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Report on

Tests of Model CXAR Aircraft Radio Transmitting Equipment

Manufactured by the Bendix Radio Corporation  
Baltimore, Maryland

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## AUTHORIZATION

1. The tests herein reported were authorized by Bureau of Ships letter, reference (a). Additional references pertinent to these tests are listed as references (b) and (c).

- Reference: (a) BuShips ltr. C-NOs-73237(1-23-DRI) of 28 January 1941.  
(b) Specifications RE 13A 583A.  
(c) Bendix descriptive specifications.

## OBJECT OF TEST

2. The object of these tests was to determine the compliance of the equipment with the requirements of the specifications, references (b) and (c) and to determine its adaptability for use in the Naval Aircraft Service.

## ABSTRACT OF TEST

3. The equipment was tested for mechanical construction, electrical performance and its suitability for use in the Naval Service. Flight tests were conducted at the Naval Air Station, Anacostia, D. C., the results of which are appended to this report.

4. The tests covered the following points:

(a) Mechanical.

- (1) Workmanship.
- (2) Material used.
- (3) Size and weight.
- (4) Mounting features.
- (5) Ruggedness.

(b) Electrical.

- (1) Power output.
- (2) Calibration accuracy.
- (3) Audio characteristics.
- (4) Frequency stability vs. variable temperature.
- (5) " " " variable humidity.
- (6) " " " reset.
- (7) " " " tune-operate position.
- (8) " " " vibration.
- (9) " " " variation of primary power supply.
- (10) " " with half-hour key locked operation.
- (11) " " vs. roll and pitch.
- (12) Effect of other channels on one in operation.
- (13) Effect of detuning the P.A. circuit.
- (14) Power drain on primary supply.

## Conclusions

As a result of the tests, the following conclusions were reached:

(a) In its present condition the equipment is not satisfactory for use in the Naval Aircraft Service.

(b) In general the design and workmanship is excellent.

(c) With the exception of the method of securing the transmitter base to the mounting plate, the equipment is sufficiently rugged to insure long and reliable service. The rear clips for securing the transmitter base to the mounting plate carried away when the equipment was subjected to an acceleration of 6.4 g. This failure occurred with the equipment mounted in a horizontal position but with the front panel down. The equipment was not dropped in a similar plane with the face up, but it is obvious that the snap fasteners on the front of the mounting base are not rugged enough to withstand a similar acceleration. No other damage occurred and the equipment successfully withstood the acceleration in the normal position.

(d) The convenience of installation is discussed in the flight test report. The design of the equipment is such as to provide for quick and easy removal and reinstalling of the units. Certain operational features exist which are undesirable. Numerous tuning adjustments are located on the sides of the channel units in addition to those mounted on the front panel. This necessitates removal of the unit to make adjustments. Under certain conditions as much as one half hour was required to properly tune the equipment. With the most adequate calibration charts and thorough familiarity with the performance of the equipment this time may be considerably reduced, but probably not within satisfactory limits. A tool is provided for making most of the adjustments, but a wrench (not provided), is necessary for changing the link connections. The M.O. operates on  $1/2$  and  $1/3$  of the output frequency. It is impossible with the LM crystal frequency indicator to determine the proper harmonic frequency.

(e) One switch contact of the channel selector switch failed. This was due to too much stock being drilled out for the rivet holes; as a result the contact arm broke off.

(f) The equipment is not designed for ready accessibility for replacing parts or servicing. Due to the multiplicity and bunching of the wiring, servicing would be a difficult and tedious operation even for experienced personnel.

(g) All parts on the model submitted for test were not marked for identification.

(h) The specifications refer to a 40 ampere fuse in the dynamotor input circuit. These fuses as supplied with the equipment were rated at 50 amperes. Several of these fuses failed, usually when starting after the dynamotor had been idle for some time. After replacement with 60 ampere fuses no further failures occurred.

Conclusions (Continued)

(i) Friction dial locks are provided. Unless the H.O. dial is held firmly while tightening the lock, a change of frequency occurs.

(j) Color coding of the wiring has been incorporated but due to duplicate coloring and cabling of the mass of wires, tracing of circuits is impossible.

(k) It is possible to preset the H.O. stage on the bench or in the airplane, provided in the latter case the airplane engine is running. Otherwise the current drain is too great on the airplane battery.

(l) The equipment is not arranged to provide for use of a throat microphone.

(m) The frequency variation due to variation of temperature does not in all cases meet the requirements of the specifications. The maximum variation in the low frequency bands is 0.045% where the allowable variation is 0.025% and in the high frequency band is 0.0324% where the allowable variation is 0.01%.

(n) The equipment meets the frequency variation due to change in relative humidity except on the high frequency band where the variation is 0.034%. The allowable variation is 0.02%.

(o) The variation of frequency when switching from the tune to operate position was a maximum of 0.085%. The allowable variation is 0.01%.

(p) Removing or replacing channels adjacent to one in operation had an appreciable effect on the output frequency. Changes up to 23 kilocycles were observed.

(q) The transmitter was 1/4" oversize in width and 3/8" oversize in depth. The control box is oversize 1" in width and 11/16" in depth.

(r) The contacts on the "pilot's control unit" and "transmitter extension" cable connectors are not marked individually.

(s) In most cases the push button operation is so sensitive that very slight pressure, such as brushing against them with the sleeve, etc. causes the circuit to operate.

## DESCRIPTION OF EQUIPMENT UNDER TEST

5. The subject equipment is manufactured by the Bendix Radio Corporation of Baltimore, Maryland, and is known as the Model CXAR Aircraft Radio Equipment.

6. The equipment consists of a four channel transmitter unit and an ICS unit with associated controls and cables. Each unit is provided with its own dynamotor and the entire equipment operates from a 24 to 28 volt D.C. power supply.

7. The equipment is designed for remote and local control.

8. The transmitter provides for three types of emission - CW, MCW, and voice, and the two low frequency channels each cover the frequency range of 540 to 1500 kcs. and the two high frequency channels each cover the frequency range of 3000 to 9050 kcs. Any combination of channels may be used in the transmitter.

9. The design of the transmitter is based on the master oscillator power amplifier principle.

## METHOD OF TEST

10. A description of the methods used in conducting the tests follows:

(a) The equipment was checked for size, weight, mechanical construction and workmanship. It was then assembled and tested for electrical performance.

(b) For all tests, except as otherwise specified, the primary voltage was kept constant at 28 volts, and a 300  $\mu$ f, 40 ohm artificial antenna was used.

(c) The current drain was determined with the use of a laboratory type precision ammeter and voltmeter.

(d) Power output measurements were made with various antenna characteristics in accordance with the specifications. The power output was calculated from the recordings of an R.F. ammeter and known values of resistance in the antenna.

(e) The overall audio characteristics were determined with the use of a beat frequency oscillator, mixer unit and a wave analyzer. With the modulation frequency varied from 200 to 3000 cycles and modulated approximately 75 per cent the output voltage was recorded at the various steps as indicated by the wave analyzer.

(f) The audio distortion was determined with the use of the same apparatus as above. The output voltage of successive harmonics of the modulation frequency as indicated by the wave analyzer were recorded and

the audio distortion determined as the RMS of these values.

(g) For frequency stability measurements when subjected to a variation of temperature and relative humidity the equipment was installed in a temperature control chamber and the frequency change measured with an LM frequency drift indicator. For frequency drift due to temperature change, the humidity was maintained at a value below 50% throughout the test. The temperature was varied between the limits of +50°C. to approximately -25°C. in steps of 10°. At each ten degree change the equipment was operated key locked on CW for thirty minutes after which the frequency was measured.

(h) To determine the frequency drift due to change of relative humidity the temperature was maintained between 40° and 45°C. The first step was to operate the equipment on CW key locked for a period of 15 minutes at the end of which the frequency was measured as above. The second step was to increase the relative humidity to approximately 95% and again operate the equipment key locked for one half hour at the end of which the frequency was again measured. The third step was to reduce the relative humidity to 30% and after a half hour key locked operation a frequency measurement was made. The overall frequency change was determined as the frequency difference at the end of the second and third steps with respect to that at the end of the first step.

(i) The reset measurements were made as follows: The equipment was tuned up on a predetermined frequency. The frequency then measured with an LM frequency indicator. Then by means of the push buttons, the equipment was switched to each of the other channels and returned to the original position. The frequency was measured after each reset. Reset measurements were made on each channel.

(j) The frequency deviation of the M.O. between the tune and operate positions was determined by tuning the M.O. in the "Tune" position, then switching to the "Operate" position and tuning to the antenna without readjusting the M.O. The deviation was the frequency difference as measured under each of the above conditions.

(k) The vibration test was made by mounting the transmitter on a vibration table and operating on CW, key locked, full power for one hour. The frequency was measured before starting vibration and at regular intervals during the one hour test.

(l) For key locked operation the temperature was maintained at approximately +45°C. and the relative humidity at 30 per cent. On CW, key locked, full power operation the frequency was measured after a five minute period at regular intervals for one half hour.

(m) For the roll and pitch measurements the equipment was mounted on a platform designed to tilt 45° from the vertical. For the roll measurement the equipment was inclined from side to side and for pitch back and forth from the vertical position. With the equipment operating at full power, CW, key locked for one half hour and inclined to the specified angle at a rate between 4 and 10 cycles per minute, frequency measurements were made at regular intervals in the vertical position and at the point of maximum deviation during the 45° movement.

(n) To determine the effect on the frequency of a channel in operation by removing and replacing adjacent channels, the equipment was adjusted for normal operation. The frequency of a particular channel was measured, then the adjacent channel was removed and replaced by each of the other channels in turn, and the frequency measured at each change.

(o) Frequency change due to detuning the P.A. was determined by measuring the frequency under normal operation and again after detuning the P.A. circuit 25% above and below normal plate current.

(p) The acceleration test was made by mounting the equipment on an accelerometer capable of acceleration in excess of 3 g. The equipment was subjected to acceleration mounted in the normal vertical position and at 90° from this position, i.e. face down.

#### DATA RECORDED DURING TEST

11. Data recorded during the tests in the form of tables and charts are appended to this report. These and other data pertinent to the tests are discussed in the "Results of Tests."

#### DISCUSSION OF PROBABLE ERRORS

12. Following is a list of the apparatus used in conducting the tests with the margin of error according to the manufacturer's guarantee:

		<u>Ser.No.</u>	<u>Accuracy</u>
Weston DC voltmeter	Model 45	41660	+ .05%
Weston DC ammeter	Model 45	41433	+ .05
Westinghouse R.F. ammeter	Type CX		+2.0
General Radio wave analyzer	Type 736 A	276	+5.0
General Radio Beat frequency oscillator	Type 713 B	209	+2.0
General Radio electron oscillograph	Type 687-BS5	379	
Radio Research crystal frequency indicator	Type LM-2	583	+ .001
Radio Research frequency drift indicator	Type LK-1	1	+ .015
G. Luff hygrometer			-15.0
Frigidaire temperature chamber			+2.0
NAF accelerometer			+10.0
NRL mixer unit			+ 5.0

## RESULTS OF TESTS

13. The results of the tests of the subject equipment will be discussed with regard to its compliance with the specifications, reference (c). The numbers of the sub-paragraphs are in agreement with those of the specifications.

### I INTRODUCTION

1-1 The equipment consists of the following items:

1. Transmitter and mounting.
2. Dynamotor and mounting.
3. Pilot's control box.
4. Complete set of cables.
5. Complete set of tubes.
6. Slip cover.
7. Ten instruction books (Two were supplied)
8. One set of spare tubes was supplied.
9. Ten sets of drawings (Two sets were supplied).
10. Ten sets of test data (Two sets were supplied).

1-2 The weight of the first five items is 103.5 lbs. which is 3.5 lbs. over the specification requirements. Weights and dimensions are shown on Table I.

1-5 The equipment covers the frequency ranges of 350 to 1300 Kc. and 3000 to 9050 Kc. Each of these ranges is covered by a single plug in channel. The transmitter is provided to accommodate four channels and two each covering the above ranges were supplied for test.

1-6 By means of a push button band switching device any one of the four channels may be selected. This may be accomplished by either local or remote control.

1-7 The equipment is provided for CW, MC or voice emission.

1-8 The equipment is based on the master oscillator power amplifier principle.

1-9 The transmitter is designed to operate into a fixed and trailing wire antenna, the latter limited to a maximum of 350 feet.

1-10 The equipment is designed for maximum convenience of installation but certain features of operation were observed that were undesirable. Due to the multiplicity of tap switches, and the method of changing these taps, the time required to change frequency is much greater than is deemed satisfactory in the Naval Service even with the use of calibration charts. Without calibration charts it becomes prohibitive. The master oscillator operates on one-half or one-third of the output frequency. Since the CPI is coupled to the MO circuit it is impossible to identify the proper harmonics.

I-11 The performance of the equipment at high altitude is discussed in the flight test report appended to the report.

## II

### SUB-SPECIFICATIONS AND GENERAL REQUIREMENTS

- 2-2 The tubes used are included on the Navy approved list and performed satisfactorily and without failure throughout the tests.
- 2-3 One switch contact failed on channel A. This was due to the fact that, when drilling the holes in the spring contact arm for the purpose of riveting to the main switch arm, too little material remained and at this point the contact arm broke off. Examination disclosed that all contacts of the channel selector switch were of similar construction and therefore not sufficiently rugged for satisfactory performance.
- 2-4 Push button switches are so arranged that each unit may be easily removed and replaced without disturbing any other unit.
- 2-6 The equipment does not allow for ready accessibility for replacement or servicing. Some of the tube socket, relay and switch replacements would require considerable disassembly, and "trouble shooting" of the wiring or replacing of cable connector receptacles would be a decidedly tedious and difficult operation. The contacts of the pilots control unit and transmitter extension receptacles are not completely identified as only the outer circle of terminals are numbered.
- 2-8 The component parts on the model submitted for test were not all marked for identification purposes.
- 2-15 Both the oscillator and power amplifier stages are series fed.
- 2-17 The meters are so mounted as to be readily substituted with others of the same nominal size having the maximum dimensions permitted by the meter specifications.
- 2-18 With the exception of the tap switches on the sides of the channel units, which are pre-set and require no further adjustment unless a change of frequency or antenna is desired, the controls are all located on the front panels of the respective unit.
- 2-19 A special tool is provided for making all necessary adjustments, except changing the condenser links in the channel unit, and is carried in a container mounted on the left side of the transmitter. In case of loss or misplacement, of this tool a screwdriver or coin will serve as a substitute.

- 2-21 The relays are accessible for examination and adjustment on removing the transmitter from the cabinet. The keying relay permits satisfactory keying up to 30 words per minute.
- 2-23 (4) Numerous fuses are incorporated in the equipment. With one exception they proved adequate. The exception was the fuse in the dynamotor input, rated in the descriptive specifications at 40 amperes, but actually in the equipment a 50 ampere fuse. This fuse burned out on several occasions, usually when first starting the dynamotor after a comparatively long idle period. This was then replaced with a 60 ampere fuse and no further failures occurred.
- (6) Inflammable material is not used in the equipment.
- 2-27 Friction locks are provided on the various dials. Unless the M.O. dials are held securely, tightening of the lock causes a change in frequency.
- 2-28 Each channel is provided with a calibration chart for two frequencies within its band for reset purposes. These charts are mounted on the front panel of the channel units.
- 2-29 Each control is identified by engraving the name of the control on the panel and in addition has a designating letter.
- 2-30 The arrangement and operation of controls is such that only with complete calibration data for a given antenna can the equipment be adjusted for proper operation within a time period of 5 minutes. Without the above information as much as one-half hour has been necessary to adjust for proper operation. Thorough familiarity with the performance of the equipment will reduce the above time of tuning by an appreciable amount.
- 2-31 The performance of the equipment under various climatic conditions is discussed later in this report.
- 2-33 The equipment performed satisfactorily with key locked full power operation considerably in excess of one-half hour.
- 2-35 The mounting of component parts as well as all connections is excellent in that there is a minimum possibility of vibration, crystallization or any other action which might effect the frequency stability.
- 2-36 The insulated wiring in the equipment is color coded; however, there are so many duplicates of the coloring and the wiring is so bunched that it is impossible to rely on the color code for tracing circuits.
- 2-46 The performance of the equipment when subjected to shock and vibration will be discussed later in this report.

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- 2-47 The equipment did not withstand an acceleration of 8 g. in all directions. When mounted in a horizontal plane as for normal operation it performed satisfactorily. When mounted in a horizontal plane but with front panel facing down the transmitter partially carried away from the mounting base due to failure of the rear mounting clips. This occurred at 6.4 g. No further drops were attempted. No damage occurred to the equipment other than that mentioned above. The acceleration curve is shown on Plate 9.
- 2-52 Access to the transmitter for the purpose of inspection, repair and replacement of tubes is obtained by removing the chassis from the cabinet. Likewise the tuning units are removable from the chassis. In both cases they are secured in place by means of knurled thumb screws.

