Presented to:

93rd Annual
Illuminating Engineering Society
Aviation Lighting Committee
2022 Fall Technology Meeting

AVCON

Bonding vs. Grounding

Versus

Grounding vs. Bonding

IESALC | Illuminating Engineering Society of North America
Aviation Lighting Committee

Presented by:
Carl Johnson, ACE

Legal Disclaimer

Carl Johnson serves on the NFPA 780 Technical Committee, the UL 96 Standard Technical Panel and the IES RP-37 Subcommittee. The views and opinions expressed in this presentation are Mr. Johnson's and shall not be construed as an official position of NFPA, UL or IES and shall not be considered as, nor be relied upon as, a Formal Interpretation.

CARL JOHNSON

Presented to:

93rd ANNUAL

ILLUMINATING E[illegible] SOCIETY

AVIATION L[illegible]TTEE

2022 F[illegible]TING

AVCON

Bondi[illegible] vs. Groundin[illegible]

[illegible]rounding vs. Bonding

Presented by:

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IESALC | ILLUMINATING ENGINEERING SOCIETY of NORTH AMERICA
AVIATION LIGHTING COMMITTEE

Bonding Vs. Grounding

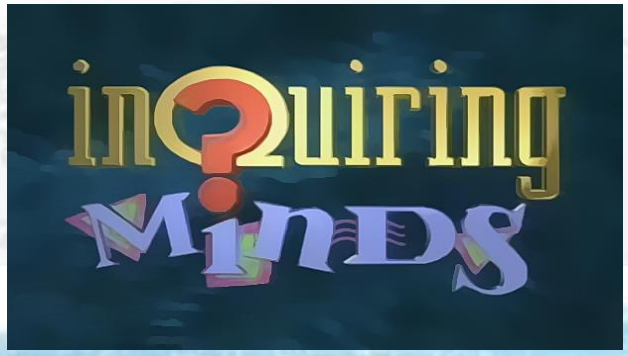
Spy

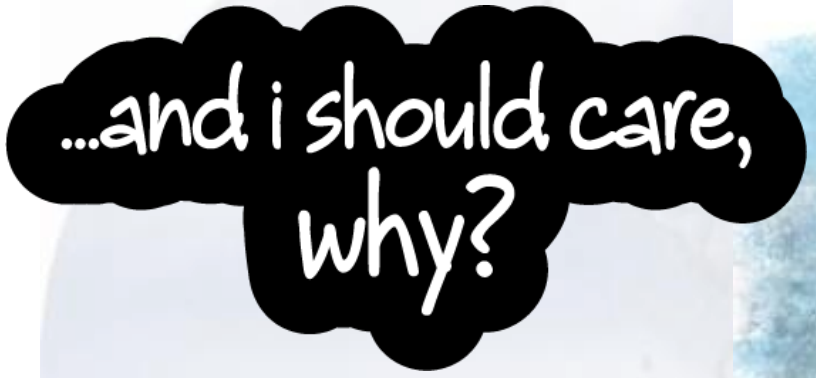
Grounding Vs. Bonding

Spy

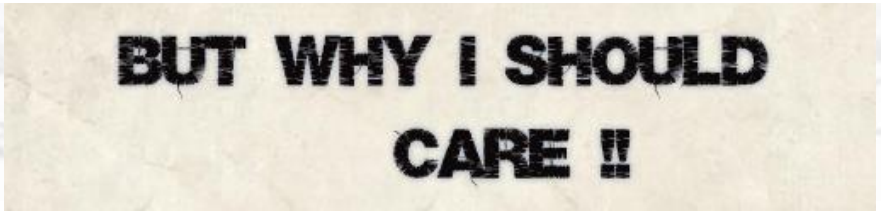
BING Images

Bonding Vs. Grounding





INQUIRING MINDS WANT TO KNOW: WHY?



Grounding Vs. Bonding

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Genesis 11:7

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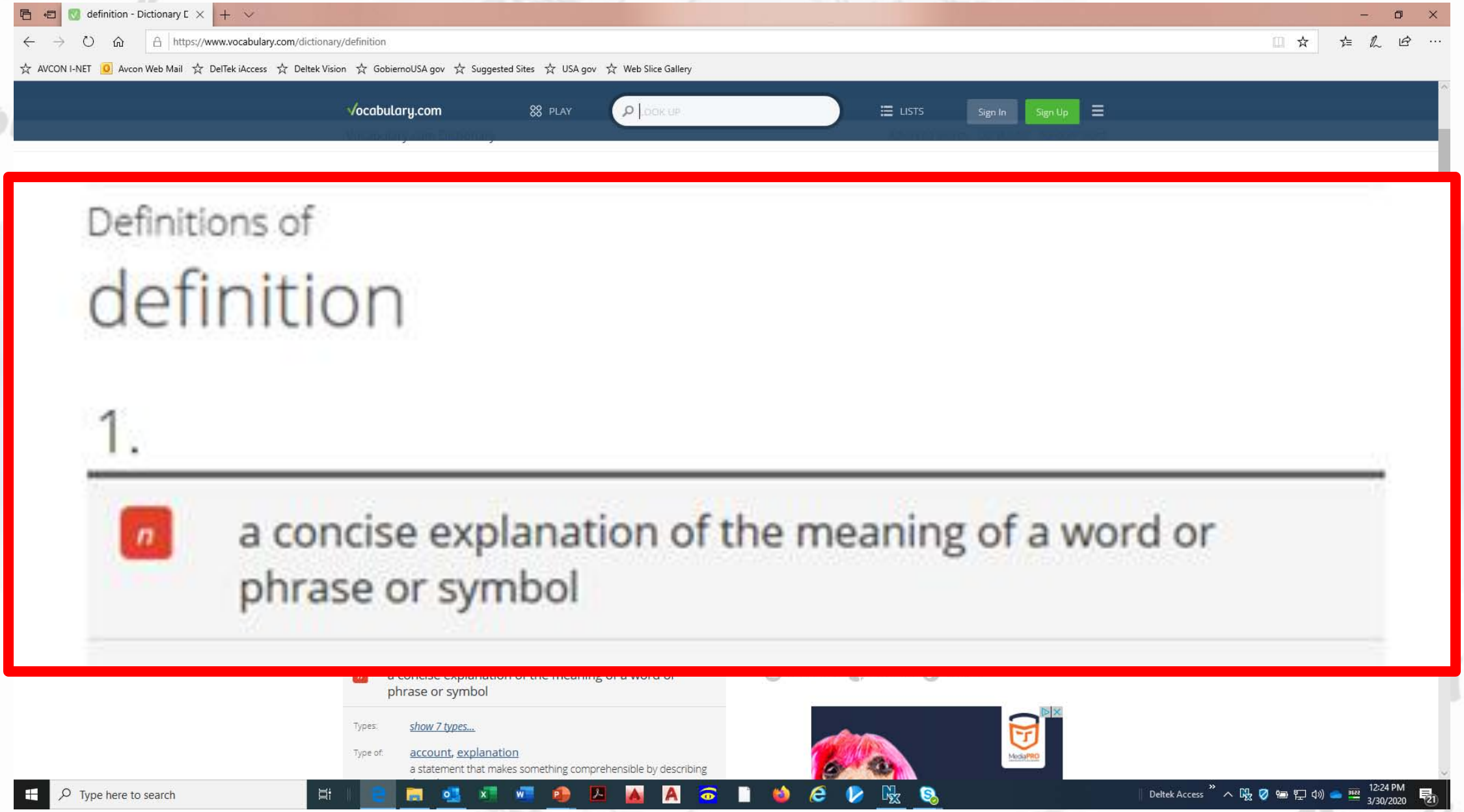
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definition
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a concise explanation of the meaning of a word or phrase or symbol
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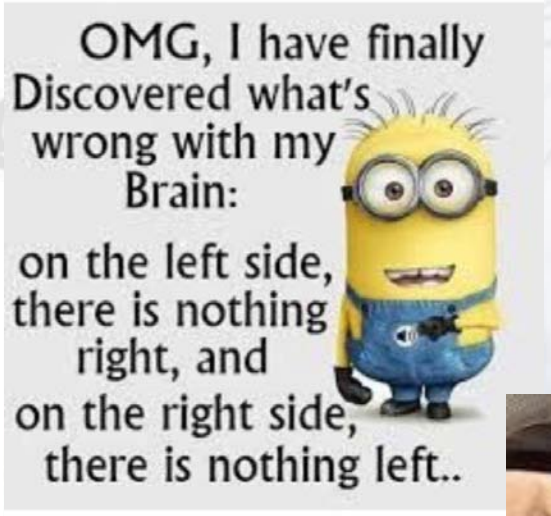
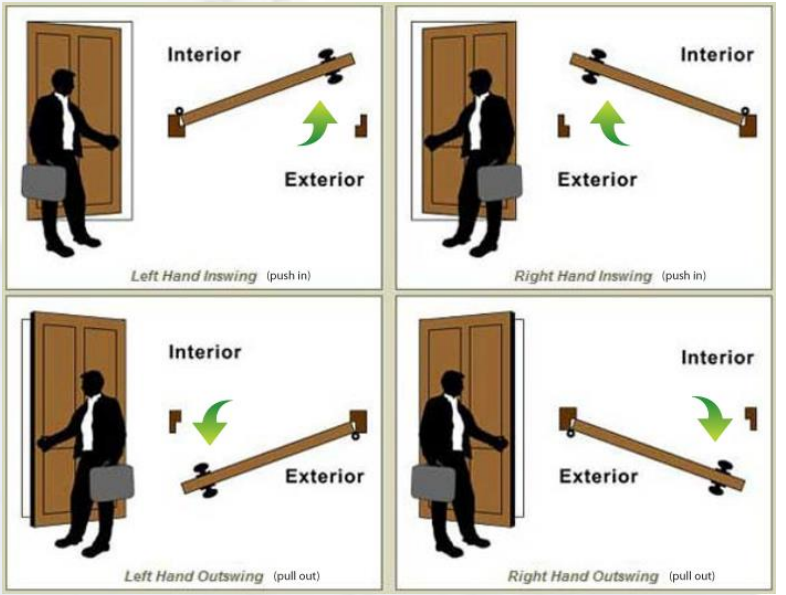
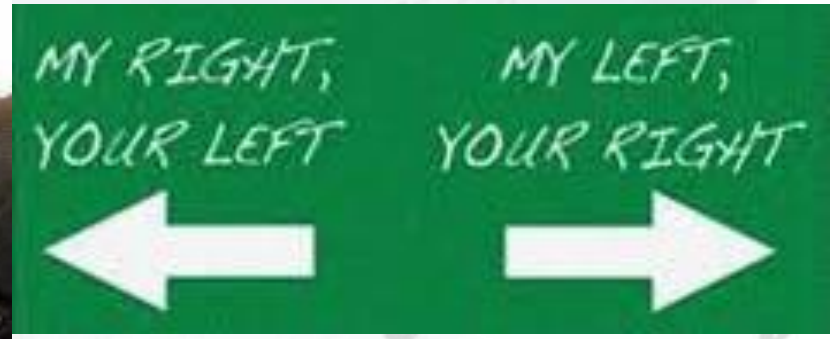
Significant Definitions







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SAFETY

NFPA 70E Tip: Know the Terms

Avoid NFPA 70E misunderstandings by ensuring your whole team knows the terminology.

Mark Lamendola

APR 17, 2020

COMPLIMENT

COMPLEMENT

GROUNDING CONDUCTOR

GROUNDED CONDUCTOR

https://www.ecmweb.com/safety/article/21129089/nfpa-70e-tip-know-the-terms?utm_source=EB+ECM+Safety+Matters&utm_medium=email&utm_campaign=CPS200417028&o_eid=5587D0016634E1Z&rdx.ident%5Bpull%5D=omeda%7C5587D0016634E1Z&oly_enc_id=5587D0016634E1Z

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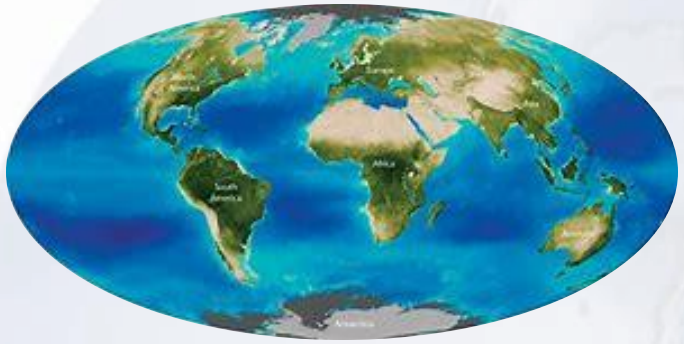

Ground. The earth. (CMP-5), [NFPA 70-2023]

Grounded (Grounding). Connected (connecting) to ground or to a conductive body that extends the ground connection. (CMP-5), [NFPA 70-2023]

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Significant Definitions

Bonded (Bonding). Connected to establish electrical continuity and conductivity. (CMP-5), [NFPA 70-2023]

Bonding. An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents. [NFPA 780-2023]

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EC&M

Randy Barnett
Electrical Codes & Safety Program Manager
for NTT Training
rbarnett@nttinc.com
303-957-4311

8:25 / 1:10:29 1x

Slides | Speaker Details

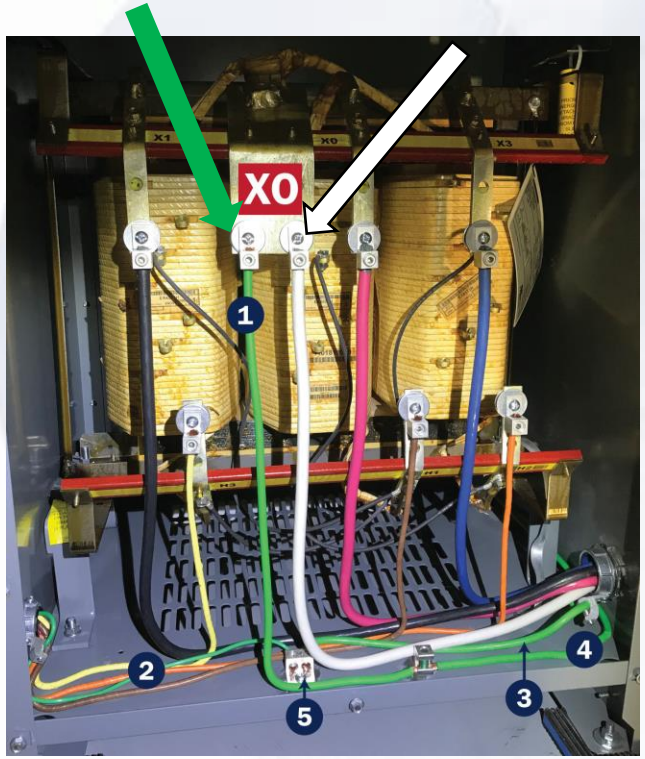
This Webinar

- What exactly is the difference between grounding and bonding anyway?
- Correct terminology and underlying principles.
- We will provide an overview of all 10 Parts of Article 250 Grounding and Bonding
- Address some of the most common installation requirements
- Other applicable standards
- Measuring the resistance of the ground connections

Grounding is connecting something to the earth.

Bonding is joining metal together with metal.

Significant Definitions



Grounded Conductor. A system or circuit conductor that is intentionally grounded. (CMP-5)

Informational Note: Although an equipment grounding conductor is grounded, it is not considered a grounded conductor.

