Title
BUILDING 52 BALL POTENTIAL DETECTOR

Author
Winningstad, C.N.

Publication Date
1952

UCRL-1652

UNIVERSITY OF CALIFORNIA – BERKELEY

RADIATION LABORATORY

UCRL-1652

RESTRICTED
SECURITY INFORMATION

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

UNCLASSIFIED

Declassified locally 6-3-54 per RK Wakerling

BUILDING 52 BALL POTENTIAL DETECTOR

C. N. Winningstad

January, 1952

This material contains information affecting the National Defense of the United States within the meaning of the espionage laws, Title 13, U.S.C., Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

Berkeley, California

RESTRICTED
SECURITY INFORMATION

BUILDING 52 BALL POTENTIAL DETECTOR

C. N. Winningstad

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

January, 1952

The rf ball potential voltage probe system used in Building 52 is as shown in Figs. 1 and 2. The system is essentially a capacity divider combined with a positive peak reading voltmeter. The capacity from the ball to the probe has been computed by three people using independent methods. The value arrived at was consistently 0.00294 mmfd.

The shunt input capacity of the detector, or peak reading voltmeter, was measured at 12.2 mc by attaching the detector to a "Q" meter[1] with short heavy leads. The value of effective shunt input capacity at 12.2 mc was 13 mmfd ± 1 mmfd. Measuring the capacity at 1000 cycles with an impedance bridge is not practical because of the 10 K ohm diode return resister shunting the very high reactance of 13 mmfd at 1000 cycles. Owing to the construction, it is not practical or worthwhile to remove the 10 K resister for the measurement. Since the detector capacity is shunted by the much larger probe to ground capacity, high accuracy is not necessary in the determination of the detector capacity.

The probe to ground capacity was measured with a special coaxial lead[2] arrangement which plugged into the probe, in a similar manner to the method of plugging in the detector. The coaxial lead in turn connected to a general radio impedance bridge.[3] The capacity measured for the probe to ground alone was 220 mmfd ± 4 mmfd. The capacity reading of the impedance bridge was checked with a G.R. Precision Condenser.[4] Thus, assuming the inaccuracy on the sphere to probe capacity to be ± E%, the ball potential is, neglecting second order effects of shunt conductances and inductance, the following factor times the detector indicated voltage: 79,300 ± (2 + E)%.

The calibration of the detector was done by connecting the detector in parallel with a General Radio AC VTVM[5a] and exciting from a variable amplitude 12 mc source.[5b] The General Radio VTVM calibration was checked against d.c. and 60 cycle a.c.[6a] for absolute accuracy in indicating positive peak voltage at 60 cycles. It was compared with a Hewlett Packard AC VTVM[6b] for maintenance of calibration from 60 cycles to 12 mc.

The d.c.-60 cycles and the Hewlett Packard comparison tests were made at approximately 25 volts RMS. Linearity and present accuracy was checked with a conventional voltmeter[7] at 60 cycles. The detector calibration is repeatable to 2 percent, considering the GR meter cannot be read to be better than 1 percent and the linearity correction of the order of 1 percent, for 10 v or more detector output. Least reading introduces the possibility of greater deviations below 10v. The overall equation, relating ball potential "B" to detector output "D", was derived graphically[8] and is subject to deviations due to both the 2 percent detector calibration, and the (2 + E) percent on the capacity divider.

$$B = 0.0918\,(D - 0.5) \pm (4 + E)\%$$

B in megavolts
D in volts
E is % error sphere to probe capacity

Remarks

1. Boonton Radio Corp. type 160A "Q" Meter, Serial No. 686.1. Resonated "Q Meter" at 12.2 mc on 4.5-12 mc band with Type 103A 1μh inductance. Read capacitor dial as 162 μμf. Connected detector, with heater on, to capacitor terminals and re-resonated "Q Meter" with capacitor dial. Capacitor dial read 149 μμf. Repeatable to ± 1 μμf.
2. Special coaxial lead details shown in Fig. 3. The 831 R with the banana plugs is made to plug into the GR Z bridge.
3. General Radio Co., Type 650A "Impedance Bridge," Serial No. 6895. Measurement set

up shown in Fig. 4. With the coaxial lead plugged into the probe housing, but not quite touching the probe, the bridge was balanced, and a capacity reading was made (55 μμf). Inserting the coaxial lead further contacted the probe, and a second balance was made (274 μμf). The difference between the two readings, 220 μμf, was repeatable to ± 4 μμf.

