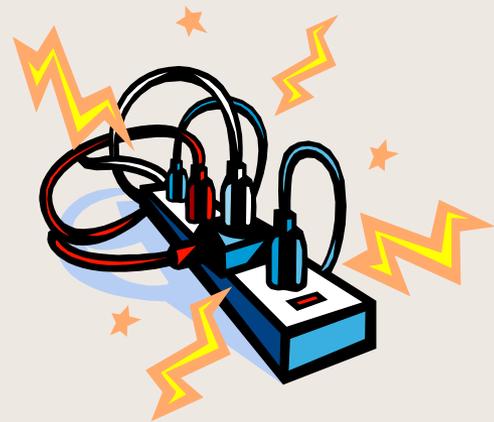


Electrical Protection



Electrical Faults

- Phase to phase
- Phase to ground
- Phase to phase to phase
- Phase to phase to phase to ground



Purpose of Protection System

- Minimize damage
- Leave unaffected equipment in-service
- Maintain equipment operating limits
- Maintain electrical system stability

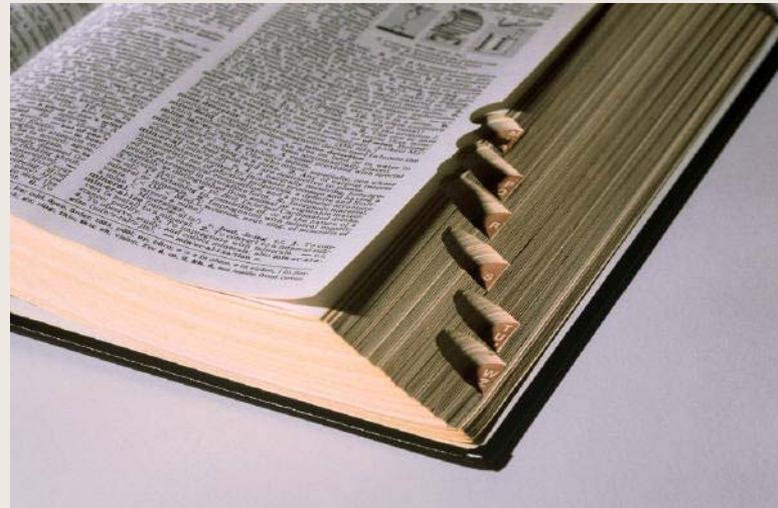


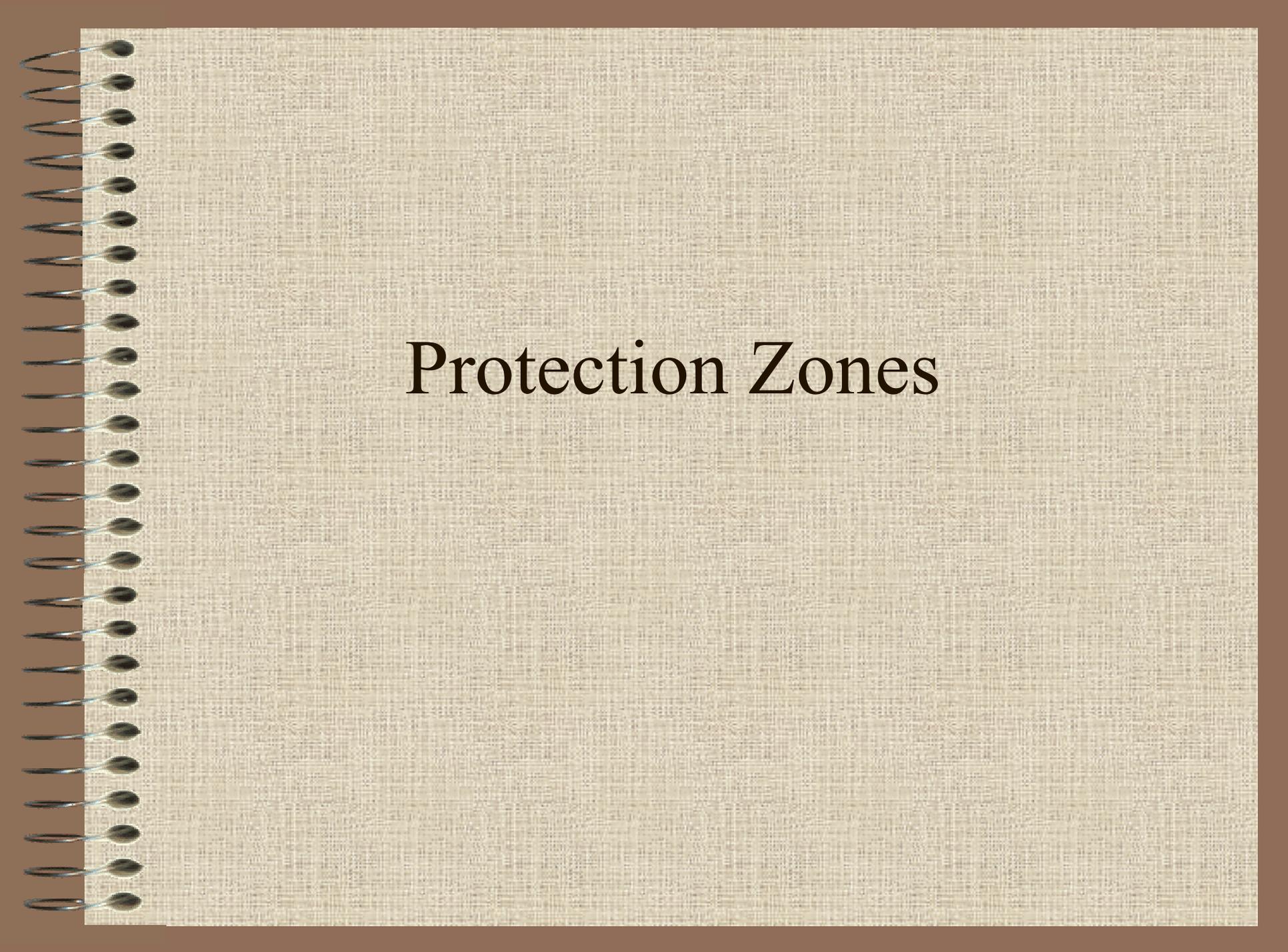
Requirements of a Protection System

- Speed
- Reliability
- Security
- Sensitivity

Some terms

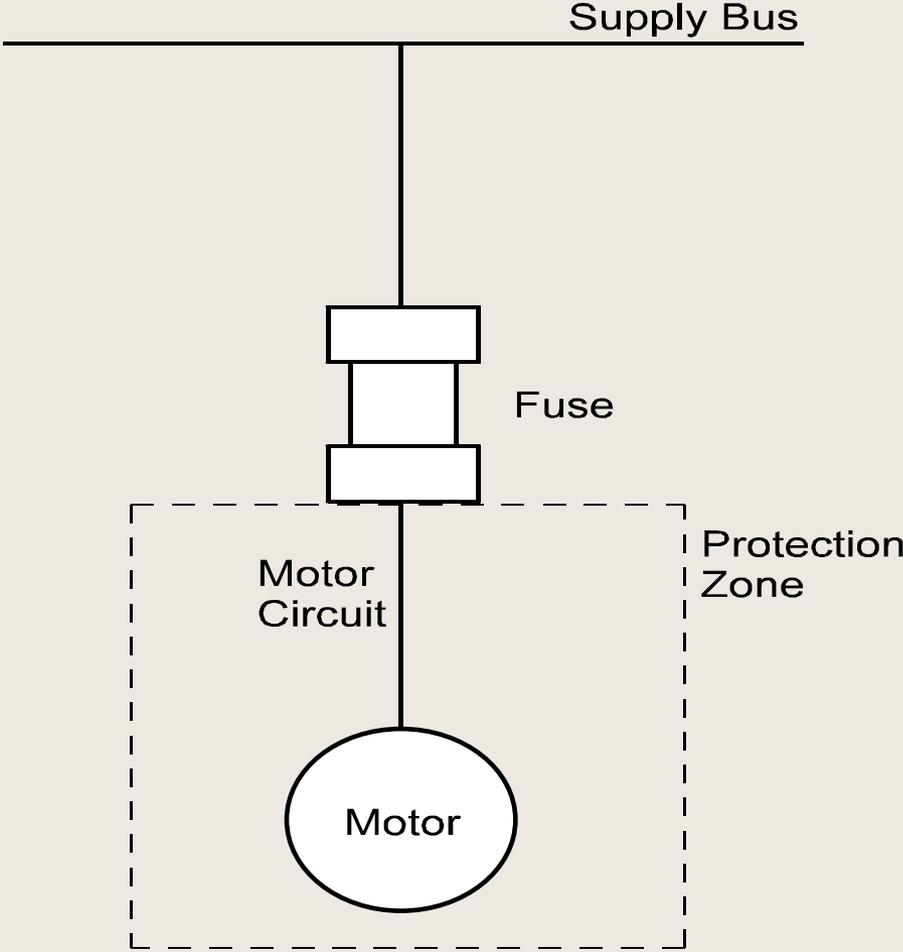
- Over-current
- Overload
- Inverse time



A spiral-bound notebook with a light beige, textured cover. The metal spiral binding is on the left side. The text "Protection Zones" is printed in the center of the cover in a black, serif font.