[NFPA 70-2023]

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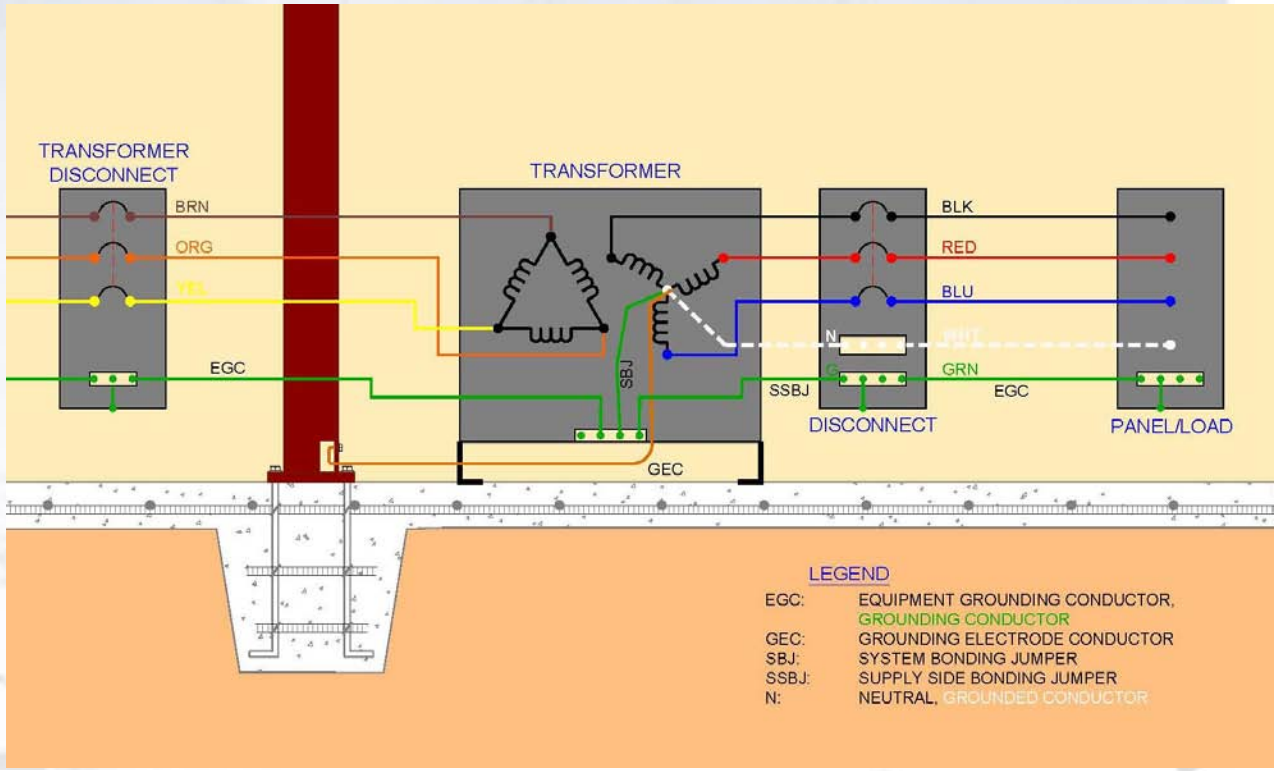
Significant Definitions

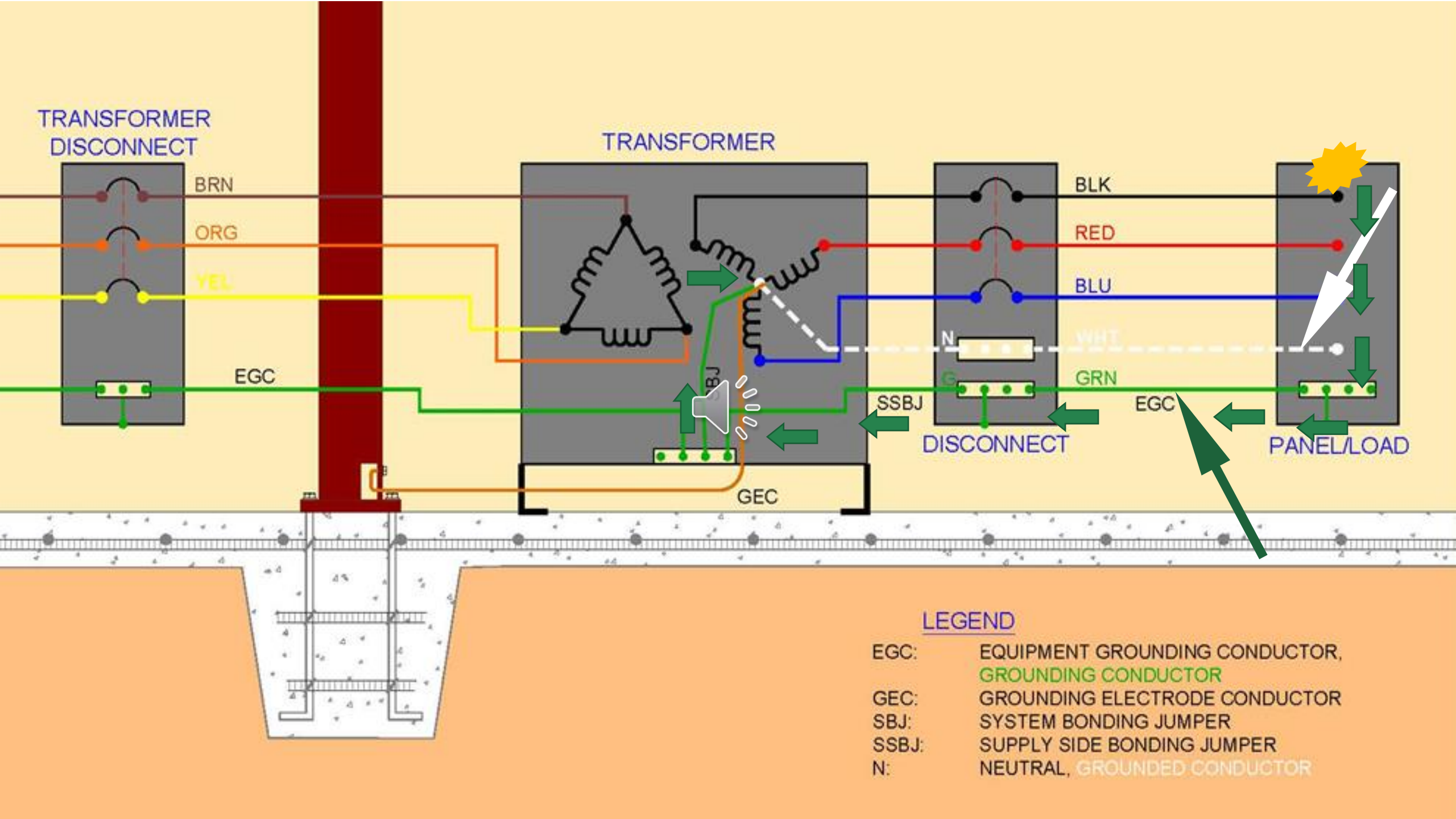
Grounding Conductor, Equipment (EGC). A conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both. (CMP-5)

Informational Note No. 1: It is recognized that the equipment grounding conductor also performs bonding.

Informational Note No. 2: See 250.118 for a list of acceptable equipment grounding conductors.

[NFPA 780-2023]




TRANSFORMER
DISCONNECT
TRANSFORMER
BRN
ORG
YEL
EGC
BJ
SSBJ
GEC
BLK
RED
BLU
N
WHT
G
GRN
EGC
DISCONNECT
PANEL/LOAD
LEGEND
EGC: EQUIPMENT GROUNDING CONDUCTOR, GROUNDING CONDUCTOR
GEC: GROUNDING ELECTRODE CONDUCTOR
SBJ: SYSTEM BONDING JUMPER
SSBJ: SUPPLY SIDE BONDING JUMPER
N: NEUTRAL, GROUNDED CONDUCTOR

FAA Safety BRIEFING
The FAA Safety Policy Voice of Non-commercial General Aviation

The Importance of Speaking Plane-ly

Aviation's General Spoken Medium

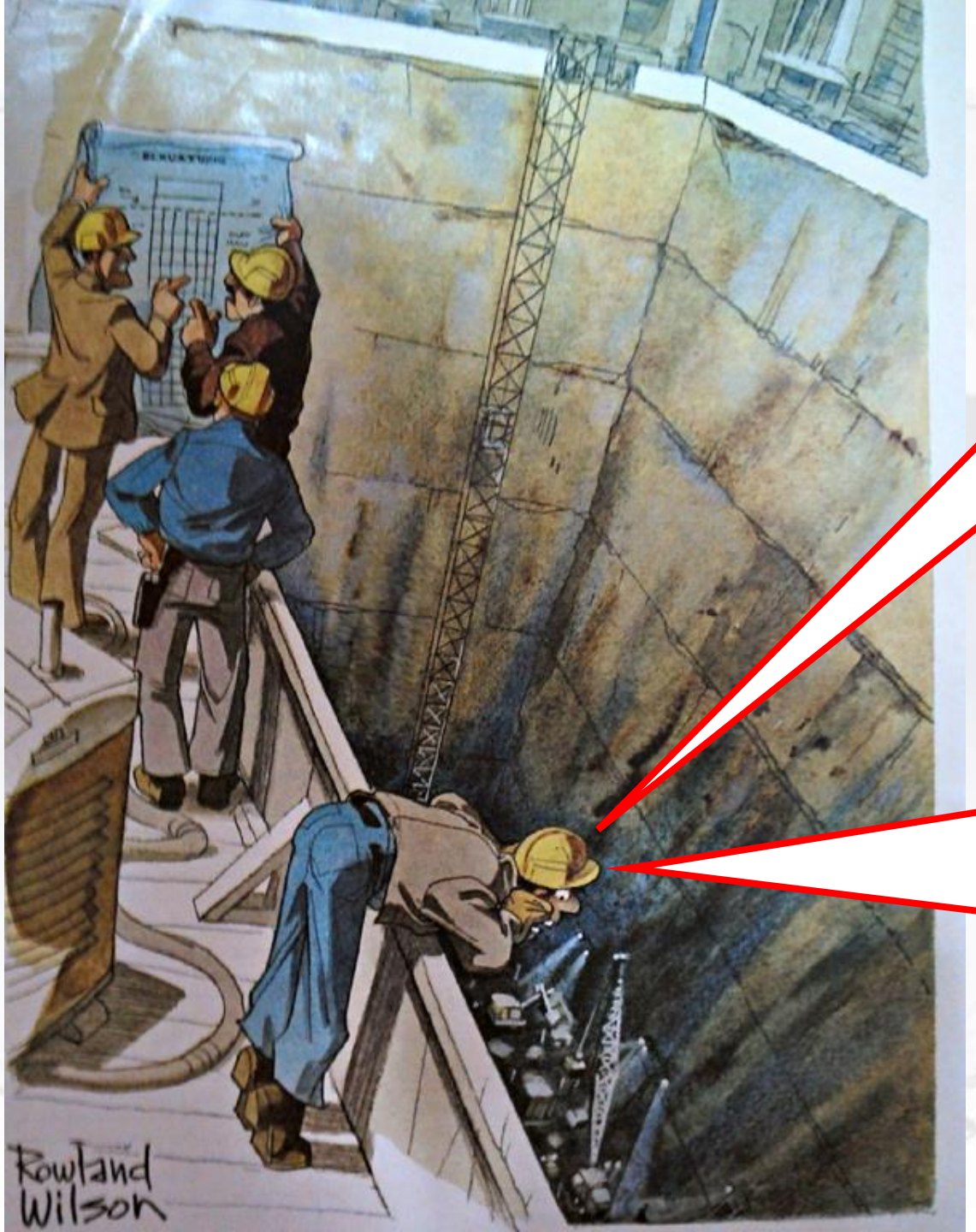
FAA Safety Briefing Follow
Apr 30 · Unlisted

by Susan K. Parson, FAA Safety Briefing Editor

An early lesson in the "Fundamentals of Instruction" curriculum for

Bonding Vs. Grounding

Accurate and Concise Communication is the Key to Success!



STOP DIGGING!

THE PLANS WERE UPSIDE DOWN!

Why do we GROUND and BOND?

Excuse me, but why do we have to know this?

Getty Images

Why do we GROUND and BOND?

"250.4 General Requirements for Grounding and Bonding.

The following general requirements identify what grounding and bonding of electrical systems are required to accomplish. The *prescriptive methods* contained in this article shall be followed to comply with the performance requirements of this section." [NFPA 70-2023]

Emphasis by presenter.

Why do we GROUND?

"**(A) Grounded Systems.**

1) **Electrical System Grounding.** Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by *lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation*." [NFPA 70-2023]

Emphasis by presenter.

Why do we GROUND?

"**(A) Grounded Systems.**

2) Grounding of Electrical Equipment. Normally non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be *connected to earth so as to limit the voltage to ground on these materials*." [NFPA 70-2023]

Emphasis by presenter.

Why do we BOND?

"**(A) Grounded Systems.**

3) Bonding of Electrical Equipment. Normally non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be *connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path*." [NFPA 70-2023]

Emphasis by presenter.

Why do we BOND?

"**(A) Grounded Systems.**

4) **<u>Bonding</u> of Electrically Conductive Materials and Other Equipment.** Normally non-current-carrying electrically conductive materials that are likely to become energized shall be <u>connected together</u> and to the electrical supply source in a manner that establishes an effective ground-fault current path." [NFPA 70-2023]

<u>Emphasis by presenter.</u>

Why do we BOND?

"**(A) Grounded Systems.**

5) Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source. The earth shall not be considered as an effective ground-fault current path." [NFPA 70-2023]

Emphasis by presenter.

Why do we Bond and GROUND?

"250.4(B) Ungrounded Systems.

250.4(B)(4) Path for Fault Current.

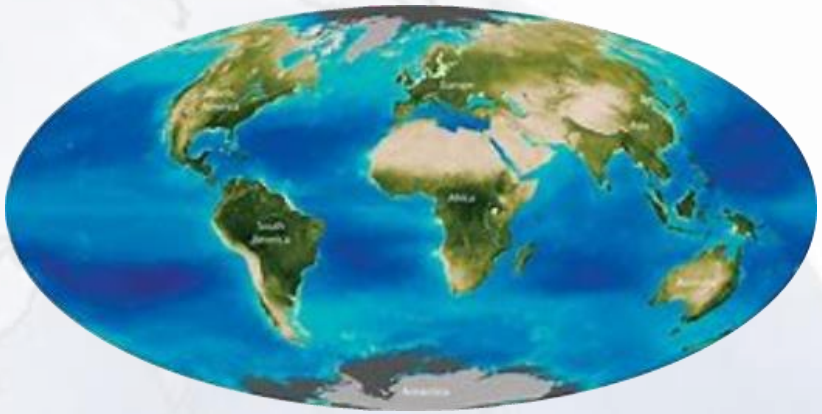
Electrical equipment, wiring, and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit from any point on the wiring system to the electrical supply source to facilitate the operation of overcurrent devices should a second ground fault from a different phase occur on the wiring system. The earth shall not be considered as an effective fault-current path." [NFPA 70-2023]

Emphasis by presenter.

Why do we GROUND and BOND?

Why do we GROUND?

to limit the voltage imposed



- Lightning,
- Line surges,
- Unintentional contact with higher-voltage lines,
- Stabilize the voltage to earth during normal operation,
- Non–current-carrying conductive materials are connected to earth to limit the voltage to ground on these materials.

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Why do we BOND?

- To establish an effective ground-fault current path.

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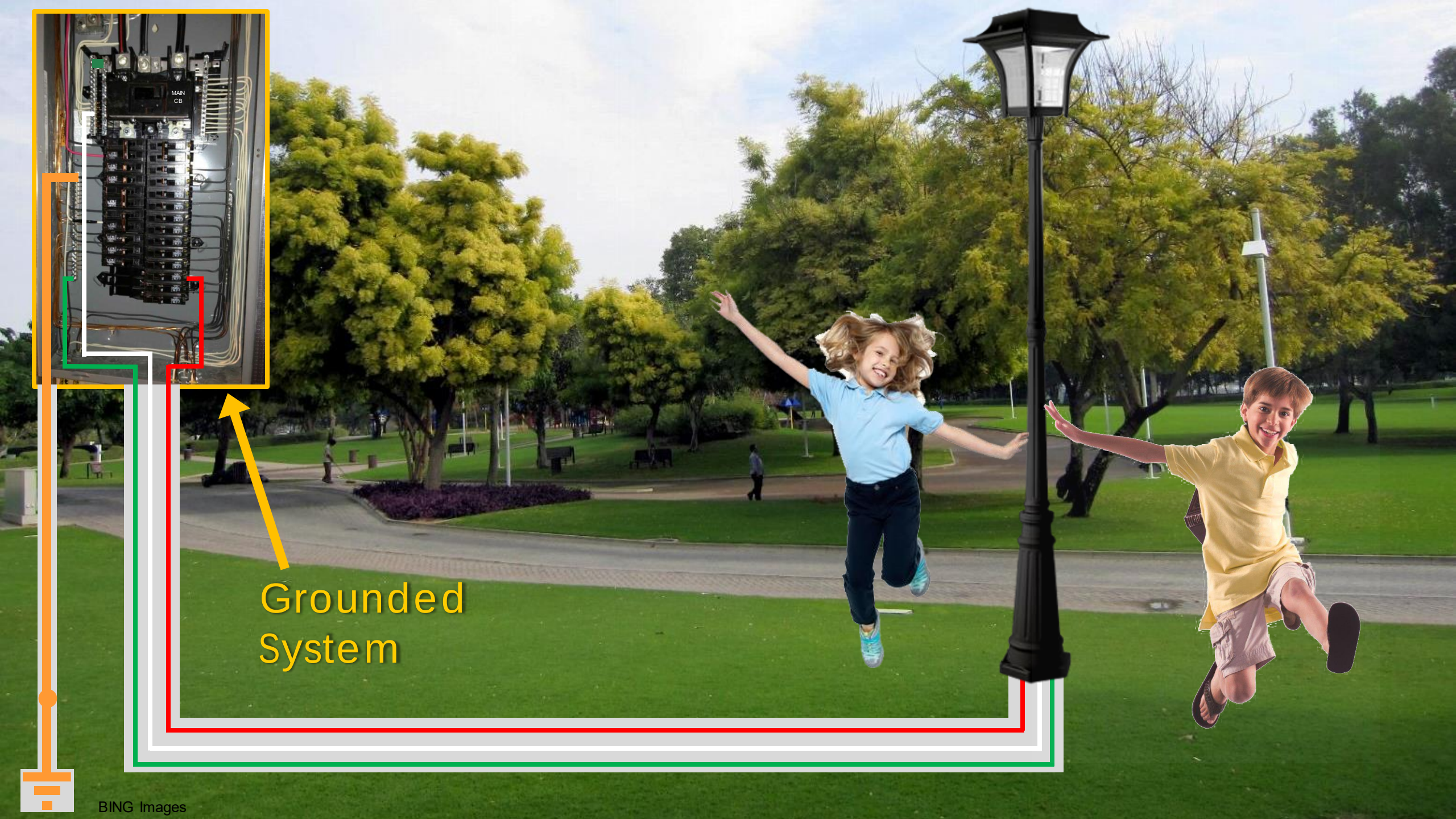

