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Los Alamos Notebook # [illegible].5

Assigned for use in recording Electronic circuits and related data.

Clifford Beck

Begin recording data here

Monday, April 1, 1946 W. J. Leland

Began preparations for experimental work. Journeyed to location where tests were to be made & group discussed overall plans & instrumentation. Recieved a number of circuit diagrams as follows:

1. Pre-amplifier Model 500 Dwg No. 372
2. Pre amplifier Model 100 Dwg. No. 346
3. " " " Chassis Layout Dwg No 346-B
4. " " " Point to Point Diag. 346-A
5. Amplifier Model 100 Dwng No. 366
6. Survey Meter Drawing No. PM 10595
7. Higinbotham Scale of 64 with discriminator P-4 Dwg No 281-B
8. Los Alamos Scale of 64 with discriminator P4 Dwng No. 281 Revised
9. Higinbotham Scaler unit for 6SL7 & 6H6 Dwg No 348
10. Los Alamos Scaler Unit Plate Dwg No 249.01
11. D.C. Amplifier for safety circuit B Dwg No. 242 B01
12. Power supply for DC Amplifier Dwg No. 242 A01
13. Bias Battery Chassis for safety circuit Dwg No 242C01

The instrumentation for the experiments was decided upon as follows:

Two ionization chambers filled with BF_3 to be located around sides of pile to monitor neutrons, giving a continuous reading and affording a visual means of following process readily.

Two proportional counters (Boron lined) to be located under pile to be used for quantitative measurements.

The circuit for ionization chamber is the D.C. amplifier (item 11 page 5)
The circuits for proportional counters are Items 6, 8 + 9 page 5

The ionization chambers were connected up but were found to be inoperative. This was corrected by straightening out cable connections and tightening loose top on resistor in one amplifier. Circuits & chambers were then found to respond satisfactorily to a neutron source.

Wednesday April 3 W.J.L.

One proportional counter circuit was found inoperative. This was corrected by resoldering a loose connection and replacing rectifier tube for high voltage. With both counters operating it was found they were coupled in some manner so that when one circuit was ~~counting~~ the other would count also. This was corrected by increasing the spacing between the electronic units themselves.

Thursday April 4

Experimental work began. Apparatus apparently working satisfactorily. One counter giving rather low count but probably due to unfavorable geometry as regards to source location.

Friday April 5

The ion chamber not responding satisfactorily. Chamber found to be leaky or developing a voltage. New chamber procured and circuit adjusted as to current through filaments. Also additional voltage applied to 1A5 plate + screen to enable 1 μA drain from plate to top. Chamber operating satisfactorily.

April ~~8~~ → April 12.

Spent time in electronics shop talking with Hanes & Watts. Rebuilt laboratory sweep circuit + precision pulser. Arrangements made to obtain model 100 amplifier + preamplifier, model 200 scaler, + model 110 preamplifier.

Monday April 15

Spent more time in electronics shop. Discussed multiple pulse circuits. Obtained circuit diagrams. Also discussed DC amplifier developed in Chicago base on principle of converting DC signal to AC, amplifying, rectifying & feeding back. Reported ultimate sensitivity of 10^{-14} amperes.

