17 July 1934

Report No. R-1063
BuEng. No. R5-10

NAVY DEPARTMENT

BUREAU OF ENGINEERING

ADDENDA TO REPORT NO. R-1027

Test of Models RAA and RAB Receiving Equipments.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 11 Plates - 18

Authorization: BuEng. let.S67/46/L5(12-22-W8) of 26 Dec.1933.

Date of Test: 5 February 1934 to 15 March 1934.

Submitted by:

John H. Gough, Associate Radio Engineer.

Reviewed by:

T.McL. Davis, Radio Engr. Section Head.

A. Hoyt Taylor, Supt., Radio Division.

Approved by:

H. R. Greenlee, Captain, U.S.Navy
Director.

Distribution:
Bu.Eng.(5)

mbe

TABLE OF CONTENTS

ADDENDA TO REPORT NO. 1027

	SUBJECT	PAGE
VIII.	TESTS	1
IX.	RESULTS OF TESTS	7
X.	CONCLUSIONS	8
XI.	RECOMMENDATIONS	11

Appendices

Audio Frequency Characteristics of CRV-30019 Input Transformer and CRV-4555 Amplifier with Type '56 Tubes Replacing Navy Type 38027..... Plate 200A

Audio Characteristics of CRV-30019 Input Transformer CRV-4555 Amplifier and Type CRV-53001 Low Pass Filter with Type '56 Tubes Replacing Navy Type 38027..... Plate 201A

Audio Characteristics of CRV-30019 Input Transformer CRV-4553 Amplifier, CRV-53001 Low Pass Filter, CRV-53002 Band Pass Filter in Model RAA with Type '56 Tubes Replacing Type 38027 Tubes..... Plate 203A

Audio Characteristics of Types CRV-30019 Input Transformer, CRV-4553 Amplifier, CRV 53001 Low Pass Filter and CRV-53010 Band Pass Filter with Type '56 Tubes Replacing Type 38027 Tubes..... Plate 205A

Schematic of Measuring Circuits Employed..... Plate 217

Schematic of Measuring Circuits Employed..... Plate 218

Regulation Curves for Type CRV-4554 Power Unit..... Plate 219

Harmonic Analysis of 200 volt Section of Voltage Divider of Type CRV-4554 Power Unit Operated at Normal Full Load..... Plate 220

Harmonic Analysis of CRV 4554 Power Unit at Input Low Frequency Filter at Normal Full Load..... Plate 221

R.F. Attenuation Characteristics of RF Filter and Power Transformer as used in CRV-4554 Power Supply Unit.. Plate 222

Harmonic Analysis of Model RAA Receiver Without Band Pass Filter, With and Without A.V.C..... Plate 223

Harmonic Analysis of Model RAA Receiver with Band Pass Filter Both with and without A.V.C.....Plate 224

Harmonic Analysis of Model RAB Receiver Without Band Pass Filter Both With and Without A.V.C.....Plate 225

Harmonic Analysis of Model RAB Receiver With Band Pass Filter Both With and Without A.V.C.....Plate 226

Overload Characteristics of CRV-30019 Input Transformer, CRV 4553 Amplifier and CRV-53001 Low Pass Filter as Used in Models RAA and RAB Receivers with A.V.C. operating (3 levels).....Plate 227

Overload Characteristics of CRV-53002 Band Pass Filter, CRV-30019 Input Transformer, CRV-4555 Amplifier, CRV-53001 Low Pass Filter as Used in Audio System of RAA Receiver with A.V.C. Operating (3 levels).....Plate 228

Overload Characteristics of CRV-53010 Band Pass Filter, CRV-30019 Input Transformer, CRV-4555 Amplifier, CRV-53001 Low Pass Filter as Used in Audio System of RAB with A.V.C....Plate 229

Frequency Characteristics of CRV-30019 Input Transformer CRV-4555 Amplifier and CRV-53001 Low Pass Filter as Used in RAA and RAB Receivers.....Plate 230.

ADDENDA

VIII TESTS

8-1. The following discussion is a continuation of Report No. R-1027 dated 19 February 1934, covering further tests made on the RAA and RAB Receiving Equipments.

a. Outline of Tests.

8-a-1. The tests described in this addenda cover six phases of investigation, namely:

(1) Performance of the RAA and RAB audio systems with the CRV-38027 tubes replaced by RCA '56 tubes.

(2) Performance of the CRV-4554 rectifier power unit embracing regulation characteristics and harmonic analysis of the pulsating and filtered d.c. voltages.

(3) Attentuation characteristics of the audio frequency filter section of the CRV-4554 rectifier power unit.

(4) Harmonic analysis of a 1000 cycle output signal from the RAA and RAB Receiving Equipments.

(5) Overload characteristics of the RAA and RAB audio systems with the A.V.C. of each system adjusted to limit the output level to 0.5, 2 and 5 milliwatts.

(6) Investigation of the cause of the attenuation of the higher audio frequencies by the A.V.C. in the RAA and RAB audio systems.

b. Methods of Conducting Tests.

8-b-1. The measuring equipment listed in Table III and employed in making the above tests were selected not only for their reliability and accuracy, but because they best adapted themselves to the class of measurements required under these investigations.

8-b-2. In setting up the measuring circuits, all leads carrying audio or radio frequency currents and voltages were of shielded, twisted conductors. Input and output pairs of leads were spaced widely apart so as to minimize coupling and feed-back effects as much as possible. All ground connections from the units under test, measuring instruments and other associated apparati 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 ground reference. In making tests 1, 5 and 6 described in paragraph 8-a-1, the reference ground was the conduit housing the power lines to the laboratory. In all of the other tests, this ground was the screening or the screened booth in which the tests were conducted.

8-b-3. Measuring Equipment

TABLE III

NAME OF APPARATUS	TYPE NO.	SERIAL NO.	LIST WHERE USED REF. TO PAR. 8-a-1.
General Radio Beat Frequency Audio Oscillator.	513B	80	1
General Radio Wave Analyzer	636A	102	1 2 4 5 6
General Radio Beat Frequency Audio Oscillator	513B	44	5 6
Daven A.C. Voltmeter	180D	1453	1 5 6
Biddle Decade Resistance	1438		1 5 6
General Radio Decade Res.	102K	5720	1 6
General Radio Output Meter	583A	72	1 3 4 5 6
600 ohm Output Meter	NRL		5
General Radio Standard Signal Generator	LC-1	15	3 4
Weston Set Analyzer	660		2
Weston A.C. Voltmeter 150-750 volts.	341	5484	2
Weston A.C. Voltmeter 3-6 volts	341	8489	2
General Radio "Variac"	200C		2
Low Frequency Receiver	RAA	115	2 3
High Frequency Receiver	RAB	2	3

8-b-4. Overall Audio Frequency Discrimination Characteristics.

The procedure followed in making tests for overall audio frequency discrimination characteristics were the same as described in paragraphs 4-b-6 and 4-b-7 of Report R-1027.

8-b-5. Mention should be made at this time that only overall audio frequency discrimination characteristics of the RAA and RAB audio systems were measured since changing the tubes would obviously have no effect one way or another upon the individual audio frequency discrimination characteristics of the filters themselves.

8-b-6. Refer to Table IV for circuit constants and for reference to type of measuring circuit used to obtain the curves.

8-b-7. Regulation of CRV-4554 Rectifier Power Unit. In making the tests for the regulation of the CRV-4554 Rectifier Power Unit, the line voltages to the unit were fed through a General Radio "Variac" which is a variable auto-transformer providing accurate adjustment in voltage over a wide range. The power unit was loaded to its normal capacity, this load being for these tests a standard RAA Receiver.

8-b-8. The line voltage to the power unit was measured with a Weston type 341, 150-750 volt A.C. Voltmeter. The D.C. voltages from the ground terminal to the several taps on the internal voltage divider of the power unit were measured with a Weston type 660 set Analyzer used as a high resistance voltmeter. The heater voltages were measured with a Weston type 341-3-6 volt, A.C. Voltmeter.

