

FR-1043

R-1043

REPORT NO. R-1043

DATE 3 April, 1934

SUBJECT

Test of Model TBF-a Transmitting Equipment



BY

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

DISTRIBUTION STATEMENT A APPLIES
 Further distribution authorized by UNLIMITED only.

3 April 1934

Report No. R-1043
BuEng.Prob.T5-8

NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report on
Test of Model TBF-a
Transmitting Equipment.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 12 Tables - 39 Plates - 12
Authorization: BuEng let.NOs-26769(5-22-W8) of 12 Jan.1934
Dates of Test: January 12 to March 24, 1934
Prepared by: R. B. Meyer, Associate Radio Engineer (Chief of Section)
Reviewed by: A. Hoyt Taylor, Physicist. Supt. Radio Division
Approved by: H. R. Greenlee, Captain, U.S.N. Director

Distribution: BuEng (4)

Table of Contents

Authorization	Page 1
Object of Tests	1
References	1
Materials under Test	1
Abstract of Tests	1
Method and Results of Tests	3
Recommendations	11
Discussion	12

Appendices

Power required from supply line	Table 1
Determination of power output	2
Continuity and overlap	3
Variation of frequency per division of marking	4
Line voltage variation	5
Line voltage variation	6
Line voltage variation	7
Detuning of resonant circuits	8
Difference between tune and operate adjustments	9
Locked key tests	10
Intermittent key tests	11
Frequency change due to changing tubes	12
Frequency change due to changing tubes	13
Test of temperature control devices	14
Test of temperature control devices	15
Test of temperature control devices	16
Test of temperature control devices	17
Shock test	18
Horizontal force test	19
Accuracy of reset	20
Test for back-lash	21
Variation in power output	22
High power vs low power operation	23
Short circuited antenna tests	24
Change in ambient temperature at 4500 kcs	25
Change in ambient temperature at 4500 kcs	26
Change in ambient temperature at 3000 kcs	27
Change in ambient temperature at 3000 kcs	28
Change in ambient temperature at 2000 kcs	29
Change in ambient temperature at 2000 kcs	30
Change in ambient temperature at 2000 kcs	31
Change in ambient temperature at 2000 kcs	32
Change in ambient temperature at 3000 kcs	33
Change in ambient temperature at 3000 kcs	34
Change in ambient temperature at 4500 kcs	35
Change in ambient temperature at 4500 kcs	36
Change in ambient temperature (summary)	37
Change in ambient temperature (averages)	38
Change in ambient temperature at 4500 kcs	39

Appendices (cont'd)

Ambient temperature change, 4500 kcs	Plate 1
Ambient temperature change, 4500 kcs	2
Ambient temperature change, 3000 kcs	3
Ambient temperature change, 3000 kcs	4
Ambient temperature change, 2000 kcs	5
Ambient temperature change, 2000 kcs	6
Ambient temperature change, 2000 kcs	7
Ambient temperature change, 2000 kcs	8
Ambient temperature change, 3000 kcs	9
Ambient temperature change, 3000 kcs	10
Ambient temperature change, 4500 kcs	11
Ambient temperature change, 4500 kcs	12

1. AUTHORIZATION

The tests herein reported were authorized by the Bureau of Engineering in letter NOs-26769(5-22-W8) of 12 January 1934 to Director, Naval Research Laboratory.

2. OBJECT OF TESTS

The object of the tests was to determine compliance with the requirements of the contract and, additionally, to determine the desirability of extending the application of the principles involved in the design of the Model TBF-a equipment to other equipment of approximately the same frequency range. It was requested that thorough consideration be given to the character of the emission regarding key clicks, variations due to vibration or other causes, harmonics, etc., in order to determine the communication performance which might be expected when using this type of transmitter with the various types of receivers now employed in the service.

3. REFERENCES

- (a) BuEng let.NOs-26769(5-22-W8) of 12 January 1934.
- (b) Specifications RE 13A 442B.
- (c) NRL Report No. RE-171, BuEng.Prob.T5-3, on test of preliminary model of TBF Transmitter.
- (d) NRL Report No. R-1040 on test of three Model TBF transmitters relative to par.3-7-2 of Specs.RE 13A 442B.
- (e) BuEng let.NOs-26769(5-22-W8) of 3 Aug.1933 to INM, Hartford, Conn.

4. MATERIALS UNDER TEST

The materials under test consisted of one complete Model TBF-a transmitting equipment, serial no. 1. The frequency range of the transmitter is 2000 kcs to 18,100 kcs. This equipment is destined for final installation on the USS IDAHO and was received at the Naval Research Laboratory on January 12, 1934.

5. ABSTRACT OF TESTS

The Model TBF-a transmitter is similar in construction to the Model TBF transmitting equipments. The frequency range covered by the Model TBF equipment is 2000 kcs to 4525 kcs, while the range of the Model TBF-a is 2000 kcs to 18,100 kcs. This extension to the frequency range is accomplished by the addition of a range switch and the proper proportioning of the inductance and capacity values which form the tank circuits of the various stages of amplification. The master oscillator circuit is identical to that used in the regular TBF transmitter. Only one additional control has been added in order to obtain this extension of the frequency range; namely, the range switch which is of the multi-contact type. A

unique feature incorporated in the TBF-a equipment lies in the fact that the various amplifiers are resonated by varying the capacity and inductance values simultaneously. One control varies a rotating inductor and a variable air capacitor at the same time and in this manner the L/C ratio of the amplifier circuits is kept substantially constant over the entire frequency range. This feature is a decided advantage in a transmitter which is required to cover a large frequency range.

The mechanical and electrical defects which were observed in the preliminary model of the TBF equipment and which were covered in ref.(c), have been corrected in the Model TBF-a equipment. For a detailed summary of these corrections the Bureau is referred to Section 11 of ref.(d).

The difficulties encountered in connection with the tests of the Model TBF-a equipment are listed below:

During the early tests of the transmitter considerable lilt was noted in the emission although the signal was pure C.W. Since the lilt appeared to be excessive an examination of the transmitting equipment was made. A defective brush was discovered on the 2000 volt commutator which caused bad sparking under load. This brush was replaced with one secured from the spare parts supplied with the equipment and no further sparking was noticeable. The lilt was greatly reduced and was discernible only at the high end of the frequency range but was not of sufficient magnitude to interfere with ordinary reception of signals.

After installation a poor contact was discovered in the automatic starter between the overload coil and the main contactor which caused erratic operation. A screw had worked loose, causing an arcing contact. After the screw had been tightened no further difficulty was observed.

During the tests of the TBF-a equipment the motor armature failed. The failure apparently was due to a short circuited coil. The exact cause of this failure could not be discovered. The motor generator was again placed in commission by installing the armature provided in the spare parts.

Difficulty was experienced in properly coupling to the antenna system when operating at 18,100 kcs. (A complete discussion of this effect will be found in the body of this report.)

A type 38161 tube failed in the power amplifier. The cause for this failure is ascribed to over-excitation of the power amplifier. (A complete discussion of this phenomenon will be found in a later portion of this report.)

A wide variation in power output at 18,100 kcs was noted when changing tubes in the power amplifier. Tube No.26278 gave only 200 watts output; tube no.26292 gave 325 watts output and tube no. 26302 gave 347 watts output at 18,100 kcs. All three tubes, however, gave equally good outputs at the lower frequencies. This difficulty must undoubtedly be attributed to variations in the tube constants and should not be considered as a defect in the transmitter.

6. METHOD AND RESULTS OF TESTS

Since the Model TBF-a transmitter was constructed in accordance with the same specifications which governed the design and construction of the Model TBF equipments (except for the additional requirement of the extended frequency range) no detailed discussion of Specifications RE 13A 442B, paragraph by paragraph, is undertaken in this report. The Model TBF-a equipment was submitted to the required tests and was closely examined and found to meet the requirements of the specifications with the exceptions noted under Section 5 of this report. The results of the tests required by Section X of Specifications RE 13A 442B are listed in detail in Tables 1 to 39 inclusive and Plates 1 to 12 inclusive which are appended hereto.

Table 1 covers the results of tests conducted to determine the power required for starting, no load operation and full load operation. The requirements of the specifications are complied with.

Table 2 lists the results of tests conducted in accordance with par. 10-2-3 of the specifications in order to determine the power output at various frequencies. Ref.(c) required:

"When functioning as a 75 watt transmitter the equipment shall be capable of delivering to the antenna 75 watts, exclusive of load coil losses, over the frequency band of 2000 to 6000 kcs inclusive, 65 watts for higher frequencies up to 7500 kcs and 60 watts for the remaining portion of the band up to 9050 kcs inclusive. "

"When functioning as a 500 watt transmitter the equipment shall be capable of delivering the output now required for the band 2000 to 4525 kcs (i.e., 500 watts exclusive of load losses at any frequency below 3035 kcs, not less than 450 watts at 4105 kcs and not less than 400 watts at 4525 kcs), and somewhat reduced output for higher frequencies up to 18,100 kcs inclusive. The output over this portion of the band shall be approximately a straight line function of 400 watts at 4525 kcs to 300 watts at 18,100 kcs. "

An examination of Table 2 shows that the Model TBF-a when functioning as a low power transmitter (nominally 75 watts) is capable of 100 watts output over the entire frequency range of 2000 to 9050 kcs, without overloading the output tube.

It will further be noted that when functioning as a high power transmitter (nominally 500 watts) the TBF-a fully meets the requirements of the contract. As previously stated, however, it was discovered that a difference exists in 38161 tubes. One tube (no.26278) while it gave excellent output at frequencies below 14,000 kcs, failed to give the required output at 18,100 kcs. However, since two other 38161 tubes (nos.26292 and 26302) gave more output than is required by the provisions of the contract, it is the opinion of the Laboratory that the Model TBF-a meets the requirements of this test.

Table 3 demonstrates that the transmitter circuits cover the required frequency range continuously and with sufficient overlap to warrant good operation.

Table 4 illustrates the variation of resonant frequency of the master oscillator circuit per division of marking of the master control. Par.3-14 requires that variation of resonant frequency shall not exceed 0.01%. It will be noted that this value is exceeded in some portions of the range by a slight amount, but the average is well within the specification requirements and no difficulty is experienced in adjusting the master oscillator circuit.

Tables 5, 6, and 7 list tests conducted in accordance with par. 3-7-1 of ref.(b). It will be noted that the percentage values arrived at vary considerably depending upon the condition of the transmitter and the method of conducting the tests. If the voltage is decreased instead of increased a different value is obtained and if the transmitter had been subjected to a series of key locked tests previous to conducting the tests in question the results vary from those obtained when the transmitter is subjected to these tests without any preliminary warming up. Furthermore, a rapid variation of the line voltage produces a result different to that obtained if the voltage is varied in 1% steps per minute.

Table 8 demonstrates the fact that the Model TBF-a transmitter complies fully with the requirements of par.3-7-3 of the specifications in that the detuning of any resonant circuit (other than the frequency establishing circuit) does not cause a frequency change greater than 0.005%.

Table 9 shows that the TBF-a transmitter may be placed in the "Adjust", "Tune", or "Operate" conditions with only a very slight effect upon frequency. The requirements of par.3-7-4 are complied with.

Table 10 illustrates the fact that the requirements of par. 3-7-5 are complied with.

Table 11 illustrates the fact that the requirements of par. 3-7-6 are complied with.

Tables 12 and 13 show that changing tubes in the master oscillator circuit produces a smaller frequency shift than the amount permitted by the specifications, while changing tubes in the stage following the master produces practically no frequency change. Several tubes of RCA and Hygrade Sylvania manufacture were operated in the master oscillator circuit of the Model TBF-a transmitter and gave results similar to the tubes supplied by the Westinghouse Electric and Manufacturing Company with the transmitter. While these tubes were in the circuit the transmitter was subjected to vibration but no unusual frequency shifts were noted.

Tables 14, 15, 16, and 17 tabulate the results of tests conducted in conformity with par.3-7-8 of Specifications RE 13A 442B. The frequency shifts observed at no time exceeded the value of 0.01% permitted by the revised specifications. It was during these tests that a 38161 tube (serial no. 26302) failed.

The falling off in emission encountered in connection with locked key tests was first reported to the Bureau in ref.(c). Although numerous attempts have been made to isolate the cause of the loss of emission in 38161 tubes, the results obtained by the Laboratory do not permit definite conclusions to be drawn. It appears, however, that once a tube has been subjected to the conditions which cause loss of emission for a considerable period of time, say 25 to 35 hours, such a tube has been inherently weakened and will not function properly if subjected to key locked tests for periods of time in excess of one or two hours. However, a new tube may apparently be subjected to key locked operation for a considerable period before the deteriorating effects become apparent. It is also believed that carbon anode tubes will not lose emission as rapidly as metal anode tubes.

This phenomena was studied in connection with the tests conducted with Model TBF transmitter serial nos. 32, 34, and 35 at the Bureau of Standards. Records were kept of the D.C. grid current and the D.C. plate current. After a considerable period of operation, it was noticed that the D.C. grid current values would fall off. The plate current values also showed a tendency to decrease but not in direct proportion to the grid current values. It is believed that in many instances the grids of the tubes are operated at saturation and that a much lower value of grid excitation would suffice and still permit the tube to be operated at full output. Usually the tube can be restored to normal operation by removing the plate potential and permitting the filaments to burn for a period of time at normal brilliancy. However, in the case of tube no. 26302 such a large quantity of gas was liberated that this restoring process was not effective.

A study of the Schematic Diagram furnished with the Model TBF-a transmitter (Westinghouse drawing no.T-7603742) reveals that the manufacturer apparently designed the grid circuit of the power amplifier

stage with a view of holding the grid excitation to a reasonable level. However, in actual operation it is found that the excitation varies over wide limits. This is partly due to the fact that the TBF-a covers a 9 to 1 frequency range and partly due to the fact that the intermediate amplifier must be capable of operating as the output stage when the transmitter is adjusted to "Low Power". Reference to Table 2 of this report reveals the fact that the power amplifier grid current (DC), which can be taken as an approximate measure of the grid excitation, varies between the limits of 87 ma and 32 ma. Under certain conditions of adjustment grid currents in excess of 90 ma have been observed. The Laboratory believes that these grid current values should not exceed 50 ma and a series of tests conducted wherein the TBF-a was excited from a separate master or driver (decade control unit) substantiate this belief. This data was further substantiated by tests wherein the regular oscillator circuit of the TBF-a was used to excite the transmitter. In these latter tests condenser C-58, which is a 0.0001 mfd variable air condenser, was adjusted for each output frequency to which the transmitter was tuned during these tests. It was found that the power amplifier could be excited to full output at any frequency when the PA grid current was limited to 50 ma. Unfortunately, when C-58 is adjusted for optimum operation at 18,000 kcs, this setting gives insufficient excitation at 2000 kcs and, vice versa, when the proper adjustment for 2000 kcs is obtained the grid circuit is over-excited at 18,000 kcs. Thus no single setting of C-58 gives proper operation over the entire frequency range. If C-58 were controllable from the front panel, the proper setting could be made for any frequency, but it is felt that a control of this kind would not be in accordance with the spirit of the governing specifications.

In the TBF-1 transmitter (RCA version) the tuning of the intermediate amplifier is accomplished solely through the medium of a variable condenser. This permits a separate excitation tap to be used for driving the Power Amplifier which is at considerably lower voltage than the tap used to drive the antenna circuit when the intermediate amplifier is used as the output stage (low power operation). In this manner excessive grid currents are avoided. This method is not applicable to the present TBF-a design since the intermediate amplifier is resonated by means of a variable inductor and a variable capacitor simultaneously while the exciting voltage is derived from the drop over one portion of this condenser when operating as a low power transmitter and from the drop across the entire tank circuit when exciting the grid of the 38161 tube.

It should be pointed out that the difficulties from over-excitation herein discussed become apparent only during locked key tests. Under ordinary operation (handling of traffic) it is believed that no difficulties will be encountered since the handling of traffic does not involve key locked operation and the time delay relay in the transmitter does not permit the key to remain closed for more than five seconds. But in order to obtain the data required by the governing specifications it is necessary to subject the transmitter to long

periods of key locked operation at full power. It is suggested, therefore, that the Bureau give consideration to permitting the specification tests which require long periods of key locked operation to be conducted at reduced power in order to avoid injury to the 38161 tubes. Since most of these key locked tests are for the purpose of determining frequency stability, and since the master oscillator circuit could always be operated at full power, it is believed that results obtained in this manner would be as enlightening as the results obtained with the power amplifier operating at full power.

It is believed that every effort should be made to discover the exact cause of the difficulties encountered with 38161 tubes. This investigation, however, should be made independently and not as a part of the tests of any particular type of transmitter. An investigation of this character consumes a large amount of time and would delay the completion of transmitter tests very considerably, at the same time subjecting the entire transmitting equipment to unduly long periods of full power, key locked operation. It is suggested that the Bureau of Engineering assign this investigation to the Vacuum Tube Section of the Naval Research Laboratory.

Table 18 contains the data which shows that the Model TBF-a transmitter complies fully with the requirements of par. 3-7-9. The shock test to simulate gun fire produces a negligible effect upon the output frequency.

Table 19 shows that the application of a horizontal force of 200 pounds to the top frame members of the transmitters produces practically no effect upon the output frequency.

In this connection it should be pointed out that an additional series of tests were conducted with the Model TBF-a transmitter in order to determine the effects of vibration. A 1/2 horse power motor was bolted securely to the frame of the transmitter. An eccentric weight was secured to the shaft of the motor and provision was made for varying the speed of rotation. In this manner the frequency and amplitude of vibration could be varied at will. Although no quantitative measurements of the degree of vibration could be made, it is believed that the vibration produced in this manner is sufficient to bring out any defects in the transmitters, such as poor contacts, defective tubes or defective flexible mountings.

In order to test for the effect of vibration and shock, a code message was transmitted while the TBF-a transmitter was subjected to varying degrees of vibration. In addition, while the transmitter was being subjected to vibration it was also subjected repeatedly to the shock test as outlined under par. 3-7-9 of Specifications RE 13A 442B. Reception was accomplished through the medium of a Model RAB receiver. The test was transmitted on two frequencies, 4500 kcs and 18,100 kcs. After the tests were started the receiving operator was not permitted to retune the receiver. Solid copy was obtained at both 4500 kcs and 18,100 kcs. The RAB receiver was adjusted to the "broad" condition of tuning. The results of these tests indicate that traffic may be

handled with the TBF-a transmitter and the RAB receiver while the transmitter is being subjected to a considerable degree of vibration and shock, even at frequencies as high as 18,100 kcs, which is the maximum frequency to which the TBF-a may be tuned. The effect of vibration was hardly noticeable at the receiver; the effect of shock was noticeable but did not prevent reception by a skilled operator.

Table 20 reveals that it is possible to reset the TBF-a transmitter to a predetermined frequency in one man minute to within an accuracy of approximately 0.0005%.

Table 21 indicates that the frequency establishing controls of the transmitter possess very little back-lash.

Reference to Table 22 shows that it is possible to vary the output of the Model TBF-a transmitter on both "high" and "low" power adjustments between the limits of 100% and 10% by means of the motor generator field rheostat. The variation of power through these limits produces a negligible frequency shift.

The Model TBF-a transmitter may be shifted from "high" to "low" power operation with a small attendant shift in frequency. Table 23 contains the data collected during this test.

Table 24 tabulates the data obtained in tests wherein the antenna circuit was shorted and open circuited. In each case the transmitter drew less power under the abnormal conditions than it did when adjusted to normal operating conditions.

