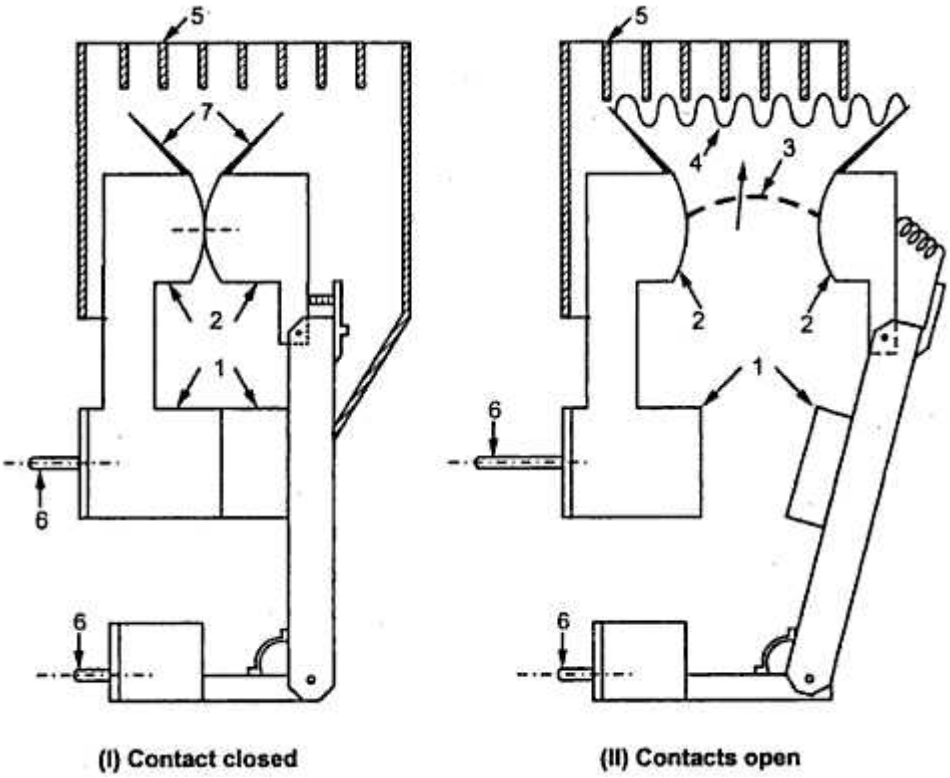
Air Blast Circuit Breaker Working

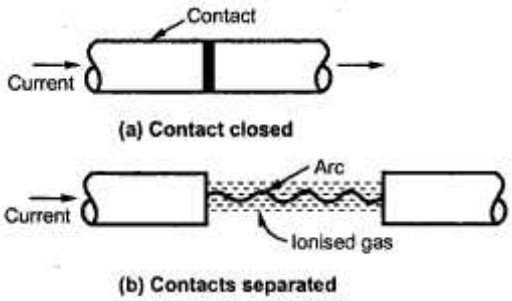
In the air blast circuit breakers the arc interruption takes place to direct a blast of air, at high pressure and velocity, to the arc. Dry and fresh air of the air blast will replace the ionized hot gases within the arc zone and the arc length is considerably increased.Consequently the arc may be interrupted at the first natural current zero. In air blast circuit breakers, the contacts are surrounded by compressed air. When the contacts are opened the compressed air is released in forced blast through the arc to the atmosphere extinguishing the arc in the process.A compressor plant is necessary to maintain high air pressure in the receiver.

The air blast circuit breakers are especially suitable for railways and arc furnaces, where the breaker operates repeatedly. Air blast circuit breakers is used for interconnected lines and important lines where rapid operation is desired. In air blast circuit breaker (also called compressed air circuit breaker) high pressure air is forced on the arc through a nozzle at the instant of contact separation. The ionized medium between the contacts is blown away by the blast of the air. After the arc extinction the chamber is filled with high pressure air, which prevents restrike. In some low capacity circuit breakers, the isolator is an integral part of the circuit breaker. The circuit breaker opens and immediately after that the isolator opens, to provide addition gap.



moving air is not allowed to





In the air reservoir there is a high pressure air stored between 20 to 30 kg/cm2. And that air is taken from compressed air system. On the reservoir there are three hollow insulator columns mounted with valves at their base. On the top of the hollow insulator chambers there are double arc extinguishing chambers mounted . The current carrying parts connect the three arc extinction chambers to each other in series and the pole to the neighboring equipment. since there exist a very high voltage between the conductor and the air reservoir, the entire arc extinction chamber assembly is mounted on insulators. Since there are three double arc extinction poles in series, there are six breakers per pole. Each arc extinction chamber consists of one twin fixed contact. There are two moving contacts. The moving contacts can move axially so as to open or close. Its opening or closing mechanism depends on spring pressure and air pressure.

The operation mechanism operates the rods when it gets a pneumatic or electrical signal. The valves open so as to send the high pressure air in the hollow of the insulator. The high pressure air rapidly enters the double arc extinction chamber. As the air enters into the arc extinction chamber the pressure on the moving contacts becomes more than spring pressure and it causes the contacts to be open.The contacts travel through a short distance against the spring pressure. At the end of contacts travel the part for outgoing air is closed by the

moving contacts and the entire arc extinction chamber is filled with high pressure air, as the air is not allowed to go out. However, during the arcing period the air goes out through the openings and takes away the ionized air of arc.

While closing, the valve is turned so as to close connection between the hollow of the insulator and the reservoir. The valve lets the air from the hollow insulator to the atmosphere. As a result the pressure of air in the arc extinction chamber is dropped down to the atmospheric pressure and the moving contacts close over the fixed contacts by virtue of the spring pressure. the opening is fast because the air takes a negligible time to

travel from the reservoir to the moving contact. The arc is extinguished within a cycle. Therefore, air blast circuit breaker is very fast in breaking the current.Closing is also fast because the pressure in the arc extinction chamber drops immediately as the value operates and the contacts close by virtue of the spring pressure.

Advantages:

How air blast circuit breaker is better than oil circuit breaker:

1. The growth of dielectric strength is so rapid that final contact gap needed for arc extinction is very small. this reduces the size of device.

2. The risk of fire is eliminated.

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

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

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

6. 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 that in oil circuit breakers, thus resulting in less burning of contacts.

