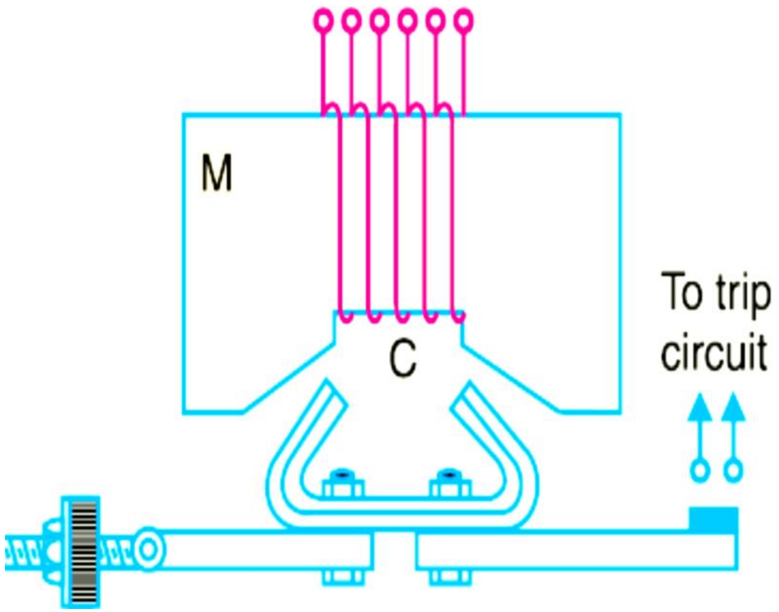
Electromagnetic Attraction Relays

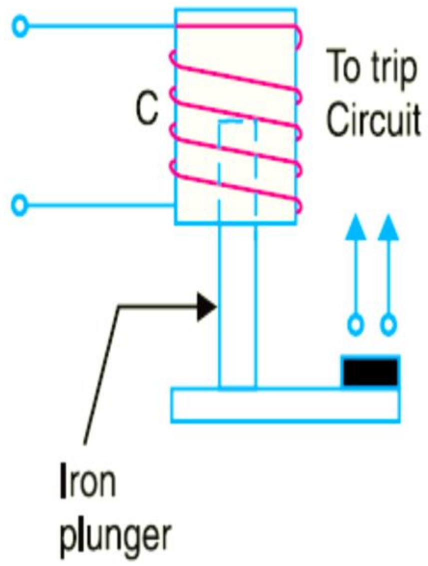
(*1*) Attracted armature type relay

- 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.
- Under normal operating conditions, the current through the relay coil *C* is such that counterweight holds the armature in the position shown.
- However, when a short-circuit occurs, the current through the relay coil increases sufficiently and the relay armature is attracted upwards.
- The contacts on the relay armature bridge a pair of stationary contacts attached to the relay frame.
- This completes the trip circuit which results in the opening of the circuit breaker and, 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.
- It is a usual practice to provide a number of tappings on the relay coil so that the number of turns in use and hence the setting value at which the relay operates can be varied.



Electromagnetic Attraction Relays

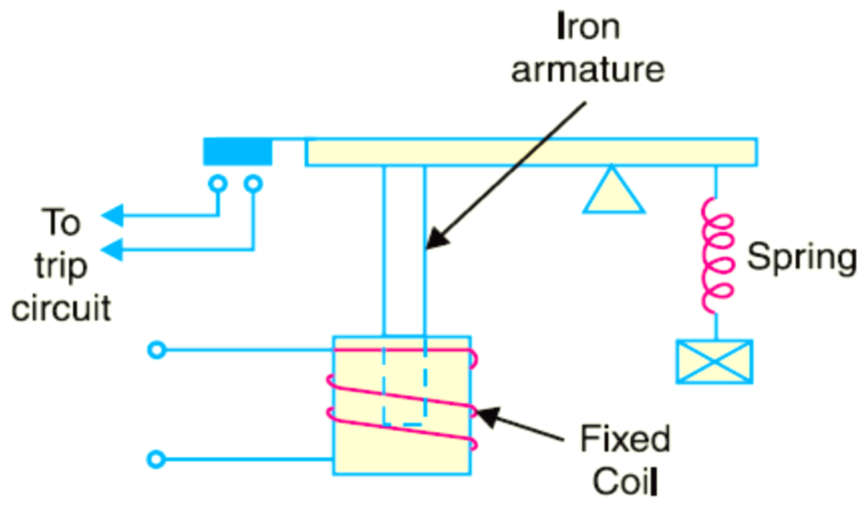
(*1*) Solenoid type relay



- It consists of a solenoid and movable iron plunger arranged as shown. Under normal operating conditions, the current through the relay coil *C* is such that it holds the plunger by gravity or spring in the position shown.
- However, on the occurrence of a fault, the current through the relay coil becomes more than the pickup value, causing the plunger to be attracted to the solenoid.
- The upward movement of the plunger closes the trip circuit, thus opening the circuit breaker and disconnecting the faulty circuit.

