Where does HUM come from?

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It’s all caused by Power Engineers with the express purpose of irritating Broadcast Engineers

Hum is usually caused by 60 Hertz or a harmonic of 60 Hertz that is an unwanted signal in the audio or video information stream.

How does it get there?

Conduction - To a Power Engineer this is a direct connection between the source of 60 Hertz power and the signal circuit.

(This is usually the result of a misconnection by the Broadcast Engineer)

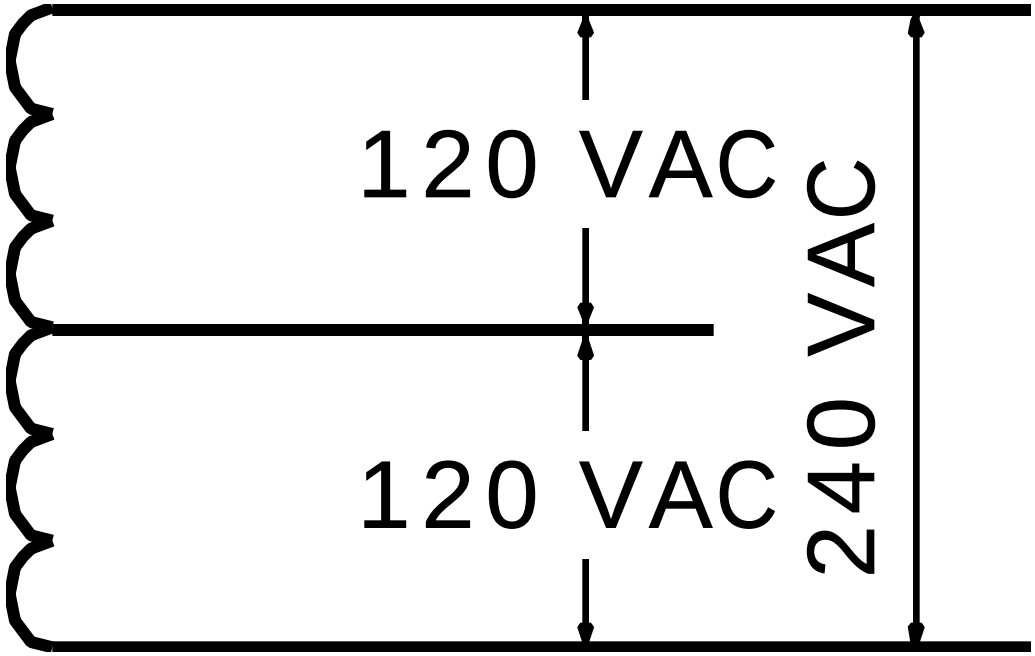
Induction - To a Power Engineer this is the introduction of a 60 Hertz signal via the magnetic field caused by AC power wiring.

(This is usually the result of a Broadcast Engineer getting too close to a Power Engineer.)

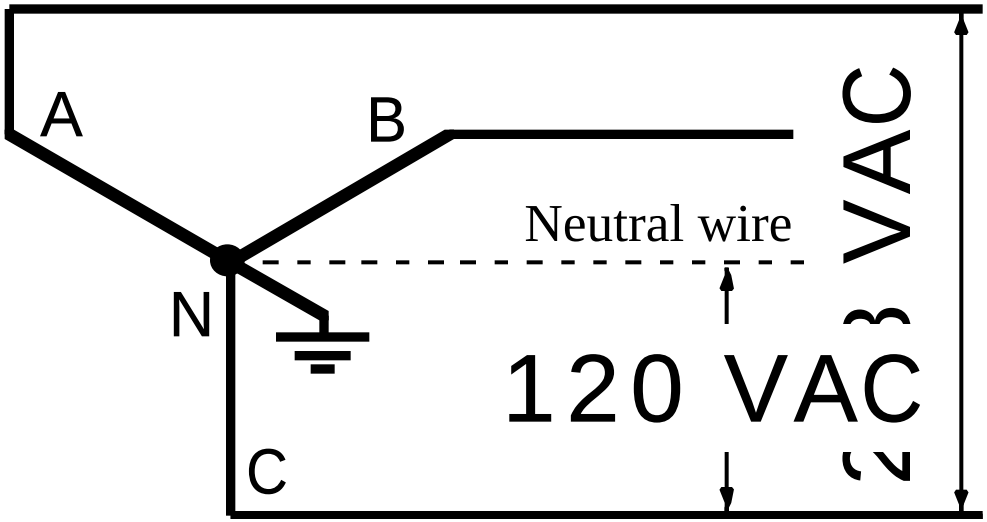
Stray currents - This can be described in many ways. I will discuss how I believe most of you will encounter stray currents.

(Usually caused by both the Power and the Broadcast Engineer, neither one realizing the problem they have created.)

This is a 120/240 volt system similar to what you have at home

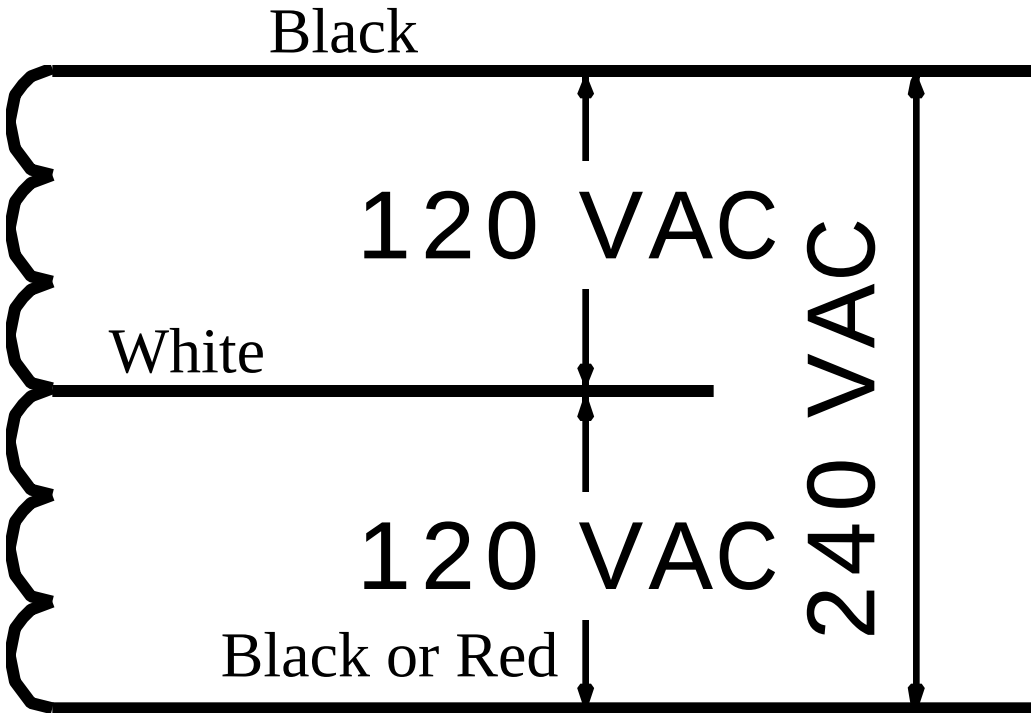


At work you probably have a 120/208 volt system.



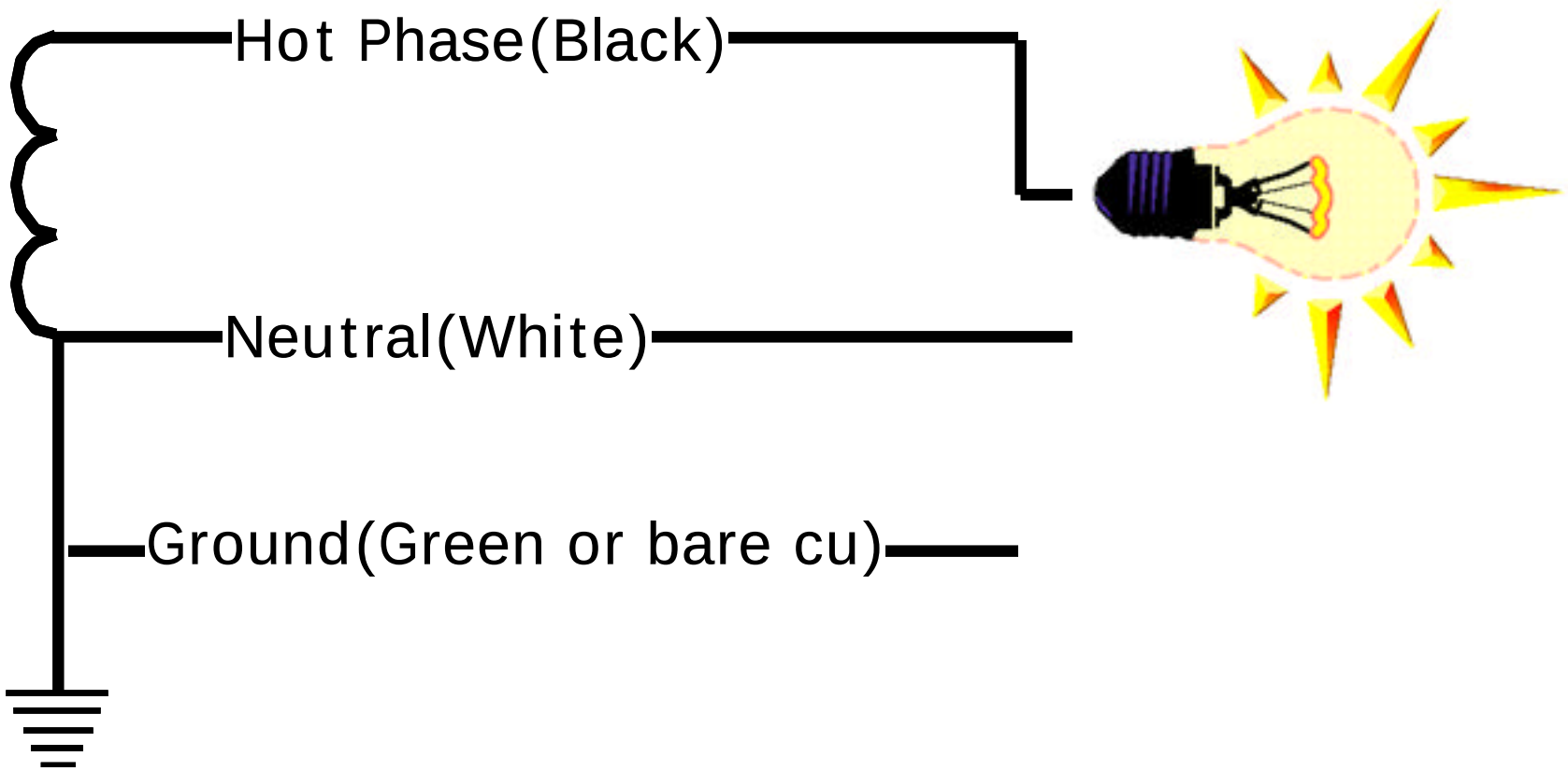
Let’s start with a typical building electrical system. To simplify the drawings I will assume a 120 volt single phase system serving the entire building.

