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NAVY DEPARTMENT
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Report on

Model CO Production Set,
Serial #33
Hygrade Sylvania Corporation

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Appendix A - NAS Anacostia Report RT-3

AUTHORIZATION

1. This problem was authorized by Bureau of Engineering letter reference (a). There are listed four additional references, (b) to (e), pertinent to the problem.

Reference: (a) Bu.Eng.let.F42-1(9-7-W3) of 19 September 1934.
(b) NRL Report No. A-1056 of 31 May 1934.
(c) NAS Anacostia Report RT-3 of 12 March 1935.
(d) Specifications RE 13A 472A.
(e) Hygrade Sylvania Instruction Book for Model
GO Transmitting Equipment.

OBJECT OF TEST

2. The object of the test was to determine the performance of a production Model GO transmitter manufactured by the Hygrade Sylvania Corporation on Contract NOS32109, with particular reference to compliance with the changes recommended in the two preliminary sets submitted for acceptance tests as reported by reference (b).

ABSTRACT OF TEST

3. A check of the recommended changes made in paragraph 29 of reference (b) was supplemented by further investigations of the transmitter power output, voltage regulation of the rectifier, relay action, noise levels for reception and keying, and side tone level in connection with break-in operation.

CONCLUSIONS

- (a) The changes recommended in reference (b) have been met satisfactorily.
- (b) Performance of Model GO transmitter, Serial No. 33, as determined by the Naval Air Station, Anacostia, D.C., in flight tests, reference (c), and by bench tests at this Laboratory, is not satisfactory for service use.
- (c) The noise level in the head phones for both key up and key down positions is generally excessive when listening with a Model RU-2 receiver adjusted to maximum gain and sensitivity for the particular antenna conditions.
- (d) Means to reduce the noise level in the key up position is essential for satisfactory break-in operation when using the same antenna for transmitting and receiving.
- (e) Better relay action is desirable. The 800 cycle supply does not appear desirable for energizing the relay solenoids.
- (f) A reduction of the noise level in the key down position is desirable.
- (g) Satisfactory rated output from the transmitter requires a voltage of 130 from the 800 cycle generator, whereas the normal supply for an airplane installation is 120 volts.
- (h) The regulation of the power supply is not as good as that of the preliminary models, which results in somewhat reduced transmitter output.
- (i) Evidence of poor workmanship was found, in that the side tone potentiometer was incorrectly wired into the circuit and damaged. This condition was partly responsible for poor side tone, as reported in paragraph 22 of reference (c).
- (j) Reset accuracy is good.
- (k) The MCW and CW note is good.
- (l) In general, the equipment is well constructed and rugged.

RECOMMENDATIONS

It is recommended:

- (a) That this equipment be considered unsatisfactory for service use until the manufacturer reduces the interference to the receiver in the key up position. This was accomplished in the transmitter under test by by-passing the side tone terminal with a 0.05 mfd. condenser.
- (b) That the following considerations be given to the requirements for future equipment of a similar nature.
 - (a) Key in the primary of the plate transformer, if mercury type rectifier tubes are used.

- (b) Increase the contact pressure of all relay contacts to a minimum of 3 oz. per contact per 0.1 sq.in. of contact cross section.
- (c) Operate relays from uni-directional current instead of from the 800 cycle supply.
- (d) Provide means of eliminating or of nullifying the receiver r.f. pick-up in the key down position. This should be done by a method which will largely suppress the key clicks at the same time.
- (e) Use high vacuum type rectifier tubes if at all practical.

MATERIAL UNDER TEST

4. The tests covered in this report were made on a Model GO transmitter, Serial No. 33, manufactured by the Hygrade Sylvania Corporation under Contract 32109. A single complete equipment consists of:

- (a) Power Unit, Type CHS-23026.
- (b) High frequency transmitter unit, Type CHS-52020.
- (c) Intermediate frequency transmitter unit, Type CHS-52021.
- (d) Antenna reel, Type CHS-71001-A.
- (e) Antenna weight, Type CHS-71003.
- (f) Telegraph key, Type CHS-26003-A.
- (g) Side tone connecting cord.

METHOD OF TEST

5. It was possible to determine by inspection, compliance or non-compliance with most of the recommendations made in paragraph 29 of reference (b). For convenience, these recommendations are repeated herewith.

- (1) Reduce the frequency drift on the intermediate frequencies.
- (2) Provide sufficient insulation on the power transformer terminal board to prevent arcing at altitudes up to 17,500 feet.
- (3) Provide a safety gap on the power transformer.
- (4) Ground one side of the A.C. line.
- (5) Provide a radio frequency by-pass across the power transformer primary.
- (6) Shield the relay coils.
- (7) Shield the key lead.
- (8) Change the vacuum tube sockets to correspond to the sample submitted by the contractor.
- (9) Provide a stronger shock mounting on the top of the units.
- (10) Provide a coupling for the shock mountings so that the removable portion may be secured in place before mounting the transmitter.
- (11) Replace the present type filament rheostat with a more rugged type, such as the "Chmite".
- (12) Cut down the size of the tuning knobs on all control cranks.
- (13) Provide identification markings to distinguish between the tuning knob and the lock on controls "C" and "E" of the intermediate frequency unit.
- (14) Shorten the pointers on controls "A", "C", "D", and "F".
- (15) Remove the CFI binding posts.
- (16) Provide an additional cross member on the left side of the high frequency transmitter frame and fasten the side to the cross member by means of latches.
- (17) Use stronger isolantite supports for the intermediate frequency antenna loading coil.
- (18) Relocate oil holes on the tuning coil contact arms.
- (19) Use flat washers under lock washers at all points where the wire is bent around the screw for contact.
- (20) Use smaller nuts for securing the latch studs.
- (21) Increase the capacity of the high frequency antenna condenser to eliminate the fixed parallel capacitor.

6. Those items requiring verification by test were treated as follows:

(a) The frequency drift measured at 355 kilocycles and 544 kilocycles for 1/2 hour on the intermediate frequencies was key locked, full power, by the standard frequency equipment.

(b) An altitude flight was conducted up to 18,500 feet, reported in reference (c).

7. Standard laboratory type instruments were used throughout so far as applicable. The photronic cell and lamp load employed to measure radio frequency output from the transmitter constitutes one of the most accurate methods available at present to make such measurements. A curve is made of the currents generated by a photronic cell due to the light excitation from known inputs to an incandescent lamp, as measured by an accurate wattmeter from a 60 cycle source or by high grade d.c. meters from a d.c. source. Corresponding currents through the photronic cell caused by radio frequency current through the lamp is taken to indicate the equivalent energy dissipation by the lamp.

8. Output levels of noise from the receiver were measured by a General Radio output milliwattmeter. Care had to be used on all such noise level tests to make sure the receiver was accurately adjusted by the antenna capacitor to maximum sensitivity for the antenna and receiver conditions obtaining at the given time. Failure so to do gave wholly false results.

9. Data for preparation of Plate 6, curves of operation of the rectifier, have been taken with a resistor load in order to permit the wide variation of values necessary to secure sufficient points to plot accurately. Since only the rectifier output is involved, resistance loading is satisfactory. Data of radio frequency performance on full, half, and quarter power at various frequencies were also taken. It is given as Table 6. Circuit diagrams accompany the curves and data tables.

10. A number of oscillograms show the current wave forms in different parts of the circuit. The value and wave form of current flow through the 866 rectifier tubes were investigated especially.

11. Much of the work done has been undertaken as the result of difficulties arising during the flight tests, reference (c), and efforts to find their cause and remedy.

12. A list of the instruments used includes principally:

Wattmeter - Weston Model 310, Form 3, #5574.
Wattmeter - Weston Model 310, Form 1, #7934.
Voltmeter - Weston Model 341, #710.
Ammeter - Weston Model 155, #28214.
Voltmeter - Weston Model 45, #40640.
Milliammeter - Weston Model 1, #32195.
Output Power Meter - General Radio Type 583-A, #67.

13. An especial effort was made to simulate, so far as practicable, aircraft conditions of grounding by mounting both the transmitter and the receiver with its battery and connecting cables on a large copper ground

sheet with soldered grounding connections to transmitter and receiver. The supply lead from the generator was fully shielded and carefully grounded to the motor generator base and to the copper ground sheet.