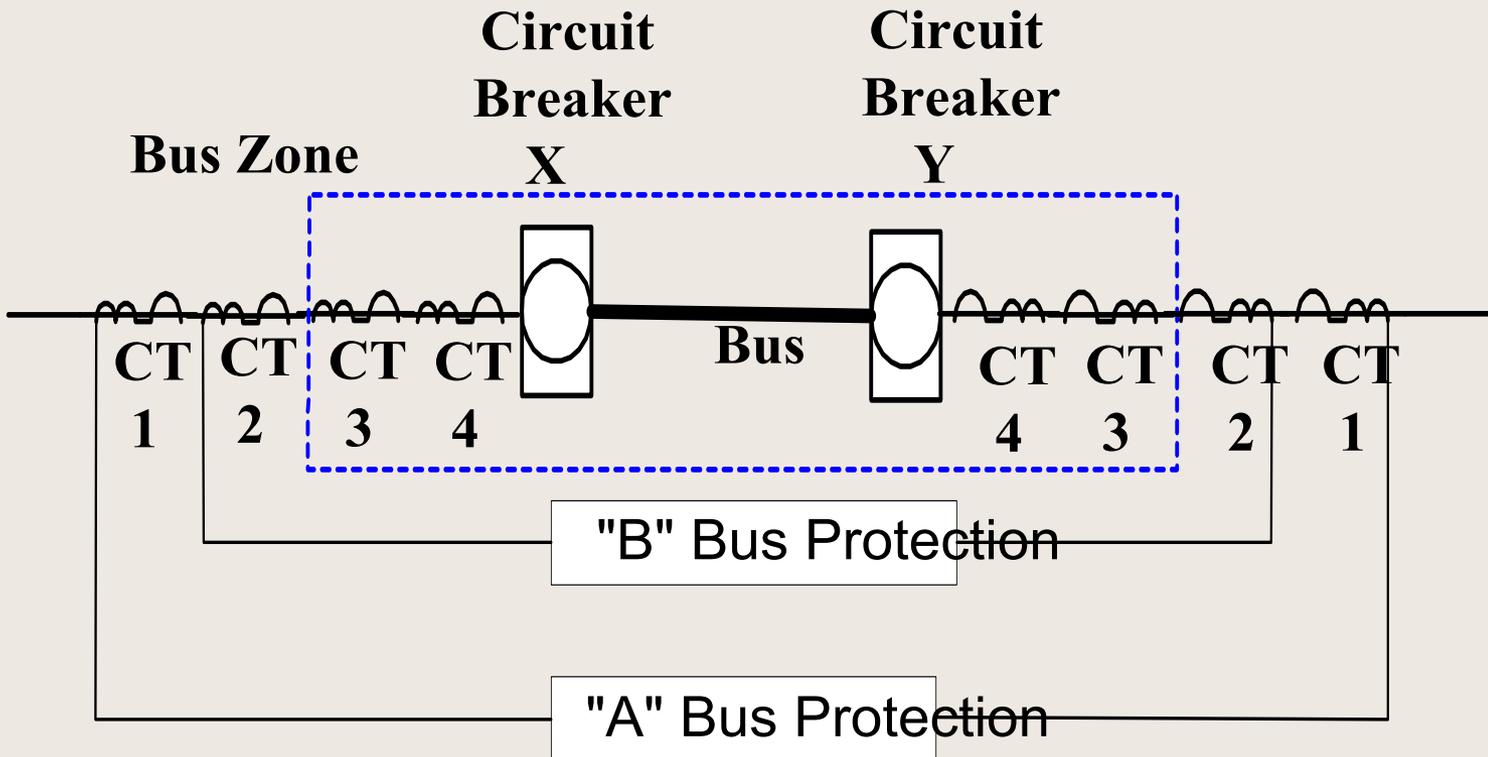
Protection Zones

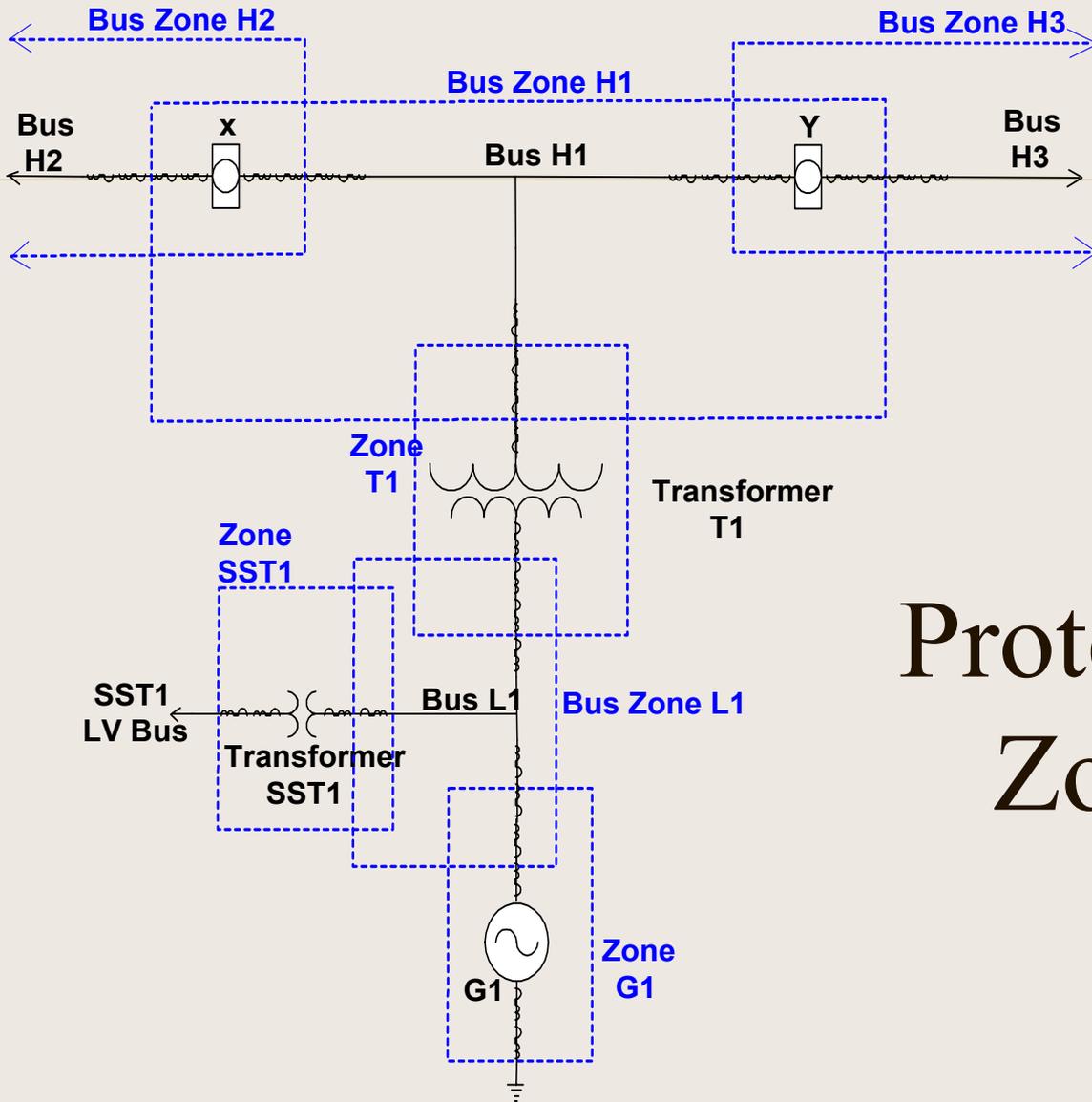
Simple Zone





Double Protection

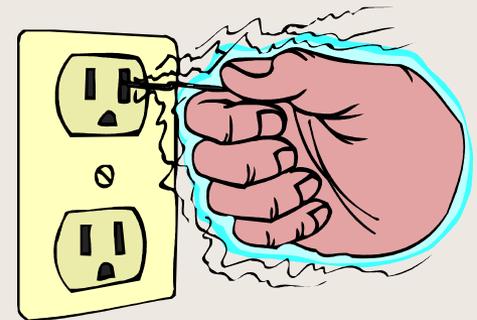




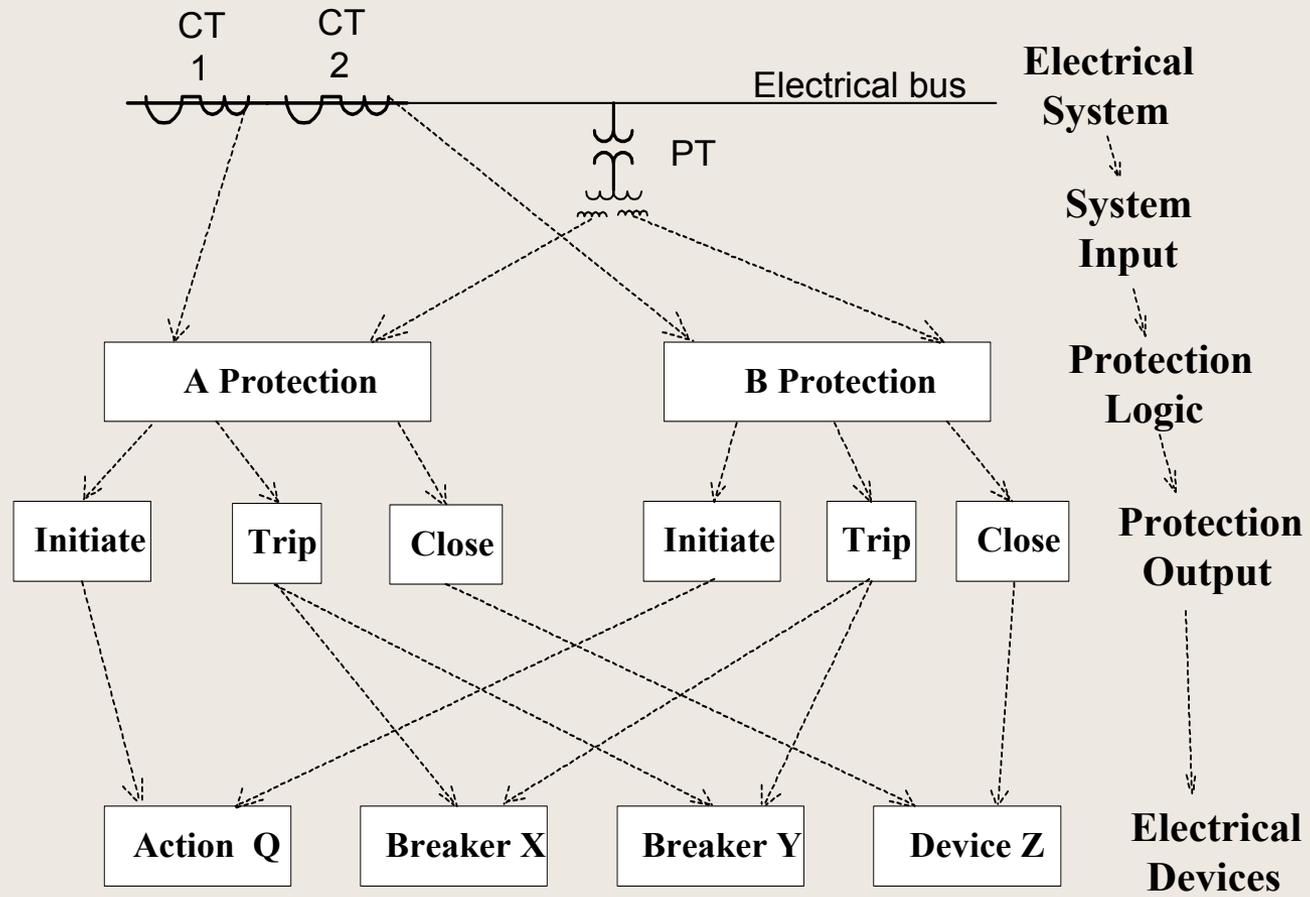
Protection Zones

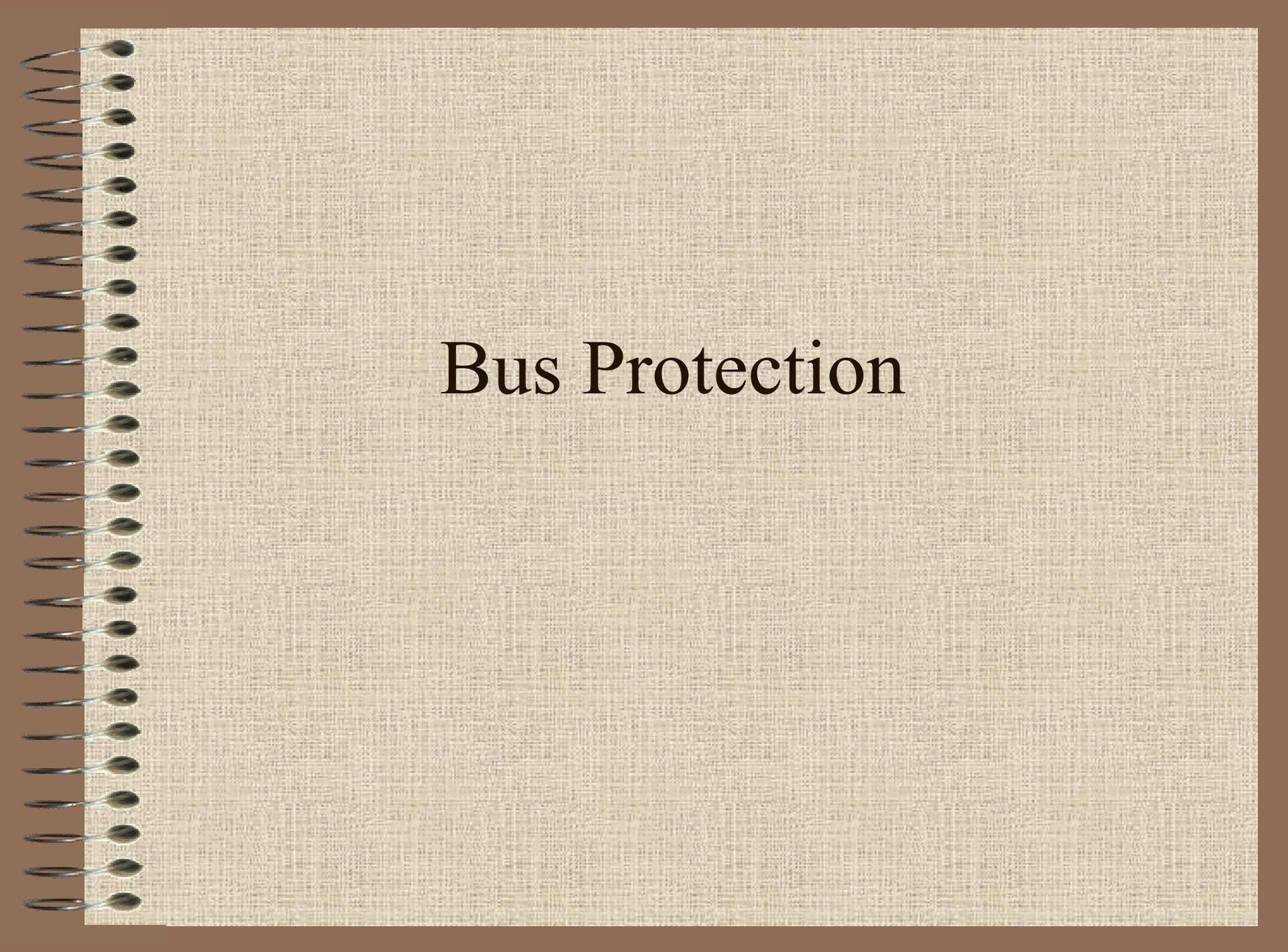
Breaker Failure

- Minimizes the amount of equipment removed from service in event of a failure
- Failure Determination
 - Not started opening in a certain time
 - Not open in a certain time
 - Current not broken in a certain time



Duplicate Protection Schemes



A spiral-bound notebook with a light beige, textured cover. The spiral binding is on the left side. The text "Bus Protection" is centered on the cover in a black, serif font.

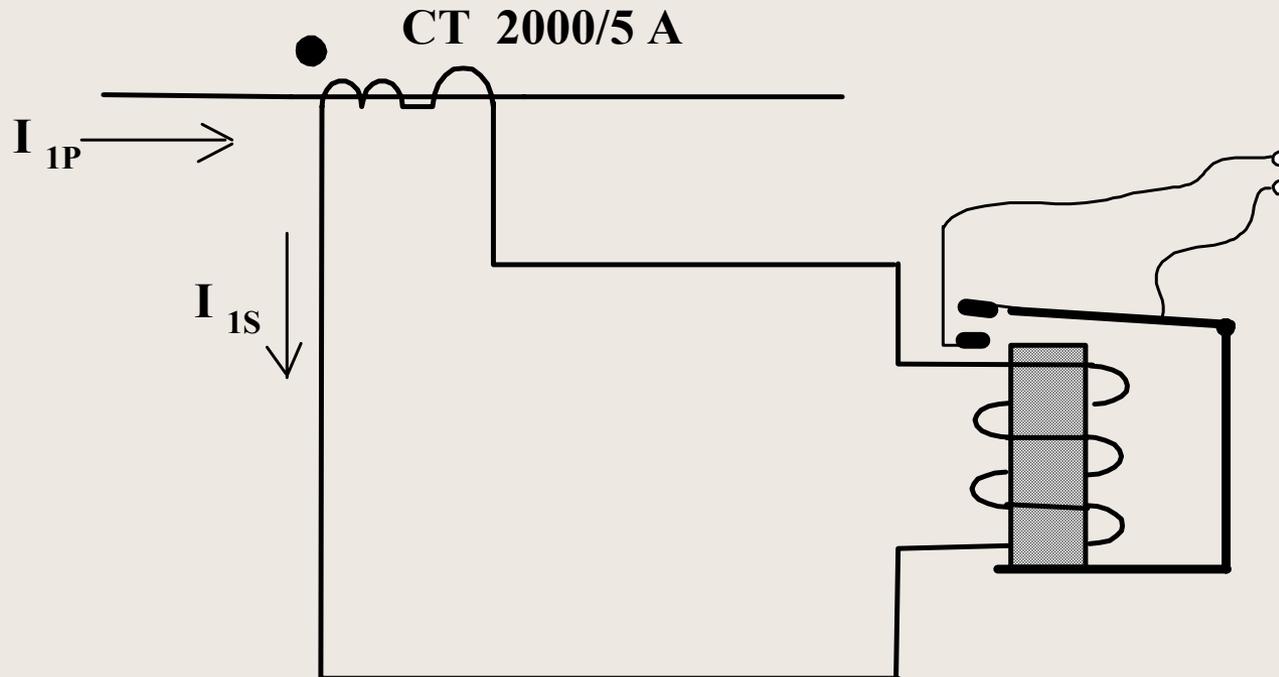
Bus Protection

Bus Protection

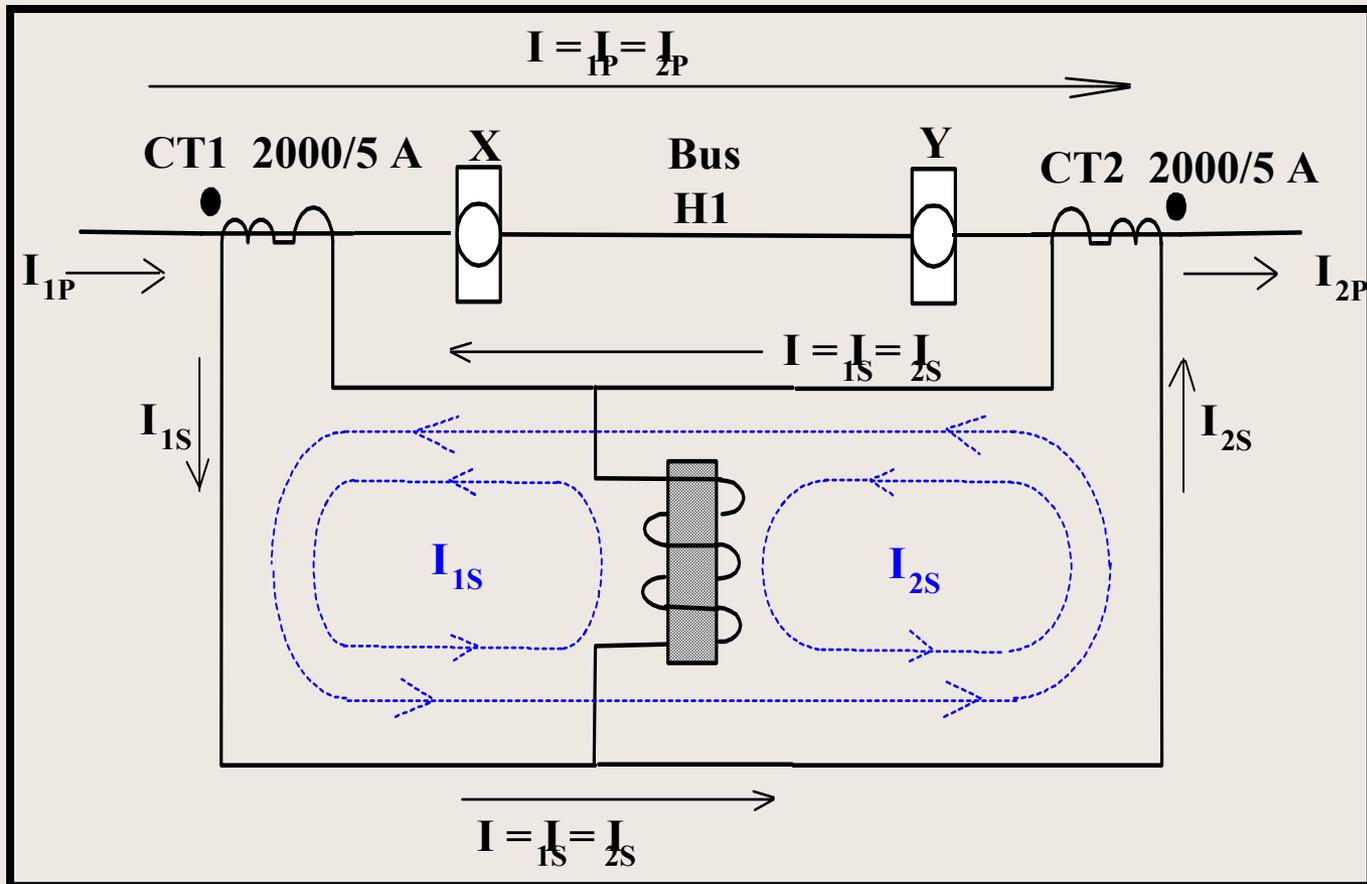
- Over-current
- Differential
- Back-up
- Under voltage



