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19 February 1934

Report No. R-1027
BuEng No. R5-10

S67/46
RAA + RAB

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

TEST OF MODELS RAA AND RAB RECEIVING EQUIPMENTS

(This report is submitted in three sections, this section dealing with the test of the Audio System.)

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Number of Pages:	Text - 15	Plates - 17
Authorization:	BuEng let.S67/46/L5(12-22-W8) of 26 Dec.1933.	
Date of test:	January 12 to February 1, 1934.	
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Distribution:	BuEng (4)	

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APPENDICES

I AUTHORIZATION

1.1 The tests as reported upon herein were authorized by Bureau of Engineering letter S67/46/L5(12-22-W8) of 26 December 1933.

II OBJECT

2.1 This problem requires that exhaustive tests and examination of the Model RAA and Model RAB receiving equipments be made to provide the required data necessary for the preparation of revised specifications covering such equipments.

III DESCRIPTION OF EQUIPMENT

3.1 The receivers tested were manufactured by the RCA Victor Company of Camden, New Jersey, on Contract 22837. The Model RAA consists of the following:

1 - CRV 4550 Radio Frequency Tuner Serial #115
1 - CRV 4551 Intermediate and Audio Amplifier Serial #115
1 - CRV 4554 Power Unit Serial #157

The Model RAB consists of the following:

1 - CRV 4552 Radio Frequency Tuner Serial #74
1 - CRV 4553 Intermediate and Audio Frequency Amplifier Serial #74
1 - CRV 4554 Power Unit Serial #203

3.2 The audio system as reported upon and covered by the data, shown on Plates 200 to 217 inclusive, was not the one included in either of the receiver models, but was made up of the following parts purchased from the same company and under the same specifications as apply in the receiver contract, on Naval Research Laboratory Contract N-173 S-1893.

1 Type CRV 30019 input transformer, 35.7-1 ratio
1 Type CRV 53001 low pass filter
1 Band pass filter either (Type CRV 53002 for the RAA or (Type CRV 53010 for the RAB.
1 Type CRV 4555 audio chassis

3.3 The voltage supply to the assembled audio system was as indicated in the instruction books supplied with the RAA and RAB equipments. The standard power unit was used for voltage supply in all cases where wave form and harmonic analysis data was taken. A Laboratory power pack was employed in other tests due to there being but one complete standard model of each type of equipment available, these being required almost continuously for other tests which were made simultaneously with the audio tests.

3.4 Both receivers are of the superheterodyne type. The RAA covers the range of 10 to 1000 and the RAB 1000 to 30000 kcs. These equipments are AC operated from a 60 cycle 110 volt power supply and have an output impedance suitable for use with from one to four pairs of 600 ohm telephone receivers connected in parallel.

3.5 The Model RAA employs an antenna coupling capacitor to the first of two loosely coupled tuned circuits which are followed by a single type 38035 R.F. amplifier tube. The R.F. amplifier tube has a tuned plate circuit which is inductively coupled to the tuned grid of the first detector. The first detector as well as the second function as plate detectors for weak signals while for stronger signals they function with both grid and plate rectification due to the presence of grid leak and stopping condensers as well as cathode bias resistors. Both the first and the second oscillators are type 38027 tubes. Their oscillator circuits are inductively coupled to the detector cathode bias lead. The coupling transformers from the first detector to first I.F., from first to second I.F., and from second I.F. to second detector have tuned primary and tuned secondaries which are slightly less than critically coupled, inductively. The second detector feeds into a low pass filter cutting off at around 4,000 cycles and a band pass filter may be cut in at will giving appreciable attenuation below 750 and above 1250 cycles. The audio amplifier consists of a resistance coupled stage employing a type 38024 tube followed by 38027 output stage feeding into a 600 ohm output transformer. An automatic volume control is provided which may be cut in at will. This consists of a high ratio step up transformer the primary of which, for AVC action, is cut in parallel with the output transformer. The secondary is center tapped and feeds to two 38027 vacuum tubes connected as biased rectifiers. As the receiver audio output voltage is applied to the rectifier anodes (plate-grid), this anode resistance decreases. This resistance is reflected through the high ratio transformer resulting in a lowering of the effective impedance load in the receiver output stage plate circuit, thus limiting the output voltage. The degree of limitation is controlled by a variable cathode bias on the rectifier tubes, thus providing an audio output level that can be controlled by the bias voltage.

3.6 The Model RAB receiver input couples to the antenna through a variable coupling capacitor which is used to compensate for various antenna constants, thus providing the ability to obtain resonance in the first tuned input circuit. There are two capacitively coupled tuned circuits preceding the first R.F. tube, which is a type 38058 pentode. This tube's grid is connected through a 1.0 megohm leak to a fixed 1.5 volt negative bias and is coupled to its grid circuit through a 250 uufd capacitor. The plate of the first R.F. tube connects to a mid tap of the inductance forming a part of the tuned grid circuit of the second R.F. stage. The tuned grid circuit of this stage, as well as that of the first and that of the first detector also, employs a fixed series capacitor in addition to the customary variable. The capacitance of this fixed capacitor varies from about double to triple that for the maximum of the variable depending upon the frequency band. The grid coupling capacitor for both of the R.F. amplifier grids is connected between the fixed and the variable capacitors. The grid of the second R.F.

tube obtains its bias voltage through a 1.0 megohm leak which is connected to a potentiometer volume control. The bias voltage variation obtainable from this volume control is from -1.5 to -75 volts. The plate of the second R.F. tube connects to the detector tuned grid at a mid point on the inductance similar to the preceding stage. The grid of the detector, however, is connected directly to the plate of the second R.F. tube through a coupling capacitor and to ground or -B through a 1.0 megohm leak. The detector functions as a plate rectifier for weak signals due to a cathode bias resistor but for sufficiently strong signals to draw grid current, both grid and plate rectification occur. Both the first and the second oscillators are type 38064 tubes. These oscillators couple to their respective detectors inductively through couplings provided in their cathode circuits. The oscillator filaments are heated by direct current supplied from the rectified B supply potential divider. The plate circuit of the first detector is tuned to the I.F. and coupled through a low impednace line to the tuned grid circuit of the first I.F. tube (type 38035). The coupling transformers between the first I.F., second I.F., (type 38035) and the detector (type 38024) are similar and consist of separately tuned grid and tuned plate circuits, capacitively coupled. Both of the I.F. grids obtain their bias voltages from the same volume control voltage regulating potentiometer as does the second R.F. tube mentioned previously. The second detector differs from the first in that it is a straight cathode biased plate rectifier. The plate circuit of this detector is provided with an R.F. filter in addition to the transformer primary which feeds the low pass filter as mentioned in connection with the Model RAA audio system previously described. The audio system is similar to that described for the Model RAA except for the characteristics of the band pass filter system which passes from 700 to 1300 cycles with slight attenuation and with appreciable attenuation below 600 and above 1600 cycles.

3.7 The type CRV-4554 power supply unit which is adaptable to either the Model RAA or the RAB has been designed to operate from a 60 cycle 110 volt line drawing approximately 235 watts. The power supply circuit consists essentially of an R.F. filter in the 110 volt supply line to the electrostatically shielded power transformer, two type 38180 rectifier tubes, a two stage filter, a voltage regulator tube and the voltage divider system. The two type 38180 rectifier tubes are operated in parallel and the type 38274 regulator tube is employed to stabilize the 90 volt B supply which feeds the oscillator plates and improves frequency regulation.

3.8 In view of the detailed description given in the instruction books supplied with each type of equipment, only a brief description has been given herein. If further detail is desired, the reader is referred to RCA-Victor Company's instruction books as issued with Contract NOs 22837 dated 30 June 1931, #IB-23206 applying to the Model RAA and #IB-23207 to the Model RAB.

IV TESTS

a. Outline of Tests.

4.a.1 Inasmuch as the audio systems of the RAA and RAB receivers are nearly identical and differ only in their respective band pass filters, the following tests were made using a CRV-30019 input transformer, CRV-4555 amplifier, and CRV-53001 low pass filter common to the two audio systems and one of each of the CRV-53002 and CRV-53010 band pass filters. These units were detached units which were not installed in either of the RAA and RAB receivers for these tests. The units were arranged on a separate "breadboard" layout so that tests could be conducted without interrupting other tests which were being made on the receivers simultaneously with those covered by this report.

4.a.2 Tests which were conducted and whose data are presented in this report are:

(A) Audio frequency characteristics of CRV-30019 input transformer and CRV-4555 audio amplifier with and without the automatic volume control operating.

(B) Audio frequency characteristics of CRV-30019 input transformer, CRV-4555 audio amplifier, and CRV-53001 low pass filter with and without the automatic volume control operating.

(C) Audio frequency characteristics of CRV-30019 input transformer, CRV-4555 audio amplifier, CRV-53001 low pass filter, and CRV-53002 band pass filter with and without the automatic volume control operating.

(D) Audio frequency characteristics of the CRV-30019 input transformer, CRV-4555 audio amplifier, CRV-53001 low pass filter, and CRV-53010 band pass filter with and without the automatic volume control operating.

(E) Attenuation characteristic of CRV-53001 low pass filter.

(F) Attenuation characteristic of the CRV-53002 band pass filter.

(G) Attenuation characteristic of the CRV-53010 band pass filter.

(H) Harmonic analysis of the CRV-30019 input transformer, CRV-4555 amplifier, and CRV-53001 low pass filter with and without the automatic volume control operating.

(I) Harmonic analysis of the CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter, and CRV-53002 band pass filter with and without the automatic volume control operating.

(J) Harmonic analysis of the CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter, and CRV-53010 band pass filter with and without the automatic volume control operating.

(K) Overload characteristics of the CRV-30019 input transformer, CRV-4555 amplifier, and CRV-53001 low pass filter with and without the automatic volume control operating.

(L) Overload characteristics of the CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter and CRV-53002 band pass filter with and without the automatic volume control operating.

(M) Overload characteristics of the CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter, and CRV-53010 band pass filter with and without the automatic volume control operating.

(N) Output impedance versus milliwatts output of CRV-30019 input transformer, CRV-4555 amplifier, and CRV-53001 low pass filter with and without the automatic volume control operating.

(O) Overall voltage gain of the audio system without band pass filters.

b. Methods of Conducting Tests.

4.b.1 The measuring equipments listed in Table I and employed in making these tests were selected not only for their reliability and accuracy, but because they best adapted themselves to the class of measurements required under this investigation.

4.b.2 In setting up the measuring circuits, all leads carrying audio frequency currents and voltages were of shielded conductors. Input and output pairs of audio leads were spaced widely apart so as to prevent as much feed back as possible. All ground connections from units under test, measuring instruments, and other associated apparatus used in these tests, as well as the shielding on the leads, were connected to a common terminal which, in turn, was connected to a common reference ground. This ground, the best obtainable in the Laboratory, was the conduit housing the power lines.

4.b.3 The rectifier power supply for the amplifier under test was located at some distance from the units under test and their associated measuring equipment in order to minimize the hum pick-up. The same precaution was exercised for the same reason in selecting the position for the audio frequency oscillator which had a self contained rectifier power supply.

4.b.4 Measuring Equipment.

TABLE I

Name	Type No.	Serial	Test where used
General Radio Beat freq.audio oscil.	513B	44	A B C D E F G H I J K L M N O
General Radio 600 ohm var."H" pad.	452	66	E F G
General Radio amplifier	249T	186	E F G
General Radio wave analyser	636A	102	A B C D E F G H I J K L M O
Daven A.C. voltmeter	180D	1453	A B C D E F G N
Biddle decade res.	1438		A B C D E F G H I J N
General Radio decade res.	102K	5720	A B C D E F G H I J N
General Radio decade res.	102L	629	E F G
General Radio decade res.	102K	5724	E F G
General Radio output meter	583A	72	A B C D H I J K L M N O

4.b.5 The measuring circuits used in this test are shown on Plates 215 and 216.

4.b.6 Overall Audio Discrimination Characteristics. In general, the procedure in making tests on overall audio discrimination was to impress the audio signal from the audio frequency oscillator across a non-inductive decade voltage divider having a total resistance of 10,000 ohms because this load afforded the best matching conditions for the oscillator for a minimum wave distortion. A portion of this voltage was tapped off and fed to the input of the amplifier or amplifier and filter combinations, as the case may be, through the input transformer (CRV-30019) normally working out of the plate of the detector. Inserted in series with the voltage divider tap and one side of the primary of the input transformer was a 250,000 ohm resistor whose function was to simulate the normal plate load of the detector. The other end of this primary winding was connected to the ground end of the voltage divider. The output of the audio system under test was fed to a 600 ohm resistor which was the internal load of a General Radio output meter. This instrument served not only as a load but as an indicator of the output.