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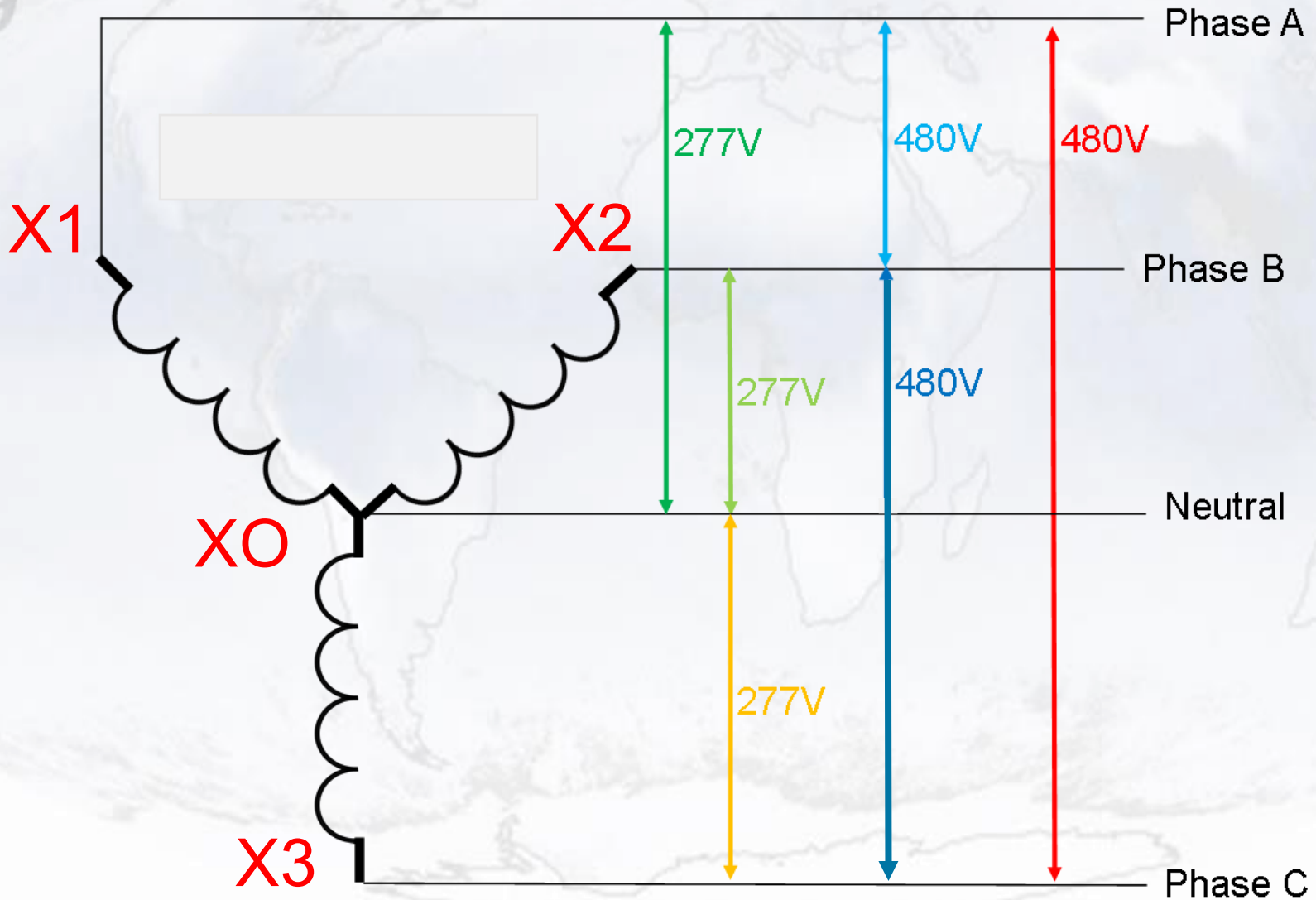
What do I mean by “Stabilize/Limit the Voltage”



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MAIN
CB
Grounded
System
Equipment Grounding Conductor (EGC)
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Equipment Grounding Conductor (EGC)

How electrical current affects the human body

Table 1. *Estimated Effects of 60 Hz AC Currents*

1 mA	Barely perceptible
16 mA	Maximum current an average man can grasp and "let go"
20 mA	Paralysis of respiratory muscles
100 mA	Ventricular fibrillation threshold
2 Amps	Cardiac standstill and internal organ damage
15/20 Amps	Common fuse or breaker opens circuit*

*Contact with 20 milliamps of current can be fatal. As a frame of reference, a common household circuit breaker may be rated at 15, 20, or 30 amps.

https://www.cdc.gov/niosh/docs/98-131/pdfs/98-131.pdf

How electrical current affects the human body

Wet conditions are common during low-voltage electrocutions.

Under dry conditions, human skin is very resistant. (100,000Ω)

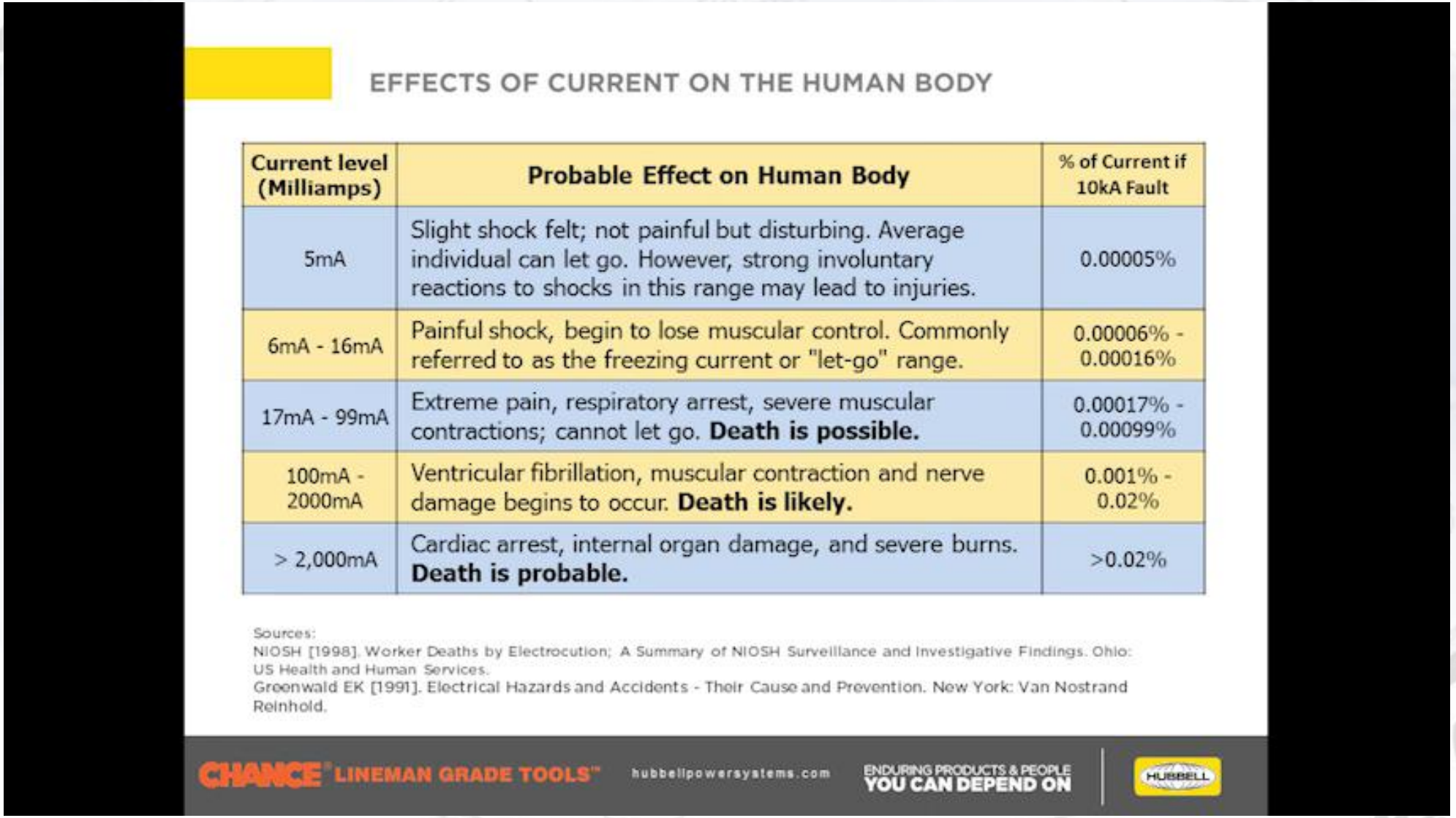
Wet skin dramatically drops the body's resistance. (1,000Ω)

Dry Conditions: Current = Volts/Ohms = 120V/100,000Ω = 1mA
a barely perceptible level of current.

Wet conditions: Current = Volts/Ohms = 120V/1,000Ω = 120mA
sufficient current to cause ventricular fibrillation.

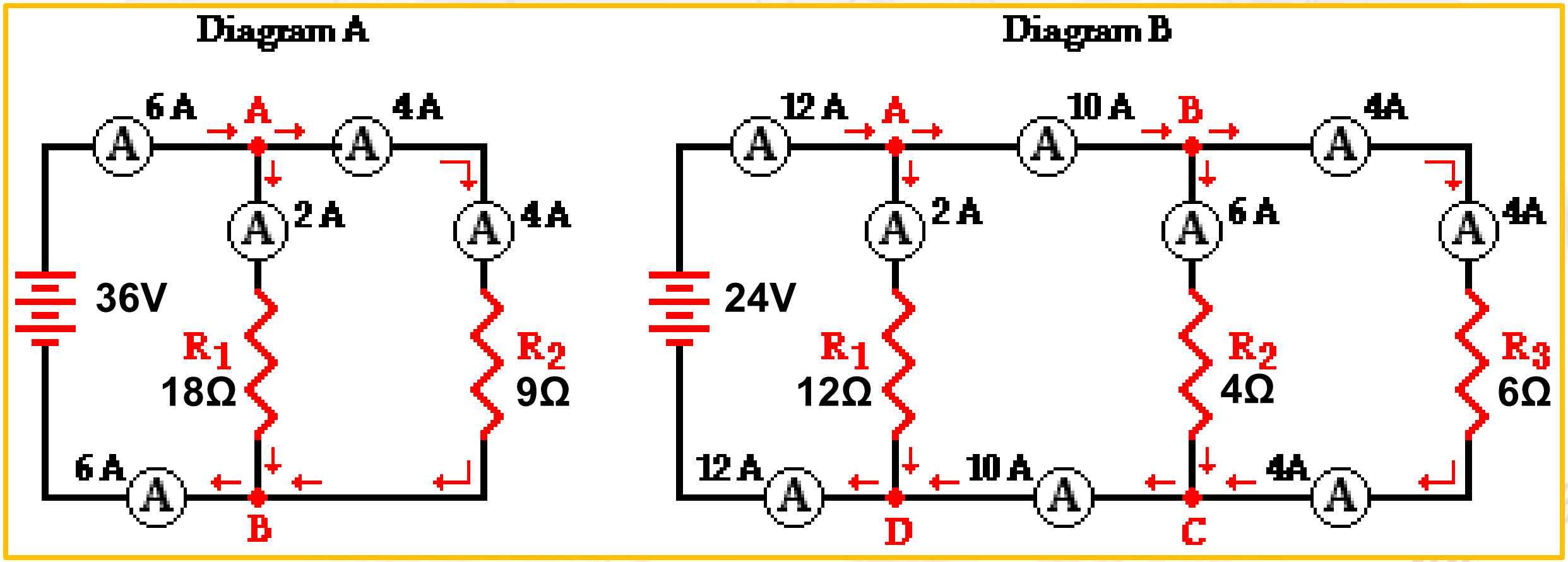
https://www.cdc.gov/niosh/docs/98-131/pdfs/98-131.pdf

How electrical current affects the human body



https://www.youtube.com/watch?v=_whwyuM1cPo

Why Does an EGC Work?



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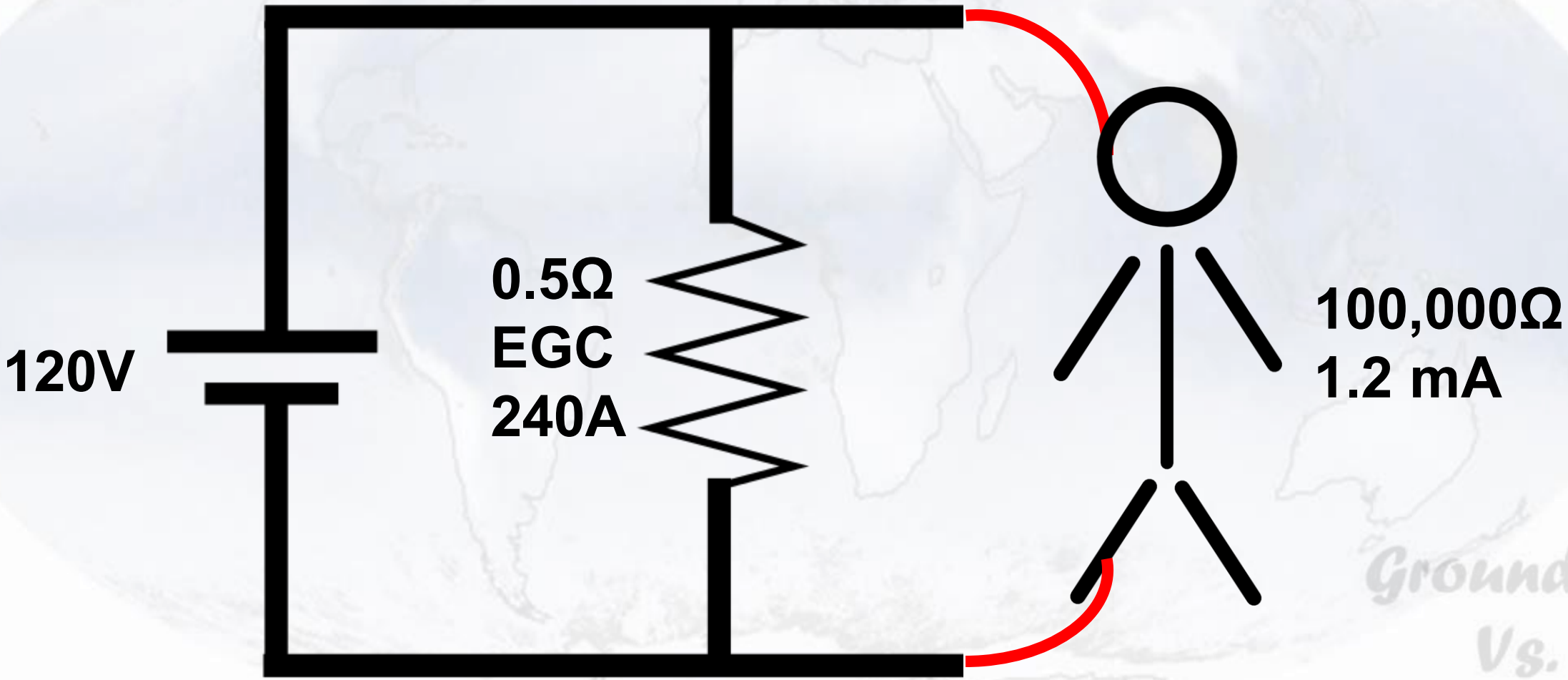
How Does an EGC Work?



