Instrumental Technique

Sparks Discharge: Mechanism and Applications

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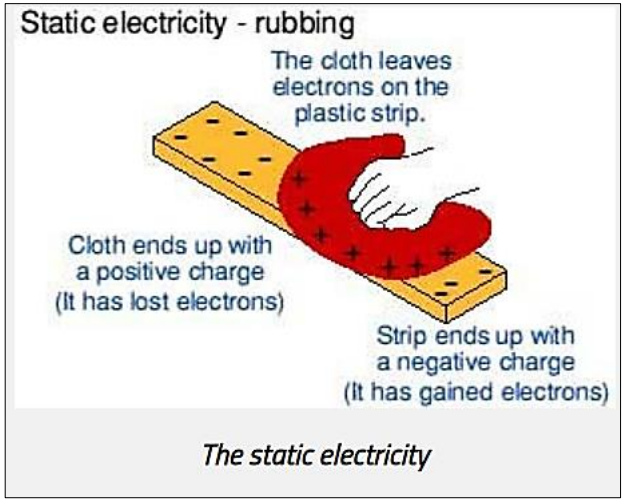
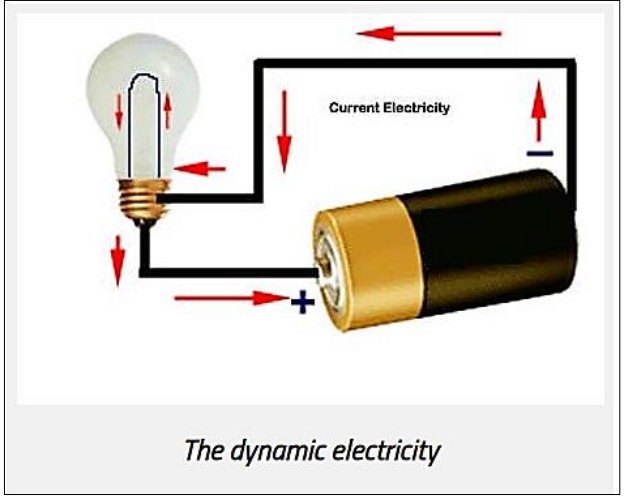
Background

Static electricity	Dynamic electricity
Static electricity is the accumulation of electrical charges on the surface of a material, usually an insulator or non-conductor of electricity. It is called "static" because there is no current flowing, as in case of (AC)/ (DC) electricity.	Dynamic electricity is the flow of electric charges through a conductor; in other words, an electric current.



