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Research & Computation Diary

(Continued from Book 6)

This begins August 3, 1965

& extend three

See p. 60 for list of computation series
8/3/65

Just returned from 3 weeks at Bethany Beach. While there, finished settling with Tom & Milton by telephone on "Dendro-somatic" revisions for "Experimental Neurology". Science did not accept.

Now, must concentrate upon slides for Tokyo and also figures for retinal cell paper. The drawings were left with art department before going to Bethany. Figs. 5, 10 & 11 were done first, as requested, they have today returned. Thence for minor corrections.

List of figures as of 7/6/65 as when working with Gordon

1. Recording arrangement & schematic Golgi anatomy
2. Full experimental series with histological drawings
3. Periods I, II & III at four labels GL, EPL, MBI, GRL
4. Spheres and Potential Divider
5. Intracellular & extracellular at three levels for passive vs. active
6. Theoret Series, three passive & four active
7. Apparent Velocity plot
8. Theoretical gradients at 1st, 2nd, 3rd, 4th, 5th, 6th
9. Experimental gradients
10. Theoretical grumule reconstruction
11. Superposition

Dates taken to photography
Don't want to leave a few extra alleles. But must prepare
them in time to be ready.
1. New slide to be made from Text Fig. 142 of Phillips et al., which shows recording conditions rel. to bulb. and shows mitral cell. Also makes clear origin of data.

2. Periods I, II, III at three or four levels, with schematic mitral and granule cells. May need to use this slide twice during talk.

3. Slide showing sphere, cone and pot. divider. Whether should present compartmental model or such check over Ojan slides.

4. Fig. 5 Intracell, Extracell & P.D. compnt. illustration.

5. Four level data (con show that periods I & II approx. had not shown period III & -granule)

6. Fig. 10 Granule intracell, Extracell & P.D. compnt. illust.

7. Superposition


9. Golgi diagram could be used as basis for discussion.

10. Tom's serial sections reconstruction, or pair of synapses?
8/4/65

Be prepared to justify \( A \) and \( \frac{7}{2} \) lengths and also to say something about safety factor. How much of this to incorporate in slide.

8/9/65

Tom Reese got letter of acceptance from Dr. Whipple, apparently no changes required.

Also Tokyo trip authorization, passport, reservations etc all in order by end of previous week. Also got letter from Messrs. F-L inviting me to preCongress symposium on ebullicum.

Also references job done for Mike Fitzgibbons & one coming. Thanks.

8/12/65

Today have a complete set of slides & prints. Thereof, except for those needed from Tom Reese.

8/27/65

Slides all ready, rough outline ready.

Letters written.

Today concentrate on sending Gordon a set of Figs. 5-11 and the rough typing. He is to take care of Figs 1 & 2.

9/20/65

Back from Tokyo. Waited after reprints. Went over notes of trip + plans to mail more reprints. Thinking about foreign travel report. Prepared forms for travel reimbursement to Phil Nelson. Called & wanted to send over Tom Smith manuscript & verification.
Per says that Eccles says this is like a condenser with ground side at the depth & not at the surface.

My inspection of the records suggests slight leak around but not much, and actually neither end seems to be at ground.
9/24/65

Per Andersen visited. With physicist Torstein Rudjord
He has built a neuron model
of copper & simulates electrotomes
with heat conduction
& radiation. I urged him
to double-check scaling of A.

He feels in hippocampus, it is important to distinguish
between the smooth dendritic trunks of large
diameter & the small calibre side branches
which have many spines. He thinks the small
side branches may get almost short-circuited, but
Their fine stems (may have significant core resistance
emphasized) whereas trunks have little decrement.

They seem to be inclined to conclude impulse
propagation along the smooth trunks. May be
valid because the offered spike does get delayed
and apparently not attenuated with distance.
However, must be cautious because
mostly extracellular. Regard ground as at the
depth (no appreciable curvature in this
region.

\[ \text{Diagram: 1.2 mm} \]
9/27 Foreign travel report completed. Dorothy retyping. Bill Haggard sent me papers to refere.

Dan Paller showed about 2 newly estimated 3 to 10 and tapered dc link, electrolyte et al causing them trouble. I suggested they fit my $e^{-Kz}$

Karl Frank, Phil Nelson & Tom Smith wish to talk about remote synapses, etc. Refer back to P 89 - 115 of Book C

Also soon to field effects in Book C

Initial slope from astro.

$$\left. \frac{dV}{dt} \right|_{t=0} = (1-V_{os}) \frac{ΔG_z}{C_m}$$

for $I_y$ constant

also, if initially $I_y E$ are zero $V_{os} = Y$ and $1-V_{os} = 1 - Y$

also, from p 90 of book C, locally induced eps peaks

$$= \frac{C_{\varepsilon}}{\mu^2} \left(1 - e^{-\mu t}\right)$$

$$= (1-V_{os}) \frac{ΔG_z}{C_m} \left(1 - e^{-\mu t}\right)$$

$$= (1-V_{os}) Δ G_z \left(1 - e^{-\mu t}\right) \left(\frac{1}{G_z + G_c}\right)$$

where $\mu$ is inversely $G_z$ in case of anomalous art.

ie, hyperpol increases $\mu$ of $(1-V_{os})$ but decreases $\mu$ of
\[ \frac{0.235}{0.13} = 1.8 \]

\[ \frac{1.42}{0.43} = 3.3 \]

But this criterion depends upon square \( \varepsilon \) and absence of late \( \varepsilon \).
preparing memo for T.G. Smith, R. Warner, K. Frank & P.G. Nelson.

This revised manuscript seems to be slanted as though Eccles chemical synapse at soma is only serious suggestion to aim at. But actually, in 1960, on p.521, I specifically compared EPSP & IPSP and suggested that "IPSP is initiated mainly near the soma" and "that a significant amount of IPSP initiation probably takes place in the dendrites as well as the soma."

I recalculated & plotted some of problems 65, 103-107 see book 6 pp. 87-115. To get EPSP amplitude about 10% of driving potential, using square conductance steps of 0.25 m/s duration at compartment 2 (0.75-0.85) 0 to 0.27 away from soma need E=2, while for compartment 8 (1.4 to 1.6 away from soma) need E=20, i.e. tenfold. True latency for 8 is 0.75 s compared with 0.25 for 2 i.e. 3 times. However, have problem of initial lag. Try to handle this by looking at maximum rate of rise, or a time of rise from 20% to 80% of peak where 2 gives 0.13 s and 8 gives 0.235 s, a factor of about 1.8

*However, this may be the time to get away from square conductance changes. Also, for longer lasting conductance changes, the distinction also gets blurred. Idea would be to generate " and make the appropriate Rs depend upon this.*
The concept of "constant current source" is not really fully appropriate. I wrote Jerry Lettvin (March 1962) to point out that the evidence leading to this suggestion could be accounted for by dendritic synapses. What is "injection" of current? How? Not by the electrical synapse. My electrical synapse is not independent of the postsynaptic membrane potential. Also, it does not operate without a conductance change effective in the postsynaptic element.

\[ -70 \text{ mV} \]

During presynaptic impulse, this goes transiently from \(-70 \text{ mV}\) to peak (? +30 mV) overshoot.

The driving potential for current "injected" is the difference between \(V_i\) of postsynaptic element and \(V_i\) of presynaptic element.

When injected currents are put in parallel, the conducting conductances are also put in parallel.
When this was discussed with K. Frank & Phil Nelson, Phil placed great emphasis upon the greater amplitude of the presynaptic action potential, to get perhaps as much as a factor 2, corresponding to my 1.5 at bottom of p. 16.

However, K. agreed that might have to consider average or integral over spike, except that Toru’s method does have some time resolution during conductance change.

Gray is this \[ \text{IPSP} = (-V_{\text{post}} + V_{\text{pre}}) G_c \]

where \( V_{\text{post}} \) changes only slightly, but can be altered by applied current

\( V_{\text{pre}} \) is det. by presynaptic spike

or is simply \( V_e \) for conventional case.

\( G_c \) is a function of time

Thus \( I(t) = \Delta V(t) \times G(t) \)

For a given IPSP, we can take \( I(t) \) as given. Therefore, for each trial:

\[ (V_e - V_{\text{post}}) G_c = (V_{\text{pre}} - V_{\text{post}}) G_c \]
Compare Electrical & Standard Synapses at Soma

Suppose \( R_N = 10^6 \) ohm for large neuron

And naive \( C_N^* = 2 \text{ msec} = 2 \times 10^{-3} \text{ sec} \)

Then naive \( C_N^* = \frac{C_N^* \text{ sec}}{R_N} = \frac{2 \times 10^{-3}}{10^6} = 2 \times 10^{-9} \text{ farad} \)

For a respectable EPSP, max rate of rise \( \approx 10 \text{ mV/sec} \)

\( = 10 \text{ volt/sec} \)

In peak current, \( \text{peak current, } I^* = C^* \frac{dV}{dt} \)

\( = 2 \times 10^{-9} \times 10 = 2 \times 10^{-8} \text{ amperes} \)

If this peak current is driven through the coupling resistance by 100mV, driving potential, we can estimate the required parallel resistance of these coupling resistances

\( I^* = 10^4 \text{ volt} \times \Sigma G_c \)

\( \Sigma G_c = 2 \times 10^{-7} \text{ mho} \)

compared with \( G_N = 10^{-6} \text{ mho} \)

Thus, opening switch to ensure \( \Sigma G_c \) should give a 20% increase in conductance.

Now for standard, driving potential to be only 60mV

Then get \( \Sigma G_c = 3 \times 10^{-7} \text{ mho} \), or 30% increase in conductance.
The final upshot seems to be that Tom is incorrect in believing that electrical case produces significantly less apparent conductance change, or that it is independent of postsynaptic membrane potential. These points are true only for his hypothetical "constant current source."

It seems likely that somatic EPSP should have been detected for either chemical or electrical model. Thus, data seem to show that dendritic loci must be used except for that late component that sometimes turns over & sometimes shows a conductance change.

Furthermore, Phil points out that original motivation for the current source was to explain EPSP that did not increase with hyperpolarization, but rather they have this effect explained by anomalous rectification of electrical synapse does not explain it.

K. said that not entirely happy at having court EPSP amplitude result from balance between increased driving force & decreased membrane resistance. He felt apparently independently thought of possibility of limited charge transfer, thought in terms of fixed grain of quantal packets available instead of anomalous rect. Also must wonder whether anomalous rect. could reduce detectability of conductance change.

* * * I called Phil on phone about this; he agreed for amplitude, but early slope might not be affected.
\[ \int_{0}^{\infty} q_{i0} e^{-\lambda_{jt}} dt = q_{i0} \left[ -e^{-\lambda_{jt}} \right]_{0}^{\infty} = \frac{q_{i0}}{\lambda_{ji}} \]

\[ \int_{0}^{\infty} \left( \frac{q_{i0}}{\lambda_{ji} - \lambda_{oj}} \right) e^{-\lambda_{jt}} dt \]

\[ = q_{i0} \left\{ \left[ -\frac{(\lambda_{ji}) e^{-\lambda_{jt}}}{\lambda_{ji} - \lambda_{oj}} \right]_{0}^{\infty} - \left[ -e^{-\lambda_{jt}} \right]_{0}^{\infty} \right\} \]

\[ = q_{i0} \left\{ \ln \frac{\lambda_{ji} - \lambda_{oj}}{\lambda_{ji}} \right\} = \frac{q_{i0}}{\lambda_{oj}} \]

Check Solution:
\[ \frac{dq_{i}}{dt} = \left( \frac{q_{i0} \lambda_{ji}}{\lambda_{ji} - \lambda_{oj}} \right) \left( -\lambda_{oj} e^{-\lambda_{jt}} + (\lambda_{ji}) e^{-\lambda_{jt}} \right) \]

\[ = \lambda_{ji} q_{i0} \left( -\lambda_{oj} e^{-\lambda_{jt}} + \lambda_{oj} e^{-\lambda_{jt}} - \lambda_{jt} + (\lambda_{ji} - \lambda_{oj}) e^{-\lambda_{jt}} \right) \]

\[ = -\lambda_{oj} q_{j} + \lambda_{ji} q_{i} \]

Q.E.D.

Peak occurs when
\[ \frac{\lambda_{oj} e^{-\lambda_{jt}}}{\lambda_{ji} - \lambda_{oj}} = \lambda_{ji} e^{-\lambda_{jt}} \]

\[ \frac{\lambda_{ji}}{\lambda_{oj}} = e \]

\[ \ln(\frac{\lambda_{ji}}{\lambda_{oj}}) = (\lambda_{ji} - \lambda_{oj}) t^* \]

\[ t^* = \frac{\ln(\lambda_{ji}/\lambda_{oj})}{\lambda_{ji} - \lambda_{oj}} \]
Plan to do future computations with $E$ not square with time changes, but rather made transient by making appropriate dependent upon dummy compartments having exponential rise and fall.

\[ \frac{dq_j}{dt} = \nu_{ji} q_i - \lambda_{oj} q_j \]

\[ q_i = q_{io} e^{-\nu_{ji} t} \]

\[ \frac{dq_j}{dt} = \nu_{ji} (q_{io} e^{-\nu_{ji} t}) - \lambda_{oj} q_j \]

Assume $q_j(t=0) = 0$

Then Laplace transformation gives, using $s$ for transformed variables:

\[ s q_j = \frac{\nu_{ji} q_{io}}{s + \nu_{ji}} - \lambda_{oj} q_j \]

\[ q_i = \left(\frac{q_{io}}{s + \nu_{ji}}\right) \frac{\nu_{ji}}{(s + \lambda_{oj}) (s + \nu_{ji})} \]

\[ q_j = \left[ q_{io} \frac{\nu_{ji}}{\nu_{ji} - \lambda_{oj}} (e^{-\lambda_{oj} t} - e^{-\nu_{ji} t}) \right] \]
Eccles gave a lecture in Wilson Hall, although the announced title was "Ideas on the way in which the centrosome loco C6 cerebellum processes the information coming to it from limb receptors." K-Frank announced that he had changed the title. New paper more biophysical with emphasis on antidiromics in the Purkinje cell—which he thought the NIH audience would be more interested in. He explicitly said that the interpretations involved complicated considerations of the dendrites which he did not feel competent to handle fully; it would take me to work out. In effect, he was taking credit for slaying the problem to me, but trying to provoke me into interpretations. At no time did he actually account for the extracellular potentials. He did point out that symmetrically placed off-axis dendrites would tend to balance each other, which things also told me—but they have a vague idea that they are better off with dendrites in the plane (Purkinje peculiarity) which I don't see as valid.

He never said what the extracellular spike is a measure of. Lest us think it measured membrane current density. He said no. I said he had left it implicit—he agreed and did not explain.

He has discovered that after 90, could be due to soma membrane repolarization. I did this in 61 to Frank & Nelson because publish. He thinks he has evidence for instantaneous invasion of dendrites cut about 2/3 of the way. The theorem is sloppy.
If \( b = a \), then \( B = aA_0e^{-at} \)

\[
\frac{dB}{dt} = aA_0e^{-at} - a^2A_0te^{-at} = aA - aB
\]

\[
\frac{dB}{dt} = 0 \text{ for } t^* = \frac{1}{a}
\]

and for this \( t \), we have \( B^* = A_0e^{-1} \)

Also \( \int_0^\infty B(t)dt = aA_0\int_0^\infty te^{-at}dt = aA_0\left[\frac{e^{-at}}{a^2}(-at-1)\right]_0^\infty = \frac{A_0}{a} \)

So area under B curve = \( \frac{A_0}{a} = e^* (B^*, t^*) \)

To put this another way, if want area equal to limit for \( \Delta t \)

\[
\text{Choose } \Delta t \text{, choose } B^* = 1 \text{ or } A_0 = e \text{ and choose } t^* = \frac{\Delta t}{a}, \text{ or } a = \frac{\Delta t}{t^*}
\]

Could choose \( A_0 = e \) and \( a = \frac{e}{\Delta t} \)

Then area under curve = \( \Delta t \)

peak amplitude = 1

But there is no need to have peak amplitude = 1. So to page 26426
yields an observable intracellular EPSP. The parallel fiber input is more confined to dendritic periphery and seems to produce less EPSP at soma.

Interesting that small spontaneous EPSP disappear during large EPSP. This is presumably the G conductance effect.

Recomb. 20

\[ A \rightarrow \begin{array}{c} a \rightarrow B \rightarrow \quad a > b \\ \end{array} \]

\[ \frac{dA}{dt} = -aA \]
\[ \frac{dB}{dt} = aA - bB \]

\[ A = A_0 e^{-at} \]
\[ B = \frac{A_0}{a-b} (e^{-bt} - e^{-at}) \]

\[ \frac{dB}{dt} = \frac{A_0}{a-b} (-be^{-bt} + ae^{-at}) \]

for \( \frac{dB}{dt} = 0 \), \( t = t_x = \frac{\ln(a/b)}{a-b} \)

\[ B^* = \frac{A_0}{a-b} (a-b)e^{-bt_x} + b e^{-bt_x} - ae^{-at_x} \]

\[ = A_0 e^{-bt_x} \]

as though initial amount \( A_0 \) decays with rate \( b \).

Also, area under B curve equals \( \frac{A_0}{b} \)

while that of A is \( \frac{A_0}{a} \)
area under curve = \( e \) times area of layered rectangle

amplitude at \( a = \frac{4t}{T} \) peak area of fact at about \( \frac{7}{4} \) of that under curve

If \( A_0 = 4 \) and \( a = \frac{4t}{T} = \frac{1}{T} \) or \( t^* = \frac{At}{4} \)

Then peak = \( \frac{4}{2 \sqrt[2]{13}} = 1.475 \)

and area up to \( At \) becomes

\[
\frac{A_0}{a} \left[ e^{-4(-4)} + \right] = (1 - 5.01832) \Delta t = (1 - 0.091) \Delta t
\]
following p. 23, it is of interest to examine the amplitude of \( B \) and area under \( B \) up to \( t = \Delta t = \frac{\Delta t^*}{\alpha} \) at \( t = \frac{\Delta t^*}{\alpha} \):

\[
B = e A_0 e^{-\frac{\Delta t^*}{\alpha}} = A_0 e^{-1} e^{-\frac{\Delta t^*}{\alpha}} \approx 0.18 A_0
\]

Compared with \( B = A_0 e^{-1} = 0.368 A_0 \)

In other words, down to half of peak.

Also,

\[
\int_0^{\Delta t^*} B dt = \frac{A_0}{\alpha} \left[ e^{-e^{-1}} - (-1) \right]
\]

\[
= \frac{A_0}{\alpha} \left[ (0.066)(-3.72) + 1 \right] \Delta t
\]

\[
= \frac{A_0}{\alpha} \left[ 1 - 0.245 \right] \Delta t
\]

Or about \( 3/4 \) of area.

If want less tail come alternatively set, for example:

\[
A_0 = 5 \quad \text{then if} \quad \frac{A_0}{\alpha} = \Delta t \quad \text{get} \quad \alpha = \frac{A_0}{\Delta t} = \frac{5}{\Delta t}
\]

Then peak = \( A_0 e^{-1} = \frac{5}{2.718} = 1.84 \)

And area up to \( \Delta t \) becomes:

\[
\frac{A_0}{\alpha} \left[ e^{-5}(-5-1) + 1 \right] = \frac{A_0}{\alpha} \left[ 1 - 6(-0.067) \right] = \frac{A_0}{\alpha} \left[ 1 - 0.44 \right] \Delta t
\]

\[
= (1 - 0.04) \Delta t
\]
If $B^* = 2$, and full area under $B = \Delta t$

Then, because $\Delta t = eB^*t^* = 2et^*$

it follows that $t^* = \frac{\Delta t}{2e} = \frac{\Delta t}{5.44}$

or $a = \frac{5.44}{\Delta t}$

and that $A_0 = eB^* = 2e = 5.44$

at $\Delta t$, factor $= \left[ e^{-5.44 \times (5.44-1)} + 1 \right]$

$= 1 - 4.44(0.00434)$

$= 1 - 0.01925$

io. approx 2% of area is in tail
98% is during $\Delta t$

peak of 2 occurs at $0.184 \Delta t$

$= 0.046$ for $\Delta t = 0.25$

Suppose use $T$ scale, and $\Delta T = 0.25$

Then $A_0 = 5.437$; $a = u_{ij} = u_{aj} = 21.748$

$= 21.75$
Upshot of previous pages is if set $b = a$, then have $B = a A_0 e^{-at}$, at $t^* = \frac{1}{a}$.

