Steve Jobs, Bill Gates, and the PC
and
Course Review

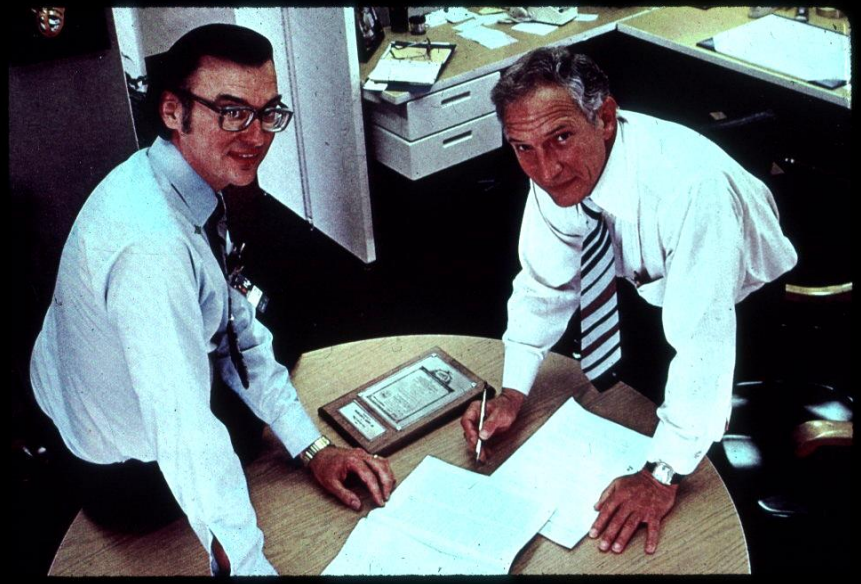
Radical Innovation and the Transformation of Daily Life

CEE 102: Prof. Michael G. Littman
Course Administrator: Peter Wang pywang@princeton.edu

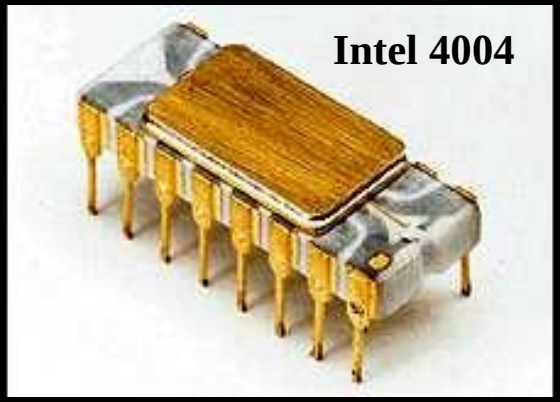
Computers for NOTETAKING ONLY
Please - NO Cell Phones, texting, email, shopping

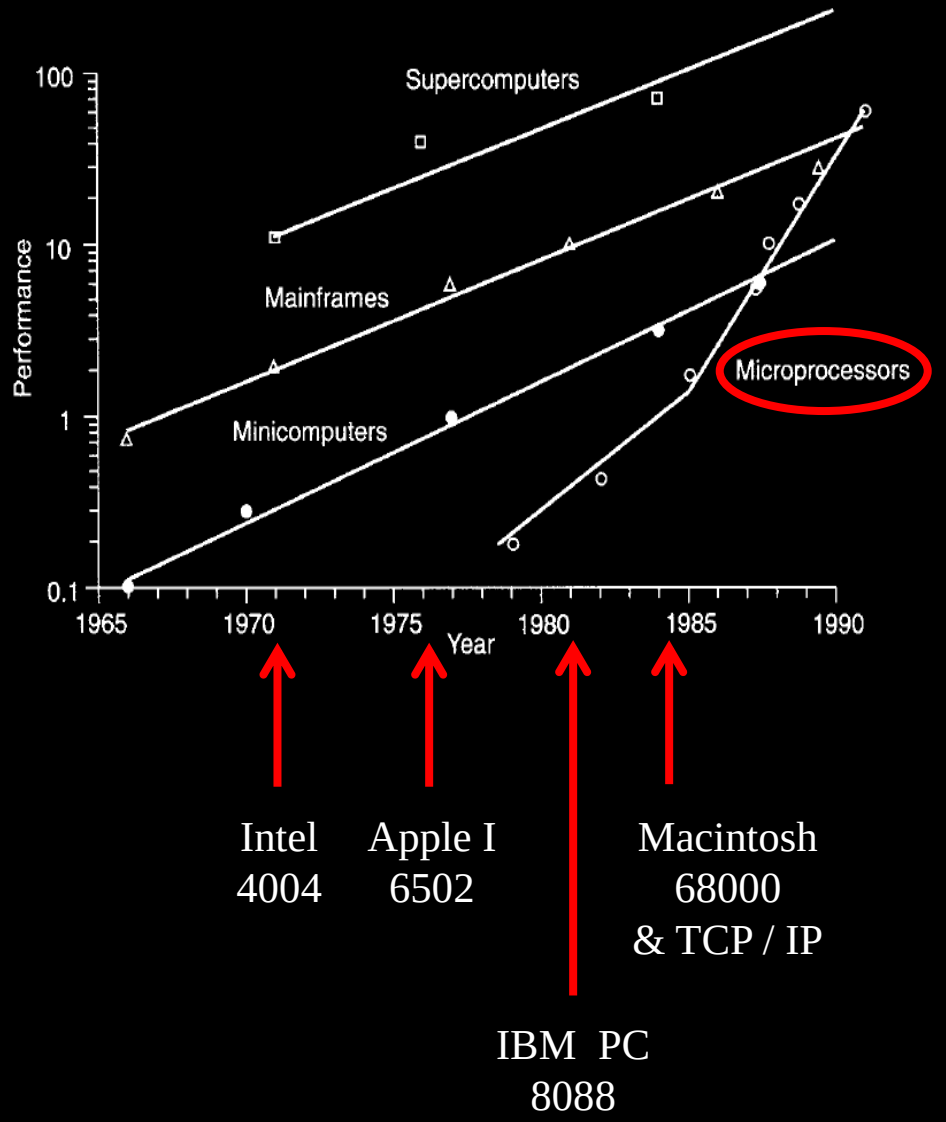
Components of Innovation

Inventor and Entrepreneur



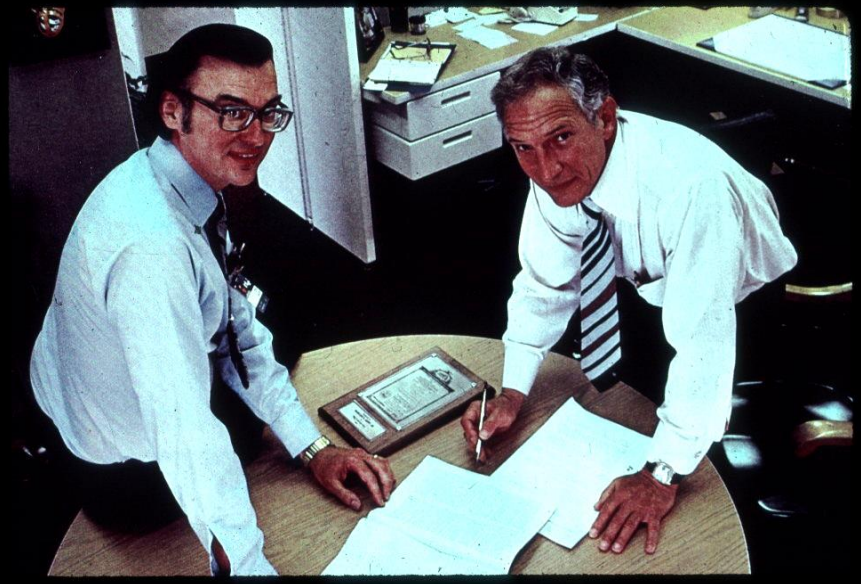
Noyce and Hoff – 4 bit Microcomputer



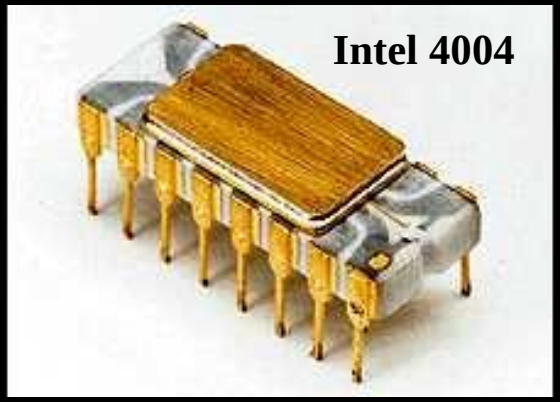


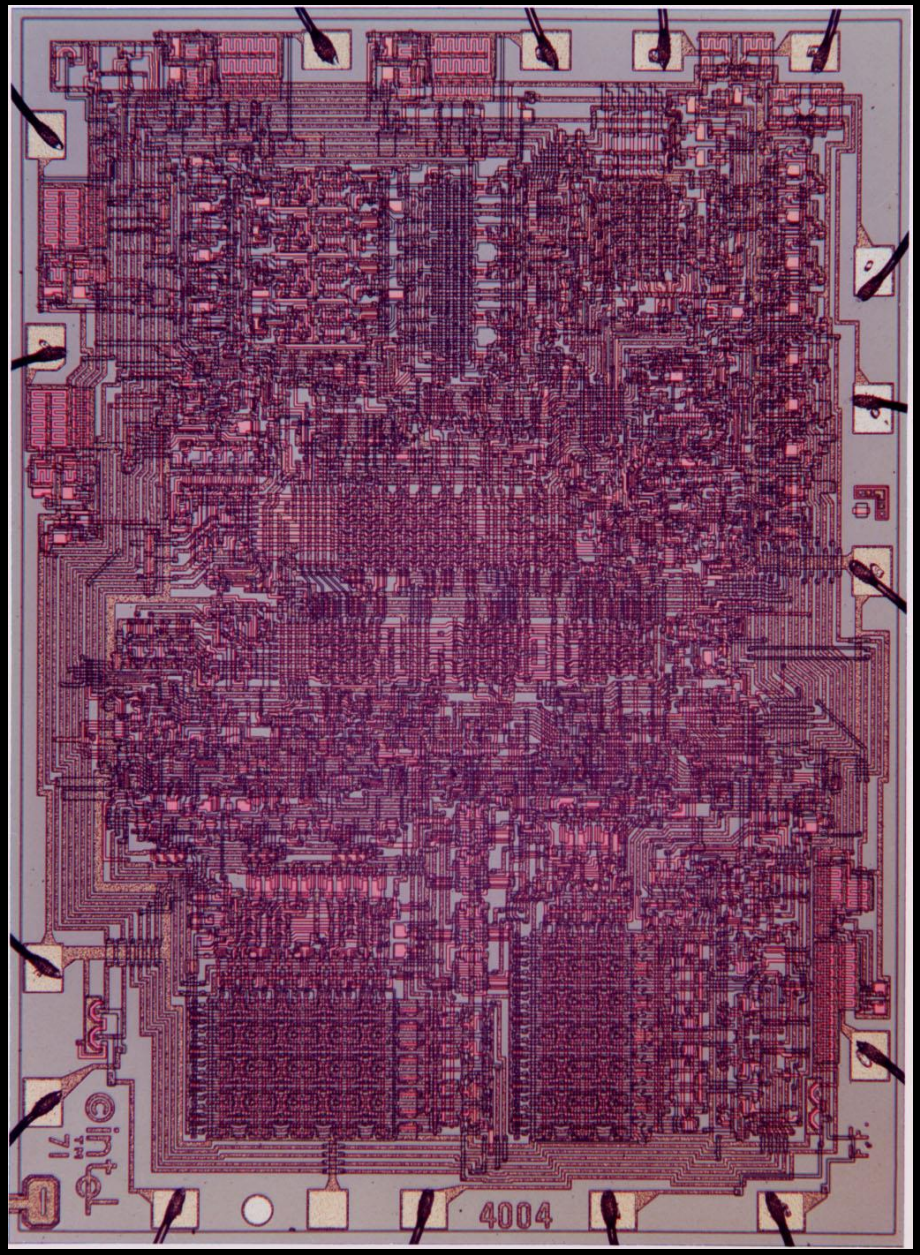
Components of Innovation

Inventor and Entrepreneur



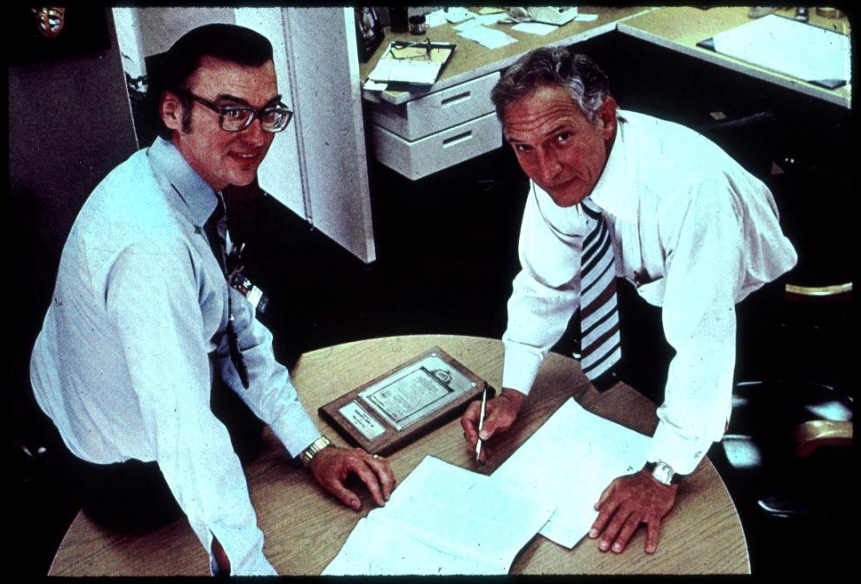
Noyce and Hoff – 4 bit Microcomputer



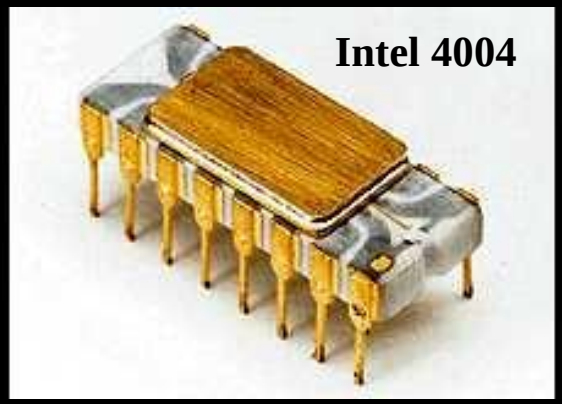


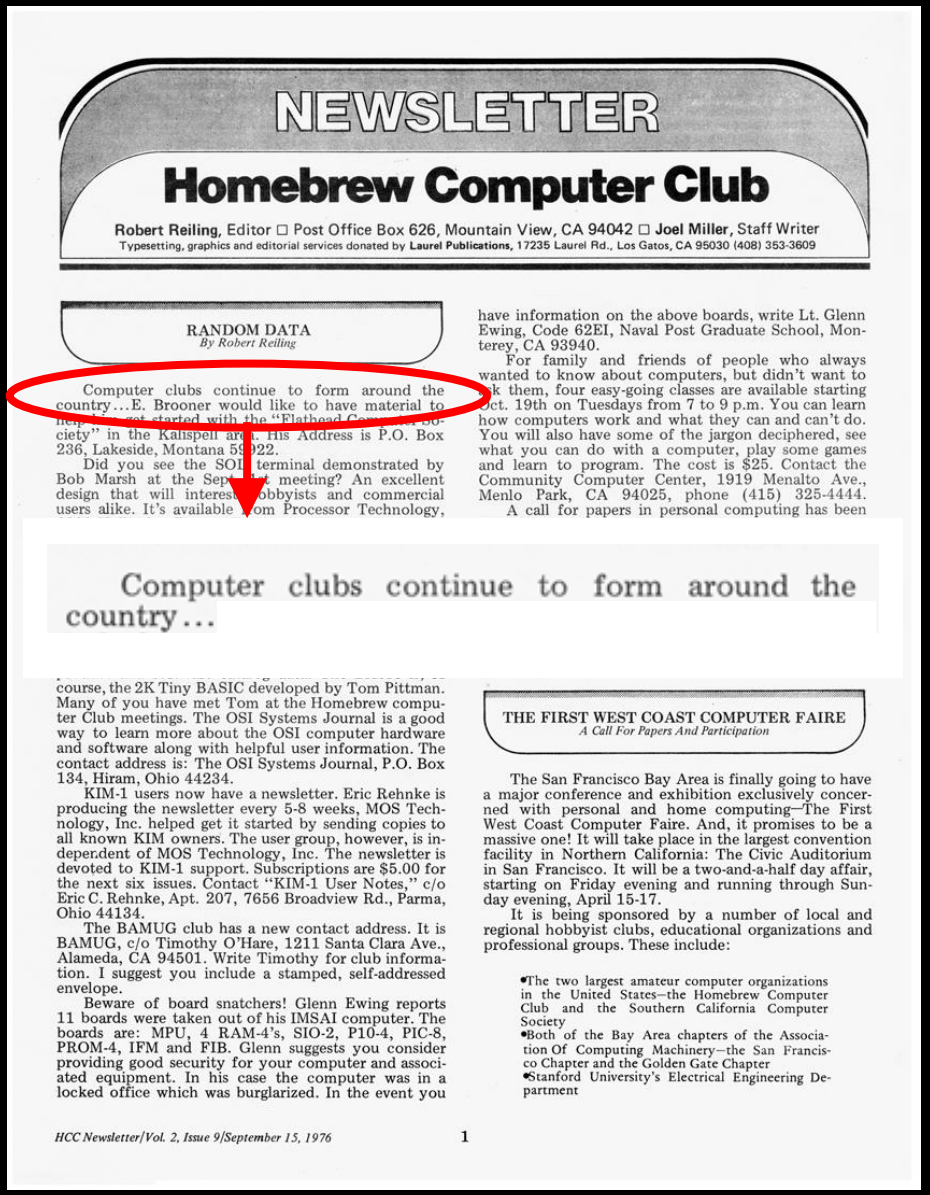
Components of Innovation

Inventor and Entrepreneur



Noyce and Hoff – 4 bit Microcomputer





NEWSLETTER

Homebrew Computer Club

Robert Reiling, Editor □ Post Office Box 626, Mountain View, CA 94042 □ **Joel Miller**, Staff Writer
Typesetting, graphics and editorial services donated by **Laurel Publications**, 17235 Laurel Rd., Los Gatos, CA 95030 (408) 353-3609

RANDOM DATA
By Robert Reiling

Computer clubs continue to form around the country...E. Brooner would like to have material to help him get started with the "Flathead Computer Society" in the Kalispell area. His Address is P.O. Box 236, Lakeside, Montana 59922.

Did you see the SOI terminal demonstrated by Bob Marsh at the September meeting? An excellent design that will interest hobbyists and commercial users alike. It's available from Processor Technology,

Computer clubs continue to form around the country...

course, the 2K Tiny BASIC developed by Tom Pittman. Many of you have met Tom at the Homebrew computer Club meetings. The OSI Systems Journal is a good way to learn more about the OSI computer hardware and software along with helpful user information. The contact address is: The OSI Systems Journal, P.O. Box 134, Hiram, Ohio 44234.