The static electricity



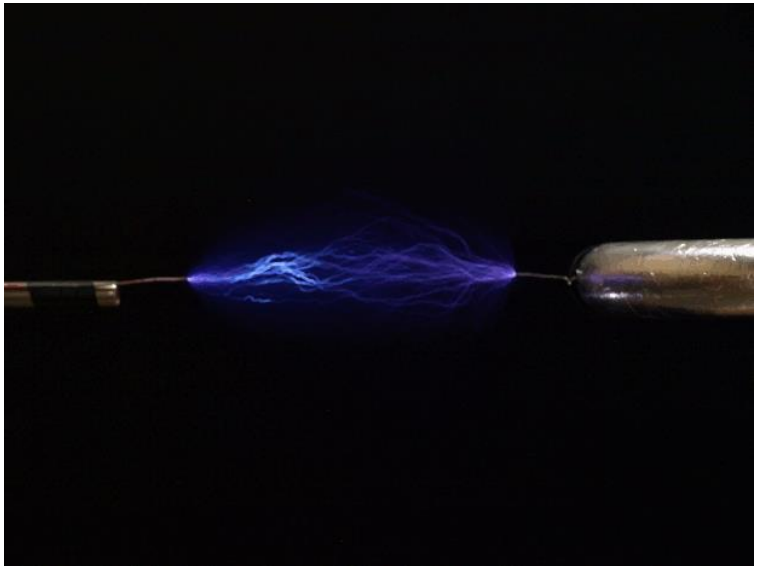
The dynamic electricity

Static Electricity Sparks

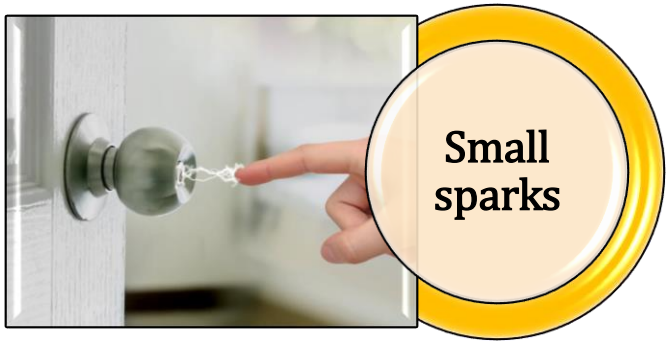
- A **static electricity spark** is an electrostatic discharge or sudden flow of electric current across an air gap, heating the air to high enough temperatures to cause it to glow.

- The size of the spark depends on the separation of the sources of electrical charges and their potential difference in voltage.

- A spark may be only a few millimeters, several meters or even kilometers in length. The amount of heat and noise created depend on the size of the spark.

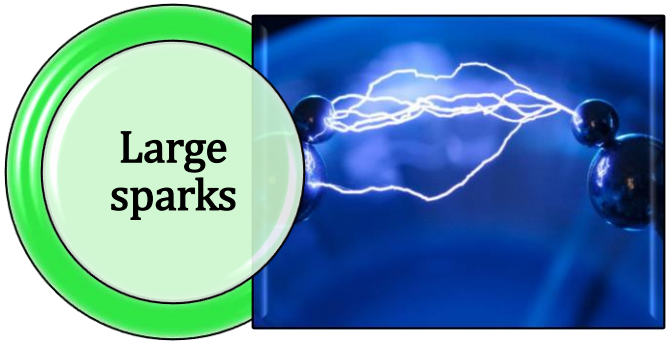


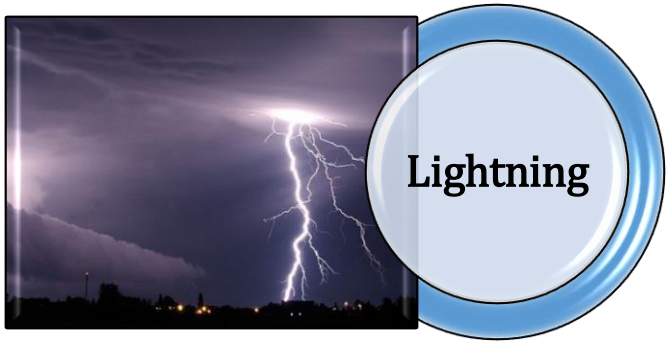
The noise made from such a spark is a snapping sound, cause by the rapid heating of the air.



The amount of voltage required for a 2 millimeter spark from your finger to the doorknob is about 6000 volts. Since the current is very low, there is no real danger from such a high voltage.

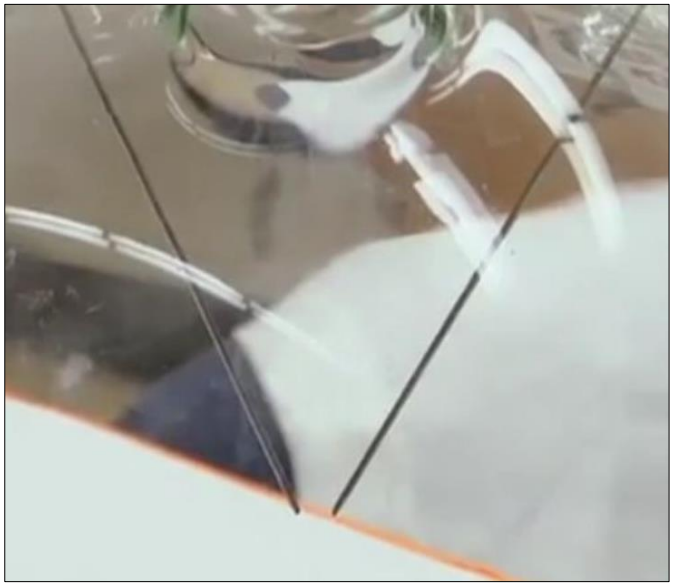
A Van de Graaf static electric generator can produce over 400,000 volts of potential energy. This is sufficient to send a spark from the generator globe to another metal sphere over 50 cm or 20 inches away.

