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NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report on Tests
of
Model GP Telephone and Telegraph Transmitter
manufactured by R.C.A.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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TABLE OF CONTENTS.

<u>SUBJECT</u>	<u>PAGE</u>
1. Authorization	1
2. Object of Test	1
3. Abstract of Test	1
(a) Conclusions.	
(b) Recommendations.	
4. Description of Material Under Test	3
5. Method of Test	3
6. Data Recorded During Test	8
7. Discussion of Probable Errors	8
8. Results of Test	8
9. Summary of Results	24
10. Conclusions	28

APPENDICES

Frequency drift with Ambient Temperature Change -	
Original Model	Table (1A)
Resubmitted Model	Table (1B)
Original Model GP Power Output, A Box	Table 2(A Box)
Original Model GP Power Output, B Box	Table 2(B Box)
Original and Resubmitted Model GP Power Output D Boxes	Table 2(D Box)
Original and Resubmitted Model GP Power Output E Boxes	Table 2(E Box)
Original and Resubmitted Model GP Power Output F Boxes	Table 2(F Box)
Original Model frequency variation due to Reset, Backlash, 25% change in antenna and 10% voltage change.....	Table 3
Resubmitted Model frequency variation due to 30 minutes 25 WPM keying, 30 minutes 85 watts locked key phone position, 10% ($\pm 5\%$) supply voltage change, and 25% change of plate current due to change of antenna constants	Table 3a
Percentage of modulation, original model, with various microphone input volts at 800 Kc.....	Table 4
Percentage of modulation, original model, at constant microphone input voltage at various radio frequency carriers	Table 5
Audio frequency response of the modulator system.....	Table 6
Audio harmonic content in the modulated carrier.....	Table 6A
Power conversion factor.....	Table 7
Plate voltage regulator	Table 7A
Oscillograms of:	
Phone operation, grid and plate supply ripple.....	Plate 1
CW operation, grid and plate supply ripple	Plate 2
Keying action, 25 WPM at 800 kc. & 9000 Kc.....	Plate 3
Modulation patterns at 800 Kc., Box B1 and B2, 100 to 500 cycles	Plate 4
Modulation patterns at 800 Kc., Box B1, 1000 to 5000 cycles and 100 cycles wave form.....	Plate 5
Modulation pattern at 352 Kc., 800 Kc., 3475 Kc., 4550 Kc., and 9050 Kc., 100, 200, 300 and 500 cycles.....	Plate 6
Modulation pattern at 352 Kc., 800 Kc., 3475 Kc., 4550 Kc., and 9050 Kc., 1000, 2000, 3000 and 5000 cycles.....	Plate 7

APPENDICES (Continued)

Appendix I, NAS-A Report RT-5 of 13 August 1935.

Appendix II, NAS-A Report let. F42-1(9)/NA6 of 22 April 1936.

AUTHORIZATION.

1. This problem was authorized by the Bureau of Engineering letter, reference (a). Other additional references pertinent to this problem are listed as references (b) to (f).

- Reference:
- (a) BuEng. let. NOS-35625 (5-9-W8) of 20 June 1934.
 - (b) Specifications RE 13A 490B.
 - (c) BuEng. let. NOS-35625 (5-9-W8) of 21 Mar. 1935.
 - (d) NAS. Report No. NASA RT-4 of 13 Aug. 1935, Appendix I.
 - (e) NAS. Report Let. F42-1(9)/NA6 of 22 April 1936, Appendix II.
 - (f) BuEng. let. NOS-35625 (5-28-W8) of 6 June 1935.

OBJECT OF TEST.

2. These tests were conducted to determine the mechanical and electrical characteristics of the Model GP aircraft transmitter as called for by reference (a) in accordance with the governing specifications, reference (b).

ABSTRACT OF TESTS.

3. The Model GP equipment was tested in the Laboratory for compliance with the governing specifications, reference (b). These tests covered the following:

- (a) Mechanical, including
 - (1) Workmanship
 - (2) Size and weight
 - (3) Materials
 - (4) Shock mountings
 - (5) Controls
- (b) Frequency range
- (c) Power Output
- (d) Frequency stability under conditions of:
 - (1) 30 minutes keying at 25 w.p.m.
 - (2) Variation of ambient temperature
 - (3) 10% change of supply voltage
 - (4) Reset from calibration
 - (5) Variation of antenna constants
- (e) Tests of power supply including:
 - (1) Input
 - (2) Rectifier efficiency
 - (3) Percentage ripple
 - (4) Regulation
 - (5) Compensation
- (f) Modulation capabilities including:
 - (1) Phone power
 - (2) Modulation percentage
 - (3) Harmonic distortion
- (g) Observance of character of emission
- (h) Tests of keying action
- (i) General inspection of the equipment to determine suitability for Naval Service

4. The equipment was transferred to the Naval Air Station, Anacostia, D.C. for flight tests at the conclusion of the Laboratory tests.

CONCLUSIONS.

It is concluded that

- (a) The Model GP equipment as first submitted did not comply with the specifications, reference (b), and was considered unsatisfactory for Naval Service.
- (b) After modification the Model GP equipment conforms to the requirements of the specifications except in a few minor details and that with correction of these minor defects it will be suitable for the Naval Service.
- (c) The output of the modified model is adequate at all frequencies and into the specified types of antennae.
- (d) The frequency stability is very good except for initial warm up at the 4500 kc. end of "D" box in the modified model. "A" and "B" boxes should be improved.
- (e) The modulation capabilities and characteristics while not meeting the requirements of the specifications at 100 cycles are excellent. The specification requirements are met at all other audio frequencies.
- (f) Insufficient clearance has been provided at certain places for high altitude work.
- (g) The sequence of tuning does not follow the alphabetical designation of the controls. The locking devices require pins to prevent loss.
- (h) The tuning unit handles do not provide sufficient space for handling when wearing heavy gloves.
- (i) Mercury vapor rectifier tubes are not well suited for aircraft high voltage power supplies and the newer high vacuum types should be used.

RECOMMENDATIONS.

It is recommended that

- (a) The production models of this equipment be considered satisfactory for the Naval Service when the following recommendations are complied with in a manner satisfactory to the Bureau of Engineering and provided they conform to the resubmitted model in all other respects.
- (b) The frequency stability be made in accordance with reference (b) for all boxes.
- (c) The antenna coupling device be made flexible enough to adjust to any one of the specified antennas and give the required power output at all frequencies.
- (d) The power factor correcting device be marked in capacity and of such value that the filament voltage regulation will not exceed 5% under any condition when operating with the specified generator.
- (e) A red line be put on the voltmeter and plate milliammeter at the proper operating point.
- (f) The plate voltage be reduced to 1250 as a maximum under all operating conditions without reducing power output below the specified requirement.
- (g) All controls and locking devices be suitable for adjustment by one wearing gloves in accordance with specification 3-30.
- (h) All wiring at the bottom of the set to be protected from water. The bottom should be covered with a detachable pan in accordance with specification 2-5.
- (i) More attenuation be provided at the control boxes and the side tone coupled direct to the control box with no amplification. A potentiometer instead of the series resistor for volume control is suggested.
- (j) The instruction books contain adequate information for proper servicing.
- (k) The coil carrying cases be made as small as possible to accommodate the coil boxes. All latches function properly and that the retainer screws do not bind inside of the cases.
- (l) The second sentence of specification 5-1 be changed to read:

"This box shall house a volume control capable of regulating the intensity of the pilot's head phone signal throughout a range of from zero signal to the maximum supplied to the control box."

- (m) A high voltage warning sign and spare fuse clip be provided in the fuse compartment. An interlock switch on the fuse compartment door be required in future specifications. For closed door position the supply line fuses should be connected to the line. In the open door position the power should be disconnected and the fuse clips grounded. The power factor correcting condenser should be in the circuit between the generator and the interlock switch so that there is no chance of being shocked while changing fuses in accordance with specification 2-33.
- (n) The A and B boxes should be resubmitted with better frequency stability.
- (o) Several small mechanical defects as follows should be corrected in the production models. The bulkhead between the tube and coil boxes should be more rigid. The top should be hinged at the back with latches instead of screws in front. The coil box micalex terminal strips should be mounted solid with no possibility of strain or breakage. All knurled nuts should be non-detachable. The antenna loading coil should be marked "disconnect for frequencies above 540 Kc". The calibration chart should be properly protected from water. The ICS plug should be marked with red and the letters "ICS".
- (p) Spare parts be furnished with the test models so that repairs can be rapidly made when necessary.
- (q) The controls be marked in the normal operating sequence of adjustment, master oscillator switch "A" dial "B", power amplifier switch "C" dial "D" and antenna coupling "E" loading "F" tuning "G".
- (r) Specifications 3-21(2) be changed to give the individual frequency variation allowance for each specified cause in addition to the overall collective percent allowed and (2c) be changed to read "any variation in antenna constants that cause $\pm 25\%$ change in plate current".
- (s) The fourth sentence in specification 3-30 be eliminated and the following substituted, "The design and construction of the tuning controls shall be such that the combined torque and backlash shall not exceed 0.05 percent of any operating frequency in the range. The angular difference mechanically measured at any control shall not exceed 0.5% of one revolution".
- (t) Specification 5-1 be changed to require signal variation from 0 to the full output of the receiver and side tone and not as expressed "from 15 to 20 decibels".

DESCRIPTION OF MATERIAL UNDER TEST.

5. The Model GP aircraft transmitter was manufactured by the Radio Corporation of America. The frequency range covered is from 350 to 1500 Kc. and 3000 to 9050 Kc. The tuning range is accomplished by five plug-in coil boxes. The transmitter provides CW, MCW or voice modulation signals. One type 38111-A tube is used as a master oscillator, one type 38110 tube as speech amplifier, one type 38111-A tube as power amplifier, and two type 38145 tubes as modulators in class A prime. The filaments are lighted from the 800 cycle NEA-1 alternator through a proper transformer. The plate supply is furnished by rectifying the high voltage 800 cycle with a pair of type 38266 high vacuum rectifier tubes. The bias voltage is supplied by a special winding on the power transformer and rectified by a type 38180 tube. For frequencies below 544 Kc. an antenna loading coil is provided. A pilot's control box, operator's control box, with microphone and key for each position, is supplied. An antenna fairlead and reel is furnished.

METHOD OF TEST.

6. The frequency drift was tested by beating the Model GP equipment with the crystal harmonics of the Model LK frequency measuring equipment and visually observing the audio beat frequency difference at room temperature during 1/2 hour key locked, 1/2 hour 25-word per minute keying with an automatic keyer and continuous key locked signal at phone power (equipment installed in a special refrigerator) over a period of time long enough to change temperature slowly from -30° to $+50^{\circ}$ C. to record temperature and frequency change every five minutes. The greatest frequency change over any 10° C change was recorded and an average 10° change in frequency was determined by dividing the total frequency drift over a change of 80° by 8. Frequency drift due to 10% variation in supply voltage was also checked with the Model LK equipment. The method of taking frequency variations due to antenna characteristic changes as specified by paragraph 3-21(2c) has been altered for convenience of obtaining conditions more nearly accurate at all frequencies. 25% change in plate current due to variation of all antenna characteristics is used instead of 25% change of inductance, capacity, resistance and length of trailing wire.

7. The frequency shift due to poor switch and rotor contacts were checked by moving the switch arm or coupling coil slightly and noting the frequency change on the visual indicator. Reset frequency measurements were made with the Model LK frequency measuring equipment when the proper settings were reached by rotating the master oscillator dial in an increasing numerical direction after the original frequency measurement had been made by rotating the dial in a similar manner to determine the proper setting. Similar procedure for reset measurements during flight was used in setting all dials. The frequency measurements during flight tests were made with the Model LF heterodyne frequency measuring equipment because the Model LK equipment is not sensitive enough to operate on received signals.

8. The backlash was checked by rotating the Model GP master oscillator dial in a clockwise direction to a desired frequency as indicated by the Model LK frequency equipment, then detuning the master oscillator and resetting this dial to the same scale reading by approaching

in a counter-clockwise direction and noting the frequency difference. The difference in frequency between the first and second reading is calculated in percent of the operating frequency to determine the backlash. The backlash of all other dials is difficult to measure by noting changes in frequency because they are not part of the frequency determining circuit. It takes a great deal more movement of these dials to change frequency of the master oscillator than the slight movement caused by backlash. It is difficult to determine how much is backlash and how much is dial movement when noting frequency shifts caused by any control other than the master oscillator.

9. The antenna coupling was checked by adjusting the equipment to numerous frequencies into dummy antennae that resemble the fixed and trailing wires that will be used with this set in service operation. After the coupling was properly adjusted at each frequency the antenna and ground terminals were shorted to note any damage that might result.

10. Power output measurements were taken by two methods. In some cases a light, photo cell and microammeter, calibrated at 60 cycles, was operated as an RF output load. Other power measurements were made by using an RF ammeter with zircon rods or Ward Leonard plaques as a load and calculating the power output by formula ($W = I^2R$). Where W = Power output
 I = RF current
 R = Resistance

11. Power input measurements were made with a wattmeter, ammeter and voltmeter while power output measurements were being recorded.

12. The frequency changes due to 10% variation of the supply voltage were recorded by visually observing the Model LK frequency measuring equipment and at the same time observing the filament voltage. Three points were taken. The normal voltage being 10 volts, 9.5, 10 and 10.5 volts were used as reference points.

13. The mercury vapor and high vacuum rectifier tubes were checked by varying the temperature from -30°C to $+50^{\circ}\text{C}$ and noting them in operation.

14. The ripple in the plate and grid power supply after rectification and filtration was measured by an Gaisco 2 element string oscillograph, associated with the necessary high capacity blocking condenser and high ratio transformer. 60 cycle supply was used as a timing wave. The elements were calibrated for sensitivity at the desired frequencies with an audio oscillator and voltmeter.

15. The wave form of the audio system from microphone input to modulator output under condition of resistance load was observed on the cathode ray oscillograph. An audio beat frequency oscillator was coupled to the input of a special laboratory audio amplifier and its output coupled to the microphone input terminals through a mixing panel. The cathode ray terminals on the mixing panel were connected to the control terminals on the cathode ray to hold the image in place.

16. The audio power output called for by specification par. 4-3 was calculated, by the following formulas (1) and (2) after measuring the audio voltage across the modulator plate load resistor which was substituted for the Radio Frequency power amplifier load. The voltage was

measured across a portion of this plate load resistor with a rectifier type of AC voltmeter and the cathode ray oscillograph was used to check the voltmeter at all frequencies.

$$(1) \quad E_2 = E_1 \times \frac{R_2}{R_1}$$

$$(2) \quad W = \frac{(E_2)^2}{R_2}$$

where R_1 = A portion of the modulator plate load resistor

R_2 = Modulator plate load resistor

E_1 = Voltage across a portion of the plate load resistor

E_2 = Calculated voltage across the plate load resistor

W = Calculated modulator power output

The calculated power output is converted from watts to decibels by using 6 milliwatts as zero level.

17. The percentage of modulation was measured by connecting one pair of the cathode ray plates to a portion of the dummy antenna system and the other plates to the cathode ray terminals on the mixing panel. The voltage to these terminals is controlled by a volume control on the panel. The microphone input voltage is controlled by another volume control and the D.C. microphone current by another control. The audio sweep length is adjusted to the same length as the RF sweep voltage with no modulation. The two combined form a square. With 100% modulation and no phase shift in the audio amplifier system a perfect triangle is formed provided no overloads or distortion occur throughout the system. Where phase shifts occur in the audio amplifier system and modulator the pattern on the screen appears as a cylinder with a short wall on one side and a long wall on the other. The percentage of modulation can be determined by the formula -

Maximum length minus minimum length, divided by maximum length plus minimum length times one hundred.

$$\left(\frac{E_{\max} - E_{\min}}{E_{\max} + E_{\min}} \times 100 = \% \right)$$

18. The percentage of audio frequency harmonic content in the modulated RF carrier was measured by rectifying a portion of the voltage expressed across the dummy antenna and measuring the percentage directly with a General Radio wave analyzer.

19. The plate voltage was measured with a Weston D.C. voltmeter, Model #45, Serial #40640, at the filter output of the rectifier system

after the filament voltage was adjusted to 10 volts A.C. as determined by the voltmeter on the front panel of the transmitter, by regulating the transmitter AC input to 119.5 volts as determined by Weston AC voltmeter, Model #341, Serial #5423. The percentage of plate and filament voltage regulation was determined by the following formula:

$$\frac{E_1 - E_2}{E_1} = \% \text{ regulation}$$

Where E_1 = voltage key up

E_2 = voltage key down

E_2 may be greater than E_1 , in some cases, with over compensation. In such cases the regulation percentage is said to be negative. E_1 is expressed as the key up voltage, in accordance with paragraphs 3-35 and 3-39 of the specifications.

20. The rectifier power conversion factor is computed in the following manner using a pure resistance load.

$$\frac{(W + W_1) - W_2}{(W_3 - W_4) + W_f} =$$

When:

W = Key down, D.C. watts, consumed by resistance load.

W_1 = Key down, D.C. watts, consumed by voltmeter and bleeder resistance.

W_2 = Key up, D.C. watts, consumed by voltmeter and bleeder resistance.

W_3 = Key down, A.C. watts, consumed by transmitter input.

W_4 = Key up, A.C. watts, consumed by transmitter input.

W_f = Key up or down, A.C. watts, consumed by rectifier filaments.

The above described method is necessary due to the fact that the filament and rectifier voltages are all supplied by one transformer. It is impossible to eliminate the filament load and keep the rectifier input voltage and regulation the same as it is under normal operating conditions. The A.C. input voltage was held constant at 119.5 for key up and key down, as measured at the transformer side of the power factor condenser, during this test.

21. The operation of dials, controls and switches was checked by manipulation at -30°C and $+50^{\circ}\text{C}$. All structural mechanical details were checked by careful observation.

22. The operator's and pilot's volume control were checked by supplying the side tone signal to these boxes and checking the signal.

output control with a power output meter.

