April 17,1962

Dear Beth:

Have been having difficulty in obtaining Proton Signal. Gain of system is greater than necessary. I called Varian Corp.,Palo Alto,California and physicist told me that it is not uncommon and that they have many complaints due to non-function of their magnetometer.

It's usually due to gradients.
Many soils produce too high a gradient. Even short duration signal not present. Plane of protons must be flat, if curved due to gradient, signals do not add and NO output results.

He checked what I was doing and he thinks everything should work.
Signal, if present is of sufficient amplitude to be easily detectable even without a tuned amplifier. Use of tuned amplifier necessary when counting to clear up wave forms and eliminate spurious counts.
He didn't think it necessary for beat system.
He said much information on gradients can be obtained if a meter on a magnetometer us connected to indicate signal output amplitude.

If you have a magnetometer there could you check these bottles?
I think the magnetometer has a counter meter that can be switched to monitor proton signal amplitude.

Bob tells me you are having difficulty getting echoes.
I am sending coil for transducer soon as I get it wound.
I think the trouble is due to sync jitter. The reflected signals are so weak that it takes from ten to 30 repeat sweeps to build up the signal so it can be seen. If jitter is present the signals don't "add".
I will send coil and directions for adjustment and installation ~~of~~ in transducer as it seems the most probable cause of the trouble.

The transducer circuit is enclosed.

Best of luck and hope the weather is better than it is here,We've been having a weekend of snow showers.

Sincerely,

Grey

Dear Beth, Dec 17 - 62

Some notes on gradient magnetometer.

Item.

An excellent proton signal is obtained from one bottle.

The signal is much lower from both bottles series conn.

The reduction may be due to interference from second bottle

or reduced current due to ~~res~~ resistance of second bottle.

A. Test can be made using 2 ohm resistor to simulate second bottle and using only one bottle for test. Signal should be faint if due to reduced I. (The timing should be maintained constant)

B. 1 If test produces weak signal we maybe can increase applied E for polarization.

B2. If test produces strong signal we can look elsewhere for proton damping.

1. Possible capacitance of second bottle may damp resonance.

2. Complex inductive effect may kill precession due to induced currents.

We may be able to determine reason for deterioration of signal ~~with~~ due to addition of second bottle.

—

A solution is also possible using separate input circuits and mixing in later stage but switching and cabling become more complex. I think some tinkering is in order

I wonder if Oxford has any later info on getting healthy signal with both bottles (theory should be 2X as loud!) so it is being damped

A good strong signal would allow reduction in polarizing time + lower drain on batteries.

Grey.

simplification the shapes have been idealized, and for other reasons, this is not strictly true but will serve as an approximation. The potential, Ω_o, outside then becomes

$$\Omega_o = - [1 - \frac{\mu_1 - \mu_2}{\mu_1 + \mu_2} \cdot \frac{a^2}{r^2}] H_o r \cos \theta$$

where a = radius of the cylinder and r = distance from its axis to the surface of the ground. (The fact that the sensor is held approximately 50 cm above the ground surface has also been neglected.) The field $(H_r)_o$ in the direction of the sensor, then becomes:

$$(H_r)_o = - \frac{\partial \Omega_o}{\partial r} = [1 + \frac{\mu_1 - \mu_2}{\mu_1 + \mu_2} \cdot \frac{a^2}{r^2}] H_o \cos \theta$$

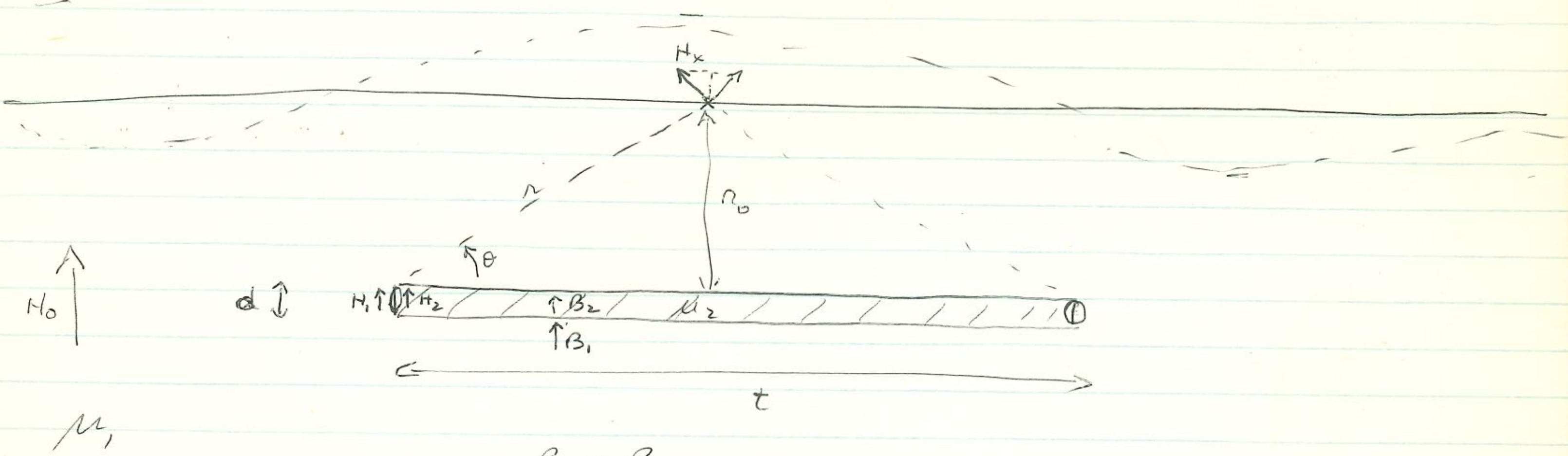
With the sensor directly above (90^o), $\cos \theta = 1$. To determine μ_1 and μ_2, we have the relationship, $\mu = 1 + 4\pi\chi$ where χ is the magnetic susceptibility. As mentioned previously (M.S. p. 16), for the deep clay, $\chi = 1 \times 10^{-4}$ emu/cc and for bricks (or roof tiles), $\chi = 10.4 \times 10^{-4}$ emu/cc. For an estimation of the less magnetic stone cylinder, we must infer from the fact that stone walls in the upper 1-2 meters of the earth are not detectable magnetically on the plain of Sybaris. ~~Therefore,~~ For this reason we may assume that their susceptibilities are similar to those of the upper earth layers. The measurements at Oxford (M.S., p. 16) indicate the susceptibility to be of the order of 0.7×10^{-4} emu/cc.

With these values and a = 0.62 meters (area of 1 meter) and r = 4.5 meters, we calculate the following:

indent

For stone cylinder in deep clay, $(H_r)_o = -0.2\gamma$

For cylinder of roof tiles in deep clay, $(H_r)_o = + 5\gamma$



$$B_1 = B_2$$

$$B_1 = \mu_1 H_1 = B_2 = \mu_2 H_2$$

$$H_2 = \frac{\mu_1}{\mu_2} H_1$$

$$H_1 - H_2 = \frac{i}{d}$$

$$H_1 - \frac{\mu_1}{\mu_2} H_1 = \frac{i}{d}$$

$$d\left(\frac{\mu_2 - \mu_1}{\mu_2}\right) H_1 = i$$

emu $\left(H = \frac{2i}{r}\right)$

$$H_x = \frac{i}{2\pi r} = \frac{d(\mu_2 - \mu_1) H_1}{\mu_2 \, 2\pi \sqrt{r_0^2 + (\frac{t}{2})^2}}$$

emu $\left(\begin{array}{l} \Delta H_1 = 4\pi i \\ \frac{d(\mu_2-\mu_1) H_1}{4\pi \mu_2} = i \end{array}\right)$

$$_x H_{tot} = \frac{2}{\sqrt{2}} \frac{d(\mu_2 - \mu_1) H_1}{\mu_2 \, 2\pi \sqrt{r_0^2 + (\frac{t}{2})^2}}$$

$$B_{tot} = \frac{\mu_1 H_1 d}{\sqrt{2}\pi} \frac{(\mu_2 - \mu_1)}{\mu_2 \sqrt{r_0^2 + (\frac{t}{2})^2}}$$

$$B_{far} = \mu_1 H_1$$

$$\text{ratio} = \frac{d}{\sqrt{2}\pi} \frac{(\mu_2 - \mu_1)}{\mu_2} \frac{1}{\sqrt{r_0^2 + (\frac{t}{2})^2}}$$

$H_1 = 0.3$ gauss

$r_0 = 4.5$

$t = 10$ (4)

$d = 0.4$

$\mu_2 = 1 + 10 \times 10^{-4}$

$\mu_1 = 1 + 1 \times 10^{-4}$

$\mu_2 - \mu_1 = 9 \times 10^{-4}$

$\mu_2 \approx 1$

susceptibilities
for estimate of magnetization
suggest susc $\times 4$

$$\text{ratio} = \frac{0.4 \times 9 \times 10^{-4}}{1.4 \times 3.14 \times 1 \times \sqrt{\cancel{20.2}+\cancel{25}}}$$

6.7

$$= \frac{.4}{3} \times 10^{-4} = \frac{.13}{5} \times 10^{-4}$$

$$= 1.3 \times 10^{-5} \quad (1.7)$$

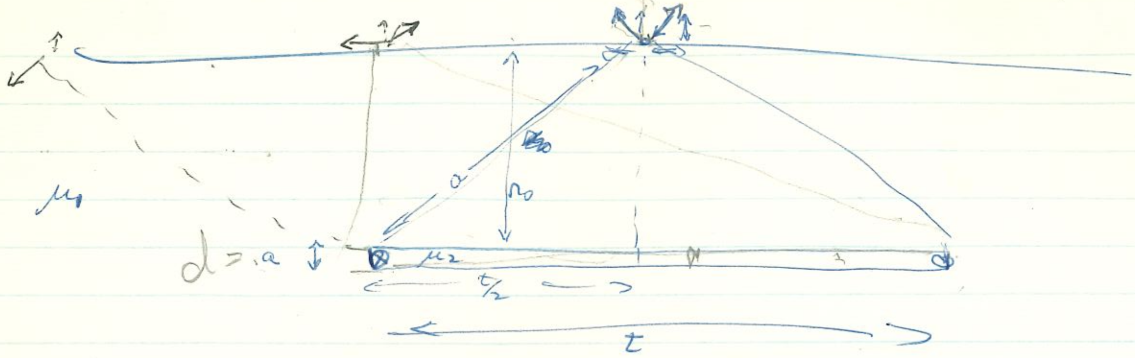
$$\text{anom} = 0.4 \times 10^{-5}$$

$$= 0.4\ \gamma \quad (.6)$$

$$1.6 \quad (2.4)$$

5

Beth Ralph



EV6-7400

treat it as a uniformly magnetised sheet in 2 dimensions

replace sheet by current

$$H_r = \frac{2}{\sqrt{2}}\,\frac{i}{2\pi\sqrt{r_0^2+\frac{t^2}{4}}}$$

$$= \frac{(\mu_i-\mu_0)\,a\,H_0}{\mu_i\sqrt{2}\,\pi\sqrt{r_0^2+\frac{t^2}{4}}}$$

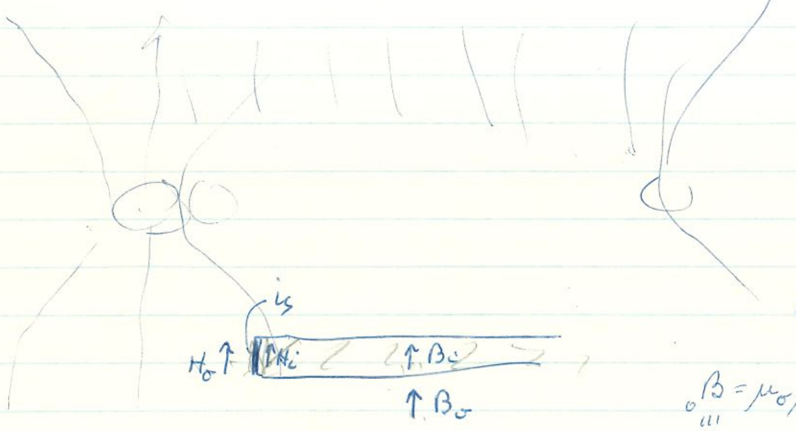
$=$

$$B = \frac{\mu_0}{4\pi}\, i \oint \frac{dl \times r}{r^2}$$

$$\int H\cdot dl = i$$

MKS

$$B = \frac{\mu_0\mu_0 i}{2\pi a}$$



$B = \mu\mu_0 H$

$m_v = \frac{\mu-1}{\mu} B = (\mu-1)\mu_0 H$

$= \chi_m \mu_0 H$

$\chi = \mu - 1$

$\mu = \chi + 1$

$_oH_t - {_iH_t} = \frac{i_{surface}}{a}$

$_oB = \mu_0\mu_0\, {_oH_t}$

$_iB = \mu_i\mu_0\, {_iH_t}$

but $\frac{_oB}{\mu_0} = \frac{_iB}{\mu_i}$

$\mu_0 H_0 = \mu_i H_i$

$H_i = \frac{\mu_0}{\mu_i} H_0$

$H_0 - \frac{\mu_0}{\mu_i} H_0 = \frac{i_s}{a}$

$H_0 \frac{(\mu_i-\mu_0)}{\mu_i} = \frac{i}{a}$

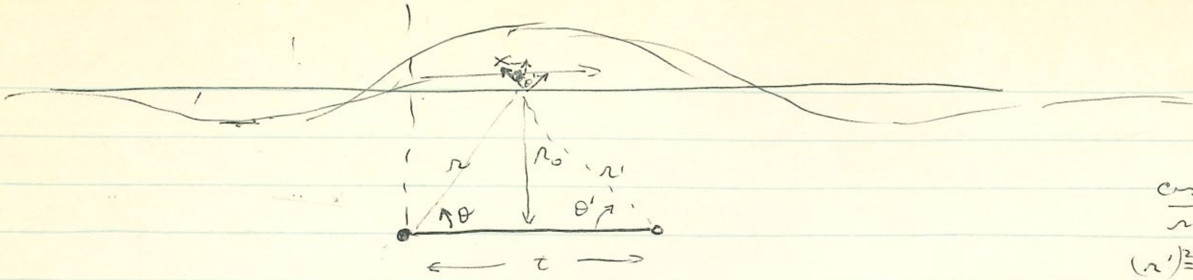
$$B_{center} = \mu_0 H = \frac{\mu_0(\mu_i-\mu_0)\,a\,H_0}{\mu_i\,\sqrt{2}\,\pi\sqrt{r_0^2+\frac{t^2}{4}}}$$

$$\frac{\cancel{B}'}{H_0} \simeq \frac{\Delta\cancel{\chi}\,a\,\cancel{H_0}}{\mu_i\sqrt{2}\,\pi\sqrt{r_0^2+\frac{t^2}{4}}}$$ mks units