KIM-1 users now have a newsletter. Eric Rehnke is producing the newsletter every 5-8 weeks, MOS Technology, Inc. helped get it started by sending copies to all known KIM owners. The user group, however, is independent of MOS Technology, Inc. The newsletter is devoted to KIM-1 support. Subscriptions are $5.00 for the next six issues. Contact "KIM-1 User Notes," c/o Eric C. Rehnke, Apt. 207, 7656 Broadview Rd., Parma, Ohio 44134.

The BAMUG club has a new contact address. It is BAMUG, c/o Timothy O'Hare, 1211 Santa Clara Ave., Alameda, CA 94501. Write Timothy for club information. I suggest you include a stamped, self-addressed envelope.

Beware of board snatchers! Glenn Ewing reports 11 boards were taken out of his IMSAI computer. The boards are: MPU, 4 RAM-4's, SIO-2, P10-4, PIC-8, PROM-4, IFM and FIB. Glenn suggests you consider providing good security for your computer and associated equipment. In his case the computer was in a locked office which was burglarized. In the event you have information on the above boards, write Lt. Glenn Ewing, Code 62EI, Naval Post Graduate School, Monterey, CA 93940.

For family and friends of people who always wanted to know about computers, but didn't want to ask them, four easy-going classes are available starting Oct. 19th on Tuesdays from 7 to 9 p.m. You can learn how computers work and what they can and can't do. You will also have some of the jargon deciphered, see what you can do with a computer, play some games and learn to program. The cost is $25. Contact the Community Computer Center, 1919 Menalto Ave., Menlo Park, CA 94025, phone (415) 325-4444.

A call for papers in personal computing has been

THE FIRST WEST COAST COMPUTER FAIRE
A Call For Papers And Participation

The San Francisco Bay Area is finally going to have a major conference and exhibition exclusively concerned with personal and home computing—The First West Coast Computer Faire. And, it promises to be a massive one! It will take place in the largest convention facility in Northern California: The Civic Auditorium in San Francisco. It will be a two-and-a-half day affair, starting on Friday evening and running through Sunday evening, April 15-17.

It is being sponsored by a number of local and regional hobbyist clubs, educational organizations and professional groups. These include:

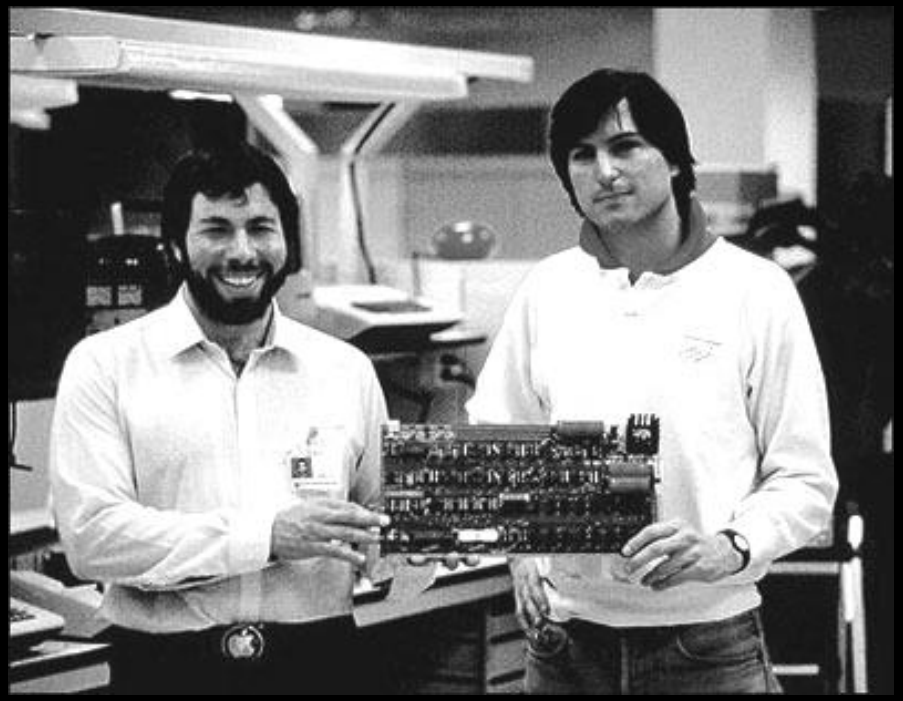
- The two largest amateur computer organizations in the United States—the Homebrew Computer Club and the Southern California Computer Society
- Both of the Bay Area chapters of the Association Of Computing Machinery—the San Francisco Chapter and the Golden Gate Chapter
- Stanford University's Electrical Engineering Department

HCC Newsletter/Vol. 2, Issue 9/September 15, 1976 1

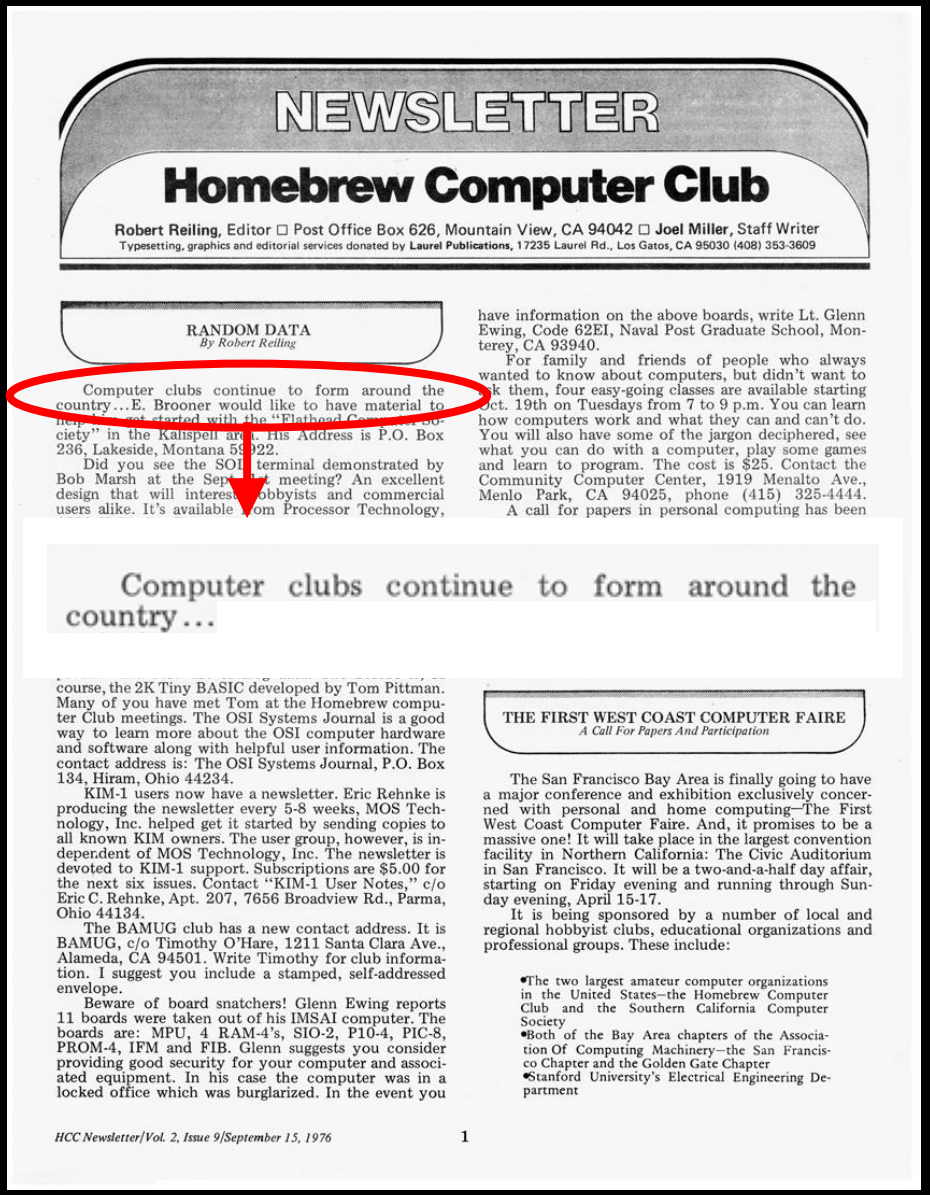
Homebrew Computer Club
Silicon Valley 1975

Components of Innovation

Inventor and Entrepreneur



Wozniak and Jobs
Apple Computer founded in 1976
(MOS Technology 6502 – 8 bit)



NEWSLETTER

Homebrew Computer Club

Robert Reiling, Editor □ Post Office Box 626, Mountain View, CA 94042 □ Joel Miller, Staff Writer
Typesetting, graphics and editorial services donated by Laurel Publications, 17235 Laurel Rd., Los Gatos, CA 95030 (408) 353-3609

RANDOM DATA
By Robert Reiling

Computer clubs continue to form around the country...E. Brooner would like to have material to help [illegible] get started with the "Flathead Computer Society" in the Kalispell area. His Address is P.O. Box 236, Lakeside, Montana 59922.

Did you see the SOL terminal demonstrated by Bob Marsh at the Sept[illegible] meeting? An excellent design that will interest hobbyists and commercial users alike. It's available from Processor Technology,

Computer clubs continue to form around the country...

have information on the above boards, write Lt. Glenn Ewing, Code 62EI, Naval Post Graduate School, Monterey, CA 93940.

For family and friends of people who always wanted to know about computers, but didn't want to ask them, four easy-going classes are available starting Oct. 19th on Tuesdays from 7 to 9 p.m. You can learn how computers work and what they can and can't do. You will also have some of the jargon deciphered, see what you can do with a computer, play some games and learn to program. The cost is $25. Contact the Community Computer Center, 1919 Menalto Ave., Menlo Park, CA 94025, phone (415) 325-4444.

A call for papers in personal computing has been

course, the 2K Tiny BASIC developed by Tom Pittman. Many of you have met Tom at the Homebrew computer Club meetings. The OSI Systems Journal is a good way to learn more about the OSI computer hardware and software along with helpful user information. The contact address is: The OSI Systems Journal, P.O. Box 134, Hiram, Ohio 44234.

KIM-1 users now have a newsletter. Eric Rehnke is producing the newsletter every 5-8 weeks, MOS Technology, Inc. helped get it started by sending copies to all known KIM owners. The user group, however, is independent of MOS Technology, Inc. The newsletter is devoted to KIM-1 support. Subscriptions are $5.00 for the next six issues. Contact "KIM-1 User Notes," c/o Eric C. Rehnke, Apt. 207, 7656 Broadview Rd., Parma, Ohio 44134.

The BAMUG club has a new contact address. It is BAMUG, c/o Timothy O'Hare, 1211 Santa Clara Ave., Alameda, CA 94501. Write Timothy for club information. I suggest you include a stamped, self-addressed envelope.

Beware of board snatchers! Glenn Ewing reports 11 boards were taken out of his IMSAI computer. The boards are: MPU, 4 RAM-4's, SIO-2, P10-4, PIC-8, PROM-4, IFM and FIB. Glenn suggests you consider providing good security for your computer and associated equipment. In his case the computer was in a locked office which was burglarized. In the event you

THE FIRST WEST COAST COMPUTER FAIRE
A Call For Papers And Participation

The San Francisco Bay Area is finally going to have a major conference and exhibition exclusively concerned with personal and home computing—The First West Coast Computer Faire. And, it promises to be a massive one! It will take place in the largest convention facility in Northern California: The Civic Auditorium in San Francisco. It will be a two-and-a-half day affair, starting on Friday evening and running through Sunday evening, April 15-17.

It is being sponsored by a number of local and regional hobbyist clubs, educational organizations and professional groups. These include:

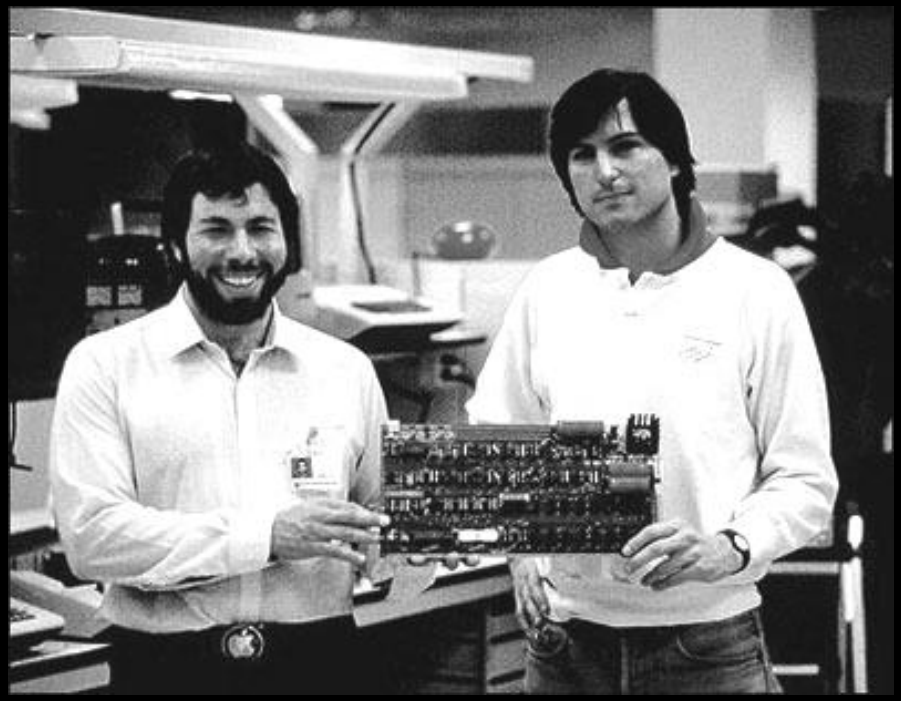
- The two largest amateur computer organizations in the United States—the Homebrew Computer Club and the Southern California Computer Society
- Both of the Bay Area chapters of the Association Of Computing Machinery—the San Francisco Chapter and the Golden Gate Chapter
- Stanford University's Electrical Engineering Department

HCC Newsletter/Vol. 2, Issue 9/September 15, 1976 1

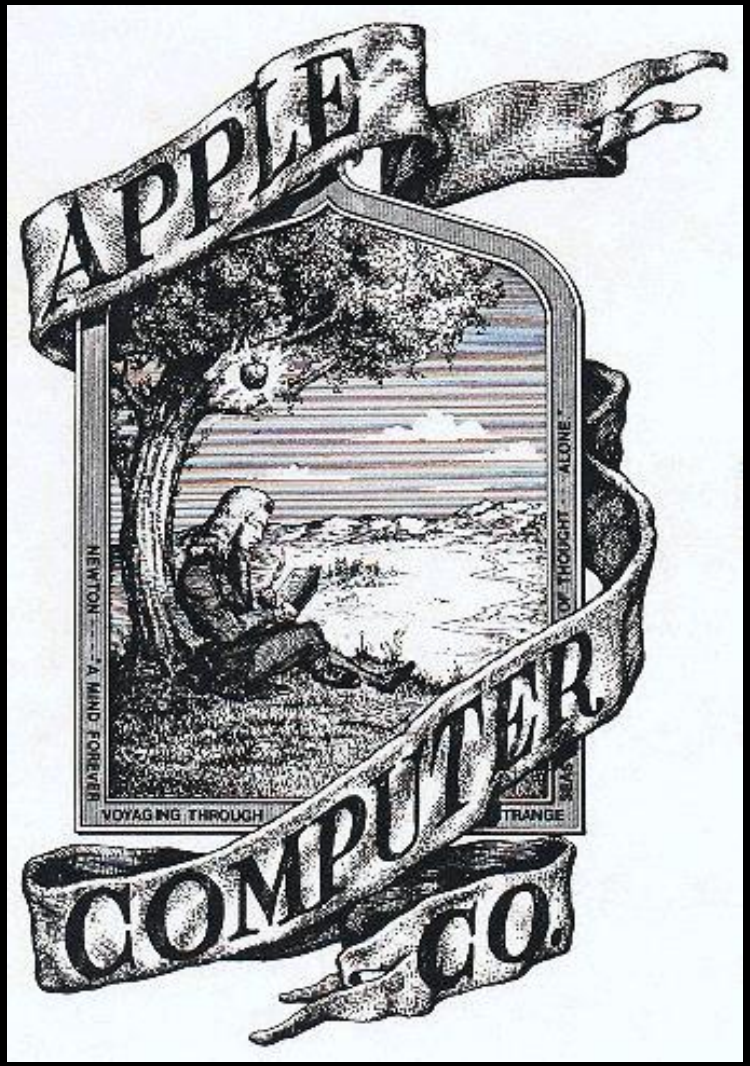
Homebrew Computer Club
Silicon Valley 1975

Components of Innovation

Inventor and Entrepreneur



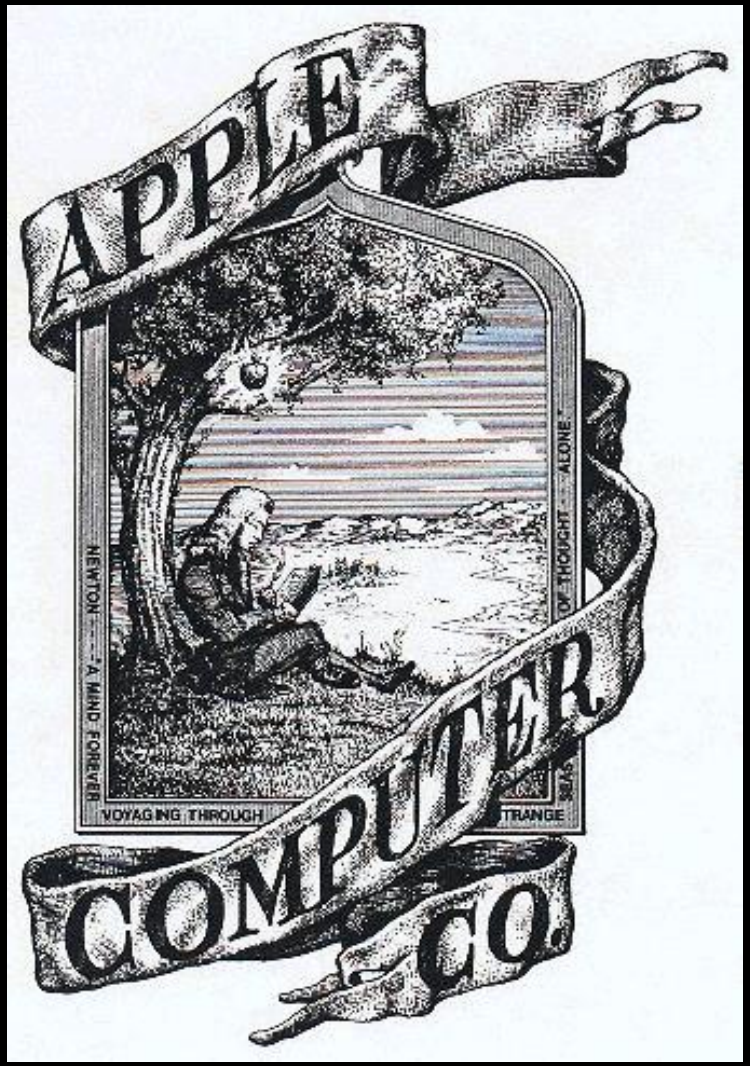
Wozniak and Jobs
Apple Computer founded in 1976
(MOS Technology 6502 – 8 bit)


APPLE
NEWTON ---"A MIND FOREVER
OF THOUGHT --- ALONE"
VOYAGING THROUGH
STRANGE
COMPUTER
CO.

