EECS Presentation

- **Untold 8 Year History of the Microprocessor's Origins**
  From vacuum tubes (1963) to first microprocessor (1971) and how U of M influenced the transition.

- **Tips and insight for budding U of M entrepreneurs**
  Making your first million

- **Free Lunch**
  Who said there's no such thing

1963 64 65 66 67 68 69 70 1971

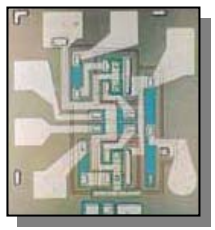
History's Lost Years

Birth of semiconductor industry

- Vacuum tubes to transistors -

- U of M computer logic design still based on vacuum tubes, then the industry standard.

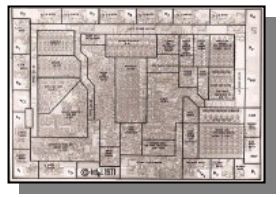
- Fairchild invents planar processor in 1958 leading to first simple IC gate in '63.



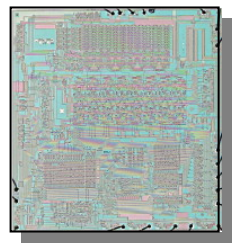
- Graduated U of M with solid background in vacuum tube circuit and logic design plus a desire to start my own electronics company (but making what?)

Birth of the microprocessor

- Intel announces first microprocessor 8008. TI quickly follows with 1795.



8008



1795

- TI would later claim to be originator and demand billions in usage royalties from the worlds biggest corporations.

- The "Who Invented the Microprocessor" litigation would rage for 10 years before ending abruptly in 1995 (see epilog).

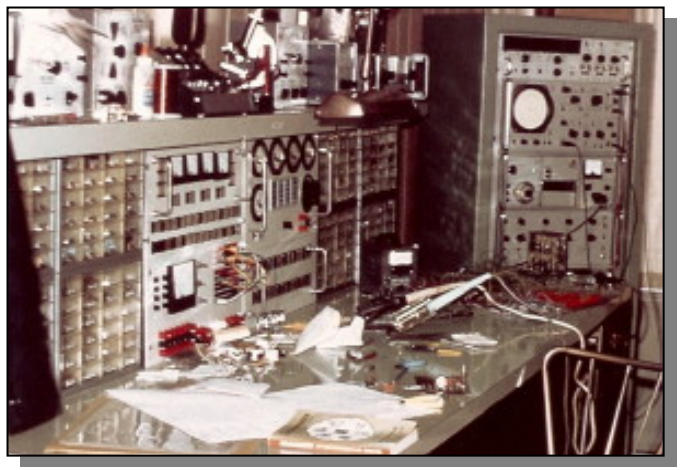
1963 64 65 66 67 68 69 70 1971

Reality sets in

- Douglas anti-satellite system in LA & JI -

- Drink from fire hydrant. Responsible for (transistorized) launch sequence system.
- 50% of major obsolete in 3-5 years (but 3 minutes?). Crash course in transistor logic
- Tips for the entrepreneur:
  *Take jobs offering learning opportunities
  *ME, accounting, etc courses invaluable
  *Expect to spend extra 15-20 hours/week to stay ahead of the pack.

Johnson Island dual launch anti-satellite system.



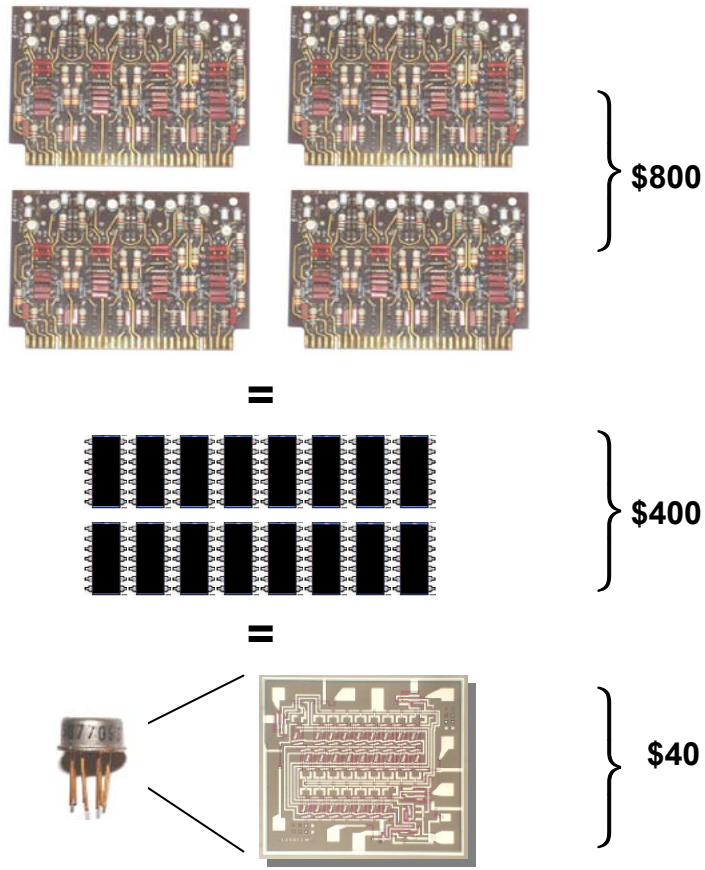
Garage (bedroom) lab using military surplus.

