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NAVY DEPARTMENT
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Report on

Tests of Preliminary Models GF-1 and RU-3 Aircraft Radio Equipment.

Naval Research Laboratory
Anacostia Station
Washington, D.C.

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APPENDICES

AUTHORIZATION

1. This problem was authorized by Bu.Eng.letter, ref.(a). Other additional references pertinent to this problem are listed as references (b) and (c).

Reference: (a) BuEng.let. C-F42-1/52(4-13-W8) of 16 April 1934.
(b) Specifications RE 13A 457C.
(c) Aircraft Radio Corporation telegram of 12 June 1934 to N.R.L.

OBJECT

2. The object of these tests was to determine whether or not the preliminary Model GF-1 equipments met the requirements of specifications RE 13A 457C.

ABSTRACT OF TESTS

3. Two preliminary model GF-1 equipments were submitted and tested. The first was an earlier development, the second incorporated improvements over the first. Both equipments included a transmitter, receiver and auxiliary equipment for power supply, control and connection.

4. Tests were made at the Laboratory covering the following points:

(1) Mechanical, which includes workmanship, size, weight and interchangeability of parts.
(2) Receiver sensitivity on MCW and CW.
(3) Receiver selectivity.
(4) Noise output and microphonics.
(5) Audio fidelity of both receiver and transmitter.
(6) Frequency stability of both transmitter and receiver over wide ranges of ambient temperature.
(7) Frequency range and overlap.
(8) Effect of variation in voltage of primary power source.
(9) Action of automatic sensitivity control.
(10) Power output of transmitter.
(11) Modulation percentage on voice and MCW.

5. The equipments were then installed in airplanes and flight tests made, noting the character of the emissions, the effect of vibration, interaction between receivers, plane to ground and plane to plane ranges, and operations with homing loops.

(a) CONCLUSIONS:

The first model GF-1 transmitter does not meet the requirements of the specifications, ref.(b), with respect to frequency stability, while the second or improved model satisfactorily meets these requirements. It was found that the range of the antenna ammeter was insufficient. The second or improved model transmitter is satisfactory for the Naval Service provided an antenna ammeter of adequate range is supplied.

Both models of the receiver fail to meet the specifications, ref. (b), with respect to sensitivity. The second or improved model receiver approaches the required sensitivity so closely that the service performance will not be affected by the slight difference between the measured and required sensitivity. The fidelity of the audio systems of the first model meets the requirements of the specifications, ref. (b), while that of the improved model does not. Therefore, the second or improved model of the receiver will be suitable for the Naval Service provided the fidelity of the audio system meets the performance of that incorporated in the first model of the receiver.

Several lock washers were missing on the auxiliary equipment. A "Send-Receive" toggle switch on the switch box, which is required by the specifications, was omitted by the manufacturer since it unnecessarily complicates the operation of the equipment. If the missing lock washers are supplied the auxiliary equipment is satisfactory for the Naval Service.

(b) RECOMMENDATIONS:

It is recommended that the subject equipment be considered satisfactory for the Naval Service provided the following details are carried out:

(1) That the manufacturer be required to furnish transmitters having a temperature compensated oscillator coil as furnished in the improved preliminary model.

(2) That the range of the antenna ammeter be increased to 1.25 amperes.

(3) That the receivers have the heterodyne oscillator coupled into the cathode circuit of the detector as was done in the improved preliminary model of the receiver.

(4) That the audio system of the production receivers equal the fidelity characteristics of the first of the preliminary models of the receivers.

(5) That the requirement for a "Send-Receive" switch on the switch box be waived.

(6) That lock washers be provided under the heads of the screws holding the bases to the control box, switch box and antenna relay.

It is further recommended that future specifications for similar equipment require the following:

(1) That a trimmer condenser for adjusting the oscillator to its calibration be provided. Such a condenser was provided in the improved model of the transmitters submitted for test.

(2) That the transmitter calibration chart be mounted on the panel supporting the plug-in coils.

(3) That the "Send-Receive" toggle switch on the switch box be eliminated.

(4) That the jack be a three contact jack to accommodate a three contact telephone plug having the tip so connected as to permit keying the transmitter with the microphone push button.

(5) That the requirements for frequency stability in aircraft receivers be made more rigid. The frequency drift tolerance should be equal to that of modern transmitters, namely, $\pm$ 0.05%.

EQUIPMENT UNDER TEST

6. The model GF-1 equipment is a fighting plane radio equipment for transmitting CW, MCW or voice signals and receiving the same. The transmitter normally covers the frequency range of 6200 Kcs. to 7700 Kcs. by means of a single set of plug-in coils. The receiver covers 224 Kcs. to 13,575 Kcs. by means of plug-in coil sets. The receiver may be used independently and when thus used is known as the model RU-3 receiver. The primary power source is a 12 volt storage battery.

7. The equipment as submitted for test by the Aircraft Radio Corporation of Boonton, N.J., consists of the following units:

(1) Transmitter with mounting base.
(2) Transmitter control box.
(3) Junction box.
(4) Transmitter remote control.
(5) Dynamotor unit.
(6) Receiver and mounting base.
(7) Receiver switch box.
(8) Receiver remote tuning control and shaft.
(9) Receiver local tuning control.
(10) Antenna relay.
(11) Antenna-loop switch remote control.
(12) Dual coil remote control.
(13) Dual coil set and container.
(14) Plug-in coil sets and containers.
(15) Connecting cables and associated plugs.

8. The transmitter is contained in an aluminum case and mounted on a shock absorbing base. The oscillator uses a type 38110A vacuum tube in a temperature compensated circuit tuned by means of a variable condenser controlled from the front panel. The radio frequency amplifier uses another type 38110A tube. The modulator is a type 38142A tube, while the audio amplifier is a type 38110A tube. The audio amplifier is used as an audio oscillator for MCW transmission. The transmitter control box provides for the type transmission desired, that is, CW, MCW or voice, by means of a three position switch. A telegraph key also is incorporated in the control box. The throttle switch is in parallel with this key so that it may also be used for keying. The filament current is taken from the battery directly while the dynamotor unit supplies the plate power and grid bias voltage.

9. The receiver is mounted in a case similar to the transmitter. It consists of a tuned radio frequency amplifier, detector, oscillator audio frequency amplifier and automatic sensitivity control. The tubes used are three type 78 as radio frequency amplifiers, one type 77 detector, one type 77 as an automatic sensitivity control tube and one type CJ, which is a dual triode, one section of which is the beat oscillator and the other section the audio frequency amplifier. All tuning is

accomplished by a single control. A receiver switch box controls the selection of manual or automatic sensitivity control and CW or MCW reception. The filament supply is direct from the battery and the plate supply from the dynamotor unit.

10. The dynamotor unit consists of a dynamotor and filter. The input to the dynamotor is 12 volts. The output is 360 volts at 100 m.a.

11. An antenna relay unit is provided for transferring the antenna from the receiver to the transmitter to allow break-in operation with a single antenna.

12. All units are joined together by means of plug-in cables running from each unit to a junction box. The junction box also houses a relay which transfers the dynamotor supply from the receiver to the transmitter when the transmitter is keyed.

13. Two models of both the transmitter and the receiver were submitted. The only difference in the transmitters was in the compensation for temperature variations. In the first model a bimetallic strip varied the capacity in the circuit with tube temperatures. The improved model had a temperature compensated inductance for frequency stabilization.

14. The difference in the receivers was in the method of coupling the beat oscillator into the detector. The first model used grid coupling while the improved model used cathode coupling. The cathode coupling permitted a higher sensitivity with less reaction on the automatic sensitivity control tube.

15. The photographs of Plates 1 and 2 show this equipment.

METHOD OF TEST

16. The tests herein reported were conducted as nearly as possible in accordance with the governing specifications, ref.(b). A visual inspection of workmanship was made after which the various units were measured and weighed.

17. Receiver sensitivity was measured using model LC-A Standard Signal Generator Serial No. 2. Standard output was 10 milliwatts into a 600 ohm non-inductive resistor. The signal generator was connected to the receiver through a phantom antenna consisting of a 100 micro-micro-farad capacitor mounted on the receiver antenna binding post. The leads were less than six inches long. Selectivity was measured by noting the number of kilosycles off resonance necessary to require an increase in radio frequency input of 10, 20 and 100 times that necessary at resonance for standard output.

18. The audio fidelity was measured by using an external modulation source for the signal generator and noting the audio output of the receiver for various modulation frequencies. The carrier frequency was 4000 Kcs.

19. Measurement of the frequency stability of the receiver was made by beating the receiver against a crystal oscillator and noting the change in beat note frequency over a period of time either with a constant or variant ambient temperature. The audio beat frequency was measured by means of an audio oscillator.

20. The action of the automatic sensitivity control was noted by measuring the audio output, both CW and MCW with a change in radio frequency input of 10, 100 and 1,000 times that necessary for standard output.

21. The frequency stability and accuracy of calibration was measured by a standard frequency meter. These measurements were made at a varying ambient temperature. The temperature was controlled by placing the transmitter in an insulated box in which the temperature could be controlled. It was necessary to cool the transmitter to the minimum temperature without any power being dissipated in the box since the capacity of the cooling system would not permit the lowest required temperature otherwise.

22. The power output of the transmitter was determined by measuring the radio frequency current through a known resistance and then calculating the power from these values.

23. A cathode ray oscillograph was used for studying the modulation characteristics of the transmitter. Since this method was used for the first time at this Laboratory in the test of the model GF-1 transmitter, it will be discussed at length.

24. The radio frequency output voltage was connected to one set of plates of the cathode ray oscillograph. To the other set of plates the output of an audio oscillator was connected. This audio oscillator was also used to modulate the transmitter.

25. In order to have the D.C. current through the microphone transformer a 200 ohm resistor was substituted for the microphone. The modulating voltage was then fed into the audio system of the transmitter across this resistor. A coupling transformer and capacitor was introduced into the circuit between the audio amplifier and the input to the transmitter. Before any measurements were made the coupling system was connected to the oscillograph to be sure that no distortion or phase shift was produced by the system used. A schematic diagram of this setup is shown on Plate 3.

26. The figures of Plate 4 show various patterns produced on the fluorescent screen of the cathode ray tube when the transmitter and oscillator are connected as described above. These patterns are not outlines but are solid figures since the radio frequency causes too rapid a motion of the cathode spot to be distinguished as lines. If the radio frequency is applied to the tube independently, the spot will oscillate back and forth and produce a straight line on the screen. If the audio frequency alone is applied to the other set of plates a line at right angles to the first will be produced. As shown on Plate 4, the radio frequency produces a line along the Y axis. The audio frequency produces a line along the X axis.

27. When the unmodulated carrier and an audio frequency are applied to their respective plates of the cathode ray tube at the same time a rectangle as shown by Figure 1 of Plate 4 is produced. The X dimension being determined by the amplitude of the audio voltage and the Y dimension by the radio frequency voltage.

28. The condition for 100% modulation is that the modulating voltage should produce a variation in the amplitude of the radio frequency voltage such that the peak amplitude is twice the unmodulated carrier amplitude and the minimum just reaches zero. The pattern of Figure 2 represents such a condition. The unmodulated carrier amplitude is "A" while the increase due to modulation is "B", which equals "A", and the decrease due to modulation is "A".