### III

#### TRANSMITTER PERFORMANCE REQUIREMENTS

- 3-1 Unless otherwise noted all measurements were made with a 40 ohm 300 mmf artificial antenna. The power output on CW, MCW, and voice measured with the above and various other antenna values meets the requirements of the specifications. The results of this test are shown on Tables 2 and 3.
- 3-3 All of the pilot's controls are located on the pilot's control box, and all of the operator's controls are located on the front panel of the transmitter. The equipment may be adjusted to any frequency within a band from the front panel but changing bands necessitate removing the channel unit from the chassis and adjusting the tap switches and condenser links.
- 3-4 Either the pilot or the operator independently of the other can start or stop the transmitter. By means of link adjustment within the transmitter it is possible to operate the equipment with the pilot's control box cable removed.
- 3-5 (1) It is possible with the aid of a crystal frequency indicator and a calibrator chart, "but not with the crystal frequency indicator alone for reasons discussed in paragraph 1-10," to pre-set the MO stage to any one frequency in each band for operation into the airplanes fixed antenna. This may be accomplished on the bench or in the airplane during periods of silence provided in the latter case the airplane engine is running; otherwise, the drain on the storage battery is too great.
- 3-5 (2) With the equipment set up on a fixed antenna it is possible by means of a switch on the front panel to change to a trailing wire which may be reeled out a sufficient amount to resonate without adjustment of any other controls; however, readjustment of the antenna loading and/or coupling may be necessary to obtain maximum radiation efficiency.

- 3-6 (1) It is possible for the pilot or operator to select either of the channels independently of each other. Since the push buttons of the pilot's control box and of the transmitter are in parallel pushing the button of one causes the hold in coils to draw in both buttons thus visually indicating the channel in use. Changing from one pretuned channel to another requires less than 30 seconds.
- 3-6 (2) It is unnecessary to readjust any power controls due to shifting bands.
- 3-7 (1) Either the pilot or operator may select code or voice emission. The operator in addition may select MCW which is not required for the pilot in these specifications. The time required for changing the type of emission is within 30 seconds.
- 3-7 (2) It is not necessary to readjust any power controls when changing the type of emission.
- 3-8 (1) The equipment provides for a variation of power output by means of a two position switch marked Tune-Operate. In the tune position it is impossible to operate the transfer relay.
- 3-8 (2) In the operate (full power) position no tubes oscillate in the key up position.
- 3-8 (3) A test key is located on the front panel which may be keyed or locked when the switch is in the "operate" position.
- 3-9 (1) The overall audio frequency characteristic meets the requirements of this paragraph as shown on Table 4.
- 3-9 (2) The audio frequency distortion is within the 15 per cent r.m.s. requirement of this paragraph. The results are shown on Table 5.
- 3-10(1) Selection of the type of emission automatically selects the proper sidetone signal.
- 3-10(2) The sidetone frequency on CW is 1350 cycles and on MCW 1060 cycles.
- 3-10(3) The sidetone audio characteristic is within the requirement of this paragraph.
- 3-10(4) The sidetone circuit to each receiver has an adjustment of impedance from 50 to 300 ohms, and side tone level from .1 to 8 volts in 10 steps.
- 3-10(5) Voice and sidetone output levels are separately adjusted.

- 3-10(6) The above are installation adjustments and access is obtained by removing the chassis from the cabinet.
- 3-11 No headset volume controls are provided in the equipment.
- 3-12 In addition to other functions the keying relay when closed, closes the sidetone circuits to the two receivers and grounds the output antenna terminals to the receivers.
- 3-13 The pilot's control box and transmitter panel are each provided with a microphone switch marked "Radio-Off-I.C.S." In the radio position with the transmitter turned on it is possible to operate the transfer relay and to modulate the transmitter. The pilot's control box is provided with a throttle switch jack.
- 3-14 The equipment in its present condition is suitable for use with an RS-38 microphone on either radio or I.C.S. positions but is not suitable for use with a throat microphone. The wiring of the pilot's control box does not conform with the schematic diagram N90562-A of the descriptive specifications reference (c), but the wiring in either case does not provide for the use of a throat microphone. It was determined that shorting the tip contact of the microphone jack to ground permitted the use of the throat microphone. Throttle switch operation has been provided in the pilot's control box. Closing one microphone button or throttle switch does not energize the other microphone. The operation of one microphone has no effect on the other since their circuits are segregated.
- 3-15 Either the pilot or the operator can start or stop the I.C.S. independently of each other. However with the "Local Power" switch of the I.C.S. unit on any position except off neither the pilot or operator can release the I.C.S. button. When the I.C.S. is made operative microphone current is available to either microphone provided the microphone switch concerned is on the I.C.S. position. The operation of the transmitter does not interfere with I.C.S. operation. Power to the I.C.S. unit is brought in on the same cable which brings power to the dynamotor and transmitter units.
- 3-16 A receiver selector switch is not provided on the transmitter or pilot's control box.
- 3-17 An under voltage relay is provided in the transmitter which operates automatically when the input voltage falls below 24 volts allowing for operation at reduced output. An additional filament adjustment is not provided.
- 3-18 Two meters are supplied and mounted on the front panel of the transmitter. One indicates the radiating current and the other by means of a switch indicates filament voltage, the P.A. grid current and the P.A. plate current.

- 3-19(1) The frequency stability due to variation of temperature does not in all cases meet the requirements of the specifications. The results are shown on Tables 6 and 7.
- (2) The equipment meets the frequency stability and power output requirements for change of relative humidity on all except the high frequency channel. The results are shown on Tables 8 to 11.
- (3) The equipment meets the reset requirements of this paragraph. The results are shown on Table 12.
- (4) The equipment does not meet the "Tune-Operate" frequency change requirement of the paragraph. The results are shown on Table 13.
- (5) The apparatus used for vibration tests is not adaptable to fine adjustment. The amplitude is not consistent throughout the surface area and varies between the limits of .031 to .062 inch. The vibration characteristic is more of an impact than of a sine wave form of movement. The measurements as made included the normal key locked drift in addition to the vibration effect and since the key locked measurements were for the duration of one-half hour and the vibration for one hour, the actual frequency deviation will be somewhat less than shown on the tables. With better control of the vibration table operation, the effect of vibration on the equipment would be further reduced. Subject to the above conditions it is believed that the equipment would meet the requirements of this paragraph. The results of the tests are shown on Table 14.
- (6) On full power CW operation a change of supply voltage from 24 to 28 volts had no measurable effect on the emitted frequency.
- 3-19(7) The equipment meets the frequency stability requirements for key locked, full power, CW operation for one-half hour at constant ambient temperature. The results are shown on Table 15.
- (8) The equipment meets the frequency stability requirements for roll and pitch. The results are shown on Table 16 and Plates 5 to 7, inclusive.
- (9) The effect on the frequency of a channel by removing and replacing adjacent channels showed a frequency change up to approximately 23 Kc. The results are shown on Table 17. The effect of detuning the P.A. circuit is shown on Table 18. The total current drain on the primary source is shown on Table 1A.
- 3-20(1) The overall width of the transmitter including the mounting base and tool compartment is  $1/4$ " over the specification requirement of 20  $1/2$  inches and the depth  $3/8$  inch over the allowed 13 inches. The results are shown on Table 1.

- 3-20 (4) The plug connections are located as shown on drawing W90564 of the specifications.
- (5) The plug connections are so arranged that when using right angle plugs the cables extend downward. In this condition the equipment must be elevated for clearance during bench operation unless the cable end of the transmitter can be located so as to overhang the end of the bench.
- (6) It is necessary to withdraw the chassis from the cabinet in order to have access to the tubes. The specifications describe a catch to prevent complete removal of the chassis from the cabinet without releasing this catch. The subject equipment is not provided with a device of this type.
- 3-21 The pilot's control box is outside the dimensions of drawing C56164 of the specifications. The results are shown on Table 1.
- 4-1 The dynamotor meets the dimensions of drawing C56165 of the specifications as shown on Table 1.
- 4-2 The dynamotor and transmitter withstood continuous operation under conditions of key locked, full power at 28 volts on numerous occasions for periods in excess of 6 hours.
- 4-3 Operation in service use over a long period of time is necessary to determine the life of the dynamotor. However, during the tests it was in operation in excess of 100 hours with entirely satisfactory performance.
- 5-4 The cables meet the overall length requirements of this paragraph. Dimensions are shown on Table 1.

#### CONCLUSIONS

14. As a result of the tests, the following conclusions were reached:

(a) In its present condition the equipment is not satisfactory for use in the Naval Aircraft Service.

(b) In general the design and workmanship is excellent.

(c) With the exception of the method of securing the transmitter base to the mounting plate, the equipment is sufficiently rugged to insure long and reliable service. The rear clips for securing the transmitter base to the mounting plate carried away when the equipment was subjected to an acceleration of 6.4 g. This failure occurred with the equipment mounted in a horizontal position but with the front panel down. The equipment was not dropped in a similar plane with the face up, but it is obvious that the snap fasteners on the front of the mounting base are not rugged enough to withstand a similar acceleration. No other damage

occurred and the equipment successfully withstood the acceleration in the normal position.

(d) The convenience of installation is discussed in the flight test report. The design of the equipment is such as to provide for quick and easy removal and reinstalling of the units. Certain operational features exist which are undesirable. Numerous tuning adjustments are located on the sides of the channel units in addition to those mounted on the front panel. This necessitates removal of the unit to make adjustments. Under certain conditions as much as one half hour was required to properly tune the equipment. With the most adequate calibration charts and thorough familiarity with the performance of the equipment this time may be considerably reduced, but probably not within satisfactory limits. A tool is provided for making most of the adjustments, but a wrench (not provided), is necessary for changing the link connections. The M.O. operates on  $1/2$  and  $1/3$  of the output frequency. It is impossible with the LM crystal frequency indicator to determine the proper harmonic frequency.

(e) One switch contact of the channel selector switch failed. This was due to too much stock being drilled out for the rivet holes; as a result the contact arm broke off.

(f) The equipment is not designed for ready accessibility for replacing parts or servicing. Due to the multiplicity and bunching of the wiring, servicing would be a difficult and tedious operation even for experienced personnel.

(g) All parts on the model submitted for test were not marked for identification.

(h) The specifications refer to a 40 ampere fuse in the dynamotor input circuit. These fuses as supplied with the equipment were rated at 50 amperes. Several of these fuses failed, usually when starting after the dynamotor had been idle for some time. After replacement with 60 ampere fuses no further failures occurred.

(i) Friction dial locks are provided. Unless the M.O. dial is held firmly while tightening the lock, a change of frequency occurs.

(j) Color coding of the wiring has been incorporated but due to duplicate coloring and cabling of the mass of wires, tracing of circuits is impossible.

(k) It is possible to preset the M.O. stage on the bench or in the airplane, provided in the latter case the airplane engine is running. Otherwise, the current drain is too great on the airplane battery.

(l) The equipment is not arranged to provide for use of a throat microphone.

(m) The frequency variation due to variation of temperature does not in all cases meet the requirements of the specifications. The maximum variation in the low frequency bands is 0.045% where the allowable variation is 0.025% and in the high frequency band is 0.0324% where the allowable variation is 0.01%.

(n) The equipment meets the frequency variation due to change in relative humidity except on the high frequency band where the variation is 0.034%. The allowable variation is 0.02%.

(o) The variation of frequency when switching from the tune to operate position was a maximum of 0.085%. The allowable variation is 0.01%.

(p) Removing or replacing channels adjacent to one in operation had an appreciable effect on the output frequency. Changes up to 23 kilocycles were observed.

(q) The transmitter was 1/4" oversize in width and 3/8" oversize in depth. The control box is oversize 1" in width and 11/16" in depth.

(r) The contacts on the "pilot's control unit" and "transmitter extension" cable connectors are not marked individually.

(s) In most cases the push button operation is so sensitive that very slight pressure, such as brushing against them with the sleeve, etc., causes the circuit to operate.

TABLE 1  
WEIGHT AND DIMENSIONS

	<u>Height</u>	<u>Depth</u>	<u>Width</u>	<u>Weight</u>	
Transmitter with MTG and Tubes	10 3/4"	13 3/8"	20 3/4"	68.0	lbs.
Dynamotor	8 3/8"	10"	6 3/8"	26.5	"
Control box	5 1/2"	3 1/4"	5 1/2"	3.25	"
ICS Unit with MTG and Tubes	6 7/8"	8 1/4"	5 1/2"	10.375	"

CABLES

	<u>Length</u>	<u>Weight</u>
Dynamotor to Battery	48"	1.375 lbs.
Dynamotor to Transmitter	48"	1.625 "
Transmitter to Control Box	96"	2.687 "
Transmitter to GFX Dynamotor	48"	1.437 "
Transmitter to ICS Unit	48"	1.437 "

TABLE 1-A  
CURRENT DRAIN ON PRIMARY POWER SUPPLY  
VOLTAGE CONSTANT AT 28 VOLTS

<u>Emission</u>	<u>I</u>
CW	15.4 Amperes
MCW	17.8
Voice (No Mod.)	18.2
Voice (with Mod.)	18.6

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TABLE 2  
POWER OUTPUT AND CALIBRATION ACCURACY  
CHANNEL A

Cal. Setting	Actual Freq.	Cal. Accuracy	Emission	Type	Ant.			
					Cap. MUF	Reg	I	Watts
540 Kc.	547.68 Kc.	1.42%	CW	T	300	40	1.3	67.5
"			MCW	T	300	40	1.35	73.0
"			MCW	F	300	40	1.32	69.6
"			Voice	T	300	40	1.2	57.7
"			Voice	F	300	40	1.18	55.7
"			CW	T	400	12	1.81	39.5
"			CW	F	80	6	No Output	
"			CW	F	80	2	" "	

CHANNEL B


1000	1009.0	0.9%	CW	T	300	40	1.3	67.5
"			MCW	T	300	40	1.35	73.0
"			MCW	F	300	40	1.33	70.8
"			Voice	T	300	40	1.22	59.5
"			Voice	F	300	40	1.2	57.7
"			CW	T	400	12	1.85	45.65
"			CW	F	80	6	1.3	10.14
"			CW	F	80	2	1.65	5.45

Note T - Trailing Antenna

F - Fixed Antenna

  
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TABLE 3  
POWER OUTPUT AND CALIBRATION ACCURACY  
CHANNEL C

Cal. Setting	Actual Freq.	Cal. Accuracy	Emission	Type	Cap. MMF.	Ant.	I	Watts
						Res. 		
3000	3043	1.43%	CW	T	300	40	1.4	78.3
"			MCW	T	300	40	1.5	90.0
"			MCW	P	300	40	1.16	54.0
"			Voice	T	300	40	1.15	53.0
"			Voice	F	300	40	1.17	54.8
"			CW	F	150	40	1.4	78.3
"			CW	T	400	12	2.21	58.7
"			CW	F	80	6	2.1	26.5
"			CW	F	80	2	2.61	13.6

CHANNEL D

9050	9081	0.34%	CW	T	300	40	1.35	73.0
"			MCW	T	300	40	1.5	90.0
"			MCW	P	300	40	1.18	55.7
"			Voice	T	300	40	1.15	53.0
"			Voice	F	300	40	1.16	54.0
"			CW	F	150	40	1.25	62.5
"			CW	T	400	12	1.49	26.6
"			CW	F	80	6	1.65	16.35
"			CW	F	80	2	2.2	9.68

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TABLE 4

## AUDIO CHARACTERISTIC

OUTPUT ADJUSTED FOR 1.0 VOLT AT A MODULATION FREQUENCY  
OF 1000 CYCLES

Mod. Freq. ~	Output Volts			
	Channel B 540 Kc.	Channel B 1000 Kc.	Channel C 3000 Kc.	Channel D 9000 Kc.
200	0.68	0.66	0.7	0.65
400	0.99	0.96	0.98	0.95
600	1.0	0.97	1.01	0.98
800	1.01	1.0	1.015	1.0
1000	1.0	1.0	1.0	1.0
1500	0.97	0.98	0.99	0.98
2000	0.92	0.94	0.96	0.96
2500	0.88	0.91	0.94	0.93
3000	0.83	0.89	0.91	0.91
Max. Variation Between 400 and 3000 ~	1.7 DB	1.0 DB	0.95 DB	0.9 DB

TABLE 4-A

PERCENTAGE OF MODULATION FOR MAXIMUM UNDISTORTED OUTPUT

Mod. Freq.	Channel A 540 Kc.	Channel B 1000 Kc.	Channel C 3000 Kc.	Channel D 9000 Kc.
200 ~	59	62	62	60
500 ~	56	60	60	55
1000 ~	50	55	56	55
2000 ~	58	57	60	55

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TABLE 5  
AUDIO DISTORTION

Mod. Freq.	RMS Distortion			
	Channel B 540 Kc.	Channel B 1000 Kc.	Channel C 3000 Kc.	Channel D 9000 Kc.
200	6.8 %	6.78%	5.4 %	6.4 %
400	10.87	8.88	11.06	11.55
600	11.26	9.0	13.04	11.9
800	11.32	9.4	13.42	12.57
1000	10.43	9.07	13.2	12.25
1500	8.45	8.26	11.65	11.48
2000	6.64	7.18	11.0	10.73
2500	5.5	6.18	8.77	9.7
3000	4.7	5.23	7.23	8.42

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TABLE 6

## FREQUENCY STABILITY VS VARIABLE TEMPERATURE

Frequency Measurements Made at End of One Half Hour Key Locked Full  
Power Emission at Each 10 Degree Change of Temperature

## CHANNEL A 550 Kc.

Temp. C.	Freq.	Freq. Change Over 10° Temp. Change	
		~	%
+ 50	2460		
+ 40	2460	0	0
+ 30	2475	15	.0027
+ 20	2460	15	.0027
+ 10	2470	10	.0018
0	2375	95	.0173
- 10	2125	250	.045 ← Max.
- 20	2060	65	.0118

## CHANNEL B 1000 Kc.

+ 50	2400		
+ 40	2510	110	.011
+ 30	2650	140	.014
+ 20	2770	120	.012
+ 10	2900	130	.013
0	3110	210	.021 ← Max.
- 10	3310	200	.02
- 20	3400	90	.009
- 27	3470	70	.007

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TABLE 7

## FREQUENCY STABILITY VS VARIABLE TEMPERATURE

Frequency Measurements Made at End of One Half Hour Key Locked Full  
Power Emission at Each 10 Degrees Change of Temperature

CHANNEL C		3000 Kc.	
Temp. °C.	Freq.	Freq. Change Over 10° Temp. Change	%
+ 50	1900	~	
+ 40	1975	75	.0025
+ 30	2100	125	.004
+ 20	2220	120	.014
+ 10	3050	530	.0177
0	3660	610	.02 ← Max.
- 10	4050	390	.011
- 20	4225	175	.0058
- 24	4480	225	.0085
CHANNEL D		9000 Kc.	
+ 50	0		
+ 40	1110	1110	.0135
+ 30	3710	2600	.029
+ 20	6490	2780	.0309
+ 10	8460	1970	.0219
0	10810	2350	.026
- 10	12100	1290	.0143
- 20	15010	2910	.0324 ← Max.
- 25	14910	100	.001

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TABLE 8

## FREQUENCY STABILITY VS VARIABLE HUMIDITY

CHANNEL A 550 Kc.

