Power System Analysis

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Topics

1. *Symmetrical Fault Analysis*
2. *Unsymmetrical Fault Analysis*
3. *Power System Transients*
4. *Insulation coordination*
5. *Corona*
6. *Uncompensated Transmission Line*

Lightning & Protection of Power System Against Lightning.

Definition Of Lightning:

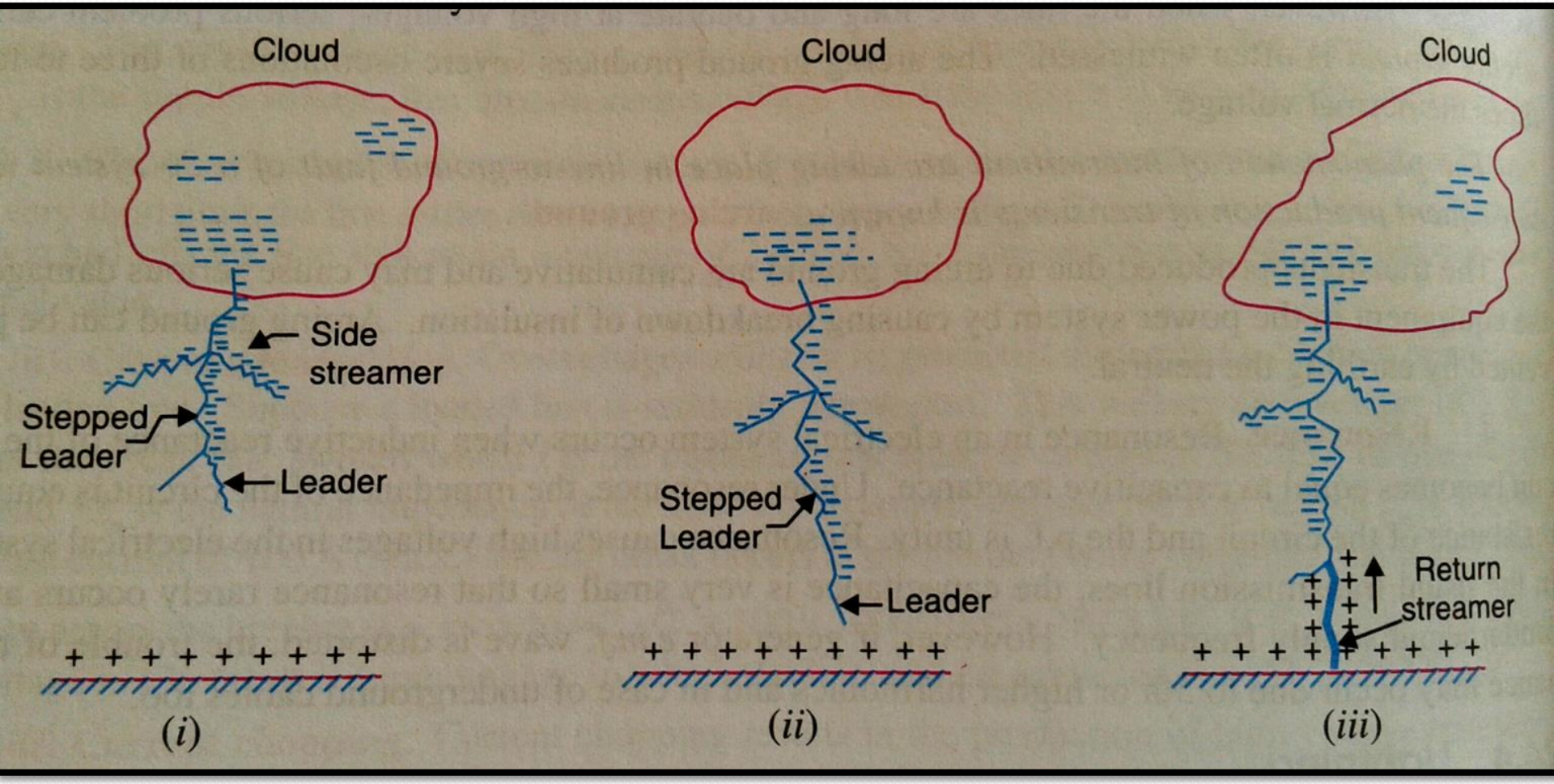
An Electric discharge between cloud & earth, between clouds or between charge centers of the same cloud is known as ***lightning****.*

Mechanism of Lightning : (Summary of Simpson & Scrase theory)

- *Lighting is a huge spark takes place when clouds are charged to a high potential with respect to the earth or neighbouring cloud & dielectric strength of air gets destroyed.*
- *During the uprush motion of warm air friction between air & tiny particles of water causes building up of charges.*
- *Larger drops becomes positively charged & smaller drops become negatively charged.*
- *Hence potential of cloud depends upon the droplets it contains.*
- *Due to increase in charge of the cloud to high value it gets discharged to the earth or to the neighbouring cloud & tries to attain electrical Stability.*
- *That discharge appears in the form of huge spark that we call as Lightning.*

Mechanism of Lightning Discharge:

- *Charged cloud induces equal & opposite charge on the earth below.*
- *Clouds are generally negatively charged hence they induces positive charge on earth as shown in fig.*
- *Electrical discharge or lightning takes place when potential gradient is above 5 kV/cm to 10 kV/cm. This results in lightning stroke.*
- *Streamer which passes towards the earth is known as leader streamer.*
- *Path of leader streamer is a path of ionization, as the leader streamer reaches to the earth a return streamer shoots up from the earth to the cloud which follows same path of leader streamer. This completes lightning action.*
- *Any further discharge or lightning from the cloud may have to originate from some other portion from it.*