Where for area under curve to equal $\Delta t$ we choose $\frac{A_0}{a} = \Delta t$ such as following examples:

<table>
<thead>
<tr>
<th>$A_0$</th>
<th>$\Delta t$</th>
<th>$t^*$</th>
<th>$B^*$</th>
<th>area of tail before $\Delta t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.718</td>
<td>$\frac{3.718}{\Delta t}$</td>
<td>$\frac{\Delta t}{2.718}$</td>
<td>1</td>
<td>$0.245 \Delta t$</td>
</tr>
<tr>
<td>4</td>
<td>$\frac{4}{\Delta t}$</td>
<td>$\frac{\Delta t}{4}$</td>
<td>1.475</td>
<td>$0.091 \Delta t$</td>
</tr>
<tr>
<td>5</td>
<td>$\frac{5}{\Delta t}$</td>
<td>$\frac{\Delta t}{5}$</td>
<td>1.84</td>
<td>$0.04 \Delta t$</td>
</tr>
<tr>
<td>5.44</td>
<td>$\frac{5.44}{\Delta t}$</td>
<td>$\frac{\Delta t}{5.44}$</td>
<td>2.0</td>
<td>$0.019 \Delta t$</td>
</tr>
</tbody>
</table>

If want to avoid tail completely, could use with peak twice average height, could even shift off center. Probably should try both.

More precisely 5.4366

For $A_0 = 2.718$ and $\Delta t = 0.25$, $a = 10.872$, $t^* = \frac{1}{a} = .092$. 
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Print Card</td>
<td>6.</td>
<td>12</td>
</tr>
<tr>
<td>2nd &amp; 4th Card</td>
<td>6.</td>
<td>12</td>
</tr>
<tr>
<td>5th Card</td>
<td>8.</td>
<td>8.</td>
</tr>
<tr>
<td>Koppa Cards</td>
<td>6.</td>
<td>6.</td>
</tr>
<tr>
<td>New 2 Cards</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Fourth Change Cards</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>0</td>
<td>12</td>
<td>-30</td>
</tr>
<tr>
<td>0</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>0</td>
<td>12</td>
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<td>0</td>
<td>8</td>
<td>61</td>
</tr>
<tr>
<td>0</td>
<td>8</td>
<td>61</td>
</tr>
</tbody>
</table>

Got back 10/7/65
See p.
10/5/65  
next page

Setup new 65.500 Series for ESP with transient conductance change.

Later plan to have only 5 compartments of layers AZ but first, plan to match previous 65.100 series as closely as possible.

Also, do I very soon.

Also, setup 65.108 (refer back to pp. 89-105 0/00 0/06).

Try \( \varepsilon = 30 \text{ in} \ 10 \ \varepsilon = 40 \text{ in} \ 10 \)

\( \varepsilon = 30 \text{ in} \ 6 \ \varepsilon = 60 \text{ in} \ 8 \)

got back 10/17/65

see p. 40

Took old 65.107 and change to 65.108.

At 20 SAAM22 at 28 10.5.65

#2 65.108

1st pink card, change 4 to 10, 4 duplicate

2nd

Kappa card 10 1.25

New P cards (10 11)

Time change cards 0 12 10 12 26 30 31 1 duplicate

\[ 
\begin{array}{ccc}
0 & 12 & -30 \\
0 & 10 & 31 \\
0 & 10 & 1 & \text{duplicate} \\
10 & 12 & 40 \\
0 & 12 & -40 \\
0 & 10 & 41 \\
\end{array} 
\]
2 \times 55 = 110
2 \times 30 = 60
4 \times 10 = 40
\text{Tot} = 15
\frac{15}{225} = 0.0667
\frac{11 \times 14}{12 \times 15} = 0.958

Use 11x and E for first tac.
12x for second tac.

During first time period, let 13 feed 14 so 15 = 1.0
2nd...
13 feed 15 so 14 = 1.0

Instead of manipulating out A of perturbed q, 1.0 use an additional loss into eq. 1.6

Initial Condition Changes

\begin{array}{c|c}
13 & 5.487 \\
11 & 0.0 \\
12 & 1.0 \\
14 & 0.0 \\
15 & 0.0 \\
\end{array}

Note hierarchy within each time change:
1. Initial values of A and q set
2. Independence relations satisfied
3. Finally dependence factor introduced.
65,500 Series

Cont#1 13 65,500 20 2.0 19 1.5 65,500 40 4.0 40 PALL 1 47 1.5 1.5 1.5 1.5

Got back 10/7/65

See p.38

10/5/65

0.01 0.98 0.98 0.98

65.5 2

65.5 3

65.5 4

Data Cards:

First three cards as before setting opt. 1 at -1, +.35 and 0.

4th data card 12 05

5th peak 2 3

6th yellow line 4th

7th 126

1.0

8th

200 0.05 65.0 duplicate twice

1200 0.1 10.0

Initial Conditions

11 4 12 as before set 11 = 1.

4 13 57.437

Koppa 12 0.5

10 0.5

10 0.5

12

Lambdas to add 9.10 12

14 13 21.75 21.75

15 13 21.75 21.75

Perturbled 7

0 10 12 58 59

14

16 2 2.0 14

2 11 2.0 14

14 14 14 14

16 8 20 15

8 12 20 -20 15

12 20 15
<table>
<thead>
<tr>
<th>16</th>
<th>5</th>
<th>10.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>10</td>
<td>10.</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>10.</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>10.</td>
</tr>
<tr>
<td>0</td>
<td>12</td>
<td>-20.</td>
</tr>
</tbody>
</table>

$\Sigma_{max} = 12$

<table>
<thead>
<tr>
<th>17</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>5</td>
</tr>
</tbody>
</table>

26

Old dependent relations:

- delete 56 & 65

26, 13 at 5.437

26

20, 14

21.75

14, 13

21.75
10/5/65

65,600 Series

Two short 5 compartment chains \( \lambda_{ij} = 6.25 \)

One time change to start transient \( E \) at \( T = 1.0 \)

Save 11 for initialization

12 for

13 for source to 14

14 for transient

15 for extra sink

16 for source of applied current

#1 65,600 SAAM 22 10.5.65 Roll TWO CHAIN TRANSIENTS

2

Data cards three cards for 1 as before

200.  1.  10.

1.  1.05  2

200.  0.05  20.  #34.

Kappa Sept 2,3,4 7,8 at 0.5

2,4, 5, 9, 10 at 0.25

Kappa 4, 5, 9, 10 at 0.25

Kappa 4, 5, 9, 10 at 0.25

\( \lambda_{12} = 6.25 \), all other \( \lambda_{ij} \) depend except at last two. 2.25 & 2.65

all \( \lambda_{ij} = 1 \)

\( \lambda_{20} = 14 = 21.75 \) after TC

\( \lambda_{21} = 15 = 1.0 \)

\( \lambda_{26} = 15 = -1.0 \)

\( \lambda_{20} = 15 = -1.0 \)
10/5/65
Having set up these problems and new series. Try to return to idea of writing in the morning & doing odd correspondence and chores in the afternoon. As of now, chores are

Note to Jordan — collaboration memo to Research Grants already sent. Wait reprints to Japan, F. O. Schmitt, Wenzhong, 3 others.
Write note to Katz
Write Wernon, Tsuru, Kotozato, ?

10/6/65 Began to work on Cortical Potential Field Theory paper, going over old notes.

Concentrate first one


Then pick up

Extracellular Potential Field for Single Neuron with Radially Symmetric Dendritic Arborization

  — J. Neurophysiol.
  — Exp. Neural.
  — Proc. Brain Research (not as yet)
EEG & Clin Neurophysiol, J. Physiol.
for more precision could make $T_{max} = 2.02$

with smallest $\Delta T = 0.02$

because $(110)(002) = 2.02$

and double amplitude scale. \checkmark did for 502

for 502 Changed scales
also changed II.C. in 13 from 5.437 to 2.718
and II 2014, 2015, 214, 123, 215, 13 all
from 21.75 to 10.87
This makes peak $= 1$ at $T = 0.37 \Delta T$

$= 0.09$ for $\Delta T = 0.25$

See pp 26-28

for 602 also changed 5.437 to 2.718
21.75 to 10.87

also reduced data points
4 corrected erroneous data values.
10/7/65

65.108} Successful
65.109

65.501 present here now
65.601 did not run because 250 data point limit was exceeded by one

65.501 Transient C

with I.C. m (13) set at 5.437
and $v_{14} = v_{15} = 21.75 = 4(5.437)$

Thus, opt 14 should have had a peak value of 20, at $T = 0.046$
and should have been 98% complete at $T = 0.25$

In (2), $E = 2 \times 9_{14}$ which peaked at 4 but averaged 2 over $\Delta T = 0.25$

This gave in opt 1 peak at $T = 0.02$ compared with 0.25 for square
65.106

also, steepest slope was +0.94 compared with 0.48
at $T = 0.07$
and $T = 0.10$

But need finer resolution of data points for precision.
falling slope $t_{1/2} = -0.11$ agrees with 65.106

In (8), $E = 20 \times 9_{15}$ which peaked at 40 but averaged 20

This gave in opt 1 peak time + slope.
$T = 0.75$ $+ 2\Delta T = 0.05$

; revise, see below
65.109  Square G  \( E = 30 \text{ in} \) ⑥
\( E = 60 \text{ in} \) ⑧

\( E = 30 \text{ in} \) ⑥

designation

peak in ⑥ was 0.65\% at \( T = 0.25 \)
peak in ① was 0.197 \% at \( T = 0.50 \)

close

max slope \( \approx 0.7 \) at \( T = 0.25 \)
falling slope at half max \( \approx -0.1 \) at \( T = 1.35 \)

\( E = 60 \text{ in} \) ⑧

peak in ⑧ was 0.827 at \( T = 0.25 \)
peak in ① was 0.161 at \( T = 0.75 \)

max slope \( \approx 0.43 \) at \( T = 0.35 \)
falling slope at halfway \( \approx -0.076 \) at 1.75

Decided to do new runs with better time resolution and also use iterations to fit
the desired epsp max amplitude

See 65.150 series p.42
65,108 Square G

\( \epsilon = 30 \text{ in} \) [10]
\( \epsilon = 40 \text{ in} \) [10]

\( \epsilon = 30 \text{ in} \) [10]
peak in [10] was 0.778 at \( T = 0.25 \)
peak in [10] was 0.085 at \( T = 0.9 \)
max slope approx +0.2 at \( T = 0.45 \)
falling slope at half max \( \approx -0.045 \) at \( T = 1.90 \)

\( \epsilon = 40 \text{ in} \) [10]
peak in [10] was 0.828 at \( T = 0.25 \)
peak in [10] 0.0921 at \( T = 0.9 \)
max slope approx +0.22 at \( T = 0.45 \)
falling slope \( \approx -0.043 \) at \( T = 1.90 \)

almost 0.0/0
incorporated in chart
amplitude of spsp to be fitted

\[ \frac{65}{424} \]

Same time + data card setup as 65.1522
But specify weighted data card here

\[ \begin{array}{cccc}
4 & 12 & 27 & 42 \\
10 & 0.35 & 0.20 & 45 \\
60 & & & \\
\end{array} \]

Dependence Cards

\[ \begin{array}{cccccc}
4, 5 & 9, 10 & 19, 20 & 24, 25 & 27 \\
0 & 12 & 0 & 13 & -1, \\
4 & 12 & 0 & 13 & +1, \\
13 & 4 & 0 & 13 & +1, \\
\end{array} \]

\[ \text{ahead of this need control cord} \]

100.

\[ \begin{array}{cccc}
42 & 3.7 \\
0.01 & 1 & \\
\end{array} \]
Studied 65, 108 & 109
Since we know peak locations, it is now possible to redo this with an iteration to get peaks amplitudes almost exactly matched.

Also, can get finer detail for early slopes.
Possibly change scales, as done yesterday on page 37 for 0.502

Method would be to use $\lambda_{2013}$ as dummy factor
for adjusting $\lambda_{12,12}$
and $\lambda_{13,12}$ also as a smile
for $\lambda_{13,6}$

Then have dependence relations of $\lambda_{2013}$ upon $\lambda_{2013}$

This was done 10/11/65 Roll Square G FIT

<table>
<thead>
<tr>
<th>Iterations</th>
<th>min</th>
<th>max</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>12</td>
<td>27</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Dependence Cards

<table>
<thead>
<tr>
<th>Dependence Cards</th>
<th>45</th>
<th>9,10</th>
<th>19,20</th>
<th>24,25</th>
<th>27,5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>13</td>
<td>-1.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>13</td>
<td>+1.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>13</td>
<td>+1.</td>
</tr>
</tbody>
</table>

Weighted Data Card

<table>
<thead>
<tr>
<th>Weighted Data Card</th>
<th>1.25</th>
<th>0.20</th>
<th>0.32</th>
<th>0.15</th>
<th>Weight</th>
</tr>
</thead>
</table>
\[
\begin{array}{c|c|c|c}
L = 1 & L = 2 & L = 3 & L = 4 \\
\hline
x_1^2 = 1 + 9.87 = 10.87 & 1 + 20.47 = 21.47 & 1 + 10.097 = 21.097 & 1.0 \\
\hline
x_2^2 = 1 + 39.48 = 40.48 & 1 + 9.87 = 10.87 & 1 + 4.387 = 5.387 & 10.9 \\
\hline
x_3^2 = 1 + 88.83 = 89.83 & 1 + 22.2 = 23.2 & 1 + 9.88 = 10.88 & 23.2 \\
\hline
x_4^2 = 1 + 157.9 = 158.9 & 1 + 39.5 = 40.5 & 1 + 17.54 = 18.54 & 159.0 \\
\hline
\end{array}
\]

Could publish this table.

Might rename \( x_n^2 \), say \( x_m \)

or use \( x_m = \frac{x_n}{x_n^2} \)

Then \( x_n^2 = x_m / x_m \)

\[
\tau_m = \frac{x_m}{1 + \left(\frac{\sqrt{\tau_n}}{x_m}\right)^2}
\]
Write: Note on Time Constants of Non-Uniform Decay

Passive Membrane of Potential

Passive Decay of Non-Uniform Membrane

Begin from Eqs. 30-35 of N.Y. Acad. Science paper.

Set $k^2 = 1$, $V^* = 0$, consider $V(0, T)$ and $V(Z_m, T)$

where $Z_m = B = L$ of old paper, $L = \int_0^L \frac{dl}{l}$

$$V(0, T) = \sum_{m=0}^{\infty} C_m e^{-\alpha_m^2 T}$$

$$V(Z_m, T) = \sum_{m=0}^{\infty} C_m (-1)^m e^{-\alpha_m^2 T}$$

$$\alpha_m^2 = 1 + \left(\frac{mT}{Z_m}\right)^2$$

$$C_m = \frac{1}{Z_m} \int_0^{Z_m} V(z_0) \cos\left(\frac{mT}{Z_m} z\right) dz$$

$$C_0 = \frac{1}{Z_m} \int_0^{Z_m} V(z_0) dz$$

for $m > 0$, $C_m = \frac{2}{Z_m} \int_0^{Z_m} V(z_0) \cos\left(\frac{mT}{Z_m} z\right) dz$
\[
\begin{align*}
\text{for } A/h = 0.05 & \text{ set } \frac{\sin 90^\circ}{1/2} = \frac{0.1564}{1.5708} = 0.099567 \\
\text{for } \frac{A}{11} & = \frac{0.180}{3.1416} = 0.098357 \\
\sin 270^\circ & = \frac{.4540}{4.7124} = 0.096341
\end{align*}
\]

Suppose \( \frac{A}{h} = 0.1 \)

Then \( \sin \left( \frac{\pi A}{L} \right) = \sin (18^\circ) = 0.309 \)

and \( C_1 = 2 \left( \frac{0.309}{\pi} \right) (V_o - V_B) = 0.197 (V_o - V_B) \approx 0.2 (V_o - V_B) \)

\[
C_2 = \frac{2 (V_o - V_B)}{2\pi} \sin (36^\circ) = \frac{(V_o - V_B) (0.588)}{3.14} = 0.187 (V_o - V_B)
\]

\[
\begin{align*}
\frac{C_1}{V_o - V_B} & = \frac{0.3090}{1.5708} = 0.196715 \\
\frac{C_2}{V_o - V_B} & = \frac{0.5878}{3.1416} = 0.18702 \\
\frac{C_3}{V_o - V_B} & = \frac{0.8090}{4.7124} = 0.171674 \\
\frac{C_4}{V_o - V_B} & = \frac{0.9511}{6.2832} = 0.15371
\end{align*}
\]

If \( A = \frac{L}{4} \), would get \( C_1 = 2 (V_o - V_B) \left( \frac{\sin \left( \frac{\pi}{4} \right)}{\pi} \right) = 0.45 (V_o - V_B) \)

\[
\begin{align*}
C_2 & = \left( \frac{2 \pi}{2\pi} \right) \left( \frac{\sin \left( \frac{\pi}{4} \right)}{2\pi} \right) = 0.318 (V_o - V_B) \approx 0.3 (V_o - V_B) \\
C_3 & = 0 \\
C_4 & = 0 \\
C_5 & = 2 (V_o - V_B) \left( \frac{\sin \left( \frac{\pi}{4} \right)}{5\pi} \right) = 0.09 (V_o - V_B) \approx 0.1 (V_o - V_B) \\
C_6 & = 0 \\
C_7 & = 0 \\
C_8 & = 0
\end{align*}
\]
Suppose $V(z, 0) = \begin{cases} V_0 & \text{for } 0 \leq z \leq A \\ V_B & \text{for } A \leq z \leq B \end{cases}$

Then $C_0 = \frac{1}{L} \int_0^L V \, dz = V_B + \left( \frac{A}{L} \right) (V_0 - V_B)$

$$C_m = \frac{2}{L} \left[ V_B \int_0^L \cos \left( \frac{m\pi z}{L} \right) \, dz + (V_0 - V_B) \int_0^A \cos \left( \frac{m\pi z}{L} \right) \, dz \right]$$

$$= \frac{2}{L} \left[ \frac{V_B L}{m\pi} \sin \left( \frac{m\pi L}{L} \right) \right]_0^A + \frac{2}{L} \frac{(V_0 - V_B) L}{m\pi} \left[ \sin \left( \frac{m\pi z}{L} \right) \right]_0^A$$

$$= \frac{2 (V_0 - V_B)}{m\pi} \sin \left( \frac{m\pi A}{L} \right)$$

For $m = 1$, and $\frac{A}{L}$ small, get $C_1 = 2 (V_0 - V_B) \left( \frac{A}{L} \right)$

But if, for example, $A = \frac{L}{2}$, then get $C_1 = 2 (V_0 - V_B) \frac{L}{2\pi}$

$\frac{V_B}{L} = 0.6366$

$-\frac{\pi}{L} = -0.2122$

$+\frac{\pi}{L} = +0.1273$

$C_m = \left( \frac{2}{m\pi} \right) (V_0 - V_B) (-1)^{m-1/2}$

and $C_2 = 0$

$C_B = -1$
Step NonUniformity

\[ C_5 = \frac{2 (V_0 - V_B)}{5 \pi} \sin \left( \frac{6 \pi}{4} \right) = \frac{(4)(0.383)}{11} (V_0 - V_B) = 0.0488 (V_0 - V_B) \]

\[ C_6 = \frac{2 (V_0 - V_B)}{6 \pi} \sin \left( \frac{6 \pi}{4} \right) = \frac{(6.454)}{3 \pi} (V_0 - V_B) = 0.0482 (V_0 - V_B) \]

\[ A/h = 0.025 \]

\[ C_1 = \frac{\sin 45^o}{\sqrt{2}} = \frac{0.7071}{1.5708} = 0.449974 \]

\[ C_2 = \frac{0.1564}{3 \cdot 1416} = 0.49783 \]

\[ C_3 = \frac{0.2334}{4 \cdot 7124} = 0.049528 \]

\[ C_4 = \frac{0.3090}{6 \cdot 2832} = 0.049178 \]

\[ A/h = 0.0333 \]

\[ \sin \frac{6}{\sqrt{2}} = \frac{0.1045}{1.5708} = 0.066526 \]

\[ 3 \sin \frac{2\pi}{11} = \frac{0.2079}{3 \cdot 1416} = 0.066176 \]

\[ \frac{0.3090}{4 \cdot 7124} = 0.065571 \]

\[ \frac{0.4067}{6 \cdot 2832} = 0.064728 \]

\[ \frac{1}{2} (V_0 - V_B) \left( 1 + \cos \frac{\pi \pi}{L} \right) \]

\[ \frac{\sin 22.5}{27 + \frac{1}{2}} = \frac{0.3827}{6.540} = 0.48726 \]

\[ \frac{0.4540}{9.4248} = 0.48170 \]

\[ 2A = \frac{1}{4} \]