1963 64 65 66 67 68 69 70 1971

What's an MOS?

- How'd they cram all that in one chip? -

- Staff job led to interest in DDAs (serial CPUs) for inertial guidance platforms.
- GME IC sales pitch included CTO Frank Wanlass who told of new device packing 16 bit SR in a TO5 can. No way!!! >>>
- Tips:
  *Staff jobs good big picture perspective.
  *Attach yourself to a high tech mentor.
  *When opportunities are limited move on.



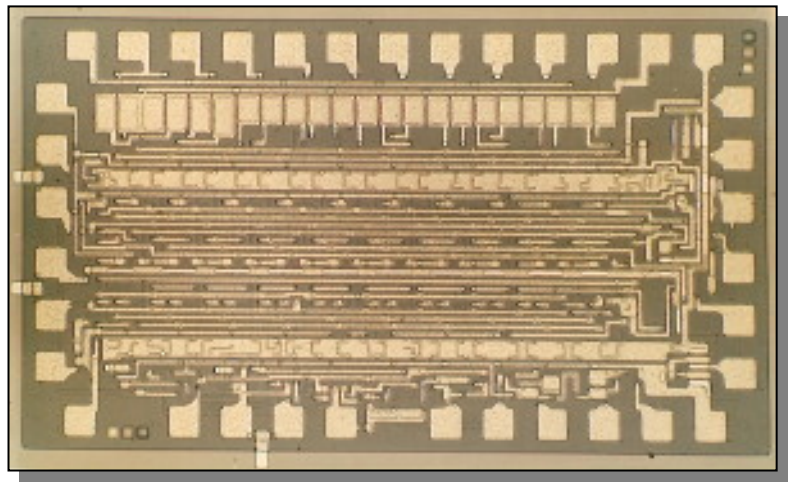
GME's 16 bit MOS shift register in a TO5 can and its circuit card and IC equivalent.

1963 64 65 66 67 68 69 70 1971

IBM (FSD Huntsville Alabama)

- Saturn moon rocket computer systems -

- **$200K TD to explore next-gen MOS data acquisition options. Swiss army knife. GI (Wanlass) for chip fab $30K. 10/65**
- **On 2/66 trip to GI, Wanlass taught me all his circuit and mask layout tricks. SSCC**
- **DDA vs IBM mainframe with ROM control.**
- **Tips:**
  ***Hands on production floor experience!**
  ***Again if opportunities limited move on.**



First LSI (>100 gates) system on a chip. 2/66 Multifunction chip configurable as 10 bit A/D, D/A, or 8-channel MUX. (GI MEM 5015)

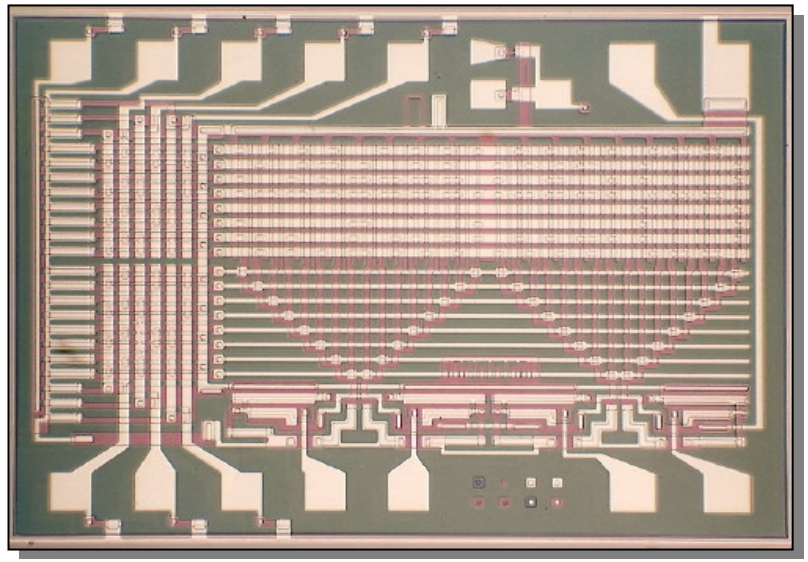
MUX layout with gate mask programmability. (No CAD) Voila, the semiconductor ROM!