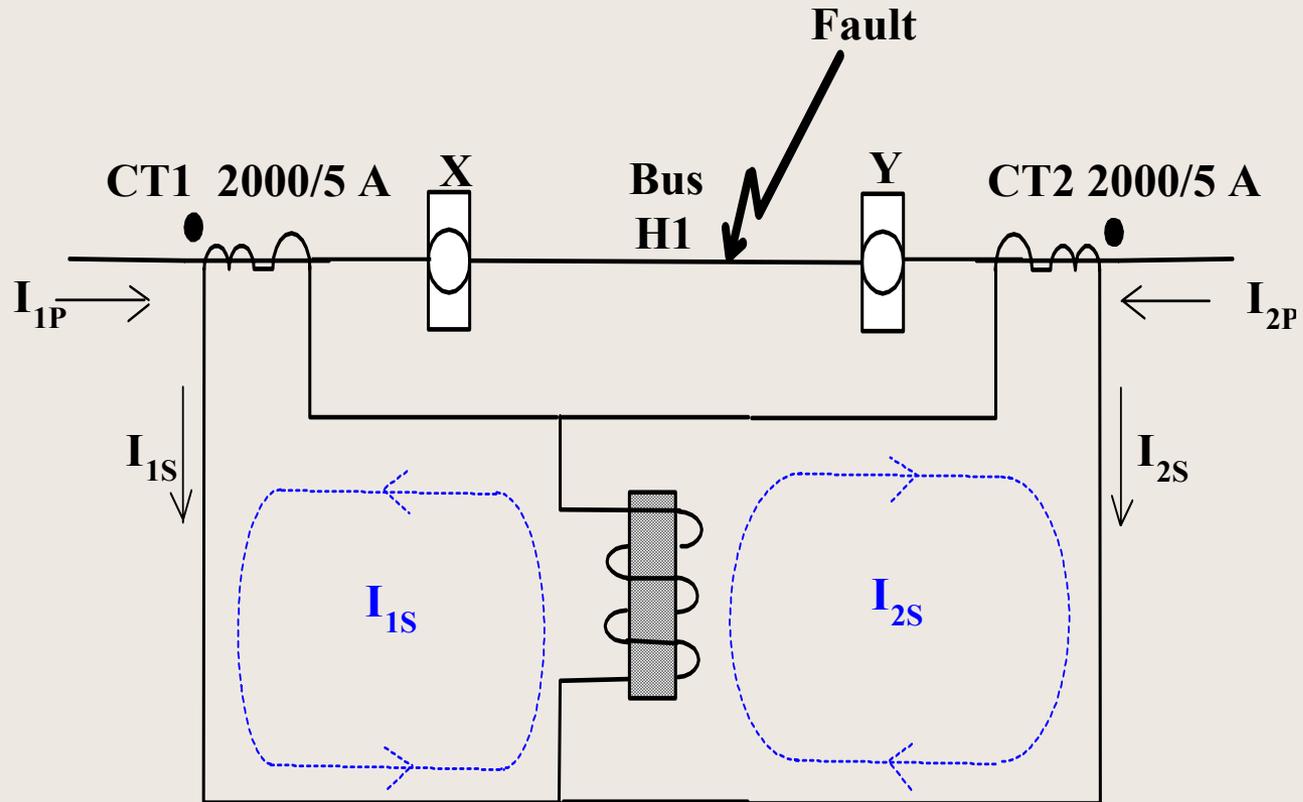
Over-current Relay

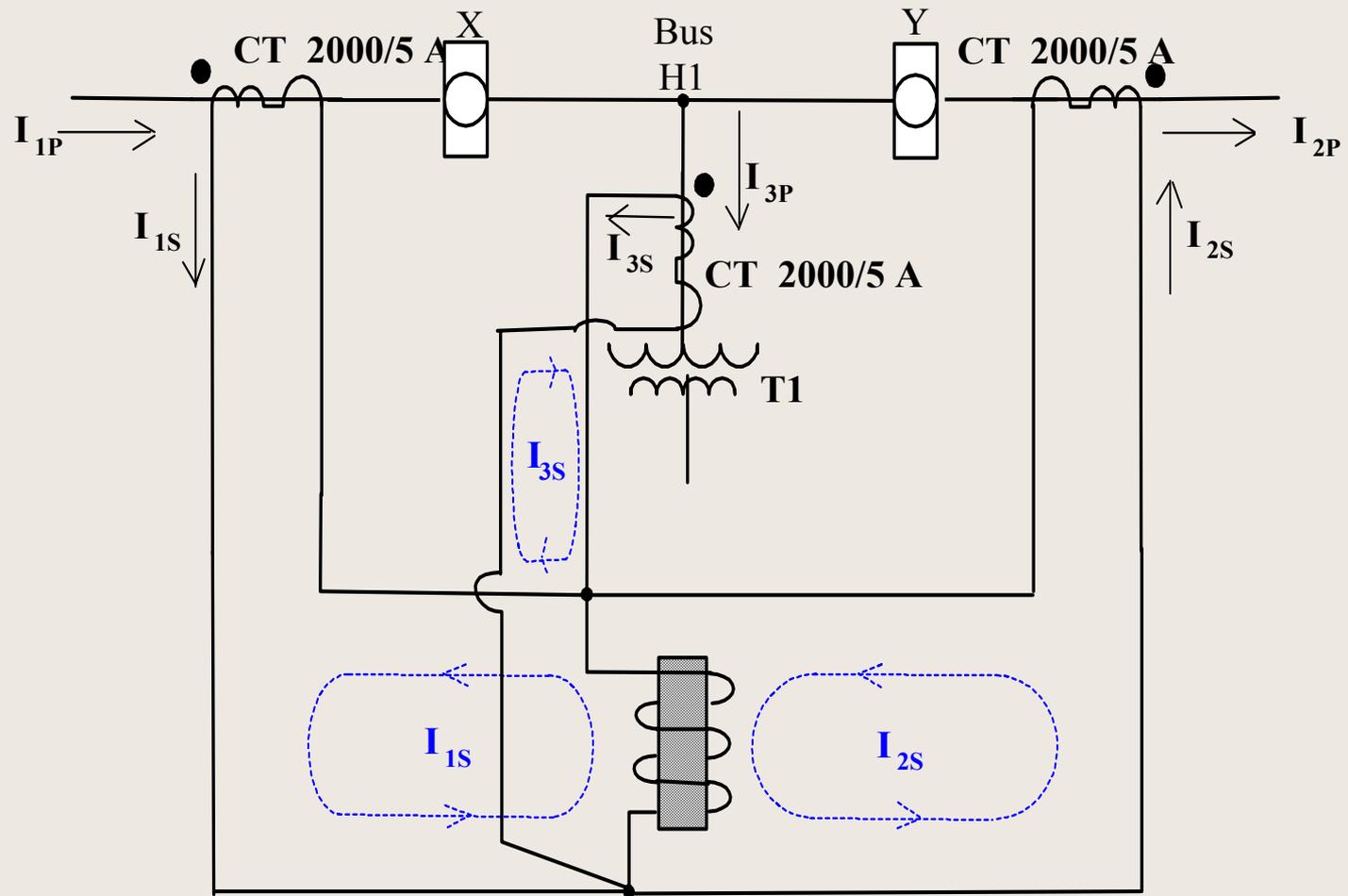


Differential Protection

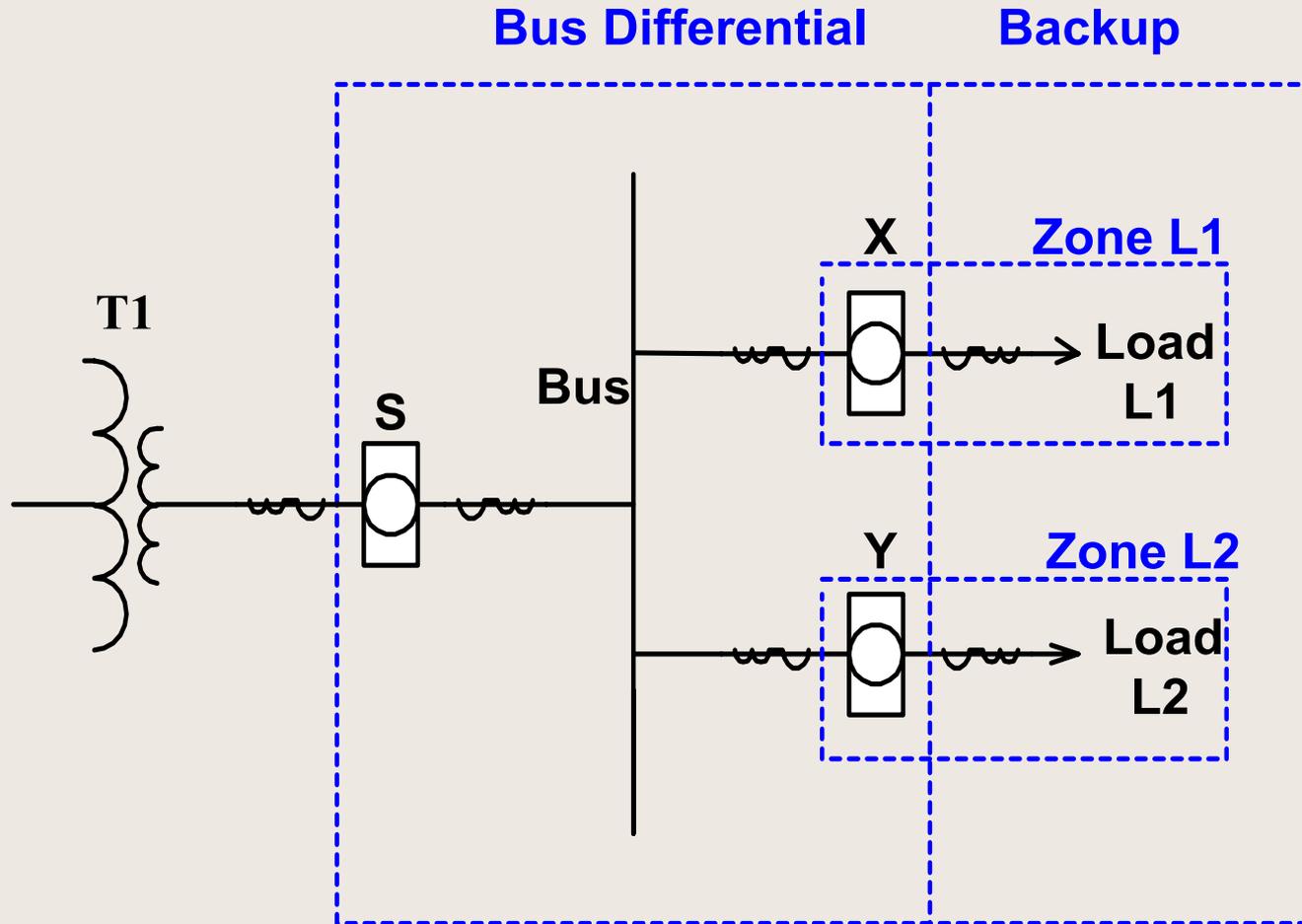


Fault Conditions

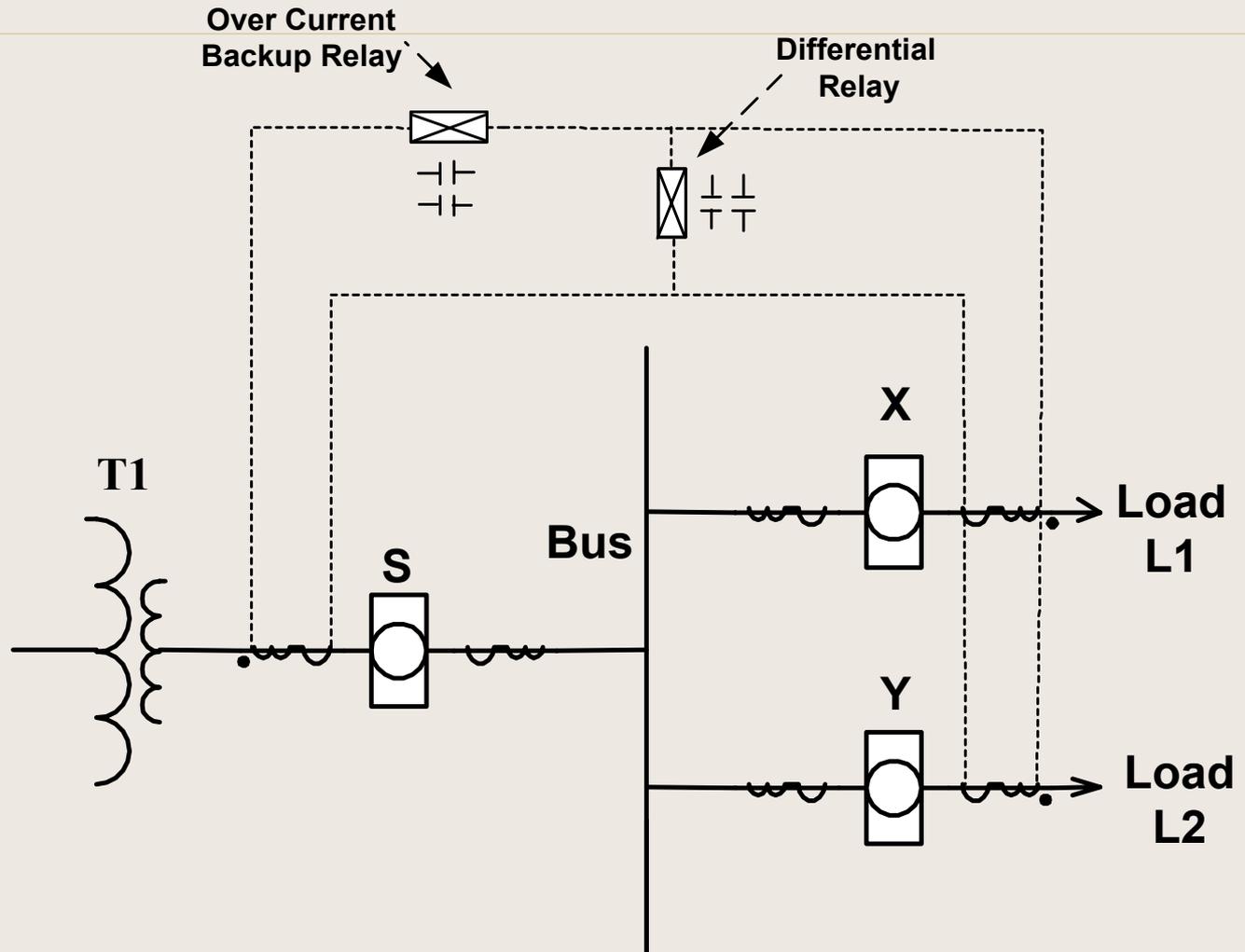




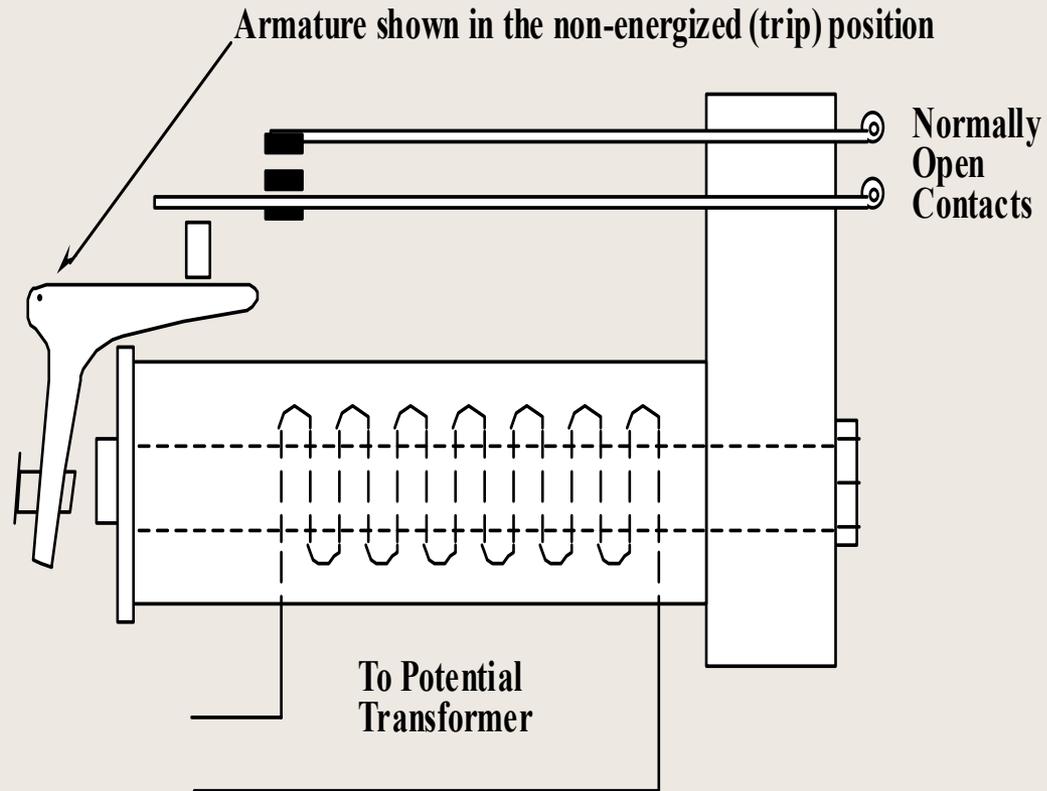
Bus Protection Scheme



Back-up relay



Bus Under Voltage Protection







Bus Protection

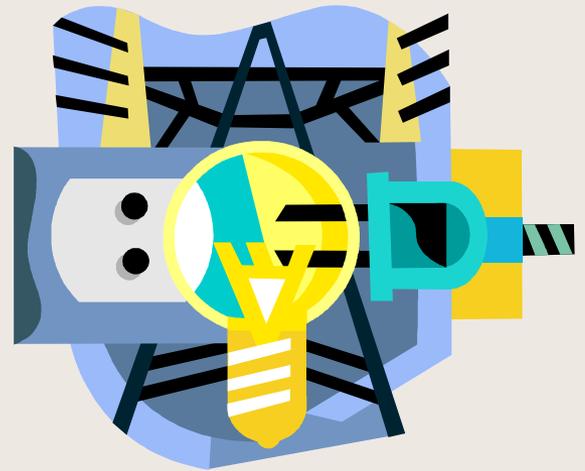
- Over-current
- Differential
- Back-up
- Under voltage

A spiral-bound notebook with a light beige, textured cover. The spiral binding is on the left side. The title "Transformer Protection" is printed in a black serif font in the center of the cover.

Transformer Protection

Transformer Protection

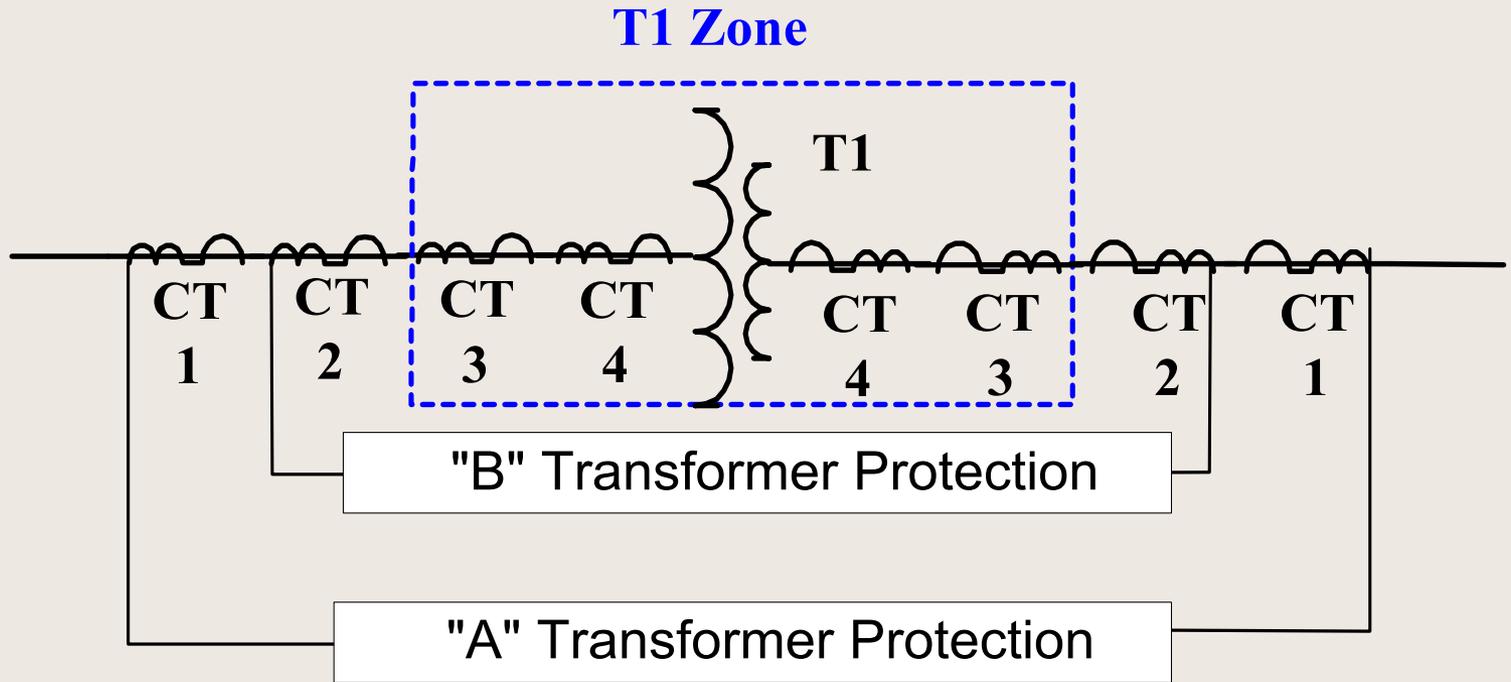
- Instantaneous
- Differential
- Gas
- Thermal Overload
- Ground



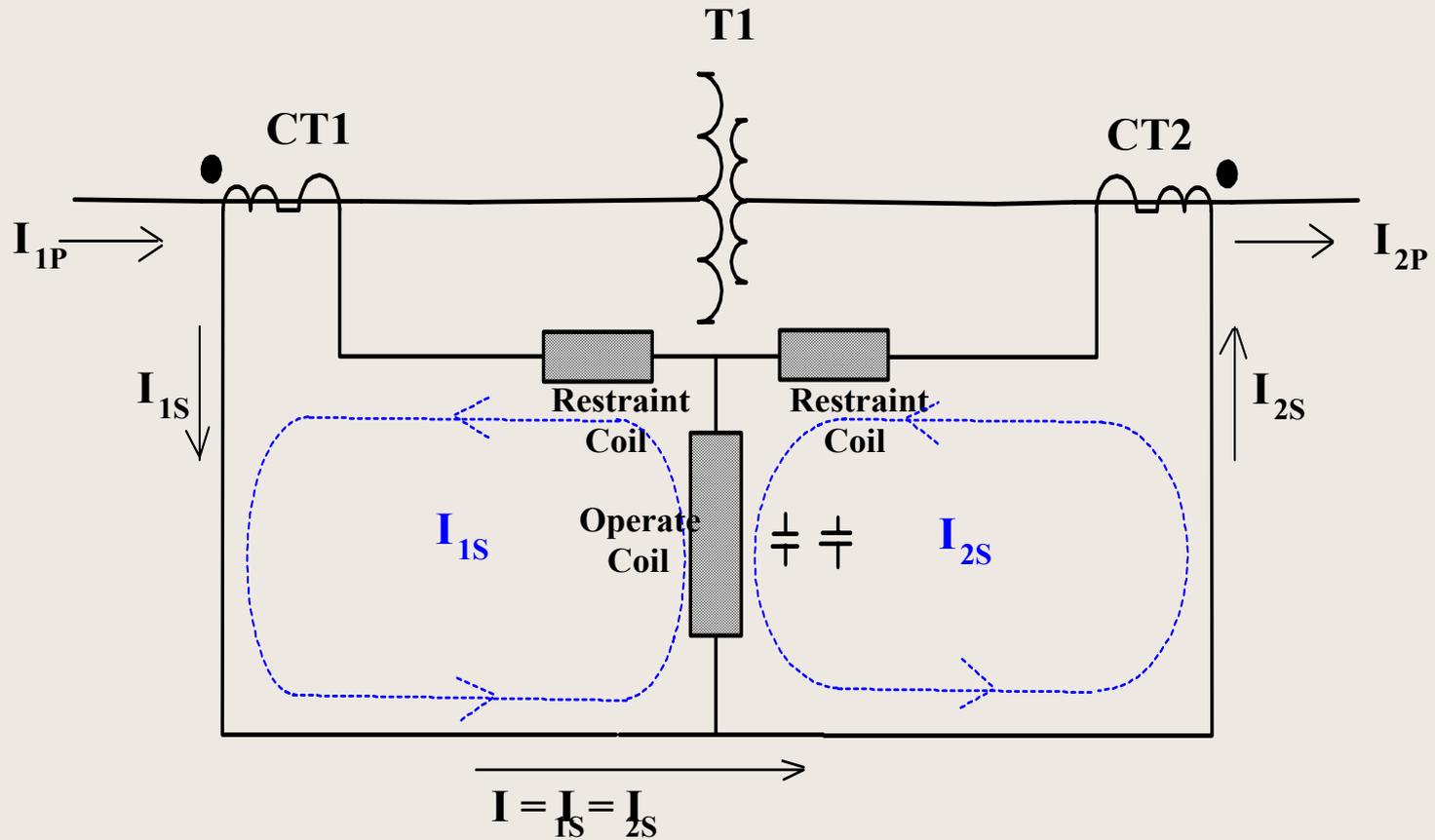
Transformer Characteristics

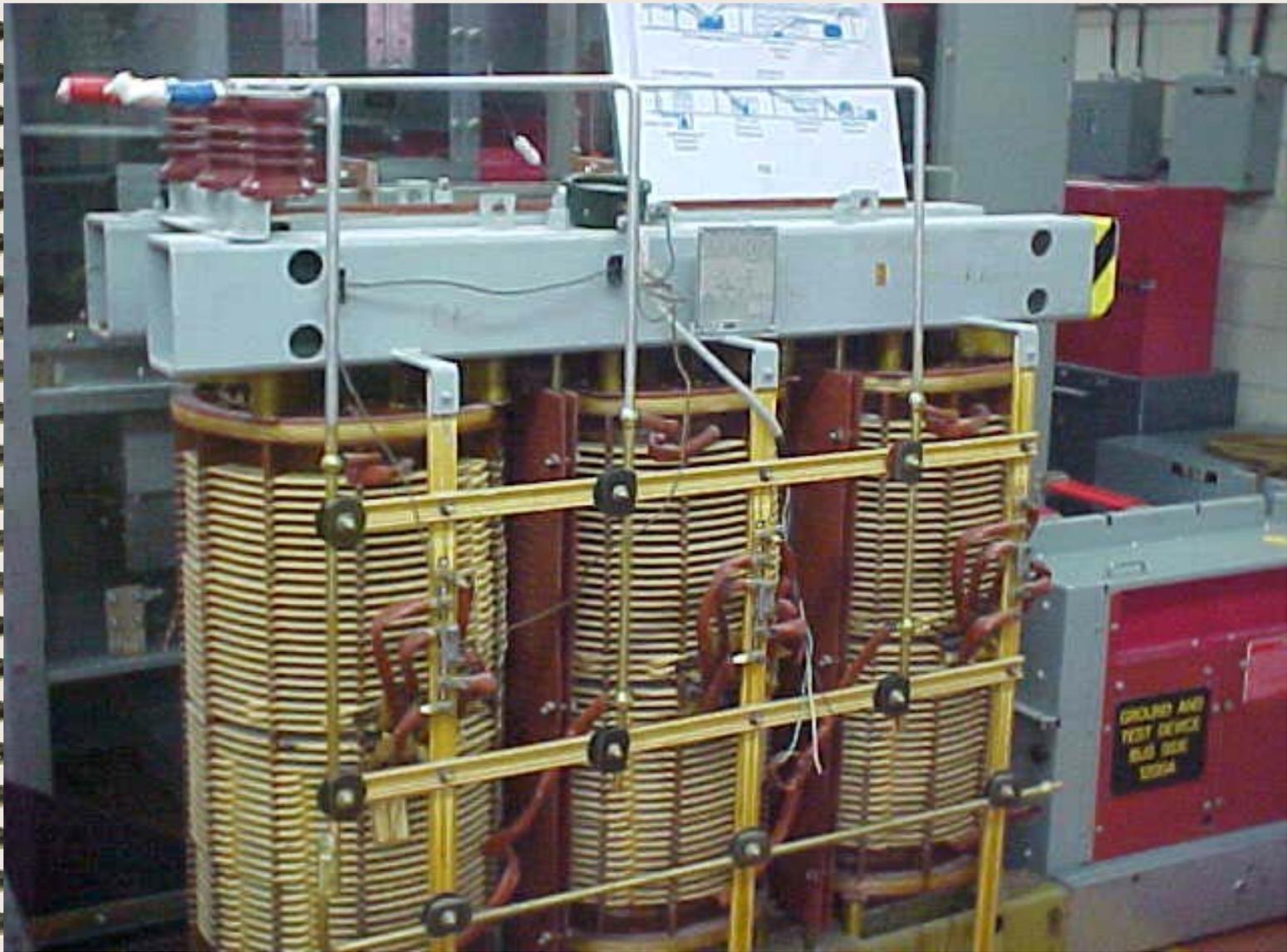
- High magnetizing inrush currents
- Ratio mismatch with CTs aggravated by tap-changers
- Phase shifts
- Transformers are affected by over-fluxing
- Affected by over-temperature

