22 August 1935

NRL Report No. R-1186
BuEng Prob. T5-19

FR-1186

NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

Test of Model TBN-2
Radio Transmitting Equipment

(Contractor: Westinghouse Electric and Manufacturing Company)

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages:	Text - 67 Tables - 54 Plates - 48
Authorization:	BuEng let.NOs-38614(5-9-W8) of 17 May 1935.
Date of Test:	May 17 - August 15, 1935.
Prepared by:	R. B. Meyer, Associate Radio Engineer Chief of Section
Reviewed by:	A. Hoyt Taylor, Physicist Superintendent, Radio Division
Approved by:	H. M. Cooley, Captain, U.S.N. Director
Distribution:	BuEng (5)

ELJ
LP

Table of Contents

Appendices

Appendices continued.

AUTHORIZATION OF TEST

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

Reference: (a) BuEng let.NOs-38614(5-9-W8) of 17 May 1935.
(b) Specifications RE 13A 497A.
(c) Specifications RE 13A 442D.
(d) Contract NOs-38614 of August 3, 1934.
(e) Westinghouse Co.Descriptive Specs.R-816.
(f) Westinghouse Co.Descriptive Specs.R-770.
(g) Westinghouse Co.Type Test Data, H.F.Unit.
(h) Westinghouse Co.Type Test Data, I.F.Unit.
(i) Westinghouse Co.let.WG-17535 NOs-38614 of 9 Jan.1935 to BuEng.
(j) Sub Contractor's description of speech equipment. (1-30-35)
(k) Westinghouse Co.let.of May 15, 1935, to INM, Hartford.
(l) INM, Hartford, let.to BuEng, L5-1(NOs-38614) (256) NIRA, L5-1(NOs-36091)(511) NIRA of 31 May 1935.
(m) BuEng let.NOs-38614(5-9-W8) of 26 June 1935 to NRL.
(n) INM Hartford let.L5-1(NOs-38614)(261)NIRA, L5-1(NOs-36091)(582)NIRA of 19 June to BuEng.
(o) Westinghouse let.of 10 June 1935 to INM,Hartford.
(p) BuEng let.S67/49(7-27-W8) of 30 July 1935
(q) BuEng let.NOs-38614(7-15-W8) of 31 July 1935.

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) The nature of changes necessary to correct any departures from contract requirements.

(d) Recommendations regarding possible improvements considered necessary to meet service requirements.

(e) Recommendations regarding desirable improvements for service use.

(f) Recommendations regarding future specifications, particularly concerning telephone features.

ABSTRACT OF TESTS

3. The tests herein reported were conducted to determine the degree of compliance of the Model TBN-2 transmitting equipment (preliminary model) with the mechanical and electrical requirements set forth in refs. (b), (c), and (d). Specifically, tests were conducted to determine the following:

(a) Ability to withstand shipment.
(b) Check of mechanical or physical construction and assembly; general workmanship; materials used; corrosion resisting measures and adequacy of electrical circuits.
(c) Power output; power input; overall efficiency and flexibility of antenna coupling circuits.
(d) Quality of emitted signals; lilt; undesirable modulation; key clicks; keying speeds and break-in operation.
(e) Check of dimensions and weight.
(f) Determination of cycles per division of tuning over range of master oscillator circuits.
(g) Check of temperature control circuits.
(h) Check of protective circuits.
(i) Determination of frequency of modulation, percentage of modulation and power output while operating MCW.
(j) Frequency stability and accuracy under following conditions:

(1) Key locked.
(2) Intermittent keying.
(3) Reset accuracy and back-lash.
(4) Variation of supply line voltage.
(5) Variations in ambient temperature and humidity.
(6) Variation in antenna constants.
(7) Detuning of amplifier stages.
(8) Change of vacuum tubes.
(9) Effect of Adjust-Tune-Operate control.
(10) Effect of vibration and roll or pitch.
(11) Effect of shock simulating gun fire.
(12) Effect of power output control.

(k) Rectifier units: determination of efficiency of conversion; voltage regulation and percentage and frequency of ripple voltage.

(l) Effect of short-circuiting and open-circuiting the antenna system.
(m) Effect of grounding any one phase of the supply circuit.
(n) Degree of interference caused by mercury vapor rectifiers in nearby receivers.
(o) Check of telephone equipment to determine distortion; frequency response; percentage modulation and the general action of the speech input equipment.

Conclusions

(a) The external appearance of the equipment is excellent; the controls are rugged and well located and the accessibility provided is as great as the limiting conditions permit. The internal wiring is orderly and of good quality, securely held in place and protected where necessary. The component parts comprising the various assemblies are arranged and located with a view of effecting economy in space, orderly appearance and yet permit as great accessibility for servicing operations as possible. In general, the assemblies reflect engineering skill, good design, good workmanship, and efforts to comply with the requirements of Navy specifications.

(b) Both transmitting units produce the required amount or more than the required power output except in the region of 300 to 500 kilocycles, when employing the restricted antenna constants required by Navy conditions. The tuning adjustments are simple and direct and flexible antenna coupling circuits have been provided.

(c) No major operational failures occurred during the course of extensive tests. Certain difficulties were encountered from which it is concluded that further attention is required to provide a power amplifier choke for the intermediate frequency unit which will withstand continuous operation at all frequencies within the range of the transmitter without overheating and that the design of the 800 cycle audio oscillator circuit in the intermediate frequency unit should be amended to prevent overheating.

(d) With respect to the speech input equipment and voice operation the tests showed that the microphone circuits require certain modifications if more natural and desirable qualities of speech are to be retained. The present circuits produce understandable speech but a distinct difference is noted between the microphone circuits supplied in the modulator unit and the microphone circuits incorporated in the master monitor, station control, and station extension units, the former circuit producing the better quality. The results of tests indicate that the carbon button type of microphone is more suitable for use with this equipment than the sound power type of microphone.

(e) The modulation meters provided for monitoring the equipment are capable of accurate indications but are subject to failure from several causes. These conditions must be overcome before the modulation meter can be considered satisfactory for service use. In addition, precautions must be taken and means provided to prevent arc overs occurring within the transmitter when high level modulation is being used.

(f) The speech input circuits have been provided with exceedingly flexible controls which appear adequate for coping with all normal conditions of operation. Precautions must be observed, however, that reasonable voice levels are maintained at the various points of control since more than one operator may be employing the same speech channel; that the microphones are not subjected to prohibitive noise levels, particularly when

voice control of the carrier is being used and that all operators and observers endeavor to adjust themselves to the levels of speech and hearing set by the master control operator in order to minimize the difficulties resulting from the variations between individual characteristics of speech and hearing.

(g) From observing the operation of this type of equipment it is evident that certain methods of operation and policy which are not necessary in connection with CW operation will have to be formulated and observed in order to maintain the equipment at a high state of efficiency. Abnormal overloading of circuits must be avoided, proper modulation levels must be maintained, power output reduction should not be accomplished by reducing the potentials applied to the tubes and the various vacuum tubes employed in connection with voice operation cannot be used until the last bit of life has been extracted from them, if high quality operation is to be realized.

(h) A number of changes, modifications, and corrections are indicated in order to provide greater safety factors, improve operation of the equipment and to effect greater ease in handling by the operating personnel.

(i) The fact that the equipment successfully withstood extensive tests over a period of several months wherein it was subjected to the difficult conditions encountered on board Naval vessels, as nearly as Laboratory conditions would permit, including numerous overload tests, locked key operation at full power for periods as long as eight hours, severe vibration, shock, and the motion designed to simulate the rolling of a vessel, variations in temperature from zero to 50° C, conditions of high humidity wherein the equipment was actually saturated for several hours, indicates that the apparatus is well designed, well constructed, and possesses liberal safety factors which should insure reliable operation in the Naval Service.

Recommendations

It is recommended:

(a) That carbon resistors be employed only in such circuits where it is definitely proven that standard wire wound resistors are unsuitable. (See par.35)

(b) That the use of 38056 vacuum tubes in the audio amplifier be approved. (par. 36)

(c) That the front panel of the master monitor unit be strengthened and that more secure means for fastening the front hinged panel be provided. (par.40)

(d) That additional doors be provided on the sides of the telephone power unit to improve accessibility and that additional perforations be pumched in the top cover of the telephone power unit directly over the Rectox units in order to improve ventilation. (par.41)

(e) That the interconnection wires to the station control units be connected to the front studs and that the permanent interior wiring be connected to the rear studs in order to simplify placing the units into commission. (par.42)

(f) That the covers of the station extension units be modified so that sufficient space is available to stow a microphone and headset when the hinged cover is closed. (par.43)

(g) That the corrosion resisting qualities of the equipment be improved by requiring that all metallic parts of "Lord" mountings be constructed from non-corrosive metal; that the cores of all relays be sufficiently covered with suitable paint or compound to prevent rust and that the worm on the master oscillator tuning control be constructed of stainless steel. (par. 46)

(h) That all hinges provided with the equipment be fabricated from nickel plated brass. (par. 47)

(i) That the micalex supporting strips in antenna tuning variometer be fabricated from isolantite and that the screen grid connections in the rear of the high frequency unit be insulated by means of isolantite in place of the present bakelite. (par.48).

(j) That the "Deion" breaker which now serves as the main switch and as an overload protective device be so proportioned that it operate on overloads of at least 50% and that all overload relays be furnished so that they may be properly adjusted, together with specific instructions as to whether oil should or should not be used in the dash pot. (par.50)

(k) That the top of the rectifier modulator unit be provided with perforations in order to increase ventilation. (par. 53)

(l) That proper precautions be taken to see that the power amplifier plate chokes in the high frequency unit are properly connected in all production models to prevent overheating. (par.54-a)

(m) That steps be taken to prevent overheating of the audio oscillator circuit in the intermediate frequency units and that a more satisfactory design of power amplifier plate choke in the intermediate frequency unit be evolved before it is considered satisfactory for service use. (par.54-b)

(n) That care be exercised to provide fuses in the telephone power unit which will withstand the effects of vibration. (par.58-c)

(o) That the volume control on the modulator unit be provided with a dial and pointer to indicate the various steps of adjustment. (pars.61 and 149)

(p) That the connections to the key relay in the intermediate frequency unit be modified so as to prevent any of the leads from becoming accidentally grounded. (par. 66)

(q) That the tube socket in the speech relay circuit be plainly marked with the type number of the tube which is to be employed in this socket. (par. 70)

(r) That the sequence of control markings on the intermediate frequency unit be modified to correspond with the suggested order listed in Table 11 and that a stop be provided on Control "F" to prevent this control from moving too far to the left. (par. 81-a)

(s) That the calibration card supplied with the high frequency unit be enlarged to provide space for listing the calibration data for 12 frequencies, (par. 82)

(t) That the frequency tolerance determined by the tests at 1,000 and 2,000 kilocycles be considered satisfactory. (par. 96)

(u) That the compensating condenser in the high frequency unit be adjusted so that it will provide the same degree of frequency control as was obtained in the original TBK equipments, and that a more flexible ground strip be employed to ground the master oscillator compartment of the high frequency unit. (par. 97)

(v) That the power output of the intermediate frequency unit at 300 and 500 kilocycles be considered satisfactory in view of the fact that there appears to be no satisfactory method of increasing the efficiency within the present space limitations. (par. 111)

(w) That the frequency per division of marking of the intermediate frequency unit master oscillator dial be considered satisfactory and that no changes be required in this connection. (par. 115)

(x) That the height of the hand rails on the intermediate frequency unit, the modulator rectifier unit, and the high frequency unit be so located that they all will be equidistant above the deck level. (par. 126)

(y) That additional precautions be taken to insure that the frequency changes resulting from the shock of gun fire will not exceed that requirements of the specifications. (par. 127-a)

(z) That further information be obtained from the manufacturer to determine whether it is possible and feasible to design the microphone circuits in such a manner as to prevent level changes when the number of microphones connected into a given circuit is varied. (par. 129-d)

(aa) That the necessary inspection precautions be taken to insure that all level indicators are satisfactory and that no pointers stick. (par.133-1)

(bb) That the Bureau consider the advisability of eliminating the range switches on the transmitter line level indicators. (par. 133-5)

(cc) That high frequency buzzers be provided in place of the present low frequency buzzers in the master monitor unit and the station control units. (par. 133-15)

(dd) That a suitable desk stand be provided for the hand set at the master monitor station in place of the present telephone receiver hook. (par. 133-16)

(ee) That approval be granted to construct the master monitor unit within the dimensions as they now exist. (par. 133-17)

(ff) That the requirement which provides that the doors of the station control units shall be held in a horizontal position be cancelled. (par.137)

(gg) That the low level signals which may be heard at station extension units on channels to which the unit is not regularly connected be not considered of sufficient importance to justify the complicated changes which would be necessary to eliminate such signals. (par. 138-g)

(hh) and (ii) That the frequency characteristics of the microphone circuits in the master monitor unit, station control units and station extension units be modified sufficiently to give the same characteristics as the microphone circuit in the modulator rectifier unit. (pars. 142, 143, and 148)

(jj) That the accuracy of the modulation meter provided (last sample submitted) be considered satisfactory, but that the modulation meters of this type be considered as unsatisfactory for service use until steps have been taken to insure their continued operation under operating conditions and that corrective measures be taken to prevent the P.A. tank circuit condenser from arcing over when high level modulation is being used. (par. 150 and 151)

(kk) That the response characteristics of the speech relay as provided in the preliminary equipment be considered satisfactory. (par. 154 and 155-B)

(ll) That the marking and control designations of the station control units, station extension units, and master monitor unit be revised in accordance with the suggestions contained in par. 159.

(mm) That precautions be taken to insure that inspection of production models will result in satisfactory adjustment of the friction devices which hold the covers of the station control units open. (par. 160, par. I)

(nn) That hand type microphone units be supplied with each modulator unit and that provision be made for properly securing these units to the panel of the modulator unit. (par. 161 and 162)

(oo) That a separate "start-stop" switch be provided on the panel of the rectifier modulator unit so that the equipment may be started or shut down, at the will of the operator, when the selector switch is in the "rectifier test" position. (par. 192)

(pp) That the suggestions of the Inspector of Naval Material, Hartford, as approved in paragraphs 206 to 222 inclusive, of this report, be complied with.

(qq) That the improved type of lifting device in accordance with the sample submitted by the contractor, be approved for all units of the TBN-2 equipment requiring lifting devices. (par. 73)

(rr) That future specifications require that a standby switch be provided on the rectifier unit. (par. 193)

(ss) That future contracts involving the supplying of preliminary models require that the contractor furnish a complete set of interconnection cables, properly marked, for the duration of the test period. (par.202)

(tt) That the Bureau consider the advisability of making a noise survey on board the various vessels which will be equipped with four channel voice operated equipment, in order that the various stations may be located in places where disastrous noise levels will not interfere with the efficient and satisfactory operation of the equipment.

(uu) That the preliminary model of the TBN-2 equipment be considered satisfactory for Naval use after the recommendations listed above have been complied with in a manner meeting the approval of the Bureau of Engineering.

MATERIAL UNDER TEST

4. The material under test consists of the following:

1 - Type CAY-20033 Modulator Rectifier Unit
1 - Type CAY-52046 I.F. Transmitter Unit
1 - Type CAY-52048 H.F. Transmitter Unit
1 - Type CW-23071 Master Monitor Unit (4 channel)
1 - Type CW-20035 Telephone Power Unit (4 channel)
2 - Type CW-23069 Station Control Units
2 - Type CW-23068 Station Extension Units
2 - Type CW-51005 Microphone Units (Chest Type)
1 - Hand Set (Microphone and Receiver)

5. The Model TBN-2 equipment was manufactured under Contract NOs-38614 by the Westinghouse Electric and Manufacturing Company (Western Electric Company, sub-contractor for speech input equipment). The equipment operates from a primary power source of 440 volts, 3 phase, 60 cycles. The intermediate frequency transmitter has a nominal output of 1 kw and covers the frequency range of 300 to 2,000 kilocycles and may be operated CW or MCW output. The high frequency transmitter has a nominal output of 500 watts on high power and 75 watts on low power, and covers the frequency range of 2,000 to 18,100 kilocycles on high power and 2,000 to 9,050 kilocycles on low power. The high frequency unit may be adjusted for CW, MCW, or telephone operation. The modulator rectifier unit contains the necessary modulating equipment and also contains the various rectifiers required to develop the voltages for energizing both the high frequency and intermediate frequency transmitter units. Only one transmitter can be energized at one time. The master monitor, telephone power unit, and the station control and extension units are designed to actuate and distribute the control of the equipment when voice (telephone) operation is selected.

6. The modulator rectifier, high frequency transmitter and speech input equipment was received at the Naval Research Laboratory on May 17,1935. The intermediate frequency transmitter was received at the Washington Navy Yard, Friday, May 31, 1935, and transferred to the Naval Research Laboratory on Wednesday, June 5, 1935. Transportation was accomplished by means of motor truck express from the Chicopee Falls plant of the manufacturer.

METHOD OF TEST

7. The equipment, when received, was carefully examined to determine whether any breakage had occurred during transportation and whether adequate precautions had been observed in preparing the apparatus for shipment.

8. The equipment was then wired up and placed into commission, particular attention being paid to the preliminary instructions governing the installation to determine whether they were complete and adequate.

9. Power output determinations were accomplished through the medium of a 500 watt lamp and a calibrated photronic cell, the output of which was measured by a microammeter. The base of the lamp was removed in order to minimize capacity losses. At intermediate frequencies output measurements were made using dummy antennas of the proper characteristics and the I^2R method of determining power was employed.

10. Frequency changes and drifts were checked by means of the Model LH and LK frequency indicating equipments, the transmitters being operated at full power output whenever the governing specifications required this method of operation.

11. Frequency range, overlap, and kilocycles per division of marking were determined by means of a Type CAG-74016 heterodyne calibrator.

12. Determinations of the temperature coefficient of the transmitting equipment were made at full power output over the temperature range of zero to 50°C. Frequency measurements were made by means of the LK visual frequency indicating equipment.

13. Input power checks were made by means of a polyphase wattmeter. The efficiency of conversion was determined from input measurements made by means of the polyphase wattmeter and output measurements were calculated from d.c. voltmeter and ammeter readings.

14. Keying records were made through the medium of a recording oscillograph actuated by the rectified antenna current.

15. Measurement of the ripple voltage present in the output of the various rectifiers was made by means of a Model 636 wave analyzer.

16. Model RAB-1 RAB-2-a, and RAA receivers were used in the tests for determining the quality of emission and the effect of the rectifier tubes and a.c. contactors upon adjacent receivers. The same receivers were used to determine the effect of grounding one phase of the primary supply voltage. All three phases of the power supply were grounded in rotation.

17. Distortion measurements of the speech equipment were made by means of a Model OB audio analyzer.

18. The frequency characteristic of the various elements in the speech equipment was determined by means of a Type 377-B L.F. oscillator, Type 546-A A.F. microvolter and Model OB audio analyzer. Additional checks were made through the use of vacuum tube voltmeters, Type D-180 output meters and the necessary impedance matching transformers.

19. Modulation investigations were conducted by three methods; i.e., by means of the cathode ray oscillograph, the peak voltmeter method included in the Model OB audio analyzer and by means of the Type CAY-22230 modulation meter furnished as a part of the equipment under test. Phase adjustment and undistorted amplification was provided through the medium of special "Ampli-filters" used in connection with the cathode ray oscillograph. The cathode ray oscillograph was carefully checked to insure linearity of response and the trapezoid method of determining the percentage modulation was used. In order to insure accuracy the phase of the sweep circuit voltage was reversed during each measurement and the average of the two readings used in calculating the final result.

20. Key clicks were observed in the usual manner by listening on nearby receivers. In addition, direct comparisons were made between the keying systems provided in the H.F. and I.F. transmitter units and the results obtained when using the special anti-click method of keying developed at the Naval Research Laboratory.

21. 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 equipment upon a special test stand whereby vibration could be applied in a manner simulating that encountered afloat. The same test stand simulates the roll of a vessel so that the equipment may be inclined at angles 45° from the vertical at a period corresponding to the roll of a vessel.

DATA RECORDED

22. Complete data was recorded on all tests conducted and this information is contained in Tables 1 to 54 and Plates 1 to 48 inclusive.

PROBABLE ERRORS IN RESULTS

23. Every effort was made to minimize errors in the results obtained during the tests recorded herein. In many cases several tests of the same kind were conducted in order that an average might be arrived at.

24. The visual frequency indicating equipment, Model LH and Model LK have been repeatedly checked and have been found to be accurate to within one or two cycles in 1,000,000.

25. The accuracy of the heterodyne calibrator is about 0.005%.

26. Power output measurements should be accurate to within 5%. The values of resistance used in the dummy antennas were corrected with respect to frequency and the resistance of the capacitors used in these measurements was allowed for. Precision type radio frequency ammeters were employed for determining antenna current.

27. The a.c. and d.c. meters used in making measurements for the determination of power, voltage, and current were all instruments of the precision type whose calibrations had been verified to insure accuracy.

28. The method used for determining the magnitude and frequency of ripple voltages compares favorably with accurate oscillographic methods.

29. The determination of percentage modulation by means of the trapezoid method employing the cathode ray oscillograph is probably about 5% accurate at the lower levels with increasing accuracy at the high levels.

30. The equipment used for measuring distortion is accurate to within 5% above 2% distortion. For measurements below this value the accuracy decreases to 15% at 0.5% distortion.

RESULTS OF TESTS

31. Upon receipt of the Model TBN-2 equipment it was noted that satisfactory precautions had been taken to safeguard the material during shipment. In addition, the equipment was packed in a manner which permitted of easy disassembly of the cases and the removal of the various units without exposing them to injury.

32. In the following paragraphs of this report reference is made to the governing specifications, RE 13A 497A (and RE 13A 442D) under which this equipment was constructed. Where no specific reference is made to any particular paragraph it is to be understood that the equipment under test complies with this paragraph and that no further explanatory remarks are considered necessary.

33. In accordance with the instructions contained in par.6 of ref.(a), the 500 watt high frequency transmitter unit was not subjected to the usual complete tests on CW operation, since this is the same unit which was submitted as the preliminary model on Contract NOs-36091 (Model TBK). A sufficient number of tests were conducted, however, to insure that the unit was in satisfactory operating condition and that the changes incorporated in this unit to adapt it to telephone and MCW operation did not adversely affect the CW operation. (NRL Report No. R-1087 covers in detail the tests conducted with this unit under Contract NOs-36091).

34. Section I. The Model TBN-2 equipment meets the general scope of this introductory section of the specifications.

35. Par.2-2-a. The following items employed in the equipment do not conform with the specifications referenced under this paragraph.

Resistors R1, 2, 3, 4, 5, 18, 19, and 20 in the intermediate frequency unit.

Several items of small resistors in the master monitor unit.

Capacitors C-137 and C-138 in the microphone circuit of the rectifier modulator unit and other capacitors in the telephone power unit.

Resistors R2, R19, and R20 are carbon type resistors. These units are employed in the grid circuits of the master oscillator and power amplifier tubes and were undoubtedly employed by the contractor because of the necessity of providing a non-inductive resistor. These resistors provided satisfactory operation and in view of the fact that the intermediate frequency transmitter is called upon to cover a frequency range considerably in excess of that usually employed it appears that special means of stabilization are required. If the manufacturer is in a position to furnish data indicating that the ordinary wire wound vitreous enamelled type of resistor is unsatisfactory for use in these locations it is recommended that the Bureau consider the advisability of waiving the use of standard resistors in these particular applications. The remaining non-standard resistors mentioned above are not included in the radio

frequency circuits and hence their use is not justified. It should be mentioned that these carbon type resistors employ ferrules which appear to be molded from a lead alloy.

The use of non-standard resistors in the master monitor unit was authorized in BuEng let.NOs-38614(12-13-W8) of 24 December 1934 to INM, Hartford.

The use of copper oxide rectifiers and electrolytic filter capacitors was approved for potentials not in excess of 50 volts on page 9 of ref.(d).

In addition, the H.F. unit of the TBN-2 equipment was provided with a spirit thermometer. From the information contained in INM, Hartford, letter of 31 May 1935, ref.(1), it is understood that mercury thermometers will be provided in production equipment. The manufacturer submitted a mercury thermometer, but due to a difference in mounting dimensions it was not practical to substitute this replacement thermometer. The experience of the Naval Research Laboratory indicates that mercury thermometers may be used successfully in locations where the radio frequency field is not excessive. Therefore, it is recommended that the use of mercury thermometers, conforming to the governing specifications, be provided in the production models of the TBN-2 equipments.

The remaining items listed under par.2-2-a of the specifications comply with the requirements of the referenced specifications.

36. Par.2-2-b. Pages 9 and 10 of ref.(a) authorize the following tube line-up for the Model TBN-2 equipment:

6 - 38172A - Main plate rectifier
2 - 38166A - Auxiliary plate rectifier
2 - 38166A - Bias rectifier
2 - S-289416D - Rectigons, control circuit.
2 - 38110 - Audio amplifier
1 - 38110 - Telephone control circuit
2 - 38111A - Intermediate audio amplifier
2 - 38149 - Modulation

The actual tubes supplied in the modulator rectifier unit are as follows:

6 - 38172A - Main plate rectifier
2 - 38166A - Auxiliary plate rectifier
2 - 38166A - Bias rectifier
2 - S289416D - Rectigons - control circuit
2 - 38056 - Audio amplifier
1 - 38110 - Telephone control circuit
2 - 38111A - Intermediate audio amplifier
2 - 38149 - Modulation

It will be noted that two 38056 tubes have been substituted in the audio amplifier in place of the two 38110 tubes authorized in ref.(a). 38056 tubes are not listed in RE 13A 346T but they have been included in Navy Specifications RE 13A 600A with the proviso that specific approval must be obtained for their use in new equipment. It is pointed out that the

master monitor unit employs four 38056 tubes, hence the use of the 38056 tubes in the modulator unit in place of the 38110 tubes does not increase the number of types of tubes used. Therefore, in view of the fact that the 38056 tube is being used in the master monitor unit, and that the use of the 38056 in the audio amplifier has given excellent results during test, it is recommended that the substitution of these tubes in place of the 38110 tubes be authorized. It may be pointed out that the 38056 tubes cost less than the 38110 and take up less space.

37. The remainder of the Model TBN-2 equipment employs the following tubes. It will be noted that with the exception of the four 38056 tubes used in the master monitor unit, all tubes used are listed in Navy specifications as standard tubes.

Intermediate frequency unit
3 - 38160 tubes
1 - 38151 tube

High frequency unit
4 - 38160 tubes
1 - 38161 tube

Master monitor unit
4 - 38056 tubes

Telephone power unit
1 - 38180 tube

38. Par.2-3. The construction details of the high frequency unit are discussed in par.30 of NRL Report No. R-1087. The main frame of the modulator rectifier unit is constructed of aluminum alloy angle 3/16" x 3" x 3", secured by means of 3/16" x 7" x 7" gusset plates at the corners. The front panels are of 3/16" cast aluminum, provided with stiffening ribs. The side and back shields are fabricated from 3/32" aluminum with punched holes for ventilation. The top of this unit consists of a plate of 1/4" aluminum, unperforated, and forms the support for various transformers and other items included in the modulator system. This method of support appears to be entirely adequate since little or no bowing or bending could be detected. The intermediate frames of this unit are 3/16" x 2" x 2" and are secured at the corners by 3/16" x 4" x 4" gusset plates. All frame members are spot welded.

39. Par.2-3. Intermediate Frequency Unit. The main frame of this unit consists of aluminum alloy angles 3/16" x 1-1/2" x 1-1/2" secured by 3/16" x 5" x 5" gusset plates at the corners. The intermediate framework consists of the same size angle secured by 3/16" x 4" x 4" gusset plates. The front panels are of 3/16" cast aluminum while the shields are of 3/32" perforated aluminum sheet. All frame members are spot welded. The construction used in the modulator-rectifier unit, the high frequency unit and the intermediate frequency unit provides a very rugged assembly of high grade materials.

40. Par.2-3. Master Monitor Unit. This unit is constructed of aluminum angles and sheets. The entire front panel is hinged at the bottom so that it may be opened in order to provide access to the interior of the unit. As mentioned in the INM,Hartford, letter, this panel bends under the load it carries when in the open position. It is believed that the thickness of this panel should be increased from 1/8", its present thickness, to at least 3/16". In the event that 3/16" sheet appears to have insufficient strength, stiffening members should be provided. This panel is secured in place by means of four "V" slotted catches. It is recommended that a more secure method of fastening be provided. It is believed that four non-removable thumb screws, similar in style to those employed on Navy Type RAB receivers would be more suitable, rugged and yet permit ready access. The use of the present form of securing devices, with the improvements recommended in reference (1) will be satisfactory on the other doors of this unit.

41. Par.2-3. Telephone Power Unit. This unit is so constructed that it may be secured to the deck or on top of a table or desk. Par.6-1 of ref.(1) recommends that two side doors be substituted for the top door in order to improve access. In the opinion of the Laboratory these side doors should be provided in addition to the top door in order to provide for greater accessibility under all conditions of installation. In addition, it is recommended that additional perforations be provided in the top panel of this unit directly above the seven Rectox rectifier units to improve ventilation, since the successful operation of these units is impaired if they operate at temperatures in excess of 60°C, according to the information supplied by the manufacturer of these rectifiers.

42. Par.2-3. Station Control Units. These units are of rugged construction and are contained in heavy cast aluminum housings. As recommended in par.8-1 of ref.(1) the process of making interconnections between units would be simplified if the permanent interior wiring were connected to the rear studs on the terminal blocks instead of on the front, thus permitting the interconnecting wiring to be secured to the outside row of studs which are more accessible.

43. Par.2-3. Station Extension Units. These units are of construction similar to that employed in the Station Control Units. The Laboratory agrees with the recommendation contained in par.9-1 of ref.(1) wherein the consideration of the Bureau of Engineering is invited to increasing the depth of the door of these units sufficiently to accommodate a microphone unit and a telephone head set when the unit is closed. This would form a permanent stowage place for these units and thus decrease the dangers of breakage and loss.

44. Par.2-4. In general, the workmanship employed throughout the entire equipment is of excellent quality and high grade materials have been used. Such items which it is believed require improvement or correction will be discussed in detail under appropriate paragraph headings of the governing specifications.

45. Par.2-5. The intermediate frequency unit and rectifier modulator unit were subjected to temperatures varying between the limits of zero degrees Centigrade and 50 degrees Centigrade without any damage to the equipment.

46. Par.2-6. Precautions have been taken to prevent corrosion as far as is practicable in most instances. Exposed metal parts have been painted black, such as transformer channels and laminations, or have been provided with a metallic coating of corrosion resisting qualities. Exposed aluminum parts have apparently been subjected to a dipping or pickling process which acts as a deterrent to corrosion. However, at the end of certain tests wherein the equipment became saturated with moisture it was noted that the following items became rusty and corroded.

Metallic parts of Lord mountings used for supporting tube assembly in intermediate frequency unit.

Core of Relay K-4 in the intermediate frequency unit.

Worm on master oscillator tuning control in intermediate frequency unit.

Cores of Relays K-101, 102, 104, 111, and 112 in the modulator rectifier unit.

It was noted that the Lord mountings used in the modulator rectifier unit did not corrode, the metallic portion of this device apparently being constructed of a different metal than that used for the mountings in the intermediate frequency unit. It is believed that if the cores of the relays are coated with a sufficiently heavy layer of suitable paint that the corrosion resisting qualities of these units will be improved. The worms on the tuning controls should be constructed of stainless steel in order to prevent rust from forming, which in time may render the control inoperative.

47. Par.2-7. The use of iron and steel, except where specifically required for electro-magnetic purposes or in the interests of strength, has been reduced to a minimum. The following exceptions are noted:

(a) The door hinges and door stops on the master monitor unit are of coated steel.

(b) The door hinges on the telephone power unit are steel.

(c) The supports which hold the doors of the station control units in a vertical position are constructed of steel, nickel plated, as well as the securing handles.

(d) The securing handles of the station extension units are steel.

It is recommended that all hinges be constructed of nickel plated brass in order to prevent corrosion from affecting their operation. The door supports on the station control units could be constructed of brass without interferring with

their strength. The door handles on the station control and extension units should be kept as strong as possible and in these instances the use of steel is advisable.

48. Par.2-8. Phenolic insulation has not been used at frequencies above 2,000 kilocycles. Liberal use has been made of Micalex and Isolantite insulation. Pages 11 and 12 of ref.(a) authorize the use of Steatite insulation. However, as far as can be determined by inspection the preliminary equipment under test has been insulated with Isolantite, judging by its color. It was noted that a number of the Micalex supporting strips used in the rotor assemblies of the antenna tuning inductor, Control "H", were split. This defect may have resulted from improper machining or from an inferior grade of material. Phenolic insulation has been used for insulating potentials in excess of 500 volts d.c. in the high frequency unit. The screen grid connections for the power amplifier and audio oscillator tubes, which derive their potentials from taps on resistors R-15 and R-16 are secured to the bakelite resistor mounting strip in the right hand rear corner of the transmitter. Means should be provided for insulating these two connections with Isolantite, Steatite or Micalex, since the potentials run as high as 750 volts.

49. Par.2-9. No wood has been used in the construction of this equipment.

50. Par. 2-10. The design of the electrical circuits and controls is liberal. All parts which are likely to carry an overload are protected by circuit breakers, relays, or fuses. In connection with the circuit breakers and overload relays, however, certain exceptions are noted which require correction.

(a) The 440 volt, 3 phase line is brought into the rectifier through a De-Ion circuit breaker and combination switch rated at 10 amperes. By means of an external resistance load, 21 amperes were caused to flow through each blade of this breaker for 30 seconds without causing the breaker to open. This corresponds to an overload of more than 300% of normal. It is recommended that a breaker which will operate on lower current be provided.

(b) The intermediate frequency unit is provided with three overload relays, K-5, K-6, and K-7. Only relay K-5, bias rectifier, could be adjusted to trip at slightly more than normal current. Apparently the contact trigger of K-7, main plate overload, was set so tight that sufficient energy could not be produced to trip it.

(c) The high frequency unit is also provided with three overload relays, K-7, K-8, and K-9. These relays could be adjusted to operate in a satisfactory manner. However, in this connection it is desired to point out that the overload relays are of the dash pot type. Some of the relays bear a legend directing the use of oil while on other relays of a similar nature this legend has been blotted out. The use of oil adds a time delay to the operation of the relay and also tends to increase the value of current required to trip the relay. Instruction books and descriptive data should provide definite instructions as to whether oil is required or whether it should be omitted. Inspection of production models should insure that all overload relays can be adjusted to operate at slightly more than normal current.

(d) The a.c. and d.c. overload relays in the rectifier unit can be adjusted to operate satisfactorily.

(e) No overload protection is provided for the tubes in the modulator unit other than that provided by overload relay K-109 in the common return of the main plate rectifier. It is believed, however, that this relay is sufficient to protect the modulator tubes against any serious overload.

51. Par.2-11. As described in par.50 above, vacuum tube protective relays have been incorporated in this equipment. Both the intermediate frequency and high frequency units are provided with five second relays which open the keying circuit in the event the remote keys remain closed for more than five seconds.

52. Par.2-12. No access doors on the modulator rectifier unit, the intermediate frequency unit or the high frequency unit can be opened without removing power from the equipment. This is accomplished by means of suitable door interlocks, adequately insulated. The door interlocks function smoothly and are proof against vibration and shock. The speech input equipment is not provided with door interlocks since they are unnecessary in these locations due to the low voltages involved.

53. Par.2-13. The equipment is provided with perforated shielding in order to provide ventilation. This appears to be adequate in most cases. However, in the interest of safety it is recommended that the following changes be made:

(a) That the top shield above the 38149 modulator tubes in the modulator rectifier unit be perforated to provide additional ventilation as suggested in par.11-4 of ref.(1).

(b) That additional perforations be supplied in the top shield of the telephone power unit directly above the Rectox rectifier units as recommended in par.41 of this report.

54. Par.2-15. This paragraph requires that the equipment must be capable of operating for two hours locked key at full power without damage to any part.

(a) High Frequency Unit. See pars. 40 and 72 of NRL Report No. R-1087 covering Model TBK equipment for two hour locked key tests on CW operation. Since the requirement of MCW and phone operation has been added since the original tests of this unit, additional tests were conducted to determine the action of this equipment on phone and MCW. Table 1, appended hereto, lists the results of a test conducted with the telephone equipment at 100% modulation (negative peaks). The highfrequency unit was operated at 2,000 kilocycles and the modulating frequency of 400 cycles was introduced into the master monitor unit. No signs of overheating were detected at the conclusion of the test. Table 2 lists a test conducted with the high frequency unit operating on MCW. No overheating occurred during this test. However, during subsequent tests while percentage modulation investigations were being made the power amplifier plate choke L-15 became overheated and charred. Apparently this damage was the cumu-

lative result of a number of locked key tests. Investigation revealed that the inside terminal of the choke was connected to the r.f. side of the circuit. These connections were reversed and no further trouble was experienced. The charred choke was replaced by a representative of the manufacturer and no further difficulty was experienced from this source.

(b) Intermediate Frequency Unit. Table 3 shows the data collected during a two hour locked key test wherein the intermediate frequency unit was operated at 300 kilocycles, MCW. During this test it was noted that capacitor C-13 in the audio oscillator circuit became extremely hot and the audio frequency transformer in this circuit exuded wax. The temperature of this transformer had reached 105°C at the end of the test. In spite of this temperature rise the equipment continued to function. This condition, however, is considered unsatisfactory and the manufacturer should be required to correct it. As will be noted from Table 2, the audio transformer in the high frequency unit did not overheat during a similar two hour run. Table 4 lists a two hour test conducted at 300 kilocycles, CW. No overheating occurred during this test. Table 5 lists a two hour test conducted at 500 kilocycles, CW. During the first attempt to conduct this test the smallest coil of the three coil power amplifier plate choke L-4 overheated badly and the test at 500 kilocycles had to be abandoned. A representative of the manufacturer replaced this coil and the test listed in Table 5 was then conducted. At the end of this test the largest coil in the choke (low frequency end) was considerably hotter than the other coils although it continued to function. The manufacturer then replaced the entire choke coil with a new assembly and this coil performed satisfactorily on locked key operation. However, during temperature tests of the intermediate frequency unit at frequencies of 500, 1,000, and 2,000 kilocycles, when the key was locked for long periods of time, this replacement choke again showed signs of overheating, although it continued to function. The insulating covering of the wire became discolored due to the heat. It may prove necessary to provide two chokes in the P.A. circuit, one for the lower frequencies and another for the higher frequencies, to be selected by the range change switch, in case it is impossible to provide a single choke which will cover the entire range satisfactorily. As noted on Table 5 an examination of the charred coil indicated that the insulation of the wire may have been damaged during the winding process, which undoubtedly was a contributing factor to the failure. Table 6 shows the result of a two hour test at 2,000 kilocycles, CW. No overheating occurred during this test.

(c) Both the high frequency and intermediate frequency units were subjected to a keying test at 100 words per minute and no signs of brush discharge, corona, or arcing were noted.

(d) Modulator Rectifier Unit. This unit withstood the numerous two hour locked key tests, both CW and phone, without revealing any signs of overheating.

(e) The Master Monitor unit, telephone power unit and associated equipment withstood two hour tests without two hour tests without any damage resulting.

55. Par.2-16. See par.41 of NRL Report No. R-1087 for performance of high frequency unit when subjected to the antenna short circuited and open circuited test. Table 7 appended hereto shows the results of tests conducted in connection with the intermediate frequency unit at 2,000, 1,000, and 500 kilocycles. Although in some cases the power amplifier tube showed considerable plate temperature, no damage was incurred.

56. Par.2-17. The vacuum tubes incorporated in the equipment operate within the limits laid down in Navy Tube Specifications.

57. Par.2-19. This paragraph states "The design must fulfill the demand that the equipment operate successfully and without damage on a moving platform inclining up to 45° from the vertical in any direction and following the roll and pitch of a ship at sea in heavy weather." In order to simulate the conditions mentioned, a test stand was constructed at the Naval Research Laboratory upon which it is possible to mount the transmitting equipment and subject it to a roll of 45°. The test stand is provided with a turntable so that the equipment may be rocked from side to side or in a fore and aft direction. As described under par.58 of this report, the stand is so designed that it is possible to subject the equipment to vibration of various amplitudes and frequencies. Plates 24 to 29, inclusive, attached hereto, show various views of the TBN-2 equipment while installed on this test stand.

(a) Plate 24 is a view of the modulator rectifier unit and the intermediate frequency unit mounted on the test stand, with the movable platform of the stand in a horizontal position.

(b) Plate 25 is a view of the modulator rectifier unit and the intermediate frequency unit, with the platform inclined 45° to the left.

(c) Plate 26 is a view of the modulator rectifier unit and the intermediate frequency unit, with the platform inclined 45° to the right.

(d) Plate 27 is a view of the high frequency unit, master monitor unit, telephone power unit (barely visible behind the transmitter), one station control unit and one station extension unit mounted on the test stand with the platform in a horizontal position. The modulator rectifier unit is visible to the right of the test stand.

(e) Plate 28 is a view of the high frequency unit and associated telephone equipment inclined at an angle of 45° to the left.

(f) Plate 29 is a view of the high frequency unit and associated telephone equipment inclined at an angle of 45° to the right.

57-A. It will be noted that in all cases the heavy units of equipment; namely, the rectifier modulator, the intermediate frequency and the high frequency unit were supported by guy rods secured to the four top corners of the equipment through the medium of a welded steel frame. In addition, the equipment was bolted to the test stand by means of the mounting holes provided in the pedestals of the various units. The associated telephone equipment was secured to the test stand by means of the regular securing bolts provided with the equipment, no additional supports being provided. The intermediate frequency unit was tuned up to full power at a frequency of 1,000 kilocycles and was operated into a regular outdoor antenna. The flexible antenna lead can be seen in Plates 24, 25, and 26. The high frequency unit was operated, full power, at 2,000 kilocycles, both CW and voice. A low resistance lamp load was substituted for the antenna.

57-B. The equipment was subjected to the 45° roll for a period sufficiently long to observe frequency effects, operation, and quality of the emitted signal. It should be stated that the test stand operates at a speed of approximately five cycles per minute. The following results were noted:

(a) Intermediate frequency unit and rectifier modulator unit. No mechanical failures occurred in either unit and the quality of the emitted signal was not affected. The only noticeable effect was a slow frequency change of about 40 cycles (in 1000 kilocycles) corresponding to the period of oscillation of the test stand.

(b) High frequency unit - CW operation. No mechanical failures occurred during this test. A slight frequency change of about 30 cycles (in 2000 kilocycles) was noted corresponding to the period of oscillation of the test stand. A slight roughness of the emitted signal was noticeable for a second or so just as the test stand completed the roll to the left. This disturbance was of such a minor nature as to be practically negligible.

(c) High frequency unit - Phone operation. No mechanical failures occurred during the test nor was it possible to detect any frequency variation or changes in the emitted signal which could be attributed to the rolling of the equipment. The voice retained the same quality as emitted with the equipment at rest in the horizontal position.

58. Par.2-20. The test stand shown in Plates 24 to 29 inclusive is so arranged that the equipment mounted upon it may be subjected to vibration of various periods and amplitudes. Plates 26 and 29, which give a partial view of the underside of the stand show the variable speed motor, pulley and belt arrangement and the eccentrically weighted fly wheel by means of which the vibrations are produced and regulated.

(a) Intermediate frequency and rectifier modulator unit. The intermediate frequency unit was operated at a frequency of 1,000 kilocycles, full power output. The equipment was subjected to vibrations of varying degrees of amplitude and frequency for a total time of about one hour. During the test the natural period of various units in the equipment such as the flexibly mounted tube racks, keying relay, etc., was found and this period was maintained for several minutes in order to determine whether injury or

breakage would result. The test showed that low frequency vibrations of very considerable amplitude had no noticeable effect upon the emitted signal of the transmitter. Only when the frequency of vibration became very high was a roughness introduced into the emitted signal and at no point in the test was the signal influenced sufficiently to interfere with solid copy. No physical damage resulted from this vibration test.

(b) High frequency unit - CW operation. The test was conducted in a manner similar to that described under sub-paragraph (a) above. The transmitter was tuned to 2,000 kilocycles and at no time did the vibration interfere with solid copy nor did a post trial inspection show any damage to the equipment.

(c) High frequency unit - Voice operation. The equipment was operated at a frequency of 2,000 kilocycles. During the vibration tests of the voice modulated equipment it was possible to detect the influence of vibration but it in nowise rendered the speech unintelligible. The vibration made itself felt as an additional modulation of low intensity. However, during one period of this test a high level of a.c. hum became apparent which did interfere with reception. Finally, as the test continued the modulated output disappeared entirely. Inspection of the telephone power unit revealed that a one ampere fuse in the primary of the plate transformer which provides the plate potential for the 38056 line amplifier tubes in the master monitor unit had become open circuited. Investigation showed that this fuse had not burned out but that the small fuse wire had vibrated loose, thus making intermittent contact and developing the high noise level noted during this portion of the test. When the defective fuse was replaced normal operation was again secured. The results of this test indicate that intelligible speech may be obtained in the presence of severe vibration, provided that the noise, if any, produced by this vibration does not impinge directly upon the microphone and that all units in the equipment are in first class operating condition. No breakage of wires took place and no loose connections, other than that noted above in connection with the fuse, were observed. In this connection it should be pointed out that the microphone used for energizing the voice equipment was located in a sheltered booth about 75 feet distant from the transmitter so that the noise could not affect the microphone. Both the regular type carbon microphone and the special dynamic type microphones were used during this test. As far as vibration was concerned the results were similar.

59. Par. 2-21. All vacuum tubes in the intermediate unit, high frequency unit and rectifier modulator unit have been cushioned against the effects of vibration and shock through the medium of flexible mountings. The key relay in the intermediate frequency unit has also been cushioned by means of "Lord" mountings. (See par.45 of NRL Report No. R-1087 for further details relative to flexible mountings in the high frequency unit.) Tubes in the master monitor unit and in the telephone power unit have been provided with cushion type sockets.

60. Par. 2-22. The design and control of the circuits employed in the high frequency unit, intermediate frequency unit, and the rectifier modulator unit are considered to be the simplest possible within the requirements of the governing specifications. It is believed that some simplification of the

controls of the speech input equipment may be realized and a discussion of these factors will be found under appropriate headings when discussing Section III-A of the governing specifications.

61. Par. 2-23. All necessary controls and indicating devices are located on the front panels of the equipment and are suitably marked for identification and operation. It is recommended, however, that the modulator volume control R-121 located on the front panel of the modulator rectifier unit be provided with a dial and pointer, in order that this control can be reset to a predetermined point. Certain changes in the markings and controls of the speech input equipment are offered for consideration in the interests of greater simplicity and these will be discussed under Section III-A of Specifications RE 13A 497A.

62. Par.2-24. All control shafts and bushings have been grounded or insulated for the protection of personnel.

63. Par.2-25. All electrical indicating instruments used in the equipment are of the 3.5 inch diameter, flush type, with bakelite case. Voltmeters employing external multipliers have a sensitivity of 1,000 ohms per volt. The instruments supplied were checked against precision type instruments and were found to comply with the specification requirements of 2% accuracy. (A discussion of the percentage modulation meter and the level indicators in the speech input equipment will be found later in this report under Section III-A of the specifications.) Meters are so mounted that it is possible to substitute replacement meters of the same nominal size, although in the case of certain meters it would be necessary to change the formation of the wiring.

64. Par.2-26. Appropriate nameplates have been affixed to all major units.

65. Par.2-30. The controls of the Model TBN-2 equipment comply with this requirement of the specifications in that the values of settings increase numerically or alphabetically with the final controlled effect.

66. Par.2-31. Sufficient tolerances have been provided for the ready replacement of tubes. However, access to the power amplifier tube will be improved if the flexible lead connecting between the key relay K-1 in the intermediate frequency unit and the antenna tuning inductance is raised an inch or two to prevent it from becoming grounded.

67. Par.2-32. The weights of the various units comprising the Model TBN-2 equipment are listed in Table 8. The specifications allow a total weight of 3350 pounds for Class 2345-A equipment, exclusive of the speech input equipment. The weight of these units as submitted is 2820 pounds. The specifications state that the total weight for the speech input equipment for a four-channel system shall not exceed 400 pounds. Reference to Table 8 reveals that the total weight of the master monitor unit, telephone power unit, five station control units and 16 station extension units is 835.5 pounds. Bureau of Supplies and Accounts letter NOs-38614(SPM) of 5 March 1935 to Contractor authorized an increase in weight of 475 pounds.

68. Par.2-33. Any single unit of the TBN-2 equipment is capable of passing through a door 26" wide by 66" high and through a hatch 60" long by 30" wide.

69. Par.2-34. The equipment operated satisfactorily when subjected to the power supply variations listed in par.6-3 of the specifications.

70. Par.2-35. All resistor mountings were not marked with Navy Type Number designation nor with the value of resistance. However, since the equipment under test is a preliminary model, the manufacturer was undoubtedly awaiting formal approval before applying these markings. All items are marked with the symbols by which the item is identified in the wiring diagram, with the exception of the tube socket of the 38110 tube in the modulator rectifier unit. It is recommended that this socket be clearly marked to indicate the type of tube.

71. Par.2-36. The design of the shock proof mountings is such that a minimum amount of assembly is necessary in order to replace worn out rubber members.

72. Par.2-37. It is possible to maintain filament potentials at the normal value when the line voltage supply varies $\pm$ 5%.

73. Par.2-38. Lifting devices have been installed in each of the four top corners of the heavy units in order to facilitate hoisting and lowering of the equipment. The manufacturer submitted a sample lifting device which he intends to utilize in the production equipment. This sample device is exceedingly rugged and well designed and it is recommended that this method of construction be approved for the production models. Nameplates have been secured to the side shields near the top to indicate the position of the lifting devices.

74. Par.2-39. The front panels of the transmitters and rectifier modulator unit have been finished with a durable black wrinkle finish. The other external surfaces have been finished with a flat black coating. The master monitor unit and the telephone power unit are finished with black wrinkle finish while the station control units and station extension units are painted with battleship gray.

75. Par.3-1. The design and construction of the equipment is such that two transmitter units are supplied, one for intermediate frequency operation and the other for high frequency operation. Each unit consists of a single mechanical assembly of the dimensions listed in Table 9.

76. Par.3-3. The equipment is so constructed that either transmitter unit may be operated from a common power supply, although both transmitters cannot be operated simultaneously. This transfer of power is accomplished through the medium of a single four position switch located in the modulator rectifier unit. The positions on this switch are marked as follows:

Pos. No. 1 - HF Trans. CW - MCW
Pos. No. 2 - HF Trans. Phone
Pos. No. 3 - Rectifier Test
Pos. No. 4 - Intermediate Freq. Trans.

Thus it will be seen that an additional position was incorporated into this switch over and above the suggested number of positions contained in the Contract Note, page 2. The additional position was required by virtue of the fact that different potentials are required for voice operation of the H.F. unit than those required for CW operation.

77. Pars.3-4 to 3-9 inclusive. The equipment as supplied meets the general requirements of these paragraphs of the specifications.

78. Par.3-10. The emitted signals produced by both the intermediate frequency and high frequency units are free from lilt and undesirable modulations. The harmonics and key clicks present are of about the same magnitude as noted in other equipments of similar design and power. That key clicks of very considerable amplitude or intensity are produced by conventional methods of keying is a well known fact and a method of eliminating this form of interference was reported to the Bureau in NRL Report No. R-1135 of 13 March 1935. The anti-click keying unit described in this report was used in connection with the intermediate and high frequency units of the Model TBN-2 equipment and the results obtained are illustrated in Plate 38 appended hereto. It is a simple matter to adapt the anti-click keying unit to either transmitter since only a few interconnections are required. When the anti-click unit is employed the interference caused by keying operations in nearby receivers virtually disappears. Fig.1 in Plate 38 is an oscillogram of a keyed character (a single dot) as produced by the normal method of keying in the intermediate frequency unit. Fig.2 shows the resulting key click in a Model RAB receiver tuned slightly off resonance. Fig.3 is the dot produced when using the anti-click keying unit and Fig.4 is an oscillogram taken under the same conditions of sensitivity and tuning as Fig.2. It will be noted that the key click has entirely disappeared. Fig.5 shows a dot produced by the regular keying system of the high frequency unit; Fig.6 is the key click resulting from this method of keying; Fig.7 shows a dot produced by the anti-click keying unit and Fig.8 shows the degree of interference diminution obtained with the keying unit. The keying tests illustrated were made at a speed of 100 words per minute but similar results are obtained at speeds lower than this. These tests indicate that a very decided improvement results when the anti-click method of keying is employed.