1963 64 65 66 67 68 69 70 1971

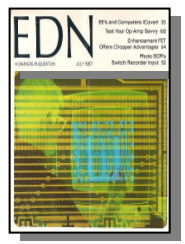
Fairchild (to head new MOS group)

- For show only no budget -

- Job description, to transfer MOS process from R&D to manufacturing and design a few analog MUX gates & simple devices.
- My objective was to design standard building blocks for off- the-shelf MOS computers. 1st item semiconductor ROM.
- Tips:
  *Don't be afraid to get your hands dirty.
  *Learn all areas, many hats required later.



First semiconductor ROM 9/66.
Industry's top publication Electronics ran article in 2/67 & it later appeared on EDN cover 7/67

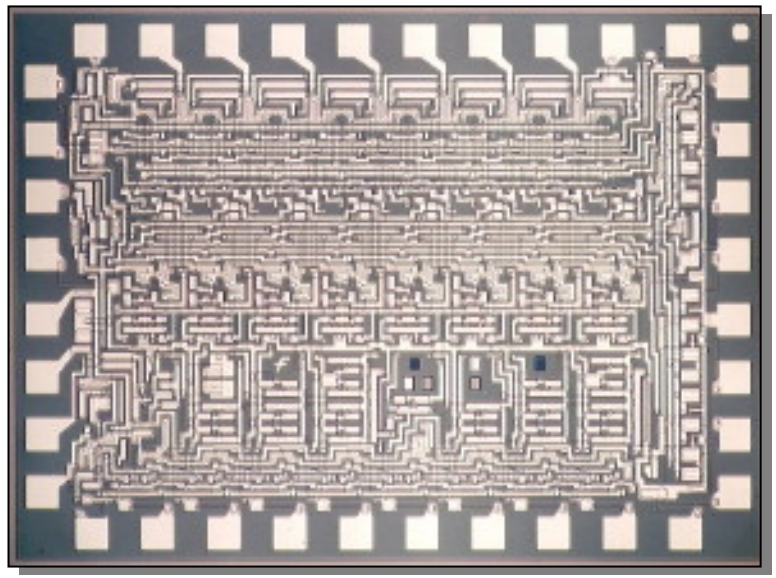


1963 64 65 66 67 68 69 70 1971

Fairchild

- Assembled scrappy blue-collar team -

- ALU sold to management as up down counter until Electronics did major article.
- Hired 4 system engineers. Trained to think from system to logic to circuit design and then hand-crafted mask layout. No CAD!
- Tips:
  *Build well trained, dedicated team.
  *Don't get hung up on degrees.



First ALU slice 3800 (8-bit with carry look ahead)
3/67 Article appeared in Electronics 3/68

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Fairchild

- Dozens of CPU building block chips -

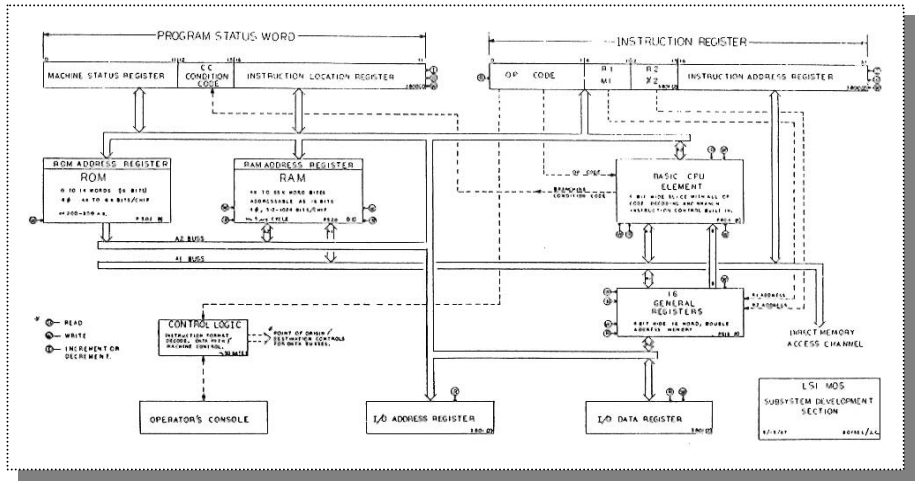
- **Operating below radar MOS group still threatened status quo on two fronts.**

