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SUBJECT

Report on

Test of RCA Type TMV-75B

Field Intensity Meter

by

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NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

Test of RCA Type TMV-75B Field Intensity Meter

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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TABLE OF CONTENTS

APPENDICES

AUTHORIZATION

1. The problem reported herein was undertaken by authority of Bureau of Engineering letter, reference (a). Other relevant correspondence is indicated under references (b) to (e).

Reference: (a) BuEng. let. S67/74(11-30-R8) of 9 Dec. 1938.
(b) NAS Anacostia let. F42-1/57/NA6 (425) of 13 April 1938 to BuEng.
(c) NAS Anacostia let. F42-1/57/NA6/S74 of 28 July 1938 to BuEng. with encl. (A).
(d) NRL let. S67/57 of 27 Jan. 1939 to BuEng.
(e) RCA Mfg. Co. Engineering Bulletin No. 40.

OBJECT OF TEST

2. The purpose of this test was to determine the suitability of the subject radio field strength measuring equipment for use in the Naval Service.

ABSTRACT OF TEST

3. Two field strength measuring equipments manufactured by the Radio Corporation of America were tested to determine their accuracy as compared to the Navy Model OC equipment, frequency drift of oscillators, linearity of detectors and amplifiers, frequency range, microvolt range, and operating life with recommended dry batteries. An appropriate recording milliammeter was attached and suitability of the equipments as field intensity recorders determined. In addition the equipments were examined for mechanical faults and notes made of same. The Q of the loop circuit was measured and noted.

Conclusions

(a) In view of the excessive frequency drifts, numerous mechanical faults, weight, and battery drain, this equipment is not considered suitable as a portable field strength measuring device for use in the Naval Service.

(b) While by exercise of unusual care it may be possible to obtain reasonably accurate results on high frequencies, it is believed improbable that relatively inexperienced personnel located at various points in the Naval Service would be able to produce data capable of correlation.

(c) No humidity tests were conducted on this equipment. Nevertheless, due to lack of proper protection to the various components and due to inferior insulation, it is believed that subjection of the equipment to rigorous climatic conditions as encountered in the Naval Service would soon necessitate repair and replacement of parts and thereby require considerable servicing by Navy personnel.

(d) In view of data presented in paragraph 25 of this report, the equipment cannot be considered suitable as a field intensity recorder.

Recommendations

It is suggested that no additional equipment of this type be purchased without consideration of the following recommendations.

(a) In the event field intensity meters are purchased for use in the Navy, electrostatically shielded loops should be employed, except where impractical due to frequency range, required dimensions of the loop, etc.

(b) Particular attention should be paid to design of incorporated oscillators with a view to minimizing frequency drift. Frequency drift with conditions under which the subject equipment was tested should not exceed .05% for first 45 minutes of operation.

(c) Loop contacts, slip rings, and general loop construction should be of the best type known or available.

(d) The Q of the loop circuit should be as high as practicable.

(e) The receiver portion of the field intensity meter should be constructed in accordance with the same standards of excellence employed in Navy communication receivers.

(f) The power supply requirements should be brought to the absolute minimum.

(g) The weight and dimensions of this type of equipment should be held to a minimum consistent with requirements for stable operation and ease of portability.

DESCRIPTION OF MATERIAL UNDER TEST

4. The material under test consisted of two RCA type TMV-75B field intensity meters, serial numbers 552 and 580.

5. These equipments embody a loop antenna, a super-heterodyne receiver and a self contained calibrating oscillator. The loop antenna is connected to the first detector of the receiver. Following the first detector is an attenuator having eight steps and providing attenuation factors of 1, 5, 20, 100, 500, 2000, 10,000, and 50,000 times. A three stage intermediate frequency amplifier peaked at 300 kilocycles follows the attenuator. The second detector is of the rectifier type whose output actuates a microammeter providing an indication of carrier level. The output of the calibrating oscillator incorporated in this equipment is fed into the center of the loop at an initially predetermined voltage, permitting adjustment of receiver gain to a standard level. A schematic circuit diagram of the equipment is furnished in Plate 8.

6. Each equipment is supplied with a battery box, connecting cable and plugs, four loop antennas, and four sets of plug-in coils. The battery box also serves as a carrying case for the loop antennas, connecting cable and plug-in coils. Plate 9 shows the equipment ready for transportation. Plate 10 shows the equipment set up for operation and Plate 11 portrays the chassis with the various shield cover plates removed.

7. The exterior of this equipment is finished with a gray leatherette paint and the interior with sand blast and clear lacquer. The interior of the battery box, however, is finished with aluminum paint.

8. The field intensity meter proper with cover in place ready for carrying weighs 49.5 lb. The battery box containing four loops, three sets of plug-in coils, connecting cable, three #21308 Burgess super heavy duty "B" batteries or equivalent and one H-15-B General "C" battery or equivalent weighs 78.6 lb. A light duty lead storage battery suitable for use with this equipment will weigh approximately 25 lb., making a total of 153.1 lb.

METHOD OF TEST

9. Accuracy compared to Model OC. Both RCA equipments and the OC were set up at a distance several

wavelengths from a transmitter located in the Laboratory. The frequency and power output of the transmitter being capable of adjustment, measurements were taken at two power levels on various frequencies with both RCA equipments and the OC. For data obtained in the broadcast band, measurements were taken on several broadcast stations.

10. Frequency drift. Frequency drift of the heterodyne oscillator was determined by introducing a signal to the loop circuit from a Navy Model LD-2 frequency meter and tuning the LD-2 to resonance with the field intensity meter as indicated by the output meter. Frequency drift of the calibrating oscillator was measured by beating the calibrating oscillator against the LD-2 frequency measuring equipment.

11. Linearity of detectors and amplifiers. These data were obtained by applying the output of a General Radio 605-B signal generator operating on 300 kilocycles directly to the grid of the first detector and on 3000 kilocycles by injecting the output of the 605-B into the center of the loop circuit across a 1 ohm non-inductive resistor. Since the output of the signal generator was introduced into the center of the loop across a 1 ohm resistor, the values for microvolts input shown in plates 4 and 6 are not absolute values but are merely relative and simply show that the equipment is linear with respect to a voltage introduced into the loop circuit. Values for microvolts input in plates 3 and 5 are absolute within the accuracy of the signal generator.

12. Frequency range. The frequency range was determined by the use of a calibrated radio frequency driver coupled to the loop circuit.

13. Microvolt range. The lower limit of the microvolt range was checked against the Model OC field strength measuring equipment by using both equipments to measure a transmitting station whose field intensity lay in the vicinity of 20 microvolts per meter. No suitable equipment is available at the Laboratory for checking the upper limit of the microvolt range; i.e., 6 volts per meter.

14. Dry battery life. Dry batteries as recommended in reference (e) were installed in this equipment as follows: 8 Burgess little six dry cells (#6

METHOD OF TEST (continued)

dry cell equivalent) connected in series parallel to provide 6 volts, 3 #5308 45 volt Burgess "B" batteries and 1 H-15-B General "C" battery. This battery complement was subjected to intermittent operation, the equipment checked for operation at intervals and battery voltages under load recorded.