.3 χ

4

1.2 χ



$$\frac{\cos\theta'}{r'}$$

$$(r')^2 = (r_0^2 + (t-x)^2)$$

$$\cos\theta' = \frac{t-x}{r'}$$

$$H_r(x) = \frac{i}{2\pi r}\cos\theta = \frac{i}{2\pi}\frac{x}{r^2} = \frac{i}{2\pi}\left(\frac{x}{(x^2+r_0^2)} + \frac{(t-x)}{(r_0^2+(t-x)^2)}\right)$$

check at $x = \frac{t}{2}$

$$\frac{i}{2\pi}\left(\frac{\frac{t}{2}}{((\frac{t}{2})^2+r_0^2)} + \frac{\frac{t}{2}}{(r_0^2+(\frac{t}{2})^2)}\right)$$

$$\frac{i}{2\pi}\frac{t}{(r_0^2+(\frac{t}{2})^2)} \quad \frac{10}{\frac{(20.2+25)}{45}}$$

$\frac{1}{4.5}$ $\quad t = 10$

$$\frac{\sqrt{2}}{\sqrt{2}}\sqrt{r_0^2+(\frac{t}{2})^2}$$

$$\frac{1.4}{6.7}$$

$r_0 = 4.5$
$t = 10$

$H_r \frac{2\pi}{i}$	x	
$\frac{t}{(r_0^2+(\frac{t}{2})^2)}$	$\frac{t}{2}$	$\frac{10}{(20+25)} = \frac{1}{4.5}$
$\frac{t}{(r_0^2+t^2)}$	0	$\frac{10}{20+100} = \frac{1}{12}$
$\frac{3t}{4(r_0^2+(\frac{3}{2}t)^2)} - \frac{t}{2(\;)}$	$-\frac{t}{2}$	$\frac{3\times 10}{4(20+225)} - \frac{10}{2(20+25)} = \frac{1}{60} - \frac{1}{9} \approx -\frac{1}{9}$
0	$-\infty$	

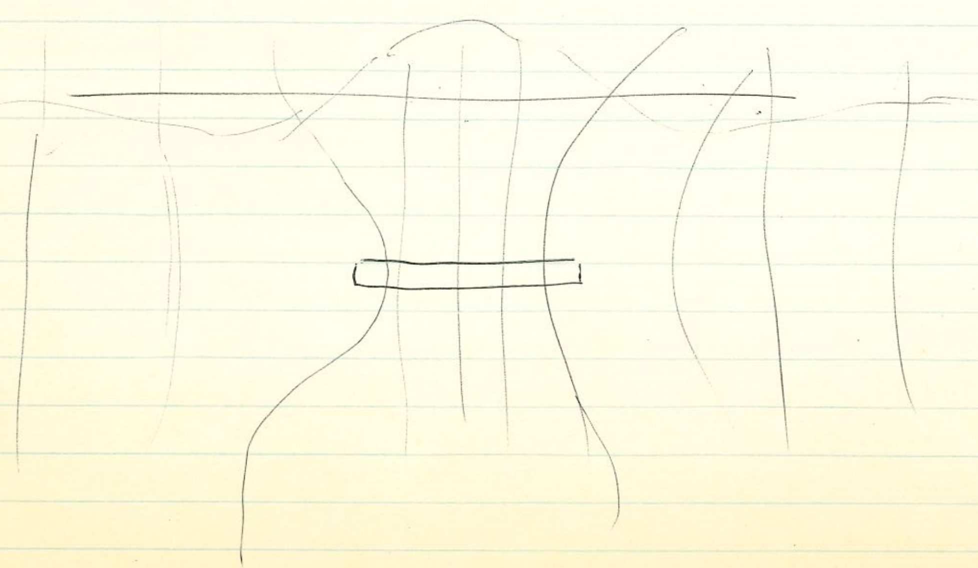
$$-\frac{t}{2((\frac{t}{2})^2+r_0^2)} + \frac{\frac{3}{2}\frac{t}{2}}{r_0^2+(\frac{3}{2}\frac{t}{2})^2}$$

$$\Delta = \frac{1}{4.5} + \frac{1}{9} = \frac{3}{9} = .33 \qquad \frac{d}{2\pi}(\mu_2-\mu_1) = \frac{1}{3}\times\frac{.4 \;\; 9\times 10^{-4}}{2\times 3.14} = .2\;10^{-4}$$

$$= 2\times 10^{-5}$$

$$\Delta = \frac{1}{3}\times 2\times 10^{-5} = \frac{2}{3}\,10^{-5}$$

$$= \frac{2}{3}\,\gamma$$



$.9$
$.5$
$.45$

$$H \sim \frac{\Delta \chi \, a \, H_0}{\sqrt{2}\,\pi\,\sqrt{r_0^2 + \frac{t^2}{4}}}$$

$$\sim \frac{9.4 \times 10^{-4} \times 0.2 \times .446}{1.414 \times 3.14 \times 6.73} \qquad \frac{84 \times 10^{-6}}{30}$$

$$\sim 2.8 \times 10^{-6} \sim 0.28\ \gamma$$

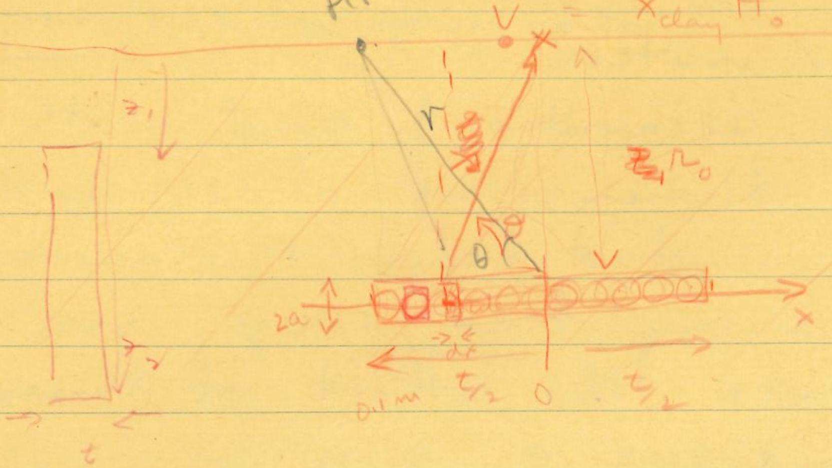
$$\frac{0.4 \times 37.6 \times 10^{-4}}{1.414 \times 3.1416 \underbrace{\sqrt{(4.5)^2 + 25}}_{\equiv\, 6.73}} = \frac{15.04 \times 10^{-4}}{29.89}$$

$$30\overline{)\,.48}\ \ .02$$

$\sim 5.0\gamma$

$$.4 \times 1.2 \times 10^{-4} = \frac{0.48 \times 10^{-4}}{29.89}$$

$= \cancel{.16}$
$= 0.2$



$$\left[1 + \frac{b a^2}{(x^2 + r_0^2)}\right]$$

$$\cos\theta = \frac{x}{\sqrt{x^2 + r_0^2}}$$

$$H_0 \int_{-t/2}^{t/2} [\,\cdot\,] \cos\theta \, dx$$

$$V_{clay} = 2 \times 10^5 \chi_{clay} [\quad]$$

$$V_{tile} = 2 \times 10^5 \chi_{tile} H_0 [\quad]$$

$$V_{stone} = \qquad [\quad]$$

$$b = \frac{\mu_1 - \mu_2}{\mu_1 + \mu_2} \approx \frac{\cancel{4}2\pi \Delta\chi}{2}$$

$$\mu_1 = 1 + 4\pi\chi_1$$

$$V_{tile} - V_{clay} = 2 \times 10$$

$$\pi a^2 = \frac{2a\,dx}{\pi}$$

$$H_0 \int_{-t/2}^{t/2} \left(\cancel{1} + \frac{b a^2}{\pi(x^2 + r_0^2)}\right) \frac{x}{\sqrt{x^2 + r_0^2}} \, dx \qquad 2a\,dx$$

$a = r_0^2 \quad c = 1 \quad b = 0 \quad q = 4ac = 4r_0^2 \quad q = 4ac - b^2$

$$\frac{2ab}{\pi} H_0 \int_{-t/2}^{t/2} \frac{x \, dx}{(x^2 + r_0^2)^{3/2}} = \frac{2(2r_0^2)}{\cancel{4r_0^2}\sqrt{x^2 + r_0^2}} = \frac{1}{\sqrt{x^2 + r_0^2}}\Bigg|_{-t/2}^{+t/2}$$

$$= 4 \frac{1}{\sqrt{\frac{t^2}{4} + \frac{r_0^2}{4}}}$$

$$\Delta H = 2ab H_0 \frac{4}{\sqrt{t^2 + r_0^2}} = \frac{2a \; 2\cancel{\pi}\Delta\chi}{\sqrt{t^2 + r_0^2}} H_0$$

If we ~~look~~ think of the large anomaly ~~in Fig. 7~~ ~~30~~ northeast of Excavation 1 in Fig. 7 as caused by deposits of roof tiles 0.2 meters thick at an average depth of 4.5 meters (as found nearby in the excavation) and with horizontal dimensions of 10 by 80 meters (estimated from the anomaly), then, in a simplified way, we may estimate the magnetic effect of these roof tiles versus a similar mass of stones. (Let us represent ~~these~~ the tiles ~~as~~ by a horizontal sheet as shown below in cross section ~~with~~ ~~Since~~ The ~~length~~ (80 meters), ~~the third dimension~~ considered to be infinite., ~~and~~ Then $t = 10$ meters, $z_1 = 4.4$ meters, and $z_2 = 4.6$ meters

$a = 0.1\,m$

$t = 10\,m$

$r_0 = 4.5\,m$

$$\Delta H_r = 2H_0 \int_0^{t/2} \left(\frac{\pi \Delta x\, 2a\, dx}{\pi (x^2 + r_0^2)} \right) \frac{x}{\sqrt{x^2 + r_0^2}}\, dx$$

$$= 2H_0\, 2a\, \Delta x \int_0^{t/2} \frac{x\, dx}{(x^2 + r_0^2)^{3/2}} =$$

p. 66 Handbook

$$= \left[\qquad \right] - \frac{1}{\sqrt{x^2 + r_0^2}} \Bigg|_0^{t/2}$$

$t = 10$

$$= -4\, a\, \Delta x\, H_0 \left[\frac{1}{\sqrt{t^2/4 + r_0^2}} - \frac{1}{r_0} \right]$$

$4 \,\overline{)\,.0100}$
$.0025$

$.4$
$.3.6$
$.5$
1.80

$$= -4 \times 0.1 \times 9.4 \times 10^{-4} \times .446 \left[\frac{1}{\sqrt{\frac{100}{4} + (4.5)^2}} - \frac{1}{4.5} \right]$$

$25.$
20.25

$$= -1.68 \times 10^{-4} \left[\frac{1}{\sqrt{45.25}} - \frac{1}{4.5} \right]$$

$$= \left[\frac{1}{6.727} - \frac{1}{4.5} \right]$$

$.222222$
$.14865$
$.07357$

$$= 1.68 \times 10^{-4} \times .736 \times 10^{-1}$$

10^{-5}

$$= 1.24\ \gamma$$

1.2
$\frac{.3}{9} = .03$
$.036$

Stones, $\approx 0.04\ \gamma$

One cylinder $a = 0.1\,m$

$$H_r = \left[1 + \frac{\mu_1 - \mu_2}{\mu_1 + \mu_2} \cdot \frac{a^2}{r^2}\right] H_0$$

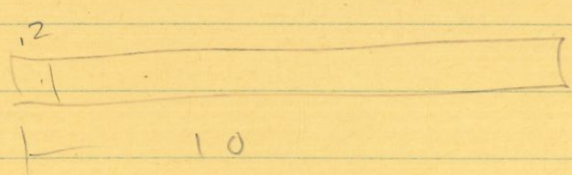
12.6
9.4
126

$$= \left[1 + \frac{4\pi \times 9.4 \times 10^{-4}}{2} \times \frac{(.1)^2}{(4.5)^2}\right] .446$$

$$= \left[1 + \frac{118.1 \times 10^{-6}}{40.50}\right] .446$$

$$= 1.000003 \times .446 = 446001$$

$$\Delta H = +0.1\,\gamma$$



50 cyls. in 10 m, $\Delta H \sim 5\,\gamma$

~~p. 177 Dobrin~~

~~& p. 274~~

Roof Tiles

Vertical Sheet

$$V = 2 \times 10^5 \, I t \left[\frac{1}{Z_1\left(1+\frac{x^2}{Z_1^2}\right)} - \frac{1}{Z_2\left(1+\frac{x^2}{Z_2^2}\right)} \right]$$

$t = 10$ m

$Z_1 = 4.4$ m

$Z_2 = 4.6$ m

$I = kH$

$= 10.4 \times 10^{-4} \times .446$

$= 4.64 \times 10^{-4}$

$$V = 2 \times 10^5 \times 4.64 \times 10^{-4} \times 10 \left[\frac{1}{4.4} - \frac{1}{4.6} \right]$$

.227
.217
.010

$$V = 9.28 \times 10^2 \left[1 \times 10^{-2} \right]$$

$= 9.28 \ \gamma$ 8.38

Stones -

$I = 0.7 \times 10^{-4} \times .446 = .312 \times 10^{-4}$

$V = 0.624 \ \gamma$ .268

Should k = diff. in susceptibilities ?