8-b-9. Except for the 90 volt tap, measurements of all of the D.C. voltages and A.C. heater voltages were made with a line voltage variation of from 90 to 120 volts in steps of 5 volts. The regulation of the 90 volt tap was measured for a line voltage variation of from 60 to 120 volts in steps of from 60 to 120 volts in steps of 5 volts. In the latter instance, voltage readings were taken for an increasing as well as a decreasing line voltage in order to obtain exact performance data for the action of the regulator tube, and to ascertain at the same time over what range of line voltage variation, the regulator tube maintains constant voltage at the 90 volt tap.

8-b-10. In making the above tests, it was felt that reducing the line voltage to less than 90 volts or increasing it to more than 120 volts would be of no value except for those voltage measurements made at the 90 volt d.c. tap. This was based on the reasoning that a change of plus or minus 5% in the line voltage from its normal (115 volts) would be the normal expected line voltage variation for any installation.

8-b-11. Refer to Table IV for reference to measuring circuit used and curves.

8-b-12. Wave Form Analyses of CRV-4554 Rectifier Power Unit. The wave form of ripple voltage appearing between the ground and +120 volt terminals of the internal voltage divider of the power unit was analyzed with a General Radio Wave Analyzer and the magnitudes of the harmonics present measured with the instrument. The unfiltered pulsating voltage entering the filter was similarly analyzed and the harmonics measured. The set-up for making these measurements was the same as that used in making the regulation measurements, except that the Wave Analyzer was employed, and, also, that the line voltage to the rectifier was kept constant at 110 volts.

8-b-13. Refer to Table IV for reference to measuring circuit used and curves.

9-b-14. Attenuation Characteristics of R.F. Filter in CRV-4554 Rectifier Power Supply. The attenuation characteristic of the Radio Frequency

Filter was measured at frequencies ranging from 13 Kc to 2400 Kc using the RAA and RAB receivers as vacuum tube voltmeters at frequencies within their respective limits. A modulated radio frequency signal from a General Radio Type LC-1 Standard Signal Generator was fed into the input of the filter. The attenuated signal from the output of the filter was fed into the antenna circuit of the RAA or RAB receiver, depending upon the frequency. The receiver was then tuned for resonance with the frequency of the signal from the signal generator. The output of the receiver was connected to a General Radio Output Meter whose function was to indicate the audio output level. The signal from the signal generator was adjusted to produce 2 milliwatts audio signal output from the receiver, and a reading of the microvolts input from the signal generator recorded. The receiver was then connected across the signal generator output and in parallel with the filter input. Again the signal output from the signal generator was adjusted until the audio signal output from the receiver was again 2 milliwatts in level, and the setting of the signal generator attenuator recorded. The ratio between these two measurements is the attenuation which the filter offers to the particular frequency concerned. This procedure was repeated for several frequencies within the range mentioned above.

8-b-15. The above procedure was repeated except that the attenuated signals were measured across the plate winding of the power transformer.

8-b-16. A 300 ohm resistor was connected between the signal generator and the filter input as shown in circuit no. 8 of Plate 218. In like manner, another 300 ohm resistor was connected in series with the antenna lead to the receiver. These resistors were inserted to prevent loading the filter due to the natural low input and output impedances, respectively, of the receiver and signal generator. In making these measurements, the signal generator was set outside of the screened booth to prevent any possible radio frequency pick up in the filter due to the close proximity with the signal generator. This was true only when the RAA receiver was used. When the RAB receiver was used, all measurements were made outside of a screened booth because of the inconvenience involved in any attempt to move the only RAB Receiving Equipment available for these tests into a screened booth.

8-b-17. Refer to Table IV for reference to measuring circuit and curves.

8-b-18. Harmonic Analysis of 1000 cycle Signal Output from RAA and RAB Receiving Equipments. A 1000 Kc radio frequency signal modulated 30% with 1000 cycle audio signal from a General Radio Standard Signal Generator was fed to the antenna circuit of the RAA receiver, tuned to the signal generator frequency. The input signal was adjusted to give output levels across 600 ohm load of 1, 2, 3, 4, and 5 milliwatts, as indicated on a General Radio Output Meter. The wave form of these output signals were analyzed with a General Radio Wave Analyzer to determine the harmonic content in terms of percent of the 1000 cycle signal. Observations were made for the equipment operating with and without A.V.C. and with and without the band pass filter.

8-b-19. Similarly, a harmonic analysis of 1000 cycle output signal for 1, 2, 3, 4 and 5 milliwatt levels were made on the RAB Receiver also tuned

to 1000 Kcs.

8-b-20. Refer to Table IV for reference to circuit used and curves.

8-b-21. Overload Characteristics of the RAA and RAB Audio System, with A.V.C. of each system adjusted to Limit Output Level to 0.5, 2 and 5 milliwatts. The procedure followed in this test was the same as described in paragraph 4-b-14 of Report 1027 except that when the output level was limited to 0.5 milliwatts, the NRL 600 ohm Output Meter was used to indicate the output levels for various input signal magnitudes.

8-b-22. Refer to Table IV for measuring circuit used and reference to curves.

8-b-23. Investigation of Attenuation of the Higher Audio Frequencies by the A.V.C. in the RAA and RAB Audio Systems. Refer to paragraphs 4-b-6 and 4-b-7 of Report R-1027 for general method for conducting this test. Data was obtained for the following:

(a) Audio System common in RAA and RAB Receiving Equipments (exclusive of band pass filters) operating without A.V.C.

(b) Same as (a) except operating with A.V.C.

(c) Same as (b) except with A.V.C. tubes removed.

(d) Same as (c) except with a 12 m.m.f. condenser shunted across each half of the A.V.C. transformer.

In the above tests the CRV-38027 tubes were used.

TABLE IV.

Circuit Constants, References to Measuring Circuits and Curves.

Description of List	Circuit Ref. Plates 215 to 218	Curve Reference		Audio Oscil. Volts	R_1 Ohms	R_2 Ohms	R_3 Ohms
Audio Frequency Characteristics of CRV-30019 and CRV-4555	#1	Plate 200A	No AVC	4.5	200	9800	250000
			AVC	4.5	500	9500	250000
Audio Frequency Characteristics of CRV-30019 CRV-4555, and CRV-53001	#2	Plate 201A	No AVC	4.5	200	9800	250000
			AVC	5.0	400	9600	250000
Audio Freq. Characteristics of CRV-30019, CRV-4555, CRV-53001, CRV-53002	#2	Plate 203A	No AVC	9.0	200	9800	250000
			AVC	9.0	500	9500	250000
Audio Freq. Characteristics of CRV-30019, CRV-4555, CRV-53001, CRV-53010	#2	Plate 205A	No AVC	6.0	200	9800	250000
			AVC	7.5	400	9600	250000
Regulation of CRV-4554 Rectifier Power Unit	#6	Plate 219					
Harmonic Analysis of CRV-4554 Rectifier Power Unit.	#7	Plates 220 & 221					
Attenuation Characteristics of R.F. Filter of CRV-4554 Rectifier Power Unit.	#8	Plate 222					
Harmonic Analysis of Model RAA Receiver without Band Pass Filter	#9	Plate 223					
Harmonic Analysis of Model RAA Receiver with Band Pass Filter.	#9	Plate 224					
Harmonic Analysis of Model RAB Receiver without Band Pass Filter.	#9	Plate 255					
Harmonic Analysis of Model RAB Receiver with Bond Pass Filter	#9	Plate 226					
Overload Characteristics of RAA & RAB Audio Systems without Band Pass Filters and Circuiting AVC.	#4	Plate 227			10000		250000
Overload Characteristics of RAA Audio System with Band Pass Filter and with Limiting AVC	#4	Plate 228			10000		250000
Overload Characteristics of RAB Audio System with Band Pass Filter and with Limiting AVC	#4	Plate 229			10000		250000

10-12. Plates 227, 228 and 229 show the overload characteristics of the RAA and RAB audio systems with the automatic volume control operating and limiting the output to 0.5, 2 and 5 milliwatts. The input signal was measured across the primary of the transformer working out of the detector. The output level was measured across a volume load. All measurements taken at 1000 cycles.