15. Test in conjunction with recorder. An Esterline-Angus 5 MA continuous strip chart recorder was attached to the equipment per information contained in the instruction book furnished with this equipment. The complete installation was set up in a shielded cage along with an oscillator circuit operating on 1,000 kilocycles. Battery voltages to the field intensity meter were maintained constant as were battery voltages to the 1,000 kilocycle oscillator. The frequency of the oscillator was controlled by a low temperature coefficient crystal having a temperature coefficient of frequency of 1 part per million per degree C. A 24 hour recording of field intensity of the crystal oscillator was made under these conditions.

16. Measurement of loop circuit Q. The four loop antennae including loop support and contacts were connected to a Boonton Radio Corporation Q meter and the Q or figure of merit obtained.

DATA RECORDED DURING TEST

17. Data recorded during test or those computed therefrom are furnished in Tables 1 to 4 inclusive, Plates 1 to 6 inclusive and paragraphs 19 to 28 inclusive.

DISCUSSION OF PROBABLE ERRORS

18. The frequency drift measurements may be relied upon to within .01%. Linearity of detectors and amplifiers was determined to within 5%. The frequency range was ascertained correctly to within 2%. In regard to measurements of field intensity compared to the Navy Model OC: Measurements made on the OC can be considered accurate to ± 1 decibel. In comparing measurements made on the RCA equipments to those made on the OC, a ± 1 decibel correction due to observational error, etc., is in order.

RESULTS OF TEST

19. With reference to Table 3 and paragraph 14 of this report, it is noted that the equipment is

RESULTS OF TEST (continued)

inoperative on two bands after one hour of operation. This fact will necessarily limit the use of this equipment for work in the field where portability is a desirable feature. Paragraph 8 of this report outlines what may be considered a suitable battery complement and states the weight of each item. The battery life test was conducted on Serial #552 only. The "A" battery and "B" battery current drain of both equipments is as follows:

	E_A	I_A	E_B	I_B
#552	5.9 volts	1.51 amps.	135 volts	.029 amps.
#580	5.9	1.55	135	.032

20. Table 4 indicates relative accuracy as field intensity measuring apparatus compared to the Navy Model OC. The average error of Serial No. 552 was 4.09 db and that of Serial No. 580, 2.24 db. Allowing an error in the OC of ± 1 db and an observational error of ± 1 db in making the comparison, the absolute error of these equipments may approach ± 2 db.

21. In making field strength measurements at frequencies above 3,000 kilocycles the use of unshielded loops causes considerable confusion in the attempt to obtain a minimum on a transmitting station, hand capacity adding to the antenna effect and making difficult the determination of a minimum or maximum.

22. Plates 3, 4, 5, and 6 show linearity of detectors and amplifiers. The fact that the equipment appears to be linear with respect to input voltage both at the center of the loop and the grid of the first detector indicates the absence of oscillation or feedback in the I.F. amplifier and also permits an accurate estimate of the upper limit of the microvolt range.

23. Frequency drift of the heterodyne and calibrating oscillators of both equipments was determined as described in paragraph 10 and the results shown in Plates 1 and 2. At a signal frequency of 19,000 kilocycles the heterodyne oscillator frequency drift was sufficient to require retuning of the equipment for every minute of operation. For each five minutes of operation, drift was sufficient to reduce the indicated field intensity to 30% of the initial value. The excessive frequency drift of the calibrating oscillator makes the process of calibration

at high frequencies a tedious one. The plate and filament battery voltages were maintained constant throughout frequency drift tests.

24. The lower limit of the microvolt range was found to be substantially as indicated in reference (e); i.e., 20 microvolts per meter. Lack of suitable equipment for experimentally ascertaining the upper limit of the microvolt range necessitated use of the formula for field intensity given in the instruction book as follows:

$$\text{Field strength uv/m} = \frac{\text{meter reading x attenuator setting x C}}{\text{Frequency (kc)}}$$

where "C" is the loop constant. By employing representative values in the above formula it is evident that the maximum field intensity measurable is in excess of 1 volt per meter for all frequencies within the range of the equipment. However, by means of the capacity attenuator in the input circuit an additional attenuation factor of approximately 25 is provided thereby extending the upper limit of the microvolt range to a value greater than 6 volts per meter. When using the capacity attenuator it is necessary to calibrate for each frequency as set forth in reference (e) since the attenuator operates at the signal frequency and the attenuation factor does not necessarily remain constant for all frequencies.

25. A test for operation of this equipment as a field intensity recorder was conducted as set forth in paragraph 15 of this report. At 1,000 kilocycles over a period of 24 hours, the frequency drift was sufficient to reduce the reading on the output meter from 130 to 70. This corresponds to a reduction of apparent field intensity in excess of 46%. Upon retuning of the equipment, the meter reading returned to 130. The recorder was connected to the equipment as specified in the instruction book. A schematic diagram of the necessary external connections is provided in Plate 7. With continued operation the voltage of the 22.5 volt dry battery drops considerably, necessitating compensation by means of "R", Plate 7. Due to this continual change in recorder compensating voltage and frequency drift of the equipment, accurate recordings of field intensity at 1,000 kilocycles could not be expected for over 1 hour at a time and probably less than this when the plate and filament voltages are not regulated. At higher frequencies, the results of attempts at recording would be even more erratic due to greater change in apparent field intensity with frequency drift of the heterodyne os-

RESULTS OF TEST (continued)

cillator. This test was conducted on Serial No. 552 only.

26. The frequency ranges and dial readings of both equipments are shown in Tables 1 and 2. Each equipment covers the frequency range from 500 kilocycles to 20,000 kilocycles without hiatus.

27. The Q of the loop circuit is relatively low, having a detrimental effect on the selectivity of the input circuit. A tabulation of Q for each loop is given below:

Loop	Frequency	Q
A	550	115
	1200	50
B	1500	125
	3700	45
C	4600	75
	7500	30
D	10,000	40
	20,000	40

28. A list of mechanical faults noted follows:

(a) Inferior grade insulation throughout (black bakelite).

(b) Inaccessible mechanical construction.

(c) The vacuum type thermocouple floating about inside of a can secured only by its leads. (See "a" Plate 11.)

(d) Tubular paper cased capacitors supported only by their leads are used throughout.

(e) Contacts between loop support and loop of inferior type and erratic contact results from slight movement of loop.

(f) Dials and shaft couplings or tuning elements have an inherent "springiness" making adjustment on high frequencies very difficult.

(g) I-F amplifier coils and r-f chokes used in this equipment mounted on wax impregnated wood forms.

CONCLUSIONS

29. In view of the excessive frequency drifts, numerous mechanical faults, weight, and battery drain, this equipment is not considered suitable as a portable field strength measuring device for use in the Naval Service.

30. While by exercise of unusual care it may be possible to obtain reasonably accurate results on high frequencies, it is believed improbable that relatively inexperienced personnel located at various points in the Naval Service would be able to produce data capable of correlation.

31. No humidity tests were conducted on this equipment. Nevertheless, due to lack of proper protection to the various components and due to inferior insulation, it is believed that subjection of the equipment to rigorous climatic conditions as encountered in the Naval Service would soon necessitate repair and replacement of parts and thereby require considerable servicing by Navy personnel.

32. In view of data presented in paragraph 25 of this report, the equipment cannot be considered suitable as a field intensity recorder.

