The History of Electrical Discovery, Leading to the Formation of Our Industry and the Advent of Metering

Prepared by Rob Reese
Midwest Regional Sales Manager

for MEMS 2019
September 2019

Visionaries, Technical Advancements, and a "War of Ego's"

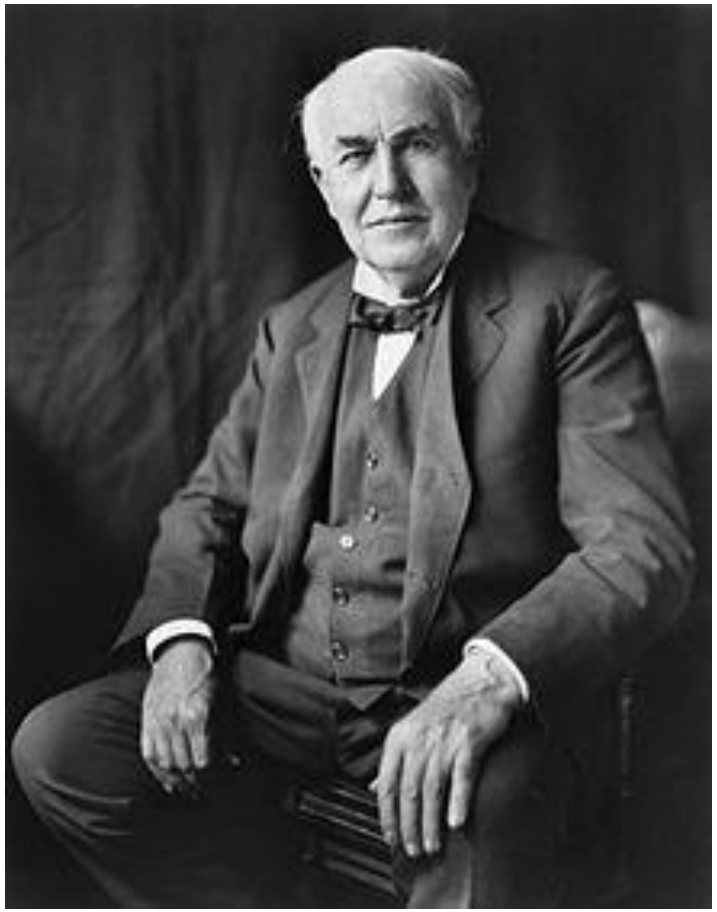
- "Founding Fathers" of our Industry
- Milestone Breakthroughs, Technical Advancements, and Patents
- Chronological Order (somewhat)
- A glimpse into the future…

Food for Thought

"In history, a great volume is unrolled for our instruction, drawing the materials of future wisdom from the past errors and infirmities of mankind."
Edmund Burke – statesman, member of British Parliament 1766 to 1794

Food for Thought

"I have not failed. I have just found 10,000 ways that won't work."
Thomas Edison – American Inventor and Businessman



Food for Thought

Modern Time Example – AMI Systems Adoption and Deployment

Those utilities that are only just now embracing and deploying AMI systems have the opportunity to learn from the experiences from early AMI adopters.

Learn from History!

Harnessing the Power of Electricity

Before we could use electricity, we first had to control it.

Let’s go back in time!

Harnessing the Power of Electricity

First Known Observations and Uses of Electricity

Lightning

Possibly the earliest and nearest approach to the discovery of the identity of lightning, and electricity from any other source, is to be attributed to the Arabs, who before the 15th century had the Arabic word for lightning *ra'ad* (رعد) applied to the electric ray.

Harnessing the Power of Electricity

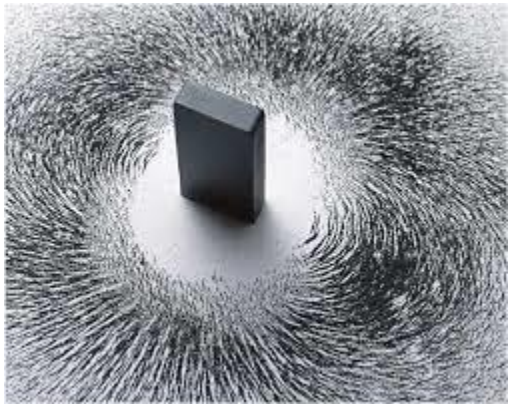
First Known Observations and Uses of Electricity

Electric Fish

Ancient Egyptian texts from 2750 BCE referred to these fish as the "Thunderer of the Nile." They were again reported millennia later by ancient Greek, Roman, and Arabic naturalists and physicians. Ancient writers, such as Pliny and Elder and Scribonius Largus, attested to the numbing effect of electric shocks delivered by the fish, and knew that such shocks could travel along conducting objects. Patients suffering from ailments such as gout or headache were directed to touch electric fish in the hope that the powerful jolt might cure them.