Use vertical component only of H ?

Cylinder, k_1 in field E_0 in medium k_2

axis $\perp E_0$ $\qquad k = 1 + 4\pi\chi$

For sphere
Vol. = 1 m^3
$V = \frac{4}{3}\pi a^3$
$a^3 = \frac{3 \times 1}{4\pi} = .238$
$a = .620$

$$V_0 = -\left(1 - \frac{k_1 - k_2}{k_1 + k_2}\frac{a^2}{r^2}\right) E_0 r \cos\theta$$

$$(E_r)_0 = -\frac{\partial V_0}{\partial r} = \left[1 + \frac{k_1 - k_2}{k_1 + k_2}\frac{a^2}{r^2}\right] E_0 \cos\theta$$

For cyl., cross-sect.
$A = \pi a^2$
$a^2 = .384$

$$= \left[1 + \left(\frac{4\pi \times 9.4 \times 10^{-4}}{4\pi(11.1 \times 10^{-4}) + 2}\right)\frac{.384}{25}\right] E_0 \cos\theta$$

$$= \left[1 + \frac{118.3 \times 10^{-4}}{2} \times \frac{.384}{25}\right] E_0$$

$$= \left[1 + .91 \times 10^{-4}\right] E_0$$

$$= \begin{matrix} 1.00000 \\ .00009 \end{matrix} \times 44600 = 44604 = +4\gamma$$

$r = 4.5\,m$

Non-magn. cyl. $\quad K_1 \sim 0.7\times10^{-4} \quad K_2 = 1 + 4\pi\chi$

$$\cancel{(E_r)_0 = \left[1 + \left(\frac{-(1+4\pi\times1\times10^{-4})}{1+4\pi\times1\times10^{-4}}\right)\frac{.384}{20.5}\right]E_0\cos\theta}$$

$$= \left[1 + \frac{-(4\pi\times0.3\times10^{-4})}{4\pi\times1.7\times10^{-4}+2}\,\frac{.384}{20.5}\right]E_0\cos\theta$$

$$3.84 \quad .4 \quad 1.52$$

$$= \left[1 - \frac{1.45\times10^{-4}}{41}\right]E_0\cos\theta$$

$$41\overline{)1.45}\;\; .03$$

$$= 1.0000000000$$
$$\;\; 0000000354$$
$$\;\; .99999646 \times .446 = .445998 = -0.28$$

Magn. cyl.

$$(E_r)_0 = \left[1 + \frac{118.3\times10^{-4}}{2}\times\frac{.384}{20.5}\right]E_0$$

$$= \left[1 + 1.11\times10^{-4}\right]E_0$$

$$= 1.000111 \times .446 = .44605 = +58$$

~~p. 54~~ p. 136

Page & Adams ~~$P = \frac{3}{4\pi}\frac{k-1}{k+2}E$~~ $\mu = 1 + 4\pi\chi$

p. 92 From non-magnetic sphere

$$V_0 = -\left(E_0 r\cos\theta + \frac{k-1}{2k+1}\frac{a^3}{r^2}E_0\cos\theta\right)$$

$$(E_r)_0 = -\frac{\partial V_0}{\partial r} = \left(1 - 2\frac{k-1}{2k+1}\frac{a^3}{r^3}\right)E_0\cos\theta$$

$\mu \sim k = 1 + 4\pi\chi$

$$E_{r_0} = \left[1 - 2\left(\frac{4\pi\times1\times10^{-4}}{2(4\pi\times1\times10^{-4})+1}\,\frac{.238}{125}\right)\right]E_0\times1$$

$$= \left[1 - 2\left(\frac{12.6\times10^{-4}}{1}\times\frac{.238}{125}\right)\right].44600$$

$$= \left[1 - .5\times10^{-5}\right].44600$$

$$= \begin{array}{r} 1.0000000 \\ .0000048 \\ \hline .9999952 \end{array} = .445998 = -0.2\,\gamma$$

$$\frac{4\pi\times1\times10^{2}}{2(4\pi\times1\times10^{2})+1}\cdot\frac{.238}{125}$$

$$\frac{12.6\times10^{2}}{25.2\times10^{2}}\cdot\frac{.238}{125} = 9.5\times10^{-4}$$

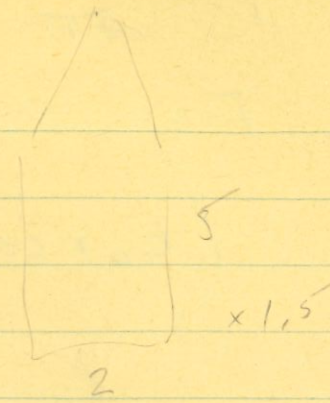
$$\begin{array}{r} 1.0000 \\ .0019 \\ \hline .9981 \end{array}$$

$= .44515$

$= -85\,\gamma$

Outside

$$H_r = \frac{2 p_H \cos\theta}{r^3}$$



$$= \frac{2 p_H \times 1}{125}$$

Brick, $P_H = 41.6 \times 10^2 \frac{emu}{m^3}$

$P_H = \frac{H_r r^3}{2}$ $r = 500$ cm

$H_r = .44600$ oersteds, $r = 5$ m

$4 \times 10^2 \frac{emu}{m^3}$

$P_H = \frac{.446 \times (125)}{2} = 27.875 \frac{emu}{m^3}$

$P_H = 4 \times 10^{+2}$ emu/m^3, ∴ vol. = 14.350

$$\begin{array}{ll} .5 & 5 \\ .2 & 2 \\ .3 & 10 \\ & .3 \\ & .30 \end{array}$$

Above brick $P_{H_s} = 27.8$, $P_{H_B} = 10.4 \times 10^{-4} \times (\text{vol.})$

62.5

$P_{H_B} = \frac{.44615 \times 125}{2} - 27.875 = 27.884$

$$\begin{array}{r} 27.884 \\ 27.875 \\ \hline .009 \end{array}$$

$\frac{9 \times 10^{-3}}{10^{-4}}$

$P_{H_B} = 10.4 \times 10^{-4} \times \text{vol.} = .009$

vol. = 8.65 m^3

Magnetic sphere (k_1) in field E in medium k_2

Harnwell, p. 75

$$V_0 = -\left[1 - \left(\frac{k_1 - k_2}{k_1 + 2k_2} \right) \frac{a^3}{r^3} \right] E_0 r \cos\theta$$

$$(E_r)_0 = -\frac{\partial V_0}{\partial r} = \left[1 + \left(\frac{k_1 - k_2}{k_1 + 2k_2} \right) \frac{a^3}{r^3} \right] E_0 \cos\theta$$

$$= \left[1 + 2 \left(\frac{4\pi \times 9.4 \times 10^{-4}}{4\pi (10.4 \times 10^{-4} + 2 \times 1 \times 10^{-4}) + 3} \right) \frac{.238}{125} \right] E_0 \cos\theta$$

$$= \left[1 + 2 \left(\frac{118.3 \times 10^{-4}}{3} \times \frac{.238}{125} \right) E_0 \right.$$

$$\begin{array}{r} 118.3 \\ 2 \\ \hline 236.6 \end{array}$$

$$= \left[1 + 2 \left(.075 \times 10^{-4} \right) \right] E_0$$

$$= \begin{array}{r} 1.0000000 \\ + .0000150 \end{array} \times 44600$$

$$= 446007 = +0.78$$

From magnetic sphere in uniform field

$$V_0 = -\left(1 - \frac{k-1}{k+2}\frac{a^3}{r^3}\right)E_0 r\cos\theta$$

$$(E_r)_0 = \frac{-\partial V_0}{\partial r} = \left(1 + 2\,\frac{k-1}{k+2}\frac{a^3}{r^3}\right)E_0\cos\theta$$

$$= \left[1 + 2\,\frac{4\pi\times 10.4\times 10^{-4}}{4\pi\times 10.4\times 10^{-4}+3}\;\frac{.238}{125}\right]E_0$$

$\mu = 1+4\pi\beta$

$\mu-1 = 4\pi\beta$

$\mu+2 =$

$$= \left[1 + 2\left(\frac{131\times 10^{-4}}{3}\;\frac{.238}{125}\right)\right]E_0$$

$$= \left[1 + 2\left(.083\times 10^{-4}\right)\right]E_0 \quad = 446007 = +0.7\gamma$$

$$\begin{array}{r} 1.000000 \\ .0000166 \\ \hline 1.0000166 \end{array}$$

$$\begin{array}{r} 0.44600 \\ \underline{000016} \end{array}$$

p.208 Sphere — Nettleton

$I = kH \qquad k = 10.4\times10^{-4} = \cancel{100\times10^{-6}}$

$I = 10.4\times10^{-4} \times .446 = 4.64 \times10^{-4}$

R = .620
Vol. = 1 m^3
Z = 5 m

$$H_z = \frac{4\pi\ .238 \times 4.64\times10^{-4}}{3\times125} \times 2$$

$H_z = .074\times10^{-4} = 0.74\ \gamma$

$$\begin{array}{r} 1.3 \\ .2 \\ 2.6 \\ 4.03 \\ 375\overline{)\,1600.000} \end{array}$$

p.209 ~~the~~ Cyl. $Z = 5$ m

$$H_z = \frac{2\pi\ .384 \times 4.64\times10^{-4}}{25} \times 1$$

$= .45\times10^{-4} = 4.5\ \gamma$

$$\begin{array}{r} 1.3 \\ .2 \\ \hline 2.6 \\ 8 \\ \hline 20.8 \end{array} \qquad \begin{array}{r} .07 \\ 370\overline{)\,20.00} \end{array}$$

$$\begin{array}{r} 125 \\ 5 \\ \hline 625 \\ 5 \\ \hline 3125 \end{array} \qquad \begin{array}{r} 6 \\ .4 \\ \hline 2.4 \\ 5 \\ \hline 12.0 \end{array}$$

$Z = 4$ m

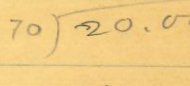
$H_z = 7.0\ \gamma$

---

p.215 $\qquad H_0 = Z_0$

$$H_z = -\frac{\overset{39.4\times10^{-4}}{\overset{\shortparallel}{4/3\pi \times 9.4\times10^{-4}}} \times .370}{1 + 4/3\pi \times 9.4\times10^{-4}} \times \frac{.223}{125}\left[-2\right]$$

$$\begin{array}{r} 8 \\ .4 \\ \hline 3.2 \\ 1 \end{array}$$



$\cos 34^\circ = \dfrac{Z_0}{.446}$

$Z_0 = .370$

$$H_z = \frac{6.50\times10^{-4}}{1.25\times10^{2}} = 0.5\ \gamma$$

(Over)

$$\Delta V = 2\pi \left(I_1 - I_2 \right)$$

$$= 2\pi \left(10.4 - 1 \right) \times 10^{-4} \times .446$$

$$= 263 \ \gamma$$

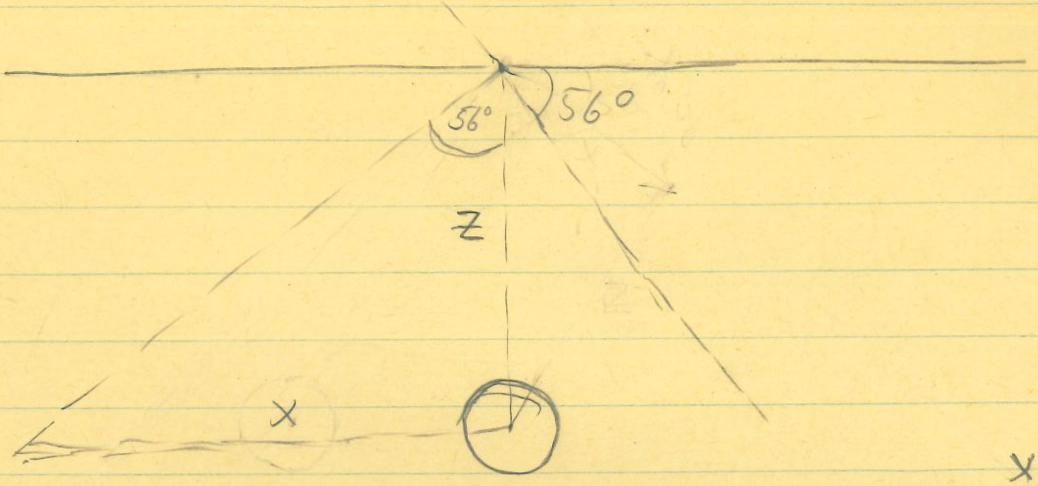
Ω

$$(H_r)_0 = -\frac{\partial \Omega_0}{\partial r} = \left[1 + \frac{\mu_1 - \mu_2}{\mu_1 + \mu_2}\frac{a^2}{r^2}\right] H_0 \cos\theta$$

