



Classic Silicon Valley: 1976

1975, MP; Gordon
French garage; O

■ Homebrew Computer Club

– Hobbyists meeting in
Menlo Park and at SLAC

– Steve Wozniak
and Steve Jobs

– The Apple I
(to sell to friends)



Classic Silicon Valley: 1976

- Wozniak-Jobs partnership
 - called it “Apple Computer Company”
 - Started in a **garage** in Los Altos
 - Now has largest stock market capitalization
 - Most **valuable brand** in the world

**How could this happen?
Why in the SF Bay Area?**

Before 1900 ...



The Santa
Clara Mission

“Valley of the
Heart’s Delight”



Before 1900

This was more typical ...



Let's Go Back ...

■ Federal Telegraph

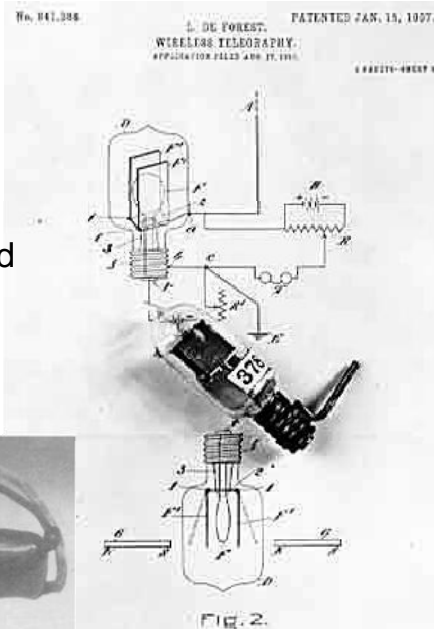
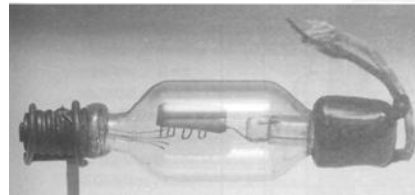
– Formed in 1909 in Palo Alto (by Cyril Elwell, a Stanford grad)

– **Lee de Forest** invented the audion oscillator and amplifier in 1907

– Pioneered continuous-wave radio



De Forest tube



Federal Telegraph

- Paulsen Arc Transmitter, 1909
 - Demonstrated sending CW and voice
- Raised funds from “angel investors”, including David Starr Jordan, Stanford’s president
- Demonstrated communication from S.F. to Honolulu in 1912 →
- **First venture capital**
- **Stanford’s Involvement**



Federal Telegraph

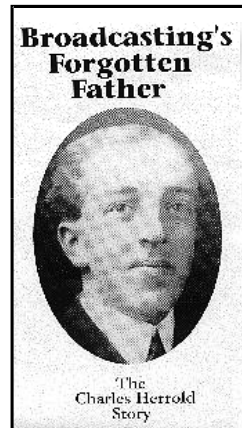
- By 1926, had three high-power stations that covered much of the Pacific Ocean
- In support of maritime shipping companies
- California Historical Plaque in Palo Alto



Let's Go Back ...

■ 1st regular commercial radio broadcast

- Charles “Doc” Herrold
 - Early Stanford EE grad
 - Started a San Jose school near SJSU to teach radio arts (1909)
- First Commercial broadcast, San Jose, 1909
 - voice and music: “San Jose Calling”
- FN, then SJN, then KQW, **becomes KCBS**
740 AM, 106.9 FM (also founded KLIV)



Example: Early Roots of Entrepreneurial Technology

■ Otis Moorhead

- Early Stanford EE grad
- Radio amateur & vacuum tube entrepreneur
- Established **Moorhead Laboratories**
 - In San Francisco in 1917
- Moorhead manufactured “bootleg” receiving tubes for radio sets
- A **patent-infringement lawsuit** put him out of business in the early 1920s.