10-13. A study of the curves shown on Plate 230 reveals that the falling off of the frequency characteristics of the RAA or RAB audio system at the upper ranges of audio frequencies with the A.V.C. operating is due to the leakage reactance of the A.V.C. transformer and not to the grid to cathode capacitances of the A.V.C. tubes. This conclusion is based on the fact that the frequency characteristic curve is little changed by the removal of the A.V.C. tubes or by the shunting across the secondary winding of the AVC transformer, condensers adjusted to equal the grid to cathode capacitances of the A.V.C. tubes.

XI. RECOMMENDATIONS

11-1. The use of RCA-56 tubes in place of CRV-38027 tubes would not only improve the performance of the audio systems of the RAA and RAB Receiving Equipment somewhat but would be a move toward modernizing these equipments. The CRV-38027 tubes are fast becoming obsolete and in a short time will be costly to replace.

11-2. It is recommended that reference be made to report R-1042 entitled "Investigation of Hum in Model RAB Receiver" so that the reader may become familiar with the exhaustive tests made for hum on the RAB Receiving Equipment and the recommendations made for reducing the hum.

11-3. It is believed that the A.V.C. transformer CRV-30018 could be redesigned to have lower leakage reactance so that the frequency characteristic of the transformer will not seriously attenuate the higher audio frequencies within the range of 1000 to 4000 cycles per second.

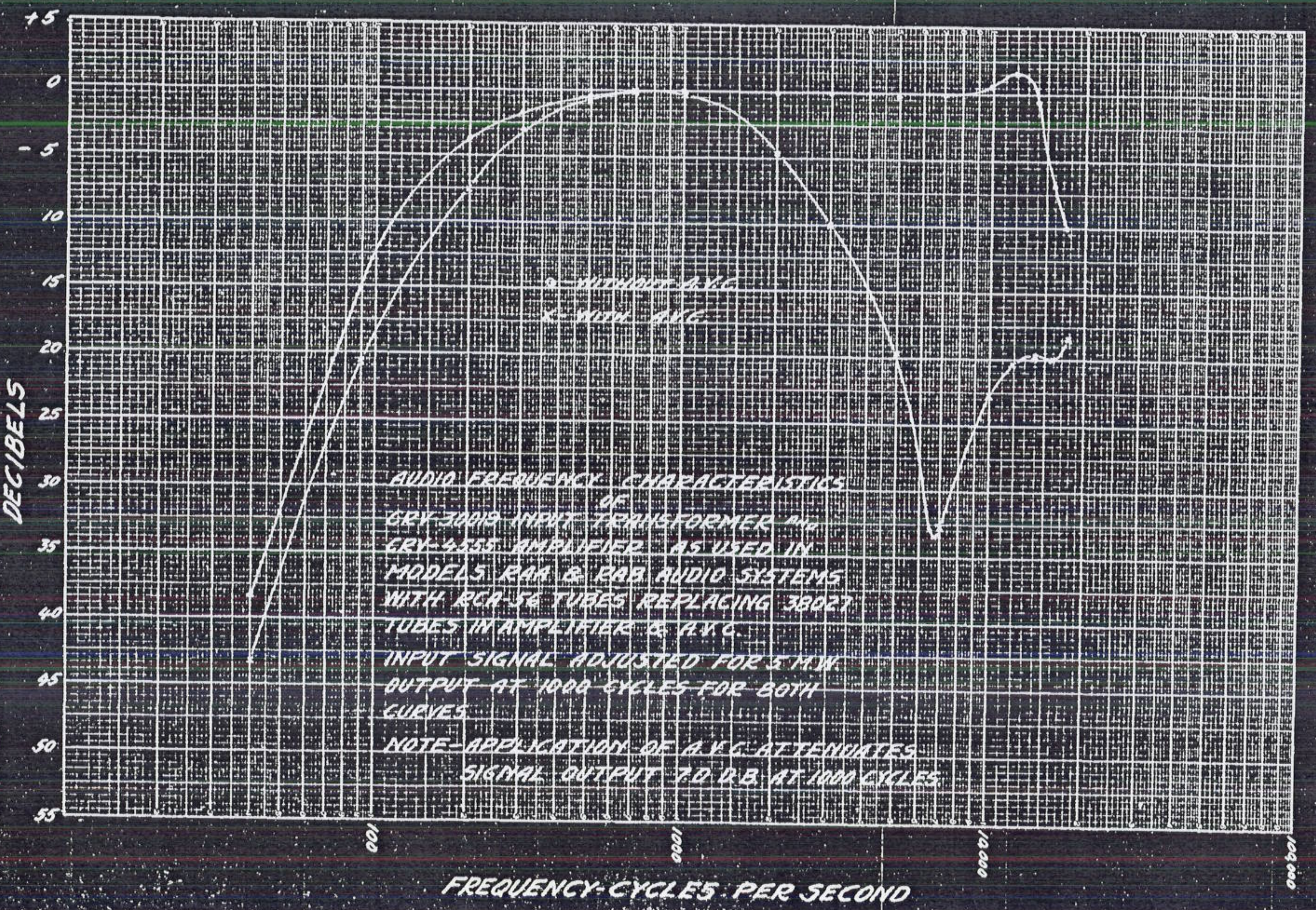

AUDIO FREQUENCY CHARACTERISTICS
OF
CRV-30018 INPUT TRANSFORMER AND
CRV-4555 AMPLIFIER AS USED IN
MODELS RAA & RAB AUDIO SYSTEMS
WITH RCA-56 TUBES REPLACING 38027
TUBES IN AMPLIFIER & A.V.C.
INPUT SIGNAL ADJUSTED FOR 5 M.W.
OUTPUT AT 1000 CYCLES FOR BOTH
CURVES
NOTE-APPLICATION OF A.V.C. ATTENUATES
SIGNAL OUTPUT 7.0 D.B. AT 1000 CYCLES
DECIBELS
+5
0
-5
10
15
20
25
30
35
40
45
50
55
100
1000
10,000
100,000
FREQUENCY-CYCLES PER SECOND