23. The following instruments were used:

- (a) Radio Research frequency measuring equipment, Model LK, Serial #1.
- (b) N.R.L. heterodyne frequency measuring equipment, Model LF, Serial #1.
- (c) N.R.L. RF wattmeter, consisting of a 115 volt, 150 watt lamp and a Weston photo cell Model 594, set in position #3, and calibrated on 60 cycles, 110 volts, with Weston wattmeter Model 310, Serial #3958, was used for all power output measurements when possible.
- (d) Some RF power measurements were made by the (I^2R) method. Ward Leonard plaques and Zircon rods measured by a type S Leeds and Northrup Wheatstone Bridge in combination with one of the following three Weston RF ammeters Model 425, 2 amps. Serial #2480, 5 amps. Serial No. 22205 and 5 amps. Serial 74922, calibrated on 60 cycles a.c. against Weston Model 370, Serial 2791.
- (e) Weston AC wattmeter, Model 310, Serial 3958.
- (f) Weston AC voltmeter, Model 341, Serial 5423.
- (g) Weston AC ammeter, Model 370, Serial 2123.
- (h) Weston DC voltmeter, Model 45, Serial 40640, with multiplier Model 24, Serial 40640, 0-2500-500 volts.
- (i) Weston DC ammeter, Model 45, Serial 19967.
- (j) General Radio Cathode Ray Oscillograph, Type 687-4, Serial #132.
- (k) General Radio beat frequency oscillator, Type 513-B, Serial #80.
- (l) N.R.L. Bridge type audio amplifier, Serial #1.
- (m) General Radio audio power output meter, Type 583-A, Serial #63.
- (n) Westinghouse Osiso string type oscillator, style 509823, Serial #913659.
- (o) General Radio wave analyzer, Type 636-A, Serial #102.
- (p) Leeds and Northrup Wheatstone Bridge, Type S, Serial #220303.
- (q) Creed and Company standard automatic keyer.
- (r) Special N.R.L. refrigerator.

DATA RECORDED DURING TEST.

24. The data recorded during these tests is shown in the plates and tables of the appendix and includes the following:

- (a) Frequency drift at three different frequencies of coil boxes A, B, D and F and two frequencies of coil box E.
- (b) Temperature frequency drift at one frequency of each coil box.
- (c) Frequency reset on the bench and during flight.
- (d) Frequency difference due to backlash in m.o. dial.
- (e) Radio Frequency power output measurements with plate power input recorded at the same time.
- (f) Frequency variations due to $\pm 5\%$ variation in supply voltages.
- (g) Audio frequency response of the modulator system taken from microphone transformer input to audio output.
- (h) Oscillograms showing the percentage of modulation.
- (i) Oscillograms showing the percentage of ripple in the power supply.
- (j) Oscillograms showing the keying action at 25 words per minute.
- (k) Audio frequency harmonic content in the modulated carrier.
- (l) Rectifier power conversion and voltage regulation.

DISCUSSION OF PROBABLE ERRORS.

25. The probable errors are as follows:

Frequency measurements $\pm 0.001\%$
Frequency drift measurements ± 20 cycles
Power Output $\pm 10\%$
Power Input $\pm 0.5\%$
Modulation percentage $\pm 2\%$
Audio frequency power or voltage $\pm 5\%$
Audio harmonic percentage $\pm 1\%$

RESULTS OF TESTS.

26. No comment will be made on paragraphs that are of a general nature unless serious defects are only covered by such paragraphs. All paragraphs that are successfully complied with will be omitted.

- 1-1. The equipment as originally submitted and resubmitted is intended for use in the Naval aircraft service and it will be suitable when the defects herein discussed are properly corrected in the production models.

- 1-3. Coil box "C", covering 1500 to 3000 Kc., has been eliminated and the modulator unit has been combined with the transmitter unit.

To avoid delays in testing equipment it is suggested that spare parts be furnished with the models sent to the Laboratory for test.

- 1-5. The equipment is not designed for maximum convenience of installation and operation in Naval aircraft. The power plugs are difficult to install and remove.

II.

GENERAL

- 2-2. (a) All electrical indicating instruments are satisfactory except for red line marker on the voltmeter and milliammeter.
- (b) Fixed capacitor #34 should stand the highest voltages supplied to the plate circuit to prevent breakdown.
- (d) The antenna isolantite insulator was cracked in set #1.
- (e) Vacuum tubes used are in accordance with Navy specifications except the 38180 which is for replacement only unless specifically approved by the Department.
- (f) The audio transformers were not disassembled for inspection.
- (g) The name plates are in accordance with the latest revised edition of Navy Department Specifications.
- 2-3. The antenna series vacuum condensers and mountings in the original model were too fragile. They should have been better protected mechanically and electrically connected properly to prevent breakdown. This has been corrected in the resubmitted model. Break-in operation is not satisfactory due to mechanical and electrical faults in the keying relay and receiver blocking. This has been improved in the resubmitted model.
- 2-5. This equipment is not spray-proof due to the open bottom and ventilating holes. Due to the high power and small size of this equipment the ventilating holes are essential.
- 2-6. Stainless steel is used for the case. At points where drilling, tapping, shearing and bending has been done slight magnetic properties are shown by suspending a magnetized needle on a string and holding it close to these points.
- 2-7. This equipment, as originally submitted, gave unsatisfactory operation as follows. The mercury vapor rectifier tubes would not ionize at ambient temperatures below minus 25°C and at plus 49°C and higher arc back or flashovers occur. The toggle switches used for standby and power "on-off" are

unreliable at temperatures below minus 25°C. The frequency variation with ambient temperature changes was excessive for all frequency bands tested. See Table 1A.

The resubmitted model employs high vacuum low internal drop tubes. These tubes are not seriously affected by temperature changes. The frequency stability of the resubmitted "D", "E" and "F" boxes, passes the specified requirements except for the short period just after applying plate power at the start of "D" box run. See Table 1B.

- 2-8. The RF ammeter in the original model would not carry the current when the antenna was short-circuited or grounded. In the resubmitted model, this meter was changed from 5 to 9 amps. and the possibility of a burn out minimized.

This equipment was not subjected to a test where its antenna was within 50 feet of an antenna emitting 2 Kw pure CW.

- 2-9. The ventilation and cooling of tubes and resistors is adequate. The loading coil becomes very hot but it would be difficult to correct this condition.
- 2-11. No orientation platform or accelerating equipment is available in the Laboratory. These tests were determined by actual flight tests as reported by the Naval Air Station in Appendix I and II.
- 2-13. Spare parts are not furnished with the test models and it is difficult to make quick repairs in case of failure during the bench and flight tests.
- 2-14. An appropriate name plate is not provided for the antenna loading coil marked "Disconnect for frequencies above 540 Kc."
- 2-15. The equipment will not operate, without injury, in all degrees of temperature and humidity encountered in aircraft service in any part of the world. This equipment was cooled to -20°C and allowed to warm up slowly over a period of 16 hours until a temperature of +4°C existed and a condition of 100% humidity or the dew point was reached. With the set thoroughly saturated it failed to operate. The coil box was removed and the interlock switch held closed. With the power turned on in this manner of test brushing was observed at numerous points associated with the high voltage circuit. The power amplifier plate choke flashed over to ground and burned the lead off. This was repaired and the set functioned properly.
- 2-16. Damage and faulty operation resulting from shock and vibration encountered during flight tests is reported by the test flight section of the Naval Air Station, Anacostia, in Appendix I and II of this report.
- 2-17. Satisfactory provision or warning has not been made to prevent personnel from accidentally coming in contact with voltage in excess of 25 volts when changing fuses even if the power is

shut off of the equipment. This shock hazard is due to voltage stored up in the power factor correcting capacity.

- 2-18. No cracking or flowing of capacitor compound was noted throughout the temperature runs from -30°C to $+50^{\circ}\text{C}$.
- 2-19. Suitable shock proof mountings are used to secure the equipment to the plane structure but the locking device is so constructed that the set can be inserted too far into the channels and the locking keys are easily lost or misplaced.
- 2-20. The wire associated with the master oscillator inductance is not supported sufficiently to eliminate frequency changes and frequency modulation in boxes "D", "E" and "F" of the original submitted model. Flexible stranded leads, variable resistance in the rotor shaft and switch contacts contribute to these frequency variations. In the resubmitted model these faults have been corrected.
- 2-22. All vacuum tubes are rigidly mounted to the chassis to prevent frequency variations due to movement. The only shock proofing is accomplished by mounting the set as referred to in specification 2-19.

The vacuum series antenna condensers were poorly mounted in the original model and satisfactorily mounted in the resubmitted model.
- 2-23. All vacuum tube sockets are of the single unit type.
- 2-24. The design and control of the circuits of this equipment are the simplest possible within the requirements of these specifications. The controls are not marked in the normal sequence of adjustment starting with the master oscillator and stopping with the antenna tuning.
- 2-25. The filament voltmeter and plate milliammeter are not marked with red lines to indicate normal operating filament voltage and plate current.
- 2-26. All electrical indicating instruments included in this equipment are of the 2.5 inch size.
- 2-27. All controls used for making adjustments are designed so that the values of settings increase numerically with increase of frequency clockwise rotation of the control knobs increases frequency. The indicator used to count the revolutions of the control dial moves in a counter-clockwise direction.
- 2-28. The attachment plugs (or blocks) are designed so that they fit only in the correct position and that shorts or shocks can not occur when the plug comes in contact with flat metal surfaces. The cables are covered with a tough rubber cover. To prevent receiver interference the attachment plugs have metal covers and the cables are of the metallically shielded type. Shielded cables covered with rubber are not easy to bond as required by this

specification. This type of shielded cable, however, has the advantage of preventing noise in the receiver when the cables shift or touch each other and is considered satisfactory.

- 2-29. (1) The equipment has been subjected to several heating cycles from -30°C to $+50^{\circ}\text{C}$ without damage to any parts except two mercury vapor rectifier tubes at $+49^{\circ}\text{C}$. Undesirable operation due to high humidity is reported in paragraph 2-15. High vacuum tubes are used in the resubmitted model which eliminated the difficulty due to temperature change.
- (2) The component parts of this equipment were not subjected to a salt atmosphere of 90% relative humidity at a temperature of $+50^{\circ}\text{C}$. This test would necessitate removal of parts and no spares were furnished to replace parts damaged by such a test. The equipment will be subjected to these conditions at times in the tropics and subject to correction by the manufacturer under the service guarantee, par. 1-6.
- 2-31. The equipment does not insure exactly the same modulator power output when using 845 modulator tubes whose characteristics vary within the limits set by Navy standard specifications. No constant plate current value is required for these tubes when biased for class A' or B modulation. Of the three pairs of modulator tubes available no two showed the same characteristics when biased for class A' modulation. One pair drew 50 mills unmodulated, another pair 42 mills and the third pair 5 mills, all drew 110 mills modulated 100%.
- 2-33. The operation of replacing fuses is not safe. The thirteen microfarad condenser used for power factor correction discharges through the fingers when making fuse replacements. This can be avoided if a piece of metal or wire is connected to the ground and touched to the set side of the fuse clip. It is suggested that the specifications for future equipment require an interlock switch on the fuse compartment door to disconnect the line and short circuit the power factor correcting device to avoid any possibility of shock at the time of replacing fuses.
- 2-36. The total weight of the original model with the heaviest coil box and all cables is 89 lb. 10 oz. This is 1 lb. and 10 oz. over the maximum allowed weight of 88 lbs.
- 2-37. It is possible to pass this equipment through a hatch 18 inches by 18 inches when it is uncrated.
- 2-38. Oscillographic pictures of the keying speed show that it is possible to accomplish good keying at 25 W.P.M. See Plate #3. For phone modulation see Plates 4, 5, 6 and 7. At high altitudes corona brushing causes frequency shifts, flash over and poor keying at any speed. See flight test report Appendix II.
- 2-40. The antenna reel is subjected to frequencies above 4000 Kc. In this case phenolic insulating material should be allowed as no other satisfactory substitute is available.

- 2-41. The power supply plugs are difficult to detach and practically impossible to remove when wearing heavy gloves.
- 2-42. Each side of the AC supply line was alternately grounded to check the operation of this equipment in accordance with this specification and no difficulty was encountered.

III.

- 3-1. The equipment is capable of taking the specified electrical energy, converting it to supply CW, MCW and voice modulated radio frequency energy to any of the specified antenna systems at output frequencies from 350 to 1500 Kc. and 3000 to 9050 Kc. The frequency stability and power output is not in strict accordance with these specifications as shown by the test data. See tables #1, 2A, 2B, 2D, 2E and 2F.

(2) The transmitter rectifier is a single unit. The power input connections and control box cable connections are on the right side of the transmitter rectifier case near the top and front. The antenna terminal insulators are on the left side of the transmitter case near the top and front when the observer is facing the front panel. The overall dimensions and weight of this unit complete with all mountings exceed the specified limits as noted in par. 2-36. The excess dimensions will not permit this equipment to be installed in the tray provided in scouting planes which is shown on the drawing attached to the specifications.

The modulator is not a separate unit as specified but a part of the transmitter rectifier unit.

(4) Individual tuning units are provided covering all specified frequency bands except (c) 1500 to 3000 Kcs. This coil box was not furnished under the contract reference.

(5) The transmitter will deliver minimum specified radio frequency power output exclusive of load losses. Some of the measurements at low frequency fall a few watts shy of meeting this specification but they are considered within the probable error of measurement. It is also noted that voltage in excess of 1250 is required to obtain this output and if kept within the tube specification limits the circuit losses must be reduced to produce the required output. See Tables No. 2A, B, D, E and F.

Complete modulation of the carrier is possible.

The tests conducted in the Laboratory, with dummy antenna of similar characteristics to the required fixed antenna, show that 50 watts, CW, MCW, and voice modulated, could not be obtained at all radio frequencies required. It was difficult to couple at 6200 and 9000 kc. The equipment as originally submitted would not operate satisfactorily on full power CW, MCW and voice at altitudes of 17500 feet above sea level. Details of flight operation are contained in Appendix I and II.

The keying relay and tube socket clearance are unsatisfactory for altitude of 5000 feet and higher. In the resubmitted model the keying relay has been redesigned and the socket clearances are better but corona discharge causes poor operation above 10,000 feet.

- 3-2. The transmitter-rectifier unit complete with shock-proof mountings will not mount in the box provided in the model O-3-U planes, as shown on drawing (sheet 41-A.) in the specifications, due to the power cable projections and antenna lead in insulators.
- 3-4. The terminal strip, supporting the electrical connection plugs that fit into the coil boxes in the original model, was too fragile. This was corrected in the resubmitted model by using more rigid support and thicker micalex.
- 3-5. In the original and resubmitted models suitable access to the bottom of the equipment and coil boxes is not provided. The tubes are difficult to remove when cold and practically impossible when hot. There is not enough clearance for one wearing heavy gloves to remove the tubes through the coil box compartment. The removable top section could be more readily opened by proper hinge and latches instead of numerous screws.
- 3-6. The dial locking devices are not pinned to the operating knobs and they are too close to the base of the set for proper operation when wearing heavy gloves.

The back lash and torque does not exceed the specified allowance as checked at several frequencies. See Table 3.

- 3-8. To permit convenient transfer to either trailing wire or fixed antenna a change over switch would be necessary. This equipment is provided with an antenna post and it is necessary to shift the trailing wire and fixed antenna leads which is considered suitable.
- 3-9. Contacts are provided on the keying relay to alternately connect and disconnect the receiver from the transmitting antenna at keying speed and ground the receivers in the transmit position. These contacts operate in such a manner that the receiver, when connected, is directly coupled to the antenna and not through any loading inductor or capacitors except when using the external loading coil as called for by this paragraph.

For keying speed of receiver connection as observed during flight tests, see Appendix II.

- 3-10. In the original model submitted the 800 cycle, 10 to 15 volt side tone was fed through the receiver audio system causing saturation of the audio tube with resultant sharp clicks. During the period of flight tests this system was changed and the side tone connected direct to the output jack for use with 600 ohm phones. The 20,000 ohm phone requirement can be eliminated or a potentiometer type of volume control can be used.
- 3-13. The system of adjusting the antenna coupling to regulate power output in the model GP equipment is very satisfactory. It gives

smooth and uniform power variation and is much more desirable than the step by step method.

- 3-14. In the original model the power factor correcting device was inadequate. This was corrected in the resubmitted model, by adding 2 mfd. to that supplied in the original model.
- 3-15. When listening on the same frequency that the transmitter is tuned to it is difficult to operate and hear a "break" due to receiver blocking and slow recovery as reported in the flight test data. See Appendix I and II.

In the key up position of the original model, the mercury vapor rectifier tubes caused an untunable noise level in the receiver limiting its range. This has been corrected by using high vacuum low internal resistance tubes in the resubmitted model.

- 3-16. For keying characteristics at 25 words per minute see Plate #3 and paragraph 5 of reference (e).
- 3-18. When shifting from CW to MCW or voice transmission or vice versa it is not necessary to readjust the filament, plate or bias voltage but the power factor correcting device should be changed to give the best voltage regulation for each operating condition. This is a direct means for correcting the filament, plate and bias voltages for proper operation and not in strict accordance with this specification.
- 3-20. Provision has been made for mounting a calibration card on the front panel of the transmitter under a transparent non-breakable shield with spaces for recording the proper settings of the various controls except the antenna tuning controls, for output frequencies over the frequency range of the transmitter. This chart is not properly protected with a waterproof shield. A rubber gasket is used for this purpose and it does not fit tight at all points and it binds at the screws making it difficult to mount or remove. Each control dial is identified by engraving on the panel near the dial indicating the function and a designating letter. These controls are not lettered consecutively in order of adjustment "C should be A", "A should be B", "D should be C", and "B should be D", while "E", "F" and "G" are satisfactory. If the controls were marked in this order the adjustments would progress in the proper manner.
- 3-21. The question of adjusting the Model GP transmitter to any desired frequency by means of a frequency meter in one man minute depends on the man, the position of the dials and the antenna reel with respect to the desired frequency. It can be stated that positive indication of the position of each control can be determined rapidly and efficiently at all frequencies.

(1) The transmitter when adjusted for operation at any frequency within its range except those frequencies where the normal drift exceeds the specified allowance, can be reset to within an accuracy of .03% in one man minute. See Table #3 for accuracy of reset.

(2) The original model when adjusted to any frequency within its range and without further adjustment does not maintain a frequency accuracy of .05% under the specified conditions except a portion of "A" and "B" boxes as shown in Table #3. The "D", "E" and "F" boxes have been worked over and resubmitted and except for the initial start of the 4500 Kc. "D" box run the frequency stability is in accordance with this specification. See Table 3A.

The drift of the "B" box is excessive and should be corrected in the production models.

(2a) Telegraphic and voice carrier outputs are satisfactory except as stated above. For keying action see Plate 3 and paragraph 5 of reference (e).

(2b) Satisfactory for an average 10° change in temperature except "B" box. For any 10° change in temperature all boxes except "E" and "F" exceed this specification during the first 10° C change in each run.

(2c) The method of making this test did not strictly comply with this specification. For convenience of repeating conditions at all frequencies $\pm 25\%$ change in plate current due to variation of the antenna constants, instead of 25% inductance, capacity and resistance change was used and at some frequencies the variation was excessive. See Tables 1 and 3A.

(2b) The maximum frequency shift due to 10% change in voltage does not exceed the specified allowance. See Tables 3 and 3A.