TABLE 1

FREQUENCY RANGE

Serial No. 552

Freq. Band	Loop Dial	Het. Osc. Dial	Cal. Osc. Dial	Freq.	Remarks
A	8.6 143.	3.6 145.5	5.5 *	500 1500	*upper limit of cal. osc. 1480 Kc.
B	6.2 142.	3.2 144.	1.7 130.2	1400 4600	
C	10.5 140.8	4.7 141.4	7.8 140.5	4600 10,000	
D	23. 137.4	3.3 138.3	8.4 137.4	10,000 20,000	

TABLE 2

Frequency Range

Serial No. 580

Freq. Band	Loop Dial	Het. Osc. Dial	Cal. Osc. Dial	Freq.	Remarks
A	6.2 139.2	12.8 **65.	4.3 *	500 1500	*upper limit of cal. osc. 1475 Kcs.
B	3. 135.5	9. 149.	4.5 134.1	1400 4600	**low beat with het. osc.
C	9.3 138.1	7. 143.	10. 141.5	4600 10,000	
D	21.6 136.6	7. 138.	8.2 146.5	10,000 20,000	

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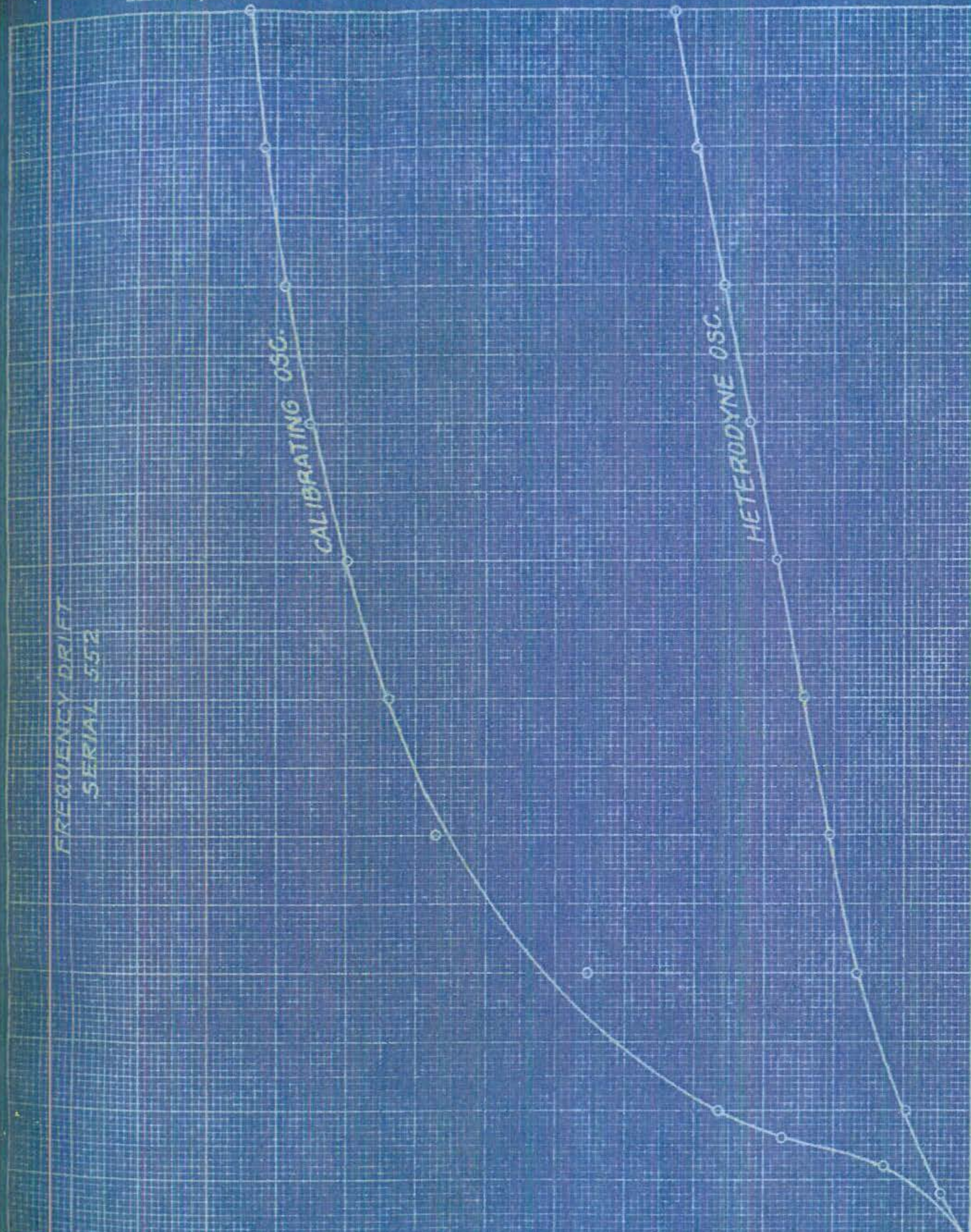

PLATE I

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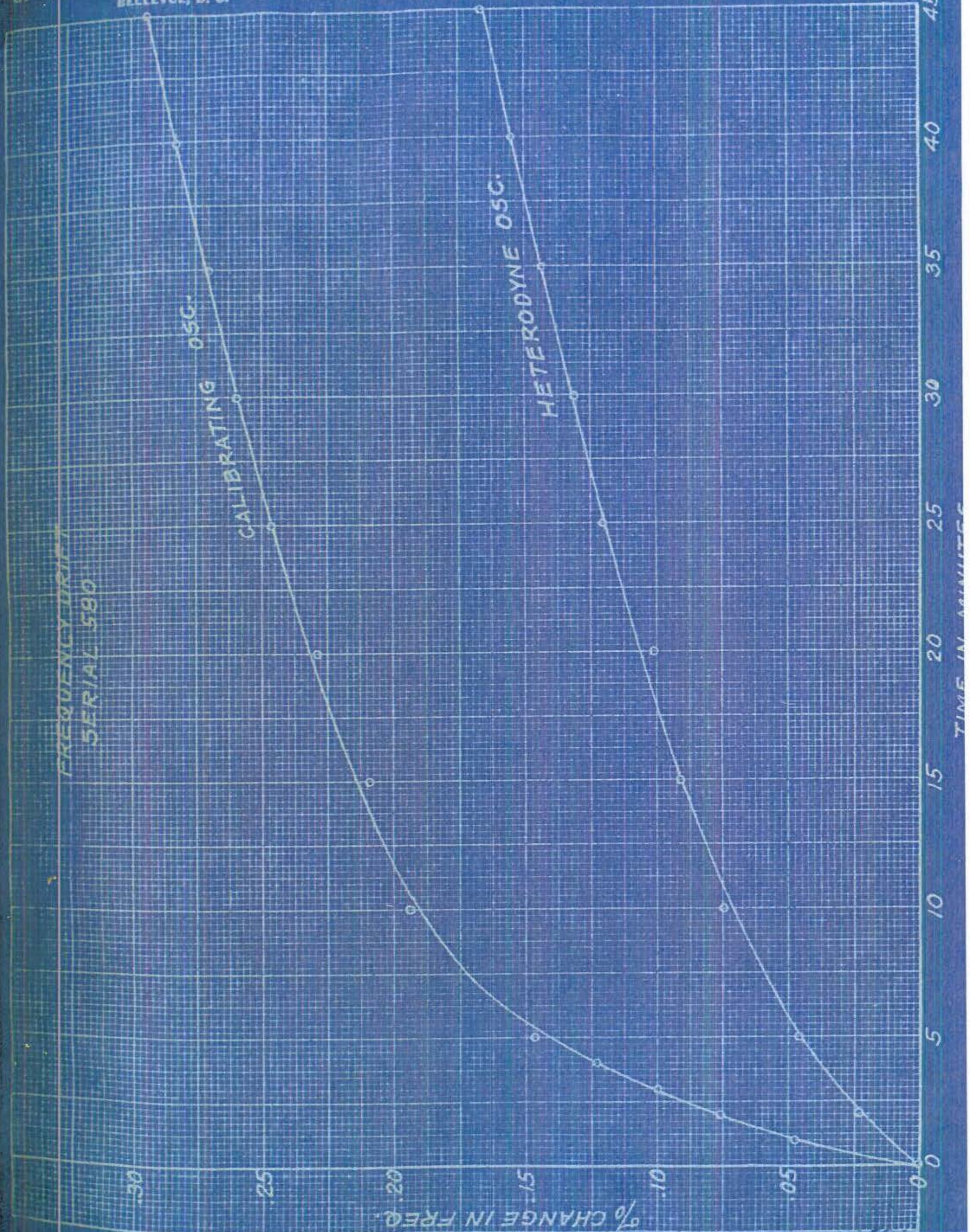
DATE



