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SUBJECT

Test of Model TEL-2 Radio Transmitting Equipment

(Contractor: Westinghouse Electric and Manufacturing Company)

BY

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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NAVY DEPARTMENT

BUREAU OF ENGINEERING

CONFIDENTIAL

Report on

Test of Model TBL-2 Radio Transmitting Equipment

FR-1318

(Contractor:

Westinghouse Electric and Manufacturing Company)

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Authorization: BuEng.let.C-NOs-47359(7-6-W8) of 13 July 1936.

Date of Test: July 13 to September 18, 1936.

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Appendices

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AUTHORIZATION OF TEST

1. The tests herein reported were authorized by reference (a). Other pertinent data are listed as references (b) to (k) inclusive.

Reference: (a) BuEng let.C-NOs-47359(7-6-W8) of 13 July 1936.
(b) Specifications RE 13A 465C.
(c) Contract NOs-47359, 16 March 1936.
(d) Westinghouse Descriptive Specifications R-903.
(e) Westinghouse Test Data on Model TBL-2 Equipment.
(f) BuEng let.C-NOs-47359(7-6-W8) of 22 July 1936.
(g) BuEng let.C-NOs-47359(7-21-W8) of 27 July 1936.
(h) BuEng let.NOs-47359(8-6-W8) of 19 August 1936.
(i) WEM Co.let.to INS, Aug.13, 1936 (Suppressor Grid Modulation)
(j) BuEng let.C-NOs-47359(7-6-W8) of 3 Sept.1936.
(k) BuEng let.NOs-47359(7-6-W8) of 22 August 1936.

OBJECT OF TEST

2. The object of the tests was to determine the following:

(a) The actual performance of the equipment with respect to contract requirements.
(b) Any departures from contract requirements.
(c) Features of design or operation of special value in Naval use.
(d) The nature of changes necessary to correct any departures from contract requirements.
(e) Recommendation regarding possible improvements considered necessary to meet service requirements.

ABSTRACT OF TESTS

3. The tests herein reported were conducted to determine the degree of compliance of the Model TBL-2 equipment (preliminary model) with the mechanical and electrical requirements set forth in references (b) and (c).

4. Specifically, tests were conducted to determine the following:

(a) Ability of the equipment to withstand shipment.
(b) Check of mechanical or physical construction and assembly; general workmanship; materials used; corrosion resisting measures employed and adequacy of electrical circuits to withstand operation under Naval service conditions.
(c) Power output; power input; overall efficiency and flexibility of antenna coupling circuits.
(d) Quality of emitted signals; lilt; undesirable modulation, and break-in operation.
(e) Check of dimensions and weights.

(f) Determination of frequency overlap, limiting frequencies of various circuits and cycles per division of master oscillator dials.
(g) Check of adequacy of temperature control circuits.
(h) Check of protective circuits.
(i) Determination of percentage modulation, MCW power output and frequency of audio oscillator.
(j) Frequency stability and accuracy under following conditions:
    (1) Accuracy of reset.
    (2) Lost motion - backlash and torque lash.
    (3) Operation of Adjust-Tune-Operate Control.
    (4) Detuning of circuits.
    (5) Operation of power output control.
    (6) Change of tubes.
    (7) Variation of supply line voltage.
    (8) Variation in ambient temperature.
    (9) Variations in humidity.
    (10) Locked key operation for two hours.
    (11) Key locked to intermittently keyed condition.
    (12) Continuously keyed to intermittently keyed condition.
    (13) Inclination due to roll and pitch.
    (14) Vibration.
    (15) Shock.

The above tests were conducted at intermediate frequencies and also at high frequencies, generally two frequencies in each range being investigated.

5. The adequacy of the power equipment was determined including voltage regulation and percentage of voltage ripple.

Conclusions

(a) The general appearance and construction of the Model TBL-2 equipment is excellent. A rugged framework, adequately supported and strengthened, provides the basis of a design in which component parts of good design and workmanship and excellent quality have been assembled in a manner to provide as great a degree of accessibility as the limiting conditions permit. The internal wiring is of good quality, arranged in an orderly manner, bonded at frequent intervals and protected against chafing where necessary. The use of colored nameplates to indicate the dual or individual nature of the various controls affords a ready means of identification to assist operating personnel in making rapid shifts from one frequency band to another. All controls are rugged, suitably located and identified and the symmetry of arrangement is as complete as the restricted conditions permit.

(b) The power output requirements of the specifications, at high frequencies and at intermediate frequencies, have been complied with in all instances. In numerous instances, particularly while employing high frequency operation, the actual power output obtainable exceeds the specification value of 200 watts by 100%. Flexible output circuits have been provided to cope with the wide variation of antenna constants met with in Naval Service and the necessary adjustments can be accomplished with ease and rapidity.

(c) While, in general, the equipment operates in a safe and satisfactory manner, two deficiencies were encountered which are considered of major importance. The 38160 tube employed in the 2nd intermediate amplifier stage is subjected to overloads of such magnitude as to cause the failure of this tube in approximately 25 hours of key locked operation. This overload condition must be remedied to insure safe operation under service conditions.

(d) The second major deficiency involves the operation of the temperature control circuits. An exceedingly flexible arrangement has been provided to cope with wide ranges in ambient temperature and large variations in supply line voltage. The elements incorporated in the system to insure operation over wide limits of temperature are entirely automatic, while protection against line voltage variations requires a manual adjustment. In order to insure adequate reliability steps must be taken to prevent excessive arcing of relay contacts, to protect the control thermostat from undue stresses and to provide a more suitable arrangement of temperature indication.

(e) A number of changes, modifications and corrections of a minor nature are indicated in order to provide greater safety factors, effect greater ease in handling by operating personnel, and in a small degree, to increase frequency stability to comply with specification requirements.

(f) The equipment possesses, in general, a remarkable degree of frequency stability when subjected to the various conditions required by the governing specifications. Satisfactory operation is obtained over wide limits of temperature and humidity and when the equipment is subjected to shock and vibration. With the correction of existing deficiencies the Model TBL-2 equipment should be capable of reliable and satisfactory operation under service conditions.

Recommendations

It is recommended:

(a) That resistors of satisfactory voltage ratings be employed throughout the TBL-2 equipment. (See par.31)

(b) That all variable inductors be so adjusted that they operate freely and satisfactorily and that improved stops be provided on such inductors to prevent the contact wheel from leaving the windings. (34-1-a)

(c) That precautions be exercised to insure good contact of the "Adjust-Tune-Operate" switch. (34-1-b)

(d) That the use of steel as employed in the starter cabinet, and in the cases of condensers C20, C25, C100, C101, C102, C103, and C104 be approved, since they are suitably protected against corrosion and do not interfere with the operation of the equipment. (38).

(e) That a suitable nameplate be affixed near relay no. K4 to indicate that the use of oil is necessary for the proper functioning of this relay. (41-3)

(f) That proper precautions be exercised to prevent set screws in door interlocks from working loose and grounding the 230 volt circuit. (43)

(g) That filament transformers of adequate design be employed to insure satisfactory service under all conditions of operation. (45)

(h) That the high frequency 2nd intermediate amplifier circuit be so modified and corrected that overloading of the 38160 vacuum tube employed in this circuit will be eliminated, and that this circuit be made suitable for the use of all tubes complying with Navy tube specifications at all frequencies within the range of the equipment. (48)

(i) That green colored nameplates, in accordance with the samples submitted, be substituted for the orange colored nameplates originally provided to designate the high frequency controls of the TBL-2 equipment. (55)

(j) That the shaft of control "D" be properly grounded. (56)

(k) That the use of plain glass be permitted in the panel opening of the high frequency antenna ammeter; that anti-glare glass be employed in the vision opening of the key relay. (57)

(l) That more flexibility be provided in the wires connecting to control panel on left hand transmitter frame to insure greater accessibility for servicing operations. (59)

(m) That proper precautions be observed to insure that the indicator light assemblies are securely anchored to the panel. (69)

(n) That suitable protective means be provided to prevent the application of plate potentials in the absence of grid bias potentials. (72)

(o) That the overlap characteristics of the intermediate frequency circuits be considered satisfactory; that the contractor be required to provide a 3% overlap in the high frequency circuits. (84)

(p) That the tuning knobs on controls "E", "F", "G", and "K" be modified to eliminate sharp edges on the knurled portion and that control knobs "B" and "N" be modified to permit greater ease in adjustment by making these controls of the "cross-bar" type. (85)

(q) That the Bureau consider the advisability of eliminating the two cathode meters, replacing one with a suitable voltmeter to indicate the potential of the 1,000 volt auxiliary generators and providing a possible location for a voice control. (98)

(r) That the oscillations engendered in the coil circuit of the plate overload relay be eliminated by shunting this coil with a suitable resistor. (111)

(s) That proper precautions be observed to provide suitable power amplifier screen grid potentials in order that the proper degree of modulation may be obtained on MCW operation. (112)

(t) That the backlash characteristic of the intermediate frequency master oscillator control be considered as satisfactory. (114)

(u) That the method of mounting the master oscillator compartment be modified sufficiently to prevent excess frequency variations when the equipment is subjected to the roll and pitch encountered by vessels operating in heavy weather. (125)

(v) That the kilocycles per division of the intermediate frequency master oscillator dial be considered as satisfactory. (128)

(w) That necessary modifications be made in the temperature control circuits to insure satisfactory operation under all conditions outlined in the governing specifications and contract. (132)

(x) That a properly adjusted device be provided to insure against overheating of the temperature controlled compartment. (133)

(y) That the backlash characteristic of the high frequency master oscillator control be considered as satisfactory. (136)

(z) That the frequency characteristic of the master oscillator circuit with respect to tube replacements be considered as satisfactory. (140)

(aa) That the remote keying circuit connections be such that the key relay remain unenergized until the motor generator has attained full operating speed. (152)

(bb) That the power consumption of the TBL-2 equipment be considered as satisfactory. (161)

(cc) That steps be taken to reduce the amplitude of ripple voltage in the output of the 1,000 volt generator. (173)

(dd) That an interlock be provided on the access door to the filter unit, unless, in the opinion of the Bureau of Engineering, adequate protection to personnel and material will be provided by securing the door by means of a padlock. (174)

(ee) That hinges of the removable pin type be provided on the filter unit access door. (175)

(ff) That proper steps be taken to insure that the panel thermometer will not suffer from off-scale indications. (178 d)

(gg) That acceptance of the preliminary Model TBL-2 equipment be held in abeyance until satisfactory assurance has been offered by the contractor that all of the items referred to above will be corrected in a manner which meets with the approval of the Bureau of Engineering.

MATERIAL UNDER TEST

6. The material under test consists of one preliminary Model TBL-2 radio transmitting equipment complete with motor generator equipment designed to operate from a 230 volt d.c. line supply. This equipment was manufactured under Contract NOs-47359 by the Westinghouse Electric and Manufacturing Company. The motor generator equipment was manufactured by the Continental Electric Company of Newark, N. J. The transmitter is rated at a nominal output of 200 watts and is capable of covering the frequency ranges of 175 to 600 kilocycles and 2000 to 18,100 kilocycles. The equipment is capable of both CW and MCW emission in the intermediate frequency range, while CW emission only is available in the high frequency range.

7. The Model TBL-2 equipment was received at the Naval Research Laboratory on Saturday, July 11, 1936. Transportation was accomplished by means of motor truck express from the Chicopee Falls plant of the manufacturer.

METHOD OF TEST

8. The equipment, when received, was carefully examined to determine whether adequate precautions had been observed in preparing the material for shipment and whether any damage had been incurred during the process of transportation.

9. The equipment was then wired up and placed into commission. The adequacy of the preliminary instruction books was determined during this process.

10. Power output measurements at high frequencies were made through the medium of a 500 watt, 115 volt lamp and a calibrated photronic cell. The base of the lamp was removed in order to minimze capacity losses. Intermediate frequency output measurements were made using dummy antennas of the proper characteristics employing essentially non-inductive resistors and low loss capacitors. A precision type instrument connected in the ground side of the dummy antenna was used for measuring the radio frequency current.

11. Frequency changes and drifts were checked by means of the Model LK frequency indicator, Ser.No.2, the transmitter being operated at full power output whenever the governing specifications required this method of operation.

12. Frequency range, overlap, and kilocycles per division of dial marking were determined by means of Model LD-2 equipment.

13. The transmitting equipment, including motor generator, starter and filter unit were placed within the Naval Research Laboratory test chamber and subjected to variations in ambient temperature between the limits of -1° to $+50^{\circ}$ C and variations in relative humidity between the limits of approximately 30% and 95%. Frequency measurements were made by means of the LK visual frequency indicator.

14. Measurement of the ripple voltage present in the outputs of the various generators was made by means of a Model 636 Wave Analyzer.

15. The percentage of modulation was determined by means of a cathode ray oscillograph and by means of Model OB audio analyzer.

16. Model RAA and RAB receivers were employed for determining the quality of emission.

17. The ability of the equipment to withstand vibration and the roll and pitch of a vessel in a heavy sea was determined by mounting the entire equipment on a special test stand capable of producing the necessary vibration and inclined operation.

18. Shock tests were conducted by subjecting the equipment to blows from a 20 pound weight suspended in the manner required by the specifications.

19. The degree of amplitude modulation present in the CW output was determined by the following method. A half wave rectifier, with tuned input, was coupled to the output of the transmitter. The output of the rectifier was adjusted to give 100 volts d.c. across the load circuit. The d.c. was then blocked off by means of a 6 mfd condenser and the audio component determined by means of a suitable output meter.

DATA RECORDED

20. Complete data were recorded during all tests conducted and this information is appended hereto as Tables 1 to 61 and Plates 1 to 8 inclusive.

PROBABLE ERRORS IN RESULTS

21. Precautions were taken to minimize errors in the results obtained during the tests recorded herein. Where time permitted, identical tests were conducted at several points in the frequency range in order to determine the reliable average operation of the equipment.

22. The visual frequency indicating equipment employed is capable of measuring beat note frequencies to within one or two cycles.

23. The accuracy of the LD-2 equipment is approximately 0.001%.

24. Power output determinations are considered accurate to within ± 5%.

25. All external meters employed were of the precision type whose calibrations were verified to insure accuracy.

26. The measurement of modulation is considered accurate to within 5% at the levels involved.

27. The ripple content in the output of the motor generators was checked by two methods, including the Model 636 Wave Analyzer, and the results obtained are considered accurate to within 5%.

RESULTS OF TESTS

28. The Model TBL-2 equipment was received in undamaged condition, proper precautions having been taken to insure safe transportation. The equipment was so packed that removal of the packing cases could be accomplished with ease and without subjecting the equipment to injury.

29. In the following paragraphs of this report reference is made to the governing specifications RE 13A 465C under which the equipment was constructed. Where no specific reference to any particular paragraph is made it is to be understood that the equipment under test complies with this paragraph and that no further explanatory remarks are considered necessary.

30. In general, the Model TBL-2 equipment as submitted for test meets the requirements of the introduction section of the specifications. The frequency ranges and type of emission are those called for in par. 1-2. Such defects in operation or design as would prevent the equipment functioning in a satisfactory manner under service conditions are pointed out under appropriate paragraph headings.

31. Par.2-2. (1) As far as could be determined from tests and inspection without resorting to disassembly and destruction of the various component parts, the requirements of the referenced specifications have been complied with in the construction and assembly of the Model TBL-2 equipment., with the exception of certain fixed resistors. Specifications RE 13A 372G covering Navy Standard Fixed Resistors contain ratings with respect to wattage and voltage. In general a 60 watt size resistor shall not be subjected to potentials in excess of 250 volts over 1,000 ohms; 100 watt resistors are limited to 450 volts over 2,000 ohms, and 200 watt resistors are limited to 600 volts over 1800 ohms. Table 1 appended hereto lists all fixed resistors used in the TBL-2 equipment. The resistors are tabulated in accordance with the symbol number given by the manufacturer of the TBL -2 equipment, the resistance in ohms, the type of resistor, the rated watts and voltage, the actual measured watts and voltage and the condition under which these last measurements were made; i.e., key open or key closed. An examination of this table reveals that in 6 instances resistors exceed the voltage ratings of RE 13A 372G by an amount greater than 10%. In no case is the wattage rating exceeded. The resistors which exceed the specification requirements with respect to voltage are as follows:

R6 - H.F. M.O. Screen Resistor
R24 - 2000 volt Supply Potentiometer
R25 - 2000 volt Supply Potentiometer
R32 - 1000 volt Supply Potentiometer
R43 - Screen Potentiometer
R44 - Screen Potentiometer

All fixed resistors of the vitreous enamel type are colored green, with the exception of the series resistors employed in connection with the indicator lamps. It is the understanding that the green coating indicates resistors which have received special treatment to insure satisfactory operation in a salt spray atmosphere. In the interests of uniformity and compliance with specifications, the resistors used in connection with the indicator lamps should be of the improved type.

32. Par.2-2. (2). It is understood that the use of Type 803 tubes in this equipment was approved by the Bureau of Engineering subject to certain conditions with respect to tubes of this type manufactured by the contractor.

33. Par.2-2. (3) The Model TBL-2 equipment employs component parts which are of special design. Standard parts have been utilized in the construction wherever the use of such parts would permit satisfactory operation. In view of the fact that the TBL-2 equipment is a modern design incorporating new and advanced principles of operation, component parts of special characteristics not heretofore employed have, of necessity, been incorporated in the construction.

34. Par.2-3. The equipment is ruggedly constructed of excellent materials and light weight alloys have been employed wherever possible in the interest of weight reduction.

(1)(a) Controls "F", "G", and "K" are of the continuously variable inductor type which use a grooved wheel for the variable contact. During the early portion of the tests difficulty was encountered in connection with these inductors due to poor intermittent contact. During inspection of the equipment by a representative of the manufacturer the tension of these contacts was adjusted, after which satisfactory operation was secured. These same controls are fitted with stops which in their present form are unsatisfactory. This permits the contact rollers or wheels to run off the end of the inductor and it is necessary to remove the shields and manually replace the contact wheels. If care is not exercised in replacing these contacts accurately, the calibration of the circuit affected is destroyed. The manufacturer's representative stated that it is the intention to cast a suitable stop integral with the dial mechanism which will prevent this difficulty.

(1)(b) The "Adjust-Tune-Operate" Switch makes poor contact in "Tune" position (Step 2).

(1)(c) The contacts of heater relay K-1 stick or freeze together intermittently. This action seriously affects the frequency stability of the master oscillator circuit, especially when employing high frequency operation.

(2) All switches are of the self-positioning type and operate with positive action. The operation of the "tune-Operate" switch, mentioned in par.2-3(1)(b) above is an exception to this statement. During the course of these tests no other switch contact trouble was encountered.

(3) The variable resistors used in the TBL-2 equipment, namely the filament rheostat and the plate generator field rheostat, are of the 6" plate type, and gave satisfactory operation during the course of these tests.

35. Par.2-4. In general, excellent workmanship is reflected in the Model TBL-2 assembly. Such items as do not comply in detail with this requirement are discussed under appropriate paragraph headings.

36. Par.2-5. With the exception of one characteristic, the equipment operates satisfactorily in any ambient temperature between the limits of -1°C and +50°C and at any value of humidity between low values and 95%. The noted exception is the operation of the heater relay which controls the amount of heat delivered to the temperature controlled master oscillator compartment. The contacts of this relay are excessively at low temperatures. This defect is discussed in detail in par.132 of this report.

37. Par.2-6. No signs of corrosion were noted in the equipment during the course of these tests. No separate component parts were received which could be subjected to the 200 hour, 20% salt spray test and to determine thickness of plating. It is understood that these tests were or will be conducted at the point of manufacture.

38. Par.2-7. In general, the use of iron and steel, except where required for electro-magnetic purposes, has been kept to a practical minimum. Magnetic steel has been employed in the following items where the use of such material is not required by electro-magnetic considerations:

(a) Starter cabinet.
(b) Cases of condensers C-20 and C-25 in Transmitter Unit.
(c) Cases of condensers C100, C101, C102, C103 and C104 in Filter Unit.

All of the above items have been treated to resist corrosion. The starter cabinet has an exterior coating of gray paint, while the interior is finished in black. The condenser cases are protected by an aluminum colored coating. None of these items showed signs of corrosion during the tests conducted. None of the hinges employed in the construction of this equipment are of steel, with the exception of the hinges employed on the starter cabinet.

39. Par. 2-8. The insulating material used in the construction of the Model TBL-2 equipment is of a high quality and non-ceramic materials are used in such applications as permitted by the specifications and the governing contract.

40. Par. 2-9. Wood is not employed in the construction of the Model TBL-2 equipment.

41. Par. 2-10. The design of the electrical circuits and controls is liberal and they have been proportioned to care for overloads or have been provided with suitable protective devices in the form of fuses or overload relays. There is one important exception to this statement, however; namely, the operation of the 38160 vacuum tube employed in the 2nd I.P.A. stage of the transmitter. This defect will be discussed in detail under the heading of par.2-17 of the governing specifications and will be found in par.48 of this report.

(1) Renewable type cartridge fuses are used to protect circuits where the potential involved is less than 440 volts. Specifically the following circuits are fused in this manner:

(a) 230 volt supply line (in transmitter unit)
(b) Filament Supply (in generator terminal housing)
(c) 250 volt d.c. Generator (in generator terminal housing)

(2) Fuses provided for the protection of high voltage circuits are of the renewable "High Voltage Little Fuse" type and are located at the generator terminals, as follows:

(a) 1000 volt d.c., 5000 volt 1/4 amp.fuse
(b) 2000 volt d.c., 5000 volt 1-1/2 amp. fuse

(3) The design of the overload relays is such that they may be adjusted to function at any value between full load and 25% overload. All overload relays of the plunger type are provided with nameplates stating whether oil shall or shall not be used. The 5 second time delay relay, K4, uses oil but is not provided with a nameplate to indicate the use of oil. The overload relays were adjusted to operate as follows:

(a) K-8, M.O. overload relay, opens at 280 ma, remains closed at 250 ma.
(b) K-9, Bias overload relay, opens at 400 ma, remains closed at 360 ma.
(c) K-10,H.V. overload relay, opens at 410 ma, remains closed at 360 ma.

42. Par. 2-11. Suitable protective relays have been provided to protect the equipment against overloads as outlined in par.41(3) above. The keying circuit is opened by relay K-4 if the remote key is closed for five seconds.

43. Par. 2-12. All doors on the transmitter unit are fitted with interlock switches. When the door is opened all voltages other than the 230 volt line supply, are removed from the transmitter. The door of the filter unit is not provided with an interlock. Since this compartment contains voltages up to 2000 volts an interlock should be provided. When the TBL-2 equipment was received, the fuses in the 230 volt supply blew every time the power was turned on. This failure of fuses was finally traced to the interlock switch in the left hand tube compartment. Connections to the interlock switch are held in place by two set screws. One of these set screws had not been tightened and the head of the screw came in contact with the frame of the transmitter. Tightening of the set screw overcame the difficulty. The interlocks operated satisfactorily when subjected to the shock test simulating gun fire. The insulation provided appears to be adequate.

44. Par. 2-13. Ventilation is obtained by means of perforated shielding and during the course of these tests no evidence of overheating was noted which could be attributed to lack of ventilation.

(Note: The overheating of the 2nd I.P.A. tube, described in par.48 below, is not caused by lack of ventilation but is due to overloading.)

45. Par. 2-14. During the course of these tests no leakage of compound from any of the component parts was noted with the exception of a slight leakage from the filament transformer. This transformer showed slight signs of leakage when the equipment was received at the Naval Research Laboratory and it appears that a small additional leakage occurred during the course of these tests.

46. Par. 2-15. The TBL-2 equipment is so constructed that it is capable of operating for two hours locked key without damage to parts or showing signs of overheating, other than the excessive heating of the 38160 tube in the 2nd I.P.A. stage at high frequency, as reported in par. 48 below. The equipment is capable of being keyed at any rate up to 100 words per minute.

47. Par. 2-16. The equipment is so designed and constructed that it is capable of operating, when adjusted for full power, without damage when the antenna is short circuited or open circuited. Table 2 outlines tests conducted at 175, 300, and 600 kilocycles, while Table 3 covers tests conducted at high frequencies; i.e., 2000, 8000, and 18,100 kilocycles. No damage resulted from these tests.

48. Par. 2-17(a). This paragraph of the governing specifications requires that the design of the equipment must be such that the vacuum tubes will operate within the limitations of Navy tube specifications, RE 13A 600A, Mod.4, and in such a manner as will assure a tube life expectation for keyed operation of 2000 hours for tubes rated above 7.5 watts. Naturally, it is impossible to conduct a 2000 hour keying test in the limited time available, but doubt exists as to the ability of the 38160 vacuum tube in the 2nd intermediate amplifier to fulfill the requirements of the specifications in this respect. During power output tests at 18,100 kilocycles it was noted that the plate of the 2nd I.P.A. tube became excessively hot under key locked condition and that the plate current was about 125 milliamperes. The plate voltage applied to the tubes was then reduced to a point where the 2nd I.P.A. tube drew 100 milliamperes and the tube showed only faint color. This occurred at a plate potential of 1700 volts, but under these conditions the power output from the transmitter fell from the original value of 250 watts to a value of 100 watts.

(b) As the tests of the equipment proceeded and tubes of various makes were inserted in the 2nd I.P.A. stage to determine the frequency shifts which occurred when changing tubes, it was noted that the tubes of different manufacturers drew different values of plate current, although the operating adjustments of the transmitter remained fixed. This phenomenon was investigated at several frequencies with the following results:

Manufacturer	Ser.No.	2nd I.P.A. Plate I	Plate E
(Frequency: 500 kcs)			
Westinghouse	43812	80	2000
"	43810	82	2000
RCA	11902	118	2000
"	11900	111	2000
General Electric	58120	88	2000
" "	58121	89	2000
Hygrade Sylvania *	1892	95	2000
" " *	1796	95	2000
* Graphite plates			
(Frequency: 200 kcs)			
Westinghouse	43812	70	2000
RCA	11899	125	2000
"	11902	125	2000
"	11904	125	2000
General Electric	58121	88	2000
Hygrade Sylvania	1892	90	2000
(Frequency: 18,100 kcs)			
Westinghouse	43810	127	2000
RCA	11902	146	2000
"	11900	142	2000
General Electric	58121	127	2000
" "	58120	125	2000
Hygrade Sylvania	1892	145	2000
" "	1796	140	2000

(c) During the course of the prescribed tests, it was discovered that the Type 38160 tube used in the 2nd I.P.A., Ser. WL-43812, failed to produce sufficient excitation to drive the P.A. stage. Investigation revealed that this tube had lost emission sufficiently to be inoperative. The tube had been subjected to approximately 20 to 30 hours operation, key locked and intermittent keying. Previous to this, Tube WL 38160, Ser.43928, had failed under similar circumstances and had been replaced by Ser.No. 43812. On August 21, Ser.No. 43812 was replaced by WL 38160, Ser.No. 43810. However, since Ser. 43810 had been in service in another circuit for a few hours, it was decided to use a tube which had had no service. Ser.No. WL-43932 was selected and its emission measured. This tube complied with specification requirements (Ef - 7.5). After 22-1/2 hours of key locked operation on various frequencies, including two hours locked key at 18,100 this tube lost emission sufficiently to become inoperative at 18,100 kilocycles. This tube was then replaced with Ser.No. 43798, whose emission had been checked and found satisfactory and normal output was again obtained from the transmitter.