The important part is that each system has Black (HOT) wires and White neutral wires for 120 volt loads

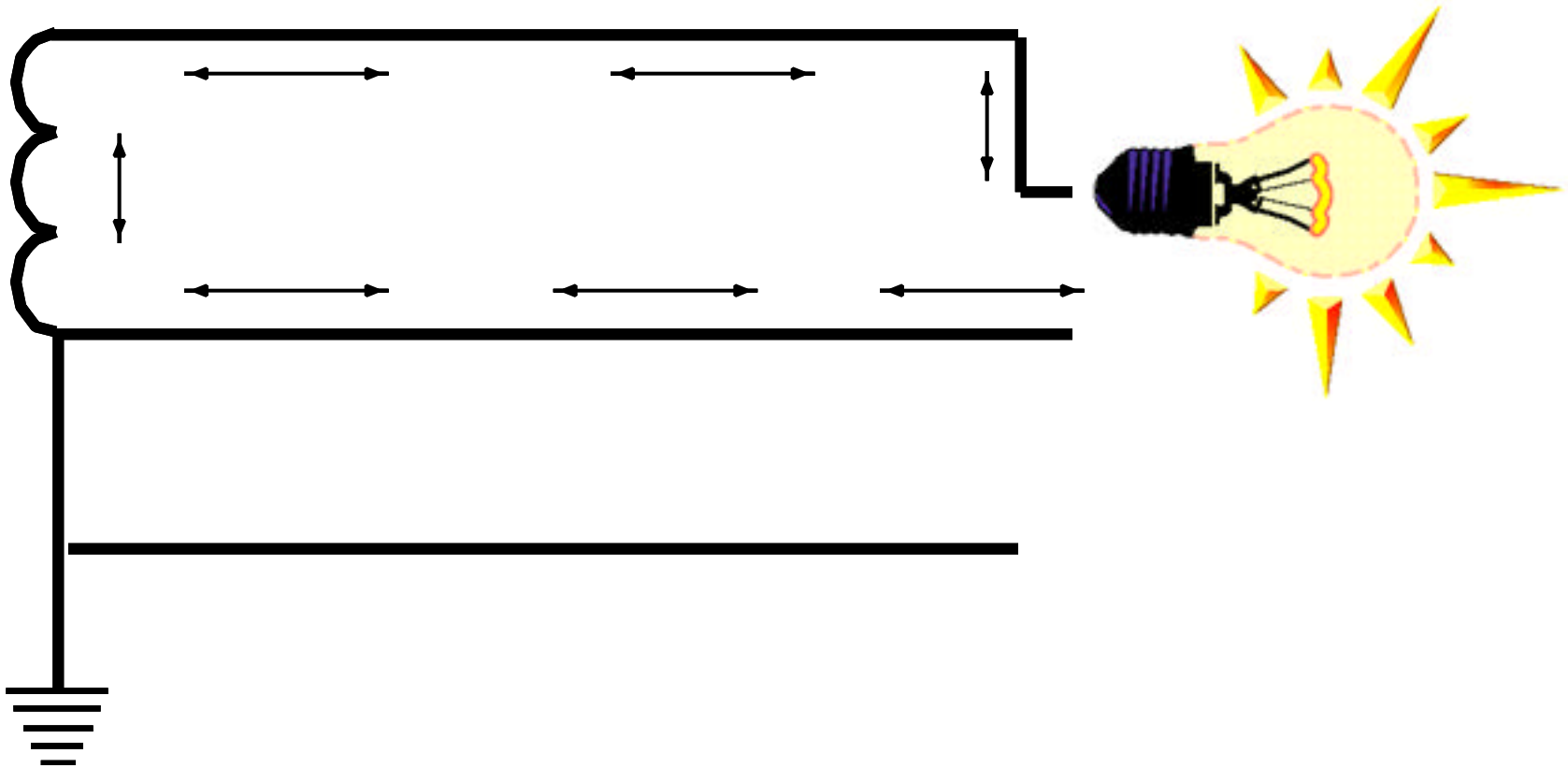


This is a normal connection

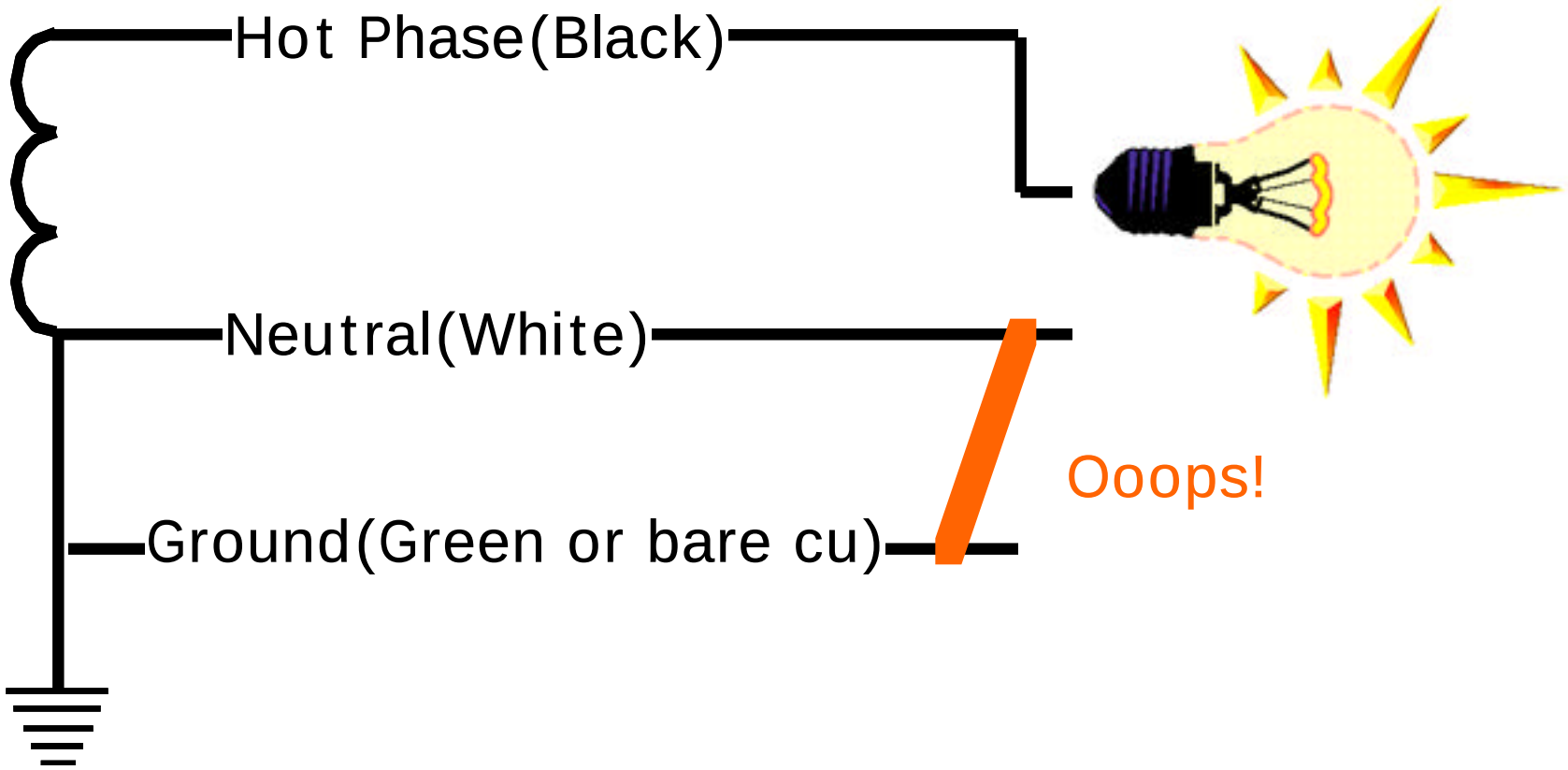
(not very exciting is it?)



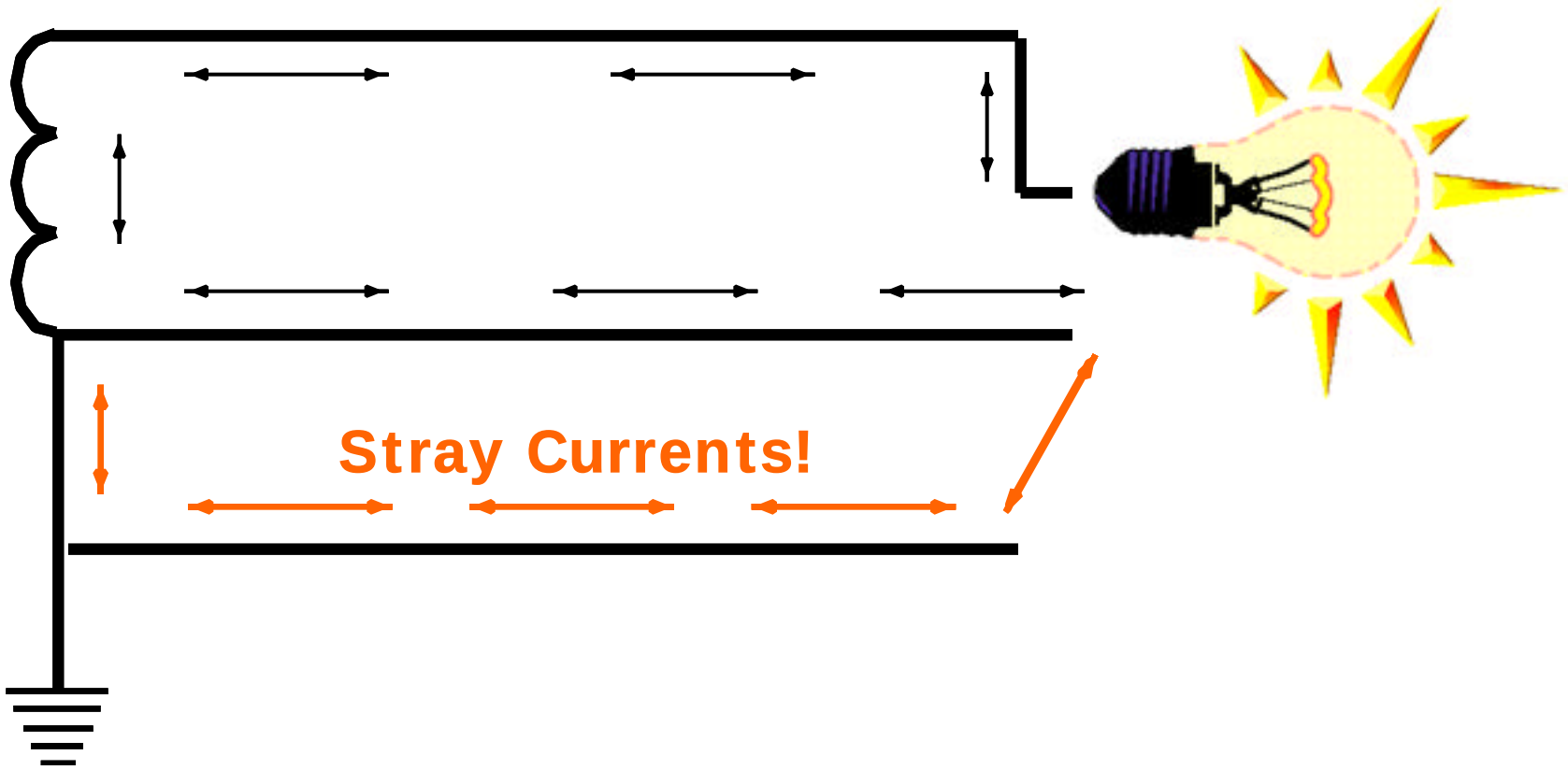
If the current stays on the Black and White wire and none flows on the ground wire, all is well.