Disadvantages:

1. Considerable maintenance is required for the compressor plant which supplies the air blast.

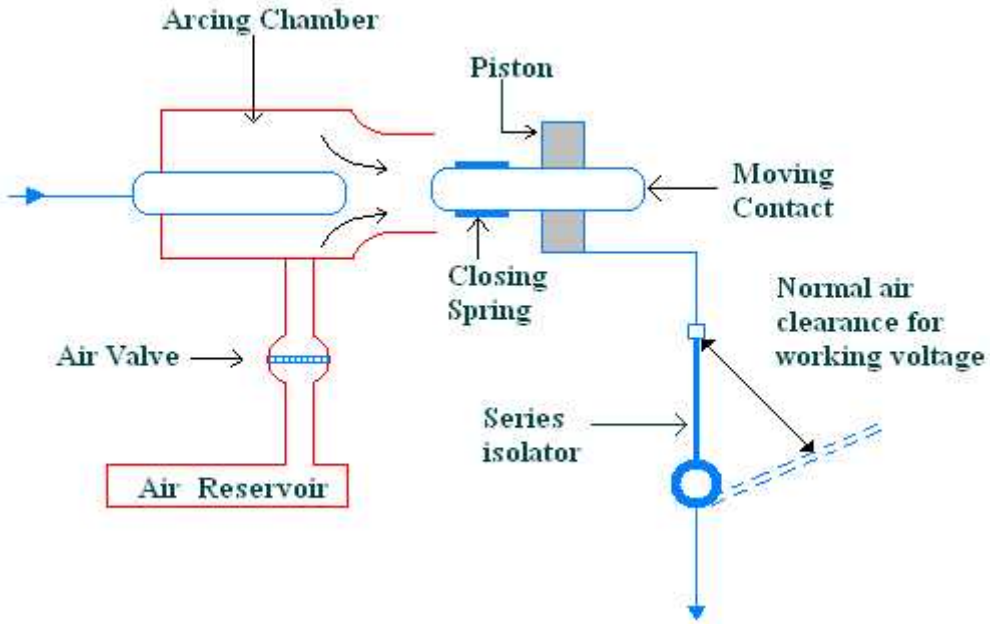
2. Air blast circuit breakers are very sensitive to the variations in the rate of restriking voltage.

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

I] Axial-blast air circuit breaker

 The figure below shows the essential components of a typical axial blast circuit breaker. The fixed and moving contacts are held in 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 tripping impulse when a fault occurs on the system.

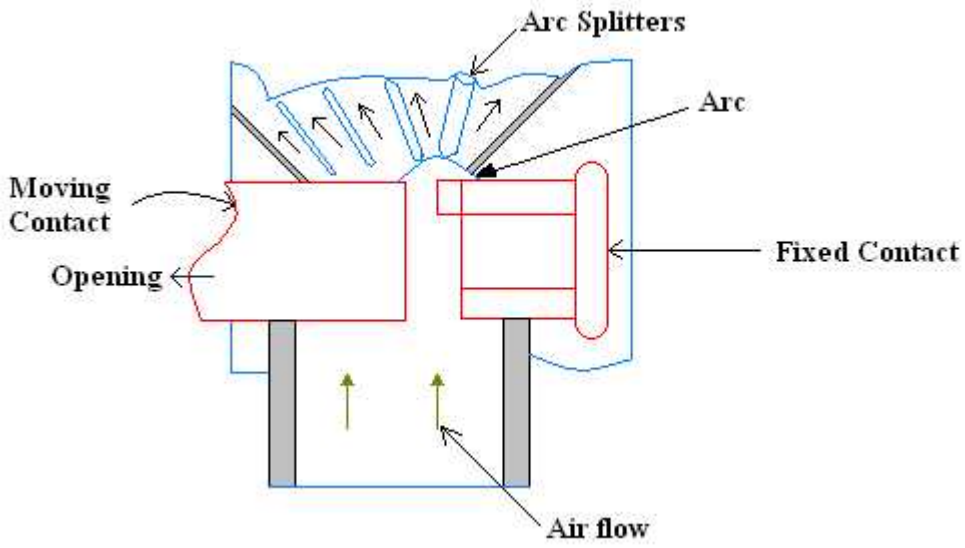


 When a fault occurs,the tripping impulse causes the opening of the air valve which connects the circuit breaker reservoir to the arcing chamber.The high pressure air entering the arcing chamber pushes away the moving contact against spring pressure.

 The moving contact is separated and an arc is struck.At the same time,high pressure air blast flows along the arc and takes away the ionised gases along with it.Consequently,the arc is extinguished and current flow is interrupted.

 It may be noted that in such circuit breakers,the contact separation required for interruption is generally small about 1.75 cm. Such a small gap may constitute inadequate clearance for the normal service voltage.Therefore,an isolating switch is incorporated as part of this type of circuit breaker.This switch opens immediately after fault interruption to provide necessary clearance for insulation.

II] Cross Blast air circuit breaker



thermal action. The arc ends travel along the Arc Runner (Arcing horns). The arc moves upwards and is split by arc splitter plates (5). The arc is extinguished by lengthening, cooling, splitting etc. In some breakers the arc is

In this type of circuit breaker,an air blast is directed at right angles to the arc.The cross-blast lengthens and forces the arc into a suitable chute for arc extinction.Figure below shows the parts of a typical cross- blast air circuit breaker

When the moving contact is withdrawn,am arc is struck between the fixed and moving contacts.the high pressure cross-blast forces into a chute consisting of an arc splitters and baffles.The splitters serve to increase the length of the arc and baffles give improved cooling.The result is that arc is extinguished and flow of current is interrupted.Since the blast pressure is same for all currents,the inefficiency at low currents is eliminated.The final gap for interruption is great enough to give normal insulation clearance so that series isolating switch is not necessary.

Air break circuit breaker

These circuit breakers employ high resistance interruption principle. The arc is rapidly lengthened by means of the arc runners and arc chutes and the resistance of the arc is increased by cooling, lengthening and spilitting the arc. The arc resistance increases to such an extent that the voltage drop across the arc becomes more than the supply voltage and the arc extinguished.

Air breaker circuit breakers are used in d.c circuits and a.c circuits upto 12 kV.

Magnetic field is utilized for lengthening the arc in high voltage air break circuit breaker.

The arc resistance is increased to such an extent that the system voltage cannot maintain the arc and the arc gets extinguished.

There are two set of contacts: Main contacts (1) and Arching contacts (2).

Main contacts conduct the current in closed position of the breaker. They have low contact resistance and are silver plated. The arching contacts (2) are hard, heat resistance and usually made of copper alloy. While opening the contact, the main contacts dislodge first. The current is shifted to the arching contacts. The arching contacts dislodge later and arc is drawn between them (3). This arc is forced upwards by the electromagnetic force and

drawn in the direction of the splitter by magnetic field.

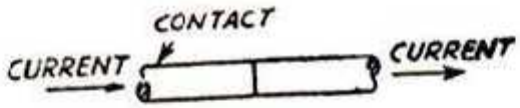
Operating Mechanisms for Air Break Circuit Breakers

The operating mechanisms are generally operating spring. The closing force is obtained from the following means:

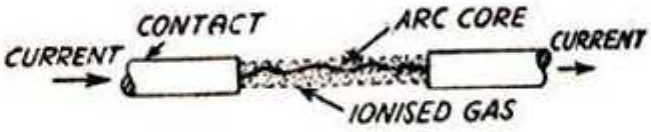
a. Solenoid
b. Spring charged manually or by
motor c. Pneumatic

The solenoid mechanisms drive power from battery supply or rectifiers. The solenoid energized by the direct current gives the necessary force for the closing of the circuit breaker.