79. Par.3-11. Neutralization has been employed in the Model TBN-2 equipment to the extent necessary to insure satisfactory operation.

80. Par.3-12. Both the intermediate frequency and high frequency transmitter units have front panel controls by means of which the frequency is continuously variable within the limits specified.

81. Par.3-14, 3-15, 3-16. The frequency range of both units is divided into several bands by means of range selector switches.

(a) Intermediate Frequency Unit. Table 10 lists the controls provided on the front panel of the intermediate frequency unit, together with the control designations. Where required, the controls are fitted with interlocks to remove power from the equipment while these controls are being changed. Table 11 lists the control designations as supplied with the intermediate frequency unit together with a list wherein certain changes are suggested in order to make the sequence of letters agree more nearly with the order in which the controls would be adjusted. It is recommended that the marking of the controls be changed to conform with this latter list. The dials of the antenna tuning inductance controls are colored black and red. When the control is set on the black it indicates that the Litz coils are in the antenna circuit, while the red indicates that the solid wire tuning inductors are being utilized. The Litz coils are used at the low end of the frequency range while the solid conductor coils are used at the high end of the frequency range. Antenna coupling switch "F" (Coarse) is not provided with a stop on the lower end. Therefore, if this switch is thrown to the extreme left position the interlock remains open and the set is inoperative. A stop should be provided to overcome this defect.

(b) High Frequency Unit. Table 12 lists the controls provided for the operation of the high frequency unit.

82. Par.3-17. A calibration card, under a transparent non-breakable, waterproof shield is mounted on the front panel of both the intermediate and high frequency units. On the intermediate frequency unit provision has been made for 12 frequencies, while on the high frequency unit provision has been made for 10 frequencies. This latter discrepancy is undoubtedly due to the fact that the high frequency unit was originally constructed under Specifications RE 13A 442D which required the calibration card to accommodate only 10 frequencies. In order to make provision for 12 frequencies it will be necessary to increase the size of the calibration card holder.

83. Par.3-18. It is possible to shift from one frequency to any other frequency, or from one type of emission to another, without readjusting the voltages. Such voltage variations as are necessary are taken care of automatically by the controls in question.

84. Par.3-19. A three position switch has been incorporated in both the intermediate and high frequency units to facilitate frequency shifting and to reduce interference. These switches operate as follows:

Step 1 - Plate potential is removed from power amplifier.
Step 2 - Plate potential is reduced on power amplifier.
Step 3 - Full operating potentials are applied to all tubes.

As these switches are operated the actual voltage present on the power amplifier tube is indicated by the plate voltmeters on the panels of the transmitter units. Table 13 lists the frequency changes resulting from the operation of the Tune-Operate switch when the intermediate frequency unit was adjusted to various output frequencies within the range of the transmitter.

In the opinion of the Laboratory the action of the intermediate frequency unit is satisfactory from this viewpoint. The action of the tune operate switch of the high frequency unit will be discussed later in this report under the heading of par.3-7-4 of Specifications RE 13A 442D.

85. Par.3-20. A suitable three position test key has been provided on both transmitter units to comply with the requirements of this paragraph. The five second drop out relay is inoperative when the local test key is in the closed position.

86. Par.3-21. The verniers supplied with this equipment comply with the requirements of positive gearing.

87. Par.3-22. Both transmitter units have been provided with suitable friction type locking devices on all continuously variable controls. These locks operate in such a manner that they have little or no effect upon the frequency and are designed so that they do not interfere with tuning operations.

88. Par.3-23. It is possible to adjust either the intermediate frequency unit or the high frequency unit for proper operation in one man minute within the limits of accuracy specified. The equipment is not provided with adjustable positioning devices and in the opinion of the Laboratory there is no need for such devices.

89. Par.3-24. The Contract Note, which forms part of the governing specifications under which this equipment was constructed, provides that the intermediate frequency unit comply with par.3-24 of RE 13A 497A with respect to frequency stability requirements while the high frequency unit shall comply with par.3-7 of Specifications RE 13A 442D. Furthermore, as stated in par.33 of this report, only such tests were conducted with the high frequency unit on CW operation to insure that the equipment had undergone no marked changes since the time of its original test as part of the Model TBK equipment.

90. Par.3-24-2. Intermediate Frequency Unit. The reset accuracy of this unit was tested at 500, 1,000, and 2,000 kilocycles and the results of these tests are listed in Table 14. It is possible to reset all the controls necessary for shifting frequency within one man minute. The maximum frequency change noted during these tests was 160 cycles when operating at 2,000 kilocycles. Table 15 lists the results of tests conducted to determine the degree of backlash present in the master oscillator control. The results of these tests are considered satisfactory, since most of the frequency error resulting from backlash may be avoided by always approaching a given setting from the same direction.

91. Par.3-24-3. Tests were conducted to determine the effect of variation of temperature upon the emitted frequency of the intermediate frequency unit.

(a) Tables 16 and 17 and Plates 30 and 31 show the results of tests conducted at 500 kilocycles wherein the temperature was varied between the limits of zero and 50° C; Tables 18 and 19 and Plates 32 and 33 show similar information at 1,000 kilocycles while Tables 20 and 21 and Plates 34

and 35 cover similar test at 2000 kilocycles. Table 22 contains a summary of the results obtained during all of the temperature tests of the intermediate frequency unit.

(b) As these tests progressed it was noted that there appeared to be a distinct relation between the percentage of relative humidity and frequency. This effect will be noted on Plate 30 at 1220. The humidity was permitted to rise rather suddenly and a noticeable drop in frequency was noted almost instantly. Similar effects, although of a less pronounced degree will be noted on Plate 32 and 34. As a result of these observations it was decided to conduct a test wherein the temperature was held constant and the humidity was varied through wide limits. The results of this test will be discussed below.

(c) Another phenomenon was noted during the course of these temperature tests. The six tests listed in Tables 16 to 21, inclusive, were conducted in the following order:

(1) 500 kilocycles, 25 to 50
(2) 500 kilocycles, 25 to zero
(3) 1000 kilocycles, 25 to 50
(4) 1000 kilocycles, 25 to zero
(5) 2000 kilocycles, 30 to 50
(6) 2000 kilocycles, 30 to zero

Each test consumed practically an eight hour day; thus at the end of the test period the test room was left at a temperature of either zero or 50°. After the test the doors of the test room were opened, the heating and refrigerating equipment shut down and the temperature in the test room permitted to seek the normal level. When the cold room was permitted to drift back up to normal temperature there was a decided tendency for water to condense upon the equipment under test. At the end of the 1,000 kilocycle test at zero degrees, particularly, the high humidity prevailing caused the entire equipment to become saturated so that the transmitter and rectifier unit were literally dripping water and it was necessary to run the test room at a high temperature to dry out the apparatus in addition to blowing the water out by means of compressed air. The various parts of the equipment being saturated to some degree made it difficult to obtain absolute frequency equilibrium in an hour. Thus, it is believed that the larger frequency shifts and the erratic nature of these shifts noted in Tables 18 and 20, were not entirely due to temperature changes but due to the fact that parts of the frequency establishing circuit of the transmitter still contained appreciable amounts of moisture.

(d) Plate 36 illustrates the results of a test conducted with the intermediate frequency unit at 2,000 kilocycles to determine the effect of humidity. The temperature was held substantially constant at 35°C and the percentage of relative humidity was varied between the limits of 20 to 100%. It will be noted that the frequency varied inversely as the humidity once the relative humidity exceeded 40%. It is interesting to note that the effect of a change in humidity upon the frequency is practically instantaneous, there being no appreciable lag as is the case in temperature changes. In fact, the results of these tests indicate that undoubtedly some

of the frequency shifts attributed to temperature are probably due to changes in humidity. The amount of water vapor in the atmosphere varies greatly with temperature and if no effort is made to control this factor it will influence the frequency. It may further be noted that the master oscillator circuit of the intermediate frequency unit contains no variable air condensers, the circuit being tuned by means of a variometer. Hence it appears that the presence of water vapor tends to increase the inductance of the circuit, or affects the resistance in such a manner as to cause a decrease in frequency, or both.

(e) Plate 37 illustrates the results of a test conducted with the high frequency unit, at 2000 kilocycles, to determine the effect of humidity. The temperature was held constant at approximately 35° C and the percentage of relative humidity was varied between the limits of approximately 20% and 100%. The resulting curve possesses the same characteristics as the curve shown in Plate 36 covering the intermediate frequency unit. However, the change in frequency is decidedly less in the case of the high frequency unit. Whereas the intermediate frequency transmitter changed approximately 800 cycles the high frequency unit changed only 40 cycles for the same range of relative humidity. Stated in percentage values, the intermediate frequency transmitter changed 0.04% while the high frequency transmitter changed 0.002%. Thus it will be seen that the use of a temperature controlled master oscillator aids greatly in minimizing the effects of humidity. It may also be possible that the electron coupled oscillator employed in the high frequency unit plays some part in this matter.

(f) During the humidity tests the speech equipment, including the modulator unit, master monitor unit, telephone power unit, station control unit, and station extension unit, were also subjected to the range of humidities encountered; namely 20% to 100% at 35°C (95 F.). The speech equipment was checked at short intervals from the various control points and it was found that the equipment functioned normally without any evidence of breakdown. Thus it appears that the entire TBN-2 equipment is capable of continuous operation when subjected to conditions of high humidity.

92. Par.3-24-4. Intermediate Frequency Unit. Variation of supply line voltages. The supply line voltage was varied between the limits of 418 and 462 volts; i.e. ± 5% of 440 volts. Table 23 shows the results of tests conducted at 500, 1,000, and 2,000 kilocycles. The maximum frequency change encountered was 90 cycles at 2,000 kilocycles for a 1% per minute change, while a rapid change in voltage resulted in a frequency change of 20 cycles at 2,000 kilocycles.

93. Par.3-24-5. Intermediate Frequency Unit. Variation in antenna constants. Table 24 lists the results of tests conducted at 500, 1,000 and 2,000 kilocycles to determine the frequency change resulting from a 25% variation in antenna constants. The maximum frequency change encountered was 17 cycles at 1,000 kilocycles. This table also lists the frequency changes resulting from detuning the power amplifier circuit.

94. Par.3-24-6. Intermediate Frequency Unit. Control of Power Output. Table 25 lists the results of tests conducted wherein the power output of the transmitter was varied by means of the rectifier tap switch. The maxi-

mum frequency change noted at 500 kilocycles was 93 cycles; at 1000 kilocycles, 84 cycles; and at 2,000 kilocycles, 100 cycles. It should be noted that the power actually varied between the approximate limits of 117% and 11%.

95. Par.3-24-7. Intermediate Frequency Unit. Change of Vacuum Tubes. Table 26 lists the results of tests conducted to determine the change in frequency resulting from changing tubes in the master oscillator and power amplifier circuits. These tests were conducted at 500, 1,000, and 2,000 kilocycles and it will be noted that the largest variation was 171 cycles for the master circuit at 1,000 kilocycles and 164 cycles for the power amplifier at 2,000 kilocycles.

96. Par.3-24. Summary. Intermediate Frequency Unit. A summary of the results of the tests conducted under the terms of par.3-24 is shown in Table 27. It will be noted that at 1,000 and 2,000 kilocycles, the frequency variations caused by the several factors exceed the specification requirements. In this connection, however, it should be observed that the values used for changes in ambient temperature are those which, as pointed out in par.91 of this report, appeared to be abnormal due to the presence of large amounts of moisture. If more normal values are inserted in Table 27, such as approximately 90 cycles change at 1000 kilocycles and 125 cycles at 2,000 kilocycles, the equipment complies with the specification requirements. Since the conditions which caused the large frequency changes listed in Tables 18 and 20 are the results of abnormal conditions which are not likely to be met with in nature, it is the opinion of the Laboratory that these abnormal figures should be excluded. If this is permitted the equipment complies with the specification requirements as listed in par.3-24 of the governing specifications.

97. Par.3-7 of Specifications RE 13A 442D. Tables 28, 29, 30, 31, and 32 show the results of tests conducted with the high frequency unit.(For complete details see NRL Report No. R-1087 on TBK equipment.) The results of the frequency stability tests showed that the equipment complies with the requirements of the governing specifications. Attention is invited to the fact, however, that upon receipt of the equipment, tests conducted in conformity with pars.3-7-5 and 3-7-6 of Specifications RE 13A 442D gave results inferior to those obtained when this equipment was tested as a part of the Model TBK equipment, although they still conformed with the specifications. An effort was made to determine the reason for this divergence of results and inspection finally revealed that the leads which carry the a.c. current to the master oscillator compensating transformer had become broken. Apparently these flexible leads were too short to permit full movement of the flexibly mounted master oscillator compartment. After this circuit had been re-established the results obtained were somewhat better than the original results but not as good as the results obtained with the TBK equipment. The adjustment of the compensating condenser was changed in an effort to improve operation and some improvement resulted when the condenser was set at maximum. The indications were that a larger condenser would improve the results. The smallest frequency change noted when tested in accordance with par.3-7-5 (filament not lighted) was 125 cycles, while the largest change noted in the TBK tests under similar conditions was 47 cycles at 4500 kilocycles. It is recommended that the

attention of the manufacturer be called to the results of these tests in order that he may investigate the cause for this discrepancy and correct same. The metallic strip by means of which the master oscillator compartment is grounded to the frame of the transmitter is of such an inflexible nature that it interferes with the free movement of this unit. It is recommended that a more flexible grounding strip be provided.

98. Par.3-25. Both the intermediate and high frequency units are equipped to work break-in and tests show that this feature operates satisfactorily. No signal is emitted when the key is open.

99. Par.3-26. It is possible to vary the power output of both the intermediate and high frequency units from the maximum value specified to a minimum value of less than 25%. See Table 25 appended hereto for details of this test on the intermediate frequency unit and Table 41 for test of the high frequency unit. The power output of both units is varied through the medium of a seven point tap switch located on the modulator rectifier unit.

100. Par.3-27. Suitable indicator lights have been provided on the panel of the various units in conformity with this paragraph of the specifications and in accordance with par.3-26 of Specifications RE 13A 442D for the high frequency unit. Table 33 appended hereto lists the number, color, and purpose of the various lights provided. The lamps can be replaced with ease and are satisfactory in the presence of severe vibration and shock.

101. Par.3-28. The electrical indicating instruments supplied with the Model TBN-2 equipment comply with this paragraph of the specifications. Table 34 appended hereto lists all the instruments supplied on the panels of the modulator rectifier unit, the intermediate frequency unit and the high frequency unit.

102. Par.3-29. Both the intermediate frequency and high frequency units are equipped with filament life meters of the self starting type, with dials which are capable of recording 10,000 hours.

103. Par.3-30. The intermediate and high frequency units are completely shielded both externally and internally. The r.f. connections are made with nickel plated copper tubing while other connecting leads are of the lead sheathed type, securely bonded together and grounded at frequent intervals. Protective buffers of heavy, black felt are provided at locations where damage is likely to occur to the lead sheath. The wiring reflects excellent workmanship, has been carefully laid out and good quality material has been used.

104. Par.3-31. All electrical indicating instruments, with the exception of self-contained radio frequency meters, in the modulator rectifier, intermediate frequency and high frequency units have been protected against stray radio frequency fields by being by-passed with 0.006 mfd capacitors Type 4-A Dubilier, rated at 1,000 volts.

105. Par.3-32. All filament transformer primaries are designed for use on either 110 or 220 volts. As furnished, the primaries are operating at 220 volts. No overheating of these transformers was detected during key locked operation.

106. Par.3-33. All transformers are equipped with suitable terminal boards and the terminal posts are marked to indicate their function.

107. Par.3-34. No undue variation of filament voltage occurs when the transmitter is keyed. Tests showed that under full power keying loads the filament potential varied approximately 1.0 %.

108. Par.3-35. The equipment is so constructed that:

(a) Modulator rectifier, intermediate frequency and high frequency units may be installed with the back flush against a bulkhead.

(b) The three units are provided with foundation pedestals of four inch channel, which may be bolted to the deck for security.

(c) All terminal connections may be effected at accessible terminal panels located near the bottom of the units and protected behind interlocked hinged access doors. The terminal panels in the modulator rectifier and high frequency units are 7 inches above the deck while that in the intermediate frequency unit is 6-1/2 inches above the deck level.

(d) The renewal of tubes can readily be accomplished through access doors in the front panels. As noted previously in par.66 of this report, a slight modification of the wiring should be made in the intermediate frequency unit to permit the ready removal of the power amplifier tube. In addition, the audio oscillator tube in the high frequency unit should be moved slightly forward to increase clearance, as suggested in par.10-6, page 12 of ref.(1).

(e) The keying relay in the intermediate frequency unit is accessible from the front through the tube access door. The keying relay of the high frequency unit projects through the top front panel and is protected by a metal cover provided with a glass vision opening.

(f) Antenna connections are made through circular openings in the top shields to rugged, insulated terminals within the transmitter units.

109. Pars. 3-36, 3-37, and 3-38. The side and rear shielding of the rectifier modulator, intermediate frequency and high frequency units are secured by means of non-removable knurled head screws. Slotted holes in the shields permit ready removal of the shields when the knurled head screws are backed off. The only access doors are on the front panel of the various units and they are of the hinged type secured by means of rugged, insulated knobs or latches. All large doors are provided with two latches and the hinges are of the full length piano type. All doors are provided with stops to prevent injury to the hinges.

110. Par.3-39. The design of the intermediate frequency transmitter unit complies with the requirements of this paragraph of the specifications.

111. Par.3-40. Tables 35 and 36, appended hereto, show the results of test conducted to determine the power output of the intermediate frequency unit transmitter when operating into antennas of the constants indicated. It will be noted that in all cases the equipment complies with the requirements of the specifications and the values guaranteed by the manufacturer in ref.(e), with the exception of the operation obtained at 300 and 500 kilocycles. On these two frequencies the required value of 700 watts output could not be obtained in low resistance low capacity antennas. A slight increase in antenna resistance and capacity permits the required output to be obtained. At the higher frequencies the output obtained exceeds the specified values by as much as 50%.

112. Par.3-41. Table 37,appended hereto, covers the results of tests conducted to determine the operation of the intermediate frequency unit on MCW. It will be noted that in all respects the equipment complies with the requirements of the specifications, regarding power output, percentage of modulation, and frequency of modulation. However, as pointed out in par.54-b of this report certain portions of the audio oscillator circuit; namely, capacitor C-13 and the audio frequency transformer, overheated. Steps should be taken to correct this condition. Table 40, appended hereto, lists the results of tests conducted to determine the operation of the MCW feature of the high frequency unit. The operation of this unit complies with the specifications and no signs of overheating or defective operation were noted.

113. Par.3-42. The results of the frequency stability tests conducted in accordance with the requirements of par.3-24 of Specifications RE 13A 497A are summarized in Table 27 and details of the tests are discussed in pars. 90, 91, 92, 93, 94, 95, and 96 of this report.

114. Par.3-43. The design of the transmitter units is such that all tubes cease to oscillate when the key is up and satisfactory keying is obtained at any rate up to 100 words per minute. (See Plates 20 to 23 inclusive for oscillographic keying records at various speeds.

115. Par.3-44. Verniers have been provided on all tuning controls, except step by step controls, by means of positive gearing. This paragraph requires that in the master oscillator circuit the vernier shall be of such a ratio as to provide for a variation of the resonant frequency per division of marking of not more than 0.025 nor less than 0.01 of 1% of any frequency to which the circuit is tuned. Examination of Table 38

reveals the fact that at no place in the frequency range is the figure of 0.025% exceeded. However, in several places in the range the variation per division of marking is less than 0.01%. It is pointed out, however, that the arrangement provided permits of a smooth variation of frequency; that the variation of frequency can be made rapidly so that the entire transmitter may be adjusted to a predetermined frequency in less than one man minute and that the smaller change in frequency per division of marking in nowise interferes with the operation of the equipment. It is recommended that the variation provided be considered as entirely satisfactory. The width of the smallest division of marking is 0.08".

116. Par.3-45. The Contract Note deletes this paragraph and substitutes therefor paragraph 3-1 of Specifications RE 13A 442D with the additional proviso that the equipment incorporate one Type 38160 tube in a suitable audio oscillator stage. The high frequency unit as submitted complies with this amended specification.

117. Par.3-46. For complete power output details see Tables 4 and 5 in NRL Report No. R-1087 covering Model TBK equipment. Additional power output tests were conducted to insure that any changes made in the high frequency unit had not adversely affected the operation. The results of these tests are listed in Table 39 appended to this report. It will be noted that the power output is in agreement with the specification requirements and agrees closely with the data reported in Report No. R-1087. Suitable provision has been made to permit voltage or current feed of antennas.

118. Par.3-47. Par.3-14 of Specifications RE 13A 442D was substituted for this paragraph. The high frequency unit complies with the specifications as amended. A complete list of controls contained in the unit will be found in Table 12 appended hereto.

119. Pars.3-48, 3-49, 3-50, 3-51, and 3-52 were deleted by the contract note due to the substitution of the electron coupled oscillator for the crystal control oscillator circuit.

120. Pars.3-53 and 3-54. (Par.3-8 of Specifications RE 13A 442D was substituted for par.3-53.) The high frequency unit complies with the amended specifications.

121. Pars.3-55, 3-56, and 3-57 are deleted by the Contract Note.

122. Par.3-58. Par.3-7 and 3-19 of RE 13A 442D were substituted for this paragraph. See NRL Report No. R-1087 for data.

123. Pars.3-59 and 3-60. Pars. 3-17 and 3-12 of Specifications RE 13A 442D were substituted for these paragraphs. See NRL Report No. R-1087 for complete details.

124. Par.3-61. Tests conducted showed that none of the rotating machinery used in the construction of the Model TBN-2 equipment created interference in nearby receivers.

cuits. This is accomplished through the medium of "T" type attenuators and level indicators, each transmitter and receiver channel being supplied with its own individual attenuator and level indicator. This equipment is located in the master monitor unit. The attenuators have a range of 22 db and are variable in 11 steps of approximately 2 db each.

(b) The equipment is so designed that the signal level (received speech signals) remains substantially constant regardless of the number of receivers connected for radio reception. With only one head set connected into the circuit at the master monitor location, a signal was tuned in and adjusted to a satisfactory level. A load simulating 9 additional head sets (approximately 127 ohms) was then thrown in parallel with the head set in use. No diminution in signal level could be detected. With a signal of such low level that it could barely be read when using a single head set, the addition of the 127 ohm load reduced the volume by an almost imperceptible amount. The equipment is so designed that whenever a headset or hand set is withdrawn from the circuit an equivalent 600 ohm load is automatically switched into the circuit thus keeping the total load constant.

(c) A test was conducted which simulated the condition which would prevail if 4 channels were modulated by a single microphone. The speech level remained substantially constant regardless of whether 1, 2, 3 or 4 channels were in operation.

(d) The requirement that constant level be maintained regardless of the number of microphones connected to the same transmitter is not complied with in an automatic manner. Reference to Table 42 reveals the fact that the introduction of a second microphone into a given circuit causes the level to drop between 3 and 4 db. Switching additional microphones into the circuit would cause corresponding drops in the level. It should be understood, however, that it would be possible for the operator at the master monitor station to correct the level by means of the proper attenuator. Thus, means are provided for maintaining a constant level, although this adjustment requires manual control. It may be pointed out that the variation in level caused by the use of additional microphones is of an order of magnitude equal to that which would be encountered in the speech of various individuals or in the speech of the same individual if he moved his microphone slightly while speaking. Table 42 shows also that the same audio potential applied at various stations results in different levels. As will be noted, a drop of about 4 or 5 db resulted between the master monitor unit and the station control and extension units. The station control units were connected to the master monitor unit through about 25 feet of cable.

130. Par.3A-5. Tests were conducted wherein the high frequency transmitter and one or two receivers were operated on the same frequency without encountering around the circuit howls. In this connection it is pointed out that the complete 4 channel equipment was not available for these tests.

131. Par.3A-7. The master monitor unit has provision for four radio and five interphone channels. The unit is designed for desk mounting and all operating controls are mounted on the front panel with the exception of the antenna potentiometers which are accessible through the door in the top of the unit. The construction of the unit is sufficiently rugged with

the exception of the strength of the front panel and the means for securing this panel as pointed out in par.40 of this report. Suitable provision has been made for connecting cables from the four receivers, five station control units and the transmitter control lines as well as connections to the associated power units. Satisfactory provision has been made for connecting four antennas with four receivers. The antenna connections and associated gear is contained in a separate unit which may be withdrawn from the master monitor. This unit contains jacks and patching cords by means of which any desired combination of antennas and receivers may be obtained. Provision has been made for securing the cables where they enter the master monitor in the rear of the unit.

132. Par.3A-8. Suitable connections have been provided for the antennas and grounds on the rear of the unit and the multiple jacks and patching cords referred to in the preceding paragraph give the equipment the necessary flexibility with respect to the antennas and receivers used.

133. Par.3A-9. The meters and controls provided have been symmetrically arranged with respect to the circuits affected. The interphone controls are located along the bottom of the front panel, separated from the radio controls as far as the physical dimensions of the unit permit.

(1) Four output level indicators have been provided, one for each channel or receiver. The damping of these meters appears to be satisfactory for this application, although meters of a similar nature have been tested at this Laboratory which were provided with a greater damping factor. The range of the meter extends from -10 db to +6 db with the zero level at 6 milliwatts. A range switch has three positions which extends the range of the instruments from -20 db to +16 db. This range switch gives the following ranges:

Position	Range
-10	-20 to -4
0	-10 to +6
+10	0 to +16

The Contract Note (page 9) indicates that a two position range switch should be provided. The three position switch, however, permits the use of a less restricted scale and it is recommended that the use of the three position switch be approved. In this connection, it is pointed out that the meter in Channel B sticks at mid scale reading. Inspection of the production models should insure that all meters work freely over the entire range. Tests show that the operation of the range switches have no noticeable effect upon the output level of the receivers.

(2) Four antenna potentiometers have been provided for adjusting receiver radio input to provide proper decrease in input when the internally mounted relay, as selected by the transmitter circuit controls, is operated by the talk-listen switch or the transmitter voice relay, to prevent the receiver, when adjusted to the same frequency as the transmitter, from blocking and to provide proper radio side tone. One control is provided for each receiver. These controls are not mounted on the front panel, but are located in the top of the unit and are accessible through the top door. This location is considered satisfactory and desirable, since these controls do not require frequent adjustment and may be left set for long periods of time. Ref.(k), page 11, of Bureau of Engineering letter NOs-38614(5-9-W8) of May 17, 1935, indicates that the receivers must function satisfactorily when the receiving antenna is subjected to potentials as high as 10 volts. Tests were conducted wherein the receiving antenna was subjected to potentials ranging up to 12 or 15 volts. The protective relay and potentiometer in the master monitor functioned satisfactorily and a suitable side tone signal was obtained. No signs of overheating or arcing were detected.

(3) Four attenuators are provided, one for each receiver channel, for attenuating the receiver audio output to the desired level. These controls operate without undue noise and have a range of 22 db in eleven steps of approximately 2 db each.

(4) Four 2-position telephone type keys have been provided for connecting or disconnecting the output of one to four receivers, or any combination thereof, to the telephone receiver of the combination hand set used at the master monitor location.

(5) Four transmitter line level indicators have been provided, one for each transmitter channel. These indicators are exact duplicates of those described above for the receiver channels. The use of these level indicators and their attendant range switches give rise to certain undesirable results in the operation of the equipment. Table 43 shows the effect of the range switches has upon the percentage modulation and how the distortion increases when the range switch is thrown to the -10 setting. Thus, if the master monitor operator should throw the range switch of the line level indicator while

the particular channel to which it is attached was in operation, an increase or decrease in the modulated output would result together with a greater degree of distortion in the case where the range switch was thrown to -10. In order to overcome these objections the following alternatives are submitted for the Bureau's consideration:

(A) Substitute a constant impedance type level indicator in order to keep the load on the line at a constant level regardless of the position of the range switch.

(B) Attempt to obtain an instrument whose resistance is sufficiently high so that when the range switches are operated the change in load will be so small that no appreciable change in output will result.

(C) Eliminate the range switches entirely and retain the level indicator with a single range only; namely, -10 db to +6 db. This scale would cover the useful range of line levels since experience with the equipment indicates that the line level will usually be set somewhere between -5 db and zero db. This range could be shifted one way or the other, that is up or down, by merely readjusting the volume control which is provided on each modulator rectifier unit. This last alternative possesses the additional advantage that it would eliminate four switches from the already overcrowded panel of the master monitor unit.

(6) Four transmitter line level controls or attenuators have been provided, one for each transmitter channel. These controls operate on the output of their respective line amplifiers, which amplifiers are contained in the master monitor unit. These attenuators are identical with those described in sub-paragraph (3) above.

(7) Four 2-position telephone key switches have been provided, one for each of the four transmitter channels, to permit the selection of any of the transmitter circuits individually or collectively. When these switches are in the "on" position the "talk-listen" switch, the microphone of the combination hand set and the transmitter or channel indicators lights on this unit and all other station control units are properly connected to the circuits chosen. When in the "off" position the

microphone is disconnected and the indicator lights at all stations are extinguished unless this same circuit or circuits have been selected by one or more of the other control stations.

(8) Four transmitter circuit warning or indicator lights have been provided, one for each transmitter channel, marked "A", "B", "C", and "D". These indicators light when the particular selector key on this or on the station control units are "on" and go out when the particular channel is not selected from any station.

(9) A three position key switch has been provided to connect the combination hand set to "radio", "interphone" or to the "off" position.

(10) A radio "talk-listen" switch has been provided which operates the relays in the master monitor unit thereby reducing the radio frequency input to the receivers used with the particular transmitters selected, to a proper value as determined by the adjustment of the receiver input control or potentiometer. This switch remains in the "talk" position only while held depressed by the operator. This switch also controls the transmitter carrier, except when voice control of the carrier has been selected through the medium of the proper switch on the panel of the modulator-rectifier unit. When voice control has been selected the receiver input relays operate automatically without requiring the use of the "talk-listen" switch.

(11) Jacks have been provided for a separate microphone and head set. When these plugs are inserted the corresponding portion of the permanently connected hand set is disconnected from the circuit.

(12) A red indicator light has been supplied on the panel of the master monitor unit to indicate when power is applied to this unit.

(13) An "on-off" switch has been supplied on the panel for controlling the power to this unit. This switch does not control the power to the telephone power unit.

(14) Five interphone "call-off-talk" keys have been provided on the panel of the master monitor unit. The interphone call light and the buzzer on the called station control unit operate only while the switch is depressed. It is possible to call

a station control unit by simply using the interphone calling key, regardless of the position of the other controls on this or other units. In addition it is possible for the master monitor operator to connect any two or all station control units into the circuit so that any station control operator may speak to any other station control operator as well as to the master monitor operator. This is accomplished by merely depressing the talk keys at the master monitor unit.

(15) Five interphone indicator call lights, one for each station control unit, are provided on the panel of the master monitor unit. These lights are numbered from 1 to 5 to correspond to the five station control units. It is also possible to throw a buzzer into the circuit so that two methods of signalling are available, or, it is possible to disconnect the buzzer at the master monitor by throwing a small toggle switch to the "off" position. In connection with the interphone buzzers it may be pointed out that they are of the ordinary low frequency type. When this equipment is installed on board ship it is possible that some of the units will be installed in compartments where similar buzzers are being used in connection with other activities. In order to prevent confusion among signals it is recommended that the buzzers supplied with the TBN-2 equipment be of the high frequency type so that the distinctive tone produced will prevent the operators of various types of equipment from becoming confused.

(16) Provision is made for permanently connecting a combination hand set to the master monitor unit. The mount provided for holding this hand set was of the ordinary hook variety which must be secured to a vertical member, such as the side of a desk. It is believed that a regular desk stand, such as are supplied with the French telephone units, but without the switch, would be more convenient and satisfactory, and it is recommended that such stands be supplied. In addition, each permanently connected hand set at all locations should be provided with a spring clip in order to secure it in the mount so that the hand set will not become dislodged or rattle under the influence of vibration or the rolling of a vessel in a heavy sea.

(17) Reference to Table 9, appended hereto, shows that the dimensions of the master monitor unit exceed slightly the specified dimensions.

134. Par.3A-10. The telephone power unit is designed so that it may be mounted beneath a desk, or on the desk, as desired. This unit requires very little attention or servicing beyond replacement of the 38180 rectifier tube and an infrequent adjustment of the low potential supply from the Rectox units. Table 44 lists the results of a two hour test conducted to determine the temperature rise of the Rectox units when they were subjected to a 5 to 6 ampere load. Seven of these units are supplied, connected in parallel, and it is doubtful whether they will ever be required to supply a five or six ampere load for any length of time under service operation. The maximum load drawn from these units with the equipment furnished for test was something less than two amperes. It will be noted that the temperature of the bottom row rose 6°C in two hours, while the top row rose 9°. With the additional ventilation suggested in par.41 of this report, it is believed that the telephone power unit will give satisfactory operation from the temperature standpoint. Table 9 lists the physical dimensions of this unit.

135. The telephone power unit obtains its energy from the 110-115 volt supply provided in the rectifier modulator unit and provides the necessary potentials for operating the speech input equipment. The equipment is so arranged that the microphone supply remains on when the rest of the speech input equipment is shut down. Some slight re-adjustment of the microphone supply is required after installation to take care of aging of the Rectox units. This is easily accomplished and it is understood that this adjustment must be made only once.

136. Par.3A-12. The telephone power unit contains the necessary filters. These filters utilize capacitors of the electrolytic type as authorized on page 9 of the Contract Note.

137. Par.3A-13. The station control unit is of the cast aluminum type of the dimensions listed in Table 9. The unit is so designed that it is water tight when the cover is closed. The door or cover hinges are located at the bottom and a spring device has been provided to prevent the cover from swinging when in the open position. The panel to which the controls and indicators are secured is of two ply aluminum. The outer and thinner layer is finished in black enamel upon which the legends have been etched in a pleasing manner. Provision has been made for permanently connecting the incoming cables from the master monitor and station extension units in a water tight manner, regardless of whether the cover is open or closed. The unit is so constructed that it may be securely mounted to a bulkhead. In accordance with the requirement contained in Contract Note, page 3, provision has been made for securing the cover of the station control unit in a horizontal position. When the cover is in the horizontal position the equipment takes up considerably more space and it is believed that this requirement serves no useful purpose. The shape of the cover, which is concave, prevents it from being used as a shelf for writing purposes and the arm which holds it in place is inclined to rattle. It is recommended that the Bureau consider the advisability of cancelling the requirement which provides for the horizontal position of this cover. Attention is also invited to par.42 of this report which suggests a re-arrangement of the wiring to the terminal blocks in the station control unit. See also par. 160 (I).

138. Par.3A-14. The station control unit is provided with the following indicating devices and controls, located on the front panel in a symmetrical manner.

(1) Four 3-position "remote-off-local" switches have been provided, one for the control of each transmitter channel. When in the local position the microphone of the combination hand set is connected to control the output of the transmitter selected. It is also possible to control more than one transmitter simultaneously from the same microphone by simply selecting the desired channels through the use of these switches. When any of these switches are thrown to either local or remote control the corresponding indicator lights on all station control units and on the master monitor unit light. When the switch is thrown to remote, control of that particular transmitter is transferred to the corresponding extension unit. Throwing more than one of these switches to the remote position effects connection only to the particular extension units desired and does not connect the extension unit to more than one transmitter channel. When all switches in one transmitter circuit are in the "off" position, all indicator lights are extinguished. These switches also connect the "talk-listen" switch to the receiver circuits used and effect the necessary reduction in signal for radio side tone operation.

(2) Four indicator lights have been provided, one for each transmitter channel, to show when any such circuit has been selected at any point of control.

(3) Four 2-position "off-local" receiver switches have been provided, one for each receiver circuit, to permit an operator at the station control unit to select one or more receiver circuits and listen simultaneously thereon, using the receiver of the hand set combination. Use of these controls does not energize the microphone or disconnect the receiver circuits from the station extension units. Manipulation of two or more of these switches simultaneously gives rise to a condition where the station extension units are enabled to hear signals to which that particular extension is not connected. For example, if extension No. 1 is connected to Channel "A" and the station control operator selects Channels "A" and "B" simultaneously, the operator at extension No. 1 can hear the signal coming in over Channel "B". This signal is decidedly weaker than the normal signal obtained through Channel "A", but is perfectly readable if

Channel "A" is not in use or has no incoming signal at that particular time. This same condition exists at all extension units and for all combinations of the various channels. Manipulation of more than two receiver selector keys at the master monitor unit gives rise to the same conditions. The signals are coupled through any particular head set or hand set which happens to be connected to two channels at the same time. There appears to be no simple method of overcoming this condition and, since the signal which is actually intended for any particular station extension unit always overrides the undesired signal, the condition presents no serious difficulties other than permitting an extension unit operator to listen in on signals not actually intended for him.

(4) The station control unit is provided with an interphone call light to indicate when the operator at the master monitor unit is calling the station. A buzzer also announces the call while both light and buzzer operate only while the control at the master monitor station is in the call position.

(5) An interphone call button has been provided at the station control unit to permit the operator to call the master monitor operator. Although the specifications do not require interphone between station control units this method of communication is actually provided, as explained in par.133(14) of this report. It is recommended that no action be taken to eliminate this additional feature since it would appear to serve a desirable and useful purpose.

(6) A "talk-listen" switch has been provided on the panel of the station control unit and operates in the manner described in par.133(10) of this report.

(7) An interphone-off-radio switch has been provided for connecting the hand set to the desired circuit or for removing it from both circuits.

(8) Separate telephone and microphone jacks have been provided to permit connecting a chest type microphone and a 600 ohm head set. When the plugs of these are inserted the corresponding portion of the hand set combination is disconnected from the circuit.

(9) A combination hand set, permanently connected, has been provided. The hand set can be hung on a mounting hook so arranged that the unit is housed within the water-tight box when the cover is closed. (See par.133 (16) of this report relative to providing spring clips for securing hand sets.)

139. Par.3A-15. The station extention units provided are of cast aluminum construction of the dimensions listed in Table 9. They are provided with watertight covers and are designed for bulkhead mounting.

(1) Provision has been made for connecting the shielded cable from the station control unit to this unit in such a manner that it is not affected by opening or closing the cover.

(2) When the cover of the extension unit is open it is possible to insert plugs for connecting a microphone and a head set. No two-circuit plugs were available during this test but the mounting of the jacks is such that it is believed that two circuit plugs will fit if it is found desirable to use this type. The receiver circuit supplied to the station extension unit is in operation at all times as long as a receiver is connected and it is impossible for controls at other locations to disconnect the receiver.

(3) A talk listen switch has been provided in compliance with this paragraph and the Contract Note (page 10).

(4) Two chest type microphones were supplied with the preliminary equipment.

140. Par.3A-16. The circuits and equipment required for voice modulation of the high frequency unit, with the exception of the master monitor, telephone power, station control, and station extension units, have been assembled and combined with the rectifier unit as a combined modulator-rectifier unit.

141. Par.3A-17. The modulator equipment is capable of effecting 100% modulation of the final 500 watt stage of the high frequency transmitter unit when supplied with a speech input from the master monitor unit at a 6 milliwatt level. The determination of the percentage modulation was made by means of a cathode ray oscillograph, the peak voltmeter method for determining positive and negative peaks and by means of the modulation meter provided as part of the modulator equipment. The audio frequency distortion was determined at various levels of modulation and under a variety of conditions.

(a) Plate 1 is a graph showing the percent distortion at various levels of modulation ranging from 10% to 100%. The audio input during this test was impressed directly across the input terminals of the modulator unit, the master monitor unit circuits not being included in this test. The distortion was approximately 4% at 100% modulation, which is well within the specification limit of 10%.

(b) Plate 2 is a graph showing the percent distortion at various levels of modulation, with the audio input voltage impressed across amplifier terminals Nos.29 and 30 of the master monitor unit. The microphone circuit was not included in this test. The distortion as measured was less than 4% at 100% modulation.

(c) Plate 3 shows the increase in distortion resulting from the introduction of the microphone circuit into the system under test as compared with the distortion obtained when the input voltage was impressed across the amplifier terminals Nos. 29 and 30.

(d) Plate 4 shows the increase in distortion, particularly at the higher levels of modulation, resulting from the use of a low emission tube in the line amplifier. It should be noted that both tubes comply with specification limits relative to emission.

(e) Plate 5 shows the distortion characteristic of the four channel amplifiers, "A" to "D" inclusive. The audio input was impressed across the microphone terminals. It will be noted that all four channels gave similar results.

(f) Table 43 shows the effect of the level indicators which are connected across the output of the line amplifiers. As pointed out previously, a noticeable increase in distortion results when the level indicator is connected directly across the line without any series resistance.

(g) Table 45 lists the results of tests conducted to determine the effect of varying values of d.c. current in the microphone circuit upon the percentage of modulation. Tests were conducted at 300, 1,000, and 5,000 cycles. This effect, that is, the reduction in percentage modulation with increased d.c. microphone current, is still more pronounced in the region of 100 cycles.

From the foregoing data it will be observed that at no time was the specification limit of 10% distortion exceeded under any circumstances.

142. Par.3A-18. This paragraph states "The frequency characteristics of the modulator and associated amplifier equipment shall be flat within ± 2 db over the range of 100 to 5,000 cycles."

(a) Plate 6 shows the frequency characteristic of the equipment when the audio voltage was impressed directly upon the input terminals of the modulator unit. The master monitor circuits were not included in this test.

(b) Plate 7 shows the frequency characteristic obtained when the audio input voltage was impressed across the microphone terminals in the modulator rectifier unit. No d.c. current was permitted to flow in the microphone circuit during this test.

(c) Plate 8 shows the frequency characteristic obtained when the audio input voltage was impressed across the microphone terminals in the modulator rectifier unit with 60 M.A. d.c. flowing in this circuit.

(d) Plate 9 shows the frequency characteristic obtained when the audio input voltage was impressed across the microphone terminals in the modulator rectifier unit with 120 M.A. d.c. flowing in the microphone circuit. The effect of the d.c. current can be plainly noted by comparing this curve with those in Plates 7 and 8.

(e) Plate 10 shows the frequency characteristic obtained when the audio input voltage was impressed across the input transformer terminals of one of the amplifiers in the master monitor unit. (Terminals Nos.23 and 24). The microphone circuit was not included in this test.

(f) Plate 11 shows the frequency characteristic obtained when the audio input voltage was impressed across the microphone terminals in the master monitor unit. No d.c. current was flowing in the microphone circuit during this test. (Compare Plate 7 with Plate 11.)

(g) Plate 12 shows the frequency characteristic obtained when the audio input voltage was impressed across the microphone terminals in the master monitor unit with 60 M.A. d.c. flowing in the microphone circuit. Plate 13 illustrates the circuit used in conducting this test. (Compare Plate 8 with Plate 12.)

(h) Plates 14, 15, and 16 show the frequency characteristics of the amplifiers in the master monitor unit taken under three different conditions. Plate 14 shows the results obtained when the measurements were made between terminals 23 and 24, and 7 and 8. Plate 15 included the output level indicator with the attenuator set for minimum or zero attenuation. Plate 16 shows the results obtained with the attenuator set on tap 5, the tap usually used for full output. It will be noted that under all conditions of operation the frequency characteristic is substantially flat.

143. From the foregoing data it is apparent that the frequency characteristic of the Model TBN-2 equipment fails to meet the requirements of the specifications (par.3A-18 of Specifications RE 13A 497A) when overall measurements are made; that is, when the microphone circuit of the speech input equipment is included in the circuits under test. It is also noted that the frequency characteristic of the microphone circuit supplied in the rectifier-modulator unit is flatter over the range of audio frequencies specified, 100 to 5,000 cycles, than the characteristic of the microphone circuits in the master monitor, station control or station extension units. That the frequency characteristic curves obtained in these tests represent the true response of the circuits is amply borne out by listening tests conducted at various locations. A number of different observers, using various types of receiving equipment, including RAB, RAB-1, and RAB-2a receivers, located at different points unfailingly reported that the quality of speech emanating from a microphone plugged into the modulator-rectifier unit speech circuits was superior to that obtained when the microphone circuits in the master monitor unit were employed.

144. In accordance with the instructions contained in ref.(p), tests were conducted with a Type E-1 sound power microphone, which was submitted by the Bureau of Engineering. In order to compensate for the low level of energy produced by this type of microphone it was necessary to resort to additional amplification so that an output level of 6 milliwatts could be obtained from the master monitor unit. This was accomplished by connecting amplifiers "A" and "B" in the master monitor unit in series and adjusting the attenuation so that the desired level could be obtained. Plate 17 shows the frequency characteristic obtained under these conditions. Listening tests were conducted at a point removed from the transmitter and different observers were requested to rate the received signals in accordance with their quality. The observers were unaware of the nature of the tests at the transmitting end. These tests consisted of the following:

(1) Speech transmitted by means of the regular carbon microphone furnished with the equipment, utilizing the microphone circuits as supplied by the manufacturer. (Channel D was used for this test.)

(2) Speech transmitted by means of the sound power microphone, through the medium of amplifiers "A" and "B" in cascade. A Type 166, General Radio telephone transformer was inserted in the circuit between the microphone and the input terminals of amplifier "A" for impedance matching purposes.

(3) Speech transmitted by means of the regular carbon microphone furnished with the equipment, utilizing the microphone circuit in the modulator-rectifier unit.

In all three tests the percentage of modulation was held substantially at the same level and the same operator transmitted the same message for all three conditions of test. The receiver adjustments remained fixed, while two types of headsets were employed; namely, the 600 ohm type and the 2200 ohm type.

145. The consensus of opinion at the receiving end rated the quality of the received speech in the following order:

First - Test 2
Second - Test 3
Third - Test 1

Both tests 2 and 3 were decidedly superior to test 1. While there was a recognizable difference between tests 2 and 3, with test 2 giving the better quality, the difference was not as marked as between test 2 or 3 and test 1. In all cases the 600 ohm head sets produced the best quality. The signal level of the 600 ohm phones appeared to be greater with the same receiver setting. Due to the low output level obtained from the Western Electric sound power microphone and the additional amplification required to produce sufficient energy to bring the level up to workable amplitude, it is the opinion of the Laboratory that this type of sound power microphone is not suitable for use in connection with the TBN-2 equipment.

146. In accordance with ref.(p) additional tests were conducted with various types of microphones. The tests indicated that the results obtained with the Western Electric carbon button microphone, hand set Type E-2, were almost identical with the results obtained with the chest type carbon button microphone CW-51005. Therefore, these two microphones may be used interchangeably. The Stromberg Carlson microphone No. 6 did not produce as satisfactory operation as the Western Electric carbon microphones with respect to quality, intelligibility or output level and hence it is not considered a satisfactory substitute. On July 29, 1935, three sound power microphones Type PB-112-B1 were received from the RCA Manufacturing Company and these microphones were also included in the comparative test. The relative output levels obtained with the various microphones on average voice frequencies are approximately as follows:

Western Electric carbon button microphone E-2	-	zero db
Stromberg Carlson carbon button microphone No.6	-	-1 to 2 db.
RCA sound power microphone, PB 112-B1	-	-18 to 20 db.
Western Electric sound power microphone E-1	-	-25 db

After numerous tests by various speakers and observers the two microphones of each type which gave the most satisfactory performance were selected for further comparison tests. These microphones were the Western Electric carbon button microphone, E-2, and the RCA sound power microphone PB 112-B1. Due to the very noticeable difference between the microphone circuit in the master monitor unit and the microphone circuit in the modulator rectifier unit the carbon microphones were tested in both circuits. Since the sound power microphones required the additional amplification supplied by the 38056 tube in the master monitor line amplifier the sound power microphone could not be tested directly in the modulator rectifier unit. In order to adapt the sound power microphone for service it was necessary to employ an impedance matching transformer and for this purpose a General Radio

Type 166 transformer was used. The microphone was connected to the primary of this transformer and the secondary of the 166 transformer was connected to the primary of the input transformer of Channel "D" in the master monitor unit. Three conditions of operation were employed and the following tests conducted:

Test No.1 - Western Electric carbon button microphone in the master monitor unit microphone circuit.

Test No.2 - RCA sound power microphone connected to Channel "D" of the master monitor unit through the Type 166 transformer.

Test No.3 - Western Electric carbon button microphone in the modulator rectifier unit microphone circuit.

Four speakers and ten listeners were selected from the Officer and Enlisted personnel of the Radio Materiel Schools in order to conduct the tests. Each speaker enunciated a list of ten unrelated words ranging from single syllable to multi-syllable words for each condition of test. These words were selected from the list of common words appearing in ordinary telephone conversations as described in Bell Telephone System Technical Publication B-491 and from the Navy Standard Spelling List. Words were pronounced once only. Thus each listener copied 120 words and a total of 400 words was spoken over each microphone. Reception was accomplished by means of an RAB-2a receiver and Type 49023 600 ohm head sets. The frequency of transmission was 2600 kilocycles and the modulation level was adjusted so that approximately 50 to 60% peaks were the maximum obtained under all conditions of test with all speakers. At the end of the test each listener was requested to indicate which test in his opinion sounded most natural and intelligible. Every word that the listeners copied wrongly or failed to identify were considered as errors.

147. Table 54 appended hereto tabulates the results of this test. The total errors made in the three tests were as follows:

Test No. 1 - 51 errors - 12.8%
Test No. 2 - 175 errors - 43.8%
Test No. 3 - 47 errors - 11.8%

Eight listeners voted preference for Test No.3, while two voted for Test No. 1. The second tabulation in Table 54 lists the errors according to speakers, indicating, as was to be expected, difference in the enunciation of various individuals. The third tabulation in the table lists the errors made on the various speakers according to the microphone or microphone circuits used. This indicates that regardless of the individual characteristics of a speaker's voice the ratio of errors of any one speaker was about the same as the ratio of errors made by all four speakers. The only exception is in the case of Speaker "B".

148. From the foregoing results it is plainly evident that the sound power microphone will not be suitable for use in connection with the Model TBN-2 equipment. It further illustrates that the type of microphone circuit employed in the modulator rectifier unit produces speech of a quality preferred by the average listener in the ratio of 4 to 1 over the quality of speech produced with the same microphone in the microphone circuit of the master monitor unit. The difference in understandability or intelligibility between the two microphone circuits when employing the same type of microphone is not very great but what difference exists is in favor of the microphone circuit employed in the modulator rectifier unit. Since the preference for the quality of speech produced by the microphone circuit in the modulator rectifier unit is so marked it is recommended that steps be taken to modify the microphone circuits in the master monitor, station control, and station extension units (these circuits are identical) in order to improve the quality. The modifications required to accomplish this end are not extensive since it is believed that slight changes in the characteristics of the audio choke coil and microphone transformer will bring about the desired results.

149. Par.3A-19-1. A suitable gain control attenuator has been incorporated in the rectifier-modulator unit which may be adjusted from the front panel. This control has a range of 30 db and is adjustable in 20 steps of approximately 1.5 db each, thus providing a more flexible control than is required by the specifications, which calls for a range of 25 db in 2 db steps. With this attenuator set at approximately center position, an input of 6 milliwatts to the modulator produces an output of 100% modulation In order that this control may be readily adjusted to the same setting it is recommended that it be provided with a dial and pointer. A calibration mark for each step on the attenuator would be satisfactory. At the present time this control is not provided with a dial or pointer.