(2c) No frequency shift was noted due to other transient causes except backlash. See Table 3.

(2f) All filaments were operating five minutes just prior to these tests as specified.

The specified .05% allowance covers all collective causes for frequency shift and not the allowance for just one cause. It is suggested that the specifications be changed to give the individual percent allowance for frequency shift due to each outlined cause as well as the collective specified percentage.

3-22. In the original model momentary frequency variations exceeding 350 cycles occurred especially on box D¹ and D². These variations were caused by poor switch contacts and the mica tuning condenser used in the master oscillator of "D" box.

In the resubmitted model these variations have been corrected by using better switches and eliminating the mica condenser in the "D" box.

The combined frequency shifts due to various causes exceeds .05% in all boxes. The "A" box passes the requirements except for a small frequency range near the high frequency end.

(2) The original model when adjusted to any frequency within its range and without further adjustment does not maintain a frequency accuracy of .05% under the specified conditions except a portion of "A" and "B" boxes as shown in Table #3. The "D", "E" and "F" boxes have been worked over and resubmitted and except for the initial start of the 4500 Kc. "D" box run the frequency stability is in accordance with this specification. See Table 3A.

The drift of the "B" box is excessive and should be corrected in the production models.

(2a) Telegraphic and voice carrier outputs are satisfactory except as stated above. For keying action see Plate 3 and paragraph 5 of reference (e).

(2b) Satisfactory for an average 10° change in temperature except "B" box. For any 10° change in temperature all boxes except "E" and "F" exceed this specification during the first 10° C change in each run.

(2c) The method of making this test did not strictly comply with this specification. For convenience of repeating conditions at all frequencies $\pm 25\%$ change in plate current due to variation of the antenna constants, instead of 25% inductance, capacity and resistance change was used and at some frequencies the variation was excessive. See Tables 1 and 3A.

(2b) The maximum frequency shift due to 10% change in voltage does not exceed the specified allowance. See Tables 3 and 3A.

(2c) No frequency shift was noted due to other transient causes except backlash. See Table 3.

(2f) All filaments were operating five minutes just prior to these tests as specified.

The specified .05% allowance covers all collective causes for frequency shift and not the allowance for just one cause. It is suggested that the specifications be changed to give the individual percent allowance for frequency shift due to each outlined cause as well as the collective specified percentage.

3-22. In the original model momentary frequency variations exceeding 350 cycles occurred especially on box D^1 and D^2 . These variations were caused by poor switch contacts and the mica tuning condenser used in the master oscillator of "D" box.

In the resubmitted model these variations have been corrected by using better switches and eliminating the mica condenser in the "D" box.

The combined frequency shifts due to various causes exceeds .05% in all boxes. The "A" box passes the requirements except for a small frequency range near the high frequency end.

The "B" box is unsatisfactory due to excessive frequency drift at the high frequency end. At a small band of frequencies near the low frequency end of the dial the stability is satisfactory.

In the original model boxes "D", "E" and "F" were unsatisfactory; these have been corrected and resubmitted. They are satisfactory except for the start of the 4500 Kc. run of "D" box.

- 3-23. The trailing wire and kite antennae are similar in characteristics therefore tests were only made with the trailing wire and fixed antenna. The operation of this equipment into these types of antennae are included in the flight test reports, Appendix I and II. All tests made at the Laboratory on the bench were conducted with dummy antennae.
- 3-24. The dummy antennae characteristics were made to approximate the values shown on Sheets 42 to 47 inclusive as called for by this specification.
- 3-25. Same characteristics as 3-24.
- 3-26. The fixed antenna as installed on the N.A.S. 8833 scout airplane showed different characteristics than the dummy especially at 6200 Kc. and 9050 Kc. as shown by the flight test data appendix I and II.
- 3-27. Reasonably satisfactory operation can be accomplished for all conditions except short circuited or grounded antenna. At normal adjustment of the equipment from 6400 to 9000 the antenna ammeter would burn out in the original model if the antenna is grounded or shorted. In the resubmitted model a 9 ampere meter is used in place of the 5 ampere and at times this meter goes off scale. In some cases the plate meter goes off scale and excessive power is drawn from the rectifier system and power supply with possible change of injury to tubes, chokes, transformer and power supply. See paragraph 6 of reference (e).
- 3-28. The plug-in tuning units are in accordance with this paragraph but the switches in the original model did not make positive contact, causing frequency variations due to the changing resistance of these contacts which were associated with the master oscillator. These switches have been improved in the resubmitted model.

Satisfactory frequency range is covered by each box without any frequency gaps between 350 kc. and 9050 kc. except "box C 1500 to 3000 Kc" which was not furnished with the equipment.

- 3-29. This equipment, as originally submitted, did not cease oscillating in the key up position. The mercury vapor tubes caused high frequency oscillations that disturbed reception on all frequencies. This was corrected in the resubmitted model by using high vacuum rectifier tubes.
- 3-30. The master oscillator and power amplifier tuning control locks are too close to the bottom of the set and they are difficult to grip when wearing heavy gloves. The backlash and torque lash are

satisfactory. See Plate 3. Considering the "E" box range of 4500 to 6500 Kc. or 2000 Kc. total range in 1000 dial divisions times 3 equal taps or 3000 divisions. The specification allowance of 0.2 percent permits an allowance of 6 divisions backlash at 667 cycles per division, a total of 4002 cycles at 4500 kc. or 0.089% of the operating frequency. This means that the total frequency drift of 0.05% for all collective causes as specified in paragraph 3-21(2) would be exceeded by 0.039% for backlash alone. This allowance is considered too lenient.

- 3-31. The locking device used for the various controls is the friction type and both main and vernier dials are locked. This specification calls for a lock on the main, not vernier dials. This is satisfactory to prevent the condenser from shifting due to vibration but with a gear ratio of 100 to 1 the leverage of this ratio will permit movement of the main dial when locked and injure the gears, therefore both dials are locked at the same time to prevent movement. The knurled knob used with this locking device is threaded and screwed in place backed up by a locking nut. This is unsatisfactory. These knobs should be pinned to the shaft.
- 3-32. The rectifier or power portion of this equipment is adequate to supply the necessary power including the modulator which is a portion of the transmitter rectifier and not a separate unit.
- 3-33. A suitable winding on the 800 cycle power transformer is used to supply the filament power.
- 3-34. A suitable rectifier system, except for the mercury vapor tubes furnished with the original model, is used to supply the plate voltage. These tubes do not start at temperatures below -25°C and flashovers occur at temperatures above $+49^{\circ}\text{C}$. These tubes also cause receiver interference due to high frequency oscillation of the ionized mercury vapor. In the resubmitted model high vacuum, low internal drop tubes have been furnished and the temperature and interference difficulties are corrected.
- 3-35. The rectifier system employing mercury vapor tubes is not of such a character as to assure proper operation of the equipment at all times due to the noise created in close-by receivers and the temperature characteristic as stated above. This has been corrected in the resubmitted model. The rectifier circuit is the full wave type employing two single wave rectifier tubes.

The voltage regulation from no load to full load does not meet this specification. See Table 7A.

The efficiency of the rectifier system under conditions of full load, or in other words rectifier power conversion measured from the plate transformer input to the direct current output, is satisfactory. See Table 7.

- 3-36. When this equipment is installed with all shields and cases in proper position, personnel will not come in contact with voltages in excess of 25 volts but when it is necessary to replace fuses it is possible to be shocked by the discharge of the power factor

correcting condenser unless care is taken and this terminal is shorted to ground before removal of the blown fuse.

- 3-37. The telegraphic side tone voltage supplied in this equipment is in accordance with this specification but the operation is not satisfactory therefore it is suggested that changes be made in the circuit wiring as outlined by the flight test section of the Naval Air Station in report, Appendix I. The circuits were originally so arranged that this voltage was supplied to the grid of the audio output tube in the receiver. This causes tube blocking in the receiver. During the flight tests this circuit was modified so that the side tone is supplied direct to the phones with no tube circuits involved. The potentials and volume controls are satisfactory for 600 ohm phones. If the volume control was connected as a potentiometer instead of a series resistor maximum attenuation would be accomplished and 20,000 ohm phones could also be used. To prevent undue loading of the output circuit the phone jack could be arranged to open the potentiometer when the phones are removed from the socket. The 20,000 ohm phone requirement could be eliminated and avoid this change in view of the fact that these phones are being discarded in the service.

- 3-38. The rectifier filters are such that the total voltage ripple in the high tension D.C. plate supply for CW operation is 0.32%. The specified maximum allowed is 0.5%.

Due to the added plate power load for the speech amplifier modulator system in the phone position the ripple in the power supply is 0.95% which exceeds the maximum specified allowance of .5%. See Plates 1 and 2 for ripple oscillograms.

As long as this ripple does not cause unsatisfactory operation it is recommended that the requirements of 0.5% be disregarded for this equipment. In so far as the ripple in the power supply is concerned CW, MCW and phone transmission is satisfactory.

- 3-39. The original model when operatively connected to a NEA-1 plane power supply has excessive filament voltage variation from key up to key down. See Plate 7a. The resubmitted model when operatively connected to a NEA-1a plane power supply has satisfactory filament regulation due to a better generator and added power factor correcting capacity in the equipment.

- 3-40. The power factor correcting device was not adequate in the original model to give the proper voltage regulation for all operating conditions, thus causing excessive plate, grid bias and filament voltage variations as referred to in paragraphs 3-35 and 3-39.

In the resubmitted model two mfd's. have been added to the power factor correcting device which is adequate for operation with the NEA-1a generator.

- 3-41. The microphone transformer used for sidetone operation is satisfactory for operation with the Model RU-2 receiver but not with the Model RU-3. The audio gain of the Model RU-3 is less than the Model RU-2. This equipment should operate satisfactorily with both receivers.

IV.

- 4-1. The modulator unit is a part of the transmitter and not a separate unit. It has sufficient power to provide substantially complete modulation. See Tables 4 and 5, and Plates 4, 5, 6 and 7.
- 4-2. The modulator was made a part of the transmitter to conserve weight and space.
- 4-3. The audio frequency characteristics of the modulator as measured between microphone input and modulator output when operation at a level equivalent to 90% modulation of the transmitter varies more than 2 decibels from the average over the frequency range of 100 to 3000 cycles. See Table #6. This variation beyond the maximum allowed exists at frequencies below 200 cycles and is not considered serious.
- 4-4. At rated transmitter output the distortion of the modulated radio frequency measured between microphone input and modulated radio frequency output exceeds the maximum 10% combined R.M.S. harmonics at 100 cycles. At all other audio frequencies the percentage of combined harmonics is less than the maximum 10% allowed. See Table 6A.

These specifications call for modulation characteristics from 100 to 3000 cycles. The equipment meets these requirements from 200 to 3000 cycles and it is suggested that the requirements below 200 cycles be disregarded as it is not necessary for satisfactory voice communication. Satisfactory voice communication is assured. Random selected sentences were transmitted and received during flight tests to determine the intelligibility.

- 4-7. The method of reducing power with the Model GP equipment is satisfactory and it is not necessary to detune the antenna system and cause unnecessary load on the power supply and tubes. This is accomplished by loosening the antenna coupling. A low power tap is provided for tuning purposes.
- 4-8. The antenna loading coil operates over the specified frequency range. It would be desirable if possible to reduce the losses without increasing the size.
- 4-11. The dimensions of the external loading coil are satisfactory but the mounting holes are not satisfactory as referred to in the flight test report, Appendix I.
- 4-12. The mounting holes should be changed in accordance with the flight test recommendations, see Appendix I.

V.

- 5-1. A pilot's control box is provided for mounting on either side of the pilot's cockpit. This box houses a volume control for regulating the intensity of the signal in the pilot's phones but the attenuation is insufficient. This control should be connected in such a manner that the volume would be controlled by a potentiometer instead of series resistance and the 20,000 ohm phones would

operate as well as the 600 ohm phones. The phone jack should be arranged to open the potentiometer circuit when the phone plug is removed. The level indication of from 15 to 20 decibels is not a clear specification and should be changed. This box also houses a two position switch marked "ICS" and "Radio". When adjusted for ICS it is possible for the pilot to communicate with the radio operator without controlling the radio phone. When the transmitter is adjusted for radio phone by the operator it is possible for the pilot to use radio phone by shifting his switch to "Radio" position at his control box. The necessary jacks and cable fittings are supplied. It is possible to connect several pilot's control boxes in the circuit and obtain the same operation at any control box. The proper types of plugs and connections are supplied. The type of interphone furnished uses the last audio stage of the receiver; therefore all incoming radio signals will be heard in the ICS position. It is also possible for the pilot to cause interference, with the radio operation while receiving radio instructions, by talking over the interphone or with the slip stream noise in the microphone. If the pilot has a key to signal the radio operator to listen on the ICS, and the transmitter is running, the transmitter will emit signals at the same time. This might occur during radio silence or cause interference with radio reception in more than one plane. If only a side tone was present in the phones it would disturb radio reception. A signal light should be provided. The radio operator should be able to prevent all interference that it is possible for the pilot to cause and permit two positions or more to communicate with ICS without interfering with radio reception. Future equipment should call for requirements of 5-18(b). The model RU-3 and RU-4 receivers do not give satisfactory ICS operation as reported in paragraph 4 of reference (e).

- 5-2. The operator's control box is supplied with the necessary standard cable fittings, key jack, microphone jack and an "ICS-Radio" change-over switch as used on the pilot's control box. The cables are of the lock plug type.

- 5-3.(1) The pilot's control box weighs 1 lb. 2 oz. - specified 2 lb. 8 oz.

<u>Dimensions</u>		<u>Specified Dimensions</u>
Depth	2"	2"
Height	3-13/16"	4"
Length	5-1/2"	5-1/2"

- (2) The operator's control box weighs 2 lbs. 8 oz. - specified 2 lb. 8 oz.

<u>Dimensions</u>		<u>Specified Dimensions</u>
Depth	2-9/32"	2-3/8"
Height	3-15/16"	4"
Length	8"	8"

- 5-4. All electrical connections external are effected at suitable locations on the unit assemblies. The microphone and key connections are effected by telephone jacks at the required units.

- 5-5. The power plug contacts are good and the plugs will not permit a short circuit to occur when laid down in any position on a flat metal surface.

The cable connecting plugs when in position project beyond the surface of the cabinet. The terminals are well protected from water. It is only possible to insert the power plugs in one way.

- 5-6. Connections to the transmitter-rectifier are located on the side of the unit and are in a position which will permit removal of the unit when proper shelves are provided for mounting. The projection of these plugs prevent the equipment from being installed in the O-3-U boxes as described in these specifications, Sheet 41A. If the cable leads are tied close to the equipment they will prevent the proper operation of the shock-proof mountings.
- 5-7. The design and construction of the cable and connection blocks or plugs is such that they prevent danger from short circuits and fire hazards or danger to personnel.
- 5-8. The cable connections consist of a suitable number of conductors of appropriate cross section flexibly stranded and provided with suitable plugs as specified herein. Two conductors are used for each lead in the AC circuit to provide the proper cross section. The individual leads are insulated with solid color coded rubber composition of suitable wall thickness but not covered with a solid color coded cotton braid of the same color as specified. The conductor is twisted together and the whole covered with a tough rubber sheath. Between the cable and rubber sheath a metal shielding of the ribbon type is used. In some of the cables this shield was used as one of the circuits and faulty operation resulted due to mechanical breaks. The maximum outside cable dimension allowed is 5/8" and the actual size is 9/16". The minimum allowed length of cables and actual lengths furnished follow:

	<u>Allowed</u>	<u>Actual size</u>
Power supply cable	10'	9'
Key cable	3'	3'6"
Mike cable	6'	
Pilot's control box cable	10'	10'
Operator's control box cable	3'	2'8"
Monitoring receiver cables	3'	2'10"

- 5-9. Cables carrying the 800 cycle input to the transmitter rectifier are of the shielded type. The power input cable has a plug connection for affixing to the transmitter rectifier and connections on the other end for attaching to the plane distribution board. The cables for the keys and microphones are attached with suitable plugs on the other end of the cable for plugging into the respective units.
- 5-11. Two microphones are supplied with each equipment complete with cables and plugs.
- 5-12. Two type 26003 flame-proof telegraph keys complete with cables and plugs are furnished. The finish and knob size is not as specified as reported in Appendix II.

- 5-13. The insulated antenna reel supplied will accommodate 500 feet of flexible stranded aircraft antenna wire (Model J, 1/6 inch outside diameter) when wound under service conditions. 500 feet of wire is supplied with each reel.
- 5-14. Certain defects were noted in the reel construction during flight tests and reported in the flight test report, Appendix I. This reel has not been resubmitted for further check since corrections have been made.
- 5-15. (a) Antenna weights are furnished.
(b) Five strain insulators are furnished.
(c) One type 61083 fairlead is furnished.
- 5-16. Suitable provision has been made for fusing the 120 volt, 800 cycle power supply. The high voltage circuit is not fused. The fuses are accessible for replacement in flight but no warning sign has been placed in the fuse compartment to prevent personnel from coming in contact with voltage in excess of 25 volts as specified by (2-17). The compensating condenser associated with this circuit holds charge when a fuse is blown and it should be discharged before attempting to remove or replace the fuse. It is also desirable to have additional fuses available in this compartment.
- 5-17. Water-proof slip covers are provided to protect the equipment against rain.
- 5-18. B (Optional - see schedule).
Compliance with this paragraph is not specifically called for by the schedule but these features would be desirable with this equipment as noted below:
- (1) Scouting or cruising singly
- (a) With both pilots on ICS and no radio in use the Model GP system is satisfactory. If radio and ICS are desired at the same time the Model GP system is unsatisfactory. The audio amplifier of the radio receiver is used to amplify the ICS therefore both types of reception interfere with each other and can only be used individually.
- (b) To isolate the radio operator and permit inter-communication between pilots a separate ICS is required.
- (c) If the side tone is used to call the radio operator on the ICS the transmitter will also be keyed at the same time. If the side tone is made independent of the transmitter it will interfere with radio reception. If a signal light is used there is a possibility that it will not be seen. Therefore, it would be desirable to have both with a switch to cut off the side tone signal for ICS but not for keyed transmissions. This would permit the radio operator to completely isolate himself if necessary and permit the pilots to use ICS or listen to the radio signals.