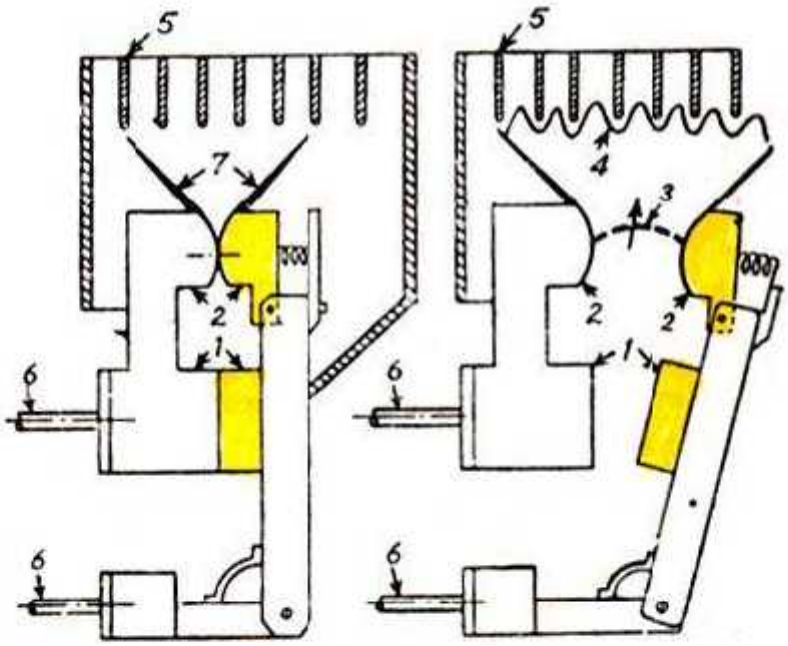
The springs used for closing operation can be charged either manually or by motor driven gears. At the time of closing operation the energy stored in the spring is released by unlatching of the spring and is utilized in closing of the circuit breaker.



(a) Contects in closed



(b) Contects Separated in air at atmospheric pressure

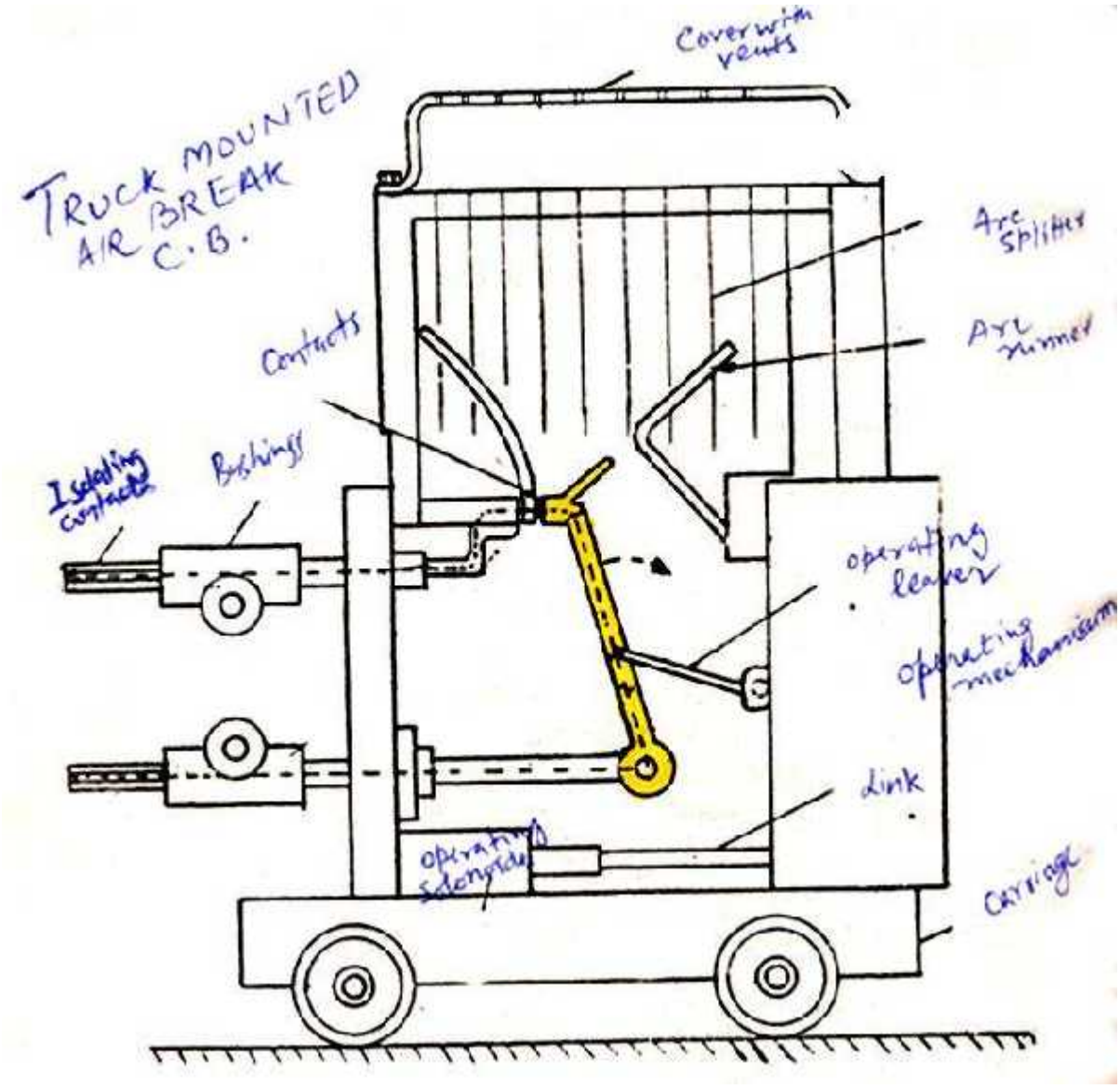


(I) Contacts Closed (II) Contacts Open

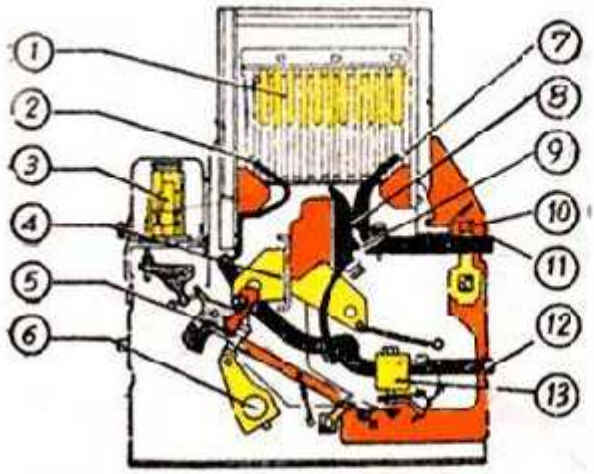
Principle of air-break circuit-breaker

1. Main contacts
2. Arcing contacts
3. Arc rising in the direction of the arrow
4. Arc getting split
5. Arc splitter plates
6. Current carrying terminals
7. Arc runners

Arc extinction is air-break circuit-breaker.