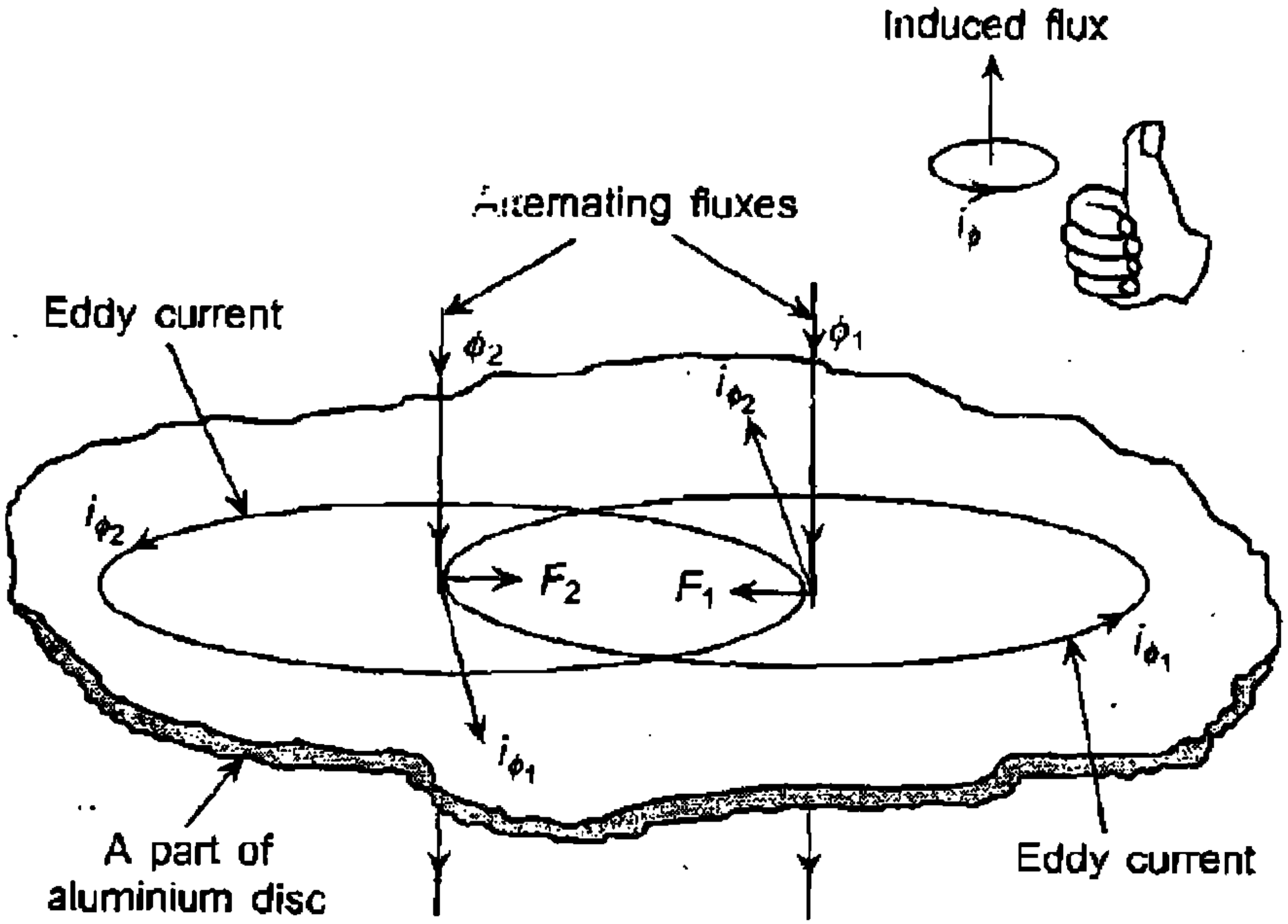
Electromagnetic Attraction Relays

(1) Balanced beam type relay



- ✓ It consists of an iron armature fastened 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.
- ✓ However, when a fault occurs, the current through the relay coil becomes greater than the pickup value and the beam is attracted to close the trip circuit.
- ✓ This causes the opening of the circuit breaker to isolate the faulty circuit.

Induction Relays



Operating principle of induction disc type relay.