See p. 50
Consider $A = 0.1$ and compare $L = 1, 2, 3$

For $L = 1$, get $V(0, T) = \left[ V_B + 0.1(V_0 - V_B) \right] e^{-\frac{T}{\tau}} + 0.2(V_0 - V_B) e^{-\frac{11T}{\tau}} + \cdots$

For $L = 2$, get $V(0, T) = \left[ V_B + 0.05(V_0 - V_B) \right] e^{-\frac{T}{\tau}} + 0.1(V_0 - V_B) e^{-\frac{3.5T}{\tau}} + \cdots$

For $L = 4$, get $V(0, T) = \left[ V_B + 0.025(V_0 - V_B) \right] e^{-\frac{T}{\tau}} + 0.05(V_0 - V_B) e^{-\frac{1.5T}{\tau}} + 0.05(V_0 - V_B) e^{-\frac{6.6T}{\tau}} + \cdots$

Consider also $V(z, 0) = \sum_{n=0}^{\infty} V_B e^{\frac{n+1}{2}(V_0 - V_B) \cos \left( \frac{\pi z}{L} \right)}$

Then, orthogonality knocks out all $C_n$ for $n > 1$

$C_0 = V_B$

$C_1 = \frac{1}{L} \int_0^L \sqrt{V \cos \left( \frac{\pi z}{L} \right)} \, dz = \frac{V_0 - V_B}{2}$

$C_m = 0$ for $m > 1$

$V(z, 0) = \begin{cases} V_B & \text{for } 2A \leq z \leq B \\ V_B + \frac{1}{2}(V_0 - V_B) \cos \left( \frac{4\pi z}{L} \right) & \text{for } 0 \leq z \leq \frac{L}{4} = 2A \end{cases}$

See p. 50
Test for $k = 5$ to compare with $A = 0.01$

Then $C_1 = \left( V_0 - V_B \right) \frac{25 \sin \frac{\pi}{5}}{\pi (25 - 5)} = \frac{0.9511}{25} \left( V_0 - V_B \right) = 0.0078 \left( V_0 - V_B \right)$

$C_2 = \left( V_0 - V_B \right) \frac{25 \sin \frac{2\pi}{5}}{2\pi (25 - 4)} = \left( V_0 - V_B \right) \frac{25 \sin \frac{9511}{2628}}{2628} = 0.0582 \left( V_0 - V_B \right)$

$C_3 = \left( V_0 - V_B \right) \frac{25 \sin 108^\circ}{3\pi (25 - 9)} = \left( V_0 - V_B \right) \frac{25 \sin 108^\circ}{3\pi (16)} = 0.158 \left( V_0 - V_B \right)$

$C_4 = \left( V_0 - V_B \right) \frac{25 \sin 144^\circ}{4\pi (25 - 16)} = \left( V_0 - V_B \right) \frac{25 \sin 144^\circ}{4\pi (9)} = 0.13 \left( V_0 - V_B \right)$

$C_5 = \frac{1}{2k} = 0.1 \quad n = k$

$C_6 = \left( V_0 - V_B \right) \frac{25 \sin (-360^\circ)}{6\pi (25 - 36)} = \left( V_0 - V_B \right) \frac{25 \sin (-360^\circ)}{6\pi (-11)} = 0.071 \left( V_0 - V_B \right)$

$25 \left( \frac{0.588}{\pi} \right) = 7.58$

$25 \left( \frac{0.9511}{\pi} \right) = 7.68$
\[ C_0 = V_B + \frac{1}{2} (V_0 - V_B) \left( 1 + \cos \left( \frac{RTZ}{L} \right) \right) \]

\[ = V_B + \frac{(V_0 - V_B)}{2k} \left\{ \frac{\sin \frac{RTZ}{L}}{\frac{RTZ}{L}} + \frac{\sin \frac{RTZ}{L}}{\frac{RTZ}{L}} \right\} \]

\[ = V_B + \frac{(V_0 - V_B)}{2k} \left\{ \frac{\sin \frac{RTZ}{L}}{\frac{RTZ}{L}} + \frac{\sin \frac{RTZ}{L}}{\frac{RTZ}{L}} \right\} \]

\[ C_m = \left( \frac{2}{L} \right) \left( \frac{1}{2} \right) (V_0 - V_B) \left\{ \cos \frac{RTZ}{L} + \frac{MTZ}{L} \right\} dZ + \cos \frac{MTZ}{L} dZ \]

\[ \text{where } \frac{1}{k} \text{ may be greater than } \frac{1}{M} \]

\[ = \frac{(V_0 - V_B)}{L} \left\{ \frac{\sin \frac{MRT}{L}}{2\pi (RT+k)} + \frac{\sin \frac{MRT}{L}}{2\pi (RT-k)} \right\} \]

\[ \text{for } m < k \text{ get } \]

\[ \frac{V_0 - V_B}{L} \left\{ \frac{\sin \frac{MRT}{k}}{2\pi (k+m)} + \frac{\sin \frac{MRT}{k}}{2\pi (k-m)} \right\} \]

\[ = \frac{V_0 - V_B}{2\pi (k^2-m^2)} \left( 2M \sin \frac{MRT}{k} \right) + \frac{V_0 - V_B}{2\pi (k^2-m^2)} \sin \frac{MRT}{k} \]

\[ \# \text{ for } n = k \text{ get } \]

\[ = \left( \frac{2}{L} \right) \left( \frac{1}{2} \right) (V_0 - V_B) \left( \frac{RT}{L} \right) \left( \frac{M}{2} \right) = \frac{(V_0 - V_B)}{2k} \]

\[ \# \text{ for } 2k > m > k \text{ get } \]

\[ \frac{V_0 - V_B}{L} \left\{ \frac{\sin \frac{(m-k)RT}{k}}{2\pi (k+m)} + \frac{\sin \frac{(m-k)RT}{k}}{2\pi (k-m)} \right\} \]

\[ = \left( \frac{V_0 - V_B}{L} \right) \left\{ \frac{2M \sin \frac{(m-k)RT}{k}}{2\pi (m^2-k^2)} + \frac{m \sin \frac{(m-k)RT}{k}}{\pi (m^2-k^2)} \right\} \]

\[ \# m \text{ is a multiple of } k \text{ orthog. gives zero } \]

\[ \text{agree with none } \]
also change some time interval values as shown on 10/13/65 output of 65.502
10/13/65 10/14/65

Got manuscript off to good start.

New check over computer output.

65.501 Transient G shifted can hurt there was an error proving importance of monitoring 14415
1
Must put in Q dependence of 714/13 upon 11 wire 53.59
715/13 12
11
3 Change amplitude to 0.9 max to 0.09
4 Change Keppes 2 to 0.5, 4, 6, 8 to 0.25
13 to 0.025

65.603 paired chains trans. G
1 Needs another 26 card or two

65.1522 Change to 65.422 Square G fit
needs a control card ahead of the single "observed" value
100.
01 at 42
1 at 57
This is std. dev.
This means std dev.

65.1524 Change to 65.424 Square G fit
same need here.
Coef first for semilog plot

Let \((v_0 - v_L) = v_L = 1.0 \), \(A = 0.1\)

For \(L = 4\), set I.C. = 1.0 in eqn 1, 2, 3, 4, 5, 6, 7

- \(\lambda_{0.7} = 1.0\)
- \(\lambda_{0.1} = 1.62\)
- \(\lambda_{0.2} = 4.47\)
- \(\lambda_{0.3} = 6.56\)
- \(\lambda_{0.4} = 10.87\)
- \(\lambda_{0.5} = 16.4\)
- \(\lambda_{0.6} = 23.2\)

- \(\sigma_{0.7} = 0.05\)
- \(\sigma_{0.2} = 0.498\)
- \(\sigma_{0.3} = 0.3985\)
- \(\sigma_{0.4} = 0.492\)
- \(\sigma_{0.5} = 0.487\)
- \(\sigma_{0.6} = 0.482\)
- \(\sigma_{0.7} = 1.025\)

\(\lambda_{0.55} = 1.0\)
- \(\lambda_{0.1} = 3.47\)
- \(\lambda_{0.2} = 10.87\)
- \(\lambda_{0.3} = 23.2\)
- \(\lambda_{0.4} = 40.5\)
- \(\sigma_{0.1} = 0.1\)
- \(\sigma_{0.2} = 0.498\)
- \(\sigma_{0.3} = 0.96\)
- \(\sigma_{0.4} = 0.94\)
- \(\sigma_{0.5} = 1.05\)

Then can alternate signs for \(z = L\)

\(65.741\)
- \(L = 4, z = 0,\) semilog
- \(0.742\)
- \(L = 4, z = L, s\)
- \(0.743\)
- \(L = 4, z = 0,\) arithmetic
- \(0.744\)
- \(L = 4, z = L,\) arithmetic

Plot code for program (Column 4)
1. send 2 page
2. send 1 page
3. with 2 page
4. with 1 page
10/15/65

Got the table II of paper 4 and decided to setup simulation runs. Table I is on page 43.

Table II is:

<table>
<thead>
<tr>
<th>$\frac{L}{A}$</th>
<th>$\frac{L}{A}$</th>
<th>$\frac{L}{A}$</th>
<th>$\frac{L}{A}$</th>
<th>$\frac{L}{A}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>$\frac{A}{l}$</td>
<td>.01</td>
<td>.05</td>
<td>.0333</td>
<td>.025</td>
</tr>
<tr>
<td>200</td>
<td>.100</td>
<td>.0667</td>
<td>.0500</td>
<td></td>
</tr>
<tr>
<td>$c_{1}/(V_0-V_L)$</td>
<td>.197</td>
<td>.100</td>
<td>.0665</td>
<td>.0500</td>
</tr>
<tr>
<td>$c_{2}/(V_0-V_L)$</td>
<td>.187</td>
<td>.098</td>
<td>.0662</td>
<td>.0498</td>
</tr>
<tr>
<td>$c_{3}/(V_0-V_L)$</td>
<td>.172</td>
<td>.096</td>
<td>.0656</td>
<td>.0495</td>
</tr>
<tr>
<td>$c_{4}/(V_0-V_L)$</td>
<td>.151</td>
<td>.094</td>
<td>.0647</td>
<td>.0492</td>
</tr>
<tr>
<td>$(c_{0}-V_L)/(V_0-V_L)$</td>
<td>.100</td>
<td>.050</td>
<td>.0333</td>
<td>.0250</td>
</tr>
</tbody>
</table>

Compare page 74 for exponential non-uniformity.

If $A/l = 0.1$, then use first column only.

Actually, first column $L/A = 10$, second is $L/A = 20$, $L/A = 30$, $L/A = 40$.

Of course, reverse order to and with $L/A = 2$.
65.503 Transient peak of form p. 28 with $A_0 = 2.718$, $\alpha = 10.87$
which has peak = 1.0 at $T^* = \frac{\tau} {2.718} = 0.092$

With $\text{peak} = 2$ in (2),

$\text{peak} = 0.086286 \text{ at } T = 0.24 \pm 0.01$
$\text{peak} = 0.08136 \text{ at } T = 0.28$

With $\text{peak} = 20$ in (8),

$\text{peak} = 0.4689 \text{ at } T = 0.20$
$\text{peak} = 0.11027 \text{ at } T = 0.88$

Compared with earlier, $G_{65.501}$ where $\text{peak} = 200 \text{ at } T^* = 0.046$
because $A_0 = 5.437$, $\alpha = 21.75$

Then get peak in (2) $0.046222 \text{ at } T = 0.025$
$\text{peak} = 0.1092 \text{ at } T = 0.15 \pm 0.025$
$\text{peak} = 0.09937 \text{ at } T = 0.20 \pm 0.025$

$\text{peak} = 0.05604 \text{ at } T = 0.10 \pm 0.025$
$\text{peak} = 0.09887 \text{ at } T = 0.75 \pm 0.025$

Note that faster transient of 65.501 nearly had same peak = 0.01 in (1)

That slower transient of 65.503 got less from (2)
more from (8)

Presumably became (2) $\rightarrow$ (1) is more sensitive to peak in (2)
where (8) $\rightarrow$ (1) is more sensitive to gain from low pass filter.
10/15/65 & 10/18/65 for comments written up

Got back four runs, studied & new submit.

65-422. Square C fit almost worked T Trouble was that the 100
        control and for standard of "observed" point was not cleared immediately after
        st.dev. 5 7
        Need to use 100.
        Observed 1
        Fine value 1
        Clear 100.

also shifted peaks to 026 and avoided extra data point
because decimal precision makes two. Therefore should flush data generation at desired fine value

65-424 made similar repairs & fixed a goof of its own

Both resubmitted.

65-603 paved chains with trans G

This worked, reduced Koppa fine but
Summer off 117 got double esp, not G.

Setup 65-604 with $J_{17,10} = -100$ also Koppa17 = 0.1

Later on try 65-605 controls with $\eta_{15} = 0 = \eta_{1,12}$

and $\eta_{0,12} = -10$.

They soon wish to duplicate this deck + possible fit for

65-503 was successful transient G in 2 and 8

65-511 transient C + fit for esp; peak = 0.1

Setup 65-511 transient C + fit
Nonuniform decay - Semilog plot at \( z = 0 \) for \( L = 2 \)

- Arthur plot \( z = L \)

Successful, now put back

Semilog plot at \( z = L \)

May need to increase \( (V_0 - V_L) / V_L \)

Note for future 65.426

<table>
<thead>
<tr>
<th>( T )</th>
<th>2013</th>
<th>65</th>
<th>61</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Also change \( \kappa_{13,2} \) to \( \kappa_{13,26} \)

Dependence relations

\( \kappa_{2,12} \) to \( \kappa_{7,12} \) upon \( \kappa_{13,2} \)
10/18/65  Got back five sums

65.422 Square G fit  fit was perfect  \[ E_{\text{peak}} = 4.2036 \text{ mV} \]
\[ t_{\text{peak}} = 0.2256 \text{ mV} \]
\[ t_{\text{peak}} = 0.200 \text{ mV} \]
But plotting scale was ruined up & will never es nonlinear fit with dummy time change
to make way \( T = 1.1 \) instead of 2.02
Then \( \Delta T = 0.01 \) is OK for only part

65.424 Square G fit - perfect  \[ E_{\text{peak}} = 10.567 \text{ mV} \]
\[ t_{\text{peak}} = 0.3792 \text{ mV} \]
\[ t_{\text{peak}} = 0.200 \text{ mV} \]
Remake plot with dummy time change

65.604 Paired Chans with Transient G

Untended goofzone \[ Q_{17} = Q_5 - Q_{10} \]
which gives difference between

\[ \rightarrow \text{ hyperpolarized} \]  \[ \text{depolarized} \]
\[ \text{epsp mV} \]  \[ \text{epsp mV} \]

But really meant to get \[ Q_{17} = Q_1 - Q_6 \]
to give difference at soma end
10/19/65 Computation Series Recap

65.100 New Eq. Cyl. EPSP Series 3/17/65 Date begun
Square G 10/5/65

65.200 Applied Current Step & Square G 3/19/65

65.300 Applied Current Sinusoidal & II 3/30/65

65.400 Square G fit 10/11/65 - 10/15/65

65.500 Transient G (chain 0/10) 10/5/65

65.600 Paired Chains with TRNS G 10/5/65

65.700 Non-Uniform Decay transients 10/15/65
Needs 10 eqts. \( \lambda_{0,10} \) is dummy for \( V_0-V_L \),
8 and 9 are summand
7 is zero order
I.C. = 1.0 in eqts. 1 thru 7
\[ \lambda_{0,10} = 2.0 \] to represent \( V_0-V_L \)

\[
\begin{array}{c}
0.7 = 1.0 \\
0.1 = 1.62 \\
0.3 = 4.47 \\
0.4 = 6.56 \\
0.5 = 16.4 \\
0.6 = 23.2 \\
\end{array}
\]

Make \( \mathbf{J}_{8,j} \) and \( \mathbf{J}_{9,j} \) for \( j = 1 \) to 7 dependent

Then \( \mathbf{J}_{8,1} = 0.05 \mathbf{J}_{0,10} \)

\[
\begin{array}{c}
2 \\
3 \\
4 \\
5 \\
6 \\
7 \\
\end{array}
\begin{array}{c}
0.0498 \\
0.0495 \\
0.0492 \\
0.0487 \\
0.0482 \\
0.025 \mathbf{J}_{0,10} + 1.0 \\
\end{array}
\]

\[
\begin{array}{c}
\mathbf{J}_{9,1} = -0.78 \mathbf{J}_{8,1} \\
\mathbf{J}_{9,3} = -0.5 \mathbf{J}_{8,3} \\
\mathbf{J}_{9,5} = -0.5 \mathbf{J}_{8,5} \\
\mathbf{J}_{9,2} = \mathbf{J}_{8,2} \\
4 \\
6 \\
7 \\
\end{array}
\]

See p. 66
10/19/65

Today got back 65-571 Transient G FIT

This worked, but took 10 minutes & ran out of time before computing final solution & plotting.

Found Epeikin 2 showed he 2.50 to give epsp = 0.10
[65-12]

17:30

Resume with these values & zero iterations

Non-uniform Decay

Analyzed 65-720 series & decided that should add a secondummer & thus get z = L & z = 0 simultaneously. Much less wasteful & more efficient. Renamed series 657.

Setup 657-421

L = 4

(Vo-VL) = 2 rel to V = 1

Also A = 0.1

After many tests, can extend to others.

Square G, Plot of Previous FIt

65-422 & 424 needed 126. 0 10

for second TIC card to avoid negative values.

Resubmitted

65-605 Paired Chains with TRANSG Worked.

Will call this. Decided to have control simultaneous difference against control.
Should also prepare 6570221
10/20/65

**655.0 Series**

- Printed out of 655.21 — renamed 655.0/2
- Convinced me to avoid time change & fit one at a time
- Reduced to 15 cpts & got rid of data points

**Setup 655.14**

- with dummy $T_{05} = 4.5$ (4.0 - 6.0)
- fitting at $T = .36$

- $T_{05} = 17.3$ (17.2 - 17.4)
- fitting at $T = .88$

---

657.421 Nonuniform Decay

- $L = 4$
- $V_0 - V_L = 2$
- $V_L = 1$

ran O.K. & needs minor
improvement to time values & amplitude scale
fixed & resubmitted — Took 0.5 min.

To take care of $T_7$ order, begin with $T = .06$

- $\frac{T_0}{T_7^2} = 1 + \left(\frac{\pi}{4}\right)^2 \approx 1 + 30 \approx 31$
- $\frac{T_0}{T_0^2} = 1 + \left(2\pi\right)^2 = 40.5$

Because $e^{-31(6.0)} = e^{-1.86} \approx .15$ and this $/20 \approx .0075$
- less than 1%

- for $T_6$, get $e^{-1.38} \approx .25$

- for $T_8$, get $e^{-2.4} \approx .09$ and $/20 \approx .0045$
\begin{align*}
\text{Problem} & : \text{Find the value of } x. \\
\text{Solution} & : \text{Given} \quad 2x + 3 = 7 \\
& \Rightarrow 2x = 4 \\
& \Rightarrow x = 2.
\end{align*}
First shot was 65.611 but had too many keppes & exceeded limits, took stock.

Cpts 1-5 1st chain, (+) curved step, E=mi 5

6-10 2nd chain, (-) ii, ii, E=mi 10

11-15 3rd chain, current step only.

Cpt 16 is a dump for perturbed cpts, leak

17 is a summer \( Q_{17} = \frac{1}{2} (Q_{11} - Q_{16}) \)

18 \( \cdots \) ii \( Q_{18} = Q_{11} - Q_{17} \)

19 is source cpt for constant current

20 is depleting source for transient generator

21 is transient G time course

22 is source cpt for Ee

24 \( Rij \)

7 other J out of A

2 Sigmas in excess of summers

22 compartments (hence out J)

3 keppes minimum needed

58 which is less than 60
10/20/65

65.422 4 65.424 now successfully plotted

Rename

654  Square G FIT

654.22  e psp peak = 0.2 m
\[ E = 4.2035 \text{ at } T = 0.20 \]

654.24  e psp peak = 0.2 m
\[ E = 10.567 \text{ at } T = 0.345 \]

Trimming time was 2.1 to 2.5 minutes

Setup

654.26  expect \( E \approx 30 \) 6 e psp peak = 0.5

654.28  61 \( \theta \) 0.76

Plan

654.210  try  \( E \approx 200 \), 100 to 500,
\[ \text{at } T = 1.0 \]
10/21/65

Received Terzuela, Plinas & Thomas green manuscript.

