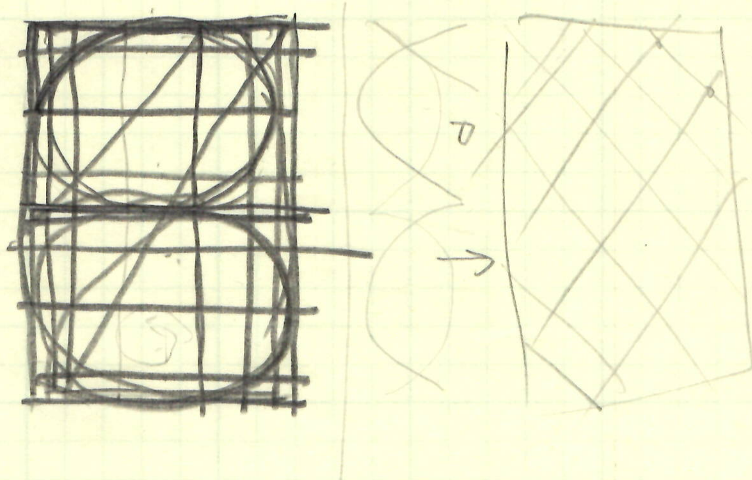
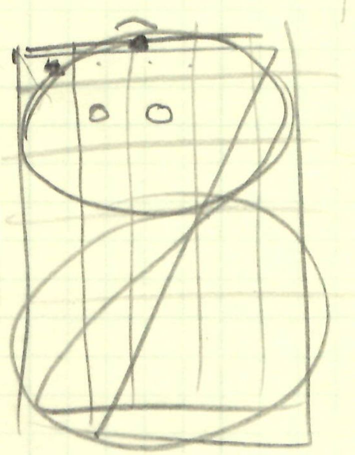
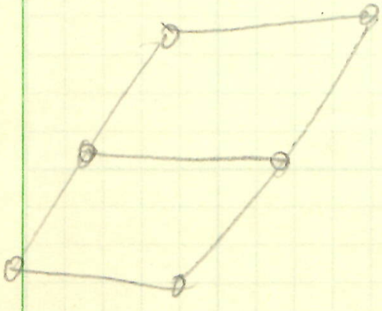