Transformer Zone

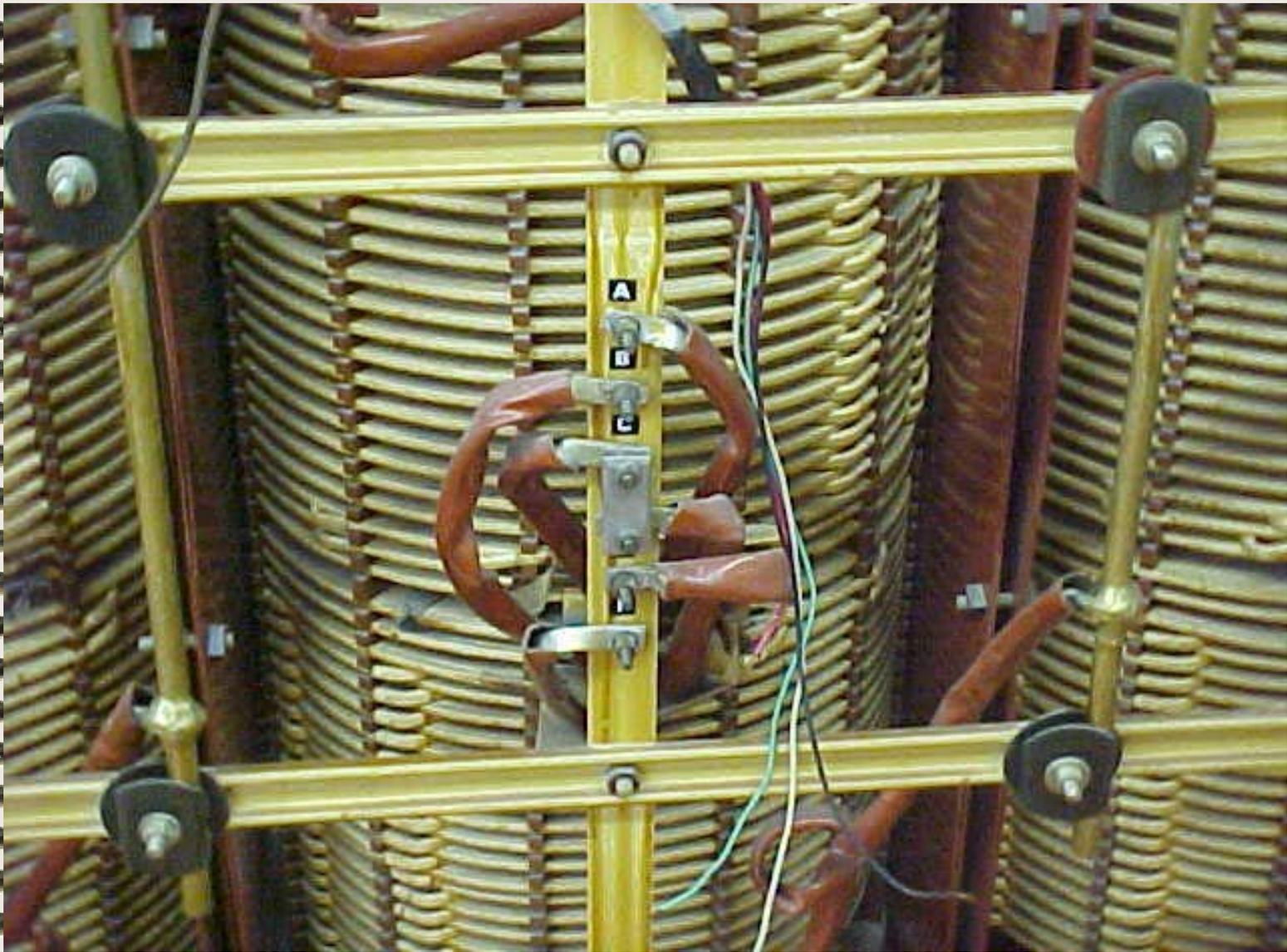


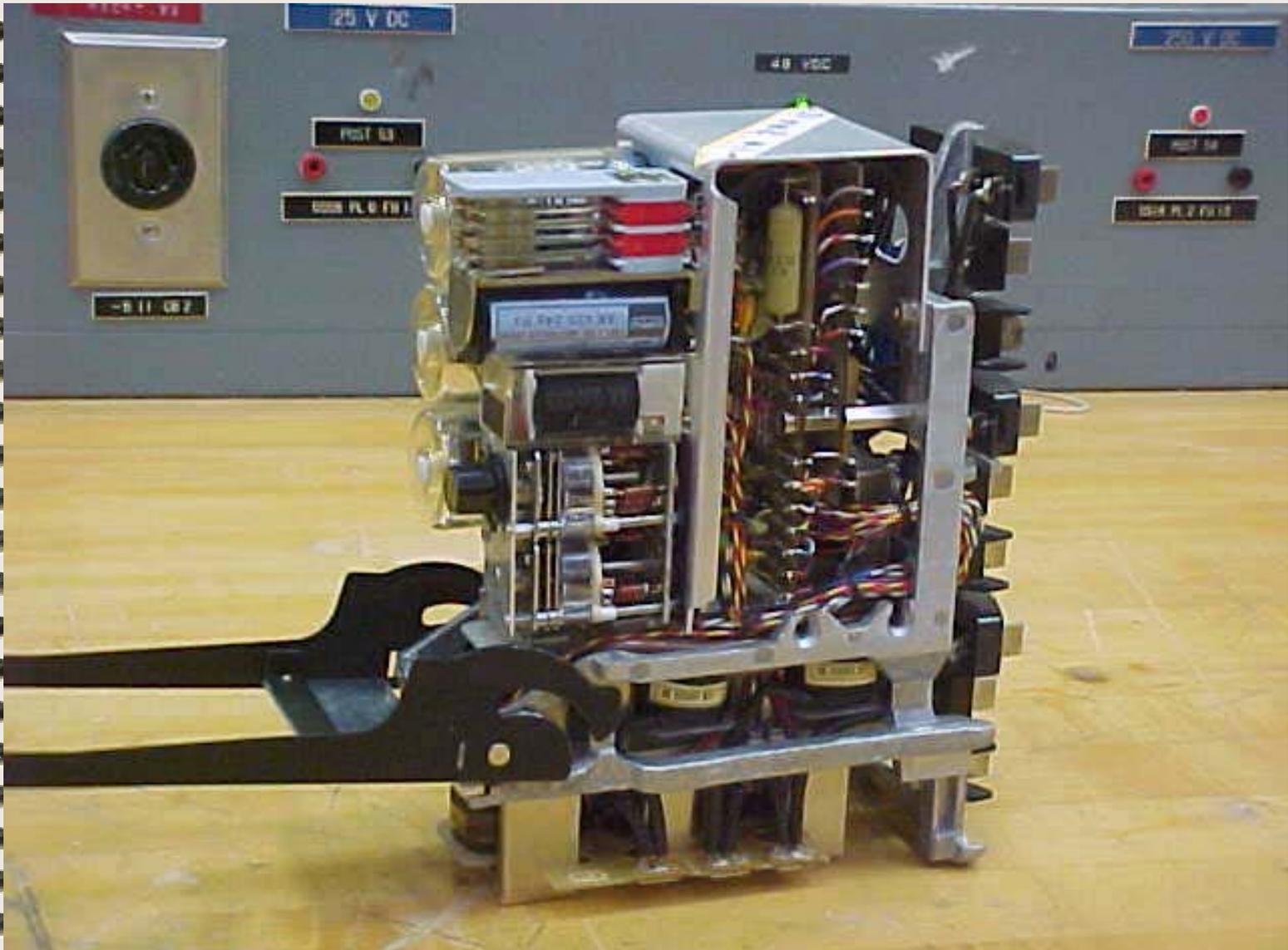
Differential

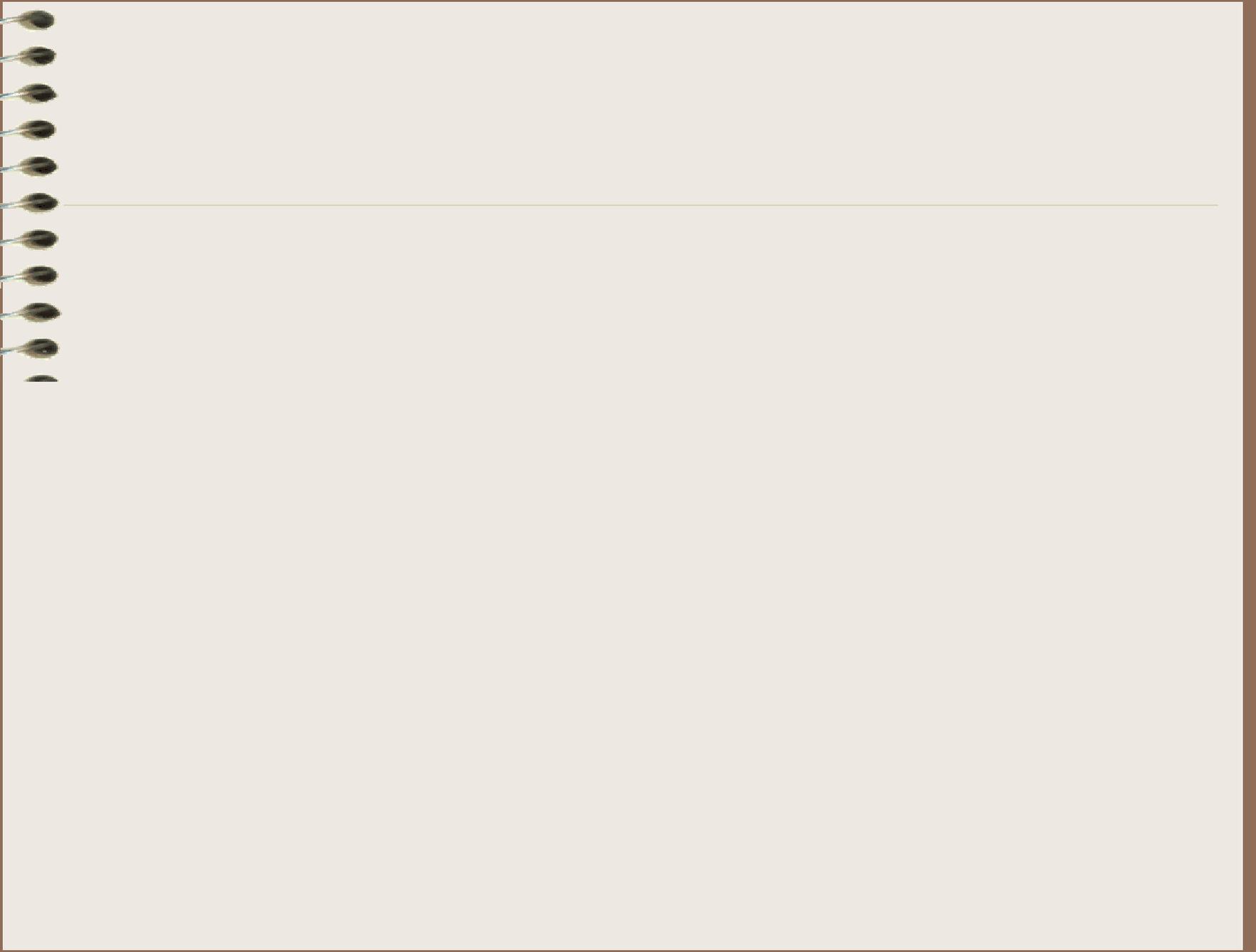
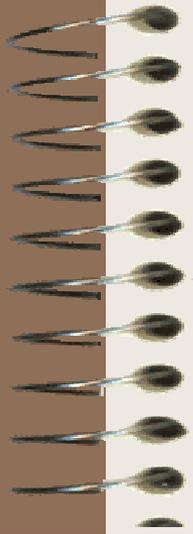




