

20

1975-P-50 TM



COMPUTATION NOTE BOOK

43-648

Course Dye Dil. + C.O.
Name W^m Thornton, Capt MC USAF

AMD, BAFB Oct. 65 - July 66

5131 Lancelot Dr. San Antonio, Tex

Hynson, Wescott & Dunning
Baltimore 1, Md.

25 Oct.

Need - Pipettes 5-25 λ - 5 ml Volumetric
Mixer for pump -
Yokes for 25 + 50 ml -
Cable for Oximeter

27 Oct.

Plan: Calibrate densitometer -

1. Use micropipettes + add 10 15 20 + 25 μ l to
5 ml of blood - make 3 ^{sets of} samples - and run
 $\bar{c}$ E for M -

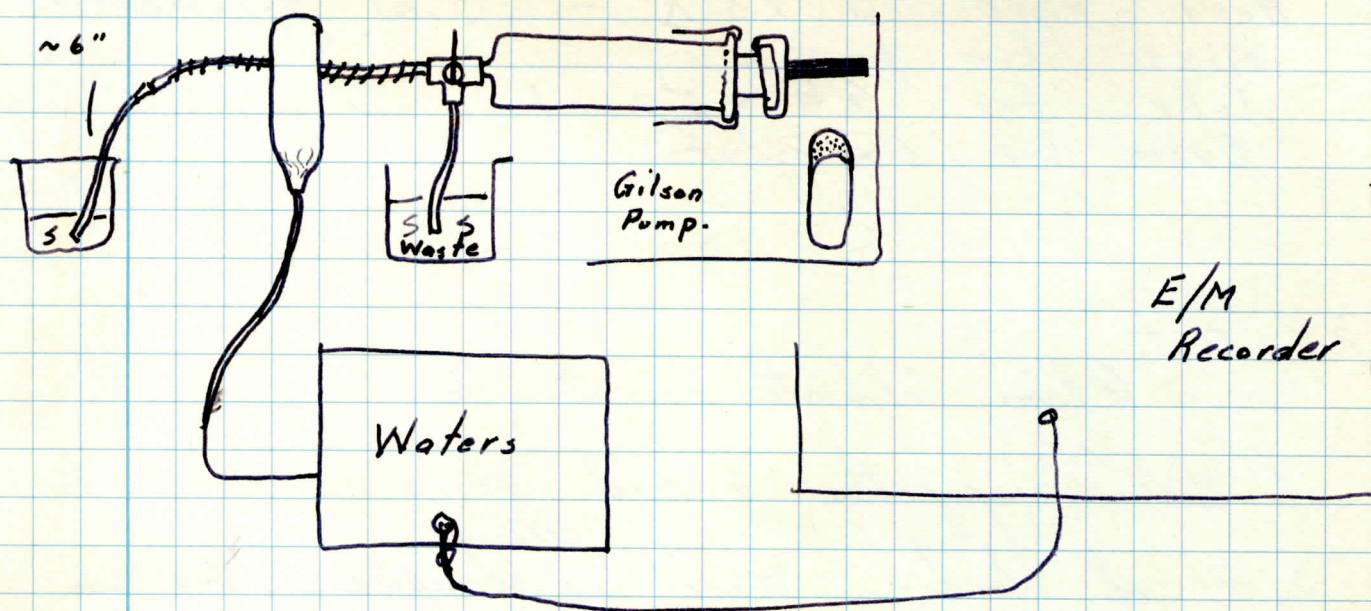
2. Use micropipette and add 20 μ l to
5 ml + dilute to 10 + 5 ml. run 3 X.

29 Oct.

Curves run previously (27th) had a variety of
faults of which the chief was variation of
the curve at fixed concentrations. The arrangement
used for recording is shown on the rear of this
page - Gilson withdrawal pump at 1.

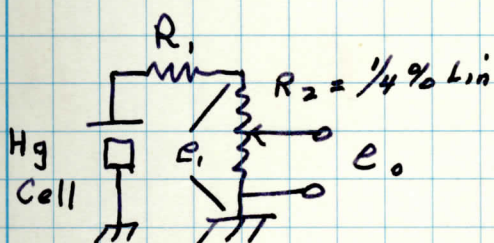
Gain: ?	Run		mm cm Defl	2 mm.	3 mm.
	Concentration				
	10 λ per 5 ml.		40	46	43
	15 λ "	"	69	—	70
	20 λ "	"	98 *	102 *	—
	25 λ "	"	130 Δ	129	
	40 λ "	10 "			
	20 λ "	"			
	10 λ "	"			

Drug (50 mgm) is dil. $\bar{c}$ 10 ml (syringe)
for 5 mgm/ml -



2 Nov.
~~30 Oct.~~ The ~~per~~ dens. was being zeroed $\bar{c}$ blank blood running. This was changed. Previous records do not have a linear response $\bar{c}$ conc. but actually a power function. Records taken by technician were inadequately marked.

4 Nov. Still check linearity of recorder both against densitometer scale and as below.



Does dilution play a role?

$$1/\lambda = 10^{-6} \text{ L} = 10^{-3} \text{ ml}$$

$\bar{c}$ 5 ml. + 2.5 λ for ex.

Figures below taken $\bar{c}$

$$\text{Desired dil.} = \frac{x}{5.000}$$

$$R_1 = 16 \text{ K}\Omega$$

e/e

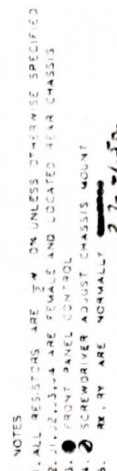
Defl. mm.

Dev. from 100% slope.

$$\text{Actual} = \frac{x}{5.025} \text{ or } \approx \frac{1}{2} \% \text{ var}$$

	Defl. mm.	Dev. from 100% slope.
0.	0	mm
.1	12.5	+1.
.2	24.5	+7.5
.3	36.0	.5
.4	47.5	-.1
.5	59.	+3
.6	70.5	+2
.7	82.	+2
.8	93.	+1
.9	104.	~0.
1.0	115.	0.
.5	70.5	+3.
.0	0.	

Meter	Densitometer Defl. mm.
0.	0.
5	11.
10	22.
15	32.5
20	43.
25	53.5
30	64.
35	73.5
40	84.
45	94.
50	104.5