Cloud
Side
streamer
Stepped
Leader
Leader
(i)
Cloud
Stepped
Leader
Leader
(ii)
Cloud
Return
streamer
(iii)

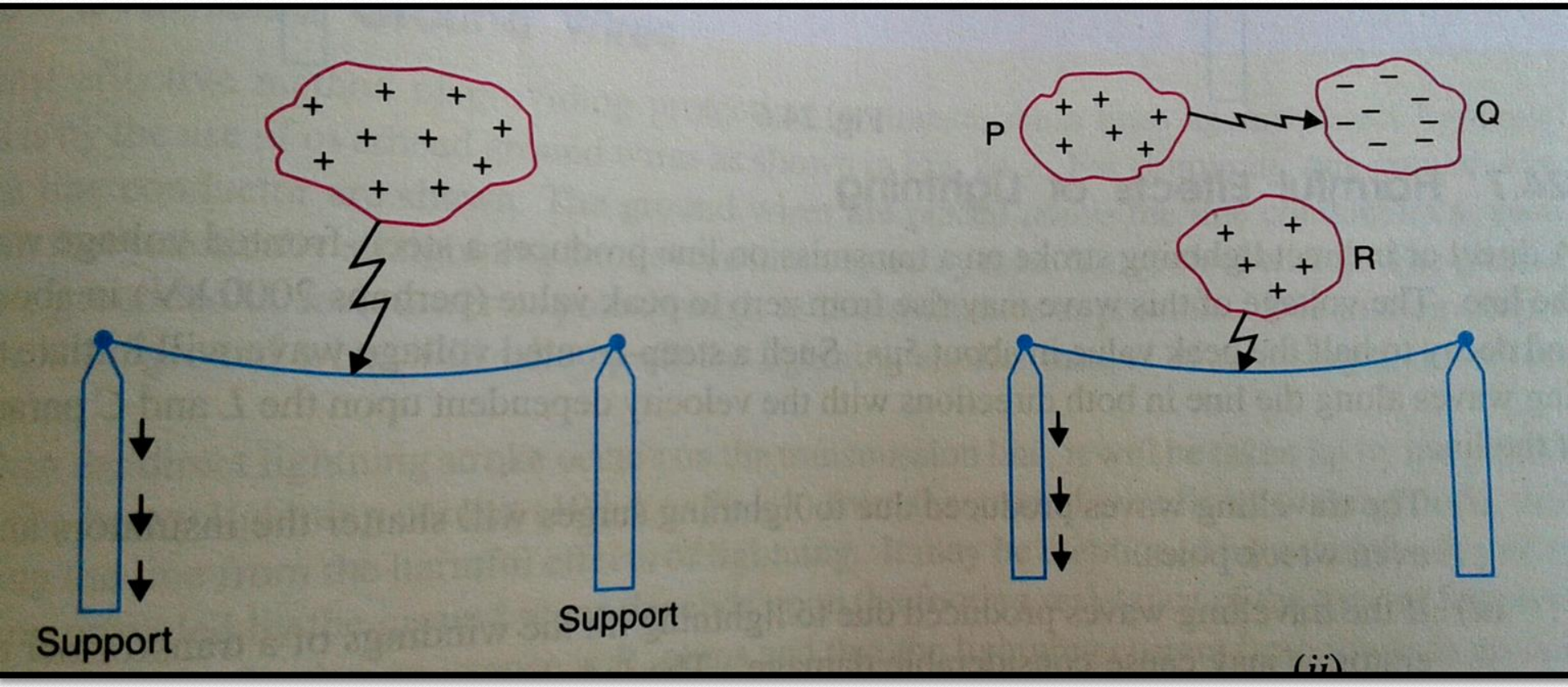
Types of Lightning Strokes :

1) **Direct Strokes**
2) **Indirect Strokes**

- **Direct Stroke** : *When lightning discharge takes place directly from cloud to the earth or to the equipment on the earth such as transmission lines then it is called as Direct lightning stroke.*

- **Indirect Stroke** : *Indirect strokes result from the electrostatically induced charges on the conductors due to the presence of the charged clouds.*