Testing tubes, 1919

Defining Events

- Independent private **wealth**, from gold rush
- Titanic Sinking in 1912
- World War I
 - Importance of **technology**
- US Navy “push” for ship-to-shore and other communications modes
- **Economics**: desire to replace expensive telegraph lines, undersea cables with the new “wireless” technology
- Brought frenzy of activity, funds to S.F. Bay Area



We Now Follow Three Pioneers

- **William Eitel**
- **Jack McCullough**
- **Charles Litton**

- Bay Area families with a strong history of entrepreneurship
- Born/raised here

William Eitel

- Took shop classes at Los Gatos High School
- Worked in his father's quarry
 - ass't blacksmith, machine operator
- Visited shops of Hall-Scott Motor Car Co.
 - Operation of Complex machinery

William Eitel, **W6UF**
1908 - 1989



Bill Eitel in 1941 (Photo courtesy of Dave Atkins, W6VX)

sports cars
aircraft "Liberty engine"

Jack McCullough, Charles Litton

- Attended **California School of Mechanical Arts**
Now Lick-Wilmerding High School, San Francisco (private)
- Opened in 1895; free education for boys, girls
- One of the best West Coast **technical high schools**
 - Rigorous training in the mechanical trades
 - Gained "a realistic 'feel' of materials and processes" [Litton]

Jack McCullough, **W6CHE**
1908 - 1989



Jack McCullough, Charles Litton

- **McCullough** continued at a local junior college
- **Litton** enrolled in Stanford's Mechanical Engineering dept:
 - Small department (3 instructors)
 - Classes with strong practical flavor
 - Got BS-Mechanical Engineering in 1924
 - Grad work in communication engineering
 - Took Stanford's first course on communication engineering fundamentals

Eitel, Litton, and McCullough

- Introduced to **amateur “ham” radio** through their families and friends in 1910's, '20's
 - Became acquainted with the technology of power tubes through activities in ham radio
- **Ham Radio in SF Bay Area**
 - Isolated; maritime orientation; major seaport
 - Several military bases; US Navy presence
 - Shipping companies needed radio operators
 - Over 1,200 licensed amateurs
 - **10 percent** of US total (a **bubble**)

Ham Radio in SF Bay Area

- Active center of radio mfg in the 1910s, '20s
- Electronics firms:
 - **Remler** - made radio sets
 - **Magnavox** - leading manufacturer of loudspeakers
 - **Heintz and Kaufman**
 - Designed custom radio equipment
 - **Federal Telegraph**
 - Produced radio transmitters in the 1910s; up to 1,000,000 watts in 1919.
- Radio parts available to **local hobbyists**
- Jobs for radio amateurs

Ham Radio Subculture

- **Camaraderie** and intense sociability
 - A way to make friends
 - Communicating "over the air" and face to face
- **Egalitarianism** and a democratic ideology
 - little heed to **distinctions of class**, education
 - Santa Clara County radio club, which Eitel chaired in the mid 1920s, had "**farm boys, Stanford students, Federal Telegraph technicians, and retired executives**"

Ham Radio Subculture

- Strong interest in extending radio technology
 - Built personal reputations:
innovating new circuitry; devising clever transmitters;
contacts with faraway lands
- Mix of **competitiveness** and **collaboration**

A lot like Home Brew Computer Club, and today's Silicon Valley ...

The Tube Business

- General Electric, Westinghouse, AT&T
 - All East Coast companies
 - Developed hi-power transmitting tubes in early 1920s
 - Difficulties in producing consistent, reliable ones
 - Required precise machining, glass blowing (Pyrex)
 - Exotic materials, sophisticated sealing techniques

Following our Entrepreneurs ...