Harnessing the Power of Electricity

First Known Observations and Uses of Electricity

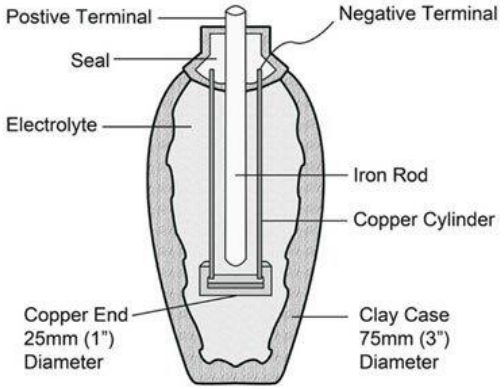


Observations of Magnetism

Ancient cultures around the Mediterranean knew that certain objects, such as rods of amber, could be rubbed with cat's fur to attract light objects like feathers. Thales of Miletus made a series of observations on static electricity around 600 BCE, from which he believed that friction rendered amber magnatic, in contrast to minerals such as magnetite, which needed no rubbing. Thales was incorrect in believing the attraction was due to a magnetic effect, but later science would prove a link between magnetism and electricity.

Harnessing the Power of Electricity

First Known Observations and Uses of Electricity

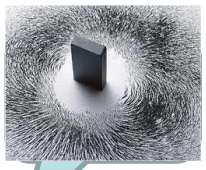


Bagdad “Battery”

According to a controversial theory, the Parthians may have had knowledge of electroplating, based on the 1936 discovery of the Bagdad Battery, which resembles a galvanic cell, though it is uncertain whether the artifact, dated to 250 BCE to 250 CE, was electrical in nature.

Harnessing the Power of Electricity

A Large Time Lapse in Development



1600

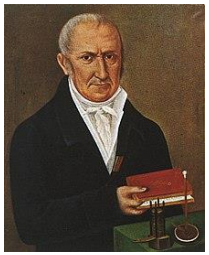
Mankind knew something was there, but they couldn't explain it…

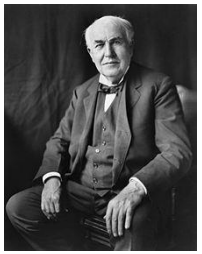
…fast forward to 1600.

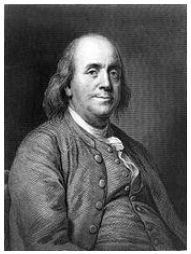
Harnessing the Power of Electricity

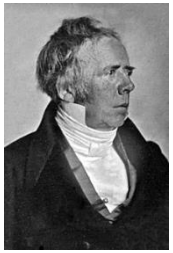
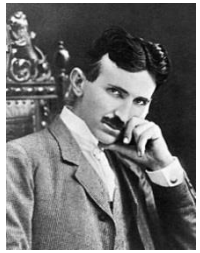
1600 to early 1900's – Development Accelerates









Our Industry's "Founding Fathers"

During the renaissance, the age of learning, many, many individuals spent their entire lives enhancing our understanding of electricity and the craft in which we all work.

Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

William Gilbert

(English 1544-1603)

- First distinguished static electricity from magnetism

- First used the new latin word "***electricus"*** to define the property of attracting light objects after being rubbed

Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Stephen Gray

(English 1666-1736)

- First to make the distinction between electric conductors and insulators

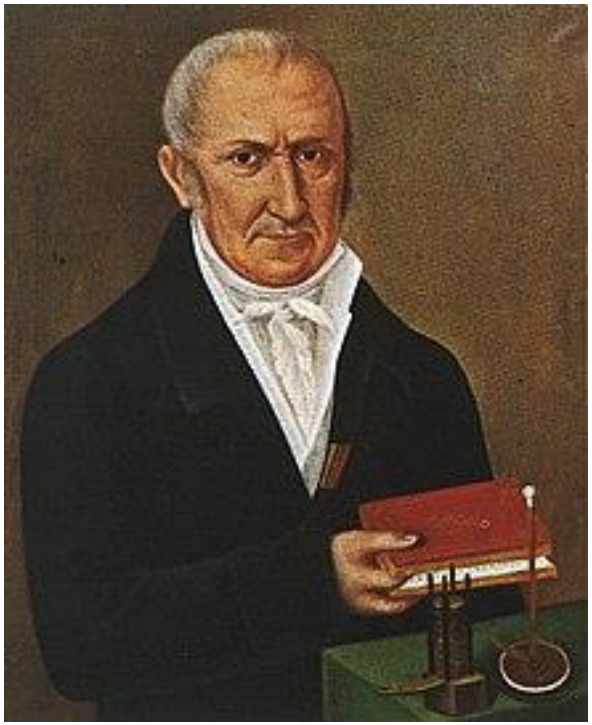
Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Alessandro Volta

(Italian 1745-1827)

- Invented the first battery, the ***voltaic pile***
- The "***volt***" was named after him
- Proved that electricity could be created chemically, and debunked the common theory that it could only be created by living things



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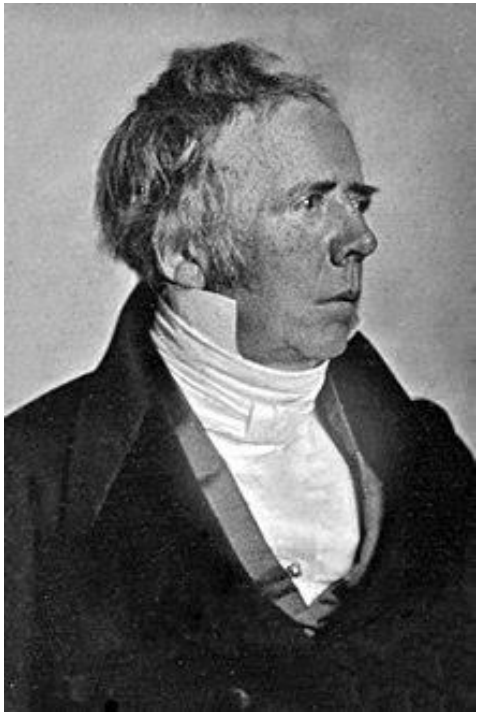
Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Hans Christian Orsted

