Classic Silicon Valley: 1976

- Homebrew Computer Club (hobbyists)
  - 6502 Processor

    - 4,000 transistors
    - Design-around Motorola 6800
    - Cheap (1/6th the price)
    - Hobbyist-level device
  - Steve Jobs and Steve Wozniak
  - The Apple I (to sell to friends)

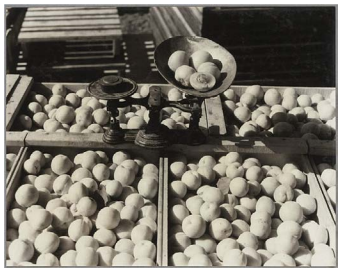
Classic Silicon Valley: 1976

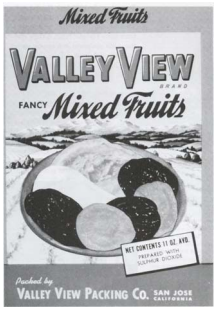
- Wozniak-Jobs partnership
  - called it Apple Computer Company
  - Started in a garage in Los Altos
  - Sold 200 or so; attracted attention of investors
  - IPO in 1980: 2nd-largest IPO since Ford Motor Company 25 years earlier
  - Now largest stock market capitalization

–How could this happen? Why here?

Before 1920

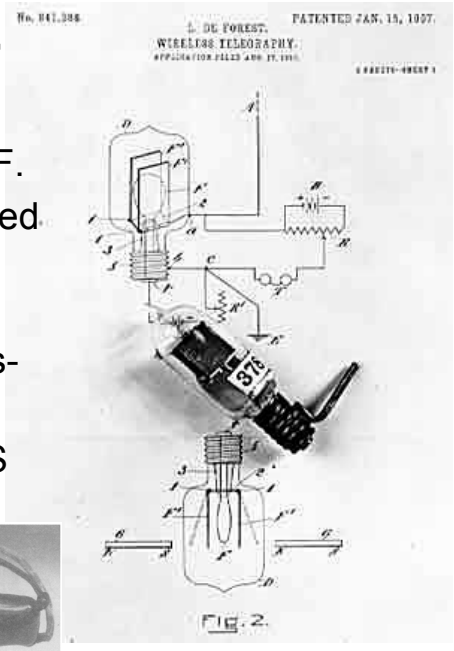
This was more typical …



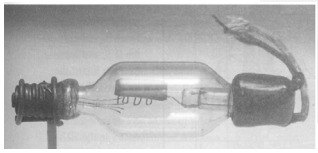


Let's Go Back …

- **Federal Telegraph**
  - Formed in 1909 in S.F.
  - **Lee de Forest** invented the audion oscillator and amplifier in 1907
  - Pioneered continuous-wave radio
  - Sold equipment to US Navy in World War I



De Forest tube



Defining Events

- Titanic Sinking in 1912
- World War I
- Importance of Technology
- US Navy "push" for ship-to-shore and other communications modes
- Brought frenzy, funds to S.F. Bay Area

Let's Go Back …

- 1st commercial radio broadcast
  - Charles "Doc" Herrold
    - Early Stanford EE grad
    - Started an SF firm
    - Destroyed in the 1906 earthquake/fire
    - Started a San Jose school to teach radio arts (1909)
  - First Commercial broadcast, San Jose, 1909
  - FN, then SJN, then KQW, becomes KCBS

Near Fairmont; Audio in 1910

Clear-Channel; Music til Dawn

Early Roots …

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

We Now Follow Three Pioneers

- **William Eitel**
- **Jack McCullough**
- **Charles Litton**
- Deep roots in the Bay Area
- Families with a strong history of entrepreneurship
- Born/raised in San Francisco, San Mateo and Santa Clara counties

William Eitel

- Mechanical skills: shop at Los Gatos HS
- Worked in his father's quarry
  - ass't blacksmith, machine operator
- Visited shops of Hall-Scott Motor Car Co.
  - Learned about machine-shop practice
  - Operation of complex machinery