Test 1 15 min. Key Locked Full Power

Time Min.	Temp. C.	Hum. %	Freq. ~	Ant. 1
0	38.5	28	500	1.17
5	39.0	28	500	1.17
10	39.5	28	500	1.16
15	39.8	28	500	1.16

Test 2 30 min. Key Locked Full Power

0	41.5	88	494	1.16
5	42.0	90	498	"
10	43.0	90	500	"
15	44.0	90	500	"
20	45.0	91	502	"
25	45.7	91	502	"
30	46.5	90	503	"

Test 3 30 min. Key Locked Full power

0	39.0	31	510	1.16
10	38.5	30	510	"
20	38.5	30	510	"
30	39.0	29	513	"

Max. Freq. Change Between Test 1 and Test 2 = 6 ~ = .001%

" Power Output Change 0

Max. Freq. Change Between Test 1 and Test 3 = 13 ~ = .0023%

" Power Output Change 0

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TABLE 9

## FREQUENCY STABILITY VS VARIABLE HUMIDITY

CHANNEL B 1000 Kc.

## Test 1 15 min. Key Locked Full Power

Time Min.	Temp. °C.	Hum. %	Freq. ~	Ant. I
0	40.0	29	2560	1.18
5	40.0	29	2500	1.18
10	40.0	30	2460	1.17
15	40.5	30	2250	1.17

## Test 2 30 min. Key Locked Full Power

0	41.0	81	2290	1.17
5	41.5	90	2290	1.16
10	42.5	90	2310	"
15	43.5	92	2260	"
20	44.0	91	2300	"
25	45.0	93	2250	"
30	45.0	91	2300	"

## Test 3 30 min. Key Locked Full Power

0	39.5	32	2325	1.16
10	40.0	30	2290	"
20	39.5	29	2300	"
30	39.5	28	2160	"

Max. Freq. Change Between Test 1 and Test 2 = 30 ~ = .006%

Output Power Change 0.9 w. = 1.64%

Max. Frequency Change Between Test 1 and Test 3 = 90 ~ = .009%

Output Power Change

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TABLE 10

## FREQUENCY STABILITY VS VARIABLE HUMIDITY

CHANNEL C 3000 Kc.

Test 1 15 min. Key Locked Full Power

Time Min.	Temp. °C.	Hum. %	Freq. ~	Ant. I
0	42.0	33	1925	1.24
5	42.0	32	1900	"
10	42.0	31	1800	"
15	43.0	31	1750	"

Test 2 30 min. Key Locked Full Power

0	45.0	79	1550	1.23
5	45.0	79	1510	"
10	45.0	79	1500	"
15	45.0	79	1450	"
20	45.0	79	1450	"
25	45.0	79	1450	"
30	45.0	79	1490	"

Test 3 30 min. Key Locked Full Power

0	43	32	1510	1.23
10	42	31	1620	"
20	42	31	1640	"
30	42	30	1640	"

Max. Freq. Change Between Test 1 and Test 2 = 300 ~ = 0.01%

Output Change 1.0 W. = 1.62%

Max. Freq. Change Between Test 1 and Test 3 = 240 ~ = 0.008%

Output Change

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TABLE 11

## FREQUENCY STABILITY VS VARIABLE HUMIDITY

CHANNEL D 9000 Kc.

## Test 1 15 Min. Key Locked Full Power

Time Min.	Temp. °C.	Hum. %	Freq. ~	Ant. I
0	40	29	2700	1.19
5	42	30	3250	"
10	42	30	3900	"
15	40	28	3900	"

## Test 2 30 Min. Key Locked Full Power

0	44	85	6840	1.17
10	44	80	6750	"
20	45	80	6875	"
30	45	80	6975	"

## Test 3 30 Min. Key Locked Full Power

0	43	30	6340	1.17
10	42	28.5	6250	"
20	41	28.5	6150	"
30	40	30	6150	"

Max. Freq. Change Between Test 1 and Test 2 - 3075 ~ = 0.034%

Output Power Change 1.8 W. = 3.18%

Max. Freq. Change Between Test 1 and Test 3 - 2440 ~ = 0.027%

Output Power Change 0



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## TABLE 12

## RESET

## CHANNEL A

	Freq. Kc.	Change From Original ~	Max. Change
Original	247.800		
Reset 1	"	0	
" 2	"	0	
" 3	247.805	+5	5 ~

## CHANNEL B

Original	500.428		
Reset 1	500.414	-14	
" 2	500.423	- 5	
" 3	500.400	- 28	28 ~

## CHANNEL C

Original	1499.785		
Reset 1	1499.831	+46	46 ~
" 2	1499.780	- 5	
" 3	1499.805	+20	

## CHANNEL D

Original	3001.500		
Reset 1	3001.450	-50	
" 2	3001.400	-100	100 ~
" 3	3001.420	- 80	

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TABLE 13

FREQUENCY STABILITY OF MO FROM TUNE TO OPERATE POSITION

Channel	Freq. Kc.		Deviation	
	Tune	Operate	~	%
A	549.200	549.672	472	0.085
B	1000.038	1000.152	114	0.0114
C	3001.550	3002.050	500	0.0166
D	9000.760	9002.280	1520	0.0169

TABLE 14

VIBRATION

Channel B 1000 Kc.			Channel D 9000 Kc.		
Time Min.	Approx. Vibration Freq.		Time Min.	Approx. Vibration Freq.	
	~ Per Sec.	~		~ Per Sec.	~
0	32	500	0	23	2300
1	35	475	1	28	1800
5	36	480	16	25	1850
6	16	480	20	24	2600
10	15	490	25	18	2650
15	38	485	30	16	2670
20	18	465	35	31	2770
25	25	430	37	38	2300
30	21	438	40	33	2350
35	17	410	43	30	2400
40	36	360	45	28	2950
45	23	300	50	27	3050
55	26	300	55	23	3150
60	18	225	60	50	2850

Total Vibration and Normal Key Locked Drift 275 ~ - - - - - 1350 ~  
 Less 1/2 Hr. Key Locked Drift (178 ~) 97 ~ - - - - - (450 ~) 900 ~  
 Vibration Effect Less Than .0097% - - - - - .009%

TABLE 15

LOCKED KEY OPERATION

Channel A 550 Kc.				Channel B 1000 Kc.			
Time Min.	Temp. °C.	Hum. %	Freq. ~	Time Min.	Temp. °C.	Hum. %	Freq. ~
0	47.2	35	470	0	43.0	30	560
5	44.0	32	485	5	43.5	29	482
15	43.5	31	498	15	44.0	29	425
25	44.0	29	518	25	44.2	29	388
35	44.0	29	530	35	44.5	27	382

Freq. Change After First 5 Min. .008% - - - - - .01%

Channel C 3000 Kc.				Channel D 9000 Kc.			
Time Min.	Temp. °C.	Hum. %	Freq. ~	Time Min.	Temp. °C.	Hum. %	Freq. ~
0	42.0	24	2650	0	43.0	28	2100
5	43.0	24	2560	5	44.0	28	2400
15	43.5	24	2500	15	44.0	27	2450
25	43.5	24	2500	25	44.0	26	2340
35	45.0	25	2500	35	44.5	26	2550

Freq. Change After First 5 Min. .002% - - - - - .0023%



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TABLE 16

## FREQUENCY STABILITY VS ROLL AND PITCH

CHANNEL B 1000 KC.

Time Min.	Roll			Pitch		
	L ~	H ~	R ~	F ~	V ~	B ~
0	405	400	390	420	415	360
5	390	370	360	430	420	375
10	385	365	350	425	415	365
15	390	375	355	425	415	365
20	395	380	360	425	420	370
25	395	380	360	425	415	365
30	385	365	350	425	415	365
AVERAGE DIFF.						
	16 ~	16 ~		9 ~	50 ~	
	.0016%	.0016%		.0009%	.005%	

CHANNEL D 9000 Kc.

0	670	770	870	375	450	550
5	700	800	950	375	550	725
10	650	750	850	350	525	700
15	500	625	700	425	575	750
20	600	700	800	525	650	800
25	625	750	850	550	700	850
30	600	725	850	575	725	875
AVERAGE DIFF.						
	110 ~	107 ~		150 ~	155 ~	
	.0012%	.001%		.0016%	.0017%	


  
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TABLE 17

## INTERACTION BETWEEN CHANNELS

<u>Channel In Operation</u>	<u>Original Freq.</u>	<u>Removed Channel</u>	<u>Freq.</u>	<u>Replaced Channel</u>	<u>Freq.</u>	<u>Removed All Other Channels</u>
D	9001.9 Kc.	C	8991.81 Kc.	C By A	9022.534 Kc.	8998.4 Kc.
C	3000.1	D	2996.952	D By A	3004.856	2977.096
B	1000.895	A	998.495	A By D	999.276	997.962
A	549.59	B	549.200	B By D	549.546	549.209
A	549.59	Interchange A and B			544.137	
D	9001.9	"	C and D		8982.28	

Removing a channel and replacing in same position had a negligible effect on frequency.

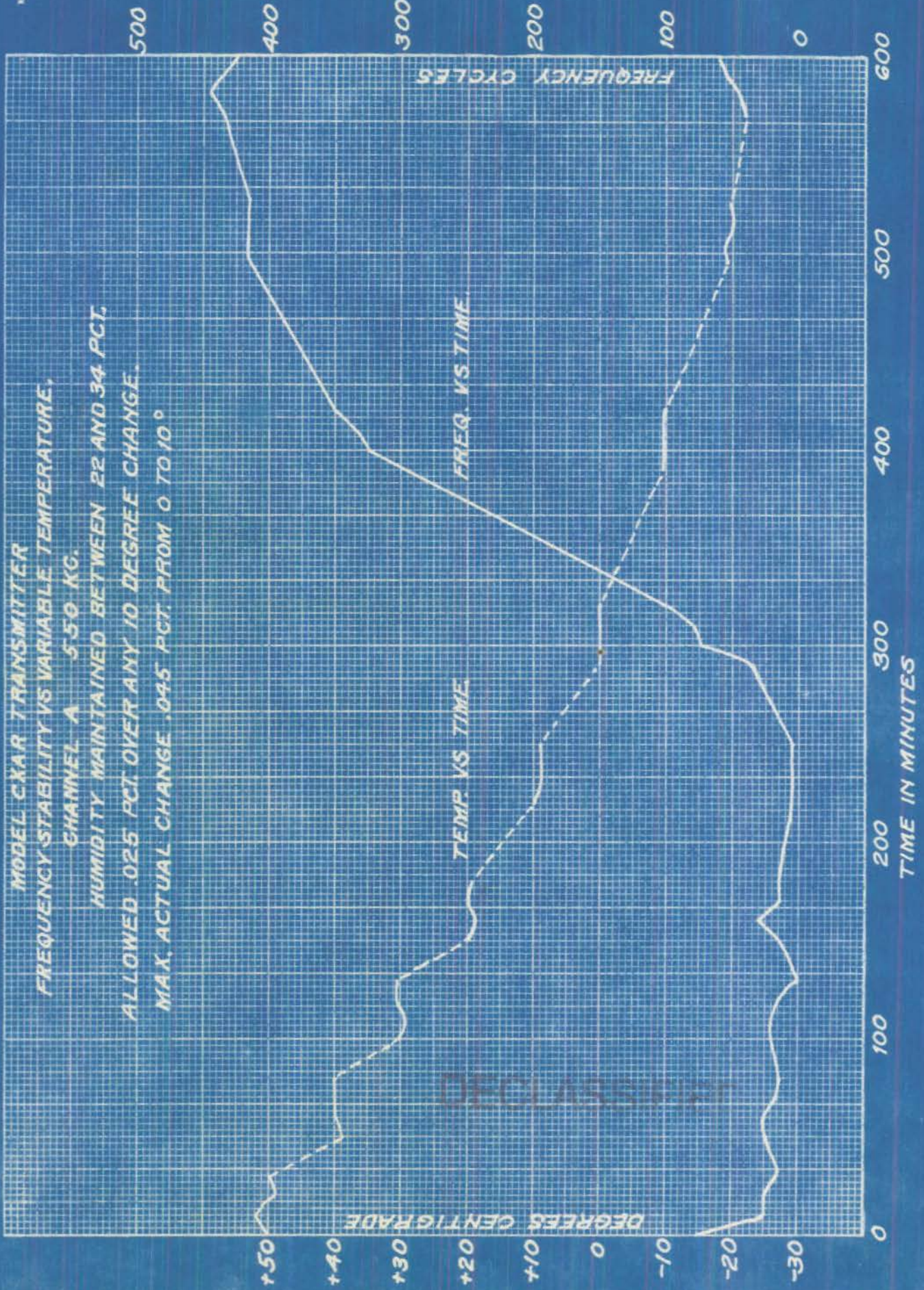
TABLE 18

## DETUNING P.A. CIRCUIT 25%

<u>Channel</u>	<u>Original Freq.</u>	<u>Detuned</u>	
		<u>+ 25%</u>	<u>- 25%</u>
A	549.543	549.524	549.600
B	1000.286	1000.190	1000.342
C	3002.427	3002.280	3002.570
D	9002.280	9002.090	9001.710