Jobs

Hewlett - Packard

Ford



Think different.

Apple Introduces the First Low Cost Microcomputer System with a Video Terminal and 8K Bytes of RAM on a Single PC Card.

The Apple Computer. A truly complete microcomputer system on a single PC board. Based on the MOS Technology 6502 microprocessor, the Apple also has a built-in video terminal and sockets for 8K bytes of on-board RAM memory. With the addition of a keyboard and video monitor, you'll have an extremely powerful computer system that can be used for anything from developing programs to playing games or running BASIC.

Combining the computer, video terminal and dynamic memory on a single board has resulted in a large reduction in chip count, which means more reliability and lowered cost. Since the Apple comes fully assembled, tested & burned-in and has a complete power supply on-board, initial set-up is essentially "hassle free" and you can be running within minutes. At $666.66 (including 4K bytes RAM!) it opens many new possibilities for users and systems manufacturers.

You Don't Need an Expensive Teletype.

Using the built-in video terminal and keyboard interface, you avoid all the expense, noise and maintenance associated with a teletype. And the Apple video terminal is six times faster than a teletype, which means more throughput and less waiting. The Apple connects directly to a video monitor (or home TV with an inexpensive RF modulator) and displays 960 easy to read characters in 24 rows of 40 characters per line with automatic scrolling. The video display section contains its own 1K bytes of memory, so all the RAM memory is available for user programs. And the Keyboard Interface lets you use almost any ASCII-encoded keyboard.

The Apple Computer makes it possible for many people with limited budgets to step up to a video terminal as an I/O device for their computer.

No More Switches, No More Lights.

Compared to switches and LED's, a video terminal can display vast amounts of information simultaneously. The Apple video terminal can display the contents of 192 memory locations at once on the screen. And the firmware in PROMS enables you to enter, display and debug programs (all in hex) from the keyboard, rendering a front panel unnecessary. The firmware also allows your programs to print characters on the display, and since you'll be looking at letters and numbers instead of just LED's, the door is open to all kinds of alphanumeric software (i.e., Games and BASIC).

8K Bytes RAM in 16 Chips!

The Apple Computer uses the new 16-pin 4K dynamic memory chips. They are faster and take ¼ the space and power of even the low power 2102's (the memory chip that everyone else uses). That means 8K bytes in sixteen chips. It also means no more 28 amp power supplies.

The system is fully expandable to 65K via an edge connector which carries both the address and data busses, power supplies and all timing signals. All dynamic memory refreshing for both on and off-board memory is done automatically. Also, the Apple Computer can be upgraded to use the 16K chips when they become available. That's 32K bytes on-board RAM in 16 IC's—the equivalent of 256 2102's!

A Little Cassette Board That Works!

Unlike many other cassette boards on the marketplace, ours works every time. It plugs directly into the upright connector on the main board and stands only 2" tall. And since it is very fast (1500 bits per second), you can read or write 4K bytes in about 20 seconds. All timing is done in software, which results in crystal-controlled accuracy and uniformity from unit to unit.

Unlike some other cassette interfaces which require an expensive tape recorder, the Apple Cassette Interface works reliably with almost any audio-grade cassette recorder.

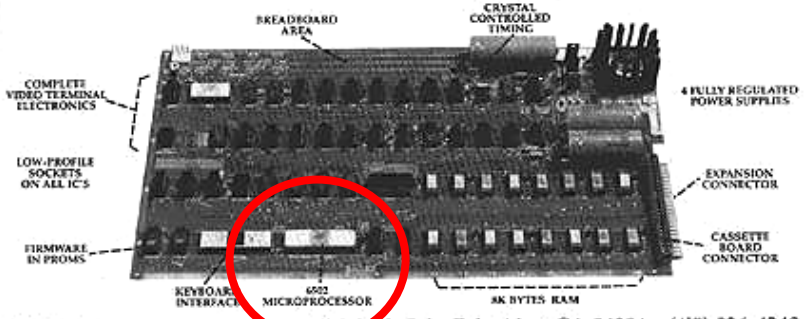
Software:

A tape of **APPLE BASIC** is included free with the Cassette Interface. Apple Basic features immediate error messages and fast execution, and lets you program in a higher level language immediately and without added cost. Also available **now** are a dis-assembler and many games, with many software packages, (including a macro assembler) in the works. And since our philosophy is to provide software for our machines free or at minimal cost, you won't be continually paying for access to this growing software library.

The Apple Computer is in stock at almost all major computer stores. (If your local computer store doesn't carry our products, encourage them or write us direct). **Dealer inquiries invited.**

Byte into an Apple $666.66*

*Includes 4K bytes RAM



APPLE Computer Company • 770 Welch Rd., Palo Alto, CA 94304 • (415) 326-4248

Think different.

Apple Introduces the First Low Cost Microcomputer System with a Video Terminal and 8K Bytes of RAM on a Single PC Card.

The Apple Computer. A truly complete microcomputer system on a single PC board. Based on the MOS Technology 6502 microprocessor, the Apple also has a built-in video terminal and sockets for 8K bytes of on-board RAM memory. With the addition of a keyboard and video monitor, you'll have an extremely powerful computer system that can be used for anything from developing programs to playing games or running BASIC.

Combining the computer, video terminal and dynamic memory on a single board has resulted in a large reduction in chip count, which means more reliability and lowered cost. Since the Apple comes fully assembled, tested & burned-in and has a complete power supply on-board, initial set-up is essentially "hassle free" and you can be running within minutes. At $666.66 (including 4K bytes RAM!) it opens many new possibilities for users and systems manufacturers.

You Don't Need an Expensive Teletype.

Using the built-in video terminal and keyboard interface, you avoid all the expense, noise and maintenance associated with a teletype. And the Apple video terminal is six times faster than a teletype, which means more throughput and less waiting. The Apple connects directly to a video monitor (or home TV with an inexpensive RF modulator) and displays 960 easy to read characters in 24 rows of 40 characters per line with automatic scrolling. The video display section contains its own 1K bytes of memory, so all the RAM memory is available for user programs. And the Keyboard Interface lets you use almost any ASCII-encoded keyboard.

The Apple Computer makes it possible for many people with limited budgets to step up to a video terminal as an I/O device for their computer.

No More Switches, No More Lights.

Compared to switches and LED's, a video terminal can display vast amounts of information simultaneously. The Apple video terminal can display the contents of 192 memory locations at once on the screen. And the firmware in PROMS enables you to enter, display and debug programs (all in hex) from the keyboard, rendering a front panel unnecessary. The firmware also allows your programs to print characters on the display, and since you'll be looking at letters and numbers instead of just LED's, the door is open to all kinds of alphanumeric software (i.e., Games and BASIC).

8K Bytes RAM in 16 Chips!

The Apple Computer uses the new 16-pin 4K dynamic memory chips. They are faster and take ¼ the space and power of even the low power 2102's (the memory chip that everyone else uses). That means 8K bytes in sixteen chips. It also means no more 28 amp power supplies.

The system is fully expandable to 65K via an edge connector which carries both the address and data busses, power supplies and all timing signals. All dynamic memory refreshing for both on and off-board memory is done automatically. Also, the Apple Computer can be upgraded to use the 16K chips when they become available. That's 32K bytes on-board RAM in 16 IC's—the equivalent of 256 2102's!

A Little Cassette Board That Works!

Unlike many other cassette boards on the marketplace, ours works every time. It plugs directly into the upright connector on the main board and stands only 2" tall. And since it is very fast (1500 bits per second), you can read or write 4K bytes in about 20 seconds. All timing is done in software, which results in crystal-controlled accuracy and uniformity from unit to unit.

Unlike some other cassette interfaces which require an expensive tape recorder, the Apple Cassette Interface works reliably with almost any audio-grade cassette recorder.

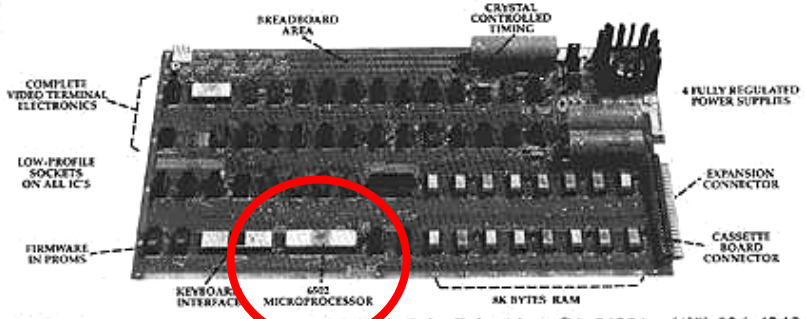
Software:

A tape of **APPLE BASIC** is included free with the Cassette Interface. Apple Basic features immediate error messages and fast execution, and lets you program in a higher level language immediately and without added cost. Also available **now** are a dis-assembler and many games, with many software packages, (including a macro assembler) in the works. And since our philosophy is to provide software for our machines free or at minimal cost, you won't be continually paying for access to this growing software library.

The Apple Computer is in stock at almost all major computer stores. (If your local computer store doesn't carry our products, encourage them or write us direct). **Dealer inquiries invited.**

Byte into an Apple $666.66*

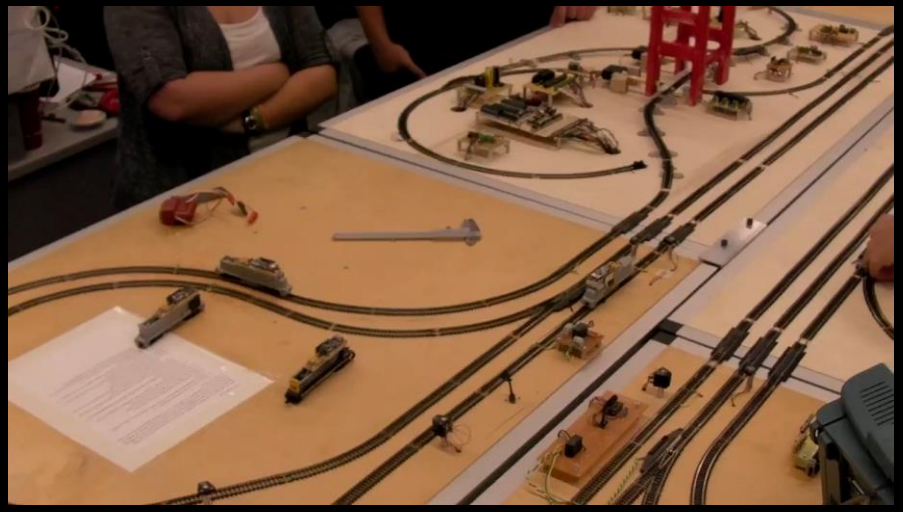
*Includes 4K bytes RAM



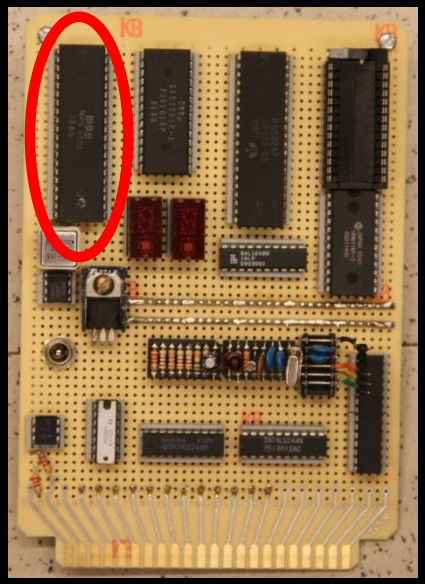
APPLE Computer Company • 770 Welch Rd., Palo Alto, CA 94304 • (415) 326-4248

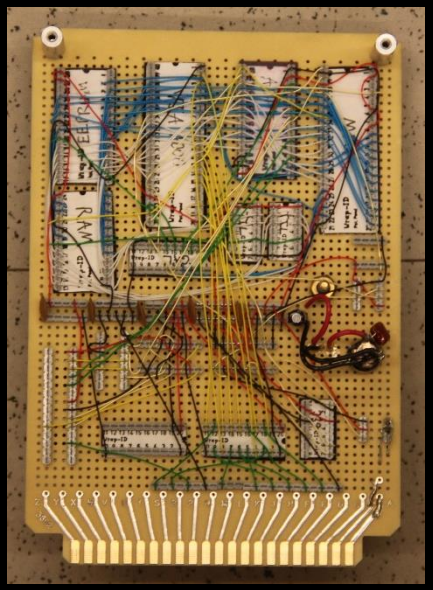
Demonstration

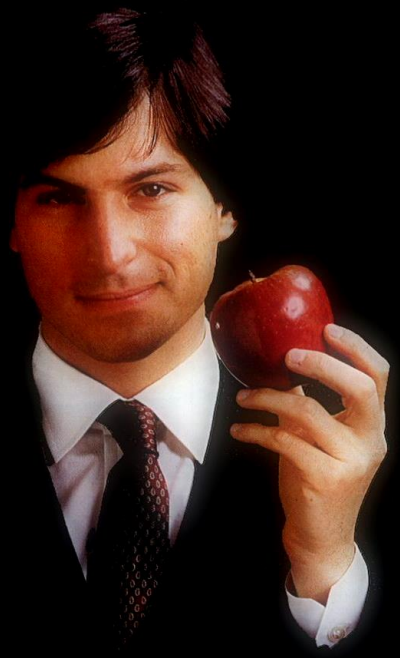
Think different.



6502

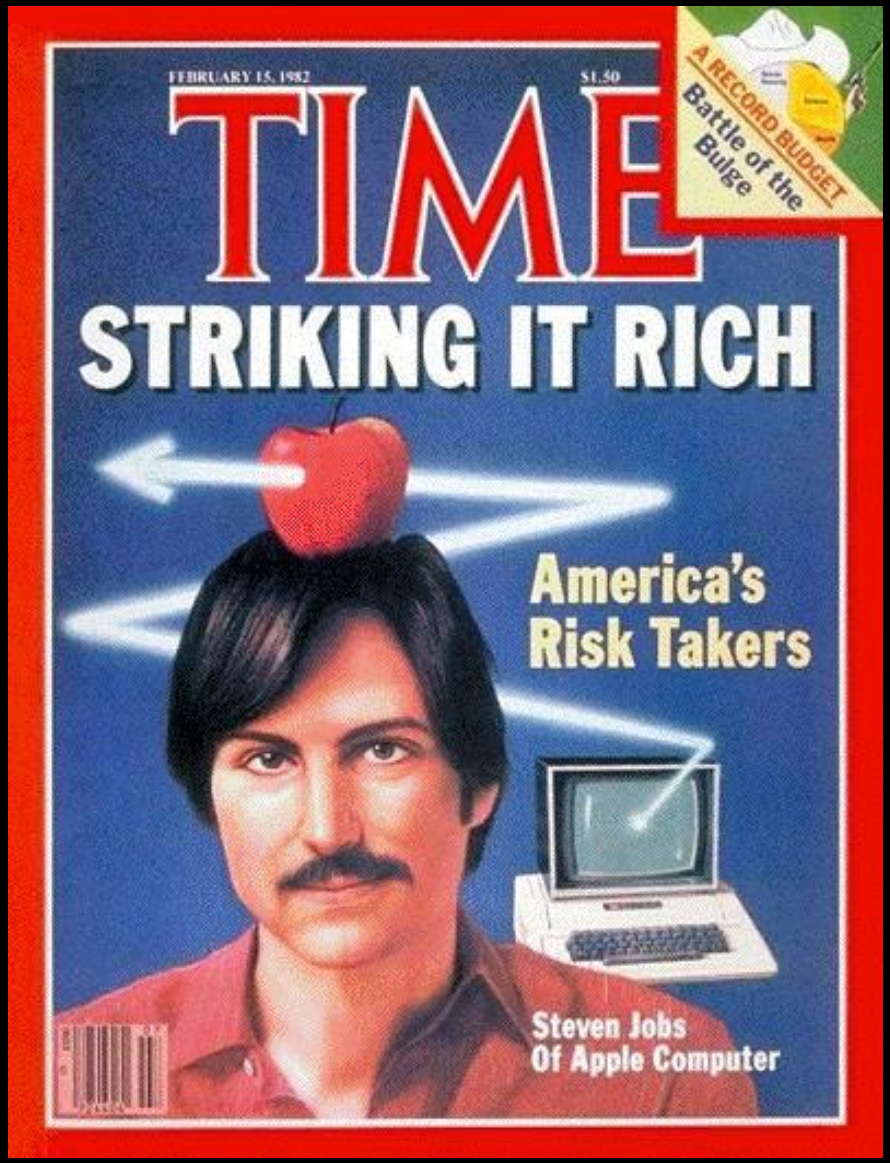


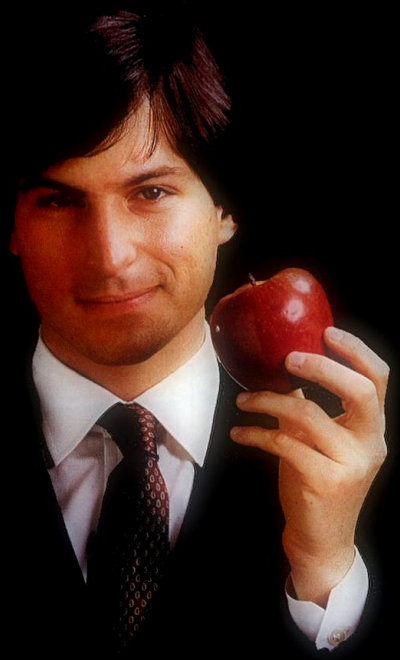




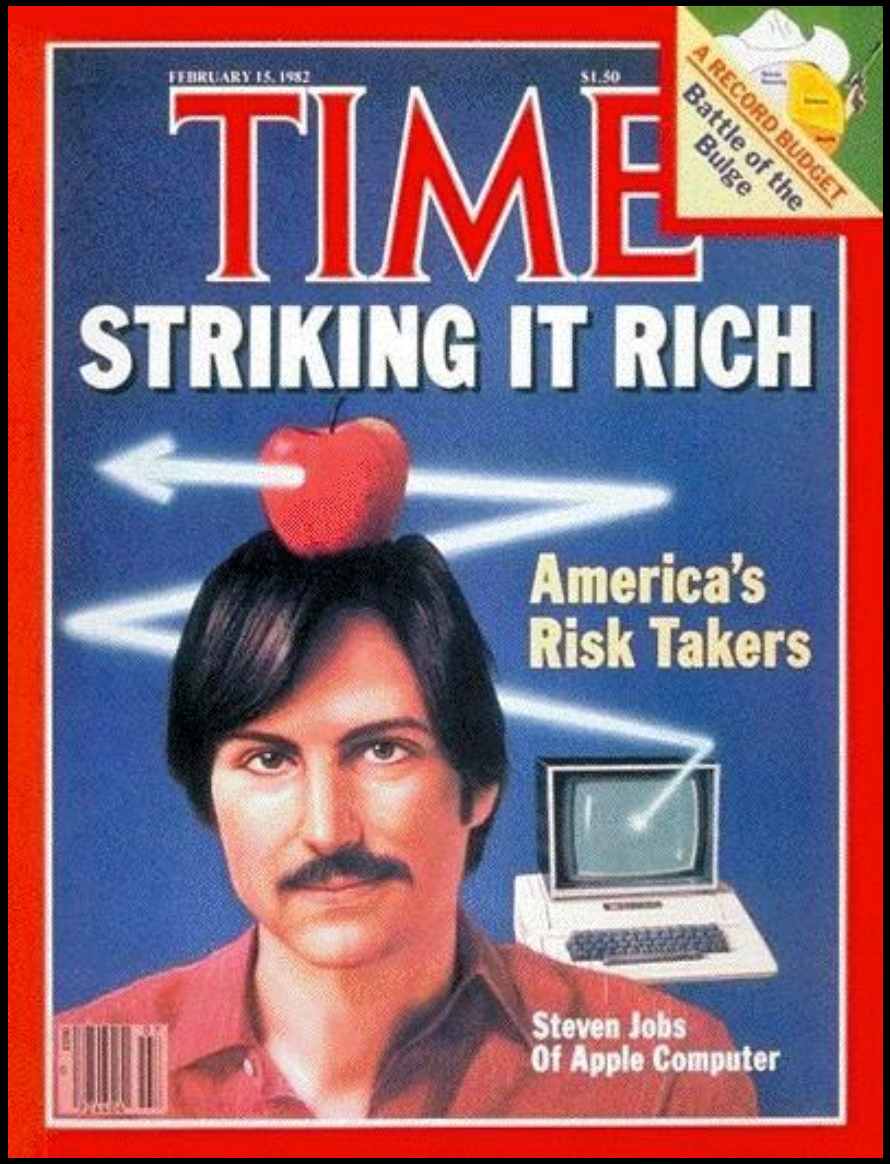
Demonstration

Think different.