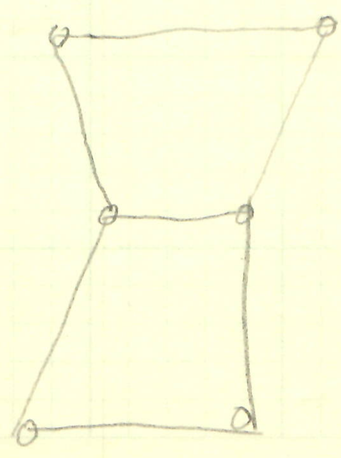
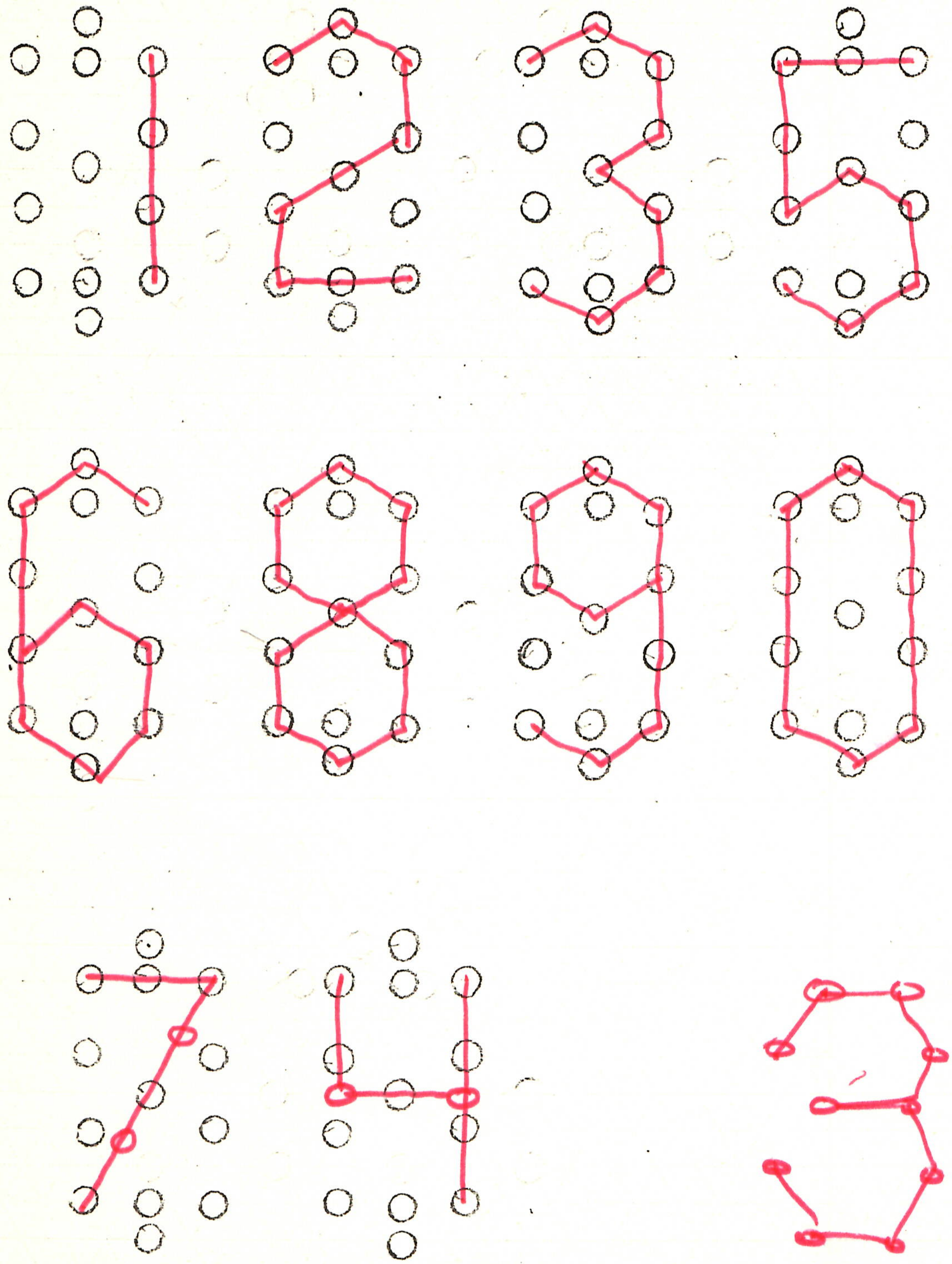
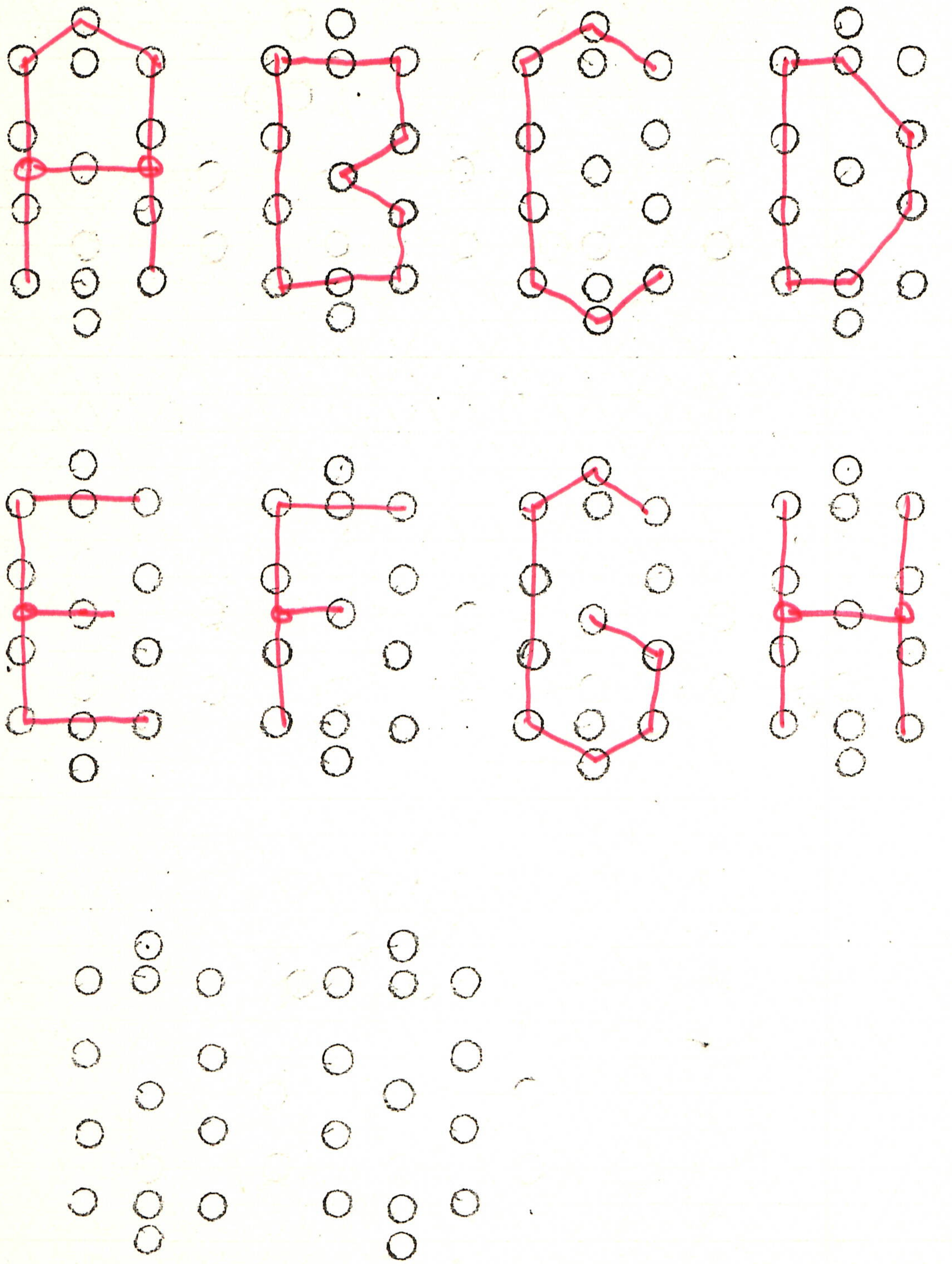


