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NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report

on

Test of Model GF-2 Equipment
manufactured by Aircraft Radio Corporation.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
Washington, D.C.

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 CONDUCTED ON THE SUBJECT EQUIPMENT.

Conclusions

The tests conducted on the Model GF-2 equipment show that it meets the requirements of the specifications, reference (c), on the following:

- (a) Adaptability for installation and operation in the type of Naval planes specified.
- (b) Wave form of the transmitter.
- (c) Audio harmonic distortion.
- (d) Reset of the transmitter.
- (e) Sensitivity of the receiver on CW and MCW.
- (f) Audio fidelity.
- (g) Loop coupling.
- (h) Frequency drift of the receiver.

The points on which the equipment does not meet these requirements follow:

- (a) Power output. The power output meets the requirements of the specifications on CW but is less than these requirements on MCW and Voice.
- (b) The percentage of modulation meets the requirements of the specification except on 100 cycles at which frequency it is less than these requirements.
- (c) The frequency drift of the transmitter on 6500 kcs. meets the requirements of the specifications but on 3500 - 4000 and 8000 kcs. is greater than these requirements.
- (d) The transmitter is not adaptable for use with the Model LJ or Model LJ-1 crystal frequency indicators.
- (e) Selectivity of the receiver on CW or MCW.
- (f) Automatic volume control.
- (g) Size and weight.

The method of control of the interior communication system and the control of the signal lever in the headphones, while they do not violate requirements of the specifications, are not entirely satisfactory.

The points wherein the equipment does not meet the requirements of the specifications are possibly of a minor nature and, it is believed, will not detract seriously from the suitability and serviceability for Naval aircraft use. The other unsatisfactory features mentioned should be corrected in future equipment to permit greater efficiency and ease of operation.

DESCRIPTION OF EQUIPMENT UNDER TEST

4. The Model GF-2 equipment consists of a transmitter rated at 15 watts output over the frequency range 3000 to 4525 kcs. and 12 watts over the frequency range 6000 to 9050 kcs. on CW, MCW and Voice. Electrically this transmitter comprises a radio frequency oscillator, a radio frequency amplifier, a coupling circuit for transferring the radio frequency power to the antenna and a modulator stage for amplifying either internal or external modulation voltages and modulating the radio frequency amplifier therewith. The modulator tube also acts as a tone oscillator generating an audio frequency modulating voltage for MCW telegraphy. The radio oscillator is a Type 89 tube connected as a triode, with the plate, suppressor and screen grids connected together to form a single anode. The radio amplifier stage consists of two Type 837 pentodes connected in push-pull. The modulator-audio-oscillator tube is a second Type 89 tube connected as a pentode.

5. The equipment includes a receiver capable of collecting CW-MCW and Voice signals on frequencies from 224 to 13,575 kcs. The receiver comprises three stages of radio frequency amplification, a detector and one audio amplifier, an A.G.C. stage and a heterodyne oscillator. The radio amplifier tubes are Type CRP-38078, the detector and A.G.C. tubes 38077, and the combined oscillator and audio amplifier tube is a Type CRP-38233.

6. A dynamotor driven by the ship's 12 volt storage battery supplies all the electrical power necessary to operate the equipment.

7. Extension boxes and control cables permit remote control of the equipment in addition to local control.

METHOD OF TEST

8. A description of the methods used in conducting the tests follows. The equipment was checked for size, weight, and mechanical construction. It was then assembled as a complete unit and tested for electrical performance.

9. For determining the percentage of modulation a beat frequency oscillator was coupled to the horizontal plates of a cathode ray oscillograph through an audio amplifier and mixer. The output of the transmitter taken from across the artificial antenna was coupled to the vertical plates of the oscillograph. When the apparatus was properly adjusted photographic records were made of the resultant image produced on the screen of the oscillograph. The percentage of modulation was calculated from the figures on the film.

10. The audio frequency wave form was determined by coupling a beat frequency oscillator through an audio amplifier and a mixer to an oscillograph. The modulation transformer was also coupled to the oscillograph. With the input voltage kept at a constant level, tracings were made of the figure produced on the screen of the oscillograph at various settings of the beat frequency oscillator.

11. The frequency drift was taken by installing the transmitter in a temperature controlled chamber, the output being coupled to a Model LK

frequency measuring equipment. The temperature was reduced to the minimum required and gradually increased to the maximum. Readings were taken, at five minute intervals, of temperature and frequency drift, the latter as indicated by the frequency measuring equipment. These readings were made on the middle of the band of each plug-in unit.

12. The power output of the transmitter was measured in the following manner. An artificial antenna consisting of a 100 mmfd. variable condenser, a Weston 0-2 R.F. ammeter, and a non-inductive resistor in series across the antenna and ground binding posts was used and the results recorded from the usual $W = I^2R$ formula. These tests were repeated using several values of resistance on each frequency, thus simulating various antenna characteristics.

13. For determining the audio harmonic distortion of the modulated radio frequency output a beat frequency oscillator was coupled through an audio amplifier and a mixer into the microphone jack of the transmitter. The modulated output of the transmitter was coupled through a rectifier into a wave analyzer. The beat frequency oscillator was then adjusted to the audio frequency desired and the readings of the wave analyzer recorded at the various harmonics of these frequencies.

14. The reset of the transmitter was determined during a flight test of the equipment which was installed and operated as in actual service use. The transmitter was set on previously selected frequencies. The exact setting of all controls was recorded by the operator in the plane, and the frequency measured at this Laboratory using the Model LF frequency measuring equipment. The set was then detuned and reset according to the recorded positions of the controls and again measured by the Model LF equipment. By comparison of the measurements the accuracy of the reset was determined.

15. The sensitivity of the receiver was determined with the use of a standard signal generator to supply the input and a power output meter to measure the output. The standard signal generator was coupled to the receiver through an artificial antenna consisting of a .0001 mfd. fixed condenser in series with the antenna lead. This lead and the ground lead were not over six inches in length. With the receiver adjusted for maximum sensitivity the input voltage necessary to obtain standard output was recorded at various frequencies. The measurements were made on CW and MCW positions of the selector switch and on manual and automatic positions of the volume control.

16. The MCW selectivity measurements were taken with the same apparatus as that used in making the sensitivity measurements. The procedure was as follows. The standard signal generator and receiver were tuned to resonance and for standard output. The standard signal generator was detuned and the output multiplier adjusted to the next higher step (the attenuator remaining fixed). The standard signal generator was then retuned until standard output was again obtained. The setting of the tuning control of the standard signal generator is recorded in both positions and the selectivity calculated as the frequency difference of these settings. Measurements were made at various frequencies and at input values representing 10, 5 and 1 per cent of resonance sensitivity.

17. CW selectivity measurements are unsatisfactory when using the same method as that employed for MCW. The reason is that for any change in radio frequency input there is a corresponding change in the audio frequency beat note. The resulting measurements would be a combination of the radio frequency selectivity and the audio characteristics of the receiver. Due to the automatic volume control feature of this receiver it is possible to measure the CW selectivity of the radio frequency circuits with the use of the test meter plugged into the meter jack. This meter reads the plate current of the R.F. stages. The frequency control of the standard signal generator was adjusted until the needle of the meter just started to dip and measurements were made at this point instead of at standard output as indicated by the output meter.

18. The audio fidelity measurements were made by coupling a beat frequency oscillator through an audio amplifier to a standard signal generator. The receiver was adjusted for standard output in the MCW position. With the apparatus properly adjusted and all other controls remaining fixed, the milliwatts output is recorded at various frequencies of the beat frequency oscillator.

19. In measuring the noise output a standard signal generator was used and the receiver adjusted for standard output in the MCW position. With the modulation switch of the standard signal generator on the external position (which cuts off modulation) the output was recorded.

20. The action of the automatic volume control was determined with the use of a standard signal generator on CW and MCW signals. The input was adjusted to increasing values, the output recorded, and the ratio of input to output determined.

21. The overload measurements were made using a standard signal generator for the input source with the output coupled to an oscillograph. The input was adjusted to produce output signals up to 300 milliwatts and the figure on the oscillograph screen observed.

22. The loop coupling characteristics were determined using a standard signal generator for the input and measuring the relative sensitivity of the receiver in the antenna and loop positions. For this measurement the artificial antenna described above was used and for the loop condition a coil of negligible capacity having an inductance of .11 millihenries and a resistance of 6 ohms was connected in series across the loop terminals. A .0001 mfd. fixed condenser was also connected across these terminals.

23. The frequency drift measurements of the receiver were made using a Model LD-2 heterodyne calibrator for the input and beating the output of the receiver against a signal from a beat frequency oscillator. Readings were taken at 5 minute intervals over a period of 60 minutes.

DATA RECORDED DURING TEST

24. Data recorded during the test in the form of tables, charts, and photographs, are appended to this report. These data are listed below. This and other data are discussed in "Results of Test".

25. The equipment was checked for size, weight, construction and performance. Photographs were made of the equipment in a group and as installed in an airplane.

26. Transmitter data were recorded on the following:

- (a) Percentage of modulation.
- (b) Audio frequency wave form.
- (c) Frequency drift.
- (d) Power output.
- (e) Audio harmonic distortion.
- (f) Reset.

27. Receiver data were recorded on the following:

- (a) Sensitivity.
- (b) Selectivity.
- (c) Audio fidelity.
- (d) Noise output.
- (e) Automatic volume control.
- (f) Overload.
- (g) Loop coupling.
- (h) Frequency drift.