(Danish 1777-1851)

- During a demonstration to colleagues of how a conductive wire could carry an electric current, he accidentally observed the movement of a needle on a nearby compass.
- Was the first to discover that their was a relationship between electricity and magnetism



Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Andre-Marie Ampere

(French 1775-1836)

- Continued Orsted's work

- Discovered that when an electric current was applied to two conductors, in the same direction, the conductors would attract each other, and vice versa

- The "***ampere***" or "***amp***" is named for him

Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Michael Faraday

(English 1791-1867)

- Proved that electricity can be induced by changes in the electromagnetic field
- Expanded Orsted's and Ampere's work to invent "***electro-magnetic rotary devices***"
- Pre-cursors to our modern electric motors

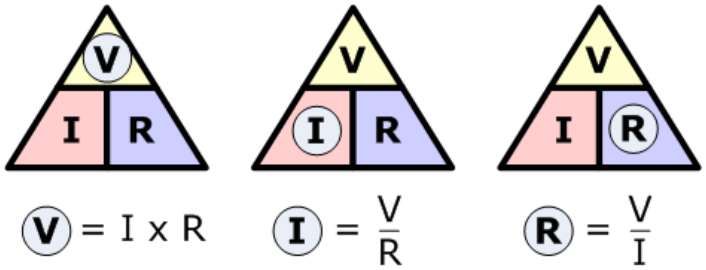
Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

George Ohm

(German 1789-1854)

- Using Volta's electro-chemical cell, Ohm discovered a direct proportionality between the voltage applied across a conductor and the amount of current – now known as "***Ohm's Law***"



Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Sir Joseph Wilson Swan

(British 1828-1914)

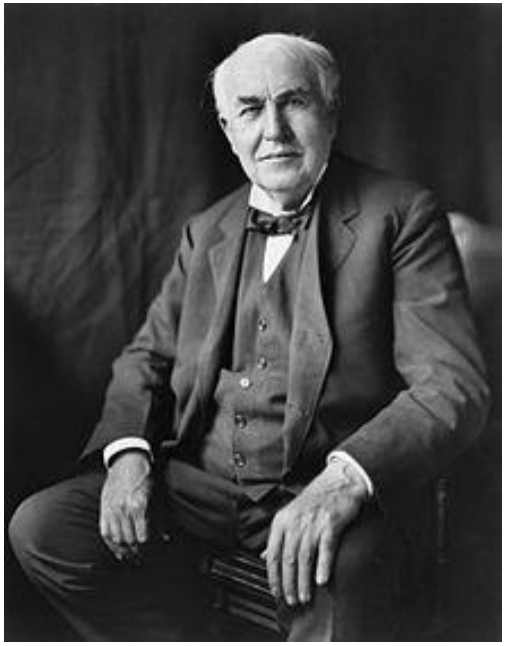
- In 1850, he obtained a British patent for a partial vacuum, carbon filament incandescent lamp.
- The lack of a good vacuum and an adequate electric source resulted in an inefficient light bulb with a short lifespan.

Harnessing the Power of Electricity

1600 to early 1900's – Development Accelerates

Thomas Alva Edison

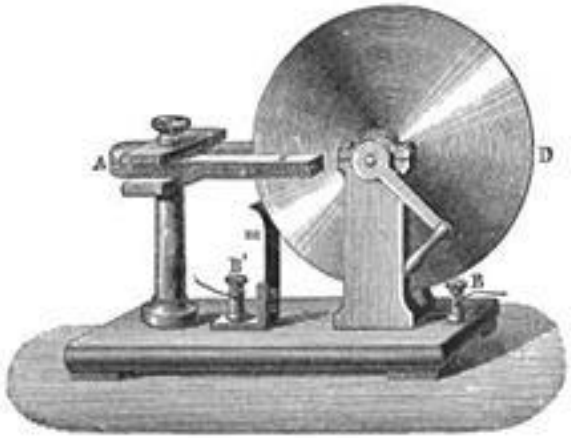
(American 1847-1931)



- On November 4, 1879, Edison filed for US patent 223,898 for an electric lamp using "a carbon filament or strip coiled and connected to platina contact wires".
- This was the first commercially practical incandescent light.
- Lasted only approx. 13.5 hours
- Would further refine the design to extend the lamp's life to 1,200 hours.

Harnessing the Power of Electricity

- These developments, discoveries, and inventions greatly increased our understanding of electricity and left the world hungry to enjoy its benefits, including electric lighting and motors.