DATA RECORDED

14. The data recorded during these tests include:
- (a) Measurement of the intermediate frequency drift, Plate 1.
 - (b) Reset data taken during the flight tests, reference (c), reported under "Results".
 - (c) Noise level measurements, Tables 1-4.
 - (d) Relay contact pressure, reported under "Results".
 - (e) Oscillograms of keying transients, Plate 7.
 - (f) Oscillograms at various places in the 800 cycle circuits, Plates 8 to 11 inclusive.
 - (g) Curves of rectifier performance, Plate 6.
 - (h) Table of overall performance, Table 6.

PROBABLE ERRORS

15. The probable errors of the various measurements are as follows:

(a) Frequency drift	-	<u>+0.001%</u>
(b) Input power	-	<u>+1%</u>
(c) D.C. voltage	-	<u>+1/2%</u>
(d) D.C. current	-	<u>+1/2%</u>
(e) A.C. voltage	-	<u>+1%</u>
(f) A.C. current	-	<u>+1%</u>
(g) Audio output	-	<u>+10%</u>
(h) Radio frequency output	-	<u>+10%</u>

Meters (b) to (f) inclusive are standard Weston with a normal accuracy of 1/4 and 1/2%. This accuracy is probably not attained on the 800 cycle A.C. and pulsating D.C. measured, and slightly greater values of variation have been noted above. Low accuracy attaches to the receiver output measurements because of the instability of the signal level.

RESULTS

16. Intermediate Frequency Drift. Plate 1 shows the results of two 30-minute key locked, full power runs; the first at 355 kilocycles and the second at 544 kilocycles. The maximum change at 355 kilocycles was 140 cycles, equal to 0.04% and at 544 kilocycles it was 327 cycles, equal to 0.06%. But if allowance is made for the four-minute period required for the bimetallic capacitor to become adjusted, the maximum frequency drift over the 27 minutes following is only 117 cycles, or .022%. Such a procedure is necessary to make a fair comparison with the drift for 355 kilocycles, which was taken after that on 544 kilocycles and before the coil system had time to cool fully. The specification limit is 0.05%. Frequency correction for temperature change is obtained by a bimetallic capacitor so connected in the master oscillator circuit as to offset frequency change in it due to variations of temperature.

24. Reset measurements in flight, paragraph 3-27(1) of reference (d), are recorded in Table 5. In all cases except one they are well within the specified requirements.

25. Power Output. Power outputs are recorded in Table 6. From this table it will be noted that the measured power outputs are somewhat below that required by reference (d) and lower than the tests of the preliminary model, as reported in reference (b). However, taking into account a probable error of $\pm 10\%$, these outputs are satisfactory. It should further be noted that the measured outputs are consistently lower than should be expected from this transmitter.

26. Keying Relays. Serious difficulty is to be expected from service operation of the three keying relays. These relays use the 800 cycle supply to energize the solenoids. In spite of a 0.55 mfd. capacitor in series with the key lead to give better solenoid action, the pull is low. Table 7 and Plate 2 give comparative values of contact pressure for different types of solenoid excitation.

27. Arcing occurs across the hand key contacts unless a wide spacing is used. Such arcing results in a chattering at the contacts of the relays until a definite circuit break is made at the hand key contacts. The full line voltage used tends to accentuate such arcing and no capacitor by-pass or other means is practicable to suppress it because of the 800 cycle frequency.

28. A further factor unfavorable to good relay operation is the wide gap required on the antenna arms of the relays for direct break-in operation to prevent danger of an arc back from the antenna circuit across the antenna relay in the key down position. This factor has led to the use of an extension arm to carry the contacts so as to get a multiplication of the solenoid plunger travel, which in turn reduces the contact pressure in the same ratio as the arm is extended.

29. The combination of low solenoid pull inherent in the 800 cycle power supply and the reduced contact pressure from use of an extension arm, plus the arcing tendency at the hand key due to breaking full line voltage, produces a very poor keying system where a reliable keying system is highly essential. A definite demonstration of the failure to make satisfactory contact has been obtained numerous times when an excessive noise level from the receiver in the key down position was found due to intermittent, imperfect conductivity on the grounding contact of the antenna relay. An increase of pressure applied to this contact by a stick made a very great difference in the noise level. Rugged, reliable construction and operation of the keying relay is necessary to utilize efficiently the rest of the radio installation.

30. Tests were made of the relay pull for various types of power supply, as covered by Table 7 and Plate 2, to secure comparative values for 800 cycle, rectified 800 cycle and D.C. excitation of the relay solenoids.

31. While data are not at hand regarding values of contact pressure advisable, it would seem that a minimum value of 3 oz. per contact per 1/10 sq.in. is desirable and this value is recommended as the minimum to be required in the future for transmitter relays.

32. The many advantages of unidirectional current over A.C. for the excitation of keying relays in the pull obtainable and the ease of filtering for reduction of key clicks renders its use very desirable. Available power sources for an airplane installation are the battery, metallic rectifier from the 800 cycle generator and tube rectifier from the 800 cycle generator. The battery source requires extra leads. The metallic rectifier is heavy and the rectifier tube requires a separate filament winding. Of the three, the battery supply is most logical source. It requires only the two extra leads. In case it is essential to utilize the 800 cycle source, the tube rectifier seems less objectionable than the metallic rectifier unless a special lightweight unit can be procured.

33. Noise Level - Key Up for Receiving. Reference (c) reports in paragraph 10 that break-in reception was found impossible. Numerous tests verify such a conclusion. Tables 1 - 4 give some measured results and bear out other tests made with the phones only. Great variation occurs constantly in the noise output, but the consistent fact stands forth that break-in reception is not practicable with the conditions secured during the series of tests here reported. For Table 1, the field lead was not shielded nor was there a filter battery connected to the exciter. Table 2 used another generator with full shielded leads, control box, and battery filter, but the transmitter and receiver were on wood supports. Table 3 is the same as Table 1 except that the field leads are shielded and the filter battery connected to the exciter and Table 4 has the same conditions as for Table 1 with special care taken to tune the receiver to maximum sensitivity.

34. In all four tables, Column A is the condition with the filaments of the transmitter tubes lighted but the plate switch off (primary of plate transformer open so that no voltage is applied to the type 38166A rectifier tubes); Column B is with the plate switch on and sending key up, which causes the rectifier tubes to operate through the bleeder resistor of 86,000 ohms, but current through the type 38160 tubes is blocked. This constitutes the normal receiving condition; Column C is key down and side tone potentiometer turned back to minimum; Column D is the same as Column C but with the side tone turned on full.

35. Equally effective noise reduction was obtained by opening the transformer secondary at the caps of the rectifier tubes as by opening the primary of the transformer. Removing the receiver antenna lead from the "receive" post on the transmitter had very much the same effect as opening the power transformer primary. Considerable pick-up was secured on the receiver antenna lead by touching it to points on the transmitter frame, the signal increasing with distance from the ground plate.

36. From these and other tests, the conclusion was further supported that radio frequency from the rectifier tubes caused the interference. Passing to all points of the transmitter by conductive and by capacitive effects, a direct RF voltage is impressed on the exposed parts of the receiver antenna lead which blankets any normal external signal in the key up position so long as the rectifier is functioning. Since the bias system of keying is used, with the rectifier tubes active continually through the bleeder to secure better regulation of the high voltage, there is at all times, when the key is up, a feed of radio frequency energy into the receiver from the transmitter. No method of eliminating this radio frequency feed from the rectifier has been found except that of stopping all current flow through the rectifier tubes.

The simplest means to this end is keying in the primary of the plate transformer.

37. It is pertinent to note at this point that the Model GO is the only transmitter of the patrol plane class with bias keying. The Model GH, Model GH-1, Model GI and Model GO-1 all use keying in the primary of the plate transformer. While this method sometimes causes lilt in the transmitted signal, on the other hand it definitely assures reception free from transmitter interference.

38. A further examination of Tables 1 to 4 shows a very high noise level for the key down position, which accounts in part for the lack of side tone reported in paragraph 22 of reference (c). Another complication found later was a misconnection of the side tone potentiometer which caused an open with an apparent intermitten contact across the break. A great improvement in the side tone was noticed when this potentiometer was replaced and properly connected.

39. Measurement of the side tone voltage by a Weston Model 341 voltmeter, 0 - 30 range, having a resistance of 296 ohms, taken directly across the side tone terminals of the power transformer with the transmitter adjusted on 4,000 kilocycles, gave the values of Table 8.