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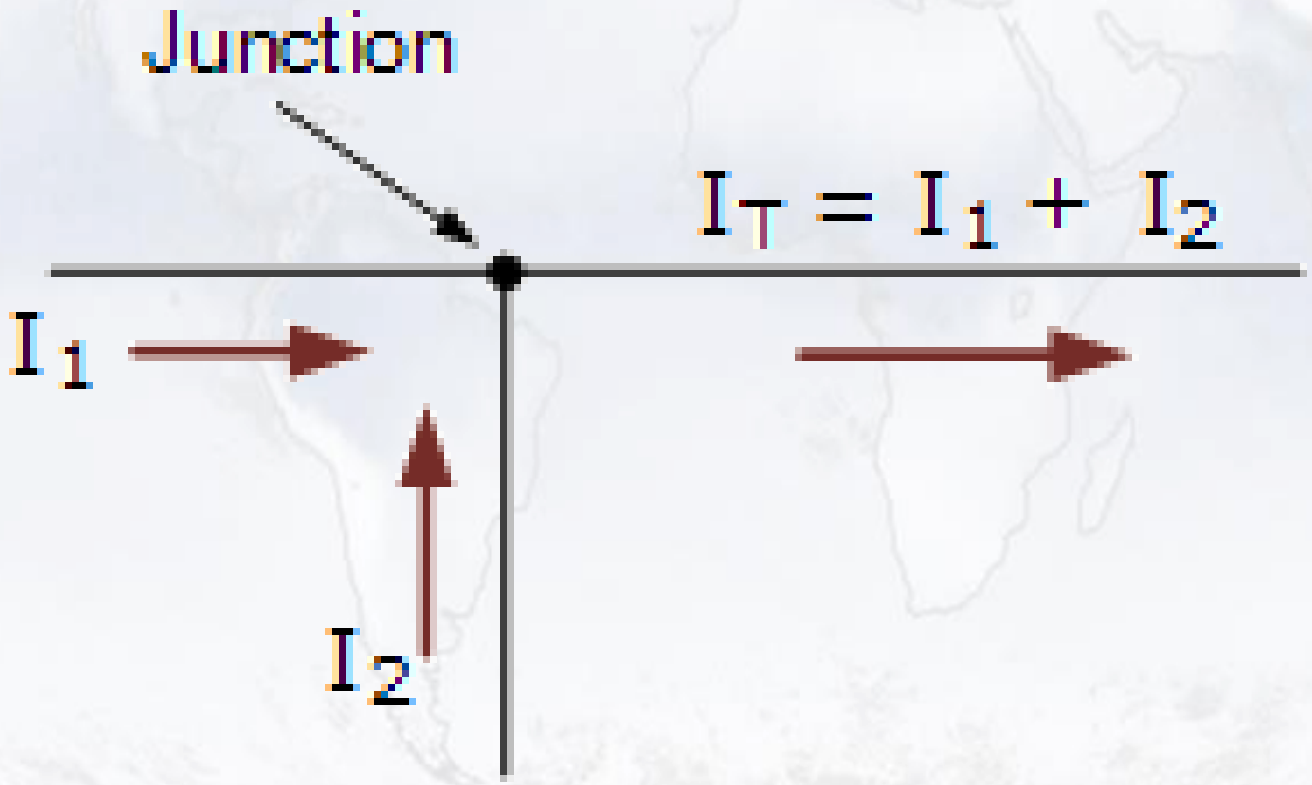
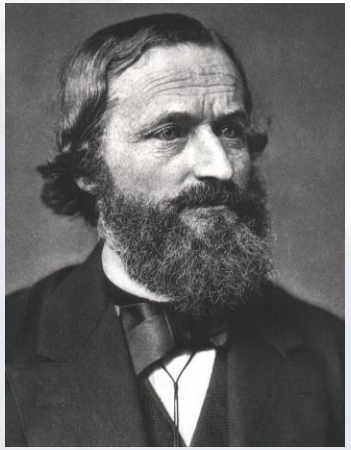
Kirchhoff's Current Law





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Kirchhoff's Current Law

6.6A

6.6A

Gustav Kirchhoff

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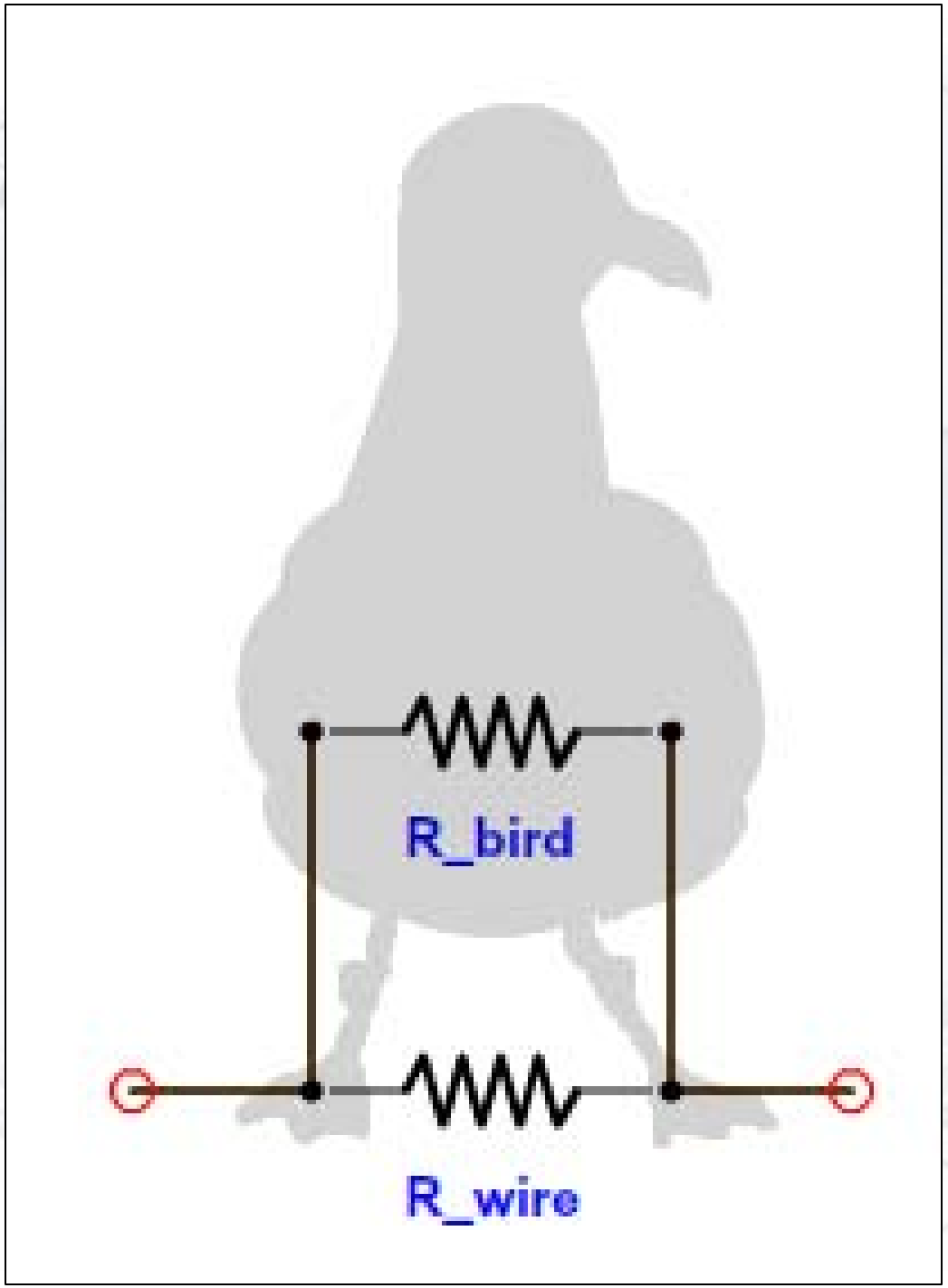
Bird on a Wire

Bird on a Wire



2 AWG Copper wire = 0.194Ω/1,000 Ft.

R_bird = 100Ω

R_wire = 49µΩ

I_bird = 49µA

I_wire = 99.99A

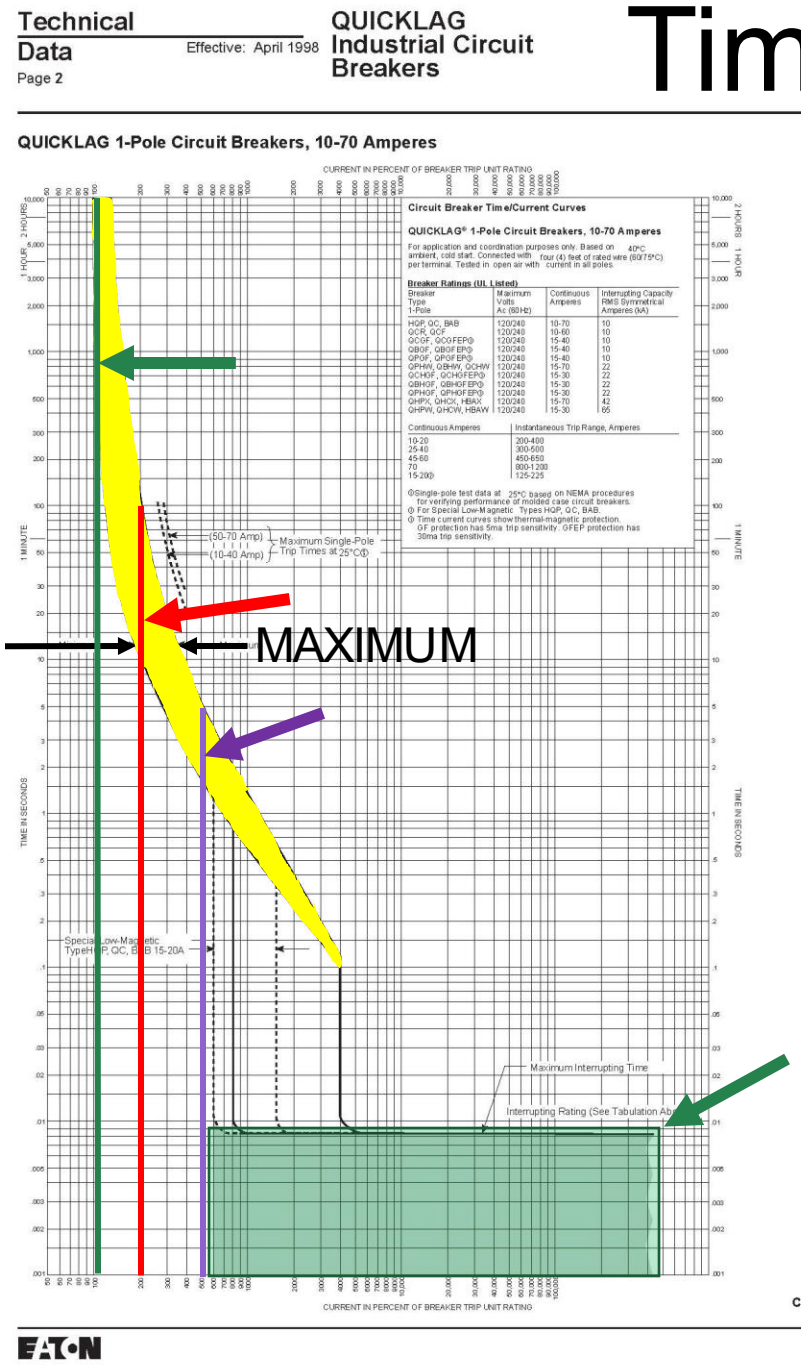
BING Images


Day 24: They still suspect nothing.
But I fear all will be lost if they ask me to conduct electricity.

Time Current Curve

Maximum
Minimum
Region

20-amp current takes from 1,500 seconds up to several hours to trip.



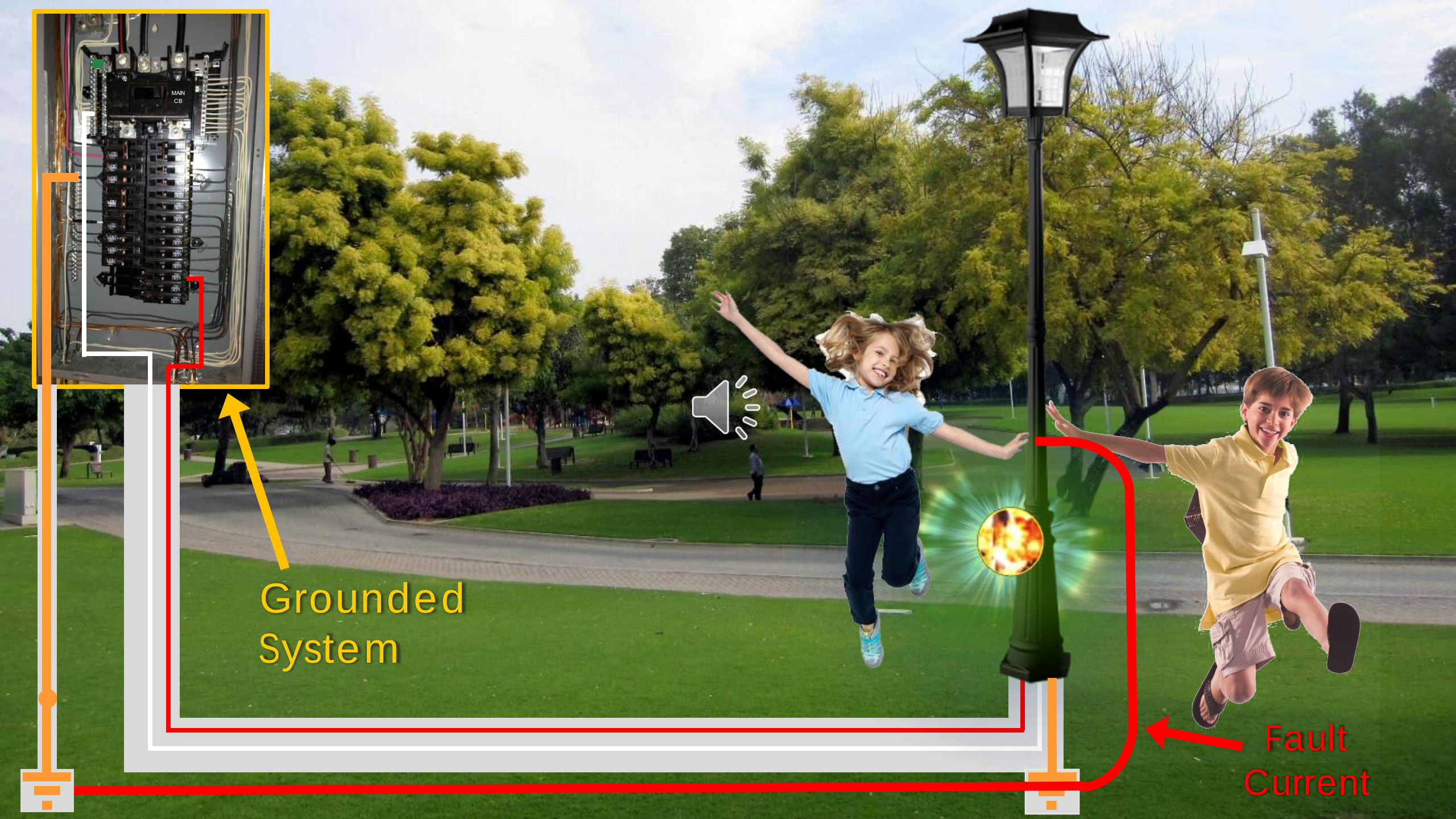
40-amp current takes 10 seconds to 100 seconds to trip.

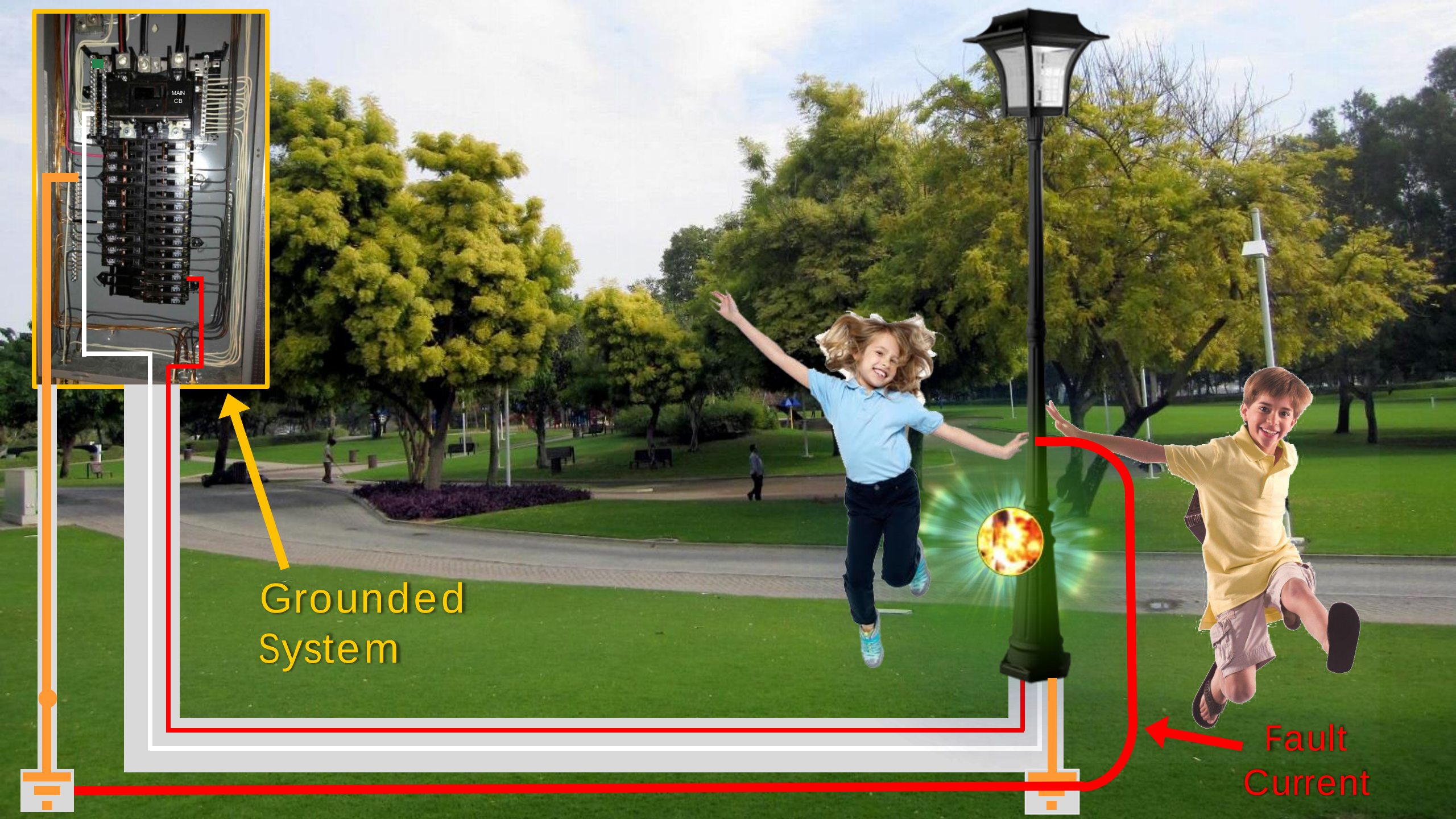
100-amp current takes 1.75 seconds to 5.25 seconds to trip.

Instantaneous region. Six times or greater CB rating, takes 1/1000th of a second to 1/100th of a second to trip.


