Sept 5, '56

Meeting at IBM with Engr & Prod. Planning People

Steve Dunwell (In charge of product.)
Dr. Fred Brooks (from Harvard Comp Lab)
Frank Beckman (prod. planning)
John Cock (from Duke U.)
Larry Serahan? (prod planning in charge of Math planning)
John Griffith (prod planning)
Bill Wolleski (engr. - planning of computers)
Dr. Werner Buchholz (in charge of Math Planning) since 1948
Bill Stringfellow (engr. group - service, checking, maint, etc)
Lura Sweeney (prod. planning - from Endicott)
Dr. Warren Hunt (med. phys. - planning in 10 M. pulse prog.)
Rex Seeber (SSEC man surveillance
Jim Pomerene (Engr. - arith units etc Sort adv. study)

Floyd Johnson (dig)

Kolsky
Carlson
Voorhees
Frank
Woods
Lazarus

~~Nature of Problems.~~

(Dunwell)

Have been thru several cycles of planning - not frozen now -
constraints are broad ones - total gear - cost of mem -
- question of indexing & indirect addressing - good example.

Hope to Work as Joint team with LASL

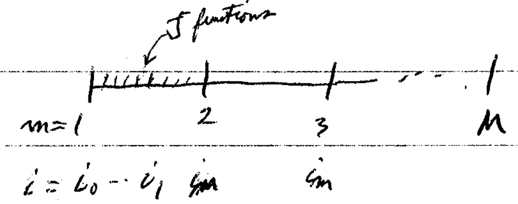
question of traveling & visiting - both sides visit -

- plan projects with smaller groups of people - sub committees.

Time scale - not rigid now - will make one later.
must proceed stepwise

(Lazarus) Example problem:

$$\frac{\partial A}{\partial t}_{i-\frac{1}{2},j} = \sum_{j'=1}^{J_m} A_{i-\frac{1}{2},j'} \sum_{k=1}^{K} \alpha_{jj'}^{k}(m) \frac{C_{i-1,k}+C_{i,k}}{2}$$



M: 3 – 15

J_m : 1 – 20

K: 4 – 7

i_M : 30 – 150

$$i_{m-1} < i < i_m$$

α matrix: stretch out & collapse leaving out zeros.

for α's 20×20 matrix are largely 0's 60, out of 400.

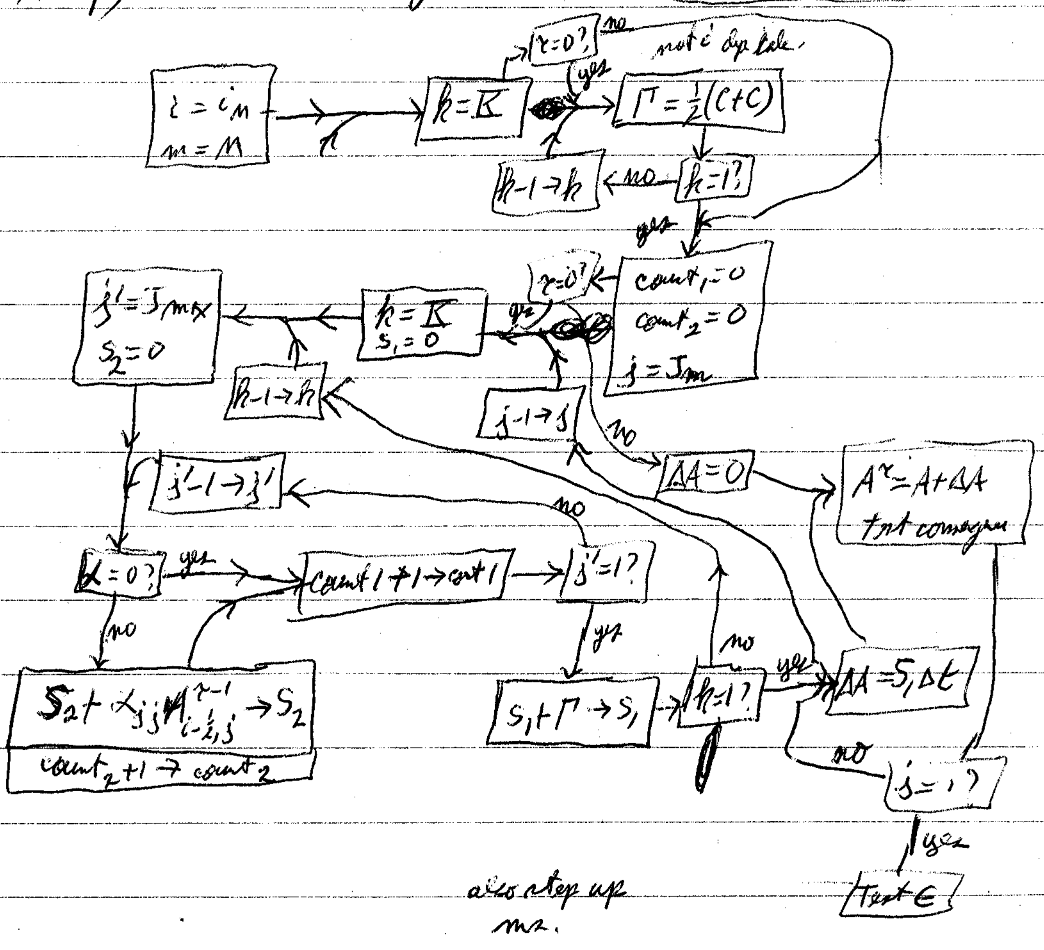
Solve as $\Delta A^{\tau} = \left(\sum \overset{\tau-1}{A} \sum\right)\Delta t$