Direct Stroke



Indirect Stroke

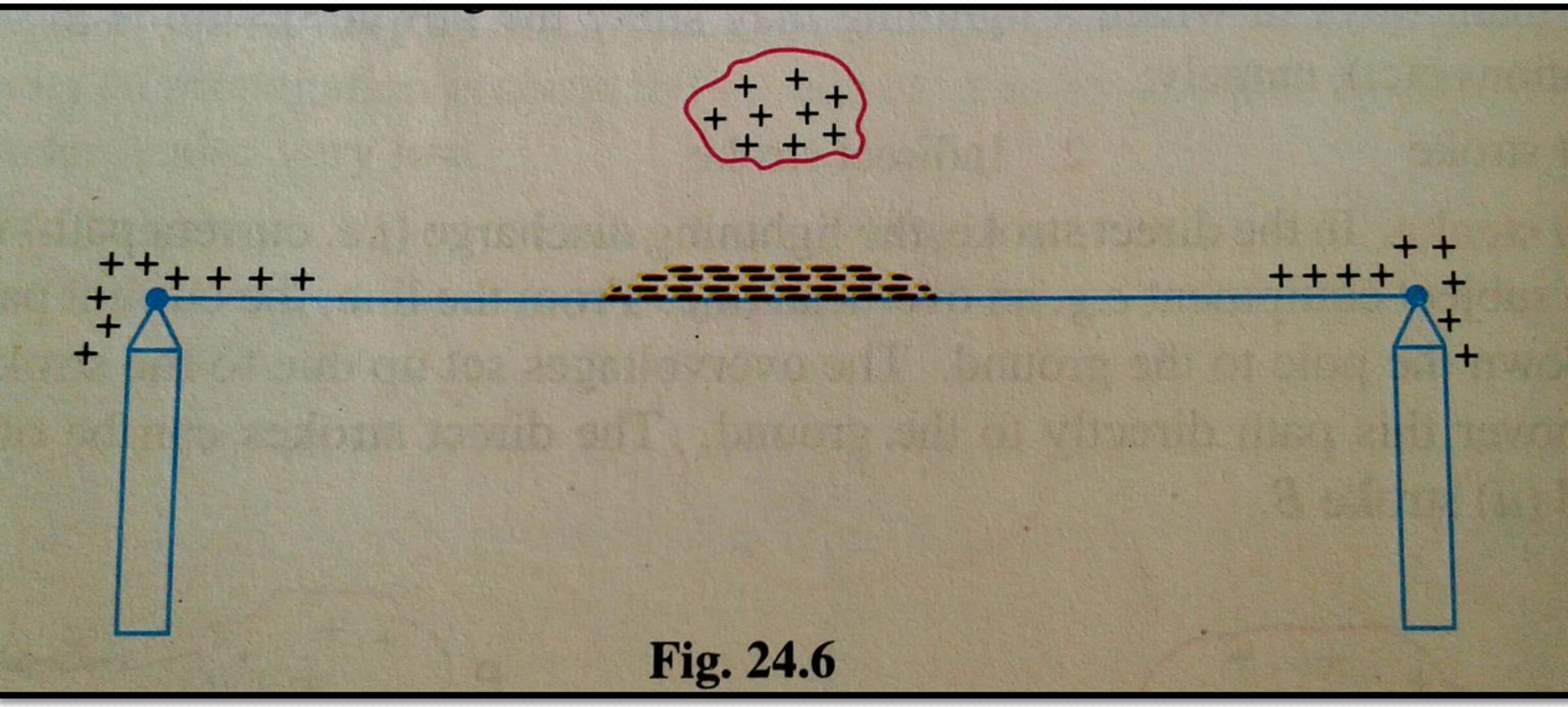


Fig. 24.6

Silent features of Lightning :

✓ *Lightning discharge is made up of number of separate strokes those travel down the same path. The interval between them varies from 0.0005 to 0.5 second.*

✓ *About 87% of lightning strokes are due to negatively charged clouds & only 13% are due to positively charged clouds.*

✓ *Throughout the world there occur about 100 lightning strokes per second.*

✓ *Lightning discharge may have currents in the range of 10 kA to 90 kA.*

✓ *The velocity of lightning stroke varies from 10% to 50% of that of light.*

Harmful Effects of Lightning :

1) *Direct or indirect stroke on transmission line produces a steep fronted voltage wave on line which may rise from zero to peak value (perhaps 2000 kV) in about 1 microsecond & decay to half the peak value in about 5 microseconds.*
2) *Travelling waves produced due to lightning surges will shatter the insulators and may even wreck poles.*
3) *Travelling waves produced due to lightning may damage the part where those hit or strikes.*
4) *Insulation failure may occur due to lightning, particularly in case of transformers, alternators etc.*
5) *Formation of Arc may possible due to very excessive heat which is involved in lightning stroke. This arc can abruptly damage Electrical system because it sets up very disturbing oscillations in the system.*

Protection Against Lightning :

1) Earthing Screen
2)Overhead ground wires
3)Lightning arresters or surge diverters

The Earthing Screen :

- *Power stations or substations can be protected by direct lightning strokes with the help of these Earthing Screen.*

- *It consists of network of copper conductors (generally called shield or screen) mounted all over the Electrical equipment in the power station or sub station.*

- *The shield is properly connected to the earth on at least two points through low impedance.*

Overhead Ground Wires :

- *Most effective method for providing protection to transmission lines against direct strokes.*

- *These wires are placed above the line conductors in such a way that practically all lightning strokes are intercepted by them.*

- *Ground wires are grounded at each pole or tower to provide low resistive grounding path to the lightning stroke.*