SHEET

PLATE 2

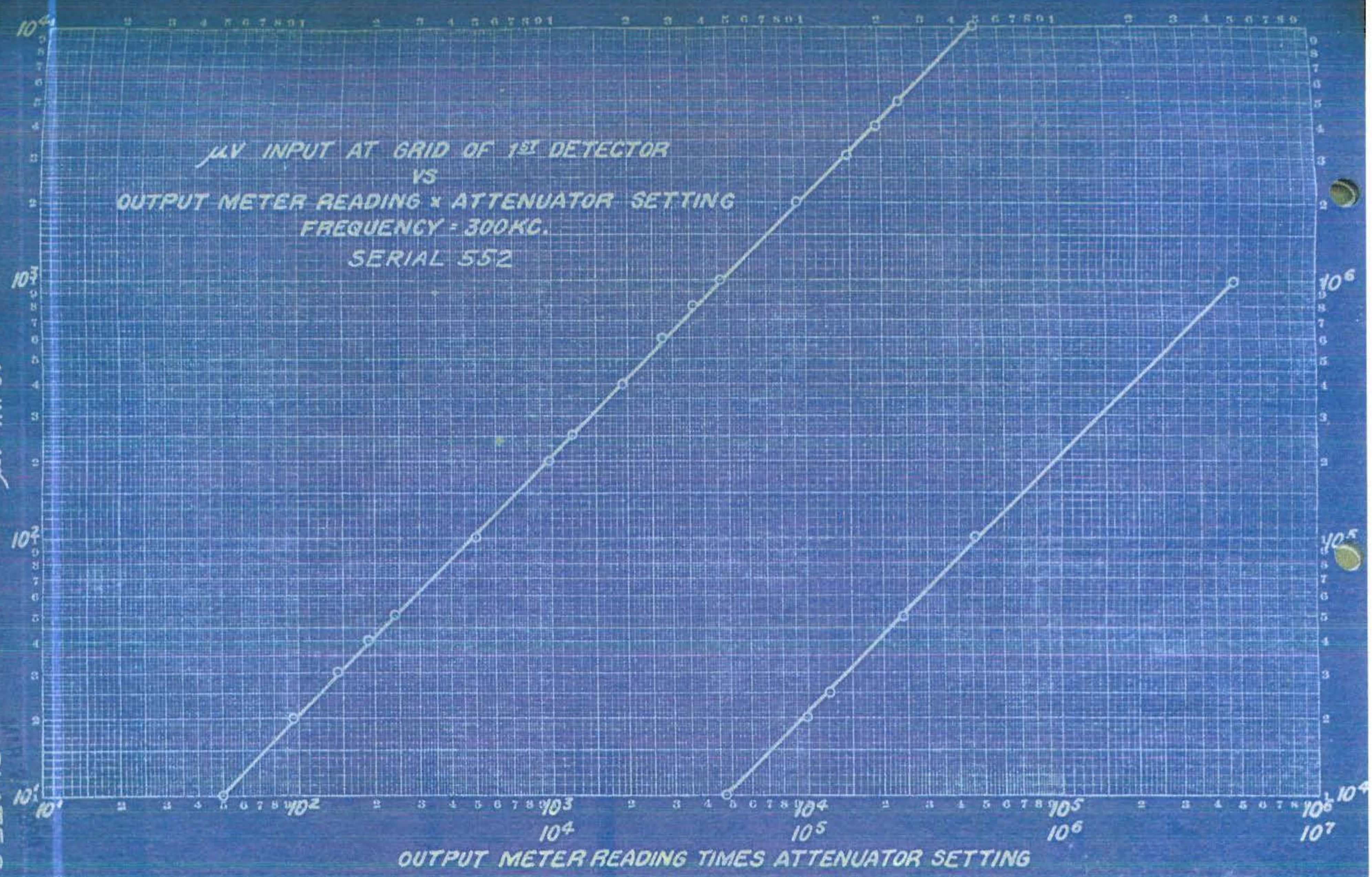

μV INPUT AT GRID OF 1ST DETECTOR
VS
OUTPUT METER READING x ATTENUATOR SETTING
FREQUENCY = 300 KC.
SERIAL 552
μV INPUT
OUTPUT METER READING TIMES ATTENUATOR SETTING