MAIN
CB
Grounded
System
Fault
Current


MAIN
CB
Grounded
System
Fault
Current


MAIN
CB
Grounded
System
Fault
Current


MAIN
CB
Grounded
System
Fault
Current

IEEE Std 142-2007, Table 4-2

Resistivity of Soils and Resistance of Single Rods

Soil Description	Group Symbol[a]	Average Resistivity (ohm-cm)	Resistance of 15.88 mm x 3 m (5/8 in x 10 ft) rod (ohm)
Well-graded gravel, gravel-sand mixtures, little or no fines	GW	60,000 to 100,000	180 to 300
Poorly graded gravels, gravel-sand mixtures, little or no fines	GP	100,000 to 250,000	300 to 750
Clayey gravel, poorly graded gravel, sand-clay mixtures	GC	20,000 to 40,000	60 to 120
Silty sands, poorly graded sand-silts mixtures	SM	10,000 to 50,000	30 to 150
Clayey sands, poorly graded sand-clay mixtures	SC	5,000 to 20,000	15 to 60
Silty or clayey fine sands with slight plasticity	ML	3,000 to 8,000	9 to 24
Fine sandy or silty soils, elastic silts	MH	8,000 to 30,000	24 to 90
Gravelly clays, sandy clays, silty clays, lean clays	CL	2,500 to 6,000[b]	17 to 18[b]
Inorganic clays of high plasticity	CH	1,000 to 5,500[b]	3 to 16[b]

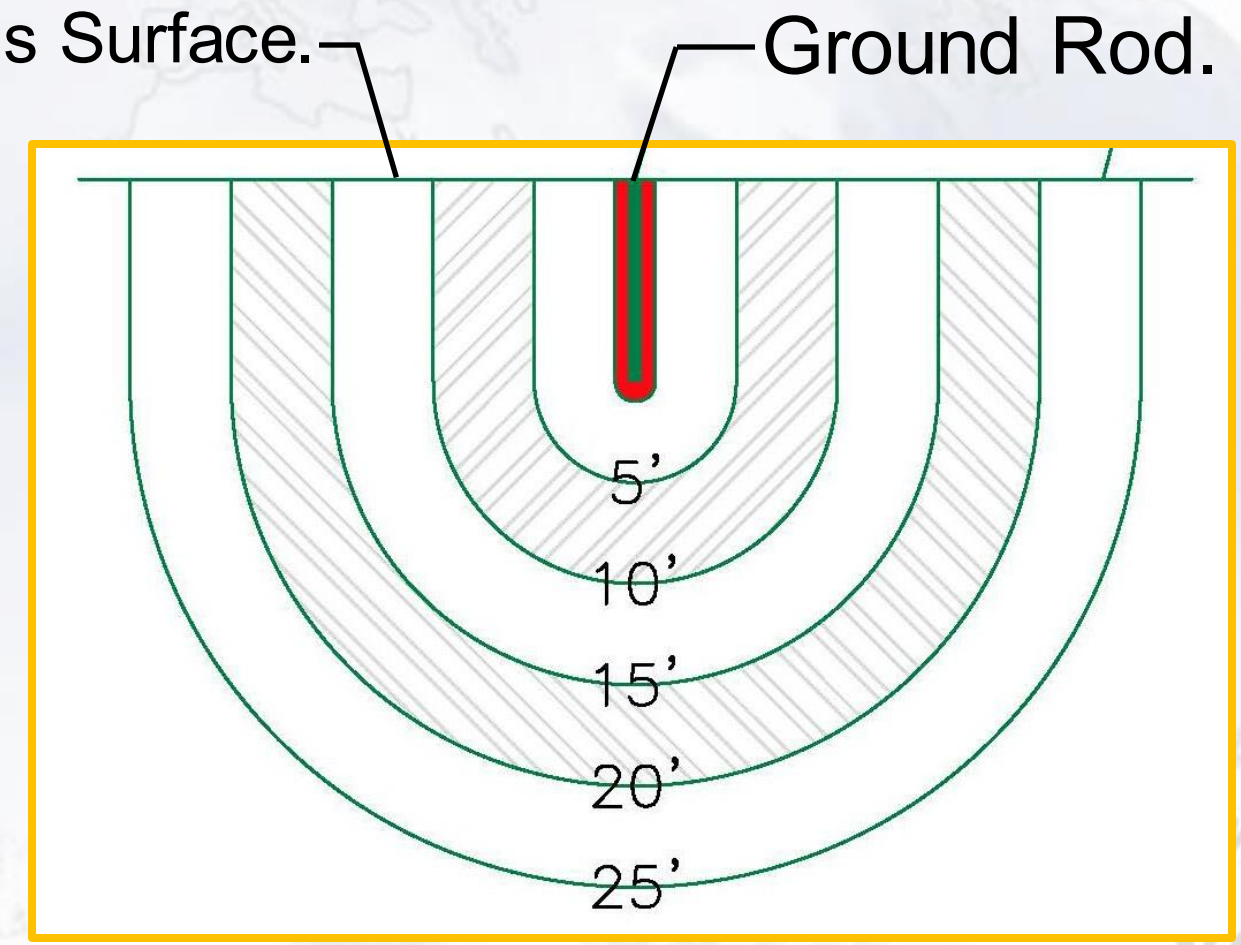
[a] The terminology used in these descriptions is from the United States Soil Classification System (USCS) and is a standard method of describing soils in a geotechnical or geophysical report.

[b] These soil classification resistivity results are highly influenced by the presence of moisture.

IEEE Std 142-2007, Table 4-1

Electrode Resistance at a Radius (r)(ft) 5/8 X 10’ Grounding Electrode

Distance from Electrode Surface (*r*) (ft)	Approximate Percentage of Total Resistance
0.1	25
0.2	38
0.3	46
0.5	52
1.0	68
5.0	86
10.0	94
15.0	97
20.0	99
25.0	100
(100.0)[a]	(104)
(1000.0)[a]	(117)



[a] These figures show that for the most practical reasons the majority of the resistance to remote earth occurs within 25 feet of the electrode. At 1,000 feet the resistance only increases by 17%.

IEEE Std 142-2007, Table 4-1

Electrode Resistance at a Radius (r)(ft) 5/8 X 10’ Grounding Electrode

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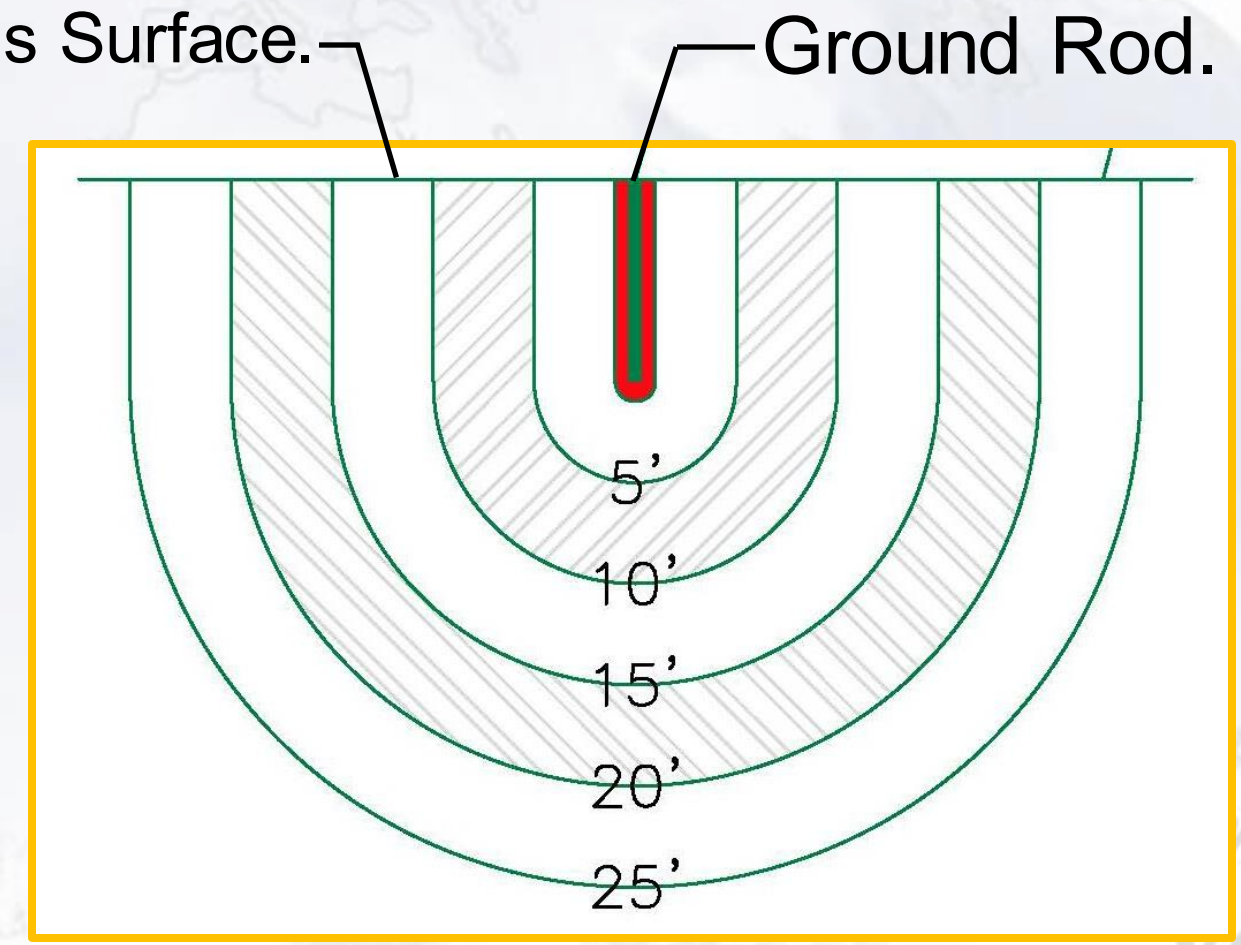
(100.0)[a]	(104)
(1000.0)[a]	(117)

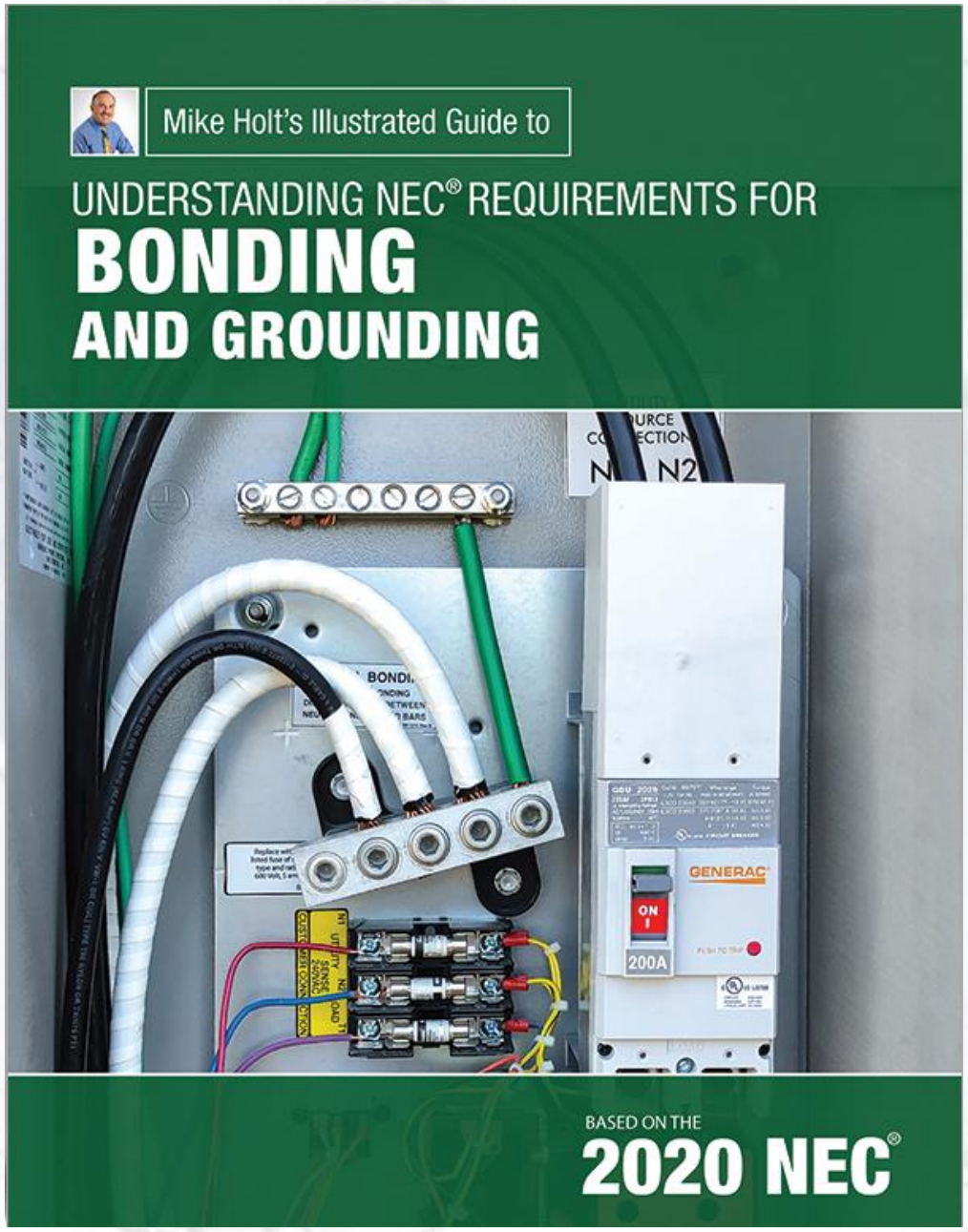


[a] These figures show that for the most practical reasons the majority of the resistance to remote earth occurs within 25 feet of the electrode. At 1,000 feet the resistance only increases by 17%.

Ultimate Solution for those

Hard-To-Ground Situations

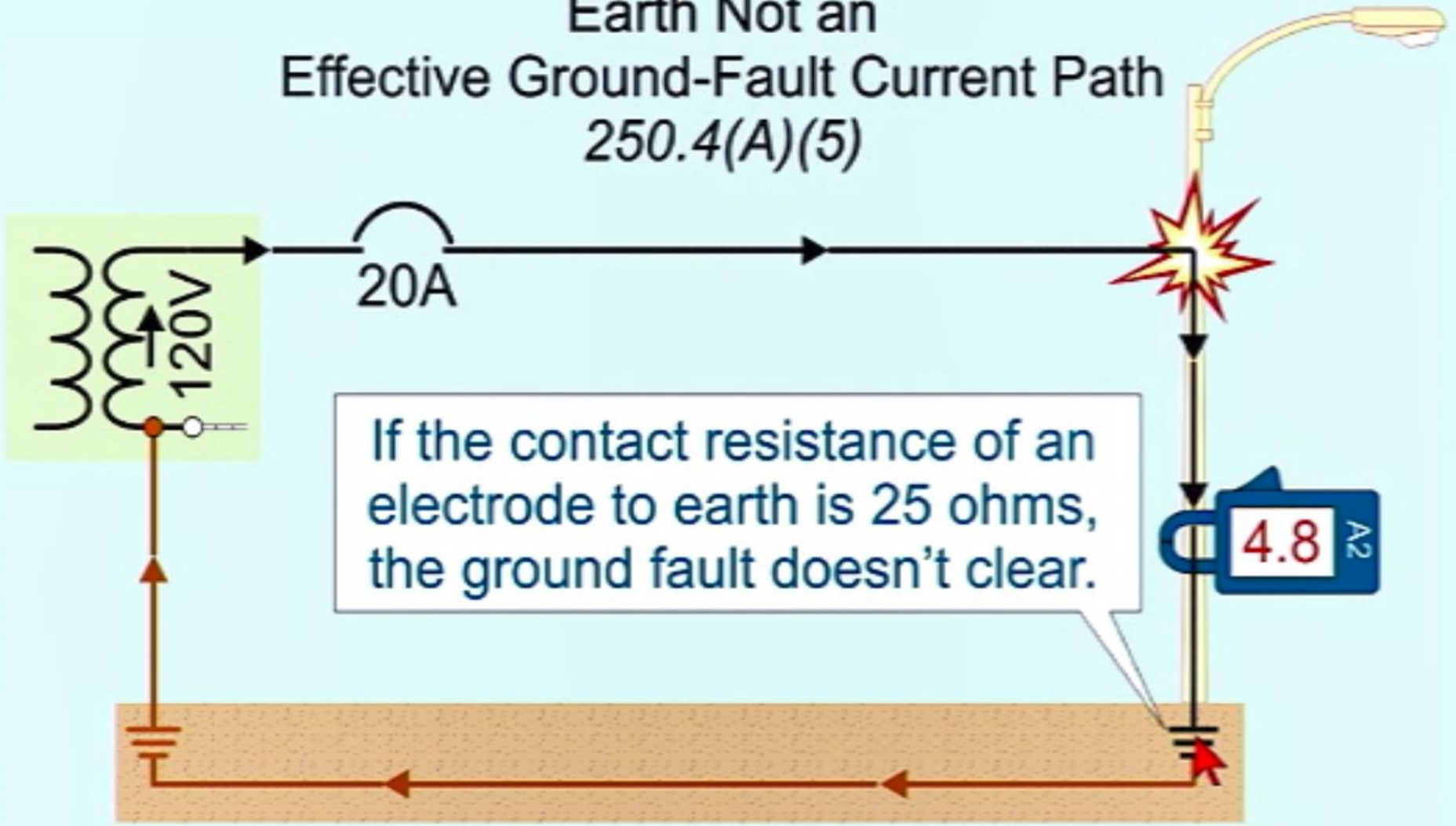
COMPLEMENTS OF EDUARD ALF



https://www.mikeholt.com/free-resources.php

Earth Not an Effective Ground-Fault Current Path

250.4(A)(5)