DISCUSSION OF PROBABLE ERRORS

28. Following is a list of apparatus used with the margin of error according to the manufacturer's guarantee:

- | | |
|--|--------------------------|
| (a) Refrigerator unit, Frigidaire. | $\pm 1^{\circ}\text{C}.$ |
| (b) Frequency measuring equipment, Model LK, Serial #1. | $\pm .001\%$ |
| (c) General Radio standard signal generator, Model LC, Serial #2. | $\pm 10.0\%$ |
| (d) General Radio output power meter, Type 533-A, Serial #63. | $\pm 5.0\%$ |
| (e) General Radio wave analyzer, Type 636-A, Serial #102. | $\pm 2.5\%$ |
| (f) General Radio beat frequency oscillator, Type 513-A, Serial #44. | $\pm 2.5\%$ |
| (g) General Radio electron oscillograph, Type 687-A, Serial #132. | |
| (h) General Radio heterodyne oscillator, Model LD-2, Serial #1. | $\pm .005\%$ |
| (i) Weston thermo ammeter, 0-2 amps., Type 425, Serial #2430. | $\pm 2.0\%$ |

(j) NRL audio amplifier.

(k) NRL mixer unit.

RESULTS OF TEST

29. The results of these tests, wherein the equipment does not meet the requirements of the specifications, reference (c), will be discussed in the order of the paragraphs in which they appear. In those paragraphs not discussed the equipment will be regarded as in full compliance with the specifications. The numbers of the following subparagraphs are in agreement with the numbers of the paragraphs in the specifications.

II. General

30. Par.2-4. The workmanship is of a very high order and is indicative of long and dependable service.

31. Par.2-5. The material used is in accordance with this paragraph, and where necessary has been treated to prevent corrosion.

32. Par.2-7. The equipment operates satisfactorily in temperatures from -30°C . to $+55^{\circ}\text{C}$. which is the maximum range of the equipment used to make this test.

33. Par.2-8. A 2 KW pure CW output was not available to conduct this test; however, the equipment is designed to withstand or has a suitable protective device incorporated to prevent damage due to overload.

34. Par.2-11. Apparatus is not available at this Laboratory to conduct the tests required by this paragraph. During flight tests, however, the equipment was subjected to numerous take-offs and landings and positions of various degrees from vertical and in all cases functioned satisfactorily.

35. Par.2-12. Wooden dowels are used for low frequency coil forms. No satisfactory substitute seems available.

36. Par.2-13. The interchangeability of parts meets the requirements of this paragraph. However, the transmitter coils are calibrated for operation in the transmitter bearing the same serial numbers and if used with any other transmitter will operate satisfactorily, but the calibration charts may be inaccurate.

37. Par.2-15. The equipment does not in all cases meet the requirements of the specifications as regards size and weight. These discrepancies will be discussed later in these results.

38. Par.2-17. Provision has been made for protection of personnel from coming in contact with high voltages. However, while the jacks for measuring the transmitter currents are insulated a standard plug which employs the sleeve for one contact, when used in the jacks, has a high voltage from sleeve to case which is at ground potential. A three contact plug with the sleeve grounded would eliminate this condition.

39. Pars. 2-26, 2-27, 2-28. The items referred to in these paragraphs require testing before being approved for use in the construction of the equipment.

40. Par. 2-32. Only two plug-in coils for the receiver were supplied with this equipment covering the frequency bands of 400 to 600 kcs. and 3000 to 4525 kcs. on a dual coil and 5220 to 8230 kcs. on a single coil. With additional coils the receiver is capable of operation over the specified range of 224 to 13,575 kcs.

41. Par. 2-40. Electrolytic condensers are not used.

42. Par. 2-41. The receiver is designed for low (600 ohm) impedance phones only.

43. Par. 2-44. The receiver uses six tubes including the following types: three CRP-38078, two CRP-38077, and one CRP-38233. The transmitter uses four tubes, including the following types: two 89 and two 837.

44. Pars. 2-49, 2-50, 2-51, and 2-52. These paragraphs are "Type Test" requirements. Parts and equipment were not available to conduct these tests.

45. Par. 2-55. See results of tests conducted at various temperatures.

46. Par. 2-57. The equipment does not operate satisfactorily with Models LJ or LJ-1 crystal frequency indicators. When the transmitter key is depressed the plate voltage is removed from the CFI and also from the receiver, making it impossible to check the transmitter frequency with the CFI or monitoring with the receiver.

III. Mechanical Requirements

47. Par. 3-2. Items 21, 22, 23, 25 and 26 were not submitted with the equipment for test.

48. Par. 3-3. The transmitter is 3/8 inch oversize in height. See Table 13.

49. Par. 3-5. The transmitter control box is 1/8 inch oversize in width (see Table 13). There is no provision made for use of a type 26003-A telegraph key. It is not provided with an ICS-Radio switch and the receptacle for connecting to the extension box has been eliminated. The connection to the extension box is discussed later.

50. Par. 3-7. The receptacle on the junction box which is referred to as connecting to the primary power source (the ship's 12-volt battery) is used in this equipment to connect to the extension box. The connection from the primary power source is to a receptacle in the base of the dynamotor. The junction box is two ounces overweight and 23/32 inch oversize in depth. See Table 14.

51. Par. 3-9. The dynamotor unit does not contain the drop resistor necessary to supply the proper voltage to the receiver and the crystal frequency indicator. This resistor is located in the junction box. The dynamotor unit is oversize $\frac{3}{8}$ inch in height, $1\frac{1}{4}$ inches in length, $1\frac{1}{4}$ inches in width, and is 4 pounds overweight. See Table 14.

(a) An alternate dynamotor unit was not supplied with this equipment.

52. Par. 3-10. (2) Oversize $\frac{1}{4}$ inch in width. See Table 14.
(3) Overweight 10 ounces. See Table 14.

53. Par. 3-12. The meter, plug and cord referred to in this paragraph was not supplied with the equipment. The heterodyne oscillator switch is marked "CW-MCW". The box is oversize $\frac{1}{8}$ inch in width, $\frac{15}{16}$ inch in height, and is 3 ounces overweight. See Table 15.

54. Par. 3-15. The antenna relay unit is oversize $\frac{1}{2}$ inch in height and $1\frac{1}{16}$ inches in length. See Table 15.

55. Par. 3-21. The connecting cable referred to in this paragraph as No. 21 and which should connect the junction box to the primary power source, is marked No. 121 and is used as a connection between the dynamotor unit and the primary power source. The cables referred to as Nos. 133, 34, 237, and 75 are Marked Nos. 233, 134, 37, and 175 respectively. Cable No. 236 is six feet overlength and one pound 10 ounces overweight. Cable No. 80 is 5 feet overlength and 10 ounces overweight. See Table 16.

56. Par. 3-23. A phantom antenna was not furnished with this equipment.

57. Par. 3-24. As before stated, a test meter, cable, and plug were not supplied with this equipment.

58. Par. 3-25. Slip covers were supplied for the transmitter and receiver.

59. Par. 3-32 to 3-38 inclusive. A life test is necessary to obtain accurate results. An examination of the unit reveals that it is of the same type of construction as similar units which have given satisfactory performance over long periods of service use.

60. Par. 3-46. No tools were furnished with the equipment.

IV. Definitions

61. This section describes methods and values to be used in conducting the tests and does not require comment.

V. Operating Characteristics

62. Par. 5-2. Satisfactory except for subparagraph C, operation (a). As mentioned before, there is no "Radio-ICS" switch on the transmitter control box.

63. Par.5-3. The equipment is satisfactory for operation as required by subparagraphs A, B, D and F. For the requirements of subparagraph C, as there is no "Radio-ICS" switch on the transmitter control box, it is necessary for the switch on the extension control box to be on the "Radio" position. The equipment does not meet the requirements of subparagraphs E and G, and since the reason is again due to the fact that the "Radio-ICS" switch has been omitted from the transmitter control box, the following conditions exist. The pilot at all times has control of the equipment in so far as the radio and interior communication system positions are concerned. The operator has no control of these positions at all. He has to depend on the pilot to throw the switch of the extension control box on the ICS position before he can communicate with him without the emission of radio frequency energy. A method suggested in the instruction book, reference (d), is for the operator to attract the pilot's attention by adjusting the selector switch on the transmitter control box to the "Voice" position and pressing the microphone button which causes the indicator lamps to light. The pilot interprets this to mean that the operator desires to communicate with him so adjusts the switch on the extension box to the ICS position. They now have a means of communication with each other without the emission of radio frequency energy. This arrangement allows an unsatisfactory condition to exist. If the operator is in CW or MCW communication with a distant station and this station requests voice signals from the plane, the operator adjusts his switch to the voice position, presses the microphone button (which lights the indicator lamp) and starts talking. In the event that the pilot's attention is occupied to such an extent that he is unable to follow the radio communication, and this is quite possible particularly if he has reduced the signals in his headphones, he notices the indicator lamp lighted and thinking the operator wishes to communicate with him throws his switch to the ICS position, thus making the transmitter inoperative as far as radio communication is concerned and thus breaking off the message. Another disadvantage of the system is that in the event of the lamp burning out or becoming inoperative the operator has no means of attracting the pilot's attention.

64. Par. 5-6. The receiver is operative over this frequency range with the proper plug-in coils but two coils only were submitted with the equipment covering the bands of 400 to 600 kcs. and 3000 to 4525 kcs. on a dual coil and 5220 to 8230 kcs. on a single coil.

65. Par. 5-16. Temperature tests were made on the equipment, the results of which appear under more specific paragraphs of these specifications. This Laboratory is not equipped to conduct the humidity tests.