Displacement of Anomaly
S

$\cancel{\sin 56^\circ = \frac{y}{x}}$

$\cancel{y = .829 \times 5 = 4.15}$



$\cancel{\cos 56^\circ = \frac{x'}{x}, \; x' = .559 \times 5}$

$x' = 2.8$

$z = 5 \text{ m}, \; \cancel{x = 5 \text{ m}, \; x' =}$

$\tan 56^\circ = \frac{x}{z}, \; x = 1.48 \times 5 = 7.4 \text{ m}$

Non-magnetic

$a = 1$ m

$Z = 4.5$ m $H = .446$

$I = kH_V$ $\angle dip = 56°$

$H_V = .370$

$k = 1 \times 10^{-4}$

$I = .370 \times 10^{-4}$

$$H_z = \frac{4\pi a^3 I}{3z^3} \times 2$$

$$H_z = \frac{4\pi \times 1 \times .370 \times 10^{-4} \times 2}{3 \times 91.1}$$

$$H_z = \frac{9299}{273} = 3.394 \times 10^{-6}$$

$= 0.38\gamma$

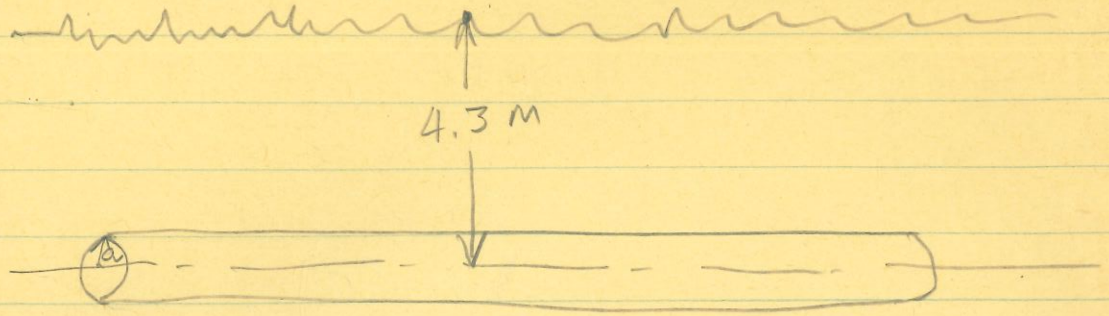
12.566
.7
8.4 $\times 10^{-4}$

.03
274) 8.00

274) 9.30

4.5
4.5
225
180
20.25
4.5
10125
8100
91125

Q22 Anomaly ~~z~~ $L = 80\,m$, $W = 10\,M$



$\Delta H = 10\,\gamma$ (30 - 10 units)

$x = 0$

$$\Delta H = \frac{2\pi a^2 I}{z^2}$$

$$a^2 = \frac{\Delta H z^2}{2\pi I}$$

$$a^2 = \frac{10 \times 10^{-5} \times 18.6}{6.28 \times 3.84 \times 10^{-4}}$$

$a^2 = .78$

$a = 0.88\ m$

$I = k H_v$

$H = .446$

$\angle dip = 56^\circ$

$H_v = .370$

$k = 10.4 \times 10^{-4}$

$I = 3.84 \times 10^{-4}$

$z = 4.3\ m$

Vol. roof tiles $= \pi a^2 L = \pi .78 \times 80 = 196\ m^3$

Kennelly - mks sys

Rationalised | Unrationalized

$\mu_0 = 4\pi \times 10^{-7} = 1.257 \times 10^{-6}$ h/m $\mu_0' = 10^{-7}$ ∴

free space

k = magnetic susceptibility
μ_m = metallic permeability

$\mu = \mu_0 + \mu_m$

$\mu' = \mu_0' + 4\pi k'$

$k' = \frac{(\mu' - \mu_0')}{4\pi}$

$\mu_m = \mu - \mu_0 = 4\pi k$ henrys/m

Ratio of total permeability to space per...

$\mu/\mu_0 = 1 + \frac{\mu_m}{\mu_0}$

$\frac{\mu'}{\mu_0'} = 1 + 4\pi k'/\mu_0'$

Table III

Multiply no. of C.G.S.U. of μ by 1.257×10^{-6} to expr. μ in h/m
" " " permeance 1.257×10^{-8} " P in web/amp turn
" " gauss by 10^{-4} " B in webers/m^2
" " oersteds by 80 " H in amp-turns/m

~~$\mu = 1 + 4\pi\chi$~~

BA 2-6941

~~$\mu = \mu_0 + \mu_m = 4\pi\chi$~~

~~$\chi_m = \mu - 1$~~

$\mu = 1 + 4\pi\chi_m$ (vol. susceptibility)

537.9 St 73.2

Stoner, Magnetism & Matter - 1934
~~Spooner~~ - Properties & Testing of Magnetic Materials, 1927

$\chi_{air} \sim 5 \times 10^{-6}$ or $.15 \times 10^{-6}$

7261 Hannah
7201 McCray

$r = \infty$

$$V = Ar\cos\theta + \frac{B\cos\theta}{r^2}$$

$$\frac{\partial V}{\partial r} = A\cos\theta = E_0$$

$$\frac{\partial V}{r\partial\theta} = -A\sin\theta$$

$a = 5\ cm$

$r = 5\ m$

$V = \frac{4}{3}\pi a^3 =$

$\chi_m = \mu - 1$

Inside $H = \dfrac{3H_0}{\mu+2} = \dfrac{3H_0}{\chi_m + 3} = \dfrac{3 \times .5}{\quad}$

$$V_2 = -\left[1 - \frac{a^3}{r^3}\left[\frac{(1+\chi_2) - (1+\chi_1)}{(1+\chi_1) + 2(1+\chi_2)}\right]\right] E_0$$

$$= -\left[1 - \frac{125}{125 \times 10^6}\left[\frac{9}{24}\right]\right] .5 \cancel{10}$$

$24 \overline{)4.500}$ = $.22$

$$\simeq -\left[1 - 10^{-6} \times .2\right.$$

$\chi =$

M = magnetic moment / unit vol. = magnetization

$$B = \frac{M}{\left(\frac{1}{\mu_v} - \frac{1}{\mu}\right)}$$

~~V = E~~

$$B = \mu_0 H$$

$$H = \frac{M}{\mu\left(\frac{1}{\mu_v} - \frac{1}{\mu}\right)}$$

$$H = \frac{B}{\mu}$$

$$M = \left(\frac{1}{\mu_v} - \frac{1}{\mu}\right)\mu_0 H$$

$$B = \mu_v H$$

$$M = k H$$

$$k = \frac{(\mu - \mu_v)}{\mu_v}$$

$$\mu_v = 4\pi \times 10^{-7}$$

$$\text{oersted} = \frac{4\pi \times 10^{-7}}{4\pi \times 10^{-3}}$$

$$= 10^{-4}$$

$$M = 1 \times 10^{-4} =$$

Math. analy.

χ = electric susceptibility

$K = 1 + \chi$

$$E_s = \left(\frac{3k_2}{k_1 + 2k_2} \right) E_0$$

$k_2 = 1 + 4 \times 10^2$

$k_1 = 1 + 41.6 \times 10^2$

$$E_s = \frac{3 \times 401}{401 \times}$$

N. $\rightarrow$

News release or

Pos.	Top	5.3 m Bottom	Top/Bot.	4 m deep	Top/4 m
0	47.7°	21.2	2.25	28.0	1.70
1	38.2	21.2	1.80	26.8	1.43
2	22.0	19.8	1.11	24.0	.917
3	12.9	17.6	.733	20.2	.639
4	8.0	15.1	.530	16.2	.494
5	5.3	12.9	.411	12.9	.411
6	4.0	11.1	.360	10.5	.381

	÷2.25	×20	×44	÷2.25	÷1.7	×20
0	20.0	45.0	99.0	44.0	20.0	34.0
1	16.0	36.0	79.3	35.2	16.8	28.6
2	9.9	22.2	49.0	21.8	11.3	19.2
3	6.5	14.7	32.3	14.4	7.5	12.8
4	4.7	10.6	23.4	10.4	5.8	9.8
5	3.6	8.2	18.1	8.0	4.8	8.2
6	3.2	7.2	15.8	7.0	4.5	7.6

	$2\frac{1}{2}$ m deep	Top/$2\frac{1}{2}$ m	×44	÷1.74	÷1.7	×44
0	27.4	1.74	76.6	44.0	44.0	74.8
1	24.9	1.53	67.3	38.7	37.0	62.9
2	19.6	1.12	49.3	28.3	23.7	40.3
3	14.2	.91	40.0	23.0	16.5	28.1
4	10.0	.80	35.2	20.2	12.8	21.7
5	7.4	.72	31.7	18.2	10.6	18.1
6	5.5	.73	32.1	18.4	9.9	16.8

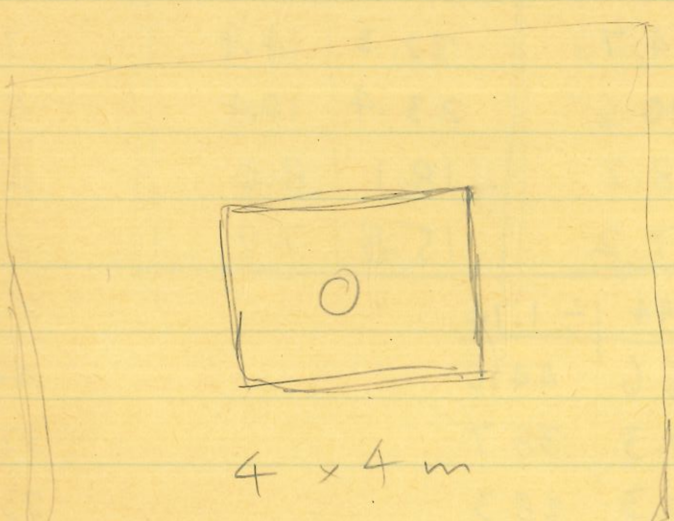
Harnwell -
p. 63
p. 75
Smythe - p. 96

$$\frac{80,000 - \text{Unit } \cancel{44,600}}{80,000} \times H = 1\,\gamma$$

.1 γ

.05 γ

.5 γ



$Vol. = 4 \times 4 \times 1 = 16\ m^3 = 16 \times 10^6\ cc$

$16 \times 10^6\ cc \times 1 \times 10^{-4} = 16 \times 10^2\ emu \approx 2\,\gamma$

Kennelly - Am. Phil. Soc. Proc., v. 76
p. 343 (1936).

4th PS61 - Am 3.51

mks

$\mu = \dfrac{\text{inductance}}{\text{length}}$ $\dfrac{\text{henry}}{\text{meter}} = \dfrac{\text{volt-sec}}{\text{amp-m}}$

μ_0 for vac. $= 4\pi \times 10^{-7} = 1.257 \times 10^{-6}$ henry/m

Relative permeability, $\mu_r = \dfrac{\mu}{\mu_0}$

Nettleton, L.L. Gravity & Magnetic Calculations, Geophysics, vol. 7, pp. 293-310, 1942

Not in library

622.12 N385 Nettleton, L.L. Geophysical Prospecting for Oil, McGraw-Hill, 1940. p. 103 ff.

S.

Carnegie - Magnetism Phila. Italy - 1945

507 +72° $I = +56°$

5th W 2732, 3 etc. .57 $H = .44$

no. 578

$\omega^2 LC = 15 \times 10^{-8} \times 10^{4} = 5 \times 10^{-4}$

$$\begin{array}{r} 6.28 \\ 2 \\ \hline 12.56 \end{array} \qquad \begin{array}{r} 1.26 \\ .06 \\ \hline .0756 \end{array}$$

$156 \overline{)1.000}$ .006

$f = 2000 \sim$

$\omega L = \dfrac{1}{\omega C}$

$\omega^2 = \dfrac{1}{LC}$

$2\pi f = \sqrt{1/LC}$

$f = \dfrac{1}{2\pi}\sqrt{1/LC}$

$LC = \dfrac{1}{\omega^2} = \dfrac{1}{(6.28 \times 2 \times 10^3)^2} = \dfrac{1}{156 \times 10^6}$

$LC = .0064 \times 10^{-6}$

$C = 1\,\mu f,$

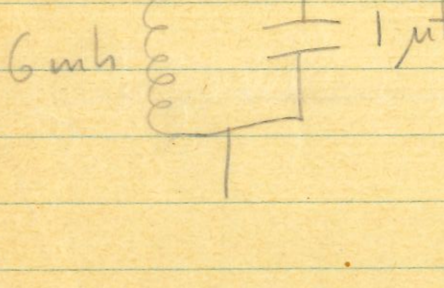
$L = 6\,mh$

$L = 0.1\,h$

$C = .06 \times 10^{-6}\,f$

$.06 = .060000$

$.1 \times .05 = .005$



$X_L = 2\pi f L = 6.28 \times 2 \times 10^3 \times .1 = 1.26 \times 10^3\,\Omega$

$X_C = \dfrac{1}{2\pi f C} = \dfrac{1}{1.26 \times 10^4 \times .06 \times 10^{-6}} = \dfrac{1}{.076 \times 10^{-2}}$

$= \dfrac{1}{.76 \times 10^{-3}} = 1.2 \times 10^{3}$

5000 Ω

1000 Ω

2   330 K Ω

2   390 K Ω

$15 \times 10^{-6} \times 2.7 \times 10^5$

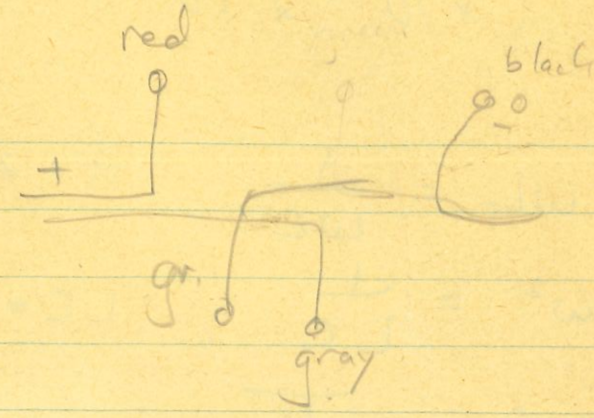
~ 4 sec.

