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Report on

Vibration Test of Type 38064 Vacuum Tubes

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WASHINGTON, D. C.

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Table of Contents

Authorization	Page 1
Object of Test	1
Abstract of Test	1
Conclusions	1a
Recommendations	1b
Description of Material under Test	2
Method of Test	3
Data recorded during Test	3
Discussion of Probable Errors	3
Results of Test	4
Conclusions	5

Appendices

Data on Electro-vibratory Tests, RCA Radiotron Company	Table 1
Data on Electro-vibratory Tests, Hygrade Sylvania Company	2
Data on Electro-vibratory Tests, Duovac Radio Tube Corp'n	3
Data on Electro-vibratory Tests, Amperex Electronic Products	4
Data on Electro-vibratory Tests, Deforest Radio Company	5
Average Characteristics Chart	Plate 1
Schematic Diagram of Test Circuit Used	2

AUTHORIZATION

1. This test was authorized by the Bureau of Engineering in ref.(a). Other additional references pertinent to this report are refs. (b), (c), and (d).

Reference: (a) BuEng let.S67/38/L5(8-4-W8) of 20 Aug.1934.
(b) Navy Specifications RE 13A 411E.
(c) Tentative Navy Specifications RE 13A 600A.
(d) NP, let.S67/38/38064 of 8 April 1935.

OBJECT OF TEST

2. The object of this test was to determine the magnitude of voltage irregularity occurring internally in type 38064 triodes when subjected to mechanical vibration of specified characteristics; to compare the test results obtained on this type of vacuum tube made by various manufacturers whose samples were available; and to determine a maximum allowable value of internal electrical disturbance that can be tolerated for Naval use.

ABSTRACT OF TEST

3. The vacuum tubes under test were mounted rigidly in a vertical position on a horizontal table and subjected to simple harmonic motion with an amplitude of 0.04 inch (total travel 0.08 inch) and over a frequency range of 25 to 34.5 cycles per second. The tubes were again tested in the above manner, after being rotated 90° about a vertical axis. The electrical disturbance set up within the tube was measured in both instances by means of a thermal milliammeter after being amplified through a suitable linear amplifier. In addition, the wave form of the voltage disturbance was viewed by a cathode ray oscillograph placed in the amplifier output circuit.

Recommendations

It is recommended that 75 millivolts RMS be accepted as the maximum microphonic output allowable on type 38064 vacuum tubes and that this value be placed in the tentative vacuum tube specifications RE 13A 600A.

DESCRIPTION OF MATERIAL UNDER TEST

4. Seventy-two type 38064 triodes obtained as sample vacuum tubes from five manufacturers were used in the test herein reported. The tubes were arranged in twelve groups of six each. The following table gives the serial number or numerical designation assigned to each tube, the manufacturer, the source of supply, and date received at this Laboratory.

Group	Trade Name	Serial Number or NRL Numerical Designation	Source	Date Received
1	RCA Radiotron	CRC 21, 22, 23, 24, 25, 31.	Purchased on contract.	7-9-34
2	" "	CRC 2, 5, 6, 7, 10, 15.	Purchased on open market.	7-9-34
3	Hygrade Sylvania	CHS 1, 2, 3, 4, 5, 6.	Samples submitted by manufacturer for test.	2-24-34
4	" "	CHS 7, 8, 9, 10, 11, 12.	"	3-5-34
5	Duovac	CBW 1, 2, 4, 5, 7, 8.	"	12-1-31
6	"	CBW 10, 12, 14, 16, 18, 19.	Purchased on contract.	8-1-34
7	Amplex	CEP 1, 2, 3, 4, 5, 6.	Samples submitted by manufacturer for test.	2-17-34
8	DeForest	CF 1, 2, 3, 4, 5, 6.	"	No record.
9	RCA Radiotron	CRC 33, 34, 35, 36, 37, 38.	"	10-25-34
10	" "	CRC 39, 40, 41, 42, 43, 44.	"	11-14-34
11	Hygrade Sylvania	CHS 13, 14, 15, 16, 17, 18.	"	9-26-34
12	Amperex	CEP 9273, 9276, 9277 9278, 9279, 9280.	"	11-14-34

