

Defining Supercomputing

Seymour Cray and CDC 6600

Wolfgang Stief
VCFE 2016, Munich, Germany

whoami

- Electrician, Degree in Electrical Engineering
- self-employed, sys4 AG
storage, e-mail, project management
- Computermuseum München, Cray-Cyber.org
“Everything below 30 A is considered leakage current.”
- <https://about.me/stiefkind>
 stiefkind

00_README.txt

- Work in Progress
- Cray and Surroundings
 - Companies
 - People
 - Technologies
 - Branches and Subsidiaries
- Series of lectures on VCFE (Munich) and VCFB (Berlin)
- <http://www.speakerdeck.com/stiefkind/>

```
# ls -l
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- Control Data Corporation
ca. 1960 - 1970
- CDC6600, CDC7600, CDC8600

What happened so far...

- CSAW (US Navy, WWII) → ERA (1946) → Remington-Rand (1951)
→ Sperry-Rand (1951) → Control Data (1957)
- 1951: Seymour Cray (*1925 †1996) starts working for ERA
B. Sc. Electrical Engineering (1949), M. Sc. Applied Mathematics (1951)
- Control Data Corporation (fall 1957)
Plan: U\$ 600.000 seed money, all shares in private ownership
seed money reached: U\$ 1.2 Mio.
- CDC Little Character (proof of concept for transistor computer)
- CDC 1604 (1959)
48bit, 0.2 MHz → fastest computer on earth

*“All I know how to do is build computers,
so I’ll do that.”*

— Seymour Cray, 1957

CDC6600 – The Beginning

- development starts immediately after finishing the 1604
- design goals
 - > 50x faster 1604
 - > 1-3 MFLOPS
 - > clock cycle 100ns $\hat{=}$ 10 MHz
- UNIVAC LARC → Goal: 100x faster than predecessor
 - > “spectacular flop”
- “Cash Cow” → 1604, 160/160A (“Desktop”), CDC3600



“Five-year goal: Build the biggest computer in the world. One year goal: One fifth of the above.”

— Seymour Cray

Strutwear Building und Chippewa Falls

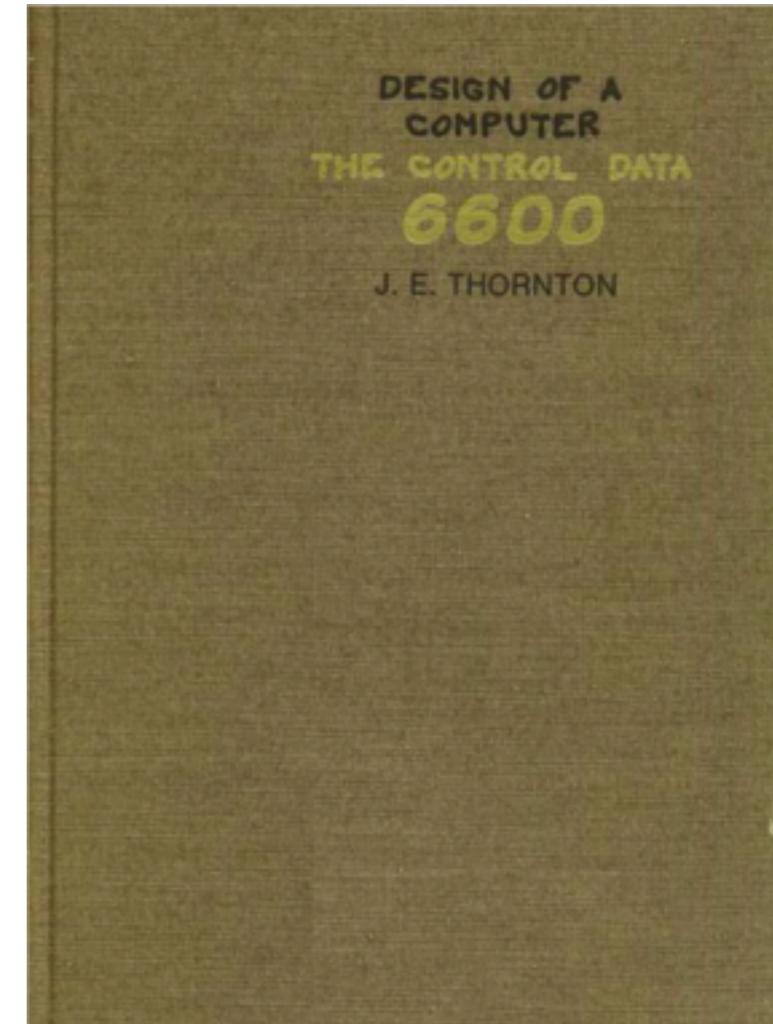
- 1960: relocation Cray + developers
 - > former underwear factory, “Strutwear Building”
 - > in Minneapolis, close to headquarter
- Cray is in great demand because of success 1604
 - > (too) much visits from customers and sales
 - > needs silence to do his work
- 1962: Cray + team relocates to Chippewa Falls
 - > ca. 80 miles away, not easy to reach from Minneapolis
 - > long distance calls were complicated (via operator)
 - > far away from possible targets of atomic bomb (1962, cold war!)