VI. Electrical Requirements

66. Par. 6-2. The transmitter is adapted for the transmission of unmodulated continuous wave, modulated continuous wave, and radio telephony. Tuning is accomplished on the front panel by means of a dial for control of the master oscillator, and a small tuning control (not a dial) for tuning the amplifier to resonance. A thermal ammeter is also provided on the front panel for indicating antenna current.

67. Par. 6-3. The frequency drift does not meet the requirements of this paragraph. The measurements were made with a variation of

temperature from -30°C . to $+50^{\circ}\text{C}$. The total drift on 3500 kcs. over 81° change in temperature was 5250 cycles or .15 per cent. The drift over 50° change in temperature after a 5 minute warm-up period was 3000 cycles or .085 per cent. The total drift on 4000 kcs. over 81° change in temperature was 4800 cycles or .12 per cent. The drift over 50° change in temperature after a 5 minute warm-up period was 2400 cycles or .06 per cent. The total drift on 6500 kcs. over 70° change in temperature was 4500 cycles or .069 per cent. The drift over 50° change in temperature after a 5 minute warm-up period was 2700 cycles or .041 per cent. The total drift on 8000 kcs. over 76° change in temperature was 8300 cycles or .103 per cent. The drift over 50° change after a 5 minute warm-up period was 4750 cycles or .059 per cent. The results of these tests are shown on Plates 8, 9, 10, and 11 respectively. The reset measurements as shown on Table 5 are well within the requirements of this paragraph.

68. Par. 6-4. Calibration charts are supplied with the equipment and are mounted on the panel of the plug-in coils. The accuracy of the calibration is within the specified 0.1%.

69. Par. 6-5. The percentage of modulation shown on Tables 2 and 3 and Plates 3, 4, 5 and 6 meet the requirements of this paragraph except at the external modulation frequency of 100 cycles on the 3250 kcs. coil. With the maximum allowable audio frequency voltage of 0.5 volt, the percentage of modulation was 54%.

70. Par. 6-6. The power output does not meet the requirements of this paragraph. The results of these measurements are shown on Table 1.

71. Par. 6-7. Satisfactory telephone communication between two planes was conducted on several occasions at distances ranging from 75 to 150 miles. The equipment during these tests was mounted in a O3U-1 radio test airplane and an R-2-D transport plane.

72. Par. 6-8. With the switch of the receiver control box on the automatic position break-in communication on, CW and MCW was not possible due to the large time constant of the automatic volume control. On the Manual position break-in communication was satisfactory up to approximately 15 words per minute.

73. Par. 6-9. The transmitter units and junction box are not electrically adaptable for operative interconnection with the Models LJ or LJ-1 crystal frequency indicators. When the key is depressed the plate voltage is removed from the receptacles which supply the CFI and the receiver. It is therefore impossible to use the CFI to check the transmitter frequency or to use the receiver for monitoring. The audio harmonic distortion of the output, while not called for in the specification, was determined. The results may be seen in Table 4.

74. Par. 6-12. The transmitter side tone on CW and MCW in the Manual position, while meeting the requirements of this paragraph, is excessive and the operator has no means of reducing the signal in his headphones. In the "Auto" position the operator can reduce the signal but as stated above, at the expense of break-in communication.

75. Par. 6-15. The requirements of this paragraph will depend on the experience of the personnel. With proper experience the frequency can be changed in one man minute.

76. Par. 6-17. Extended operation under service conditions will be necessary to determine this requirement.

77. Par. 6-18. The total current drain imposed by the combined equipment on the primary power source is 11.5 amperes at 14 volts.

78. Par. 6-20. The receiver is capable of operating satisfactorily over the frequency range specified.

79. Par. 6-21. The receiver is capable of covering this band with 11 plug-in coil units.

80. Par. 6-22. With this equipment the bands 400 to 600 and 3000 to 4525 kcs. are covered by a dual coil and 5220 to 8230 kcs. by a single coil.

81. Par. 6-29. The output tube and audio system are adaptable for use as part of an interior communication system.

82. Par. 6-30. The receiver is designed for the use of low impedance phones only.

83. Par. 6-32. Satisfactory. The results of this test are shown in Table 6.

84. Par. 6-33. The equipment meets the requirements of this paragraph. Table 11 shows the comparative input voltage on the antenna and loop coupling to obtain standard output of 10 milliwatts. Table 12 shows the mw. output in the loop coupling with the same input voltage necessary to obtain 10 mw. output in the antenna coupling.

85. Pars. 6-34 and 6-35. The equipment does not meet the selectivity requirements of these paragraphs on either MCW or CW. The results of these tests are shown in Tables 7 and 8.

86. Par. 6-36. The audio fidelity of the receiver taken at 600 and 4100 kcs. does not meet the requirements of this paragraph. Table 9 shows the results of these tests.

87. Par. 6-37. The receiver does not meet the overload requirements of 300 milliwatts undistorted output. The maximum undistorted output was 250 milliwatts. There was slight cutting off of the negative peaks at 300 milliwatts output.

88. Par. 6-38. The noise output measured as specified was negligible being of the order of 0.8 milliwatt.

89. Par. 6-39. Laboratory and flight tests indicate that the microphonic tendencies are negligible.

90. Par. 6-40. Operation in aircraft is satisfactory.

91. Par. 6-41. Satisfactory except as described before -- the operator has no control of the side tone signal strength in the Manual position.

92. Par. 6-43. A trailing wire not over the specified maximum of 50 feet had no effect when using the loop for direction finding. Long trailing antenna materially reduces the sharpness and accuracy of radio bearings.

93. Par. 6-51. Use of the equipment over a long period of time under service conditions is necessary to determine these requirements.

94. Par. 6-52. The automatic volume control action does not meet the requirements of this paragraph. The results of this test are shown in Table 10.

95. Par. 6-54. The receiver operates satisfactorily with variation of the primary power voltage from 12 to 16 volts.

96. Par. 6-55. The frequency drift of the receiver is within the requirements of this paragraph. The results of this test are shown on Plate 12.

97. Par. 6-56. One calibration chart only was submitted with the equipment, this one being mounted on the receiver cabinet.

CONCLUSIONS

98. The tests conducted on the Model GF-2 equipment show that it meets the requirements of the specifications, reference (c), on the following:

- (a) Adaptability for installation and operation in the type of Naval planes specified.
- (b) Wave form of the transmitter.
- (c) Audio harmonic distortion.
- (d) Reset of the transmitter.
- (e) Sensitivity of the receiver on CW and MCW.
- (f) Audio fidelity.
- (g) Loop coupling.
- (h) Frequency drift of the receiver.

99. The points on which the equipment does not meet these requirements follow:

- (a) Power output. The power output meets the requirements of the specifications on CW but is less than these requirements on MCW and Voice.

- (b) The percentage of modulation meets the requirements of the specification except on 100 cycles at which frequency it is less than these requirements.
- (c) The frequency drift of the transmitter on 6500 kcs. meets the requirements of the specifications but on 3500 - 4000 and 8000 kcs. is greater than these requirements.
- (d) The transmitter is not adaptable for use with the Model LJ or Model LJ-1 crystal frequency indicators.
- (e) Selectivity of the receiver on CW or MCW.
- (f) Automatic volume control.
- (g) Size and weight.

100. The method of control of the interior communication system and the control of the signal level in the headphones, while they do not violate requirements of the specifications, are not entirely satisfactory.

101. The points wherein the equipment does not meet the requirements of the specifications are possibly of a minor nature and, it is believed, will not detract seriously from the suitability and serviceability for Naval aircraft use. The other unsatisfactory features mentioned should be corrected in future equipment to permit greater efficiency and ease of operation.

TABLE 1

Power Output of Transmitter

Freq. kcs.	Ant. Resis. (ohms)	Watts Output			Freq. kcs.	Ant. Resis. (ohms)	Watts Output		
		CW	MCW	Voice			CW	MCW	Voice
2950	4.2	11.7	6.36	3.87	6000	4.2	11.27	6.05	3.9
	6.3	13.4	7.5	4.55		6.3	12.87	7.08	4.13
	8.5	13.86	7.82	4.79		8.5	14.8	8.16	4.79
	24.3	13.67	8.03	3.89		24.3	16.35	8.7	4.92
3250	4.2	9.9	5.8	3.4	6600	4.2	12.25	6.36	3.99
	6.3	12.7	6.7	4.26		6.3	14.17	7.62	4.55
	8.5	13.5	7.68	4.79		8.5	15.04	8.5	4.79
	24.3	15.55	8.75	4.92		24.3	16.77	9.18	5.02
3650	4.2	9.45	4.9	3.6	7300	4.2	13.0	7.1	3.95
	6.3	12.7	6.7	4.55		6.3	13.8	7.62	4.65
	8.5	13.94	8.16	5.16		8.5	15.65	8.5	5.31
	24.3	16.35	8.7	6.08		24.3	16.77	9.18	5.02
3675	4.2	11.6	6.15	4.13	7350	4.2	12.85	7.1	4.46
	6.3	12.55	7.1	4.55		6.3	12.35	6.8	4.23
	8.5	14.8	8.5	5.44		8.5	13.1	7.35	4.53
	24.3	16.35	8.7	6.08		24.3	16.35	8.75	4.92
4025	4.2	11.4	6.05	3.86	8050	4.2	13.7	7.44	4.37
	6.3	14.15	7.62	4.75		6.3	12.72	6.68	4.03
	8.5	15.65	8.84	5.44		8.5	13.77	7.25	4.53
	24.3	17.5	9.62	8.7		24.3	16.35	8.75	4.92
4475	4.2	9.58	5.8	3.11	8950	4.2	13.7	7.26	4.37
	6.3	16.75	8.5	5.8		6.3	13.2	6.94	4.23
	8.5	16.15	9.18	5.44		8.5	14.35	7.68	4.53
	24.3	15.92	8.75	4.92		24.3	17.15	9.34	6.08

TABLE 2

Per Cent Modulation of Model GF-2 Transmitter.