TRUCK MOUNTED
AIR BREAK
C.B.
Cover with vents
Arc Splitter
Arc runner
Contacts
Isolating contacts
Bushings
operating lever
operating mechanism
link
operating solenoid
carriage

f an ideal arc



1. Arc chutes having deionization plates coated with plastic paint on the top half.
2. Arc runner for extending the arc for effective and quick extinction.
3. Magneto thermal release with inverse time current characteristic on overload and instantaneous tripping on heavy fault currents.
4. Moving contact carrier.
5. Main trip rocker arm on which the super rapid tripping device acts.
6. Main operating shaft.
7. Arcing horn.
8. Arcing contacts.
9. Main contacts.
10. Current transformer for feeding releases.
11. Line terminal.
12. Load terminal.
13. Super rapid tripping device: a built-in protection device which trips the breaker from the function point.

Sectional view of a low voltage circuit-breaker.

SF6 circuit breaker.

At this point we are aware that the medium in which arc extinction of the circuit breaker takes place greatly influences the important characteristics and life of the circuit breaker. In the last article the working of a vacuum circuit breaker was illustrated. We already know that the use of vacuum circuit breaker is mainly
restricted to system voltage below 38 kV. The characteristics of vacuum as medium and cost of the vacuum CB does not makes it suitable for voltage exceeding 38 kV. In the past for higher transmission voltage Oil Circuit Breaker (OCB) and Air Blast Circuit Breaker (ABCB) were used. These days for higher transmission voltage levels SF_6 Circuit Breakers are largely used. OCB and ABCB have almost become obsolete. In fact in many installations SF_6 CB is used for lower voltages like 11 kV, 6 kV etc..

interrupting medium. So SF_6 is extensively used these days as an arc interrupting medium in circuit breakers ranging from 3 kv upto 765 kv class. In addition to this SF_6 is used in many electrical equipments for insulation. Here first we discuss in brief, some of the essential properties of SF_6 which is the reason of it's extensive use in circuit breakers

i] Sulphur Hexafluoride symbolically written as SF_6 is a gas which satisfy the requirements of an ideal arc.

SF_6 gas has high dielectric strength which is the most important quality of a material for use in electrical equipments and in particular for breaker it is one of the most desired properties. Moreover it has high Rate of Rise of dielectric strength after arc extinction. This characteristics is very much sought for a circuit breaker to avoid restriking.

SF_6 is colour less, odour less and non toxic gas.

SF_6 is an inert gas. So in normal operating condition the metallic parts in contact with the gas are not corroded. This ensures the life of the breaker and reduces the need for maintenance.

SF_6 has high thermal conductivity which means the heat dissipation capacity is more. This implies greater current carrying capacity when surrounded by SF_6 .

The gas is quite stable. However it disintegrates to other fluorides of Sulphur in the presence of arc. but after the extinction of the arc the SF_6 gas is reformed from the decomposition.

SF_6 being non-flammable so there is no risk of fire hazard and explosion.

A sulfur hexafluoride circuit breaker uses contacts surrounded by sulfur hexafluoride gas to quench the arc. They are most often used for transmission-level voltages and may be incorporated into compact gas-insulated switchgear. In cold climates, supplemental heating or de-rating of the circuit breakers may be required due to liquefaction of the SF6 gas.

Advantages:

Due to superior arc quenching property of sf6 , such breakers have very short arcing time

Dielectric strength of sf6 gas is 2 to 3 times that of air, such breakers can interrupt much larger currents.

Gives noiseless operation due to its closed gas circuit

Closed gas enclosure keeps the interior dry so that there is no moisture problem

There is no risk of fire as sf6 is non-inflammable

There are no carbon deposits

Low maintenance cost, light foundation requirements and minimum auxiliary equipment

sf6 breakers are totally enclosed and sealed from atmosphere, they are particularly suitable where explosion hazard exists

Disadvantages:

sf6 breakers are costly due to high cost of sf6

sf6 gas has to be reconditioned after every operation of the breaker, additional equipment is required for this purpose

i] Sulphur Hexafluoride symbolically written as SF_6 is a gas which satisfy the requirements of an ideal arc

The construction and working principles of SF_6 circuit breaker varies from manufacturer to manufacturer. In the past double pressure type of SF_6 breakers were used. Now these are obsolete. Another type of SF_6 breaker design is the self blast type, which is usually used for medium transmission voltage. The Puffer type SF_6 breakers of single pressure type are the most favoured types prevalent in power industry. Here the working principle of Puffer type breaker is illustrated (Fig-A).

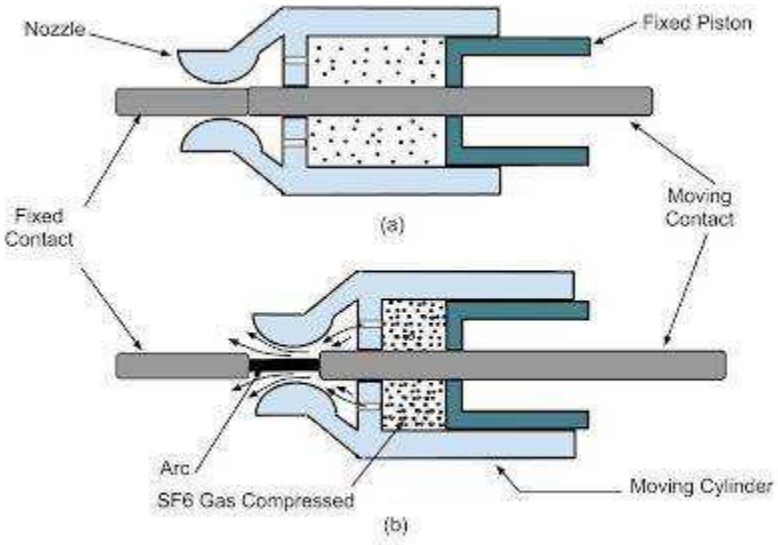


Fig-A: Puffer Type SF6 Circuit Breaker

Fig-B: SF6 Circuit Breaker

As illustrated in the figure the breaker has a cylinder and piston arrangement. Here the piston is fixed but the cylinder is movable. The cylinder is tied to the moving contact so that for opening the breaker the cylinder

along with the moving contact moves away from the fixed contact (Fig-A(b)). But due to the presence of fixed piston the SF_6 gas inside the cylinder is compressed. The compressed SF_6 gas flows through the nozzle and over the electric arc in axial direction. Due to heat convection and radiation the arc radius reduces gradually and the arc is finally extinguished at current zero. The dielectric strength of the medium between the separated contacts increases rapidly and restored quickly as fresh SF_6 gas fills the space. While arc quenching, small quantity of SF_6 gas is broken down to some other fluorides of sulphur which mostly recombine to
form SF_6 again. A filter is also suitably placed in the interrupter to absorb the remaining decomposed byproduct.
The gas pressure inside the cylinder is maintained at around 5 kgf per sq. cm. At higher pressure the dielectric strength of the gas increases. But at higher pressure the SF_6 gas liquify at higher temperature which is undesired. So heater is required to be arranged for automatic control of the temperature for circuit breakers where higher pressure is utilised. If the SF_6 gas will liquify then it loses the ability to quench the arc.