 - > Spring 1962 → Cray + 14 engineers + 4 programmers

A supercomputer comes into being – CDC6600

- circuits from 1604, but better transistors (higher quality)
 - > only moderate success
- tweaks on circuits
 - > many rounds
 - > won't get faster, but reliability gets worse
- “despairingly” changes from Ge to Si
 - > new development by Fairchild Semiconductor
 - > impressive electrical properties
 - > in particular much faster circuit time

A supercomputer comes into being – CDC6600

- Si transistor: circuit design by Cray
 - > much simpler than 1604 circuits
- faster circuit time of Si transistor
 - > faster switching cycles
 - > higher clock frequency
 - > less signal runtimes
 - > bottleneck: propagation delay!



- Jim E. Thornton

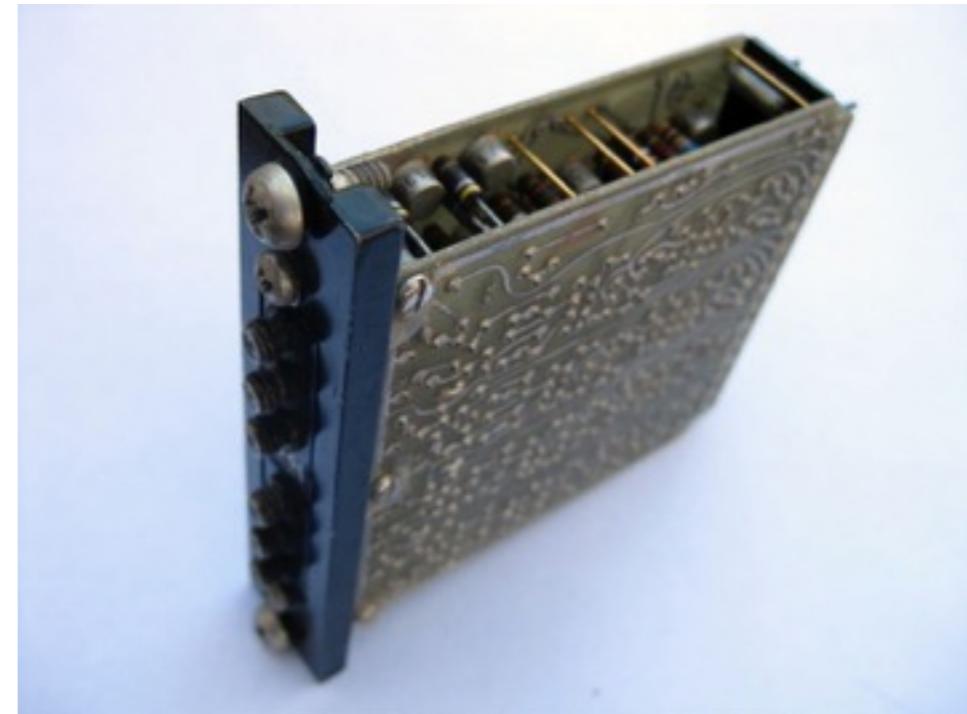
The Control Data 6600 – Design of a Computer

CPU-Design 6600: Cray/Thornton

http://ygdes.com/CDC/DesignOfAComputer_CDC6600.pdf

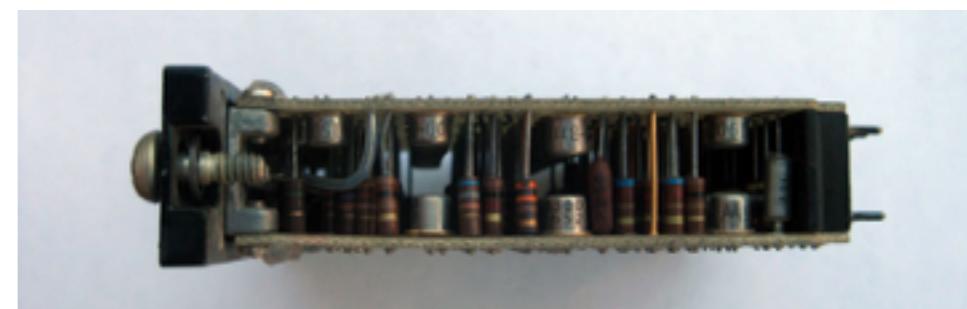
A supercomputer comes into being – CDC6600

- 10x - 20x more gates then 1604
 - > cordwood package
 - > 64 gates / cordwood
 - > high package density → more heat
- air cooling → liquid cooling
 - > totally new for computers at this time
 - > engineer Dean Roush → built cooling systems before CDC
- 1st draft: hybrid with air/freon
 - > not enough cooling power
- 2nd draft: liquid cooling only with Freon
 - > prototype gets built



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A Supercomputer comes into being – CDC6600

- cooling principle
 - > aluminium cap per cordwood modul
 - > cap has heat conduction contact to a pipe system
 - > for heat transmission: Freon in the pipe system