A further check as to the accuracy of reset and over-all adjustment of the Model TBF-a transmitter was made as follows. The transmitter was tuned to 18,100 kcs and an RAB receiver was adjusted so as to give a 1000 cycle beat note with the emitted frequency. The adjustment of the receiver was then left undisturbed for a period of three days. On the third day the TBF-a was again reset to the original adjustment and the frequency of the beat note obtained in the RAB receiver was measured. The signal came in on the receiver at a 1800 cycle beat note after five minutes key locked operation. At the same time the Model "LH" frequency measuring equipment showed that the transmitter had shifted only 300 cycles from the original setting. After a short period of operation the transmitter had drifted to its original frequency, as measured by the "LH" equipment. At this point the beat note in the RAB receiver was between 300 and 400 cycles. This indicates that the RAB receiver was drifting to a greater degree than the transmitter, but it also indicates that no difficulty would be experienced in making contact for the handling of traffic under these conditions.

Attempts were made to determine the degree of interference which might be attributed to key clicks produced by the Model TBF-a transmitter. The work done in connection with Problem T9-2 to date indicates that there is no simple method for obtaining quantitative measure-

ments of the interference produced by key clicks. Furthermore, it is exceedingly difficult to determine the amount of interference which should be ascribed to the transmitter and the amount which should be ascribed to the receiver. From the results of the tests conducted with the TBF-a transmitter it can only be stated that the degree of interference produced by key clicks is approximately the same for the Model TBF-a as it is for the Model TBA transmitter. Both transmitters were operated at the same frequency, on the same antenna, and the degree of interference was measured by means of an output meter connected to the output terminals of an RAB receiver.

In the Model TBF-a transmitter the antenna ammeter is connected in the ground side. While tuning the transmitter at the high end of the frequency band, in the neighborhood of 18,000 kcs, apparent antenna currents as high as 15 amperes were obtained. It was noted, however, that an ammeter connected in the high side of the antenna circuit showed no current whatever. When this adjustment is obtained it is possible to actually disconnect the antenna and still retain the large current reading on the antenna ammeter in the transmitter proper. It is believed that this condition would be confusing to an operator since the natural tendency would be to use the antenna ammeter as a guide for maximum output. However, when this false adjustment is being used the plate current of the power amplifier does not act normally so that if the operator used the plate ammeter as a guide, he would avoid this condition. It is believed, however, that the best method of preventing false adjustments would be to transfer the antenna ammeter from the ground side to the high side of the antenna. With the antenna ammeter so connected the operator would never be confronted with the excessive antenna currents which actually indicate that the antenna is radiating no power.

It should be pointed out, however, that when a transmitter is called upon to cover the large frequency range which the Model TBF-a covers, the antenna current varies widely with frequency. Therefore, when operating at 2000 kcs or 4000 kcs it would be necessary to have an antenna ammeter of about 10 amperes range. At 18,000 kcs the current in the antenna is so small that no noticeable deflection of the meter can be noted. In this latter event the operator has to be guided by the plate current indications of the power amplifier tube. This same condition exists in connection with previous transmitters, for example, the Model TBA.

The necessary tests to determine the temperature coefficient of the Model TBF-a transmitter, in accordance with par.3-7-2 of Specifications RE 13A 442B, were conducted at the Bureau of Standards. Since this transmitter was constructed under Contract NOs-26769, it is assumed that the special requirements specifying a temperature coefficient of 0.0009% apply to the Model TBF-a equipment.

Tables 25 to 30 inclusive give the detailed results of tests wherein the ambient temperature was varied between the limits of zero degrees and 50 degrees Centigrade. Tests were conducted at three frequencies; i.e., 2000 kcs, 3000 kcs, and 4500 kcs. Plates 1 to 6 inclusive present this data in graphical form. The foregoing data was

obtained with the original adjustment of the compensating condenser as received from the manufacturer.

Tables 31 to 36 inclusive and Plates 7 to 12 inclusive give the results of tests wherein the ambient temperature was varied between the limits of zero degrees and 50 degrees Centigrade after the compensating condenser had been re-adjusted. This re-adjustment was accomplished by turning the adjusting screw of the compensating condenser by 40 degrees past the point of contact with the condenser plate. The tests were again conducted at three frequencies; namely, 2000 kcs, 3000 kcs, and 4500 kcs.

An examination of ref.(d), which is NRL Report No. R-1040 covering the test of Model TBF transmitters, serial nos.32, 34, and 35, will reveal that the smallest temperature coefficient was obtained when the compensating condenser was adjusted to 40 degrees. Therefore, in the test of the Model TBF-a it was thought desirable to compare the original adjustment of the compensating condenser with the 40 degree adjustment. Table 37 appended hereto is a summary of the results obtained with the original compensating adjustment and with the 40 degree adjustment. It will be noted that the results obtained under the two sets of conditions are similar. This indicates that the original adjustment of the Model TBF-a was very close to the optimum adjustment. After the tests had been conducted and it was possible to determine the setting of the compensating condenser, it was found that the adjusting screw had been set at 45°. Since there is little difference between the two adjustments, the Model TBF-a compensating condenser was left adjusted to the 40° setting.

Table 38 represents a recapitulation of the data obtained during all the tests in connection with par.3-7-2 of the specifications. It will be noted that in both series of tests the total average temperature coefficient is less than 0.0009%.

Referring to Table 35 it will be noted that the temperature coefficient obtained during this test between the limits of 10° and 5° was 0.0015%. This figure appeared to be out of line with the remainder of the results and it was feared that some unobserved phenomena had influenced this test. It was decided, therefore, to repeat this portion of the test. Table 39 gives the result of this repeat run and it will be noted that the temperature coefficient obtained during the second test is 0.00087%. The results of this repeat run are shown on Plate 11 by means of dotted lines.

7. RECOMMENDATIONS

The following recommendations are submitted, based on the information obtained during the course of the tests conducted with the Model TBF-a transmitting equipment.

- (a) Prior to the installation of the Model TBF-a, Serial No.1, on the USS IDAHO, the antenna ammeter should be removed from the low side of the antenna circuit and be placed in the high side in order to reduce the possibility of making false antenna circuit adjustments.
- (b) In future equipment of this type the contractor shall be required to design the antenna coupling circuit in such a manner that false antenna adjustments are avoided.
- (c) The rating of the 38161 tube should be so modified, or the transmitter specifications should be so worded, that excessive grid currents will be avoided. The maximum D.C. grid current which appears necessary or desirable is 50 ma. It is suggested that further and more complete data on this point be obtained by authorizing the Vacuum Tube Section of the Naval Research Laboratory to make the necessary investigation.
- (d) If the necessary limitations in accordance with (c) above cannot be established prior to the construction and test of transmitters similar to the Model TBF-a, it is recommended that locked key tests for the determination of frequency drift be conducted at reduced transmitter output in order that injury to the 38161 tubes may be avoided during such tests.
- (e) The investigation recommended in (c) above should be amplified to determine the reason why certain 38161 tubes fail to give proper output in the band above 14,000 kcs although functioning normally at lower frequencies.
- (f) Since the effect of vibration becomes increasingly more important at the higher frequencies, it is suggested that the specification requirements concerning vibration be amplified to include a definite test to determine the effect of this phenomenon.

8. DISCUSSION

In general, it may be stated that the construction of the Model TBF-a equipment reflects excellent workmanship and the materials used in the construction of the transmitter are of good quality. During the course of two months of tests the transmitter was in actual operation for a period of 158 hours. During this period operations were interrupted or interfered with from the following causes:

- Defective brush in generator
- Defective contact in starter
- Defective armature
- Failure of 38161 tube

The first two defects were of a minor character and were easily remedied. The reason for the failure of the armature could not be discovered and the armature was replaced from the spare parts. The tube failure was undoubtedly the result of too long a period of key locked operation at full power.

The transmitter was subjected to tests wherein service traffic conditions were simulated as closely as laboratory facilities permitted. The results of these tests indicate that the Model TBF-a should handle traffic successfully under service conditions. Vibration, to the extent which could readily be produced in the laboratory, had little effect upon the frequency of the transmitter and did not interfere with communications. Shock and impact had a noticeable effect upon the output but the effect was not severe enough to interrupt communications. Although some lilt is noticeable at the high end of the frequency range, it was not of sufficient intensity to interfere with copy by an operator. It is pointed out, however, that some difficulty might be experienced from this cause if high speed automatic transmission and reception were attempted.

As previously mentioned, the drift in receivers very frequently exceeds the drift of the transmitter and if two or more receivers have a tendency to drift in opposite directions it would be necessary for the receiving operators to make adjustments. The need for such adjustments, however, should not be construed to indicate a defect in the transmitter since the transmitter would be responsible for only a minor portion of the drift.

The principal source of criticism which may be directed against the Model TBF-a equipment lies in the fact that the antenna coupling system permits conditions to arise which may be confusing to an inexperienced operator, or to an operator who is not familiar with this type of equipment. Every effort should be made to eliminate this defect in future equipment of this type.

With reference to the test data submitted by the manufacturer covering the Model TBF-a it may be stated that a comparison between the data submitted and the data obtained during the tests at the Naval Research Laboratory shows a close agreement.

Table 1

Test per paragraph 10-2-2 of Specifications RE 13A 442B
Power required from Supply Line

For Starting:	212 V	25 A	5.30 KW
No Load:	218 V	6 A	1.30 KW
Full Load:	218 V	14 A	3.05 KW

Table 2

Test per paragraph 10-2-3 of Specifications RE 13A 442B
Determination of Power Output

All output measurements obtained by using a photronic cell to determine power dissipated in a 500 watt, 110 V. "C" lamp.

Freq. Kc	Power Range	M.O. Isg	M.O. Ip	Doub Ip	I.A. Ig	I.A. Ip	P.A. Ig	P.A. Ip	Ant I	Ep	Watts Output
Type CWL-38161 Tube, Serial No.26278 used in P.A. Stage											
2000	Hi	13.6	62	46	17	62	87	350	3.4	3KV	602
2500	"	13.0	70	38	22	58	72	350	3.0	3	593
3000	"	13.0	68	42	26	54	52	350	-	3	560
3500	"	12.8	71	28	21	50	42	350	-	3	547
4000	"	13.0	70	30	17	52	32	350	-	3	532
4500	"	12.8	73	32	16	58	76	350	-	3	635
6000	"	12.5	72	52	18	48	49	350	-	3	580
8000	"	12.2	78	60	24	50	46	350	-	3	543
10000	"	13.0	70	62	18	70	40	350	-	3	520
12000	"	12.0	75	60	18	80	40	350	-	3	465
14000	"	12.0	73	60	26	88	48	350	-	3	365
16000	"	12.0	72	62	26	90	50	350	-	3	310
18100	"	13.0	86	60	18	110	38	350	-	3	200
The following data secured using Tube No.26292 in P.A.											
14000	"	12.0	72	62	24	89	46	350	-	3	485
16000	"	12.2	75	67	29	110	45	350	-	3	452
18100	"	12.5	70	54	22	114	44	350	-	3	325
The following data secured using Tube No.26302 in P.A.											
14000	"	12.0	72	59	24	88	51	350	-	3	502
16000	"	13.0	73	82	20	100	46	350	-	3	497
18100	"	13.0	76	75	22	115	46	350	-	3	347
Low Power Operation											
2000	Lo	14.0	64	108	36	100			-	3	100
2500	"	13.2	70	72	43	100			-	3	103
3000	"	13.0	72	40	28	100			-	3	102
3500	"	13.0	79	52	38	100			-	3	100
4000	"	13.0	76	58	42	100			-	3	103
4500	"	13.0	78	49	20	100			-	3	109
6000	"	13.0	75	76	24	100			-	3	110
8000	"	13.0	75	78	30	100			-	3	108
9050	"	12.0	76	90	22	100			-	3	100

Table 3

Test as per paragraph 3-15 of Specifications RE 13A 442E

Test for Continuity and Overlap

<u>Frequency</u>	<u>Control "A"</u>	<u>Control "B"</u>	<u>Control "C"</u>	<u>Control "D"</u>	<u>Control "E"</u>	<u>Control "F"</u>
2000	1	791	15	16	49	58
2100	1	1389				
2200	1	1908				
2300	1	2388				
2400	1	2884				
2500	1	3672	34	54	302	312
2400	2	1425	31	49	257	265
2500	2	1955				
2600	2	2360				
2700	2	2694				
2800	2	3015				
2900	2	3325				
3000	2	3665	50	70	511	506
3000	3	1255	50	70	511	506
3100	3	1980				
3200	3	2345				
3300	3	2640				
3400	3	2900				
3500	3	3142				
3600	3	3380				
3700	3	3612				
3800	3	3855				
3900	3	4120				
4000	3	4444	(75 75	86 41	760 465	755) Low 491) High
3900	4	1830	73	38	444	471
4000	4	2221				
4100	4	2495				
4200	4	2720				
4300	4	2930				
4400	4	3120				
4500	4	3300				
4600	4	3478				
4700	4	3660				
4800	4	3843				
4900	4	4040				
5000	4	4255				
5100	4	4518	92	61	669	680

(Note: 4000 kcs can be obtained with range switch in either the low frequency or high frequency position.)

Table 4

Test as per paragraph 3-14 of Specifications RE 13A 442B

Variation of resonant frequency of master oscillator per division of marking.

<u>Frequency</u>	<u>Control "A"</u>	<u>Control "B"</u>	<u>Divisions Change</u>	<u>Kc per Division</u>	<u>Percent Change</u>
2000 kcs	1	791			
2100	1	1389	598	0.168	0.0080
2200	1	1908	519	0.192	0.0088
2300	1	2388	480	0.208	0.0090
2400	1	2884	496	0.202	0.0084
2500	1	3672	788	0.126	0.0050
2400	2	1425			
2500	2	1955	530	0.188	0.0076
2600	2	2360	405	0.246	0.0094
2700	2	2694	334	0.298	0.0110
2800	2	3015	321	0.312	0.0112
2900	2	3325	310	0.322	0.0112
3000	2	3665	340	0.294	0.0098
3000	3	1255			
3100	3	1980	725	0.138	0.0044
3200	3	2345	365	0.254	0.0080
3300	3	2640	295	0.340	0.0102
3400	3	2900	260	0.384	0.0112
3500	3	3142	242	0.414	0.0118
3600	3	3380	238	0.420	0.0116
3700	3	3612	232	0.430	0.0116
3800	3	3855	233	0.428	0.0112
3900	3	4120	265	0.378	0.0096
4000	3	4444	324	0.308	0.0078
3900	4	1830			
4000	4	2221	391	0.256	0.0064
4100	4	2495	274	0.362	0.0088
4200	4	2720	225	0.444	0.0106
4300	4	2930	210	0.476	0.0110
4400	4	3120	190	0.526	0.0120
4500	4	3300	180	0.556	0.0124
4600	4	3478	178	0.560	0.0122
4700	4	3660	182	0.550	0.0118
4800	4	3843	183	0.546	0.0114
4900	4	4040	197	0.508	0.0104
5000	4	4255	215	0.464	0.0092
5100	4	4518	263	0.380	0.0074

Table 5

Test as per Specifications RE 13A 442B, Paragraph 3-7-1

Frequency shift caused by line voltage variations in steps of 1% per minute between limits of minus 10% to plus 10% of normal voltage. Normal line voltage equals 230 volts D.C.

	1	2	3	4
<u>Line Volts</u>	<u>2000 kcs</u>	<u>2000 kcs</u>	<u>3000 kcs</u>	<u>3000 kcs</u>
207.0	654	497	862	724
209.3	652	498	864	732
211.6	653	499	862	732
213.9	650	499	862	731
216.2	640	501	864	729
218.5	636	502	863	729
220.8	633	504	859	731
223.1	629	508	857	735
225.4	625	511	859	745
227.7	622	514	854	747
230.0	618	514	851	748
232.3	613	517	848	750
234.6	608	521	843	750
236.9	604	528	838	753
239.2	598	531	829	761
241.5	594	535	830	765
243.8	589	539	822	771
246.1	584	543	814	776
248.4	579	548	809	784
250.7	571	556	804	788
253.0	561	561	798	798
Maximum Shift:	93 cy. .0046 %	64 cy. .0032 %	66 cy. .0022 %	74 cy. .0024 %

Note: The results listed under Columns 1 and 3 were obtained by increasing the voltage in 1% steps from the value of 207 volts. The results listed under Columns 2 and 4 were obtained by decreasing the voltage in 1% steps from 253 volts.

Table 6

Test as per Specifications RE 13A 442B; Paragraph 3-7-1

Frequency shift caused by line voltage variations in steps of 1% per minute between limits of minus 10% and plus 10% of normal voltage. Normal line voltage equals 230 volts D.C.

	1	2	3	4
<u>Line Volts</u>	<u>4500 kcs</u>	<u>4500 kcs</u>	<u>4500 kcs</u>	<u>4500 kcs</u>
207.0	828	996	505	588
209.3	845	990	514	584
211.6	851	995	526	580
213.9	860	990	527	581
216.2	862	982	540	581
218.5	885	988	541	573
220.8	885	990	550	581
223.1	891	1019	551	578
225.4	900	1010	556	574
227.7	905	1001	560	576
230.0	900	991	566	574
232.3	900	989	562	571
234.6	907	984	571	571
236.9	908	983	571	569
239.2	906	979	576	577
241.5	917	974	573	574
243.8	923	976	576	580
246.1	964	965	577	582
248.4	970	980	582	581
250.7	976	977	587	591
253.0	876	976	594	594
Maximum shift:	148 cy. .0033%	54 cy. .0012%	89 cy. .002%	25 cy. .0005%

Note: The results listed under Columns 1 and 3 were obtained by increasing the voltage in 1% steps from the value of 207 volts. The results listed under Columns 2 and 4 were obtained by decreasing the voltage in 1% steps from 253 volts.

Table 7

Test as per Specifications RE 13A 442B; Par.3-7-1

Frequency shift caused by line voltage variations between the extreme limits of 207 volts and 253 volts. Line voltage varied as rapidly as controls would permit.

<u>Line Volts</u>	<u>2000 kcs</u>	<u>3000 kcs</u>	<u>4500 kcs</u>
207	497 cy.	724 cy.	996 cy.
253	527	775	1090
Change:	30 cy.	51 cy.	94 cy.
% " :	.0015 %	.0017 %	.002 %

Table 8

Test as per Specifications RE 13A 442B; Par.3-7-3

Frequency change caused by detuning resonant circuits of TBFA Transmitter except that one in the Master Oscillator which is employed to fix the frequency.

<u>Circuit detuned</u>	<u>2000 kcs</u>		<u>3000 kcs</u>		<u>4500 kcs</u>	
	<u>cycles</u>	<u>%</u>	<u>cycles</u>	<u>%</u>	<u>cycles</u>	<u>%</u>
	<u>change</u>	<u>change</u>	<u>change</u>	<u>change</u>	<u>change</u>	<u>change</u>
"C" Dblr Grid Tuning	16	.0008	86	.0028	220	.0048
"D" Dblr Plate Tuning	8	.0004	32	.0010	170	.0037
"E" Int. Amp Tuning	3	.0001	28	.0009	55	.0012
"F" P.A. Tuning	2	.0001	6	.0002	10	.0002
"H" Antenna Coupling	2	.0001	4	.0001	6	.0001
"J" Ant Tuning Cond	2	.0001	4	.0001	8	.0001
"K" Ant Tuning Ind.	1	Neg.	2	Neg.	8	.0001

Transmitter operated at full power, key locked

Change permitted by specifications: 0.005%

Table 9

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

Frequency change between adjusting condition, tune condition and operate condition. Full power used in "operate" condition.

