Introduction to

ELECTRICALLY- CAUSED FIRE

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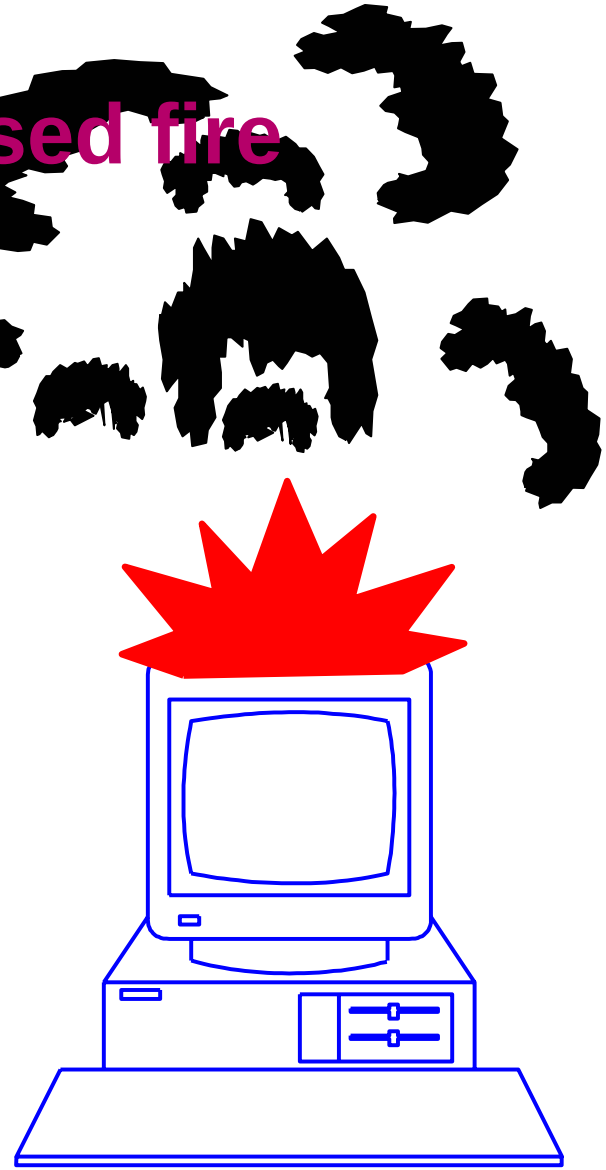
agenda

- **DEFINITION**
  - ELECTRICALLY-CAUSED FIRE
- **VIDEO DEMONSTRATIONS**
  - FIRE SAFETY and TV SETS,
  - FIRE CONCEPTS and BEHAVIOR
  - GE COFFEEMAKER FIRE
- **PYROLYSIS, IGNITION, FLAMING, FIRE, and COMBUSTION**
- **ELECTRICAL ENERGY CONVERSION TO THERMAL ENERGY**

Electrically-caused fire



Electrically-caused fire is

- **electrical heating of a material to ignition temperature**

followed by

- **ignition and**
- **combustion.**

Fire
Video Demonstration

European Flame Retardants Association

“Fire Safety and TV Sets”

17 minutes

Fire
Video Demonstration

NFPA

“Fire Concepts and Behavior”

circa 1970

> Note the physical state of the fuel necessary for flame. <

18 minutes

Fire
Video Demonstration

ABC News

“GE Coffeemaker Fire”

Excerpted from *Prime Time*, October 17,1991

> Note the description of the physical state of the flaming fuel. <

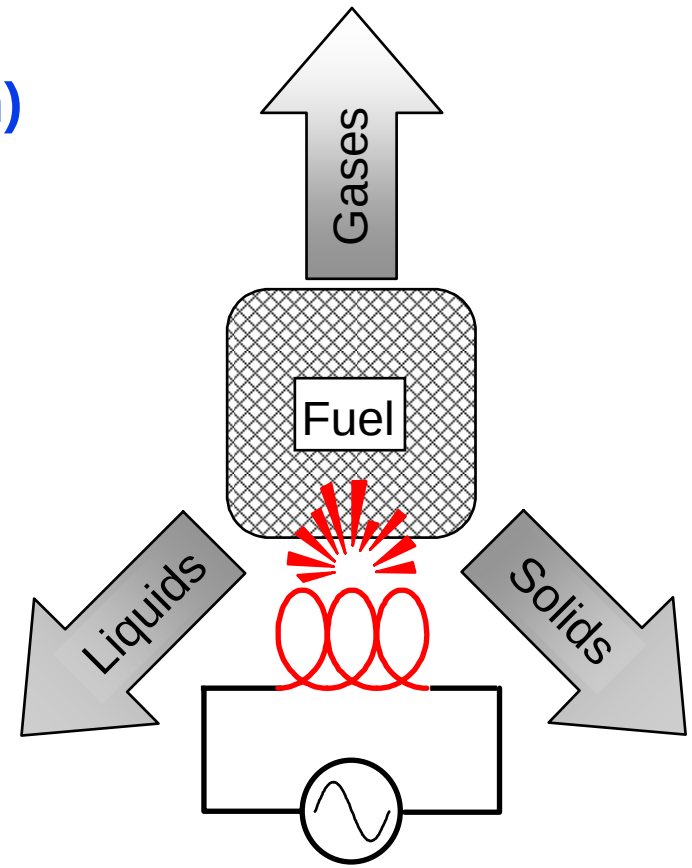
3 minutes

Pyrolysis

Pyrolysis is the transformation (usually chemical decomposition) of a compound into one or more other substances by heat alone.