PLATE 200A

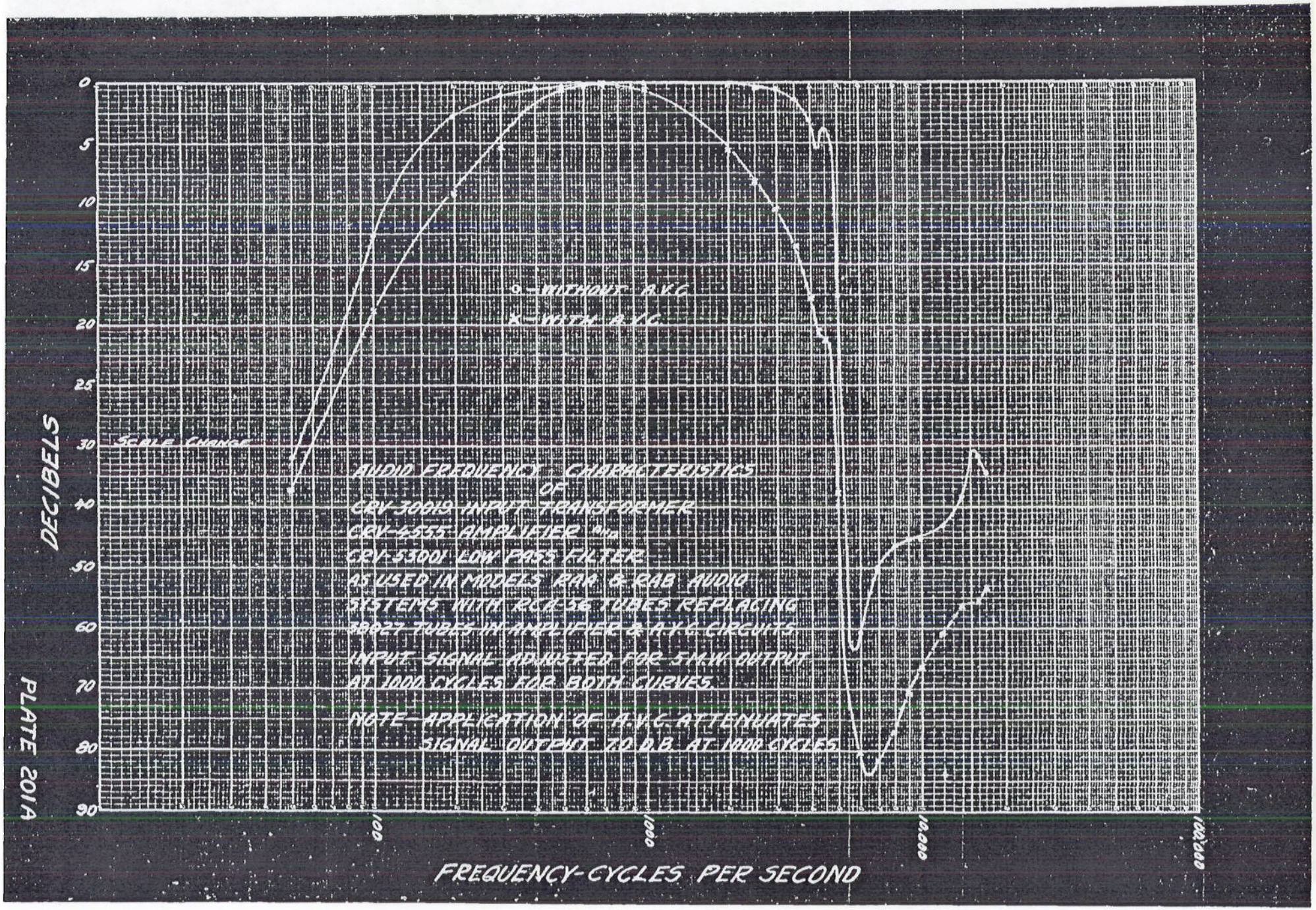
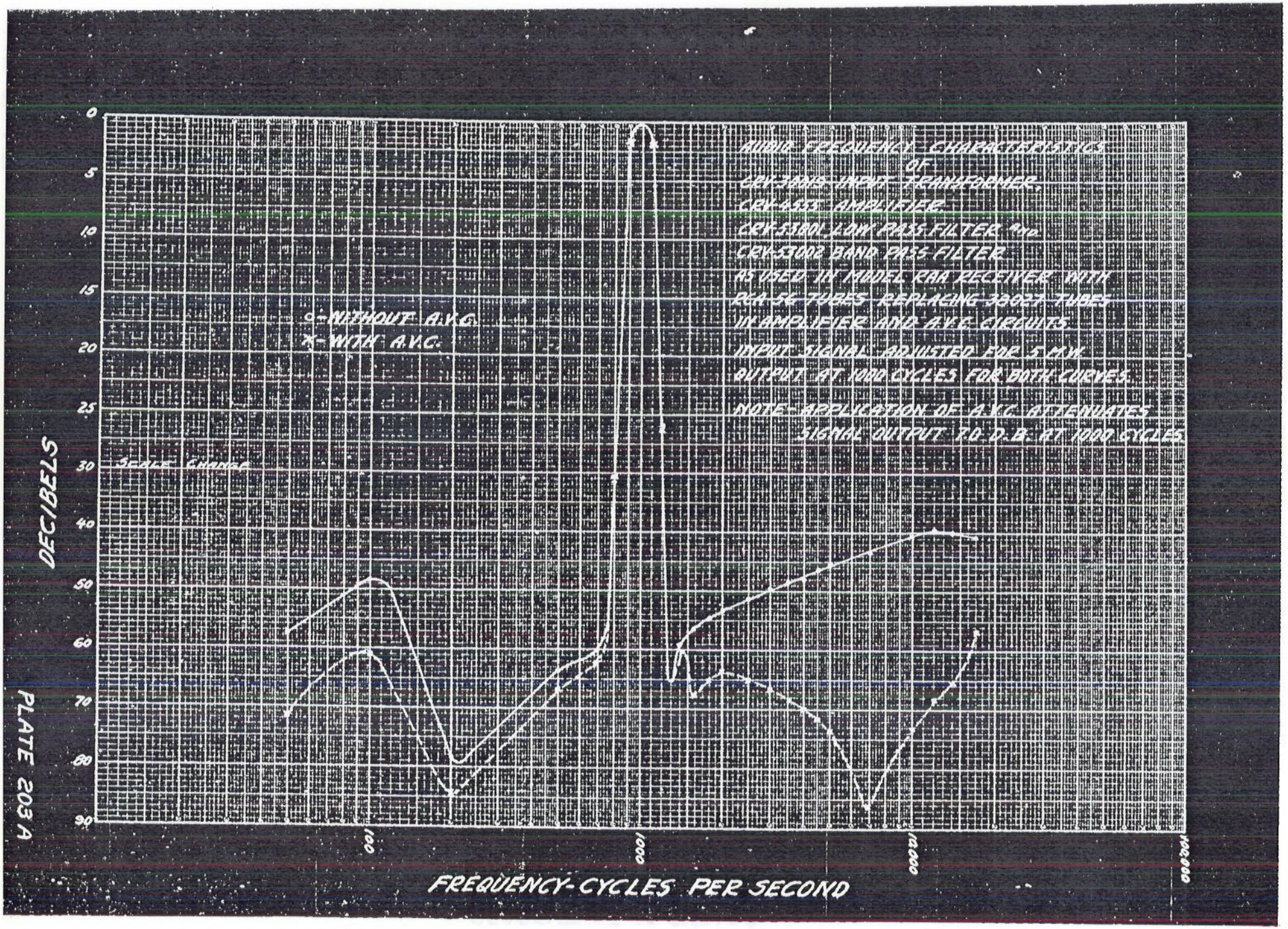
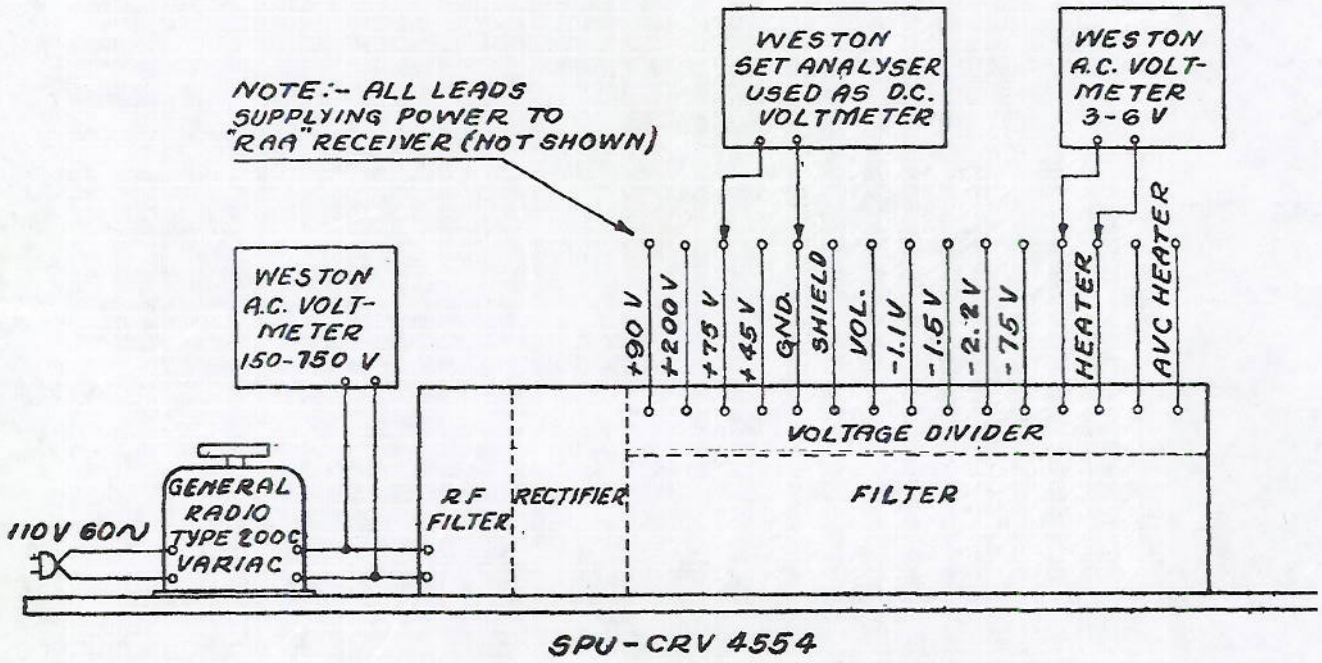