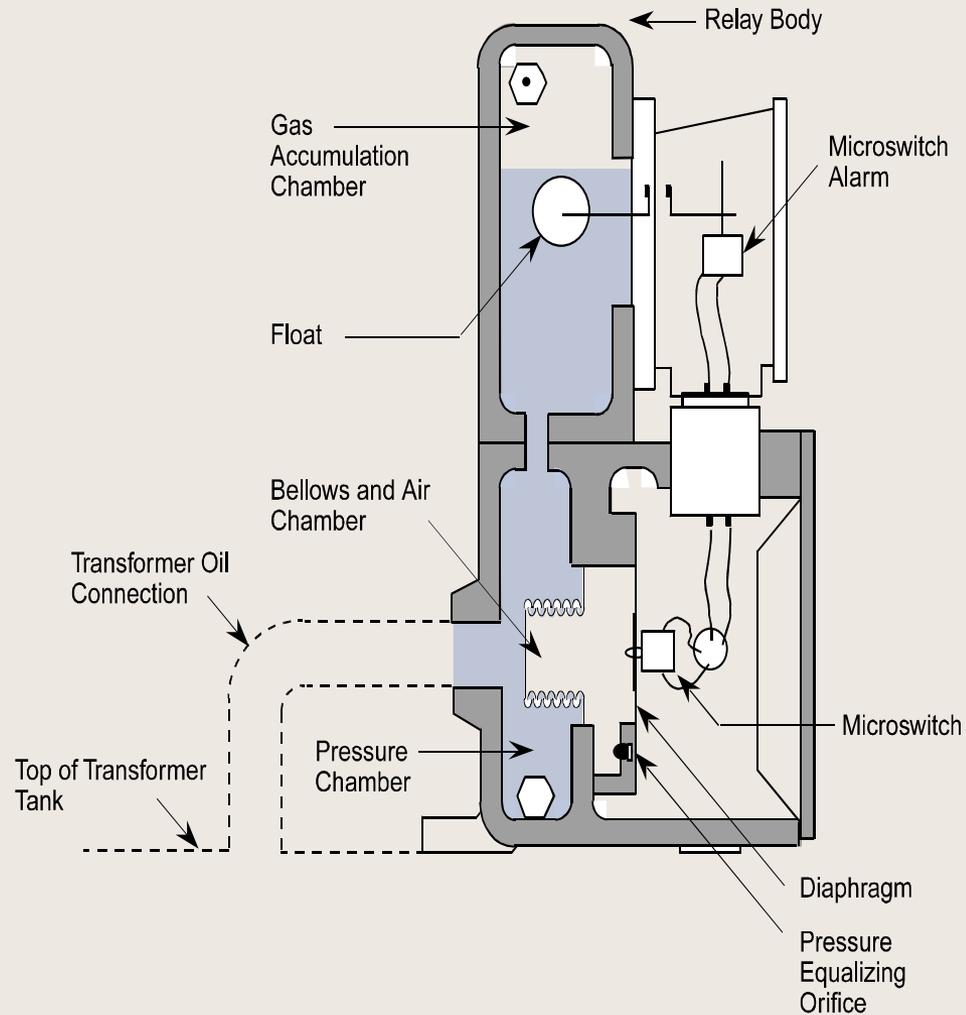
GROUND AND
TEST DEVICE
BUS SIDE
100KA



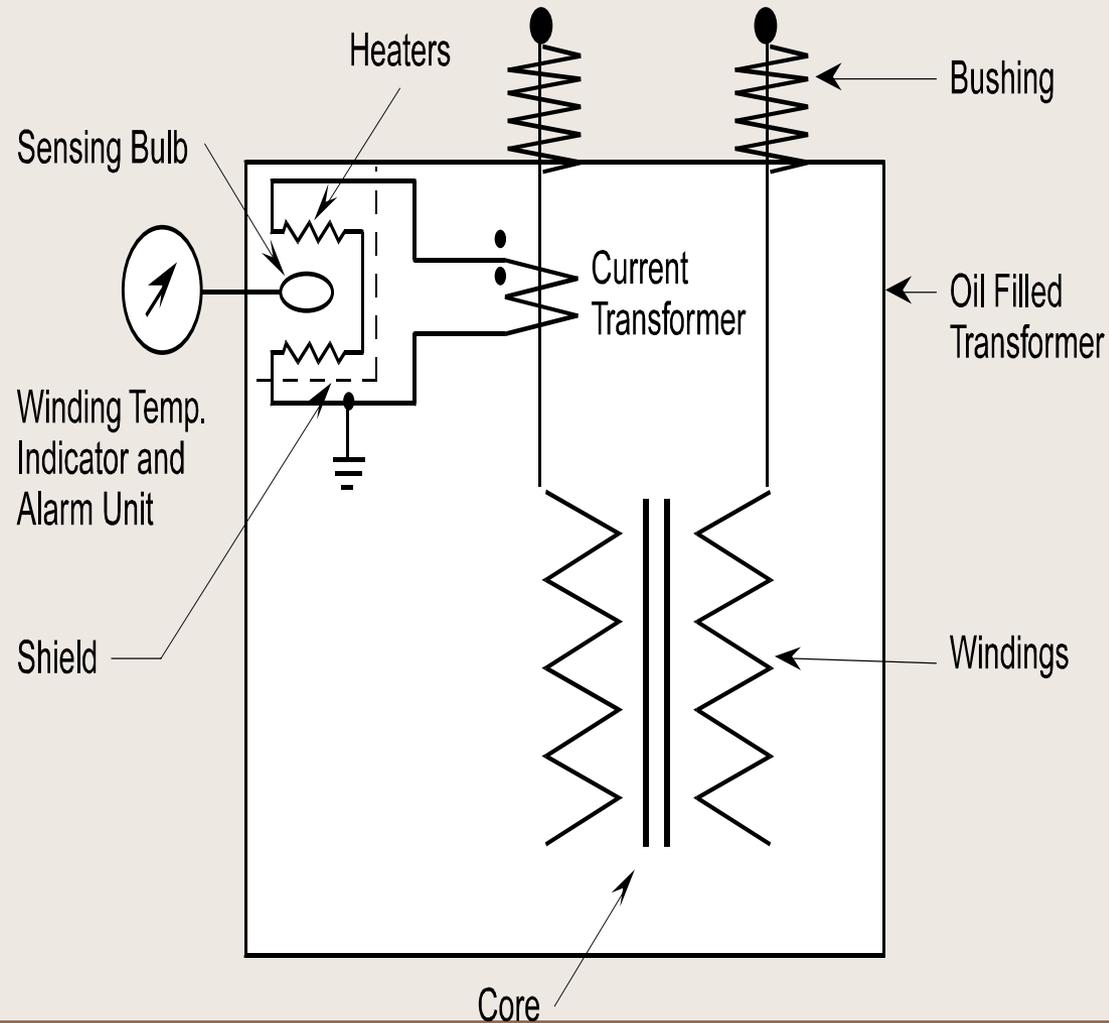




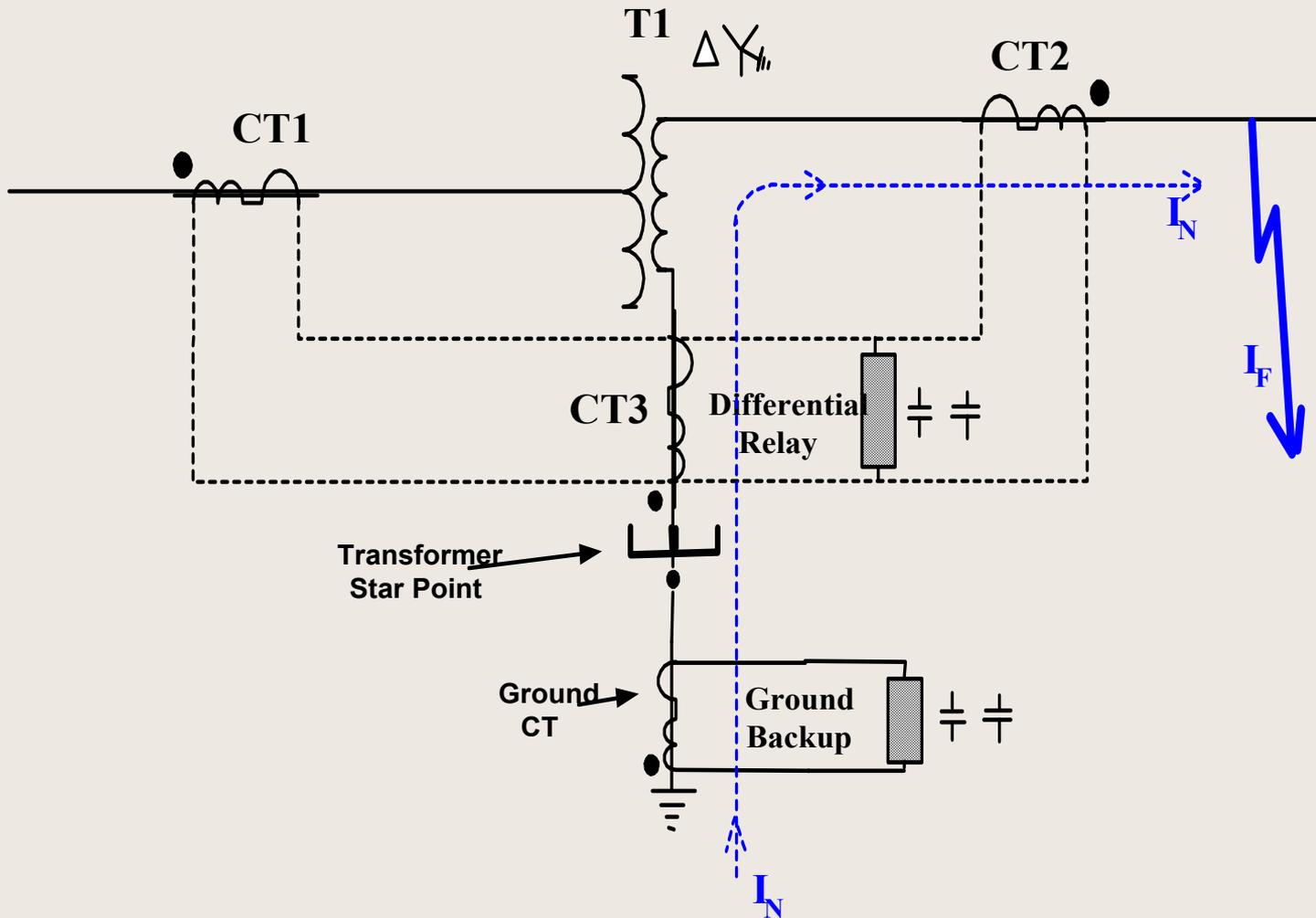
Gas Relay



Winding Temperature

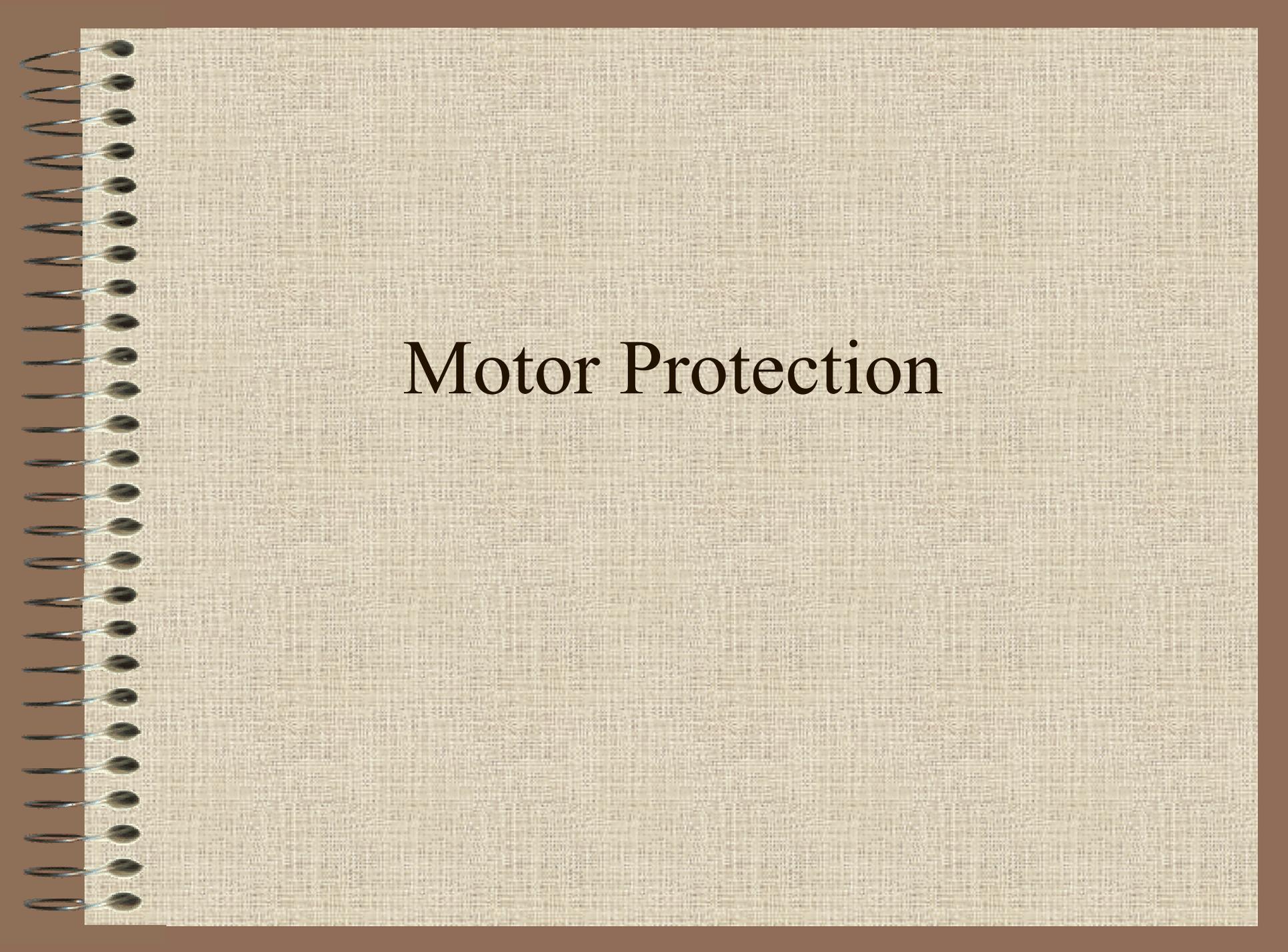


Ground Fault Protection



Transformer Protection

- Instantaneous
- Differential
- Gas
- Thermal Overload
- Ground

A spiral-bound notebook with a light beige, textured cover. The spiral binding is on the left side. The text "Motor Protection" is centered on the cover in a black, serif font.

Motor Protection

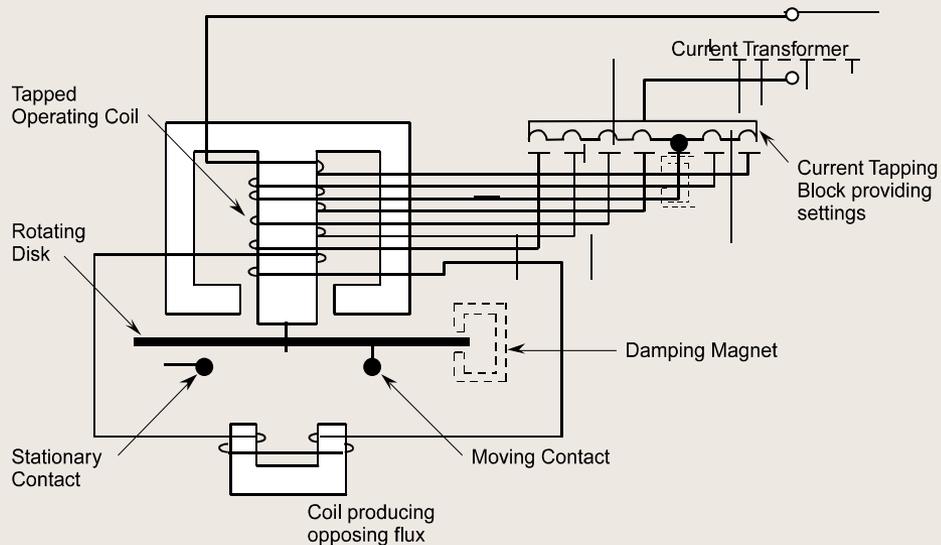
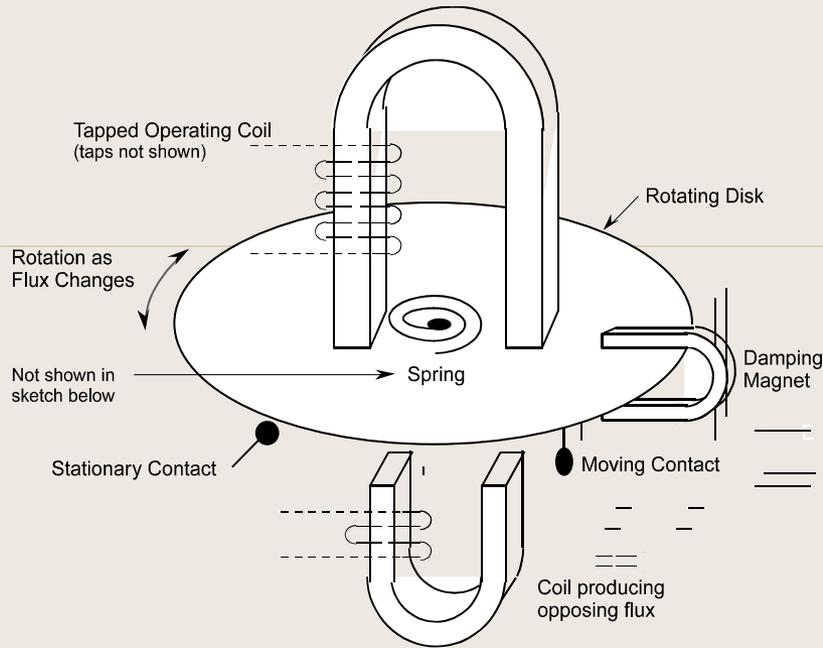
Service Factor

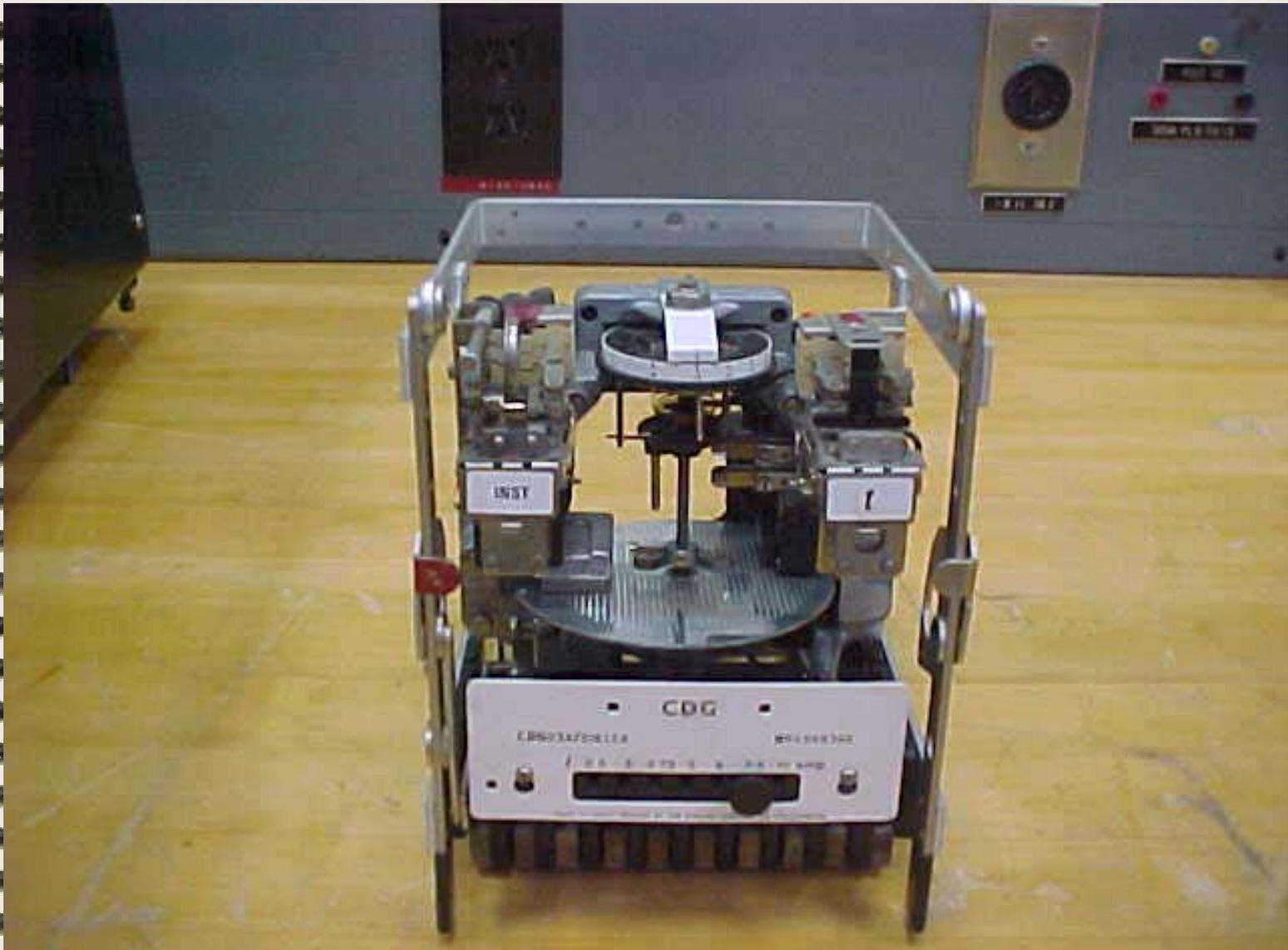
- Continuous allowable overload
 - Many motors come with a power rating and a service factor
 - A 10 HP motor with a service factor of 1.15 has a maximum continuous output of 11.5 HP

Motor Protection Summary

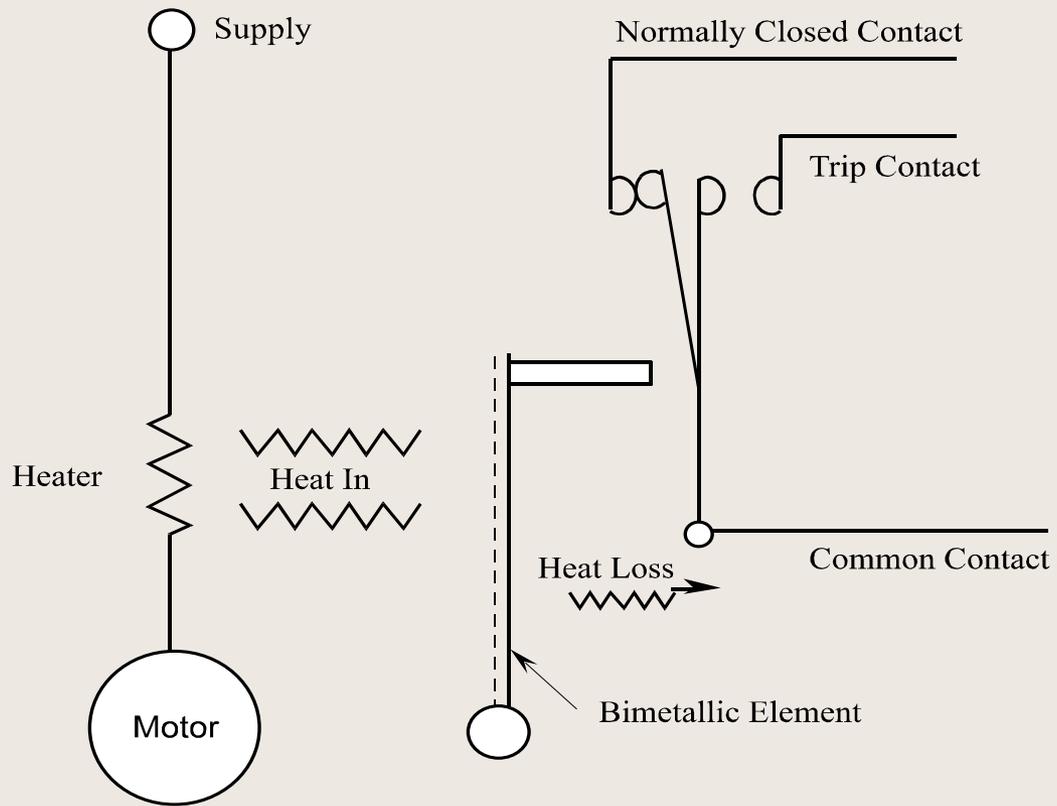
- Instantaneous Over-current
- Stall
- Thermal Overload
- Phase Unbalance
- Ground