METHOD OF TEST

5. Each tube was mounted rigidly in a vertical position on a horizontal table which may be vibrated in a horizontal plane with simple harmonic motion of 0.04 inch in amplitude (total travel of 0.08 inch). The specified voltages were applied to the electrodes of each tube and a suitable load resistance inserted in series with the plate circuit (the plate voltage supply being raised to compensate for the voltage drop in the resistor). The table was then put in motion and vibrated through a variable frequency range of 25 to 34.5 cycles per second. The RMS value of the alternating voltage produced across this resistor, as a result of microphonic disturbance, was measured by a linear vacuum tube amplifier, the range of which is 15 to 6000 cycles. The output of the amplifier was indicated by a thermal type milliammeter and the wave form of the output was viewed by a cathode ray oscillograph.

6. The tube under test was then rotated 90° about a vertical axis and the test repeated.

7. The diagram shown in Plate 2 illustrates the arrangement of the circuit and measuring apparatus.

DATA RECORDED DURING TEST

8. The maximum reading of the thermal output meter with the corresponding frequency of vibrating platform was recorded for both directions of vibration for each tube tested. The voltage disturbance across the load resistor R_o was then calculated.

9. The microphonic output of each tube as operated into an infinite load is obtained from the relation:

$$E_m = E_p \left[1 + \frac{R_p}{R_o} \right]$$

where E_m = total microphonic disturbance in tube.

E_p = RMS value of the alternating voltage produced across the load resistor (R_o).

R_p = dynamic plate resistance of tube under test.

R_o = load resistor.

10. Tables 1 to 5 in the appendix give all data for each tube tested.

DISCUSSION OF PROBABLE ERRORS

11. Results obtained through electro-vibratory tests can be considered accurate to ± 3.5 %. In making measurement, the amplifier is calibrated to an accuracy of ± 2.5%. The thermal milliammeter has an accuracy of ± 1%.

The output resistor is known to better than ± 1/10 %. The frequency is accurate to ± 0.25 cycle.

RESULTS OF TEST

12. A summary of results giving maximum, minimum, and average values output voltage irregularities for each group of tubes tested, is as follows:

SUMMARY OF RESULTS

Vibration Test of Type 38064 Vacuum Tubes

Group	Numerical Designation or Serial No.	Number of Hours of Service Operation	Output Electrical Disturbance working into an Infinite Load - Millivolts		
			Maximum	Minimum	Average
1	CRC 21, 22, 23, 24, 25, 31.	1000	56.5	3.22	20.9
2	CRC 2, 5, 6, 7, 10, 15.	1000	267	3.49	60.43
3	CHS 1, 2, 3, 4, 5, 6.	1000	158.2	25.7	54.9
4	CHS 7, 8, 9, 10, 11, 12.	1000	157.5	21.9	57.94
5	CBW 1, 2, 4, 5, 7, 8.	1000	36.35	11.28	25.03
6	CBW 10, 12, 14 16, 18, 19.	675	26.1	3.24	14.79
7	CEP 1, 2, 3, 4, 5, 6.	1000	22.8	3.92	9.97*
8	CF 1, 2, 3, 4, 5, 6.	1000	274	22.6	69.47
9	CRC 33, 34, 35, 36, 37, 38.	0	71.2	13.0	32.83
10	CRC 39, 40, 41, 42, 43, 44.	0	40.0	3.02	21.92
11	CHS 13, 14, 15, 16, 17, 18.	0	116.5	0	40.57
12	CEP 9273,9276,9277, 9278, 9279,9280.	0	298.0	21.5	129.68

* Average of five tubes only. Elements touch on tube CEP #6 at a vibration frequency of 27 cycles per second.

13. The cathode ray oscillograph shows that the output voltage irregularity is the result of an extremely complex combination of coupled mechanical systems and that it consists of a number of frequencies, one for each element of the tube structure. The resultant wave form is found to be different for various tubes of the same type. Some tubes give a voltage disturbance whose wave form is close to sinusoidal in shape, whereas other tubes produce a distorted wave form, despite the fact that they have identical design. Each tube has been found to have a number of points where mechanical resonance occurs, where the electrical disturbance in the output increases considerably. Wherever this occurs, the frequency of vibration must be varied slowly so that the maximum disturbance can be successfully measured.