4. General Radio Co. type 222-S Precision Condenser, Serial No. 831. The measurement setup is as shown in Fig. 4 except the special cable is connected to the precision condenser instead of being plugged into the probe. With the precision condenser set for minimum capacity, 77 μμf, the bridge was balanced. Then the bridge was set for 220 μμf higher. The "DQ" dial on the bridge and the precision capacitor were used to rebalance the bridge. The precision capacitors second setting was 297 μμf, repeatable to ± 1 μμf. The impedance bridge settings were 132 μμf and 352 μμf. This test shows that the bridge will accurately show a difference of 220 μμf between the settings of 132 and 352 μμf; however, there is no reason to expect an error in excess of a few μμf to occur between the settings of 55 and 274 μμf, as compared to 132 to 352 μμf.

5. a. General Radio Type 726A Vacuum Tube Voltmeter, Serial No. 3995.

   b. A special rf oscillator was built for use as a 12 mc source. It is shown schematically in Fig. 5. The regulated supply was used to keep ripple modulation to a minimum and to keep the rf level free of line voltage flutter for the periods of time required to read the meters.

   c. Weston Electric Inst. Corp. Model 622, Serial No. 9342 calibrated by meter shop. 0-50/100/200/500/1000 μ a.

   d. Mepco Wm-4 1 Meg 1 percent 1W resistor checked on Leeds & Northrup Type S Test Set No. 5300 Resistance Bridge. The measurement setup is shown in Fig. 6. The "low" side of the GR VTVM probe was connected to the "ground" shell of the detector by means of a copper band around the detector with a banana jack soldered directly to the copper band. The ground lead from the oscillator was attached at this junction. The "high" side of the GR VTVM was connected to the "hot" tip of the detector probe by soldering a banana jack directly to a tip jack, allowing the two to be joined with very short leads. The "hot" lead from the oscillator was connected to the junction of the two probes. The oscillator was then adjusted to approximately 12.2 mc with a grid dip meter. Readings were then taken from 40 μa down, by adjusting the rf level appropriately by varying the power supply voltage and the position of the "hot" oscillator lead on the tank inductance. With no rf input the Edison current was 5.5 μa.[9] This value has been observed to be consistent to 50 percent for a year, to date.

6. a. The absolutecalibration of the General Radio VTVM was done previously (9/14/51) by means of a precision d.c. voltage bucking a 60 cps sine wave, to indicate positive peak voltage as shown in Fig. 7. By adjusting the pot. "p" the sine wave can be displaced in the negative direction. The 60 cps chopper will establish zero volts half the time and show the sine wave the other half. The chopper is phased to show the positive peak of the sine wave. The diode and battery is a degenerative limit clamp to prevent over driving the oscilloscope. The reading on the d.c. voltmeter "V", calibrated by the meter shop, showed the GR probe to be correct to the order of 1 percent above 20 v RMS which is about as well as the GR voltmeter scale can be read. Below 20 v RMS, the meter cannot be read consistently to 1 percent on the 50 v range.

b. The GR VTVM was checked for accuracy at 12 mc by comparing the readings of Hewlett Packard Model 410A VTVM Serial No Q273 at 60 cps and 12 mc with the GR VTVM. The GR VTVM is down less than ½ percent at 60 cps according to GR's instruction book. The H.P. probe required the use of a 0.1 uf input coupling capacitor to have a small 60 cps error. The GR and the H.P. VTVM's were connected in parallel and connected to a variac and a 60 cps source. The variac was advanced to make the H.P. VTVM read 30 v RMS. The GR VTVM reading was noted (25.8). Then the setup of Fig. 6 was used, with the H.P. VTVM substituted for the det; and the rf oscillator adjusted for a reading of 30 v RMS on the H.P. VTVM (with the standard coupling capacitor back in place of the 0.1 μf), and the GR VTVM read the same as at 60 cps as closely as could be read (1 percent).

7. Weston Electric Inst. Corp. Model 433 0-30/60 VAC Serial No. 35444. With the Weston meter and the GR VTVM in parallel, supplied from a 60 cps source through a variac, the variac was adjusted until the GR VTVM read the same as when the data were taken. The Weston meter was then read and corrected according to the meter shop calibration. The corrections were not more than about 1 percent.