- **Litton** got local job through a ham friend:

- Research at **Federal Telegraph**
- Built up to 60 engineers
- Became sole supplier of radios to IT&T



- **Eitel** got local job through ham friend:

- Mechanic at **Heintz and Kaufman Inc**
 - Heintz was a ham
 - focus on HF radio equipment
- Recruited **McCullough** a year later

Federal Telegraph,
at Perham home,
916 Emerson St,
Palo Alto, 1912

The Tube Business in the '20s

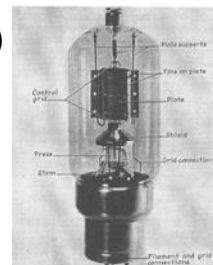
- Could not buy transmitting tubes on open market
 - Navy, AT&T & GE set up **RCA** to ensure US dominance
 - Took over non-US companies: Telefunken, Marconi ...
 - RCA, GE, Western Electric, and Westinghouse
 - **Exclusive cross-licensing** of 2000 radio patents
 - Sole producers/distributors of power-grid tubes
 - Refused sale to Bay Area firms
 - Threats to RCA's and USA's domination
- So both companies developed their own tubes
 - Litton, Eitel headed their tube shops

Tube Shops' Challenge

- Design around ~250 RCA patents
 - Enormously difficult task
- Hired locally (many were hams)
 - Eitel, Litton **collaborated** with each other *(novell)*
 - Based on friendships over the years
- Worked closely with **patent attorneys**

Tube Shops' Challenges

- Heintz, Eitel, and McCullough engineered a rugged **new** power tube:
 - New materials, manufacturing methods
 - Tube's plates of tantalum (avoid patents)
 - New shock-resistant seals
 - Create high vacuums (better reliability)
- More reliable, longer life than RCA's tubes
- **Didn't infringe RCA's patents**



Heintz and Kauffman
354 Power Triode Tube

The US Depression

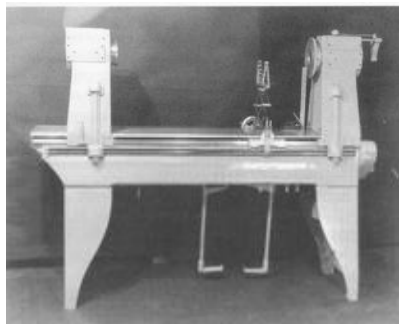
- Formed Eitel-McCullough Inc (Eimac)
 - To build high-power, high-frequency tubes
- Financing:
 - Harrison: real-estate agent in San Bruno
 - Preddey: ran movie theaters in San Francisco
 - Eitel and McCullough brought their know-how
 - Ownership, profits to be shared



Precursor to today's Menlo Park Venture-Capital Firms

Tube Shops' Challenge

- Litton **invented** the glass lathe
 - For assembly, glass blowing, and sealing
 - Make complex tubes in large quantities
 - Allowed high repeatability, precision
- Built tube shop on **parents' property**



The US Depression

- Litton, Eitel, McCullough **cooperated** closely
 - Litton helped set up Eimac vacuum tube shop
 - Gave castings, engineering blueprints for lathe
 - **Freely exchanged** technical, commercial information
 - Reduced risks, for the two small tube-related businesses

**Like Jobs & Wozniak,
Homebrew Computer Club
and MeetUps today ...**

The US Depression

- 1936: **Frederick Terman*** asked Litton to join Stanford EE department as lecturer
 - Shared knowledge with staff, students
 - Sperry \$1000 Litton klystron grant: let Terman bring **Packard** to campus for grad studies
 - with Litton, Hewlett, others
- Formed Hewlett-Packard



Demonstrates University/Industry cooperation

* Built his first radio receiver at 13; 6XH with HH Jr; turned this hobby into a career.

Threats to Peace

- Growing threats from Japan and Germany
 - President Roosevelt rebuilt the Army, Navy
 - New electronic system: **radio detection and ranging (radar)**
- Needed high-voltage high-frequency transmitting tubes
 - Only Eimac's best tubes worked at the high voltages and frequencies needed

The Klystron

- Russell and Sigurd Varian
- They worried about Germany
 - Hoped to use microwaves to detect planes
 - 1937: Moved to Stanford's labs to work with Hansen
 - developed the **klystron** in 1937
 - Used Litton's free **advice**
 - Used Hansen's theoretical assistance