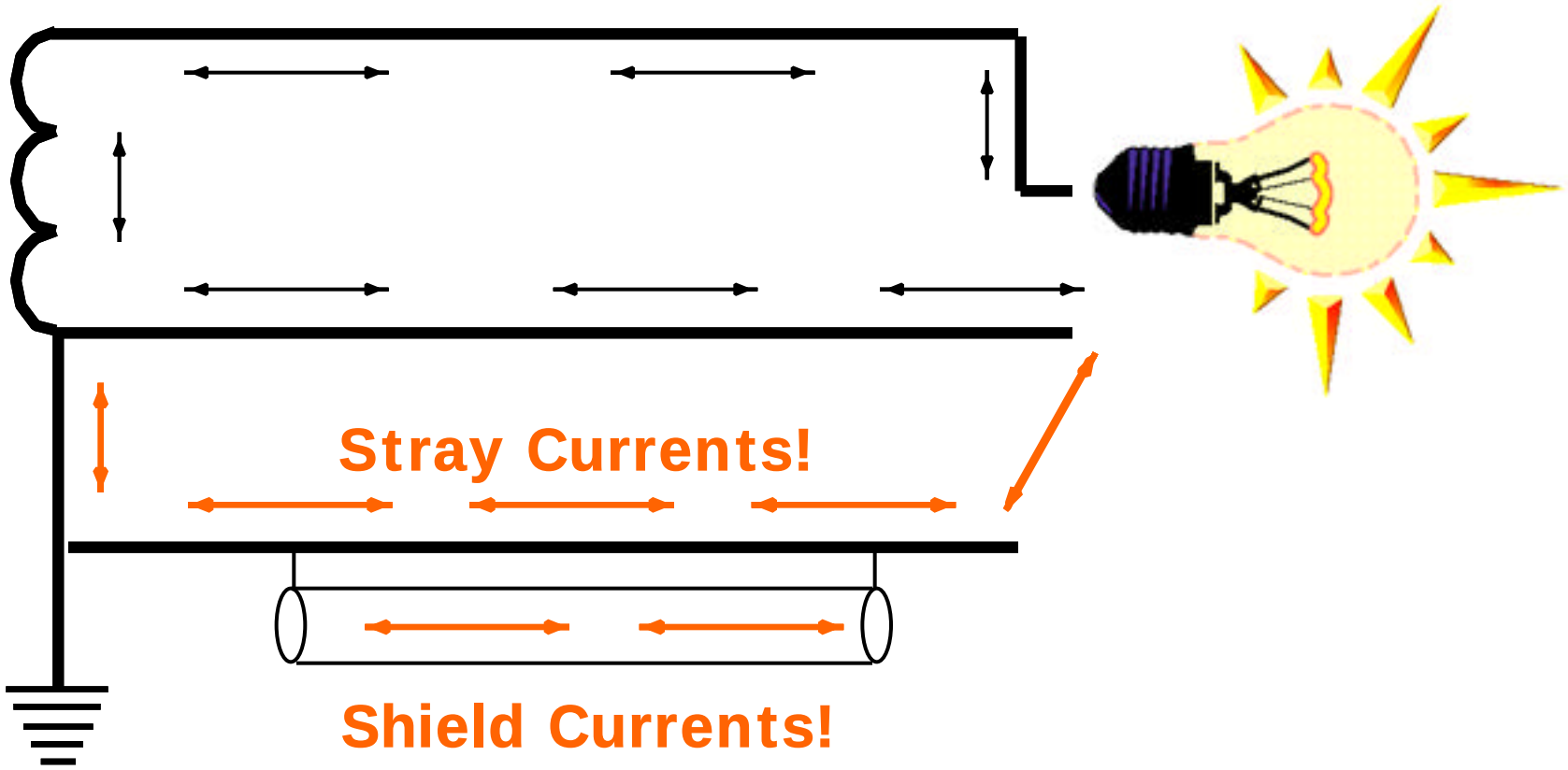


Somebody grounds the neutral conductor (a second time)



Now we have stray currents!





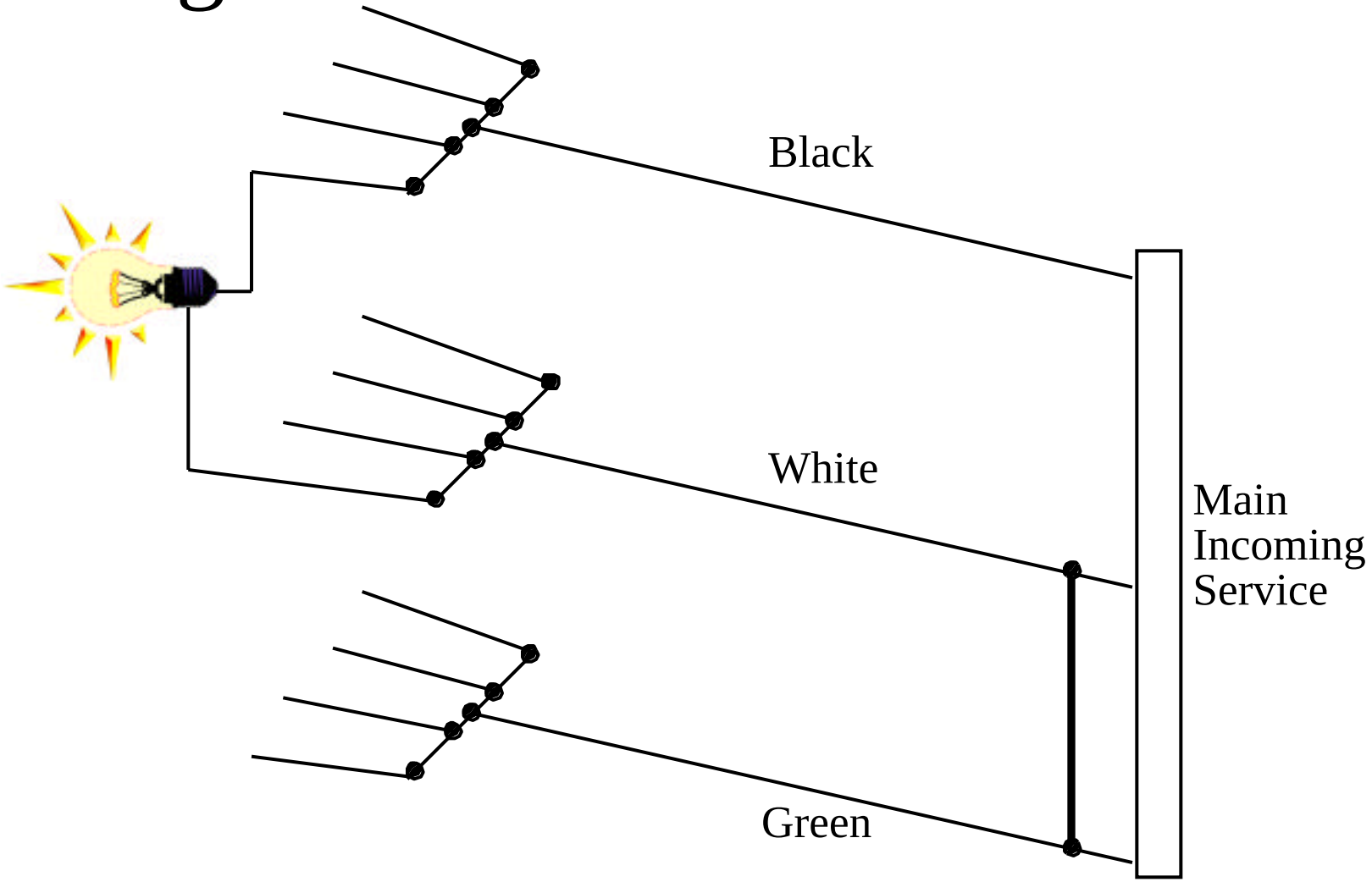
Your shielding braid provides an another path for the stray current to flow.

Now you have stray currents!

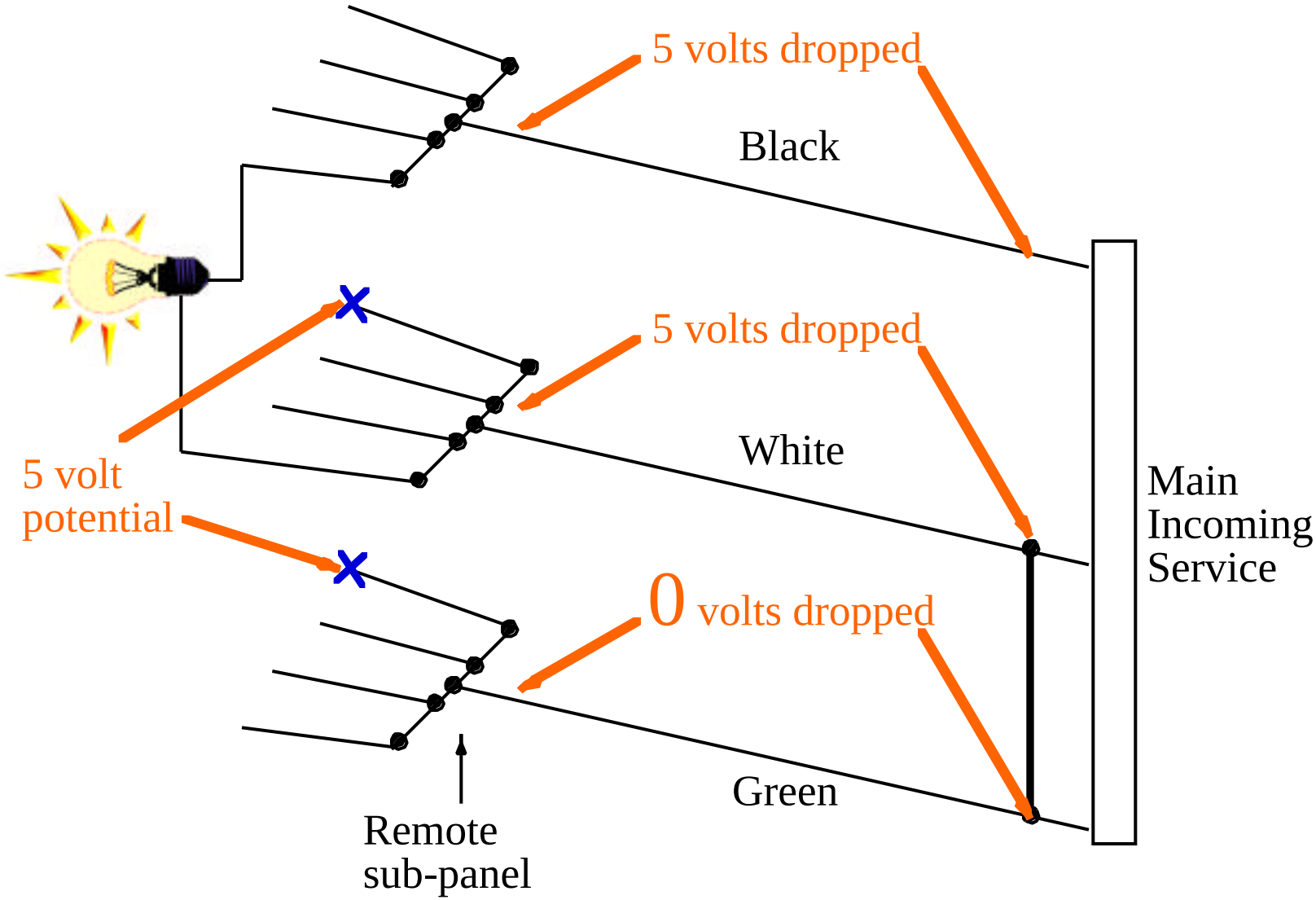
The trick is to find the source of the stray currents and eliminate them

Think of a large building with the Black (hot) wires on the second floor, the White (neutral) wires on the first floor and the Green ground wires in the basement.