40. In order to utilize the sensitivity of present aircraft receivers, it would seem essential to keep the noise level in the phones below a value that dulls the sensitivity of the operator's ears. Since the sensitivity of the Model RU-2 and RU-3 receivers is so great, means should be incorporated in such receivers or in the transmitter to nullify the radio frequency receiver stages in the key down position so that the receiver will be responsive to RF excitation only in the key up position. Any such arrangement should also be made to reduce greatly or to eliminate from the head phones the noise of key clicks. The operator would then be able to utilize his full capabilities for reception and with the minimum of discomfort. One possible method is a relay in the receiver system operated from the transmitter keying system to open the plate supply to the radio frequency tubes in the transmitter key down position.

41. 800 Cycle Voltage Input. Paragraph 13 of reference (c) states that a steady voltage of 120 was delivered by the generator to the transmitter and paragraph 26(a) recommends an increase in value of the power factor correcting capacitor. The Sylvania instruction book lists the input voltage as 130 for all their type performance and tuning data. Bench tests on set #33 indicate that an even higher voltage, as 135, is desirable for good output. The higher input voltage also gives better operation of the transmitter. With 130 volts input or greater, the 11 mfd. in the power factor correcting capacitor has been found adequate on all bench tests to give good filament regulation.

42. Since the filter battery with control box tends to keep the generator voltage at a normal value of 120, it would seem advisable for the Model GO installations to utilize some method which will maintain the voltage from the generator to the transmitter at 130 volts or slightly higher or else to modify the plate transformers for the lower input voltage. Otherwise the output will be low necessarily and operation tend to be unsatisfactory, as reported in reference (c).

43. Rectifier Tubes. Substitution of the high vacuum type of rectifier tubes for the mercury type of rectifier tubes is desirable in future equipment. The inherent qualities of the mercury type which set up radio frequency oscillations in the rectifier circuit are a great disadvantage where receiving and transmitting means are so closely associated as is necessary in airplanes.

44. Oscillograms. A group of oscillograms taken to determine accurately conditions in various parts of the circuit are shown on Plates 8 to 11 inclusive. Plate 3 gives the circuit diagrams. An "X" indicates the part of the circuit where the oscillogram was taken. Table 9 gives the generator current, voltage and power for each oscillogram and the rectifier voltage across the load. The peak value of current recorded on the oscillogram is stated in the column marked "Peak Amps".

45. Plate 8 was taken at point "D" of Plate 3 to determine the wave form and maximum value of the current through the type 38166A rectifier tubes for regular operating conditions. This is with the condenser connection to point "Q", forming an inductive filter so as to put a definite limit on the peak current through the tube which can be drawn by the filter capacitor.

46. The records of Plate 8 are directly comparative. They show the effect of varied power input to the plate transformer. Film #2A is full power, film 1B is half power, and film 1C is for quarter power output from the transmitter. Plate 9, films 2B and 2C show the effect of changing the filter capacitor connection to "P", thus converting the filter to the capacitor type. This connection gives better power output from the rectifier and from the transmitter at the cost of a higher peak current through the tubes. Although the oscillograms show that a higher peak occurred at half power than at full power, being 0.33 and 0.32 amps, respectively, it is to be noted that neither value approaches the maximum peak rating of the type 38166A tube, which is 0.600 amp. The higher peak at half power than at full power results from the effect of directly charging the filter capacitor without the limiting effect of the choke on the initial surge of current.

47. Plate 9, film 3A, is similar to Plate 8 except that the filter condenser was open-circuited so as to get the ICW condition of operation.

48. Plates 8 and 9 were taken with a resistor load so as to make it possible to ground the rectifier circuit at "D". This was necessary to protect the oscillograph elements.

49. Plates 10 and 11, films 3C, 4A and 4B were taken at points "A", "B" and "C" respectively, of Plate 3, with normal transmitter loading at 3,000 kcs. to show the characteristics of and differences in the current form at these three points. This is the normal connection of the transmitter.

50. Plate 11, film 6A, is the MCW condition existing at "B" of Plate 3, secured by opening the circuit of the filter capacitor.

51. The straight line projection below the zero line on all films taken at "D" of Plate 8 is not definitely understood. It is believed to show the high frequency transient of the 366 tubes rather than a reversal of power current from the transformer.

52. Plate 5 is an elementary diagram of the Model G0 transmitter to show how measurements were made of voltage surges superimposed on the rectifier D.C. output caused by keying and by closing the primary of the rectifier (plate) transformer. A high value non-inductive resistance R1, R2 is connected from the plus D.C. high voltage to ground so as to receive the same instantaneous potentials as are applied to the filter capacitor and to the plates of the transmitter tubes. Taps are taken to the cathode ray plates across R2 of such value as to give a satisfactory deflection on the cathode ray tube. Any variation of potential impressed across R1, R2 is then reproduced exactly across R2 and recorded on the cathode ray tube.

53. Three transients were observed: (A) when the plate switch was closed energizing the rectifier from a dead condition, (B) when the transmitting key was closed (key down), allowing plate current to flow through the transmitter tubes, and (C) when the transmitting key was opened (key up), blocking off plate current through the transmitter tubes. The transmitter was adjusted to 8,000 kilocycles and full power. The voltage across R1, R2 measured 2600 key up and 2200 key down.

54. A graph of the key down transient traced by eye is reproduced in Plate 5. It was taken with care and represents generally the conditions obtaining. The key up transient was of much less amplitude, estimated at 400 volts above the key down position, giving a total voltage of 2600 for it. An amplitude about equal to or slightly greater than that for key down was observed when the "Plate On" switch was closed. This latter was especially difficult to estimate accurately.

55. Plate 7 gives photographs of these three transients taken with the transmitter adjusted to full power on 4000 kilocycles.

Input from generator	- 660 watts
Generator volts	- 130
R.F. output	- 118 watts
Plate volts key up	- 2500
Plate volts key down	- 2050

Measured values of the transients from Plate 7 are:

Key down - 910 volts above key down position or $2050 + 910 = 2960$ volts above zero.

Key up - 910 volts above key down position or $2050 + 910 = 2960$ volts above zero.

Plate on - 3600 volts above zero.

56. Although rather poor agreement exists between the observed values and photographed values for the transients, it is certain that transients do exist which impress momentary voltages on the high voltage D.C. plate supply network far exceeding the normal steady plate potentials.

57. Table 6, in connection with Plate 4, records data of current, voltage, and power in the input and output circuits for 1/4, 1/2, and full power at six representative frequencies covering the high and intermediate frequency bands.

58. The meter marked "I_p" is the "Plate Current" meter on the transmitter power unit. It reads higher than "A2" because the former includes the grid current in addition to the plate and screen grid currents, while "A2" measures only the high voltage current from the rectifier.

59. Performance of Generator and Power Unit. Plate 6 shows in the form of various curves the performance of the generator and power unit when the rectifier is loaded by a resistance and the generator voltage held constant.

60. In connection with the divergence between V₁, the generator voltage, and V₂, the input voltage to the plate transformer, it is interesting to note that the normal rating of the plate transformer is 125 volts, as given in reference (e). With a generator voltage of 120, the value to be expected for a standard airplane installation with voltage control box and filter battery, the voltage at the transformer for full power is likely to be less than 110, resulting in low transmitter output. That is equivalent to substitution of a smaller and less efficient transmitter for the Model GO without reduction of weight or other gain. Attention is invited to the transformer input voltages of Table 6 in this regard.

CONCLUSIONS

61. The changes recommended in reference (b) have been met satisfactorily.

62. Performance of Model GO transmitter, Serial No. 33, as determined by the Naval Air Station, Anacostia, in flight tests, reference (c), and by bench tests at this Laboratory is not satisfactory for service use.

63. The noise level in the head phones for both key up and key down positions is generally excessive when listening with a Model RU-2 receiver adjusted to maximum gain and sensitivity for the particular antenna conditions.

64. Means to reduce the noise level in the key up position are essential for satisfactory break-in operation when using the same antenna for transmitting and receiving.

65. Better relay action is desirable. The 800 cycle supply does not appear desirable for energizing the relay solenoids.

66. A reduction of the noise level in the key down position is desirable.

67. Satisfactory rated output from the transmitter requires a voltage of 130 from the 800 cycle generator, whereas the normal supply for an airplane installation is 120 volts.

68. The regulation of the power supply is not as good as that of the preliminary models, which results in somewhat reduced transmitter output.

69. Evidence of poor workmanship was found in that the side tone potentiometer was incorrectly wired into the circuit and damaged. This

condition was partly responsible for poor side tone, as reported in paragraph 22 of reference (c).

- 70. Reset accuracy is good.
- 71. The MCW and CW note is good.
- 72. In general, the equipment is well constructed and rugged.

TABLE 5.