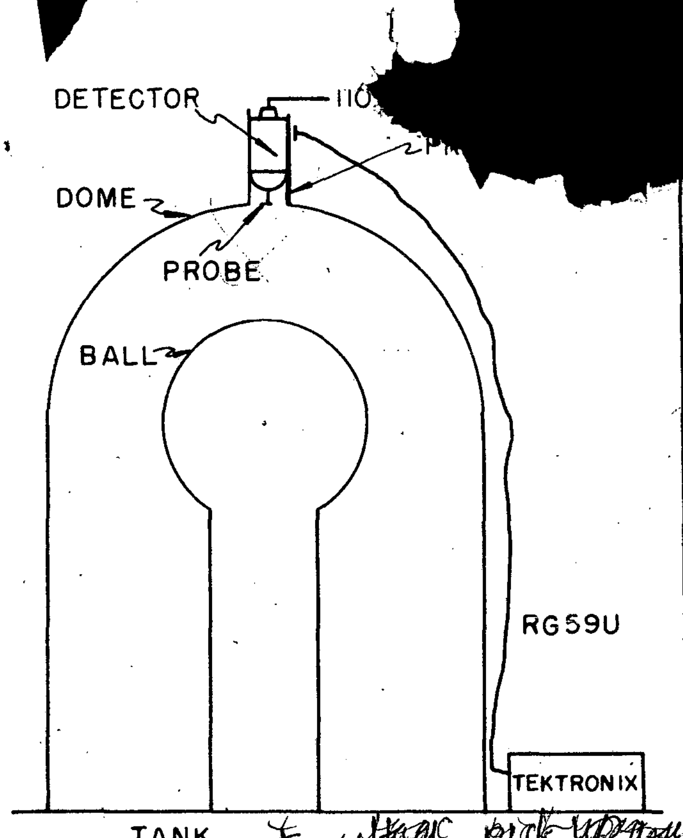
8.

Detector Output + Volts (5 c,d)	AC Input RMS Volts (5a)	Linearity Corrected AC Input (7)	AC Input Mult. by 1.414 Peak Volts	Peak Input Mult. by 79,300 Megavolts
0.5	0	0	0	0
40.0	32.7	32.5	46.0	3.65
35.0	28.5	28.5	40.3	3.20
30.	24.	24.1	34.1	2.705
25.	20.	20.1	28.4	2.25
20.	15.8	16.0	22.6	1.794
15.	11.9	12.1	17.1	1.358
10.	7.8	7.9	11.2	0.889
5.	3.8	-	5.375	0.426

See Fig. 8 for graph of above.

9. Diode dependency of the calibration is reasonably low, especially at outputs in excess of 10 volts. Measurements were made at a level of 25 volts output. In order to produce a decreased reading of 1 percent, the heater voltage had to be

lowered from 6.3 to 4.7 v RMS, or the load decreased from the rated 1 meg to $\frac{1}{2}$ megohm. Thus reasonable errors in terminating resistor (1 meg) or aging of the diode have minor effects. Also, $\pm$ 10 percent line voltage changes in heater potential have small effects.



4K7036 test cavity voltage pick up assembly.
4K9495 — FIG. 1 cav. asse. str.
4K6834 = test cavity dom

