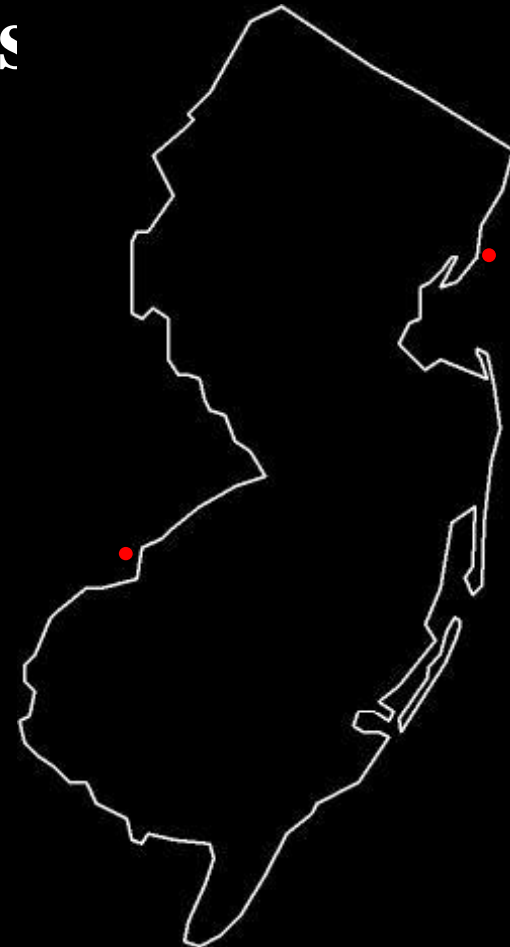


# **Beyond Einstein : New Jersey' s\* Contributions to World Science and Technology**

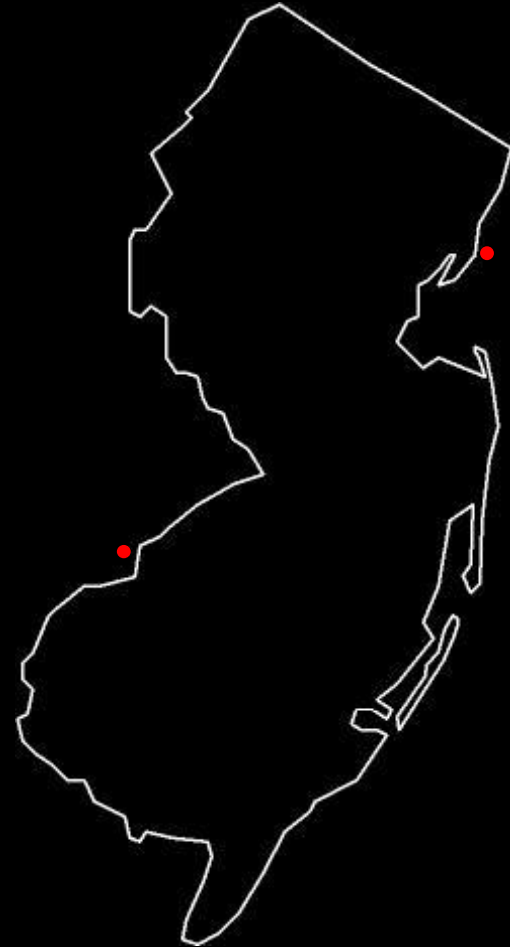
\* also New York City and Philadelphia



Michael G. Littman  
Mechanical and Aerospace Engineering  
Princeton University

Since 1664 ...

- What radical innovations originate and thrive in NJ ?
- Who are the key people ?
- How has society changed ?



For this talk ...

- List NJ innovators, innovations, and organizations
- Select the most significant
- Group them

Common theme emerges –  
NJ contributions to origin and  
development of electric power  
and information networks is  
extensive

Since 1664 ...

- What radical innovations originate and thrive in NJ ?
- Who are the key people ?
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# CEE 102 “Engineering in the Modern World”

## DESIGN

Structures	Civil
Machines	Mechanical
Networks	Electrical
Processes	Chemical

## DISCOVERY

Physics  
Astronomy  
Chemistry  
Geology

No Life Science or Medicine

For this talk ...

- List NJ innovators, innovations, and organizations
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Common theme emerges –  
NJ contributions to origin and development of electric power and information networks is extensive



## Edward Sorel – “People of Progress” – 20<sup>th</sup> Century

(left to right): Philo T. Farnsworth, George Washington Carver, Jonas Salk, Henry Ford, Orville Wright, Wilbur Wright, Albert Einstein, Charles H. Townes, Charles Steinmetz, J. C. R. Licklider, John Von Neumann, William H. Gates III, Robert Goddard, James Dewey Watson, Wallace Hume Carothers, Rachel Carson, Willis Carrier, Gertrude Elion, Edwin H. Armstrong, Robert Noyce





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## Christian Schussele – “Men of Progress” – 19<sup>th</sup> Century

(left to right): William Thomas Green Morton, James Bogardus, Samuel Colt, Cyrus Hall McCormick, Joseph Saxton, Charles Goodyear, Peter Cooper, Jordan Lawrence Mott, Joseph Henry, Eliphalet Nott, John Ericsson, Frederick Sickels, Samuel Finley Breese Morse, Henry Burden, Richard March Hoe, Erastus Bigelow, Isaiah Jennings, Thomas Blanchard, and Elias Howe.

Benjamin Franklin

Peter Cooper

Joseph Henry

Alfred Vail's  
Telegraph Register

Samuel F.B. Morse

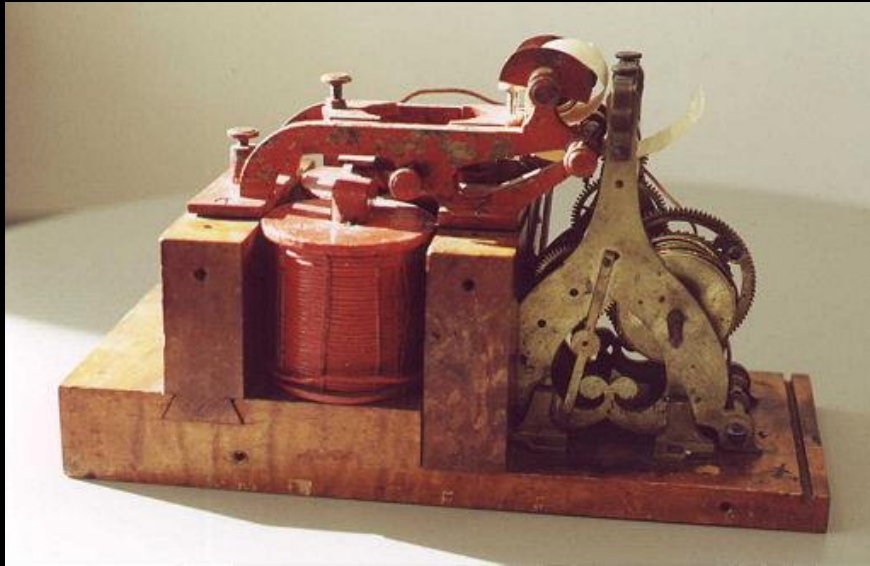


## Christian Schussele – “Men of Progress” – 19<sup>th</sup> Century

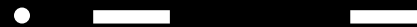
(left to right): William Thomas Green Morton, James Bogardus, Samuel Colt, Cyrus Hall McCormick, Joseph Saxton, Charles Goodyear, Peter Cooper, Jordan Lawrence Mott, Joseph Henry, Eliphalet Nott, John Ericsson, Frederick Sickels, Samuel Finley Breese Morse, Henry Burden, Richard March Hoe, Erastus Bigelow, Isaiah Jennings, Thomas Blanchard, and Elias Howe.