3250 kcs.

Input Volts	.2	.25	.3	Input for 100% Modulation
Freq. Cycles	%	%	%	
100	25.	28.	36.	Max. input of .5 volts results in 54% Mod.
200	54.	61.	79.	.45
300	68.	76.	84.	.35
500	70.	76.	100.+	.27
1000	70.	76.	100.+	.28
2000	61.	69.	77.	.35
3000	50.	58.	66.	.45
5000	39.	50.	58.	Max. input of .5 volts results in 82% Mod.

TABLE 3

Per Cent Modulation of Model GF-2 Transmitter

8050 kcs.

Input Volts	.2	.25	.3	Input for 100% Modulation
Freq. Cycles	%	%	%	
100	44.	39.	38.	Max. input of .5 volts results in 60% Mod.
200	60.	65.	71.	.41
300	71.	78.	85.	.34
500	78.	85.	100.+	.27
1000	78.	85.	100.	.3
2000	64.	71.	78.	.38
3000	55.	63.	76.	.48
5000	46.	53.	62.	Max. input of .5 volts results in 84% Mod.

TABLE 4

Audio Harmonic Distortion of Output of Model GF-2 Transmitter.

Audio Freq. Cycles	R.F. Freq. kcs.	Harmonics					
		2	3	4	5	6	%
400	8050	5.3	2.2	.6	.34	1.5	5.77

TABLE 5

Reset Measurements of GF-2 Transmitter.

Assigned Freq. kcs.	Measured Freq. kcs.	Reset #1 Freq. kcs.	Freq. Diff. Cycles	%	Reset #2 Freq. kcs.	Freq. Diff. Cycles	%
3445	3443.26	3442.47	790	.023	3442.44	820	.024
4385	4384.	4383.5	500	.011	4383.5	500	.011
6500	6498.5	6498.2	300	.0046	6498.1	400	.006
8880	8878.7	8882.1	3400	.038	8882.1	3400	.038

TABLE 6

Sensitivity of Model RU-3A Receiver.

(Impedance 600 ohms - Output 10 mw. - Full Gain)

Freq.(kcs.)	Microvolts Input			
	CW		MCW	
	Manual	Auto	Manual	Auto
445	1.3	1.1	4.2	2.0
515	1.05	1.1	4.4	2.1
600	0.83	1.0	3.7	1.7
3100	1.12	0.7	5.0	2.25
3765	0.7	0.35	4.69	1.95
4415	0.7	0.48	3.9	1.5
5465	1.63	1.0	6.0	4.25
6900	1.5	0.9	7.5	4.8
7930	2.8	2.2	8.5	5.0

TABLE 7

Selectivity of Model RU-3A Receiver

Freq. kcs.	MCW					
	+10%	+5%	+1%	-1%	-5%	-10%
445	7.56	9.72	16.56	16.56	9.0	6.48
515	10.26	13.68	22.78	21.66	12.16	9.12
600	14.4	19.0	32.4	28.44	16.92	12.6
3100	24.3	32.4	59.4	56.7	29.7	24.3
3765	32.4	40.5	70.2	59.4	32.4	24.3
4415	40.5	59.4	94.5	81.0	43.2	29.7
5465	36.0	45.6	74.4	60.0	33.6	26.4
6700	39.0	52.0	78.0	80.6	44.2	31.2
7930	46.9	60.3	107.2	100.5	53.6	40.2

TABLE 8

Selectivity of Model RU-3A Receiver

CW

Freq. kcs.	+10%	+5%	+1%	-1%	-5%	-10%
445	5.0	7.2	11.52	12.6	6.84	4.32
515	6.0	9.5	15.69	12.92	7.6	5.3
600	6.84	11.52	21.24	22.0	12.6	10.0
3100	21.6	27.0	54.0	45.9	21.6	16.2
3765	32.4	35.1	62.1	51.3	24.3	18.9
4415	24.3	35.1	70.2	70.2	35.1	32.4
5465	36.0	48.0	79.2	81.6	60.0	36.0
6700	23.4	33.8	75.4	57.2	31.2	23.4
7930	26.8	46.9	100.5	100.5	53.6	40.2

TABLE 9

Audio Fidelity of Model RU-3A Receiver.

Audio Freq.	4100 kcs. Output mW	600 kcs. Output mW
50	7.0	5.0
100	8.5	8.0
200	9.5	9.0
300	10.0	9.0
400	10.0	9.5
500	10.0	9.5
600	10.0	10.0
700	10.5	10.0
800	10.0	10.0
900	10.0	10.0
1000	10.0	10.0
1200	10.0	10.0
1400	9.5	9.0
1600	9.0	8.5
1800	8.5	8.0
2000	8.0	7.0
2500	7.0	5.0
3000	4.5	3.0

TABLE 10

Automatic Volume Control of Model RU-3A Receiver.

<u>CW</u>		<u>MCW</u>	
<u>Input</u> <u>Microvolts</u>	<u>Output</u> <u>Milliwatts</u>	<u>Input</u> <u>Microvolts</u>	<u>Output</u> <u>Milliwatts</u>
0.35	10	2.4	10
10.0	300	50.0	50
350.0	320	2400.0	60

TABLE 11

Loop Coupling.

<u>Freq.</u> <u>kcs.</u>	<u>Input, Microvolts</u>		<u>Output</u> <u>Milliwatts</u>
	<u>Ant.</u>	<u>Loop</u>	
445	1.1	0.85	10
515	1.0	0.92	10
600	1.06	0.75	10

TABLE 12

<u>Freq.</u> <u>kcs.</u>	<u>Input, Microvolts</u> <u>Loop</u>	<u>Output</u> <u>Milliwatts</u>
445	1.1	40
515	1.0	25
600	1.06	22

TABLE 13

SIZES AND WEIGHTS

<u>Transmitter</u>	<u>Actual</u>	<u>Allowable</u>
Weight without tubes	10 lbs. 14 oz.	14 lb. 8 oz.
Length	12-1/4 in.	15-11/16 in.
Width	6-3/4 in.	7-1/4 in.
Height	8 in.	7-5/8 in.
 <u>Mounting Base</u>		
Weight	10 oz.	10 oz.
Length	13-1/8 in.	15-11/16 in.
Width	6-1/4 in.	6-1/4 in.
Height	1-3/4 in.	1-3/4 in.
 <u>Transmitter Control Box</u>		
Weight	12 oz.	3 lb.
Length	5-1/16 in.	5-1/2 in.
Width	2-7/17 in.	2-5/16 in.
Height	3-7/8 in.	4-1/8 in.
 <u>Extension Control Box</u>		
Weight	14 oz.	2 lbs.
Length	5-1/16 in.	5-1/2 in.
Width	3-7/8 in.	4-1/8 in.
Height	2-3/8 in.	2-5/16 in.

TABLE 14

Table of Sizes and Weights.

	<u>Actual</u>	<u>Allowable</u>
<u>Junction Box</u>		
Weight	2 lb. 2 oz.	2 lb.
Length	7-3/8 in.	7-3/8 in.
Width	2-7/8 in.	2-5/32 in.
Height	5-1/2 in.	5-1/2 in.
<u>Dynamotor Unit</u>		
Weight	14 lbs.	10 lbs.
Length	8-5/8 in.	7-3/8 in.
Width	5-5/8 in.	4-3/8 in.
Height	6-3/8 in.	6 in.
<u>Receiver</u>		
Weight	13 lbs. 8 oz.	12 lbs. 14 oz.
Length	14-3/4 in.	15 in.
Width	7-1/2 in.	7-1/4 in.
Height		
<u>Receiver Mounting Base</u>		
Weight	10 oz.	10 oz.
Length	15-1/2 in.	15-11/16 in.
Width	6-1/4 in.	6-1/6 in.
Height	1-3/4 in.	1-3/4 in.