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The output signal or voltage across this load was measured with a General Radio wave analyser which is also an excellent vacuum tube voltmeter. The wave analyser was used so as to assure measurements of fundamental signal frequencies instead of their harmonics, because it had been found that audio signals from the audio oscillator had large percentages of second and third harmonics. The wave analyser has an input impedance of 100,000 ohms and hence produces no loading effects across the 600 ohm output meter.

4.b.7 In order to facilitate circuit manipulations, switches were provided in the set up for cutting the several filters in and out of the main circuit at will.

4.b.8 Refer to Table II for circuit constants and for reference to the type of measuring circuit used to obtain the curves.

4.b.9 <u>Attenuation Characteristics of Filters.</u> In order to simulate normal circuit conditions in measuring the attenuation characteristics of the filters, the audio signal was reduced to a low value and fed across a 10,000 ohm non-inductive decade voltage divider. The tap from the voltage divider was brought out at 600 ohms. The filter under test was bridged across the 600 ohm portion of the voltage divider. The output of the filter under test was fed to a General Radio resistance coupled amplifier through a General Radio variable "H" pad, which was used to attenuate the signal to the resistance coupled amplifier. This amplifier was loaded with a 20,000 ohm non-inductive decade resistor and the output signal across this resistance measured with the General Radio wave analyser.

4.b.10 The reason for attenuating the signal level to the resistance coupled amplifier was to prevent overloading of the amplifier within the pass band of the filters, and to keep the output level of the amplifier within the range of the wave analyser. The gain of the amplifier was kept constant throughout these measurements, so that the errors due to its frequency characteristic would remain constant for all of these tests.

4.b.11 Refer to Table II for circuit constants and references to the type of measuring circuit used and curves.

4.b.12 <u>Measurement of Harmonic Content</u>. In the determinations of the harmonic content of the RAA and RAB audio systems at 1,000 cycles, the circuit set up was the same as described under par.4.b.6. The wave analyser in this case was used to break down the signal frequency and measure its component harmonics. In all of these tests the output level for each amplifier and filter combination was adjusted to give outputs ranging from 1 to 5 milliwatts approximately. Measurements were taken for each test condition with and without AVC. The readings obtained were converted into percent of 1,000 cycle output signal level and plotted against milliwatts output.

4.b.13 Refer to Table II for circuit constants and reference to type of measuring circuit used to obtain the curves.

4.b.14 Overload Characteristics. In making these tests the signal from the audio frequency oscillator was fed directly across the primary of the input transformer having shunted across it a 250,000 ohm resistor. Otherwise the arrangement of the measuring circuit is the same as described under par. 4.b.6. The wave analyser was used in these measurements, however, to measure the input voltage impressed across the 250,000 ohm resistor. The output level in milliwatts was indicated on the General Radio output meter. Observations were made on the combinations of units which have been previously described, with and without AVC until overloading of the audio system was reached.

4.b.15 Refer to Table II for circuit constants and references to measuring circuit used to obtain the curves.

4.b.16 Output Impedance Characteristics. The measuring circuit set up for these tests was similar to that described under par. 4.b.6 except that the input voltage was measured with a Daven A.C. voltmeter having an internal resistance of 20,000 ohms. This test was made using only that portion of the audio system which is common to both the RAA and RAB receivers.

4.b.17 Output levels were measured with and without AVC for a constant 1,000 cycle signal input level while the load impedance was varied. Curves of milliwatts output versus load impedance were plotted. See Table II.

4.b.18 The data compiled for the attenuation characteristics of the filters were corrected to compensate for the error due to the frequency characteristic of the measuring system as shown on Plate 213. The harmonic analysis data in like manner was corrected to make due allowance for the harmonic content of the audio frequency oscillator as shown on Plate 214.

TABLE II
Circuit Constants, ref. to Measuring Circuits and Curves.

Test	Description of Test	Circuit ref. Plates 215,216	Curve ref.		Audio oscil. volts.	Atten. Setting DB	R_1 ohms	R_2 ohms	R_3 ohms	R_4 ohms	R_5 ohms
A	Audio freq. characteristics of CRV-30019 and CRV-4555.	#1	Plate 200	No AVC AVC	6.25 6.25	- -	200 400	9800 9600	250,000 250,000	- -	- -
B	Audio freq. characteristics CRV-30019 and CRV-4555 and CRV-53001	#2	Plate 201	No AVC AVC	6.5 8.0	- -	200 400	9800 9600	250,000 250,000	- -	- -
C	Audio freq. characteristics CRV-30019, CRV-4555, CRV-53001 and CRV-53002.	#2	Plate 203	No AVC AVC	6.5 8.0	- -	400 800	9600 9200	250,000 250,000	- -	- -
D	Audio freq. characteristics CRV-30019, CRV-4555, CRV-53001 and CRV-53010.	#2	Plate 205	No AVC AVC	5.75 5.75	- -	300 800	9700 9200	250,000 250,000	- -	- -
E	Attenuation characteristic of CRV-53001	#3	Plate 202	-	1.0	5.0	600	9400	-	600	20,000
F	Attenuation characteristic of CRV-53002	#3	Plate 204	-	1.0	1.0	600	9400	-	600	20,000
G	Attenuation characteristic of CRV-53010	#3	Plate 206	-	1.0	1.0	600	9400	-	600	20,000
H	Harmonic analysis of CRV-30019, CRV-4555, and CRV-53001.	#2	Plate 207	No AVC AVC	- -	- -	200 400	9800 9600	250,000 250,000	- -	- -

TABLE II (cont'd)

Test	Description of Test	Circuit ref. Plates 215,216	Curve ref.		Audio oscil. volts.	Atten. Setting DB	R1 ohms	R2 ohms	R3 ohms	R4 ohms	R5 ohms
I	Harmonic analysis of CRV-30019,CRV-4555,CRV-53001 and CRV-53002.	#2	Plate 209	No AVC	-	-	200	9800	250,000	-	-
				AVC	-	-	400	9600	250,000	-	-
J	Harmonic analysis of CRV-30019,CRV-4555,CRV-53001 and CRV-53010.	#2	Plate 208	No AVC	-	-	200	9800	250,000	-	-
				AVC	-	-	400	9600	250,000	-	-
K	Overload char. of CRV-30019, CRV-4555 and CRV-53001.	#4	Plate 211	No AVC	-	-	250,000	-	-	600	-
			Plate 212	AVC	-	-	250,000	-	-	600	-
L	Overload char. of CRV-30019, CRV-4555,CRV-53001 and CRV-53002.	#4	Plate 211	No AVC	-	-	250,000	-	-	600	-
			Plate 212	AVC	-	-	250,000	-	-	600	-
M	Overload char. of CRV-30019, CRV-4555,CRV-53001 and CRV-53010.	#4	Plate 211	No AVC	-	-	250,000	-	-	600	-
			Plate 212	AVC	-	-	250,000	-	-	600	-
N	Output impedance characteristics of CRV-30019, CRV-4555, and CRV-53001.	#5	Plate 210	No AVC	15	-	200	9800	25,000	-	-
				AVC	15	-	200	9800	25,000	-	-

V. RESULTS OF TESTS

5.1 The results for all of the measurements were plotted in curve form and are shown on the plates indexed as follows:

Plate No.	Description of Curves.
200	Audio frequency characteristics of the CRV-30019 input transformer and CRV-4555 amplifier.
201	Audio frequency characteristics of the CRV-30019 input transformer, CRV-4555 amplifier, and CRV-53001 low pass filter.
202	Attenuation characteristic of CRV-53001 low pass filter.
203	Audio frequency characteristics of CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter, and CRV-53002 band pass filter.
204	Attenuation characteristic of CRV-53002 band pass filter.
205	Audio frequency characteristics of CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter, and CRV-53010 band pass filter.
206	Attenuation characteristic of CRV-53010 band pass filter.
207	Harmonic analysis of CRV-30019 input transformer, CRV-4555 amplifier, and CRV-53001 low pass filter.
208	Harmonic analysis of CRV-30019 input transformer, CRV-4555 amplifier, CRV -53001 low pass filter, and CRV-53010 band pass filter.
209	Harmonic analysis of CRV-30019 input transformer, CRV-4555 amplifier, CRV-53001 low pass filter, and CRV-53002 band pass filter.
210	Output impedance characteristic of CRV-30019 input transformer, CRV-4555 amplifier,and CRV-53001 low pass filter.
211	Overload characteristics of RAA and RAB audio systems without AVC.
212	Overload characteristics of RAA and RAB audio systems with AVC.

Plate No.	Description of Curves
213	Audio frequency characteristic of Measuring System.
214	Harmonic analysis of beat frequency audio oscillator.

5.2 The overall gain of the integral part of the RAA and RAB audio systems (exclusive of band pass filters) is 28.58 db for 5 milliwatts output across the 600 ohms at 1,000 cycles and input measured across the input transformer (CRV-30019 primary).

VI CONCLUSIONS

6.1 Plate 200 reveals that: without AVC the audio frequency characteristic of the CRV-30019 input transformer and CRV-4555 amplifier combination is substantially flat from 250 to 10,000 cycles, but falls off quite decidedly from 250 to 50 cycles. This response characteristic is free of resonant peaks throughout its spectrum.

6.2 With AVC the audio frequency characteristic of the above combination assumes band pass characteristics which not only attenuate the upper range of frequencies, but also attenuate the lower range frequencies more than is already done by the natural response characteristic of the combination without automatic volume control.

6.3 Examination of Plates 201 and 202 develops that: without the automatic volume control, the curve shown on Plate 201 is equivalent, or nearly so, to the curve shown on Plate 202 superimposed on that shown on Plate 200. The region between 1,000 cycles and cut off frequency of the curve shown on Plate 201 differs from that shown on Plate 202. It will be noted that the frequency beyond which the signals are sharply attenuated occurs at 4,500 cycles on Plate 201 and 3,500 cycles on Plate 202. Moreover, the humps for the two curves are dissimilar. In view of the fact that the curves are otherwise closely identical except at frequencies of maximum attenuation, it is believed that there is sufficient mismatching between the low pass filter and its coupling input and output transformers to cause this shift in cut off frequency and alteration of the shape and magnitude of these respective "humps". This would also account for greater maximum attenuation for the curve shown on Plate 201 than on Plate 202. The distributed capacities of the wiring of the amplifier would also contribute to this difference in attenuation.

6.4 It would be well at this stage to point out that the above reasoning is based on the fact that the attenuation characteristic of the low pass filter was measured with the input and output terminals bridging 600 ohm non-inductive resistors. While this filter is without a doubt designed for 600 ohm circuits, it is not known at the time of writing of this report just exactly what the reflected impedances "facing" the filter are. There is a strong indication that these impedances are more capacitive than inductive. Such a state of affairs would quite naturally introduce phase difficulties which were not considered under this investigation and which would play an important in determining the cut off frequency and attenuation of the filter.

6.5 The effect of the automatic volume control on this combination is similar to that shown on Plate 200 except that its band pass properties are more accentuated due to the assistance it receives from the low pass filter.

6.6 Without automatic volume control, the overall frequency characteristics of the RAA and RAB audio systems, as shown on Plates 203 and 205 respectively, are closely identical with the attenuation characteristics of their respective band pass filters. The discrepancies between the overall characteristics and the characteristics of their respective band pass filters are due to the differences in the accuracies of the methods used in measuring the attenuation curves for each audio system and to the fact that the low pass filter enters into the "overall" picture.

6.7 With AVC, as is to be expected, greater attenuation is realized on both sides of the pass band of both the RAA and RAB audio systems. These characteristics with AVC follow the characteristics without AVC up to the points of maximum attenuation. Beyond these points greater attenuation is realized with AVC.

6.8 The harmonic analyses of the RAA and RAB audio systems show that without automatic volume control the hum from the power supply which appears at the output terminals is largely the second harmonic of the A.C. power frequency and that this harmonic is practically constant for all loads up to 5 milliwatts, the rated output of the system. The fundamental of the power frequency is practically nil at full output, but increases as the output is decreased. The second, third, and fourth harmonics of the 1,000 cycle input signal are in evidence without the band pass filter. With the band pass filter, the second harmonic disappears.

6.9 With automatic volume control, the 60 cycle fundamental of frequency from the power supply disappears entirely for all loads. The second harmonic is not quite so constant and the third harmonic, while less in magnitude, has the same general curve as does the second. The magnitudes of the second, third, and fourth harmonics of the 1,000 cycle input signal and their variation with output, are affected quite extensively by the band pass filters.