DANGER

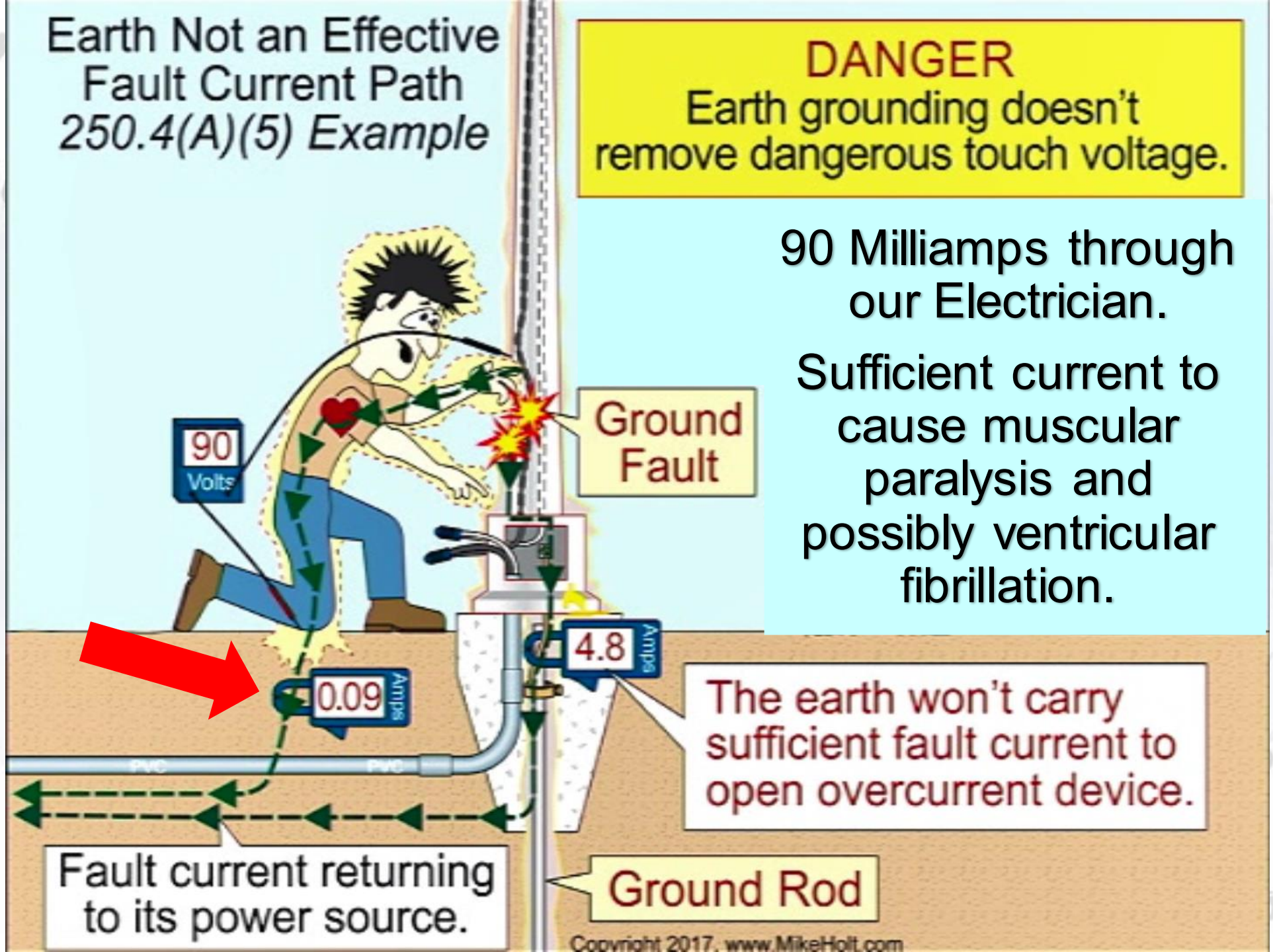
Earth grounding doesn't clear a ground fault.

I = E/R = 120V/25 ohms = 4.80A

Earth Not an Effective Fault Current Path

250.4(A)(5) Example

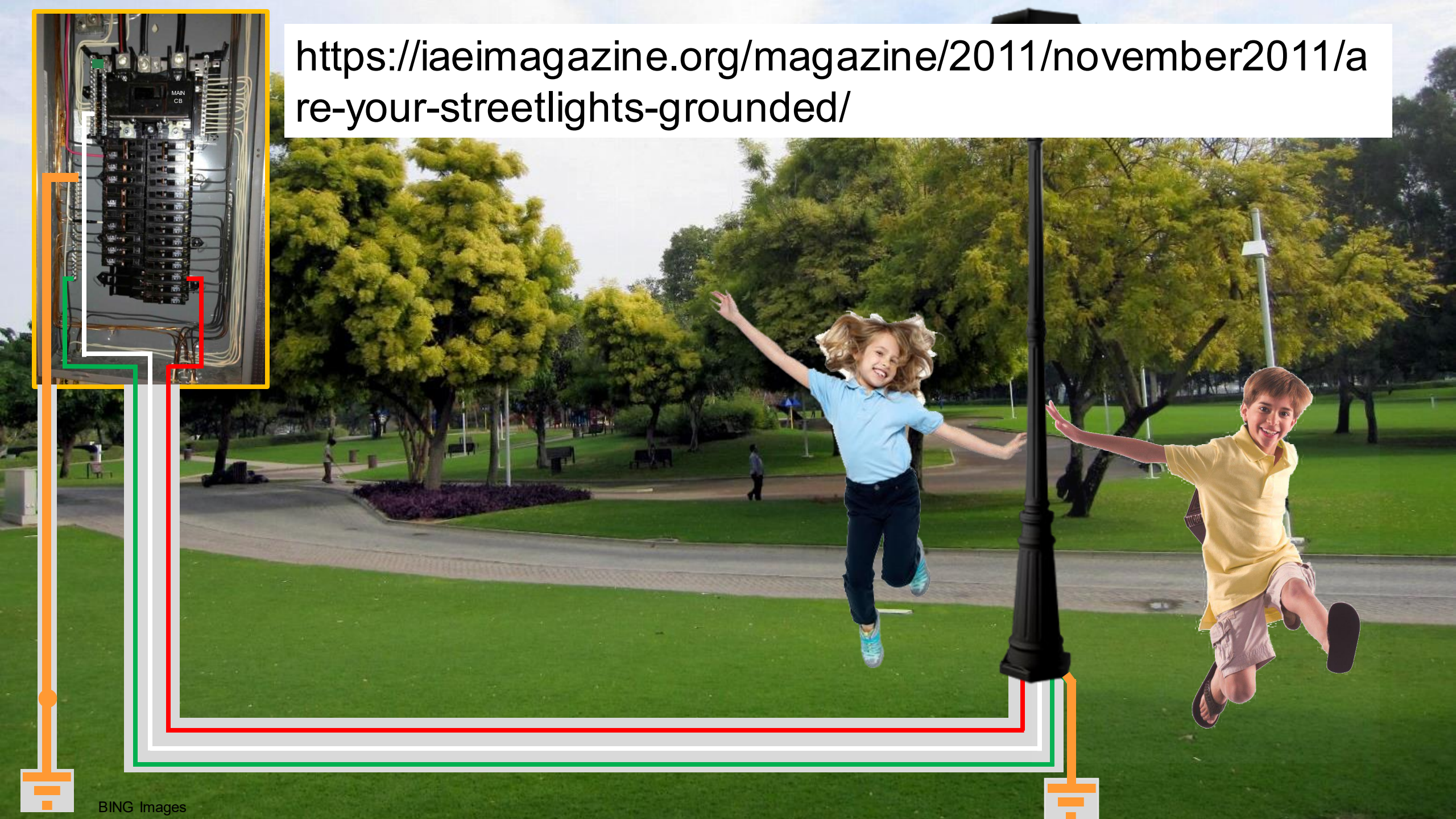
DANGER
Earth grounding doesn't remove dangerous touch voltage.



90 Milliamps through our Electrician.

Sufficient current to cause muscular paralysis and possibly ventricular fibrillation.

The earth won't carry sufficient fault current to open overcurrent device.



https://iaeimagazine.org/magazine/2011/november2011/are-your-streetlights-grounded/

BING Images

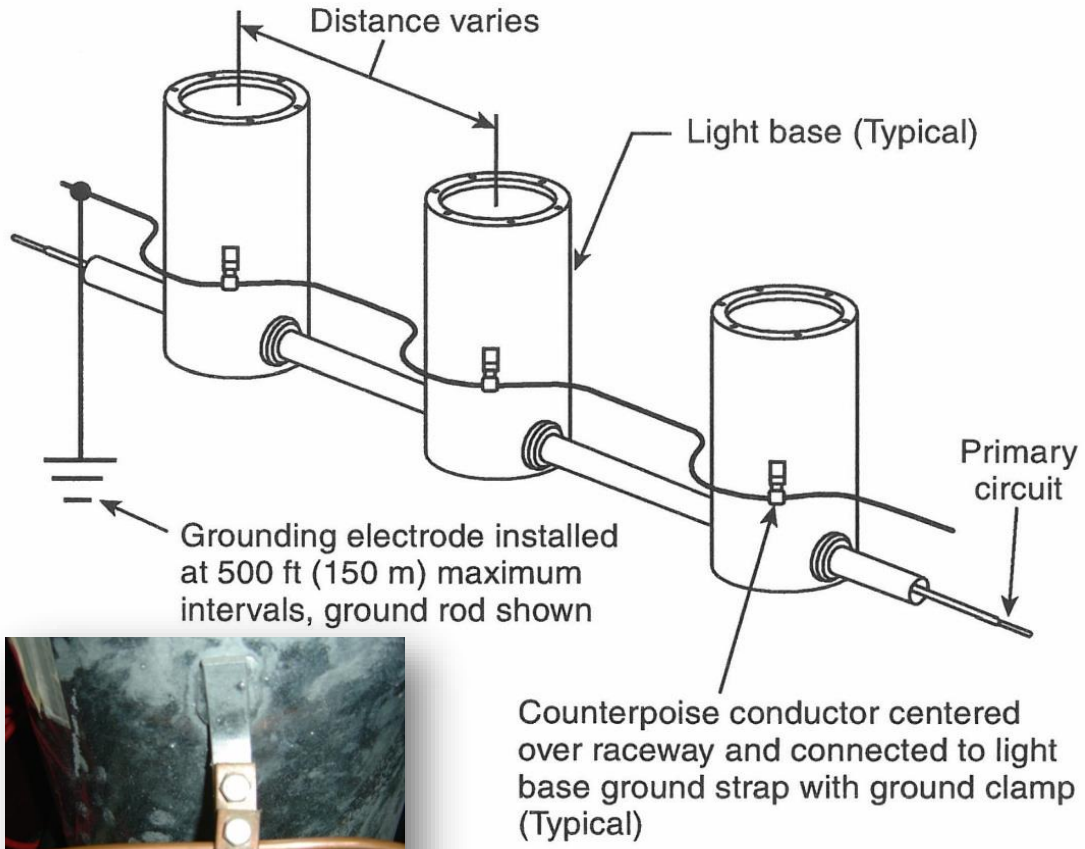
Light Base Earth Resistance

Light Base Installed in Earth Backfill 300 Ohm Earth Resistance

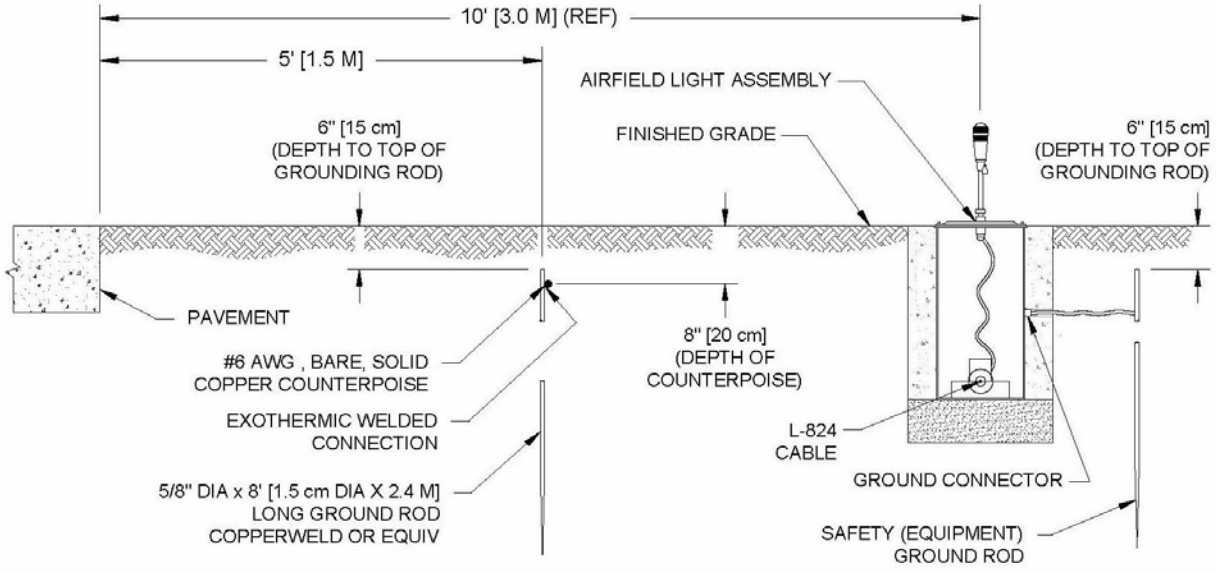
Light Base Installed in 6” Concrete Backfill 40 Ohm Earth Resistance

Two Methods of Lightning Protection for Airfield Lighting Systems

EQUIPOTENTIAL



ISOLATION



NOTES

1. TYPE AND MINIMUM NUMBER OF GROUND RODS ARE AS SPECIFIED ON THE PLAN.
2. INSTALL GROUND ROD AT MAXIMUM 500' [152 .4 M] SPACING. USE GROUND ROD TO TERMINATE THE COUNTERPOISE AT BOTH ENDS OF DUCT.
3. COST OF GROUND RODS IS INCIDENTAL TO THE ASSOCIATED ITEMS REQUIRING GROUNDING UNLESS OTHERWISE SPECIFIED.
4. THE NUMBER OF GROUND RODS IS SITE SPECIFIC AND MAY DEPEND ON SOIL RESISTIVITY.