- 6700 cordwood modules
 - > 400.000 logic gates

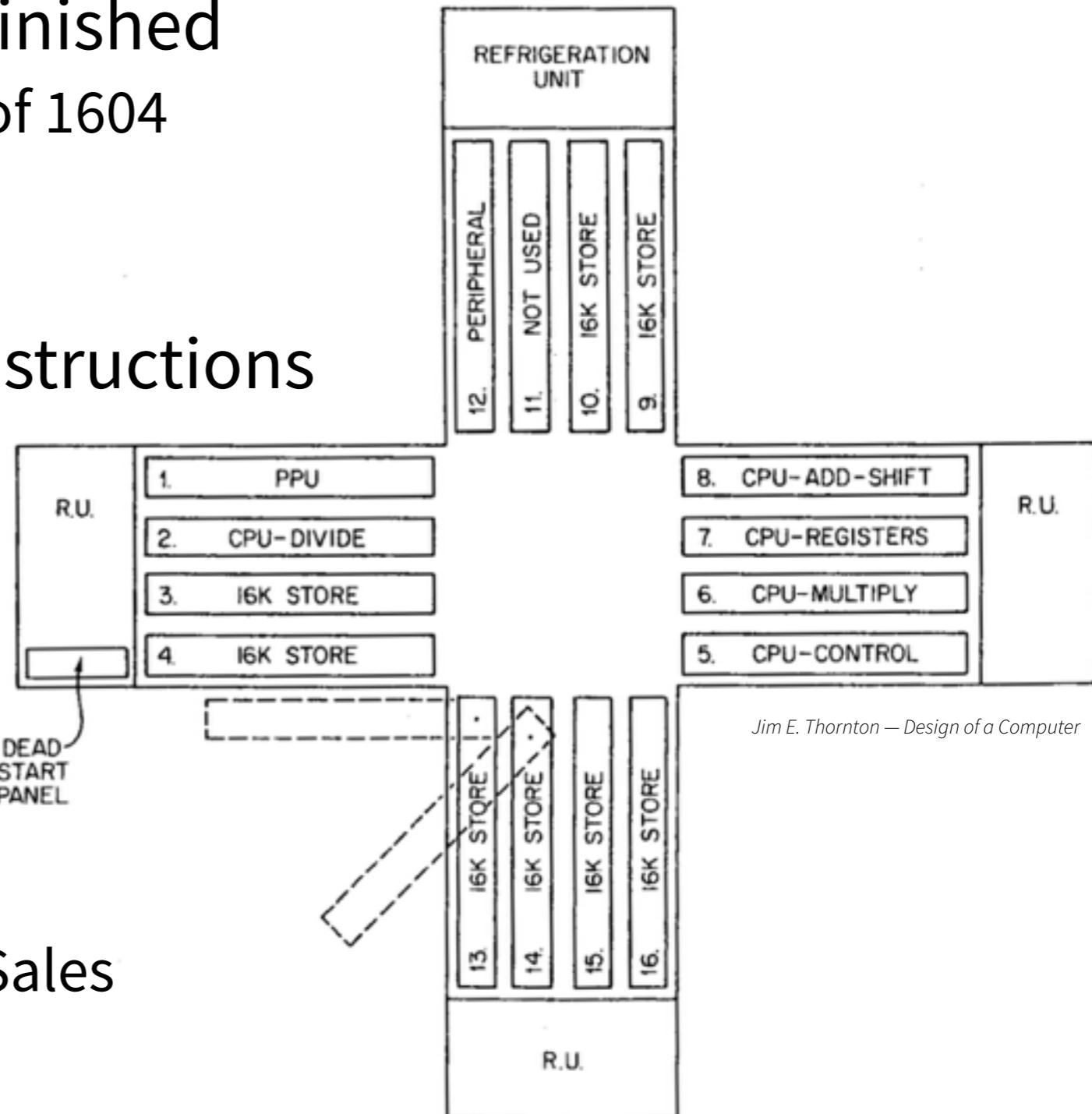
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A supercomputer comes into being – CDC6600

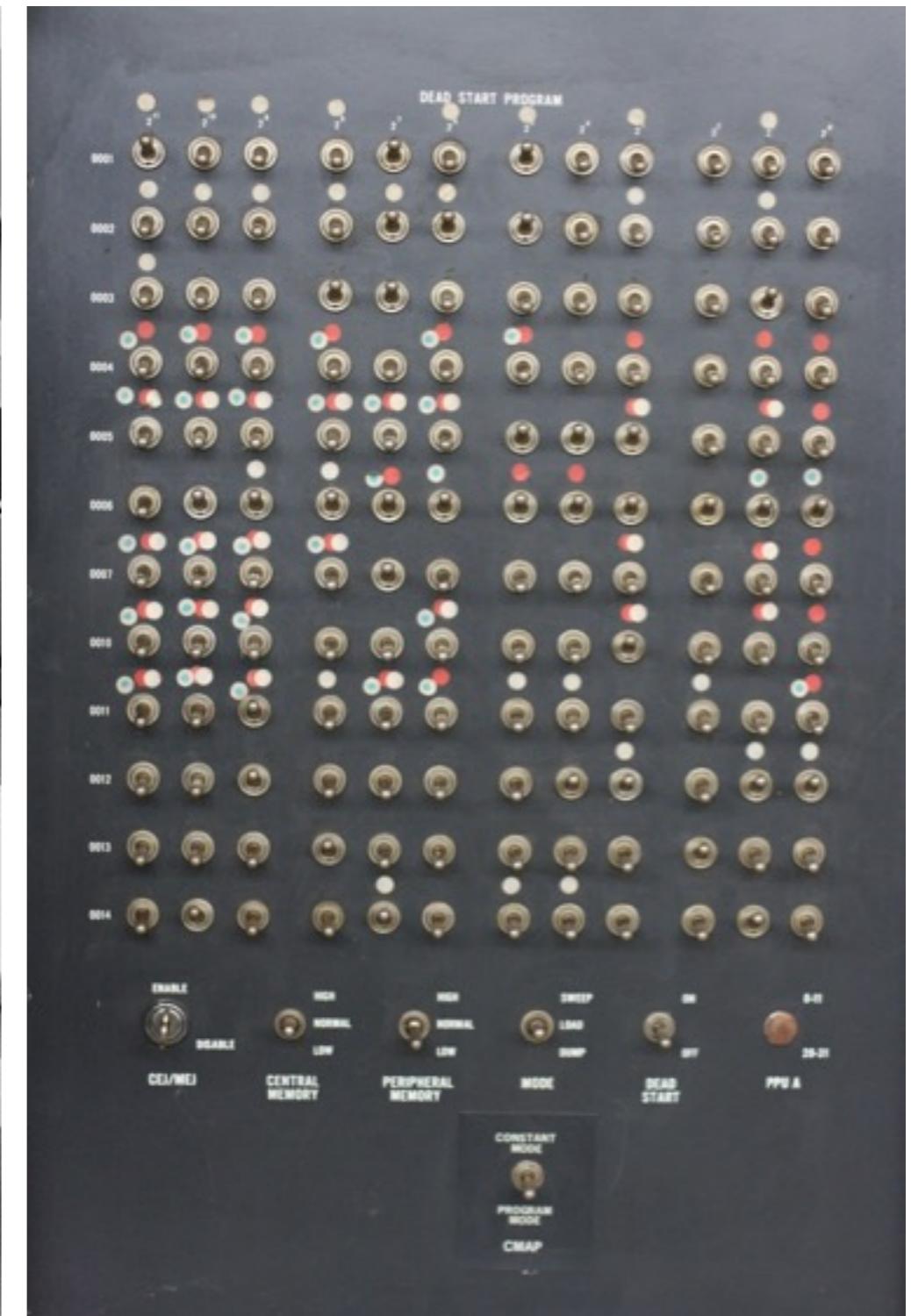
- mid 1963: development finished
 - > first tests: 50x performance of 1604
 - > design goal reached
- instruction set: only 64 instructions
 - ≈ 20 years before “RISC”
- ≈ 3 MIPS
- competition
 - > IBM ASC-1 (never finished)
 - > IBM S360/90 → FUD by IBM Sales



A supercomputer comes into being – CDC6600



Computer History Museum



Wolfgang Stief, CC0

“Last week Control Data had a press conference during which they officially announced their 6600 system. I understand that in the laboratory developing this system there are only 34 people, including the janitor. Of these, 14 are engineers and 4 are programmers, and only one person has a Ph.D., a relatively junior programmer. Contrasting this modest effort with our own vast development activities, I fail to understand why we have lost our industry leadership position by letting someone else offer the world’s most powerful computer.”

— Thomas J. Watson, President IBM Corp.

Goldrush – Rise and Fall

- in ca. 1965

- > computer division
- > research division
- > peripherals division
- > Chippewa Laboratory
- > system sciences division
- > data center division
- > government systems division

	Share	# employees
1957	1 U\$	1957 11
1961	126 U\$	1959 325
1964	300 U\$	1961 1.500
		1962 2.200
		1963 3.500
		1965 >9.000

- 15 offices: 11x USA, 3x in Europe, 1x Honolulu
- 1965: relocation headquarter to Bloomington
 - > suburb Minneapolis