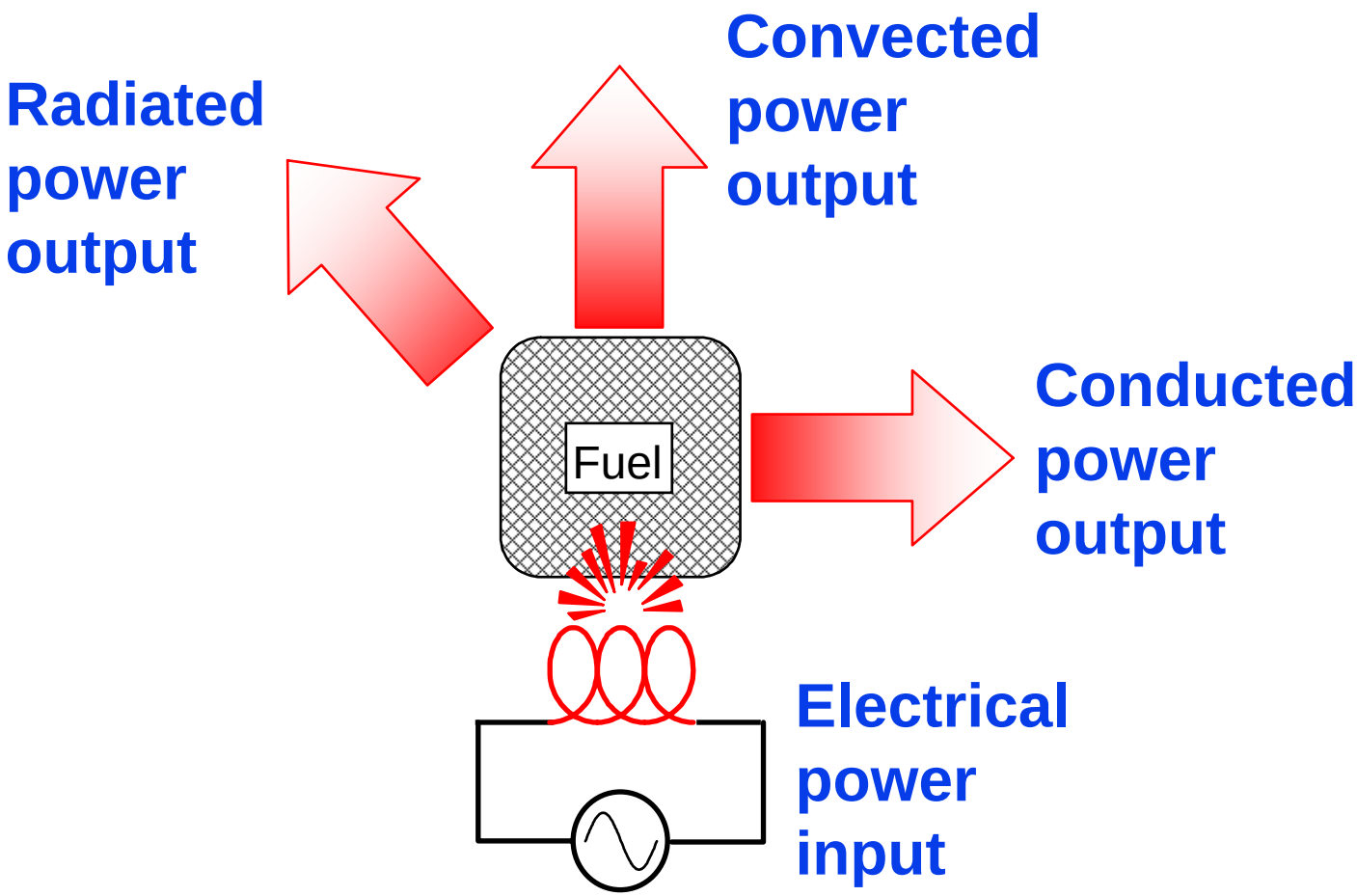
Pyrolysis products include

- non-combustible gases
- combustible gases
- liquids
- solids, including soot

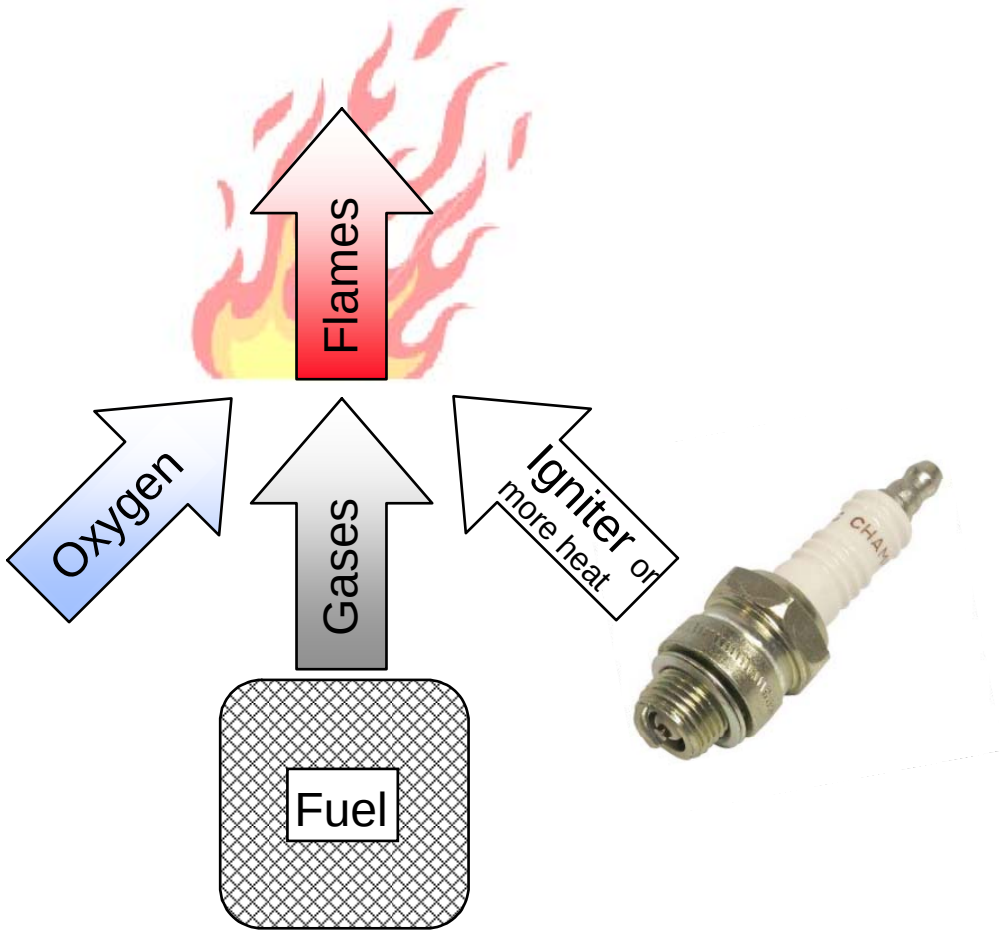


Jurgen Troitzsch, International Plastics Flammability Handbook, Hanser Publishers, 1990.

Conservation of energy

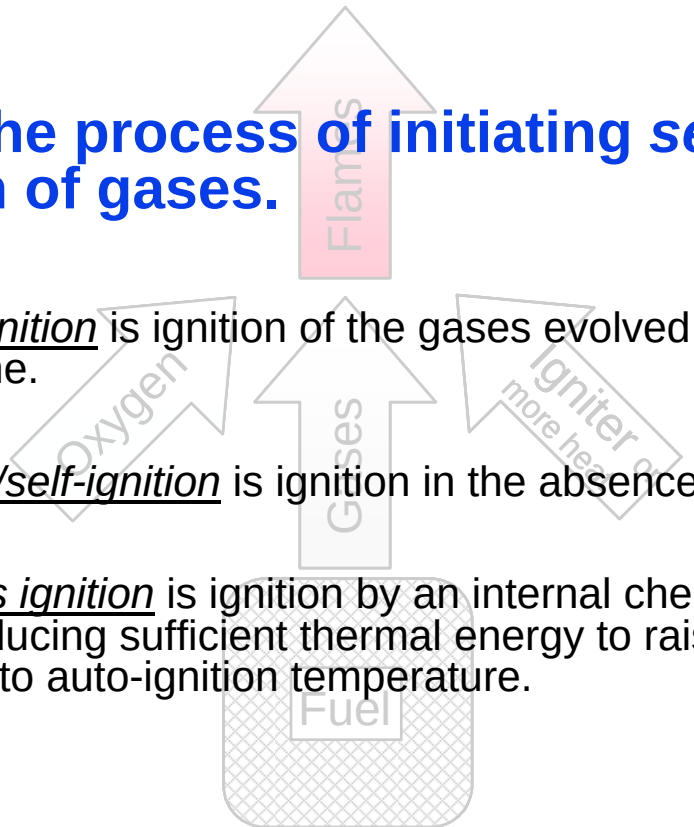


Ignition process



Ignition and ignition types

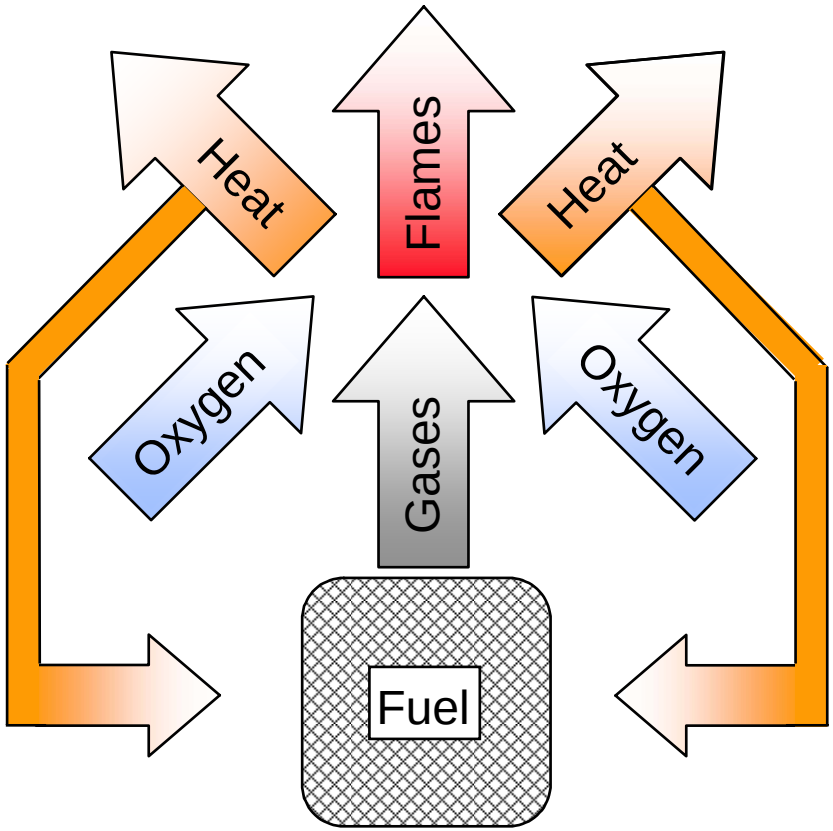
Ignition **is the process of initiating *self-sustained* combustion of gases.**



- *Flash/pilot ignition* is ignition of the gases evolved from the fuel by a spark or flame.
- *Auto-ignition/self-ignition* is ignition in the absence of a spark or flame.
- *Spontaneous ignition* is ignition by an internal chemical or biological reaction producing sufficient thermal energy to raise the material temperature to auto-ignition temperature.

