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A TESTER FOR PILE FLUX MONITORS

by

L. Cathey
Instrument Development Division

September 1954

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E. I. du Pont de Nemours & Co.
Explosives Department — Atomic Energy Division
Technical Division — Savannah River Laboratory

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INSTRUMENTATION

ABSTRACT

A mechanoelectrical instrument is described which is used to calibrate logarithmic micro-microammeters and associated period measuring systems.

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FIGURES

A TESTER FOR PILE FLUX MONITORS

INTRODUCTION

For the safe operation of a pile it is necessary to know the neutron flux level and its rate of change. The instruments for obtaining this information at the Savannah River Plant contain a logarithmic micromicroammeter and a period computer to determine the rate of change of the neutron flux by measuring the current from an ion chamber.

An instrument to calibrate the micromicroammeter and pile period computer was necessary. This report covers the development of such a device.

SUMMARY

A tester was developed that satisfactorily simulates the currents produced by ion chambers in pile service. The tester can generate currents in the range 10^{-13} to 10^{-4} amperes and can supply the following signals:

1. A current that increases or decreases exponentially with time over a range of two decades. The period may be chosen between 1.5 and 180 seconds.

2. Any steady current in the range of the tester.

3. Stepwise changes in current that are adjustable in magnitude up to 9 per cent of the current.

The generation of an exponentially varying signal is achieved by rotating at constant speed three ganged helipots that are connected in a network with fixed resistances. The circuit is so designed that the output voltage from the network approximates an exponential function of the angle of rotation of the helipots.

Four units are in use at the Savannah River Plant.

DISCUSSION

The safe operation of a pile is very dependent upon knowledge of the neutron flux level and rate of change of this flux level. Since the growth or decay of the neutron flux in a pile approximates an exponential curve, it is convenient to compute the coefficient of the exponential as the inverse period of growth or decay of the neutron flux. The period is computed by taking the derivative with respect to time of the logarithm of the pile flux.

Monitoring of the pile flux is done by neutron-sensitive ion chambers. The logarithmic and differentiation computations on the ion chamber currents are both done electronically. The aging of vacuum tubes will vary the calibration of these electronic computers, so some means of standardization is necessary.

DESCRIPTION

The tester consists of four main units on one chassis: power supply, two transient generators, and an attenuator. The circuit diagram is shown in Figure 1.

The power supply, which is regulated by a glow tube, delivers 105 ± 3 volts direct current. The current is well filtered to reduce the 60 cycle ripple content. The transformer and choke are mounted as far as possible from the attenuator to avoid interaction.

The first transient generator inserts a preset voltage into the high voltage D.C. line as a "step" by opening and closing the push button microswitch marked "ΔP". The voltage step is also fed to a connector marked "SYNC". The "SYNC" signal is for measurements of response time on safety circuits associated with the pile flux monitor.

The second transient generator consists of a motor-driven helipot combination which supplies an output voltage that varies exponentially with time. The exponential covers two decades of voltage, i.e. from 1.05 volts to 105 volts. The motor control box varies the motor speed and direction of rotation. The motor speed determines the period of the growth or decay of the exponential voltage. The direction of the motor rotation determines whether the exponential is growing or decaying. Any period between 1.5 seconds and 180 seconds can be generated. The motor control is a General Radio Model 1701 AE and is shown in Figure 2.

The output of the motor-driven helipots only approximates an exponential curve; a graph of the voltage output for various shaft positions is shown in Figure 4. The deviation from an ideal exponential curve is about two per cent of the maximum value. The slight ripple in the response characteristic causes a fluctuation in the logarithmic derivative. Over about 90 per cent of the range of the helipots, the median of the fluctuating derivative is within 10 per cent of the constant logarithmic derivative of the "ideal" curve. More complicated methods of curve compensation in the network are possible(1)(2), but the circuit that is used here is adequate for the purpose.

The voltages from the transient generators are fed to an attenuator. The resistor values shown in Figure 1 were sufficient to cover the current range from 10^{-13} amperes to 10^{-4} amperes. To get 10^{-13} and 10^{-12} amperes, the attenuator is set to 10^{13} ohms and the exponential generator is run down until the output voltage to the attenuator is 1.05 volts and 10.5 volts respectively. A voltmeter to read this voltage is shown in Figures 1 and 2.

USE

To use the tester, the signal output is connected to the input of the pile flux monitor with a length of high quality RG-11/u coaxial cable. With the A.C. power on, the monitor and the tester should be allowed to warm for about an hour.