150. Par.3A-19-2. A modulation meter calibrated in "percentage modulation" has been provided on the panel of the modulator-rectifier unit. When received this meter was inoperative and in attempting to operate the modulator circuits it flashed over. A representative of the manufacturer returned the meter to the factory and a replacement meter was later provided. This meter was reinstalled in the equipment and tests were conducted to determine its accuracy. The checks were made in comparison with a cathode ray oscillograph and a Model OB modulation meter which registers negative and positive peaks. The cathode ray was used as the standard of comparison. The first tests revealed that the modulation meter in the modulator-rectifier unit, Type CAY-22230, read high over the entire range by about 15%. The meter was then adjusted to as near zero setting as the adjustment would permit. The minimum point to which the indicator could be adjusted corresponded to about 6% modulation. After this adjustment was made the meter was again checked and it was found that the error had decreased. Up to about 40 or 50% modulation the error is negligible but above these levels the percentage error increases, until at 90% modulation it reads high by approximately 10%. Plate 18, appended hereto, shows graphically the results of the tests conducted with this meter. After the foregoing tests had been completed, the rectifier modulator unit, together with associated equipment, was subjected to temperature and humidity tests. During the course of these latter tests it was

noted that the pointer of the modulation meter stuck at the lower portion of the scale. After the equipment had been removed from the temperature test room the pointer continued to stick and the meter was removed from the equipment. As soon as the meter was removed the needle or pointer appeared to be free, so the instrument was reinstalled. Again the pointer stuck at the lower portion of the scale. The meter was again removed and again the needle appeared to be free. Particular pains were taken to see that the screws by means of which the meter was secured to the panel did not exert enough pressure to bind the works and when the meter was removed from the equipment approximately the same weight was secured to the four studs in order to duplicate installation conditions. However, as long as the meter was not installed in the rectifier modulator unit the pointer remained free, but would bind as soon as the meter was installed in its regular location. No definite reason for this action could be determined.

151. On July 24 a representative of the manufacturer submitted another modulation meter for test. This meter was installed in the modulator unit and the results of the test are shown in Plate 18. This latter meter is referred to as "meter no.2", while the previous meter is referred to as "meter no.1". It will be noted that meter no.2 gave extremely accurate results when tested in comparison with other methods of determining percentage modulation. Therefore, from the standpoint of accuracy, meter no.2 was entirely satisfactory. However, during the course of these tests, Condenser C-39, which is a variable air condenser in the power amplifier tank circuit of the high frequency unit, arced over. The detuning resulting from this arcing caused the power amplifier tube to draw about 425 milliamperes plate current. Although the modulation meter was not under direct observation at the instant the arcing occurred, it is believed that this overload caused the modulation meter to burn out, since a few moments later it was found that the modulation meter was inoperative. At the time the arc over occurred the normal P.A. plate current was 270 m.a. and the frequency of operation was 2600 kilocycles. Several times during the test of this equipment on voice operation momentary arc overs occurred. During these tests efforts were made to adjust the voice levels so that over modulation would not result, although it is difficult to state with certainty that peaks in excess of 100% did not occur. However, these same conditions will be encountered in service operation and hence it appears that steps must be undertaken to provide a power amplifier tank condenser which will not arc over and a modulation meter which will not burn out in the presence of d. c. plate current surges. The d.c. plate overload relay in the transmitter was set as lightly as possible without opening up on keying surges; namely, about 500 m.a. In general, it may be stated that the type of modulation meter provided is capable of providing accurate measurements, but judging from the samples tested, this type of meter does not possess a sufficient safety factor for service operation and means must be provided to protect the meter before it will be satisfactory for service use.

152. Par.3A-20. The indicating instruments provided on the panel of the modulator equipment are listed in Table 34. It will be noted that the instruments furnished are in agreement with the specifications as modified by BuS&A letter of 7 February, 1935, NOs-38614(SPM) to Westinghouse Electric and Manufacturing Company, and are adequate for the proper operation of the equipment.

153. Par.3A-21. The modulator equipment is provided with three stages of push-pull amplification of satisfactory characteristics. The tube line up has been discussed under par.36 of this report.

154. Par.3A-22. In addition to the talk-listen control circuit, operated by a key switch on the master monitor, station control, and station extension units, provision has been made for voice control of the carrier. This circuit utilizes a 38110 tube. The specifications state that the operation of this feature shall be such that full carrier is obtained in less than 0.015 second after the speech input to the modulator has reached a level 25 db below that required for complete modulation. After cessation of speech the carrier shall be maintained for not less than two-tenths of a second to prevent cutting off the carrier between syllables or words. Suitable means shall be provided to adjust the sensitivity of the voice control feature by means of a suitable control on the front panel of the equipment.

155. A number of tests were conducted to determine the action of the automatic voice relay. Considerable difficulty is experienced in accurately adjusting the modulation to 25 db below that required for normal operation, since it is difficult to measure a level of this magnitude. The equipment employed indicated that the lowest level used in these tests was -22 db, although this figure cannot be guaranteed to be correct closer than ± 3 or 4 db. With the sensitivity control adjusted to the point which appeared to give the best results for ordinary speech work a number of oscillographic records were obtained at speech input levels of -22 db, -6 db, and zero db. Zero db equals 6 milliwatts output from the master monitor and the volume control on the modulator rectifier unit was adjusted to the point where this level would provide complete modulation. The results of the oscillographic analysis revealed the following:

	Time for application of carrier		Time carrier
Input Level	after audio voltage was applied	after audio voltage reached full normal level	persisted after removal of audio voltage
-22 db	0.065 sec.	0.048 sec	0.049 sec
-6 db	0.012	0.006	0.512
zero	0.014	0.006	0.609

The above figures represent the average values obtained from a number of tests conducted at the three levels specified. Plate 19 shows three of the oscillograms obtained at levels of -22, -6, and zero. It would have been possible to adjust the sensitivity of the equipment to a point where the lowest input level would have given more rapid response but it is felt that such extreme sensitivity would not be practicable under service operating conditions, since very low noise levels would tend to turn on the carrier. Therefore, in the opinion of the Laboratory, the speech relay as supplied is considered satisfactory. It will be noted that the carrier is maintained for more than 0.2 seconds after the audio voltage has been removed.

155-A. Information obtained from the Interior Communication Division of the Laboratory reveals that the noise levels encountered in what may be termed the more quiet spaces on board vessels of the type on which the TBN-2 equipment is to be installed averages around 70 db above the threshold of audibility. In various other locations and under various conditions, such as increased machinery speeds, tuning up of planes, etc., the noise level rises to 90 db and even 100 db. Tests were conducted which showed that the sensitivity control provided on the speech relay could be adjusted to operate on noise levels between 50 db and 90 db. This range of adjustment was that provided by the sensitivity control only. A much wider range may be obtained by varying the attenuation in the master monitor unit and by varying the volume control on the modulator unit. It can readily be seen that the speech relay must be adjusted so that it will not operate on a noise level of at least 70 db, and probably 80 db above the threshold of hearing. Therefore, the specification requirement that the speech relay operate in 0.015 second after the speech input has reached a level of 25 db below zero level of 6 milliwatts, will undoubtedly be found to be impracticable on board ship. However, it is believed that experience under actual service conditions will readily indicate the degree of sensitivity necessary and that this degree of sensitivity will be obtainable with the controls now provided on the TBN-2 equipment.

155-B. Noise levels of the order of 80 db, with the attenuation controls of the master monitor unit adjusted for normal operation, produce outputs of approximately 40% to 50% modulation. Thus it will be seen that care must be exercised in selecting locations for the various microphone units in order to avoid areas of high noise level.

156. Par.3A-23. Provision has been made in the design of the modulator equipment to permit the selection of either manual control or voice control of the carrier. This is accomplished by means of a three position anti-capacity switch with the "off" position in the center.

157. Par.3A-24. Provision has been made so that voice control of the carrier as well as manual control operates the receiver input relays on the master monitor unit to reduce the input to the receivers to a satisfactory level.

158. The overall noise level of the equipment was determined at 50% and 100% modulation. No microphones were in the circuits when these measurements were made. The noise level was 36 db below at 50% modulation and 41 db down at 100% modulation.

159. In order to simplify or clarify the handling of the speech input equipment in service, the following changes and additions to the nomenclature used in designating certain controls is suggested.

(a) Station control unit. "Talk" switch should be marked "Talk-Radio". This switch is used only for radio purposes and not for interphone use.

(b) Station extension units. Each group of four station extension units supplied with the station control units should bear designating letters "A", "B", "C", and "D" to correspond to the channels to which they are connected. These markings should be visible whether the cover of the extension unit is open or closed, which will call for double marking. The markings should be made in large size, permanent letters.

(c) Master monitor unit. The suggestion contained in par.7-3 of ref.(1) for isolating the various circuit controls on the panel of the master monitor by means of vertical and horizontal lines would be of aid to operators not thoroughly familiar with the equipment.

160. On page 14 of ref.(a), the Bureau of Engineering requests comment by the Laboratory of the various items discussed in Westinghouse Electric and Manufacturing Company letter of January 9, 1935, WG-17535, which constitutes ref.(r) of ref.(a). The following comments are submitted:

Par.(A). The necessity for increasing the weight allowance for four-channel speech input equipment is obvious and has been authorized by BuS&A letter NOs-38614(SPM) of 5 March 1935.

Par.(B). The color and type of finishes used for the various items of speech input equipment is satisfactory and will undoubtedly be in harmony with the surroundings of the various compartments in which the units will be located.

Par.(C). The use of nickel plated brass screws and hinges is to be preferred to plated steel. In the preliminary model the hinges supplied on the master monitor unit and on the telephone power unit are of steel. These should be replaced with nickel plated brass hinges, as discussed in par.47 of this report.

Par.(D). The design of the rear panel of the master monitor unit is satisfactory and will cause no inconvenience if the unit is installed in a location whereby a clear space of about one foot is available to the rear of the unit. The entire antenna circuit assembly may be removed from the unit by sliding it out from the rear.

Par.(E). No comment.

Par.(F). The Laboratory is in agreement with the belief of the contractor that the addition of an audio oscillator for setting speech levels would not be warranted. It is believed that when the equipment is installed on board ship a few routine drills coupled with an alert master monitor operator will indicate the proper methods to be adopted for obtaining satisfactory speech performance from the equipment.

Par.(G). Experiments conducted with receivers located adjacent to the speech input equipment demonstrated that the buzzers contained in the TBL-2 equipment do not cause any electrical interference in the receivers. The master monitor unit, which is likely to be located near radio receivers when installed on board ship, has been provided with a buzzer cut-off switch. Thus if the buzzer causes aural interference it can be dispensed with and the master monitor operator can depend on visual signals from the indicator lamps.

Par.(H). The equipment as furnished provides for both "radio side tone" and "straight side tone" operation. Both of these methods were checked thoroughly and both operated satisfactorily. Of course, radio side tone is to be preferred since it gives direct assurance that the speech is actually being transmitted. Various combinations of antennas were connected to the master monitor unit and various patching combinations were utilized without any interference between receivers being noted. This included the operation of two receivers, tuned to adjacent frequencies, utilizing the same antenna. Since only one high frequency unit was furnished with the preliminary model exact duplication of simultaneous four-channel operation could not be obtained. However, by employing the signals from local broadcasting stations while the high frequency unit was in operation, the results indicated that satisfactory operation may be expected. Some interaction between antennas is obtained, but the interaction experienced during these tests was of such a nature that it did not interfere with normal operation. For example; with receiver "A" connected to an antenna, but no antenna connected to receiver "B", signals of low intensity were heard on receiver "B", due to the stray pick-up in the antenna gear. However, these signals were always at least 20 db down from the level they would assume when a satisfactory antenna was connected to receiver "B". A test of straight side tone was made and satisfactory results were obtained. The change from radio to straight side tone can be accomplished by changing a few connections, in accordance with instructions contained in the instruction books, at the various locations, such as station extension and station control units.

Par.(I). The friction type fastening for holding the covers of the watertight station control and station extension units will prove satisfactory if care is exercised in the fit of the pin and socket by means of which the clamping action is obtained. The station control and station extension units were mounted on the test stand as illustrated in Plate 27 and subjected to a roll of 45°. No trouble was experienced with the smaller station extension units but the cover of one of the station control units would swing free at the end of the 45° roll and in the presence of vibration. The tension on the second station control unit is so intense that it is difficult to dislodge the door from its vertical position by main force. This apparently is due to a deformed pin or to some irregularity in the socket. If these pin and socket arrangements are machined and adjusted to give a tension approximately half way between the two degrees now provided, they will prove satisfactory.

Par.(J). In connection with the choice of interconnecting cables, the Laboratory is of the opinion that the suggestion made in par.3 on page 18 of ref.(a) will prove most satisfactory.

161. Refer to page 15 of ref.(a). With respect to the discussion contained in BuEng 3rd endorsement NOs-38614 (1-8-W8) of 23 Feb.1935 to BuS&A, the following comments are submitted. Both the hand set and the chest type of microphones submitted with the equipment were tested in the "test position" on the modulator unit. A check of the microphones revealed the following:

Hand set in master monitor draws 60 m.a. d.c.
Hand set in modulator unit draws 120 m.a. d.c.

Chest microphone in master monitor draws 30 m.a.
Chest microphone in modulator draws 60 m.a.

The voltage drop across the hand set in the modulator unit is 2 volts while the drop across the chest type is 13 volts. Both types of microphones give essentially the same speech quality as near as could be determined from listening tests. In the interests of flexibility and ease of handling it is recommended that each modulator unit be provided with a hand set type of microphone rather than the chest type. It is believed that the hand type will be more convenient for the transmitting room operator to handle. Means should be provided for hanging up the microphone on the panel of the modulator unit in a convenient location and further means should be provided to prevent it from going adrift in a heavy sea, or rattling around under the influence of vibration. As previously stated, each modulator unit should be provided with such a microphone. The microphone power supply in the modulator unit is complete and independent and does not require the operation of the telephone power unit.

162. Par.2 of the above cited reference contains the following statement. "In view of this similarity and the fact that one of the station control units (in the case of four-channel equipment) will be installed near the transmitter, the additional microphone for local test purposes will not be required". Attention is invited to the fact that the hand set which is furnished as a part of the station control units is permanently connected to these units and cannot be removed. Hence, even though a station control unit is located near the modulator unit, it will be necessary to provide additional microphones.

163. Reference: par.9 of ref.(a). Two Navy type receivers were used in conjunction with the tests of the speech input equipment, one Type RAB and one RAB-2a. The latter receiver contains a carrier operated automatic volume control. Satisfactory results were obtained with both types of receivers. The advantages in using the RAB-2a consist in the establishment of a constant signal level and the phenomena where the presence of the carrier lowers the noise level in the receiver.

164. Reference: page 18 of ref.(a). The Laboratory concurs in the opinion of the contractor that alternative no.3 will prove to be the most satisfactory solution of the problem of providing adequate interconnection cables. This provides for the use of a standard Navy TPTA-30 cables and an additional no.6 conductor for the ground return.

165. Par.5-1 to 5-7 incl. The equipment furnished is so constructed that it complies with the requirements of these paragraphs of the specifications.

166. Par.5-8. The keying relays of the high frequency and intermediate frequency units operate satisfactorily at speeds up to 100 words per minute, as illustrated in the attached oscillograms, Plates 20 to 23 inclusive.

167. Par.5-9. An indicator lamp has been provided on the transmitter panel of each transmitter unit in accordance with the specifications and provision has been made for the connection of an external monitor light. The circuit is the same as supplied with the Model TBK equipment and a false indication may be obtained as explained on page 21, par.115 of NRL Report No. R-1087.

168. Par.5-10. Prominently marked emergency switches have been supplied on the panels of the intermediate frequency, high frequency, and modulator-rectifier units.

170. Par.5-11. The current required in the transmitter remote start-stop control circuits is approximately 0.5 ampere.

171. Par.5-24. A suitable source of 110 volts a.c. has been provided in the equipment through the medium of a step-down transformer in the rectifier unit. It was noted that all a.c. contactors operate quietly. A source of 110 volts d.c. consisting of a full wave rectifier utilizing two Rectigon tubes is provided for the operation of relays which demand d.c. potentials.

172. Par.5-25. The emergency shut down feature is so arranged that it is impossible to re-start the equipment from any other point than the location at which the emergency shut down was accomplished.

173. Par.6-3. The equipment functions satisfactorily when subjected to supply line voltage variations between the limits of $\pm$ 5%.

174. Par.6-4. The power equipment operates satisfactorily when subjected to full power key locked operation for periods of two hours or more.

175. Par.6-5. Reference to Table 47 shows that the intermediate frequency unit requires 3800 watts for full power operation on CW and 3220 watts for full power MCW operation. Table 48 shows that the high frequency unit requires 3350 watts for CW operation, full power and 4010 watts for full power, 100% modulation, when operating as telephone equipment. These tables also list the power consumed when operating on the various voltage taps of the rectifier, the power output obtained and the power required for the various individual circuits in the equipment. The specifications have been complied with in all cases and for all types of operation.

176. Par.6-41. The rectifiers necessary for the operation of the equipment are contained in a single unit of the dimensions listed in Table 9. The modulator equipment is contained in the same unit.

177. Pars.6-42, 6-43, and 6-44. The individual rectifiers supplied in this unit conform to the requirements of these paragraphs of the specifications.

178. Par.6-45. The efficiency of conversion of the main plate rectifier, using the intermediate frequency transmitter as a load at full power output was 83.7%, as shown in Table 49.

179. Par.6-46. The voltage regulation of the various rectifiers complies with the specification requirements, as illustrated in Table 50.

180. Par.6-47. The voltage ripple content in the output of the various rectifiers complies with the requirements of the specifications as illustrated in Table 51.

181. Par.6-48. Suitable time delay relays have been provided to permit the filaments of the rectifier tubes to attain full operating temperature before the application of plate potential.

182. Par.6-49. A suitable undervoltage relay has been incorporated in the rectifier which operates an alarm and removes plate voltage when the line voltage drops to a value too low for safe operation.

183. Par.6-50. A rugged 7-point tap switch has been provided on the panel of the rectifier unit through the medium of which it is possible to control the output voltage of the main plate rectifier. Table 52 lists the output voltages obtained with various settings of the tap switch. The variation provided conforms with the requirements of the specifications.

184. Par.6-52. All tubes in the rectifier equipment are accessible through a door in the front panel of the unit.

185. Par.6-53. Suitable indicating instruments, whose accuracy conforms with the requirements of the governing specifications, have been incorporated in the rectifier equipment. Table 34 lists the meters provided. The output voltage of the various rectifiers is read by means of a single meter which is switched from one circuit to another through the medium of a ruggedly constructed tap switch.

186. Par.6-54. A source of 115 volts d.c. has been provided in the rectifier unit.

187. Par.6-55. The total power required from the supply mains for the operation of this equipment is less than the amount permitted by the governing specifications.

188. Par.6-56. A main switch has been provided on the panel of the rectifier equipment for removing power from all units. This switch combines the function of switch and overload protection and should be modified to provide protection at lower currents as described in par.50(a) of this report. A suitable emergency switch has been provided on the rectifier panel.

189. Par.6-58. Suitable overload relays in accordance with the requirements of this paragraph of the specifications have been provided in the rectifier unit.

190. Par.6-59. The rectifier tube compartment has been equipped with a thermostatically controlled heating circuit which prevents the temperature of this compartment from dropping below 15° C. Reference to Tables 16 to 21 inclusive show that at zero degrees C. the tube compartment was maintained at a temperature of approximately 20° while in an ambient temperature of 50°C, the tube compartment temperature was between 60 and 65°.

191. Par.6-60. The rectifier equipment is so designed that it may be installed adjacent to either or both of the transmitter units or as a separate unit as required for any particular installation.

192. Par.6-61. A local start-stop switch on the rectifier unit has not been actually provided, although it is possible to start the rectifier from the rectifier position. The means provided for doing this operate as follows. Switch S-107 on the panel of the rectifier unit provides means for applying the necessary voltages to the high frequency unit or the intermediate frequency unit or confining the voltages to the rectifier unit, as described in par.76 of this report. One portion of S-107 consists of a multi-contact drum type switch. Thus when the switch is thrown to rectifier test position the rectifier is automatically started and will remain in operation until switch S-107 is moved to one of the other three positions. Although this arrangement possesses certain commendable features, it is believed that it does not definitely meet the requirements of the specifications, since no local "start-stop" switch is provided. It is recommended that such a local start-stop switch be provided on the panel of the rectifier unit so that when the transfer switch S-107 is in "Rectifier Test" position, the operator will be provided with a means of turning on and off the rectifier without the necessity of throwing switch S-107 to another position. A suitable emergency switch has been provided, as previously stated.

193. Par.6-62. The various switches and controls on the rectifier modulator unit are suitably marked with the exception of the volume control, as pointed out in par.149 of this report. A list of the controls provided on the modulator rectifier unit will be found in Table 53. The filament "Stand-By" switch mentioned has been provided so that plate potentials may be available immediately without waiting for the time delay relay to operate. Although the specifications did not require the contractor to supply this device it is considered to be a very useful adjunct and should be retained. In the various positions of the transfer switch the filament stand-by switch operates as follows:

Pos. 1, H.F. Transmitter CW-MCW: Controls the rectifier filaments.

Pos. 2, H.F. Transmitter, Phone: Controls the rectifier and modulator filaments.

Pos. 3, Rectifier Test: has no control over filaments.

Pos. 4, Intermediate frequency transmitter: Controls the rectifier filaments.

194. Par.6-65. Suitable insulated hand rails have been provided on the rectifier modulator unit. See par.126 of this report for a description of these hand rails.

195. Par.6-66. The equipment as furnished complies with the requirements as outlined in this paragraph of the specifications in order to provide for alternate operation of the high frequency and intermediate frequency units and to provide for voice operation of the high frequency unit.

200. Section VII. The specifications do not require the furnishing of spare parts with the preliminary model for test purposes.

201. Section VIII. The bidders descriptive specifications, refs.(e) and (f) comply with the requirements of this section of the governing specifications.

202. Section IX. The instructions furnished with the preliminary model were complete and adequate for placing the equipment into operation. In this connection it is pointed out that the contractor furnished a complete set of inter-connection cables, properly marked, for the entire equipment. This additional service is of great value since it greatly simplifies the work of placing the equipment into operation, reduces the possibilities of making errors in the initial set-up and effects a considerable saving in the cost of conducting the tests. It would appear desirable that in future contracts involving the test of preliminary models, that the contract be so worded as to require the contractor to furnish a complete set of interconnection cables for the period of the test, the cables to remain the property of the contractor and to be returned to him at the completion of the tests. Since it is necessary for the manufacturer to provide these cables in order to conduct his own tests, this additional requirement should not involve a material increase in cost and will effect a considerable saving to the Navy.

203. Section X. The material covered by this section of the specifications has been discussed in detail under the preceding sections of the specifications. In conformity with the authority contained in par.10-8 the following additional tests were conducted.

204. Each phase of the 440 volt supply was grounded, one after the other, to determine whether such grounds influenced the emitted signal of the transmitter or interferred with operation in any respect. No effects, whatever, could be noted when such direct grounds were applied to the power supply lines.

205. RAA and RAB receivers were set up adjacent to the rectifier equipment to determine whether the rectifier tubes or any of the a.c. operated equipment created interference in the receivers. As in previous tests of this nature, some interference was detected at frequencies below 50 kilocycles, when the antenna lead was brought very close to the rectifier equipment and the gain control of the receiver was adjusted to higher than the usual sensitivity. It is believed that this type of interference will have no ill effect upon receivers operating under normal conditions.

206. Bureau of Engineering 1st endorsement, NOs-38614 (5-31-38) of 11 June 1935 requested the Laboratory to comment on the various points cited in ref.(1). These points are discussed, item by item, in the following paragraphs of this report. Reference is made to the paragraph numbers of the Inspector's letter.

207. 2-1. The new type of lifting device referred to is a distinct improvement over the former type and approval for its use should be granted.

2-2. The cast aluminum panels and doors provided on the preliminary model are excellent in appearance and are strong and rugged. Approval for use of this type of construction should be granted.

2-3. The type of wire supplied in the I.F. unit is satisfactory and approval for its use in the entire equipment is recommended.

2-4. No comment.

2-5. Certain items in the preliminary model were not supplied with type number designations. As explained, type numbers will be provided in the production equipment.

2-6. It is recommended that suitable mercury thermometers be provided for indicating the temperature of the master oscillator compartment. During previous tests of various types of equipments it was often noted that the reading of the thermometer was influenced by the ambient temperature. As commented on by the Inspector and the contractor, this was not an indication that the temperature within the compartment had changed radically, since the frequency measurements indicated that the cabinet temperature must have remained substantially constant. In order to avoid stem effects and yet make provision to have the thermometer properly protected against physical damage and to provide a convenient location for the graduated portion of the instrument, undue complications would result. It would appear reasonable to consider the thermometer as an indicating instrument the purpose of which was to inform the operator that the heater system of the master compartment was functioning and that no undue importance should be attached to minor variations in the readings.

208. 4-1. The same type of lifting eyes will be suitable for the rectifier unit.

4-2. The tests conducted with this equipment have indicated that the substitution of 38056 tubes in place of 38110 tubes in the first stage of the audio system is entirely satisfactory. Distortion measurements, the determination of frequency characteristics, noise level measurements and power output tests indicate that the 38056 are adequate for the purpose intended. As pointed out previously, the 38056 will effect economy in first cost and replacements. It is recommended that approval be granted for the use of 38056 tubes in this location.

4-3. It is recommended that approval be granted to increase the time of operation of the voice relay at -25 db level from 0.015 second to 0.030 second. As pointed out in the discussion under par.155-A of this report it is believed that due to the noise levels encountered on vessels in the Navy that it will be found impracticable to operate the voice relay at maximum sensitivity.

4-4. The distortion and frequency characteristic curves submitted with the type test data are in close agreement with the data obtained during the tests at the Naval Research Laboratory. Attention is invited to the fact that these curves represent the characteristics of the circuits contained in the modulator-rectifier and high frequency transmitter units. A large variation between this data and data obtained when the master monitor unit was included in the test circuit was obtained as illustrated in the plates attached to this report.

4-5. Table 50 appended to this report shows that the measurements made at the Naval Research Laboratory determined the voltage regulation of the main plate rectifier to be 5.4%. This slight increase above the specification value might well be attributed to observational errors. In this connection it is interesting to note that the voltage regulation of a rectifier is influenced by the wave shape of the primary voltage. The regulation of this rectifier was studied when operating on two different sources. The source which had a wave form very closely approaching a true sine wave gave the regulation figure of 5.4%. Another source, which under certain conditions of operation apparently had a wave form containing saw tooth characteristics gave a regulation figure of approximately 7%. It would appear unjustified to hold the filter system of a rectifier responsible for the vagaries and discrepancies existing in the source of supply. In the opinion of the Laboratory the rectifiers as supplied are suitable for the purpose intended and essentially meet the requirements of the specifications.

4-6. Recommend approval.

4-7 and 4-8. Recommend approval.

4-9. Agree with the comments of the Inspector.

209. 5-1. All terminal markings and markings on the various component units should be made in a permanent manner. The recommendations of the Inspector should be complied with.

5-2. The thickness of the door catches should be increased to provide additional strength as recommended by the Inspector. In addition, attention is invited to the comments in par.40 of this report.

5-3. The Laboratory has consistently recommended that the identifying symbols of the various units should be placed near rather than on a replaceable part and agrees with the recommendation of the Inspector in this respect.

221. Sub-par.3(k). The frequency of the audio oscillator was measured before and after a two hour key locked run and no appreciable difference was noted. Table 37 tabulates the percentage of positive and negative peaks noted. In some instances the value of the negative peaks exceeded 100%, or, since it is not possible to actually obtain more than 100% negative peaks, it should be stated that the voltage reached zero level and remained at zero for a considerable portion of the negative half cycle. This over-modulation, if sufficiently great, might tend to reduce the power somewhat on the desired frequency due to the generation of harmonics. However, since the purpose of the MCW method of operation is to produce a broad signal for emergency purposes it is believed that the equipment as submitted is satisfactory. A slight reduction in the modulating voltage could be made, if desired, to prevent serious over-modulation.

222. Sub-par.3(l). The type of equipment used and the methods employed are listed under the section of this report headed "Method of Test" and under "Probable Errors in Results". Additional information is contained in the plates presenting the frequency characteristics obtained under various conditions of operation.

223. Ref.(q) forwarded comments from the Westinghouse Electric and Manufacturing Company and the Inspector of Naval Material, Hartford, in connection with proposed changes in the construction of the rotor spacers in the intermediate frequency unit antenna variometer and in the insulators employed on the P.A. coil. It is recommended that the rotor spacers in the antenna variometer be made of Isolantite, since as pointed out in par.48 of this report, the Micalex strips now employed are cracked and are not considered suitable. The insulators now employed in the P.A. tank coil are of Isolantite and have proved satisfactory.

224. A summary of the defects noted and such items as do not comply with the requirements of the governing specifications, together with suggested changes which it is believed will improve the performance of the Model TBN-2 equipment, are listed below. The numerals enclosed in parentheses refer to the paragraph of this report under which these items are discussed in detail.

(a) (35) Several items of carbon non-standard resistors are employed.

(b) (36) Two 38056 vacuum tubes are employed in the audio amplifier; specifications call for 38110 tubes.

(c) (40) Front panel of master monitor unit should be strengthened; more secure means for fastening front panel should be provided.

(d) (41) Additional doors recommended on sides of telephone power unit; additional perforations recommended in top cover of telephone power unit.

(e) (42) Method of wiring terminal blocks in station control units should be modified.

(f) (43) Stowage space for microphone and head set recommended in station extension unit.

(g) (46) Certain items not proof against corrosion.

(h) (47) Steel parts are used in the construction of the speech input equipment.

(i) (48) Micalex supporting strips in antenna tuning inductance of I.F. unit are split; bakelite has been used to insulate potentials in excess of 500 volts in H.F. unit.

(j) (50) "Deion" breaker does not provide adequate protection; overload relays in I.F. unit could not be adjusted to operate properly; use of oil in dash pot relays should be clearly described in instructions.

(k) (53) Top of rectifier-modulator unit should be provided with perforations for ventilation purposes.

(l) (54-a) Power amplifier plate choke in H.F. unit overheated.

(m) (54-b) Audio oscillator circuit in I.F. unit overheated; power amplifier plate choke in I.F. unit overheated.

(n) (58-c) Fuse in telephone power unit open circuited due to vibration.

(o) (61 and 149) Volume control on modulator unit should be supplied with a dial and pointer.

(p) (66) Connections to key relay in I.F. unit should be modified.

(q) (70) 38110 tube socket in speech relay circuit is not marked.

(r) (81-a) Sequence of control markings on I.F. unit should be modified; provide stop on Control "F" of I.F. unit.

(s) (82) Calibration card on H.F. unit has provision for only 10 frequencies.

(t) (96) Frequency tolerance exceeded at 1000 kilocycles and 2000 kilocycles.

(u) (97) Compensating condenser in H.F. unit requires investigation; grounding strip should be more flexible on master oscillator compartment.

(v) (111) Power output of I.F. unit at 300 and 500 kilocycles deficient in low resistance antennas.

(w) (115) Frequency per division of marking of I.F. master oscillator dial does not conform with specifications. (No change recommended.)

(x) (126) Height of hand rails above deck should be uniform on all units.

(y) (127-a) Frequency change of I.F. unit due to shock test exceeds specification limit.

(z) (129-d) Audio frequency level changes with addition of microphones.

(aa) (133-1) Channel "D" output level indicator sticks at mid scale position.

(bb) (133-5) Range switches on transmitter line level indicators affect percentage modulation and percentage of distortion.

(cc) (133-15) Recommend high frequency buzzers in place of the low frequency buzzers now supplied.

(dd) (133-16) Desk stand in place of hook is recommended for master monitor unit combination hand set.

(ee) (133-17) Dimensions of master monitor unit exceed specification limits.

(ff) (137) Recommend cancelling requirement stating that door of station control unit shall be held in horizontal position.

(gg) (138-3) Simultaneous operation of more than one selector control gives rise to "cross talk" at station extension units.

(hh) (142 and 143) Frequency characteristic of speech input equipment does not comply with flatness of response required by specifications.

(ii) (148) Recommend improvement in microphone circuits.

(jj) (150 and 151) Modulation meter inoperative when received; second meter sticks; third meter failed due to overload; P.A. tank condenser in H.F. unit arcs over on voice operation.

(kk) (154-155.9) Response of speech relay at -25 db not in accordance with specifications.

(ll) (159) Changes in marking and control designations recommended on station control unit, station extension units and master monitor unit.

(mm) (160 par.I) Adjustment of friction locks for holding doors of station control units in vertical position when open should be improved.

(nn) (161 and 162) Hand type microphone unit recommended for each modulator unit together with means for securing same when not in use.

(oo) (192) No separate "start-stop" switch provided on rectifier modulator unit.

(pp) (206 to 222 inclusive) The recommendations and suggestions of the Inspector of Naval Material, Hartford, as approved in these paragraphs, should be complied with.

CONCLUSIONS

225. The external appearance of the equipment is excellent; the controls are rugged and well located and the accessibility provided is as great as the limiting conditions permit. The internal wiring is orderly and of good quality, securely held in place and protected where necessary. The component parts comprising the various assemblies are arranged and located with a view of effecting economy in space, orderly appearance and yet permit as great accessibility for servicing operations as possible. In general, the assemblies reflect engineering skill, good design, good workmanship, and efforts to comply with the requirements of Navy Specifications.

226. Both transmitting units produce the required amount, or more than the required power output, except in the region of 300 to 500 kilocycles, when employing the restricted antenna constants required by Navy conditions. The tuning adjustments are simple and direct and flexible antenna coupling circuits have been provided.

227. No major operational failures occurred during the course of extensive tests. Certain difficulties were encountered from which it is concluded that further attention is required to provide a power amplifier choke for the intermediate frequency unit which will withstand continuous operation at all frequencies within the range of the transmitter without overheating and that the design of the 800 cycle audio oscillator circuit in the intermediate frequency unit should be amended to prevent overheating.

228. With respect to the speech input equipment and voice operation the tests showed that the microphone circuits require certain modifications if more natural and desirable qualities of speech are to be retained. The present circuits produce understandable speech but a distinct difference is noted between the microphone circuits supplied in the modulator unit and the microphone circuits incorporated in the master monitor, station control and station extension units, the former circuit producing the better quality. The results of tests indicate that the carbon button type of microphone is more suitable for use with this equipment than the sound power type of microphone.

229. The modulation meters provided for monitoring the equipment are capable of accurate indications but are subject to failure from several causes. These conditions must be overcome before the modulation meter can be considered satisfactory for service use. In addition, precautions must be taken and means provided to prevent arc overs occurring within the transmitter when high level modulation is being used.

230. The speech input circuits have been provided with exceedingly flexible controls which appear adequate for coping with all normal conditions of operation. Precautions must be observed, however, that reasonable voice levels are maintained at the various points of control since more than one operator may be employing the same speech channel; that the microphones are not subjected to prohibitive noise levels, particularly when voice control of the carrier is being used and that all operators and observers endeavor to adjust themselves to the levels of speech and hearing set by the master control operator in order to minimize the difficulties resulting from the variations between individual characteristics of speech and hearing.

231. From observing the operation of this type of equipment, it is evident that certain methods of operation and policy which are not necessary in connection with CW operation will have to be formulated and observed in order to maintain the equipment at a high state of efficiency. Abnormal overloading of circuits must be avoided, proper modulation levels must be maintained, power output reduction should not be accomplished by reducing the potentials applied to the tubes and the various vacuum tubes employed in connection with voice operation cannot be used until the last bit of life has been extracted from them, if high quality operation is to be realized.

232. A number of changes, modifications, and corrections are indicated in order to provide greater safety factors, improve operation of the equipment and to effect greater ease in handling by the operating personnel.

233. The fact that the equipment successfully withstood extensive tests over a period of several months wherein it was subjected to the difficult conditions encountered on board Naval vessels, as nearly as Laboratory conditions would permit, including numerous overload tests, locked key operation at full power for periods as long as eight hours, severe vibration, shock and the motion designed to simulate the rolling of a vessel, variations in temperature from zero to 50° C, conditions of

high humidity wherein the equipment was actually saturated for several hours, indicates that the apparatus is well designed, well constructed, and possesses liberal safety factors which should insure reliable operation in the Naval Service.

TABLE 1

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Telephone Unit

2 HOUR LOCKED KEY ENDURANCE TEST, 100% MODULATION, 2000 KC AT FULL POWER OUTPUT.

Test as per paragraph 2-15 of Specifications RE 13A 497A

Time	Percent Mod.	Mod. Input Amp. Ip	Mod. Inter. Amp. Ip	Modulator Ip #1	Modulator Ip #2	RF P.A. Ip	Plate Volts	Ant. I
2:30	100	9.0	150	118	108	270	2650	8.5
2:45	99	9.0	150	118	106	270	2650	8.5
3:00	99	9.0	150	117	105	270	2660	8.5
3:15	98	9.0	149	116	104	270	2650	8.5
3:30	98	9.0	148	116	104	268	2650	8.4
3:45	98	9.0	148	116	104	269	2660	8.4
4:00	97	9.0	149	116	104	270	2660	8.4
4:15	96	8.7	148	114	103	265	2620	8.3
4:30	98	8.8	149	117	105	268	2660	8.4

Post trial inspection showed no signs of damage or overheating.

TABLE 2

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

2 HOUR LOCKED KEY ENDURANCE TEST, MCW, 2000 KC, FULL POWER.

Test as per paragraph 2-15 of Specifications RE 13A 497A.

Time	Antenna Current	P.A. Ip	Aud.Osc. Ip	Percent Mod. Neg.	Percent Mod. Pos.	Watts MCW	Temp. of Aud. Trsf.
0915	8.1	260	48	77	12	394	40
0930	8.1	262	48	77	12	394	45
0945	8.1	260	48	75	12	384	51
1000	8.0	262	50	75	12	384	55.5
1015	8.0	262	50	75	12	384	60
1030	8.0	261	50	74	11	384	62
1045	8.0	261	50	74	11	384	64
1100	8.0	261	50	74	11	384	65
1115	8.0	261	50	74	11	384	65.5

Antenna resistance: 6 ohms Plate voltage: 3000

Post trial inspection showed no signs of overheating in the equipment.

TABLE 3

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

2 HOUR LOCKED KEY RUN AT 300 KC, MCW, FULL POWER.

Test as per paragraph 2-15 of Specifications RE 13A 497A

Time	Ambient Temp. C.	Frequency Kilocycles	Antenna Current	Plate Volts	Plate Current	Line Volts
1020	26.8	300.541	9.1	2220	420	440
30	26.8		9.1	2230	420	440
40	27.2	.555	9.1	2230	410	440
50	27.2		9.1	2220	410	440
1100	27.7	.598	9.1	2230	410	440
10	27.6		9.1	2230	410	440
20	28.0	.599	9.1	2230	410	440
30	28.0		9.1	2230	410	440
40	27.5	.559	9.2	2240	420	442
50	28.0		9.2	2230	420	442
1200	28.0	.539	9.15	2250	420	442
10	28.0		9.1	2250	420	442
20	28.2	.571	9.20	2250	410	442

Maximum frequency change: 60 cycles; 0.02%.

Post trial inspection showed that capacitor C-13 was extremely hot and that the audio transformer exuded wax. The temperature of this transformer rose to 105° Centigrade.

(Antenna resistance: 5 ohms)

TABLE 4

Model TBN-2 Equipment (Preliminary Model)

Intermediate Frequency Unit

2 HOUR LOCKED KEY RUN AT 300 KC, CW, FULL POWER.

Test as per paragraph 2-15 of Specifications RE 13A 497A

Time	Ambient Temp. C.	Frequency Kilocycles	Antenna Current	Plate Volts	Plate Current	Line Volts
1320	27.8	300.630	12.65	2210	690	442
30	28.2	.568	12.75	2220	700	442
40	29.0	.560	12.75	2220	700	442
50	29.5	.567	12.75	2220	700	442
1400	29.5	.600	12.75	2220	690	442
10	30.0	.556	12.75	2220	700	442
20	30.2	.565	12.75	2220	700	442
30	30.6	.555	12.75	2220	690	442
40	30.6	.582	12.75	2220	690	442
50	30.8	.598	12.70	2220	680	442
1500	30.8	.555	12.75	2220	700	442
10	30.8	.550	12.70	2220	700	442
20	30.9	.551	12.70	2220	700	442

Maximum frequency change: 80 cycles; 0.027%.

Post trial inspection showed no signs of overheating.

(Antenna resistance 5 ohms).

TABLE 5

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

2 HOUR LOCKED KEY RUN AT 500 KC, CW, FULL POWER.

Test as per paragraph 2-15 of Specifications RE 13A 497A.

Time	Ambient Temp. C.	Frequency Kilocycles	Antenna Current	Plate Volts	Plate Current	Line Volts
1350	27.2	500.402	12.5	2200	660	438
1400	27.4	.380	12.5	2200	660	438
10	27.8	.380	12.6	2230	660	440
20	28.0	.350	12.6	2220	660	440
30	28.0	.350	12.6	2220	660	440
40	28.0	.348	12.7	2230	660	441
50	28.3	.356	12.7	2220	660	441
1500	28.4	.350	12.7	2220	660	441
10	27.8	.351	12.7	2220	660	442
20	28.0	.360	12.7	2220	660	442
30	28.5	.357	12.7	2220	660	442
40	28.2	.368	12.7	2220	660	442
50	28.0	.380	12.7	2220	660	442

Maximum change in frequency - 52 cycles; 0.1%.

Note: Before making the above run one coil of the 3-coil choke was replaced. After making this substitution an increase in efficiency was noted at 500 KC. An examination of the coil which was removed revealed poor insulation on the wire, indicating that shorted turns may have existed.

After the above test it was noted that the largest coil in the P.A. choke was much hotter than the other two coils, which may indicate shorted turns.

Original coil: 740 M.A. plate current gave 764 watts output.
Replacement coil: 680 M.A. plate current gave 820 watts output.

(Antenna resistance: 5.05 ohms.)

TABLE 6

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

2 HOUR LOCKED KEY RUN AT 2000 KC, CW, FULL POWER.

Test as per paragraph 2-15 of Specifications RE 13A 497A.

Time	Ambient Temp. C.	Frequency Kilocycles	Antenna Current	Plate Volts	Plate Current	Line Volts
0900	23.2	2000.865	16.0	2190	990	440
10	23.2	.623	16.05	2190	1000	440
20	24.1	.762	16.1	2200	1000	440
30*	24.2	.835	14.2	2220	720	440
40	24.2	.931	14.2	2220	720	440
50	24.2	2001.030	14.2	2220	720	440
1000	24.0	.100	14.2	2220	720	441
10	24.7	.150	14.2	2220	720	441
20	24.8	.200	14.25	2220	720	443
30	24.8	.240	14.25	2230	720	443
40	25.3	.250	14.25	2230	720	443
50	25.6	.275	14.25	2230	720	444
1100	26.0	.350	14.25	2230	720	444

Maximum frequency drift: 727 cycles, 0.036%.

* Note: Power output reduced to 1200 watts.
Antenna resistance: 6 ohms.

Post trial inspection revealed no serious overheating.

TABLE 7

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

ANTENNA SHORT CIRCUITED AND OPEN CIRCUITED.

Test as per paragraph 2-16 of Specifications RE 13A 497A.

Frequency Kilocycles	Antenna	Plate Volts	P. A. Ip	Antenna Current
2000	Normal	2220	940	16.0
2000	Shorted	2150	1250	0
2000	Open	2200	1000	0
	(Tube very hot on shorted and open)			
1000	Normal	2230	600	13.7
1000	Shorted	2200	900	0
1000	Open	2200	940	0
	(Tube hot)			
500	Normal	2220	740	12.3
500	Shorted	2280	310	0
500	Open	2280	320	0
	(Tube OK)			

TABLE 8

Model TBN-2 Transmitter (Preliminary Model)

TABLE OF WEIGHTS.

Data as per paragraph 2-32 of Specifications RE 13A 497A

Unit	Weight
Intermediate Frequency Unit	626 pounds
High Frequency Unit	748 "
Modulator Rectifier Unit	1445 "
Total	2820 pounds
Master Monitor Unit	125 pounds
Telephone Power Unit	180 "
Station Control Unit	40.5 "
Station Extension Unit	20.5 "

Total weight of one Master Monitor Unit, one Telephone Power Unit, five Station Control Units and sixteen Station Extension Units, exclusive of connecting cables, microphones and headsets: 835.5 pounds.

TABLE 9

Model TBN-2 Transmitter (Preliminary Model)

LIST OF DIMENSIONS.

Unit	Specification Requirements	Actual Dimensions of Frame	Actual Overall Dimensions
Intermediate Frequency Unit			
Height -	72 in.	71-1/2 in.	71-3/4 in.
Width -	32	30-3/4	31-7/8
Depth -	24	20-1/2	24-1/4
High Frequency Unit			
Height -	72	71-3/4	71-7/8
Width -	32	31	32
Depth -	24	20-7/8	24-3/8
Modulator Rectifier Unit			
Height -	72	71-1/2	71-3/4
Width - (See note)	32	36-3/4	38
Depth -	24	20-1/2	24-1/2
Master Monitor Unit			
Height -	20		20-1/4
Width -	24		24-1/2
Depth -	16		18
Telephone Power Unit			
Height -			20-1/2
Width -			24
Depth -			16-1/2
Station Control Unit			
Height, closed -			22
Height, open -			43
Width -			10
Depth -			8-3/4
Station Extension Unit			
Height, closed -			15-1/2
Height, open -			30-1/4
Width -			9
Depth -			8-3/4

Note: Increase in width of modulator unit from 32 inches to 38 inches authorized by Bureau of Supplies and Accounts letter NOs-38614(SPM) of 31 December 1934 to contractor.

TABLE 10

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

LIST OF CONTROLS FOR OPERATION OF INTERMEDIATE FREQUENCY UNIT.

Control Designation	Purpose
A	Master oscillator tuning.
B	Master oscillator range switch, 10 steps.
C	Range selector, 6 steps.
D	Intermediate amplifier tuning.
E	Power amplifier tuning.
F	Antenna coupling, coarse, 8 steps.
G	Antenna tap switch, 9 steps, interlocked.
H	Antenna tuning inductance (black).
J	Antenna tuning inductance (red).
K	Antenna coupling, fine, 6 steps.
	CW-MCW switch.
	Adjust-tune-operate switch, interlocked.
	Filament rheostat.
	Local-remote switch.
	Start-stop switch.
	Emergency switch.
	Test key.
	Plate overload reset.

TABLE 11

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

LIST OF CONTROLS ON INTERMEDIATE FREQUENCY UNIT.

Test as per paragraph 3-16 of Specifications RE 13A 497A.

Control	As Furnished	Suggested
A	Master oscillator tuning.	Master oscillator tuning.
B	Master oscillator range switch.	Master oscillator range switch.
C	Range selector.	Range selector.
D	Intermediate amplifier tuning.	Intermediate amplifier tuning.
E	Power amplifier tuning.	Power amplifier tuning.
F	Antenna coupling (coarse).	Antenna coupling (coarse).
G	Antenna tap switch.	Antenna coupling (fine).
H	Antenna tuning inductance (black).	Antenna tap switch.
J	Antenna tuning inductance (red).	Antenna tuning inductance (black).
K	Antenna coupling (fine).	Antenna tuning inductance (red).

The above rearrangement of letters is suggested in order to make the sequence of letters agree with the order in which the circuits are normally tuned.

TABLE 12

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

LIST OF CONTROLS ON HIGH FREQUENCY UNIT.

Data as per paragraph 3-16 of Specifications RE 13A 497A.

Control Designation	Purpose
A	Master oscillator range switch.
B	Master oscillator tuning.
C	Doubler grid tuning.
D	Doubler plate tuning.
E	Intermediate amplifier tuning.
F	Power amplifier tuning.
G	Antenna feed (voltage-current).
H	Antenna coupling.
J	Antenna tuning capacitor.
K	Antenna tuning inductance.
L	Frequency range switch.
M	Power amplifier grid coupling.
	Test key, 2 position, toggle.
	Master oscillator filament stand-by, toggle.
	Start-stop switch, toggle.
	Remote-local switch, toggle.
	Tune operate switch, 3 position, rotary.
	Emergency switch, toggle.
	CW-MCW switch, 2 position, rotary.
	Low-high power switch, 2 position, rotary.
	Filament rheostat.
	Overload relay reset button.

TABLE 13

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

FREQUENCY CHANGE DUE TO OPERATION OF "ADJUST-TUNE-OPERATE" SWITCH.

Test as per paragraph 3-19 of Specifications RE 13A 497A.

Switch Position 1 - Adjust
Switch Position 2 - Tune
Switch Position 3 - Operate

Switch Position	Frequency Kilocycles	Beat Note	Maximum Frequency Change Cycles	Percent
1	300	810		
2	300	712		
3	300	630	180	0.060
1	400	935		
2	400	885		
3	400	840	95	0.024
1	500	915		
2	500	827		
3	500	760	155	0.031
1	600	900		
2	600	810		
3	600	684	216	0.036
1	700	864		
2	700	750		
3	700	620	244	0.035
1	800	815		
2	800	700		
3	800	590	225	0.028
1	900	745		
2	900	660		
3	900	580	165	0.021
1	1000	850		
2	1000	775		
3	1000	725	125	0.012
1	1250	650		
2	1250	590		
3	1250	540	110	0.009

(Continued)

TABLE 13 (Continued)

Switch Position	Frequency Kilocycles	Beat Note	Maximum Frequency Change Cycles	Percent
1	1500	500		
2	1500	485		
3	1500	475	25	0.0017
1	2000	550		
2	2000	508		
3	2000	460	90	0.0045

TABLE 14

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

RESET ACCURACY.

Test as per paragraph 3-24-2 of Specifications RE 13A 497A.

Trial No.	Frequency Kilocycles	Time Seconds	Deviation in Frequency Cycles	Percent
Original	500.580			
1	.635	75	+ 55	0.0109
2	.655	55	+ 75	0.0129
3	.660	55	+ 80	0.0160
4	.690	53	+110	0.0218
5	.618	54	+ 38	0.0076
		Average:	+ 71.6	0.0143
Original	1000.720			
1	.830	40	+110	0.0110
2	.830	50	+110	0.0110
3	.828	48	+108	0.0108
4	.845	45	+125	0.0125
5	.875	43	+155	0.0155
		Average:	+121.6	0.0121
Original	2000.800			
1	.840	48	+ 40	0.0020
2	.830	38	+ 30	0.0015
3	.825	33	+ 25	0.0012
4	.960	40	+160	0.0080
5	.930	38	+130	0.0065
		Average:	+ 77	0.0038

TABLE 15

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

TEST FOR LOST MOTION AND BACK LASH.

Frequency when approaching setting in clock-wise direction	Frequency when approaching setting in counter-clockwise direction	Cycles back-lash.
501.300	500.855	445
.270	.840	430
.270	.850	420
.260	.852	408
.280	.852	428
	Average:	426
1001.000	1001.690	690
.050	.690	640
.000	.690	690
.005	.692	687
.000	.669	669
	Average:	675
2001.085	2001.700	615
.060	.700	640
.065	.705	640
.080	.700	620
.090	.680	590
	Average:	621

TABLE 16

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT OF CHANGE IN AMBIENT TEMPERATURE; 500 KC, FULL POWER.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
0910	25.0	500.460	42.0	-	0.96	436
20	24.5	.465	42.0	58	0.95	437
30	24.8	.472	41.8	54	0.96	436
40	24.0	.477	40.8	65	0.98	435
50	25.8	.488	40.5	66	0.98	435
1000	25.0	.485	40.2	62	0.98	435
10	25.3	.482	40.1	62	0.98	435
1020	30.0	500.484	43.0	61	0.98	445
30	29.5	.480	43.3	61	0.98	445
40	30.0	.476	40.0	61	0.98	444
50	30.5	.476	43.8	59	0.98	444
1100	29.8	.481	44.0	58	0.98	444
10	29.5	.482	43.5	61	0.98	444
20	29.6	.485	43.5	61	0.98	444

Difference in ambient temperature: 5°.
Difference in frequency: +3 cycles; 0.0006%.