$* 3.3 \times 10^5 \sim 5$ sec.

$$\begin{array}{r} 2.7 \\ 15 \\ \hline 135 \\ 27 \\ \hline 40.5 \end{array} \qquad \begin{array}{r} 3.3 \\ 15 \\ \hline 165 \\ 33 \\ \hline 49.5 \end{array}$$

Proton Magnetometer

Old		New	
red	1	red	+12v
lavendar	2	green	+6v
yellow	3	gray	−6v?
black	4	black	0



10K
2 x 270K
1 meg
2 meg

2/4/63

2280 cps in ll w. 1 bottle
thru 0.01 mfd

Input at T-1 = 0.001 v
Output at T-4 = 0.4 v GAIN = 400
" " T-5 = 0.25 (2 in)
T-6 2.7
T-7 3.9 → 4.3

.005 → ⏚ out sw 1

1/11/63

GRADIOMETER CALCULATIONS

Input

$F = 0.55$ oersteds

$L = 0.054$ h

For ~~8~~ 48,000 γ ; $f = 2000$ cps

" 48,001 γ , $f = 2000.04$ cps

" 55,000 γ , $f = 2280$ cps

$$
\begin{array}{r}
7000 \\
.04 \\
\hline
28000
\end{array}
$$

$$C = \frac{1}{\omega^2 L} = \frac{1}{(14.33 \times 10^3)^2 \times 54 \times 10^{-3}}$$

$$= \frac{1}{206 \times 54 \times 10^3} = \frac{1 \times 10^{-6}}{11{,}100} = 0.09 \times 10^{-6}$$

2.28

6.28

$$11 \overline{)1.00}^{\;.09}$$

For 2 bottles, $C = 0.045\ \mu f$

1024

65
130
20
2600

$$\frac{1}{C} = \frac{1}{.1} + \frac{1}{.0002} = \frac{.1002}{.00002}$$

$C = .0002$

f = 2000 cps ~ cycles per second

1 ms

1024

48,000 γ ≃ 2000 c/s
48,001 γ ≃ 2000.04 c/s
48,030 ≃ 2001.20 c/s

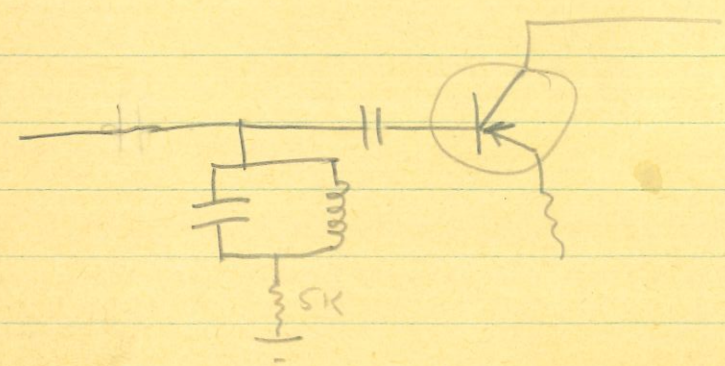
.04
30
1.20

$40)\overline{1.00}$ .02

~1 cps

50,000
1024

$$LC = \frac{1}{\omega^2} = \frac{1}{(6.28)^2} = \frac{1}{39.2} = .0255 = 2.55 \times 10^{-2}$$
$$= 25500 \times 10^{-6}$$



1/11/63

HP Audio Oscillator 200 AB, 2280 cps in ll w. one bottle thru .01 mfd
Ballantine VTVM

Input at T-1 = 0.005 v
Output at T-4 = 1.7 v with conds. 1, 2, 4, 8 in
Preamp gain = 320
Without osc. + bottle, noise = 0.003 v
" " with ", " = 0.01 V

With 20 mv from osc. at A (T-5 input), Cond. 2 in
output at T-7 coll. = 3.6 ; gain = 180 (noise = 0.2v)
" " T-10 " = 2v " = 100 (" = 0.4v)
without bottle

output at T-5 coll. = 0.015 (0.018) 0.03 .04 .02
T-6 " = 0.34 0.6 0.8 .5
T-7 " = 3.4 3.6 3.8

$\omega = 2\pi f$ $\quad f = 2280$

$h = .06\ h$

$\omega L = \dfrac{1}{\omega C}$ $\quad c$

$C \approx$ input cap.

also $\frac{1}{2} C$

0.4 .002 .005 .01 .04

$C = .035 \times 10^{-6}$

$f = 2 \times 10^{3}$

$\omega L = \frac{1}{\omega C}$

$L = \frac{1}{\omega^2 C} = \frac{1}{(6.28)^2 \times 4 \times 10^6 \times 3.5 \times 10^{-8}}$

39.4

158

5.53

$.001 \times 10^{-4}$

$600 \overline{)1.000}$

$= \frac{1}{5.530}$

.02

$55 \overline{)1.00}$

$= 0.181$

$= 180 mh$

70,000

20,000

48,000 $\simeq$ 2000 ~/s

+ 22,000

− 28,000

$28 \times 10^3 \times 4 \times 10^{-2}$

~ 1000

$f = 3 \times 10^3$

$C = \frac{1}{\omega^2 L} = \frac{1}{39.4 \times 9 \times 10^6 \times 1.8 \times 10^{-1}}$

354 $\quad 6.38 \times 10^6$

$= \frac{1}{6.38 \times 10^7}$

$= 0.016\ \mu f$

$f = 1 \times 10^3$

$C = \frac{1}{39.4 \times 1 \times 10^6 \times 1.8 \times 10^{-1}}$

$= \frac{1}{7.1 \times 10^6} = 0.14 \times 10^{-6}$

SETTING UP MAGNETOMETER

1. after attaching cable to instrument, connect free end of cable to Junction box and one bottle to Junction box.

2. Use shorting plug in place of second bottle for amplifier tuning adjustment when first setting up.

3. Use approximately 12 units to tune one bottle - may be 13 or more.

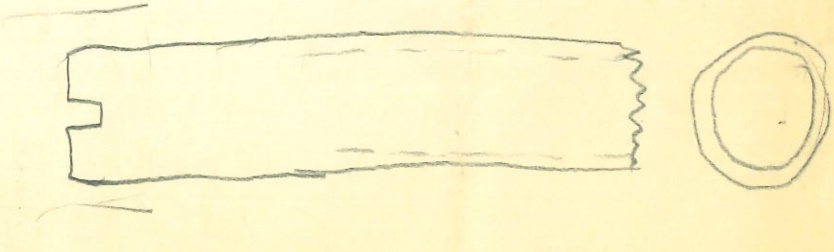
4. Adjust amp. tuning and bottle tuning until clear, strong precession note is obtained. Should be full scale and drop to about 5 at end of listening period.

5. Connect second bottle.

   a. Shielded bottle should go to "shielded" plug. Other bottle to "B" plug.
   b. Bottles may be reversed by reversing plug.
   c. Switch bottle tuning to approx. 4 units.

Note: Do not readjust amplifier tuning. Adjust only bottle tuning until maximum signal is obtained.
Maximum signal at 10 drops to about 7. Noise level is higher.
Orient bottles for minimum noise. Power line noise is chief problem.

Stopwatch



ASSEMBLY OF MAGNETOMETER

The bottles screw onto aluminum sections. The short section on the bottom, the two fitted sections between the bottles.
The aluminum plug is provided to keep water out of the top hole, and to provide a tie point.

The controls are marked and the gain control provides a limited range of adjustment. The weter switch in BATT position should indicate between 5 and 6 for charged batteries.
The battery voltage will drop rapidly when near end of charge.

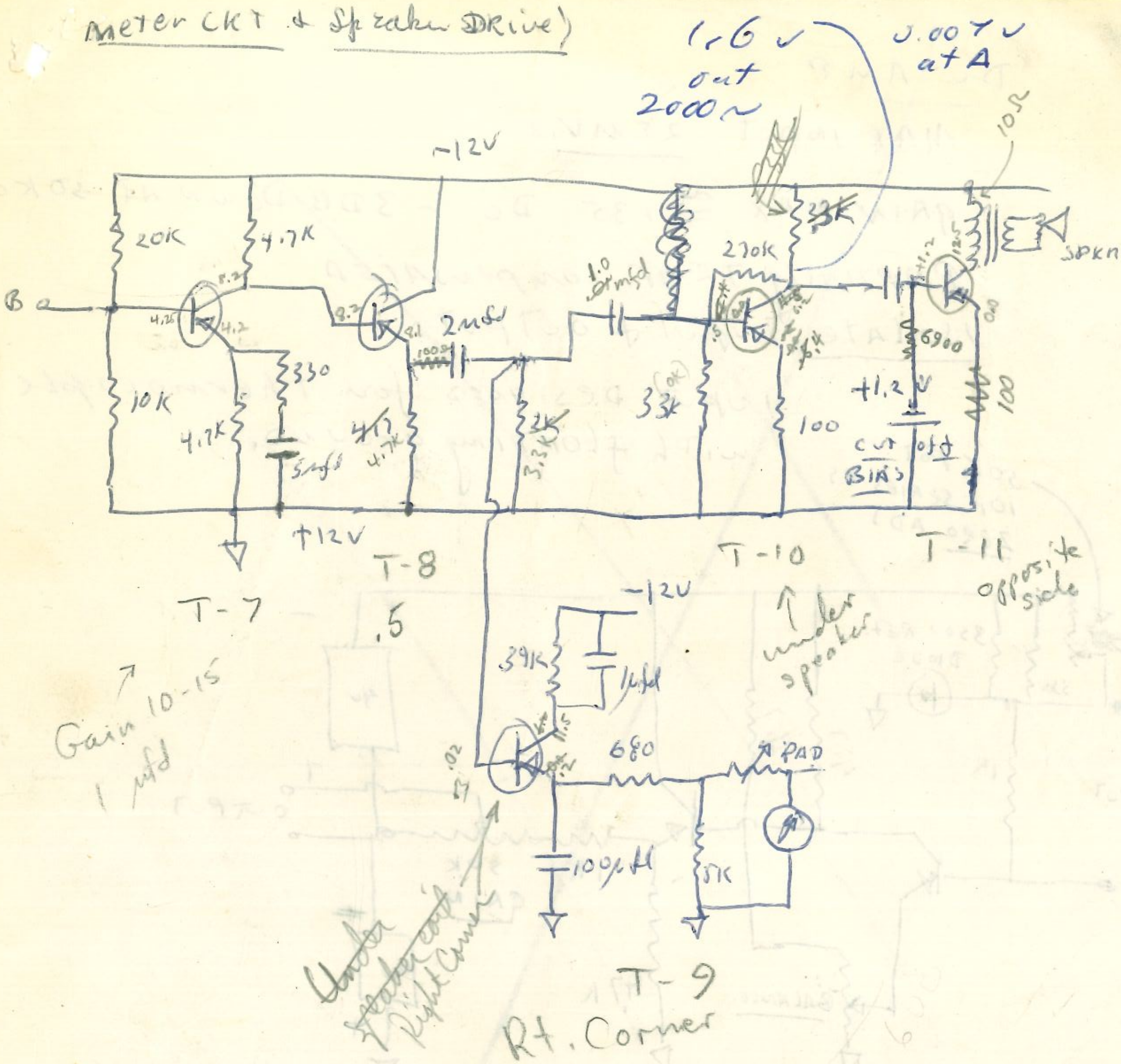
To charge, plug in 110 volt cord into panel with switches in OFF position.
For 6 or 12 volt charging, use cord and plug.

For 12 volt - connect adapter plug on end of cable. This connects batteries for 12 volt charging.
Batteries should charge at 0.5 ampere rate and will charge in 8 to 12 hours.

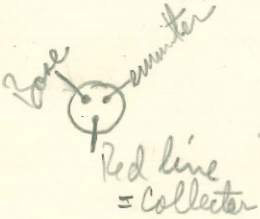
A wider range of gain adjustment is available through a hole in the side of the cabinet. To adjust, slide equipment from leather case, insert screw driver through access hole to adjust trimpot.

The meter is not connected to read integrated signal output but when equipment is operating as expected, it will be easy to provide.