	<u>2000 kcs</u>	<u>3000 kcs</u>	<u>4500 kcs</u>
Adjust:	970 cy.	1007 cy.	700 cy.
Tune:	975	1005	694
Operate:	975	1000	690
Maximum change:	5 cycles	7 cycles	10 cycles
Permitted by Specs, .0025% or:	50 cycles	75 cycles	113 cycles

Table 10

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

Change in frequency between full power condition (key locked for 10 minutes) and the intermittently keyed condition (a single ten second dash beginning not less than 20 minutes after discontinuing the key locked condition). Motor generator stopped for 18 minutes during the interval between the end of the key locked condition and the beginning of the 10 second dash.

Test No. 1

(Oscillator filament not lighted during period motor generator was shut down; i.e., filament dynamotor not running.)

	<u>2000 kcs</u>	<u>3000 kcs</u>	<u>4500 kcs</u>
End of 10 min key lock:	638	620	561
End of 10 sec dash:	744	763	840
Change:	106 cy	143 cy	279 cy.
% change:	.0053	.0047	.0062

Test No. 2

(Oscillator filament lighted from dynamotor during period motor generator was shut down.)

	<u>2000 kcs</u>	<u>3000 kcs</u>	<u>4500 kcs</u>
End of 10 min key lock:	630	638	576
End of 10 sec dash:	730	765	825
Change:	100 cy.	127 cy	249 cy
% change:	.005	.0042	.0055

Frequency change permitted by revised specifications - 0.007%

Table 11

Test as per paragraph 3-7-6 of Specifications RE 13A 442B

Change in frequency between the continuously keyed full power condition (40 words per minute for at least 30 minutes) and the intermittently keyed condition (a single 10 second dash beginning 20 minutes after discontinuing the continuously keyed full power condition).

	<u>2000 kcs</u>	<u>3000 kcs</u>	<u>4500 kcs</u>
End of 30 min. keying:	755 cy.	780 cy	875 cy.
End of 10 sec. dash:	837	900	1100
Change:	82	120	225
% change:	.0041	.004	.005

Frequency change permitted by revised specifications: 0.007%

Table 12

Test as per paragraph 3-7(7) of Specifications RE 13A 442B

Average variation in frequency from the mean frequency of 10 tubes picked at random from the same manufactured lot.

Frequency - 2000 kcs

<u>Tube No.</u>	<u>Master Oscillator Circuit</u>		<u>Variation from Mean</u>
	<u>Serial No.</u>	<u>Frequency</u>	
1	40220	2000.875	+ 41
2	40497	2001.015	+181
3	40391	2000.743	- 91
4	40368	2000.573	-261
5	40350	2000.794	- 40
6	40640	2000.935	+101
7	40625	2000.850	+ 16
8	40629	2000.910	+ 76
9	40616	2000.920	+ 86
10	40614	2000.727	-107

Mean frequency of 10 tubes - 2000.834

Avg. variation from mean - 99.8 cycles or 0.005%

Max. plus variation from mean - 181 cycles or 0.009%

Max. minus variation from mean - 261 cycles or 0.013%

Avg. variation from mean allowed by Specs. - 0.03%

Stage following Master Oscillator

The changes in frequency encountered when tubes were changed in the stage following the master oscillator were of such small magnitude that they could not be attributed to tube changes, since, if the transmitter were allowed to stabilize for a minute or two after making the tube change, the frequency always returned to the original value. The above results are obtained only when the key is locked long enough to eliminate drift.

Table 13

Test as per Specifications RE 13A 442B, paragraph 3-7(7)

Average variation in frequency from the mean frequency of 10 tubes picked at random from the same manufactured lot.

Frequency - 4525 kcs

Master Oscillator Circuit

<u>Tube No.</u>	<u>Serial No.</u>	<u>Frequency</u>	<u>Variation from Mean</u>
1	40220	4525.480	-183
2	40497	4526.680	+1017
3	40391	4525.470	- 193
4	40368	4525.350	- 313
5	40350	4525.608	- 55
6	40640	4526.660	+ 997
7	40625	4525.760	+ 97
8	40629	4525.490	- 173
9	40616	4525.710	+ 47
10	40614	4524.420	-1243

Mean frequency of 10 tubes - 4525.663

Avg. variation from mean - 432 cycles or 0.0095%

Max. plus variation from mean - 1017 cycles or 0.0225%

Max. minus variation from mean - 1243 cycles or 0.0275%

Avg. variation from mean allowed by Specs. - 0.03 %

Stage following Master Oscillator

The changes in frequency encountered when tubes were changed in the stage following the master oscillator were of such small magnitude that they could not be attributed to tube changes, since, if the transmitter were allowed to stabilize for a minute or two after making the tube change, the frequency always returned to the original value.

Table 14

Test as per paragraph 3-7-8 of Specifications RE 13A 442B

Change in frequency during full power run of two hours beginning three hours after voltage was applied to temperature regulating devices and 20 minutes after start of full power key locked condition.

Frequency - 2000 kcs

<u>Time</u>	<u>LH Freq. Indicator</u>	<u>Temperature of Master Cabinet</u>	<u>Ambient Temp</u>	<u>Line Volts</u>
1330	1000	59.50	21.5	223
35	957	59.50	21.2	222
40	934	59.50	21.0	223
45	908	59.55	21.3	222
50	884	59.75	22.0	222
55	861	59.80	22.6	222
1400	844	59.95	22.3	222
05	827	60.00	22.4	223
10	815	60.10	23.3	223
15	800	60.30	23.6	223
20	789	60.45	23.8	222
25	781	60.55	23.7	222
30	771	60.60	23.7	223
35	768	60.80	23.0	223
40	765	60.85	23.0	222
45	764	60.95	23.3	221
50	763	61.00	23.8	221
55	762	61.05	24.0	222
1500	758	61.20	24.5	222
05	761	61.25	24.3	223
10	760	61.35	23.9	223
15	758	61.40	23.5	223
20	754	61.45	23.0	223
25	754	61.50	23.5	222
30	752	61.50	23.7	223
35	750	61.55	23.3	222
40	746	61.60	23.7	222
45	747	61.65	24.0	222
50	747	61.70	24.3	222

Greatest change between 1350 and 1550 - 115 cycles or 0.0057%

Voltage applied to transmitter at 1030.

(Note: G.E. carbon anode tube used in this test in P.A.

Type 38161 serial no. 15515)

Frequency change permitted by revised specifications - 0.01%

Table 15

Test as per paragraph 3-7(8) of Specifications RE 13A 442B.

Change in frequency during full power run of two hours beginning three hours after voltage was applied to temperature regulating devices and 20 minutes after start of full power key locked condition.

Frequency - 2000 kcs

<u>Time</u>	<u>LH Freq. Indicator</u>	<u>Temperature of Master Cabinet</u>	<u>Ambient Temp.</u>	<u>Line Volts</u>
1115	1095	59.40	23.0	220
20	1016	59.45	23.0	220
25	986	59.50	23.7	220
30	950	59.55	24.0	222
35	925	59.60	24.3	222
40	905	59.80	24.5	222
45	877	59.90	25.0	222
50	860	60.00	24.8	222
55	850	60.20	24.6	222
1200	835	60.30	24.0	222
05	820	60.50	24.4	220
10	810	60.50	23.4	220
15	802	60.70	24.0	220
20	790	60.80	24.8	220
25	782	60.90	25.0	220
30	782	61.00	25.3	220
35	782	61.10	25.4	220
40	775	61.20	24.9	220
45	773	61.20	25.3	220
50	770	61.30	24.6	222
55	765	61.40	24.3	222
1300	765	61.50	25.2	223
05	763	61.50	24.6	223
10	759	61.60	24.6	223
15	755	61.70	23.5	223
20	747	61.80	24.6	220
25	742	61.80	23.0	220
30	738	61.90	23.1	220
35	733	61.90	24.4	220
Differ- ence	192 cy. .0096 %	1.0°	2.4°	3.0 V

Heater voltage applied to transmitter at 0835. Oscillator filament not lighted during three hour heating period.

Frequency change permitted by revised specifications - 0.01%

Table 16

Test as per paragraph 3-7-8 of Specifications RE 13A 442B

Change in frequency during full power run of two hours beginning three hours after voltage was applied to temperature regulating devices and 20 minutes after start of full power key locked condition.

Frequency - 3000 kcs

<u>Time</u>	<u>LH Freq. Indicator</u>	<u>Temperature of Master Cabinet</u>	<u>Ambient Temp</u>	<u>Line Volts</u>
0820	953	59.2	20.9	230
25	916	59.2	21.6	230
30	875	59.4	21.7	228
35	858	59.45	22.0	227
40	838	59.5	21.7	226
45	816	59.55	22.0	225
50	809	59.65	22.6	225
55	798	59.8	22.5	224
0900	792	59.9	22.4	224
05	785	60.0	21.4	224
10	776	60.05	21.3	224
15	774	60.2	21.4	224
20	768	60.3	21.5	223
25	763	60.4	21.5	226
30	767	60.45	21.5	226
35	768	60.6	22.6	226
40	773	60.6	23.0	226
45	783	60.7	23.4	225
50	785	60.75	23.6	225
55	788	60.8	24.2	225
1000	793	60.8	24.3	225
05	803	60.9	24.3	225
10	810	60.95	24.3	225
15	812	61.0	24.5	224
20	815	61.0	24.3	224

Greatest change between 0840 and 1020 - 75 cycles or 0.0025%

Voltage applied to transmitter at 0536

Frequency change permitted by revised specifications - 0.01%

Table 17

Test as per paragraph 3-7-8 of Specifications RE 13A 442B.

Change in frequency during full power run of two hours beginning three hours after voltage was applied to temperature regulating devices and 20 minutes after start of full power key locked condition.

Frequency - 4500 kcs.

<u>Time</u>	<u>LH Freq. Indicator</u>	<u>Temperature of Master Cabinet</u>	<u>Ambient Temp.</u>	<u>Line Volts</u>
0930	1000	59.40	21.3	224
35	840	59.45	21.5	224
40	812	59.50	21.7	225
45	790	59.55	21.8	226
50	775	59.60	21.9	224
55	769	59.70	21.9	226
1000	757	59.75	22.0	224
05	750	59.85	22.4	225
10	742	60.00	22.7	225
15	740	60.05	22.8	224
20	743	60.10	22.9	224
25	739	60.25	22.7	224
30	775	60.40	22.5	224
35	800	60.45	22.5	224
40	825	60.50	22.4	224
45	860	60.50	22.7	225
50	885	60.60	23.1	225
55	900	60.65	24.5	226
1100	930	60.70	24.7	226
05	952	60.80	23.6	226
10	966	60.90	23.4	225
15	972	60.90	23.2	225
20	972	60.90	23.1	226
25	981	61.00	23.4	226
30	993	61.00	23.4	226

Greatest change between 0955 and 1130 - 254 cycles or 0.0056%

(Note: G.E. carbon anode tube used in this test in P.A.
Type 38161 serial no. 15515)

Frequency change permitted by revised specifications - 0.01%

Table 18

Test as per paragraph 3-7-9 of Specifications RE 13A 442B

Shock Test to simulate Gun Fire

<u>Col. 1</u>	<u>Col. 2</u>	<u>Col. 3</u>				
<u>Freq. 1</u>	<u>Freq. 2</u>	<u>Freq. at</u>				
<u>minute</u>	<u>minutes</u>	<u>instant</u>				
<u>before</u>	<u>after</u>	<u>of</u>				
<u>shock</u>	<u>shock</u>	<u>shock</u>	<u>Difference</u>		<u>Difference</u>	
			<u>between col. 1</u>		<u>between col. 1</u>	
			<u>and col. 2.</u>		<u>and col. 3.</u>	
(Frequency 2000 kcs)						
594	582	589	12 cy. -	.0006%	5 cy. -	.0002%
582	571	576	11	.0005	6	.0003
571	561	566	10	.0005	5	.0002
561	553	558	8	.0004	3	.0001
(Frequency 3000 kcs)						
729	731	729	2 cy. -	Neg.	0	-
731	698	732	33	.0011%	1	- Neg.
739	741	740	2	Neg.	1	- Neg.
741	746	744	5	.0001	3	- Neg.
(Frequency 4500 kcs)						
520	524	520	4 cy. -	.0001%	0	-
524	534	527	10	.0002	3 cy. -	Neg.
534	536	532	2	Neg.	2	- Neg.
536	534	534	2	Neg	2	- Neg.

Frequency change permitted by specifications - 0.02%

Table 19

Test as per paragraph 3-7-10 of Specifications RE 13A 442B

Application of Horizontal Force of 200 lbs.

2000 kcs - A shift of not over 5 cycles was noted
when the force was applied.

3000 kcs - No shift noted when force was applied.

4500 kcs - No shift noted when force was applied.

Frequency change permitted by specifications - 0.002%.

Table 20

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

Accuracy of reset and time required to shift frequency.

Frequency - 2000 kcs

<u>Operator No.</u>	<u>Original Beat Note</u>	<u>Reset Beat Note</u>	<u>Percentage Difference</u>
1	595	594	Neg.
2	583	587	0.0002
3	588	577	0.0005

Frequency - 4500 kcs

1	843	813	0.0006
2	695	690	0.0001
3	726	746	0.0004

Note: It is possible for one man to shift frequency in
from 50 to 60 seconds.

Table 21

Test for lost motion and back-lash in master oscillator.

<u>Trial</u> <u>No.</u>	2000 kcs		<u>Difference</u>	4500 kcs		<u>Difference</u>
	<u>Right</u>	<u>Left</u>		<u>Right</u>	<u>Left</u>	
1	550	563	13 cycles	813	840	27 cycles
2	523	537	14	728	683	55
3	521	532	11	810	650	160

(Note: The above adjustments were made by three different operators.)

1	684	691	7 cycles	830	840	10 cycles
2	668	681	13	818	820	2
3	661	675	14	826	808	18
4	650	660	10	827	865	38
5	650	661	11	846	838	8

(Note: The above adjustments were made by a single operator, indicating that the amount of back-lash present is not comparable to the personal error between operators.)

"Right" - denotes approaching the designated setting from the right hand side, or counter clockwise.

"Left" - denotes approaching the designated setting from the left hand side, or clockwise.

Table 22

Test as per paragraph 3-19 of Specifications RE 13A 442B

Variation in Power Output from 100% to 10%

<u>Power Output</u>	<u>Plate Volts</u>	<u>Plate Current</u>	<u>Beat Note</u>
<u>(2000 kcs - High Power Operation)</u>			
100%	3000	350 ma	550
56.8	2250	265	552
21.3	1500	150	550
7.3	1100	70	547
<u>(2000 kcs - Low Power Operation)</u>			
100 %	3000	100 ma	607
56.3	2250	75	606
21.0	1500	42	606
10	1100	28	607
<u>(4500 kcs - High Power Operation)</u>			
100%	3000	350 ma	603
54.4	2200	260	595
18.6	1500	130	584
8.0	1200	70	579
<u>(4500 kcs - Low Power Operation)</u>			
100%	3000	100 ma	646
52.5	2250	70	605
20.0	1500	40	581
6.7	1000	20	578
<u>(9000 kcs - High Power Operation)</u>			
100%	3000	350 ma	776
47.1	2250	220	790
12.9	1500	90	825
6.2	1300	50	825
<u>(9000 kcs - Low Power Operation)</u>			
100 %	3000	100 ma	452
49.0	2200	58	482
19.0	1500	38	518
10.0	1200	25	530
<u>(18000 kcs - High Power Operation)</u>			
100%	3000	350 ma	1000
41.9	2200	200	990
12.9	1500	90	970
3.6	1250	30	960

Table 23

Change in frequency resulting from changing from high power operation (500 watts) to low power operation (75 watts).

<u>Frequency</u> <u>kcs</u>	<u>Beat Note</u> <u>High power</u>	<u>Beat Note</u> <u>Low power</u>	<u>Cycles</u> <u>Change</u>	<u>Percentage</u> <u>Change</u>
2000	700	692	8	0.0004%
3000	650	666	16	0.0005
4500	456	625	169	0.0037

Table 24

Test as per paragraph 2-16 of Specifications RE 13A 442B

Antenna short circuited and open circuited.

	<u>Antenna</u> <u>Normal</u>	<u>Antenna</u> <u>Shorted</u>	<u>Antenna</u> <u>Open</u>	<u>Antenna</u> <u>Normal</u>	<u>Antenna</u> <u>Shorted</u>	<u>Antenna</u> <u>Open</u>
Frequency	3000 kcs	3000 kcs	3000 kcs	4500 kcs	4500 kcs	4500 kcs
Power Range	high	high	high	high	high	high
M.O. I_{sg}	12.5	12.5	12.5	12.7	12.9	12.9
M.O. I_p	69	71	68	70	73	72
Doubler I_p	45	35	46	40	32	33
Int Amp I_g	30	23	31	19	15	16
Int Amp I_p	48	58	60	60	48	52
Pr Amp I_g	40	69	44	82	57	88
Pr Amp I_p	350	105	345	340	60	163
Ant I	2	-	-	-	-	-
Pr Amp E_p	3000	3100	3000	3000	3120	3120
E filaments	10	10	10	10	10	10

Single wire antenna used, 80 feet in length.

Table 25

TBFa Transmitter, Serial No.1
 Effect of change in ambient temperature.
 Original adjustment of compensating condenser
 4500 kcs.

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0900	24.0	59.7	4500.985	227
10	24.6	59.8	.807	230
20	25.2	60.0	.760	229
30	25.0	60.2	.660*	229
40	25.0	60.4	.645	228
50	25.0	60.5	.433*	229
1000	25.0	60.7	.436	228
10	25.0	60.8	.440	226
Key open 10 minutes while temperature was changed.				
1020	29.8	60.9	4500.665	228
30	30.0	61.0	.610	228
40	30.0	61.0	.670	228
50	30.0	61.2	.710	228
1100	30.0	61.2	.735	228
10	30.0	61.3	.770	228
20	30.0	61.4	.790	228
30	30.0	61.5	.820*	225
Key open 10 minutes while temperature was changed.				
1140	35.0	61.5	4501.010	228
50	35.1	61.5	.035	230
1200	35.0	61.6	.050	230
10	34.8	61.7	.065	230
20	35.1	61.7	.075	230
30	35.0	61.8	.100	224
40	35.1	61.9	.131	225
50	35.0	61.9	.155	220
Key open 10 minutes while temperature was changed.				
1300	49.4	61.9	4501.520	220
10	49.2	62.0	.555	219
20	49.2	62.0	.635	219
30	50.0	62.1	.680	219
40	50.0	62.2	.735	219
50	50.0	62.2	.760	220
1400	50.8	62.4	.801	228
10	50.0	62.5	.855	234
Key open 10 minutes while temperature was changed.				
1420	24.8	62.2	4501.600	56
30	25.0	62.0	.385	57
40	24.8	62.0	.275	56
50	25.0	61.9	.225	56
1500	25.0	61.8	.160	56
10	25.2	61.8	.114	56
20	25.0	61.7	.093	55
30	25.0	61.7	.054	55

* Sudden frequency change.

Talbe 25 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 5.0°C

Difference in frequency - 380 cycles

Difference per degree Centigrade - 76 cycles, .0017%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 335 cycles

Difference per degree Centigrade - 67 cycles, .00149%

Difference between readings taken at 1250 and 1410

Ambient temperature - 15.0°C

Difference in frequency - 700 cycles

Difference per degree Centigrade - 46.5 cycles, .00103%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 801 cycles

Difference per degree Centigrade - 32 cycles, .00071%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 614 cycles, .0135%

Table 26

TBF-a Transmitter, Serial No.1
 Effect of change in ambient temperature.
 Original adjustment of compensating condenser
 4500 kcs.