CONCLUSIONS

14. From a study of the values of electrical disturbance found occurring in type 38064 triodes and based on the non-microphonic requirements for satisfactory radio receiver operation, the maximum allowable microphonic output should not exceed 75 millivolts, root mean square. Tubes which completely meet this requirement, as shown on Plate 1, are those of Groups 1, 5, 6, 7, 9, and 10. Those tubes, as shown on Plate 1. which only partially meet this requirement are those of Groups 2, 3, 4, 8, and 11. Those tubes, as shown on Plate 1, which do not meet this requirement to any degree, are those of Group 12.

Table 1
Data on Electro-vibratory Tests, RCA Radiotron Company

E_f 1.1 volts
E_b 90 volts
E_c -4.5 "

Vibration frequency 25 - 34.5 cycles per second
Load resistance - 2175 ohms.

Mfr. Num. Desig.	Vibration Frequency at Max. Disturbance (cycles)	Maximum Alternating Voltage across Load Resistor with Vibrations: Parallel to Fil.Pins RMS	Maximum Alternating Voltage across Load Resistor with Vibrations: Perpendicular to Fil.Pins RMS	A.C. Plate Resis. (ohms)	Max.Microphonic Output with Vibrations: Paral. to Fil.Pins RMS	Max.Microphonic Output with Vibrations: Perpendic. to Fil.Pins RMS	Avg. Output RMS
CRC 21	32	2.75		13850	20.35		
	32		3.82			28.25	24.3
CRC 22	33		3.76	12900		26.25	
	33	2.65			18.5		22.37
CRC 23	33	.90		13000	6.32		
	33		.90			6.32	6.32
CRC 24	33		5.29	12750		36.5	
	33	2.00			13.8		20.15
CRC 25	32	.45		13350	3.22		
	33.5		.90			6.45	4.84
CRC 31	33		7.69	13750		56.5	
	28	5.20			38.2		47.4
CRC 2	32.5		17.80	12300		119.2	
	32.5	14.40			96.5		107.9
CRC 5	32.5	4.00		14800	31.3		
	32.5		5.20			40.7	36.0
CRC 6	33	2.75		12550	18.75		
	33		4.20			28.6	23.68
CRC 7	31	11.00		12250	73.3		
	33.5		40.05			267.0	170.2
CRC 10	29.5		2.75	12300		18.4	
	31.5	3.10			20.75		19.58
CRC 15	31.0	.90		14600	6.98		
	31.0		.45			3.49	5.24
CRC 33	31		10.25	12830		71.2	
	29	7.15			49.7		60.45
CRC 34	32.5	5.0		13300	35.75		
	27		2.2			15.72	25.74
CRC 35	31		1.8	13450		13.0	
	32	2.7			19.5		16.25
CRC 36	32	4.4		12900	30.7		
	29		4.75			33.1	31.9
CRC 37	27.5		4.0	12700		27.5	
	27	6.06			41.7		39.6
CRC 38	34	3.85		13000	27.1		
	30		2.70			18.97	23.04
CRC 39	29.5	2.2		12550	15.0		
	31		5.71			38.9	26.95

Table 1 (cont'd)

Mfr. Num. Desig.	Vibration Frequency at Max. Disturb. (cycles)	Maximum Alternating Voltage across Load Resistor with Vibrations: Parallel to Fil.Pins RMS	Maximum Alternating Voltage across Load Resistor with Vibrations: Perpendicular to Fil.Pins RMS	A.C. Plate Resis. (ohms)	Max. Microphonic Output with Vibrations: Para. to Fil.Pins RMS	Max. Microphonic Output with Vibrations: Perpendic. RMS	Avg. Output RMS
CRC 40	33		5.31	12450		35.9	
	33.5	4.25			28.75		32.33
CRC 41	29	.87		13000	6.11		
	29		.43			3.02	4.57
CRC 42	30		4.68	12600		32.1	
	30	3.70			35.3		33.7
CRC 43	29	1.70		13900	12.6		
	32		5.40			40.0	26.3
CRC 44	31		1.29	13100		9.15	
	29	.87			6.17		7.66

Table 2

Data on Electro-vibratory Tests, Hygrade Sylvania Company

E_f 1.1 volts
E_b 90 volts
E_c -4.5 "

Vibration frequency 25 - 34.5 cycles per second
Load resistance - 2175 ohms.

