

Switchgear and Protection

Course Objectives

- To realize the need of protection in power system
- To grasp knowledge of construction and working principles of various circuit breakers, relays
- To impart knowledge of different types of faults in generators, transformers, motors, transmission lines and bus
- To impart knowledge of protection provided to above components of power system

Course Outcomes

After completion of this course students will be able to

- Comprehend the relaying principles and working of circuit breakers**
- Identify, formulate and solve problems in protection of transformer, generator, transmission lines, bus bar, motors etc.**
- Decide and select proper component of protection system such as relays, circuit breaker, etc.**

Switchgear and protection panels are installed for:

- 1. Normal, routine switching, control and monitoring**
- 2. Automatic switching during abnormal and faulty operating conditions**

Faults and Abnormal Conditions

- **Electrical fault is defined as a defect in electrical circuit due to which the current is diverted from its intended path.**

- **General Causes:**

Breaking of conductors, insulation failure, mechanical failure, accidents, excessive stresses, etc.

- **The fault impedance being low, the fault currents are relatively high**
- **The voltage of three phases become unbalanced**
- **The power flow is diverted towards the fault and the supply to the neighboring zone is affected**

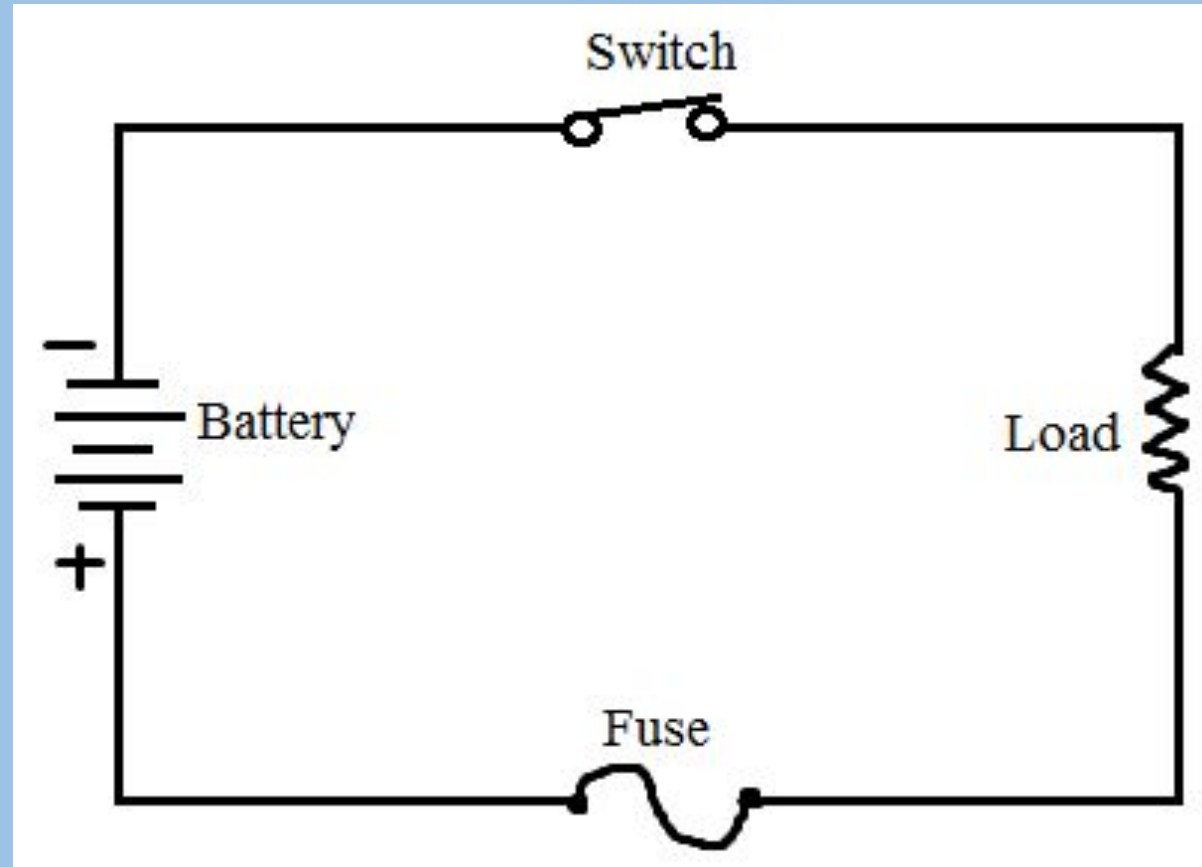
A.C. faults can be classified as:

- 1. Single line to ground**
- 2. Double line to ground**
- 3. Three phase fault**
- 4. Three phase to ground**
- 5. Line to line**
- 6. Open circuit fault**

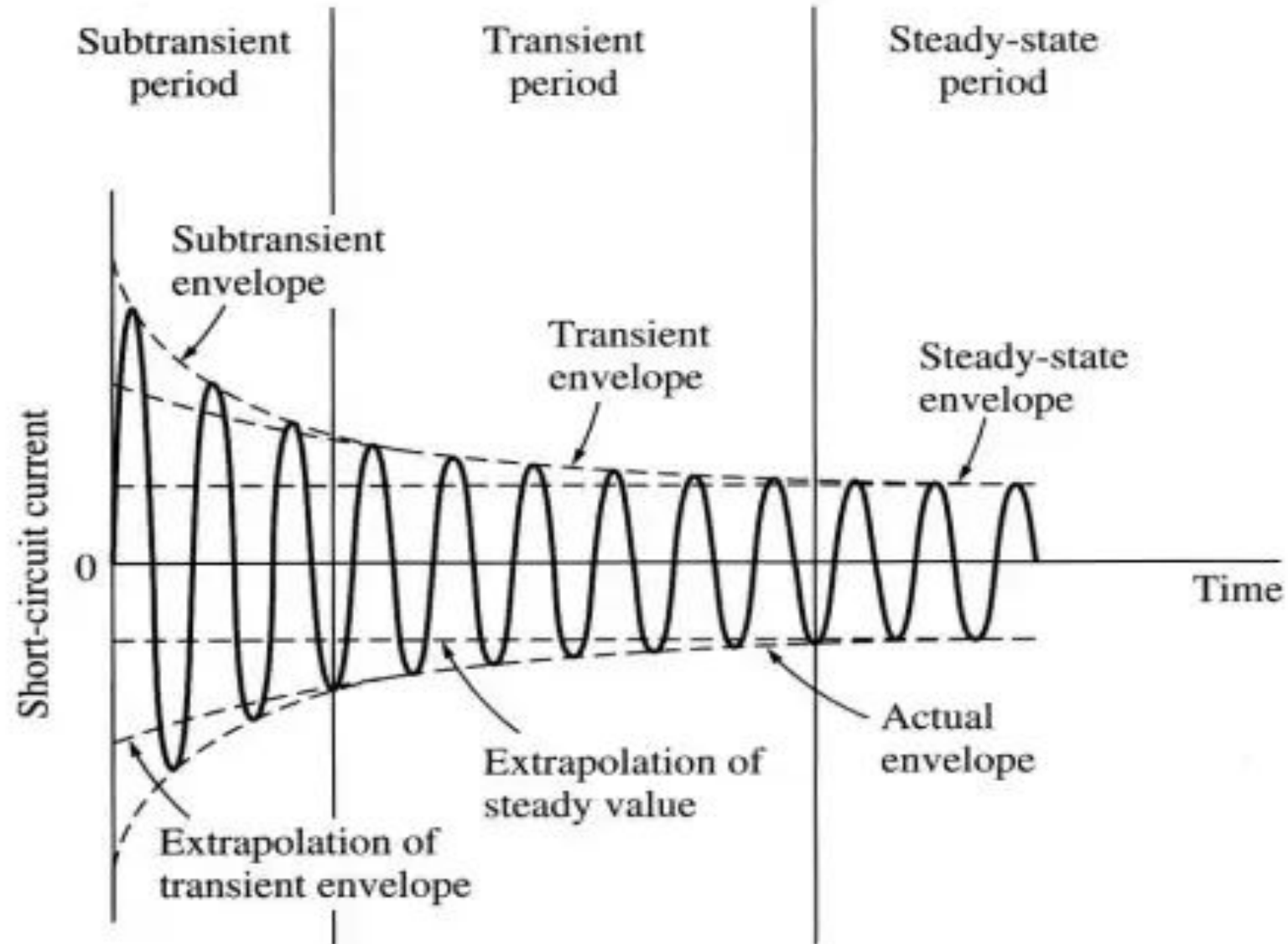
Other abnormal conditions:

1. Voltage and current unbalance
2. Overvoltage
3. Reversal of power
4. Power swings
5. Under-frequency
6. Instability, etc.