1130	34.0	500.482	46.0	53	0.98	444
40	34.7	.482	47.5	54	0.98	444
50	34.5	.475	47.0	57	0.98	444
1200	34.5	.474	47.0	52	0.98	444
10	34.5	.465	47.0	68	0.98	444
20	36.0	.323*	48.0	85*	0.98	444
30	35.0	.451	48.0	57	0.98	444

* Large change in frequency undoubtedly due to large change in relative humidity.

Difference in ambient temperature: 5°.
Difference in frequency: -34 cycles; 0.0068%.

1240	39.0	500.431	50.0	69	0.98	445
50	40.5	.375	52.5	67	0.98	445
1300	40.5	.392	53.0	65	0.98	445
10	40.0	.431	54.0	56	0.98	445

(Continued)

TABLE 16 (Continued)

Time	Ambinet Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1320	40.5	500.445	54.0	53	0.98	445
30	40.5	.450	54.0	54	0.98	445
40	39.5	.454	54.0	53	0.98	445
	Difference in ambient temperature: 5°. Difference in frequency: +3 cycles; 0.0006%.					
1350	47.3	500.455	58.4	38	1.00	445
1400	45.0	.460	58.0	42	0.98	445
10	45.0	.470	58.5	41	0.98	445
20	45.5	.480	59.0	43	0.98	445
30	44.8	.485	59.6	42	0.98	445
40	45.3	.494	59.6	47	0.98	445
50	45.0	.500	60.5	45	0.98	445
	Difference in ambient temperature: 5°. Difference in frequency: +46 cycles; 0.0092%.					
1500	49.7	500.504	63.0	39	0.98	445
10	50.0	.518	63.0	36	0.98	445
20	50.0	.534	64.0	38	0.98	445
30	50.2	.549	64.5	36	0.98	445
40	49.5	.560	64.0	36	0.98	445
50	50.0	.570	65.0	35	0.98	445
1600	50.0	.579	65.0	35	0.98	445
	Difference in ambient temperature: 5°. Difference in frequency: +79 cycles; 0.0158%.					

TABLE 17

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT OF CHANGE IN AMBIENT TEMPERATURE; 500 KC; FULL POWER.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
0830	25.2	500.560	36.0	59	0.96	428
40	25.2	.572	39.0	55	0.96	428
50	25.2	.580	39.8	55	0.95	424
0900	25.2	.589	40.5	55	0.98	442
10	25.2	.600	40.8	51	0.98	442
20	25.1	.610	40.4	51	0.98	442
30	25.0	.613	40.9	51	0.99	442
0940	20.2	500.618	39.6	58	0.99	442
50	17.2	.629	36.6	65	0.99	442
1000	18.9	.630	37.0	71	0.99	442
10	19.9	.628	36.2	70	1.00	442
20	20.0	.630	36.7	74	1.00	444
30	20.0	.627	36.6	70	1.00	442
40	20.0	.622	36.7	75	1.00	442
	Change in ambient temperature: 5°. Change in frequency: +9 cycles; 0.0018%.					
1050	15.1	500.636	33.6	71	1.00	442
1100	15.0	.651	33.0	77	1.10	442
10	15.1	.651	32.0	73	1.10	442
20	15.0	.653	31.6	71	1.10	442
30	15.0	.652	31.6	76	1.10	442
40	15.0	.652	32.0	71	1.10	442
50	15.0	.656	32.0	71	1.10	442
	Change in ambient temperature: 5°. Change in frequency: +34 cycles; 0.0068%.					
1200	10.5	500.677	29.2	61	1.10	442
10	10.2	.680	27.4	66	1.10	442
20	10.0	.679	26.8	58	1.10	440
30	10.1	.687	26.5	58	1.10	440
40	10.1	.689	26.8	65	1.10	440
50	10.0	.690	26.7	72	1.10	440
1300	10.1	.691	26.7	65	1.10	440
	Change in ambient temperature: 5°. Change in frequency: +35 cycles; 0.007%.					

(Continued)

TABLE 17 (Continued)

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1320	5.1	500.710	22.4	59	1.10	444
30	5.0	.716	21.1	-	1.10	440
40	5.1	.721	21.4	66	1.10	440
50	-	.724	(Blower cut out)			440
1400	6.5	.729	22.4	60	1.10	440
10	5.0	.731	21.1	66	1.10	438
20	5.0	.735	20.5	-	1.10	438
	Change in ambient temperature: 5°.					
	Change in frequency: +44 cycles; 0.0088%.					
1430	0.5	500.747	17.8*	-	1.10	438
40	0.0	.757	21.4*	-	1.10	438
50	0.0	.760	22.5*	-	1.10	438
1500	0.4	.760	22.4*	-	1.10	438
10	0.0	.763	22.2*	-	1.10	438
20	0.0	.769	21.0*	-	1.20	438
30	0.0	.769	21.5*	-	1.20	438

(Note: * denotes that rectifier tube compartment heater was on.)

Change in ambient temperature: 5°.
Change in frequency: +34 cycles; 0.0068%.

TABLE 18

Model TBW-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT OF CHANGE IN AMBIENT TEMPERATURE; 1000 KC; FULL POWER.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
24.9	1000.080	39.0	66	0.83	436
25.2	.335	39.0	66	0.83	436
24.5	.435	39.0	62	0.83	436
25.1	.577	39.0	70	0.83	436
24.5	.662	39.3	70	0.83	436
24.5	.765	39.0	63	0.83	436
25.0	.810	39.0	62	0.83	436
29.0	1000.890	41.0	58	0.83	436
30.9	.845	42.5	69	0.83	436
30.9	.920	42.9	69	0.83	436
29.0	.990	41.9	61	0.83	436
29.0	1001.095	42.4	58	0.83	436
30.0	.140	42.6	56	0.82	436
29.9	.170	42.5	58	0.82	438
Change in ambient temperature: 5°. Change in frequency: +360 cycles; 0.036%.					
35.0	1001.190	45.0	51	0.82	437
35.0	.215	45.7	54	0.82	436
35.4	.250	46.4	54	0.82	436
35.4	.260	46.4	54	0.82	436
35.4	.310	46.8	52	0.81	436
35.4	.350	46.6	52	0.81	437
35.2	.350	46.5	52	0.81	436
Change in ambient temperature: 5°. Change in frequency: +180 cycles; 0.018%.					
40.5	1001.250	49.6	72	0.81	436
40.1	.100	51.5	70	0.81	436
39.0	.375	51.0	70	0.81	436
41.0	.200	51.9	62	0.80	436
40.0	.250	52.2	62	0.80	436
40.9	.300	53.0	54	0.80	436
40.0	.360	53.2	54	0.80	436
Change in ambient temperature: 5°. Change in frequency: +10 cycles; 0.001%.					

(Continued)

TABLE 18

Model TBW-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT OF CHANGE IN AMBIENT TEMPERATURE; 1000 KC; FULL POWER.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
0840	24.9	1000.080	39.0	66	0.83	436
50	25.2	.335	39.0	66	0.83	436
0900	24.5	.435	39.0	62	0.83	436
10	25.1	.577	39.0	70	0.83	436
20	24.5	.662	39.3	70	0.83	436
30	24.5	.765	39.0	63	0.83	436
40	25.0	.810	39.0	62	0.83	436
1000	29.0	1000.890	41.0	58	0.83	436
10	30.9	.845	42.5	69	0.83	436
20	30.9	.920	42.9	69	0.83	436
30	29.0	.990	41.9	61	0.83	436
40	29.0	1001.095	42.4	58	0.83	436
50	30.0	.140	42.6	56	0.82	436
1100	29.9	.170	42.5	58	0.82	438
	Change in ambient temperature: 5°. Change in frequency: +360 cycles; 0.036%.					
1110	35.0	1001.190	45.0	51	0.82	437
20	35.0	.215	45.7	54	0.82	436
30	35.4	.250	46.4	54	0.82	436
40	35.4	.260	46.4	54	0.82	436
50	35.4	.310	46.8	52	0.81	436
1200	35.4	.350	46.6	52	0.81	437
10	35.2	.360	46.5	52	0.81	436
	Change in ambient temperature: 5°. Change in frequency: +180 cycles; 0.018%.					
1220	40.5	1001.250	49.6	72	0.81	436
30	40.1	.100	51.5	70	0.81	436
40	39.0	.375	51.0	70	0.81	436
50	41.0	.200	51.9	62	0.80	436
1300	40.0	.250	52.2	62	0.80	436
10	40.9	.300	53.0	54	0.80	436
20	40.0	.360	53.2	54	0.80	436
	Change in ambient temperature: 5°. Change in frequency: +10 cycles; 0.001%.					

(Continued)

TABLE 18 (Continued)

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1330	45.1	1001.400	56.0	49	0.80	438
40	45.5	.430	57.5	45	0.80	438
50	45.8	.475	58.0	46	0.80	438
1400	44.3	.500	57.9	46	0.80	438
10	44.5	.510	57.5	47	0.80	438
20	44.5	.535	57.6	52	0.80	438
30	45.2	.550	58.4	49	0.80	438
	Change in ambient temperature: 5°.					
	Change in frequency: +190 cycles; 0.019%.					
1440	51.0	1001.600	61.2	40	0.80	438
50	49.8	.660	62.0	38	0.80	438
1500	50.3	.725	63.7	38	0.80	438
10	50.3	.775	62.4	38	0.80	438
20	50.2	.800	63.2	38	0.80	438
30	50.3	.850	64.0	38	0.80	438
40	49.8	.875	63.5	38	0.80	438
	Change in ambient temperature: 5°.					
	Change in frequency: +325 cycles; 0.032%.					

TABLE 19

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT OF CHANGE IN AMBIENT TEMPERATURE; 1000 KC; FULL POWER.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
0920	26.0	1000.640	34.4	48	0.81	436
30	21.2	.776	36.8	74	0.82	436
40	23.8	.768	38.4	73	0.82	436
50	25.0	.762	40.0	78	0.82	437
1000	24.8	.770	39.6	78	0.82	437
10	25.0	.772	39.9	78	0.82	437
20	25.0	.774	39.9	78	0.82	436
1030	20.1	1000.840	37.1	75	0.82	436
40	20.1	.843	36.0	80	0.82	437
50	20.0	.830	35.5	85	0.82	437
1100	20.0	.828	35.5	85	0.82	436
10	20.0	.830	35.5	80	0.82	436
20	20.0	.825	35.0	75	0.82	436
30	20.0	.825	35.0	80	0.82	436
	Change in ambient temperature: 5°. Change in frequency: +51 cycles; 0.0051%.					
1140	14.5	1000.865	32.0	71	0.82	436
50	15.0	.935	30.9	76	0.82	436
1200	15.0	.925	30.5	71	0.82	436
10	15.0	.925	30.5	71	0.82	436
20	15.0	.920	29.9	71	0.82	436
30	15.0	.932	29.7	71	0.82	436
40	15.0	.918	29.9	71	0.82	437
	Change in ambient temperature: 5°. Change in frequency: +93 cycles; 0.0093%.					
1250	9.4	1000.958	26.8	66	0.82	437
1300	10.1	.954	25.5	53	0.82	437
10	10.0	.956	25.1	59	0.82	437
20	10.1	.953	24.6	59	0.82	437
30	9.9	.962	24.5	59	0.83	438
40	9.9	.955	24.4	59	0.83	438
50	10.0	.952	24.3	59	0.83	438
	Change in ambient temperature: 5°. Change in frequency: +34 cycles; 0.003[illegible]%.					

(Continued)

TABLE 19 (Continued)

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1400	4.5	1000.982	21.5	-	0.83	438
10	5.4	.980	20.5	-	0.83	438
20	4.9	.985	20.4	-	0.83	438
30	5.0	.970	19.6	-	0.83	438
40	4.9	.970	19.6	-	0.83	438
50	4.9	.968	19.6	-	0.83	438
1500	5.2	.963	24.0*	-	0.83	438
	Change in ambient temperature: 5°.					
	Change in frequency: +11 cycles; 0.0011%.					
1510	0.2	1000.998	23.3*	-	0.83	438
20	0.2	1001.060	22.0*	-	0.83	438
30	0.2	.050	22.5*	-	0.83	438
40	0.8	.050	22.0*	-	0.84	438
50	0.1	.030	21.5*	-	0.84	438
1600	0.0	.050	21.0*	-	0.84	438
10	0.0	.050	21.0*	-	0.84	438
	Change in ambient temperature: 5°.					
	Change in frequency: +87 cycles; 0.0087%.					

Note: * denotes that rectifier tube compartment heater was turned on.

TABLE 20

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT OF CHANGE IN AMBIENT TEMPERATURE; 2000 KC.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1020	31.0	2000.779	48.5	63	0.80	436
30	28.8	.921	46.5	65	0.80	436
40	29.3	2001.050	45.2	76	0.80	436
50	29.4	.060	45.0	79	0.80	438
1100	29.4	.250	44.6	76	0.80	438
10	29.4	.600	44.8	76	0.82	438
20	29.1	.685	44.1	76	0.82	438
1130	37.0	2001.200	47.4	76	0.82	438
40	34.5	.310	47.0	52	0.82	438
50	34.8	.425	46.9	54	0.82	438
1200	35.3	.475	47.0	54	0.82	438
10	35.1	.550	47.2	54	0.82	438
20	35.0	.590	47.0	52	0.82	438
30	34.5	.625	47.0	52	0.82	438
	Difference in ambient temperature: 5°.					
	Change in frequency: -60 cycles; 0.003%.					
1240	42.0	2000.450	51.3	66	0.82	438
50	40.2	.475	51.5	76	0.82	438
1300	39.0	.250	51.5	76	0.82	438
10	40.9	.375	52.6	58	0.82	438
20	41.5	.590	53.6	50	0.82	438
30	40.2	.690	54.0	55	0.82	438
40	40.3	.755	54.3	53	0.82	438
	Change in ambient temperature: 5°.					
	Change in frequency: +130 cycles; 0.0065%.					
1350	44.5	2000.825	55.3	48	0.82	438
1400	46.7	.875	57.7	41	0.82	438
10	56.0	2002.000	58.7	44	0.82	438
20	45.0	.075	58.6	42	0.82	438
30	45.0	.160	59.0	42	0.82	438
40	45.1	.215	59.0	42	0.82	438
50	45.0	.250	59.0	37	0.82	438
	Change in ambient temperature: 5°.					
	Change in frequency: +495 cycles; 0.024%.					

(Continued)

TABLE 20 (Continued)

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1500	50.2	2002.300	62.5	38	0.82	438
10	50.5	.325	63.0	40	0.82	438
20	49.2	.350	63.0	-	-	438
30	50.0	.500	63.0	36	0.40*	438
40	50.0	.460	63.0	36	0.40	438
50	50.2	.445	64.0	38	0.46	438
1600	49.9	.250	63.6	40	0.47	438

Change in ambient temperature: 5°.
Change in frequency: 0.

Note: * Power amplifier plate current, and output, dropped suddenly at 1520. Examination revealed no breakdown or cause for this condition. After the transmitter was shut down for a period of some hours and restarted, power amplifier plate current was normal and normal output was obtained. This difficulty was not encountered again.

TABLE 21

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

EFFECT IN CHANGE OF AMBIENT TEMPERATURE; 2000 KC; FULL POWER.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Comp't.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
0800	31.0	2000.654	35.4	60	0.86	436
10	28.8	.864	40.5	55	0.86	436
20	30.8	2001.140	44.0	61	0.86	436
30	29.5	.260	43.8	61	0.86	436
40	30.0	.340	43.8	65	0.86	436
50	30.0	.400	43.8	65	0.86	436
0900	30.0	.440	43.3	65	0.86	436
0910	24.5	2001.575	41.5	62	0.86	436
20	25.7	.510	41.0	66	0.86	436
30	25.0	.550	41.0	66	0.86	436
40	25.0	.550	40.5	66	0.86	436
50	24.8	.560	40.4	66	0.86	436
1000	25.0	.550	40.4	66	0.86	437
10	24.7	.550	40.0	66	0.86	437
	Change in ambient temperature: 5°.					
	Change in frequency: +110 cycles; 0.0055%.					
1030	21.5	2001.625	38.2	67	0.86	437
40	18.8	.675	36.3	75	0.86	437
50	22.2	.600	37.2	81	0.86	437
1100	20.2	.600	36.4	71	0.86	437
10	18.5	.650	35.7	80	0.86	437
20	19.8	.640	35.5	71	0.86	437
30	20.1	.600	35.5	76	0.86	437
	Change in ambient temperature: 5°.					
	Change in frequency: +50 cycles; 0.0025%.					
1140	14.0	2001.750	32.2	75	0.86	437
50	15.0	.750	32.0	72	0.86	437
1200	15.0	.750	31.0	71	0.86	437
10	15.0	.750	31.0	71	0.86	437
20	15.0	.750	30.5	71	0.86	437
30	14.4	.750	30.0	70	0.86	437
40	15.0	.725	30.3	77	0.86	437
	Change in ambient temperature: 5°.					
	Change in frequency: +125 cycles; 0.0062%.					

(Continued)

TABLE 21 (Continued)

Time	Ambient Temp. °C.	Frequency Kcs.	Temp. Rect. Compt.	% Relative Humidity	Pr. Amp. Plate Current	Line Volts
1250	11.0	2001.800	28.0	68	0.86	438
1300	10.0	.860	25.9	66	0.86	438
10	10.0	.875	26.0	66	0.86	438
20	10.0	.875	25.3	61	0.86	438
30	9.5	.900	24.9	72	0.86	438
40	10.0	.900	24.8	79	0.86	438
50	10.0	.875	24.9	79	0.86	438
	Change in ambient temperature: 5°.					
	Change in frequency: +150 cycles; 0.0075%.					
1400	6.0	2001.925	24.5	-	0.86	438
10	5.0	.950	22.0	76	0.86	438
20	5.2	.950	20.8	69	0.86	438
30	5.1	.950	20.5	75	0.86	438
40	5.6	.960	20.1	75	0.86	438
50	5.0	.975	20.1	75	0.86	439
1500	5.0	.975	20.1	75	0.86	439
	Change in ambient temperature: 5°.					
	Change in frequency: +100 cycles; 0.005%.					
1510	1.0	2002.000	18.5*	-	0.86	438
20	0.4	.025	20.7*	-	0.86	438
30	0.2	.100	21.0*	-	0.86	438
40	-1.0	.090	22.6*	-	0.86	438
50	0.0	.100	22.0*	-	0.86	438
1600	0.0	.100	21.2*	-	0.86	439
10	0.0	.100	21.4*	-	0.86	438
	Change in ambient temperature: 5°.					
	Change in frequency: +125 cycles; 0.0062%.					

Note: * denotes that rectifier tube compartment heater came on.

TABLE 22

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

SUMMARY OF TABLES 16 to 21, INCLUSIVE.

Test as per paragraph 3-24-3 of Specifications RE 13A 497A.

Temperature Range	Cycles Frequency Change per 5 degrees C. at 500 Kcs.	1000 Kcs.	2000 Kcs.
0 to 5	+34	+ 87	+125
5 to 10	+44	+ 11	+100
10 to 15	+35	+ 34	+150
15 to 20	+34	+ 93	+125
20 to 25	+ 9	+ 51	+ 50
25 to 30	+ 3	+360	+110
30 to 35	-34	+180	- 60
35 to 40	+ 3	+ 10	+130
40 to 45	+46	+190	+495
45 to 50	+79	+325	0

TABLE 23

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

VARIATION OF SUPPLY LINE VOLTAGE.

Test as per paragraph 3-24-4 of Specifications RE 13A 497A.

Line Volts	Frequency Kilocycles	Plate Volts	Rectifier Fil. Volts	Antenna Current
418.0	500.750	2100	190	11.6
422.4	.752	2120	192	11.8
426.8	.752	2150	193	11.9
431.2	.755	2180	196	12.0
435.6	.756	2200	198	12.1
440.0	.752	2220	200	12.3
444.4	.760	2240	201	12.4
448.8	.763	2280	203	12.5
453.2	.762	2300	206	12.6
457.6	.763	2320	208	12.7
462.0	.763	2340	209	12.8

Maximum frequency change: -13 cycles.
Rapid change in voltage from +5% to -5% caused a shift of 20 cycles.

418.0	1000.660	2080	190	13.8
422.4	.655	2100	191	14.0
426.8	.645	2120	193	14.2
431.2	.650	2150	196	14.3
435.6	.656	2180	198	14.5
440.0	.660	2200	200	14.7
444.4	.665	2220	201	14.8
448.8	.670	2240	203	15.0
453.2	.677	2270	205	15.2
457.6	.680	2290	208	15.3
462.0	.695	2320	209	15.6

Maximum frequency change: -50 cycles.
Rapid change in voltage from +5% to -5% caused a shift of 5 cycles.

418.0	2000.670	2090	193	14.2
422.4	.650	2100	194	14.3
426.8	.635	2130	197	14.6
431.2	.615	2150	198	14.8
435.6	.610	2190	200	15.0
440.0	.600	2210	201	15.2
444.4	.595	2220	203	15.4
448.8	.595	2250	206	15.5
453.2	.585	2280	208	15.8
457.6	.585	2300	210	16.0
462.0	.580	2320	212	16.2

Maximum frequency change: +90 cycles.
Rapid change in voltage from +5% to -5% caused shift of 20 cycles.

TABLE 24

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

25% VARIATION IN ANTENNA CONSTANTS.

Test as per paragraph 3-24-5 of Specifications RE 13A 497A.

Control Varied	Normal Frequency	Frequency when Ip increased 25%	Cycles Change	Frequency when Ip decreased 25%	Cycles Change
Antenna	500.721			500.711	-10
Antenna	.718	500.719	+1		
Power Amplifier	.715	.720	+5		
Antenna	1000.640	1000.641	+1		
Antenna	.649			1000.658	+17
Power Amplifier	.653	.651	-2		
Antenna	2000.551	2000.551	0		
Antenna	.547			2000.550	+ 3
Power Amplifier	.548	.550	+2		
Power Amplifier	.572			.570	- 2

TABLE 25

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

CONTROL OF POWER OUTPUT.

Test as per paragraph 3-24-6 of Specifications RE 13A 497A.

Tap Switch	Frequency Kilocycles	Plate Volts	Antenna Current	Percent Power	Percent Voltage
		(Antenna resistance: 5.05 ohms)			
7	500.597	2410	13.85	117.3	107.0
6	.600	2250	12.80	100.0	100.0
5	.632	2010	11.55	81.4	89.3
4	.642	1810	10.10	62.3	80.4
3	.652	1580	8.75	46.7	70.2
2	.665	1380	7.35	32.9	61.3
1	.690	1140	5.90	21.2	50.6
	Maximum frequency change: +93 cycles; 0.018%.				
		(Antenna resistance: 5.3 ohms)			
7	1000.712	2390	16.10	116.0	107.6
6	.712	2220	14.95	100.0	100.0
5	.738	2000	13.40	80.4	90.1
4	.752	1790	11.80	62.3	80.6
3	.760	1570	10.10	45.7	70.7
2	.780	1370	8.40	31.6	61.7
1	.796	1130	6.50	18.9	50.9
	Maximum frequency change: +84 cycles; 0.008%.				
		(Antenna resistance: 6.0 ohms)			
7	2000.617	2400	14.35	118.0	107.6
6	.590	2220	13.20	100.0	100.0
5	.645	2000	11.80	79.9	90.0
4	.660	1800	10.15	59.1	81.1
3	.679	1580	8.50	41.4	71.2
2	.690	1380	6.65	25.4	62.2
1	.690	1130	4.40	11.1	50.9
	Maximum frequency change: +100 cycles; 0.005%.				

TABLE 26

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

CHANGE IN FREQUENCY DUE TO CHANGE OF VACUUM TUBES.

Test as per paragraph 3-24-7 of Specifications RE 13A 497A.

Serial Number of Tube		Frequency Kilocycles
	Master Oscillator	
Wstg-41845	(original)	500.466
Wstg-41852		.500
Wstg-41809		.541
Wstg-41846		.530
	Maximum change: +75 cycles.	
	Power Amplifier	
Wstg-25673	(original)	500.530
HySl-1004		.556
HySl-1008		.531
HySl-1006		.560
	Maximum change: +30 cycles.	
	Master Oscillator	
Wstg-41845	(original)	1000.650
Wstg-41853		.734
Wstg-41852		.821
Wstg-41809		.738
	Maximum change: +171 cycles.	
	Power Amplifier	
Wstg-25673	(original)	1000.764
HySl-1006		.740
HySl-1004		.716
HySl-1008		.727
	Maximum change: -48 cycles.	
	Master Oscillator	
Wstg-41845	(original)	2000.500
Wstg-41809		.460
Wstg-41853		.580
Wstg-41852		.604
	Maximum change: +104 cycles.	
	Power Amplifier	
Wstg-25673	(original)	2000.428
HySl-1004		.510
HySl-1008		.592
HySl-1006		.567
	Maximum change: +164 cycles.	

TABLE 27

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

SUMMARY OF FREQUENCY STABILITY TESTS.

Test as per paragraph 3-24 of Specifications RE 13A 497A.

Test	Maximum Frequency Change at 500 Kcs.	1000 Kcs.	2000 Kcs.
(1) Initial errors in calculation	0	0	0
(2) Errors in resetting	+110	+155	+160
(3) Change in ambient temperature 5°C.	+ 79	+360*	+495*
(4) Variation in line voltage	- 13	- 50	+ 90
(5) Change in antenna constants	- 10	+ 17	+ 3
(6) Control of power output	+ 93	+ 84	+100
(7) Change of tubes	+ 75	+171	+164
Algebraic sum:	334	737	1012
Permitted by specifications:	475	600	850

* See paragraph 96.

TABLE 28

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

VARIATION OF LINE VOLTAGE.

Test as per paragraph 3-7-1 of Specifications RE 13A 442D

Line Volts	1% per minute Variation	Rapid Variation
418.0	4500.475	4500.508
422.4	.469	
426.8	.468	
431.2	.474	
435.6	.475	
440.0	.480	
444.4	.486	
448.8	.488	
453.2	.493	
457.6	.499	
462.0	.518	4500.518
Cycles change:	43	10
Percent change:	0.0009%	0.0002%

Permitted by specifications: 0.0025%.

TABLE 29

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

FREQUENCY CHANGE CAUSED BY DETUNING RESONANT CIRCUITS.

Test as per paragraph 3-7-3 of Specifications RE 13A 442D

Circuit Detuned	Cycles Change	Percent Change
"C" Doubler Grid Tuning	38	0.0008
"D" Doubler Plate Tuning	3	Neg.
"E" Intermediate Amplifier Tuning	4	"
"F" Power Amplifier Tuning	2	"
"H" Antenna Coupling	2	"
"J" Antenna Tuning Capacitor	1	"
"K" Antenna Tuning Inductance	1	"

Test Frequency: 4500 Kcs.

Permitted by Specifications: 0.005%.

TABLE 30

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

FREQUENCY CHANGE BETWEEN "ADJUST," "TUNE," AND "OPERATE."

Test as per paragraph 3-7-4 of Specifications RE 13A 442D.

	2000 KC	2500 KC	3000 KC	3500 KC	4000 KC	4500 KC
Step 1 "Adjust"	241	237	257	206	240	210
Step 2 "Tune"	238	250	244	175	223	200
Step 3 "Operate"	237	251	240	151	232	193
Maximum change	4	14	17	55	17	17
Percent change	0.0002	0.0005	0.0005	0.0015	0.0004	0.0003

Permitted by Specifications: 0.001%.

TABLE 31

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

KEY LOCKED TEST.

Test as per paragraph 3-7-5 of Specifications RE 13A 442D.

Test No. 1 - Oscillator filament not lighted during shut down.
Transmitter tested as received from manufacturer.

End of 10 minute key lock	4500.500
End of 10 second dash	4500.810
Change in cycles	310
Percent change	0.0069%

Test No. 2 - Oscillator filament lighted during shut down.
Transmitter tested as received from manufacturer.

End of 10 minute key lock	4500.400
End of 10 second dash	4500.480
Change in cycles	80
Percent change	0.0018%

Test No. 3 - Oscillator filament not lighted during shut down.
After restoring circuit to compensating transformer.

End of 10 minute key lock	4500.521
End of 10 second dash	4500.680
Change in cycles	159
Percent change	0.0035%

Test No. 4 - Oscillator filament lighted during shut down.
After restoring circuit to compensating transformer.

End of 10 minute key lock	4500.529
End of 10 second dash	4500.480
Change in cycles	49
Percent change	0.0011%

Test No. 5 - Oscillator filament not lighted during shut down.
After moving compensating condenser in 3.5 turns from original setting.

End of 10 minute key lock	4500.565
End of 10 second dash	4500.690
Change in cycles	125
Percent change	0.0028%

(Continued)

TABLE 31 (Continued)

Test No. 6 - Oscillator filament not lighted during shut down. After moving compensating condenser out 3 turns from original setting.

End of 10 minute key lock	4500.570
End of 10 second dash	4500.750
Change in cycles	180
Percent change	0.004%

Permitted by specifications:

Filament not lighted	0.01%
Filament lighted	0.005%

TABLE 32

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

40 WORDS PER MINUTE KEYING TEST.

Test as per paragraph 3-7-6 of Specifications RE 13A 442D Transmitter tested as received from manufacturer (circuit to compensating transformer open).

End of 30 minute keying	4500.460
End of 10 second dash	4500.510
Change in cycles	50
Percent change	0.0011%

Permitted by specifications: 0.0025%

TABLE 33

Model TBN-2 Transmitter (Preliminary Model)

LIST OF INDICATOR LIGHTS

Data as per paragraph 3-27 of Specifications RE 13A 497A

Color	Legend	Purpose
	Rectifier Modulator Unit	
Red	A.C. overload relay	Lights when A.C. overload is open.
Green	Filament on	Lights when rectifier filaments are lighted.
	Intermediate Frequency Unit	
Green	Bias voltage	Lights when bias voltage is on.
Blue	Rectifier on	Lights when rectifier is on.
Red	Plate voltage	Lights when plate voltage is applied to transmitter.
	High Frequency Unit	
Blue	Rectifier on	Lights when rectifier is on.
Red	Plate voltage	Lights when plate voltage is applied to transmitter.
Amber	Heater circuit	Lights when master oscillator heater circuit is energized.
Green	Bias voltage	Lights when bias voltage is on.
White	Master oscillator filament	Lights when master oscillator filament is lighted.

TABLE 34

Model TBN-2 Equipment (Preliminary Model)

LIST OF METERS.

Data as per paragraph 3-28 of Specifications RE 13A 497A

Modulator Rectifier Unit

1 - Percentage modulation meter, 0-100, CAY-22230.
1 - Intermediate amplifier plate ammeter, 0-250 MA, DC, CAY-22065.
2 - Modulator plate ammeters, 0-250 MA, DC, CAY-22065.
1 - Input amplifier plate ammeter, 0-50, DC, CAY-22056.
1 - Filament voltmeter, 0-15 volts, AC, CAY-22080.
1 - Output ammeter, 0-2 amps., CAY-22002.
1 - Plate voltmeter, 0-3500 volts, DC, CAY-22145.
1 - Bias voltmeter, 0-500 volts, DC, CAY-22198.
1 - Filament transformer primary voltmeter, 0-250 volts, AC, CAY-22086.

Intermediate Frequency Unit

1 - Antenna ammeter, 0-25 amps., RF, with external heating element. (No type number.)
1 - Power amplifier plate ammeter, DC, 0-2 amps., CAY-22002.
1 - Intermediate amplifier plate ammeter, DC, 0-250 MA, CAY-22065.
1 - Master oscillator plate ammeter, DC, 0-250 MA, CAY-22065.
1 - Audio oscillator plate ammeter, DC, 0-250 MA, CAY-22065.
1 - Filament voltmeter, AC, 0-15 volts, CAY-22080.
1 - Power amplifier tube hour meter, 120 volts, 60 cycles, CAY-22199.
1 - Bias voltmeter, DC, 0-500 volts, CAY-22198.
1 - Plate voltmeter, DC, 0-3500 volts, CAY-22145.

High Frequency Unit

1 - Master oscillator screen grid ammeter, DC, 0-50 MA, type NX.
1 - Master oscillator plate ammeter, DC, 0-100 MA, type NX.
1 - Intermediate amplifier grid ammeter, DC, type NX, 0-100 MA.
1 - Doubler plate ammeter, DC, 0-250 MA, type NX.
1 - Power amplifier grid ammeter, DC, 0-100 MA, type NX.
1 - Intermediate amplifier plate ammeter, DC, 0-250 MA, type NX.
1 - Power amplifier plate ammeter, DC, 0-500 MA, type NX.
1 - Filament voltmeter, AC, 0-15 volts, type NA.
1 - Tube filament life meter, 10,000 hours.
1 - Bias voltmeter, DC, 0-500 volts, type NX.
1 - Plate voltmeter, DC, 0-3500 volts, type NX.
1 - Audio oscillator plate ammeter, DC, 0-500 MA, CAY-22065.
1 - Antenna ammeter, 0-15 amps., RF, with external heating element.

TABLE 35

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

DETERMINATION OF POWER OUTPUT.

Test as per paragraphs 8-2 and 10-2-3 of Specifications RE 13A 497A.

Column No.	1	2	3	4
Control or Meter	300 Kcs.	500 Kcs.	750 Kcs.	1000 Kcs.
A	658	1714	1250	1342
B	1	3	5	6
C	1	3	4	5
D	22	34	57	53
E	19	24	49	52.5
F	4	4	5	6
G	1	3	5	7
H	54	24	-	-
J	-	-	538	1073
K	5	5	1	6
MO Ip	38	42	38	39
IA Ip	83	85	90	94
PA Ip	1000	990	990	1000
Ant I int.*	16.1	17.8	23.3	20.8
Ant I ext.*	14.99	16.4	20.5	19.5
Ep	2190	2200	2190	2190
Eg	275	282	272	274
Ef	11	11	11	11
Ant Cap.	403.5	403.5	465	403.5
Ant Res.	2.8	2.0	2.0	3.0
Ant Pr ext.*	627	538	840	1140
Guar. Power	700	700	825	1000

* Note: "Ant I int." refers to the current reading of the antenna ammeter located on the panel of the transmitter.

"Ant I ext." refers to the current reading of a precision type instrument located in the low side of the dummy antenna.

"Ant Pr ext." is the output calculated from the external precision ammeter readings.

TABLE 36

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

DETERMINATION OF POWER OUTPUT.

Test as per paragraphs 8-2 and 10-2-3 of Specifications RE 13A 497A.

Column	1	2	3	4
Control or Meter	1250 Kcs.	1500 Kcs.	1750 Kcs.	2000 Kcs.
A	1501	1717	1998	2419
B	7	8	9	10
C	5	6	6	6
D	80	44	74	92
E	72	38	57	69
F	7	7	7	8
G	9	9	9	9
H	-	-	-	-
J	308	730	543	898
K	1	1	6	1
MO Ip	48	50	50	52
TA Ip	90	90	90	93
PA Ip	1000	1000	990	975
Ant I int*	19.4	16.6	15.8	12.75
Ant I ext*	17.55	16	14.2	12.4
Ep	2190	2190	2190	2190
Eg	270	271	265	265
Ef	11	11	11	11
Ant Cap	731	973	1250	1500
Ant Res	4.5	6.3	7.9	10.25
Ant Pr Ext*	1387	1610	1592	1575
Guar. Power	1000	1000	1000	1000

* Note: "Ant I int" refers to the current reading of the antenna ammeter located on the panel of the transmitter.

"Ant I ext" refers to the current reading of a precision type instrument located in the low side of the dummy antenna.

"Ant Pr ext" is the output calculated from the external precision ammeter readings.

TABLE 37

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

MCW OPERATION.

Test as per paragraph 3-41 of Specifications RE 13A 497A.

Freq. Kcs.	Audio Osc. Ip	P.A. Ip	Watts MCW	Watts CW	Percent of CW Power	Percent Mod. Neg.	Pos.
300	79	540	325	627	51	100	-
1000	71	590	653	1140	58	100	15
1250	78	620	822	1387	59	100	16
1500	77	620	970	1610	60	100	16
1750	68	610	957	1592	60	100	16
2000	76	580	991	1575	63	100	16

Specifications require that the signal be modulated not less than 70% and that the power be reduced to not less than 50%.

Frequency of Modulation

Measured - 813 cycles
Required - 800 cycles plus or minus 5%.

TABLE 38

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

VARIATION OF RESONANT FREQUENCY OF MASTER OSCILLATOR PER DIVISION OF DIAL MAKING.

Test as per paragraph 3-44 of Specifications RE 13A 497A

Control "A"	Control "B"	Frequency KC	Divisions Change	KC per Div.	Percent per Div.
614	1	300			
1051	1	310	437	0.023	0.007
1394	1	320	343	0.029	0.009
1728	1	330	334	0.030	0.009
2500	1	342.8	772	0.017	0.005
0	2	341.5			
604	2	350	604	0.014	0.004
1793	2	400	1189	0.042	0.010
2050	2	410	267	0.037	0.009
145	3	410			
1024	3	450	879	0.045	0.010
1700	3	500	676	0.074	0.015
2265	3	540	565	0.071	0.013
676	4	540			
1439	4	600	763	0.079	0.013
1950	4	650	511	0.098	0.015
2427	4	680	477	0.063	0.009
748	5	680			
1595	5	800	847	0.141	0.017
2135	5	900	540	0.185	0.020
2400	5	940	265	0.150	0.016
238	6	910			
937	6	950	699	0.057	0.006
1415	6	1000	478	0.105	0.011
2090	6	1100	675	0.148	0.013
2408	6	1140	318	0.126	0.012
90	7	1120			
1224	7	1200	1134	0.070	0.006
1826	7	1300	602	0.166	0.012
2337	7	1400	511	0.195	0.014

(Continued)

TABLE 38 (Continued)

Control "A"	Control "B"	Frequency KC	Divisions Change	KC per Div.	Percent per Div.
1179	8	1400			
1768	8	1500	589	0.170	0.011
2197	8	1600	429	0.186	0.012
678	9	1600			
1765	9	1700	1087	0.092	0.0054
2440	9	1800	675	0.148	0.008
1170	10	1800			
1983	10	1900	813	0.123	0.0065
2405	10	2000	422	0.237	0.012

Width of smallest division of marking: 0.08 inch.

TABLE 39

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

DETERMINATION OF POWER OUTPUT.

Test as per paragraph 3-3 of Specifications RE 13A 442D.

Output measurements obtained by using a photronic cell to determine power dissipated in a 500 watt lamp.

Freq. Kcs.	M.O. Isg	M.O. Ip	Doub. Ip	I.A. Ig	I.A. Ip	P.A. Ig	P.A. Ip	Ant. I	Plate Volts	Watts Output
4000	12	84	42	13	58	60	350	1.0	3060	610
7500	15	90	62	23	52	47	350	1.0	3050	552
18000	13	78	58	21	122	42	350	-	3050	340
				Low Power Operation						
2000	13	78	58	32	99				3060	85
3000	12	80	49	31	130				3060	100
4500	12	72	100	25	130				3060	102
9000	11.5	83	70	22	130				3060	97

TABLE 40

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

MCW OPERATION.

Test as per paragraph 3-41 of Specifications RE 13A 497A.

Freq. Kcs.	Osc. Ip	P.A. Ip	Watts MCW	Watts CW	Percent of CW Power	Percent Mod. Neg.	Pos.
4,000	45	333	445	574	77.5	68	19
8,000	45	282	373	500	74.5	65	20
12,000	45	290	308	416	74.0	65	18
18,000	45	274	221	316	70.0	71	21

Specifications require that the signal be modulated not less than 70% and that the power be reduced to not less than 50%.

Frequency of Modulation: Measured - 775 cycles
Required - 800 cycles plus or minus 5%.

TABLE 41

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

CONTROL OF POWER OUTPUT.

Test as per paragraph 3-25 of Specifications RE 13A 442D.

Voltage Tap	Frequency Kcs.	Plate Volts	Plate I	Watts Output	Percent Power
7	4500.210	3310	363	680	118
6	.200	3020	338	576	100
5	.225	2680	300	436	76
4	.200	2300	260	306	53
3	.225	2000	200	278	48
2	.220	1640	120	155	27
1	.245	1320	70	86	15

Maximum frequency change: 45 cycles or 0.001%.

TABLE 42

Model TBN-2 Transmitter (Preliminary Model)

Telephone Equipment

CHECK OF OUTPUT LEVELS FROM VARIOUS POINTS OF CONTROL.

Input voltage to microphone terminals 400 cycles, held constant at 500 millivolts.

Input voltage applied at	D.B. Level Indicator	Channel
Master Monitor	0	A
Master Monitor	+0.8	B
Master Monitor	+0.5	C
Master Monitor	+1.0	D
Station Control #2	-5.8	A
Station Control #2	-4.8	B
Station Control #2	-5.0	C
Station Control #2	-4.8	D
Ext. 1 on Station Control #2	-5.2	A
Station Control #1	-5.3	A
Station Control #1	-4.8	B
Station Control #1	-5.0	C
Station Control #1	-4.5	D
Ext. 1 on Station Control #1	-5.3	B

Station control #2 on Channel "A" alone produced a level of -5.5 D.B. When selector key on Master Monitor, Channel "A", was closed the level dropped to -7.0. When the "Radio-Interphone" key on Master Monitor was thrown to radio the level dropped to -9.0 D.B.

Note: With this latter condition prevailing, Channel "A" could be modulated from two locations at the same time, i.e., from Station Control #2 and from the Master Monitor position.

TABLE 43

Model TBN-2 Transmitter (Preliminary Model)

Telephone Equipment

DISTORTION CHARACTERISTIC OF LEVEL INDICATORS ON MASTER MONITOR.

Test as per paragraph 3A-9-5 and 6 of Specifications RE 13A 497A.

Explanation: With a constant audio input at 400 cycles, the Transmitter Line Level Control was adjusted to -6 D.B., which is equal to 50% modulation. The range switch controlling the Transmitter Line Level Indicator was then thrown to each of the three positions in turn, i.e., -10, 0 and +10. The distortion characteristic of the Line Amplifier in the Master Monitor was then determined for each position of the Line Level Indicator Range Switch.

CHANNEL "A"

Percent Modulation	Percent Distortion	Position of Range Switch
50	3.5	0
43	6.6	-10
50	3.2	+10

CHANNEL "B"

50	3.8	0
42	6.2	-10
51	3.7	+10

CHANNEL "C"

50	3.9	0
42	7.2	-10
52	3.7	+10

CHANNEL "D"

50	3.7	0
42	5.9	-10
52	3.6	+10

In the following tests the percentage modulation was held constant at 50% in all three positions of the range switch and the distortion measured under these conditions.

CHANNEL "A"

50	3.6	0
50	7.2	-10
50	3.2	+10

(Continued)

TABLE 43 (Continued)

Percent Modulation	Percent Distortion	Position of Range Switch
	CHANNEL "B"	
50	3.6	0
50	6.4	-10
50	3.4	+10
	CHANNEL "C"	
50	3.8	0
50	7.5	-10
50	3.6	+10
	CHANNEL "D"	
50	3.7	0
50	6.2	-10
50	3.6	+10

TABLE 44

Model TBN-2 Transmitter (Preliminary Model)

Telephone Power Unit

TEMPERATURE RUN ON RECTOX UNITS.

Test as per paragraph 3A-10 of Specifications RE 13A 497.

Time	Ambient Temp. °C.	Temp. of Top Row	Temp. of Bottom Row	Output Voltage	Load Current
1430	30.0	35.0	32.8	11.5	6.0
1445	30.6	38.2	35.3	11.1	5.8
1500	30.5	42.0	38.0	10.8	5.5
1515	30.7	43.7	38.5	10.5	5.4
1530	30.4	44.0	39.0	10.4	5.4
1545	30.8	44.1	38.7	10.3	5.3
1600	30.8	44.2	38.8	10.3	5.2
1615	30.0	43.5	37.6	10.3	5.2
1630	30.8	43.9	38.5	10.1	5.2

Load current adjusted to 6 amps. at start.
Line volts at start of test -(440) 110
Line volts at end of test - (442) 110.5

TABLE 45

Model TBN-2 Transmitter (Preliminary Model)

Telephone Equipment

EFFECT UPON MODULATION OF D.C. CURRENT IN MASTER MONITOR MICROPHONE CIRCUIT.

Input voltage at 1000 cycles.

Microphone Current	Input Voltage	Percent Modulation
0 MA	0.520	95
10	0.545	95
20	0.570	95
30	0.620	95
40	0.695	95
50	0.915	95
60	1.000	51

Input voltage at 300 cycles.

0	1.00	51
10	1.00	48
20	1.00	44
30	1.00	36
40	1.00	27
50	1.00	14

Input voltage at 5000 cycles.

20	0.600	92
50	0.600	56
60	0.600	22

TABLE 46

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

SHOCK TEST.

Test as per paragraph 3-65 of Specifications RE 13A 497A

Shock No.	Frequency before Shock	Frequency after Shock	Cycles Difference
1	2000.515	2000.565	50
2	.565	.623	58
3	.623	.660	37
4	.660	.698	38
5	.698	.723	25
	Maximum frequency change: 58 cycles; 0.0029%		
	Average frequency change: 41 cycles; 0.002%		
1	1000.415	1000.348	67
2	.352	.327	25
3	.327	.319	8
4	.319	.318	1
5	.318	.324	6
	Maximum frequency change: 67 cycles; 0.0067%		
	Average frequency change: 21 cycles; 0.0021%		
1	300.574	300.548	26
2	.548	.540	8
3	.540	.560	20
4	.560	.549	11
5	.549	.531	18
	Maximum frequency change: 26 cycles; 0.0086%.		
	Average frequency change: 16 cycles; 0.0053%.		

All dial locks securely locked before test; one preliminary shock given before each test.

TABLE 47

Model TBN-2 Transmitter (Preliminary Model)

Intermediate Frequency Unit

POWER REQUIRED FROM SUPPLY LINES.

Test as per paragraph 6-5 of Specifications RE 13A 497A

	Watts
Control circuit, rectifier filaments, and heater	870
All circuits energized, key open	1800
Complete transmitter, key locked, full power (Tap 6)	3800
Control circuits and heater only	450
Control circuits only	200

Transmitter operating at 2000 kcs. into 6 ohm antenna (CW).

Rectifier Tap	P.A. Ip	P.A. Ep	Antenna Current	Watts Input from Line Key Open	Key Closed
7	800	2400	14.15	1850	4180
6	740	2220	13.0	1800	3800
5	660	2010	11.6	1740	3380
4	570	1800	10.0	1680	3000
3	470	1580	8.45	1620	2600
2	380	1380	6.7	1580	2280
1	260	1140	2.4	1550	2000
MCW					
6	450	2250	5.0	1800	3220

TABLE 48

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Unit

POWER REQUIRED FROM SUPPLY LINES.

Test as per paragraph 6-5 of Specifications RE 13A 497A

	Watts
Control circuits, rectifier filaments and heater	900
All circuits energized, key open, heater on	1930
Complete transmitter, full power, tap 6, key locked, CW	3350
Complete transmitter, full power, phone, 100% modulation	4010
Control circuits and heater only	500
Control circuits only	270

Transmitter operating at 2000 kcs. into 6 ohm antenna (CW).

Rectifier Tap	P.A. Ip	P.A. Ep	Antenna Current	Watts Input from Line	
				Key Open	Key Closed
7	375	3410	9.8	2020	3740
6	350	2990	9.7	1930	3350
5	290	2630	8.2	1820	2910
4	242	2250	6.8	1740	2520
3	190	1940	5.4	1670	2230
2	140	1620	2.0	1600	2000
1	80	1320	0.6	1550	1820

TABLE 49

Model TBN-2 Transmitter (Preliminary Model)

Rectifier Unit

CONVERSION FACTOR OF MAIN PLATE RECTIFIER.

Test as per paragraph 6-45 of Specifications RE 13A 497A.

Input watts: 2482
Output watts: 2078

Efficiency of conversion: 83.7%

Efficiency of conversion required by specifications: not less than 80%.

TABLE 50

Model TBN-2 Transmitter (Preliminary Model)

Rectifier Unit

VOLTAGE REGULATION OF RECTIFIERS

Test as per paragraph 6-46 of Specifications RE 13A 497A

Rectifier	Voltage No Load	Voltage Full Load	Percent Regulation
Main Plate	2310	2185	5.4%
Mid Tap	1140	1120	1.7%
Auxiliary Plate	1055	1040	1.4%
Bias	305	302	1.0%

Permitted by Specifications:

Main Plate	5%
Auxiliary	6%
Bias	6%

TABLE 51

Model TBN-2 Transmitter (Preliminary Model)

Rectifier Equipment

MEASUREMENT OF RIPPLE VOLTAGES.

Test as per Specifications RE 13A 497A, Paragraph 6-47.

Rectifier	DC Voltage	Ripple Voltage at (Cycles) 60	120	180	240	360	720
Main Plate	2210	1.2	4.5	-	-	0.75	3.4
Mid Tap	1085	0.6	-	0.9	-	1.4	1.2
Auxiliary	1015	-	4.9	-	3.2	1.3	-
Bias	307	-	1.3	-	-	-	-
Control	110	4.5	6.3	2.3	2.2	0.75	-

(In addition the control rectifier showed 1.8 volts at 300 cycles; 1.2 volts at 420 cycles; and 0.7 volts at 540 cycles.)

SUMMARY

Rectifier	Total Ripple	Percent Ripple
Main Plate	5.75 volts	0.26
Mid Tap	1.87	0.17
Auxiliary	6.0	0.59
Bias	1.3	0.40
Control	8.66	7.80

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

Permitted by Specifications:

Main Plate	0.5%
Auxiliary	0.5%
Bias	0.5%

TABLE 52

Model TBN-2 Transmitter (Preliminary Model)

Rectifier Unit

VARIATION OF RECTIFIER OUTPUT VOLTAGE.

Test as per paragraph 6-50 of Specifications RE 13A 497A.

Rectifier Tap Switch	Rectifier Output Voltage	Percentage of Normal
7	3310	110
6	3020	100
5	2680	89
4	2300	76
3	2000	66
2	1640	55
1	1320	44

TABLE 53

Model TBN-2 Transmitter (Preliminary Model)

Rectifier Unit

LIST OF CONTROLS FOR OPERATION OF RECTIFIER UNIT.

Volume Control
Intermediate Amplifier Bias Control
Modulator Bias Control, Tube No. 1
Modulator Bias Control, Tube No. 2
Voice Relay Sensitivity Control
Filament Rheostat
2-Position "Talk-Off" Switch
3-Position "Voice Relay-Manual" Switch
Microphone Jack
Emergency Switch
Power Supply Switch
Voltmeter Switch
Filament Stand-by Switch
Filament Rheostat
Transfer Switch, 4 points, interlocked
Tap Switch, 7 points, interlocked

TABLE 54

Model TBN-2 Transmitter (Preliminary Model)

High Frequency Telephone Unit

INTELLIGIBILITY TEST OF MICROPHONES

Observer	Errors made by Listeners			Preference of Observer
	Test No. 1	Test No. 2	Test No. 3	
A	2	15	2	Test No. 3
B	2	14	8	Test No. 1
C	7	16	1	Test No. 3
D	11	21	10	Test No. 3
E	11	18	11	Test No. 3
F	4	19	4	Test No. 3
G	4	20	1	Test No. 3
H	3	16	5	Test No. 1
I	3	14	3	Test No. 3
J	4	22	2	Test No. 3
Totals -	51	175	47	(8 for Test 3) (2 for Test 1)

Tabulation of Errors according to Speakers.

