

## **Lecture-7**

Theory of arc interruption, circuit breaker,  
restriking  
voltage transients

# Topic Covered

- ▶ Introduction of Circuit Breaker
- ▶ Operating Principle
- ▶ Electric Arc
- ▶ ARC in AC and DC circuits
- ▶ Principles of Arc extinction
- ▶ Restriking Voltage

# Circuit Breaker

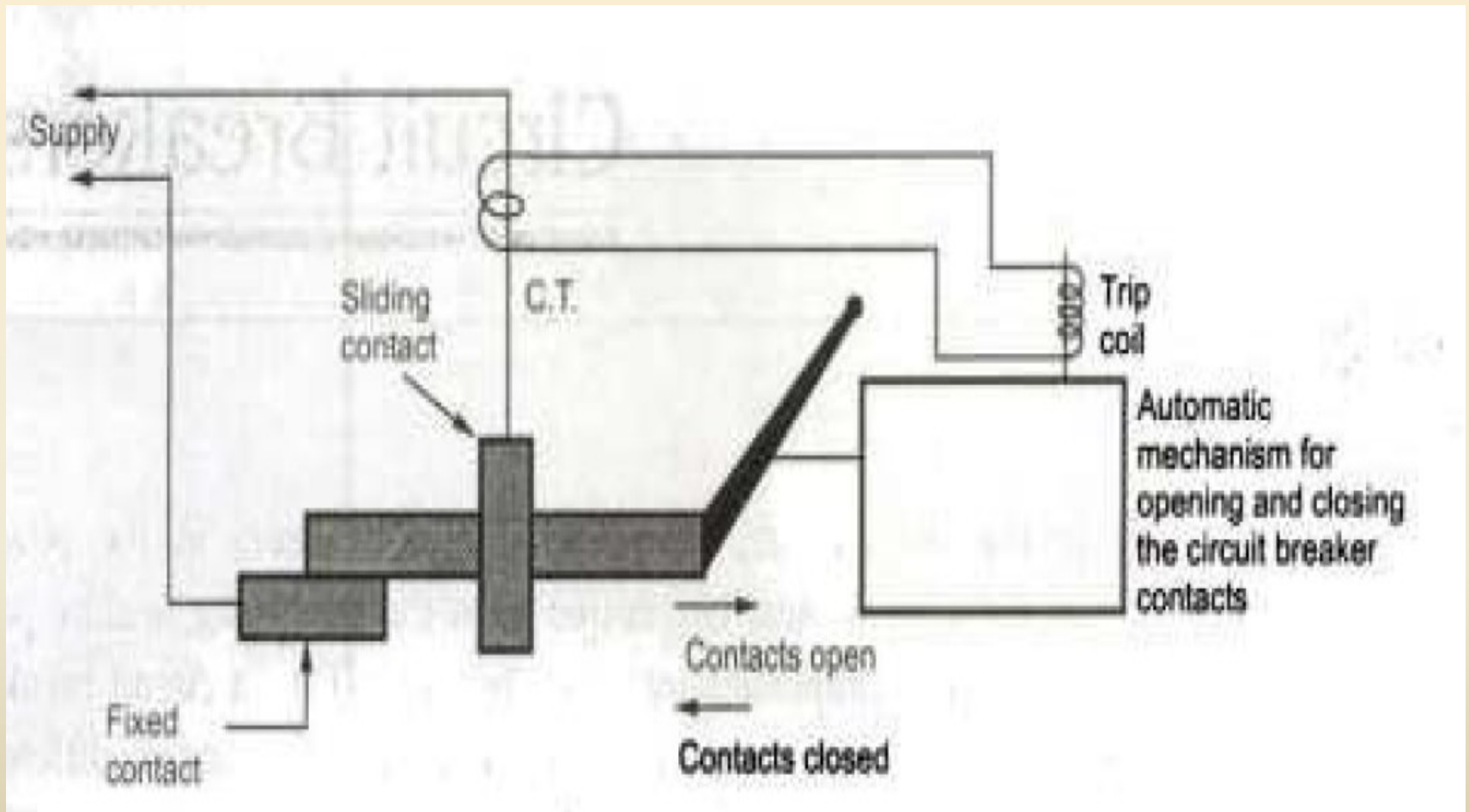
A circuit breaker is a piece of equipment which can Make or break a circuit either manually or by remote control under normal conditions.

- ▶ Break a circuit automatically under fault condition
- ▶ Make a circuit either manually or by remote under fault condition