6.10 In any event, the maximum sum total of harmonics does not exceed 3.5% without AVC or 10% with AVC. This increase in harmonic content with AVC is due to the AVC transformer. The action of this AVC is to cause rectification to take place in the AVC tubes and when this does take place, the current passes through the tubes, producing in effect a partial "short" across the AVC transformer. This, of course, drops the reflected impedance across the output transformer to the extent that the output tube no longer operates into its normal plate load and hence the distortion is increased. As is to be expected, this increase in distortion decreases with decrease in output because the action of the AVC is less pronounced.

6.11 Plates 211 and 212 show the overload characteristics of the RAA and RAB audio systems with and without AVC. It will be noted that without AVC, overload is reached at different levels depending upon the type of band pass filter used. With only the low pass filter in operation, overload is reached at about 190 milliwatts. The action of the AVC is also dependent upon the type of band pass filter used. The effect of the band pass filter is to require higher input signals to cause the output to reach a constant value.

6.12 Plate 210 shows that the output is properly designed to match a 600 ohm load without AVC and that this load can be varied over a wide range without detriment to the available output. With AVC, the load which gives maximum output, or in other words, the correct matching load, is 100 ohms which is further evidence for the "shorting" action of the AVC.

6.13 The audio characteristic of the measuring system shown on Plate 213 is largely due to the General Radio amplifier. The errors introduced in the meter calibrations and the attenuator over the audio frequency spectrum is small.

6.14 Audio discrimination data is accurate to within ± 1/2 db over the pass bands and accurate to within ± 2 db within the attenuated regions. This decrease in accuracy is due to leakages throughout the measuring circuit.

6.15 The performance of the RAA and RAB audio systems is commendable. The data show that considerable thought and consideration were given to the engineering of these two designs. The characteristic of the amplifier itself is such as to attenuate A.C. ripple from the rectifier to a level as to render it inaudible in the head phones when an audio signal is present.

6.16 The low pass filter meets in all respects the manufacturer's specification as well as Navy Specifications RE 13A 403C.

6.17 The band pass filters of both the RAA and RAB audio systems more than meet both the Navy's and manufacturer's specifications.

6.18 There is some indication of instability in the two audio systems especially in the RAB audio system. More exact data will be taken on this matter for presentation in a future report. This data will be taken on the audio systems in their respective receivers.

VII RECOMMENDATIONS

7.1 In future designs it is recommended that the following improvements be considered.

(A) The first audio tube (38024) be shielded to prevent instability.

(B) The second audio tube (38027) and AVC tubes (38027) be replaced with the type 56 tube which is much more up to date and is likely to stay in production over a longer period. Data will be taken to determine the feasibility of using this new tube in the present circuit without further modifications. The results of these tests will be released in a future report.

7.2 Calculations will be made to determine if smaller low pass and band pass filters can be made having the same, if not better performance than those in the RAA and RAB audio systems through the use of special alloy steels for the cores of the filter reactors. Future recommendations as to the feasibility of including such filters in future designs will be made in a later report.

7.3 Investigations of the power supply unit will be made with the objects in view of obtaining data on regulation, ripple, and radio frequency disturbance for a future report.

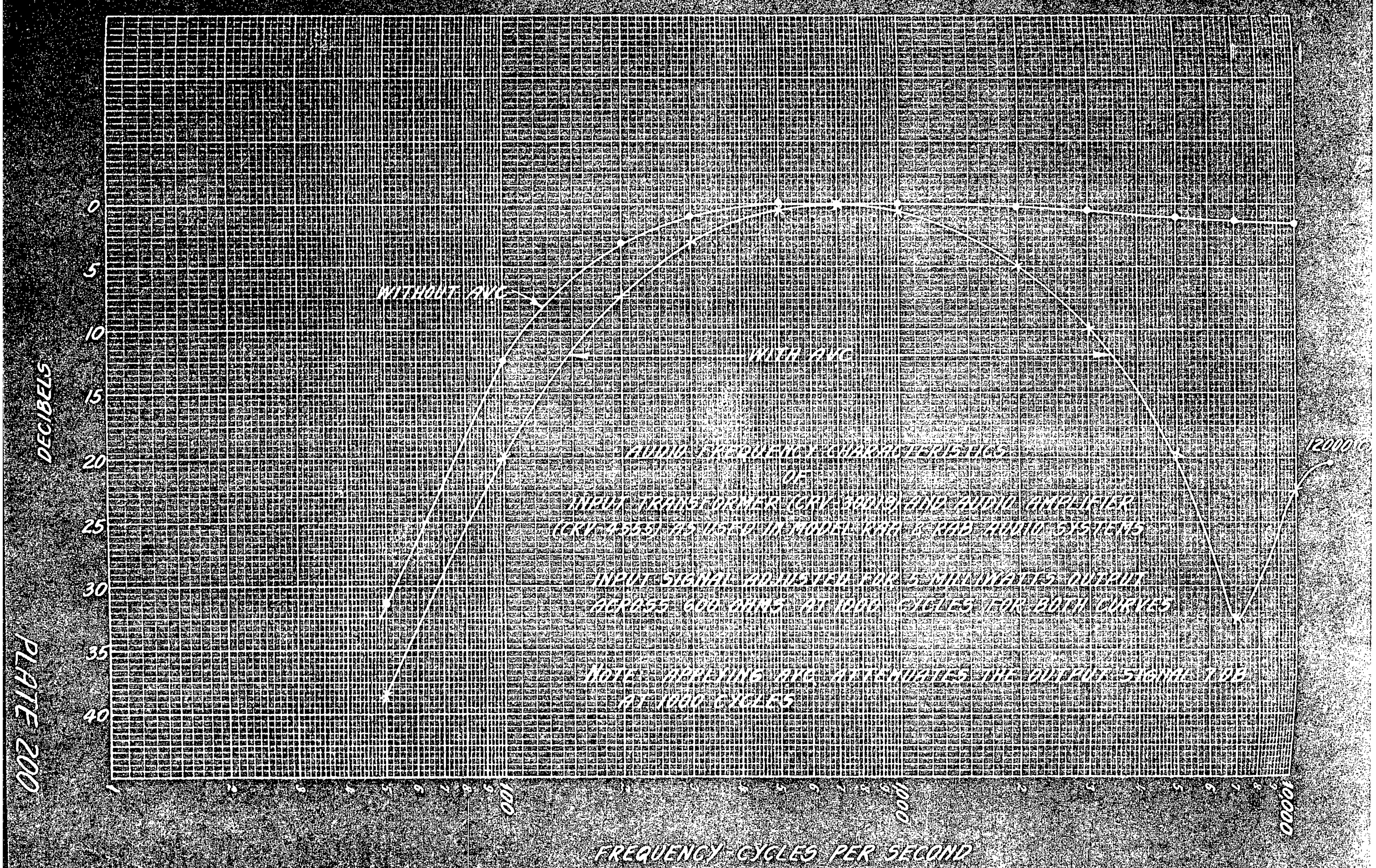


PLATE 200

UNCLASSIFIED

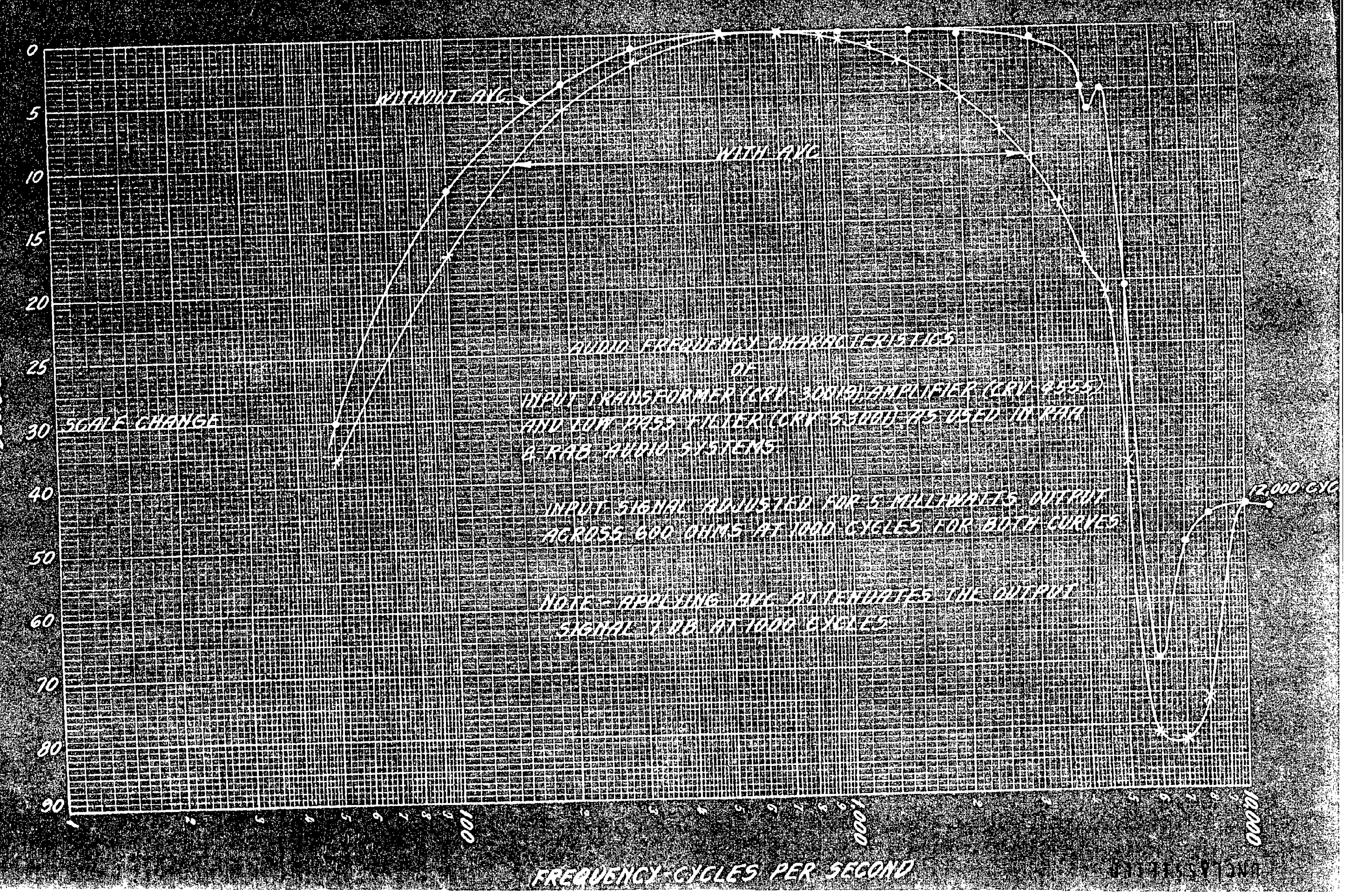

WITHOUT AVC
WITH AVC
SCALE CHANGE
AUDIO FREQUENCY CHARACTERISTICS
OF
INPUT TRANSFORMER (CRV-30019) AMPLIFIER (CRV-4555)
AND LOW PASS FILTER (CRV-53000) AS USED IN RAA
& RAB AUDIO SYSTEMS
INPUT SIGNAL ADJUSTED FOR 5 MILLIWATTS OUTPUT
ACROSS 600 OHMS AT 1000 CYCLES FOR BOTH CURVES
NOTE - APPLYING AVC ATTENUATES THE OUTPUT
SIGNAL 7 DB AT 1000 CYCLES
12,000 CYC
DECIBELS
0
5
10
15
20
25
30
40
50
60
70
80
90
1
100
1,000
10,000
FREQUENCY-CYCLES PER SECOND