# Telegraph Register (Printer) by Alfred Vail of Morristown NJ



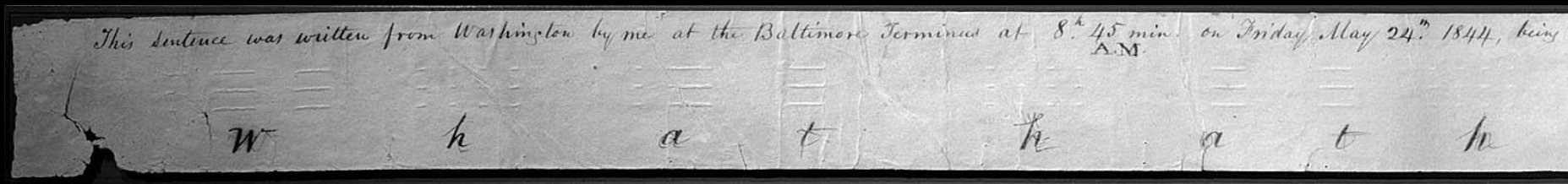
← moving tape



← Morse code



Register base-plate signed by Alfred Vail in 9 places – note on bottom .... "This lever and roller were invented by me in the sixth story of the New York Observer office, in 1844, before we put up the telegraph line between Washington and Baltimore... I am the sole and only inventor of this mode of telegraph embossing writing. **Professor Morse gave me no clue to it... and I have not asserted publicly my right as first and sole inventor**, because I wished to preserve the peaceful unity of the invention, and because I could not, according to my contract with Professor Morse, have got a patent for it. "



# First Grouping

- Ideas
- Inventions
- Industries

## First Grouping

- Ideas
- Inventions
- Industries

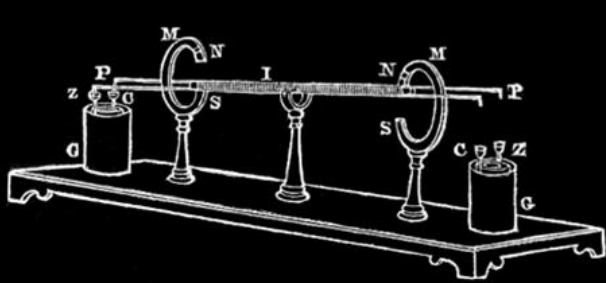
## Ideas

Joseph Henry  
strong electromagnet

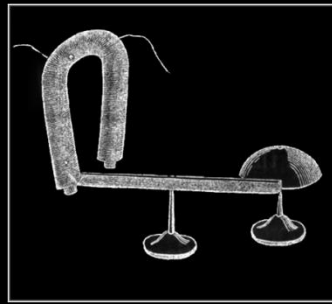
Albert Einstein  
theory of relativity

John von Neumann  
stored-program  
digital computer





Electric Motor  
POWER



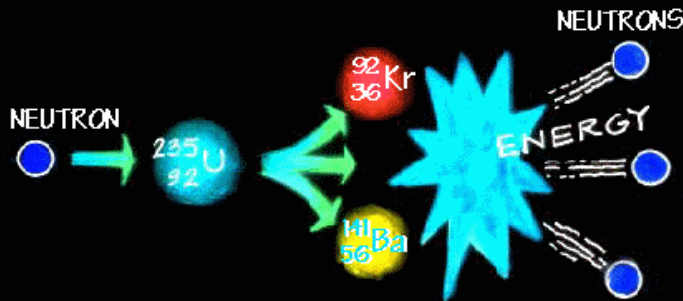
Telegraph  
INFORMATION

# Ideas

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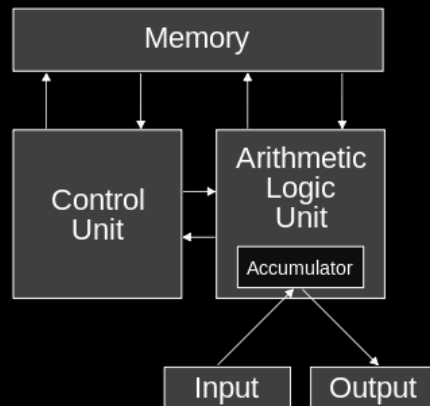
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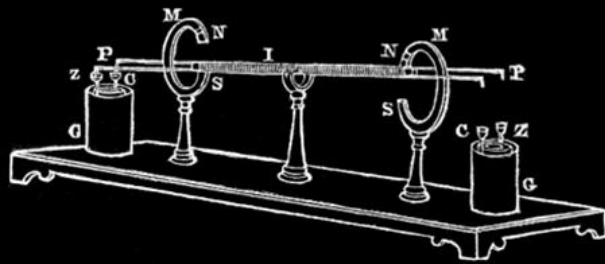


NUCLEAR POWER      NUCLEAR WEAPONS

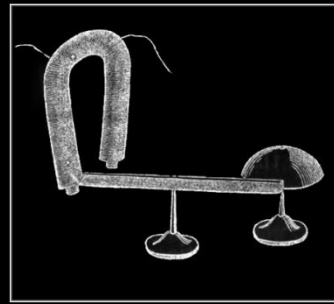
Memory used for  
program and data



# How society changed

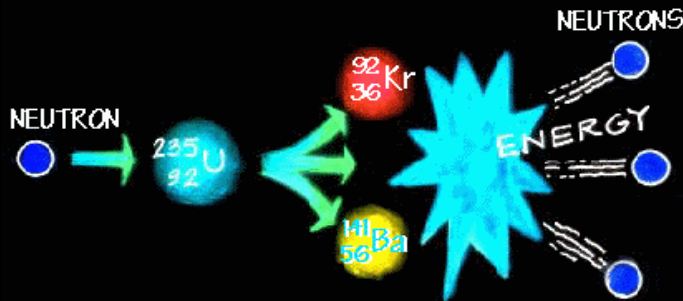


Electric Motor  
**POWER**



Telegraph  
**INFORMATION**

At the time of ... my original experiments on electro-magnetism ..., I was urged by a friend to take out a patent, both for its application to machinery and to the telegraph, but this I declined, on the ground that I did not then consider it compatible with the dignity of science ... In this perhaps I was too fastidious. – J. Henry 1876

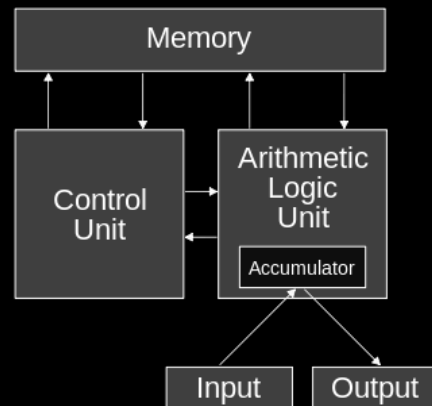


**NUCLEAR POWER**

**NUCLEAR WEAPONS**

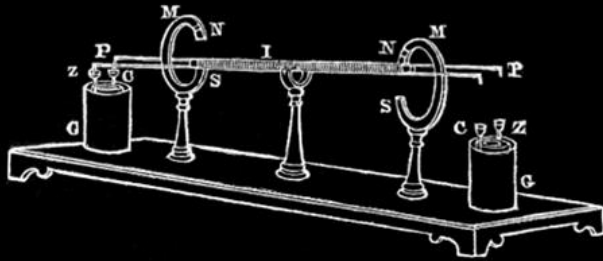
The release of atom power has changed everything except our way of thinking...the solution to this problem lies in the heart of mankind. If only I had known, I should have become a watchmaker. – A. Einstein 1945