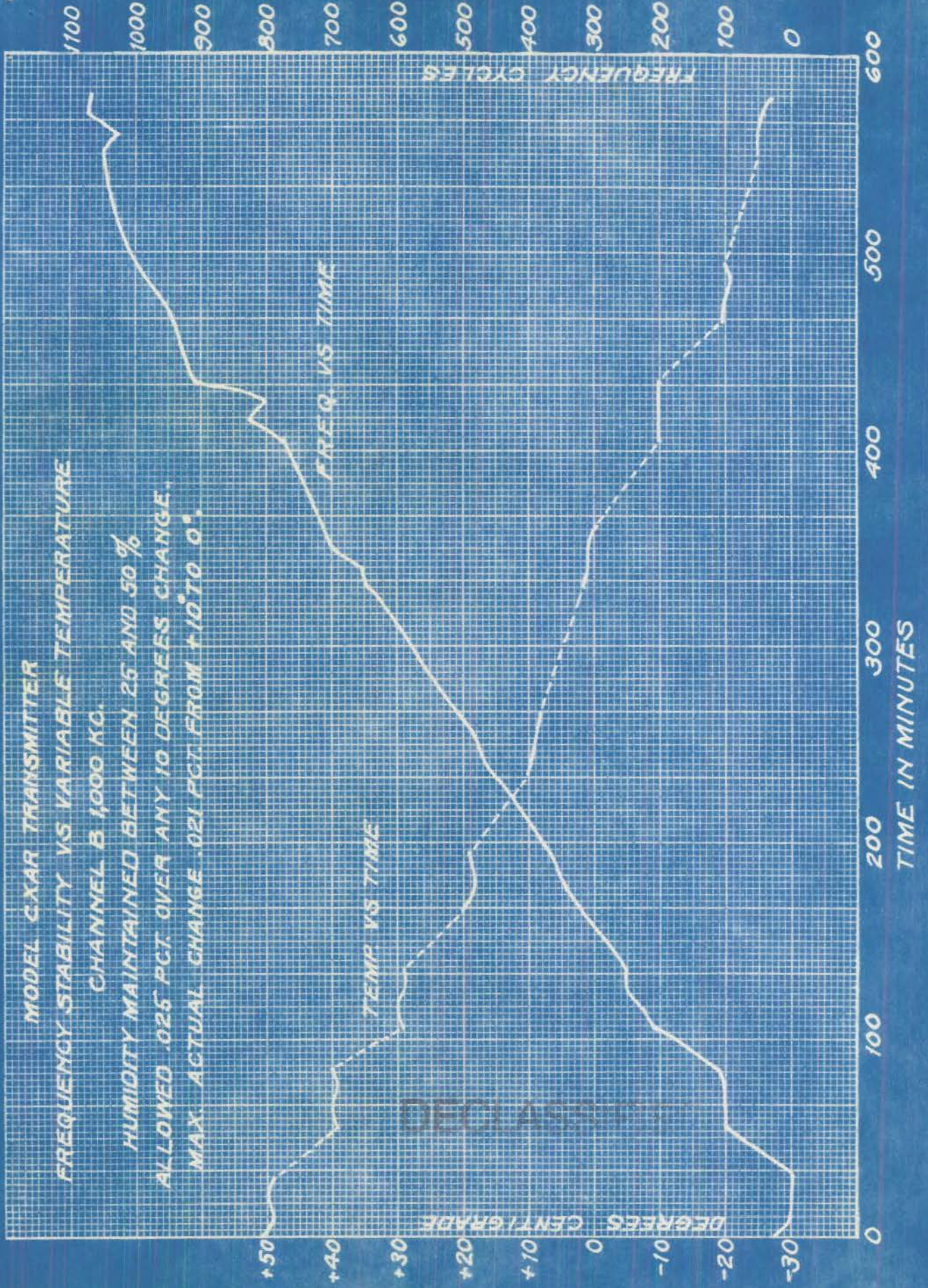


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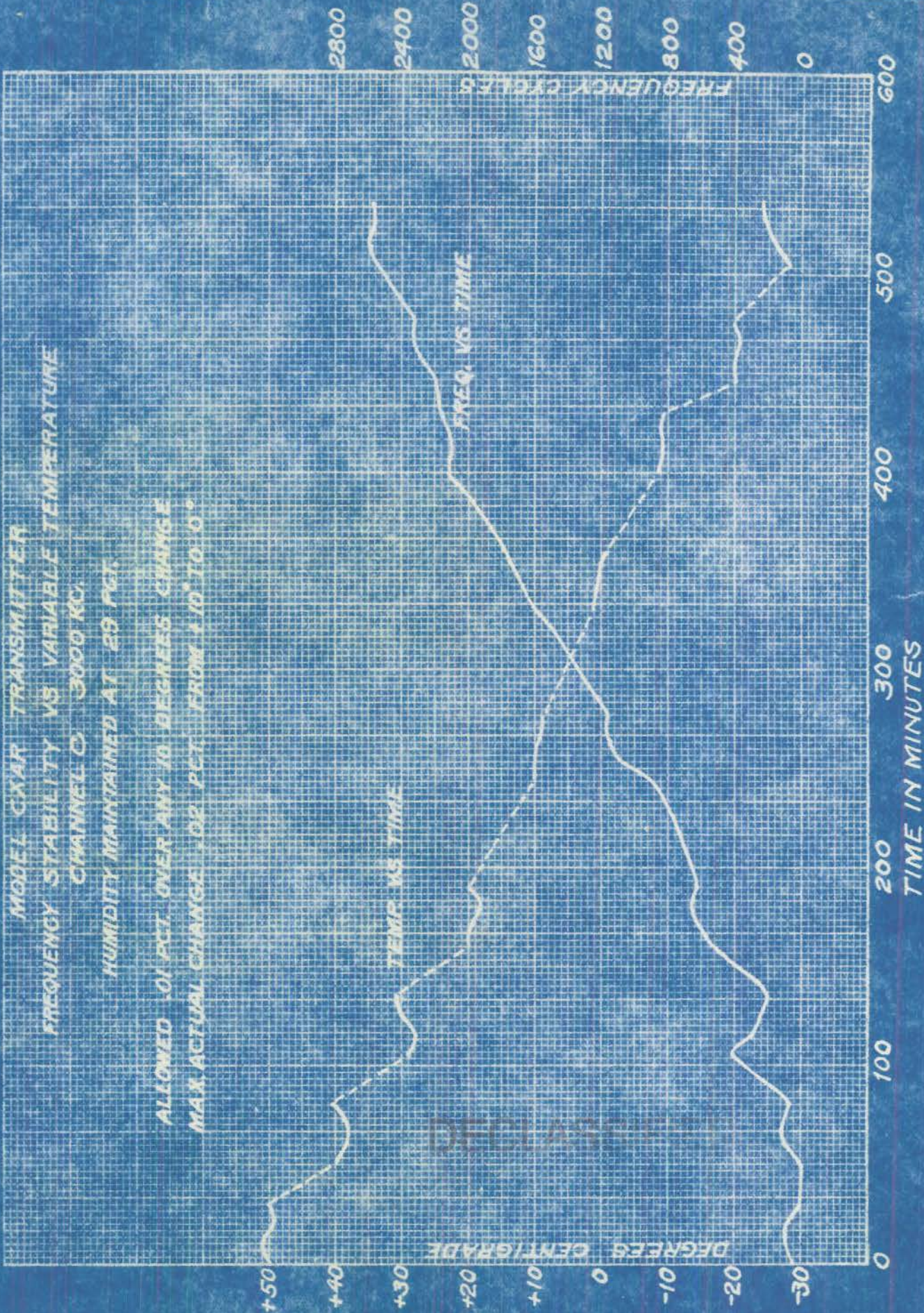
MODEL C-X-R TRANSMITTER  
 FREQUENCY STABILITY VS VARIABLE TEMPERATURE,  
 CHANNEL A 5.50 KG.  
 HUMIDITY MAINTAINED BETWEEN 22 AND 34 PCT,  
 ALLOWED .025 PCT OVER ANY 10 DEGREE CHANGE.  
 MAX. ACTUAL CHANGE .045 PCT FROM 0 TO 10°

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MODEL GXAR TRANSMITTER  
 FREQUENCY STABILITY VS VARIABLE TEMPERATURE  
 CHANNEL B 1000 KC.  
 HUMIDITY MAINTAINED BETWEEN 25 AND 50 %  
 ALLOWED .025 PCT OVER ANY 10 DEGREES CHANGE.  
 MAX ACTUAL CHANGE .021 PCT FROM +10 TO 0.

N. R. J. 81A

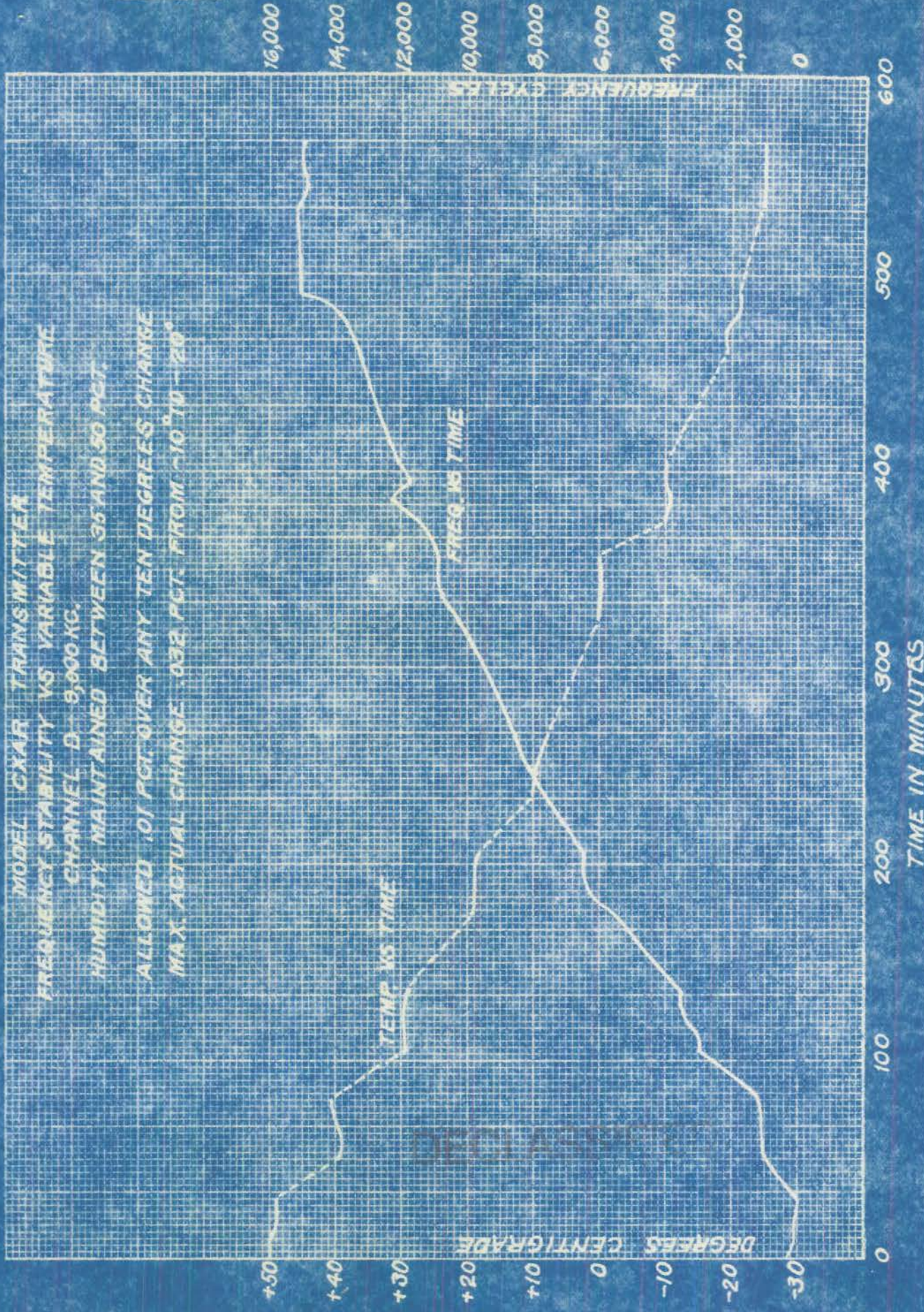


MAXIMUM TEMPERATURE

MINIMUM TEMPERATURE

PLATE 3

N. R. L. 34A



MODEL C-1A TRANSMITTER  
 FREQUENCY STABILITY VS. TRANSMITTER  
 CHANNEL OF 9000 KC  
 STABILITY MAINTAINED BETWEEN 30 AND 40

ALLOWED FOR OVER ALL TEN DEGREES CHANGE  
 IN ACTUAL CHANNEL FROM 10 TO 1000

TEMPERATURE - 1000 KC

TEMPERATURE

DEGREES CENTIGRADE

TIME IN MINUTES

PLATE 4

N. R. L. 34A

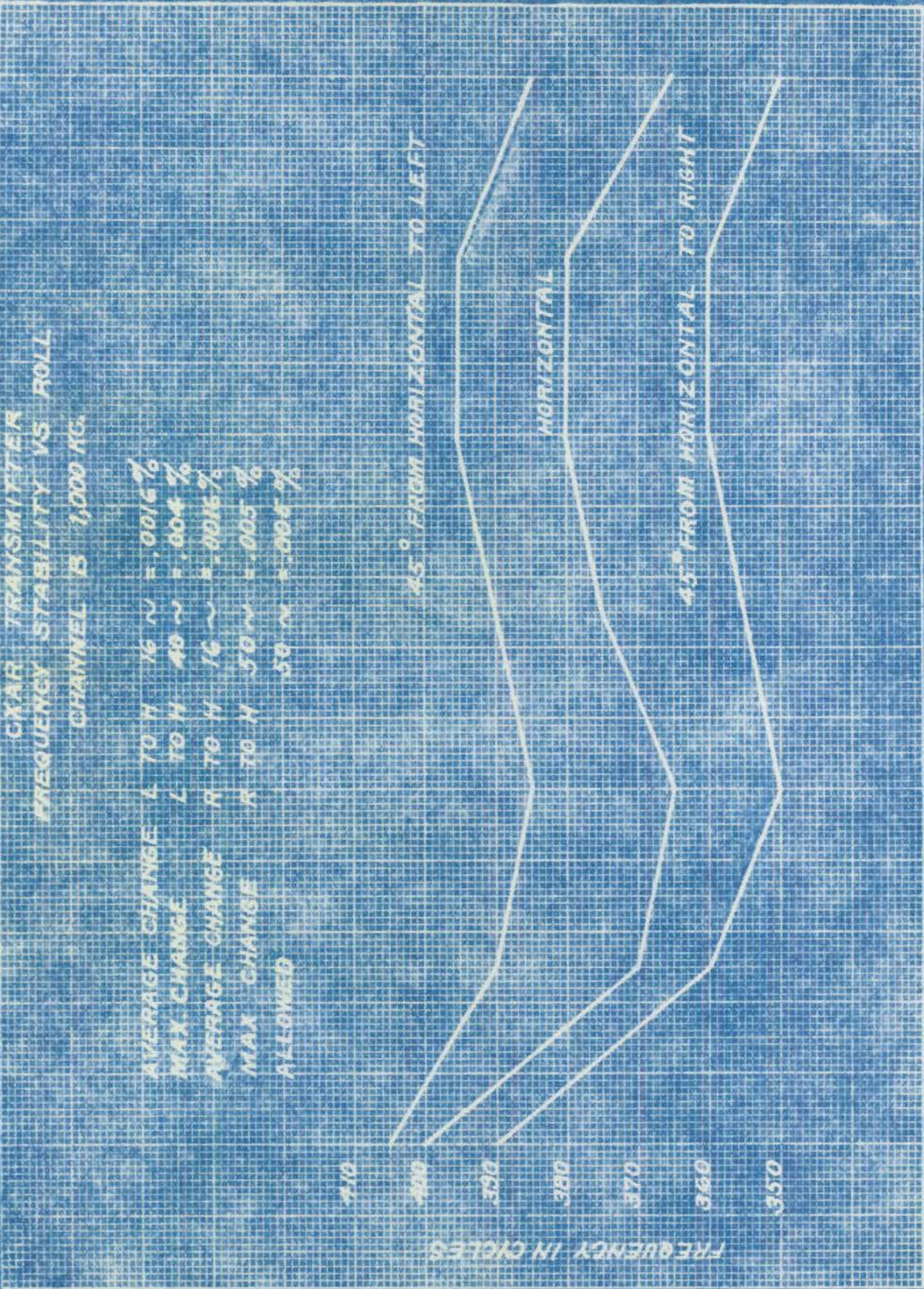
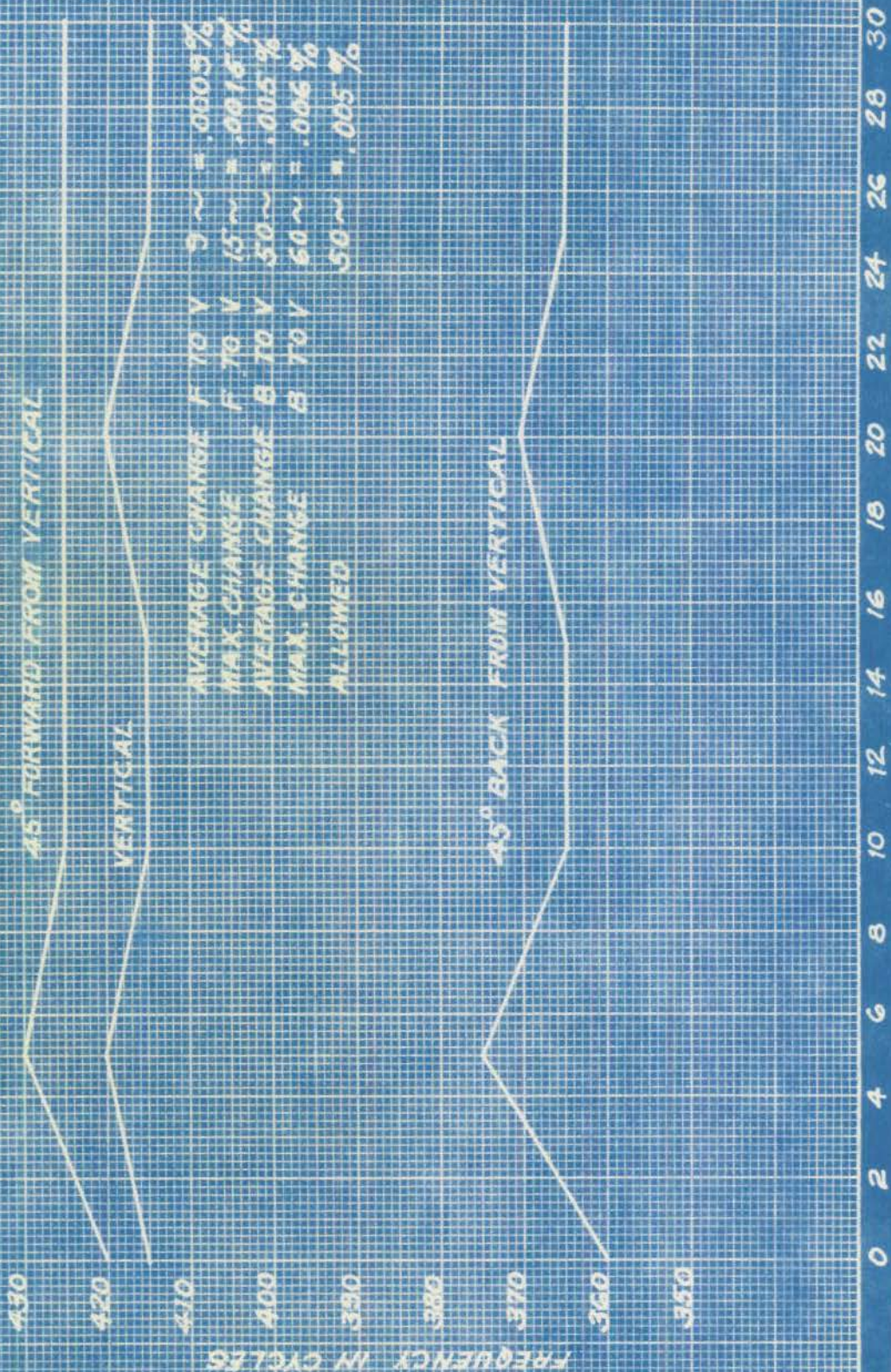
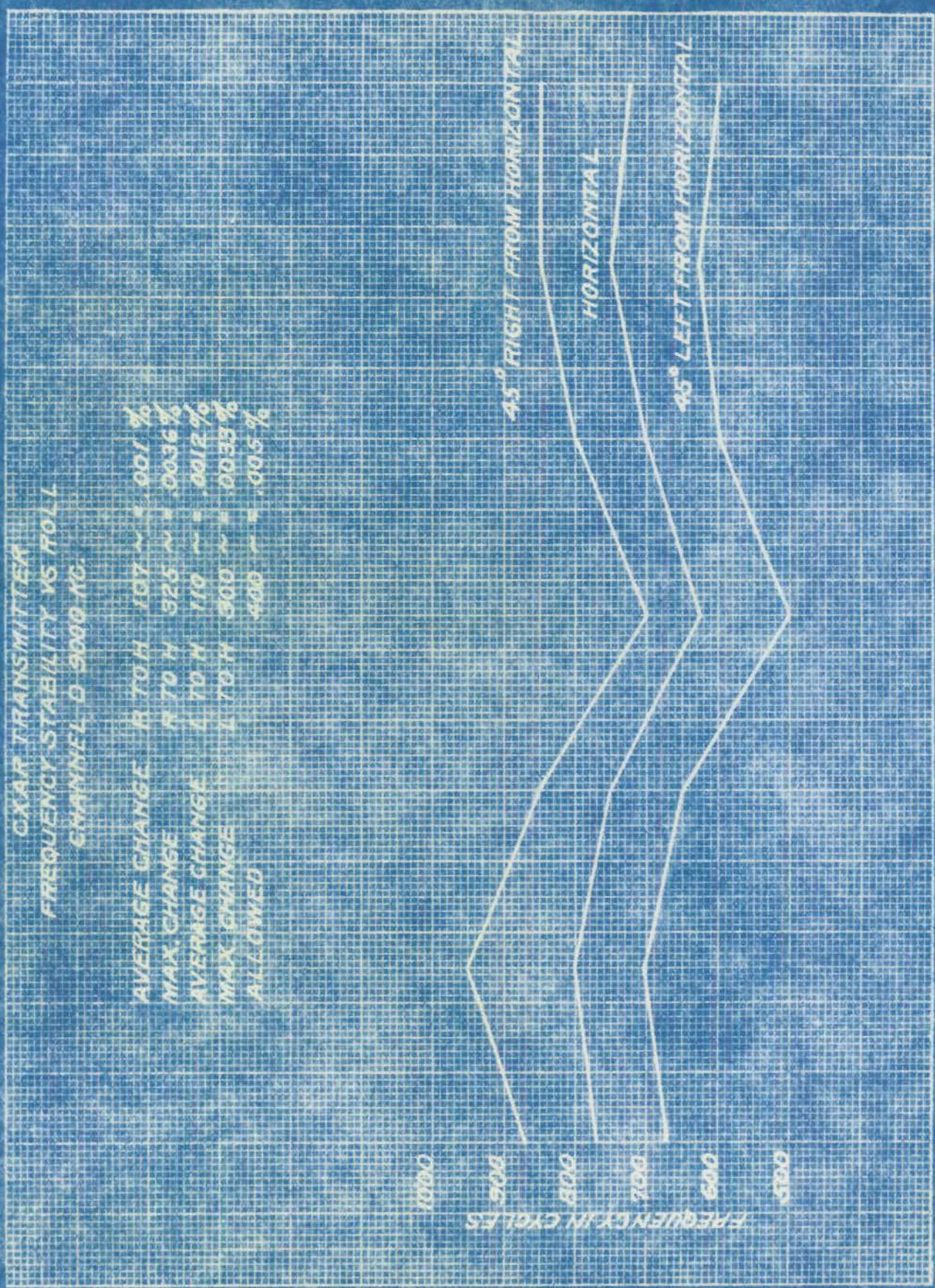