- (d) Satisfactory operation with the Model GP equipment.
 - (e) Satisfactory operation with the Model GP equipment.
 - (g) Several extension boxes could be connected in parallel and each provide functions as above outlined.
 - (h) Key operation of the radio should be controlled by the radio operator. When a pilot desires to operate the radio equipment the key circuit could be switched to the desired pilot's position.
- (2) Ferrying separate ICS system required with no radio equipment. A plug-in rectifier system or dynamotor could be used for this purpose.
 - (3) Maneuvering squadron on "Phone"
 - (a) Model GP satisfactory.
 - (b) Model GP satisfactory.
 - (4) Radio Direction Finding
 - (a) All stations on received signal. If separate ICS system is used the radio operator can switch radio signal on ICS system when called for by pilots.

VI.

- 6-1. The spare parts required for each set of equipment were not furnished with the models tested.

IX.

- 9-1. Two preliminary models, faithfully representing the equipment which the manufacturer offers as complying with these specifications have been examined and rejected by the Navy. One of these same models has been modified to improve the frequency stability and has undergone tests for approval. The design of this model does not faithfully represent the models to be furnished by production lot. All changes in the structure of the set and antenna reel, which were recommended originally, should be effected before final acceptance by the Navy.

SUMMARY OF RESULTS.

27. The result of tests on the original model GP transmitting equipment showed that this equipment could be made to conform to the specifications in a satisfactory manner. The serious defects that follow were pointed out to the manufacturer at a conference held at the Navy Department the 22nd, 23rd and 24th of May 1935, reference (f).

- (a) High frequency tuning units did not permit operations into specified fixed antennas at all frequencies. This was corrected in the resubmitted model.
- (b) Isolantite post supporting terminal connection strip in set #1 cracked.
- (c) Locking device of G control in box E-1 did not function properly.

- (d) Insufficient clearance was provided to remove rear rectifier tube. This was corrected by using high vacuum tubes.
- (e) Stand-by toggle switch failed to operate properly at low temperatures.
- (f) Power amplifier plate choke leads burned off when set was operated after being subjected to conditions of extreme humidity. This was corrected by more careful assembly.
- (g) Main and vernier control locking knobs were not properly secured.
- (h) Calibration chart mountings were not waterproof.
- (i) The micalex terminal strip of the D-1 tuning unit cracked.
- (j) There was a loose turn on the antenna loading coil of the F-1 coil box.
- (k) There was 1/16 inch backlash in the transmitting key.
- (l) Antenna coupling controls were not aligned properly.
- (m) Power amplifier tube socket clearances were inadequate.
- (n) Mounting channels provided permitted transmitter to be inserted too far in plane box.
- (o) Stand-by switch with bakelite knob was difficult to operate. This was corrected in the resubmitted model.
- (p) A poor contact was located in P.A. amplifier circuit.
- (q) Coil unit retainer screws bound inside carrying cases.
- (r) Filament voltage regulation exceeded 5% under certain conditions. This was corrected in the resubmitted model.
- (s) The voltage rating of capacitor #34 in the speech amplifier circuit was exceeded under certain conditions. This was corrected in the resubmitted model.
- (t) Voltages in excess of 1250 volts were applied to certain tubes.
- (u) The frequency stability requirements of the specifications were not met.
- (v) Frequency shift was caused by the band switch. This was corrected with better switches.
- (w) Frequency determining circuits were inadequately protected from heat from the vacuum tubes.
- (x) Short circuiting of the antenna while using the F box endangered the equipment. This was improved to a practical limit in the resubmitted model.

- (y) The triangle section of the top of the case is very difficult to remove.
- (z) Keying relay broke down under high altitude conditions. There was insufficient insulation. Antenna relay chattered. Side tone should permit proper break-in operation. Insufficient range of control of head-phone signal was provided in pilot's and operator's control boxes. The ICS cable to receiver should be provided with plugs which cannot be mounted in wrong jacks.
- (aa) Vitreous enamel mica card resistors broke down. Rectifier bleeder resistors opened. These were replaced with tubular resistors.
- (bb) The bottom panels of the transmitter and coil boxes are difficult to remove and the bottom panel of the transmitter does not completely cover the latter.
- (cc) Proper accessibility was not provided for reel mounting bracket where mounting holes should be spaced 4 inches between centers. The counter gears jammed or broke when slipping reel drum into place. The counter mounting on the micalex plate lacked proper strength and the single screw mounting of the center head was not rigid enough. The brake knob locking screw was easily lost. The winding handle securing screws drew arcs from drum and wire. A second connector prong with binding post on the antenna reel was found necessary but was not provided.
- (dd) Antenna tuning unit had mounting holes on opposite side to that desired. It is desired that the panel be marked "Disconnect at frequencies above 540 Kcs."
- (ee) End stops were not provided on antenna controls.
- (ff) Tuning unit handles could not be grasped properly by one wearing heavy gloves.
- (gg) Vacuum type condensers were not sufficiently rugged. External mounting means were not rugged enough. This was corrected in the resubmitted model.
- (hh) Transmitter mounts retaining lock strips were hard to operate and were detachable.
- (ii) Internal bulkhead between tubes and coil boxes were too light.
- (jj) Extra clips were not provided for spare fuses in fuse compartment. A warning against hazard of condenser discharge should also be placed in this compartment.
- (kk) Snap slides on some coil cases did not function properly.
- (ll) All knurled nuts of external binding posts were not of the non-detachable type.

- (mm) Nameplate of voltage compensating capacitor should be marked in terms of capacitance.
- (nn) Proper operation of rectifier tube was not obtained over the required ambient temperature range. It is believed that this difficulty will be overcome if high vacuum rectifier tubes are used. In this case the heaters required for use with mercury vapor tubes are not necessary. This has been corrected.
- (oo) Tube sockets were not marked to show purpose and type of tube accommodated.
- (pp) Poor contacts were provided by spring washers used at the coil rotors. This has been corrected in the resubmitted model.

28. One of the original model equipments was reconstructed in certain details at the factory and resubmitted for laboratory and flight tests. Some of the tests conducted with the original model were not repeated due to satisfactory performance during the first tests. The modulation was visually observed and compared with the original oscillograms.

29. Another conference was held at the Navy Department December 19, 1935 after the resubmitted model had been tested at the Laboratory and the following deficiencies were discussed.

1. 1. The M.O. tap switch on "E" box makes poor contact at times causing frequency shifts of 8 Kc. at 6500 Kc. apparently due to poor assembly.
2. Altitude tests at 17,800 feet and below resulted in partial breakdown on MCW of all three boxes (D, E and F) evidenced by failure of dots to transmit properly, rendering code practically unreadable. "D" box also failed similarly on CW position. The above failures were self-healing at lower altitudes and no apparent permanent damage resulted.
3. Destructive flashover between rectifier socket filament prong and ground screw resulted in the laboratory.
4. P. A. tube failed apparently due to flashover in base of tube.
5. P. A. plate resistor phone by-pass condenser failed.
6. Antenna terminal on keying relay flashed over to winding terminal at altitude. This was corrected by better alignment.
7. Keying became sluggish as a result of shield in keying cable cracking and causing higher resistance. This shield should not be used as one of the conductors.
8. Keying relay contact for receiving antenna was found open in flight.

Production of "D", "E" and "F" boxes as resubmitted with correction of the deficiencies will be satisfactory. Other defects noted show that care should be taken in assembly and inspection of material.

In addition it was considered that the following features not covered previously should be incorporated in the production Model GP and GP-2 equipments.

- (a) The ICS plug should be marked with the letters "ICS" in addition to the red marker.
- (b) Volume controls on pilot's and operator's control boxes should be connected as potentiometers.
- (c) A suitable red warning plate should be placed on the transmitter unit to guard against application of voltage to rectifier tubes before filaments are up to operating temperature.
- (d) The ICS levels specified should be possible with the Model GP and GP-2 when operating with a Model RU-3 receiver. Any of the above changes will not involve a delay in production.

30. All deficiencies are to be corrected in the production Model GP equipments which were not practical to make in the resubmitted model. Final acceptance will depend upon the result of inspection and test of these equipments.

CONCLUSIONS.

31. The Model GP equipment as first submitted did not comply with the specifications reference (b) and was considered unsatisfactory for Naval Service.

32. After modification the Model GP equipment conforms to the requirements of the specifications except in a few minor details and that with correction of these minor defects it will be suitable for the Naval Service.

33. The output of the modified model is adequate at all frequencies and into the specified types of antennae.

34. The frequency stability is very good except for initial warm up at the 4500 kc. end of "D" box in the modified model. "A" and "B" boxes should be improved.

35. The modulation capabilities and characteristics while not meeting the requirements of the specifications at 100 cycles are excellent. The specification requirements are met at all other audio frequencies.

36. Insufficient clearance has been provided at certain places for high altitude work.

37. The sequence of tuning does not follow the alphabetical designation of the controls. The locking devices require pins to prevent loss.

38. The tuning unit handles do not provide sufficient space for handling when wearing heavy gloves.

39. Mercury vapor rectifier tubes are not well suited for aircraft high voltage power supplies and the newer high vacuum types should be used.

Table No. 1A.

Frequency Drift with Ambient Temperature Change.

Original Model GP.

Box	Frequency	Frequency change for the first 10°C temperature change			Total Temperature Frequency Change			Average 10°C Temp. Frequency Change
					Temp.	Freq.	Percent	
A ₁	500 Kc.	975 cy.	.195%	69°C	1,125 cy.	.22%		.032%
B ₁	1200 Kc.	2,500 cy.	.21%	67°C	7,500 cy.	.62%		.093%
D ₁	4500 Kc.	32,500 cy.	.722%	75°C	56,000 cy.	1.24%		.166%
E ₁	5500 Kc.	10,000 cy.	.182%	78°C	25,700 cy.	.46%		.059%
F ₁	7500 Kc.	20,000 cy.	.267%	78°C	34,600 cy.	.46%		.059%

Table No. 1B.

Resubmitted Model GP.

Box	Frequency	Frequency change for the first 10°C temperature change			Total Temperature Frequency Change			Average 10°C. Temp. Frequency Change
					Temp.	Freq.	Percent	
A ₁	Not resubmitted							
B ₁	Not resubmitted							
D ₁	4500 Kc.	2,975 cy.	.067%	51°C	2975 cy.	.067%		.013%
E ₁	6500 Kc.	2,000 cy.	0.0307%	60°C	5225 cy.	.08%		.013%
F ₁	9000 Kc.	1,650 cy.	.018%	76°C	3550 cy.	.039%		.005%

Table No. 2(A).

Power Output "A" Boxes

Original Model GP Serial Nos. 1 and 2.

Coil	Box	Freq.	Line Watts	Amplifier Plate & Grid Current	Antenna Res.	Power Output	Power Required
A ₁	CW	350	700	212	28.5	82*	85
A ₂	CW	350	710	220	28.5	92	85
A ₁	MCW	350	700	209	28.5	82*	85
A ₂	MCW	352	750	220	28.5	98	85
A ₁	Phone carrier	350	628	212	28.5	56	60
A ₂	Phone carrier	352	670	170	28.5	52	60
A ₁	CW	545	650	200	32.4	112	100
A ₂	CW	545	680	200	28.5	114	100
A ₁	MCW	545	670	202	32.4	117	100
A ₂	MCW	545	700	200	28.5	126	100
A ₁	Phone carrier	545	630	180	32.4	87	75
A ₂	Phone carrier	545	640	175	28.5	87	75
A ₁	CW	800	650	200	32.4	136	100
A ₂	CW	800	660	200	28.5	144	100
A ₁	MCW	800	690	205	32.4	147	100
A ₂	MCW	800	680	200	28.5	151	100
A ₁	Phone carrier	800	620	180	32.4	105	75
A ₂	Phone carrier	800	644	180	28.5	114	75

Table No. 2(B).

Power Output "B" Boxes

Original Model GP Serial Nos. 1 and 2.

Coil	Box	Freq.	Line Watts	Amplifier Plate & Grid Current	Antenna Res.	Power Output	Power Required
B ₁	CW	800	644	200	32.4	138	125
B ₂	CW	800	650	200	36.3	153	125
B ₁	MCW	800	680	202	32.4	146	125
B ₂	MCW	800	670	200	36.3	160	125
B ₁	Phone Carrier	800	620	178	32.4	105	85
B ₂	Phone Carrier	800	610	170	36.3	118	85
B ₁	CW	1200	644	200	26.4	135	125
B ₂	CW	1200	640	200	36.3	160	125
B ₁	MCW	1200	670	200	26.4	142	125
B ₂	MCW	1200	664	200	36.3	176	125
B ₁	Phone Carrier	1200	608	175	26.4	100	85
B ₂	Phone Carrier	1200	620	170		124	85
B ₁	CW	1500	654	200	18.2	123	125
B ₂	CW	1500	680	200	24.3	146	125
B ₁	MCW	1500	660	200	18.2	128	125
B ₂	MCW	1500	700	205	24.3	152	125
B ₁	Phone Carrier	1500	612	180	18.2	92	85
B ₂	Phone Carrier	1500	652	180	24.3	107	85

Table No. 2(D).

Power Output "D" Boxes

Original Model GP Serial Nos. 1 and 2.

Coil	Box	Freq.	Line Watts	Amplifier Plate & Grid Current	Light Mic. Amp. meter Photo- cell	Power Output	Power Required
D ₁	CW	3475	710	200	R-24.6	96.5	125
D ₂	CW	3475	760	200	182 ma	151	125
D ₁	MCW	3475	700	200	R-24.6	96.5	125
D ₂	MCW	3475	740	200	200	160	125
D ₁	Phone Carrier	3475	670	173	R-24.6	71	85
D ₂	Phone Carrier	3475	690	180	110	119	85
D ₁	CW	4235	726	200	R-24.6 ohm	96.5	125
D ₂	CW	4235	742	200	168	147	125
D ₁	MCW	4235	720	200	R-24.6 ohm	96.5	
D ₂	MCW	4235	770	200	185	152	
D ₁	Phone Carrier	4235	680	173	R-24.6 ohm	71	85
D ₂	Phone Carrier	4235	710	180	92	110	85

Table No. 2(D).

Power Output "D" Boxes

Resubmitted Model GP - No Serial Number

Coil	Box	Frequency	Line Watts	Amplifier Plate & Grid Current ma.	Dummy Antenna ohm	RF Output Watts	Power Required Watts	
D ₁	CW	3000	650	210	4.24	49	50	Fixed Ant.
D ₁	MCW	3000	670	210	4.24	49	50	Fixed Ant.
D ₁	Phone	3000	630	182	4.24	33	50	Fixed Ant.
D ₁	CW	3000	650	210	24.3	140	125	T.W.
D ₁	MCW	3000	660	210	24.3	146	125	T.W.
D ₁	Phone	3000	630	175	24.3	104	85	T.W.
D ₁	CW	4500	680	210	4.24	64	50	Fixed Ant.
D ₁	MCW	4500	700	210	4.24	64	50	Fixed Ant.
D ₁	Phone	4500	650	180	4.24	46	50	Fixed Ant.
D ₁	CW	4500	680	210	24.3	160	125	T.W.
D ₁	MCW	4500	690	210	24.3	168	125	T.W.
D ₁	Phone	4500	650	180	24.3	121	85	T.W.

Table No. 2(E).

Power Output "E" Boxes

Original Model GP Serial Nos. 1 and 2.

Coil	Box	Frequency	Line Watts	Amplifier Plate and Grid Current	Power* Output	Power Required
E ₁	CW	4550	592	200	160	125
E ₂	CW	4550	570	170	143	125
E ₁	MCW	4550	640	205	165	125
E ₂	MCW	4550	584	170	148	125
E ₁	Phone Carrier	4550	570	185	119	85
E ₂	Phone Carrier	4550	560	155	115	85
E ₁	CW	5472	654	200	160	125
E ₂	CW	5472	660	200	141	125
E ₁	MCW	5472	660	200	165	125
E ₂	MCW	5472	690	205	150	125
E ₁	Phone Carrier	5472	620	180	114	85
E ₂	Phone Carrier	5472	650	182	109	85
E ₁	CW	6225	660	200	155	125
E ₂	CW	6625	692	200	151	125
E ₁	MCW	6225	704	209	165	125
E ₂	MCW	6625	688	200	144	125
E ₁	Phone Carrier	6225	646	185	116	85
E ₂	Phone Carrier	6625	660	180	110	85

*Dummy antenna 110 volt 150 watt lamp.

Table No. 2(E).

Power Output "E" Boxes

Resubmitted Model GP -- No Serial Number.

Coil	Box	Frequency	Line Watts	Amplifier Plate & Grid Current ma.	Dummy Ohms	RF Output	Power Required	Antenna
E ₁	CW	4500	670	210	4.9	90.6	50	Fixed
E ₁	MCW	4500	670	210	4.9	90.6	50	Fixed
E ₁	Phone	4500	640	180	4.9	63.6	50	Fixed
E ₁	CW	4500	680	210	36	174	125	T.W.
E ₁	MCW	4500	690	210	36	182	125	T.W.
E ₁	Phone	4500	650	180	36	130	85	T.W.
E ₁	CW	6500	700	210	4.9	113	50	Fixed
E ₁	MCW	6500	710	210	4.9	118	50	Fixed
E ₁	Phone	6500	670	180	4.9	73.3	50	Fixed
E ₁	CW	6500	710	210	36	174	125	T.W.
E ₁	MCW	6500	720	212	36	174	125	T.W.
E ₁	Phone	6500	690	180	36	120	85	T.W.

Table No. 2(F).

Power Output "F" Boxes

Original Model GP Serial Nos. 1 and 2.

Coil	Box	Frequency	Line Watts Not	Amplifier Plate and Grid Current	Power* Output	Power Required
F ₁	CW	6200	recorded	200	165	125
F ₂	CW	Would not couple antenna series condenser, too small				125
F ₁	MCW	6200	Not recorded	200	165	125
F ₂	MCW	Would not couple antenna series condenser, too small				125
F ₁	Phone Carrier	6200	Not recorded	180	152	85
F ₂	Phone Carrier	Would not couple antenna series condenser, too small				85
F ₁	CW	7700	Not recorded	200	152	125
F ₂	CW	7700	684	200	146	125
F ₁	MCW	7700	Not recorded	200	165	125
F ₂	MCW	7700	692	200	149	125
F ₁	Phone Carrier	7700	Not recorded	180	119	85
F ₂	Phone Carrier	7700	660	180	111	85
F ₁	CW	9050	Not recorded	200	144	125
F ₂	CW	9050	710	200	146	125
F ₁	MCW	9050	Not recorded	200	155	125
F ₂	MCW	9050	736	200	149	125
F ₁	Phone Carrier	9050	Not recorded	180	110	85
F ₂	Phone Carrier	9050	690	180	109	85

*Dummy antenna 110 volt 150 watt lamp

Table No. 2(F).

