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BuShips Problem M-64

NAVY DEPARTMENT

BUREAU OF SHIPS

Report of Test

On

Head Telephone Receivers,

Headband, and Cord

PERMOFLUX CORPORATION

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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to Director, NRL.

Date of Test: December 15, 1942 to March 22, 1943.

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Distribution
BuShips (10)

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AUTHORIZATION

1. This problem was authorized by references (a) and (b). The governing specifications are listed as references (c), (d), and (e). References (f) and (g) are also pertinent.

- References:
- (a) BuShips ltr S67/49 (932) of Dec. 12, 1942 to Director, NRL.
 - (b) BuShips ltr S67/49 (932) of March 15, 1943 to Director, NRL.
 - (c) Specification RE 13A 511B.
 - (d) Specification RE 49AA 117.
 - (e) Specification RE 49AA 120B.
 - (f) Bell System Technical Journal, Vol. XI, pp. 293-317, April, 1932.
 - (g) NRL Report No. R-1066.

OBJECT OF TEST

2. The object of the tests was to determine the suitability of the telephone receivers, headbands and cord for naval use.

ABSTRACT OF TEST

3. The receivers were tested to determine the following characteristics:

- (a) Dimensions and materials.
- (b) Effect of mechanical shock.
- (c) D. C. resistance.
- (d) Operation at high energy input (50 milliwatts).
- (e) Impedance at the frequency of primary resonance.
- (f) Efficiency factor at the frequency of primary resonance.
- (g) Primary resonance frequency.
- (h) Magnitude of secondary resonance peak.
- (i) Band width of primary resonance peak.
- (j) Band width of secondary resonance peak.
- (k) Effect of humidity on sensitivity.
- (l) Effect of humidity on insulation resistance.
- (m) Effect of humidity on materials.

CONCLUSIONS

These headphones were constructed to have a flat characteristic for radio telephone reception, and they were tested by reference (c) which was designed to evaluate peaked response head telephones suitable for continuous wave reception. Efficiency factors are measured at the frequency of primary resonance (peak sound output per reference millivolts input), and therefore this method of test would tend to favor strongly the peaked type of headphone.

It is concluded:

- (a) That the average sound pressure output from 200 to 2000 cycles per second expressed in decibels above 1 bar per volt for these phones compares satisfactorily with that of the permanent magnet, bipolar type of construction in which the diaphragm is utilized to complete the magnetic circuit.
- (b) That the efficiency in bars output per microwatt input is lower than that of approved headphones of the permanent magnet type of construction.
- (c) That these headphones offer exceptionally high resistance to humidity.
- (d) That the frequency response characteristic, efficiency, and resistance to humidity of the improved type of Permoflux construction are substantially identical with those of the earlier type of construction, except that the improved type contains more irregularities in its frequency response curve.
- (e) That the response of all the telephones of both types as a function of frequency is somewhere between the peaked type and the extremely flat type.
- (f) That they are suitable for voice communication.
- (g) That these telephones will not accommodate standard Navy headphone cord tips without the live part being exposed.
- (h) That the angle which the two major portions of the headset make with each other exceeds 20 degrees.
- (i) That the dimensions of the headphone supporting pins do not meet the minimum requirements of reference.(e).

- (j) That the headbands are not properly marked.
- (k) That the phone cords are not properly marked.
- (l) That the phone tips of the cords do not conform to the required dimensions.
- (m) That each conductor of the phone cord contained an insufficient number of strands.

RECOMMENDATIONS

It is recommended:

- (a) That the efficiency of the headphones in bars output per microwatt input be improved.
- (b) That the weight of the headphones be reduced.
- (c) That the headbands be altered to conform to reference (e).
- (d) That the phone cord be altered to conform to reference (d).
- (e) That the permoflux head telephones be considered suitable for Naval use in certain applications when these recommended changes have been made.

MATERIAL UNDER TEST

4. The Permoflux Corporation, 4916 W. Grand Ave. Chicago, Illinois submitted twelve dynamic type head telephones having non-removable covers, one headband, and one phone cord for test. Six of the headphones constituted a first model, and six a second improved model. The samples of the earlier model bear NRL nos. 238 to 243 inclusive; the improved telephones are numbered 257 to 260 inclusive and 263 and 264. The telephones do not conform to any type described in reference (c). Plates 1 to 4 inclusive are views of the earlier model. Plate 1 shows front and side views of the headphone. Plate 2 shows the cap and metal band which holds the non-removable cap to the case. Plate 3 shows the voice coil, conic diaphragm, and permanent magnet. Plate 4 shows the impedance matching transformer, internal arrangement of the case, and the disc which protects the diaphragm. Plate 5 shows that the improved model differs from the earlier model, by the use of a rubber cap fitting underneath the receiver case. The head band was unmarked but corresponded to type 49028 described in reference (e). The phone cord was unmarked but corresponded most closely to type 49012 described in reference (d).

METHOD OF TEST

5. The equipment used in the tests included the following:

- (a) Bell Telephone Laboratories Artificial Ear, described fully in reference (f), and type 1-AS condenser microphone.
- (b) Bell Telephone Laboratories volume indicator.
- (c) General Radio Co. Interpolation Oscillator, Type 617-A, Ser. No. 37.
- (d) General Radio Co. Type 329-J attenuation box.
- (e) Ballantine Electronic Voltmeter, Model 300, Ser. No. 310*
- (f) General Radio Co. Impedance Bridge, Type 650-A Ser. No. 1555.
- (g) Hewlett-Packard Audio Signal Generator, Model 205AG.
- (h) Dumont Cathode-Ray Oscillograph, Type 208, Ser. No. 438.
- (i) General Radio Co., Sound Analyzer, Type 760A Ser. No. 287.
- (j) General Radio Co., Wave Analyzer, Type 736A, Ser. No. 118.
- (k) General Radio Co., Megohm Bridge, Type 544-B, Ser. No. 246.
- (l) Weston D. C. milliammeter, Model 322, Ser. No 4748.
- (m) Leeds & Northrup Wheatstone Bridge, No. 5300, Ser. No. 474910.

- (n) Weston milliammeter, Model 269, Ser. No. 57693.
- (o) Weston a.c. microammeter, Model 301, Ser. No. 1084255*

*This a.c. voltmeter and a.c. microammeter were calibrated against Weston laboratory standard a.c. voltmeter model 326 Ser. No. 1203, and Weston standard potential transformer model 577 Ser. No. 103, prior to their use in the subject tests.

6. The telephone receivers were tested in all respects as outlined in reference (c), except for the order in which tests were made. The mechanical shock tests were made last. All tests involving receiver output as a function of frequency were made with a constant closed circuit reference voltage across the receiver. A brief discussion of some of the tests follows. Reference (c) may be referred to for a more extended description. Reference (g) may also be referred to for a further discussion of certain of the tests.

- (a) The receivers were carefully inspected as to dimensions and materials according to paragraphs 4-2, 4-3, 4-4 and 4-7 of reference (c).
- (b) The mechanical shock test was made in conformance with paragraphs 5-9 and 6-2 of reference (c).
- (c) The D. C. resistance was measured on a wheatstone bridge at 20°C.
- (d) The input level at which the voice coil or diaphragm touched the magnet or other part was determined by connecting an oscilloscope across the receiver input and observing the waveform.
- (e) The impedance of the receivers at the frequency of primary resonance was determined by measuring the inductance and "Q" on a General Radio Co. Type 650-A impedance bridge. The a-c resistance was computed from the formula X/Q , and the value of R thus obtained was used in calculating Z.
- (f) The efficiency factor, bars²/microwatts, was determined by measuring the watts input to the telephone, $E^2/Z \times P.F.$, and converting the electrical output of the artificial ear into terms of pressure developed at the microphone by means of curves supplied by the Bell Telephone Laboratory.
- (g) The primary resonant frequency f_0 was determined by varying the frequency of current supplied to the telephone at a constant voltage, and measuring the output of the artificial ear with the volume indicator.
- (h) The magnitude of the secondary resonant peak was determined in the same manner as (g) above.