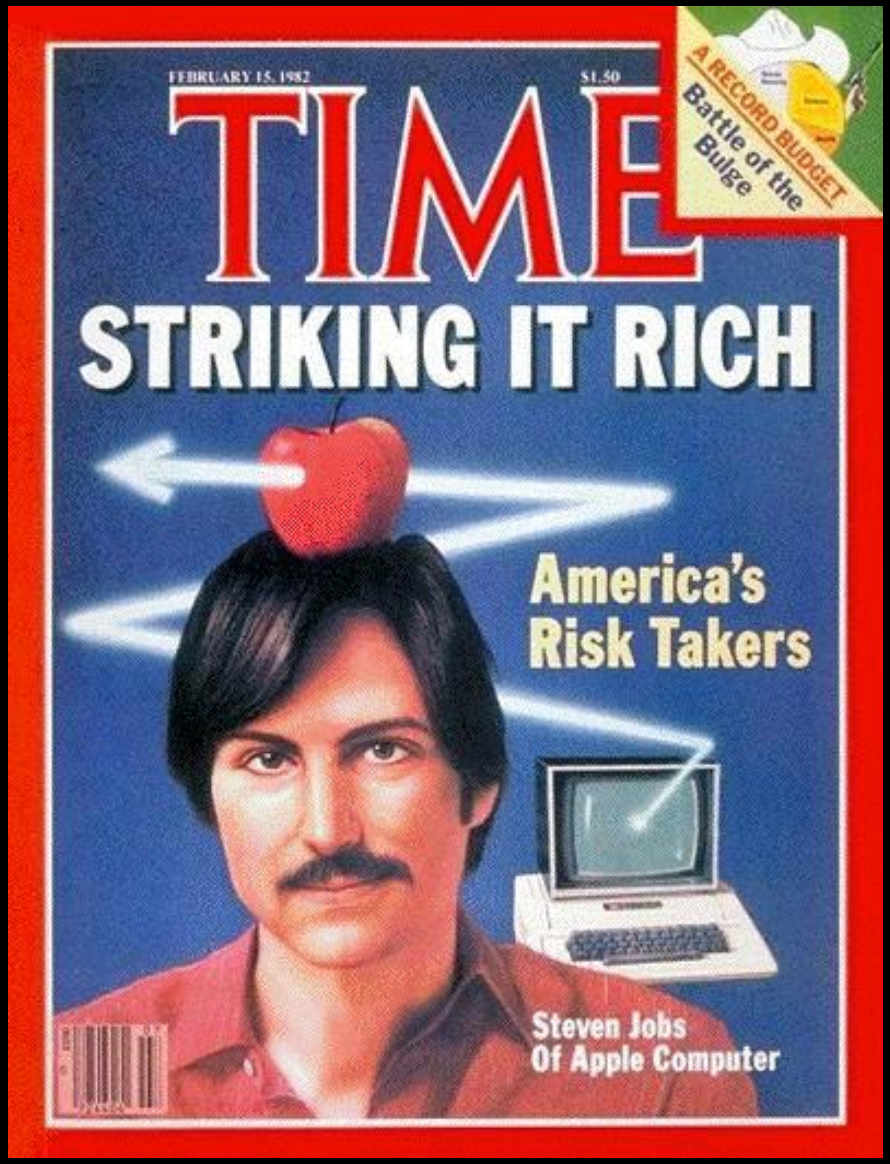


Think different.

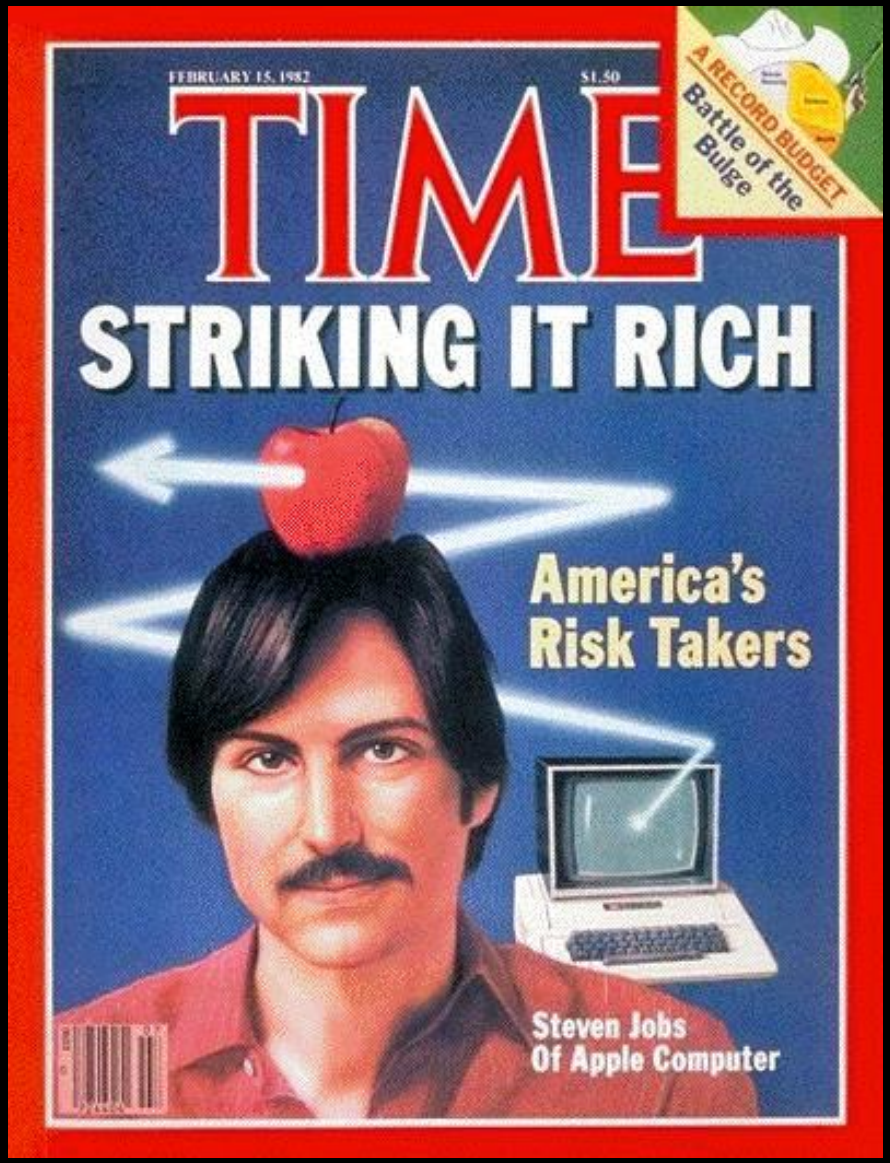


Macintosh 128K – 1984
(Motorola 68000 – 16 bit)
Graphical User Interface

DEMONSTRATION



PERQ - 1979
(Custom Bit Slice Processor)
Graphical User Interface
First GUI Computer


FEBRUARY 15, 1982
$1.50
TIME
A RECORD BUDGET
Battle of the Bulge
STRIKING IT RICH
America's Risk Takers
Steven Jobs
Of Apple Computer

DIVORCE
The New Debate
TIME
EXCLUSIVE: Inside the Apple-Microsoft Deal
"Bill, thank you. The world's a better place."
—Steve Jobs talking to Bill Gates by cell phone last week about saving Apple

KACZYNSKI SPEAKS
TIME
Steve's Jobs
He saved Apple with his hot new iMac. He struck gold at Pixar with digital movies like Toy Story 2. You'd think he'd learn to chill. Think different.

DIVORCE
The New Debate
TIME
EXCLUSIVE: Inside the Apple-Microsoft Deal
"Bill, thank you. The world's a better place."
—Steve Jobs talking to Bill Gates by cell phone last week about saving Apple

KACZYNSKI SPEAKS
TIME
Steve's Jobs
He saved Apple with his hot new iMac. He struck gold at Pixar with digital movies like Toy Story 2. You'd think he'd learn to chill. Think different.

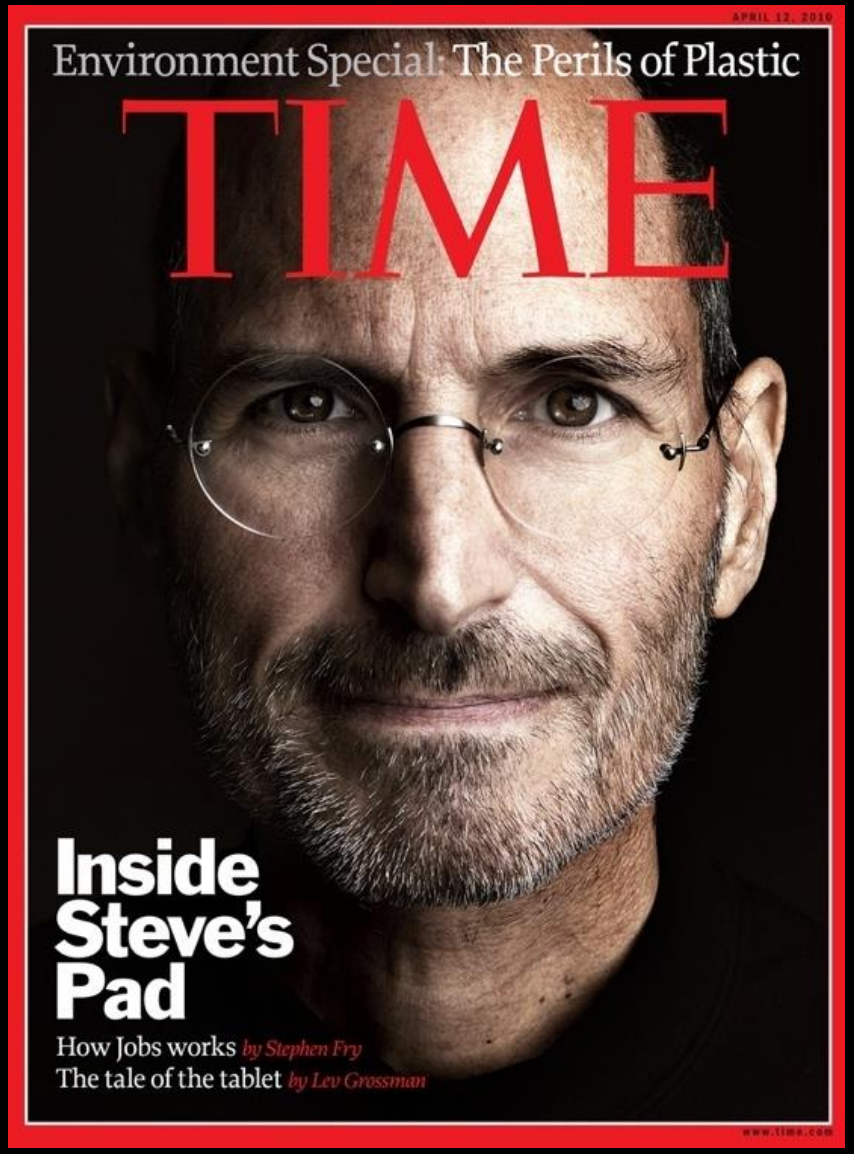
AFGHANISTAN: DEADLY HUNT
INDIA & PAKISTAN: WAR DANCE
TIME
FLAT-OUT
COOL!
Steve Jobs thinks he has seen the future—again. Apple's new iMac is an all-in-one hub for music, pictures and movies. It's elegant and affordable. But will millions of PC users get it?

OCTOBER 24, 2005
www.time.com AOL Keyword: TIME
IRAQ: SUICIDE TRAINER ■ THE GREAT PLANET HUNT ■ FAT FIGHTERS
TIME
THE MAN WHO ALWAYS SEEMS TO KNOW...
WHAT'S NEXT
PLUS
TRENDSPOTTING with Moby, Malcolm Gladwell, David Brooks and Esther Dyson
5 NEW THINGS that will blow your mind
CLINT EASTWOOD'S revolutionary movie for 2006
Apple CEO Steve Jobs with the new video iPod and iMac

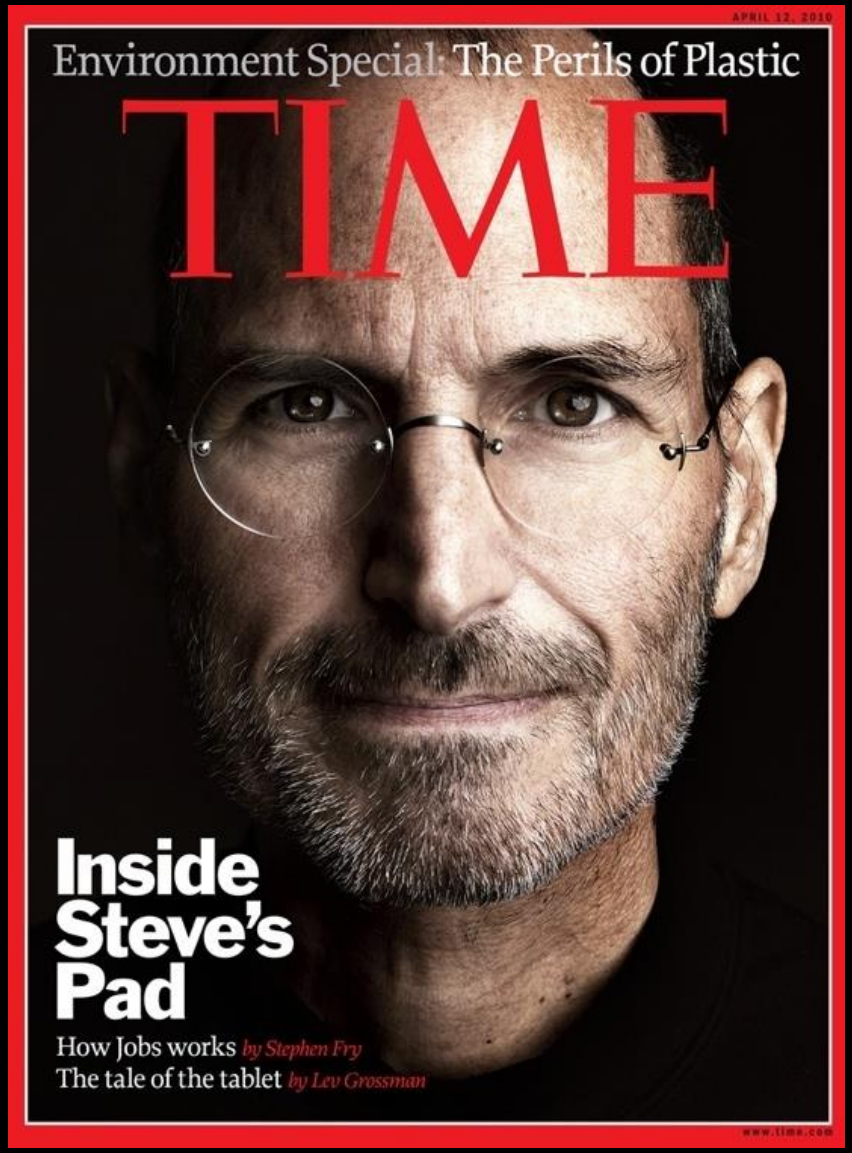
JANUARY 14, 2002
www.time.com AOL Keyword: TIME
AFGHANISTAN: DEADLY HUNT ■ INDIA & PAKISTAN: WAR DANCE
TIME
FLAT-OUT COOL!
Steve Jobs thinks he has seen the future—again. Apple's new iMac is an all-in-one hub for music, pictures and movies. It's elegant and affordable. But will millions of PC users get it?