Power Output "F" Boxes

Resubmitted Model GP - No Serial Number

Coil	Box	Frequency	Line Watts	Amplifier Plate and Grid Current	Dummy ohms	RF Power		Antenna
				ma.		Output watts	Required watts	
F ₁	CW	6500	680	210	4.9	112	50	Fixed
F ₁	MCW	6500	690	210	4.9	112	50	Fixed
F ₁	Phone	6500	655	180	4.9	98	50	Fixed
F ₁	CW	6500	675	210	28.6	172	125	T.W.
F ₁	MCW	6500	688	210	28.6	179	125	T.W.
F ₁	Phone	6500	650	180	28.6	126	85	T.W.
F ₁	CW	9000	750	210	8.2	145	50	Fixed
F ₁	MCW	9000	762	210	8.2	151	50	Fixed
F ₁	Phone	9000	723	180	8.2	106	50	Fixed
F ₁	CW	9000	745	210	61.6	158	125	T.W.
F ₁	MCW	9000	755	210	61.6	158	125	T.W.
F ₁	Phone	9000	720	180	61.6	112	85	T.W.

Frequency Variations

Original Model GP Serial Nos. 1 and 2.

Box	Freq.	3-21 (1) Reset Measure- ments	3-21 (2a) Keying 25 W.P.M. for 30 min.	3-21 (2c) +25% Change	3-21 (2c) -25% Change	3-21 (2d) +5% voltage change	3-21 (2d) -5% voltage change	3-21 (2e)
		Cycles %	Cycles %	Cycles %	Cycles %	Cycles %	Cycles %	Cycles %
A2	355	75 .021	80 .023	+250 .072	+150 .042	Power supply and com- pensation inadequate.	22 .006	
A1	500	10 .002	255 .05	155 .031	122 .024	40 .008	12 .0025	
A2	500	85 .017	235 .047	+175 .035	+90 .018	10 .006	55 .01	
A2	710	15 .002	540 .076	-10 .001	-140 .02	+20 .003	100 .014	
B2	891	140 .016	410 .046	+100 .011	+350 .039	Power supply and com- pensation inadequate	15 .002	
B1	1232	37 .003	1690 .14	-500 .041	+240 .020	+40 .003	402 .033	
B2	1232	75 .006	600 .049	-190 .015	+450 .036	Power supply and com- pensation inadequate	375 .03	
B2	1501	160 .011	2800 .19	-250 .017	+350 .023	+100 .006	500 .033	
D2	3003	Rapid drift	5000 .16	+200 .007	-250 .008	Drift too rapid to measure		
D1	3500	Rapid drift	9250 .26	Drift too rapid to measure	Drift too rapid to measure			
D2	4504	Rapid drift	11400 .26	Drift too rapid to measure	Drift too rapid to measure			
E1	4500	100 .002	2750 .06	2000 .044	+50 .001	-50 .001	700 .016	
E2	4504	700 .015	2100 .47	-500 .011	+40 .001	+40 .001	650 .014	
E2	6159	Not Complete	4920 .08	+1100 .018	Drift too rapid for good measurement			
F2	6159	375 .006	3000 .049	+40 .006	+100 .0016	-100 .0016	555 .009	
F1	7540	Drift too rapid	8800 .018	10 -	300 .004	450 .0066	1500 .002	
F2	9000	-	7200 .08	-	-	-	-	

Table No. 3a

Frequency Variation

Resubmitted Model GP - No Serial Number

Frequency drift at room temperature 25°C.

Box	Freq.	3-21 (1) Reset Measure- ments Cycles %	3-21 (2a) Keying 25 W.P.M. for 30 min. Cycles %	3-21 (2c) +25% Change Cycles %	3-21 (2c) -25% Change Cycles %	3-21 (2d) +5% voltage change Cycles %	3-21 (2d) -5% voltage change Cycles %	3-21 Locked key Phone Carrier Cycles %
D ₁	3000		450 .015	+400 .013	-700 .023	-10 .0003	-40 .001	545 .018
D ₁	4500		850 .019	-150 .003	+1350 .03	+100 .002	-250 .005	1250 .026
E ₁	4500		1225 .027	-1800 .04	+500 .011	+55 .001	-30 .0007	1175 .026
E ₁	6500		No data taken					1450 .022
F ₁	6500		No data taken					1250 .027
F ₁	9000		No data taken					3350 .036

Table No. 4

Percentage of Modulation

Original Model GP Serial Nos. 1 and 2

800 kilocycles.

(See Oscillograms
Plate No. 4)
Spec. (4-1).

Box B ₂ 560 cycle modulation		Percentage of Modulation Box B ₁				
Input Volts		Input Volts				
1.0	49.2%	.5	9.69%	35.6%	31.2%	33.3%
1.5	76%	1.0	29.0%	50.0%	56%	62.8%
1.9	100%	1.5	33.3%	79.2%	86.2%	86.7%
.5	31.2%	2.0	60.0%	100%+	100%+	100%+
No modulation			100 cy.	200 cy.	300 cy.	500 cy.
See Plate #5						
		.5	36.7%	36.7%	36.7%	30%
		1.0	66.2%	66.2%	72%	49.2%
		1.5	100%+	100%+	100%+	75.5%
		2.0	100%+	100%+	100%+	100%
			1000 cy.	2000 cy.	3000 cy.	5000 cy.

Note: Data table is arranged to correspond to oscillograms of Plate No. 4.

100%+ shows over modulated carrier.

Table No. 5.

Original Model GP Serial Nos. 1 and 2.

(See Oscillograms
Plate #6)
Spec. (4-1)

Box	A ₂	B ₂	D ₂	E ₂	F ₂
Carrier Freq.	352 kc.	800 kc.	3475 kc.	4550 kc.	9050 kc.
Power Output	60 watts	75 watts	85 watts	84 watts	84 watts
Microphone Input	1.2 volts	1.2 volts	1.2 volts	1.2 volts	1.2 volts
Cycles	Percentage of Modulation				
100	20.7	24.2	43.6	37.1	38.2
200	56.6	60.0	70.5	73.8	70.0
300	66.0	73.5	79.0	82.1	74.5
500	67.5	73.0	78.5	84.5	77.7
(See Oscillograms Plate #7)					
1000	72.6	77.8	83.7	88.1	85.0
2000	81.5	85.2	91.6	91.0	88.5
3000	77.8	85.2	91.6	91.0	89.2
5000	55.6	60.0	61.6	72.8	63.8

Table No. 6

Original Model GP Serial Nos. 1 and 2.

Spec. (4-3)

Audio frequency Response of the Modulator System.

The average level of the modulator system when operating
at an equivalent of 90% modulation is 39.5 db.

Microphone D.C. mills	A. C. Input Microphone - volts	Frequency	Equivalent P. A. Load Current - mills	A. C. Output Volts across 7800 ohms	Modulator plate Current - mills	Equivalent P. A. Plate Volts.	Audio power developed in watts	D B	D B variation 100 to 3000 cycles average of 39.51	Specified D B variation allowed
55	1.24	100	150	434.7	125	1200	25.4	36.26	3.25	2.0
55	1.24	200	145	557.55	120	1175	44.6	38.71	.80	2.0
55	1.24	300	150	558.9	135	1200	46.2	38.86	.65	2.0
55	1.24	500	150	680.4	142	1200	63.2	40.22	.71	2.0
55	1.24	1000	145	756	135	1175	77.8	41.12	1.61	2.0
55	1.24	2000	150	756	142	1200	77.8	41.2	1.61	2.0
55	1.24	3000	150	700	140	1200	66.2	40.42	1.91	2.0
50	1.24	4000	150	624	127	1200	52.7	39.44	.07	Not specified
50	1.24	5000	150	425	110	1200	24.3	36.07	3.44	Not specified
50	1.24	6000	150	304	95	1200	12.4	33.15	6.36	Not specified
50	1.24	7000	150	208	85	1200	5.85	29.89	9.62	Not specified
50	1.24	8000	150	170	75	1200	3.92	28.14	11.37	Not specified
50	1.24	9000	150	113	70	1200	1.73	29.59	14.92	Not specified
50	1.24	10000	150	85	65	1200	.97	22.06	17.45	Not specified
50	0			0	52	1250	0	No modulation		

Table No. 6A.

Original Model GP Serial Nos. 1 and 2.

Audio harmonic content in the modulated carrier.

(Spec. 4-4).

<u>Cycles</u>	At 840 Kc. % Combined <u>RMS Harmonics</u>	At 9000 Kc. % Combined <u>RMS Harmonics</u>
100	23.1	28.4
200	4.23	5.86
300	3.35	8.03
500	5.27	9.87
1000	6.27	8.79
2000	5.33	7.82
3000	4.94	6.96

Note that the large percent of combined R.M.S. harmonics at 9000 Kc. is due to less side band cutting at the higher radio frequency which allows a greater percentage of modulation of the higher audio harmonics.

Table #7

Original Model GP Serial Nos. 1 and 2

Power Conversion Factor

Specs. 3-35.

(Serial #1)	A. C. Input		D. C. Output			
	Watts	Fil. volts	:: Bleeder :: watts	Watts	Volts	M.A.
Key down	660	10	17.4	378	1350	280
Key up	238	10	33.3	1.7	1870	.9
Difference	422					

(Serial #2)

Key down	684	10	18.7	392.0	1400	280
Key up	245	10	34.4	1.7	1910	.9
Difference	439					

Serial #1.

Transformer)

$$\begin{array}{l} \text{input to DC)} \\ \text{Output} \end{array} \frac{378 + 17.4 - (1.7 + 33.3)}{422} = 360.4 = 85.4\%.$$

With filament)

$$\begin{array}{l} \text{power loss} \\ \text{included} \end{array} \frac{387 + 17.4 - (1.7 + 33.3)}{422 + 25} = \frac{360.4}{447} = 80.6\%.$$

Serial #2.

$$\begin{array}{l} \text{Transformer input)} \\ \text{to D.C. output} \end{array} \frac{392.0 + 18.7 - (1.7 + 34.4)}{439} = \frac{374.6}{439} = 85.4\%.$$

With filament)

$$\begin{array}{l} \text{power loss} \\ \text{included} \end{array} \frac{392.0 + 18.7 - (1.7 + 34.4)}{439 + 25} = \frac{374.6}{464} = 80.8\%.$$

	Max. specified allowance	AC input to DC output	AC input to DC output plus fil. watts loss
Power conversion	Set #1 80%	85.4%	80.6%
Power conversion	Set #2 80%	85.4%	80.8%

Table No. 7A

Original Model GP Serial Nos. 1 and 2

Plate Voltage Regulation.

Spec. 3-35.

Set #1 E max. or no load = 1870
 Plate voltage
 regulation E min. or full load = 1350

$$\frac{1870 - 1350}{1870} = \frac{520}{1870} = 27.8\%$$

Set #2 E max. or no load = 1910
 Plate voltage
 regulation E min. or full load = 1400

$$\frac{1910 - 1400}{1910} = \frac{510}{1910} = 26.7\%$$

Set #1 E max. or no load = 10.75
 Filament voltage
 regulation E min. or full load = 10.00
 AC input

Spec. 3-39.

E = 121 $\frac{10.75 - 10.00}{10.75} = \frac{.75}{10.75} = 6.98\%$

	Max. specified allowance		Measured	
E _p regulation	15%		Set #2	26.7%
	15%		Set #1	27.8%
E _f regulation	5%		Set #1	6.98%

PHONE OPERATION

BIAS = 245V GRID BIAS RIPPLE OF MODEL GP 1560 CYCLES
 $E_{PER} MM = .426$ $11X.426 = 4.68V$ $\frac{4.68}{245} = 1.9\% \text{ PEAK TO PEAK}$
 RIPPLE MM = 11 $.95\% \frac{1}{2} \text{ PEAK TO PEAK}$



60 CYCLE TRACER

PLATE = 1400V PLATE VOLTAGE RIPPLE OF MODEL GP 1600 CYCLES
 $E_{PER} MM = 2.7$ $10X2.7 = 27.0V$ $\frac{27.0}{1400} = 1.9\% \text{ PEAK TO PEAK}$
 RIPPLE MM = 10 $.95\% \frac{1}{2} \text{ PEAK TO PEAK}$



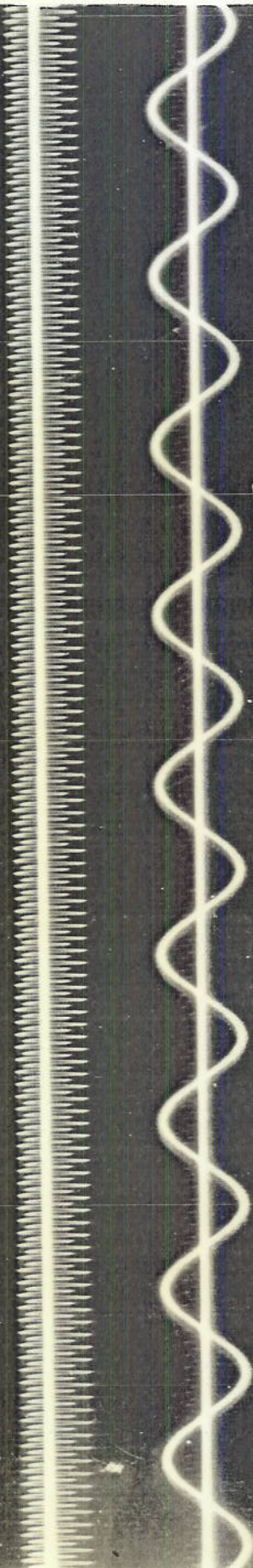
60 CYCLE TRACER

Plate #2 Q4

2 CW OPERATION 2

BIAS 245 V GRID BIAS RIPPLE OF MODEL GP 1560 CYCLES

E PER MM = 4.26 V 11 X .426 = 4.68 V $\frac{4.68}{245} = 1.9\%$ PEAK TO PEAK
RIPPLE MM = 11 $\frac{.95\%}{2}$ PEAK TO PEAK



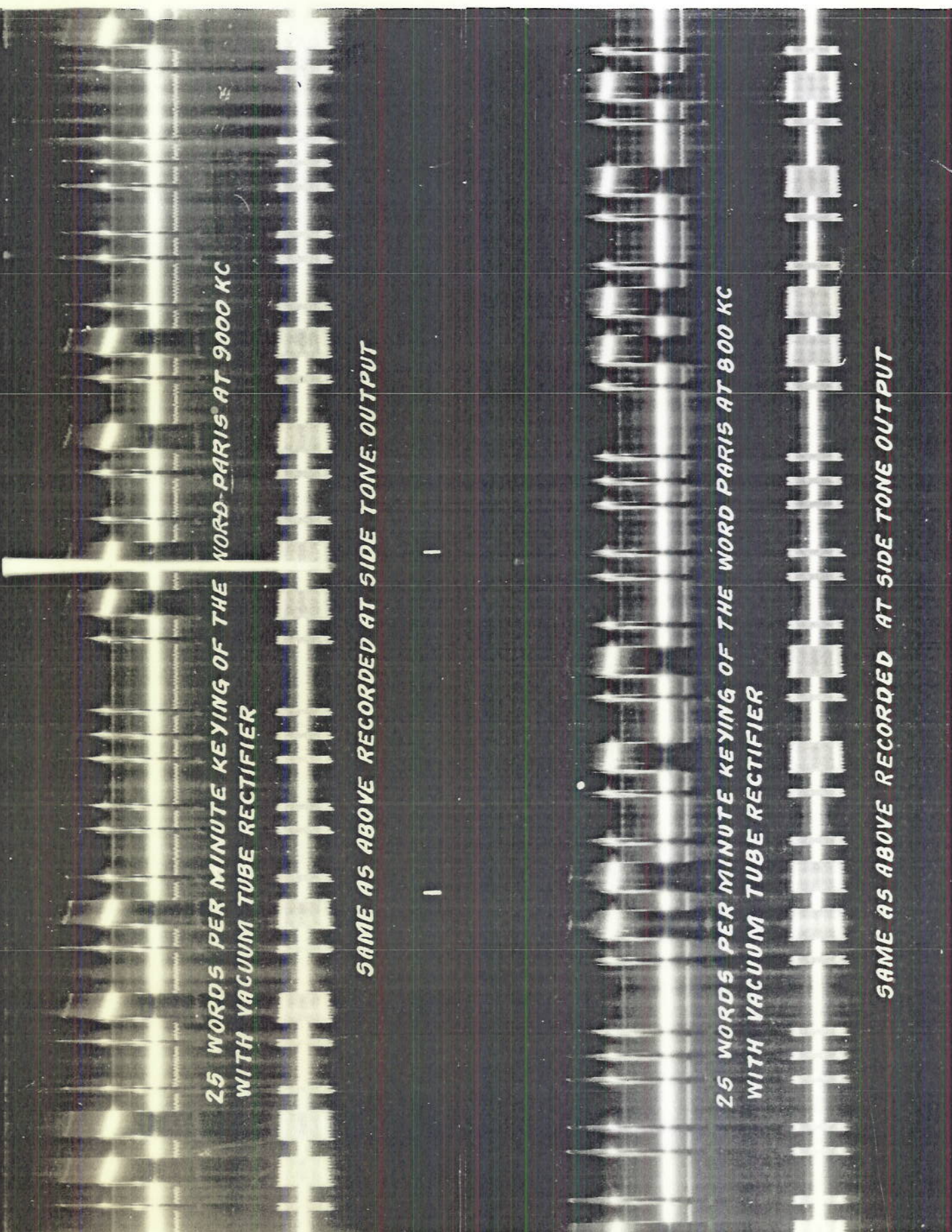
60 CYCLE TRACER

Plate #2 Q6

PLATE 1400V PLATE VOLTAGE RIPPLE OF MODEL GP - 1600 CYCLES
E PER MM = 1.49 6 X 1.49 = 8.94 V $\frac{8.94}{1400} = .64\%$ PEAK TO PEAK
RIPPLE = 6 $\frac{.32\%}{2}$ PEAK TO PEAK



60 CYCLE TRACER



25 WORDS PER MINUTE KEYING OF THE WORD-PARIS AT 9000 KC
WITH VACUUM TUBE RECTIFIER

SAME AS ABOVE RECORDED AT SIDE TONE OUTPUT

25 WORDS PER MINUTE KEYING OF THE WORD PARIS AT 800 KC
WITH VACUUM TUBE RECTIFIER

SAME AS ABOVE RECORDED AT SIDE TONE OUTPUT

800 KG. BOX B₂

1.0 VOLT



1.5 VOLTS



1.9 VOLTS



.5 VOLT



NO MODU-
LATION



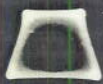
500 ~

MODEL GP
800 KG. BOX B₁

.5 VOLT



1.0 VOLT



1.5 VOLTS



2.0 VOLTS



100 ~

200 ~

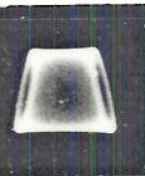
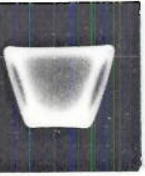
300 ~