(d) These various tube failures and the different values of plate current drawn by tubes of various manufacturers led to an investigation of control grid and screen grid potentials. An RCA and a Westinghouse tube were inserted in the 2nd I.P.A. and the control grid potential measured, with the following results:

Tube No. & Mfr.	Actual Control Grid Voltage Key Open	Key Closed
WL 43812	150	178
RCA 11899	148	153

The differences between the key open and key closed voltages noted indicated that the WL tube drew considerable grid current which resulted in additional bias being applied due to grid leak action. An additional investigation by the Vacuum Tube Section confirmed this opinion.

(e) The investigation of the screen grid potentials brought forth the following data:

Tube No. & Mfr.	Screen volts Key down	Plate Current
WL 43810	620	125
RCA 11902	680	142
GE 58121	660	125
HS 1892	645	145

Thus it will be seen that another difference exists between tubes of various manufacturers. The additional current drawn by the Westinghouse tube causes a greater drop across the screen grid series resistor, which in turn reduces the screen grid potential applied to the tube and helps to lower the plate current. This action of the screen grid plus the differences in control grid operation undoubtedly explains the reason why tubes of different manufacturers draw varying amounts of plate current.

(f) In cooperation with representatives of the contractor, optical pyrometer tests were conducted to determine the actual plate dissipation of a Westinghouse 38160 tube in the 2nd I.P.A. stage when operating key locked at 18,100 kilocycles. These tests indicated that the tube was dissipating approximately 160 to 170 watts, whereas maximum dissipation permitted by Navy vacuum tube specifications is 100 watts.

(g) In an effort to determine whether adjustments could be arrived at which would tend to reduce the overloading of the 2nd I.P.A. stage, the following test was conducted. Series resistors of various values were connected in the plate circuit of the 2nd I.P.A. tube, with the following results:

Resistance ohms	2nd I.P.A. I_p	Pr Amp I_g	Gen. Volts	Power Output*
3500	107	23	2000	125 watts
1800	115	29	2000	165
1000	120	33	2000	193
none	123	39	2000	245

* Denotes power delivered to dummy antenna lamp load.

From the foregoing it will be seen that when the 2nd I.P.A. plate current was reduced to a value where excessive heating did not occur the output from the transmitter was greatly reduced.

(h) In cooperation with the contractor's representative attempts were made to improve operation by reducing the stray capacities and capacities to ground which are undoubtedly affecting the operation of the 2nd I.P.A. stage. Removal of the 2nd I.P.A. variable tank capacitor from the circuit reduced the plate current by about 20 milliamperes. In this connection it may be pointed out that the input capacity of the 38803 tubes is 35 uuf (2 tubes) which undoubtedly is an influencing factor in the overload experienced by the 2nd I.P.A. stage. However, if the 38803 tubes are removed from the circuit, the 2nd I.P.A. stage still draws 90 milliamperes (at 18,100 kilocycles), which power is being dissipated to overcome circuit losses.

(i) One tube of each manufacturer tested in the manner outlined above was subjected to a static test to determine the plate current drawn under these conditions. The conditions of test were as follows:

E_p - 2000 volts
E_{sg} - 500 volts
E_g - neg. 25 volts

The following results were obtained:

Tube No.	Manufacturer	Plate Current
43798	WEMCo	41.5
11902	RCA	61.5
1892	Hygrade Sylvania	48.0
58121	General Electric	58.9

(j) Summary. A serious overload condition is present in the 2nd I.P.A. stage which causes the failure of the 38160 tubes employed in this circuit, due to loss of emission. Tubes fail after approximately 25 hours of locked key operation. This failure apparently occurs regardless of the frequency of operation. The evidence of failure, however, is first noted when operating in the 18,000 kilocycle band, since high frequency operation, coupled with the fact that the 2nd I.P.A. stage is being used as a doubler, requires adequate emission. Tubes of different manufacture draw different values of plate current and hence cannot be considered as completely interchangeable in the 2nd I.P.A. stage. While the number of hours of operation under keying conditions which may be expected from this circuit cannot be determined at this time, in the opinion of the Naval Research Laboratory, the operation provided by the TBL-2 equipment in this respect, does not comply with the governing specifications.

49. Par. 2-18. In general, the equipment is so designed that safe operation and satisfactory performance are assured. However, as pointed out under appropriate paragraphs of the governing specifications certain defects in operation were encountered during the course of these tests where remedial action is required before it can be stated, without qualification, that the Model TBL-2 equipment is entirely suitable for the Naval Service.

50. Par. 2-19. The design of the equipment is such that it fulfills the demand that when secured at the base only as under service installation conditions, it operates successfully and without damage on a moving platform inclining 45° from the vertical in any direction, simulating the roll and pitch of a vessel in heavy weather.

51. Par. 2-20. The Model TBL-2 equipment was subjected to shock and vibration without injury or interference with normal operation. Non-corrosive lock washers have been employed throughout.

52. Par. 2-21. Vacuum tubes are flexibly mounted by means of suitable rubber suspensions. The I.F. and H.F. master oscillator tube sockets are rigidly mounted in the oscillator assembly which in turn is flexibly mounted within the transmitter frame.

53. Par. 2-22. The design and control of the circuits in the TBL-2 equipment has been made as simple as possible within the requirements of the governing specifications.

54. Par. 2-23 (1) All indicating instruments are mounted on the front panel and have been arranged in as symmetrical a manner as the size and space limitations permit.

55. Par. 2-23 (2) Nameplates have been placed adjacent to each control designating the purpose of each control, and in addition letters are affixed near the controls to aid in preparing calibrations. No filling material is employed in the marking, non-magnetic nameplates of the etched type being furnished. A very distinctive, pleasing and effective method of marking has been provided to distinguish intermediate frequency controls from the high frequency controls. General controls which apply equally to high or intermediate frequency operation employ silver letters or numerals against a black background. Emergency controls have silver lettering against a red background. Intermediate frequency controls use silver lettering against a blue background and high frequency controls have silver lettering against an orange background. Transfer switches used for shifting from high to intermediate frequency operation carry both the orange and blue backgrounds and are marked H.F. and I.F. additionally. Thus, when high frequency operation is desired, a glance is sufficient to determine whether all necessary controls are in the H.F. position. Under certain conditions of lighting it was noted that reflections occurred in connection with the high frequency controls which caused the silver lettering to appear gold or orange, thus reducing the contrast. In order to obviate this difficulty the manufacturer submitted sample nameplates of various colors. Tests show that the green and blue combination is most effective. When these colors are employed no difficulty from reflections is encountered. Hence it is recommended that green be substituted for the orange nameplates and that all other markings remain as originally furnished with the preliminary model. In order that the Bureau of Engineering may have an opportunity to examine these nameplates, samples of various colors are being forwarded under separate cover. Table 4, attached hereto, lists the various controls found on the front panel of the TBL-2 equipment.

56. Par. 2-24. All control knobs and handles are insulated to prevent the possibility of high frequency shock or burns. All control shafts are grounded with the exception of the H.F. doubler circuit tuning control "D". This shaft can readily be grounded and apparently is an oversight.

57. Par. 2-25. All electrical indicating instruments provided with this equipment are of the 3.5 inch diameter flush type with bakelite case. The meters are fitted with anti-glare glass with the exception of the high frequency antenna ammeter. This meter, being in the high side of the antenna circuit is mounted behind the panel and the hole in the panel is covered by a blank meter case. Thus this meter is behind two glass windows and the manufacturer explains that if glass of the anti-glare type is used on the panel, it is difficult to read the meter calibration. It appears, therefore, that the use of anti-glare glass under these conditions is not feasible and it is recommended that the use of regular glass in this connection be approved. The meter itself is provided with anti-glare glass. The key relay of the TBL-2 equipment is housed beneath a protective cover which protrudes from the front panel and is fitted with a glass cover through which the operation of the relay may be observed. This glass is of the ordinary type, and although not definitely required by the governing specifications, it is suggested that anti-glare glass be used in this location in order to conform with the appearance of the majority of the meters and to reduce the chances of glare.

(1) As stated above, the antenna ammeter in the high frequency portion of the equipment is located in the high side of the antenna, but the use of anti-glare glass in this location is detrimental to clear vision, and it is recommended that ordinary glass be approved for this purpose.

(2) Meters are so mounted with respect to adjacent equipment that replacement meters of the same nominal size may be substituted for those now installed. All d.c. voltmeters with external multipliers have a sensitivity of 1,000 ohms per volt and all d.c. meters and multipliers are by-passed with 0.006 mfd capacitors rated at 1,000 volts d.c. working potential.

58. Par. 2-26. Nameplates have been affixed to all major units, but as pointed out in contractor's letter of 4 August 1936, which was forwarded as enclosure (B) of reference (h), the nameplates of the motor generator equipment vary in appearance and material from those supplied with the remainder of the equipment and it is the intention of the manufacturer to supply nameplates of a uniform type and appearance.

59. Par. 2-31 (3) A slanting panel is affixed to the left hand unit of the TBL-2 equipment directly above the access door to the relay and terminal board compartment. This panel carries three meters, four indicator lights, four switches and the overload reset button. The panel is removable but it is impossible to withdraw it sufficiently from the opening to gain access to the switch and meter connections. If the wires which connect to this panel were somewhat longer and more flexible it would be possible to gain access to the various instruments. It is recommended, therefore, that the contractor be requested to modify the wiring in a manner which will permit greater accessibility to these parts.

60. Par. 2-32. The weights of the various units which comprise the TBL-2 equipment are listed in Table 5. It will be noted that the combined weight of all units is 1,641 pounds, which is within the limitation of 1700 pounds permitted by the specifications.

61. Par. 2-33. Any single unit of the equipment, when uncrated for installation, i.e., the transmitter separated into two sections, will pass through the hatches and doors specified in the governing contract. See Table 5.

62. Par. 2-34. The equipment functions satisfactorily without damage when the line supply is varied between the limits of -23% and +15% of normal. Due to the lack of a suitable source of d.c. power, it was impossible to subject the equipment to a line voltage of +45% as called for in the governing specifications.

63. Par. 2-35. Component parts of the equipment are marked with identifying symbols corresponding to the marking used in the wiring diagrams and instruction book. These markings are located near the item rather than on the part, so that identification will not be lost when replacements are made. All resistor mountings are suitably marked to indicate the Navy type number and the value of the resistor. Tube mountings are marked to indicate the Navy type number of the tube employed in each socket.

64. Par. 2-38. Suitable lifting devices of rugged construction are located at each top corner of the transmitter units to facilitate hoisting and lowering of equipment aboard ship. These devices are rattle-proof and appropriate nameplates have been affixed to the exterior shielding to indicate the location of the lifting eyes.

65. Par. 2-39(1). The front panel of the transmitter unit is finished with a black wrinkle coating. The external shielding is finished in the same manner as the front panel.

66. Par. 2-39(3). All screw heads, etc., which are manipulated in normal process of installation and servicing have been finished with a dull metallic coating.

67. Par. 2-39(4). All interior surfaces of aluminum have been treated to prevent corrosion.

68. Par. 2-40(1). All indicating lamps are of a given type except for color of lens. The lamp is rated at 18 volts with candelabra screw base.

69. Par. 2-40(2). The indicator lamp assemblies provided comply with the requirements of this paragraph. It should be noted, however, that one of the assemblies was not securely fastened to the panel, making it difficult to remove the colored lens. The glass lens extends 7/8" beyond the panel.

70. Par. 2-40(3). The following indicators are provided on the front panel of the equipment:

Color	Purpose
Blue	Motor generator start and run
Red	Plate potential on
Amber	Heater circuits on
Green	Bias potential on

71. Pars. 2-42 to 2-49. These paragraphs of the specifications require type tests of component parts. It is the understanding that the required tests will be made at the point of manufacture, since no sample parts were submitted.

72. Par. 2-50. The requirement that provision shall be made to prevent the application of plate potentials prior to or in the absence of filament or grid potentials has not been complied with in the preliminary model of the TBL-2 equipment. The protection as furnished operates as follows. The bias overload relay, K-9, has its contacts in series with the starting contactor. Thus if an overload occurs the entire equipment is automatically shut down. A fuse is inserted in the output of the 250 volt bias generator at the generator terminals. If this fuse blows the high voltage generators receive no excitation and hence plate potentials will not be developed. However, in the absence of bias potential due to other causes, such as a faulty connection in the transmitter, or a break in the circuit between transmitter and generator, it is possible for plate and filament potentials to be applied to the equipment in the absence of the fixed bias potential. Under this condition the equipment continues to function in an almost normal manner. Biasing voltage is developed across the grid leaks of the various tubes and although grid currents and plate currents increase to some extent, the power drawn is insufficient to trip any of the plate overloads and the equipment continues to function. For short periods of time, no damage results to the equipment. It is likely, however, that damage would result from long periods of operation under these conditions since the grid currents drawn are of greater magnitude than encountered during normal operation, which in time, would have an adverse effect upon the vacuum tubes. Should a fuse in the filament supply blow, plate potentials are still applied to the tubes, although no output is obtained under these conditions. The intent of the specifications would be met if a bias operated contactor were provided which would prevent plate potentials from being established whenever the coil of this contactor remained unexcited.

73. Par. 3-1. The TBL-2 equipment consists of two units bolted together which operate as a single mechanical assembly. The dimensions of the equipment are listed in Table 5.

74. Par. 3-2. The equipment is of such dimensions, when disassembled, as to comply with the requirements of par. 2-33 with respect to passing through hatches and doors of limited dimensions.

75. Par. 3-3. The design of this equipment is such that two complete radio frequency systems are provided which operate from a common power source and utilize a common set of tubes.

76. Par. 3-4. The transmitter includes, integral with its assembly, all vacuum tubes, radio frequency circuits, meters, filament transformers, relays, accessories and controls necessary for its operation. The filter unit is contained in a separate cabinet which may be mounted near the generator equipment. The incoming power lines to the transmitter are by-passed with 0.01 mfd capacitors of adequate voltage rating, 1,000 volts for the bias supply and 5,000 volts for the main and auxiliary plate supplies.

77. Pars. 3-5, 3-6 and 3-7. The Model TBL-2 equipment is designed to operate into antennas of the constants outlined in these paragraphs of the governing specifications. A detailed discussion of power outputs at intermediate frequencies will be found under the heading of par.3-44 and 3-45 while high frequency operation is described under par.3-50.

78. Par. 3-8. The TBL-2 equipment is provided with a three position switch, by means of which it is possible to transfer the antenna as follows:

High frequency operation
Intermediate frequency operation
Receive.

Provision has been made for "break-in" operation when employing the intermediate frequency band.

79. Par. 3-9. The equipment is capable of operation in the frequency band 175 to 600 kilocycles for CW or MCW emission and for CW emission only in the band 2000 to 18,100 kilocycles.

80. Par. 3-10. The quality of emission obtained from the TBL-2 equipment in the intermediate and high frequency bands is excellent and is free from lilt and undesirable modulation. Harmonic determinations were not made during these tests in accordance with the terms of par.10-31. In accordance with the directions contained in par.2(f) of reference (j), quantitative investigations of key clicks were not conducted. It may be stated, however, that the key clicks present appear to be of the order of magnitude generally encountered in modern equipment not supplied with actual key-click elimination circuits (vacuum tube keying). As pointed out in par.48 of this report, the operation of the 2nd I.P.A. stage overloads the type 38160 tube which would have a tendency to emphasize harmonics in the output of the transmitter. The master oscillator circuits employed in this equipment do not oscillate continuously, being energized only when the key is closed, and hence do not radiate unwanted energy. The design and construction of the equipment is such that amplitude modulation when the transmitter is operating at full power for CW transmission is less than 0.5%. As illustrated in Table 6, the actual percentage of modulation measured at 4500 kilocycles was 0.45%, while that measured at 500 kilocycles was 0.4%.

81. Par. 3-11. The use of screen grid vacuum tubes in this equipment eliminates the necessity of any additional degree of neutralization.

82. Par. 3-12. The transmitter is capable of adjustment to any frequency within the specified ranges by means of controls located on the front panel.

83. Par. 3-13. The design of the equipment is such that the use of "plug-in" coils has been avoided.

84. Par. 3-14 (a) The frequency range of the TBL-2 equipment is divided into several bands controlled by range selector switches. Reference to Table 4 reveals that the following range switches are supplied and indicates that controls are provided with interlocks to prevent destructive sparking when changing settings with power applied to the equipment. It will be noted that there is a main range or transfer switch "A", which permits selection of I.F. or H.F. operation. When employing H.F. operation two additional range switches are provided, i.e., control "B" the high frequency master oscillator range switch and control "H" which divides the amplifier circuits into two bands, position 1 permitting operation from 2000 kilocycles to approximately 4,000 kilocycles and position 2 permitting operation from 4,000 kilocycles to 18,100 kilocycles. On intermediate frequency position two additional range switches, controls "N" and "P" together with the antenna inductor tap switch "V" are provided to cover the necessary range of frequency. Tables 7, 8, and 9 appended hereto contain detailed information with respect to overlap on intermediate frequency operation. Tables 10 and 11 contain overlap data as applied to high frequency operation.

(b) Table 7 shows primarily the overlap obtainable in the intermediate frequency master oscillator circuit, but reveals at the same time that the entire intermediate frequency circuits are capable of adjustment to any frequency within the specified range without hiatus. This table lists the frequencies obtainable at the high and low settings of the I.F. master tuning control "O" on each tap of the seven point range switch "N". The actual frequency range covered is 158.11 kilocycles to 638.06 kilocycles. The percentage overlap ranges from the lowest value of 3.71% between taps 6 and 7 to 23.3% at the bottom of tap no.1. The exact requirements of the governing specifications have not been complied with in two instances, i.e., between taps 2 and 3 and between taps 6 and 7.

(c) Table 8 lists the degree of overlap existing in the intermediate frequency I.P.A. and P.A. circuits as a function of the I.F. range switch "P". In all instances the overlap is in excess of the 5% specified.

(d) Table 9 lists the degree of overlap existing in the antenna circuits. Two typical values of antenna capacitance were employed during these measurements and the data reveals that the antenna circuits possess satisfactory flexibility. Naturally with a wide variation of antenna constants a practically infinite number of combinations of settings could be obtained.

(e) Table 10 lists the degree of overlap obtained using high frequency operation. Here again, as in the case of Table 7 for I.F. operation, Table 10 primarily covers the overlap of the master oscillator circuit on high frequency. This table, however, also reveals that all subsequent circuits are capable of covering the entire frequency range without hiatus, and that in no case were the controls which govern the tuning of the doubler circuit, 1st I.P.A., 2nd I.P.A., P.A. or antenna circuits set to their extreme values; i.e., the master oscillator is the limiting circuit. The extreme range of frequency covered extends from 1984 kilocycles to 4652.4 kilocycles. In four instances the percentage of overlap fails to meet the specified value of 5%, namely at the low and high frequency ends of the range and between taps 4 and 5 and taps 6 and 7.

(f) Table 11 lists the degree of overlap existing between positions 1 and 2 of the range switch "H". This was determined as 58.1 kilocycles or 1.34%, which fails to meet the specification requirements of 5%.

(g) Intermediate Frequency Overlap. While in two instances the intermediate frequency master oscillator does not strictly comply with the governing specifications, the deficiency is of such a magnitude that it may be neglected since, in the opinion of the Laboratory, it will never interfere with the satisfactory operation of the TBL-2 equipment even though replacement of parts may be necessary during the course of service operation.

(h) High Frequency Overlap. When employing high frequency operation the discrepancies in overlap are of greater magnitude than those encountered on intermediate frequency operation. In this connection it is recommended that the high frequency overlap of the master oscillator circuit be revised in a manner calculated to establish the limits of 3% as outlined in enclosures (A) and (B) submitted with reference (h). This degree of leeway should give satisfactory assurance that no hiatus in the frequency range will be established when replacement capacitors in accordance with Navy specifications are supplied.

85. Par. 3-15. The transmitter is adjustable to any frequency within the specified range by means of controls located on the front panel. The number of controls has been kept to a minimum commensurate with the requirements of the governing specifications. It is desired to point out, however, that the tuning knobs on the 1st I.P.A., 2nd I.P.A., P.A. tank and antenna inductance circuits (H.F.), controls "E", "F", "G", and "K", are furnished with sharp knurled edges which makes them uncomfortable to operate. It is recommended that these edges be rounded off to permit greater ease in handling. The control knobs on controls "B", H.F. MO range switch, and "N", I.F. MO range switch, are difficult to operate, particularly when a slight amount of oil or grease may be present. It is recommended that controls of the "cross-bar" type, similar to those provided on controls "P" and "W" be supplied. Care should be exercised however that these controls be of a size which will not interfere with adjacent knobs or controls.

86. Par. 3-16. Each control is identified by appropriate name-plates located near the control and designating letters ranging from "A" to "W" are secured near each control as listed in Table 4.

87. Par. 3-17. Two calibration card holders are secured to the access door in the left hand section of the transmitter. Cards suitable for recording the settings for 12 frequencies are contained in these holders which are further protected by means of a waterproof transparent covering.

88. Par. 3-18. No adjustable positioning devices are furnished in connection with the TBL-2 controls.

89. Par. 3-19. It is possible to shift from one frequency to another and from one type of emission to the other without readjustment of any voltage controls.

90. Par. 3-20. A three position "Adjust-Tune-Operate" switch has been provided on the front panel of the equipment to facilitate adjustment and tuning operations with safety and a minimum of interference. As mentioned in par.34(1)(b), this switch makes poor contact in "tune" position, Step No. 2. Suitable contact should be provided.

91. Par. 3-21. A three position, lever type test key of suitable voltage and insulation characteristics, has been provided on the panel adjacent to the hand rail secured to the right hand side of the equipment. Down position of this key gives momentary contact, central position is open and the up position locks the key. The test key is so connected into the circuit that the five second drop out relay is ineffective.

92. Par. 3-22. Positive gearing has been employed for providing vernier control of the various circuits.

93. Par. 3-23. Friction type locking devices have been provided on all continuously variable tuning controls. These locking devices do not adversely affect the frequency or calibration of the circuits, are positive in operation, do not interfere with the operation of the control and are so designed and disposed that they will not injury an operator's hand.

94. Par. 3-24. The design of the transmitter is such that signals which are readable with the transmitter shut down are also readable with the transmitter turned on but with the key open. Break-in operation is provided on the intermediate frequency band. Actual tests demonstrated the satisfactory operation of this feature. An RAA receiver connected to the I.F. (receiver) antenna terminal was capable of receiving signals on the same frequency as that upon which the transmitter was operating whenever the key was open.

95. Par. 3-25. The design of the keying circuits is such that all tubes cease to oscillate when the key is open and satisfactory keying characteristics are obtained up to speeds of 100 words per minute.

96. Par. 3-26. Tests conducted at high and intermediate frequencies revealed that the rotating machinery used in connection with the TBL-2 equipment; i.e., blower motor in temperature control circuit and the motor generator set, produced negligible interference in RAA and RAB receivers operating in the immediate vicinity of the transmitter.

97. Par. 3-27. It is possible to vary the output power of the transmitter between the limits of 100% and 25% by means of the plate generator rheostat located on the front panel of the equipment. It is possible to make this adjustment while the equipment is transmitting. See Tables 24 and 47.

98. Par. 3-28. The indicating instruments supplied with the TBL-2 equipment are listed in Table 12. It will be noted that no voltmeter is supplied to indicate the plate potential applied to the master oscillator tubes. A meter is provided for indicating the combined plate current drawn by the two power amplifier tubes and two individual meters are also supplied which read the current flowing in the cathode circuit of each power amplifier tube (38803). While this latter arrangement possesses certain advantages, it is believed that in general practice the use of a single plate ammeter to read the combined plate current of the two P.A. tubes will prove to be satisfactory. If the two cathode meters were eliminated, one of these meters could be replaced with a voltmeter to indicate the plate potential applied to the master oscillator tubes and the space vacated by the second cathode meter could probably be utilized to mount a switch suitable for controlling voice communication, should this feature be provided. A line voltmeter has been provided and separate antenna ammeters for high frequency and intermediate frequency operation. The high frequency antenna ammeter is in the high side of the antenna circuit, but the use of anti-glare glass in this location proved to be unfeasible as explained in par.57.

99. Par. 3-30. The transmitter is completely shielded, both externally and internally. Lead sheathed cable, protected where necessary by felt buffers, is used for interconnections except for radio frequency circuits. The lead sheaths are bonded together and grounded at frequent intervals and the entire wiring is of high quality and of an orderly appearance.

100. Par. 3-32. All vacuum tube filaments are lighted from a common transformer. The primary circuit is so arranged that by means of adjustable links operation on either 115 or 230 volts is available.

101. Par. 3-33. When the TBL-2 equipment was received at the Naval Research Laboratory, it was noted that a small amount of insulating compound had leaked from the filament transformer, adhering to it in the form of a streamer. Numerous hours of key locked operation, however, failed to reveal any signs of breakdown.

102. Par. 3-34. No undue variation of filament voltage results when the equipment is keyed and the line voltage may be varied over extreme limits without appreciably affecting the filament voltage.

103. Par. 3-36. The transmitting equipment is so constructed that:

(1) It can be installed with its back flush against a bulkhead.

(2) The foundation pedestal bolts to the deck for security and is of ample strength.

(3) All cable connections are effected at a terminal board located in the bottom of the left hand unit. The door giving access to this compartment is provided with an interlock for protection of personnel and equipment. The lower edge of the terminal board is 4-3/8" above the deck and the arrangement is such that all cables enter the transmitter at the same deck level on which the equipment is installed. All exterior connections may be made without interfering with internal connections.

(4) The renewal of vacuum tubes and adjustment of circuits, relays or auxiliaries may be accomplished through access doors in the front panel. Certain of the overload relays, while accessible from the front of the equipment, are difficult to adjust from this position, but due to the crowded condition resulting from the limiting dimensions specified, it appears impossible to increase accessibility.

(5) The keying relay is mounted on the front panel of the right hand unit. A glass vision opening permits examination of the relay during operation and a removable cover makes for ready accessibility.

(6) Antenna leads are connected through the top shield to suitable terminals.

