Fernbach, Norton, MacNaughton, Russell, Tiede — Adams, Leiner, Amdahl, Rochester, Schmidt — Loeb, Kolsky, Cocke, Robinson

20 Oct 60

Meeting with Livermore at Res. center. 9:30 am

(E. Adams) Super Stretch

100 × stretch machine ~$100 M total cost -- straight forward approach 1965 -- less cost later...

(1) circuit speed problem:

- ~~device technology~~
- circuit elements 10× STRETCH (±2 factor) are best one can do. (20 to 25 ns in stretch)
- peripheral storage - disks tapes -- etc (These are big in space) can't be miniaturized as much,

→ machine will be built of small fast units - with long delays between need local storage at units (one more hierarchical

- This gives machine + program organization problem.

100× machine must require high degree of parallelism.

Q: several units with units - all using central store? A: not necessarily local stores ~100 words to get speed -- a shuffling of data.

indep. or semi-autonomous elements -- organized into network of longer slower stores. -- hierarchy of

(Fernbach) - more willing to back down from 100× than to go to a large amt of parallelism -

(Rochester) - hierarchy of mems (fast) slow

(Fernbach) - when one gets to $/bit -- it takes practically an act of congress,

cryogenics - thin film -

(Fernbach) what is story on tunnel diodes ?

cost -- present price $10 - $100 ea but will get cheaper

will pay ~ $1 per bit eventually, } 2 to 10 diodes per bit

ie ~ $100 per word.

∴ large volumes of fast mem will have to be magnetics.

(Shenel) Mag. memories

- biggest fastest problems.

1. Transmission delays (100 m/μs now in core) → cut by factor of 3 or 5
2. circuit delays (within mem - decode - amplif.)
3. fast capability for elements
4. drive current capability

One solution: make cores small, simplest

cores 10^{-9} volt sec signal - must be amplified - takes time

Thin films 10^{-12} volt sec signal

10 - 10 ns per level in stretch (can be reduced ~ 10× maybe)

cores: 10 ns writing ~10 ns destructive read (13 - 18 OD / ID mils core)

non-destructive -- less (don't know limit)

[present cores are 30 - 50 mils ID OD]

drivers: 5 ns response time now

7302 mem.

- a problem with cores which thin films don't have
- must wait after writing before reading again for ferrites, for spatial switching techniques.

Telemeter Mag., Philips etc. - need wait ~1 μs, for ferrite cores we have seen 2 - 0.1 μs delays.

75% of cost of mem are in drive circuitry (not tested cores)
(Shenel proposes lowering cost of core arrays by factor of two not circuitry)

10 ns response ~ $2 each from Pok lab.
5 ns $10 ea.

2.5 Mcycle rate - on index core of stretch

7302 memory: 0.43 μs core switching time

{ 0.86 μs read write time
{ 0.20 amp delay

for 2.0 μs mem cycle.

→ showed small core array (1800 per sq inch)

5.0 Mc non-destruct read out has been observed, 200 ns

50 ns write time

Q: If 7302 were read-only: (sense lines ringing - puts in delay)
0.5 μs decode + 0.43 ≃ 1 μs.

(Fernbach) what about thin films ?

(Steel) - same array problems -- can't get much closer than core densities. - power dissipation is ~ 1/10 in films,

1 mm spots ~ worse than cores

1/2 mm spots ~ equiv. to cores.

1/4 mm spots -- don't know how to do

decode delay - same as cores
ampl delay -- longer - need more ampl.

thin films: Read + Write ≥ 10ns .01

other delays become largest items

- to design -- do sense ampl first - then take film spot largest to be constant.

eg. 100 words thin films are probably best
10000 words cores are best. - power dissipation.

1 amp 100 ohm line cores
~ 10 ohm line films.

50 ns read plus write cores — can do now

(Adams) other semi conductor devices:

- Esaki diode circuits
- Esaki diode + transistor circuits - seem best

5½ ns delay -- considered standard now

Some E. diode + transistor average ~1 ns for chains of stages have been seen -- probably can't do better than this.

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cryogenic circuits

- low duty cycle - power density, but at 4°K

Epitaxial Transistors -- vapor growth -- very fast, small "split-β" junctions etc.

Cryojunction 2.6×10^{-12} joules - switching,

~1 ns seems about limit

0.1 ns superconductivity begins to fail.

packing density?