500 ~

PLATE 4

MODEL GP
800 KC. BOX B,

.5 VOLT



560 ~
100% MOD.
9050 KC.
1.36 V. INPUT
84 WATT
CARRIER

1.0 VOLT

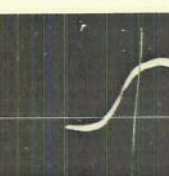


1.5 VOLTS



50 MA. NO MOD.
110 MA. MOD.
TUBES 24225
22700

2.0 VOLTS



42 MA. NO MOD.
110 MA. MOD.
TUBES 23768
24274

1000 ~

2000 ~

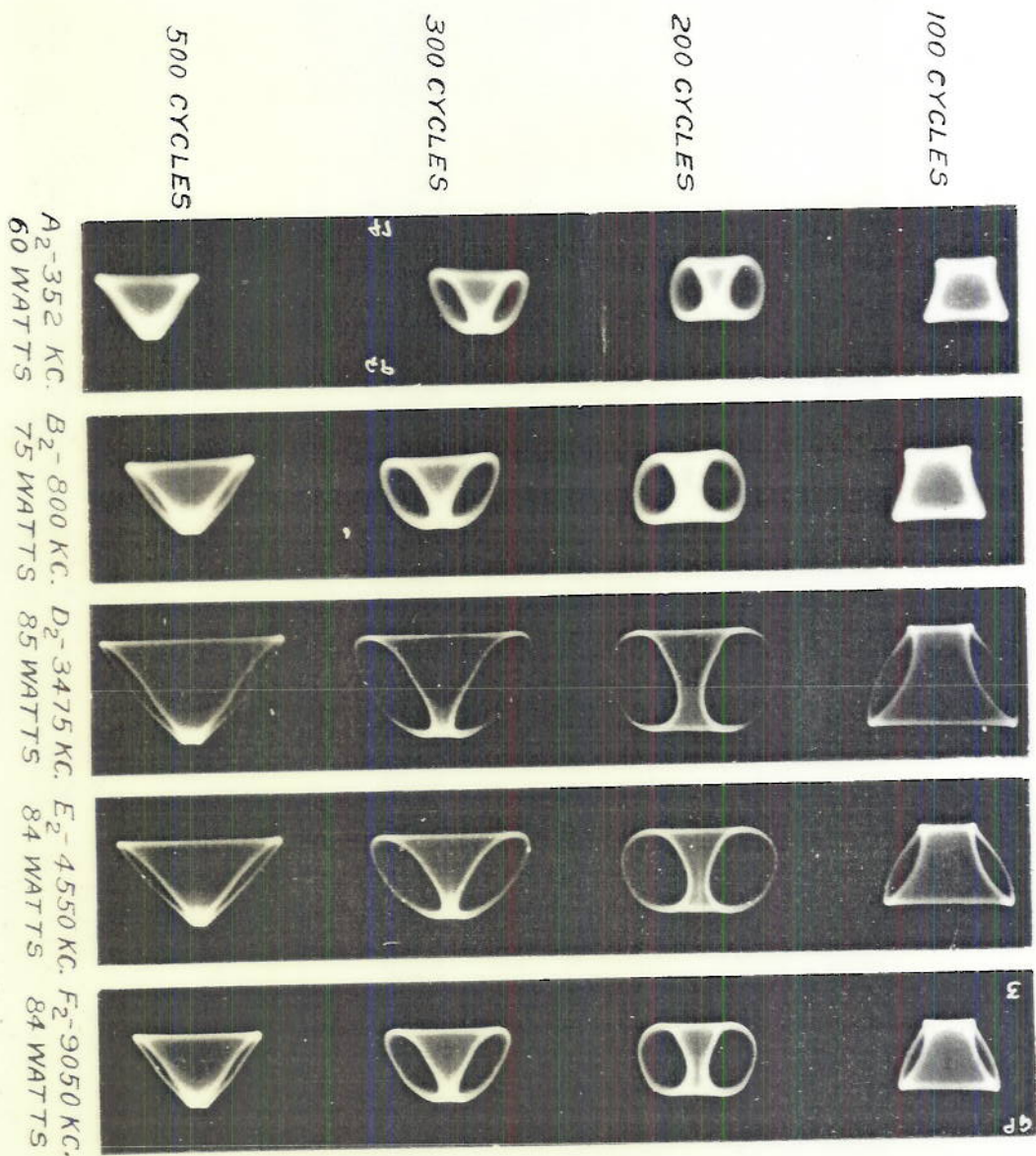
3000 ~

5000 ~

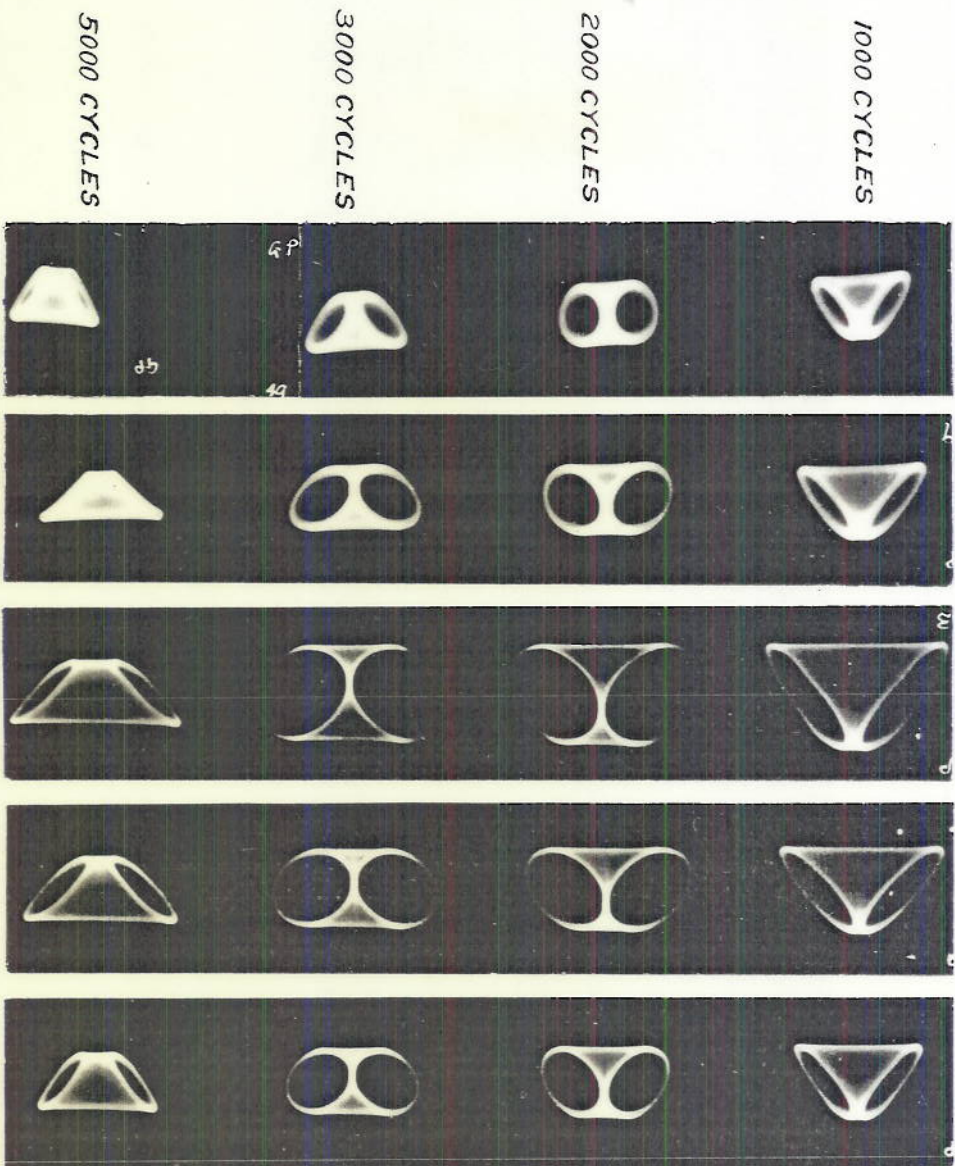
WAVE FORM
OF 100 ~
1.36 VOLTS
INPUT



MODEL 6P
AUDIO INPUT 1.2 VOLTS



MODEL 6P
AUDIO INPUT 1.2 VOLTS



13 August 1935.

NASA Report RT-5

NAVY DEPARTMENT
U. S. NAVAL AIR STATION
ANACOSTIA, D.C.

Report on
FLIGHT TESTS OF
MODEL GP RADIO TRANSMITTING EQUIPMENT

Number of Pages: Text - 19; Appendix A-4; B-5; C-2;
Plates - 12.

Authorization: BuAero ltr. Aer-E-31-FAM, F42-1,
Fl-5(1) of 27 November 1934.

Dates of Test: 1 May to 13 June, 1935.

Reported by: M. P. Hanson, Assoc. Radio Engr.

Reviewed by: G. B. H. Hall, Lieutenant, U.S.N.
Radio Test Officer.

Approved by: A. E. Montgomery, Commander, U.S.N.
Commanding Officer.

Distribution: N.R.L. (2)
BuAero (2)
N.A.F. (1)

TABLE OF CONTENTS

	<u>Page:</u>
AUTHORIZATION - - - - -	4
REFERENCES - - - - -	4
OBJECT OF TESTS - - - - -	4
EQUIPMENT UNDER TEST - - - - -	5
ABSTRACT OF TESTS - - - - -	6
RESULTS OF TESTS - - - - -	7
CONCLUSIONS AND RECOMMENDATIONS - - - - -	13

APPENDICES

N.R.L. letter outlining requested tests - - -	Appendix A
Memo on changes suggested by Anacostia - - -	Appendix B
Supplementary Memorandum - - - - -	Appendix C

PHOTOGRAPHS

Schematic Diagram of model GP equipment - - - - -	Plate 1
Photograph AN-33472. Interconnected mock-up view of units - - - - -	Plate 2
Photograph AN-33476. Front view with tuning unit removed and fuse door open - - - - -	Plate 3
Photograph AN-33477. Rear top view with portion of case removed - - - - -	Plate 4
Photograph AN-33473. Bottom shock mounting and fixed mounting slides - - - - -	Plate 5
Photograph AN-33474. Bottom view of transmitter unit - - - - -	Plate 6
Photograph AN-33475. Dismantled antenna reels and antenna weight - - - - -	Plate 7
Photograph AN-33454. Top forward view of GP flight test installation - - - - -	Plate 8
Photograph AN-33452. Right top view of GP flight test installation - - - - -	Plate 9
Photograph AN-33453. View from left rear of GP flight test installation - - - - -	Plate 10
Photograph AN-33455. View of flight test installation in pilot's cockpit - - - - -	Plate 11
Photograph AN-33451. O3U-1 airplane with fixed antenna used in flight tests - - - - -	Plate 12

AUTHORIZATION

1. The tests reported herein were conducted under authority of BuAero ltr. Aer-E-31-FAM, F42-1, Fl-5(1) of 27 November, 1934, in accordance with the procedure outlined in BuEng. ltr. F42-1(11-8-W3) of 17 November, 1934, and in conformity with the procedure suggested by NRL under Appendix (A) herewith.

REFERENCES

2. The following references (a), (b), (c), and (d) served as guides in conducting the tests herein reported; references (e) and (f), as appended to this report, were prepared at the verbal request of the Bureau of Engineering to summarize, in preliminary form, difficulties encountered with and changes suggested in the subject equipment.

- (a) N.R.L. ltr. F42-1/52 to C.O., N.A.S. Anacostia, dated 8 May, 1935; Appendix (A) herewith.
- (b) R.C.A. - Victor Co's. Instruction Book for Preliminary Models, GP Equipment, with appended drawings.
- (c) I.N.M. Philadelphia Type Test Data for preliminary model (Ser. No. 2) GP Transmitter.
- (d) BuEng. specification RE 13A 490B, dated 15 March, 1934.
- (e) N.A.S. Anacostia memorandum to BuEng., dated 22 May 1935, on suggested changes in GP equipment, Appendix (B) herewith.
- (f) N.A.S. Anacostia supplementary memorandum, dated 13 June 1935, Appendix (C) herewith.

OBJECT OF TESTS

3. The object of these tests was to determine from examination, installation, and actual flight operation, the degree of suitability of the Model "GP" equipment for installation and service use aboard Naval airplanes, and to obtain information for the determination of compliance with requirements of the governing specifications.

EQUIPMENT UNDER TEST

4. The equipment tested was the contractor's sample, Serial No. 2, of the model GP radio transmitting equipment, manufactured and submitted by the R.C.A. - Victor Company, Inc., of Camden, N. J., under contract NOS. 35625, dated 14 April 1934. The equipment, as received, comprised the following major units:

- (a) CRV-52051 Transmitter unit, less coil box
and less tubes - - - - - 53.78 lbs.
- (b) Complete set of tubes (8) as follows: - - - - - 2.50 lbs.
 - 2 - CRC 38145 Modulator tubes
 - 2 - CRC 38111 M.O. and P.A. tubes
 - 2 - CRC 38166-A Rectifier tubes
 - 1 - CRC 38110 Speech amplifier tube
 - 1 - CRC 38180 Modulator bias rectifier
- (c) CRV-71006 Antenna reel (with 500' Model J wire) - - 7.00 lbs.
- (d) CRV-71003 Antenna weight - - - - - 2.40 lbs.
- (e) CRV-61083 Antenna fairlead - - - - - 1.06 lbs.
- (f) CJB-26003A Sending Keys (2) - - - - - each - 1.30 lbs.
- (g) RS-38A Microphones (2) with cords, - - - - each - 1.00 lbs.
- (h) CRV-47079 Antenna loading coil - - - - - 3.00 lbs.
- (i) CRV-23057 Operator's control box - - - - - 2.28 lbs.
- (j) CRV-23058 Pilot's control box - - - - - 1.16 lbs.
- (k) Connecting cables, set of - - - - - 10.31 lbs.
- (l) CRV-47078A Tuning unit, 350-800 kcs. - - - - - 14.40 lbs.
- (m) CRV-370S Tuning unit, 800-1500 kcs. - - - - - 14.40 lbs.
- (n) CRV-47078D Tuning unit, 3000-4525 kcs. - - - - - 13.75 lbs.
- (o) CRV-47078E Tuning unit, 4525-6200 kcs. - - - - - 13.00 lbs.
- (p) CRV-47078F Tuning unit, 6200-9050 kcs. - - - - - 13.00 lbs.
- (q) Protective boxes for tuning units (5) - - each - 5.50 lbs.
- (r) Preliminary instruction book for GP models - - - - -

5. The model GP transmitter is required to cover a frequency range from 350 to 9050 kilocycles, in six overlapping steps by means of detachable tuning units; only five of these were supplied under the present contract, the 1500-3000 kcs. range being omitted. Emission is provided on (a) CW telegraphy, (b) MCW, approximately 50 per cent tone modulated telegraphy, and (c) Radio Telephony, substantially completely modulated. A carrier power output of 50 watts is required into the standard fixed antenna on frequencies between 3000 and 9050 kcs. on all types of emission. Into optimum lengths of trailing antenna, power output requirements are as follows:

<u>Watts CW & MCW</u>	<u>Watts unmodulated 'Phone Carrier</u>	<u>Frequency, Kcs.</u>
85	60	350 - 500
100	75	500 - 800
125	85	800 - 9050

6. As shown by the schematic diagram reproduced on Plate 1, the radio-frequency circuit comprises a triode master oscillator, a neutralized triode power amplifier coupled thereto, and a suitably loaded and resonated antenna circuit connected to the amplifier output by variable inductive coupling. High-level, class A-B plate modulation of the power amplifier is provided, the grids of the push-pull modulator tubes being excited through a speech amplifier. The circuits used in the various tuning units differ to some extent, the two lowest frequency units employing Colpitts oscillator circuits inductively coupled to the power amplifiers, whereas the remaining units incorporate Hartley oscillators with capacitive coupling to the output stage. As indicated in Plate 2, the equipment is controlled either by the operator or the pilot, and is interconnected for break-in use with the model RU-2 or RU-3 receiver. Amplified interphone communication is provided between pilot and radio operator. The equipment is designed to obtain its power from the type NEA-1, NEA-1A, or NEA-2 generator which supplies 120 volts 800 cycle alternating current, and approximately 14 volts of direct current.

ABSTRACT OF TESTS

7. The equipment was received from N.R.L. 25 April, 1935; after preliminary bench tests, it was installed in O3U-1 airplane No. 8810, with type NEA-2 generator. 27 flights were made with the GP equipment, aggregating 40.4 hours, during the period from 3 May to 6 June, 1935. The flight tests were made to determine throughout the frequency range of the equipment the following performance factors:

- (a) 2-way plane-to-ground communication, with check on speech intelligibility, both with N.R.L. and N.A.S. Anacostia.
- (b) Altitude flights to 17,500 feet, for frequency drift measurements by N.R.L.
- (c) Frequency re-set and antenna de-tuning tests, for measurement by N.R.L.
- (d) Tuning and coupling adjustments into fixed antennae of 15 and 18 feet length, and into trailing antennae of various lengths.

- (e) Altitude break-down tests of electrical insulation in rarified atmosphere up to 18,000 feet.
- (f) Reception tests, including rectifier and break-in noises, and side tone levels, also ICS communication.
- (g) Suitability of shock cushioning, both in flight and during taxiing on ground, and general ruggedness.
- (h) Distance communication tests, on intermediate frequency.
- (i) Flight performance with NEA-1, NEA-1A, and NEA-2 types of generator.

8. The equipment was removed from the O3U-1 airplane and installed for test during the last three flights in XTBD-1 all-metal, low-wing, monocoque fuselage airplane No. 9720, in order to determine the suitability of installation facilities in this airplane and to conduct tests with fixed antennae. The equipment was then set up in the radio laboratory to check the wave form and the power factor compensation with the NEA-1 generator, and to obtain oscillograms of the break-in keying action; it was returned by air, direct to the contractor at Camden, N.J., on 14 June, 1935.

RESULTS OF TESTS

9. The following test results were obtained in accordance with reference (a), enclosed herewith as Appendix (A); they are listed under correspondingly numbered sub-paragraphs, in conformity with the governing specification, reference (d).