  1) Fairchild: MOS would cannibalize IC sales. (1 $5 MOS = 12 $5 Bipolar ICs)

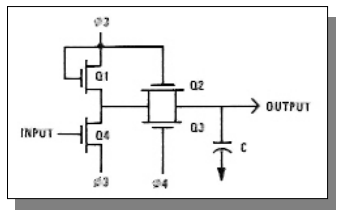
  2) Computer company engineers didn't want to relinquish design control.

- **No viable solid state memory.**

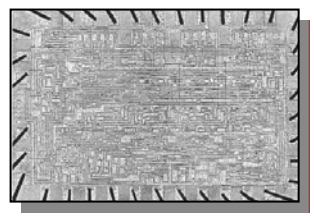
- **Tips:**
  ***No NIH! Leave ego at the door!**



Block diagram of complete LSI CPU based on 32-bit IBM 360 mainframe. Key exhibit in a dozen litigations. 9/13/67



Dynamic 4Φ logic = 10x density (>1000 gates/chip), 10x speed, & 1/10 power with 1st gen. process



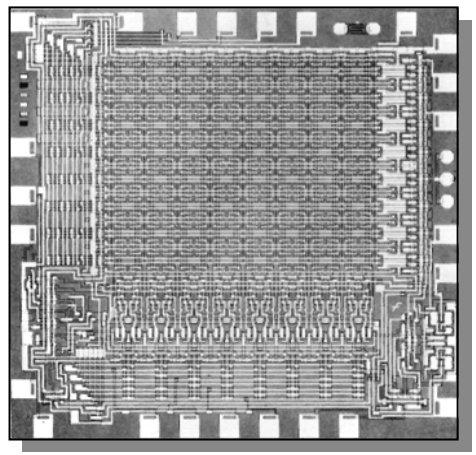
3804 First ALU with bidirectional bus.

1963 64 65 66 67 68 69 70 1971

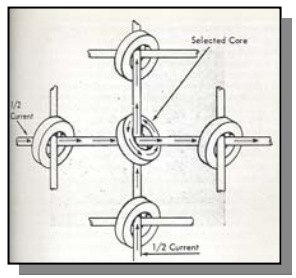
DRAM (Dynamic RAM)

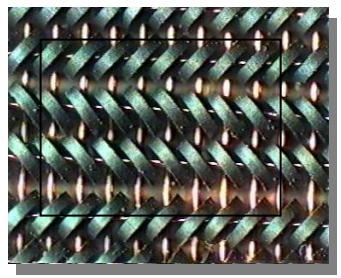
- Last piece for MOS-LSI computer -

- Magnetic core memory used in all CPUs. No core memory courses at U of M.
- Spent two years trying to develop RAM. Finally figured out a combination of SR dynamics with RAM addressability was weird but ideal for CPUs with terminals.
- "Computer nobody wanted!" If we wanted it built we'd have to do it ourselves.



First DRAM 7/68 (256-bit with CPU & video ports)





Core memories used magnetic toroids to store zeros and ones. Big, pricey, & single ported.

1963 64 65 66 67 68 69 70 1971

Fairchild explosion

- Big bang creation of "Silicon Valley" -

- **Investors thought idea of building IBM class computer using unproven MOS for CPU (not to mention memory) was nuts!**
- **But when Intel's Chairman and founder Bob Noyce (inventor of the IC) agreed to invest and join the Four-Phase board investors came in with $1.5M.**
- **Tips:**
  ***Get good board members & utilize them.**
  ***Don't worry about control. VCs have it!**