Like vacuum breaker, SF_6 breakers are also available in modular design form so that two modules connected in series can be used for higher voltage levels. SF_6 breakers are available as both live tank and dead tank types. In Fig-B above a live tank outdoor type 400 kV SF_6 breaker is shown.

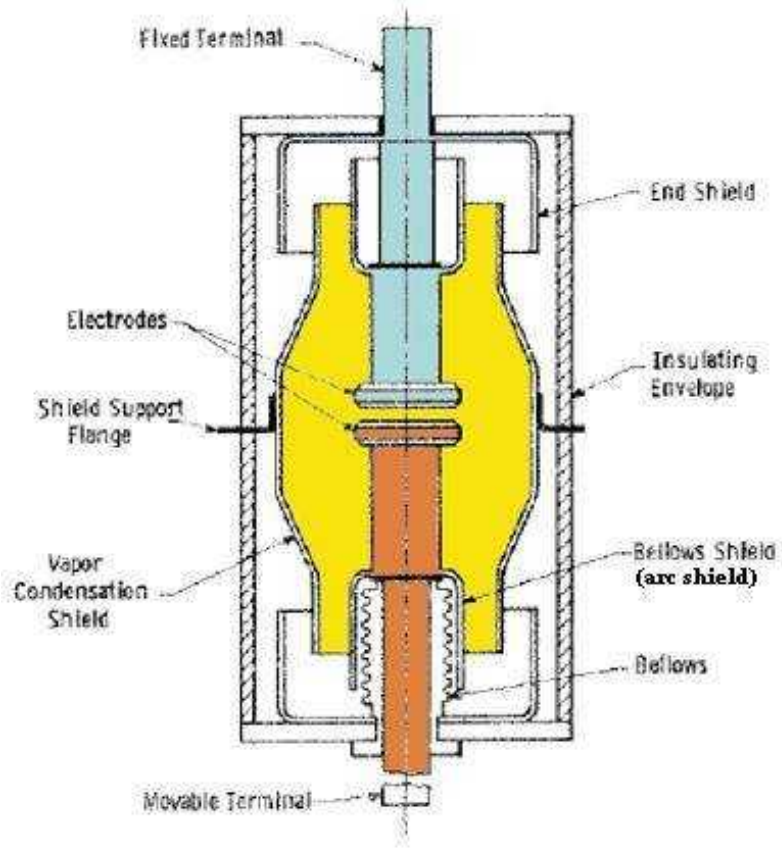
Vacuum Circuit Breakers(VCB)

In this breaker, vacuum is being used as the arc quenching medium. Vacuum offers highest insulating strength, it has far superior arc quenching properties than any other medium. When contacts of a breaker are opened in vacuum, the interruption occurs at first current zero with dielectric strength between the contacts building up at a rate thousands of times that obtained with other circuit breakers.

Principle:

When the contacts of the breaker are opened in vacuum (10 -7 to 10 -5 torr), an arc is produced between
the contacts by the ionization of metal vapours of contacts. The arc is quickly extinguished because the metallic vapours, electrons, and ions produced during arc condense quickly on the surfaces of the circuit breaker contacts, resulting in quick recovery of dielectric strength. As soon as the arc is produced in vacuum, it is

As illustrated in the figure the breaker has a cylinder and piston arrangement. Here the piston is fixed but the cylinder is movable. The cylinder is tied to the moving contact so that for opening the breaker the cylinder



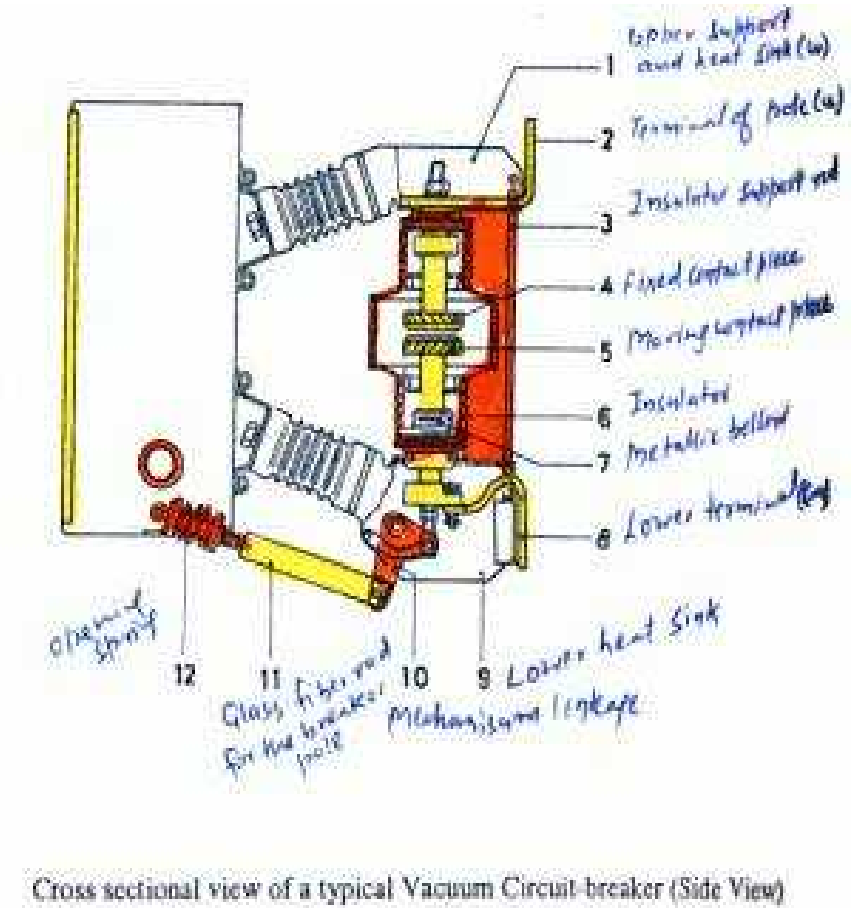
Representation of vacuum interrupter chamber in vacuum circuit breaker

Construction:

Fig shows the parts of a typical vacuum circuit breaker. It consists of fixed contact, moving contact and 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 contacts separates from the fixed contacts and an arc is struck between the contacts. The production of arc is due to the ionization of metal ions and depends very much upon the material of contacts. The arc is quickly extinguished because the metallic vapours, electrons and ions produced during arc are diffused in short time and seized by the surfaces of moving and fixed members and shields. Since vacuum has very fast rate of recovery of dielectric strength, the arc extinction in a vacuum breaker occurs with a short contact separation.