Using the motor control box, run the motor until the voltmeter needle rises to the top of the voltmeter and stops. Turn the motor off. Any current between 10^{-11} and 10^{-4} amperes may be put into the monitor micromicroammeter by selecting the correct attenuator resistor on the dial marked "P". For 10^{-13} and 10^{-12} amperes, the motor must be reversed and run until the voltmeter reads one per cent of its scale; then the 10^{13}- and 10^{12}-ohm resistors may be used.

To use the "step" generator for measuring response time of instruments, set the "P" attenuator to the desired resistance value with the voltmeter reading full scale. Connect the "Start" input of a time measuring instrument, such as a Hewlett Packard Model 522B Interval Timer, to the tester "SYNC" output. Connect the interval timer "STOP" input to the circuit point of interest in the pile controls. By pressing the "ΔP" microswitch on the tester, the interval timer is started. When the pile control responds, the interval timer is stopped and the time delay can be read on the panel of the interval timer.

To calibrate a period circuit for positive periods, the motor is run so as to cause the voltmeter to drop to one per cent of full scale. The motor is stopped and the "Forward-Reverse" switch is set on "Forward". The attenuator

"P" should be set to give the desired initial current. To begin with, the Variac speed control is set to about 3 or 4. The motor switch is turned "ON" and a stopwatch is used to time the number of seconds required for the voltmeter needle to travel from 1 per cent to 100 per cent of full scale. The period is given by:

$$\text{Period} = \frac{\text{Seconds to travel from 1 to 100}}{4.6} \text{ seconds}$$

The Variac speed control should be varied until the desired period is generated; the period indicated on the period meter may then be compared to that calculated above.

To generate negative periods, the voltmeter has to start from the 100 per cent position and "P" must be set to give an appropriate initial current.

