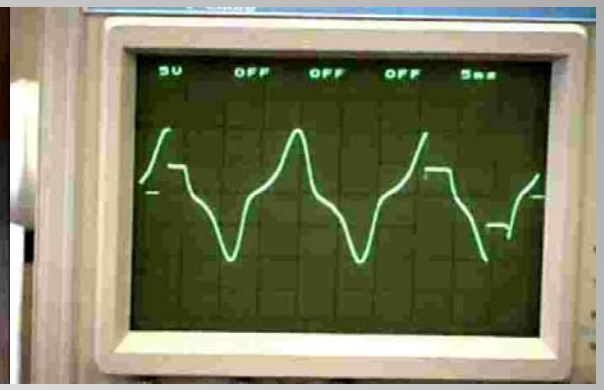
Current Transformers

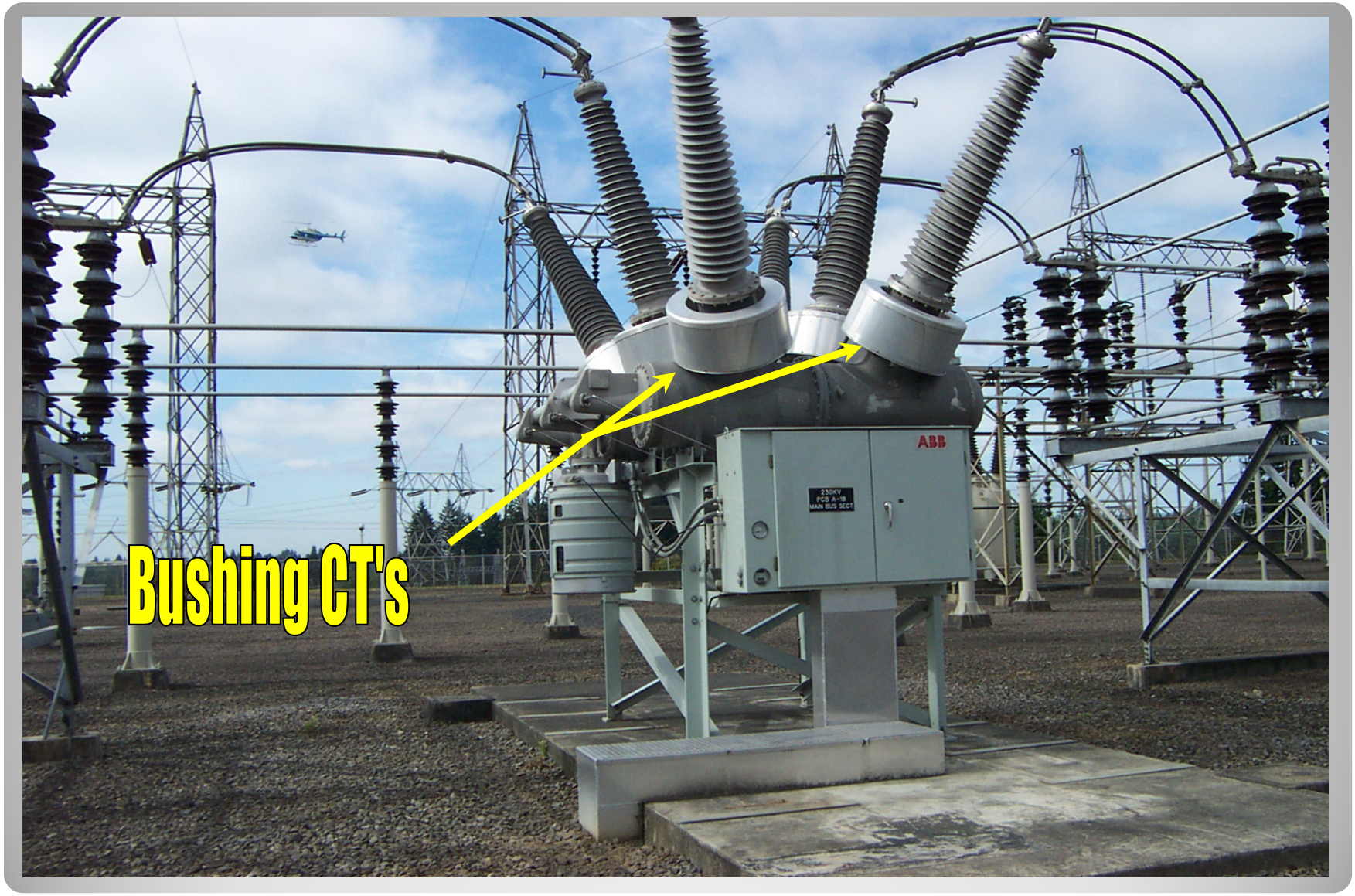




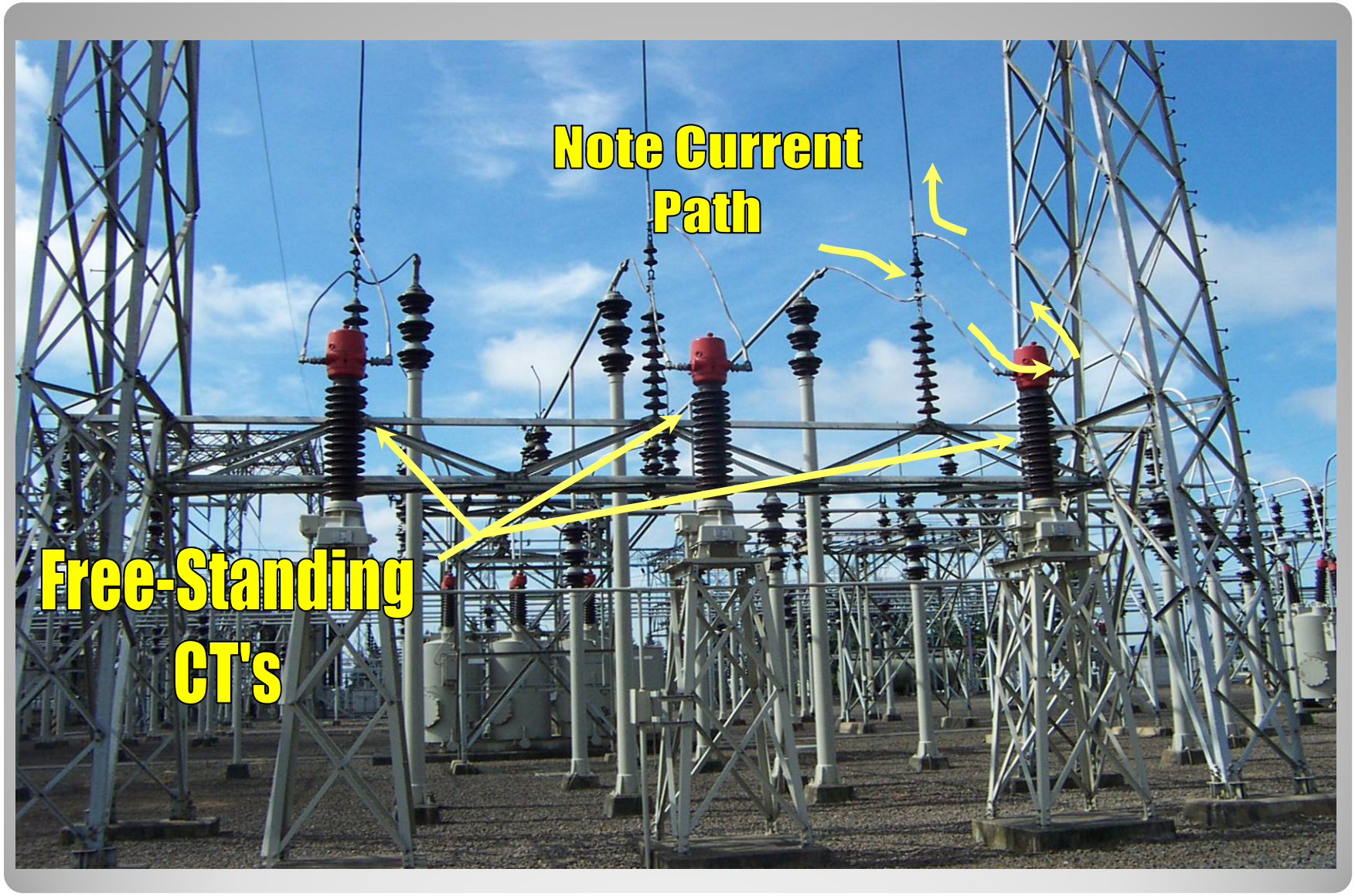
- **Bonneville Power Administration**
  - Steve Laslo
    - **For the Hands On Relay School (3-13)**
      - **Revision 1.1 (Basic)**

Objective of the presentation:

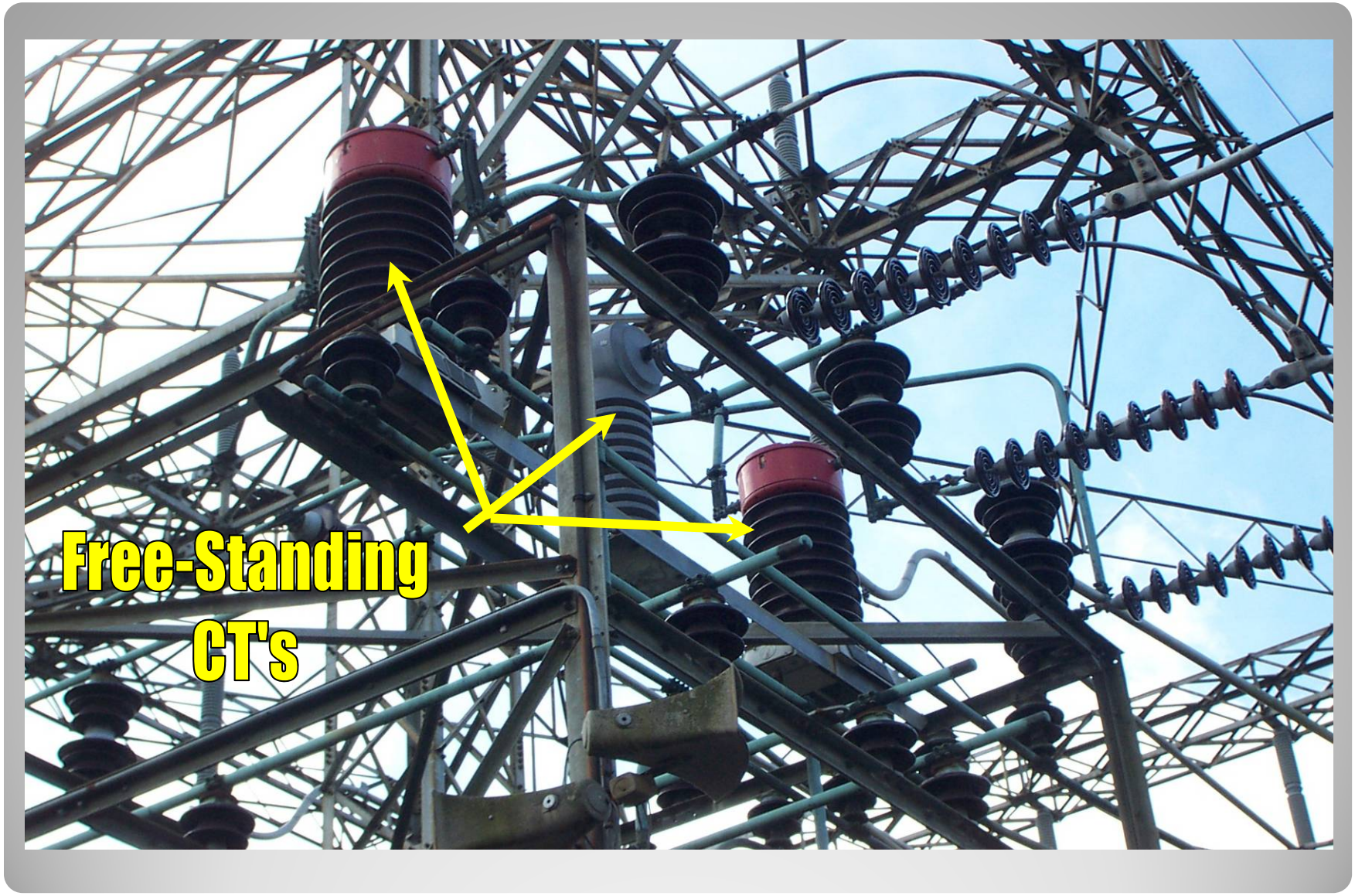
- For participants to increase their knowledge level of Current Transformers in the following areas:
  - CT Theory
    - Basic Operation
    - CT Polarity
    - CT Connections
  - Safety Hazards
  - Basic Safe Work Practices