104. Par. 3-37. All side shielding is secured by means of knurled head screws. These screws are staked so as to prevent loss. The top and interior shielding is secured by means of machine screws.

105. Par. 3-38. All hinged doors are provided with piano type hinges of non-magnetic material. Each door is equipped with a stop to prevent the hinges from being strained and the stop is equipped with a device which holds the door open and prevents it from swinging.

106. Par. 3-39. Access doors in the front panel are of ample size to permit the replacement of tubes by service personnel. The doors are of the overlapping type, fitted with strong latches and knobs.

107. Par. 3-40. Exceedingly rugged, insulated hand rails are provided on the front panel adjacent to each side of the transmitter.

108. Par. 3-41. The design of the equipment is such that suitable blocking condensers are provided to prevent high voltage d.c. from reaching the antenna.

109. Par. 3-42. Suitable indicators have been provided on the front panel to meet the requirements of this paragraph of the specifications. See par. 70 of this report.

110. Par. 3-43. For intermediate frequency operation, the TBL-2 equipment employs the following tubes:

1 - 38160 - Master Oscillator
1 - 38160 - Intermediate Amplifier.
1 - 38160 - Audio Oscillator
2 - 38803 - Power Amplifier

The TBL-2 equipment employs inductive coupling to the antenna when operating at intermediate frequencies. The system provided is flexible and permits satisfactory adjustment of the equipment. As is usual in circuits of this type a change in the antenna coupling adjustment reacts slightly upon the tuning of the power amplifier tank circuit and a readjustment of the power amplifier tank circuit changes the degree of antenna coupling to a slight extent. Thus, if proper precautions are not observed it may require a large number of small refinements in adjustment to keep the circuits resonated and permit the P.A. tubes to draw the desired amount of plate current. This condition may be avoided in the following manner. Set the antenna coupling to a low value and then resonate the P.A. tank circuit. When this is accomplished increase the antenna coupling until the desired output is obtained, permitting the P.A. tank adjustment to remain fixed. This permits efficient operation although seemingly the P.A. tank is not in exact resonance as indicated by minimum plate dip. It is recommended that the final instruction books incorporate a description as to the proper adjustment of these circuits.

111. Par. 3-44. Tests were conducted to determine the power output of the equipment when operating into antenna constants of the values specified in par.3-44 and in the preceding paragraphs, 3-5, 3-6, 3-7, and 3-9. The results of these tests are detailed in Tables 13, 14, 15, 16, 17 and 18 attached hereto.

(a) Tables 13 and 14 show the results obtained at 175, 200, 245, 300, 375, 400, 500, and 600 kilocycles when operating into antenna constants simulating those of submarine flat tops. It will be noted that in all cases the power output obtained is in excess of that required by the governing specifications and in excess of that guaranteed by the contractor in his Descriptive Specifications. It will also be noted that in these tests full 2,000 volts plate potential was not employed. At the time these tests were conducted it was noted that when full voltage was applied to the tubes, plate current continued to be drawn by the P.A. tubes when the key was open. The addition of 32 volts grid bias

(by means of an external battery) permitted operation at 2000 volts and also increased the power output from the transmitter. Investigations conducted at a later date with the assistance of a representative of the manufacturer, revealed that the plate current being drawn with the key up was due to an unwanted oscillation at approximately 45 kilocycles. The main elements which caused this spurious oscillation were the filter condensers across the 2000 volt generator (located in the filter unit) and the coil of the plate overload relay. By connecting a shunt resistance of 2500 ohms across the relay coil, all traces of the 45 kilocycle oscillation disappeared and normal operation was obtained. Under these conditions, the output obtained with full plate voltage of 2000 volts was very similar to that listed at the bottom of Tables 13 and 14 wherein 32 volts additional bias had been employed.

(b) Table 15 outlines the results of tests conducted when employing antenna constants to simulate those of submarine loops. In all cases the power output obtained was in excess of that required by specifications. (The remarks relative to spurious oscillations discussed in par.111(a) apply equally to the tests outlined in Table 15 as well as those to be discussed under Tables 16 and 17.)

(c) Table 16 outlines the results of tests conducted to determine the operation of the TBL-2 equipment when employing antenna constants simulating those of small surface craft flat top antennas. In these determinations the power output obtained exceeded the specification requirements by amounts ranging between 25% and 75%.

(d) Table 17 covers tests to determine the power output when employing antenna constants simulating those of antennas used on board large surface craft. Here again more than the required output was obtained even at reduced plate voltage, except in the case of 600 kilocycles. However, when 32 volts additional bias was employed the output obtained complied with specification requirements and later, after the 45 kilocycle oscillation had been eliminated and full 2000 volts could be employed with normal bias, more than the 175 watts required by specifications was obtained.

(e) Table 18 covers tests conducted to determine the effect of varying antenna constants by 25%. Suitable operation was obtained, even though the values selected for the 25% variation were marginal ones.

(f) Summary. The TBL-2 equipment is capable of producing power outputs at intermediate frequency operation which equal or exceed the values required by the governing specifications, while operating into the wide variety of antenna constants encountered upon vessels of various types. Spurious oscillations must be guarded against. The elimination of such oscillations is easily accomplished in a manner which does not detract from the operation of the equipment. Due to the value of resistance employed, 2300 ohms, the calibration of the overload relay was not affected, since the resistance of the relay coil is small.

112. Par. 3-45. When the TBL-2 equipment was first operated on MCW it was impossible to obtain the required 70% modulation, although the power output exceeded the 50% value required by the governing specifications. An investigation conducted in cooperation with a representative of the contractor revealed that the screen grids of the P.A. tubes were operating at too high a voltage. When this voltage was reduced from a value of approximately 600 volts to 350 volts, the percentage of modulation was increased to 70% at 600 kilocycles ranging upward to 100% modulation at 175 kilocycles as illustrated in Table 19. However, at 175 kilocycles, the percentage of MCW power to CW power is less than 50%, although the 45 watts obtained is exactly that which is required by the specifications on the basis of 90 watts output CW. Furthermore, the percentage of modulation is high which would cause the signal to be more effectively received with a non-oscillating receiver. In view of the fact that the TBL-2 equipment supplies more than the required amount of power at CW operation and that the percentage of modulation at 175 kilocycles is in excess of 70%, it is recommended that the MCW characteristics of the TBL-2 equipment be considered as satisfactory. The frequency of modulation is 768 cycles, which is within 4% of the specified 800 cycles. Selection of CW or MCW emission is effected by means of a suitable switch on the front panel of the transmitter.

113. Par. 3-46(1). Accuracy of reset to previously calibrated frequencies. (I.F.Operation). It is possible for an operator to adjust the equipment by means of controls on the front panel, in a period of less than one-man-minute, to a previously calibrated frequency with an accuracy greater than that required by the specifications. Referring to Table 20, attached hereto, it will be noted that the average of five reset trials at 200 kilocycles was 0.0088%, while at 500 kilocycles the average of five trials was 0.0036%. The maximum departure from the calibrated frequency was 0.025% at 200 kilocycles and 0.0074% at 500 kilocycles. The TBL-2 equipment complies with the requirements of this paragraph of the governing specifications.

114. Par. 3-46(2). Lost motion, backlash and torque lash. (I.F. Operation). Table 21 covers tests conducted to determine the degree of lost motion inherent in the controls which govern the frequency establishing circuits at intermediate frequencies. At 200 kilocycles the frequency error due to the causes listed above averaged 0.0308% for five trials, exceeding the specification value of 0.03% by a negligible amount. No single trial exceeded the specification value of 0.06%. At 500 kilocycles the average error was 0.0084% for five trials and the largest deviation for any one trial was 0.01%, which values are well within those permitted by the governing specifications. It is recommended that the TBL-2 equipment be considered as complying with the specification requirements outlined in par.3-46(2).

115. Par. 3-46(3). Operation of Adjust-Tune-Operate Control. (I.F.Operation). As illustrated in Table 22, the equipment under test complies with the specification requirements outlined in this paragraph. The greatest divergence was found to be 0.01% (at 500 kilocycles) whereas the specifications permit a value of 0.05%. As previously pointed out, however, steps must be taken to improve the contact of this switch in the "Tune" position.

116. Par. 3-46(4). Detuning of Circuits. (I.F.Operation) Table 23 illustrates the results of tests conducted at 200 and 500 kilocycles to determine the degree of frequency shift resulting from detuning circuits subsequent to the frequency establishing circuit. At 200 kilocycles the largest deviation encountered was 0.013% while at 500 kilocycles the largest deviation was 0.0092%. The equipment complies with this portion of the governing specifications, which limits the frequency change to a value of 0.025%.

117. Par. 3-46(5). Operation of Power Output Control. (I.F. Operation). Table 24 outlines the results of tests conducted at 200 and 500 kilocycles for the purpose of determining the frequency shift incident to the operation of the power output control, i.e., the plate motor generator field rheostat. The power output was varied between the limits of 100% and approximately 20% and the largest shift in frequency which occurred during this operation was found to be 0.013% at 200 kilocycles and 0.0042% at 500 kilocycles. The equipment complies with the requirements of the governing specifications which limit the variation in frequency to a value of 0.02%.

118. Par. 3-46(6). Change of Tubes. (I.F. Operation). As illustrated in Table 25, the average deviation from the mean frequency caused by the substitution of ten tubes in the master oscillator circuit, at 200 kilocycles, was 23 cycles, or 0.012%. The deviation at 500 kilocycles was 52 cycles or 0.01%. Specifications permit a maximum deviation of 0.02%. Changing tubes in the intermediate amplifier and power amplifier produced no measurable change in frequency. The TBL-2 equipment complies with the requirements of the governing specifications.

119. Par. 3-46(7). Variation of Supply Line Voltage. (I.F.Operation). The effect upon the output frequency of the TBL-2 transmitter when the supply line voltage is varied between the limits of $\pm$ 10% of normal, is practically negligible, as is illustrated in Table 26. This desirable condition is brought about through the action of an efficient speed regulator on the driving motor which holds the speed of rotation essentially constant regardless of supply line voltage fluctuations. As will be noted from Table 26, an additional test was conducted wherein the supply line voltage was varied from a value of 23% below normal to 15% above normal. Here again the frequency variations were negligible. Attempts were made, during this test, to obtain a line supply which could be varied to 45% above normal. However, no suitable supply could be obtained which could be raised higher than 265 volts.

120. Par. 3-46(8). Variation in Ambient Temperature. (I.F.Operation.). In accordance with instructions contained in reference (j), this test was conducted in 10° steps instead of the 5° steps specified in reference (b). Tests were conducted at one frequency in the intermediate frequency range of the transmitter, i.e., 500 kilocycles. Table 27 and Plate 1 cover the results of this test, and it will be noted that the TBL-2 equipment complies with the governing specifications. The maximum frequency change per degree Centigrade noted was 0.0006%, whereas the specifications permit a variation of 0.007% per degree Centigrade.

121. Par. 3-46(9). Variations in Humidity. (Intermediate Frequency Operation). Table 28 presents the data collected during a humidity test at 500 kilocycles, wherein the temperature was held substantially constant at 40° C and the relative humidity was varied between the limits of approximately 30% and 95%. Plate 2 presents this data in graphic form. The maximum frequency change encountered during this test was 22 cycles, or 0.0044%, while the maximum decrease in power attributable to the effects of high humidity was 5.6%. The governing specifications permit a frequency change of 0.05% and a power reduction of 5%. The value of 5.6% cited above is considered as complying with specification requirements, since errors inherent in radio frequency measurements make it necessary to allow tolerances in excess of .6%.

122. Par. 3-46(10). Locked Key Operation for Two Hours. (I.F. Operation). Table 29 covers a two hour locked key test conducted at 200 kilocycles and Table 30 covers a similar test conducted at 500 kilocycles. In both instances the equipment under test complies with the requirements of the governing specifications.

123. Par. 3-46(11). Change from Key Locked to Intermittently (I.F.Operation). Reference to Table 31 reveals that the TBL-2 equipment complies fully with the requirements of the governing specifications relative to the frequency changes encountered when changing from locked key condition to an intermittently keyed condition, both with master oscillator filament lighted or unlighted during the 20 minute interval specified.

124. Par. 3-46(12). Change from Continuously Keyed to Intermittently Keyed Condition. (I.F. Operation). The equipment complies with the specifications with respect to the frequency change caused when changing from continuously keyed to intermittently keyed condition, as will be noted from the data contained in Table 32. Tests were conducted at 200 kilocycles and 500 kilocycles. The maximum frequency change encountered was 0.0018% at 500 kilocycles whereas the specifications permit a value of 0.02%.

125. Par. 3-46(13). Inclination due to roll and pitch of ship. (Intermediate Frequency Operation). The entire TBL-2 equipment, including transmitter unit, motor generator, starter and filter was mounted on a test stand which permitted inclination through an angle of 45° on either side of the vertical at a rate of 6 cycles per minute. All units of the equipment were secured by means of the regular securing fittings provided and the equipment was subjected to a 30 minute test at 500 kilocycles. Table 33 and Plate 3 attached hereto cover the results of this test. From Table 33 it will be noted that the maximum shift in frequency noted during the test was 72 cycles or 0.014%, while the maximum deviation from the frequency noted when the equipment was at rest is 44 cycles, or 0.0088%. Specifications permit a value of 0.005% from the frequency as measured with the equipment in the vertical position. These values were obtained when the transmitter was rolled from side to side. When the transmitter was inclined in a fore and aft direction, the frequency change was only 23 cycles, or 0.0046%.

126. Par. 3-46(14). Vibration. (Intermediate Frequency Operation). The equipment was subjected to vibration for a period of 30 minutes while operating at 500 kilocycles. Table 34 and Plate 4 cover the results of this test. Vibration had little effect upon the emitted signal and the

equipment complies with the specification requirements. The maximum frequency shift encountered during test was 15 cycles, or 0.003%; specifications permit 0.005%.

127. Par. 3-46(15). Shock. (I.F. Operation). Table 35 covers shock tests conducted at 200 and 500 kilocycles. The maximum set in frequency recorded at 200 kilocycles, due to shock was 3 cycles or 0.0015%; at 500 kilocycles the maximum frequency change was 5 cycles, or 0.001%. The specifications permit a maximum deviation of 0.005%.

128. Par. 3-47. The variation of the resonant frequency, per division of marking of the intermediate frequency master oscillator control, is illustrated in Table 36. The specifications require that the variation per degree of marking shall not be greater than 0.03% or less than 0.015%. It will be noted that these values are exceeded, particularly at the high frequency end of the range where values as small as 0.008% per division are obtained. However, this slight deviation from the requirements of the specifications in nowise interferes with the efficient functioning of the equipment. The type of control provided can be manipulated rapidly and accurately, particularly in the range of 500 to 600 kilocycles, as is illustrated in Table 20. Furthermore as pointed out in enclosure (B) to reference (h), the inherent characteristics of variometer control are such that frequency change is necessarily slow near the end positions. The Naval Research Laboratory, therefore, agrees with the recommendation of the Inspector of Naval Material, Hartford, Conn., as contained in enclosure (A) to reference (h), and suggests that the Bureau of Engineering approve the present arrangement provided in the preliminary model of the TBL-2 equipment.

129. Par. 3-48. The TBL-2 equipment does not employ quartz crystals as a means of frequency control. The transmitter contains the following circuits for high frequency operation:

(1) A self excited master oscillator circuit, of the electron coupled oscillator type is employed, using one 38160 vacuum tube. This circuit covers the nominal frequency range of 1000 to 2262.5 kilocycles. The actual frequency range was measured as 992 kilocycles to 2326.2 kilocycles. This circuit is housed in a temperature controlled compartment, together with the master circuit of the intermediate frequency range portion of the equipment. The vacuum tube, however, is not housed in this compartment. The suitability of the temperature control circuits will be discussed below, under par.3-51. The temperature controlled compartment and all associated master oscillator elements are flexibly suspended to protect the equipment against the results of vibration.

(2) A suitable master oscillator output doubler circuit is provided. This circuit is housed in the flexibly mounted compartment described above.

(3) A first intermediate amplifier circuit is provided, which uses a 38160 tube. This circuit covers the nominal frequency range of 2000 to 9050 kilocycles.

(4) A second intermediate amplifier circuit, employing a 38160 covers the frequency range of 2000 kilocycles to 18,100 kilocycles. An overload condition exists in this circuit, as described previously in par. 48 of this report.

(5) The power amplifier circuit uses two 38803 pentode tubes in parallel and covers the frequency range of 2000 to 18,100 kilocycles.

(6) Suitable antenna tuning and coupling circuits are provided for operation into the various types of antennas specified.

130. Par. 3-49. Provision is made in the TBL-2 equipment for current feeding and voltage feeding the antenna on high frequency operation.

131. Par. 3-50. In all cases the TBL-2 transmitter exceeded the specified power output of 200 watts at the various frequencies tested and while using various values of antenna constants. Tables 37 and 38 show the results obtained over the frequency range of 2000 to 18,000 kilocycles when using a 500 watt, 110 volt lamp as the output load. Tables 39 and 40 show the results obtained when using dummy antennas of various resistance values in connection with an antenna capacity of 1000 micromicrofarads, at 2000, 3000 and 4000 kilocycles. The power output characteristics of the TBL-2 transmitter at high frequency is remarkable, since in many instances the power output exceeds 400 watts with P.A. plate currents of considerably less than the maximum value of 350 m.a. These large power outputs are mainly due to the employment of the Type 38803 tubes and the efficient output circuits provided. In this connection, however, a doubtful factor is introduced. Specifications covering the 38803 tubes limit the plate dissipation per tube to 125 watts or 250 watts for two tubes. Referring to column 3 of Table 38, it will be observed that the power input to the P.A. stage was 640 watts (320 ma at 2000 volts). The power output was 268 watts; plate dissipation permitted 250 watts. Thus there remains a total value of 122 watts unaccounted for. It is possible that circuit losses may account for this portion of the power or some portion of it may be dissipated by the plate. It must be stated, however, that all during the course of these tests no signs of heating were detected on the plates of the 38803 tubes, no signs of excessive heating were noted in the output circuits and in general the power amplifier and antenna circuits appeared to be functioning in a normal and efficient manner. After many hours of key locked and intermittent operation, the original 38803 tubes are functioning as efficiently as at the start of the tests. No satisfactory method is available to determine plate dissipation when these tubes are operating in the transmitter since the plates show no signs of color. However, since 38803 tubes have not previously been employed in Navy transmitters of this type, the Naval Research Laboratory was impelled to call attention to any factors which might have a bearing on the operation of these tubes even though no definite conclusions could be arrived at during the short period of time these tubes were under observation. A discussion of the possible influence of the 38803 tubes upon the operation of the 2nd intermediate power amplifier is found in par.48 of this report.

132. Par. 3-51. The frequency determining elements of the IF. and H.F. master oscillator circuits are contained in a cast aluminum housing which is covered with heavy black felt. A motor driven blower located at the bottom of the compartment circulates the air throughout the compartment. The temperature is controlled by means of a mercury-in-glass thermostat of the angle type located in the air stream just above the blower. This thermostat may be inspected or replaced without opening the temperature chamber. A great deal of thought and ingenuity is reflected in the temperature control system provided in the TBL-2 equipment in order to make it capable of coping with the diverse and rigorous factors outlined in the governing specifications, such as large temperature changes, humidity changes, large fluctuations in line voltage and a variety of keying conditions. The excellent frequency stability of the equipment is, in a large share, attributable to the methods employed in maintaining the temperature constant under these varying conditions, but unfortunately, the system in its present state is not entirely reliable and certain defects must be overcome before the equipment can be considered suitable for the Naval Service.

(a) Shortly after the equipment was placed into operation, it was noted that the operating point became progressively and consistently higher. Examination revealed that the mercury thermostat had suffered a fracture of the capillary column. This fracture did not extend completely through the stem but was sufficiently large to permit a quantity of mercury to enter the void thus formed and interfere with the proper operation. The contractor provided a new thermostat and to date this replacement has operated satisfactorily. It is felt, however, that the clips which hold the thermostat in place and at the same time form the electrical contacts, are too stiff and rigid and may be partly responsible for fracturing the original thermostat.

(b) The heater relay (K-1) which is controlled by the mercury thermostat must, necessarily, be of a sensitive type and yet be capable of controlling a considerable amount of power by means of its contacts. A small permanent magnet has been affixed over these contacts to aid in extinguishing arcs and an arc suppressor circuit of resistance and capacity is connected across the contacts. The operation of the original relay provided became progressively inconsistent, due to sticking of the contacts until it reached a condition which interferred seriously with the functioning of the transmitter. A replacement relay was provided by the contractor and to date this relay has operated satisfactorily and consistently at temperatures above 10° C. However, low ambient temperatures introduce an additional load upon the relay contacts which results in a vicious and destructive arc. Frequently, while operating around 0° C this arc would persist for several seconds. This additional load is brought about in the following manner. Normally the heat provided in the compartment is produced by a 155 ohm resistor connected across the 230 volt line. However, at low ambients this amount of energy is not capable of maintaining the internal temperature at 60° C. A bimetallic thermostat of the "Westinghouse Watchman" type is located in the transmitter, exterior to the temperature compartment. At approximately 10° C this thermostat makes contact and actuates an additional heater resistor, within the temperature controlled compartment. This

resistor has a value of 265 ohms and is connected in parallel with the 155 ohm resistor. At a line voltage of 210, the heater relay contacts must break in excess of 400 watts which causes destructive arcing. As the line voltage rises, the arcing becomes greater since at 230 volts the energy in the heaters equals 500 watts. As the line voltage continues to rise, provision is made to counteract the effect by means of a switch on the front panel. Instructions state that this should be thrown to the "on" position in order to insert additional resistance in series with the heaters and thus cut down the energy. However, it is believed that this relay would not continue to operate at normal line voltage of 230 volts at low ambient temperatures, and should an operator fail to throw the necessary switch when high line voltage prevails, destruction of the relay contacts is certain.

(c) Provision has also been made to cut down the time of heating from a cold start. Another bimetallic thermostat of the watchman type is mounted inside the heat chamber. When the temperature in this compartment is below 50° C, the thermostat operates to connect the additional 265 ohm heater resistor into the circuit, thus speeding up the process of attaining the operating temperature. At approximately 50° this thermostat opens and removes the additional heater from the circuit. During this heating up process the arcing at the relay contacts is more pronounced than during normal operation. With the aid of this device the temperature controlled compartment can be brought to equilibrium at 60° C from a cold start in 2-1/2 hours.

(d) Par.1(9) of Bureau of Engineering letter C-NOs-47359(3-26-W8) of 10 April 1936, which was submitted as enclosure (A) of reference (a), requires that satisfactory operation be demonstrated when shifting from intermediate frequency operation to high frequency operation. Accordingly the test illustrated in Table 41 was conducted. The transmitter was operated for a period of 15 minutes key locked at 2000 kilocycles and the frequency noted at the end of this period. The transmitter was then switched to intermediate frequency operation at 500 kilocycles and keyed at 30 words per minute for one hour. At the end of this period the equipment was re-transferred to high frequency operation at 2000 kilocycles and operated for an additional 15 minutes key locked. During the 2000 kilocycle operation no controls were readjusted. At the end of the second 15 minute period the frequency was compared with that obtaining at the end of the first 15 minute period and was found to have changed by 30 cycles, or 0.0015%. In the opinion of the Laboratory this demonstrates that satisfactory operation is assured when transferring from I.F. operation to H.F. operation.

(e) Summary. In order to increase the reliability of the temperature control system employed in the TBL-2 equipment certain remedial measures must be effected:

(1) Improved contacts should be provided to prevent injury to the mercury thermostat.

(2) Improvement in the operation of the heater relay must be assured. Since operation in connection with standard mercury thermostats requires sensitive relays which militates against their ability to break heavy loads in the contact circuit, it may be necessary to provide an additional heavy duty relay, the contacts of which would be adequate to break the necessary load and the coil circuit of which could be controlled by means of the present heater relay.

133. Par. 3-52. A bimetallic thermostat of the "Westinghouse Watchman" type is located within the temperature controlled compartment for the purpose of protecting the equipment against excessive temperatures. The original thermostat provided for this purpose failed to function at the required temperature of approximately 70° C. The temperature within the compartment rose to 80° and the thermostat failed to function. At this point the test was abandoned in order not to subject the equipment to dangerous temperatures. The contractor furnished a replacement thermostat. Tests conducted showed that this thermostat operates in the manner intended. With the heater relay contacts blocked shut, the temperature rose to 69.8° at which point the protective thermostat opened the circuit. After the temperature had dropped to 59.5°, the protective thermostat re-established the heater circuit and normal operation was resumed.

134. Par. 3-53. Positive geared verniers have been provided in the construction of the TBL-2 equipment. The variation of resonant frequency of the master oscillator control per division of dial marking does not exceed the specification value of 0.01%. As will be noted from Table 42, the percentage value per division falls between the limits of 0.0012% and 0.0065%. The controls which govern the remaining circuits are such as to provide for the non-critical and satisfactory adjustment of these circuits.

135. Par. 3-54 (1). Accuracy or reset to previously calibrated frequencies. (H.F.Operation). It is possible to adjust the TBL-2 equipment to a previously calibrated frequency, when employing high frequency operation, in a period of one-man-minute or less. The average accuracy of 5 reset trials was found to be 0.00035% at 2000 kilocycles and 0.0034% at 4500 kilocycles. The specifications permit an average accuracy of 0.005%. No one trial exceeded the specification requirement of 0.01%, the largest single deviation being 15 cycles or 0.00075% at 2000 kilocycles and 195 cycles, or 0.0043% at 4500 kilocycles. Examination of Table 43 reveals that a 10 cycle variation due to the heat cycle of the temperature controlled compartment is encountered at 2000 kilocycles and a 20 cycle variation at 4500 kilocycles. These variations occurred at an ambient temperature of approximately 30° C. As the ambient temperature increases or decreases from this value, the rapidity of the heat cycle decreases and becomes practically unnoticeable.

136. Par. 3-54(2). Lost motion, back-lash and torque lash. (H.F.Operation). The degree of back-lash present in the high frequency master oscillator control is illustrated in Table 44. At 2000 kilocycles the average deviation for 5 trials was 0.00045% and 0.0055% at 4500 kilocycles. This latter value exceeds the specification limit by 0.0005%, which is considered a negligible amount. No single trial exceeded the specification value of 0.008%.

137. Par. 3-54(3). Operation of Adjust-Tune-Operate Control. (H.F.Operation. The action of the Adjust-Tune-Operate control was observed at 6 frequencies within the range of the equipment. The maximum frequency shift noted was at 4500 kilocycles, where a 38 cycle deviation was encountered; i.e., 0.00085%. Specification permits 0.001%. See Table 45.