- (i) The band width of the primary resonance peak was determined by finding points f_1 and f_2 on each side of the peak, 4 db down, and recording the frequency at these points. The band width is expressed as $\frac{f_1-f_2}{f_0}$ in percent. This procedure was repeated for points 8db down.
- (j) The band width of the secondary resonance peak was determined in a similar manner to that of (i) above.
- (k) The effect of humidity on sensitivity was determined by comparing the outputs of the telephones at a given input and frequency, measured before and after exposure to humidity applied according to paragraph 5-10 of reference (c). In addition, six samples were submitted to four cycles of salt water immersion. Each cycle consisted of submersion in a saturated salt water solution at 65°C for two hours, followed immediately by two hours in a 0°C bath. The head-phone was then removed, washed in clear water, and thoroughly dried with air. Its sensitivity and peak frequency were then remeasured.
- (l) The effect of humidity on insulation resistance was determined by measurement at 100 volts on a General Radio Co. Type 544-B megohm bridge.
- (m) The effect of humidity on materials was determined by inspection following exposure.

DATA RECORDED DURING TEST

7. Certain data are recorded in Table I and plates 7 to 19 inclusive. Other data are recorded in RESULTS OF TESTS.

POSSIBLE ERROR OF RESULTS

8. The errors in the determination of the various values are estimated to be within the values given below:

Dimensions	.001 inch
D. C. Resistance	0.5 ohm
Impedance	18%
Frequency	2 cycles/sec
Efficiency Factor	18%
Peak outputs	0.2 db
Humidity	10%
Temperature	0.5°C

RESULTS OF TEST

9. Certain observed or computed data are given in Table I for each of the receivers. A table of "weights", Table II, was compiled in accordance with paragraphs 7-5

and 7-6 of reference (c). The Permoflux head telephone receivers were not designed to meet these specifications, reference (c), and can not be expected to pass paragraph 7-7. No particular significance should be attached to the low total "weight" obtained by each sample. In compiling Table II, the possible error of measurement was taken into consideration, so that any receiver is considered to have passed the test if the observed value after being adjusted by the amount of possible error lies within the limits.

10. The following comments on the results of tests refer to the similarly numbered paragraphs of reference (c).

4-2 The receiver cases are made of magnetic metal. The receiver cap shown in the right-hand figure of Plate 2 is made of an insulating compound. Dimensions which should correspond to sheet 12B of reference (c) were as follows:

B - 1 5/8"

I - 2 1/32"

The distance through the receiver corresponding roughly to dimension C, was 1 inch.

4-3 The non-removable receiver caps were made of hard rubber or some phenolic material. The metal ring shown in plate 2 was used to secure the cap to the receiver case.

4-4 The receivers contained no electro-magnets. The input transformers were wound of enameled wire, and were protected from the entrance of moisture by covering with wax and wrapping.

4-5 The eyes of the receiver cases were not made of non-ferrous material, but were of sufficient size.

4-6 The receivers would not accomodate standard cord tips without the tips being exposed.

4-7 The resistance of the whole receiver to humidity was exceptional. See 6-10 below.

4-8 Spacing between voice coil and magnet was satisfactory.

4-9 The diaphragms were apparently made of treated paper or phenolic material.

4-10 The cords did not conform to the specification. They were unmarked, each conductor contained only 12 strands,

and dimension A of the cylindrical type tip was 1/2". The tip also had an annular depression 1/8" long and approximately 1/64" deep near the outer end.

4-11 The headband was covered with webbing. The locking devices were coiled springs. The headband did not conform to the dimensions of reference (e). The angle was 22 degrees. The wide portion of the pin measured .126", the narrow portion .065".

4-12 The receivers, headband and cord bore no type numbers.

6-2 No samples were physically damaged during the mechanical shock test.

6-3 The D. C. resistances are shown in Table I.

6-4 The impedances are shown in Table I.

6-5 The efficiency factors are shown in Table I.

6-6 The primary resonant peak frequencies are shown in Table I. Plate 13 compares the response curve of the permoflux headphone with two peaked headphones. The average sound pressure output from 200 to 2000 cycles per second of the permoflux phone was 49 db, those of two other peaked samples 53.5 and 40.8 db.

6-7 The secondary peak amplitudes are shown in Table I.

6-8 The primary peak band widths are shown in Table I.

6-9 No point could be found on any of the receivers of the earlier type 3 db down on the high side of the secondary peak in the neighborhood of 300 cycles/sec.

6-10 The humidity tests showed results as follows: (The db output is based upon a reference input voltage, of 0.1 r-m-s volts, and is dependent upon the microphone calibration and the gain and loss of all the associated equipment energized therefrom). Blank spaces indicate the particular sample was not submitted to this test.

NR. SAMPLE #	Prior to Humidity	After usual humidity test of reference (c)	After saltwater immersion			
			1st Cycle	2nd	3rd	4th
<u>Frequency of Primary Resonance (cycles/sec)</u>						
238	2200	2469				
239	2250	2404				
240	2215	2207				
241	2249	2243				
242	2280	2228	2651	2073	Inoperative	
243	2166	2241	1991	1949	2054 In-operative	
257	2356	Not made				
258	2321	"	Inoperative			
259	2325	"	2446	2413	1971	
260	2298	"	2060	1869	2056	
263	2558	"				
264	2183	"	Inoperative			

<u>Output (decibels)</u>						
238	-13.8	-13.8				
239	-13.6	-13.75				
240	-14.3	-14.3				
241	-14.3	-14.7				
242	-14.1	-14.3	-10.5*	-29.8		
243	-14.3	-14.3	-14.3	-20.2	-26.3 In-operative	
257	-14.8	Not made				
258	-15.2	"	Inoperative			
259	-15.3	"	-11.8*	-14.8	-19.2	
260	-14.5	"	-16.5	-31.6	-25.6	
263	-14.1	"				
264	-15.0	"	Inoperative			

*Increase in output unaccounted for.

Plate 5 shows sample no. 243 after four cycles of salt water immersion.

6-11 Insulation resistances are shown in Table I.

6-12 No apparent damage was done to the insulation materials by exposure to humidity, when tested under reference (c).

CONCLUSIONS

These headphones were constructed to have a flat characteristic for radio telephone reception, and they were tested by reference (c) which was designed to evaluate peaked response head telephones suitable for continuous wave reception. Efficiency factors were measured at the frequency of primary resonance (peak sound output per reference millivolts input), and therefore this method of test would tend to favor strongly the peaked type of headphone.

It is concluded:

- (a) That the average sound pressure output from 200 to 2000 cycles per second expressed in decibels above 1 bar per volt for these phones compares satisfactorily with that of the permanent magnet, bi-polar type of construction in which the diaphragm is utilized to complete the magnetic circuit.
- (b) That the efficiency in bars output per microwatt input is lower than that of approved headphones of the permanent magnet type of construction.
- (c) That these headphones offer exceptionally high resistance to humidity.
- (d) That the frequency response characteristic, efficiency, and resistance to humidity of the improved type of Permoflux construction are substantially identical with those of the earlier type of construction, except that the improved type contains more irregularities in its frequency response curve.
- (e) That the response of all the telephones of both types as a function of frequency is somewhere between the peaked type and the extremely flat type.
- (f) That they are suitable for voice communication.
- (g) That these telephones will not accommodate standard Navy headphone cord tips without the live part being exposed.
- (h) That the angle which the two major portions of the headset make with each other exceeds 20 degrees.
- (i) That the dimensions of the headphone supporting pins do not meet the minimum requirements of reference (e).

- (j) That the headbands are not properly marked.
- (k) That the phone cords are not properly marked.
- (l) That the phone tips of the cords do not conform to the required dimensions.
- (m) That each conductor of the phone cord contained an insufficient number of strands.

TABLE I

PermoFlux Head Telephones

(Letters in column headings correspond to the letter headings of Paragraph 7-5 of reference (c).)

Sample No.	D. C. Resistance (ohms) (b)	Impedance (ohms) (c)	Efficiency Factor (d)	Peak Frequency Cycles (e)	Sec. peak db below pri... (f)	Pri. band width % 4 db 8 db (g)	Sec. band width % 3 db (h)	Insul. Resis. Megohms (j)
238	13.54	281.3	91.5	2200	8.0	61.5	95.5	2,000
239	13.05	287.3	97.9	2250	8.2	60.3	93.0	4,000
240	13.14	275.8	80.0	2215	6.9	68.9	117.1	3,500
241	13.14	274.4	79.2	2249	7.1	58.4	109.8	15,000
242	12.95	265.9	80.6	2280	6.8	59.6	103.0	4,000
243	13.06	270.2	78.3	2166	7.7	63.1	111.77	2,500
257	*	255.0	75.5	2356	*	*	*	*
258	*	283.0	76.3	2321	*	*	*	*
259	*	252.6	64.8	2325	*	*	*	*
260	*	247.0	77.7	2298	*	*	*	*
263	*	264.4	90.2	2558	*	*	*	*
264	*	254.3	69.1	2183	*	*	*	*

*Not measured or calculated on improved model.