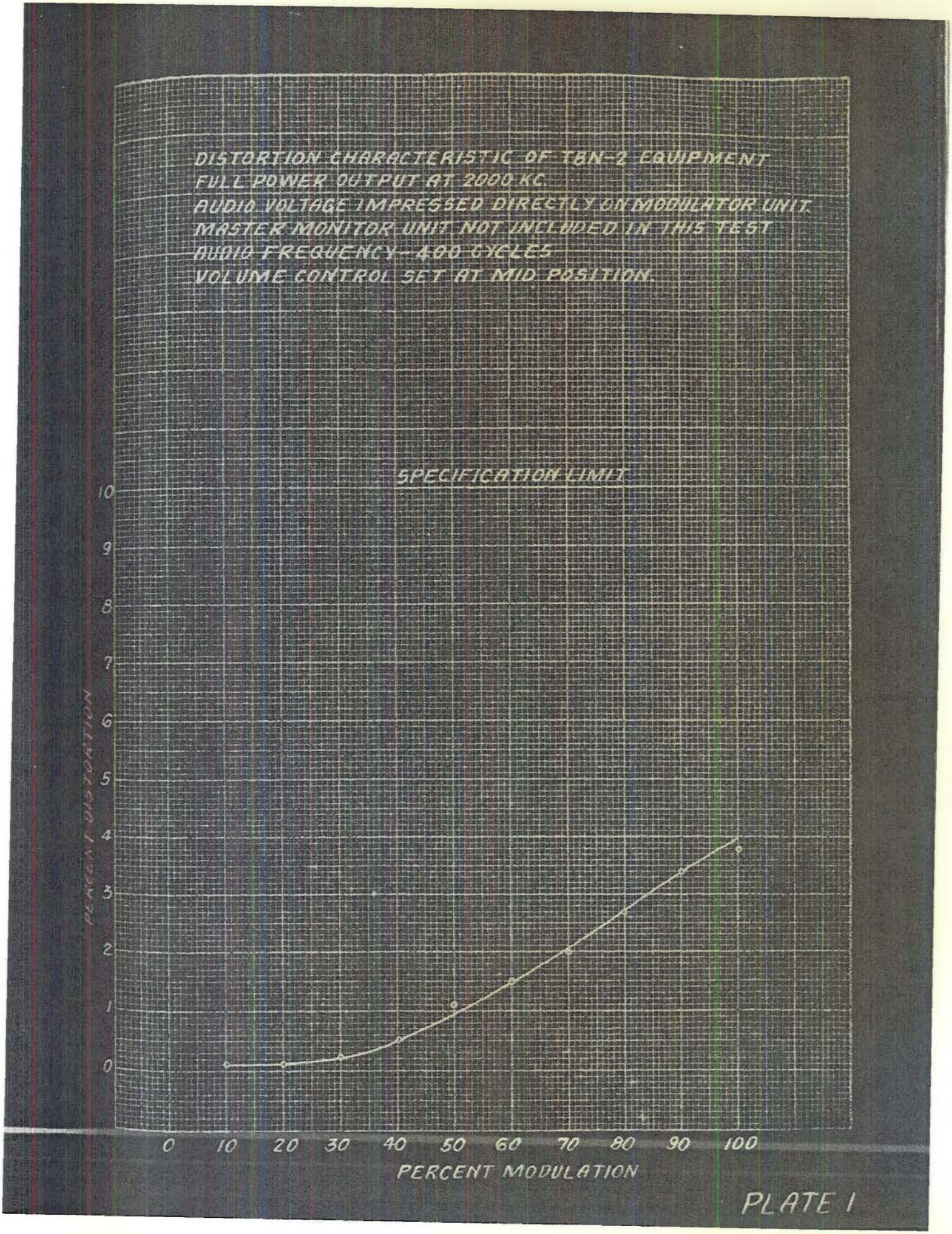
Observer	Speaker A	Speaker B	Speaker C	Speaker D
A	6	5	3	5
B	6	7	3	8
C	8	4	5	7
D	15	13	5	9
E	13	11	7	9
F	8	4	6	9
G	6	7	5	7
H	9	6	5	4
I	6	5	3	6
J	7	7	6	8
Totals -	84	69	48	72

(Continued)

TABLE 54 (Continued)

Tabulation of errors according to speakers and microphones.

Observer	Speaker A Test No.			Speaker B Test No.			Speaker C Test No.			Speaker D Test No.		
	1	2	3	1	2	3	1	2	3	1	2	3
A	1	5	0	1	3	1	0	2	1	0	5	0
B	1	1	4	0	5	2	0	3	0	1	5	2
C	3	5	0	1	3	0	2	3	0	1	5	1
D	3	8	4	3	5	5	2	3	0	3	5	1
E	3	7	3	3	4	4	3	2	2	2	5	2
F	1	6	1	1	3	0	1	4	1	1	6	2
G	1	5	0	1	6	0	0	4	1	2	5	0
H	1	6	2	1	4	1	0	4	1	1	2	1
I	1	5	0	1	3	1	1	2	0	0	4	2
J	0	7	0	0	6	1	2	3	1	2	6	0
Totals	15	55	14	12	42	15	11	30	7	13	48	11


DISTORTION CHARACTERISTIC OF TBN-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC.
AUDIO VOLTAGE IMPRESSED DIRECTLY ON MODULATOR UNIT.
MASTER MONITOR UNIT NOT INCLUDED IN THIS TEST
AUDIO FREQUENCY - 400 CYCLES
VOLUME CONTROL SET AT MID POSITION.
SPECIFICATION LIMIT
PERCENT DISTORTION
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
90
100
PERCENT MODULATION
PLATE I

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

DATE

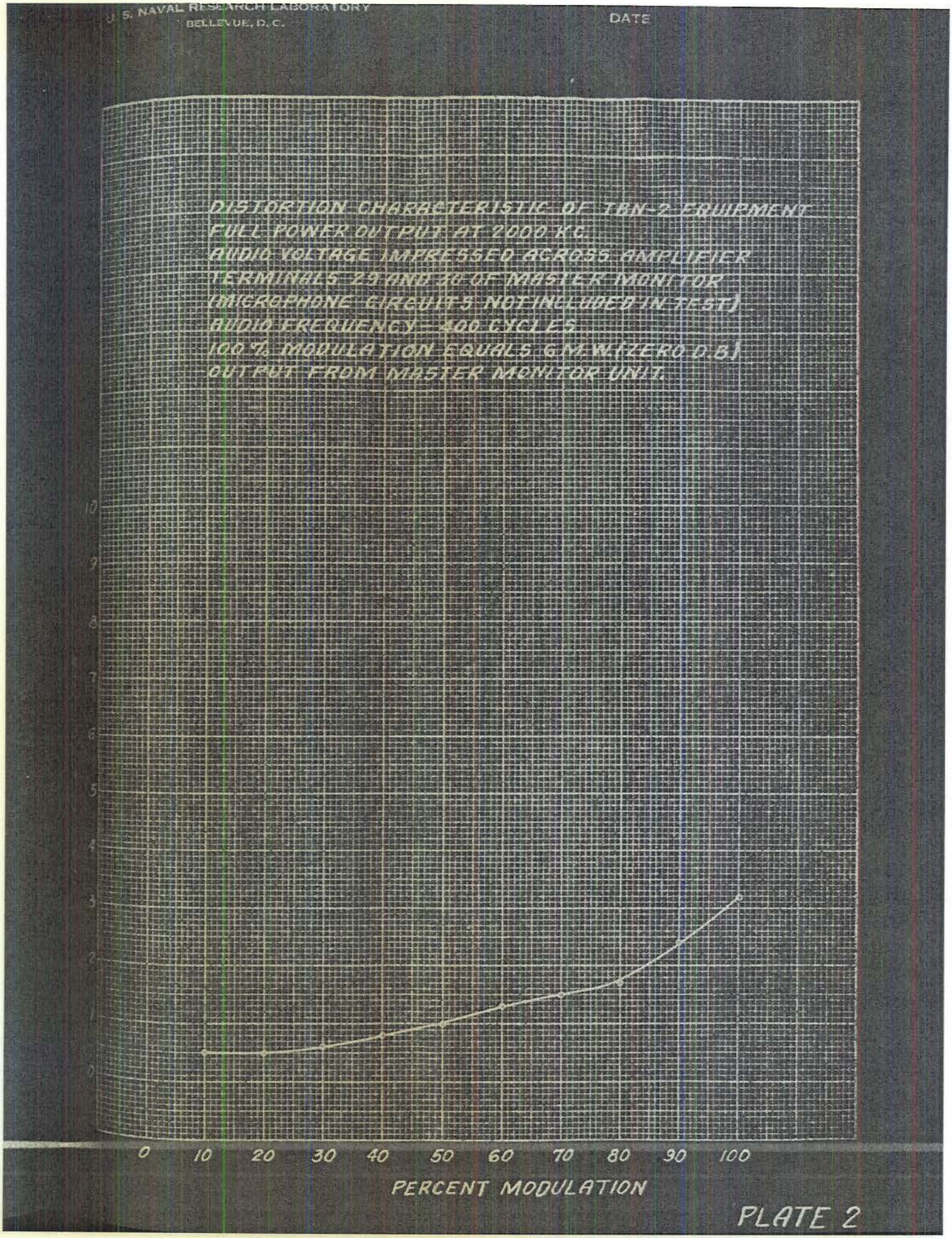


PLATE 2

NAVAL RESEARCH LABORATORY
BELLEVUE, D. C.

DATE

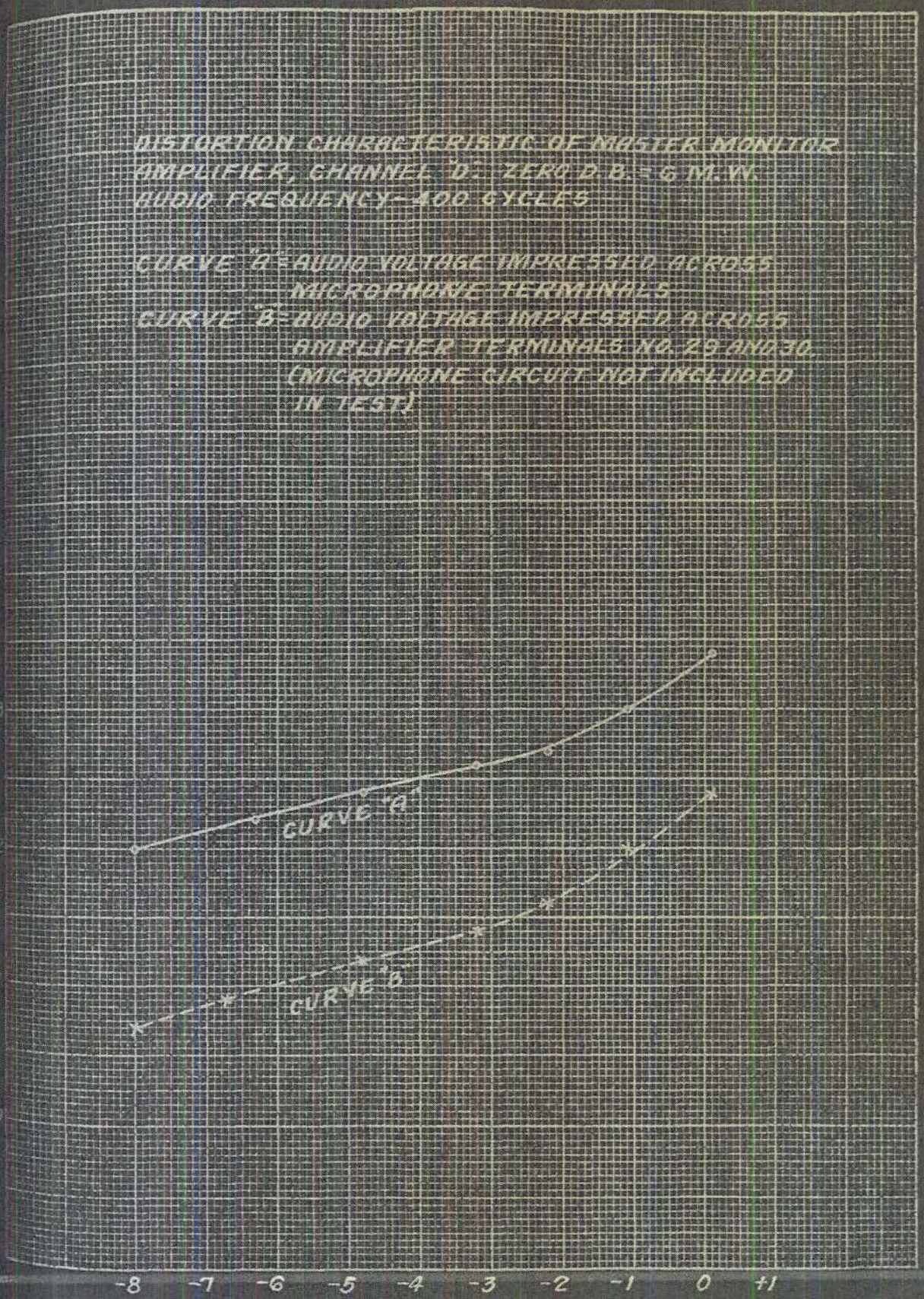


PLATE 3

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

DATE

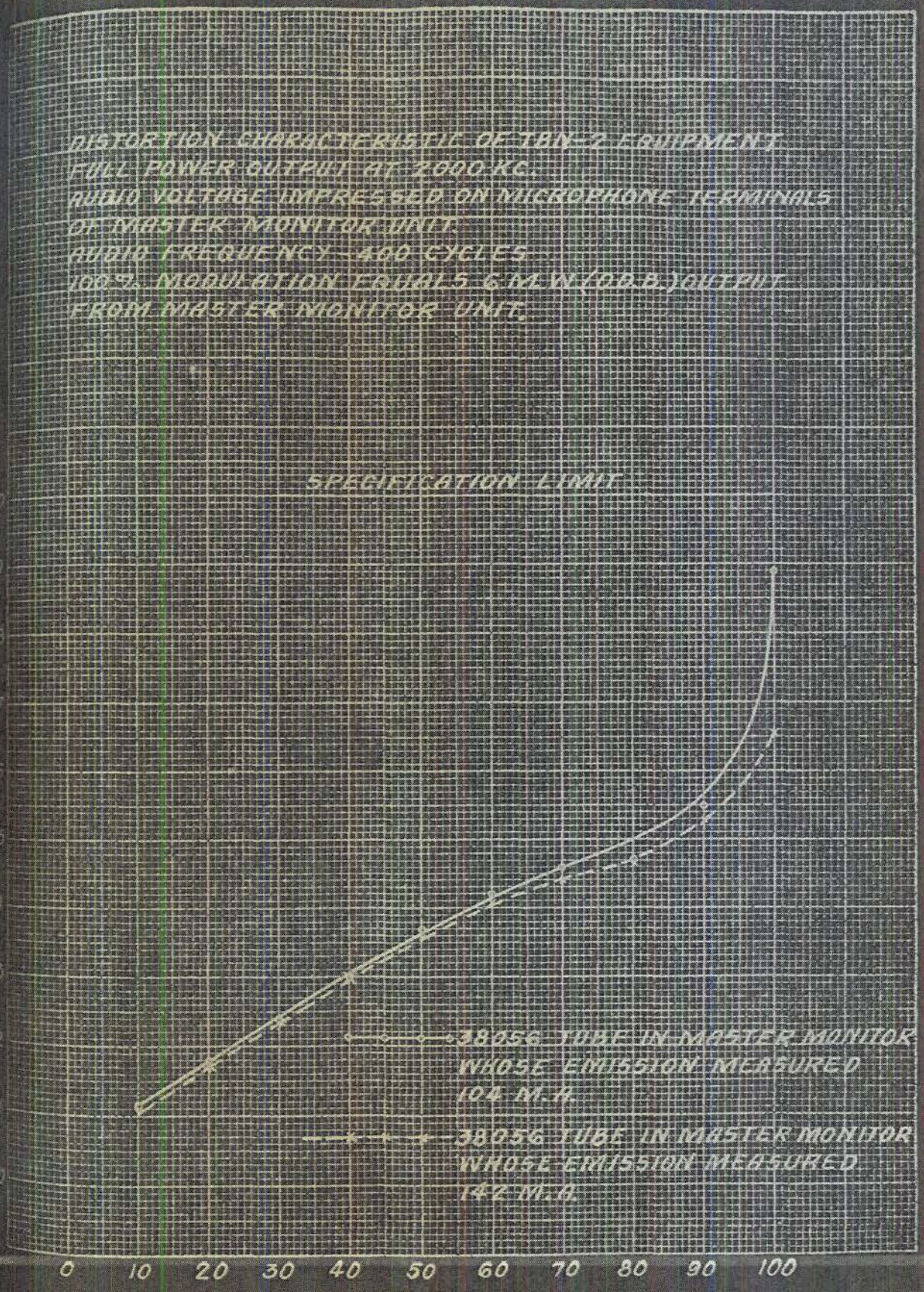


PLATE 4

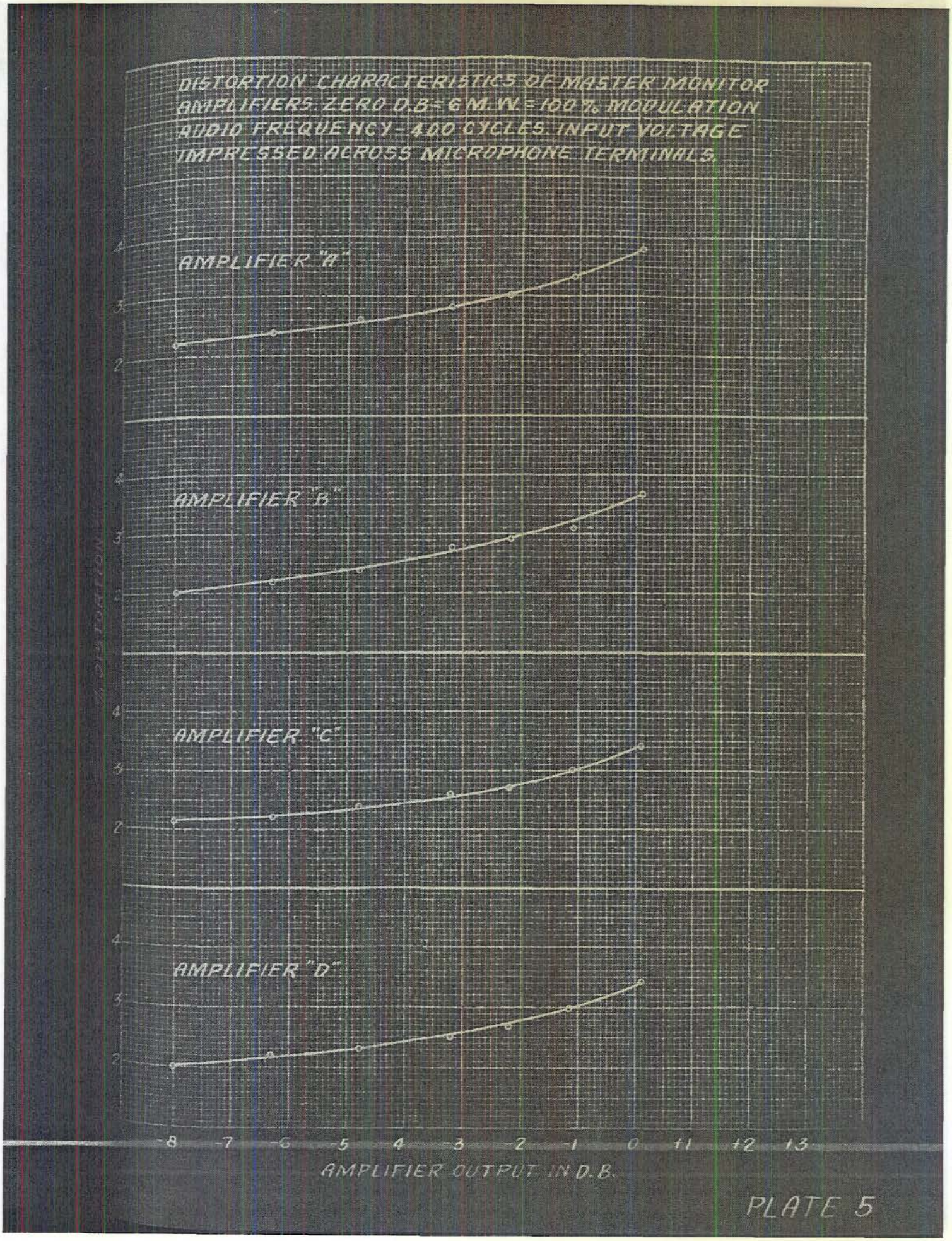
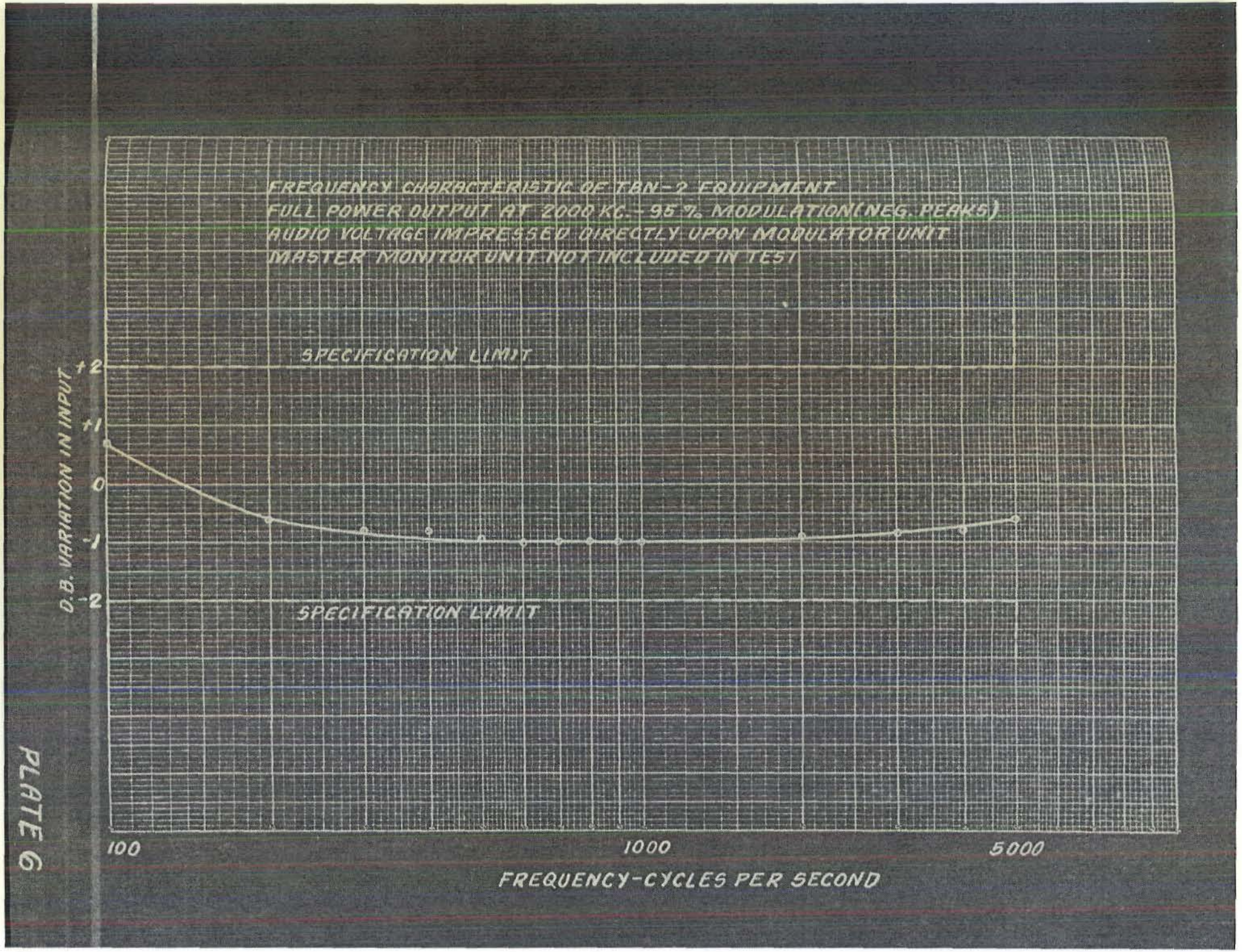
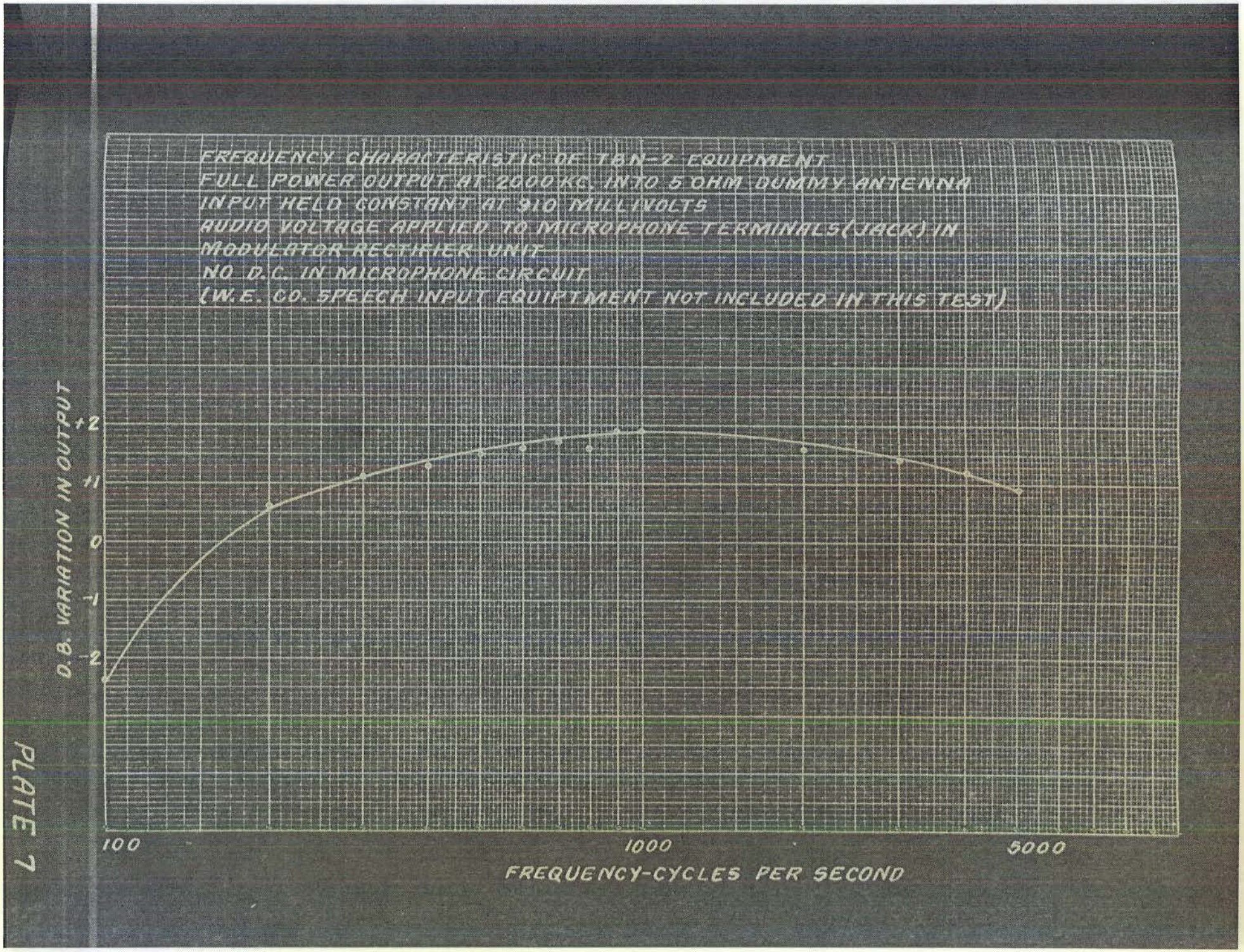
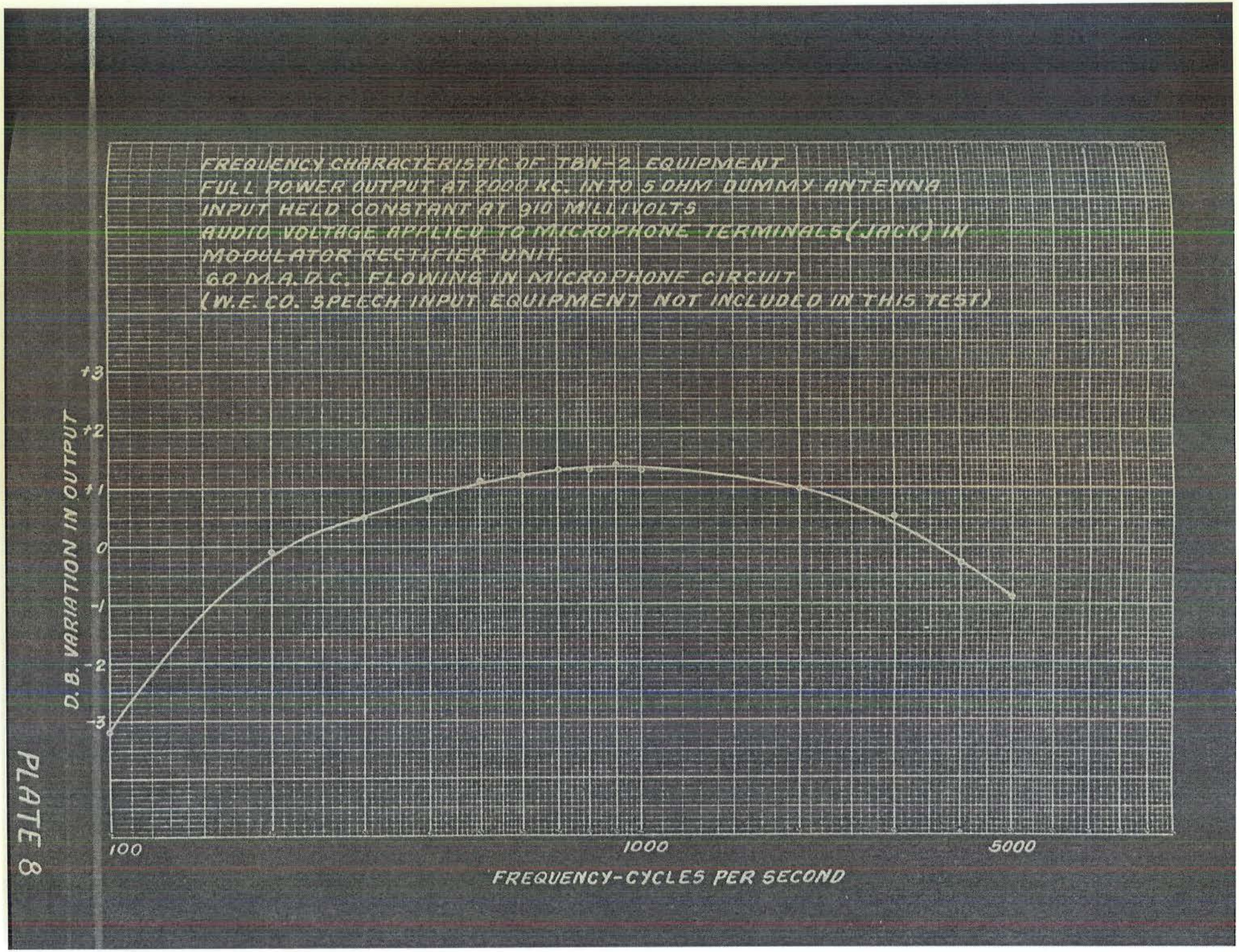

DISTORTION CHARACTERISTICS OF MASTER MONITOR AMPLIFIERS. ZERO D.B = 6 M.W. = 100% MODULATION AUDIO FREQUENCY - 400 CYCLES. INPUT VOLTAGE IMPRESSED ACROSS MICROPHONE TERMINALS.
AMPLIFIER "A"
AMPLIFIER "B"
AMPLIFIER "C"
AMPLIFIER "D"
% DISTORTION
2
3
4
-8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2 +3
AMPLIFIER OUTPUT IN D.B.

PLATE 5


FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC. - 95 % MODULATION (NEG. PEAKS)
AUDIO VOLTAGE IMPRESSED DIRECTLY UPON MODULATOR UNIT
MASTER MONITOR UNIT NOT INCLUDED IN TEST
SPECIFICATION LIMIT
SPECIFICATION LIMIT
D.B. VARIATION IN INPUT
+2
+1
0
-1
-2
100
1000
5000
FREQUENCY-CYCLES PER SECOND
PLATE 6


FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC. INTO 5 OHM DUMMY ANTENNA
INPUT HELD CONSTANT AT 910 MILLIVOLTS
AUDIO VOLTAGE APPLIED TO MICROPHONE TERMINALS (JACK) IN
MODULATOR RECTIFIER UNIT
NO D.C. IN MICROPHONE CIRCUIT
(W.E. CO. SPEECH INPUT EQUIPTMENT NOT INCLUDED IN THIS TEST)
D.B. VARIATION IN OUTPUT
+2
1
0
-1
-2
100
1000
5000
FREQUENCY-CYCLES PER SECOND
PLATE 7


FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC. INTO 5 OHM DUMMY ANTENNA
INPUT HELD CONSTANT AT 910 MILLIVOLTS
AUDIO VOLTAGE APPLIED TO MICROPHONE TERMINALS (JACK) IN
MODULATOR RECTIFIER UNIT.
60 M.A. D.C. FLOWING IN MICROPHONE CIRCUIT
(W.E. CO. SPEECH INPUT EQUIPMENT NOT INCLUDED IN THIS TEST)
D.B. VARIATION IN OUTPUT
+3
+2
+1
0
-1
-2
-3
100
1000
5000
FREQUENCY-CYCLES PER SECOND
PLATE 8

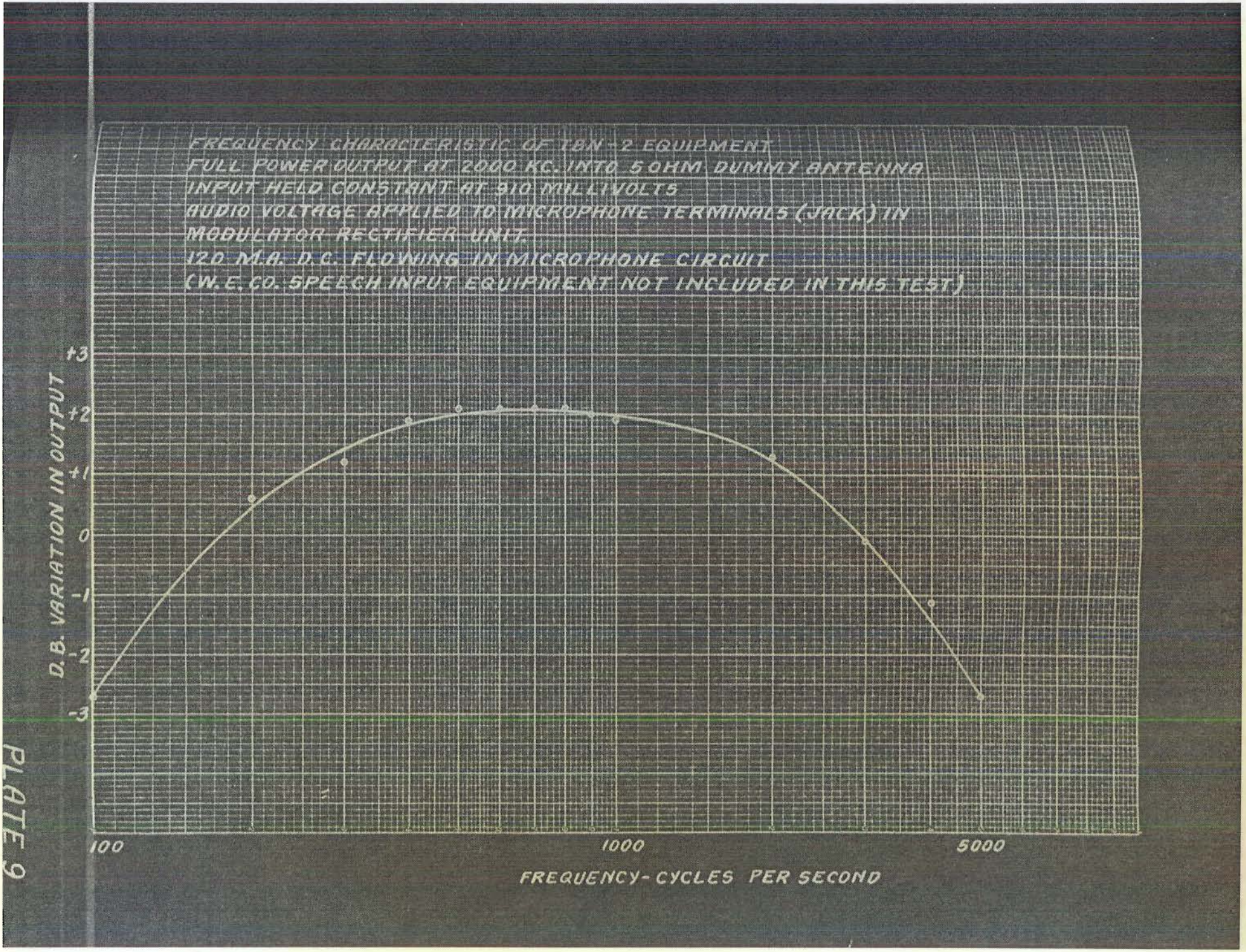
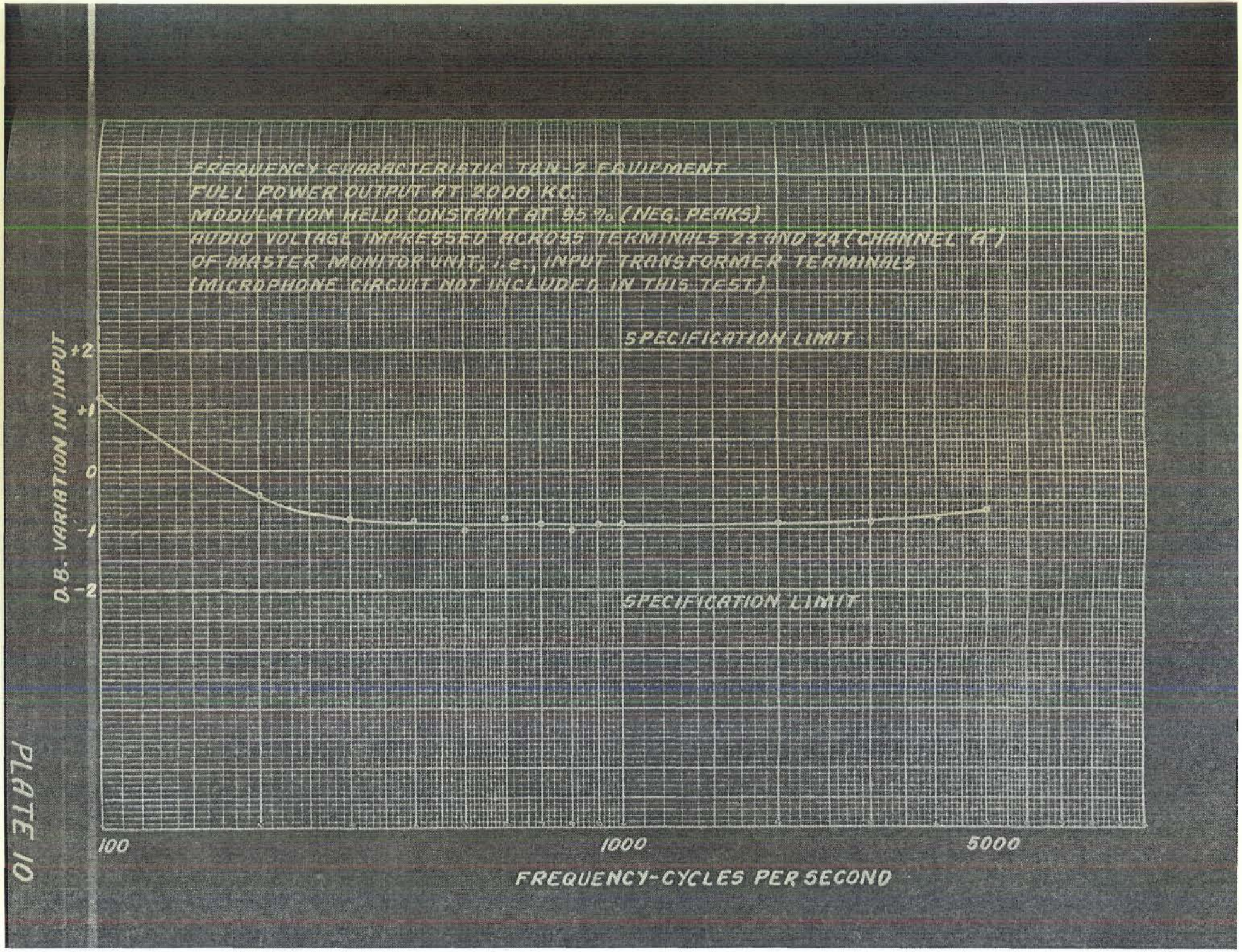
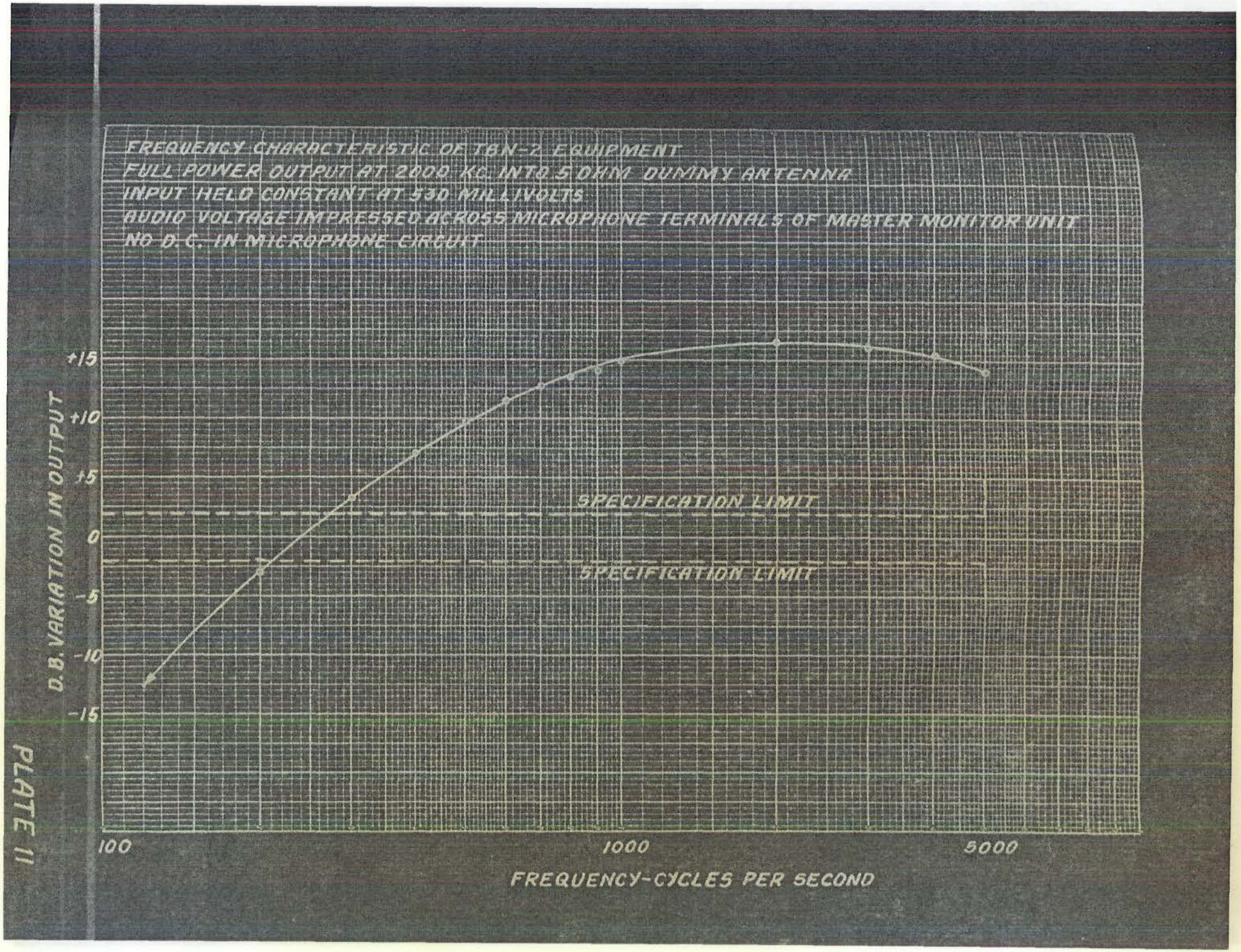
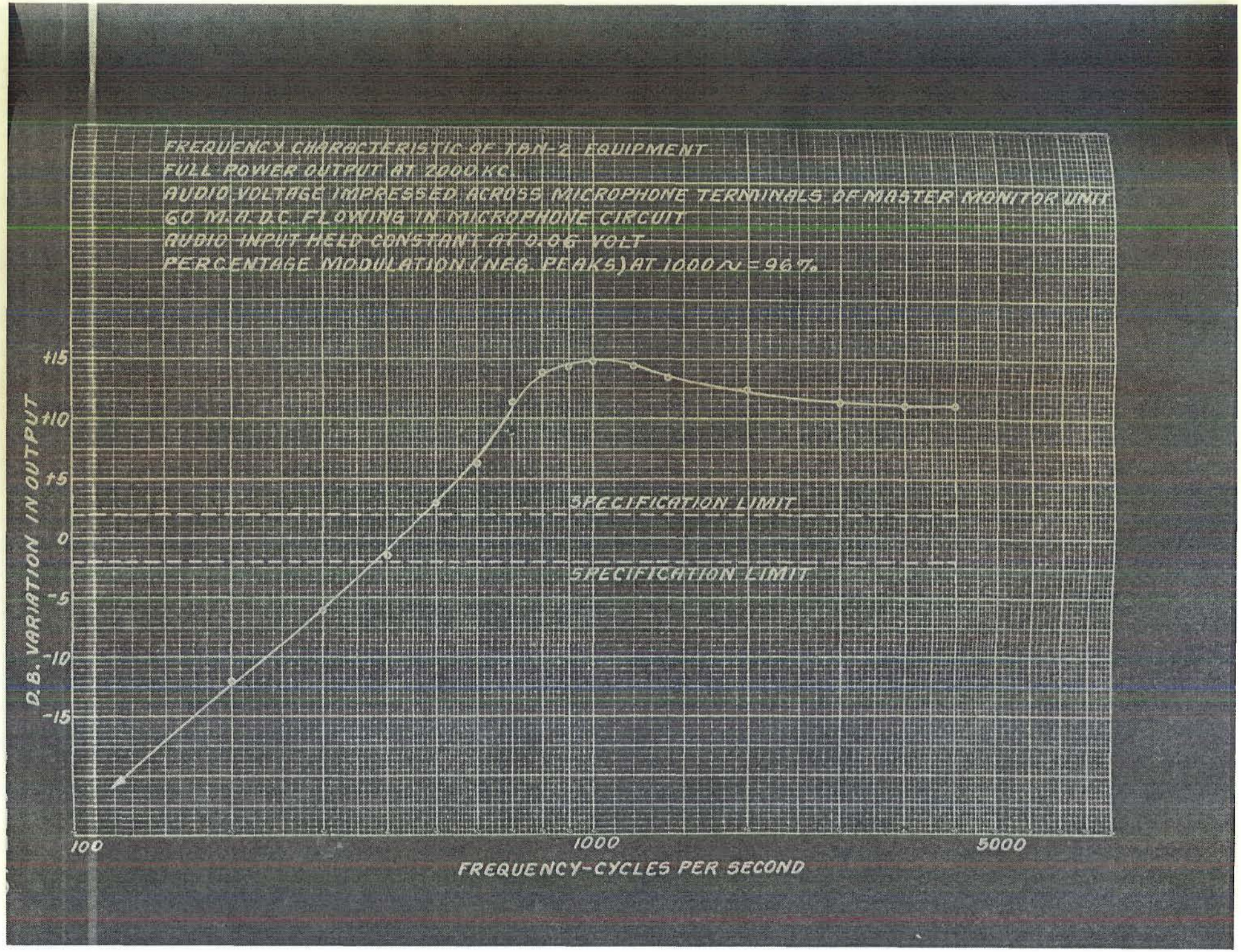
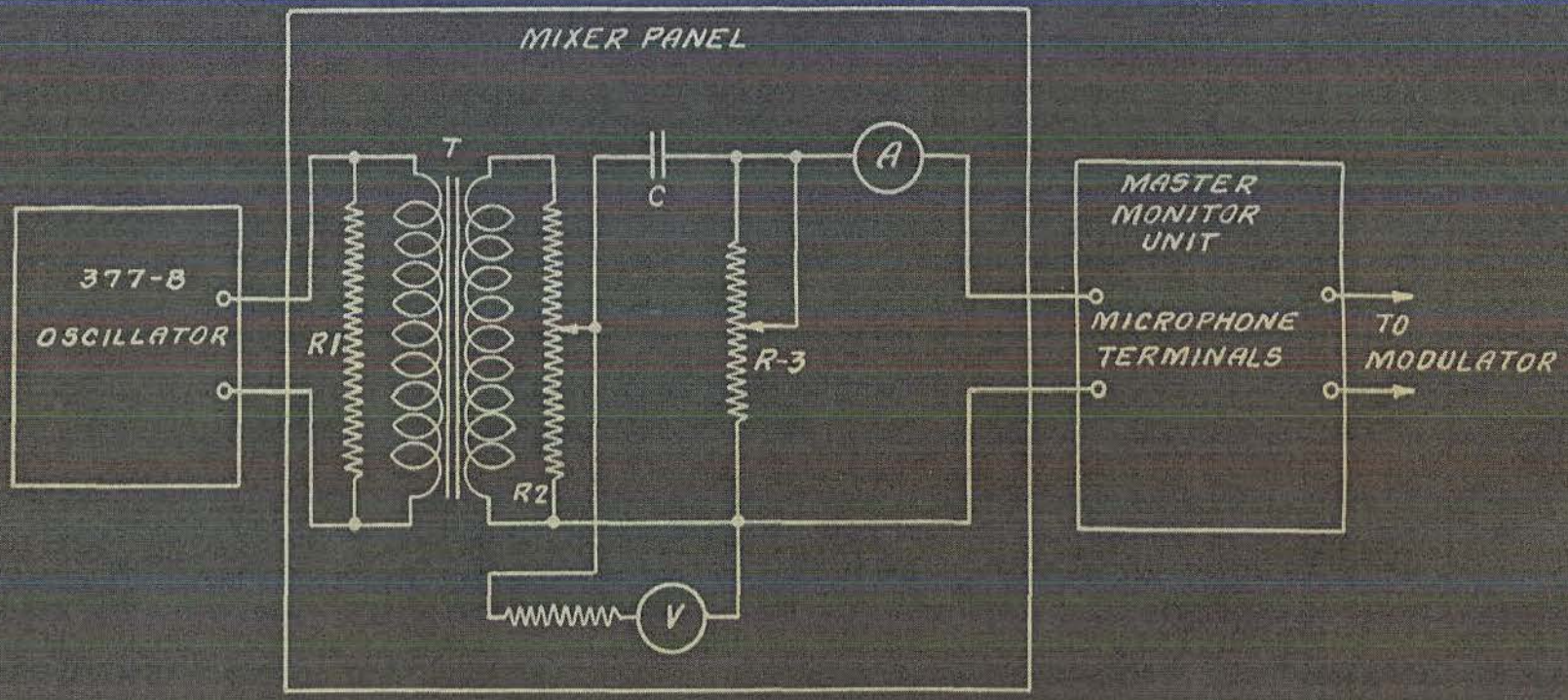

FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC. INTO 50 OHM DUMMY ANTENNA
INPUT HELD CONSTANT AT 310 MILLIVOLTS
AUDIO VOLTAGE APPLIED TO MICROPHONE TERMINALS (JACK) IN
MODULATOR RECTIFIER UNIT.
120 M.A. D.C. FLOWING IN MICROPHONE CIRCUIT
(W.E. CO. SPEECH INPUT EQUIPMENT NOT INCLUDED IN THIS TEST)
D.B. VARIATION IN OUTPUT
+3
+2
+1
0
-1
-2
-3
100
1000
5000
FREQUENCY - CYCLES PER SECOND

PLATE 9


FREQUENCY CHARACTERISTIC TAN-Z EQUIPMENT
FULL POWER OUTPUT AT 2000 K.C.
MODULATION HELD CONSTANT AT 95% (NEG. PEAKS)
AUDIO VOLTAGE IMPRESSED ACROSS TERMINALS 23 AND 24 (CHANNEL "A")
OF MASTER MONITOR UNIT, i.e., INPUT TRANSFORMER TERMINALS
(MICROPHONE CIRCUIT NOT INCLUDED IN THIS TEST)
SPECIFICATION LIMIT
SPECIFICATION LIMIT
D.B. VARIATION IN INPUT
+2
+1
0
-1
-2
100
1000
5000
FREQUENCY-CYCLES PER SECOND
PLATE 10


FREQUENCY CHARACTERISTIC OF T8N-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC. INTO 5 OHM DUMMY ANTENNA
INPUT HELD CONSTANT AT 530 MILLIVOLTS
AUDIO VOLTAGE IMPRESSED ACROSS MICROPHONE TERMINALS OF MASTER MONITOR UNIT
NO D.C. IN MICROPHONE CIRCUIT
D.B. VARIATION IN OUTPUT
+15
+10
+5
0
-5
-10
-15
SPECIFICATION LIMIT
SPECIFICATION LIMIT
100
1000
5000
FREQUENCY-CYCLES PER SECOND
PLATE 11


FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
FULL POWER OUTPUT AT 2000 KC.
AUDIO VOLTAGE IMPRESSED ACROSS MICROPHONE TERMINALS OF MASTER MONITOR UNIT
60 M.A. D.C. FLOWING IN MICROPHONE CIRCUIT
AUDIO INPUT HELD CONSTANT AT 0.06 VOLT
PERCENTAGE MODULATION (NEG. PEAKS) AT 1000 ~ = 96 %
+15
+10
+5
0
-5
-10
-15
D.B. VARIATION IN OUTPUT
SPECIFICATION LIMIT
SPECIFICATION LIMIT
100
1000
5000
FREQUENCY-CYCLES PER SECOND



R1 = 50,000 OHMS
R2 = 5,000 OHMS
R3 = 500 OHMS
C = 250 MFDS.

