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FEASIBILITY TEST: FAST BACKLEG BEAM DEFLECTION

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Collider Accelerator Department

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Upton, New York

AGS DIVISION TECHNICAL NOTE

No. 71

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December 8, 1969

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A test was conducted to determine whether a fast (1.0 msec max.) orbit perturbation could be generated using a backleg winding. However, suppose a pulse is applied to a backleg winding thus generating a voltage in that main winding. This voltage would be dropped across the windings of the rest of the magnets in the ring. The resulting counter-acting flux change would completely nullify the flux change in the initial magnet if there were no flux leakages, and if the shunt capacitances and magnet inductances formed a lossless delay line. Thus, the object of the test was to determine the transmission characteristics of the magnet ring to a step input to a backleg winding and its departure from an ideal LC line.

A simple test circuit was built which does the following. A large capacitor, Co, is charged through the normally closed contacts of a mercury relay. Approximately once per second the relay is energized connecting the charged capacitor across a 5-turn backleg winding. The specific magnet used for the test was at E-6. Photographs of the response across the main windings of E-6, E-5, E-4, E-3 and E-1 were taken using the A-B function of a TEK 454 scope. These voltages were numerically integrated to obtain $2\int V_o dt$, $\int V_1 dt$, $\int V_2 dt$, $\int V_3 dt$ and $\int V_5 dt$ respectively. An extrapolation was made to obtain values of $\int V_n dt$ for which the response was not measured. These were combined to form

$$2\int_0^t V_o dt - 2\sum_{n=1}^{18} \cos n\,\Delta\theta \int_0^t V_n dt$$

which is proportional to the angular change the beam orbit should experience at the time t for the voltage applied as it passes through this series of magnets. $\Delta\theta$ is 13.15^o/magnet assuming a ν of 8.75. This result is plotted in Fig. 1.

The rise of the response at the main winding of E-6 is slowed by the leakage inductance which introduces a time constant of $(1-k^2)$ $L/R \approx 21$ μsec causing V_o to be a poor step, where L is the main winding inductance and R is the resistance across the coil packs. However, if V_o were a step, an analytic form for the voltage across any coil can be obtained for $t < \frac{L}{R}$. The form of the solution involves exp. $(n^2RC/4t)$. This was used as the basis for making the extrapolation for those unmeasured responses mentioned above. However, there is no reason to expect that the measured responses should agree closely with this calculated response.

The result of the test indicates that beam perturbations of the order of 100 μsec duration can be accomplished using this approach. The net effect of the voltage across the adjacent magnets causes a small negative correction on the beam bending effect of the field change generated in the core of the magnet energized by the backleg winding. The leakage inductance and the resistance across the coil packs effectively put a lower limit on the duration of the beam deflection.