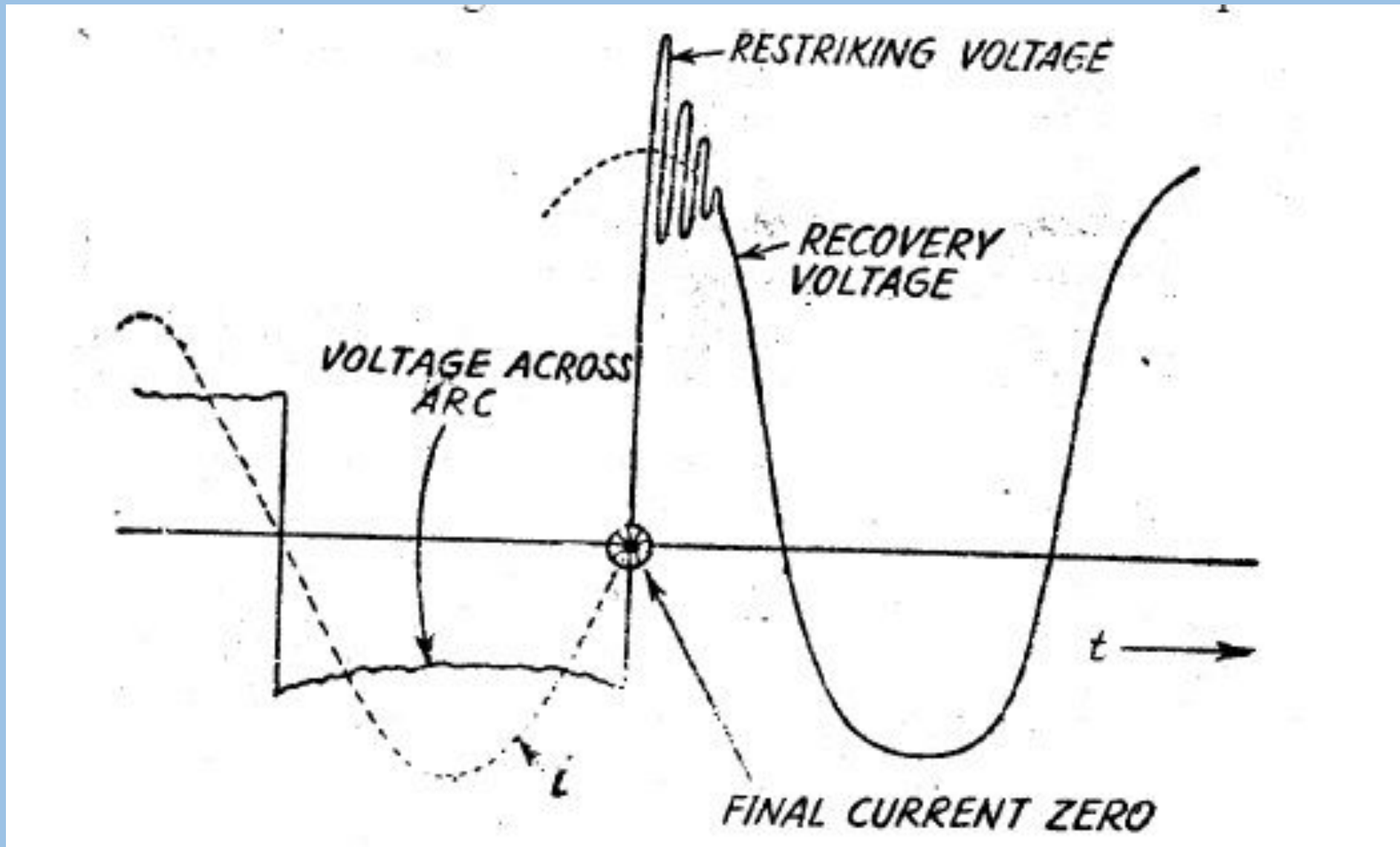
Basic Circuit with Fuse



Transient Phenomenon



Transient Recovery Voltage



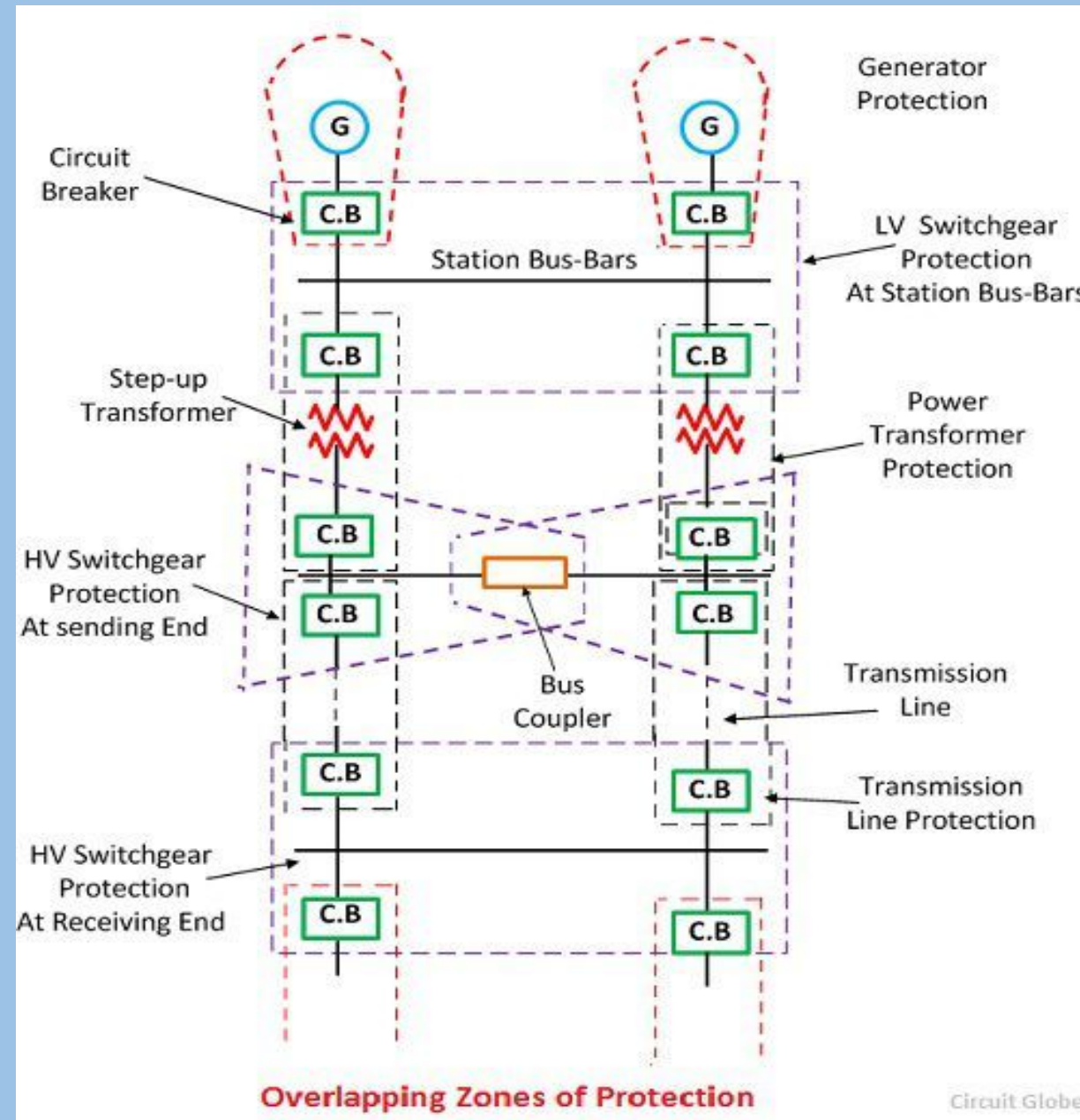
Harmful effects of faults:

- 1. Excessive heating due to heavy currents**
- 2. Fire**
- 3. Arc may cause damage to the elements in the power system**
- 4. Instability in Power system**
- 5. Complete shut down in some parts of power system**
- 6. Damage to other equipment due to overheating and abnormal mechanical forces set up**

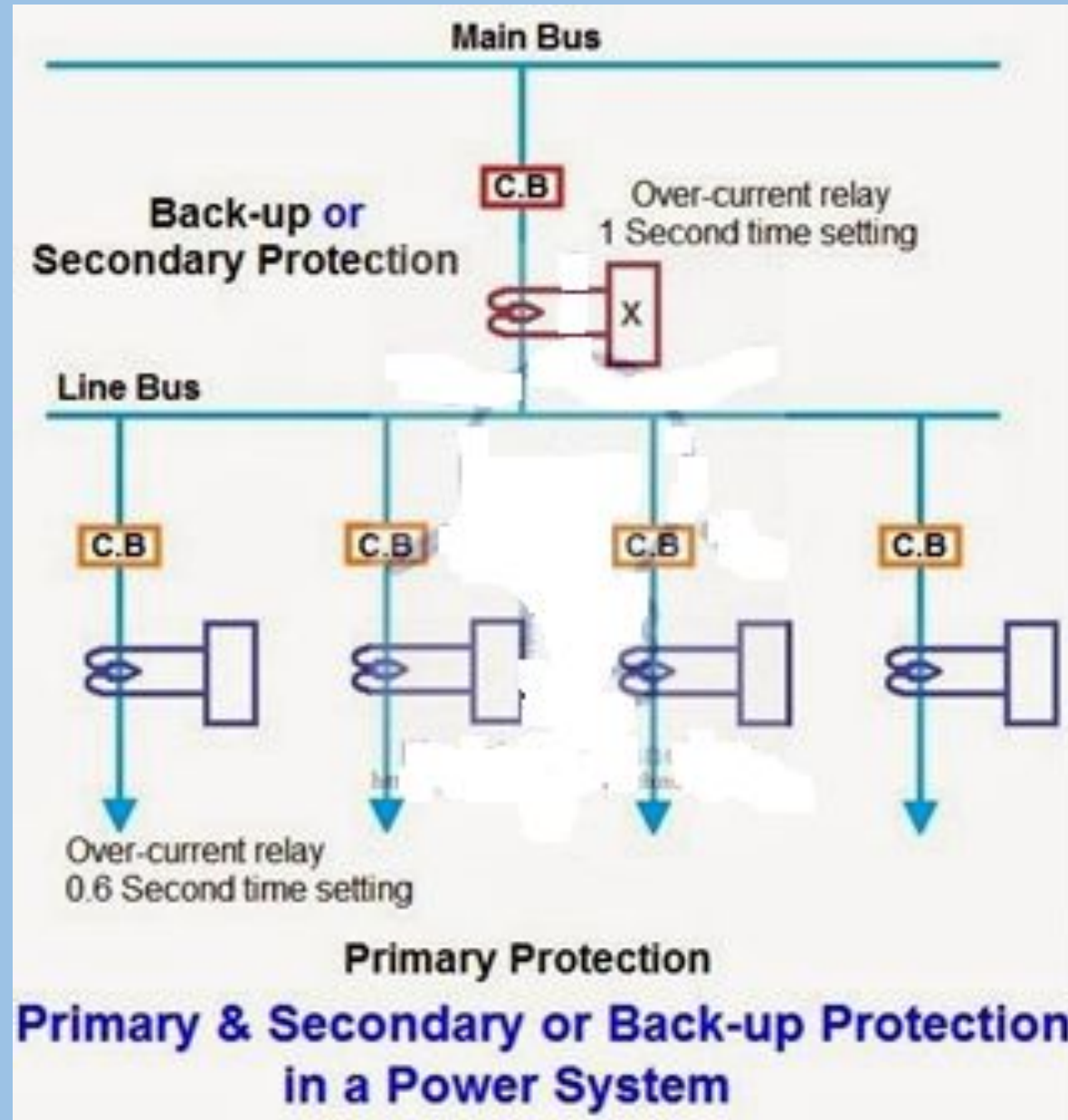
Measures to minimize faults:

1. Improvement in quality of machines and installations
2. Improvement in system design, layout, etc.
3. Adequate and reliable protection schemes
4. Regular and detailed maintenance
5. Trained personnel for operation and management

Protective Zones



Primary and Backup Protection



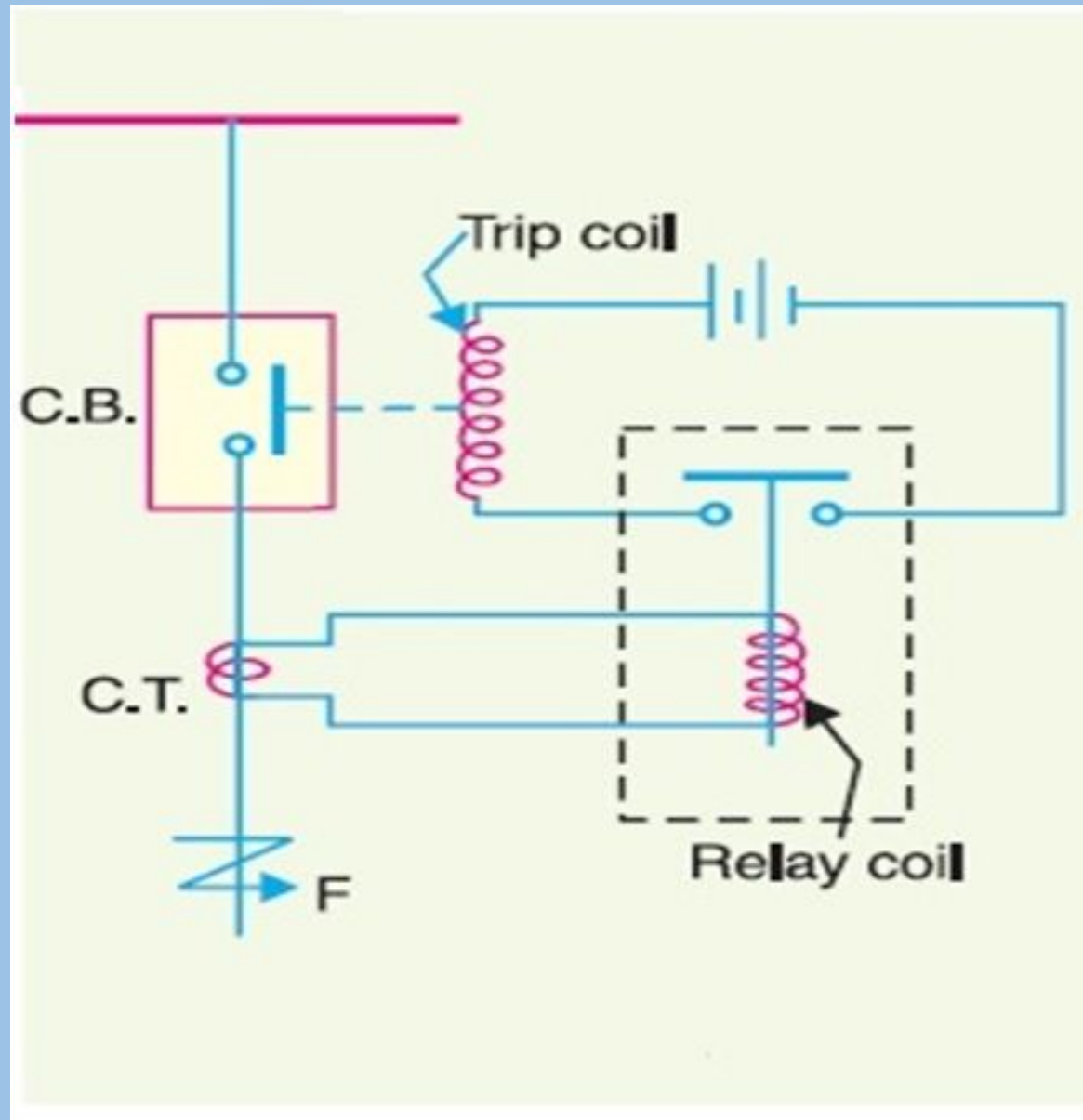
Methods of Backup Protection

- **Relay backup:** Same CB but different relay
- **Breaker backup:** Different CB
- **Remote backup:** Main and backup provided at different stations and are completely independent
- **Centrally coordinated backup:** Central control continuously supervises the load flow and frequency. The main protection is at various stations and backup protection for all stations is at central control center.

Desirable Qualities of Protective Relaying

- **Selectivity and Discrimination**
- **Relay time and fault clearing time**
- **Sensitivity**
- **Stability**
- **Reliability**
- **Adequateness**