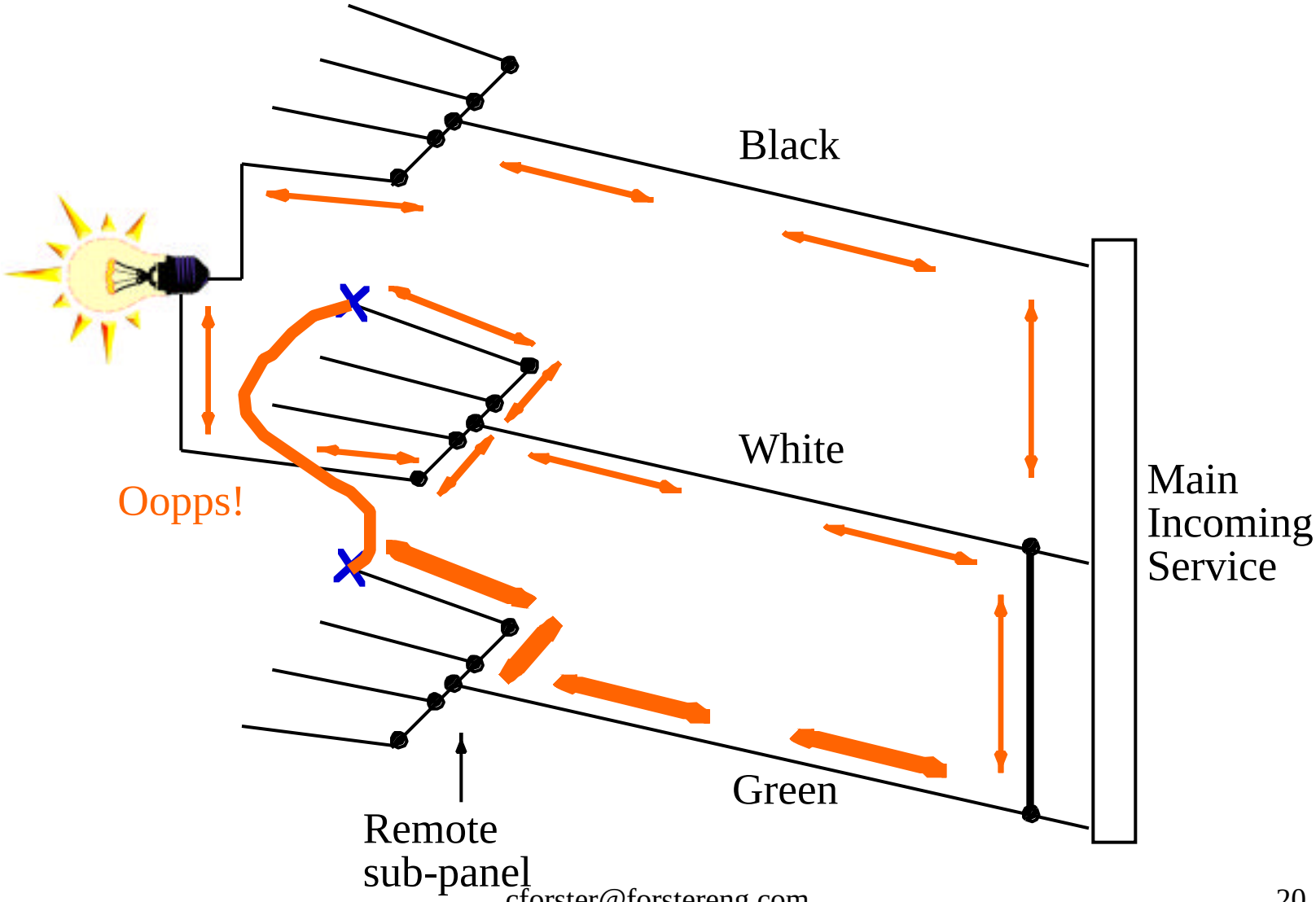
It might look like this...



The neutral current causes a voltage drop along the neutral wires.



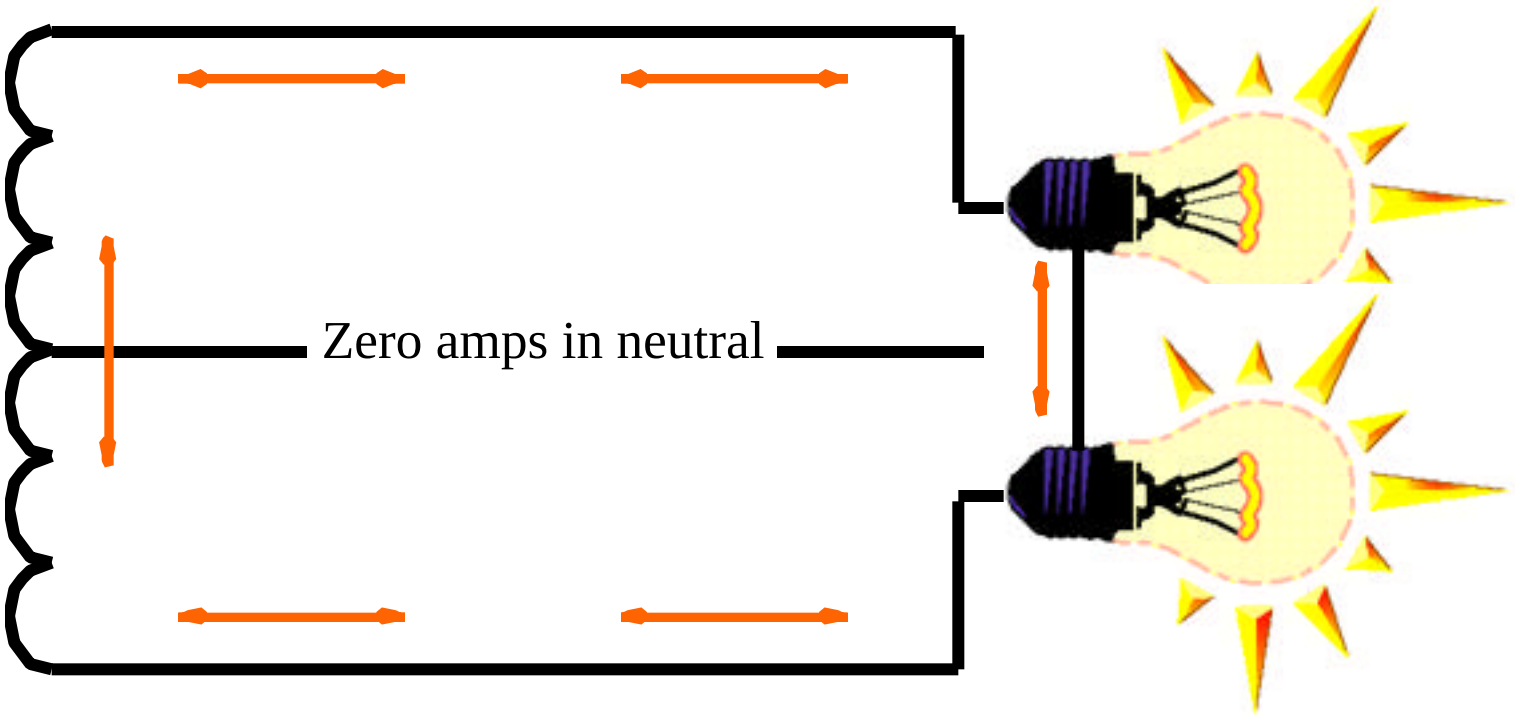
Consider a remote appliance that is turned off, but has the white neutral shorted to the grounded case.



How do you find that one?

Let’s make the problem worse. I have been showing nice incandescent light bulbs as the load.

Balanced loads result in zero neutral current so who cares if the ground and neutral are connected at a remote point?



Well, if your loads include:

Solid-state fluorescent lamps.

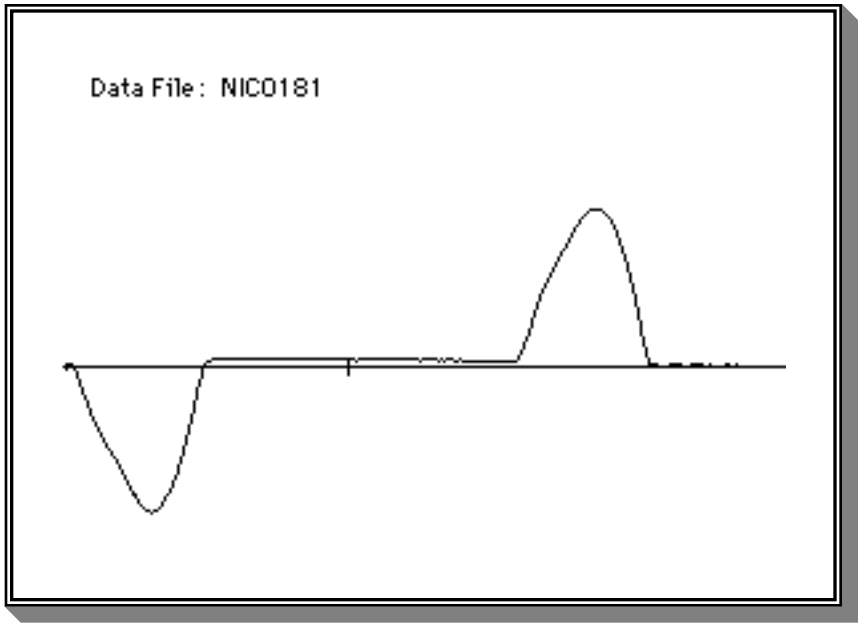
Solid-state lamp controllers.