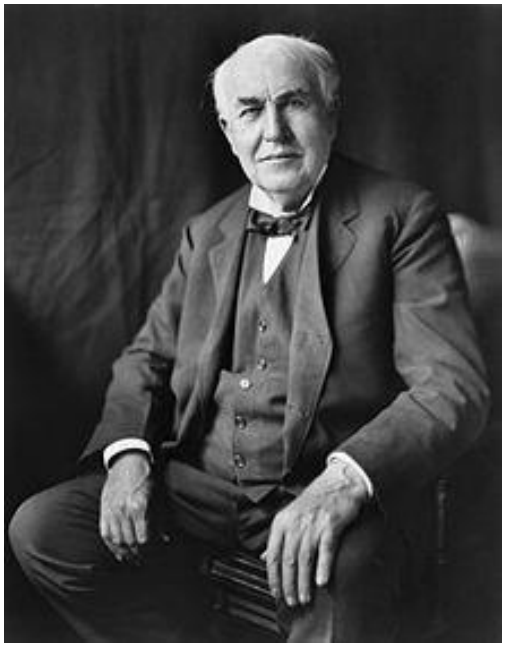
- This desire for electric lighting and the benefits of electric motors lead to a show-down between two of the most influential individuals in our emerging industry…

Early Development of the Power Grid

The War of the Currents

Early Development of the Power Grid

- Born in Milan, OH
- Initially a telegraph operator
  - 1,093 patents
- Automatic repeating telegraph device
  - phonograph
- Shrewd businessman



Early Development of the Power Grid

- Established a research lab at Menlo Park, in New Jersey

- Wanted the lab to have "a stock of almost every conceivable material".

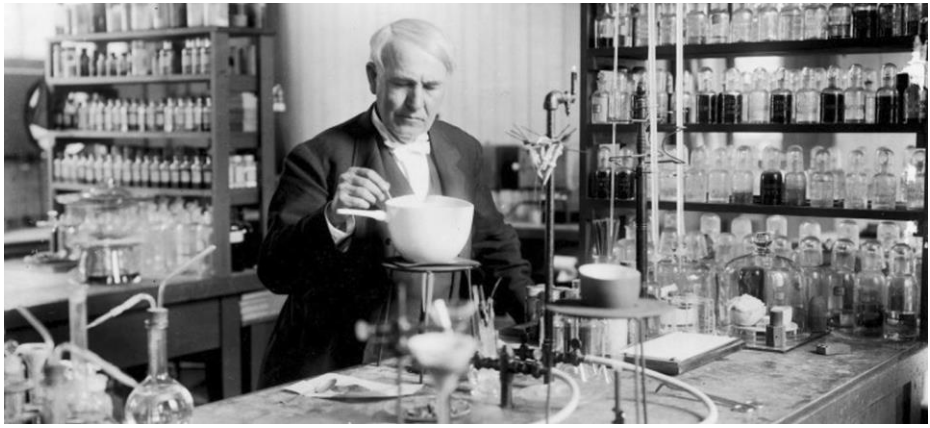
  - Every kind of screw made

  - Every kind of cord or wire

  - Hair of humans, horses, cows, camels, etc.

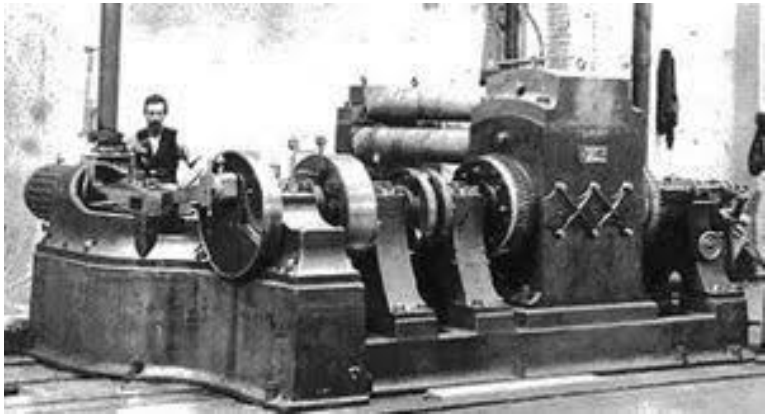
- Known as the "***Wizard of Menlo Park***"

- Here he perfected the incandescent light bulb



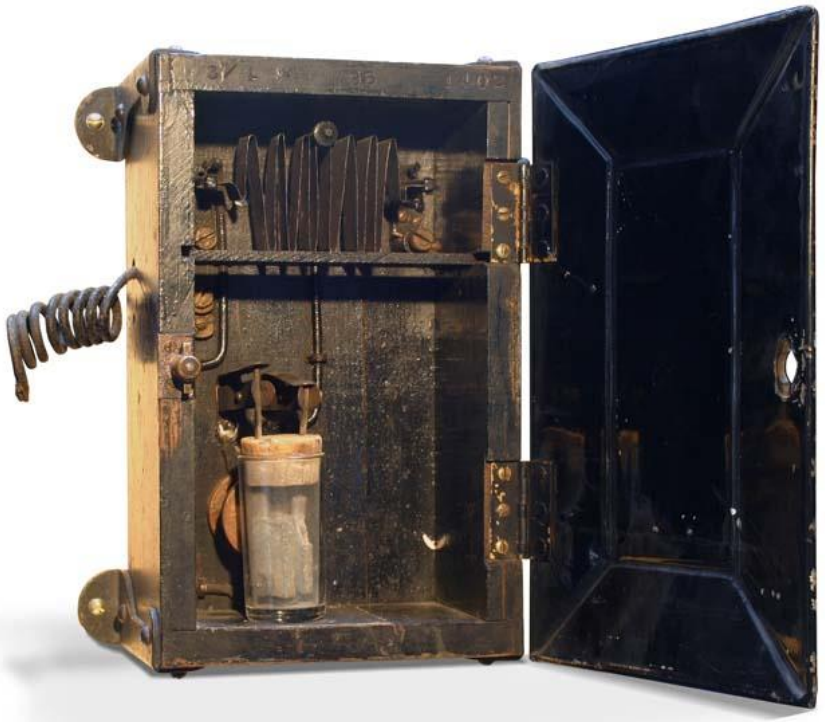
Early Development of the Power Grid

- After perfecting the incandescent light bulb, Edison set his sights on distributing electricity to his new customer base.
- Initial model – DC batteries delivered via wagon
- After that model was found to be inefficient, Edison opened the Pearl Street Power Plant in lower Manhattan