138. Par. 3-54(4). Detuning of Circuits (H.F.Operation). Table 46 lists the results of tests conducted at 2000 and 4500 kilocycles to determine the frequency shifts which occur when any circuit subsequent to the frequency establishing circuit is detuned. It will be noted that the maximum frequency change at 2000 kilocycles was 15 cycles, or 0.00075%, while at 4500 kilocycles the maximum change was 77 cycles or 0.0017%. Specifications permit a value of 0.003%.

139. Par. 3-54(5). Operation of Power Output Control. (H.F. Operation). The variation in frequency which occurs when the power output is varied from a value of 100% down to approximately 22% is illustrated in Table 47. It will be noted that at 2000 kilocycles the maximum frequency change was 10 cycles, or 0.0005%, while at 4500 kilocycles the frequency change was 15 cycles or 0.0003%. The specifications permit a frequency change of 0.001%.

140. Par. 3-54(6). Change of Tubes. (H.F.Operation). The governing specifications require that the substitution of tubes in the master oscillator circuit shall not cause an average variation from the mean frequency of greater than 0.01%. Tubes to be selected at random from any lot within the limitations of Navy tube specifications. Tubes complying with Navy specifications were selected from lots manufactured by the Westinghouse Electric and Manufacturing Company and the Radio Corporation of America. Reference to Table 48 reveals that at 2000 kilocycles the average variation from the mean was 0.0085%, while at 4500 kilocycles the variation was 0.017%, which is in excess of specification requirements. It will further be noted that if the tubes of any one manufacturer are considered alone, the specification requirements of 0.01% are met. When tubes are changed in circuits subsequent to the frequency establishing circuit, the frequency change encountered was negligible. During this test it was discovered that tubes of different manufacture drew different values of plate current. This was especially noticeable at 18,100 kilocycles in the 2nd intermediate amplifier stage. While a difference could be noted in other stages of the transmitter between tubes of different manufacturers, the power drawn by these stages is so low that the difference in plate current encountered can be considered negligible. A complete discussion of this effect is found under par.48 of this report since this condition has a bearing on the overload condition existing in the 2nd intermediate amplifier stage.

141. Par. 3-54(7). Variation of Supply Line Voltage. (H.F.Operation.) Table 49 covers tests conducted at 2000 and 4500 kilocycles where the supply line voltage was varied between the limits of -10% and +10% of normal in one minute, and additionally in a time of 5 minutes. In no case was the specification value of 0.002% exceeded. The line voltage was also varied between the limits of -23% and +15%, with a negligible change in frequency.

142. Par. 3-54(8). Variations in ambient temperature. (H.F.Operation.) In accordance with instructions contained in reference (j), this test was conducted in 10° steps instead of the 5° steps specified in reference (b). Tests were conducted at 4500 kilocycles in the high frequency range. Table 50 and Plate 5 cover the results of this test. It will be noted that the maximum frequency change per degree Centigrade encountered during this test was 0.00028%, whereas the specifications permit a value of 0.0005%.

143. Par. 3-54(9). Variations in Humidity. (H.F.Operation). With the TBL-2 equipment adjusted to a frequency of 4500 kilocycles, the relative humidity was varied between the limits of approximately 30% and 95%. The temperature was held substantially constant at 40° C. Table 51 covers the results of this test, while Plate 6 presents this data in graphic form. It will be noted that the maximum frequency shift encountered was 150 cycles, or 0.0033%, whereas specifications permit a value of 0.005%. The maximum decrease in power output which is attributable to the effects of high humidity is 10 watts, or 2.35%, whereas the specifications permit a power decrease of 5%.

144. Par. 3-54(10). Locked Key Operation for Two Hours. (H.F.Operation.) Table 52 covers a two hour locked key test at 2000 kilocycles, while a two hour locked key test at 4500 kilocycles is illustrated in Table 53. In both instances the frequency shifts occurring are less than those permitted by the governing specifications.

145. Par. 3-54(11). Change from Key Locked to Intermittently Keyed Condition. (H.F.Operation). Table 54 covers tests conducted at 2000 kilocycles and 4500 kilocycles to determine the frequency shift occasioned when changing from key locked to intermittently keyed condition. The frequency changes noted are considerably less than those permitted by the governing specifications.

146. Par. 3-54(12). Change from Continuously Keyed to Intermittently Keyed Condition. (H.F.Operation). This test, conducted at 2000 and 4500 kilocycles, is illustrated in Table 55. In both instances, it will be noted, the frequency shift is decidedly less than that permitted by the specifications.

147. Par. 3-54(13). Inclination due to Roll and Pitch of Ship. (H.F.Operation). With the entire equipment mounted on the test stand which permitted inclination through an angle of 45° on either side of the vertical at the rate of 6 cycles per minute, a 30 minute test was conducted at 4500 kilocycles. From Table 56 it will be noted that the maximum frequency change encountered during the test was 45 cycles or 0.001%, while

the maximum change from the frequency with the transmitter at rest in the vertical position was 35 cycles, or 0.00078%. Specifications permit a value of 0.001%. Plate 7 attached hereto is the record of this test as produced by the recording mechanism of the LK frequency indicator.

148. Par. 3-54(14). Vibration (H.F.Operation). The equipment was subjected to vibration for a period of 30 minutes while operating at 4500 kilocycles. Table 57 and Plate 8 cover the results of this test. It will be noted that the maximum frequency change due to vibration was 28 cycles, or 0.0006%. Specifications permit a value of 0.001%.

149. Par. 3-54(15). Shock (H.F.Operation) Shock tests conducted in accordance with this paragraph are covered by Table 58. Tests were conducted at 2000 kilocycles and 4500 kilocycles. In both tests the frequency change resulting from shock was negligible.

150. Pars.5-1 to 5-5. The control system provided with the TBL-2 equipment complies with the requirements of these paragraphs of the specifications.

151. Par. 5-6. The keying relay is an integral part of the transmitter assembly and is accessible from the front panel. This keying relay performs the following functions:

(1) Controls the emission of the transmitter for telegraph signalling, both on high frequency and intermediate frequency operation.

(2) Provides break-in operation when the intermediate frequencies are being employed.

(3) Is provided with contacts which permit the control of a grounding relay at the receiver.

152. Par. 5-7. As originally received, the keying circuit could not be energized from the local position until the motor generator equipment was brought up to full speed. However, keying could be accomplished from the remote key with the motor generator set shut down. This condition was remedied, in cooperation with a representative of the manufacturer, in the following manner. Originally a connector joined terminals P1 and P5 in the starter. This connection was shifted so that P5 was connected to the test link in the starter. After this modification had been accomplished the keying circuit could not be energized, from either local or remote position, until the motor generator had reached full speed.

153. Par. 5-8. The keying relay is capable of operation at 115 volts and was found to draw 82 milliamperes. The relay operates satisfactorily up to speeds of 100 words per minute.

154. Par. 5-9. An indicator lamp is provided on the panel of the transmitter which is connected in parallel with the starting contactor. Terminals for a Navy Type 23005 remote control unit are provided. The circuit arrangement is such that the remote monitor light functions only when the equipment is started from the remote position. This is effected

by providing a special three bladed local-remote switch, which is capable of interrupting remote circuits 1, 3, and 4.

155. Par. 5-10. The local start-stop switch is so connected that it is in series with the remote start-stop switch. An emergency switch, prominently marked in red, is located on the front panel of the transmitter. This emergency shut down feature is so arranged that the equipment cannot be started from any point other than the one from which it has been shut down.

156. Par. 5-11. The current required by the remote control circuits is 500 milliamperes.

157. Par. 5-25. The contactors provided in the preliminary Model TBL-2 equipment (d.c. supply) operate in a quiet manner.

158. Par. 6-1. The power equipment supplied with the TBL-2 equipment (manufactured by the Continental Electric Company) gave safe and satisfactory operation during the course of these tests. Attention is invited to a phenomenon which occurs at low ambient temperatures between zero and +10° C. Reference to Tables 27 and 50 reveals that the output voltage of the plate generator rises as the temperature decreases, without any manual readjustment of the controls. An investigation was conducted to determine whether this variation in voltage was due to the effect of temperature upon the speed regulator. The speed of rotation of the motor generator was measured at an ambient temperature of 40° C and found to be approximately 1770 r.p.m. Another check was made at zero degrees Centigrade and it was found that the speed was the same. Hence, it must be decided that the effect of temperature upon the resistance of the various windings of the motor generator and the field controls is responsible for this voltage variation. It is pointed out that this variation in voltage caused no ill effects and that the equipment operated satisfactorily at both high and low temperatures.

159. Par. 6-3. As will be noted from Tables 26 and 49, the motor generator equipment functions satisfactorily when subjected to line voltage variations between -23% and +15%. Operation at +45% could not be obtained due to lack of a suitable power source.

160. Par. 6-4. The motor generator equipment was subjected to numerous key locked tests for period of between 2 and 8 hours and operated satisfactorily on all tests.

161. Par. 6-5. Table 59 lists the amount of power drawn from the supply lines under various conditions of operation. It will be noted that when the transmitter is delivering the output required by the specifications that the power input does not exceed 3200 watts, which conforms with specification requirements. When the power output is in excess of specification requirements at a frequency of 18,100 kilocycles, the power input required is slightly in excess of 3200 watts. In view of the fact that it is always possible to reduce the power output to that required by specifications, or to much lower values if necessary, it is recommended that the TBL-2 equipment be considered as complying with the governing specifications.

162. Par. 6-6. Power for filament lighting is obtained from collector rings on the exciter generator, which also is the source of bias voltage.

163. Par. 6-7. Main plate power is obtained from a 2000 volt generator; auxiliary plate power is obtained from a 1,000 volt generator; bias voltage is obtained from the 250 volt exciter generator and screen potentials are obtained from potentiometers connected across the 1,000 and 2,000 volt generators.

164. Par. 6-8. Excitation voltage and bias voltage is obtained from a 250 volt generator.

165. Par. 6-9. All generators are assembled on a common bed plate with the driving motor.

166. Par. 6-10. The d.c. supply motor generator furnished with the preliminary Model TBL-2 equipment is of the three unit six bearing type.

167. Par. 6-17. All motor and generator frames are grounded to the bed plate. Substantial metal protective covers are fitted over all terminal blocks which are capable of withstanding a weight of 250 pounds without deformation or injury to leads.

168. Par. 6-18. Suitable eyebolts, properly marked, have been provided for lifting individual units, while the base of the generator is provided with suitable lifting devices.

169. Par. 6-19. The dimensions of the motor generator conform with the requirements of the governing specifications as modified by the contract notes. See Table 5.

170. Par. 6-23. Suitable fuses are installed at the generator terminals as described in detail in par.41 of this report.

171. Par. 6-25. The motor generator equipment is of the drip-proof type and operates satisfactorily at temperatures of 50° C. The motor is rated at 3.5 h.p.

172. Par. 6-26 and 6-27. The motor starter is of the drip-proof type. It is of the two step type giving definite time acceleration and is provided with a manual reset overload relay.

173. Par. 6-31. The voltage regulation of the generators is less than 5%, as illustrated in Table 60. The ripple voltage of the 2,000 volt and 250 volt generators is less than 0.25%. However, the ripple voltage of the auxiliary plate generator, 1,000 volts, exceeds the specification value of 0.25%, having been measured as 1.3%. See Table 61. The major portion of this ripple voltage is at a frequency of 120 cycles.

174. Par. 6-35. The high voltage filter is contained in a separate enclosed case. This unit is not fitted with interlock protection, and as discussed in par.43, it is recommended that such protection be provided.

175. Par. 6-36. The door on the starter cabinet is mounted on hinges with removable pins which are secured by short chains to prevent loss. The door on the filter unit is provided with permanent hinges which cannot be removed.

176. Section X. The tests required by this section of the specifications are described in the body of this report under appropriate paragraph headings. Certain tests were not conducted in accordance with the directions contained in reference (j).

177. Reference (a). Bureau of Engineering letter C-NOs-47359(7-6-W8) of 13 July 1936, to Director, Naval Research Laboratory.

(a) Par. 2. This paragraph of reference (a) requests specific comment with respect to the CRC-38803 tubes and the effectiveness of the electron coupled oscillator as employed in the TBL-2 equipment. The power output obtained from the two 38803 tubes employed as power amplifiers, is, in general, greater than that required by the specifications. In some instances the excess power is as high as 100% or more. A complete discussion of the operation of these tubes in the TBL-2 equipment will be found under pars. 111, 112, and 131 of this report. Par. 48(h) discusses the effect of the rather high input capacity of these tubes.

(b) The electron coupled oscillator provided as the frequency establishing circuit for high frequency operation produces adequate power output and results in a frequency stability characteristic which in most cases is greatly superior to that required by the governing specifications. With the proper heater circuit modifications, this master oscillator should give excellent results. The fact that the master osc. circuit of the intermediate frequency portion of the equipment is also temperature controlled, and operates at half the output frequency (as does the H.F.oscillator) results in excellent frequency stability at intermediate frequencies. Changing from intermediate to high frequency operation, or vice versa, has no appreciable effect upon the frequency stability of the equipment.

(c) The feasibility of adapting the TBL-2 equipment to voice communication by means of suppressor grid modulation was not actually investigated. This investigation was cancelled by the terms of reference (j). The methods outlined in Westinghouse Electric and Manufacturing Company's letter of August 13, 1936, to Inspector of Naval Material, U.S.N., Hartford, appear to be satisfactory. The elimination of the two cathode meters, as pointed out in par. 98 of this report would assist in providing room for the necessary telephone controls.

178. Bureau of Engineering letter C-NOs-47359(3-26-W8) of 10 April 1936, to Inspector of Naval Material, Hartford. (Submitted as enclosure (A) to reference (a).) In general, the points covered by this letter have been complied with in the construction of the TBL-2 equipment; however, the following comments are submitted:

(a) Par. 1(3). The use of a separate filter unit appears to be unavoidable, since all available space has already been used in the transmitter proper.

(b) Par. 1(8). The manually operated switch and associated resistors authorized by this paragraph for the protection of the heater circuits, has been provided. As previously pointed out in this report, however, no source of power was available which would permit tests to be conducted at +45% of normal line voltage. Since it is understood that an adequate source is available at the point of manufacture, it is suggested that the resident inspector pass upon the suitability of the heater arrangementment to withstand the maximum voltage in the event that an operator failed to make the proper adjustments.

(c) Par. 1(9). A complete discussion of the effect of transferring from intermediate frequency operation to high frequency operation is contained in par. 132(d) of this report.

(d) Par. 1(10). As indicated in this paragraph, the manufacturer provided a suitable means of inserting a test thermometer in the temperature controlled master oscillator compartment. Tables 28, 50, and 51 contain data which illustrates the results obtained when comparing the panel thermometer with the test thermometer readings. The thermometer labelled "External Thermometer" in these tables refers to the test thermometer which was inserted in the temperature controlled compartment. From these tables it will be noted that the panel thermometer went off scale (below 58°) when the ambient temperature was approximately 20° C. (Table 50) It will further be noted that at an ambient of 40° the panel thermometer indicated approximately 58.5°, which is close to the bottom of the calibration. Table 50 reveals that the test thermometer indicated temperatures between the limits of 61° and 55.4°. Although the test thermometer was an accurate instrument, it was calibrated for total immersion, as is the case with most thermometers. Yet about 9/10th of the thermometer was subjected to the ambient temperature and only the remaining 1/10th was immersed in the heat chamber. It is extremely doubtful, therefore, that the interior temperature of the heat chamber actually varied between the limits indicated. The degree of frequency stability obtained during the wide range of ambient temperatures supports this conclusion, since it was demonstrated that a temperature variation of 6° would cause a far greater frequency shift than was encountered during the test illustrated in Table 50. It is concluded, therefore, that the temperature of the heat chamber is being maintained within the limits demanded by the specifications, but that the thermometers read erroneously since they are calibrated for total immersion. These tests indicate that the panel thermometer, calibrated between 58 and 62° C is unsuitable for use in the TBL-2 equipment in its present form.

(e) Par. 1(12). The method to be employed in calculating the degree of frequency overlap as specified in this paragraph was employed in the tests discussed in detail in par.84 of this report.

179. Reference (f). Bureau of Engineering letter C-NOs-47359(7-6-W8) of 22 July 1936 to Director, Naval Research Laboratory.

(a) Par. 2. This paragraph requests that the Naval Research Laboratory test WL-803 tubes in the Model TBL-2 equipment. Reference (j), however, later directed that these tests be cancelled. Hence, no report can be made as to the suitability of the WL-803 tubes.

(b) Par. 3. The motor generator equipment furnished in connection with the TBL-2 equipment is designed in such a manner that the three terminal housings may be mounted on the side of the unit or may be mounted on the top of the unit. This transfer is easily accomplished by removing 4 screws, swinging the housing to the other location and re-securing it by means of the same 4 screws. Leads of sufficient length are provided so that this operation will not subject the wires to damage. The motor generator was secured to a test stand which could be tilted at an angle of 45° from the vertical. The motor generator functioned successfully when inclined at this angle. The motor generator was tested with the short axis of the bed plate inclined at an angle of 45° and also with the long axis of the bed plate inclined to 45°. The equipment functioned satisfactorily under these conditions.

180. Bureau of Engineering letter NOs-47359(6-26-W8) of 7 July 1936 to Inspector of Naval Material, Hartford. This letter deals with the suitability of operating 38803 tubes with key open voltages in excess of 600 volts. The screen potential is derived from a potentiometer across the 2,000 volt generator. As received, the screen potential applied to the 38803 tubes was approximately 600 volts (key closed). However, as pointed out in par.112 of this report, suitable MCW operation could not be obtained with this screen voltage. Tests indicated that in order to obtain a satisfactory percentage of modulation over the entire intermediate frequency range, a screen potential of approximately 350 volts (key closed) was necessary. Satisfactory CW output could still be obtained when employing 350 volts on the screen grid. The insulation employed in the screen grid circuits is adequate to withstand the key open potentials impressed upon these circuits. However, as pointed out in par.31 of this report and in Table 1, resistors R24 and R25 which form a part of the potentiometer by means of which proper screen potential is provided, are working beyond their voltage rating, as limited by Specifications RE 13A 372G. Resistors R43 and R44 are also working at potentials in excess of that permitted. These latter resistors form the screen grid potentiometer for the 1st intermediate amplifier.

181. Reference (g). Bureau of Engineering letter C-NOs-47359 (7-21-W8) of 27 July 1936 to Director, Naval Research Laboratory. This letter requests comments on par.4 of Inspector of Naval Material, Hartford, letter of 21 July 1936, which was submitted as enclosure (A).

(a) Par. 4 (10-6). The Laboratory agrees with the Inspector of Naval Material in describing the method of assembly and general workmanship as "excellent". Even though the accessibility of the terminal compartment is not as great as may be desirable, it is believed that the removal of resistors and relays to the filter unit would not prove to be satisfactory. The size of the filter unit would have to be increased and a large number of inter-connecting leads would be required.

(b) Par. 4 (10-7). The Laboratory concurs in the recommendation of the Inspector of Naval Material in that door interlocks be provided on filter units.

(c) Par. 4 (10-8). The tests at the Laboratory indicated that the indicator lights functioned satisfactorily at line voltages of 265 volts, the maximum obtainable. However, the equipment was not run for any length of time at this voltage and was not operated at all on the +45% line voltage. Tests conducted at the point of manufacture by the Inspector of Naval Material are suggested to determine the necessity of providing additional protection for the indicator lights.

(d) Par. 4 (10-33). The motor generator equipment supplied operated consistently and satisfactorily, as outlined in this report. The percentage of ripple voltage which modulates the output of the 1,000 volt generator exceeds the specification value of 0.25%.

182. Reference (h). Bureau of Engineering letter NOs-47359(8-6-W8) of 19 August 1936 to Director, Naval Research Laboratory. This letter submitted for comment, letters from the Inspector of Naval Material, Hartford, and the Westinghouse Electric and Manufacturing Company. The following sub-paragraphs refer to the Inspector of Naval Material, Hartford, letter of 6 August 1936.

(a) Par. 2 (a) (1). The use of colored nameplates to distinguish intermediate frequency controls from the high frequency controls is an excellent arrangement and should be retained. However, as pointed out in par. 55 of this report, the orange colored nameplates suffer from reflections, and it is recommended that the green nameplates submitted by the manufacturer be substituted for the orange. The remaining colors are suitable.

(b) Par. 2 (b). It is recommended that the backlash characteristics of the Model TBL-2 equipment be considered as satisfactory.

(c) Par. 2 (c). The employment of colored lights to indicate normal and abnormal temperatures in the master oscillator compartment would further complicate an already complicated system of temperature control. If the more serious heater circuit difficulties discussed in par.132 of this report are corrected in a satisfactory manner, it is believed that excellent frequency stability will be obtained. The inability of the panel thermometer to correctly register the internal temperature as discussed in par.178(d) of this report is an annoying characteristic rather than a serious one. It is recommended that efforts be made to re-locate the position of this thermometer so that at normal ambient temperatures (20 to 30° C) the thermometer would register 60°. Then when high or low temperatures are encountered the scale of the present thermometer would accommodate the variation which obtains. If this is impracticable, it is suggested that the Bureau of Engineering consider the advisability of permitting the use of a thermometer of similar size but with a greater calibrated range. The frequency stability of the equipment when changing from intermediate frequency to high frequency operation is covered in par. 132(d) of this report.

(d) Par. 2 (d). The suitability of the fixed resistors provided is covered in detail in par. 31 and Table 1 of this report.

(e) Par. on "Range Overlap". The recommendations of the Naval Research Laboratory are contained in par. 84 of this report.

(f) Par. on "Frequency Division per MO Dial". This subject is covered in par. 128 of this report.

(g) Par. on "Power Required from Supply Lines". The data contained in Table 59 which is discussed in par.161 of this report, reveals that under normal conditions of operation the TBL-2 equipment meets the specification requirements of 3200 watts. Under unusual circumstances, such as line voltages above normal and power output in excess of specification requirements, the equipment draws more than 3200 watts. Since the connection cables recommended are capable of handling this overload and the equipment is guaranteed to withstand such operation, it is recommended that the excess power drawn from the supply lines be waived rather than restrict the power output of the equipment.

(h) Par. on Size of M.O. Tube compartment. It is recommended that the 1/2" reduction in the size of the tube compartment (MO) be authorized. It is recommended, however, that the opening which gives access to the MO tube be kept substantially the same size by cutting off approximately 1/2" of the casting which forms the frame to this compartment. This reduction can be made on the left hand side of the opening without the sacrifice of strength and thus permit the same degree of accessibility as now prevails.

183. Inspector of Naval Material Hartford letter NOs-47359(50) RNV of 17 August 1936 to Bureau of Engineering, enclosing copy of Westinghouse Electric and Manufacturing Company letter of 13 August 1936. The methods outlined by the manufacturer for providing voice modulation appear to be a satisfactory solution of this problem. However, as previously stated, no actual investigation was conducted at the Naval Research Laboratory in accordance with the directions contained in par. 2(a) of reference (j).

184. Reference (j). Bureau of Engineering letter C-NOs-47359 (7-6-W8) of 3 September 1936 to Director, Naval Research Laboratory. This letter circumscribed certain tests and eliminated other tests in connection with the TBL-2 equipment (preliminary model). The instructions contained in this letter were followed in the conduct of the tests herein reported. Naturally, these restrictions tend to make the data collected less complete than may be desirable and prevents the formulation of recommendations and conclusions with respect to certain aspects of the equipment. Notably, the suitability of WL-803 vacuum tubes and the possibilities of suppressor grid modulation remains undecided.

185. A summary of the defects noted and such items as do not comply with the requirements of the governing specifications, are listed below. The numerals enclosed in parentheses refer to the paragraph of this report under which these items are discussed in detail.

(a) (31) Certain resistors fail to comply with specification requirements.

(b) (34-1-a) Inductors "F", "G", and "K" makes poor contact and are fitted with inadequate stops.

(c) (34-1-b) "Adjust-Tune-Operate" switch makes poor contact in "Tune" position.

(d) (34-1-c) Heater relay contacts failed to operate properly.

(e) (38) Steel is employed in several items where its use is not dictated by electro-magnetic requirements.

(f) (41)(3) No oil nameplate provided on relay K4.

(g) (43) Failure of door interlock due to grounding; no interlock provided on filter unit.

(h) (45) Filament transformer showed signs of leakage of compound.

(i) (48) 38160 vacuum tubes fail in 2nd IPA stage.

(j) (56) Ungrounded shaft on Control "D".

(k) (57) Plain glass instead of "Anti-Glare" glass used in panel opening over h.f. antenna ammeter and in vision opening of keying relay.

(l) (59) More flexibility should be provided in wires connecting to control panel on left hand transmitter frame.

(m) (69) Indicator lights not securely fastened to panel.

(n) (72) Plate potentials can be applied in the absence of bias potential.

(o) (84) Overlap requirements are not complied with in the TBL equipment.

(p) (85) Certain tuning controls require modification to eliminate sharp corners and to provide greater ease of adjustment.

(q) (111) Spurious oscillations were encountered on intermediate frequency operation.

(r) (112) MCW operation was unsuitable until voltages had been readjusted.

(s) (114) Back lash prevails in the I.F. MO control to a degree slightly in excess of that permitted by specifications.

(t) (125) Frequency variation due to inclination test at 500 kilocycles greater than that permitted by specifications.

(u) (128) The kilocycles per division of I.F. master oscillator dial does not comply with specification requirements.

(v) (132) Operation of temperature control circuit is unsatisfactory.

(w) (133) Over-temperature device failed to operate properly in master oscillator compartment.

(x) (136) Back-lash in H.F. MO control slightly in excess of specification requirements at 4500 kilocycles.

(y) (140) Frequency variation due to change of MO tubes at 4500 kilocycles exceeds specification limits.

(z) (152) Original connections of remote keying circuit did not comply with specifications.

(aa) (173) Excess ripple voltage in output of 1,000 volt generator.

(bb) (174) No interlock on filter compartment.

(cc) (175) Filter unit is provided with non-removable door.

(dd) (178 d) Panel thermometer does not indicate correct temperature.

CONCLUSIONS

186. The general appearance and construction of the Model TBL-2 equipment is excellent. A rugged framework, adequately supported and strengthened, provides the basis of a design in which component parts of good design and workmanship and excellent quality have been assembled in a manner to provide as great a degree of accessibility as the limiting conditions permit. The internal wiring is of good quality, arranged in an orderly manner, bonded at frequent intervals and protected against chafing where necessary. The use of colored nameplates to indicate the dual or individual nature of the various controls affords a ready means of identification to assist operating personnel in making rapid shifts from one frequency band to another. All controls are rugged, suitably located and identified and the symmetry of arrangement is as complete as the restricted conditions permit.