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0900	25.8	59.7	4501.010	230
10	25.0	59.9	4500.812	230
20	25.0	60.0	.722	230
30	25.2	60.2	.670	230
40	25.0	60.5	.628	230
50	25.0	60.5	.605	230
1000	25.0	60.7	.358*	229
10	25.0	60.9	.338	228
Key open 10 minutes while temperature was changed.				
1020	9.8	60.7	4500.750	229
30	9.8	60.7	.585	229
40	9.8	60.6	.522	229
50	10.0	60.6	.478	229
1100	9.8	60.6	.446	229
10	10.2	60.6	.437	218
20	9.8	60.6	.440	229
30	10.0	60.6	.418	230
Key open 10 minutes while temperature was changed.				
1140	4.8	60.5	4500.610	229
50	5.0	60.5	.440	230
1200	5.0	60.5	.378	230
10	5.0	60.4	.344	230
20	5.0	60.4	.325	232
30	5.0	60.4	.307	230
40	5.2	60.5	.294	230
50	5.0	60.5	.284	230
Key open 10 minutes while temperature was changed.				
1300	0.0	60.4	4500.456	230
10	0.0	60.3	.297	229
20	-0.2	60.3	.240	230
30	0.0	60.2	.207	229
40	0.0	60.2	.187	218
50	0.0	60.2	.186	230
1400	0.0	60.2	.170	230
10	0.0	60.2	.150	228
Key open 10 minutes while temperature was changed.				
1420	25.0	60.2	4500.520	226
30	24.8	60.3	.494	224
40	24.8	60.5	.526	226
50	24.8	60.6	.536	229
1500	25.2	60.8	.532	230
10	25.0	61.0	.534	229
20	25.0	61.0	.532	230
30	25.0	61.2	.532	229

* Sudden frequency change.

Table 26 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 15°C

Difference in frequency - 80 cycles

Difference per degree Centigrade - 5.3 cycles, .00018%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 134 cycles

Difference per degree Centigrade - 26.8 cycles, .0006%

Difference between readings taken at 1250 and 1410

Ambient temperature - 5.0°C

Difference in frequency - 134 cycles

Difference per degree Centigrade - 26.8 cycles, .0006%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 375 cycles

Difference per degree Centigrade - 15 cycles, .00033%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - .0155%

Table 27
TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature.
Original adjustment of compensating condenser
2000 kcs.

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual frequency</u>	<u>Line Volts</u>
0900	24.2	59.7	3000.730	202
10	24.8	59.7	.640	197
20	25.2	59.9	.615	221
30	25.2	60.0	.580	221
40	25.0	60.2	.462	223
50	25.0	60.4	.444	218
1000	25.0	60.5	.434	219
10	25.0	60.6	.428	216
Key open 10 minutes while temperature was changed.				
1020	30.0	60.7	3000.544	218
30	29.8	60.7	.510	217
40	30.0	60.9	.522	216
50	30.2	61.0	.535	216
1100	30.0	61.0	.532	214
10	30.0	61.2	.536	217
20	30.0	61.2	.616*	220
30	30.0	61.3	.615	217
Key open 10 minutes while temperature was changed.				
1140	35.0	61.3	3000.640	222
50	35.0	61.3	.636	222
1200	35.0	61.5	.628	224
10	35.2	61.5	.615	226
20	35.2	61.5	.616	229
30	35.0	61.6	.608	228
40	35.0	61.7	.604	225
50	35.0	61.8	.588	225
Key open 10 minutes while temperature was changed.				
1300	49.8	61.8	3000.740	220
10	50.0	61.9	.755	219
20	50.3	62.0	.745	219
30	50.0	62.0	.785	221
40	50.0	62.2	.780	224
50	49.8	62.2	.795	222
1400	50.0	62.3	.793	222
10	50.0	62.4	.805	226
Key open 10 minutes while temperature was changed.				
1420	30.0	62.0	3000.775	230
30	28.2	61.8	.665	223
40	27.0	61.5	.600	226
50	26.8	61.5	.560	228
1500	26.0	61.4	.520	227
10	25.8	61.3	.490	226
20	25.2	61.2	.465	226
30	25.0	61.2	.450	226

Note: The wide range of ambient temperatures between 1420 and 1530 was due to the lack of refrigeration.

Table 27 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 5.0°C

Difference in frequency - 187 cycles

Difference per degree Centigrade - 37.4 cycles, .0014%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 27 cycles

Difference per degree Centigrade - 5.4 cycles, .00018%

Difference between readings taken at 1250 and 1410

Ambient temperature - 15.0°C

Difference in frequency - 217 cycles

Difference per degree Centigrade - 14.5 cycles, .00048%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 355 cycles

Difference per degree Centigrade - 14.2 cycles, .00047%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 22 cycles, .00073%

Table 28
TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature.
Original compensating condenser adjustment
3000 kcs

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0910	25.0	59.7	3000.775	226
20	25.2	59.7	.688	226
30	25.0	59.8	.635	226
40	25.0	60.0	.598	226
44	D.C. power off, key opened - Power on at 0957			
1000	25.6	59.9	3000.708	229
10	25.5	60.1	.622	228
20	25.0	60.4	.610	229
30	25.0	60.5	.584	228
40	25.0	60.6	.570	229
50	25.1	60.7	.560	229
58	D.C. power off, key opened - Power on at 1106			
1110	25.0	61.0	3000.680	229
20	25.2	61.0	.576	230
30	25.0	61.0	.562	229
40	25.0	61.0	.555	229
Key open 10 minutes while temperatures was changed.				
1150	10.2	61.0	3000.650	232
1200	10.0	60.8	.564	231
10	9.8	60.7	.524	232
20	10.0	60.7	.520	232
30	9.8	60.7	.504	233
40	10.0	60.6	.502	232
50	9.8	60.7	.496	232
1300	10.0	60.6	.492	231
Key open 10 minutes while temperature was changed.				
1310	5.0	60.6	3000.592	230
20	5.0	60.5	.522	230
30	5.4	60.5	.500	232
40	5.2	60.5	.483	232
50	5.0	60.4	.466	230
1400	5.0	60.5	.460	229
10	5.0	60.4	.455	230
20	5.0	60.4	.450	229
Key open 10 minutes while temperature was changed.				
1430	0.6	60.3	3000.542	230
40	0.2	60.1	.462	230
50	0.0	60.1	.450	230
1500	0.0	60.0	.435	230
10	0.0	60.0	.424	230
20	0.0	60.0	.424	230
30	0.0	60.0	.415	229
40	0.0	60.0	.412	230
Key open 10 minutes while temperature was changed.				

Table 28 (cont'd)

<u>Temp.</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
1550	25.2	60.1	3000.574	228
1600	25.0	60.3	.545	230
10	25.2	60.5	.530	234
20	25.0	60.6	.530	220
30	25.0	60.8	.526	234
40	25.0	61.0	.520	230
50	25.1	61.0	.516	233
1700	25.0	61.1	.514	234

Note: The extra time between 0910 and 1140 was allowed to enable transmitter to reach equilibrium after voltage failures.

Difference between readings taken at 1140 and 1300

Ambient temperature - 15.0°C

Difference in frequency - 63 cycles

Difference per degree Centigrade - 4.2 cycles, .00014%

Difference between readings taken at 1300 and 1420

Ambient temperature - 5.0°C

Difference in frequency - 42 cycles

Difference per degree Centigrade - 8.4 cycles, .00028%

Difference between readings taken at 1420 and 1540

Ambient temperature - 5.0°C

Difference in frequency - 38 cycles

Difference per degree Centigrade - 7.6 cycles, .00025%

Difference between readings taken at 1540 and 1700

Ambient temperature - 25.0°C

Difference in frequency - 102 cycles

Difference per degree Centigrade - 4 cycles, .00013%

Difference between readings taken at 1140 and 1700

Ambient temperature - none.

Difference in frequency - 41 cycles, .0013%

Table 29

TBF-a Transmitter, Serial No.1
 Effect of change in ambient temperature.
 Original adjustment of compensating condenser
 2000 kcs.

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0940	25.0	60.0	2000.900	232
50	25.0	60.2	.825	230
1000	25.0	60.4	.755	231
10	25.0	60.7	.740	232
20	25.0	61.0	.710	233
30	25.0	61.2	.680	232
40	25.0	61.4	.670	234
50	25.0	61.6	.658	234
Key open 10 minutes while temperature was changed.				
1100	10.0	61.4	2000.732	233
10	10.0	61.2	.669	232
20	10.0	61.2	.640	233
30	10.0	61.2	.624	232
40	10.0	61.2	.612	234
50	10.0	61.2	.603	233
1200	10.1	61.2	.595	234
10	10.0	61.2	.586	234
Key open 10 minutes while temperature was changed.				
1220	4.8	61.1	2000.683	235
30	5.0	61.1	.626	233
40	5.2	61.0	.603	232
50	5.1	61.0	.585	233
1300	5.0	61.0	.571	234
10	4.9	61.0	.564	232
20	5.0	61.1	.556	235
30	5.0	61.1	.551	234
Key open 10 minutes while temperature was changed.				
1340	0.0	60.9	2000.640	233
50	0.0	60.8	.584	234
1400	0.0	60.8	.568	232
10	0.0	60.8	.556	234
20	0.0	60.8	.545	234
30	0.0	60.8	.538	234
40	0.0	60.9	.533	234
50	0.0	60.9	.526	234
Key open 10 minutes while temperature was changed.				
1500	24.0	60.8	2000.650	231
10	25.1	61.0	.627	231
20	25.0	61.1	.616	230
30	25.1	61.4	.608	233
40	25.0	61.5	.600	233
50	25.0	61.7	.598	233
1600	25.0	61.8	.596	234
10	25.0	62.0	.608	233

Table 29 (cont'd)

Difference between readings taken at 1050 and 1210

Ambient temperature - 15.0°C

Difference in frequency - 72 cycles

Difference per degree Centigrade - 4.8 cycles, .00024%

Difference between readings taken at 1210 and 1330

Ambient temperature - 5.0°C

Difference in frequency - 35 cycles

Difference per degree Centigrade - 7 cycles, .00035%

Difference between readings taken at 1330 and 1450

Ambient temperature - 5.0°C

Difference in frequency - 25 cycles

Difference per degree Centigrade - 5 cycles, .00025%

Difference between readings taken at 1450 and 1610

Ambient temperature - 25.0°C

Difference in frequency - 82 cycles

Difference per degree Centigrade - 3.2 cycles, .00016%

Difference between readings taken at 1050 and 1610

Ambient temperature - none

Difference in frequency - 50 cycles, .0025%

Table 30

TBF-a Transmitter, Serial No.1
 Effect of change in ambient temperature.
 Original adjustment of compensating condenser,
 2000 kcs.

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0900	25.0	59.6	2000.614	231
10	25.1	59.7	.517	232
20	25.1	60.0	.455	230
30	25.2	60.4	.411	230
40	25.0	60.6	.378	230
50	25.0	60.9	.354	231
1000	25.0	61.1	.330	229
10	25.0	61.3	.325	230
Key open 10 minutes while temperature was changed.				
1020	30.0	61.3	2000.402	228
30	30.2	61.5	.390	228
40	30.0	61.6	.382	230
50	30.0	61.7	.374	228
1100	30.0	61.8	.366	227
10	30.2	62.0	.364	226
20	30.0	62.0	.364	227
30	30.0	62.1	.367	228
Key open 10 minutes while temperature was changed.				
1140	35.0	62.0	2000.454	229
50	35.0	62.0	.434	228
1200	35.0	62.1	.433	229
10	35.2	62.2	.429	229
20	35.0	62.3	.427	230
30	34.9	62.4	.425	228
40	34.9	62.5	.429	227
50	35.0	62.5	.425	228
Key open 10 minutes while temperature was changed.				
1300	50.0	62.5	2000.523	228
10	50.0	62.5	.508	222
20	49.8	62.6	.510	220
30	50.0	62.7	.519	225
40	50.3	62.8	.533	225
50	50.0	62.9	.530	226
1400	50.4	63.0	.528	224
10	50.0	63.0	.536	225
Key open 10 minutes while temperature was changed.				
1420	25.8	62.7	2000.523	228
30	25.0	62.5	.436	228
40	25.0	62.3	.406	227
50	25.0	62.2	.391	227
1500	24.9	62.2	.380	226
10	25.0	62.2	.378	225
20	24.9	62.2	.368	227
30	25.0	62.2	.365	233

Table 30 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 5.0°C

Difference in frequency - 42 cycles

Difference per degree Centigrade - 8.4 cycles, .00042%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 58 cycles

Difference per degree Centigrade - 11.6 cycles, .00058%

Difference between readings taken at 1250 and 1410

Ambient temperature - 15.0°C

Difference in frequency - 111 cycles

Difference per degree Centigrade - 7.4 cycles, .00037%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 171 cycles

Difference per degree Centigrade - 6.8 cycles, .00034%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 40 cycles, .002%

Table 31
TBF-a Transmitter, Serial No. 1
Effect of change in ambient temperature
After adjustment of compensating condenser (40°)
2000 kcs

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0950	25.2	59.7	2000.646	230
1000	25.0	59.8	.545	228
10	25.2	60.0	.488	228
20	25.0	60.3	.444	229
30	25.0	60.6	.415	228
40	25.1	60.8	.392	229
50	25.0	61.0	.369	230
1100	25.0	61.0	.353	230
Key open 10 minutes while temperature was changed.				
1110	10.0	61.1	2000.425	232
20	9.8	61.0	.347	232
30	10.0	61.0	.313	232
40	10.0	61.0	.291	234
50	9.9	61.0	.277	234
1200	10.0	61.0	.268	234
10	10.0	61.1	.253	235
20	10.0	61.1	.242	234
Key open 10 minutes while temperature was changed.				
1230	5.0	60.9	2000.337	232
40	5.0	60.8	.267	232
50	4.5	60.8	.240	232
1300	4.9	60.8	.213	231
10	5.0	60.9	.200	230
20	5.0	60.9	.194	230
30	5.0	60.9	.190	230
40	5.0	60.9	.185	230
Key open 10 minutes while temperature was changed.				
1350	0.0	60.7	2000.285	231
1400	0.0	60.6	.242	230
10	0.1	60.7	.231	230
20	0.0	60.7	.217	232
30	0.0	60.7	.207	234
40	0.0	60.9	.199	232
50	0.0	60.9	.196	232
1500	0.0	61.0	.190	232
Key open 10 minutes while temperature was changed.				
1510	24.9	61.0	2000.325	226
20	25.2	61.0	.296	228
30	25.0	61.2	.287	228
40	25.0	61.4	.277	228
50	25.2	61.5	.273	228
1600	25.2	61.6	.271	231
10	25.0	61.8	.263	232
20	25.0	61.8	.257	233

Table 31 (cont'd)

Difference between readings taken at 1100 and 1220

Ambient temperature - 15.0°C

Difference in frequency - 111 cycles

Difference per degree Centigrade - 7.4 cycles, .00037%

Difference between readings taken at 1220 and 1340

Ambient temperature - 5.0°C

Difference in frequency - 57 cycles

Difference per degree Centigrade - 11.4 cycles, .00057%

Difference between readings taken at 1340 and 1500

Ambient temperature - 5.0°C

Difference in frequency - 5 cycles

Difference per degree Centigrade - 1 cycle, .00005%

Difference between readings taken at 1500 and 1620

Ambient temperature - 25.0°C

Difference in frequency - 67 cycles

Difference per degree Centigrade - 2.7 cycles, .00013%

Difference between readings taken at 1100 and 1620

Ambient temperature - none

Difference in frequency - 96 cycles, .0048%

Table 32
TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature.
After adjustment of compensating condenser (40°)
2000 kes

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0900	25.0	59.7	2000.644	230
10	25.0	59.7	.554	229
20	24.9	60.0	.496	229
30	25.0	60.3	.453	229
40	25.0	60.6	.418	230
50	25.2	60.8	.393	228
1000	25.0	61.0	.374	229
10	25.0	61.2	.360	229
Key open 10 minutes while temperature was changed.				
1020	30.0	61.2	2000.445	227
30	30.0	61.4	.412	226
40	30.2	61.5	.399	227
50	30.0	61.6	.399	226
1100	30.2	61.7	.396	228
10	30.0	61.7	.392	226
20	29.8	62.0	.385	225
30	30.0	62.0	.385	226
Key open 10 minutes while temperature was changed.				
1140	35.0	62.0	2000.478	228
50	35.1	62.0	.460	228
1200	35.0	62.1	.452	228
10	35.0	62.1	.438	229
20	35.0	62.2	.430	229
30	35.0	62.3	.422	228
40	35.0	62.4	.419	227
50	35.0	62.4	.418	228
Key open 10 minutes while temperature was changed.				
1300	50.0	62.4	2000.540	226
10	50.0	62.4	.540	225
20	50.1	62.5	.546	225
30	50.0	62.7	.548	225
40	50.0	62.8	.550	225
50	49.0	62.9	.550	225
1400	50.2	63.0	.555	225
10	50.0	63.0	.557	225
Key open 10 minutes while temperature was changed.				
1420	25.0	62.7	2000.530	231
30	24.6	62.5	.442	231
40	25.0	62.4	.408	229
50	24.8	62.2	.392	228
1500	25.0	62.2	.380	228
10	25.0	62.1	.366	228
20	24.8	62.1	.370	229
30	25.0	62.0	.384	229

Table 32 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 5.0°C

Difference in frequency - 25 cycles

Difference per degree Centigrade - 5 cycles, .00025%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 33 cycles

Difference per degree Centigrade - 6.6 cycles, .00033%

Difference between readings taken at 1250 and 1410

Ambient temperature - 15.0°C

Difference in frequency - 139 cycles

Difference per degree Centigrade - 9.3 cycles, .00046%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 173 cycles

Difference per degree Centigrade - 6.9 cycles, .00034%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 260 cycles, .013%

Table 33
TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature.
After adjustment of compensating condenser
3000 kcs

<u>Time</u>	<u>Ambient °C</u>	<u>Cabinet °C</u>	<u>Actual Frequency</u>	<u>Line Volts</u>
0900	25.0	59.8	3000.530	230
10	25.0	59.8	.387	230
20	25.2	60.0	.328	230
30	25.2	60.1	.310	229
40	25.0	60.4	.292	228
50	25.2	60.5	.272	229
1000	25.2	60.6	.266	228
10	25.0	60.6	.268	229
Key open 10 minutes while temperature was changed.				
1020	10.0	60.6	3000.336	230
30	10.0	60.5	.268	230
40	9.8	60.5	.242	232
50	9.8	60.5	.214	230
1100	10.2	60.5	.202	232
10	9.8	60.5	.196	232
20	10.0	60.5	.186	231
30	10.0	60.5	.186	232
Key open 10 minutes while temperature was changed.				
1140	5.0	60.4	3000.254	231
50	5.0	60.3	.196	230
1200	5.0	60.2	.174	232
10	4.8	60.2	.156	231
20	5.0	60.2	.144	232
30	5.0	60.2	.130	230
40	5.0	60.2	.126	231
50	5.0	60.2	.123	231
Key open 10 minutes while temperature was changed.				
1300	0.0	60.1	3000.200	231
10	0.0	60.0	.146	230
20	0.0	60.0	.126	232
30	0.0	60.0	.116	230
40	0.0	60.0	.086	231
50	0.0	60.0	.078	231
1400	0.0	60.0	.070	230
10	0.0	60.0	.062	230
Key open 10 minutes while temperature was changed.				
1420	25.0	60.0	3000.219	228
30	25.0	60.2	.212	228
40	24.8	60.4	.214	229
50	25.0	60.5	.208	228
1500	25.2	60.6	.210	228
10	25.0	60.7	.211	226
20	25.0	60.9	.210	227
30	25.0	61.0	.212	228

Table 33 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 15.0°C

Difference in frequency - 82 cycles

Difference per degree Centigrade - 5.4 cycles, .00018%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 63 cycles

Difference per degree Centigrade - 12.6 cycles, .00042%

Difference between readings taken at 1250 and 1410

Ambient temperature - 5.0°C

Difference in frequency - 61 cycles

Difference per degree Centigrade - 12.2 cycles, .00041%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0

Difference in frequency - 150 cycles

Difference per degree Centigrade - 6 cycles, .0002%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 56 cycles, .0018%

Table 34

TBF-a Transmitter, Serial No.1
 Effect of change in ambient temperature.
 After adjustment of compensating condenser (40°)
 3000 kcs.