Mfr. Num. Desig.	Vibration Frequency at Max. Disturb. (cycles)	Maximum Alternating Voltage across Load Resistor with Vibrat'ns Parallel to Fil.Pins RMS	Perpendic. to Fil Pins RMS	A.C. Plate Resis. (ohms)	Maximum Microphonic Output with Vibrations Parallel to Fil.Pins RMS	Perpendic. to Fil.Pins RMS	Avg. Output RMS
CHS 1	28		6.39	13850		47.3	
	29	4.55			33.5		40.35
CHS 2*	33		22.3	13200		158.2	
	32.5	4.55			32.3		95.25
CHS 3	26.5	6.75		14000	50.3		
	29		11.2			83.4	66.35
CHS 4	33		2.75	18100		25.7	
	32.5	3.92			36.6		31.25
CHS 5	31		3.65	16600		31.5	
	32.5	3.92			33.9		32.7
CHS 6	32.5	6.39		14550	49.3		
	33		10.07			77.7	63.5
CHS 7	32	2.92		14300	22.2		
	32		5.29			40.2	31.1
CHS 8	34		19.10	15700		157.5	
	33	9.31			76.8		117.15
CHS 9	30.5	7.00		18650	67.0		
	30.5		8.70			83.2	75.1
CHS 10	32.5		6.20	21800		69.5	
	29	5.82			65.2		67.35
CHS 11	34	2.55		16500	21.9		
	31		4.38			37.6	29.75
CHS 12	31	2.00		24800	24.8		
	32.5		2.39			29.6	27.2
CHS 13	30		3.0	12580		20.45	
	32	6.0			40.9		30.68
CHS 14	33	16.4		13100	116.5		
	31.5		6.65			47.3	81.9
CHS 15	-		-	12330		-	
	32	2.0			13.43		6.72
CHS 16	31	9.5		12150	62.8		
	31		7.7			50.9	56.85
CHS 17	31		1.88	12000		12.32	
	31	3.85			25.25		18.79
CHS 18	32	9.14		12680	62.7		
	32		5.0			34.3	48.5

* Tube vibrated at angle 45° with plate structure.

Table 3
Data on Electro-vibratory Tests, Duovac Radio Tube Corp'n

E_f 1.1 volts
E_b 90 volts
E_c -4.5 volts

Vibration frequency 25 - 34.5 cycles per second
Load resistance - 2175 ohms

Mfr. Num. Desig.	Vibration Frequency at Max. Disturb. (cycles)	Maximum Alternating Voltage across Load Resistor with Vibrat'ns Parallel to Fil.Pins RMS	Maximum Alternating Voltage across Load Resistor with Vibrat'ns Perpendic. to Fil.Pins RMS	A.C. Plate Resis. (ohms)	Maximum Microphonic Output with Vibrations Parallel to Fil.Pins RMS	Maximum Microphonic Output with Vibrations Perpendic. to FilPins RMS	Avg. Output RMS
CBW 1	32		2.75	14000		20.55	
	32	2.55			19.05		19.80
CBW 2	32	4.20		13450	30.3		
	32.5		3.65			36.35	33.33
CBW 4	34		1.82	11200		11.28	
	28.5	4.00			24.8		36.08
CBW 5	34.5	1.82		13550	13.25		
	32		1.82			13.25	13.25
CBW 7	33		2.75	16300		23.4	
	33	2.20			18.7		21.05
CBW 8	33		3.65	12600		24.8	
	33.5	4.20			28.5		26.65
CBW 10	33		3.65	12900		25.4	
	34	3.48			24.2		24.8
CBW 12	30.5	2.39		12350	16.05		
	33		2.39			16.05	16.05
CBW 14	34		.45	13400		3.24	
	34	.45			3.24		3.24
CBW 16	32	.90		11450	5.68		
	34		1.37			8.65	7.17
CBW 18	32	2.39		13300	17.1		
	32		3.65			26.1	21.6
CBW 19	33	3.48		12100	22.95		
	33		1.37			8.81	15.88

Table 4
Data on Electro-vibratory Tests, Amperex Electronics Products.