29. In cases where the modulation is less than 100% a tropezoidal figure such as shown by Figure 3 results. Here the increase in amplitude "D" is less than the unmodulated amplitude "A" and the decrease "C" is also less than "A". The percentage modulation can be calculated by measuring the total maximum deflection and the total minimum deflection and calculating from the following formula:

$$\text{Modulation percentage} = \frac{\text{Max} - \text{min}}{\text{Max} + \text{min}} \times 100$$

30. In both the above cases the modulation is produced by a modulating voltage with a symmetrical wave form. In other words, the peak positive value of the modulating voltage is numerically equal to the peak negative value. If these values are not equal, the oscillograph produces a pattern as shown in Figure 4. Here the increase in the amplitude of the modulated carrier "F" is not equal to the decrease in amplitude. This particular figure indicates a greater degree of modulation on the negative half cycle of the modulating voltage. This condition is called amplitude distortion.

31. Over modulation is represented by Figure 5. Here the amplitude of the radio frequency voltage reaches zero before the minimum value of the modulating voltage is reached, thus causing an actual

cutting off of the carrier for a portion of each audio frequency cycle. This is shown by the distance "G" being less than the distance "X". The maximum amplitude will usually be greater than that required for 100% modulation.

32. All of the above figures represent only one-half cycle of the modulating voltage. The left edge of the figures represents the peak value of the modulating voltage (sometimes called positive peak) while the right edge represents the minimum value of this voltage (sometimes called negative peak). If there is absolutely no distortion in the modulating voltage the succeeding half cycle will produce an identical pattern superimposed on the original pattern and so producing absolutely no change in that pattern. If, however, some distortion is present, two superimposed patterns of slightly different outline will be formed which may take the appearance of Figures 6 and 7.

33. Figure 7 represents a phase distortion due to the audio circuits of the transmitter. If we consider the figure as a cylinder cut at the top and bottom by two oblique planes it is easier to visualize the effect of this phase distortion. Considering the figure as such a cylinder it will be seen that this cylinder has been slightly rotated from its normal position as represented by Figure 3. That is, the maximum and minimum amplitudes are no longer at the right and left edges of the pattern but occur at distances "S" and "K" in from these edges. The modulation percentage may still be calculated from the formula previously given.

34. The phase angle may be calculated by the method diagrammed in Figure 8. Here the ellipse forming the top of the pattern is projected onto a circle. The minimum point is at distance "K" from the right edge or has been rotated from its normal position by an angle ϕ. The right angled triangle is constructed as shown. Then the cosine ϕ is the adjacent side divided by the hypotenuse of the triangle. The hypotenuse is also the radius of the circle. The radius of the circle is 1/2 X. The adjacent side is "L" which equals the radius minus "K".

$$\text{Thus } \cos\phi = \frac{L}{1/2\,X} = \frac{1/2\,X - K}{1/2\,X} = \frac{X - 2K}{X}$$

K should equal J so to average measurements we may write:

$$\cos\phi = \frac{X - (K + J)}{X}$$

$$\text{The phase angle } \phi = \cos^{-1} \frac{X - (K + J)}{X}$$

35. The two equipments were installed in type O3U-1 airplanes and flight tests conducted maintaining communication between the planes and between each plane and ground. During these tests the range was determined. The character of the signals from the planes was noted. The wing loop was connected to the receiver and the usefulness of the receiver with this loop determined. A milliammeter was plugged into the meter jack in the receiver switch box and the switch set to "automatic" to note the action of this meter for directional indications.

DATA RECORDED DURING TESTS

36. The data recorded during these tests include:

(1) Receiver sensitivity on MCW and CW.
(2) Receiver selectivity.
(3) Noise output.
(4) Audio fidelity of both receiver and transmitter.
(5) Frequency measurements on both receiver and transmitter over a period of time at constant and variable ambient temperatures.
(6) Total current required from storage battery and the effect of voltage variation.
(7) Audio output for various radio frequency inputs when using the automatic sensitivity control.
(8) Power output of the transmitter.
(9) Modulation percentage of the transmitter.

This data is presented in the form of tables and the plates of the Appendix, and is discussed under RESULTS.

DISCUSSION OF PROBABLE ERRORS

37. All voltage and current measurements were taken with laboratory instruments with an accuracy of $\pm$ 0.5%. The power output measurements were calculated from the current as read by a radio frequency ammeter and the D.C. resistance of the phantom antenna. This resistance was wound non-inductively. The accuracy of these results is $\pm$ 10%. Temperatures are accurate to $\pm$ 0.1°. Modulation percentages should be accurate to $\pm$ 2.5%. The audio frequency readings for fidelity and change of beat frequency are good to $\pm$ 2%. The radio frequency measurements have an accuracy of $\pm$ 0.001%.

RESULTS AND DISCUSSION

38. The results of these tests will be discussed for compliance with each individual paragraph of the specifications, ref.(b). Certain of these paragraphs are of a general nature or are for manufacturing

information only and will not be discussed. The numbering of the following sub-paragraphs agrees with the numbering of the paragraph of the specification under discussion.

2-2. The foil paper capacitors are not hermetically sealed as required by specification RE 13A 488A.

2-3. Satisfactory.

2-4. The workmanship is excellent.

2-5. Satisfactory.

2-6. Iron and steel have been used only where necessary.

2-7. The volume control binds at temperatures below -10°C and becomes very hard to operate.

2-8. This equipment is suitably protected as required by this paragraph.

2-9. Satisfactory.

2-10. Continuous operation is possible without damage.

2-11. Satisfactory.

2-12. No wood is used.

2-13. Satisfactory.

2-14. Satisfactory.

2-15. Satisfactory.

2-16. No lock washers are provided for the screws holding the receiver and transmitter control boxes to their base. Otherwise satisfactory.

2-17. Satisfactory.

2-18. All paper foil capacitors should be hermetically sealed.

2-19. Satisfactory. "Lord" live rubber shock absorbers are used for supporting the receiver and transmitter.

2-20. Satisfactory.

2-21. Satisfactory.

2-22. All shock proofing is provided in the mounting and is satisfactory.

2-23. Satisfactory.

2-24. Satisfactory.

2-25. Plug-in coils to cover the required frequencies are provided for both receiver and transmitter.

2-26. Satisfactory.

2-27. A Weston 2.5 inch, 0-1 ampere radio frequency ammeter is provided for reading antenna current. The range of this meter should be increased to 1.25 amperes.

2-28. Satisfactory.

2-29. Satisfactory.

2-30. Satisfactory.

2-31. No electrolytic capacitors are used.

2-32. The antenna relay permits the use of only one antenna. Loop input is provided on the receiver.

2-33. Satisfactory.

2-34. A single changeable soldered connection inside the receiver permits the use of either low (600 ohm) or high (20,000 ohm) impedance phones.

2-35. Satisfactory.

2-36. Satisfactory.

2-37. Three types of vacuum tubes are used for the receiver; namely, types 38077, 38078, and Raytheon type CJ. The transmitter uses types 38110A and 38142A.

2-38. This equipment will operate with standard Navy type tubes, except for the type CJ which has no equivalent standard Navy type.

2-39. Satisfactory.

2-40. See results of tests conducted at various temperatures.

2-41. Satisfactory.

3-1. Satisfactory.

3-2. Items (21), (22), and (23) were not submitted for test.

3-3. Transmitter. Both oscillator and amplifier coil are mounted on a single panel and plug in as a unit. The dimensions are as shown on sheet 65 c. The weight is 10 lbs.

3-4. Mounting base. The mounting base weighs 10 oz. The dimensions and construction are exactly as specified.

3-5. Transmitter control box. This control box is exactly as specified except that no toggle switch for throwing from "Transmit" to "Receive" is provided. Such a switch is unnecessary. It would be advisable to change the microphone jack to one which would accommodate a three contact plug so wired that the microphone button would operate the keying relay. The box weighs 13 oz.

3-6. Junction box. The junction box is as specified. The dimensions are as shown on sheet 69 c. The weight is 2 lbs. 4 oz.

3-7. Transmitter remote control. A Navy type 24004 throttle switch and cable are provided.

3-8. Dynamotor unit. The dynamotor unit is as specified. The dynamotor weighs 9 lbs. 6 oz.

3-9. Receiver.

(1) The receiver is housed in a black wrinkle finish case.
(2) The dimensions and arrangement conform exactly to the drawing on sheet 67 c.
(3) The receiver and one coil set weigh 13 lbs.

One coil set weighs 1 lb. 14 oz.
One coil container weighs 10 oz.

(4) Controls are provided as specified.
(5) All controls except the dual coil selector switch are on the front panel of the receiver. The dual coil selector switch is mounted so that it is controlled from the end of the coil toward the front panel.
(6) As specified.
(7) Five inches clearance permits changing any coil sets.
(8) A removable panel is provided on top of the receiver for access to the vacuum tubes.
(9) Satisfactory.

3-10. Receiver mounting base. The weight of this unit is 10 oz. The dimensions are as shown on sheet 67 c.

3-11. Receiver switch box. This unit contains the parts and performs the operations required by this paragraph. The dimensions conform to those specified on sheet 66 c. The weight is 13 oz.

3-12. Receiver remote tuning control and mechanical linkage. This unit is constructed according to the drawing of sheet 68 c. It meets all requirements of this specification. The tuning unit weighs 1 lb. while the mechanical linkage weighs 1 lb. 4 oz. for the 10 ft. length.

3-13. Receiver local tuning control. This unit weighs approximately 2 oz.

3-14. Antenna relay unit. This unit has the outline dimensions shown on sheet 66 c. It weighs 1 lb.

3-15. Antenna-loop switch local control. A satisfactory control is provided which may be removed for connection of the remote control.

3-16. Antenna-loop switch remote control. A control similar to the local control with a suitably marked name place is provided with 6 feet of mechanical linkage. The complete unit weighs 1 lb.

3-17. Dual coil set local control. A switch control exactly like the antenna loop switch control is provided.

3-18. Dual coil set remote control. This unit is identical with that furnished for the antenna-loop remote control except for the markings on the name plate.

3-19. Plug-in coils and containers. The coils and containers supplied are in accordance with these specifications.

3-20. Satisfactory.

3-21. Connecting cables and plugs. The cable lengths and weights were found to be as follows:

Cable No. 21 - Length 4 ft. 6 in., weight 12 oz.
Cable No. 33 - Length 9 ft. 4 in., weight 2 lbs.
Cable No. 34 - Length 3 ft. 8 in., weight 14 oz.
Cable No. 35 - Length 4 ft. 11 in., weight 1 lb. 1 oz.
Cable No. 36 - Length 4 ft. 6 in., weight 1 lbs. 2 oz.
Cable No. 37 - Length 7 ft. 9 in., weight 1 lb. 8 oz.
Cable No. 75 - Length 5 ft. 10 in., weight 10 oz.
Cable No. 77 - Length 9 ft. 1 in., weight 12 oz.

3-22. No insulators were furnished for test.

3-23. No phantom antenna was furnished for test.

3-24. No test meter was furnished for test.

3-25. Satisfactory.

3-26. The sensitivity control binds at low temperatures.

3-27. Satisfactory.

3-28. Satisfactory.

3-29. The determination of the suitability of the contacts over a long period of time requires a life test which could not be conducted at the Laboratory within the allotted time. From previous experience these contacts should be satisfactory.

3-30. The arrangement of parts and the construction permits easy servicing.

3-31. From previous experience with similar equipment these units appear to be satisfactory. However, it would be desirable to have more complete sealing of the transformers.