Time	Ambient °C	Cabinet °C	Actual Frequency	Line Volts
0900	25.0	59.8	3000.686	228
10	25.2	59.9	.610	228
20	25.0	60.0	.560	230
30	25.0	60.1	.534	231
40	25.0	60.3	.511	231
50	25.0	60.5	.493	230
1000	25.0	60.6	.484	231
10	25.0	60.7	.475	229
Key open 10 minutes while temperature was changed.				
1020	30.0	60.7	3000.584	230
30	30.0	60.8	.580	229
40	30.0	60.9	.580	229
50	30.0	61.0	.568	227
1100	30.0	61.1	.568	228
10	30.1	61.1	.568	228
20	30.0	61.2	.564	230
30	30.0	61.3	.570	230
Key open 10 minutes while temperature was changed.				
1140	35.0	61.2	3000.672	230
50	35.0	61.3	.662	229
1200	35.0	61.4	.666	231
10	35.0	61.5	.660	231
20	35.0	61.5	.650	232
30	35.0	61.5	.646	229
40	35.0	61.5	.650	230
50	35.0	61.6	.670	229
Key open 10 minutes while temperature was changed.				
1300	50.0	61.6	3000.823	227
10	50.0	61.7	.853	226
20	50.2	61.8	.875	228
30	50.0	62.0	.885	226
40	50.0	62.0	.900	226
50	50.0	62.1	.910	226
1400	50.0	62.2	.915	224
10	50.0	62.3	.927	225
Key open 10 minutes while temperature was changed.				
1420	25.0	62.0	3000.885	232
30	24.8	61.9	.793	228
40	25.0	61.7	.695	231
50	25.0	61.6	.644	231
1500	25.0	61.5	.594	231
10	25.0	61.4	.574	233
20	25.0	61.4	.560	232
30	25.0	61.3	.540	233

Table 34 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 5.0°C

Difference in frequency - 95 cycles

Difference per degree Centigrade - 19 cycles, .00063%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 100 cycles

Difference per degree Centigrade - 20 cycles, .00066%

Difference between readings taken at 1250 and 1410

Ambient temperature - 15.0°C

Difference in frequency - 257 cycles

Difference per degree Centigrade - 17.1 cycles, .00057%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 387 cycles

Difference per degree Centigrade - 15.5 cycles, .00053%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 65 cycles, .0021%

Table 35
TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature
After adjustment of compensating condenser 40°
4500 kcs.

Time	Ambient °C	Cabinet °C	Actual Frequency	Line Volts
0900	25.0	60.0	4500.582	232
10	24.8	60.0	.430	230
20	25.0	60.1	.350	228
30	25.0	60.3	.298	228
40	24.8	60.5	.275	226
50	25.2	60.5	.260	228
1000	25.0	60.7	.234	227
10	25.0	60.8	.252	227
Key open 10 minutes while temperature was changed.				
1020	10.0	60.7	4500.272	229
30	10.0	60.6	.140	229
40	10.0	60.6	.062	228
50	10.0	60.5	.010	228
1100	10.0	60.5	.138	228
10	10.0	60.5	.116	228
20	10.0	60.5	.102	228
30	10.0	60.5	.080	228
Key open 10 minutes while temperature was changed.				
1140	5.0	60.5	4500.060	232
50	5.0	60.4	4499.917	232
1200	5.0	60.4	.855	234
10	5.2	60.3	.817	234
20	5.0	60.3	.785	233
30	5.0	60.3	.760	232
40	5.0	60.4	.752	232
50	5.0	60.4	.739	232
Key open 10 minutes while temperature was changed.				
1300	0.0	60.2	4499.932	232
10	0.0	60.1	.807	232
20	0.0	60.1	.752	232
30	0.0	60.1	.705	230
40	0.0	60.0	.677	231
50	0.0	60.0	.649	232
1400	0.0	60.0	.632	229
10	0.0	60.0	.630	230
Key open 10 minutes while temperature was changed.				
1420	24.6	60.1	4499.982	228
30	25.0	60.3	4500.007	230
40	25.0	60.5	.045	227
50	25.0	60.6	.034	228
1500	24.8	60.7	.007	228
10	25.0	60.9	4499.990	228
20	25.2	61.0	.994	228
30	25.0	61.0	4500.006	229

Table 35 (cont'd)

Difference between readings taken at 1020 and 1130

Ambient temperature - 15.0°C

Difference in frequency - 170 cycles

Difference per degree Centigrade - 11.3 cycles, .00025%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 343 cycles

Difference per degree Centigrade - 68.6 cycles, .0015%

Difference between readings taken at 1250 and 1410

Ambient temperature - 5.0°C

Difference in frequency - 109 cycles

Difference per degree Centigrade - 21.8 cycles, .00048%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 376 cycles

Difference per degree Centigrade - 15 cycles, .00033%

Difference between readings taken at 1030 and 1530

Ambient temperature - none

Difference in frequency - 576 cycles, .0128%

Table 36
TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature
After adjustment of compensating condenser 40°
4500 kcs

Time	Ambient °C	Cabinet °C	Actual Frequency	Line Volts
0900	25.0	59.9	4500.580	231
10	25.0	60.0	.513	230
20	25.0	60.0	.456	230
30	25.0	60.2	.394	230
40	24.8	60.4	.366	230
50	25.0	60.5	.362	228
1000	25.0	60.6	.352	229
10	25.0	60.7	.347	228
Key open 10 minutes while temperature was changed.				
1020	30.0	60.8	4500.558	230
30	29.6	60.8	.544	230
40	30.0	61.0	.598	229
50	30.0	61.0	.630	230
1100	30.2	61.2	.658	229
10	30.0	61.3	.645	229
20	30.0	61.4	.662	230
30	30.0	61.4	.684	228
Key open 10 minutes while temperature was changed.				
1140	35.0	61.4	4500.925	231
50	35.2	61.4	.992	232
1200	35.0	61.5	4501.035	232
10	35.2	61.6	.063	233
20	35.4	61.7	.095	233
30	35.2	61.7	.114	232
40	35.0	61.7	.126	231
50	35.0	61.8	.142	230
Key open 10 minutes while temperature was changed.				
1300	49.5	61.8	4501.342	225
10	50.0	61.9	.456	230
20	49.8	62.0	.492	229
30	50.2	62.1	.532	228
40	50.4	62.3	.572	228
50	50.0	62.3	.607	228
1400	50.0	62.4	.622	228
10	50.0	62.4	.632	228
Key open 10 minutes while temperature was changed.				
1420	25.2	62.2	4501.422	232
30	25.0	62.0	.180	232
40	25.0	61.9	.052	232
50	25.0	61.8	.035	232
1500	25.2	61.7	4500.990	234
10	25.0	61.7	.970	232
20	25.0	61.6	.935	232
30	25.0	61.7	.900	232

Table 36 (cont'd)

Difference between readings taken at 1010 and 1130

Ambient temperature - 5.0°C

Difference in frequency - 337 cycles

Difference per degree Centigrade - 67.4 cycles, .0014%

Difference between readings taken at 1130 and 1250

Ambient temperature - 5.0°C

Difference in frequency - 457 cycles

Difference per degree Centigrade - 91.6 cycles, .002%

Difference between readings taken at 1250 and 1410

Ambient temperature - 15.0°C

Difference in frequency - 490 cycles

Difference per degree Centigrade - 32.7 cycles, .00072%

Difference between readings taken at 1410 and 1530

Ambient temperature - 25.0°C

Difference in frequency - 732 cycles

Difference per degree Centigrade - 29.3 cycles, .00065%

Difference between readings taken at 1010 and 1530

Ambient temperature - none

Difference in frequency - 320 cycles, .0071%

Table 37

TBF-a Transmitter, Serial No.1
Summary of Tables 1 to 12 inclusive .

<u>Temperature °C</u>	<u>Freq. kcs.</u>	<u>Percentage frequency drift per degree C before adjustment of condenser</u>	<u>Percentage frequency drift per degree C after adjustment of condenser</u>
0 - 25	2000	.00016	.00013
0 - 25	3000	.00013	.0002
0 - 25	4500	.00033	.00033
25 - 30	2000	.00042	.00025
25 - 30	3000	.0014	.00063
25 - 30	4500	.0017	.0014
30 - 35	2000	.00058	.00033
30 - 35	3000	.00018	.00066
30 - 35	4500	.0015	.0020
35 - 50	2000	.00037	.00046
35 - 50	3000	.00048	.00057
35 - 50	4500	.0010	.00072
50 - 25	2000	.00034	.00034
50 - 25	3000	.00047	.00053
50 - 25	4500	.00071	.00065
25 - 10	2000	.00024	.00037
25 - 10	3000	.00014	.00018
25 - 10	4500	.00018	.00025
10 - 5	2000	.00035	.00057
10 - 5	3000	.00028	.00042
10 - 5	4500	.0006	.0015
10 - 5 (Repeat run)	4500		.0086
5 - 0	2000	.00025	.00005
5 - 0	3000	.00025	.00041
5 - 0	4500	.0006	.00048

Table 38

TBF-a Transmitter, Serial No.1
Average percentage frequency drift per degree
Centigrade from 0 to 50 before and after ad-
justing compensating condenser.

<u>Before Adjustment</u>		<u>After Adjustment</u>	
<u>Freq.</u> <u>Kcs</u>	<u>Average</u> <u>percentage</u> <u>drift per °C</u>	<u>Freq.</u> <u>Kcs</u>	<u>Average</u> <u>percentage</u> <u>drift per °C</u>
2000	.00034	2000	.00031
3000	.00026	3000	.00045
4500	.00082	4500	.00091
After repeat run on		4500	.00084
Total average .00047			.00055
After repeat run on		4500	.00053

Table 39

TBF-a Transmitter, Serial No.1
Effect of change in ambient temperature.
Repeat of part of test shown on Plate 11 and Table 35
4500 kcs

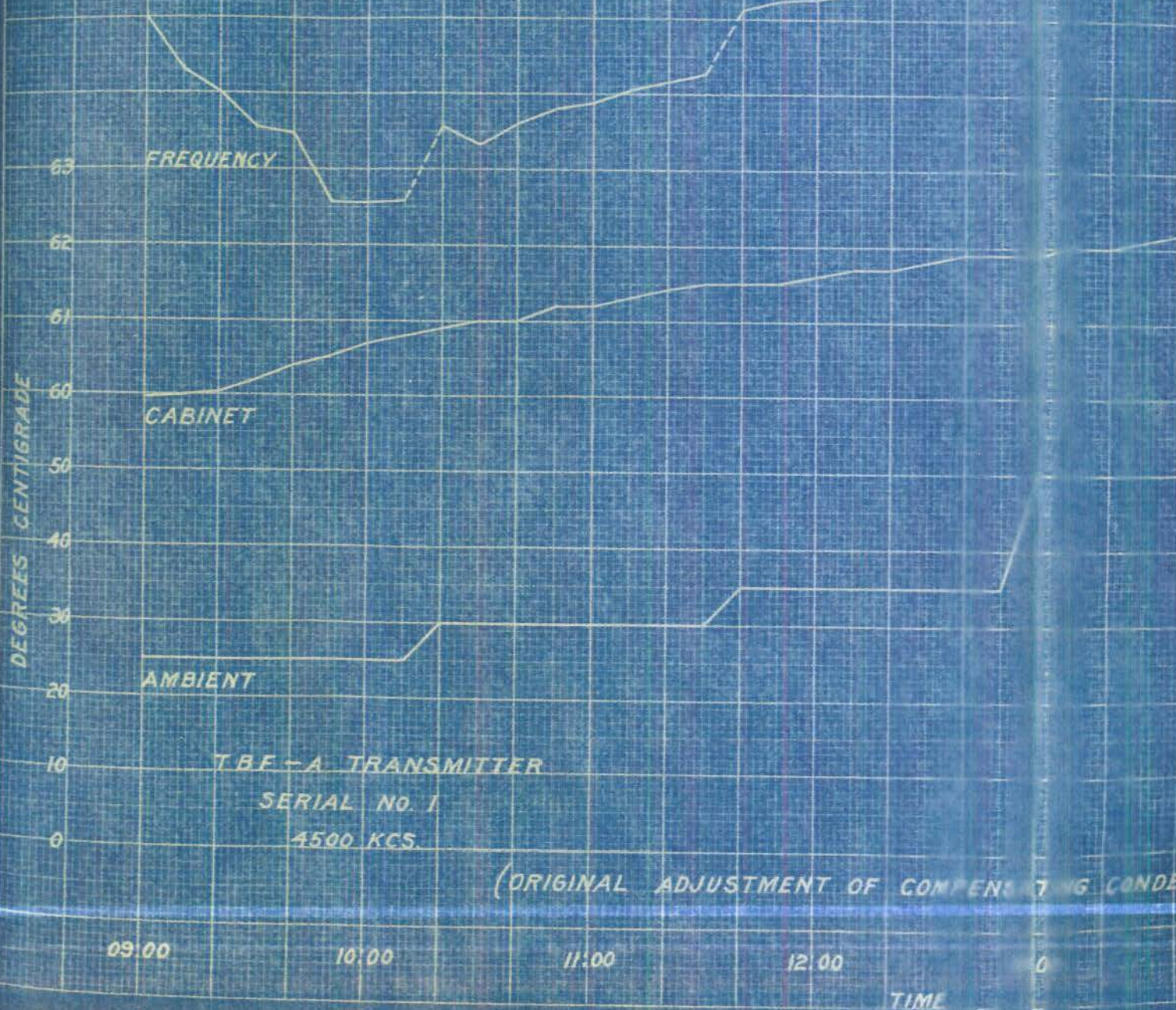
<u>Time</u>	<u>Ambient</u> <u>°C</u>	<u>Cabinet</u> <u>°C</u>	<u>Actual</u> <u>Frequency</u>	<u>Line</u> <u>Volts</u>
0910	10.0	59.7	4500.272	232
20	10.0	59.7	.122	229
30	10.0	59.8	4499.982	230
40	10.0	59.9	.917	230
50	9.8	60.0	.839	230
1000	10.2	60.0	.809	230
10	10.0	60.1	.817	229
20	10.0	60.2	.777	229
Key open 10 minutes while temperature was changed.				
1030	5.0	60.1	4499.932	229
40	5.0	60.0	.795	230
50	4.8	60.1	.724	230
1100	5.0	60.1	.672	230
10	4.8	60.1	.639	229
20	5.0	60.1	.604	231
30	5.0	60.2	.588	231
40	5.0	60.2	.582	231

Difference in temperature - 5.0°C

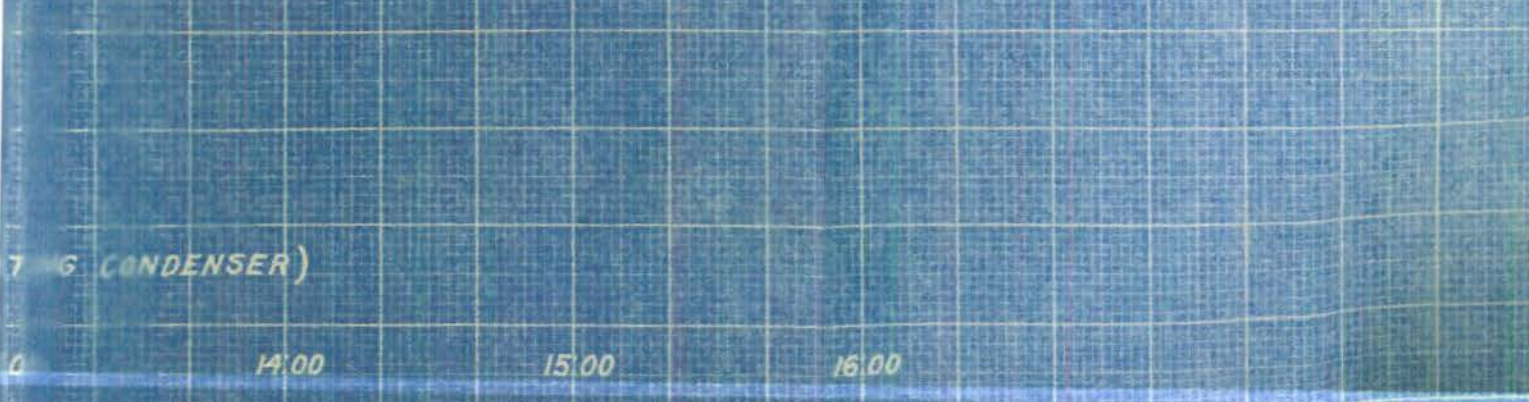
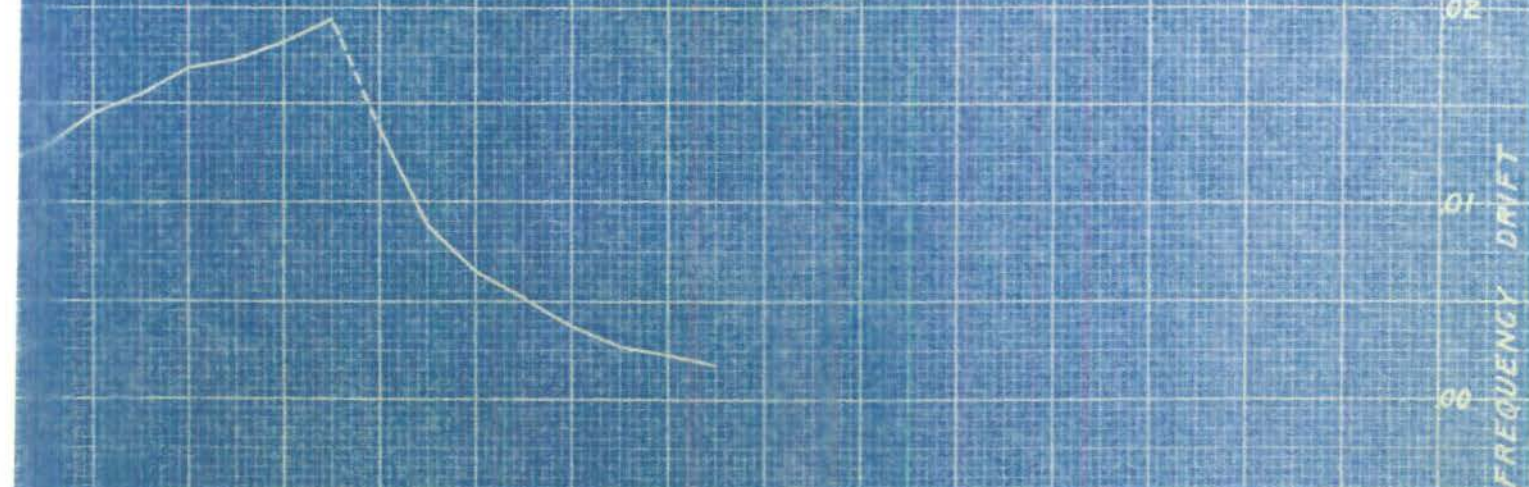
Difference in frequency - 195 cycles