SI	A	B	C	D	E	F
POSITION 2	—	—	—	—	—	—
POSITION 3	—	—	—	—	—	—
POSITION 1	—	—	—	—	—	—

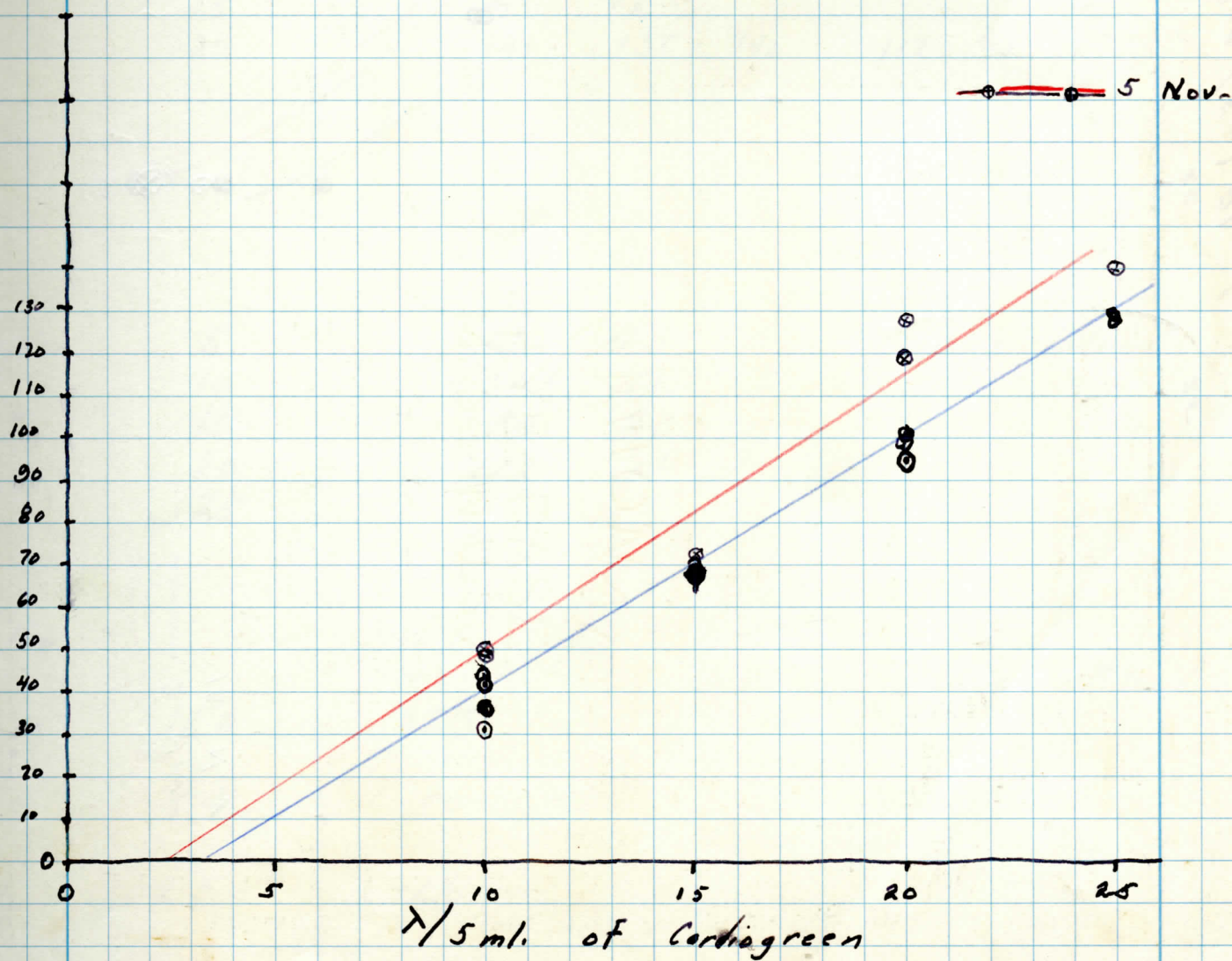
SUBS	
POSITION 1	400 BALANCE
POSITION 2	400 BALANCE
POSITION 3	400 BALANCE
POSITION 4	400 BALANCE
POSITION 5	400 BALANCE
POSITION 6	400 BALANCE

CONSULETÉ
R46, R47, R48

ASURING CELL

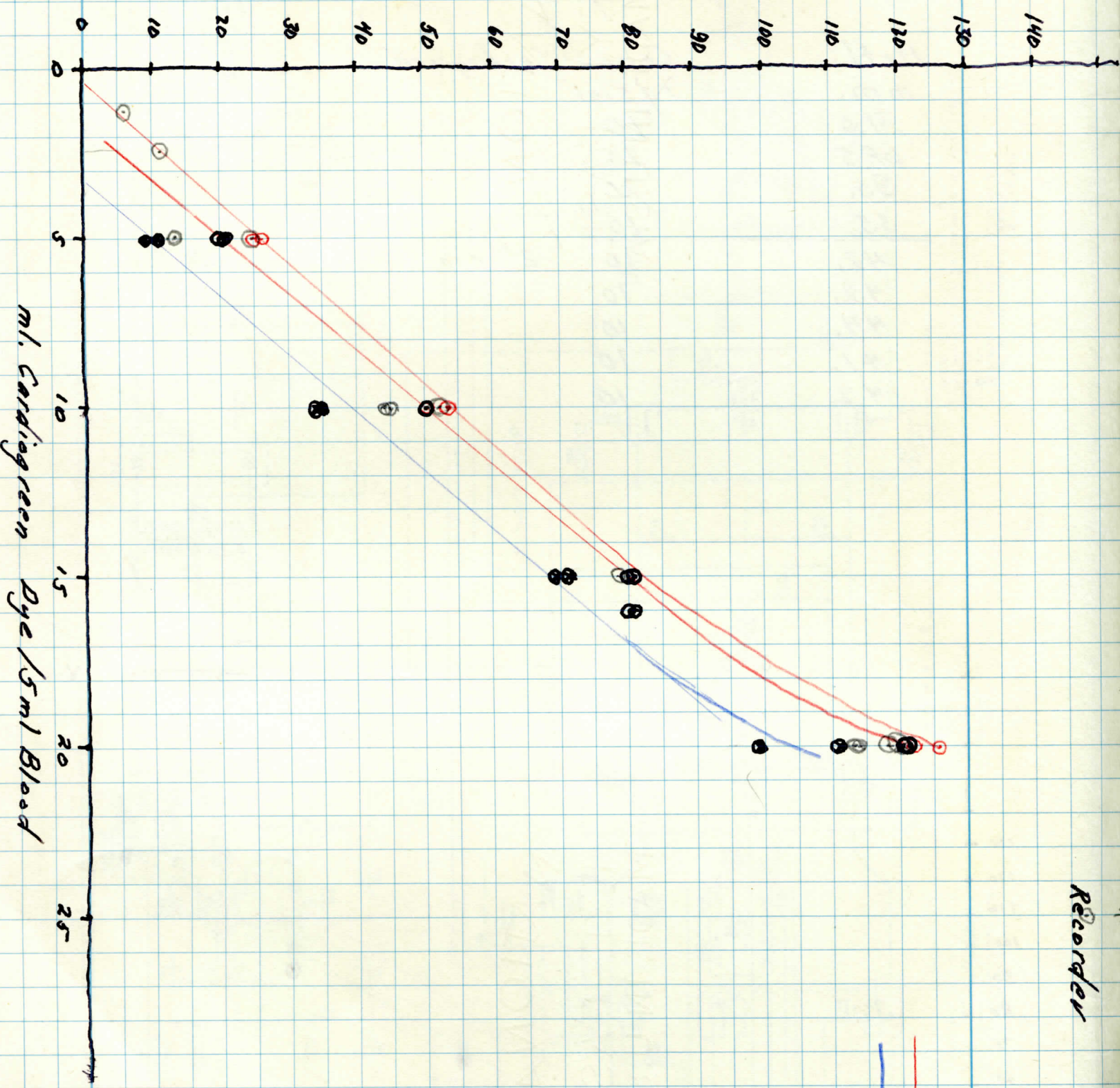
Calib. of dye response-

Defl. mm.	Conc. Cardiogreen - $\gamma/5\text{ml}$	
31.5	10	
68.5	15	
95.	20	
35.	10	
42.	10	2 ^o run.
42.	10	
44.	10	
41.	10	
42.	10	



Recorder

16 Nov.
9 Nov
18 Nov



ml. Cardiogreen Dye / 5ml Blood

5 Nov. Calibration Run

Conc./5ml.	Defl. mm	1	2	3	* est. Poor Record.
10 λ		48	51		
15 λ		72.5	77.5*	73.	
20 λ		119.	128*		
25 λ		130.			

Plotted on p. 5. —

Records run on 5 Nov. had a variety of faults including poor recording technique esp. as regards a stable base line — and the dye dilutions had an impossibly large spread — but the slope was probably different from previous records. Will make attempts to secure automatic pipetting techniques.