TABLE II

"Weights" for PermoFlux Head Telephone Receivers

(Letters in column headings correspond to the letter headings of Paragraph 7-5, reference (c).)

Sample Test No.	(a)	D.C. \bar{R} (b)	Impedance (c)	Efficiency Factor (d)	Peak Freq. (e)	Sec. Peak (f)	Pri. Band Width (g)	Sec. Band Width (h)	Band Width (i)	Effect of Humidity (j)	Humidity (k)	Total
238	2	5	20	0	0	2	0	2	20	2	2	55
239	2	5	20	0	0	2	0	2	20	2	2	55
240	2	5	20	0	0	2	0	2	20	2	2	55
241	2	5	20	0	0	2	0	2	20	2	2	55
242	2	5	20	0	0	2	0	2	20	2	2	55
243	2	5	20	0	0	2	0	2	20	2	2	55

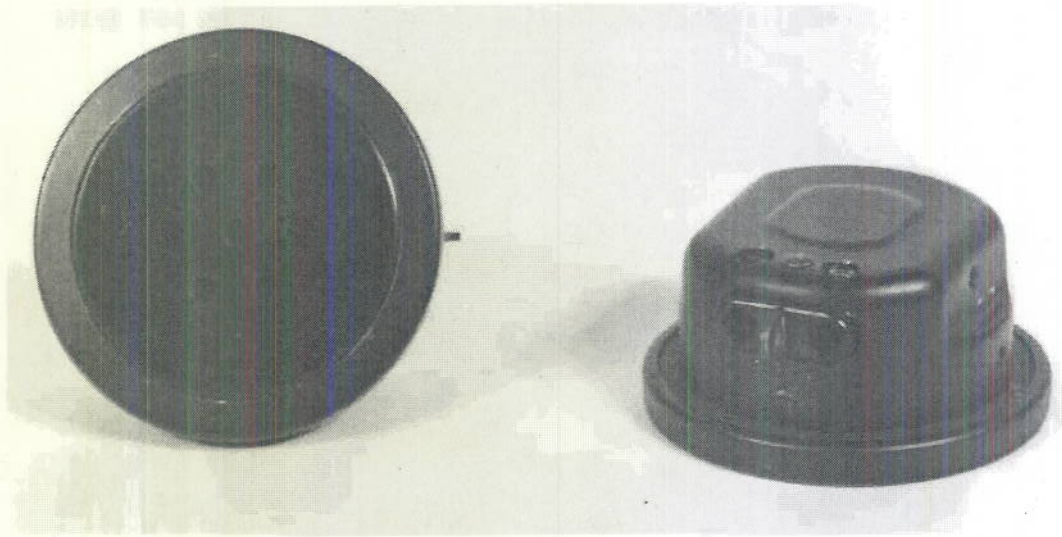


PLATE I

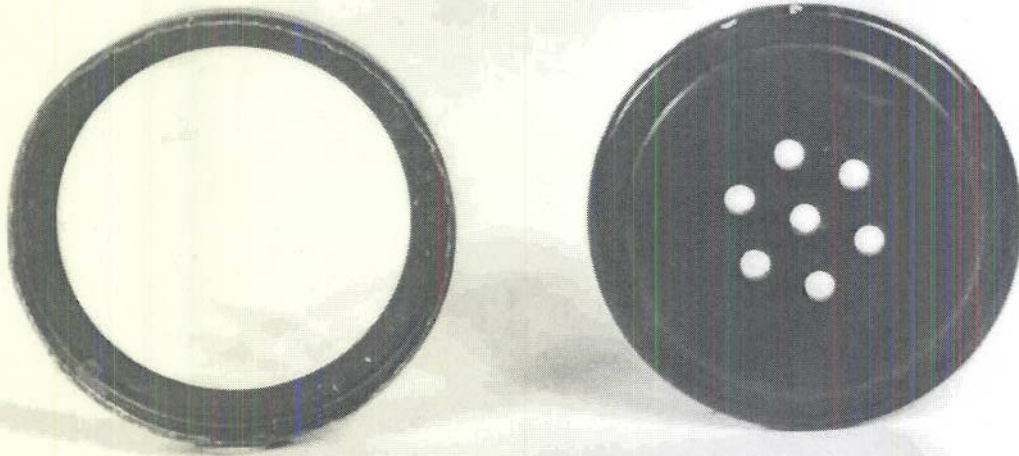
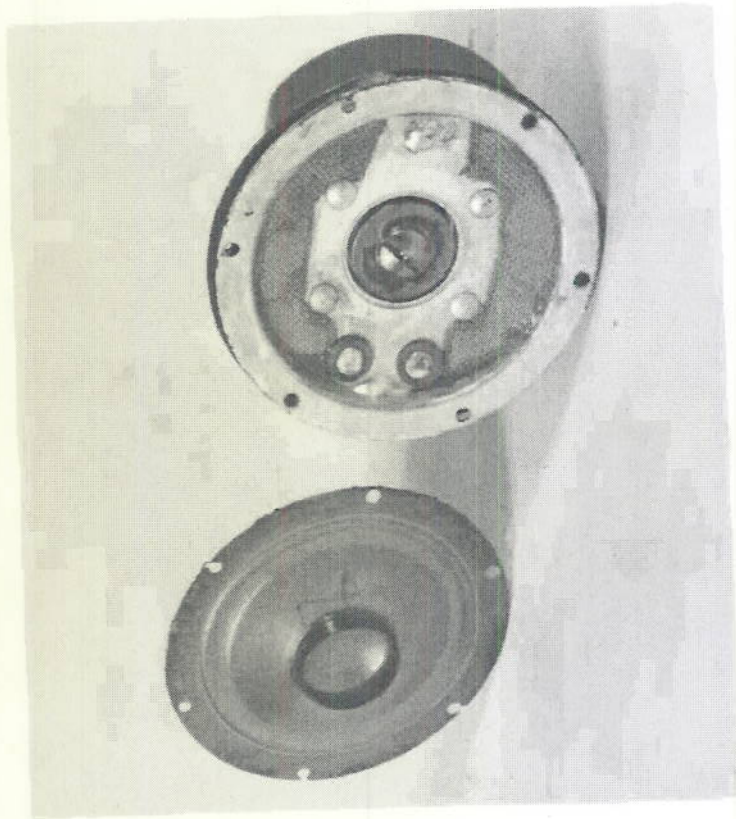


