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SUBJECT

Tests on Model XGR and XRAP Aircraft Radio

Transmitting and Receiving Equipment

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NAVAL RESEARCH LABORATORY

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Tests on Model XGR and XRAP Aircraft Radio Transmitting and Receiving Equipment

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BuEng Prob.A2-8C

NAVY DEPARTMENT

Report on

Tests on Model XGR and XRAP Aircraft Radio Transmitting and Receiving Equipment

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NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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(3) The i-f rejection meets the requirement except on frequencies which are harmonics of the intermediate frequency.

(4) Bands A and B do not meet the resonance stability requirements for temperature variation.

(5) The receiver meets the requirements for undistorted power output at all specified frequencies except 200 cycles.

(6) The automatic sensitivity control meets the requirements when the input necessary for 50 milliwatts output is 5 microvolts or more. With lower values of input voltage which necessitate approaching full gain for 50 milliwatts output, the receiver does not meet the requirements. Since the value of input voltage is not specified, it is concluded that the equipment meets the requirements.

(7) The "Q" of the loop does not meet the requirements.

(8) The loop movement to obtain full scale right or left indication and the right and left bearing agreement do not meet the requirements on all frequencies.

(9) The equipment does not meet the requirements for weight and dimensions in all instances.

[redacted]

Recommendations

As a result of these tests, it is recommended:

(a) That the equipment be considered unsatisfactory for Naval aircraft service use until the manufacturer demonstrates that he can correct the deficiencies herein noted to the satisfaction of the Bureau of Engineering.

(b) That the specifications be checked for requirements as to "frequency stability for ambient temperature change versus temperature coefficient of the crystals." Paragraph 3-9 gives a tolerance of 0.01% while the frequency stability under Production Tests (6-13-6-c-1) gives 0.005%.

(c) That the specifications be checked for requirements as to dimensions of receiver control box. Paragraph 3-2(11) and attached drawing are not in agreement. Also paragraphs 2-29 and 4-2(2) concerning the housing for the visual course indicator are not in agreement.

(d) That the changes listed in references (h) and (i) be incorporated in the equipment with the exception of that of paragraph 3-33 of reference (i). This paragraph should be changed to read, "The undistorted power output at 400 to 2500 cycles taken at that point at which the receiver output voltage contains 10% total harmonics shall not be less than 400 milliwatts."

[redacted]

EQUIPMENT UNDER TEST

4. The transmitting equipment consists of a four channel transmitter, control box, dynamotor and connecting cables. The transmitter consists of four crystal controlled channels which may be tuned to any crystal frequency in the band of from 3,000 to 7,000 kilocycles. Four frequencies may be set up at one time and the changing of frequencies is accomplished electrically by a motor controlled at the pilot's control box. The transmitter is of the crystal oscillator - power amplifier type using the same tubes for all frequencies, switching only the associated coils. A common modulator and amplifier for microphone pick-up is provided, plate modulating the power amplifier tubes in the transmitter. All controls are for screw driver tuning only, the oscillator controls being provided with a locking device. The equipment is for voice transmission only. It is designed to operate off the airplane battery, a dynamotor furnishing the necessary plate supply.

5. The receiving equipment consists of a conventional superheterodyne receiver and visual homing indicator circuits. It may be used for the reception of phone, cw, and mcw signals within the frequency range of 200 to 1600 kilocycles and 2 to 8 megacycles. There is, in addition, a fixed frequency of 278 kilocycles. The frequency range, including the fixed frequency, is covered by six electrically switched bands. The equipment is designed for remote control only. A remote control unit, a remote tuning unit, dynamotor, left-right indicator, loop antenna and associated connecting cables are a part of the equipment. The entire power source is obtained from the airplane battery.

METHOD OF TEST

Transmitter

6. Power input. The d-c electrical input was measured at a battery voltage of 13 volts by means of an ammeter in series with the leads connecting the dynamotor to the battery. Measurements were made simultaneously with carrier power measurements.

7. Carrier power output. The carrier power output into a dummy antenna was measured by reading the antenna current at the ground end of the dummy antenna by means of an r-f ammeter previously calibrated at a frequency of 60 c.p.s. The dummy antenna consisted of a combination of Ward Leonard plaque resistors and an air condenser.

8. Frequency range of channels. Each channel was tuned to each crystal supplied between 2950 kilocycles and 7050 kilocycles or eleven crystals in all as follows:

2950 kilocycles
3000
3105
3120
3130
4220
5200
6210
6630
7000
7050

[redacted]

9. Frequency drift with ambient temperature change. The transmitter was placed in the refrigerator and tuned to four frequencies; 3000, 3105, 6200, and 6210 kilocycles. The refrigerator was cooled down to approximately -30° C when the transmitter was turned on. The change in frequency was measured on a Model LK-1 frequency drift meter. The temperature of the refrigerator box was then allowed to drift up to +50° C and readings were taken of the frequency drift and temperature of the box. Only four frequencies could be measured due to the limitations of the measuring equipment. A battery voltage of 13 volts was maintained throughout the tests.

10. Crystal accuracy. The various crystals supplied ranging in frequency from 2950 to 7050 kilocycles were inserted in the transmitter and the circuits adjusted for maximum r-f output. Measurement of the crystal frequencies was then made on a Navy type heterodyne frequency meter. Measurements were made on each crystal at a room temperature of approximately 30° C.

11. Interaction between channels. The transmitter was adjusted for maximum output from channels 1 and 2, each channel containing a crystal of the same frequency. With channel 1 in operation, channel 2 was first detuned in single stages and then completely detuned. This procedure was to determine interaction, if any, between the channels. Then with channel 2 in operation, channel 1 was detuned. The above procedure was repeated with the exception that the crystal in channel 2 was replaced by a crystal of twice the frequency of that in channel 1.

12. Audio frequency response. The transmitter was tuned to one frequency in each channel; namely, 3000, 4220, 6210, and 7000 kilocycles. A diode detector was coupled to the r-f output and the voltage across a resistor in the diode cathode circuit was measured. This voltage value was taken as a measure of the modulating characteristic. A General Radio beat frequency oscillator furnished the modulating voltage for the transmitter. The microphone current was previously measured and the microphone mixer circuit between the beat frequency oscillator and transmitter was adjusted for this current value. The transmitter was then adjusted for 85% modulation at 1,000 cycles as observed on a cathode ray oscillograph. The audio voltage as read across the cathode resistor in the diode detector by means of a Ballantine electronic voltmeter was taken as the base voltage for calculation of the change in output in decibels. Modulation frequencies from 200 cycles to 5,000 cycles were then fed into the transmitter. The audio voltages developed in the diode detector were noted. The change in decibels was calculated for each modulation frequency and a response curve was plotted for each transmitter carrier frequency.

13. Distortion measurements. With maximum power output of the transmitter, a modulation signal of 400 cycles from the beat frequency oscillator was impressed through the microphone mixer to the transmitter. The modulated r-f output was observed on the cathode ray oscillograph. The audio input was adjusted to give 85% modulation. The output of a diode detector coupled to the transmitter was fed into a previously calibrated wave analyzer which gave the percentages of harmonics present. From these values the total harmonic distortion was calculated for one frequency in each band.

14. The transmitter was tuned for maximum power output. Using a Navy Type RS-38 microphone, the modulation characteristics were noted on a cathode ray coupled to the transmitter output.

15. Carrier noise. This measurement was made at the same time the frequency response curve was taken by measuring the voltage across the cathode resistor of the diode detector with no modulation voltage input to the transmitter.

16. Time for changing frequencies. The time for changing frequencies; that is, changing from one channel to another channel was noted by observing the time required to change from channel 4 to channel 1, the maximum time for any change, by the use of a stop watch, noting the time between the changing of the control knob and the time the transmitter motor control had arrived at the new setting.

17. The construction of the shock absorbers used was examined for compliance with requirements of the specifications.

Receiver

18. Current drain. A precision ammeter was connected in the primary supply circuit. The receiver was adjusted to the condition of maximum current drain with the right-left indicator connected. The current was recorded at various voltages from 11 to 15 volts inclusive.

19. Frequency range, calibration accuracy and overlap. A crystal frequency indicator and an output power meter were used in conducting this test. The resonance frequency was measured at the extreme ends of the tuning range and at the calibration points of each band. From the results, the frequency range, calibration accuracy, and overlap were determined.

20. Sensitivity. The sensitivity of the receiver was determined on cw and mcw with the use of a standard signal generator and an output power meter. With the receiver adjusted for a noise level within the specification requirements, the input in microvolts necessary to produce standard output were recorded for various frequencies.

21. Selectivity. A standard signal generator and an output power meter were used in conducting this test. With a 10 microvolt input, the receiver was adjusted for standard output. The standard signal generator was detuned from resonance, the input to the receiver increased 10, 100, and 1000 times and the signal generator tuned, from above and below, toward resonance at each of these multiples of input voltage until standard output was again obtained. The selectivity was determined as the spread in kilocycles between these settings and that at resonance.

22. Fidelity. A beat frequency oscillator, standard signal generator, and an output power meter were used in determining the fidelity of the receiver. The receiver was adjusted for standard output with a 100 microvolt carrier modulated 30% at 400 cycles.

[redacted]

The modulation frequency was then adjusted in steps from 200 to 2500 cycles and the output recorded at each frequency. The fidelity was recorded as the output variation in terms of decibels with respect to the output at 1000 cycles.

23. Image response. The image response was determined with the use of a standard signal generator and an output power meter. The receiver was adjusted for standard output. With all controls of the receiver remaining fixed, the signal generator was tuned to the image frequency and the input to the receiver adjusted to obtain standard output. The attenuator being limited to 0.1 volt and this value being insufficient to obtain standard output at the lower frequencies, a fixed input of 1.0 volt was applied. The output under this condition was observed and the input to obtain the same output at resonance was recorded. The image response was determined as the ratio of the input voltages at the image and resonance frequencies.

24. Rejection of conversion frequency. The rejection of the conversion frequency was determined in the same manner as the image response except that the input to the receiver was at the intermediate frequency.

25. Resonance stability. The effect of temperature variation on the stability of the receiver was determined with the use of a temperature control chamber and a frequency indicator. The equipment was installed in the chamber and allowed a half hour warm-up period. The output of the frequency indicator was coupled to the receiver which was adjusted for standard output with the sensitivity control adjusted for low noise level. The temperature was varied over the range of the control chamber (-20° to +50° C) and at regular intervals the frequency indicator was adjusted for maximum output when the receiver was adjusted for mcw and for zero beat when adjusted for cw. The frequency was recorded at each adjustment and the drift determined over any 20° change of temperature.

26. The effect due to humidity variation was determined with the use of the same apparatus as above. A humidity condition was introduced within the chamber ranging from a low value to approximately 100%. The receiver was turned on and the temperature brought up to 40° C and this temperature was maintained throughout the test. After allowing the receiver to stabilize, the percentage of humidity was varied and the frequency measured in the same manner as for temperature variation.

27. With the receiver adjusted for standard output at resonance with a primary source of 13 volts, the voltage was varied to 11 and 15 volts and the frequency measured.

28. For the effect of vibration, the receiver was mounted on a vibration table to simulate normal aircraft vibration. From a cold start, the frequency was measured at regular intervals for one hour.

29. With the receiver adjusted for resonance, the sensitivity control was adjusted from maximum to as near minimum as was possible to obtain a measurable signal, and the frequency checked at both conditions.

[redacted]

30. Undistorted power output. The apparatus used to determine the undistorted power output was a beat frequency oscillator, a standard signal generator, an output power meter and a wave analyzer. The receiver was adjusted for 500 milliwatts output with the input modulated 30% at 400 cycles. The output was coupled to a wave analyzer, and with the modulation frequency varied from 200 to 2500 cycles by means of the beat frequency oscillator, the output voltage at the harmonics of each of the modulation frequencies was recorded. The percentage of distortion was determined as the r-m-s of these values.

31. Reset. The reset measurements were made with the use of a frequency indicator. The receiver on mcw was tuned to resonance as indicated by maximum reading of the output meter. The dial setting was noted, then the receiver was detuned and reset to the original setting and the input frequency adjusted to again obtain maximum output. The reset was made several times from both clockwise and counterclockwise directions and the frequency measured at each reset. The accuracy of reset was determined as the frequency difference between the most remote points of the clockwise and counterclockwise resets. These measurements were also made with the receiver in the cw position.

32. Manual and automatic sensitivity control. The apparatus used to conduct this test was a standard signal generator and an output power meter. With the receiver in the manual position, an input signal of 500,000 microvolts or greater was introduced. The sensitivity control was then reduced to minimum and the output observed. With the receiver in the AVC position, the level was set at 50 milliwatts output. The input was then increased in steps to 10,000 times the original value and the output recorded.

33. Additional tests, not covered by the specifications, were conducted on the receiver for overload and frequency change at constant ambient temperature. For the overload test, the receiver was adjusted for standard output and the input increased until the receiver blocked.

34. The frequency change at constant ambient temperature was determined by tuning the receiver to resonance, then measuring the frequency at regular intervals over a period of one hour. These measurements were made from a cold start.

35. The loop measurements were made in a shielded room with a transmission line of known characteristics symmetrically located therein, excited by a standard signal generator for a power source. The loop was mounted on a turn table and located at a specific distance from the transmission line at which distance the field strength was known with respect to the input to the transmission line.

36. To determine the range of minimum, the loop was adjusted for maximum output at zero on the azimuth scale, then rotated until minimum signal was obtained. The loop was then rotated left and right until a slight deflection of the right-left indicator was observed and the minimum determined as the number of degrees between these points. The reciprocal bearing was determined in the same manner after rotating the loop until a minimum signal was again obtained.

[redacted]

37. To determine the equality of the angular deflection of the meter, the sensitivity of the right-left indicator was adjusted for full scale deflection with a 20 microvolt/meter signal when the loop was rotated 90° from minimum. The loop was then rotated 90° to the opposite side of minimum position and the deflection of the right-left indicator observed.

38. To determine the accuracy of the reciprocal bearing, the loop was adjusted for on course minimum, then rotated until a minimum signal was again obtained. The setting of the calibrated scale was observed in both positions.

39. To determine the loop accuracy over the frequency range, the loop was adjusted for minimum signal with inputs of 100 microvolts per meter and 200,000 microvolts per meter at each of various frequencies within the range and the setting of the scale observed.

40. To determine the number of degrees of rotation necessary to obtain full scale deflection of the right-left indicator, the loop was adjusted for minimum signal and with the sensitivity at full gain, the loop was rotated to the left and right of minimum until full scale deflection was obtained and the number of degrees of rotation observed.

DATA RECORDED DURING TEST

41. The data recorded during the test are given in the form of tables and charts, and will be discussed under RESULTS.

DISCUSSION OF PROBABLE ERRORS

42. Table 10 of the appendix gives the list of instruments used and their accuracies. The accuracy of the tests is not necessarily that of the instruments used for the tests. R-F power output should be within ± 5%. Modulation percentages are accurate to ± 5%. Harmonic analysis is accurate to less than 2%. The frequency drift measurements have a high degree of accuracy due to the fact that no absolute frequency measurement is required; only a change in frequency is measured.

RESULTS OF TESTS

43. The results of measurements made on this equipment are shown as data recorded which are tabulated in Appendix A. Flight test data are given in the Naval Air Station report, reference (d), which is included in this report as Appendix B. The discussions will be based on specific requirements of the specifications, reference (b). In those paragraphs not discussed, the equipment will be assumed to have complied with the requirements. Discussion will be in the order of the paragraphs as they appear in the specifications, reference (b), and the numbers will be in agreement.

2-3. The equipment is of rugged construction and of the best material known for each specific employment.

2-4. The workmanship is excellent.

[redacted]

2-5. There was evidence of corrosion on some parts of the equipment.

2-6. The use of iron or steel has been confined to specific requirement.

2-7. There was variation of power output observed during the variation of temperature and humidity tests.

2-8. The by-pass condenser in the speech amplifier stage shorted, causing failure of the plate dropping resistor.

2-9. There was no indication of over-heating except for the modulation transformer.

2-13. It is not practicable for identification marking on some units of the equipment. Provision for identifying these parts is discussed in reference (h).

2-18. There was evidence of leakage of the impregnating compound from the modulation transformer.

2-19. The shockproof mountings are of the approved Lord type.

2-29. The requirements of this paragraph that all electrical indicating instruments be of the 2.5 inch size are not in agreement with paragraph 4-2(2) which specifies a standard aircraft meter case for housing the visual course indicator.

2-34. An electrolytic capacitor is used to by-pass the second a-f cathode resistor. This is a low voltage condenser and is considered satisfactory.

2-38. The tubes used in the receiver are not on the Navy approved list, but have been given contract approval for this equipment.

2-39. The equipment is completely shielded electrically, with cabinets and all parts external to them at ground potential.

2-56. The Cannon type K plugs and receptacles used in this equipment eliminate the necessity of rubber sleeves.

3-1. The adaptability of the equipment for installation and operation in Naval aircraft is discussed in Naval Air Station flight test report, reference (d), Appendix B of this report.

3-2. <u>Weight and dimensions</u>. The equipment does not meet the weight and dimension requirements in all cases. A complete list is shown on Table 1. The requirements of paragraph 3-2(11) and attached drawing of reference (b) are not in agreement. The transmitter and receiver, dynamotor to battery cables supplied with the equipment were not of the internally shielded rubber covered type.

3-3. <u>D-C Power Supply</u>. The operation of the equipment when obtaining a d-c source from an aircraft storage battery floating across an NEA-2 generator is discussed in reference (d), Appendix B.

[redacted]

3-4. Carrier power. The r-f power output is above the requirements for the full "V" antenna characteristics and is below the requirements for 6210 kilocycles for the half "V" antenna characteristics. The results are given on Table 2, Appendix A.

3-5. Frequency range. The transmitter is of the crystal controlled oscillator power amplifier type and will tune to any crystal frequency from 3,000 to 7,000 kilocycles in each band.

3-6, 3-7. Frequency selection. Voice modulation is provided. Frequency selection is effected by means of an electric motor manually controlled by a four point switch.

3-8. Circuit arrangement.

(1) A four point switch for selecting any one of the four pre-tuned frequencies is provided.

(2) Depression of the microphone button accomplishes the effect required by this paragraph. The receiver antenna is grounded during transmission. Microphone current flows only when the "press to talk" button is pressed.

(3) Release of the "press to talk" button returns the equipment to standby.

(4) Indicator lights have been provided.

3-9. Temperature Coefficient. The temperature coefficient of three of the four crystals tested were well within the requirements. The output power at these crystal frequencies varies from 15 to 20% using the starting output power as a base. The 6210 kilocycle crystal jumped frequency at +46° C. The frequency drift up to the point where it jumped frequency is excessive being 0.013%. The holders are sealed as required.

3-10. Crystal accuracy. The 3105 and 6630 kilocycle crystals are within the requirements. The 4220 and 6210 kilocycle crystals are outside the requirements. These tests were made at room temperature of approximately 28° C. Out of eleven crystals whose frequencies cover a range of 2950 to 7050 kilocycles, five were within the tolerance. Results are given in Table 3, Appendix A.

3-11. Interaction of circuits. No reaction was found between two circuits tuned to the same frequency, but when one circuit was tuned to the harmonic of the other a slight reaction was obtained on the fundamental by operating tuning controls of the adjacent channel tuned to the second harmonic.

3-12. Overall audio response. Tests were conducted at four crystal frequencies. The required 3 decibels down was obtained between 200 and 300 cycles for three crystal frequencies, 4220, 6210, and 7000 kilocycles. At 3000 kilocycles, the 3 decibel value was above 300 cycles. The requirement for -10 decibels at 4000 cycles was not obtained for any of the test frequencies, the -10 decibel point being very near 5000 cycles for all test points. Results are given in Table 4 of Appendix A.

[redacted]

3-13. Audio frequency distortion. Tests were conducted at four crystal frequencies. At 3000 and 4220 kilocycles the distortion is outside the tolerance. For 6210 and 7000 kilocycles, the total distortion is within the tolerance. At all frequencies at 85% modulation the upward modulation peaks are cut off. The results are given in Table 5, Appendix A.

3-14. Microphone modulation characteristics. The equipment is capable of 100% modulation using a Navy Type RS-38 microphone.

3-15. Carrier noise level. The carrier noise level is well within the requirements.

3-16. Time for changing frequencies. The equipment is well within the requirement. Approximately 1.2 seconds needed.

3-17. Shock mounting. The equipment meets this requirement.

3-18. The equipment gave satisfactory performance under vibration during flight and is designed to withstand landing shocks.

3-19. The receiving equipment is protected against exposure to unfavorable climatic conditions.

3-20. Current drain. The receiving equipment operates satisfactorily from an 11 to 15 volt d-c source and meets the current drain requirements of this paragraph. The results are shown on Table 11, Appendix A. The band changing motor draws approximately 2 additional amperes. However, this is a momentary condition and is not present when the equipment is in an operative condition.

3-21. The receiver covers the frequency range of 200 to 1600 kilocycles in three bands and 2000 to 8000 kilocycles in two bands and has in addition a fixed band on 278 kilocycles. Any band can be quickly and accurately selected. The frequency range and overlap are shown on Table 12, Appendix A.

3-22. The receiver is of the superheterodyne type, having two tuned circuits, exclusive of oscillator circuit, preceding the high frequency detector and is designed for manual and/or automatic control.

3-23. The receiver is designed for remote control only.

3-24. The receiver is designed for operation in conjunction with a loop antenna which is coupled to the receiver by means of a transmission cable.

3-25. From observation it appeared that the audio transformers and chokes were not hermetically sealed. To definitely determine this would mean considerable disassembly of the equipment. Reference (h) recommends that audio transformers and chokes used in the receiver be thoroughly impregnated and hermetically sealed.

3-26. The equipment is designed for use with one and two pairs of head phones of 600 ohms impedance each. The phone jacks are located in the control box. An output transformer isolates the head phones from the d-c supply.

[redacted]

3-27. Calibration accuracy. The calibration accuracy does not meet the requirements. The results are shown on Table 12A, Appendix A.

3-28. Sensitivity. The sensitivity is well within the requirements. The results are shown on Table 13, Appendix A.

3-29. Selectivity. The selectivity meets the requirements. The results are shown on Table 14, Appendix A.

3-30. Fidelity. The equipment does not entirely meet the requirement for overall fidelity. The results are shown on Table 15, Appendix A.

3-31(1). Image response. The equipment meets the requirements for image response ratio. The results are shown on Table 16, Appendix A.

(2). I-F rejection. The equipment meets the requirements except on those frequencies which are harmonics of the i-f frequency. Measurements were made on those points least advantageous on each band. The results are shown on Table 17, Appendix A.

3-32. Resonance stability.

(1) The equipment does not meet the requirements for frequency stability over 20° C temperature variation on Bands A and B. The results are shown on Tables 18 to 24 inclusive of Appendix A. It will be noted that measurements were made on Band C with the equipment in both cw and mcw positions, and that the frequency change was much less on mcw.

Additional tests, not required by the specifications, reference (b), were conducted for frequency change at constant ambient temperature. These tests were made with the equipment on cw and mcw positions. Here it will again be noted that the frequency change is much less on mcw which would indicate that the cw oscillator is the more susceptible to temperature change. The results of these tests are shown on Tables 26 and 27, Appendix A.

(2) The receiver meets the requirements for humidity variation. The results are shown on Table 25, Appendix A.

(3) There was no appreciable frequency change due to variation of the battery voltage of ± 2 volts from a starting point of 13 volts.

(4) There was no measurable frequency change due to vibration.

(5) There was no measurable frequency change due to manipulation of the sensitivity control.

3-33. The equipment fails to meet the undistorted power output at 200 cycles. The results are shown on Table 28, Appendix A. An overload test, not required by the specifications, reference (b), were made and the results shown on Tables 29 to 31 inclusive, Appendix A.

[redacted]

3-34. The equipment is provided with a remote tuning control of mechanical type and electrical switching to any band including the fixed frequency band of 278 kilocycles.

3-35. Reset. The equipment meets the reset requirements. The results are shown on Table 32, Appendix A.

3-36. The receiver remote tuning control meets the requirements of this paragraph.

3-37. The sensitivity control meets the requirements of this paragraph. However, in the manual position, the control is too critical and should be modified to provide more linear control of the output power. The AVC action meets the requirements depending on the method used in conducting the test. The input voltage is a determining factor and is not specified. The results of these tests are shown on Table 33, Appendix A.

3-38. The receiver control box contains all the necessary receiver controls except the remote tuner which is a separate unit.

3-39. The loop is designed to cover the range of 200 to 1500 kilocycles.

3-40. The operation of the homing system with the receiver and loop separated not over six feet would be determined in the flight tests.