Memory used for  
program and data

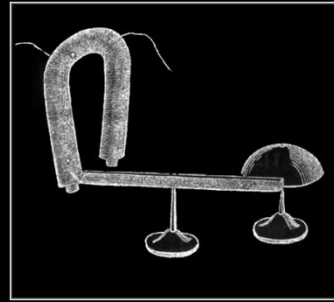


It would appear that we have reached the limits of what it is possible to achieve with computer technology, although one should be careful with such statements, as they tend to sound pretty silly in 5 years. – J. von Neumann 1949

# All residents of Princeton NJ



Electric Motor  
**POWER**

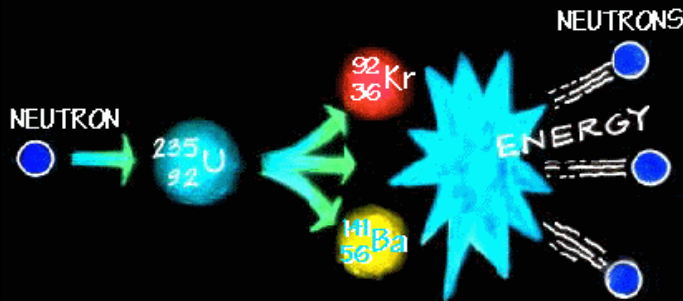


Telegraph  
**INFORMATION**



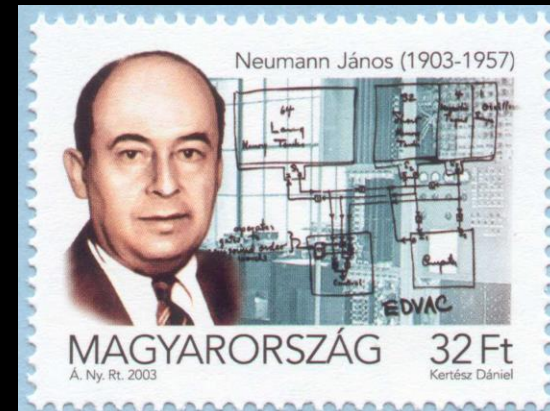
Daniel Chester French  
Statue of Joseph Henry  
at Princeton University

Horse-shoe  
Electromagnet

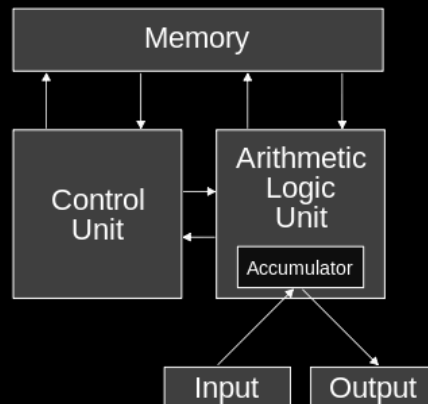


**NUCLEAR POWER**

**NUCLEAR WEAPONS**



Memory used for  
program and data





# Inventions

Edison

Phonograph

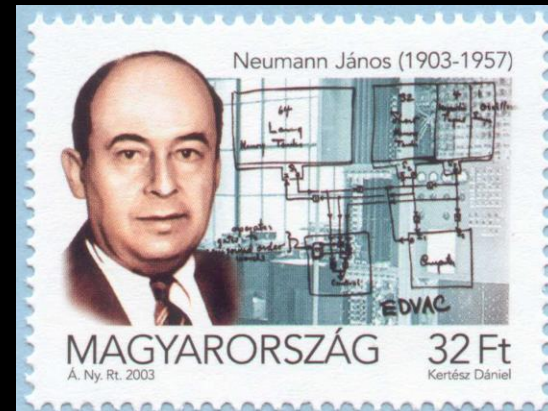
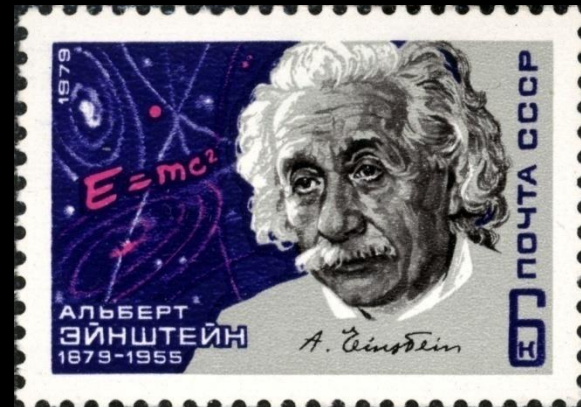
Bardeen, Brattain, Shockley  
Transistor

Townes, Schawlow  
Laser



Daniel Chester French  
Statue of Joseph Henry  
at Princeton University

Horse-shoe  
Electromagnet



# Inventions

Edison

Phonograph

Bardeen, Brattain, Shockley

Transistor

Townes, Schawlow

Laser



**Lasers** can provide light in a narrow beam of high intensity and pure color. They were first operated in 1960 and revolutionized technologies from communications to surgery and led to everyday items like CD players.

CELEBRATE THE CENTURY – 1960s

# How society changed

Archival recordings of voice and music - as significant as photography



Miniature electronic devices; portable, rugged, fast, instant on



Optical storage of digital data;  
Optical transmission of data

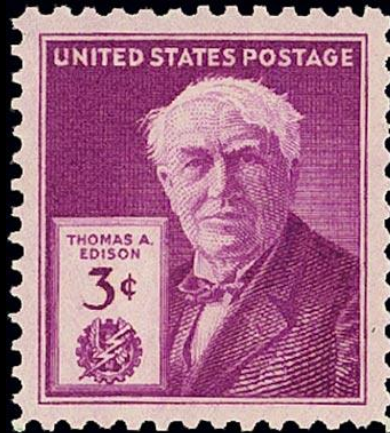


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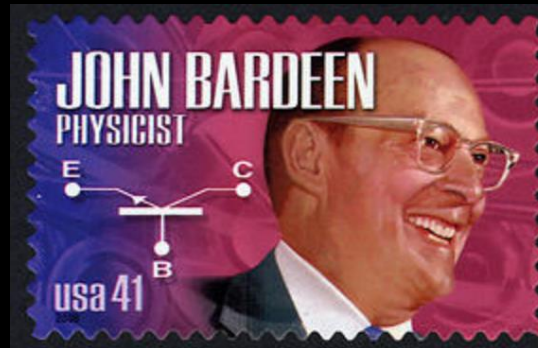
CELEBRATE THE CENTURY - 1960s



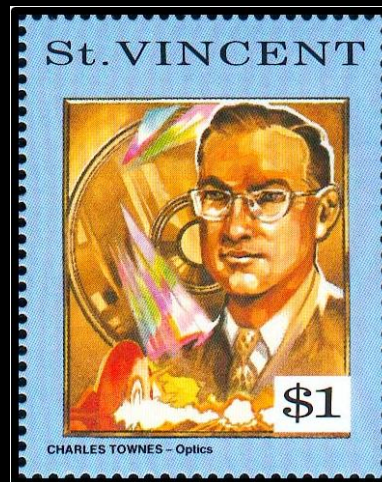
Menlo Park, NJ  
West Orange, NJ



Murray Hill, NJ



New York, NY  
Murray Hill, NJ



**Lasers** can provide light in a narrow beam of high intensity and pure color. They were first operated in 1960 and revolutionized technologies from communications to surgery and led to everyday items like CD players.