Computers.

Other devices with switching power supplies.

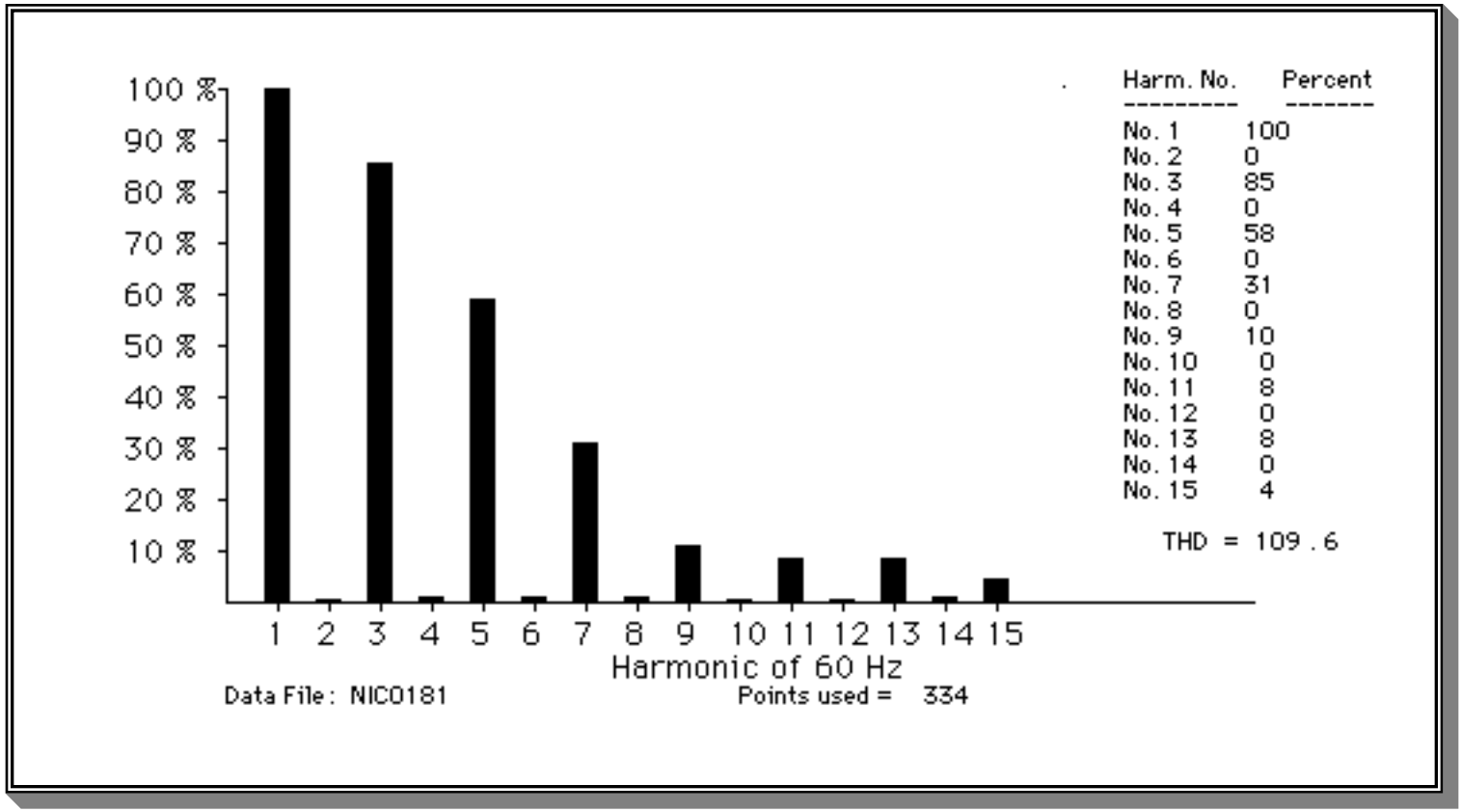
These loads draw a distorted current waveform.

Current draw from just one switching power supply as found in a PC



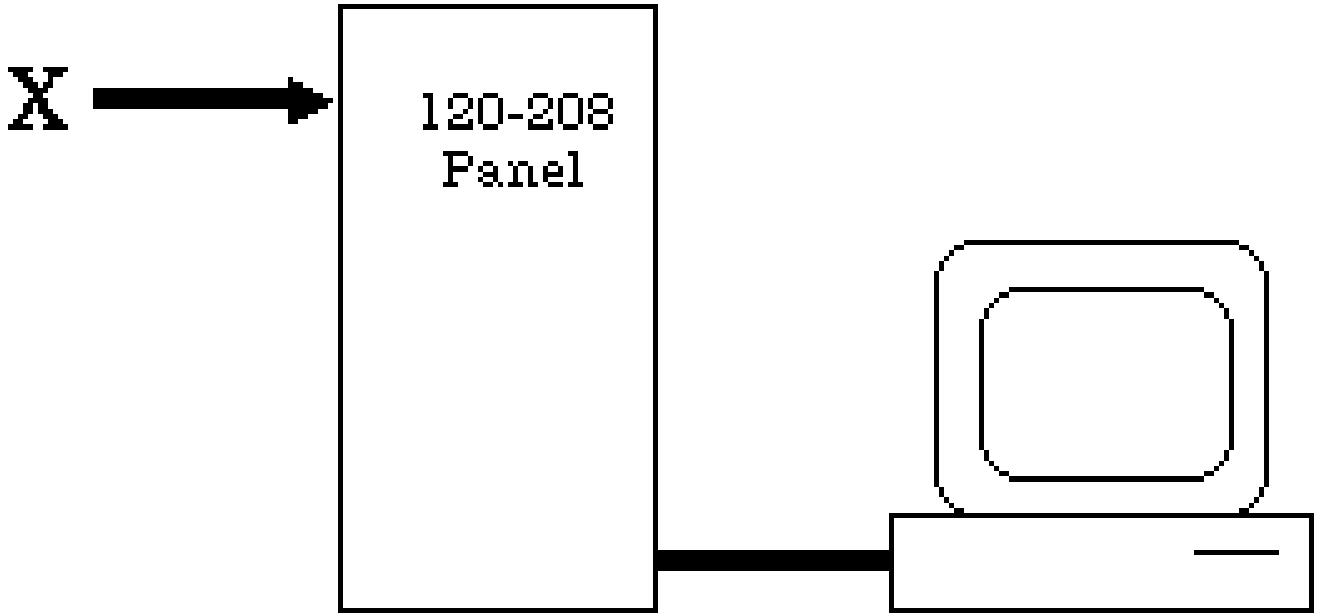
The frequency spectrum of the PC load current