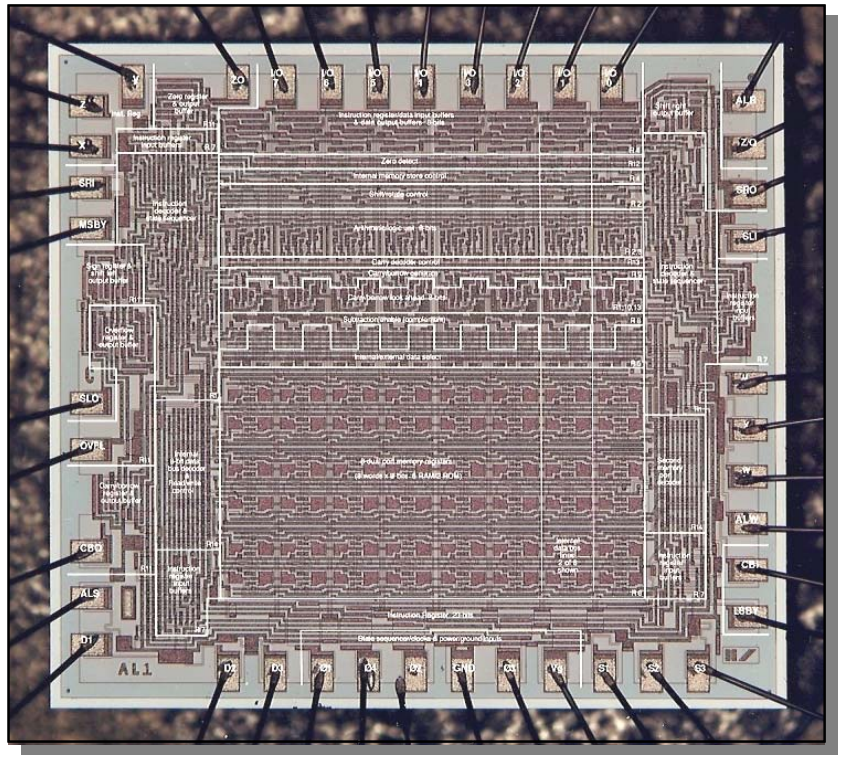
In late 1968 Fairchild spawned dozens of spinout startups leading to what is today known as "Silicon Valley". Chart above shows the major survivors.

1963 64 65 66 67 68 69 70 1971

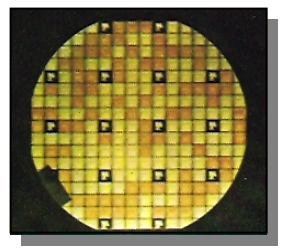
Four-Phase Systems Inc.

- AL1 included all basic computer elements -

- **Chip worked 100% at bipolar speed (3/69).**
- **Bob Noyce was struck by its speed, power and yield ($3/chip). Envisioning the potential for Intel (then a RAM & EROM company) he oversaw the creation of a computer group and hiring of computer engineers including Stanford's Ted Hoff.**



AL1 microprocessor (3/69). Designed for 8, 16, 24, or 32bit configurations. 1¼ in. wafer yield resulted in $3/chip cost.



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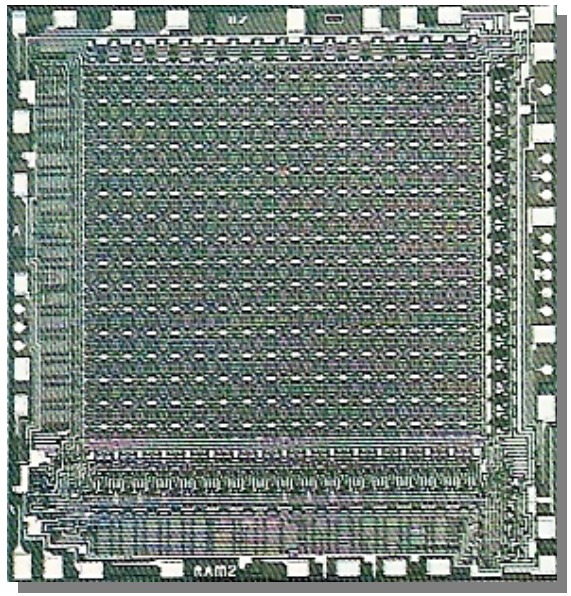
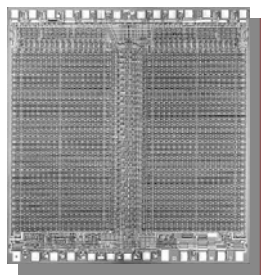
Four-Phase

- 1K DRAM first chip competitive with core -

- **Wide margins, high yields, and 1us speed matched best cores. Quickly went to 2K DRAM. (<1¢/bit. vs. core at 1-2¢/bit)**
- **Intel's Bob Noyce seemed stunned that it actually worked, not to mention at core speed. Bob returned to Intel "explaining" DRAMs were core killers and redirected their MOS memory program to DRAMs.**
- **Tips:**
  ***Good PR helps fund raising with VCs.**