Two Methods of Lightning Protection for Airfield Lighting Systems

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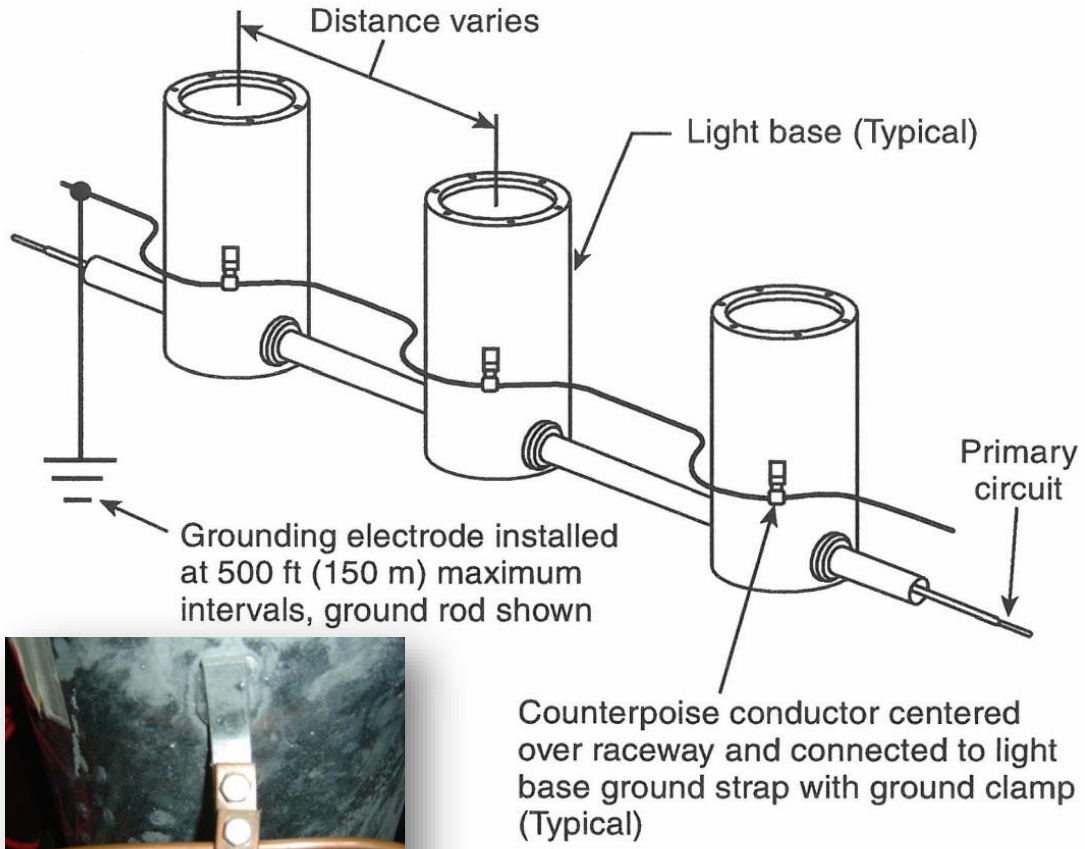

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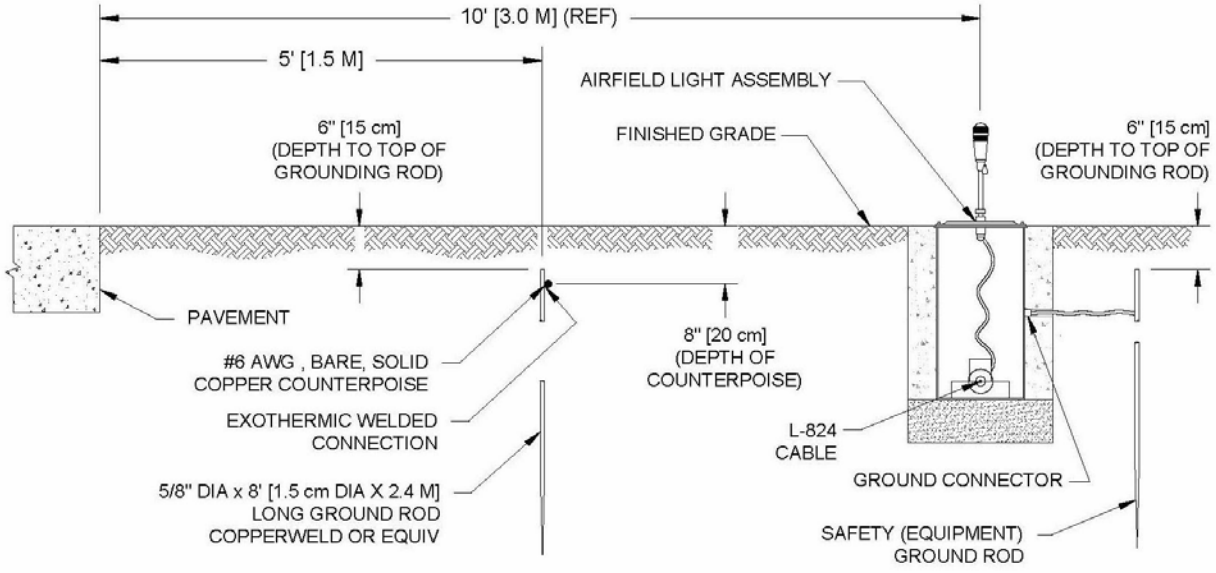

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Two Methods of Lightning Protection Systems for Airfield Lighting

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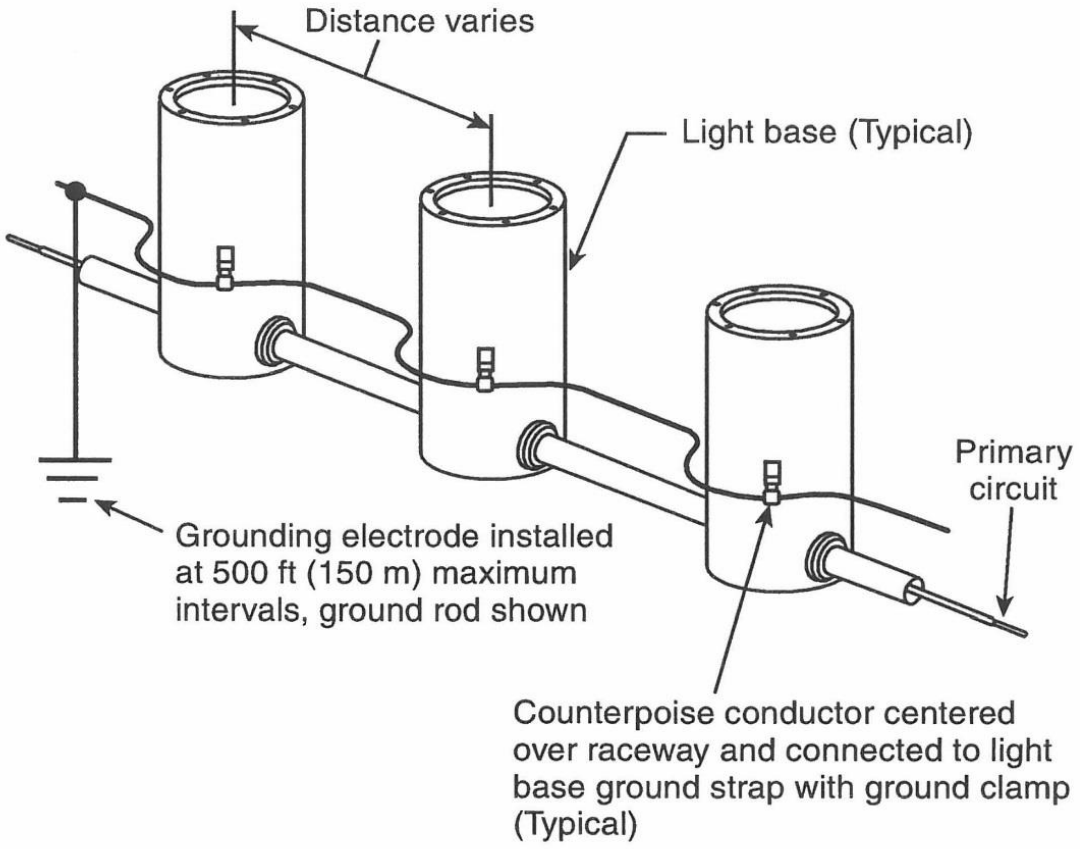

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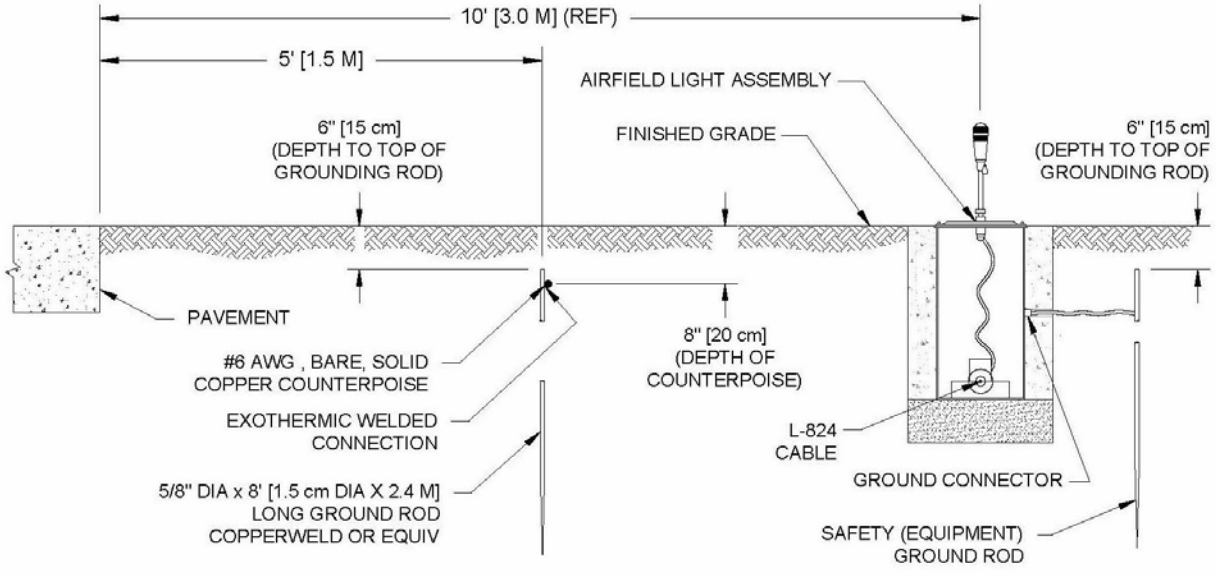

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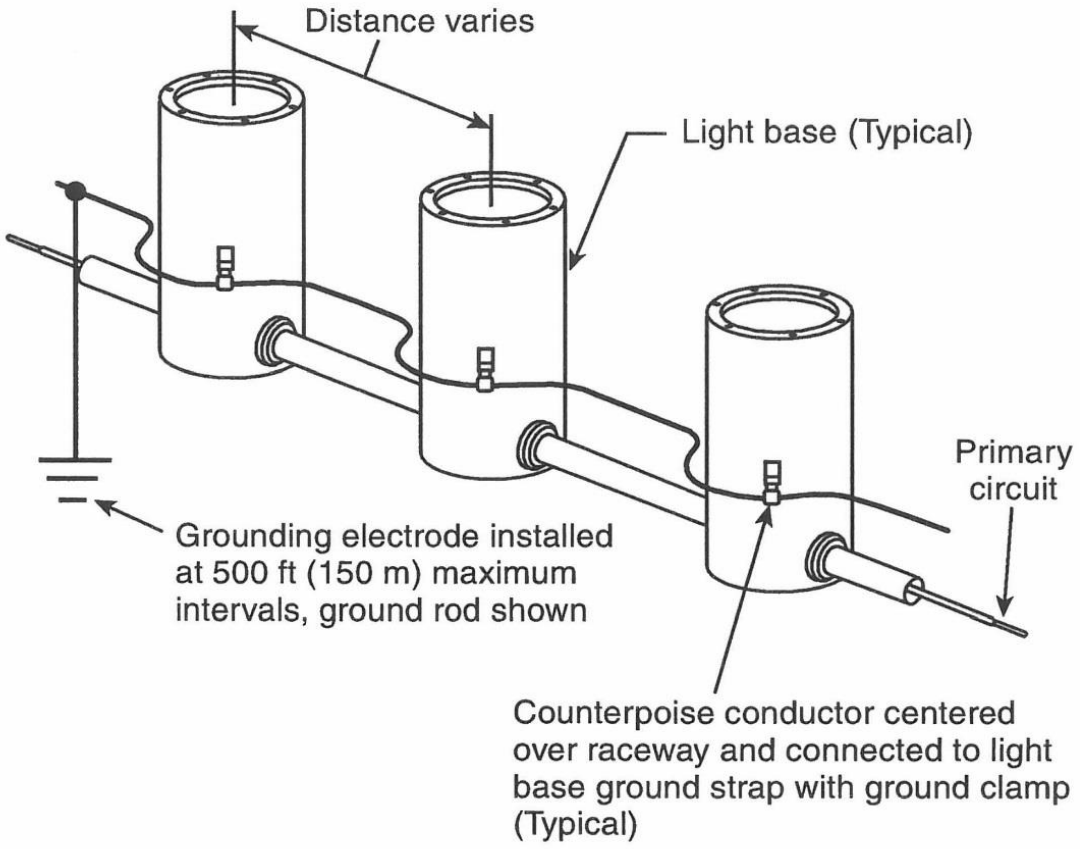

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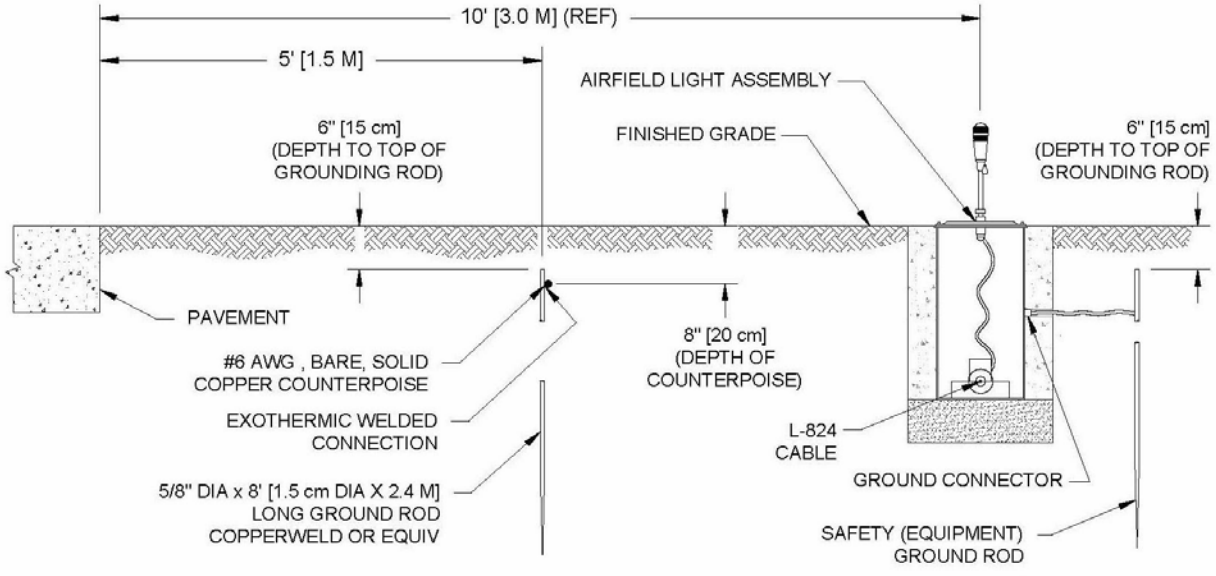

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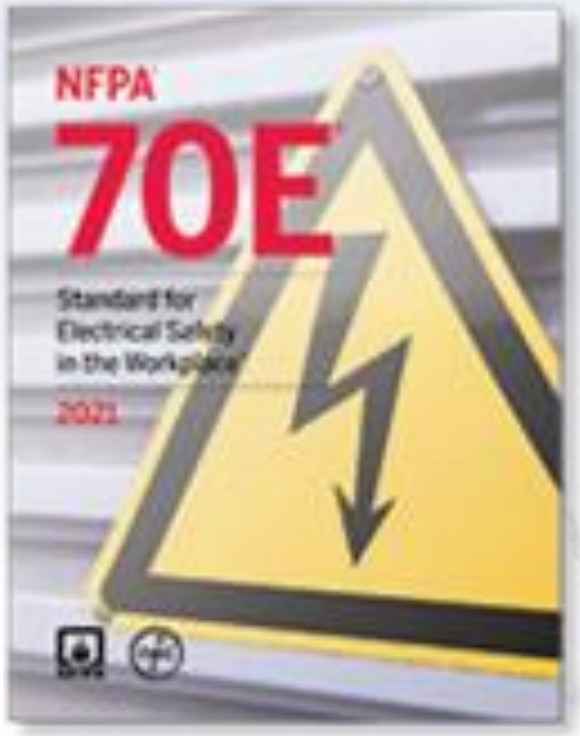
100% PROTECTION

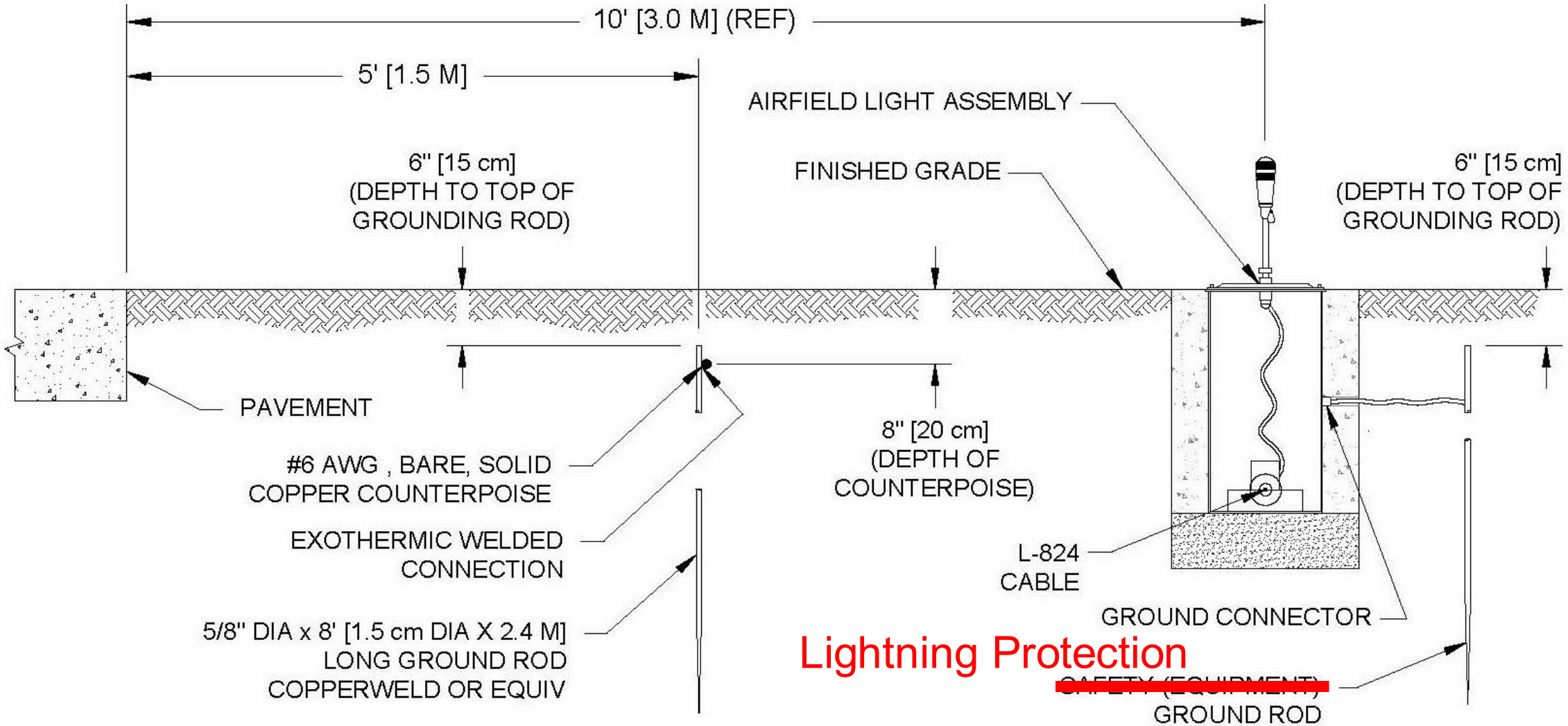
TURN IT OFF



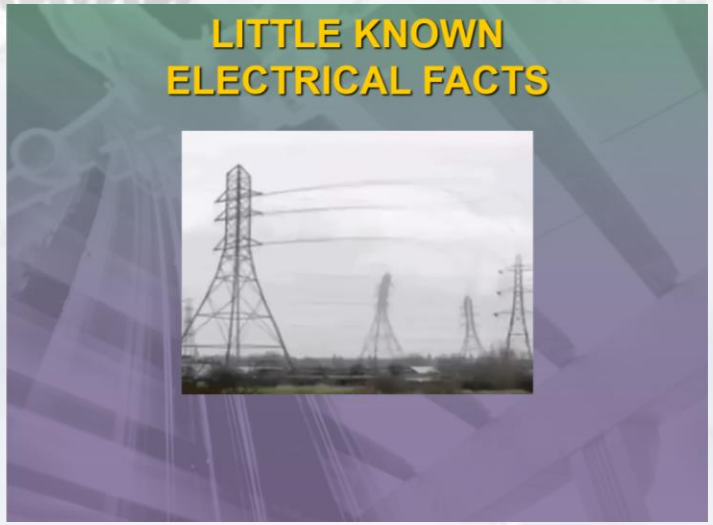
CREATE AN ELECTRICALLY SAFE WORK CONDITION