 - > stays headquarter until closing down the company

Goldrush – Rise and Fall

- CEO Norris: wants to broaden CDC portfolio
 - > many acquisitions between end 1950 and end 1960
 - > Cedar Engineering, Bendix Corporation (Computer Division),
Holley Computer Products, Daystrom (Control Systems Division),
Control Corporation, Meiscon Engineers
 - > 8 companies in 1963, 12 companies in between january 1964 und 1965
- goak: complete solutions portofolio
 - > science/engineering, hardware, software, machine time for rent
 - > consulting, software programming
- growth (foo) fast, pressure to succeed
- 1966: 4 key engineers leave the company

Goldrush – Rise and Fall

- integration of acquisitions → cost-intensive → liquidity (!)
- stability problems with first several delivered CDC6600
 - > Delivery to LLNL scheduled February 1964, delivered beginning 1965
- IBM awakens
 - > aware of CDC internal problems
 - > IBM sales spread *fear, uncertainty and doubt* (FUD)
 - > S360/90 allegedly much faster than CDC6600
 - > ca. 126 Mio. U\$ development costs (1965),
but still not even a prototype exists

Goldrush – Rise and Fall

- IBM 360/90 can't keep up with promise
 - > unreliable, many technical problems, not accepted by market
- CEO Norris mad on IBM
 - > unfair marketing, market monopoly, antitrust laws
- lawsuit CDC ./. IBM
 - > nobody dared before, IBM is well known for its huge army of lawyers
 - > “*they could bury a company in paperwork*”
 - > goal Norris: stop IBM business practice to not experience it again with CDC7600

Vor Gericht

- lawyers get permission to read documents of opposite party
 - > CDC provides IBM ca. 8 Mio. documents