Early Development of the Power Grid

- One generator produced enough power for 800 electric light bulbs.
- In 14 months, the Pearl Street Station had 508 subscribers and 12,732 light bulbs
- Initially, electricity was sold at a per lamp rate
- Later, Edison developed a chemical ampere-hour meter – a jar containing two zinc plates connected across a shunt in the customer's circuit.
- The change in the plate's weight between readings was the measure of electricity consumption.



Early Development of the Power Grid

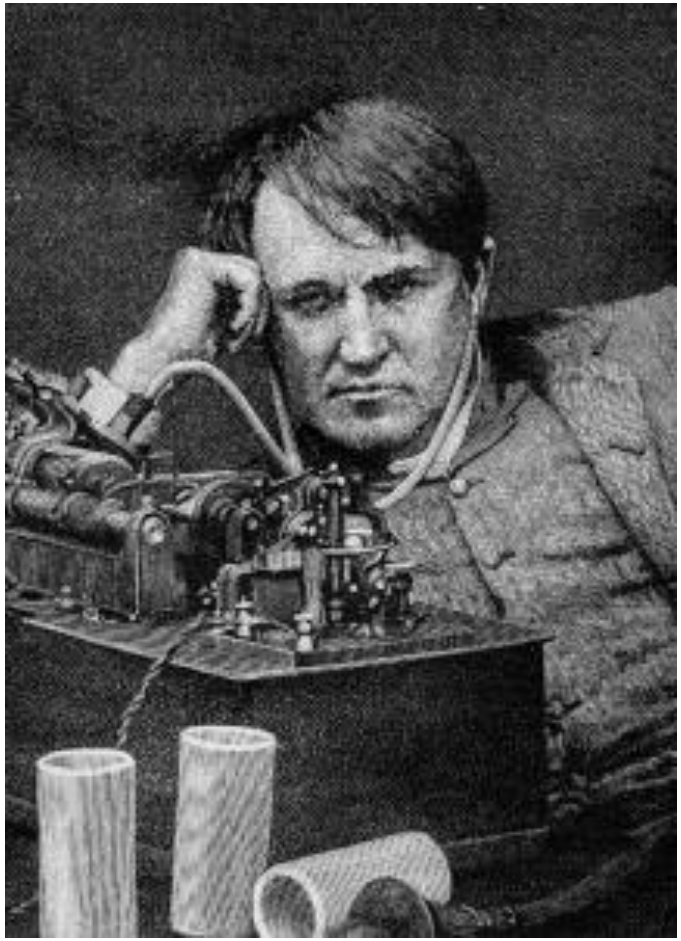
Life is Good for Edison!...

…But wait!

Early Development of the Power Grid

Edison's System (DC) had its limitations…

- High line losses mandate generating stations close to the customers
- Difficult to change voltages with DC

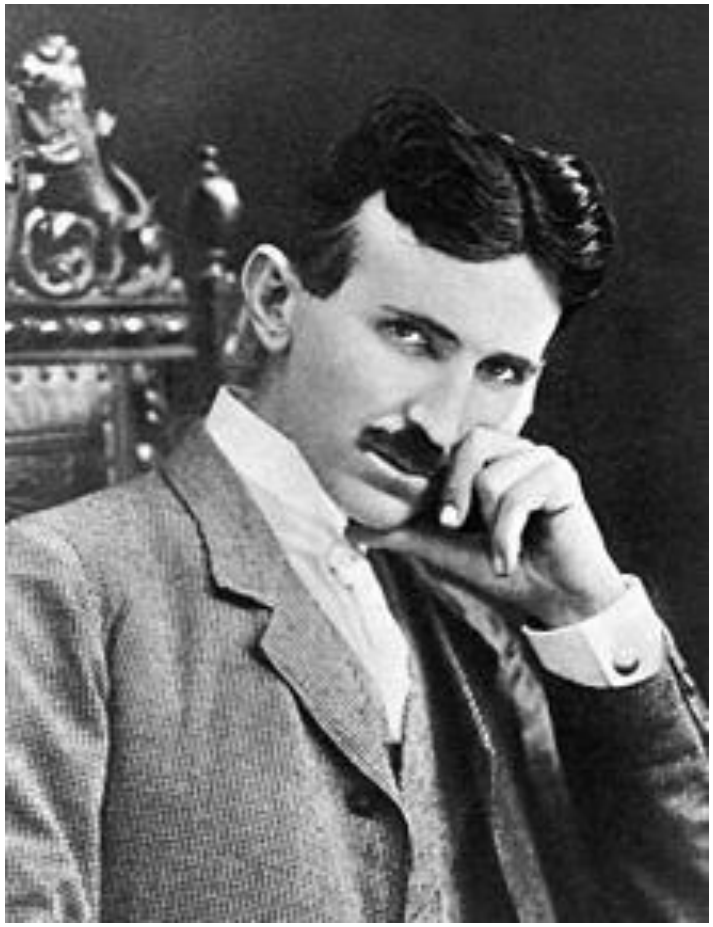


Early Development of the Power Grid

Nikola Tesla (Никола Тесла)