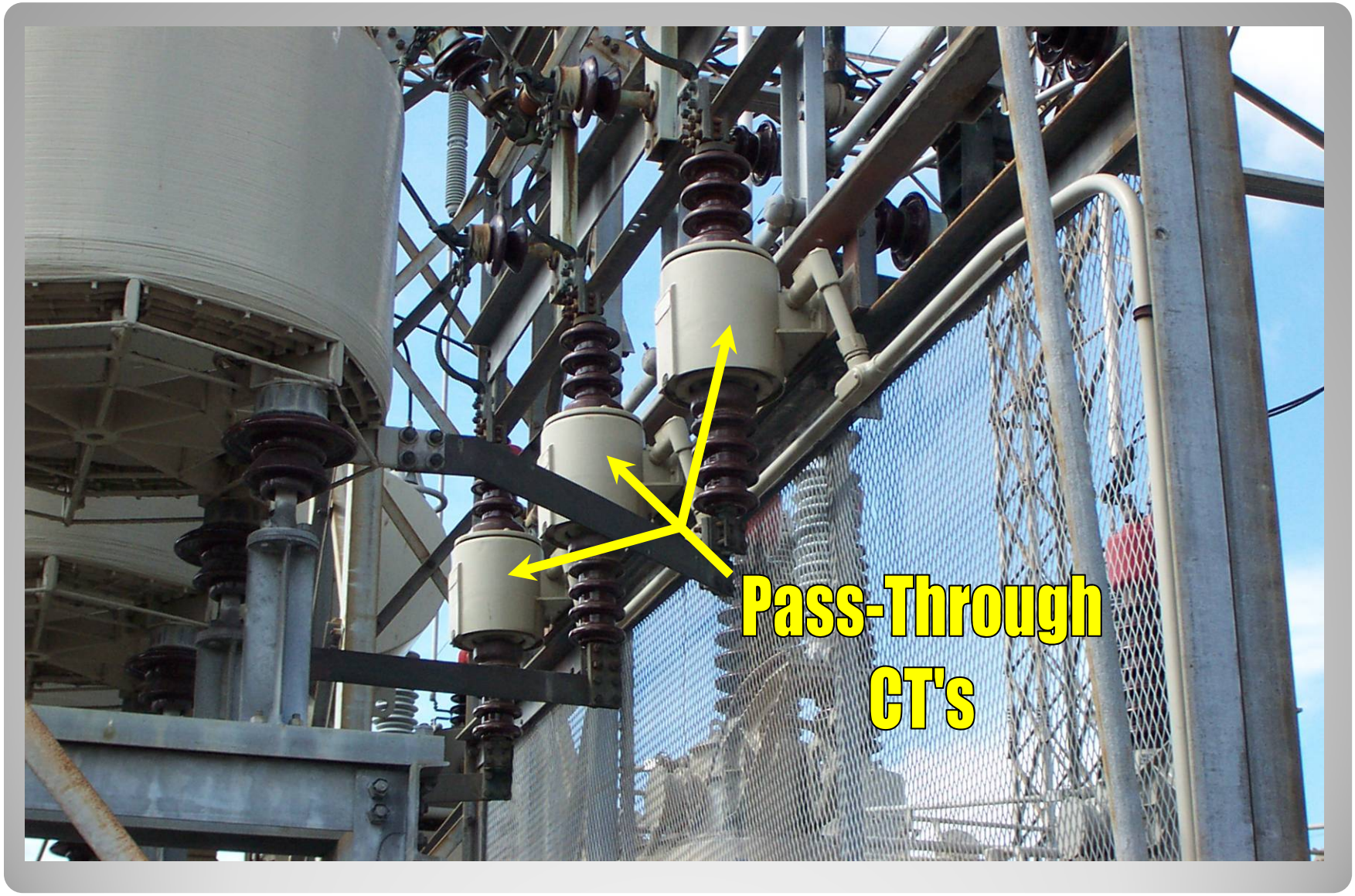
Examples of CT's



Examples of CT's

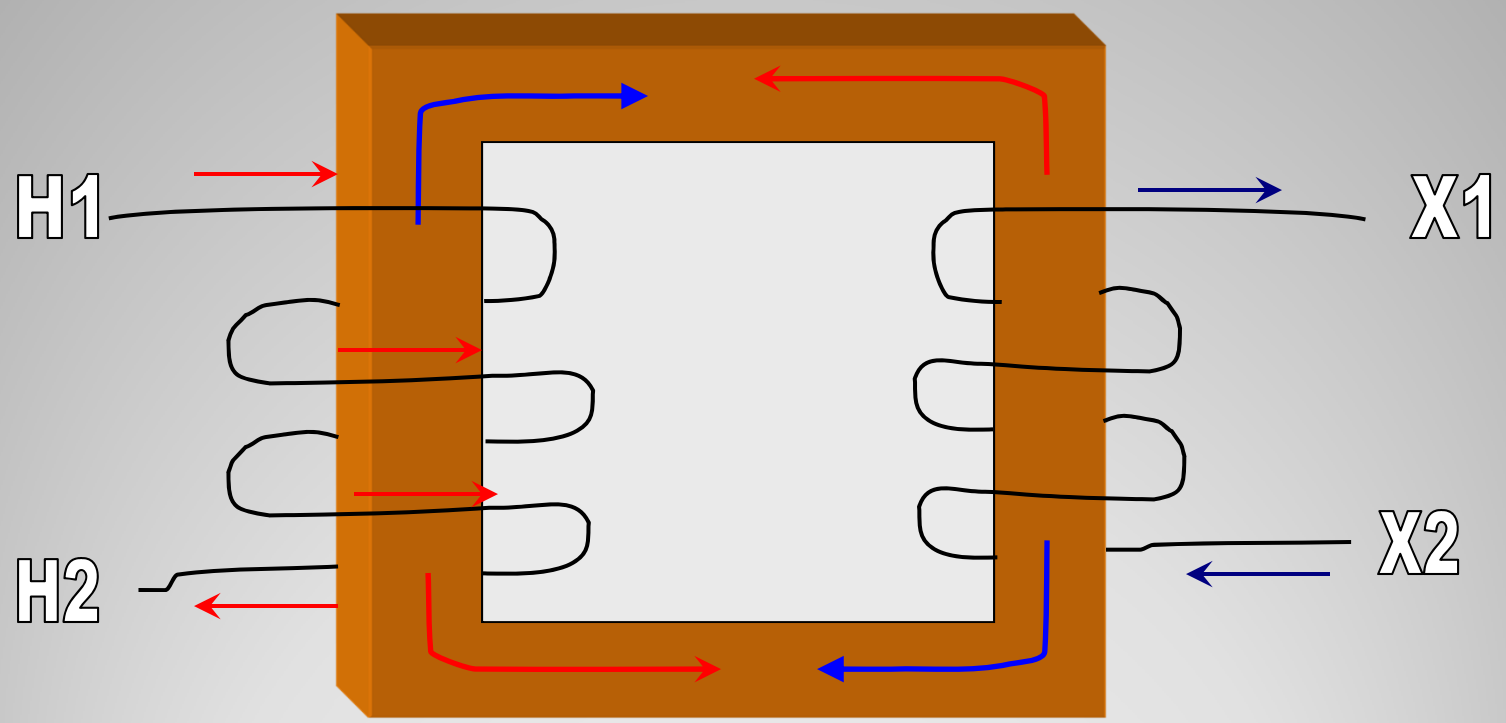


Examples of CT's

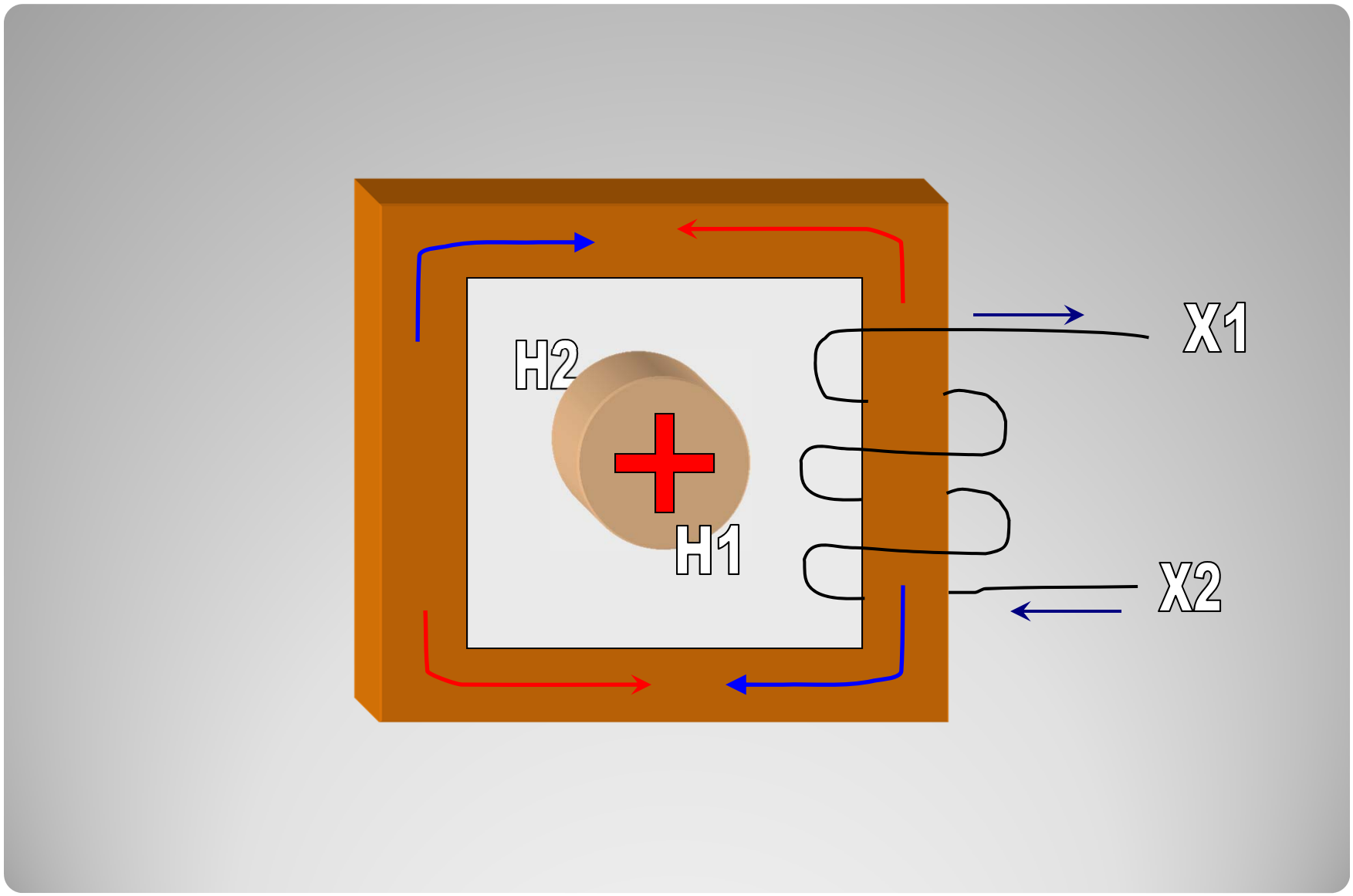


Examples of CT's

Basic Theory:

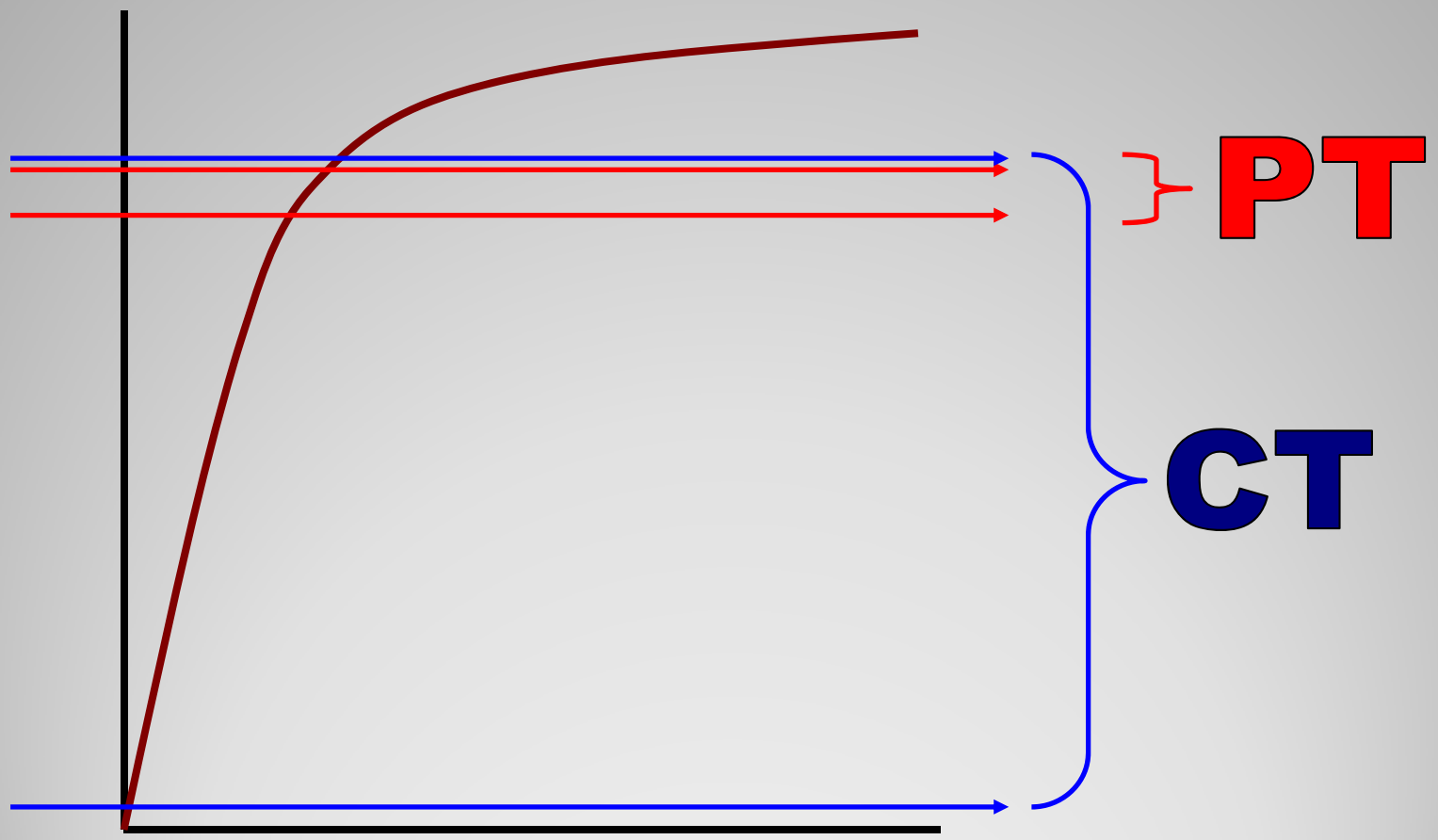


CT as a Voltage Transformer

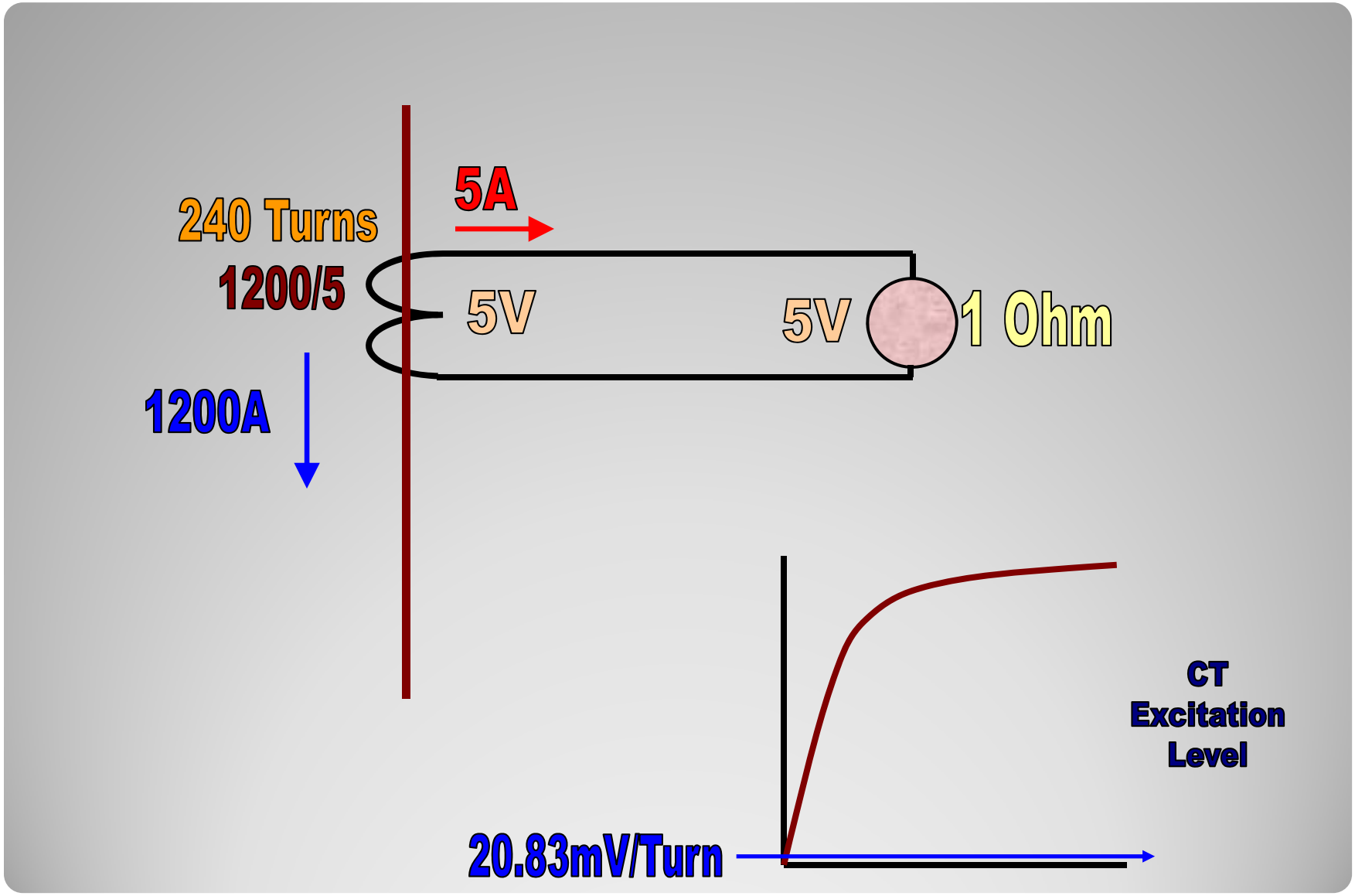


CT as a Voltage Transformer

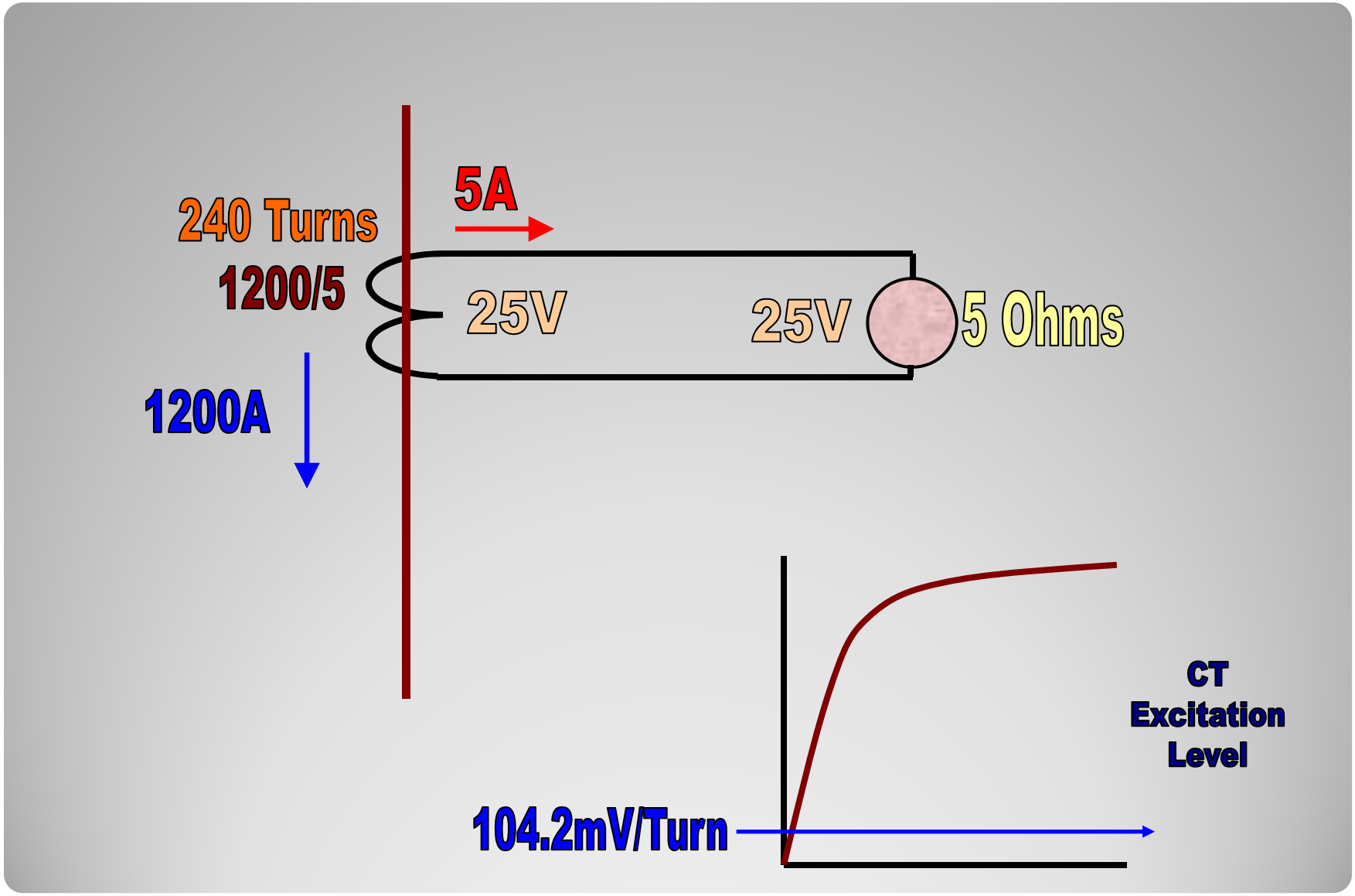
Working Range of (relative) flux levels on core:



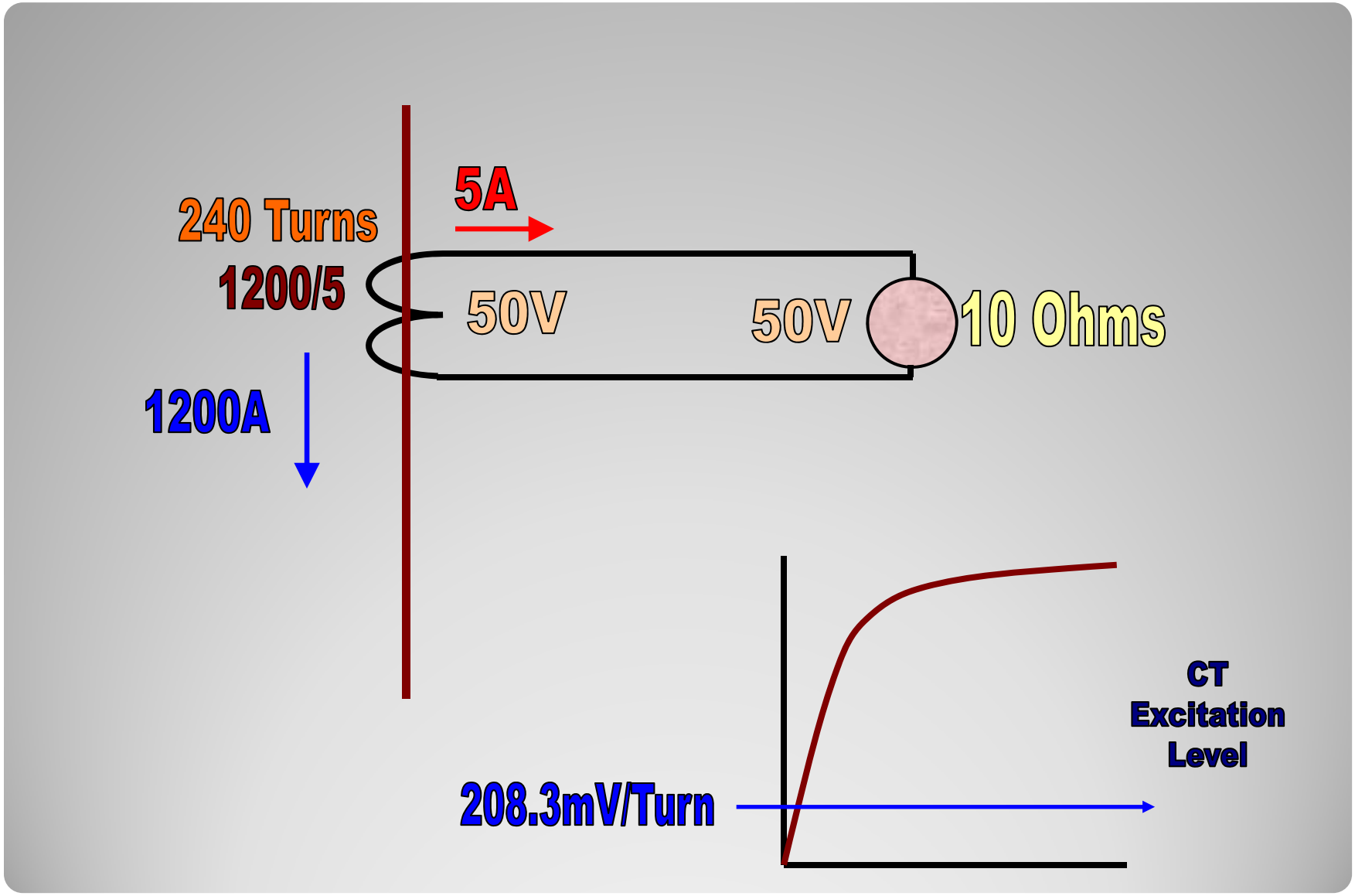
Saturation Curves



CT with varying burden

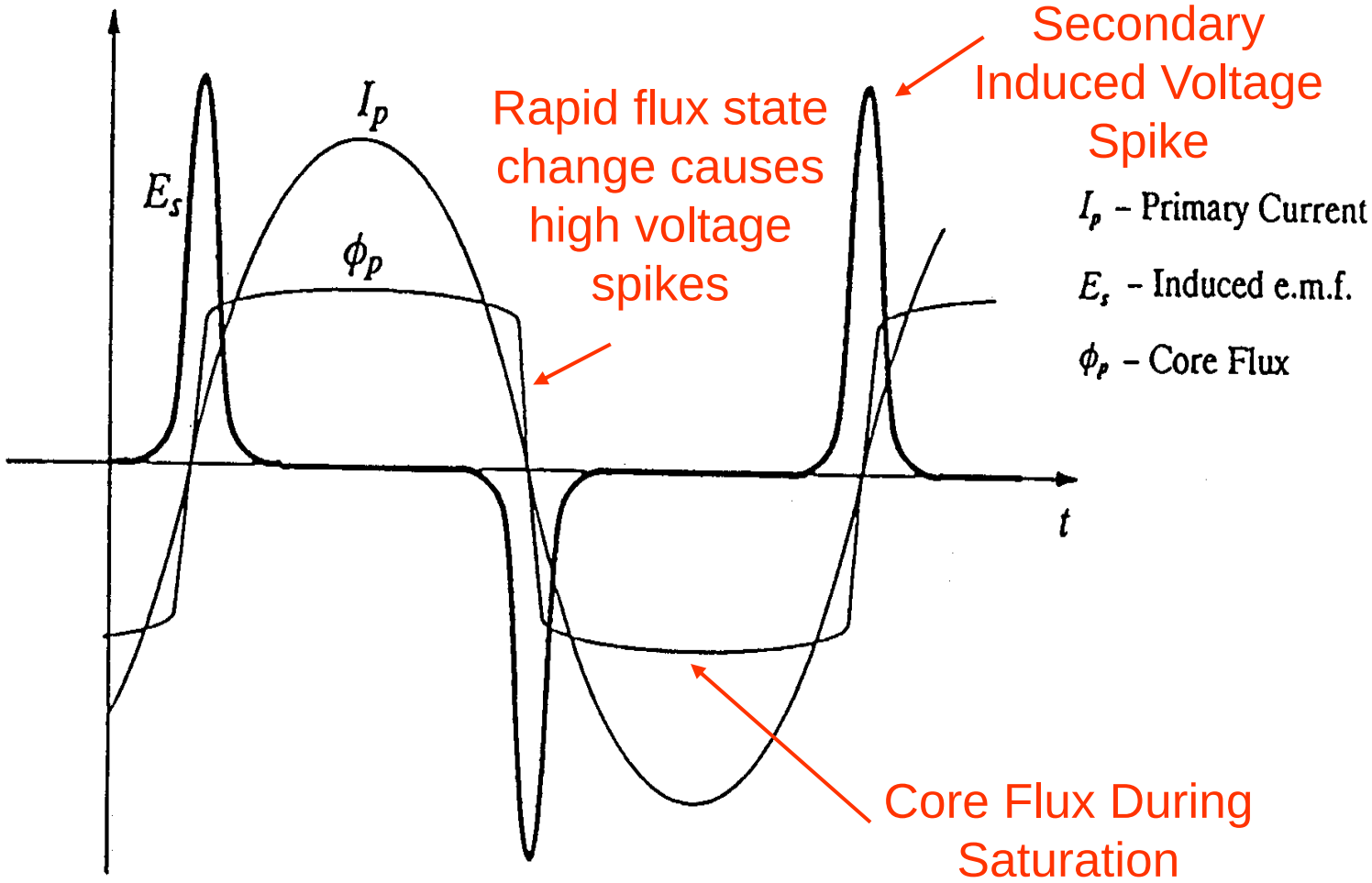


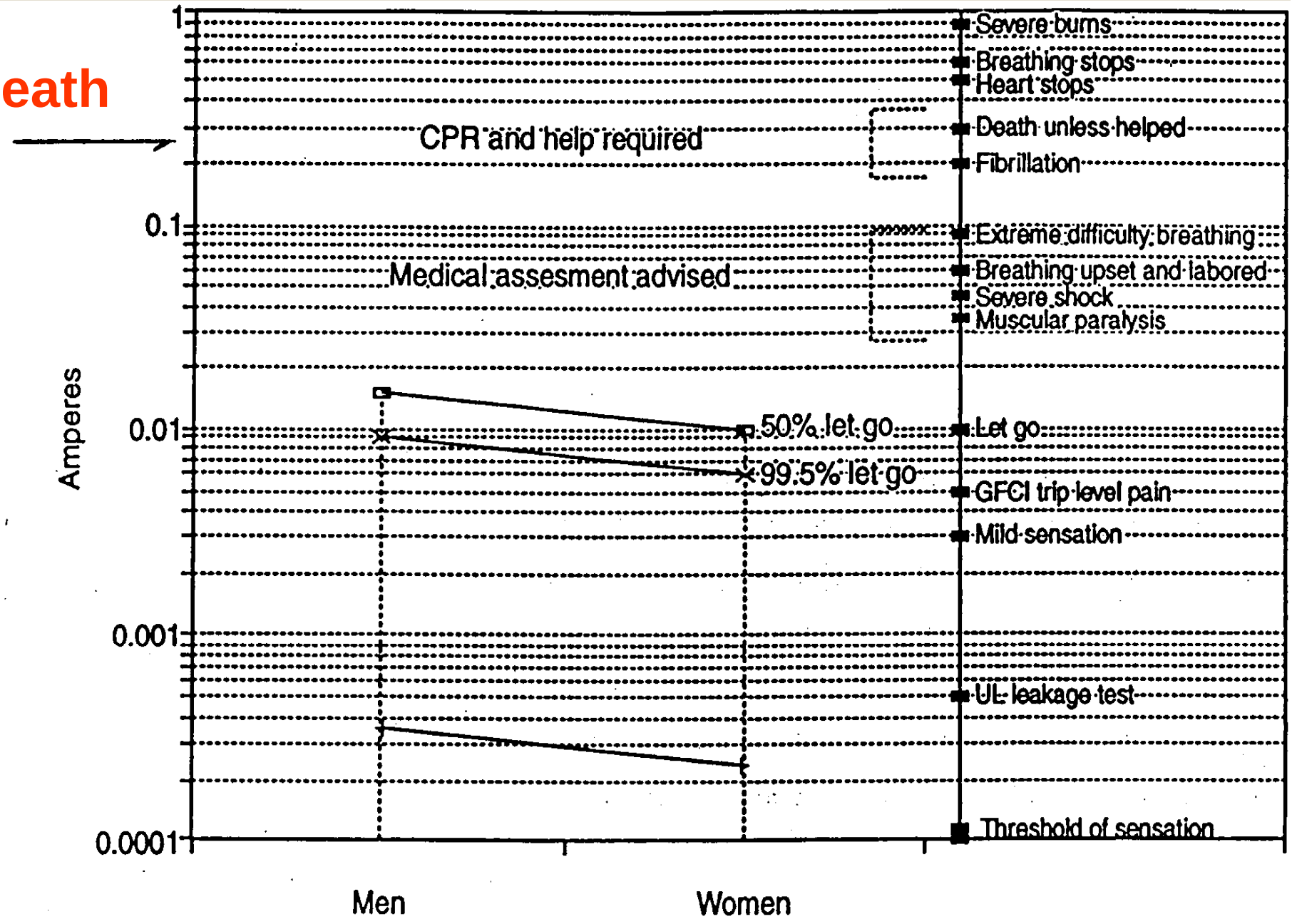
CT with varying burden



CT with varying burden

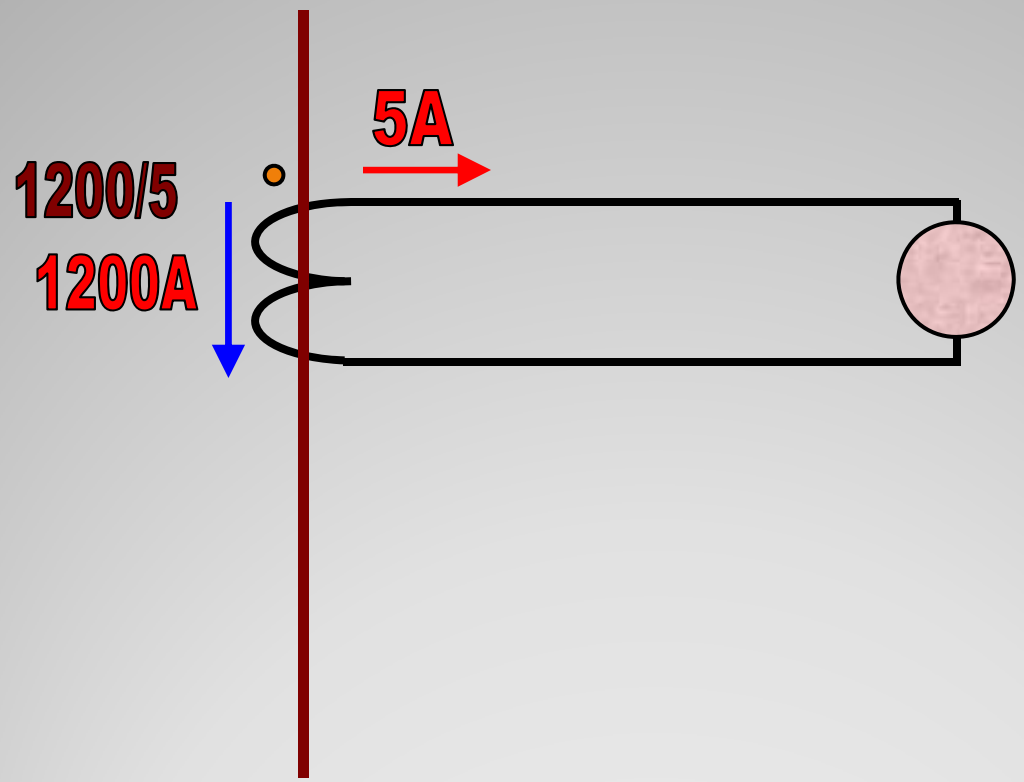
Secondary open circuit wave shapes





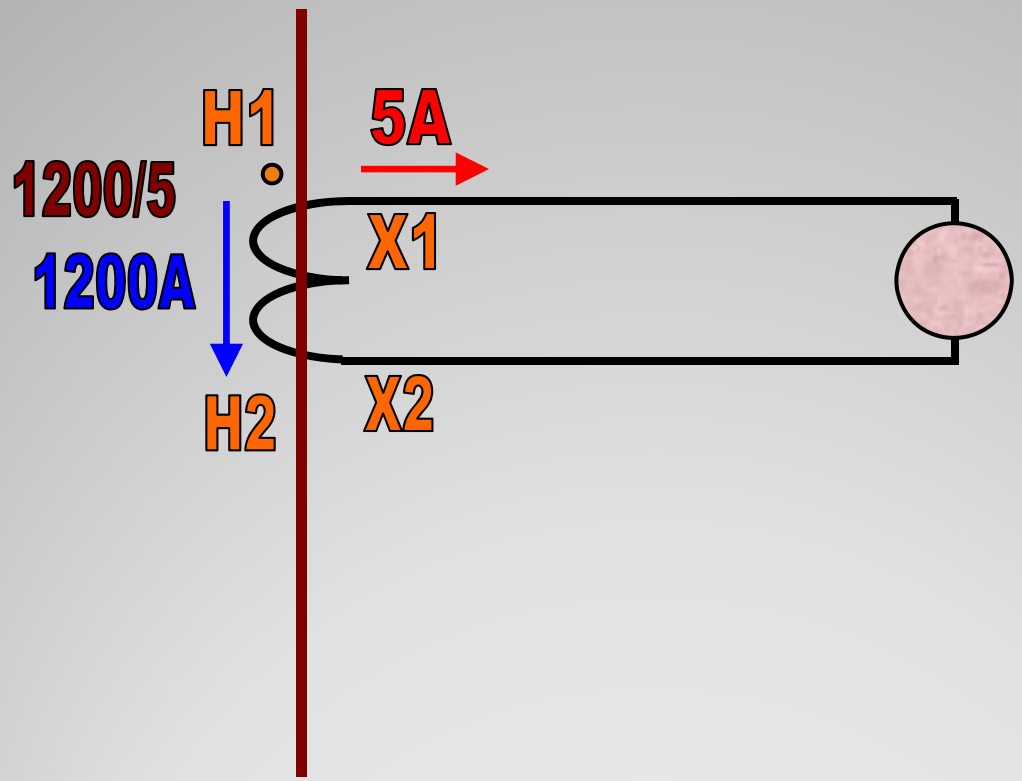
A CT can easily supply currents above lethal levels!

The open circuit situation resolves to high voltages and lethal currents… WATCH THIS!!



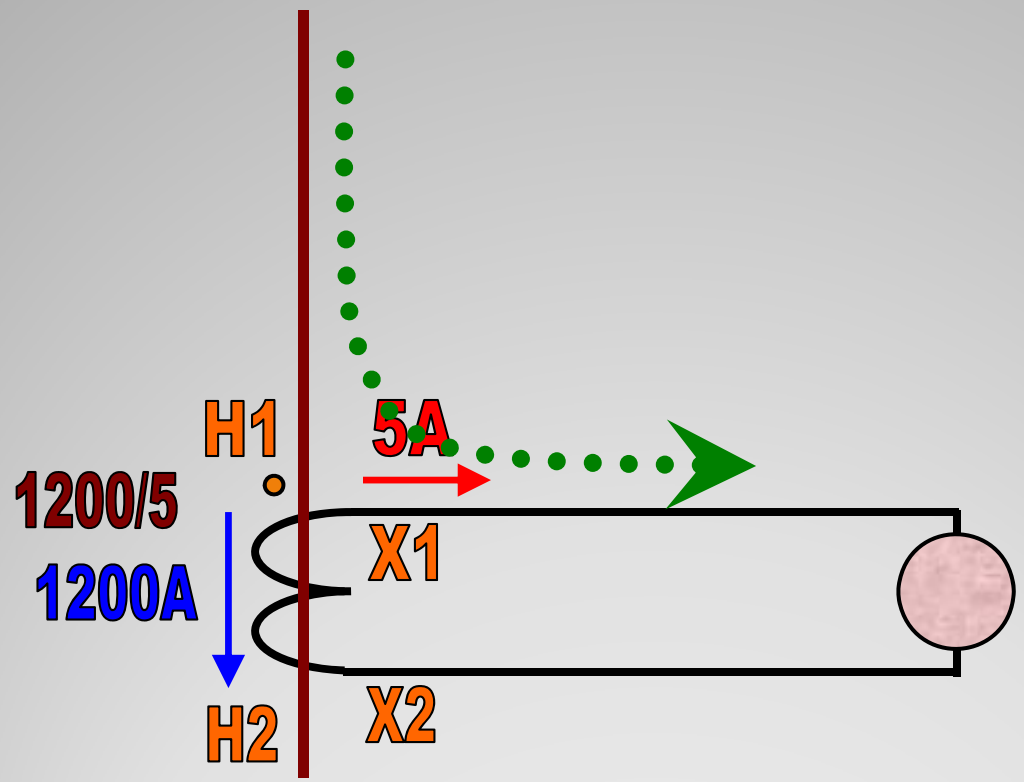
- Shows instantaneous current flow
- Polarity Mark generally indicates H1/X1 terminals.

CT Polarity



- Instrument Transformers are almost universally 'Subtractive' polarity

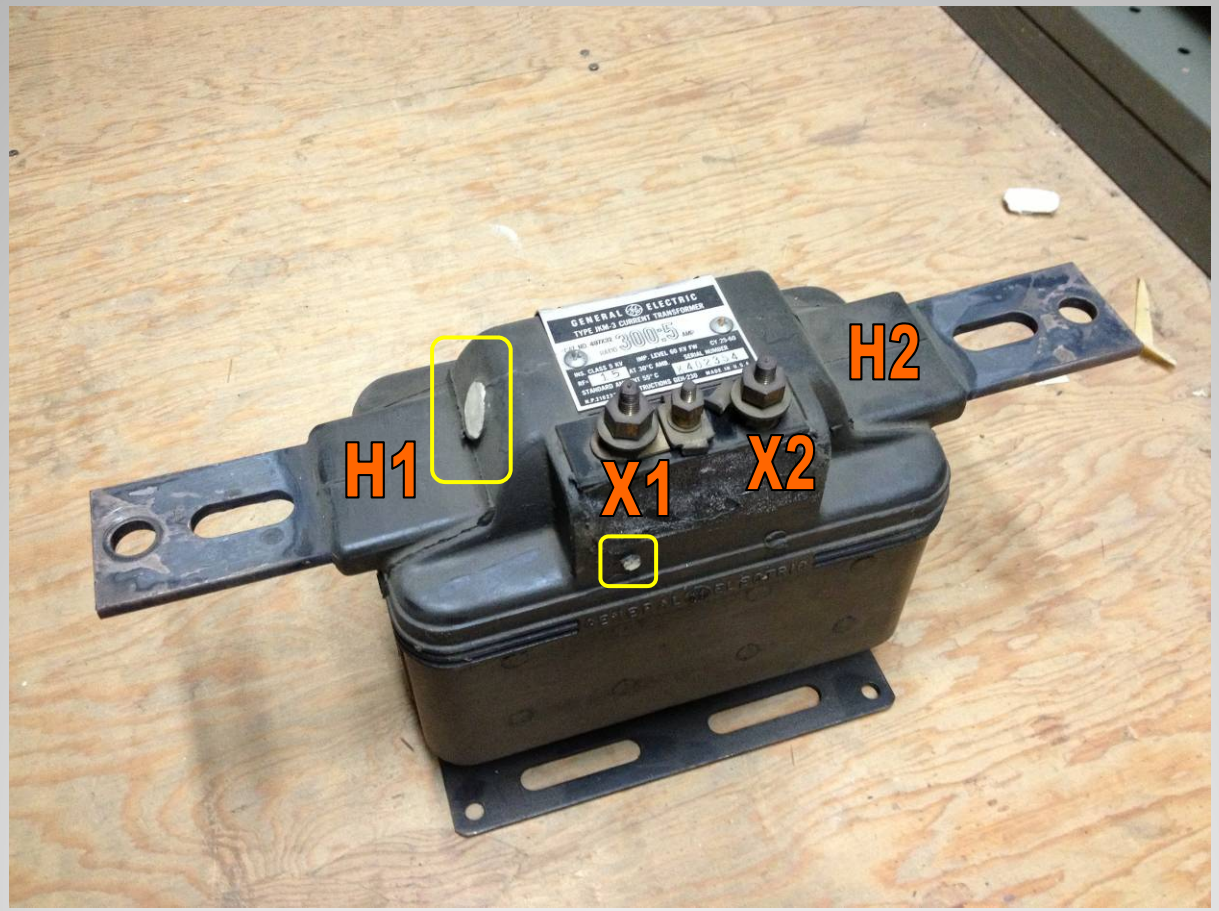
CT Polarity



- Another view on polarity:
- Current flows as if there is a physical connection.