 - > CDC demands ca. 15 Mio. documents from IBM
- CDC employs assistants only for the lawsuit
 - > screening and sorting documents
 - > “import” documents into computer (with special forms)
 - > lawyers then can search for words and strings (on tape)
- first time, that a computer played an important role in a lawsuit
 - > 2 years document screening, sorting, extracting

Dissatisfied staff

- engineering becomes more and more dissatisfied
 - > integration of acquisition costs money
 - > reduction in engineering budgets
 - > management is growing and becomes more expensive
- Computer Division extra angry
 - > they are responsible for success/revenue (1604, 3600, 6600)
 - > massive reductions in budgets
- from startup to large-scale enterprise with all practical constraints
- engineering loses control over their own work

Meanwhile in Chippewa Falls

- CDC6600 not very reliable
 - > **but:** better to use CDC6600 nine hours at a stretch, then 40h calculation time of same problem on a competitors machine
- Cray still is reclusive
 - > no interviews
 - > no visits of management, sales, customers
 - > withdrawal from CDC board due to time constraints
- ca. 1969: work on 6600 and variants finished
 - > 6600 → high performance CPU, parallel functional units
 - > 6400 → less performance, no parallel functional units
 - > 6500 → 2x 6400 CPU
 - > 6700 → 6600 CPU + 6400 CPU

What's next? → n+1 – CDC7600

- development CDC7600 (1965-1969)
 - > initially, there should be a 6800
 - > microcode incompatible to 6600, therefore name change
 - > Cray is head of development
- design goal: 25ns clock cycle (27.5ns?)