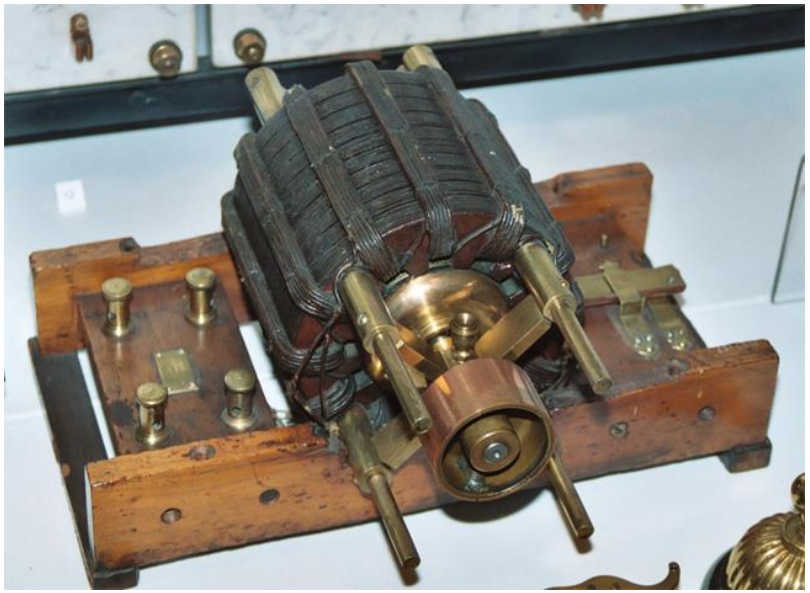
(Serbian-American 1856-1943)

- Born in present day Croatia, in the Austrian Empire
- Even though his father, an Eastern Orthodox priest, wanted him to enter the priesthood, he enrolled at Austrian Polytechnic in Graz, Austria – he would never graduate, addicted to gambling and argued with his professors.



Early Development of the Power Grid

- Early in his career, he actually worked for Edison in both Paris and New York.
- May have quit over un-paid bonuses.
- Founded the Tesla Electric Light and Manufacturing Company
- Continued to pursue an AC system
- 1887 – Developed an AC induction motor

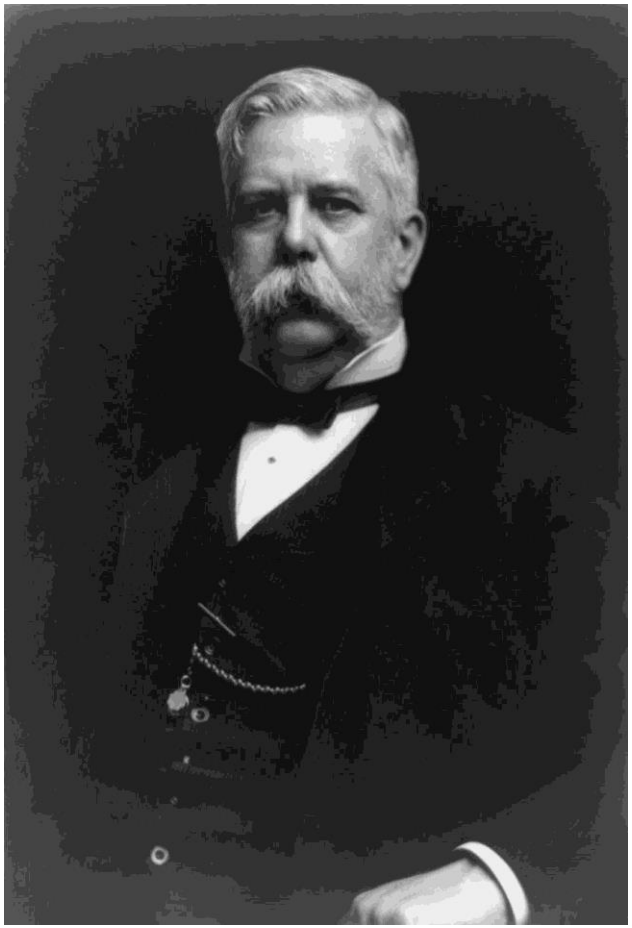


Early Development of the Power Grid

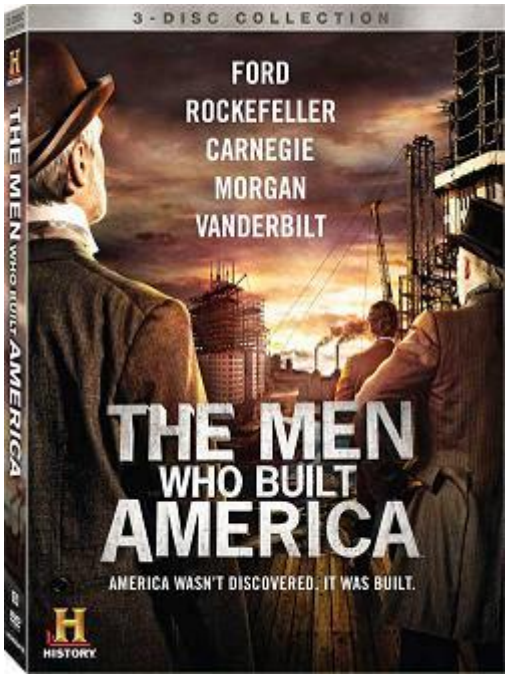
- In 1888, George Westinghouse licensed the motor and transformer designs for $60,000 and a $2.50 royalty for every horsepower each motor produced.