Got back

655.170 A Transient S FIT PLOT
peak for E in 4 came in 1 at T = 0.44 although expected 0.36
0° overshoot in E estimate case,
initial E = 41° was adjusted to 5.2256

Perman 0.140B with weighted data point at T = 0.44
and 2.05 range 5.1, 4.8 - 5.3

655.180 did not rise because of minor cord
producing error. 4 no dependence relation missing

To have opportunity to anticipate peak shift
from 0.88 to 0.96

Integrated peak shifts as due to transient E
peak gain + 0.04 after square step rise.

655.181 will incorporate this anticipation

657.421 Nonuniform Decay
sufficient setup Keppa = 78, 7

Successful

new setup 657.457 by changing 70.10 to 5.
For $M = 0.1$ 

$$(Co-V_{2})(Vo-V_{2}) = 0.1/L$$

And 

$$C_m/(Vo-V_{2}) = \frac{0.2L}{l^2 + (\frac{mR}{10})^2}$$

For $l = 1$

$M = 1$ gives $\frac{0.2}{1 + 0.9881} \approx 0.182$

$m = 2 \approx 0.143$

$m = 3 \approx 0.105$

$m = 4 \approx 0.077$

$m = 5 \approx 0.057$

For $l = 2$

$0.4 \approx 0.0244 \approx 0.1$

$m = 2 \approx 0.143$

$m = 3 \approx 0.105$

$m = 4 \approx 0.077$

$m = 5 \approx 0.057$

$m = 6 \approx 0.04$

For $l = 3$

$m = 3 \approx 0.105$

$m = 4 \approx 0.077$

$m = 5 \approx 0.057$

$m = 6 \approx 0.04$

For $l = 4$

$m = 4 \approx 0.078$

$m = 5 \approx 0.058$

$m = 6 \approx 0.04$

$m = 7 \approx 0.03$

Dorothy has done these more exactly on the fides. See p. 74
10/22/65

Exponential Nonuniformity

\[ V(z, 0) = V_b + (V_0 - V_m) e^{-z/A} \]

Then

\[ C_0 = V_b + (V_0 - V_a)(A/L) \int_0^L e^{-z/A} \, dz \]

\[ = V_b + (V_0 - V_a)(A/L)(1 - e^{-L/A}) \]

where for \( L/A > 5 \), \( e^{-L/A} < 0.01 \)

\[ C_m = \frac{2}{L} \int_0^L (V_0 - V_b) e^{-z/A} \cos(\frac{\pi z}{L}) \, dz \]

\[ = \frac{2(V_0 - V_b)}{L} \int_0^L e^{-z/A} \left( \cos \left( \frac{\pi z}{L} \right) - \frac{\pi z}{L} \sin \left( \frac{\pi z}{L} \right) \right) \, dz \]

\[ = \frac{2(V_0 - V_b)}{L \left( \frac{L^2 + (\pi M)^2}{L^2 A^2} \right)} \left[ e^{-L/A} \left( 0 - \left( \frac{L}{A} \right)^n \right) - 1 \left( 0 - \frac{L}{A} \right) \right] \]

\[ = (V_0 - V_b) \left( \frac{2LM}{L^2 + (\pi M)^2} \right) \left( 1 - \left( \frac{L}{A} \right)^n e^{-L/A} \right) \]

\[ = (V_0 - V_b) \frac{2LM}{L^2 + (\pi M)^2} \quad \text{for} \quad e^{-L/A} < 1 \]

\[ = (V_0 - V_b) \frac{2M/L}{1 + (\pi M/L)^2} \]

Compare back to pp 44-48 to stop non-uniform

p. 48-50 for cosine

\[ \theta \text{ p. 50} \]

cf. p. 74
Papers can introduce Table II. Then point out that step exaggerates higher order term unnaturally—hence consider exponential for cosine nonuniformly.

Note, here varying L with M constant—suppose it is P. That is uncertain. Then should hold $M/L \approx \text{very } L$

Then $M/L \approx (0.1)L \approx \text{very } L$

For cosine dust can have only second order term, for all half & half cases:

$p.58 \kappa = 1.00$

Then $C_1 = V_0 - V_n = 1/2$

$C_0 = V_n + \frac{1}{2}(V_0 - V_n)$

$C_m = 0 \text{ for } M > 1$
Table III

<table>
<thead>
<tr>
<th>$\frac{(C - V_B)}{(V_0 - V_B)}$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(C_1)/(V_0 - V_B)$</td>
<td>0.182</td>
<td>0.098</td>
<td>0.0659</td>
<td>0.0497</td>
</tr>
<tr>
<td>$(C_2)/(V_0 - V_B)$</td>
<td>0.145</td>
<td>0.091</td>
<td>0.0639</td>
<td>0.0488</td>
</tr>
<tr>
<td>$(C_3)/(V_0 - V_B)$</td>
<td>0.106</td>
<td>0.082</td>
<td>0.0607</td>
<td>0.0474</td>
</tr>
<tr>
<td>$(C_4)/(V_0 - V_B)$</td>
<td>0.078</td>
<td>0.072</td>
<td>0.0567</td>
<td>0.0455</td>
</tr>
<tr>
<td>$(C_5)/(V_0 - V_B)$</td>
<td>0.058</td>
<td>0.062</td>
<td>0.0523</td>
<td>0.0433</td>
</tr>
<tr>
<td>$(C_6)/(V_0 - V_B)$</td>
<td>0.044</td>
<td>0.053</td>
<td>0.0478</td>
<td>0.0409</td>
</tr>
</tbody>
</table>

| 2M/L                          | 0.200 | 0.100 | 0.0667 | 0.0500 |

Exponential non-uniformity

$M = 0.1$

But see new Table II on p. 78.

Maybe only cite 1st col. of this Table III in text to compare for $L/M = 10$. 

74
\[ V(z,0) = V_L + \frac{1}{2}(V_0-V_L)(1+\cos(\frac{\pi z}{2A})) \quad \text{for } 0 \leq z \leq 2A \]

**Table III**

<table>
<thead>
<tr>
<th>$4/A$</th>
<th>10</th>
<th>10</th>
<th>4</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(C_0-V_L)/(V_0-V_L)$</td>
<td>.10</td>
<td>.10</td>
<td>.25</td>
<td>.50</td>
</tr>
<tr>
<td>$C_1/(V_0-V_L)$</td>
<td>.18</td>
<td>.20</td>
<td>.42</td>
<td>.50</td>
</tr>
<tr>
<td>$C_2/(V_0-V_L)$</td>
<td>.14</td>
<td>.18</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td>$C_3/(V_0-V_L)$</td>
<td>.11</td>
<td>.16</td>
<td>.12</td>
<td>.00</td>
</tr>
<tr>
<td>$C_4/(V_0-V_L)$</td>
<td>.08</td>
<td>.13</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>$C_5/(V_0-V_L)$</td>
<td>.06</td>
<td>.10</td>
<td>-.01</td>
<td>.00</td>
</tr>
<tr>
<td>$C_6/(V_0-V_L)$</td>
<td>.04</td>
<td>.07</td>
<td>.00</td>
<td>.00</td>
</tr>
</tbody>
</table>

Case 1: $4/A = 10 = 1/2k$ is already done on page 49

For $4/A = 2$, have $C_1/(V_0-V_L) = A/k = 0.5$, $C_{4n} = 0$ for $n > 1$

For $4/A = 4$, compare $M$ with $4/2A = 2$

- For $M = 1$, get 
  \[ \frac{1}{2\pi} \left( \frac{1}{2} \right) \sin \left( \frac{\pi}{2} \right) = \frac{1}{2\pi} = 0.16 
  \]

- For $M = 3$, get 
  \[ \frac{1}{2\pi} \left( \frac{1}{3\pi} \right) \sin \left( \frac{5\pi}{2} \right) = \frac{1}{6\pi} = 0.16 
  \]

- For $M = 5$, get 
  \[ \frac{1}{2\pi} \left( \frac{1}{5\pi} \right) \sin \left( \frac{11\pi}{2} \right) = \frac{1}{10\pi} = 0.03 
  \]

\[ R = 4/2A \]
\[ 4/A = 2A \]
\[ C_6/(V_0-V_L) = 0.07 \]
Suppose \( M/L = 0.1 \)

From p. 72, we have:

\[
\frac{C_0}{(V_0 - V_L)} = 0.1 \text{ for all } L
\]

\[
\frac{C_m}{(V_0 - V_L)} = \frac{0.02L^2}{L^2 (1 + 0.0987L^2)}
\]

\[
= \frac{0.02}{1 + 0.0987L^2} \text{ for all } L
\]

Which is same as case for \( L = 1, \ M = 0.1 \)

Return to cosine case, but consider only \( R = 5, 2 \) and \( 1 \) to compare with Table II p. 78

Perhaps rename \( R = \frac{\sqrt{\	ext{eff}}}{2\pi} \) for \( R = \frac{1}{4\pi} \)

from p. 50, we have:

\[
C_0 = V_L + (V_0 - V_L) \left( \frac{A}{L} \right)
\]

and:

\[
C_m = \frac{(R^2 - m^2)}{m^2} \sin \left( \frac{\pi m}{R} \right)
\]

\[
\Rightarrow \left( \frac{1}{m^2} \right) \sin \left( \frac{\pi m}{R} \right)
\]

\[
= \left( \frac{1}{m^2} \right) \left( \frac{1}{1 + \left( \frac{2\pi A}{L} \right)^2} \right) \sin \left( \frac{2\pi A}{L} \right)
\]

For \( m = \frac{L}{2\pi} \), get \( C_m = \frac{A}{2L} \)

For \( m \) not a multiple of \( \frac{L}{2\pi} \), get:

\[
\left( \frac{1}{m^2} \right) \left( \frac{1}{1 + \left( \frac{2\pi A}{L} \right)^2} \right) \sin \left( \frac{2\pi A}{L} \right)
\]
Exponential Non Uniformity
from pp 83-84

\[
\frac{C_1}{V_0-V_b} = \frac{182.309}{315} = 0.288, \quad 0.33
\]

\[
\frac{C_2}{V_0-V_b} = \frac{144}{147} = 0.92, \quad 1.07
\]

\[
\frac{C_3}{V_0-V_b} = \frac{106}{0.763} = 0.078, \quad 0.043, \quad 0.05
\]

\[
\frac{C_4}{V_0-V_b} = \frac{0.78}{0.46} = 0.47, \quad 0.025, \quad 0.0247, \quad 0.0286
\]

\[
\frac{C_5}{V_0-V_b} = \frac{0.58}{0.304} = 0.31, \quad 0.016, \quad 0.0185
\]

\[
\frac{C_6}{V_0-V_b} = \frac{0.44}{0.215} = 0.22, \quad 0.011, \quad 0.0129
\]

\[
\frac{C_0}{V_L} = \frac{1.5}{1.46} = 1.035
\]

\[
\frac{(C_0-V_b)}{(V_0-V_b)} = 0.1, \quad 0.245, \quad 0.4324
\]

\[
\text{for } (V_0-V_b)/V_b = 1/2A
\]
10/22/65  Revised Table II

Step Nonuniformity

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{1}{A} )</td>
<td>10</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>( \frac{C_0 - V_L}{(V_0 - V_L)} )</td>
<td>0.10</td>
<td>0.10</td>
<td>0.25</td>
</tr>
<tr>
<td>( C_1 / (V_0 - V_L) )</td>
<td>0.18</td>
<td>0.20</td>
<td>0.45</td>
</tr>
<tr>
<td>( C_2 / (V_0 - V_L) )</td>
<td>0.14</td>
<td>0.19</td>
<td>0.32</td>
</tr>
<tr>
<td>( C_3 / (V_0 - V_L) )</td>
<td>0.11</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>( C_4 / (V_0 - V_L) )</td>
<td>0.08</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>( C_5 / (V_0 - V_L) )</td>
<td>0.06</td>
<td>0.13</td>
<td>-0.09</td>
</tr>
<tr>
<td>( C_6 / (V_0 - V_L) )</td>
<td>0.04</td>
<td>0.10</td>
<td>-0.11</td>
</tr>
</tbody>
</table>

\[ \frac{C_0}{V_L} \] for \( \frac{(V_0 - V_L)}{V_L} = \frac{1}{2} A \)

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
for 657 series

With \( L/2A = 5 \), \( A/L = 0.1 \), use \( (V_0 - V_L)/V_L = 5 \)

\( L/2A = 2 \), \( A/L = 0.25 \), use \( (V_0 - V_L)/V_L = 2 \)

\( L/2A = 1 \), \( A/L = 0.5 \), use \( (V_0 - V_L)/V_L = 1 \)

The value of \( L \) determines the eigenvalues

The value of \( L/2A \) determines

and, given step, cosine or exp, det \( C_m \)
10/22/65

1655.141 successful

\( \epsilon_{\text{peak}} = 5.0086 \text{ in} \ 4 \)

\( \text{torex}: \epsilon_{\text{peak}} = 0.1 \text{ in} \ 1 \)

\( \text{for} \ T = 0.44 \)

correct 655.020 (p.62)

\( \epsilon_{\text{peak}} = 2.50 \text{ in} \ 2 \)

\( T = 0.285 \)

655.182 goofed

within 1%

655.512

10/25/65 found 17.073

set up 655.161

try \( \epsilon = 10 \),

at \( T = 0.60 \)

Set up also

657.425 for \( L = 4 \), and \( 2A \) Cosmic Nolby

and \( 5 = 1/2A \)

\( \text{ie.} \ A/4 = 0.1 \)

using results on page 75 for Cowles

Also fixed Keppa 7 dependent in right place.

656.510 returned but without cards

errors to have summer 18 fed by summer 17

Need \( \phi_{18,1} = -5 \)

\( \phi_{18,6} = +0.5 \)

as well, \( \phi_{18,11} = 1.0 \) as now

also will need Keppa_{21} = 0.45 and Keppa_{18} = 50.
10/22/65 got code

654.260 Square G Fit for E = 31.1 in. (6)
to get q
apprx = 0.2 in. (1)
at T = 0.50

654.280 something went wrong,
repair 200 cor. & range 2013

657.221 was successful for old case of L = 2
A = 0.01
V₁ - V₂ = 2.0

But no longer want this A₁ = 0.05 is not really very important

if p = 78 versus p = 5.4
\[ C_0 = V_b + (V_0 - V_b) \left( \frac{A}{L} \right) \left( 1 - e^{-\frac{L}{A}} \right) \]

For \( \frac{L}{A} = 10 \), this is simply \( V_L + (V_0 - V_L) \left( \frac{A}{L} \right) \left( 0.4 \right) \)

For \( \frac{L}{A} = 4 \), this is \( 0.96 V_L + (3 - 0.96) V_L \left( \frac{1}{4} \right) (0.982) \)

\[ + V_0 = 3V_L \]

\[ = \left( 0.96 + 2 \times 0.4 \right) V_L = 1.46 V_L \]

For \( \frac{L}{A} = 2 \), this is \( 0.843 V_L + (2 - 0.843) V_L \left( \frac{1}{2} \right) \left( 1 - 0.133 \right) \)

\[ + V_0 = 2V_L \]

\[ = \left( 0.843 + 1.157 \left( \frac{1}{2} \right) \left( 0.8647 \right) \right) V_L \]

\[ = \left( 0.843 + 0.50 \right) V_L = 1.343 V_L \]

\[ C_m = \frac{(V_0 - V_b)(2A/l)}{2 \left[ 1 + \left( \frac{mA}{l} \right)^2 \right]} \]

For \( \frac{L}{A} = 10 \), see same as before, on p. 72

For \( \frac{L}{A} = 4 \), get \( \frac{C_m}{V_0 - V_L} = \left( \frac{3 - 0.962}{2} \right) \left( \frac{1}{2} \right) \left( 1 + \left( \frac{mA}{l} \right)^2 \right) \)

\[ = (1.02) \left( 1 + 0.017/m^2 \right) \]

For \( \frac{L}{A} = 2 \), get \( \frac{C_m}{V_0 - V_L} = \left( \frac{2 - 0.843}{1} \right) \left( 1 + \left( \frac{mA}{l} \right)^2 \right) \)

\[ = (1.157) \left( 1 + \frac{2.447}{23.2^2} \right) \]

\[ m = 1 \]

\[ \frac{1}{3.467} = 0.288 \times 1.157 = 0.333 \]

\[ m = 2 \]

\[ \frac{1}{10.86} = 0.0922 \times 1.157 = 0.107 \]

\[ m = 3 \]

\[ \frac{1}{23.2} = 0.0431 \times 1.157 = 0.050 \]

\[ m = 4 \]

\[ \frac{1}{40.5} = 0.0247 \times 1.157 = 0.0286 \]

\[ m = 5 \]

\[ \frac{1}{62.16} = 0.016 \times 1.157 = 0.0185 \]

\[ m = 6 \]

\[ \frac{1}{89.88} = 0.0114 \times 1.157 = 0.0129 \]
Define \( V(z,0) = V_b + (V_o - V_b) e^{-z/A} \)

where \( V_L = V(z,0) = V_b + (V_o - V_b) e^{-z/A} \)

also \( V_o - V_b = (V_L - V_b) e^{+z/A} \)

or \( V_b = \frac{V_L - V_o e^{-z/A}}{1 - e^{-z/A}} \)

In particular, if \( \frac{z}{A} = 10 \), \( e^{-10} \approx 0.000045 \) and \( V_b \approx V_L \)

If \( \frac{z}{A} = 4 \), \( e^{-4} = 0.0183 \), and if \( V_o = 3 V_L \)

Then \( V_b = \frac{1 - 3(0.0183)}{1 - 0.0183} = \frac{1 - 0.0549}{0.982} = \frac{0.945}{0.982} = 0.962 \)

and \( \frac{V_o - V_b}{V_o - V_L} = \frac{(1 - 0.962)(5/4)}{2} = \frac{0.038}{2} = 0.019 \)

i.e., \( (V_o - V_b)/V_L = 1 = \frac{1}{2} A \)

If \( \frac{z}{A} = 2 \), \( e^{-2} = 0.1353 \), and if \( V_o = 2 V_L \)

Then \( V_b = \frac{1 - 2(0.1353)}{1 - 0.1353} = \frac{1 - 0.2706}{0.8647} = \frac{0.7294}{0.8647} = 0.843 \)

and \( \frac{V_o - V_b}{V_o - V_L} = \frac{2 - 0.843}{2 - 1} = 1.157 \approx 1.16 \)

\( V_o - V_b = (1 - e^{-z/A})V_o - V_L + V_o e^{-z/A} \)

\( = \frac{V_o - V_L}{1 - e^{-z/A}} \)

Use these results on p. 777
Oct 25/65

Get book

655, 161 So 7 - incomplete change to eq. 6

655.182 Transient G fit - Success \( E = 17.073 \text{ m}^2 \)

for peak in 1 of 0.010

at \( T = 0.86 \)

657, 425 Nonuniform decay

success \( L = 4 \), coarse weight \( 4/2A = 5 \)

\( A/L = 0.01 \)

setup 657, 422 for \( 1/2A = 2 \), changed \( T \) at \( 2\alpha_{10} \) as needed

Next, set 657, 0.225

654, 210 see p. 68

654, 160 use 654, 260 with change of data card

\( \phi \) of \( T \)

Try 655, 110 try \( E = 50 \), \( 45^\circ \rightarrow 70^\circ \), in \( 10 \)

at \( T = 1 \).
10/26/65 Got letter from Brodchart on 10/22/65 in reply to mine of 10/26/65 received refereeing job.

10/27 - 10/28 Spend time on refereeing job, dentist, & also a little on memo for Tom Smith, K Phil & Ray.

A new refereeing job is 
that assumption 1. the dipole contradicts assumption 2. axial symmetry around axis of cell, for all \( \theta \) different from \( \pm \pi/2 \), where \( \theta \) defined.

10/29 - 10/30/65

Roughed out refereememo & also memo for Smith et al.

Also measured & prepared new charts

\[
\begin{align*}
654.22, & \ 0.424, \ 0.260 \ \text{for Square \ G-fit Series} \\
655.12, & \ 0.141, \ 0.182 \ \text{for transversal G-fit Series}
\end{align*}
\]

Charts are obviously incomplete.
11/1/65

Got both batch of computations.
NBS computer had broken down.

656.511 Three chains, Step C, TRNSG.
There was one too many Kappa, became juddled.
Adopt Kappa 2.
Also, improperly making $A_5, 22, A, 10, 12, 20, 22$
$A_{16,5}, A_{16,10}$ all dependent
upon $A_{16}$.

This facilitate adjusting $E$. [Setups 656, 572]

655, 161 Transient G fit plot. $E = 55$ was much too
much in (6)

Peek occurred at $T = .64$
set $70, 50, 10, 50, -20$

655, 110 $E = 45$ was too much in (10) peek at 100
set $70, 50, 40, 20, -45$

Square G plot fit
654, 160 $E = 9.67^72$ in (6) to make BVP peak $= 1$ in (12)
Successful

654, 280 $E = 50$ was not enough; peak in (8) was 189
at $T = .74$
and peak in (8) was nearly saturated.
$R_B + C_B$ represent approx to soma transient response characteristics

$R_A$ and $C_A$  ... general input ...