9 Nov.	Conc- λ /5ml	Defl- mm	Run	1	2	3		
	5			11.	9	9		
	10			35.	35	34		
	15			69	72			
	20			131	135	140	112	97

16 Nov.	5	21.	20.	Bovine Blood
Done by W.T.	10	50.5.	51.	
	15	80	82.	
	20	122	121	
	25			

16 Nov			Bovine Blood
#			
1-40 λ in 10ml?	126	123	
2- $\frac{1}{2}$	54	50	
3- $\frac{2}{2}$	25	26	

There now appears to be appreciable deviation from linearity at both the low and high ends of the densitometer scales. The max. conc. for dens. lin. is 48 mgm./L. The dil. of the dye is Repeated dilutions may be the best scheme for calib.

orig Vol Part. Rem
100% - 10 ml. $\rightarrow$ 5 ml + 2.5 ml = 66%

or

18 Nov. Calib.

Conc.
x/5 ml

1. Defl.
mm.

2.
mm.

3 4
mm. mm.

5

13

13

26

27

10

45

44

56

56

15

79

79

20

118

113

25

147

158

20

125

10

52.5

5

25

2.5

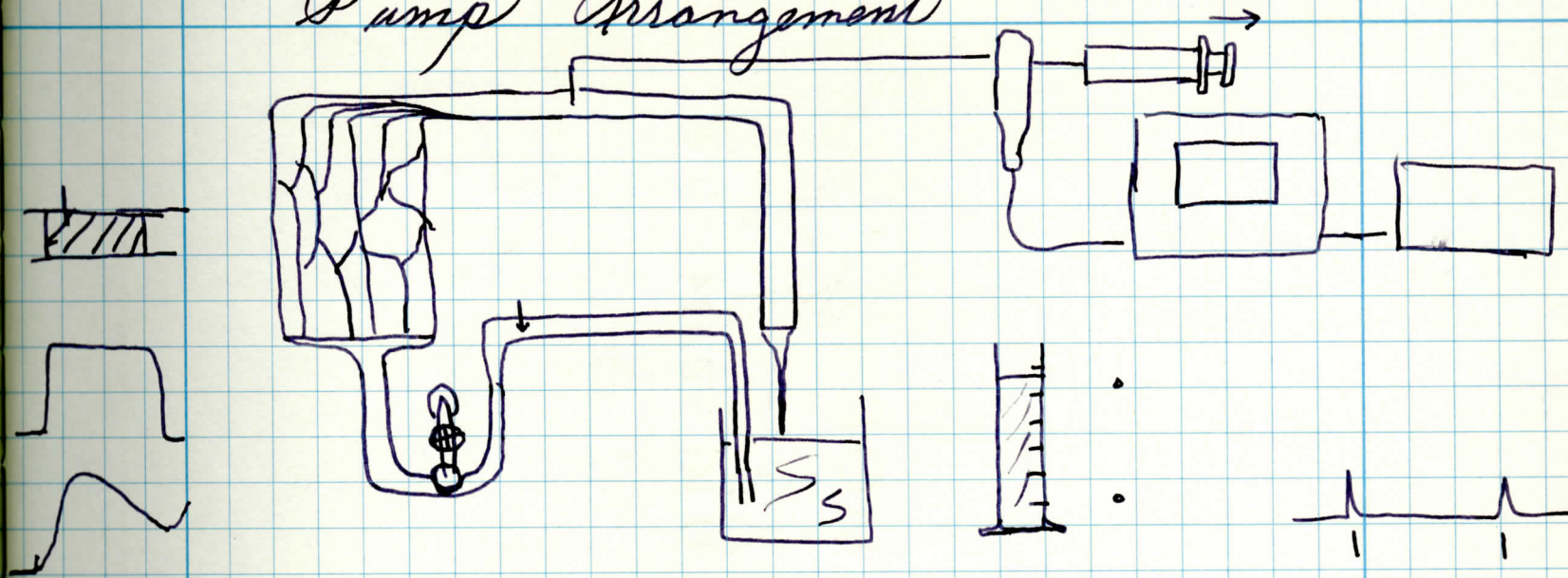
11

1.25

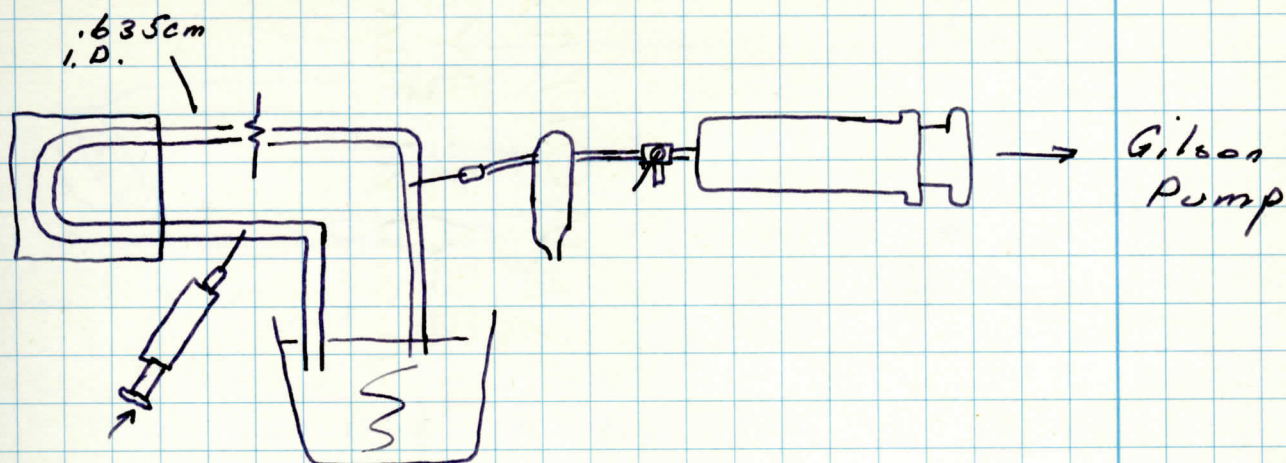
6

Bovine Blood

Pump Arrangement



30 Nov - '65



3-

$$\lambda = 10^{-6} \text{ L}$$

$$\text{Conc} = 5 \text{ mgm/ml}$$