Reset Measurements in Flight.

<u>Assigned Freq.</u>	<u>Original Setting</u>	<u>Reset</u>	<u>% Change</u>
355 kcs.	356.402	356.549	+0.04
544	542.186	542.233	+0.009
4135	4134.75	4134.81	+0.0014
8270	8279.32	8268.45	-0.131
12705	12704.02	12698.475	-0.043

TABLE 6.

Kcs.	Pwr.	A3	V2	W1	A3xV2	V3	A2	V1	I _p	Ef	A4	A1	Ant. Watts	Ant. Ser. Cap.	A2xV1
12615	.25	2.25	130	280	290	121	.100	1070	115	10	3.6			0	107
"	.5	3.15	130.5	400	410	123	.145	1430	165	10	3.8	4	35	0	207
"	Full	6.08	130.5	705	790	117	.235	2220	260	10	3.6	50.4	87	0	520
8470	.25	2.2	130	270	285	121.5	.095	1070	110	10	3.7			0	89
"	.5	2.9	129.5	365	375	120.5	.132	1410	150	10	3.6	4	35	0	186
"	Full	5.6	130.5	655	730	119	.210	2060	240	10	3.6	70	100	0	432
4205	.25	2.15	131	265	280	121	.087	1190	105	10	3.6			0	103
"	.5	2.9	130	360	380	118.5	.125	1410	145	10	3.6	11	48	0	176
"	Full	5.45	130.5	640	710	114	.205	2025	235	10	3.5	107	122	0	415
516	.25	2.15	129.5	260	280	118.5	.080	1060	100	10	3.6			.00035	85
"	.5	2.8	130	345	365	115	.112	1400	140	10	3.5	7	41	"	157
"	Full	4.8	130.5	550	720	107.5	.165	1970	205	10	3.4	58	92	"	324
440	.25	2.15	129.5	260	280	118.5	.080	1060	100	10	3.6			.00035	85
"	.5	2.8	129	345	445	115	.113	1400	140	10	3.5	4	35	"	158
"	Full	4.8	130	550	715	108	.165	1980	200	10	3.4	62	95	"	326
375	.25	2.15	130	260	280	120	.085	1060	105	10	3.6			0	90
"	.5	2.85	130	355	370	117	.118	1400	140	10	3.6	8	43	0	165
"	Full	5.02	130	585	760	110	.160	2000	215	10	3.5	85	109	0	320

Note: See Plate 4 for circuit diagram.

TABLE 7.

Contact Pressure of Relays.

A

Solenoid excitation	800 cycle 130 volts
Current for one relay coil	.39 amp.
Pull at A of Plate 2	3 oz.
Pull at B of Plate 2	2-1/2 oz.
Maximum pressure per contact	1-1/4 oz.

B

Solenoid excitation	Rectified 800 cycle using West- inghouse rectox unit style #575587A
Input to rectox	10 volts from filament supply of 860 tubes
Rectox output key up	9-1/4 volts by d.c. meter
" " " down	6 volts 1.7 amp. by d.c. meters
Current for one relay coil	.85 amps.
Pull at A of Plate 2	9-1/2 oz.
Pull at B of Plate 2	7-3/4 oz.
Pressure per contact	3-7/8 oz.

C

Volts	Solenoid excitation		Storage Battery	
	Amps. for One coil	Pull at A	Pull at B	Pressure per contact
1.95	.275	2.5 oz.	2 oz.	1 oz.
3.95	.575	7	5-3/4	2-7/8
5.8	.83	9	7-1/2	3-3/4

TABLE 8.

Side Tone Voltages

Primary Volts	Power Switch Position	Key up	Key down
130	1/4	14.0 volts	13.2 volts
130	1/2	18.5 "	17.3 "
130	Full	27.5 "	24.5 "

TABLE 9.

Oscillogram Data

Plate	Plate Volts	Generator			Power Switch	Fig.	Peak Amps.
		Volts	Amps.	Watts			
Plate 8, Film 2A	2200	130	4.9	595	Full	2-Q	.24
Plate 8, Film 1B	1530	127	2.7	350	1/2	2-Q	.16
Plate 8, Film 1C	1160	127	2.0	250	1/4	2-Q	.12
Plate 9, Film 2B	1960	129	3.7	470	1/2	2-P	.33
Plate 9, Film 2C	2540	140	5.95	710	Full	2-P	.32
Plate 9, Film 3A		129	4.65	570	Full	2-Q	.23
Plate 10, Film 3C	2050	130	5.45	640	Full	3(A)	.33
Plate 10, Film 4A	2050	130			Full	3(B)	.24
Plate 11, Film 4B	2050	130	5.48	640	Full	3(C)	.11
Plate 11, Film 6A	1970	130	5.24	610	Full	3(B)	.28

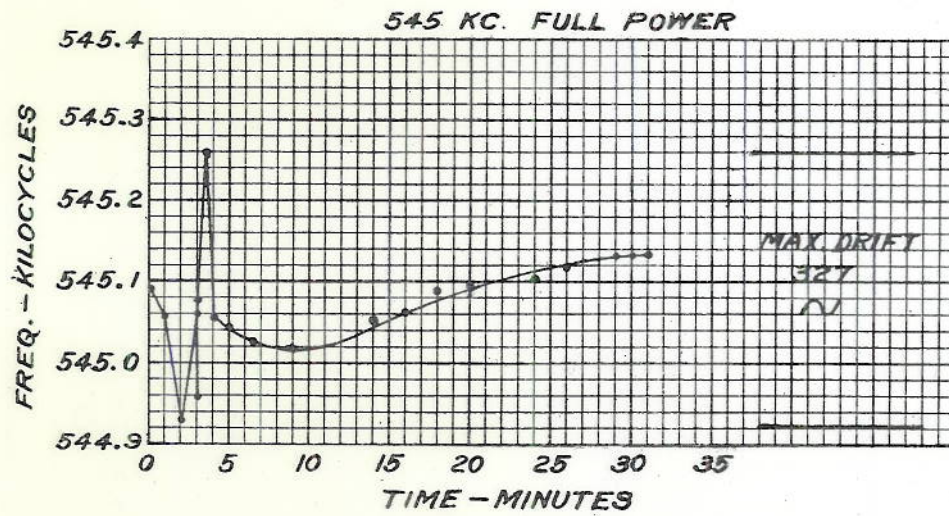
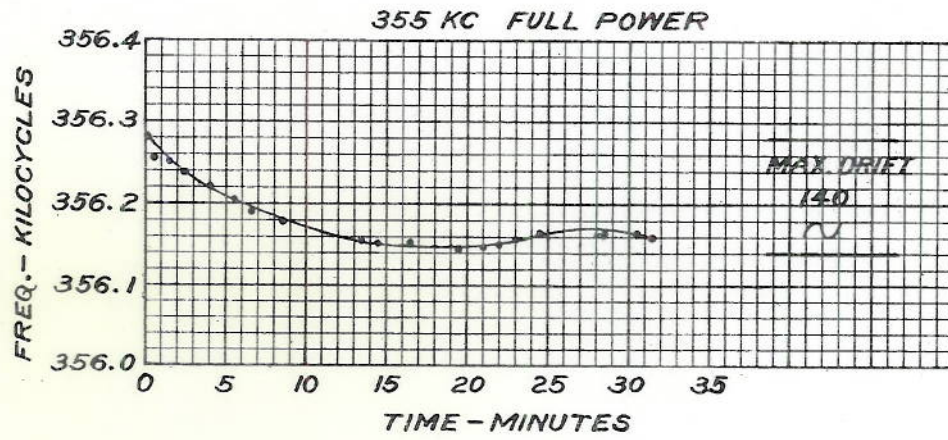
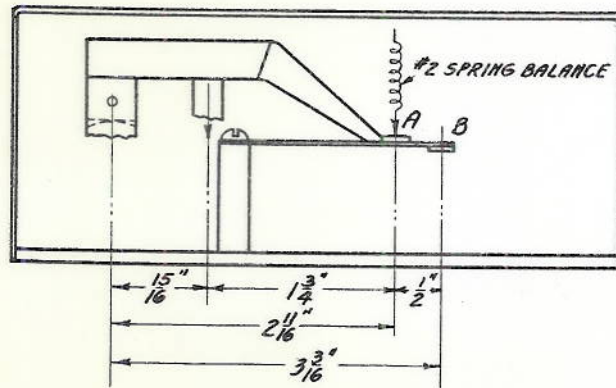
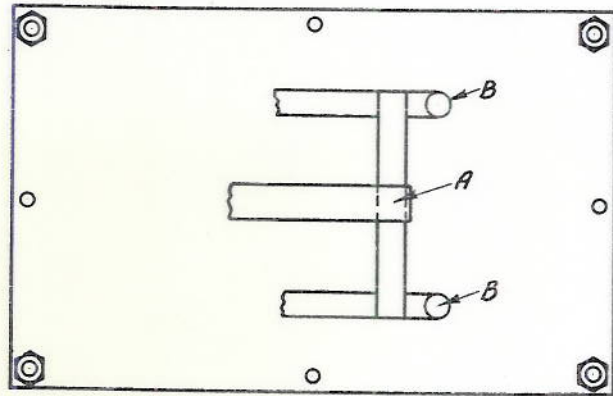