PLATE 5

CXAR TRANSMITTER  
FREQUENCY STABILITY VS. PITCH  
CHANNEL B 1000 KC



AVERAGE CHANGE F 70 V 9 ~ = .0003%  
 MAX CHANGE F 70 V 15 ~ = .0016%  
 AVERAGE CHANGE B 70 V 30 ~ = .0025%  
 MAX CHANGE B 70 V 50 ~ = .006%  
 ALLOWED 50 ~ = .005%

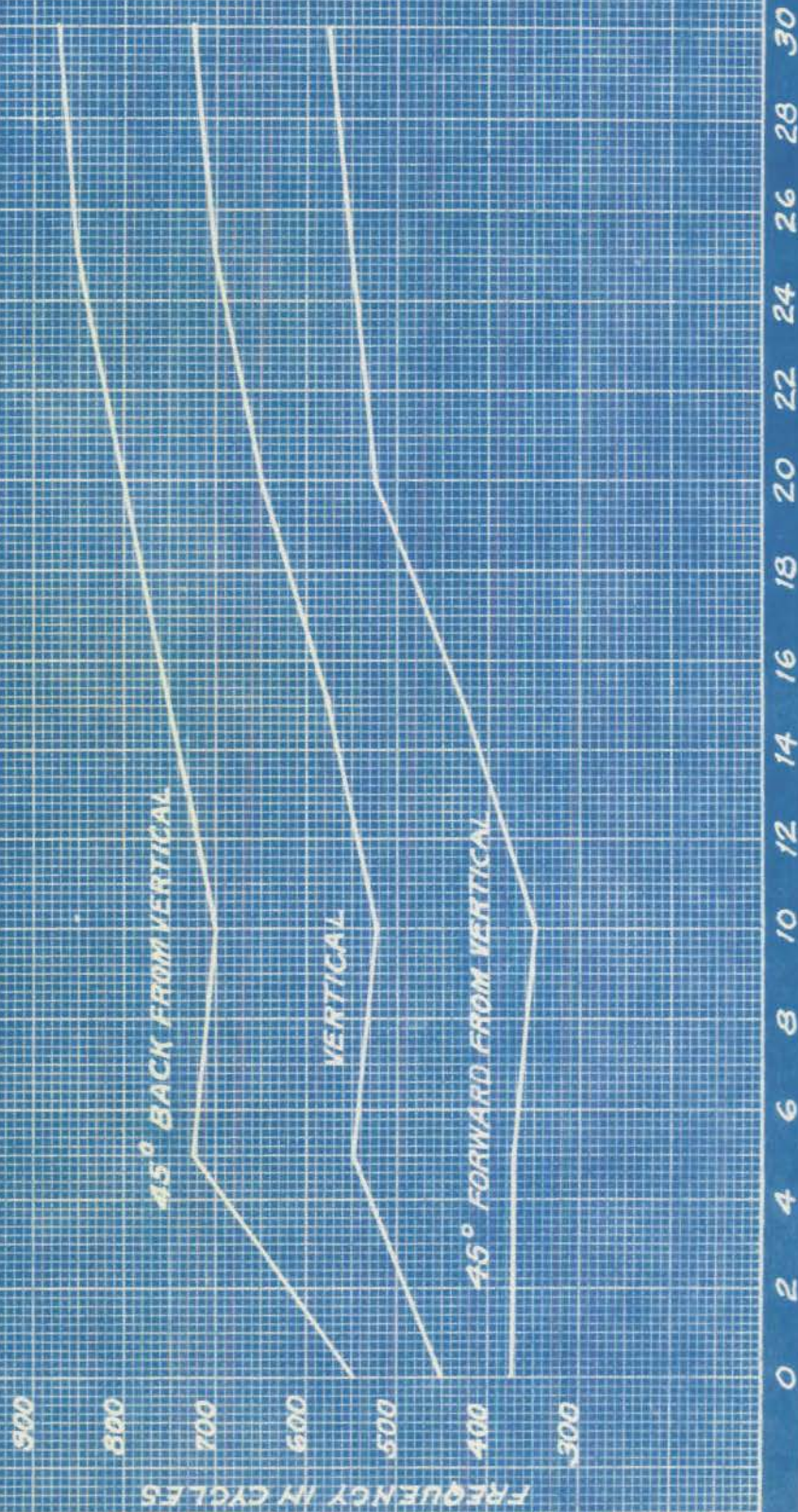


0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30  
TIME IN MINUTES

N. R. L. 81A

GNAR TRANSMITTER  
FREQUENCY STABILITY VS PITCH  
CHANNEL D 3000 KC.

AVERAGE CHANGE F TO V 150 ~ = .0016 %  
MAX CHANGE F TO V 375 ~ = .0041 %  
AVERAGE CHANGE B TO V 155 ~ = .0017 %  
MAX CHANGE B TO V 425 ~ = .0047 %  
ALLOWED 450 ~ = .005 %



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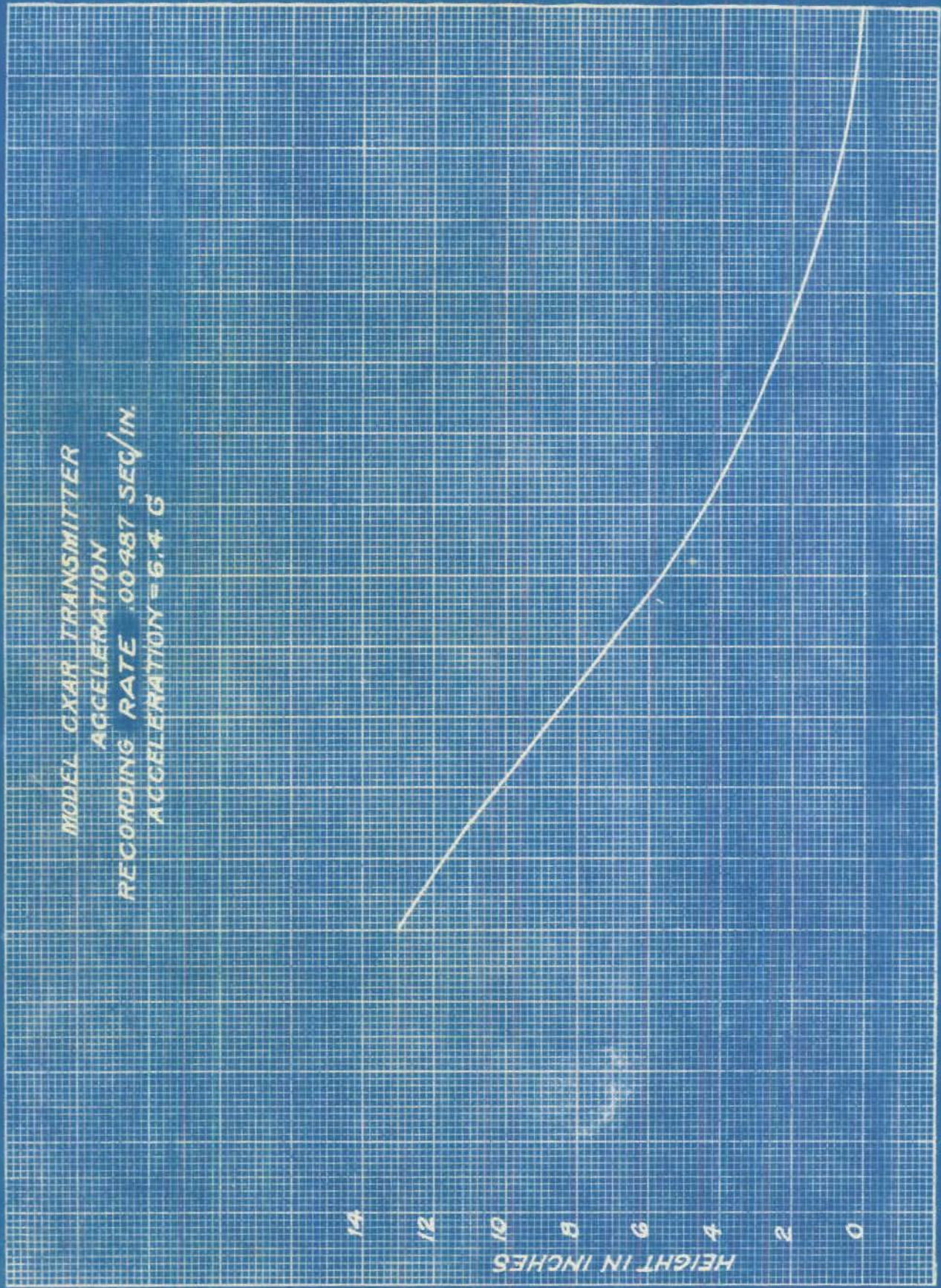
PLATE 8

MODEL CXAR TRANSMITTER

ACCELERATION

RECORDING RATE .00987 SEC/IN.

ACCELERATION = 6.4 G



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Refer to No.  
F42-1/32(9)/  
NAS (96)  
Serial 41068

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

26 FEB 1941

From: Commanding Officer.  
To: The Chief of the Bureau of Ships.

Subject: Aircraft Radio - Confidential Contract C-NOs73237  
with Bendix Radio Corporation for CXAR Equipment -  
Flight Test of Subject Equipment - Report on.

Reference: (a) BuShips ltr. C-NOs73237 (1-22-DR1) of January 28,  
1941.

Enclosure: (A) Photograph AN-57024; Model CXAR Equipment; Proposed  
Layout of Transmitter, I.C.S. Unit, and two Associated  
Receivers.  
(B) Photograph AN-37007; Model CXAR Equipment. Complete  
Equipment.  
(C) Photograph AN-37005; Model CXAR Equipment. View of  
Right Side and Rear of Transmitter.  
(D) Photograph AN-37006; Model CXAR Equipment. Front  
View of Transmitter Showing Method of Removing Coil  
Cans.  
(E) Photograph AN-57008; Model CXAR Equipment; Left  
Side and Front of Transmitter.  
(F) Photograph AN-57009; Model CXAR Equipment; Dual  
View of High Frequency Coil Cans.  
(G) Photograph AN-57010; Model CXAR Equipment; Dual  
View of Low Frequency Coil Cans.  
(H) Photograph AN-57011; Model CXAR Equipment; Top  
View of I.C.S. Unit.  
(I) Photograph AN-57012; Model CXAR Equipment; Top  
View of Transmitter Dynamotor.  
(J) Photograph AN-57015; Model CXAR Equipment; Front  
View of Pilot's Control Box.

1. This letter is the report of tests made at this station  
on the subject equipment.

2. Description of Equipment.

The subject equipment consists of a four channel quick-  
shift transmitter and a separate interphone unit. Both units oper-  
ate in conjunction with their own dynamotor and the entire equip-  
ment is designed to operate from a 24-28 volt D.C. power supply.  
The transmitter can be operated from either a local or remote posi-  
tion and provisions have been incorporated for a second remote posi-  
tion. Four separate channels can be installed in the transmitter

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and these channels are of two types. The low frequency type extends from 340 to 1000 kc and the high frequency type extends from 3000 to 9050 kc. Any combination of channels can be used but the low frequency channels are suitable for operation into a trailing antenna only. Two high frequency and two low frequency channels were furnished with the test model.

3. History of Tests.

The subject equipment arrived at this station on January 27. Preliminary bench tests were made and flight tests were begun on January 30 in JO-2 airplane #1049. Six flights were made including one to an altitude of 18000 feet. CW, MCW and voice communication was obtained on representative frequencies throughout the band when using antennas for which the equipment had been designed. During the test period the following failures occurred in the subject equipment.