Fire and explosion investigations, NFPA 921, National Fire Protection Association, 1992.

Flaming combustion processes



Flame and flame types

Flame is the luminous portion of burning gases.

– _Pre-mixed flame_ has the oxygen-gas composition fixed prior to combustion, e.g., a Bunsen burner flame, a gas stove.

– _Diffusion flame_ has the oxygen diffused into the gas mixture from the surrounding atmosphere, e.g., a candle flame, a cigarette-lighter.

Jurgen Troitzsch, International Plastics Flammability Handbook, Hanser Publishers, 1990.

Flame behavior

Flames **are burning gases.**

- The path of the burning gas is the same as the path of a hot gas.
- The flame is always vertically-oriented unless deflected by an object or by air currents.
- The volume of the flame is nearly constant.

Fire and fire types

Fire is a rapid oxidation process evolving thermal, chemical, and light energy in the form of flames.

- *Fuel-regulated fire* is a fire where the heat release rate and fire growth rate are controlled by the fuel characteristics. The supply of oxygen is relatively unlimited.

- *Oxygen-regulated fire* is a fire where the heat release rate and fire growth rate are controlled by the supply of oxygen. The supply of fuel is relatively unlimited.

Jurgen Troitzsch, International Plastics Flammability Handbook, Hanser Publishers, 1990.

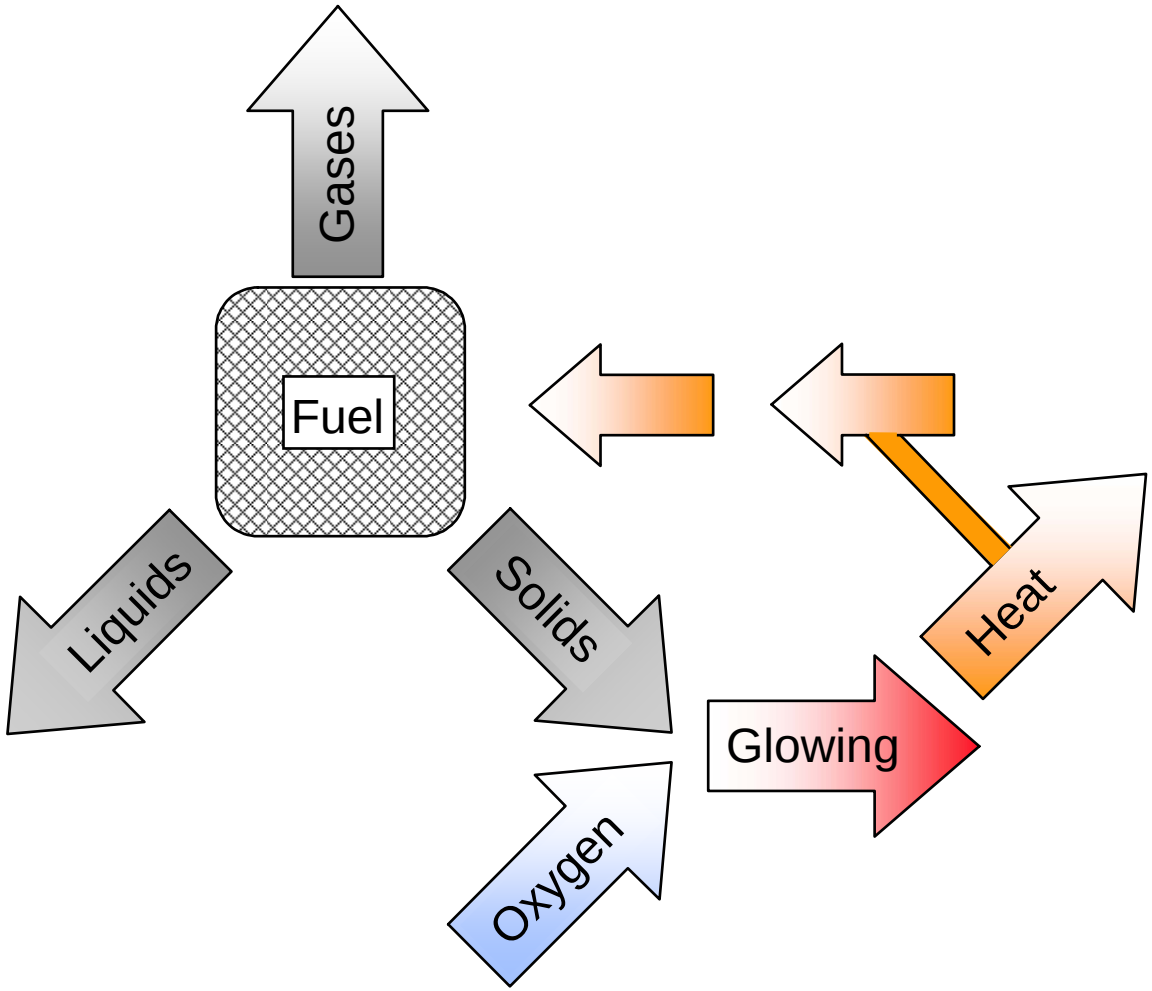
Combustion

Combustion is a self-sustained high-temperature oxidation reaction.

- *Flaming* is a gas-phase combustion process.
- *Glowing* is a solid-phase combustion process.
- *Smoldering* is an oxygen-regulated solid-phase combustion process.

Jurgen Troitzsch, International Plastics Flammability Handbook, Hanser Publishers, 1990.
Vytenis Babrauskas, Ignition Handbook, Fire Science Publishers, 2003.