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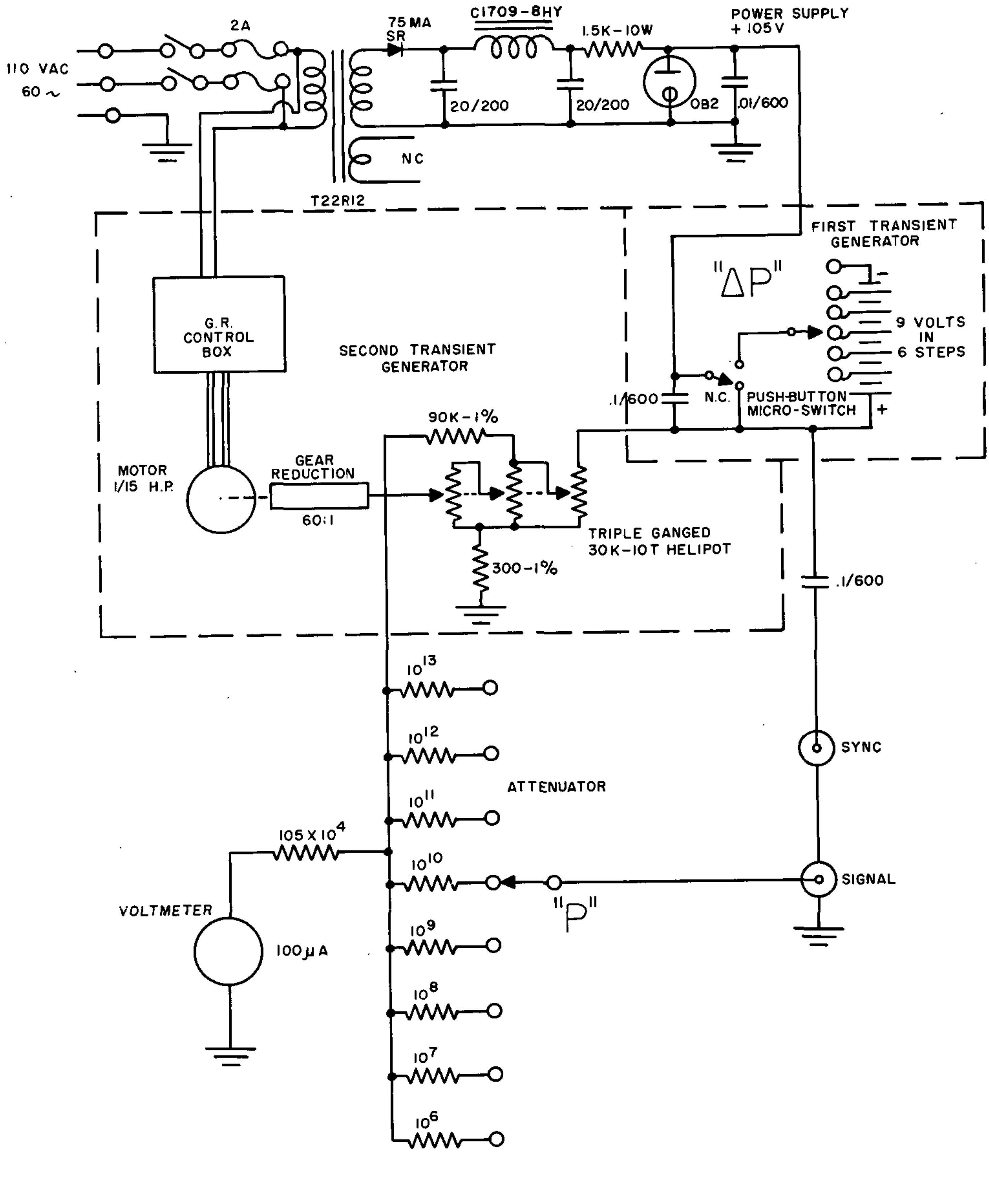
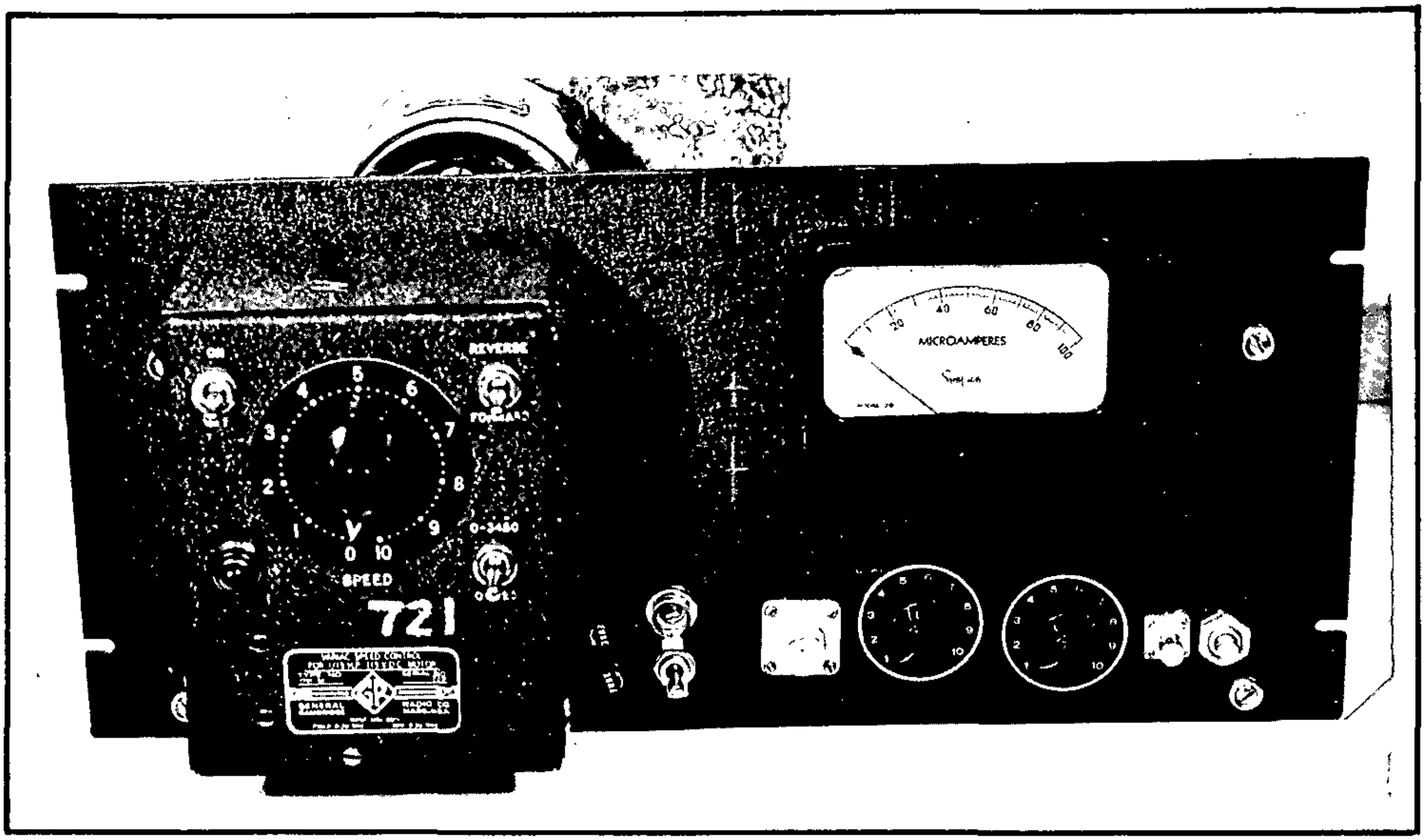
2. Potentiometer Handbook. Technology Instrument Corporation, Acton, Mass., January 1954.