- 1893 – Westinghouse was awarded the contract for a two-phase AC generating system at Niagara Falls

- The AC generation and transmission system was born.



A shameless “plug”…



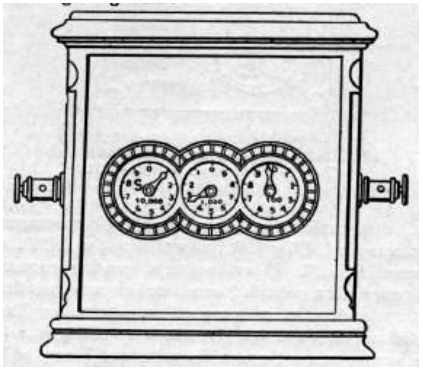
Early Electric Metering

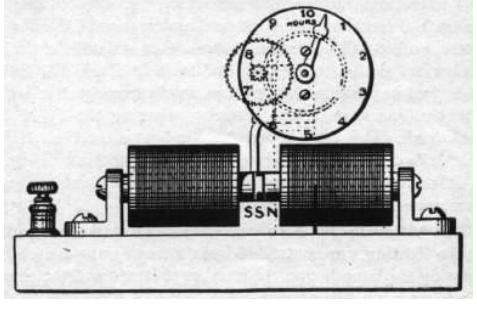
- Now that we could control and use electricity, we needed to make money on it.

  - Edison's initial rate structure was on a per-bulb basis.

- 1872 - Samuel Gardiner takes out the first known patent on an electric meter.
  - This was a DC lamp-hour meter that was a clock with an electromagnet that started and stopped the mechanism.

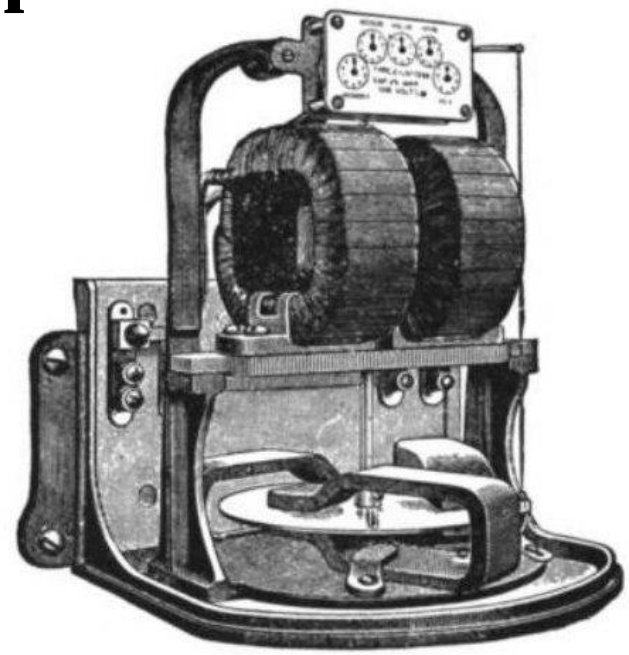
  - 1878 - J.B. Fuller takes out a patent on an AC lamp-hour meter that was a clock operated by an armature that vibrated between two coils.





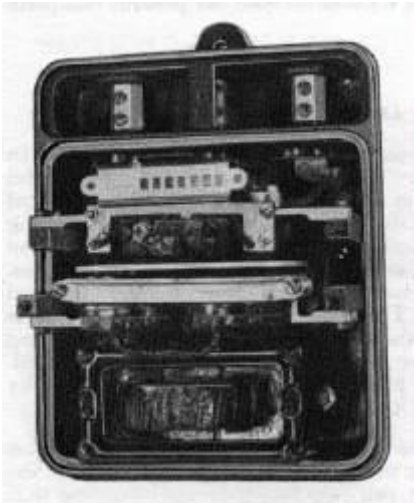
Early Electric Metering

Elihu Thomson



- 1889 - introduced his recording wattmeter
- First true watthour meter
- Initially designed for use on AC circuits –
  it also worked well with the DC circuits
- Many utilities adopting it as their "standard" model

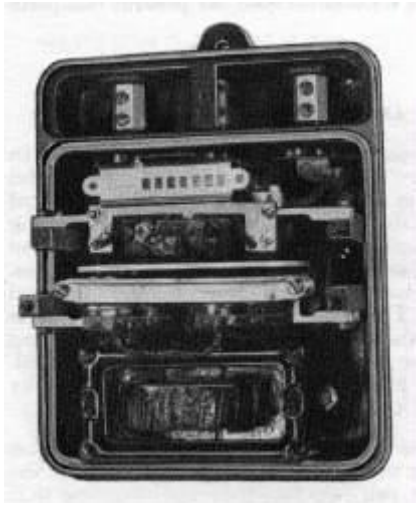
Early Electric Metering



Thomas Duncan

- 1892 - develops the first induction watthour meter
- Use a single disk for both the driving and braking element
- Never went into production.
- These early meters were unable to take into account varying voltages and low power factors on AC circuits.