3-32. Apparently satisfactory. For accurate results a life test is necessary.

3-33. Satisfactory.

3-34. Satisfactory.

3-35. Operation of the dynamotor unit at ambient temperatures between -32°C to +35°C was satisfactory.

3-36. Satisfactory.

3-37. The bearings are satisfactory.

3-38. The unit is totally enclosed.

3-39. The jacks are as specified.

3-40. Satisfactory.

3-41. Satisfactory.

3-42. Life tests are required for determination of the fulfillment of the provisions of this paragraph.

3-43. All tuning and trimming condensers are of the air dielectric type.

3-44. Total weight with single coil set without remote control of loop antenna switch, dual coil or receiver tuning is 47 lbs. 6 oz. With the dual coil set and all remote controls the weight is 52 lbs.

IV. Definitions.

No comments are required on this section of the specifications other than on paragraph 4-5(b). With a separate heterodyne oscillator for CW reception the CW selectivity depends on the audio frequency characteristics of the receiver. Therefore, the MCW selectivity should be a satisfactory index of the CW selectivity.

V. Operation

5-1. Satisfactory.

5-2. The operation of the equipment is as specified except that no "Transmit-Receive" toggle switch is provided on the transmitter control box.

5-3. Satisfactory.

5-4. Satisfactory.

5-5. Satisfactory.

5-6. Satisfactory.

5-7. Satisfactory.

5-8. Both manual and automatic sensitivity controls are provided.

5-9. Satisfactory.

5-10. The same control knob adjusts the receiver sensitivity in the "manual" position and the audio level in the "automatic" position.

5-11. Satisfactory.

5-12. Satisfactory.

5-13. Temperature tests were made on the equipment the results of which appear at various places under more specific paragraphs of these specifications. The Laboratory is not equipped to conduct the required humidity tests.

VI. Electrical Requirements.

6-1. The equipment operated satisfactorily on fixed antennae installed on type O3U airplanes.

6-2. The master oscillator is controlled by means of a dial on the front panel. The amplifier is tuned to resonance by means of the antenna tuning control which has no dial. The controls may be locked in any position. A thermal ammeter is provided in the front panel for indicating antenna current.

6-3. The frequency drift of the first model was excessive for the specified temperature range. With an initial frequency of 7390.36 Kcs. at -27°C the frequency drifted to 7400.61 Kcs. at +26°C. The total frequency change for 53°C temperature change was 10.25 Kcs.

or 0.14%. This measurement was made from a cold start. The drift for the first 30 minutes with a temperature change of only 10°C was 7 Kcs. The same test on the second model transmitter (compensated coil) resulted in only 2.54 Kcs. change for a temperature change of 64°C. With an initial frequency of 7000.88 Kcs., this represents a frequency change of 0.028%. Allowing no warming up time the measured frequency at +30°C was 6999.36 Kcs. and at -30°C was 7000.88 Kcs., a difference of only 1.52 Kcs. The results of the frequency drift measurements on the improved model are shown on Plates 5 and 6.

6-4. A calibration chart is provided as specified and is mounted on the front panel of the transmitter. The accuracy of the calibration is well within the specified 0.1%. Since this transmitter has plug-in coils it would seem advisable to mount the calibration chart on the removable panel supporting the coils.

6-5. Plates 7 and 8 show photographs of the patterns on the screen of the cathode ray oscillograph produced by the transmitter. The left hand figure of Plate 7 represents the unmodulated carrier of constant amplitude with different audio voltages applied to the second set of plates on the cathode ray tube. It will be noted that the vertical dimensions of these patterns which represent the carrier amplitude, are equal while the horizontal dimension varies with a variation in audio voltage applied to the oscillograph. It will be noted that the audio voltages for the carrier do not correspond in position to the other figures. The other figures show the patterns produced at the modulating frequencies and voltages shown on the plates.

Considerable phase distortion is present. Above 500 cycles the phase displacement is approximately 180 degrees. The phase displacement, however, remains practically constant regardless of audio voltage. Some distortion of the audio wave form is also present as indicated by the asymmetry of the elliptical pattern forming the top and bottom of the complete figure. It will be noted also that this distortion increases with increase of the modulating voltage. This undoubtedly means overloading of the modulator.

The modulation percentage as determined from measurement of the maximum and minimum amplitudes and calculated from the formula given under the discussion of the method of measurement are given in Table 1 of the Appendix.

Further analyses of the modulation patterns disclose some amplitude distortion which increases as the modulation percentage increases. Let us consider the pattern produced by an audio input of 1.5 volts at 1600 cycles. The measurements on the film give the maximum amplitude (measured in 64ths of an inch) as 66. The minimum is 27. From the unmodulated carrier we obtain an amplitude of 50. This represents an increase in amplitude during modulation of 16 and a decrease of 23.

This represents a modulation percentage of 32% on the positive half of the audio cycle and 46% on the negative half of the audio cycle. Approximately the same relation holds on the other modulating frequencies.

None of the above defects in modulation are of such a serious nature as to cause any great loss of intelligibility. For optimum results, however, all forms of distortion should be absent.

6-6. The power output as measured in shown in Table 2 of the Appendix.

6-7. With the equipment installed in two O3U-1 type airplanes the range on MCW was 60 miles. Conditions in fighting planes should be approximately the same.

6-8. Satisfactory.

6-9. Satisfactory.

6-10. The receiver may be operated with or without the transmitter units connected.

6-11. All power is off when the receiver switch box control switch is in the "off" position.

6-12. Satisfactory.

6-15. The time required for changing frequency will depend on the experience of the personnel. With proper experience the frequency can be changed in one man minute after proper calibration.

6-16. A ceramic material is used for the transmitter coil forms. The variable condensers have glass insulation.

6-17. Satisfactory.

6-18. The total current drain was measured at 7.6 amperes at 14 volts.

6-19. The signals from the transmitter were reasonably free from lilt and roughness.

6-20. Satisfactory.

6-21. Eleven coil sets are used to cover the frequency range.

6-22. Coils are furnished to cover the required bands.

6-23. Satisfactory.

6-24. Tuning is provided in the first grid circuit.

6-25. Satisfactory.

6-26. Coupling the heterodyne oscillator into the detector cathode circuit, as provided in the improved model of the receiver, is the more satisfactory method.

6-27. A slight readjustment of the antenna trimmer was found necessary for maximum sensitivity when changing frequency.

6-28. A high grade phenolic composition is used for receiver coil forms. The tuning condensers have satisfactory insulation.

6-29. A jack is provided on the front panel of the receiver for the input from an interior communication system.

6-30. Satisfactory.

6-31. No D.C. is present in the phones.

6-32. The results of the sensitivity measurements are given in Table 3 of the Appendix. The supply voltage was 12 volts. With a supply voltage of 14 volts, the sensitivity is increased approximately 20%.

6-33. Measurements on the loop input gave the sensitivities shown in Table 4 of the Appendix.

6-34. The results of the selectivity measurements are shown in Table 5 of the Appendix.

6-35. The audio fidelity of the first model was satisfactory. The improved model was not satisfactory. The curves of Plate 9 show the results of these tests.

6-36. Satisfactory.

6-37. The noise output measured as specified was not sufficient to give a readable indication on the output meter.

6-38. Flight tests and laboratory tests indicate that the microphonic tendencies are negligible.

6-39. Operation in aircraft is satisfactory.

6-40. Satisfactory.

6-41. Satisfactory.

6-42. The antenna binding post is grounded in the "Loop" position.

6-43. Satisfactory.

40. Both models of the receiver fail to meet the specifications, ref.(b), with respect to sensitivity. The second or improved model receiver approaches the required sensitivity so closely that the service performance will not be affected by the slight difference between the measured and required sensitivity. The fidelity of the audio systems of the first model meets the requirements of the specifications, ref. (b), while that of the improved model does not. Therefore, the second or improved model of the receiver will be suitable for the Naval Service provided the fidelity of the audio system meets the performance of that incorporated in the first model of the receiver.

41. Several lock washers were missing on the auxiliary equipment. A "Send-Receive" toggle switch on the switch box, which is required by the specifications, was omitted by the manufacturer since it unnecessarily complicates the operation of the equipment. If the missing lock washers are supplied the auxiliary equipment is satisfactory for the Naval Service.

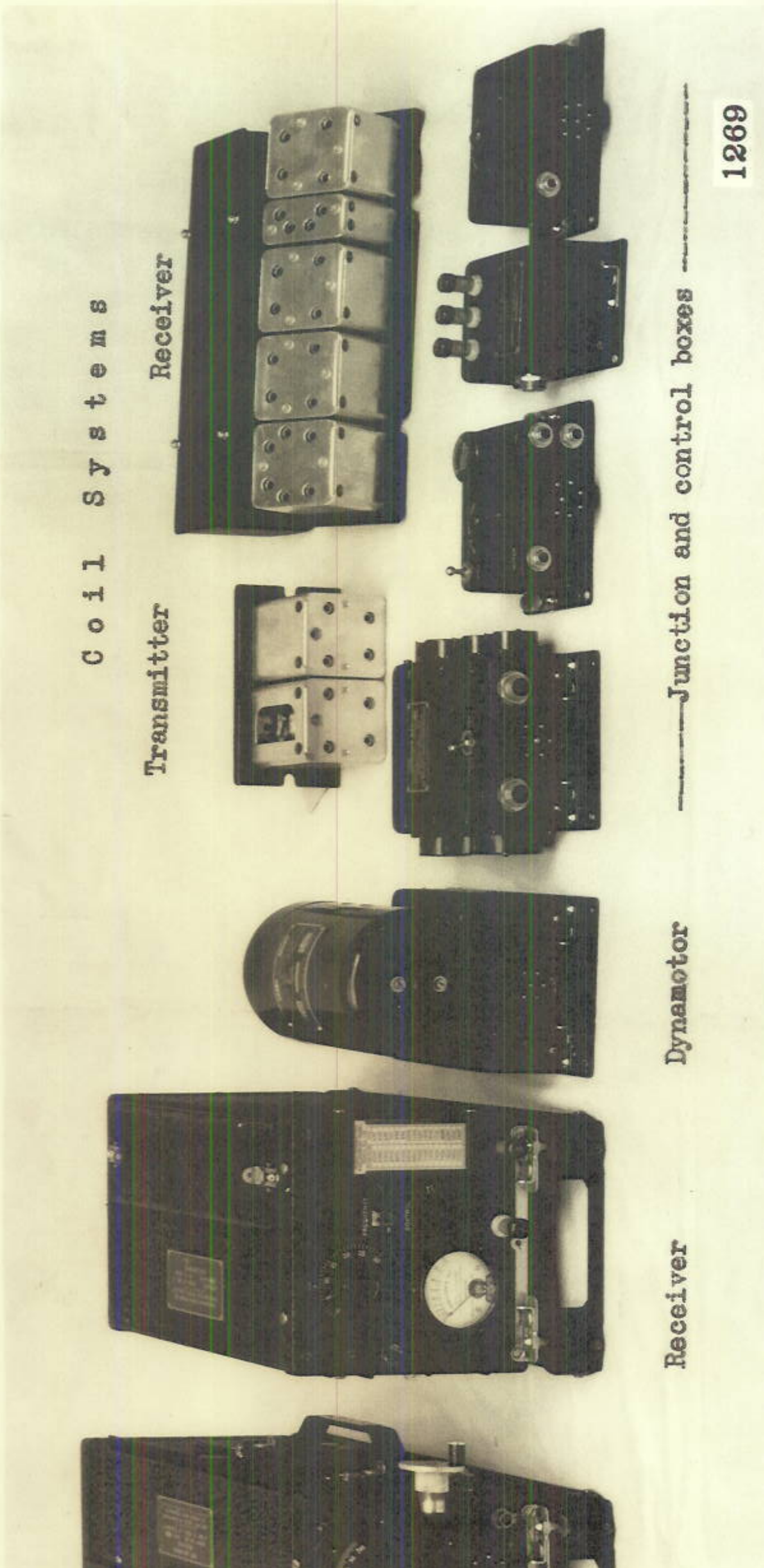

Coil Systems
Transmitter
Receiver
Transmitter
Receiver
Dynamotor
Junction and control boxes
1269