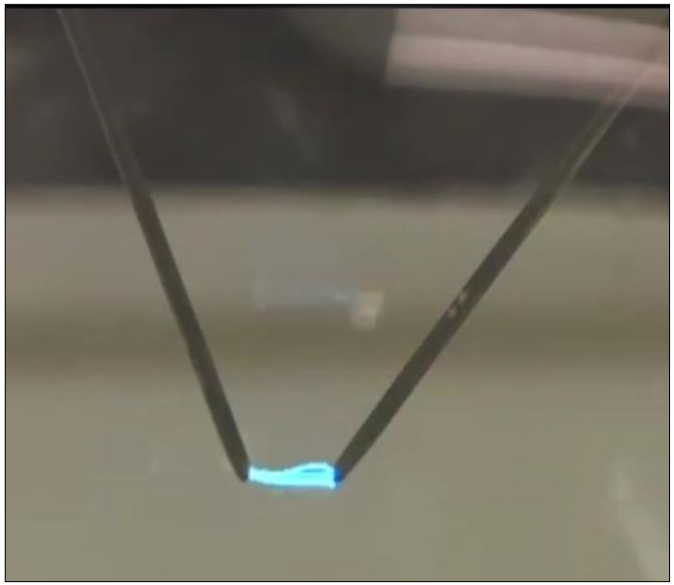




The largest sparks are seen with lighting bolts. lightning bolt can be over 1.5 km or about 1 mile in length. The amount of voltage released in a lightning bolt is typically about 100,000,000 volts.

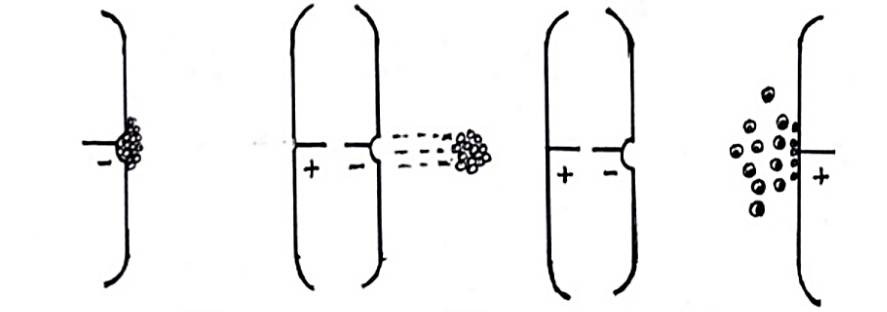
Mechanism



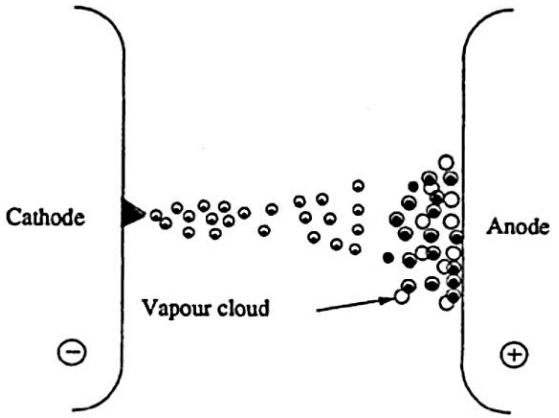


The rapid transition from a non-conducting to a conductive state produces a brief emission of light and a sharp crack or snapping sound. A spark is created when the applied electric field exceeds the dielectric breakdown strength of the intervening medium. For air, the breakdown strength is about 30 kV/cm at sea level