1-2, 3-15. Effective communication is provided except for difficulties set forth in this report. The mercury vapor rectifier tubes supplied with the equipment produced a hissing untunable noise level, during reception, equivalent to above one-twentieth micro-volt input to the receiver (one-half volt output into 600 ohms impedance). Substitution of high-vacuum type rectifier tubes eliminated this noise. Break-in operation was not satisfactory due to mechanical and electrical faults in the keying relay. Excessive signal up to receiver saturation was obtained when transmitting on or near the receiver frequency, but was remedied by altering the side-tone connections to feed directly into the receiver output (rather than the ICS jack) and by inherent low impedance by-passing excessive receiver signal.

1-5. The convenience of installation was satisfactory, except for the following:

- (a) Mounting holes in antenna loading unit were on side rather than back face.
- (b) Power cable was not supplied with necessary standard conduit fitting.

- (c) Antenna reel mounting was very inaccessible, and lacked connecting post toward fairlead.
- (d) Transmitter mounting slides have no stop in back and are provided with locking latch, which requires tools to operate, and which is easily lost.

The convenience of operation in flight was in general excellent, considering the inherent complexity of the equipment.

2-3, 2-16, 2-19. The general mechanical ruggedness of the equipment was found satisfactory, including the method of welded stainless steel construction. The shock-absorbing mountings gave sufficient protection to the equipment in flight and during taxiing on a rough field.

2-10. The following failures to parts occurred during flight tests, and were successively repaired or replaced:

- (a) Key blocking resistors in P.A. failed.
- (b) Speech amplifier plate dropping resistor failed.
- (c) Keying relay contacts got out of adjustment.
- (d) Speech amplifier coupling condenser broke down.
- (e) Contacts became unreliable on emission selector switch, and in tuning unit "E" on oscillator tap switch.

2-11, 2-16, 2-20. No damage was observed resulting from vibration or shock.

3-1. Operation on the trailing antenna was generally satisfactory; however the equipment did not fully cover the required frequency range on fixed antenna, either on the specified "Vee" having legs 18 feet in length, nor on a preferable 15 foot "Vee". Detailed data are shown subsequently in this report (paragraphs 11 and 12).

Speech intelligibility was generally excellent, and was not affected by tuning or coupling adjustments.

The power factor compensation provided was satisfactory at the normal output frequency of 800 cycle or above, with generators of the NEA-1, NEA-1A or NEA-2 types, but was not quite sufficient for satisfactory regulation at 600 cycles.

- (2) Because of projections and required ventilation, the equipment could not be properly installed in the MF type of box provided in O3U type of plane; this box was readily replaced by a more suitable mounting platform.
- (4)(a) Frequency drifts during flight tests were measured directly by N.R.L.

- (b) Tuning unit F-2 did not deliver the required output into the fixed antenna at 6200 kcs. The equipment was tested at full power and all three types of emission up to 18,000 feet altitude, with the following resultant cases of electrical flash-over:

Keying relay antenna contacts.
Master oscillator tube socket.
Antenna reel protective insulation.
Internal switch to case in "F" unit.

- 3-6. The dial lock adjustments on the tuning units are placed too near the lower edge for ready accessibility with heavy gloves.
- 3-8, 3-23, 3-27. Shifting the transmitter output from the fixed antenna to trailing antenna was accomplished conveniently, without extensive readjustment. The antenna post was alternately open-circuited and short-circuited to the fuselage, with antenna successively connected and disconnected, without damage during full-power operation.
- 3-9. The external loading unit is not required at any frequency above 540 kcs.
- 3-10. The side tone voltages were satisfactory for flight conditions, with the exception of excessive receiver output during transmission on the same frequency.
- 3-11. With the exception of the altitude breakdowns, no dangerous open sparks or arcs were observed.
- 3-18. Method of emission did not affect the filament voltage; plate or bias voltages were not measured during flight.
- 3-21. Time of re-set with frequency meter not tested, since no frequency meter was supplied or available.
- (1) Time of re-set with recorded calibration data was approximately twenty seconds; accuracy was measured by N.R.L.
- 4-7. The method of power reduction by loosening of antenna coupling was found satisfactory.
- 4-8. The antenna loading coil is suitable for adjusting to any frequency between 350 and 550 kcs. in flight.

10. Apart from electrical breakdown, the flight tests disclosed the following unsuitable component parts:

- (a) Antenna ammeter: 0-5 amperes R.F., in ground lead; went off scale on fixed antenna adjustments. Should be replaced by newly developed, open mid-scale type meter of approximately 0-8 amperes range. This recommendation supercedes

item (n) on page 2, Appendix (B).

- (b) The type of selector and tap switch employed throughout did not make dependable contact and should be replaced by the improved type as proposed by the contractor.
- (c) The headset volume control resistors as supplied in the control boxes provided insufficient attenuation and should be replaced by a more suitable type as substituted during the tests; a friction lock should prevent accidental misadjustment.

11. The following extracts from the antenna tuning and performance data are submitted; antenna currents are measured by external meter connected at the transmitter antenna post. Unless otherwise stated, emission is CW and P.A. plate current 210 M.A.

Unit:	Freq.	Ant.	Ant.	Antenna	Remarks
:	Kcs.	Cplg.	Tuning	Amps.	
<u>18 ft. "Vee" (fixed) Antenna:</u>					
D	3000	14	1-55	5.2	
D	4500	7	5-97	4.8	
E	4370	11	4-67	6 plus	190 M.A.
E	5200	48	5-100	2.7	
E	6000	68	5-100	2.1	
F	6250	100	1-00	1.1	
F	6440	22	1-00	3.2	Low Limit
F	6600	19	1-30	3.5	
F	8900	30	5-52	3.1	
F	9950	44	5-100	3.0	
<u>15 ft. "Vee" (fixed) Antenna:</u>					
D	2870	16	1-02	4.5	Low Limit
D	3000	17	1-32	4.5	
D	4500	5	5-52	5.2	
D	4700	5	5-100	5.1	High Limit
E	4400	16	4-43	5.2	Low Limit
E	4400	16	4-43	4.3	Phone - 170 M.A.
E	5600	33	5-95	3.3	
E	6000	43	5-100	2.0	
F	6250	95	1-00	0.8	
F	6475	19	1-04	3.6	Low Limit
F	6700	18	1-32	3.6	
F	9000	15	4-52	3.6	
F	9450	23	5-47	3.5	Transmitter Limit

Unit	Freq.	Ant.	Ant.	Ant.	Emis-	Plate	Ant.
	Kcs.	Length	Cplg.	Tuning	sion	M.A.	Amps.
A	350	230	35	1-45-L1	CW	210	2.1
A	350	350	55	1-05-L2	CW	210	2.4
A	350	350	55	1-05-L2	Phone	180	2.1
A	525	313	25	3-49-L4	CW	210	2.8
A	544	282	25	1-03	CW	210	2.8
A	544	500	44	2-40	CW	210	2.1
A	544	500	44	2-40	CW	210	2.2
A	544	500	44	2-40	Phone	170	2.0
A	725	290	27	4-47	CW	210	2.7
B	800	230	42	1-43	CW	210	2.6
B	1500	147	56	5-100	CW	210	2.0
D	3000	42	20	3-50	CW	210	4.5
D	3000	149	48	2-40	CW	210	2.3
D	3875	34	19	5-84	CW	210	3.5
D	3875	126	37	5-83	CW	210	2.2
D	4500	20	10	5-74	CW	210	4.2
D	4500	96	25	5-64	CW	210	2.1
E	4400	45	19	5-52	CW	210	4.2
E	4400	45	19	5-52	Phone	175	3.6
E	4400	110	46	5-52	CW	210	2.2
E	4400	110	46	5-52	Phone	180	1.9
E	5200	18	17	5-58	CW	210	4.8
E	5200	63	40	5-44	CW	210	2.2
E	5200	139	48	5-63	CW	210	1.9
E	6000	12	7	5-60	CW	210	5.7
E	6000	70	28	5-54	CW	210	2.1
F	6000	30	35	1-00	CW	210	1.5
F	6000	146	90	1-00	CW	210	1.3
F	6600	14	22	1-12	CW	210	3.2
F	6600	54	30	1-00	CW	210	3.1
F	7500	58	21	2-44	CW	210	2.4
F	8500	18	27	3-27	CW	210	1.8
F	8500	55	39	3-38	CW	210	1.5
F	9050	54	50	5-10	CW	210	1.2
F	9050	91	50	5-10	CW	210	0.75

12. The Tuning Units resonated the fixed antennae over the following frequency ranges:

Tuning Unit	Required Range, KCS	Range Covered, KCS	Length of "Vee" Ant.
D	3000 - 4500	2870 - 4550	18 ft.
		2870 - 4700	15 ft.
E	Not required	4370 - 5500	18 ft.
		4400 - 5700	15 ft.
F	6200 - 9050	6300 - 9000	18 ft.
		6450 - 9400	15 ft.

13. A distance communication flight test on 28 May 1935, to Fort Bragg, N.C., resulted in maintenance of two-way intermediate-frequency telegraph communication up to approximately 200 miles distance (15 miles north of Raleigh, N.C.; the airplane transmitted on 725 Kcs., while N.A.S. Anacostia, keyed the Arlington transmitter delivering about 750 watts on 544 Kcs. After losing contact on this frequency, the airplane shifted to 3105 Kcs., and delivered excellent voice signals to Anacostia, 225 miles distant, the ground station replying on 4135 Kcs. On the return flight the airplane on 4135 Kcs., established direct two-way telegraph communication with Anacostia's "Condor" transport plane (equipped with Model MI-K equipment) then 50 miles from Chicago, a distance of approximately 700 miles. In view of considerable reception interference experienced during this test at Anacostia, the above results in overland communication appear satisfactory. The CW telegraph signals at all times were clear, free from keying lilt or noticeable drift.

14. The antenna reel (see Plate 7) had certain deficiencies, enumerated at the beginning of Appendix A and Appendix B, herewith. The gearing and support for the antenna length counter were found weak and easily damaged. The ball bearing feature and general mechanical operation appear satisfactory; with incorporation of the recommended changes it is believed the reel will prove entirely serviceable and have desirable advantages over reels of earlier design. It should be noted that the antenna weight, also shown on Plate 7, departs from the Navy standard type by a more substantial swivel construction, a very desirable improvement; the "S" hook link, however, will tend to straighten out and lose the weight when the antenna is reeled completely in, and should therefore be omitted.

15. Attention is invited to the list of non-standard components
Appendix I - Page 12.

shown under paragraph 3, on page 2 of Appendix "C", herewith.

16. All tubes (when sufficiently cool) may be changed in flight, through the opening left in the transmitter unit after removal of the tuning unit. General accessibility for servicing should be improved, although limited by the inherent complexity and required compactness.

17. Bench and flight tests with the NEA-1A and NEA-2 generators gave satisfactory operation at all alternator frequencies from 850 down to 600 cycles, except for insufficient compensating condenser action below 650 cycles, resulting in filament voltage drop somewhat in excess of 5 per cent when the transmitting key was pressed.

18. Operation of the break-in and side-tone system was unsatisfactory in the equipment as submitted, due chiefly to overwhelming receiver output during transmission on the received frequency. At the suggestion of this station, the contractor's representative modified the side tone circuit to feed, through the keying relay directly into the headphones, instead of into the receiver ICS jack. With this connection, the low shunt impedance offered by the side tone circuit effectively by-passed the receiver output from the 'phone during transmission, thus preventing not only the excessive response stated above but also effectively reducing audible clicks accompanying the keying operation.

19. On tuning units E and F, at frequencies between approximately 4000 and 9050 Kcs., the CW beat note during telegraphy at times exhibited an unsteadiness evidenced by jumping back and forth (on successive dots and dashes) between two definite frequencies several hundred cycles apart. The cause of this behavior was not located, but might be due to variable contacts in the keying relay or elsewhere in the circuit connections or shielding.

CONCLUSIONS AND RECOMMENDATIONS

20. The model GP sample equipment tested is not considered suitable for use in the Naval Service until the following deficiencies are corrected:

- (a) Excessive frequency drift, reported by N.R.I., and frequency jumps as noted in paragraph 19.
- (b) Likelihood of electrical breakdown at various places, as disclosed mainly by flight tests.
- (c) Failure to give required output into fixed antenna over required frequency range.
- (d) Inadequate break-in system, with incorrect side-tone levels.
- (e) Miscellaneous mechanical and electrical deficiencies or desirable alterations enumerated in this report and Appendices.

21. The subject equipment is handicapped by the inherently large size of the tuning units, which will in many installations make the carrying of extra units difficult and will reduce the facility of changing during flight. To some extent this is compensated for by the location of all tuning controls in the individual units where they may be pre-set and locked, thus requiring for major frequency change merely insertion of the proper tuning unit together with a possible change of antenna length.

22. The following features of the GP model equipment are considered worthy of favorable comment:

- (a) Simple and straight forward tuning method, by which individually are adjusted the master oscillator and power amplifier settings, the continuously variable, inductive antenna coupling, and the antenna loading and tuning. All tuning adjustments are made on low power and in a manner minimizing radiation and consequent interference.
- (b) The high order of speech intelligibility, unaffected by transmitter tuning.
- (c) The clear CW telegraph note, free from "lilt" or undue ripple.
- (d) Standardization upon a selector or tap switch of advanced design, with low contact resistance and excellent detent (clicker).
- (e) Ball-bearing, easy winding antenna reel.
- (f) Development of vacuum type antenna series capacitors.
- (g) Successful manufacture of spot-welded stainless steel cabinet, control boxes, and other members, with copper plating where exceptionally low resistance and good shielding are required.
- (h) Compactness of transmitter control box and pilot's control box, combined with light weight, accessibility, and small required mounting space.
- (i) Protection of shielded flexible cables by external layer of tough rubber.

23. In view of the inherent complexity of this class of equipment and its internal inaccessibility when installed in the airplane, adequate bench test facilities appear essential for its proper maintenance in service. For this purpose, it is recommended that each operating unit be provided with extra sets of cables and control boxes, in order to facilitate bench tests of the transmitter units without requiring removal of the other components permanently installed in the airplane.

24. The preliminary model Instruction Book was found totally inadequate; the final book should be completely revised and extended. In order to insure the use of terms and phrases entirely familiar to service personnel and inclusion of necessary practical operating information, it is recommended that a draft for the final book be made available to the Naval Air Station, Anacostia, for criticism and/or suggestions.

25. It is recommended that future specifications for similar equipment incorporate more detailed requirements in regard to the following factors:

- (a) Break-in operation, with permissible lag, etc.
- (b) To avoid interference with important tactical communications as well as to meet conditions of radio silence, practically complete adjustment of this type of equipment without actual radiation should be demanded.
- (c) Definition of purity of CW telegraph note, with requirements for freedom from keying lilt, vibration modulation, and ripple due to intermittent action of generator voltage regulator.
- (d) Arrangement and size of all mounting holes.
- (e) Length of all cables and permissible diameter, in detail.
- (f) Change requirement from 18 foot to 15 foot fixed "Vee" antenna, to keep forward ends aft of trailing edge of wings, thus reducing hazard and increasing effective height.

(C O P Y)

F42-1/52

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

HFH:LP

8 May 1935.

From: Director.
To : Commanding Officer, Naval Air Station, Anacostia, D.C.
Subject: Radio - Aircraft - Tests of Model GP transmitting equipment.
Reference: (a) BuEng let. F42-1(11-8-W3) of 17 Nov. 1934.
(b) Specifications RE 13A 490B.

1. It is requested that flight tests be conducted on the Model GP aircraft transmitting equipment in accordance with ref. (a).

2. A conference was held with personnel from the Naval Air Station at the Naval Research Laboratory on May 1, 1935, and flight tests were discussed. The following tests were outlined in accordance with certain paragraphs of ref. (b).

1-2,3-15. Under actual flight conditions, determine by test how effective the communication is with the other units of the Naval Service by communication with the Naval Air Station and the Naval Research Laboratory. Also determine the reliability and absence of interference in the specified receivers called for by Specifications RE 13A 471A. Determine the reliability of the break-in features when the transmitter and receiver are tuned to the same frequency.

1-5. Determine the convenience of installation and operation in Naval aircraft.

2-3, 2-16, 2-19. Note ruggedness of equipment under flight conditions, especially the cabinet. Make note of any parts, nuts, or screws that work loose under flight conditions and any joints that work loose where solder has been depended upon for mechanical strength. Note suitability of shock-proof mountings. In tuning unit 2-A note any instability due to loose contacts, etc.

2-10. Note any failure to parts during flight tests.

2-11, 2-16, 2-20. Note any damage to the equipment or tubes resulting from repeated landings of the plane or from vibration and shock. Note whether the wiring is properly supported to minimize changes in frequency, or output, or breakage due to severe vibration under flight conditions. Note that no damage to the

F42-1/52

5-8-35

tubes or delicate instruments results from shock or vibration encountered in flight.

- 3-1. Note that satisfactory CW, MCW, and voice modulated radio frequency energy can be obtained through any of the antenna systems specified. Transmit a group of 10 disconnected words while the Naval Research Laboratory and the Naval Air Station, Anacostia, are listening, to determine the intelligibility in accordance with par. 4-4 of ref. (b). Note that proper compensation has been provided to insure good voltage regulation of the power supply under flight operating conditions. Note generator type and serial number.

- (2) Note that the equipment can be properly installed in the tray provided in O3U scout planes.

- (4) In checking the performance of the plug-in units, make special note of the two following tests:

(a) under conditions of locked key, full power CW at approximately 4500 kilocycles on tuning unit D-2 note the frequency drift. Arrange to have the frequency checked by the Naval Research Laboratory during this test. (b) On tuning unit F-2, note the ability to draw full power output at 6200 kilocycles when using a low capacity antenna system. With a trailing wire antenna not exceeding 350 feet, note that approximately the following power outputs are available and check the frequency drift at the Naval Research Laboratory as per par. 3-21(2) of ref. (b).

<u>Frequency</u> <u>Kcs</u>	<u>CW, MCW</u> <u>watts</u>	<u>Voice Modulated</u> <u>Carrier</u>
350	85	60
525	100	75
1600	125	85
4235	125	85
6200	125	85

In a fixed antenna on the type O3U airplane note that the unmodulated carrier is at least 50 watts in the phone position on the following frequencies: 3300 kilocycles, 4235 kilocycles (6200 kilocycles on tuning unit F-2) and 9000 kilocycles. Make altitude flights up to 17,500 feet and test the equipment on full power, CW, MCW, and voice modulated.

- 3-6. Note the ability to operate all controls when wearing heavy gloves during flight.

F42-1/52

5-8-35

3-8,3-23,3-27. Note the convenience of shifting from trailing wire to fixed antenna and also operation characteristics with respect to power inputs and power outputs. Open circuit, short circuit, and ground the antenna at 17,500 feet and note that no damage occurs to any parts, meters or vacuum tubes when operating on full power.

3-9. Note that the transmitter will operate without the loading coil on all frequencies above 550 kilocycles.