PLATE I



SKETCH OF RELAY ARM

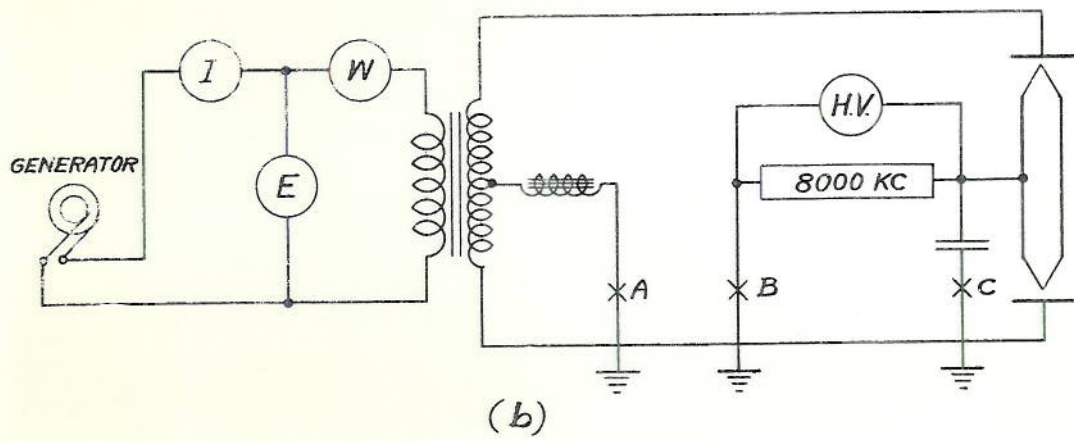
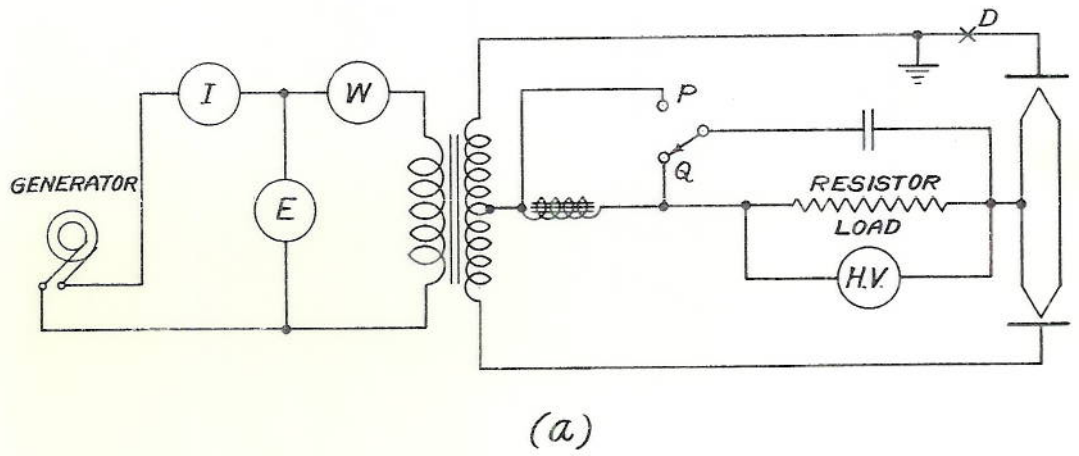


DIAGRAM FOR OSCILLOGRAMS

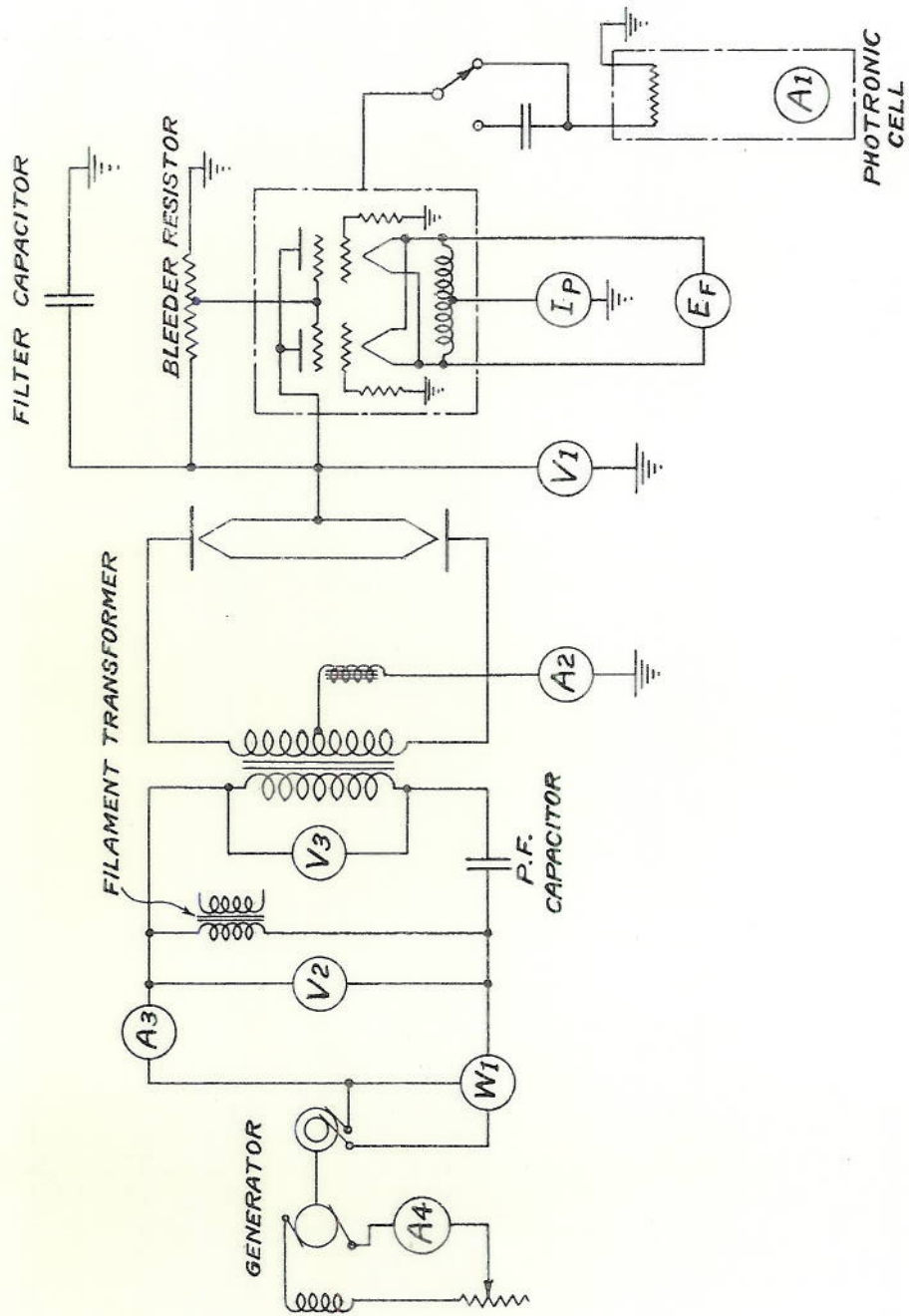
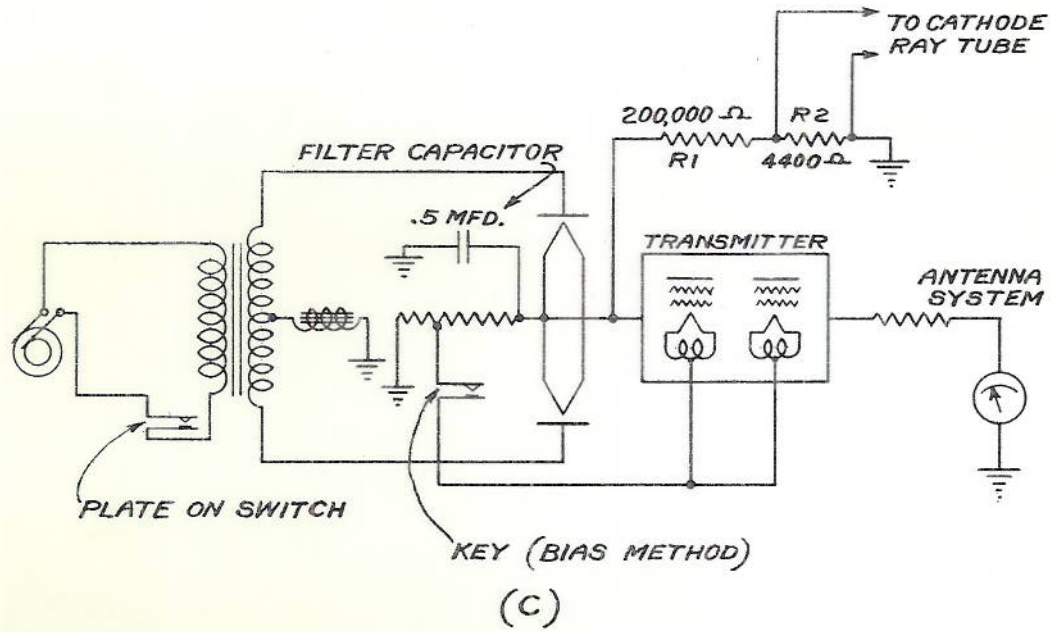
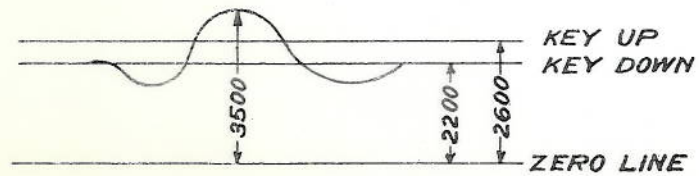