If quantal $g_{syn} = \frac{1}{4}$ nS and typical $g_{syn} = 10$ nS, then home quantal number of approx 40 elements.

If max rate of $g_{syn}$ rise is $\sim 10$ volt/sec, then this rate of rise implies

$$\frac{dV}{dt} = 2 \times 10^{-8} \text{ amperes}$$

If driving pot. across parallel $R_c$ is $\sim 100$ mV, then

one can deduce (assuming $R_e << R_c$) that $\leq g_c = 0.2 \times 10^{-6}$ mhos

so, each of 1400 synapses has $g_c = 5 \times 10^{-9}$ mhos

$\therefore \text{ each } R_c = 0.2 \times 10^{-9}$ ohms

= 200 meg
11/4/65 - 11/5/65


Attended Dick FitzHugh's seminar on his kinetic model and lunch following. Mostly bio-physics group.

Saw Dieter Lux, went over Lux & Pollen revised manuscript & Lux's questions regarding tapes. He also tried but failed to include &x with K=0 & apparently discovered the parabolic tapes were also.

Now, check out later computer output.

Array of memos was that under resting conditions, the axonial input resistance $R_i$ is significantly larger than the axonal resistance $R_c$ and that during spikes, axonal $R_i$ is significantly smaller than $R_c$. This means that for a given action potential, not simply applying a voltage, it applies a potential better to the system. See left for quantitative estimates $R_c$. To estimate $R_a$ consider from eq. 100/105: pages

$$R_a = \frac{\sqrt{R_m R_i}}{\frac{H}{2} d^{3/2}}$$

If $R_m R_i = 10^5 \text{ ohm}^2 \text{ cm}^3$

eg. $R_m = 10^3 \text{ ohm cm}^2$
$R_i = 10^2 \text{ ohm cm}$

Then $\sqrt{R_m R_i} = 3 \times 10^2 \text{ ohm cm}^{3/2}$
$= 17 \times 10^2 \text{ ohm cm}^{3/2}$

Hence $R_a = \frac{250 \text{ ohm cm}^{3/2}}{d^{3/2}}$

For $d = 1/2 \mu\text{m}$ giving $d^{3/2} = 200 \times 10^{-9}$
Now consider $t_{cusp}$ during $I_p$

\[ V_B^* = E_r + I_p R_p + \Delta V_p \]

where $\Delta V_p > \Delta V_0$

by small amount

\[ E_{IC} = (V_B^* - E_c)(N/R_c) \]

\[ = (E_r - E_c + I_p R_p + \Delta V_p)(N/R_c) \]

for $\Delta V_p = 7 \text{ mV}$

This determines potential $V_B^* - V_A^* = -100 + 30 + 7 = -123 \text{ mV}$

\[ \Sigma I_c = -24.6 \times 10^{-9} \text{ amperes.} \]

However, current discharging $C_B$ is

\[ C_B \frac{dV_B}{dt} = G_B \Delta V_p + \Sigma I_c \]

\[ = -17.6 \times 10^{-9} \text{ amperes} \]

Ratio

\[ \frac{\frac{dV_B}{dt} \text{ (with $I_p$)}}{\frac{dV_B}{dt} \text{ (without $I_p$)}} = \frac{E_r - E_c + I_p R_p + \Delta V_p (1 + G_B R_c / N)}{E_r - E_c + \Delta V_0 (1 + G_B R_c / N)} \]

\[ = 1 + \frac{I_p R_p + (\Delta V_p - \Delta V_0)(1 + G_B R_c / N)}{E_r - E_c + \Delta V_0 (1 + G_B R_c / N)} \]

\[ = 1 + \frac{I_p R_p + 6 (\Delta V_p - \Delta V_0)}{-70 \text{ mV}} \]

\[ = 1 + \frac{-30 + 12}{-70} = 1.26 \]
Thus the picture is
\[ \frac{R_c}{R_A} = \frac{200 \text{mV}}{1000 \text{mV}} = \frac{1}{5} \]
\[ \frac{R_c}{R_e} = \frac{200 \text{mV}}{10 \text{mV}} = 20 \]

During and after, let \( t^* \) be time of max. rate of rise and assume that \( \frac{dV_c}{dt} = 0 \) at this time.

\[ V_B^* = V_B + AV_0 = E_r + AV_0 \]

Peak synaptic current
\[ \Sigma I_c = (V_B^* - E_r)(N/R_c) \]

Because \( R_e \ll R_A \) and \( R_e \ll R_c \).

Thus
\[ \Sigma I_c = (E_r - E_e + AV_0)(N/R_c) \]

For \( E_r = -70 \text{mV} \)
\( E_e = 30 \text{mV} \)
\( AV_0 = 5 \text{mV} \)
\( N/R_c = 0.2 \times 10^{-6} \text{mho} \)
\( G_b = 10^{-6} \text{mho} \)
\[ G_b \frac{dV_b}{dt} = +G_b AV_0 + \Sigma I_c = -14 \times 10^{-9} \text{amp} \]

During applied polarizing current \( I_p \), first without \( \text{gsp} \)

\[ V_B = E_r + I_p R_p \]

Where \[ R_p = \left[ G_b + \frac{N}{R_c + R_A} \right]^{-1} = [1.033 \times 10^{-6}] \]
Setup \textit{ipsp} sum
In conclusion, this analysis shows that electrical synapse is not a current injection by a voltage source through a high resistance. It is a perturbation which causes a synaptic current flow which does depend upon V ≤ and does provide a measurable conductance change in the postsynaptic element, for synapses at the soma.

Should run a somatic inhibition simulation to match IPSP amplitude to EPSP amplitude.

**Summary**

All entered in Chasta

11/5/65

**New look at output**

655.162 Transient G fit

\[ \text{got } E = 986.2 \text{ mV} \]

\[ \text{for EPSP peak } 0.01 \text{ nA} \]

\[ \text{at } T = 0.62 \]

655.110

\[ \text{got } E = 33.64 \text{ mV} \]

\[ \text{for EPSP peak } 0.01 \text{ nA} \]

\[ \text{at } T = 1.00 \]

654.140 Square G fit

\[ \text{got } E = 4409 \text{ mV} \]

\[ \text{for EPSP peak } 0.01 \text{ nA} \]

\[ \text{at } T = 0.35 \]

654.281

\[ E = 300.00 \text{ mV} \]

\[ \text{for EPSP peak } 0.200 \text{ nA} \]

\[ \text{at } T = 0.74 \]
11/5/65
Began exploratory plotting of non-uniform decay.

11/8/65
Spent money talking with Jose about his capillary computations.

11/9/65
Spent all day with K. Farka, T. Smith, Phil Neilson, Bob Burke.
They accepted most of mine, but thought they could justify a smaller value for $R_A$. They considered a spherical knot as a sphere of 2 to 4 microns. I pointed out they could only use hemisphere.

Also from measurements of model resistances, they say a cat node

\[ \pi \text{ long} \]

5 to 10 micron.

According to measured 10 meg.

\[ 2\pi rl = \pi dl \]

Sodium gives \( \approx 15 \mu^2 = 15 \times 10^{-8} \text{ cm}^2 \), \( \approx 75 \times 10^{-8} \text{ cm}^2 \).

10 micron gives \( \approx 30 \mu^2 = 30 \times 10^{-8} \text{ cm}^2 \).

\[ R_m = 10^7 \times 15 \times 10^{-8} = 1.5 \Omega \text{ cm}^2 \]
\[ R_m = 10^7 \times 30 \times 10^{-8} = 3 \Omega \text{ cm}^2 \]

They said 3 to 15 \( \Omega \text{ cm}^2 \).

It may be that we should take closer detail as a better approach than model membrane.

Anyway, hemisphere of 2 micron gives

\[ A = 2\pi r^2 = 6.3 \times 4 \mu^2 \times 25 \mu^2 \]

\[ = 25 \times 10^{-8} \text{ cm}^2 \]

Small joint is same surface area as node above, giving

\[ R_A = 10^7 \Omega \text{ cm} \]

Length (4\( \mu \)) is \( \times 4 \text{ times} \), giving 107 \( \approx 20 \Omega \text{ meg} \). They estimated 3 to 30 \( \Omega \text{ meg} \).
Evaluate \( C_N^* = \frac{I_0}{\Delta V} = \frac{\sqrt{\pi T}}{R_N e^{-T}} \) for several \( T \) and for \( T = 5 \times 10^{-3} \)

\[ R_N = 10^6 \Omega \]

Thus, here \( \frac{\sqrt{\pi T}}{e^{-T}} \times 5 \times 10^{-9} \) farads

For \( T = 0.05 \), get \( \frac{\sqrt{0.15}}{0.95} \times 5 \times 10^{-9} = 2 \times 10^{-9} \)

\( T = 0.1 \)

\( 3 \times 10^{-9} \)

\( T = 0.2 \)

\( \frac{\sqrt{0.28}}{0.82} \times 5 \times 10^{-9} = 5 \times 10^{-9} \)

\( T = 0.4 \)

\( \frac{\sqrt{0.25}}{0.67} \times 5 \times 10^{-9} = 8.4 \times 10^{-9} \)

This gives quental range as \( \sum \)

\( 6 \times 10^{-9} \) amperes

\( 12 \times 10^{-9} \) amperes

and for action potential of 60 to 85 mV

This gives \( R_C \) range

\( \sum \)

\( 0.06 \)

\( 12 \times 10^{-9} = 5 \) meg

\( 0.85 \)

\( 6 \times 10^{-9} \approx 150 \) meg
11/9/85

To reestimate Re (coupling resistance)

Typical quantal size according to Kurts & Bob Burke, seems to be around 0.10 to 0.20 mV, although sometimes as large as 0.7 mV or occasionally larger.

0.2 mV in 0.5 msec

Phil used 0.5 mV in 1.5 msec as overall rise time for 0.5 mV quant.

This gives average rise rate of 0.33 volts/sec, but may rate of rise probably 1 volt/sec.

Now, if \( C = 2 \times 10^{-9} \) farads, this implies \( I = 2 \times 10^{-9} \) amperes.

and with 100 mV drive potential, this implies \( Re = \frac{100}{2 \times 10^{-9}} = 50 \) megohm.

Phil estimated 50 to 150 meg,"
Somatic  |  Dendritic  
A  |  A or B  
> 0  |  Impedance change  |  Small  
+  |  Effect on amplitude, small  |  Absence of Axon Refr.  
+  |  Effect on maximum rise, small  
short  |  short  |  e.p.s.p latency  |  short to somatic  
high  |  high  |  e.p.s.p maximum rise  |  not quite as high as somatic  

Axon, Refr.  
main effect on e.p.s.p.  
During Tp.
The upshot of all this is that one can argue that

They argued $R_C$ range 50-150 meg: my est. was 200 meg
$R_A$ range 3 to 30 meg: ... 1000 meg.

but it would like to check this against CFiber data.

But, if $R_C / R_A < 1$, then get closer to tons conductance source

for range of $R_C / R_A$ values, I could simulate.

test

$R_C / R_A$ ratios: 10, 4, 2, 1, 0.5, 0.25, 0.1

joint paper might need to deal with six cases to be compared & contrasted.

A. chemical or electric with $R_A > > R_C$

B. cond. current source case of electric $R_A < < R_C$

C. intermediate electric $R_A = R_C$

A. somatic

A2. dendritic

B. somatic

B2. dendritic

C1. somatic

C2. dendritic
Typical eff. action potential 60 to 85 mV
overshoot 5 to 15 mV
resting pot. 50 to 70 mV

? leak around electrode?

effect on initial steady state?
11/10/65

Things to do: put E in 0 and compare effect on rate of rise, etc. on detectability of E.

Note for experiments were with epsp amp. 5 to 10 mV or 1/10 to 1/5 of driving pot. in hyperpol st. was 10 to 25 mV or about twice epsp amp.

Simulate epsp peak & rate of rise in the presence of steady state hyperpol.
Get code computations yesterday. Go over now.

556. 510 Short chain fit - error

654 145 Square C fit
initial \( G = 50 \) in \( 4 \) gave peak \( -0.0773 \) in \( 4 \)
\( \Delta \) peak \( -0.0444 \) in \( 1 \)
\( \Delta \) peak \( -0.06022 \) in \( 1 \)
\( T = 0.33 \)

\( m = 500 \) in \( 4 \) gave peak \( -0.0975 \) in \( 4 \)
\( \Delta \) peak \( -0.06022 \) in \( 1 \)
\( T = 0.32 \)

Pretty close to limit.

Not worth pursuing.

\text{In fact} \ 0.1 \ \text{ipspsmax is too much to ask if} \ \frac{E_2 - E_1}{E_3 - E_6}

\( \therefore \) setup 654. 545 aimed at \( \Delta \) peak \( = 0.05 \) in \( 1 \)

654 to 181 Square C fit \( E = 18.5 \) in \( 8 \) to give \( \Delta \) peak \( = 0.01 \) in \( 1 \)
\( T = 0.76 \)

655 165 transient C fit initial \( G = 100 \) in \( 6 \) gave \( -0.0824 \) in \( 6 \)
\( \Delta \) peak \( -0.03265 \) in \( 1 \)
\( T = 0.64 \)

Time allowed exceeded at \( T = 1.5555 \)

Need to increase time factor to 100 times cell 2-10 fold

655 115

\( \text{move to} \ 655. 525 \) instead

\( A_{10,10} = 42.6 \)
\( A_{15,15} = 400 \)
Next time, setup two chems & use I.C. of inflow rate of either 1.0 or 2.0.

\[ \delta_{22,1} = 1.0 \]
\[ \delta_{22,11} = -1.0 \]

<table>
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<th>Fe</th>
<th>1.0</th>
</tr>
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<td>8</td>
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<td>0.354</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>0.299</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>0.272</td>
</tr>
</tbody>
</table>

St. St.
Nov/10/65

Begin 652,000 Series

First problem will require current step, calling for st. st. values and also for values at T = 1.0 to be used as I.C. for future problems where we put in the perturbations and obtain both transient and st. st. solutions for E = square.

There will have only conductance changes.

652.001 Step C, Square G. need 11 feats.

652.002 22 feats.

Also put this in col 36-70 of I.C. forgot.

11/12/65 found for Q_{11} = 1.31786 and inflow rate = 1.31786 that

<table>
<thead>
<tr>
<th>Day</th>
<th>T = 1.0</th>
<th>St. St.</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>2</td>
<td>0.1551</td>
<td>0.2057</td>
</tr>
<tr>
<td>3</td>
<td>0.1210</td>
<td>0.1712</td>
</tr>
<tr>
<td>4</td>
<td>0.0939</td>
<td>0.1435</td>
</tr>
<tr>
<td>5</td>
<td>0.0726</td>
<td>0.1215</td>
</tr>
<tr>
<td>6</td>
<td>0.0563</td>
<td>0.1044</td>
</tr>
<tr>
<td>7</td>
<td>0.0441</td>
<td>0.09147</td>
</tr>
</tbody>
</table>
11/12/65

See 652.001 previous page revised to 652.002

Then will run together part & insert stops from T=1.0

\[ E = 12.49 \, \text{m} \] (5)

Gives \( e_{SSP} \) peak of \( 0.18 \, \text{m} \)

at \( T = 0.95 \)

556.570 Short Chain fit, found \( E = 12.49 \, \text{m} \)

556.571 Redo on finest time scale.

654.545 Square C Plot Fit \( J = 79.232 \, \text{m} \) (4)

\( \rho_{SSP} = -0.05 \, \text{m} \)

at \( T = 0.33 \)

655.565 Transient C fit \( J = 200. \, \text{m} \)

must redo

655.525 Transient C fit \( J = 201.51 \, \text{m} \) (2)

to make \( \rho_{SSP} = -0.05 \, \text{m} \)

at \( T = 0.26 \)

\( e_{SSP} = 0.05 \, \text{m} \) (2.08)
\[ V = C_0 e^{-t/\tau_0} + C_1 e^{-t/\tau_1} + C_2 e^{-t/\tau_2} + \ldots \]

\[ \frac{dV}{dt} = -(C_0/\tau_0) e^{-t/\tau_0} - (C_1/\tau_1) e^{-t/\tau_1} - (C_2/\tau_2) e^{-t/\tau_2} + \ldots \]

\[ \frac{dy}{dt} = \frac{dV}{dt} = \frac{dV}{V} = \frac{-(C_0/\tau_0) e^{-t/\tau_0} - (C_1/\tau_1) e^{-t/\tau_1} - \ldots}{C_0 e^{-t/\tau_0} + C_1 e^{-t/\tau_1} + \ldots} \]

As \( t \to \infty \), this slope \( \to -\frac{1}{\tau_0} \)

For \( t \to 0 \), this slope \( \to -\frac{(C_0/\tau_0) - (C_1/\tau_1) - \ldots}{C_0 + C_1 + \ldots} \]

\[ = -\frac{\sum \frac{(C_n/\tau_n)}{C_n}}{\sum 1} \]

\[ = -\frac{1}{\tau_0} \left( \frac{1 + \sum \frac{(C_n/\tau_n)}{C_n}}{1 + C_1/\tau_0 + C_2/\tau_0} \right) \]

\[ \Rightarrow s_0 = \left| \frac{dV}{dt} \right| \bigg|_{t=0} \quad \text{and} \quad s_n = 0 \quad \text{for} \quad n > 1 \]

\[ s_0 = \frac{C_0/\tau_0 + C_1/\tau_1}{C_0 + C_1}, \quad \text{Then} \]

\[ s_0 = \frac{C_0/\tau_0 + C_1/\tau_1}{C_0 + C_1} \]

\[ \frac{C_1}{\tau_1} = (C_0 + C_1) s_0 - C_0/\tau_0 \]

\[ \tau_1 = \frac{C_1}{(C_0 + C_1) s_0 - C_0/\tau_0} \]
11/15/65  Consider sum of two exponentials. Several approaches.

Suppose \( y = Ae^{-at} + Be^{-bt} \)

consider \( b > a \), \( e^{-bt} < e^{-at} \)

One approach is \( y = Ae^{-at} \left\{ 1 + \frac{B}{A} e^{-(b-a)t} \right\} \)

then \( \frac{dy}{dt} = \ln y = \ln A - at + \ln \left\{ 1 + \frac{B}{A} e^{-(b-a)t} \right\} \)

also \( \ln y_2 - \ln y_1 = -a(t_2 - t_1) + \ln \left\{ 1 + \frac{B}{A} e^{-(b-a)t_2} \right\} \)

\( \Delta \ln y = \frac{\ln(y_2/y_1)}{t_2 - t_1} = -a + \left( \frac{1}{t_2 - t_1} \right) \ln \left\{ 1 + \frac{B}{A} e^{-(b-a)t} \right\} \)

Suppose \( (b-a)t_2 = 1 \) and \( (b-a)t_1 = 0.5 \) then \( \{ 1 + 0.368 \frac{B}{A} \} \)

\( \frac{B}{A} = \frac{1}{2} \) then \( \{ 1 + 0.6065 \frac{B}{A} \} = \frac{1.0736}{1.1213} = 0.958 \)

\( \ln 0.958 = -0.0429 \)

if \( t_1 = 1 \) msec, \( t_2 = 2 \) msec, then the contribution to slope is \(-0.0429 \) msec\(^{-1}\)

But, if have many points, fit by Mone's method

Other approach

\( \frac{dy}{dt} = \frac{d}{dt} (\ln y) = \frac{dy}{dt} \cdot \frac{1}{y} = -a Ae^{-at} - b Be^{-bt} \)

\( \frac{dy}{dt} = \frac{1}{y} \left\{ \frac{1 - \frac{B}{A} e^{-(b-a)t}}{1 + \frac{B}{A} e^{-(b-a)t}} \right\} \)

as \( t \to \infty \) slope \( \to -a \)

as \( t \to 0 \) slope \( \to \frac{-a A - b B}{A + B} \)
\[ C = \frac{10^{0.23}}{88.7} = 0.194 \]

\[ b = e^{0.1} = 1.1485 \]

\[ \log_{10}(b) = \frac{\log_{10}(C)}{5.36} = 3.03 \]

Graph shows a linear relationship and points plotted on a logarithmic scale.
The diagram seems to present a series of calculations and annotations. Here is a transcription of the key elements:

- The top left corner shows $C_L = 16.23 = 0.194$.
- Various calculations and annotations are present, with some arrows indicating flow direction and other markers.
- The bottom left corner shows $k_B = \text{value}$.
- There appears to be a list of numbers and calculations, possibly related to flow dynamics or fluid mechanics, with some annotations like "Sum of all decay times = 0.8973".