Inverse Time Relay

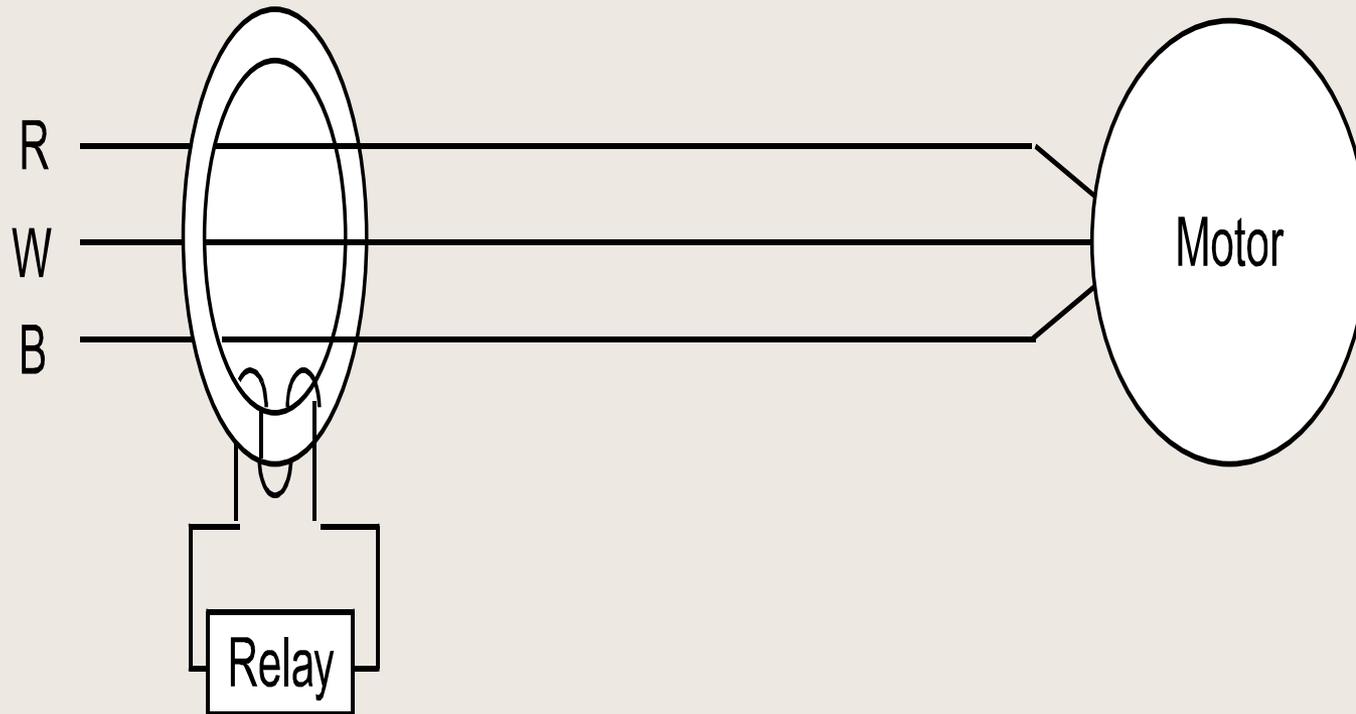




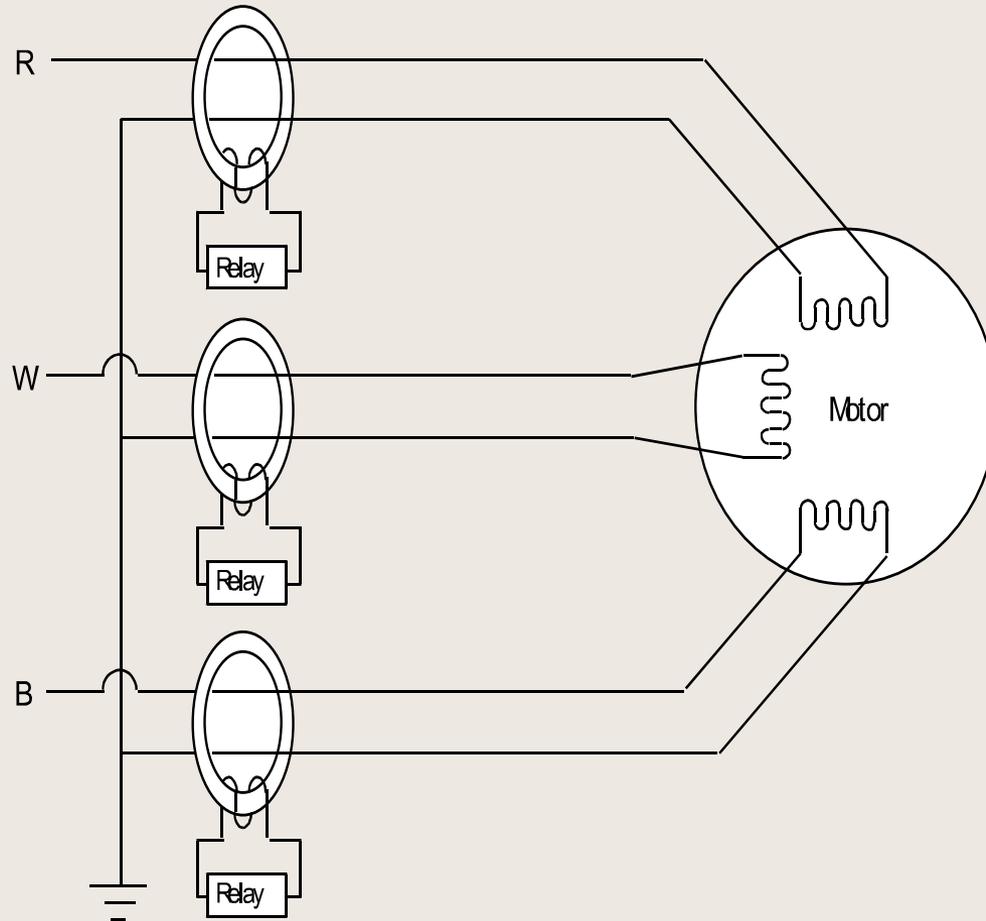
Overload



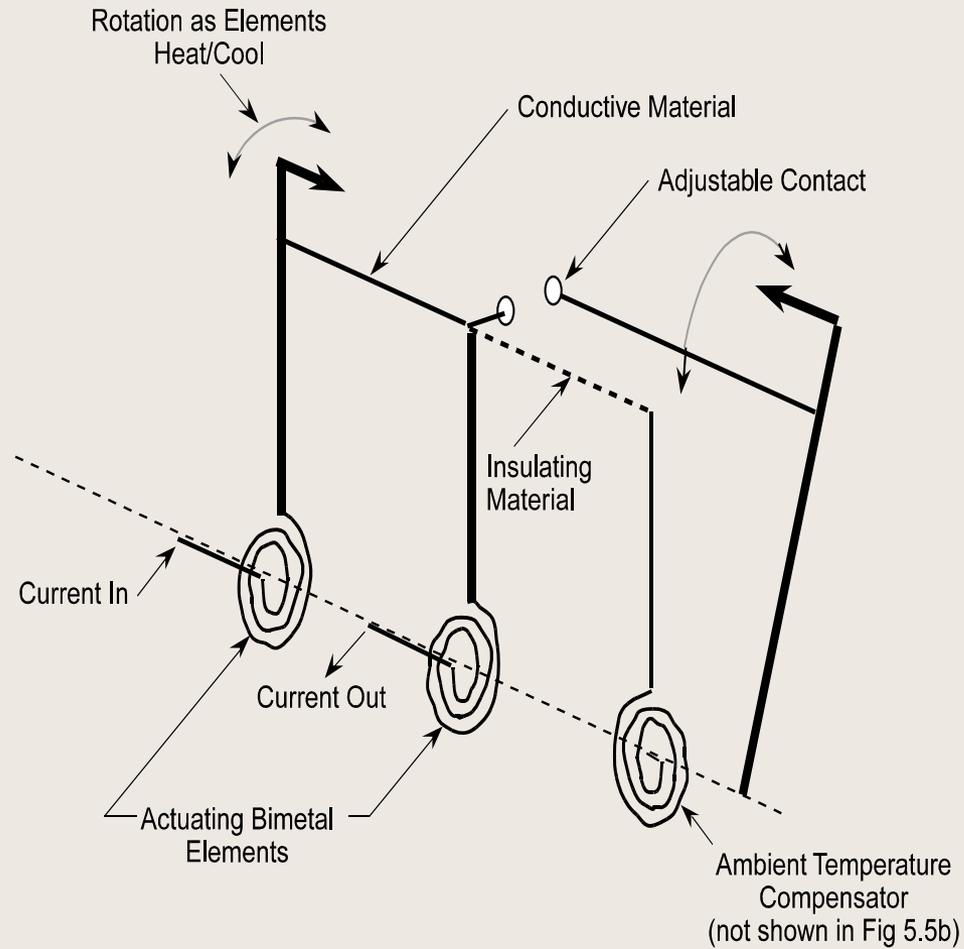
Ground Fault Protection



Single Phase to Ground Protection



Stalls



Thermal Overload & Phase Unbalance

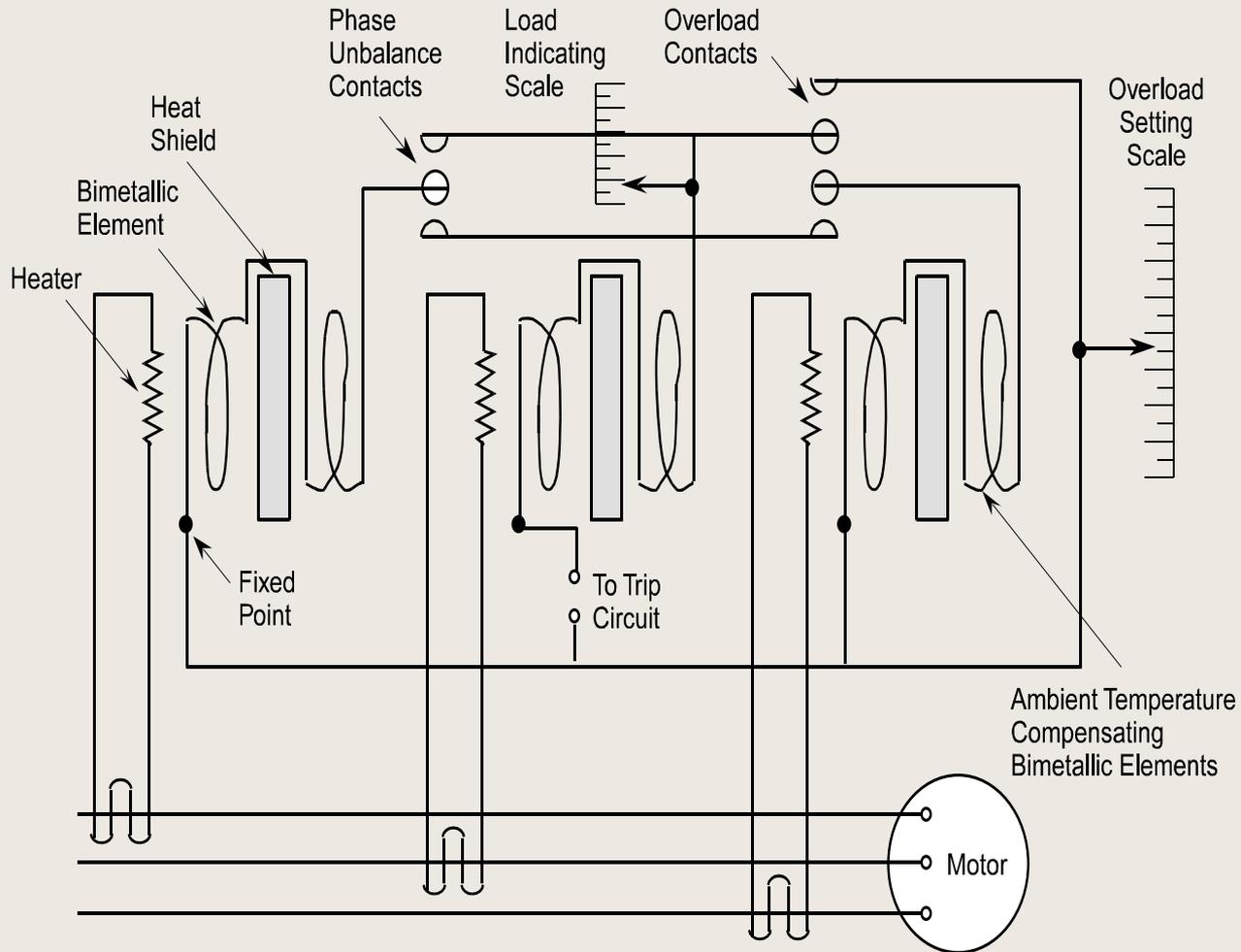
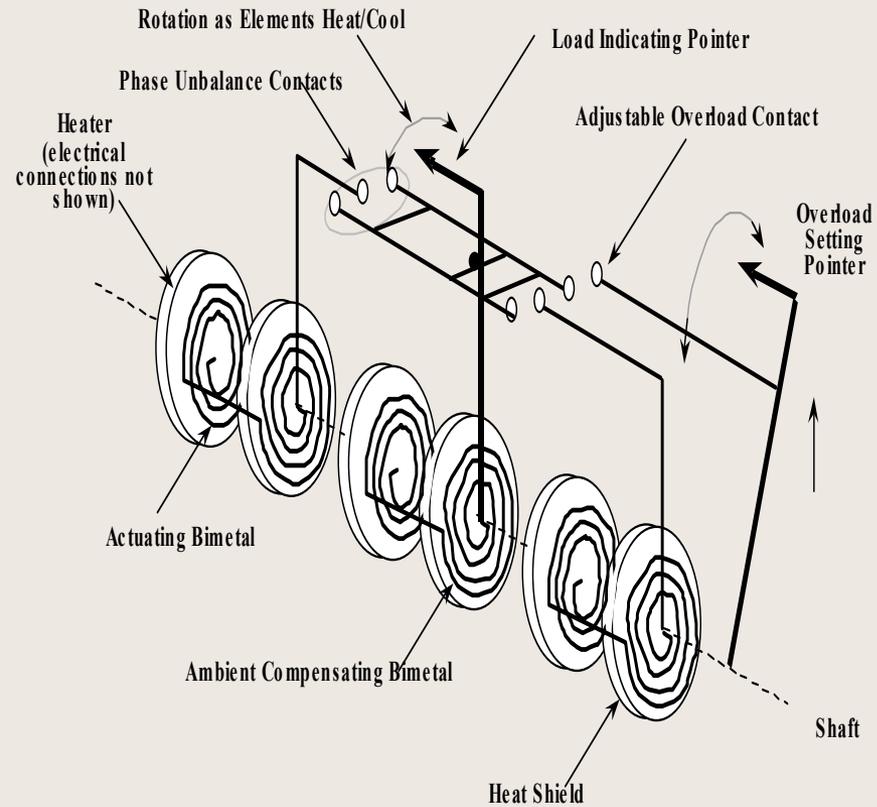
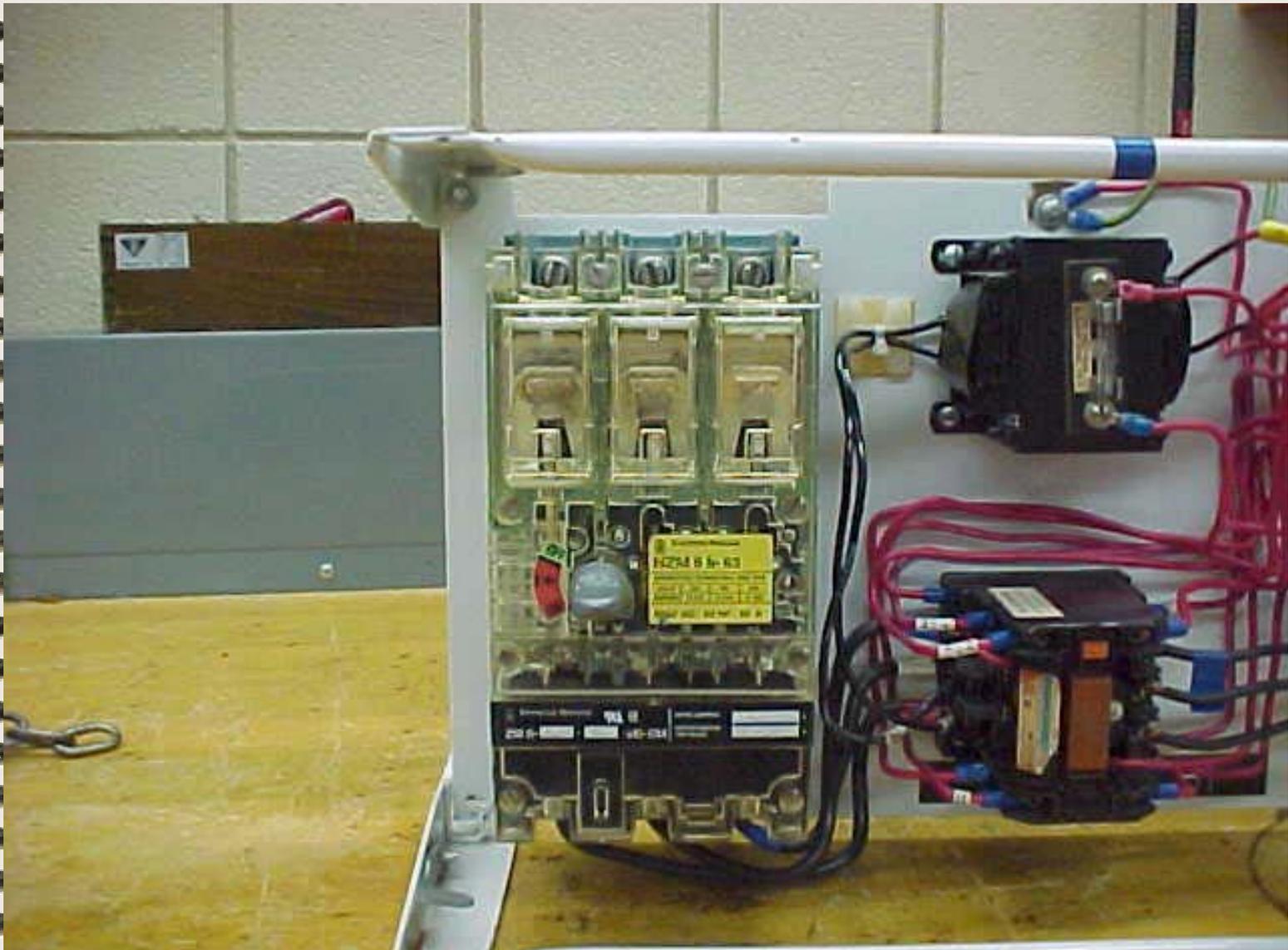
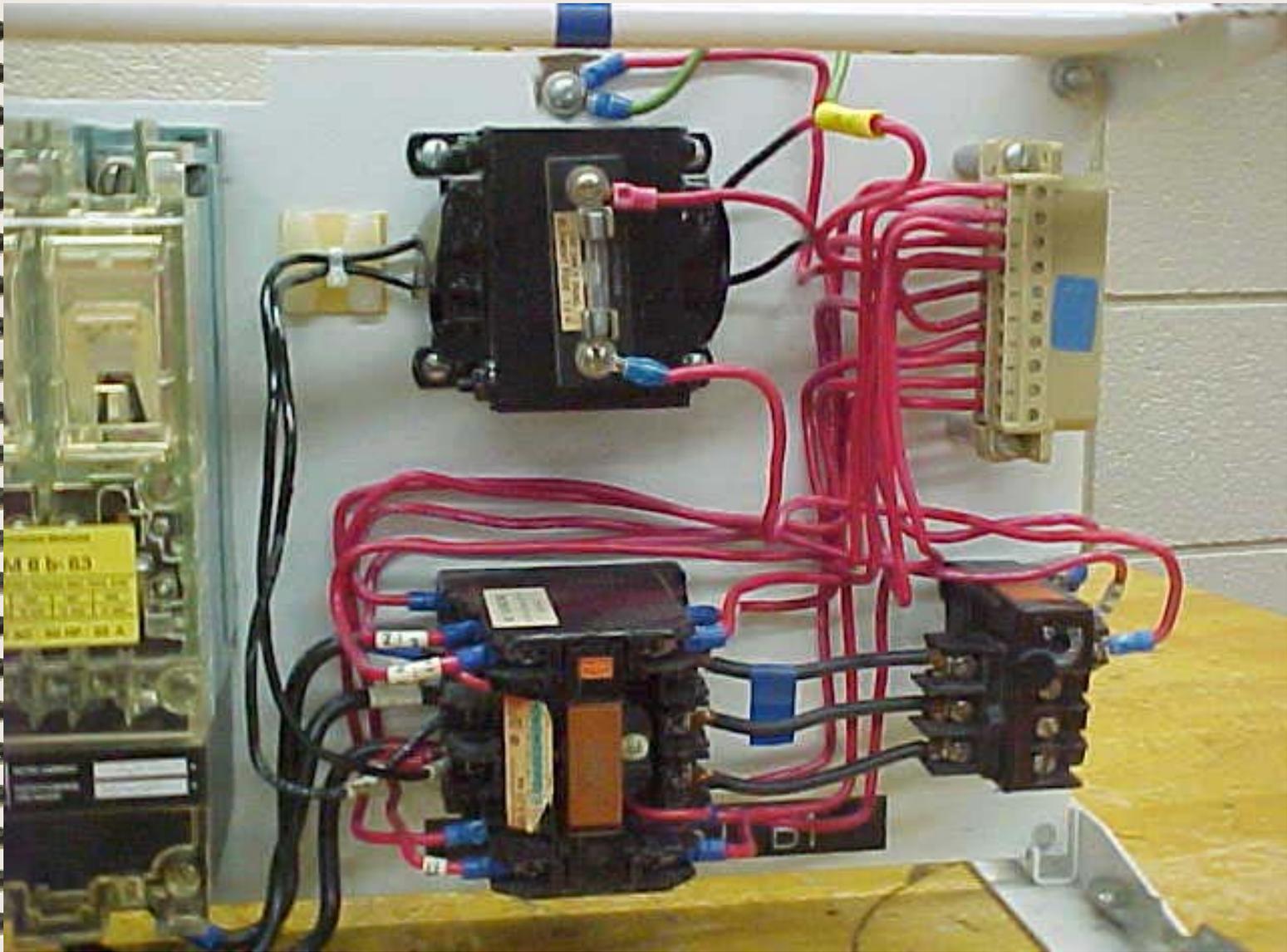
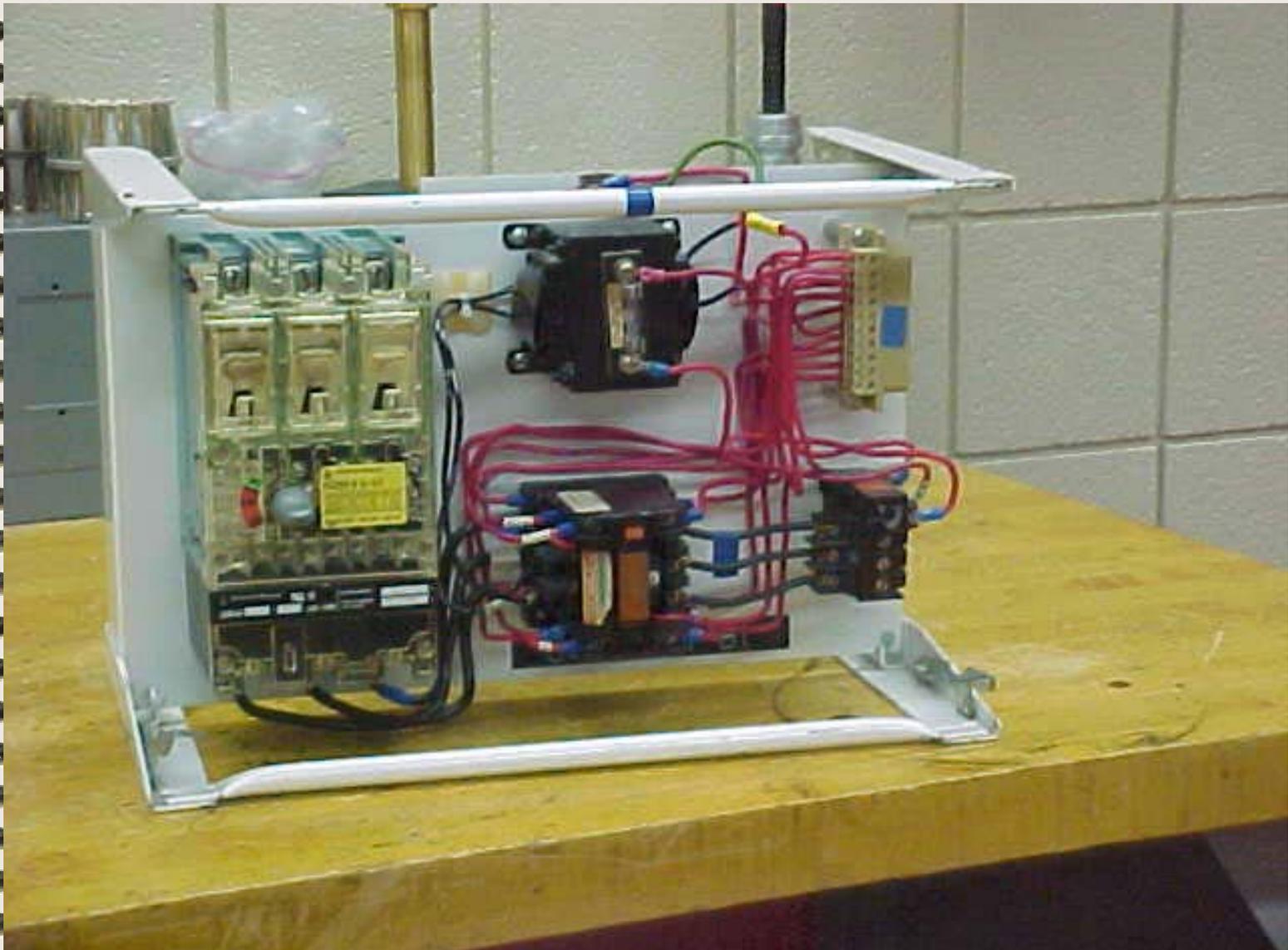