PLATE 201

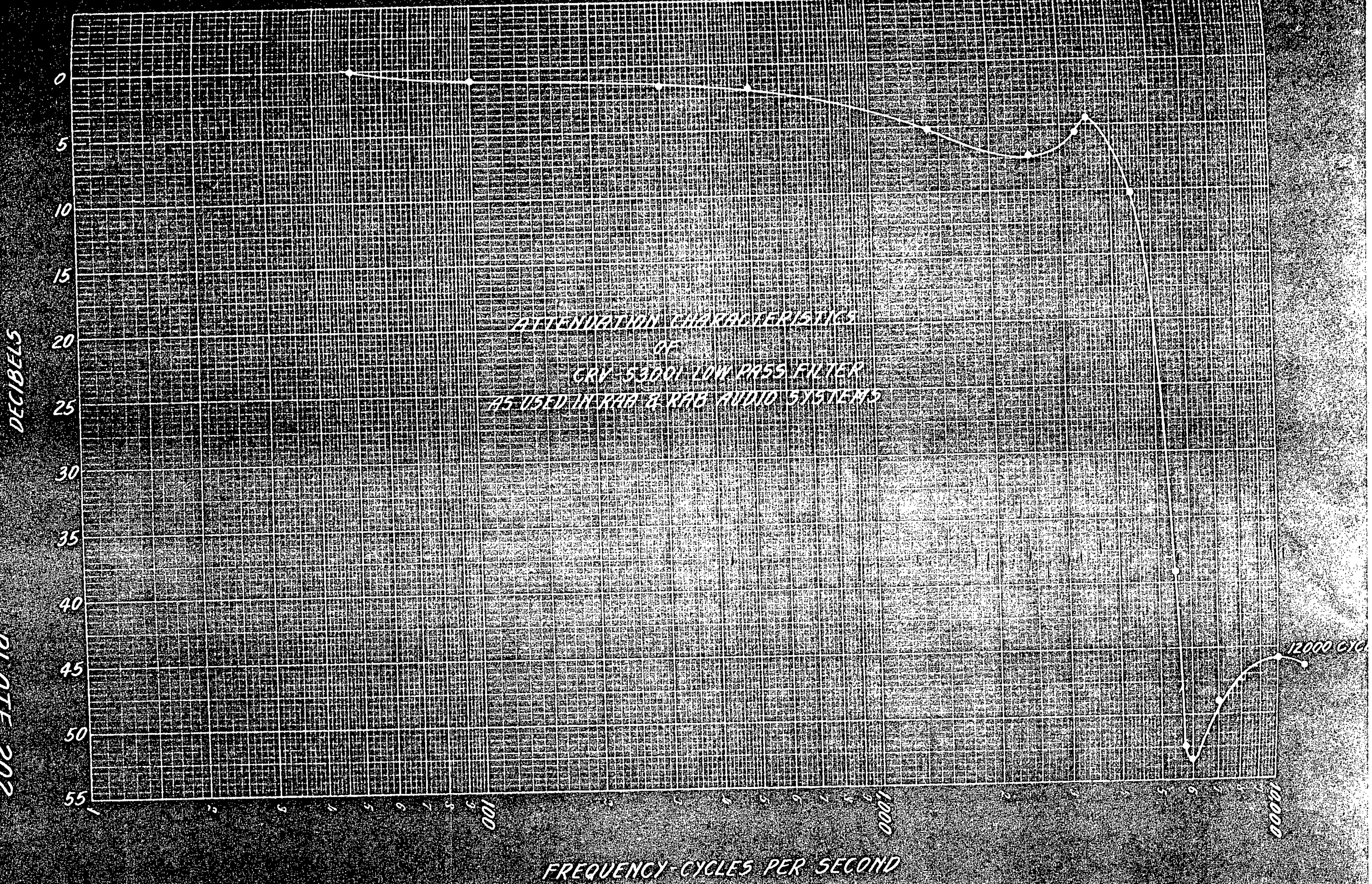
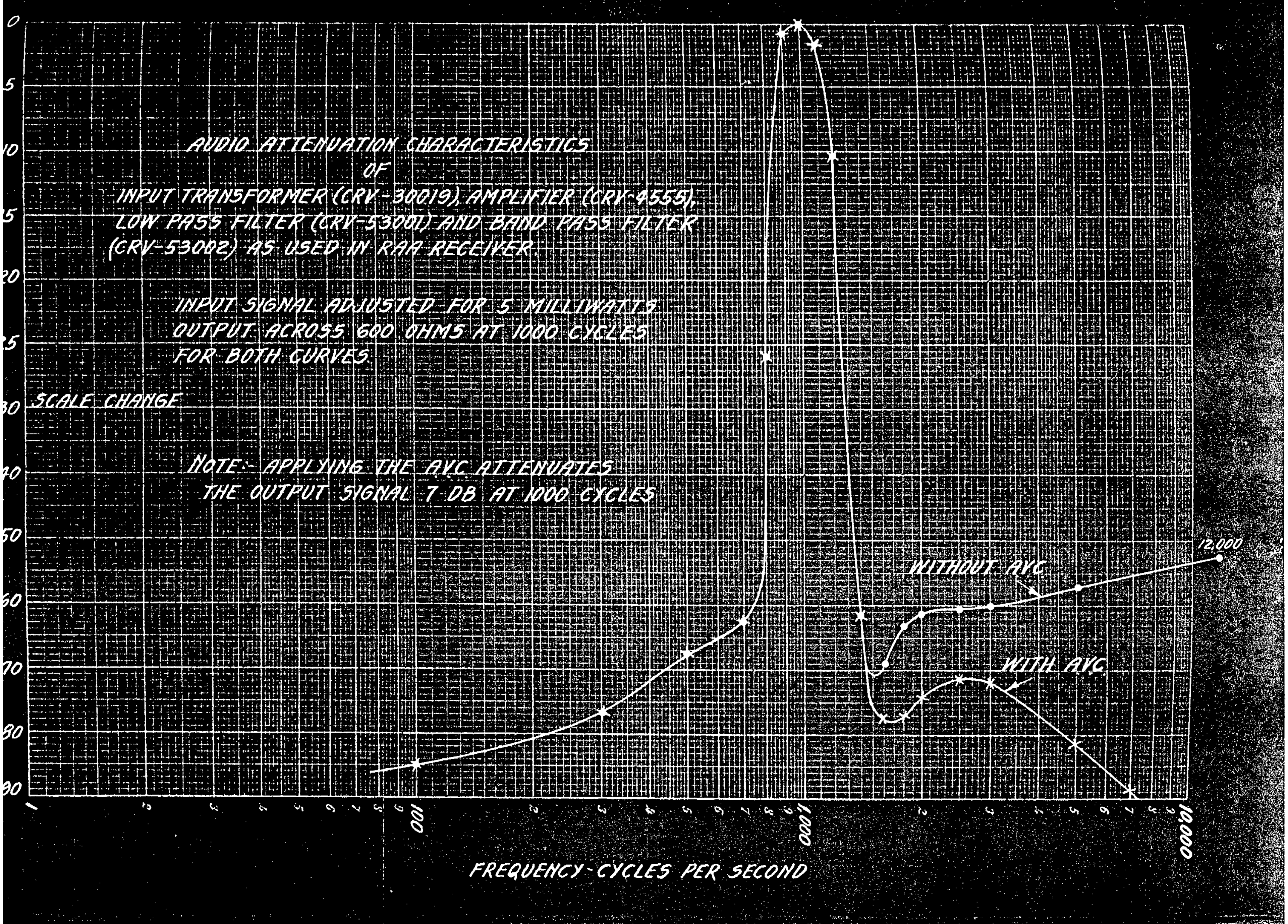


PLATE 202

UNCLASSIFIED


AUDIO ATTENUATION CHARACTERISTICS
OF
INPUT TRANSFORMER (CRV-30019), AMPLIFIER (CRV-4555),
LOW PASS FILTER (CRV-53001) AND BAND PASS FILTER
(CRV-53002) AS USED IN RAA RECEIVER.
INPUT SIGNAL ADJUSTED FOR 5 MILLIWATTS
OUTPUT ACROSS 600 OHMS AT 1000 CYCLES
FOR BOTH CURVES.
SCALE CHANGE
NOTE:- APPLYING THE AVC ATTENUATES
THE OUTPUT SIGNAL 7 DB AT 1000 CYCLES
WITHOUT AVC
WITH AVC
12,000
0
5
10
15
20
25
30
40
50
60
70
80
90
1
100
1000
10,000
FREQUENCY-CYCLES PER SECOND