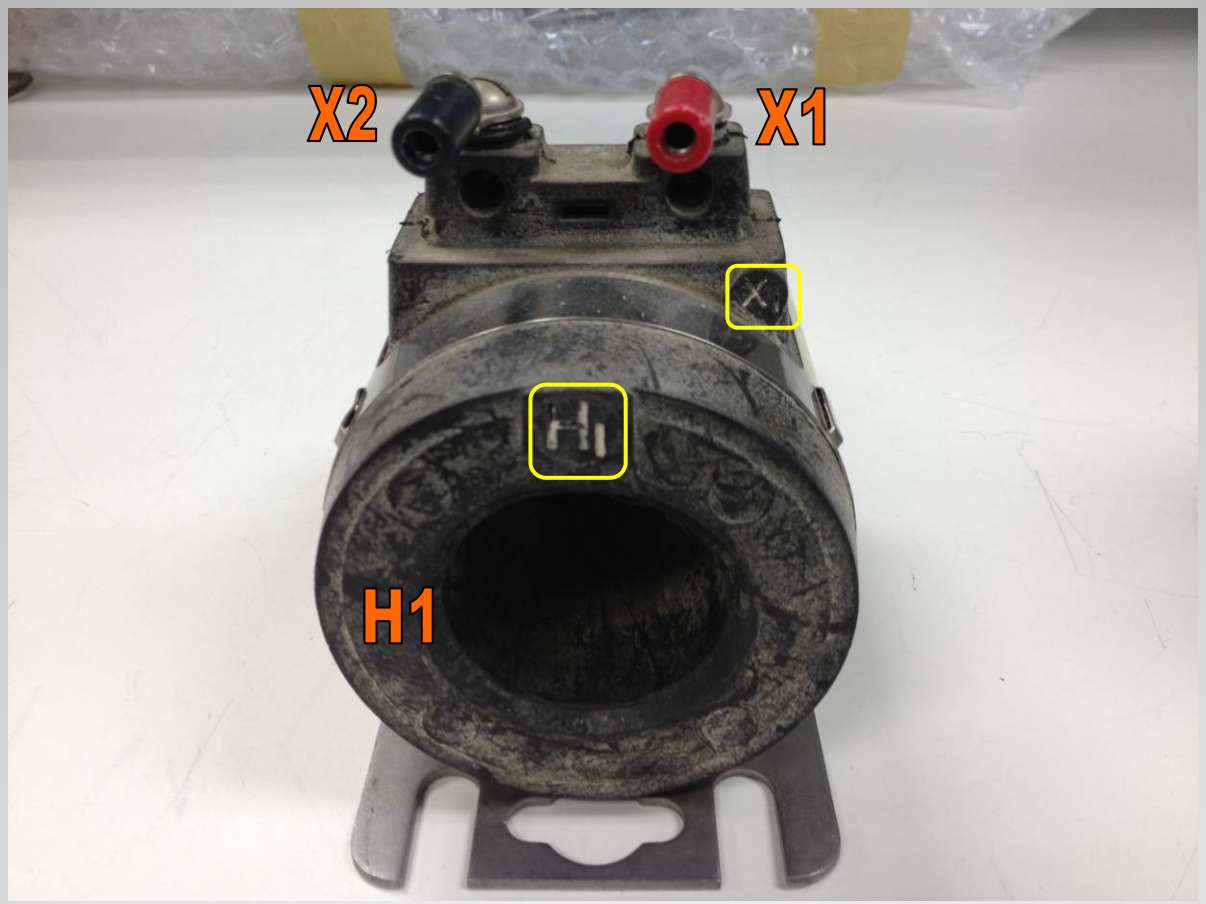
CT Polarity

- Some pictures of CT's with polarity marks:



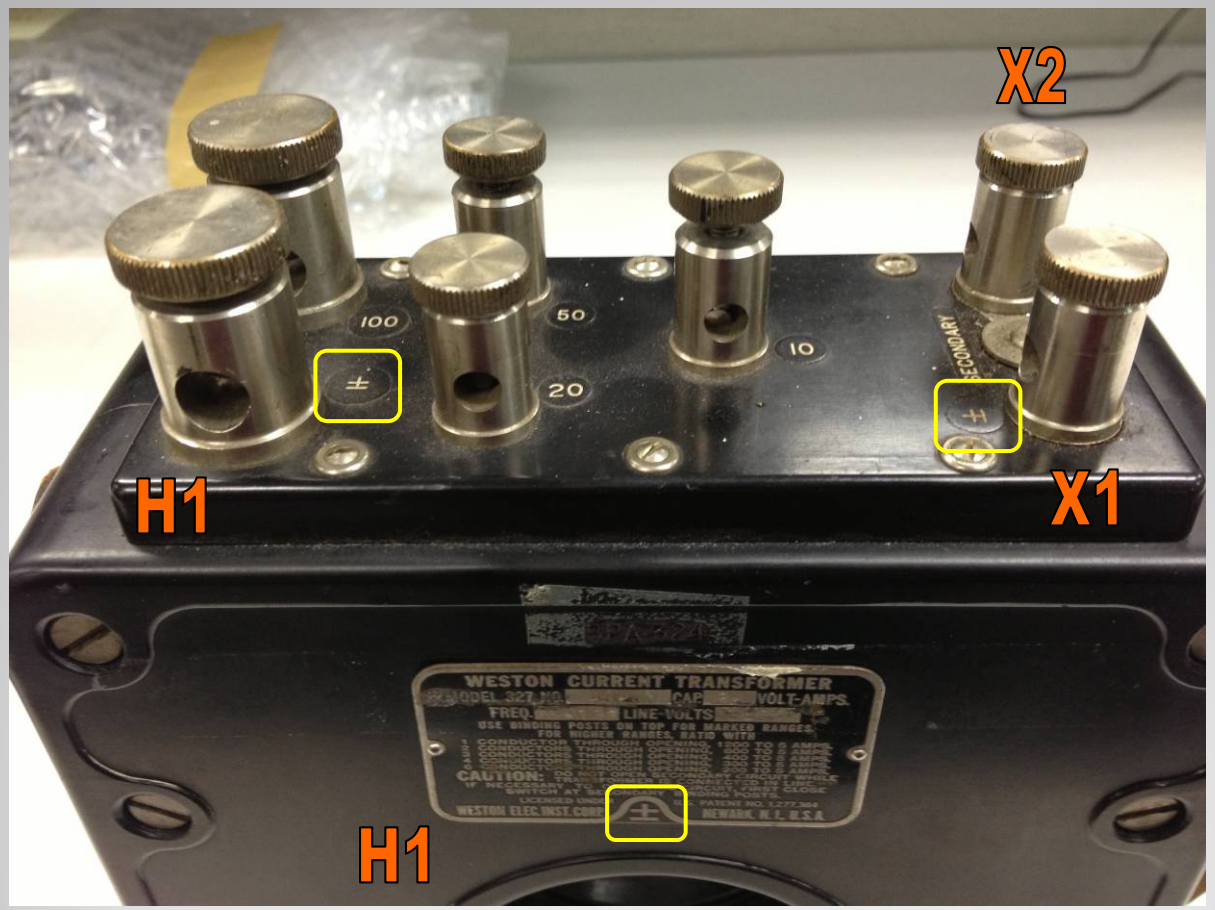
Bar-type CT

- Some pictures of CT's with polarity marks:

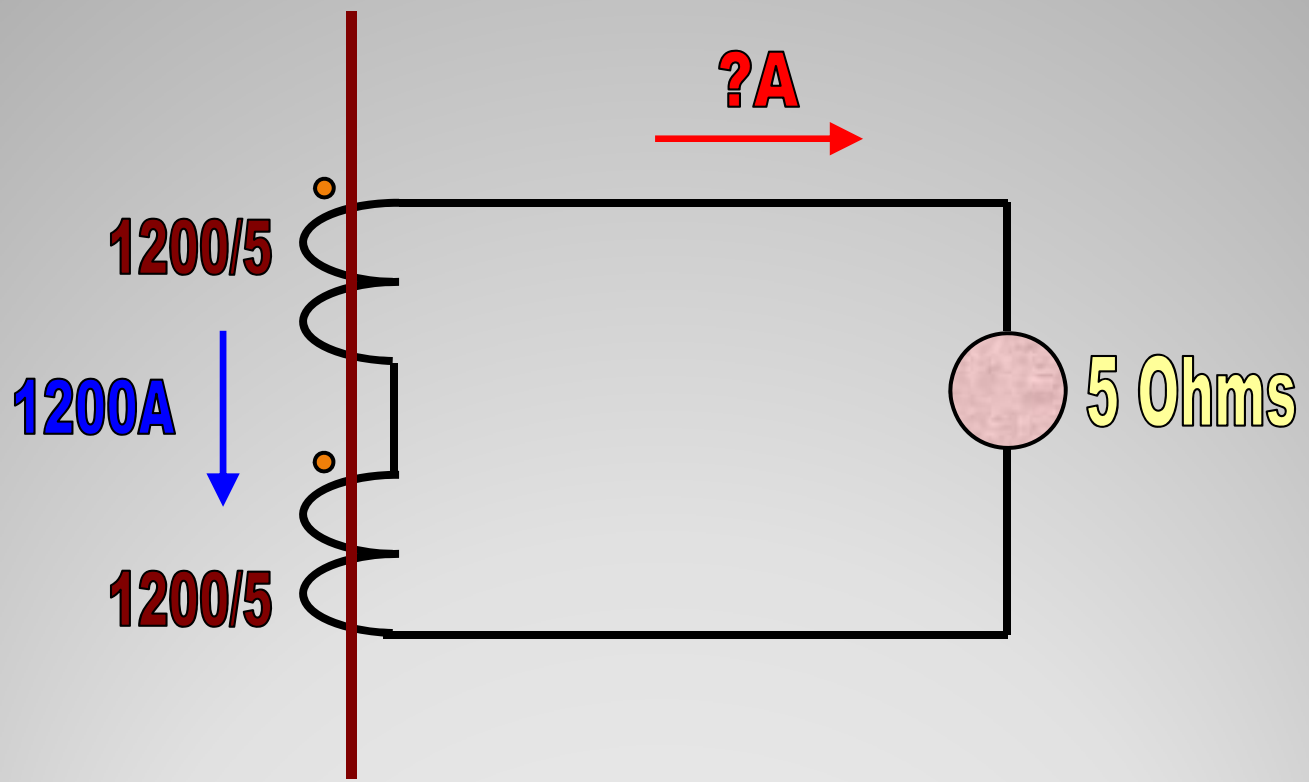


Small Window CT

- Some pictures of CT's with polarity marks:

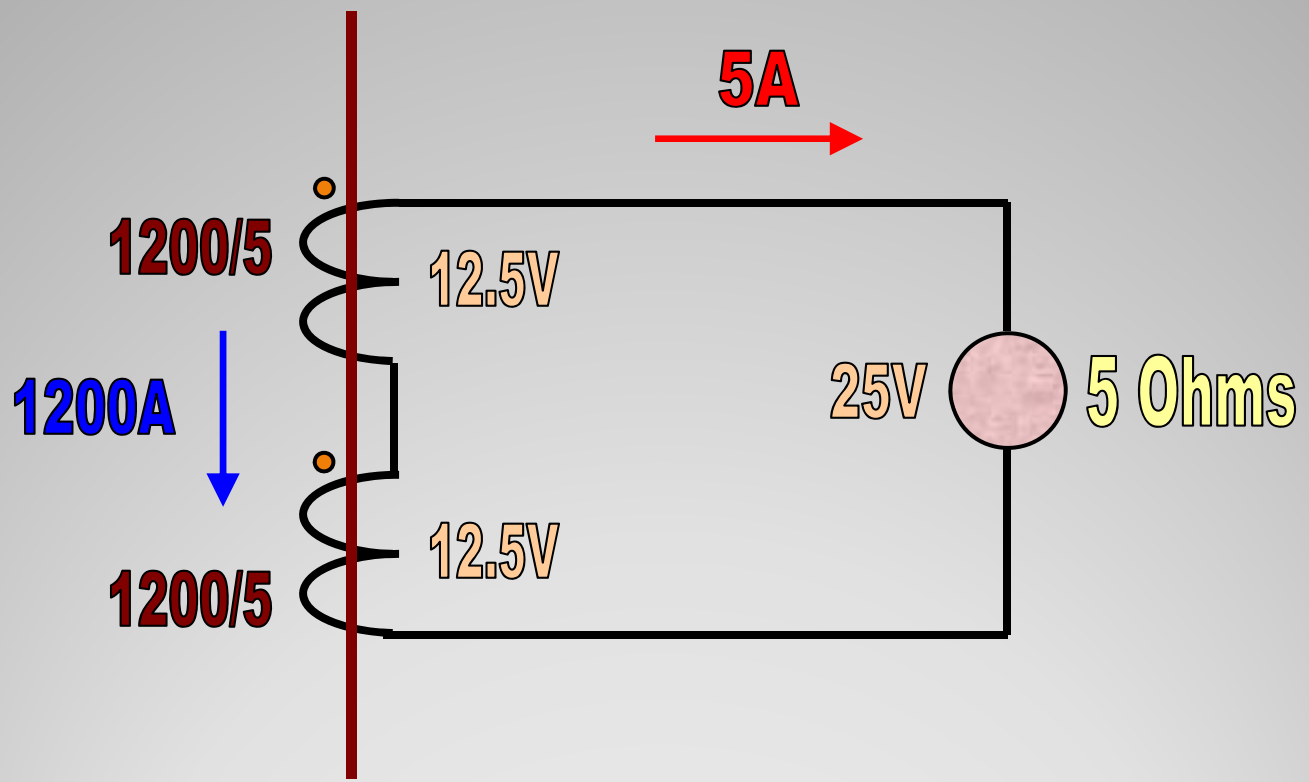


Multi-ratio Window CT



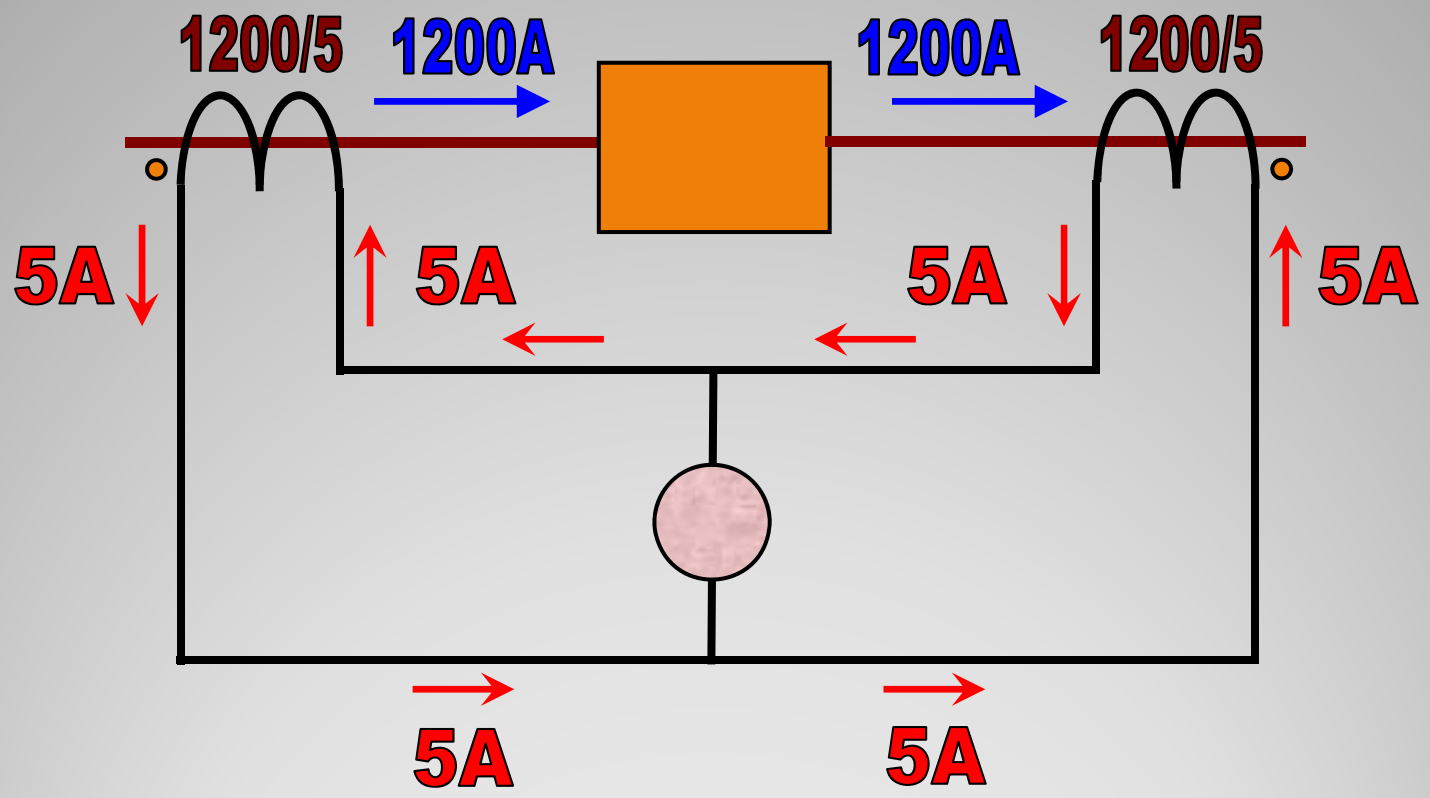
- CT Polarity is critical when CT's are being used together in single-phase or three-phase applications.

CT Polarity



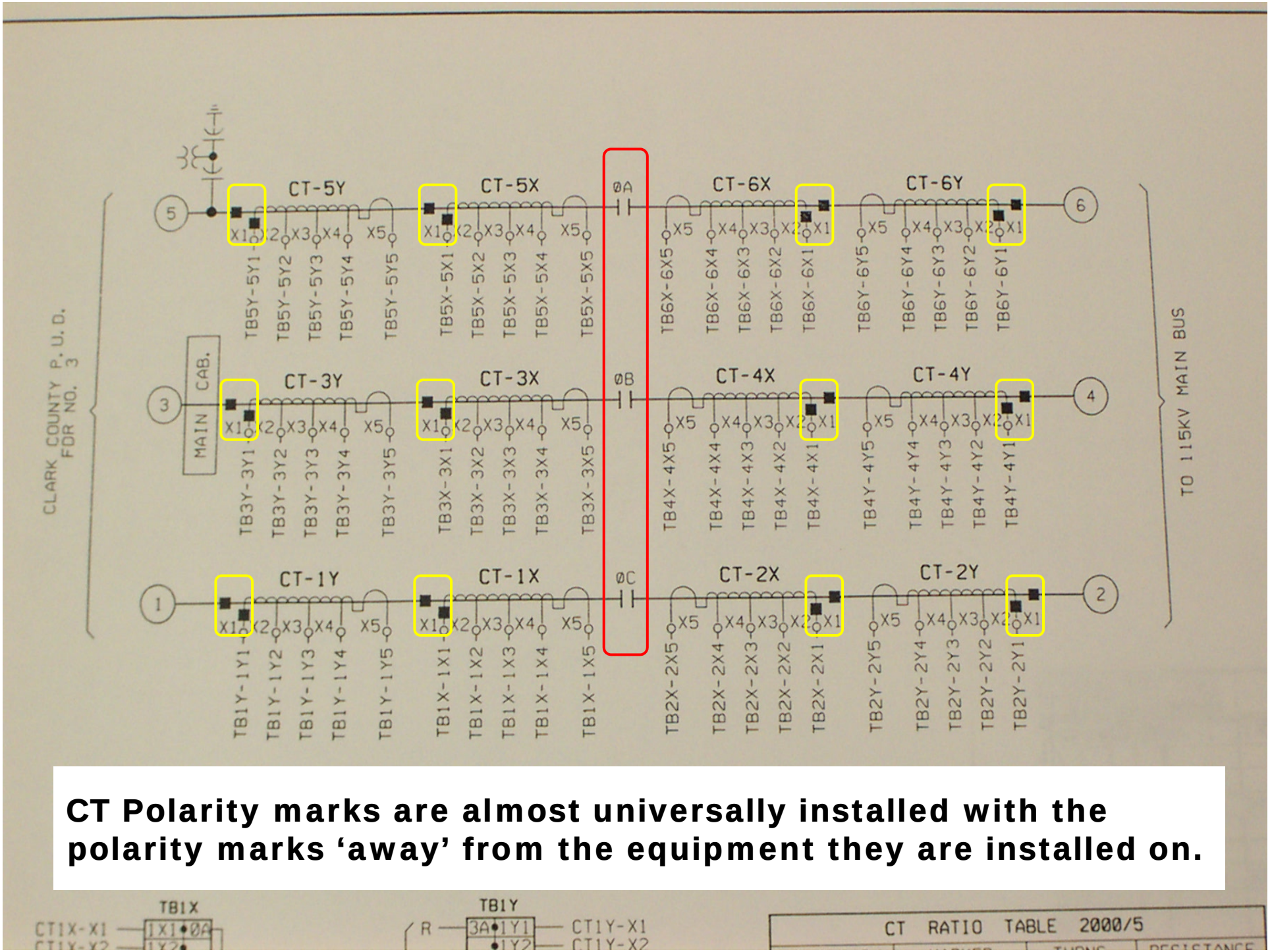
- CT's in series act together to reduce burden per CT, and increase overall performance.