PLATE 3

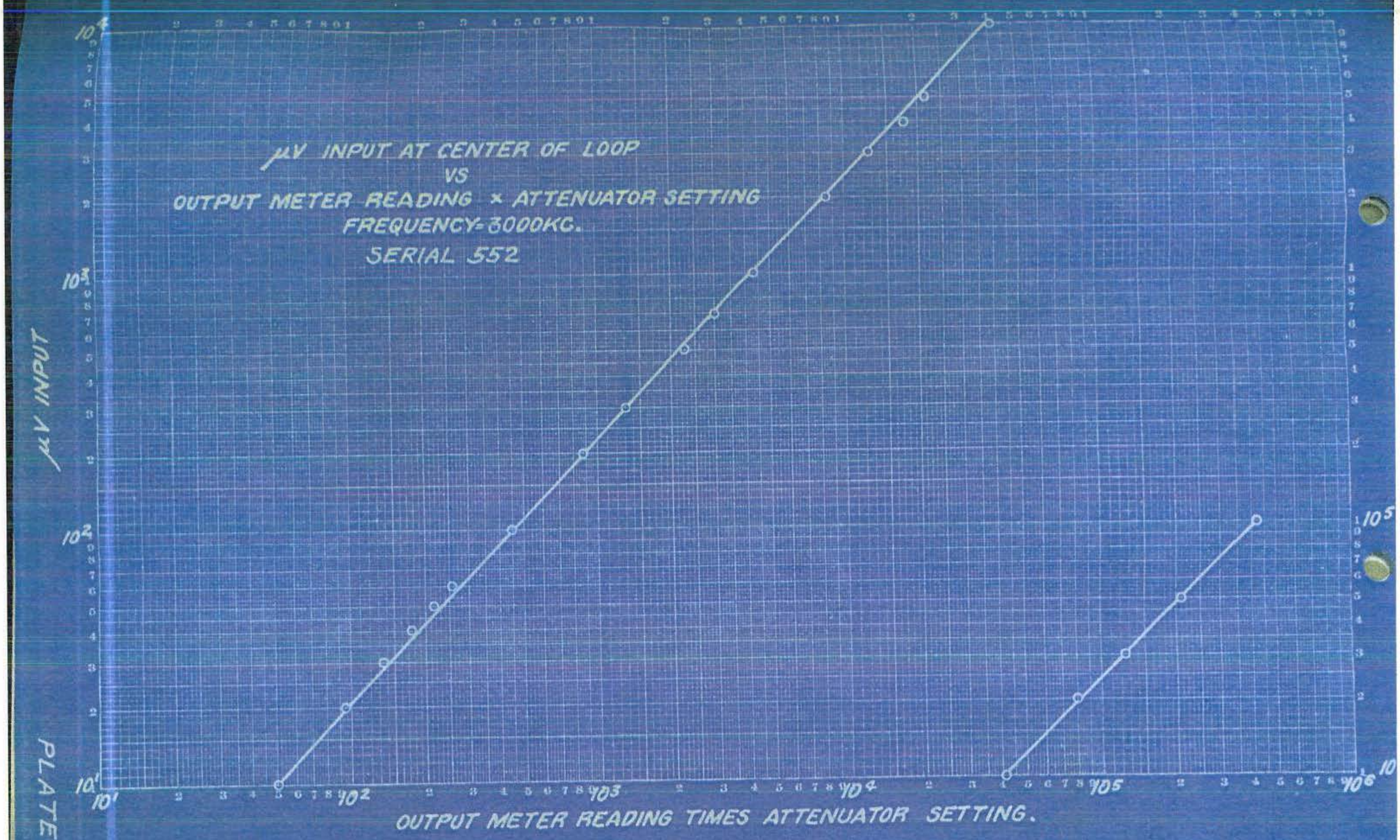

μV INPUT AT CENTER OF LOOP
VS
OUTPUT METER READING × ATTENUATOR SETTING
FREQUENCY=3000KC.
SERIAL 552
μV INPUT
OUTPUT METER READING TIMES ATTENUATOR SETTING.
10¹
10²
10³
10⁴
10⁵
10⁶

PLATE 4

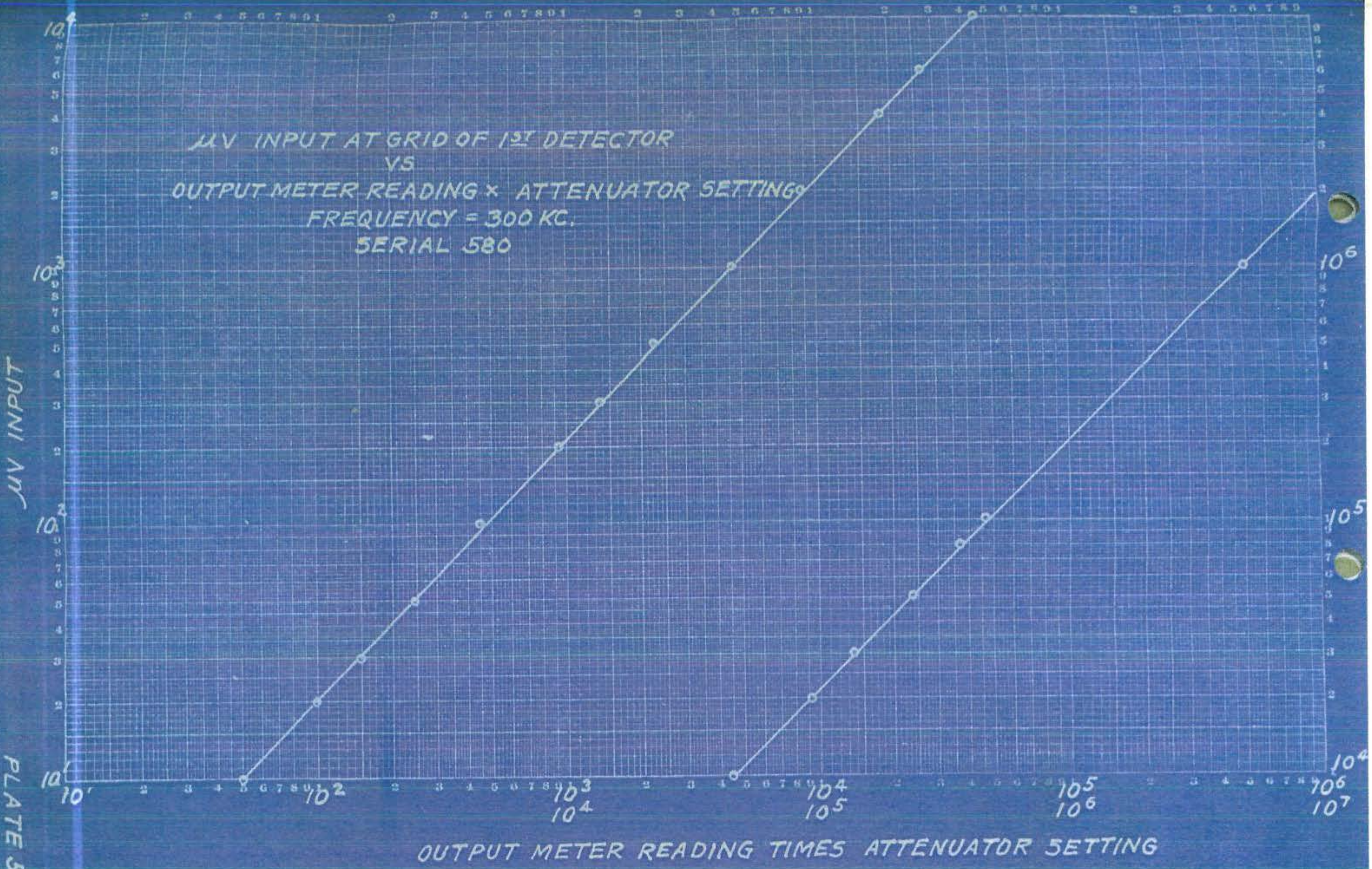

μV INPUT AT GRID OF 1ST DETECTOR
VS
OUTPUT METER READING × ATTENUATOR SETTING
FREQUENCY = 300 KC.
SERIAL 580
μV INPUT
OUTPUT METER READING TIMES ATTENUATOR SETTING