PLATE I

Control and Inter -connecting Cables

PLATE 2

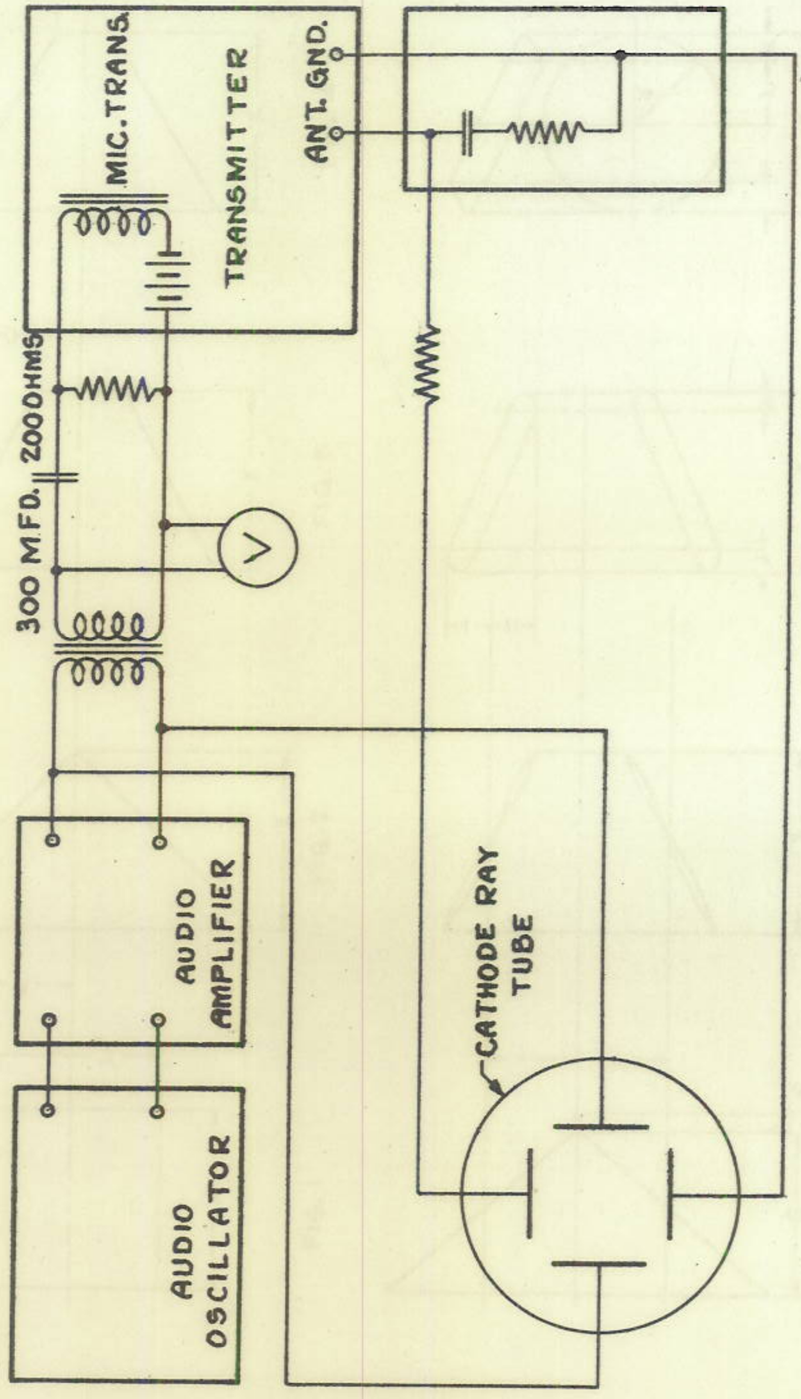

MIC. TRANS.
TRANSMITTER
ANT. GND.
200 OHMS
300 M.FD.
V
AUDIO AMPLIFIER
AUDIO OSCILLATOR
CATHODE RAY TUBE

PLATE 3

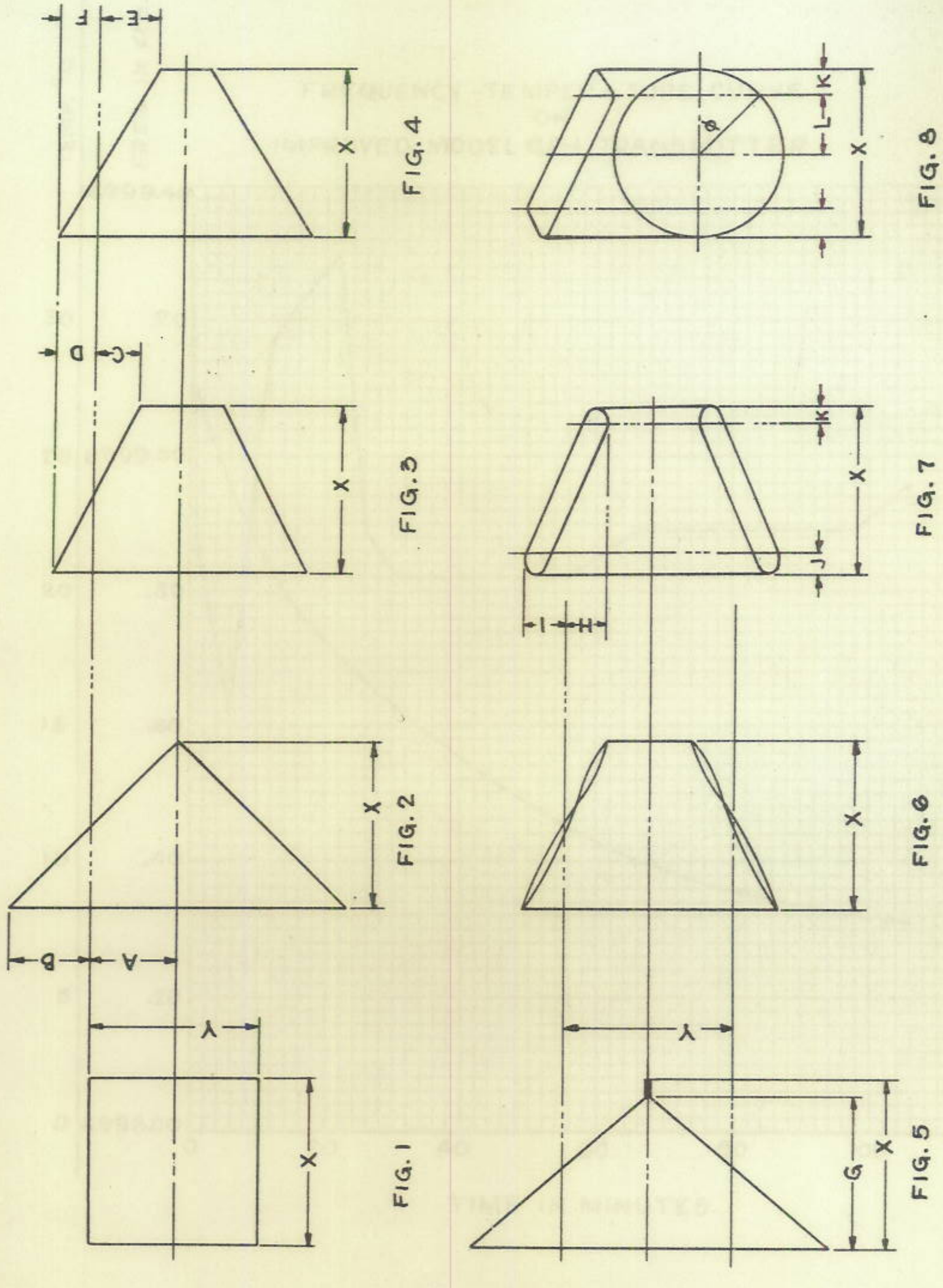
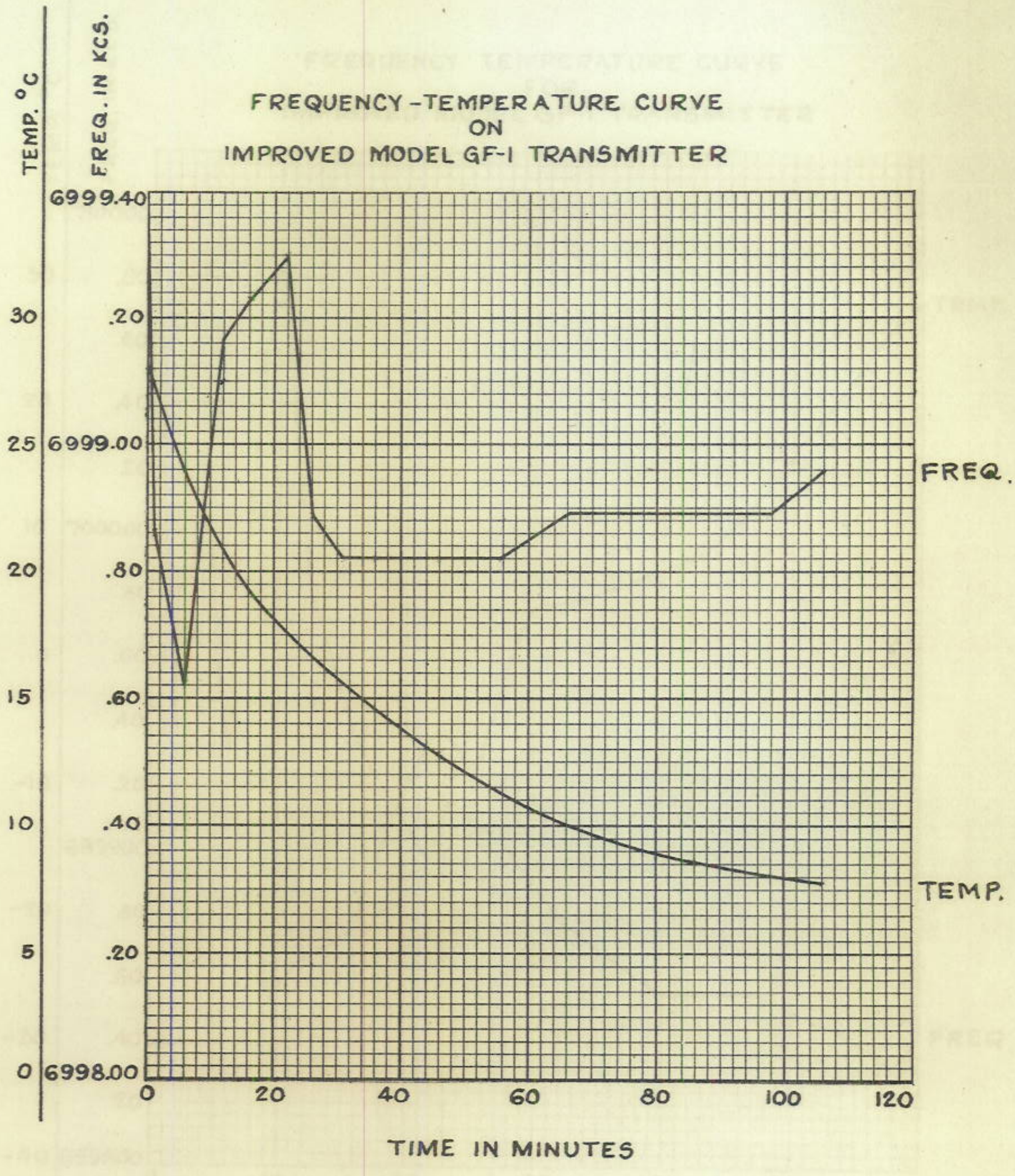


PLATE 4



FREQUENCY-TEMPERATURE CURVE
ON
IMPROVED MODEL GF-1 TRANSMITTER
TEMP. °C
FREQ. IN KCS.
6999.40
30
.20
25
6999.00
20
.80
15
.60
10
.40
5
.20
0
6998.00
0
20
40
60
80
100
120
TIME IN MINUTES
FREQ.
TEMP.