3-10. Note that there is supplied sufficient side tone voltage under all operating conditions in flight.

3-11. Note that no open spark or arcing occurs that might ignite gas fumes and cause an explosion.

3-18. Note the filament, plate, or bias voltages when changing to and from CW, MCW, or voice transmission.

3-21. Note the time necessary in flight to set the equipment in operation on any frequency by means of a Type 74015 frequency meter.

(1) Note time and accuracy of reset using recorded calibration data.

4-7. Note that the method of reducing power by varying the antenna coupling adjustment is satisfactory.

4-8. Note that the antenna loading coil is suitable for adjusting to any frequency between 350 and 550 kilocycles in flight.

3. Any additional flight tests not outlined above but considered advisable should be included in the final report.

4. The Naval Research Laboratory will establish radio communication with the airplane during these flight tests and assist in making measurements.

/s/ H. R. GREENLEE.

Copy to: BuEng.

(C O P Y)

N.A.S. ANACOSTIA.

MEMORANDUM FOR BuENG CONFERENCES, 22-23-24 May 1935.

Subject: Desirable Changes in Model GP Equipment.

- a. Antenna reel unsuitable in following respects:
 - 1. Holes in mounting bracket inaccessible for holding nuts or screw heads: bracket should be enlarged with outward flanges carrying mounting holes, preferably spaced on square 4" between centers.
 - 2. Excessive axial strain on one ball bearing transmitting locking brake pressure (easily exceeds 1,000 pounds).
 - 3. Gears easily jammed and broken when slipping reel drum in place; counter mounting too fragile (weak mycalex).
 - 4. Single screw counter head mounting allows misalignment.
 - 5. Brake knob locking screw easily lost when removing knob.
 - 6. Tendency to arc between antenna wire or reel drum and winding handle securing screws.
- b. Transmitting key has over 1/16" backlash due improper pinning.
- c. Conductors in connecting cables too finely stranded and not tinned.
- d. Antenna loading unit too deep with mounting holes on side only; mounting strips desirable interchangeable between back and either side.
- e. Preliminary Instruction Books totally inadequate for final issue; suggest following CM or similar form.
- f. Keying relay has insufficient clearance and insulation for altitude operation and should be modified for improved break-in operation without antenna contact chatter or excessive clicking in phones.
- g. Modified side tone system (across 20 ohm resistor connected directly across headsets) should be adopted to prevent excessive receiver signal when receiving approximately on transmitted frequency.
- h. Insufficient attenuation obtainable by pilot's and operator's volume control rheostats. (For better accomplishment of items (g) and (h) recommend Navy waiving requirement for operation with 20,000 ohm headsets, restricting use to 600 ohm phones).
- i. Insufficient P.A. socket clearance for high altitude operation.
- j. Increase safety margin on power pack bleeder resistors.

Subject: Desirable Changes in Model GP Equipment.

- k. Avoid use of vitreous enameled high resistors on mica cards.
- l. Mercury vapor rectifier tubes cause appreciable receiver "mush" and appear unsuited to normal acrobatic maneuvers (mercury may spill on filaments).
- m. Complete protective cover plate needed on under side of transmitter.
- n. Present antenna ammeter (0-5 amp) goes off scale on certain fixed antenna frequencies, while giving only moderate deflection on harmonic H.F. operation with trailing wire antennas; double range meter, 0-3-9 amps. with push button for reading 3 amp. scale appears very desirable; should have specially rugged aviation type pivots and hairspring, and preferably be tropically treated against moisture.
- o. P. A. plate milliammeter is insufficiently damped; should have aviation type rugged movement and preferably tropically treated.
- p. "E Box" fails to resonate specified fixed antenna between 4500 and 4600 kcs.
- q. "F Box" fails to resonate specified fixed antenna between 6200 and 6345 kcs., and between 8675 and 9050 kcs. Recommend use of shorter antenna than specified, in order to meet upper frequency limit, and require contractor to provide additional necessary loading inductance to resonate on lower frequencies.
- r. Vacuum type fixed antenna series condensers should have elements more rigidly supported inside, and should be mounted more substantially. Increase in F Box from 19 to 25 mmf appears desirable if practicable.
- s. Antenna coupling controls E not properly aligned to zero setting on all boxes.
- t. Antenna tuning controls G on all boxes need end stops to avoid setting off scale.
- u. Handles on tuning boxes are placed too high for proper insertion or withdrawal against friction of connection plugs and gate switch, and don't allow space for finger when wearing heavy gloves.

Subject: Desirable Changes in Model GP Equipment.

- v. M.O. and P.A. tuning dial lock knobs on coil boxes are placed too low for operation with heavy gloves (less than 1" between knob and bottom).
- w. Coil box calibration charts not waterproof from above.
- x. Far end of mounting channels should be flanged over to prevent transmitter sliding too far in.
- y. Detachable transmitter retaining lock strips too difficult to insert and will become lost in service.
- z. Removable portion of transmitter case above tubes should not be fastened with screws and nuts account excessive time and ready loss of screws and lock washers in service; suggest hinge and/or snap slides or knurled head, non-looseable screws.
- a'. Internal bulkhead between tubes and coil boxes should be stiffened.
- b'. Two extra clips for spare fuses desirable in fuse compartment; no extras provided for at present.
- c'. Coil unit retainer screws bind inside some of the carrying cases.
- d'. Snap slides don't function properly on some coil carrying cases.
- e'. Coil unit carrying cases are unnecessarily large and many airplanes will have insufficient space for them; present length overall 12-7/16", width 10-29/32", and height (exclusive of handles) 9". Suggested redesign to shallower and smaller box, with deeper overlapping cover, would save about 3/4" in length, 3/4" in width and 3/4" in height (exclusive handle).
- f'. Red line desirable at 210 m.a. mark on P.A. plate meter.
- g'. Recommend marking front panel of external loading unit: "Disconnect at all frequencies above 540 Kcs."
- h'. Knurled nuts on ANT, GND, and REC binding posts are easily lost; make non-detachable; also on external loading unit binding posts and on antenna reel.
- i'. Provide second connector prong with binding post on antenna reel, opposite present post, for continuation of circuit to fairlead upper bell.

Subject: Desirable Changes in Model GP Equipment.

- j'. Desirable to increase fixed portion of compensating capacitor by approximately 2 micro-farads to take care of generators and speed adjustments in service.
- k'. If requirement for 20,000 ohm phones is dropped, voltage range of side tone transformer taps may be reduced accordingly.
- l'. For contractor's information, following average values of side tone and ICS desirable, using two pairs of 600 ohm phones with maximum volume in each control box:
 - CW and MCW telegraph side tone: 2.5 volts Radio Telephone side tone (sustained peaks) 3.5 volts.
 - ICS Interphone voice communication (sustained peaks) 4.0 volts.
- m'. Ask contractor's comment on antenna series tuning capacitor instead of variometer in boxes D, E and F.
- n'. New type wiping detent switch like contractor's sample appears desirable in place of original type.
- o'. M.O. and P.A. tuning indices admit water through coil box windows; Is any water which enters drained off? Suggest protective shallow escutcheon eaves above window.
- p'. Interior of transmitter very inaccessible for servicing; should be improved.

/s/ M. P. HANSON,
Associate Radio Engineer.

(C O P Y)

N.A.S. ANACOSTIA,
13 June 1935.

MEMORANDUM for Lieut. Cogswell, BuEng.

Subject: Additional preliminary notes on Model GP tests.

1. As stated at the BuEng conference re GP equipment, it was not possible for me to submit in full our recommendations and list of troubles encountered, inasmuch as Anacostia's tests had not been concluded. Herewith is submitted additional comment on GP equipment, based upon final tests and measurements:

1. ANTENNA REEL:

- a. Fouling of wire: Unless fairlead is perfectly lined up, wire gets tangled up account piling up on one side and at intervals falling off in wide winding section. Reel was found to hold over 1,000 ft. of model J wire; recommend narrowing down winding section from present 1-1/2 inches to 1-1/4 inches; any reduction of section should be made on side toward operator so as not to move effective center line any further from bulkhead than necessary.
- b. Antenna reel does not protect operator sufficiently from skin burns at altitude. More protection required at 3 places; Rivets near edge of cover plate; three isolated screws holding cover plate; winding handle.
- c. Winding handle securing screws are not positively locked.
- d. Center plane of winding channel is non-standard (too great) distance from bulkhead, making reel non-interchangeable. Should be same as - 71001-A reel, approximately 2-5/8 inches.
- e. Slightly more creepage distance on reel insulation plate appears desirable for altitude work.

2. TUNING UNITS:

- a. Window openings for "A" and B should be raised about 1/8" or numbers behind them lowered; very difficult to read these settings in low transmitter installations.
- b. Present tuning control letter designation are inconsistent; recommend altering to make "A" the M.O. tap, "B" the M.O. Dial, "C" the P.A. tap, and "D" the P.A. dial adjustments.

3. NON-STANDARD COMPONENTS:

- a. Microphone cables are longer than standard.
- b. Key knob and guard are obsolete heavy molded type, too large.
- c. Key lacks required inner and outer protective finish.
- d. Key base mounting holes too small.
- e. Antenna fairlead is of black instead of natural color bakelite.
- f. Antenna fairlead upper bell brass instead of bronze.
- g. Antenna weight swivel large, but desirable for strength.
- h. Antenna weight "S" hook too weak and resulted in loss of weight during flight; this link should be omitted.

MEMO - ANACOSTIA, D.C. -2

4. ANTENNA RELAY:

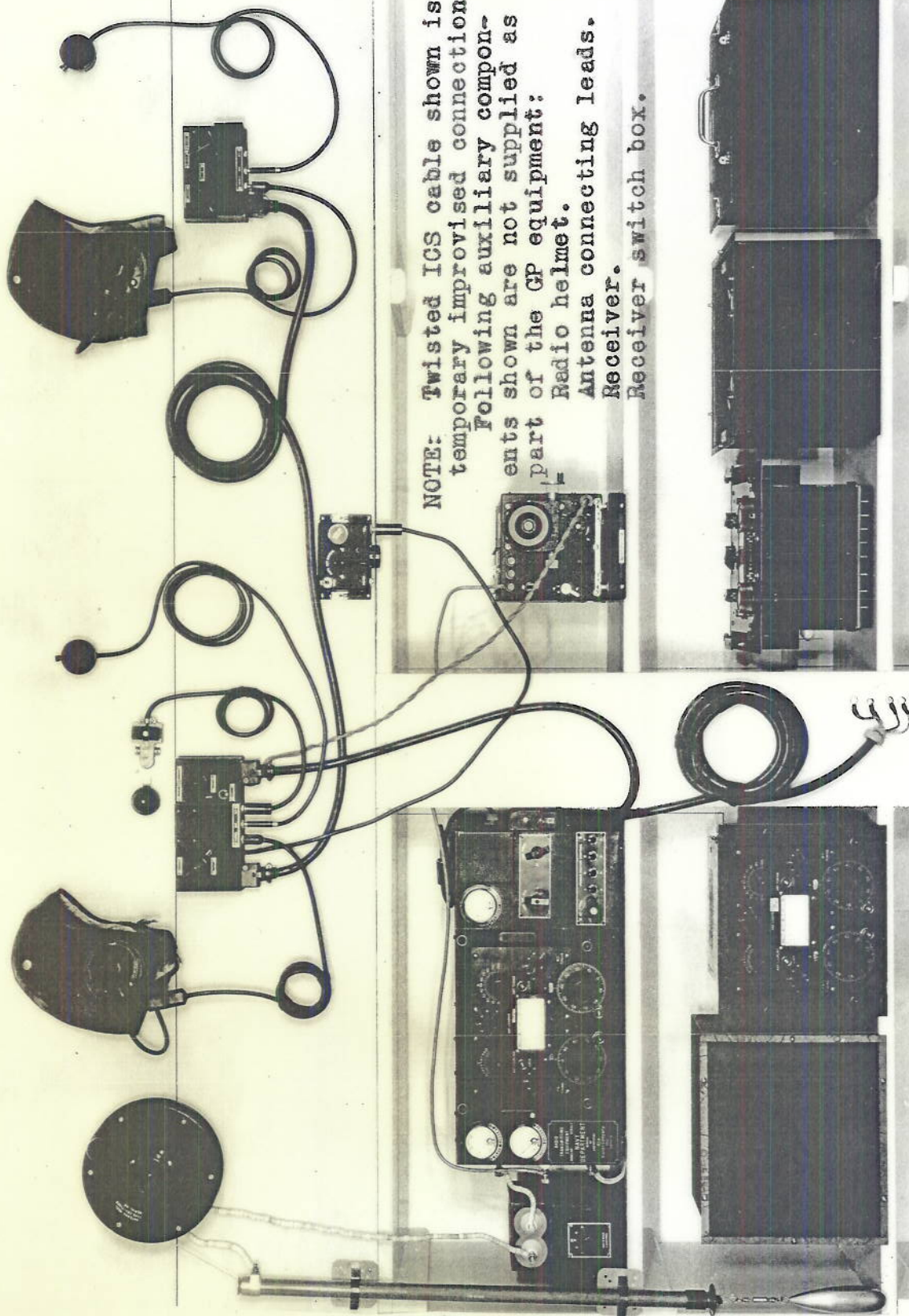
- a. Probably still has insufficient clearance; transmitter still flashes over internally above 10,000 feet altitude.
- b. Receiver contacts bounce and chatter every time key is released to "UP" position. This is easily noticed when keying with transmitter in "Stand-by/off" position, and may be responsible in part for long receiver recovery time and keying noises.

5. CABLE LENGTHS; Following ultimate lengths are recommended:

- a. Power supply cable: 6 ft.
- b. Pilot's extension control cable: 8 ft.
- c. Additional Extension control cables: 6 ft.
- d. Transmitter main control cable: 4-1/2 ft.
- e. Cord to rec. switch box: 4-1/2 ft.
- f. Cord to Rec. ICS jack: 4-1/2 ft.
- g. Microphone cord: St'd. length (46"?)
- h. Key cord: 6 ft.

cc. Mr. Coleman, RCA

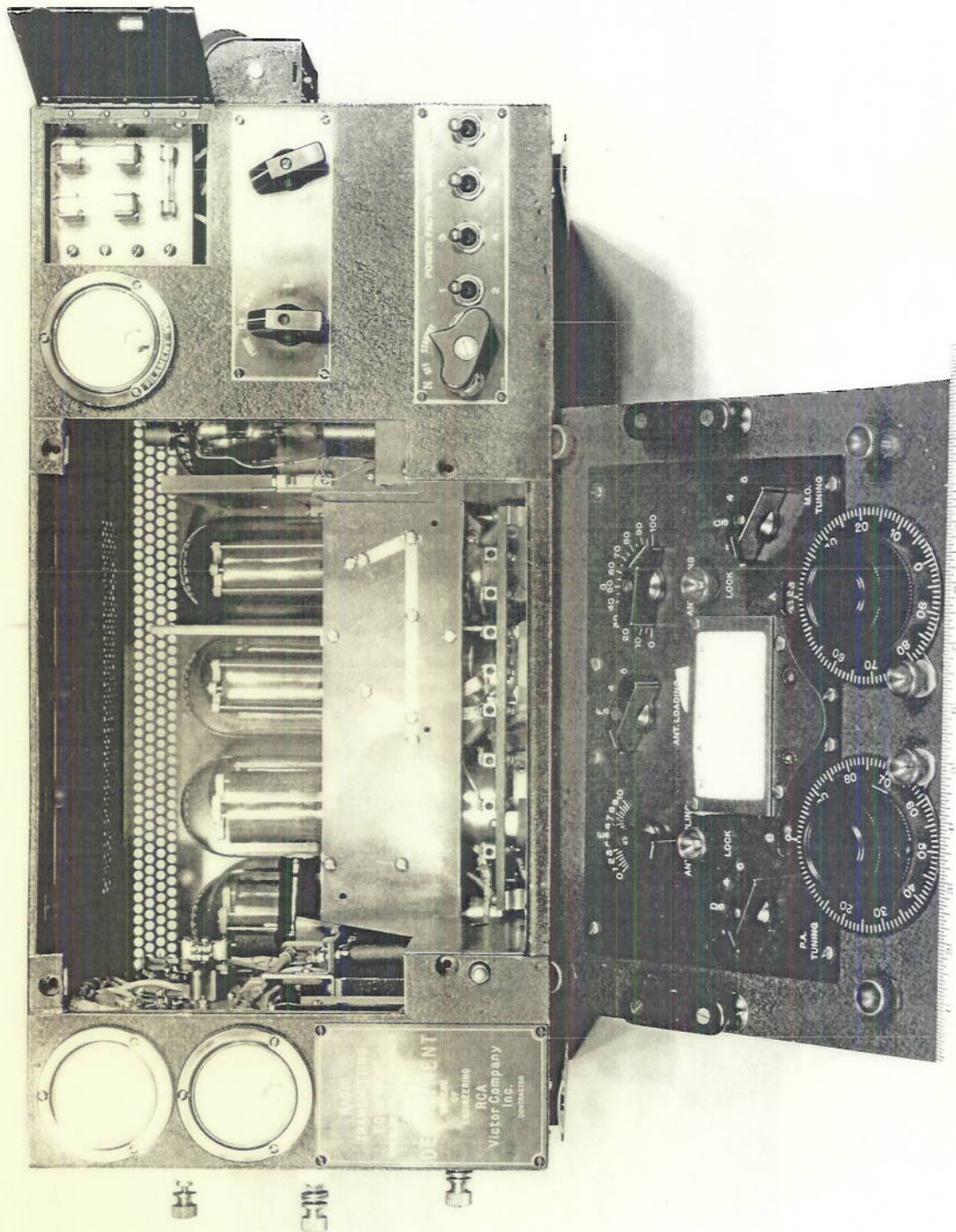
M. P. HANSON,
Radio Test Section.



NOTE: Twisted ICS cable shown is temporary improvised connection. Following auxiliary components shown are not supplied as part of the CP equipment:

- Radio helmet.
- Antenna connecting leads.
- Receiver.
- Receiver switch box.

Preliminary model CP radio equipment. 6-3-35 AN-33472 OFFICIAL NAVY PHOTOGRAPH
Interconnected mock-up view of units. NOT TO BE USED FOR PUBLICATION



Preliminary model GP radio equipment. 6-5-35 AN-33476 OFFICIAL NAVY PHOTOGRAPH
 View of fuses with fuse door open, and of tubes NOT TO BE USED FOR PUBLICATION
 with tuning unit removed.



Preliminary model GP radio equipment. 6-5-35 AN-33477 OFFICIAL NAVY PHOTOGRAPH
Rear top view with portion of case removed. NOT TO BE USED FOR PUBLICATION