Difference per degree Centigrade - 39 cycles = .00087%

A-1



A-2



ING (CONDENSER)

14:00

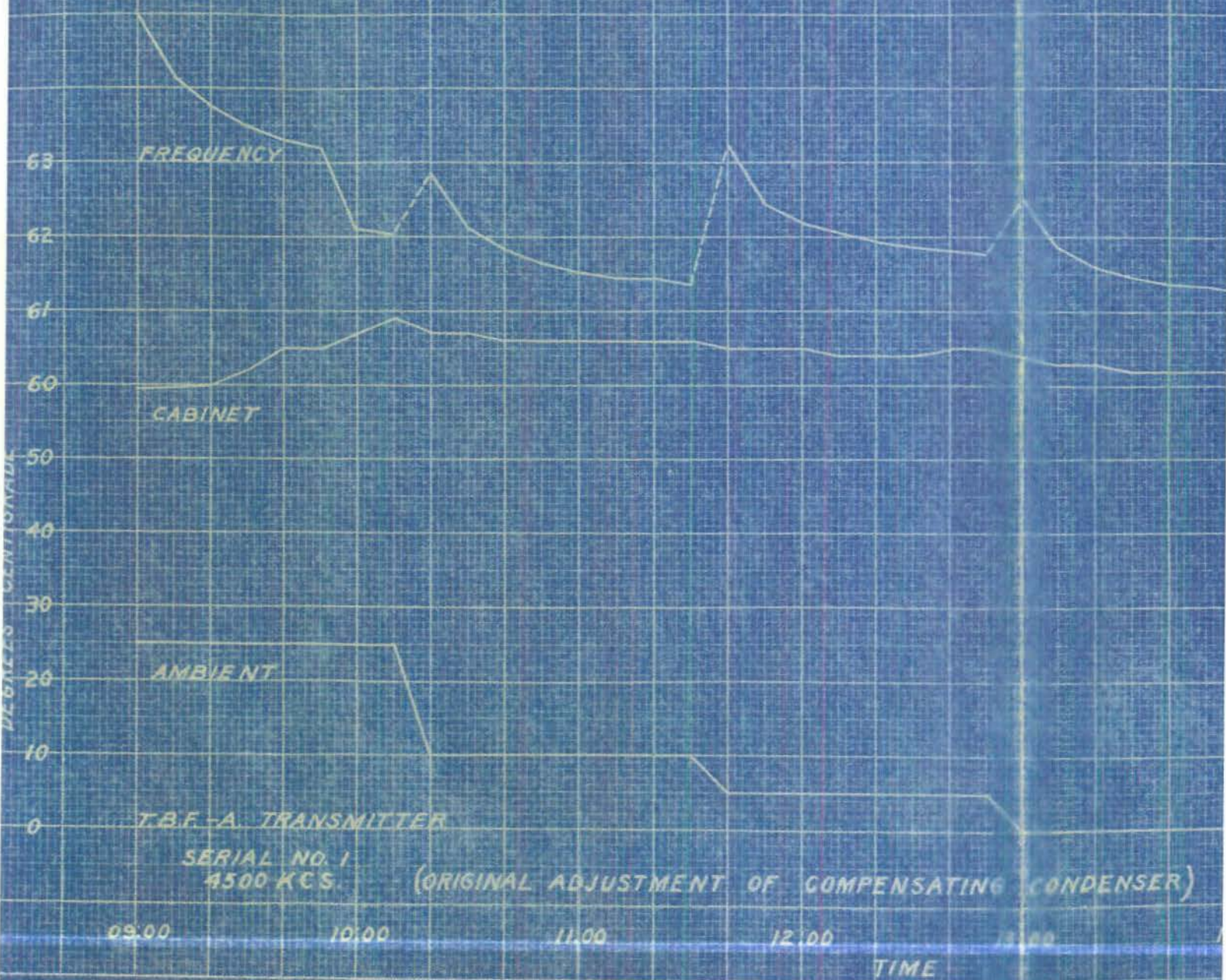
15:00

16:00

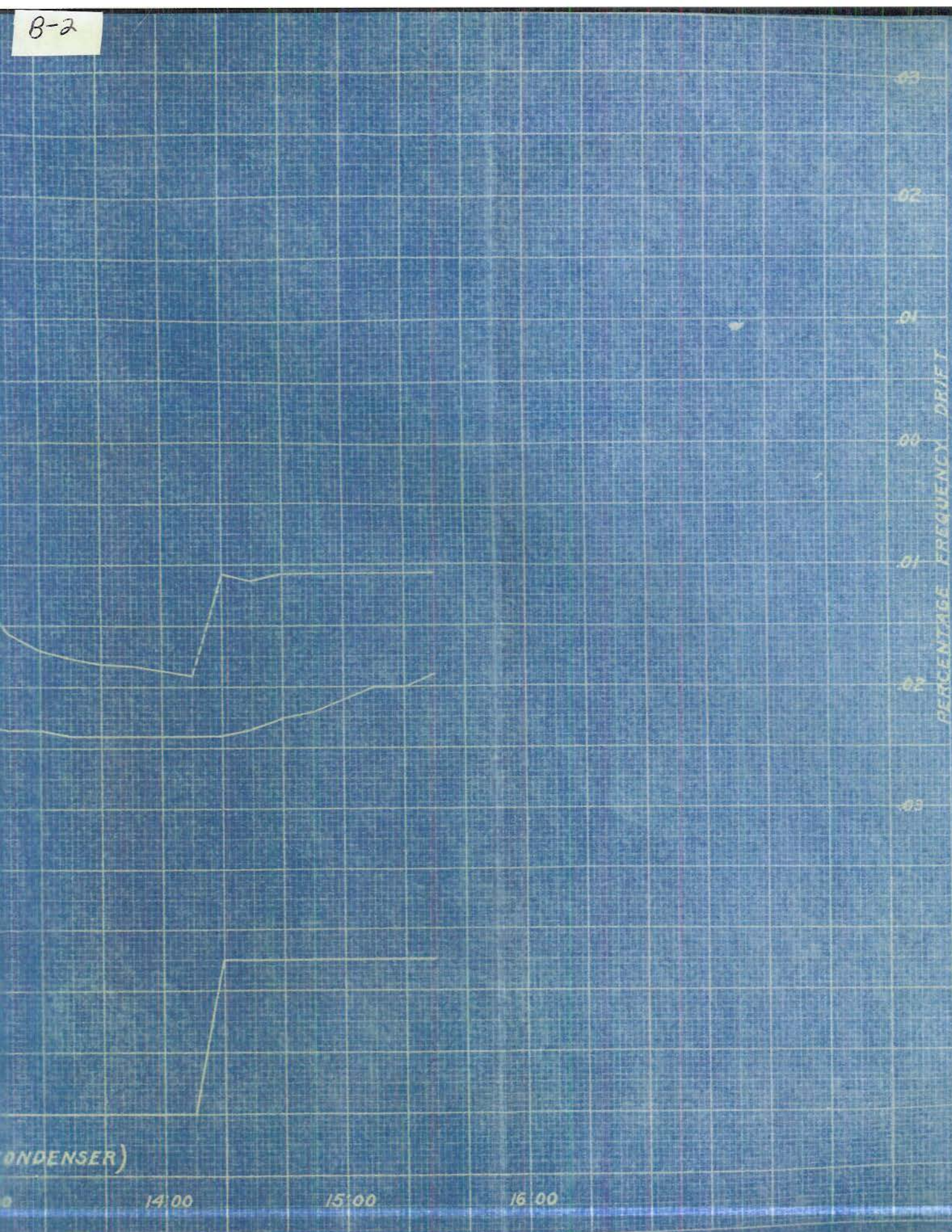
KEUFFEL & ESSER CO. N.Y.

PLATE I

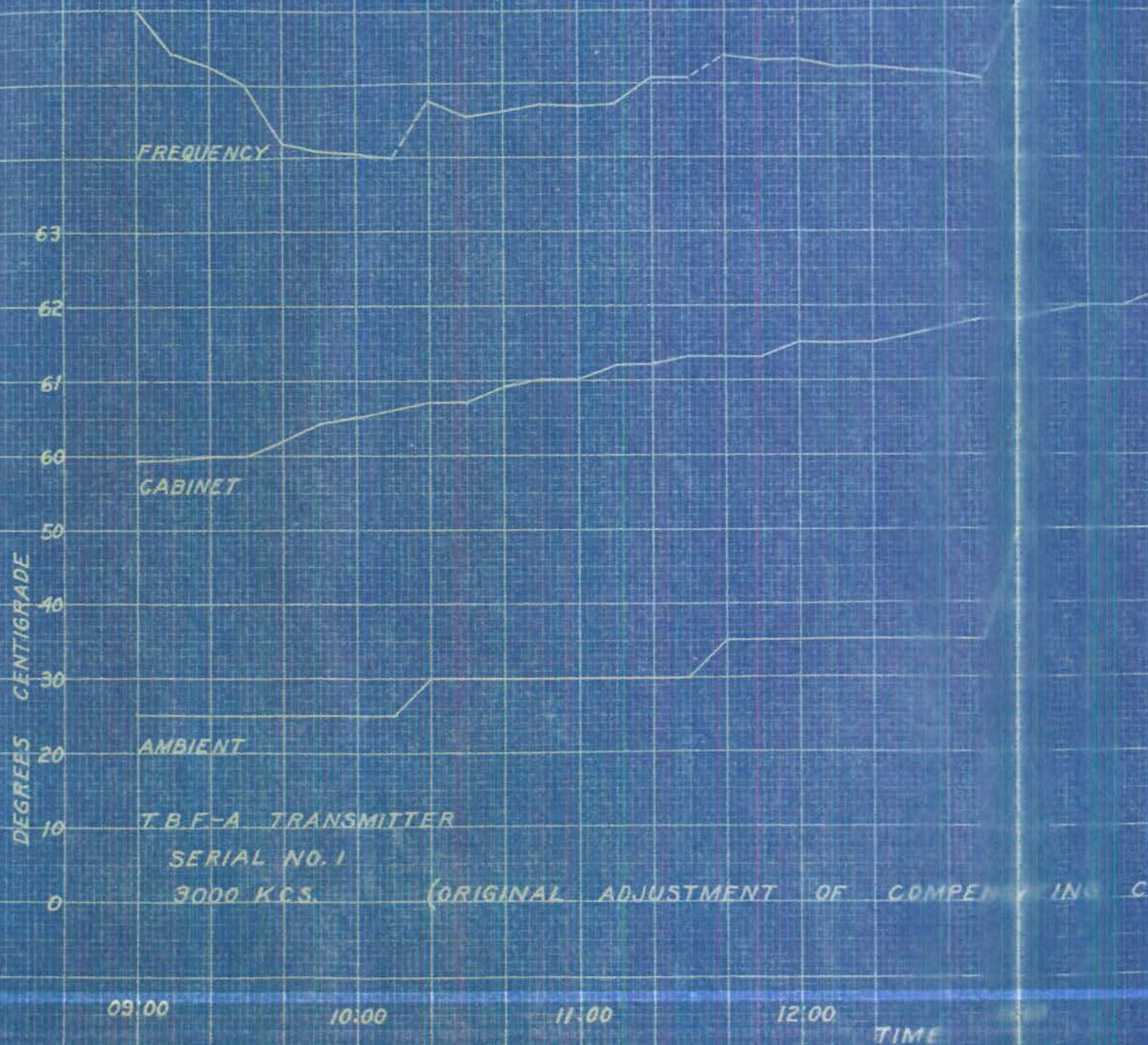
8-1



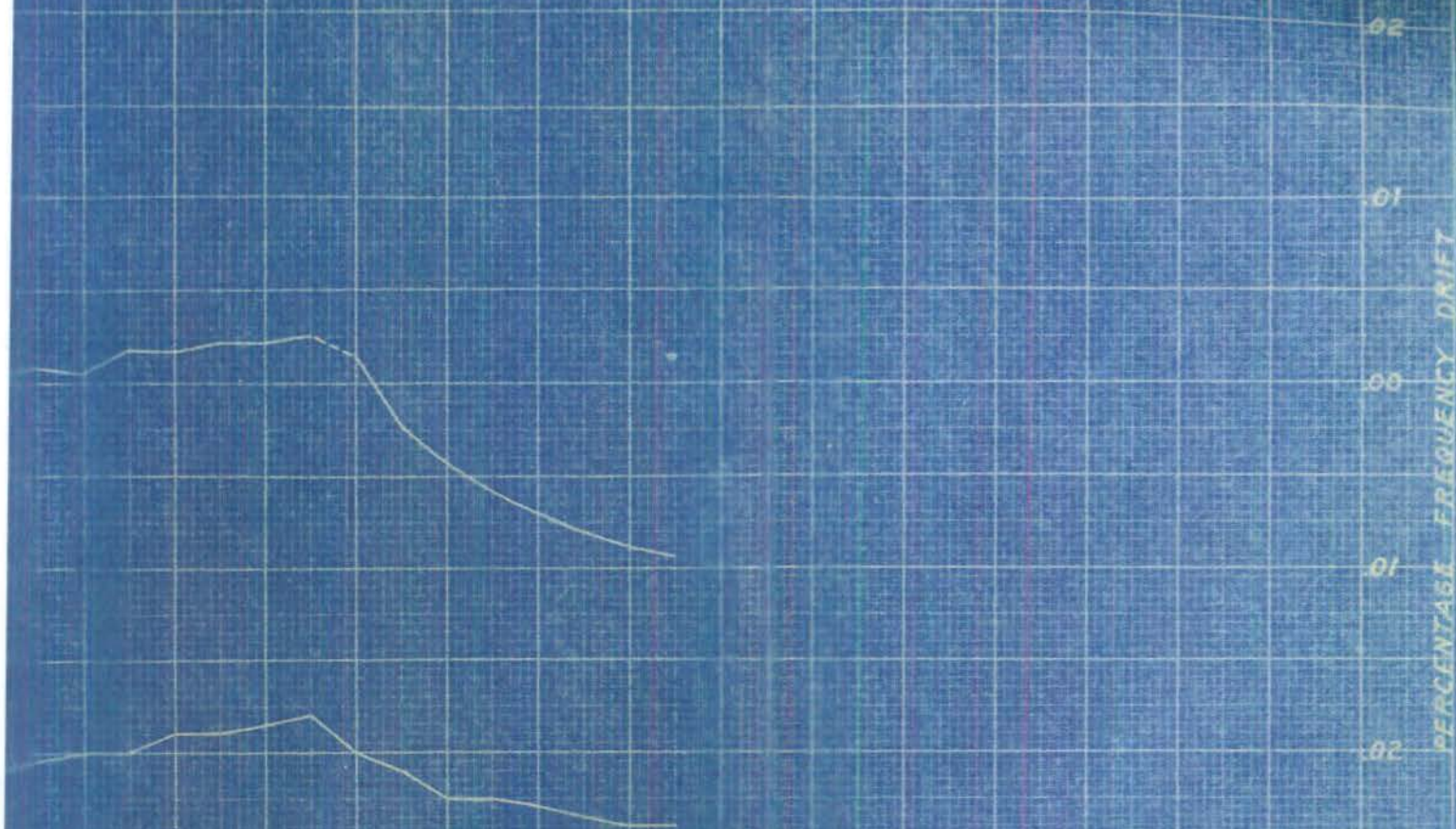
B-2



Q-1



C-2



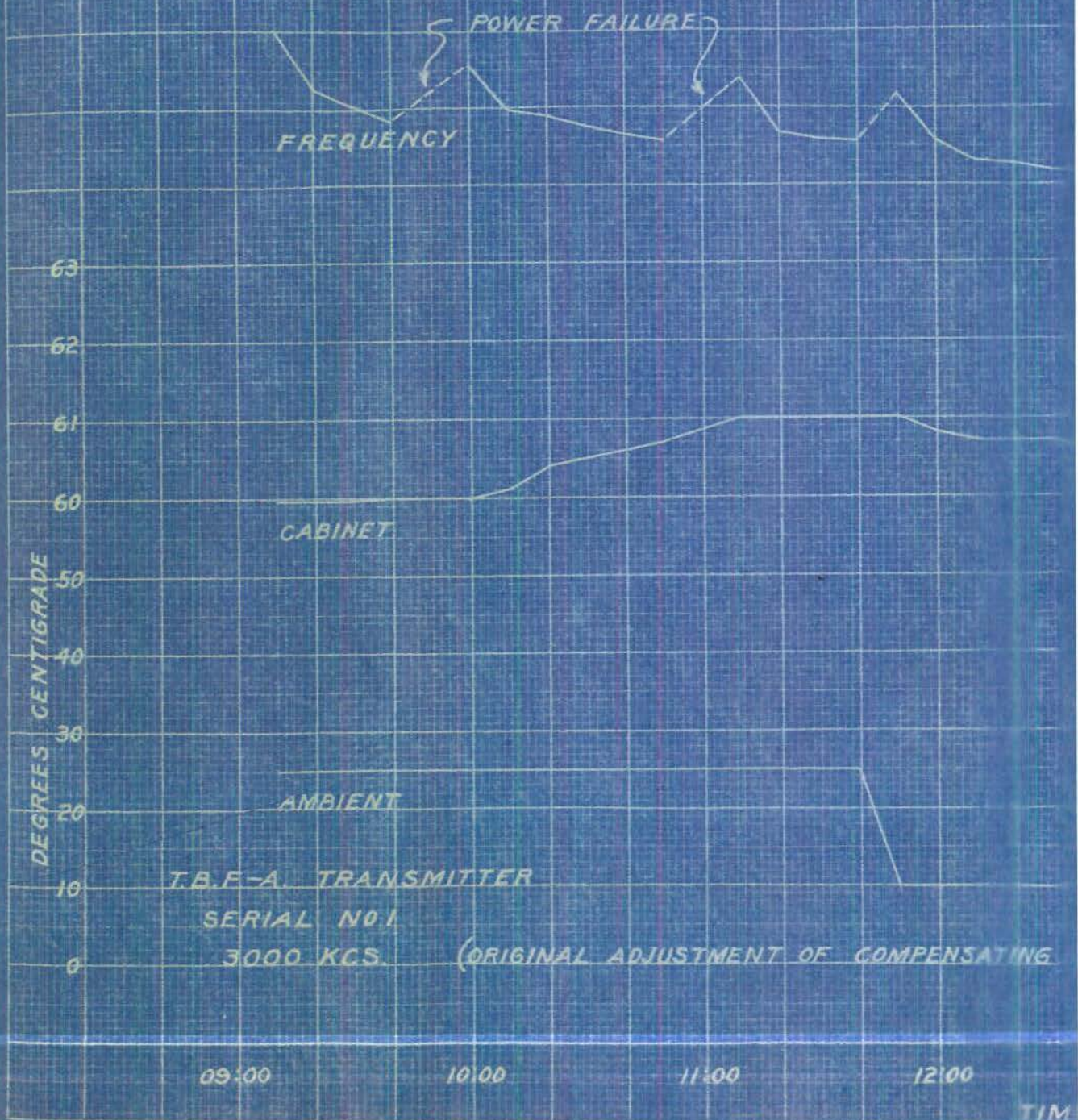
INC. CONDENSER)