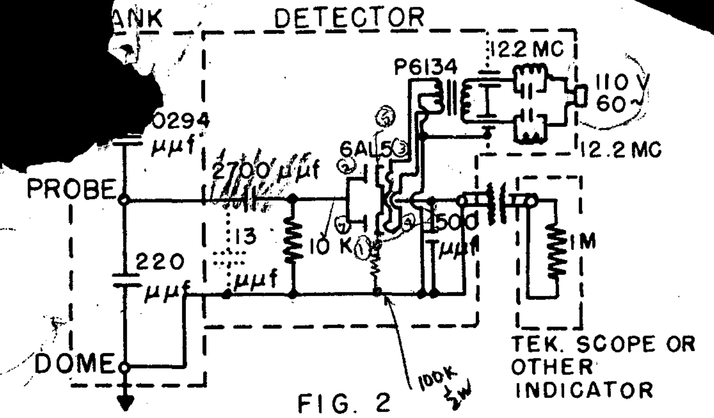


FIG. 2

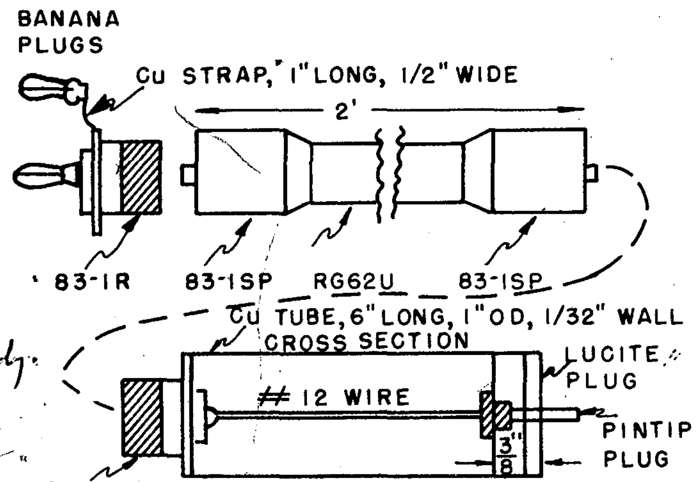


FIG. 3

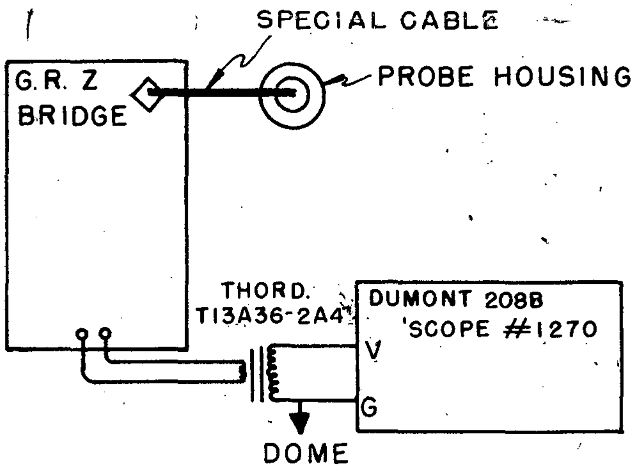


FIG. 4

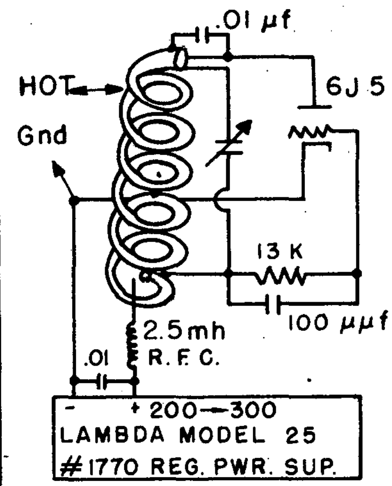


FIG. 5

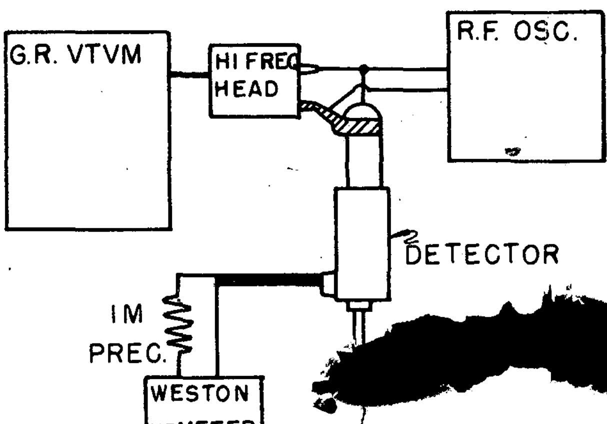