PLATE 5

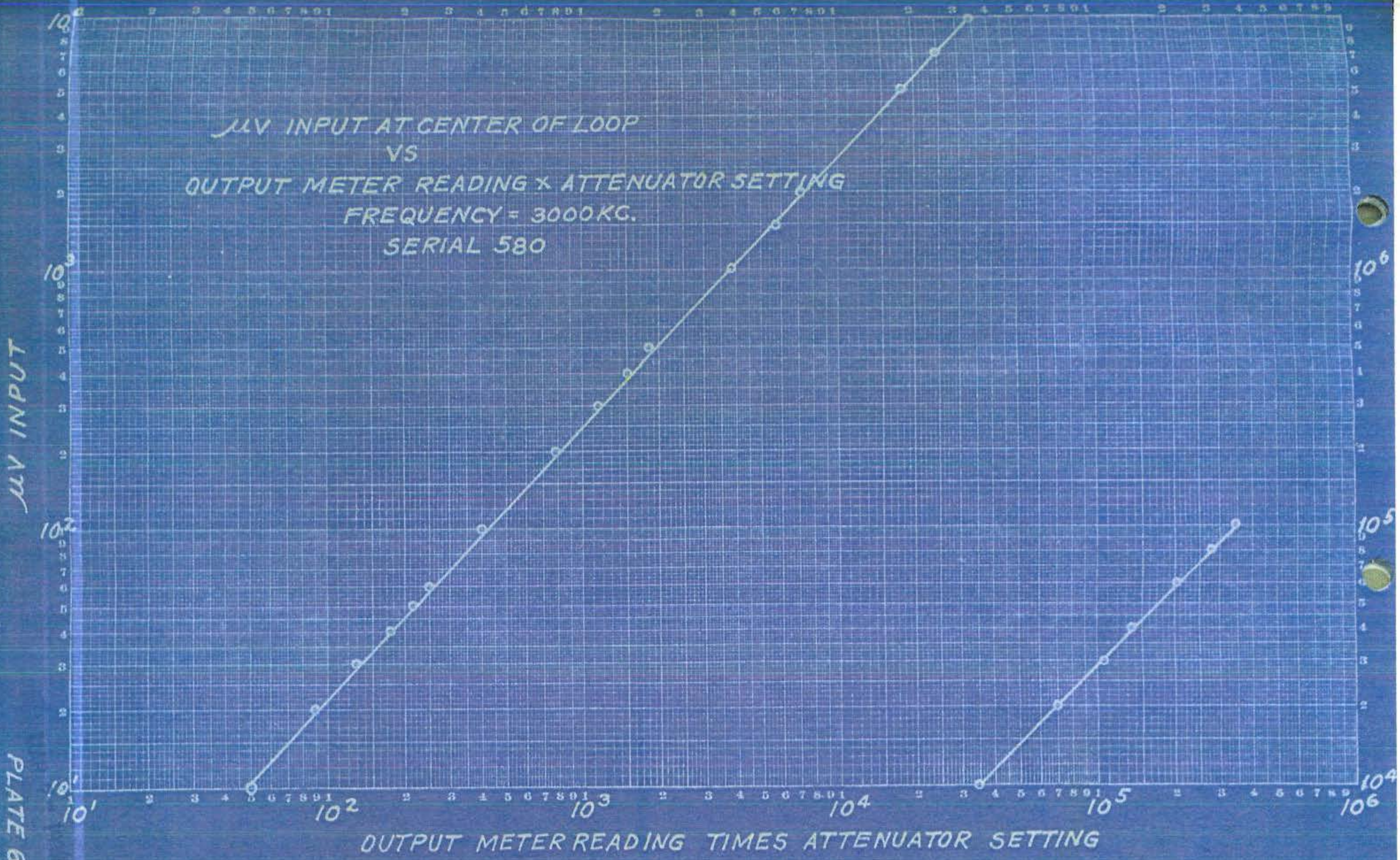

μV INPUT AT CENTER OF LOOP
VS
OUTPUT METER READING x ATTENUATOR SETTING
FREQUENCY = 3000 KC.
SERIAL 580
μV INPUT
OUTPUT METER READING TIMES ATTENUATOR SETTING
10^1
10^2
10^3
10^4
10^5
10^6