CT Polarity

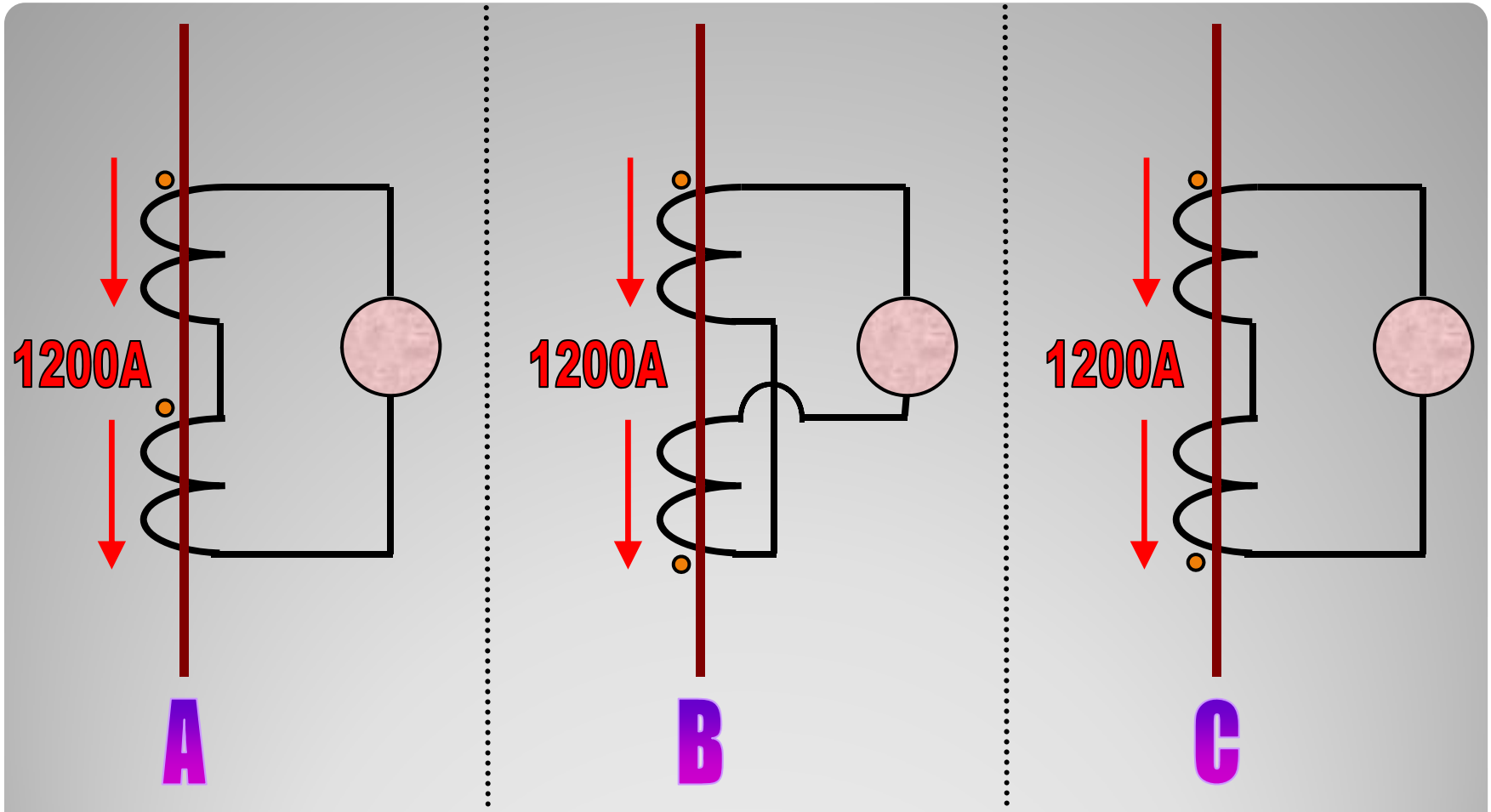


- Basic Differential circuit.
  - Correct polarity is critical to proper circuit operation.

CT Polarity

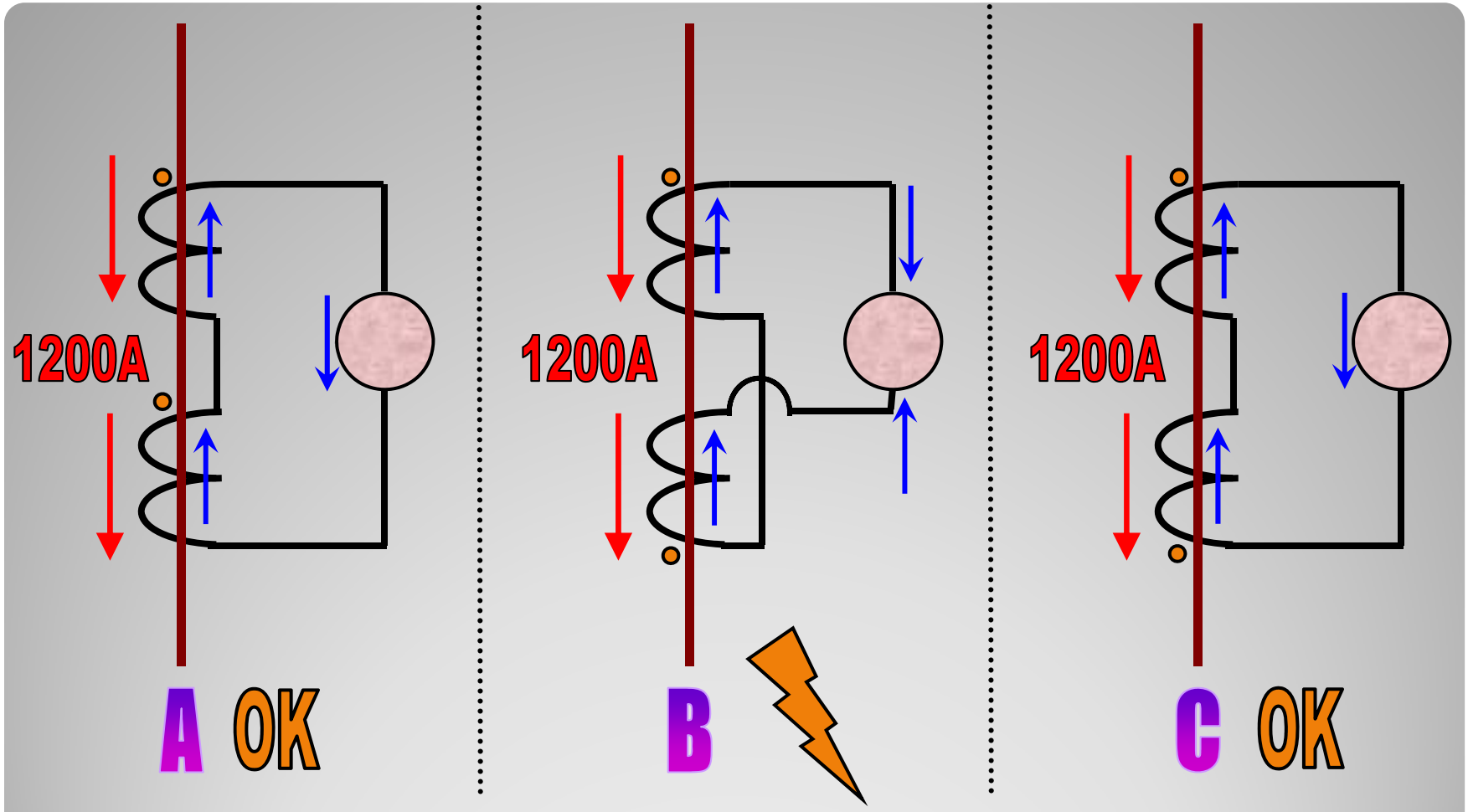


CT Polarity marks are almost universally installed with the polarity marks 'away' from the equipment they are installed on.



- Which picture's have correct polarity and which are wrong?
- What would be the effect of the 'wrong' polarity?

CT Polarity – Brain Teaser



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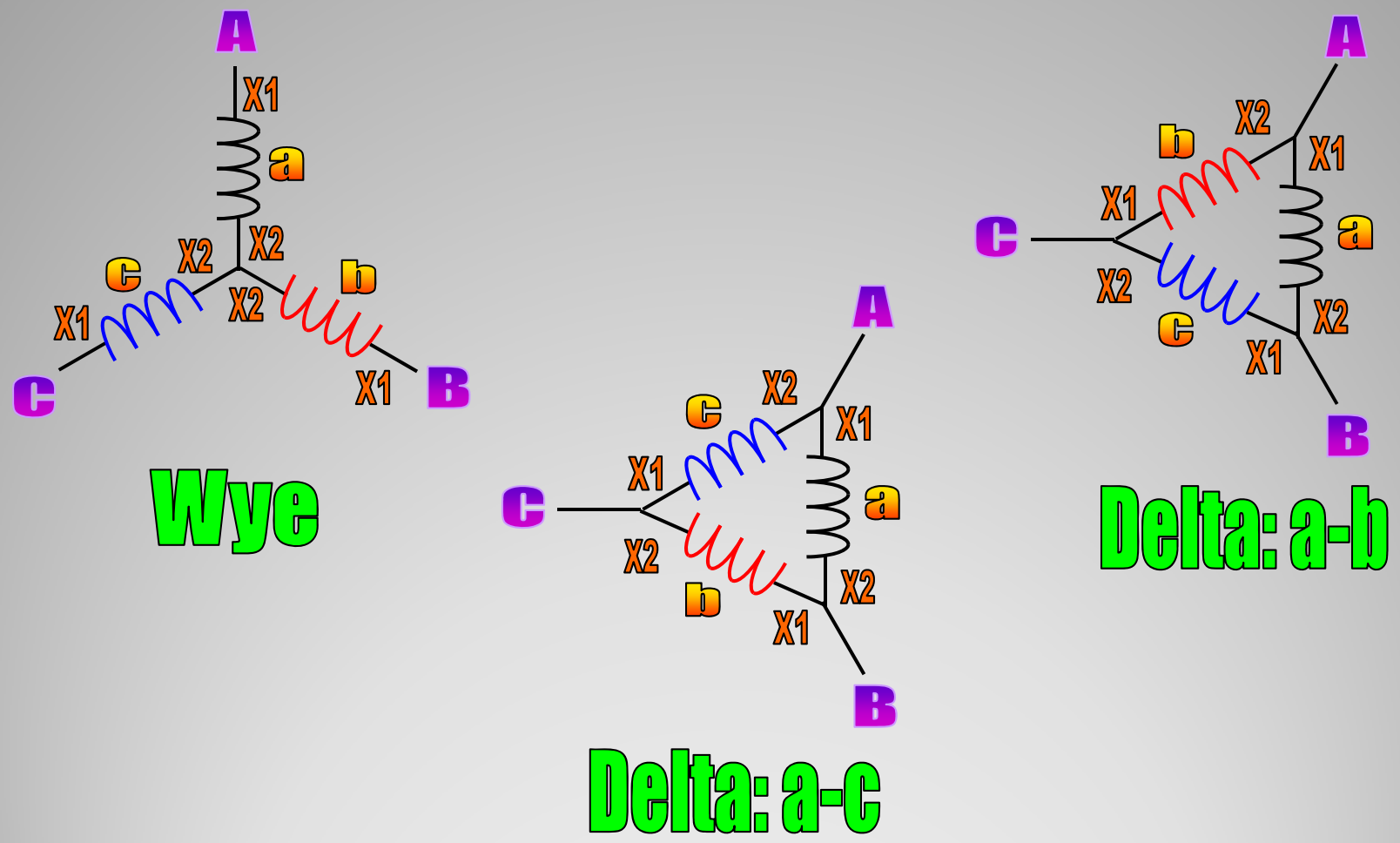
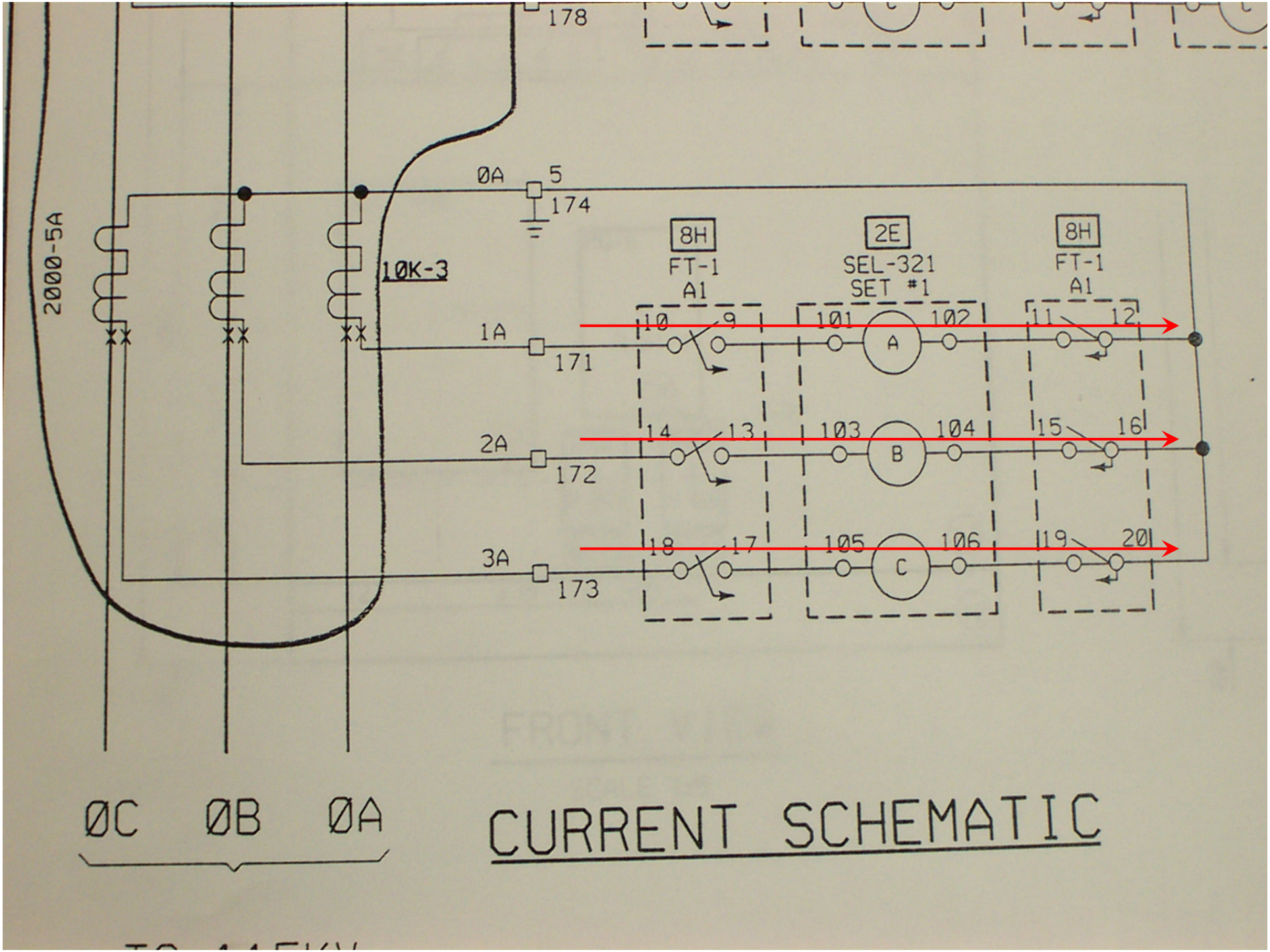
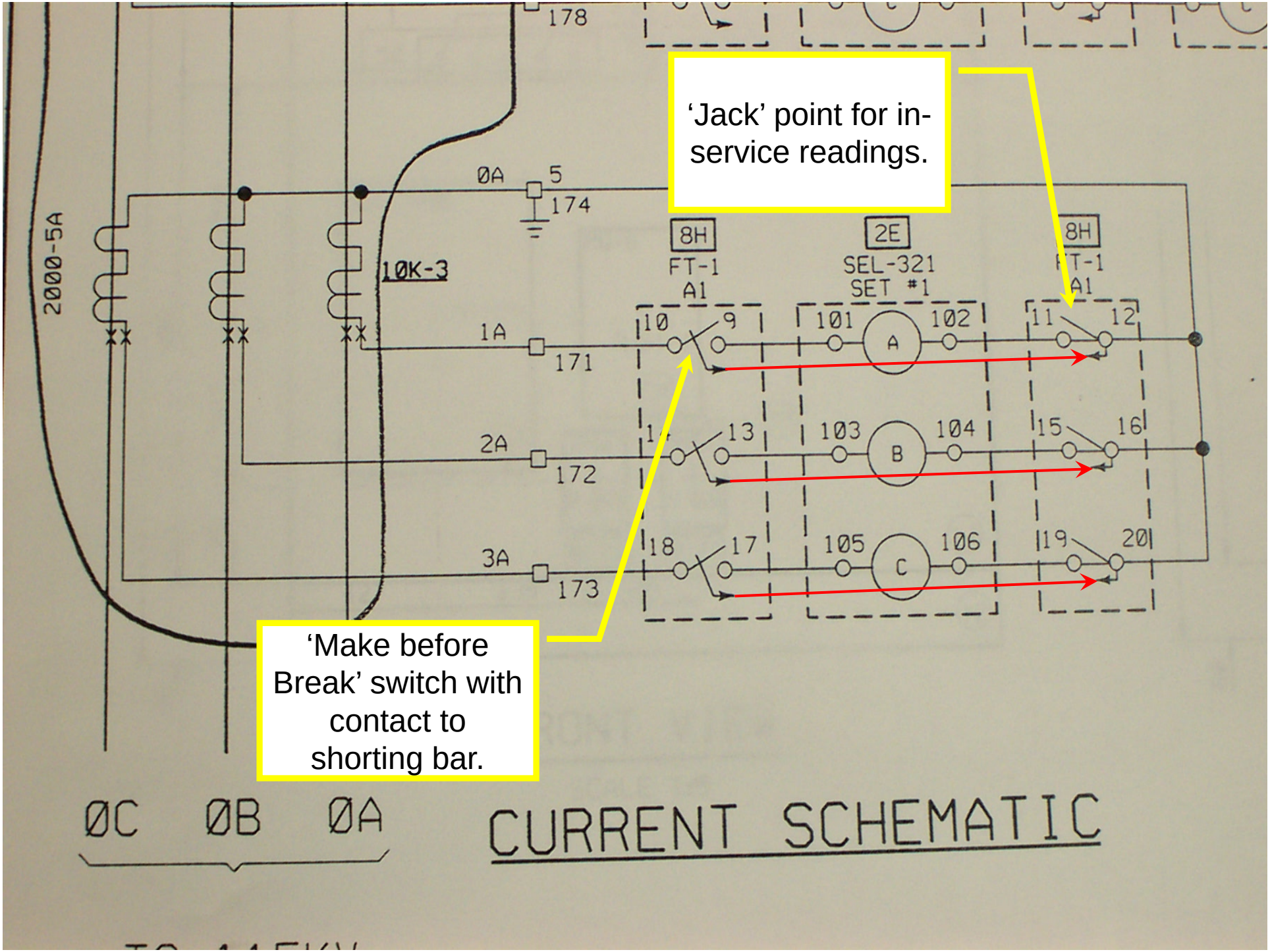
CT Polarity – Brain Teaser