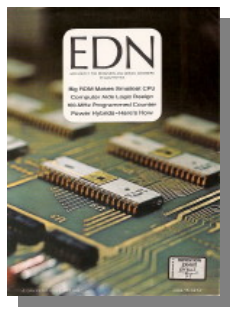


1K DRAM dual ports for CPU & video (5/69)



2K DRAM

2/16/70



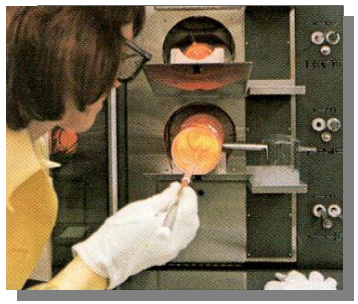
6/16/70

1963 64 65 66 67 68 69 70 1971

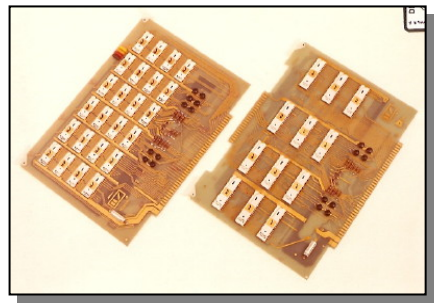
Four-Phase

- It works! -

- 12 complex chips combined successfully. (most for I/O performance enhancement)
- Power of IBM 360/30 ($250K) at <20% the price plus the ability to instantly update 32 terminals with “no I/O overhead!”
- IBM’s big 360/65 ($1M) could only handle 15-20 terminals due to I/O bottlenecking.
- Tips:
  *Move fast. “Only the paranoid survive!”



Installed wafer fab ($300K)



Memory and CPU cards.

CPU and terminal.

System announced at FJCC in Vegas in fall ’70. First order from Eastern

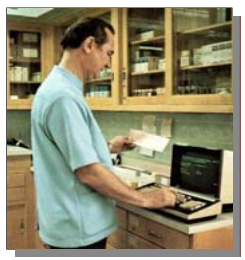
1963 64 65 66 67 68 69 70 1971

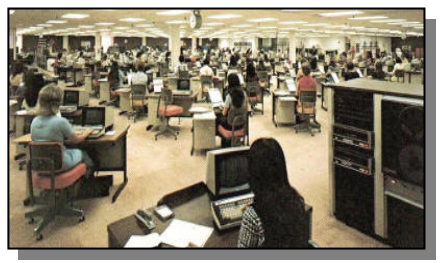
History's Lost Years

Four-Phase

- Ships $3M AL1 based CPUs in 1971 -

- Four-Phase went on to dominate video display markets including hospitals and data entry including the IRS where they processed all US tax returns until 2000.

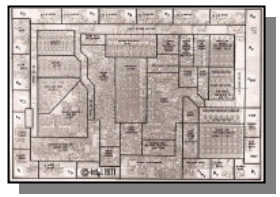




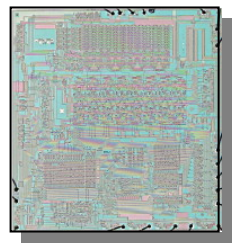
- 4-Phase became Fortune 1000 company before acquisition by Motorola in 1981. Of 100 '70s terminal competitors, 2 survived.

Birth of the microprocessor

- Intel announces first microprocessor 8008. TI quickly follows with 1795.



8008



1795

- Reasons early MOS history lost included 4-Phase playing down its semi roots to customers & Fairchild 86'ing MOS files.

- This history remained buried until TI's microprocessor litigation in late '80s.

Epilog

- 10 year legal battle ends abruptly in 1995 -

- **In the mid 1980s TI claimed invention of the microprocessor demanding billions in usage royalties from the worlds biggest corporations. A Titanic legal battle ensued.**
- **In 1991 lawyers focused on AL1 as prior art. Designers from both Intel and TI admitted to reading and using information in the 4/70 Computer Design AL1 article. >>**

- **TI, however, found expert witness (Stanford professor, etc) willing to say the AL1 was not a real computer. A week before the first trail with Dell TI lawyers learned of the AL1 jury demo and their expert witness "reconsidered" their position and all litigation abruptly ended.**

Jury demo of single chip AL1 (with '69 date code) running business & game software. Intel changed ads to: "Intel invented 'their' first micro in 1971"

Q & A