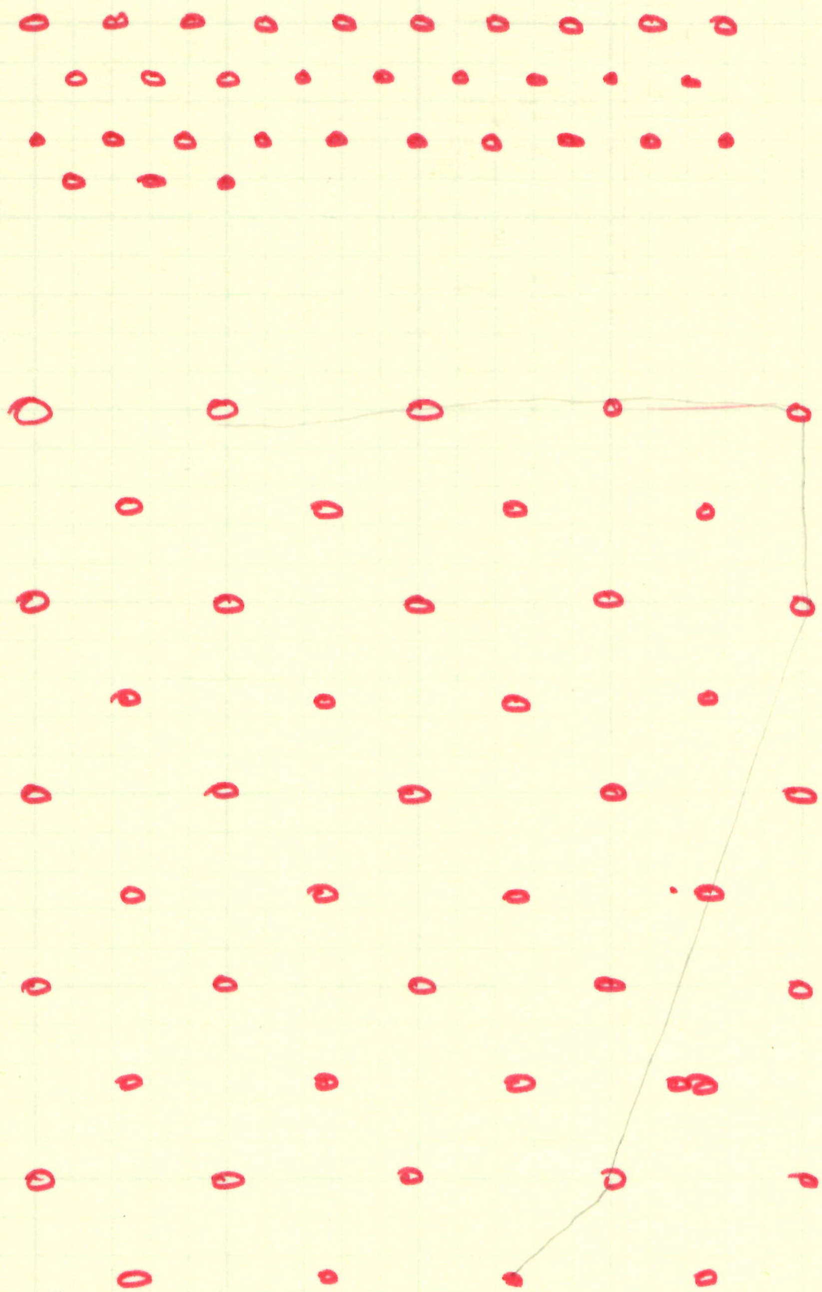








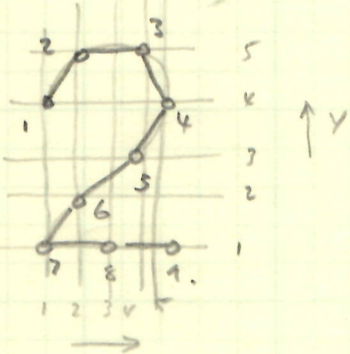

ABCD
EFGH

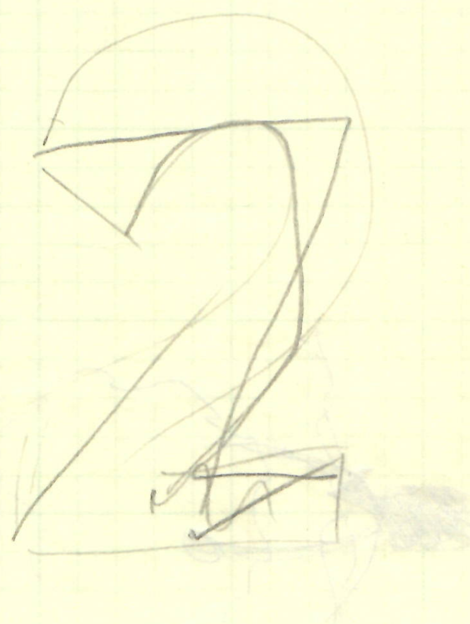


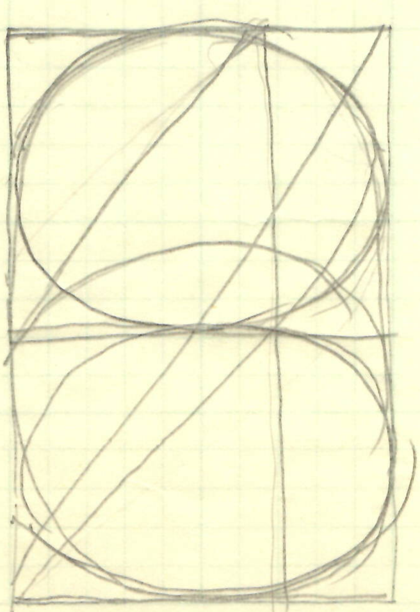
PROBLEM: (A real one.)

Given up to 9 points and the condition that these points (however many are used) are