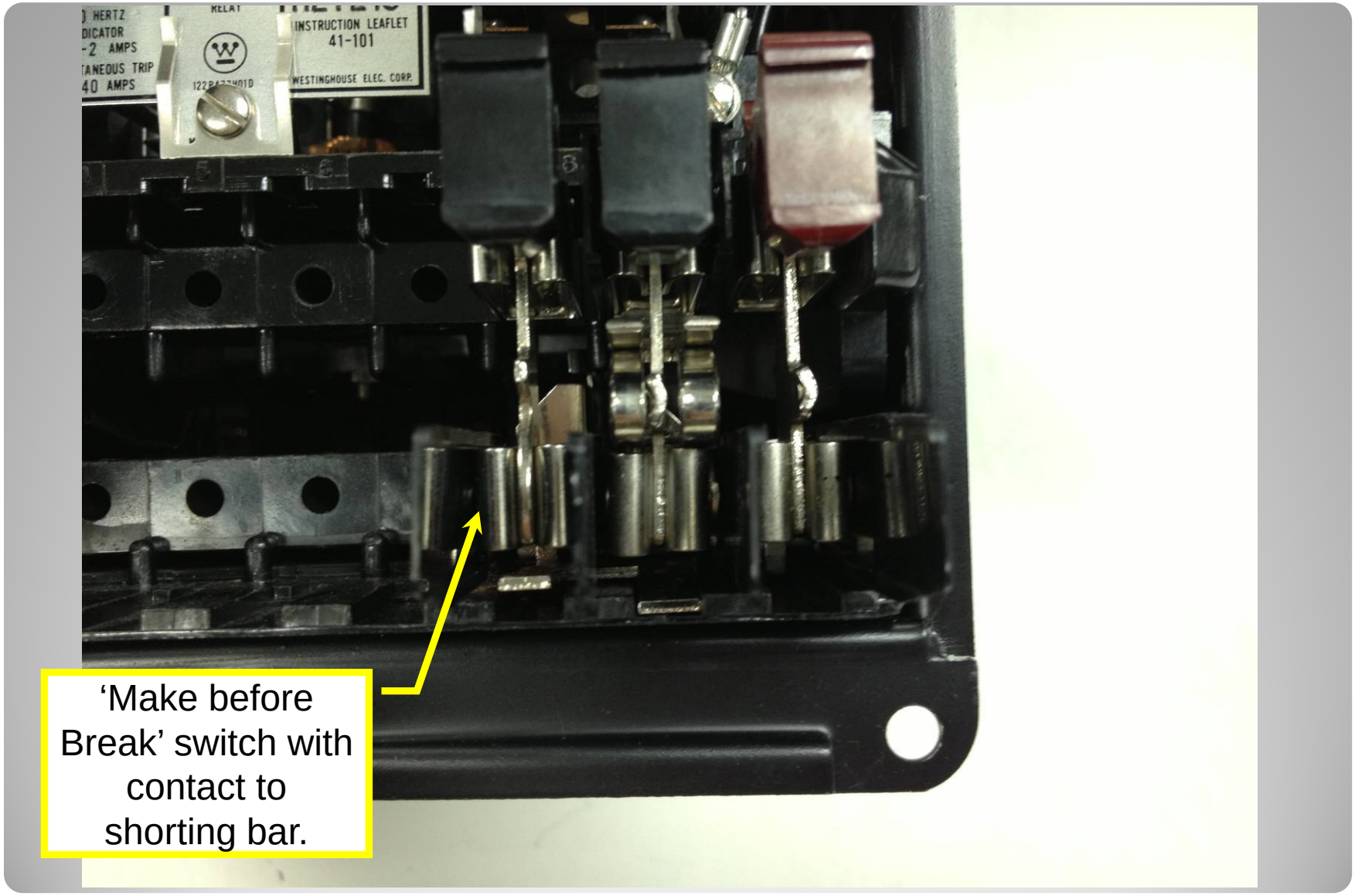


- There are 3 fundamental connections possible with CT's in 3-Phase circuits.

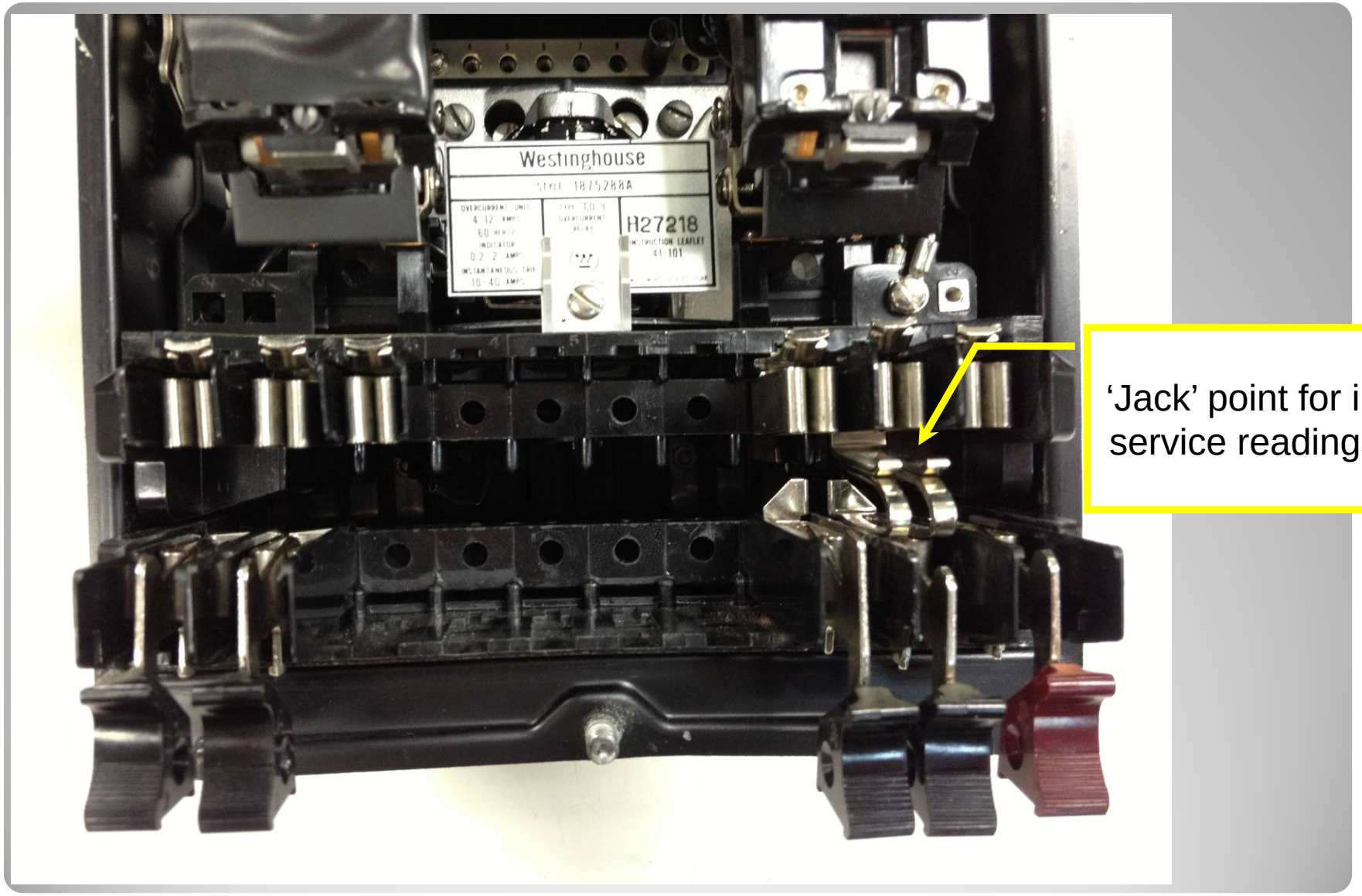
CT's in 3-Phase Circuits


178
2000-5A
10K-3
ØA
5
174
8H
FT-1
A1
2E
SEL-321
SET #1
8H
FT-1
A1
1A
171
2A
172
3A
173
10
9
101
102
11
12
A
14
13
103
104
15
16
B
18
17
105
106
19
20
C
ØC ØB ØA
CURRENT SCHEMATIC

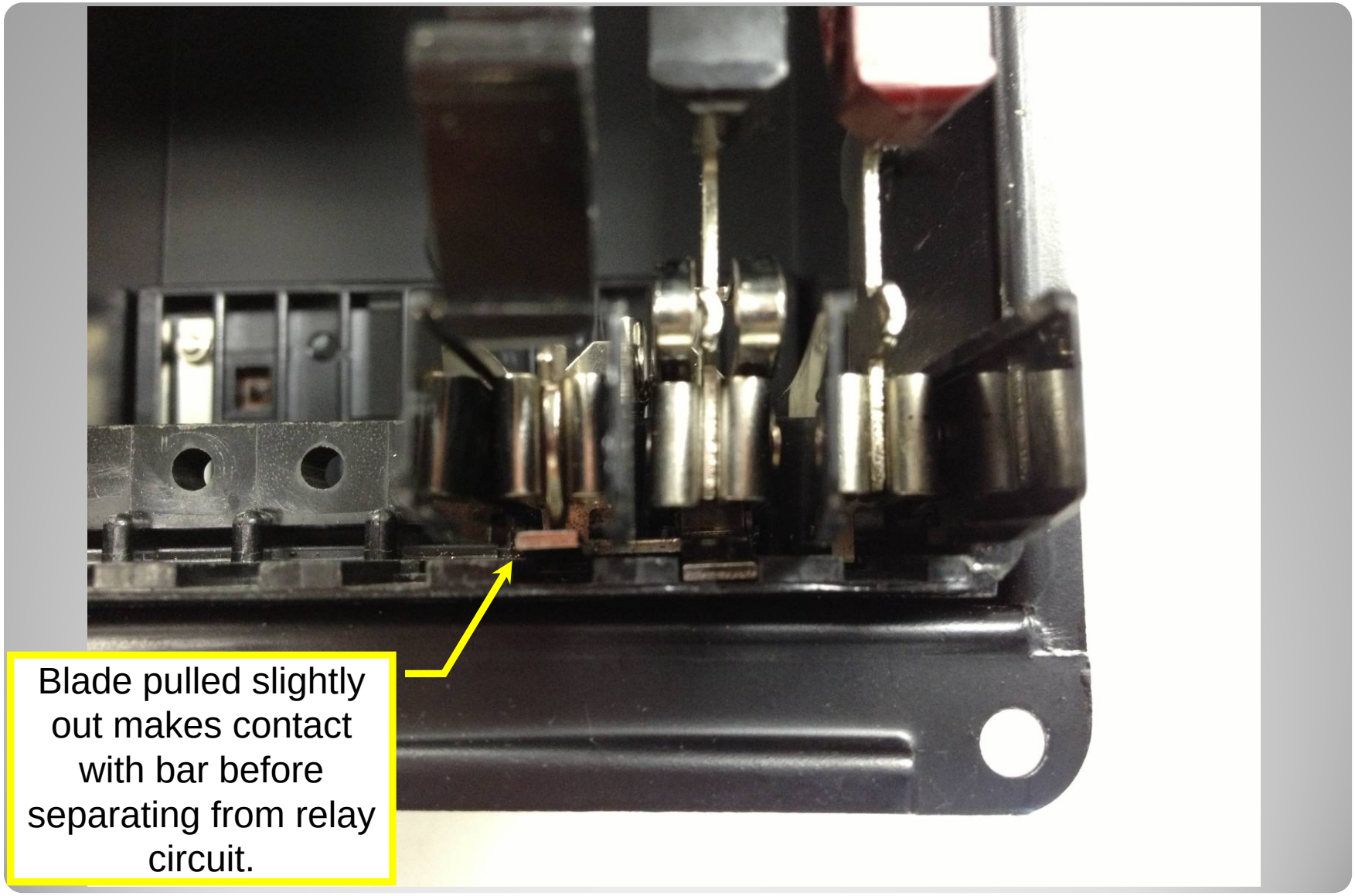

'Jack' point for in-service readings.
'Make before Break' switch with contact to shorting bar.
2000-5A
10K-3
ØA
5
174
1A
171
2A
172
3A
173
8H
FT-1
A1
2E
SEL-321
SET #1
8H
FT-1
A1
10
9
101
102
11
12
13
103
104
15
16
18
17
105
106
19
20
A
B
C
ØC ØB ØA
CURRENT SCHEMATIC