Cross sectional view of a typical Vacuum Circuit-breaker (Side View)

Advantages:

a. They are compact, reliable and have longer life.
b. There are no fire hazards
c. There is no generation of gas during and after operation
d. They can interrupt any fault current. The outstanding feature of a VCB is that it can break any heavy fault current perfectly just before the contacts reach the definite open position.
e. They require little maintenance and are quiet in
operation f. Can withstand lightning surges
g. Low arc energy
h. Low inertia and hence require smaller power for control mechanism.

Applications:

For outdoor applications ranging from 22 kV to 66 kV. Suitable for majority of applications in rural
area.

Bulk oil circuit breaker with neat diagram.

Types Of Oil Circuit Breakers

Oil circuit breakers can be classified into following types:

1)Bulk oil circuit beakers

which use a large quantity of oil. In this circuit breaker the oil serves two purposes. Firstly it extinguishes the arc during opening of contacts and secondly it insulates the current conducting parts from one another and from the earthed tank. Such circuit breakers are classified into:

a)Plain oil circuit breakers
b)Arc control circuit breakers

In the former type no means is available for controlling the arc and the contacts are exposed to the whole of the oil in the tank. In the latter special arc control devices are employed to get the beneficial action of the arc as efficiently as possible

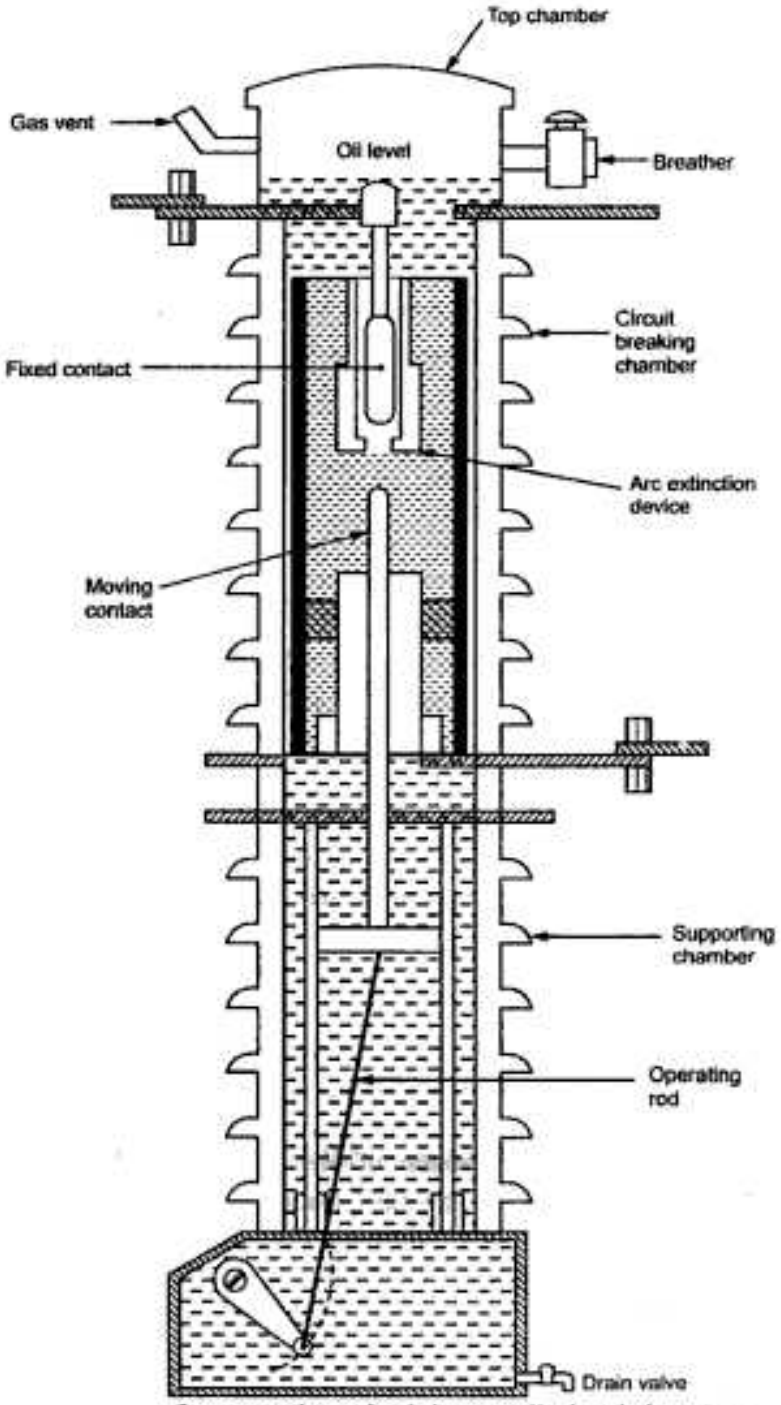
2)Low oil circuit breakers, which use minimum amount of oil. In such circuit breakers oil is used only for arc extinction, the current conducting parts are insulated by air or porcelain or organic insulating material.

Construction

There are two chambers in a low oil circuit breaker,the oil in each chamber is separated from each other.The main advantage of this is that low oil is required and oil in second chamber wont get polluted.Upper chamber is called the circuit breaker chamber and lower one is called the supporting chamber.Circuit breaking chamber consists of moving contact and fixed contact.Moving contact is connected with a piston its just for the movement of the contact and no pressure build due to its motion.There are two vents on fixed contact they are axial vent for small current produced in oil due to heating of arc and radial vents for large currents.The whole device is covered using Bakelite paper and porcelain for protection.Vents are placed in a turbulator.

Operation

Under normal operating conditions,the moving contacts remain engaged with the upper fixed contact.When a
fault occurs,the moving contact is pulled down by the tripping springs and an arc is struck.The arc vapourises oil and produces gases under high pressure.This action constrains the oil to pass through a central hole in the moving contact and results in forcing series of oil through the respective passages of the turbulator.The process of turbulation is orderly one,in which the sections of arc are successively quenched by the effectof separate streams of oil ,moving across each section in turn and bearing away its gases



Construction of minimum oil circuit breaker

Advantages

A low oil circuit breaker has following advantages compared to bulk oil circuit breaker

1. It requires lesser quantity of oil
2. It requires smaller space
3. There is reduced risk of fire

A low oil circuit breaker has following disadvantages compared to bulk oil circuit breaker

1. Due to smaller quantity of oil,the degree of carbonisation is increased
2. There is a difficulty of removing the gases from the contact space in time
3. The dielectric strength of oil deteriorates rapidly due to high degree of carbonisation.

Testing of circuit breakers.