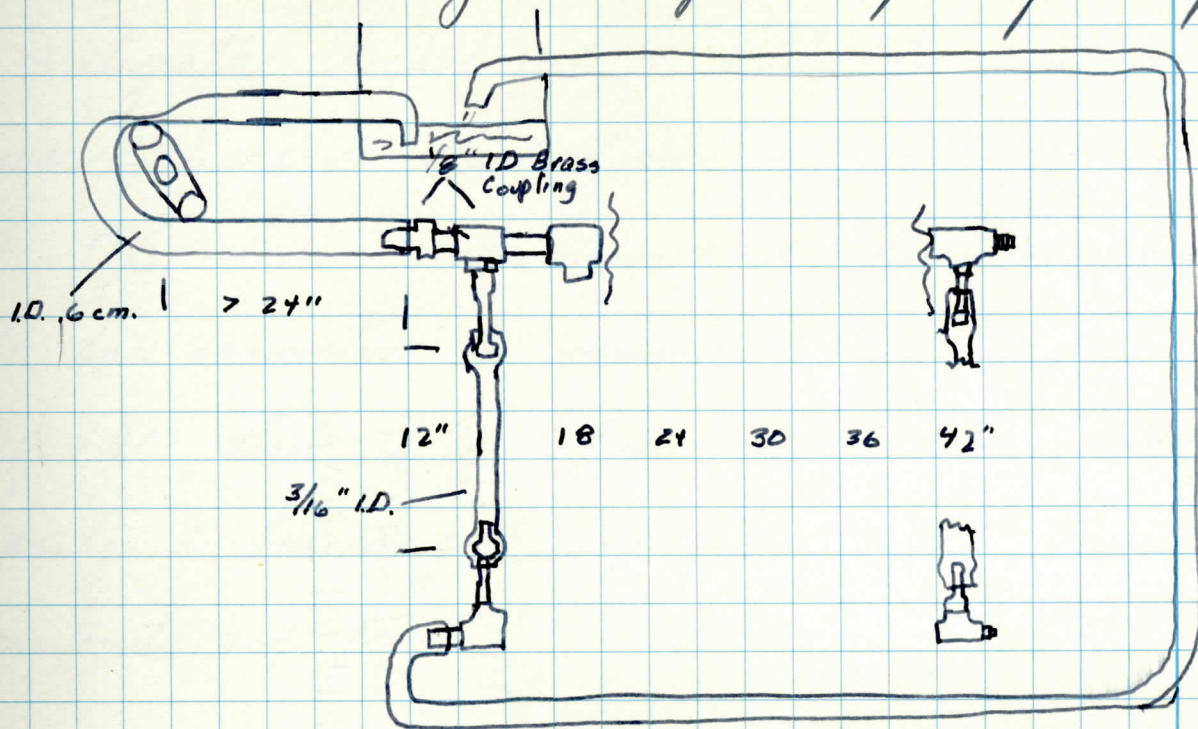
$$10 \text{ mgm L} \times 3$$

$$5 \times 10^{-6} \text{ L}$$

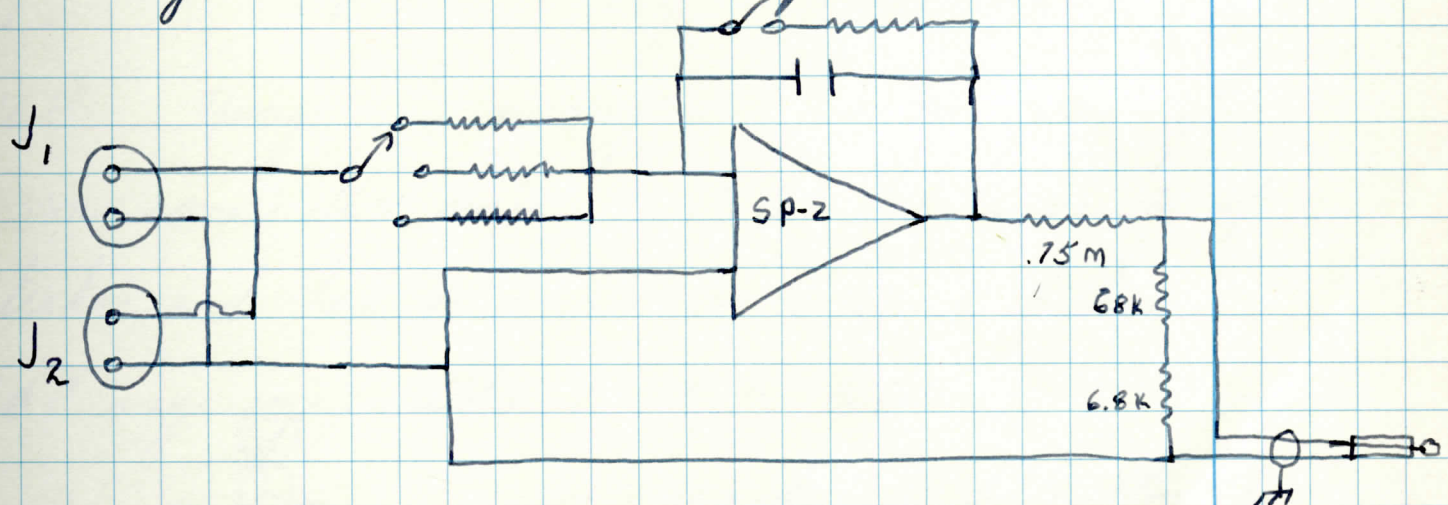
$$\times 5 \text{ mgm}/10^{-3}$$

$$= 25 \times 10^{-9} / 10^3$$

7th Dec. Arrangement of multiple flow paths



The integrator was wired as follows:

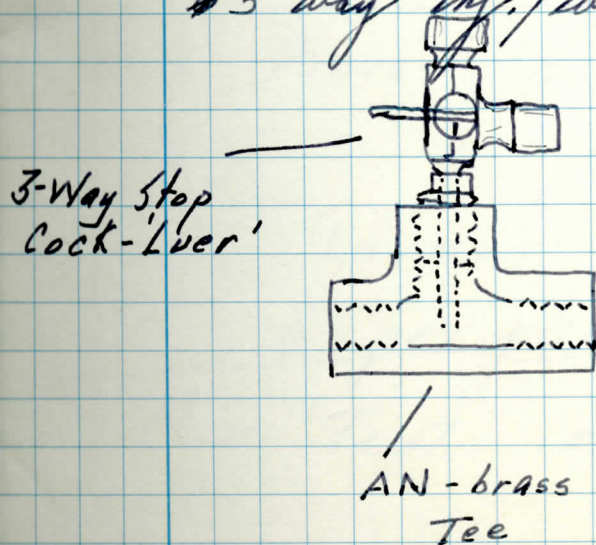


9th

Integrator checked out + ready to run dye curves. Graphic illustration of unsafe wiring - A 5.B. San extension cord had one side of the line connected to mains 3 (gnd.) pin & 110 V.A.C. thru large fuse densitometer and E/M. Sparks & burned gnd. leads in E/M D.C. amp. + densitometer out for ? -

14th ~~10th~~ Replaced burned sig. gnd. lead in amp. Found defective (coincidental) 12AT7 in statos + replaced. Integrator O.K.

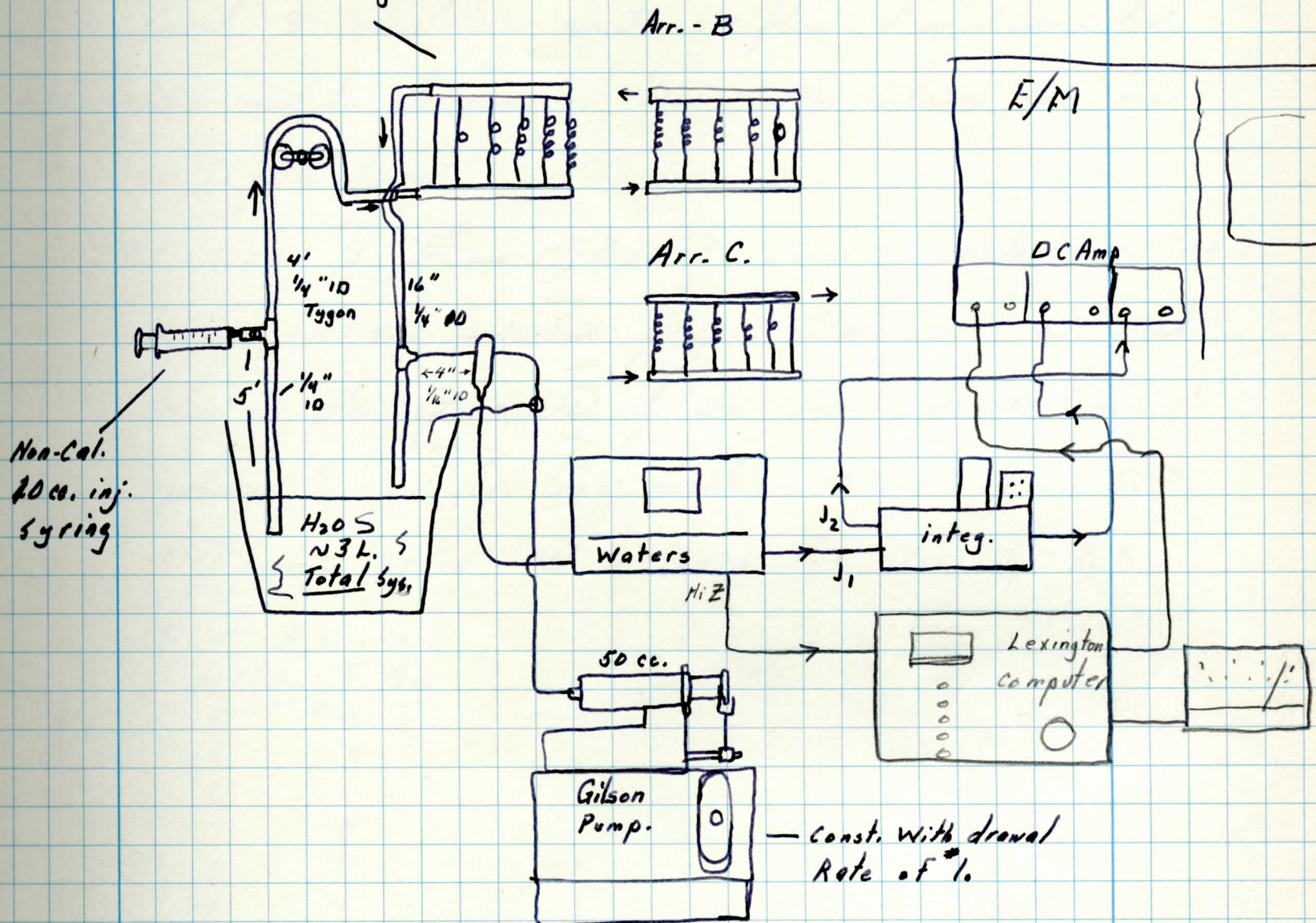
16th Using the arrangement on the prev. pg. ran some dye curves & H₂O. Had a variety of leaks and had to use hose clamps + fabricate a 3 way inj./withdrawal adapter below.