Notice the high levels of 3rd, 5th and 7th harmonics

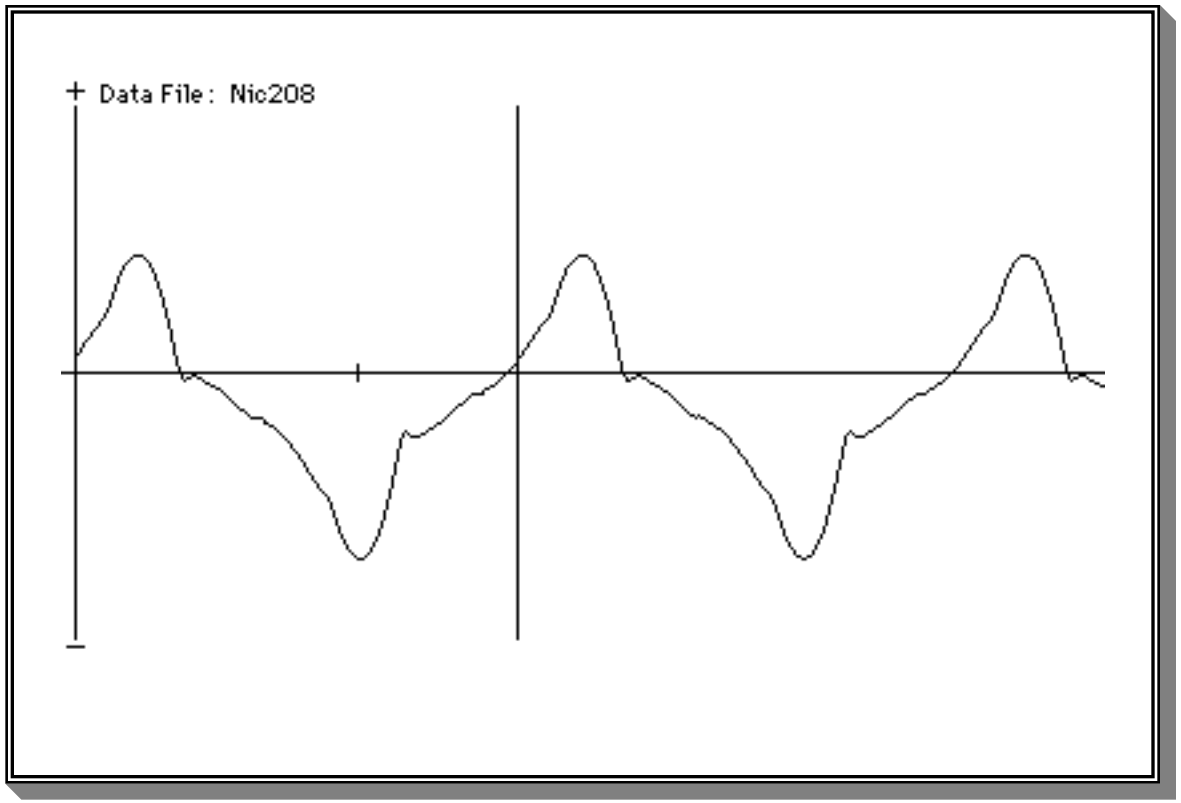


Effect of combined PC loads at the floor panel

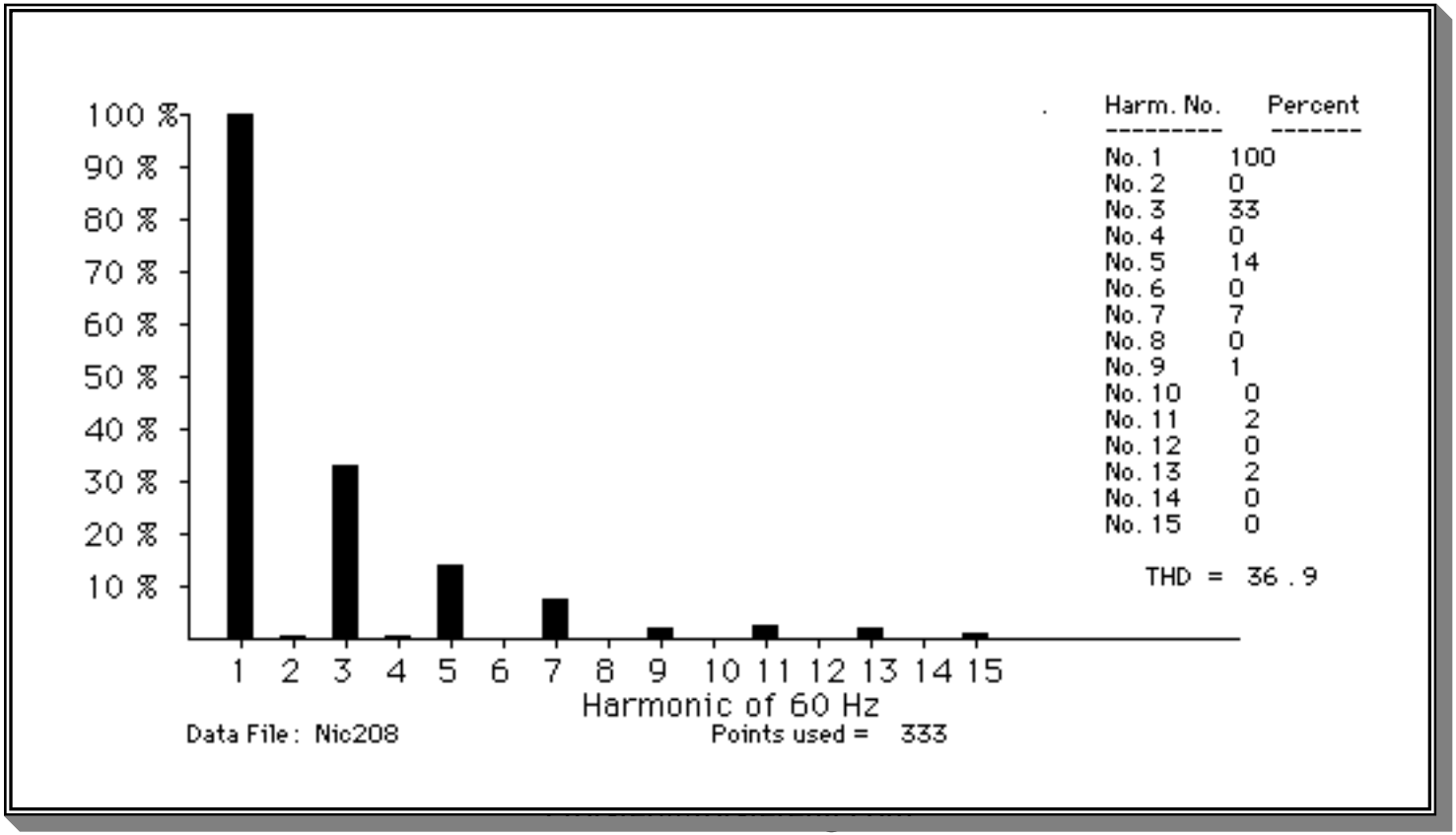
The current to the panelboard consists of PHASE current and NEUTRAL current



Typical PHASE current at the office panelboard

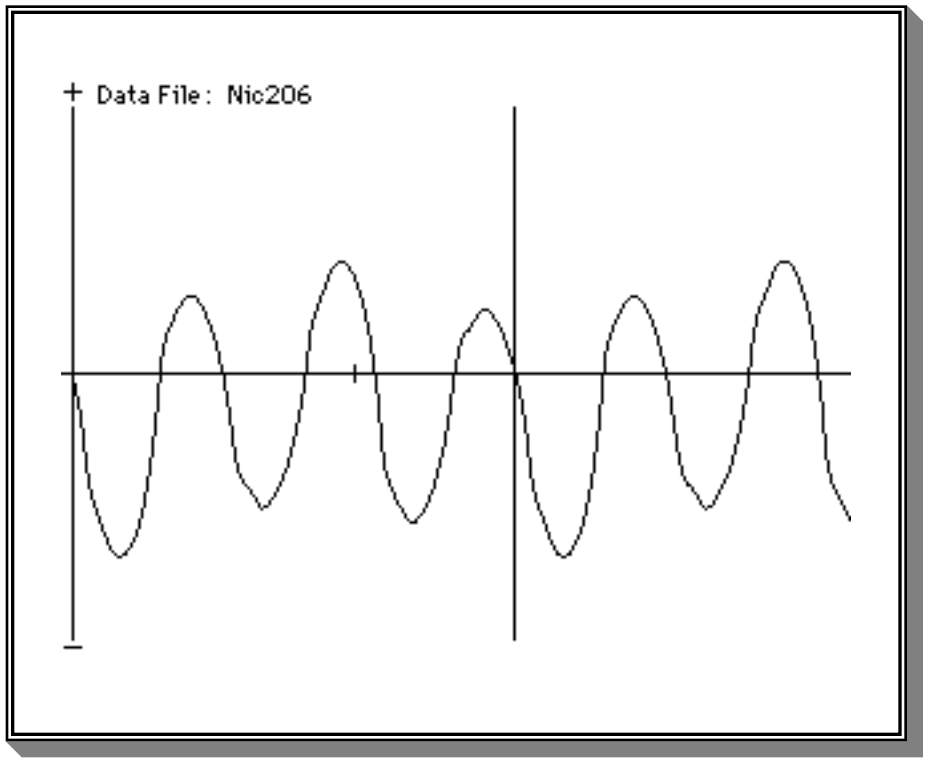


The spectrum of the PHASE current at the office panelboard



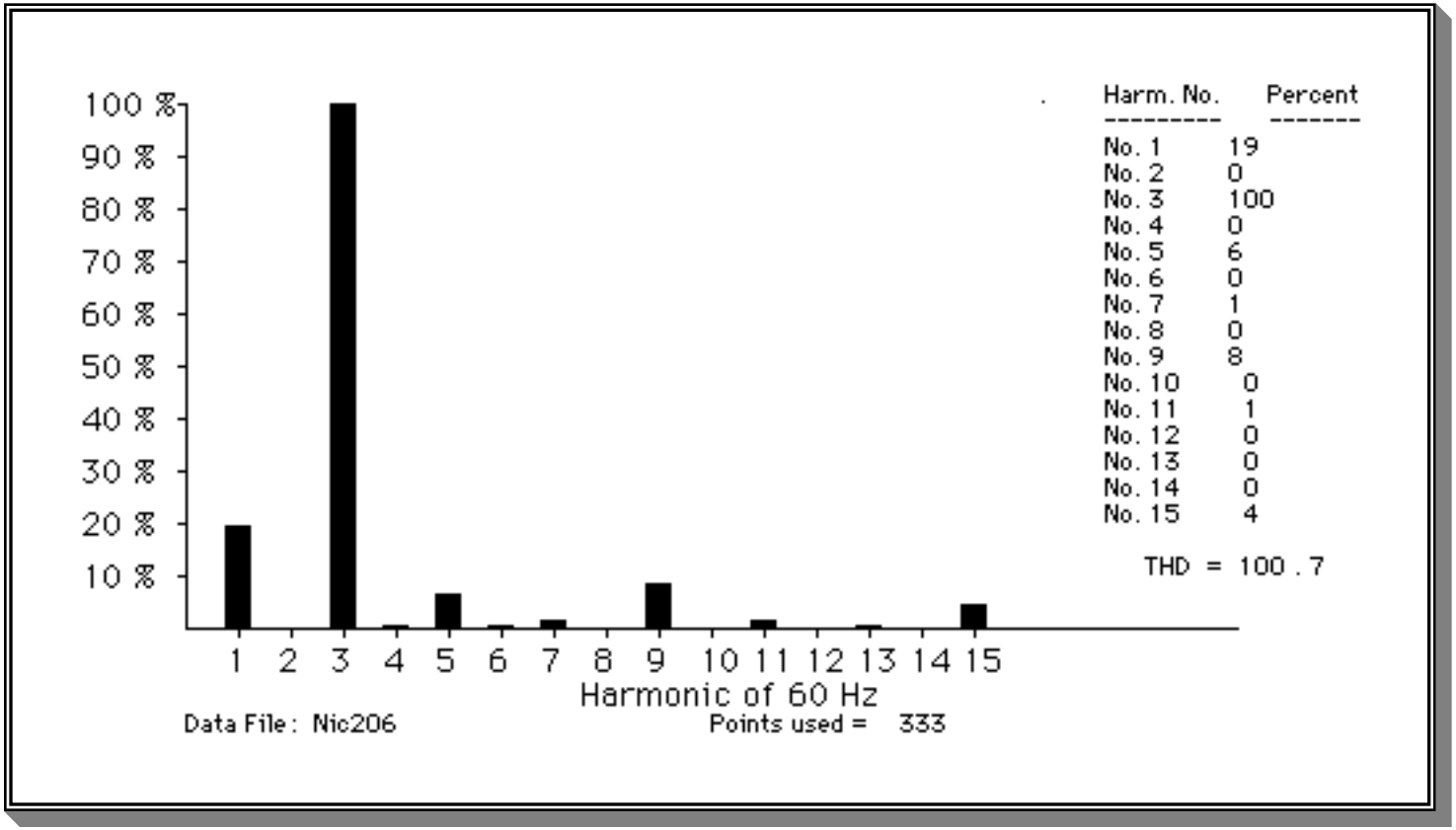
Typical NEUTRAL current at the office panel after combining three (3) phases of PC loads

Note that the current is mainly 180 Hz, not 60 Hz.



The frequency spectrum of the three (3) phase NEUTRAL currents at the office panel

Notice the current is almost all third harmonic.

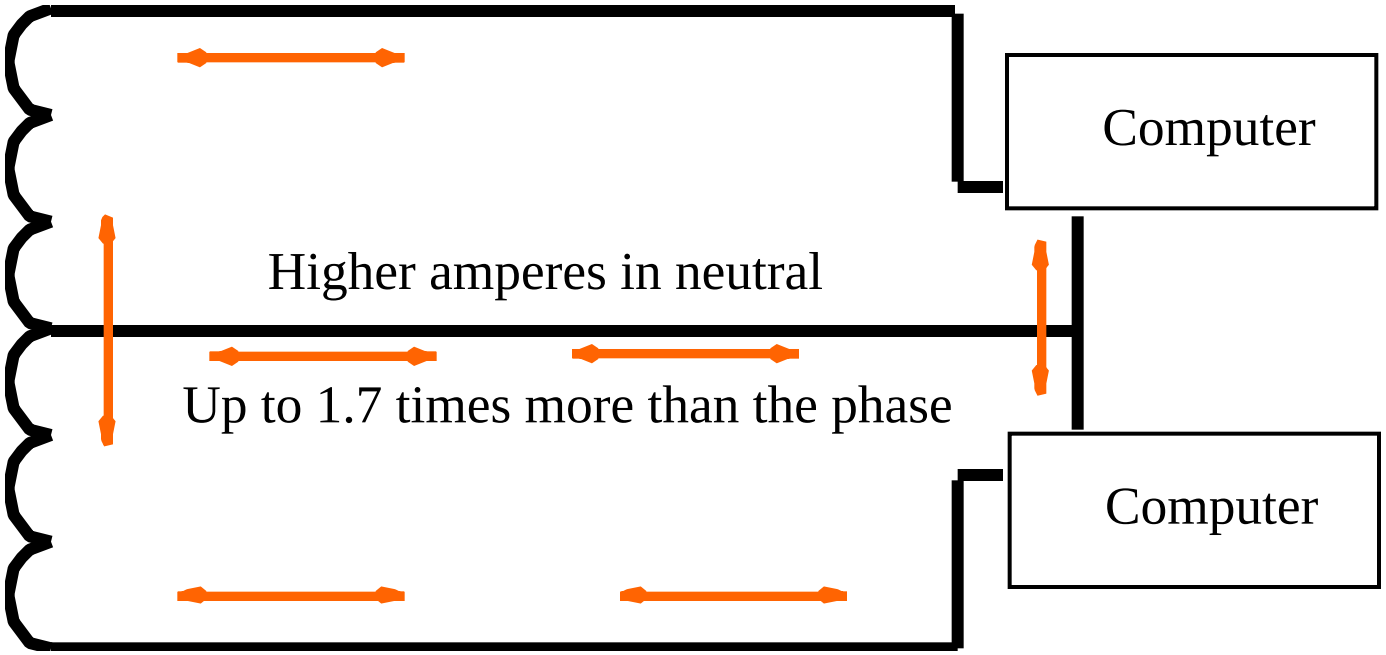


Problem #1

The current in the neutral wire is mostly 180 Hertz. The higher frequency current sees a higher impedance at 180 Hertz and creates a larger voltage drop along the neutral.