William Eitel, W6UF
1908 - 1989

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

•First displayed his new tube at the Fresno Hamfest
•Met his wife at a hamfest

Jack McCullough, Charles Litton

- Attended **California School of Mechanical Arts**
- Founded in S.F. in by **James Lick**, $540,000
- Opened in 1895; free education for boys, girls
- One of the best West Coast **technical hi schools**
  - Rigorous training in the mechanical trades
  - Became excellent machinists
  - 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 ME dept:
  - Curriculum with strong practical flavor
  - Knowledge of mechanics and metalworking
  - Organized around courses in shop work & administration, machine drawing & design, power plant engineering, chemistry courses
  - BS-ME in 1924

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
  - Ventured into **tube production** at local radio firms in the late 1920s and the early 1930s
  - Bay Area had 1,200 licensed amateurs
    - 10 percent US total

Ham Radio in SF Bay Area

- **Isolated and peripheral region**
  - A continent away from urban and industrial centers
  - But a large and vibrant ham radio community
- **Geographical and cultural factors**:
  - Strong maritime orientation
  - SF was one of the largest seaports on the West Coast
  - Several military bases; **US Navy** presence
  - **Commercial** shipping firms relied on radio comm’n
  - Considerable visibility for technology in 1900s ’10’s
  - Navy, shipping companies employed radio operators, some of whom were involved in amateur radio

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**
    - One of the earliest radio companies in the US
    - Produced radio transmitters in the 1910s.
- These firms made radio parts available to local hobbyists, hired radio amateurs

Ham Radio Subculture

- Camaraderie and intense sociability
  - A way to make friends
  - Communicating "over the air," face to face in clubs
  - Organized "hamfests" with hundreds of amateurs plus suppliers of radio equipment
- **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

- Representatives of the citizenry
  - against large companies, patent monopolies, undemocratic organizations
- Interest in extending radio technology
  - Built reputations: innovating new circuitry, devising clever transmitters, contacts with faraway lands
- Mix of competitiveness and information sharing *
- **A lot like today's Silicon Valley …**

Following our Heroes …

- Eitel, Litton, McCullough, ham friends
  - Experimented with short waves (> 500 kc)
  - Learned about **vacuum tubes**
  - Built their own equipment, parts
  - Made notable contributions
  - 1924: Litton and Stanford radio club* made first contact with Australia and New Zealand
  - 1928: Eitel pioneered 10-meter waves (30 MHz) for transcontinental communication
  - Opened VHF bands to radio communication

* K6YX: Current trustee Dave Leeson

Following our Heroes …

- Litton learned to **fabricate** vacuum tubes
  - Especially power-grid tubes (reading; disassembling)
  - Remarkable achievement for an independent experimenter (had help from ham Moorhead) lawsuit
- General Electric, Westinghouse, AT&T (WECO)
  - Developed hi-power transmitting tubes in early 1920s
  - Difficulties in producing consistent, reproducible
  - Required precise machining, glass blowing (Pyrex)
  - High vacuum; baked at high temperatures for hours to release occluded gases in their metallic elements
  - Exotic materials, sophisticated sealing techniques
  - Tight joints between envelope and metallic elements
  - Use of "getters"

Following our Heroes …

- Litton got local job through ham friend
  - Research at **Federal Telegraph**
  - Got contract with IT&T (Europe, So. America)
  - Built to 60 engineers and scientists
  - Became sole supplier of radio 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 McCollough a year later

The Tube Business in the ’20s

- Could not buy transmitting tubes on open market
  - RCA, GE, Western Electric, and Westinghouse
    - **Exclusive cross-licensing** of 2000 patents, to control market
  - **RCA** set up by GE, US Navy to ensure US dominance
    - To control ship-to-shore, transoceanic communication
  - Sole producers/distributors of power-grid tubes
    - Refused sale to Federal Telegraph, Heintz & Kaufman
  - Threats to RCA’s domination
  - RCA to sue if they bought transmitting tubes from Europe
- Both companies developed triodes
  - Litton and Eitel headed their tube shops