to be joined by equal-lengthed segments, and each point may have only one of <10 values in each of the X- and Y-direction (not necessarily linearly spaced): Find, the most satisfactory position of the points and the 20 levels (10 X and 10 Y)

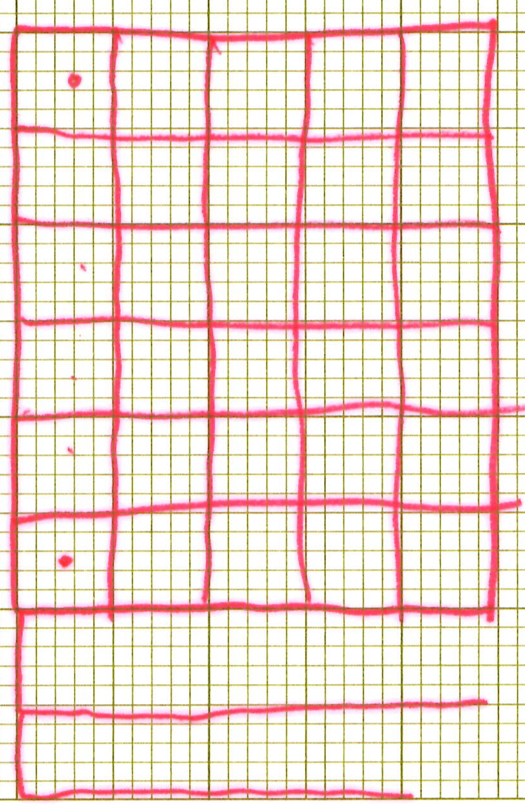
Eg.