Basic Connection of Trip Circuit



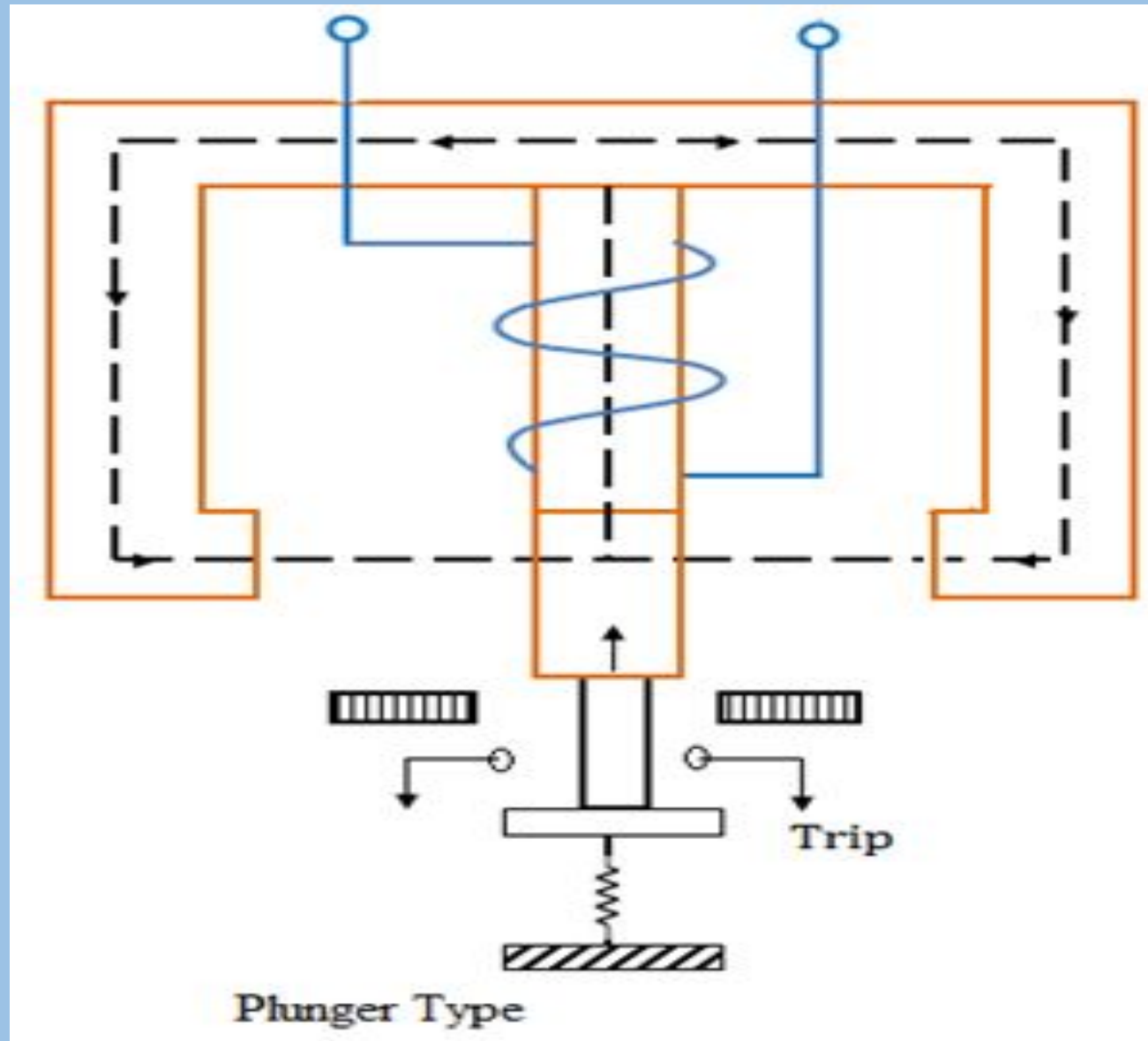
Classification of Relays

- Electromagnetic
- Directional
- Differential
- Distance

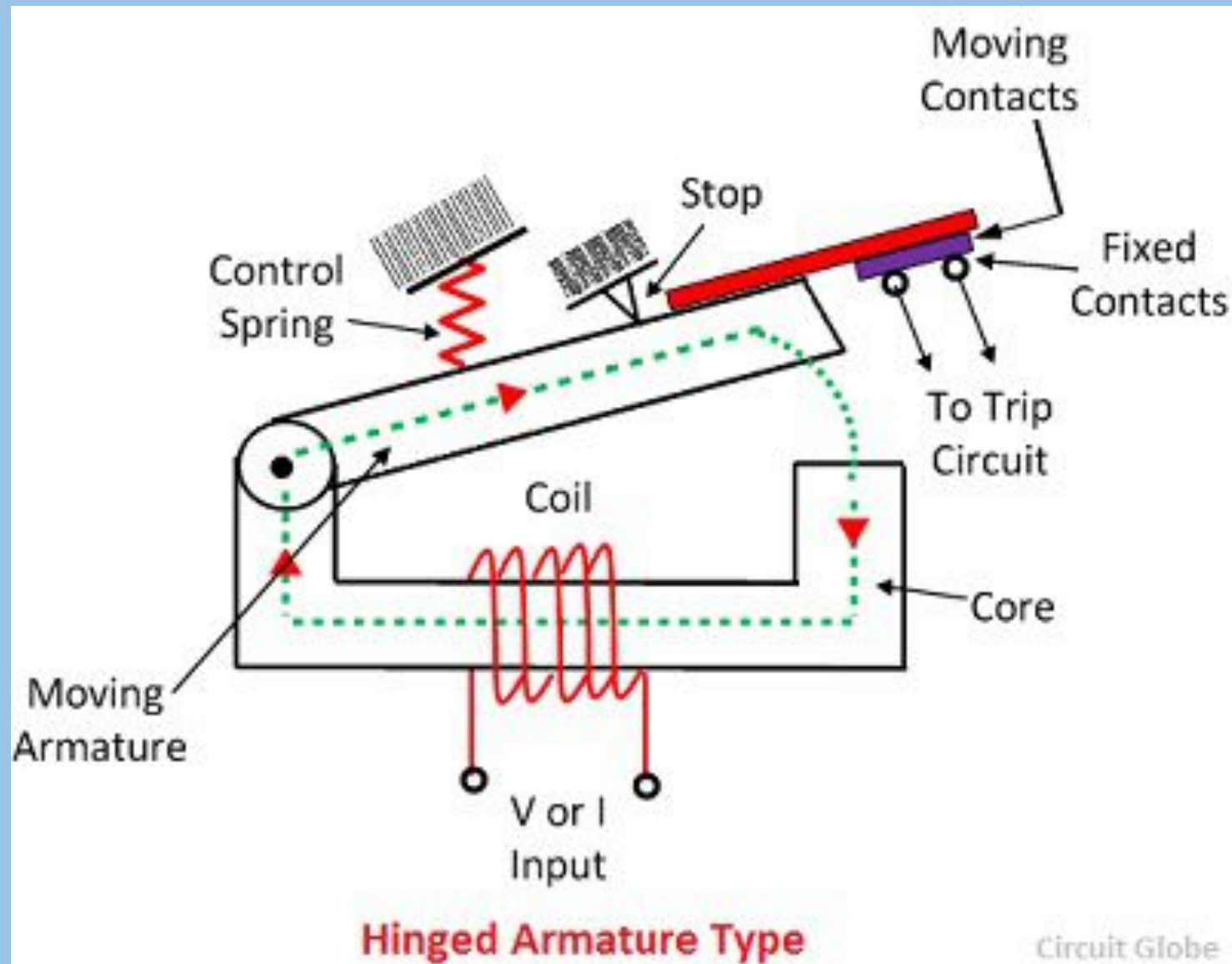
Electromagnetic Relays

- **Attracted Armature Type Relay**

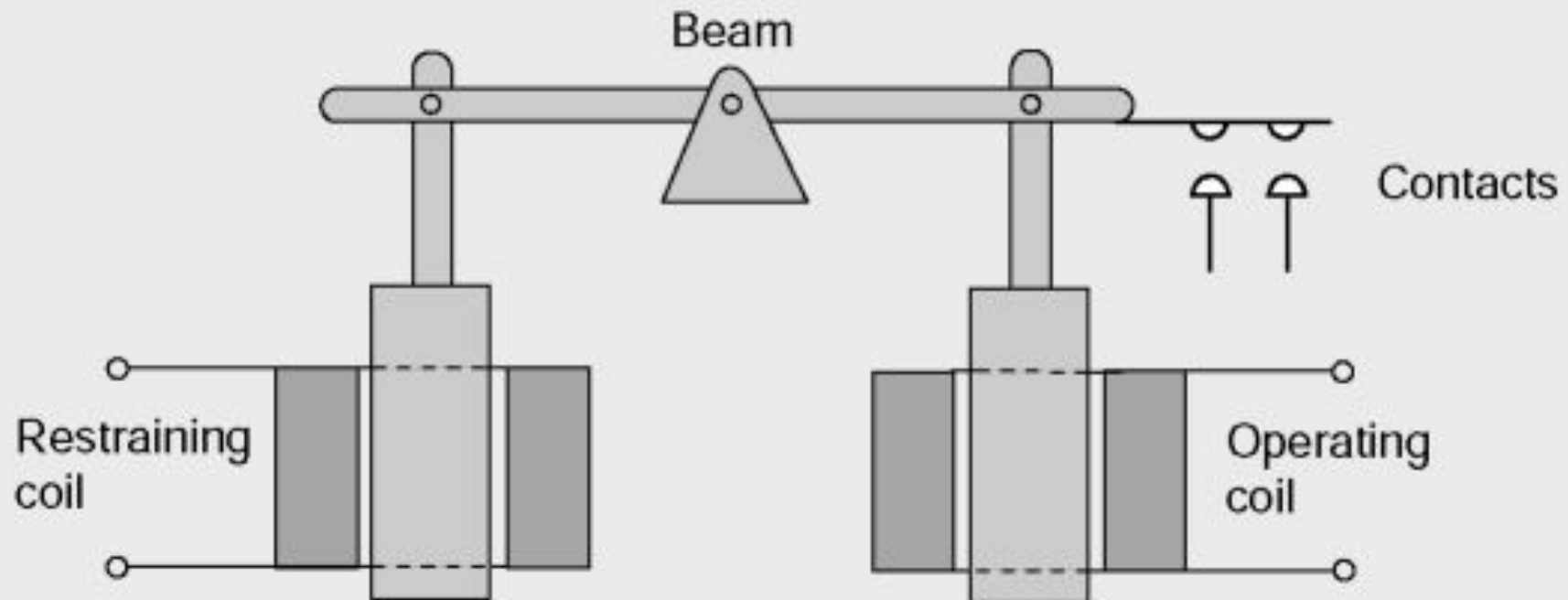
