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SHIP-SHORE RADIO DIVISION - RADIO COMM. & RADIO NAV. RECEIVER SECTION

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TEST OF ACCEPTABILITY OF PRE-PRODUCTION NAVY MODEL RXA ANTENNA MULTICOUPLER

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NRL Problem S1209T

ABSTRACT

The Model RXA Antenna Multicoupler was submitted for tests to determine its suitability for Naval use, as compared with the RCA S-8853-1 multicoupler, in accordance with reference 1. The equipment was manufactured by the Hoffman Radio Corporation, Los Angeles, California. Tests were conducted from 1 December 1945 to 1 January 1946.

The purpose of the equipment is to permit coupling up to 10 receivers to a single antenna without interaction or interference between receivers, and with minimum cross-modulation, strong signal overload, and attenuation of desired signals in the 4 to 24 Mc frequency range.

Measurements made upon the RXA multicoupler disclosed that it is superior to the RCA S-8853-1 multicoupler in respect to radiation suppression, cross-modulation, and strong signal overload from undesired signals of 10 volts or less. However, undesired signals of greater than 10 volts cause more loss in the RXA multicoupler than in the RCA S-8853-1 multicoupler. Also, the RXA multicoupler causes a greater loss in sensitivity (on a signal-to-noise ratio basis) at all frequencies (4 to 24 Mc), it provides much less gain, and it produces stronger spurious responses. The RXA multicoupler will withstand continuous operation at temperatures up to 50°C, and performance remains unchanged with temperature variation of from 25°C to 50°C.

Mechanical inspection showed the RXA multicoupler to be of unusually good construction for the type of service intended. General layout is good, components and chassis are apparently adequately protected against humidity and salt spray, wiring is neat, and accessibility is excellent.

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INTRODUCTION

1. The RXA Antenna Multicoupler was manufactured by the Hoffman Radio Corporation, Los Angeles, California. It was tested to determine its suitability for Naval use, as compared with the RCA S-8853-1 multicoupler, in accordance with the requirements of reference (1). The equipment was designed to couple up to 10 receivers to one antenna, without contributing loss or interference to desired signals in the 4 to 24 Mc range.

2. Characteristics to be compared were effect on sensitivity, gain, overload, cross-modulation, production of spurious signals, and radiation suppression. Mechanical construction features were noted, as was ability to stand relatively high ambient temperatures.

RESULTS OF TESTS

3. Sensitivity measurements were made by feeding the output from a Measurements Corporation Model 65B signal generator through a standard dummy antenna (which in the 4 to 24 Mc region appears as a resistance of 400 ohms) to (a) the antenna input of the RBC-2 receiver, (b) the input of the RXA Antenna Multicoupler, (c) the input of the RCA S-8853-1 Antenna Multicoupler. Whenever the signal generator was fed to either multicoupler, the input of an RBC-2 receiver was connected to the output of that multicoupler. The antenna trimmer of the RBC-2 was peaked for each measurement. Output of the RBC-2 receiver was observed on an externally connected General Radio Type 483C output meter. Signal generator output and receiver gain controls were adjusted for standard cw sensitivity for all measurements. Sensitivity measurements were also made for each channel of the multicoupler and were found to be within 1 db of each other.

4. As shown in Plate 1, the RXA multicoupler causes a loss in cw sensitivity at all frequencies in the 4 to 24 Mc range except from 9 to 11 Mc, where it has a gain of about 1 db. The RCA S-8853-1 multicoupler causes a loss in cw sensitivity at all frequencies in the 4 to 24 Mc range except from 8 to 14 Mc where it has a gain of about 4 db. The RCA multicoupler was operated with a 150-volt B supply in these tests; (the performance can be expected to vary with different operating voltages). The RXA unit gives lower sensitivity at all frequencies, with the difference averaging about 6 db.

5. Radiation suppression was measured from a typical receiver outlet jack to (1) an adjacent outlet jack and to (2) the antenna jack. The first measurement showed the minimum degree of isolation of "birdies" from one receiver oscillator which come in as signals on another. The second measurement showed the degree of attenuation of radiation from the antenna using the receiver oscillator as a transmitter. These measurements were made on the basis of power loss (in decibels), which takes into account the difference between input and output impedance at the appropriate multicoupler terminals.

6. The output impedance looking into a typical receiver outlet jack on the multicoupler chassis was measured with a General Radio Type 916A R-F bridge over the 4 to 24 Mc range of both the RCA and RXA multicouplers.

As shown in Plate 2, this is a rather uniform decrease from 920 ohms at 4 Mc to 565 ohms at 24 Mc on the RXA unit and from 800 ohms at 4 Mc to 180 ohms at 24 Mc on the RCA unit. The RCA unit loads the receiver more at all frequencies, which tends to reduce radiation.

7. The input impedance looking into the antenna jack of both the RCA and RXA multicouplers at the chassis is shown in Plate 3. This was measured over the same frequency range with the same R-F bridge. The RXA input impedance is 43 ohms and is somewhat inductive at 4 Mc. It increases to 2200 ohms purely resistive at 10 Mc. It then becomes capacitive, dropping to 4.8 ohms at 24 Mc. This peak in the 10 Mc region explains the improvement in sensitivity noted in paragraph 4 in the 9 to 11 Mc range, and the poor results noted at each end of the band. The RCA unit exhibits similar characteristics but only drops to 23 ohms at 24 Mc. The exact parallel resonant peak of the RCA unit was not located, as considerable extra manipulation of the bridge in this range is required, and the results appeared similar in other respects. The RXA appears to have practically reached series resonance at 24 Mc.

8. Radiation suppression was measured by feeding a known voltage from a signal generator into a multicoupler output jack, and measuring the voltage at the appropriate input jack across a series of resistive loads by a substitution method, using a decoupled receiver and signal generator. Maximum output power was determined, and was referred to input power determined from the input voltage and input impedance. The inter-channel radiation suppression thus obtained is shown in Plate 4. The RCA multicoupler suppression decreases rather uniformly from 58 db at 4 Mc to 38 db at 24 Mc. The RXA multicoupler suppression averages about 6 db better and varies more over the range. This is good performance. Suppression of radiation to the antenna is shown in Plate 5. Both multicouplers give similar performance, averaging from 120 db at 4 Mc to 85 db at 24 Mc, which is excellent.

9. Gain measurements were made by feeding the output from a Measurements Corporation Model 65B signal generator through a standard dummy antenna to (a) the antenna input of the RBC-2 receiver, (b) the input of the RXA Antenna Multicoupler, (c) the input of the RCA S-8853-1 Antenna Multicoupler. Whenever the signal generator was fed to either multicoupler, the input of the RBC-2 receiver was connected to that multicoupler. The antenna trimmer of the RBC-2 receiver was peaked for each measurement. Output of the RBC-2 receiver was observed on an externally connected General Radio Type 483C output meter. Signal generator output and receiver gain controls were adjusted for a satisfactory signal-to-noise ratio (better than 20 db), and a convenient output meter reading was obtained with the test equipment connected in accordance with (a) above. Connections were then changed as in (b) above, and the signal generator output was readjusted to restore the output reading to the original value. The difference in signal generator output levels was expressed as a gain or loss in db. Connections were then changed as in (c) above, and the foregoing procedure was repeated. Gain measurements were also made for each channel of the multicoupler and were found to agree within 1 db. The results are shown in Plate 6.

10. The RXA multicoupler provided about 12 db less gain than the RCA model. The RCA S-8853-1 multicoupler was operated at a 150-volt B supply in these tests; (the performance can be expected to vary with different operating voltages). The RXA multicoupler causes a loss in signal at all frequencies in the 4 to 24 Mc range except from 8 to 12 Mc, where it shows a maximum gain of up to 4.3 db. This is the region of highest input impedance. The RCA unit gives gain from about 5.5 to 21.0 Mc with an 18.6 db peak at 10.5 Mc, which is the region of highest input impedance. Spot frequency gain measurements were made using the same procedure and equipment, except that a dummy antenna of 60 ohms was substituted for the original 400 ohms, and a slight but not significant change in gain levels was noted.

11. Results of these gain measurements do not agree with the data supplied by the manufacturer. This may be explained by differences in test procedure, use of different types of test equipment, use of different lengths of interconnecting cables, and use of different input impedance communications receivers for the tests. The RBC-2 receiver antenna trimmer was peaked for each measurement, while the data supplied by the manufacturer did not indicate that he had done this in his tests. In practice, this would always be done if the signal were weak. These results will obviously differ widely with different antenna impedances. Neither the 50-ohm cables nor a 400-ohm antenna are likely to work into an optimum load over any appreciable frequency range, as shown in Plate 3.

12. Strong-signal overload measurements on the multicouplers were performed by simultaneously feeding the outputs of a Measurements Corporation Model 65B signal generator (fed through a 120,000 ohm protective resistor) and a Collins Model TCS-5 transmitter through a standard dummy antenna into the multicoupler input. An RBC-2 receiver was connected to a multicoupler output jack. The signal generator and receiver were set up on 6 Mc and adjusted to a level satisfactorily above noise (about 20 db signal-plus-noise to noise ratio), requiring about 12 microvolts input to the dummy antenna at 6 Mc. The transmitter was set to 11 Mc and the antenna tuning circuits were adjusted to apply high r-f voltages to the multicoupler input. These high r-f voltages were measured by a General Radio vacuum tube voltmeter connected across the multicoupler input. An attempt was made to apply 50 r-f volts to the RXA (Hoffman) multicoupler, but this resulted in destruction of the first tube (a Type 6AB7).

13. The RXA multicoupler begins to exhibit strong-signal overload with undesired r-f signals of one-half volt or more as compared to the RCA S-8853-1 multicoupler, which begins to overload with undesired r-f signals of one-tenth volt. Although the RXA multicoupler is considered better than the RCA S-8853-1 multicoupler in this respect, it would still be very vulnerable to near by radio transmitter signals. These results are shown in Plates 7 and 8.