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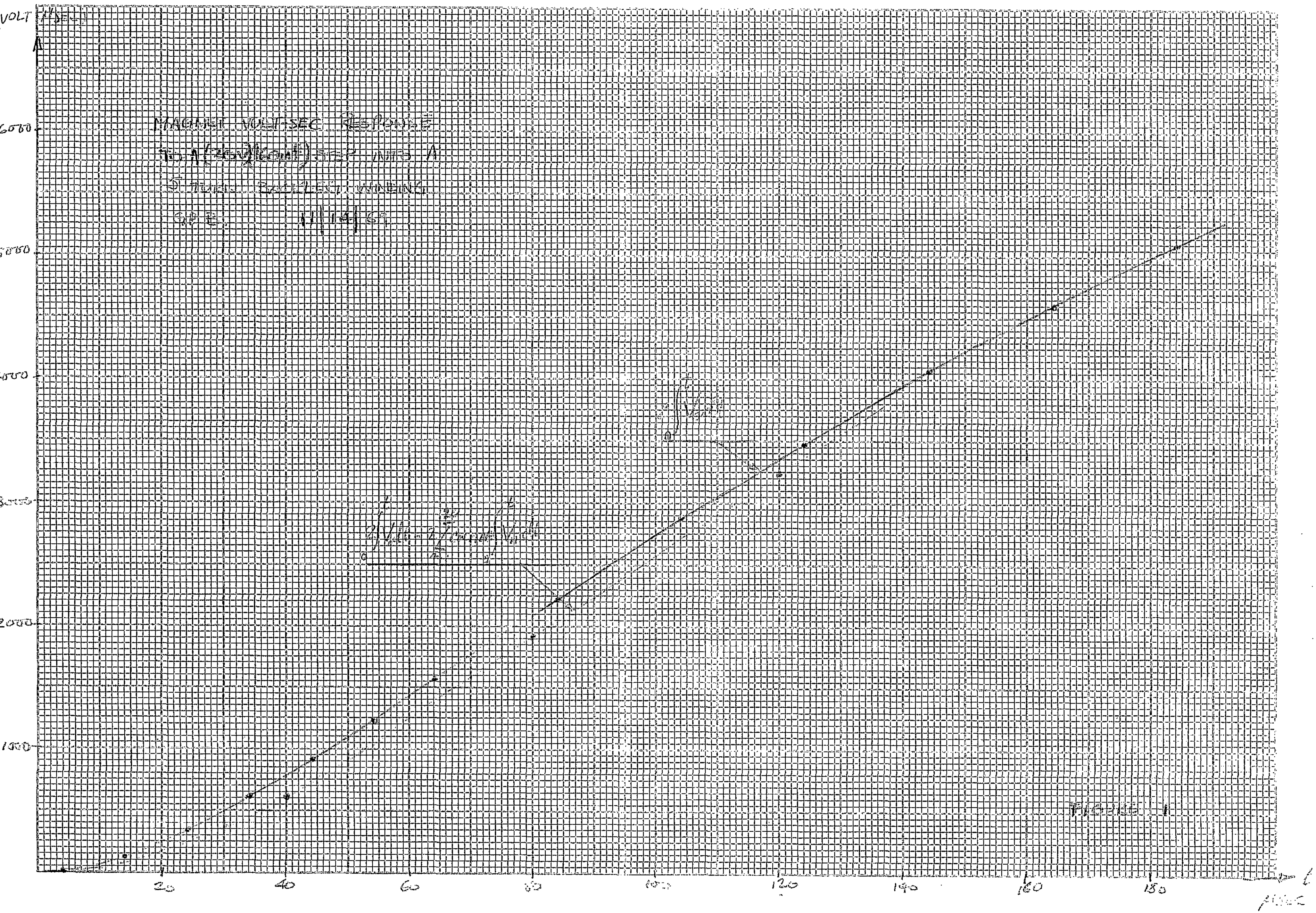