PLATE 6

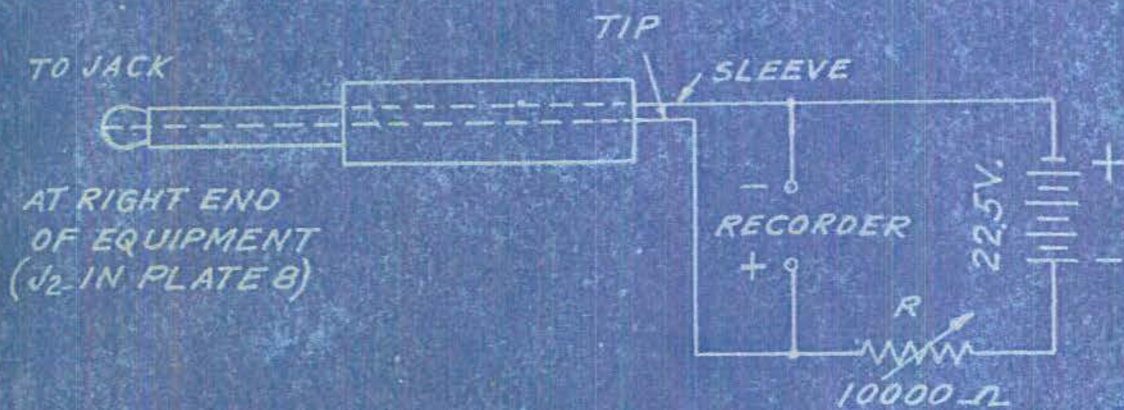

TIP
TO JACK
SLEEVE
AT RIGHT END
OF EQUIPMENT
(J2-IN PLATE 8)
RECORDER
22.5V.
R
10000 Ω

PLATE 7

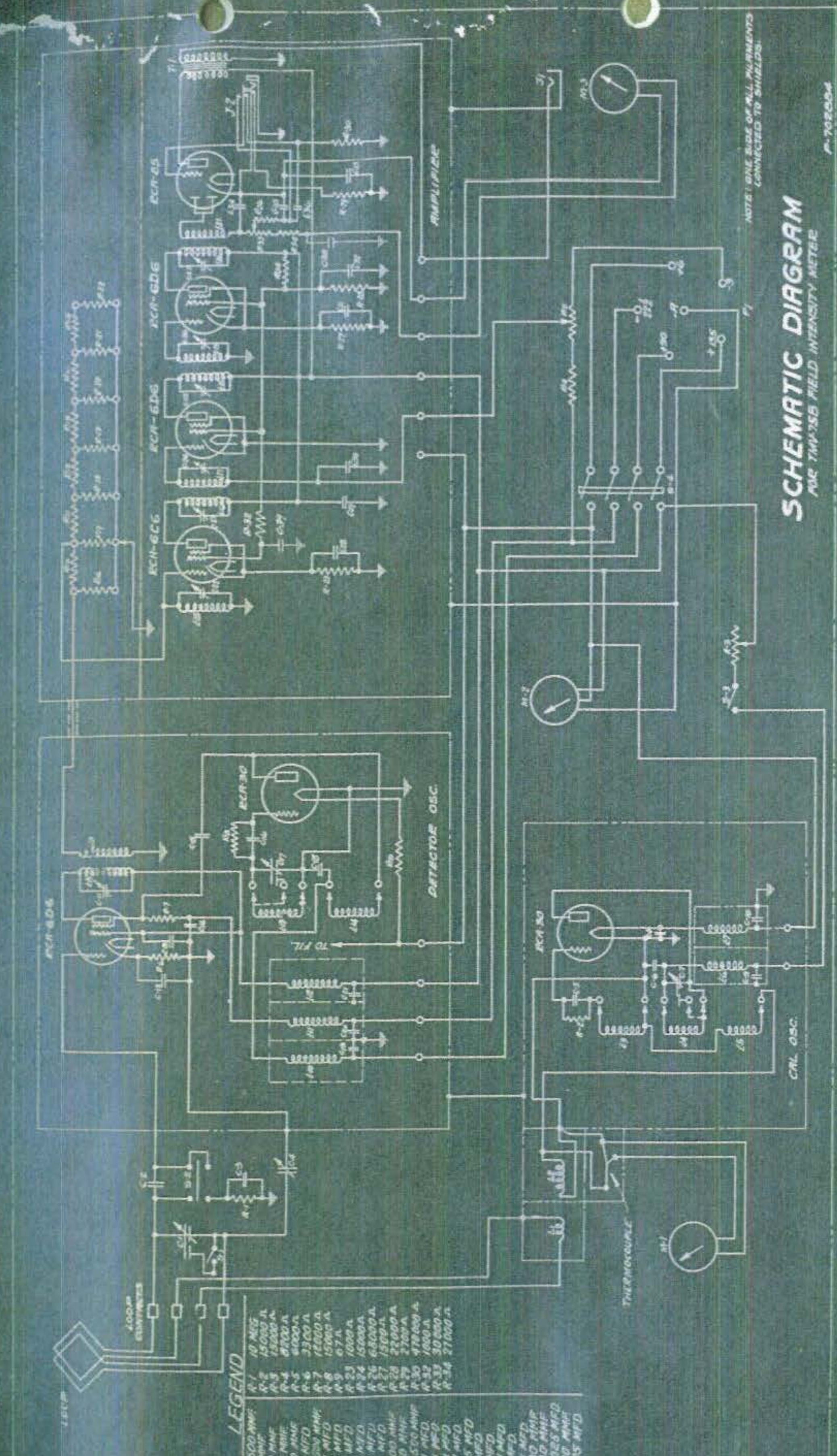

SCHEMATIC DIAGRAM
FOR TMV-75B FIELD INTENSITY METER
NOTE: ONE SIDE OF ALL FILAMENTS CONNECTED TO SHIELDS.
LEGEND
AMPLIFIER
DETECTOR OSC.
CAL. OSC.
THERMOCOUPLE
LOOP CONTACTS
LOOP
RCA-85
RCA-6D6
RCA-6C6
RCA-30