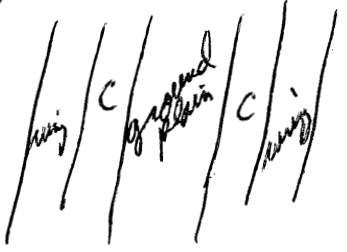
Theoretical ~.07 [illegible]

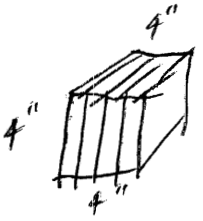
3000 cryotrons per side

actually get 1500 cryot on 4"×4" substrate

$\frac{1500}{16\text{ sq in}} = 94$ per sq in

$d = \frac{1}{\sqrt{94}} = .103$" apart





3×3×3 cube in refrigerator

704

10^6 bit mem

2500 bit computer

- signals must go clear around circuit - (can't just send a pulse down the line)
- automated design absolutely design.

(Leiner) Input/output

- organization must be diff
- more concurrency ∴ more communication within machine
- more communication probs. with outside -

1. Operator liaison
   - displays: page printers
     visual displays
   - Input tiein: " "
2. External ~~Access~~ storage
   - magnetic recording

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printers: "composition" (Endicott)
16 kc character rate
64 character font.

photo emissive cathode.

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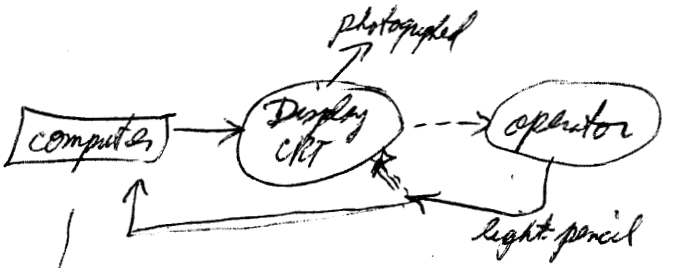
high speed character device: (NARP Omega)
10 μsec (100 kc)

Stromberg-Carlson

GEM { visual display "Graphic Expression Machine"



photograph
--high speed developer 35 mm (15 sec delay)
film type projector.
↓
CRT scanner (can be multiply controlled)
(20" x 20" projection)

[Hughes camera ~ 7 or 8 sec]

[Land premises ~ 1 sec]

50 μsec to get to spot & draw short line
3000 lines/sec
spot diameter 1-2 mils.

(Fernbach) expect to be buy next year from
Digital Equip. Corp (offshoot of Lincoln)
a device which is essentially this device of speed

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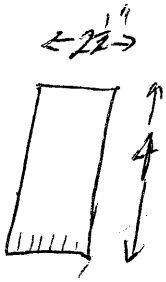
at San Jose:
10,000 bits/inch linear density.

use standard Ampex 3M tape



magnetic strip (or card)

50 cards/sec

64 Tracks

4" × 50 = 700" per sec × 10,000 = 2 Mc bit rate per band.

feasibility has been established. → { does have good transmission rate.

What are reqts. for capacity? - which should one take,

(Fernbach) capacity: 100,000 1,000,000 words

rate depends on how often one needs to transfer

- reasonable sized memory will be too expensive but some such as above

→ flow of traffic most important

⇒ (Fernbach) → trend is toward more serial type problems

100× is not news, 10× is. - but not more money.

don't want to rush, - want to be realistic

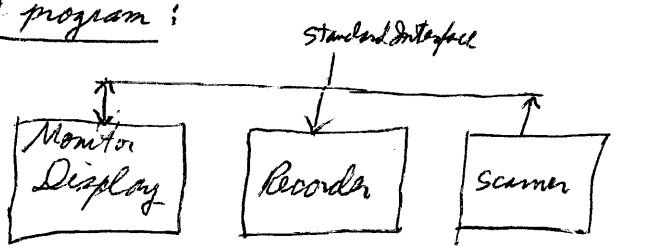
& are not now doing these problems - don't know what problems are.

- should put money on key problems.

for engs. in '63

Elmer Shoup - Poughkeepsie, Oct 20

GEM program:



CRT

both input + light pencil (1 M bit resolution)

writes on 35 mm film
- rapid process
- viewing screen (3" square 5" tube screen) (16 M bit resolution)

photo scanner

Computer specifies line segments - vector generator

no printing of film -- must be done on another machine

- high resolution & quality
- 5000 lines/min rate.

Computer program does most of control --

- Some thought concerning a character former separate box

Present Status? In product devel
In product Test: 1st quarter 62

$70,000 for copy-flow machine to print film

(Farnbach): The bottle-neck is in printing film -- UCRL gets 5 hrs worth of printing with 1 hr of machine time.