PLATE 2



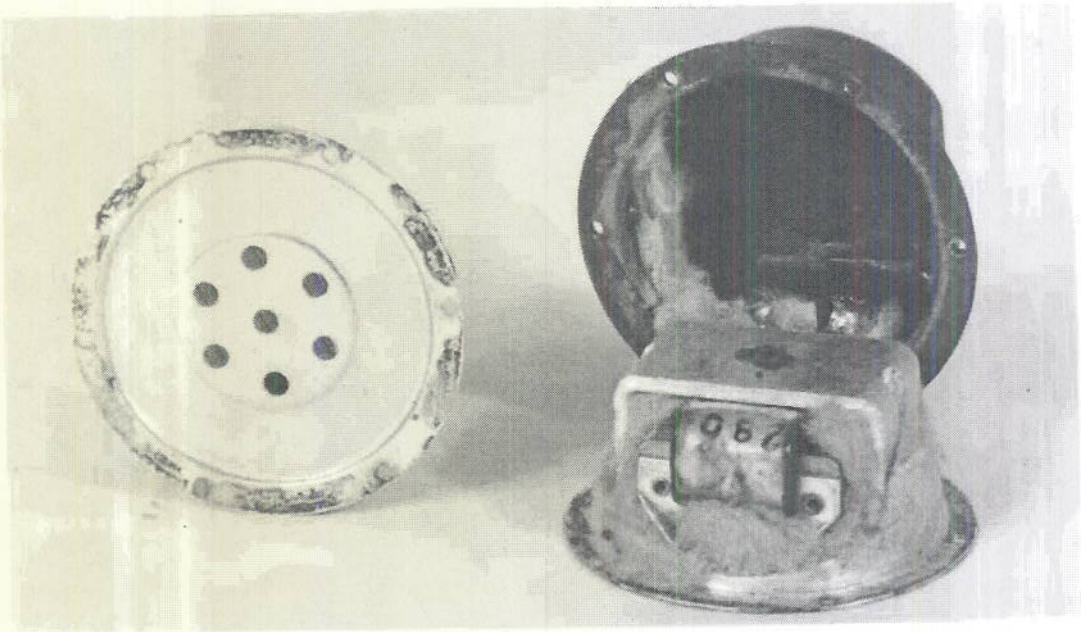


PLATE 4



PLATE 5

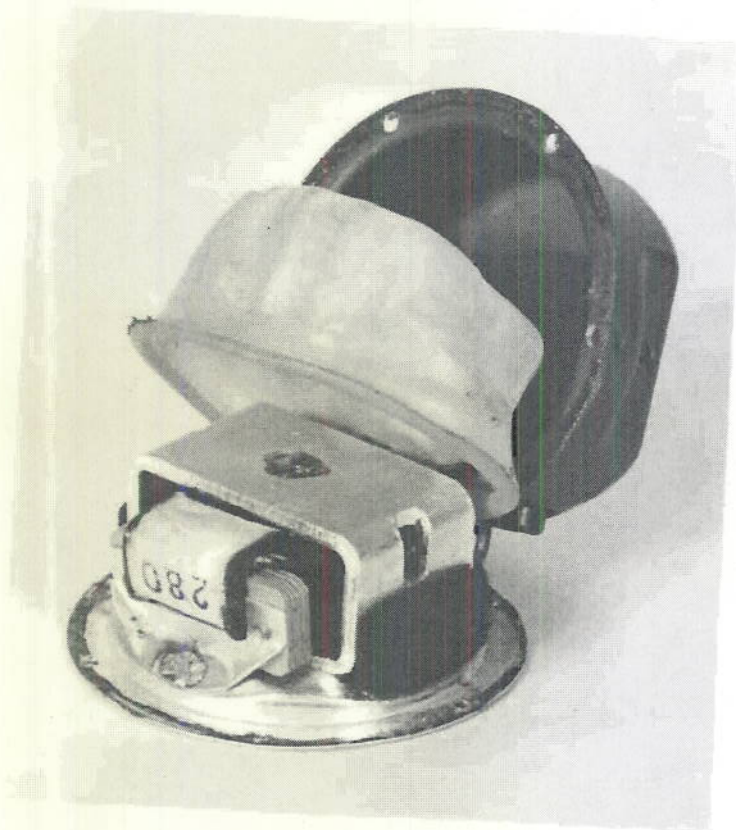
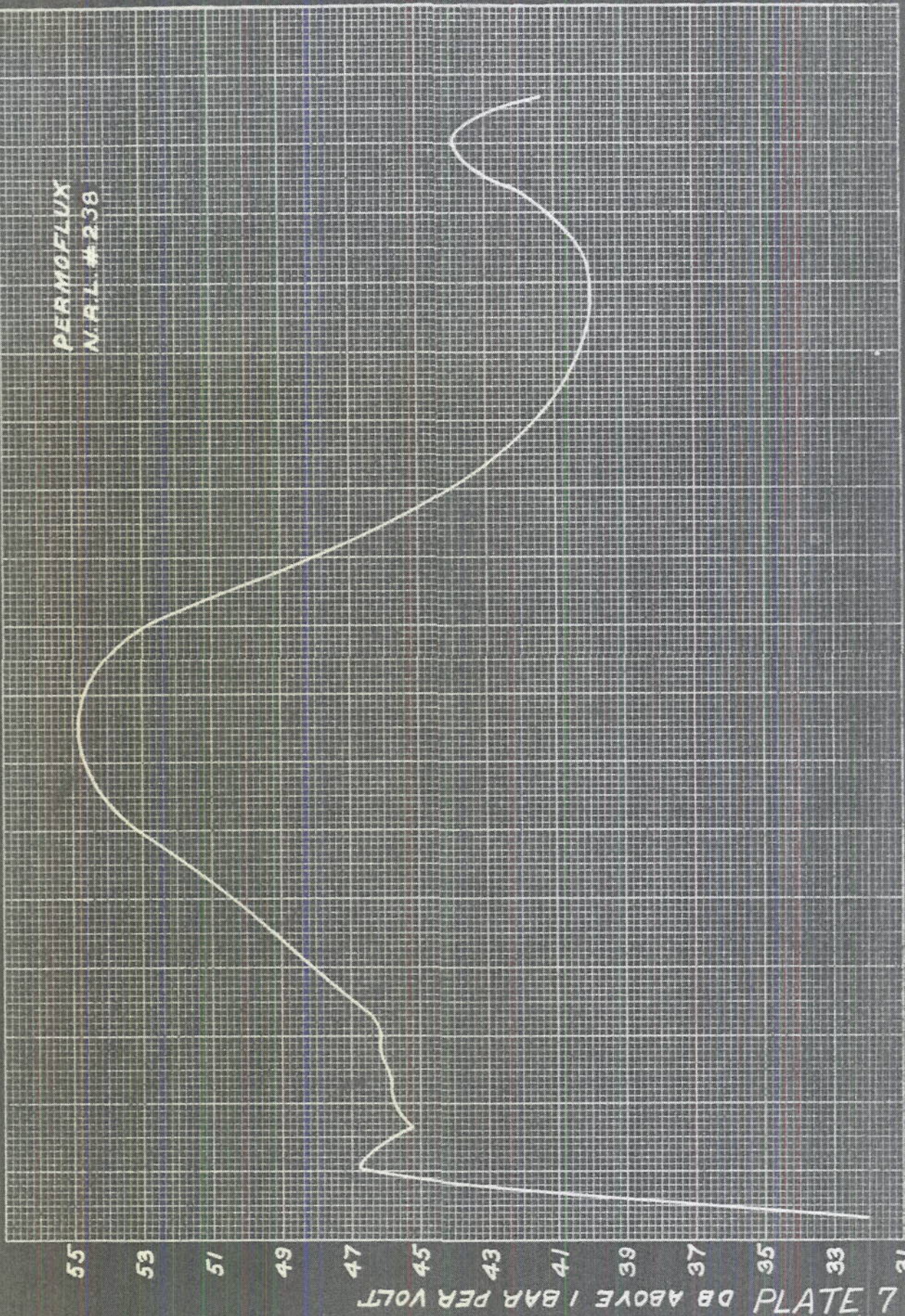