After considerable difficulty & air made a series of runs & 1 + 2 ml. of cardiogreen using the arrangement on next pg.

16th Dec. Simulated Cardiac Output

Arrangement A



	Run #	Inj.	Pump set.	Record Gain	Speed/Time	Remarks.
Arr. A	1	~1 ml.	90	? ↓	250 mm/s / 1.5	low amplitude - linear fall off
	2	1.5 ml.	90	S: 5. Dye = 7.	↓	plateau like descent - long low recirc. 2° hump from long tube.
	3	2 ml	?	↓	↓	↓
	4	↓	?	↓	↓	same ex. unexplained rapid recirc.
Arr. B	5	↓	?	↓	↓	Almost gaussian dist. & sl. prolonged. exp. fall off. + 2 slow recirc.
Arr. C	6	↓	?	↓	↓	Good rise long plateau + almost exponential fall off.

16 Dec.

Concl: $\bar{\epsilon}$ calculating resistance + flow it is obvious that $N > 1 \rightarrow$ tubes must be shortened or even another scheme used such as a filter element.

21 Dec. A Fram PB $\frac{1}{2}$ -P was inserted in the system on the previous page. There was a great delay in the appearance of the dye. On the initial injection ① no dye was visible. Pump speed '50'

② pump speed '90' - Gain dye -7, I_T - #5

③ ~ 3 cc. inj.

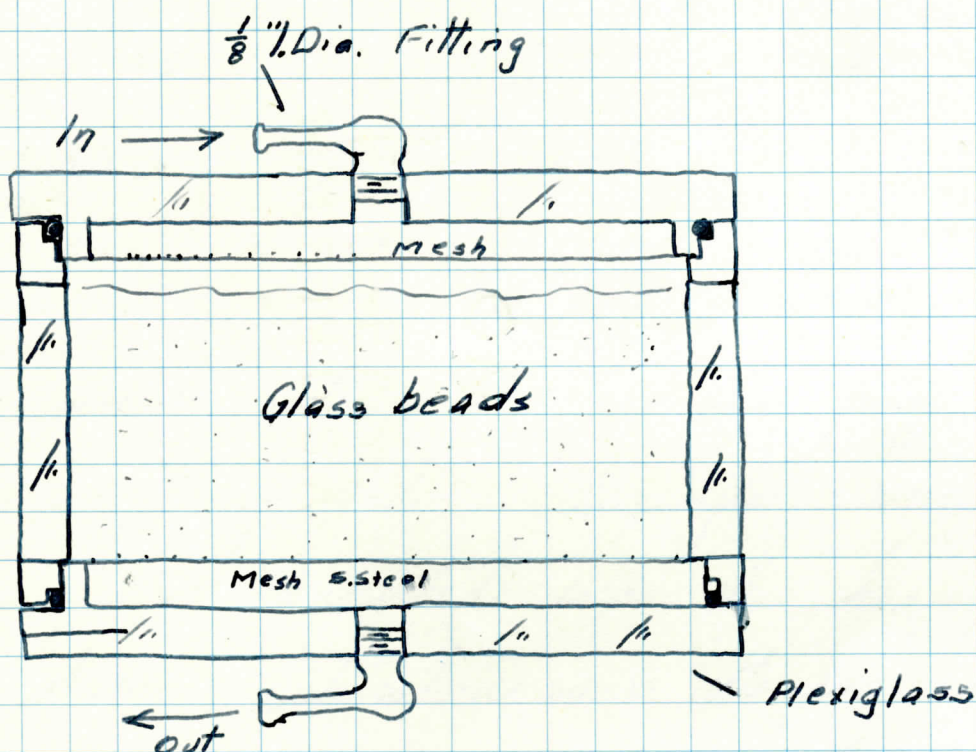
defl. mm Time

0	0
1	0
2	1
3	3
4	5
5	10
6	14
7	16
8	15
9	14
10	12
11	10
12	9
13	8

12 Jan

A glass bead maze < 1 mm dia. was const. as below.

Total
Vol.
1.22 L



This was placed in the system shown on P-19 in place of the "christmas tree".

No calibration of dye sens. or of integ. was made.
2 cc of 5 mgm./ml. was inj. and good following

chj -
inj.

- 1 - good exponential $\bar{e} \sim 11$ sec. recirc. peak - inj. to app. time ~ 2.5 sec.
- 2 - reduced vol. in bucket to 1 L ($\sim .25$ in sys) recirc. time now ~ 7.5 sec. - good exponential fit $\bar{e}$ same RC as 1 - app. time ~ 2 sec.
- 3 - good fit. app. time - 2 sec.
- 5 - $\uparrow$ pump to '35' (indicator) good $\uparrow$ in S + peak. fair fit $\bar{e} \downarrow$ RC. app. t. 2 sec. - recirc > 7.5 sec.
6. $\downarrow$ pump to 50 - 3.5 sec. no app. time - low peak + slow tail - ~ 7.5 sec recirc. (peak to peak)

10-13

Pump	Cal. #1	Pump. Set - 50		System Vol.
	Time	Vol	$\Delta X / \Delta T$	255 ml -
	30.5	870	28.5	
	31.6	905	28.6	
	30.25	860	28.4	Max var. = .4 or 1.4%
	31.6	900	28.5	
	30.4	875	28.8	
Mean $28.7 \frac{\text{ml}}{\text{sec}} \times 60 \text{ sec.} = 1722 \text{ ml/min}$				

The model used on the previous page was run again today and a Lexington analog output computer was connected via the hi-imp. jack of the Statur. Calibration was attempted using both A. micro-pipetting + B. dilution. There was poor agreement between pipetted samples + none between A + B. Some points were taken on the Statur scale that approximated the pipetted sample + the zero was taken as the balance point after correction for residual dye. 2 cc of 5 mgm/ml of Cardio green dye were inj. to pump at '50' (1.72 L/M) to 1.5 L of H₂O in system.