- (a) Pilot's voice sidetone failed and no interphone was available with two microphone buttons depressed. This condition was corrected by the contractor.
- (b) Voice - code selector circuit was broken during repair of sidetone circuit mentioned above. Circuit was repaired.
- (c) Frequency shifting mechanism failed to operate properly; two days were consumed in repairing three individual failures of the frequency shifting mechanism.
- (d) Channel D gave intermittent operation on the ground and on two flights. Trouble was due to poor contact at rear of coil can assembly.
- (e) Excessive noise is produced in the receivers by both the interphone and the transmitter dynamotors. Several efforts to cure this condition have not produced satisfactory results.
- (f) One channel indicator button in transmitter control box failed to operate properly. Button was repaired.

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(g) Numerous failures occurred due to the fingers at the rear of the coil can not making proper contact.

4. Weights and Overall Dimensions.

<u>Unit</u>	<u>Height</u>	<u>Width</u>	<u>Length</u>	<u>Weight</u>
Transmitter	10 3/4	13 3/8	20 1/2*	69.0
Trans. Control Box	4 3/4	3 1/8	5 1/2	3.5
Trans. Dynamotor	8 7/16	6 3/8	10	26.5
I.C.S. Unit	6 7/8	5 1/2	7 1/2	10.4
Cable (Trans. Dym. to Power Source)			48"	1.4
Cable (Trans. Dym. to Trans.)			48"	1.6
Cable (Trans. to I.C.S. Unit)			48"	1.5
Cable (Trans. to Trans. Control Box)			110"	3.0
			TOTAL WEIGHT	116.7

\*Additional 1 1/2" is provided on mounting plate to duplicate GP mounting provisions.

5. Installation Facility.

The original transmitter mounting plate was too short to mount in the holes drilled for the GP series transmitter and the contractor furnished a second transmitter mounting plate which was drilled with suitable mounting holes. Since a representative service installation was not possible in the JO-2 #1049 radio test airplane, the equipment was installed temporarily in SBD-1 airplane #1597. On the basis of this installation the following comments are made:

- (a) The transmitter mounting plate must extend one inch to the right of the transmitter case in order to be adaptable to the GP mount. An additional inch could be added to the transmitter case without complicating the mounting. Providing the louvers were stamped inboard, this increase in case dimension might be made as much as an inch and one-half. This additional space in the transmitter case is considered essential for purposes of accessibility, and safety factor at altitude.

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- (b) The transmitter is not accessible to the operator unless he loosens his safety belt and crawls through the gun mount. (SBD type planes).
- (c) The I.C.S. unit and the transmitter dynamotor can be mounted satisfactorily but not in positions readily accessible to the operator. The I.C.S. unit does not mount in the space provided for the GP loading coil as the lead coil mount is on the side of the ship and the weight of the I.C.S. unit precludes this type of mounting.
- (d) The pilot's transmitter control box can be mounted without undue trouble but it will be difficult to provide a satisfactory view of the front of this unit. A design of this unit which could be operated largely by the "feel" of the switches would be highly desirable.
- (e) The type of shock mounting on the CXAR transmitter requires more vertical clearance for installing the unit than the shock mounting on the GP transmitter. A change in design making the CXAR similar to the GP is considered essential.
- (f) The above comments are applicable to most installations. Details will vary depending upon the amount of accessory equipment that is to be carried. It is assumed that a frequency indicator will no longer be carried but this space will probably be required for mounting a receiver.

6. Basic Control Circuits.

The basic control circuits of the model CXAR equipment are not suitable for Naval Service. Volume controls have been placed on units which will not normally be accessible in flight; audio circuits which connect ultimately to the listener's headphones are run in the same cable with a power lead carrying 1000 volts; the transmitter unit performs the function of an interphone junction box and the interphone is inoperative without the transmitter; coordination with receivers is possible with only a single, specific type of receiver; sectionalizing of trouble is impossible in the present design; eighty-four leads coming out of the side of the transmitter make circuit tracing and servicing a job for the

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expert only. In order that this equipment may be made serviceable it is recommended that the basic design be made similar to that outlined in enclosure (A). The numbers adjacent to the inter-connecting cables indicate the approximate number of conductors in each cable necessary to perform the required functions. The following switches, jacks, and indicators will appear on the respective units:

A. Transmitter Dynamotor.

None.

B. Transmitter.

- (1) Local - Remote switch.
- (2) On- Off switch.
- (3) Emission selector switch.
- (4) Channel selector switch.
- (5) Channel indicator.
- (6) Sidetone jack.
- (7) Key jack.
- (8) Microphone jack.
- (9) Tune - Operate switch.
- (10) Test key.
- (11) Antenna switch.
- (12) Throttle jack.
- (13) CFI coupling post.

C. Pilot's Transmitter Control Box.

- (1) On- Off switch.
- (2) Channel selector.
- (3) Indicator showing pilot control of transmitter.

D. I.C.S. Unit

None.

E. I.C.S. Master Control Unit.

- (1) I.C.S. On - Off switch.

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- (2) I.C.S. Attenuator.
- (3) Rec. 1, Rec. 2, Both, switch.
- (4) Two or more jacks for interconnecting associated receivers.
- (5) Radio - I.C.S. switch (microphone only.)
- (6) Microphone jack.
- (7) Split phone jack.
- (8) Key jack.
- (9) Throttle jack.
- (10) Handphone attenuator.

F. I.C.S. Extension Control Unit.

- (1) Radio - I.C.S. switch.
- (2) Split phone jack.
- (3) Headphone attenuator.
- (4) Rec. 1, Rec. 2, switch.
- (5) Microphone jack.
- (6) Key jack.
- (7) Throttle jack.
- (8) I.C.S. attenuator.

Additional I.C.S. extension control boxes will be identical to F. As many can be used as the available audio power will permit. The control circuits will be so arranged that the transmitter will normally be on code emission ready for key operation but will shift automatically to voice whenever any microphone button or throttle switch is depressed. Both pilot and operator will have a choice of voice or code emission with appropriate sidetone regardless of which one selects the channel but the operator alone will be able to shift from CW to MCW. Assuming that all occupants wear split phones the suggested control circuit will provide the following operation:

- (a) Clear channel I.C.S. at all times regardless of whether radio communication is in progress or not.
- (b) Radio communication at all times regardless of I.C.S. circuits.
- (c) Any occupant can listen to any two-way radio conversation at any time and still monitor I.C.S.

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7. Tuning of Transmitter.

Tuning of the equipment has given the operating personnel far more than the average amount of trouble. A certain amount of this is chargeable to inadequate calibration data and lack of proper engraving on the various controls. Assuming that these items will be corrected as far as is possible the following objections still remain:

- (a) Both the low frequency and high frequency channels have eight internal tap switches and links in addition to five controls on the front panel. It is possible to pre-calibrate all controls not associated with the antenna but matching the antenna is a difficult procedure. It will be necessary to have an auxiliary power supply to operate the equipment during the process of resonating the antenna as this operation must be done in the airplane and the planes battery is not adequate for carrying the load. Tuning in flight is impractical with this equipment.
- (b) Wherever the frequency determining circuit operates at  $1/3$  of the output frequency, the operator must be aware of this fact in order that he can act up frequencies properly with the BI series frequency indicator.
- (c) The "Ant. Load" and "Ant. Var." tap switches in the high frequency channel must be used in a particular sequence in order to secure continuous coverage of antenna circuits. The correct sequence is not indicated in the present design.
- (d) Both a screw driver and a suitable wrench are now necessary to tune the transmitter. Use of tools tends to scratch the transmitter and leave sharp edges which may destroy the altitude characteristics of the equipment.
- (e) At the upper end of the high frequency channel the set will not resonate large antennas (see paragraph on antenna matching) and even where the antenna can be resonated, it is possible to destroy indications of resonance by overcoupling.

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- (f) The settings of the front panel controls bear absolutely no relationship to the frequency to which the channel has been tuned.
- (g) It is doubtful if the reset characteristics at the upper end of the band of this equipment are good enough to warrant resetting to a previously calibrated setting without again using a frequency meter. This would mean that battery power would always have to be available whenever a channel was tuned.
- (h) It is estimated that an experienced, competent radioman can tune up four high frequency channels in two hours. This estimate is based on the assumption that a battery power supply is already available and full calibration data and a frequency meter are likewise available. The transmitter must also be operating into the antenna with which it is to be used.

8. Basic Circuit Design other than Control Circuits.

The basic design of the model CXAR equipment consists of the master oscillator, power amplifier radio frequency circuit with suitable audio circuits to provide voice and tone plate modulation. This part of the design is considered thoroughly satisfactory but there are too many complications in the circuit which are not essential. Such features are two tone telegraphic sidetone, individual step adjustments of the impedance of each sidetone output, locking the key in the tune position, providing contacts on the key relay for disabling screens of associated receivers, separate microphone inputs on both transmitter and interphone, dual selsnoid key relay, filament under-voltage relay, and separate sidetone tube. Some of these features may even provide additional performance in isolated cases but their inclusion in an aircraft design where space is at a premium, is not warranted.

9. Noise in Associated Receivers.

Both the I.C.S. unit and the transmitter dynamotor caused serious radio noise in the associated receivers. Several attempts have been made to eliminate this noise and some progress

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has been made but as yet no satisfactory solution has been found. In all cases observed it was evident that the disturbance was entering the receiver via the antenna and could not be attributed to a deficiency in the receiving equipment.

10. Construction of Case.

The construction of the case is considered inferior to that of the later GP series transmitter. The GP shock mount design is also preferable. Cables are brought out of the CXAR through right angle plugs at the lower left hand side of the transmitter. Cables of the GP transmitters are brought out through straight plugs from a projection at the upper right hand side of the transmitter. This destroys the complete interchangeability of the two transmitters but causes no difficulty in the installation of the CXAR transmitter in the SBD-1 airplane.

11. Magnetic Control Switches.

Three types of magnetic control switches are used in this equipment; some are indicators as well as switches, some require momentary contact only and others must be held in position until their function has been completed. In general, they have not proven satisfactory for this type of service and it is considered desirable to eliminate them wherever possible. The basic objections to their use are as follows:

- (a) Servicing becomes complicated because troubles cannot be isolated. For example, a failure in the pilot's control box will prevent the transmitter from being operated locally even if the pilot's control box is removed from the circuit.
- (b) The control buttons are too small to make good indicators.
- (c) The control buttons operate so easily that there is no "feel" of position. This also leads to frequent unintentional operation of various circuits.

12. Keying Action.

Keying action has been satisfactory so far as the qual-

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ity of the received signals is concerned but excessive noise is produced in the operator's ears when transmitting. This is apparently due to a key relay bounce when the relay returns to the de-energized position. Use of the screen disabling feature did not eliminate any of the noise in the operator's ears; in fact under some conditions a slight additional slick was introduced by the screen disabling circuit. The more serious objection to the screen disabling system so far as the RU receiver is concerned is the fact that the main voltage divider in the RU receiver will burn up if the transmitter key is locked for five minutes. Even if this were not the case it would be too difficult to interconnect present Navy receivers to make the system practicable. Another feature of the key relay which appears unnecessarily cumbersome is the use of two solenoids on the key relay in order to prevent interaction of microphones under various service conditions.

13. Altitude Operation

Satisfactory CW, HFW, and voice operation into a small fixed antenna was obtained at 3003 kc up to an altitude of 10000 feet. Similar operation was obtained on 542 kc. when using a 250 foot trailing antenna. The set is not designed to operate into fixed antennas in the intermediate frequency range.

14. Antenna Matching.

Satisfactory operation into trailing antenna is indicated on the intermediate frequency range. On the high frequency range the operation is satisfactory at 3000 kc even when using small antennas (60 mmf) but at 9050 the set will not resonate inductive antennas. Even when the natural period of the antenna is above 9000 kc. and tuning is possible, the operation is not completely straightforward and satisfactory. At 9050 kc. the inductance and distributive capacity of the antenna loading circuits is so great that the transmitter can be tuned into its own load coil without any antenna attached and the settings will correspond closely with settings which will resonate a small antenna.

15. Frequency Reset.

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Frequencies can be reset within 0.03% under optimum conditions. However, the frequency of a particular channel is dependent not only on its location in the transmitter but also on the physical absence or presence of a neighboring channel. The frequency of a channel is also dependent on whether the adjacent channel is a high frequency or low frequency channel. The number of combinations becomes almost endless and the amount of frequency change runs as high as 1%. At 3530 kc. the frequency changed 64 kc when the adjacent coil cans were removed.

16. Power Consumption.

With 28 volt input measured on voltmeter on transmitter the current consumption was indicated.

I.C.S. Filament	1.5 amperes
I.C.S. Filament and Plate	3.0 amperes
I.C.S. Unit and Trans. key up	11.0
I.C.S. Unit and Trans. key down, CW	19.0 Amp.
I.C.S. Unit and Trans. key down, MCW	21.0
I.C.S. Unit and Trans. key down, voice	22.0

17. Associated Equipment.

Associated equipment used during tests consisted of an LI series frequency indicator, a DW-1 direction finder, and a bank of RAV receivers. Operation of the direction finder can be accomplished in installations where the I.C.S. unit is accessible to the operator; the frequency meter can be used if the starting switch on the I.C.S. unit is accessible and the operator is aware of the tripling feature in the transmitter. When setting the transmitter frequencies above 6000 kc the frequency indicator must be set to one-third of the transmitter frequency and this calculation is not always readily accomplished mentally. Coordination of this equipment with the RAV receivers required a special adapter unit which was provided by the contractor. This comment applies to RB series or any other Navy receivers now in service.

18. Filament Under-Voltage Relay.

As the voltage of the power supply decreases, the

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first component to cease operation is the key relay and the second is the dynamotor starting relay. Even with these two relays held in an actuated condition, the effect of the filament under-voltage relay is negligible and retaining it in this design is not warranted.

19. Throat Microphone Operation.

When using a Navy throat type microphone in the pilot's control box there is no means available for closing the key relay or starting the I.C.S. unit. When using the throat microphone in the transmitter, the key relay can be actuated with the test key and the I.C.S. unit may be started with the switch on the I.C.S. unit. This circuit arrangement is unsuitable.

20. I.C.S. Unit

The I.C.S. unit is a double input, 3 tube, double output design which has proven satisfactory during tests insofar as quality and output are concerned. In addition to the deficiencies of a general nature noted in the paragraph on Control Circuits, it is impossible to use the I.C.S. system when the transmitter key is locked. Furthermore the only practicable way of securing power to operate the direction finder is to lock the microphone button with the microphone in the I.C.S. position. This will feed a background of noise to the operator's ears through the I.C.S. system and make direction finding difficult if not altogether impossible. Assuming that all members of the crew are wearing split phones, it is believed that suitable, flexible operation can be obtained from a single ended input, single tube, single ended output design which will be considerably smaller, and simpler than the present design.

21. Conclusions.

A. The model CXAR equipment in its present form is not considered suitable for Naval Service. Major redesign of the equipment as detailed in the next paragraph is considered essential in order to make it suitable. The modifications listed are of such a nature that the present equipment will not serve as a model.

B. The quality of transmissions obtained from the subject equipment have been excellent. CW, MCW and voice transmissions

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have been obtained on representative frequencies throughout the entire frequency range.

C. Tuning and servicing of the equipment are both extremely difficult. The failures encountered during test have consumed approximately 50% of the test period.

D. In spite of the numerous failures which occurred during the brief test period, it is believed that all of the mechanical deficiencies can be eliminated by further development work. As a first model of an extremely difficult design, the subject equipment indicates that it will be practicable to build a four channel, quick-shift transmitting equipment suitable for Naval scouting aircraft.

22. Recommendations.

A. Basic Control Circuits similar to those outlined in enclosure (A) and detailed in paragraph 6 of this letter are considered essential.

B. Transmitter.

- (1) Make the basic radio frequency design of the transmitter such that tuning can be accomplished by service personnel in a reasonable length of time. This comment refers particularly to the design of the high frequency channels.
- (2) Eliminate two-tone telegraphic sidetone.
- (3) Eliminate impedance adjusting resistors on sidetone output.
- (4) Eliminate feature which locks key in tune position.
- (5) Eliminate screen disabling contacts on key relay.
- (6) Eliminate dual microphone input circuit.
- (7) Eliminate one solenoid on key relay.

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- (8) Eliminate filament under-voltage relay.
- (9) Permit contractor to use conventional sidetone circuit without separate sidetone tube providing sidetone of the proper level can be secured without encountering undesirable feedback.
- (10) Eliminate the noise which is now produced in associated receivers by the two dynamotors.
- (11) Avoid the use of magnetic control buttons as much as possible.
- (12) Improve operation of key relay.
- (13) Require the high frequency unit to operate into antennas whose natural period is 9050 kc or higher. Attention is invited to the fact that this will provide operation with all fore and aft antennas on all aircraft, other than patrol planes, which are now in service but will not operate with full Vee antennas above about 7.0 megacycles.
- (14) Eliminate unnecessary coupling taps in H.F. coil cans. 90% of the operation during the test period was obtained on coupling tap #3. Taps #1 and #5 were never used.
- (15) Require frequencies not to change more than 0.03% when adjacent frequency units are removed.
- (16) Make case construction similar to later model GP transmitter. This comment also applies to mounting slides. Provide tube access covers and interlock.
- (17) Permit additional width on transmitter case while still retaining interchangeability of mounting provisions with GP transmitters.
- (18) Increase size of all engraving which pertains to tuning. Engrave in frequency coverage wherever feasible. Letter all controls; stamp condensers.