Early Electric Metering



Oliver Shallenberger

- Several inventors worked to develop a new meter to meet this need
- Shallenberger hit on the most workable approach
- A small induction motor with the voltage and current coils 90 degrees out of phase with each other.
- This concept was refined into the first commercially produced induction watthour meter.
- This model was one of the heaviest ever offered at 41 pounds and one of the most expensive of its time.

Early Electric Metering

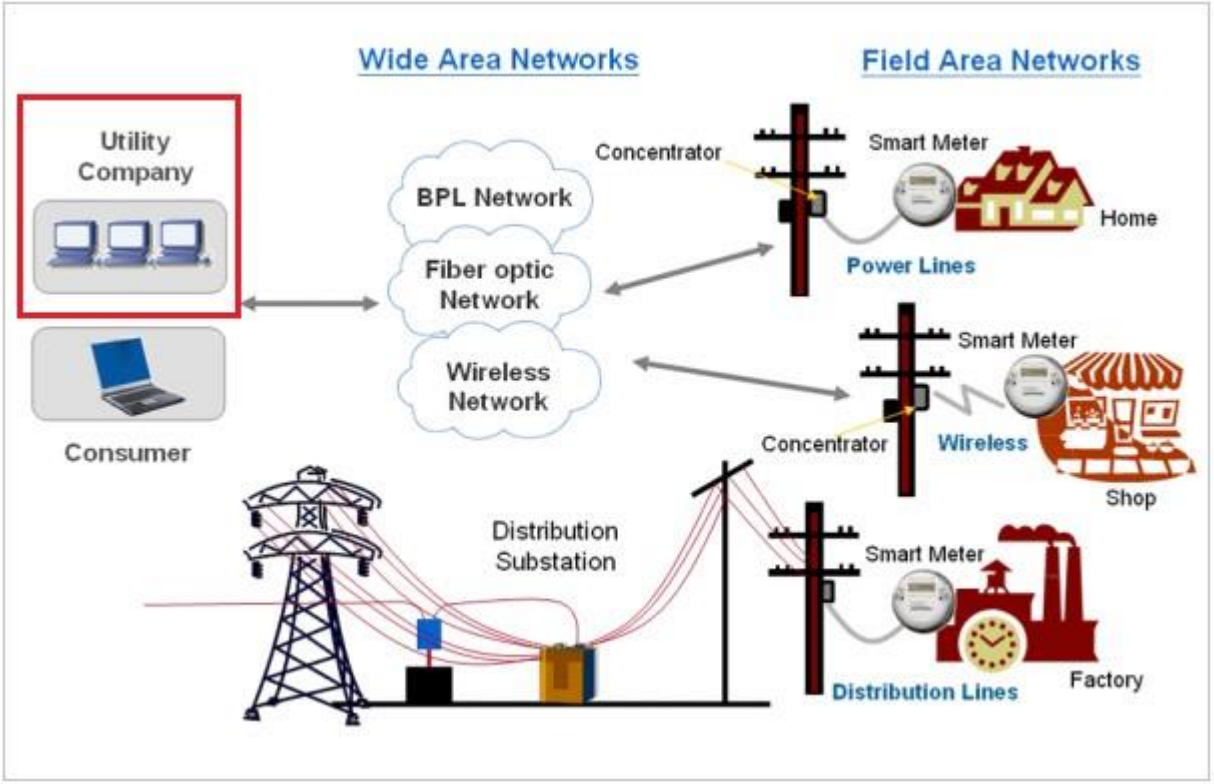
- 1920's - Overload and temperature compensation
- 1934 - Standardized Socket ("S") meters introduced.
- 1948 - Magnetic suspension bearings
- 1960 - All manufacturers use magnetic suspension bearings

Early Electric Metering

- Improvements continued in bearing and magnet technology
- 1970's saw the introduction of electronics, first into registers and later for metrology
- Solid state meters displaced the electromechanical meter by 2006.

Today's Electric Meter

- Currently – AMR/AMI Systems, communications networks, smart metering, point of use pricing, enhanced customer interactions

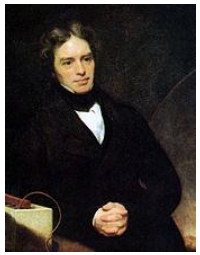


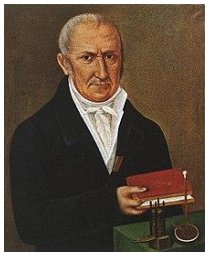
What does the future hold?...

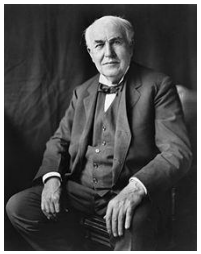
- No one can really be sure, as technological advancements continue to increase at an accelerated rate

What does the future hold?...

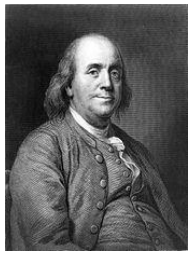
- No one can really as sure, as technological advancements continue to increase at an accelerated rate
- What is known…

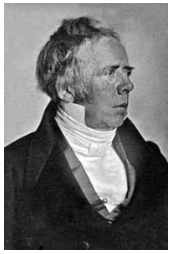
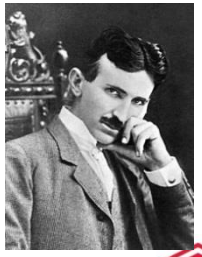










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Questions and Discussion

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