#	App. time	3.5 s.	good exp.	early peak (shunt.)	but good exponential	Comp. C.O.
1	"	4.5	"	"	"	2.1
2	"	"	"	"	"	1.8
3	"	"	"	"	"	1.9

Tried packing beads to eliminate short center path but little effect -

Modified lung simulator was cracked by tech. in attempt to stop leaks - Have ordered a diluter, Precision Sci. # 66900 from Ace Surgical Supply

1831 Olive St. St. Louis Mo. Mr. Aden -
Chesnut 1-5700 - Sales Mgr. H. T. Brown

Diluent 0.5 ml. $\pm .5\%$ + sample 0-100 μL $\pm .5\%$
reproducibility $\pm .05\%$

21st

Diluter arrived $\bar{c}$ broken diluent syringe + cracked case - Accepted by supply who has ordered a replacement syringe.

The lung simulator was cracked + repaired - A flow dispenser was added + the space entirely filled $\bar{c}$ glass beads - A series of curves run by Mr. Gomez which looked good - Cardiac computer gave reasonably consistent answers -

8 Mar

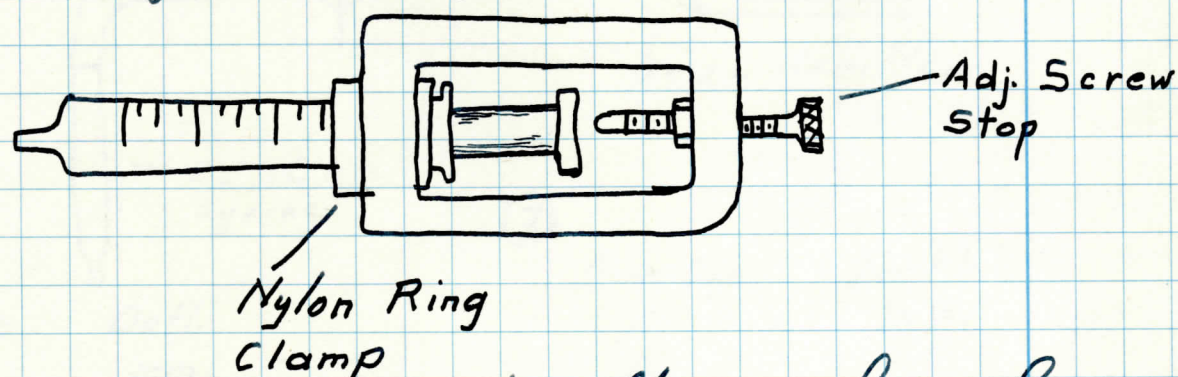
Two diluters have been purchased + both arrived damaged. The first is still being "repaired". A 50 μL Hamilton + 5 ml. syringe are being set up $\bar{c}$ fixed stops in the shop -

Yesterday the densitometer was taken to T.B. San and 3 runs were made at 625, 805 (stds) 680, 700 + 750 m μ , injecting 3 to 7 ml. of T-1824 dye dil (1:1) into peripheral veins (ante-cubital)

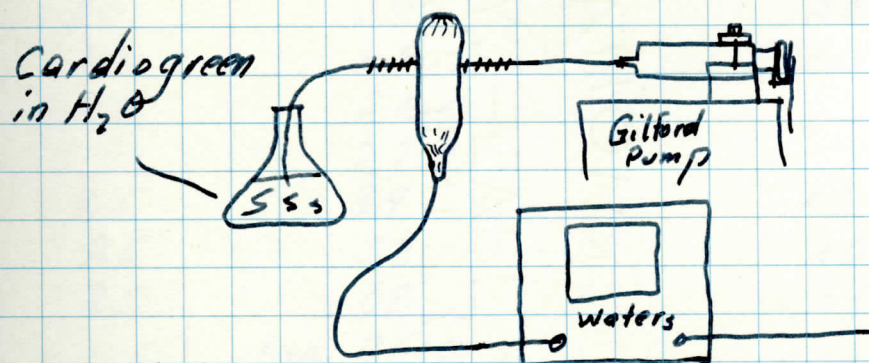
fosse). The double capsule earpiece was used & condom (R) rubber capsules & a press. of ~ 200 mm. Hg. First subj. was $\frac{45.2 \text{ mg/ml}}{10}$ 120# female & carotary disease - 3-4 ml - (45.2 mg/ml) inj. were used. Pinna of @ ear was prepared by histamine iontophoresis (~ 5 ma. for 4 min) but the small area ($\sim 1/4$ cm.) did not produce large areas of wheal & flushing. Insufficient time was probably left for equilibration after iontophoresis for there was an increase in density during the recording. This was less marked & the other two subjects. There is a marked time lag in the ^{fixed increase} reduction in intensity (I_0) after application of pressure. The "output" curves recorded nicely in every run & one ~~run~~ ^{curve} obviously prolonged by slow injection. Only curves from the first subj. were completely recorded - (625 & 805 mp only were recorded during actual injection) and although at low gains no evidence of the curve was seen on the 600, 700 or 750 mp channels.

21 Mar.

Two fixed travel hamilton syringes were fabricated by the shop.



One was a 50 μ L Hamilton & the other a 5 ml. Mr. Gomez, T.B. San. tech., made dilutions using these which are recorded below.
Recording arrangement:



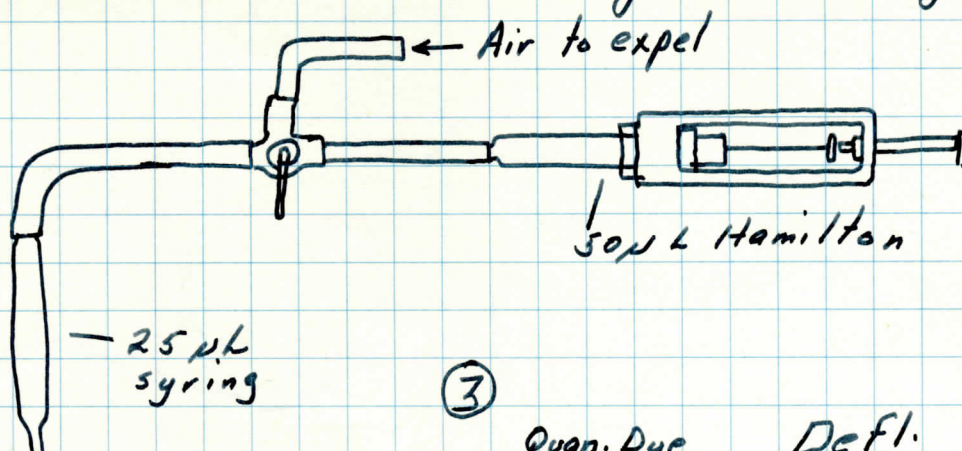
Record ①

Gain = 5.0

Quan. μ L	Defl. mm.		Quan μ L	Defl. mm.
40	33.5		10	6.5
40	30.0		10	6.0
40	33.0		10	7.0
	Avg. 32.0	12.5 μ L/mm		6.5
20	16.			
20	14.			
20	16.			
	Avg. 15.	13. μ L/mm		

1.5 μ L/mm

A second record was run using the arrangement below.



②

Gain = 5
Quan. dye

µL

Defl.

mm.

10

15.5

10

15.5

10

15.0

Avg.

15.3

15

18.5

15

18.0

15

19.0

Avg.

18.5

20

29

20

28.5

20

26.0

27.8

25

34

25

33

25

38

Avg.

35.0

③

Quan. Dye

µL

Defl.

mm.

10

15.

10

15.

10

14.

15

19

15

19.5

15

18.5

20

30.5

20

30.0

20

31.0

25

36.