Tube Shops’ Challenges

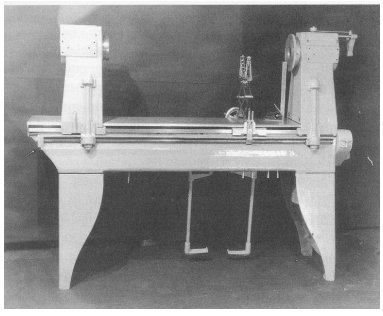
- Design around ~250 RCA triode patents
  - Enormously difficult task *(Samsung vs Apple case)*
  - RCA had shut down Sylvania’s tube business
  - Ordering materials difficult (Corning in NY)
- Hired locally (many hams); got resources from IT&T (French engineers)
  - Eitel, Litton collaborated with each other *(novel!)*
  - Based on friendships over the years
  - Didn’t compete with other’s market
- Worked closely with patent attorneys

Tube Shops' Challenges

- Heintz, Eitel, and McCullough engineered the **gammatron**
  - Rugged power tube
  - New materials, manufacturing methods
  - Tube plates of tantalum (avoid "getter" patents)
  - New shock-resistant seals
  - Create high vacuum envelopes (> reliability)
- More reliable, longer life than RCA's tubes
- Didn't infringe RCA's patents

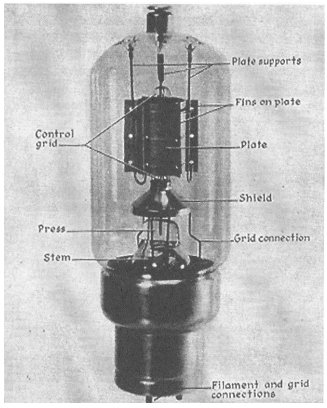
Tube Shops' Challenges

- 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

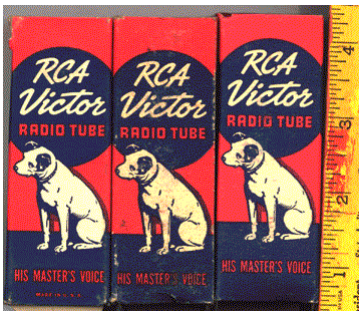


Litton Engineering Laboratories

The Ham Radio Market



Heintz and Kauffman 354
Power Triode Tube



The US Depression

- Formed Eitel-McCullough Inc
  - To build high-power, high-frequency tubes
- Financing: Walter Preddey, Bradshaw Harrison
  - Harrison: real-estate agent in San Bruno
  - Preddey: ran movie theaters in San Francisco
  - Eitel and McCullough brought their know-how
  - Profits to be shared
  - Preddey was the president, Eitel a vice-president

Precursor to today's Menlo Park Venture-Capital Firms

The US Depression

- Litton, Eitel, McCullough cooperated closely
  - Litton helped set up vacuum tube shop
  - Gave castings, engineering blueprints for lathe
  - Eitel and McCullough then made high-quality glass lathes at low cost
  - Freely exchanged technical, commercial information
  - Reduced risks, for the two small tube-related businesses
  - **Like Jobs, Wozniak, Homebrew Computer Club**

The Depression

- Eimac advertised in ARRL's **QST** Magazine

The Depression

- Litton expanded into vacuum pumps
  - Replaced mercury (cooled with liquid air) with oil
  - Compact, higher speed, better vacuum
  - Distiller, to produce his oil from commercial motor oil
- 1936: **Frederick Terman** asked Litton to join Stanford as EE department lecturer
  - Shared knowledge with staff, students
  - Litton $1000 grant: let Terman bring **Packard** to campus for grad studies, work with Litton