1 2 3 4 5 6 7
8 9 0 A B C D
E F G H I J K
L M N O P Q R
S T U V W X Y
Z



DCDOCGB

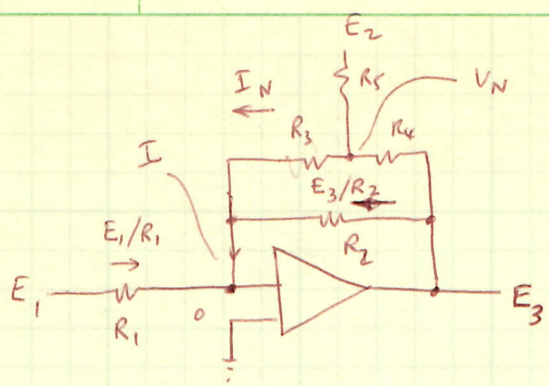
DCBRPKAL

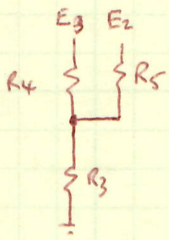
EFGHJMWV

XYZNQSTU

23456778

0





$$V_N = \frac{R_3 \| R_5}{R_4 + R_3 \| R_5} E_3 + \frac{R_4 \| R_3}{R_5 + R_3 \| R_4} E_2 = E_3 \frac{\frac{R_3 R_5}{R_3 + R_5}}{R_4 + \frac{R_3 R_5}{R_3 + R_5}} + E_2 \frac{\frac{R_3 R_4}{R_3 + R_4}}{R_5 + \frac{R_3 R_4}{R_3 + R_4}}$$

$$= E_3 \frac{R_3 R_5}{R_4(R_3 + R_5) + R_3 R_5} + E_2 \frac{R_3 R_4}{R_5(R_3 + R_4) + R_3 R_4}$$

$$\therefore \quad I_N = \frac{V_N}{R_3}$$

$$= E_3 \frac{R_5}{R_4 R_3 + R_4 R_5 + R_3 R_5} + E_2 \frac{R_4}{R_5 R_3 + R_5 R_4 + R_3 R_4}$$

$$= \frac{E_3 R_5 + E_2 R_4}{R_3 R_4 + R_3 R_5 + R_4 R_5}.$$

$$\therefore \quad I = \frac{E_3}{R_2} + I_N = \frac{E_3}{R_2} + \frac{E_3 R_5 + E_2 R_4}{R_3 R_4 + R_3 R_5 + R_4 R_5}$$

and $\quad I = -\dfrac{E_1}{R_1}$

$$\therefore \quad \frac{E_1}{R_1} - \frac{E_3}{R_2} - \frac{(E_3 R_5 + E_2 R_4)}{R_3 R_4 + R_3 R_5 + R_4 R_5} = 0$$

Now put $R_3 = (1-x)R$, $R_4 = xR$

$$\frac{E_3}{R_2} + \frac{E_3 R_5 + E_2 x R}{(1-x)xR^2 + (1-x)RR_5 + xRR_5} = -\frac{E_1}{R_1}$$

$$\frac{E_3 f(x) + (E_3 R_5 + E_2 x R) R_2}{f(x) R_2} = -\frac{E_1}{R_1}$$

$$E_3 \left[f(x) + R_5 R_2 \right] + E_2 x R R_2 = -E_1 \cdot \frac{f(x) R_2}{R_1}$$

$$E_3 = \frac{-E_1 \frac{f(x) R_2}{R_1} - E_2 \, x R R_2}{f(x) + R_2 R_5}$$

$$\therefore\ E_3 = \frac{-E_1 \frac{R_2}{R_1}\left[xR^2 - x^2R^2 + RR_5 - \cancel{xRR_5} + \cancel{xRR_5}\right] - E_2 xRR_2}{xR\left[R - xR\right] + RR_5 + R_2R_5}$$

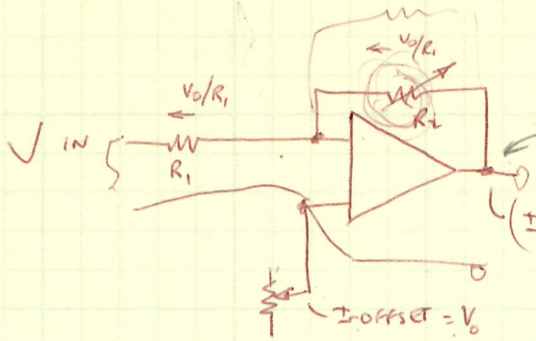
$$= \frac{-E_1 \frac{R_2R}{R_1}\left[xR - x^2R + R_5\right] - E_2 xRR_2}{R\left[xR - x^2R + R_5\right] + R_2R_5}$$

Check: As $R_5 \to \infty$ and $R \to \infty$ (say both $= A$)

becomes unity

$$E_3 = \frac{-E_1 \frac{R_2A}{R_1}\left[xA - x^2A + A\right] - E_2 xAR_2}{A\left[xA - x^2A + A\right] + AR_2}$$ becomes small

O.K.