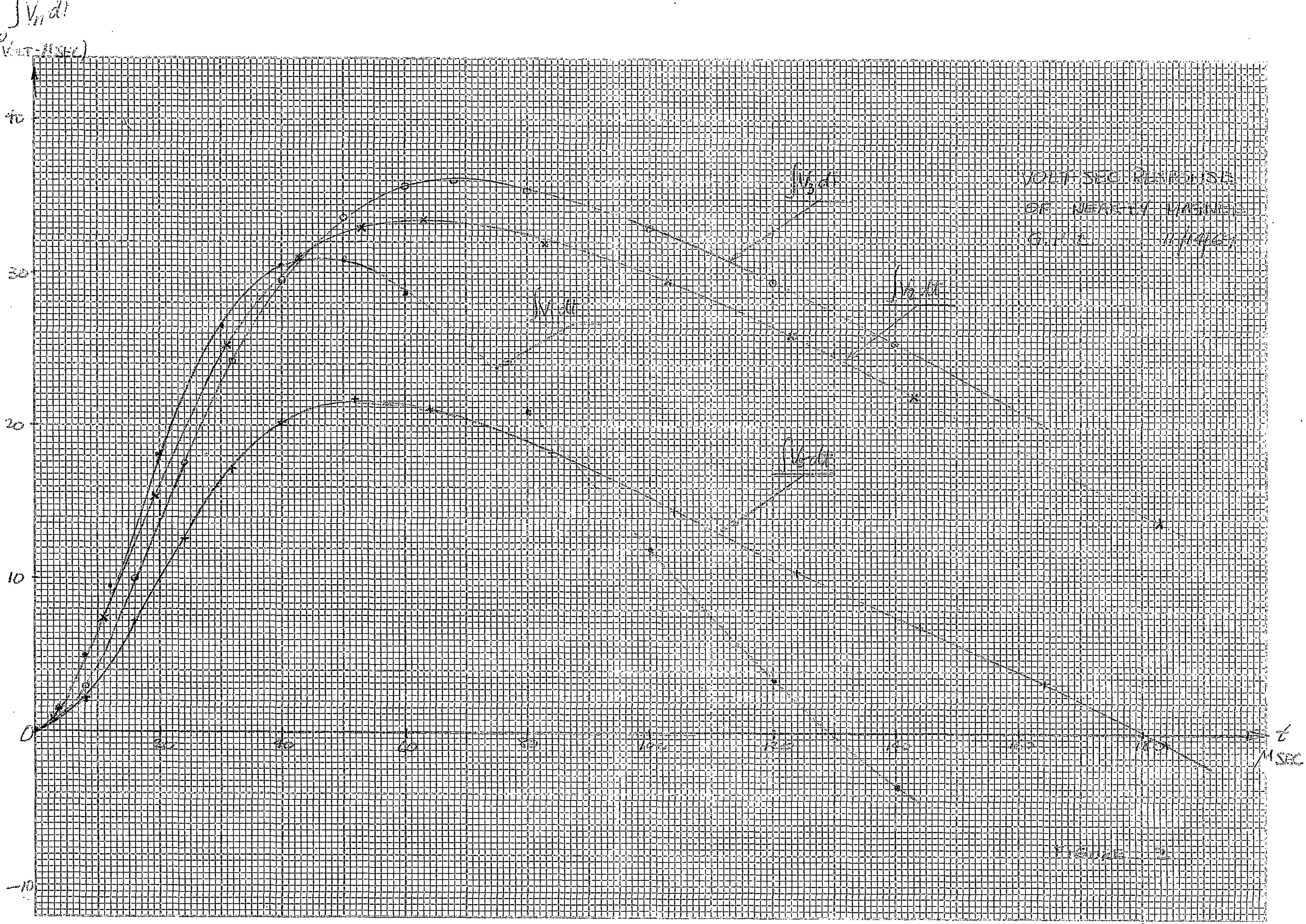
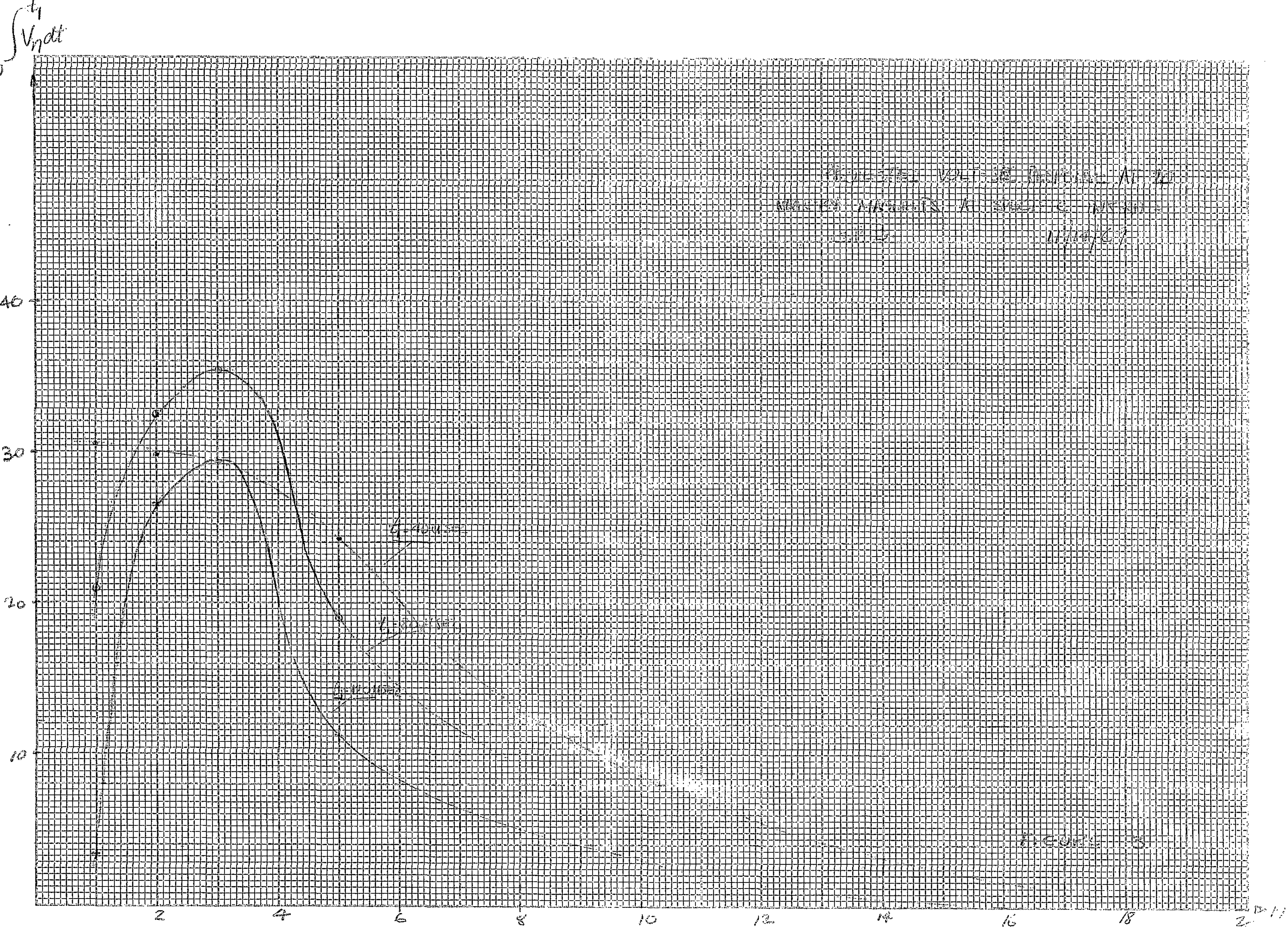