PLATE 6

PERMOFLUX
N.A.L. # 238



FREQUENCY IN CYCLES

L ETALP DB ABOVE 1 BAR PER VOLT

PERMOFLUX
PHONE #240

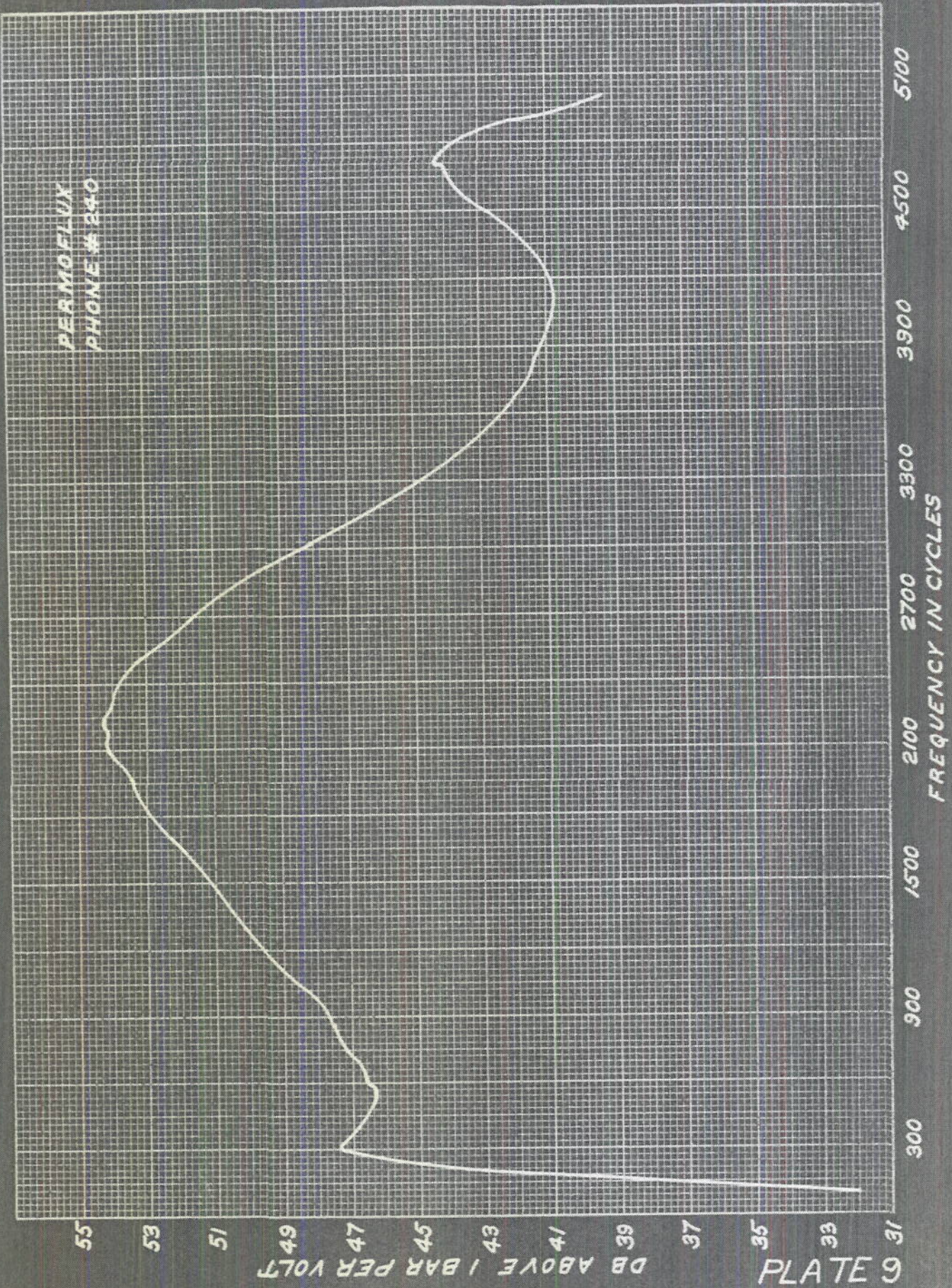
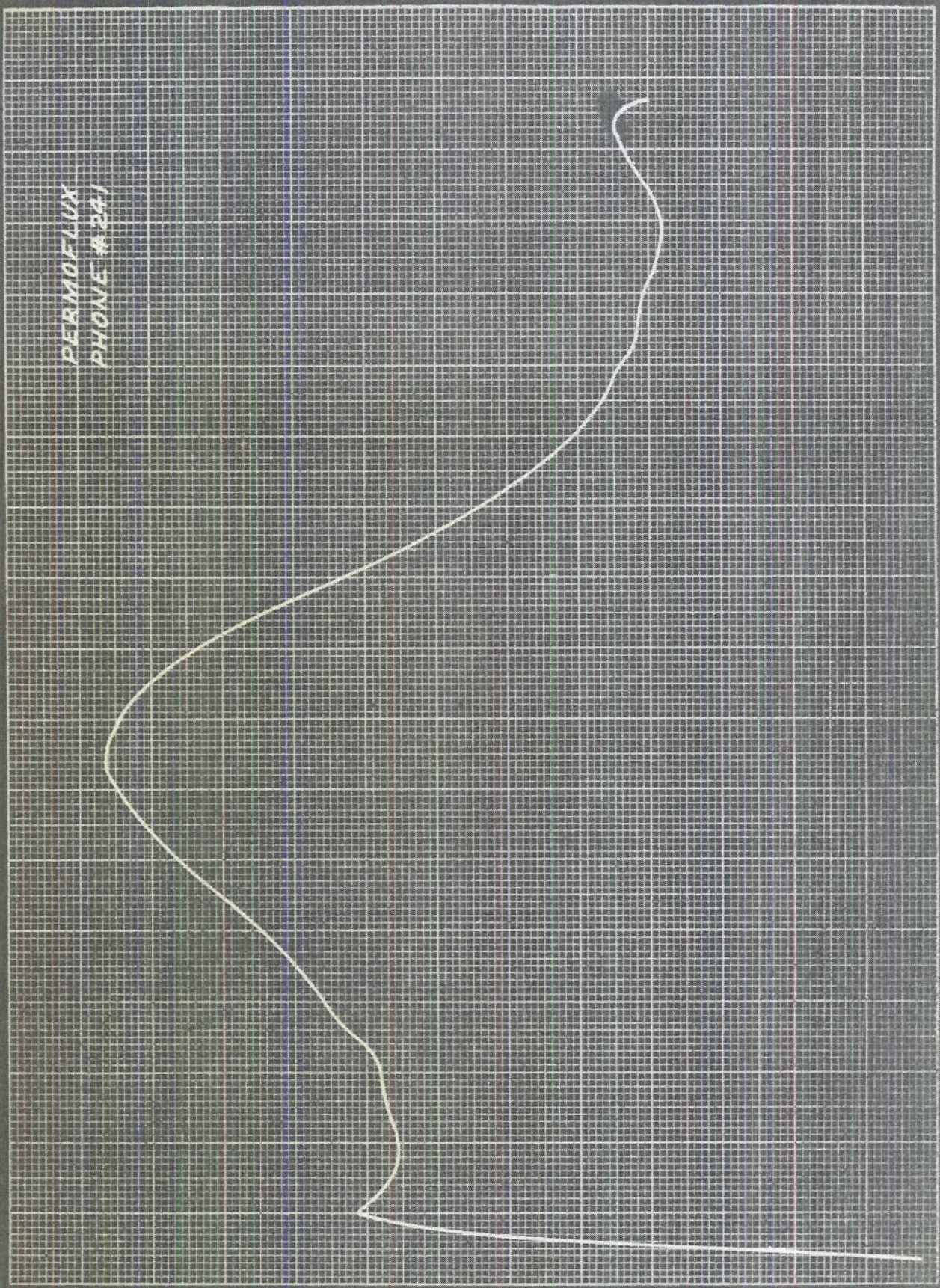