 - > 25ns $\hat{=}$ 40 MHz \approx 4x faster than CDC6600
- introduction into market 1969
 - > U\$ 8 Mio for 4x performance → often not worth the invest
 - > CDC sells only ca. $\frac{1}{2}$ quantity of CDC6600

CDC7600

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n+2 – CDC8600

- design goal:
 - > no backward compatibility
 - > 8ns clock cycle $\hat{=}$ 125 MHz (1969!)
 - > multiprocessor, quad CPU \rightarrow most problems usually sequential
 - > once again higher package density
- same proven development team as CDC6600/CDC7600
 - > Chippewa Laboratory
 - > all but Jim Thornton \rightarrow Arden Hills, STAR-100 (vector processor)

Development CDC8600

- higher package density
 - > 6" x 8" (ca. 15cm x 20cm)
- first test modules:
high current drain
 - > per module 8 circuit boards
 - > per module ca. 3kW (!) power input
- liquid cooling
 - > copper plates **in** circuit boards for heat conduction
 - > heat exchanger approx. 20t, needs space of 2x 7600 or 3x 3600
 - > single module quite heavy because of amount of copper
- problem: reliability
 - > many discrete components, many solder joints, lots of heat



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Development CDC8600

- mid 1971 → 2 years development, no progress
- budget Chippewa Lab → reduce 10% (mgmt demand)
 - > 40 engineers $\hat{=}$ 4 staff members
 - > Cray wants to hold entire staff and offers to work without payment
 - > work w/o salary not allowed → minimum wage, 1.25 U\$/h
- management/board/Norris: service company
 - > future is in services, not hardware

“Everybody who needs a computer has one.”

— Bill Norris, CEO Control Data Corp., 1971

End of development CDC8600

- Meeting Cray/Norris in Bloomington (HQ)
 - > 8600 doesn't work, fundamentally wrong
 - > new design, new development program, new budget
 - > Norris: wait 1 year, STAR-100 is expensive, two projects not possible
 - > Cray: asks for time to think it over
- Cray back at Chippewa
 - > discussions with confidants and ex CDC (among others Mullaney)
 - > U\$ 2.5 Mio seed money, 20% from Cray
 - > hand picked developer team, ca. 25% less salary
- Memo Cray → Norris, February 14 1972
 - > irresolvable problems @ 8600 development
 - > Cray + 6 engineers leaving CDC and found Cray Research Inc.