VOLT μSEC
MAGNET VOLT-SEC RESPONSE
5 TURN BACKLEG WINDING
11/14/67
6000
5000
4000
3000
2000
1000
20
40
60
80
100
120
140
160
180
t
μSEC
FIGURE 1


$\int_0^t V_n\,dt$
(VOLT-μSEC)
40
30
20
10
0
−10
20
40
60
80
100
120
140
160
180
t
μSEC
$\int V_1\,dt$
$\int V_2\,dt$
$\int V_3\,dt$
$\int V_4\,dt$
VOLT SEC RESPONSE
OF NEARBY MAGNETS
G.P.E. 11/14/67
FIGURE 2


$\int^{t_1} V_n dt$
40
30
20
10
2
4
6
8
10
12
14
16
18
$t_1 = 40\,\mu sec$
$t_1 = 20\,\mu sec$
$t_1 = 10\,\mu sec$
FIGURE 5

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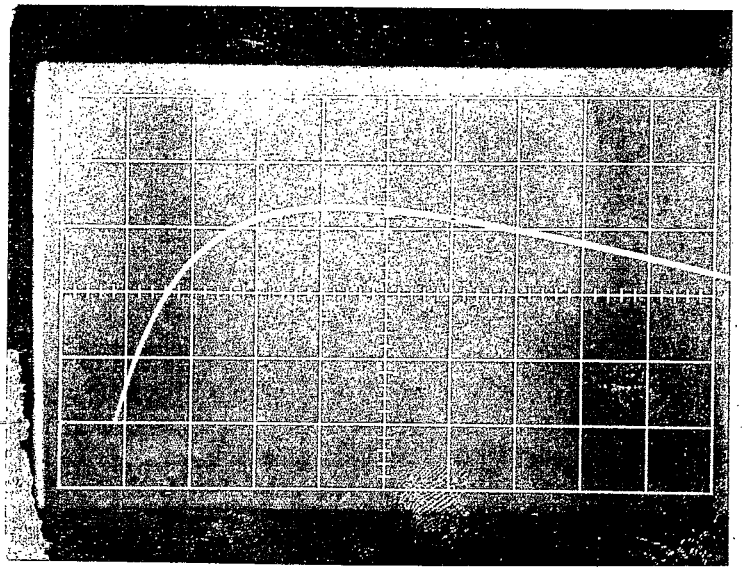
BY GPB DATE 11/11/69 SUBJECT MAGNET VOLTAGE RESPONSE TO (20 V) (160 μf) BACKLEG WINDING STEP SHEET No. ____ OF ____