Start of University/Industry cooperation

The Depression

- Eimac focused on transmitting tubes
  - Amateurs: most demanding users of tubes
  - Higher power, higher frequencies
  - Close, precise element spacing
    - Related to tube performance
    - Fabrication of VHF transmitting tubes
    - Operate: high voltages, overloads, longer lifetimes
  - High vacuums, better out-gassing
  - New lathe, vacuum, cleaning techniques were closely guarded

Eimac's Expansion

- Eitel-McCullough's new tubes
  - Marketed to radio amateurs, Small manufacturers
  - 1937: sales of $100,000 (half from each market)
- Gradually enlarged their workforce
  - Almost exclusively hobbyists from radio clubs
  - Most were in their early twenties
- Radio amateurs had the skills needed:
  - Familiarity with transmitting tubes
  - Expertise in design of radio systems

Threats to Peace

- Growing threats from Japan and Germany
  - President Roosevelt rebuilt the Army, Navy
  - New electronic system: **radio detection and ranging (radar)**
  - Secret research programs in short-wave radio at Naval Research Labs (NRL) Fort Monmouth, NJ
- Needed high-voltage transmitting tubes
  - Only Eimac tubes worked at the high voltages

Pre-War Expansion

- Eimac: two different versions of ham tube
  - Shorter leads; side entry (rectangular shape)
  - Another version of same tube for the **Navy**
- RCA, Western Electric selected for prod'n
  - NRL helped Eimac get sub-contracts
  - Bank of America financing, volume production
- Managerial techniques to thwart unions
  - Profit-sharing, cafeteria, medical clinic

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

Wartime Expansion

- Litton: Expanded
  - New plant in Redwood City
  - Lathes allocated by the War Production Board
- Became very profitable

Post-War Realignment

- Glut of tubes dumped on market
  - Layoffs, plant closings
- RCA, others focused on TV, broadcast
- Eimac developed new line of better tubes
  - Made war-surplus ones obsolete
  - Power tetrodes for high frequencies
  - FCC surprise shift of **FM radio** to VHF
  - RCA, others' tubes **wouldn't work** at VHF
  - They copied Eimac's tubes, which did work

Reversal of Fortunes

- In 1947, Eimac sued RCA and GE
  - alleging patent infringement on tetrode
  - GE and RCA had copied Eimac's new line of tubes for FM radio, TV broadcasting
  - GE, RCA lost the 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!**

The Klystron

- Russell and Sigurd Varian developed the **rhumbatron**, then the **klystron** in 1937
  - Russell went to Stanford, then worked at Farnsworth's Television Laboratory in SF
  - Philo Farnsworth pioneered TV in 1920's
- They worried about Germany
  - Hoped to use microwaves to detect planes
  - 1937: Moved to Stanford to work with Hansen
  - Used Litton's free advice
  - Used Hansen's theoretical assistance

The Klystron – PA Times, Jan. 30, 1939

TWO ANNIVERSARIES

For Franklin Delano Roosevelt it was a birthday—his 57th—and the occasion for a nation-wide rally in behalf of a great humanitarian movement, the campaign against infantile paralysis. Dimes poured into the White House from individuals in every part of the nation while movie and stage stars gathered in Washington and other cities for birthday balls

Meanwhile, across the Atlantic, Adolph Hitler celebrates the sixth anniversary of Nazi accession to power by going on the air with a warning to other nations to keep hands off Germany's development, a threat that she must have colonies, a denunciation of Bolshevism, and a defense of the policies which have raised a storm of protest among democratic nations of the world.

Palo Alto Times

DAILY

AN INDEPENDENT NEWSPAPER

47th Year—No. 25

PALO ALTO, CALIFORNIA, MONDAY EVENING, JANUARY 30, 1939

5c copy—75c month $7.00 year in advance

Hitler Warns: Let Us Alone!