E_f 1.1 volts
E_b 90 volts
E_c -4.5 volts

Vibration frequency 25 - 34.5 cycles per second
Load resistance - 2175 ohms

Mfr. Num. Desig.	Vibration Frequency at Max. Disturb. (cycles)	Maximum Alternating Voltage across Load Resistor with Vibrat'ns Parallel to Fil.Pins RMS	Perpendic. to Fil.Pins RMS	A.C. Plate Resis. (ohms)	Maximum Microphonic Output with Vibrations Parallel to Fil.Pins RMS	Perpendic. to Fil.Pins RMS	Avg. Output RMS
CEP 1	29	1.82		12900	12.70		
	34		.90			6.28	9.49
CEP 2	34		.90	14600		6.97	
	28	1.37			10.60		8.79
CEP 3	34	.45		16750	3.92		
	34		.90			7.85	5.89
CEP 4	31		3.10	13750		22.8	
	29	2.00			14.7		18.75
CEP 5	32.5	.9		14500	6.93		
	32.5		.9			6.93	6.93
CEP 6	33		.9	21400		9.76	
	27	Elements hit.					
CEP 9273	32.5	4.0		16200	33.9		
	32.5		2.7			22.9	28.4
CEP 9276	30.5		12.3	30650		185.7	
	32	6.65			100.2		142.95
CEP 9277	32	32.8		14200	248.		
	32		34.5			261	254.5
CEP 9278	30		15.8	38800		298	
	30	8.3			156.5		227.25
CEP 9279	32		1.7	16500		146	
	32	2.5			21.5		83.75
CEP 9280	32	3.85		14600	29.8		
	31		6.8			52.7	41.25