FIG. 6

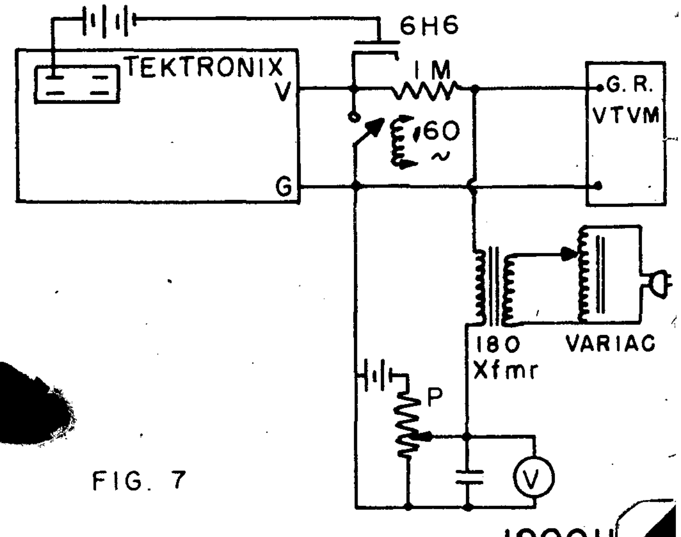


FIG. 7

1900U

RESTRICTED

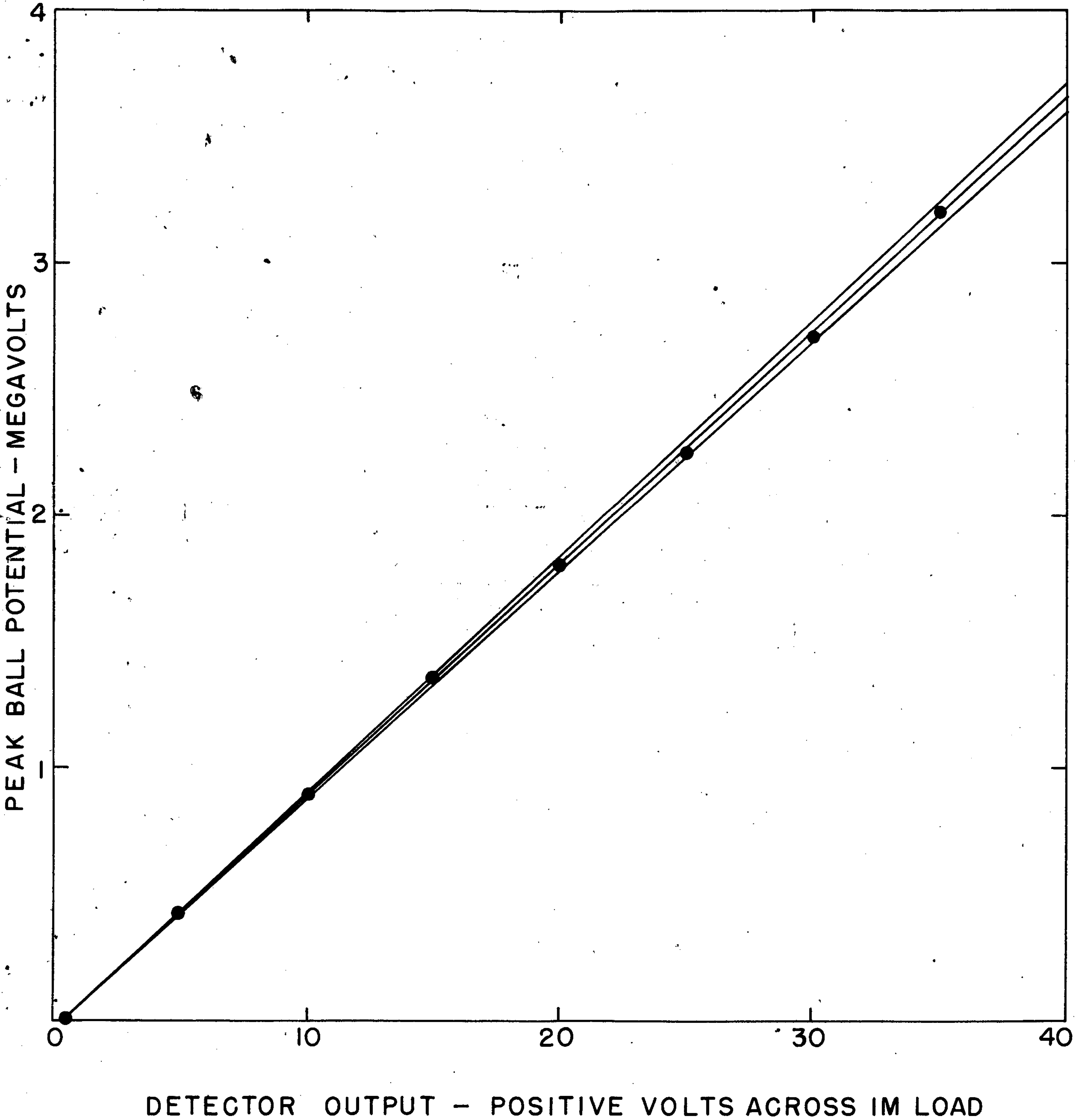


FIG. 8

RESTRICTED

190021

RESTRICTED
SECURITY INFORMATION

UNCLASSIFIED

RESTRICTED
SECURITY INFORMATION