3-41. (a) The loop windings are on phenolic forms.
(b) The distributed capacity of the loop is 29 mmf.
(c) The loop Q ungrounded is 120 and grounded 103.

These values do not meet the requirements.

3-42. The loop meets the requirements for "minimum" and reciprocal bearings. The results are shown on Table 34, Appendix A.

3-43. The operation of the equipment in airplanes incorporating head rest loops is a flight test requirement.

3-44. The suitability of the dynamotor to meet the requirements of this paragraph can be determined only after long periods of operation in actual service conditions.

3-45. The jack receptacles meet the requirements of this paragraph.

3-46. The tuning and trimming condensers meet the requirements.

3-47. All units of the equipment are easily and quickly detachable.

3-49. The side tone may be set to any level up to approximately 35 volts by means of a screw driver operated potentiometer. The level remains constant with the receiver in the manual position but is affected by the volume control in the AVC position.

4-1. The right-left indicating system is incorporated as part of the receiver.

[redacted]

4-2(2). The standard aircraft meter case for housing the right-left indicator does not meet the requirements of paragraph 2-29 of reference (b). However, such a case is standard for such meters and should be accepted.

(10). With the loop "on course," the fidelity of the received modulated signals was good. Modulation has a slight effect on the indicator needle, but not enough to interfere with operation.

(13). The switching frequency is 48 cycles.

4-4(2). The loop movement for full scale deflection and the agreement of left and right bearings do not meet the requirements. The results are shown on Table 34, Appendix A.

6-13(6)(c). In addition to the above tests, the following tests were conducted on the transmitter:

1. Frequency drift with change in temperature.
2. Frequency drift with humidity.
3. Frequency drift under vibration.

1. <u>Frequency drift with change in ambient temperature</u>. Four crystal frequencies 3000, 3105, 5200, and 6210 kilocycles were tested. The 6210 kilocycle crystal drift was outside the 0.005% tolerance allowed and also jumped frequency at +46° C. The 3000, 3105, and 5200 kilocycle crystals were within the tolerance. The results are shown on Tables 6 and 7, Appendix A.

2. <u>Frequency drift with humidity</u>. The equipment was tested at 5200 kilocycles and is within the tolerance. The results are shown on Table 9, Appendix A.

3. <u>Frequency drift under vibration</u>. The equipment was tested at 5200 kilocycles, an unmodulated carrier signal being emitted, the audio having broken down. The carrier drift was well within the requirements. Voice modulation during vibration was satisfactory as observed on a radio receiver tuned to the carrier. The results are shown on Table 8, Appendix A.

44. Photographs of the equipment are included in Plates 16 to 26 inclusive, of Appendix A.

<u>CONCLUSIONS</u>

45. The following conclusions were reached as a result of these tests:

(a) The equipment is satisfactory for use in Naval aircraft provided certain mechanical and electrical defects discussed herein and in the Naval Air Station's report, Appendix B of this report, are corrected in future equipment.

(b) In general the workmanship and material used are excellent.

(c) The defects of the transmitter are as follows:

(1) The carrier power output is low for one crystal frequency; namely, 6210 kilocycles. Later, tests proved this to be a defective crystal and as spares were not provided, no further output tests were made at this frequency.

(2) The crystal frequencies are outside the tolerance for six of the eleven crystals tested.

(3) The 6210 kilocycle crystal jumped frequency during the temperature run.

(4) The audio response is outside the tolerance at both the low and high frequency end of the audio band.

(5) The impregnating compound leaked from the modulating transformer.

(6) The plate by-pass condenser in the speech amplifier stage shorted on two occasions, once during a test at room temperature and once during a temperature run, causing failure of the plate supply dropping resistor.

(7) The channel changing mechanism freezes up at -30° C when the equipment is idle while approaching this temperature.

(8) There was some indication of corrosion on various parts of the equipment.

(d) The defects of the receiver are as follows:

(1) The calibration accuracy does not meet the requirements.

(2) The overall fidelity is slightly outside the requirements.

(3) The i-f rejection meets the requirement except on frequencies which are harmonics of the intermediate frequency.

(4) Bands A and B do not meet the resonance stability requirements for temperature variation.

(5) The receiver meets the requirements for undistorted power output at all specified frequencies except 200 cycles.

(6) The automatic sensitivity control meets the requirements when the input necessary for 50 milliwatts output is 5 microvolts or more. With lower values of input voltage which necessitate approaching full gain for 50 milliwatts output, the receiver does not meet the requirements. Since the value of input voltage is not specified, it is concluded that the equipment meets the requirements.

(7) The "Q" of the loop does not meet the requirements.

(8) The loop movement to obtain full scale right or left indication and the right and left bearing agreement do not meet the requirements on all frequencies.

(9) The equipment does not meet the requirements for weight and dimensions in all instances.

[redacted]

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Table 1

Weights and Dimensions

Unit	Weight lb.	Length in.	Width in.	Height in.
Transmitter (without tubes)	43.4	19-1/8	11-1/2	10-3/8
1 set tubes	1.0			
1 set crystals	4.64 oz			
Trans. control box	1.0	5-1/8	3-3/4	2-3/8
" cables W401	1.4	73		
" " W402	2.5	144		
" " W403	0.7	37		
" " W404	1.6	108		
" " W405	1.4	61		
" dynamotor	24.0	9-3/8	6-1/8	9-1/4
Rec. cable W701	2.4	144		
" " W702	2.8	180		
" " W703	0.6	70		
" " W704	1.2	59		
" " W705	0.8	39		
Linkage W706	1.3	120		
Receiver (without tubes)	31.6	18	9-1/2	7-3/4
Rec. control box	1.8	4-3/4	5-1/4	2-7/8
Rec. remote tuner	1.0	5-5/8	3	2-1/2
Rec. dynamotor	8.8	6-1/4	4-3/8	7-3/8
1 set receiving tubes	1.0			
Right-left indicator	1.4	Diameter 3-1/4"		Depth 3-13/16"
Loop	2.5	" 12"		Height 17"
Total weight	134.49			

[redacted]

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Table 2

Carrier Power Output

Freq kc	Antenna Amperes	Carrier Power Watts	Antenna R ohms	Antenna Cap.μμf	D-C Input Volts	D-C Input Amperes
		Full "V" Antenna				
3105	2.78	14.35	1.85	100	13	24.8
4220	2.62	13.20	1.92	120	13	24.7
5200	2.46	18.05	2.98	150	13	25.0
6210	2.55	25.50	3.92	230	13	24.5
7000	2.29	34.80	6.64	1000	13	25.4
		Half "V" Antenna				
3105	2.16	6.86	1.47	68	13	24.6
4220	2.19	7.04	1.47	70	13	24.6
5200	2.40	9.08	1.58	72	13	25.0
6210	2.09	8.00	1.83	80	13	24.8
7000	2.22	12.00	2.45	92	13	24.7

Table 3

Accuracy Output Frequency of Crystals

Crystal Holder #	Freq kc	Cycles Off	% Off
1	2950	-303	0.0103
15	3000	-155	0.0052
173	3105	-64	0.0021
6	3120	+22	0.0007
2	3130	-33	0.00105
106	4220	+621	0.0147
4	5200	+446	0.0086
110	6210	+376	0.0061
106	6630	+132	0.002
7	7000	+12,322	0.174
2	7050	-1093	0.015

[redacted]

Table 4

Audio Frequency Response Characteristics

	Channel							
	1		2		3		4	
	Freq - kilocycles							
	3000		4220		6210		7000	
Modulation Freq. cps	Volts	db	Volts	db	Volts	db	Volts	db
200	3.92	-5.27	5.75	-4.80	5.20	-4.42	4.00	-4.60
300	5.02	-3.13	7.30	-2.74	6.45	-2.54	4.95	-2.74
400	5.75	-1.93	8.30	-1.64	7.25	-1.52	5.50	-1.82
500	6.15	-1.36	9.00	-0.90	7.70	-0.99	5.90	-1.20
750	6.75	-0.56	9.80	-0.18	8.35	-0.30	6.45	-0.46
*1000	7.20	-0.00	10.00	0.0	8.65	0.0	6.80	0.0
1500	7.60	+0.47	10.00	0.0	9.10	+0.44	7.20	+0.50
2000	7.70	+0.58	10.00	0.0	9.10	+0.44	7.30	+0.60
2500	7.41	+0.25	10.00	0.0	8.60	+0.04	6.90	+0.12
3000	6.74	-0.57	8.90	-0.84	7.70	-0.99	6.20	-0.78
3500	5.15	-2.89	6.60	-3.60	5.90	-3.32	4.90	-2.86
4000	3.80	-5.55	4.80	-6.16	4.35	-5.96	3.60	-5.52
5000	2.10	-10.70	2.60	-11.70	2.45	-10.94	2.00	-10.62

Modulation volts at 1000 cycles

1.46	1.46	1.44	1.48

* 85% modulation

[redacted]

Table 5

Harmonic Distortion

		Harmonics												
		1	2	3	4	5	6	7	8	9	10	11	12	Total Distortion %
Channel	Freq kc	% Harmonics												
1	3000	100	8.5	6.5	3.7	1.6	1.9	1.9	0.6	0.7	0.35	0.02	0.08	11.78
2	4220	100	6.5	7.0	4.2	1.7	2.0	2.0	0.5	1.2	0.35	0.17	0.18	11.04
3	6210	100	6.0	6.0	3.5	1.2	1.8	1.95	0.2	0.7	0.5	0.2	0.14	9.67
4	7000	100	5.9	6.5	3.5	1.3	2.0	1.90	0.3	0.9	0.35	0.03	0.02	9.74

[redacted]

Table 6

Frequency Stability

Freq. 3105 kc			Input 13 volts DC	Freq. 3000 kc	
Time Min.	Temp. °C	Freq.change cycles	Time Min.	Temp. °C	Freq.change cycles
0	-28.2	0	0	-24	0
7	27.6	0	5	24.4	0
12	18.4	-5	10	18.0	5
17	11.1	10	15	13.0	15
22	6.3	25	20	6.0	20
27	11.0	40	25	4.5	25
32	6.3	50	30	+1.0	20
37	+0.8	50	35	3.5	20
42	5.5	50	40	6.0	20
47	8.8	45	45	10	15
52	11.5	35	50	12.5	10
57	14.0	20	55	15.5	10
62	16.1	15	60	17.2	0
67	19.5	10	65	19.5	0
72	21.2	0	70	22.0	-5
77	22.5	0	75	25.5	10
82	25.0	+10	80	26.8	25
87	28.5	25	85	28.8	25
92	29.5	25	90	30.5	30
97	31.5	30	95	33.0	35
102	33.0	35	100	33.5	35
107	34.5	35	105	30.6	40
112	38.5	45	110	32.5	45
117	41.2	50	115	41.0	50
122	44.0	50	120	42.8	50
127	46.0	55	125	44.8	55
132	47.8	65	130	46.2	60
137	50.0	70	135	48.5	65
142	50.05	70	140	48.8	65
			145	48.8	75
			150	50.2	75

Drift maximum 0.00387%

Drift maximum 0.0033%

[redacted]

Table 7

Frequency Stability

Input 13 volts DC

Freq. 5200 kilocycles			Freq. 6210 kilocycles		
Time Min	Temp °C	Freq change cycles	Time Min.	Temp °C	Freq change cycles
0	-29.0	0	0	-30.0	0
5	29.0	5	5	29.3	0
10	27.8	5	10	28.0	5
15	26.8	5	15	20.9	15
20	16.5	0	20	11.8	55
25	14.2	-5	25	6.0	70
30	6.0	25	30	1.5	120
35	6.0	50	35	+1.8	180
40	0.0	75	40	5.5	230
45	+4.0	100	45	8.8	290
50	7.5	125	50	10.2	340
55	10.6	150	55	13.5	390
60	14.0	175	60	16.7	455
65	17.0	200	65	18.5	480
70	19.6	215	70	20.5	515
75	21.6	230	75	23.3	550
80	22.0	240	80	25.0	570
85	23.9	245	85	26.8	590
90	26.0	245	90	28.8	605
95	28.8	245	95	30.2	625
100	30.8	235	100	32.7	630
105	32.1	225	105	35.6	640
110	35.0	200	110	36.5	640
115	38.4	200	115	38.0	640
120	41.7	170	120	40.4	640
125	41.0	150	125	42.2	630
130	45.0	110	130	44.0	620
135	47.8	85	135	45.5	615
140	50.3	50	Jumped frequency approximately 13 kilocycles.		
145	47.5	25			

Drift maximum 0.0047%

[redacted]

Table 8

Frequency Drift Under Vibration

5200 kilocycles

Time Min.	Cycles Change	Vibration rpm
0	0	1900
5	5	1920
10	30	1920
15	55	1900
20	70	1920
25	90	1900
30	110	1920

Maximum shift 0.0021%

Table 9

Frequency Drift Under Humidity

5200 kilocycles

Time Min.	Temp. °C	Humidity %	Cycles Change
0	39.5	94	0
5	41.0	100	10
10	39.2	95	15
15	41.0	100	40
20	39.5	93	35
25	40.6	97	50
30	39.8	92	75
35	41.0	95	85
40	40.0	90	100
45	41.2	94	125
50	40.8	90	130
55	41.8	96	135
60	40.8	89	150
65	40.8	88	180
70	41.8	95	180
75	40.0	69	190
80	36.5	60	190
85	32.0	55	190
90	28.5	53	185
95	26.0	53	175
100	22.5	53	155
105	19.5	53	110
110	17.5	52	100
115	16.5	51	75
120	15.0	50	45
125	13.0	49	15
130	11.5	48	0
135	10.0	47	-20
140	8.5	52	-55

Maximum shift % 0.0036

[redacted]

Table 10

Instruments Used for Tests

	Model	Ser.No.	Accuracy % ±
Weston DC Voltmeter 0 - 30	45	41097	0.33
Weston DC Voltmeter 0 - 20	45	41660	0.5
Weston DC Voltmeter 0 - 10	370	4586	0.25
Weston DC Ammeter 0 - 75	45	40604	0.5
Weston DC Ammeter 0 - 10	45	41433	0.5
Weston RF Ammeter 0 - 3	425	26117	2.0
Triumph Cathode Ray Oscillograph	830		
Frequency Drift Indicator	LK-1		0.0002
Heterodyne Frequency Meter	LF	1	0.0001
Crystal Frequency Indicator	LM-2	1	0.001
General Radio Beat Frequency Oscillator	Type 713B	499	2.0
General Radio Cathode Ray Oscillograph		4161	
General Radio Wave Analyzer	Type 636A	318	5.0
General Radio Wave Analyzer	Type 736A	118	5.0
General Radio Standard Signal Generator	Type 605B	814	1.0
General Radio Power Output Meter	Type 583A	67	5.0
Ballantine Electronic Voltmeter		37	
Mixing Panel	Type NRL		
Temperature Control Box			1.0° C
Toledo Balance Scales	Style 31-0841 DH	663471	0.5
G. Luff Precision Hygrometer			15.0
Vibration Table			

Table 11

Current Drain

Volts	11.0	12.0	13.0	14.0	15.0	Allowed
Amperes	4.0	4.3	4.6	4.8	5.0	6 amperes at 13 volts

The band changing motor draws approximately 2.0 amperes.

Table 12

Frequency Range and Overlap

	Band B	Band C	Band D	Band E	Band F
Min. Freq.	194.467	390.520	782.000	1955.300	3917.000
% Overlap	2.76	2.37	2.25	2.23	2.07
Max. Freq.	400.688	807.195	1607.175	4027.240	8062.640
% Overlap	0.172	0.9	0.45	0.68	0.78

[redacted]

Table 12A

Calibration Accuracy

Dial Setting	Band B		Band C		Band D		Band E		Band F	
	Frequency	% Off Cal.	Frequency	% Off Cal.	Frequency	% Off Cal.	Frequency	% Off Cal.	Frequency	% Off Cal.
200	197.700	-1.15	398.624	-0.34	797.800	-0.27	1994.320	-0.28	3990.500	-0.23
250	249.190	-0.32	498.820	-0.23	994.880	-0.51	2492.450	-0.3	5001.200	+0.02
300	299.750	-0.08	598.960	-0.17	1193.680	-0.52	2994.000	-0.2	6000.000	0
350	349.500	-0.14	699.855	-0.02	1394.340	-0.4	3494.200	-0.16	7009.700	+0.13
400	395.400	-1.15	796.755	-0.4	1582.790	-1.07	3976.600	-0.58	7961.200	-0.48

Allowed 0.25% (Specifications require frequency calibration only on Band B.)

[redacted]

Table 13

Sensitivity

Noise Level not over 12.5 mw | Standard Output 50 mw

Dial Setting

Band		Min	200	250	300	350	400	Max
		Microvolts Input for Standard Output						
A	MCW	1.7	1.7	1.7	1.7	1.7	1.7	1.7
278 kc	CW	0.7	0.7	0.7	0.7	0.7	0.7	0.7
B	MCW	2.1	2.0	1.8	1.9	1.75	1.8	1.8
200-400 kc	CW	1.6	1.5	1.2	0.6	0.6	0.9	1.1
C	MCW	1.5	1.4	1.5	1.4	1.4	1.35	1.3
400-800 kc	CW	0.65	0.7	0.75	0.5	0.4	0.5	0.55
D	MCW	1.9	1.9	1.9	1.8	1.9	3.2	3.7
800-1600 kc	CW	0.6	0.65	1.0	0.7	0.7	1.7	1.9
E	MCW	1.5	0.9	1.3	2.4	2.3	1.1	1.1
2-4 mc	CW	0.45	0.25	0.4	0.8	0.75	0.4	0.35
F	MCW	4.4	3.8	2.8	3.0	3.2	1.3	1.3
4-8 mc	CW	1.6	1.3	1.1	1.2	1.4	0.2	0.25

Allowed 5 microvolts

Sensitivity in AVC position approximately same as above.

[redacted]

Table 14

Selectivity

10 Microvolts Input for 50 Milliwatts Output at Resonance

Band	Freq kc	x 10 −	x 10 +	x 100 −	x 100 +	x 1000 −	x 1000 +
A	278	4.17 kc	3.33 kc	8.06 kc	7.23 kc	12.25 kc	10.85 kc
B	200	3.0	3.8	7.8	6.2	12.0	9.8
"	275	3.85	4.13	7.4	8.25	11.3	12.1
"	400	6.4	4.8	10.4	8.8	15.2	13.2
C	400	4.8	4.0	8.8	8.0	12.8	12.0
"	600	5.4	6.0	9.0	10.8	13.2	15.6
"	800	7.2	6.4	11.2	10.8	16.0	15.2
D	800	6.0	6.0	10.4	10.4	14.4	15.2
"	1200	7.8	7.2	12.0	12.6	16.8	18.0
"	1600	9.6	9.6	14.4	14.4	20.8	20.8
E	2000	7.0	9.0	11.0	15.0	16.0	19.0
"	2750	6.8	11.0	11.0	16.5	17.8	23.3
"	4000	8.0	8.0	14.0	14.0	20.0	22.0
F	4000	8.0	8.0	14.0	14.0	22.0	20.0
"	6000	7.5	9.0	12.0	15.0	21.0	24.0
"	8000	8.0	8.0	12.0	16.0	16.0	24.0

Allowed

Range	x 10	x 100	x 1000
200 kc	6 kc	11 kc	18 kc
400 kc	9	14	24
1200 kc	14	20	30
2000 kc and up	14	28	42

[redacted]

Table 15

Fidelity

Mod. Freq. Cycles	Fundamental Frequency 278 kc	300 kc	600 kc	1200 kc	3000 kc	8000 kc
200	+1.8 db	+0.08 db	-0.86 db	-1.3 db	-1.55 db	-1.46 db
300	+3.09	+2.3	+0.6	+0.21	0	0
400	+3.36	+2.67	+1.07	+0.75	+0.64	+0.45
500	+3.18	+2.56	+1.07	+1.0	+0.82	+0.79
600	+2.71	+2.3	+1.07	+0.93	+0.75	+0.79
700	+2.17	+1.81	+0.96	+0.75	+0.64	+0.45
800	+1.43	+1.23	+0.6	+0.49	+0.37	+0.37
900	+0.68	+0.6	+0.33	+0.29	+0.21	+0.17
1000	0	0	0	0	0	0
1500	-4.08	-3.18	-1.61	-1.03	-0.75	-0.71
2000	-7.07	-5.56	-2.9	-1.46	-0.89	-0.86
2500	-9.63	-8.29	-4.47	-2.06	-1.13	-0.96

100 Microvolts Input for 50 Milliwatts Output.

Modulated 30% at 400 cycles

Allowed ± 5 db with respect to 1000 cycles between 200 and 2500 cycles except from 200 to 500 kilocycles at 2500 cycles attenuation may be down 20 decibels.

Table 16

Image Response

Band	Res.Freq. kc	Image Input	Image Output mw	Res. Input for Same Output-mcv	Ratio
A	278	1.0 V	70	2.1	476,000
B	200	1.0V	80	2.5	400,000
"	300	1.0V	120	3.3	300,000
"	400	1.0V	210	3.7	270,000
C	400	1.0V	80	1.9	500,000
"	600	1.0V	220	3.3	300,000
"	800	1.0V	500	4.7	212,000
D	800	1.0V	60	2.1	476,000
"	1200	1.0V	110	2.6	400,000
"	1600	1.0V	16	1.8	556,000
E	2000	1.0V	330	2.9	330,000
"	3000	32,000 mcv	50	2.4	13,300
"	4000	17,000 "	50	1.1	15,000
F	4000	57,000 "	50	1.3	15,000
"	6000	9,800 "	50	1.2	3,270
"	8000	10,000 "	50	.2	7,700

Allowed Ratio

150 - 1500 kc	Not less then	50,000
1800 - 3600 "	" " "	4,000
3600 - 7200 "	" " "	3,000
7200 - 8000 "	" " "	2,000

[redacted]

Table 17

I-F Rejection

Band	Res. Freq. kc	Input at I-F Freq. mcv	Output mw	Res. Input for same output mcv	Ratio	
A	278	1,000,000	0			
B	400	1,000,000	0			
C	800	100,000	20	.8	125,000	
D	1500	6,500	50	2.0	3,250	
E	2000	6,500	50	.9	7,220	
E	3500	250	50	2.0	125	2nd har. of I-F
F	4000	12,000	50	3.6	3,300	
F	5250	650	50	3.0	217	3rd har. of I-F
F	7000	1,200	50	3.6	333	4th har. of I-F

Allowed 60 decibels (A voltage ratio of 1000 to 1)

[redacted]

Table 18

Frequency Change Due to Temperature Variation

Band A 278 kilocycles
CW

Time Min.	Temp. °C	Freq kc	Time Min.	Temp. °C	Freq kc	Time Min.	Temp °C	Freq. kc
0	+24	274.400	110	-12	278.050	220	+31	277.030
5	23	274.345	115	13	278.200	225	33	276.645
10	19	274.315	120	13.5	278.400	230	34.5	276.255
15	15	274.355	125	14	278.545	235	36.5	275.890
20	12	274.460	130	14.5	278.675	240	38.5	275.425
25	9	274.590	135	15	278.785	245	40	275.105
30	7	274.800	140	15.5	278.905	250	41.5	274.785
35	5	274.980	145	16	279.025	255	43.5	274.375
40	3	275.115	150	16.5	279.135	260	45.5	274.010
45	+1	275.400	155	16.5	279.270	265	47	273.645
50	0	275.600	160	13	279.450	270	48.5	273.355
55	-1	275.800	165	7	279.540	275	50	273.000
60	2.5	276.110	170	-2	279.565	280	45	272.610
65	4	276.305	175	+3	279.540	285	42	272.330
70	5	276.570	180	8	279.345	290	36	272.130
75	6	276.740	185	12	279.160	295	33	272.030
80	8	276.980	190	15	279.020	300	30	272.030
85	9	277.175	195	18	278.700	305	28	272.080
90	9.5	277.395	200	21	278.400	310	26	272.180
95	10	277.570	205	24	278.055	315	+24	272.315
100	11	277.755	210	27	277.645			
105	-11.5	277.910	215	+29	277.325			

Max.change over any 20°
+30° to +50° =
4.175 kc = 1.47%
Allowed 0.5%

[redacted]