PLATE 6

DB ABOVE 1 BAR PER VOLT

FREQUENCY IN CYCLES

PERMOFLUX
PHONE #241



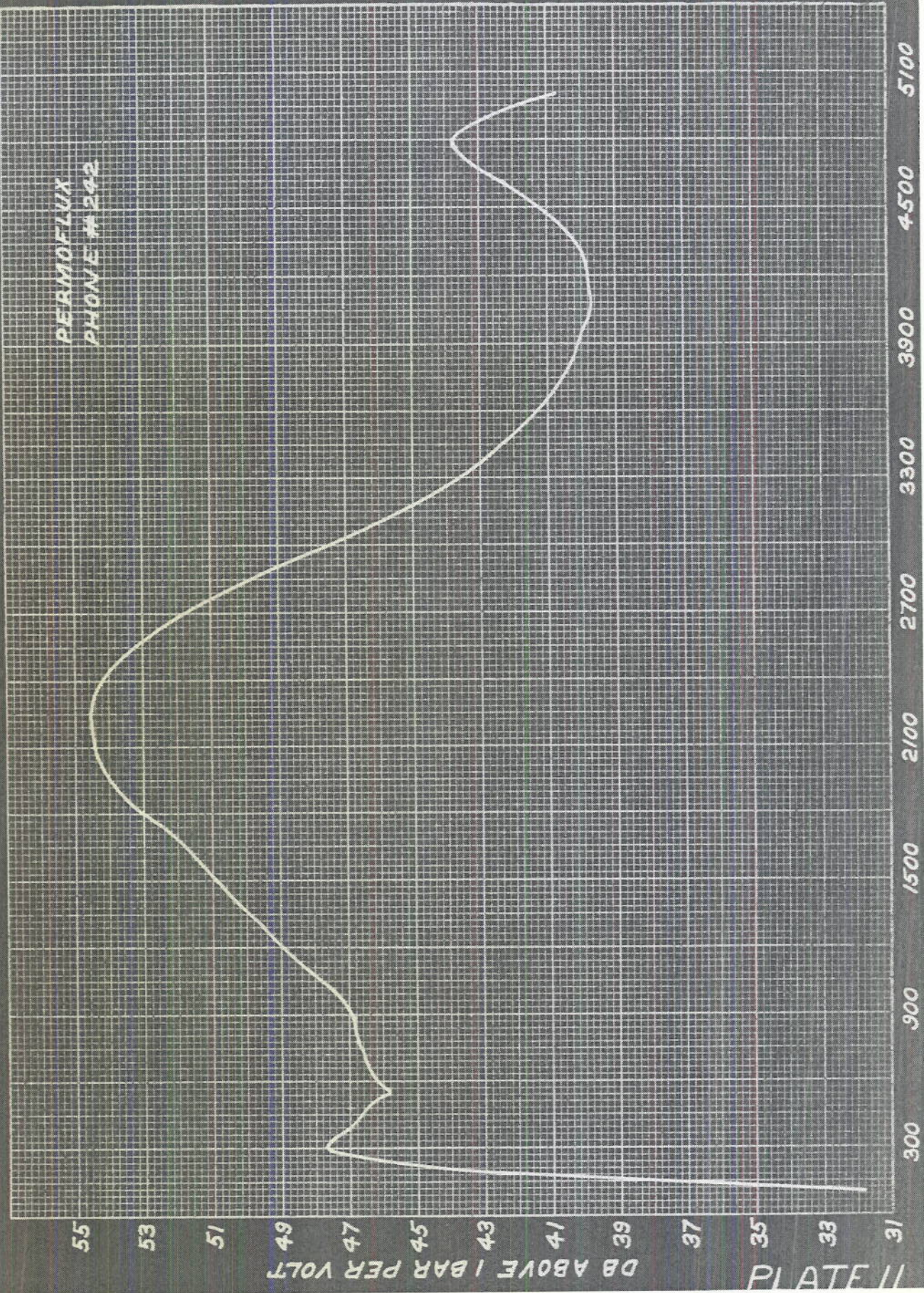
55
53
51
49
47
45
43
41
39
37
35
33
31

DB ABOVE / BAR PER VOLT

5100
4500
3900
3300
2700
2100
1500
900
300

CERAMIC WAVELENGTH