CELEBRATE THE CENTURY - 1960s

One invention leads to another –  
carbon button microphone leads to  
the phonograph

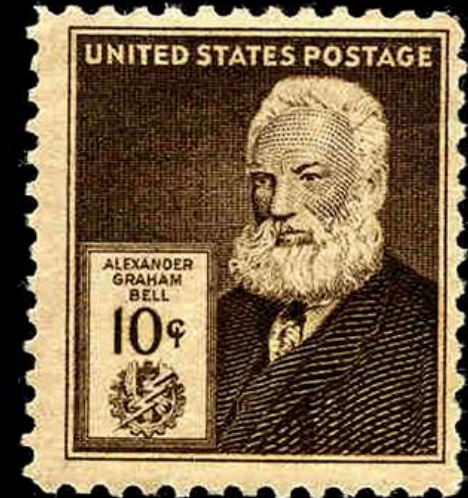
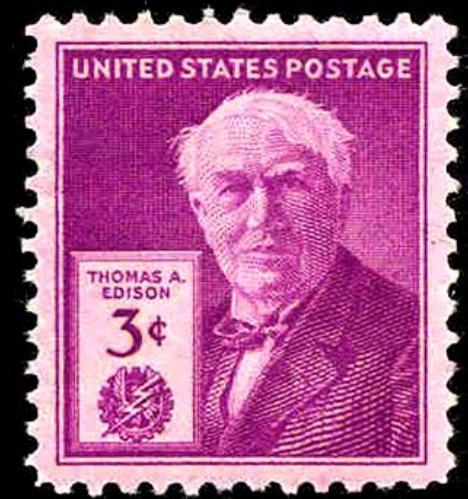


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CELEBRATE THE CENTURY – 1960s

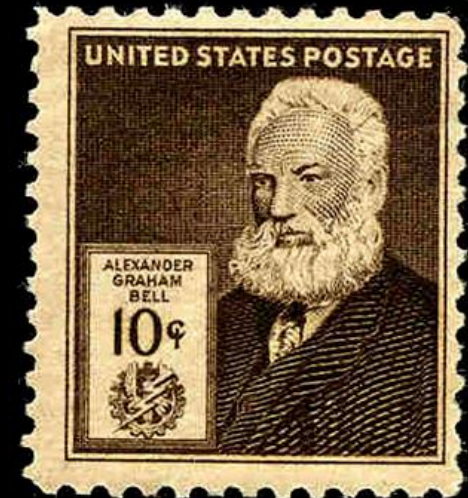
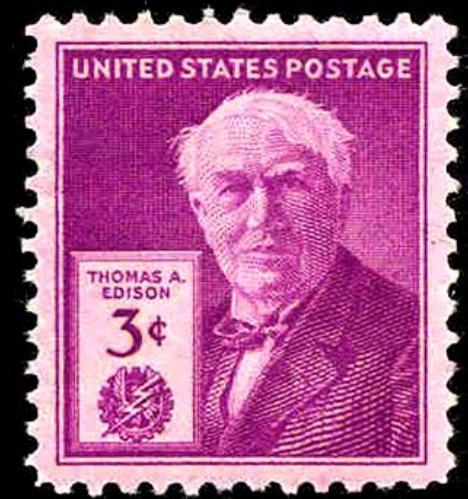
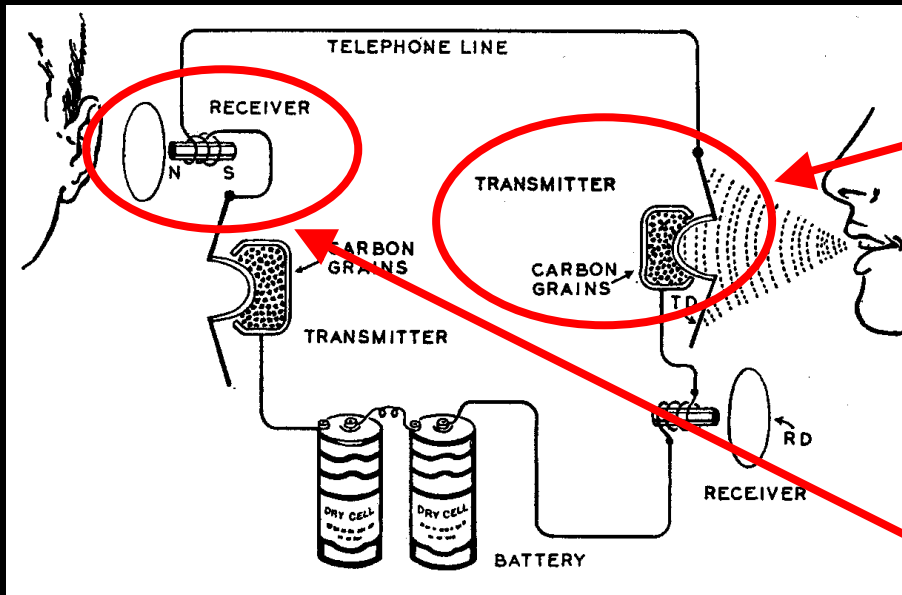


One invention leads to another –  
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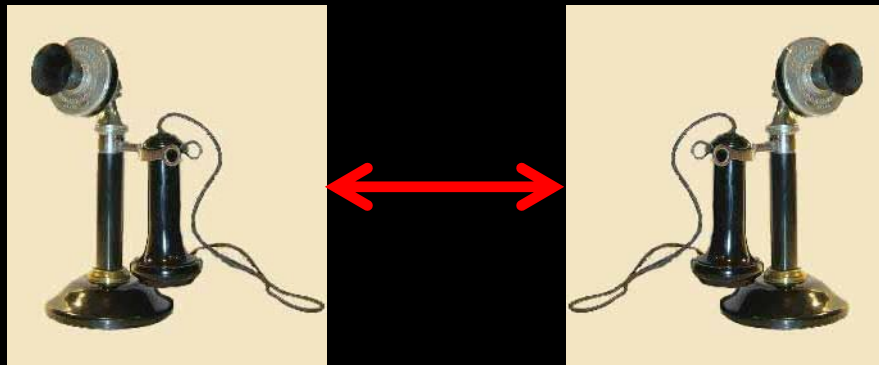
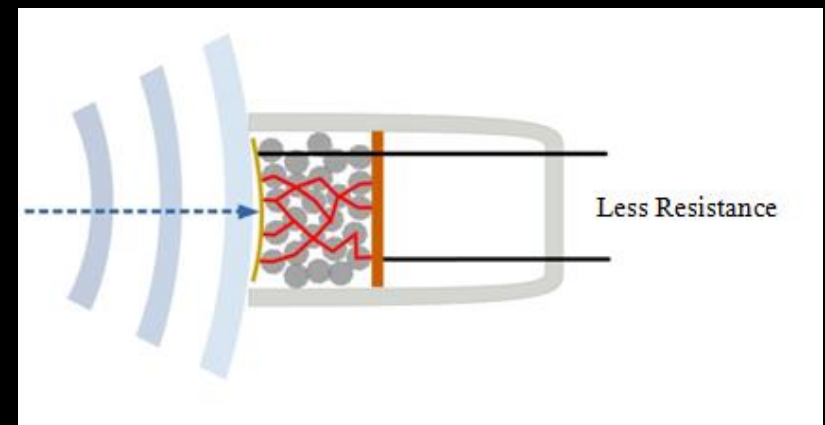
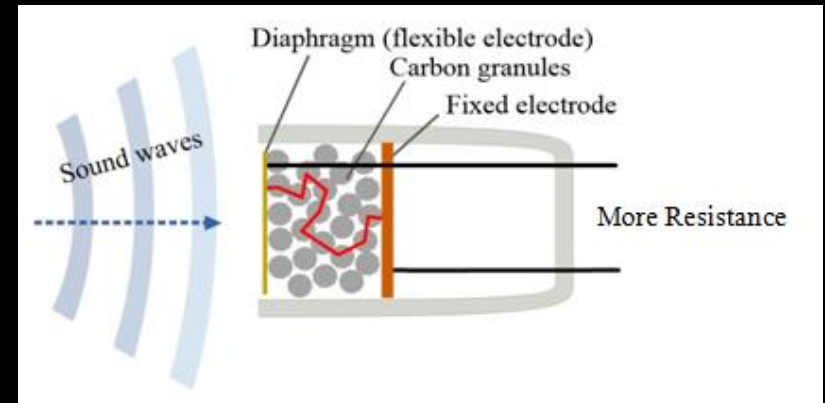
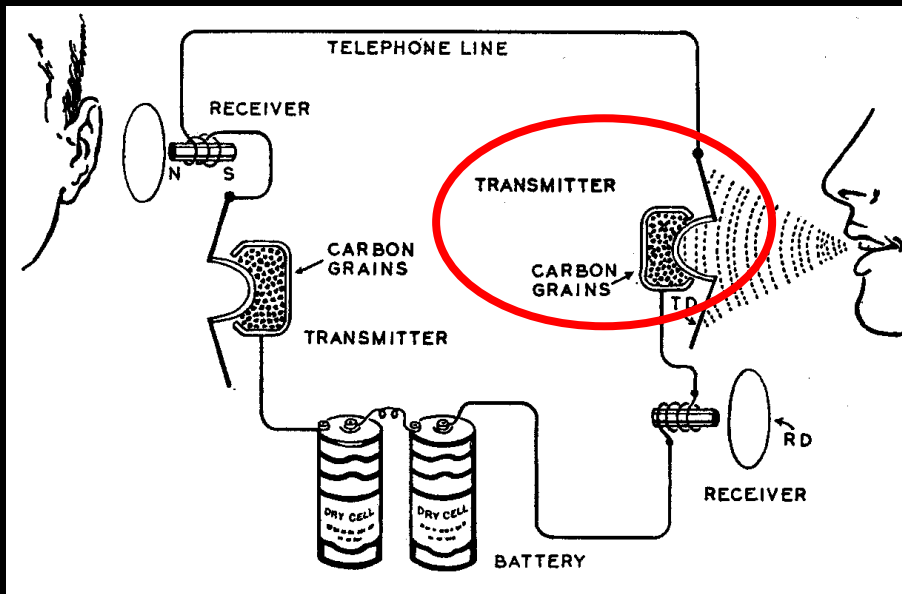