DIAGRAM FOR POWER DATA CURVES

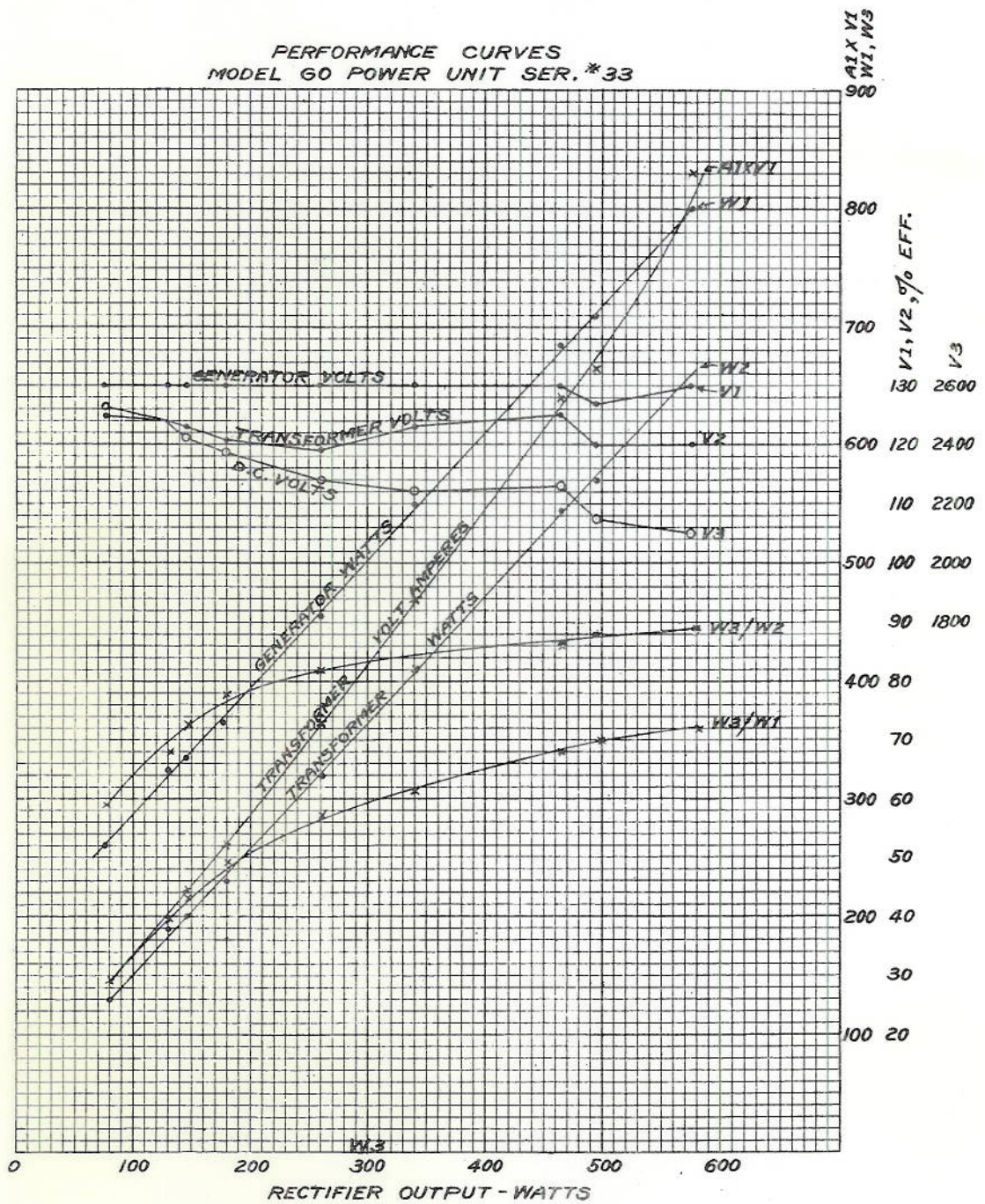


SCHEMATIC DIAGRAM FOR KEYING TRANSIENTS



KEY DOWN KEYING TRANSIENT

PERFORMANCE CURVES
MODEL 60 POWER UNIT SER. *33



APPENDIX A

12 March, 1935.

NASA Report RT-3

Navy Department
U.S. Naval Air Station
Anacostia, D. C.

Report on
FLIGHT TESTS OF
MODEL GO RADIO TRANSMITTING EQUIPMENT

Number of Pages: Text - 11; Appendix - 1;
Plates - 1.

Authorization: BuAero ltr. Aer-E-31-FAM, F42-1,
F1-5(1) of 27 Nov., 1934.

Dates of Test: 7 January to 1 February, 1935.

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

Reviewed by: _____
R. M. Signer, Lieutenant, U.S.N.
Radio Test Officer.

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

Distribution: NRL (2)
BuAero (2)
NAF (1)

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CONCLUSIONS AND RECOMMENDATIONS - - - - -	10
Memorandum regarding proposed flight tests and observations, by Naval Research Laboratory - - - - -	Appendix (A)
Photograph AN-33118, Installation in XRE-1 Plane- - - - -	Plate 1.

AUTHORIZATION:

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

OBJECT OF TESTS:

2. The object of these tests was to determine from examination, installation, and actual flight operation, the relative suitability of the model "GO" equipment for service use aboard Naval aircraft, and to indicate its compliance with certain requirements of the governing specifications.

REFERENCES:

3. The following references (a) and (b) served as guides in conducting the tests herein reported; references (c) to (f) constitute supplementary information referred to in this report.

- (a) NRL Memorandum F42-1/52 HRM/ts to NAS Anacostia, dated 8 January 1935, relative to test of model "GO" equipment, included as Appendix (A) herewith.
- (b) Instruction book for model "GO" radio transmitting equipment, supplied by Hygrade-Sylvania Corporation under Bureau Reg. 278-13X2, Cont. 32109, dated 30 June 1933.
- (c) NAS Anacostia report RT-2 on Model "LJ" frequency indicator, dated 12 February 1935.
- (d) BuEng. ltr. S67/74 (1-25-W3) to C.O., NAS, Anacostia, dated 29 Jan., 1935, with attached memorandum report on conference on "LJ-1" equipment, 24 Jan., 1935.
- (e) NAS Anacostia ltr. F42-1(21)/NA6 of 10 Jan., 1935, to the Chief of BuAero, regarding initial tests of type NEA-1A generator with type NF-1 regulator-filter box.
- (f) NAS Anacostia ltr. F42-1/52/NA6 of 7 Feb. 1935, to Director, NRL, regarding suggested improvement in side tone circuit of model "GO" transmitter.