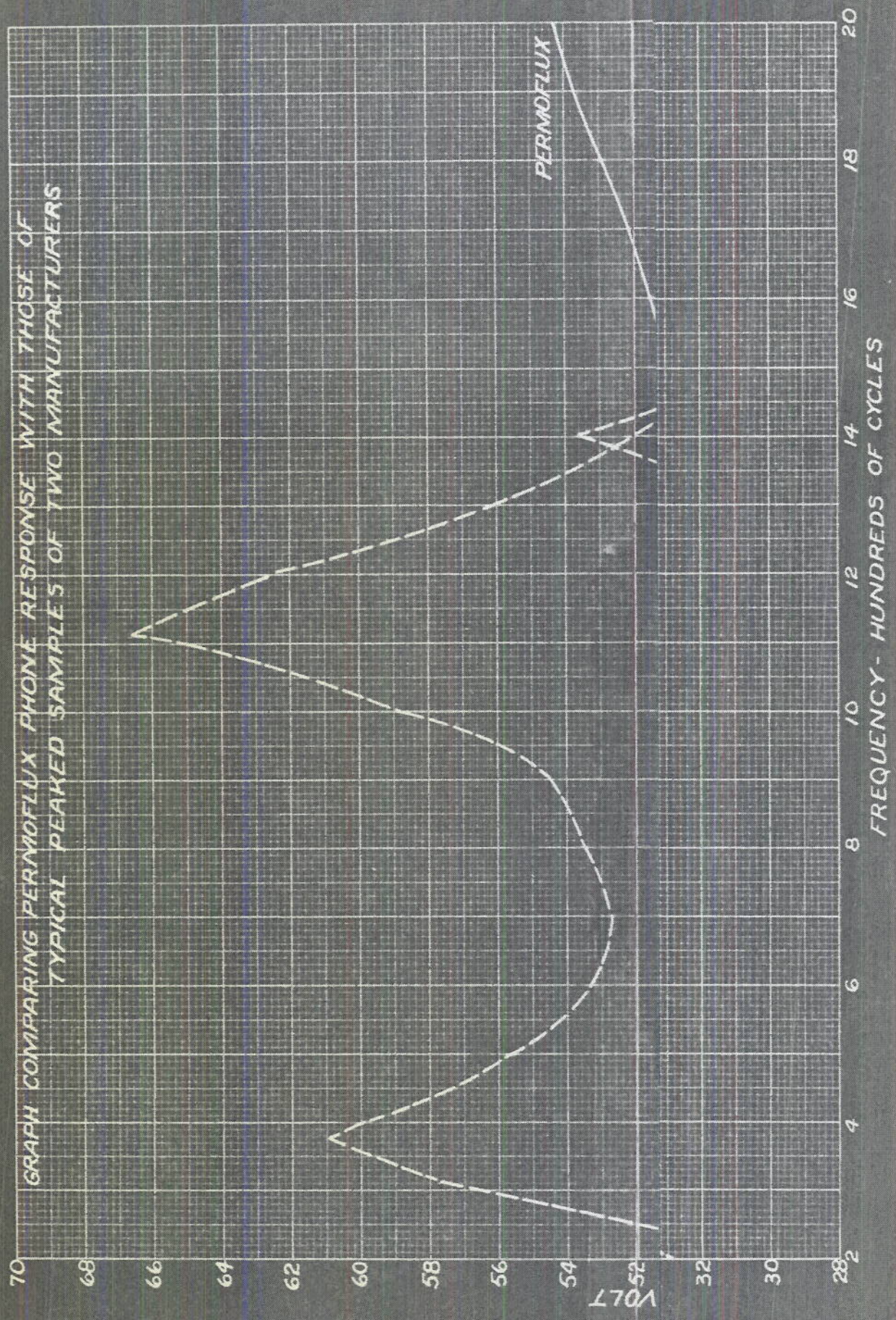
PERAMOFLEX
PHONE #242



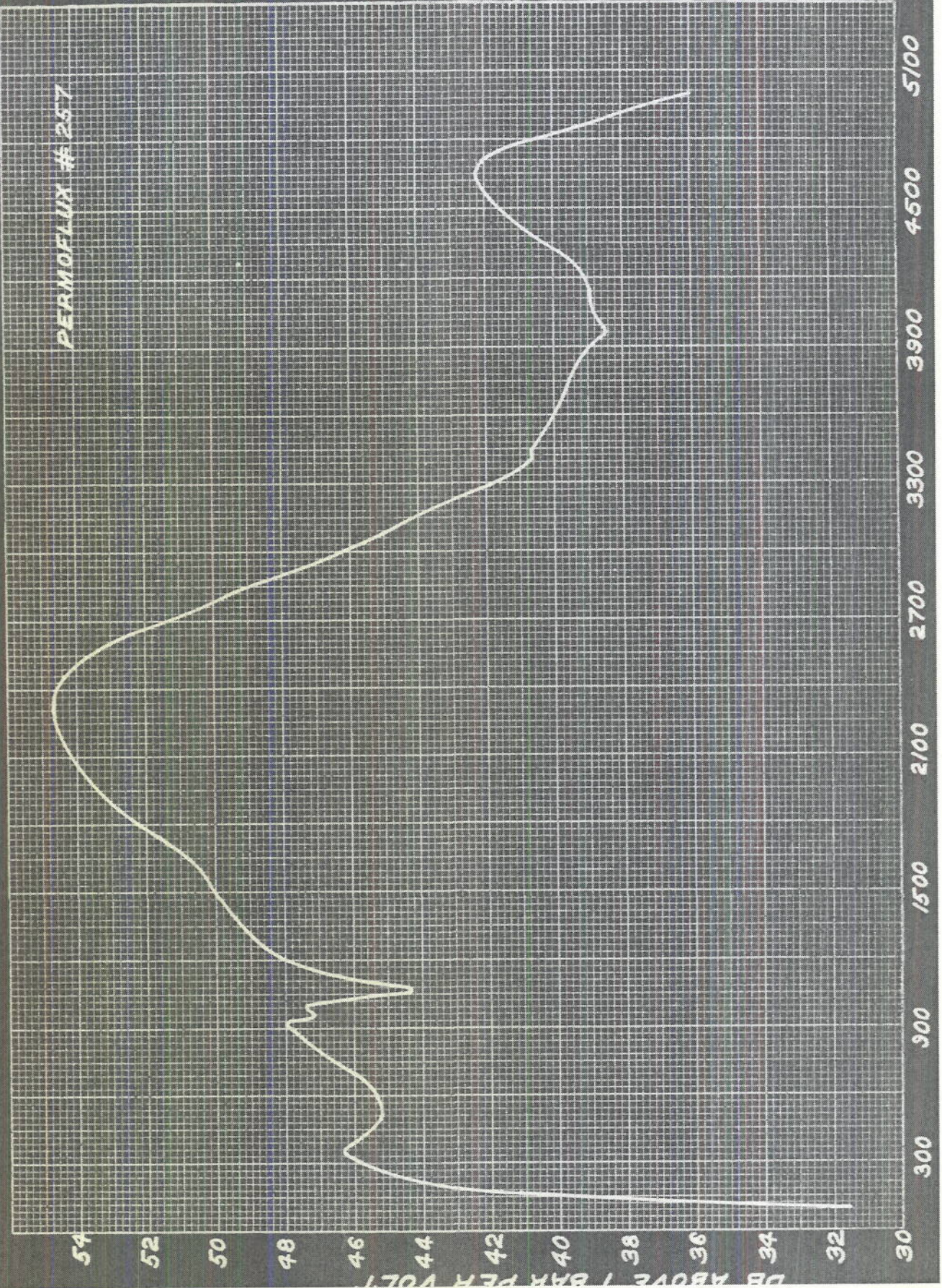
DB ABOVE 1 BAR PER VOLT

PLATE II

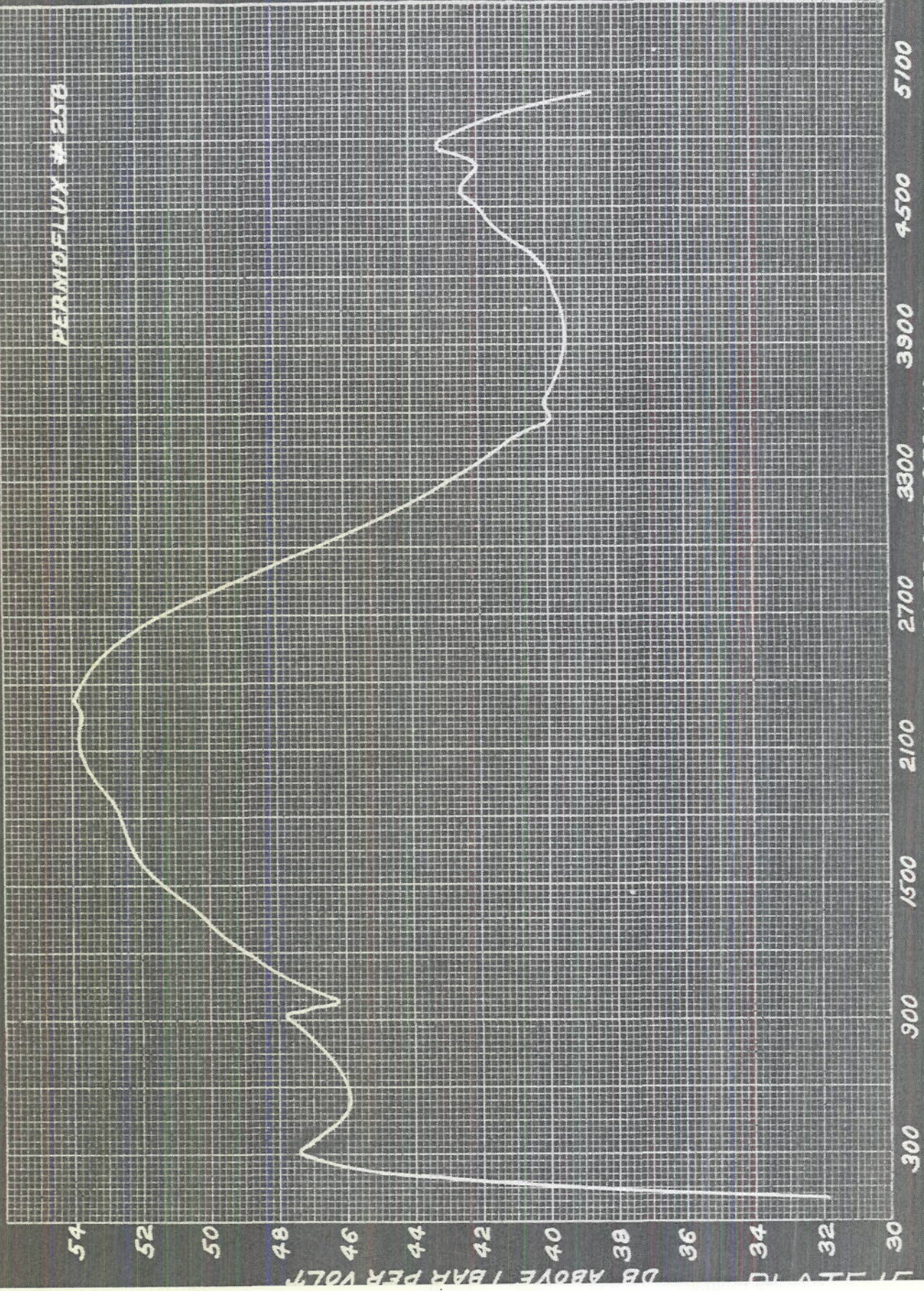
GRAPH COMPARING PERMOFLUX PHONE RESPONSE WITH THOSE OF
TYPICAL PEAKED SAMPLES OF TWO MANUFACTURERS