DECIBELS
0
5
10
15
20
25
30
40
50
60
70
80
90
SCALE CHANGE
o-WITHOUT A.V.C.
x-WITH A.V.C.
AUDIO FREQUENCY CHARACTERISTICS
OF
CRV-30619 INPUT TRANSFORMER
CRV-45551 AMPLIFIER Unit
CRV-53001 LOW PASS FILTER
AS USED IN MODELS RAP & RAB AUDIO
SYSTEMS WITH RCA 56 TUBES REPLACING
38027 TUBES IN AMPLIFIER & A.V.C. CIRCUITS
INPUT SIGNAL ADJUSTED FOR 5 M.W. OUTPUT
AT 1000 CYCLES FOR BOTH CURVES.
NOTE-APPLICATION OF A.V.C. ATTENUATES
SIGNAL OUTPUT 20 D.B. AT 1000 CYCLES.
100
1000
10000
100000
FREQUENCY-CYCLES PER SECOND

PLATE 201A


AUDIO FREQUENCY CHARACTERISTICS OF
CRY-3000 INPUT TRANSFORMER
CRY-4000 AMPLIFIER
CRY-3300 LOW PASS FILTER Pro.
CRY-3002 BAND PASS FILTER
AS USED IN MODEL KAA RECEIVER WITH
RCA 6F7 TUBES REPLACING 3002Y TUBES
IN AMPLIFIER AND A.V.C. CIRCUITS
INPUT SIGNAL ADJUSTED FOR 5 MW.
OUTPUT AT 1000 CYCLES FOR BOTH CURVES.
NOTE-APPLICATION OF A.V.C. ATTENUATES
SIGNAL OUTPUT 70 D.B. AT 1000 CYCLES.
O-WITHOUT A.V.C.
X-WITH A.V.C.
SCALE CHANGE
DECIBELS
0
5
10
15
20
25
30
40
50
60
70
80
90
100
1000
10,000
100,000
FREQUENCY-CYCLES PER SECOND
PLATE 203 A

MEASURING CIRCUIT Nº. 6



SPU - CRV 4554

PERCENT OF 60 CYCLES

MEASURING CIRCUIT Nº 7

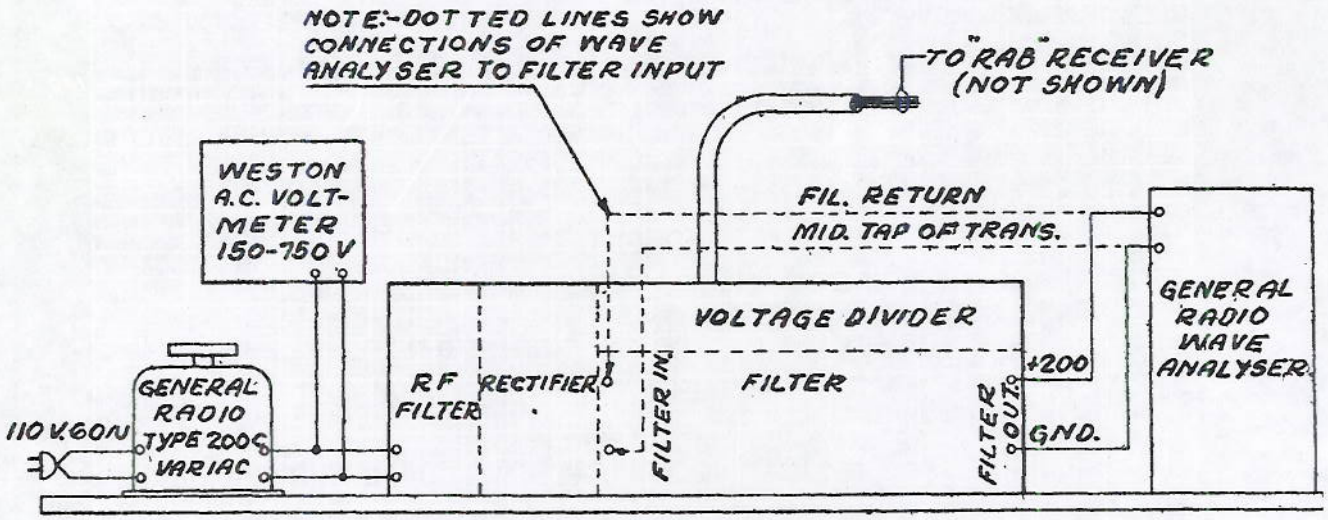
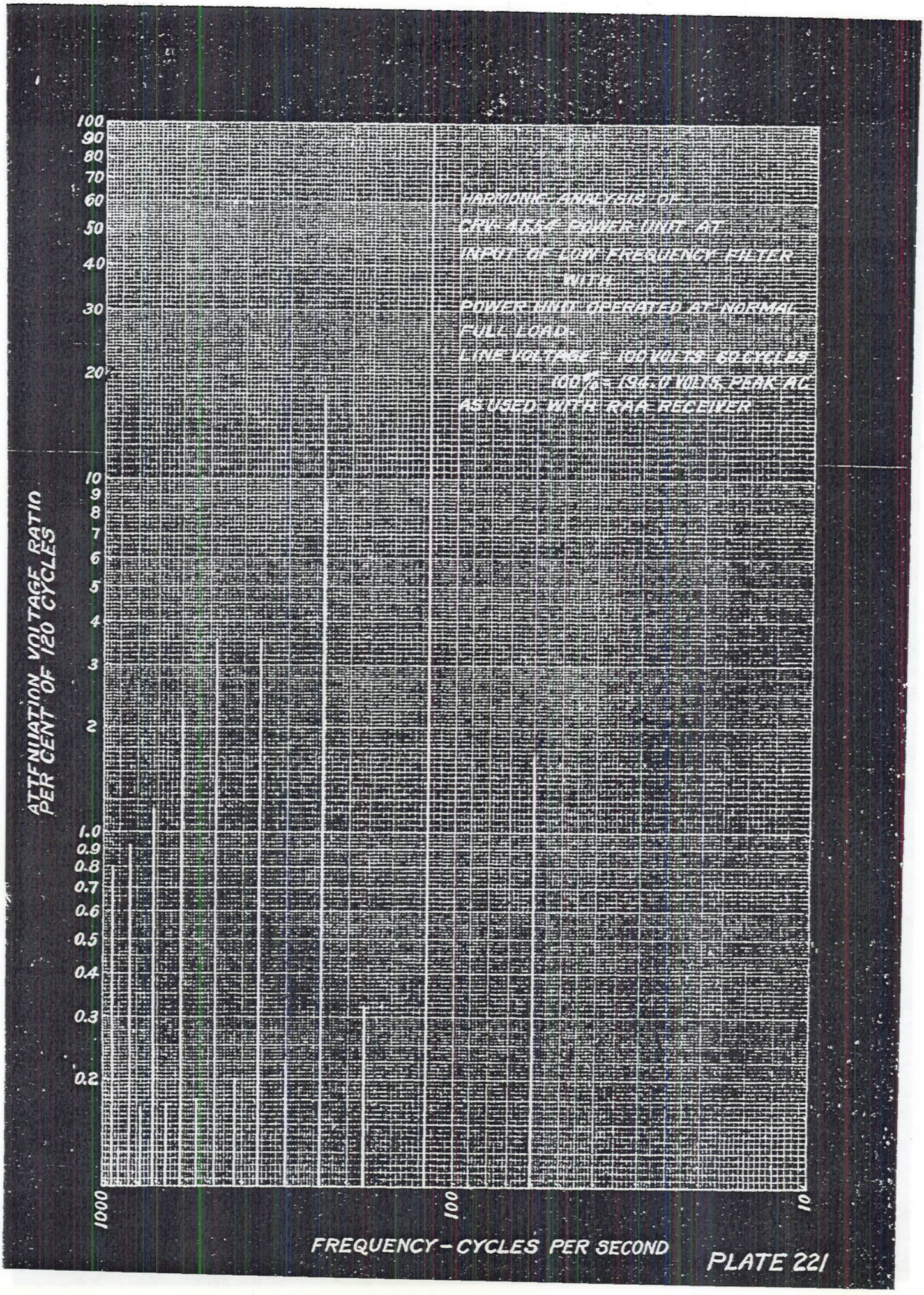