The Klystron – PA Times, Jan. 30, 1939



The Klystron

- Sperry (NY) invested, got exclusive rights
 - Bought lathes, welders, pumps from Litton
- Litton made klystrons for IT&T, for France
 - Needed for war effort, French radar
 - Transformed klystron from lab to production
 - Litton became IT&T's de facto VHF and microwave design arm
 - Continuous-wave klystrons, VHF/radar triodes

SF Bay Area/Stanford was microwave hotbed

Wartime Expansion

- Progressive Approach to business
 - Egalitarian relations among engineers, between companies
- Managerial techniques to thwart unions, keep employees happy, productive
 - **Profit-sharing**, cafeteria, medical clinics

Similar to Hewlett-Packard, Fairchild, Intel, Tandem ...

Post-War Realignment

- RCA, others focused on TV, broadcast (NBC)
- Eimac developed new line of better tubes
 - Power tetrodes for high frequencies
- FCC's surprise shift of **FM radio** to VHF (88-108MHz)
 - RCA, others' tubes **wouldn't work** at VHF
 - RCA **copied** Eimac's tubes, which **did** work

Reversal of Fortunes

- In 1947, Eimac sued RCA and GE
 - alleging patent **infringement**
 - GE, RCA lost lawsuit, halted production
 - Eimac transformed them into its own sales force and distribution network
 - Let them buy Eimac products and resell them under their own names

The “Big Dog” was now Silicon Valley!

Charles Litton After the War

- Focus on higher-power klystrons
 - For physics research, linear accelerators
 - Scaled from 30 **kilowatts** to 30 **megawatts**
 - Transformed Stanford into a major player
 - 2-mile-long linear accelerator: physics research
 - Today: radiation treatment for cancer
 - Developed **“Recipe” to build a firm:**
little initial capital; R&D contracts or a new idea;
engineering teams and a product line;
move to production

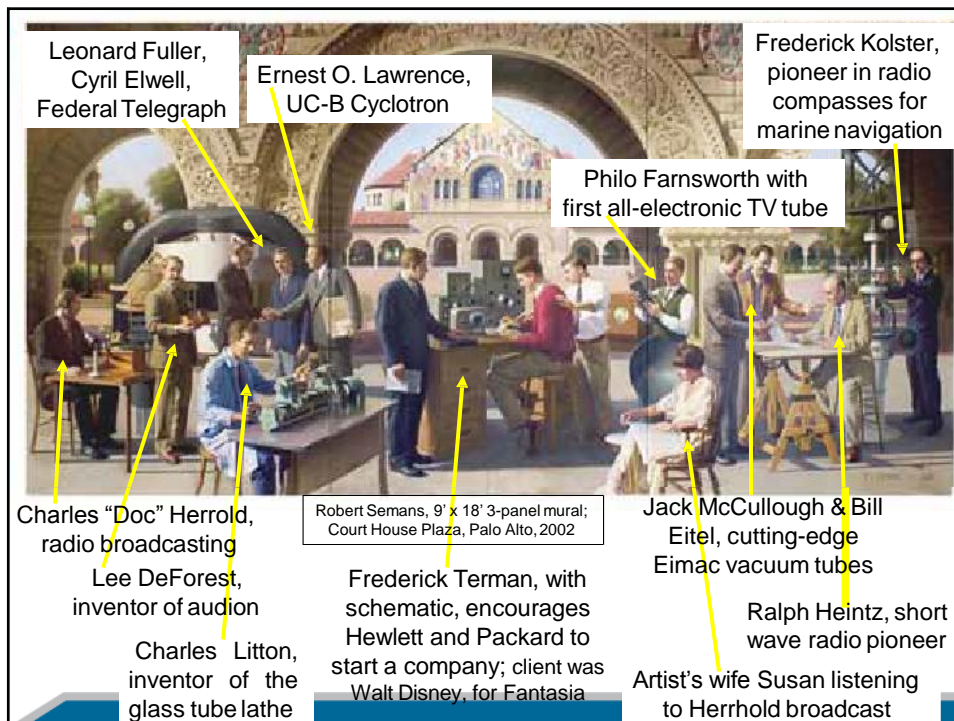
Varian Associates

- 1948: Sold microwave measurement instrument plans to H-P for \$20,000
- Enabled Hewlett-Packard to enlarge its product line, increase revenues in 1950s
- Santa Clara division became Agilent (largest IPO in history), now Keysight