187. The power output requirements of the specifications, at high frequencies and at intermediate frequencies, have been complied with in all instances. In numerous instances, particularly while employing

high frequency operation, the actual power output obtainable exceeds the specification value of 200 watts by 100%. Flexible output circuits have been provided to cope with the wide variation of antenna constants met with in Naval Service and the necessary adjustments can be accomplished with ease and rapidity.

188. While, in general, the equipment operates in a safe and satisfactory manner, two deficiencies were encountered which are considered of major importance. The 38160 tube employed in the 2nd intermediate amplifier stage is subjected to overloads of such magnitude as to cause the failure of this tube in approximately 25 hours of key locked operation. This overload condition must be remedied to insure safe operation under service conditions.

189. The second major deficiency involves the operation of the temperature control circuits. An exceedingly flexible arrangement has been provided to cope with wide ranges in ambient temperature and large variations in supply line voltage. The elements incorporated in the system to insure operation over wide limits of temperature are entirely automatic, while protection against line voltage variations requires a manual adjustment. In order to insure adequate reliability, steps must be taken to prevent excessive arcing of relay contacts, to protect the control thermostat from undue stresses and to provide a more suitable arrangement of temperature indication.

190. A number of changes, modifications, and corrections of a minor nature are indicated in order to provide greater safety factors, effect greater ease in handling by operating personnel, and in a small degree, to increase frequency stability to comply with specification requirements.

191. The equipment possesses, in general, a remarkable degree of frequency stability when subjected to the various conditions required by the governing specifications. Satisfactory operation is obtained over wide limits of temperature and humidity and when the equipment is subjected to shock and vibration. With the correction of existing deficiencies the Model TBL-2 equipment should be capable of reliable and satisfactory operation under service conditions.

Table 1

Model TBL-2 Transmitter (Preliminary Model)

VOLTAGE AND POWER RATINGS OF FIXED RESISTORS
Test as per Par.2-2 of Spec. RE 13A 465C (RE 13A 372G)

Resistor No.	Ohms	Type	Rated Watts	Rated Volts	Measured Watts	Measured Volts	Key
1	15000	A	1				
2	8000	B		250	6	220	Closed
3	6000	B		250	2.6	125	Closed
4	155	Ohmspun					
5	5000	C		450	8.4	205	Closed
6	50000	C		450	8	630*	Closed
7	5000	C		450	42.4	460**	Closed
8	300		3				
9	20000	B		250	(Cond discharge only)		
10	30000	B		250	0.6	4	Closed
11	5000	B		250	0.5	49	Closed
13	5000	B		250	1.1	75	Closed
14	5000	B		250	8	200	Closed
15	20000	B		250	0.6	115	Closed
16	3	B	60		38	11	Closed
17	30000	B		250	0.05	40	Closed
19	5000	B		250	10.6	230	Closed
20	2500	B		250	10.8	165	Closed
21	2500	B		250	8.4	145	Closed
23	2500	C		450	71	420	Closed
24	5000	D		600	119	770*	Closed
25	5000	D		600	104	720*	Closed
26	5000	D		600	47	485	Open
27	5000	D		600	46.5	482	Open
28	500	C	100		9.8	70	Closed
29	500	C	100		11.2	75	Closed
30	500	C	100		5	50	Closed
31	5000	C		450	44.5	470**	Open
32	5000	C		450	58.5	540*	Closed
33	25		5		2		Closed
34	25		5		2		Closed
35	1300	B		250	4.7	78	Closed
36	10		3		(Spark suppressor)		
37	2500	C		450	68	412	Closed
38	750	B	60		7.8	77	Closed
39	1100	B		250	8.7	98	Closed
40	265	Ohmspun					
42	30000	B		250	0.5	41	Closed
43	50000	B		250	18.5	960*	Open
44	50000	B		250	18.5	960*	Open
100	500	C	100		9.8	70	Closed
101	25	D	200		27	26	
102	25	D	200		27	26	

Table 1 (continued)

Note: * denotes that specification requirements have been exceeded.

** denotes that specification requirements have been exceeded by negligible amount (less than 10%).

Measurements were made with the key open and key closed; the higher of the two readings only is listed.

Table 2

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
ANTENNA SHORT CIRCUITED AND OPEN CIRCUITED

Test as per Par.2-16 of Specs.RE 13A 465C

Freq. Kcs.	Antenna	Plate Volts	Plate Curr.	Antenna Curr.	Output Watts
175	Normal	1900	340	7.6	120
175	Shorted	1920	80	-	-
175	Open	1920	85	-	-
300	Normal	1900	340	8.6	152
300	Shorted	1860	420*	-	-
300	Open	1860	415*	-	-
600	Normal	1920	348	9.3	179
600	Shorted	1900	440*	-	-
600	Open	1900	440*	-	-

Note: *Overload relay, K-10, opened in 3 seconds, preventing damage to P.A. tubes. At this adjustment of overload relay normal maximum plate current of 350 MA can be drawn without tripping overload.

Antenna Constants: Resistance - 2.06 ohms
Capacity - 503 uuf

Table 3

Model TBL-2 Transmitter (Preliminary Model)

High Frequency Operation

ANTENNA SHORT CIRCUITED AND OPEN CIRCUITED
Test as per Par. 2-16 of Spec.RE 13A 465C

Freq. kcs.	Antenna	Plate Volts	Plate Curr.	Antenna Curr.	Output Watts
2000	Normal	2000	300	3.9	410
2000	Shorted	1980	350	6.0	-
2000	Open	2010	80	-	-
8000	Normal	2000	270	3.4	390
8000	Shorted	2010	230	3.4	-
8000	Open	1990	340	-	-
18100	Normal	2000	290	1.4	220
18100	Shorted	2000	300	1.0	-
18100	Open	2000	290	-	-

Antenna: 500 watt, 110 volt lamp.

Table 4

Model TBL-2 Transmitter (Preliminary Model)

LIST OF CONTROLS

Control Designation	Purpose
A	Transfer Switch, 2 position, interlocked. Transfer from IF to HF operation.
B	HF MO Range Switch, 7 taps, interlocked.
C	HF MO Tuning, 5000 divisions.
D	HF Doubler Circuit Tuning, 100 divisions.
E	HF 1st Amp Tuning, 100 divisions.
F	HF 2nd Amp Tuning, 2200 divisions.
G	HF PA Tuning, 2200 divisions.
H	HF Range Switch, 2 positions, interlocked.
J	HF Antenna Coupling, 2200 divisions.
K	HF Antenna Inductance, 2200 divisions.
L	HF Antenna Capacitor, 100 divisions.
M	HF Antenna Feed, Current-Voltage.
N	IF MO Range Switch, 7 taps, interlocked.
O	IF MO Tuning, 2500 divisions.
P	IF Range Switch, 5 taps, interlocked.
Q	IF Intermediate Amplifier Tuning, 100 divisions.
R	IF PA Tuning, 100 divisions.
S	IF Antenna Coupling, 100 divisions.
T	IF Antenna Tuning, 100 divisions.
U	IF Antenna Series Capacitor, "In" - "Out" interlocked.
V	IF Antenna Inductance Tap Switch, 15 Taps, interlocked.
W	Antenna Transfer Switch, HF-IF-Receive, interlocked.
	Tune-Operate Switch, Step 1, Step 2, Operate, interlocked.
	Emergency Switch - On, Off.
	Start-Stop Switch - for starting equipment.
	Line Voltage Switch 0 for normal or high line voltage.
	Local-Remote Control Switch.
	CW - MCW Switch.
	Overload reset button.
	Local Test Key

Table 5

Model TBL-2 Transmitter (Preliminary Model)

DIMENSIONS AND WEIGHTS

Test as per Pars.2-32, 2-33, and 3-1 of Specs.RE 13A 465C

	Specification Requirements	Actual Dimensions of Frame	Overall Dimensions
Transmitter			
Height	72"	71-7/8"	71-7/8"
Width	32	31-1/4	32
Depth	24	20-3/4	23-3/4
Weight: 803 lbs.			
Right Hand Section	To pass through		
Height	hatch 25" x 20"	71-7/8	71-7/8
Width	and door 20" x 38"	18-1/4	19-5/8
Depth	with corners on 10" radius	20-3/4	23-3/4
Left Hand Section			
Height		71-7/8	71-7/8
Width		13-1/2	13-7/8
Depth		20-3/4	23-3/4
Filter Box			
Height		18-1/8	18-3/8
Width		13-3/4	16-1/4
Depth		8-1/2	8-15/16
Weight: 51 lbs.			
Starter Box			
Height		26	28-5/8
Width		14-1/2	15-5/8
Depth		14-3/4	15-1/2
Weight: 90 lbs.			
Motor Generator			
Height	15	13-7/8	14-5/8
Width	18	16-1/4	17-1/4
Length	61	59-13/16	60-3/4
Weight: 697 lbs.			

Total Weight: 1641 pounds
Permitted by specifications: 1700 pounds

Table 6

Model TBL-2 Transmitter (Preliminary Model)

AMPLITUDE MODULATION OF CW CARRIER

Test as per Par. 3-10-2 of Spec.RE 13A 465C

Operation at 4500 kilocycles, Full Power Output

Rectified Carrier: 100 volts d.c.
A.C.Component : 0.45 volts
Percent modulation: 0.45%
Permitted by Specifications: 2.0%

Operation at 500 kilocycles, Full Power Output

Rectified Carrier: 100 volts d.c.
A.C.Component: 0.4 volts
Percent modulation: 0.4%
Permitted by Specifications: 2.0%

Table 7

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF LIMITING FREQUENCIES AND OVERLAP
Test as per Par.3-14 of Specifications RE 13A 465 C.

Control	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF
N	1	1	2	2	3	3	4	4	5	5	6	6	7	7
O	000	2500	000	2500	000	2500	000	2500	000	2500	000	2500	000	2500
P	1	2	2	3	3	4	3	4	4	4	5	5	5	5
Q	11	60	50	60	54	52	85	70	60	93	58	79	75	95
R	22	58	48	78	72	21	82	50	52	78	52	69	68	85
S	71	71	70	70	70	45	30	45	30	32	31	31	31	31
T	43	45	80	65	56	45	34	64	55	85	78	63	59	75
U	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	In	In	In
V	8	13	12	14	14	15	15	15	15	15	15	15	15	15
W	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF	IF
LD-2 Coil	2	4	4	5	5	6	5	6	6	7	7	7	7	8
LD-2 Cond.°	1337	940	535	1139	881	761	2122	1990	1302	1205	773	2194	1867	1239
Freq.Kcs.	158.11	242.1	229.25	303.66	292.19	372.0	346.95	439.99	402.24	511.63	481.98	576.14	555.57	638.06
Kc Overlap	41.89	-	12.85	-	11.47	-	25.05	-	37.75	-	29.65	-	20.57	38.06
Mean Freq.	179.05	-	235.67	-	297.92	-	359.47	-	421.11	-	496.80	-	565.85	619.03
% Overlap	23.3	-	5.4	-	3.84	-	6.93	-	8.75	-	5.96	-	3.71	6.13

Specifications requirements on overlap: 5%

Table 8

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation

DETERMINATION OF OVERLAP ON I.P.A. AND P.A. CIRCUITS, CONTROL "P"

Test as per Par. 3-14 of Specifications RE 13A 465C

Control P	Control N	Control O	Control Q	Control R	Control S	Control T	Control U	Control V	Limiting Circuit	Freq. kcs.	Kc Overlap	Mean Freq.	% Overlap
1	1	0	9	13	65	44	Out	8	O	158.1	16.9	166.5	10.1
1	1	1688	75	100	65	43	Out	12	R	213.8	19.9	208.8	9.7
2	1	1511	0	14	65	46	Out	11	Q	193.9			
2	2	1456	75	100	65	65	Out	13	R	264.1	20.8	253.7	7.9
3	2	938	0	20	65	45	Out	13	Q	243.3			
3	3	2081	100	94	65	34	Out	15	Q	360.5	25.8	347.6	7.4
4	3	1563	37	0	65	29	Out	15	R	334.7			
4	6	1423	100	87	30	88	Out	15	Q	523.0	115.4	465.3	24.8
5	5	459	33	0	30	57	Out	15	R	407.6			
5	7	2466	100	90	30	76	In	15	Q	638.1	38.1	619.0	6.2

Note: Full power output obtained on all frequencies.
Antenna Capacity: 1000 uuf.
Antenna Resistance: 6 ohms

Specification Requirements: Overlap 5%

Table 9
Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF OVERLAP AND RANGE OF ANTENNA CIRCUITS
Test as per Par.3-14 of Spec.RE 13A 465C

Control V	Control N	Control O	Control P	Control Q	Control R	Control S	Control T	Control U	Antenna Cap.	Antenna Res.	Frequency kcs.
1	1	1240	1	56	67	80	0	Out	328	6	190.6
1	1	1412	1	64	76	60	100	"	"	"	199.1
2	1	1390	1	63	76	60	0	"	"	"	198.0
2	1	1579	2	31	36	100	100	"	"	"	207.9
3	1	1494	2	24	30	100	0	"	"	"	203.5
3	1	1706	2	39	45	180	100	"	"	"	214.4
4	1	1513	2	33	38	100	0	"	"	"	212.8
4	1	1851	2	45	54	100	100	"	"	"	221.9
5	1	1726	2	39	46	100	0	"	"	"	215.8
5	1	1993	2	50	59	100	100	"	"	"	228.9
6	1	1897	2	48	58	100	0	"	"	"	224.1
6	1	2232	2	58	76	100	100	"	"	"	239.2
7	1	2004	2	54	64	80	0	"	"	"	234.1
7	2	1175	3	17	28	80	100	"	"	"	251.4
8	2	1014	2	62	78	50	0	"	"	"	245.4
8	1	507	1	28	31	80	100	Out	940	6	165.2
9	1	327	1	21	27	80	0	"	"	"	161.9
9	1	933	1	43	50	60	100	"	"	"	177.1
10	1	760	1	37	43	60	0	"	"	"	171.5
10	1	1225	1	56	65	50	100	"	"	"	189.8
11	1	1100	1	50	60	50	0	"	"	"	184.0
11	1	1565	1	70	89	40	100	"	"	"	208.7
12	1	1425	1	64	79	40	0	"	"	"	200.3
12	1	2055	2	52	63	40	100	"	"	"	232.1
13	1	1865	2	46	55	40	0	"	"	"	222.9
13	2	1595	3	39	46	30	100	"	"	"	270.8
14	2	1230	2	67	84	29	0	"	"	"	253.9
14	3	1570	3	76	81	22	100	"	"	"	334.6
15	3	1090	3	64	68	22	0	"	"	"	312.0
15	6	1595	5	70	61	22	100	"	"	"	532.2
15	5	875	4	65	54	22	0	In	"	"	419.2
15	7	2500	5	95	90	20	76	"	"	"	638.1

Table 10

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETERMINATION OF LIMITING FREQUENCY AND OVERLAP
Test as per paragraph 3-14 of Specifications RE 13A 465C

Control	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF	HF
B	1	1	2	2	3	3	4	4	5	5	6	6	7	7
C	0	5000	0	5000	0	5000	0	5000	0	5000	0	5000	0	5000
D	18	34	28	44	37	54	49	64	62	75	69	81	80	89
E	8	41	31	57	46	68	83	80	77	89	84	94	93	18
F	037	413	278	629	485	800	713	971	944	1150	1045	1245	1226	990
G	108	485	390	678	539	820	798	997	959	1168	1113	1264	1228	1071
H	1	1	1	1	1	1	1	1	1	1	1	1	1	2
J	1900	1900	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970
K	376	745	542	866	630	633	770	770	765	1072	1279	1238	1271	1449
L	10	25	33	32	37	66	73	78	76	74	75	73	75	75
M	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur	Cur
LD2 Coil	13	13	13	14	14	14	14	15	15	15	15	16	16	16
LD2 Cond °	791	1999	1543	1076	578	1766	1390	773	645	1730	1130	770	650	1763
FREQ. KC	1984.0	2363.3	2221.3	2633.7	2440.4	2905.0	2758.0	3259.1	3196.7	3733.2	3436.0	4055.2	3983.6	4652.4
KC Overlap	16.0	142.0	-	193.3	-	147.0	-	62.4	-	297.2	-	71.7	-	127.4
Mean Freq.	1992	2292.3	-	2537.0	-	2831.5	-	3227.9	-	3584.6	-	4019.3	-	4588.7
% Overlap	0.8	6.2	-	7.6	-	5.2	-	1.93	-	8.3	-	1.8	-	2.8

Note: Actual measurements made on second harmonic of Master Oscillator Circuit, i.e., output frequency of transmitter.

Specification requirements on overlap: 5%.

Table 11

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETERMINATION OF FREQUENCY OVERLAP ON H.F. RANGE SWITCH, CONTROL "H".
Test as per paragraph 3-14 of Specifications RE 13A 465C.

Control	Position 1	Position 2
A	HF	HF
B	7	7
C	3705	3491
D	86	85
E	100	0
F	1316	888
G	1438	1090
H	1	2
J	1980	1980
K	1856	1860
L	58	52
M	Cur	Cur
LD-2 Coil	16	16
LD-2 Cond. °	1279	1183
Frequency KC	4363.0	4304.9
Mean Frequency	4334 KC	
Overlap	58.1 KC	
% Overlap	1.34	

Table 12

Model TBL-2 Transmitter (Preliminary Model)

LIST OF METERS

Data as per paragraph 3-28 of Specifications RE 13A 465C.

1 - MO plate current meter, 100 MA, Type CAY-22059.
1 - HF MO screen current meter, 50 MA, Type CAY-22056.
1 - 1st Int. Amp. plate current meter, 250 MA, CAY-22065.
(This instrument also used for audio osc. plate current.)
1 - 2nd Int. Amp. plate current meter, 250 MA, Type CAY-22065.
1 - PA plate current meter, 500 MA, Type CAY-22067.
1 - PA grid current meter, 150 MA, Type CAY-22061.
1 - Line voltage meter, d.c., 500 volts, Type CAY-22198.
1 - PA cathode current meter, Tube 1, 500 MA, Type CAY-22067.
1 - PA cathode current meter, Tube 2, 500 MA, Type CAY-22067.
1 - Plate voltage meter, D.C., 2.5 KV, Type CAY-22156.
1 - Bias voltage meter, D. C., 500 volts, Type CAY-22198.
1 - Filament voltage meter, A. C., 15 volts, Type CAY-22080.
1 - HF antenna current meter, 5 amps., RF, CAY-22025.
1 - IF antenna current meter, 15 amps., RF, CAY-22035.

Table 13

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-44 of Specifications RE 13A 465C
(Output into dummy antennas simulating constants of Submarine Flat Top.)

Column No.	1	2	3	4
Control or Meter	175 Kcs.	200 Kcs.	245 Kcs.	300 Kcs.
A	IF	IF	IF	IF
N	1	1	2	3
O	885	1435	1005	770
P	1	1	2	3
Q	42	64	62	59
R	44	66	72	83
S	73	66	35	66
T	25	48	65	81
U	Out	Out	Out	Out
V	4	7	10	12
MO Ip	40	40.5	35	30
IF Amp. Ip	60	58	58	53
PA Ig	58	53	57	61
PA Ip	320	310	325	322
IF Ant Cur (Panel)	7.1	8.5	9.4	9.6
Line Volts	210	215	215	215
Tube 1 Ic	233	218	225	230
Tube 2 Ic	236	222	230	233
Plate Volts*	1920	1900	1880	1880
Bias Volts	195	191	190	190
Fil Volts	10	10	10	10
Ant Res (Ohms)	2.13	1.67	1.67	1.67
Ant Cap (uuf)	503	503	503	503
Ant Cur (Exterior)**	7.73	8.38	9.1	9.27
Watts Output	127	117	139	144
Spec Requirements	90	90	-	115
Contr's Guarantee	90	-	100	-

(The following data obtained with additional 32 volts bias in order to permit use of 2000 volts Ep and still obtain cut-off (key open).

PA Ip	340
Ant Cur (Exterior)**	9.6
Plate Volts	2000
Bias Volts (Total)	218
Watts Output	154

Notes: * Max Ep at which PA tubes would block with regular Eg.
** Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.

Table 14

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-44 of Specifications RE 13A 465C
(Output into dummy antennas simulating constants of Submarine Flat Top.)

Column No.	1	2	3	4
Control or Meter	375 Kcs.	400 Kcs.	500 Kcs.	600 Kcs.
A	IF	IF	IF	IF
N	4	4	6	7
O	1248	1720	1030	1660
P	4	4	5	5
Q	53	60	63	85
R	23	49	38	77
S	43	25	80	22
T	65	86	59	83
U	Out	Out	Out	Out
V	14	14	15	15
MO Ip	28.5	30	27	30
IF Amp Ip	60	60	65	66
PA Ig	59	59	61	57
PA Ip	310	328	336	325
IF Ant Cur (Panel)	9.8	10	10.3	10.4
Line Volts	215	215	215	212
Tube 1 Ic	221	230	231	235
Tube 2 Ic	227	230	232	235
Plate Volts*	1880	1910	1880	1920
Bias Volts	191	195	191	199
Fil Volts	10	10	10	10
Ant Res (Ohms)	2.37	2.37	2.37	2.37
Ant Cap (uuf)	600	600	600	600
Ant Cur (Exterior)**	9.25	9.55	9.1	9.2
Watts Output	203	216	188	199
Spec Requirements	-	160	175	190
Contr's Guarantee	150	-	175	190

(The following data obtained with additional 32 volts bias in order to permit use of 2000 volts Ep and still obtain cut-off (key open).

Ant Cur (Exterior)**	9.85	9.9	9.55	9.5
PA Ip	330	328	340	324
Plate Volts	2000	2000	2000	2000
Bias Volts (Total)	222	223	218	226
Watts Output	231	233	216	214

Notes: * Max Ep at which PA tubes would block with regular Eg.
** Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.

Table 15

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-44 of Specifications RE 13A 465C
(Output into dummy antennas simulating constants of Submarine Loop.)

Column No.	1	2	3	4	5
Control or Meter	175 Kcs.	245 Kcs.	375 Kcs.	500 Kcs.	600 Kcs.
A	IF	IF	IF	IF	IF
N	1	2	4	6	7
O	885	1005	1248	1030	1660
P	1	2	4	5	5
Q	41	64	53	63	85
R	50	56	32	64	70
S	77	84	38	50	56
T	45	35	47	52	82
U	Out	Out	Out	Out	Out***
V	2	10	14	15	15
MO Ip	39	35	29	27	29
IF Amp Ip	60	62	61	65	63
PA Ig	57	52	61	60	56
PA Ip	332	320	330	325	315
IF Ant Cur (Panel)	7.4	8.4	9.5	9.5	7.4
Line Volts	215	215	215	215	215
Tube 1 Ic	230	219	231	230	220
Tube 2 Ic	238	228	240	238	228
Plate Voltage*	1900	1890	1920	1900	1900
Bias Volts	195	190	191	195	192
Fil Volts	10	10	10	10	10
Ant Res (Ohms)	2.52	2.52	2.76	3.12	4.91
Ant Cap (uuf)	446	446	503	503	600
Ant Cur (Exterior)**	7.1	7.93	8.8	8.21	7.45
Watts Output	127	158	213	210	273
Spec Requirements	90	-	-	175	190
Contr's Guarantee	100	120	160	190	200

Notes: * Max Ep at which PA tubes would block with regular Eg.
** Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.
*** Adjusted with control U set on "In" position but obtained less output.

Table 16

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-44 of Specifications RE 13A 465C
(Output into dummy antennas simulating constants of Small Surface Craft Flat Tops.)

Column No.	1	2	3	4	5
Control or Meter	175 Kcs.	245 Kcs.	375 Kcs.	500 Kcs.	600 Kcs.
A	IF	IF	IF	IF	IF
N	1	2	4	6	7
O	885	1005	1248	1030	1660
P	1	2	4	5	5
Q	41	62	53	63	85
R	53	72	33	52	78
S	80	65	50	40	25
T	32	28	39	76	70
U	Out	Out	Out	Out	In
V	9	13	15	15	15
MO Ip	38	34	29	27	29
IF Amp Ip	59	55	61	63	63
PA Ig	56	58	62	61	55
PA Ip	325	320	333	328	315
IF Ant Cur (Panel)	5.5	5.8	8.0	8.8	8.6
Line Volts	215	217	215	215	212
Tube 1 Ic	225	221	235	231	220
Tube 2 Ic	234	227	242	238	227
Plate Volts*	1900	1890	1930	1900	1900
Bias Volts	192	190	193	195	195
Fil Volts	10	10	10	10	10
Ant Res (Ohms)	12.04	11.13	6.14	4.52	3.81
Ant Cap (uuf)	823	823	823	823	1000
Ant Cur (Exterior)**	5.5	5.7	7.5	8.2	8.13
Watts Output	362	362	343	303	253
Spec Requirements	200	200	200	200	200
Contr's Guarantee	200	200	200	200	200

Notes: * Max Ep at which PA tubes would block with regular Eg.
** Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.

Table 17

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-44 of Specifications RE 13A 465C.
(Output into dummy antennas simulating constants of Large Surface Craft.)

Column No.	1	2	3	4	5
Control or Meter	175 Kcs.	245 Kcs.	375 Kcs.	500 Kcs.	600 Kcs.
A	IF	IF	IF	IF	IF
N	1	2	4	6	7
O	885	1005	1248	1030	1660
P	1	2	4	5	5
Q	41	62	53	63	85
R	52	75	31	46	69
S	70	50	50	58	42
T	40	62	50	52	80
U	Out	Out	Out	In	In
V	6	11	15	15	15
MO Ip	39	35	28	27	29
IF Amp Ip	59	56	60	62	62
PA Ig	56	57	60	59	54
PA Ip	331	330	335	335	315
IF Ant Cur (Panel)	6.8	7.1	8.9	9.6	10.9
Line Volts	212	212	212	212	215
Tube 1 Ic	225	225	230	230	220
Tube 2 Ic	232	232	236	235	223
Plate Volts*	1900	1890	1910	1890	1880
Bias Volts	195	191	190	190	190
Fil Volts	10	10	10	10	10
Ant Res (Ohms)	6.06	6.06	4.34	2.61	1.5
Ant Cap (uuf)	600	600	1000	1175	1440
Ant Cur (Exterior)**	6.65	7.01	8.5	9.05	10.35
Watts Output	268	298	314	214	161#
Specification Requirements	200	200	200	175	175
Contr's Guarantee	200	200	200	200	175

Notes: * Max Ep at which PA tubes would block with regular Eg.
** Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.
# When an additional external bias of 32 volts was added to the regular Eg 182 watts output was obtained with 2000 Ep and 338 PA Ip.