Overhead Ground Wires

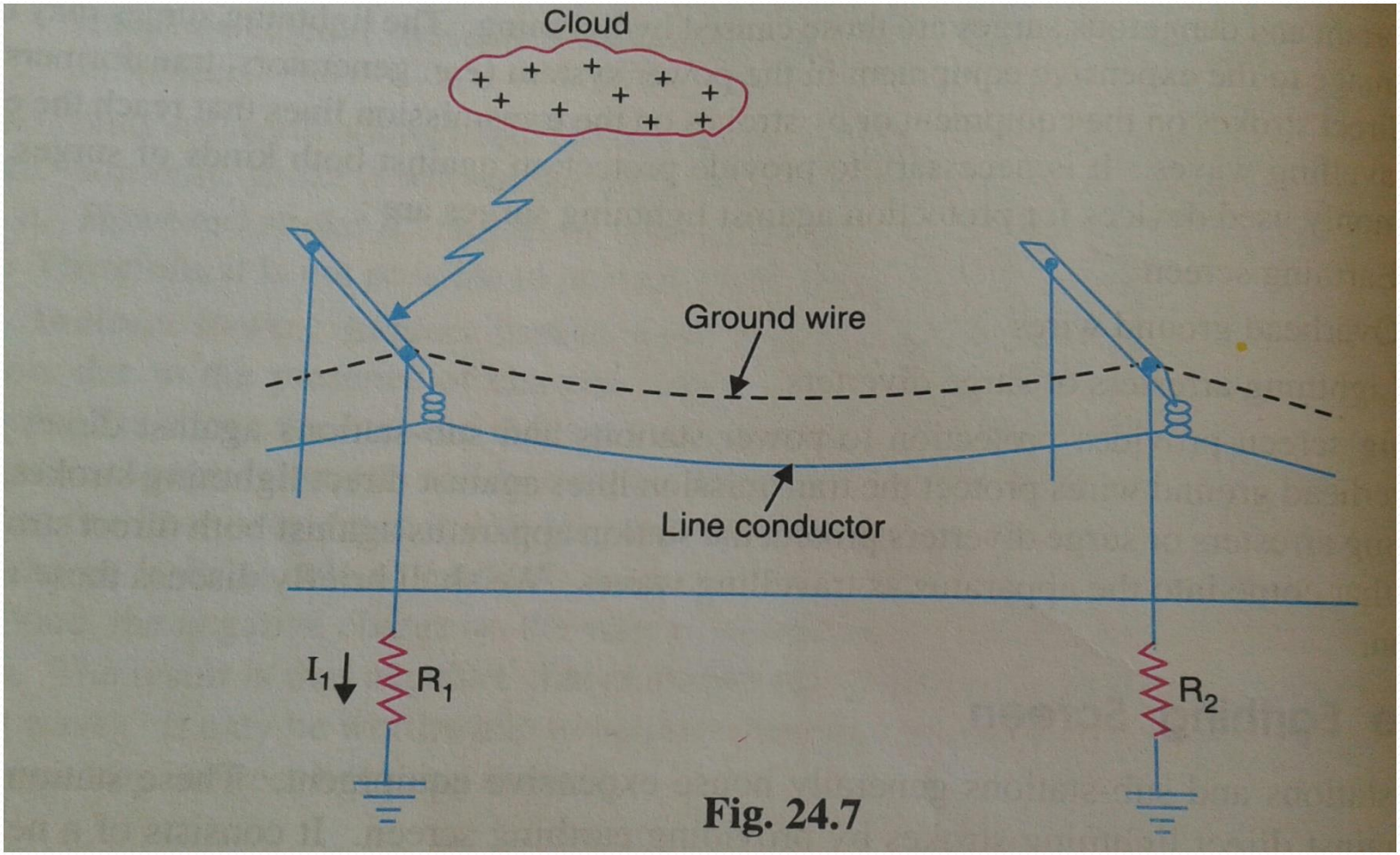


Fig. 24.7

Advantages & Disadvantages of Overhead Ground Wires :

Advantages :

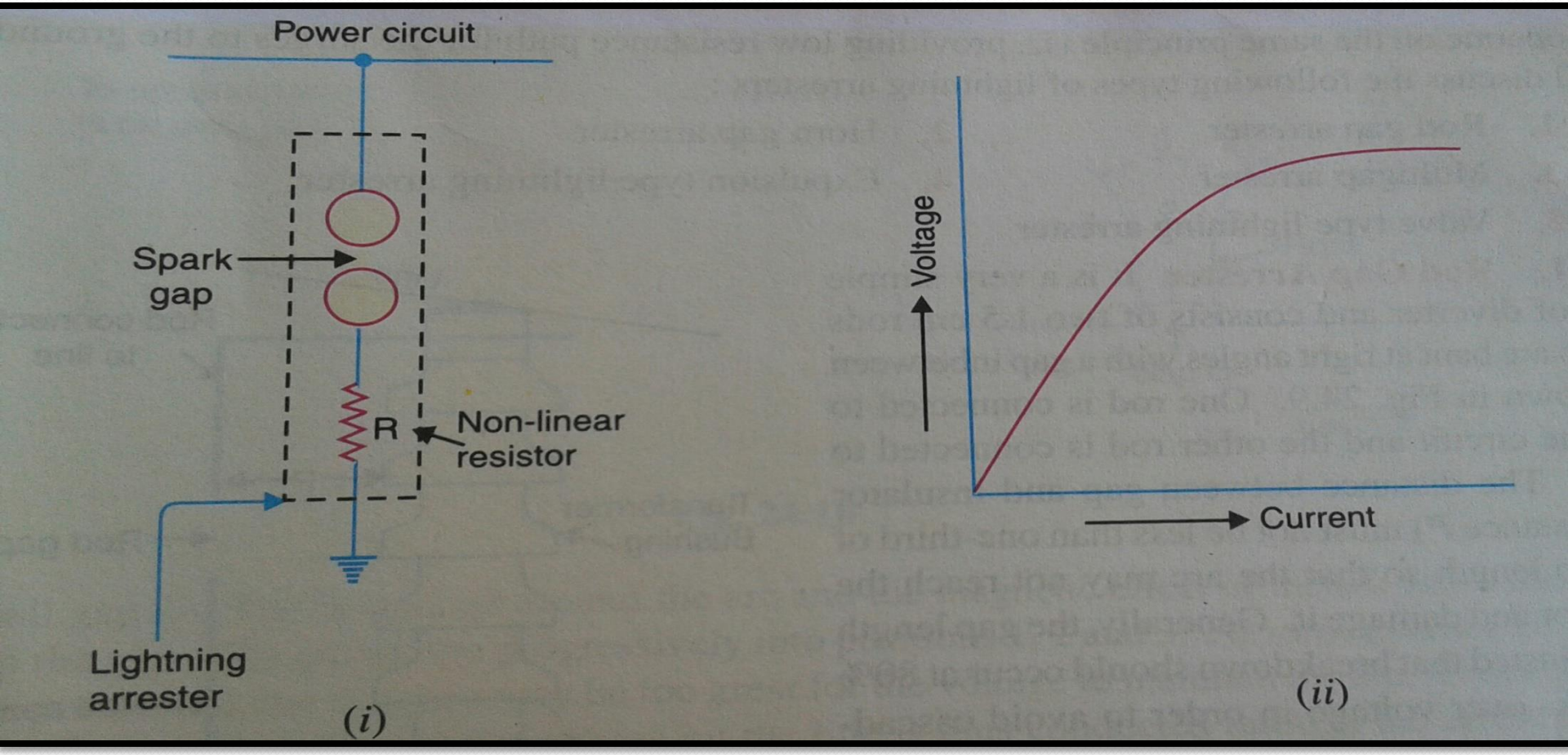
- *Provides considerable protection against direct lightning strokes on transmission lines.*
- *provides certain amount of electrostatic shielding against external fields which reduces voltage induced in the line conductors due to discharge of neighbouring cloud.*