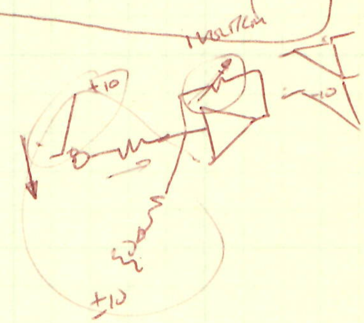


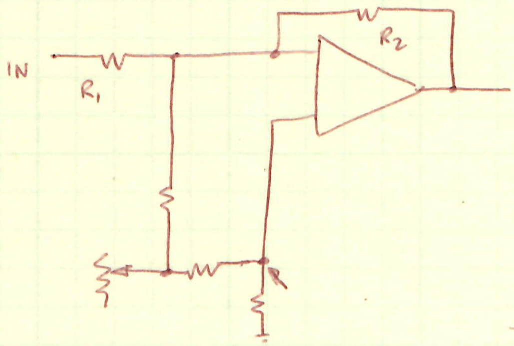
0 TO 0.2

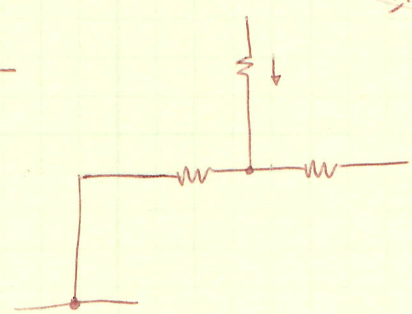
$V_0 \left(1 + \frac{R_2}{R_1}\right)$

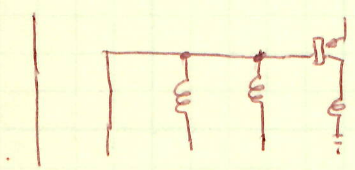
$\left(\pm \text{OFFSET} - V_0 \frac{R_2}{R_1}\right)$