Plunger Type Relay



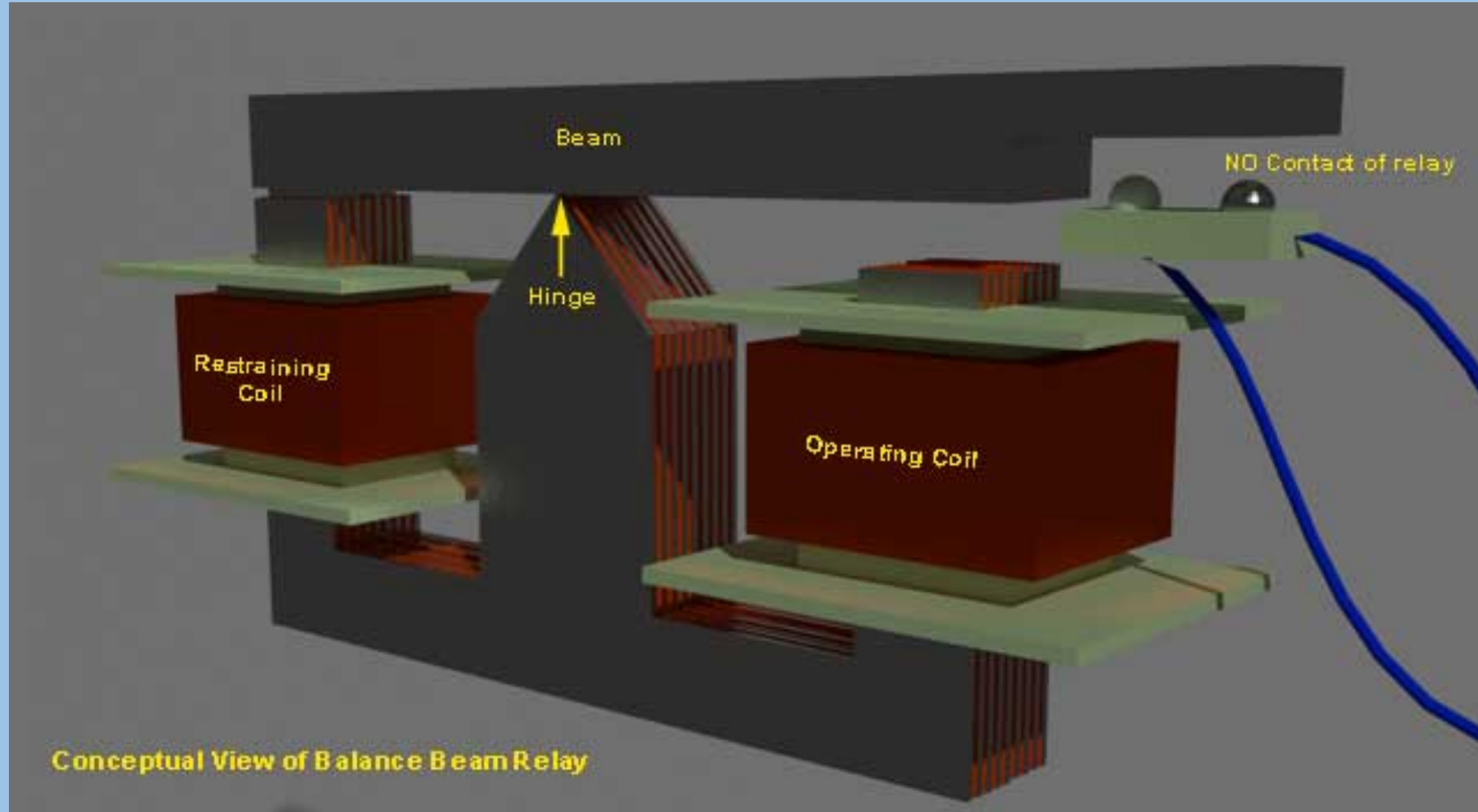
Hinged Armature Type Relay



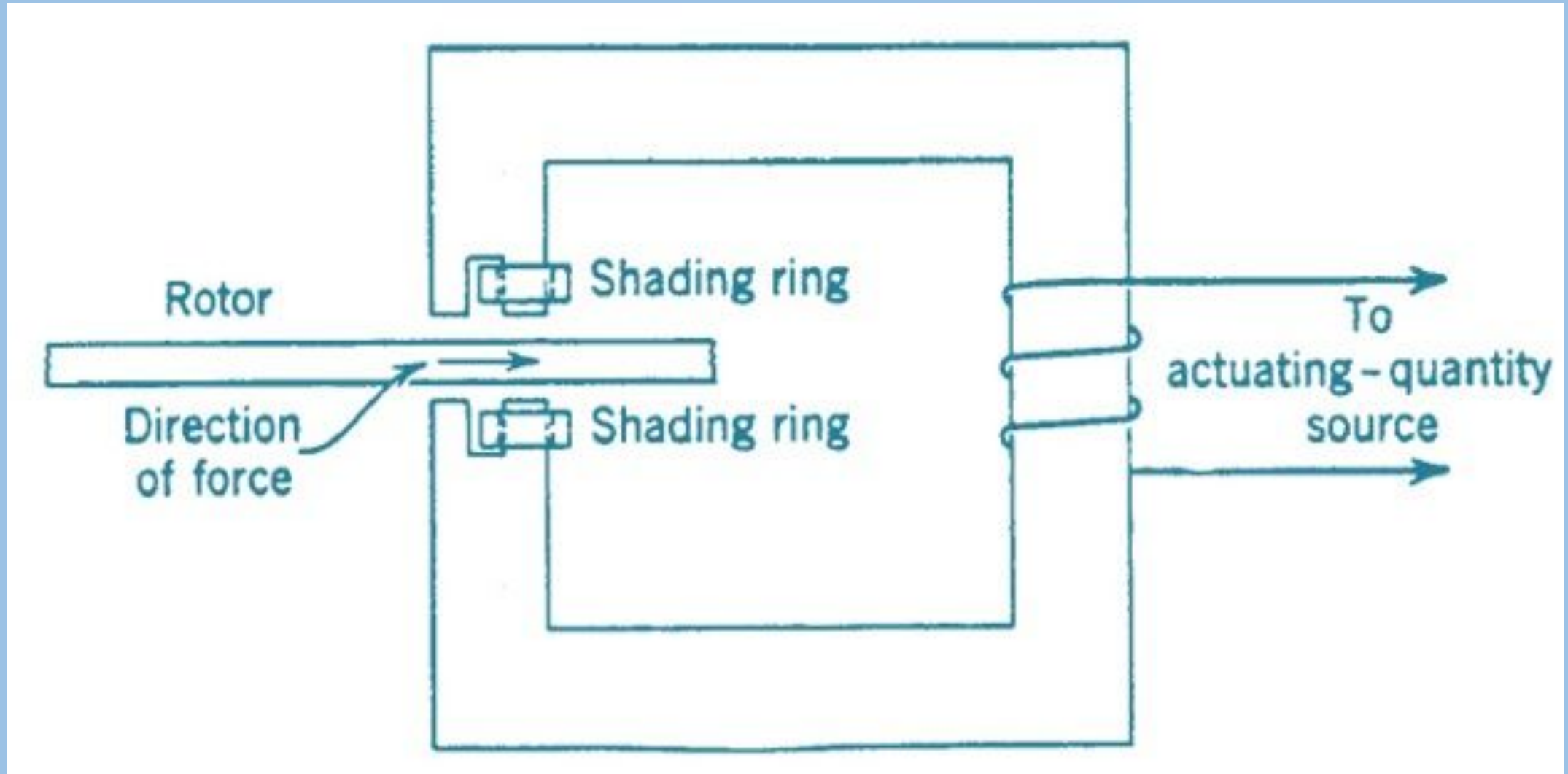
Balanced Beam Type Relay



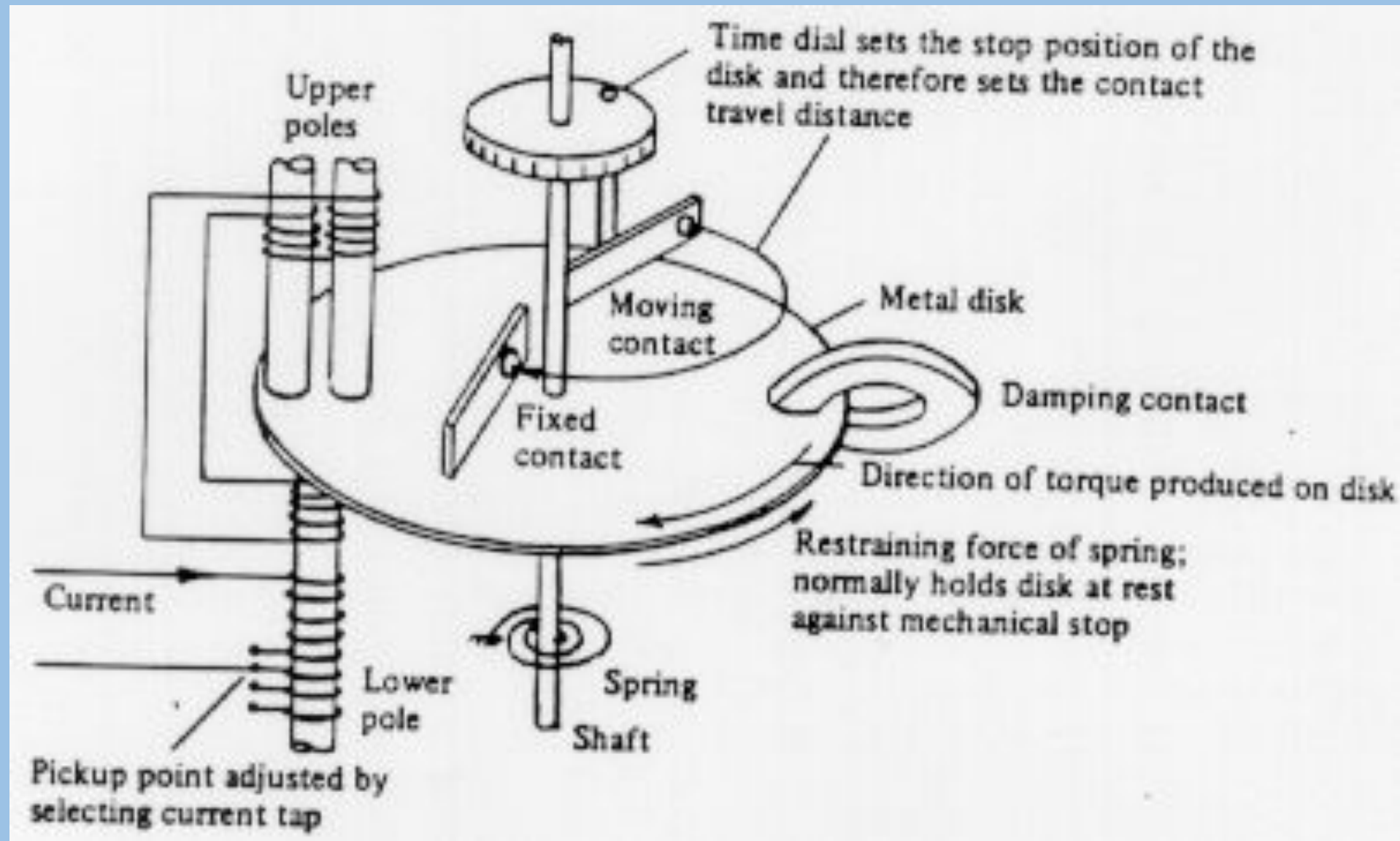
Balanced Beam Type Relay



Induction Disc Relay: Shaded Pole Type