Disadvantages :

- *Requires additional cost.*
- *There is a possibility of breaking & falling on line conductor henceforth causing short circuit. However this disadvantage has been overcome by using galvanised stranded steel conductors which provides sufficient strength to the wire.*

Lightning arresters :

A Lightning arrester is a protecting device which conducts the high voltage surges on the power system to the ground.



❖ *It consists of a Spark Gap in series with the non-linear resistance.*

❖ *One end of Surge Arrester is connected to the equipment to be protected & other end is effectively grounded.*

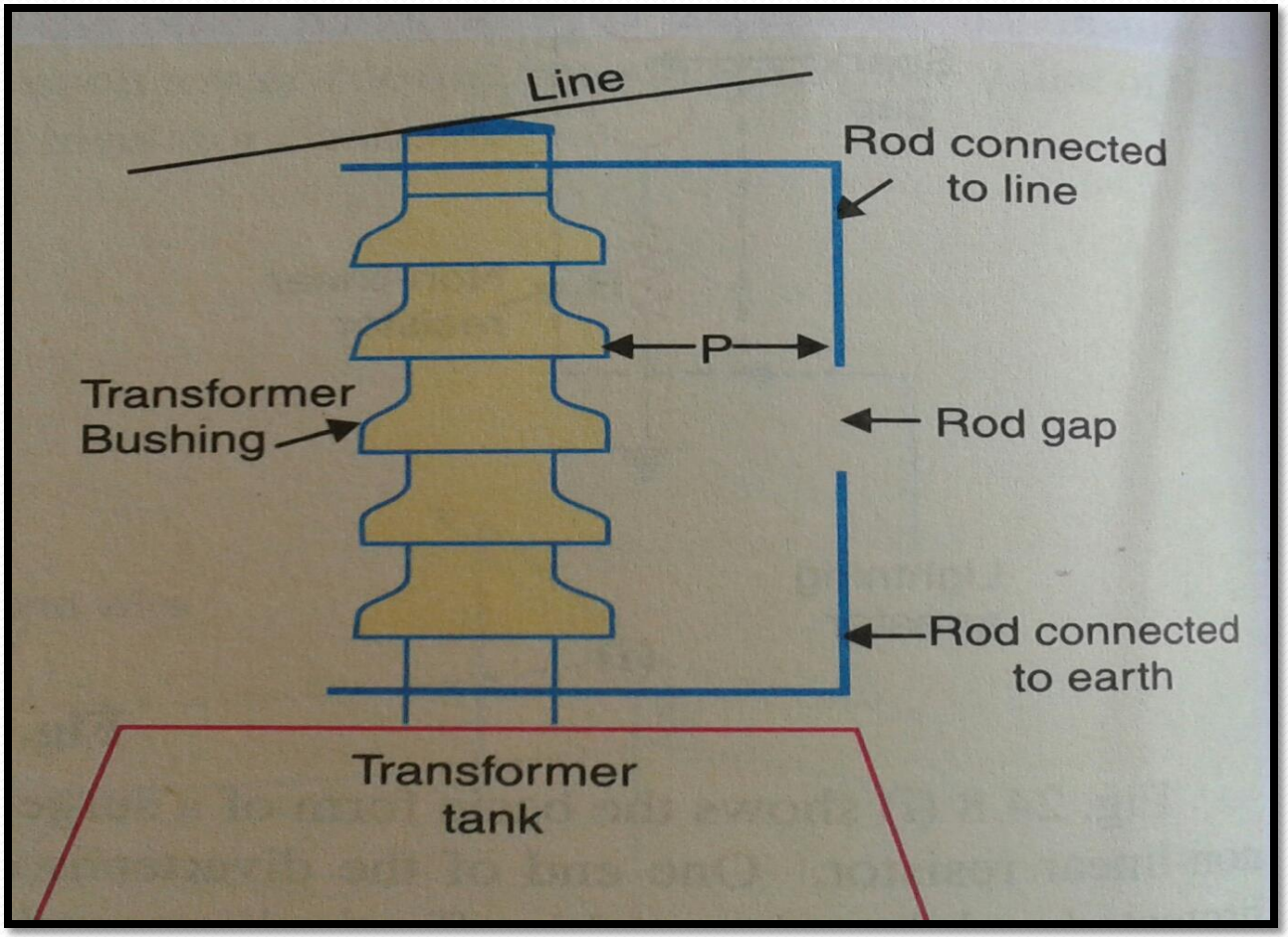
❖ *An electric spark forms in spark gap under abnormal condition (lightning) by breaking insulation capacity of air.*