14. Measurements of cross-modulation were made by feeding the outputs of two Measurements Corporation Model 65B signal generators (each through an 800 ohm resistor to present a composite impedance equivalent to a standard dummy antenna to the multicoupler) into:

(a) The antenna input of the RBC-2 receiver.

(b) The input of the RXA Antenna Multicoupler.

(c) The input of the RCA S-8853-1 Antenna Multicoupler.

When the signal generators were fed into either multicoupler, the input of the RBC-2 receiver was connected to the output of that multicoupler. Output of the RBC-2 receiver was observed on an externally connected General Radio Type 483C output meter.

15. With test equipment set up as at (a) above, it was impossible to develop any cross-modulation with the available output range of the signal generators (0 to 2.2 volts r-f). This established the fact that the RBC-2 receiver itself was free of cross-modulation effects.

16. One of the signal generators and the RBC-2 receiver were adjusted for standard cw sensitivity at 11.2 Mc. The other signal generator frequency was set above and below this frequency in 1 Mc steps at the output level (with 90% modulation at 400 cycles) necessary to cause a 3 db increase in the RBC-2 receiver output (above the 11.2 Mc standard cw sensitivity level). The RBC-2 receiver antenna trimmer was kept peaked on the 11.2 Mc signal. To determine that the 3 db output increase was always cross-modulation, the 11.2 Mc generator was turned off. If this caused the output to disappear, the output was due to cross-modulation and not to lack of selectivity.

17. As shown in Plates 9 and 10, the RXA multicoupler was better than the RCA unit at most frequencies throughout the 4 to 30 Mc range, from the standpoint of cross-modulation. However, the RCA S-8853-1 multicoupler was better through the 17 to 23 Mc range. Both of these units would probably be troublesome from this standpoint when operated near radio transmitting stations.

18. Measurements of spurious responses were made by setting one Measurements Corporation 65B signal generator at 6 Mc and a second 65B signal generator at 8 Mc. Outputs of these signal generators were fed simultaneously through 800 ohm resistors to: (a) the antenna input of the RBC-2 receiver, (b) the input of the RXA Antenna Multicoupler, (c) the input of the RCA S-8853-1 Antenna Multicoupler. Whenever the signal generators were fed into either multicoupler, the input of the RBC-2 receiver was observed on an externally connected General Radio Type 483C output meter. The two 65B signals resulted in the generation of spurious beats or responses within the particular piece of equipment being fed. The intensity of these responses varied with different signal generator output levels, and this intensity was measured by comparison to the signal from just one of the 65B signal generators operating at the frequency of the particular spurious response. The signal generator output was adjusted to obtain equivalent output of the spurious response at the receiver resonant frequency.

19. Spurious responses were measured at frequencies of 4, 10, 14, 20 and 22 Mc, and the results at 10 Mc produced by 6.0 and 8.0 Mc signal inputs are shown below. These were typical of those at the other frequencies. At a 1 volt level, the receiver alone gives a 110 db rejection, the RCA unit gives 58 db, and the RXA unit gives 36.5 db. Figures listed under columns (a) indicate the output of each of the two 65B signal generators (one at 6 Mc and the other at 8 Mc) for a certain output meter reading on the RBC-2 receiver. Figures listed under columns (b) indicate the output required of a third 65B signal generator (on 10 Mc) to duplicate the output meter reading of the RBC-2 receiver. The top figures under columns (a) and columns (b) are the minimum inputs for a signal-plus-noise to noise ratio of 3 db under m-c-w conditions.

SPURIOUS RESPONSES AT 10 Mc

RBC-2 receiver only			RXA Multicoupler			RCA Multicoupler		
SIGNAL			SIGNAL			SIGNAL		
(a)	(b)	Ratio	(a)	(b)	Ratio	(a)	(b)	Ratio
0.56 v	0.6 uv	119.5 db	0.5 v	2000 uv	48 db	17,500 uv	0.2 uv	98 db
1	3	110	1	15,000	36.5	1 v	1250	58
2	11.5	85	2	200,000	20	2	60,000	30.5

20. The RXA multicoupler was tested under conditions of high temperature with relative humidity below 50% at all times. Equipment was set up as shown in Plate 11 at room temperature (25°C), and adjusted for standard c-w sensitivity (2 microvolts at 14 Mc). The entire equipment was stabilized by operating at room temperature for 4 hours and measurement of sensitivity disclosed no change. Then heat was supplied and the temperature was stabilized at 50°C. The equipment was operated at 50°C for 36 hours and measurements of sensitivity each hour disclosed no change within measurement accuracy (about 1 db). Then the temperature was dropped to room value and with the equipment operating for an additional period of 16 hours, the final measurement of sensitivity showed no change within measurement accuracy from the original measurement. This is excellent performance over this range.

CONCLUSIONS

21. Upon the basis of the tests conducted, the subject equipment is not considered suitable for use aboard any Naval vessel upon which a transmitter could operate during periods of reception, or at any Naval shore station where the field strength of any transmitting station (operating in the frequency range from about 4 to 40 Mc) would deliver a value of 0.1 to 1.0 volt of r-f at the multicoupler input jack. In addition to being subject to cross-modulation and spurious responses, the subject equipment produces a sensitivity loss (on a signal-to-noise ratio basis) at

frequencies tested (except the narrow band of 9 to 11 Mc, where there was a peak gain of about 1 db), it produces a gain loss except in the 8 to 12 Mc region on a standard antenna, and has insufficient strong-signal overload protection. The input impedance varies widely over the useful frequency range. The mechanical construction is unusually good and well arranged, with excellent accessibility. High quality parts and excellent workmanship are displayed. The equipment will operate satisfactorily at high ambient temperatures.

RECOMMENDATIONS

22. It is recommended that devices of this nature not be used when separate antennas or direct paralleling systems can be employed. If such a device must be employed, this one is well built and gives typical performance.