Table 18

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
25% VARIATION IN CONSTANTS OF ANTENNAS
Test as per paragraph 3-44 of Specifications RE 13A 465C

Frequency KC	Antenna Res.	Antenna Cap.	P.A. Ip	P.A. Ep	Antenna Current	Output Watts
600	1.06	1750	330	1920	11.2	132
245	1.218	398	320	1900	8.7	93
175	14.7	398	295	1890	4.45	292

Table 19

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
MCW OPERATION
Test as per paragraph 3-45 of Specifications RE 13A 465C

Control or Meter	175 Kcs.		245 Kcs.		375 Kcs.		500 Kcs.		600 Kcs.	
A	IF		IF		IF		IF		IF	
N	1		2		4		6		7	
O	885		1005		1248		1030		1660	
P	1		2		4		4		5	
Q	42		62		52		89		86	
R	50		84		29		71		77	
S	64		30		36		35		22	
T	67		67		66		60		84	
U	Out		Out		Out		Out		Out	
V	3		10		14		15		15	
W	IF		IF		IF		IF		IF	
	CW	MCW	CW	MCW	CW	MCW	CW	MCW	CW	MCW
MO Ip	40	40	35	35	29	29	27	27	29	29
IPA Ip	67	68	69	69	72	72	79	80	75	77
PA Ig	47	62	62	65	64	66	62	66	59	61
PA Ip	295	155	310	305	315	225	310	230	305	230
Ant Cur (Panel)	7.7	4.7	9.4	6.8	9.9	7.9	10	8.2	10.1	8.3
Line Volts	215	215	215	215	215	215	215	215	215	215
Tube 1 Ic	210	150	218	172	223	181	220	181	210	180
Tube 2 Ic	211	150	221	176	224	184	221	185	215	180
Plate Volts	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Bias Volts	190	190	190	190	190	190	187	188	187	187
Fil Volts	10	10	10	10	10	10	10	10	10	10
Ant Cur (Exterior)	7.5	4.6	9.1	6.5	9.22	7.3	8.8	7.1	8.9	7.2
Ant Res (Ohms)	2.11	2.11	1.7	1.7	2.36	2.36	2.36	2.36	2.36	2.36
Ant Cap (uuf)	503	503	503	503	600	600	600	600	600	600

Table 19 (Continued)

Control or Meter	175 Kcs.		245 Kcs.		375 Kcs.		500 Kcs.		600 Kcs.	
	CW	MCW	CW	MCW	CW	MCW	CW	MCW	CW	MCW
% MODULATION*		100		84		78		79		70
Audio Osc Ip		62		62		66		67		65
Watts Output	119	45	141	72	200	126	183	119	187	122
Spec Requirements	90		-		-		175		190	
Contr's Guarantee	90		100		150		175		190	

Note: *Modulation almost entirely downward; percentages listed are for negative peak values.

Specifications require modulation of not less than 70% and power output on MCW of at least 50%.

Table 20

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
ACCURACY OF RESET TO PREVIOUSLY CALIBRATED FREQUENCIES
Test as per paragraph 3-46-1 of Specifications RE 13A 465C

Trial No.	Frequency KC	Time Seconds	Deviation in Frequency Cycles	Per Cent
Original	200.235			
1	200.245	35	10	0.005
2	200.183	33	52	0.025
3	200.228	31	7	0.0035
4	200.226	27	9	0.0045
5	200.225	29	10	0.005
			Average:	0.0088

Note: Power output 155 watts into dummy antenna of 2.63 ohms and 503 uuf.

Original	500.340			
1	500.335	34	5	0.001
2	500.345	29	5	0.001
3	500.303	31	32	0.0064
4	500.298	29	37	0.0074
5	500.350	29	10	0.002
			Average:	0.0036

Note: Power output 173 watts.

Permitted by specifications: 0.015% average.
0.025% for any one trial.

Table 21

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
TEST FOR LOST MOTION, BACK LASH AND TORQUE LASH
Test as per paragraph 3-46-2 of Specifications RE 13A 465C.

Trial No.	Frequency when approached from Counter Clockwise Direction	Clockwise Direction	Backlash Cycles	Backlash Per Cent
1	200.310	200.258	52	0.026
2	.325	.253	72	0.036
3	.318	.258	60	0.030
4	.308	.248	60	0.030
5	.310	.245	65	0.032
		Average:		0.0308
1	500.353	500.323	30	0.006
2	.350	.308	42	0.0084
3	.352	.308	45	0.009
5	.353	.303	50	0.01
		Average:		0.0084

Permitted by specifications:
Average - 0.03%
Maximum - 0.06%

Table 22

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
OPERATION OF ADJUST-TUNE-OPERATE CONTROL
Test as per paragraph 3-46-3 of Specifications RE 13A 465C

Frequency, Kilocycles				
Step 1 Adjust	Step 2 Tune	Step 3 Operate	Maximum Frequency Change Cycles	Per Cent
200.280	200.275	200.263	17	0.0085
300.310	300.308	300.300	10	0.0033
400.425	400.425	400.420	5	0.0012
500.318	500.300	500.268	50	0.01

Permitted by specifications: 0.05%.

Table 23

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
DETUNING OF CIRCUITS
Test as per paragraph 3-46-4 of Specifications RE 13A 465C

Circuit Detuned	Frequency KC	Change in Freq. Cycles	Percent	Frequency KC	Change in Freq. Cycles	Percent
Normal	200.310			500.303		
Q cc	.335	25	0.013	.335	32	0.0064
Q c	.335	25	0.013	.338	35	0.007
R cc	.335	25	0.013	.338	35	0.007
R c	.325	15	0.0075	.349	46	0.0092
S cc	.315	5	0.0025	.308	5	0.001
S c	.318	8	0.004	.325	22	0.0044
T cc	.328	18	0.009	.306	3	0.0006
T c	.318	8	0.004	.335	32	0.0064

Note: Q cc denotes detuned in counter clockwise direction.
Q c denotes detuned in clockwise direction.

Permitted by specifications: 0.025%.

Table 24

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
OPERATION OF POWER OUTPUT CONTROL
Test as per paragraph 3-46-5 of Specifications RE 13A 465C.

Frequency KC	Frequency Change Cycles	Frequency Change Per Cent	Plate E	Power Output	Per Cent Power	Per Cent Voltage
200.310			2000	155	100	100
.318	8	0.004	1800	117	75.7	90
.324	14	0.007	1590	79	51	79.5
.336	26	0.013	1250	36	23	62.5
500.300			2000	170	100	100
.308	8	0.0016	1750	124	73	87.5
.313	13	0.0026	1530	82	48	76.5
.321	21	0.0042	1200	36.8	21.6	60

Permitted by specifications: 0.02%.

Table 25

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
CHANGE OF TUBES
Test as per paragraph 3-46-6 of Specifications RE 13A 465C.

Manufacturer and Serial No.	Frequency KC	Deviation from Average Freq.
	(Master Oscillator Circuit)	
WL 43986	200.288	14
WL 43810	.278	4
RCA 11899	.243	31
RCA 11902	.254	20
RCA 11900	.243	31
RCA 11904	.237	37
WL 42805	.300	26
WL 42797	.303	29
WL 42795	.298	24
WL 42819	.291	17
Mean	200.374	23 cycles; 0.012%
WL 43986	500.340	47
WL 43810	.335	42
RCA 11899	.208	85
RCA 11902	.209	84
RCA 11900	.273	20
RCA 11904	.195	2
WL 42805	.331	38
WL 42797	.350	57
WL 42795	.358	65
WL 42819	.335	42
Mean	500.293	52 cycles; 0.01%

Permitted by specifications: 0.02%

(Subsequent Circuits)

Changing tubes in the Intermediate Amplifier and the Power Amplifier Circuits caused no measurable frequency change.

Permitted by specifications: 0.005%.

Table 26

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
VARIATION OF SUPPLY LINE VOLTAGE
Test as per paragraph 3-46-7 of Specifications RE 13A 465C.

Line Voltage	Plate Voltage	Filament Voltage	Power Output	Frequency KC	Frequency Change Cycles	Per Cent
	(Minus to plus 10% variation in one minute)					
207	1990	10	134	200.283		
230	2000	10	134	200.281		
253	2000	10.1	135	200.281	2	0.001
207	1980	9.9	168	500.340		
230	1980	10	169	500.340		
253	1980	10.1	170	500.340	0	0
	(Minus to plus 10% variation in five minutes)					
207	1980	9.9	127.5	200.280		
230	1980	9.9	124	200.278		
253	1980	10	123	200.278	2	0.001
207	1970	9.9	167	500.339		
230	1980	10	168	500.338		
253	1980	10	168	500.338	1	0.0002
	(Extra test, wherein line voltage was varied from minus 23% to plus 15% of normal*.)					
177	1990	9.95	159	500.338		
230	1990	10	164	500.340		
265	1995	10	164	500.339	2	0.0005

Note: * The only adequate DC supply available was limited to 265 volts maximum.

Permitted by specifications: 0.02%.

Table 27

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
VARIATION IN AMBIENT TEMPERATURE
Test as per paragraph 3-46(8) of Specifications RE 13A 465C

Time	Ambient Temperature	Relative Humidity	Frequency KC	Line Volts
9:50	52	8	500.684	210
10:00	50.5	8	.680	210
10	51	8	.679	210
20	50	9	.667	210
30	49.5	9	.695	210
40	50	9	.688	210
50	50	9	.675	210
11:00	39.5	13	.692	210
10	39.5	12	.690	210
20	39.5	12	.695	210
30	40	13	.698	210
40	39.5	12	.693	210
50	39.5	11	.695	210
12:00	32	15	.690	210
10	29.5	15	.685	210
20	29	14	.685	210
30	29	14	.683	210
40	29.5	10	.683	210
50	29.5	10	.683	210
1:00	19.5	19	.685	210
10	19	14	.686	210
20	18.5	16	.685	215
30	19	14	.686	215
40	19	14	.687	215
50	19	14	.688	215
2:00	11	19	.687	215
10	10	16	.687	215
20	10	16	.683	215
30	10	16	.687	215
40	10	16	.686	215
50	9.5	18	.695	215
3:00	-1	-	.690	215
10	0.5	-	.660	215
20	0	-	.658	215
30	-0.5	-	.662	215
40	0	-	.660	215
50	-0.5	-	.666	215
4:00	0	-	.665	215

Table 27 (continued)

Summary

Temperature Deg.C.	Cycles change per 10 Deg. C.	Percent change per 1 Deg. C.
50 to 40	20	0.0004
40 to 30	12	0.00024
30 to 20	5	0.0001
20 to 10	7	0.00014
10 to 0	29	0.0006

Permitted by Specifications: 0.007%

Table 28

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
VARIATIONS IN HUMIDITY

Test as per paragraph 3-46 (9) of Specifications RE 13A 465C

Time	Amb. Temp.	Relative Humidity	Frequency KC	Antenna Curr.	Thermometers Exter.	Panel
9:45	39.5	27	500.595	8.05	60.2	58.6
10:00	40.5	28	.595	8.00	60.2	58.6
15	39.5	29	.595	8.00	60.2	58.6
30	41.0	93	.580	7.90	60.7	59.1
45	40.5	97	.575	7.90	60.7	59.4
11:00	41.5	97	.573	7.82	60.8	59.5
15	40.0	97	.575	7.82	60.8	59.4
30	40.0	87	.575	7.82	60.6	59.2
45	40.5	42	.582	7.90	60.3	58.9
12:00	39.0	30	.587	7.82	60.0	58.5
15	40.0	29	.587	7.82	60.0	58.4
30	40.0	29	.587	7.90	60.0	58.4
45	39.5	29	.587	7.85	60.0	58.5
1:00	39.5	29	.587	7.85	60.2	58.5

Maximum change in frequency: 22 cycles
0.0044%

Permitted by Specifications: 0.05%

Maximum decrease in power: 11 watts
5.6%

Permitted by Specifications: 5%

Note: Antenna Resistance 3 Ohms, 503 uuf.

Table 29

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
LOCKED KEY OPERATION FOR TWO HOURS

Test as per paragraph 3-46-10 of Specifications RE 13A 465C

Time	Amb. Temp.	Frequency KC	Antenna Cur.	Plate Volts	Plate Current	Line Volts
1:05	30.0	200.310	7.4	2000	257	215
1:10	30.3	.298	7.4	"	256	215
1:15	30.3	.295	7.4	"	257	215
1:20	30.5	.295	7.4	"	257	215
1:25	30.5	.293	7.4	"	265	215
1:30	30.5	.291	7.4	"	265	215
1:35	30.5	.291	7.2	"	263	215
1:40	30.6	.293	7.1	"	263	215
1:45	30.6	.293	7.0	"	263	215
1:50	30.5	.293	7.0	"	263	215
1:55	30.6	.293	7.0	"	265	215
2:00	30.6	.293	6.9	"	263	215
2:05	30.6	.295	6.8	"	261	215
2:10	30.6	.295	6.8	"	259	215
2:15	30.6	.294	6.7	"	255	215
2:20	30.6	.295	6.6	"	253	215
2:25	30.6	.295	6.5	"	250	213
2:30	30.6	.296	6.4	"	247	213
2:35	30.6	.296	6.2	"	235	213
2:40	30.5	.296	6.2	"	240	213
2:45	30.5	.297	6.2	"	240	213
2:50	30.5	.297	6.4	"	245	213
2:55	30.5	.297	6.4	"	245	213
3:00	30.5	.297	6.4	"	245	213
3:05	30.5	.297	6.4	"	245	213

Change in frequency 1st five minutes: 12 cycles; 0.006%
" " " remainder of test: 7 cycles; 0.0035%

Post trial inspection showed no signs of overheated parts.

Antenna resistance: 2.71 ohms
Retuning at the end of the test period gave an antenna current of 7.0 amperes.

Specifications permit:
1st 5 minutes: 0.02%
Remainder : 0.05%

Table 30

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
LOCKED KEY OPERATION FOR TWO HOURS

Test as per paragraph 3-46-10 of Specifications RE 13A 465C

Time	Ambient Temp.	Frequency KC	Antenna Current	Plate Current	Line Volts
11:35	31.2	500.353	8.8	250	205
40	31.4	.335	9.0	250	205
45	31.4	.322	8.9	243	205
50	31.5	.315	8.8	240	205
55	31.5	.313	8.9	240	205
12:00	31.2	.313	8.8	238	205
05	31.3	.310	8.7	235	205
10	31.4	.312	8.6	230	205
15	31.5	.313	8.7	232	205
20	31.6	.315	8.7	235	205
25	31.7	.316	8.6	228	205
30	31.7	.317	8.7	228	203
35	31.7	.315	8.6	230	203
40	31.8	.317	8.5	227	203
45	32.0	.317	8.5	226	203
50	32.0	.318	8.3	220	202
55	32.2	.318	8.2	220	202
1:00	32.4	.320	7.9	210	203
05	32.5	.318	8.0	212	205
10	32.5	.317	8.0	215	205
15	32.5	.318	7.9	212	203
20	32.7	.318	7.8	210	203
25	32.7	.318	7.8	210	203
30	32.8	.318	7.6	203	203
35	33.1	.316	7.6	205	215

Change in frequency 1st five minutes: 18 cycles; 0.0036%
" " " remainder of test: 25 cycles; 0.005%

Post trial inspection revealed no signs of overheating.
Plate Voltage constant at 2000 volts.
Antenna Resistance: 2.71 ohms.
Retuning transmitter at end of test increased antenna current to 8.0 amperes.

Specifications permit:
1st 5 minutes: 0.02%
Remainder : 0.05%

Table 31

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
CHANGE FROM KEY LOCKED TO INTERMITTENTLY KEYED CONDITION

Test as per paragraph 3-46-11 of Specifications RE 13A 465C

Test Condition	Frequency at end of 10 min. key locked period (KC)	Frequency at end of 10 sec. dash 20 min. later (KC)	Change in Freq. Cycles	Percent
MO Filament Lighted	200.306	200.312	6	0.003
MO Filament not Lighted	200.288	200.288	0	0*
MO Filament Lighted	500.310	500.331	21	0.0042
MO Filament not Lighted	500.316	500.343	27	0.0054

Note: * denotes that this test was checked by second trial; frequency change noted was 1 cycle.

Permitted by Specifications:
Filament lighted: 0.02%
Filament not lighted: 0.05%

Table 32

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
CHANGE FROM CONTINUOUSLY KEYED TO INTERMITTENTLY KEYED CONDITION

Test as per paragraph 3-46-12 of Specifications RE 13A 465C

Frequency at end of 30 minutes of continuous keying	Frequency at end of 10 sec. dash after 20 min. pause	Change in Frequency Cycles	Percent
200.288	200.286	2	0.001
500.329	500.338	9	0.0018

Permitted by specifications: 0.02%

Table 33

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
INCLINATION DUE TO ROLL AND PITCH OF SHIP

Test as per paragraph 3-46 (13) of Specifications RE 13A 465C

Time	Minimum Frequency	Maximum Frequency	
1:35	500.485	500.485	Equipment Stationary
1:35			(Start test)
1:40	.447	.513	
1:45	.442	.513	
1:50	.443	.513	
1:55	.442	.510	
2:00	.441	.510	
2:05	.441	.510	

Note: Entire equipment, Transmitter, Motor Generator, Filter and Starter mounted on test stand.

Maximum variation during test: 72 cycles
0.014%
Maximum variation from frequency when transmitter was in vertical position: 44 cycles
0.0088%
Permitted by specifications: 0.005%

Table 34

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
VIBRATION
Test as per paragraph 3-46 (14) of Specifications RE 13A 465C

Time	Frequency KC	Antenna Curr.	P.A. Ip	P.A. Ep	Line Volts
11:42	500.450	6.4	288	1970	210
11:47	.455				
11:52	.464	6.4	285	1980	210
11:57	.461				
12:02	.464	6.4	285	1980	210
12:07	.464				
12:12	.460	6.4	285	1980	210

Maximum variation during test: 15 cycles
0.003%
Permitted by Specifications: 0.005%

Note: Entire equipment, Transmitter, Motor Generator, Filter and Starter mounted on vibration stand.

Table 35

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
SHOCK TEST

Test as per paragraph 3-46.-15 of Specifications RE 13A 465C

Frequency before Shock	Frequency After Shock	Frequency Difference Cycles	Percent
200.550	200.551	1	0.0005
.550	.550	0	0
.550	.550	0	0
.550	.547	3	0.0015
500.527	500.532	5	0.001
.532	.530	2	0.0004
.533	.531	2	0.0004
.531	.534	3	0.0006

Permitted by specifications: 0.005%

Table 36

Model TBL-2 Transmitter (Preliminary Model)
Intermediate Frequency Operation
VARIATION OF RESONANT FREQUENCY OF MASTER OSCILLATOR PER DIVISION OF DIAL MARKING.

Test as per paragraph 3-47 of Specifications RE 13A 465C

Control "O"	Control "N"	Frequency KC	Divisions Change	KC per Division	Percent Per Division
874	1	175			
1421	1	200	547	0.046	0.023
1910	1	225	489	0.051	0.023
1132	2	250			
1685	2	275	553	0.045	0.016
2229	2	300	547	0.046	0.015
683	3	300			
1380	3	325	697	0.036	0.011
1869	3	350	489	0.051	0.015
376	4	350			
1233	4	375	857	0.029	0.008
1689	4	400	456	0.055	0.014
2127	4	425	438	0.057	0.013
1002	5	425			
1428	5	450	426	0.059	0.013
1783	5	475	355	0.070	0.015
2134	5	500	351	0.071	0.014
991	6	500			
1475	6	525	484	0.052	0.010
1883	6	550	408	0.061	0.011
2455	6	575	572	0.044	0.008
1131	7	575			
1619	7	600	488	0.051	0.008
2072	7	625	453	0.055	0.009

Specification Requirements: Not more than 0.03% or less than 0.015% per division of marking.

Table 37

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETERMINATION OF POWER OUTPUT
(Output into 500 watt, 110 volt lamp)
Test as per paragraph 3-50 of Specifications RE 13A 465C

Column No.	1	2	3	4
Control or Meter	2000 kcs	3000 kcs	4000 kcs	8000 kcs
A	HF	HF	HF	HF
B	1	4	7	7
C	750	3288	1180	1180
D	19	56	80.5	80
E	9	71.5	93	86
F	053	853	1232	1496.5
G	204	979	1341	1625
H	1	1	1	2
J	2033	1210	1200	2137
K	201	654	1252	8195
L	30	73	75	88
M	Curr	Curr	Curr	Volt
HF MO Isg	12	11	11.3	11
MO Ip	47	57	72	68.5
1st IA Ip	41	30	27	72
2nd IA Ip	50	37	40	50
PA Ig	68	38	26	46
PA Ip	290	251	208	290
HF Ant Cur	4	3.75	3.4	3.55
Line Volts	210	212	210	208
Tube 1 Ic	225	180	145	203
Tube 2 Ic	220	175	140	195
Plate Volts	1970	2000	2000	2000
Bias Volts	195	190	185	185
Fil Volts	10	10	10	10
Photronic Cell	56*	153#	89#	60*
Watts Output	432	396	300	445
Spec.Requirements	200	200	200	200
Contr's Guarantee	200	200	200	200

Note: * denotes Cal.Curve 4; # denotes Cal.Curve 3.

Table 38

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETERMINATION OF POWER OUTPUT
(Output into 500 watt, 110 volt lamp)
Test as per paragraph 3-50 of Specifications RE 13A 465C

Column No.	1	2	3
Control or Meter	12000 kcs	16000 kcs	18100 kcs
A	HF	HF	HF
B	4	7	7
C	3288	1180	4324
D	56	80	88
E	59	86	93
F	1734	1863	1911
G	1859	1993	2057
H	2	2	2
J	800	509	468
K	2093	1994	2050
L	6	96	97
M	Volt	Volt	Volt
HF MO Isg	10.5	11	10.2
MO Ip	59	68	63
1st IA Ip	80	73	70
2nd IA Ip	90	111	122**
PA Ig	39	40	38
PA Ip	298	310	320
HF Ant Cur	2.6	1.92	1.45
Line Volts	207	210	210
Tube 1 Ic	205	210	210
Tube 2 Ic	190	198	199
Plate Volts	2000	2000	2000
Bias Volts	180	185	180
Fil Volts	10	10	10
Photronic Cell	95#	145*	124*
Watts Output	307	288	268
Spec.Requirements	200	200	200
Contr's Guarantee	200	200	200

Notes: # denotes Photo Cell Calibration Curve No. 3
* " " " " " " 2
** " 2nd Int. Amp.plate was operating at a dull red color, key down, at 18,100 kcs.

Table 39

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-50 of Specifications RE 13A 465C

Column No.	1	2	3
Control or Meter	2000 kcs	2000 kcs	2000 kcs
A	HF	HF	HF
B	1	1	1
C	750	750	750
D	19	19	19
E	9	9	9
F	055	055	055
G	125	117	115
H	1	1	1
J	2000	1580	1615
K	042	003	030
L	15	0	6
M	Curr	Curr	Curr
HF MO Isg	12	12	12.3
MO Ip	46	47	47
1st IA Ip	41	40	40
2nd IA Ip	58	52	55
PA Ig	74	68	72
PA Ip	290	305	247
HF Ant Cur (Panel)	4.35	(shorted)	4.5
Line Volts	210	210	215
Tube 1 Ic	230	235	212
Tube 2 Ic	225	230	207
Plate Volts	2000	1980	2000
Bias Volts	190	199	193
Fil Volts	10	10	10
Ant Res (ohms)	20.5	10.5	15.6
Ant Cap (uuf)	1000	1000	1000
Ant Cur (Exterior)*	4.5	6.3	4.7
Watts Output	416	417	346
Spec.Requirements	200	200	200
Contr's Guarantee	200	200	200

Note: *Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.

Table 40

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETERMINATION OF POWER OUTPUT
Test as per paragraph 3-50 of Specifications RE 13A 465C

Column No.	1	2	3
Control or Meter	4000 kcs	3000 kcs	3000 kcs
A	HF	HF	HF
B	7	4	4
C	1180	3288	3288
D	80.5	57	57
E	93	71.5	72
F	1226	853	841
G	1442	972	1044
H	1	1	1
J	2155	1525	1753
K	222	626	697
L	32	82	67
M	Volt	Curr	Curr
HF MO Isg	11.2	10.7	10.5
MO Ip	71	61	56
1st IA Ip	32	32	33
2nd IA Ip	88	38	41
PA Ig	32	38	40
PA Ip	233	260	265
HF Ant Cur (Panel)	2.7	3.15	3.93
Line Volts	210	212	210
Tube 1 Ic	169	185	185
Tube 2 Ic	160	177	177
Plate Volts	2000	2000	2000
Bias Volts	185	190	187
Fil Volts	10	10	10
Ant Res ohms	30.65	30.65	20.5
Ant Cap uuf	1000	1000	1000
Ant Cur (Exterior)*	3.3	3.55	4.3
Watts Output	334	384	381
Spec.Requirements	200	200	200
Contr's Guarantee	200	200	200

Note: * Ammeter of precision type connected into circuit between base of dummy antenna resistor and ground.

Table 41

Model TBL-2 Transmitter (Preliminary Model)

Reference: Spec. 13A 465C, par.3-51 and par.1(9) of BuEng letter C-NOs-47359(3-26-W8) of 10 April 1936.

Test to determine effect of I.F. operation upon temperature of MO Compartment and upon frequency stability at H.F. operation.

Test Condition	Time	Frequency kcs	Temperature Panel Thermometer	Temperature Test Thermometer
Key locked	10:30	2000.290	58.7	60.0
" "	35	.272	58.7	60.0
" "	40	.263	58.75	60.0
" "	45	.259	58.8	60.0
	(Operation transferred to IF at 500 kcs)			
Keyed at	10:45	500	58.8	60.0
30 wpm	55	500	58.85	60.0
"	11:05	500	58.8	60.0
"	15	500	58.75	60.0
"	25	500	58.73	60.0
"	45	500	58.7	60.0
	(Operation transferred to HF at 2000 kcs)			
Key locked	45	2000.260	58.7	60.0
" "	50	.240	58.75	60.0
" "	55	.234	58.8	60.0
" "	12:00	.229	58.85	60.0

Frequency change between 10:45 and 12:00 - 30 cycles, 0.0015%

Note: HF controls were locked and not readjusted during the test.