Mechanism



BREAKDOWN DUE TO CLUMP MECHANISM

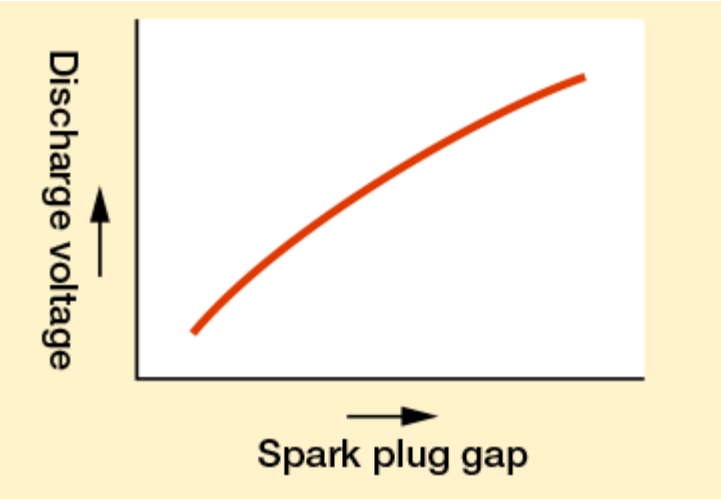


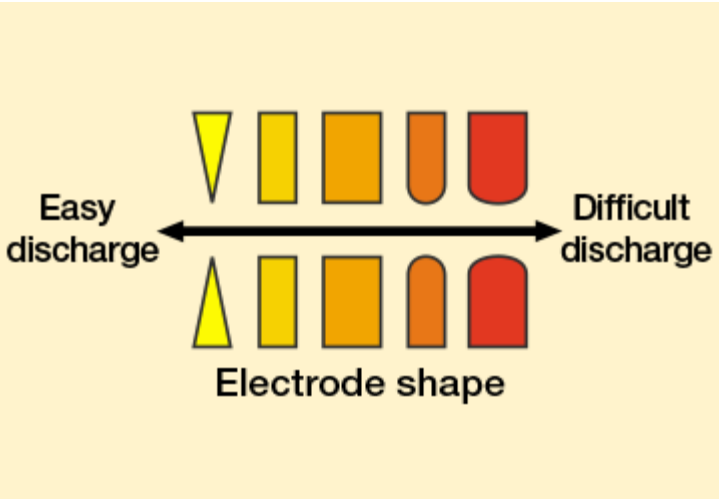
ANODE HEATING MECHANISM OF VACUUM BREAKDOWN

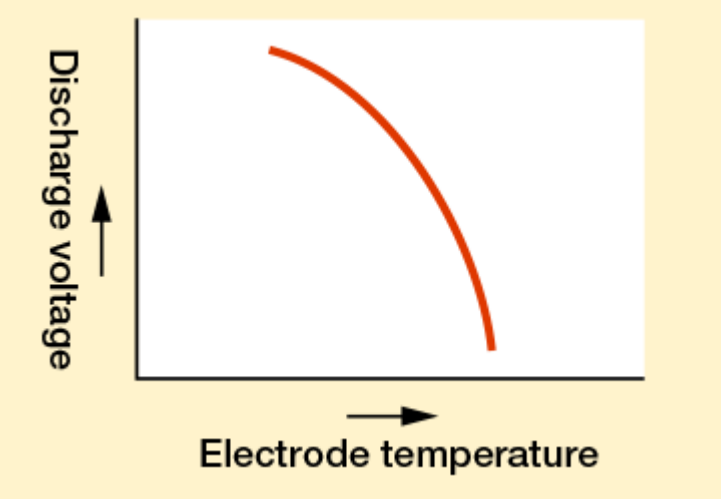
A loosely bound particle known as 'clump' exists on one of the electrode surfaces. When a high voltage is applied between the two electrodes, this clump gets charged and gets detached from the mother electrode and is attracted by other electrode