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- (19) Distinguish front panel appearance of I.F. coil can from H.F. frequency unit. This can be done by red warning plate to use with trailing antenna only.
- (20) Consider the desirability of eliminating the requirement for providing continuous antenna coverage in the I.F. frequency units.
- (21) Bring cables out so transmitter frequency units rest on deck against rear bulkhead without injury.
- (22) Provide means for removing any channel after power has failed.
- (23) Provide local channel indicator which is operative without power being on equipment.
- (24) Make tuning screw-driver fit all screw slots.
- (25) Chain cap of screw driver compartment to set.
- (26) Provide wrench for nuts on condenser; make nuts non-looseable.
- (27) Use minimum number of types and sizes of set screws.
- (28) Improve operation of contacts at rear of frequency units.
- (29) Make frequency units mechanically interchangeable.
- (30) Eliminate "Off" position on radio - I.C.S. switch.
- (31) Eliminate filament voltmeter from set; eliminate meter switch; provide separate grid meter.
- (32) Provide calibration chart with transmitter.
- (33) Improve design of test key.
- (34) Attach tune-operate knob properly.

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- (35) Provide suitable access for servicing frequency shifting mechanism.
- (36) Provide I.C.S. and sidetone adjustment controls at side of case. These are to be operable with a screw driver without removing any shields.
- (37) Locate tubes in accessible positions.
- (38) Stake all jacks.

C. Transmitter Dynamotor.

- (1) Move rear mounting holes on mounting plate forward sufficiently to clear spring loaded studs.
- (2) Eliminate radio frequency noise caused by dynamotor.

D. I.C.S. Unit.

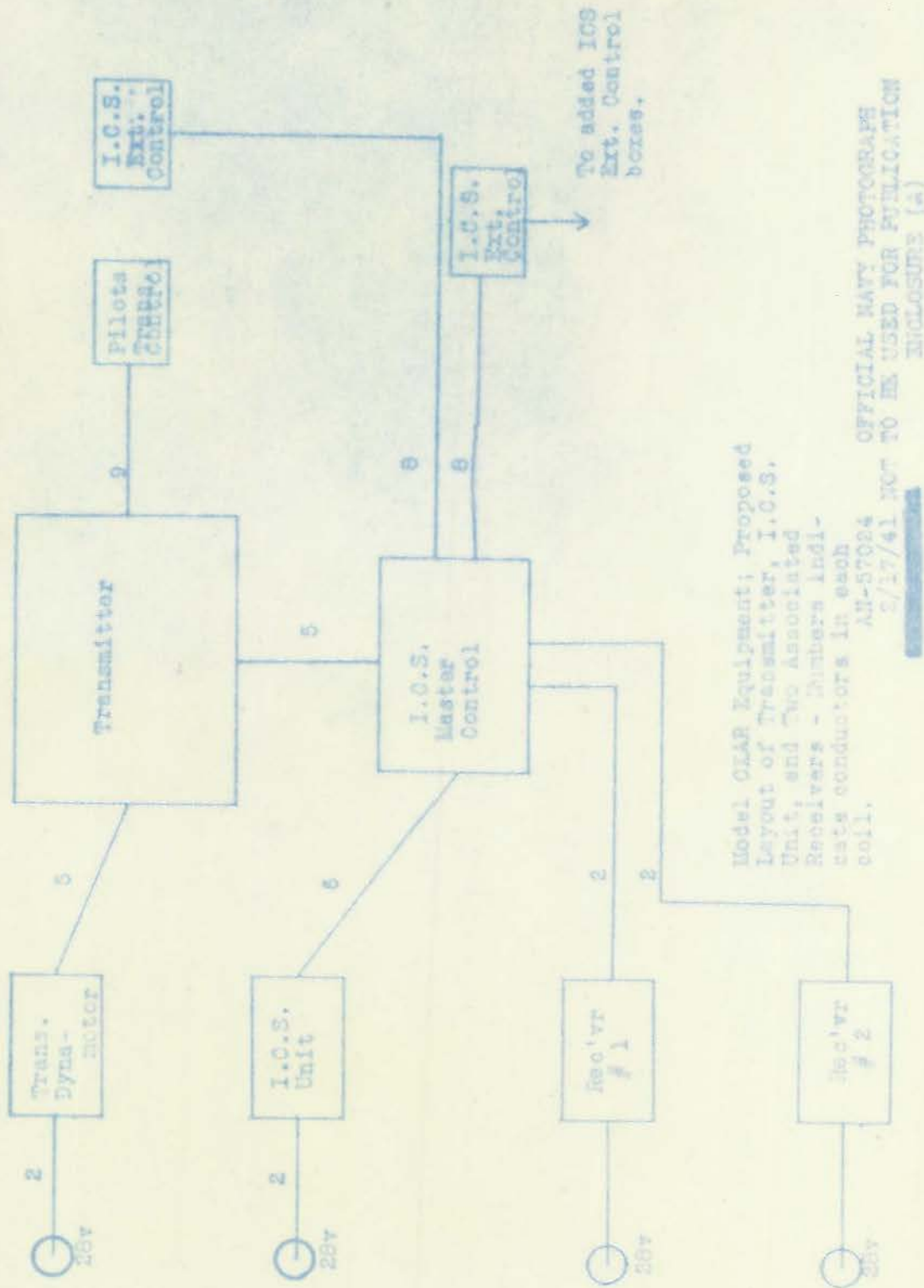
- (1) Redesign as outlined in paragraph on basic control circuits. Make mounting requirements of various units identical to those of corresponding units on other Navy equipment.
- (2) Shock mount should bottom on rubber.

E. Pilot's Control Box.

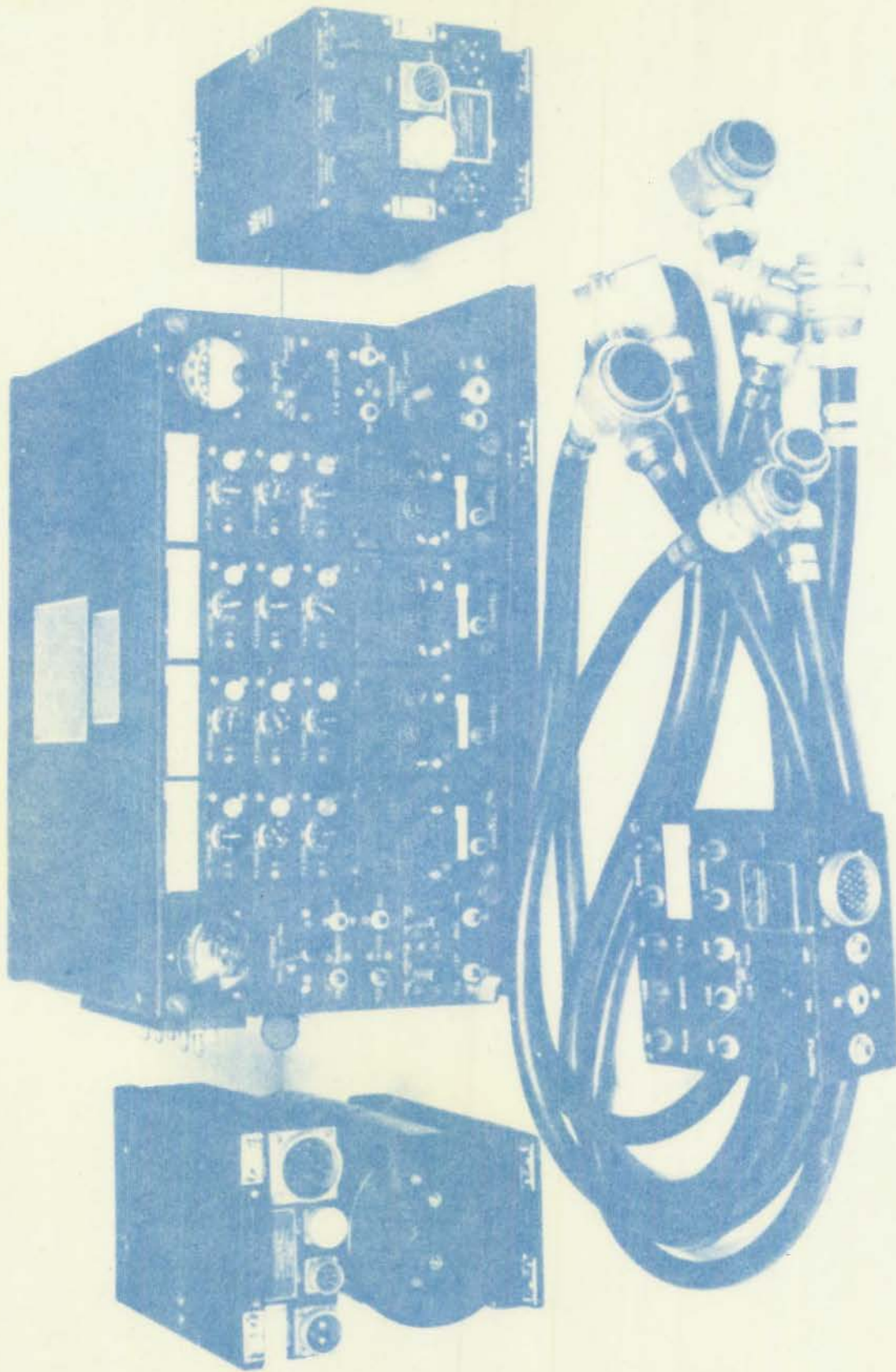
- (1) Redesign as outlined in paragraph on basic control circuits.
- (2) Make mounting requirements identical to those of corresponding units in Naval service.
- (3) Provide proper circuit arrangement for throat microphone operation.

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NRL  
NAF

O. B. HARDISON



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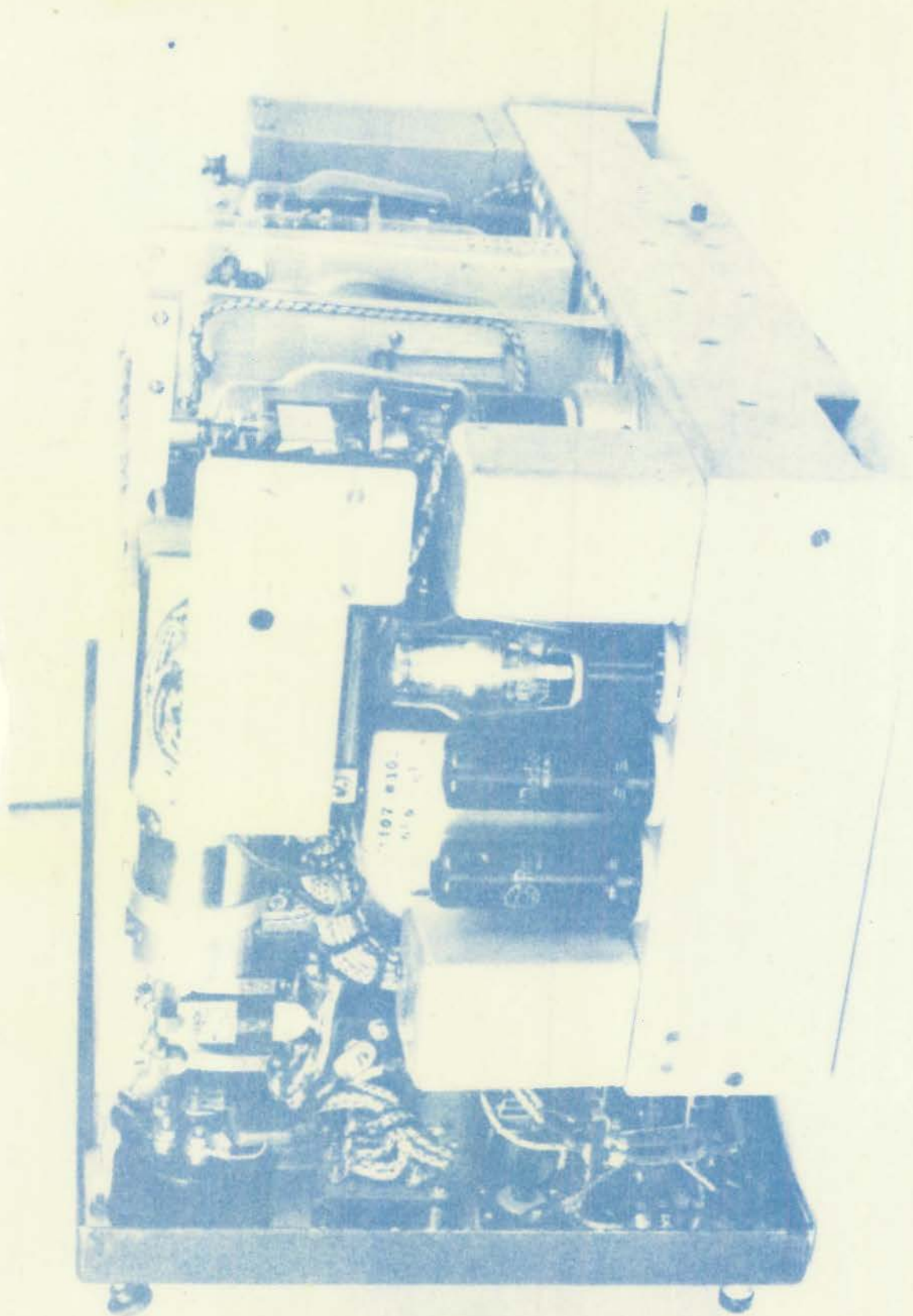


Model CXAR Equipment.  
Complete Equipment.

AN-57007  
2/18/41

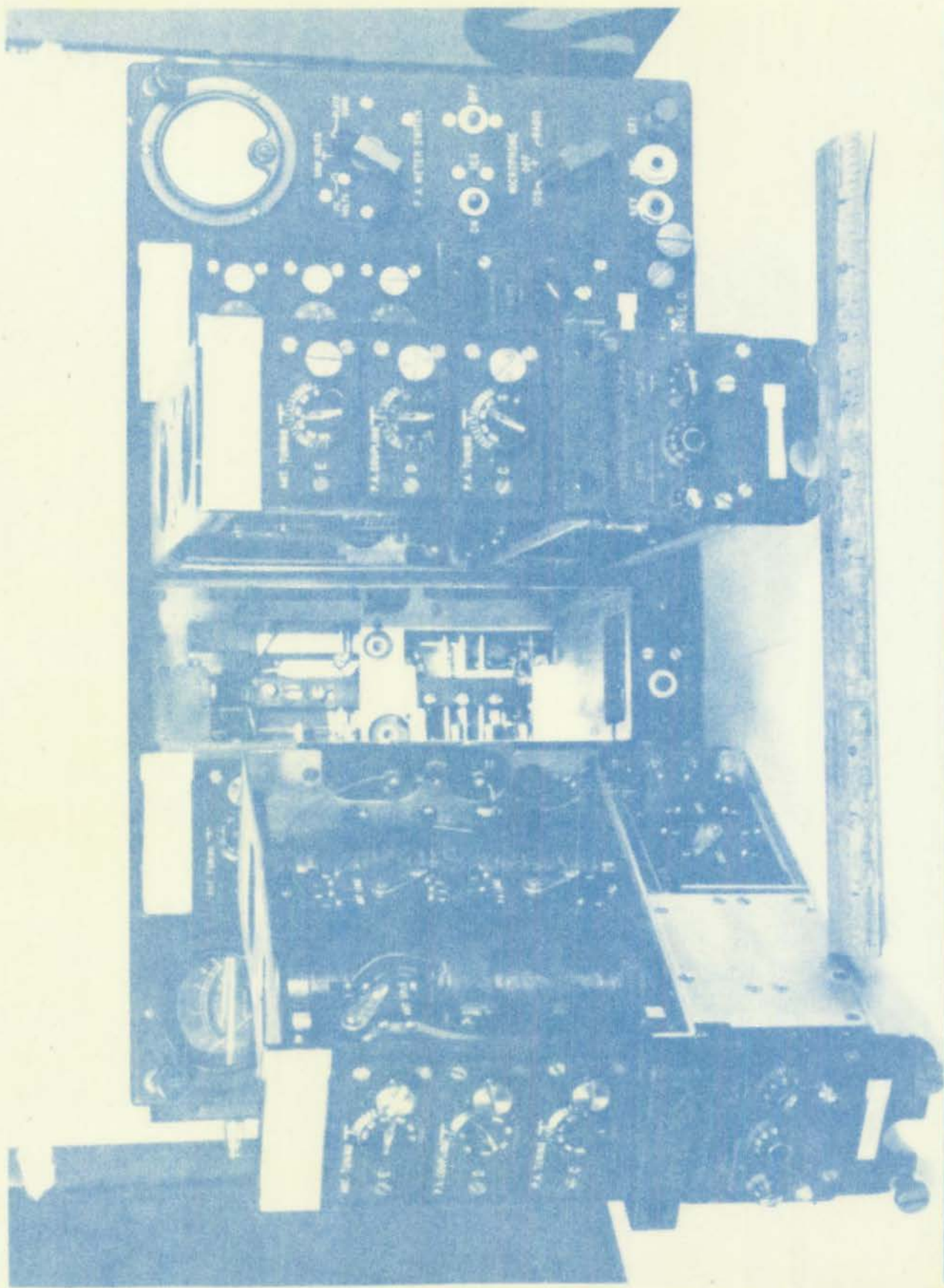
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NOT TO BE USED FOR PUBLICATION  
ENCLOSURE (B)