TABLE 15

Table of Sizes and Weights

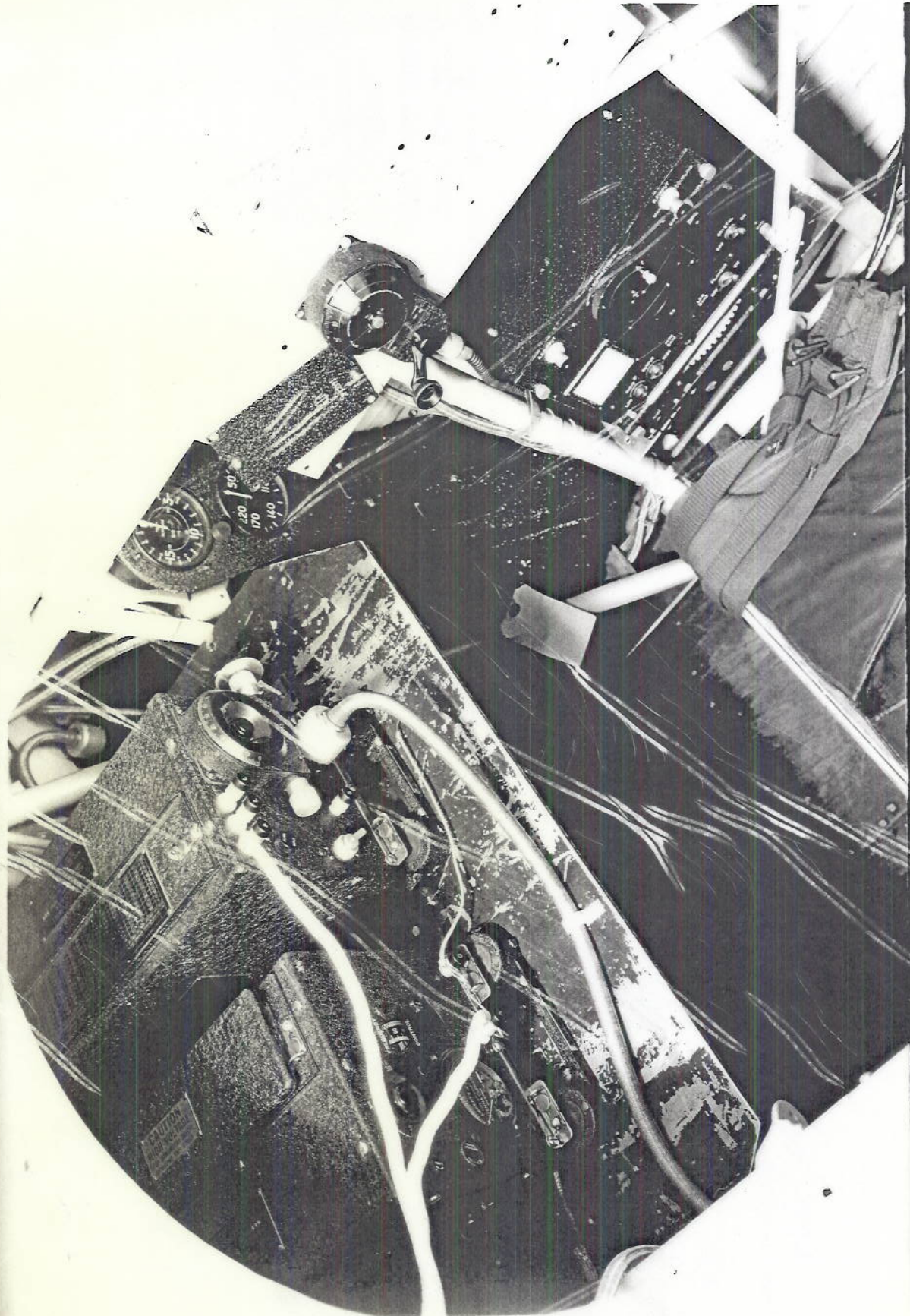
	<u>Actual</u>	<u>Allowable</u>
<u>Receiver Switch Box</u>		
Weight	1 lb	13 oz.
Length	3-11/16 in.	4 in.
Width	2-7/16 in.	2-5/16 in.
Height	5-1/16 in.	4-1/8 in.
<u>Receiver Remote Tuning Control and Mechanical Linkage</u>		
Weight	Tuning Control 1 lb.	1 lb.
Depth	" "	2-5/8 in.
Width	" "	3 in.
Height	" "	6 in.
Weight	Mechanical Linkage 20 oz.	30 oz.
Length	" "	10 ft.
<u>Receiver Local Tuner</u>		
Weight	1 oz.	3 oz.
<u>Antenna Relay Unit</u>		
Length	5-1/16 in.	4 in.
Width	3-1/2 in.	3-5/8 in.
Height	2-13/16 in.	2-5/16 in.

TABLE 16

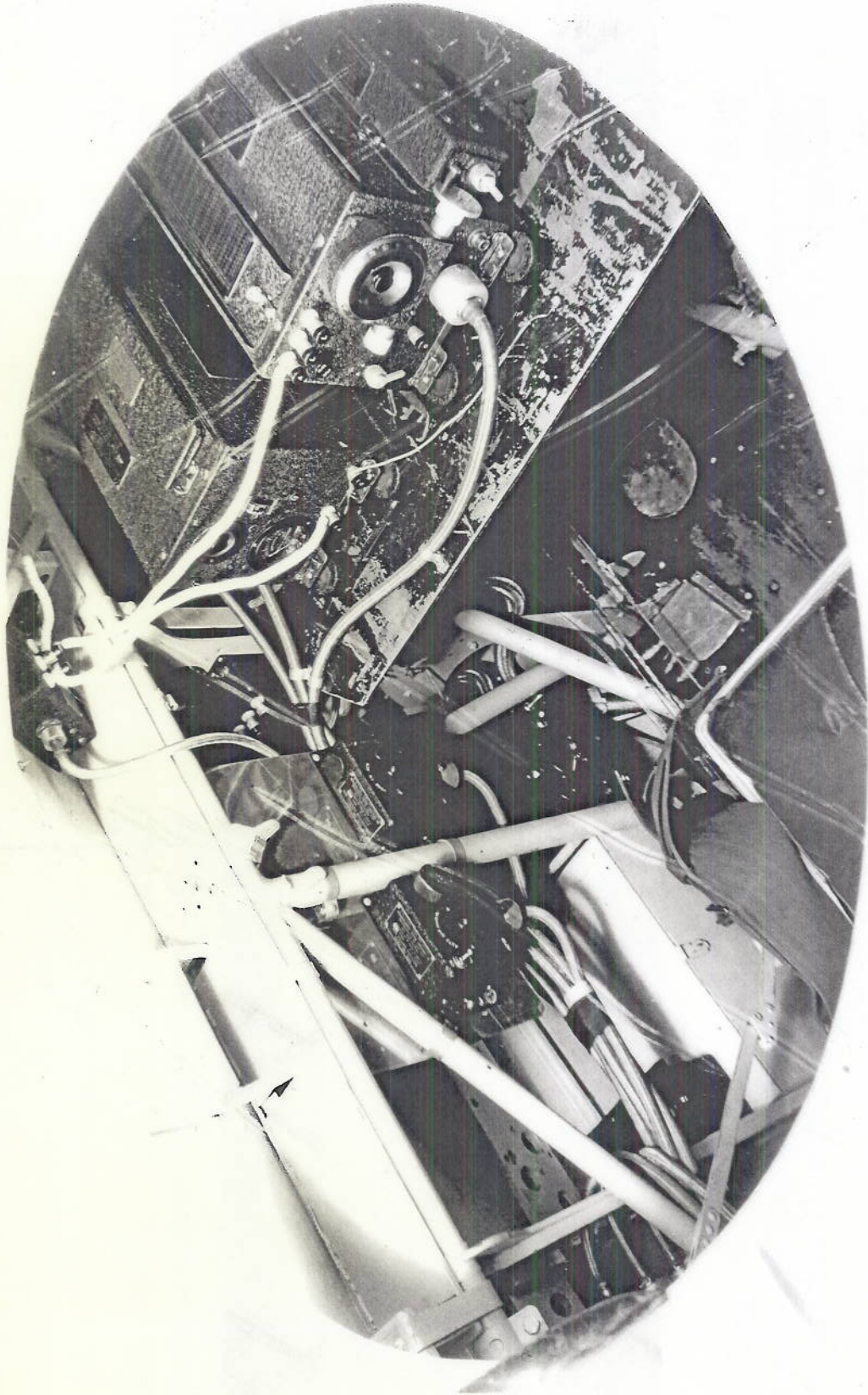
Table of Sizes and Weights.

Connecting Cables

		<u>Actual</u>	<u>Allowable</u>
Weight	Cable 21	13 oz.	13 oz.
Length	" 21	4 ft.	4 ft.
Weight	Cable 133	1 lb. 12 oz.	1 lb. 12 oz.
Length	" 133	9 ft.	9 ft.
Weight	Cable 34	15 oz.	15 oz.
Length	" 34	3-1/2 ft.	3-1/2 ft.
Weight	Cable 135	1 lb. 3 oz.	1 lb. 3 oz.
Length	" 135	4-2/3 ft.	4-2/3 ft.
Weight	Cable 236	2 lb. 2 oz.	1 lb.
Length	" 236	10 ft.	4 ft.
Weight	Cable 237	1 lb. 9 oz.	1 lb. 9 oz.
Length	" 237	7-1/2 ft.	7-1/2 ft.
Weight	Cable 75	1 lb. 1 oz.	1 lb. 1 oz.
Length	" 75	5-1/2 ft.	5-1/2 ft.
Weight	Cable 77	1 lb. 2 oz.	1 lb. 2 oz.
Length	" 77	9 ft.	9 ft.
Weight	Cable 80	1 lb. 14 oz.	1 lb. 4 oz.
Length	" 80	10 ft.	5 ft.



05U-1 #8810 11-5-35 AN-33843 "OFFICIAL NAVY PHOTOGRAPH"
GF-2 Radio Test Installation. "NOT TO BE USED FOR PUBLICATION."
Right forward view, after cockpit.



03V-1 #3810

11-5-35

AN-33844

"OFFICIAL NAVY PHOTOGRAPH"

GF-2 Radio Test Installation.
Left forward view, after cockpit.

"NOT TO BE USED FOR PUBLICATION."