PLATE 217


HARMONIC ANALYSIS OF
CRK 4644 POWER UNIT AT
INPUT OF LOW FREQUENCY FILTER
WITH
POWER UNIT OPERATED AT NORMAL
FULL LOAD
LINE VOLTAGE = 100 VOLTS 60 CYCLES
100% = 156.0 VOLTS PEAK AC
AS USED WITH RAK RECEIVER
ATTENUATION VOLTAGE RATIO
PER CENT OF 120 CYCLES
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1000
100
10
FREQUENCY - CYCLES PER SECOND
PLATE 221

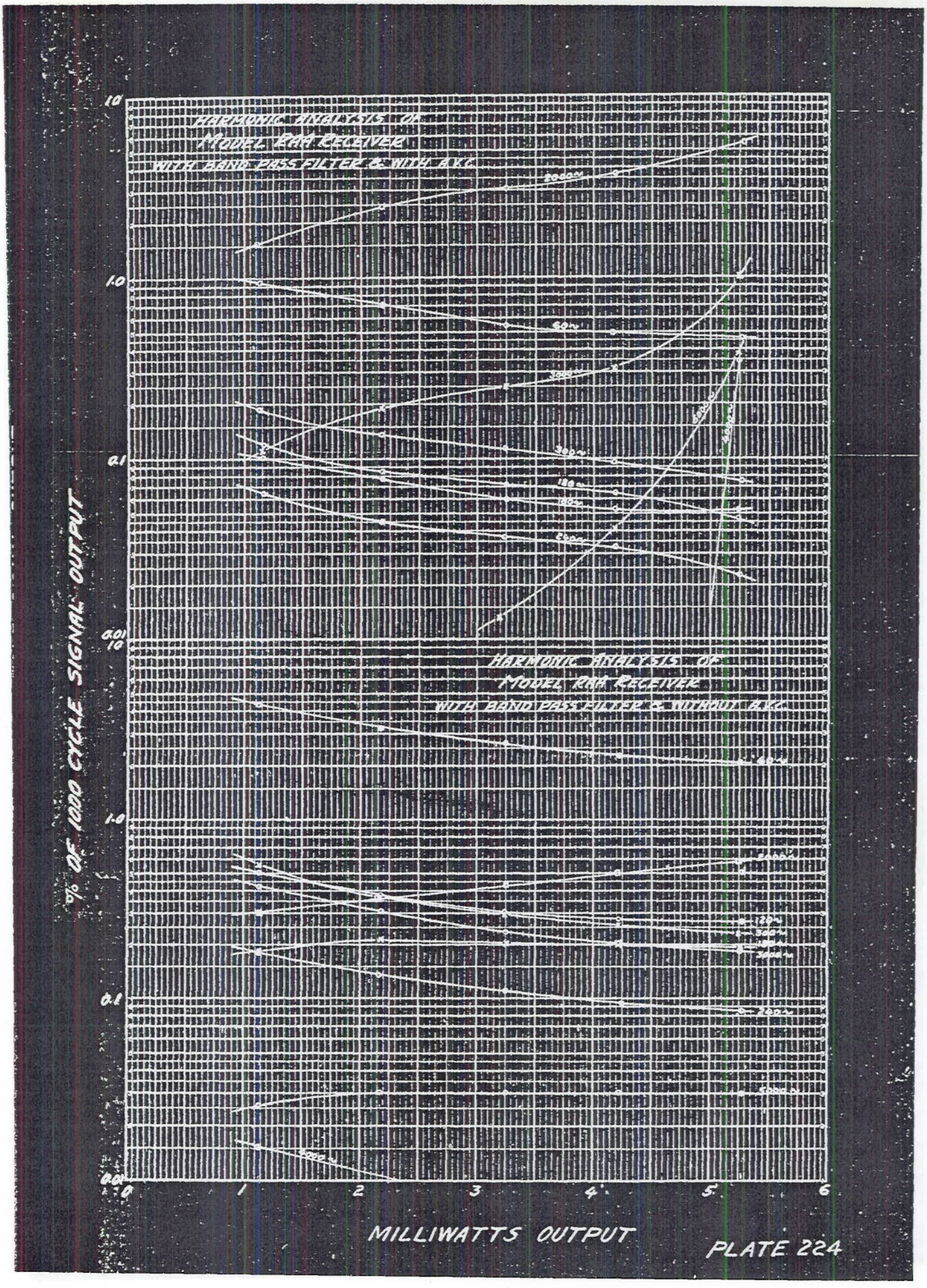
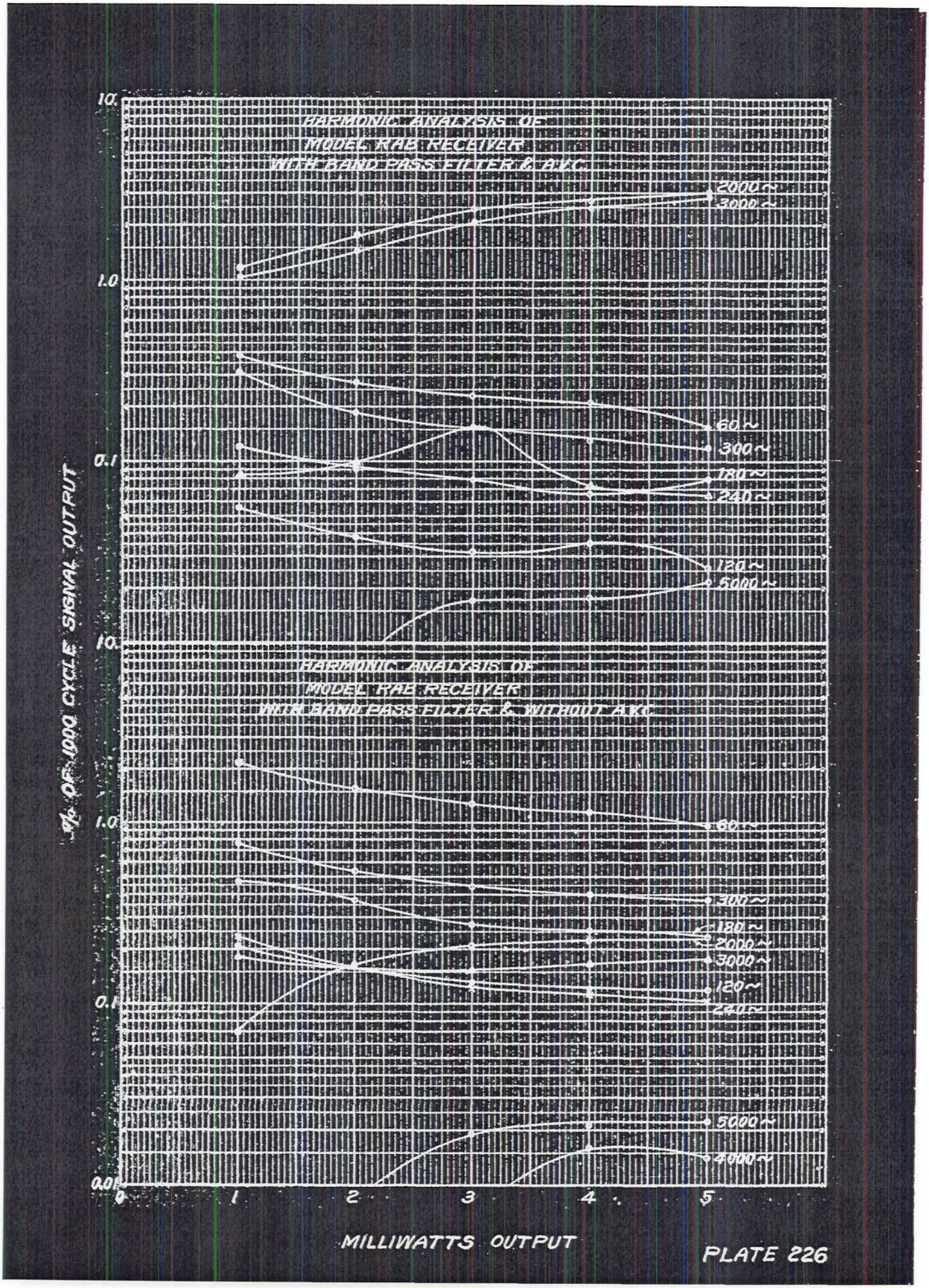