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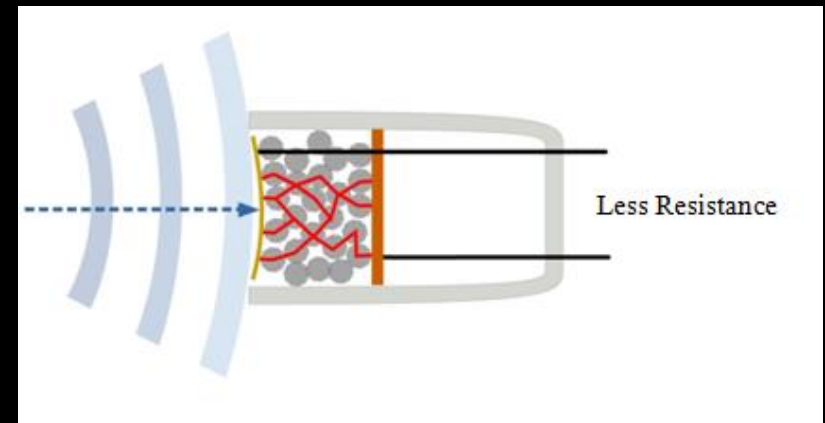
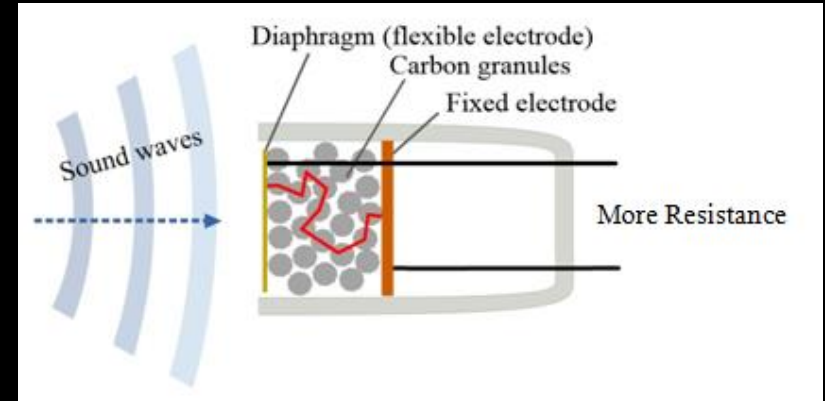
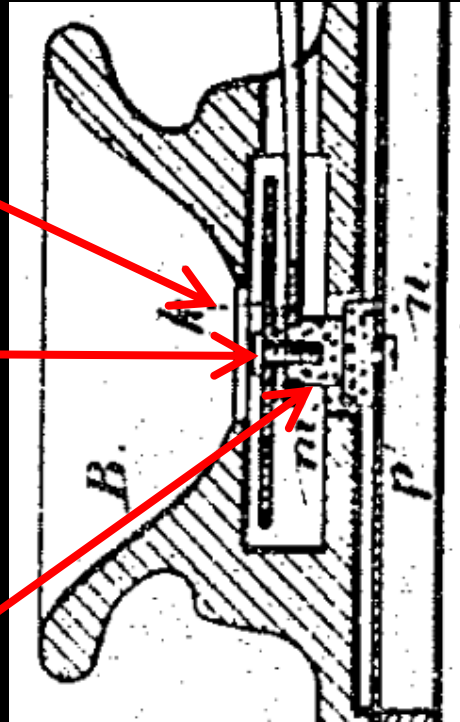


Edison Transmitter – Compressing  
carbon grains reduces resistance which  
increase current – transforms sound  
undulations into current undulations.

Diaphragm

Pin to compress granules

Carbon granules



## Edison's Patent Drawing of Carbon Microphone

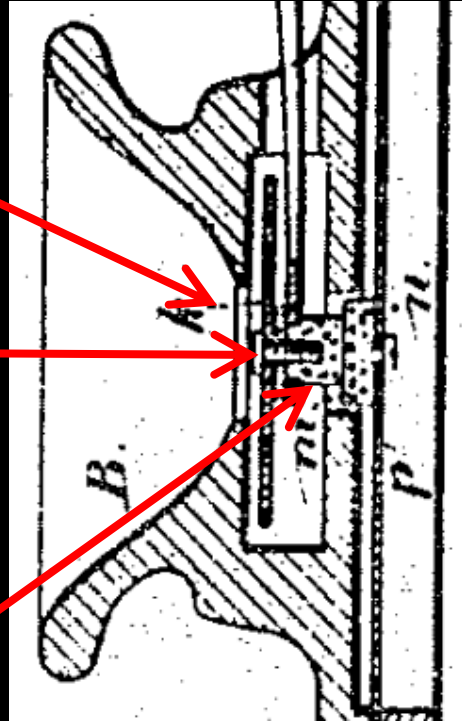
Edison Transmitter – Compressing carbon grains reduces resistance which increase current – transforms sound undulations into current undulations.