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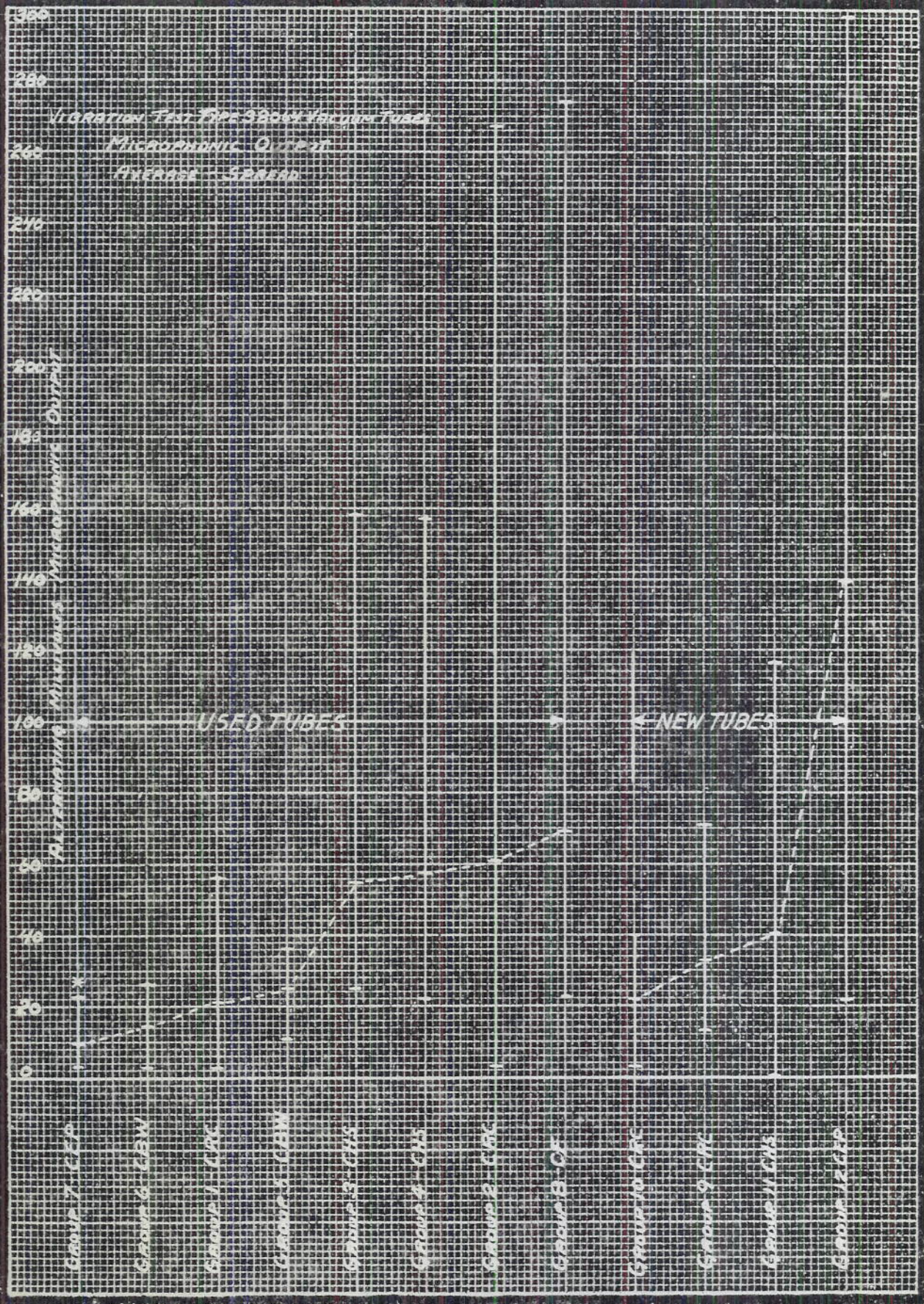
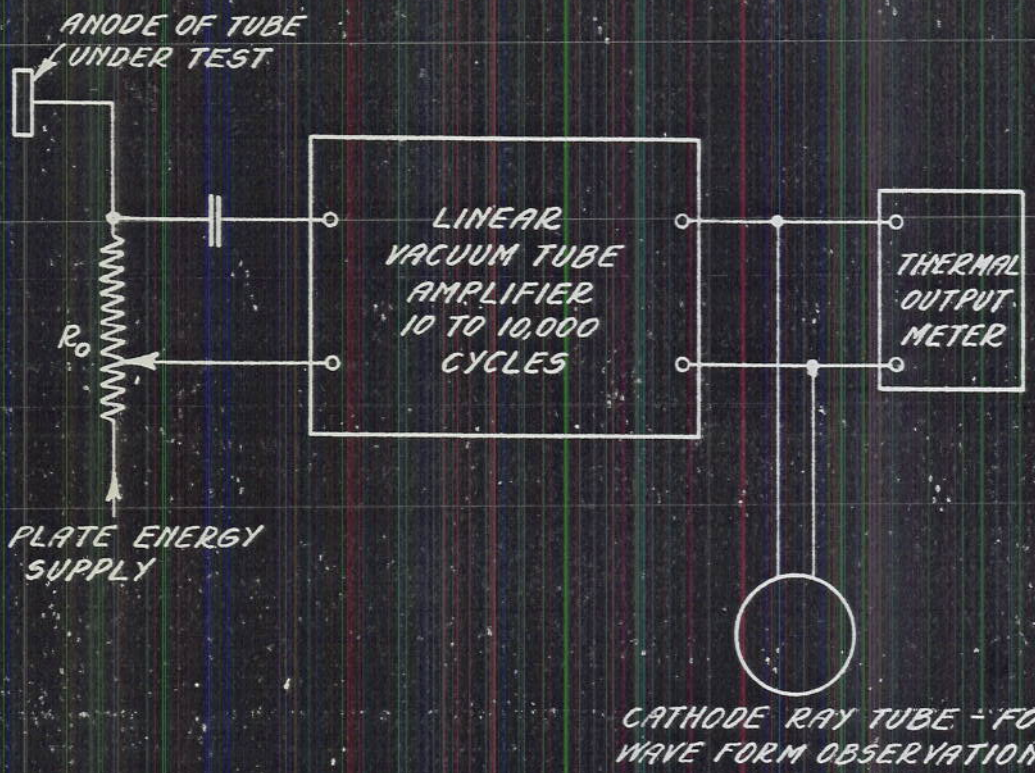


* AVERAGE OF 5 TUBES

PLATE I



SCHEMATIC DIAGRAM OF TEST CIRCUIT USED

PLATE 2