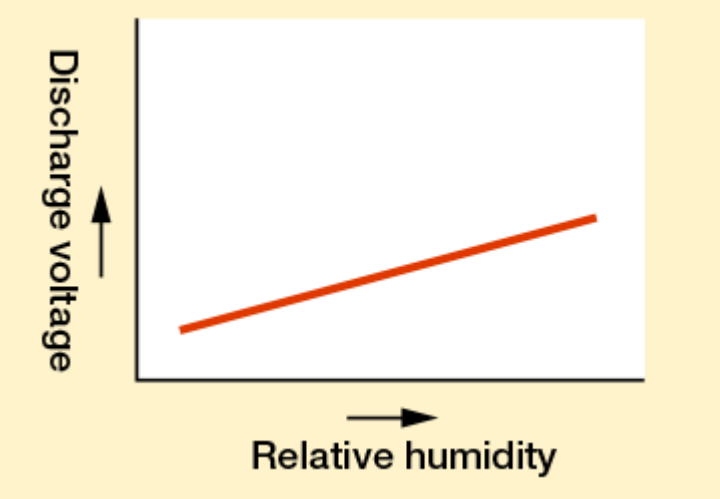
Electrons produced at small micro projections due to field emission bombard the anode causing a the local rise in temperature and release gases and vapors into the vacuum. These electrons ionize the gas and produce positive ions. These positive ions produce secondary electrons and also bombard the cathode surface producing more electrons causing breakdown.

Conditions that affect the discharge voltage









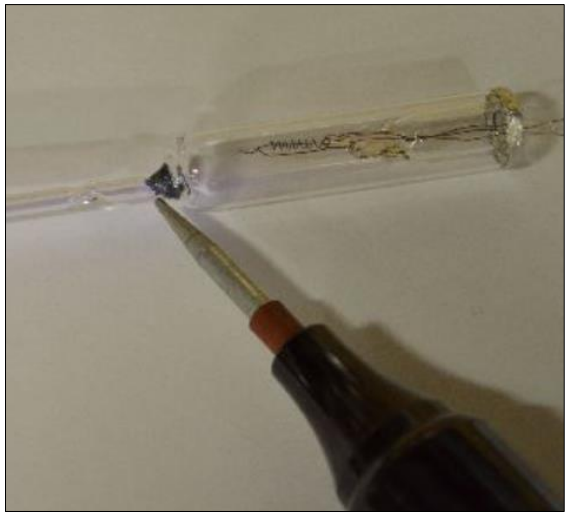
Applications

1. Vacuum Leak Detectors

Point of leakage is indicated by a bright spot where discharge enters evacuated glass assembly