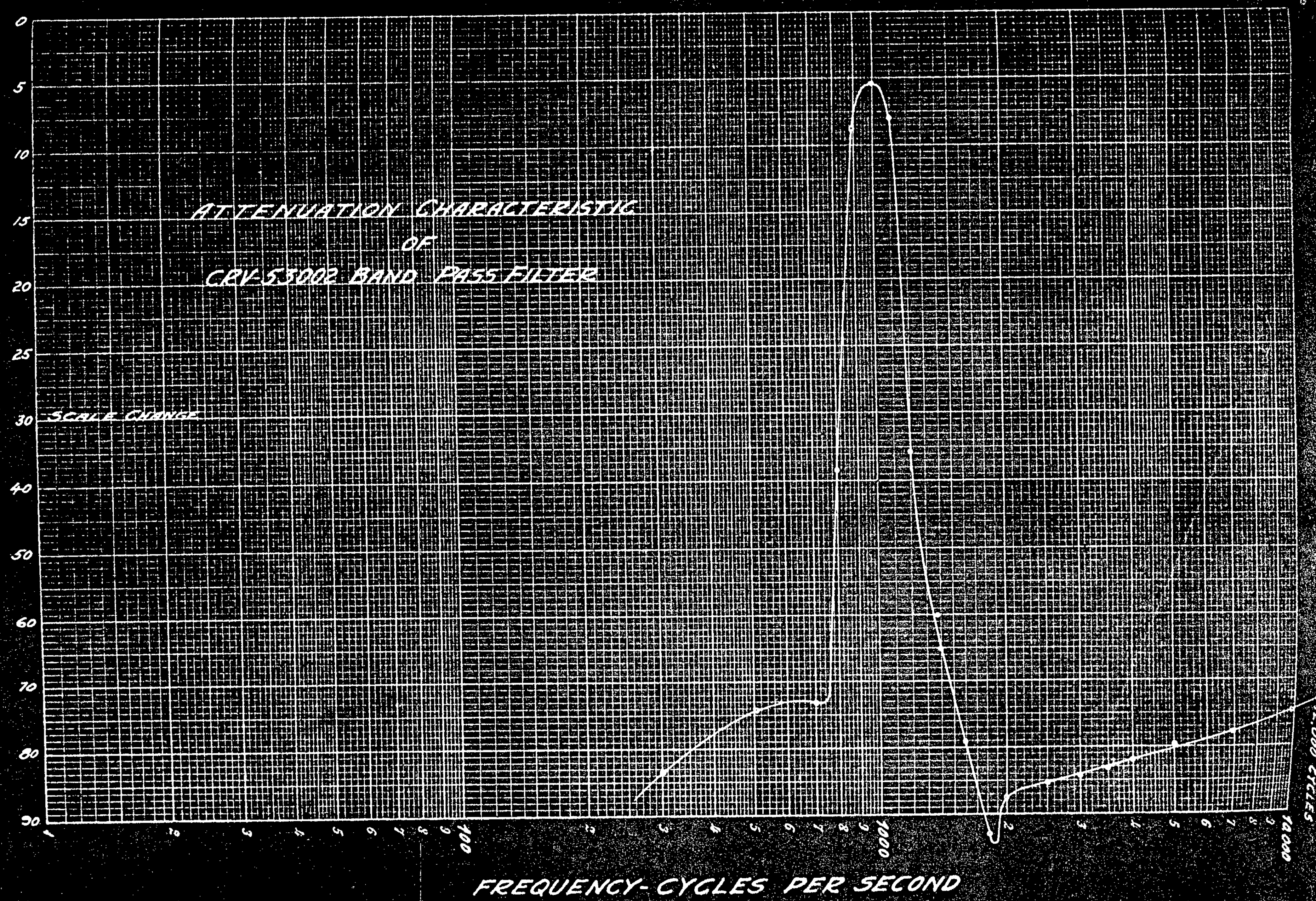
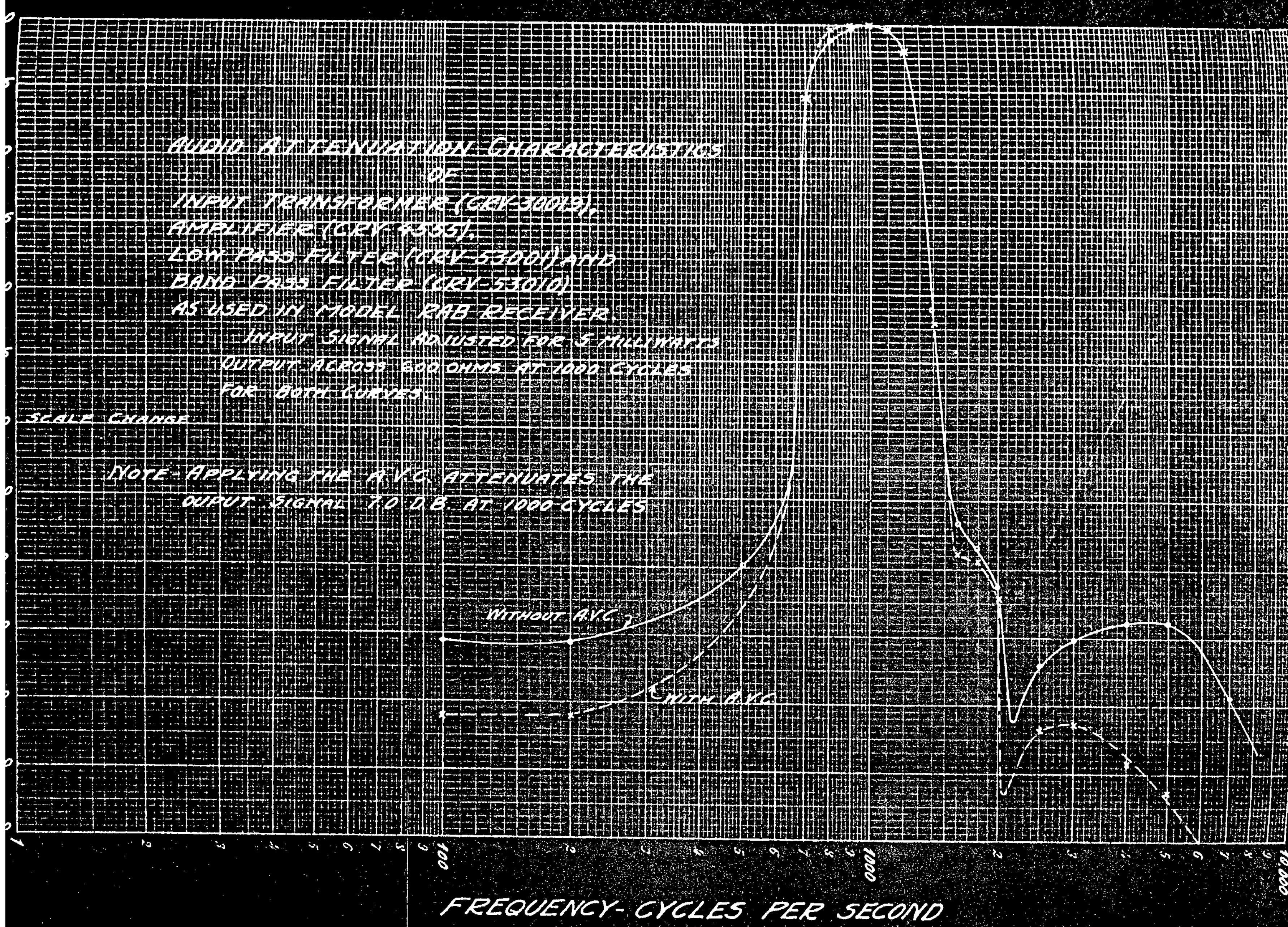
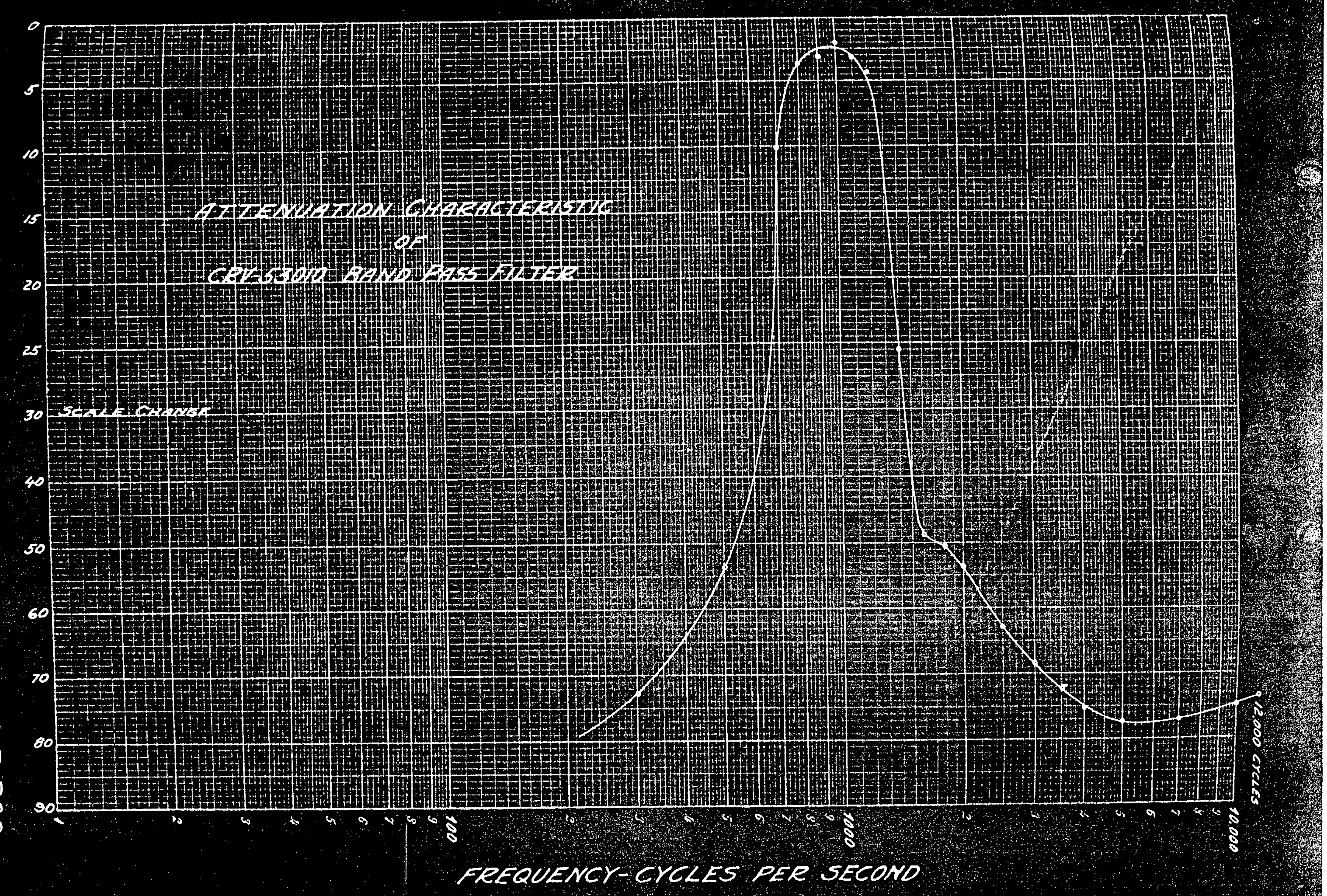

ATTENUATION CHARACTERISTIC
OF
CRV-53002 BAND PASS FILTER
SCALE CHANGE
12,000 CYCLES
FREQUENCY- CYCLES PER SECOND

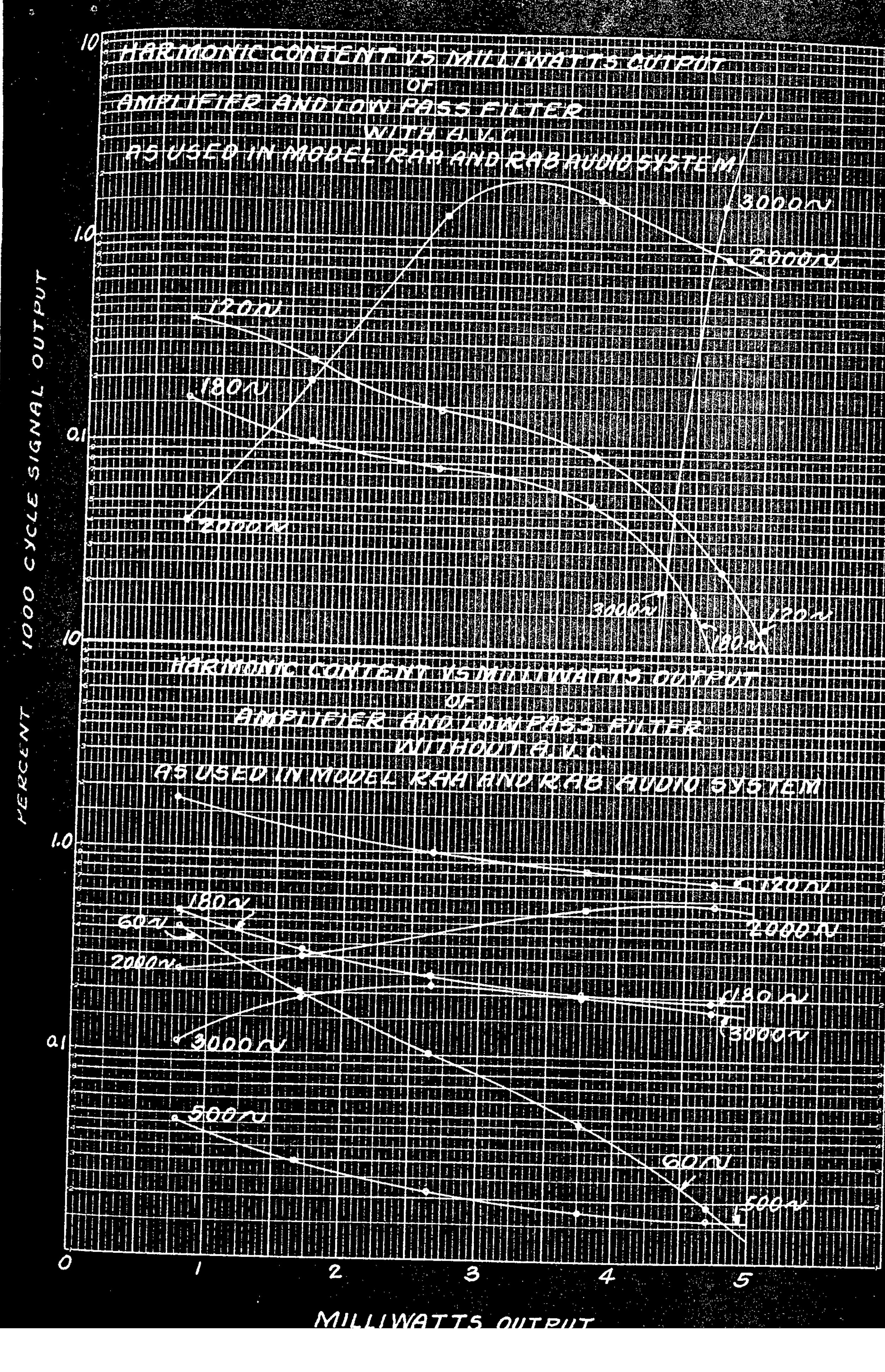
PLATE 204


AUDIO ATTENUATION CHARACTERISTICS
OF
INPUT TRANSFORMER (CRV-30019),
AMPLIFIER (CRV-4355),
LOW PASS FILTER (CRV-53001) AND
BAND PASS FILTER (CRV-53010)
AS USED IN MODEL RAB RECEIVER.
INPUT SIGNAL ADJUSTED FOR 5 MILLIWATTS
OUTPUT ACROSS 600 OHMS AT 1000 CYCLES
FOR BOTH CURVES.
SCALE CHANGE
NOTE-APPLYING THE A.V.C. ATTENUATES THE
OUPUT SIGNAL 7.0 D.B. AT 1000 CYCLES
WITHOUT A.V.C.
WITH A.V.C.
100
1000
10,000
FREQUENCY- CYCLES PER SECOND