PLATE 5

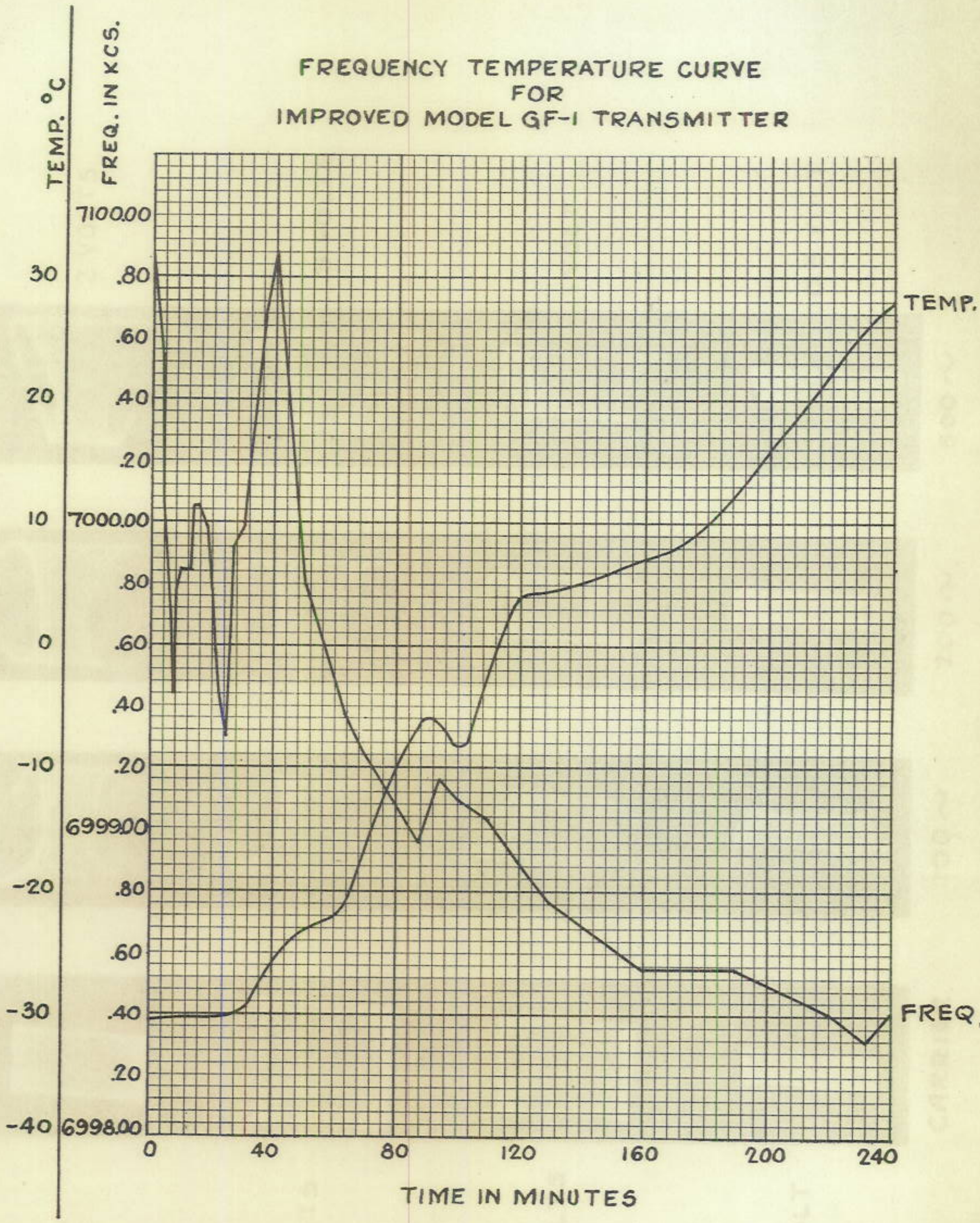
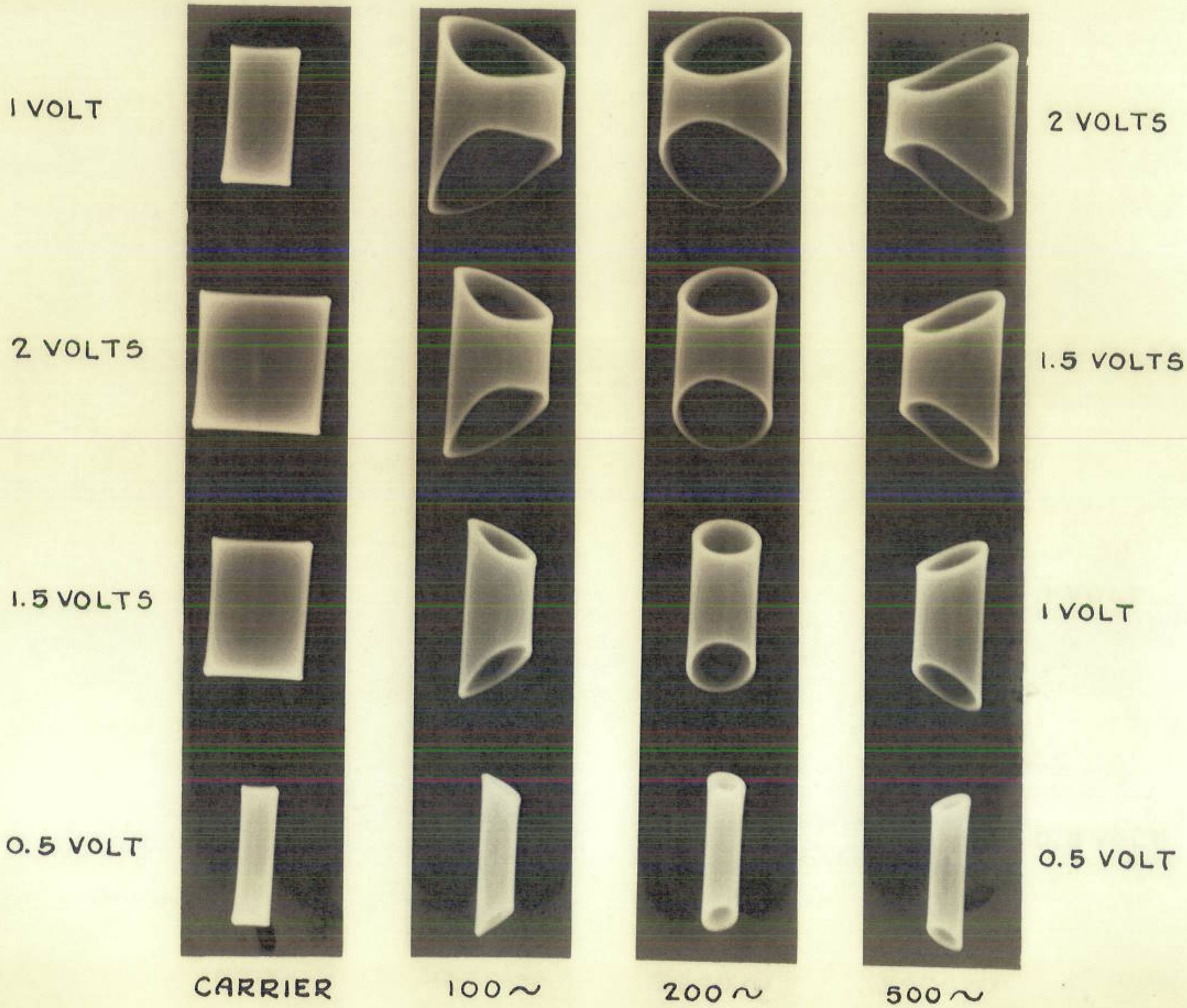

FREQUENCY TEMPERATURE CURVE
FOR
IMPROVED MODEL GF-1 TRANSMITTER
TEMP. °C
FREQ. IN KCS.
7100.00
30
.80
.60
20
.40
.20
10
7000.00
.80
0
.60
.40
-10
.20
6999.00
-20
.80
.60
-30
.40
.20
-40
6998.00
0
40
80
120
160
200
240
TIME IN MINUTES
TEMP.
FREQ.