However, without more context or clearer handwriting, it's challenging to provide a precise interpretation of the entire document.
1/16/65

As a rough estimate, instead of computing fit, take tail to get A & then extrapolate to zero to get C. Then actual initial value gives B.

Thus we have A, B & now we need L. If initial slope is reliable, we can get it. Thus

\[ \text{mag} = \left| S_0 \right| = \frac{aA + bB}{A + B} = \frac{C_0 + C_1}{C_0 + C_1} \]

Thus

\[ bB = (A + B) \left| S_0 \right| - aA \]

\[ L = \frac{(A + B) \left| S_0 \right| - aA}{B} \]

Take data of Tadija & Brookhart 1960 pp. 697-698

\[ A + B = 100 \% \text{ (corresp to 100\%)} \]

\[ \ln \left( F_{\text{peak}} \right) = 1.635 \]

\[ A = 1.4580 \]

\[ B = 0.1771 \]

\[ a = +.1084 \]

\[ \left| S_0 \right| = +.586 \]

\[ L = \frac{(1.635)(.586) - (+.1084)(1.4580)}{0.1771} \]

\[ = \frac{.259 + .158}{0.1771} \]

\[ = 1.47 \text{ or } 1.50 \]

From p. 43, \( \frac{C_0}{C_1} \) implies \( 1 < L < 2 \)

\[ \frac{C_0}{C_1} = \frac{54}{1084} = 5.26 \]

\[ C_0 = 9.2 \text{ msec} \]

\[ C_1 = 1.75 \text{ m/sec} \]
\[ \ln \left( \frac{V_2}{V_1} \right) = -\frac{t_2 - t_1}{\tau_0} + \ln \left( \frac{C_0 + C_1 e^{-(\frac{t_1}{\tau_0})}}{C_0 + C_1 e^{-(\frac{t_2}{\tau_0})}} \right) \]

\[ \frac{\ln V_2 - \ln V_1}{t_2 - t_1} = -\frac{1}{\tau_0} + \frac{1}{\tau_2 - \tau_1} \ln \text{(above)} \]

Suppose we know \( \tau_0 \), and \(-S_{12} = \frac{\ln V_2 - \ln V_1}{t_2 - t_1} \) \( S_{12} > \frac{1}{\tau_0} \)

and we want to get \( \tau_1 \)

\[ (t_2 - t_1) \left( \text{slope} + \frac{1}{\tau_0} \right) = \ln \text{(above)} \]

**Working from two points:** we essentially peel the two.

\[ C_1 e^{-t_1/\tau_1} = V(t_1) - C_0 e^{-t_1/\tau_0} = 10.16 \quad \text{peak value} \]

\[ C_1 e^{-t_2/\tau_1} = V(t_2) - C_0 e^{-t_2/\tau_0} = 5.36 \]

\[ -t_1/\tau_1 = \ln 10.16 - \ln C_1 \]

\[ -t_2/\tau_1 = \ln 5.36 - \ln C_1 \]

\[ \frac{t_1}{\tau_1} = \frac{\ln \left( \frac{10.16}{5.36} \right)}{t_2 - t_1} = \frac{\ln(1.894)}{10.16 - 5.36} = 0.639 \text{ sec}^{-1} \]

\[ C_1 = 10.16 e^{t_1/\tau_1} = (10.16)(1.894) = 19.25 \]

\[ \frac{t_0}{\tau_1} = \frac{1.639}{1.084} = 1.50 \]

\[ \tau_1 = 10.565 \text{ msec} \]

\[ \tau_0 \]

\[ \frac{13.5 - 8.15}{10.16} = 5.71 \]
\[ St = \frac{C_0/e^{-t/\tau_0} + C_1/e^{-t/\tau_1}}{C_0 + C_1} \]

If we have \( C_0, C_1, \tau_0 \) & \( \tau_1 \), a preliminary estimate of \( \tau_1 \) can be made:

\[ \tau_1 = \frac{C_1 e^{-t/\tau_1}}{(C_0 + C_1) St - (C_0/e^{t/\tau_0})} \]

Let \( V(t) = e^{-t/\tau_0} \), then

\[ e^{-t/\tau_0} = \frac{(V(t) - C_0 e^{-t/\tau_0})}{V(t) - C_0 e^{-t/\tau_0}} \cdot \frac{1}{C_1} \]

\[ \frac{1}{C_1} = \frac{16.35 - 7.32}{5.36} = 9.05 \]

at \( t = 2 \)

\[ V(t) = 72.81 \]
\[ C_0 e^{-t/\tau_0} = 67.645 \]

Here, we have a good estimate of \( C_1 \).
From Eq. 4b for step dimensionality 

for $A/L$ small, get 

$$\frac{C_0}{C_1} = \frac{V_b + (A/L)(V_0 - V_L)}{2(A/L)(V_0 - V_L)} = \frac{1}{2} \left[ 1 + (\frac{A}{L})\frac{V_L}{V_0 - V_L} \right]$$

for $A/L = \frac{1}{2}$, get 

$$\frac{C_0}{C_1} = \frac{V_b + (A/L_2)(V_0 - V_L)}{2 \left( \frac{V_0 - V_L}{V_0 - V_L} \right)} = \frac{1}{4} \left[ \frac{V_L}{V_0 - V_L} \right]^2$$

$$= 0.785 + \frac{1.57 V_L}{V_0 - V_L}$$

Continue Case for $A/L$ small get same as above

for $A/L = \frac{1}{2}$, get 

$$C_1 = \frac{1}{2}(V_0 - V_L)$$

$\frac{C_0}{C_1} = 1.0 + \frac{2V_L}{V_0 - V_L}$

Exponential Case

see pp. 83 and 84

for $A/L$ small get same as above

for $A/L = \frac{1}{2}$ get 

$$C_0 = V_b + (V_0 - V_b)(\frac{1}{2})(1 - 0.1353)$$

$$= V_b + (V_0 - V_b)(0.43235)$$

and 

$$C_1 = \frac{V_0 - V_b}{1 + (\frac{V_L}{V_0 - V_L})^2} = \frac{V_0 - V_b}{3.0467}$$

$$V_b = \frac{V_L - 0.135 V_0}{V_0 - V_L}$$

$$\frac{C_0}{C_1} = 1.5 + \frac{3.47 V_b}{V_0 - V_L}$$

$$= 1.5 + \left( \frac{3.47(V_L - 0.135 V_0)}{V_0 - V_L} \right)$$

for $\frac{1}{A} = 10$, get 

$$\frac{C_0}{C_1} = 0.5 + 0.5(\frac{V_L}{V_0 - V_L})$$

$$\frac{(V_0 - V_L)}{V_L} = \frac{5}{\frac{C_0}{C_1} - 0.5}$$

for $\frac{1}{A} = 2$, Concave Case

$$\frac{V_0 - V_L}{V_L} = \frac{2}{\frac{C_0}{C_1} - 1}$$
To summarize previous page.

Best fit to published points seems to be \(83.77e^{-t/4.2} + 16.23e^{-t/1.75}\).

However, if neglect volume at \(t=0\) as unreliable & take slope at \(t=1\) msec
gote almost the same, and if take slope = 0.1635 at \(t=2\) msec
get \(C_1 e^{-t/1.2} = 30 e^{-t/1.65}\).

Whereas, if take only the two points at \(t=1\) msec & \(t=2\) msec
(about) somewhere between

got \(C_1 e^{-t/2} = 19.25 e^{-t/1.565}\).

Thus \(\frac{C_0}{C_1}\) ranges from \(\frac{1635}{8377} \approx 0.194\) to \(\frac{30}{8377} \approx 0.0036\) to \(\frac{5}{3}\).

V/c1 ranges from \(5.26\) to \(8\).

Comparing page 43, this lies between \(\frac{3.47}{10.97}\) for \(L=2\)
for \(L=1\).

Read at p. 78 a (75) for \(\frac{L}{2} = \frac{1}{2}\),
\[\frac{C_0}{C_1} = \frac{5}{50} = 1, \quad \frac{C_0 - V_c}{C_1} = 1, \quad \frac{C_0}{C_1} = 1 + \frac{V_c}{C_1}\]

\[C_0 = 5 \text{ gives } \approx 1 \text{ for } \frac{V_c - V_r}{V_c}; \quad \frac{C_0}{C_1} \approx 3 \text{ gives } \approx 2 \text{ for } \frac{V_c - V_r}{V_c}\]

\[\frac{C_0}{C_1} = 5 \text{ gives } \approx \frac{1}{2} \text{ for } \frac{V_c - V_r}{V_c}; \quad \frac{C_0}{C_1} \approx 3 \text{ gives } \approx 1 \text{ for } \frac{V_c - V_r}{V_c}\]
11/17/65

Better notation

\[ U = C_1 e^{-t/\tau_0} \]
and

\[ h = \frac{1}{t/dt (\ln V)} \]

Then

\[ h = \frac{1}{V} \left[ \frac{U}{\tau_0} + \frac{(V-U)}{\tau_1} \right] \]

\[ \tau_1 = \frac{-hV - U}{V-U} \]

If \( U = C_0 e^{-t/\tau_0} \) and \( V = U + C_1 e^{-t/\tau_1} \)

Text could read: It is well known that \( \ln (V-U) \) vs \( t \) has a slope \(-1/\tau_1\).

This is basis for "peeling exponentials"

However, suppose we know \( U \) and we know \( h = \frac{1}{t/dt (\ln V)} \)

Can we get \( \tau_1 \) from this? Answer is yes, if we know one \( V \)

\[ \frac{dV}{dt} = \frac{-U}{\tau_0} - \frac{(V-U)}{\tau_1} \]

\[ h = -1/t \ln V = \frac{1}{V} \frac{dV}{dt} = \frac{1}{V} \left[ \frac{U}{\tau_0} - \frac{(V-U)}{\tau_1} \right] \]
\[(V_m) = \frac{20.5}{\varepsilon} \]

655.526 has been marked as not correct.

Resubmit 11/19/65
11/18/65 Computations, refer book top p. 110

652.002 too many parameters, request book to 10 cph

652.003 aim is to get 8 th, 9 th, & also values at T = 1/0 for F E in future runs.

654.525 Transient C fit. There was a card misprinted & Susa's attempt to repair also goofed on remount with correct card.

654.527

655.566 Transient C fit, needs longer time factor, ran out at T = 0.418 because initial G = 300

655.565 with G = 200 ran out at T = 1.66

655. note G = 200 gave -.03792 at T = .66

656. G = 300 gave -.04042 at T = .70

656. need to fiddle with time factor & put data point at .70

556.511 Short Chain fit E = 12.40 min
transient C

556.410 setup for E = 4 min

656.513 using E = 12.4 min

also delete cph 21 manually

add cph 2, 3, & 4 for T = 1/0
data point

also, call for steady state inflow to 1.0

for future runs.
11/24/65

6520222B
Steady State Values
- 0.25534
- 0.18555
- 0.15439
- 0.12940
- 0.10959
- 0.094165
- 0.082505
- 0.074145
- 0.068750
- 0.0661062

Wrong Data Used

65202222A
Steady State Values
1. 0.2744
2. 0.2054
3. 0.1709
4. 0.14322
5. 0.1213
6. 0.10422
7. 0.0913
8. 0.0821
9. 0.0761
10. 0.0732
11/19/65  Exp. Neural galley proofs arrived yesterday

essentially o.k. - need to correct some references.

652.003  Step C with inflow rate = 2.0

<table>
<thead>
<tr>
<th>Step</th>
<th>Stability State Values</th>
<th>V at T=1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.37710</td>
<td>0.29992</td>
</tr>
<tr>
<td>2</td>
<td>0.31218</td>
<td>0.23535</td>
</tr>
<tr>
<td>3</td>
<td>0.25975</td>
<td>0.18360</td>
</tr>
<tr>
<td>4</td>
<td>0.21771</td>
<td>0.14248</td>
</tr>
<tr>
<td>5</td>
<td>0.18438</td>
<td>0.11024</td>
</tr>
<tr>
<td>6</td>
<td>0.15843</td>
<td>0.08542</td>
</tr>
<tr>
<td>7</td>
<td>0.13881</td>
<td>0.06689</td>
</tr>
<tr>
<td>8</td>
<td>0.12474</td>
<td>0.05375</td>
</tr>
<tr>
<td>9</td>
<td>0.11567</td>
<td>0.04534</td>
</tr>
<tr>
<td>10</td>
<td>0.11122</td>
<td>0.04125</td>
</tr>
</tbody>
</table>

Compare with pp 107-108 for different inflow rate. Seems to agree, as it should.

Setup 652.222 with \( \lambda_{0,2} = 4.204 \)

FIC as above for \( T=1.0 \)

Fine range changed.

Use \( \lambda_{13,12} = 4.204 \)

652.242

prim TIC, restore \( x_{g2} \) to 1.0

with contained fine tuning.

\( \sqrt{x_{13,2}} = 0 \)
at $T=20$

\[
\begin{align*}
\text{ctf 1} & = 310717 \\
\text{ctf 6 gpm} & = 310717 \\
\text{diff} & = 621434 \\
\text{ctf 17} & = 310717 \\
\text{ctf 11} & = 316366 \\
\text{ctf 18} & = Q_u - Q_{17} = 0.005649
\end{align*}
\]
656.514  11/22/65 results

Control with $E_C = 0$ in eq. 22

This set $E_C = 0$

gives purely 6 perturbation
See if eq. 18 comes out the same

Yes it does, see left
11/19/65
655.567 Transient J fit \( J = 900 \text{ m}^3 \) is not enough for \( \gamma_p = -0.05 \text{ m} \)

Setup 655.510
655.526
fit \( J \) in Yef. 1 at \( T = 0.26 \)
resubmitted at some time

654.527 Square J fit successful \( J = 15.338 \text{ m} \)
for \( \gamma_p = -0.05 \text{ m} \)
at \( T = 0.26 \)

654.510

11/22/65
setup 654.120

656.514 Threechain trans & control agreement with 573

656.411 Shortchain fit \( E = 7.373 \text{ m} \)
to make \( \gamma_p \) peak = 0.1 m
at \( T = 0.80 \)

652.222 Step C, Square G. using I. C. 
error due \( \Delta \gamma_p \)
set to \( E \) instead of \( E + 1 \)
in future use \( \gamma_{13,4} = E \)

655.526 transient G fit \( J = 20.46 \text{ m} \)
to make \( \gamma_p \) peak = -0.05 m
at \( T = 0.27 \)

655.510 \( J = 14.83 \text{ m} \) peak occurs at \( T = 0.20 \)
654.570 square fit

need to fit at $T = 0.25$

Need to setup

$654.511$ fit at $T = 0.25$

$655.511$ fit at $T = 0.20$

Still need to corrected $652.0222$ + others

652.0222 B

556.310

656.410

self agree ICC concept to $F = 1.0$

Call for steady state answers also.

no become from G.
11/23/65

Setback 654.120 Square fit \( E = 1.9191 \)

to make \( C \) = 0.1 \( m \)  \( \text{ at } T = 0.26 \)

654.511 Square fit \( J = 9.8973 \text{ in } 0 \)

to make \( C \) = -0.05 \( \text{ in } 0 \)  \( \text{ at } T = 0.25 \)

655.511 Transverse fit \( J = 13.865 \text{ in } 0 \)

to make \( C \) = -0.05 \( \text{ in } 0 \)  \( \text{ at } T = 0.20 \)

\( \sqrt{\text{Setup 654.130}} \)

\( \sqrt{654.110} \)

\( \sqrt{655.110} \)

\( \sqrt{655.530} \)

\( \sqrt{652.242} \)
652.003 Control Values in

\[ T = 1.25 \]

\[ \frac{0.24}{0.317645} = 0.318270 \]
\[ \frac{0.32100}{0.269439} = 0.47545 \]
\[ \frac{0.047545}{0.048831} = 0.97595 \]

\[ \begin{align*}
1.26 & = 318896 \\
1.28 & = 320117 \\
1.30 & = 321309 \\
1.29 & = 275222 \\
0.27632 & = 0.044984
\end{align*} \]
11/24/65 d 11/26

finished with engineers proofs, wrote Academic Press and Wurtele. Also did refereeing got for Wurtele.

11/26/65 Got book.

556.310 short chain fit was at \( T = 0.80 \) but should have been \( T = 0.56 \)

\( \sqrt{\text{setup} 556.311} \)

652.222 B O.K. See book to page 124, where st. st. values are written down.

\( \Delta \) = 0.12176

\( \% \) decrease is \( \frac{12.176}{37710} \) = 32.3%

in opt. 1 perturbed steady state value = 0.25534
compared with control 0.37710

transient \( \Delta \) due to perturbation is 0.26943 at \( T = 0.25 + 1 \)
0.276325 at \( T = 0.30 + 1 \)
0.269627 at \( T = 0.26 + 1 \)

\( \text{steady dip} \% \) is \( \frac{4.927}{3189} \) = 15.45%

\( \sqrt{\text{setup} 652.262} \) with \( \chi^{2}_{13,6} = 31.1 \)

656.410 Three charts, stop C, times G. Starting chart for these

peak distortion (at \( T = 0.80 \)) was 2.34%
11/29/65  Taking Stock of Computations (using charts)

Square E with peak = 0.2 (654.200 series) Have 2, 4, 6, 8; need 1, 3 + 8
I Step distortion by these (652.200 series) Have 2, 4, 6; need 1, 3 + 8

Square E with peak = 0.1 (654.100 series) Have 1, 2, 3, 4, 6, 8; need 10
I Step distortion by these (652.100 series) need all 4, 6, 1, 3
(heartbreaks, though)

Square J with peak = -0.05 (654.500 series) Have 1, 2, 4; need 3 + 8
I Step distortion by these (652.500 series) need all 4, 1

Transient E with peak = 0.10 (655.100 series) Have 2, 4, 6, 8, 10; need 1 + 3
I Step distortion by these (653.100 series) need all 1, 3

Transient J with peak = -0.05 (655.500 series) Have 1, 2, 3; need 4 + 6
I Step distortion by these (653.500 series) need all 1, 3

Square E on top of steady state hyperbol (654.108 series) need 1, 2, 3, 4, 6

Short chain, transient E with peak = 0.1 (556.000 series) have 3, 4, 5; need 1 + 2

Three chain series: step E, trans E (656.010 series) have 4 + 5; need 1, 2 + 3

Other parameter that could be changed is Rij, determining chain length.
Other possible change is square E duration & trans. E duration.
654.130 Square G fit \( E = 2.9328 \text{ in} \) to make
\( \text{eps}_{\text{pulldown}} = 0.10 \text{ in} \) \( \text{1 at } T = 0.29 \)

654.110 square \( E = 1.265 \text{ in} \) \( \text{in to make} \)
\( \text{eps}_{\text{pulldown}} = 0.10 \text{ in} \) \( \text{1 at } T = 0.25 \)

655.110 Transient G-fit plot \( E = 1.7614 \text{ in} \)
\( \text{for } \text{eps}_{\text{pulldown}} = 0.10 \text{ in} \) \( \text{1 at } T = 0.22 \)

655.530 \( j = 34.58 \text{ in} \)
\( \text{for } \text{eps}_{\text{pulldown}} = 0.05 \text{ in} \) \( \text{1 at } T = 0.35 \)

652.242 Step C. Square G
\( E = 10.59 \text{ in} \)

\[ \begin{array}{c|c|c|c|c}
\text{st. st, central} & 0.37710 & 0.31889 & 0.32130 & 0.32361 & 0.32580 \\
\text{st. st. with pert.} & 0.27426 & 0.29306 & 0.29200 & 0.29317 & 0.29570 \\
\Delta = 0.10284 & 0.25532 & 0.29301 & 0.30436 & 0.30908 \\
\end{array} \]

1.32 \( \) 1.36
\( \) 0.322474 \( \) 0.324723
\( \) 0.292358 \( \) 0.294327
0.030116 \( \) 0.030396

\( 27.3\% \)
\( 9.40\% \)

Setup \( \sqrt{655.111} \) with \( E = 1.75 \) zeros iterations due to time.
\( \sqrt{655.130} \)
\( \sqrt{654.118} \) ops Square on top of steady state
\( \sqrt{654.138} \) hypergal.
\( \sqrt{654.210} \) \( \sqrt{652.162} \)
\( \sqrt{654.230} \) \( \sqrt{652.142} \)
11/29/65 late in day, got code

652.262 StPc square B

T = 1.48  1.50  1.52

StSt. control Ball 37710  330881  331828  332754 (652.003)

StSt. with fret 30033  311977  312871  313807

Δ = 0.07677  0.018904  0.018957  0.018947

20.3%  5.72%  4.13%

556.311 Short chain fit

E = 4,1316 in (3)
to make $\epsilon_{sp}\approx 0.010$ in (1) at $T = 0.56$

Setup + part = 556.210

656.310 Short chain fit

3 chains
12/11/65  Got back 10 decks & adjust

654.230  errorsens 200 cards
654.210  errorsens to card
654.118  Square G PHUSC. St.St. hyperpol. epp peak = .1377
654.138  

setup 654.128
654.168

Need to measure changes in slope etc.