David Packard and Bill Hewlett



... **Sharing/Cooperation**



The Mural in Palo Alto



Fast Forward to 1950's

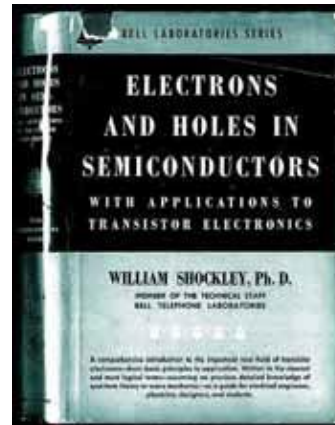
- William Shockley invented transistor while at Bell Labs
Raised in Palo Alto; CalTech, MIT
- Point-contact Germanium device
- Developed to replace vacuum tubes



William Shockley (seated), John Bardeen, and Walter Brattain, 1948.

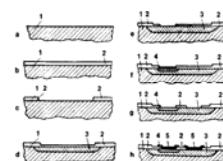
Fast Forward to 1950's

- William Shockley left the East Coast, returned to CalTech
 - His mother, graduate of Stanford, lived here
 - Funded by Beckman
 - 1955: Shockley Semiconductor in Mt View
 - “Traitorous 8” **left** him in 1957 to **form** Fairchild, with first real venture capital funding (Sherman Fairchild)



The Planar Process

- Developed by Dr. Jean Hoerni at Fairchild Semiconductor in 1959
- Required a special infrastructure:
 - **High-vacuum** technology;
 - **precise** furnaces
 - **Glass/quartz capability** and machinists
 - Ultra-pure gasses/water
- **Process control**;
continuous improvement



Built on top of all of the capabilities developed here during the '20's, 30's, '40's

The Planar Process

It all happened here ...



The Planar Process

Isaac Asimov said this was

"the most important moment since man
emerged as a life form"

... perhaps with a bit of exaggeration.



At the end ... (1960's)

- Situation had changed dramatically
- Peninsula was a major electronics center
- The main center for development and production of tubes, semiconductors, ICs
 - Half of the microwave tubes
 - In every advanced weapons, space system
 - In a wide range of industrial goods (broadcast, TV, microwave ovens)
- SV was central to the US defense effort and to the US manufacturing economy

Why?

Silicon Valley Business Climate

- **East's** large, vertically integrated firms
 - Focus on protecting current products
 - Slow to adjust to technology, market changes
- **SV:** highly fragmented, **decentralized** structure
 - **Specialized** firms, nimble/flexible, **engineering-driven**
 - Dense regional **network** of small & medium-size firms that support each other; draw from common work force
 - **California** (since 1870s) doesn't enforce employment contracts
 - Adapt **more rapidly** to change
 - Thrived in the new environment

Not so, in **Michigan!**
Fox vs Netflix

Silicon Valley Uniqueness

■ Practices, skills, and competencies:

- Developed over 100+ years
- Communities of hobbyists; collaboration
- Analog → digital → SW → biotech → mobile
 - Big Data → Deep Learning → VR → autonomous
- Large number of cutting-edge entrepreneurs
- Engineers and venture capitalists
- Local universities, research, development
- Supporting industries
- Role models, expectations
- **Special Culture of Innovation**

The '40's and '50's



AMPEX



FAIRCHILD
SEMICONDUCTOR

SPACE SYSTEMS
LORAL



The '60's



The '70's



The '80's

AUTODESK

intuit.

Adobe

ATERA

LSI

RSA

CISCO.

