**Introduction**

Advances in the fabrication of electric circuits has followed the advance of electricity and electronics.

**Electricity:** a form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current. Google Dictionary

**Electronics:** the branch of physics and technology concerned with the design of circuits using transistors and microchips, and with the behavior and movement of electrons in a semiconductor, conductor, vacuum, or gas. Google Dictionary

- Here are some goals of the project
- but the goal in education is clear:"Benefit the student"
- We can solve and simulate all we want but letting a student experience the response of a controller is far more effective
- summarize goals:
  1. Build a flight simulator
  2. Encourage faculty/student collaboration
  3. Boost interest in aerospace science

"Electric charge is more useful (and interesting) when it moves."

-David J. Broderick, Ph.D.

- This guy really knows what he's talking about.
- Make it do work
- Make it convey information
- We need two things:
    1. Something to move the charge (battery, generator, power plant, etc)
    2. A path for the charge to travel within (a circuit)

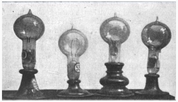
The First Battery

- Alessandro Volta (1800)

- Now we can move charge
- connections large and easy to manipulate
- Circuits were simple

- Better sense of scale from this drawing
- applications were limited, igniting black powder in this scene

**Electric Light**



- Thomas Edison (1878)

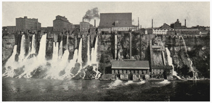
- First widespread application of electricity
- Lead to need for more generation

## Electric Light

- Edison's Pearl Street Station (1882)

- Downtown Manhattan
- Coal Fired
- served a few city blocks
- 508 customers/10,164 lamps
- 20 lights per customer

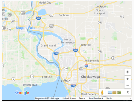
## Alternating Current



- Niagara Falls Hydro Plant (1895)

- As a young boy in (modern day) Croatia, Tesla dreamed of harnessing the power of Niagara Falls
- Had a vision of an AC motor, application more suited to industry,
- still large components
- A bit more complex
- still easy to interconnect

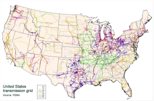
**Alternating Current**



- Generated at Niagara Falls
- Consumed in Buffalo, NY

- AC being more efficient to distribute led to larger distribution areas
- Distance was/is much greater than the few city blocks Edison could serve

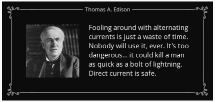
**Alternating Current**




- Edison: 3000 feet
- Tesla: 16 miles
- Present Day: 300+ miles

- Led to our current (pun intended) means of distribution

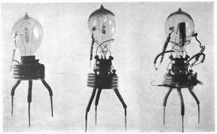
Propaganda War




- This was despite Edison trying to use scare tactics


- Tesla/Westinghouse fought back
- When is the last time you had to consider the Thevenin resistance of your wall outlet?

**The Dawn of Electronics**



- Sir John Ambrose Fleming (1904)

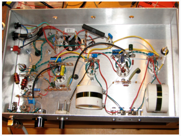
- The first Vacuum Tube
- Derived from the light bulb (kinda look alike, no?)
- Edison's lab observed the phenomena but didn't know what to do with it
- Fleming put it to use rectifying AC electricity into DC

The Dawn of Electronics

- Sir John Ambrose Fleming (1904)

- Old Scientist... for scale
- Additional grids inside the tubes allow for control of current leading to applications such as:
    1. Amplification
    2. Rectification
    3. Switching
    4. Oscillation
    5. Display

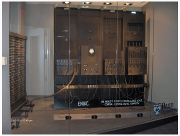
## The Dawn of Electronics



- A modern day tube amplifier

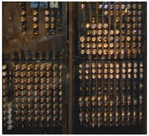
- used in analog circuits: radio rx/tx, television
- tubes are mostly obsolete now
- still used in some audio equipment
- Circuits became more complex
- still large enough for easy, albeit numerous, interconnects

The Dawn of Electronics



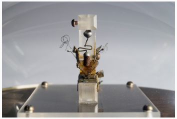

- ENIAC (1945)

- Digital circuits began with tubes as well
- This is one of Forty panels of the first digital computer
- two additional function panels



- Backside of the panel
- a whole lot of tubes
- Very Complex, But HUGE! ie "easy" to construct
- Not reliable, only functioned about 50% of the time

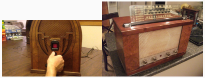
**Semiconductors**



- Shockley, Bardeen, and Brattain (1947)

- Shockley knew the theory, couldn't construct one
- Bardeen and Brattain built the first one working with Shockley
- Shockley eventually got his junction transistor to work
- Shockley usually gets most of the credit
- improved size and reliability
- still not commercially viable
- look at the screw heads for scale

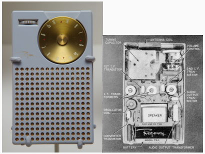
**Commercialization**



- Table-top tube radios

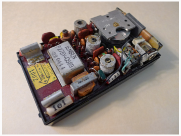
- Texas Instruments (TI) figured out how to manufacture transistors at scale
- Made radio receivers pocket-sized and battery-powered

**Commercialization**



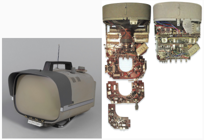
- Regency TR-1 (1956)

- Had two transistors
- one of the first commercial uses of a printed circuit board


Assembly Video

- Complexity continues to increase
- size is decreasing
- interconnect more difficult, though no impossible by hand
- watch video ( 2 minutes) and look for:
  - method of interconnect
  - method of populating parts on the board
  - how soldering was performed
  - how testing was performed
- no more point-to-point, hand soldered components
- still manually populated (no pick and place robots yet)
- still manually tested (no bed-of-nails automated testing yet)

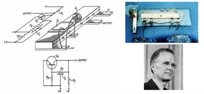
**Commercialization**



- Sony TV8-301 (1960)

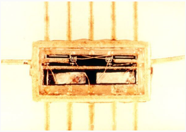
- 8 inch screen, 6V lead acid battery to make it portable
- 23 transistors (some Si, some Ge)
- 17 Diodes
- Notoriously unreliable

## Miniaturization



- Jack Kilby (1958)

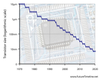
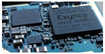
- first integrated circuit
- Components all in the same chunk of semiconductor
- interconnection between components external to semiconductor. So... almost there.
- 4 components
- Has two output states, related to oscillator, one-shot, flip-flop, and others



- Texas Instruments multivibrator #502 (1960)

- TI again led commercially available ICs
- Multivibrator (think: 555 timer)
- Has two output states, related to oscillator, one-shot, flip-flop, and others

**Miniaturization Continues**


- Decreasing transistor size

- Smaller transistors allow a more complex circuit to fit in the same space.

**Commercialization**

- Size and physical form of parts
- How are parts connected together?
- How are parts placed for mechanical assembly?
- How is soldering performed?
- How is testing performed?
- How durable/reliable are components?
- Environmental concerns

- We will examine many of these over the rest of the semester
- and a few others
- How can we build circuits?
- how are circuits manufacture?d
- how are parts/circuits tested?
- How reliable are our circuits?
- What environmental concerns are there?