MODULATION PHOTOGRAPHS

3250 KC

.2V

.25V

.3V

100%
MODULATION



100 ~



200 ~



300 ~



500 ~

PLATE 3

1281

MODULATION PHOTOGRAPHS

8050 KC

.2V

.25V

.3V

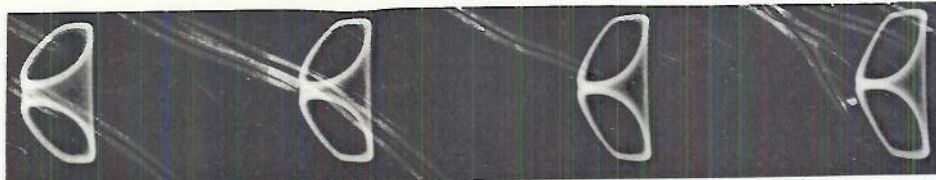
100%
MODULATION



100 v



200 v



300 v



500 v

MODULATION PHOTOGRAPHS

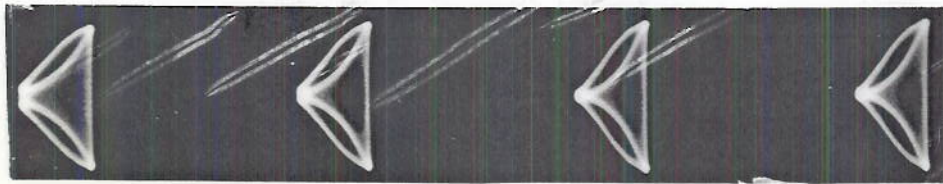
8050 KC

.2V

.25V

.5V

100%
MODULATION



1000 v



2000 v

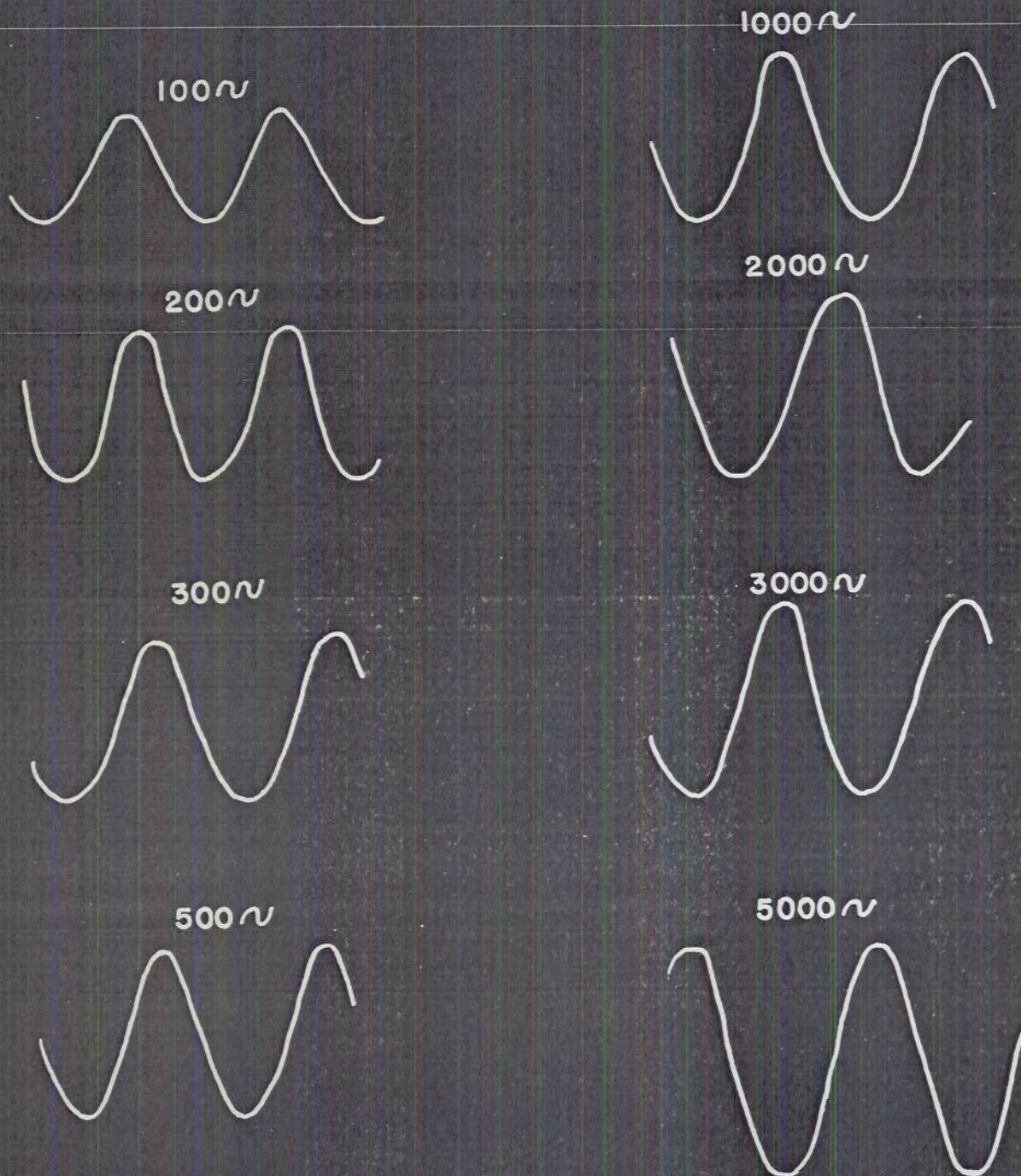


3000 v



5000 v

AUDIO FREQUENCY WAVE FORM
OF
GF-2 TRANSMITTER
INPUT CONSTANT AT .5 V.