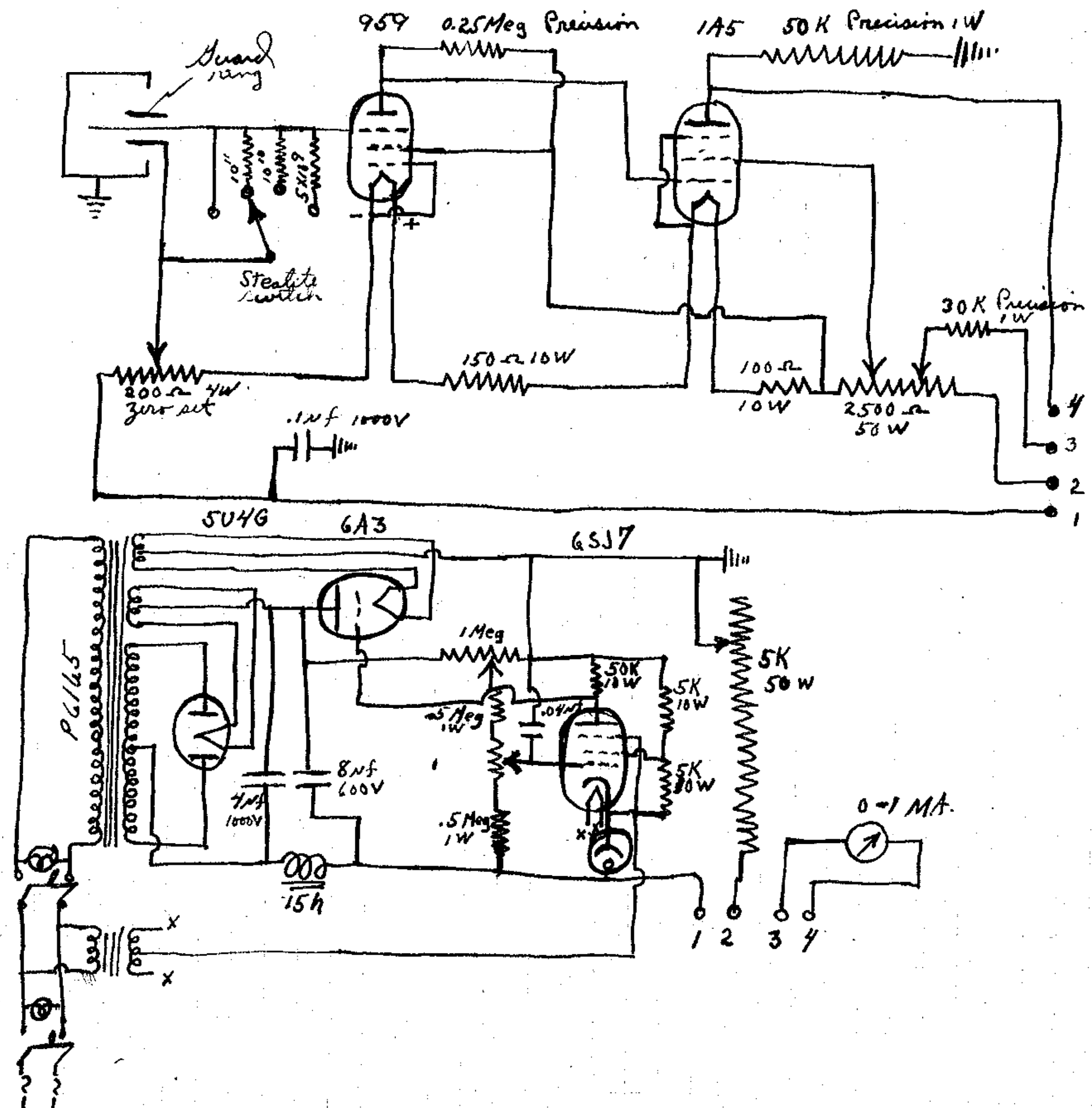
Tuesday April 16

Preliminary calibration of sweep circuit sweep times. Output of a model 200D Hewlett Packard audio oscillator fed into sweep circuit to trigger sweep. Also fed to vertical amplifier of scope. Knowing the frequency

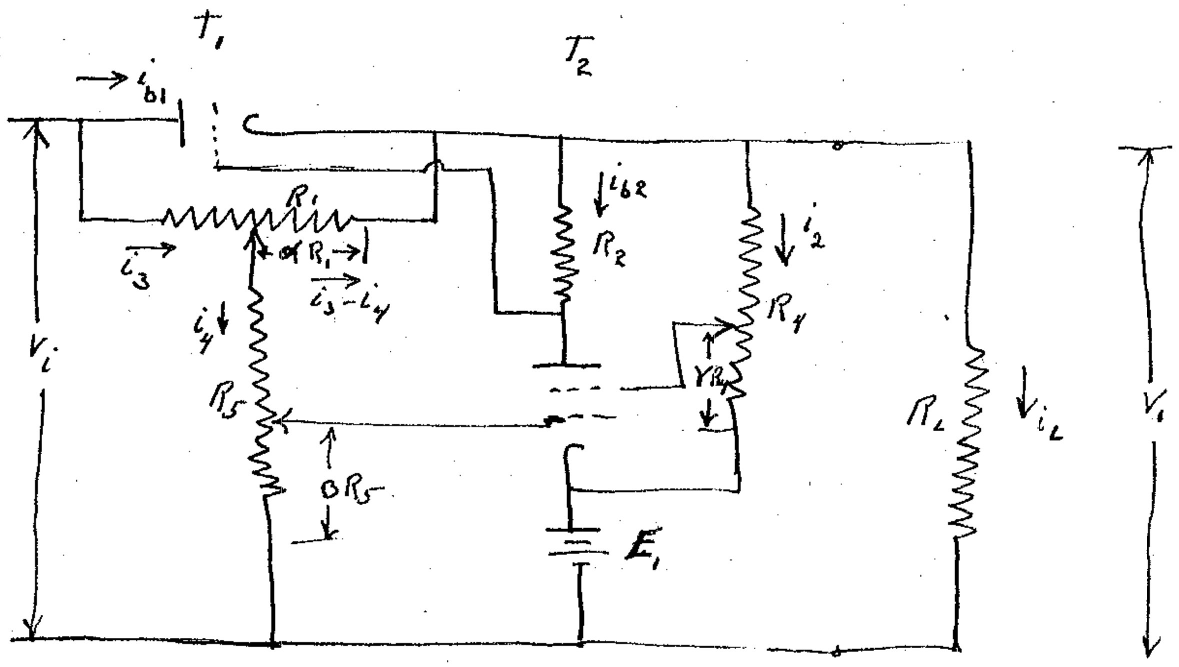
Now to consider the various instruments and circuits in some detail.