I]Advantages:

1. The growth of dielectric strength is so rapid that final contact gap needed for arc extinction is very small. this reduces the size of device.

. The risk of fire is eliminated.

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

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

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

6. 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 that in oil circuit breakers, thus resulting in less burning of contacts.

Disadvantages:

1. Considerable maintenance is required for the compressor plant which supplies the air blast.

2. Air blast circuit breakers are very sensitive to the variations in the rate of restriking voltage.

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

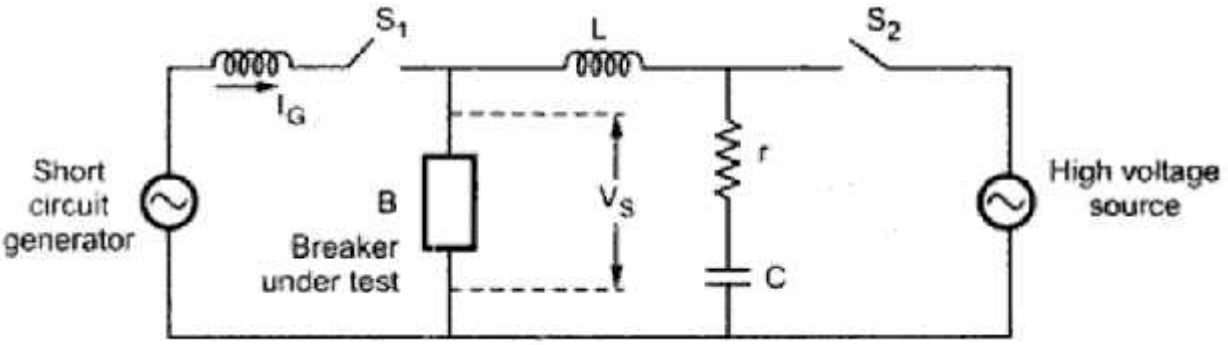
II]Synthetic testing

The principle of synthetic testing is given below. The current source provides short circuit current. The

voltage source gives restriking and recovery voltage. The test observations are proceeded by L,R & C. the circuit current is feed by closing the switch S1 [IG]. final current becomes zero when switch S2 is closed and voltage contains transient as it contains I and C .

Advantages

The breakers can be tested for desaired TRV and RRRV
The shor circuit generator has to supply currents at less voltage.
It is flexible because of independent voltage test and current test
It is very simple & it can applied to unit test also.
Upto five times of plant capacity can be tested.

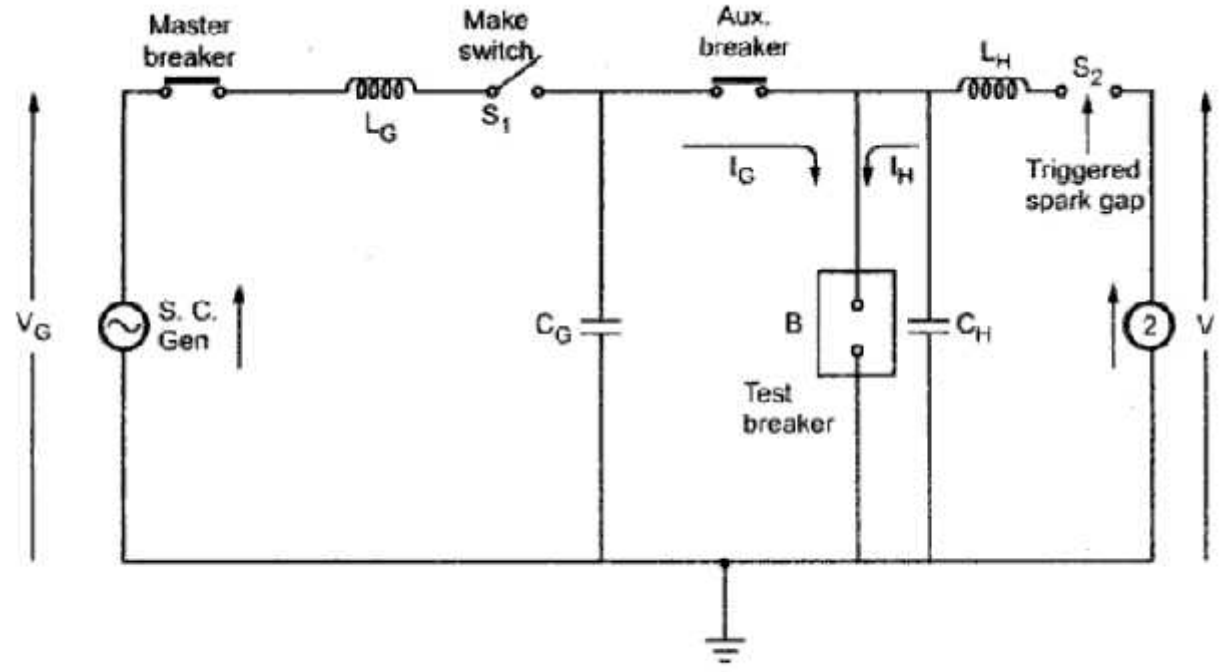


Synthetic testing

Types of Synthetic test circuits.

a.Parallel current injection b.Series current injection

a.Parallel current injection method.