Meter CKT & Speaker Drive)



Tune to



looking at bottom

D.C.-AMP

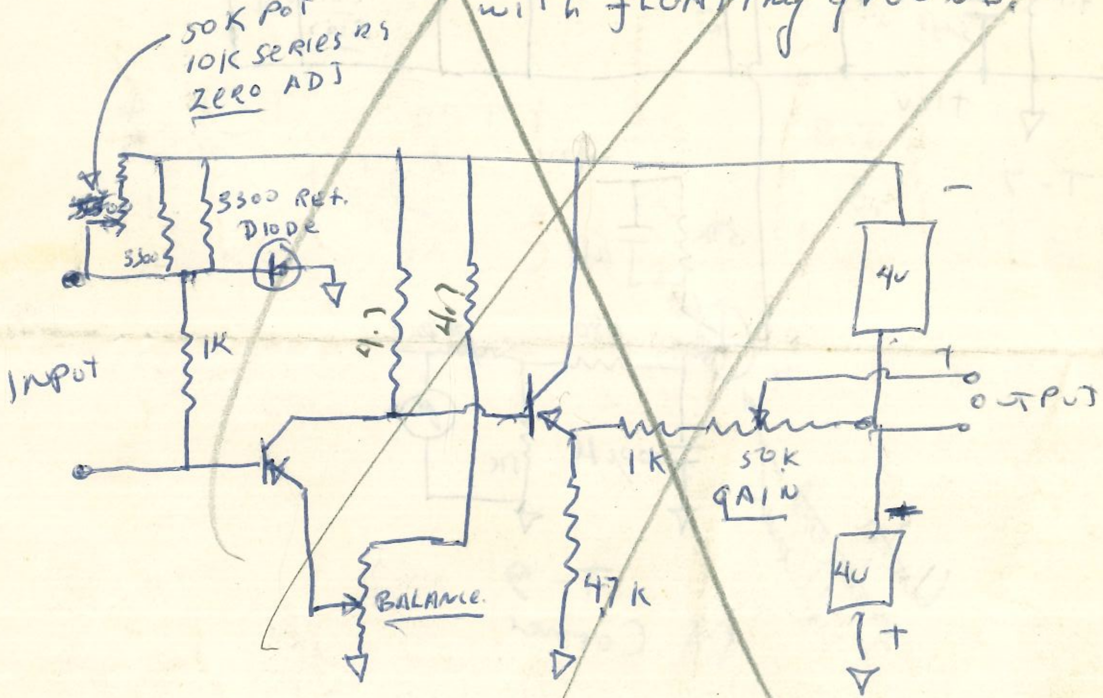
MAX INPUT 25MV.

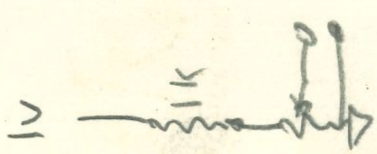
GAIN MAX ≅ 135 DC - 3DB DOWN AT 50KC

PARTIALLY TEMP COMPENSATED

ISOLATE INPUT + OUTPUT.

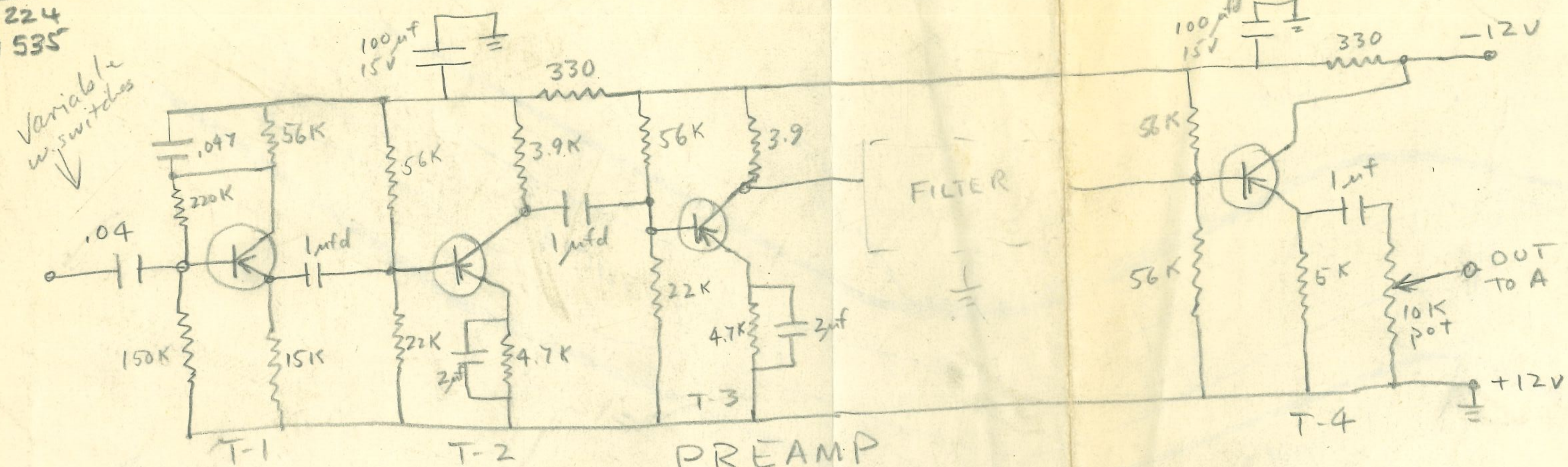
INPUT DESIGNED for Thermocouple with floating ground.