D.C. Amplifier for ionization chamber

Circuit Diagram



Consider the power supply in more detail. The characteristics of the Regulator may be obtained by analysis of following circuit



The circuit is same as regulated supply with VR tube replaced by battery E_1 & the voltage V_i substituted for the output voltage of the rectifier & filter.

For T_2

$$i_{b2} = \frac{e_{b2}}{r_{p2}} + g_{m2} e_{c2} + g_{s2} e_{s2} + c_2 \qquad (1)$$

For T_1

$$i_{b1} = \frac{e_{b1}}{r_{p1}} + g_{m1} e_{c1} + c_1 \qquad (2)$$

$$e_{b1} = V_i - V_0 \qquad (3)$$

$$e_{c1} = -R_2 i_{b2} \qquad (4)$$

Substituting (3) & (4) in (2) & noting $r_p g_m = \mu$

$$i_{b1} = \frac{V_i - V_0}{r_{p1}} + \left(-\frac{\mu_1}{r_{p1}} R_2 i_{b2}\right) + c_1 \qquad (5)$$

$$e_{b2} = V_0 - i_{b2} R_2 - E_1 = (V_0 - E_1) - i_{b2} R_2 \qquad (6)$$

$$e_{s2} = \gamma (V_0 - E_1) \qquad (7)$$

To solve for e_{c2}.

$$V_i - V_0 = i_3 R_1 - i_4 \alpha R_1$$

$$V_i = i_3 (1-\alpha) R_1 + i_4 R_5$$

$$i_4 = \frac{\begin{vmatrix} R_1 & V_i - V_0 \\ (1-\alpha)R_1 & V_i \end{vmatrix}}{\begin{vmatrix} R_1 & -\alpha R_1 \\ (1-\alpha)R_1 & R_5 \end{vmatrix}} = \frac{V_i - (1-\alpha)(V_i - V_0)}{R_5 + \alpha(1-\alpha)R_1}$$

$$= \frac{\alpha V_i + (1-\alpha) V_0}{R_5 + \alpha(1-\alpha) R_1} \qquad (8)$$

$$i_3 = \frac{\begin{vmatrix} V_i - V_0 & -\alpha R_1 \\ V_i & R_5 \end{vmatrix}}{\begin{vmatrix} R_1 & -\alpha R_1 \\ (1-\alpha)R_1 & R_5 \end{vmatrix}} = \frac{R_5 (V_i - V_0) + \alpha V_i R_1}{R_1 \left[R_5 + \alpha(1-\alpha) R_1 \right]} \qquad (9)$$

$$e_{c2} = \beta i_4 R_5 - E_1 = \beta \left[\frac{\alpha V_i + (1-\alpha) V_0}{1 + \alpha(1-\alpha)\frac{R_1}{R_5}} \right] - E_1 \qquad (10)$$

Substituting (6), (7), & (10) in (1)

$$i_{b2} = \frac{(V_0 - E_1) - i_{b2} R_2}{r_{p2}} + g_{m2} \left[\frac{\alpha \beta V_i + \beta (1-\alpha) V_0}{1 + \alpha(1-\alpha)\frac{R_1}{R_5}} - E_1 \right] + g_{s2} \gamma (V_0 - E_1) + c_2$$

$$i_{b2} \left[1 + \frac{R_2}{r_{p2}} \right] = \frac{V_0 - E_1}{r_{p2}} + g_{m2} \left\{ \left[\frac{\alpha \beta V_i + \beta(1-\alpha) V_0}{1 + \alpha(1-\alpha)\frac{R_1}{R_5}} \right] - E_1 \right\} + g_{s2} \gamma (V_0 - E_1) + c_2$$

$$i_{b2} = \frac{V_0 - E_1}{R_2 + r_{p2}} + \frac{\mu_2}{r_{p2} + R_2} \left[\frac{\alpha \beta V_i + \beta(1-\alpha) V_0}{1 + \alpha(1-\alpha)\frac{R_1}{R_5}} - E_1 \right] + \frac{\mu_{s2} \gamma (V_0 - E_1)}{r_{p2} + R_2} + \frac{c_2 r_{p2}}{r_{p2} + R_2} \qquad (11)$$