Induction Disc Relay: Shaded Pole Type



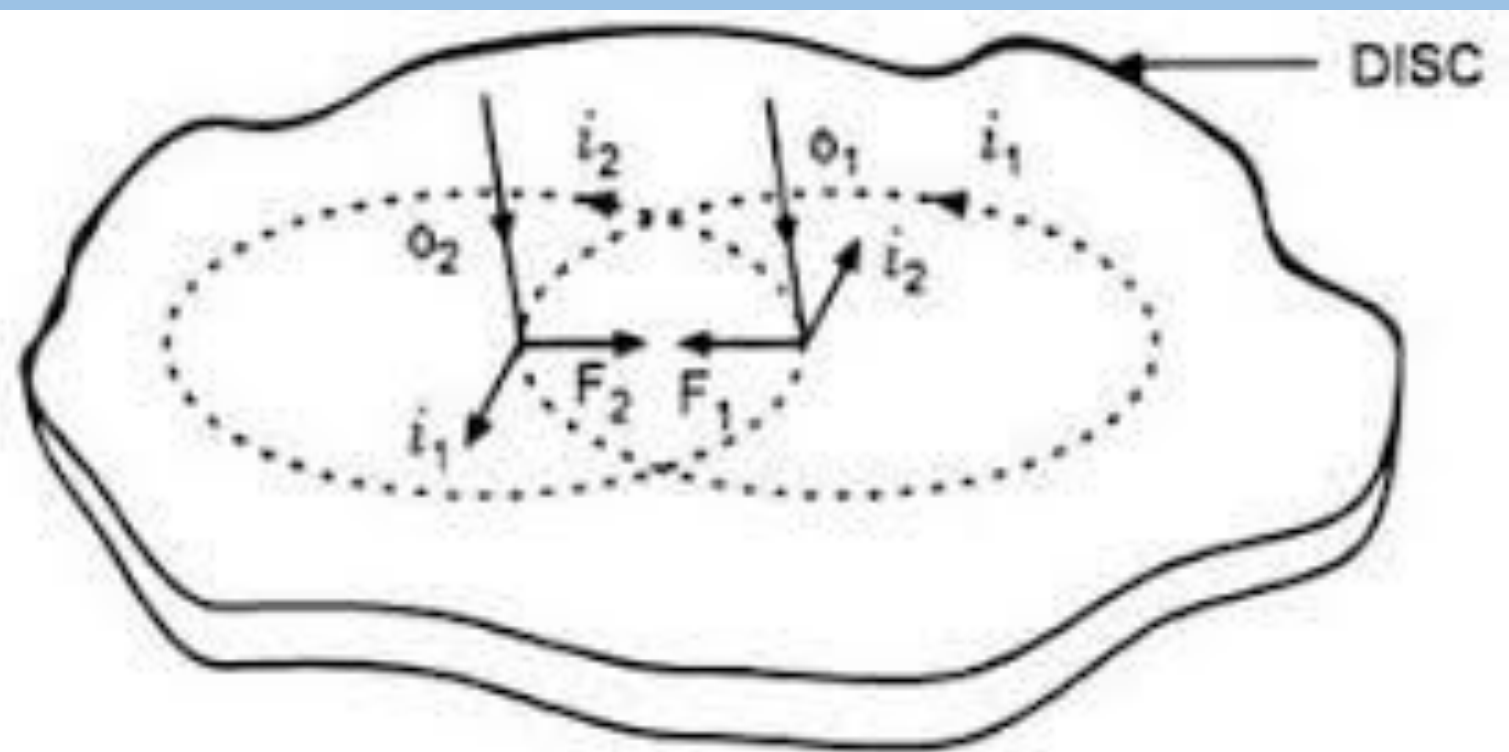


Fig. 2.6. *Production of Torque in an Induction Relay*

Induction Disc Relay: Watt-Hour Meter Type

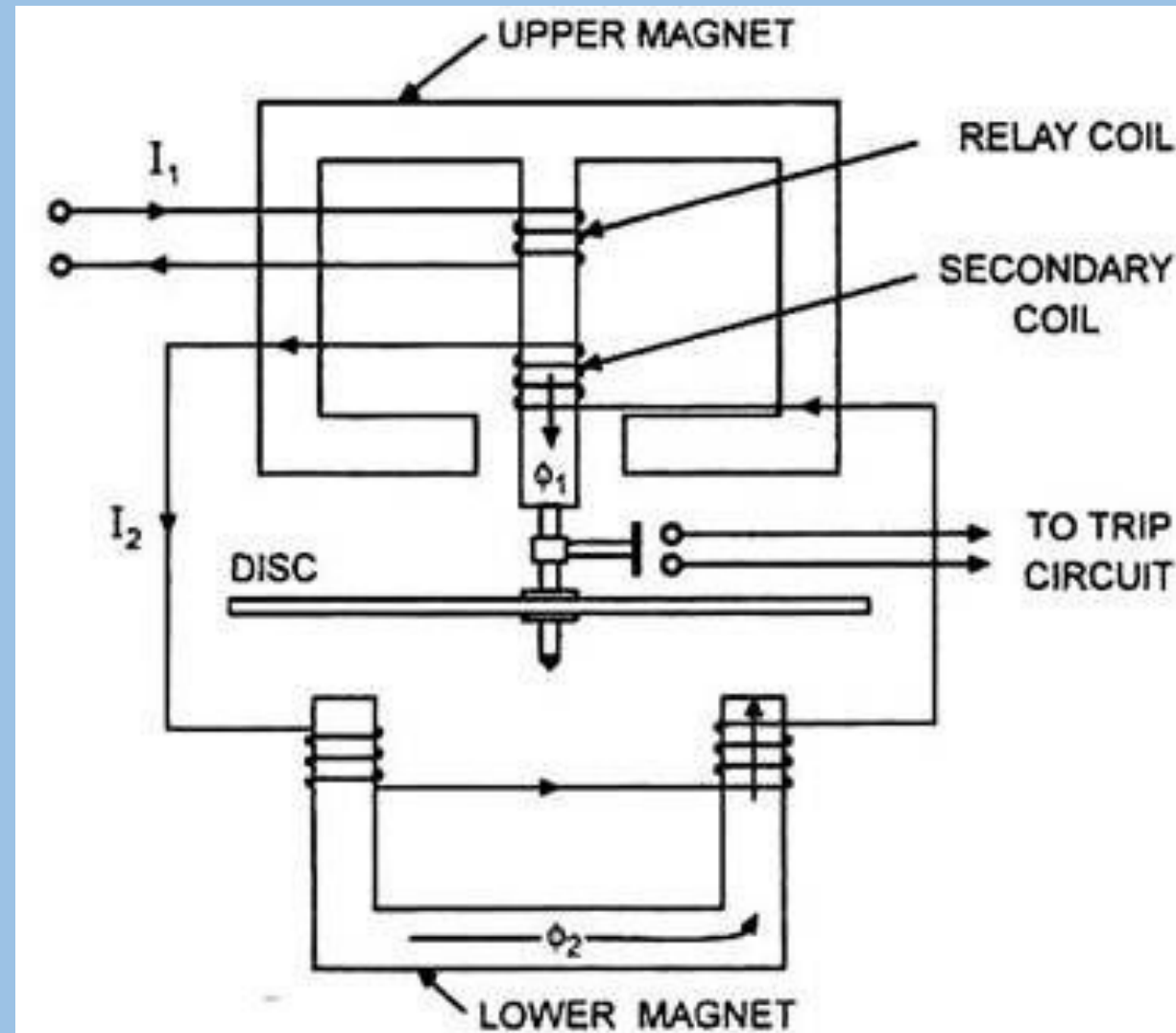
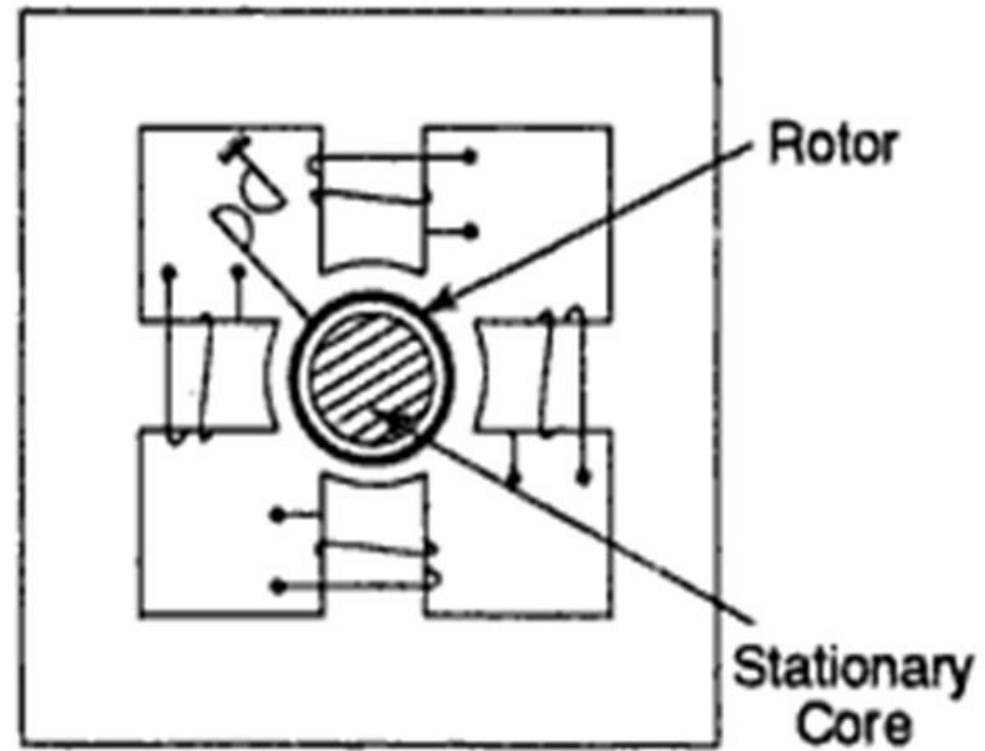
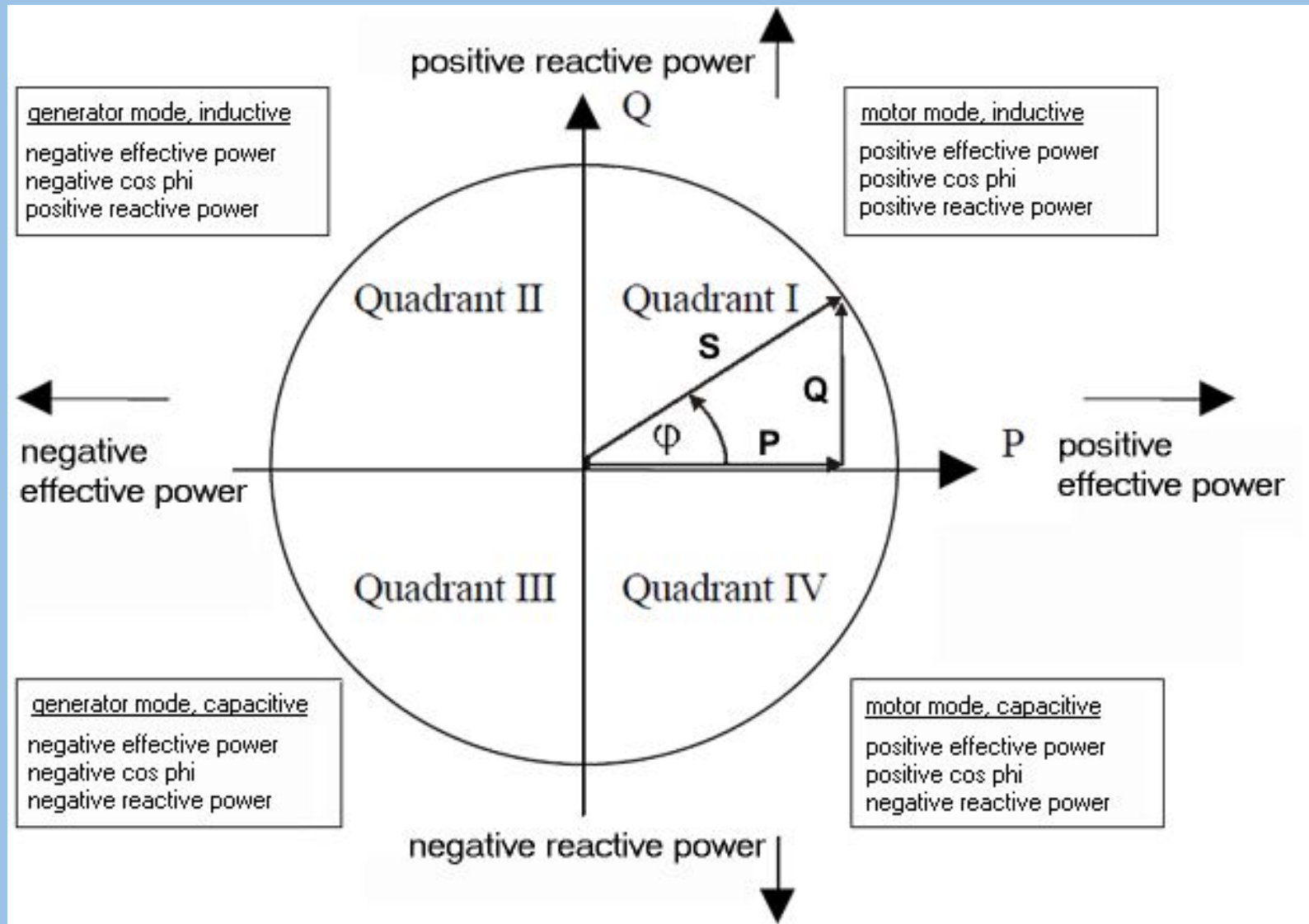