Table 19

Frequency Change Due to Temperature Variation

Band B 300 kilocycles
CW

Time Min.	Temp °C	Frequency kc	Time Min.	Temp °C	Frequency kc
0	+23	299.925	145	16	303.090
5	16	299.585	150	8	303.235
10	12	299.485	155	-2	303.200
15	9	299.390	160	+2	303.090
20	6	299.340	165	6	302.875
25	4.5	299.440	170	8	302.705
30	+ 2.5	299.485	175	11	302.365
35	0	299.635	180	14	302.150
40	-1	299.730	185	17	301.630
45	2.5	299.925	190	19	301.460
50	4	300.120	195	21	301.045
55	5	300.315	200	23	300.655
60	6	300.485	205	25	300.220
65	8	300.705	210	27	299.925
70	10	300.900	215	+29	299.535
75	11	301.090	220	+31	299.095
80	12	301.285	225	33	298.655
85	13	301.480	230	35	298.220
90	14	301.630	235	36.5	297.885
95	15	301.775	240	38	297.495
100	16	301.875	245	40	297.065
105	-16.5	302.025	250	42.5	296.510
110	-17	302.170	255	44	296.170
115	18	302.320	260	45.5	295.685
120	18.5	302.465	265	47	295.445
125	19	302.610	270	48.5	295.050
130	19.5	302.755	275	38	294.615
135	20	302.850	280	28	294.465
140	19	302.950	285	23	294.465

Maximum change over any 20°

+28.5° to +48.5° = 4.58 kc = 1.52%

Allowed 0.5%

[redacted]

Table 20

Frequency Change Due to Temperature Variation

Band C 666.6 kilocycles
CW

Time Min.	Temp. °C	Frequency kc	Time Min.	Temp. °C	Frequency kc
0	+26	666.573	165	18	669.982
5	23	666.537	170	18	670.045
10	20	666.582	175	16	670.119
15	16	666.654	180	9	670.182
20	13	666.881	185	6	670.173
25	10	667.063	190	-1	670.155
30	7	667.272	195	+3	670.056
35	5	667.528	200	5	669.900
40	3	667.700	205	8	669.737
45	+1	667.900	210	11	669.564
50	0	668.072	215	+14	669.191
55	-1	668.182	220	+17	669.027
60	2	668.355	225	19	668.736
65	4	668.454	230	21	668.518
70	6	668.600	235	23	668.263
75	8	668.727	240	26	668.045
80	9	668.773	245	28	667.827
85	10	668.836	250	30	667.672
90	11	668.900	255	33	667.481
95	12	668.964	260	35	667.300
100	12.5	669.000	265	38	667.109
105	13	669.100	270	40	666.928
110	-13.5	669.164	275	42	666.636
115	14	669.218	280	44	666.498
120	14.5	669.191	285	46	666.236
125	15	669.236	290	48	666.100
130	15.5	669.400	295	49	665.872
135	16	669.463	300	45	665.609
140	16.25	669.519	305	41	665.445
145	16.5	669.564	310	38	665.391
150	17	669.609	315	35	665.400
155	17.25	669.654	320	32	665.472
160	17.5	669.818	325	29	665.546
			330	+26	665.718

Max. Change over any 20°

+2° to -18° = 2.18 kilocycles = 0.32%

Allowed 0.5%

[redacted]

Table 21

Frequency Change Due to Temperature Variation

Band C 666.6 kilocycles
MCW

Time Min.	Temp. °C	Frequency kc	Time Min.	Temp. °C	Frequency kc
0	+22	666.483	150	17	667.336
5	21	666.463	155	17	667.363
10	18	666.409	160	13	667.391
15	13	666.463	165	9	667.436
20	10	666.508	170	-3	667.436
25	8	666.483	175	+4	667.391
30	6	666.528	180	8	667.345
35	4	666.573	185	12	667.327
40	2	666.600	190	15	667.300
45	+1	666.645	195	18	667.245
50	-1	666.660	200	21	667.200
55	2	666.705	205	24	667.155
60	3	666.780	210	26	667.110
65	5	666.836	215	+28	667.018
70	6.5	666.876	220	+31	666.932
75	8	666.912	225	33	666.885
80	9	666.930	230	35	666.836
85	10	666.957	235	37	666.573
90	10.5	666.991	240	39	666.483
95	11	667.018	245	41	666.463
100	12	667.054	250	43	666.373
105	12.5	-667.081	255	45	666.326
110	-13	667.110	260	46	666.281
115	13.5	667.137	265	48	666.236
120	14	667.164	270	49	666.191
125	14.5	667.182	275	44	666.146
130	15	667.200	280	41	666.099
135	15.5	667.227	285	37	666.054
140	16	667.263	290	34	666.009
145	16.5	667.300	295	31	666.009
			300	26	666.009
			305	23	666.099
			310	+22	666.146

Max. Change over any 20°

+26° to +46° = 0.829 kc = 0.125%

Allowed 0.5%

[redacted]

Table 22

Frequency Change Due to Temperature Variation

Band D 1200 kilocycles
CW

Time Min.	Temp. °C	Frequency kc	Time Min.	Temp. °C	Frequency kc
0	+29	1200.000	160	11.5	1205.920
5	24	1199.900	165	11.75	1206.020
10	20	1199.800	170	12	1206.080
15	16	1199.900	175	9	1206.160
20	13	1200.100	180	-1	1206.320
25	11	1200.380	185	+3	1206.280
30	9	1200.680	190	7	1206.160
35	7	1201.000	195	10	1205.920
40	5	1201.320	200	14	1205.740
45	3	1201.720	205	17	1205.440
50	2	1201.960	210	20	1205.040
55	+1	1202.280	215	+23	1204.560
60	0	1202.700	220	+25.5	1204.260
65	-1	1202.980	225	28	1203.840
70	2	1203.160	230	30	1203.400
75	3	1203.460	235	33	1202.920
80	3.25	1203.800	240	35	1202.520
85	3.5	1203.980	245	36	1202.220
90	3.75	1204.200	250	38.5	1201.840
95	4	1204.440	255	40	1201.360
100	4.5	1204.680	260	42	1200.880
105	-6	1204.860	265	44	1200.280
110	-6.5	1204.960	270	46	1199.700
115	7	1205.100	275	48	1199.320
120	8	1205.160	280	49	1198.920
125	8.5	1205.180	285	49	1198.340
130	9	1205.300	290	45	1197.940
135	9.5	1205.440	295	41	1197.600
140	10	1205.540	300	38	1197.260
145	10.5	1205.640	305	34	1197.060
150	11	1205.740	310	+29	1197.160
155	11.25	1205.840			

Max. Change over any 20°

+29° to +49° = 5.28 kc = 0.44%

Allowed 0.5%

[redacted]

Table 23

Frequency Change Due to Temperature Variation

Band E 3000 kilocycles
CW

Time Min.	Temp. °C	Frequency kc	Time Min.	Temp. °C	Frequency kc
0	+27	3000.000	165	14.5	3005.400
5	25	2999.900	170	14.75	3005.550
10	22	2999.850	175	15	3005.600
15	18	2999.850	180	14	3005.650
20	14	3000.000	185	-5	3005.800
25	12	3000.300	190	0	3005.900
30	10	3000.550	195	+6	3006.100
35	8	3000.750	200	9	3006.050
40	6	3001.050	205	12	3005.900
45	4.5	3001.350	210	16	3005.750
50	3	3001.600	215	+19	3005.600
55	2	3001.950	220	+21	3005.450
60	+1	3002.150	225	24	3005.250
65	0	3002.350	230	27	3004.950
70	-1	3002.550	235	29	3004.600
75	2	3002.700	240	31	3004.300
80	3	3002.850	245	32.5	3003.850
85	4	3003.050	250	34	3003.400
90	5	3003.100	255	36	3003.050
95	6.5	3003.200	260	38	3002.700
100	8	3003.400	265	40	3002.300
105	-9	3003.550	270	41.5	3001.800
110	-9.5	3003.800	275	43	3001.350
115	10	3003.950	280	44.5	3000.850
120	10.5	3004.150	285	46	3000.550
125	11	3004.300	290	48	3000.150
130	11.5	3004.400	295	49	2999.550
135	12	3004.550	300	50	2998.900
140	12.5	3004.700	305	45	2998.350
145	13	3004.850	310	40	2997.850
150	13.5	3004.950	315	36	2997.500
155	14	3005.100	320	31	2997.300
160	14.25	3005.250	325	+27	2997.450

Max. Change over any 20°

+30° to +50° = 5.55 kc = 0.185%

Allowed 0.25%

[redacted]

Table 24

Frequency Change Due to Temperature Variation

Band F 6500 kilocycles
CW

Time Min.	Temp. °C	Frequency kc	Time Min.	Temp. °C	Frequency kc
0	+25	6499.600	185	20	6511.100
5	23	6499.400	190	20	6511.300
10	19	6499.400	195	18	6511.700
15	15	6499.600	200	11	6512.000
20	12	6500.100	205	-4	6512.300
25	9	6500.600	210	0	6512.300
30	7	6501.000	215	+4	6512.000
35	5	6501.600	220	7	6511.700
40	3	6502.200	225	10	6511.200
45	2	6502.700	230	12	6510.600
50	+1	6503.200	235	15	6509.900
55	0	6503.600	240	17	6509.300
60	-1	6504.100	245	20	6508.500
65	2	6504.500	250	22	6507.700
70	3	6505.000	255	+25	6507.100
75	4	6505.400	260	+26	6506.100
80	5	6505.700	265	29	6505.400
85	6	6506.100	270	31	6504.600
90	6.5	6506.400	275	32	6504.100
95	7	6506.900	280	34	6503.200
100	7.5	6507.300	285	36	6502.500
105	8	6507.600	290	38	6501.700
110	8.5	6508.000	295	39	6501.100
115	9	6508.400	300	41	6500.200
120	9.5	6508.600	305	43	6499.500
125	-10	6508.800	310	45	6498.700
130	-11	6509.000	315	46	6497.900
135	12	6509.200	320	47.5	6497.100
140	13	6509.400	325	49	6496.200
145	14	6509.600	330	47	6495.000
150	15	6509.700	335	43	6494.400
155	16	6509.900	340	40	6493.600
160	17	6510.100	345	36	6493.400
165	18	6510.300	350	32	6493.400
170	18.5	6510.500	355	29	6493.500
175	19	6510.700	360	+25	6493.600
180	19.5	6510.900			

Max. Change over any 20°

+30° to +50° = 9.4 kc = 0.145%

Allowed 0.25%

[redacted]

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Table 25

Frequency Change Due to Humidity Variation

Band B 300 kilocycles				Band E 6000 kilocycles			
Time Min.	Temp. °C	Hum. %	Frequency kc	Time Min.	Temp. °C	Hum. %	Frequency kc
0	42	41	295.295	0	43	40	5992.700
10	41	40	295.200	15	43	42	5992.700
20	42	40	295.250	30	43	45	"
30	42	44	295.320	45	44	52	"
40	42	48	295.370	60	45	65	"
50	42	58	295.345	75	44	70	"
60	42	62	295.300	90	46	70	"
70	42	62	295.300	105	46	75	"
80	42	65	295.300	120	44	80	5992.400
90	42	70	295.300	135	45	85	"
100	42	97	295.325	150	46	95	"
110	46	96	295.225	165	46	96	"
120	46	97	295.100	180	45	94	"
130	46	98	294.980	195	45	95	"

Max.Freq.Change 0.390 kc = 0.13%   Max.Freq.Change 0.300 kc = 0.005%

Table 26

Frequency Change at Constant Ambient Temperature
MCW

Time Min.	278 kc Freq. kc	300 kc Freq. kc	600 kc Freq. kc	1200 kc Freq. kc	3000 kc Freq. kc	6000 kc Freq. kc
0	278.085	300.000	600.000	1200.000	3000.000	6000.000
5	278.250	300.150	"	"	3000.200	"
10	278.150	"	"	"	3000.400	"
15	278.200	"	"	"	"	"
20	"	"	"	"	"	"
25	"	"	"	"	"	"
30	"	"	"	"	"	"
35	"	"	"	"	"	"
40	"	"	"	"	"	"
45	"	"	"	"	"	"
50	"	"	"	"	"	"
55	"	"	"	"	"	"
60	"	"	"	"	"	"

[redacted]

Table 27

Frequency Change at Constant Ambient Temperature
CW

Time. Min.	278 kc Freq. kc	300 kc Freq. kc	600 kc Freq. kc	1200 kc Freq. kc	3000 kc Freq. kc	6000 kc Freq. kc
0	277.340	300.245	600.340	1198.420	3000.000	6004.300
5	277.315	300.195	600.290	1198.320	2999.700	6004.100
10	277.275	300.050	600.190	1198.120	2999.300	6003.700
15	277.180	299.950	600.090	1197.920	2999.150	6003.400
20	277.030	299.825	599.940	1197.720	2999.050	6003.200
25	276.920	299.730	599.840	1197.520	2998.900	6003.000
30	276.770	299.630	599.690	1197.340	2998.650	6002.800
35	276.670	299.530	599.590	1197.140	2998.550	6002.600
40	276.570	299.430	599.490	1197.040	2998.350	6002.500
45	276.425	299.335	599.440	1196.940	2998.200	6002.400
50	276.325	299.235	599.360	1196.740	2998.100	6002.200
55	276.230	299.140	599.340	1196.660	2998.000	6002.000
60	276.130	299.090	599.260	1196.560	2997.850	6001.800
Total Freq. change	1.21	1.15	1.08	1.86	2.15	2.5
% change	0.43	0.38	0.18	0.15	0.07	0.04

[redacted]

Table 28

Audio Distortion
Output Adjusted for 500 Milliwatts

Modulation Freq. Cycles	278 kc Harmonics 2	3	4	5	RMS	300 kc Harmonics 2	3	4	5	RMS	600 kc Harmonics 2	3	4	5	RMS
	% of Resonance Output					% of Resonance Output					% of Resonance Output				
200	10.0	4.5	3.0	0.5	11.4	9.0	4.0	2.5		10.16	10.0	4.0	3.0	1.0	11.22
400	4.0	5.0	2.0	0.5	6.72	3.5	5.0	2.5		6.6	4.5	5.0	2.5	0.6	7.2
600	3.5	5.5	2.0		6.82	3.5	4.5	2.0		6.02	4.0	4.5	2.2		6.41
800	4.5	5.0	0.8		6.73	4.5	5.0	1.0		6.8	5.5	5.0	1.0		7.5
1000	5.2	4.0	0.5		6.57	5.0	4.0	1.0		6.5	6.0	4.0	0.6		7.23
1500	3.5	1.1	0.2		3.67	4.0	1.3	0.2		4.21	4.5	1.3	0.25		4.7
2000	1.2	0.45	0.1		1.28	1.3	0.6	0.11		1.43	0.7	0.45			0.71
2500	4.0	1.2	0.2		4.18	3.2	0.8			3.3	3.0	0.8			3.1
	1200 kc					3000 kc					6000 kc				
200	10.0	4.0	3.0	1.0	11.22	10.0	4.0	3.0	1.0	11.22	11.0	4.0	3.0	1.2	12.14
400	4.5	5.0	2.5	0.6	7.2	4.5	5.0	2.5		7.2	5.5	5.0	2.4		7.81
600	4.0	5.0	2.0		6.7	4.0	4.5	2.0		6.34	5.0	4.5	2.0		7.0
800	5.0	5.2	1.0		7.28	5.0	5.0	1.0		7.14	6.0	5.0	1.0		7.87
1000	6.0	4.0	0.6		7.23	6.0	3.5	0.6		6.97	7.0	3.5	0.6		7.85
1500	4.0	1.0	0.3		4.13	4.5	1.0	0.2		4.16	5.5	1.0	0.2		5.6
2000	0.32	0.45	0.1		0.57	0.5	0.4			0.64	0.8	0.4			0.89
2500	3.5	1.0			3.64	2.7	0.8			2.8	3.0	0.8			3.1

Allowed 10%

[redacted]

Table 29

Overload
Band A 278 kilocycles

Input mcv	Output mw MCW	Output mw CW
5	320	400
8	600	450
10	725	475
20	975	500
25	1000	550
30	925	500
40	200	350
50	0	0

Band B

	Dial Setting 200		Dial Setting 300		Dial Setting 400	
	Output mw		Output mw		Output mw	
Input mcv	MCW	CW	MCW	CW	MCW	CW
5	250	250	300	750	340	500
8	500	350	550	775	600	525
10	650	380	700	700	750	550
20	950	420	1000	0	1000	625
30	1000	450	1025		950	525
40	500	500	650		225	250
50	50	525	100		0	0
60	0	550	0			
70		450				
80		250				
90		100				
100		0				

[redacted]

Table 30

Overload

Band C

Input mcv	Dial Setting 200 Output MW MCW	CW	300 Output MW MCW	CW	400 Output MW MCW	CW
5	400	500	410	625	500	525
8	675	550	650	650	725	575
10	775	575	775	650	850	600
15	875	600	850	425	925	500
20	1000	500	1000	200	1000	400
30	450	0	325	0	150	0
40	0		0		0	

Band D

Input mcv	Dial Setting 200 Output MW MCW	CW	300 Output MW MCW	CW	400 Output MW MCW	CW
5	250	450	300	500	100	280
8	500	500	550	550	250	410
10	650	525	700	575	400	470
15	750	550	800	600	550	500
20	950	550	925	575	725	525
25	975	400	975	450	825	550
30	1000	250	875	300	900	575
40	450	0	200	0	1000	600
50	50		0		975	625
60	0				775	575
70					400	450
80					100	300
90					0	0

[redacted]

Table 31

Overload

Band E

	Dial Setting					
	200		300		400	
Input	Output MW		Output MW		Output MW	
mcv	MCW	CW	MCW	CW	MCW	CW
5	625	575	250	500	650	500
6	725	600	300	525	700	525
8	850	550	500	575	850	525
10	950	425	650	600	950	500
12	970	150	750	700	1000	100
15	1000	0	850	600	850	0
20	625		950	550	150	
30	0		1025	350	0	
40			800	0		
50			200			
60			0			

Band F

	Dial Setting					
	200		300		400	
Input	Output MW		Output MW		Output MW	
mcv	MCW	CW	MCW	CW	MCW	CW
5	80	370	130	370	500	400
8	200	475	300	470	775	430
10	350	500	450	500	875	450
15	525	525	625	525	925	500
20	700	550	800	550	975	450
25	800	550	875	550	1050	300
30	900	550	950	550	950	0
40	950	500	1000	475	250	0
50	1000	350	875	350	0	
60	800	200	350	100		
70	375	0	100	0		
80	100		0			
90	0					

[redacted]

Table 32

Reset

MCW		CW	
300 kilocycles		300 kilocycles	
Counterclockwise	Clockwise	Counterclockwise	Clockwise
299.290	299.340	293.105	293.235
299.390	299.290	293.065	293.185
299.390	299.245	292.995	293.115
299.535	299.290	293.070	293.130
Max. spread 0.290 kc = 0.096%		Max. spread 0.240 kc = 0.08%	
600 kilocycles		600 kilocycles	
599.020	599.070	598.070	598.180
599.120	599.270	597.980	598.390
599.170	599.170	598.000	598.320
599.070	599.070	597.950	598.160
Max. spread 0.250 kc = 0.041%		Max. spread 0.440 kc = 0.073%	
1200 kilocycles		1200 kilocycles	
1195.700	1195.420	1192.820	1193.300
1195.420	1195.220	1193.380	1193.720
1195.900	1195.020	1192.920	1193.580
1196.200	1195.420	1193.000	1193.600
Max. spread 1.180 kc = 0.098%		Max. spread 0.900 kc = 0.075%	
3000 kilocycles		3000 kilocycles	
2996.800	2994.950	2995.750	2996.250
2997.050	2995.150	2995.500	2995.400
2996.850	2996.150	2995.650	2996.150
2997.200	2995.900	2995.250	2996.550
Max. spread 2.250 kc = 0.075%		Max. spread 1.300 kc = 0.043%	
6000 kilocycles		6000 kilocycles	
6000.800	6001.700	6006.100	6006.600
6003.200	6000.000	6005.500	6005.400
6004.900	6004.000	6005.100	6007.500
6002.500	6002.100	6007.100	6005.400
Max. spread 4.900 kc = 0.081%		Max. spread 2.400 kc = 0.04%	

Allowed 0.1%

[redacted]

Table 33

AVC Action

Receiver adjusted for standard output in manual position with allowable noise level, then with same input and receiver in AVC position, gain control again adjusted for standard output.

Input mcv	278 kc	600 kc	1200 kc	3000 kc	6000 kc
	Milliwatts Output				
x 10	135	260	320	450	450
x 100	145	285	350	500	480
x 1000	150	300	365	550	500
x 10000	165	315	395	600	510
Power ratio at 10,000 x input	3.3 to 1	6.3 to 1	7.9 to 1	12.0 to 1	10.2 to 1

Receiver in AVC position adjusted for standard output with full gain.

x 10	575	650	685	675	750
x 100	750	800	850	810	875
x 1000	850	875	910	890	925
x 10000	925	950	990	950	975
Power ratio at 10,000 x input	18.5 to 1	19.0 to 1	19.8 to 1	19.0 to 1	19.5 to 1

Receiver in AVC position adjusted for standard output with 5 mcv input.

x 10	58	58	65	95	130
x 100	62	60	68	95	135
x 1000	65	63	70	98	138
x 10000	75	73	80	110	140
Power ratio at 10,000 x input	1.5 to 1	1.46 to 1	1.6 to 1	2.2 to 1	2.8 to 1

Allowed voltage ratio 3 to 1 (power ratio 9 to 1)

[redacted]

Table 34

Loop Characteristics

On Course and Reciprocal Minimum

Freq kc	On Course	Reciprocal
200	2°	3°
500	1°	2°
1000	2°	2°
1500	2°	2°

Loop Movement for Full Scale Deflection

Freq kc	100 mcv/m Left	100 mcv/m 0	100 mcv/m Right	Total Width	200,000 mcv/m Left	200,000 mcv/m 0	200,000 mcv/m Right	Total Width
200	78°	90°	100°	22°	78°	90°	100°	22°
250	81°	90°	100°	19°	80°	90°	100°	20°
500	82°	90°	101°	19°	82°	90°	101°	19°
1000	80	90°	101°	21°	80°	90°	101°	21°
1400	74°	90°	104°	30°	78°	90°	102°	24°
1500	70°	90°	107°	37°	70°	90°	106°	36°

Freq kc	Left & right agreement (100 mcv/m)	Left & right agreement (200,000 mcv/m)
200	16.6%	16.6%
250	10.0%	0
500	27.2%	27.2%
1000	10.0%	9.0%
1400	12.5%	0
1500	15.0%	20.0%

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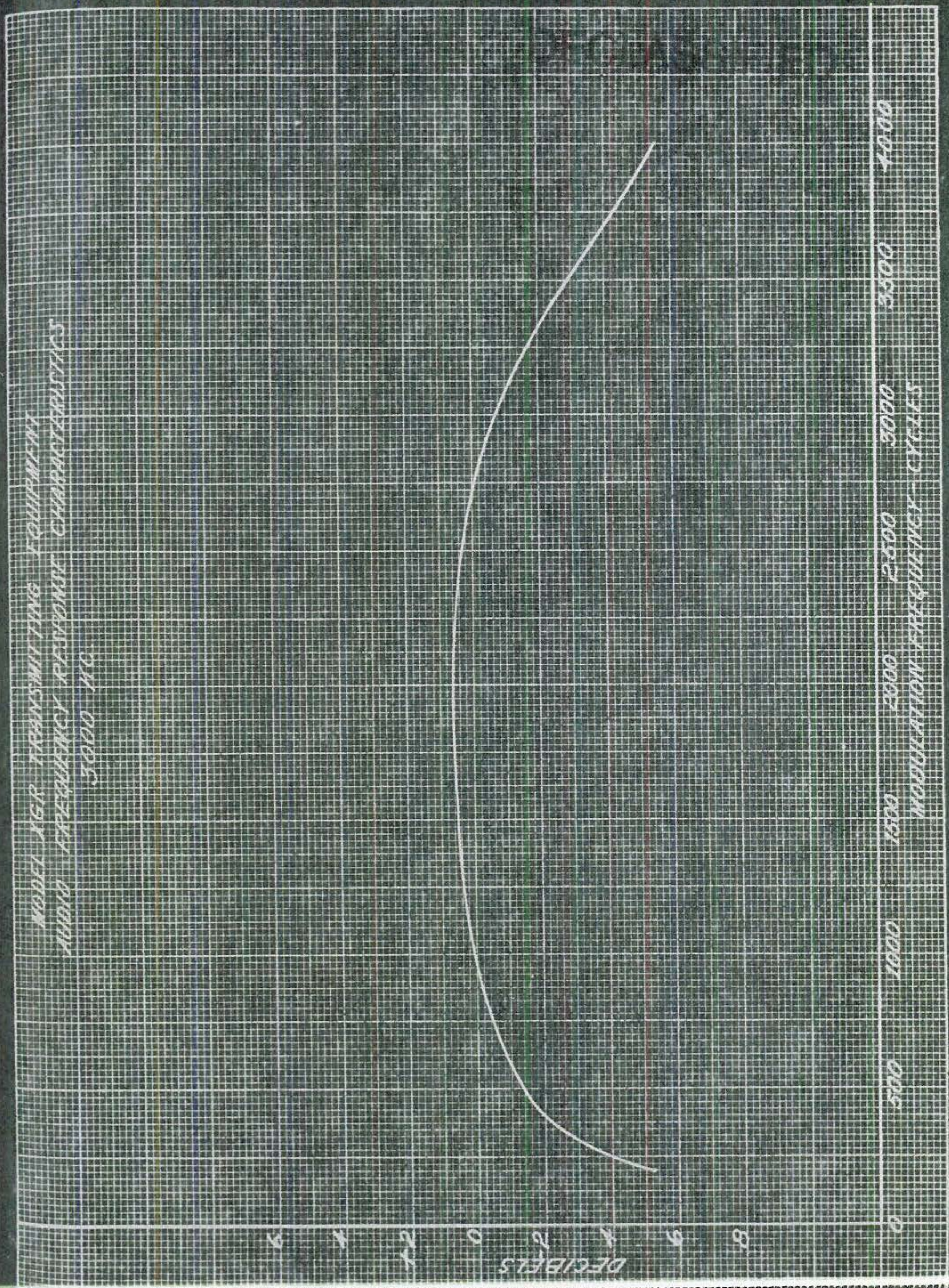