Substituting (11) in (5)

$$i_{b1} = \frac{V_i - V_0}{r_{p1}} + g_{m1}\frac{(-R_2\mu_2)}{r_{p2}+R_2}\left\{\frac{V_0 - E_1}{\mu_2} + \frac{\alpha\beta V_i}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\beta(1-\alpha)V_0}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - E_1 + \frac{\mu_{s2}}{\mu_2}\gamma(V_0 - E_1) + \frac{c_2 r_{p2}}{\mu_2}\right\} + \frac{r_{p1}c_1}{r_{p1}} \qquad (12)$$

$$i_L = i_{b1} + (i_3 - i_4) - i_{b2} - i_2 \qquad (13)$$

$$i_2 = \frac{V_0 - E_1}{R_4} \qquad (14)$$

Substituting (14), (12) + (11) in (13)

$$i_L R_L = R_L\left[i_{b1} + (i_3 - i_4) - i_{b2} - i_2\right]$$

$$\frac{V_0}{R_L} = \frac{V_i - V_0}{r_{p1}} + \frac{\mu_1}{r_{p1}}\left(\frac{-\mu_2 R_2}{r_{p2}+R_2}\right)\left\{\frac{V_0 - E_1}{\mu_2} + \frac{\alpha\beta V_i + \beta(1-\alpha)V_0}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - E_1 + \frac{\mu_{s2}}{\mu_2}\gamma(V_0 - E_1) + \frac{c_2 r_{p2}}{\mu_2}\right\} + c_1 + \frac{\frac{V_i - V_0}{R_1}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - \frac{\frac{(1-\alpha)V_0}{R_5}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - \frac{V_0 - E_1}{R_4}$$

$$- \frac{\mu_2}{r_{p2}+R_2}\left\{\frac{V_0 - E}{\mu_2} + \frac{\alpha\beta V_i}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\beta(1-\alpha)V_0}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - E_1 + \frac{\mu_{s2}}{\mu_2}\gamma(V_0 - E_1) + \frac{c_2 r_{p2}}{\mu_2}\right\}$$

$$\frac{V_0}{R_L} = V_i\left\{\frac{1}{r_{p1}} + \frac{\frac{1}{R_1}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}}\right\} + V_0\left\{-\frac{1}{r_{p1}} \frac{-\frac{1}{R_1} - \frac{(1-\alpha)}{R_5}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - \frac{V_0}{R_4}\right\} + c_1 + \frac{E_1}{R_4} - \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left\{\frac{V_0}{\mu_2} + \frac{\beta(1-\alpha)V_0}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\mu_{s2}}{\mu_2}\gamma V_0\right\} - \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left\{\frac{-E_1}{\mu_2} + \frac{\alpha\beta V_i}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - E_1 - \frac{\mu_{s2}}{\mu_2}\gamma E_1 + \frac{c_2 r_{p2}}{\mu_2}\right\}$$

$$\frac{V_0}{R_L}\left\{1 + R_L\left[\frac{1}{r_{p1}} + \frac{\frac{1}{R_1} + \frac{(1-\alpha)}{R_5}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{1}{R_4} + \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{1}{\mu_2} + \frac{\beta(1-\alpha)}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\mu_{s2}\gamma}{\mu_2}\right)\right]\right\} = V_i\left\{\frac{1}{r_{p1}} + \frac{\frac{1}{R_1}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} - \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{\alpha\beta}{1+\alpha(1-\alpha)\frac{R_1}{R_2}}\right)\right\} + E_1\left\{\frac{1}{R_4} + \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{1}{\mu_2} + 1 + \frac{\mu_{s2}\gamma}{\mu_2}\right)\right\}$$

$$+ c_1 - \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{c_2 r_{p2}}{\mu_2}\right)$$