ABSTRACT OF TESTS:

4. The model GO equipment (Serial No. 33) was delivered to the NAS Anacostia by a representative of the N.R.L. on 3 January, 1935. It was installed together with an RU-2 receiver and other incidental equipment in XRE-1 Ballanca cabin plane, No. 8938 on 7 January, 1935; this installation is shown in plate 1, herewith. Flight tests were made from 10 January to 30 January, 1935, on seven different flights aggregating approximately 18 hours. During a majority of these tests, two-way radio contact was maintained with the Naval Research Laboratory which directed the tests and made measurements and observations from

the ground. The GO equipment was examined and bench tested at Anacostia between some of the flights and after their final completion, and was returned to the Naval Research Laboratory on 1 February 1935.

5. In addition to observation of items (a) to (f) as requested by NRL under Appendix (A) herewith, particular attention was paid to determine the following points:

- (g) Operation in conjunction with model NEA-1a generator power supply and proposed model NF-1 regulator-filter unit.
- (h) General adjustments in flight, with various lengths of antenna.
- (i) Frequency adjustment and resetability in conjunction with both the model LJ and preliminary model LJ-1 frequency indicating equipments.
- (j) Observation of transmitter side tone.

EQUIPMENT UNDER TEST:

6. The equipment tested was a model GO radio transmitting equipment, serial No. 33, manufactured by the Hygrade-Sylvania Corporation (Electronics Department) of Clifton, N.J. under Bureau Requisition 278-13X2, contract 32109, dated 30 June, 1933. The equipment as received consisted of the following major units:

- (a) Power unit, type CHS 23026.
- (b) High frequency transmitter unit, type CHS 52020.
- (c) Intermediate frequency transmitter unit, type CHS 52021.
- (d) Antenna reel, type CHS 71001-A.
- (e) Antenna weight, type CHS 71003.
- (f) Telegraph key, type CHS 26003-A.
- (g) Side tone connecting cord with plugs.
- (h) Four vacuum tubes, type 38160.
- (i) Two mercury vapor rectifier tubes, type 38166-A.
- (j) Two heater units for type 38166-A tubes.

7. The GO transmitting equipment is designed to deliver 100 watts of telegraphically keyed energy, either by substantially unmodulated CW or modulated about 20 **per cent** at 1600 cycles, at a frequency from 300 to 600 kcs., and from 4,000 to 13,575 kcs., into a trailing antenna 125 to 500 feet in length. It is intended mainly for class VP airplanes as a successor to model GH and GI equip-

ments. The GO equipment uses a rectifier and power supply unit designed for normal 800 cycle operation from a type NEA-1 or NEA-1A generator. Like the GH equipment, the GO is provided on either side of the power unit with a self-contained radio transmitter, one for the high and one for the intermediate frequency band.

FLIGHT TESTS AND RESULTS:

8. Tests and results described from (a) to (f) hereunder refer to the correspondingly lettered subparagraphs in ref.(a) (Appendix A herewith); items (g) to (j) refer to additional observations listed in paragraph 5 of this report.

(a) Altitude Tests:

9. Altitude tests up to 18,500 feet failed to produce electrical break-down or flash-over anywhere in the equipment; full-power operation and output on both intermediate and high frequencies was unimpaired at any altitude within this range.

(b) Break-in Reception:

10. Transmitter operation interfered with proper reception in all frequency bands so that break-in operation was impossible except on very strong incoming signals. Use of a separate fixed antenna for reception only, with connecting leads kept well away from the transmitter, enabled break-in reception of moderately strong signals at frequencies appreciably removed from the transmitter frequency. Even with the antenna connection completely removed at the binding post on the receiver and the side-tone connection to the transmitter disconnected, transmission on 565 kcs. gave a strong mushy signal measuring 3 to 4 volts from the receiver tuned to 524 kcs. and adjusted for full gain.

11. Reception with the transmitter shut off was normal except for occasional noises due to chatter of the break-in relay under heavy vibration; more ready means for adjusting the relay tension appear desirable. When the rectifier plate supply was turned on (both "Power" and "Plate" switches closed), a disturbing mushy noise was produced in the receiver if adjusted at or near full gain. Electrical shielding and filtering of the side-tone connector cable gave only negligible improvement; use of a separate fixed antenna for reception, without passing near the transmitter, reduced the disturbance considerably. The following receiver noise level measurements were obtained in flight, measured at full gain across two 600 ohm headsets in parallel.

Freq. Kcs.	Receiving Antenna	Noise Volts	Plate Supply
530	Trailing, through trans.	5.1	ON
530	Trailing, through trans.	2.0	OFF
530	Separate fixed	1.0	ON
6000	Trailing, through trans.	3.2	ON
6000	Trailing, through trans.	0.9	OFF

(c) Transmitter Vibration Modulation:

12. Bad vibration modulation of the signal produced by the high frequency transmitter on the initial test flights was traced to the master oscillator tube which had a loosely supported internal carbon anode and an excessively long unsupported external pigtail (control grid) connection; interchanging this tube with the power amplifier tube and exercising care in a secure pigtail connection greatly improved the signal quality under vibration. Tapping or pressing upon the bulkhead of the high-frequency unit in flight had no noticeable effect upon the emitted signal. Detailed ground observations on the quality of signals transmitted by the airplane were made by the Naval Research Laboratory.

(d) Voltage Regulation:

13. Used both with the NEA-1 and the NEA-1A generator the (series) compensating condenser capacitance provided in the power unit was not quite sufficient even at its maximum value, so that the A.C. line voltage rose by two or three volts while depressing the key. The NEA-1A generator especially functioned very satisfactorily with the equipment, delivering practically a steady A.C. line voltage of 120 volts at steady engine speeds between 1600 and 1950 r.p.m. However, abrupt changes in engine speed during full electrical load were found to cause momentary instability of voltage. Thus, a sudden spurt from 1700 to 1950 r.p.m. caused the line voltage to drop from 120 to 90 volts for 3 or 4 seconds. Speeding the engine from 1700 to 1820 r.p.m. while holding down the transmitter key caused the voltage to drop momentarily from 126 to 115 volts. All foregoing voltage readings are relative only and may be in error by five to ten per cent, inasmuch as no indicating instrument suitable for flight use and calibrated on the alternator frequency and wave form was available.

(e) Shock Suspension:

14. Both the upper and lower shock mounting units appeared satisfactory and protected the equipment from undue vibration and mechanical injury both during various normal positions in flight and during take-off, landing, and taxiing on the fairly rough field.

(f) Resetability:

15. Resetability of the high-frequency unit was somewhat impaired by an undue reaction between antenna tuning or coupling and P.A. plate tuning, as described in paragraph 17; it also depended upon any limitations of the frequency indicator employed (see paragraph 21). Detailed frequency measurements in connection with reset and temperature drift were made by the Naval Research Laboratory.

(g) Generator Suitability:

16. The NEA-1A generator was found to be a suitable power supply for the CO equipment, with a flight performance described in paragraph 13, above. The preliminary model of the associated NF-1 regulator-filter box performed satisfactorily and in flight suppressed all noticeable A.C. ripple and radio-frequency disturbance effect from the generator upon the receiver.

(h) Flight Tuning Adjustments:

17. Tuning adjustments of the intermediate-frequency portion of the GO equipment in flight were made without undue difficulty; adjustments of the high-frequency transmitter unit, however, were found to be not only very critical, but also in conflict with the simple procedure set forth in the instruction book ref.(b), and were further complicated by illogical dial graduation and by mechanical defects in the adjusting mechanism.

18. The high-frequency band switch adjustment "A" had to be adjusted with care to the proper position as it lacked desirable end stops and the "clicker" detent action was too weak to insure satisfactory positioning. Antenna coupling control "D" in the high-frequency unit developed excessive shaft friction with binding and cutting which impaired facility of operation; the fact that this control is graduated to read 100 at minimum and 0 at maximum (capacitive) coupling will be a source of confusion in service, as will the counter mechanism of the antenna loading control which indicates a high value for no loading and zero for maximum (inductive) loading. Excessive friction and binding also developed in the antenna loading mechanism.