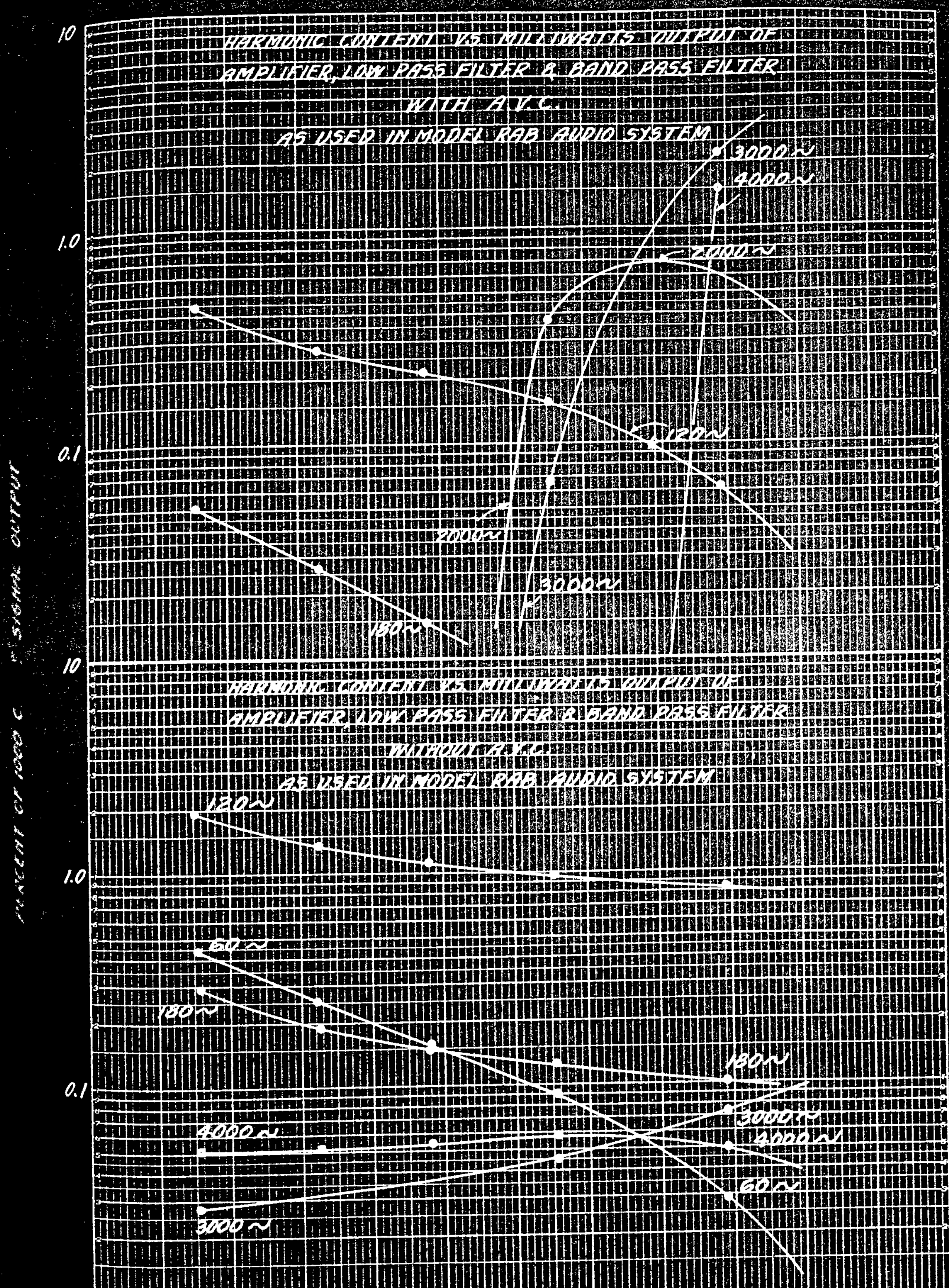


ATTENUATION CHARACTERISTIC
OF
CRV-53010 BAND PASS FILTER
SCALE CHANGE
12,000 CYCLES
FREQUENCY-CYCLES PER SECOND

PLATE 206



HARMONIC CONTENT VS MILLIWATTS OUTPUT
OF
AMPLIFIER AND LOW PASS FILTER
WITH A.V.C
AS USED IN MODEL RAA AND RAB AUDIO SYSTEM
HARMONIC CONTENT VS MILLIWATTS OUTPUT
OF
AMPLIFIER AND LOW PASS FILTER
WITHOUT A.V.C
AS USED IN MODEL RAA AND RAB AUDIO SYSTEM
3000~
2000~
120~
180~
60~
500~
PERCENT 1000 CYCLE SIGNAL OUTPUT
MILLIWATTS OUTPUT
10
1.0
0.1
0
1
2
3
4
5


HARMONIC CONTENT VS MILLIWATTS OUTPUT OF
AMPLIFIER, LOW PASS FILTER & BAND PASS FILTER
WITH A.V.C.
AS USED IN MODEL RAB AUDIO SYSTEM
3000~
4000~
2000~
120~
2000~
3000~
180~
HARMONIC CONTENT VS MILLIWATTS OUTPUT OF
AMPLIFIER, LOW PASS FILTER & BAND PASS FILTER
WITHOUT A.V.C.
AS USED IN MODEL RAB AUDIO SYSTEM
120~
60~
180~
180~
3000~
4000~
4000~
60~
3000~
10
1.0
0.1
10
1.0
0.1
0
1
2
3
4
5
MILLIWATTS OUTPUT

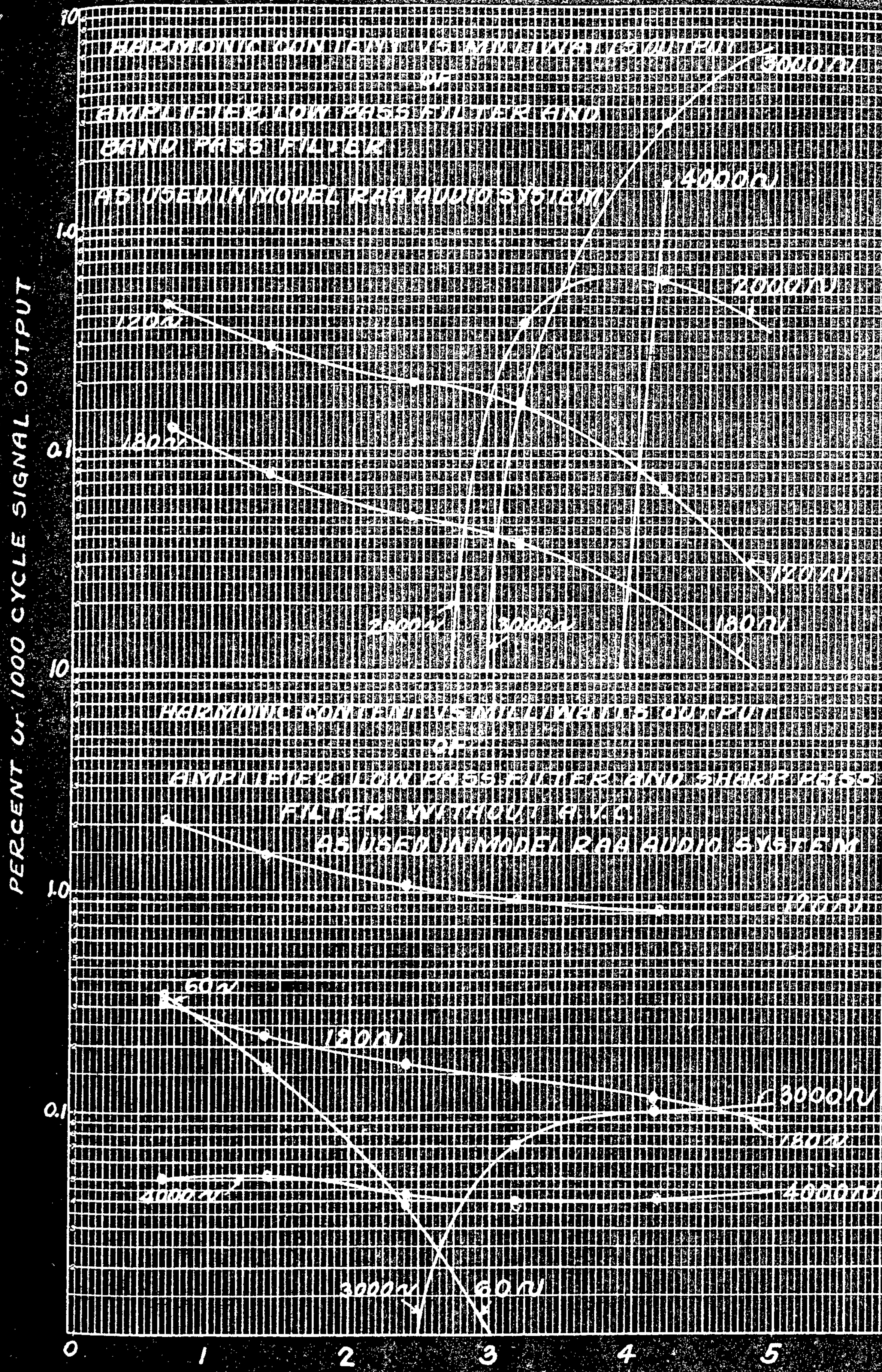
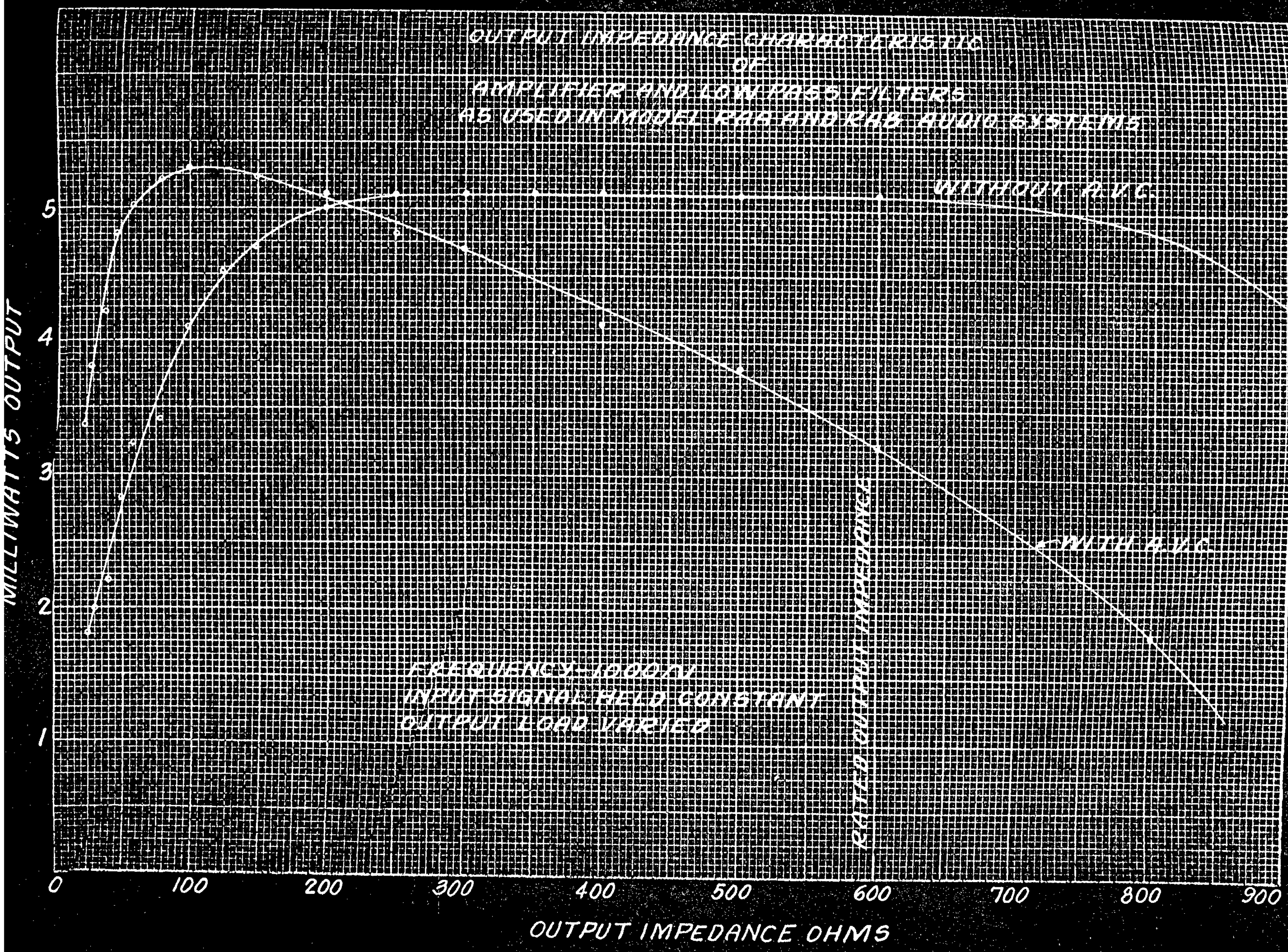

HARMONIC CONTENT VS MILLIWATTS OUTPUT
OF
AMPLIFIER LOW PASS FILTER AND
BAND PASS FILTER
AS USED IN MODEL RAA AUDIO SYSTEM
3000 ~
4000 ~
2000 ~
120 ~
180 ~
2000 ~
3000 ~
HARMONIC CONTENT VS MILLIWATTS OUTPUT
OF
AMPLIFIER LOW PASS FILTER AND SHARP PASS
FILTER WITHOUT A.V.C.
AS USED IN MODEL RAA AUDIO SYSTEM
120 ~
60 ~
180 ~
3000 ~
180 ~
4000 ~
4000 ~
3000 ~
60 ~
10
1.0
0.1
10
1.0
0.1
0
1
2
3
4
5
PERCENT OF 1000 CYCLE SIGNAL OUTPUT
MILLIWATTS OUTPUT