Tesla coil leak detector

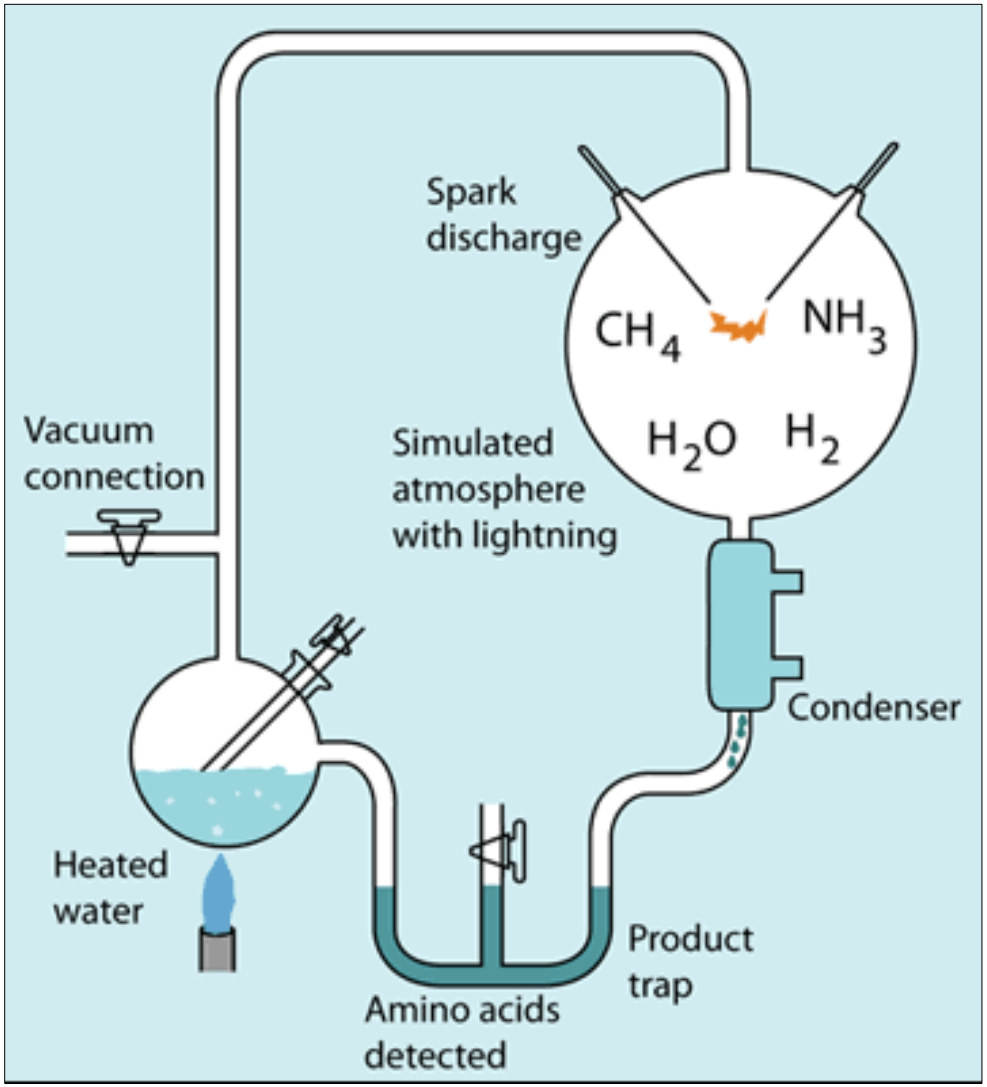
Glass Apparatus



Leak Checking

2. Conducting Miller-Urey Experiments

In 1953, Stanley Miller reported the production of biomolecules from simple gaseous starting materials, using apparatus constructed to simulate the primordial Earth's atmosphere-ocean system.



Other applications

Ignition sources	Spark gap radio transmitter
	
Gas stove burner - the electric spark flame igniter is shown at the left	Spark transmitter used for ship to shore communication up to 10 km

Hazards:

1. Sparks can be hazardous to people, animals or even inanimate objects. Electric sparks can ignite flammable materials, liquids, gases and vapors.
2. Sparks also produce ozone which, in high enough concentrations, can cause respiratory discomfort or distress, itching, or tissue damage.

Thank you

*An **electron avalanche** is a process in which a number of free electrons in a transmission medium are subjected to strong acceleration by an electric field and subsequently collide with other atoms of the medium, thereby ionizing them (impact ionization). This releases additional electrons which accelerate and collide with further atoms, releasing more electrons—a chain reaction. In a gas, this causes the affected region to become an electrically conductive plasma.

CLUMP MECHANISM :
A loosely bound particle known as 'clump' exists on one of the electrode surfaces. When a high voltage is applied between the two electrodes, this clump gets charged and gets detached from the mother electrode and is attracted by other electrode.

The breakdown occurs due to a discharge in the vapor or gas released by the impact to the particle at the opposite electrode.

FIELD EMISSION:
This theory assumed that electrons produced at small micro projections on the cathode due to
field emission bombard the anode causing a the local rise in temperature and release gases and vapours into the vacuum. These electrons ionize the gas and produce positive ions. These positive ions produce secondary electrons and also bombard the cathode surface producing more electrons causing a breakdown.

Electron field emission: is emission of electrons induced by an electrostatic field. The most common context is field emission from a solid surface into vacuum. However, field emission can take place from solid or liquid surfaces, into vacuum, air, a fluid, or any non-conducting or weakly conducting dielectric.