$A^{\tau} = A + \frac{1}{2}\Delta A^{\tau}$ $\quad \Delta A^{0} = 0$

where $S_1 = \sum_k \Gamma_k S_2$, $S_2 = \sum_k \alpha_{jj'} A_j$

$\max\left(|A^{\tau} - A^{\tau-1}|\right) < \epsilon$: stability.

Flow diag:



Shartaga

(1) Index regs.

(a) too few

(b) inflexible testing

(2) Balance between real arith & index work

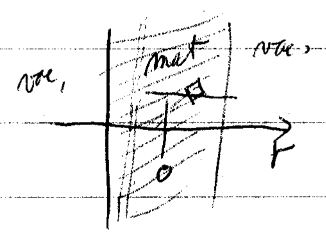
(3) Testing single bits.

→ question of skipping 0's rather than counting

compare 2 index registers & transfer on equality.

Bengt Carlson: Neutron Transport Theory

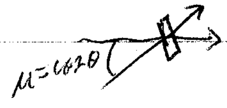
Slab geom'



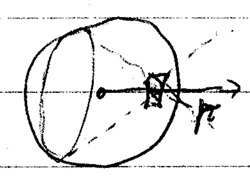
uniform prod. of neutrons

Neutron flux $N(r, \mu, v, t)$ (angle, vel)

(no./cm^2 sec)

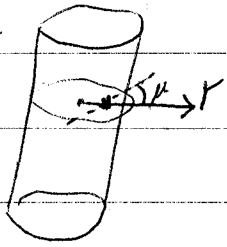


Spherical



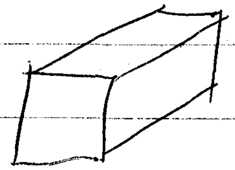
Same eq.

cyl:



have another angle, tilt of plane, ellipsoidal,

inf cyl. $N(r, \mu, \eta, v, t)$



$N(x, y, z, \mu, \eta, v, t)$

Finite cyl: $N(r, z, \mu, \eta, v, t)$

Consider Stationary case (non-t-dep.)

v-dep split $(0, V_m)$ into groups.
(velocity groups : G)

Need ~~8×G~~ storage
$(10+G+M)I + 8GM$
↑ no. of points,

would like
$G = 50$
$m = 4$
$I = 50$
$= 7{,}200$,
(1 dim. 2 mi 360,000)

For sphere or plane: $N_g(r, \mu)$ $g = 1, 2 \cdots G$
lowest highest

r-dep:

$r_0 = 0 \;\; r_1 \;\; r_2 \;\; \cdots \;\; a = r_I$
$m = 1$ | $m = 2$ |

Spherical Shells

$\Big|\overrightarrow{\Delta}\Big| \; e^{-\sigma^t \Delta\rho}$

μ-dep: (S_n method)
$n+1$ points for μ $(-1, +1)$

$\sum v_g = v$

$f_i = \sum \sigma_g f^{(i)} N_{gi}$

r_i input

$h_i = \sigma_i^t \Delta_i \rho_i$ "age"

n_i input material index

$S_{gi} = v_g f_i + \sum_{g'=g}^{G} \sigma_{gg'} N_{g'i}$ Source,

ρ_i input material density

$\{N_g^i\}$ G of these

f_i input initial fission distribution,

$\{N_i(j)\}$ $n+1$ of these

$\bar{r}_i = \frac{r_{i-1} + r_i}{2}$

$\Delta_i = \frac{r_i - r_{i-1}}{2}$ 6×G storage

$S_i = \frac{\Delta_i}{\bar{r}_i}$ +2G more

	G	G-1	G-2	G-3	...		
G	×	×	×	×	×	×	0.000
G-1		×	×	×	×	×	0.00
G-2			×	×			
	0			×			

one is interested in

$$N_s(r) = \frac{1}{2}\int_{-1}^{+1} N_g(r,\mu)\,d\mu$$

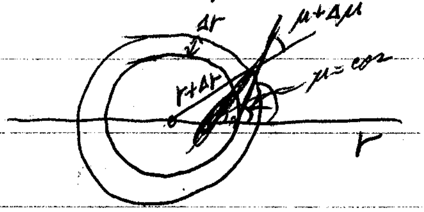
$$N_i(j) = N_g(r, \mu_j) \qquad j = 0, 1, 2 \ldots n$$

2nd Day of Meeting: Sept 6, '56

Transport of neutrons — Reactor calcs, neutron economy - size not sensitive.
" " quanta
" " radiation
" " heat
" " ions & electrons,

Numerical Exploration
Mathematical Exploration.

Derivation of neutron transport in sphere: (for given vel. group)



$N(r,\mu,t)$ — net change in spherical shell.

$$N_g(r+\Delta r, \mu+\Delta\mu, t+\Delta t) - N_g(r,\mu,t) = -\sigma_g^t\, ds\, N_g(r,\mu,t)$$

collisions per cm. no. taken out

Source term $= S_g$

$$+\,ds \sum \sigma_{gg'} N_{g'}(r)$$

$$\frac{\partial N}{\partial r}\frac{dr}{ds} + \frac{\partial N}{\partial \mu}\frac{d\mu}{ds} + \frac{\partial N}{\partial t}\frac{dt}{ds} + \sigma^t N = S$$

$$\frac{dr}{ds} = \mu \qquad \frac{d\mu}{ds} = \frac{1-\mu^2}{r^2} \qquad \frac{dt}{ds} = \frac{1}{v_g}$$

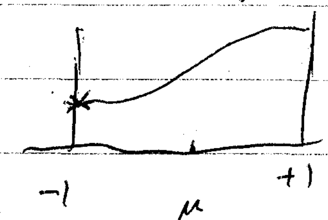
$$\left[\frac{1}{v}D_t + \mu D_r + \frac{1-\mu^2}{r} D_\mu + \sigma_g\right] N_g(r,\mu,t) = S_g(r)$$

don't consider time dep. case.

can assume $N(r,\mu,t) = N(r,\mu)\, e^{\alpha t}$

get extra term $\frac{\alpha}{v_g}$ which one adds to σ_g "time absorption"

to eliminate μ dependence.



get fn at certain finite no of points

for $\mu = \pm 1$ straight in & out.

$$(\pm D_r + \sigma_g) N_g(r,\pm 1) = S_g(r)$$

1. fix value at $\mu = -1$
2. Make assumption flux is st line near -1

$$N(\mu,r) \doteq \frac{\mu-\mu_i}{\mu_{i+1}-\mu_i} N(r,\mu_{i+1}) + \frac{\mu_{i+1}-\mu}{\mu_{i+1}-\mu_i} N(r,\mu')$$

perform integration over intervals between μ_i & μ_{i+1}

$$\int_{\mu_i}^{\mu_{i+1}}$$

get eqs of form: $\left[-a_n D_r + \frac{b_n}{r} + \sigma\right] N_g(r,j+1) + \left[-\bar{a}_n D_r - \frac{b_n}{r} + \sigma_g\right] N_g(r,j)$