REFERENCES

1. BuShips ltr. Serial No. 2162 (925Cm) of 20 Sept. 1945 to NRL.

2. Specification 16M4(RE) with amendment 1.

3. BuShips Spec. RE 13A 554E.

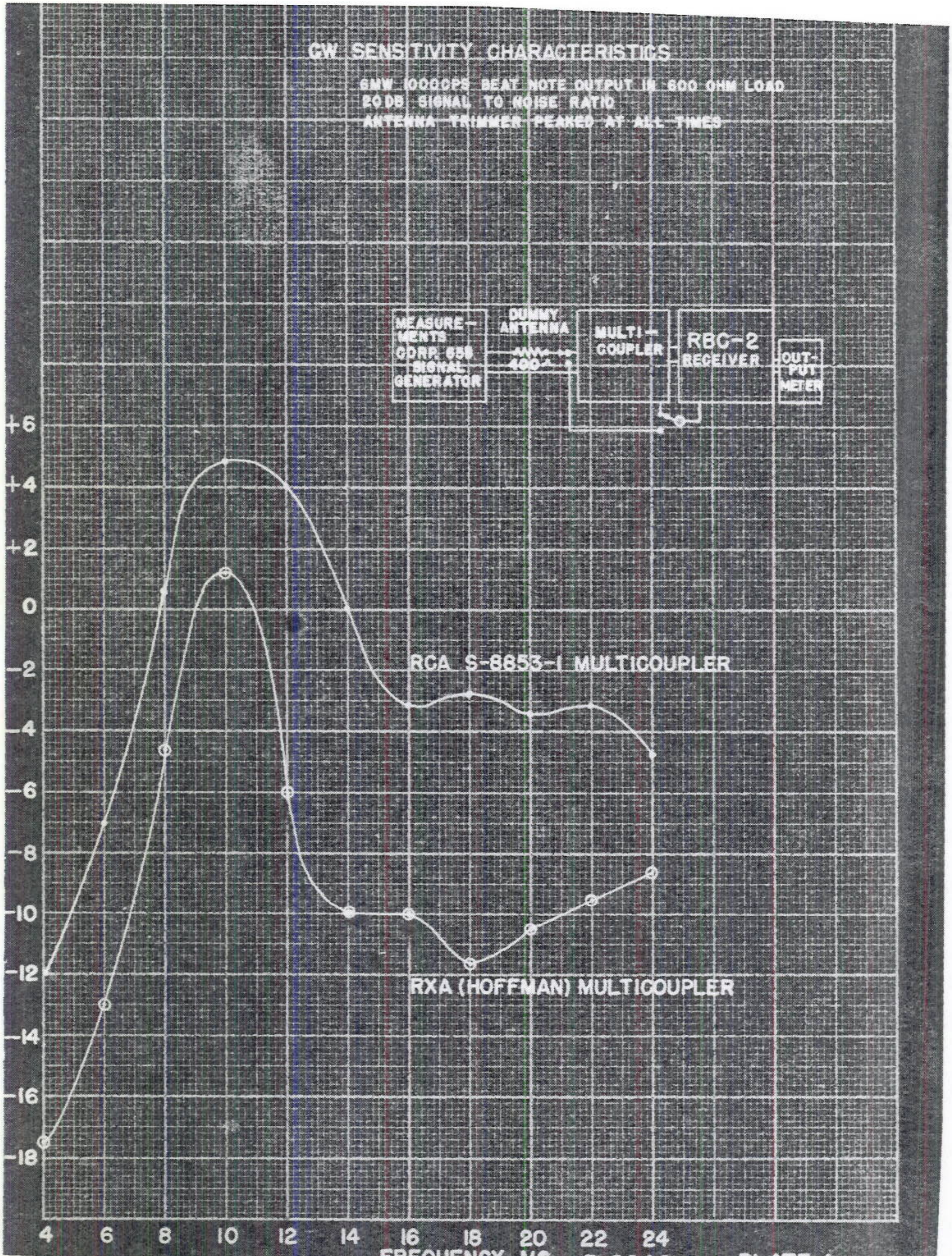

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PLATE I

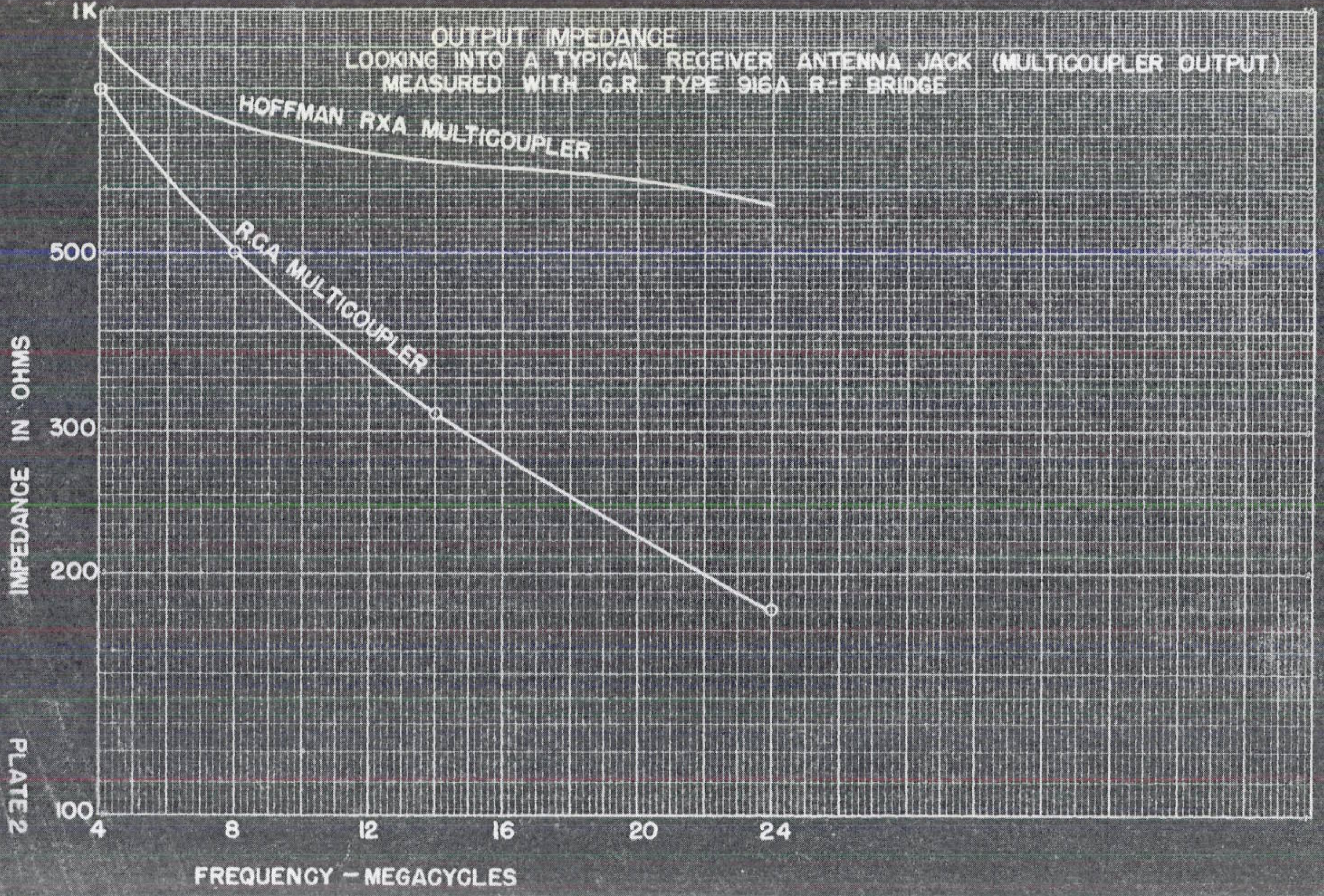

PLATE 2

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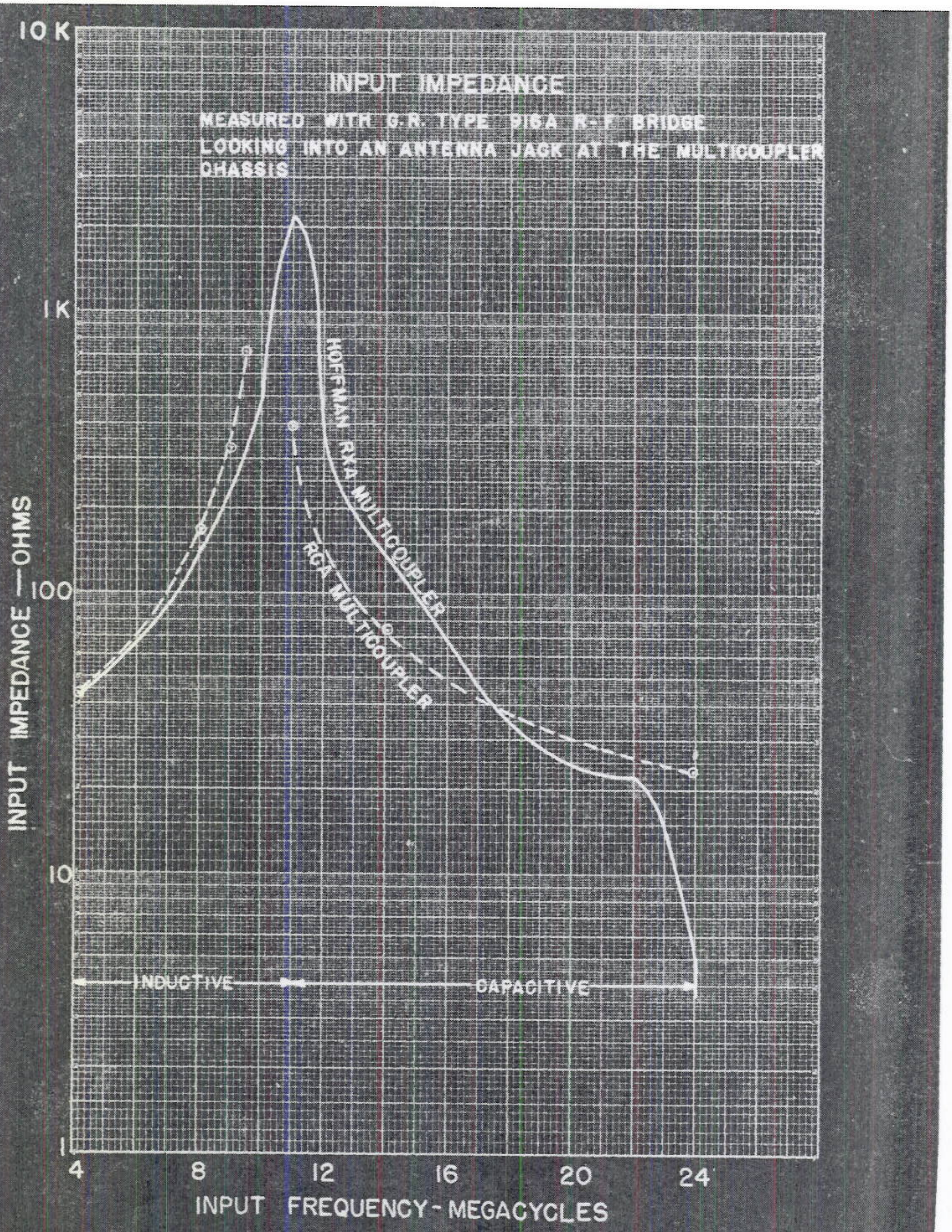