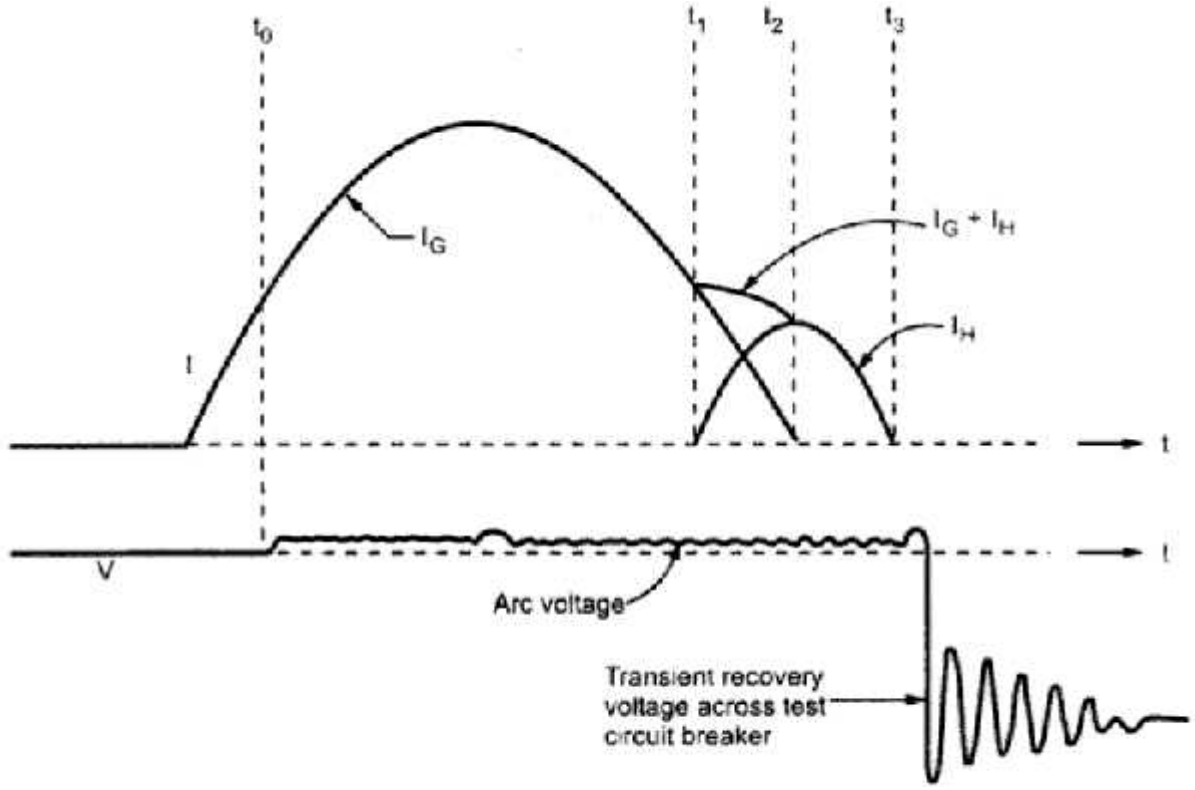


Parallel current injection method

This method is used for testing circuit breakers. It gives high frequency voltage as given by the standards. It is given by the graph.

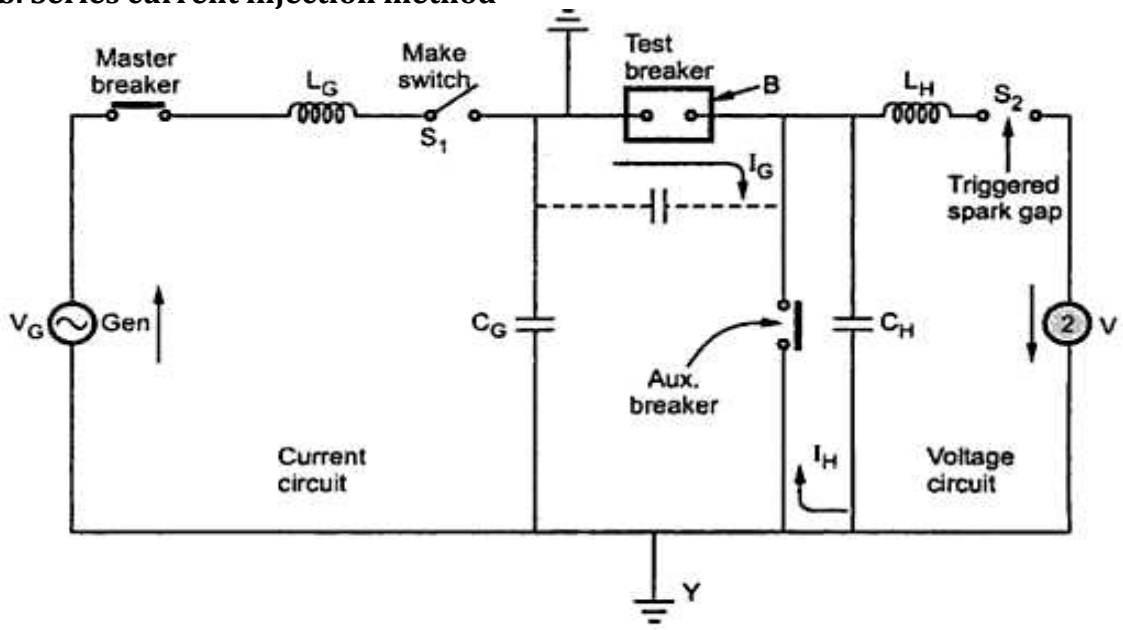
Here the voltage circuit is effectively connected in parallel with current circuit and test breaker before main IG

in test breaker current is properly simulated.



(b) Parallel current injection method waveforms

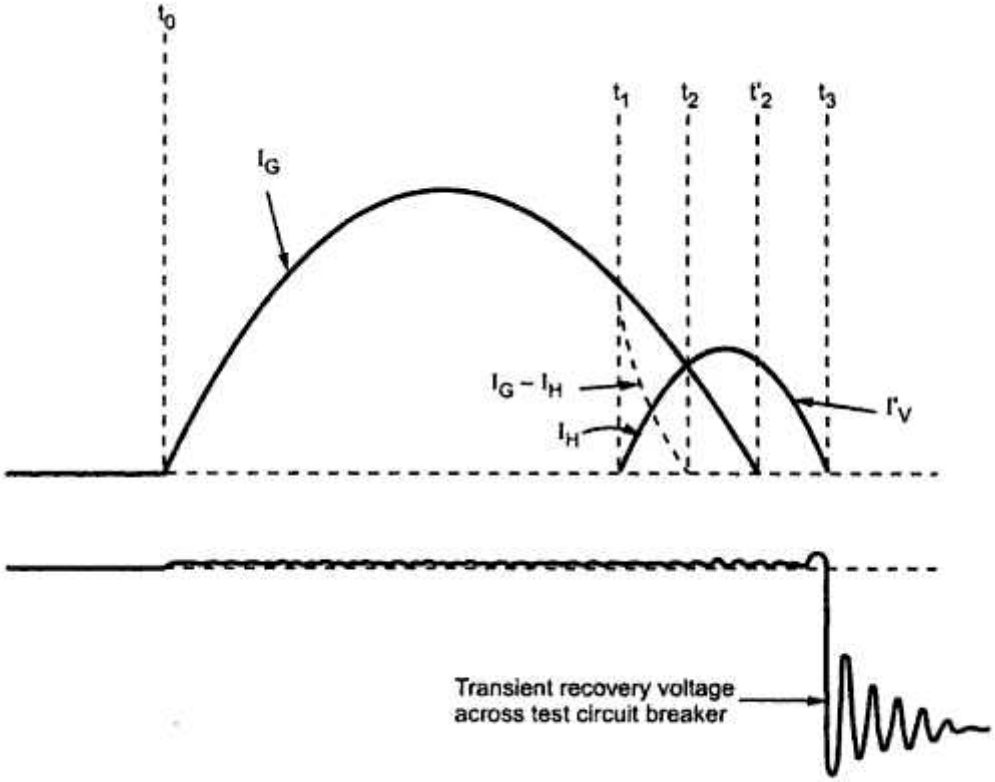
b. Series current injection method



Series current injection method

Here the voltage circuit [2] is connected to current circuit in series before main current zero. Due to this I_G and I_H are in opposition. The stresses produced in synthetic test and those in actual network must be same but it is not the actual case because of several factors like high current, high voltage , instant of applying voltage etc.,

city of the test plant can be



Series injection method waveforms