556.210  short chain TRNSG fit  E = 2.1086 m ② of force
to make epp = 0.1 m ① at T = .40

setup 556.110

656.310  Three chains, StpC, TRNSG. with E = 4.1316 m ③
gap peak distortion = 3.63% setup 656.210

652.142  StpC, Square G with E = 4.409 m ④

St. st. Control ① .37710 .323612
St. st. with pert  .31175 .308443
.06535 .015169
17.3% 4.7%

setup 652.542

652.162  E = 9.677 m ⑥

Control
with pert.
.37710 .32362
.05348 .009414

Setup 652.512
14.2% 2.84%
12/1/65

655.130 TRNSG

E = 3.5467 m 

\( t \approx 0.1 \) at \( T = 0.36 \)

655.111 TRNSG

\( t \approx 0.75 \) m 

\( t \approx 0.1 \) at \( T = 0.22 \)

Setup 653.132 TRNSG

Note:

Setup 653.112

12/2/65

No computer output - NBS computer was down.
However got my ten decks of cards back.
So decided to have them duplicated.
Just now completing interpreting these cards.
Now can setup new runs for QAM tomorrow.

Need To

Set up

652.112
652.212
652.323
652.132
653.532
653.512
655.540
655.560
654.148
654.188
654.110

658.650 service leading 655

Need a new condenser in 704.
654.128 Square G on steady state hyperbol. $Q_{ll} = 1.312$ at $T = 0.26$
agrees with 1.312 from plot (2)

654.230 Square C fit: $E = 7.000$ in $\Theta$ to make $\epsilon_{app} = 0.2$ in $\Theta$ at $T = 0.29$

656.110 Short chain fit -未 judged peak time: $T = 0.25$
$E = 1.0$ in $\Theta$ given peak $= 0.958644$ at $T = 0.26$
$E = 1.2483$ in $\Theta$ at $T = 0.25$

Estimate $E = 1.047$

654.210 Square G fit: $E = 2.763$ in $\Theta$ to make $\epsilon_{app} = 0.2$ in $\Theta$ at $T = 0.25$

654.168 Square G on steady state hyperbol $Q_{ll} = 0.11587$
at $T = 0.51$
agrees with 1.1584 from plot (6)

656.210 Three chains with $E = 20.1086$ in $\Theta$

peak $Q_{ll} = 0.077468$ at $T = 1.40$
peak $Q_{ll} = 0.2933$ at $T = 1.40$
5.96% distortion

652.542 Step $C$, $\delta = 79.23$ in $\Theta$

stir, central: 37710
stir, with part.: 21748
15962

$144$
\[ T = 1.16 \]

\[ \text{24 3407} \]
12/3/65

652.510

\[ j = 9.897 \text{ in} \]

\[ \text{st.st. control} = 0.37710 \]

\[ \text{perf} = 0.13157 \]

\[ \text{control} T = 1.26 \]

\[ \text{perf} T = 0.318270 \]

\[ \text{part} = 0.161437 \]

\[ \text{part} \times 0.24553 = 0.576333 \]

\[ 65.1\% \]

\[ 49.2\% \]

653.132

\[ \text{tensile strength} = 3.5467 \text{ in} \]

\[ T = 1.26 \]

\[ \text{control} = 3.18896 \]

\[ \text{perf} = 3.01347 \]

\[ 0.97549 \]

\[ 5.5\% \]

653.112

\[ \text{tensile strength} = 1.753 \text{ in} \]

\[ T = 1.22 \]

\[ \text{control} = 3.16363 \]

\[ \text{perf} = 2.85298 \]

\[ 0.031165 \]

\[ 24.8\% \]

\[ 9.84\% \]
late 12/3/65

There elevendoaks meeting
9 AM
12/6/65

652.282
652.712
652.158
already home

655.128
655.168
653.172
653.162
652.122
652.212
652.522

653.122
653.142
652.232
655.550
eleven doors
12/3/65

Setup

These four were picked up in the afternoon of 12/3/65

\[ \sqrt{556.110} \text{ return with test } T = 0.25 \]

\[ \sqrt{656.110} \]

\[ \sqrt{657.282} \]

\[ \sqrt{654.530} \]

\[ \sqrt{654.560} \]

Refer back to page 135 & update.

654.200 Square E (peaks = 2) Home 1, 2, 3, 4, 6, 8 (10 too much)
652.202 Step C distortion Home 2, 4, 6; need 1, 3 & 8

654.100 Square E (peaks = 1) Home 1, 2, 3, 4, 6, 8, 10
652.102 Home 1, 3, 4, 6 need 2, 8, 10

654.500 Square J (peaks = 0.05) Home 1, 2, 4, put in 3, 6
652.502 Home 1, 4, need 2, 3, 6

655.100 Transient E (peaks = 2) Home 1, 2, 3, 4, 6, 8, 10
653.102 Home 1, 3; need 2, 4, 6, 8, 10

655.500 Transient J (peaks = 0.05) Home 1, 2, 3, 4, 5 need 6?
653.502 Home 1, 3; need 2, 4, 6

654.108 Square E upon steady state hyperpol. Home 1, 2, 3, 4, 6, 8

656.000 Slow chain Trans E with peak (0.01) Home 1, 2, 3, 4, 5

656.000 Three chain, home 2, 3, 4 (put in 1)

655.108 Trans E upon steady state hyperpol. Need all 2, 6
12/6/65

Discovred erroneous 704 card in decks that were recently used for 654.0230, 654.530
654.110

Got both four decks this morning, without output.
Put in

654.111 with 704 correct
654.530

Output due today was not brought by messenger.
Phil Nelson called — we will get together Wednesday.

Take stock of present charts & plots. Have 9 charts + 2 summary plots.

654.01 Plot Summary: @ 10% to 90% of peak DT shows artificial flatness
b) rising half way to falling 1/2 way shows steep rise/overlap,
3) at rising halfway shows artificial flatness after fall.
Compared 12 was not handled correctly.
12/6/65 3:20 PM, finally got broke computer output
Four from 12/3/65 (see p. 146 gram)
Eleven from This money p. 145

556.111 Short Chain fit \( E = 10.04558 \) in O
\( \) gives ysp p peak = 0.10 at \( T = 0.25 \)

656.110 Three chains t. Used \( E = 1.047 \) which agrees 1 ppm thermal
\( \) peak \( P_{18} = 0.0277913 \) at \( T = 1.25 \)
\( P_{11} = 0.284706 \) at \( T = 1.25 \)
9.76\% distortion

Kappa #1 was too big, for prettier plot. Could see with
sweller Kappa & also with inflow to get stp

654.560 error in I.C. in 12 should be -0.1
redo submit with this fixed

654.561

654.530 load errorsnone irony card
Correction has already been submitted earlier today

652.282 Step C, Square \( E \) peak = 300. \( T = 1.74 \)
Step 1 37710
Step 2 32488
.05222
13.9\%
.012752 3.73\%

655.128 TRANS G 6 on st st. C0
\( P_{11} \) peak = .03124 \( \) at \( T = .29 \)
\( \) Not what expected
655.168 TRANS G oz ST. distr. pot = 1.15843
peaks Q1 = 0.0158636 at T = 1.62
min Q1 = -0.361236 at T = 1.62
Same pricing result
Computation 12 was not handled correctly.
Must resubmit with new data.

653.162 Step C: trans E peak = 9.862 m in 6
end step 6.3771
peak shift 0.32
40718
18.7%

653.162 Step C: trans E peak = 2.65 m in 2
end step 0.3771

653.142 Step C: trans E peak = 5.01 m in 4
end step 0.3771

652.137
652.522 \theta = 15.338 \text{ in.}^2

\begin{align*}
\text{St. St.} & : 0.3771 & T = 0.26 & 0.318896 & 1.26 \\
 & : 0.1629 & & 0.194971 \\
 & : 0.2142 & & 0.123928 \\
\end{align*}

\text{56.8\%} \quad \text{38.9\%}

652.232 \quad \text{used incorrect } \theta = 7.00

\text{value from 654.230 which had typo}

652.212 \theta = 2.763 \text{ in.}^2

\begin{align*}
\text{St. St.} & : 0.3771 & T = 0.25 & 0.318270 \\
 & : 0.2479 & & 0.255775 \\
 & : 0.2192 & & 0.062495 \\
\end{align*}

\text{34.3\%} \quad \text{19.6\%}

653.550 \quad \text{TRANS I fit } \eta = 146.47 \text{ in.}^3

\begin{align*}
\text{d.f.} & : 0.3771 & T = 0.36 & 0.324723 \\
 & : 0.18387 & & 0.228164 \\
 & : 0.19423 & & 0.096559 \\
\end{align*}

\text{51.6\%} \quad \text{29.8\%}

653.532 \quad \eta = 34.58 \text{ peak in} \text{ in.}^3

652.132 \theta = 269.33 \text{ in.}^2

\begin{align*}
\text{St. St.} & : 0.3771 & T = 0.28 & 0.320117 \\
 & : 0.3078 & & 0.280850 \\
 & : 0.0693 & & 0.019267 \\
\end{align*}

\text{18.4\%} \quad \text{6.2\%}
Still to do

654.1 10 w is in
654.2 10 put in when done returns
654.5 3+6 are in, consider 5, 8, 10

652.1 need: 4, 6, 8, 10

652.2 need: 3

652.5 vs 3, 6?

654.0108 complete

655.1 100 complete
655.5 try 5+6

656, Complete except for cosmetics & stuff

653.1 need: 4

653.5 need: 2, 4

653.162

653.522
653.542
653.552
12/6/65

652.112

E = 1.265 mi ①

T = .25

318 270

287 052

031 218

19.25%

90.8%

653.512

Jpeak = 13.666 mi ①

T = .20

3771

.315 050

.159 512

155 538

72.4%

49.4%

654.188

E = 18.498 mi ⑧

Upon st. st. hyperpl.

Q11 = .112 at T = .77
drumpot = 1.125

654.148

E = 4.409 mi ④

1.2177

Q11 = .12176 at T = .35

654.110

Error was made, already resubmitt

655.540

Found Jpeak = 72.24 mi ④

Makes ⑦ Jpeak = .05 mi ①

at T = .445

652.122

E = 1.919 mi ①

T = .26

3777

3058

10713

318 896

294 291

024 605

18.9%

77.72%
More generalizations, for a given epsp peak amplitude & location of perturbed compartment, the square part requires smaller E than does the TRNS part, for location 1-6 and reverse, p284/10

<table>
<thead>
<tr>
<th>No</th>
<th>10 epsp peak</th>
<th>TRNS factor</th>
<th>Time (ms)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.265 ± .2</td>
<td>1.75 ± .2</td>
<td>.723</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.919 ± .2</td>
<td>2.50 ± .4</td>
<td>.768</td>
<td>Early effect due to square pulse packing in more current</td>
</tr>
<tr>
<td>3</td>
<td>2.933 ± .5</td>
<td>3.546 ± .8</td>
<td>.828</td>
<td>early</td>
</tr>
<tr>
<td>4</td>
<td>4.409 ± .5</td>
<td>5.01 ± .9</td>
<td>.886</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>9.677 ± 1</td>
<td>9.862 ± 1</td>
<td>.98</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>18.498 ± 1</td>
<td>17.07 ± 1.4</td>
<td>1.085</td>
<td>Late effect due to better temporal summation of less intense, longer lasting change.</td>
</tr>
<tr>
<td>7</td>
<td>33.64 ± 1.6</td>
<td>1.63</td>
<td></td>
<td>Useful to compare peaks depicting in the pert. epsp.</td>
</tr>
</tbody>
</table>

Product that is close to perturbations, add with equal areas.

Sharpest will be most effective near soma, slowest will tend to be most effective in periphery.

Square one has features of sharpness (steadiness, absence of tail).
12/7/65

What kinds of generalizations are possible now?

Given Square $E$ of standard $\frac{1}{4}$ duration at various locations.

\[
\frac{dV}{dt} \text{ at rising halfway ranges from } 0.44 \text{ to } 0.28 \text{ from } 1 \text{ to } 8
\]

for (0.10) less then factor of two

want to express as

\[
\frac{dV}{dt} \left( \frac{1}{V} \right) = \frac{0.44}{(0.1)^5 \text{ sec}} \approx \frac{1}{\text{sec}} \text{ per sec}
\]

to \( \frac{1}{2} \) per sec

\[
654.1 \text{ series } \frac{0.95}{2(5)} \approx 1 \text{ per sec} \text{ to } \frac{0.94}{2.5(5)} \times \frac{1}{2} \text{ per sec}
\]

\[
654.2 \text{ series } \frac{0.32}{0.05(5)} \approx 1.2 \text{ per sec}
\]

\[
654.108 \text{ series } \frac{0.62}{0.1(5)} \approx 1.2 \text{ per sec}
\]

\[
655.1 \text{ series } \frac{0.76}{0.01(5)} \approx 1.5 \text{ per sec}
\]

\[
655.05 \text{ series } \frac{0.79}{0.05(5)} \approx 2 \text{ per sec}
\]

For particular TRNS used

\[
B = ae^t e^{-at}
\]

\[
B = \frac{e^2}{\Delta t} t e^{-\frac{t}{\Delta t}}
\]

or

\[
B = a e^t e^{-at} = a e t (1 - at)
\]

See pp 23-28

with area under curve $= \Delta T = \frac{a}{\Delta t}$

if peak is to be 1, then $B_0 = e^t$, $a = \frac{e}{\Delta t}$

\[
\Delta t = \frac{\Delta y}{e^{0.23576}} = 1.25 \text{ sec}
\]

\[
a = \frac{2.5175}{1.25} \approx 2.0175 \text{ per sec}
\]

So, there been using

\[
\frac{E_{max}}{E_{max}} = 5.91 e^{-\frac{t}{1.0175}}
\]

where $t$ is expressed in sec.
St. St.

No. here 175% increase of $G_s$

causes 33% increase of $G_N$

or 25% decrease of $R_N$

Transient decrease $\Rightarrow$ peak distortion $\approx 10\%$

see 653.112 on page 146
12/7/65  got back two outputs, both incorrect pp 148

\[ 654.531 \text{ found } J = 28.424 \text{ m^3} \]
\[ \text{ to make volume } = 0.05 \text{ m}^3 \text{ at } T = 0.28 \]

\[ 654.111 \text{ found } E = 50 \text{ m} \]
\[ \text{ almost enough for } \]
\[ d_{sp}=0.1 \text{ m} \text{ at } 0, \text{ actually } 0.9096 \]
\[ \text{ at } T = 0.89 \]

Setup
\[ 654.231 \]
\[ 652.532 \]
\[ 654.112 \text{ opt 10} \]
\[ 652.102 \text{ opt 10} \]
\[ 656.111 \]

\[ \text{ From current stop control } 652.003, \text{ can compute} \]
\[ \text{ that } \rho = 4.3 \]

\[ \text{ s.t.} \]
\[ \text{ curve from 0 to } 2 \propto 25 (0.3771 - 0.3122) = 1.62 \]
\[ \text{ s.t. curve from 0 } \propto 0.3771 \]

\[ \rho = \frac{1.62}{0.3771} = 4.3 \]

\[ \text{ Add steady } E = 1075 \text{ to 10} \]
\[ \text{ G}_{\text{w}} \text{ goes from } 5.3 \text{ GSR to } (5.3 + 1.75) \text{ GSR} \]
\[ \% \text{ increase of } G_{\text{w}} \text{ is } \frac{1.75}{5.3} = 33\% \]

\[ \% \text{ decrease of } P_{\text{N}} = \left( \frac{5.3 - 7.03}{5.3} \right) \times 100 = \frac{18.85 - 14.2}{18.85} = 24.7\% \]

Which agrees with 24.8% originally obtained
from the steady state values in 10, with/without pert.
2nd chart was based upon 655.110 with faint sketch of 684.110

\[ E = 34 \]

\[ E = 35 \]

\[ \frac{\Delta V}{\Delta t} (\text{instantaneous}) = 2.0 \]

for \( E = 4 \text{ mV} \), \( \frac{1}{V_{\text{max}}} \frac{\Delta V}{\Delta t} = 0.5 \text{ mV/sec}^{-1} \)

for \( E = 70 \text{ mV} \)

\( V_{\text{max}} = 7 \text{ mV} \)

\[ \frac{\Delta V}{\Delta t} = 3.5 \text{ mV/sec} \]

approx 4 that forgot in 1
12/7/65 Prepared to see K. Phil and Bob Bruce tomorrow.

Have 10 charts:
1. 654.1, 654.2, 654.5, 654.108
2. 652, 652.206, 655.1, 655.5, 656, 653.

Two plots (654.1 and 655.1 on small graph paper)

One yellow sheet covering pcalc at bottom of p. 160

Two large graphs traced from computer listings.

One presents 654.11 and 655.11 on common time + amplitude scales, comparing both E and dt.

Also the following numbers:

\[ \frac{dE}{dt} \]

Square E 7.6

Trans E 4.3

\[ \text{for } t = 4 \mu\text{sec, } \frac{dE}{dt} = 11.1 \text{ mV/\musec} \]

\[ \text{for } E_2 = 70 \text{ mV, } \frac{dE}{dt} = 7.7 \text{ mV/\musec} \]

Important to compare these with crypt.

Also \( t/e \) at 10% of max, 90%:

- \( t/e \) at 10% of max:
  - \( t = 4 \mu\text{sec} \)
  - \( t = 4 \mu\text{sec} \)
  - 0.009
  - 0.04 \mu\text{sec}
  - 0.023
  - 0.1 \mu\text{sec}

- \( t = 4 \mu\text{sec} \)
  - 0.206
  - 0.82 \mu\text{sec}
  - 0.146
  - 0.6 \mu\text{sec}

- \( t = 4 \mu\text{sec} \)
  - 0.197
  - 0.8 \mu\text{sec}
  - 0.123
  - 0.5 \mu\text{sec}

Delta t/e from 10% to 90%:

- \( t = 4 \mu\text{sec} \)
  - 0.25
  - 0.22

- \( t = 4 \mu\text{sec} \)
  - 0.24
  - 1.0 \mu\text{sec}
  - 0.20
  - 0.8 \mu\text{sec}

At the end:

- \( t = 4 \mu\text{sec} \)
  - 0.071
  - 0.072

- \( t = 4 \mu\text{sec} \)
  - 0.397
  - 0.598

- \( t = 4 \mu\text{sec} \)
  - 0.326
  - 1.3 \mu\text{sec}
  - 0.526
  - 2.0 \mu\text{sec}
3. Should check for $c = 0.65$ in two funds of series

A. Vary post-location (1 to 5) with constant E shape

B. Keep post-location at 3 say with varying E shape

B.1 Vary TRANS E duration
B.2 Vary square E duration

See if any of these can be ruled out.

4. Try superimposing EPSP on IPSP

A. at same location
B. at different location

Bob finds they often sum surprisingly well.

5. Try superimposing a 1 mV EPSP from post mi

with a 1.5 mV EPSP

A. simultaneous
B. delayed

Bob he has case of this kind which does less than 10%

6. Phil Nelson says for anomalous reef, stimulation attempts 20mV hyperpol causes $R_N$ to be approx halved. Site of conductance change not known
Fruitful meeting with K, Phil & Bob Burke.

1. Their fastest miniature and evolved EPSP seem to be about twice as fast as may result for pert. in E.
   This means that they should try faster transient E.
   Their fastest \( \frac{1}{V_{10}} \) is about 4 usec.

   Their shortest time to peak is about 0.5 usec, generally about 0.3 to 1.5 usec.

2. Bob Burke has been measuring as follows:

   Plot Time to peak versus \( b \).
   \( b + c \) versus \( b \).

   Define \( b = -\frac{V_{\text{max}}}{dt} \).
   Define \( b + c = \text{time to peak from foot intersection} \).
   Which is measured from figure.

   Average slope found to be 1.65.