End of development CDC8600

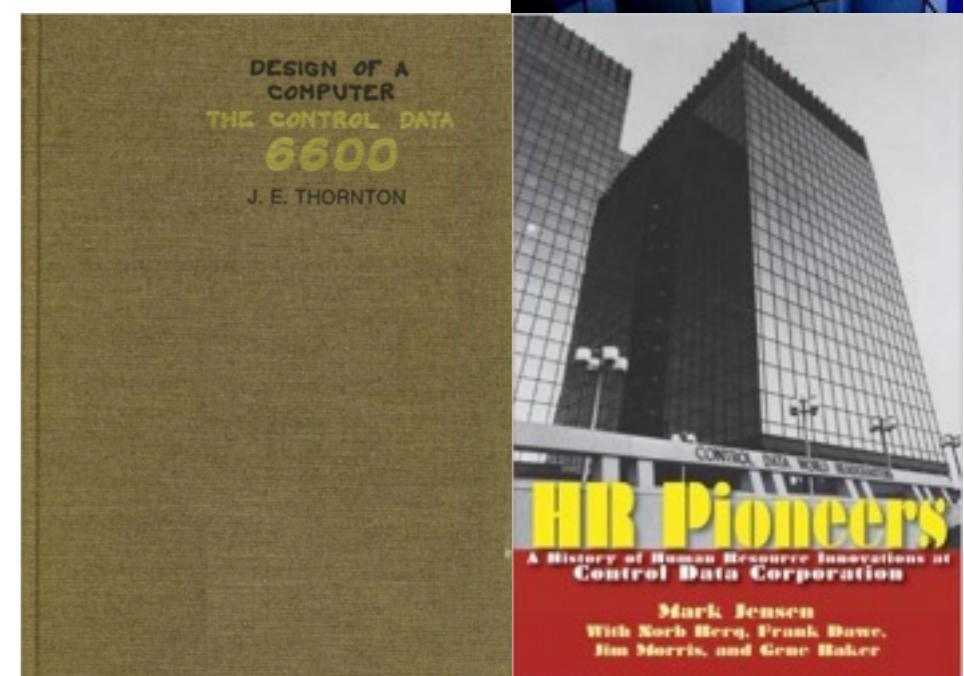
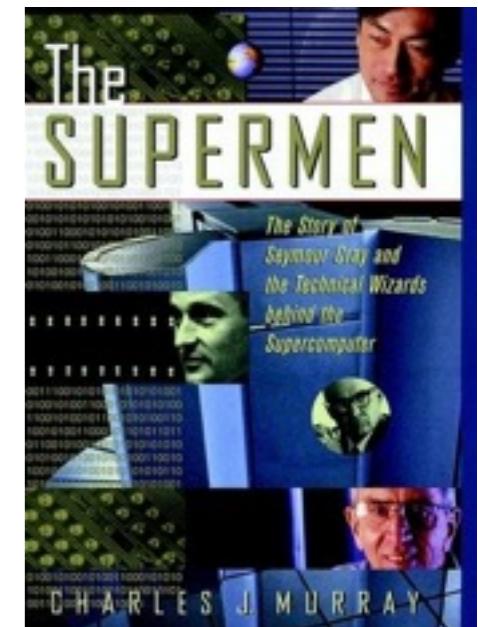
“An Employee has only one life, whereas a company could go on and on”

— Bill Norris, CEO Control Data Corp.

Norris/CDC invests U\$ 250.000 in Cray Research Inc.

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- English Wikipedia
CDC 6600, CDC 7600, CDC 8600, Engineering Research Associates, Control Data Corporation, Cray, Seymour Cray, William Norris (CEO)
- Charles J. Murray — The Supermen (Buch)
The Story of Seymour Cray and the Technical Wizards behind the Supercomputer
- Mark Jensen — HR Pioneers
A History of Human Resource Innovations at Control Data Corporation
- Jim E. Thornton — The Control Data 6600
Design of a Computer
http://ygdes.com/CDC/DesignOfAComputer_CDC6600.pdf



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- The CDC 6600 Architecture
<http://ygdes.com/CDC/cdc6600.html>
- Oral history interview with William C. Norris (1986)
<http://conservancy.umn.edu/handle/11299/107551>
- Oral history interview with Frank C. Mullaney (1986)
<http://conservancy.umn.edu/handle/11299/107538>
- Gordon Bell — A Seymour Cray Perspective (presentation)
<http://research.microsoft.com/en-us/um/people/gbell/craytalk/>

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- Seymour Cray — Cray-1 Introduction (talk, 1976, LANL)
<https://www.youtube.com/watch?v=vtOA1vuoDgQ>
- Seymour Cray — Whats all this about Gallium Arsenide?
Talk on development of the Cray-3
<https://www.youtube.com/watch?v=xW7j2ipE2Ck>
- Cray Research - A Story of the Supercomputer (documentary)
<https://www.youtube.com/watch?v=wn03wn3k47Y>

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Thanks!
Questions?

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