PLATE 6



1 VOLT
2 VOLTS
1.5 VOLTS
0.5 VOLT
CARRIER
100 ~
200 ~
500 ~
2 VOLTS
1.5 VOLTS
1 VOLT
0.5 VOLT

PLATE 7

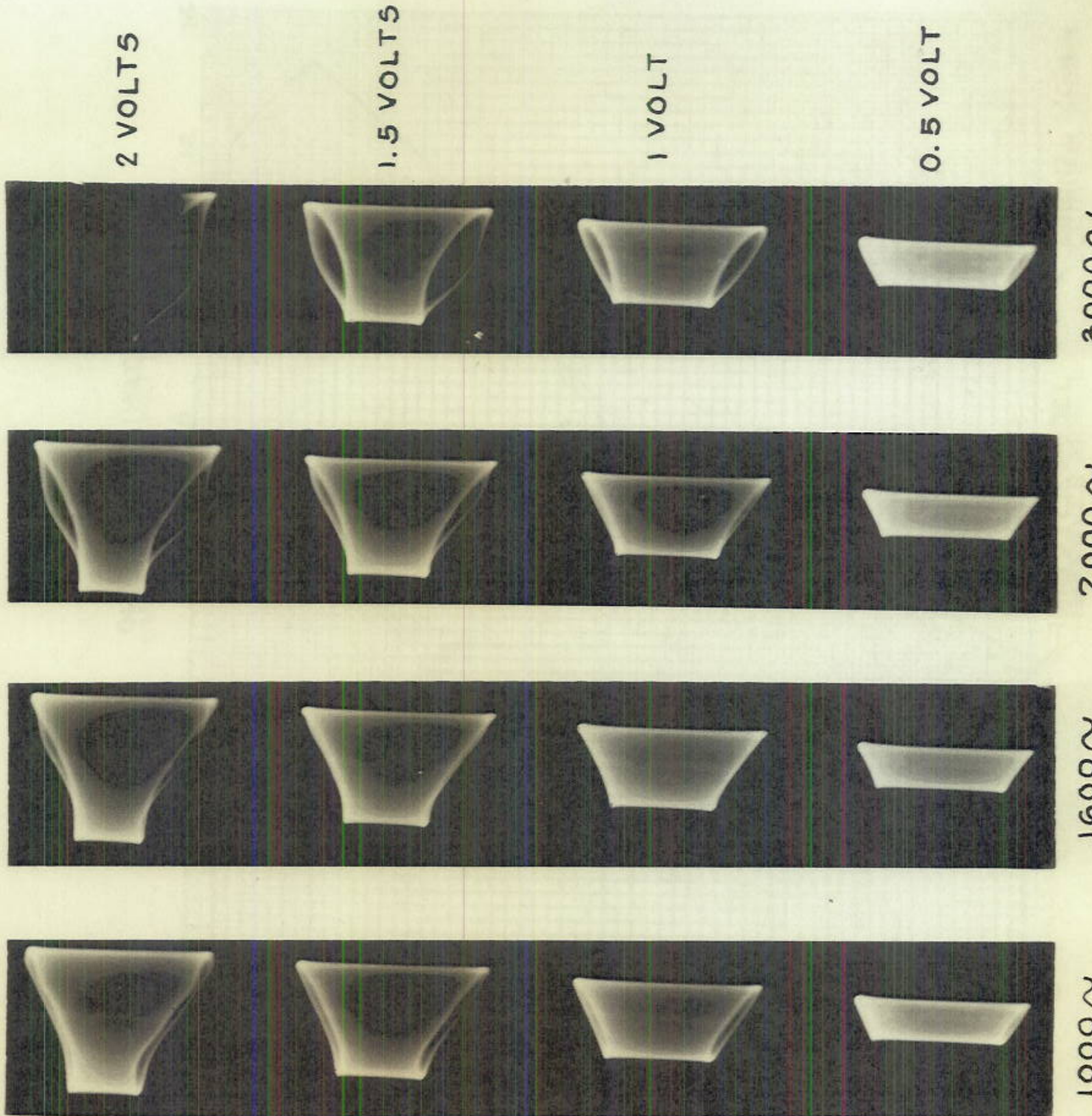


PLATE 8

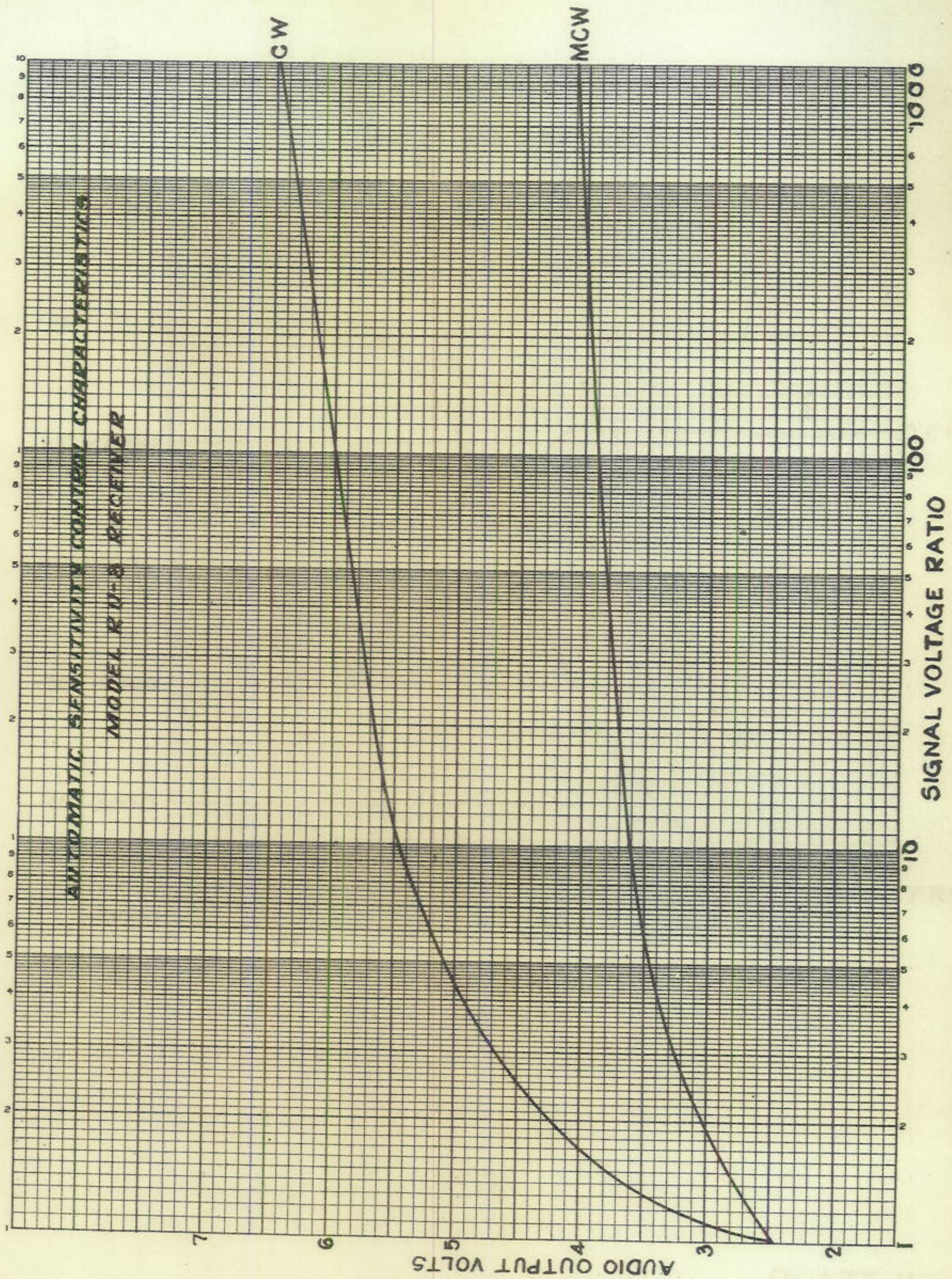

AUTOMATIC SENSITIVITY CONTROL CHARACTERISTICS
MODEL RU-8 RECEIVER
CW
MCW
SIGNAL VOLTAGE RATIO
1
10
100
1000
AUDIO OUTPUT VOLTS
2
3
4
5
6
7

PLATE 10

FREQUENCY-TEMPERATURE CHARACTERISTICS
OF
MODEL RU-3 RECEIVER
6202.5 KCS.