Table 42

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
VARIATION OF RESONANT FREQUENCY OF MASTER OSCILLATOR PER DIVISION OF DIAL MARKING
Test as per paragraph 3-53 of Specifications RE 13A 465C

Control "B"	Control "A"	Frequency kcs	Divisions Change	Kc per Division	Percent per Div.
888.5	1	2000			
1826	1	2050	937.5	0.05	0.0025
2357	1	2100	531	0.09	0.0043
2776	1	2150	419	0.12	0.0056
3151	1	2200	375	0.13	0.0059
3536	1	2250	385	0.13	0.0057
3948	1	2300	412	0.12	0.0054
4530	1	2350	582	0.09	0.0038
1419	2	2250			
2193	2	2300	774	0.06	0.0026
2660	2	2350	467	0.11	0.0047
3032.5	2	2400	372.5	0.13	0.0054
3381	2	2450	348.5	0.14	0.0057
3708	2	2500	327	0.15	0.0060
4058	2	2550	350	0.14	0.0055
4492	2	2600	444	0.11	0.0042
663	3	2450			
1715	3	2500	1052	0.05	0.0020
2228	3	2550	513	0.10	0.0039
2612	3	2600	384	0.13	0.0050
2939	3	2650	327	0.15	0.0056
3244.5	3	2700	305.5	0.16	0.0059
3549	3	2750	304.5	0.16	0.0058
3863	3	2800	314	0.16	0.0057
4232	3	2850	369	0.14	0.0049
4885	3	2900	653	0.08	0.0028
1666	4	2800			
2286	4	2850	620	0.08	0.0028
2686	4	2900	400	0.13	0.0045
3004	4	2950	318	0.16	0.0054
3284	4	3000	280	0.18	0.0060
3544	4	3050	260	0.19	0.0062
3809	4	3100	255	0.20	0.0065
4097	4	3150	288	0.17	0.0054
4418	4	3200	321	0.16	0.0050
4905	4	3250	487	0.10	0.0031

Table 42
(continued)

Control "B"	Control "A"	Frequency kc	Divisions Change	Kc per Division	Percent per Div.
643	5	3200			
2048	5	3250	1405	0.04	0.0012
2589.5	5	3300	541.5	0.09	0.0027
2952.5	5	3350	363	0.14	0.0043
3238	5	3400	285.5	0.18	0.0053
3484	5	3450	246	0.20	0.0058
3713	5	3500	229	0.22	0.0062
3936	5	3550	223	0.22	0.0062
4163	5	3600	227	0.22	0.0061
4416	5	3650	253	0.20	0.0055
4715.5	5	3700	299.5	0.17	0.0046
800	6	3450			
1777	6	3500	977	0.05	0.0014
2256	6	3550	479	0.10	0.0028
2590.5	6	3600	334.5	0.15	0.0042
2863	6	3650	272.5	0.18	0.0049
3103.5	6	3700	240.5	0.21	0.0057
3323	6	3750	219.5	0.23	0.0062
3534.5	6	3800	211.5	0.24	0.0063
3758.5	6	3850	224	0.22	0.0057
3979	6	3900	220.5	0.23	0.0059
4219.5	6	3950	240.5	0.21	0.0053
4579	6	4000	359.5	0.14	0.0035
4925	6	4050	346	0.14	0.0035
921	7	4000			
1998	7	4050	1077	0.05	0.0012
2467.5	7	4100	469.5	0.11	0.0027
2796	7	4150	328.5	0.15	0.0036
3053	7	4200	257	0.19	0.0045
3274	7	4250	221	0.23	0.0054
3471	7	4300	197	0.25	0.0058
3656	7	4350	185	0.27	0.0062
3836	7	4400	180	0.28	0.0063
4018	7	4450	182	0.28	0.0063
4217.5	7	4500	199.5	0.25	0.0056
4412.5	7	4550	195	0.26	0.0057
4649.5	7	4600	237	0.21	0.0045

Note: Frequency measurements made on second harmonic of master oscillator circuit.

Table 43

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
ACCURACY OF RESET TO PREVIOUSLY CALIBRATED FREQUENCIES
Test as per paragraph 3-54-1 of Specifications RE 13A 465C

Trial No.	Frequency kcs	Time Seconds	Deviation in Frequency Cycles	Percent
Original	2000.300	-	-	-
1	2000.285	58	15	0.00075
2	2000.295	60	5	0.00025
3	2000.300	40	0	0
4	2000.290	45	10	0.0005
5	2000.295	39	5	0.00025
			Average:	0.00035

(Note: Output power 415 watts. A 10 cycle variation is encountered at 2000 kcs due to heat cycle, all readings taken at top of heat cycle.)

Original	4500.395	-	-	-
1	4500.255	39	140	0.0031
2	4500.200	34	195	0.0043
3	4500.218	35	177	0.0040
4	4500.240	35	155	0.0034
5	4500.295	38	100	0.0022
			Average:	0.0034

(Note: Output power 420 watts. A 20 cycle variation is encountered at 4500 kcs due to heat cycle, all readings taken at top of heat cycles.)

Permitted by specifications: 0.005% average
0.01% maximum for any one trial

Table 44

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
TEST FOR LOST MOTION, BACK LASH AND TORQUE LASH

Test as per paragraph 3-54-2 of Specifications RE 13A 465C.

Trial No.	Frequency when approached from Counter clockwise Direction (kc)	Clockwise Direction (kc)	Backlash Cycles	Backlash Percent
1	2000.323	2000.310	13	0.00065
2	.325	.320	5	0.00025
3	.325	.315	10	0.0005
4	.323	.317	6	0.0003
5	.328	.317	11	0.00055
		Average:		0.00045
1	4500.425	4500.190	235	0.0052
2	.417	.148	269	0.006
3	.413	.163	250	0.0055
4	.420	.170	250	0.0055
5	.433	.185	248	0.0055
		Average:		0.0055

Permitted by specifications: Average 0.005%
Maximum for any one trial: 0.008%

Table 45

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
OPERATION OF ADJUST-TUNE-OPERATE CONTROL
Test as per paragraph 3-54-3 of Specifications RE 13A 465C

Frequency kcs	Step 1 Adjust	Step 2 Tune	Step 3 Operate	Max. Frequency Change Cycles	Max. Frequency Change Percent
2000	2000.327	2000.322	2000.320	7	0.00035
2500	2500.335	2500.340	2500.343	8	0.00032
3000	3000.320	3000.315	3000.310	10	0.00033
3500	3500.330	3500.325	3500.335	10	0.00029
4000	4000.368	4000.378	4000.363	15	0.00038
4500	4500.225	4500.230	4500.263	38	0.00085

Permitted by specifications: 0.001%

Table 46

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
DETUNING OF CIRCUITS
Test as per paragraph 3-54-4 of Specifications RE 13A 465C

Circuit Detuned	Frequency kc	Change in Freq. Cycles	Change in Freq. Percent	Frequency kcs	Change in Freq. Cycles	Change in Freq. Percent
Normal	2000.320			4500.248		
D cc	.330	10	0.0005	.320	72	0.0016
D c	.328	8	0.0004	.315	67	0.0015
E cc	.313	7	0.00035	.270	22	0.0005
E c	.335	15	0.00075	.325	77	0.0017
F cc	.310	10	0.0005	.235	13	0.0003
F c	.330	10	0.0005	.243	5	0.0001
G cc	.315	5	0.00025	.243	5	0.0001
G c	.315	5	0.00025	.243	5	0.0001
K cc	.320	0	0	.243	5	0.0001
K c	.320	0	0	.243	5	0.0001
L cc	.320	0	0	.245	3	0.0001
L c	.320	0	0	.243	5	0.0001
J cc	.320	0	0	.243	5	0.0001
J c	.320	0	0	.243	5	0.0001

Note: D cc denotes detuned in counter clockwise direction
D c denotes detuned in clockwise direction

Permitted by specifications: 0.003%

Table 47

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
OPERATION OF POWER OUTPUT CONTROL
Test as per paragraph 3-54-5 of Specifications RE 13A 465C

Frequency kcs	Frequency Change Cycles	Frequency Change Percent	Plate E	Power Output	Percent Power	Percent Voltage
2000.330			2000	415	100	100
.325	5	0.00025	1750	300	72	87.5
.320	10	0.0005	1640	205	49	82
.320	10	0.0005	1540	92	22	77
4500.270			2000	425	100	100
.280	10	0.0002	1800	330	77	90
.283	13	0.0003	1620	215	51	81
.285	15	0.0003	1430	95	22	71.5

Frequency change permitted by specifications: 0.001%

Table 50
Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
CHANGES IN AMBIENT TEMPERATURE
Test as per paragraph 3-54(8) of Specs. RE 13A 465C

Time	Amb. Temp.	Relative Humidity	Frequency kcs.	External Thermometer	Panel Thermometer
9:10	50	28	4500.483	60.9	59.6
20	50	19	.505	60.7	59.5
30	50	24	.510	60.8	59.5
40	49.5	26	.505	60.8	59.5
50	49.5	26	.500	60.9	59.5
10:00	50	26	.500	61.0	59.7
10	50	26	.495	61.0	59.8
20	42	27	.515	60.6	59.7
30	40.5	22	.548	60.3	59.5
40	40	21	.590	60.4	59.3
50	40	23	.605	60.5	59.3
11:00	40	27	.600	60.5	59.3
10	40.5	26	.600	60.6	59.4
20	40.5	26	.600	60.6	59.4
30	32	24	.620	60.0	59.3
40	31	18	.660	59.7	59.1
50	29.5	25	.681	59.5	58.9
12:00	29	32	.685	59.5	58.9
10	29	35	.680	59.5	58.9
20	30.5	31	.680	59.5	58.9
30	30.5	29	.680	59.5	58.9
40	27	32	.685	59.5	58.8
50	24.5	31	.710	59.2	58.8
1:00	20.5	24	.735	58.9	58.5
10	19	21	.755	58.6	58.4
20	19	24	.772	58.6	58.2
30	19	31	.785	58.4	Off scale
40	20	33	.790	58.5	
50	20	38	.790	58.4	
2:00	18	30	.790	58.4	
10	15.5	30	.800	58.0	
20	11	35	.795	57.1	
30	10	43	.831	56.7	
40	10	49	.873	56.4	
50	11.5	49	.915	56.4	
3:00	4.5	-	.900	55.5	
10	1.5	-	.855	55.6	
20	0.5	-	.872	55.4	
30	1	-	.880	55.5	
40	0.5	-	.880	55.4	

Table 50 (continued)

Summary

Temperature °C	Cycles Change per 10° C.	Percent Change per 1° C.
50 to 40	105	0.00025
40 to 30	80	0.00018
30 to 20	110	0.00023
20 to 10	125	0.00028
10 to 0	35	0.00008

Permitted by specifications: 0.0005%

Table 51

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
VARIATIONS IN HUMIDITY
Test as per paragraph 3-54(9) of Specifications RE 13A 465C

Time	Amb. Temp.	Relative Humidity	Frequency kcs	Power Output	Thermometers Exter.	Panel
9:30	40.0	29	4500.551	425	60.0	59.2
45	40.0	29	.555	425	60.2	59.2
10:00	40.0	29	.558	425	60.2	59.2
15	40.5	93	.445	418	60.4	59.7
30	40.0	97	.410	418	60.5	59.9
45	40.0	97	.408	418	60.5	59.9
11:00	40.0	97	.408	415	60.5	59.8
15	40.5	97	.408	418	60.5	59.7
30	41.5	30	.495	418	60.3	59.4
45	40.5	26	.550	418	60.0	59.0
12:00	41.0	28	.555	418	60.2	59.0
15	42.5	30	.555	418	60.3	59.1
30	41.5	27	.555	418	60.3	59.2
45	41.0	27	.555	418	60.3	59.3

Maximum frequency shift: 150 cycles, 0.0033%

Permitted by Specifications: 0.005%

Maximum decrease in power output: 10 watts, 2.35%

Permitted by Specifications: 5%

Table 48

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
CHANGE OF TUBES
Test as per paragraph 3-54-6 of Specifications RE 13A 465C
(Master Oscillator Circuit)

Mfr and Ser.No.	Frequency kcs	Deviation from Average Freq.
WL 43989	2000.385	220
RCA 11899	.798	193
RCA 11902	.822	217
RCA 11900	.836	231
RCA 11904	.810	205
WL 42805	.425	180
WL 42797	.587	18
WL 42795	.450	155
WL 42819	.455	150
WL 43810	.480	125
Mean	2000.605	169 cycles, 0.0085%
WL 43989	4500.345	906
WL 43810	.940	311
RCA 11899	4502.330	1079
RCA 11902	.080	829
RCA 11900	.290	1039
RCA 11904	.200	949
WL 42805	4500.288	963
WL 42797	4501.220	31
WL 42795	4500.330	921
WL 42819	.485	766
Mean	4501.250	779 cycles, 0.017%

Note: Either the RCA or the WL group of tubes alone will comply with the specification requirements.

Specification Requirements: 0.01%

(Subsequent Circuits)

Changing tubes in the 1st IPA, 2nd IPA and Power Amplifier Stages produces negligible frequency shifts not in excess of 0.0002%.

Specification Requirements: 0.001%

Table 49

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
VARIATION OF SUPPLY LINE VOLTAGE
Test as per paragraph 3-54-7 of Specifications RE 13A 465C

Line Voltage	Plate Voltage	Filament Voltage	Power Output	Frequency kcs	Freq. Cycles	Change %
	(Minus to plus 10% variation in one minute)					
207	2000	10	425	2000.338		
230	2000	10	425	2000.343		
253	2010	10.05	425	2000.338	5	0.00025
207	1990	9.95	444	4500.305		
230	2000	10	444	4500.280		
253	2000	10	450	4500.290	25	0.00055
	(Minus to plus 10% variation in five minutes)					
207	1990	9.95	423	2000.335		
230	2000	10	423	2000.295		
253	2000	10.05	423	2000.328	40	0.002
207	1990	9.95	450	4500.310		
230	1980	9.9	450	4500.310		
253	2000	10	450	4500.310	0	0
	(Extra Test wherein line voltage was varied from minus 23% to plus 14.4%* of normal.)					
177	1960	9.85	437	4500.300		
230	1970	10	437	4500.300		
263	1980	10	447	4500.303	3	0.0001

Note: * The only adequate d.c. supply available was limited to 263 volts maximum for this test.

Permitted by specifications: 0.002%

Table 52

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
LOCKED KEY OPERATION FOR TWO HOURS
Test as per paragraph 3-54-10 of Specifications RE 13A 465C

Time	Ambient Temp.	Frequency kcs	Antenna Watts	Plate Current	Line Volts
2:30	33.6	2000.282	485	295	215
35	33.6	.276	477	293	215
40	34.0	.267	457	290	215
45	34.0	.267	457	290	215
50	34.0	.265	460	292	215
55	34.0	.261	457	292	215
3:00	34.4	.256	454	290	215
05	34.5	.252	454	290	215
10	34.6	.250	450	290	215
15	34.2	.245	447	290	212
20	34.3	.242	447	290	212
25	34.2	.242	447	290	212
30	34.2	.241	447	290	212
35	34.2	.239	447	290	212
40	34.2	.237	447	290	212
45	34.3	.236	444	290	212
50	34.5	.236	444	290	212
55	34.5	.234	444	290	212
4:00	34.8	.233	440	290	212
05	34.8	.233	440	290	212
10	34.9	.230	440	290	212
15	35.0	.228	437	289	212
20	35.0	.226	437	289	212
25	35.0	.228	437	289	212
30	35.3	.227	437	289	212

Change in frequency 1st five minutes: 6 cycles, 0.0003%
Change in frequency remainder of test: 50 cycles, 0.0025%

Plate voltage constant at 2000 volts

Post trial inspection revealed no signs of overheating

Specifications permit:
1st five minutes: 0.002%
Remainder : 0.005%

Table 53

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
LOCKED KEY OPERATION FOR TWO HOURS
Test as per Specifications RE 13A 465C, paragraph 3-54-10.

Time	Ambient Temp.	Frequency kcs	Antenna Watts	Plate Current	Line Volts
9:45	29.8	4500.630	457	295	215
50		.590	457	298	215
55	30.0	.695	455	298	213
10:00		.702	448	298	213
:05	30.0	.678	445	298	211
10		.700	442	298	210
15		.685	428	295	210
20	30.3	.655	432	295	210
25		.666	432	295	210
30	30.5	.688	428	295	210
35		.465	417	292	210
40	31.0	.640	428	295	210
45		.676	428	293	210
50	31.0	.455	425	293	210
55		.560	425	293	210
11:00	31.4	.660	425	293	215
05		.682	425	293	215
10	31.5	.690	418	292	215
15		.695	418	292	215
20	31.5	.702	418	292	215
25		.703	418	292	215
30	31.8	.702	418	292	215
35		.700	415	292	215
40		.700	415	292	215
45	32.0	.690	415	292	215

Change in frequency 1st five minutes: 40 cycles, 0.0009%.
Change in frequency remainder of test: 135 cycles, 0.003%

Plate voltage constant at 2000 volts
Post trial inspection revealed no signs of overheating

Note: Heater relay, K-1, showed a tendency to stick during the test, causing a greater frequency variation than would normally have been encountered.

Specifications permit:
1st 5 minutes: 0.002%
Remainder : 0.005%

Table 54

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
CHANGE FROM KEY LOCKED TO INTERMITTENTLY KEYED CONDITION
Test as per paragraph 3-54-11 of Specifications RE 13A 465C

Test Condition	Frequency at end of 10 min. key locked period (kc)	Frequency at end of 10 sec. dash 20 min. later (kc)	Change in Frequency Cycles	Percent
MO Filament Lighted	2000.313	2000.315	2	0.0001
MO Filament not lighted	2000.310	2000.355	45	0.0023
MO Filament lighted	4500.310	4500.315	5	0.0001
MO Filament not lighted	4500.313	4500.440	127	0.0028

Permitted by specifications:
Filament lighted: 0.0025%
Filament not lighted: 0.005%

Table 55

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
CHANGE FROM CONTINUOUSLY KEYED TO INTERMITTENTLY KEYED CONDITION
Test as per paragraph 3-54-12 of Specifications RE 13A 465C

Frequency at end of 30 minutes of continuous keying	Frequency at end of 10 sec. dash after 20 min. pause	Change in Frequency Cycles	Percent
2000.308	2000.305	3	0.00015
4500.355	4500.360	5	0.0001

Permitted by specifications: 0.001%

Table 56

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
INCLINATION DUE TO ROLL AND PITCH OF SHIP

Time	Minimum Frequency	Maximum Frequency	
2:42	4500.560	4500.560	Equipment stationary
47	.537	.562	
52	.535	.570	
57	.527	.568	
3:02	.525	.568	
07	.528	.570	
12	.525	.568	

Note: Entire equipment, transmitter, motor generator, filter and starter mounted on test stand.

Maximum variation during test: 45 cycles, 0.001%
Maximum variation from frequency when transmitter was in vertical position, at rest: 35 cycles, 0.00078%

Table 57

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
VIBRATION
Test as per paragraph 3-46(14) of Specifications RE 13A 465C

Time	Frequency kcs	Antenna Curr.	P.A. I_p	P.A. E_p	Line Volts
10:40	4500.510	3.6	330	2000	208
45	.505				
50	.482	3.6	330	1990	210
55	.497				
11:00	.504	3.55	325	1980	208
05	.502				
10	.501	3.52	322	1970	210

Maximum variation during test: 28 cycles, 0.0006%
Permitted by specifications: 0.001%

Note: Entire equipment, transmitter, motor generator, filter and starter mounted on vibration stand.

Table 58

Model TBL-2 Transmitter (Preliminary Model)
High Frequency Operation
SHOCK TEST
Test as per paragraph 3-54-15 of Specifications RE 13A 465C

Frequency before Shock	Frequency after Shock	Frequency Difference Cycles	Percent
2000.523	2000.525	2	0.0001
.525	.525	0	0
.525	.527	2	0.0001
.525	.530	5	0.00025
4500.450	4500.444	6	0.00013
.445	.445	0	0
.445	.445	0	0
.445	.440	5	0.0001

Permitted by specifications: 0.002%

Table 59

Model TBL-2 Transmitter (Preliminary Model)
POWER REQUIRED FROM SUPPLY LINES
Test as per paragraph 6-5 of Specifications RE 13A 465C

	Freq. Kcs	Type of Operation	Ant. Power	Line Watts	Spec. Req.
Starting	175	CW		6060	
For guaranteed Power Output, key locked	175	CW	100	2475	3200
	600	CW	190	2850	3200
	2000	CW	200	2210	3200
	18100	CW	200	3200	3200
For Maximum Power Output, key locked	175	CW	147	2920	
	175	MCW	89.5	2860	
	600	CW	190	2850	
	600	MCW	136	2860	
	2000	CW	460	3060	
	18100	CW	262	3450	
For standby operation, key open, motor generator running.	600	CW	-	1715	
MO heater and blower on - Motor generator shut down.				365	
MO blower only				34.2	

Table 60

MODEL TBL-2 Transmitter (Preliminary Model)
VOLTAGE REGULATION OF D.C. GENERATORS
Test as per paragraph 6-31 of Specifications RE 13A 465C

Generator	No Load Voltage	Full Load Voltage	Percent Regulation
2000 V. Plate	2190	2145	2.06
1000 V. Plate	980	965	1.5
250 V. Bias	247	246	0.4%

Permitted by specifications: 5%

Table 61

Model TBL-2 Transmitter (Preliminary Model)
MEASUREMENT OF GENERATOR RIPPLE
Test as per Specifications RE 13A 465C, paragraph 6-31

Generator	D.C. Voltage	Ripple Voltage at (cycles) 30	60	90	120	240	850	Key Position
Plate	2000	1.25	1.25		0.1			Open
Plate	2000	2.0	1.25		0.4			Closed
Aux.	1000	1.25	0.3	0.3	13.0	1.0		Open
Aux.	980	1.0	0.3	0.3	12.8	1.0		Closed
Bias	245	0.3			0.4		0.07	Open
Bias	245	0.3			0.4		0.08	Closed

SUMMARY: The total ripple voltage is obtained by taking the square root of the sum of the squares at the various frequencies measured.

Generator	D.C. Voltage	Total Ripple Percent	Total Ripple Volts	Key Position
Plate	2000	0.09%	1.8	Open
Plate	2000	0.12	2.4	Closed
Aux.	1000	1.3%	13.1	Open
Aux.	980	1.3	12.9	Closed
Bias	245	0.2%	0.5	Open
Bias	245	0.2	0.5	Closed

Permitted by specifications: 0.25%

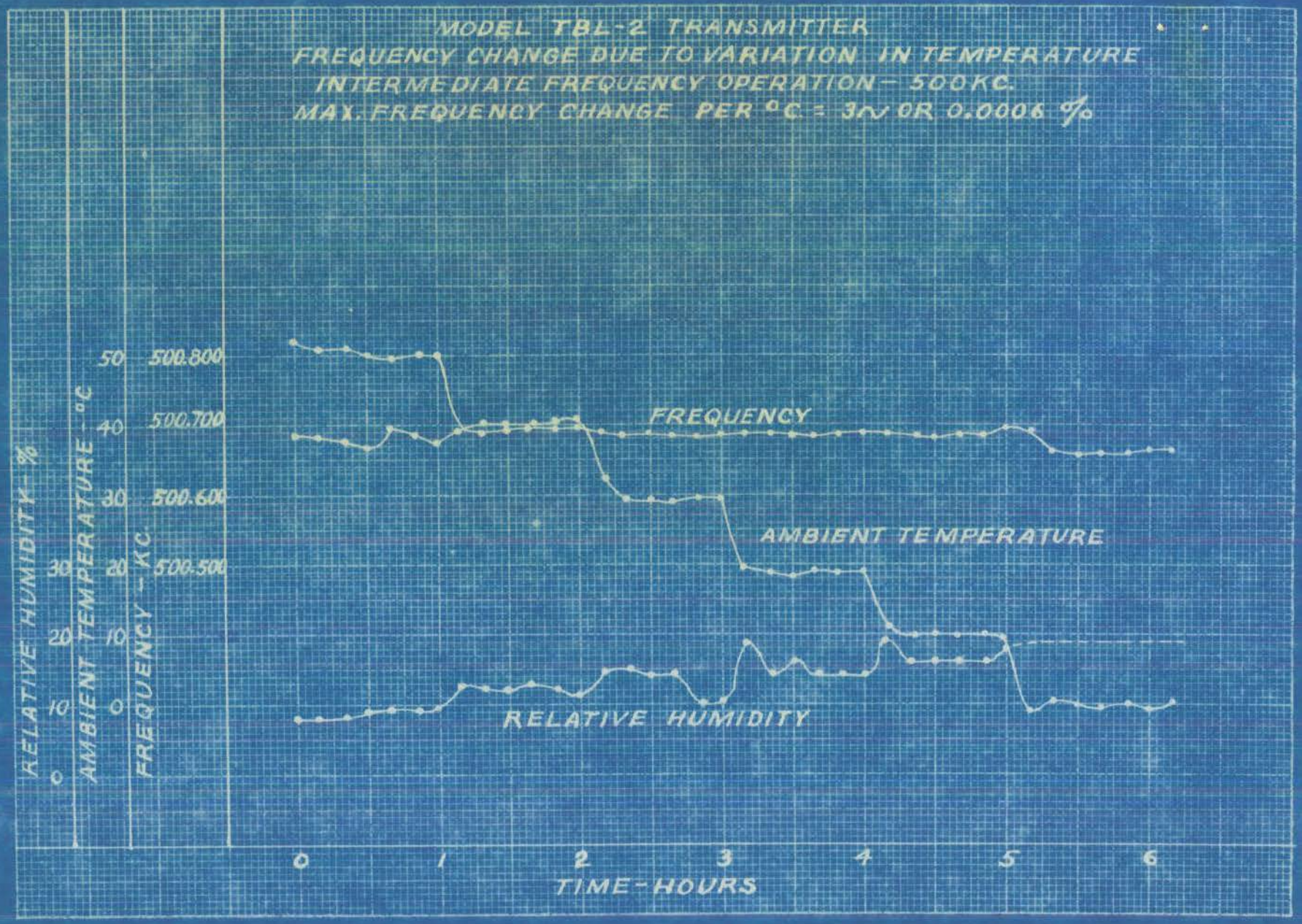

PLATE 1

MODEL TBL-2 TRANSMITTER
FREQUENCY CHANGE DUE TO VARIATION IN HUMIDITY
INTERMEDIATE FREQUENCY OPERATION - 500 KC.
MAX. FREQUENCY CHANGE DURING TEST - 22 ~ OR 0.0044%
MAX. DECREASE IN POWER OUTPUT: 5.6 %