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PLATE 3

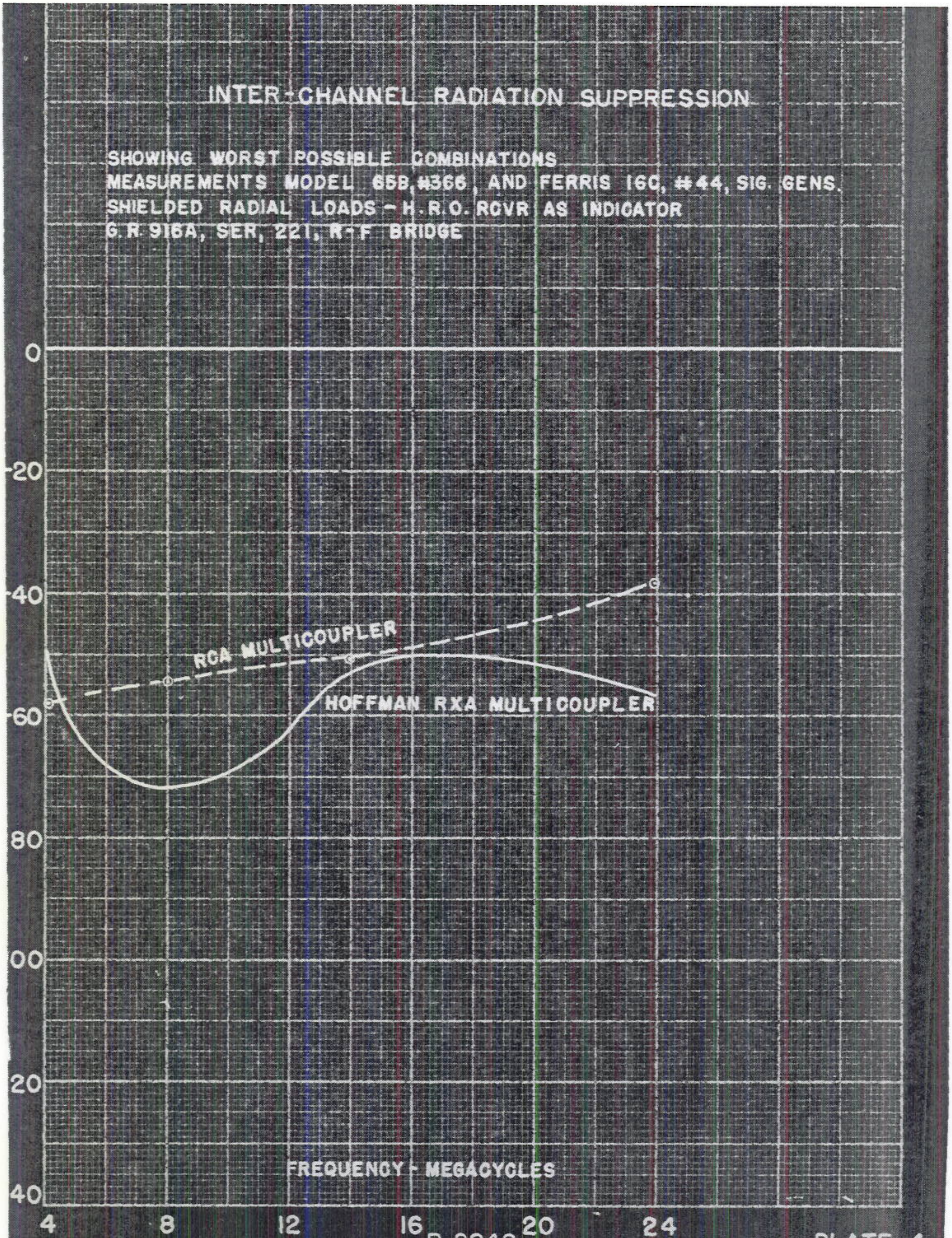
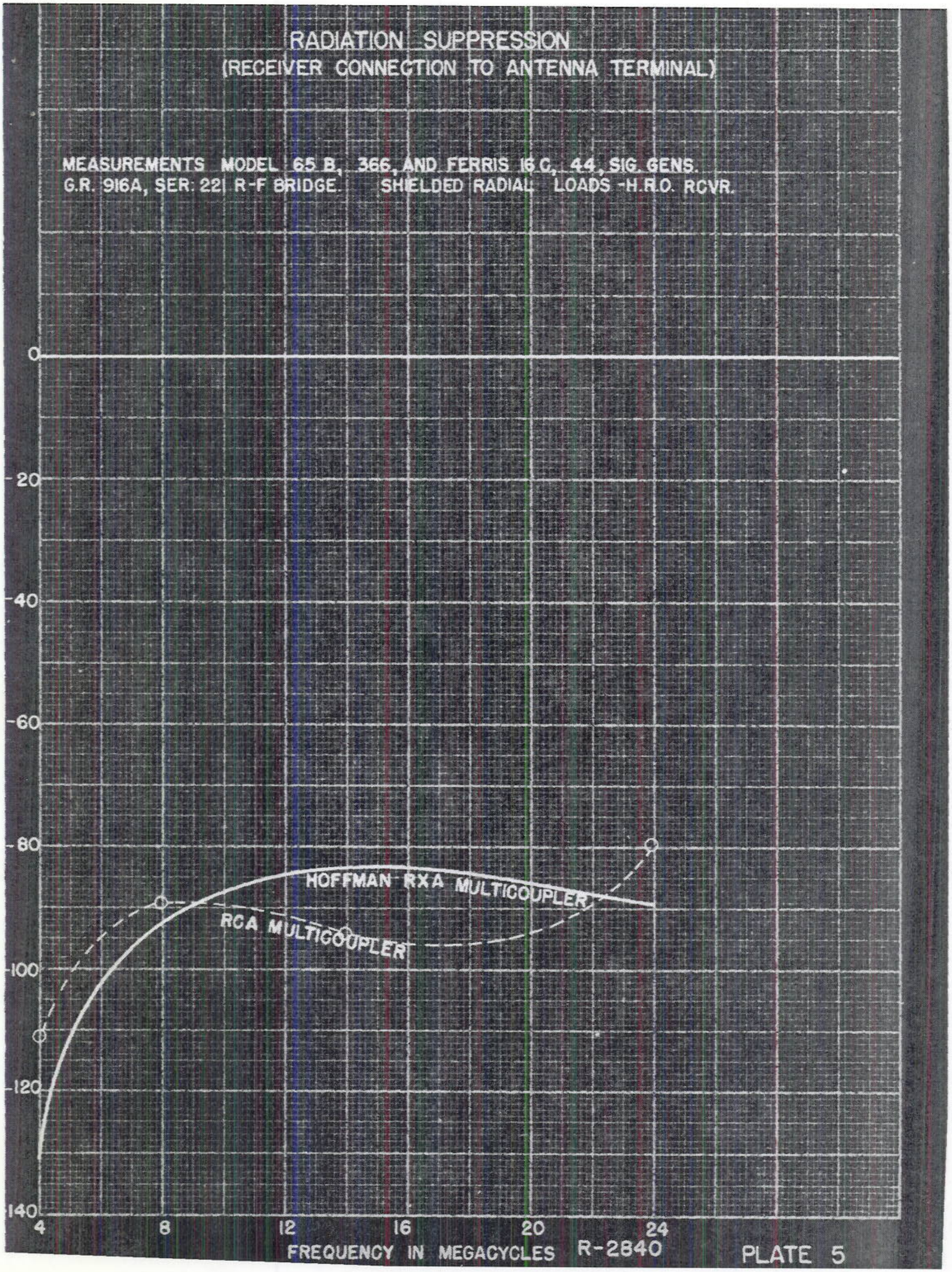

INTER-CHANNEL RADIATION SUPPRESSION
SHOWING WORST POSSIBLE COMBINATIONS
MEASUREMENTS MODEL 65B, #366, AND FERRIS 16C, #44, SIG. GENS.
SHIELDED RADIAL LOADS - H.R.O. RCVR AS INDICATOR
G.R. 916A, SER, 221, R-F BRIDGE
RCA MULTICOUPLER
HOFFMAN RXA MULTICOUPLER
FREQUENCY - MEGACYCLES
0
-20
-40
-60
80
00
20
40
4
8
12
16
20
24

PLATE 4


RADIATION SUPPRESSION
(RECEIVER CONNECTION TO ANTENNA TERMINAL)
MEASUREMENTS MODEL 65 B, 366, AND FERRIS 16 C, 44, SIG. GENS.
G.R. 916A, SER: 221 R-F BRIDGE. SHIELDED RADIAL LOADS - H.R.O. RCVR.
HOFFMAN RXA MULTICOUPLER
RCA MULTICOUPLER
0
-20
-40
-60
-80
-100
-120
-140
4
8
12
16
20
24
FREQUENCY IN MEGACYCLES
R-2840
PLATE 5

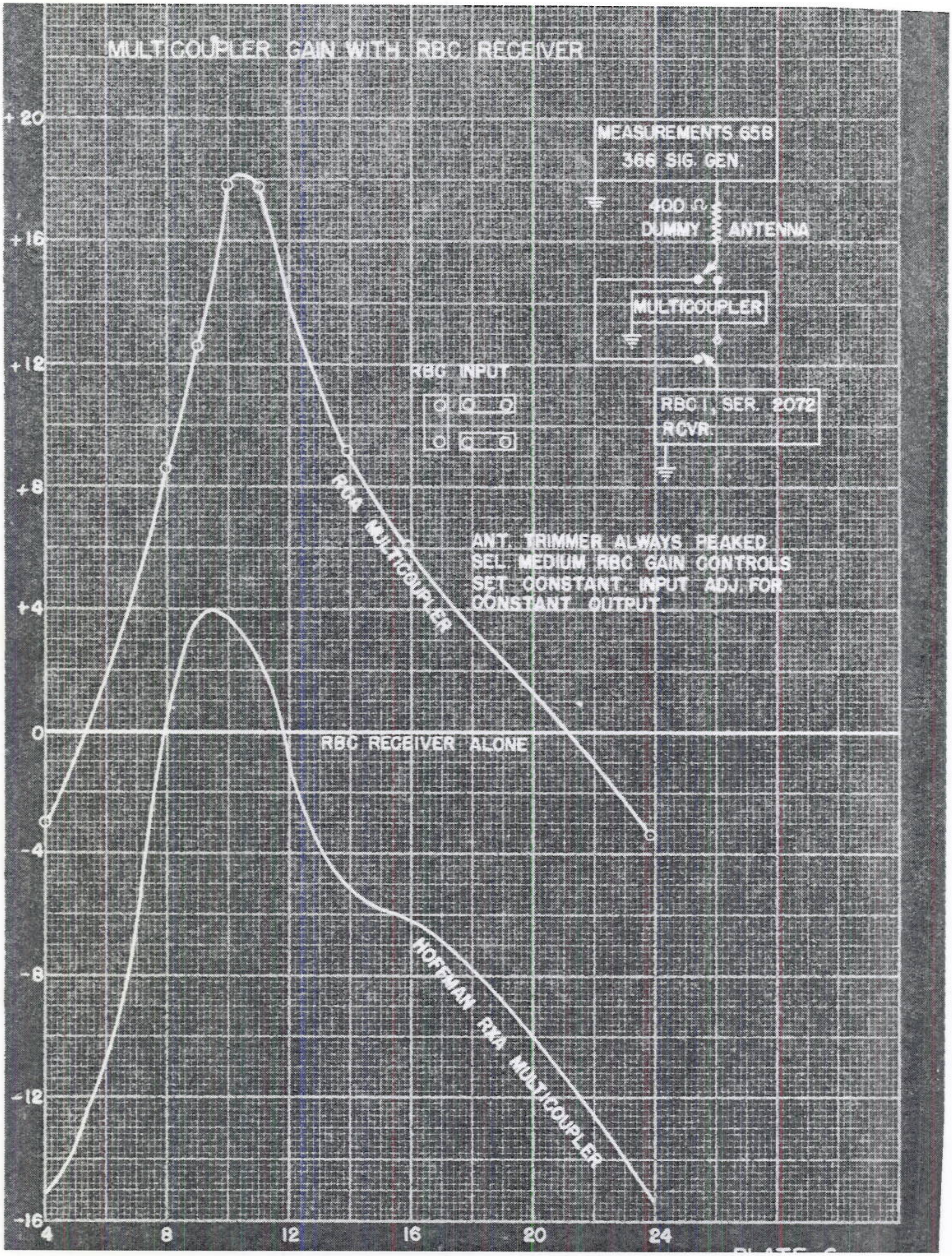

MULTICOUPLER GAIN WITH RBC RECEIVER
MEASUREMENTS 65B
366 SIG. GEN.
400 Ω
DUMMY ANTENNA
MULTICOUPLER
RBC 1, SER. 2072
RCVR.
RBC INPUT
RCA MULTICOUPLER
ANT. TRIMMER ALWAYS PEAKED
SEL. MEDIUM RBC GAIN CONTROLS
SET CONSTANT. INPUT ADJ. FOR
CONSTANT OUTPUT.
RBC RECEIVER ALONE
HOFFMAN RXA MULTICOUPLER
+20
+16
+12
+8
+4
0
-4
-8
-12
-16
4
8
12
16
20
24