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PLATE 1

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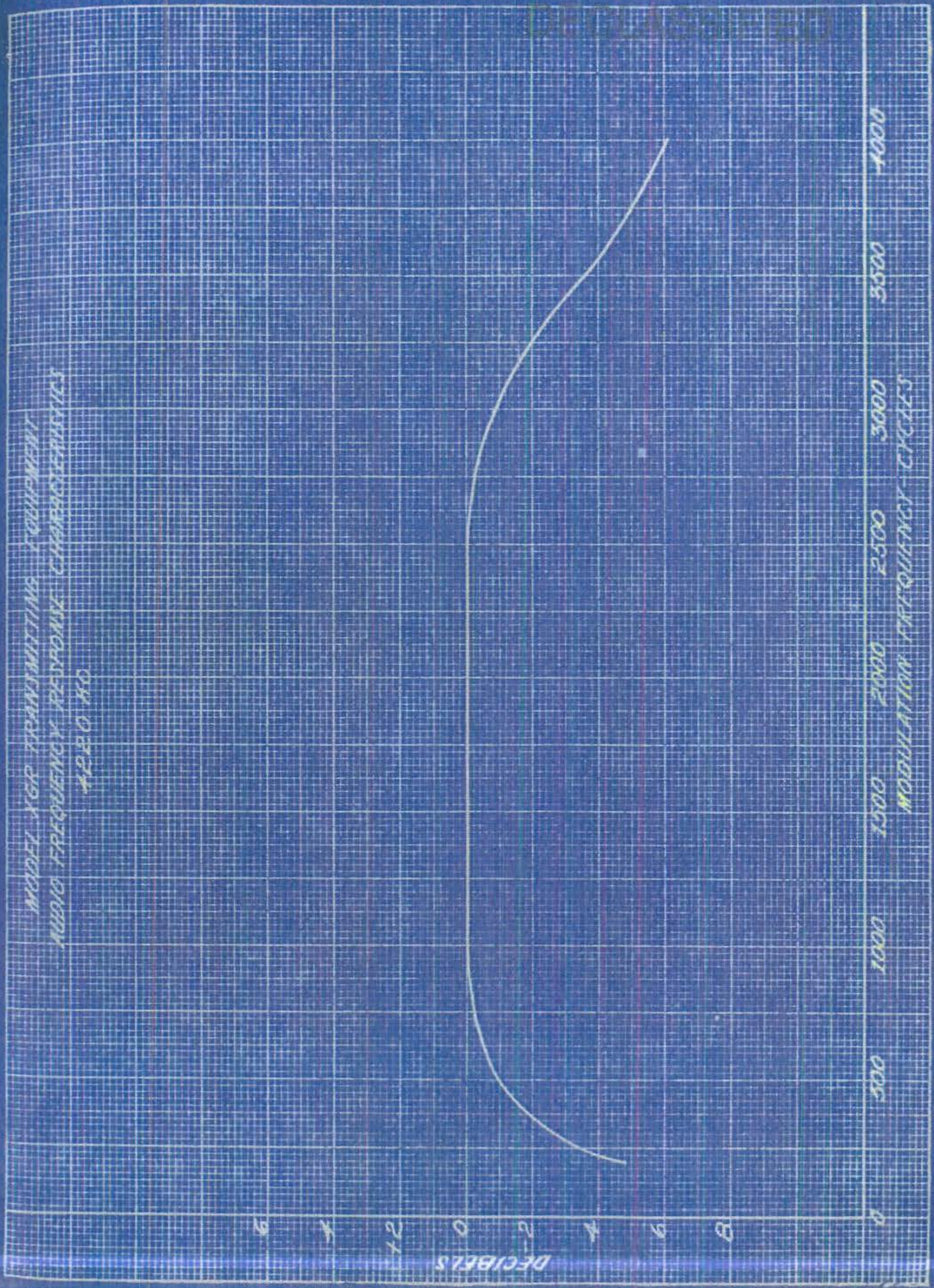

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PLATE 2

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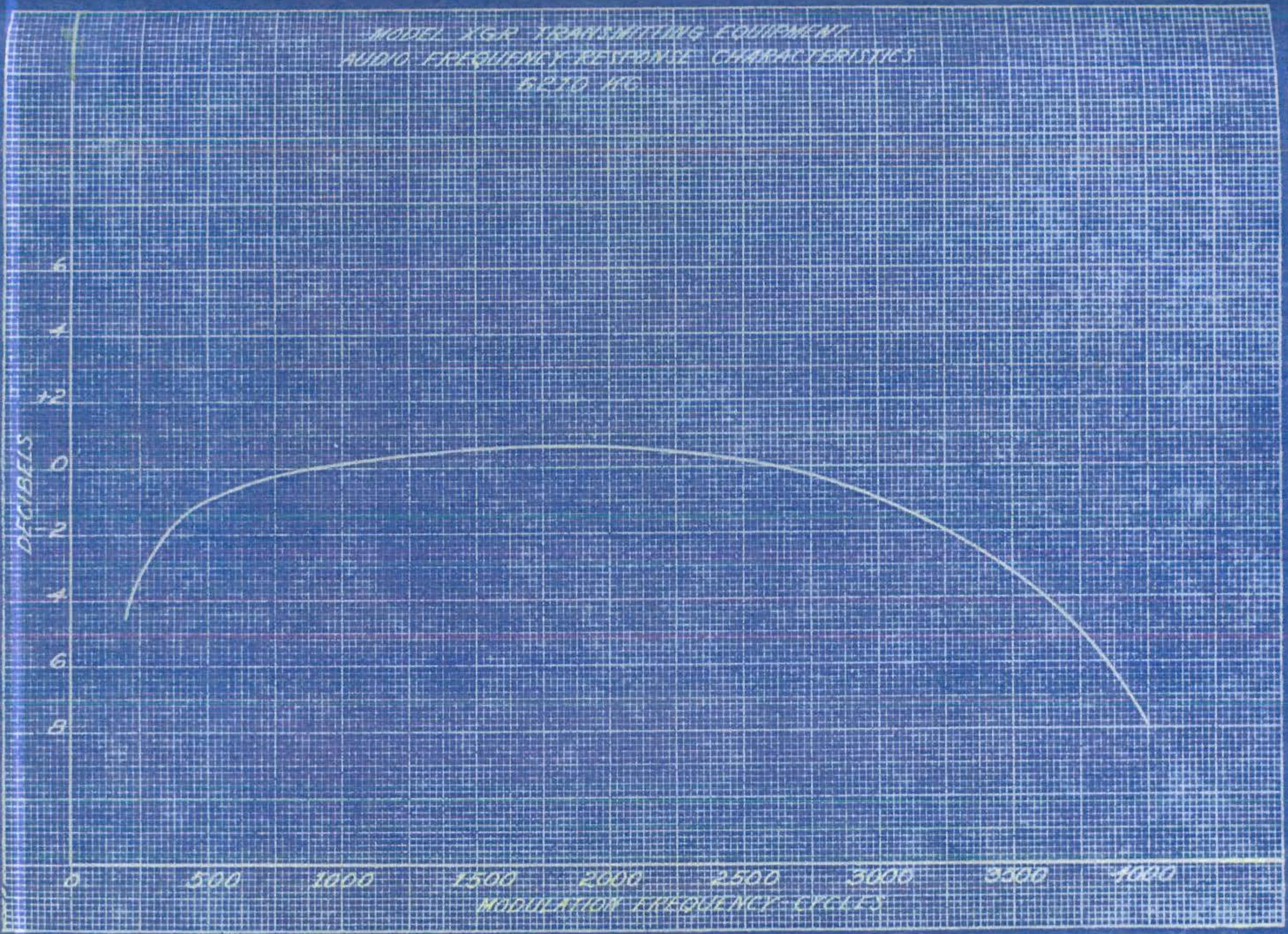

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PLATE 3

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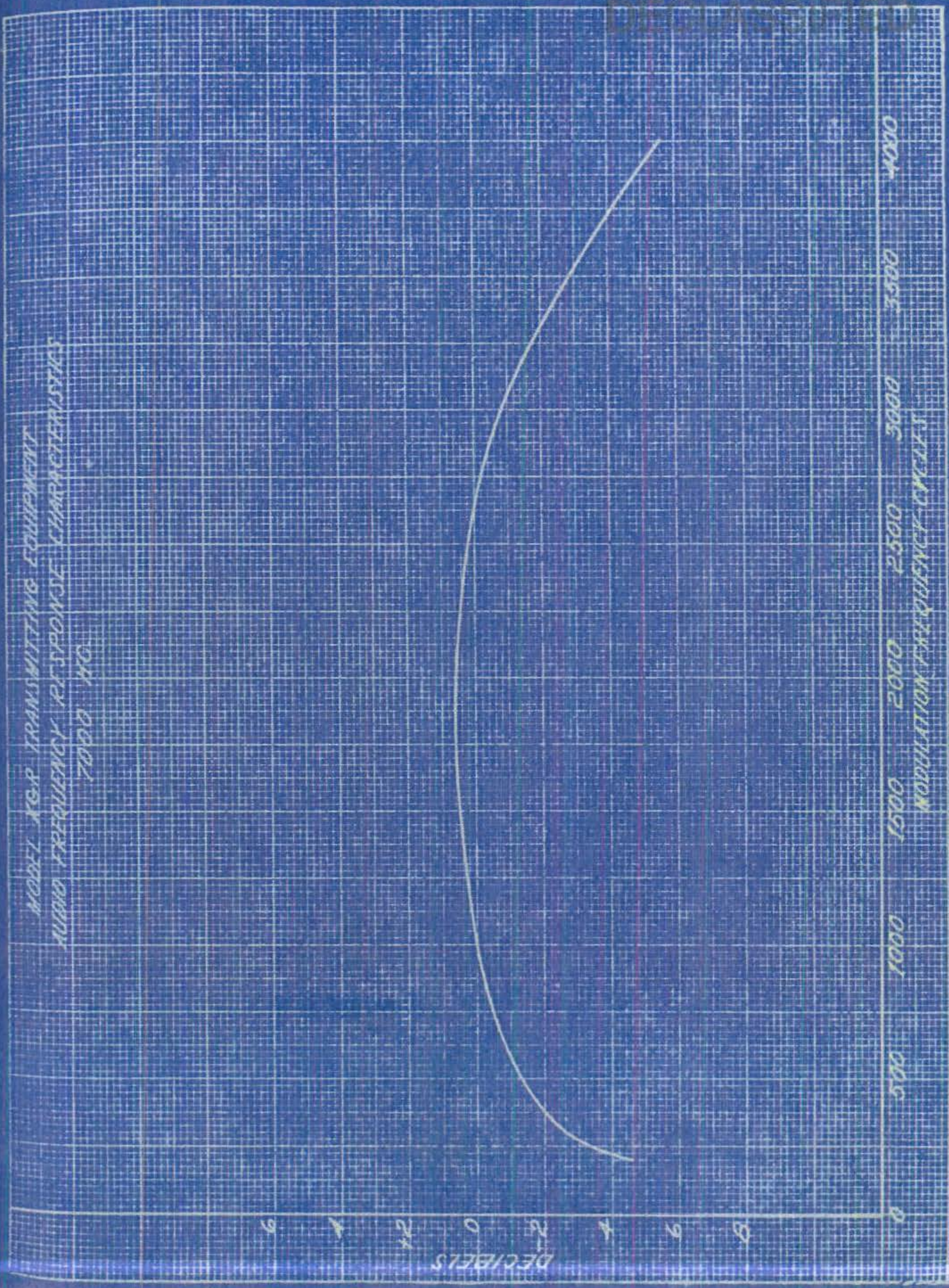

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PLATE 4

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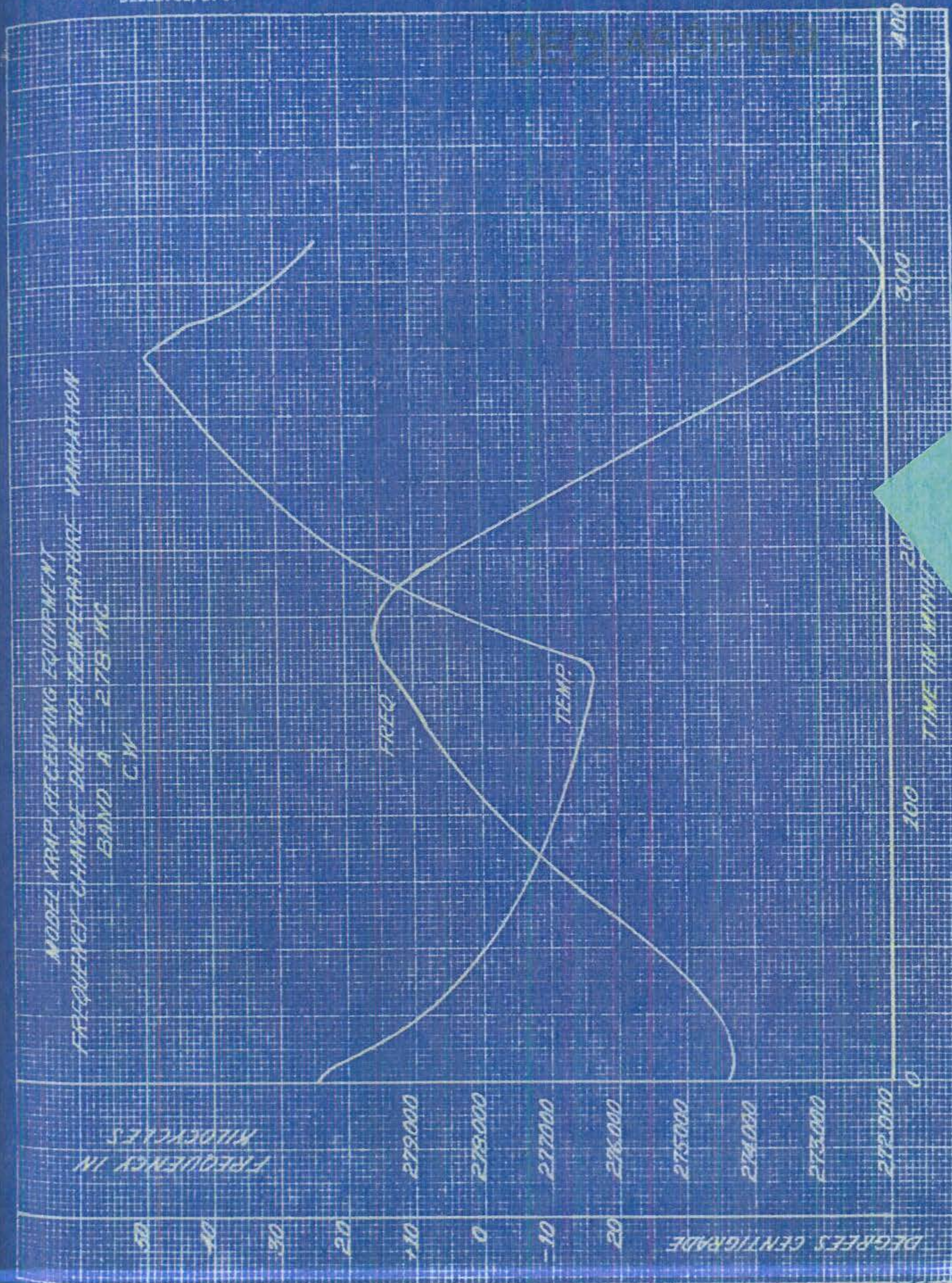

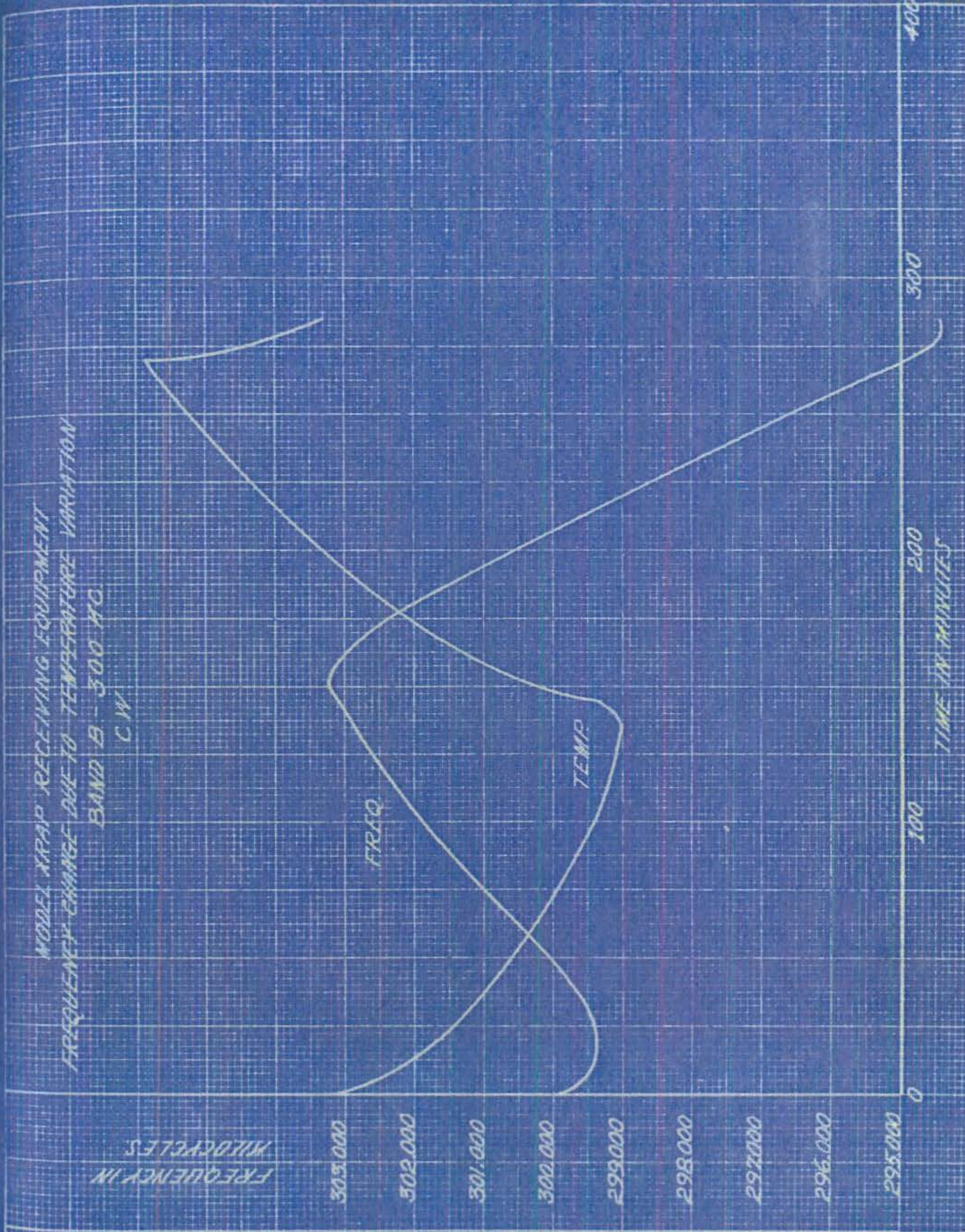
MODEL XRAP RECEIVING EQUIPMENT
FREQUENCY CHANGE DUE TO TEMPERATURE VARIATION
BAND B - 300 MC
C W
FREQ
TEMP
0
100
200
300
400
TIME IN MINUTES
FREQUENCY IN MEGACYCLES
303.000
302.000
301.000
300.000
299.000
298.000
297.000
296.000
295.000
50
40
30
20
+10
0
-10
20
DEGREES CENTIGRADE

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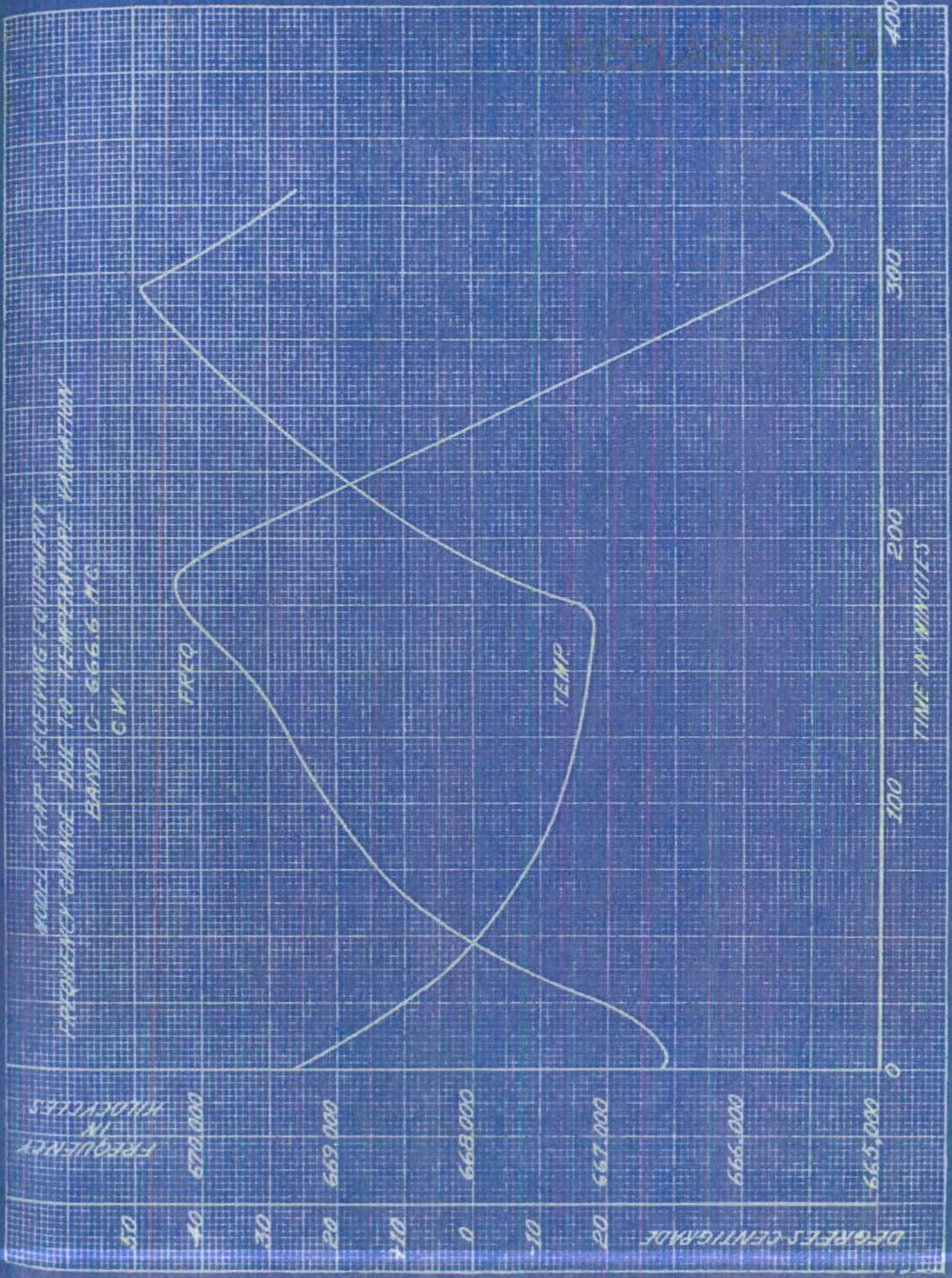