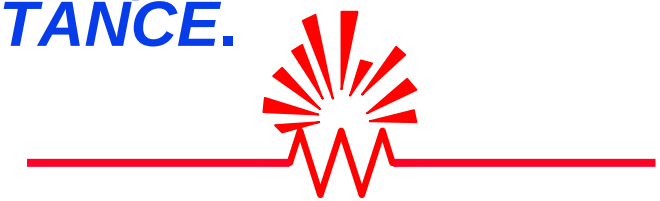
Glowing combustion process



Electrical heating

Electrical heating occurs when *ELECTRICAL ENERGY* is converted to *THERMAL ENERGY*.

Electrical energy is converted to thermal energy in a *RESISTANCE*.



Electrical heating is expressed in *WATTS*.

1 watt = 1 joule/second

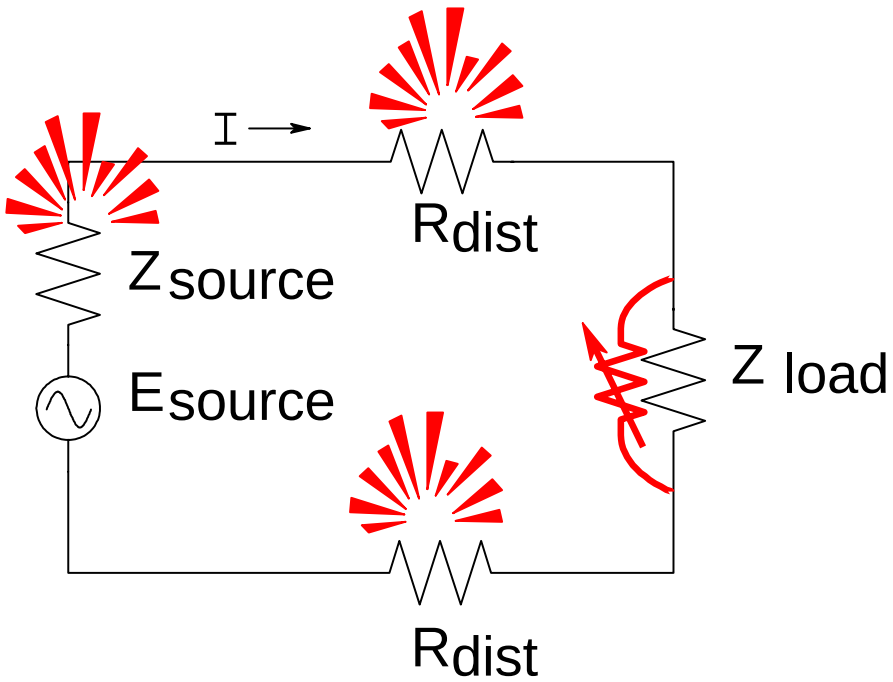
$$P = I^2 * R$$

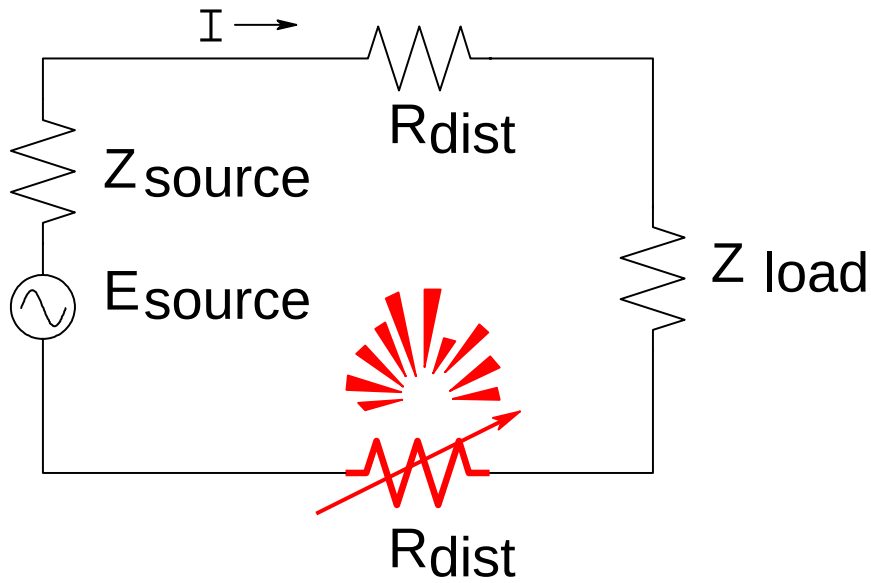
$$P = E^2 / R$$

$$P = E * I$$

Conversion to thermal energy