PLATE 6

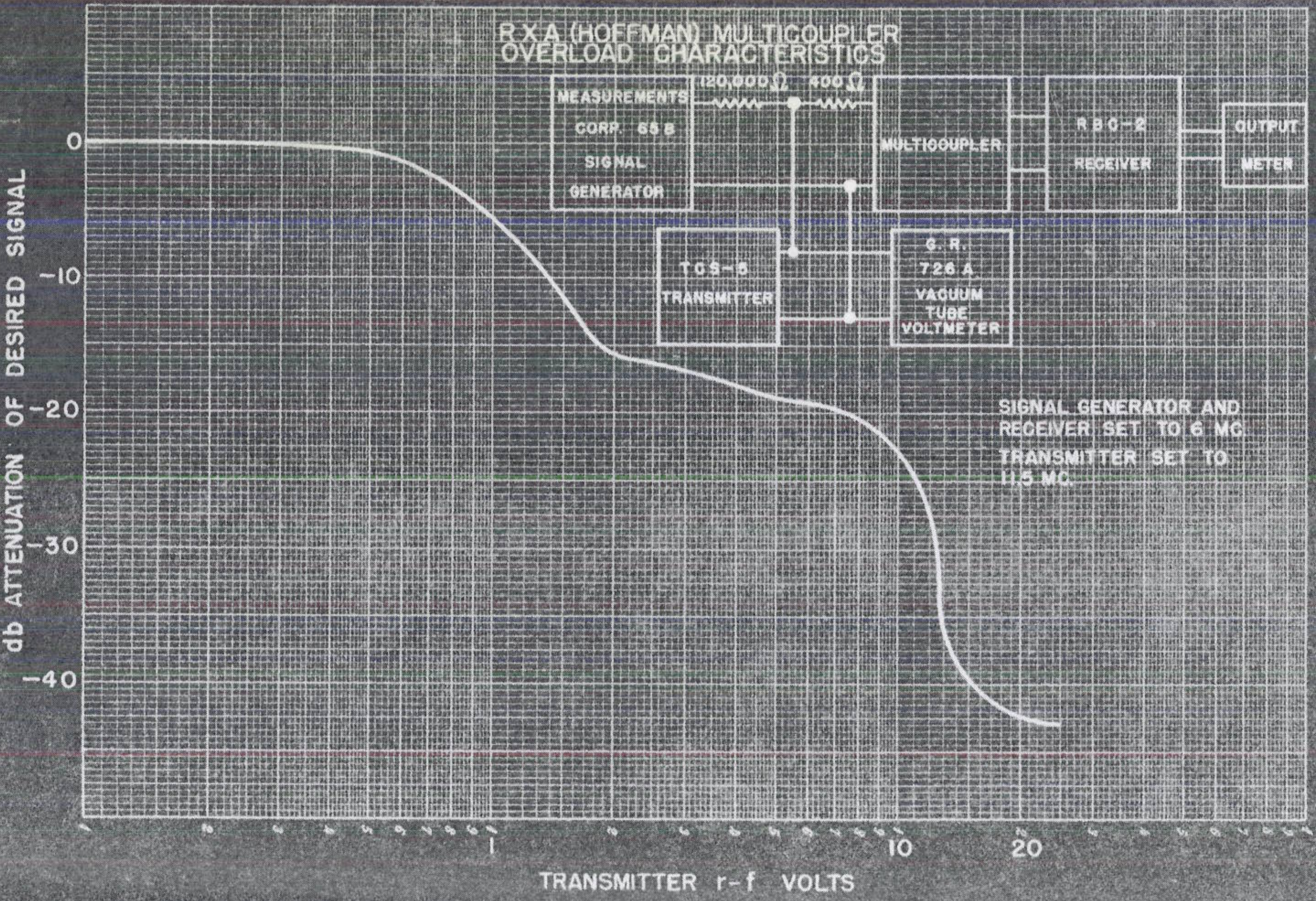


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PLATE 7

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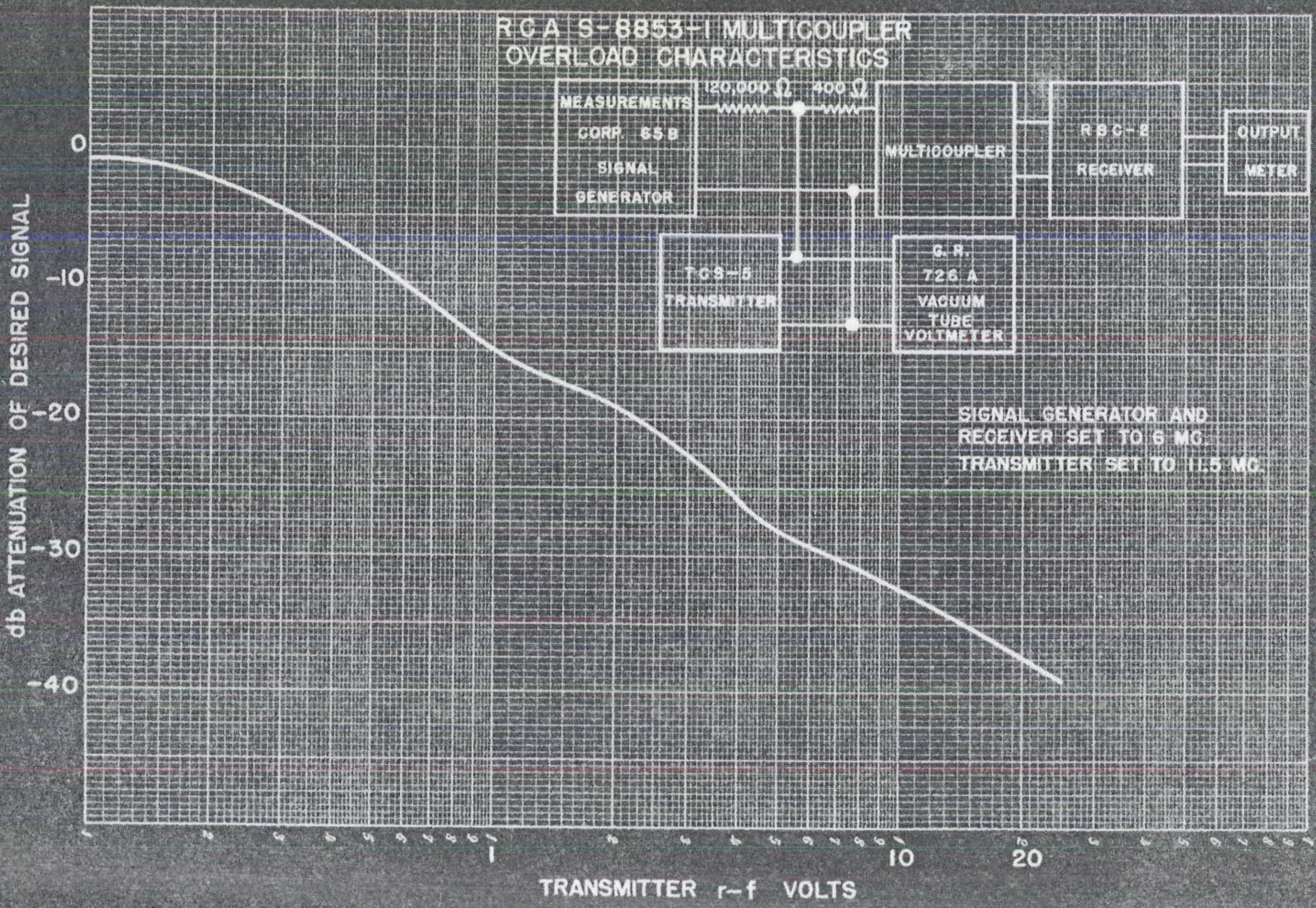
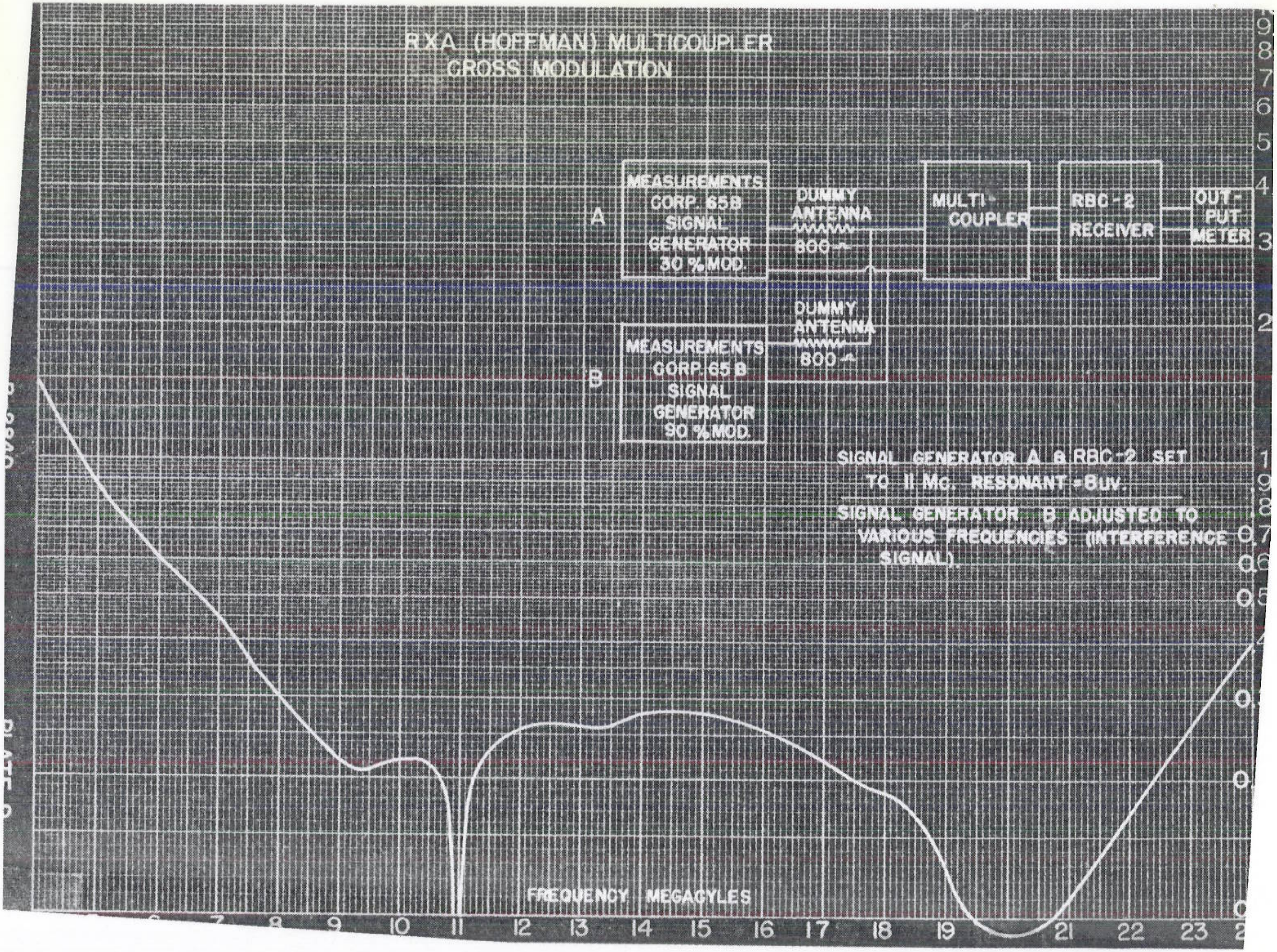