Figure 1



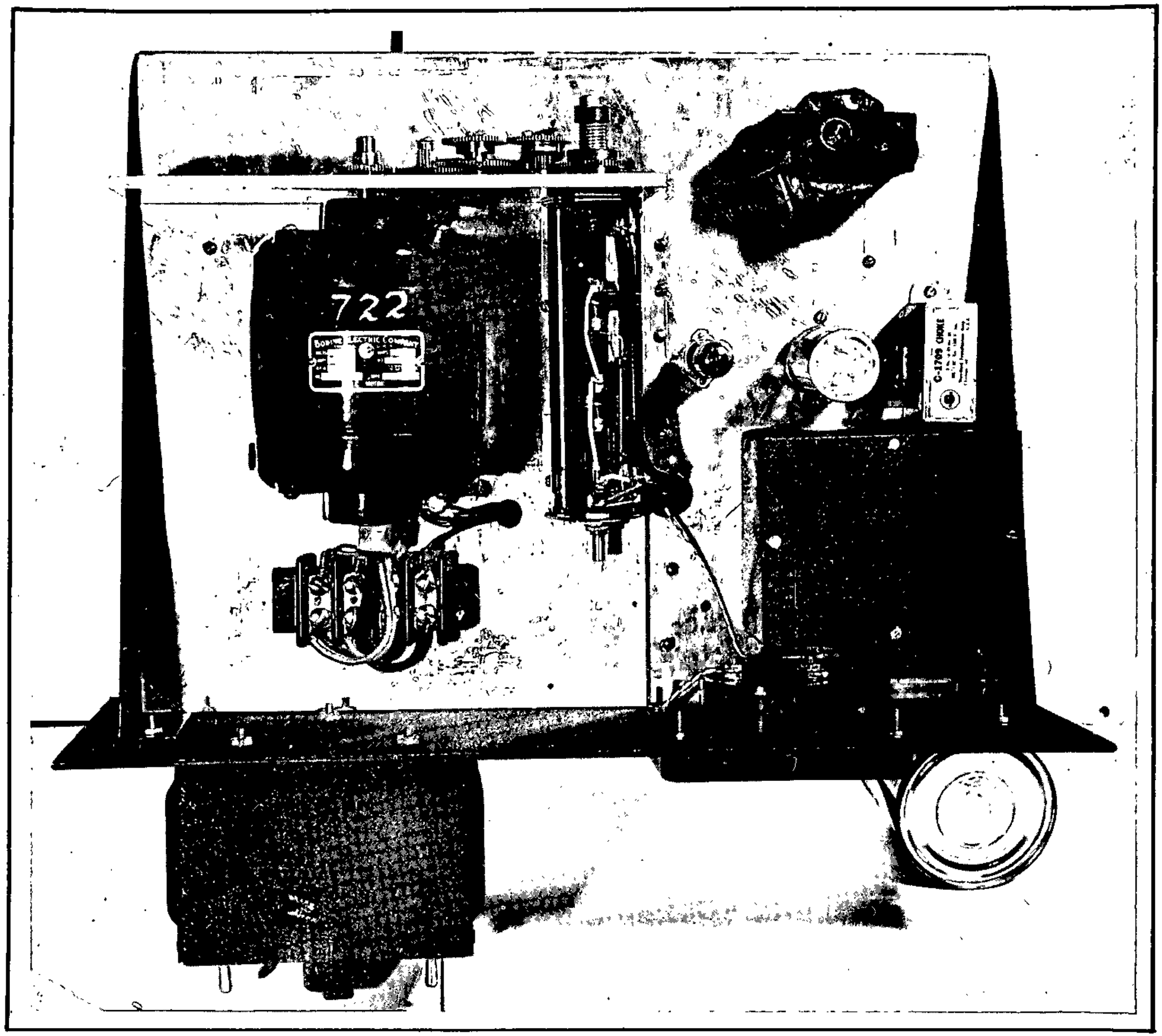
CIRCUIT DIAGRAM

Figure 2



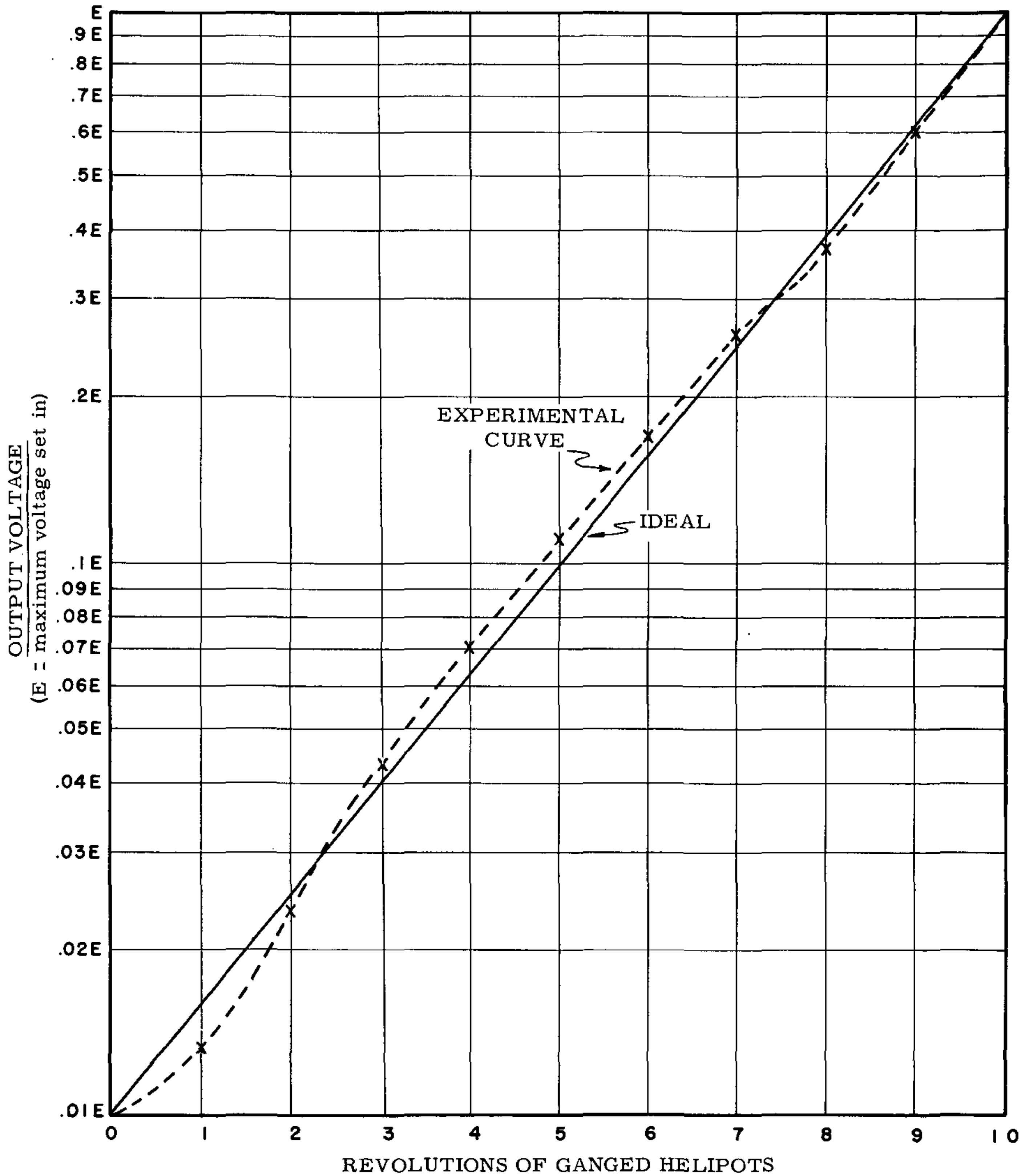
PHOTOGRAPH OF THE PANEL

Figure 3



PHOTOGRAPH OF TOP OF CHASSIS

Figure 4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.4E
.3E
.2E
.1E
.09E
.08E
.07E
.06E
.05E
.04E
.03E
.02E
.01E
OUTPUT VOLTAGE
(E = maximum voltage set in)
EXPERIMENTAL CURVE
IDEAL
0
1
2
3
4
5
6
7
8
9
10
REVOLUTIONS OF GANGED HELIPOTS