Power distribution devices





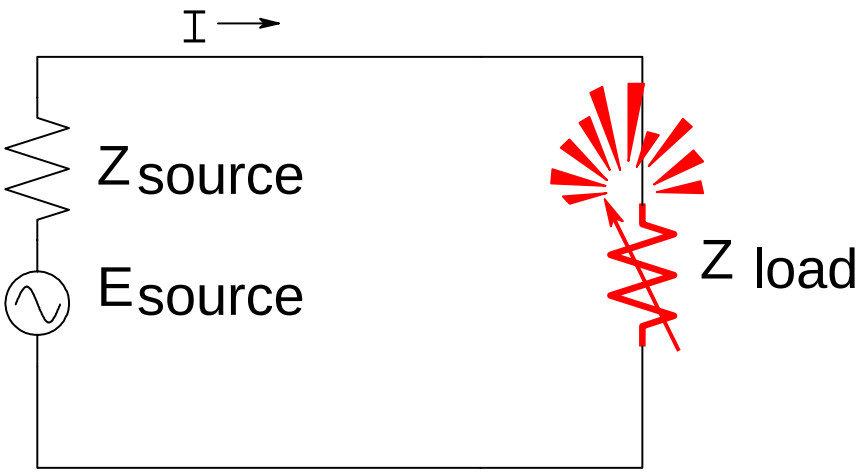
Effects of load faults

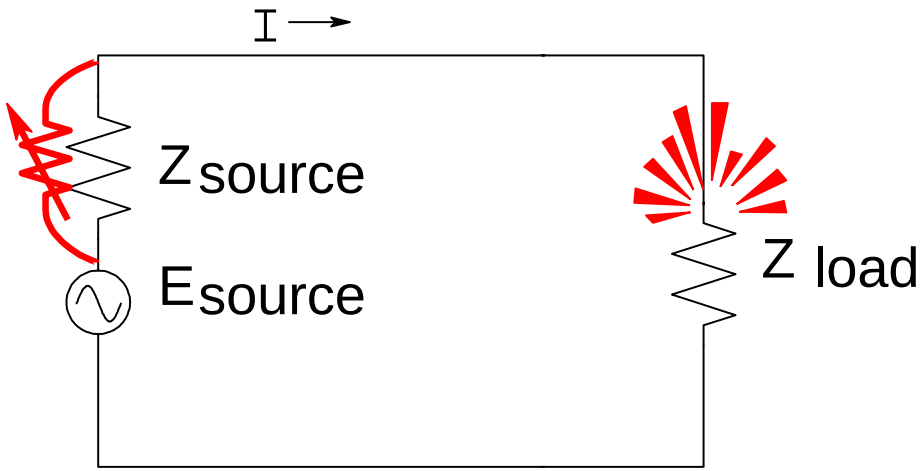
$P = I^2 * R$

Effects of distribution faults

$P = I^2 * R$

Conversion to thermal energy
Power consuming devices





Effect of component faults.

$P = E * I$

Effects of source faults.

$P = E^2 / R$

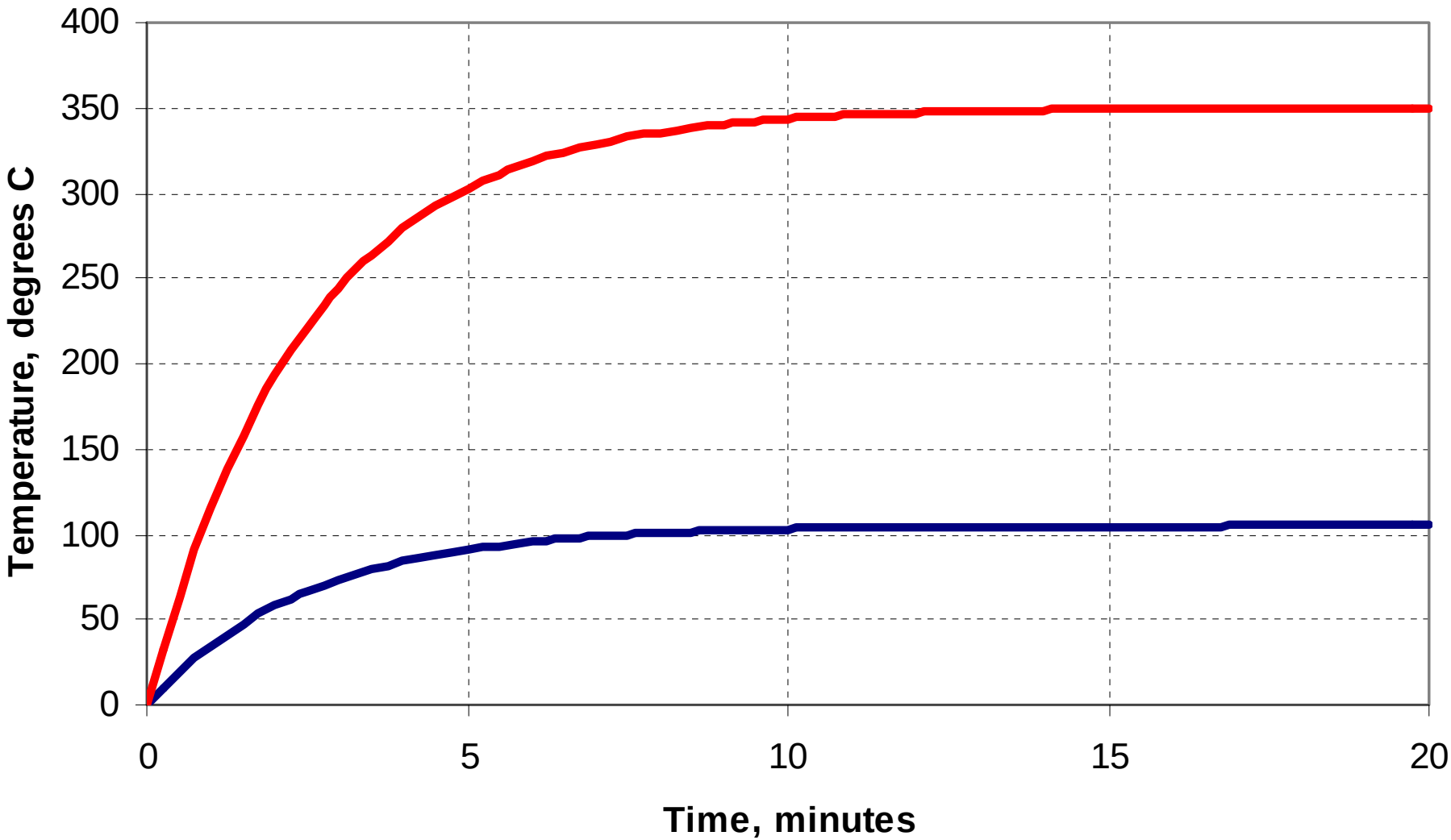
Heating

All heating (temperature rise of an object) is an exponential rise as a function of time.