25

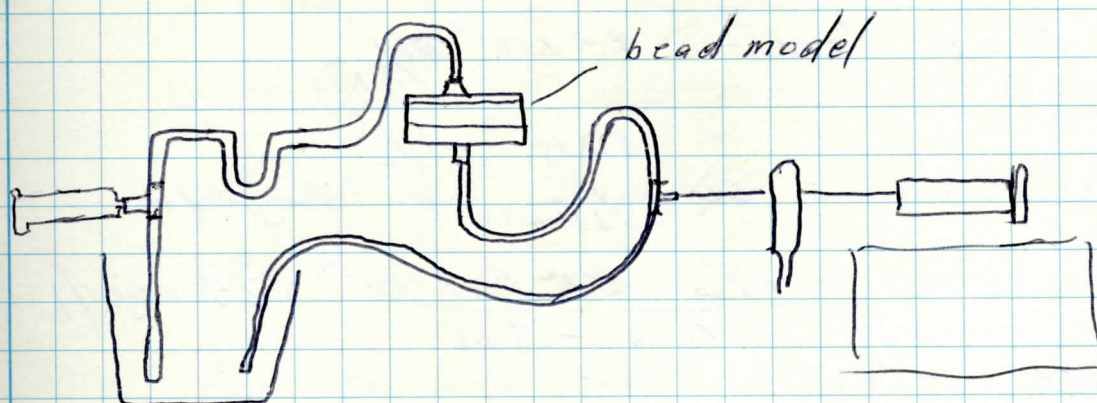
37.

25

38.5

29 Mar.

Sys. Vol 185 cc -

3 L H₂O

Calib -

3 - run 25 μ L samples Gain = 75 ml H₂O $\bar{c}$ Fixed Stop Syringe25, 20, 15 + 10 μ L $\bar{c}$ Hamilton " " "

Defl mm	Conc. μ L/5 ml	Gain "7"	Sens. mm/ μ L/5 ml
61.5	25	50 mV = 70.5 mm.	2.46

$$\begin{array}{r} 286 \\ 25 \overline{) 617} \\ \underline{50} \\ 118 \\ \underline{100} \\ 170 \end{array}$$

60.0	25
<u>61.5</u>	25
61.7	

" "

" "

"10"

50 mV. = 100 mm.

} there was hysteresis
in all these
meas. - i.e. zero
at end -

$$\begin{array}{r} 36 \\ 20 \overline{) 72.6} \\ \underline{60} \\ 12.0 \end{array}$$

72	20
73	20
<u>73</u>	20
72.6	

3.6

$$\begin{array}{r} 39 \\ 15 \overline{) 58.3} \\ \underline{45} \\ 133 \end{array}$$

58	15
59	15
<u>58</u>	15
58.3	

3.9

} hysteresis - meas from
end of run.

41.	10.
40.5	10.
<u>40.5</u>	10.
40.7	

4.07

31 Mar

? non-lin of Waters-

spec: 48 mgm/L

Our Max Conc. - $25 \times 10^{-6} \text{ g/L} / 5 \times 10^{-3}$

$$= 5 \times 10^{-3} \text{ ml/L}$$

Dye conc = 50 mgm/10 ml or 5 mgm./ml

$$\text{or } \frac{5 \times 5 \times 10^{-3}}{0.1} = 25 \text{ mgm/L}$$

#1- 45.8 45.8 } in 10 ml (2x5 ml. From diluter)
 39.7
 30.
 20.
 10.

Pump	Vol - pump vol. = 2.44 L	Flow-L/m Avg.
30	col - 968 ml/60 sec	
30	978 " / "	.974
40	680 ml/30 "	
40	690 " "	1.370
50	840 " / 30 sec	
50	840 " / 30 "	1.68
59	640 " / 20 "	
59	655 " / " "	1.944

Time
line
1/5

Spore
Calc
For
every

31 Mar. Pump, Simulator, Recorder, $\int$ + C.O. computer
Calibration:

50 mgm. of C'green. dye is dissolved in 10 ml.
dist. H₂O for nom. conc. of 5 mgm/ml.

Aliquots of tap H₂O are measured by
Prec. Sci. diluter, ckd. by vol. flask, 2 X 5 ml = 10 ml

The following quans. of dye are added to 3ea. of
the 10 ml. aliquots by a Hamilton syringe
̄ mechanical screw stop set to syring calib. line

under a magnifying glass.:

Volume dye $\times 10^{-6}$ L.	Diluted Conc. mL/L	mGm/L
45.8	4.58	22.9
39.7	3.97	19.85
30.	3.	15.
20.	2.	10.
10.	1.	5.

Water Dens. (Cuv.) was calib. by recording
output on E/M initially set at Gain = 5. ^{1.22 mm/mV.} There is a
marked hysteresis today as in previous records ̄ high dye
concentration. Zero shifted by 5 mm. which may be
inherent in PEC's, temp. effect or in complete
washout of dye. Zero was recorded ̄ tap H₂O flowing
(as the dye is recorded) but ̄ change between runs here.

Timing
lines
1/sec.

Shorter
Calib. runs
Zero before
every run -

Panel Meter Units	Sensitivity mm/mV mV/mm	Deflection* mm	Concentration mgm/L	Deflection/Concentration mV/mgm./L	
	1.22	0.8196 ⑤ 45.5	55.5 37.29	22.9	1.628 2.42
	"	45.5	55.5 37.29	"	1.628 2.42
	"	47.	57.3 38.5	"	1.68 2.50
26.5	1.61	0.621-⑦ 62	99.8 38.5	"	1.68 4.358
	"	" 63	101.4 39.1	"	1.71 4.427
	"	" 62	99.8 38.5	"	1.68 4.358
23	"	" 55	34.15	19.85	1.72
	"	" 55	34.15	"	1.72
	"	" 55.5	35.08	"	1.767
	"	" 46.5	28.87	15	1.924
	"	" 46.	28.56	15	1.904
	"	" 45.5	28.25	15	1.883
12.5	"	" 31.	19.25	10	19.25
	"	" 31.5	19.25	10	19.56
	"	" 31.	19.56	10	19.25
		16	99.36	5	19.87
		15	93.15	5	18.63
		16	99.36	5	19.87

⑤ + ⑦ are attenuator ("gain") settings -

* On 1st runs 0 = $\bar{p}$ run zero

Run 0 4,5,6 zeroed between each run

1-Apr. Assessment of data

The cardiac output computer was calibrated according to the formula. $F_{cal} = \frac{\text{Quan. of dye inj. (mgm)}}{\text{Conc. of calib. dye} \times .257 (\text{mach. const.})}$
 C.O. computer "gain" = 1.
 The densitometer was set to a point which represented $\sim 20 \text{ mgm./L of dye} - \text{scale} = 23$
 Dye "gain" = 7

$$F_{cal} = \frac{2cc \times 5 \text{ mgm/cc}}{20 \text{ mgm/L} \times .257} = \frac{10}{20 \cdot .257} = \frac{5}{.257} = \sim 1.93 \left(\begin{array}{l} \text{set on} \\ \text{lower scale} \end{array} \right)$$

The integrator was calib. as follows:

A small zero offset was required to zero the cardiac computer - I_T channel gain = 2

$$\text{Zero rate} = \frac{137.5 - 116.5 \text{ mm}}{20 \text{ sec.}} = \frac{21}{20} = 1.05 \text{ mm/sec.}$$

$$\begin{aligned} \text{Rate at } 57.5 \text{ mm defl.} &= \frac{(136 - 42) - (3 \times 1.05)}{\frac{30.95}{3} \cdot \frac{20}{3}} = \frac{94 - 1.15}{\frac{20}{3} \cdot \frac{20}{3}} = \frac{92.85}{\frac{20}{3}} \\ &= 4.64 \text{ mm./sec.} / 57.5 \text{ mm defl.} \\ &\quad (1.95 \text{ L/M}) \end{aligned}$$

With the pump running at "59", 2 cc. of dye was inj. & everything going off scale ex. the C.O. indicated 4 L. which is approx. 10% > than 2X the meas. output.