Induction Relays

- Electromagnetic induction relays operate on the principle of induction motor and are widely used for protective relaying purposes involving a.c. quantities.
- They are not used with d.c. quantities owing to the principle of operation.
- An induction relay essentially consists of a pivoted aluminium disc placed in two alternating magnetic fields of the same frequency but displaced in time and 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.

Induction Relays

- The two a.c. fluxes Φ2 and Φ1 differing in phase by an angle α induce e.m.f.s' in the disc and cause the circulation of eddy currents *i*2 and *i*1 respectively.
- These currents lag behind their respective fluxes by 90°.

$$\phi_1 = \phi_{1max} \sin \omega t \qquad \phi_2 = \phi_{2max} \sin(\omega t + \alpha)$$

- where Φ 1 and Φ 2 are the instantaneous values of fluxes and Φ 2 leads Φ 1 by an angle α.

- Assuming that the paths in which the rotor currents flow have negligible self-inductance, the rotor currents will be in phase with their voltages.

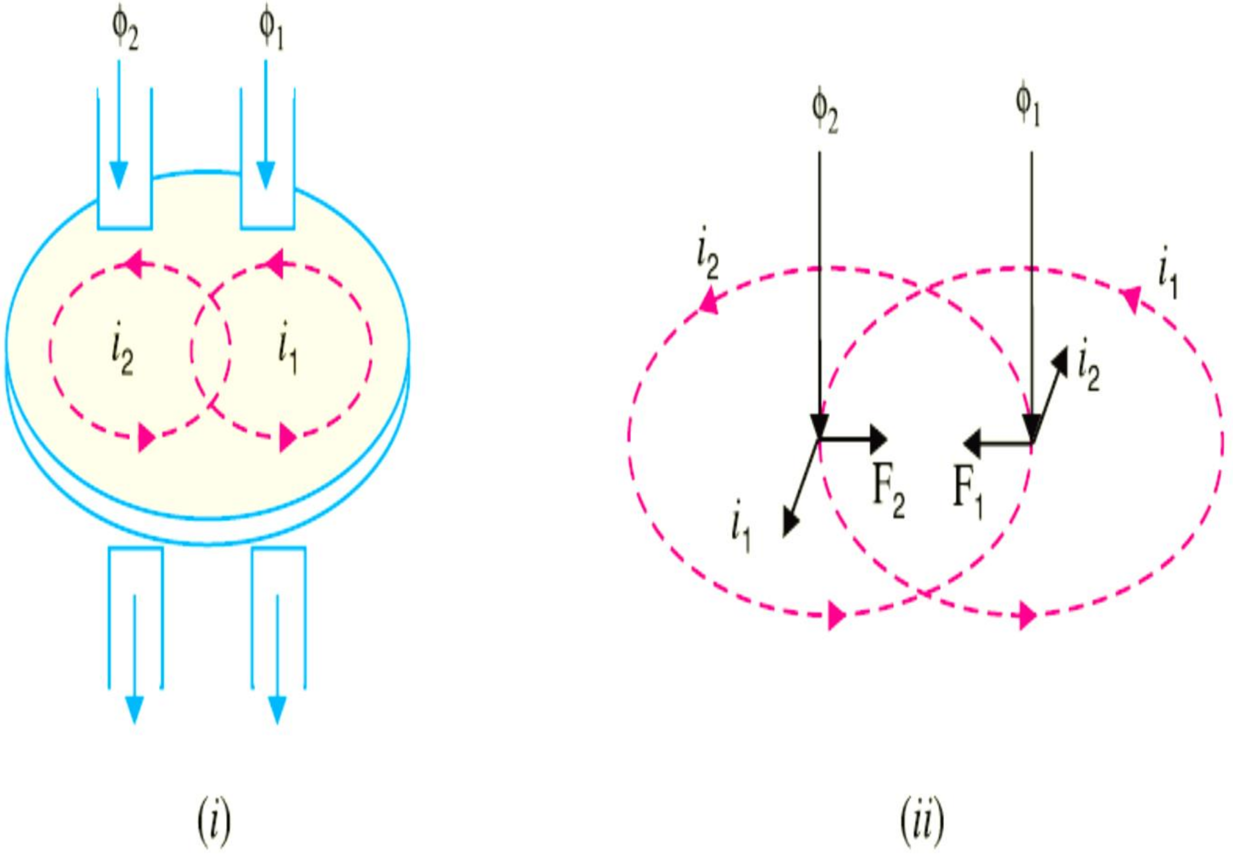
$$\therefore \qquad i_1 \propto \frac{d\phi_1}{dt} \propto \frac{d}{dt}(\phi_{1max} \sin \omega t)$$