❖ *Non-linear resistance decreases as the voltage or current increases.*

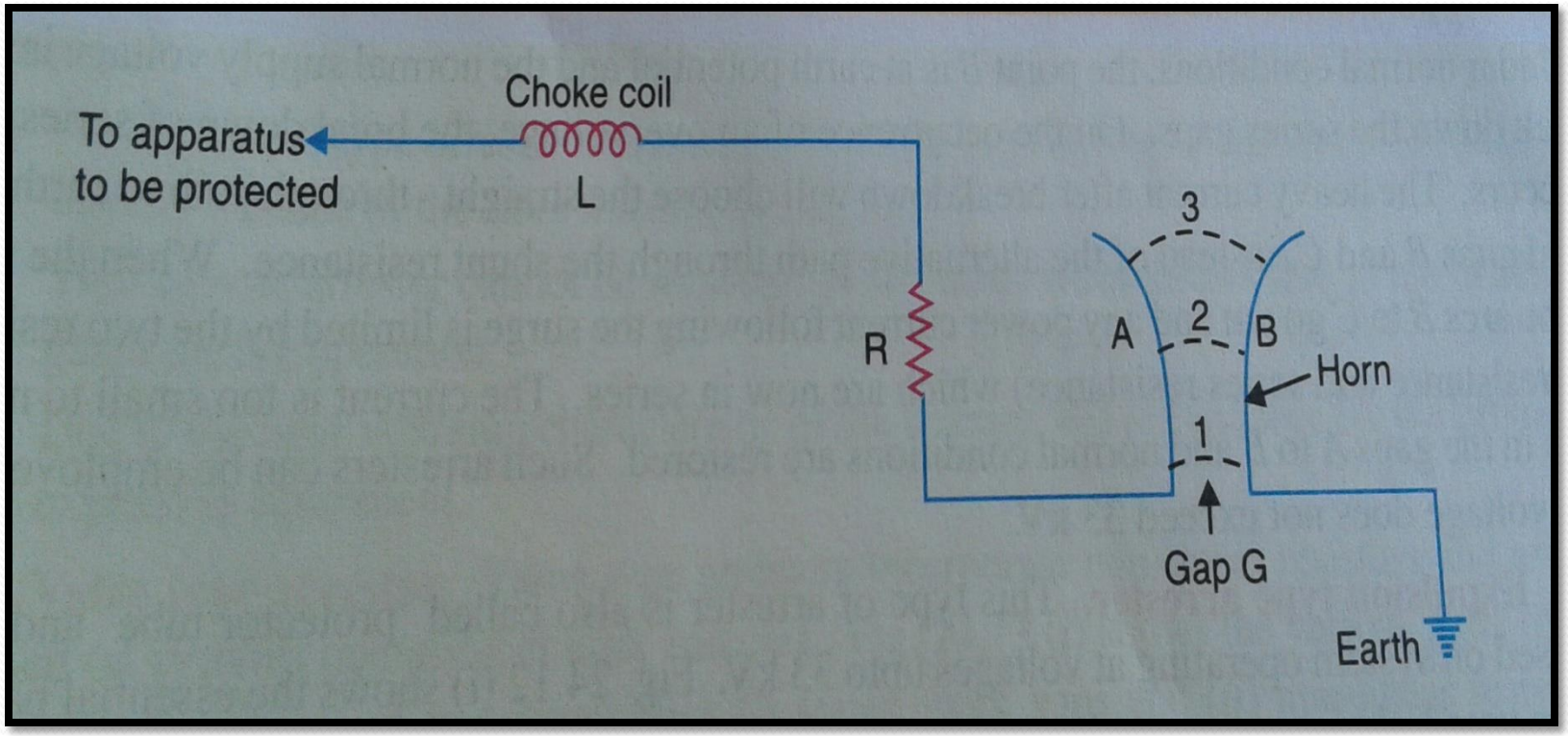
Types of Lightning Arresters :

- *Rod Gap Arrester*
- *Horn Gap Arrester*
- *Multigap arrester*
- *Expulsion type lightning Arrester*
- *Valve Type Lightning Arrester.*

Rod Gap Arrester



Horn Gap Arrester



Advantages :

- *Arc is self clearing hence no possibility of short circuit.*
- *Series resistance limits current to very low value.*

Limitations :

- *The bridging of gap by some external agency (birds) can render the device useless.*
- *Setting of horn gap can change due to corrosion.*
- *Time of operation is long.*

Multigap Arrester :