Denies Plan To Attack Other Lands

Anniversary Address Is Denunciation Of Bolshevism

By LOUIS P. LOCHNER

BERLIN, Jan. 30 (AP) — Adolf Hitler raised Germany's claim for colonies today and warned western powers against "interfering in matters concerning us alone."

Germany needs colonies for economic assistance, he told the Reichstag on the occasion of the sixth anniversary of the Nazi rise to power.

"If others do not believe this it does not matter and does not impair our rights," he continued.

He disclaimed any idea that Germany needed colonies "to set up armies there."

"I need not assure you that in the future also we shall tolerate no attempts at interference in matters concerning us alone with the purpose of preventing natural and sensible solutions."

Hitler ridiculed any idea that Nazi Germany was out to attack or divide up North or South

NEW STANFORD RADIO INVENTION HERALDS REVOLUTIONARY CHANGES

SIGURD VARIAN

'Klystron' Harnesses Ultra Short Wave Transmission

By JULIUS L. JACOBS

An invention so breath-taking in its possibilities that it may alter the future radio development of aeronautics, as well as telephone, telegraph, and television communication, was announced today by Dr. Ray Lyman Wilbur, president of Stanford University.

Born in the brain of a Pan-American Airways pilot as he flew the Latin-America runs, and perfected in the physics department of Stanford University, the invention was developed by the amazing new apparatus, which has harnessed the forces of ultra-short-wave radio transmission. These same patent rights have been turned over to the Sperry Gyroscope Corporation, which will make possible the commercial development and production of the new discovery in radio technique.

By a $25,000 gift to the Stanford physics department last year, the gyroscope people made it possible for the inventors to improve the working model.

RUSSELL VARIAN

Six Killed In Blizzard

CHICAGO, Jan. 30 (AP) — A paralyzing blizzard whipped across the southern Great Lakes states and the Ohio valley today, burying Chicago under one of the heaviest snowfalls on record.

Forecaster C. A. Donnel said if the storm continued all day the city might have snow totaling more than the existing record of 19.2 inches in March, 1930. The fall was one foot by noon.

Six deaths were recorded in the storm area. Among them was Samuel F. Manning, 60, general secretary of the Chicago board of health, who apparently died of over-exertion.

There were three elevated train collisions in Chicago in which 50 persons were injured. In each instance a heavily loaded train crashed into the rear of another.

The storm was the worst in northern and central Illinois, northern Indiana and southern Michigan but spread northeast-

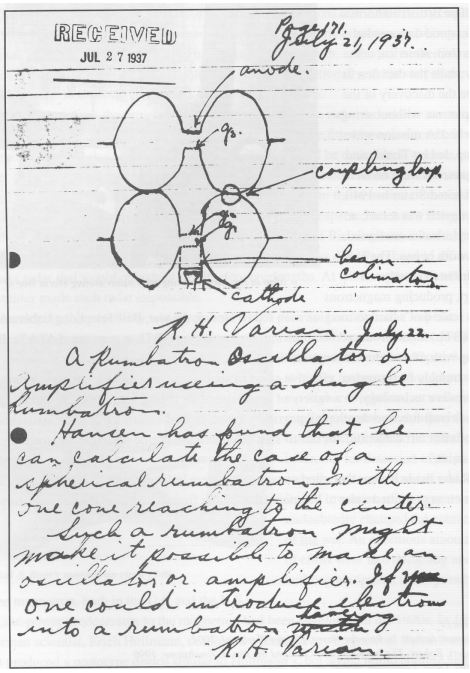
State Official Tells of Plan To Widen 101