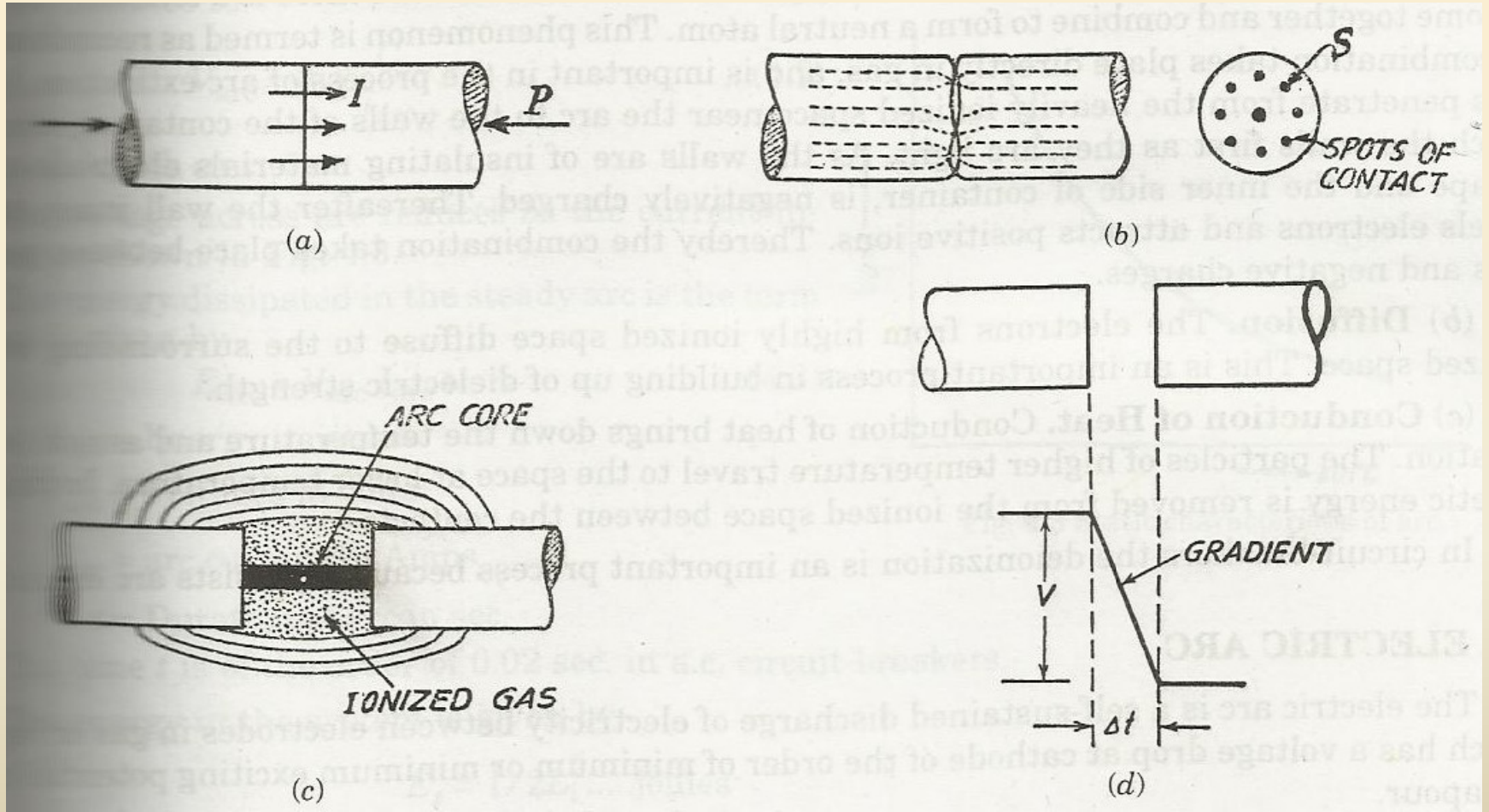
# Operating Principle

- ▶ Circuit Breaker consists of fixed and moving contacts called electrodes
- ▶ Under normal operating condition these contacts remain closed and will not open automatically unless the system becomes faulty .These contacts can be opened manually or by remote control.
- ▶ When a fault occurs in a circuit the trip coils of the circuit breaker get energized and the moving contacts are pulled apart by some mechanism ,thus opening the circuit.

# Simplified Diagram of Circuit Breaker Control



# Electric Arc



# Electric Arc

When contacts of circuit breaker starts separating the contact resistance starts increasing. This increases the  $(I^2 r)$  loss which is heat produced .

This heat increases the energy of electrons in the contact areas and the ionized particles tries to maintain the current when contacts are separated. This flow of charged particles from one contact to other is called an arc .

The medium surrounding the arc also contains ions .

Due to this charged particles the arc continues even if the breakers contacts are separated.

The voltage (potential gradient) across the arc is less and so it continues even for low voltages.

## ARC in AC and DC circuits

- ▶ DC arcs are to be interrupted by increasing the resistance interruption method in which resistance of the arc is increased so that the arc voltage can no longer maintain the current and the arc is extinguished.
- ▶ Size of DC circuit breaker increases as the voltage level increases.
- ▶ AC arcs current reduces to zero in each cycle (2 times)
- ▶ If the circuit breaker contacts are opened at time when the current passed through zero and dielectric strength of the medium is build up rapidly so that arc cannot strike again then arc can be extinguished successfully.
- ▶ Size of AC circuit breaker can be small compared to same voltage DC circuit breaker.



# Principles of Arc extinction

- ▶ Separate the contacts of circuit breaker such that the arc resistance increases to a very high value. The pd between the contacts is unable to maintain the arc current. For high voltage circuit breakers this method is impracticable since a separation of many meters will be required.(High Resistance Method)
- ▶ The ionized particles between the contacts tend to maintain the arc. If the arc path is deionized ,the arc extinction is facilitated .This may be achieved by cooling the arc or by bodily removing the ionized particles from the space between the contacts.(Low Resistance Method)

# Important terms

- Arc Voltage – It is the voltage that appears across the contacts of the circuit breakers during the arcing period as the contacts are opened.
- Recovery voltage – It is the normal frequency voltage that appears across the contacts of circuit breaker after final arc extinction.
- Rate of rise of restriking voltage – (RRRV) It is the rate of increase of restriking voltage .RRRV depends upon 1) recovery voltage and 2) Natural frequency of oscillation

# Restriking Voltage

- ▶ It is the transient voltage that appears across the contacts at or near current zero during arcing period.
- ▶ If dielectric strength rise is greater than the rise of restriking voltage then the arc will not restrike.