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PLATE 7

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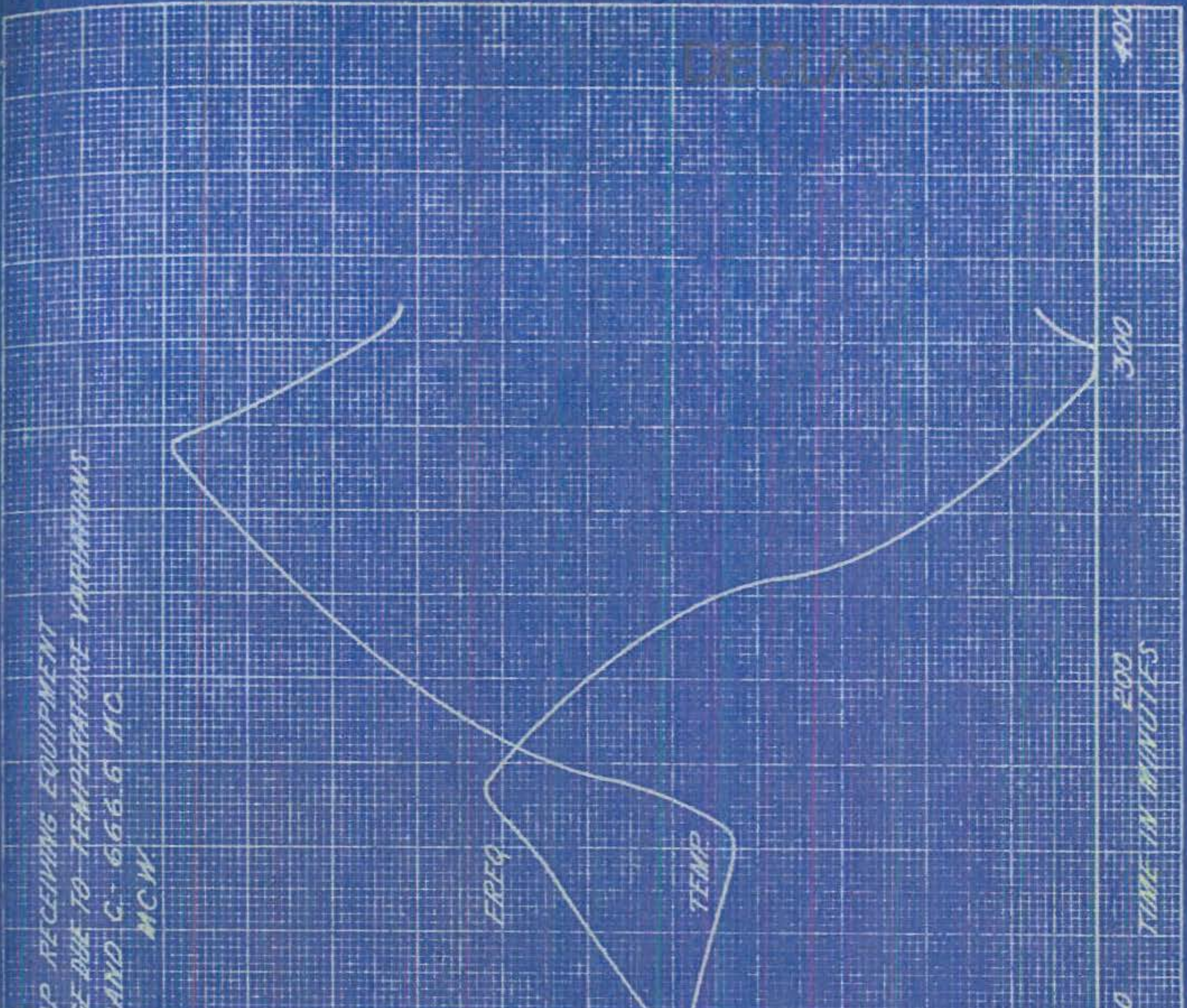

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PLATE 8

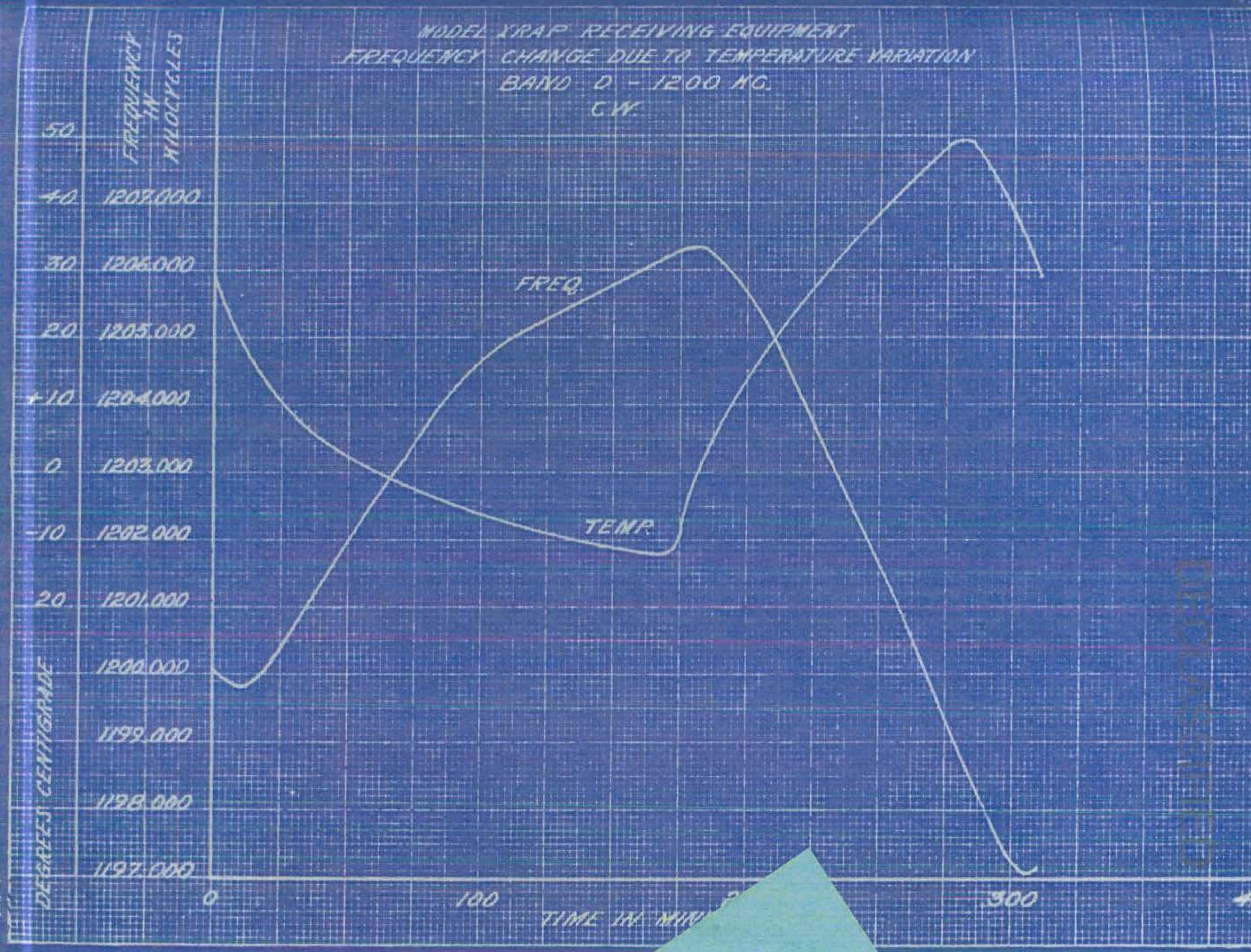

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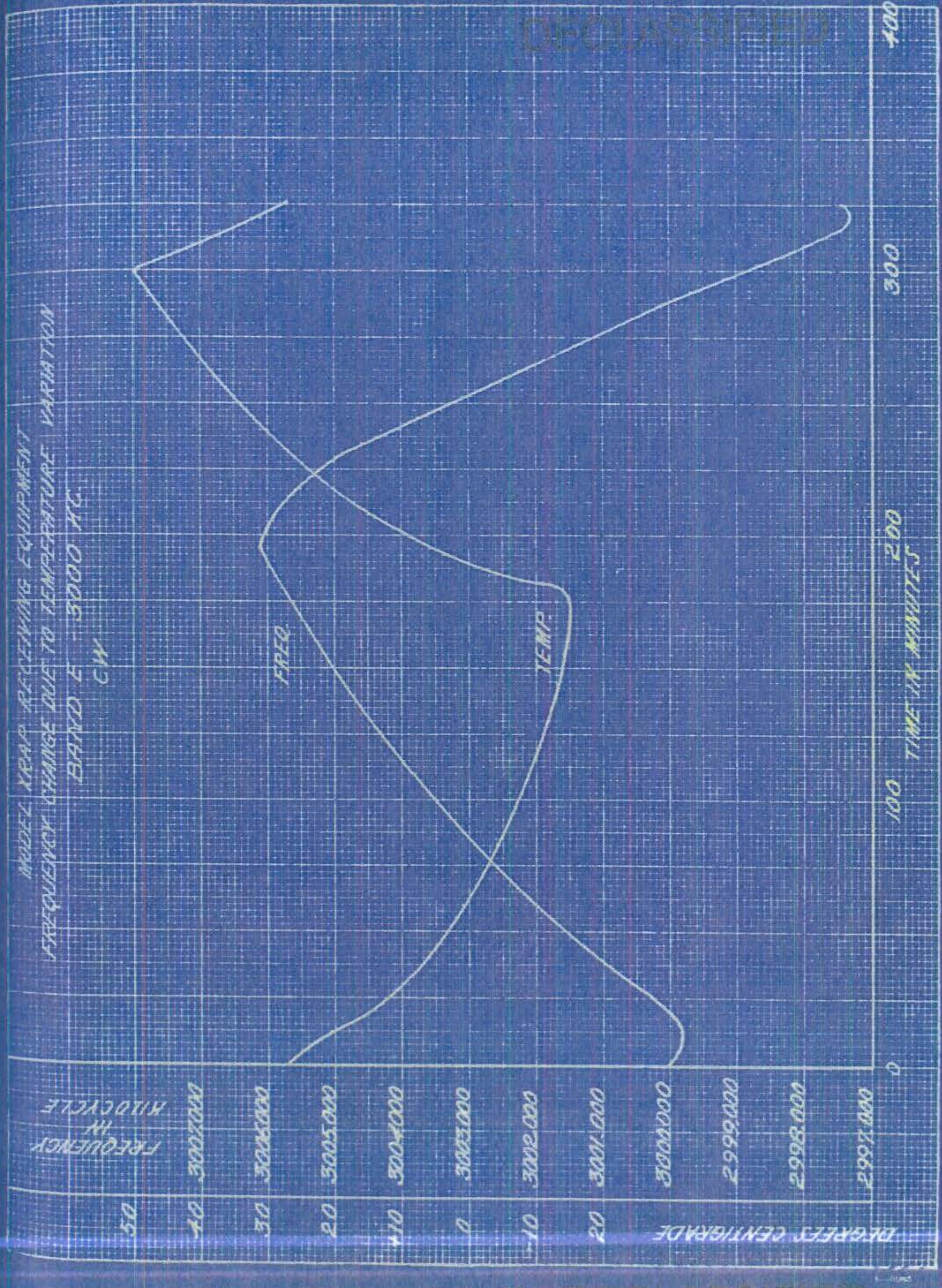
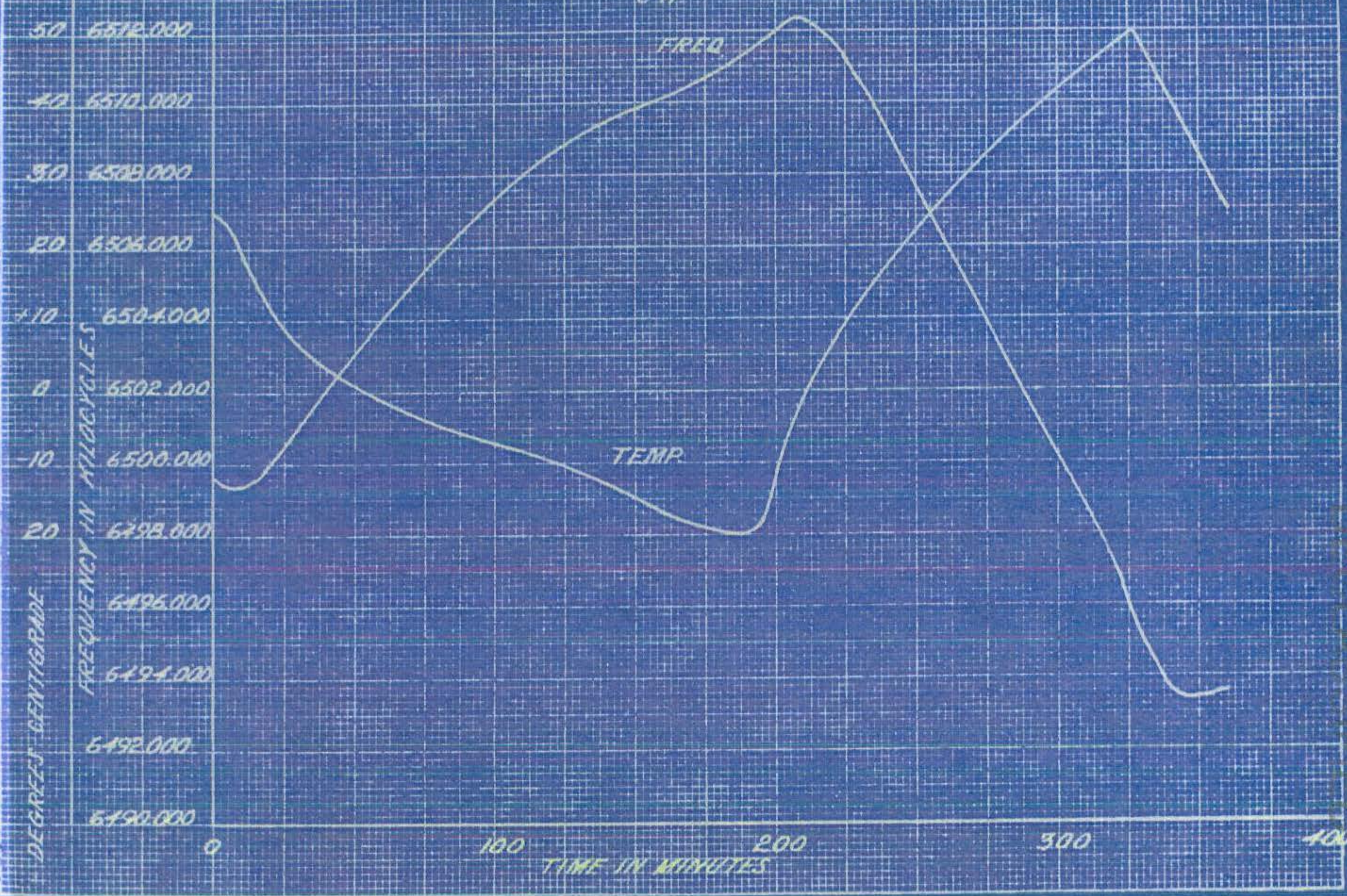
PLATE 9


MODEL XRAP RECEIVING EQUIPMENT
FREQUENCY CHANGE DUE TO TEMPERATURE VARIATION
BAND E 3000 KC.
CW
FREQ
TEMP.
0
100
200
300
400
TIME IN MINUTES
FREQUENCY IN KILOCYCLE
3007.000
3006.000
3005.000
3004.000
3003.000
3002.000
3001.000
3000.000
2999.000
2998.000
2997.000
50
40
30
20
10
0
10
20
DEGREES CENTIGRADE

MODEL XRAP RECEIVING EQUIPMENT
FREQUENCY CHANGE DUE TO TEMPERATURE VARIATION
BAND F - 6500 KC
C.W.



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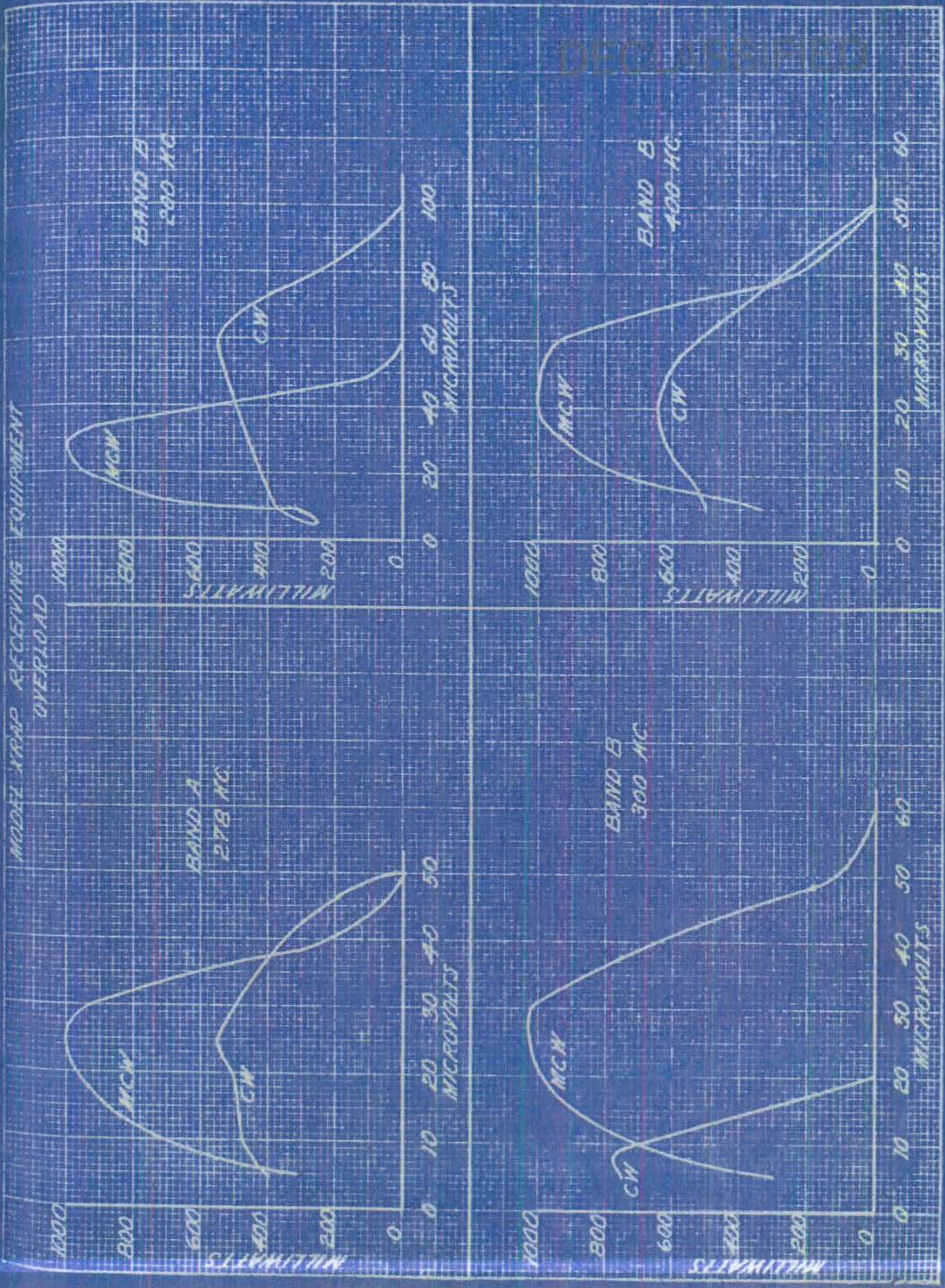

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PLATE 12

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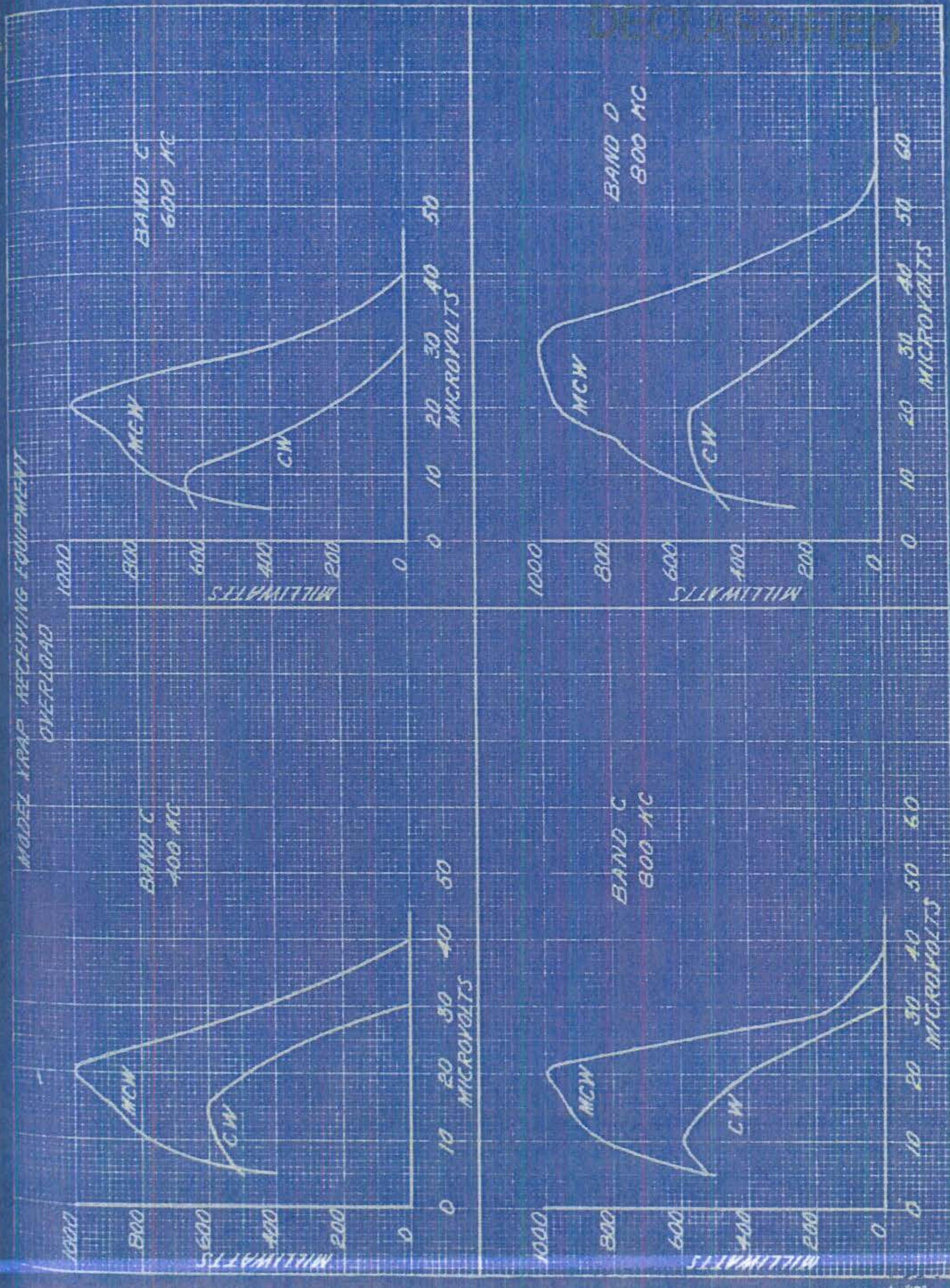