Diaphragm

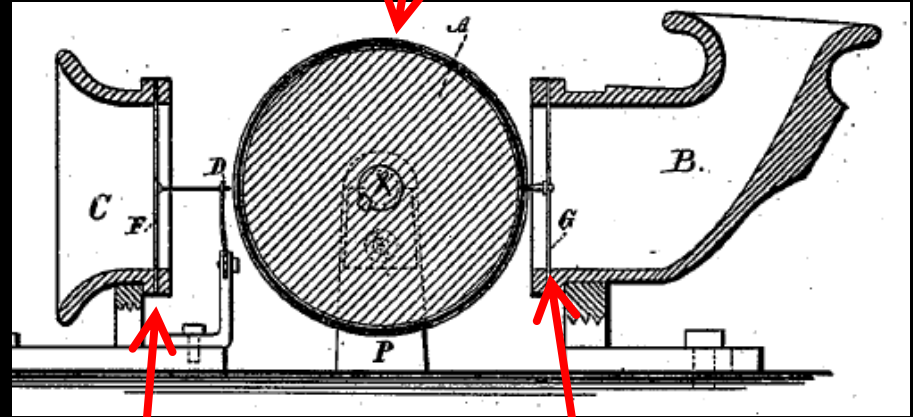
Pin to compress granules

Carbon granules



Edison's Patent  
Drawing of Carbon  
Microphone

## Rotating Tin Foil Cylinder



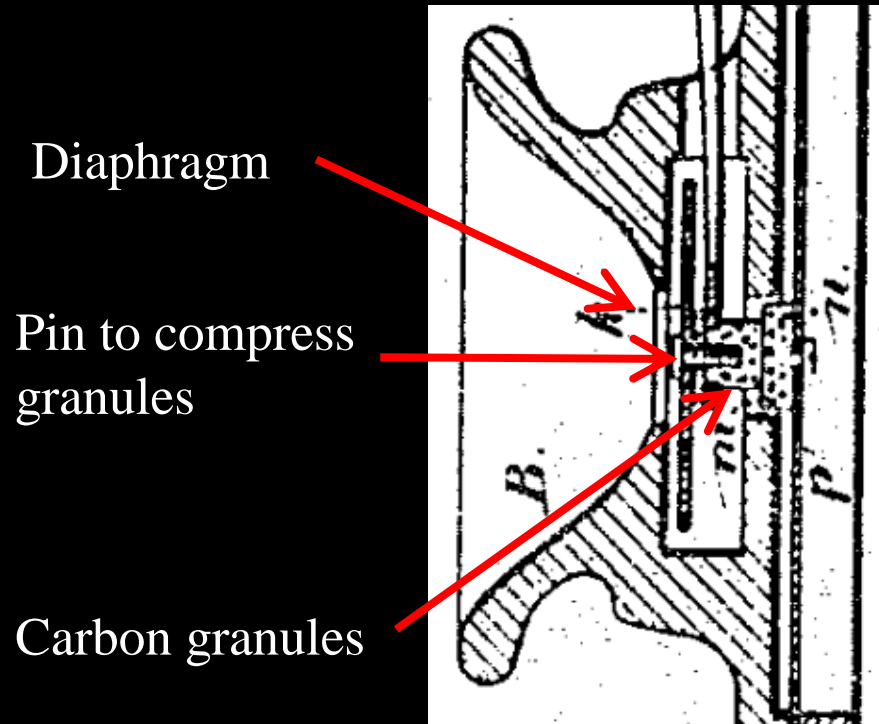
Recorder

Reproducer

Sharp pin  
deforms the foil

Blunt pin  
follows deformations

Edison's Patent  
Drawing of Phonograph



Edison's Patent  
Drawing of Carbon  
Microphone

# Industries

Edison

Electric Power

Sarnoff and Armstrong

Radio & TV

J. P. Morgan and T. N. Vail

Telegraph & Telephone

L. H. Baekeland

Bakelite – first plastics

# Industries

Edison

Electric Power

Sarnoff and Armstrong

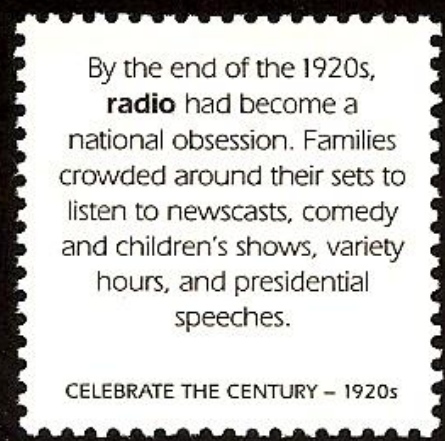
Radio & TV

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# Industries

Edison

Electric Power

Sarnoff and Armstrong  
Radio & TV

J. P. Morgan and T. N. Vail  
Telegraph & Telephone

L. H. Baekeland  
Bakelite – first plastics

Showing faith in new technology, **household purchases** focused on electric mixers, refrigerators, pop-up toasters, vacuum cleaners, and irons. The 1930s also saw the spread of sliced bread and packaged frozen foods.

CELEBRATE THE CENTURY – 1930s

32  
USA



Household Conveniences



TV Entertains America

**Commercial television** formally began July 1, 1941, and by the end of 1949 more than three million American homes had sets. Many early programs, including dramas, variety shows, new shows, and comedies, were adapted from popular radio programs.

CELEBRATE THE CENTURY – 1940s

The first **transcontinental telephone line** was completed in 1914. On January 25, 1915, the first call was made by Alexander Graham Bell in New York to Thomas A. Watson in San Francisco.

CELEBRATE THE CENTURY – 1910s

32  
USA



Telephone Spans the Nation



RCA Victor  
Radio and Phonograph



RCA  
Color Television

# Industries

Edison

Electric Power

Sarnoff and Armstrong  
Radio & TV

J. P. Morgan and T. N. Vail  
Telegraph & Telephone

L. H. Baekeland  
Bakelite – first plastics



Alpine NJ – First FM Radio Tower

# R & D Laboratories

Edison Laboratories  
Menlo Park, NJ

RCA Laboratories  
NYC; West Windsor, NJ

Bell Laboratories  
NYC; Murray Hill, NJ

# Industries

Edison  
Electric Power

Sarnoff and Armstrong  
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## R & D Laboratories

Edison Laboratories  
Menlo Park, NJ

RCA Laboratories  
NYC; West Windsor, NJ

Bell Laboratories  
NYC; Murray Hill, NJ

## Manufacturing

Edison Lamp Works  
Harrison, NJ

RCA Vacuum Tubes  
Harrison, NJ

Western Electric Company  
Kearny, NJ

General Bakelite Company  
Perth Amboy, NJ

# Manufacturing

## Second Grouping

- Capturing
- Communicating
- Computing

Edison Lamp Works  
Harrison, NJ

RCA Vacuum Tubes  
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Western Electric Company  
Kearny, NJ

General Bakelite Company  
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## Second Grouping

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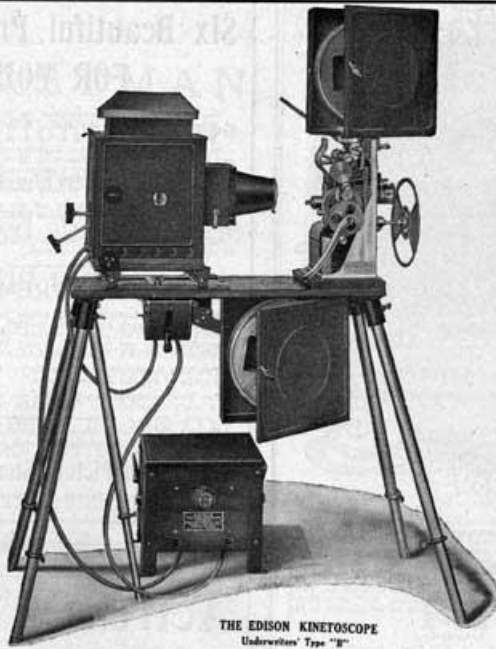
## Capturing

Edison – Phonograph - Sound  
Kinetoscope - Movies

Jansky – Radio Astronomy  
Penzias & Wilson – Big Bang

Boyle & Smith – CCD  
Digital Photography





THE EDISON KINETOSCOPE  
Underwriter's Type "B"

**W**HY isn't your motion picture show making you the great big money you read about? How is it that the man in the next block can show the same pictures you do—and take the crowds away from you? We'll tell you. It's all in the machine—you need an

## EDISON KINETOSCOPE

The Edison wins the crowd because it projects clear, flickerless pictures that don't tire the eyes and are a real pleasure to look at. There are no discouraging "intermissions for repairs". And the Edison Kinetoscope saves the extra money it makes, because it runs the longest time with the least upkeep expense. Get Posted. Send for Catalog 500 and a copy of the Edison Kinetogram.