Definite assurance that the

Prison Farm Recommended By Grand Jury

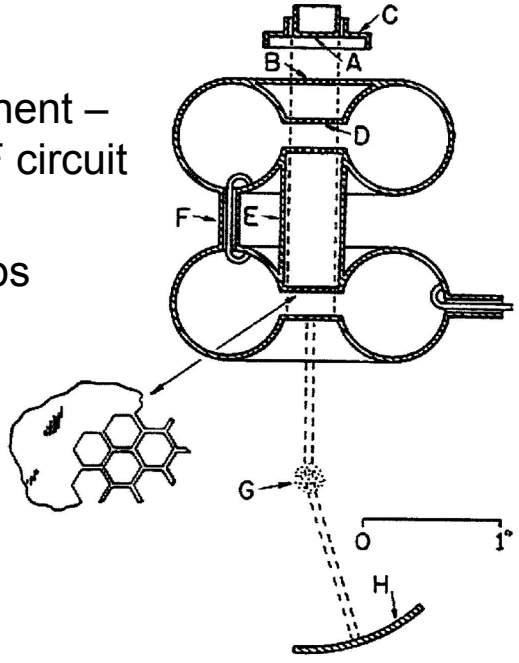
Meeting in closed session with the Santa Clara County Board

The Klystron



The Klystron

- Not just a component – an **integrated** RF circuit
- Like an antenna, with resonant traps



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
  - Korean War: Armed-Forces contracts
  - Developed "**Recipe" to build a firm:** little initial capital; R&D contracts; engineering teams and a product line; move to production

Varian Associates

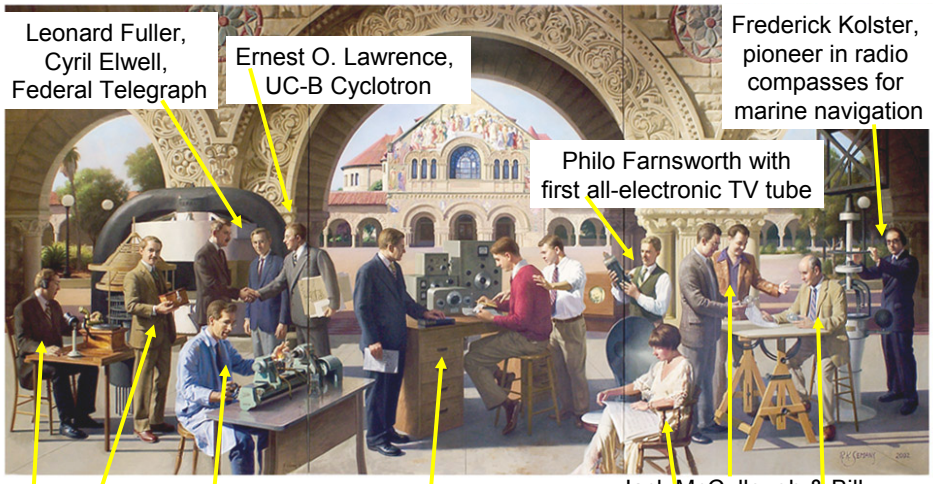
- 1948: Russell and Sigurd Varian, Edward Ginzton, Myrl Stearns, Frederick Salisbury, Donald Snow (Russell, Edward, Myrl: Stanford)
  - Families of modest means, progressive politics
  - Worker control and share in ownership
  - Small cooperative-like laboratory closely linked to university research
  - Several small defense contracts (Litton recom)
  - From GE: specialty klystron for new UHF TV (while GE worked on color television)

Egalitarian relations among engineers, companies

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

David Packard and Bill Hewlett



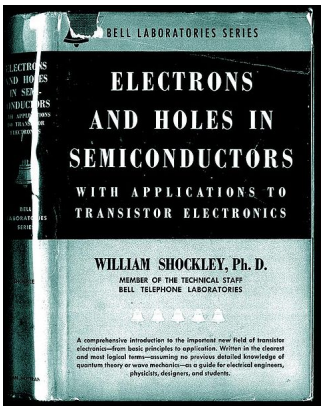
Fast Forward to Silicon Valley

- William Shockley invented transistor while at Bell Labs
- Point-contact Germanium device

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

Fast Forward to Silicon Valley

- William Shockley left the East Coast, returned to CalTech, then to Palo Alto
  - His mother, graduate of Stanford, lived there
  - Funded by Beckman
  - 1955: Shockley Semiconductor in Mt View
  - "Traitorous 8" left him in 1957 to form 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**
  - Ultra-pure gasses; **cleanliness**
  - **Process control**; continuous improvement

All of the capabilities developed during the ’20’s, 30’s and ’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.