where $a_n > 0$ if interval $(-1,0)$
$a_n < 0$ " " $(0,+1)$

intervals $(-1, 0)$

$$N_{i-1}(j) = \frac{(a_n - b_n s_i - h_i) N_i(j) + (\bar{a}_n + b_n s_i - h_i) N_i(j-1) - (\bar{a}_n - b_n s_i + h_i) N_{i-1}(j-1) + 2S_{i+\frac{1}{2}}}{(a_n + b_n s_i + h_i)}$$

where $h_i = \frac{\sigma_g \Delta r}{2}$

$s_i = \frac{\Delta r}{2 r_{i+\frac{1}{2}}}$

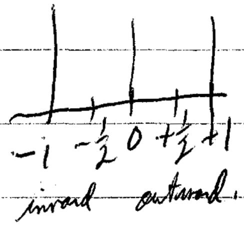
for $\mu = -1$: $\frac{N_{i-1}(-1) - N_i(-1)}{\Delta r} + \frac{\sigma_g}{2}(N_{i-1} + N_i) = \underbrace{\frac{S_{i-1} + S_i}{2}}_{S_{i-\frac{1}{2}}}$

reduces to, $N_{i-1}(-1) = \frac{(1 - h_i) N_i(-1) + S_{i-\frac{1}{2}}}{1 + h_i}$

$n+1$ of these eqs. for each g.

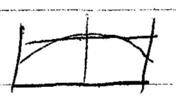
Boundary Conditions: can be zero on outside. or reflected, etc.

consider case of 4 intervals:

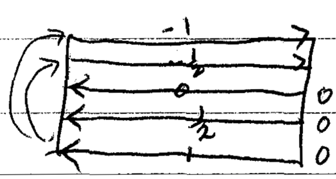


for outward fluxes

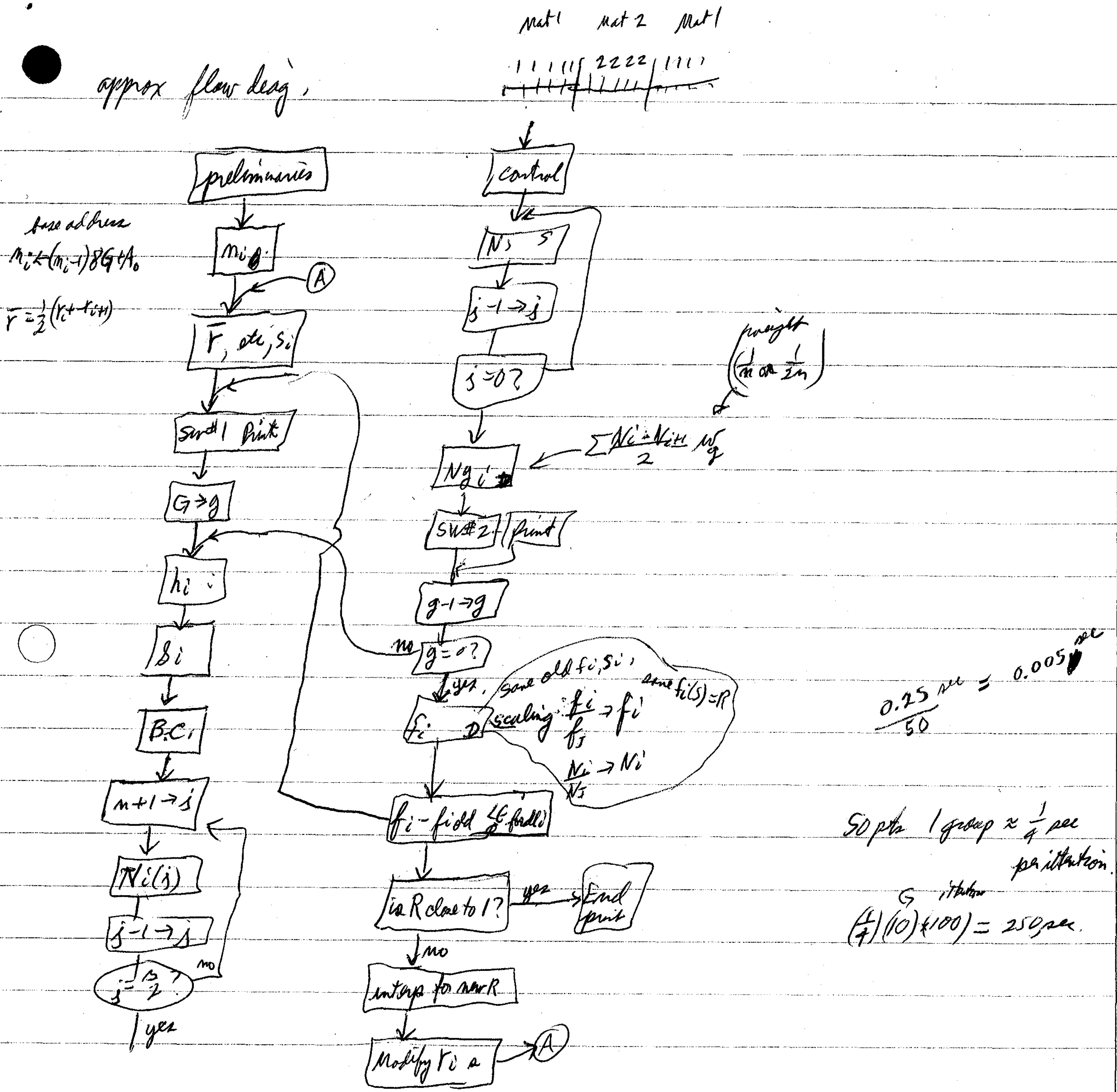
$$N_{i+1}(j) = \frac{(a_n - b_n s_i - h_i) N_i(j) + (a_n + b_n s_i + h_i) N_i(j-1) - (\quad) + 2S}{(a_n + b_n s_i + h_i)}$$