Price, with Rheostat, 110 volts, 24-40 amperes - \$225.00  
Price, " 110 volt, 60 Cycle Transformer - - 245.00

**THOMAS A. EDISON, Inc., 274 Lakeside Avenue, Orange, N. J.**

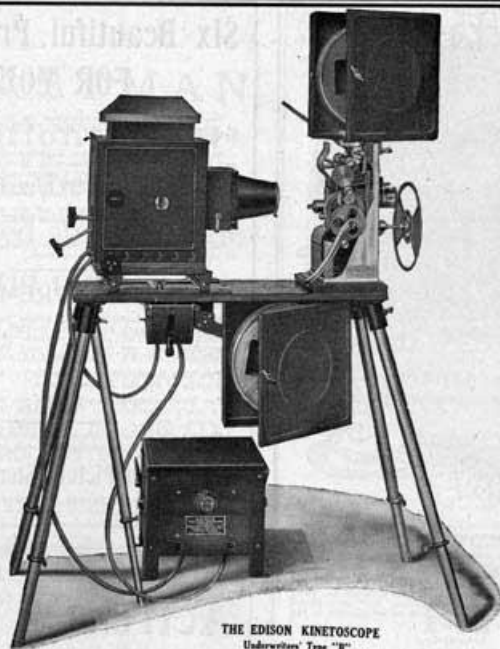
In writing to advertisers please mention "MOVING PICTURE NEWS"

# Capturing

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In writing to advertisers please mention "MOVING PICTURE NEWS"





# EDISON FILMS

PATENTED AND COPYRIGHTED.

Replete with Thrilling and Exciting Incidents in Fourteen Scenes.

## THE GREAT TRAIN ROBBERY

Was shown to enthusiastic  
audience houses during  
Xmas week in New  
York at the following  
theatres:

Hartig & Seamon's  
Circle Theatre  
Proctor's 125th St.



Keith's 14th St.  
Harlem Opera House  
Tony Pastor's  
Eden Musee  
Huber's Museum  
Orpheum, Brooklyn  
Comedy Theatre  
Orpheum Music Hall

SEND FOR FULLY  
ILLUSTRATED  
AND  
DESCRIPTIVE  
PAMPHLET.

LENGTH, 710  
FEET.  
PRICE, \$111.  
CODE WORD,  
VACUNABAN.

Edison Exhibition Kinetoscope, \$115.00. Edison Universal Kinetoscope, \$75.00.

MAIN OFFICE and FACTORY, Orange, N. J.

EDISON MANUFACTURING CO., NEW YORK OFFICE: 83 Chambers St.

OFFICE FOR UNITED KINGDOM: 52 Gray's Inn Road, Holborn, London, W.C., England.

EUROPEAN OFFICE: 32 Rempart Hotel Georges, Antwerp, Belg.

### SELLING AGENTS:

THE KINETOGRAPH CO. .... 41 E. 21st St., New York  
KLEINE OPTICAL CO. .... 52 State St., Chicago, Ill.  
PETER BACIGALUPI ..... 203 Market St., San Francisco, Cal.

## THE ORIGINAL AND ONLY





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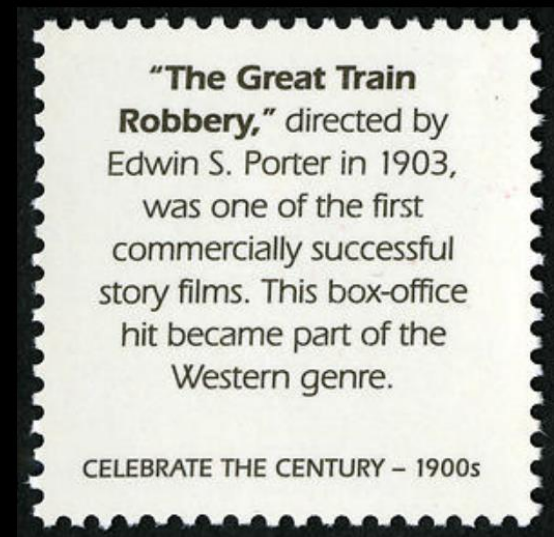
### THE ORIGINAL AND ONLY

**"The Great Train Robbery,"** directed by Edwin S. Porter in 1903, was one of the first commercially successful story films. This box-office hit became part of the Western genre.