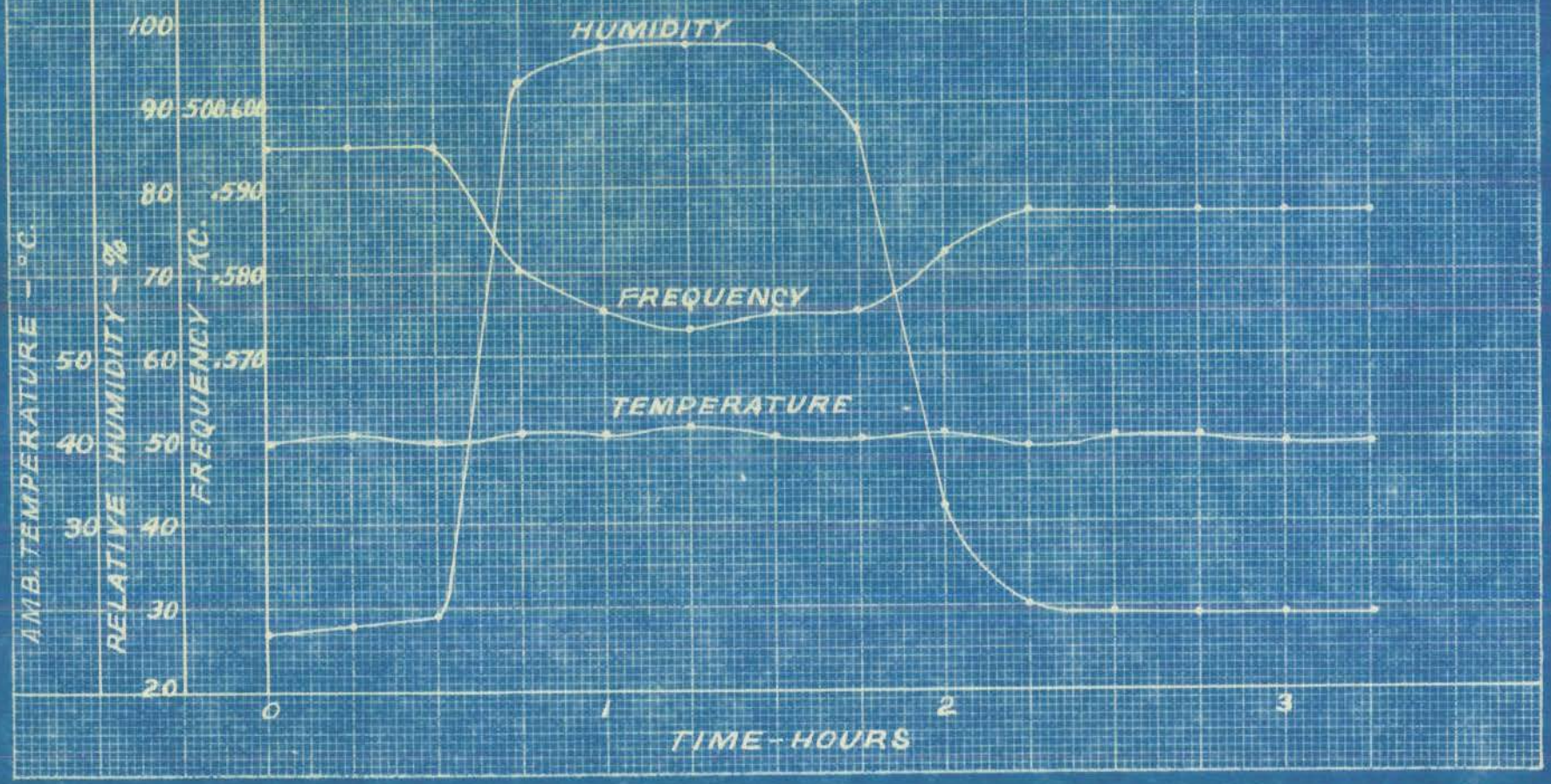

PLATE 2

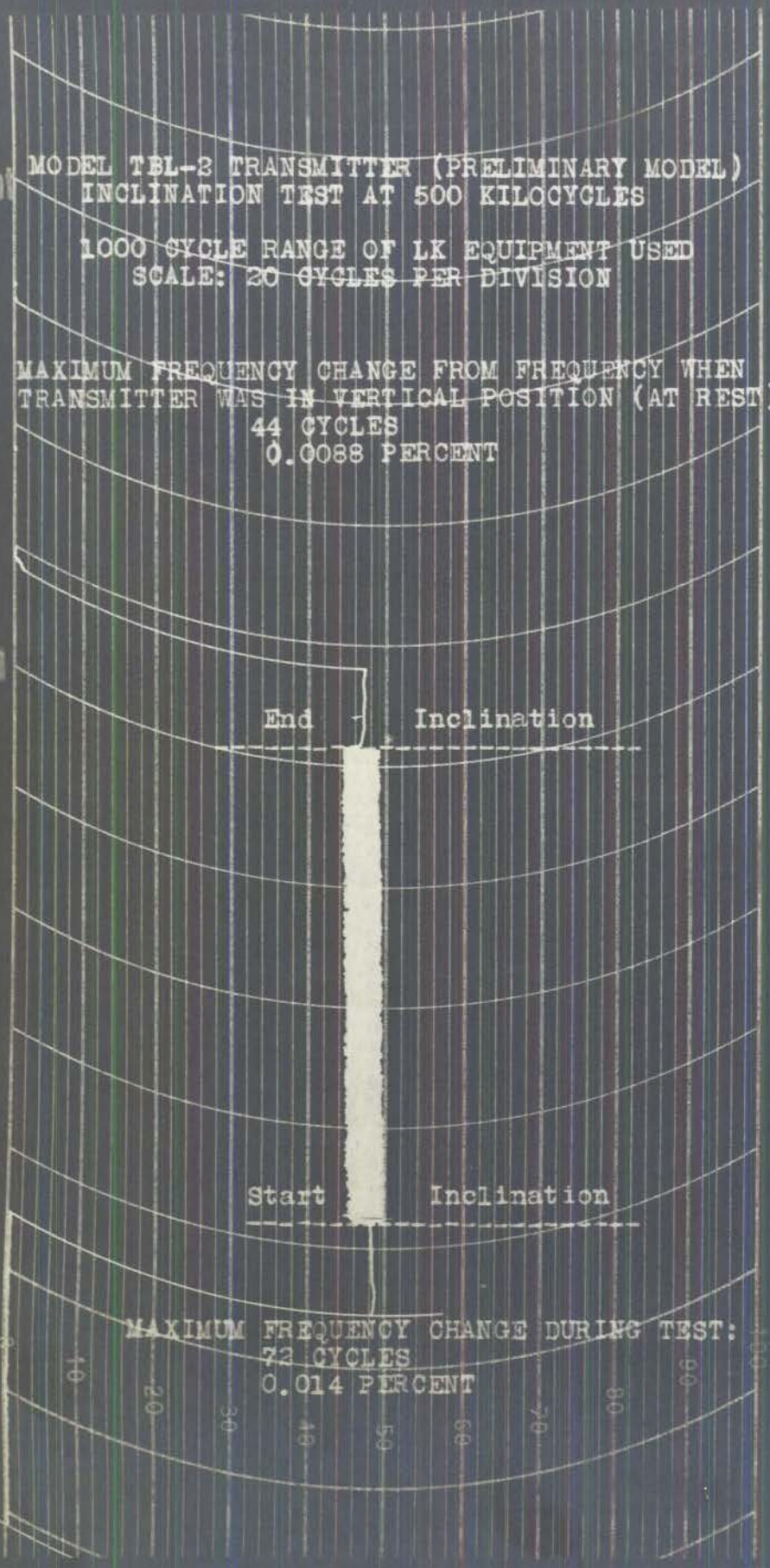

Plate 3

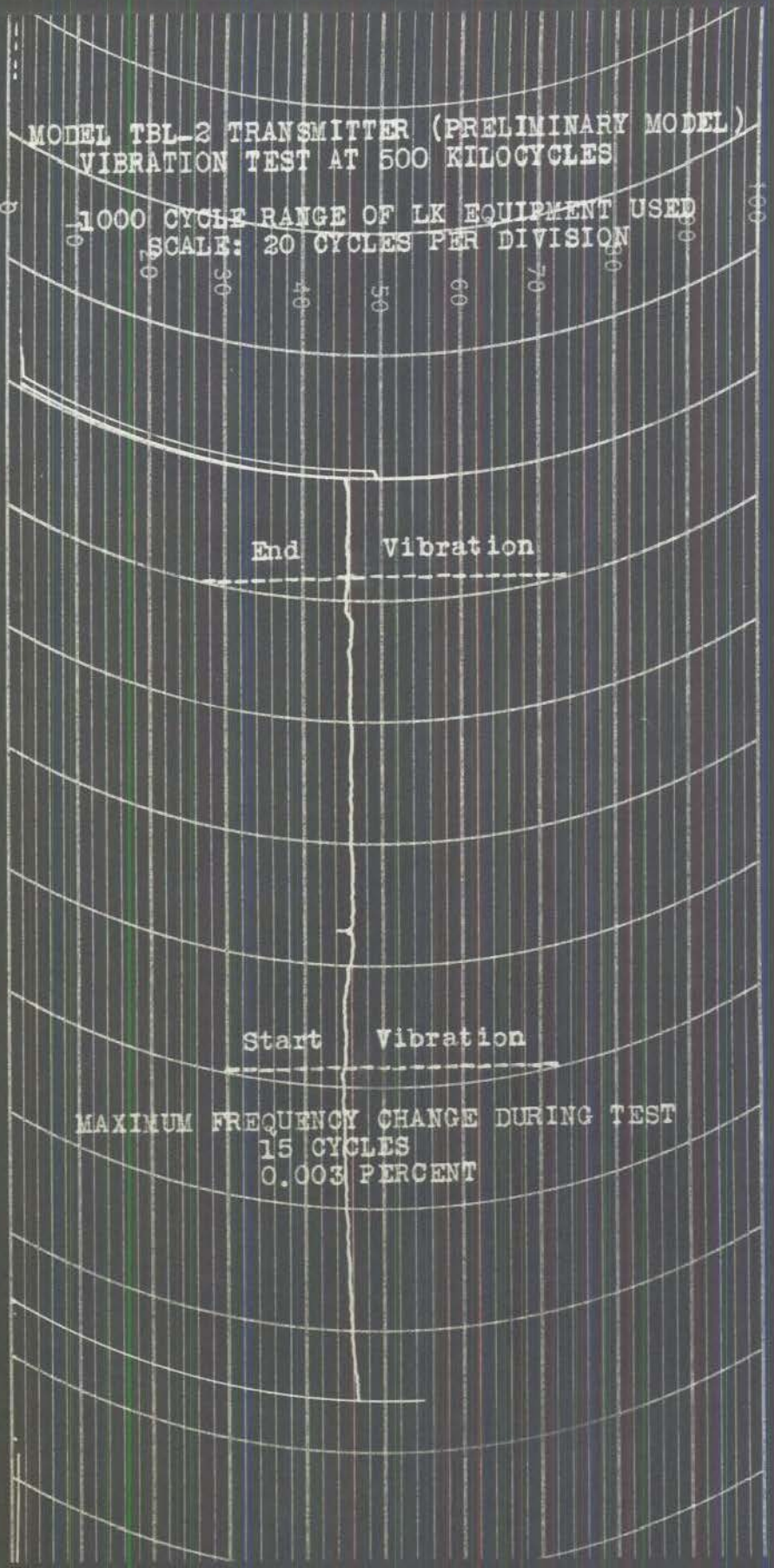

Plate 4

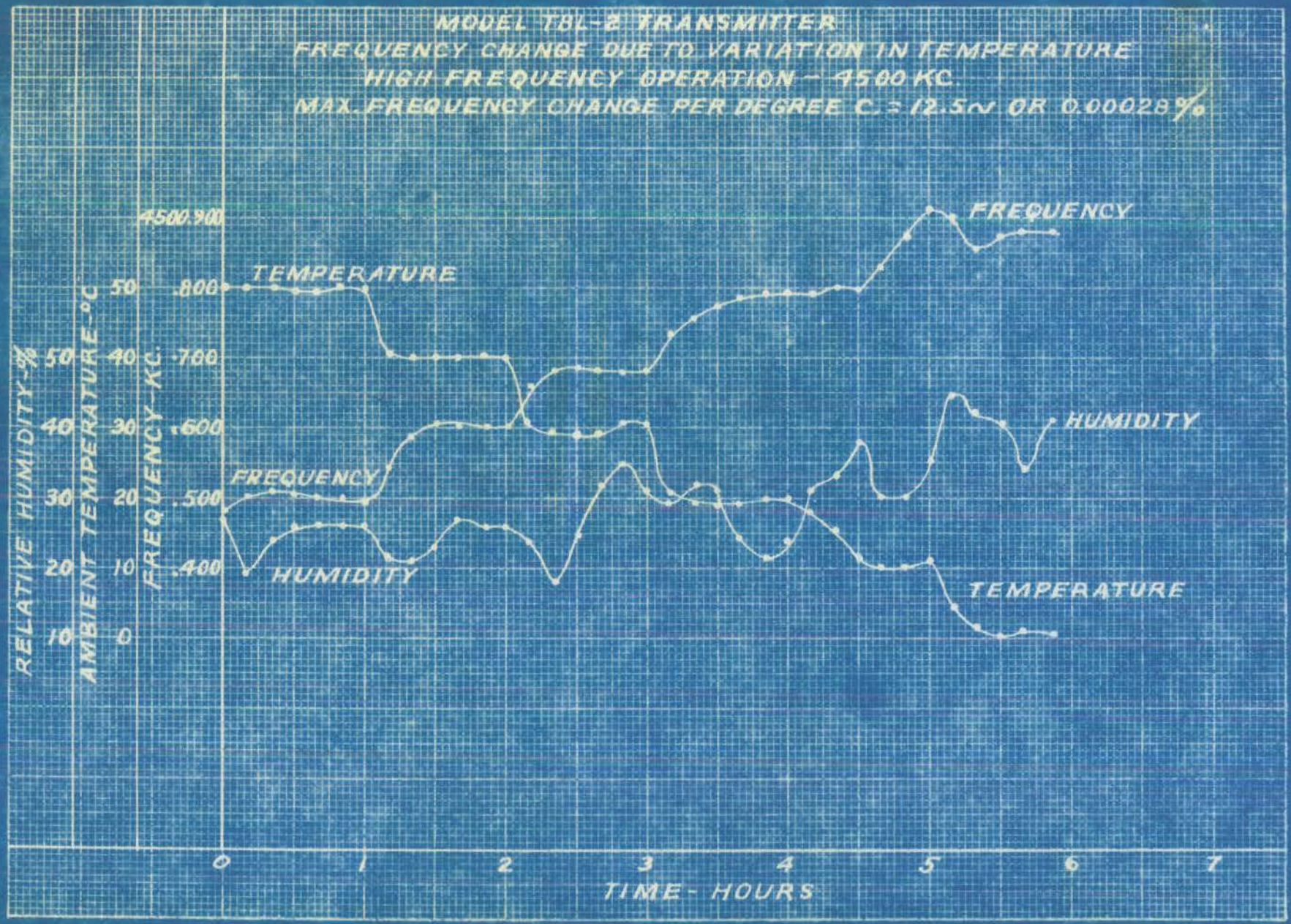

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PLATE 5

U.S. NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.
DATE

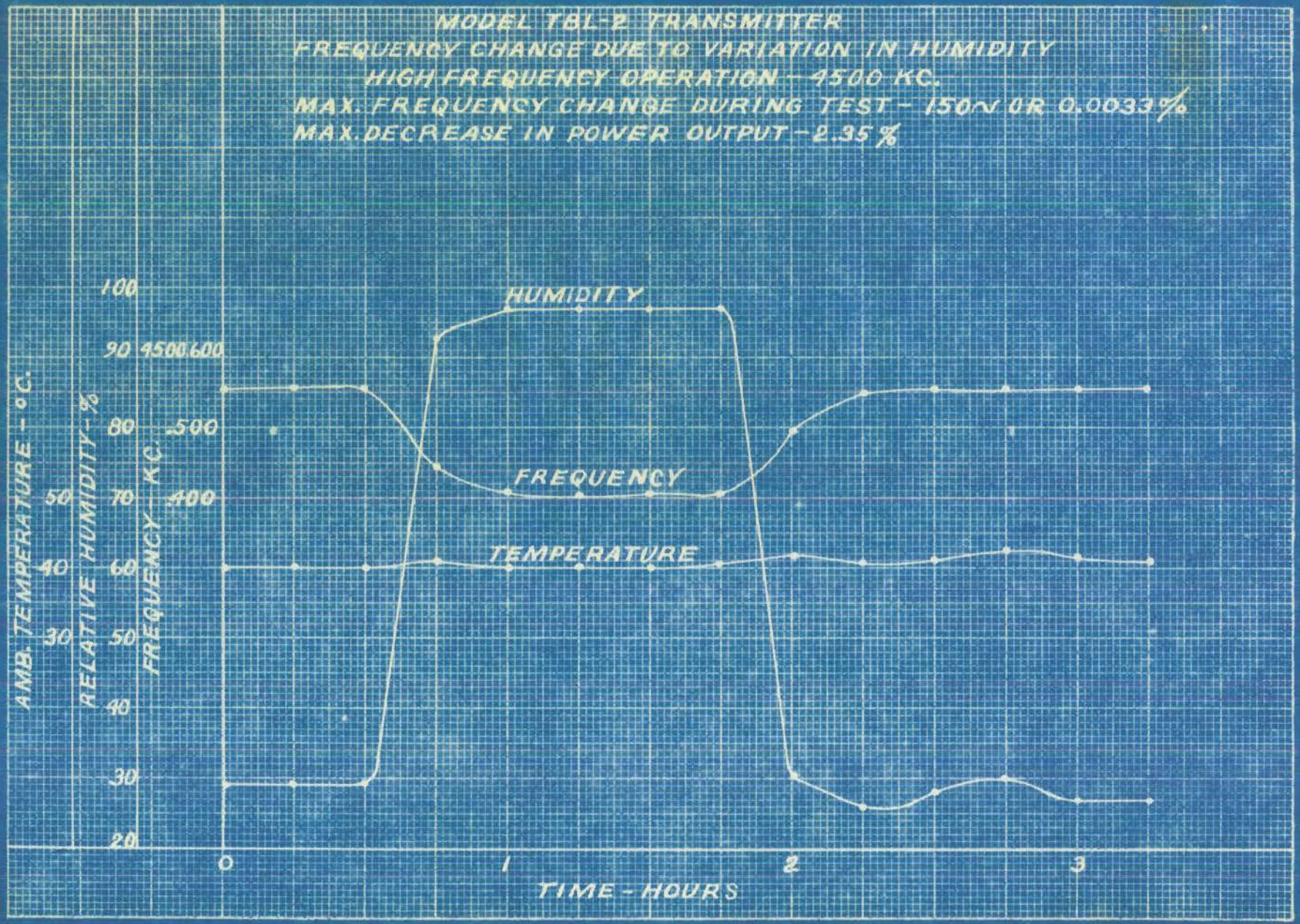
MODEL TBL-2 TRANSMITTER
FREQUENCY CHANGE DUE TO VARIATION IN HUMIDITY
HIGH FREQUENCY OPERATION - 4500 KC.
MAX. FREQUENCY CHANGE DURING TEST - 150~ OR 0.0033%
MAX. DECREASE IN POWER OUTPUT - 2.35%
HUMIDITY
FREQUENCY
TEMPERATURE
AMB. TEMPERATURE - °C.
RELATIVE HUMIDITY - %
FREQUENCY - KC.
100
90
80
70
60
50
40
30
20
4500
4600
4500
4400
0
1
2
3
TIME - HOURS

PLATE 6

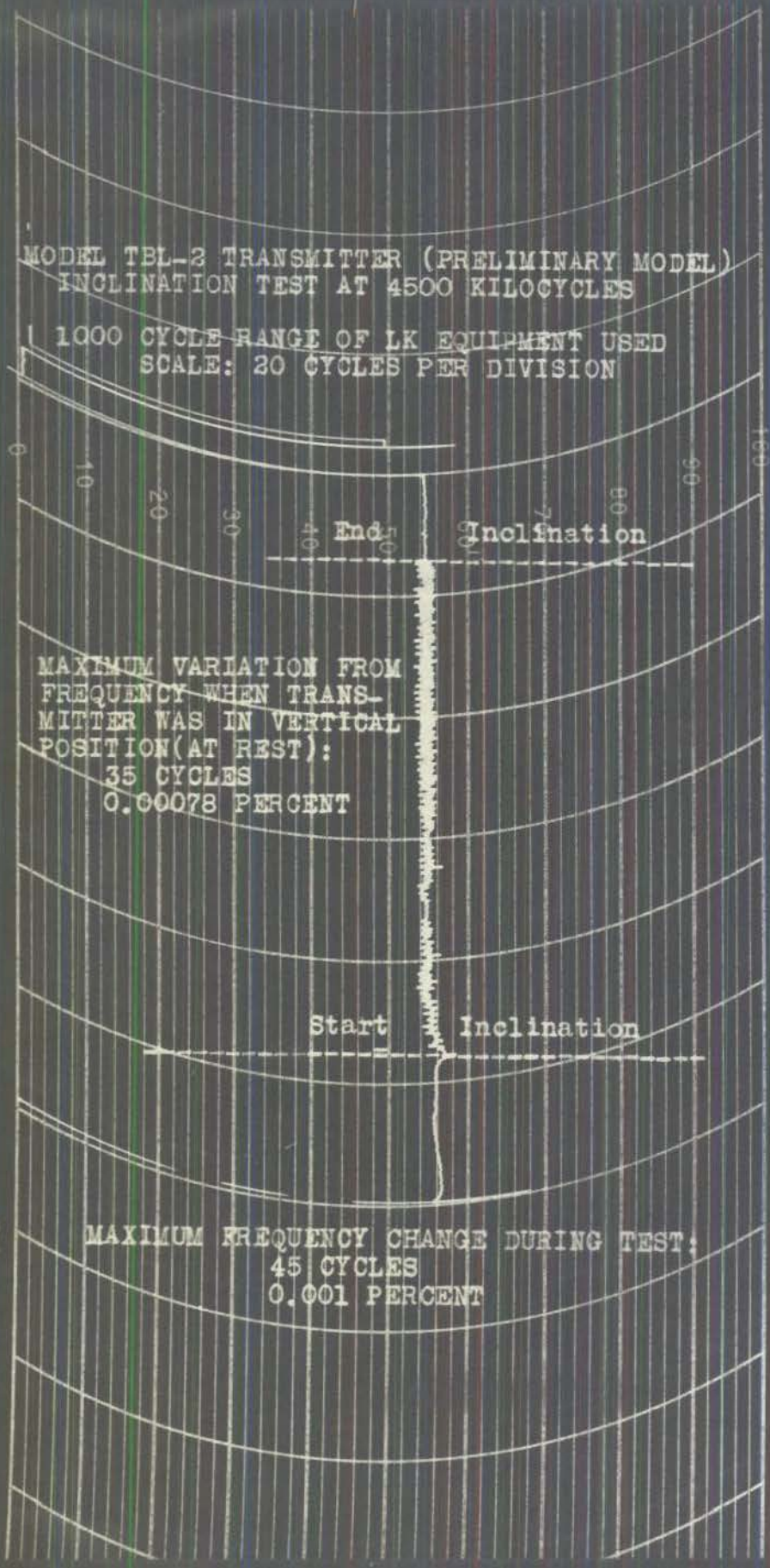

Plate 7

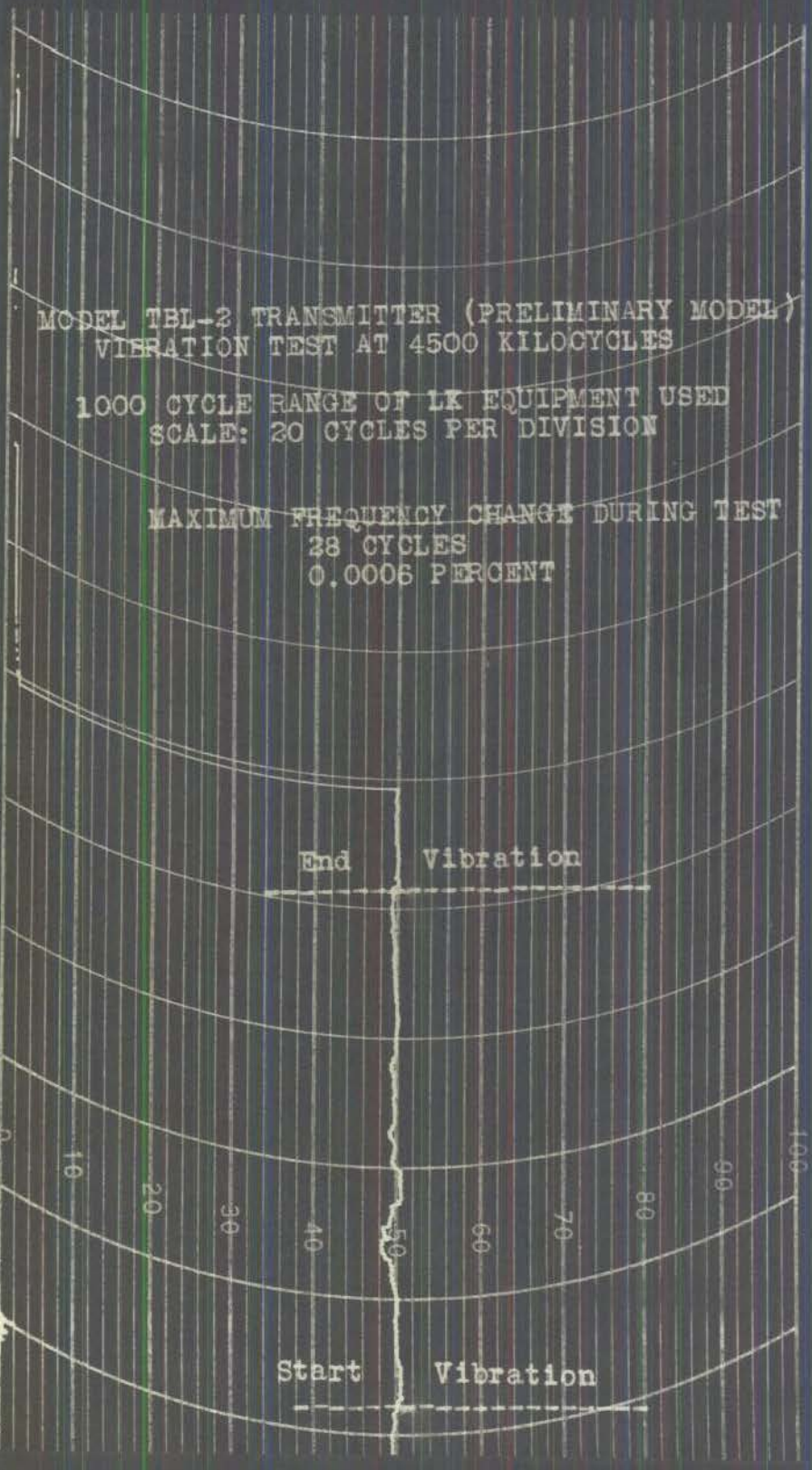

Plate 8