Fig. 2.10. Watthour Meter Type Induction Disc Relay

Induction Cup Relay





Directional Power Relay

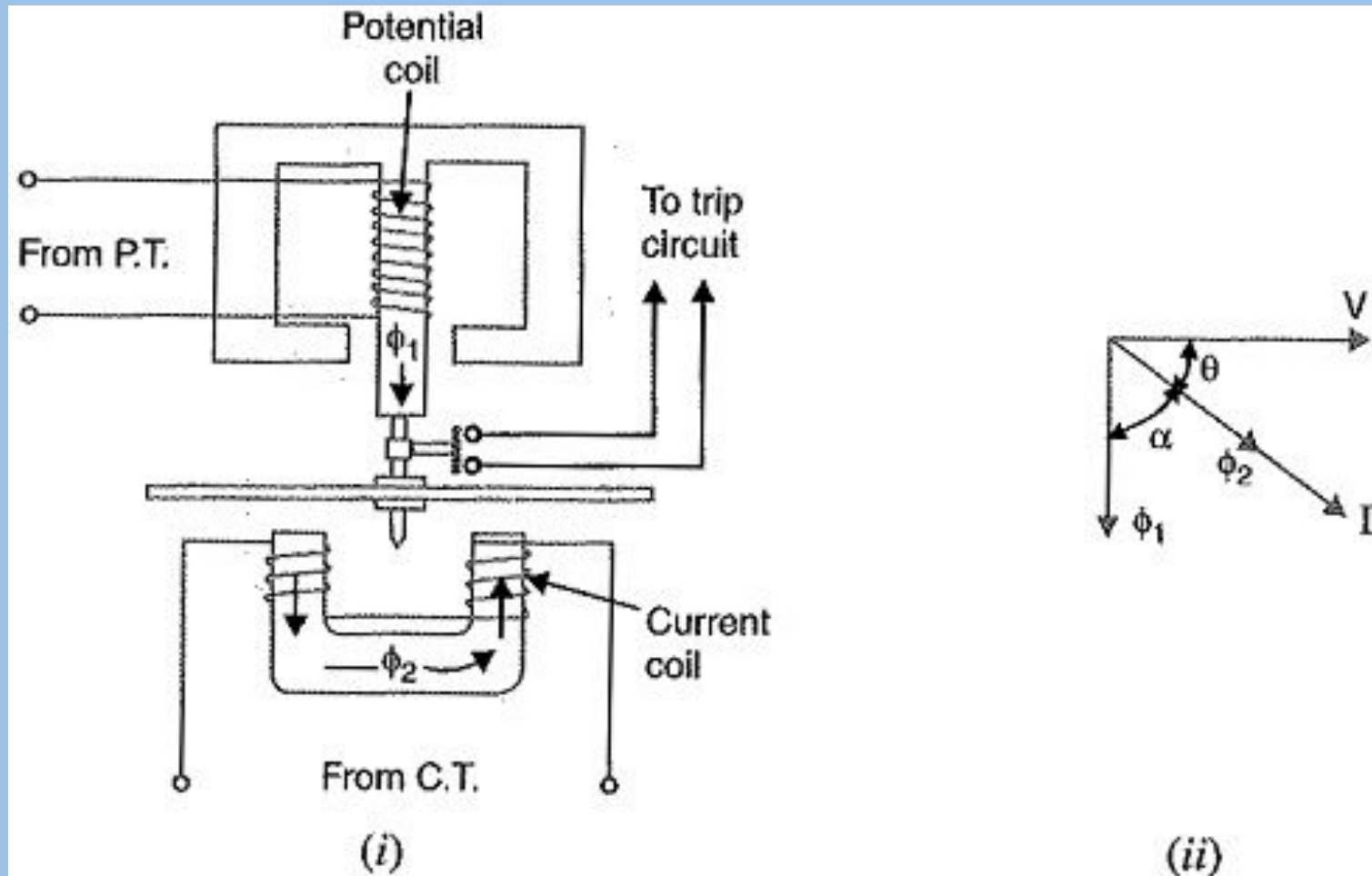
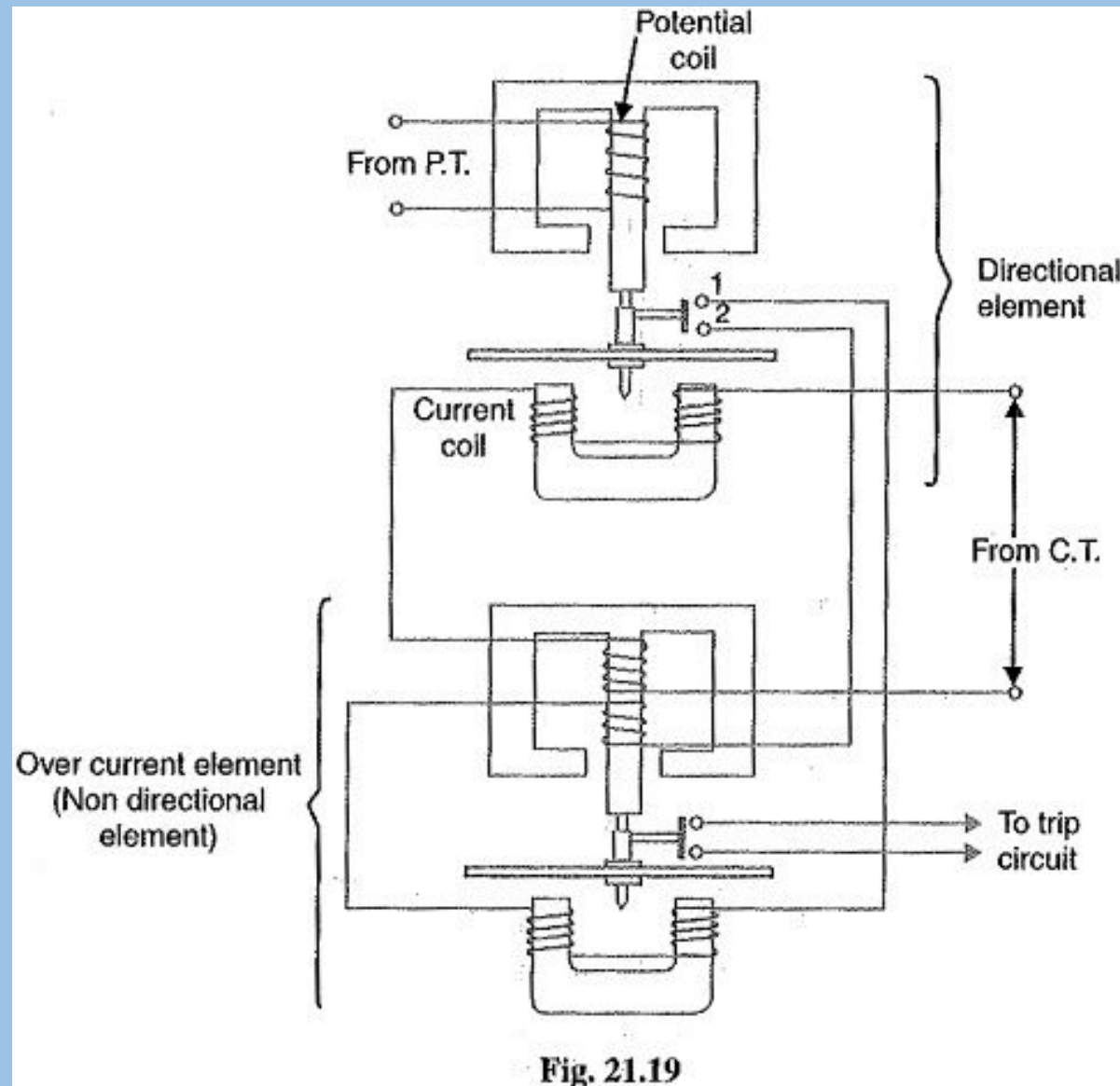
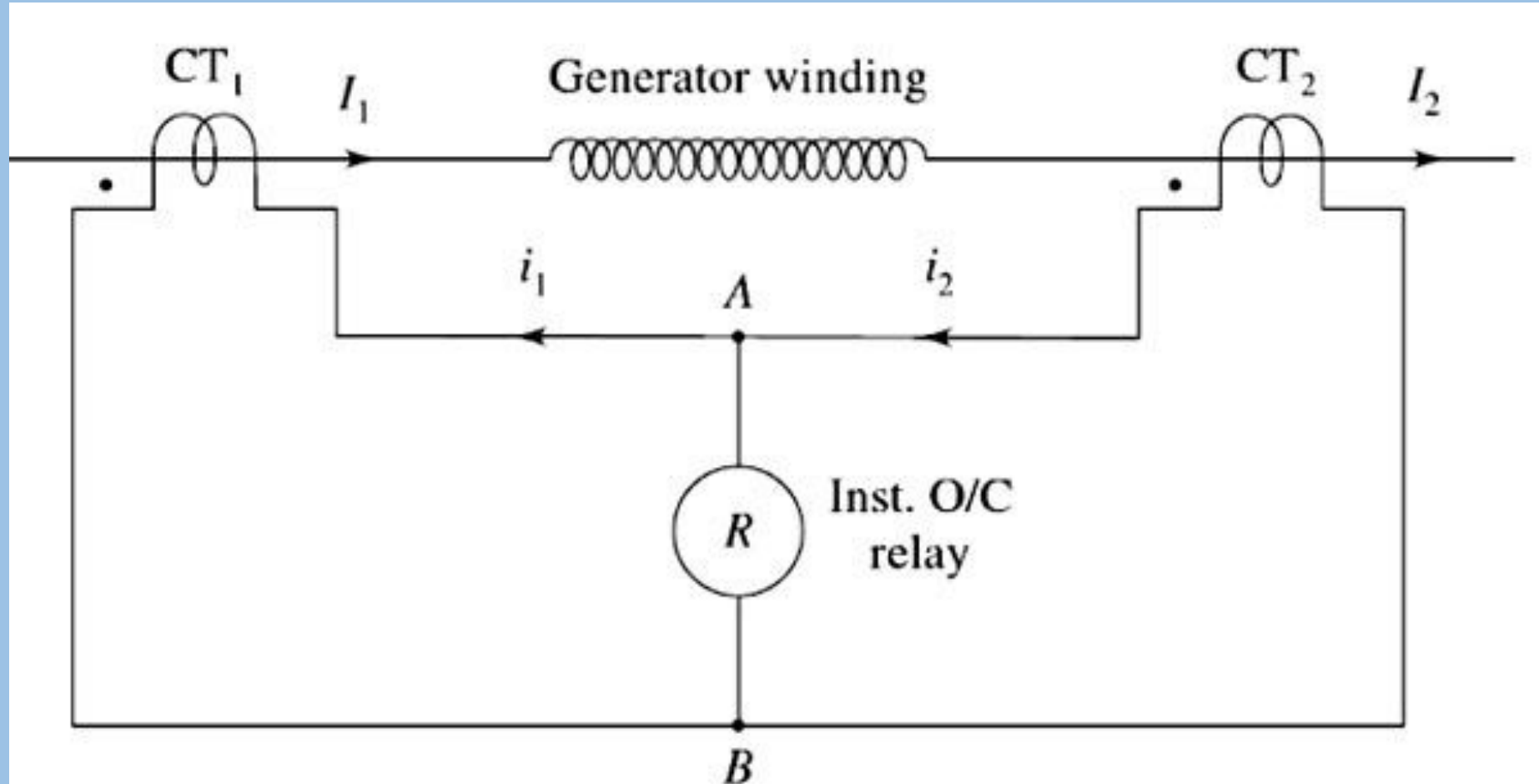