$$\boxed{= V_0 \left(1 - \frac{R_2}{R_1}\right) - V_{IN} \frac{R_2}{R_1}}$$

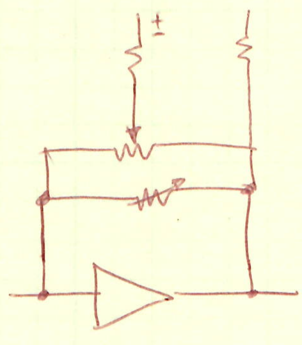




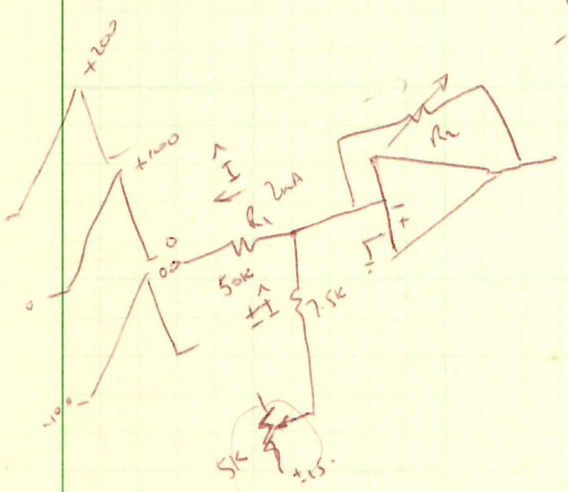


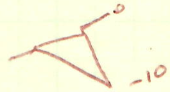


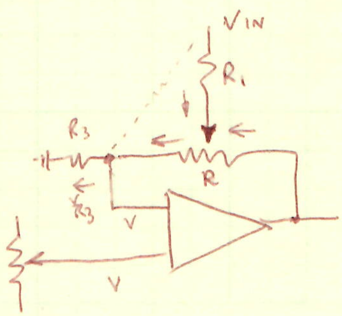
S
mS
µS
nS



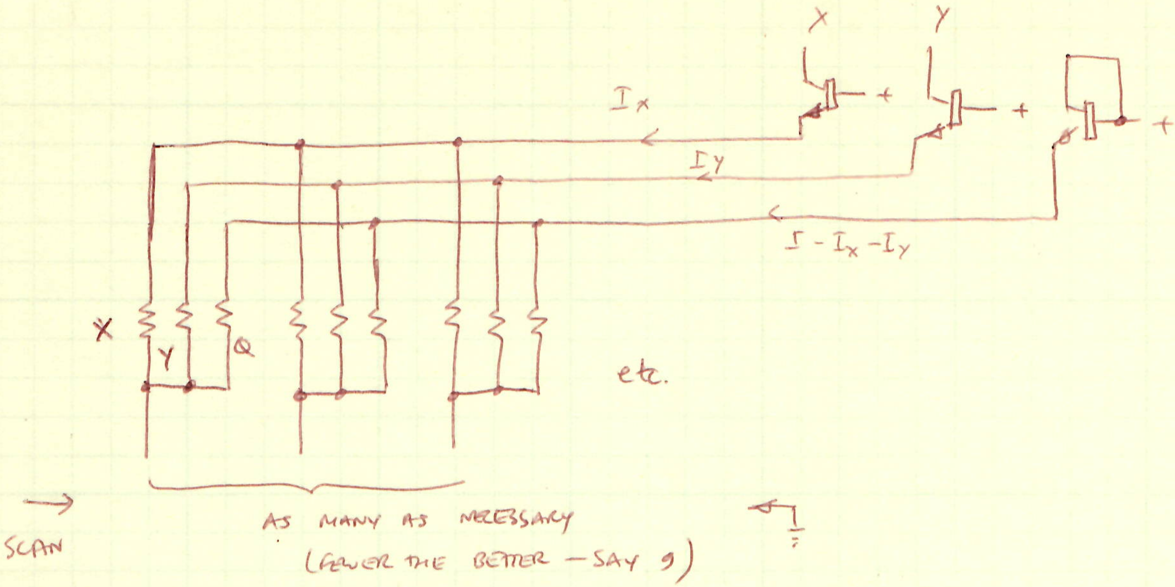
$-\frac{R_2}{R_1}$





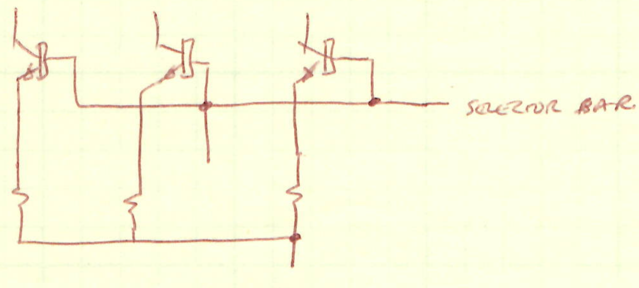


$-\frac{R}{R_1}$



10 level switch = 34 trans + 9 resistors

+ 3 below, 3 above, 33 resistors.



1) SWP
2) GND
3) −
4) SELECTOR
5) +
6) X
7) Y
8)
9)
10)

Calculate the resistors from: X_n / Y_n and $X_n + Y_n$.