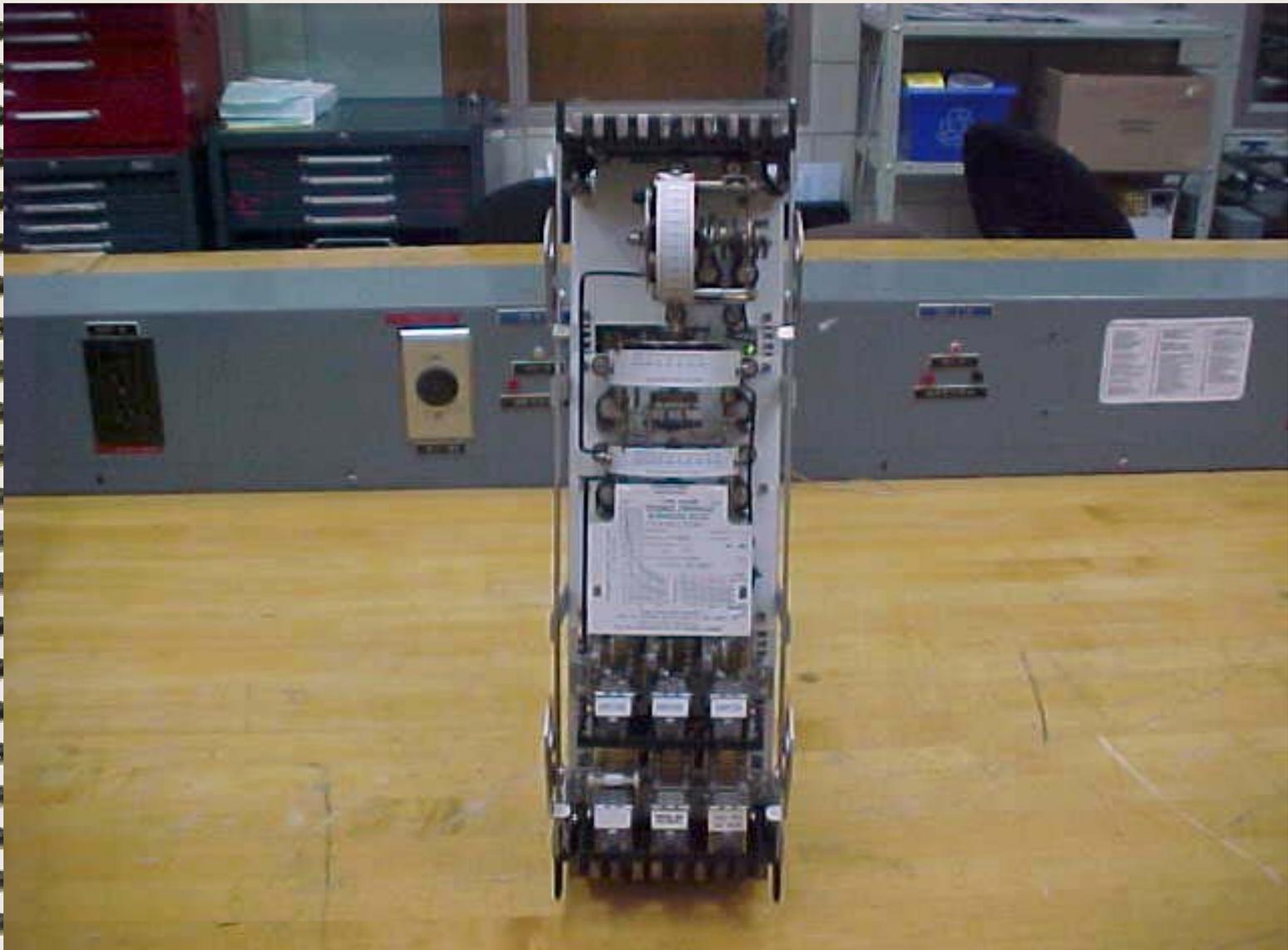
Diagram of the Unit

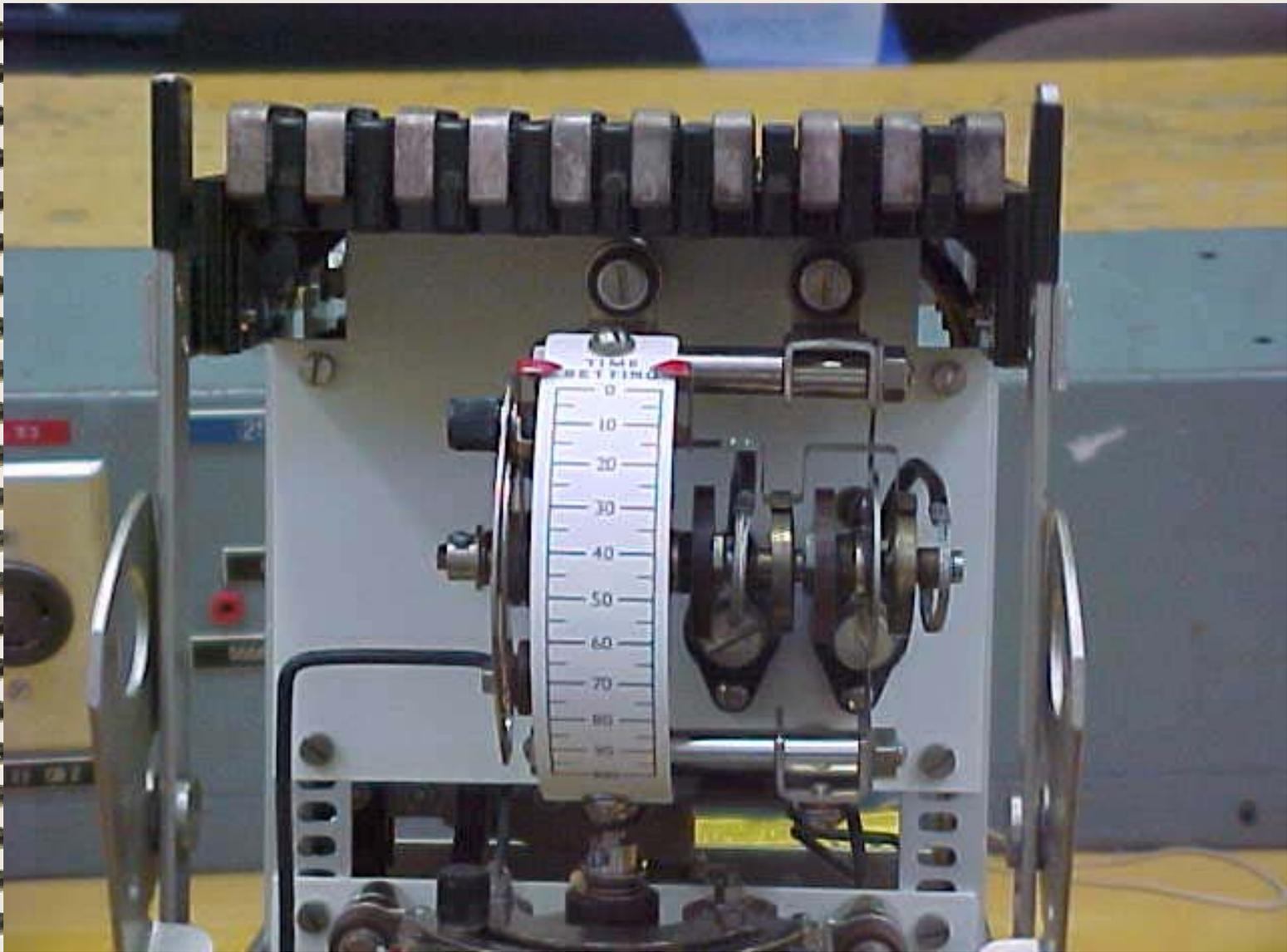


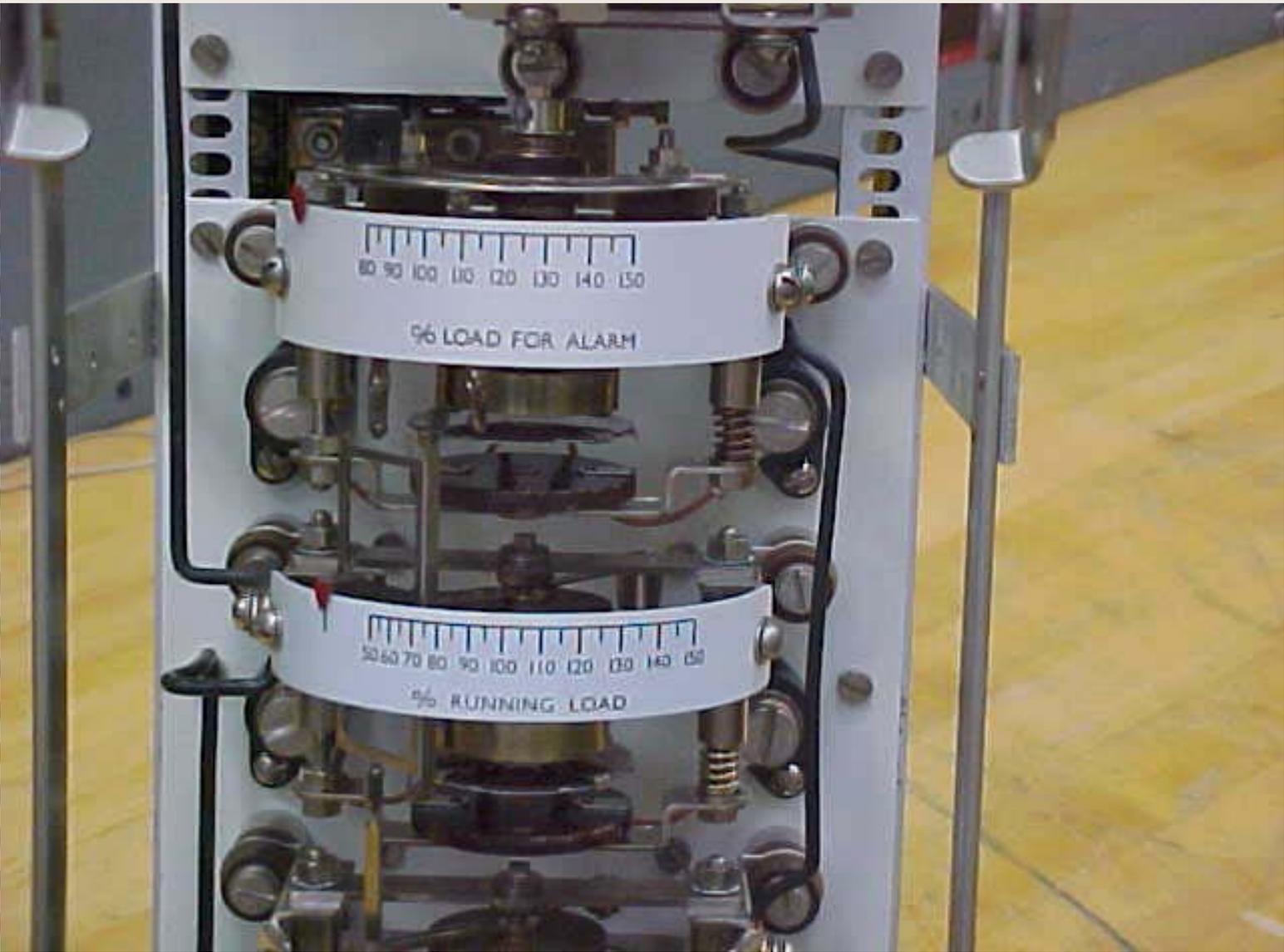










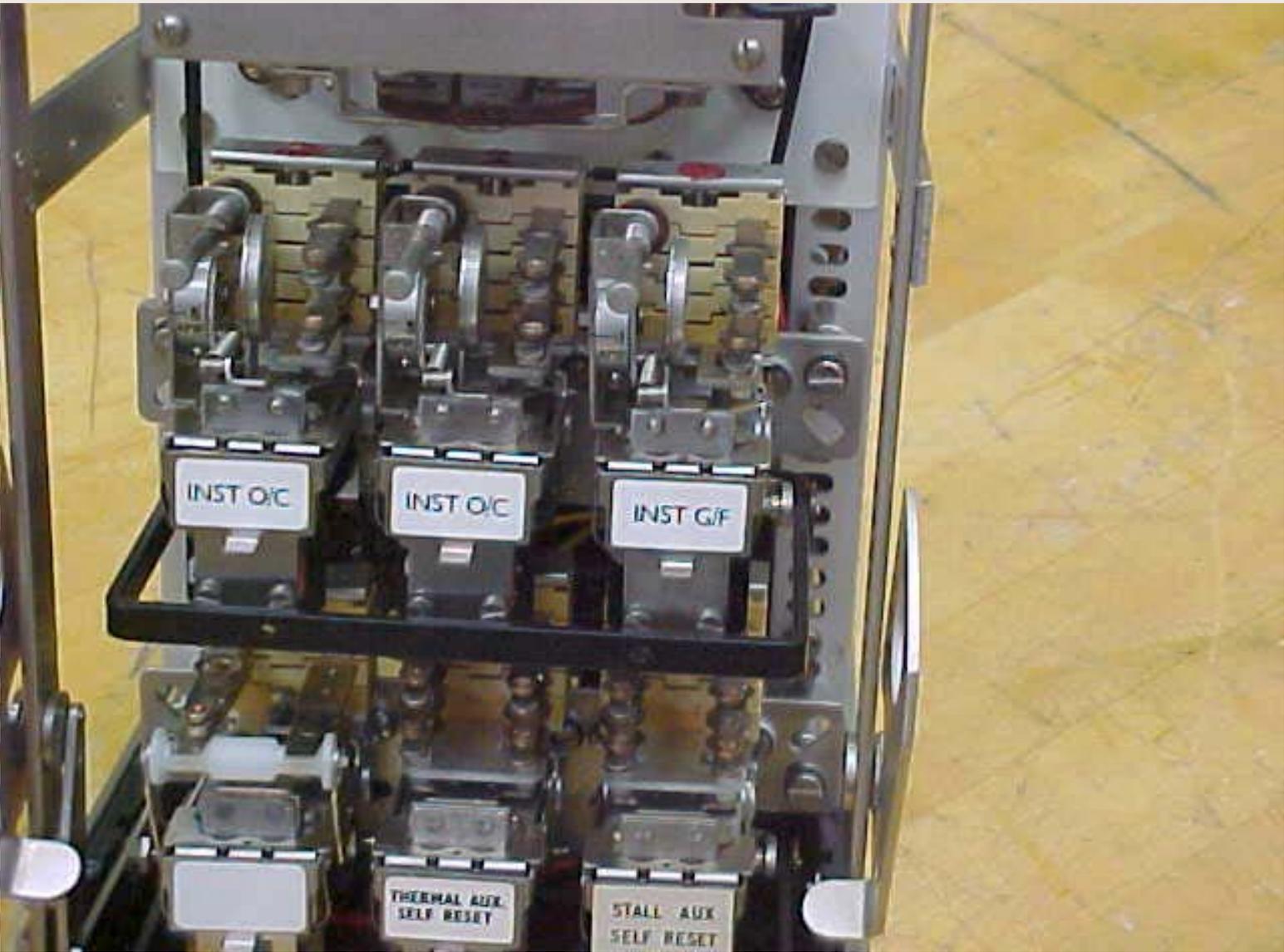


80 90 100 110 120 130 140 150

% LOAD FOR ALARM

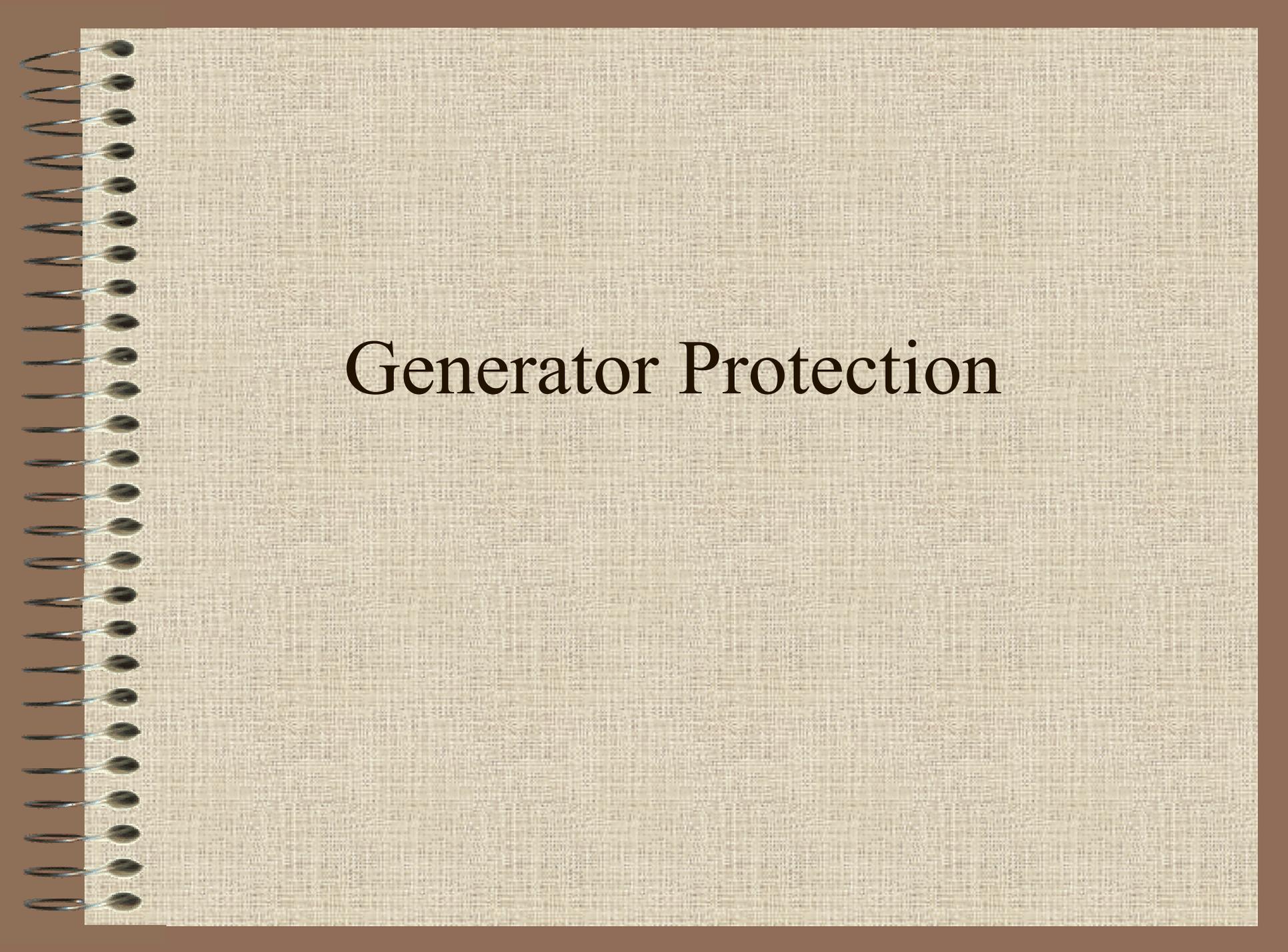
50 60 70 80 90 100 110 120 130 140 150

% RUNNING LOAD



Motor Protection Summary

- Instantaneous Over-current
- Stall
- Thermal Overload
- Phase Unbalance
- Ground

A spiral-bound notebook with a light beige, textured cover. The spiral binding is on the left side. The text "Generator Protection" is centered on the cover in a black, serif font.

Generator Protection

Classes of TG trips

- Class A
 - Trip generator breaker, field breaker and turbine
 - Electrical trips before the output breakers
- Class B
 - Trip generator output but leave it supplying station service
 - Electrical faults in the switchyard

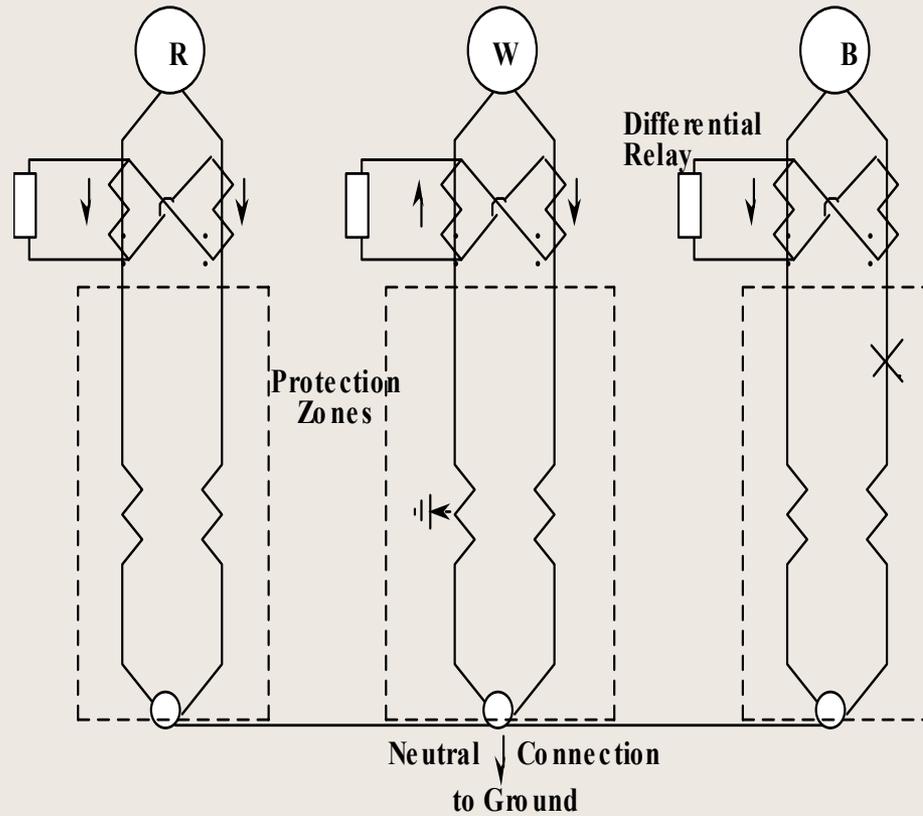
Classes of TG trips

- Class C
 - Over excitation high V/Hz