PLATE 209



OUTPUT IMPEDANCE CHARACTERISTIC
OF
AMPLIFIER AND LOW PASS FILTERS
AS USED IN MODEL RAA AND RAB AUDIO SYSTEMS
WITHOUT A.V.C.
WITH A.V.C.
RATED OUTPUT IMPEDANCE
FREQUENCY-1000 ~
INPUT SIGNAL HELD CONSTANT
OUTPUT LOAD VARIED
MILLIWATTS OUTPUT
1
2
3
4
5
0
100
200
300
400
500
600
700
800
900
OUTPUT IMPEDANCE OHMS

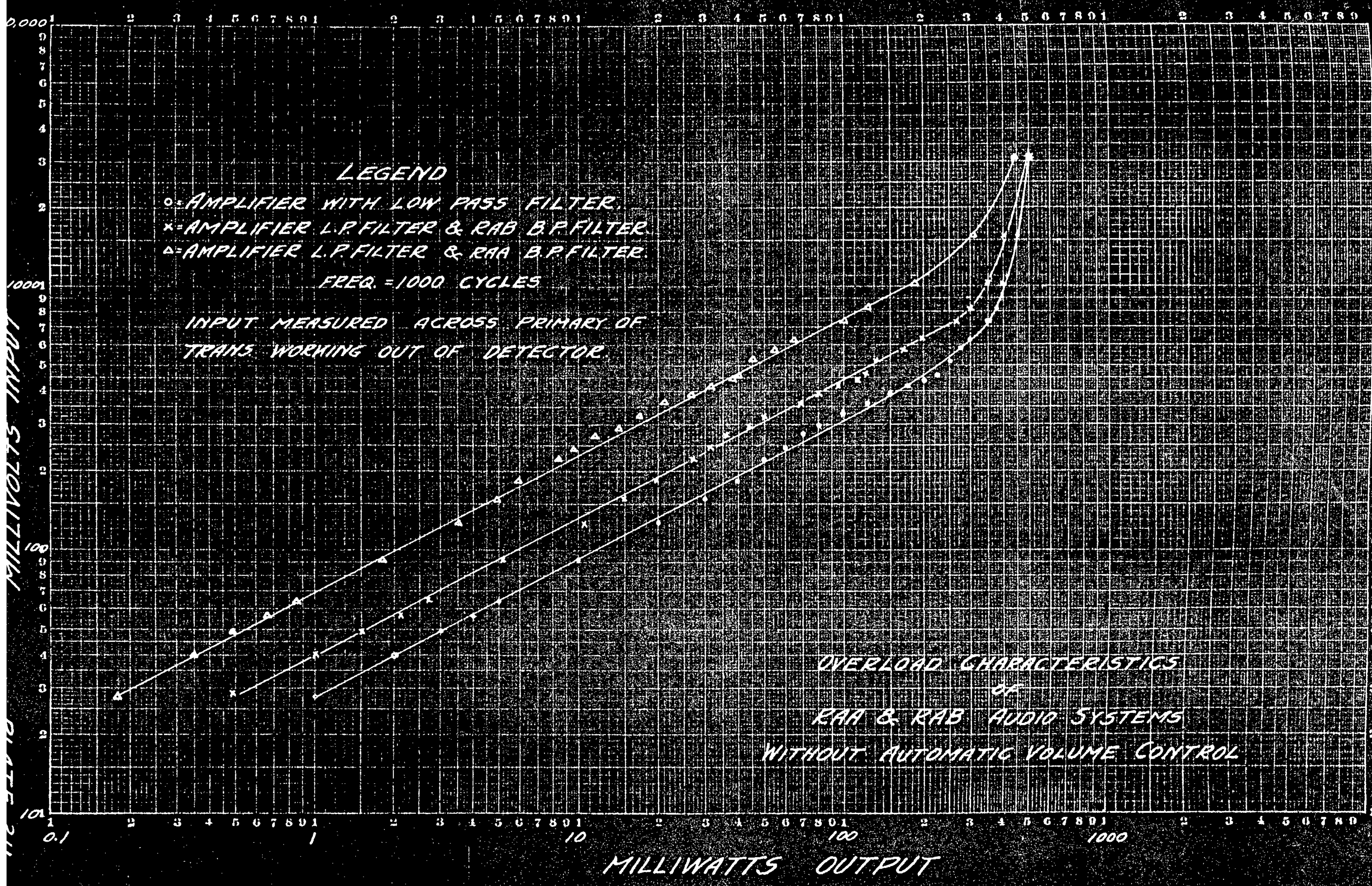


PLATE 24

UNCLASSIFIED

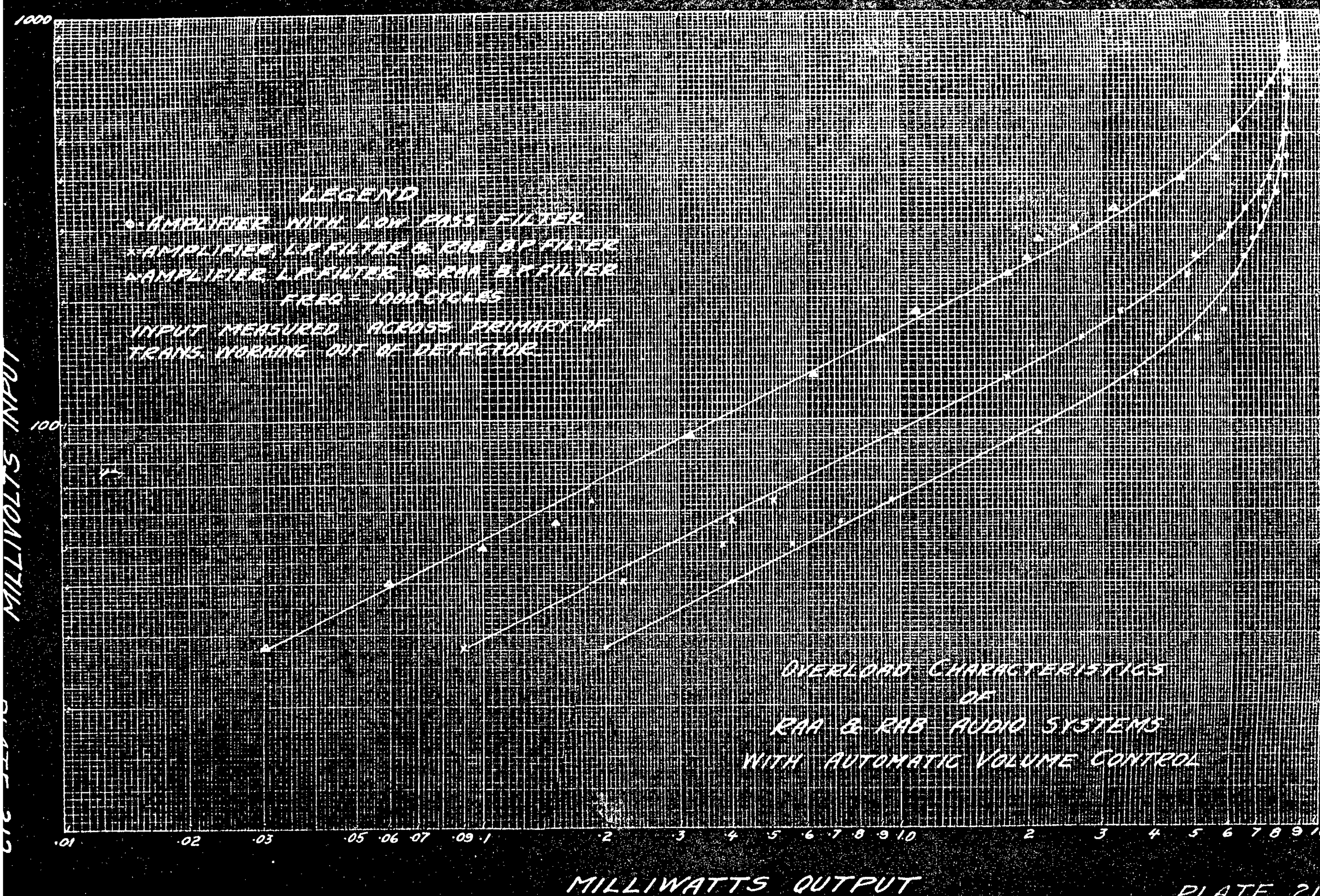

LEGEND
• AMPLIFIER WITH LOW PASS FILTER
× AMPLIFIER, L.P. FILTER & RAB B.P. FILTER
▲ AMPLIFIER, L.P. FILTER & RAA B.P. FILTER
FREQ - 1000 CYCLES
INPUT MEASURED ACROSS PRIMARY OF
TRANS. WORKING OUT OF DETECTOR
OVERLOAD CHARACTERISTICS
OF
RAA & RAB AUDIO SYSTEMS
WITH AUTOMATIC VOLUME CONTROL
MILLIVOLTS INPUT
MILLIWATTS OUTPUT
1000
100
.01
.02
.03
.05
.06
.07
.09
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
2
3
4
5
6
7
8
9
10

PLATE 212

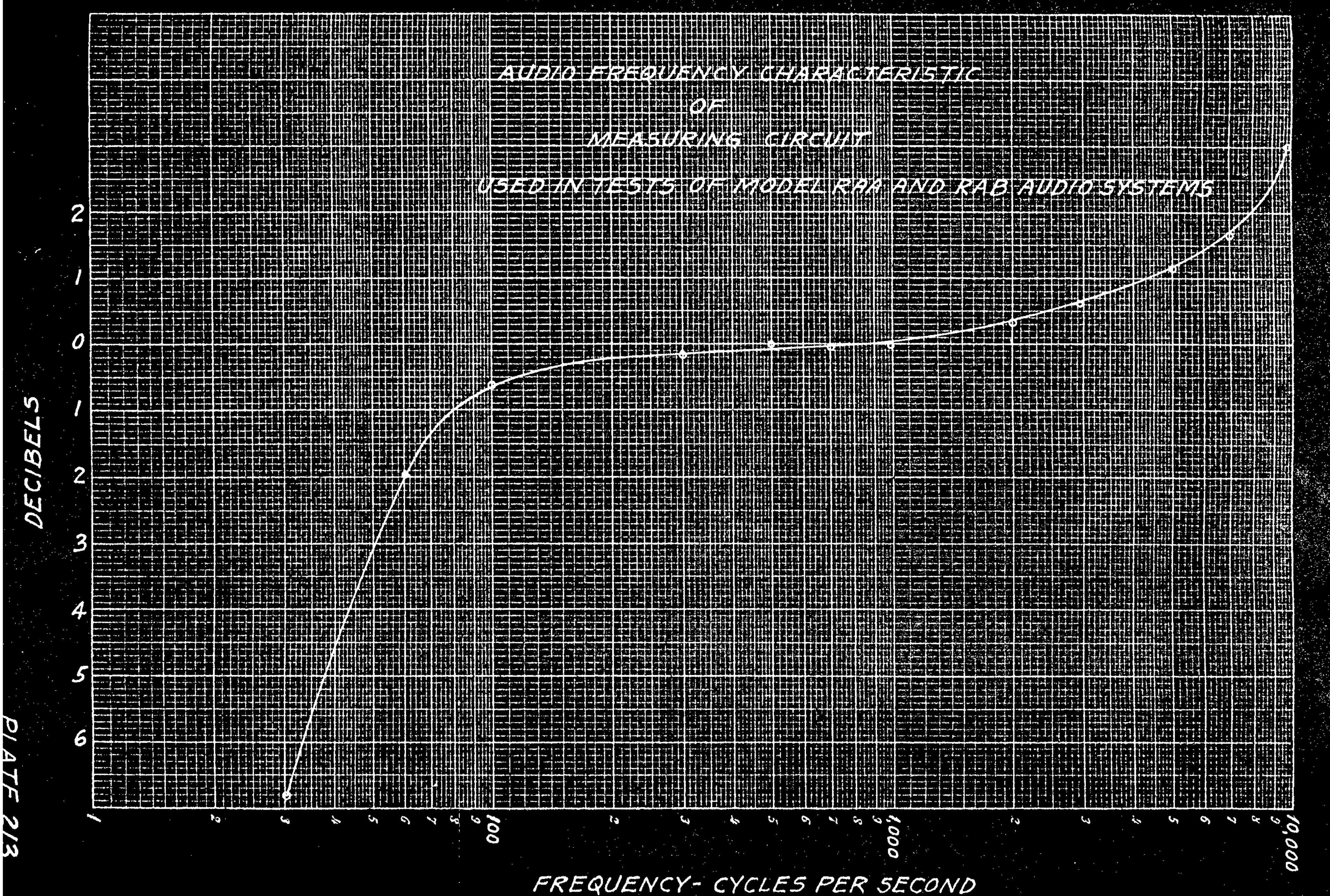

AUDIO FREQUENCY CHARACTERISTIC
OF
MEASURING CIRCUIT
USED IN TESTS OF MODEL RAA AND RAB AUDIO SYSTEMS
DECIBELS
2
1
0
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
100
2
3
4
5
6
7
8
9
1,000
2
3
4
5
6
7
8
9
10,000
FREQUENCY - CYCLES PER SECOND