Induction Relays

$$\propto \phi_{1max} \cos \omega t$$

and $$i_2 \propto \frac{d\phi_2}{dt} \propto \phi_{2max} \cos(\omega t + \alpha)$$

Now, $$F_1 \propto \phi_1 i_2 \quad \text{and} \quad F_2 \propto \phi_2 i_1$$



- Fig. (*ii*) shows that the two forces are in opposition.
- Net force *F* at the instant considered is

$$F \propto F_2 - F_1 \qquad \propto \phi_2 i_1 - \phi_1 i_2$$

$$\propto \phi_{2max} \sin(\omega t + \alpha)\, \phi_{1max} \cos \omega t - \phi_{1max} \sin \omega t\, \phi_{2max} \cos(\omega t + \alpha)$$

$$\propto \phi_{1max}\, \phi_{2max} [\sin(\omega t + \alpha) \cos \omega t - \sin \omega t \cos(\omega t + \alpha)]$$

$$\propto \phi_{1max}\, \phi_{2max} \sin \alpha \qquad \propto \phi_1\, \phi_2 \sin \alpha \qquad ...(i)$$

where Φ 1 and Φ 2 are the r.m.s. values of the fluxes.

Induction Relays

- The following points may be noted from exp. (*i*) :

(a) The greater the phase angle α between the fluxes, the greater is the net force applied to the disc. Obviously, the maximum force will be produced when the two fluxes are 90° out of phase.

(b) The net force is the same at every instant. This fact does not depend upon the assumptions made in arriving at exp. (*i*).

(c) The direction of net force and hence the direction of motion of the disc depends upon which flux is leading.

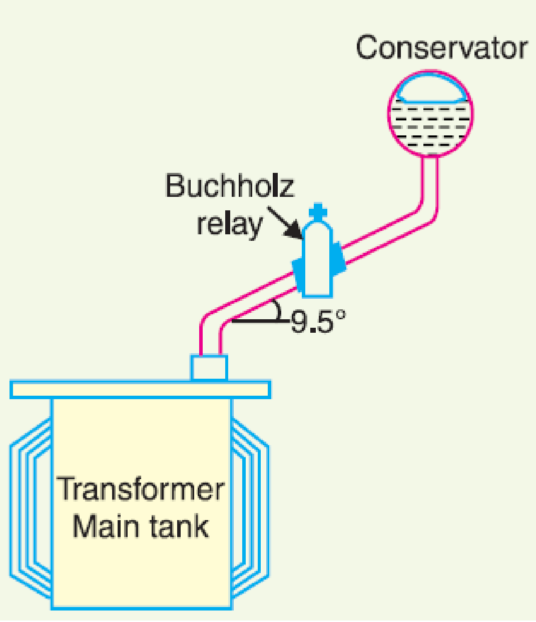
Buchholz Relay

- Buchholz relay is a gas-actuated relay installed in oil immersed transformers for protection against all kinds of faults.