 - Only used when generator is isolated from grid
- Class D
 - Trip turbine
 - Trip Generator after motoring is detected
 - Mechanical type turbine trips high condenser pressure

Generator Protection

- Over-current
- Overload
- Differential
- Split phase differential
- Ground
- Rotor ground
- Phase Unbalance
- Low field
- Under frequency
- Out of Step
- Reverse power

Generator Terminals

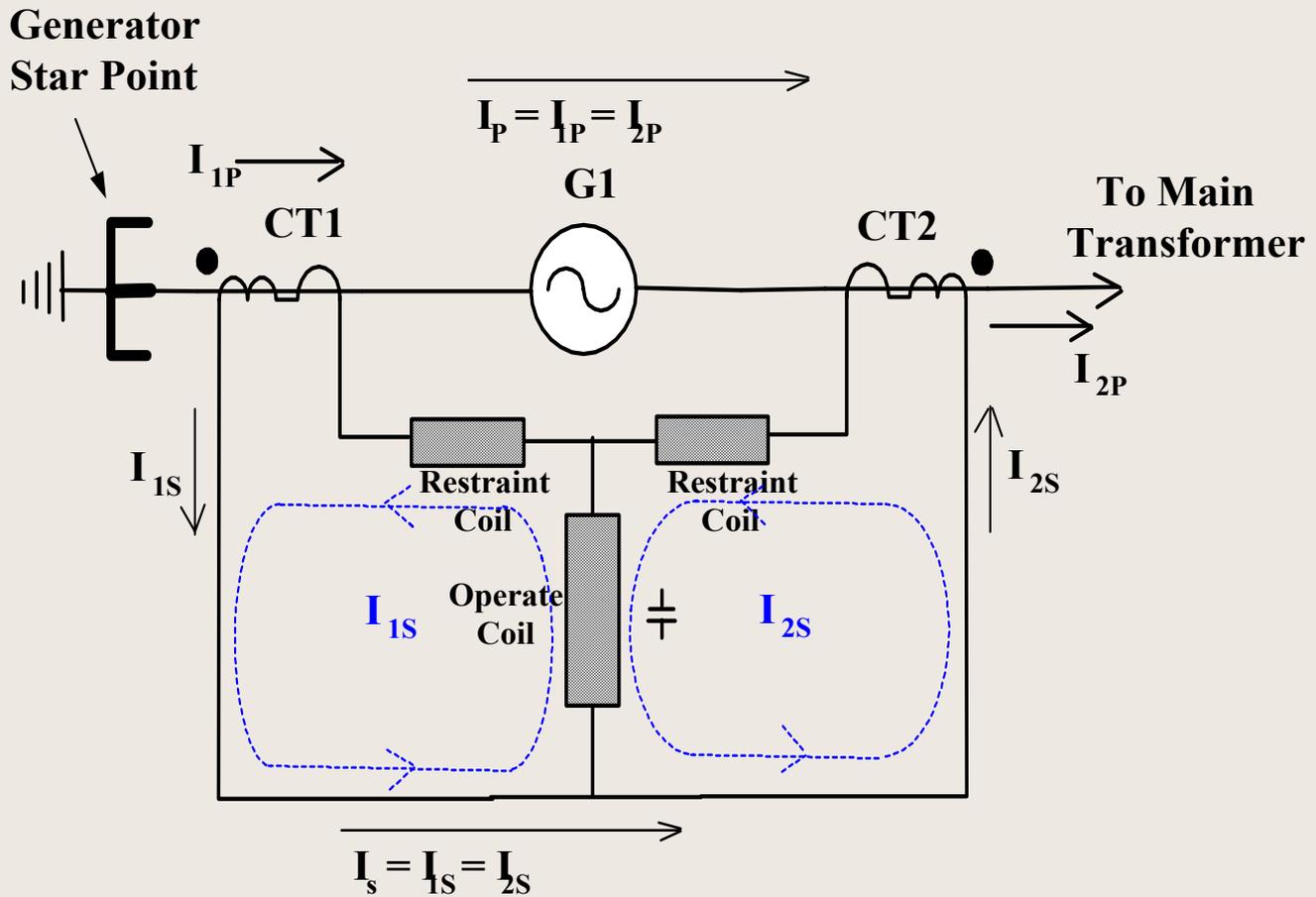


a) Healthy Phase

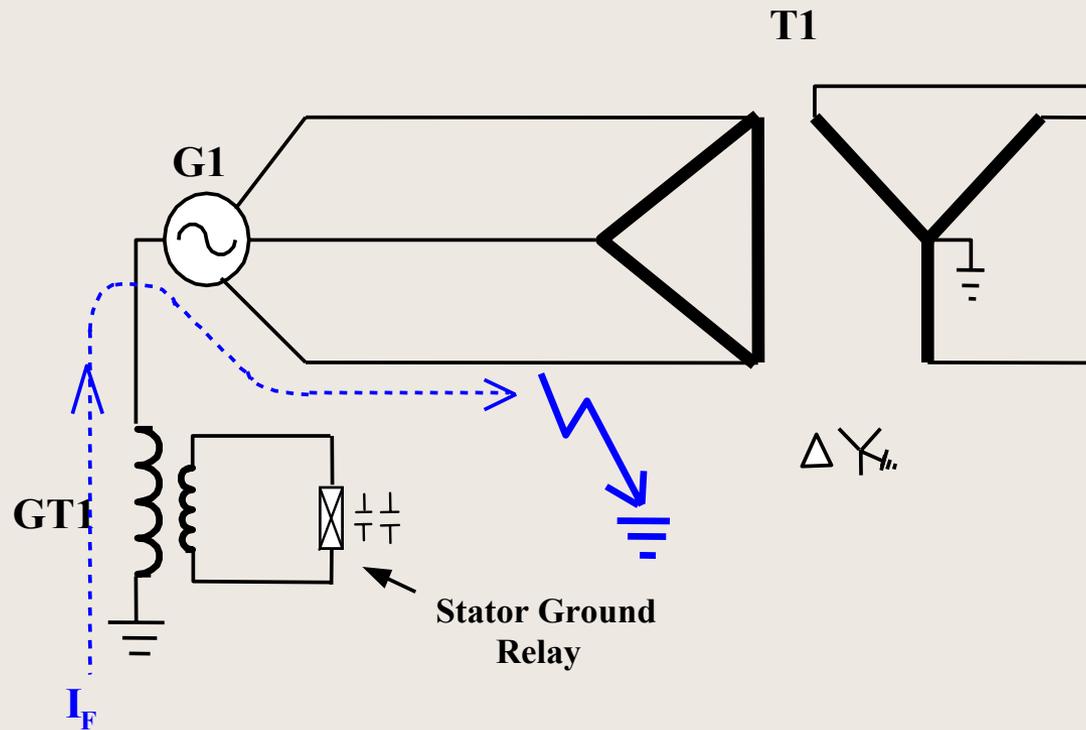
b) Faulted Phase

c) Open Circuit in the Phase

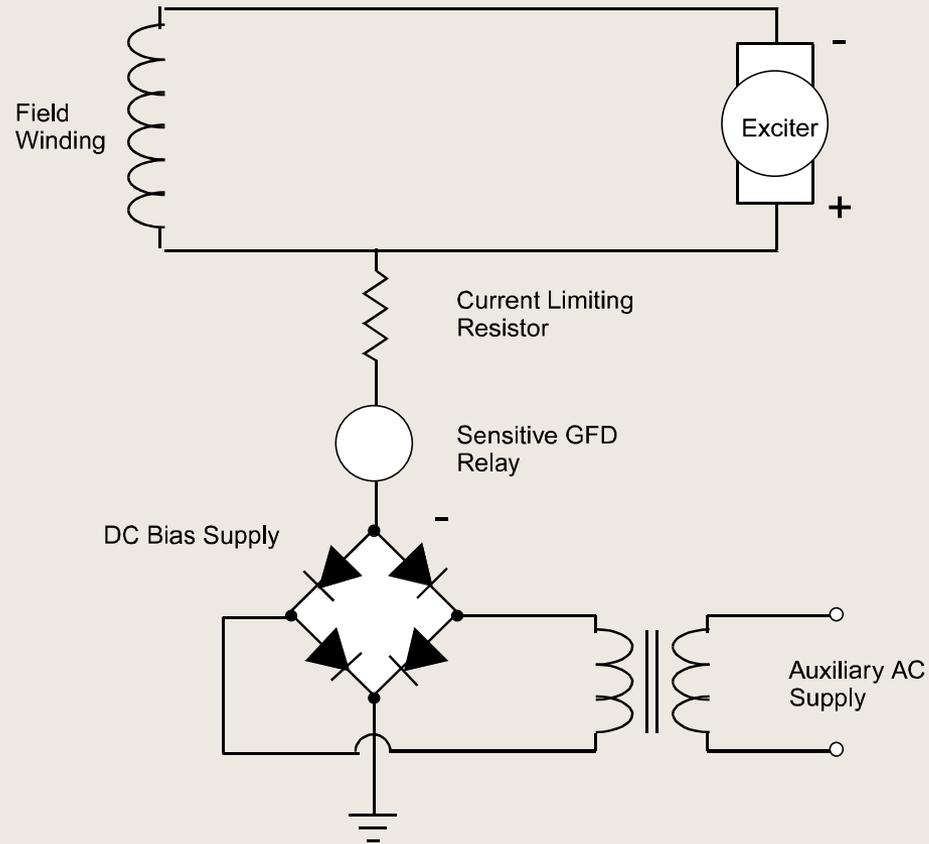
Differential



Ground Fault Protection



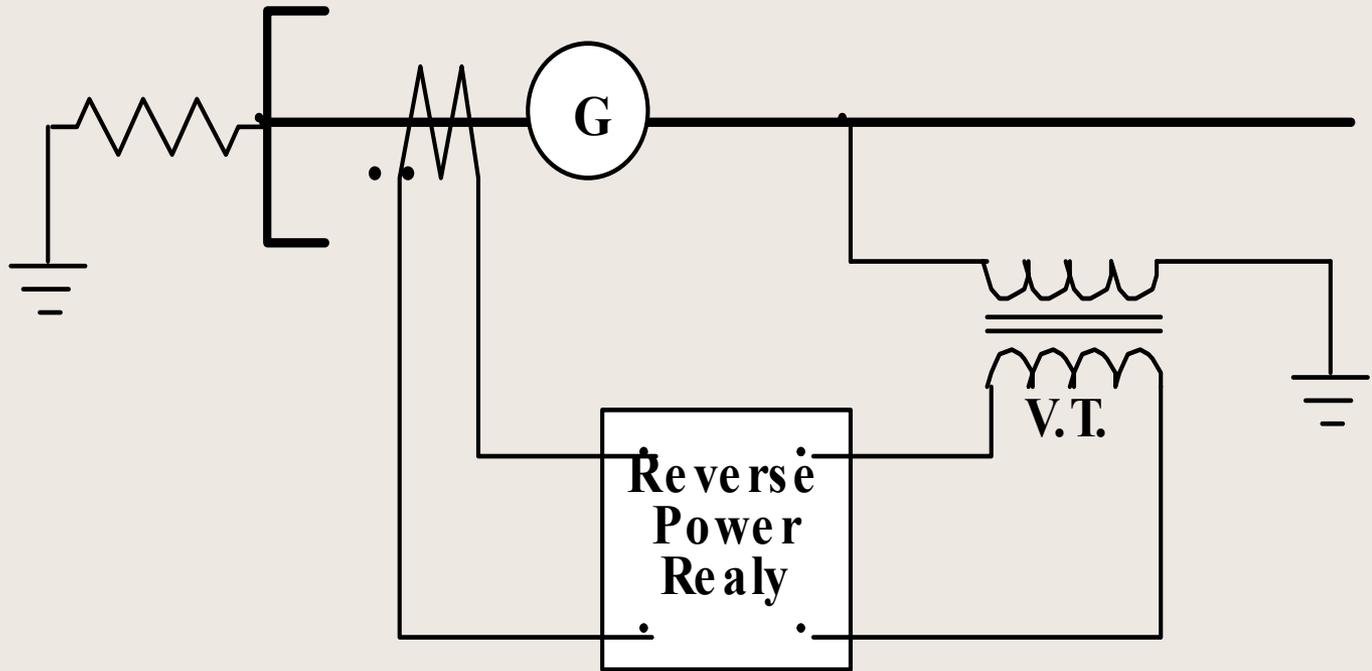
Rotor Ground Fault



Other Protections

- Phase Unbalance
- Loss of field
- Under frequency
- Out of Step

Reverse Power



Generator Protection

- Over-current
- Overload
- Differential
- Split phase differential
- Ground
- Rotor ground
- Phase Unbalance
- Low field
- Under frequency
- Out of Step
- Reverse power

For You To Do

Questions