PLATE 8


RXA (HOFFMAN) MULTICOUPLER
CROSS MODULATION
A
MEASUREMENTS CORP. 65B SIGNAL GENERATOR 30 % MOD.
DUMMY ANTENNA 800 Ω
MULTI-COUPLER
RBC-2 RECEIVER
OUT-PUT METER
B
MEASUREMENTS CORP. 65 B SIGNAL GENERATOR 90 % MOD.
DUMMY ANTENNA 800 Ω
SIGNAL GENERATOR A & RBC-2 SET TO 11 Mc. RESONANT = 8uv.
SIGNAL GENERATOR B ADJUSTED TO VARIOUS FREQUENCIES (INTERFERENCE SIGNAL).
FREQUENCY MEGACYLES
7
8
9
10
11
12
13
14
15
16
17
18
19
21
22
23

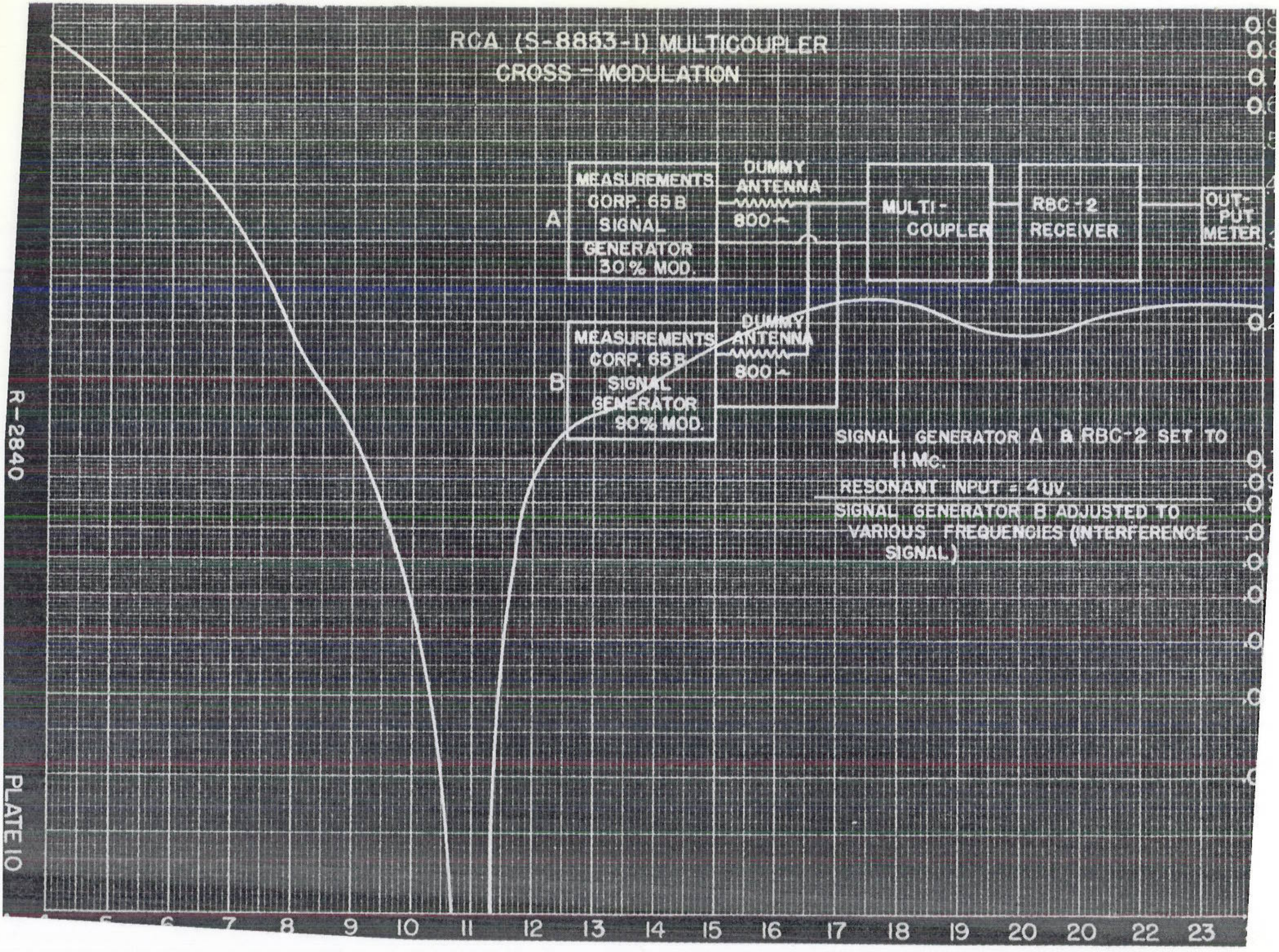


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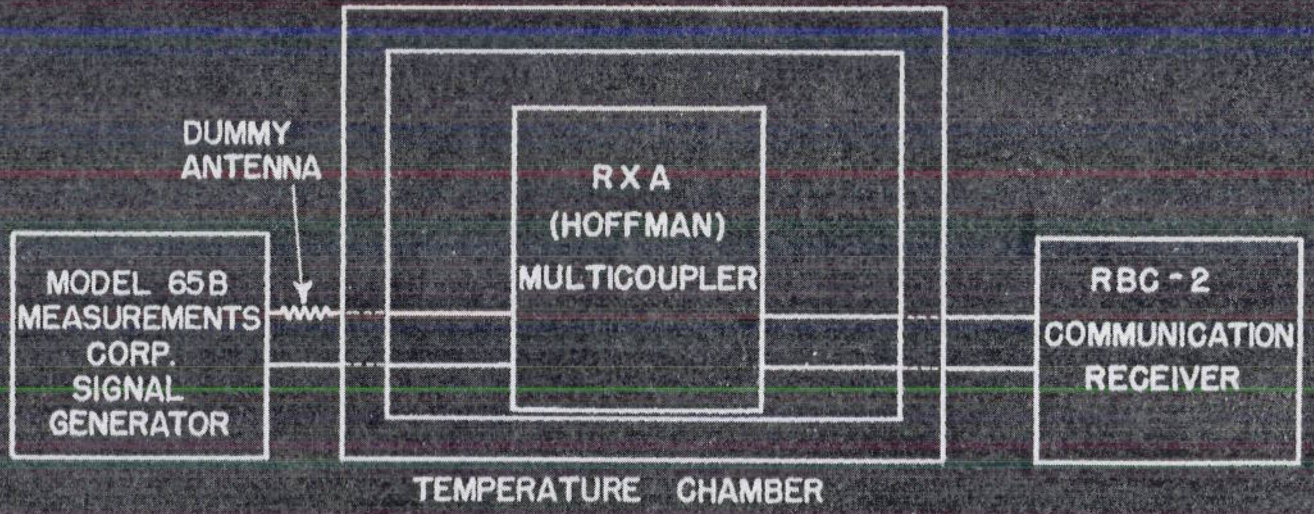
PLATE 10