FREQUENTLY DRIFT
62'S TRANSMITTER
TOTAL DRIFT 15%

DRIFT OVER 50 AFTER
5 MIN. WITH MULTIBEAM
105%

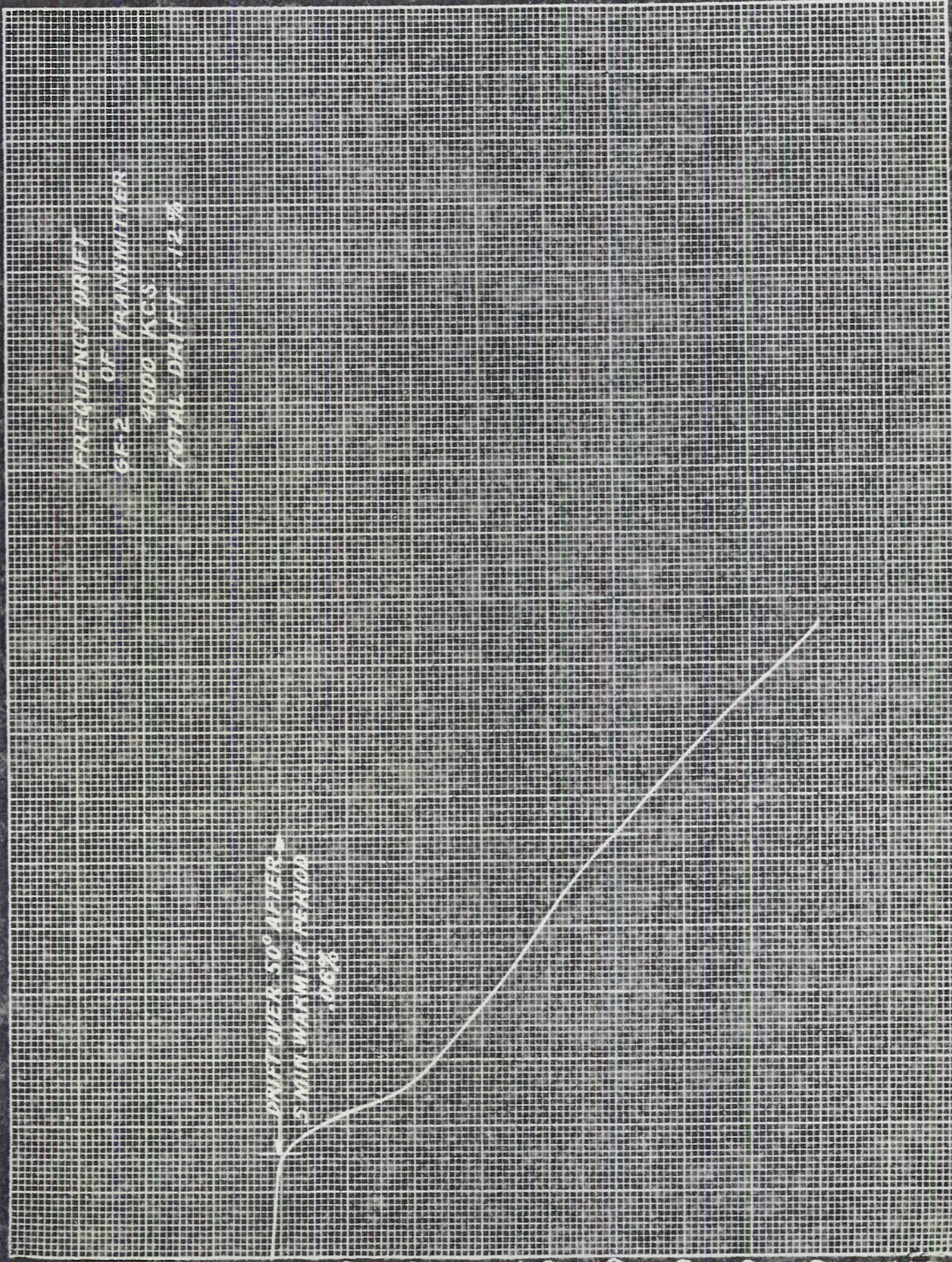


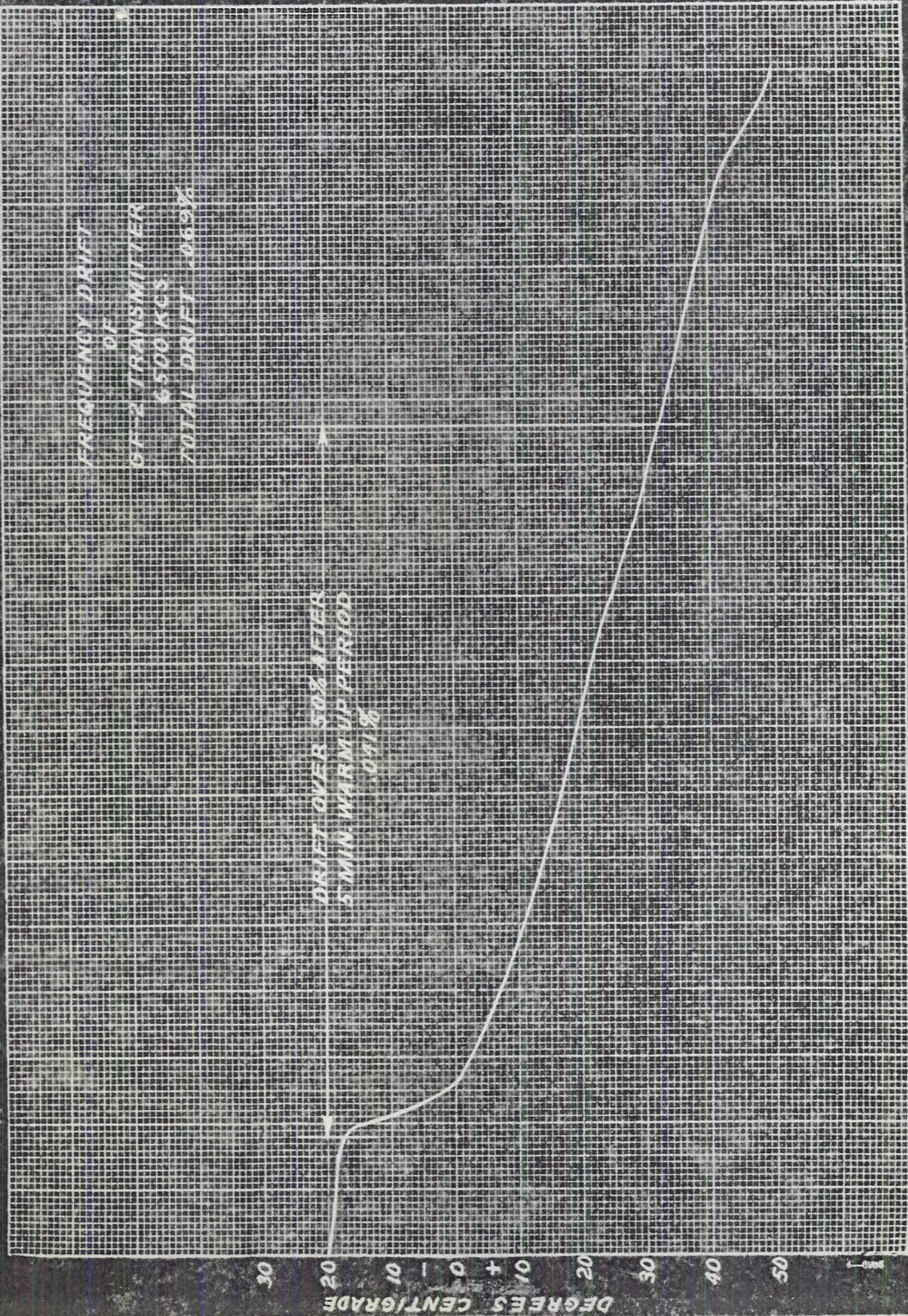
FREQUENCY DRIFT
OF TRANSMITTER
3000 KCS
TOTAL DRIFT 1.712 %

DRIFT OVER 50° AFTER
5 MIN WARM UP PERIOD
0.66%

DEGREES CENTIGRADE

0 1000 2000 3000 4000 5000





4-6088 N. R. L. 34

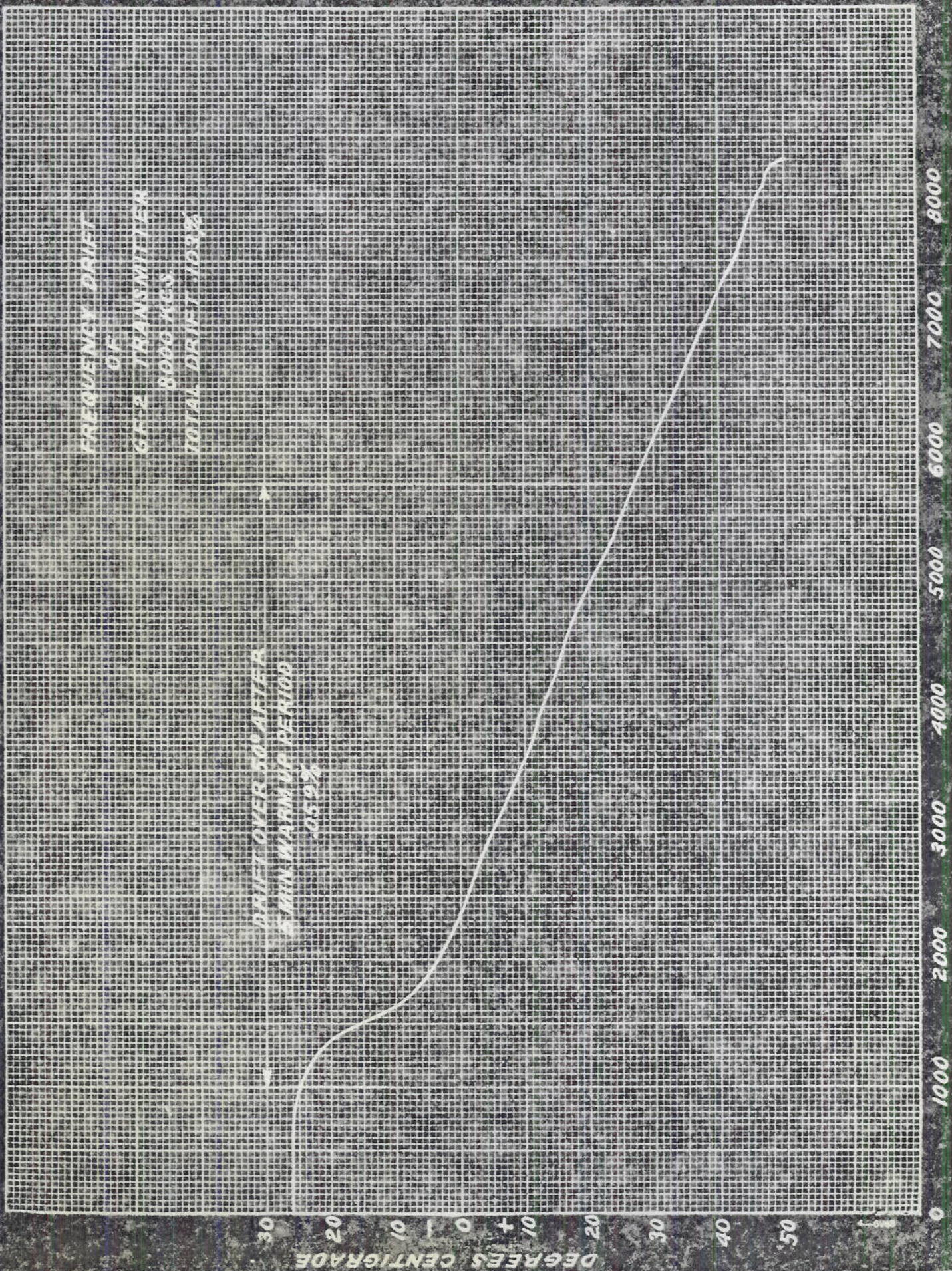
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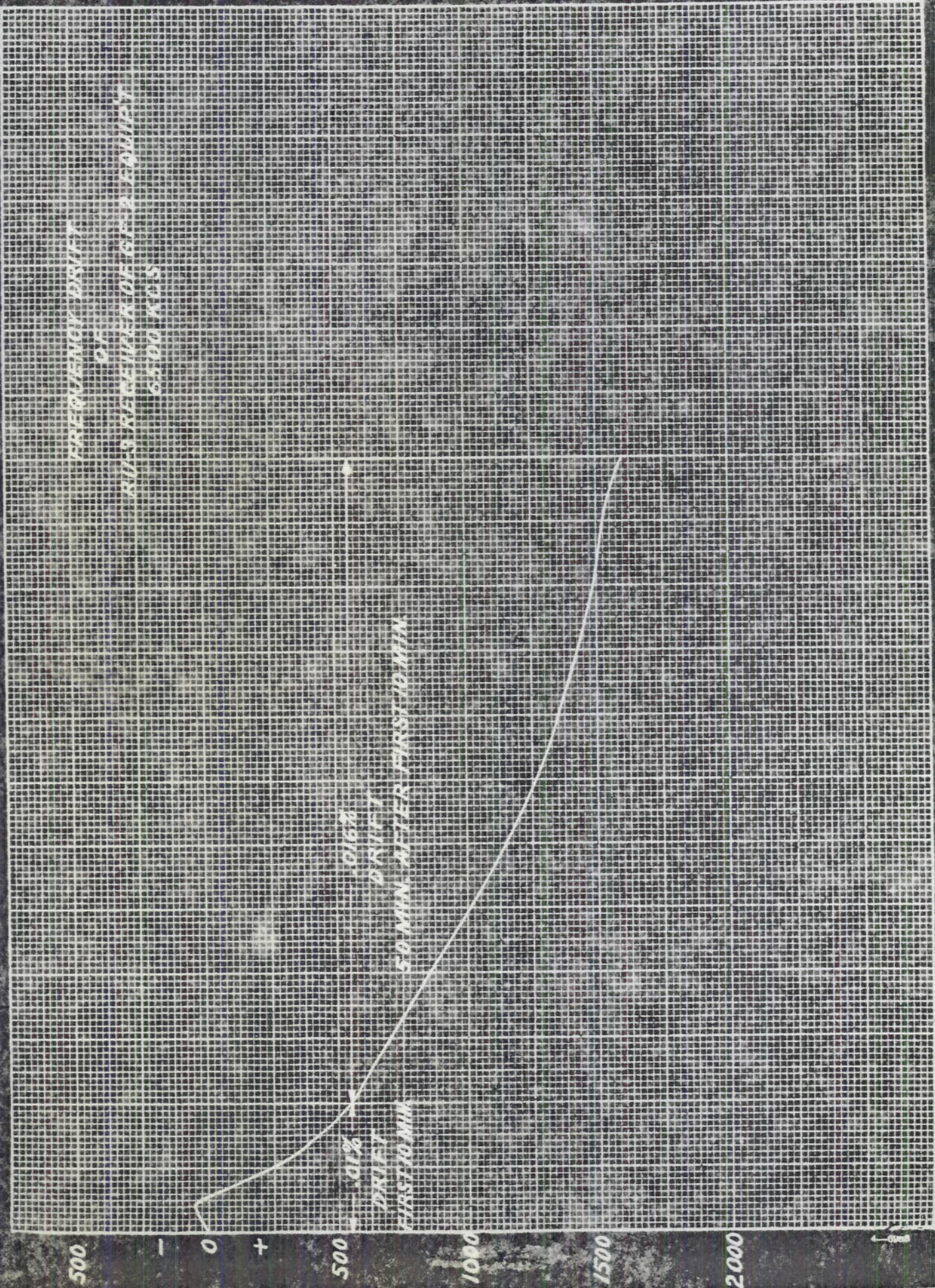
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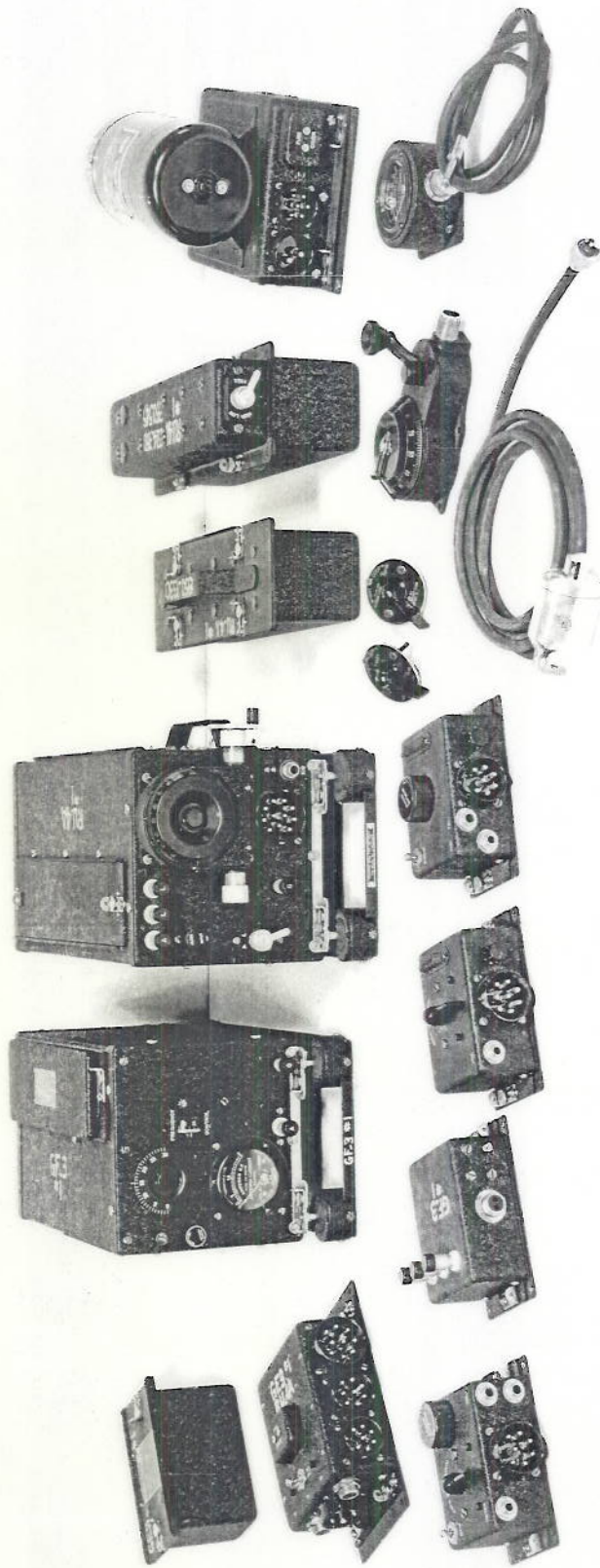
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1000