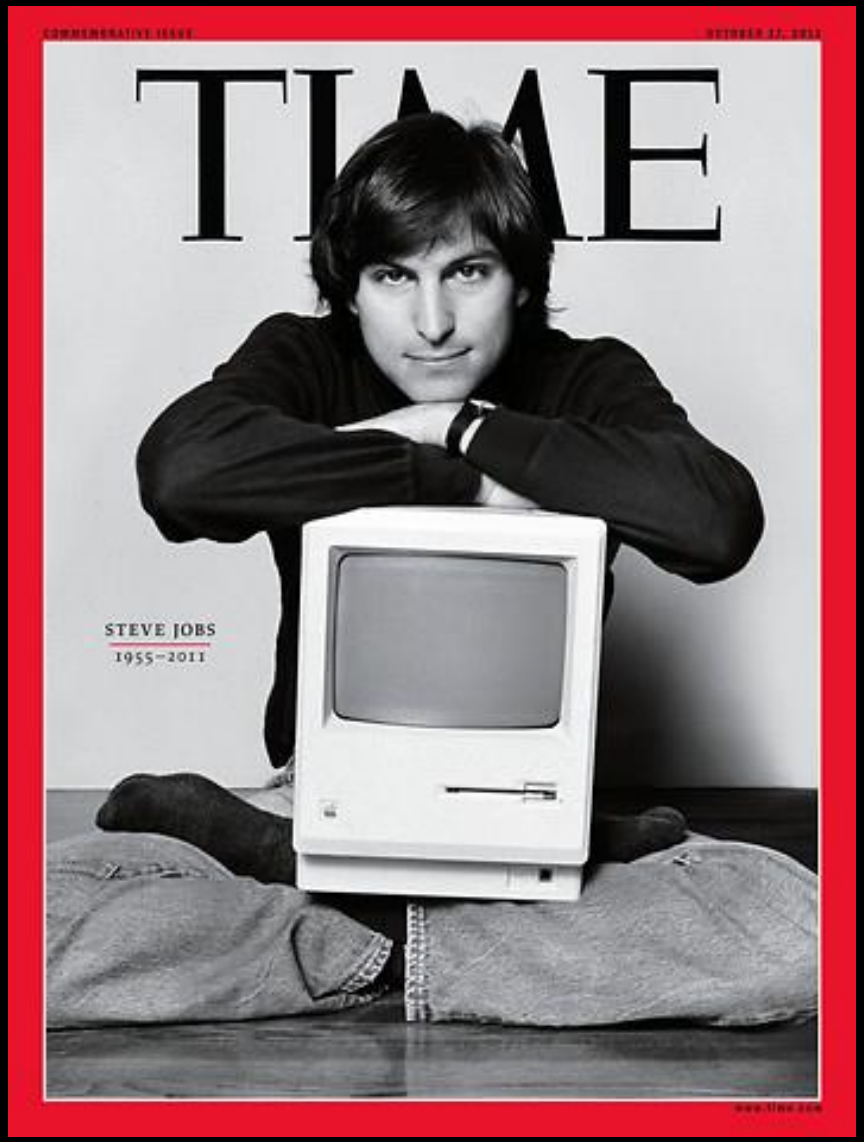
OCTOBER 24, 2005
www.time.com AOL Keyword: TIME
IRAQ: SUICIDE TRAINER ■ THE GREAT PLANET HUNT ■ FAT FIGHTERS
TIME
THE MAN WHO ALWAYS SEEMS TO KNOW...
WHAT'S NEXT
PLUS
TRENDSPOTTING with Moby, Malcolm Gladwell, David Brooks and Esther Dyson
5 NEW THINGS that will blow your mind
CLINT EASTWOOD'S revolutionary movie for 2006
Apple CEO Steve Jobs with the new video iPod and iMac

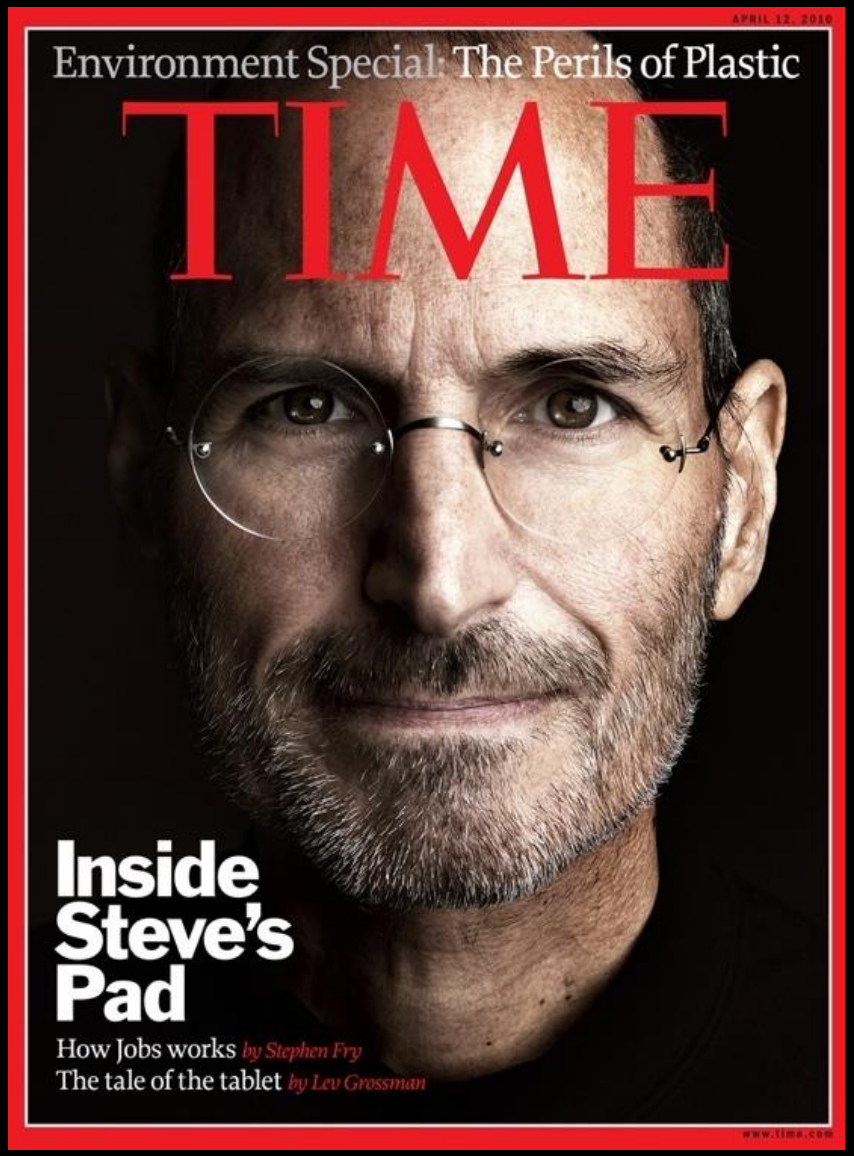
DECEMBER 25, 2007 / JANUARY 1, 2008
www.time.com
TIME
PERSON OF THE YEAR
9:41
slide to unlock
iPhone.
But seriously, we're running out of awards for this thing.


APRIL 12, 2010
Environment Special: The Perils of Plastic
TIME
Inside Steve's Pad
How Jobs works by Stephen Fry
The tale of the tablet by Lev Grossman
www.time.com

DECEMBER 25, 2007 / JANUARY 1, 2008
www.time.com
TIME
PERSON OF THE YEAR
9:41
slide to unlock
iPhone.
But seriously, we're running out of awards for this thing.

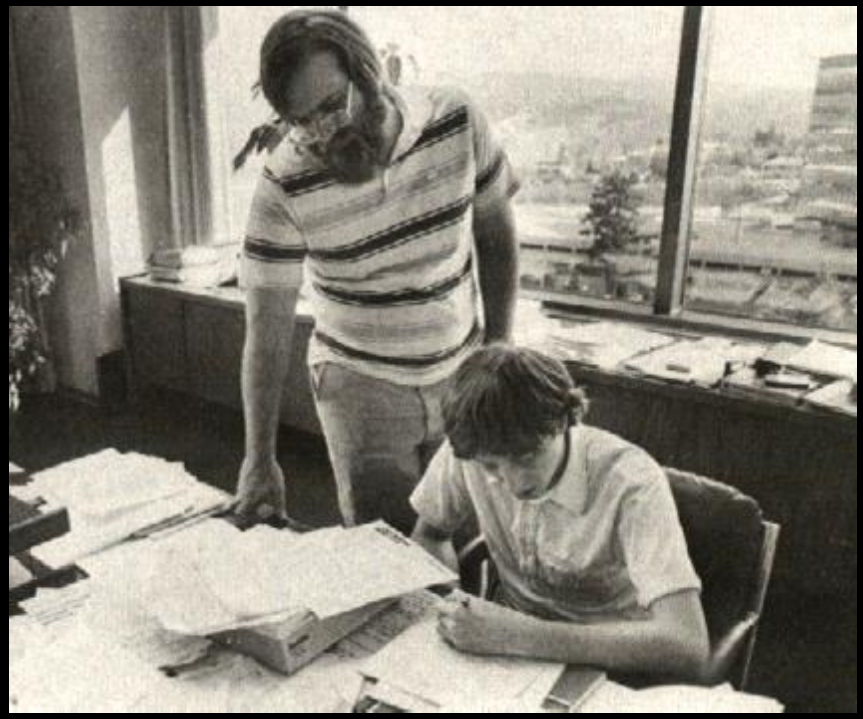

APRIL 12, 2010
Environment Special: The Perils of Plastic
TIME
Inside Steve's Pad
How Jobs works by Stephen Fry
The tale of the tablet by Lev Grossman
www.time.com


COMMEMORATIVE ISSUE
TIME
STEVE JOBS
1955–2011

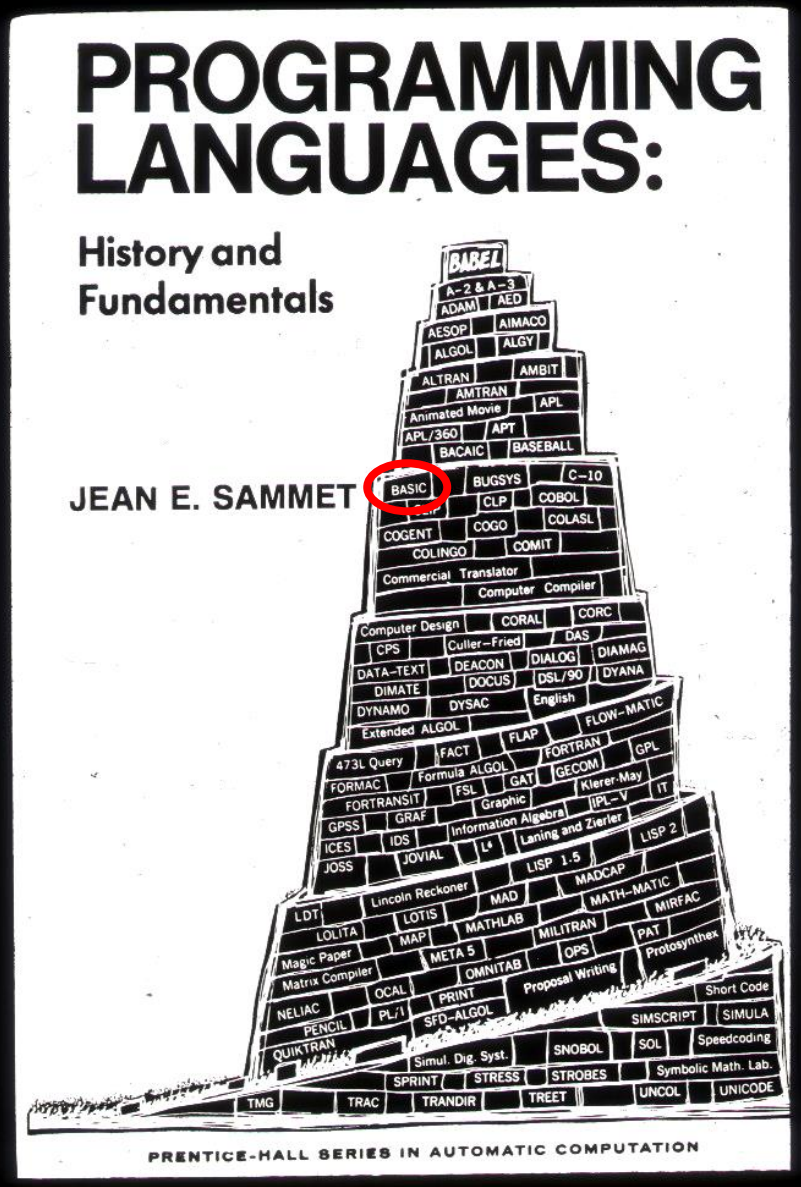


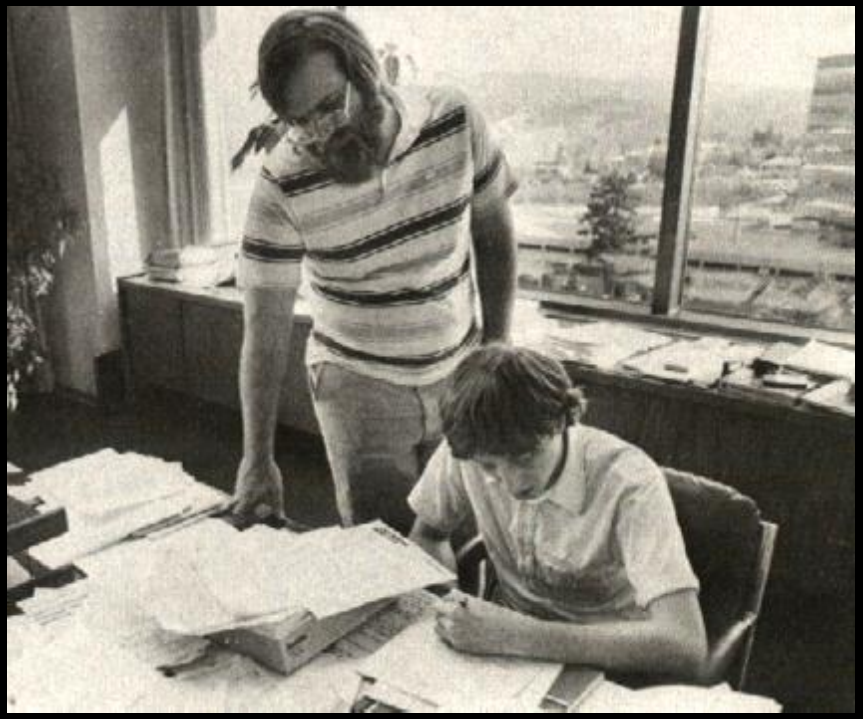
Homebrew Computer Club
30th Anniversary in 2005 - Silicon Valley

Homebrew Computer Club
30th Anniversary in 2005 - Silicon Valley



Bill Gates and Paul Allen – Micro-Soft Basic for Altair 8800 in 1975 (Intel 8080)





Bill Gates and Paul Allen – Micro-Soft
Basic for Altair 8800 in 1975 (Intel 8080)

February 3, 1976

An Open Letter to Hobbyists

To me, the most critical thing in the hobby market right now is the lack of good software courses, books and software itself. Without good software and an owner who understands programming, a hobby computer is wasted. Will quality software be written for the hobby market?

Almost a year ago, Paul Allen and myself, expecting the hobby market to expand, hired Monte Davidoff and developed Altair BASIC. Though the initial work took only two months, the three of us have spent most of the last year documenting, improving and adding features to BASIC. Now we have 4K, 8K, EXTENDED, ROM and DISK BASIC. The value of the computer time we have used exceeds $40,000.

The feedback we have gotten from the hundreds of people who say they are using BASIC has all been positive. Two surprising things are apparent, however. 1) Most of these "users" never bought BASIC (less than 10% of all Altair owners have bought BASIC), and 2) The amount of royalties we have received from sales to hobbyists makes the time spent of Altair BASIC worth less than $2 an hour.

Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?

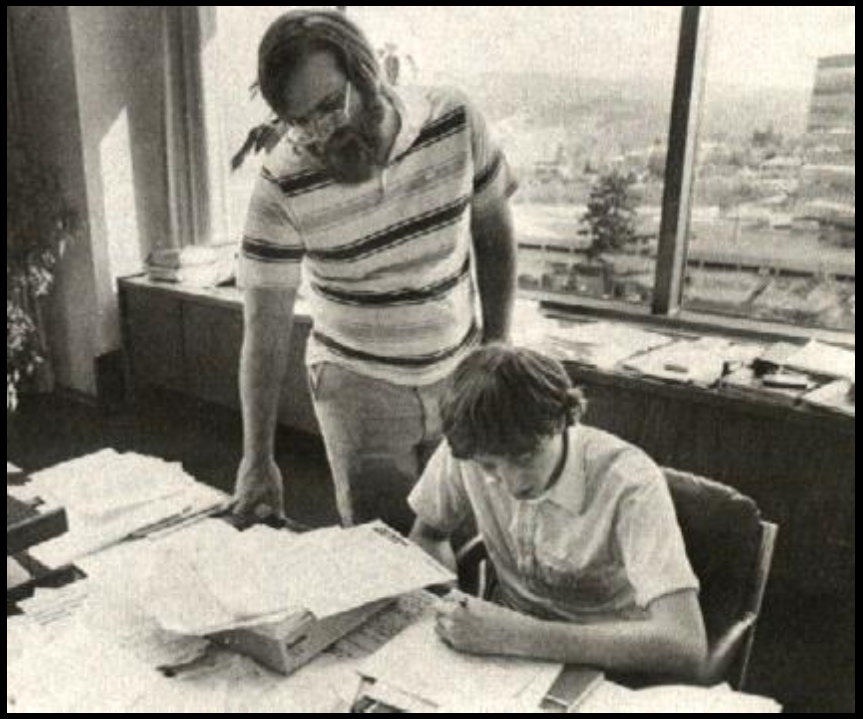
Is this fair? One thing you don't do by stealing software is get back at MITS for some problem you may have had. MITS doesn't make money selling software. The royalty paid to us, the manual, the tape and the overhead make it a break-even operation. One thing you do do is prevent good software from being written. Who can afford to do professional work for nothing? What hobbyist can put 3-man years into programming, finding all bugs, documenting his product and distribute for free? The fact is, no one besides us has invested a lot of money in hobby software. We have written 6800 BASIC, and are writing 8080 APL and 6800 APL, but there is very little incentive to make this software available to hobbyists. Most directly, the thing you do is theft.

What about the guys who re-sell Altair BASIC, aren't they making money on hobby software? Yes, but those who have been reported to us may lose in the end. They are the ones who give hobbyists a bad name, and should be kicked out of any club meeting they show up at.

I would appreciate letters from any one who wants to pay up, or has a suggestion or comment. Just write me at 1180 Alvarado SE, #114, Albuquerque, New Mexico, 87108. Nothing would please me more than being able to hire ten programmers and deluge the hobby market with good software.

Bill Gates

Bill Gates
General Partner, Micro-Soft



Bill Gates and Paul Allen – Micro-Soft Basic for Altair 8800 in 1975 (Intel 8080)

February 3, 1976

An Open Letter to Hobbyists

To me, the most critical thing in the hobby market right now is the lack of good software courses, books and software itself. Without good software and an owner who understands programming, a hobby computer is wasted. Will quality software be written for the hobby market?

Almost a year ago, Paul Allen and myself, expecting the hobby market to expand, hired Monte Davidoff and developed Altair BASIC. Though the initial work took only two months, the three of us have spent most of the last year documenting, improving and adding features to BASIC. Now we have 4K, 8K, EXTENDED, ROM and DISK BASIC. The value of the computer time we have used exceeds $40,000.

The feedback we have gotten from the hundreds of people who say they are using BASIC has all been positive. Two surprising things are apparent, however. 1) Most of these "users" never bought BASIC (less than 10% of all Altair owners have bought BASIC), and 2) The amount of royalties we have received from sales to hobbyists makes the time spent of Altair BASIC worth less than $2 an hour.

Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?

Is this fair? One thing you don't do by stealing software is get back at MITS for some problem you may have had. MITS doesn't make money selling software. The royalty paid to us, the manual, the tape and the overhead make it a break-even operation. One thing you do do is prevent good software from being written. Who can afford to do professional work for nothing? What hobbyist can put 3-man years into programming, finding all bugs, documenting his product and distribute for free? The fact is, no one besides us has invested a lot of money in hobby software. We have written 6800 BASIC, and are writing 8080 APL and 6800 APL, but there is very little incentive to make this software available to hobbyists. Most directly, the thing you do is theft.

What about the guys who re-sell Altair BASIC, aren't they making money on hobby software? Yes, but those who have been reported to us may lose in the end. They are the ones who give hobbyists a bad name, and should be kicked out of any club meeting they show up at.

I would appreciate letters from any one who wants to pay up, or has a suggestion or comment. Just write me at 1180 Alvarado SE, #114, Albuquerque, New Mexico, 87108. Nothing would please me more than being able to hire ten programmers and deluge the hobby market with good software.