PLATE 8

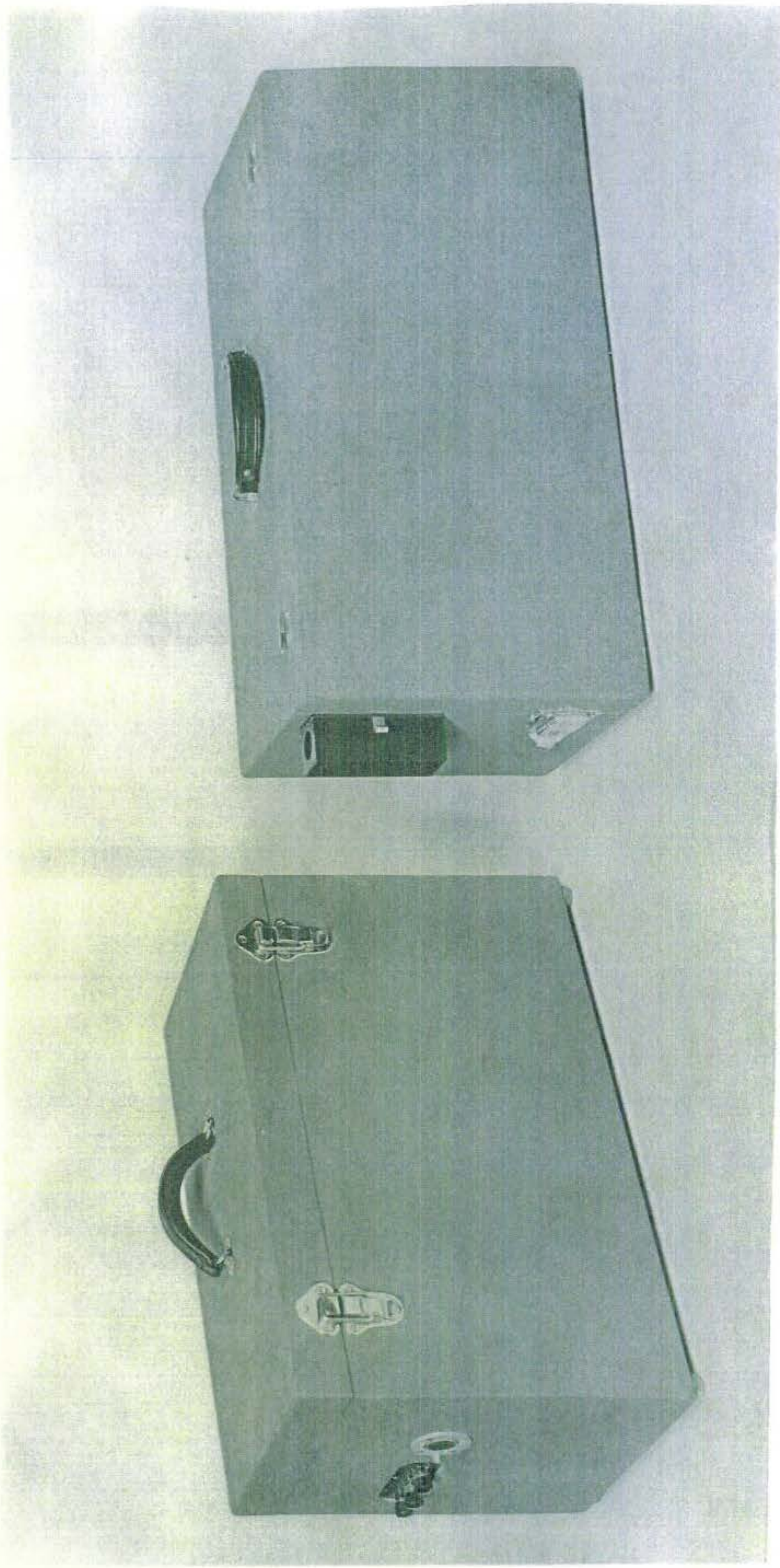


Plate 9

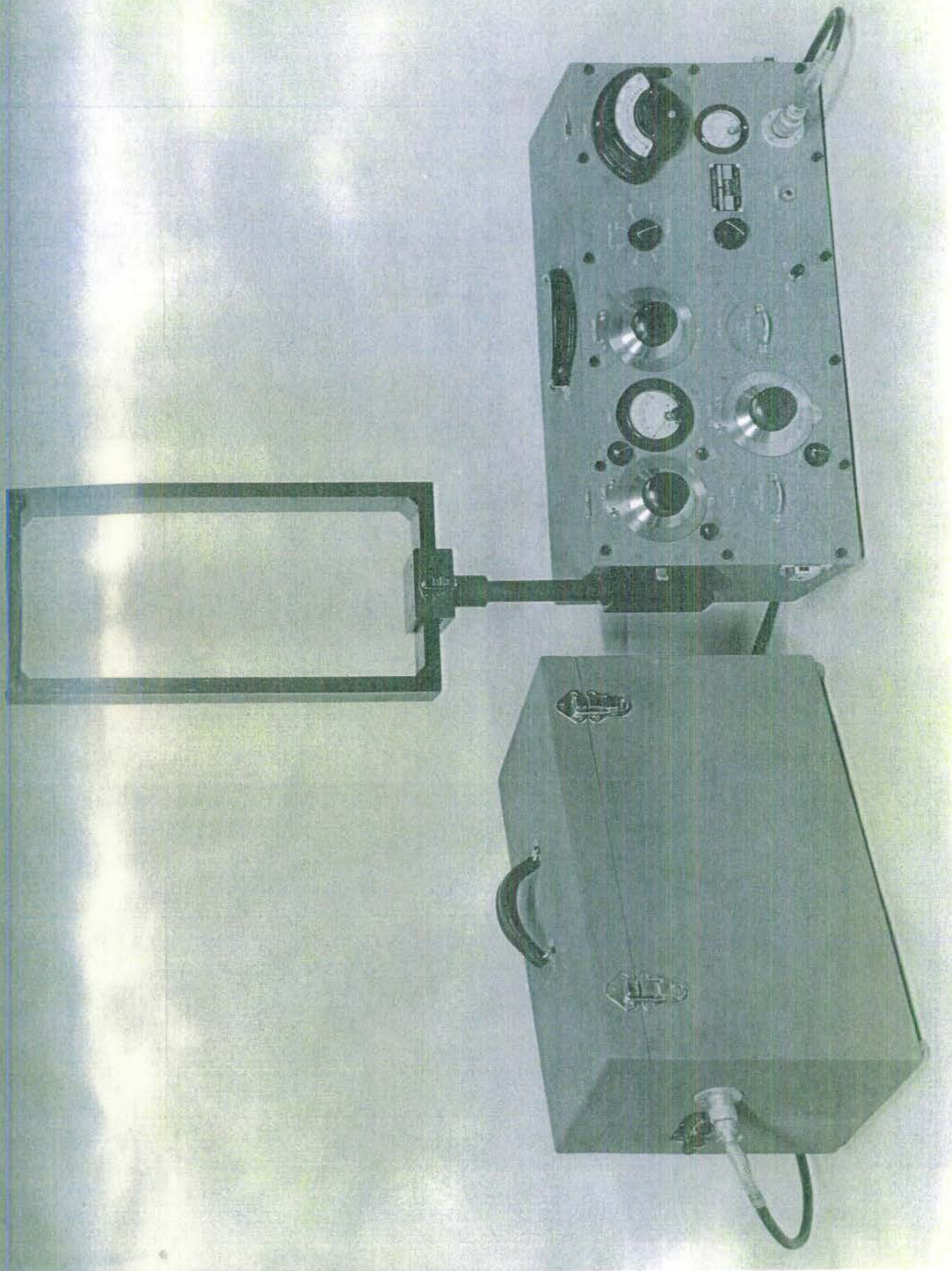


Plate 10

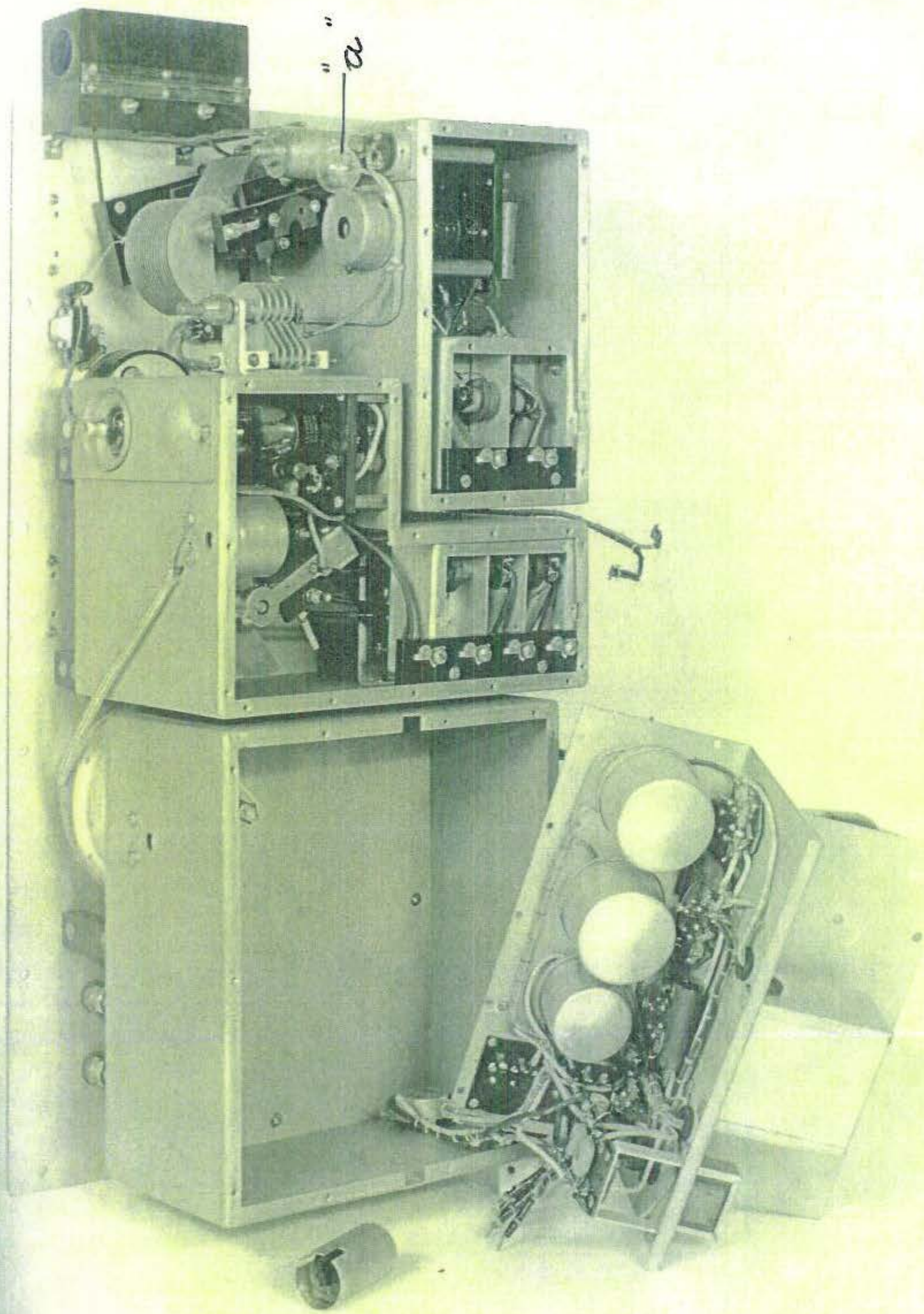


Plate 11