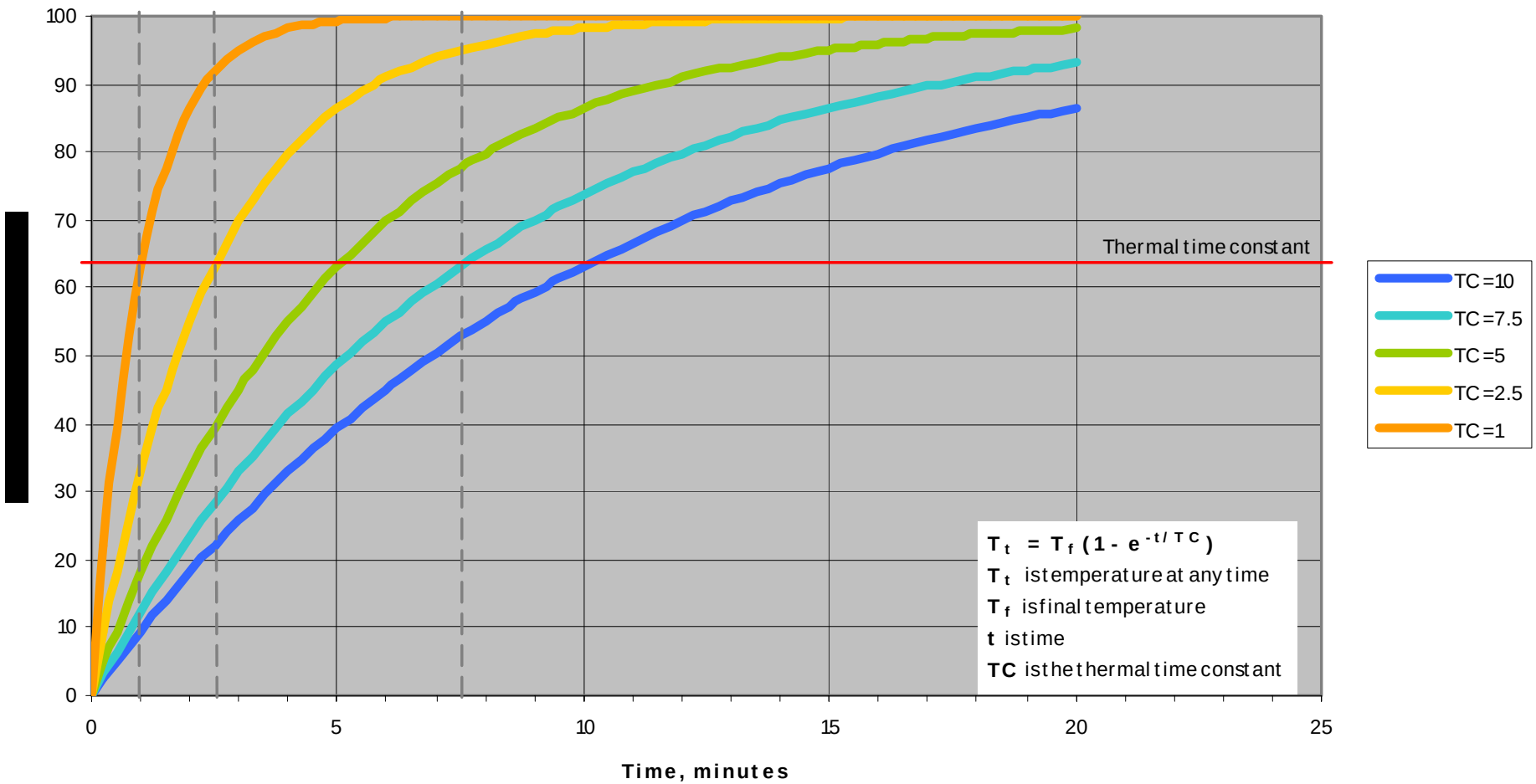
Start temperature is object's initial temperature.

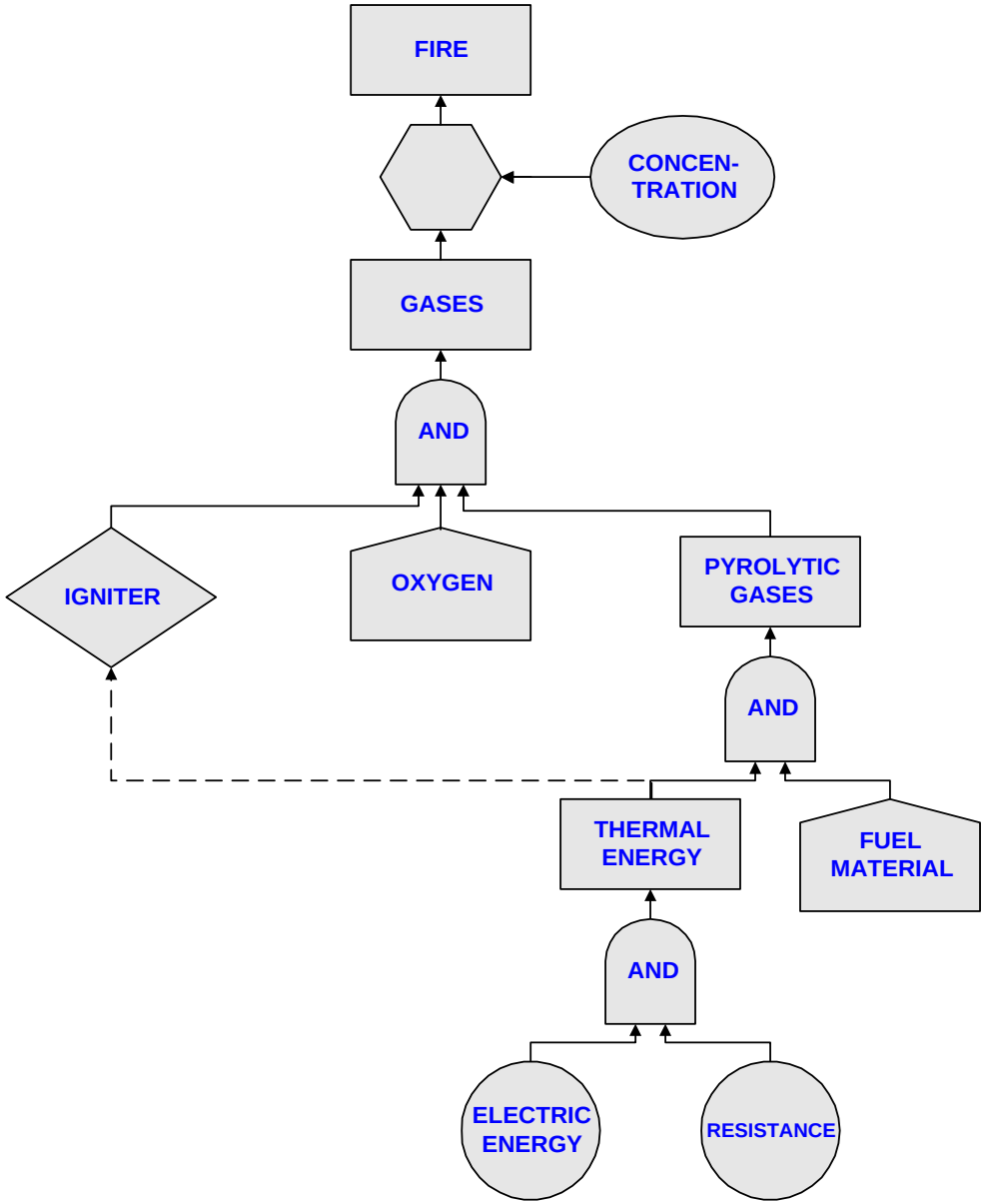
End temperature is heat source's temperature minus coupling and environmental losses.