NFPA

A Safety Ground is a Big Green Myth

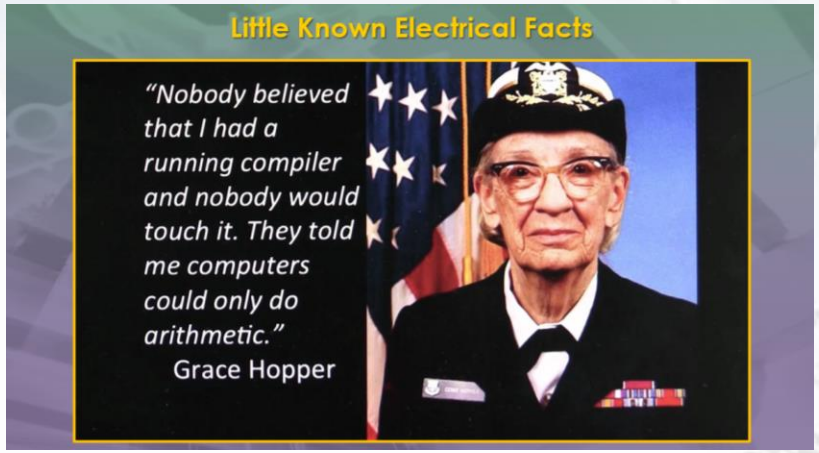


LITTLE KNOWN ELECTRICAL FACTS



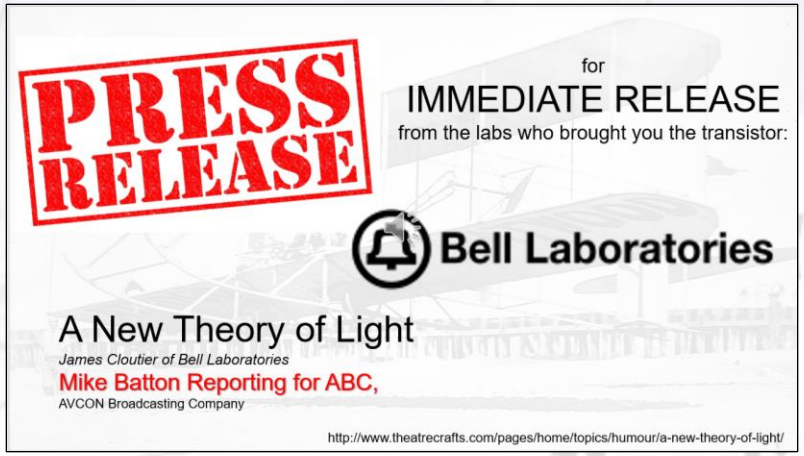
2016

2017



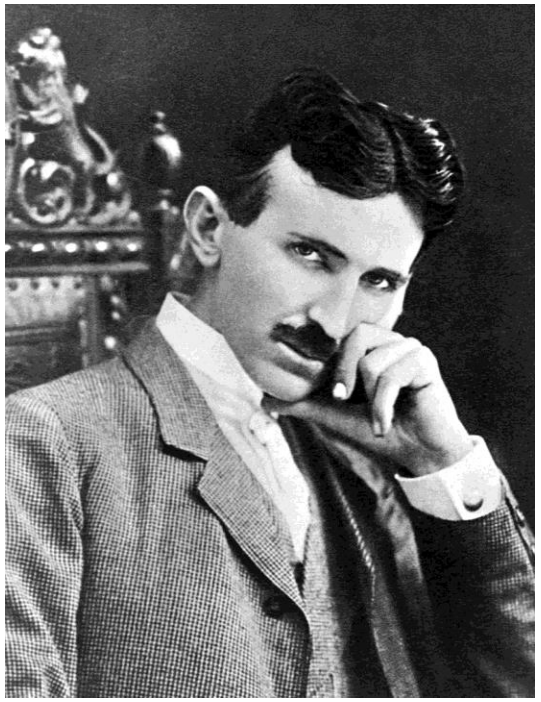
2018

2019



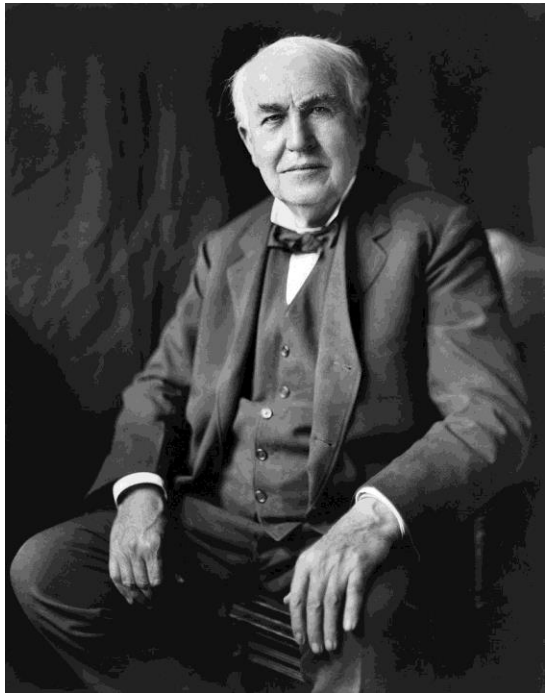

POWER CHANGES EVERYTHING
"TRULY GRIPPING... A VISUAL STUNNER"
"SUPERB PERFORMANCES"
"TERRIFIC PERFORMANCES THROUGHOUT.
NICHOLAS HOULT IS A BRILLIANT NIKOLA TESLA"
BENEDICT CUMBERBATCH MICHAEL SHANNON NICHOLAS HOULT AND TOM HOLLAND
THE CURRENT WAR

George Westinghouse Jr.
October 6, 1846 – March 12, 1914



Nikola Tesla
10 July 1856 – 7 January 1943

AC vs. DC

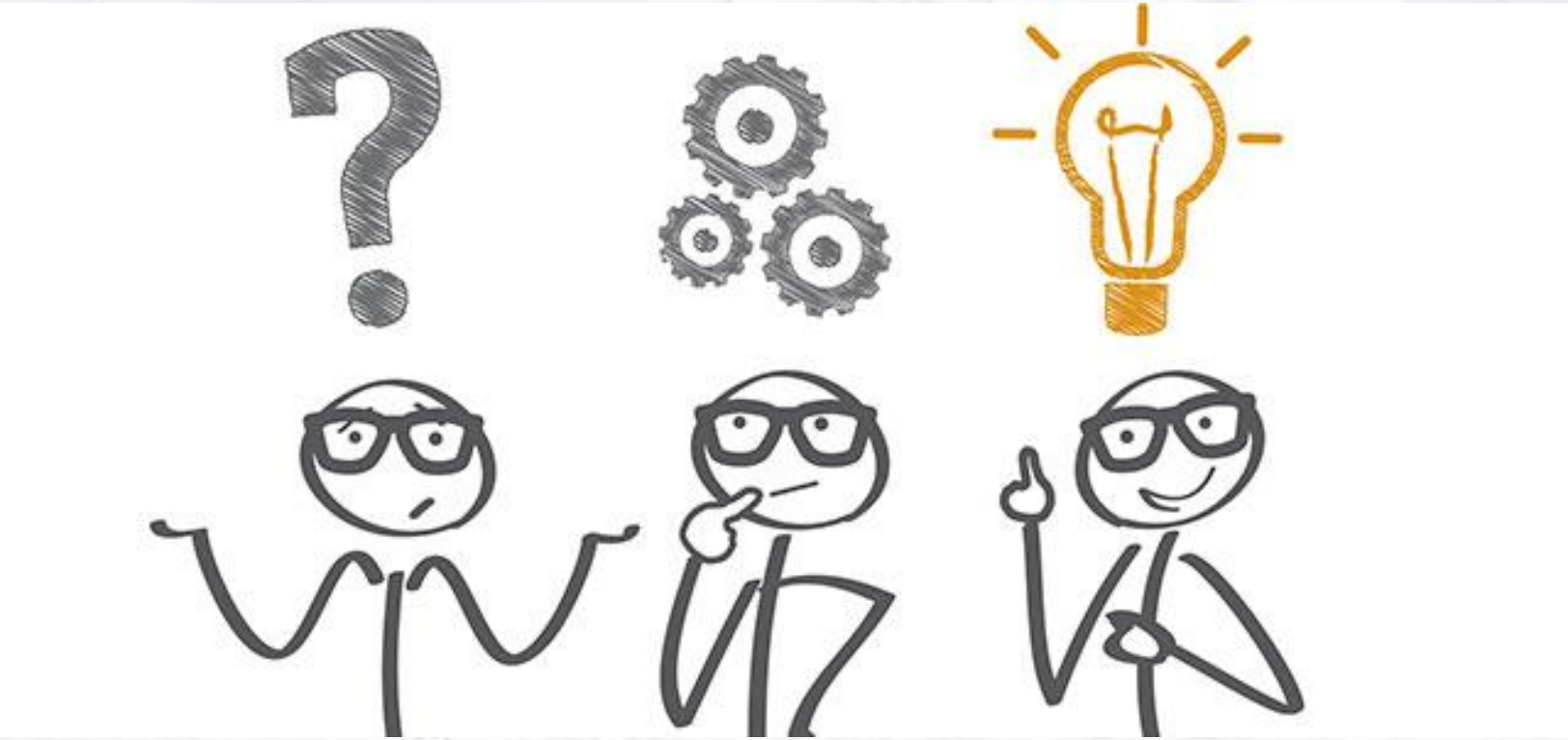


Thomas Alva Edison
February 11, 1847 – October 18, 1931

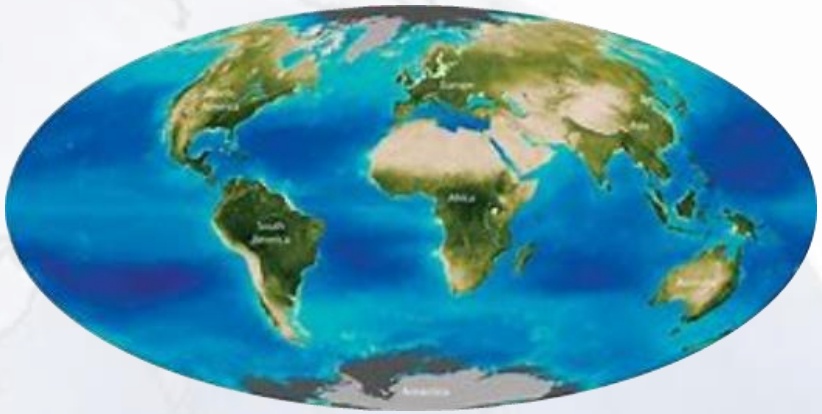
From Wikipedia, the free encyclopedia

www.energycentral.com
Bing Images

In Summary



Why do we GROUND?



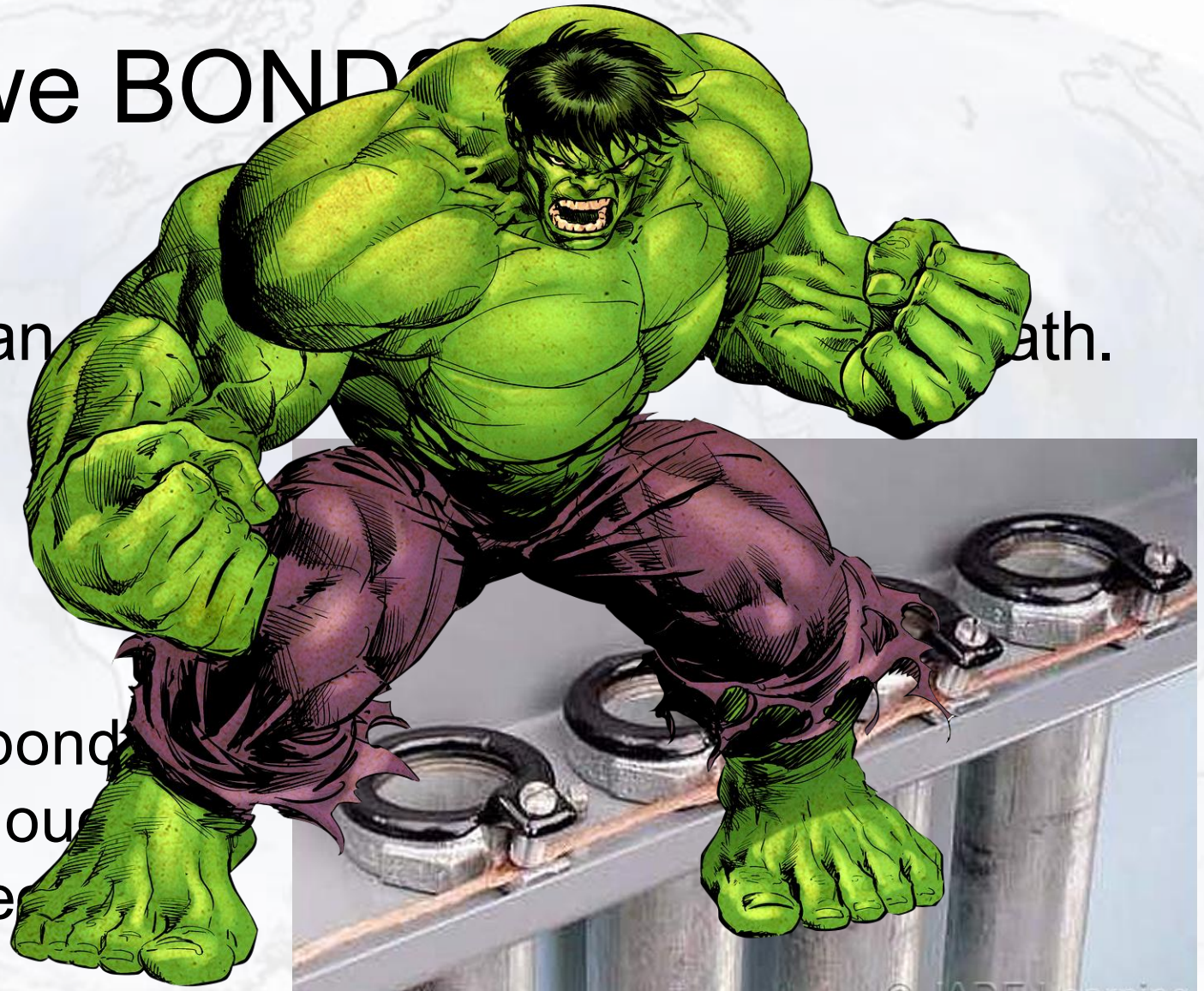
to limit the voltage imposed

- Lightning,
- Line surges,
- Unintentional contact with higher-voltage lines,
- Stabilize the voltage to earth during normal operation,
- Non–current-carrying conductive materials are connected to earth to limit the voltage to ground on these materials.

BING Images

Why do we BOND

- To establish an ath.



Reminder:

We also want our bond
to provide a low enou
impedance to prote
personnel.

BING Images

Presented to:

93rd ANNUAL
ILLUMINATING ENGINEERING SOCIETY
AVIATION LIGHTING COMMITTEE
2022 FALL TECHNOLOGY MEETING

AVCON

Thank You

Bonding vs. Grounding

VERSUS

Grounding vs. Bonding

IESALC | ILLUMINATING ENGINEERING SOCIETY of NORTH AMERICA
AVIATION LIGHTING COMMITTEE

Presented by:
Carl Johnson, ACE