HARMONIC ANALYSIS OF
MODEL RAM RECEIVER
WITH BAND PASS FILTER & WITH A.V.C.
HARMONIC ANALYSIS OF
MODEL RAM RECEIVER
WITH BAND PASS FILTER & WITHOUT A.V.C.
% OF 1000 CYCLE SIGNAL OUTPUT
10
1.0
0.1
0.01
1
2
3
4
5
6
MILLIWATTS OUTPUT

PLATE 224


HARMONIC ANALYSIS OF
MODEL RAB RECEIVER
WITH BAND PASS FILTER & A.V.C.
2000~
3000~
60~
300~
180~
240~
120~
5000~
HARMONIC ANALYSIS OF
MODEL RAB RECEIVER
WITH BAND PASS FILTER & WITHOUT A.V.C.
60~
300~
180~
2000~
3000~
120~
240~
5000~
4000~
% OF 1000 CYCLE SIGNAL OUTPUT
10.
1.0
0.1
0.01
0
1
2
3
4
5
MILLIWATTS OUTPUT
PLATE 226

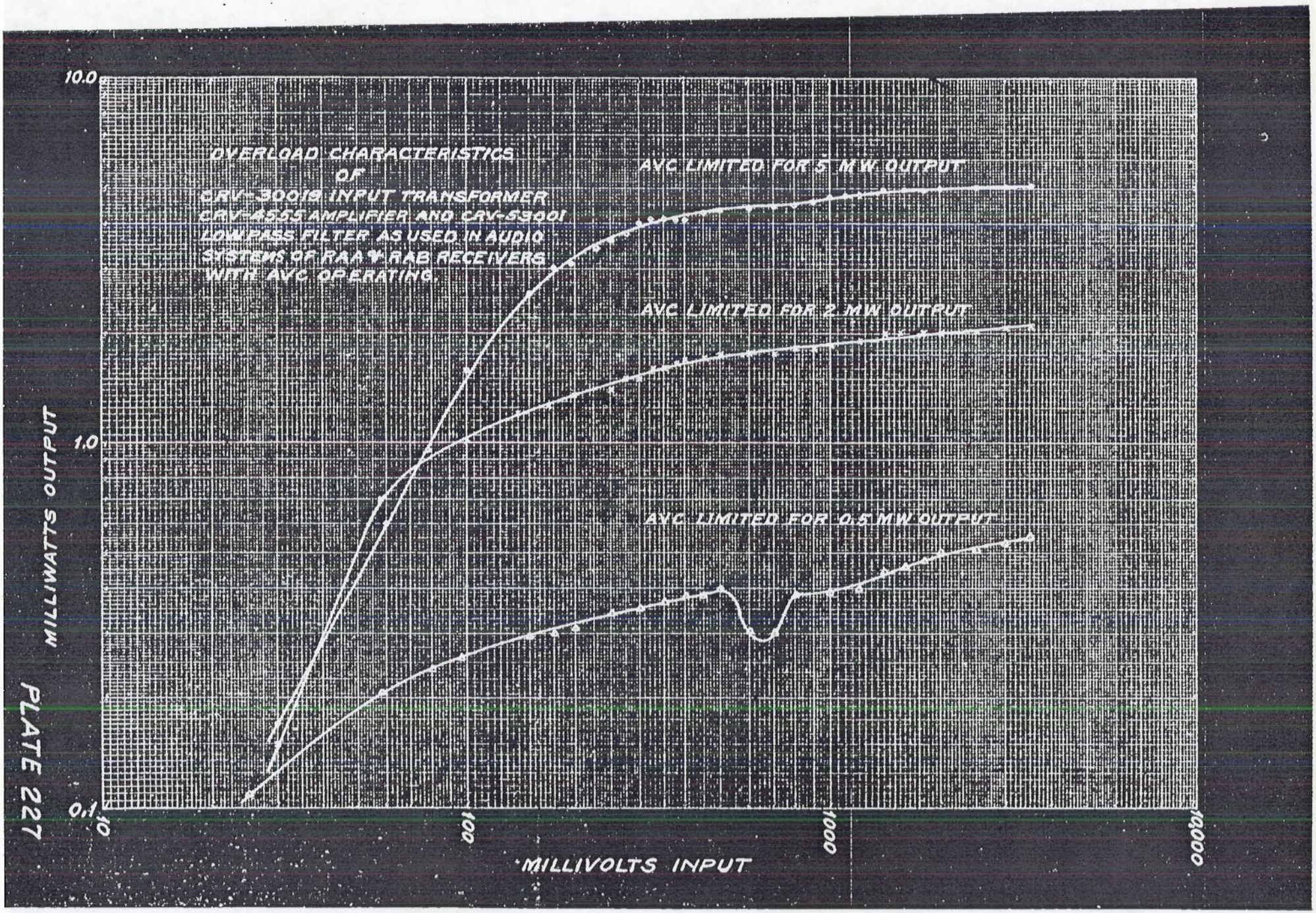

OVERLOAD CHARACTERISTICS
OF
CRV-3001G INPUT TRANSFORMER
CRV-4555 AMPLIFIER AND CRV-5300I
LOW PASS FILTER AS USED IN AUDIO
SYSTEMS OF RAA & RAB RECEIVERS
WITH AVC OPERATING.
AVC LIMITED FOR 5 M.W. OUTPUT
AVC LIMITED FOR 2 M.W. OUTPUT
AVC LIMITED FOR 0.5 M.W. OUTPUT
10.0
1.0
0.1
MILLIWATTS OUTPUT
10
100
1000
10,000
MILLIVOLTS INPUT