T = TRANSFORMER FLAT TO WITHIN 1 DB
FROM 30 TO 10000 CYCLES
V = VOLTMETER
A = AMMETER, 100 M.A.

PLATE 13

PLATE 14

FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
INPUT IMPRESSED ACROSS TERMINALS 23 AND 24 OF MASTER MONITOR AMPLIFIER
ATTENUATOR ON TAP 11 (MINIMUM)
OUTPUT MEASURED ACROSS TERMINALS 7 AND 8 OF OUTPUT TRANSFORMER IN M.W.
6 Ω SHUNTED ACROSS TERMINALS 7 AND 8
OUTPUT HELD CONSTANT AT 2.45 VOLTS (2.45 V = 6 M.W. APPROX.)
RANGE SWITCH ON ZERO

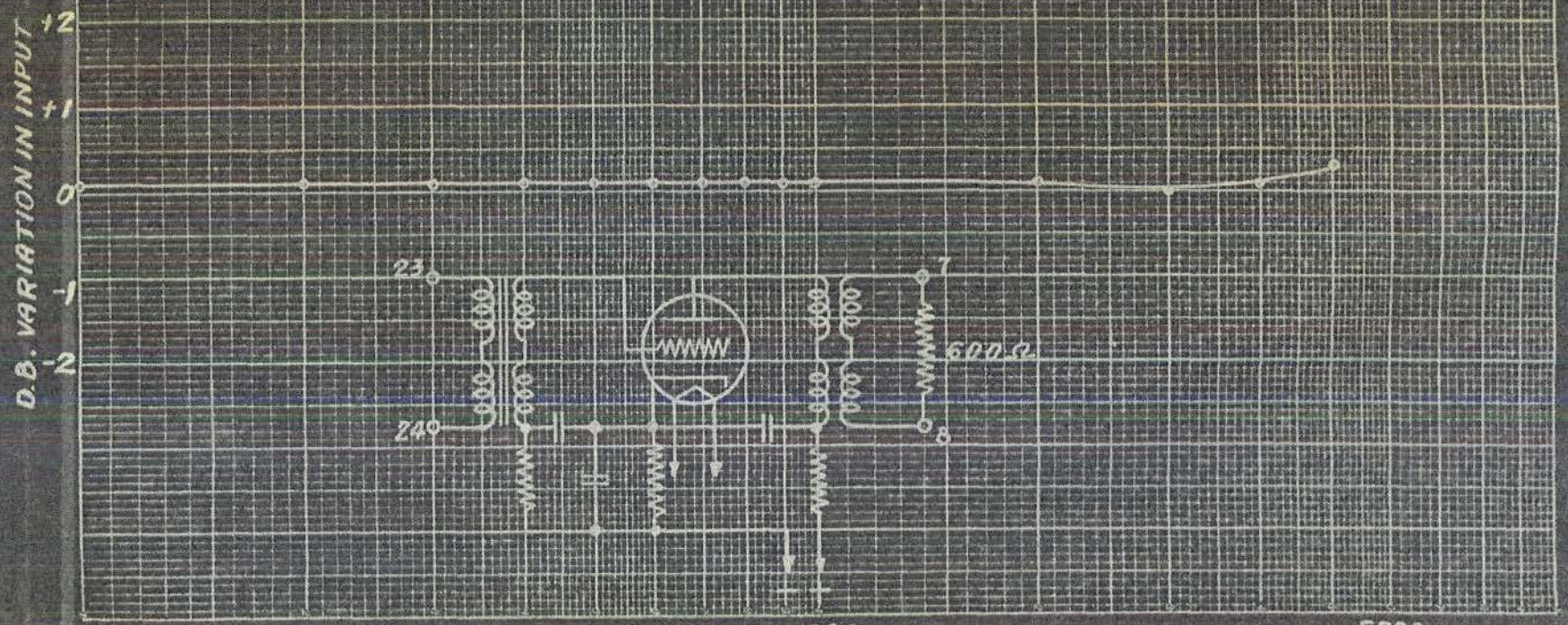


PLATE 15

FREQUENCY CHARACTERISTIC OF TAN-2 EQUIPMENT
INPUT IMPRESSED ACROSS TERMINALS 23 AND 24 OF MASTER MONITOR AMPLIFIER.
OUTPUT MEASURED AT TERMINALS 201 AND 202, BRIDGED WITH 600 Ω.
ATTENUATOR ON STEP 11; RANGE SWITCH ON ZERO
OUTPUT HELD CONSTANT AT 2.45 VOLTS (2.45 V=6 M.W.)

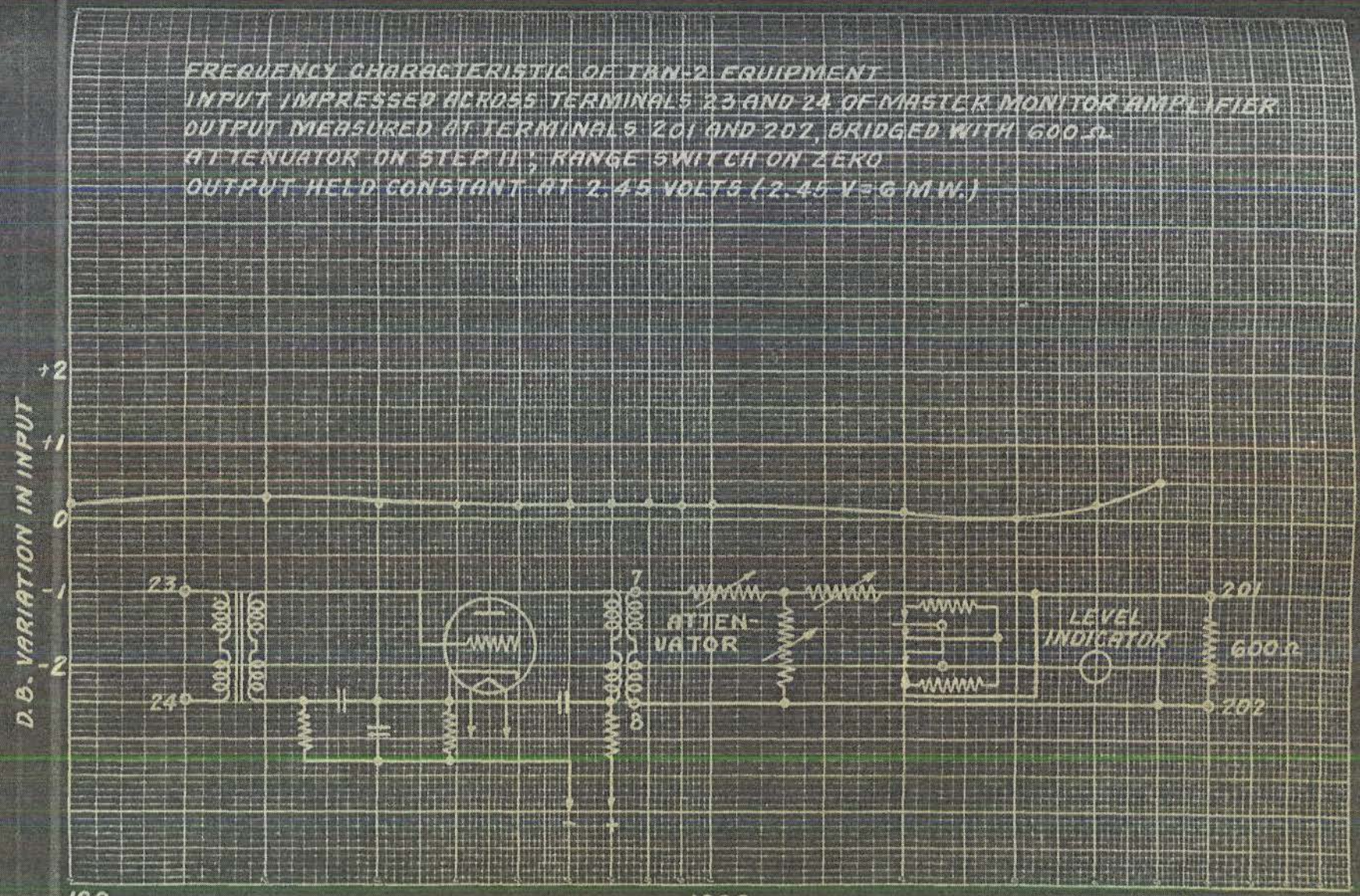
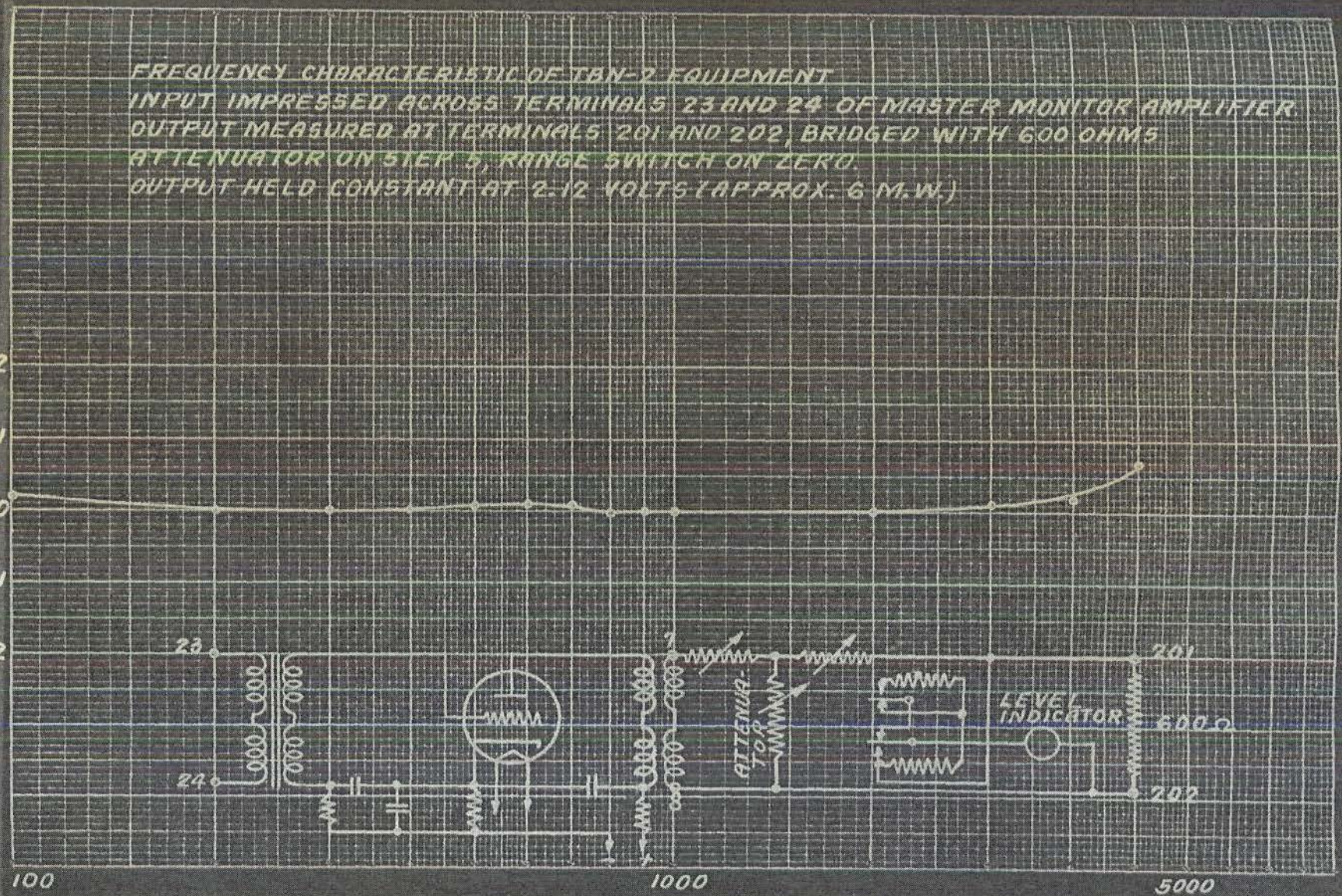
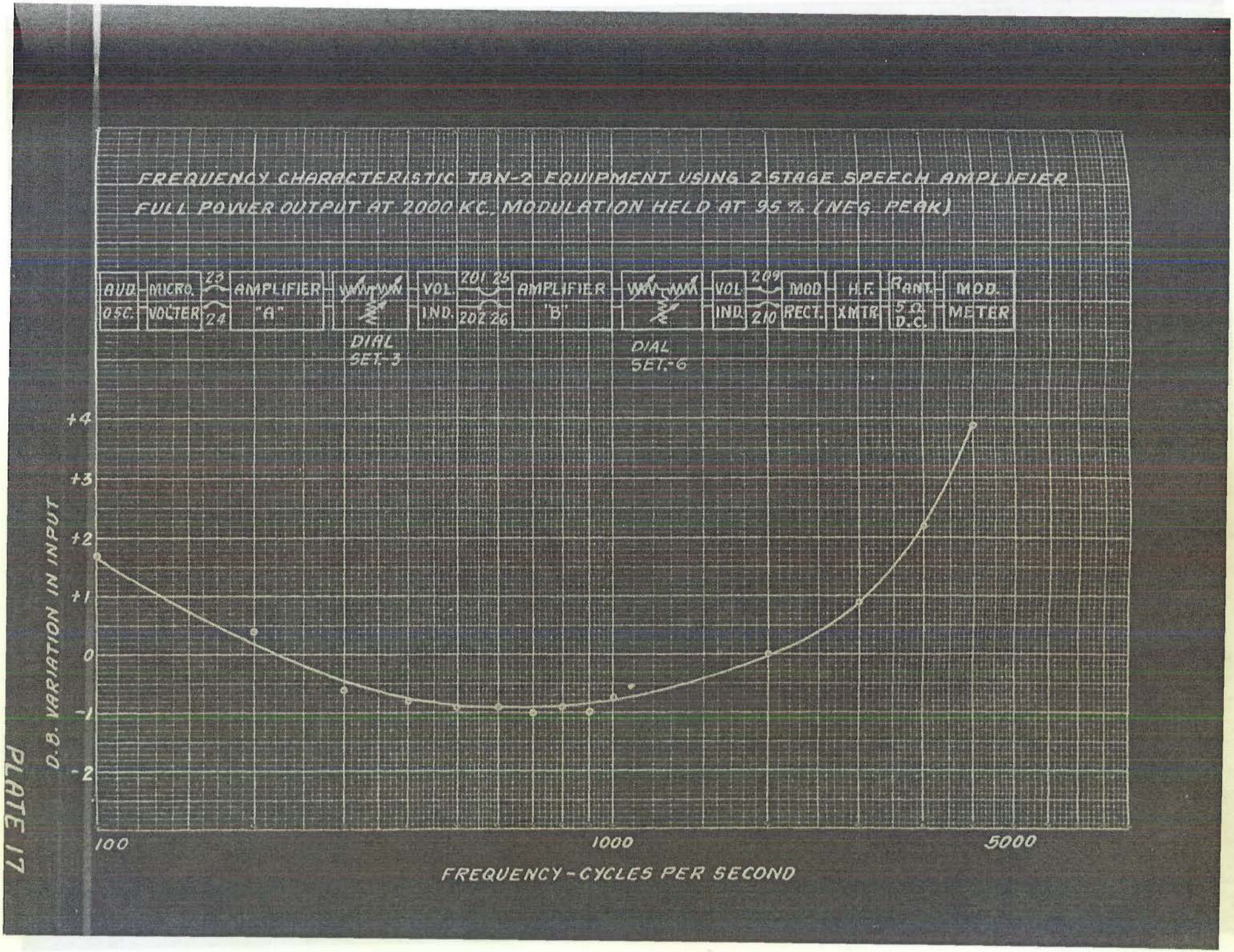


PLATE 16

FREQUENCY CHARACTERISTIC OF TBN-2 EQUIPMENT
INPUT IMPRESSED ACROSS TERMINALS 23 AND 24 OF MASTER MONITOR AMPLIFIER.
OUTPUT MEASURED AT TERMINALS 201 AND 202, BRIDGED WITH 600 OHMS
ATTENUATOR ON STEP 5, RANGE SWITCH ON ZERO.
OUTPUT HELD CONSTANT AT 2.12 VOLTS (APPROX. 6 M.W.)




FREQUENCY CHARACTERISTIC TBN-2 EQUIPMENT USING 2 STAGE SPEECH AMPLIFIER
FULL POWER OUTPUT AT 2000 KC., MODULATION HELD AT 95 %. (NEG. PEAK)
AVD. OSC.
MICRO. VOLTER
23
24
AMPLIFIER "A"
DIAL SET-3
VOL. IND.
201 25
202 26
AMPLIFIER "B"
DIAL SET.-6
VOL IND.
209
210
MOD RECT.
H.F. XMTR
RANT. 5Ω D.C.
MOD. METER
+4
+3
+2
+1
0
-1
-2
D.B. VARIATION IN INPUT
100
1000
5000
FREQUENCY - CYCLES PER SECOND
PLATE 17

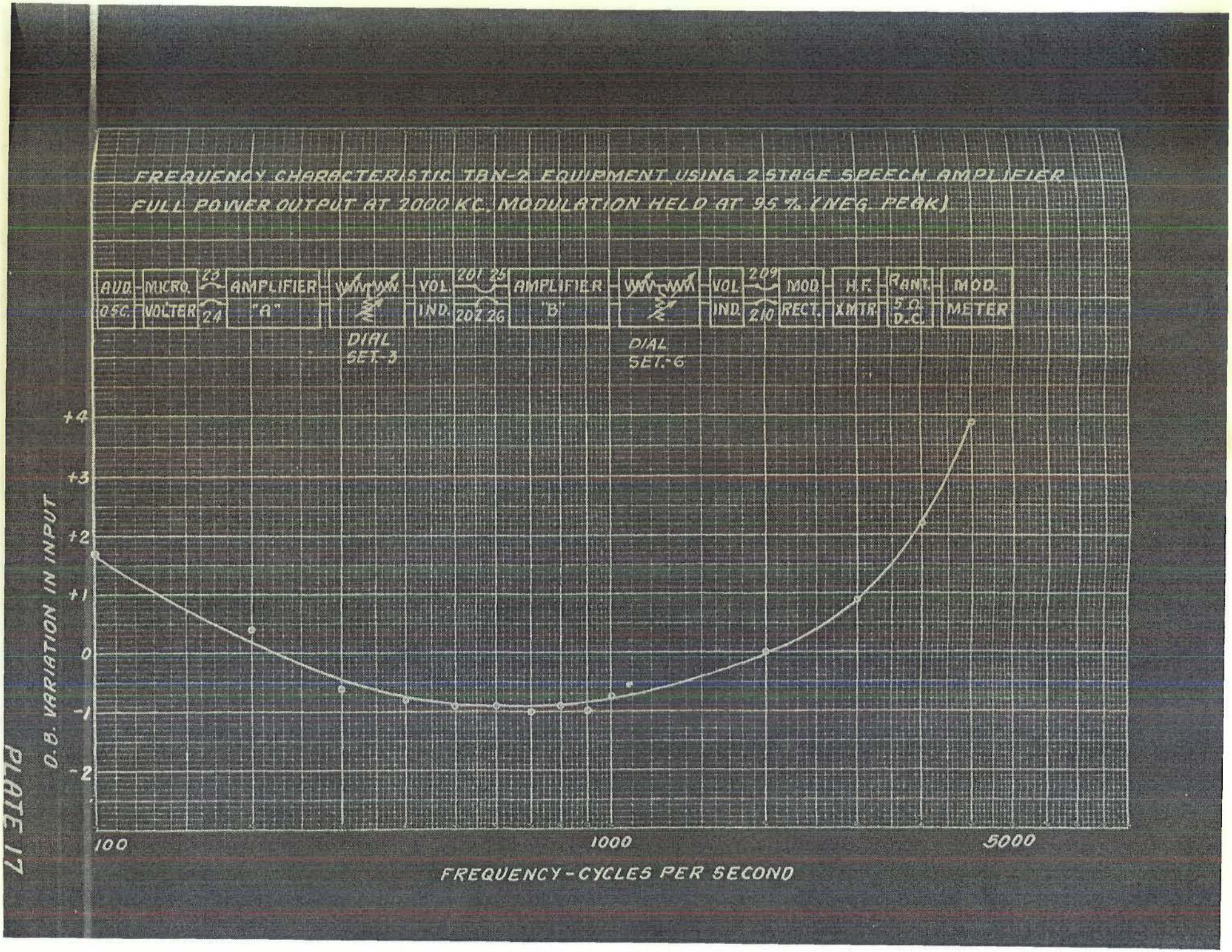

FREQUENCY CHARACTERISTIC TBN-2 EQUIPMENT USING 2 STAGE SPEECH AMPLIFIER
FULL POWER OUTPUT AT 2000 KC. MODULATION HELD AT 95 % (NEG. PEAK)
AUD. OSC.
MICRO. VOLTER
23
24
AMPLIFIER "A"
DIAL SET.-3
VOL. IND.
201
25
202
26
AMPLIFIER "B"
DIAL SET.-6
VOL. IND.
209
210
MOD. RECT.
H.F. XMTR
ANT. 50 D.C.
MOD. METER
+4
+3
+2
+1
0
-1
-2
O.B. VARIATION IN INPUT
100
1000
5000
FREQUENCY - CYCLES PER SECOND

PLATE 17

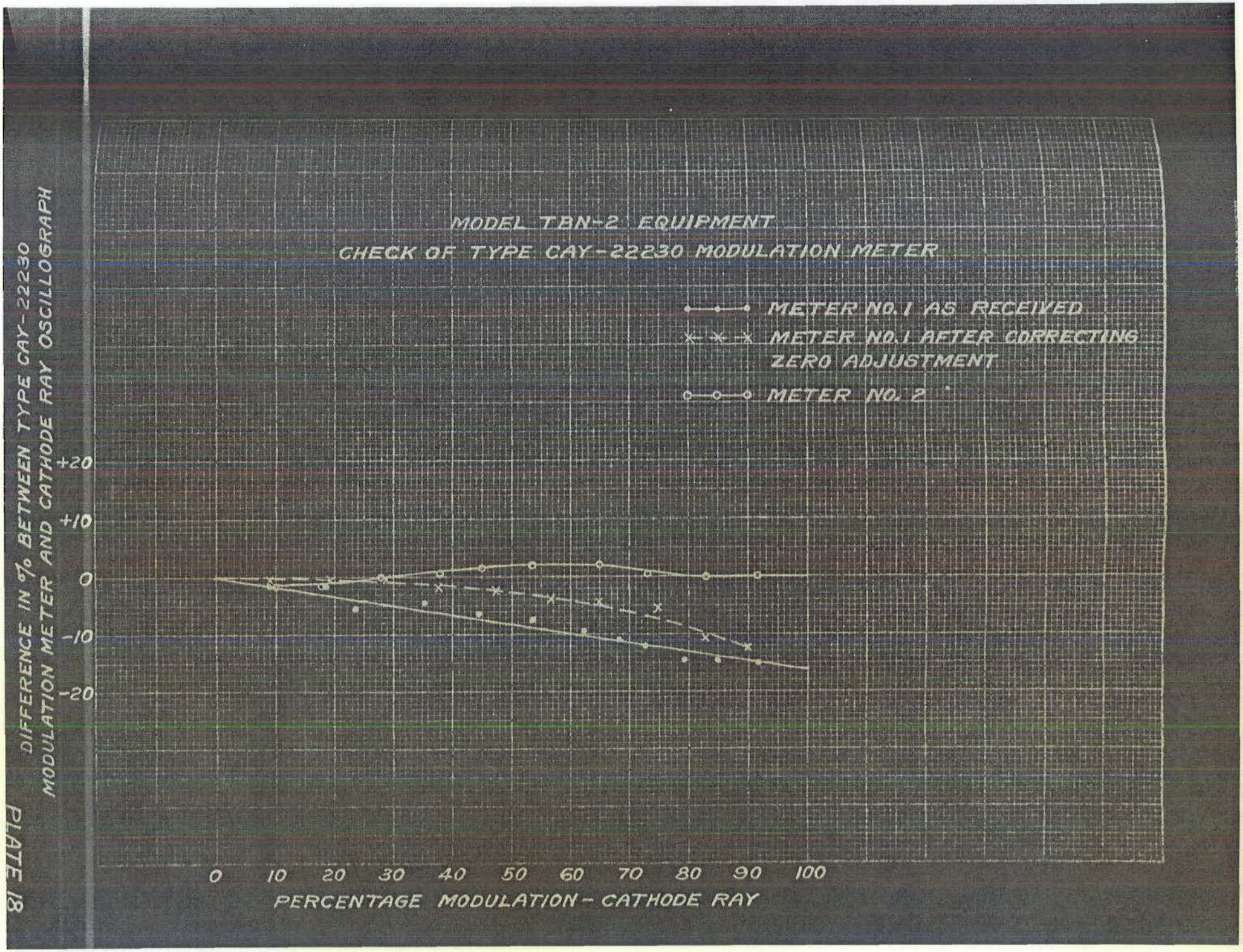

MODEL TBN-2 EQUIPMENT
CHECK OF TYPE CAY-22230 MODULATION METER
METER NO. 1 AS RECEIVED
METER NO. 1 AFTER CORRECTING ZERO ADJUSTMENT
METER NO. 2
DIFFERENCE IN % BETWEEN TYPE CAY-22230 MODULATION METER AND CATHODE RAY OSCILLOGRAPH
+20
+10
0
-10
-20
0 10 20 30 40 50 60 70 80 90 100
PERCENTAGE MODULATION - CATHODE RAY