Fig. 21.18

Directional Overcurrent Relay

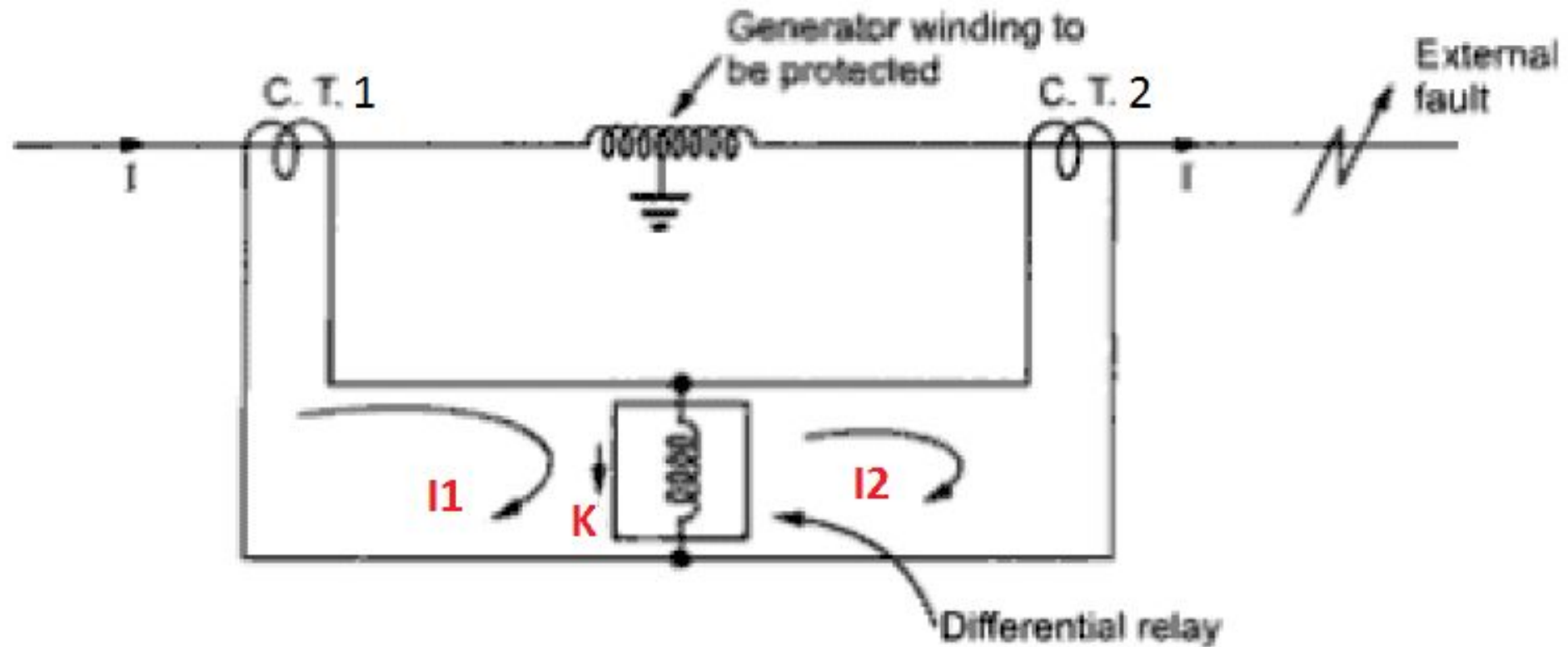


Differential Principle

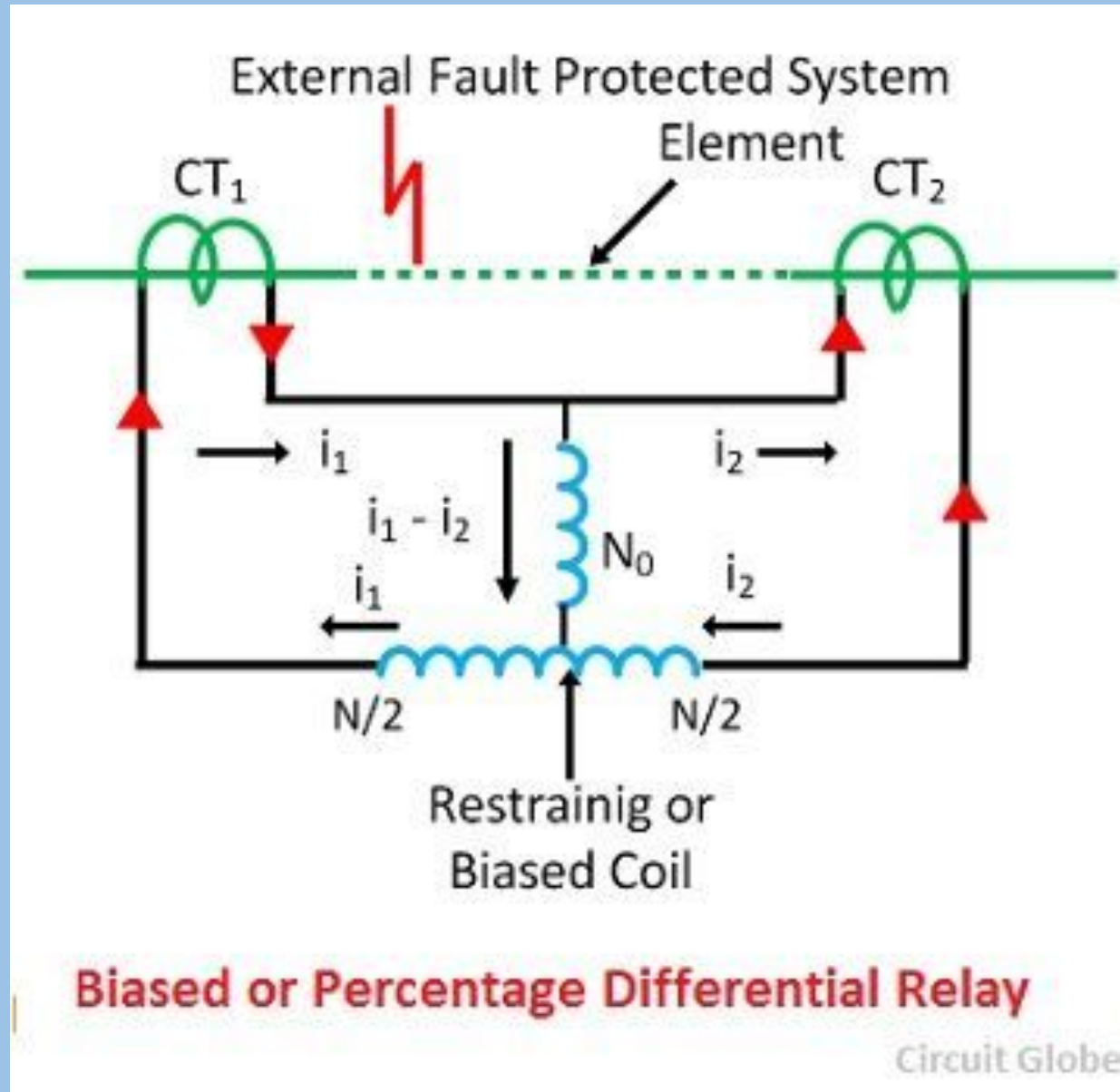


Principle of generator differential protection

Current Differential Relay



Percentage Differential Relay Principle



Distance Protection