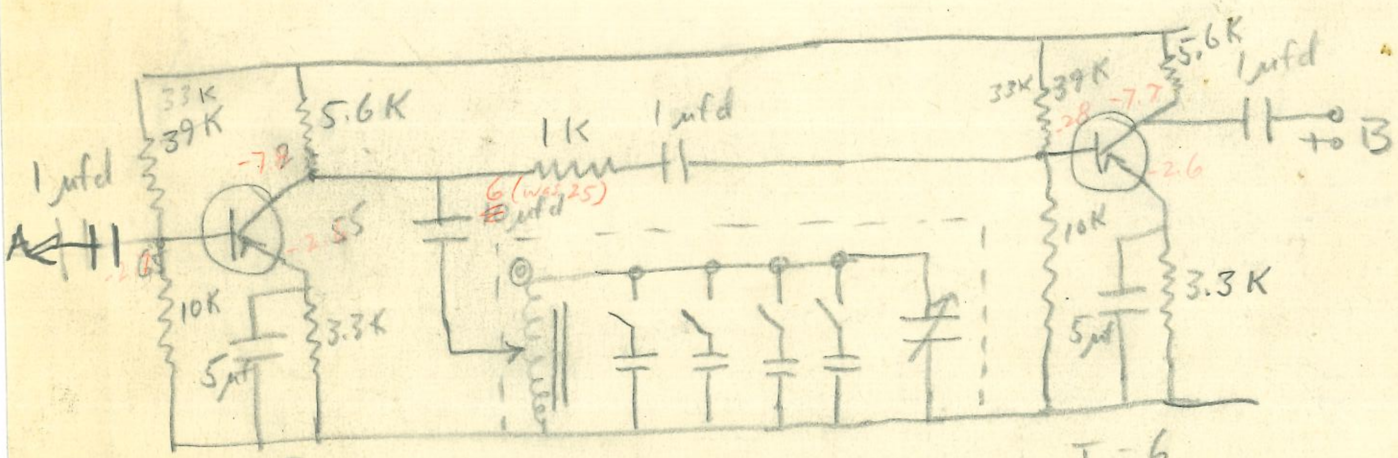


GRADIOMETER CIRCUIT

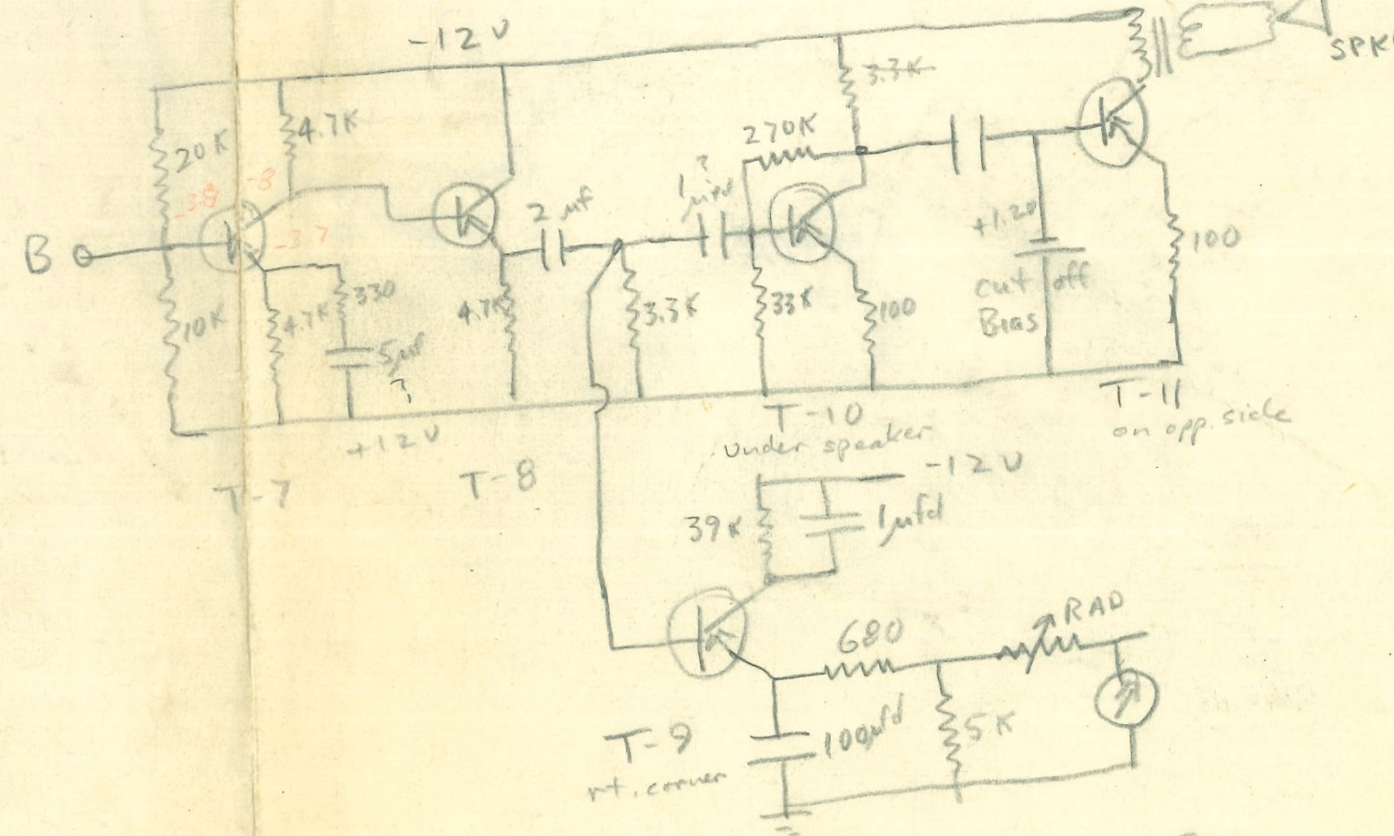
TRANSISTORS
2N224
2N535



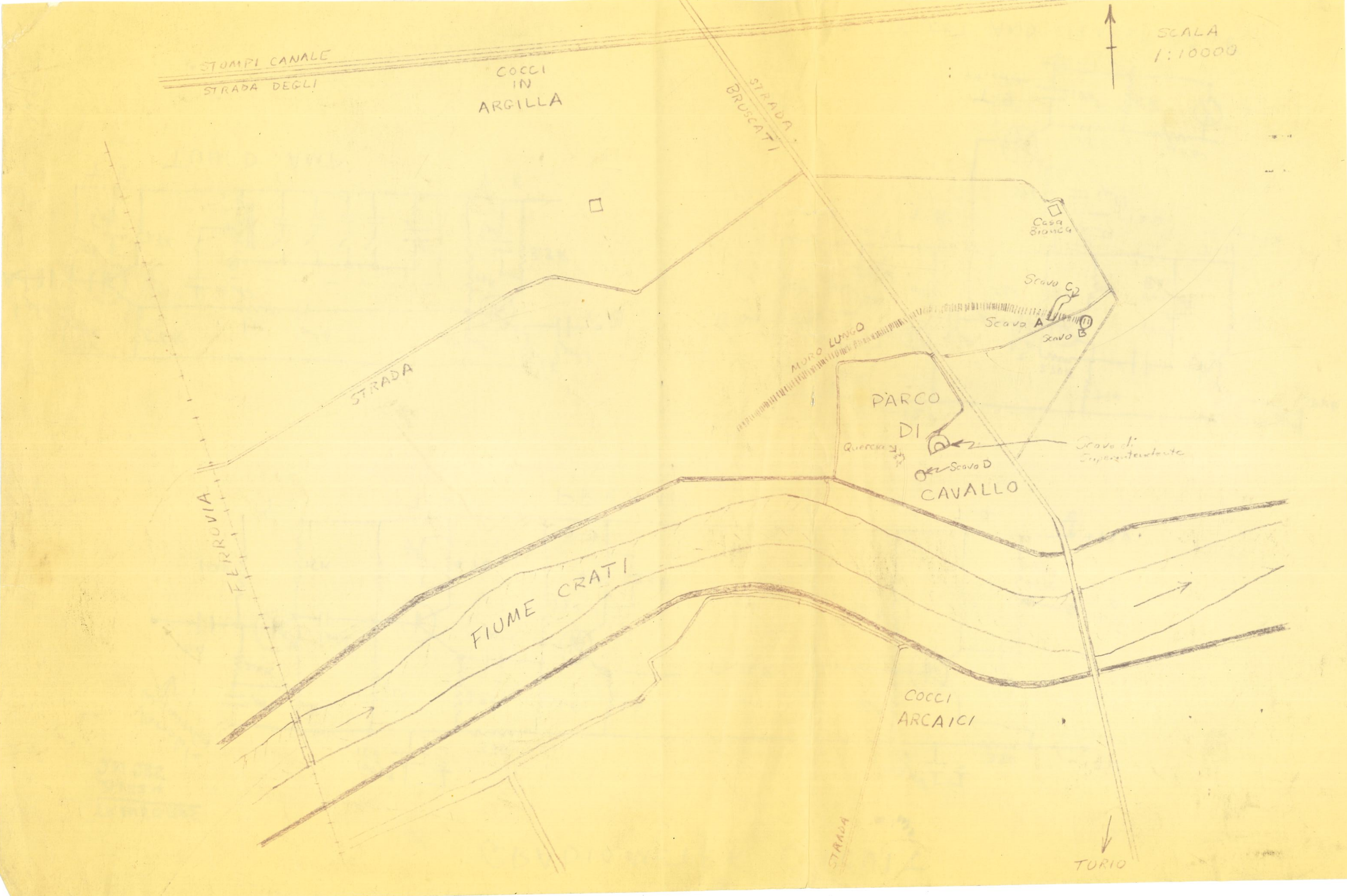
PREAMP



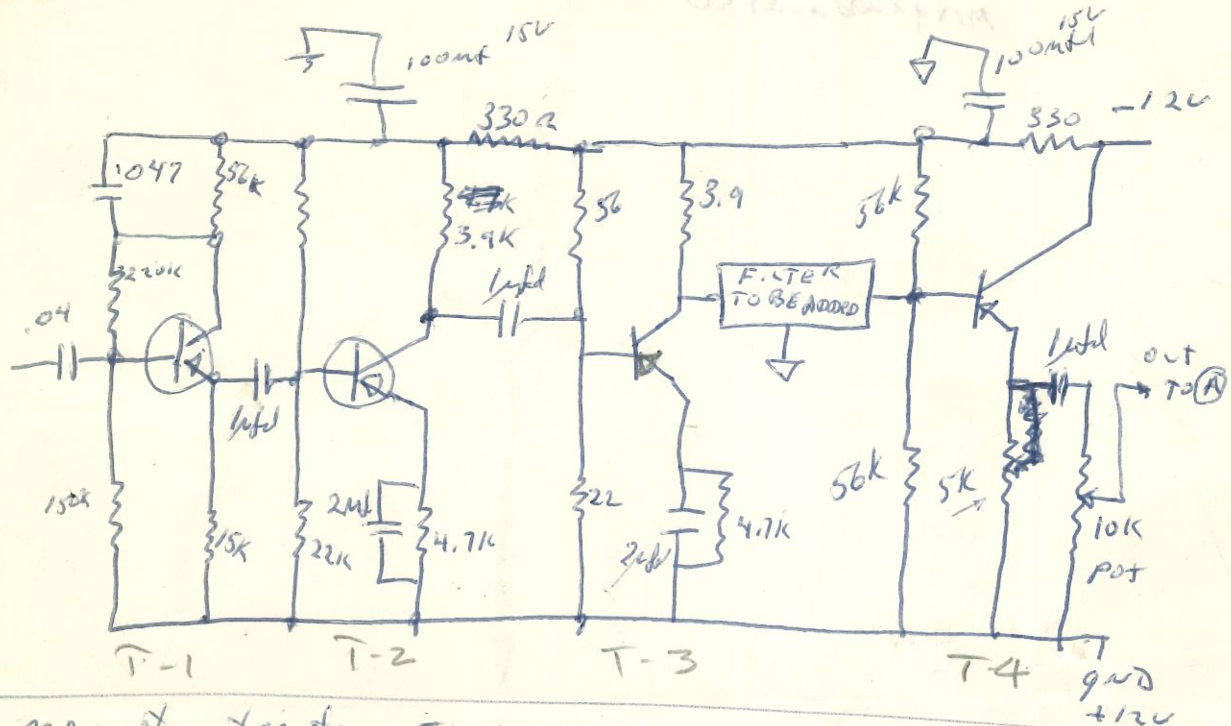
TUNED AMP



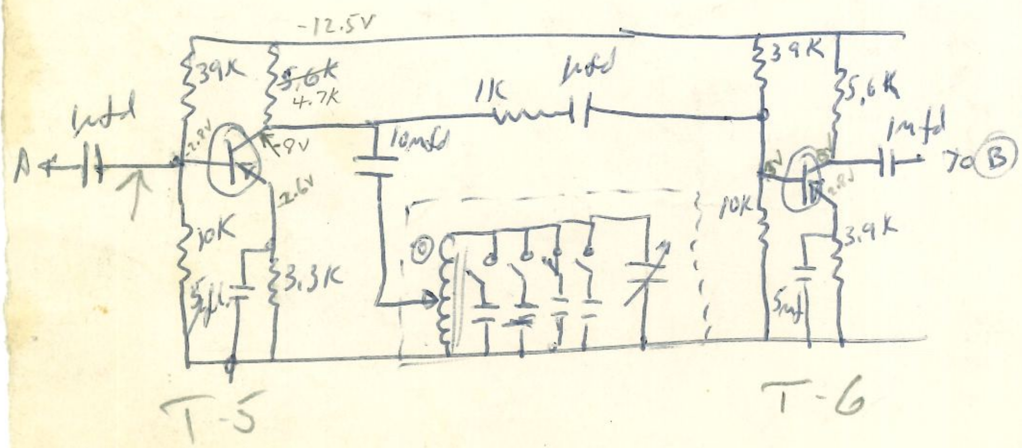
METER CKT AND SPEAKER DRIVE


STUMPI CANALE
STRADA DEGLI
COCCI
IN
ARGILLA
STRADA
BRUSCATI
SCALA
1:10000
Casa
Bianca
Scavo C2
Scavo A
Scavo B
MURO LUNGO
STRADA
PARCO
DI
CAVALLO
Quercia
Scavo di
Scavo D
FERROVIA
FIUME CRATI
COCCI
ARCAICI
STRADA
TORIO

MAGNETOMETER PREAMP



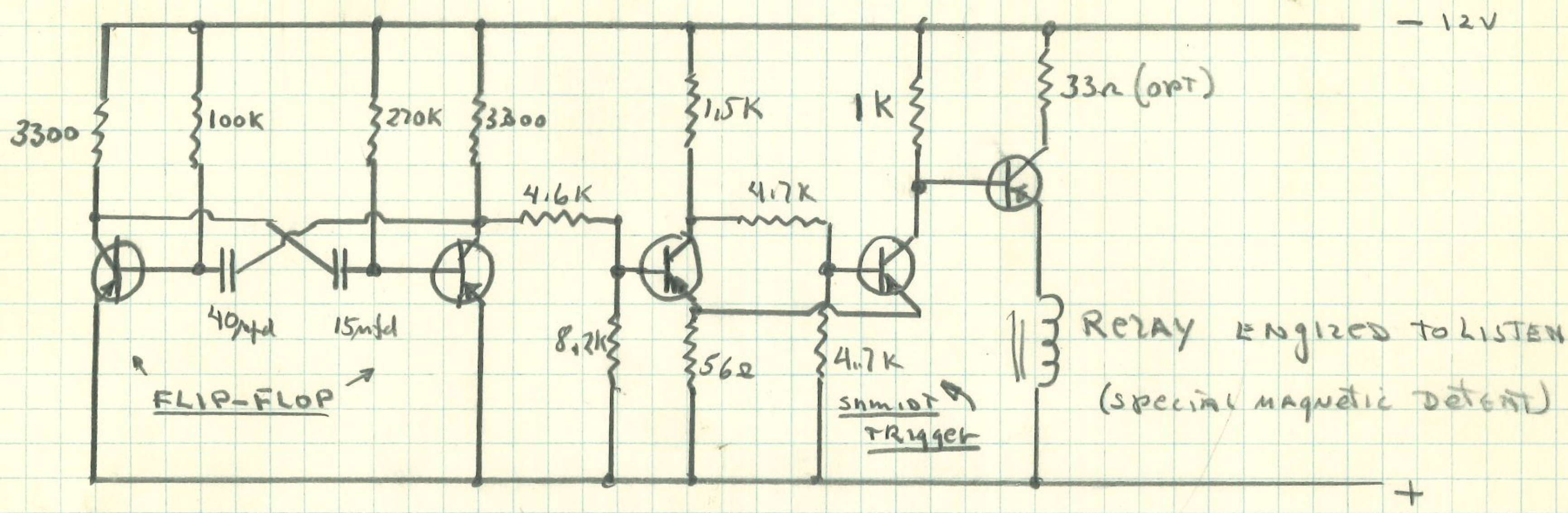
Magnetometometer TUNED AMP



2N224

2N535

magnetometer



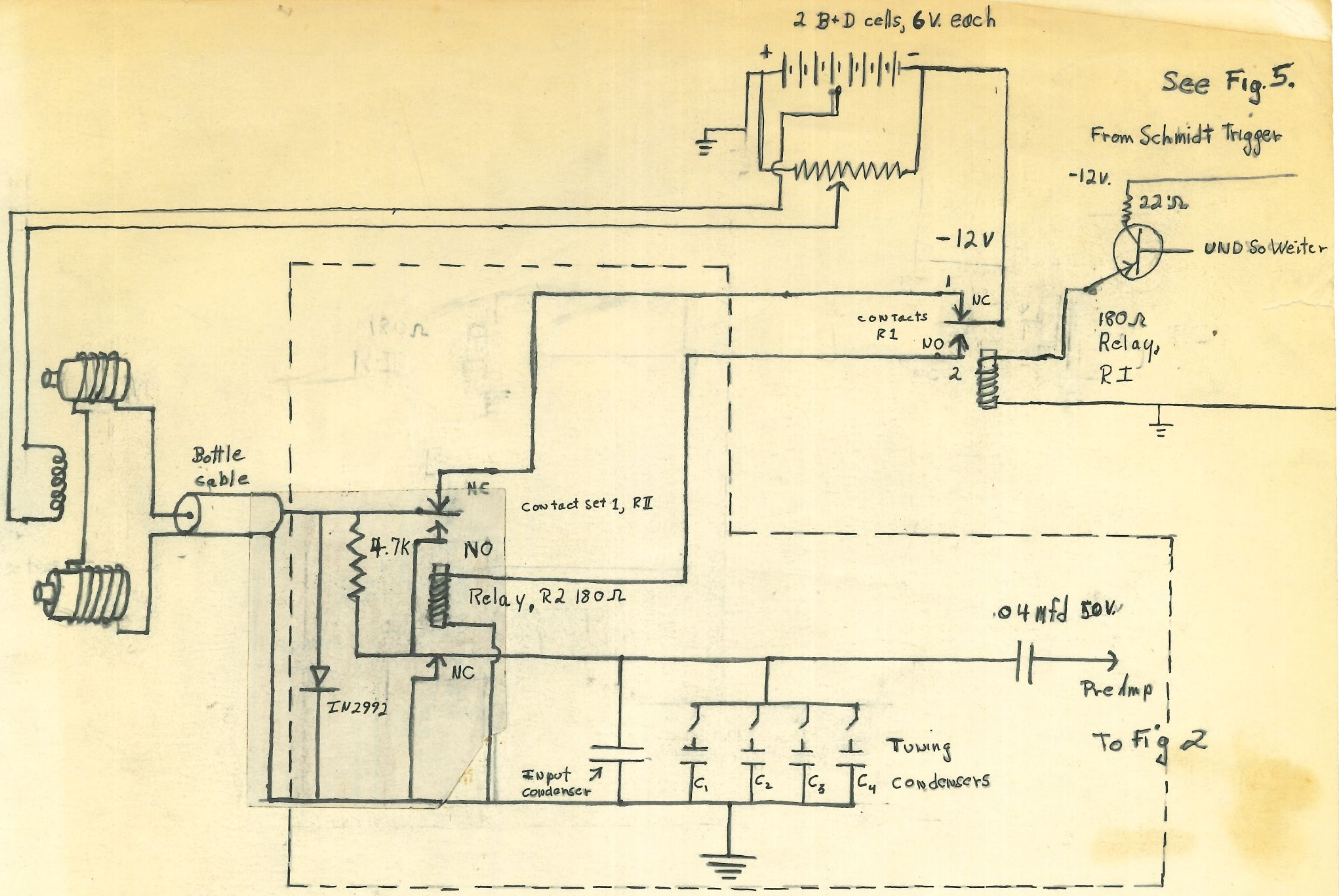
POLARIZING DURATION 3 SEC
LISTENING DURATION "

ALL TRANSISTORS 2N224 (PHILCO)

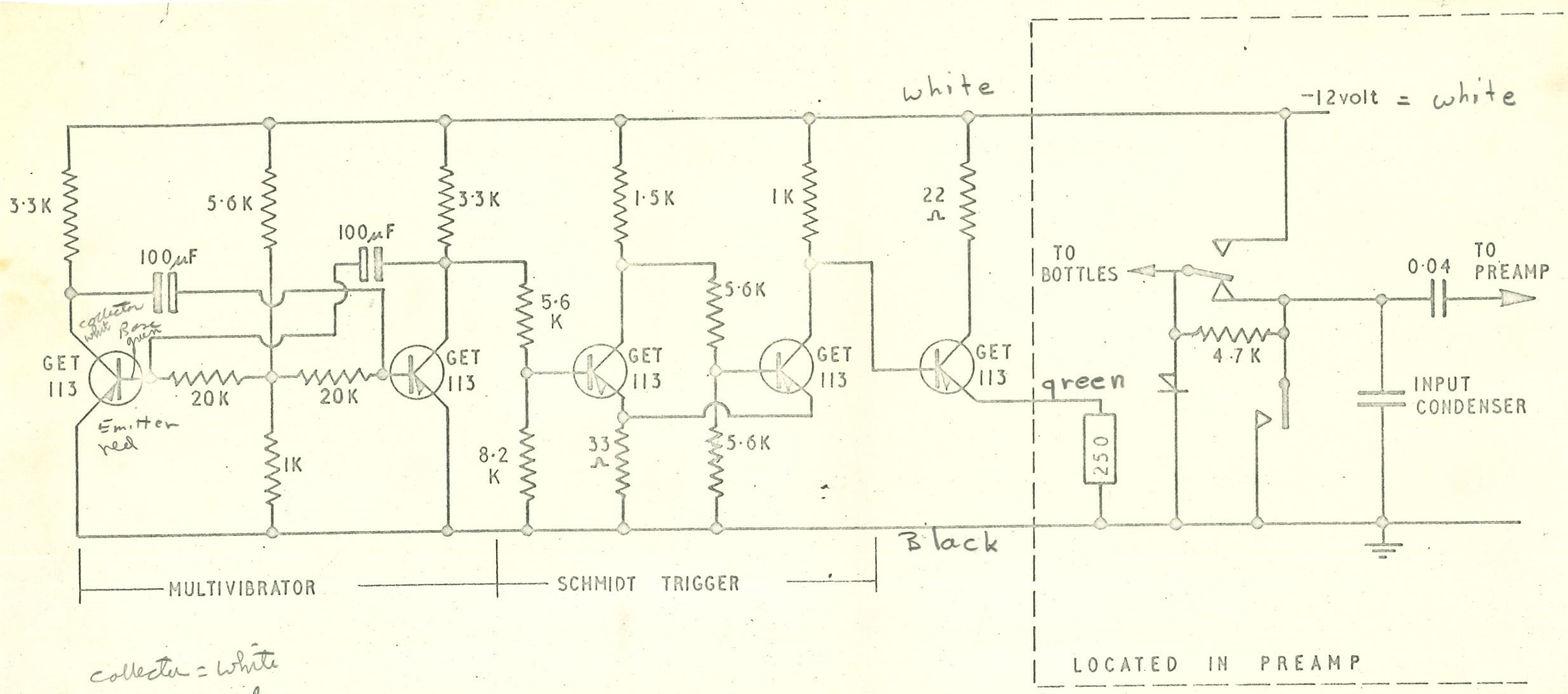
TIMING CIRCUITS FOR PROTON GRADIENT MAGNETOMETER.