14:00

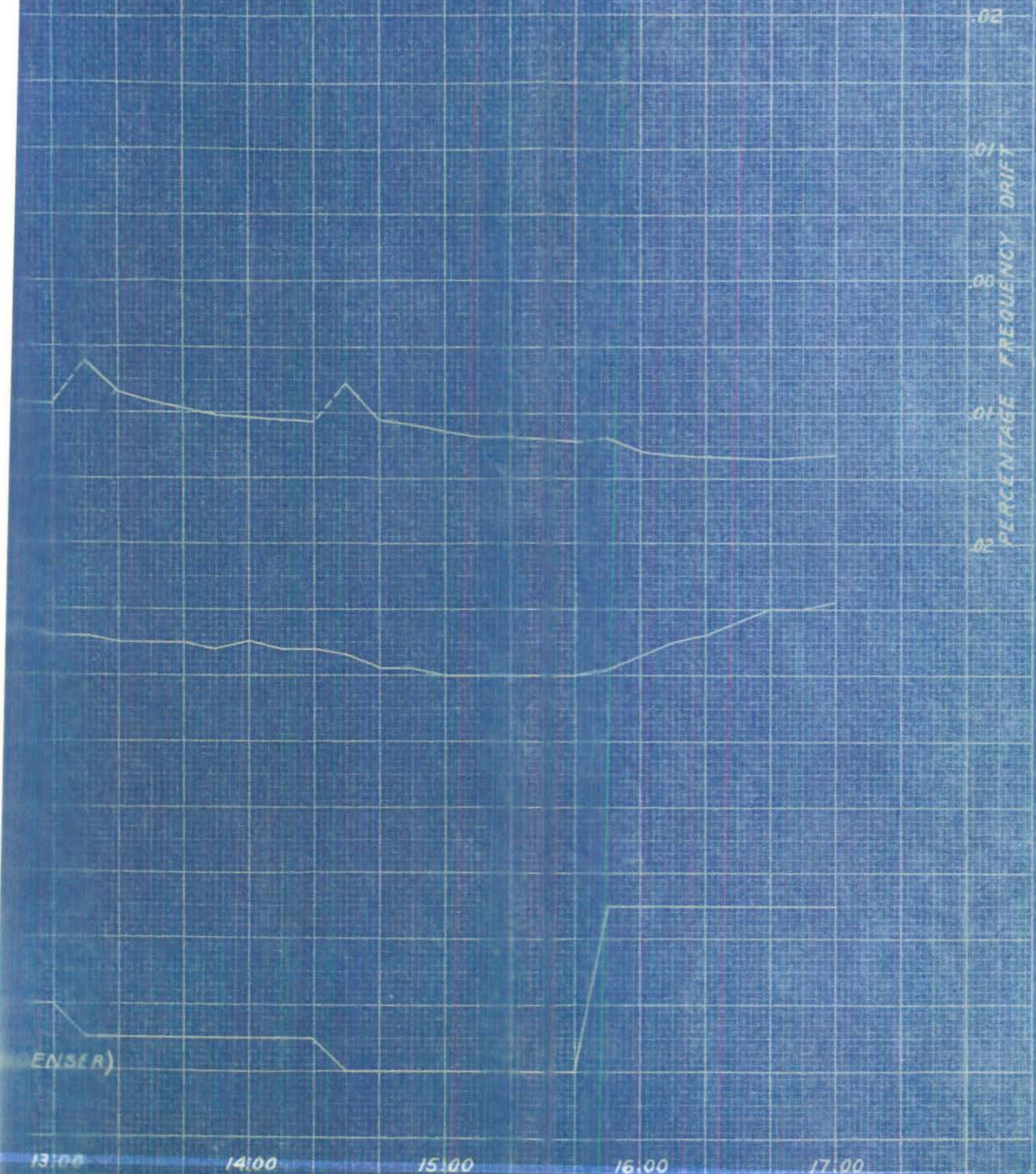
15:00

16:00

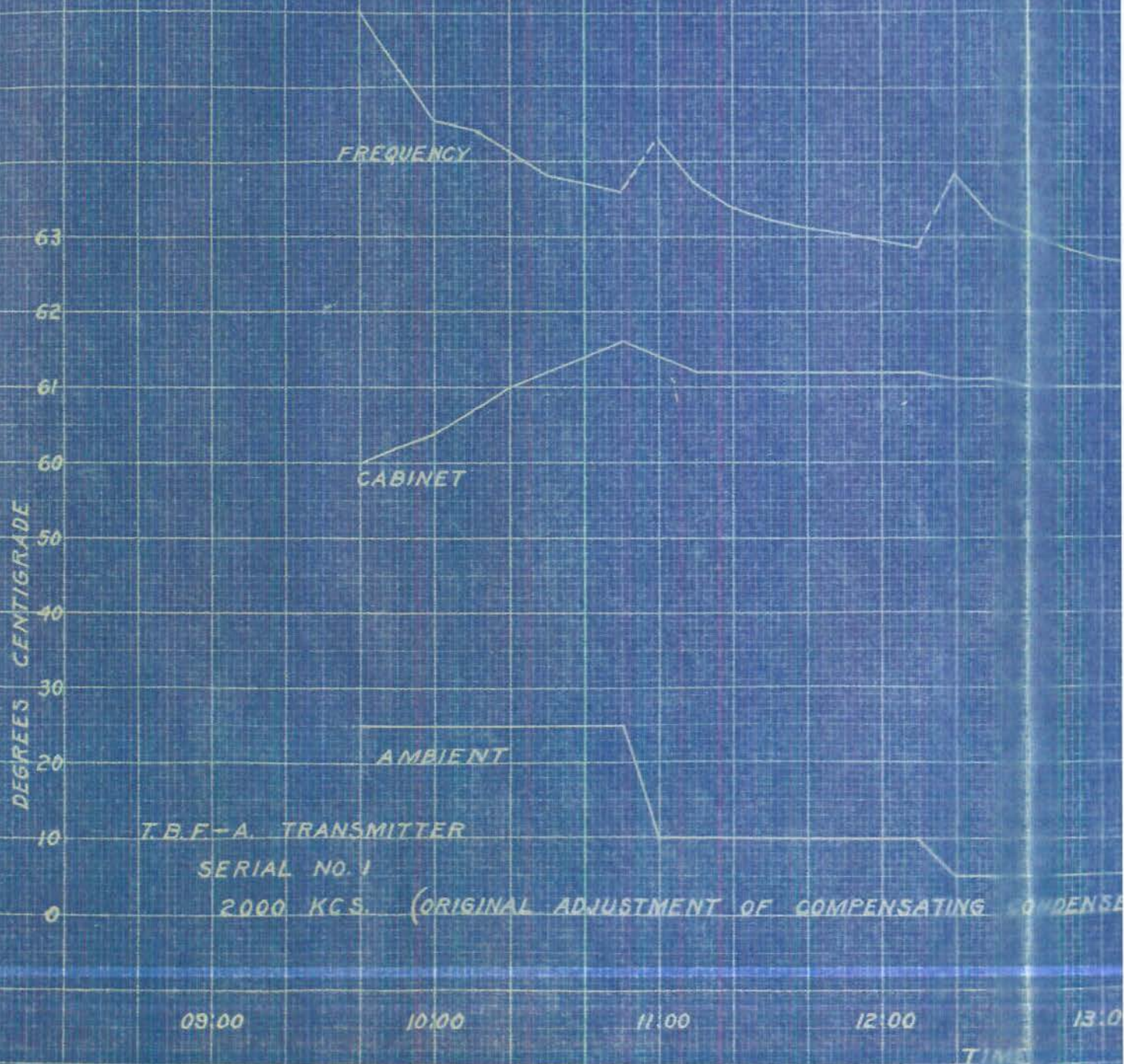
D-1



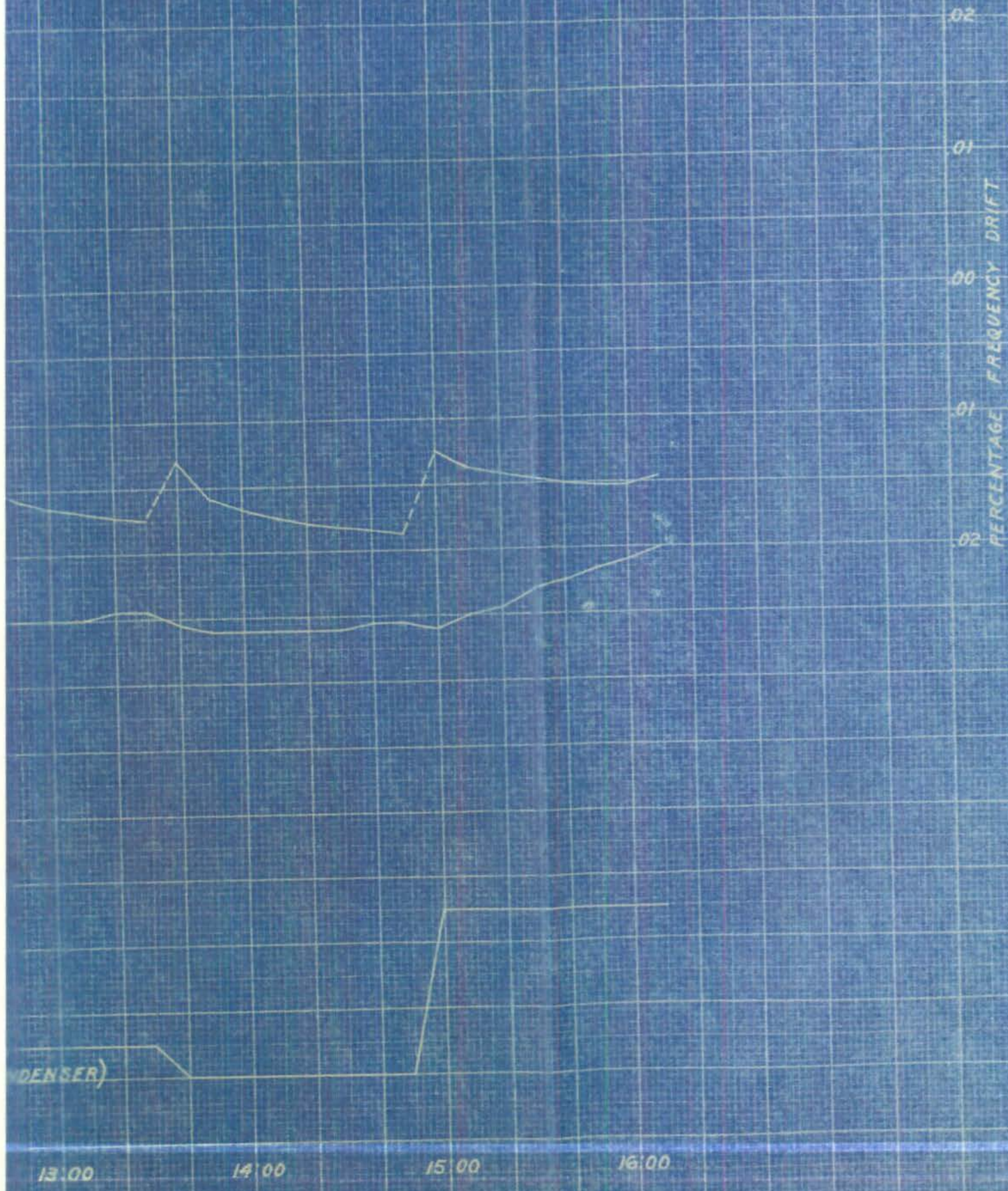
D-2



E-1

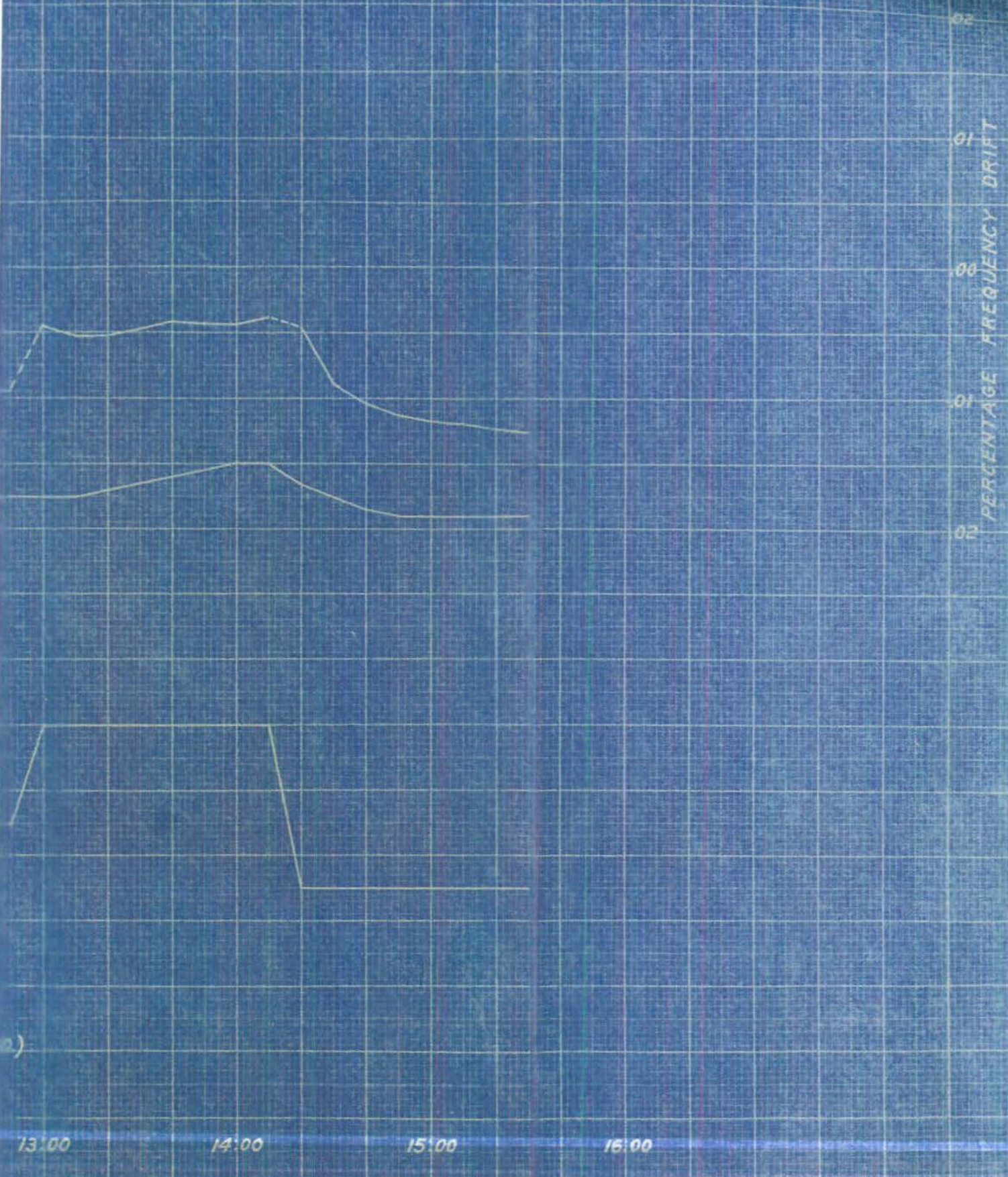


E-2

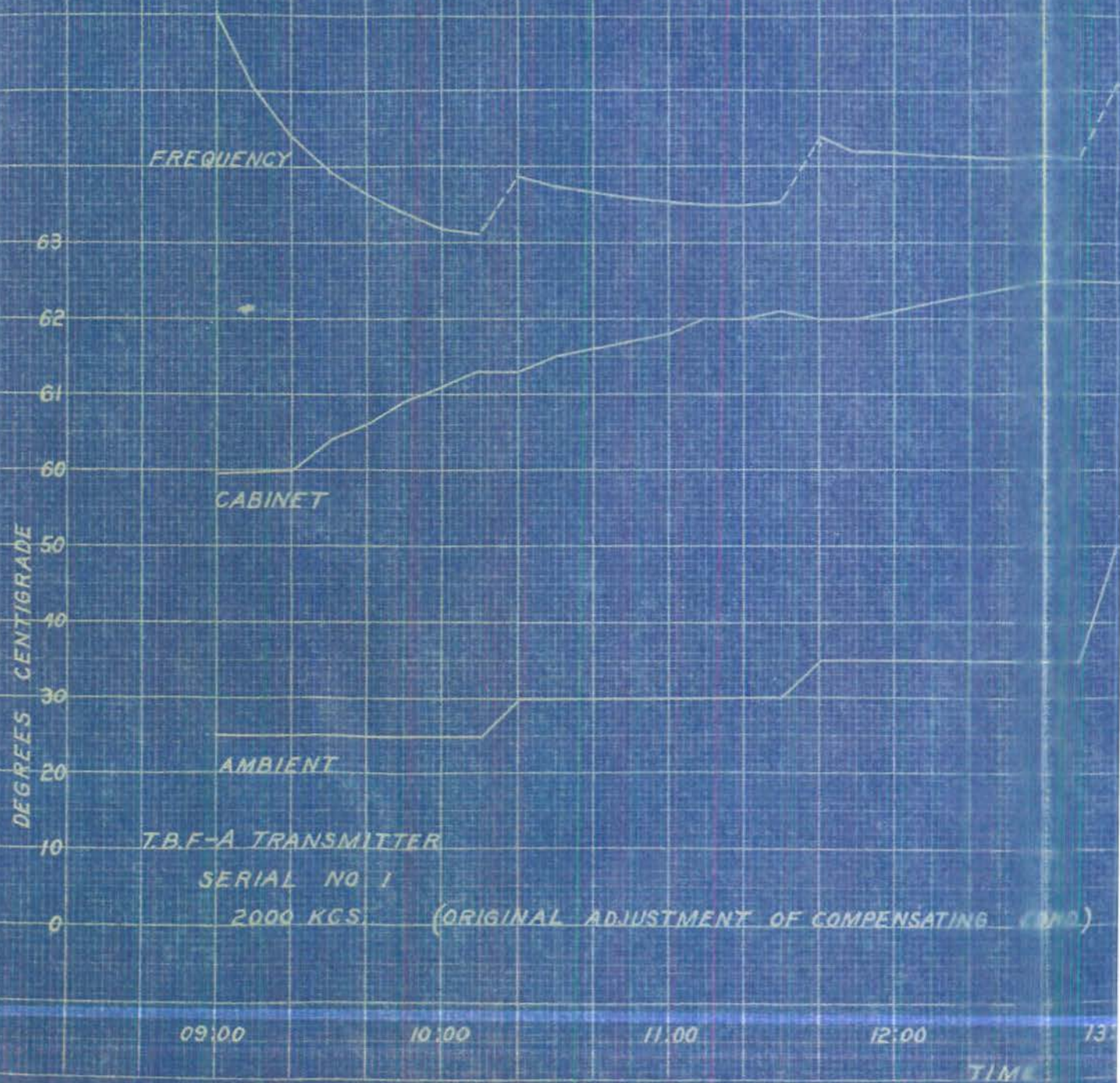


(CONDENSER)