Thus, $(RX)_n / (RY)_n = Y_n / X_n$

Say, each level is 200mV wide, and

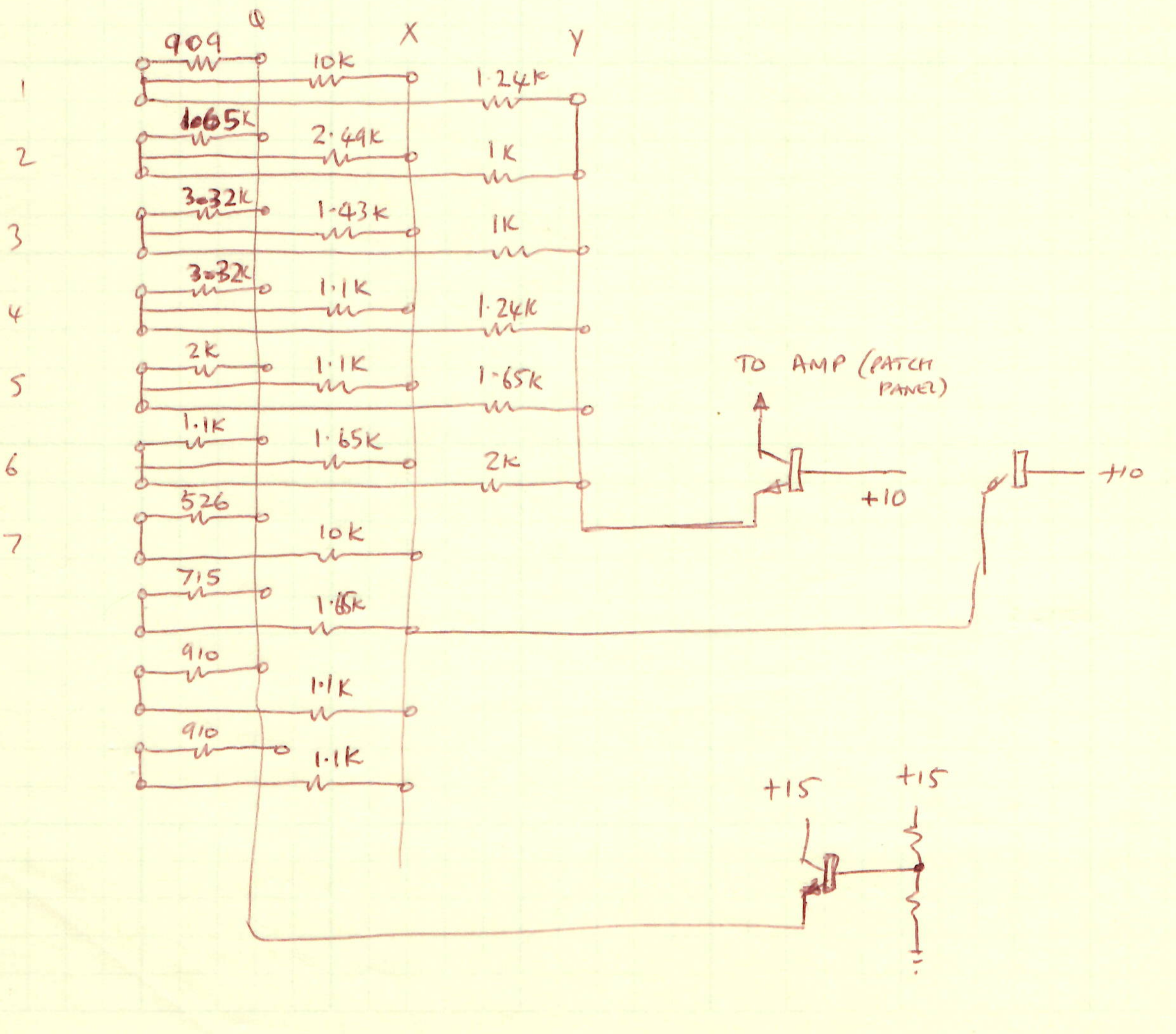
$$(X_n + Y_n) / Q_n$$

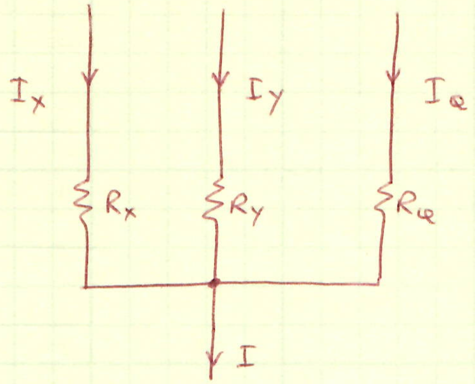
$$= \cancel{(RX)_n} \quad (RQ)_n \,/\, (RY)_n \parallel (RX)_n$$

Make EC cards with 10 inputs, 3 outputs

Try it out for the character '2' now:

	For $I = 2mA$			For $V = 1V$ ($k\Omega$)		
Pt #	I_y	I_x	I_Q	R_y	R_x	R_Q
1	0.8	0.1	1.1	1.25	10	0.91
2	1	0.4	0.6	1	2.5	1.67
3	1	0.7	0.3	1	1.43	3.33
4	0.8	0.9	0.3	1.25	1.11	3.33
5	0.6	0.9	0.5	1.67	1.11	2
6	0.5	0.6	0.9	2	1.67	1.11
7	0	0.1	1.9	o/c	10	0.526
8	0	0.6	1.4	o/c	1.67	0.715
9	0	0.9	1.1	o/c	1.11	0.91
0	0	0.9	1.1	o/c	1.11	0.91





For any point on the character, $I_x + I_y$ & I_x / I_y are known. Thus, $\frac{R_x}{R_y} = \frac{I_y}{I_x}$

and $I_x R_x = I_y R_y = I_Q R_Q = V$

or $\frac{I_x}{I_y} R_x = R_y = \frac{I_Q}{I_y} R_Q$

I_y and I_x have max value of $\frac{1}{2} I$ (say) $= 0.5\text{mA}$

V has max value of 2.5 V

$\therefore \quad I_x R_x = I_y R_y = I_Q R_Q = 2.5(\text{V})$

$(I_x + I_y + I_Q) = 1(\text{mA})$

~~Ex~~

eg. $I_x = 0.2\text{ mA}$, $I_y = 0$, $I_Q = 0.8\text{mA}$

$R_x = \frac{V}{I_x} = \frac{2.5}{0.2} = 12.5\text{K}$, $R_y = \text{o/c}$, $I_Q = \frac{2.5}{0.8} = \cancel{3.75\text{K}}$

if $I_x = 0.05$ ($\frac{1}{10}$ of f.s.) $R = 50\Omega$, too much.

Put $I = 2\text{mA}$, $I_x, I_y = 1\text{mA}$ max. $V = 1\text{V}$.

Then $I_x = 0.1\text{mA}$, $I_y = 0$ $I_Q = 1.9\text{mA}$

$R_x = \frac{1}{0.1} = 10\text{K}$, $R_Q = \frac{1}{1.9} = 0.526\text{K}$.