Grey

LOW NOISE
SELECTED 2N535B



Input Relay System



collecter = white
emitter = red
Base = green

Fig: 5. AUTOMATIC RECYCLING.

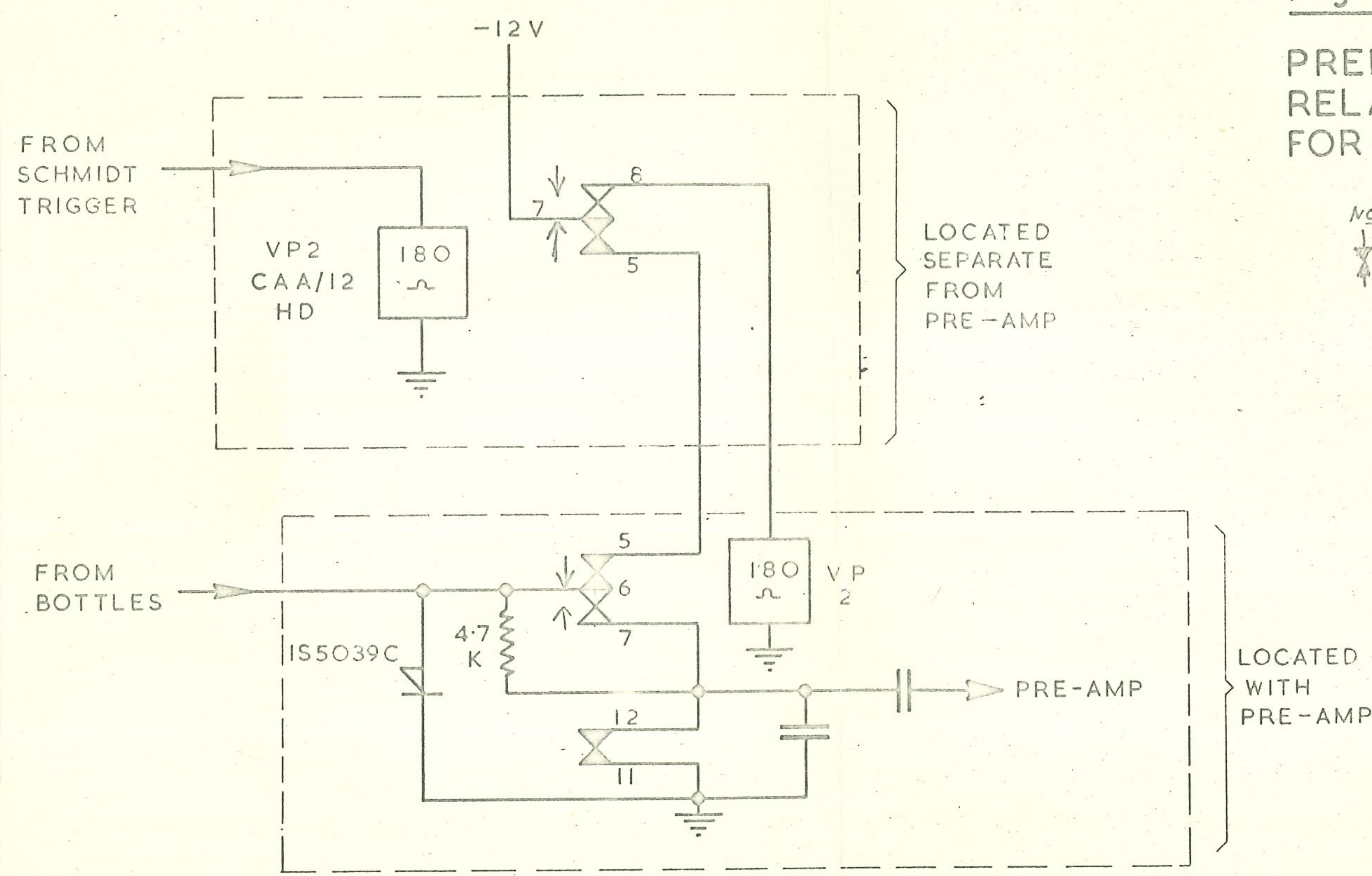
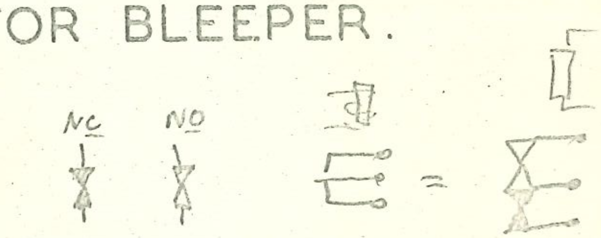


Fig. 5a

PREFERRED INPUT
RELAY SYSTEM
FOR BLEEPER.



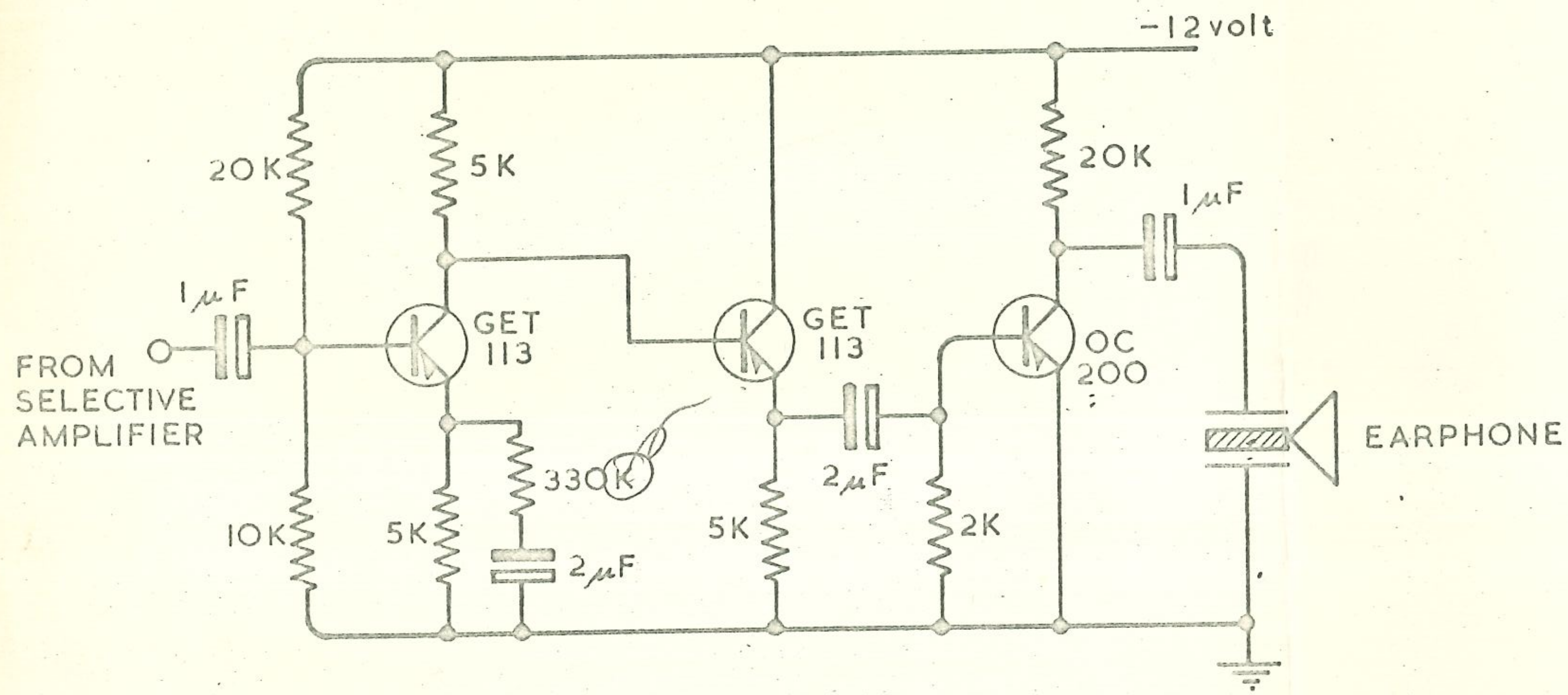


Fig: 4 . A.C. DISCRIMINATOR

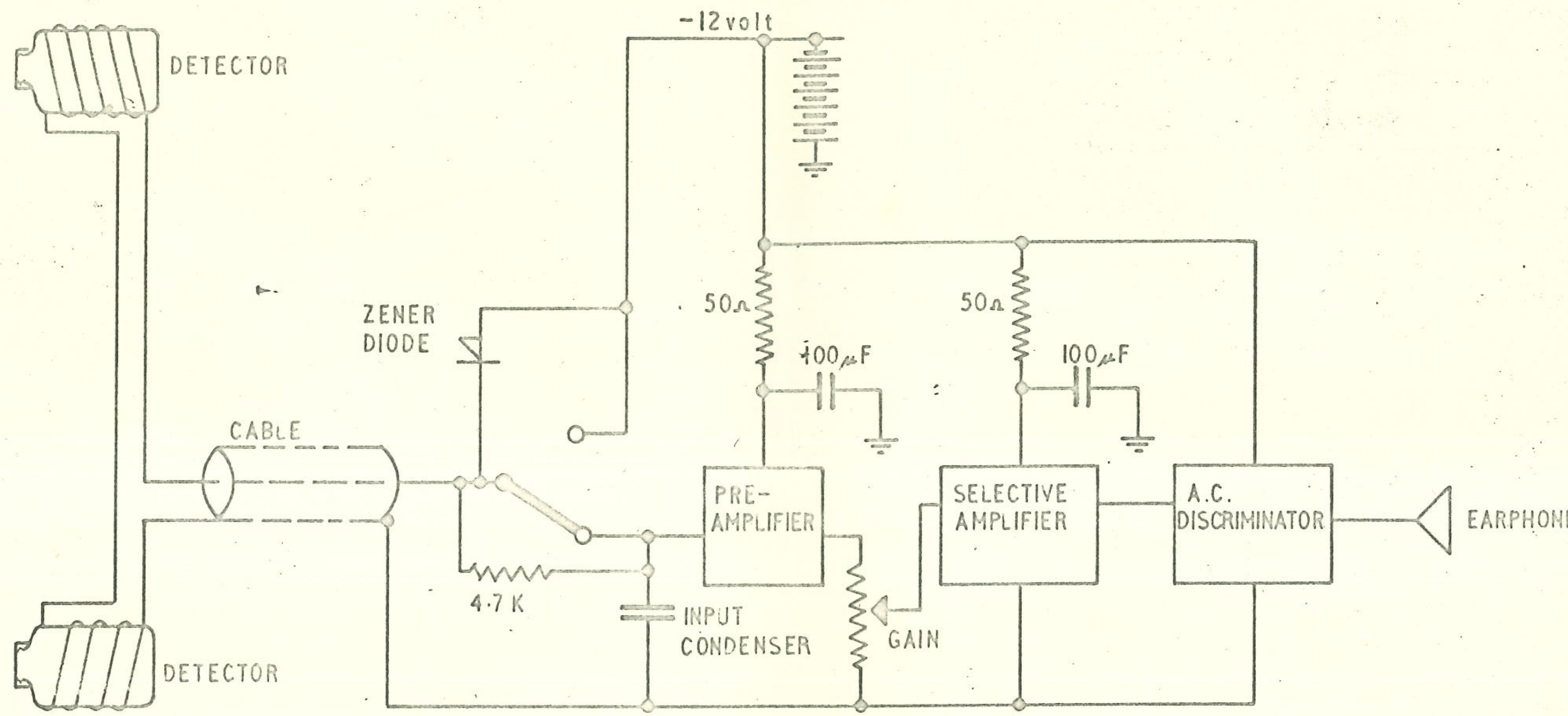


Fig:1. BLOCK DIAGRAM: "THE BLEEPER".