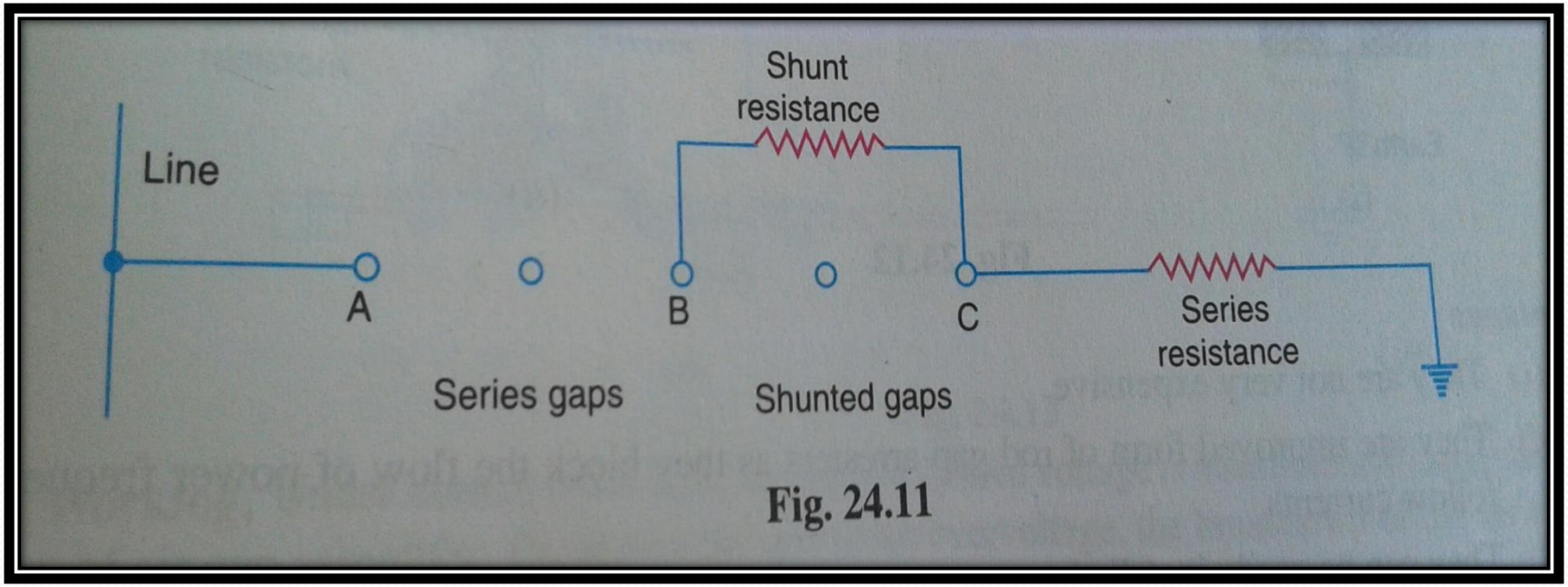


Fig. 24.11

Expulsion type Arrester :