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PLATE 13

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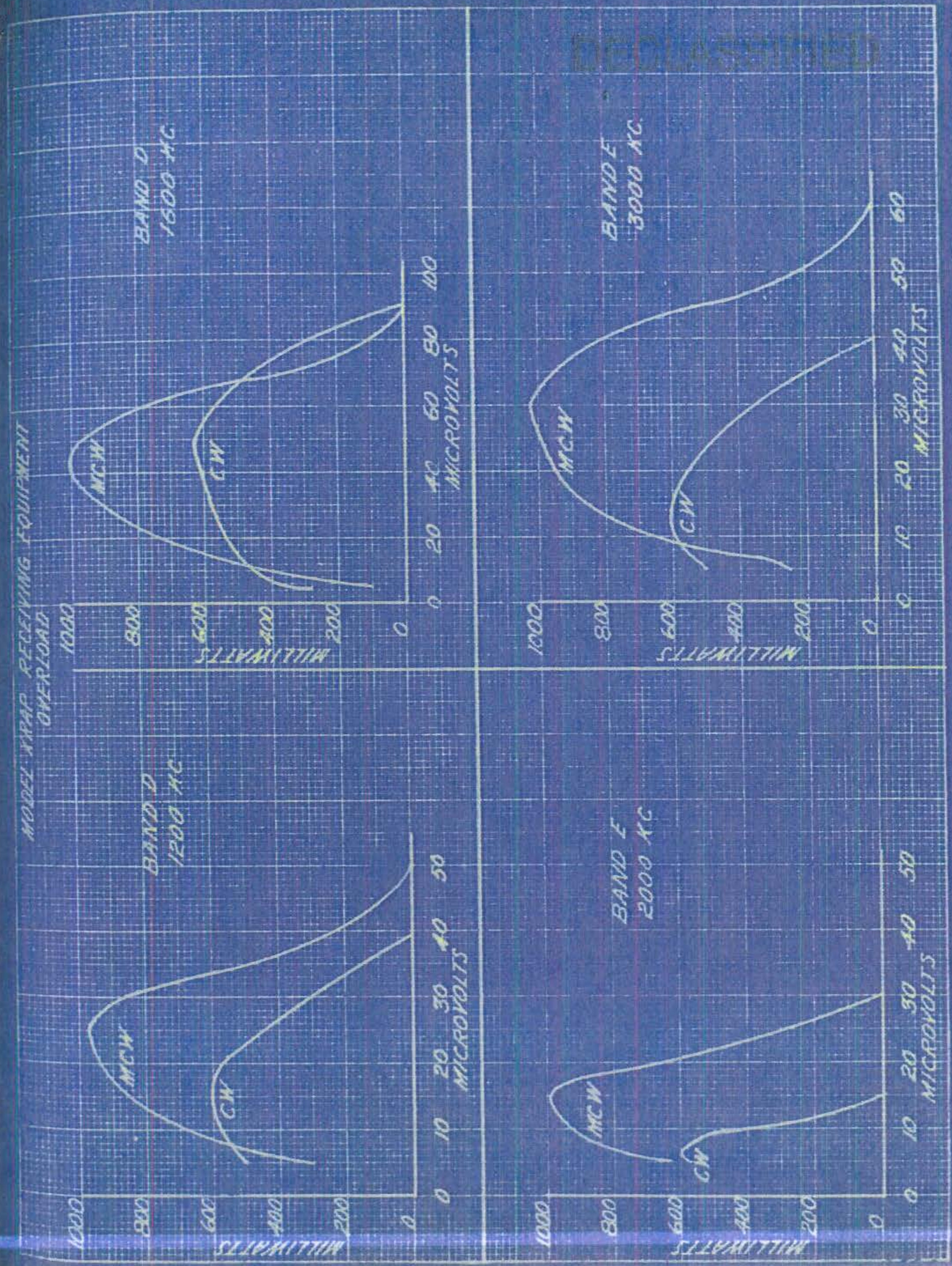

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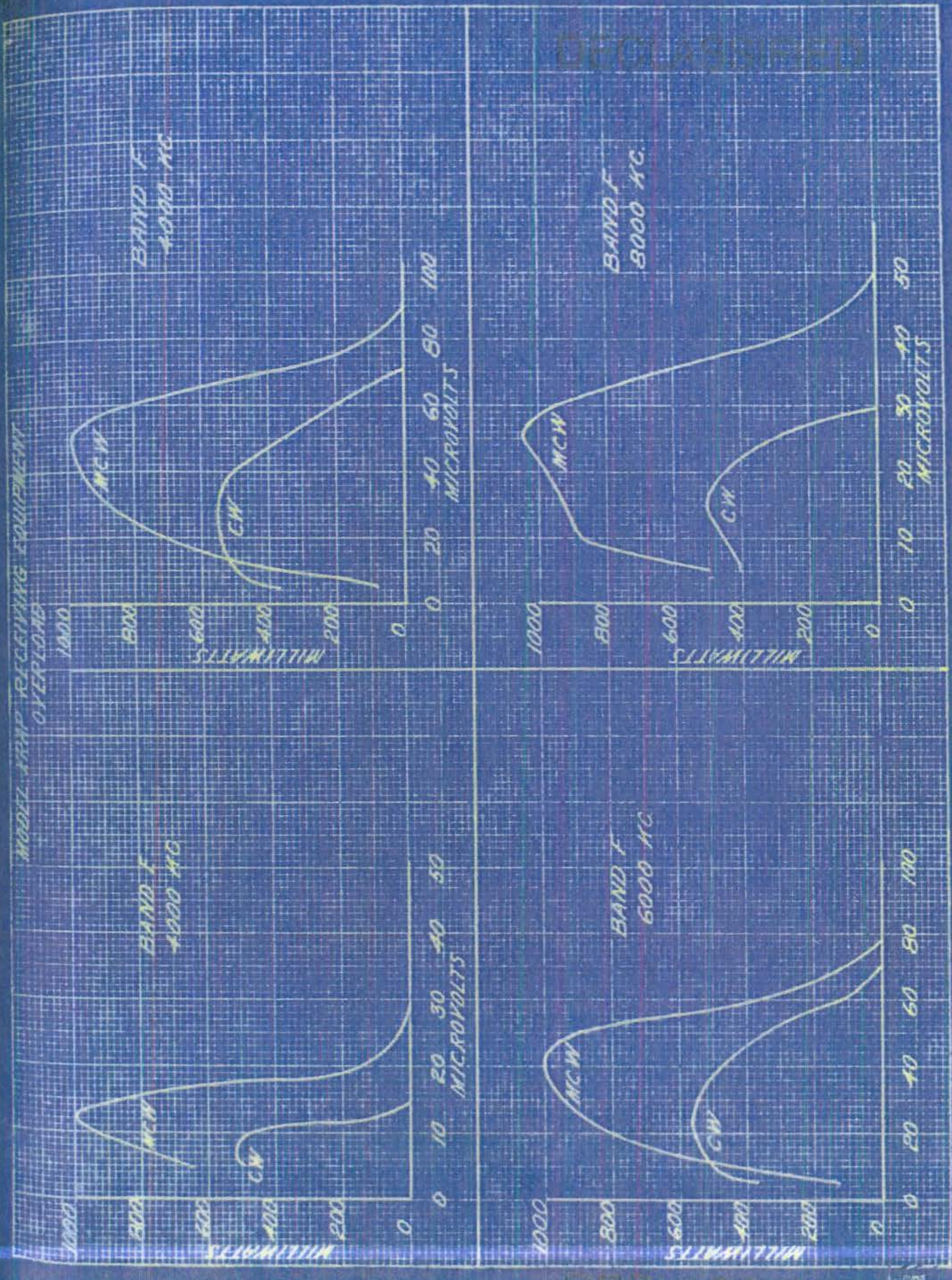

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PLATE 15

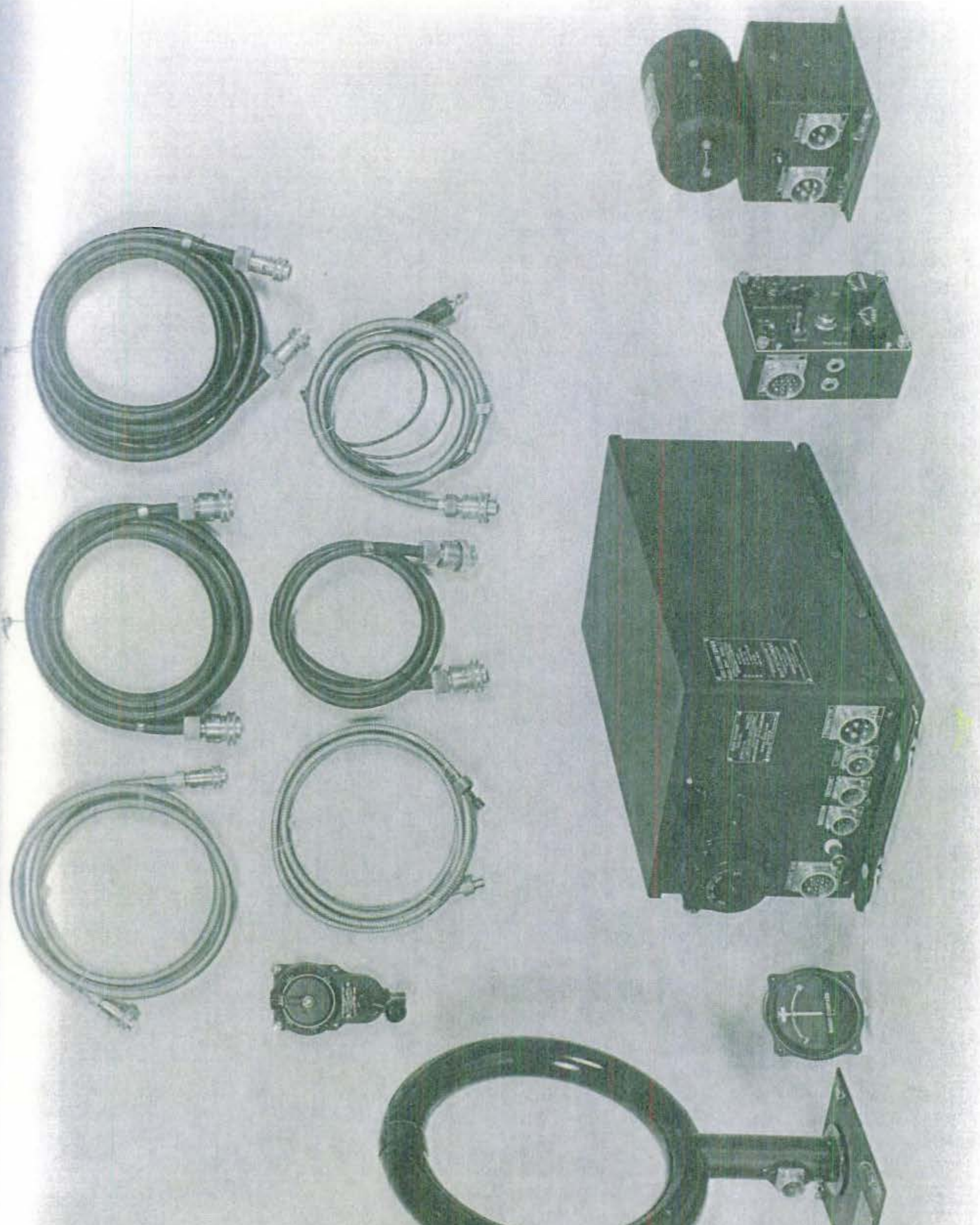

Plate 16

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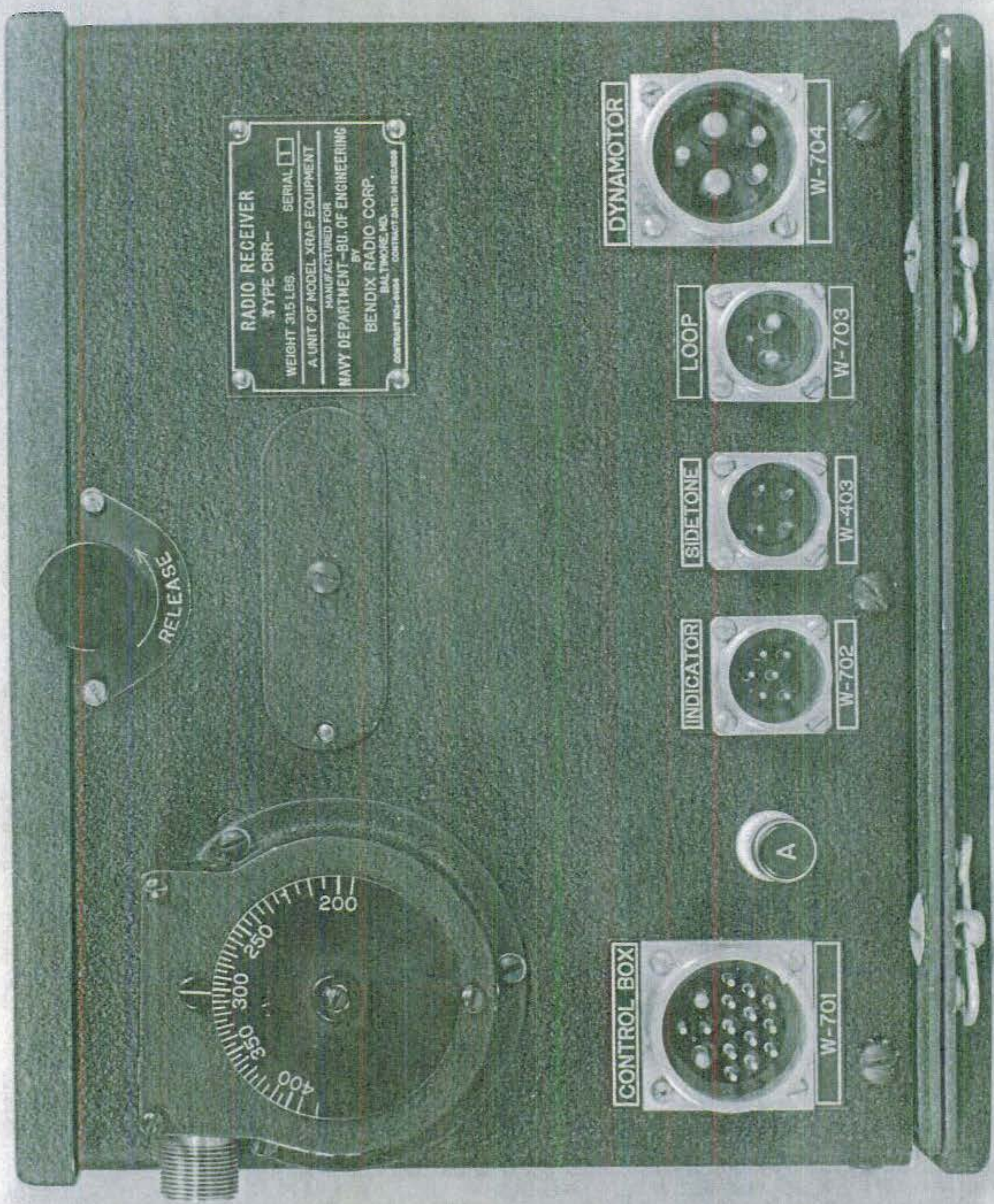

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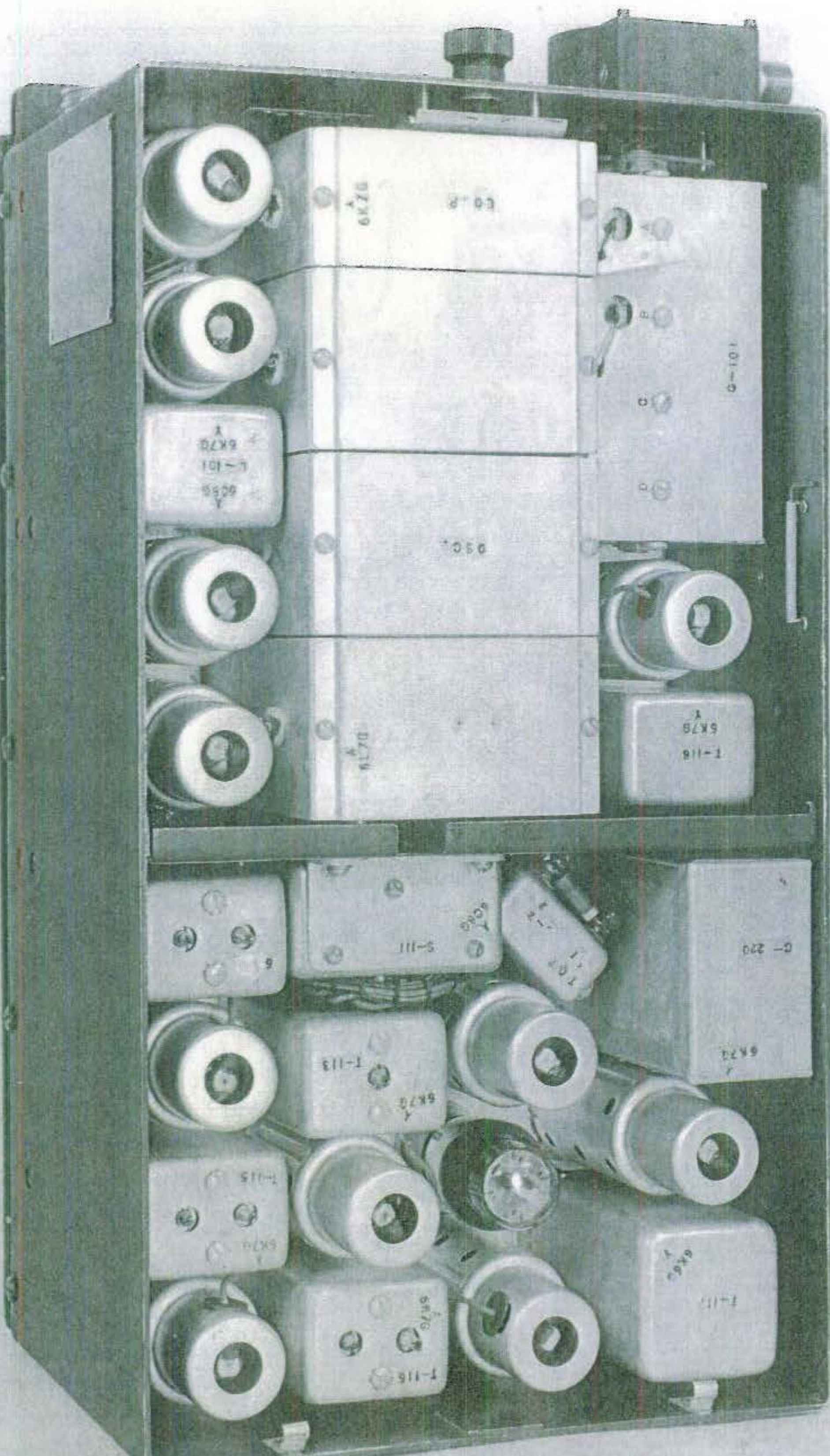

Plate 15

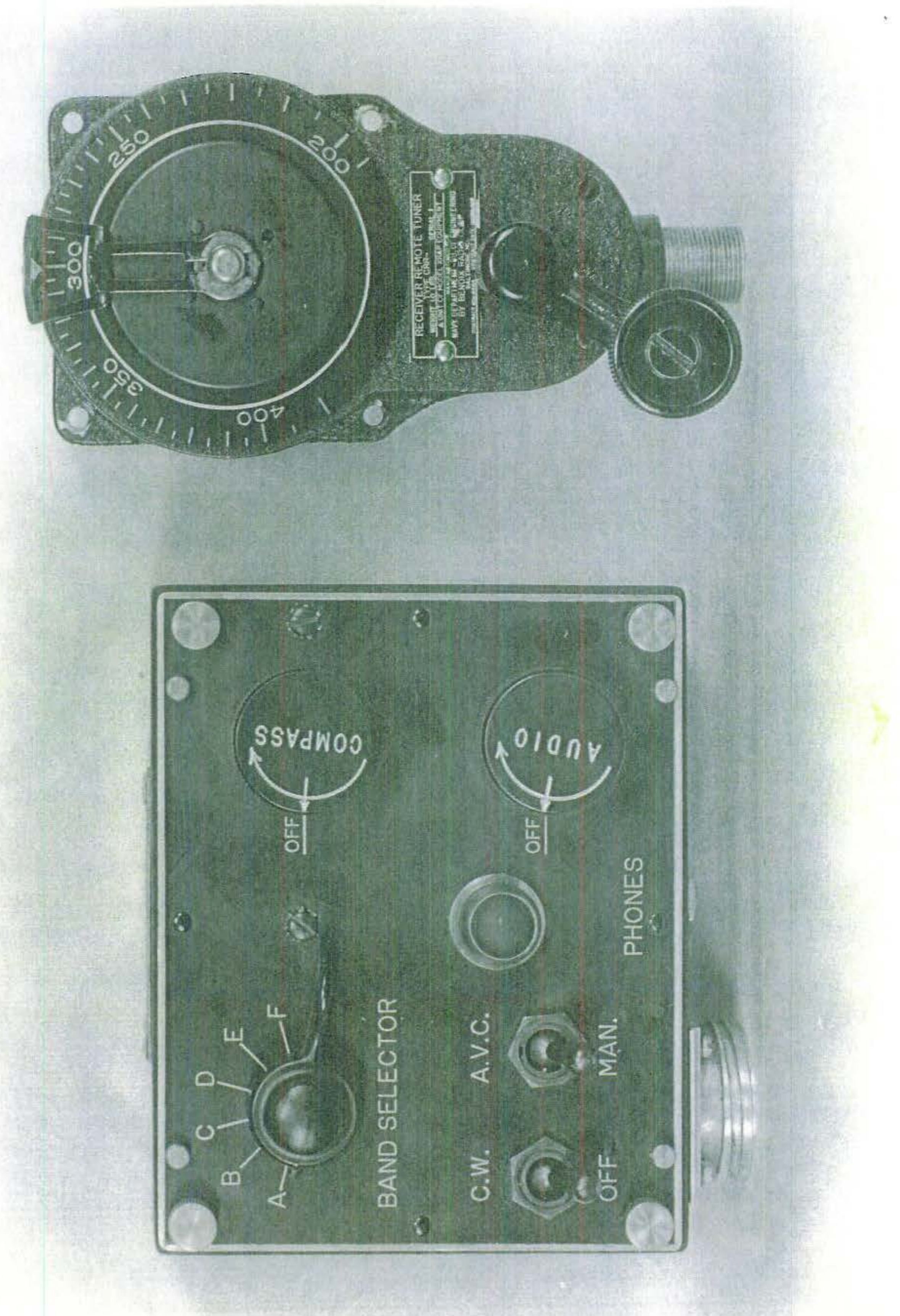
250
200
300
350
400
RECEIVER REMOTE TUNER
COMPASS
OFF
AUDIO
OFF
PHONES
A
B
C
D
E
F
BAND SELECTOR
A.V.C.
MAN.
C.W.
OFF