ELECTRONIC ARTS

SANMINA-SCI

Symantec

Logitech

Sun
microsystems

MIPS
TECHNOLOGIES

Fry's
ELECTRONICS

Atmel

Carol Bartz, CEO
1992-2006
Then, CEO of Yahoo!

The '90's and beyond

KLA Tencor
Accelerating Yield

YAHOO!

vmware

Palantir

INTUITIVE
SURGICAL

change.org

ebay

zend

The PHP Company

Google

facebook

Juniper
NETWORKS

Information Security

MARVELL

LinkedIn

bea
Think liquid.

NetApp

PayPal

NETFLIX

BROCADE

Dropbox

NVIDIA

salesforce

PANDORA

Major auto companies ...



Biotech, Genetic Engineering ...



Women in SV?

Gina Bianchini
Ning Co-Founder, CEO;
CEO, MightyBell

Anne Wojcicki
Founder, 23 and Me

Susan Wojcicki
CEO, YouTube

Safra Catz
Co-President/CTO
Oracle

Sash Sunkara
Co-Founder and CEO
RackWare

Stacy Brown-Philpot
CEO, TaskRabbit
Detroit/Penn St/Stanford

Jessica Livingston
cofounder, Y Combinator

Megan Smith
VP-GoogleX
(now USACTO)

Sequoia Taylor
Managing Partner,
Spry Ventures

Sheryl Sandberg
CEO, Facebook
& author

Diane Greene
Founder and CEO, VMWare
now Google's cloud chief

Laura Weidman Powers
Co-founder and CEO,
Code2040 (now with USACTO)

Where is "Silicon Valley"?

"A map of **Silicon Valley** in 2013, which originally just included the Santa Clara Valley from Gilroy to Palo Alto. Today it is a **metaphysical space** stretching from San Jose to San Francisco and Berkeley."

A History of Silicon Valley, p. 264



Other Technology Centers

- Silicon Roundabout (London)
- Silicon Forest (Oregon)
- Silicon Allee (Berlin)
- Silicon Cape (S. Africa)
- Silicon Alley (New York City)
- Silicon Prairie (Omaha; DFW)
- Silicon Valley-India (Bangalore)
- Silicon Valley-Taiwan (Hsinchu)
- Silicon Oasis (Dubai)
- Silicon Wadi (Israel)
- Silicon Hills (Austin)



واحة دبي للـسـيـلـيـكـون
DUBAI SILICON OASIS



SILICON ALLEY
ACCELERATORS

Where is VC funding? (Spring 2014)



Where is Innovation Today?

- Hackathons

- TechShop

- Maker Faire

- Incubators →

- Open Source software projects

 - Egalitarian use of jointly-developed software

- Android, iOS Apps

... and dozens of other collaborative spaces

Like Ham Radio, Homebrew Computer Club



500

500 Startups



Y Combinator



How Different are We?

- “In Silicon Valley, great ‘collaborators’ are prized; in Washington, DC, they are hanged. When they say ‘collaborator’, they mean ‘traitor’; here [SV], they mean ‘colleague’.”

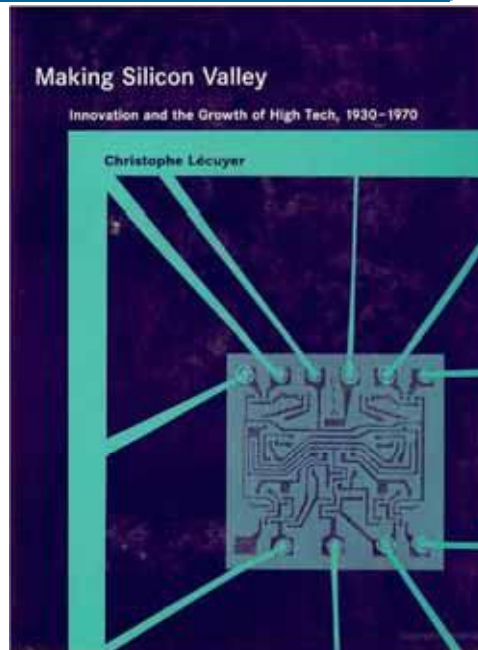
Thomas Friedman, [NY Times](#), Jan 13, 2013

- It’s our **attitude** in Silicon Valley:
“**Failure** is a **feature**, not a bug.”