Silicon Valley Business Climate

- East's large, autarkic, vertically integrated firms
  - adjust slowly to swift technological and market changes
  - Protective, inward, monopolistic (ATT, RCA)
- SV: highly fragmented, decentralized structure
  - Specialized firms, flexible, engineering-driven
  - Dense regional network of small & medium-size firms
  - Autonomous and often competing teams
  - Adapt more rapidly to change
  - Thrived in the new environment

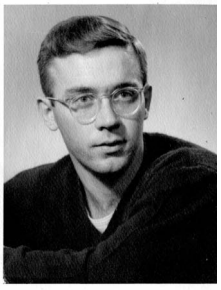
(Ref: Arjun Saxena 1994) *

Silicon Valley – Themes

- Practices, skills, and competencies
  - Accumulating here for more than 40 years
  - Community of electronics hobbyists
  - Strong universities (SJSU, UC-B, Stanford …)
  - Analog and digital techniques (and bio, sw)
  - Access to networks of engineers, financiers and entrepreneurs
  - Unique expertise in process, manufacturing, product engineering, sales, and marketing
  - Develop and grow electronics corporations

Origins of the **CPMT SCV Chapter**

- 1949: Charles (Bud) Eldon's frat mate Lew Terman suggested his dad as an advisor *(Fred Terman, son of Lewis Terman)*
- Introduced to Don Fink (*ELECTRONICS Magazine; IRE president; first Gen Mgr of IEEE*)
- Bud joined HP, working for Barney Oliver



In 1955, Barney sat on Bud's desk:

"Bill wants you to start a chapter of an IRE Group on Product Engineering"

(Bill Hewlett was the IRE president)

Using networking and volunteering to "create" opportunities

Origins of the **CPMT SCV Chapter**

- Bud gathered engineers from Varian, SRI, Litton, other local companies
- Merged with Component Parts, PMP, PHP (at merger in 1962), CHMT, then CPMT
- Now it's Components, Packaging and Manufacturing Technology!
- Our Chapter serves the whole Bay Area
  (even though we were assigned to the SCV Section after the SF Section was split into three)

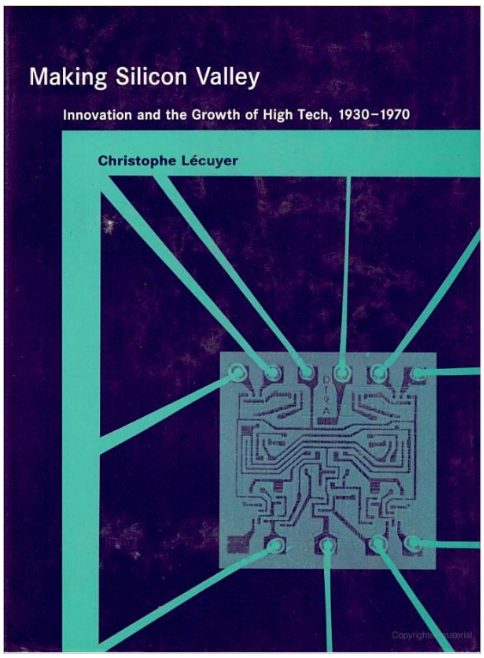
Origins of the **CPMT SCV Chapter**

- Bud became Chairman of the PHP Society
- Secured local IEEE ownership of WESCON
- Bud was Region 6 Director, then IEEE President in 1985
- Now retired in Arizona

(source: IEEE Oral History Project)

Get the book!