19. The high-frequency tuning procedure designated by the instruction book was found inadequate on short antennas and entirely unworkable on antennas of three-quarter wavelength or longer. The chief difficulty consisted of undue reaction upon the P.A. plate tuning adjustment by changes in the length, tuning, and coupling of the antenna; the value of antenna coupling also was found critical for any given antenna. Setting of the antenna tuning adjustment to a position giving peak plate current repeatedly failed to give an audible signal at a few miles distance; the peak was found to be due to de-tuning of the P.A. stage by antenna reaction. Proper output was obtained only after repeated progressive readjustment of P.A. tuning, antenna tuning (or length), and antenna coupling. When making initial antenna tuning adjustments on one-quarter power as recommended in the instruction book, frequently no resonance indication whatever was obtained, and the use of at least half power on the higher frequencies was found necessary.

20. In view of the high-range (0-5 amp.) antenna ammeter used in the high frequency unit and the small currents obtained in transmission with antennas more than one-quarter wave in length, this meter was generally of no aid in initial antenna adjustments to the vicinity of the resonance point. The typical performance data given in the instruction book for adjustments of the H.F. transmitter unit, at five out of nine different frequencies show the full power antenna current to be less than 0.2 amperes, a value insufficient to give noticeable deflection on the meter used.

(i) Tuning in Conjunction with Model LJ and LJ-1 Equipments:

21. Frequency settings of the GO equipment with aid of the LJ-1 frequency indicator were readily performed in flight. When using the model LJ equipment, however, certain difficulties were encountered as reported in NASA Report RT-2, ref.(c). The model GO equipment, even before resonating of the P.A. stage, provided sufficient electrical field for pick-up and measurement with either type of frequency indicator.

(j) Transmitter Side Tone:

22. The transmitter side tone, with the receiver turned OFF, could be varied from 0 to 8.5 volts, A.C., across three pairs of 600 ohm phones connected in parallel. With the receiver operative, however, the side tone was audible only at its maximum setting (entirely too strong for operating comfort), and at all other settings (except zero) was replaced by a disagreeable very strong "mush". While the model GO equipment was not available to this station sufficiently long to conduct experiments toward improvement of the side tone and associated noise level, it appears that these conditions may be greatly improved by substitution of a side tone adjusting potentiometer of low resistance, as suggested by this station in ref.(f).

CONCLUSIONS AND RECOMMENDATIONS:

23. The following changes are considered necessary for suitable service performance of the model GO equipment:

- (a) Correction of the difficulties with break-in reception and side tone.
- (b) Revision of the high-frequency tuning instructions, and correction of a great number of proof-reading errors in the instruction book.

24. For service installation and operation of the model GO equipments the following recommendations are made:

- (a) A separate fixed receiving antenna may have to be provided for break-in reception; the need for this can be determined by tests aboard a class VP plane after the difficulties with the side tone have been remedied.
- (b) Operating units should be cautioned to maintain all control shafts and mechanism in a properly lubricated condition.

25. It is recommended that suitable double-scale antenna ammeters be issued, when and if they become available. Such meters are now in process of development, incorporating an internal push-button switch to connect the sensitive range. Their use will enable antenna currents in normal operation on harmonics of the trailing antenna to be read with accuracy, without sacrificing ability to measure the comparatively large currents obtained on fixed antennas.

26. Further desirable changes in the model GO equipment are:

- (a) Increase in the maximum value of the power factor correcting capacitor.
- (b) Provision of tension adjustment on break-in relays.
- (c) More explicit marking of the functions and direction of control of external adjustments.

27. In general, this station considers the model GO transmitting equipment an improvement over previous equipments for patrol planes, and believes it capable of satisfactory service use after minor defects have been remedied and the operating personnel has become proficient in its adjustment and operation.

F42-1/52

HRM/ts

NAVAL RESEARCH LABORATORY

Anacostia Station,

Washington, D.C.

8 January, 1935.

MEMO FOR NAVAL AIR STATION, Anacostia, D.C.

Subject: Test of Model GO Equipment.

1. During your flight test of the model GO Transmitter Equipment, please observe the following:

(a) Watch for failure of the plate transformer by arcing or shorting across the high voltage terminals at altitudes up to 17,500 feet.

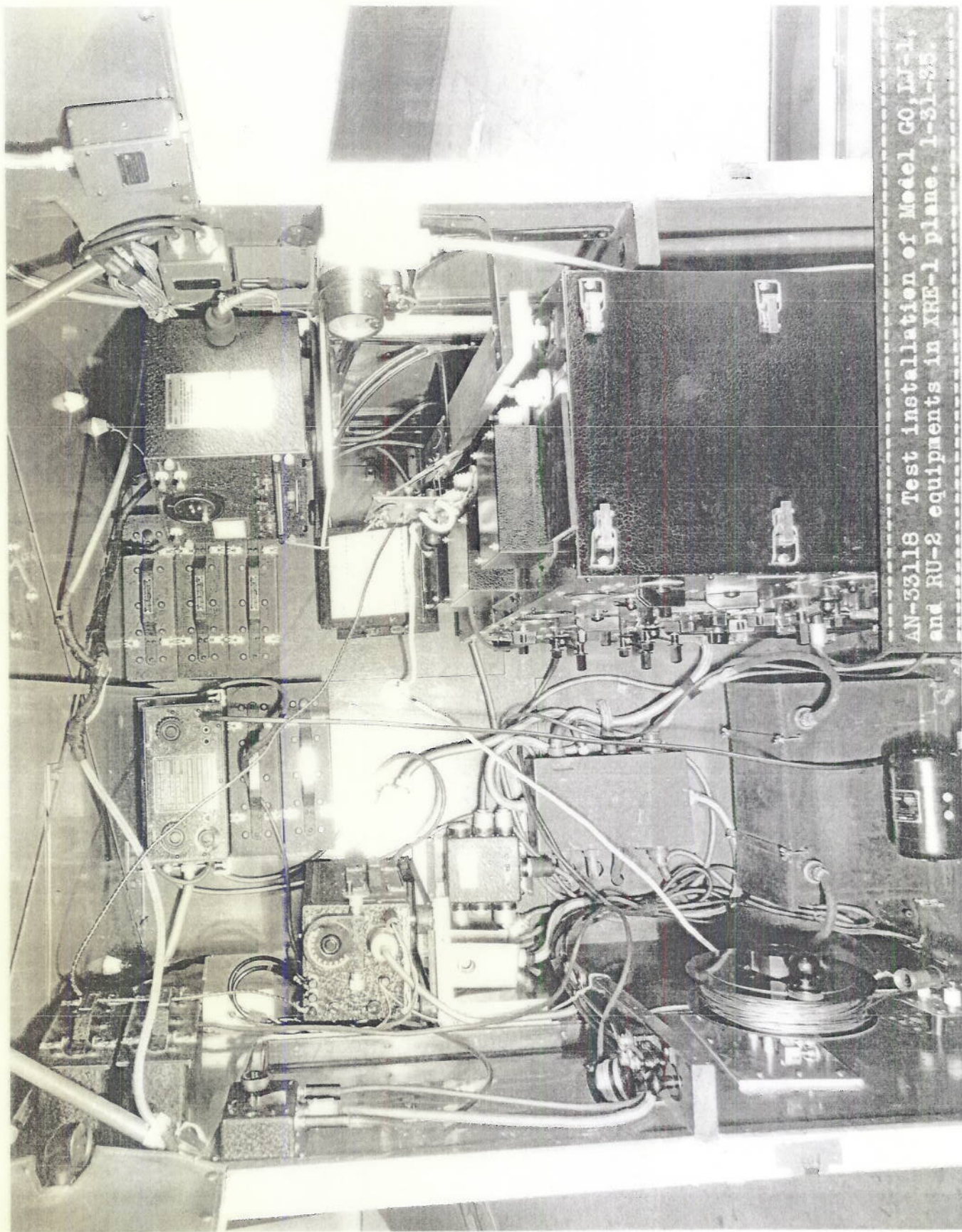
(b) Note character and intensity of interference with reception due to transmitter noises at 355, 450 and 600 kc. on the IF unit and at 4000, 8000, and 12000 kc. in the HF unit. Report on ability to copy through with normal break-in operation and the comparison of reception with the transmitter dead.

(c) Note any modulation due to plane vibration which reacts on frequency stability to give a bad note. This applies particularly to the high frequencies, caused by vibration of the side of the HF unit.

(d) Note voltage regulation under load to determine if normal output is being obtained from the generator.

(e) Note whether the transmitter upper shock mountings are adequate to hold the transmitter satisfactorily in all positions of the plane.

(f) Check resetability in accordance with instructions given during flight.



AN-33118 Test installation of Model CO, M-1,
and RU-2 equipments in XRE-1 plane. 1-31-55.