- Successful Startups: 100:1 (in SV: 100:5)

Get the book!

Learn MUCH
more about
those early
days ...

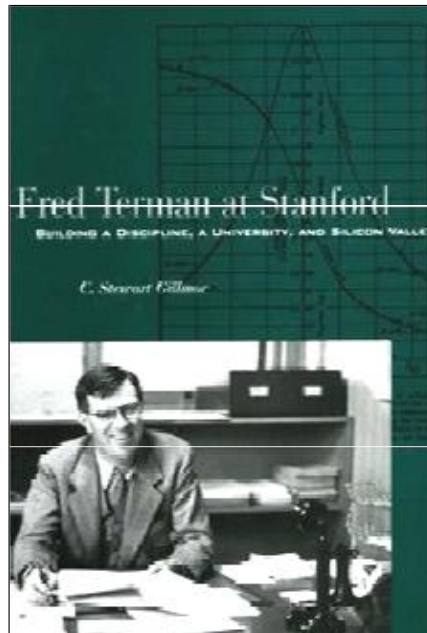


***More about that
period ...***

**Fred Terman at
Stanford:** Building
a Discipline,
a University,
and Silicon Valley
by Stewart Gillmor

2004,

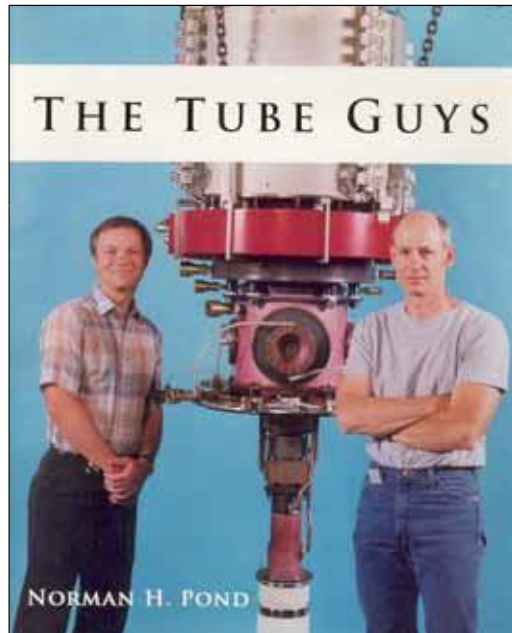
ISBN 978-0804749145



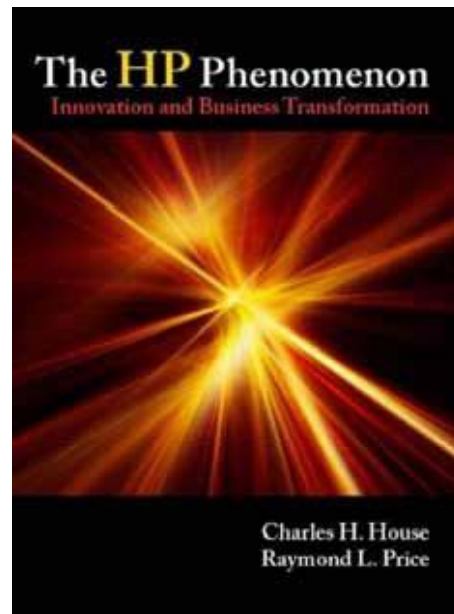
**Another
fun book**

**Norm Pond was
president of Varian
Associates (*Sigurd and
Russell's company*),
then formed Intevac
and is CEO**

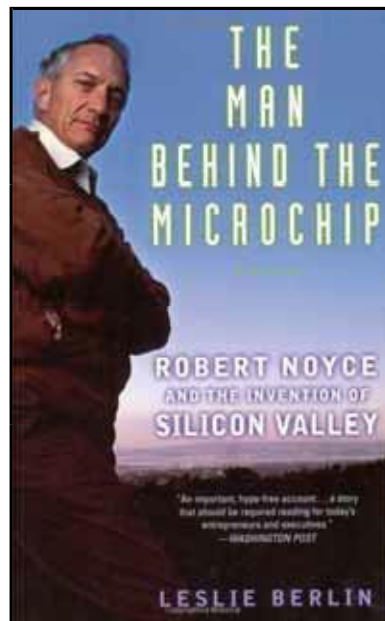
2008,
ISBN 978-0-9816923-0-2
www.russcochran.com



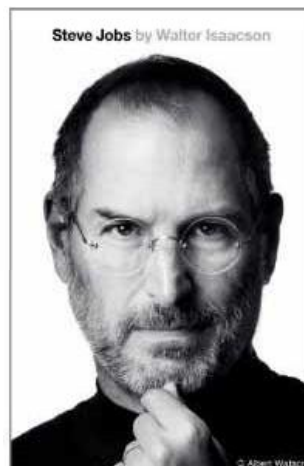
**To understand how H-P
was a product of
Silicon Valley, and
shaped its culture
through a number of
re-inventions
(1930s, up
through 2009)**



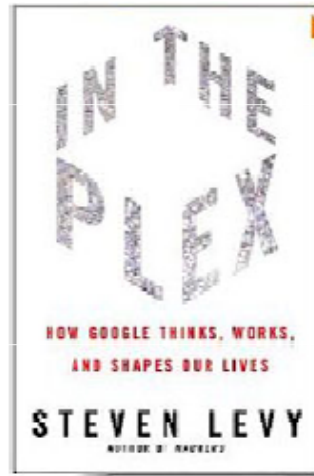
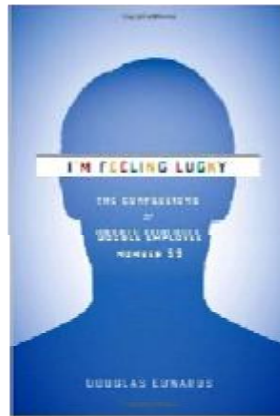
I also recommend
Leslie Berlin's
recent book on
Bob Noyce



For another