Bill Gates

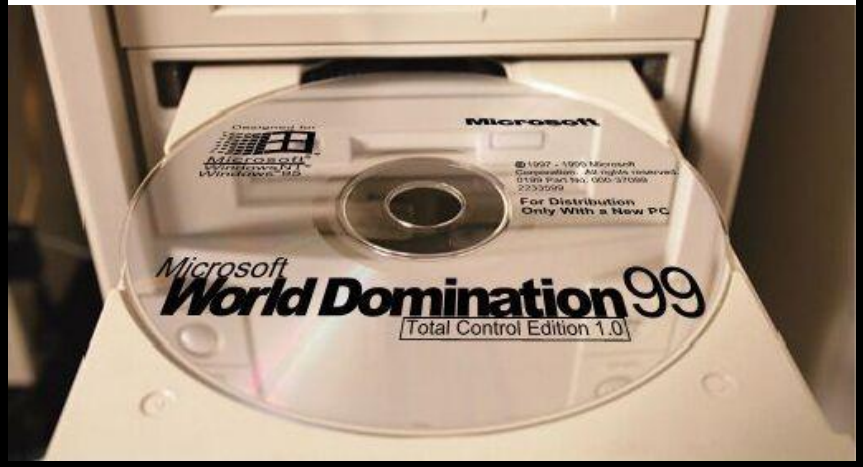
Bill Gates
General Partner, Micro-Soft

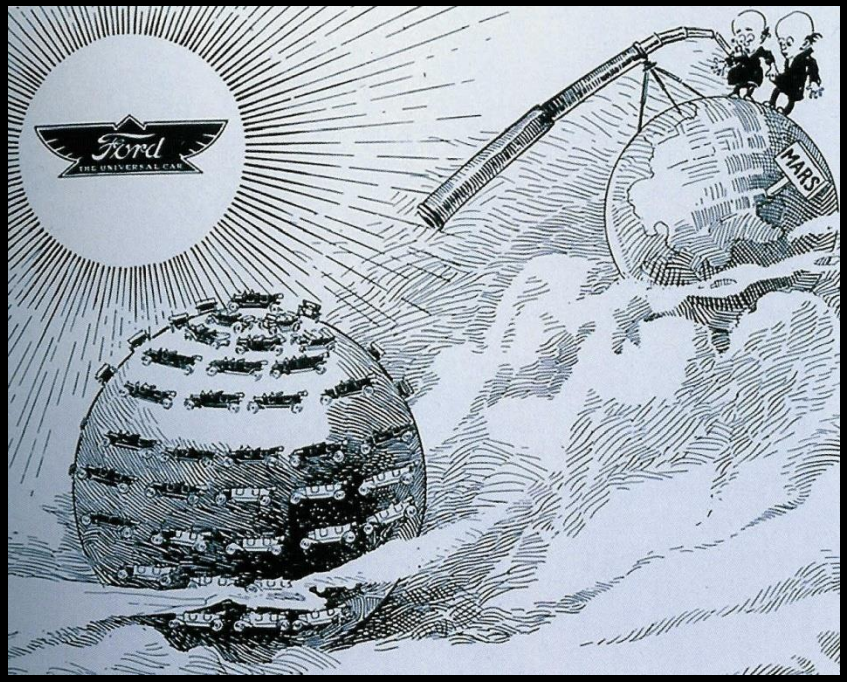
Bill Gates and Paul Allen – MiCROSOFT
MS- DOS for IBM PC in 1981

IBM Personal Computer
(Intel 8088)
Command Line Interface

Bill Gates and Paul Allen – MiCROSOFT
MS- DOS for IBM PC in 1981

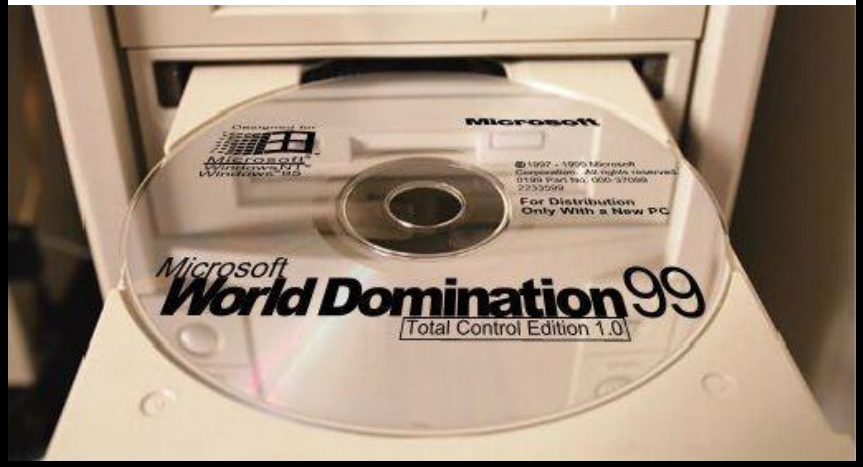
8086, 80186, 80286, 80386, 80486 16-bit
Pentium 32-bit and 64-bit

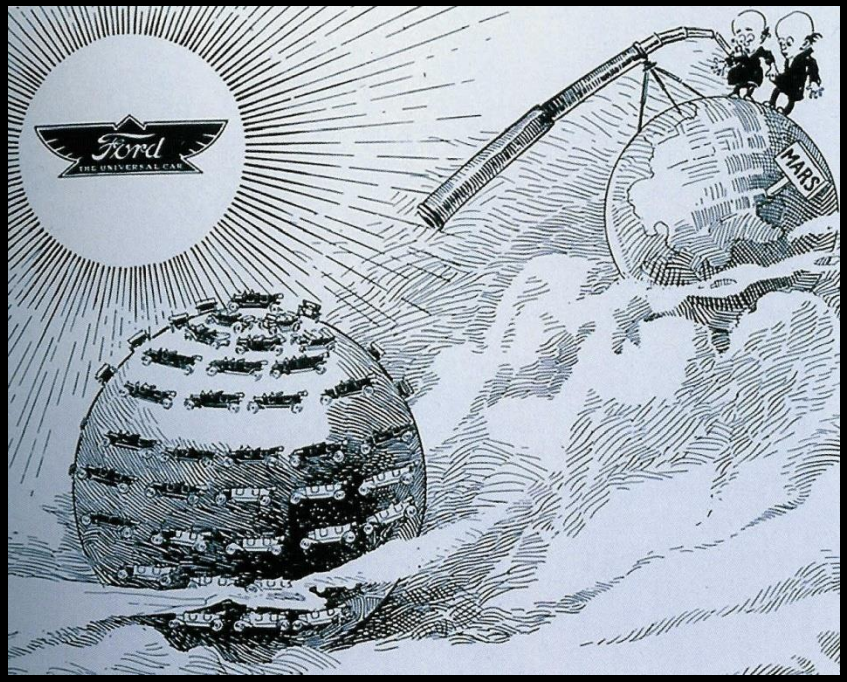




Bill Gates and Paul Allen – MiCROSOFT
MS- DOS for IBM PC in 1981

8086, 80186, 80286, 80386, 80486 16-bit
Pentium 32-bit and 64-bit





Key Ideas

Scientific :

- Whole Computer on a Chip
- Graphical User Interface

Social and Personal :

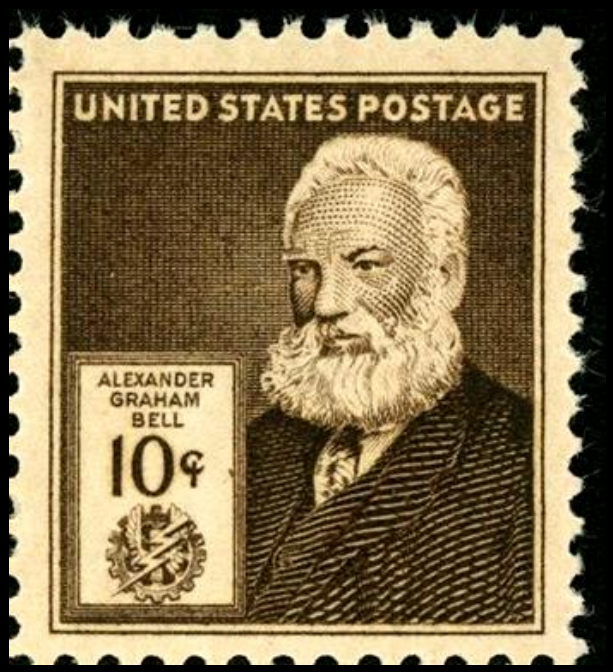
- Computation
- Communication
- Commerce

Symbolic :

- Individual Genius

Immigrants

Alexander Graham Bell
Andrew Carnegie
John Von Neumann
Othmar Ammann



Telephone for Communication

Key Ideas

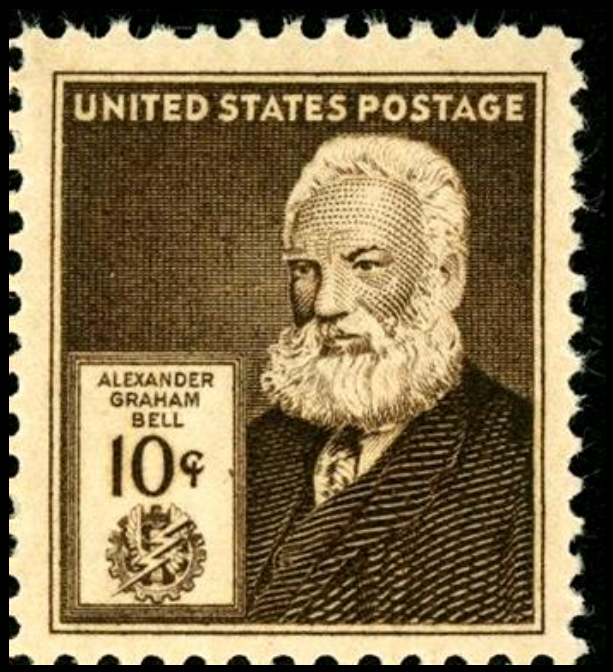
Scientific :
- Whole Computer on a Chip
- Graphical User Interface

Social and Personal :
- Computation
- Communication
- Commerce

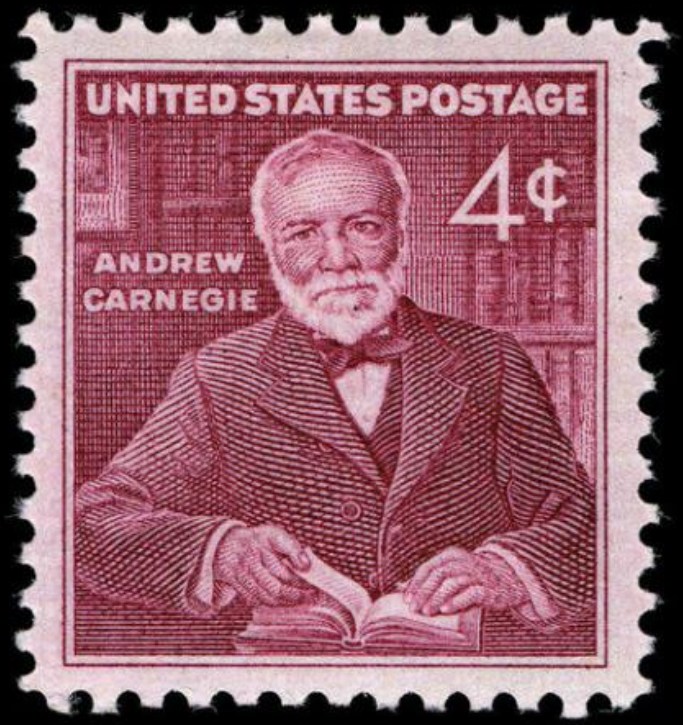
Symbolic :
- Individual Genius

Immigrants

Alexander Graham Bell
Andrew Carnegie
John Von Neumann
Othmar Ammann

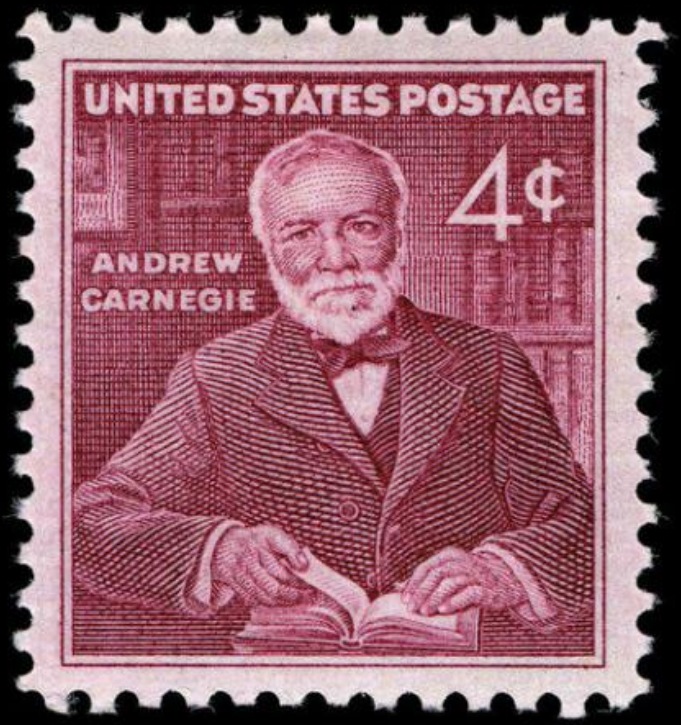


Telephone for Communication



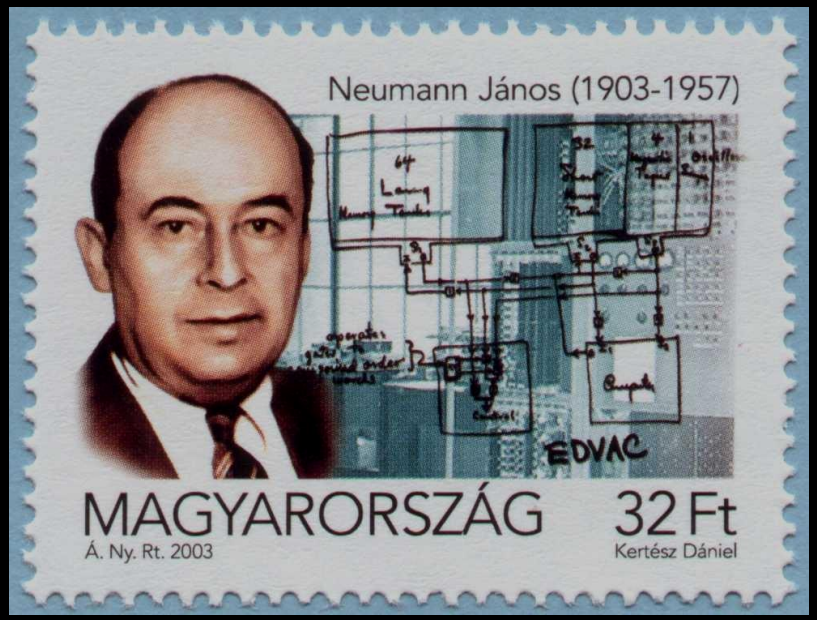
Steel for Railroads,
Bridges, and Buildings

Iconic Bridges to cross rivers



Steel for Railroads,
Bridges, and Buildings

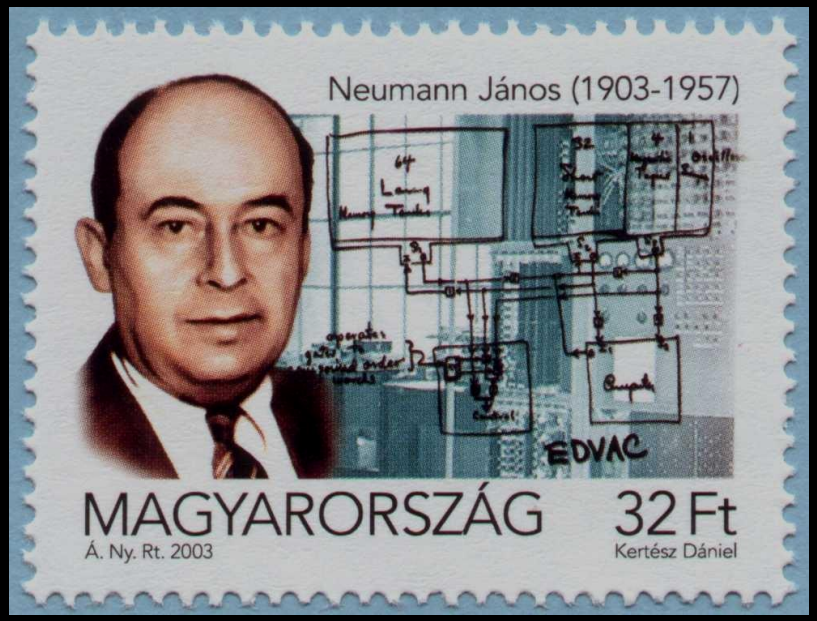
Iconic Bridges to cross rivers



Digital Computer for calculations

Inventors

Thomas Telford	Flat Bridge
Wright Brothers	Flying Machine
Thomas Edison	Centralized Power
Henry Bessemer	Strong Material



Digital Computer for calculations

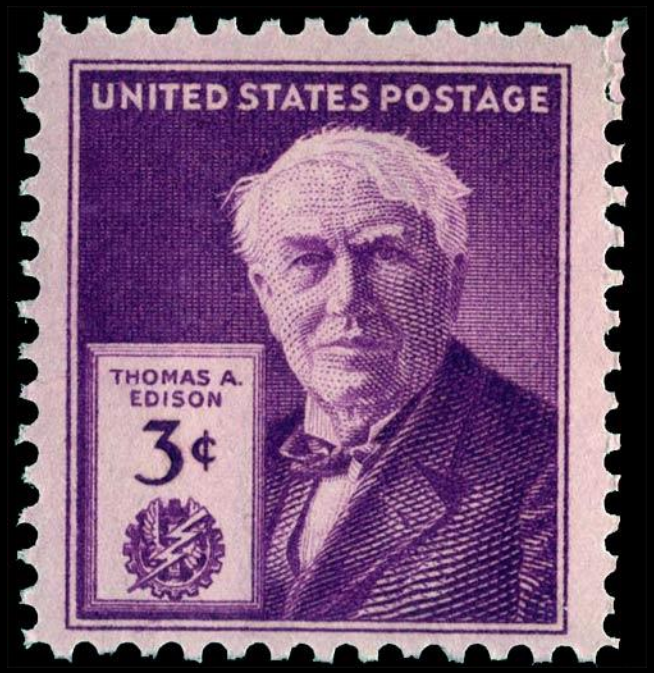
$$H = \frac{1}{8} qL \frac{L}{d}$$

Inventors

Thomas Telford	Flat Bridge
Wright Brothers	Flying Machine
Thomas Edison	Centralized Power
Henry Bessemer	Strong Material