PLATE 18

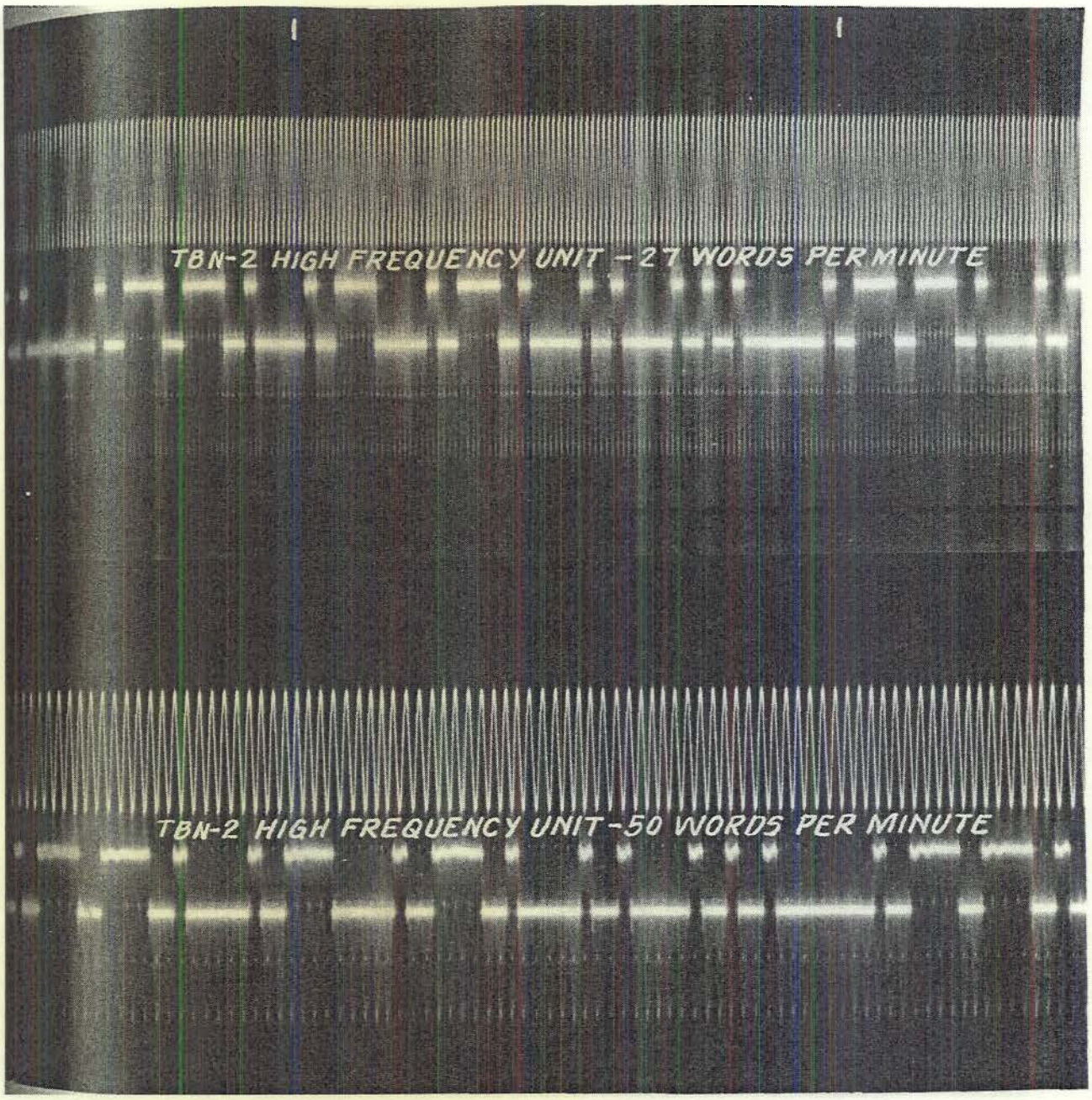

TBN-2 HIGH FREQUENCY UNIT - 27 WORDS PER MINUTE
TBN-2 HIGH FREQUENCY UNIT - 50 WORDS PER MINUTE

Plate 20

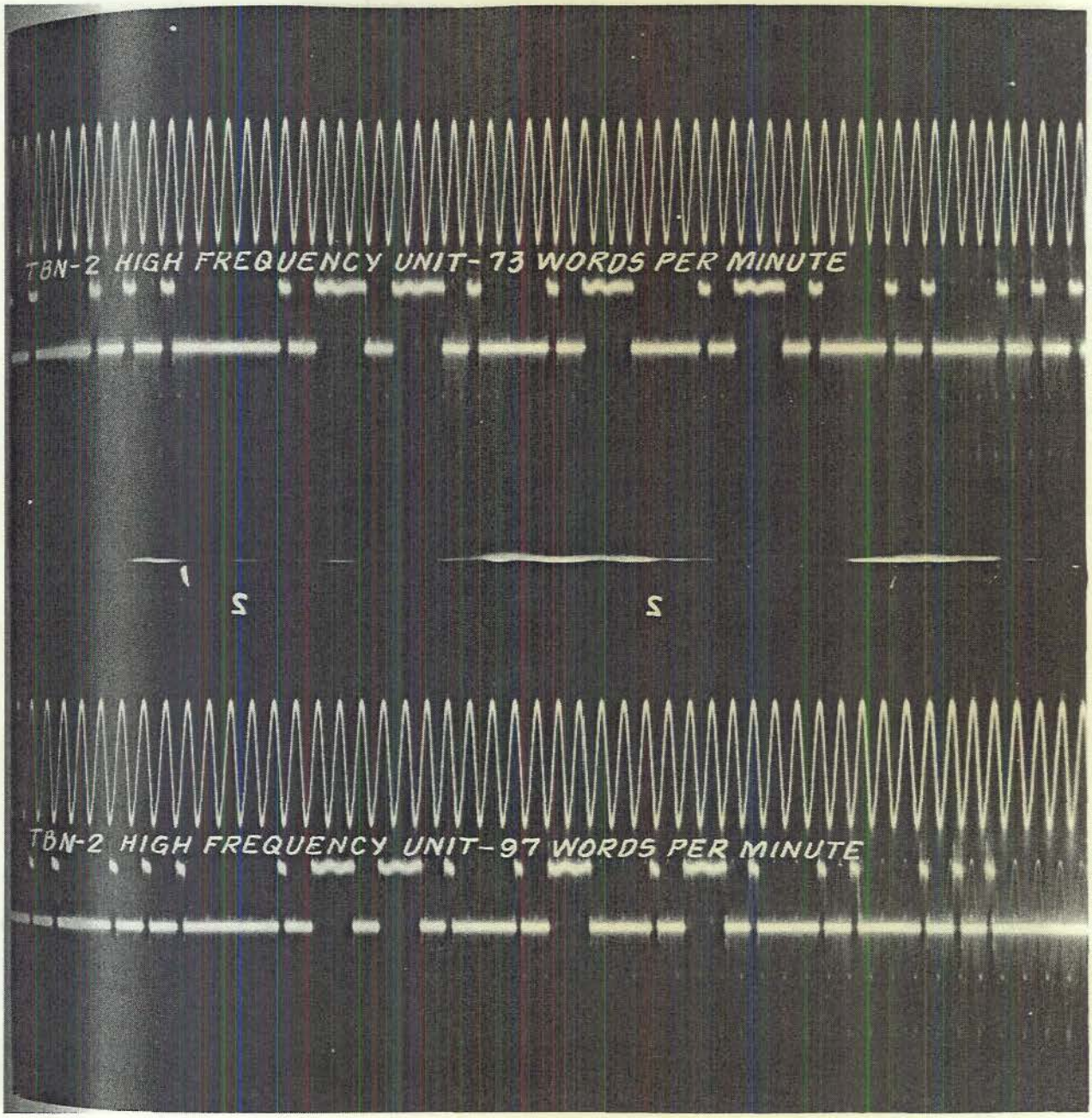

TBN-2 HIGH FREQUENCY UNIT-73 WORDS PER MINUTE
S
S
TBN-2 HIGH FREQUENCY UNIT-97 WORDS PER MINUTE

Plate 21

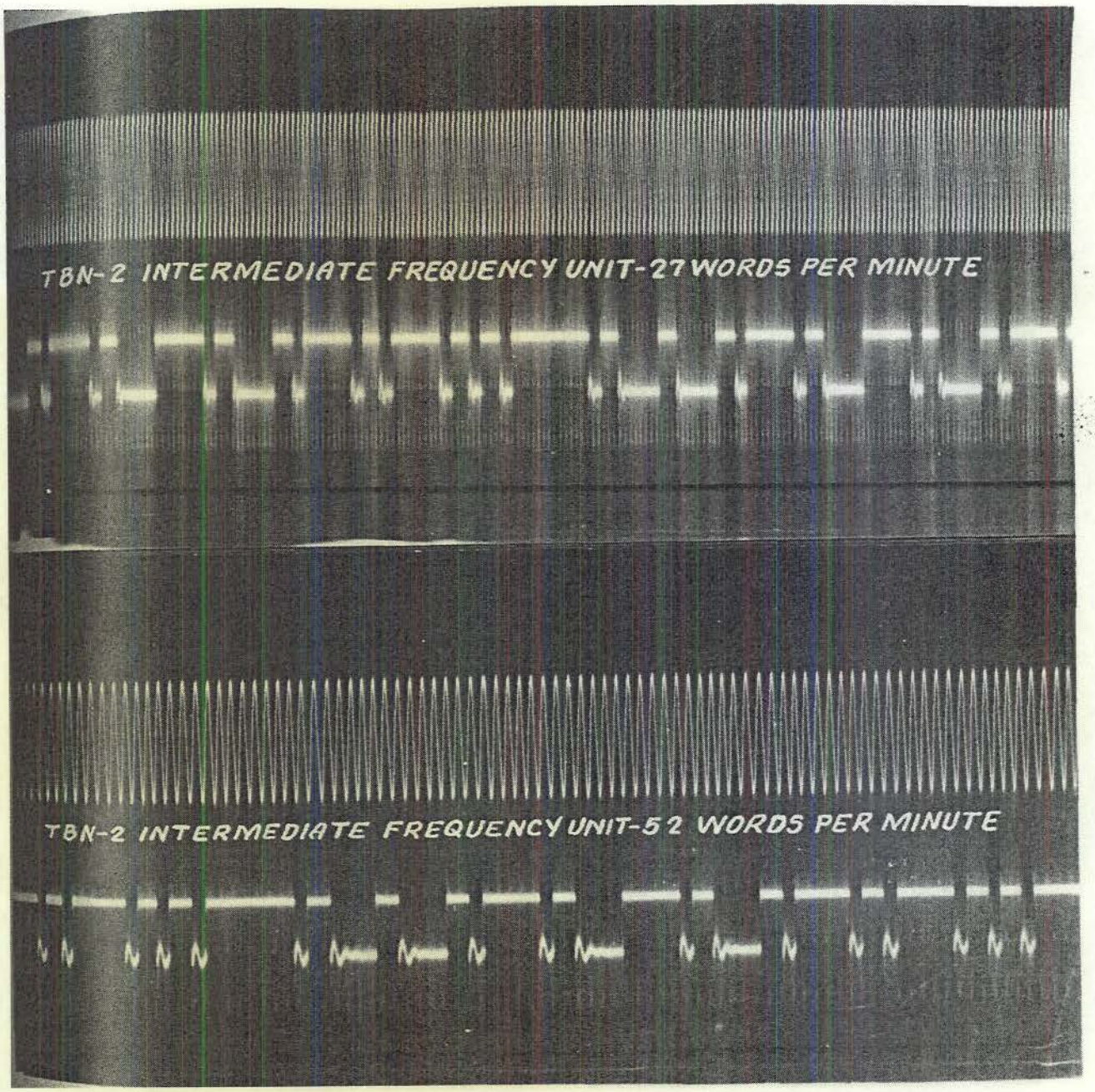

TBN-2 INTERMEDIATE FREQUENCY UNIT-27 WORDS PER MINUTE
TBN-2 INTERMEDIATE FREQUENCY UNIT-52 WORDS PER MINUTE

Plate 22

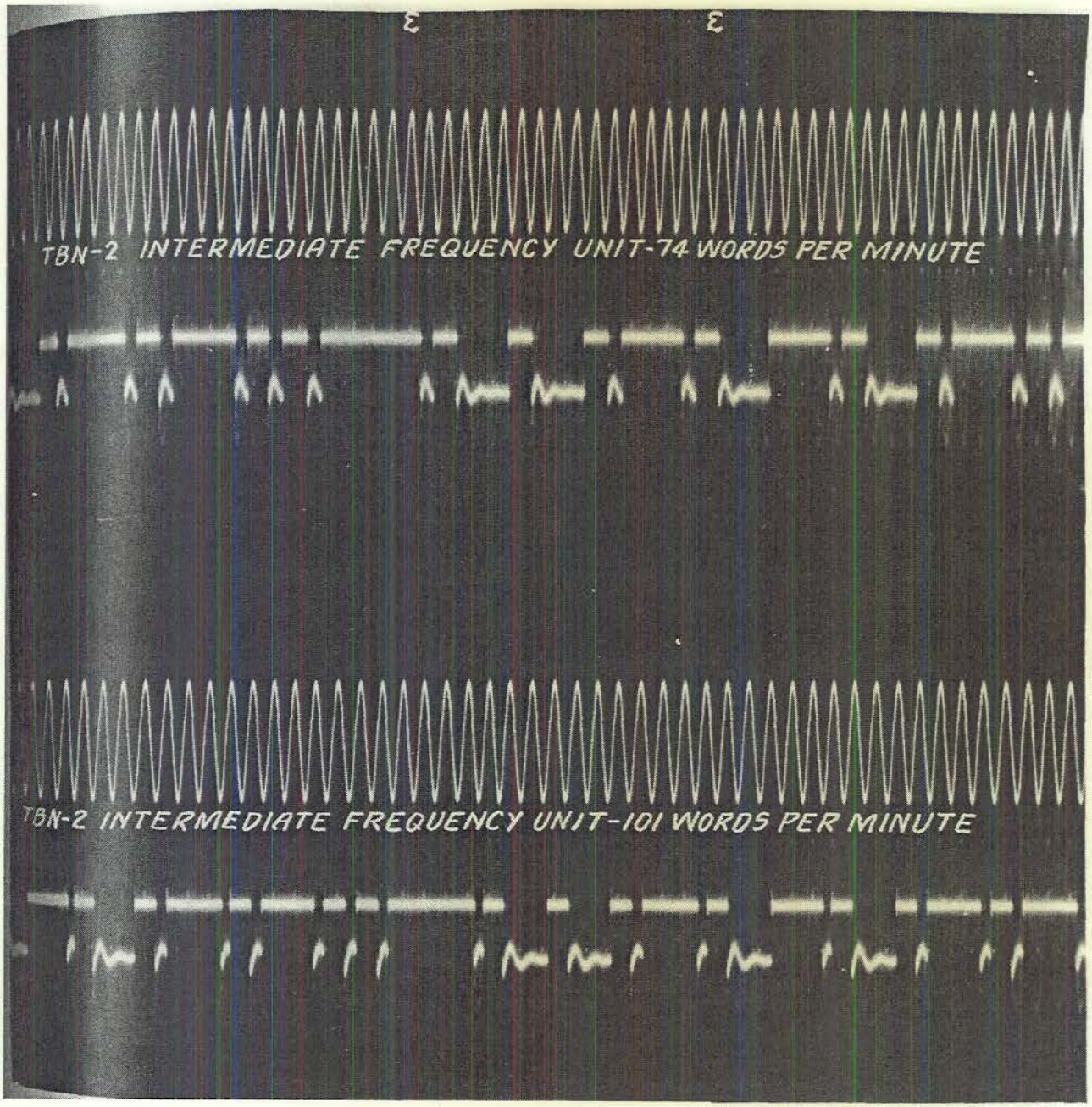

TBN-2 INTERMEDIATE FREQUENCY UNIT-74 WORDS PER MINUTE
TBN-2 INTERMEDIATE FREQUENCY UNIT-101 WORDS PER MINUTE

Plate 23

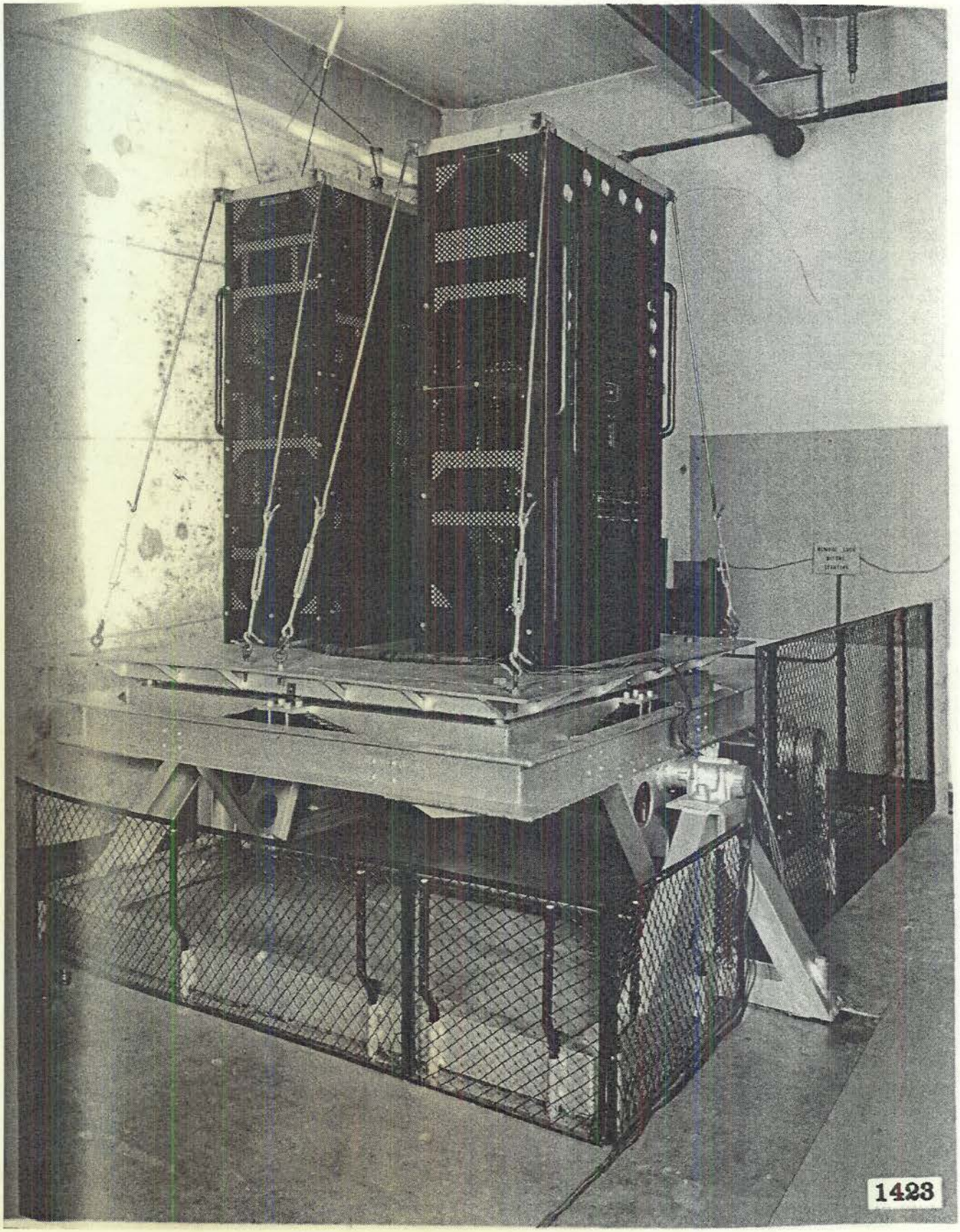


Plate 24

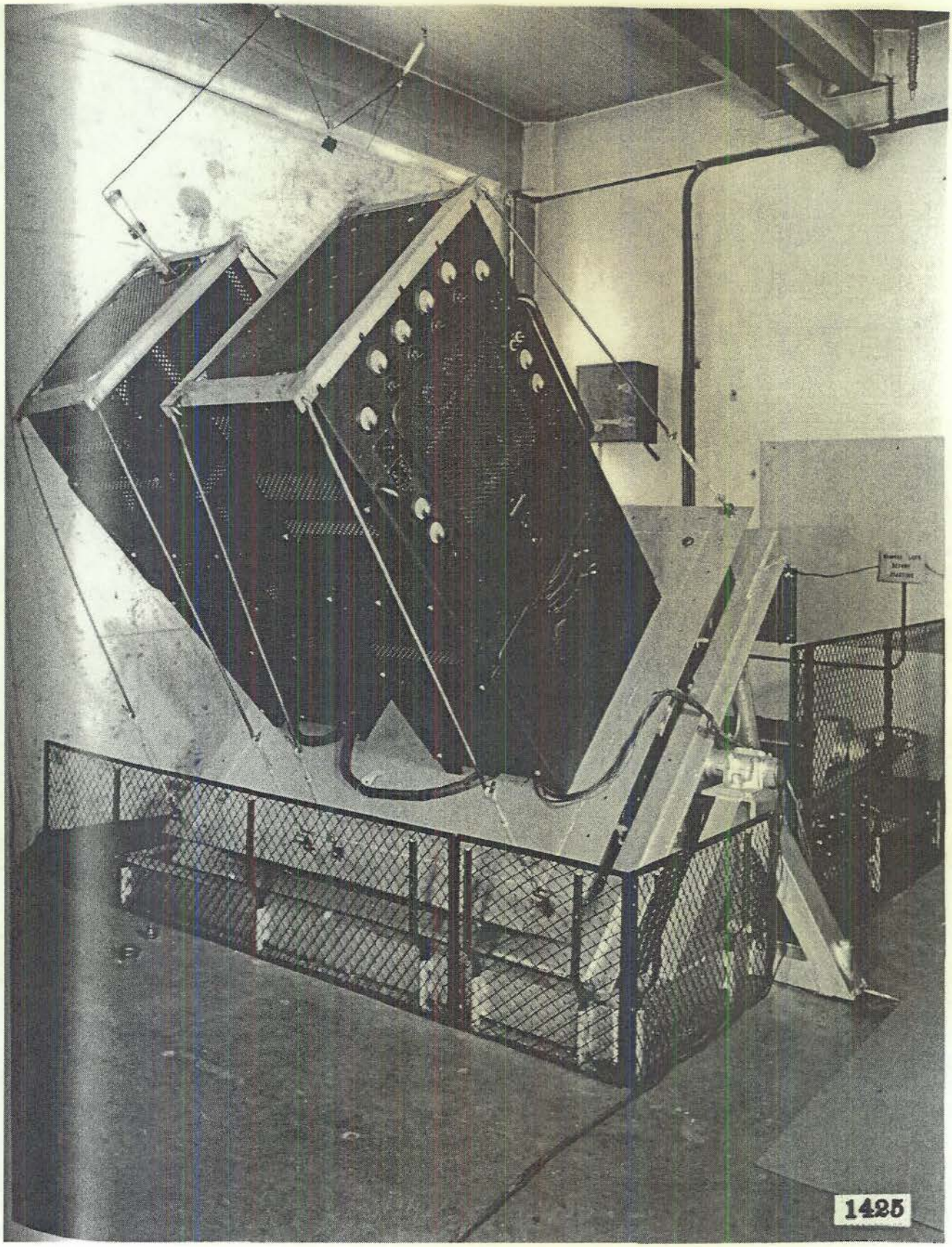


Plate 25

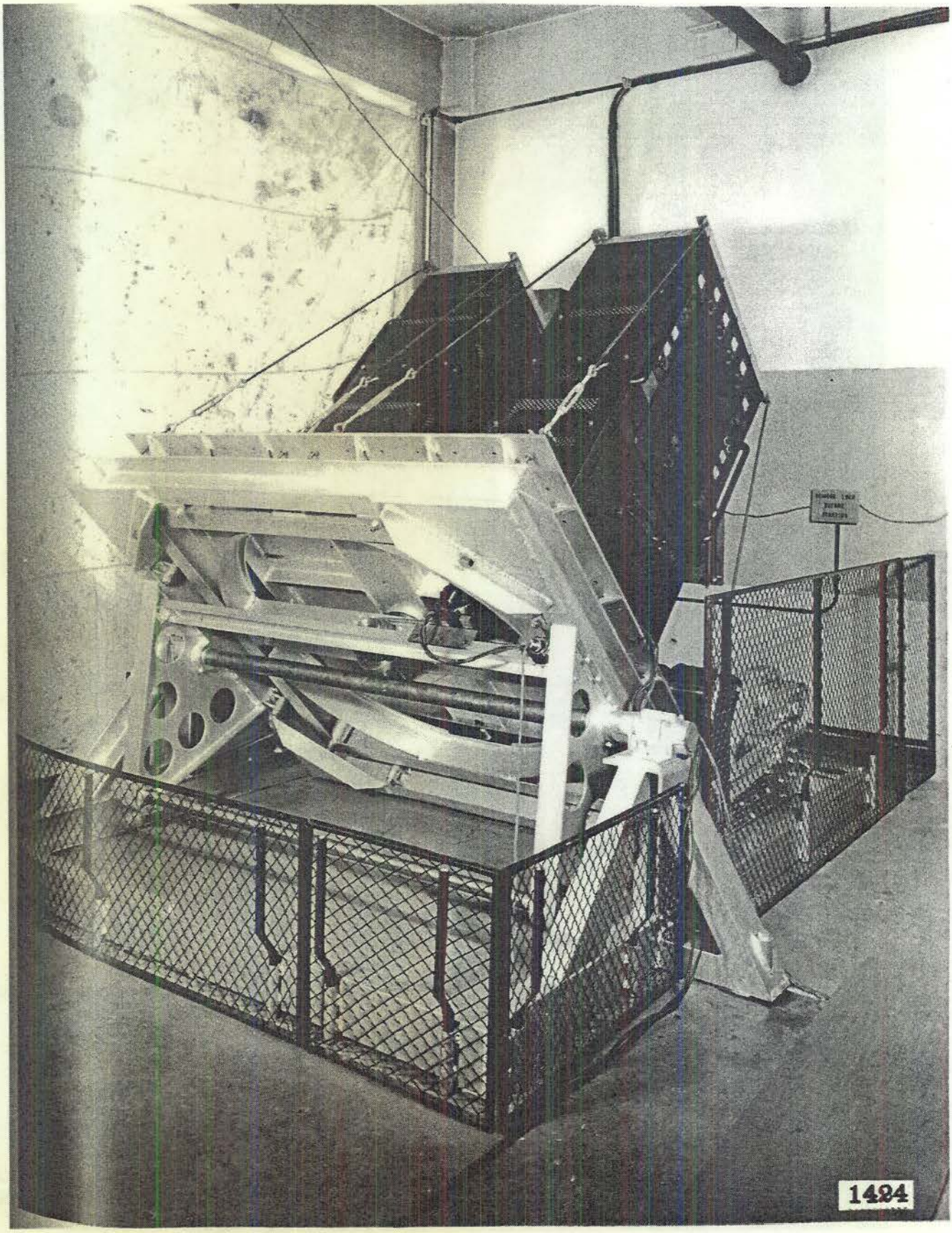


Plate 26

Plate 27

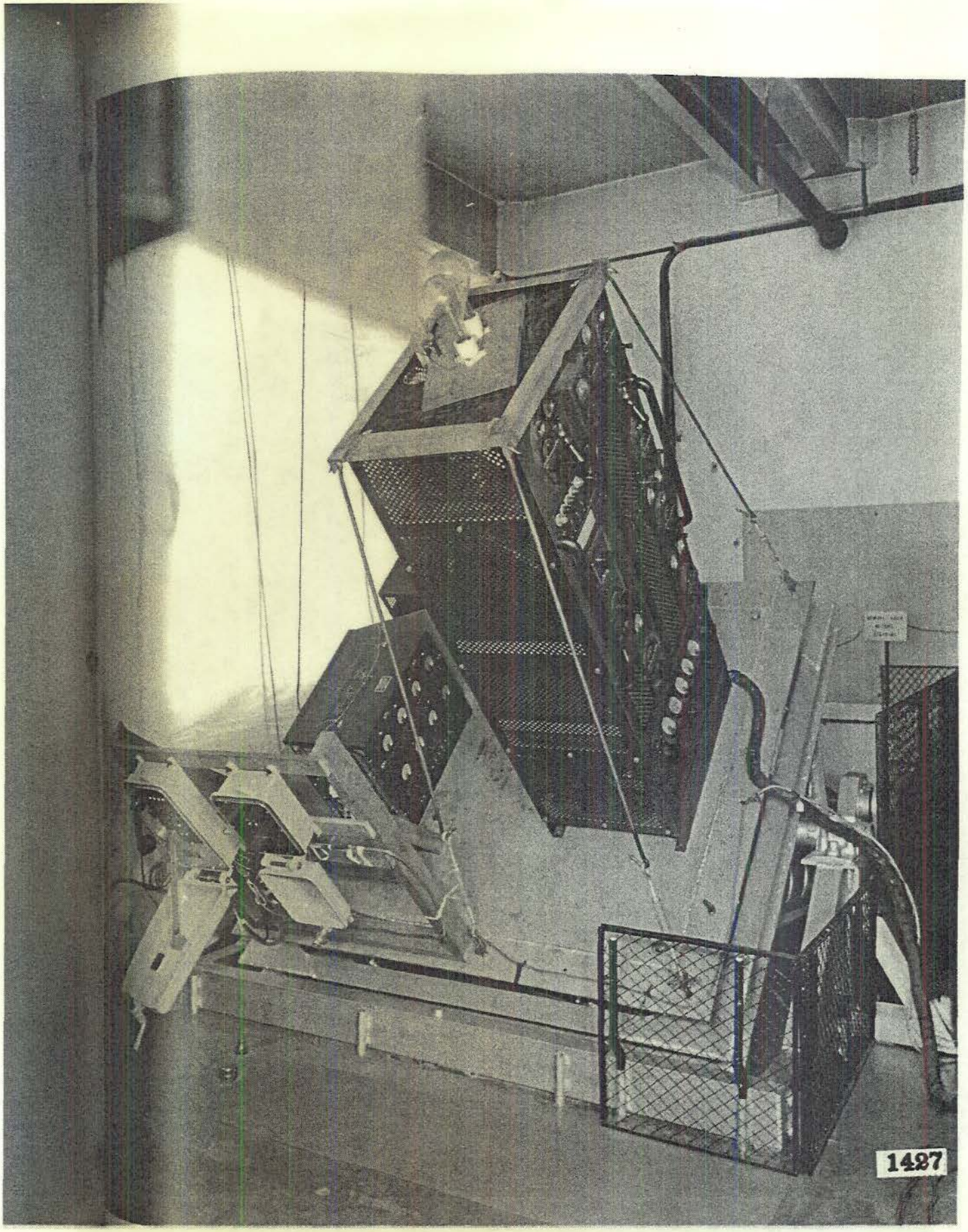

1427

Plate 29

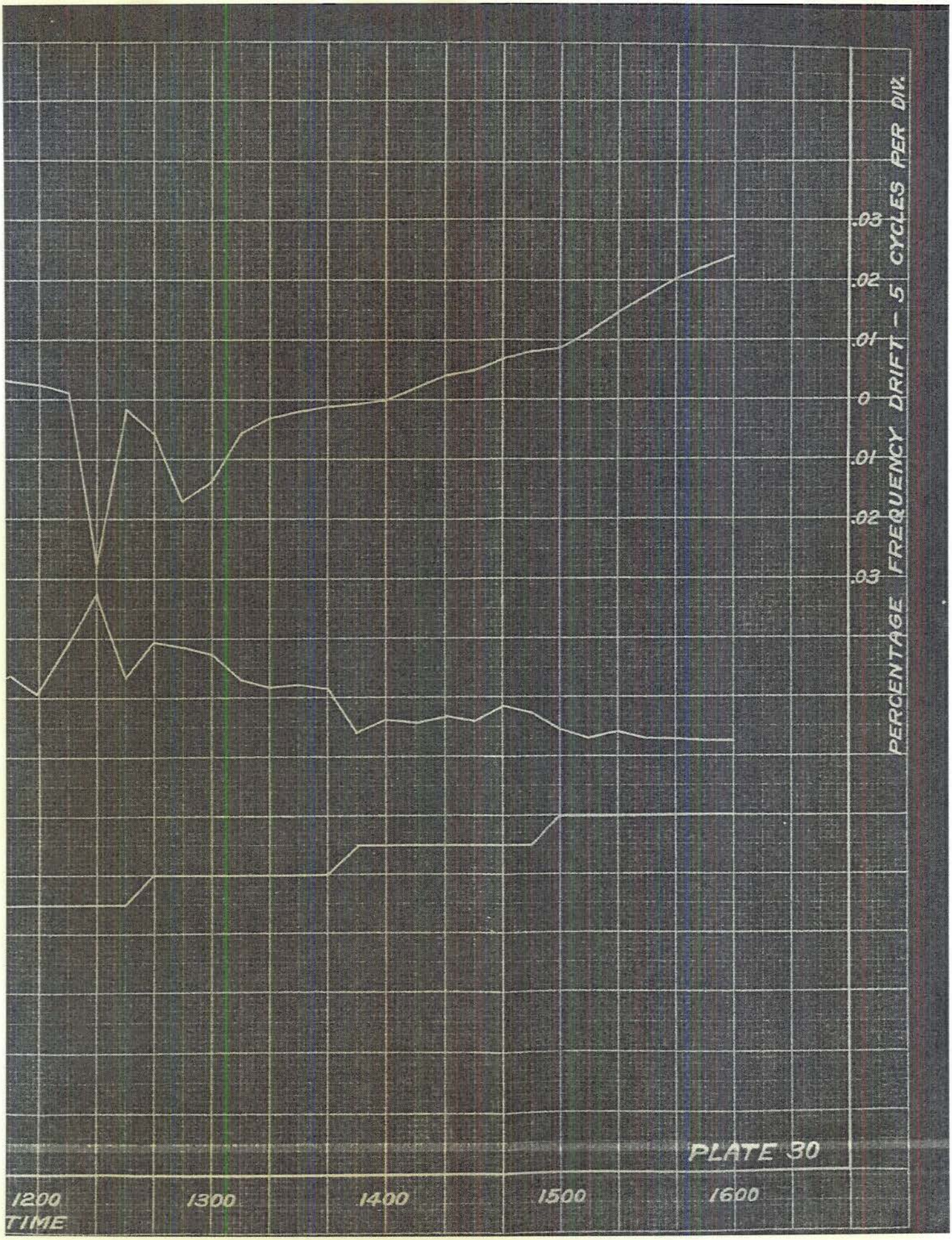
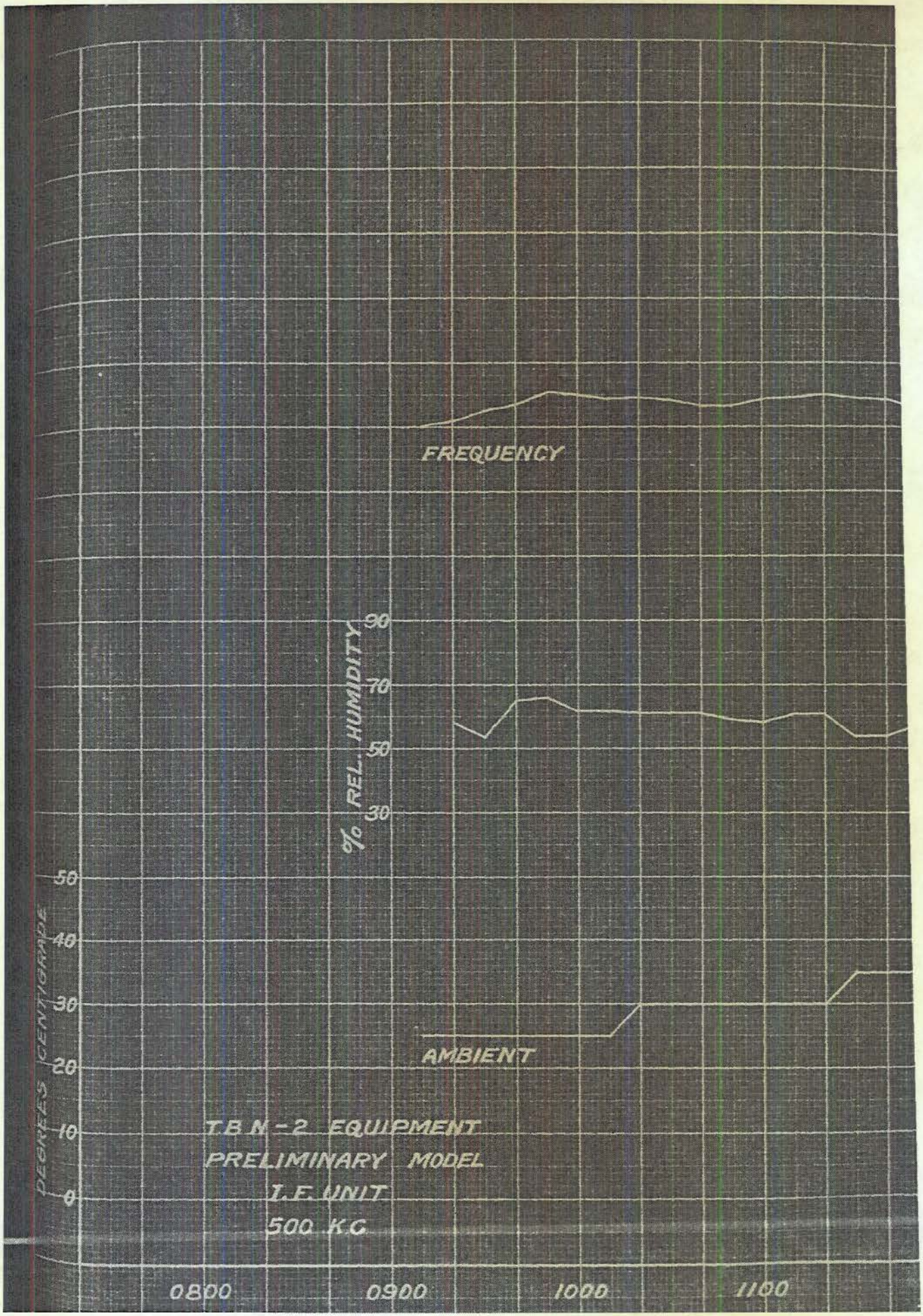

PERCENTAGE FREQUENCY DRIFT - 5 CYCLES PER DIV.
.03
.02
.01
0
.01
.02
.03
1200
1300
1400
1500
1600
TIME

PLATE 30


FREQUENCY
% REL. HUMIDITY
90
70
50
30
DEGREES CENTIGRADE
50
40
30
20
10
0
AMBIENT
T.B.M-2 EQUIPMENT
PRELIMINARY MODEL
I.F. UNIT
500 K.C.
0800
0900
1000
1100

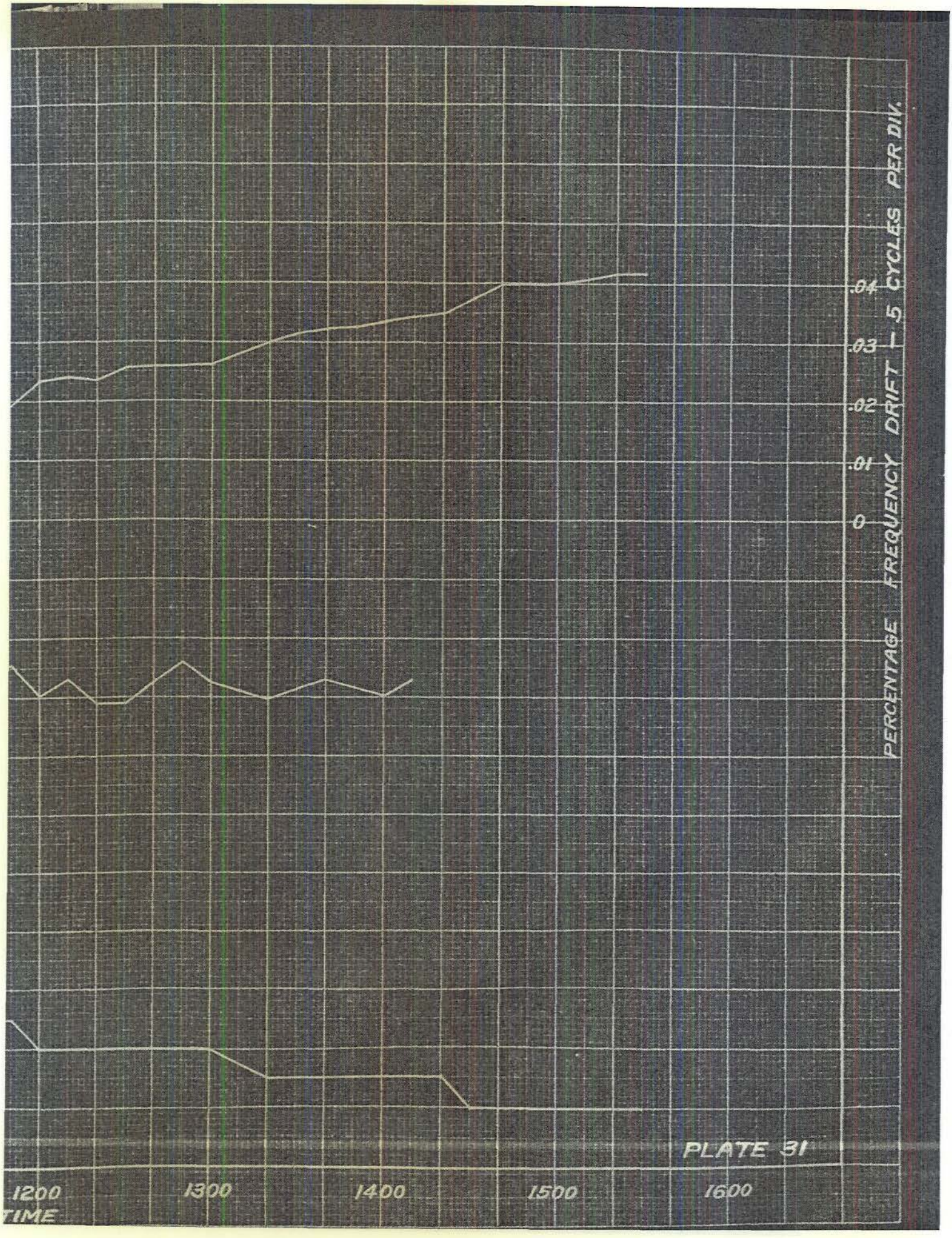
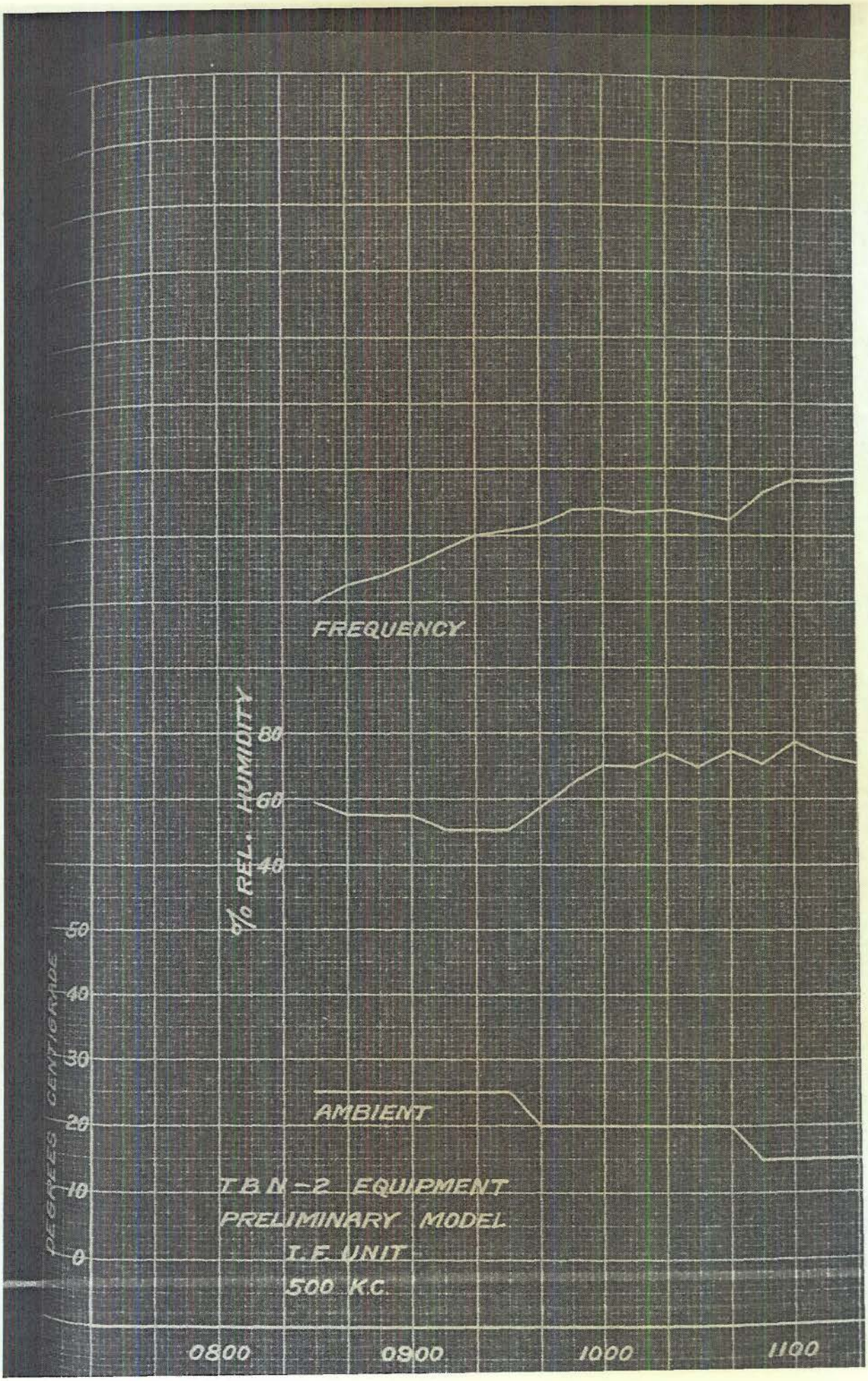

PERCENTAGE FREQUENCY DRIFT — .5 CYCLES PER DIV.
.04
.03
.02
.01
0
1200
1300
1400
1500
1600
TIME

PLATE 31


FREQUENCY
% REL. HUMIDITY
80
60
40
DEGREES CENTIGRADE
50
40
30
20
10
0
AMBIENT
T B N – 2 EQUIPMENT
PRELIMINARY MODEL
I. F. UNIT
500 K.C.
0800
0900
1000
1100

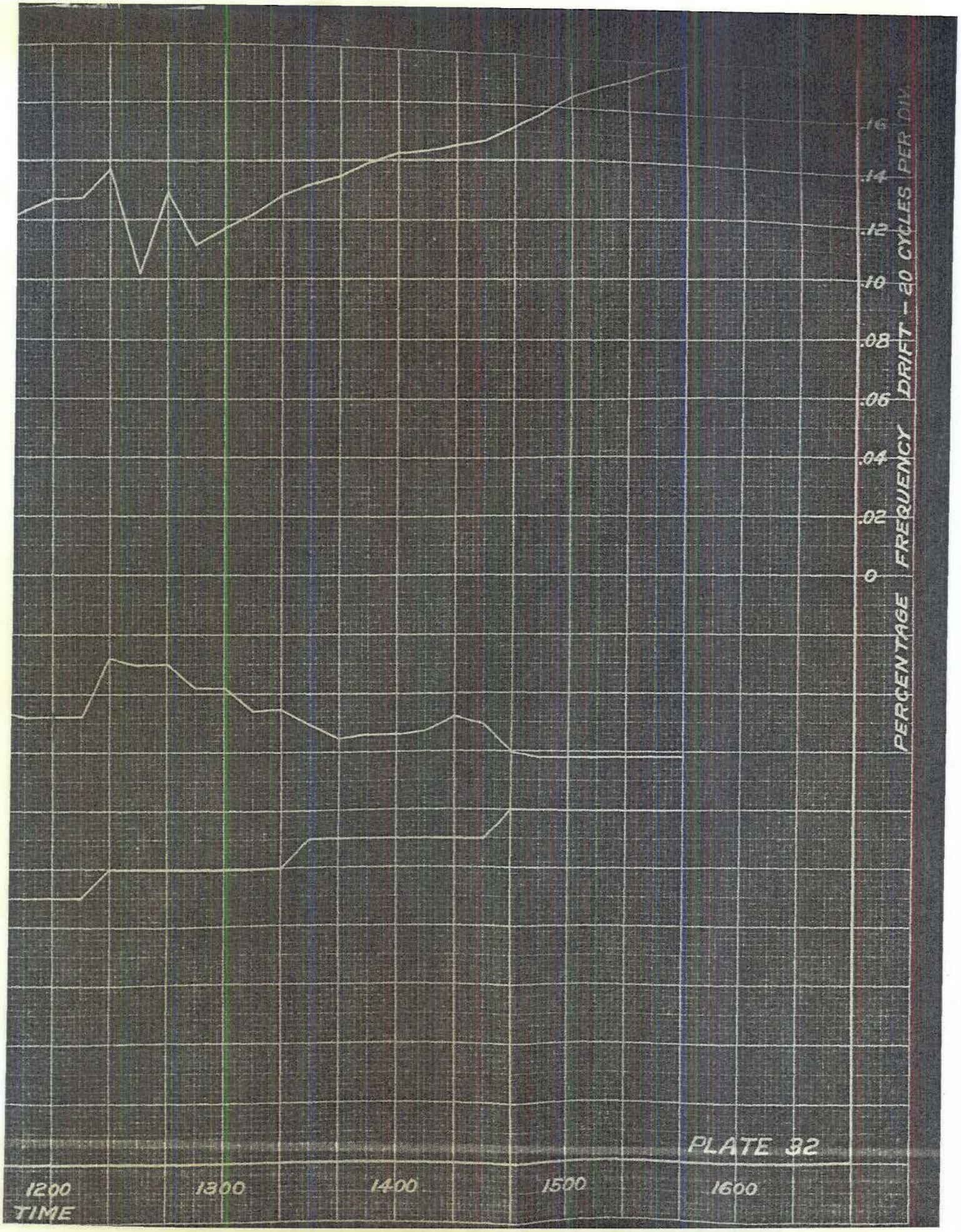
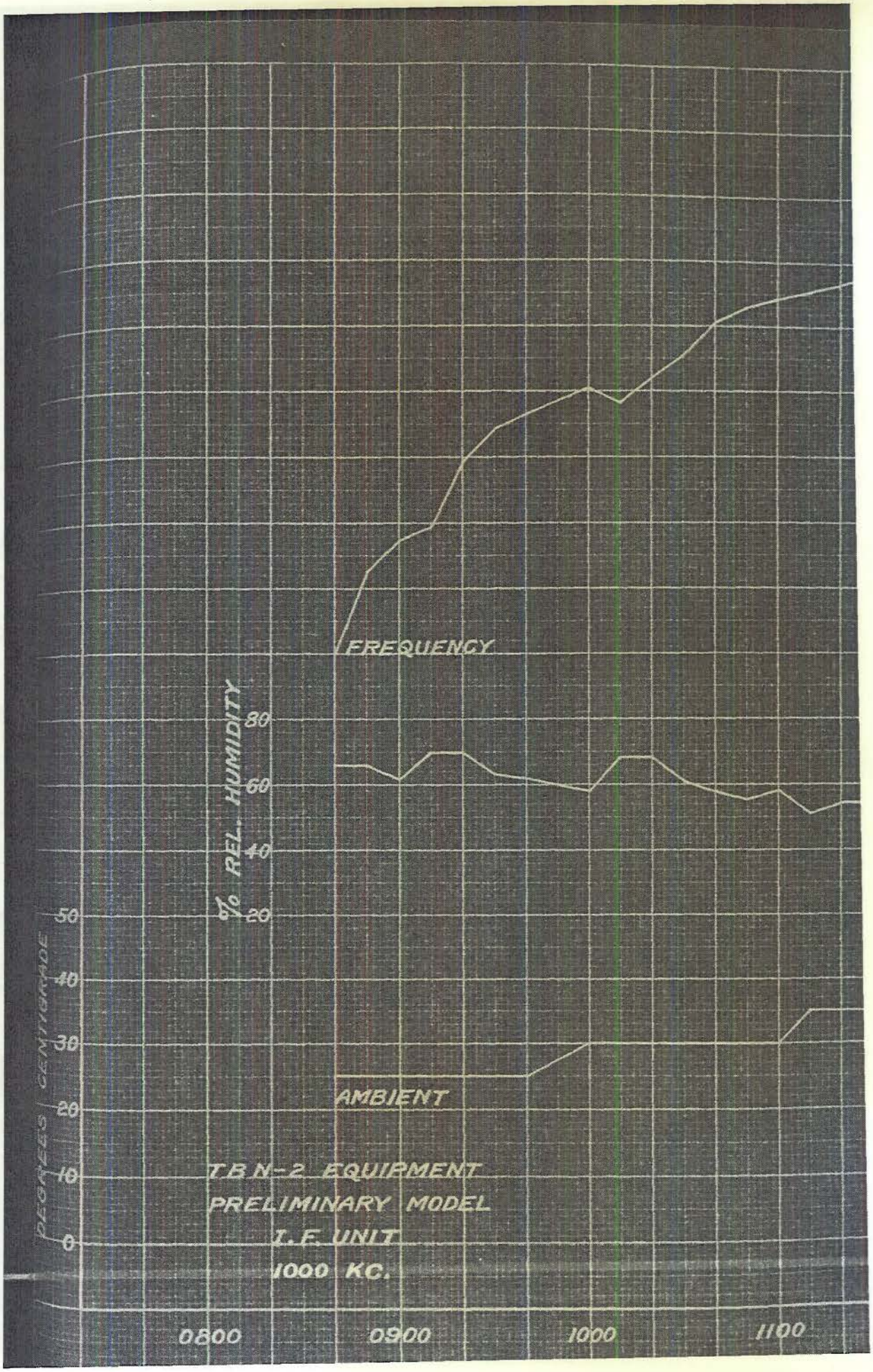

PERCENTAGE FREQUENCY DRIFT - 20 CYCLES PER DIV.
.16
.14
.12
.10
.08
.06
.04
.02
0
1200
1300
1400
1500
1600
TIME

PLATE 32


FREQUENCY
% REL. HUMIDITY
80
60
40
20
DEGREES CENTIGRADE
50
40
30
20
10
0
AMBIENT
TBN-2 EQUIPMENT
PRELIMINARY MODEL
I.F. UNIT
1000 KC.
0800
0900
1000
1100

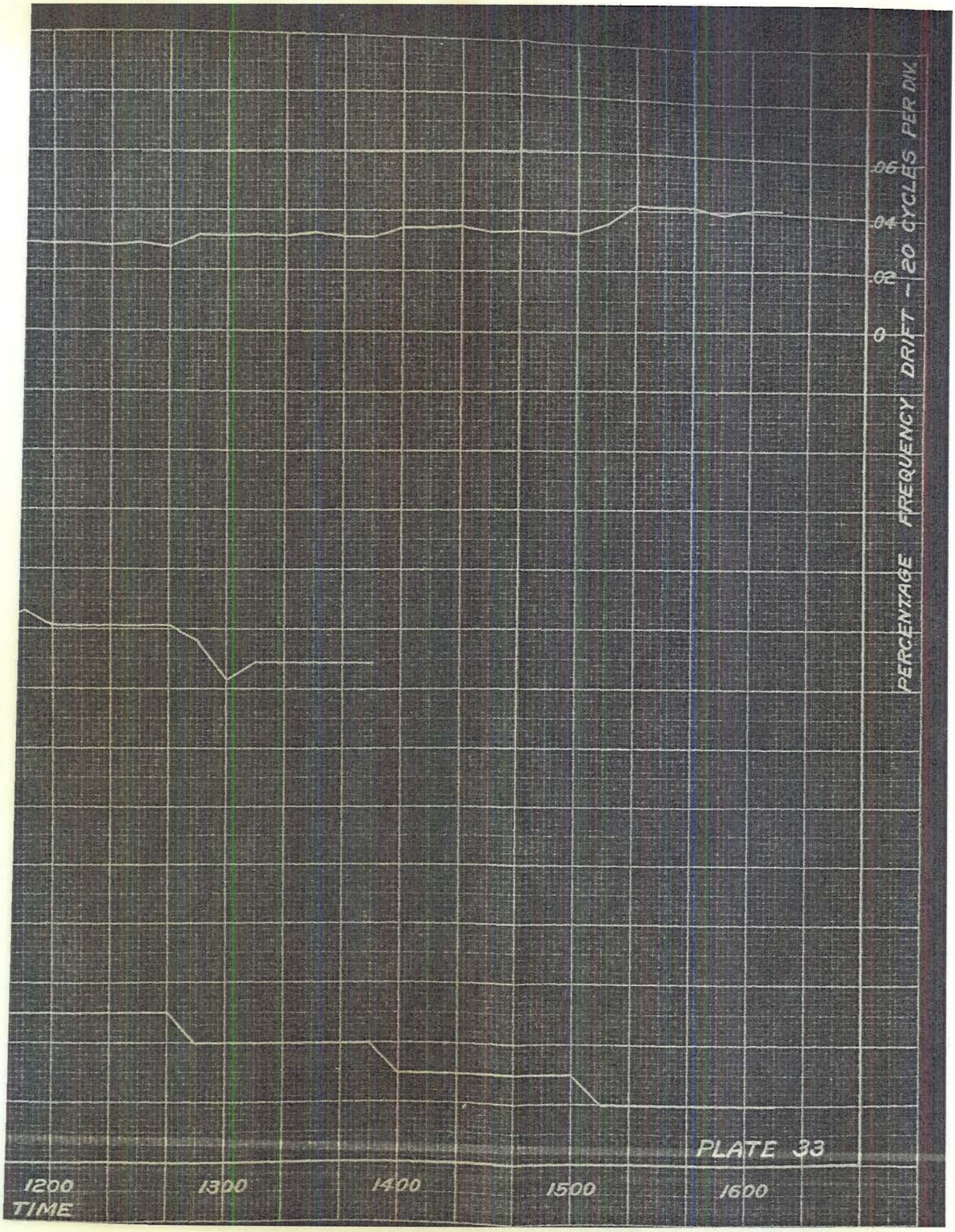
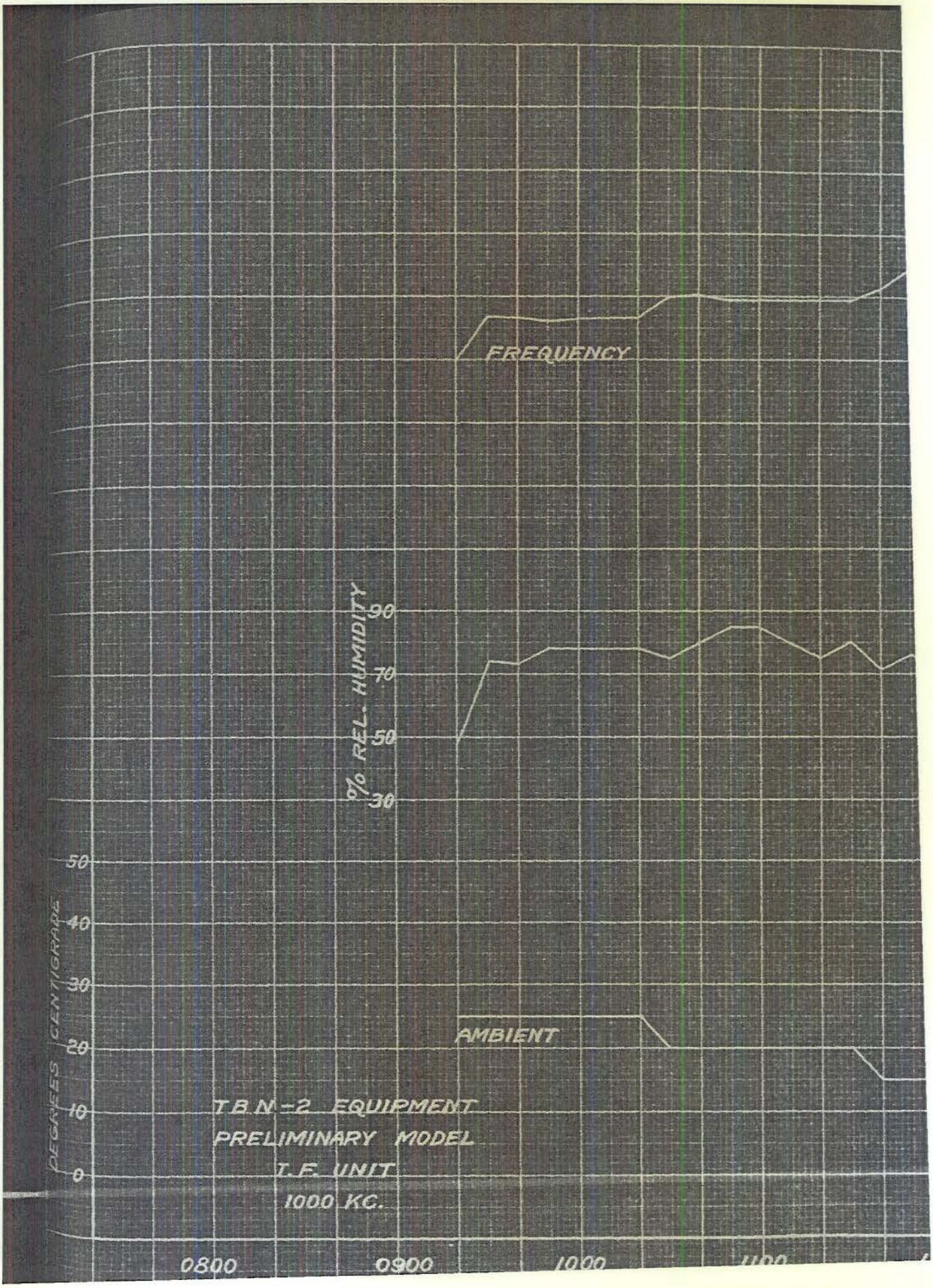
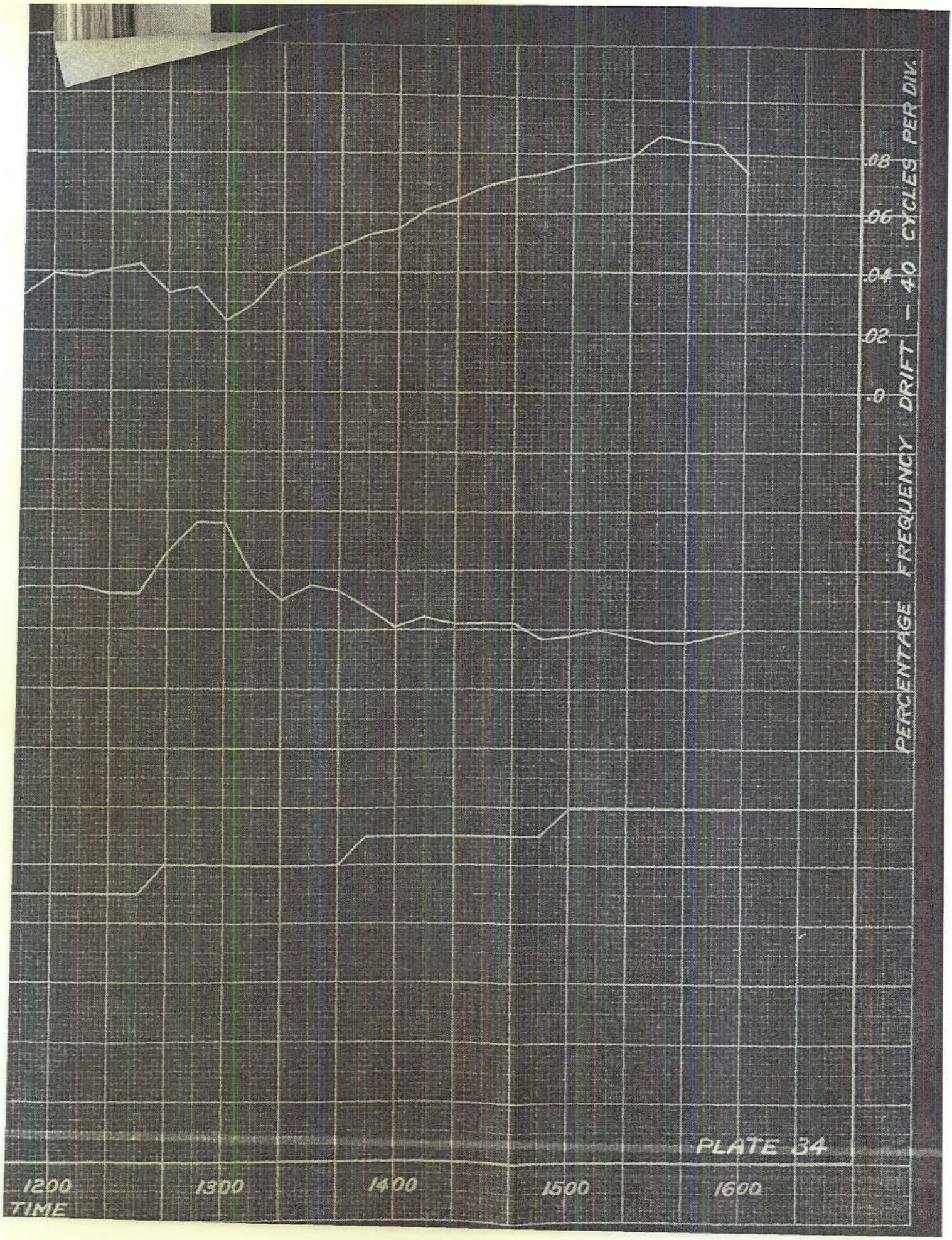
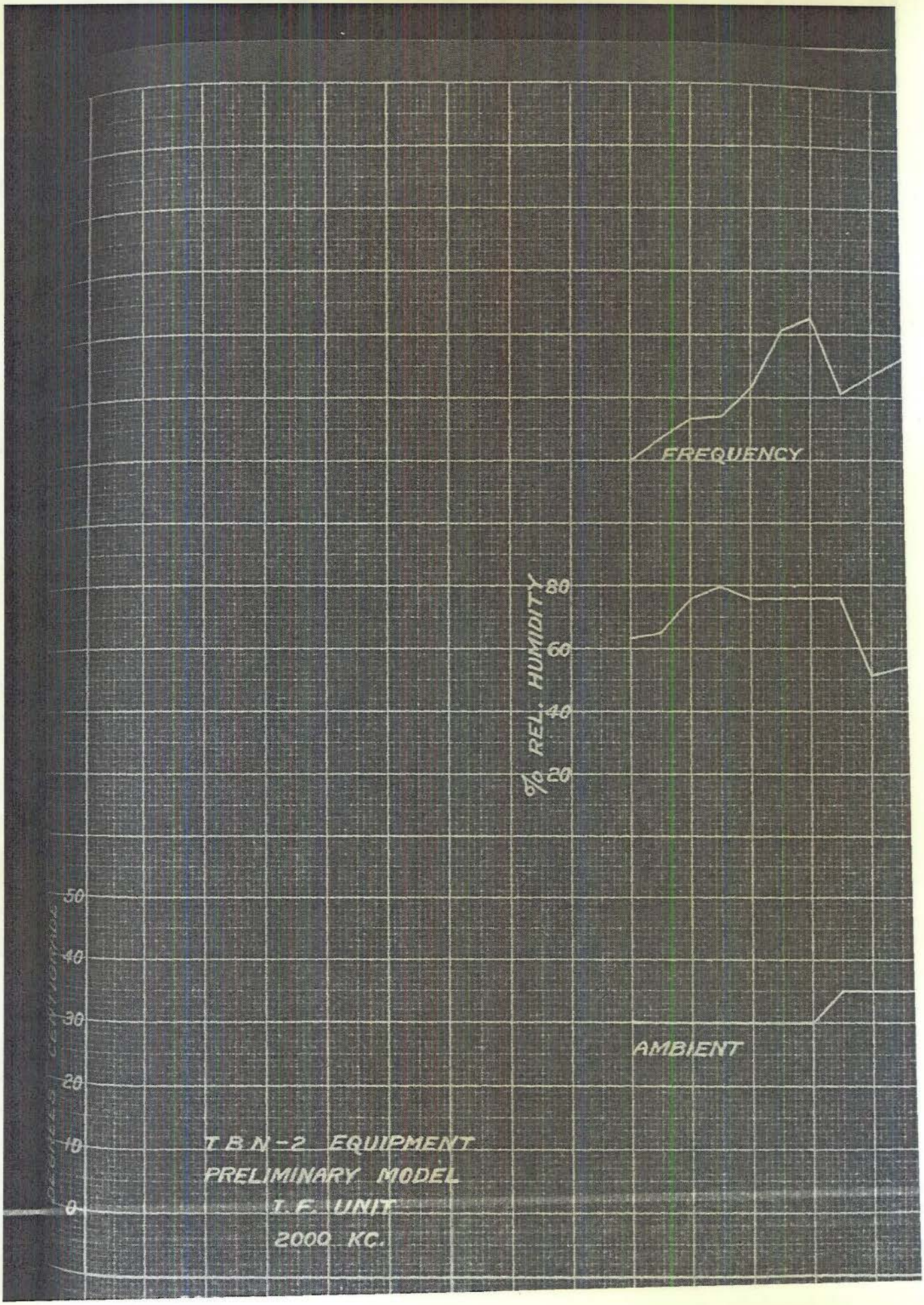
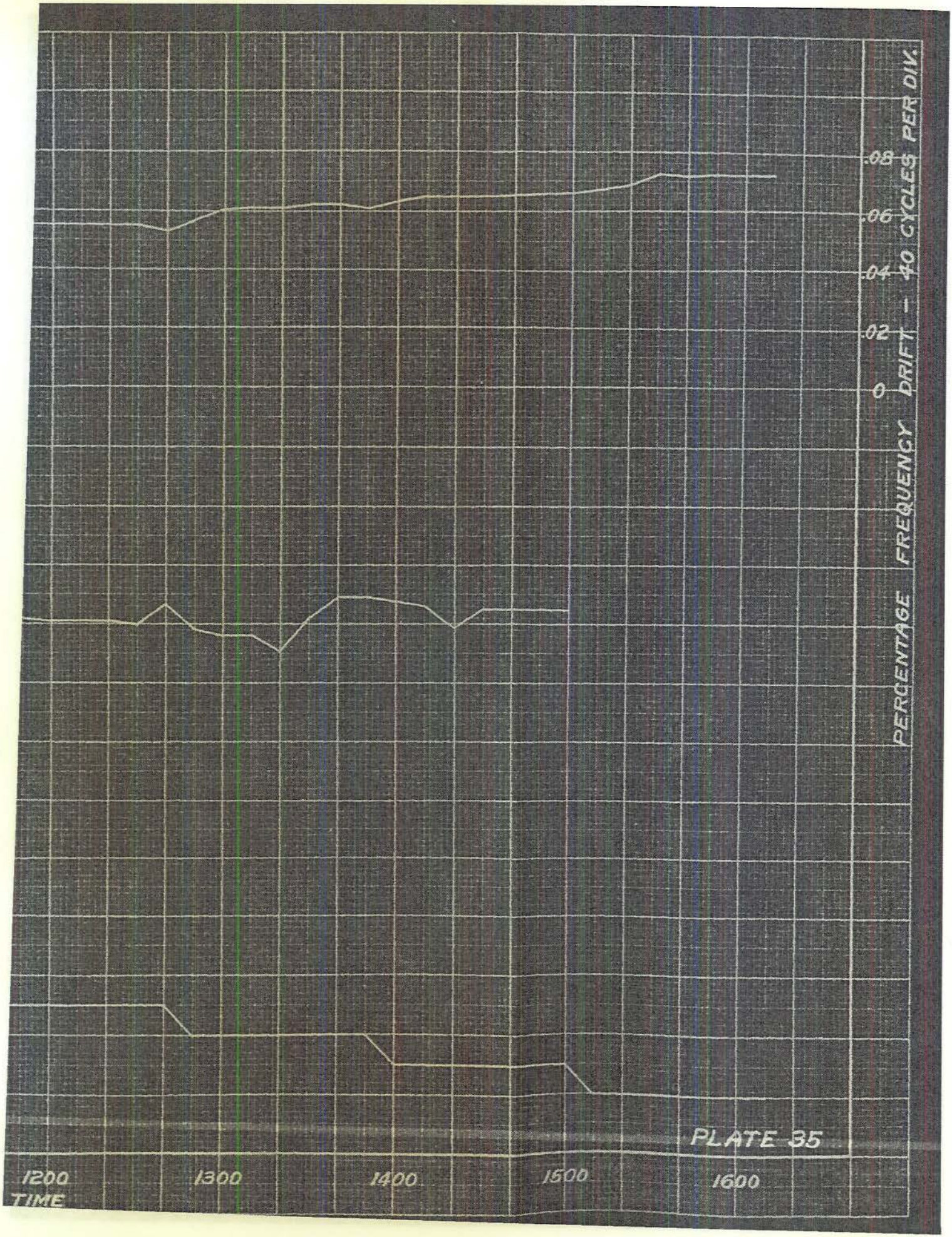