view of
Silicon Valley



**For a view
of another
Innovation
Environment**



On Netflix Streaming:

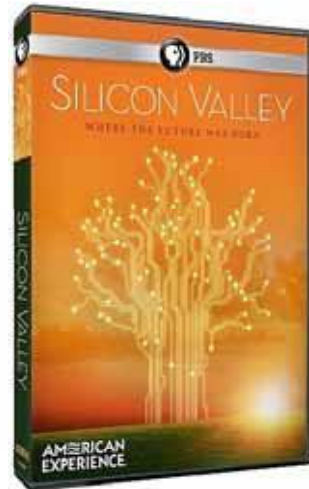
2011 video, 85 minutes
(SXSW Best Documentary)

**Covers funding and
startup of Apple, Intel,
Genentech, Tandem,
Cisco, with views from
the key funders (Rock,
Perkins ...) and
entrepreneurs (Moore,
Trevbia ...)**



On PBS's
American Adventure:
“**Silicon Valley:
Where the Future
was Born**”

video, 85 minutes, \$20
(Broadcast on Feb. 5, 2013)
Can be streamed online



“The creativity of the founders of Fairchild Semiconductor, including physicist Robert Noyce, helps transform Santa Clara County into Silicon Valley the story of the pioneering scientists.”

**Reviewing the Good Ol' Days
... to understand how
Silicon Valley became the
hub of technology development
... *and STILL is* ...**

Download the slides (3 MB)
and suggestions for further reading at:
www.e-grid.net/docs/1610-wesling.pdf

p.wesling@ieee.org