The only recorder was next calib. by

means of the int. calib.				C.O. calib. A.H. ✓	
Channel	Att.	Calib. Pot.	De Fl.	Indicated Out.-L/M	De Fl.-mm.
		mV.	mm.		
C.O.	1.	50	1	4	17
Dye	7	"	80	3	23
Integ.	3	"	29	2	34
				1.5	44
				1.	48

Action

1. a. H_2O & card. green -

3 x 3 ranges

5 10 15 20 mgm/L

b. blood & card. green -

3 x 3 ranges

5, 10 15 20

2. CK computer

a. Find error

b. Obtain electrical
computer calib.

c. generate exponential for
computer -

d. Run 2-3 days curves &
simulator & H_2O & Blood.

3. Patients

Correlate capiece & art. sampling

July 11 '66

Dr (Phd.) La Puerta has joined the T.B. San and is interested in C.O. The following has been tentatively agreed upon as exp. work -

- 1) Test ability of tech. Mr. Gomez to run repeatable calibrations - 3 run of 3 set of concentrations of cardio-green in H_2O (5, 10, 15, 20 mgm/L)

2 -

Using earpiece $\approx$ cal-

$$Dens = F(a + b + c)$$

$$D_1 = \overbrace{a_1 + b_1}^K + c_1$$

$$D_2 = \overbrace{a_1 + b_1}^K + c_2$$

a = path (unknown)

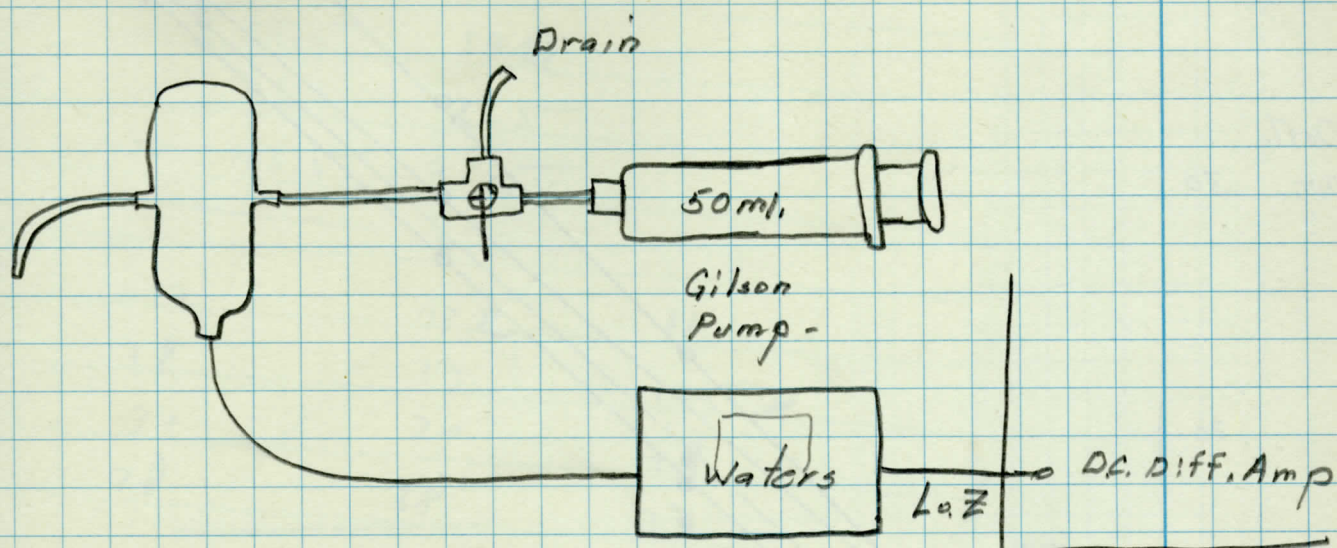
b = extinc. coeff

c = conc. (unknown)

D = meas-

$$c_2 = 2c_1$$

14 July Calib runs & Water Dens.



Zeros & H_2O were run and flow rate was varied and from 1 to 12 on Gilson pump - Temp. of H_2O was varied from 18 to 26°C - neither produced changes

1st Run		5	10	15	20
		11.5	21.2	32.5	42.5
		20 μ L in 20 mL	20 μ L in 10 mL	60 μ L in 20 mL	20 μ L in 10 mL
↑ Gain	2° Run →	27	44.5	71.6	95.2
↓	3°	37.2	66.3	97.3	127.0

2° Calib batch-

1st run Hi to Lo

2° " Lo to Hi

Zero shift

2° 2- 17. 2 mm

55.5	75.5	101.5	119.5
40.	75.	116.7	146.3

18 July - Gomez - as above

Conc.

Mgm/MI

Batch 1

Defl. - mm.

2

3

5	10	12	13.2	11.	10	10	12
13.5	10.	12	13.2	11.	10	10	12
23.5	18.	18	19.	16.5	19	18	19.5
39.	27.5	30	30.	28.	28	28	29.
43.5	36.5	38	38.	37.	35	35	36

Defl.
mm.

40

30

20

10

5

10

15

20

Conc Mg/ml

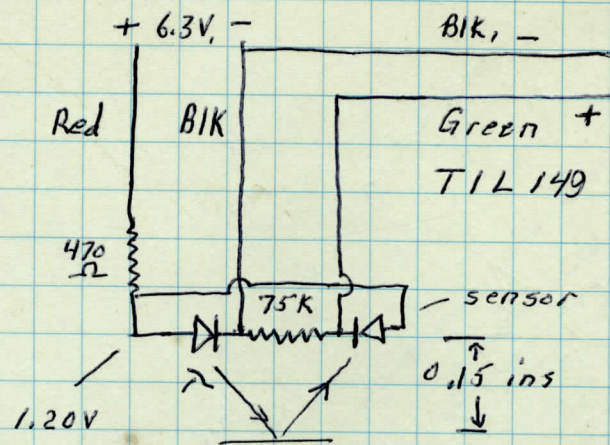
18 July
Defl vs Conc.

20 July

La Puerta is pleased $\bar{c}$ above results & wants to try
calib. at 4 pts. using H_2O & extrapolating via Act. to blood!
He will run some experiments. Trouble $\bar{c}$ him in dens. cur. today
so no runs -

21 Jan 82

Opto-electronic Sensor -



Signal .9V ± white surface at focus
~ 0.3V ± black " " "

30 Dec. Ambulatory Med. Demo.

Unpacked 2 chan. EKG recorder, pH coupler, and reproducer unit (DMA)
but EKG tapes, electrode missing. Called H.R.

31 Dec. H.R. asked me to call local DMA office.

713-780-9232 Doug Smith - svc.

Caren Sherman - sales

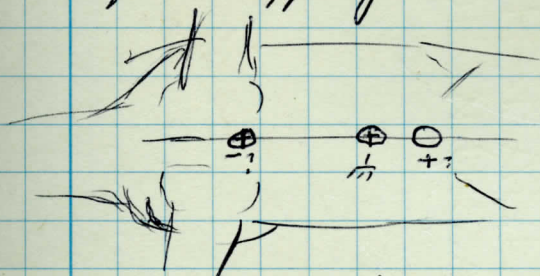
Smith said there were no spare tape, etc., C.S. had every one and was on lv. Should get some shipped from DAL ofc. Called H.R. who confirmed & didn't understand. Later rec'd. a call from Smith who left tape, electrodes, lead at Tel. ans. svc. in Westpark - picked up.

1 Jan

After repeated attempts got both recdr. and 660 running & good ~~electrodes~~ EKG's simultaneously from J.T. (via extension) and W.T.

Record was good

Next placed electrodes on horse (Domini) as below after clipping & shaving to bare skin.



Ran portions standing walk to gate ~ 120' & jog on return. Amplitude was low but usable. Marked sinus arrhythmia and sharp rate increase $\bar{p}$ jog. Complexes masked by artefact during walk/jog. See P.

Then replaced unit on WT & JT including 3 mi. run at gym & no trace of recording. Immediately checked both channels by recording short runs & recorded normally. ??