PLATE 213

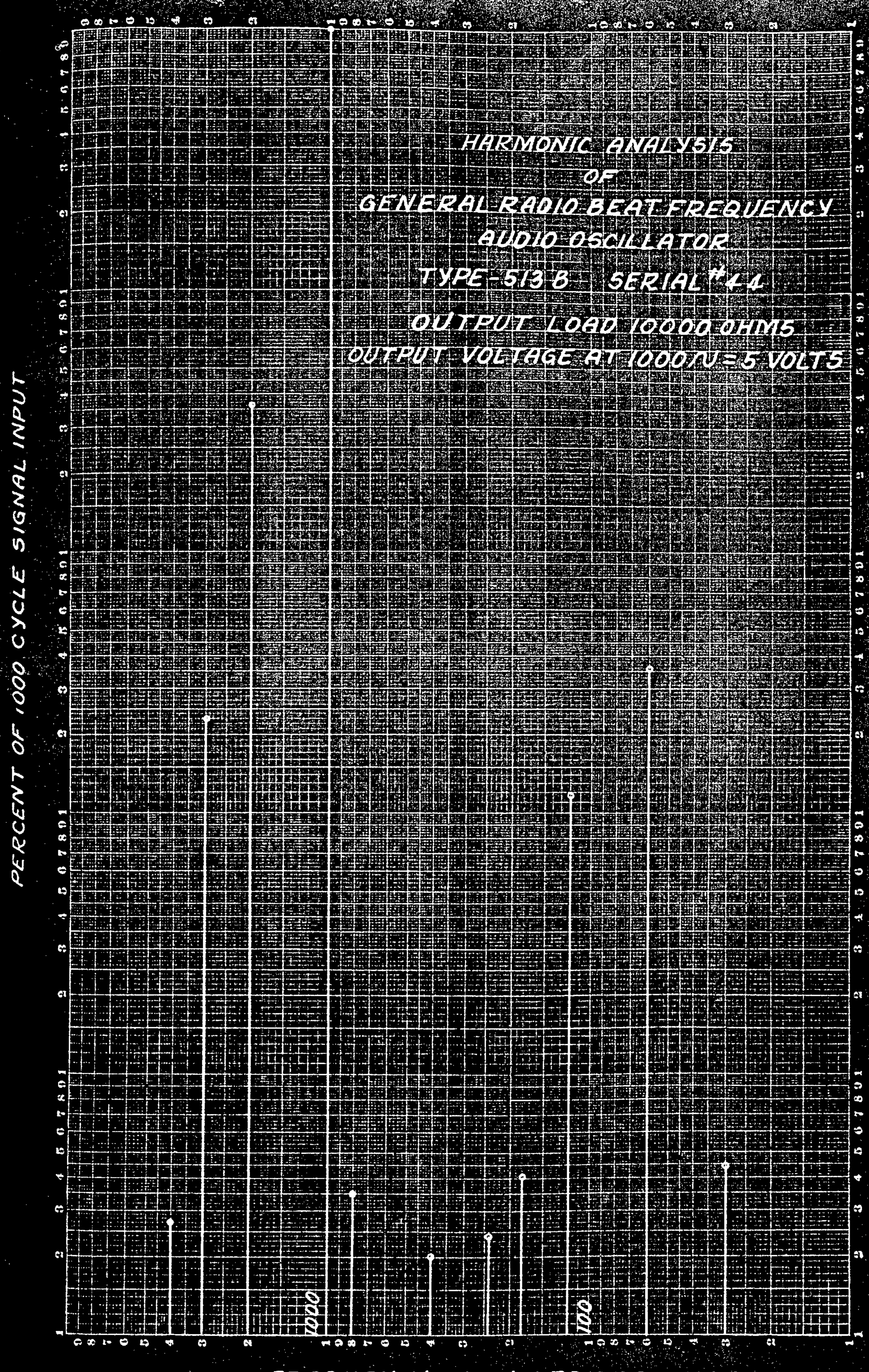
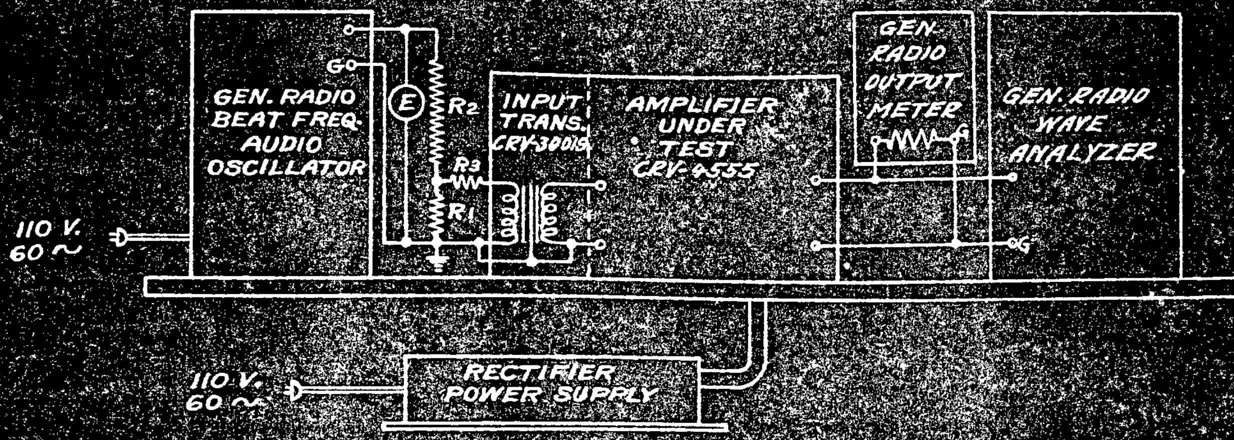
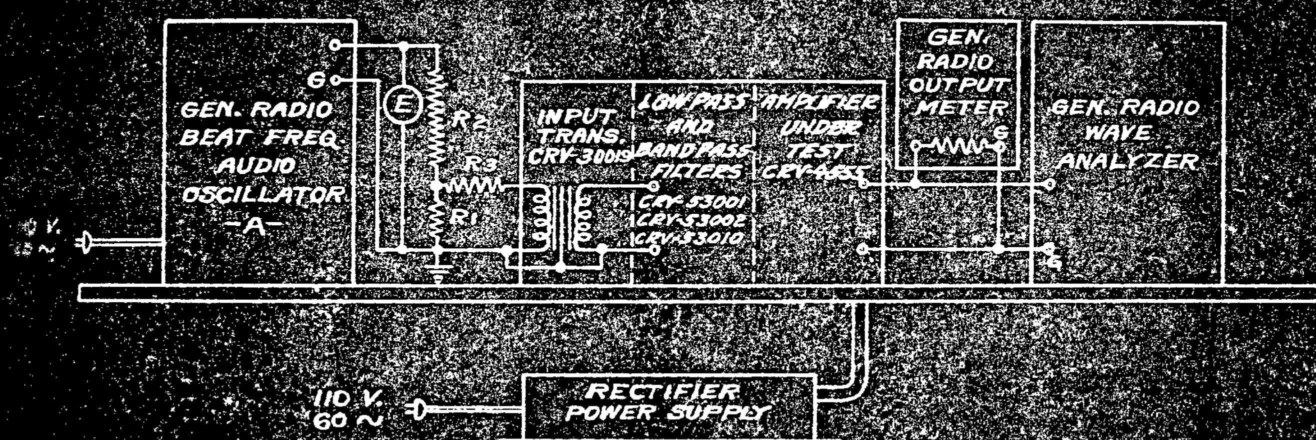

HARMONIC ANALYSIS
OF
GENERAL RADIO BEAT FREQUENCY
AUDIO OSCILLATOR
TYPE-513 B SERIAL #44
OUTPUT LOAD 10000 OHMS
OUTPUT VOLTAGE AT 1000~ = 5 VOLTS
PERCENT OF 1000 CYCLE SIGNAL INPUT
1000
100
FREQUENCY IN CYCLES PER SECOND

PLATE 214

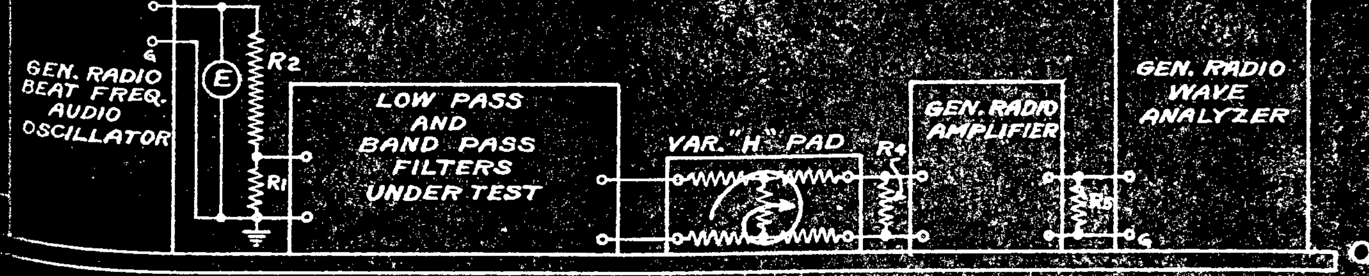
MEASURING CIRCUIT № 1



MEASURING CIRCUIT № 2

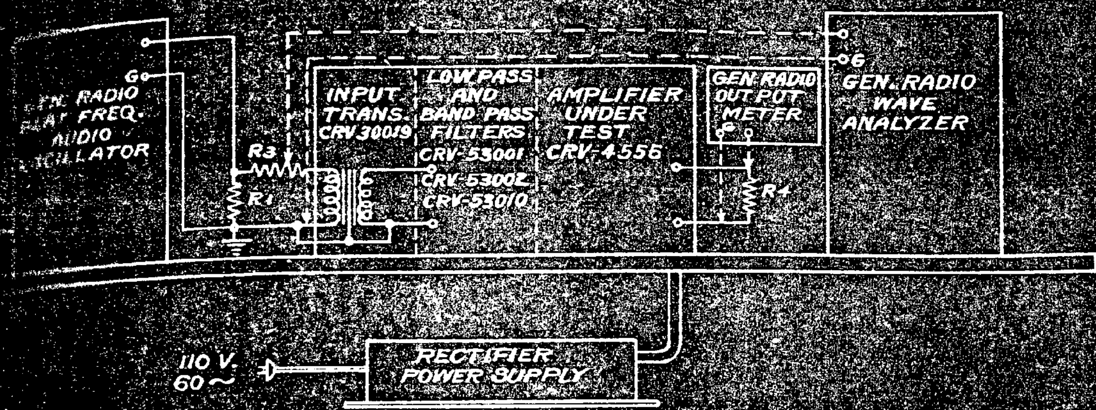


MEASURING CIRCUIT № 3



UNCLASSIFIED

MEASURING CIRCUIT No. 4



MEASURING CIRCUIT No. 5

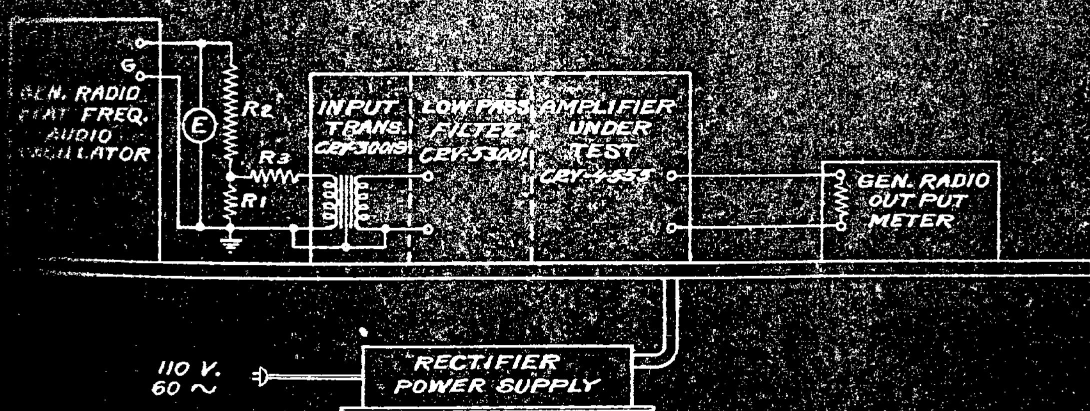


PLATE 216