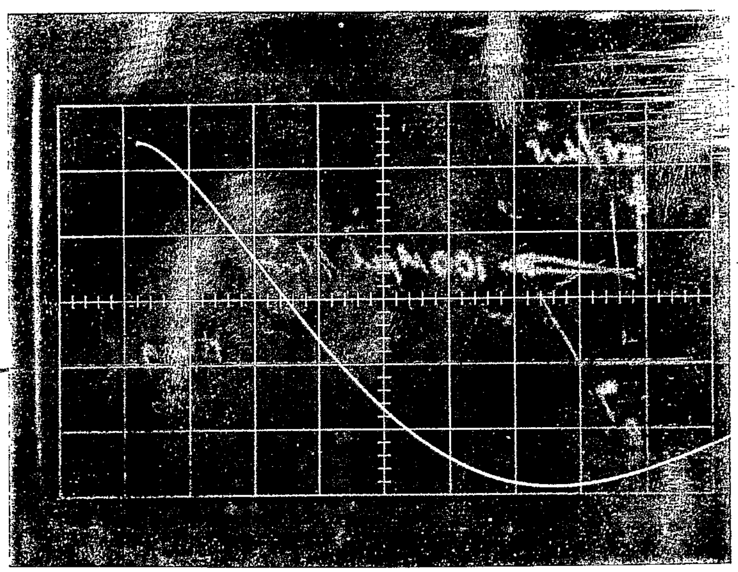
CHKD. BY ____ DATE ____ JOB No. ____

DEPT. OR PROJECT ____

$2V_o$



EG., Upper Coil Packs 10 V/Div,
20 μsec/Div



EG., Backleg Winding 5 V/Div, 100 μsec/Div
160 μf Charged to 20 V

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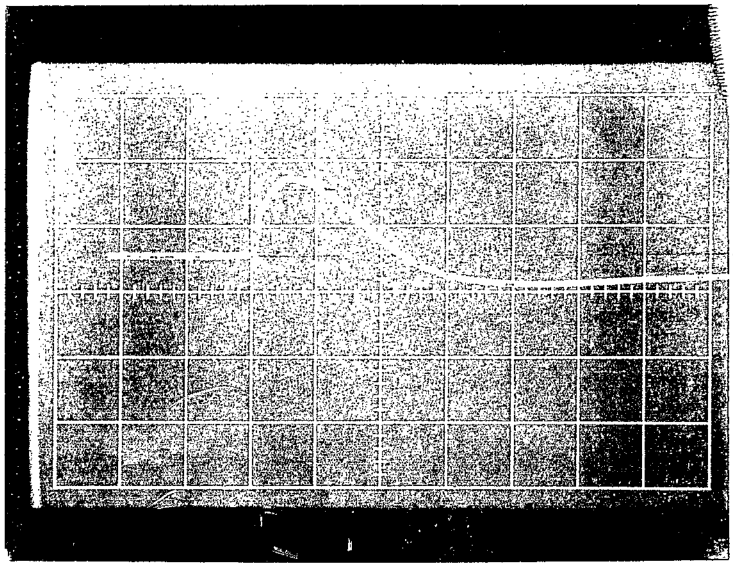
BY GPB DATE 11/11/69 SUBJECT NEAR BY MAGNET VOLTAGE RESPONSE TO BACKLEG WINDING STEP SHEET No. OF

CHKD. BY DATE JOB No.