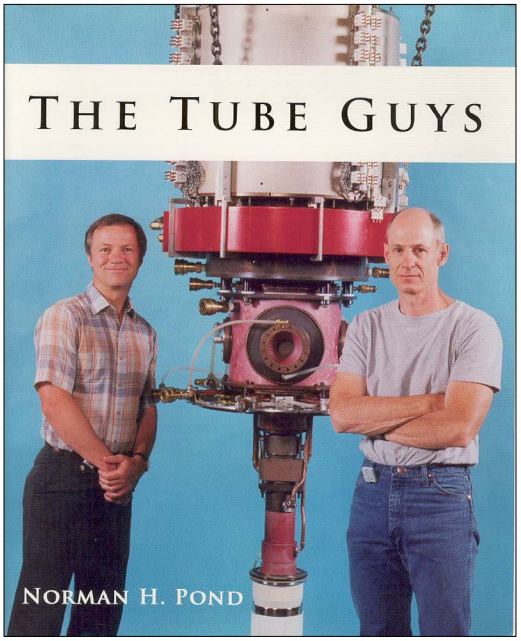
Learn MUCH more …



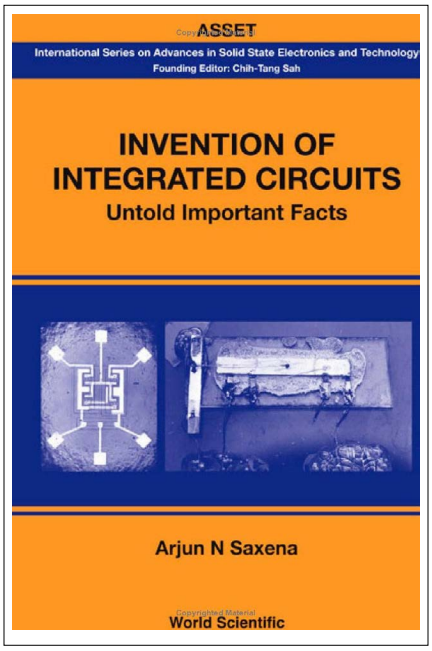
Another fun book

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

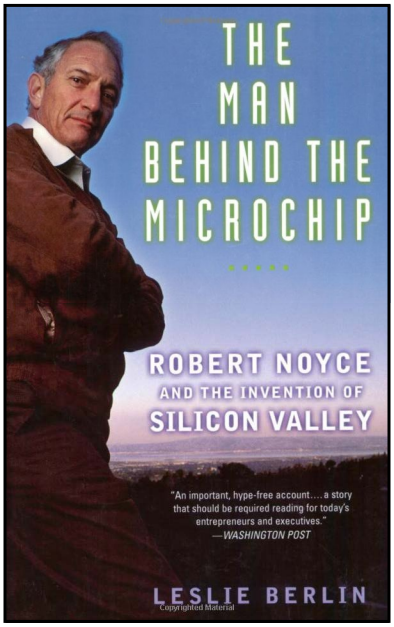
2008,
ISBN 978-0-9816923-0-2
www.russcochran.com



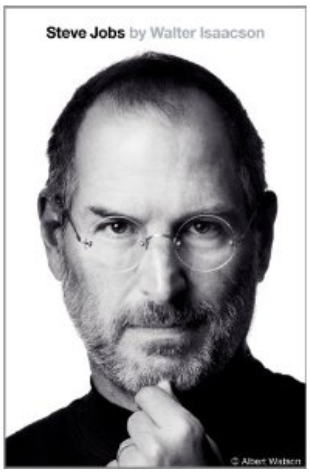
To explore the invention of the integrated circuit:



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



For another view of Silicon Valley



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, Treybig …)

Remembering the Good Ol' Days

… and understanding how Silicon Valley became the hub of technology development

Thank you for attending!

Download the slides (4 MB) at:
www.e-grid.net/docs/1209-wesling.pdf