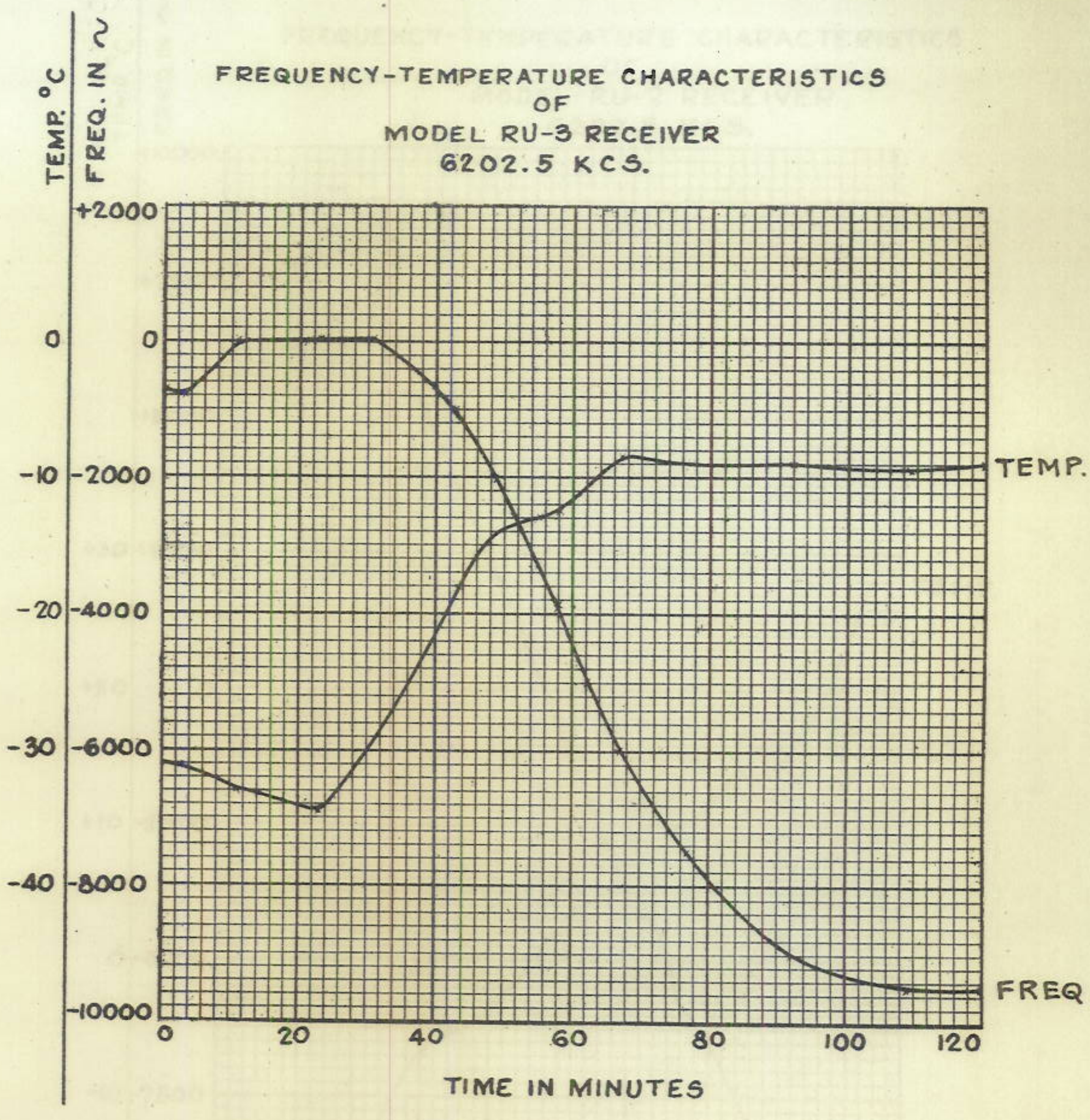


PLATE II

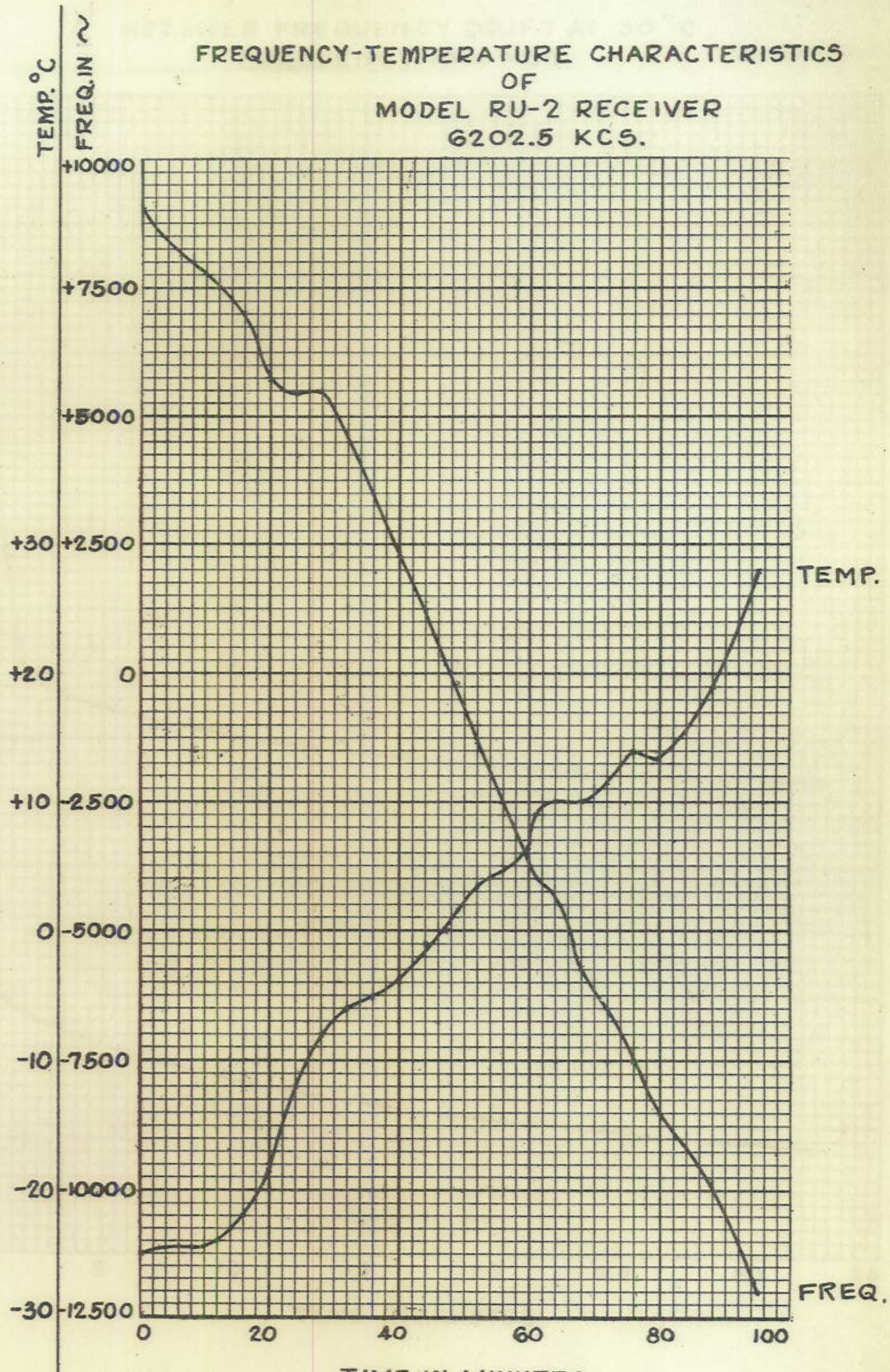

FREQUENCY-TEMPERATURE CHARACTERISTICS
OF
MODEL RU-2 RECEIVER
6202.5 KCS.
TEMP. °C
FREQ. IN ~
+10000
+7500
+5000
+30 +2500
+20 0
+10 -2500
0 -5000
-10 -7500
-20 -10000
-30 -12500
0
20
40
60
80
100
TIME IN MINUTES
TEMP.
FREQ.

PLATE 12

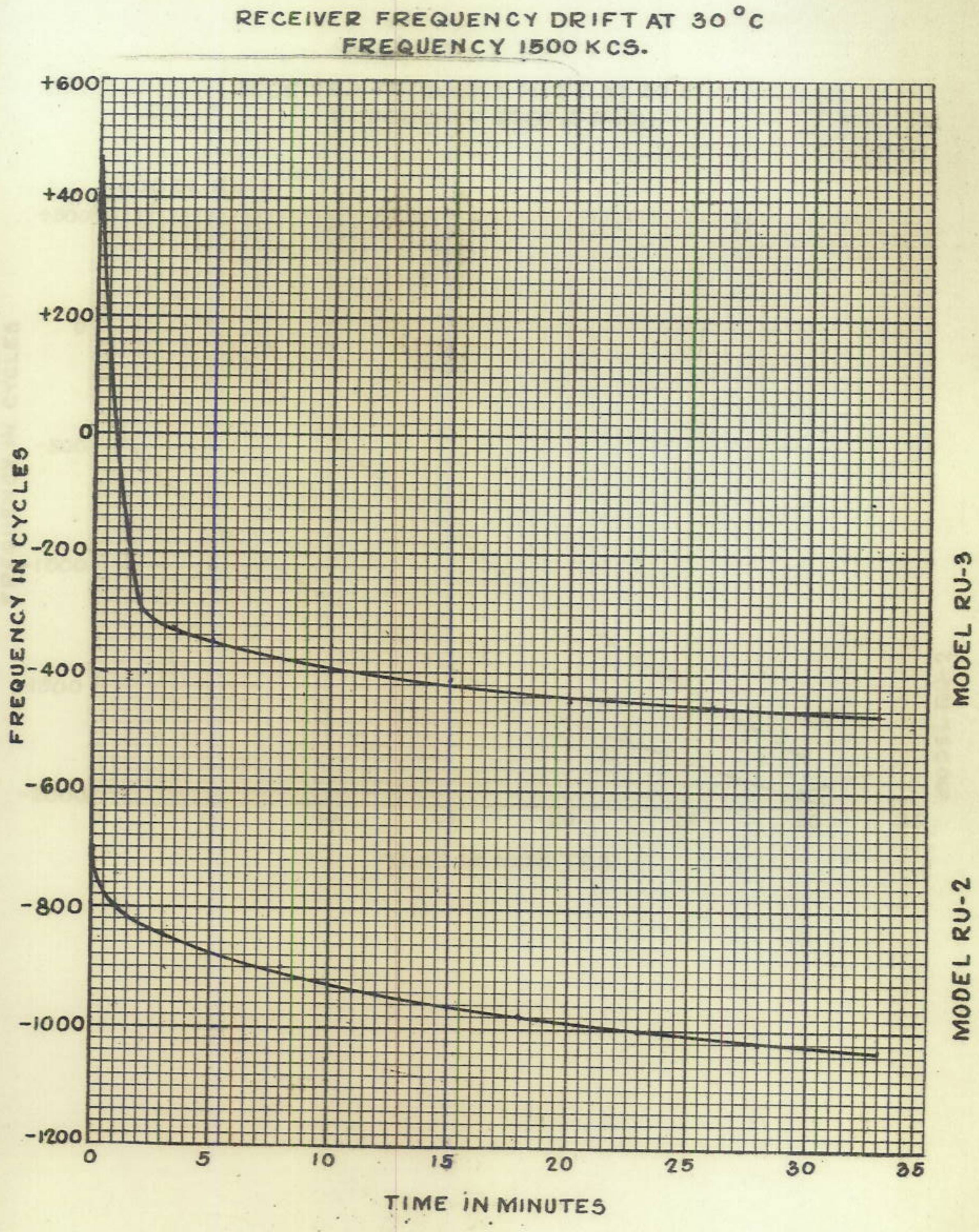

RECEIVER FREQUENCY DRIFT AT 30 °C
FREQUENCY 1500 KCS.
FREQUENCY IN CYCLES
+600
+400
+200
0
-200
-400
-600
-800
-1000
-1200
0
5
10
15
20
25
30
35
TIME IN MINUTES
MODEL RU-3
MODEL RU-2

PLATE 13

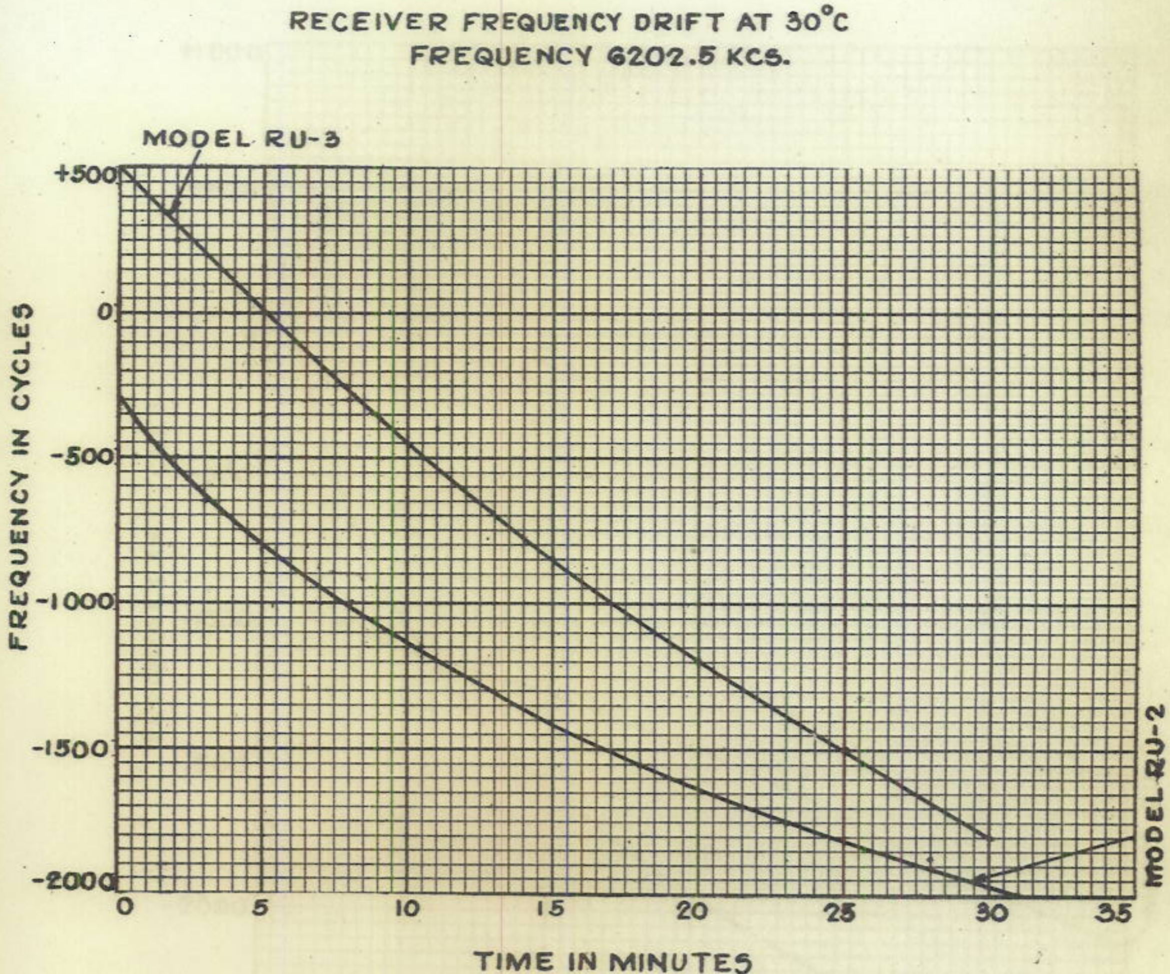

RECEIVER FREQUENCY DRIFT AT 30°C
FREQUENCY 6202.5 KCS.
MODEL RU-3
+500
0
-500
-1000
-1500
-2000
FREQUENCY IN CYCLES
0
5
10
15
20
25
30
35
TIME IN MINUTES
MODEL RU-2

PLATE 14

RECEIVER FREQUENCY DRIFT AT 30°C
FREQUENCY 8270 KCS.