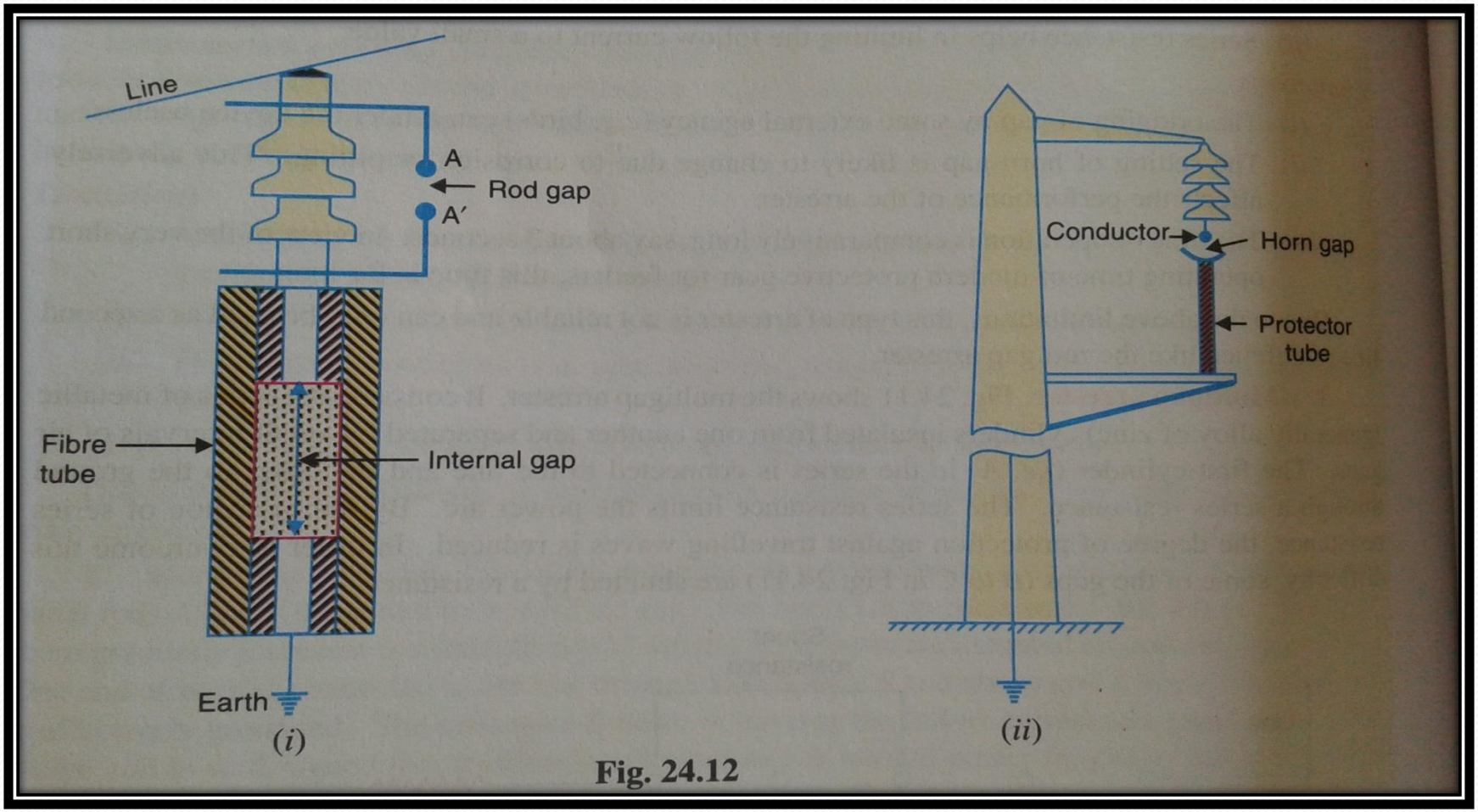


Fig. 24.12

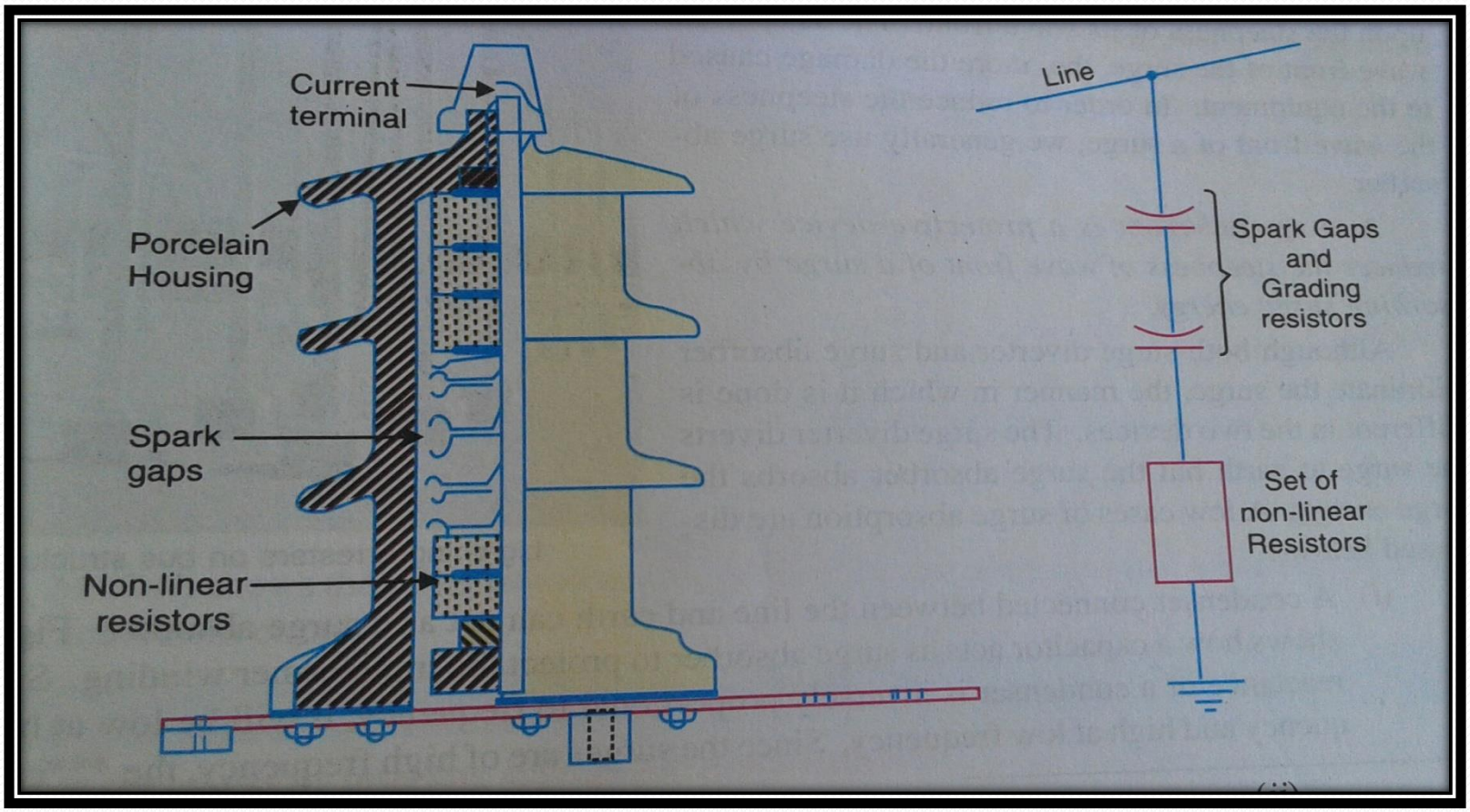
Advantages :

- *Not much expensive.*
- *Easy to install.*
- *Improved performance.*

Limitations :

- *Limited number of operations are possible because fiber material is used up during each operation.*
- *Discharge of gases during operation hence can not mounted in enclosed equipment.*
- *Poor Volt- Ampere characteristics.*
- *Not suitable for protection of expensive equipments.*

Valve type Arrester :



Advantages :

- *Very effective protection against surges.*
- *Operation is very quick & rapid (Less than 1 second).*

Limitations :

- *Performance is adversely affected by the entry of moisture into the enclosure.*

Thank You..!