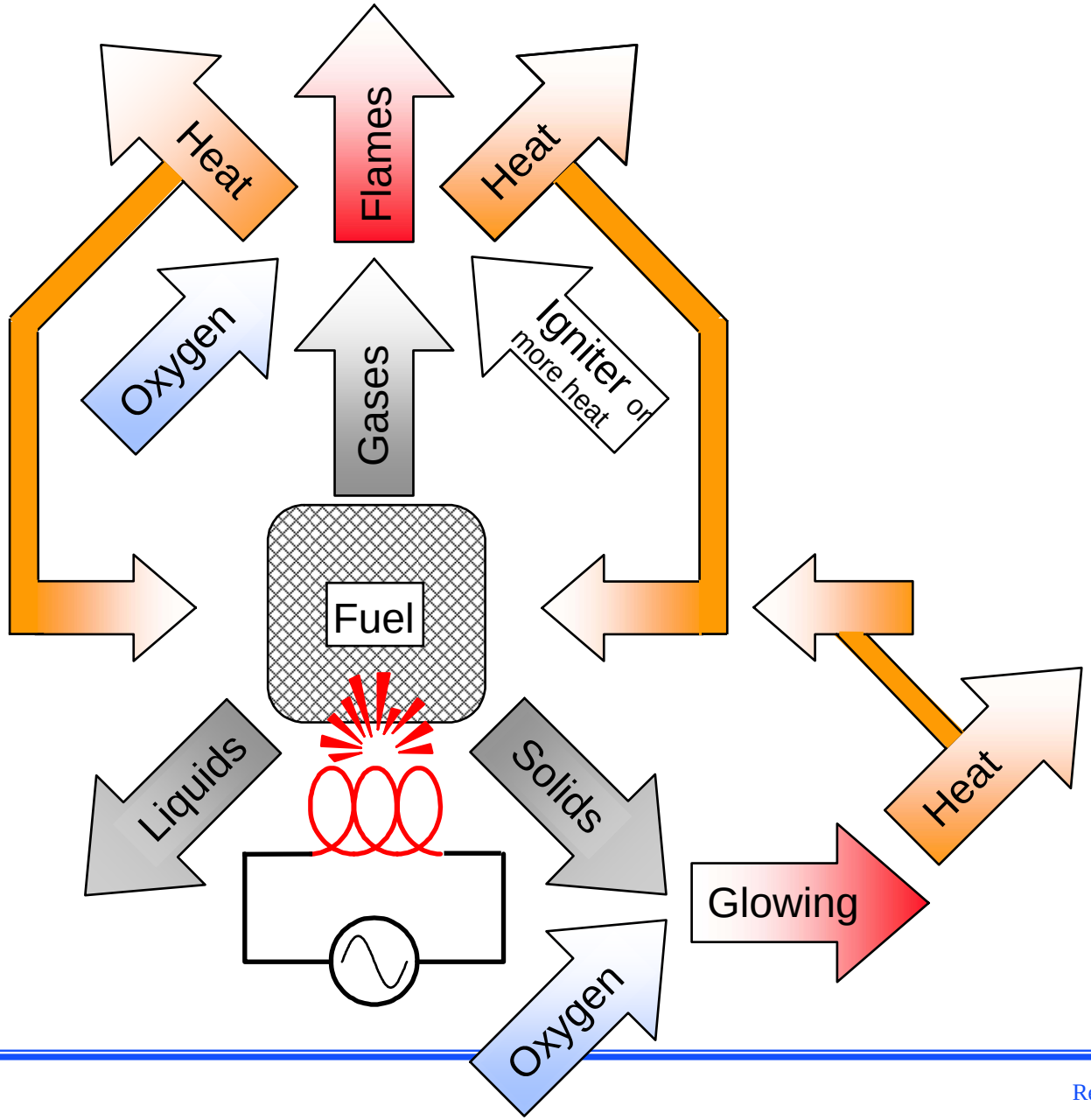
Thermal Time Constant



Thermal Time Constant







Introduction to
ELECTRICALLY- CAUSED FIRE

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