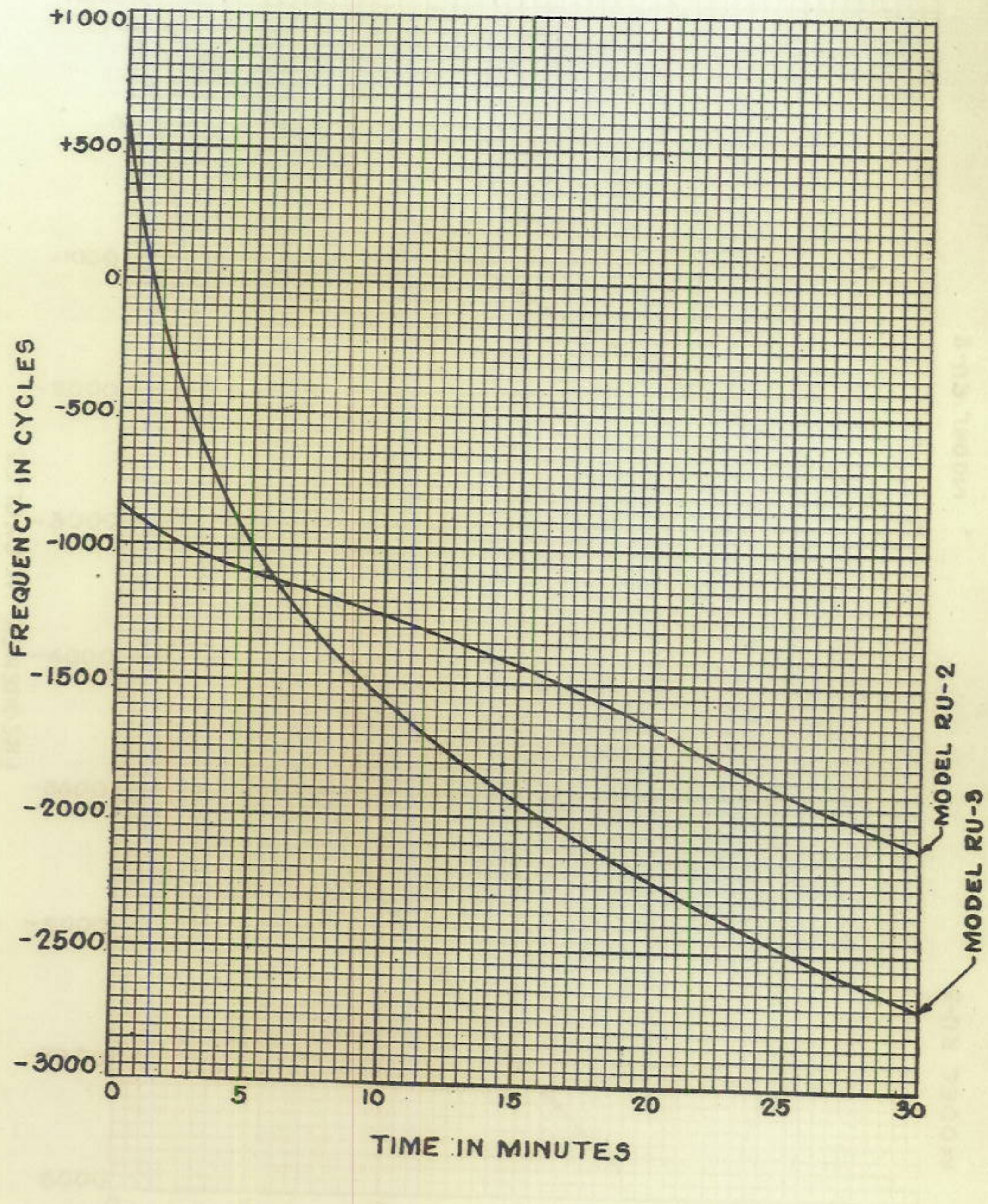


PLATE 15

RECEIVER FREQUENCY DRIFT AT 30°C
FREQUENCY 12405 KCS.

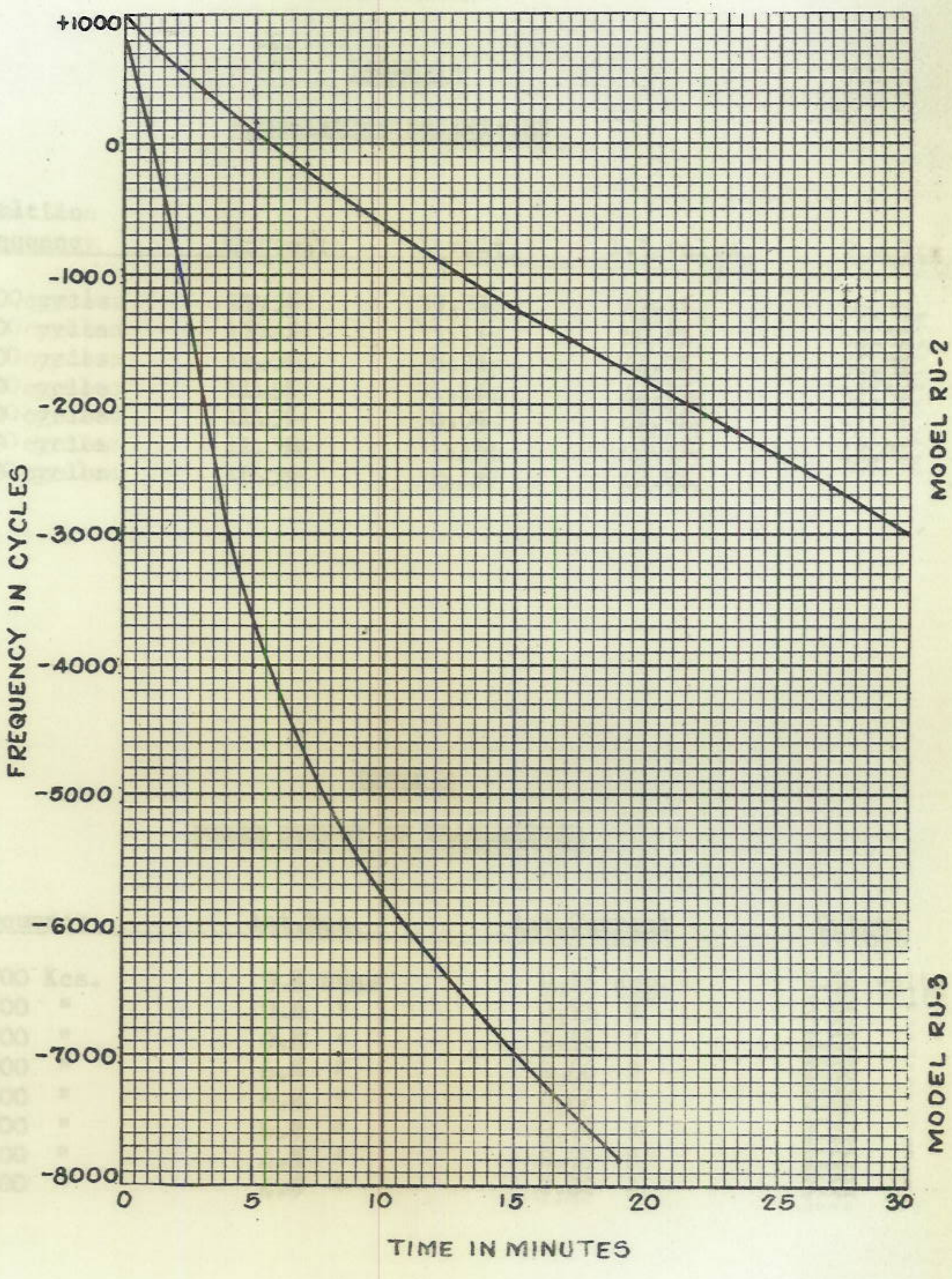


PLATE 16

TABLE 3

RECEIVER SENSITIVITY

Input in Microvolts

Freq. Kcs.	CW	MCW
231	1.46	5.5
288	1.73	6.0
352	1.64	5.5
364	1.40	4.7
450	1.55	5.0
547	1.51	4.7
557	0.85	3.3
690	1.07	3.8
838	0.84	2.7
865	1.80	4.6
1075	1.39	4.8
1310	1.07	4.3
1358	1.72	5.0
1690	1.38	4.9
2050	0.94	3.8
2075	1.70	4.4
2580	1.16	4.1
3060	0.92	3.3
2990	2.58	4.9
3700	2.00	4.4
4400	1.56	4.7
4020	3.46	7.7
4815	3.42	8.0
5840	4.00	8.2
5460	6.00	12.6
6680	4.00	11.0
7900	5.00	16.0
8400	48.0	80
9000	42.8	97
12150	47.0	52
9230	49.0	100
11300	42.0	91
13385	30.0	100

TABLE 3 (cont'd)

405	2.1	6.3	Dual coil		"Lo"
500	1.9	6.1	"	"	"
600	1.7	5.2	"	"	"
3200	2.8	8.2	"	"	"Hi"
3900	1.8	6.2	"	"	"
4525	1.6	5.0	"	"	"
405	1.2	4.5	"	"	"Lo"
500	1.4	5.0	"	"	"
600	1.4	4.8	"	"	"
5325	5.5	16.3	"	"	"Hi"
6440	7.8	18.7	"	"	"
7485	2.7	9.0	"	"	"

TABLE 4

RECEIVER SENSITIVITY ON LOOP INPUT

	Input in Microvolts	
Freq.Kcs.	CW	MCW
233	0.3	1.3
290	0.6	2.6
355	0.78	3.3
363	0.4	1.7
450	0.85	2.7
560	1.15	3.3
550	0.55	1.3
690	1.00	2.0
835	1.80	2.2
865	0.55	2.4
1070	0.90	4.2
1295	0.70	5.0
1350	1.43	6.0
1500	7.00	27.3
1680	37.00	156.0

TABLE 5

RECEIVER SELECTIVITY

Freq.Kcs.	Below Resonance 10%	5%	1%	Above Resonance 10%	5%	1%
225	4.27	5.24	8.78	3.29	4.27	7.93
290	4.75	6.01	10.55	4.64	5.91	10.76
360	6.22	7.75	13.66	5.71	7.55	11.74
560	7.37	11.05	18.43	7.37	9.38	16.75
700	7.54	9.74	18.54	9.42	12.25	20.72
840	8.85	12.20	21.95	11.30	14.64	25.00
1090	13.43	17.00	32.20	14.32	17.90	32.20
1675	13.12	17.50	33.30	17.50	22.75	38.50
2000	15.58	21.31	39.35	20.50	27.08	45.90
2580	16.02	22.25	40.05	18.70	25.80	43.60
3100	18.80	25.85	47.00	23.50	28.20	51.7
3800	18.80	25.85	51.70	25.85	35.25	58.8
4200	20.88	32.48	60.30	27.84	39.35	65.0
5100	28.85	37.75	68.8	31.10	42.20	73.2
6200	36.00	49.50	94.5	45.00	58.5	99.0
7600	46.20	66.0	118.8	52.8	72.6	125.4
9000	54.0	74.2	135.0	67.5	87.7	148.5
10600	66.0	85.8	165.00	85.8	105.6	184.8
12500	99.2	130.2	229.0	99.8	124.0	229.0
13575	94.4	129.8	230.1	106.3	135.7	248.0