Rearranging the coefficient of $\frac{v_o}{R_L}$ on left hand side

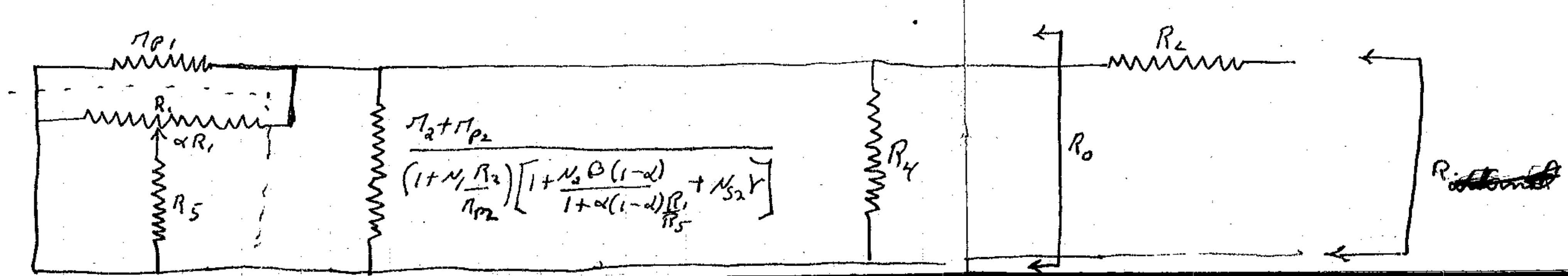
$$\text{coeff.} = \left\{ R_L + \frac{1}{\frac{1}{r_{p1}} + \frac{\frac{R_5 + (1-\alpha)R_1}{R_1 R_5}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{1}{R_4} + \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{1}{\mu_2} + \frac{\beta(1-\alpha)}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\mu_{s2} r}{\mu_2}\right)} \right\} \overbrace{\left\{ \frac{1}{r_{p1}} + \frac{\frac{R_5+(1-\alpha)R_1}{R_1 R_5}}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{1}{R_4} + \frac{\mu_2 R_2}{r_{p2}+R_2}\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{1}{\mu_2} + \frac{\beta(1-\alpha)}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\mu_{s2} r}{\mu_2}\right) \right\}}^{S}$$

$$= \left\{ R_L + \frac{r_{p1} R_4}{R_4 + \frac{\frac{r_{p1} R_4 (R_5 + [1-\alpha]R_1)}{R_1}}{R_5 + \alpha(1-\alpha)R_1} + r_{p1} + \frac{\mu_2 R_2}{R_2 + r_{p2}}\left(\frac{\mu_1 R_4 r_{p1}}{r_{p2}} + \frac{R_4 r_{p1}}{R_2}\right)\left(\frac{1}{\mu_2} + \frac{\beta(1-\alpha)}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\mu_{s2} r}{\mu_2}\right)} \right\} \left\{ S \right\}$$

$$= \left\{ R_L + \frac{r_{p1} R_4 \overbrace{\frac{R_1[R_5 + \alpha(1-\alpha)R_1]}{R_5 + (1-\alpha)R_1}}^{R_x}}{R_4 R_x + r_{p1} R_4 + r_{p1} R_x + r_{p1} R_4 R_x \left(\frac{\mu_2 R_2}{R_2 + r_{p2}}\right)\left(\frac{\mu_1}{r_{p2}} + \frac{1}{R_2}\right)\left(\frac{1}{\mu_2} + \frac{\beta(1-\alpha)}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \frac{\mu_{s2}}{\mu_2} r\right)} \right\} \left\{ S \right\}$$

$$= \left\{ R_L + \frac{r_{p1} R_4 R_x \overbrace{\frac{R_2 + r_{p2}}{\left(1+\frac{\mu_1 R_2}{r_{p2}}\right)\left[1 + \frac{\mu_2 \beta(1-\alpha)}{1+\alpha(1-\alpha)\frac{R_1}{R_5}} + \mu_{s2} r\right]}}^{R_z}}{R_4 R_x R_z + r_{p1} R_4 R_z + r_{p1} R_x R_z + R_4 r_{p1} R_x} \right\} \left\{ S \right\} = (R_L + R_o)\left(\frac{1}{R_o}\right)$$

This term represents the resistance of R_L in series with the paralleled resistors r_{p1}, R_4, R_x & R_z. The circuit is as follows



To solve for i_L or $\frac{V_0}{R_L}$

$$i_L = \frac{R_0}{R_L+R_0}\Bigg\{ V_i\Bigg[\frac{1}{r_{p1}} + \frac{R_5}{R_1[R_5+\alpha(1-\alpha)R_1]} - \frac{\mu_2\alpha\beta}{1+\alpha(1-\alpha)\frac{R_1}{R_5}}\left(\frac{1}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p2}}+1\right)\Bigg] + E_1\Bigg[\frac{1}{R_4} + \left(\frac{1}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p2}}+1\right)\left(1+\mu_2+\mu_{s2}\gamma\right)\Bigg] + c_1 - \frac{c_2 r_{p2}}{\mu_2}\left(\frac{\mu_2}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p2}}+1\right)\Bigg\}$$

When R_0 is multiplied into parenthesis each term may be interpreted as a voltage acting in series with the load resistance R_L & the internal resistance R_0

Consider the first term which is proportional to V_i. To be independent of variation in V_i this term must be zero or as small as possible.