at center no net flux  ← either

method of integration:



approx flow diag.



500 instr on 704

110 are in preliminaries 25 SD orders

if one had an indirect way of referring to decr TXG | A( ) | decr. |

or abs. decimal too?

Similarly CLA | incr | A( ) |

→ be able to take fl. pt word apart (special extract)

– suggest index reg [ctr / Δ / count]

and be able to inter current address from one to another index reg.

Rotsky – talk

General discussion: Monte Carlo: Matrix inv. Formula coding,

1. binary-decimal conv. & print ← requires special prob.
2. mult. precision
3. treatment of zero
4. what are components & capabilities
5. table look up
6. sorting
7. interpolation

Monte Carlo: – low precision mpy, low precision trig fns.

plan: General Form – information flow – division of labor

– become familiar

language – auto prog.

3rd Day Fri

(Dunwell)

1. Goals of Speed – no backing off.
2. "Relativity" – problems from one part to another – separate clocking.
3. Division of responsibility on components.
4. can't build everything at same time – scheduling
5. What parts will be known about first? mem – now, arith. – later. influencing later design.
6. machine must be small

Machine characteristics,

1. "center" is Multiple Memories, — Mem. equiv. to blackboard, rest of machine like people in room.

Memory

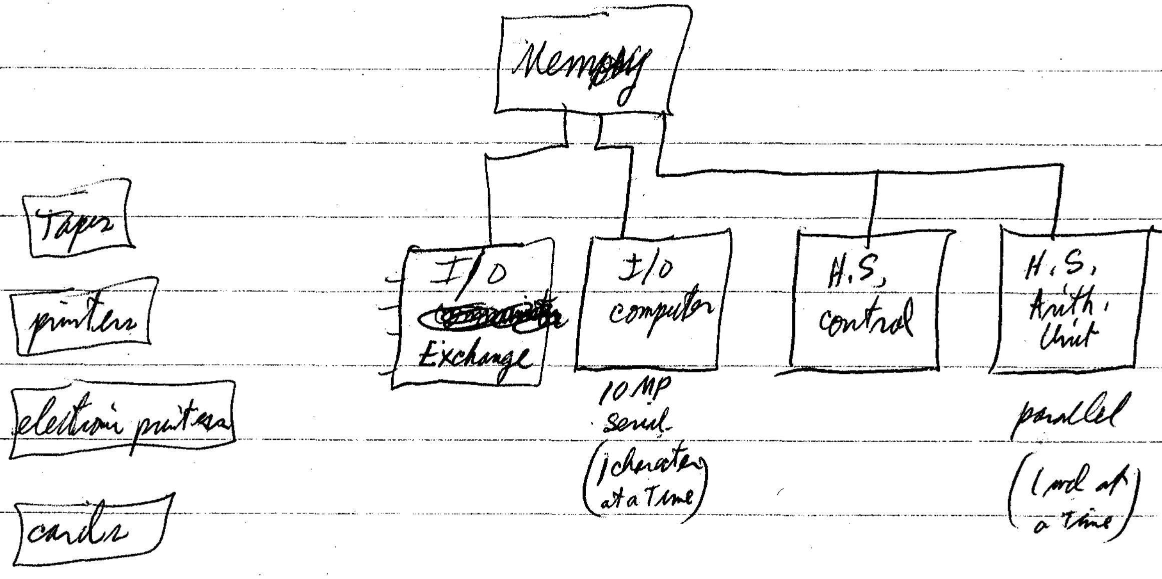
(a) communication with I/O units (word every 4 μs or so)
(b) editing
(c) high speed arith.