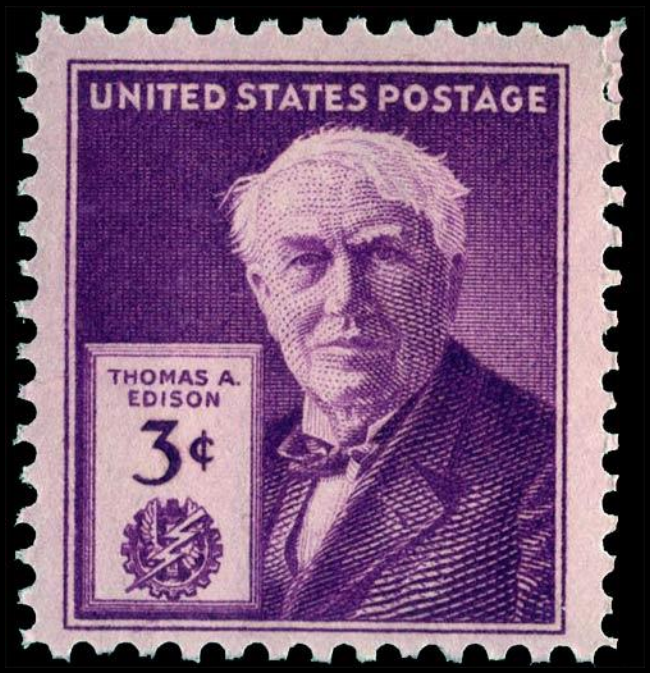
$$L = 0.00257\ V^2\ C_L\ A$$

$$H = \frac{1}{8}\ qL\ \frac{L}{d}$$



$$P_L = I^2 R$$

$$L = 0.00257\ V^2\ C_L\ A$$



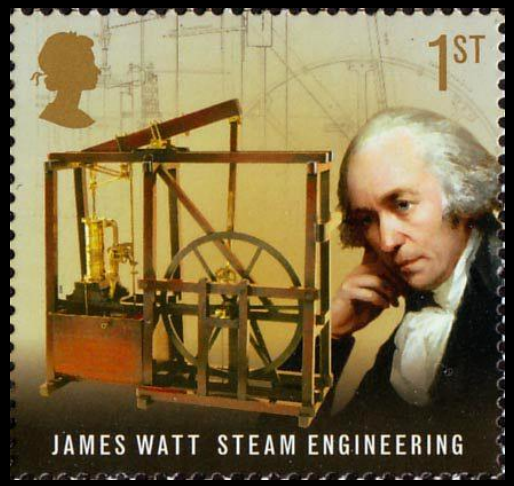
$$P_L = I^2 R$$

$$\text{Safety Factor} = \frac{f_B}{f}$$

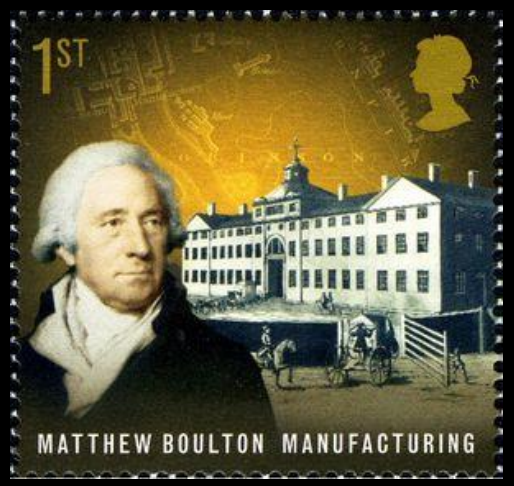
Partners

James Watt – Mathew Boulton
Robert Fulton – Robert Livingston
G.W. Goethals – Teddy Roosevelt

ENGINEER



MANUFACTURER



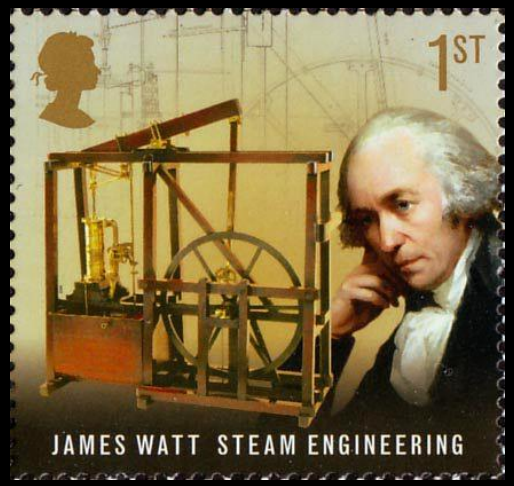
$$\text{Safety Factor} = \frac{f_B}{f}$$

Partners

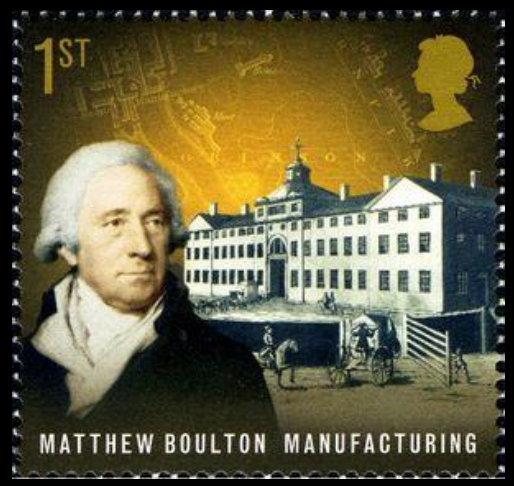
James Watt – Mathew Boulton
Robert Fulton – Robert Livingston
G.W. Goethals – Teddy Roosevelt

ENGINEER

ENGINEER



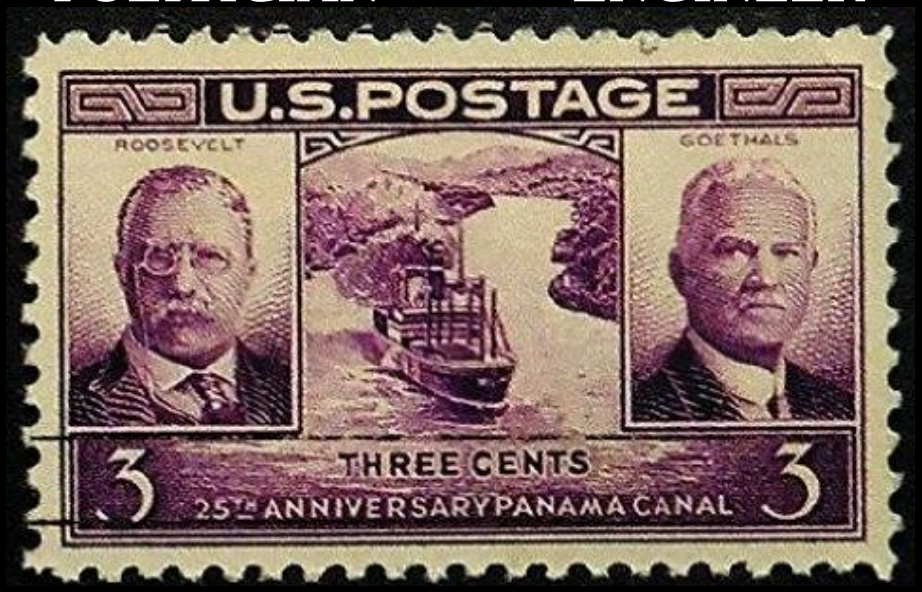
MANUFACTURER



POLITICIAN

ENGINEER

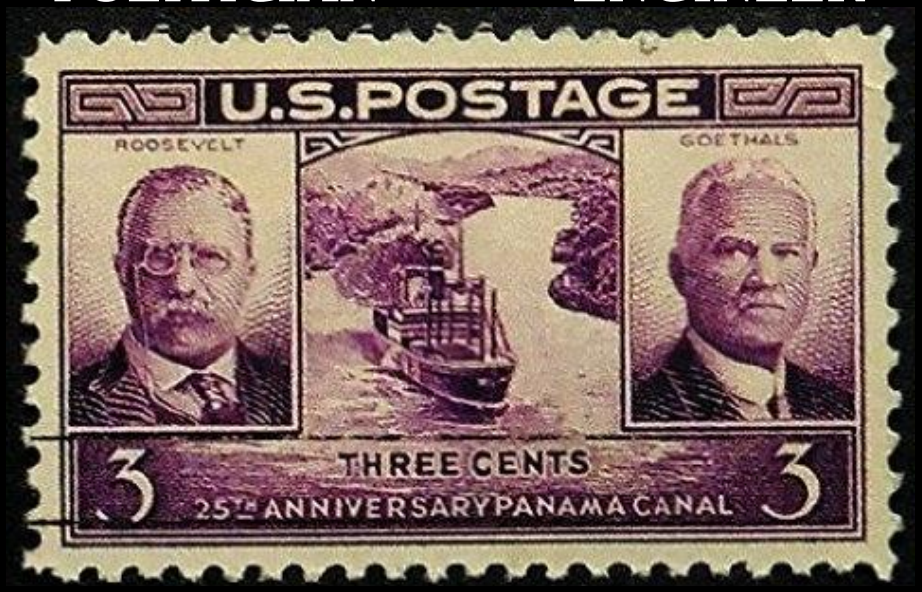
POLITICIAN ENGINEER



POLITICIAN

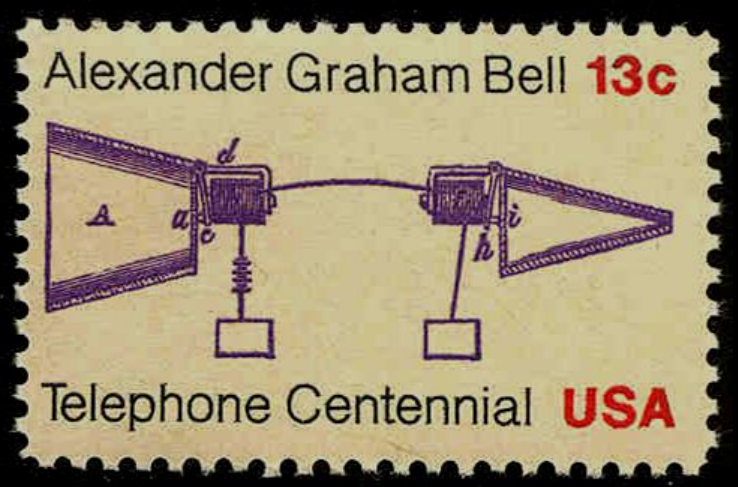
Patents

POLITICIAN ENGINEER



Telephone
Electric Light
Airplane
Radio
Rocket
Transistor
Integrated Circuit

What are positive and negative effects of patents ?



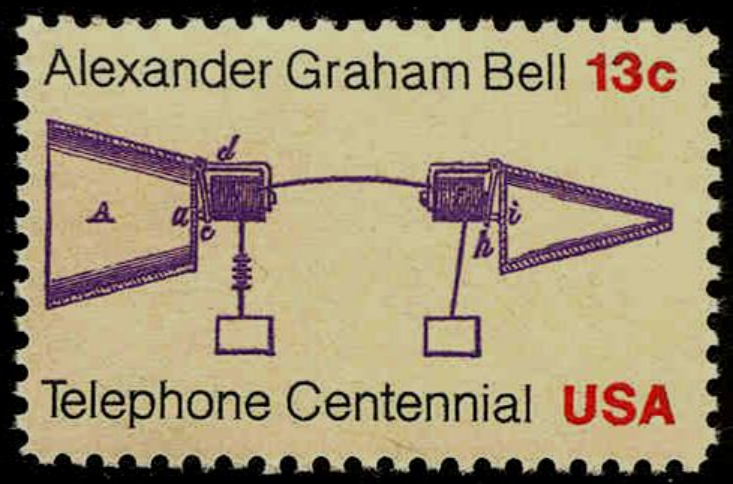
delays competition

Bell captures Edison patents from Western Union

Patents

Telephone
Electric Light
Airplane
Radio
Rocket
Transistor
Integrated Circuit

What are positive and negative effects of patents ?



delays competition

Bell captures Edison patents from Western Union

delays competition

"War of the Currents"
Westinghouse (AC) wins

delays competition

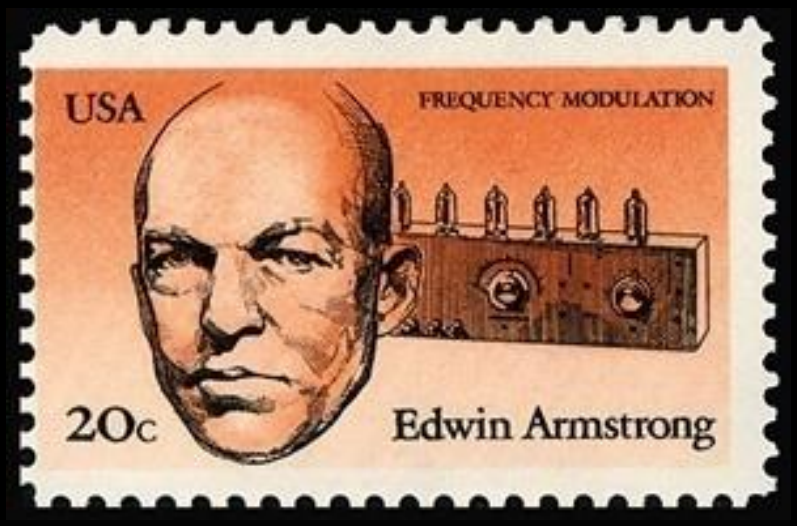
WWI – patent suspended in national interest

delays competition

"War of the Currents"
Westinghouse (AC) wins

delays competition

WWI – patent suspended in national interest

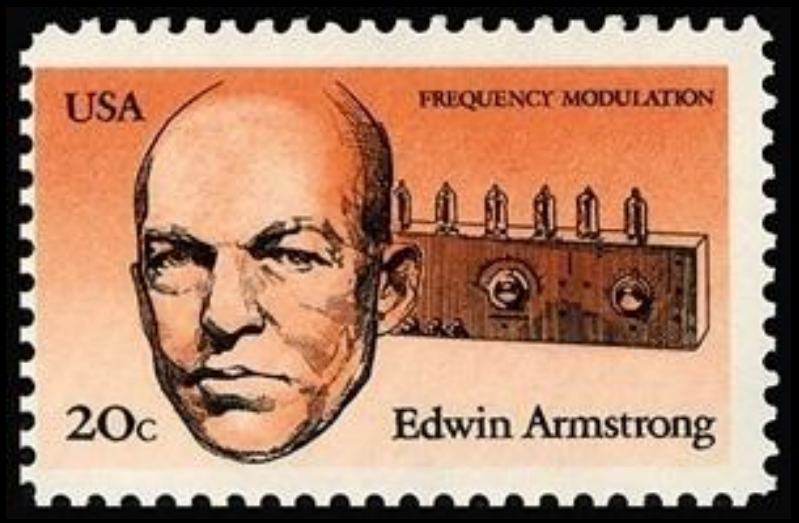


Sarnoff sues – delays FM

Armstrong suicide
Armstrong's widow wins

1964 – 50th Anniversary

Goddard not taken seriously until after WWII

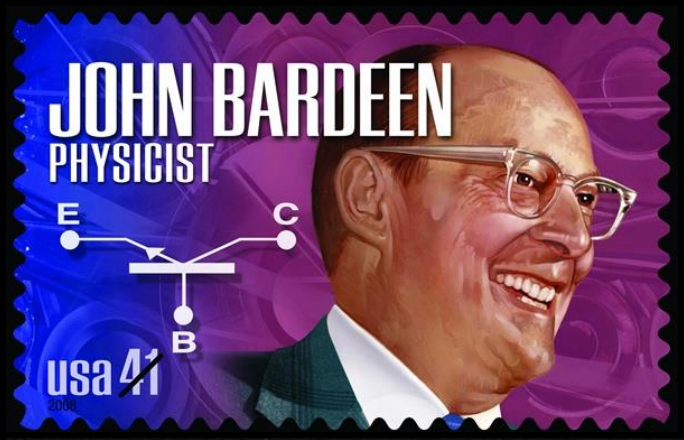


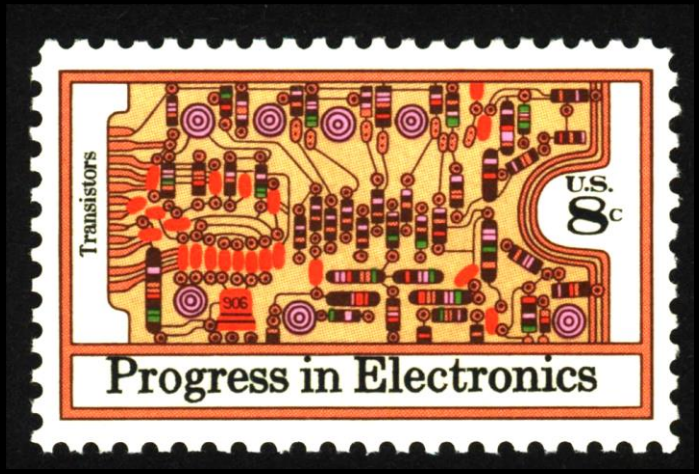
Sarnoff sues – delays FM

Armstrong suicide
Armstrong's widow wins

1964 – 50th Anniversary

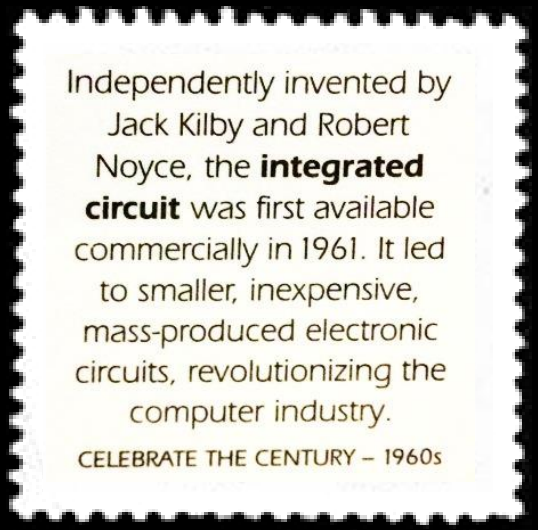
Goddard not taken seriously until after WWII