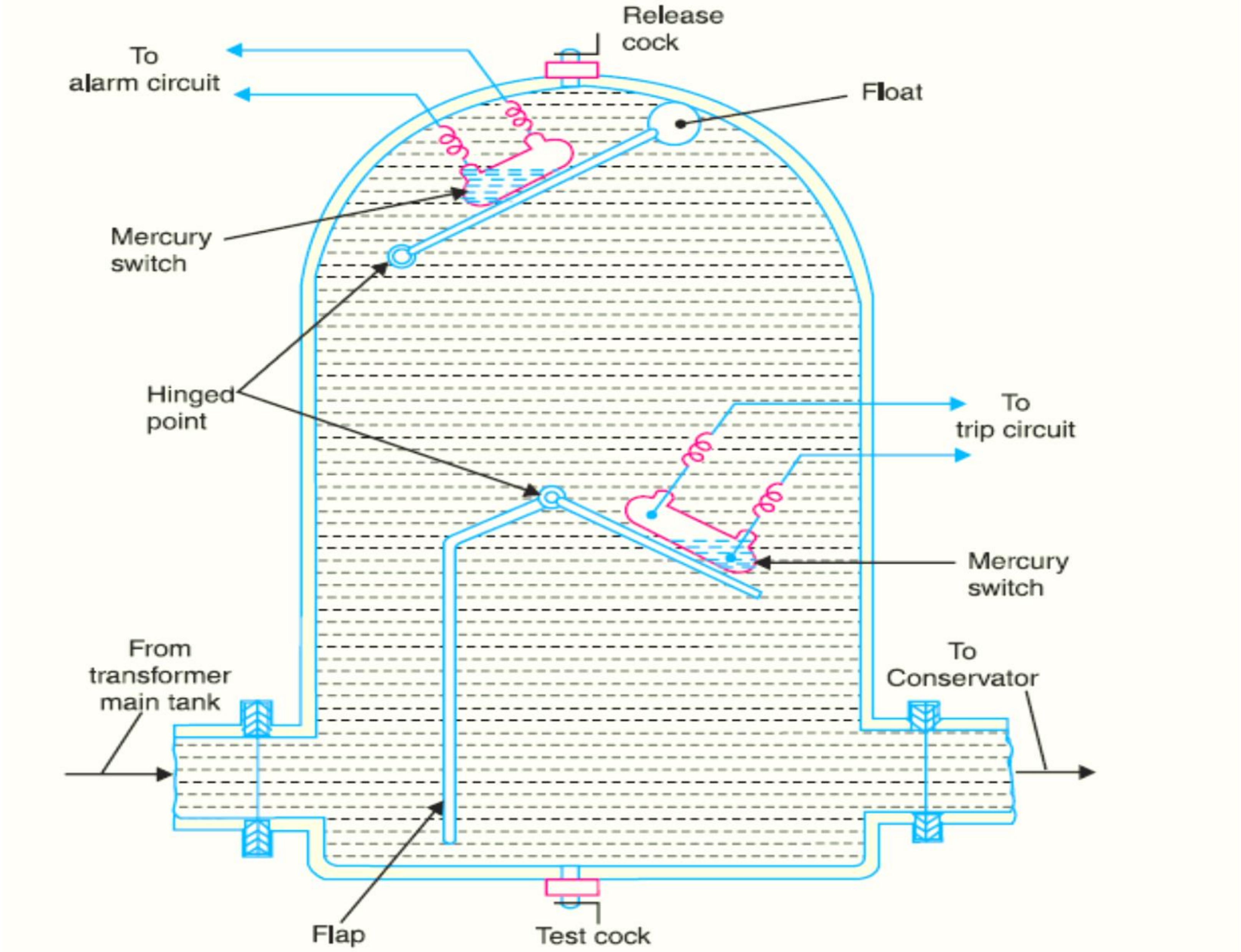
- Named after its inventor, Buchholz, it is used to give an alarm in case of incipient (*i.e.* slow-developing) faults in the transformer and to disconnect the transformer from the supply in the event of severe internal faults.

- It is usually installed in the pipe connecting the conservator to the main tank as shown in.

- It is a universal practice to use Buchholz relays on all such oil immersed transformers having ratings in excess of 750 kVA.



Buchholz Relay



Buchholz Relay

✓ **Construction**

- Above Fig shows the constructional details of a Buchholz relay.
- It takes the form of a **domed vessel** placed in the connecting pipe between the main tank and the conservator.
- The device has **two elements**.
- 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 circuit breaker in case of severe internal faults**.

Buchholz Relay

- **Operation.** The operation of Buchholz relay is as follows :

(*i*)

- 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 tries to go into the conservator and in the process gets entrapped in the upper part of relay chamber.
- When a predetermined amount of gas gets accumulated, it exerts sufficient pressure on the float to cause it to tilt and close the contacts of mercury switch attached to it.
- This completes the alarm circuit to sound an alarm.

(*ii*)

- 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 in doing so tilts the flap to close the contacts of mercury switch.
- This completes the trip circuit to open the circuit breaker controlling the transformer.

Buchholz Relay

Advantages

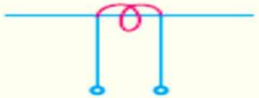
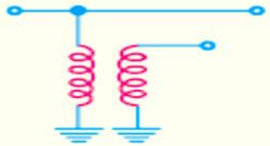
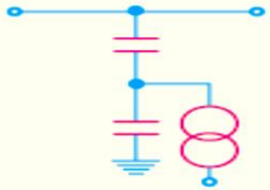
(i) It is the simplest form of transformer protection.

(ii) It detects the incipient faults at a stage much earlier than is possible with other forms of protection.

Disadvantages

(i) It can only be used with oil immersed transformers equipped with conservator tanks.

(ii) The device can detect only faults below oil level in the transformer. Therefore, separate protection is needed for connecting cables.

S.No.	Circuit element	Symbol
1	Bus-bar	
2	Single-break isolating switch	
3	Double-break isolating switch	
4	On load isolating switch	
5	Isolating switch with earth Blade	
6	Current transformer	
7	Potential transformer	
8	Capacitive voltage transformer	
9	Oil circuit breaker	
10	Air circuit breaker with overcurrent tripping device	
11	Air blast circuit breaker	
12	Lightning arrester (active gap)	
13	Lightning arrester (valve type)