TEMPERATURE CHAMBER EQUIPMENT SETUP



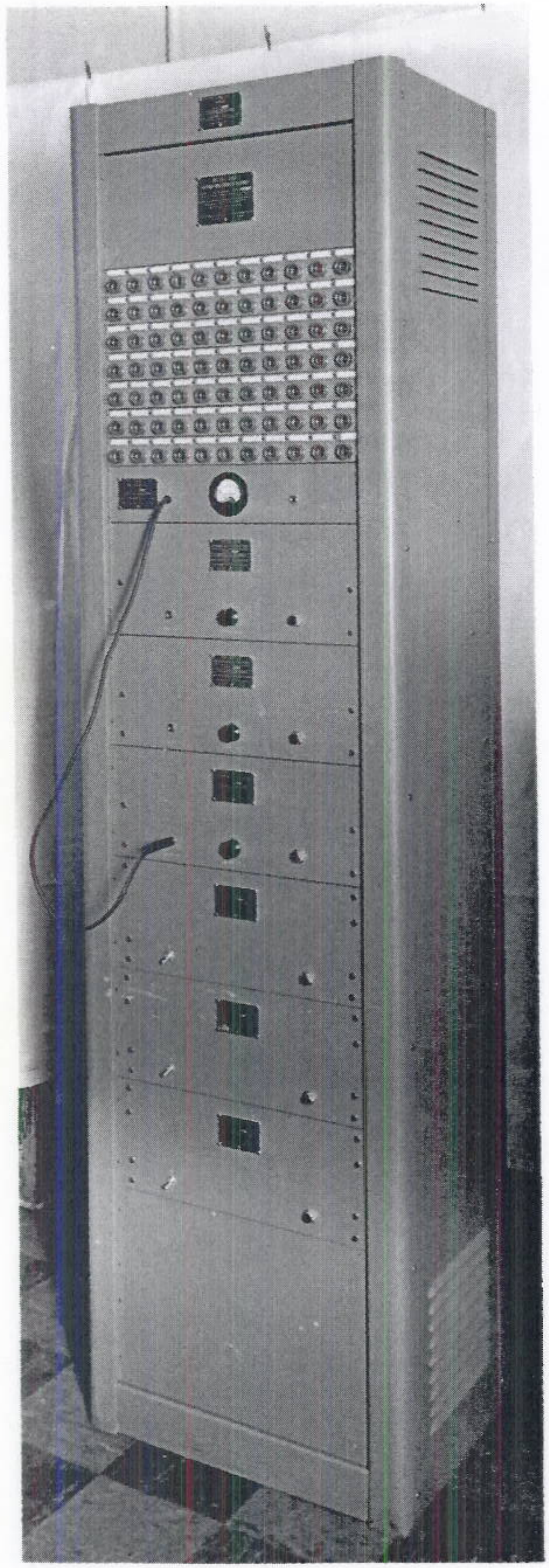


PLATE 12

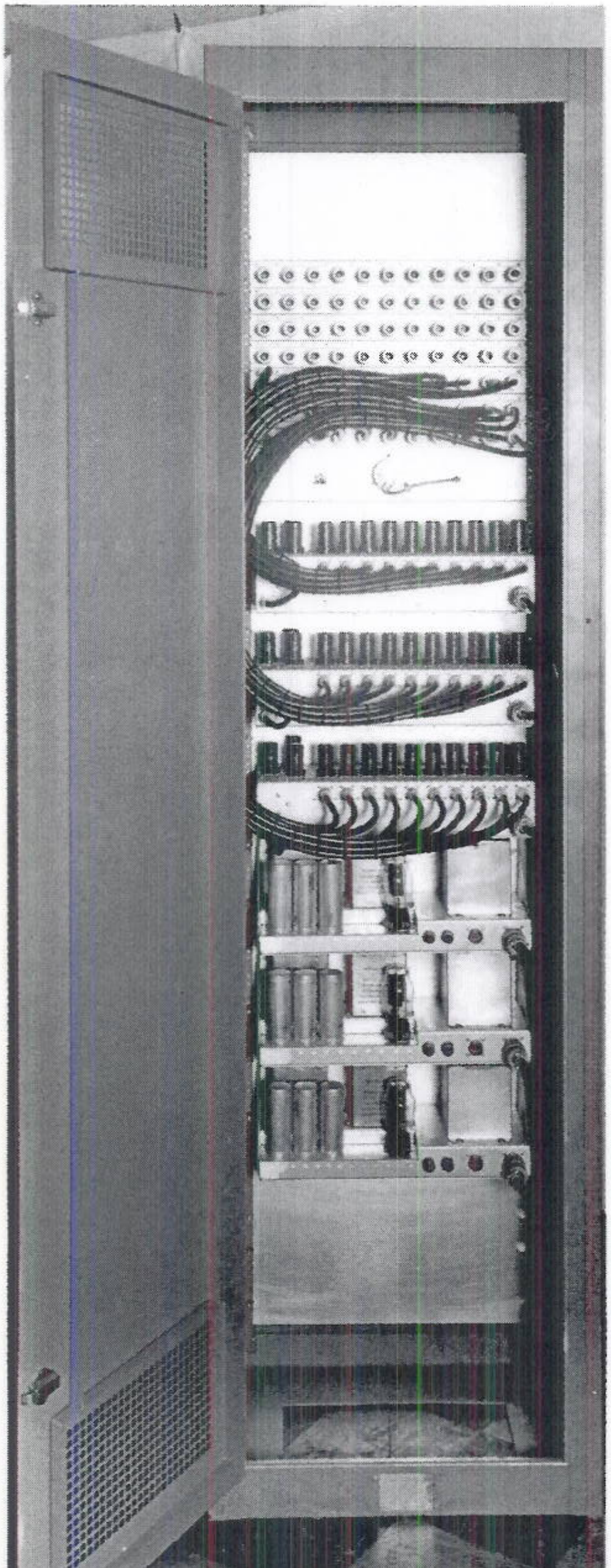


PLATE 13

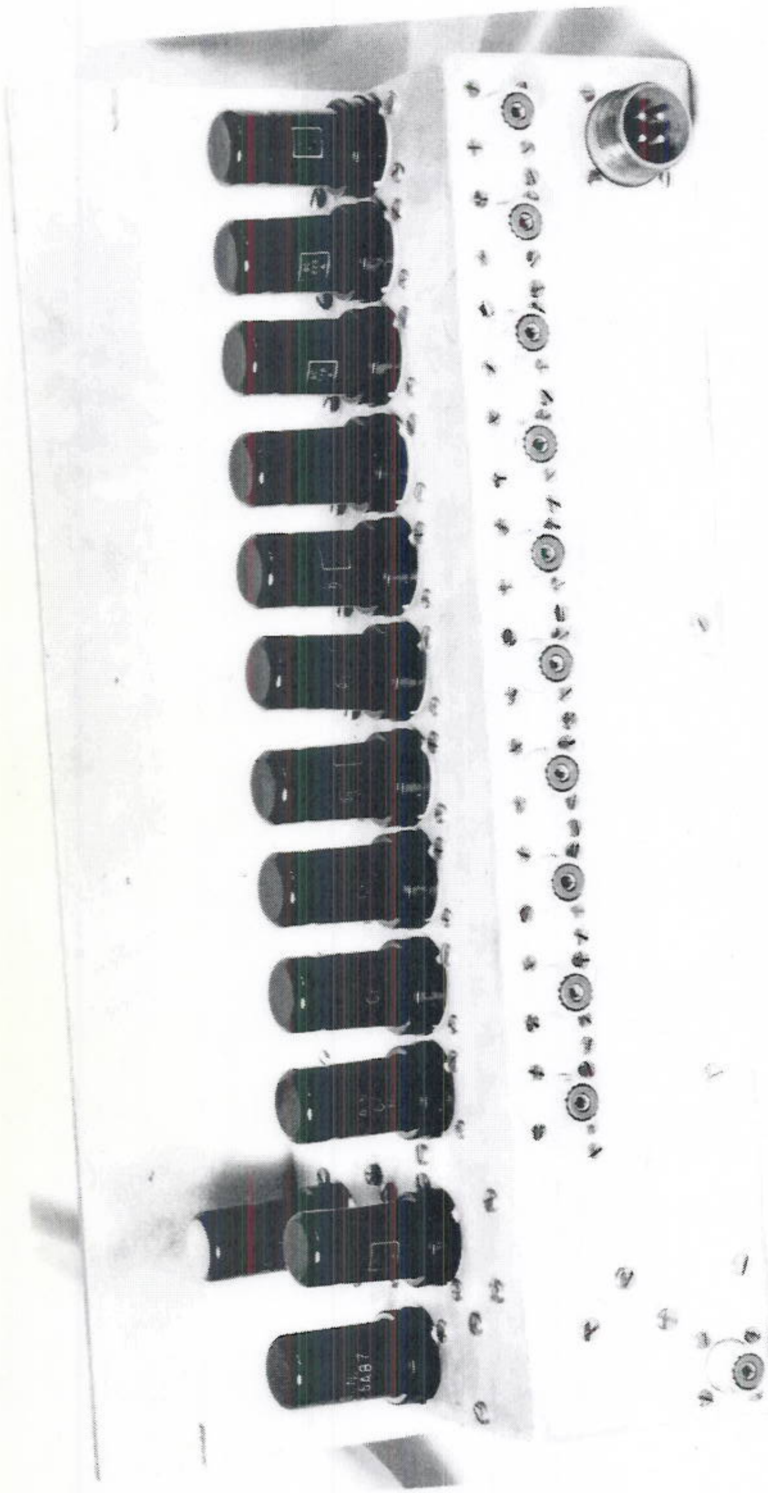