PERCENTAGE FREQUENCY DRIFT - 20 CYCLES PER DIV.
.06
.04
.02
0
1200
1300
1400
1500
1600
TIME

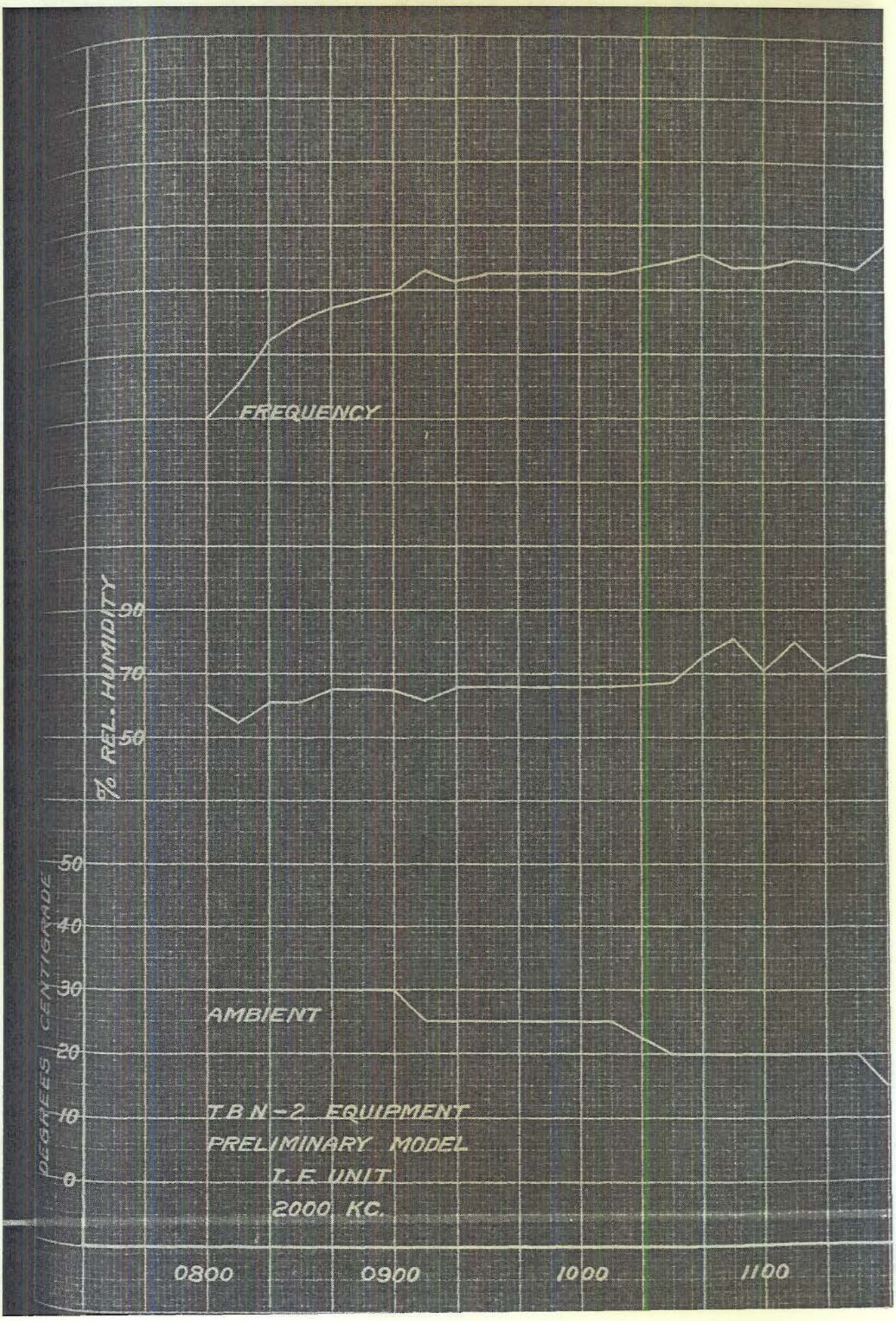
PLATE 33

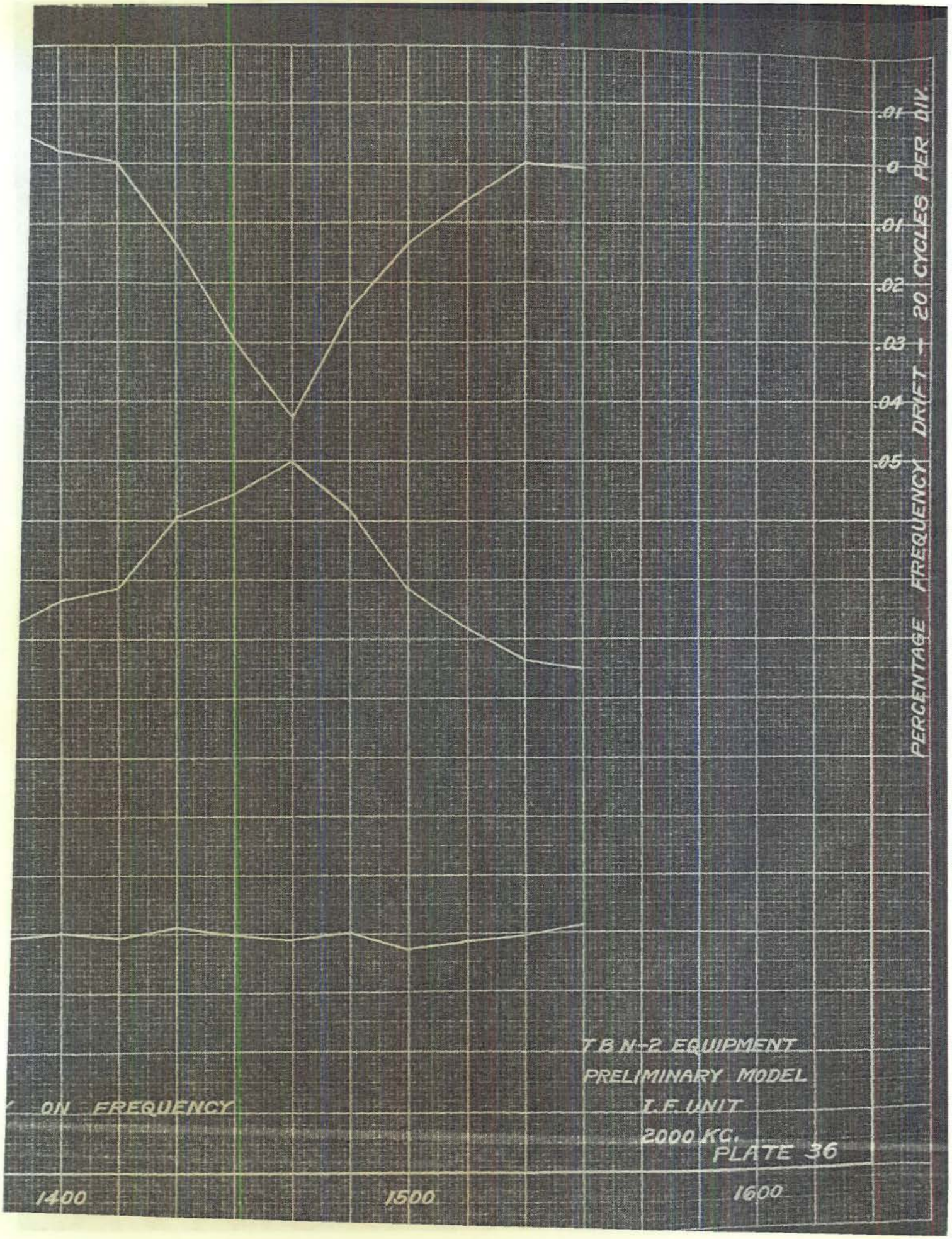

FREQUENCY
% REL. HUMIDITY
90
70
50
30
DEGREES CENTIGRADE
50
40
30
20
10
0
AMBIENT
T.B.N.-2 EQUIPMENT
PRELIMINARY MODEL
T.E. UNIT
1000 KC.
0800
0900
1000

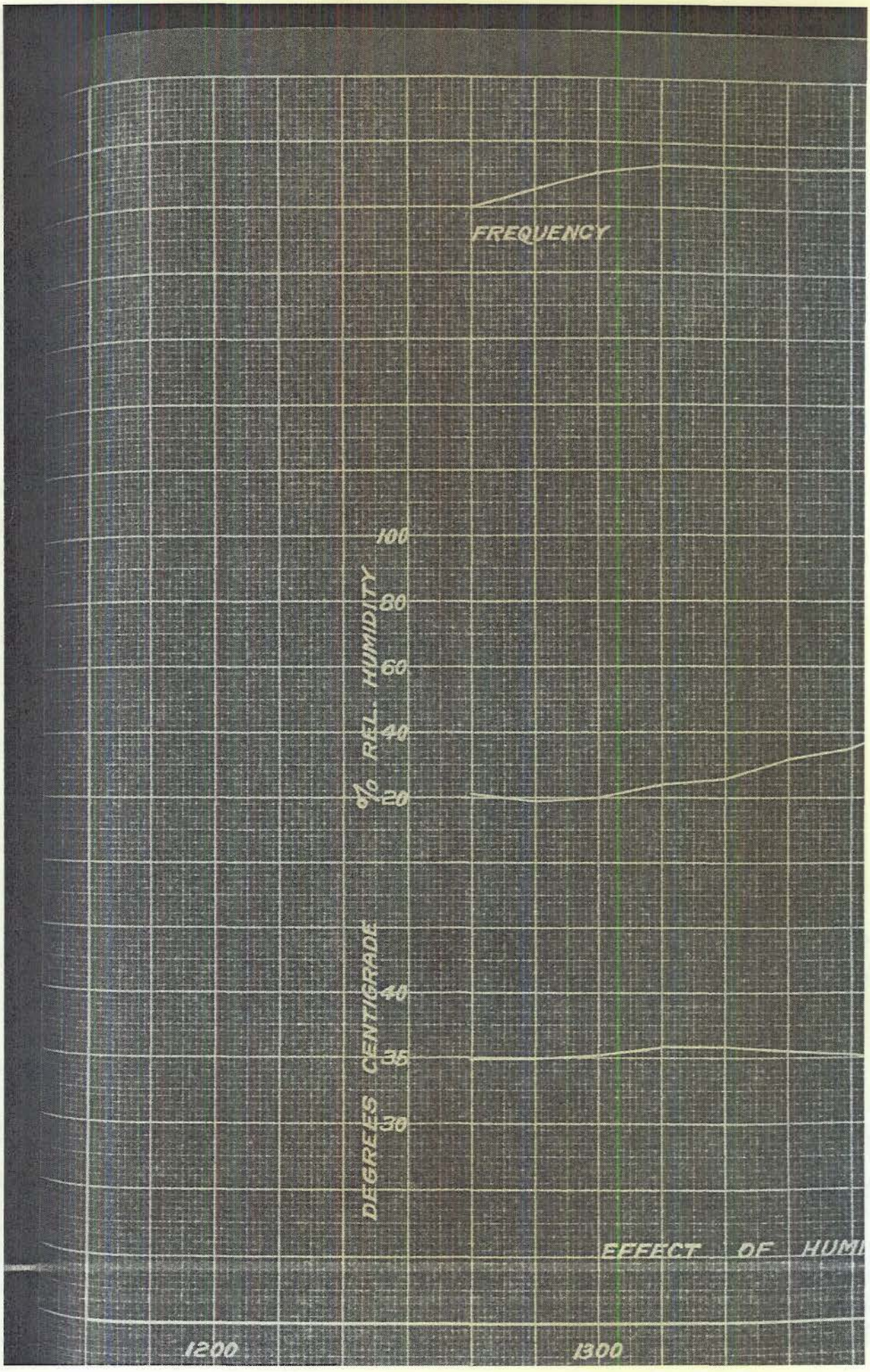

PERCENTAGE FREQUENCY DRIFT - 40 CYCLES PER DIV.
.08
.06
.04
.02
.0
PLATE 34
1200
1300
1400
1500
1600
TIME

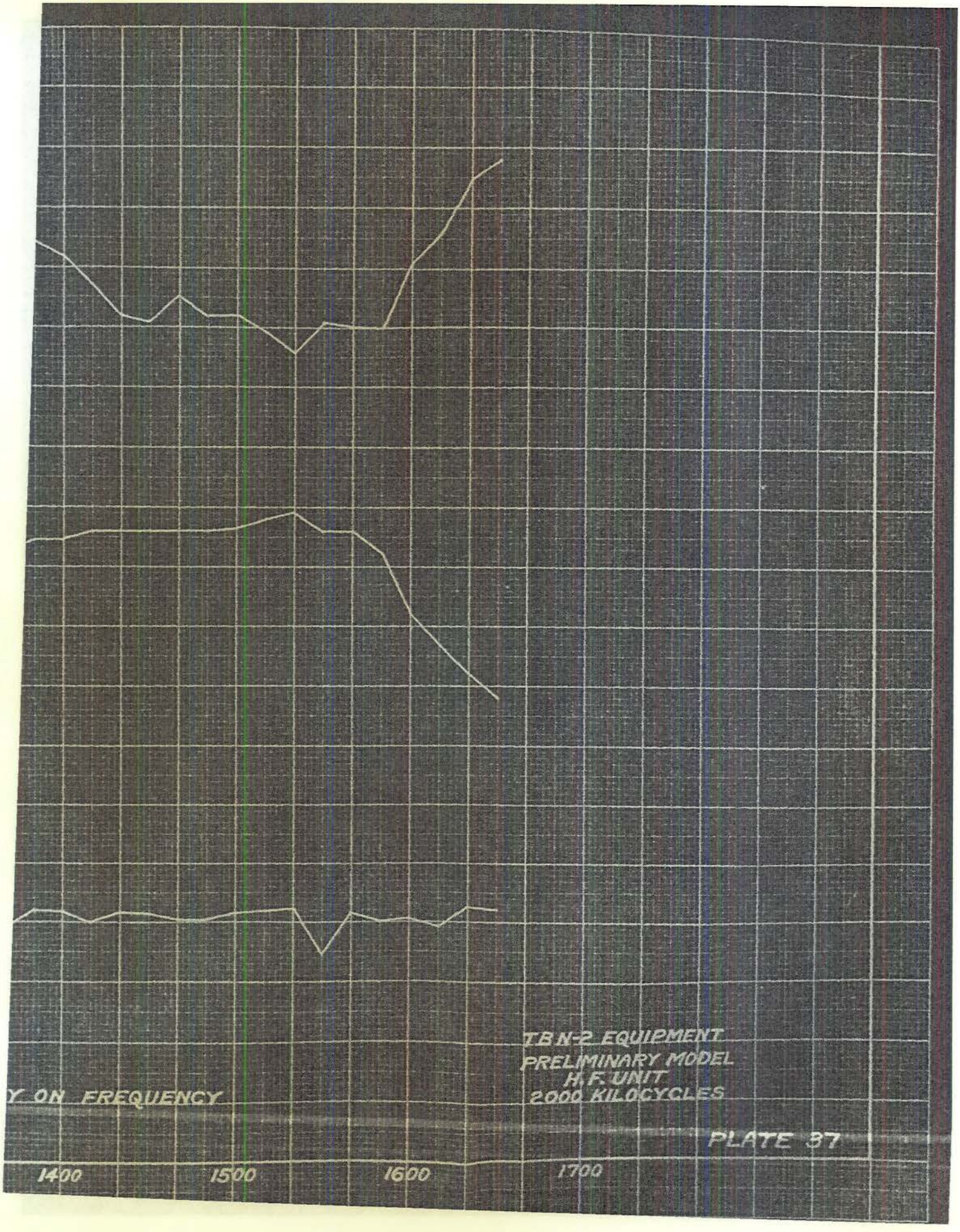

FREQUENCY
% REL. HUMIDITY
80
60
40
20
AMBIENT
50
40
30
20
10
0
TBN-2 EQUIPMENT
PRELIMINARY MODEL
I.F. UNIT
2000 KC.


PERCENTAGE FREQUENCY DRIFT - 40 CYCLES PER DIV.
.08
.06
.04
.02
0
PLATE 35
1200
1300
1400
1500
1600
TIME


FREQUENCY
% REL. HUMIDITY
90
70
50
DEGREES CENTIGRADE
50
40
30
20
10
0
AMBIENT
T B N - 2 EQUIPMENT
PRELIMINARY MODEL
T. E. UNIT
2000 KC.
0800
0900
1000
1100


.01
0
.01
.02
.03
.04
.05
PERCENTAGE FREQUENCY DRIFT + 20 CYCLES PER DIV.
T B N-2 EQUIPMENT
PRELIMINARY MODEL
I.F. UNIT
2000 KC.
PLATE 36
ON FREQUENCY
1400
1500
1600


FREQUENCY
100
80
60
40
20
% REL. HUMIDITY
40
35
30
DEGREES CENTIGRADE
EFFECT OF HUM
1200
1300


TBN-2 EQUIPMENT
PRELIMINARY MODEL
H.F. UNIT
2000 KILOCYCLES
Y ON FREQUENCY
PLATE 37
1400
1500
1600
1700

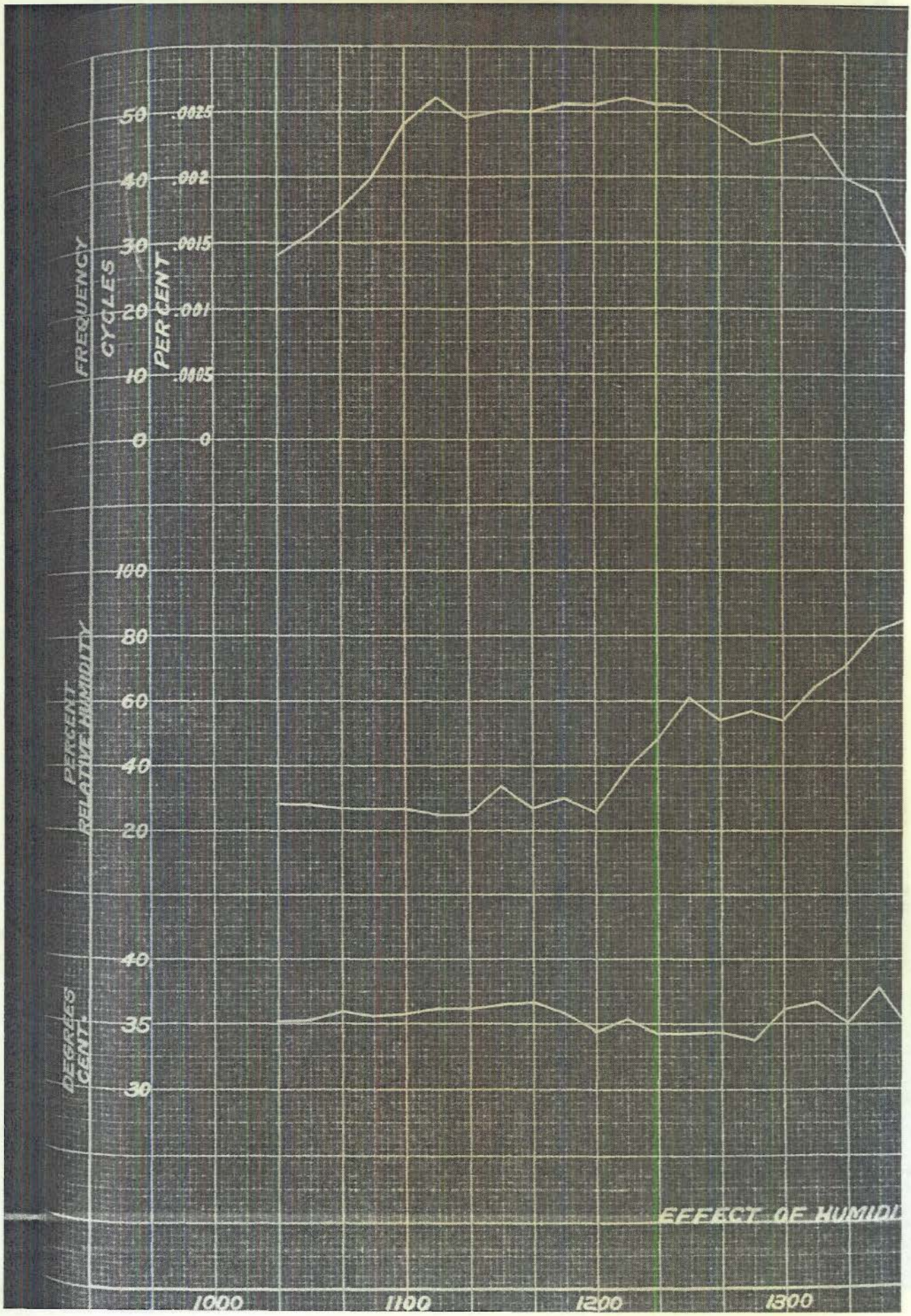

FREQUENCY CYCLES
PERCENT
50
40
30
20
10
0
.0025
.002
.0015
.001
.0005
0
PERCENT RELATIVE HUMIDITY
100
80
60
40
20
DEGREES CENT.
40
35
30
1000
1100
1200
1300

Plate 39

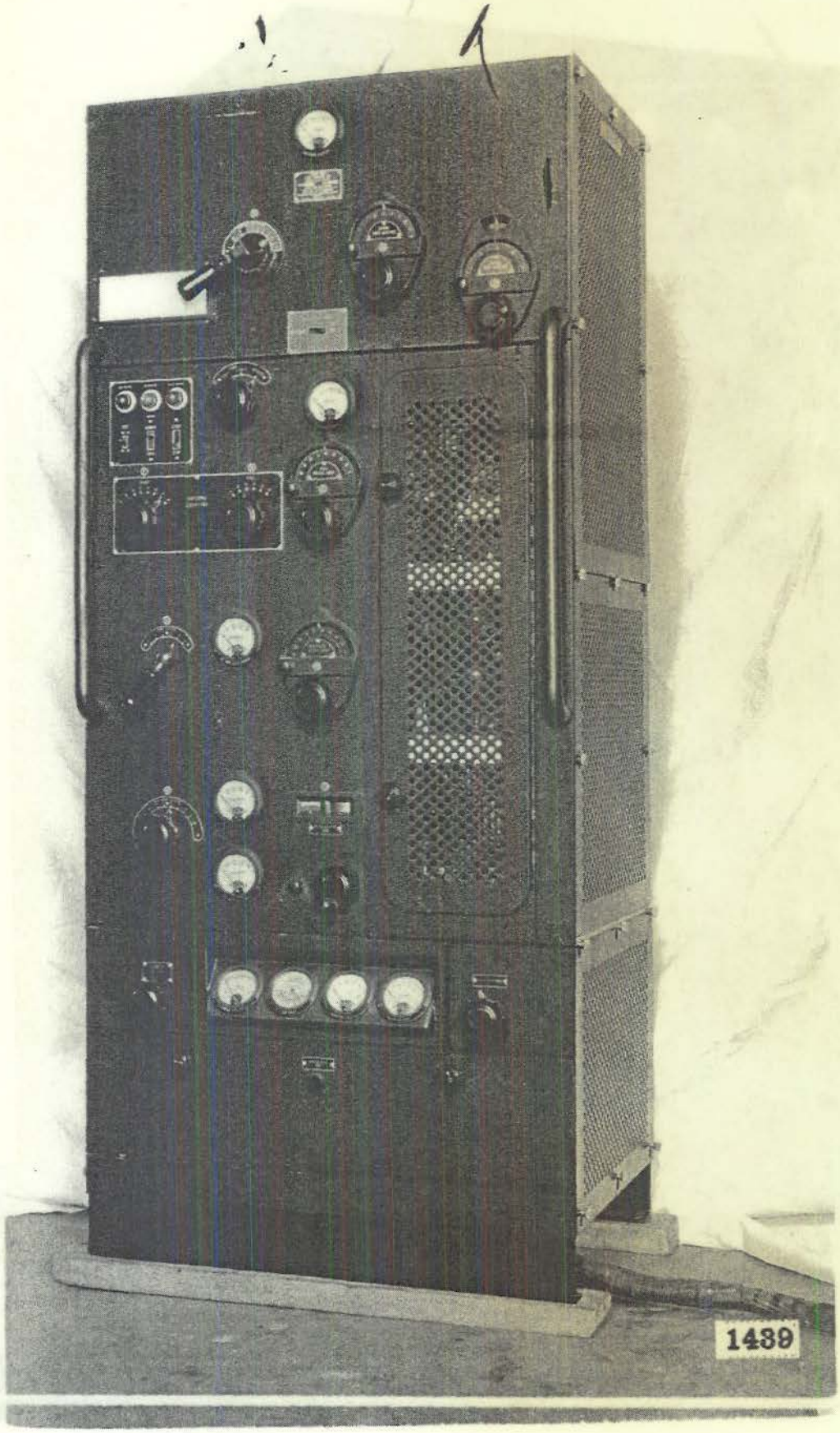


Plate 40

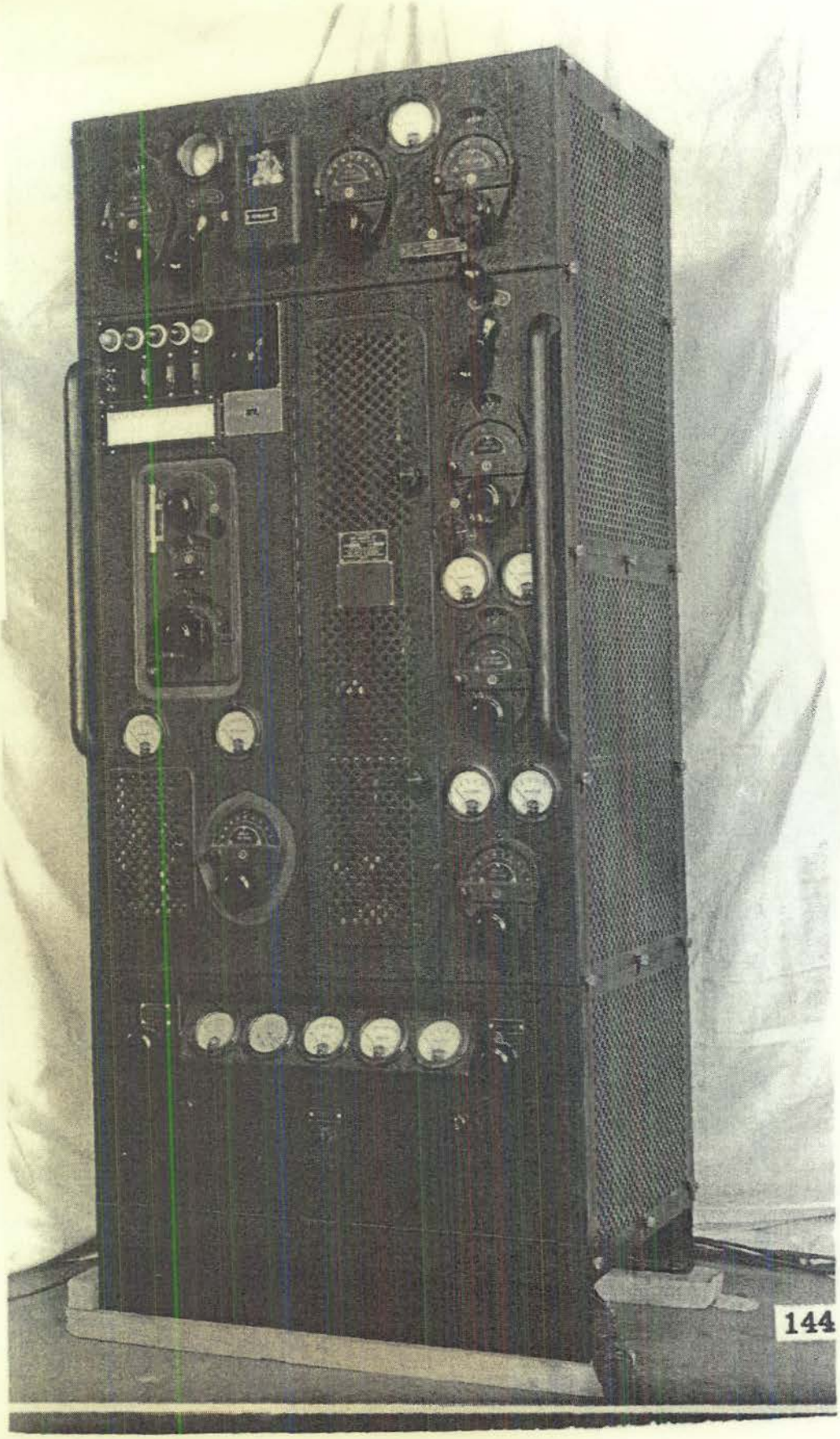


Plate 41

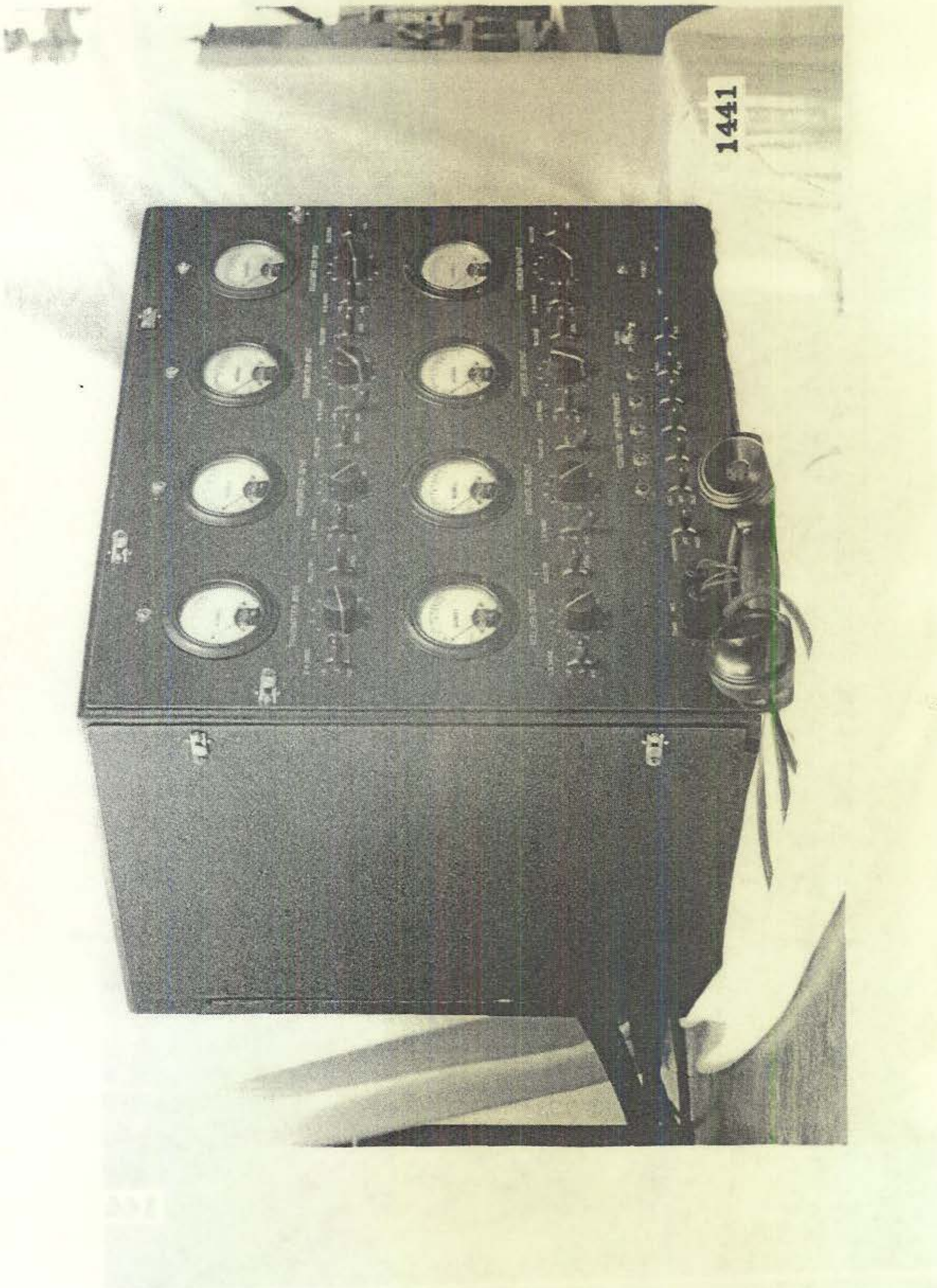
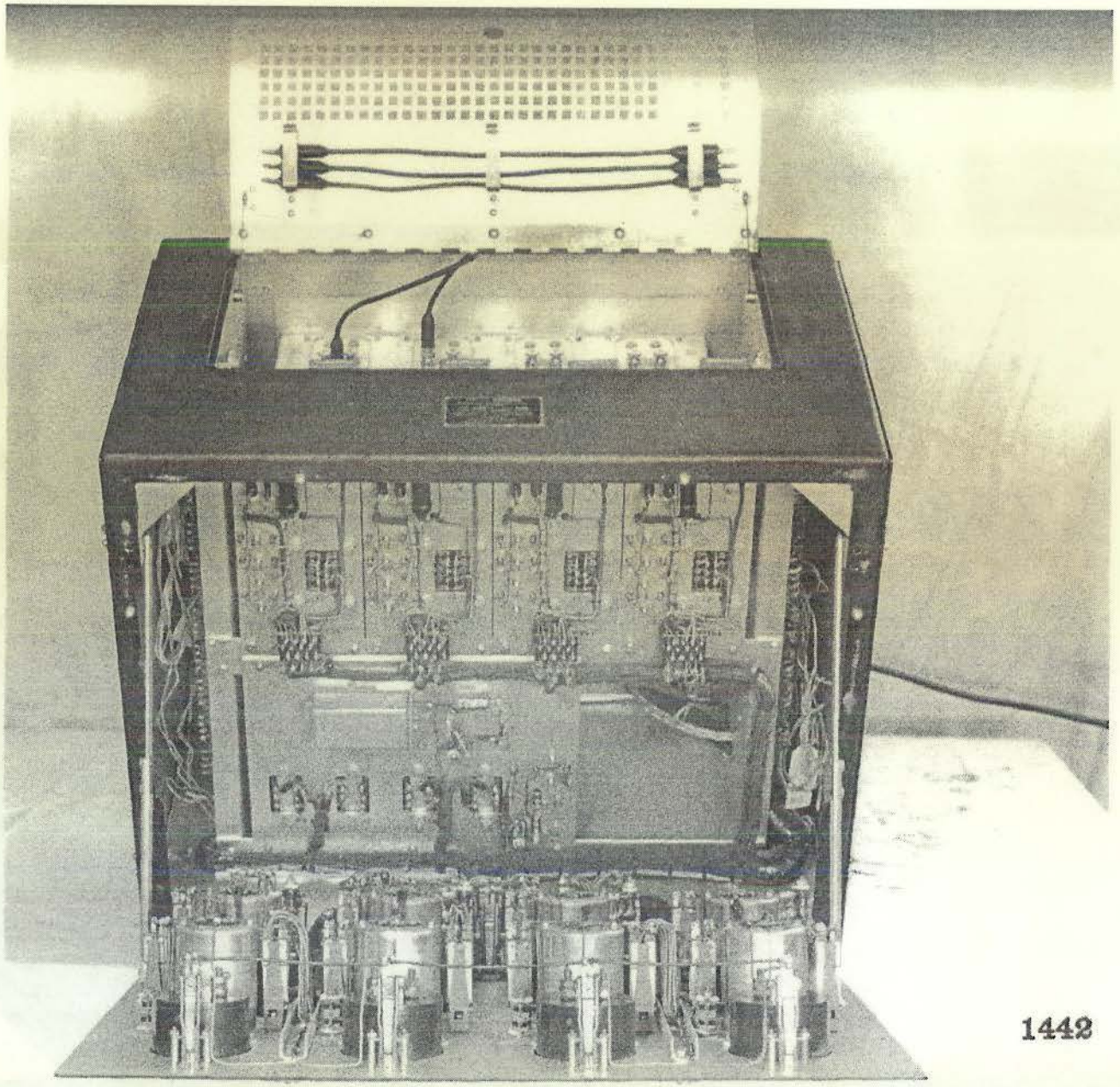


Plate 42



1442

Plate 43

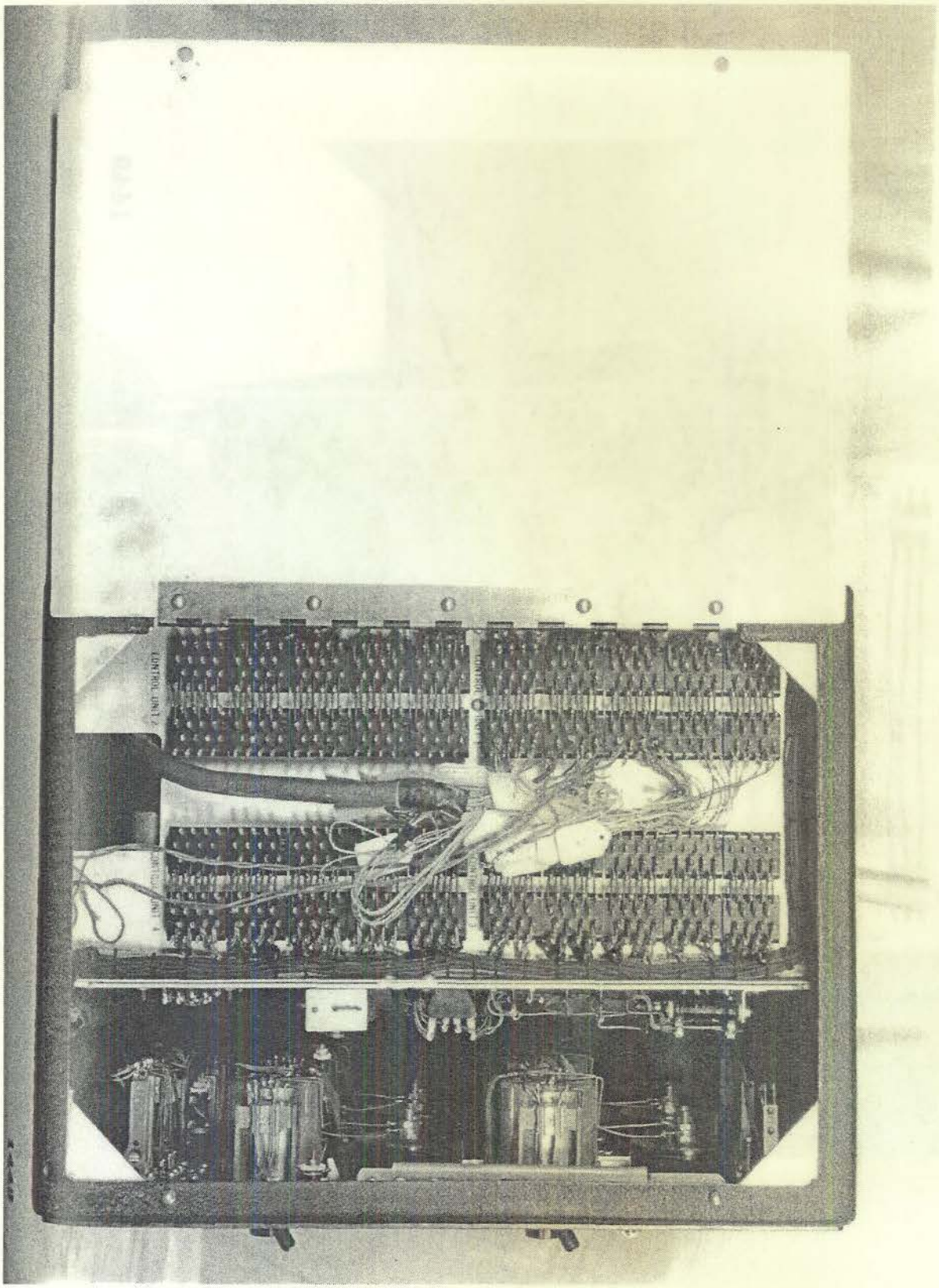


Plate 44

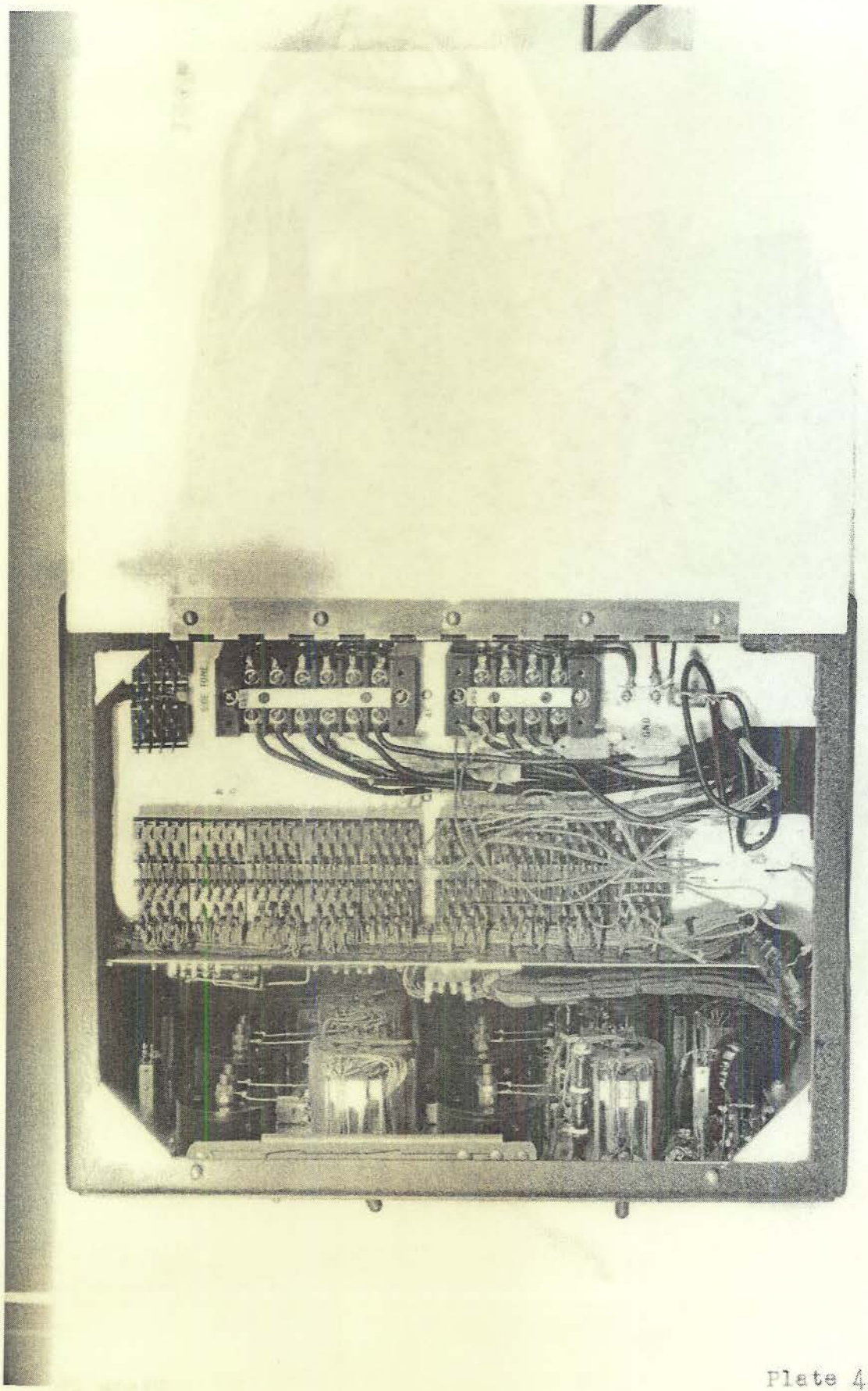


Plate 45

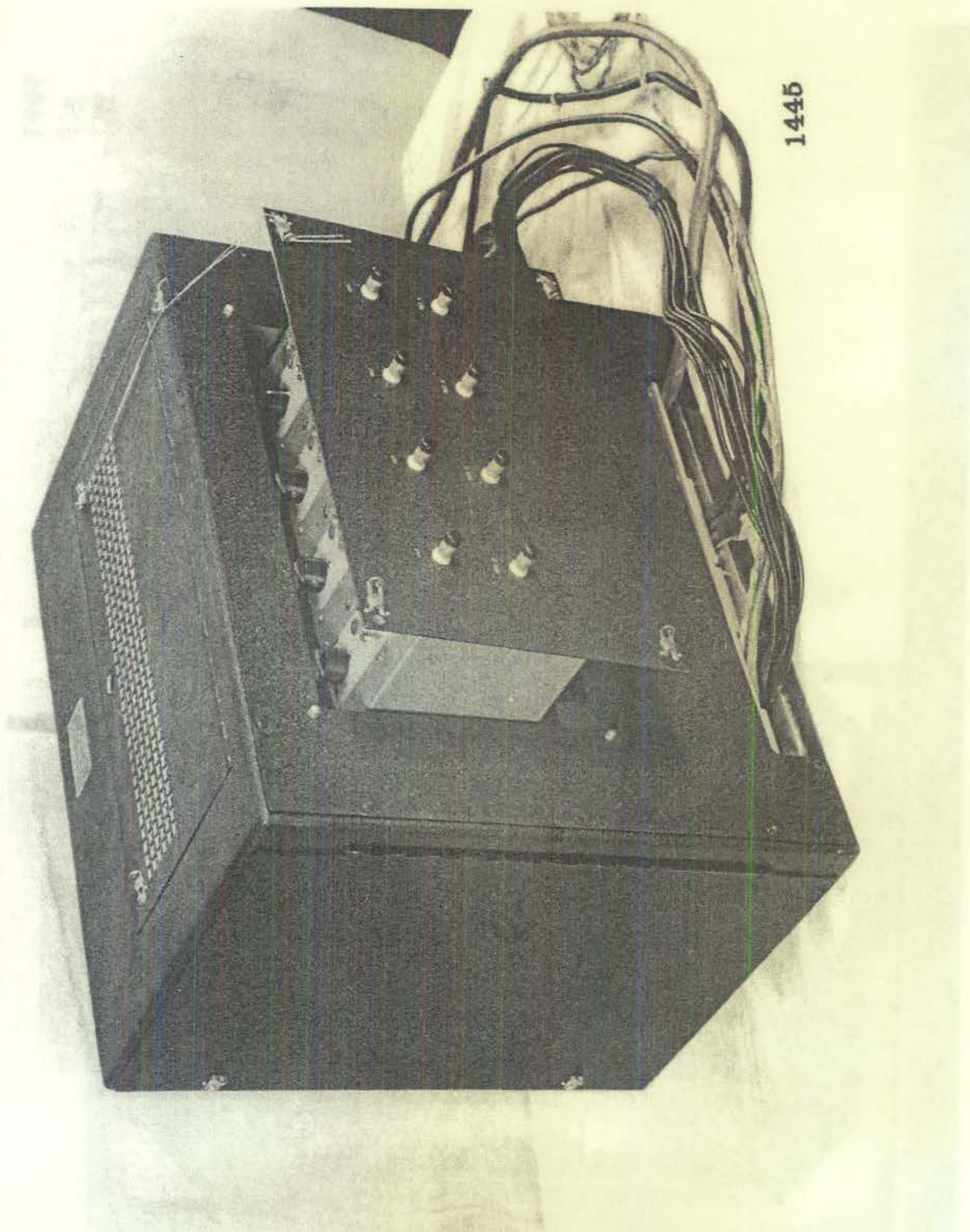
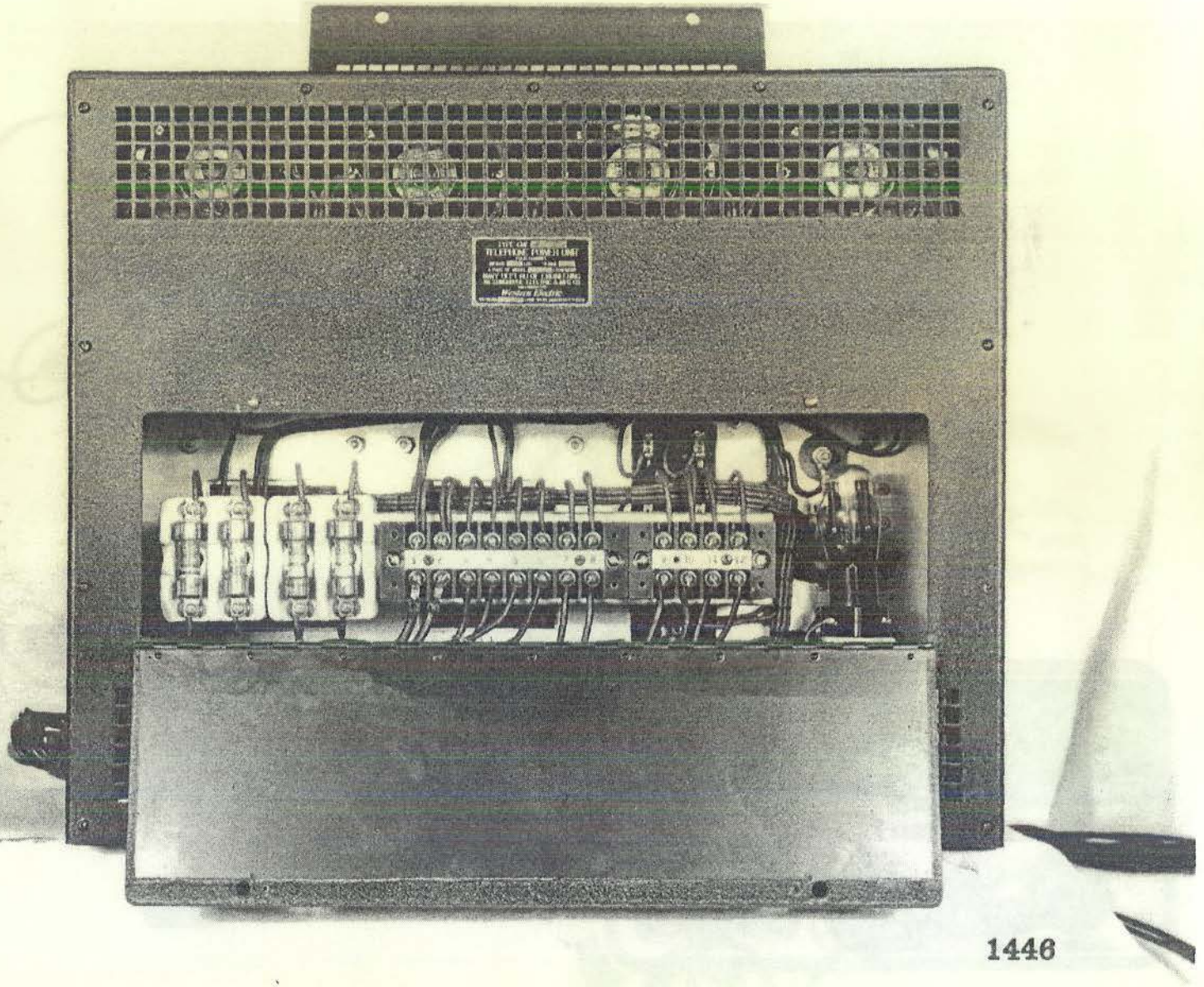


Plate 46



1446

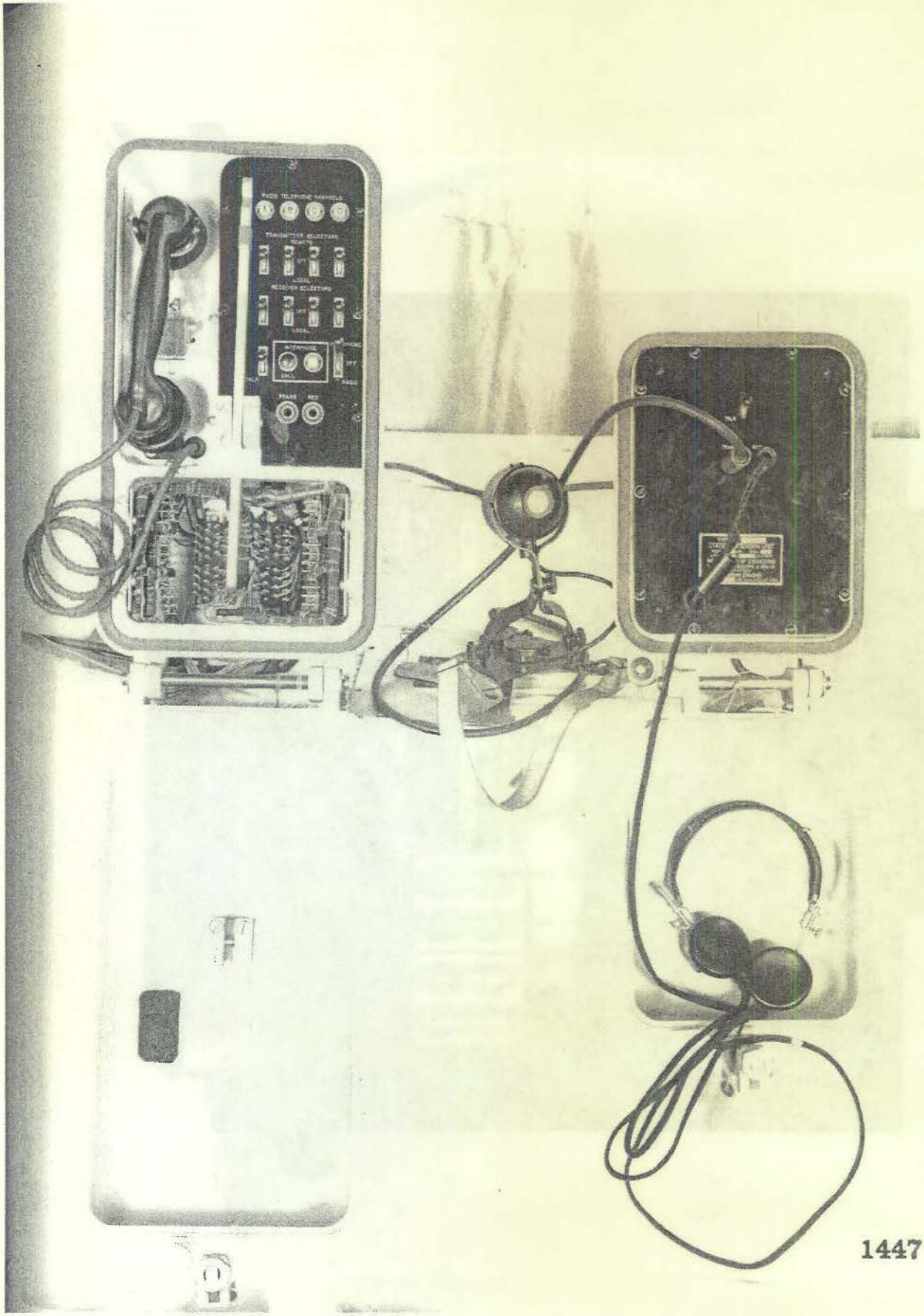


Plate 48