   This indicates that \( c = (0.65)b \) is a fairly constant characteristic of all his miniature and evolved EPSP curves.
12/8/65 Computer Output for trip 156-156

\[ J = 200 \text{ in} \] is not enough

\[ \text{given } \zeta = -0.03103 \]

\[ \text{peak } \zeta = -0.67344 \]

\[ \text{at } T = 0.49 \]

\( \text{whereas } J = 80 \) given \( \zeta = -0.02708 \) at \( T = 0.0844 \)

\[ 654.560 \text{ TRANS E on StSt. } \]

\[ \text{drum } \zeta \text{ in I is } 1.15843 \]

\[ \text{st } \zeta = -0.323171 \]

\[ \text{peak } \phi_{11} \text{ is } 0.11597 \text{ at } T = 0.62 \]

\[ 655.168 \text{ initial drum } \zeta \text{ in } \phi \text{ is } 1.31218 \]

\[ \text{peak } \phi_{11} = 0.131308 \text{ at } T = 0.29 \]

\[ 655.128 \]

\[ 653.542 \text{ using } J \text{ peak } = 72.024 \text{ in } \theta \]

\[ \text{at } T = 0.44 \]

\[ \zeta = -0.328921 \]

\[ 0.250274 \]

\[ 0.078647 \]

\[ 42\% \]

\[ 23.9\% \]

\[ 653.522 \text{ using } J \text{ peak } = 20.46 \text{ in } \theta \]

\[ \text{at } T = 0.26 \]

\[ 0.28 \]

\[ 0.318896 \]

\[ 0.320117 \]

\[ 0.195319 \]

\[ 0.196308 \]

\[ 0.123577 \]

\[ 0.123809 \]

\[ 38.8\% \]

\[ 38.8\% \]

\[ 655.557 \text{ simulation run with } \] J" = 146.47 in \( \phi \)

\[ \text{Not sufficient} \]

\[ \text{peak } = -0.0457835 \text{ at } T = 0.56 \]
Plan series based on 536.1
- 6.45
= 625.1
ii = 655.1

But with
\[ A_0 = 5.4366 \]
\[ \lambda_{ij} = 21.748 \]

In transient generator see p. 28

or could use even a little more like
\[ A_0 = 6.0 \]
\[ a = \lambda_{ij} = A_0 / 0.25 = 4A_0 = 24. \]

Then
\[ t^* = \frac{1}{a} = \frac{1}{24} \]

\[ t^* = \frac{1}{25} = 0.04 \]

\[ B^* = \frac{6.25}{2.718} = 2.3 \]

Accuracy at 0.25 is
\[ 1 - \frac{-6.25 \left( 6.25 + 1 \right)}{3} \Delta T \]
\[ \frac{1 - \left( 7.25 \right) \left( .00193 \right)}{3} \Delta T \]
\[ 1 - 0.014 \Delta T \]

i.e. 98.6%
653.162 using $E_p = 9.862$ in $6$

$T = .62$

\[ \begin{array}{c}
\text{st.st.} \\
0.3771 \\
0.3232 \\
0.0539 \\
\hline
14.3\% \\
\text{st. st.} \\
0.3771 \\
0.3117 \\
0.0654 \\
\hline
17.35\% \\
\text{st. st.} \\
0.3771 \\
0.3232 \\
0.0539 \\
\hline
14.2\% \\
\end{array} \]

2.89\%

652.142 using $E_p = 4.409$ in $4$

$T = .342$ in $6$

\[ \begin{array}{c}
\text{st.st.} \\
0.3771 \\
0.3117 \\
0.0654 \\
\hline
17.35\% \\
\text{st. st.} \\
0.3771 \\
0.309553 \\
0.015170 \\
\hline
17.75\% \\
\text{st. st.} \\
0.3771 \\
0.324723 \\
0.015170 \\
\hline
17.68\% \\
\end{array} \]

652.162 using $E_p = 9.677$ in $6$

$T = .50 - .52$

\[ \begin{array}{c}
\text{st.st.} \\
0.3771 \\
0.3236 \\
0.0535 \\
\hline
14.2\% \\
\text{st. st.} \\
0.3771 \\
0.3236 \\
0.009420 \\
\hline
2.83\% \\
\end{array} \]

652.182 using $E_p = 18.498$ in $8$

$T = .76$

\[ \begin{array}{c}
\text{st.st.} \\
0.3771 \\
0.3381 \\
0.0390 \\
\hline
10.35\% \\
\text{st. st.} \\
0.3771 \\
0.336202 \\
0.006224 \\
\hline
1.82\% \\
\end{array} \]
\[ \int_0^{T_f} BdT = aA_0 \int_0^{T_f} e^{-\alpha T} dT = aA_0 \left[ \frac{e^{-\alpha T}}{\alpha^2} (-\alpha T - 1) \right]_0^{T_f} = \frac{A_0}{\alpha} \left\{ 1 - (\alpha T_f + 1) e^{-\alpha T_f} \right\} \]

If \( \alpha = 25 \) and \( T_f = 0.25 \), then \( \alpha T_f = 6.25 \)

And area from \( T = 0 \) to \( T = 0.25 \) equals

\[ \frac{A_0}{25} \left\{ 1 - (6.25 + 1) e^{-6.25} \right\} = \frac{A_0}{25} \left\{ 1 - (7.25)(0.00193) \right\} = \frac{A_0}{25} \left\{ 1 - 0.014 \right\} = 0.986 \left( \frac{A_0}{25} \right) \]

where \( \frac{A_0}{25} \) is total area under curve.
12/9/65 from p. 24, transient femur

\[ B = a^2 \mathbf{T} \mathbf{e} \]

May occur at

\[ T' = \frac{1}{a} \]

\[ B' = \frac{A_0}{a} \]

Area under curve = \[ B' \cdot T' \cdot e = \frac{A_0}{a} \]

Sofar, we have used \[ a = 10.87 \], implying \[ T' = 0.092 \]
\[ A_0 = 2.718 \]
\[ B' = 1.0 \]

and area = 0.25

to agree with square of unit height

Now, we prefer to use \[ T' = 0.04 \], implying \[ a = 25 \]
and we can choose either

\[ A_0 = 2.718 \]

\[ B' = 1.0 \]

area under curve = \[ \frac{2.718}{25} = 0.1088 \]

which is \[ \frac{1}{203} \] of previous area

\[ A_0 = 6.25 \]

\[ B' = 2.3 \]

area under curve equal 0.025, same as before

Choosing This
12/9/65

Setup 546.100 Series

Short Chain TRNS FIT. T* = 0.04

\[ \log_{10} = 2.50 = \log_{10} \]

Setup 546.110

546.120

Setup 646.001 Current Step Control

Just noticed significant point in the 652, 653 & 656 series

for perturbation in compartment

A) pert current EPSP peak = 10\% of drive pot. makes transient distortion = 10\%

B) pert for EPSP peak = 20\%
causes transient dist of 20\%

C) pert for IPSP peak = 50\%
causes transient dist of 50\%

Very simple rule, see if holds for super TRNS.
New look formula that applies to other part site.
Consider three possible indices:

1. Peripheral E value factors
2. "Vpeak"
3. Peripheral systolic values, or T = 1.0

The 653.1, 653.5, 654.1, 654.2, 654.5 series all agree, approx. 79% of part in 1 is 61% in 2 and 48% in 3.

Checkbook on 65.3 sinusoidal current series began 3/30/65.

100 cps × 653 radians per sec ≈ 2.05 per T (of 4 mSec).

Then 3.14

π

2

In 65.300 series, use pts 13 + 14 to generate sinusoidal.

T_{13,14} = 2.5

T_{14,12} = -2.5

T_{0,13} = 2.5 - 1.0 (permitting T_{13,12} = 1.0)

T_{0,14} = -2.5

Start from earlier end values, to approach steady state.
12/9/65

65.311

Setup 65.311

Change 2.5 to 3.1416 = \pi

Then period = 2\pi

Delete plot, but leave in time factor = 8.

Use no Koppas

1.0
200.0
1.0
200.0

5.10
5.05

4.10
20.

for all tests

Purpose is to find the steady state amplitude maximum in the several components. They need to use these results at may T as initial conditions for another run.

656.111 (B) Three Chains Mod 12/9/65

Use of T = 1.0 values as initial values & also calls for T = 1.0 values.

Also put in 654.561

655.553

653.182
653.102

645.120 with T* = .04
12/9/65

652.102

\[ E = 55 \text{ in} \quad 10 \]

\[ \text{really should be } 58.86 \]

\[ T = .88 \]

\[ \begin{array}{c}
\text{set} \\
.33771 \\
.34712 \\
.0299 \\
\hline \\
.346405 \\
.341421 \\
.004984 \\
\hline \\
.449^9 \\
\end{array} \]

652.532

\[ J = 28.424 \text{ in } 3 \]

\[ T = .28 \]

\[ \begin{array}{c}
\text{set} \\
.3771 \\
.1906 \\
.1865 \\
\hline \\
.320117 \\
.222806 \\
.097311 \\
\hline \\
49.4^% \\
30.5^% \\
\end{array} \]

654.112

\[ \text{find } E = 58.8566 \text{ in } 10 \text{ causes} \]

\[ \text{eps p peak = 0.010 in } 0 \text{ at } T = .88 \]

654.231

\[ \text{find } E = 6.6 \text{ in } 3 \]

\[ \text{molex eps p peak = 0.2 in } 1 \text{ at } T = .29 \]
Put in late 12/10/65

546.130
546.140
65.311
646.110
646.120

Monday morning 12/13/65
65.311 Applied Sinusoidal Current Mod.
data exceeded 250 points; did not run.

12/10/65

656.111B Starting with I.C. from previous T = 1.0
Successful & also gets steady state perturbation
E = 1.0456 in ① of short chain
causes TRNS distortion of 9.75% at T = .25
St. St. 26.4%

New Short Chain Series \( T^* = .04 \)
Successful \( a = 25 \)

54.60110 found E peak = 1.751123 in ① of short chain
Causes epSP peak = 0.10 in ① at T = .13

whereas 556.011 value of E = 1.0456 in ①
gives epSP peak = 0.061376

54.60120 found E peak = 4.254545 in ② of short chain
Causes epSP peak = 0.10 in ① at T = .25

whereas E = 2.1086 in ② gives epSP peak = 0.053
Let opt. 16 monitor synaptic current
Then $J_{16, 4}$

Dependence rel.
$J_{16, 12}$
$J_{16, 4}$

Make kappa 16 equal to $14 \times \frac{15}{100}$

Let opt. 17 monitor loss current of part. opt. to neighbors & to latah

Let opt. 18 monitor phasing current at 0

$J_{18, 2} = 25$

$J_{18, 1} = -25$
It might be illuminating, for some of the simulations, to compare the true synaptic current from that artifactually calculated by phery formula, etc. etc.

1. True synaptic current at peripheral location.
2. True current from dendrites to soma.
3. Pseudo current assuming single lumped cell.

Best to do this with the brief transient.

Got back computer output

655.553 needs larger time factor; got up to \( f = 187.968 \) in 10

654.561 needs larger time factor

653.102 opt 10 with \( E = 33.64 \) in 10; \( T = 100 \)

\[
\begin{align*}
\text{control} & : .3771 & \text{opt} & : .349915 \\
\text{pot} & : .3487 & 0.0284 & .005455
\end{align*}
\]

7.53% 1.19%

653.182 with \( E = 17.07 \) in 8; \( T = .86 \)

\[
\begin{align*}
.3771 & \quad .345777 \\
.3390 & \quad .339218 \\
.0381 & \quad .00656 \quad 1.96%
\end{align*}
\]
Anon. Root.

\[ \lambda_{0.4} = 80.23 \] which is supposed to reduce stress 42.9%.

\[ q_{14} = 1 \]

\[ \lambda_{0.13} = 1.265 \]
\[ \lambda_{1.14} = 2.0 \]
\[ \lambda_{0.14} = 2.0 \]
\[ \lambda_{1.12} = 1 \]
\[ \lambda_{0.5} = 1.2 \]
\[ \lambda_{1.3} = 1 \]

Map I.C. 1: 0174844
2: 1461837
3: 0873048
4: 01850643
5: 01567324
6: 01346698
7: 01179939
8: 01060378
9: 009832320
10: 009454154

654.009
654.119
652.542

-2.0
12/13/65

645.120 trans G $T^* = 0.04$
no fitting obtained

however $E = 2.50 \text{ in} \varrho$ with $T^* = 0.04$
gives $Q_{pp}$ peak $= 0.05892$ at $T = 0.16$

Setup 645.121
655.149 $\triangleright$ see p. 181 Monitor Current
655.169
655.554 room with large time factor

645.100 $\triangleright$ seeking peak time
645.180 $\triangleright$ converted 653,000 decks

see p. 163
Setup 655.910 $\triangleright$ TRNS E+J,
655.940

let use

$E_1 = Q_{11} = 0.1 \quad \gamma = \lambda_{0,15}$
$E_2 = Q_{12} = 1.0 \quad \beta = \lambda_{0,16}$

Then $\lambda_{0,11} = \lambda_{15,1} = -\lambda_{0,11} = (\lambda_{0,15}) Q_{14}$
$\lambda_{1,12} = \lambda_{16,1} = -\lambda_{0,12} = (\lambda_{0,16}) Q_{14}$
12/15/65

We are with gastrointestinal virus on 12/14/65

Got back following drink without listing.
The dinks had been put in late 12/13/65

Also got back without dinks, the following listings
that had been put in morning of 12/13/65 (see p. 179)

(12/14/65)

546 140 Short Chain TRNS Fit T* = .04

initial $E = 7.374$ ini $+ 4$ gives upped $E = .05136$

at $T = .64$

peak ini at $T = .2768$
at $T = .11$

found $E = 19.575$
in $+ 4$ makes upped $E = .100565$

at $T = .66$

peak in at $T = .5386$
at $T = .10$

546 130 Initial $E = 4.1316$ ini $+ 3$ gives upped $E = .05056$

at $T = .41$

peak ini at $T = .1696$
at $T = .11$

found $E = 9.5246$
in $+ 3$ gives upped $E = .18094$

at $T = .41$

peak ini at $T = .3343$ at $T = .10$
period $= 2\pi \Rightarrow T = 1.06$ step correspond roughly to half cycle

Actually, quarter cycle might be better

100 cycles per sec $= 628$ radians per sec
$= 6.28$ rad per msec
$\approx 2.5\pi \Rightarrow \pi$ for $T = 4$ msec
$\approx 3.14 \Rightarrow 2\pi$ for $T = 5$ msec

---

Clearly, the stiffness must be smaller

Compressions for $T = 1.0$

<table>
<thead>
<tr>
<th>Value</th>
<th>rel. amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>78.4</td>
<td>74.4</td>
</tr>
<tr>
<td>61.3</td>
<td>55</td>
</tr>
<tr>
<td>47.5</td>
<td>40.7</td>
</tr>
<tr>
<td>36.7</td>
<td>30</td>
</tr>
<tr>
<td>28.5</td>
<td>22.6</td>
</tr>
<tr>
<td>22.3</td>
<td>17.0</td>
</tr>
<tr>
<td>17.9</td>
<td>14.5</td>
</tr>
<tr>
<td>15.1</td>
<td>13</td>
</tr>
<tr>
<td>13.7</td>
<td>12.35</td>
</tr>
</tbody>
</table>
646.120 had a card error, need to be resubmitted.

646.110 Three cleaner, $T^* = 0.04$ with Curr. Step 0
with I.C. comes to $T = 1.0$

import st. in c.p. (1) is 0.3435548
without st. in (1) is 0.2145063
0.1290485 37.5%

peak in (18) = 0.0271983 × 0.0272 at $T = 0.13$
control value in (1) = 0.02766 at $T = 0.13$
distortion is 98.84%.

Plotting scale here worked out quite well.

65.311 Applied Sineonidal Current — Mod (12/3/65)
does not call for plot this time.
period did come out 2π.

<table>
<thead>
<tr>
<th>c.p. No.</th>
<th>Time peak</th>
<th>Value</th>
<th>Final Value at $T = 6.00$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.25</td>
<td>-0.0946717</td>
<td>+0.0704596</td>
</tr>
<tr>
<td>2</td>
<td>5.30</td>
<td>-0.0704230</td>
<td>0.0412380</td>
</tr>
<tr>
<td>3</td>
<td>5.35</td>
<td>-0.0520894</td>
<td>0.0208313</td>
</tr>
<tr>
<td>4</td>
<td>5.45</td>
<td>-0.0385643</td>
<td>0.00726379</td>
</tr>
<tr>
<td>5</td>
<td>5.50</td>
<td>-0.0285512</td>
<td>0.00125572</td>
</tr>
<tr>
<td>6</td>
<td>5.60</td>
<td>-0.0214255</td>
<td>-0.00624141</td>
</tr>
<tr>
<td>7</td>
<td>5.70</td>
<td>-0.0166013</td>
<td>-0.00890328</td>
</tr>
<tr>
<td>8</td>
<td>5.75</td>
<td>-0.0137474</td>
<td>-0.0101573</td>
</tr>
<tr>
<td>9</td>
<td>5.85</td>
<td>-0.0122875</td>
<td>-0.0106523</td>
</tr>
<tr>
<td>10</td>
<td>5.85</td>
<td>-0.0117207</td>
<td>-0.0108001</td>
</tr>
</tbody>
</table>
\[ \int \frac{\cos \left( \frac{2\pi tx}{L} \right) \cosh \left( \frac{L-x}{A} \right)}{\cosh \frac{x}{A}} \, dx \]

\[ \frac{e^{\frac{x}{A}}}{\cosh \frac{x}{A}} \int \cos \left( \frac{2\pi tx}{L} \right) \left( e^{-\frac{xy}{A}} + e^{\frac{xy}{A} - \frac{2x}{A}} \right) \]
11/29/65  Phil mentioned
we will get together next week

rate of rise of eps/dsp with polarizing current

20mV per pot

use 1/3 steering pot
Need to resimulate 654.110 with more time for falling.

Need to apply current step to these now.
Slope of semilog plot.

Because semilog plots are commonly used in the analysis of decay transients, it is important to point out that a sum of exponentials does not, although a single exponential, plot as a straight line. A double exponential, the sum of two exponentials does not plot as two straight line segments.

\[ V = C_0 e^{-t/\tau_0} + C_1 e^{-t/\tau_1} \]

\[ \ln(V) = \ln(C_0 e^{-t/\tau_0}) = \ln(C_0) - \frac{t}{\tau_0} \]

For large \( t \), such that the term \( C_0 e^{-(t/\tau_0)} \) is negligibly small, a plot of \( \ln(V) \) versus \( t \) yields a straight line having a slope of \( -1/\tau_0 \).

For smaller \( t \), a plot of \( \ln(V) \) versus \( t \) is not a straight line, and its slope does not give \( -1/\tau_1 \). The method of plotting, however, if the slow exponential is extrapolated back to small values of \( t \), and these values are subtracted from \( V \), a logarithmic plot of this difference provides a straight line.
The slope is \( -\frac{1}{\tau} \), because

\[
\ln (V - C_0 e^{-t/\tau}) = \ln C_0 - t/\tau.
\]

However, it is possible to

If, however, one wishes to discuss the slope of \( \ln V \) versus \( t \), one can make use of the following:

\[
\frac{d}{dt} (\ln V) = \frac{1}{V} \frac{dV}{dt} = \frac{-C_0 e^{-t/\tau} - (C_1 e^{-t/\tau})}{C_0 e^{-t/\tau} + C_1 e^{-t/\tau}}.
\]

However, it is possible to discuss the slope of a logarithmic plot of a sum of exponentials.

If

\[
V = \sum_{n=0}^{\infty} C_n \exp(-t/\tau)
\]

then

\[
\frac{d}{dt} (\ln V) = \frac{1}{V} \frac{dV}{dt} = \frac{-\sum_{n=0}^{\infty} (C_n e^{-t/\tau}) \exp(-t/\tau)}{\sum_{n=0}^{\infty} C_n \exp(-t/\tau)}
\]

which means that at any time, the slope is a weighted mean of the several \( -\frac{1}{\tau n} \), with weights equal to

\[
W_n = C_n \exp(-t/\tau).
\]
For the particular case of a sum of two exponentials, if the slope is designated \( S \), the slope of \( \ln(V) \) is designated \( S \).

The magnitude of this slope can be expressed as:

\[
R = \frac{1}{\sqrt{\left( \frac{C_0}{C_1} \right)^2 \exp(-\frac{t}{\tau_0}) + \left( \frac{C_1}{C_0} \right)^2 \exp(-\frac{t}{\tau_1})}}
\]

\[
= \frac{1}{\sqrt{U}} 
\]

\[
U = C_0 \exp\left(-\frac{t}{\tau_0}\right)
\]

\[
S = \frac{1}{\sqrt{V}} \left[ \frac{U}{\tau_0} + \frac{V-U}{\tau_1} \right]
\]

\[
\frac{1}{\tau_1} = \frac{SV - U/\tau_0}{V-U}
\]

\[
\frac{\tau_0}{\tau_1} = \frac{KV - U}{V-U}
\]