Plate 20

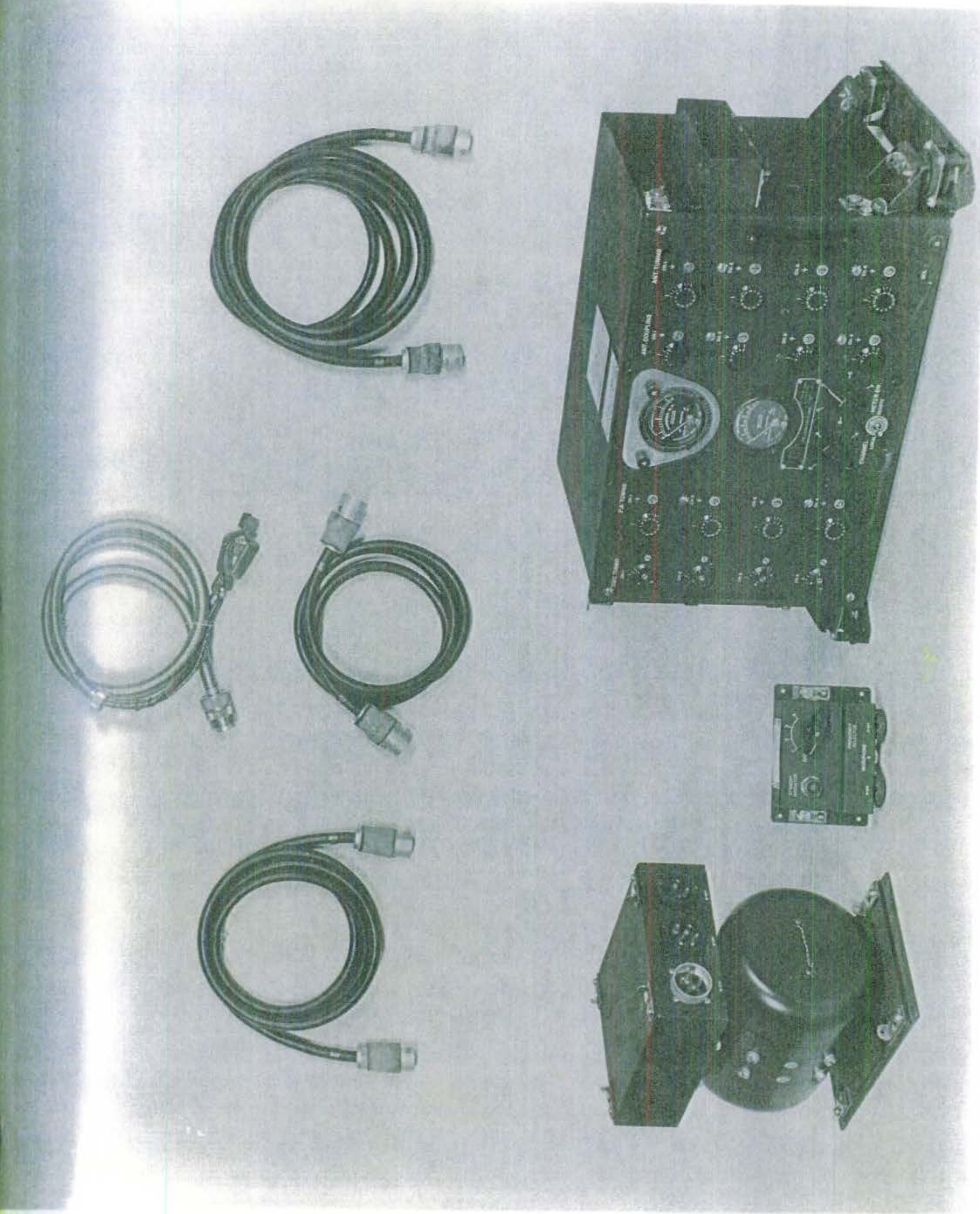

Plate 21

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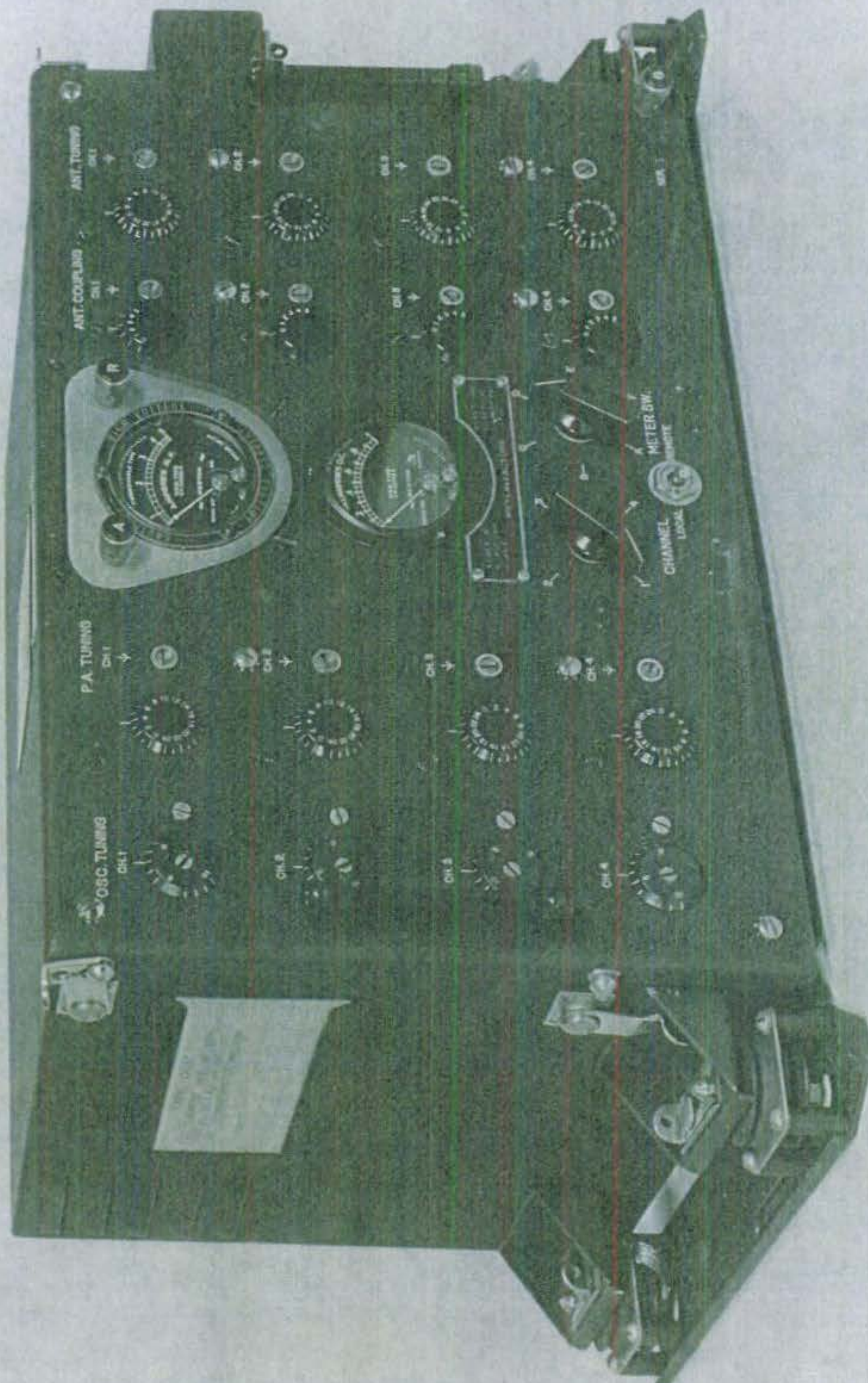


Plate 22 DECLASSIFIED

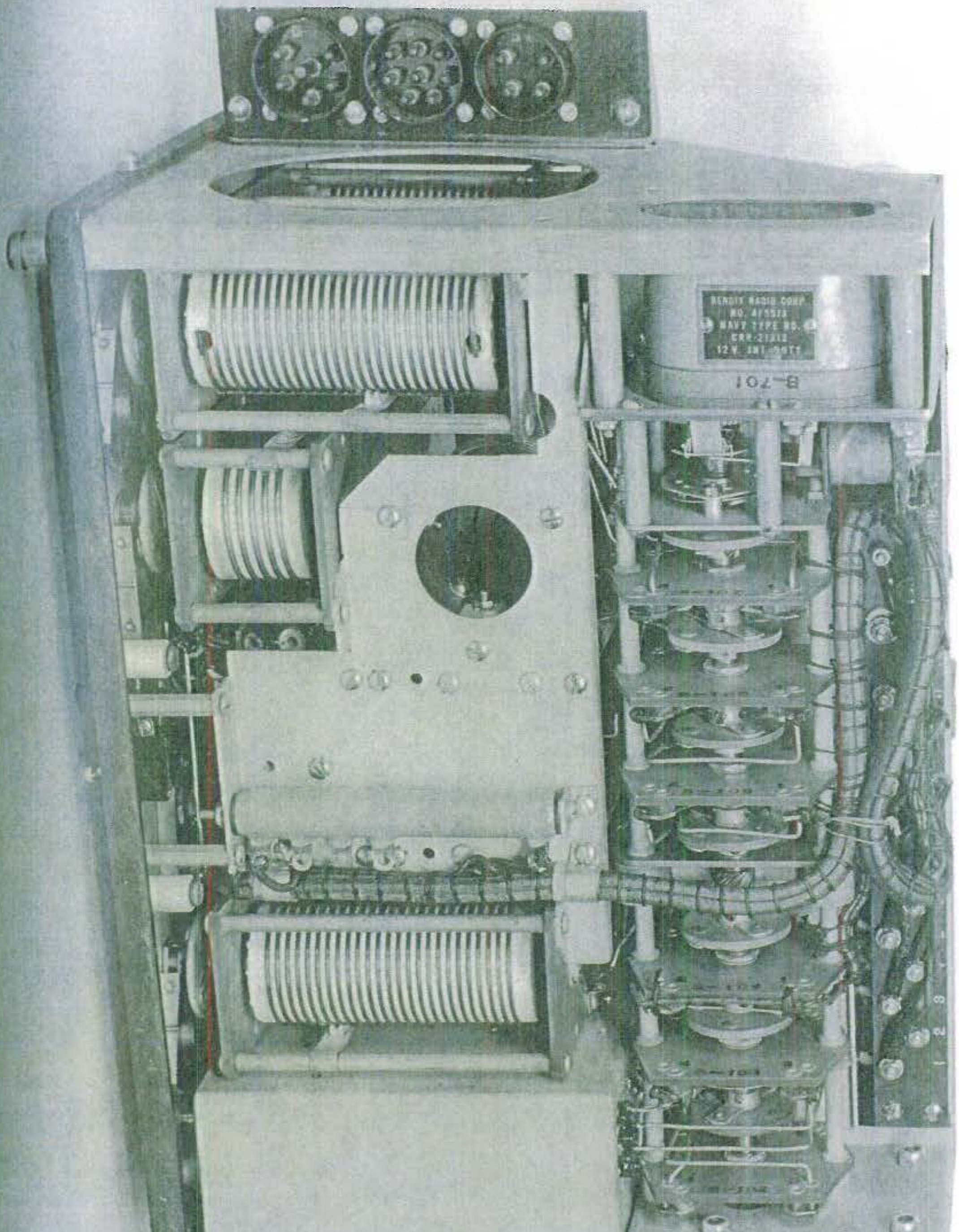


Plate 83

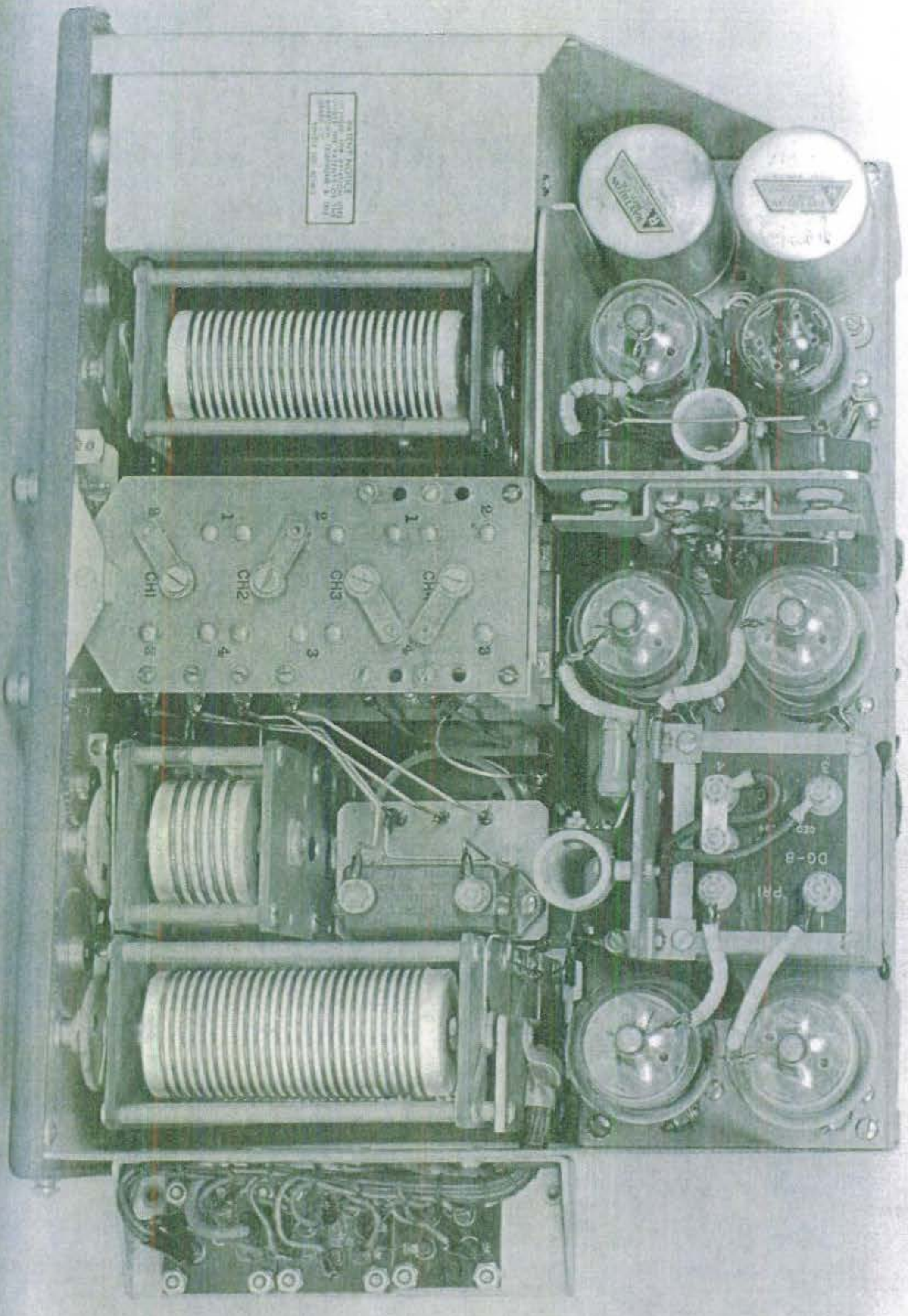
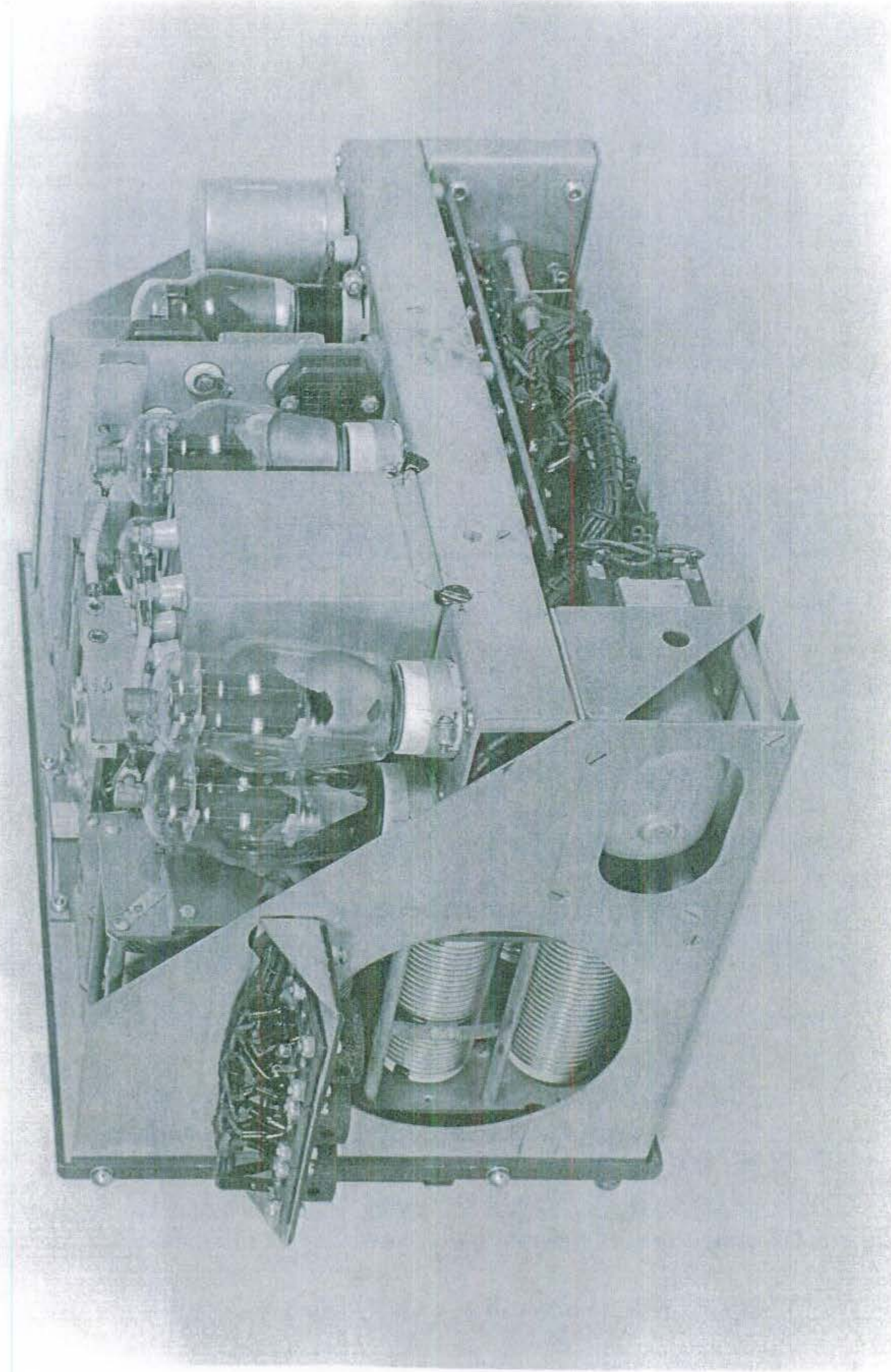


Plate 51



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C O P Y

U. S. NAVAL AIR STATION
Anacostia, D. C.

JCL/glw

F42-1/46-52(6)/
NA6 (224)
Serial #39102

7 July 1939

[redacted]

From: Commanding Officer.
To: Director, Naval Research Laboratory.

Subject: Aircraft Radio - Contract NOs-64164 - Model XGR/XRAP Equipment - Report on Tests of Preliminary Model.

Reference: (a) BuEng. letter C-NOs-64164 (3-27-R1) of 3 April, 1939 to NAS Anacostia.
(b) BuEng Conf. Specification Re-13A-541B.
(c) RINM Baltimore letter L4-3/64164 of 11 May 1939 to Bureau of Engineering.
(d) BuEng Conf. letter C-NOs-64164 (5-1-R1) of 19 May, 1939 to Director Naval Research Laboratory and CO NAS Anacostia.

Enclosure: (A) Photograph AN-53561 - Model XGR/XRAP Installation in SOC-1 Airplane #9856 - Receiver Dynamotor, Transmitter Dynamotor, Transmitter and lower part of Receiver.
(B) Photograph AN-53562 - Model XGR/XRAP Installation in SOC-1 Airplane #9856 - Loop Antenna and Receiver.
(C) Photograph AN-53563 - Model XGR/XRAP Installation in SOC-1 Airplane #9856 - Compass Meter.
(D) Photograph AN-53564 - Model XGR/XRAP Installation in SOC-1 Airplane #9856 - Transmitter and Receiver Remote Control Units on Right Side of Forward Cockpit.

1. This letter reports on tests made at this station on preliminary model XGR/XRAP equipment.

2. Description of Equipment

The XGR/XRAP equipment consists of an XGR transmitter and an XRAP receiver with built-in right-left indicator circuits. The transmitter is designed for voice transmission only, and is a four channel, pretuned, crystal controlled transmitter with a nominal power output of 15 watts. Frequencies between 3 and 7 megacycles can be set up on the transmitter provided suitable crystals are available. Selection of the desired transmitter channel is effected by a single switch located in the transmitter control box which can be mounted at any desired point in the airplane. The receiver is designed

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for the reception of modulated or unmodulated energy between the limits of 200-1600 kc and 2000 to 8000 kc, plus a fixed frequency of 278 kc. The right-left indicator circuits are built as part of the receiver and operate between the limits of 200-1600 kc and also on the 278 kc fixed frequency. Control of the receiver and right-left indicator is effected from a remote point only.

3. Tube Lineup

The tube lineups are as follows:

A. For the transmitter.

Tube	Quantity	Function
807	1	Crystal Oscillator
807	2	Power amplifier
807	2	Modulator
42	1	Speech amplifier

B. For the receiver, right-left indicator unit.

Tube	Quantity	Function
6K7G	1	Loop stage
6C8G	1	Modulator
6C8G	1	Switching oscillator
6K8G	1	RF stage
6L7G	1	Mixer tube
6K7G	1	HF Oscillator
6K7G	1	1st IF Amplifier
6K7G	1	2nd IF Amplifier
6R7G	1	2nd Det. AVC and 1st AF
6K7G	1	CW Oscillator
6K6G	1	2nd AF Amplifier
6K7G	1	Compass output stage

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4. Weights and Dimensions

Unit	Weight	Height	Width	Length
Transmitter	44	10-7/16	11-1/2	19-1/8
Trans-Control Box	1.	2-3/8	3-11/16	5-1/16
Transmitter Dynamotor	23-3/4	9-3/16	5-5/8	9-1/2
Receiver	32-5/8	7-3/4	9-3/8	18
Receiver Control Box	1-3/4	2-7/8	4-3/4	5-1/4
Receiver Tun Control	1.	2-15/32	2-31/32	5-11/16
Receiver Dynamotor	8-3/4	7-3/8	4-3/8	6-1/4
Loop Antenna	2-7/8	17	6-9/16	11-7/8(DIA)
Compass Indicator	1-3/8	3-1/4	3-1/4	3-13/16
Total	117-1/8			
Covers (2)	1-3/8			
Linkage (1)	1-1/8			
Cables (10)	14-7/8			
	134-1/2			

Weight of transmitter and receiver was recorded with tubes and crystals in the respective equipments.

5. Cable and Linkage Lengths

Cable	Length (inches)
Transmitter Dynamotor - Battery	60
Transmitter Dynamotor-Transmitter	72
Transmitter Dynamotor-Remote Control Box	108
Transmitter-Remote Control Box	144
Transmitter-Receiver (Sidetone)	36
Receiver Dynamotor-Battery	42
Receiver-Receiver Remote Control Box	144
Receiver-Loop	70
Receiver-Compass Meter	180
Receiver Remote Tuning Linkage	120

6. History of Tests

The XGR/XRAP equipment reached this station on 14 May, 1939. Flight tests were made in XSBU-1 Airplane #9222, SOC-1 airplane #9856 and JE-1 airplane #0795. Twenty flights were made totalling a flying time of approximately 30 hours.

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The XSBU-1 airplane was equipped with an NEA-1A generator, the SOC-1 with an NEA-2 generator and the JE-1 with an NEA-2 generator.

7. Outline of Tests

A. Transmitter

(1) Power output in full Vee antenna.
(2) Power output in half Vee antenna.
(3) Range of antenna coupling circuits.
(4) Quality of transmissions.
(5) Operation at altitude.
(6) Frequency stability in flight.
(7) Mechanical Inspection.
(8) Check of weights.
(9) Check of dimensions.
(10) Power input requirements.
(11) Installation facility of equipment.
(12) Operability of equipment.

B. Receiver and Right-Left Indicator.

(1) Sensitivity.
(2) Selectivity.
(3) Freedom from cross modulation.
(4) Volume control characteristic.
(5) Receiver overload.
(6) Image response.
(7) AVC operation.
(8) CW operation.
(9) Weights.
(10) Dimensions.
(11) Installation facility.
(12) Operability.
(13) Mechanical inspection.
(14) Operation at altitude.

8. Power Output of Transmitter

Transmitter power output was measured when using an NEA-1A generator and full and half Vee antennas on XSBU-1 airplane #9222. The antenna constants were not measured in this particular installation but the antenna dimensions were such that the values of resistance and capacity corresponded closely to the constants given in paragraph 3-4 of reference (b). An external antenna ammeter was used and the

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accuracy of measurements was probably 35%. The voltage regulator was adjusted to 14.3 volts with no load on the generator.

Freq.	Supply Volts Full load	Ant. R	Ant. C	Ant. Power	Ant. I
3105	12.4	1.3	68	2.9	1.5
3105	12.4	1.7	107	6.8	2.0
4220	12.4	1.4	70	3.4	1.55
4220	12.4	2.2	125	10.7	2.2
6210	12.4	2.0	82	2.9	1.2
6210	12.4	4.2	280	12.1	1.7
6630	12.4	2.3	88	4.5	1.4
6630	12.4	5.0	450	18.1	1.9

9. Range of Antenna Circuits

At 3000 kc the transmitter operated satisfactorily into trailing antenna whose length varied from 1.5 to 98 feet. At 6630 kc satisfactory operation was obtained with antennas that varied from 0 to 33 feet. This is considered satisfactory. Operation of the antenna resonating circuits is simple and straightforward.

10. Quality of Transmission (3-4)

The sensitivity of the modulator circuits in the transmitter was found to be somewhat excessive for aircraft use. Paragraph 3-14 has been met but the microphone current in the XGR transmitter is higher than required in order to produce 1 volt output across 100 ohms. A series resistance of 15 ohms in the microphone current supply reduced the microphone current to a point where the desired modulator sensitivity was achieved.

11. Operation at Altitude.

Satisfactory operation was secured up to 23000 feet altitude. For this test the transmitter was tuned up on 3000, 3105, 4220 and 6630 kc and the antenna used was a trailing antenna which extended only 3 feet beyond the fairlead. With this antenna, and tuned for full power operation on 3000 kc, the voltages developed correspond to the maximum to be encountered in service installations. No flashover or impaired operation was observed. Receiver and Compass operation was likewise satisfactory.

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12. Frequency Stability

Frequency stability of the 3000 kc crystal was measured during one flight to an altitude of 23000 feet. The shift in frequency was less than 10 cycles. During the flight the temperature varied from 30°C to 17° C. Measurements are accurate to 2 cycles.

13. Receiver Operation

Electrical characteristics of the receiver proved satisfactory in flight with the single exception of the volume control characteristic in the MVC position. The range of this control was too great and consequently the adjustment of the volume became critical. At minimum setting of the volume control, in the MVC position, the MCW receiver sensitivity should be approximately 500,000 microvolts per paragraph 3-37.