$$V_i R_0\left[\frac{R_1[R_5+\alpha(1-\alpha)R_1]+r_{p1}R_5}{r_{p1}R_1[R_5+\alpha(1-\alpha)R_1]} - \frac{\mu_2\alpha\beta R_5}{[R_5+\alpha(1-\alpha)R_1]}\left(\frac{1}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p2}}+1\right)\right] = 0$$

$$\frac{R_1[R_5+\alpha(1-\alpha)R_1]+r_{p1}R_5}{R_1 r_{p1}} = \mu_2\alpha\beta R_5\left(\frac{1}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p1}}+1\right)$$

$$\frac{R_5}{r_{p1}}\left[1+\alpha(1-\alpha)\frac{R_1}{R_5}\right] + \frac{R_5}{R_1} = \mu_2\alpha\beta R_5\left(\frac{1}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p2}}+1\right)$$

$$\left[1+\alpha(1-\alpha)\frac{R_1}{R_5}\right] + \frac{r_{p1}}{R_1} = \mu_2\alpha\beta\left(\frac{1}{r_{p2}+R_2}\right)\left(\frac{\mu_1 R_2}{r_{p2}}+1\right)(r_{p1})$$

$$\frac{1}{\alpha}\left(1+\frac{r_{p1}}{R_1}\right) - \alpha\left(\frac{R_1}{R_5}\right) = \frac{r_{p1}\mu_2}{r_{p2}}\beta\left(\frac{\mu_1 R_2 + r_{p2}}{r_{p2}+R_2}\right) - \frac{R_1}{R_5}$$

In typical case

$$\frac{1}{\alpha} - \frac{\alpha}{2} = \beta\,1.5$$

Since the grid of the 6SJ7 will run approximately 0 volts with respect to cathode it is evident that β is of the order $105/V_0$. For $V_0 = 300$ volts $\beta \cong 1/3$. Hence α must be very small (on the order of 1)

For 6A3
$r_{p1} = 800\ \Omega$
$\mu_1 = 4.2$
$c_1 = -50$ MA.

For 6SJ7
$r_{p2} =$ 0.7 Megohms
$\mu_2 = 1100$
μ_{s2} small in comparison to μ_2
$c_2 =$ 9 MA

R_1 = 1 Meg
R_5 = 2 Meg
R_3 = 50,000
R_4 = 10,000

R_o for typical case will be approximately

$$R_0 \cong \frac{800 \cdot \dfrac{.75\times10^4}{(1+4.2\frac{50{,}000}{800{,}000})(1+\frac{1100}{3})}}{800 + \dfrac{.75\times10^4}{1.2\cdot\frac{1100}{3}}} \cong$$

$R_0 \cong 800\Omega$

The coefficient of V_i will be approximately

$$800\left[\frac{1}{800}+\frac{1}{10^4} - \frac{1100\,\alpha\beta}{4536}\,\frac{6.18}{800}\right] \cong 800\left[\frac{1}{800} - \frac{\alpha\beta\,7.7}{800\cdot 5.1}\right]$$

For $\beta = 1/3$

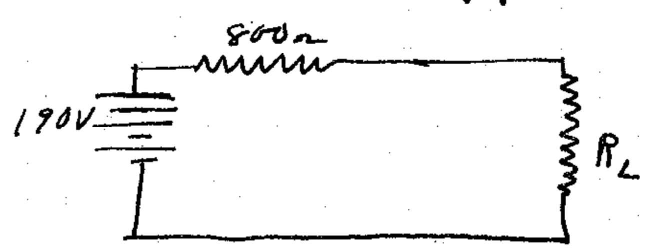
$$\cong [1 - \alpha]$$

Thus for α greater than 1 an increase in V_i will result in a decrease in i. In other words over compensation will occur. However α can be at most 1 so that in a physically realizable set up the output current will at be be just independent of V_i. The coefficient of E_1 is approximately (1.5)