radix conversion cannot be done in 4 μs. (?)

Telephone exchange type organization multiple trunks, ringing circuits, busy signals, holds, etc.

standards of error detection & correction on I/O. equip.

Control: I/O will receive control wds. from rest of machine, then computer can go on to something else & check back occasionally (limited contact)



I/O com will have separate "stored programs" built in registers
(essentially several index registers and instr. counters,

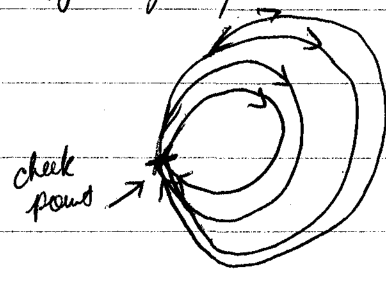
1. I/O computer does conversion + stores wds. in exact positions
2. I/O comm does "copy + read" functions.

can fast computer refer directly to I/O comm? yes.

buffering – an area in regular memory eg. RAM needs ~2000 wds. for high performance.

→ planning of I/O computer is expected to be most difficult part,
want to separate radix conv. etc. from sci. calcs.

– eg. neighbor problem can be worked on in I/O computer simultaneously,



I/O loops different programs all go back to check pt of test "priority".

HS. arith unit will operate on a subset of I/O computer instructions
same order will look the same to both machines ??

cost 1. Memory.
2. I/O communication & I/O units
3. HS arith & control most gear (would be 2nd if above transient lumped)
4. I/O computer – most complexity less gear

Possible Subjects for next time.

1. review notes of this meeting.
2. Specific statement of Hydrodynamics (2D) flow chart, done
3. Input-output considerations
4. Monte Carlo problem, (low order precision)
5. Auto Programing.
6. Floating Point definition ... binary – overflow, underflow, rounding, normalization, etc.
7. Plan attack on sig. figures problem
8. Matrix probs.

sept 19-20-21 Tentative date

(oct. 8-9 AEC Meeting at Livermore)

Stretch Meeting (at Los Alamos) Sept 11, 1956

Floating Point Nos.

1. Zero
2. Underflow
3. Overflow
4. Normalization (base?)
5. Exponent
6. MQ on floating add.
7. Double precision.

5 Exponent: Sign and magnitude of exponent

question of powers of 2 (floating shifts)

position of decimal point

2, Underflow:

Two types occur (error, or set to zero)

Two modes (a) error mode - gives tr. to error prog.

(b) Zero (plus indicator ?)

3. Overflow:

error indicator ~ what kind? $\left(\frac{0}{0}\right)$ a separate error stop.

1, Zero:

$A - B + C$ where $A = B \approx 10^{15} C$

then answer is not C - it is gibberish.

→ All zero fractions imply mathematical zero.

→ what about exponent? -127? or 0? ...

- zero detection implies time saved in arith. opns.

normalization:

on adds left shift first.

– question of growth of rounding errors.

example: $10^0 .0070 (\pm 5)$

$10^{-2} .1234$

if one shifts rt. first – we introduce error

$10^0\ 0070 (\pm 5)$
$10^0\ 0012 (\pm 5)$
$10^0\ 0082 \pm (7)$

if shift left.

$10^{+2}\ 70 (\pm 5)$
$10^{-2}\ 1234$
$10^{-2}\ 8234\ \pm (50)$ better

⇒ we want a vocabulary which will waste no time and loose no significance.

then circuitry question come up.

(a) Min. Time, no loss of information

(b) cost of implied unnormalized work.

CAS Trouble

divide trouble.