PLATE 227

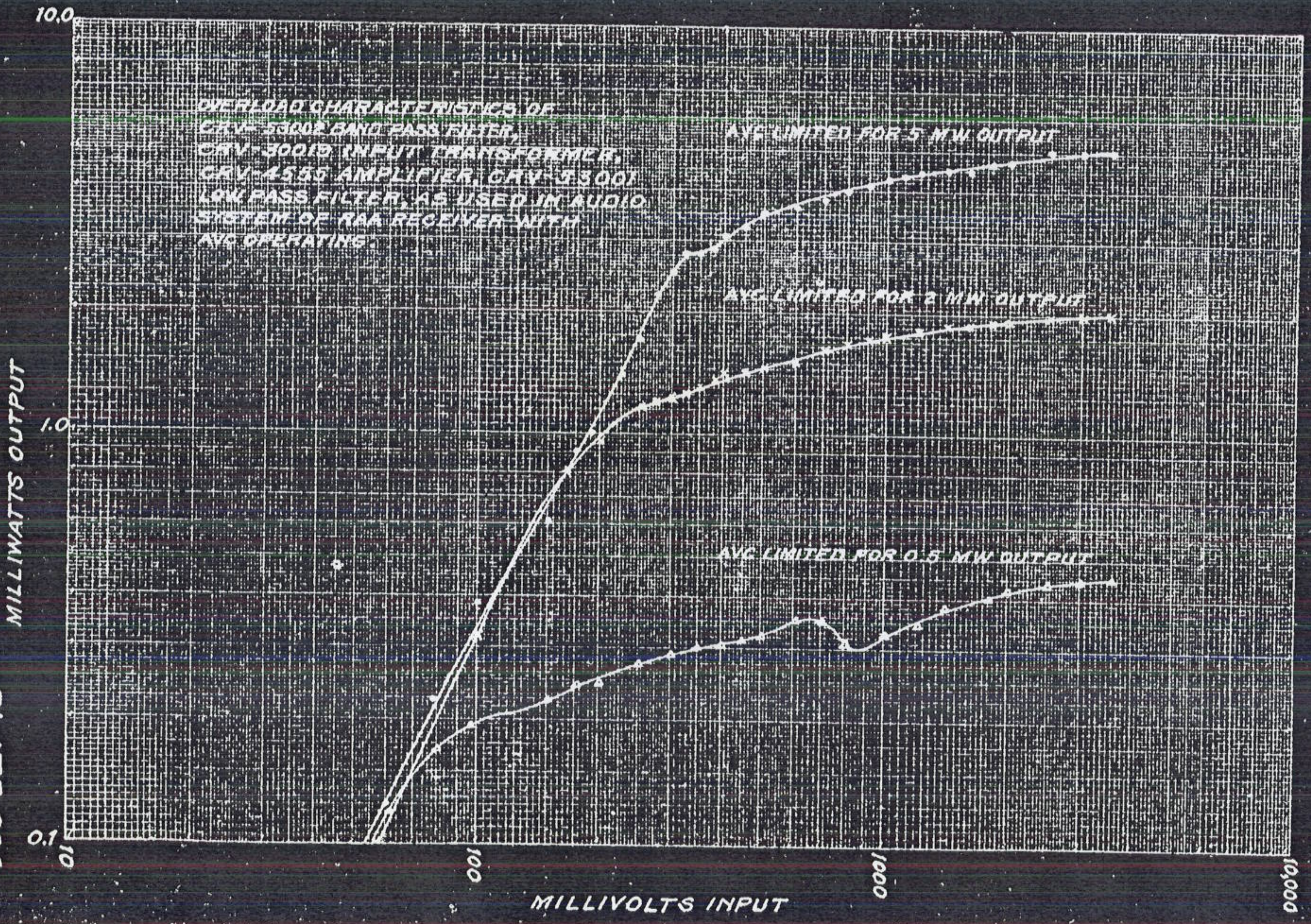

OVERLOAD CHARACTERISTICS OF
CRV-53002 BAND PASS FILTER,
CRV-30019 INPUT TRANSFORMER,
CRV-4555 AMPLIFIER, CRV-53001
LOW PASS FILTER, AS USED IN AUDIO
SYSTEM OF RAA RECEIVER WITH
AVC OPERATING.
AVC LIMITED FOR 5 MW OUTPUT
AVC LIMITED FOR 2 MW OUTPUT
AVC LIMITED FOR 0.5 MW OUTPUT
10.0
1.0
0.1
MILLIWATTS OUTPUT
10
100
1000
10,000
MILLIVOLTS INPUT

PLATE 228

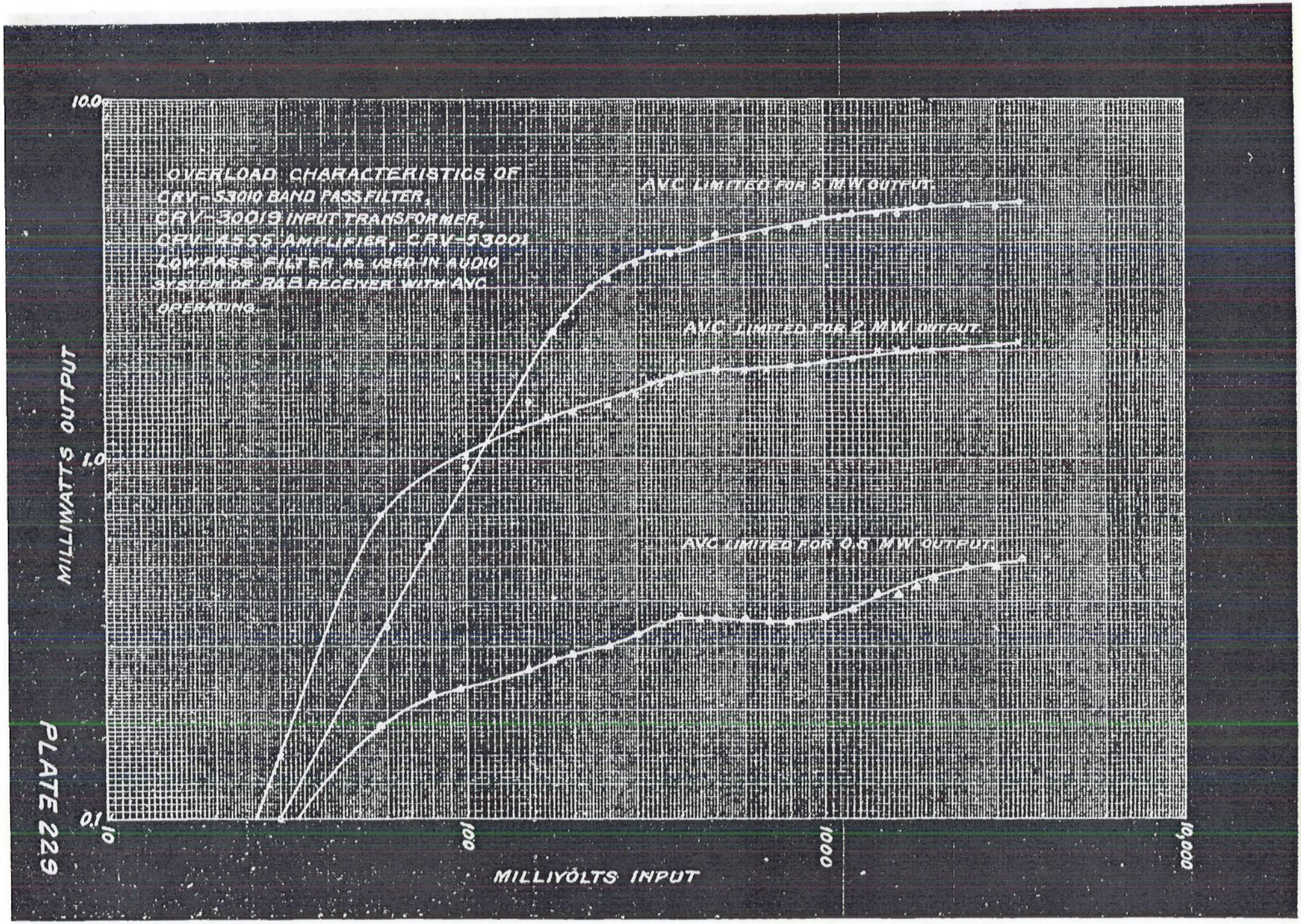

OVERLOAD CHARACTERISTICS OF
CRV-53010 BAND PASS FILTER,
CRV-30019 INPUT TRANSFORMER,
CRV-45565 AMPLIFIER, CRV-53001
LOW PASS FILTER AS USED IN AUDIO
SYSTEM OF RAB RECEIVER WITH AVC
OPERATING.
AVC LIMITED FOR 5 M.W. OUTPUT.
AVC LIMITED FOR 2 M.W. OUTPUT.
AVC LIMITED FOR 0.6 M.W. OUTPUT.
MILLIWATTS OUTPUT
10.0
1.0
0.1
10
100
1000
10,000
MILLIVOLTS INPUT

PLATE 22.9