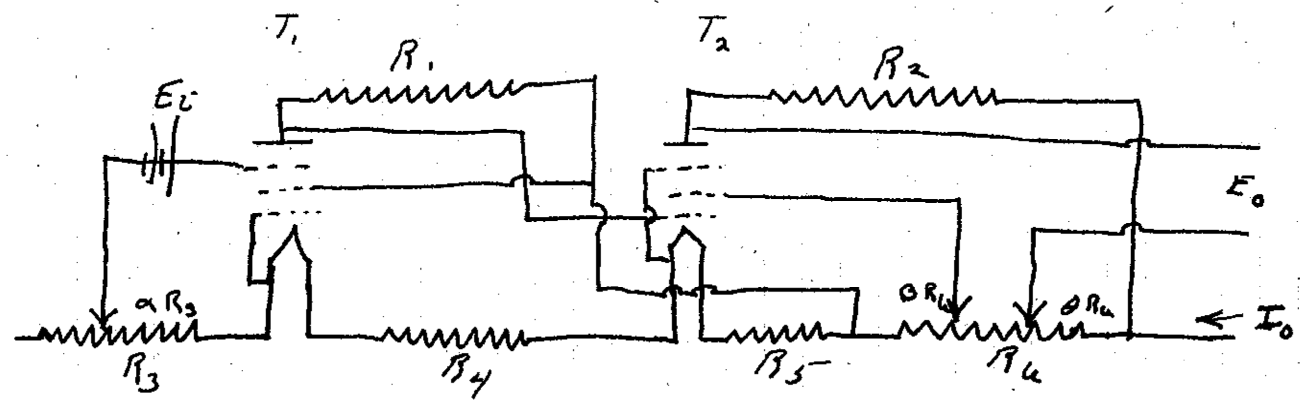
$R_0 C_1 \cong 40.$

The last term when multiplied by R_0 gives 8.6 volts

Thus for $E_0 = 105$ volts we have the following circuit as an approximation



Consider amplifier in more detail



$$i_{b1} = \frac{e_{b1}}{r_{p1}} + g_{m1}e_{c1} + g_{s1}e_{s1} + g_{g1}e_{g1} + C_1$$

Since e_{c1} is constant we may lump this term with C_1

$$e_{g1} = -I_0\alpha R_3 + E_i$$
$$e_{s1} = I_0(R_4+R_5)$$
$$e_{b1} = I_0(R_4+R_5) - R_1 i_{b1}$$

$$i_{b1} = \frac{I_0(R_4+R_5) - R_1 i_{b1}}{r_{p1}} + g_{s1}I_0(R_4+R_5) + (-I_0 g_{g1}\alpha R_3) + A_1 + g_{g1}E_i$$

$$i_{b1}\left(\frac{r_{p1}+R_1}{r_{p1}}\right) = I_0\left\{\frac{R_4+R_5}{r_{p1}} + g_{s1}(R_4+R_5) - g_{g1}\alpha R_3\right\} + A_1 + g_{g1}E_i$$

$$i_{b1} = \frac{I_0}{r_{p1}+R_1}\left\{(R_5+R_4)(1+\mu_{s1}) + (-\mu_{g1}\alpha R_3)\right\} + \frac{A_1 r_{p1}}{r_{p1}+R_1} + \frac{\mu_{g1}E_i}{r_{p1}+R_1}$$

$$i_{b2} = \frac{I_0(R_4+R_5) - i_{b2}R_2}{r_{p2}} + g_{m2}\left[I_0R_5 - i_{b1}R_1\right] + g_{s2}I_0\left[R_5+\beta R_4\right] + C_2$$

$$i_{b2} = \frac{r_{p2}}{r_{p2}+R_2}\left\{\frac{I_0(R_4+R_5)}{r_{p2}} + g_{m2}\left[I_0R_5 - i_{b1}R_1\right] + g_{s2}I_0\left[R_5+\beta R_4\right] + C_2\right\}$$

$$i_{bo} = \frac{I_0(R_6+R_5)}{R_2+r_{p2}} + \frac{\mu_2}{R_2+r_{p2}}\left\{I_0R_5 - R_1\left[I_0\left(\frac{R_4+R_5}{r_{p1}+R_1}\right)(1+\mu_{s1}) + \frac{\mu_{g1}E_i}{r_{p1}+R_1} - I_0\frac{\mu_{g1}\alpha R_3}{r_{p1}+R_1} + \frac{A_1 r_{p1}}{R_1+r_{p1}}\right]\right\} + \frac{\mu_{s2}}{r_{p2}+R_2}I_0\left[R_5+\theta R_6\right] + \frac{e_2 r_{p2}}{r_{p2}+R_2}$$

$$= I_0\left\{\frac{R_6+R_5}{R_2+r_{p2}} + \frac{\mu_2 R_5}{R_2+r_{p2}} - \frac{R_1(1+\mu_{s1})}{r_{p1}+R_1}\frac{(R_4+R_5)\mu_2}{R_2+r_{p2}} + \frac{\mu_{g1}R_1\alpha}{r_{p1}+R_1}\frac{R_3\mu_2}{R_2+r_{p2}} + \frac{\mu_{s2}}{r_{p2}+R_2}(R_5+\theta R_4)\right\} + \frac{e_2 r_{p2}}{r_{p2}+R_2} - E_i\frac{\mu_{g1}R_1}{r_{p1}+R_1}\frac{\mu_2}{R_2+r_{p2}}$$

$$E_0 = i_{o2}R_2 - \theta R_6 I_0$$

$$= I_0\left\{G_2\frac{R_6+R_5}{\mu_2} + G_2R_5 - \left[G_2G_{s1}(R_4+R_5) + G_2G_{s1}\frac{(R_4+R_5)}{\mu_{s1}}\right] - \theta R_6 + G_{g1}G_2\alpha R_3 + G_{s2}(R_5+\theta R_4)\right\} + \frac{e_2 r_{p2}R_2}{r_{p2}+R_2} - E_i G_{g1}G_2$$

where $G_2 = \dfrac{\mu_2 R_2}{r_{p2}+R_2}$

$G_{g1} = \dfrac{\mu_{g1}R_1}{r_{p1}+R_1}$

$G_{s2} = \dfrac{\mu_{s2}R_2}{R_2+r_{p2}}$

$G_{s1} = \dfrac{\mu_{s1}R_1}{R_1+r_{p1}}$

For stability it would be desirable to have E_0 independent of I_0. Hence we equate the coefficient of I_0 to zero.