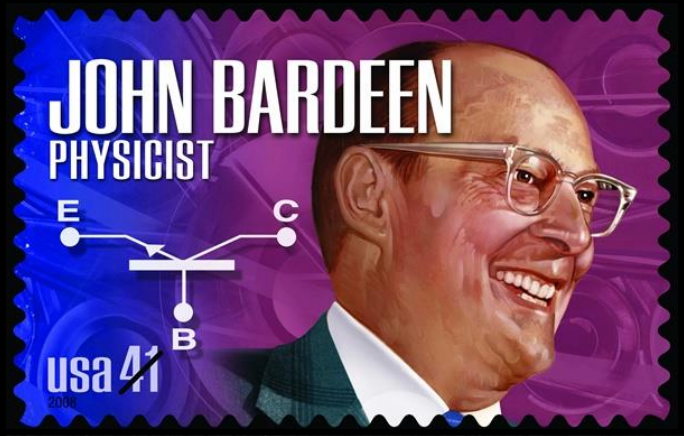


Bell Telephone Research

Transistor revolutionizes electronics industry



Kilby and Noyce
share credit and revenue

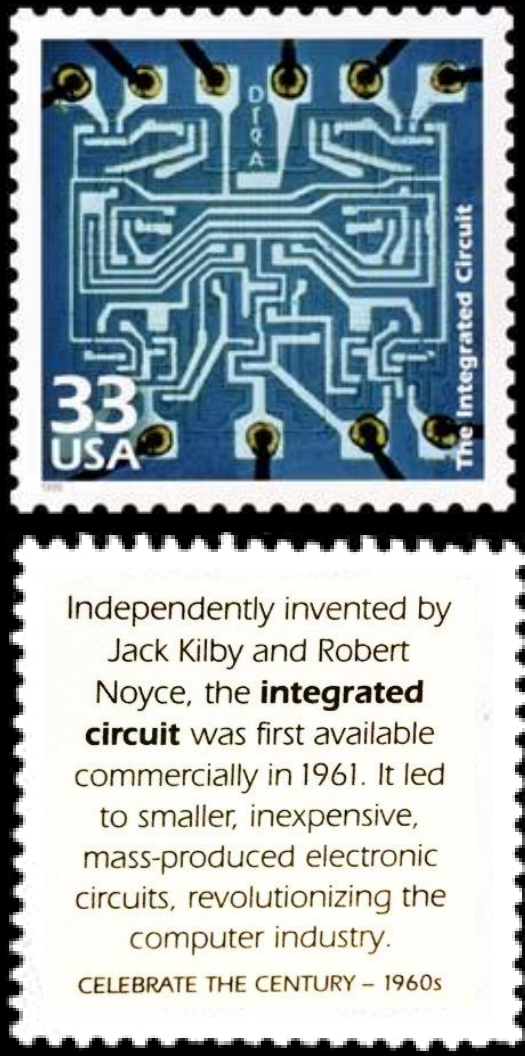


Bell Telephone Research

Transistor revolutionizes
electronics industry

Art and Engineering

Telford
Morse
Ammann



Kilby and Noyce
share credit and revenue

Elegant bridge replaces the ferry

Art and Engineering

Telford
Morse
Ammann

Intelligence at a distance

Elegant bridge replaces the ferry

Intelligence at a distance

Structural Artist
and Entrepreneur

Public Works Entrepreneurs

Ammann
Norris
Hoover

Structural Artist
and Entrepreneur

Public Works Entrepreneurs

Ammann
Norris
Hoover

TVA – REA architect
Advocate for Public Power

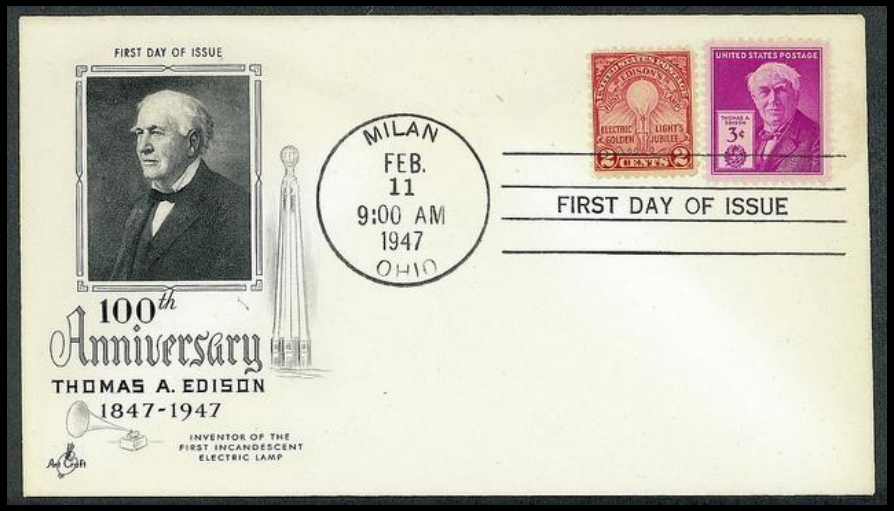
Commerce Secretary
Colorado River Compact

TVA – REA architect
Advocate for Public Power

Focus on Whole System
(and Inflexible Pioneers)

Edison
Ford
Marconi

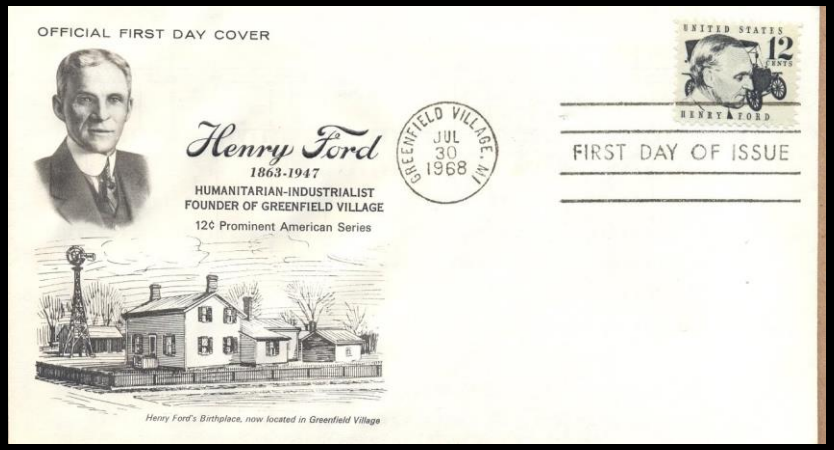
Commerce Secretary
Colorado River Compact



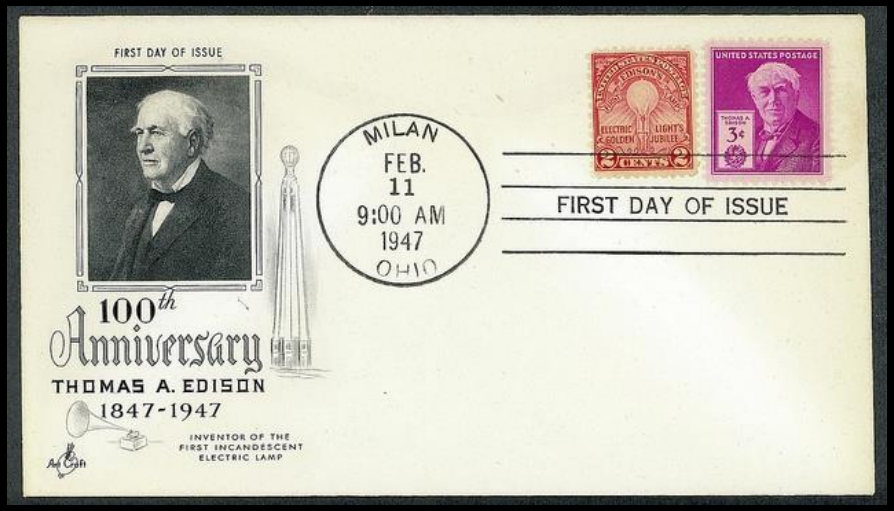
Competition with Gas Lighting

Focus on Whole System
(and Inflexible Pioneers)

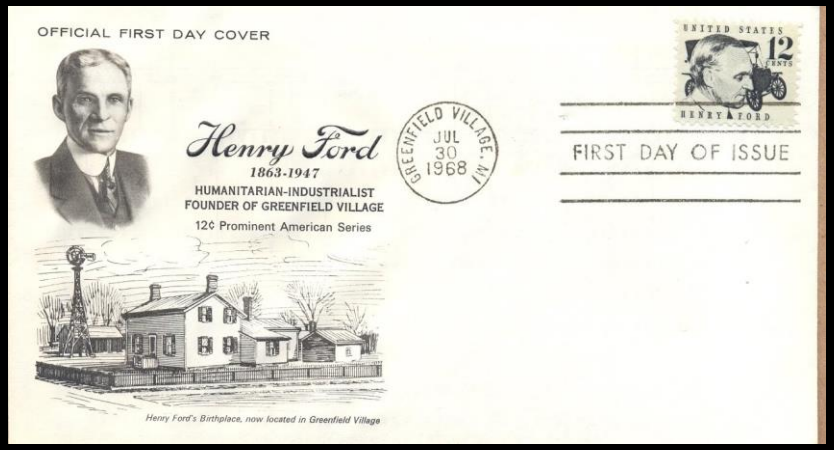
Edison
Ford
Marconi



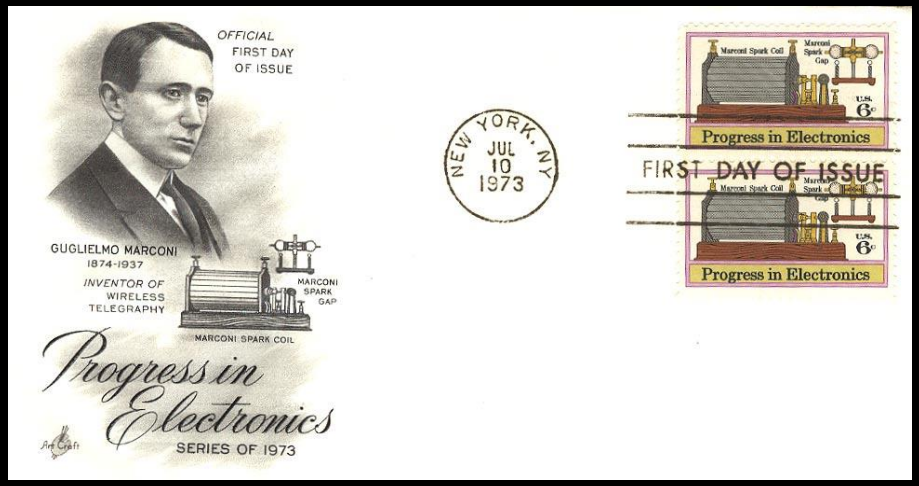
Assembly Line
Integrated Factory



Competition with Gas Lighting



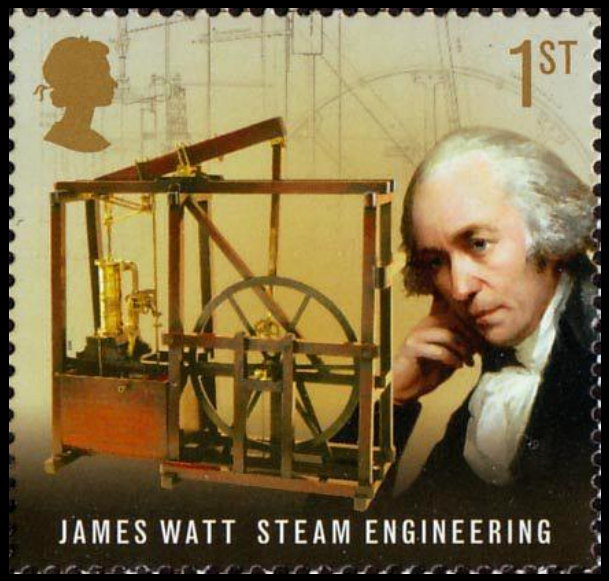
Assembly Line
Integrated Factory



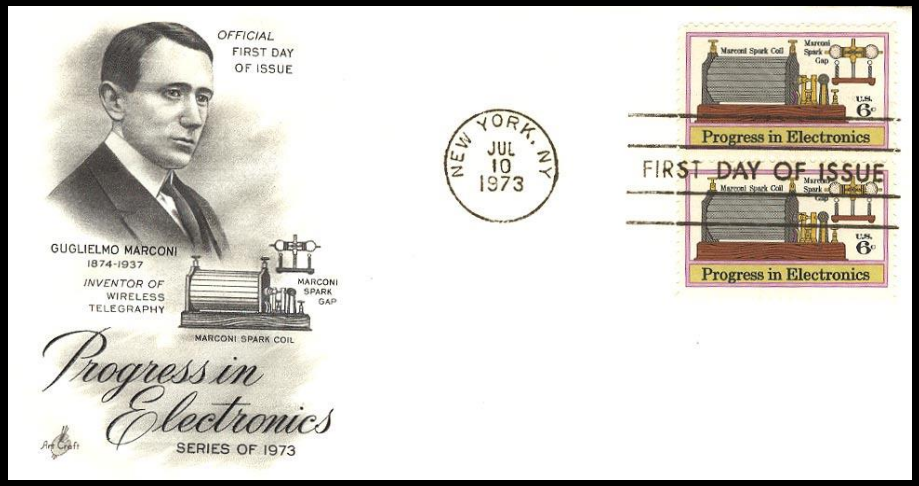
Global Wireless Network

Energy Conversion

Steam Engine
IC Engine
Jet Engine
Rocket Motor



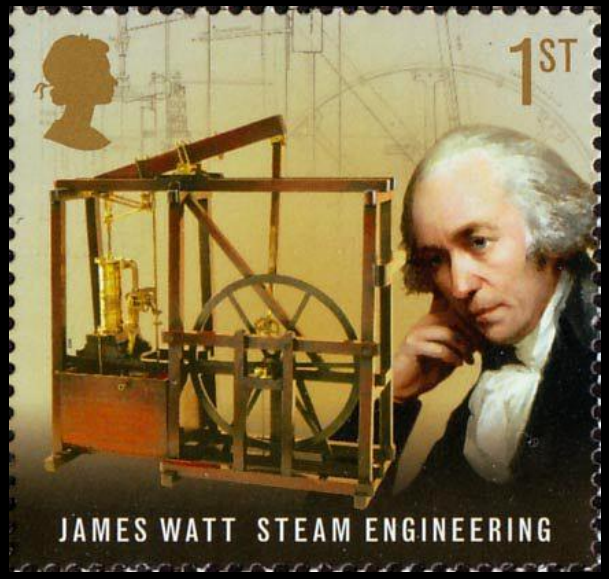
Machine replaces Horse
External Combustion



Global Wireless Network

Energy Conversion

Steam Engine
IC Engine
Jet Engine
Rocket Motor



Machine replaces Horse
External Combustion

Compact and Efficient Engine
Internal Combustion

Turbojet Engine
Batch to Continuous

Compact and Efficient Engine
Internal Combustion

Turbojet Engine
Batch to Continuous

Rocket Motor carries own O_2
Thrust in the Vacuum of Space

Regional Remedies

Port Authority
Valley Authority
River Compact

Congested
Depressed
Undeveloped

Port Authority Bridge
Automobiles

Rocket Motor carries own O_2
Thrust in the Vacuum of Space

Regional Remedies

Port Authority
Valley Authority
River Compact

Congested
Depressed
Undeveloped

Port Authority Bridge
Automobiles

Valley Authority Dam
Electric Power

River Compact Dam
Flood Control and Electric Power

Valley Authority Dam
Electric Power

Daring ‘Firsts’

Water
Air
Space

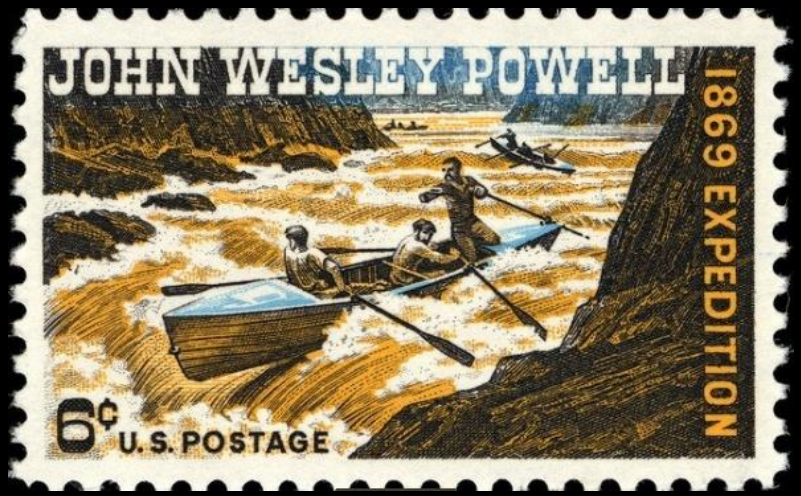
River Compact Dam
Flood Control and Electric Power

First Trip - Colorado River

Daring ‘Firsts’

Water
Air
Space

First Flight - Heavier than Air



First Trip - Colorado River

First Flight - Heavier than Air

Faster than Sound
bullet-shaped rocket plane

First Earth Orbit

Faster than Sound
bullet-shaped rocket plane

First Earth Orbit

First Moon Landing

Transformation of Daily Life

Railroad
Telephone
Electricity
Canal
Automobile
Airplane
Computer

Continent Crossed - 1869
Rails of Iron and Steel

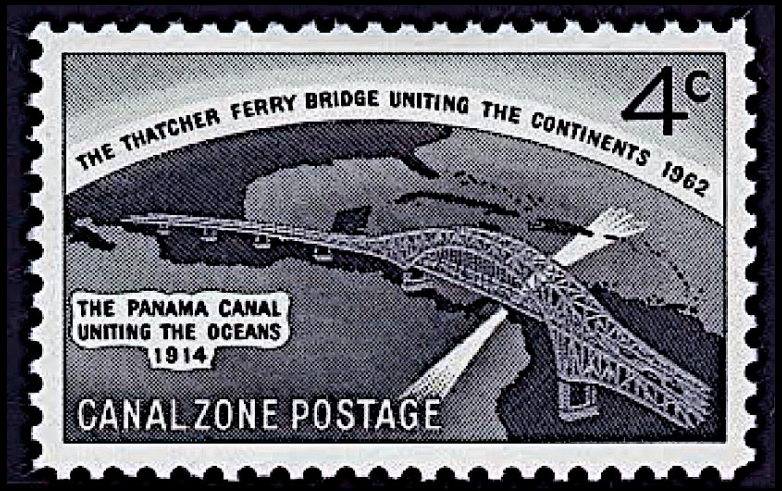
First Moon Landing

Transformation of Daily Life

Railroad
Telephone
Electricity
Canal
Automobile
Airplane
Computer

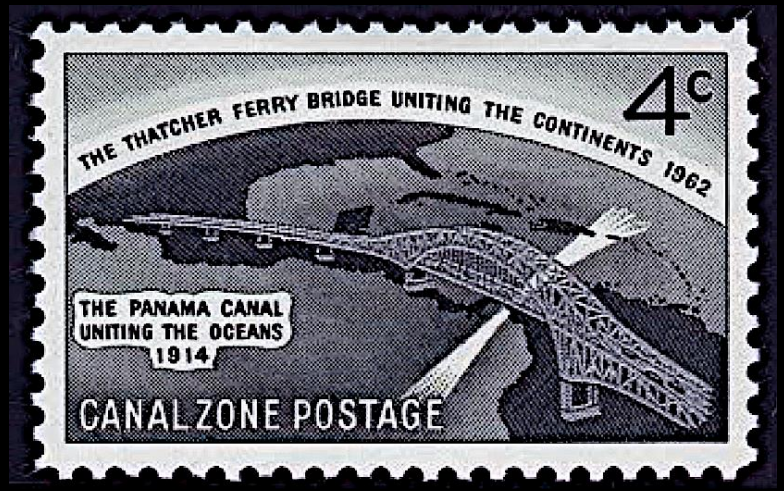
Continent Crossed - 1869
Rails of Iron and Steel

Nation Illuminated – 1879
Continent Crossed – 1915
Wires of Copper



Oceans United - 1914
Dams + Locks of Concrete and Steel

Nation Illuminated – 1879
Continent Crossed – 1915
Wires of Copper



Oceans United - 1914
Dams + Locks of Concrete and Steel

Atlantic Ocean Crossed - 1927
Airplanes of Aluminum
powered by Kerosene

Federal Highway Act - 1956
Cars powered by Gasoline
Roads of Asphalt and Concrete

Information Age begins in 1946
Transistors of Silicon

Atlantic Ocean Crossed - 1927
Airplanes of Aluminum
powered by Kerosene

Federal Highway Act - 1956
Cars powered by Gasoline
Roads of Asphalt and Concrete

Innovations

How do they happen?
Why are they important?

Information Age begins in 1946
Transistors of Silicon

Scientific :
- science – engineering inspired
- engineering – science enabled

Social Process :
- context – transformation of
  - economics
  - politics
  - culture

Symbolic :
- works of individual geniuses
  - iconic structures
  - fast efficient vehicles
  - high speed networks
  - strong useful materials

Christian Schussele – “Men of Progress”

Edward Sorel – “People of Progress”

Innovations

How do they happen?
Why are they important?

Scientific :

- science – engineering inspired
- engineering – science enabled

Social Process :

- context – transformation of
  - economics
  - politics
  - culture

Symbolic :

- works of individual geniuses
  - iconic structures
  - fast efficient vehicles
  - high speed networks
  - strong useful materials