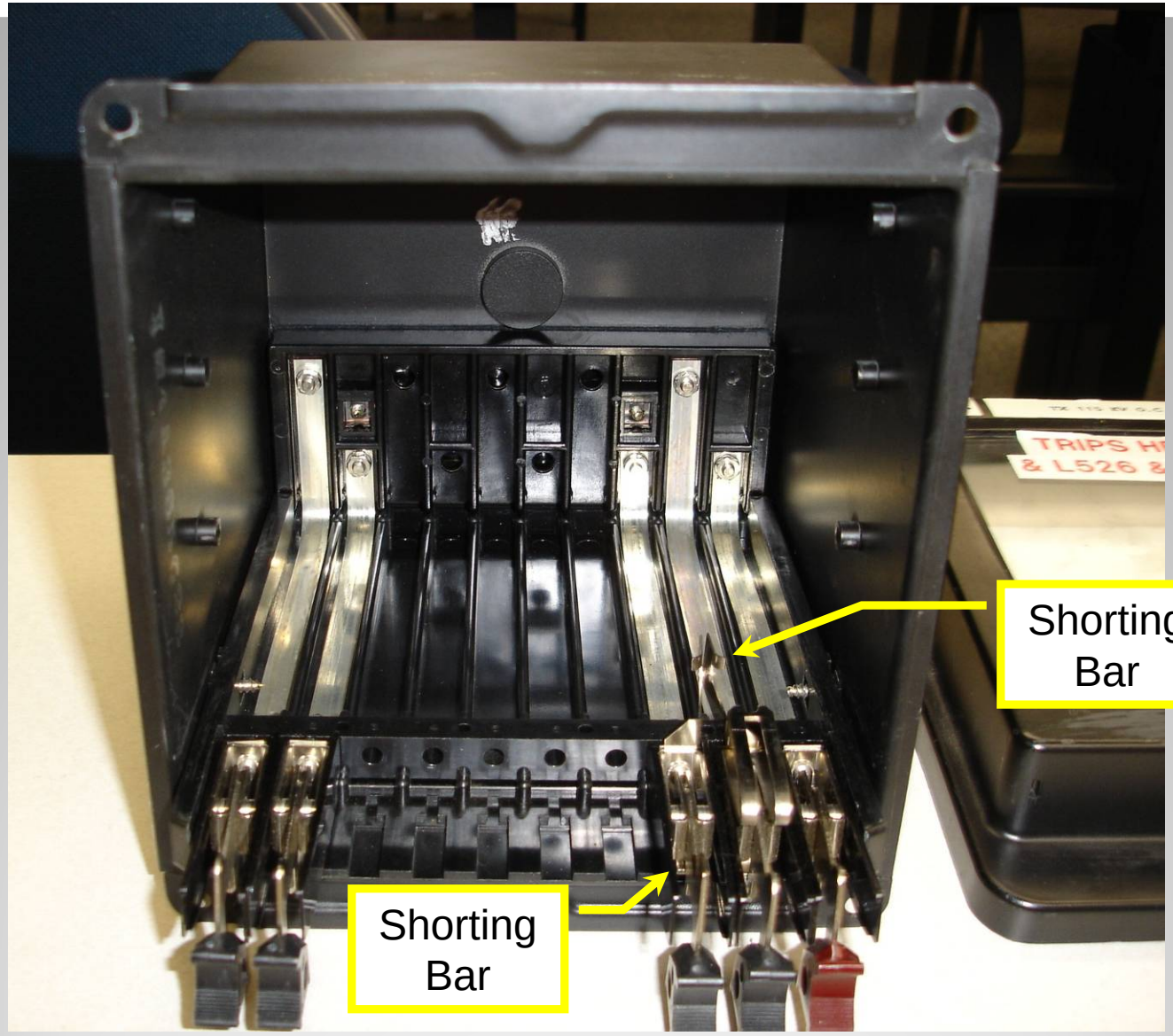
Westinghouse-ABB Case / Switches



Westinghouse-ABB Case / Switches



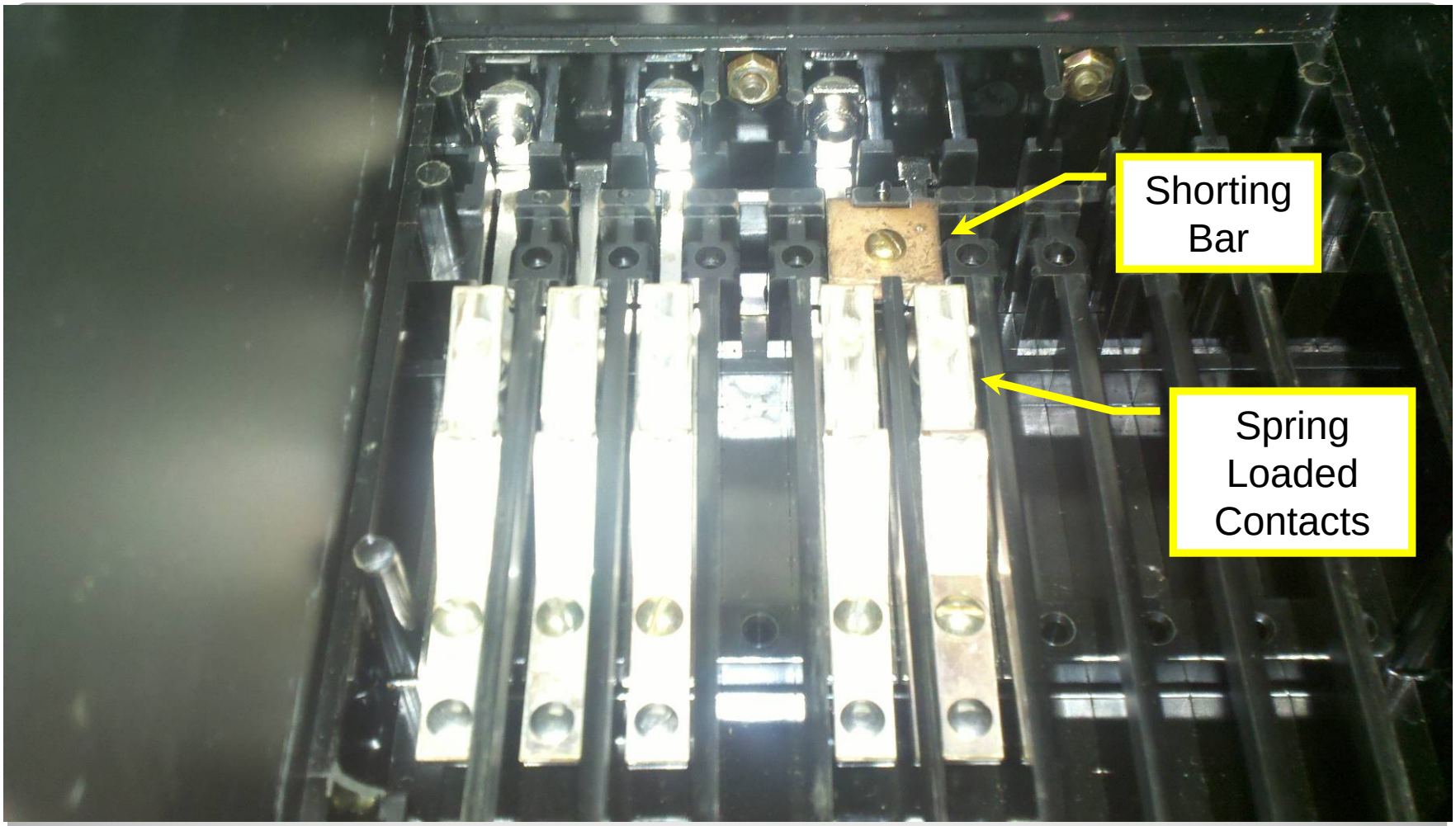
Westinghouse-ABB Case / Switches



Westinghouse-ABB Case / Switches

Test Plug

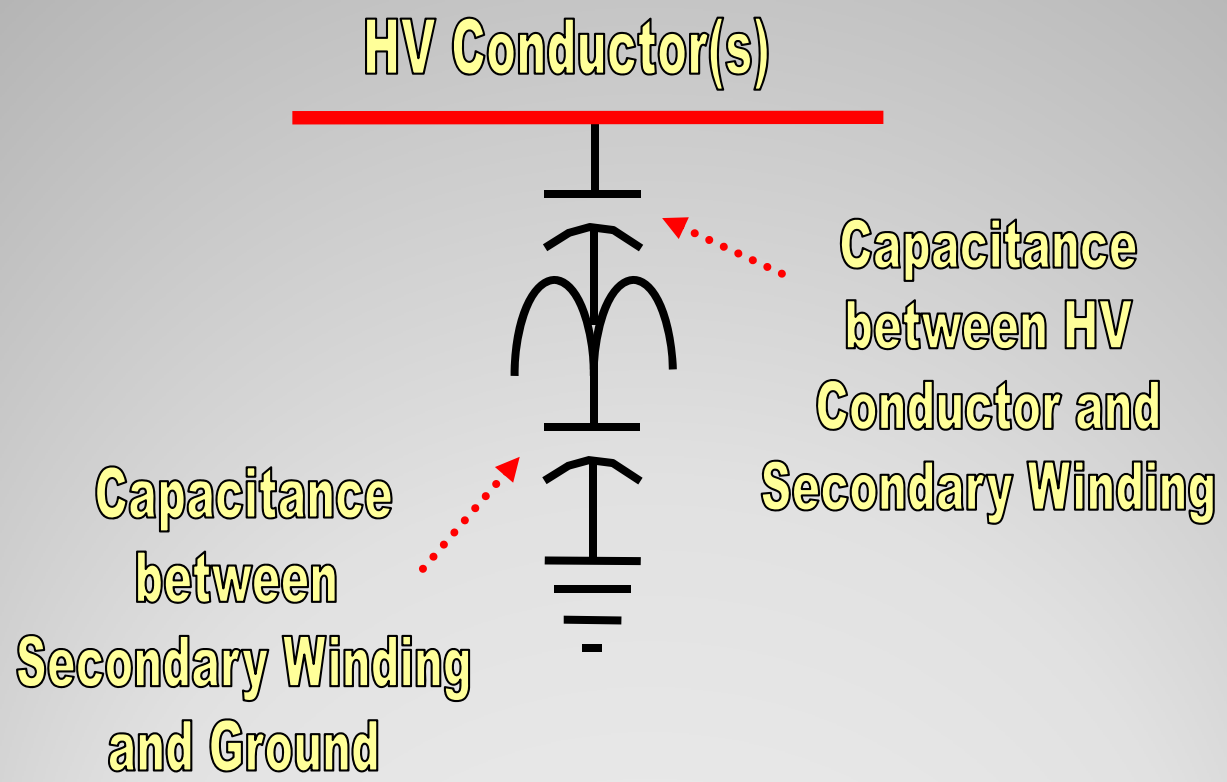
GE/Basler Style Case



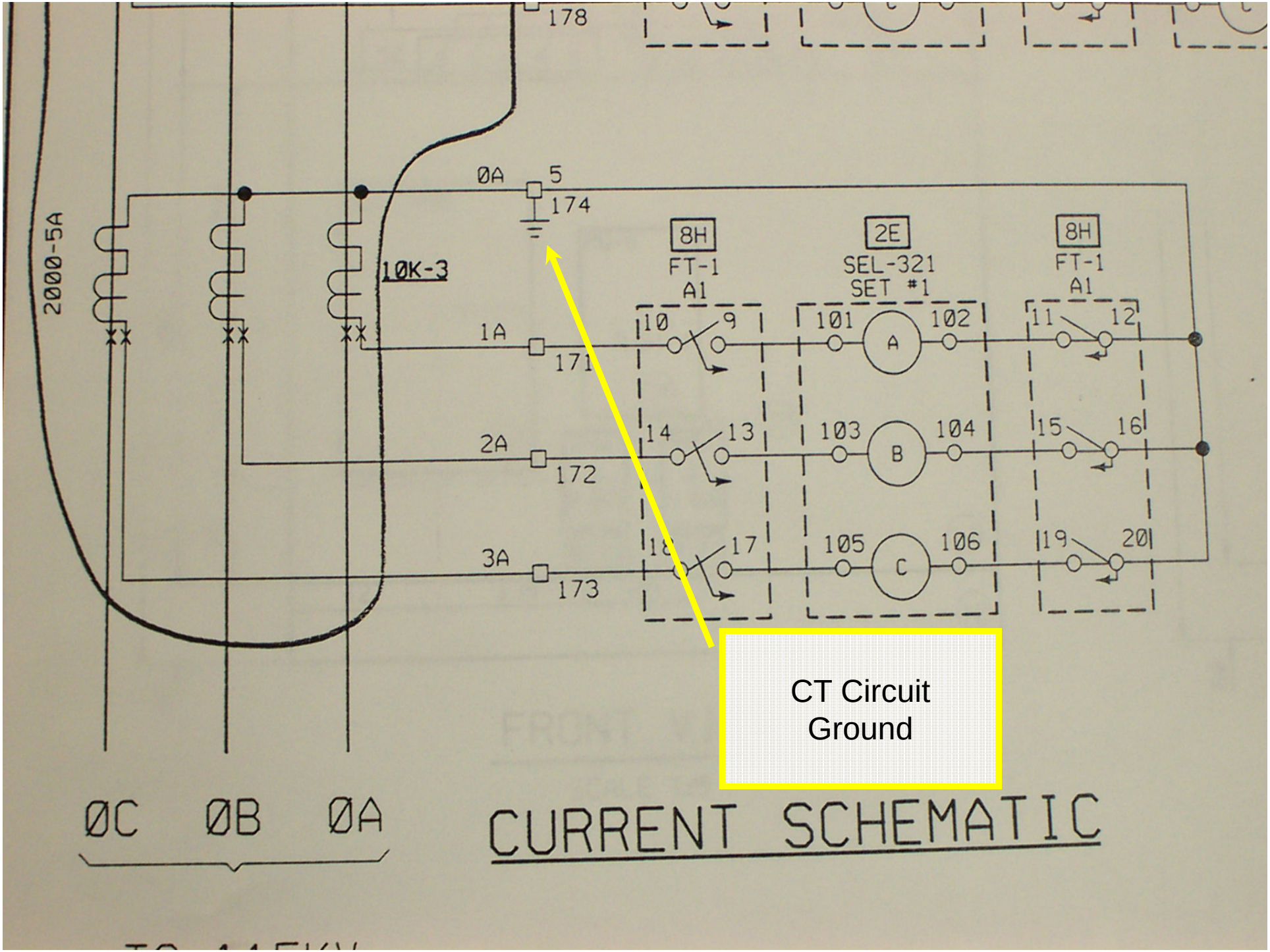
GE/Basler Style Case

- ‘Isolated’ CT Circuits are typically single-point grounded.
  - Since most CT connections are ‘Wye’, this ground is typically placed at the neutral connection.
  - The ground keeps the whole CT winding at a reasonably low potential to ground
  - This is especially important in high-voltage environments where capacitive voltage dividers can be formed which can elevate the entire CT winding to an unsafe level.

Ground Checks



Floating Secondary Issues


178
ØA
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FT-1
A1
2E
SEL-321
SET #1
8H
FT-1
A1
1A
171
2A
172
3A
173
10
9
14
13
18
17
101
102
A
103
104
B
105
106
C
11
12
15
16
19
20
CT Circuit
Ground
ØC
ØB
ØA
CURRENT SCHEMATIC

- Working around CT Circuits:
  - Circuit Identification
    - Wiring Diagram / AC Schematic Information.
  - Testing for Energized Circuits
    - Secondary Current measurement.
    - Audible/Visual arcing check.
  - Safe work practices
  - Job Briefings
  - Methods of shorting at CT Shorting Blocks

- Wiring Diagrams and/or Layout Prints should show actual placement of Terminal Blocks seen on Schematic Diagrams.
- Schematic Diagrams show Circuit Functionality and may have some Wiring Diagram information shown on them.
- Schematics and Wiring Diagrams should agree with each other.
- Your company may have standards for typical CT configurations that may aid in the identification process.

Circuit Identification

Wiring Diagram Information

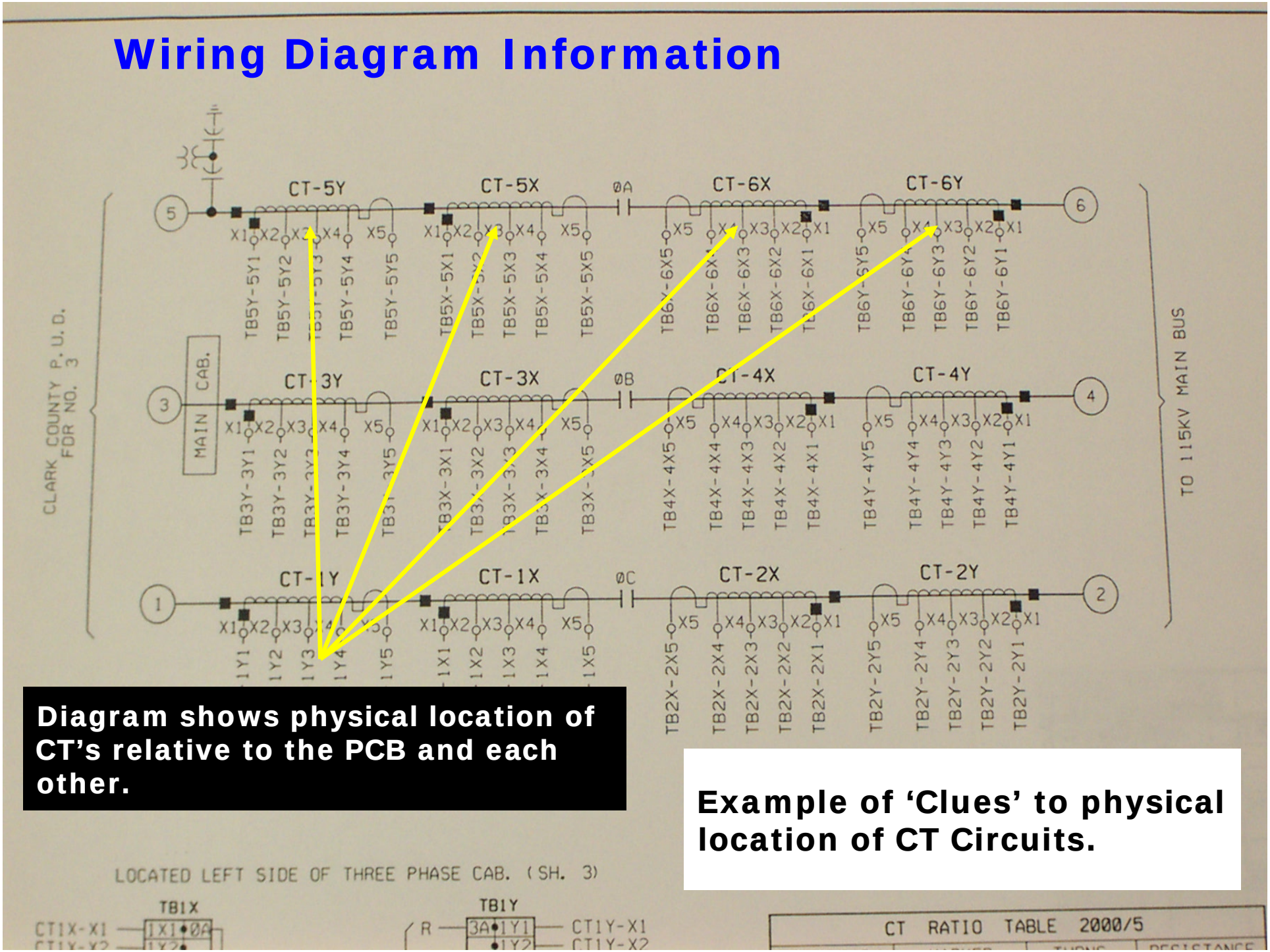
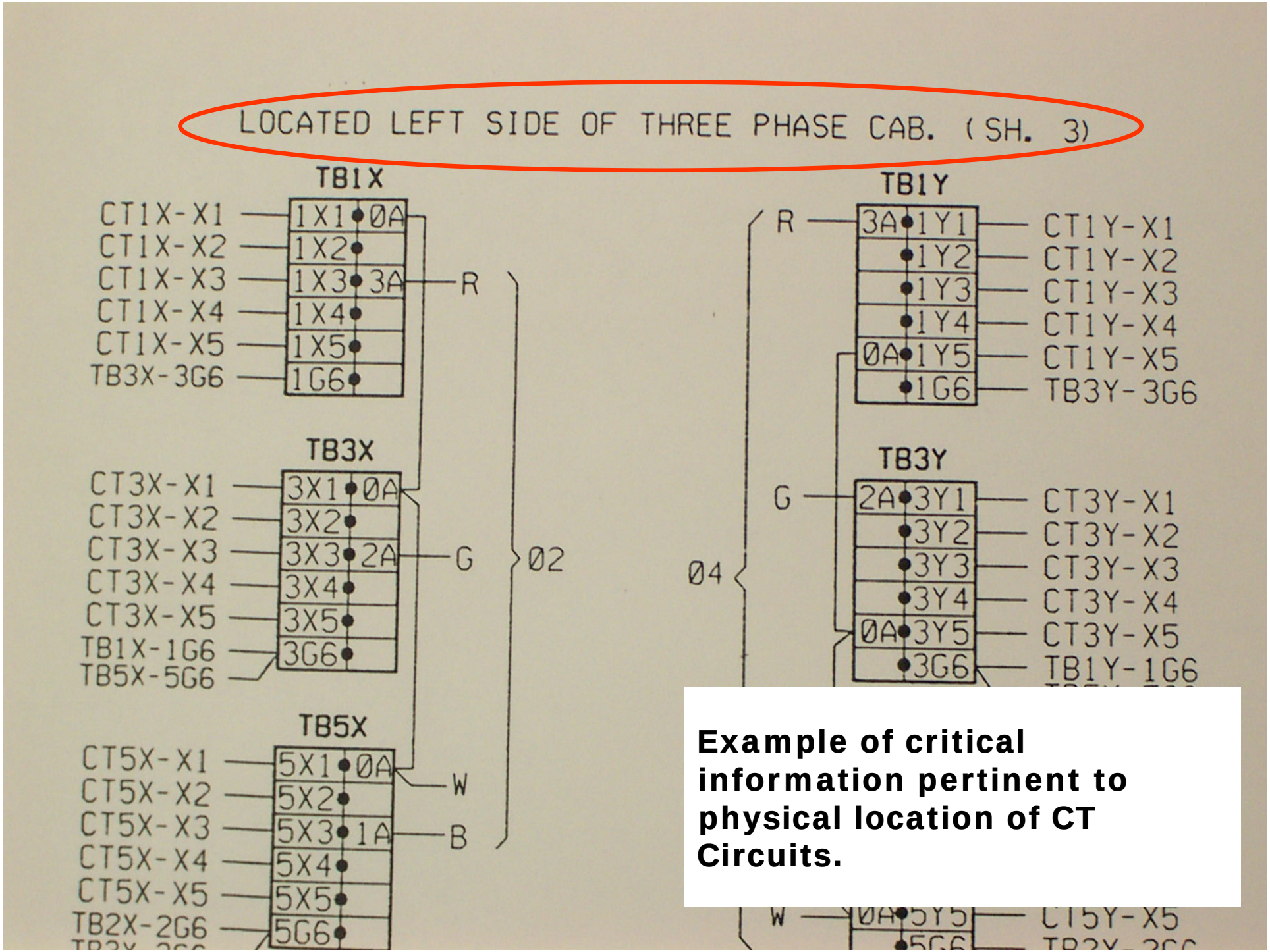


Diagram shows physical location of CT's relative to the PCB and each other.

Example of 'Clues' to physical location of CT Circuits.



Example of critical information pertinent to physical location of CT Circuits.

- CT Secondary Wires should be lifted slowly while listening for arcing as a final verification check.
- The visual/audible Arcing Check is also not 100% reliable as a test for an open-circuit CT condition.
  - In brightly lit and/or noisy areas, it may be difficult to detect the arcing condition.
  - With low values of CT secondary current, there may be little-to-no arcing when wiring is lifted.