CELEBRATE THE CENTURY – 1900s



filmed in Milltown NJ



filmed in Milltown NJ





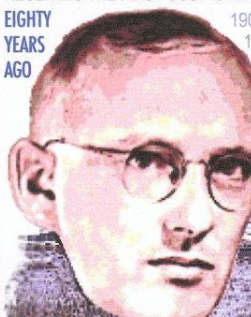

# RADIO ASTRONOMY IS BORN

KARL JANSKY OF BELL LABORATORIES REPORTED RECEIVING THE FIRST COSMIC MESSAGE

IN WASHINGTON, DC  
APRIL 27, 1933



EIGHTY YEARS AGO

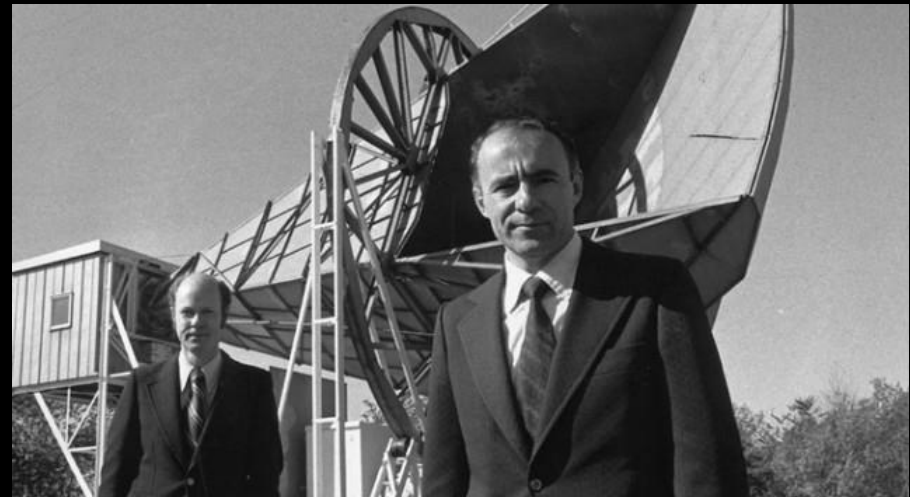
1905 – 1950

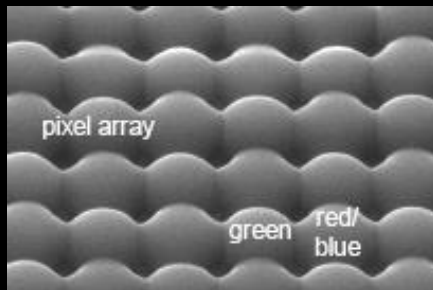
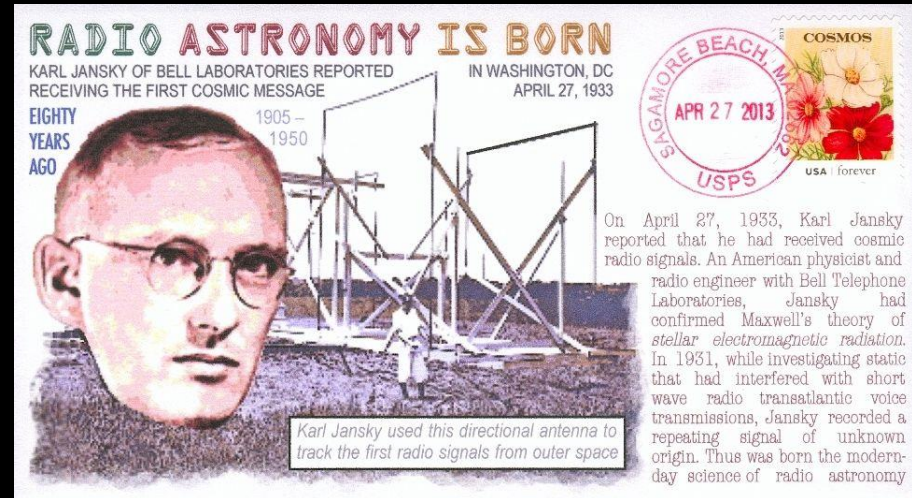
On April 27, 1933, Karl Jansky reported that he had received cosmic radio signals. An American physicist and radio engineer with Bell Telephone Laboratories, Jansky had confirmed Maxwell's theory of stellar electromagnetic radiation. In 1931, while investigating static that had interfered with short wave radio transatlantic voice transmissions, Jansky recorded a repeating signal of unknown origin. Thus was born the modern-day science of radio astronomy

Karl Jansky used this directional antenna to track the first radio signals from outer space







SEM image of  
iPhone 4 CCD



CCD invented at Bell Labs (Murray Hill NJ)  
by Willard Boyle and George Smith



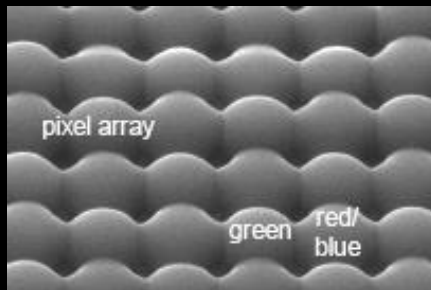
# Communicating

Telegraph & Telephone  
Bell

Radio & TV  
RCA

Satellites

Bell and RCA  
J. R. Pierce



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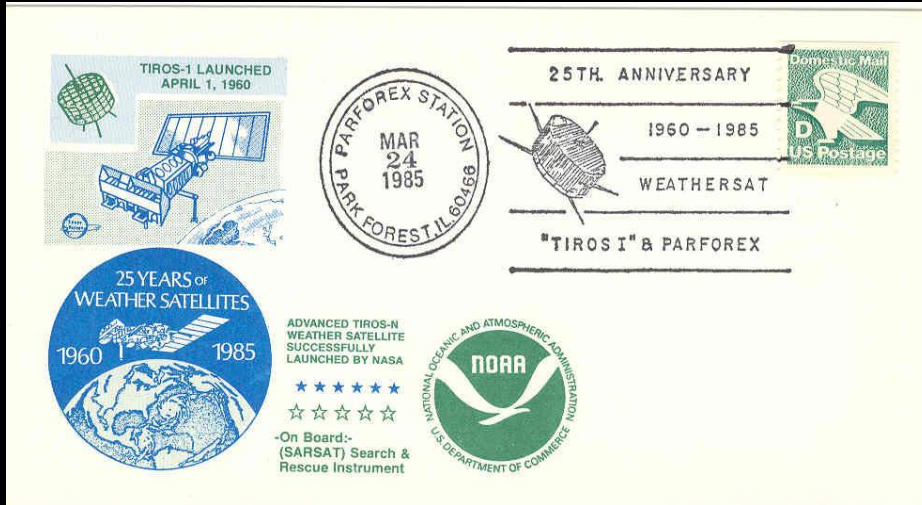
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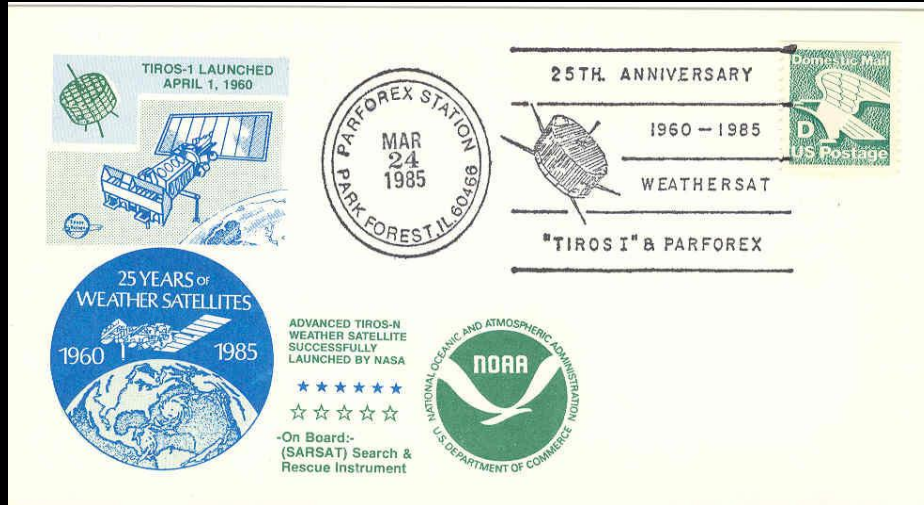
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TIROS 1 – first weather satellite  
RCA Astro Labs in East Windsor, NJ





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ECHO 1 – first communications relay  
Bell Labs – Holmdel, NJ



TELSTAR – first television pictures  
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# Computing

## Computer

John von Neumann

## UNIX

Dennis Ritchie

Ken Thompson

## C Programming Language

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Stamp issued in 1996  
50<sup>th</sup> anniversary of ENIAC



# Universities

Computer

Princeton and Penn

Telegraph

NYU

Radio & Laser

Columbia



Stamp issued in 1996  
50<sup>th</sup> anniversary of ENIAC



# PEOPLE

# Nobel Prizes

Electromagnet	Henry	
Relativity	Einstein	1921
Computer	Von Neumann	
Laser	Townes, Schawlow	1964, 1981
Electric Lamp	Edison	
Phonograph	Edison	
Transistor	Bardeen, Brattain, Shockley	1956
Satellite	Pierce	
CCD	Boyle, Smith	2009
UNIX & C	Ritchie, Thompson	
Radio & TV	Sarnoff, Armstrong	
Electric Power	Edison	
Motion Picture	Edison	
Bakelite	Baekeland	

# PLACES

Menlo Park

West Orange

Princeton

Harrison

Kearny

West Windsor

East Windsor

Trenton

Murray Hill

Holmdel

Morristown

NYC

Philadelphia

Perth Amboy

Phonograph, Electric Light

Motion Pictures, Later Phonograph

Von Neumann Computer

Lamps, Vacuum Tubes

Telephone manufacturing

Color TV

Satellite design and construction

Wire Rope for Brooklyn and GW Bridges

Transistor, Laser, CCD, UNIX

Satellite, Radio Astronomy

Telegraph tests

Central Station Electricity

ENIAC Computer

Bakelite

A few final observations and two questions ....

NJ technologies are transformational. They changed the way we live our lives.

NJ (and NYC and Philadelphia) nurtured many radical innovations (Radio, TV, Telephone, Electric Power, Transistor, Computer, Laser, Plastics). These objects and systems are the core of our modern **INFORMATION AND POWER NETWORKS.**

**It is a great history of early stage radical innovation**

**Two Questions – “Why NJ?” and “Why not NJ?”**