Problem #2

The third harmonic neutral current does not balance to zero.



So here we are:

We have 180 Hertz neutral current where in the past we had only 60 Hertz.

The higher frequency neutral current creates the potential for higher voltage drop along the neutral.

We have more neutral current than phase current, where in the past we had much less.

And….

Anyone in the building with a mis-wired appliance or power panel can really mess us up.

How do you locate the neutral to ground misconnection?

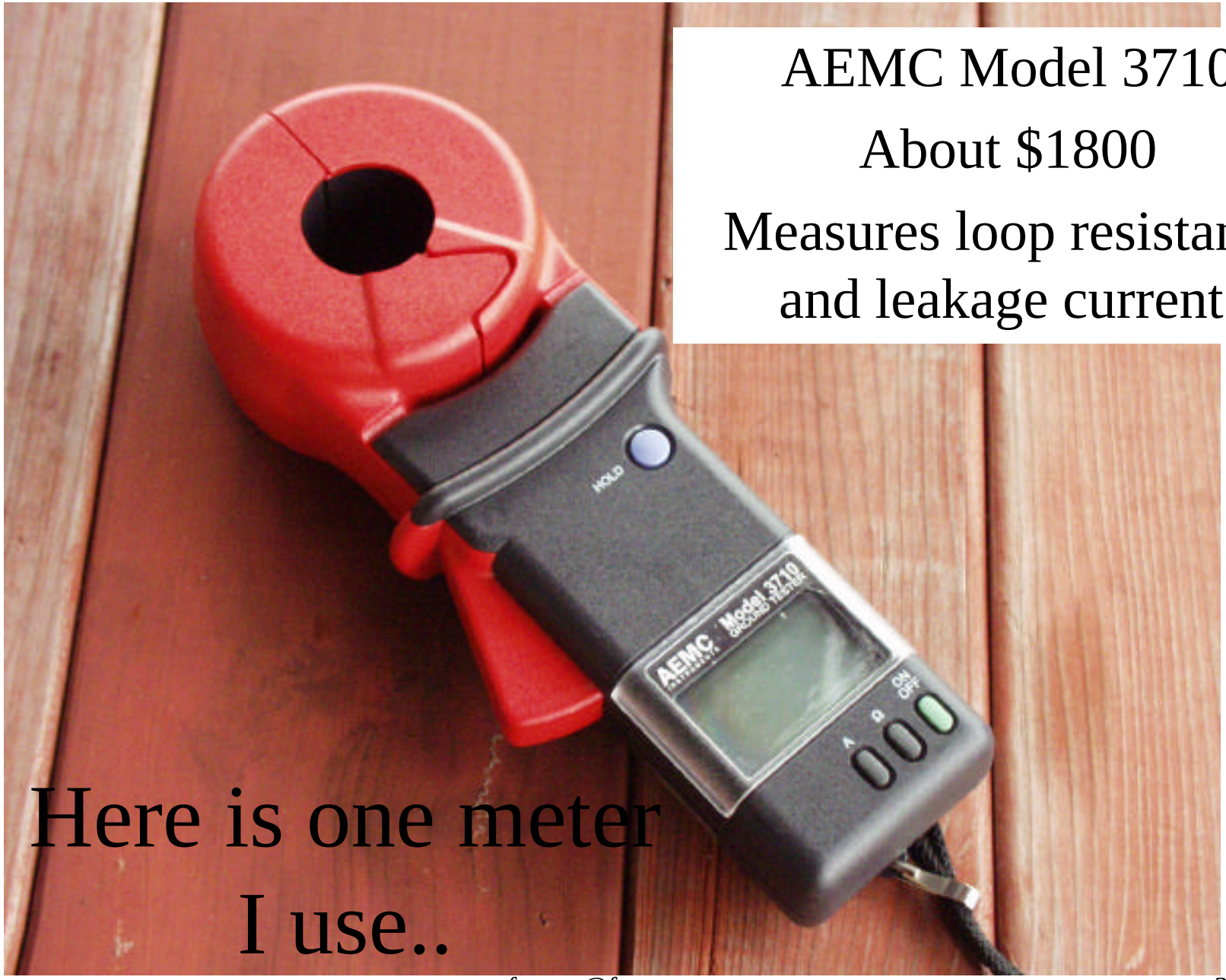
Look for currents that are in the wrong place!

This involves searching for currents…..

Looking for voltage differences between ground systems can be useful, but normally current is the culprit to look for.

Use “zero sequence” metering

If you run all the wires of a circuit through a “donut type” current transformer, whatever is measured is current that is not staying on the wires as planned. This is the “stray current” we are looking for.



AEMC Model 3710

About $1800

Measures loop resistance and leakage current.

Here is one meter I use..

Preferred meter...