$$G_2\frac{R_6+R_5}{\mu_2} + G_2R_5 - G_2G_{s1}(R_4+R_5)\left(1+\frac{1}{\mu_{s1}}\right) + G_{g1}G_2\alpha R_3 + G_{s2}(R_5+\theta R_4) - \theta R_6 = 0$$

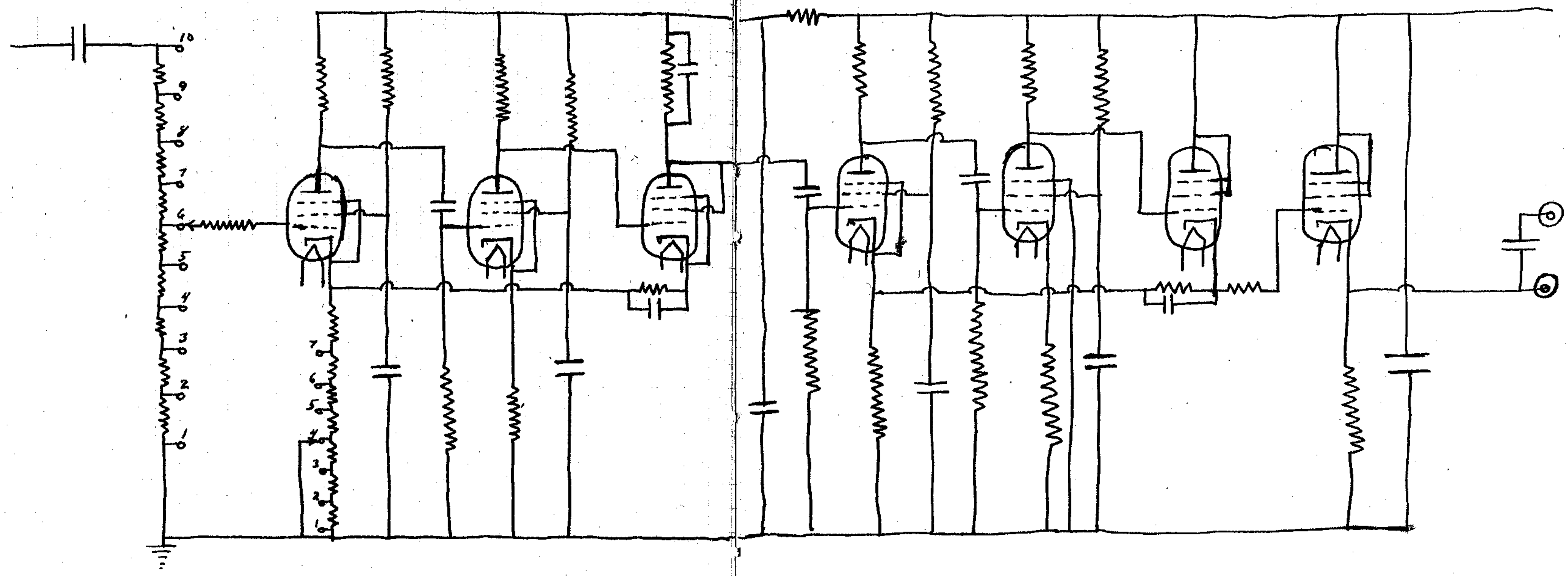
$$\frac{R_6+R_5}{\mu_2} + R_5 - G_{s1}(R_4+R_5)\left(1+\frac{1}{\mu_{s1}}\right) + G_{g1}\alpha R_3 + \frac{G_{s2}}{G_2}(R_5+\theta R_4) - \theta\frac{R_6}{G_2}$$

Model 100 amplifier & Preamplifier

a general purpose linear amplifier for fairly high speed work. can be used for collection of either positive or negative ions

Rise time is 1/2 μ second
max clipping time 25 μ sec
Overal gain is 10^4 of which 10^2 is in the preamplifier. Gain is adjustable at feed point of preamplifier to amplifier

Circuit diagram for Model 100 Amplifier



Classification Change to Decl. By
Authority of EJM. Date 5/27/60