14. Compass Operation

Some difficulties were experienced in operating the right-left compass. The compass was operative in the laboratory but no results could be secured in flight. The difficulty was traced to a spurious ground connection in the right-left meter itself. This was corrected by the contractor and the compass then operated in the air but the sensitivity was poor and the sense of the instrument was reversed. Proper sense was secured simply by reversing the loop leads and the low sensitivity was traced to the hood structure of the XSBU-1 airplane #9222. The equipment was then transferred to SOC-1 airplane #9856 and operation proved satisfactory as indicated by the following comments.

A. Sensitivity

The compass sensitivity is sufficient to give full scale meter deflection on such stations as WSVA, 550 kc, Harrisonburg, Virginia, and WRNL, 880 kc, Richmond, when flying locally and using a small sense antenna. The field strength of these stations is low enough so that identification of the station becomes extremely difficult and voice transmissions are normally not intelligible at all.

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B. Intelligibility

The compass does not affect the intelligibility of received signals when flying on course but like all compasses of the right-left type, the switching frequency can be heard when listening to off course signals. The switching frequency in the XRAP equipment is 48 cycles.

C. Selectivity

The compass selectivity was sufficient so that good bearings were obtained on station WIP Philadelphia which operates on 610 kc, 500 watts, when flying in the vicinity of WCAO Baltimore which operates on 600 kc. Similarly good bearings were obtained on range G J, Gordonsville, Virginia, 347 kc when flying over the Washington range which operates on 332 kc. Bearings were also obtained on WDEL, Wilmington, Delaware, 1120 kc, with the plane within two miles of the radio towers of WPG Atlantic City, 1100 kc.

D. Image

Frequencies between 3700-5100 kc are capable of producing an image response within the range of the compass band of the XRAP equipment. The effect of the image was checked by setting up a local transmission with the GP-3 transmitter on 4100 kc which is the image of 600 kc for the XRAP equipment. Bearings on 600 kc (WCAO Baltimore) were unaffected by the local transmission.

E. Overload

Compass and receiver operation was secured within 400 feet of WPG towers, Atlantic City. No overload was observed with the receiver operating in the AVC position.

F. Meter Damping

The damping of the right-left meter of the XRAP equipment is much greater than any similar meter tested at this station. This highly damped meter makes the course indications much easier to follow in flight, particularly when flying close to the station on which the compass is operating.

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G. Cross Modulation

Compass was unaffected by tuning to the difference frequency of WRC and WOL and flying in the immediate vicinity of the two stations.

H. Operation with Headrest Loop

Since the loop provided with the XRAP was of the low impedance type, a transformer was required to match the standard headrest loop with the XRAP equipment. The necessary transformer was provided by the contractor and suitable operation was obtained in flight and on the ground when using the headrest loop and matching transformer combination.

15. Installation Facility

A. Transmitter

Satisfactory.

B. Receiver.

Requires special mount in all planes but no plane has been found on the station where the physical space is not available for mounting the receiver. Three changes in the receiver design are considered desirable to improve installation facility. They are:

(1) Bring mechanical tuning linkage to receiver from the direction opposite to that provided on the model. In this way no additional clearance will be necessary to the left of the receiver.

(2) Use wing nut Dzus fasteners instead of present type.

(3) Provide notch in rear hold down clip at rear center mounting hole in receiver mounting base as noted in paragraph E-1 of reference (c).

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C. Loop

Satisfactory with the exception that a plus or minus 5° adjustment of the loop is considered useful for lining up the loop with the fore and aft line of the plane and a lowering of the loop outlet receptacle may facilitate mounting in planes of the transport type.

D. Dynamotors

Satisfactory.

E. Control Boxes and Receiver Remote Tuner.

Satisfactory.

16. Conclusions.

The performance of the model XGR/XRAP equipment during flight tests has been generally excellent. The transmitter is a decided improvement over the predecessor model due to the slightly lower input power required, and due also to the improved action of the crystal circuit and the greatly improved antenna resonating circuits. The receiver is superior to its predecessor model inasmuch as it incorporates a CW beat oscillator, provides beacon reception (200-400 kc) in a single band and provides a more suitable design of receiver remote controls.

The right-left compass whose circuits are built as an integral part of the receiver has given the best performance of any compass tested at this station. The SCR-242-A compass was more sensitive and more selective than the present equipment but the additional sensitivity and selectivity does not appear entirely necessary. Considering the size of the loop, the smoothness of operation, simplicity of circuits and general workmanship, the XRAP compass is much superior. Installation of the entire equipment can be accomplished in most navy planes with as little difficulty as can reasonably be expected from equipment whose design is as elaborate as that of the GR/RAP, but it is still considered desirable to make installations of only a permanent or semi-permanent nature.

17. Recommendations

The attention of the Bureau is invited to the following details for appropriate action.

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- -

A. Transmitter.

(1) The transmitter control box furnished with the model GQ is preferred to that furnished with the model GR. The two units are electrically interchangeable and mount in the same holes but the separate standby switch and the shape of the box furnished with the model GQ is desired. (3-2)(5) and (3-8)(1).

(2) Reduce modulator sensitivity, preferably by putting resistance in series with microphone current supply so that the transmitter cannot be overmodulated by the output of a standard Navy microphone. (3-14)

(3) Corrosion was observed on the plated parts of the frequency shifting mechanism. (2-5).

(4) Increase torque of frequency shifting motor in transmitter. Motor failed to operate when shifting from position 4 to position 1 on 11 volt supply. (1-5)(1).

(5) Rewrite paragraph 2-4-4(A) page 10 of instruction book as follows: "Set the meter switch to position C. Rotate the oscillator dial associated with the selected channel until the meter indicates about 75% of maximum grid current".

B. Receiver.

(1) Provide wing nut Dzus fasteners in place of screw driver type supplied on model. (1-4)

(2) Attach mechanical linkage to receiver from such an angle that no additional clearance is necessary for the linkage. (1-4)

(3) Provide notch in rear hold down clip at rear center mounting hole in receiver base. (1-4)

(4) Engrave frequency range of various bands on nameplate of receiver control box instead of present A,B,C,D, E,F, identification. See comment following RE-13A-516B under (2-2).

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(5) Engrave additional scale for 400-800, and 800-1600 bands on receiver remote tuner. The 200-400 scale should remain substantially unchanged and the additional scales be as large as space permits, while still being engraved on the bevelled surface.

The present scale is now marked as follows:

400	350	300	250	200

The desired marking is:

200	250	300	350	400
400	500	600	700	800
800	1000	1200	1400	1600

(6) Range of the volume control on MVC should be reduced to bring it just within the requirements of paragraph 3-37.

(7) Connect loop leads so right-left indicator needle points towards station. In a normal installation the loop outlet receptacle is on the left hand side of the loop when viewed from the after cockpit, and the sense antenna is above the loop.

(8) Receiver and receiver control box weight is slightly in excess of specifications (3-2)(8) and (3-2)(11).

(9) Compass sensitivity was generally satisfactory but the action of the right-left meter became sluggish when using large sense antennas. Adjustment of circuits is desirable to give improved action with large antennas.

(10) Spare right-left meter should be procured. 50% spares is considered a reasonable figure.

(11) Rewire circuit so that volume control has no effect on sidetone in AVC position.

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C. Loop Antenna

(1) Provide plus or minus 5° adjustment of the loop azimuth. This can be done simply by elongating the four horizontal mounting holes at the base of the loop shaft. (1-4)

(2) Lower the loop outlet receptacle as far as possible. This may assist in installing the loop in planes of the transport type. (1-4)

D. Cables.

(1) Provided permanent or semi-permanent installations are contemplated it is recommended that cables and linkages be furnished in bulk and then cut to length at the time of installation. If this procedure be followed, it is recommended that the transmitter-transmitter remote control box cable and the receiver-receiver remote control box cable be shortened from 144" to 132" and the transmitter-receiver (sidetone) cable be lengthened from 36" to 60" per unit. (3-2)(6)

E. Nameplates

(1) Paint on nameplates came off during test.

F. Indicator Lights.

(1) Indicator lamp in receiver failed during tests.

(2) Red bullseye on indicator lights is superior to green for power on-off indication.

G. Interphone (ICS) Circuits.

It is recommended that ICS circuits be incorporated in the XGR/XRAP equipment. This can be done without any additional units or cables and with an increase in the weight of the receiver unit of approximately 1 pound. The system which appears most feasible is this:

(1) Provide Radio - ICS switch in transmitter control box.

(2) Provide microphone transformer and two microphone jacks in the receiver itself.

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This arrangement will accomplish exactly the same results as were secured from the installation of the model GQ equipment and the TIC-2 interphone in SOC-3 airplane #1078. This arrangement permits the occupant who has access to the transmitter control box a choice of radio or ICS and permits the other occupant(s) to talk only on ICS. Provision of two microphone jacks in the receiver will permit ICS communication between two occupants without any transmitter being installed or between three occupants when a transmitter is installed.

H. Drawings

(1) One change in the installation drawings is required; the overall height of the loop should be shown as 17" instead of 17-3/16". Note reference (d).

/s/ S. P. Ginder

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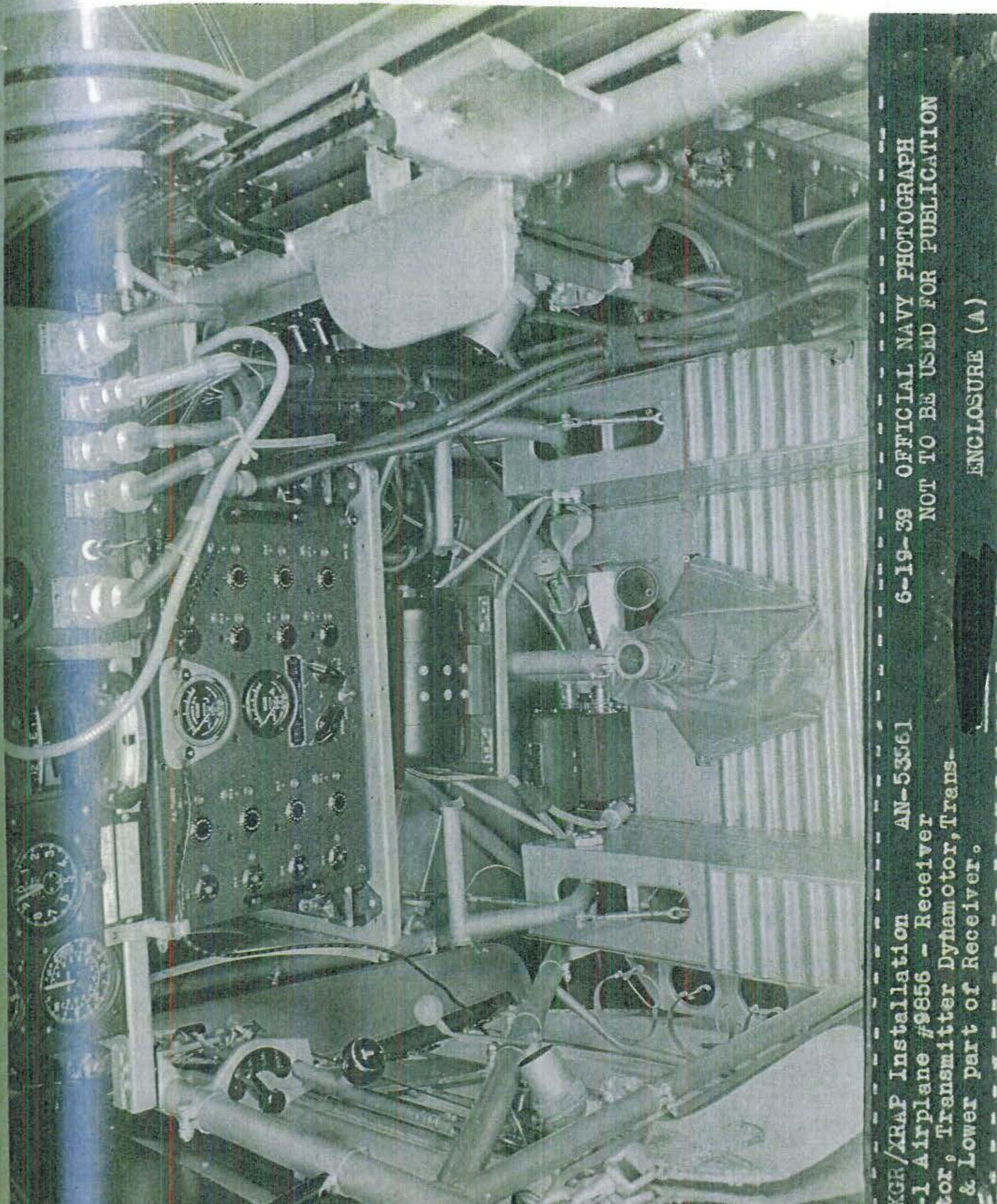

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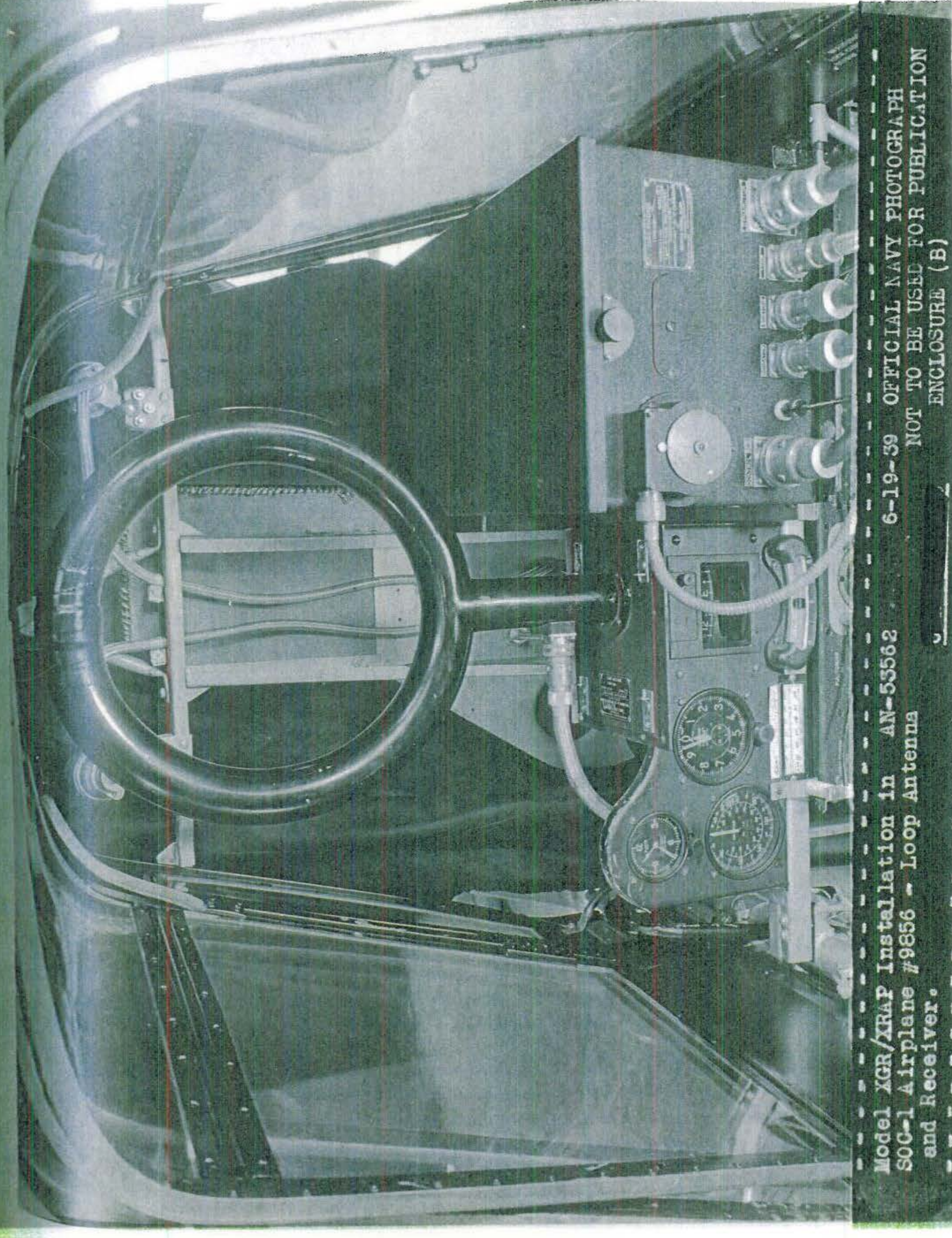

Model XGR/XRAP Installation in AN-53562 6-19-39 OFFICIAL NAVY PHOTOGRAPH
SOC-1 Airplane #9856 - Loop Antenna NOT TO BE USED FOR PUBLICATION
and Receiver. ENCLOSURE (B)

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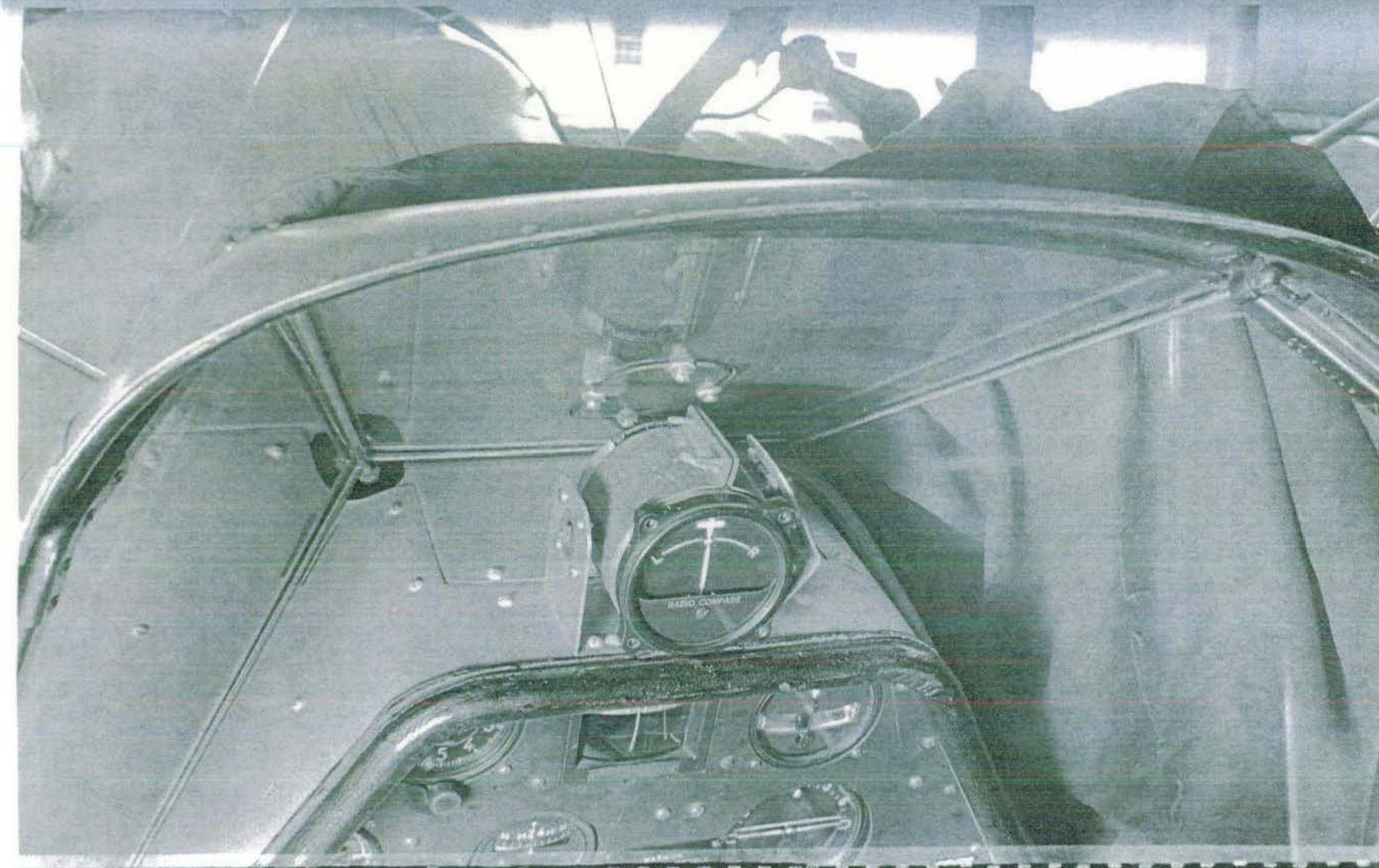

Model XGR/XRAP Installation in AN-53563 6-19-39 OFFICIAL NAVY PHOTOGRAPH
SOC-1 Airplane #9856 - Compass NOT TO BE USED FOR PUBLICATION
Meter. ENCLOSURE (C)

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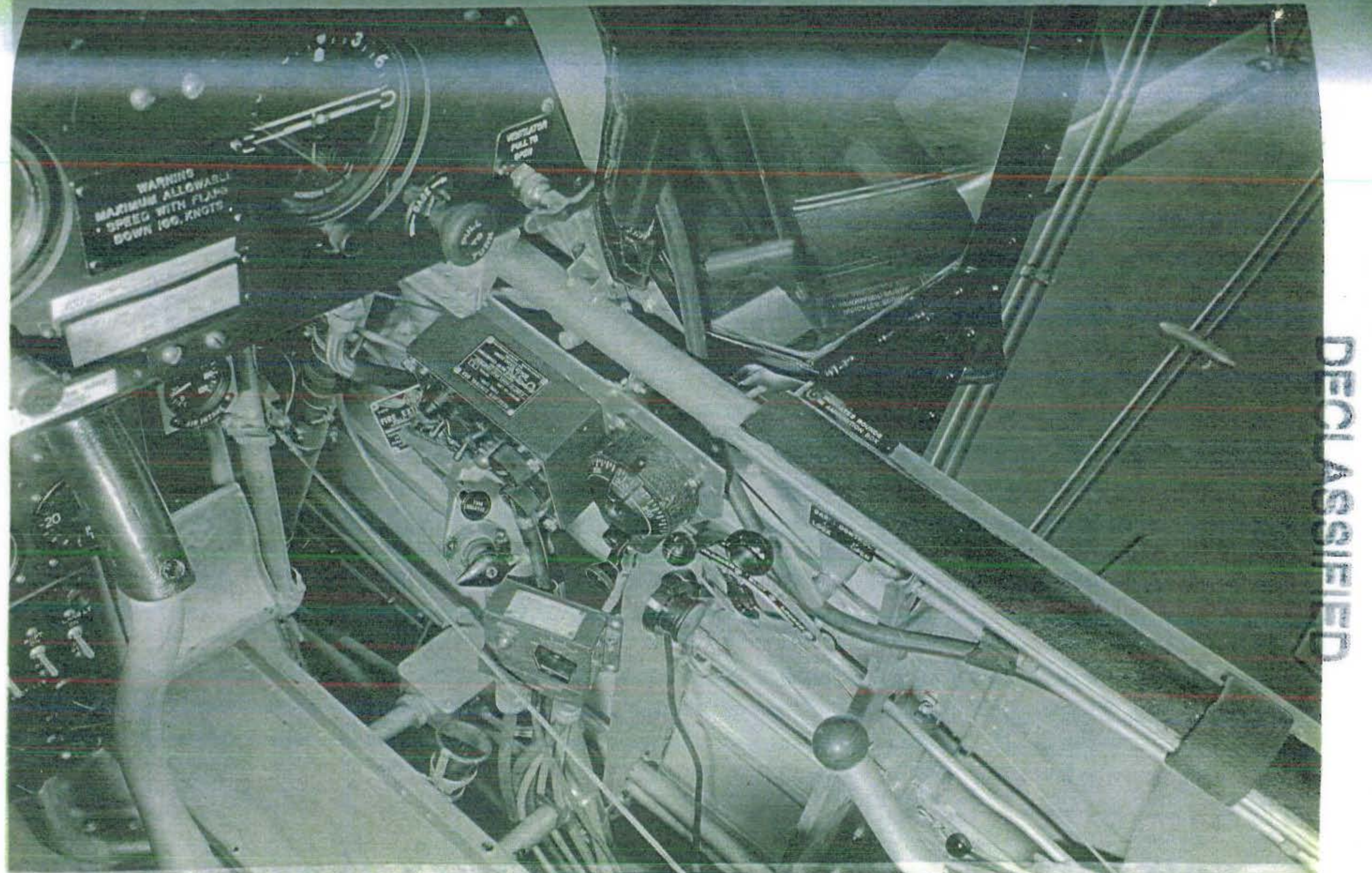

Model XGR/XRAP Installation in AN-53564 6-19-39 OFFICIAL NAVY PHOTOGRAPH
SOC-1 Airplane #9856 - Transmitter & NOT TO BE USED FOR PUBLICATION
Receiver Remote Control Unit on Right Side of Forward
Cockpit. [redacted] ENCLOSURE (D)

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