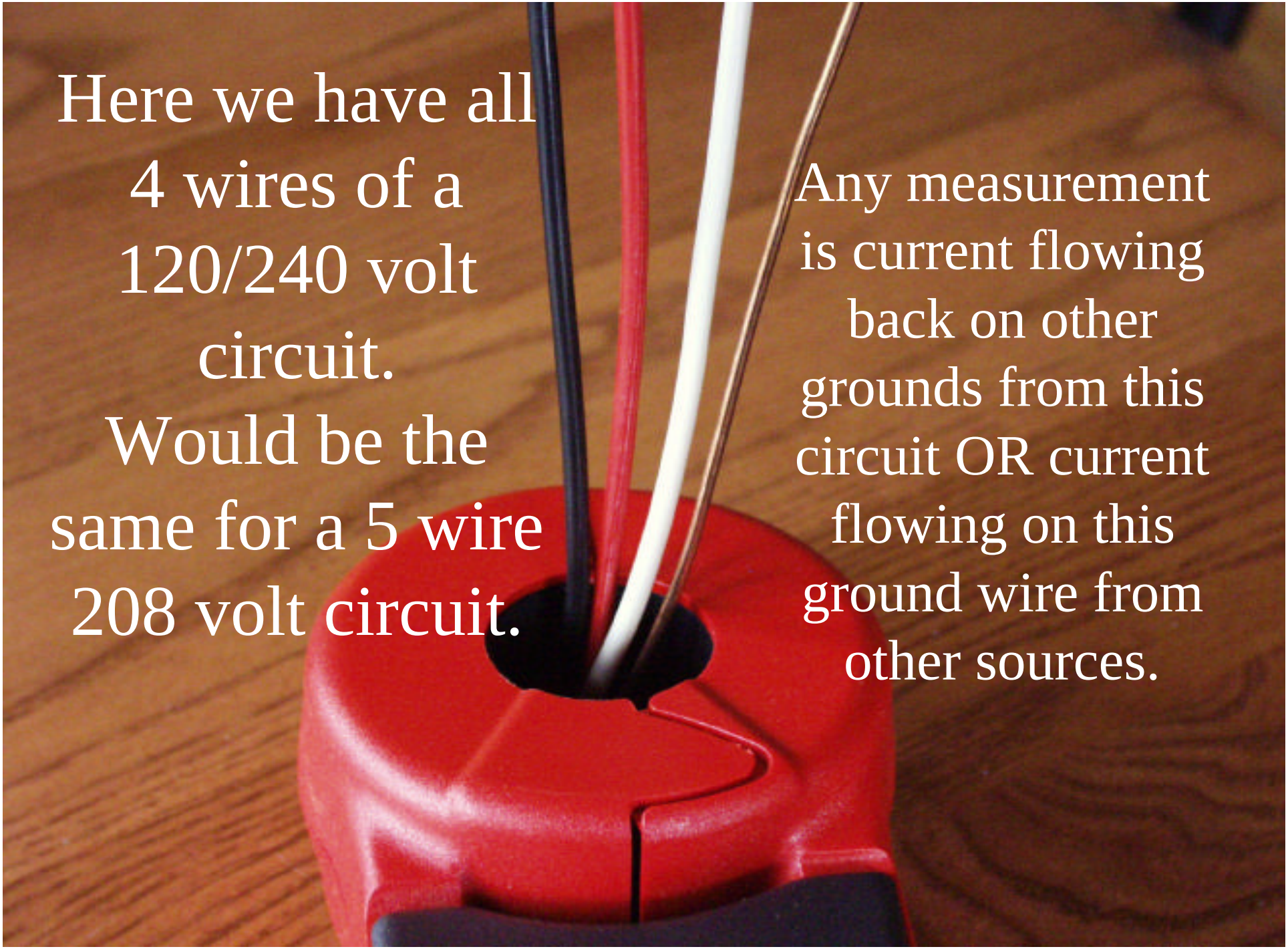
A.W. Sperry

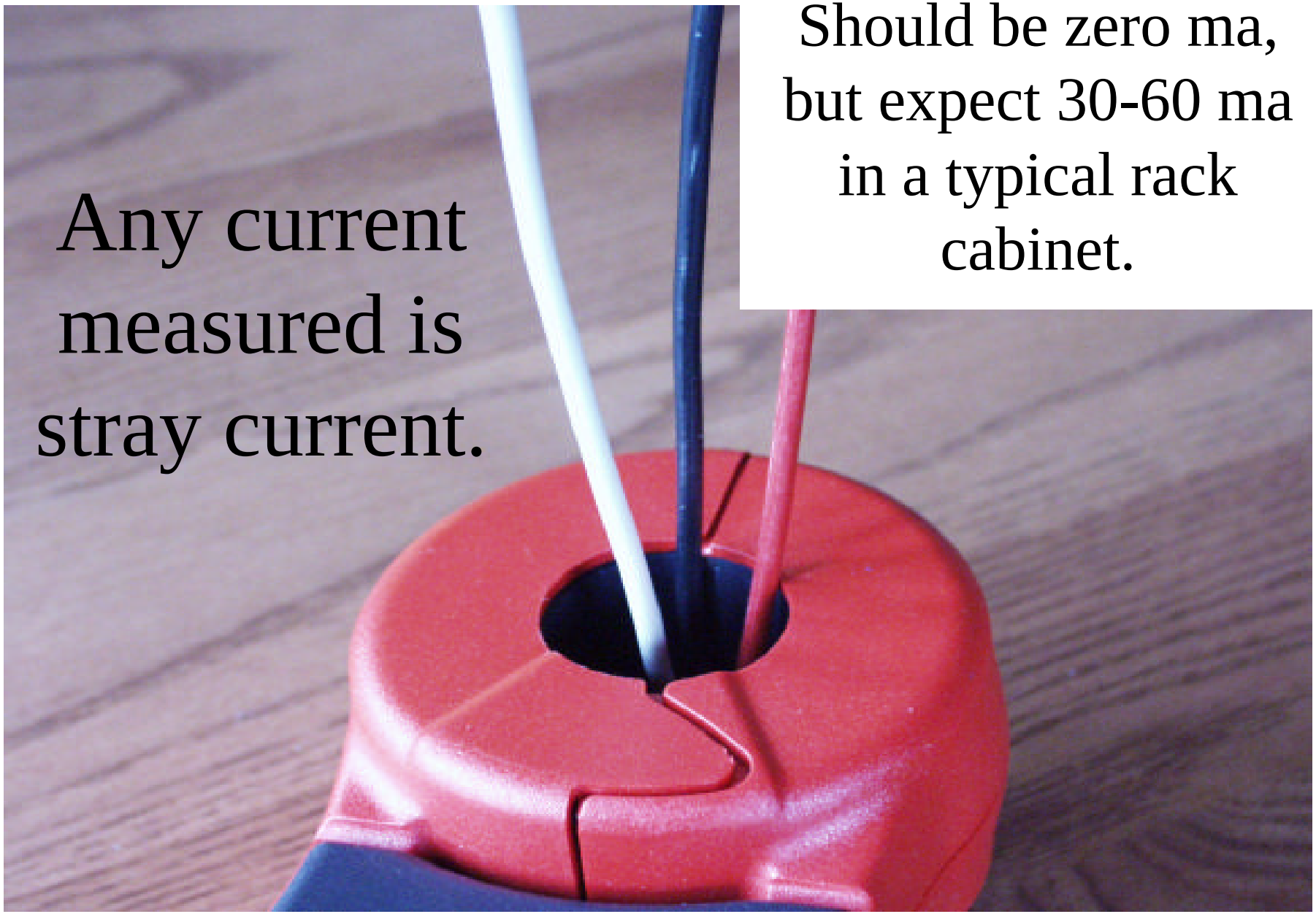
Model DSA-2413

About $450

Measures from

1 ma to 1,000 A

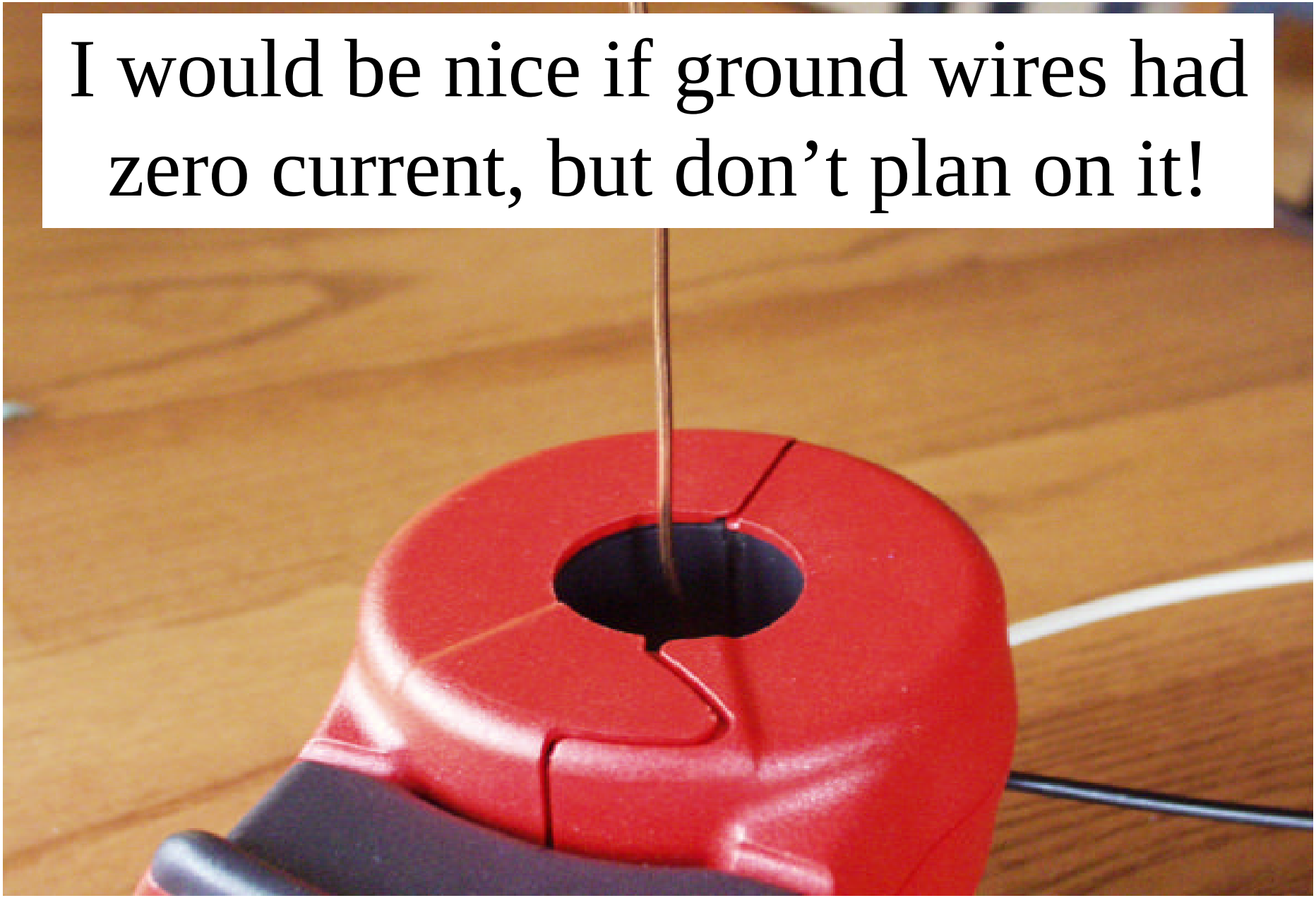

Here we have all 4 wires of a 120/240 volt circuit. Would be the same for a 5 wire 208 volt circuit.
Any measurement is current flowing back on other grounds from this circuit OR current flowing on this ground wire from other sources.



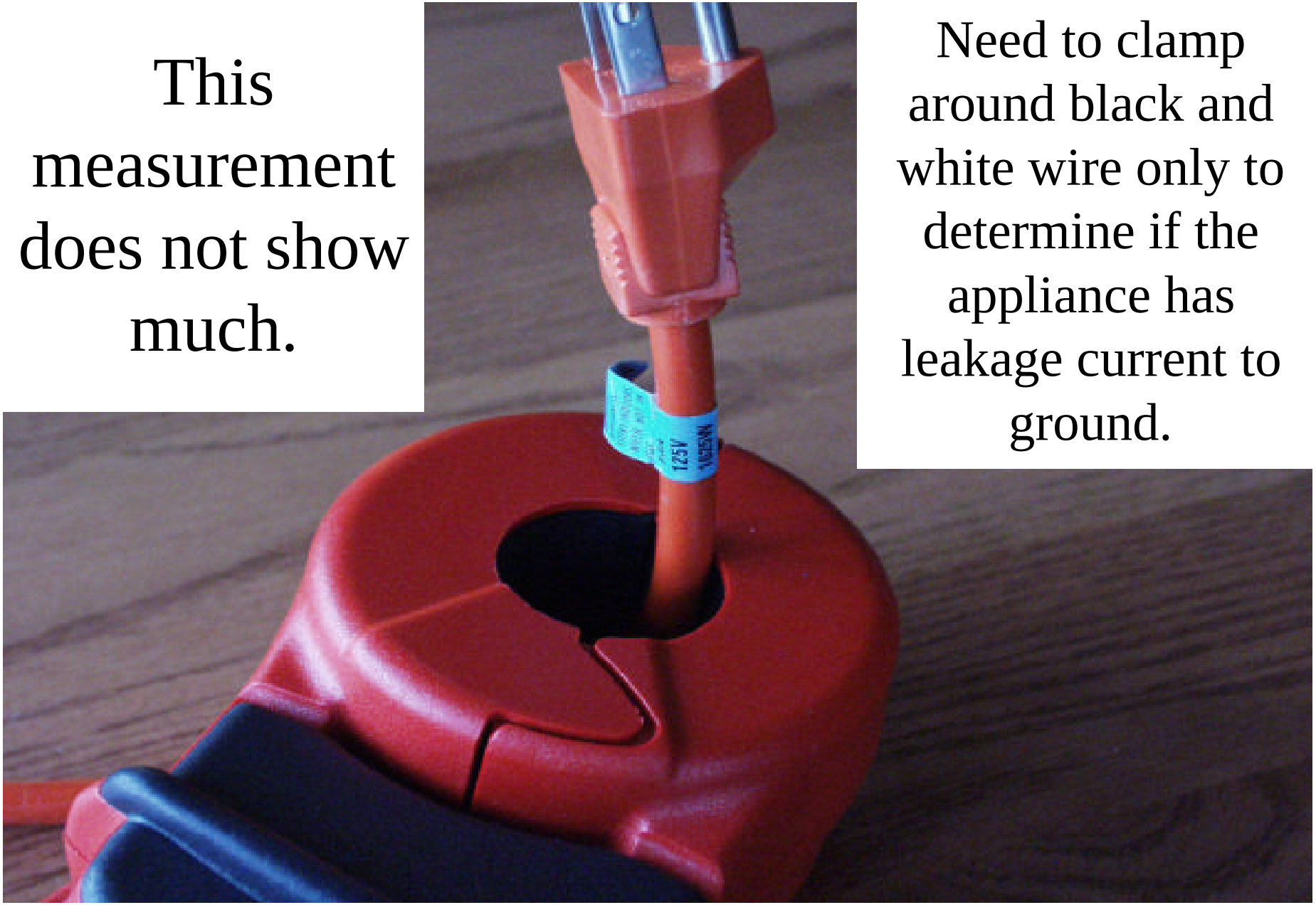
Should be zero ma, but expect 30-60 ma in a typical rack cabinet.

Careful here! Normal neutral current and stray current will be measured.

I would be nice if ground wires had zero current, but don’t plan on it!



This measurement does not show much.



Need to clamp around black and white wire only to determine if the appliance has leakage current to ground.

You can use oscilloscopes to help identify the type of current or voltage you are measuring.

Waveforms that have little distortion probably are from nearby neutral currents. Triangular or waveforms with “noise” are probably stray currents from other part of the building.

Remember that stray currents can come from other buildings.

They can flow through Utility HV neutral wires, water lines, gas lines, Telco lines, CATV or any other metallic connection to the outside world.

This just makes the problem more interesting!

Think digital and fiber!