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1644

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

U. S. NAVAL AIR STATION

ANACOSTIA, D.C.

May 4, 1936.

From: Commanding Officer.
To : The Director, Naval Research Laboratory,
Anacostia Station, D. C.

Subject: Aviation Radio - Test of Model GF-2 Radio Equipment.

Enclosure: (A) Copy of N.R.L. let. F42-1/43 of 8 Oct. 1935.
(B) Photograph AN-33843; Right forward view of GF-2 installation in after cockpit of O3U-1 airplane No. 8810.
(C) Photograph AN-33844; Left forward view of GF-2 installation in after cockpit of O3U-1 airplane No. 8810.

1. The subject equipment was received from Naval Research Laboratory 10 October 1935, and after being found operative in the Laboratory was installed in O3U-1 airplane No. 8810, together with an LJ-1 frequency meter, as shown in enclosures (B) and (C). Twelve test flights totalling approximately sixteen hours were made with this installation, between 14 October - 15 November, 1935. Subsequently, the subject equipment has been installed and operated in several new types of airplanes undergoing tests at Anacostia, with an aggregate additional flight time of about fifteen hours, during which further observations and tests of the radio equipment were made.

2. The performance of the subject equipment has been verbally reported upon and discussed at several conferences at the Bureau of Engineering, including those pertaining to the RU-4 and GF-3 equipments which incorporate generally similar features. With specific reference to paragraph 2 (a) to (i) of enclosure (A), the following comments are transmitted.

3. The complete equipment is suitable for installation in all types of Navy airplanes. The Model LJ or LJ-1 frequency indicator is not operative in conjunction with the transmitter, since the keying relay in the junction box removes the high voltage from the auxiliary (frequency meter) cable outlet while the transmitter is actuated. Since the receiver plate voltage also is removed in this condition, it is not possible to check the transmitter frequency either by frequency meter or by monitoring with the receiver.

4. The equipment resonates satisfactorily to standard types of fixed antennae as well as on a trailing antenna up to 50 feet length.

5. The re-set accuracy of the transmitter was determined directly by the Naval Research Laboratory during several test flights made for this purpose. An LJ-1 frequency meter operated from a separate second receiver installation was improvised for these tests in the airplane, in view of the failure of the frequency meter to operate directly with the GF-2 equipment as set forth in paragraph 3.

Subject: Aviation Radio - Test of Model GF-2 Radio Equipment.

6. Satisfactory 2-way, plane-to-plane telephone conversation at distances from 75 to 150 miles, was conducted on several occasions, in communication between the O3U-1 radio test airplane and an R-2-D transport airplane also carrying a GF-2 installation. Break-in communication (on CW and MCFW signals) was not possible with the receiver on AVC due to the large time constant inherent in the automatic volume control; on MVC, break-in communication was satisfactory up to keying speeds between ten and fifteen words per minute. A material further increase in break-in speed is believed possible by disconnection, inside the receiver, of one of the two one-half microfarad sections which constitute the detector cathode by-pass capacitor. This station has recommended such a change in all new receivers commencing with the RU-4 series.

7. Satisfactory transmitter output is obtainable on the average single wire fixed antenna, or on a trailing wire antenna not over twenty-five feet long, over the entire frequency range from 3000 to 9050 kcs, without change of antenna length. The large "Vee" fixed antenna with 15 feet legs as specified for GP and GP-1 installations on biplanes was found superior to the single leg antenna for communication range on the lower frequencies, but due to absence of an antenna series condenser in the equipment prevented resonance above 6950 kc as the antenna fundamental frequency was approached.

8. Transfer of reception from antenna to loop collector requires no re-tuning of the receiver, but with a small fixed loop (not a wing loop) does require change in the antenna trimming condenser except over some limited frequency band to which the loop inductance or external capacitance may be pre-adjusted. The large standard wing loop has sufficient pick-up and tunes so broadly that no readjustment of the trimmer is required with it.

9. Changing of receiver frequency bands by change of coil units did not necessitate readjustment of the antenna trimmer condenser.

10. Both the sharpness and the accuracy of radio bearings was materially reduced when a long trailing antenna was reeled out; no effect was noticed from a short antenna not over fifty feet in length.

11. Satisfactory inter-cockpit communication with amply strength of speech (10.5 volts sustained peaks across each 600 ohm headset) was obtainable in flight on ICS. The transmitter side tone was of the same strength, which on CW and ICW is deemed excessive and very tiring and deafening to the operator. Switching the receiver to AVC and reducing the gain enables regulation of the side tone by the operator, but does not enable rapid break-in telegraph operation, as explained in paragraph 6.

12. The general design and workmanship exhibited by the subject equipment appears to be of a high order, with a resultant expectancy of dependability in service. This station was experienced no breakdowns of any nature with this equipment to date, and has observed satisfactory operation during altitude tests at 18,000 feet.

13. The subject equipment is considered to be satisfactory for service use aboard naval aircraft within the requirements of the governing specifications.

Copy to: BuAero (2)
N.A.F. (1)

A.P. Flagg.