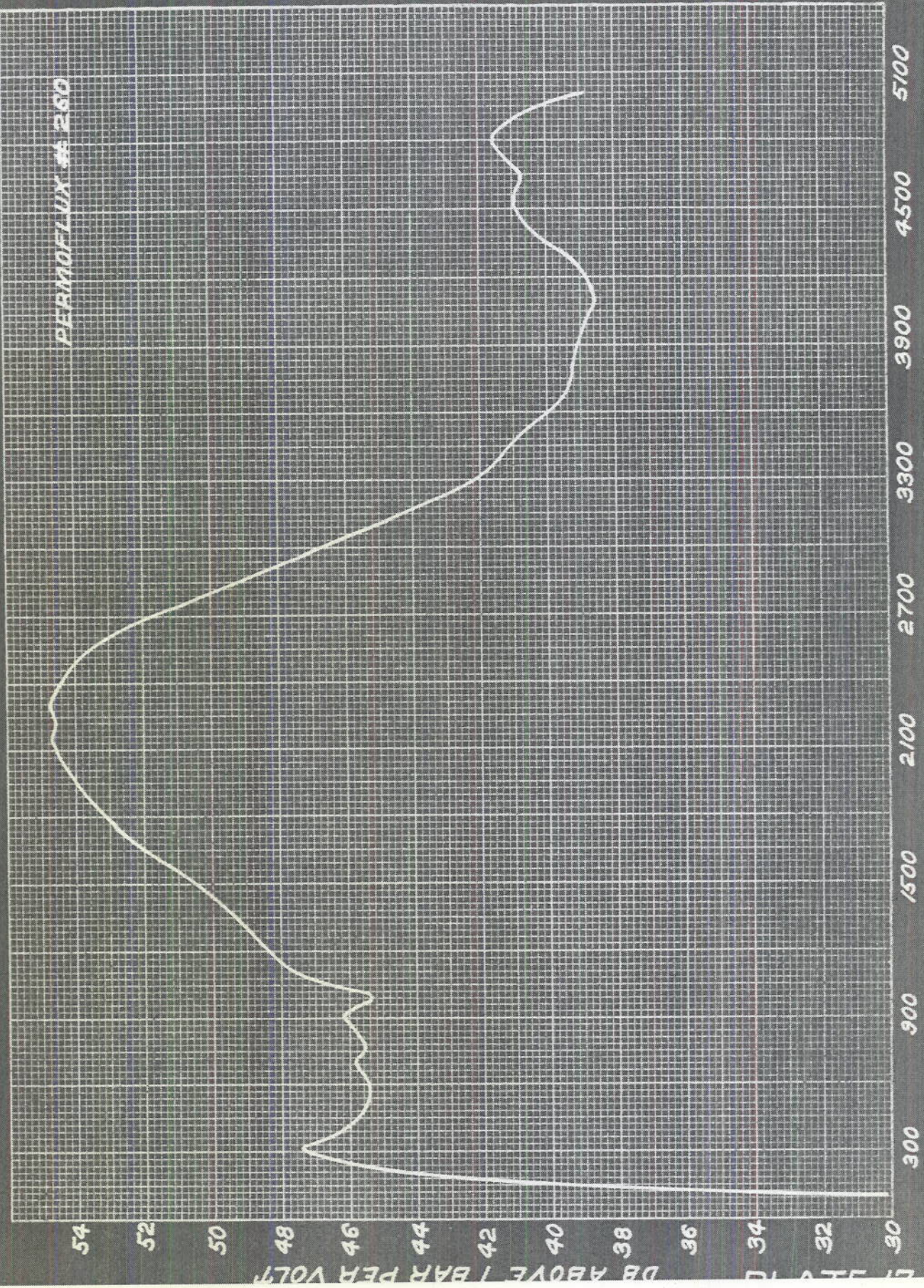
PERMOFLUX # 257



PERMOFLUX # 258



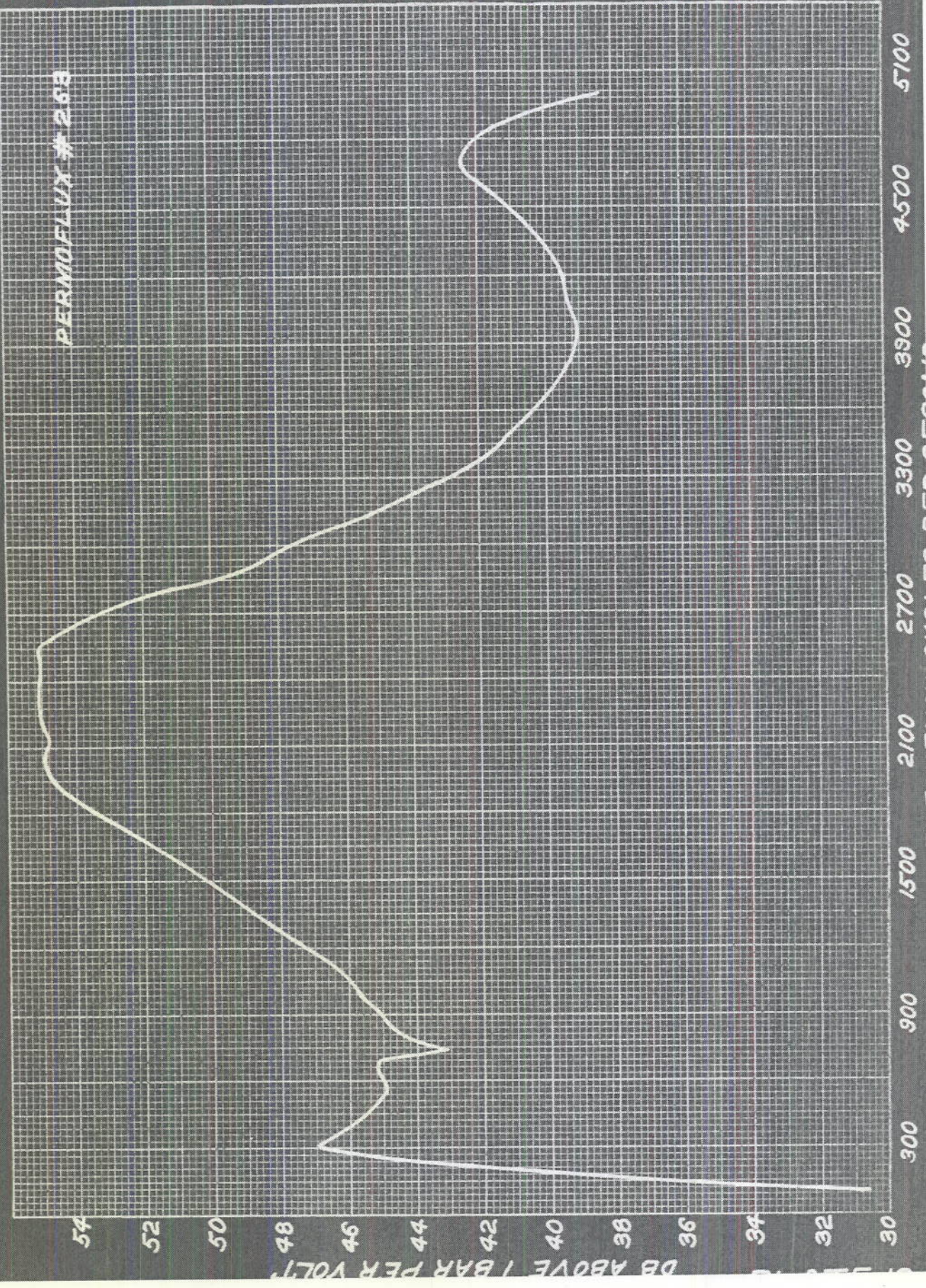
PERMOFLUX # 260



DB ABOVE 1 BAR PER VOLT

PERMOFLUX # 260

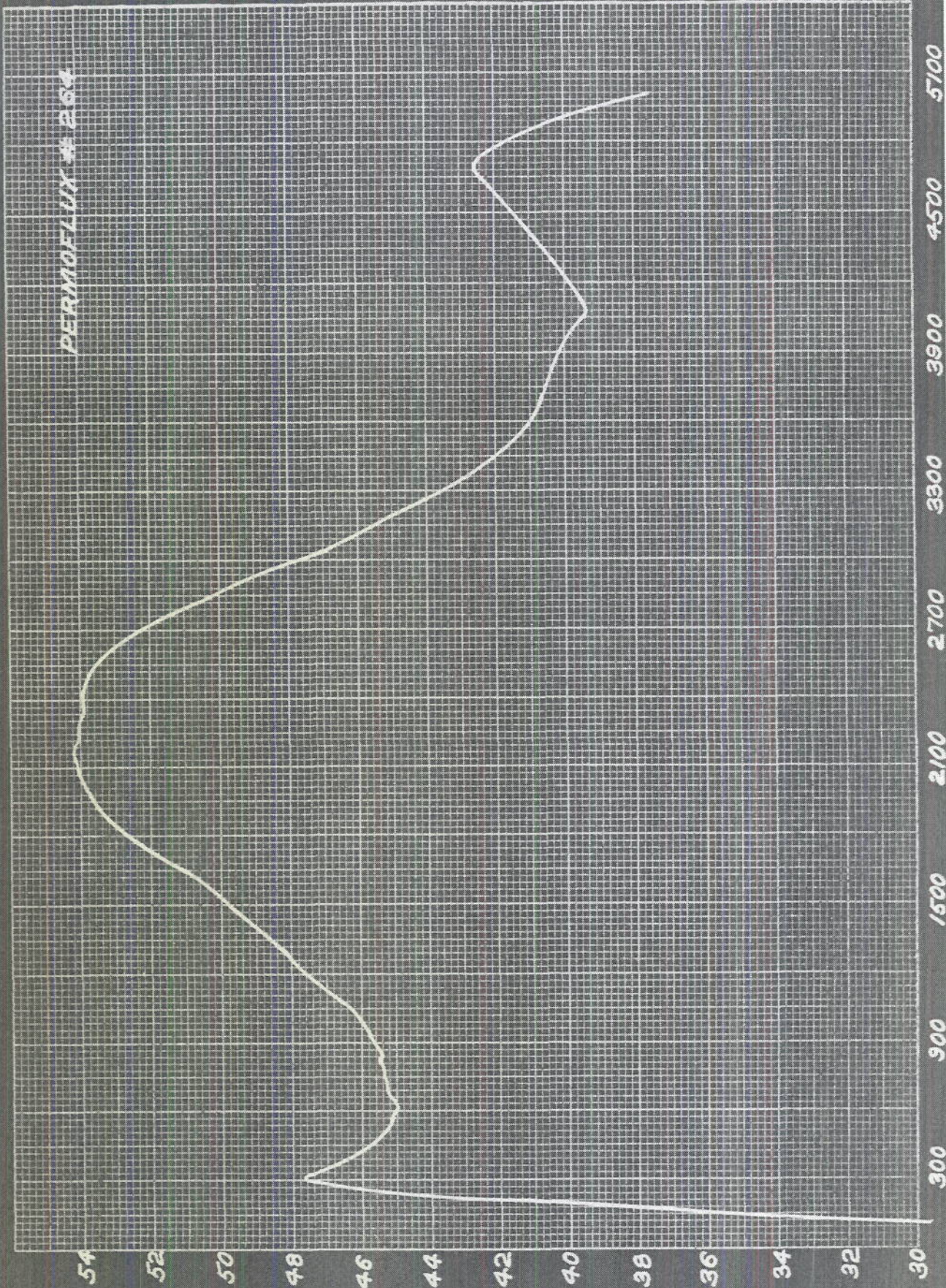
PERMOFLUX #253



DB ABOVE 1 BAR PER VOLT

PERMEABILITY UNITS PER SECOND

PETROMOLUX # 254



DEPARTMENT OF AGRICULTURE