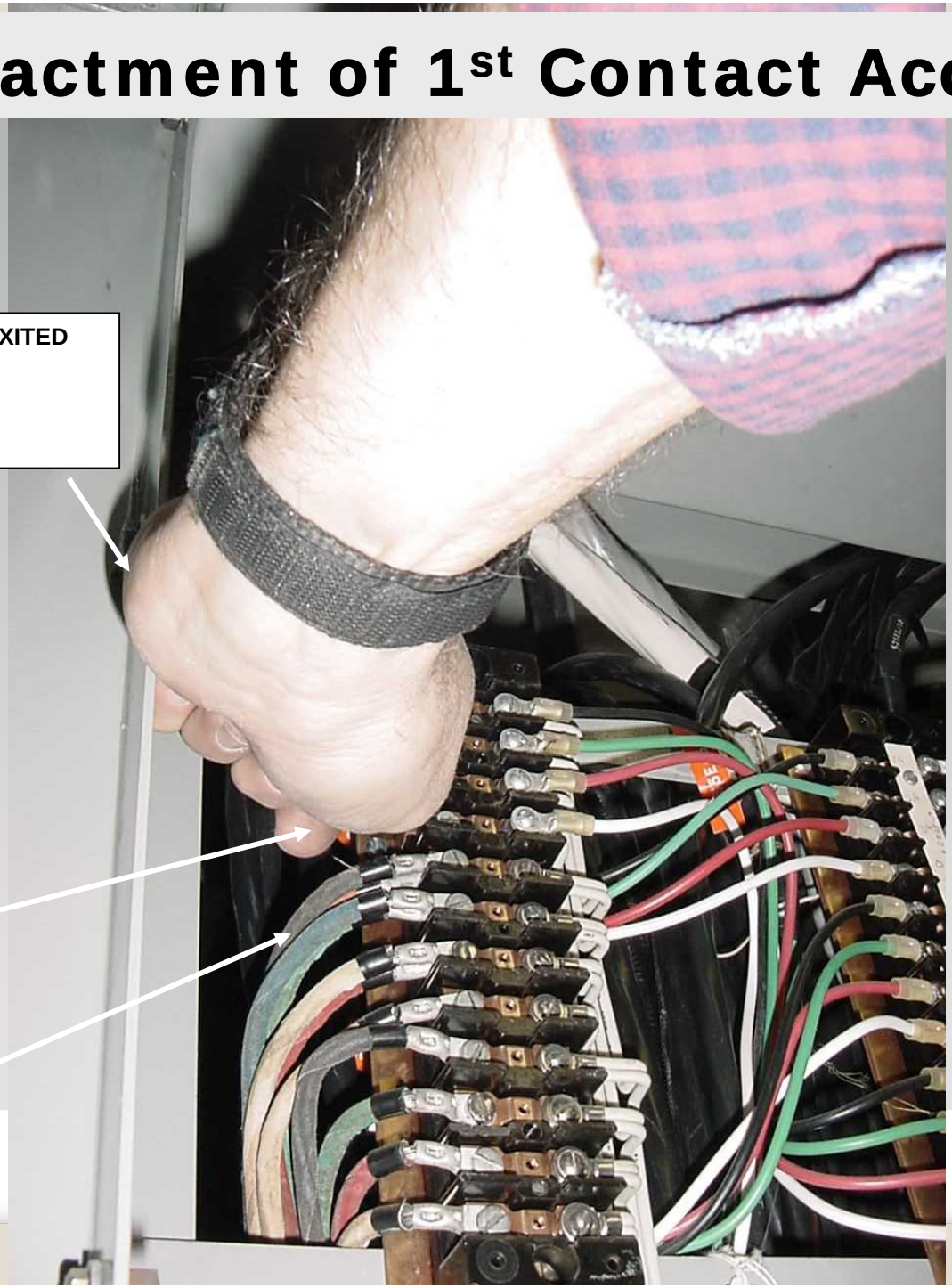
Visual/Audible Arcing Check

Using Test Instruments

Fluke Current Measuring Devices

- Care should be taken to keep yourself from becoming a possible current path for the CT should it become open-circuited.
  - Since CT Circuits are typically grounded (Wye), if you are touching Termination Frames or Relay Racks you may become part of the current path if you contact the CT conductor during an open-circuit incident.

Re-enactment of 1st Contact Accident



Quote from the Accident Report:

"The Electrician said he could smell his flesh burning"

- ❤ When shorting CT secondaries at CT Shorting Blocks, care must be taken to properly short the CT Circuit.

- Depending on the connection made at the block it may take anywhere from 2 to 6 shorting screws to fully short the CT secondaries.

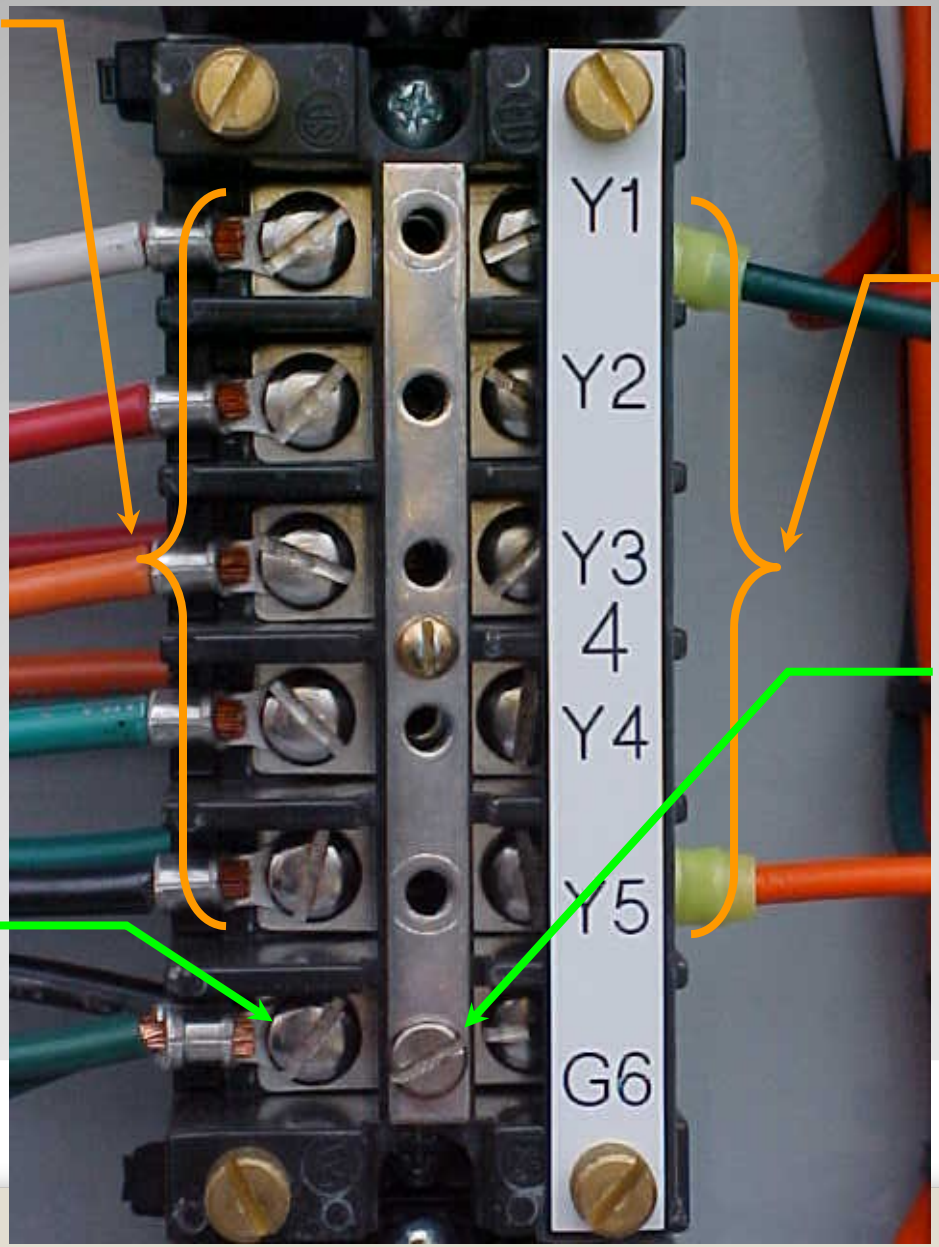
CT Shorting Blocks

‘Single-Phase’ Type CT Shorting Block

CT ratio tap wiring from one individual CT

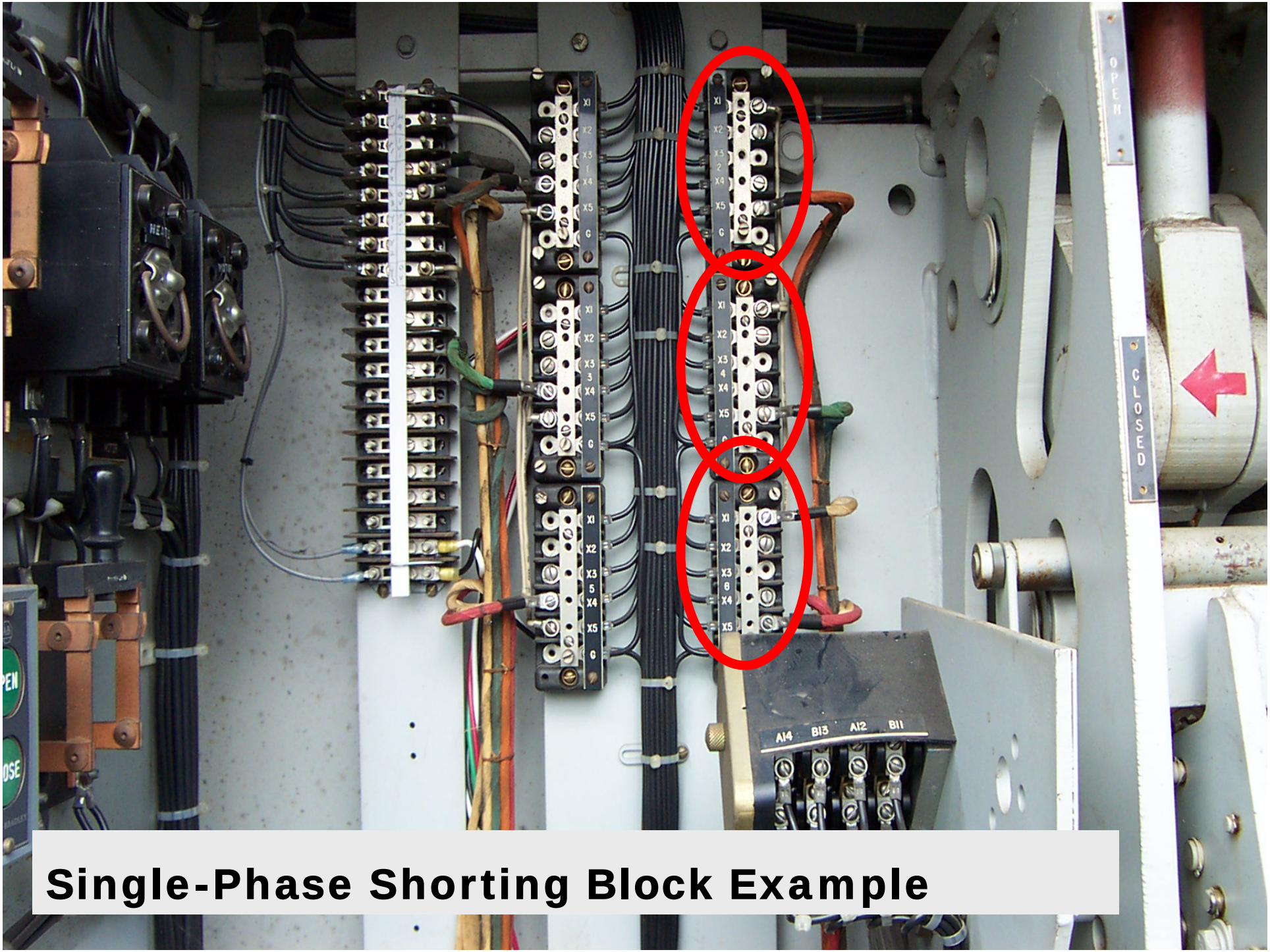
Note that a **minimum** of **two** screws are needed to short this 1 CT – if the full winding is shorted (Y1-Y5 in this case).

Shorting Block Ground



Single-Phase wiring from individual CT to relays, instruments, etc.

Ground screw connection normally left in-place.



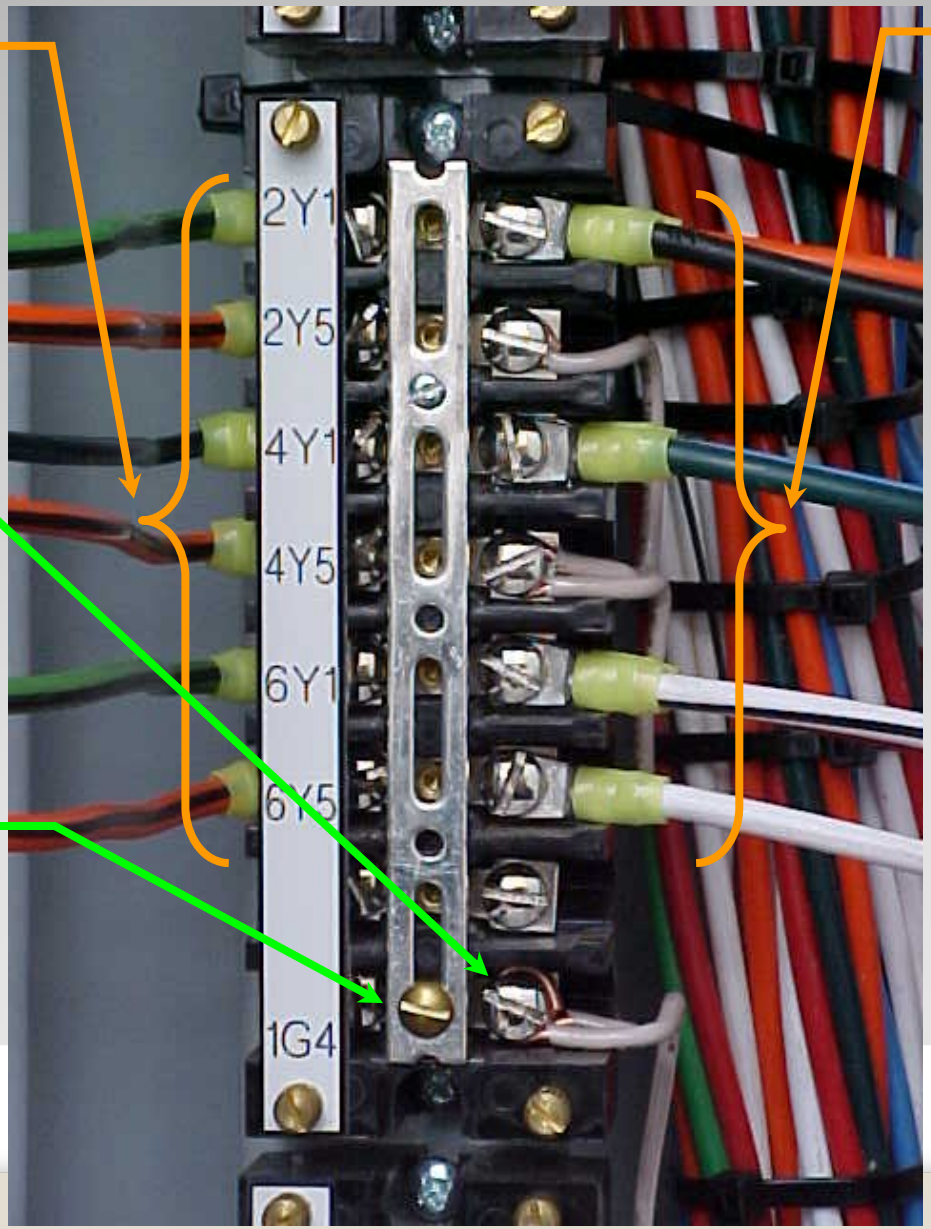
Single-Phase Shorting Block Example

‘Three-Phase’ Type CT Shorting Block

CT wiring from three single-phase individual CT’s (three pairs)

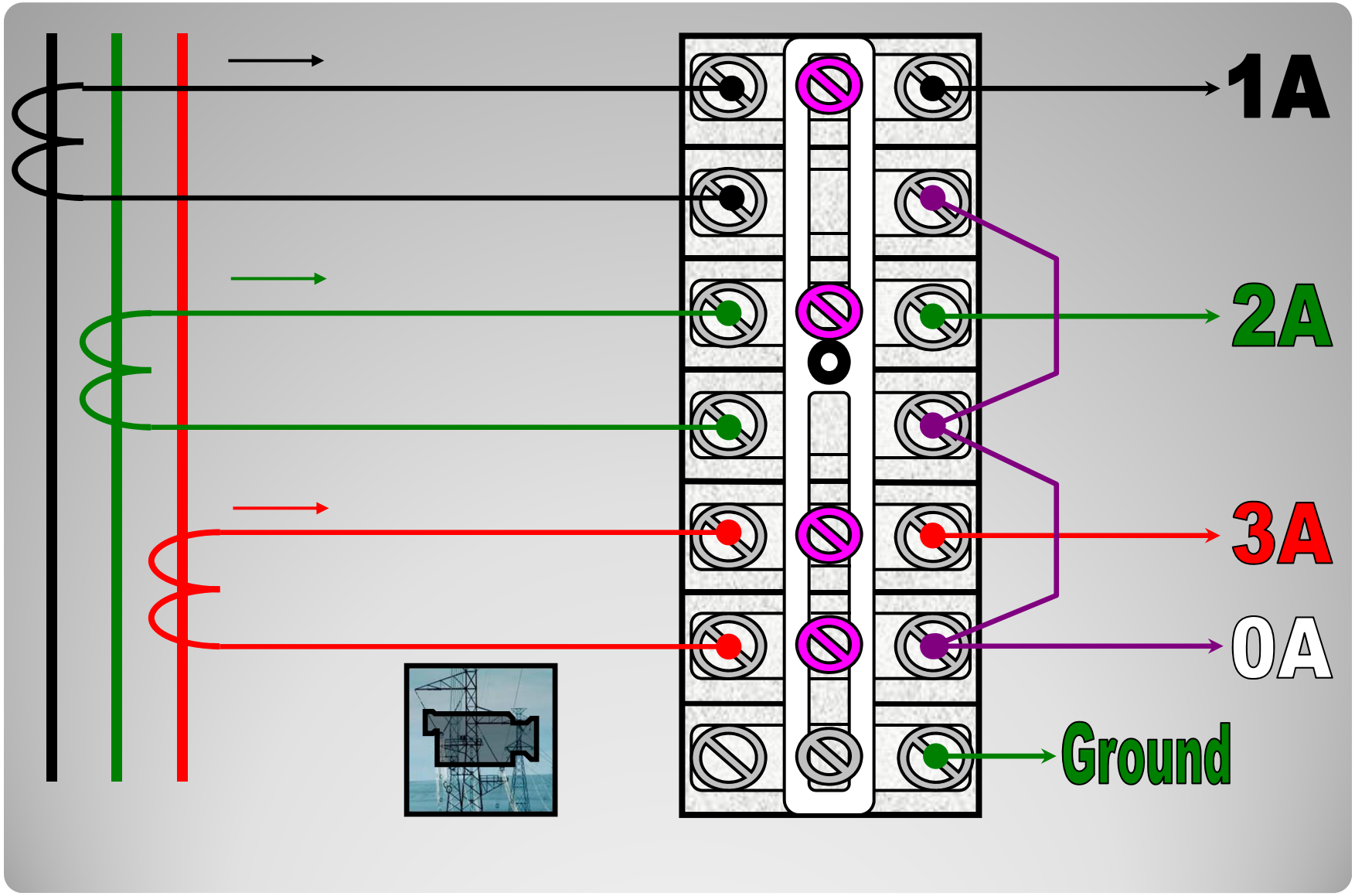
Shorting Block Ground

Ground screw connection normally left in-place.



Three-Phase wiring to relays, instruments, etc.

Note that it takes a **minimum** of **four** screws to short this set of 3 CT’s – (**2Y1**, **4Y1**, **6Y1**, and **one** of 2Y5, 4Y5, and 6Y5 in this case) – as long as the Wye connection is intact – white wiring here.



Three-Phase Block Analysis

- Make sure necessary wiring is in place to effectively short 'Three-Phase' type blocks.

- **Whenever using <u>less than</u> 6 shorting screws for a 3-phase circuit, the 'Wye' or 'Delta' connections <u>MUST</u> be intact or some CT's may not be properly shorted.**

Three-Phase Block Analysis

Questions?