PLATE 14

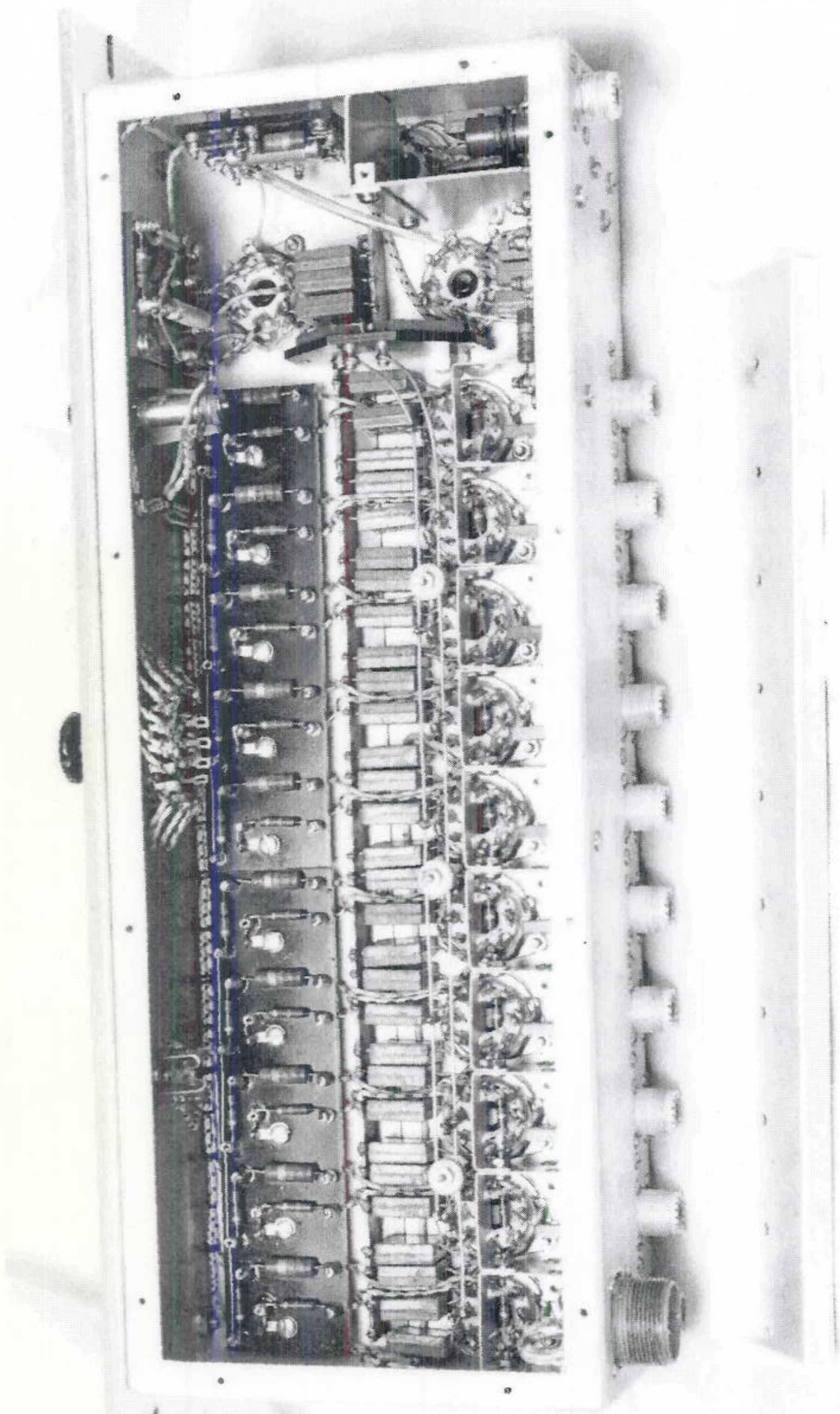


PLATE 15

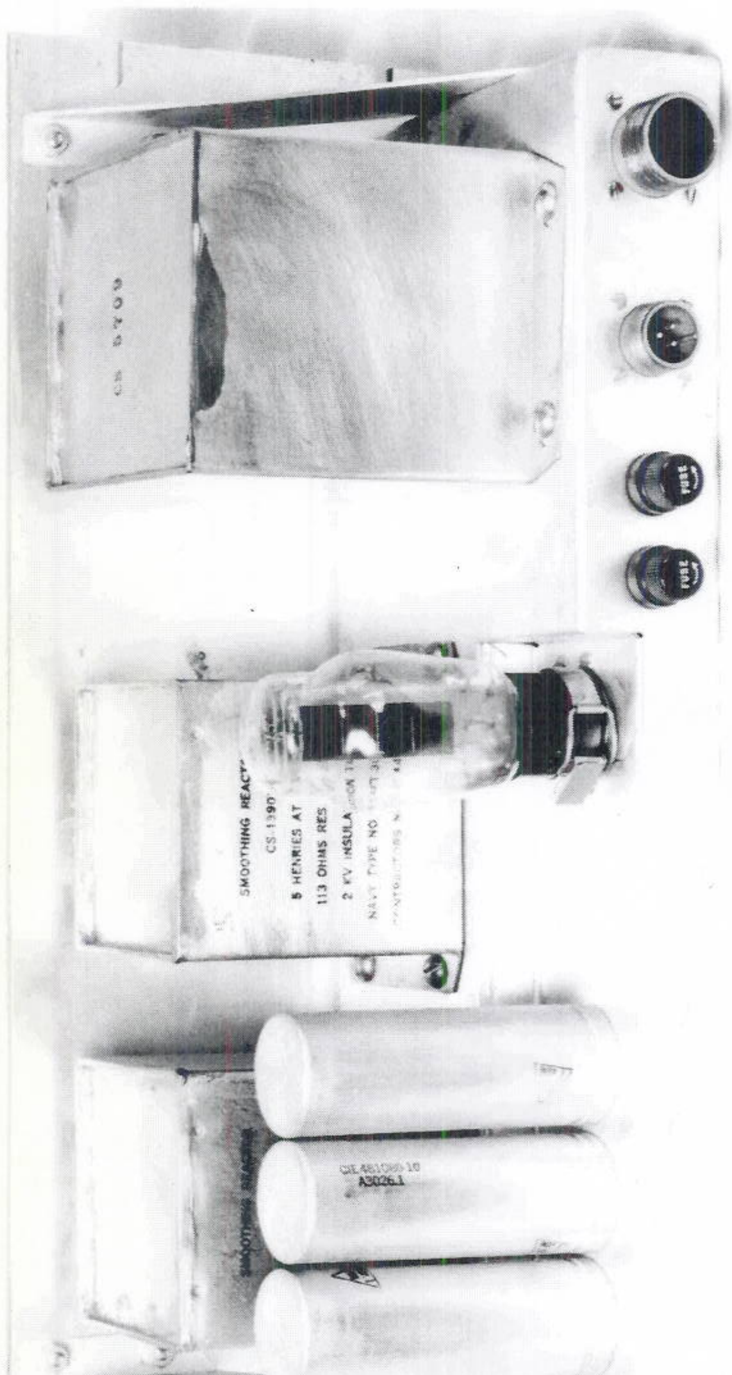


PLATE 16

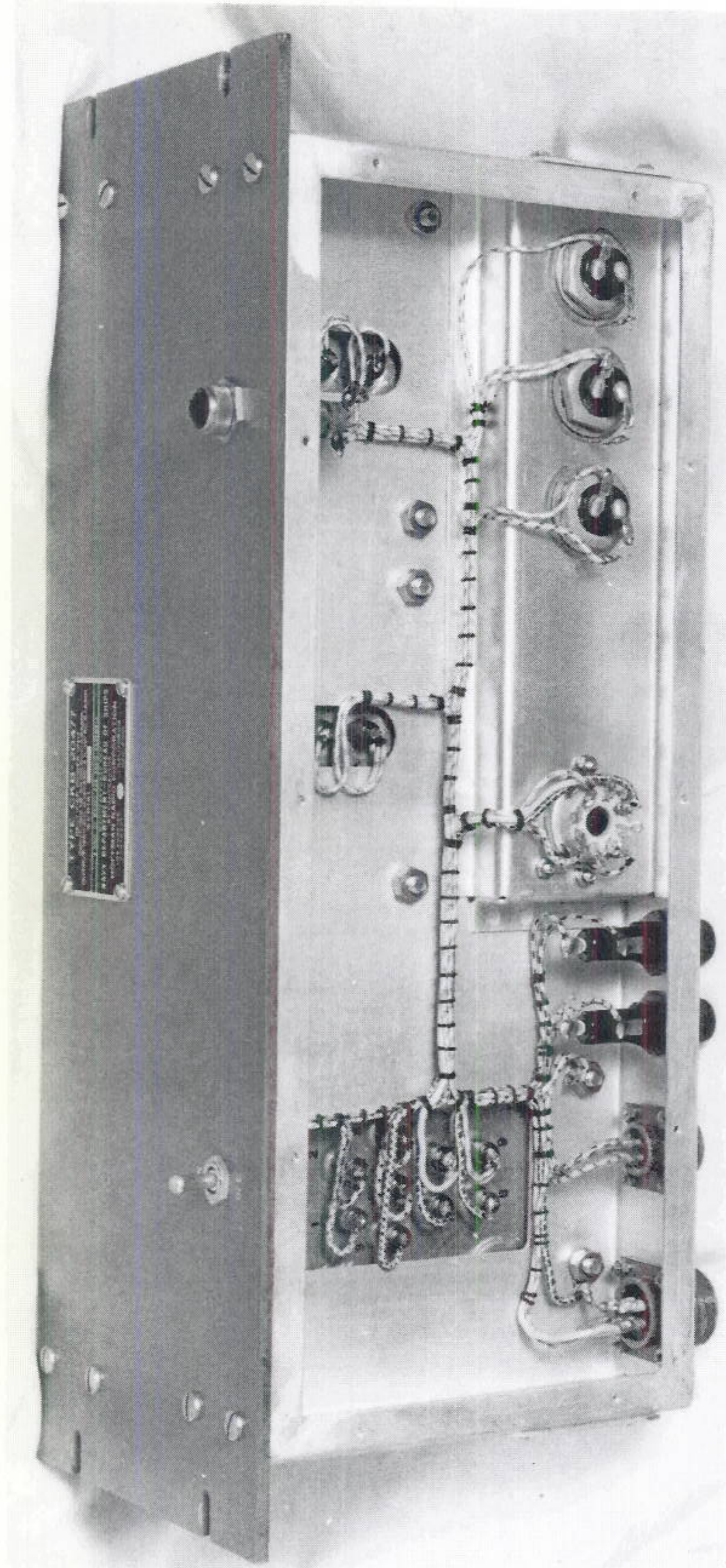


PLATE 17