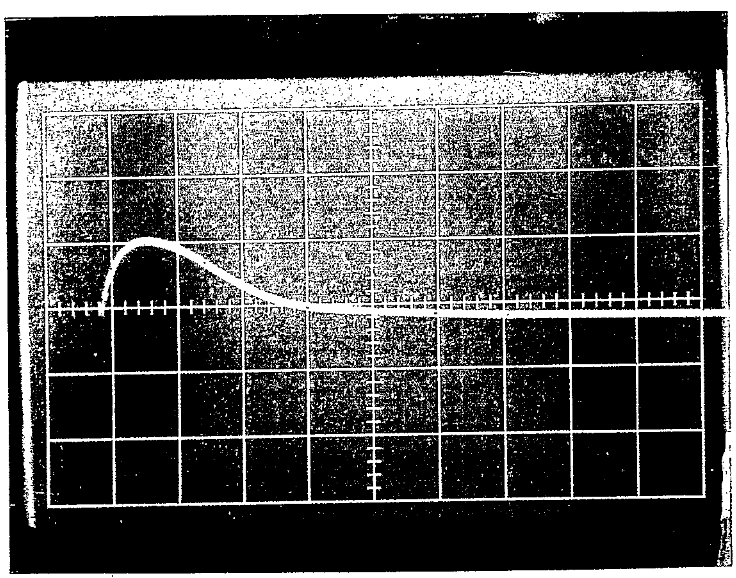
DEPT. OR PROJECT

V_1



E5, Lower 1.0 V/Div, 20 μsec/Div

V_2



E4, Upper 1.0 V/Div, 20 μsec/Div

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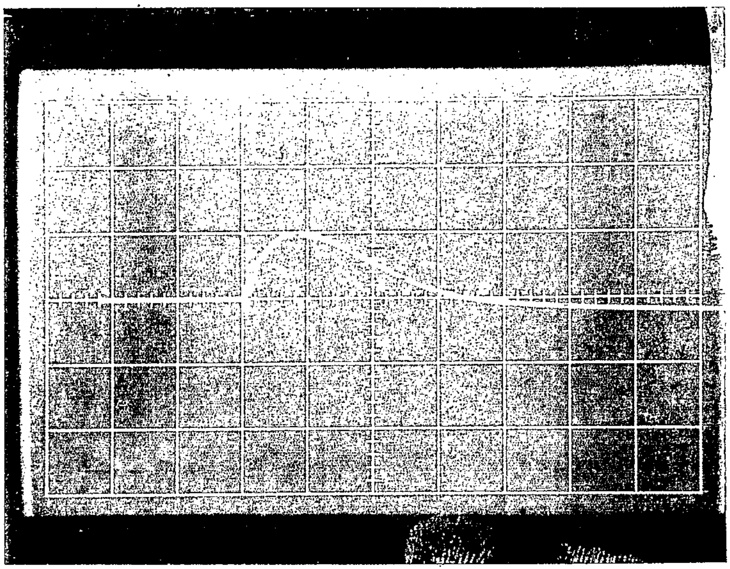
CHKD. BY ____ DATE ____ JOB No. ____

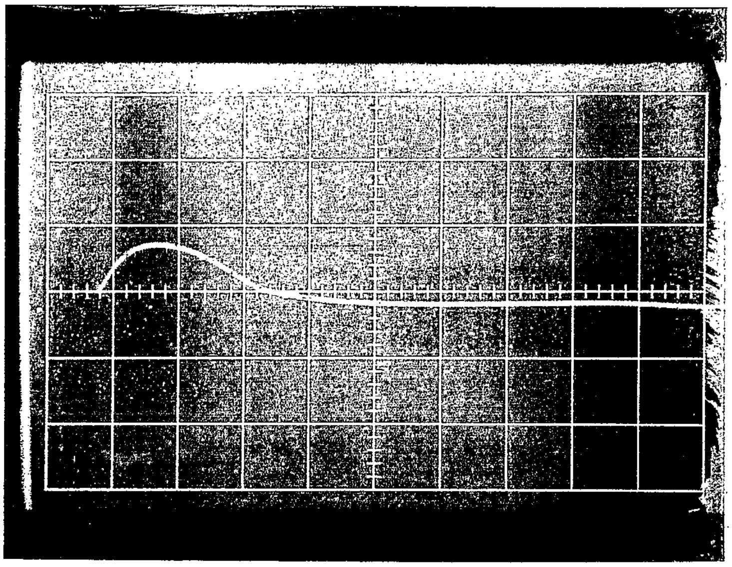
DEPT. OR PROJECT ____

V_3



E3, Lower 1.0 V/Div, 20 μsec/Div

V_5



E1, Lower 1.0 V/Div, 20 μsec/Div