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Model CXAR Equipment; View of Right Side and Rear of Transmitter. AR-57005 3/17/41 ENCLOSURE (C)

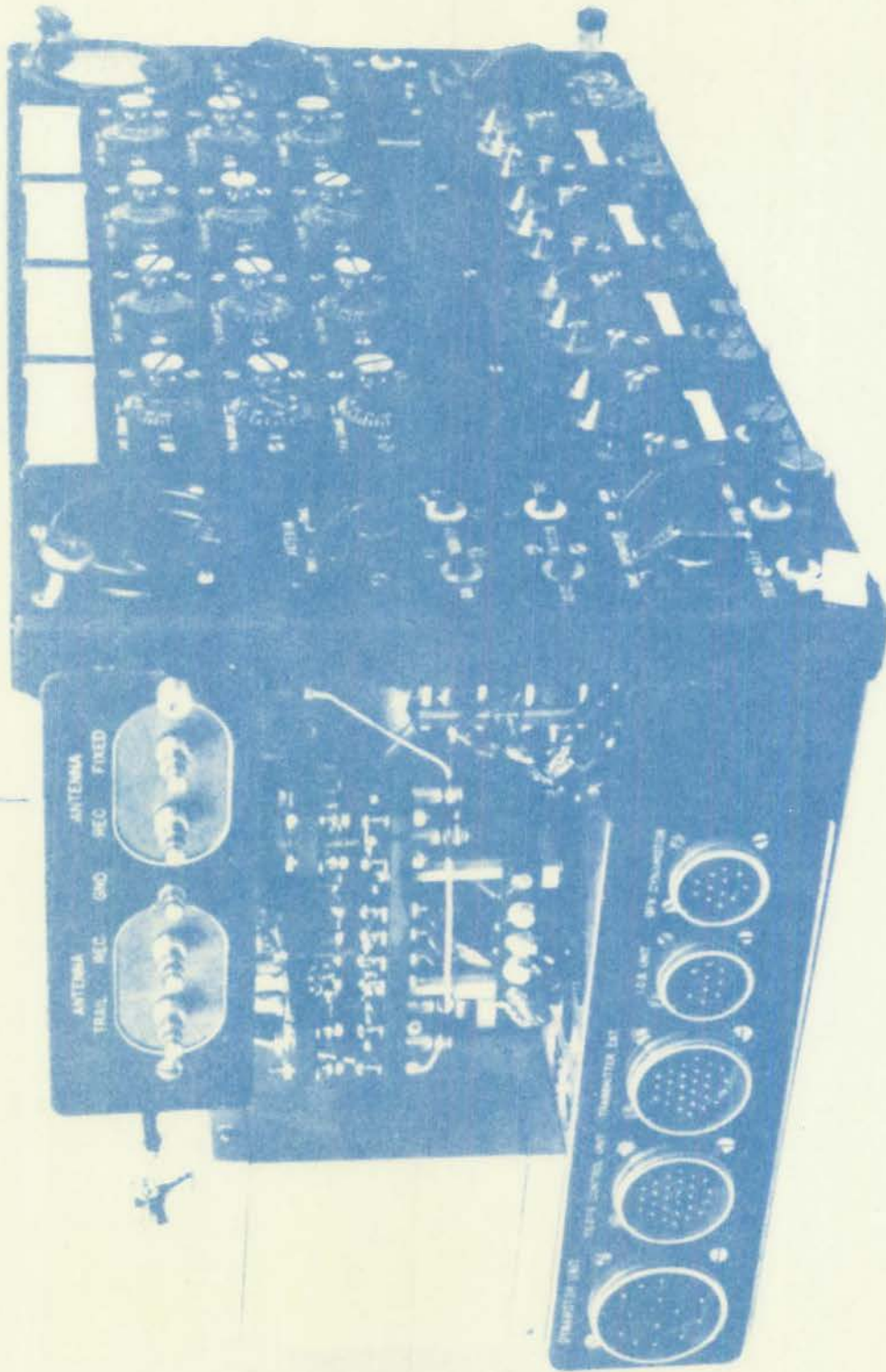
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Model CAAR Equipment, Front  
View of Transmitter Showing  
Method of Removing Coil Cans.

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ENCLOSURE (D)

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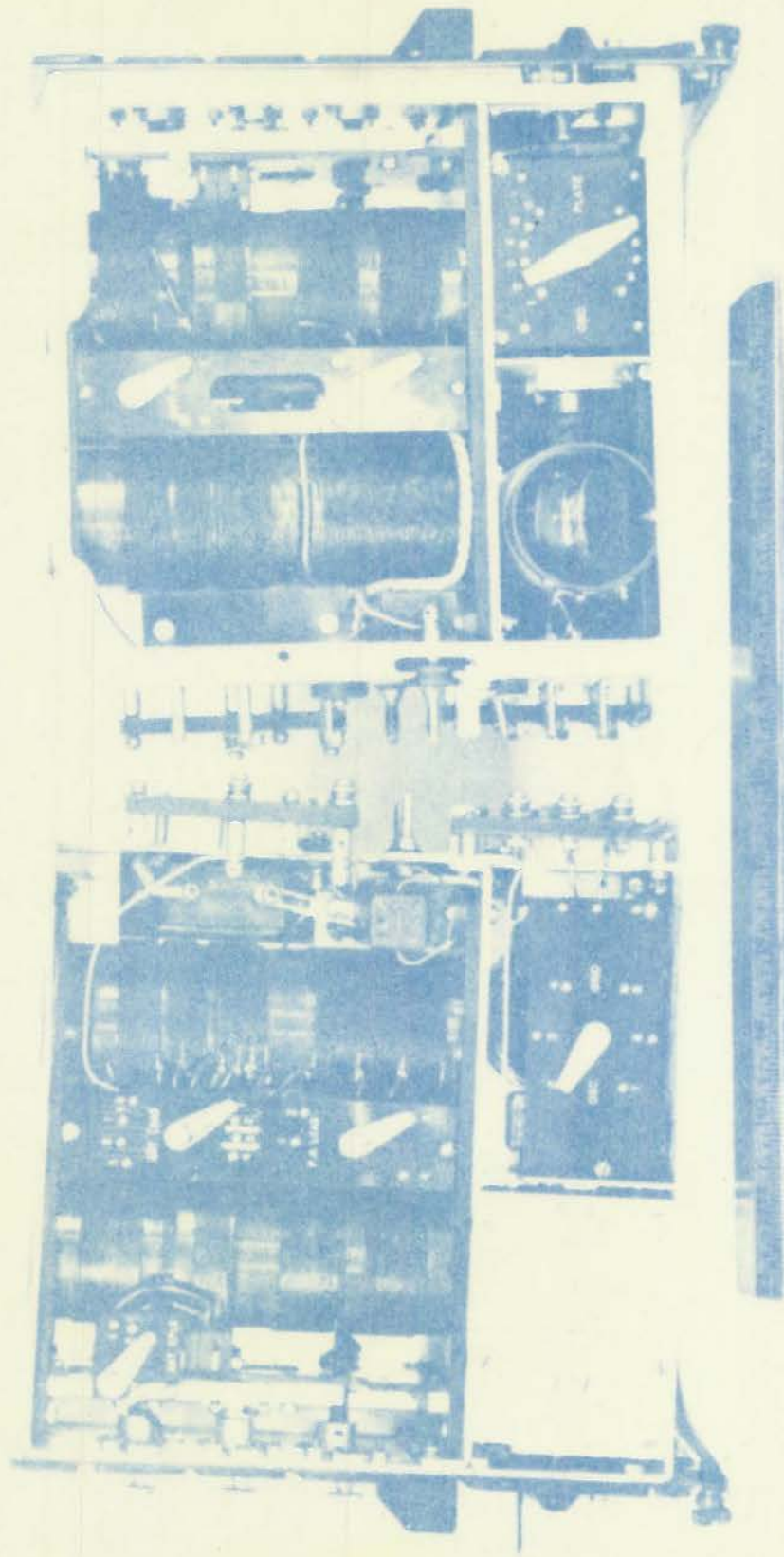


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Model CXAR Equipment; Left  
Side and Front of Trans-  
mitter.

N-57008  
2/17/41

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NOT TO BE USED FOR PUBLICATION  
ENCLOSURE (E)

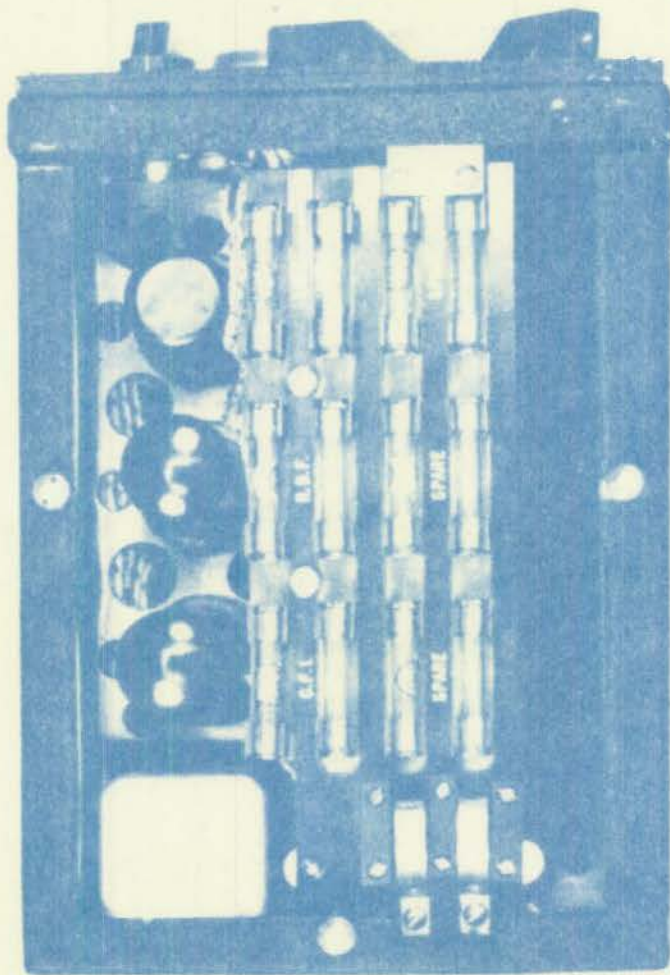


Model CLAR Equipment; Dual  
View of Low Frequency  
Coil Chans.

AN-57010  
2/17/41

OFFICIAL NAVY PHOTOGRAPH  
NOT TO BE USED FOR PUBLICATION  
ENCLOSURE (6)

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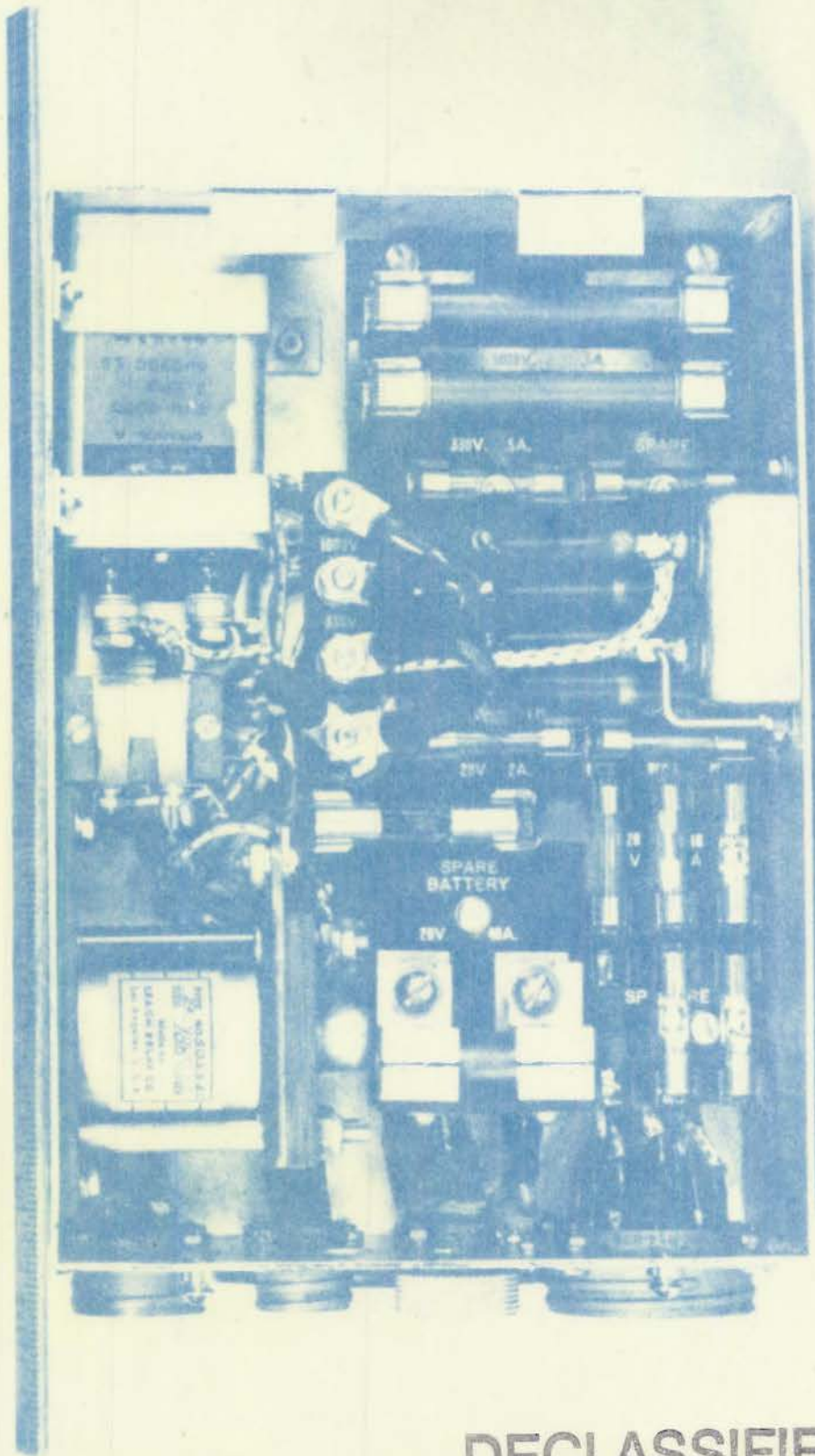
*Stratstone*

Model CXAR Equipment; Top  
View of I.C.S. Unit.

AN-57011  
2/17/41

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ENCLOSURE (H)

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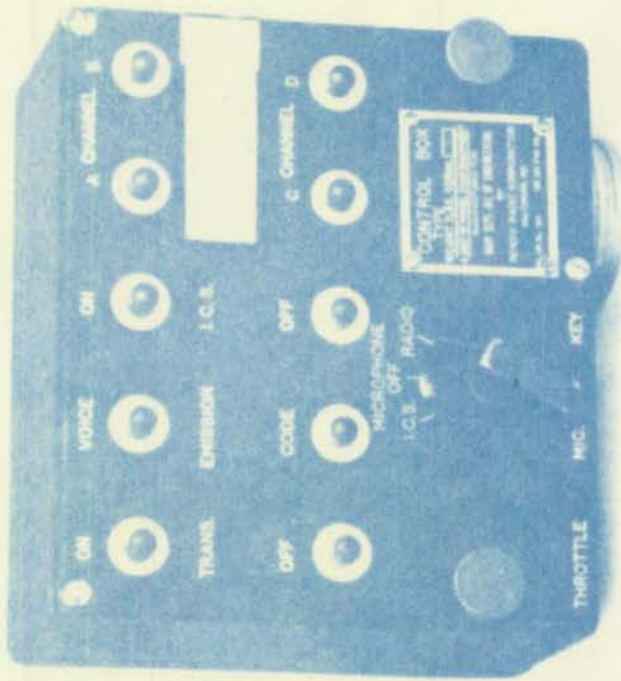


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Model CLAR Equipment; Top  
View of Transmitter  
Dynamotor.

AN-57012  
2/17/41

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ENCLOSURE (I)



Model CXAR Equipment; Front View of Pilot's Control Box. 2/17/41

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ENCLOSURE (J)

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