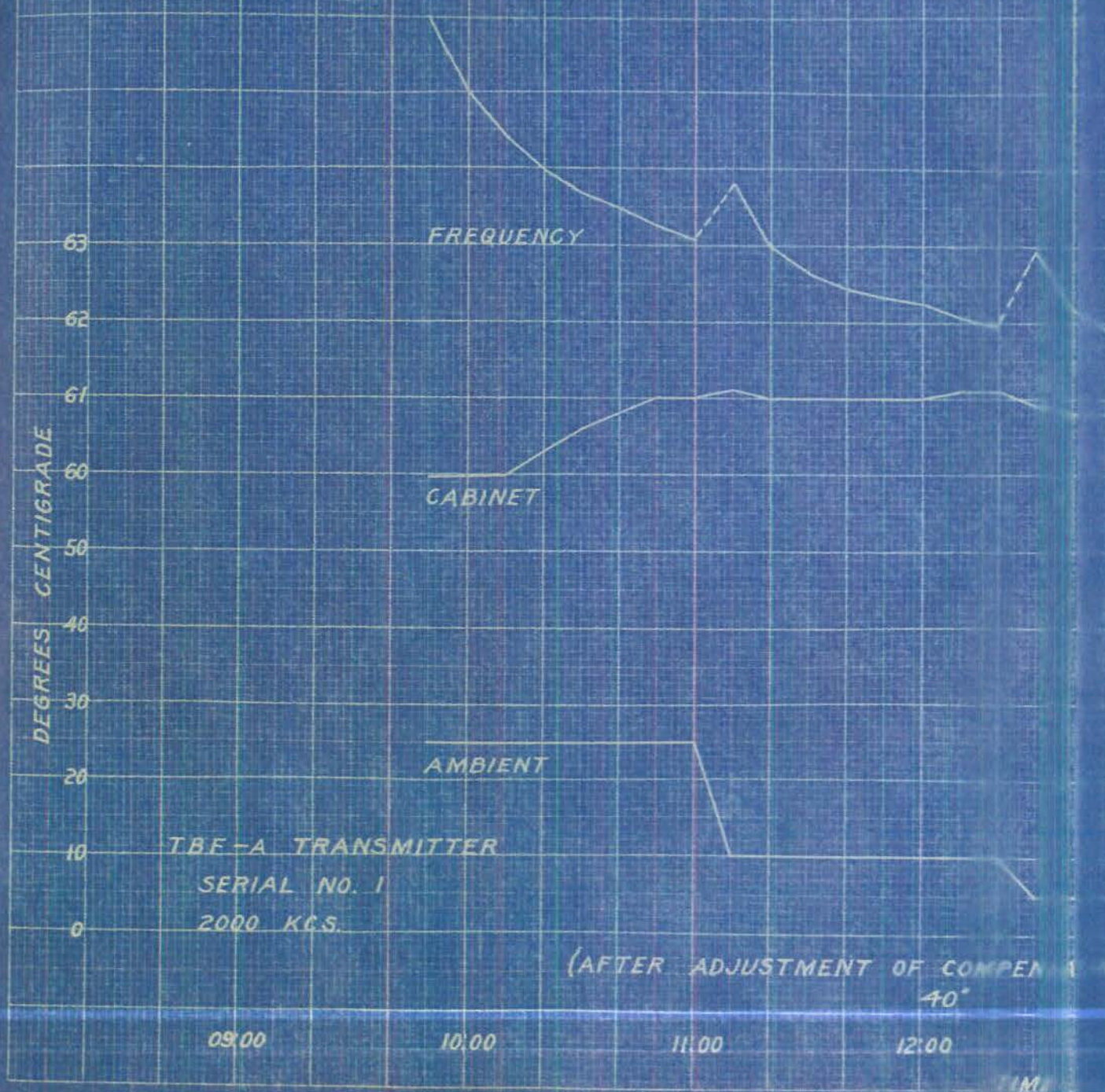
F-1



F-2



G-1



C-2

02

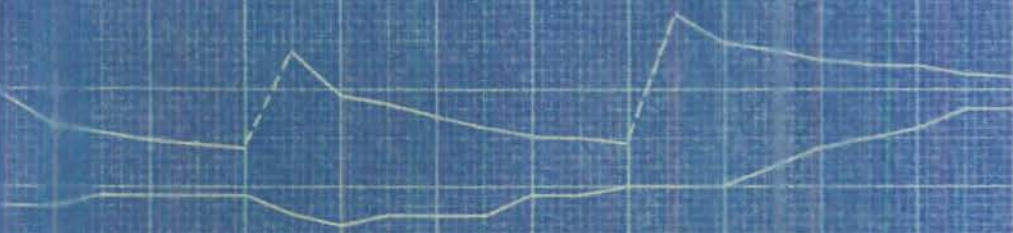
01

00

01

02

PERCENTAGE FREQUENCY DRIFT



NG CONDENSER)

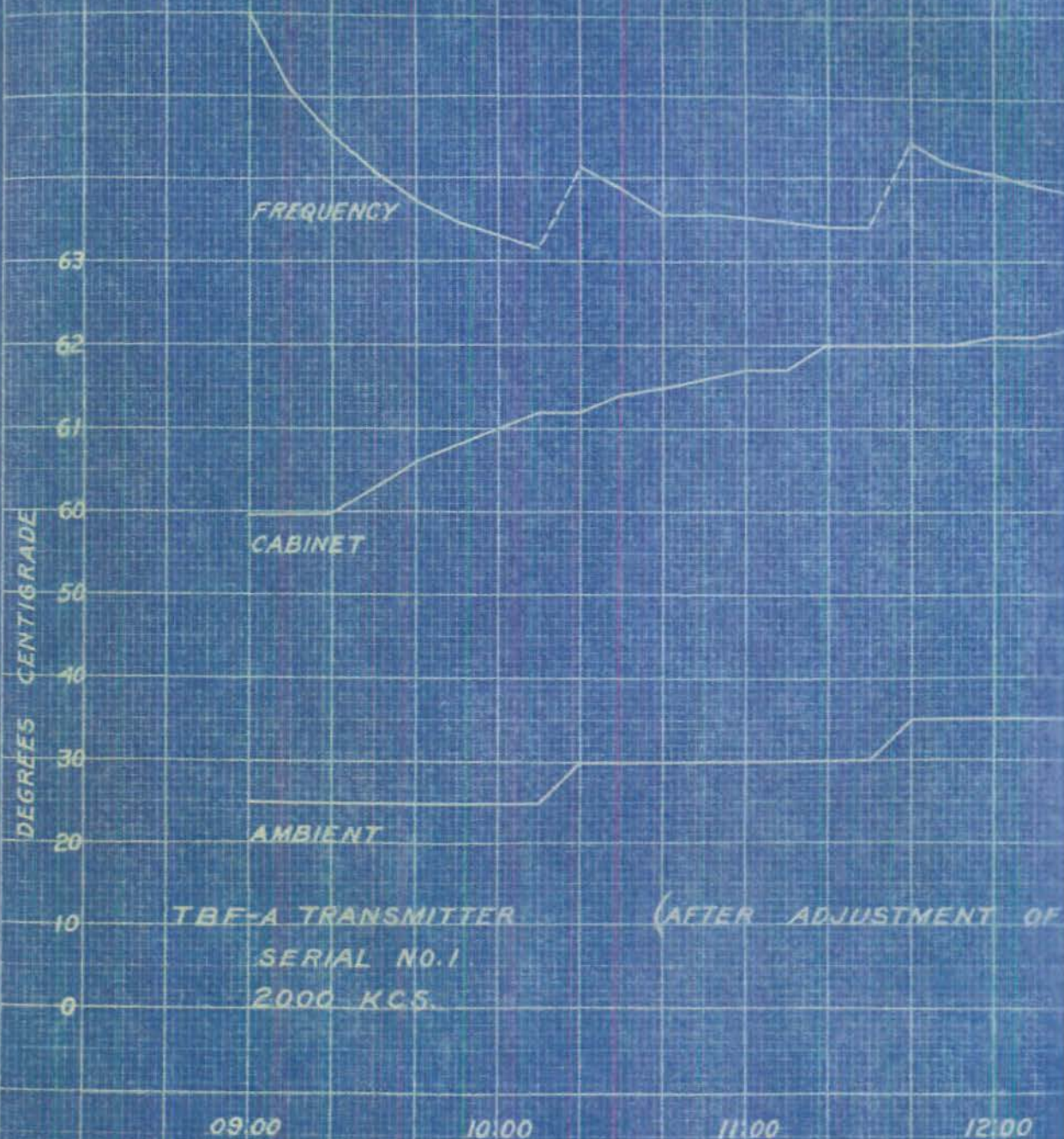
13:00

14:00

15:00

16:00

H-1



H-2

02

01

00

01

02

PERCENTAGE FREQUENCY DRIFT

ATING CONDENSER 40)

13.00

14.00

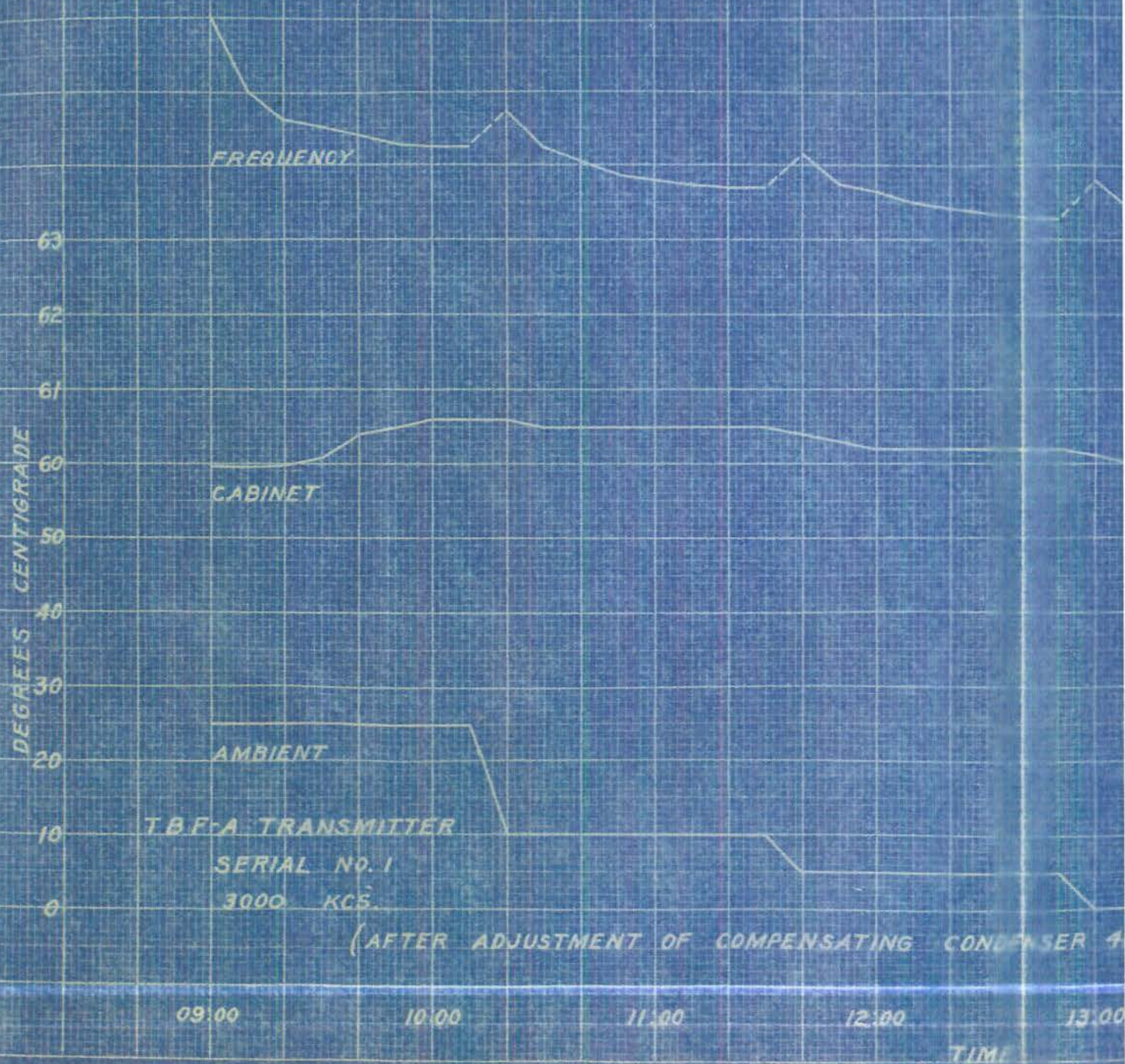
15.00

16.00

KEUFFEL & ESSER CO. N. Y.

PLATE 8

I-1



I-2

02

PERCENTAGE FREQUENCY DRIFT

01

02



SER 40)

13:00

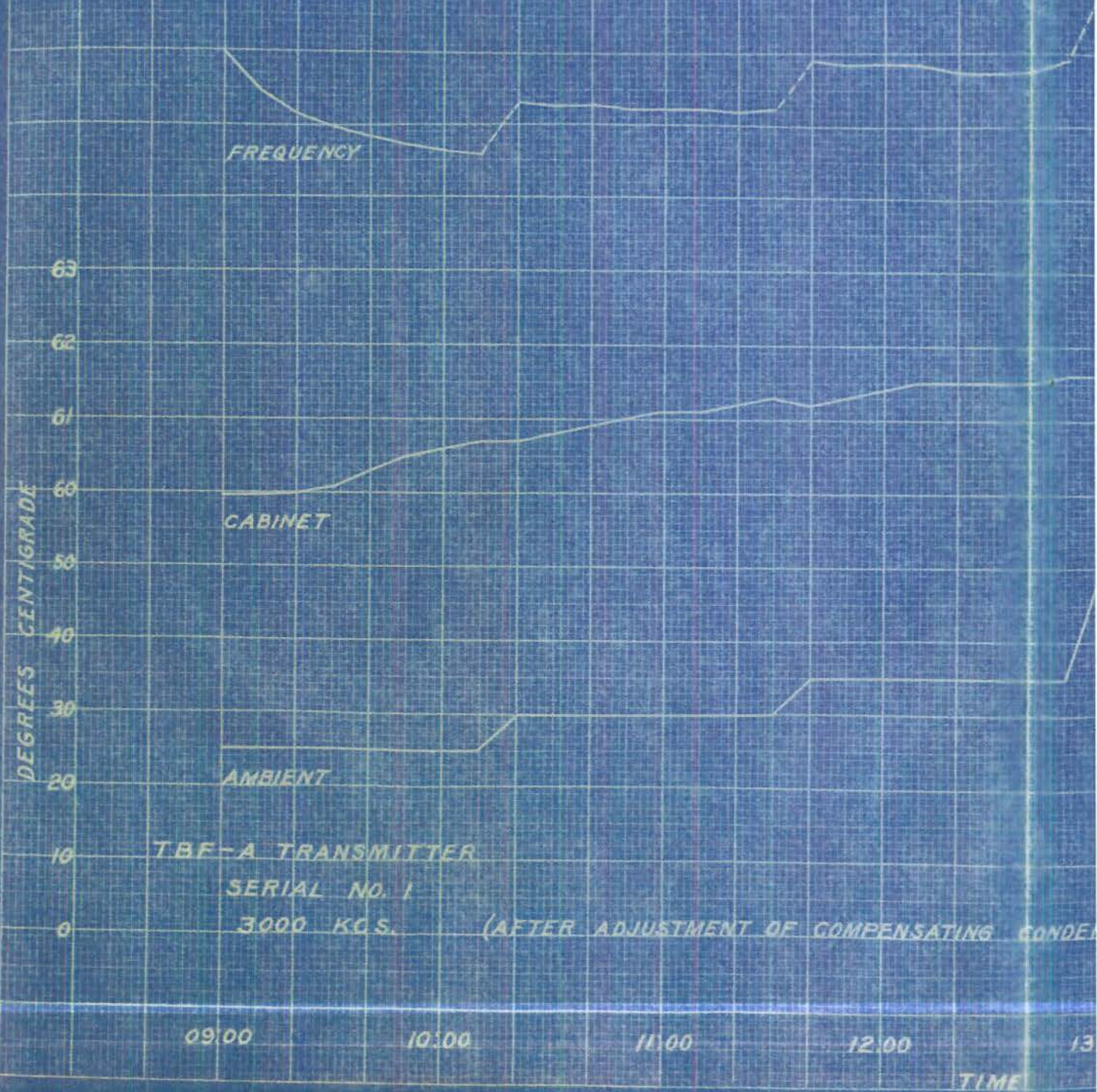
14:00

15:00

16:00

PLATE 5

J-1



J-2

02

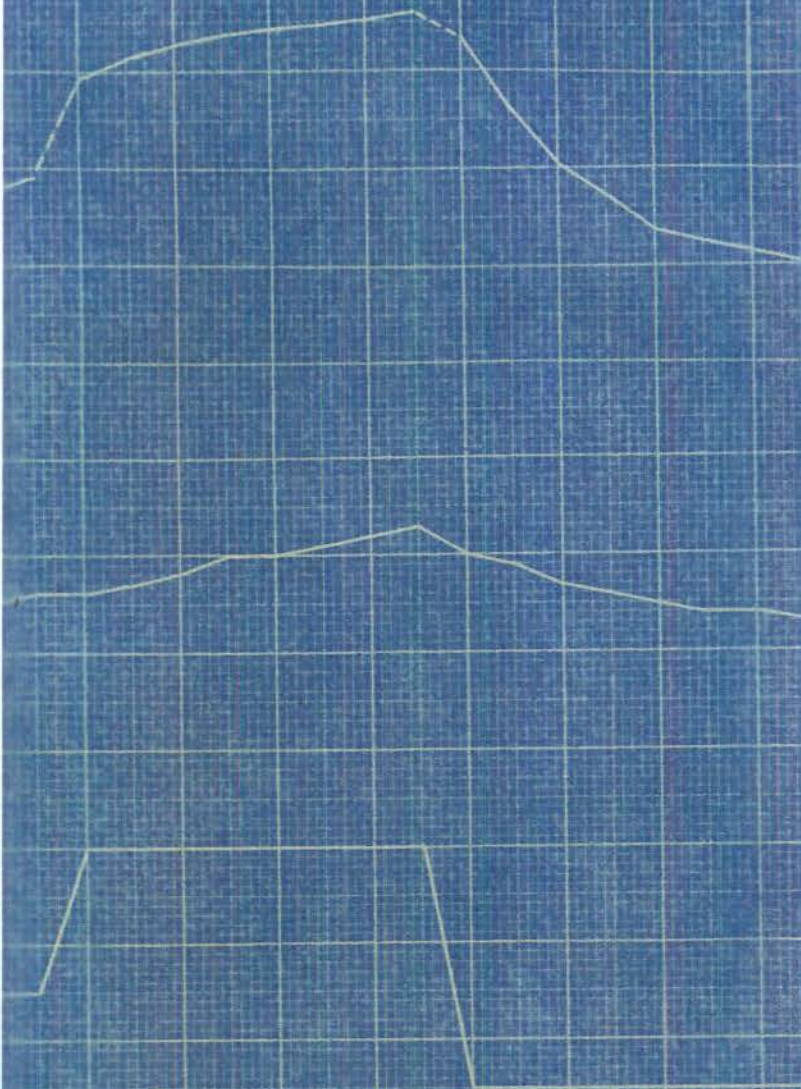
01

00

01

02

FREQUENCY DRIFT
PERCENTAGE



CONDENSER 40°)

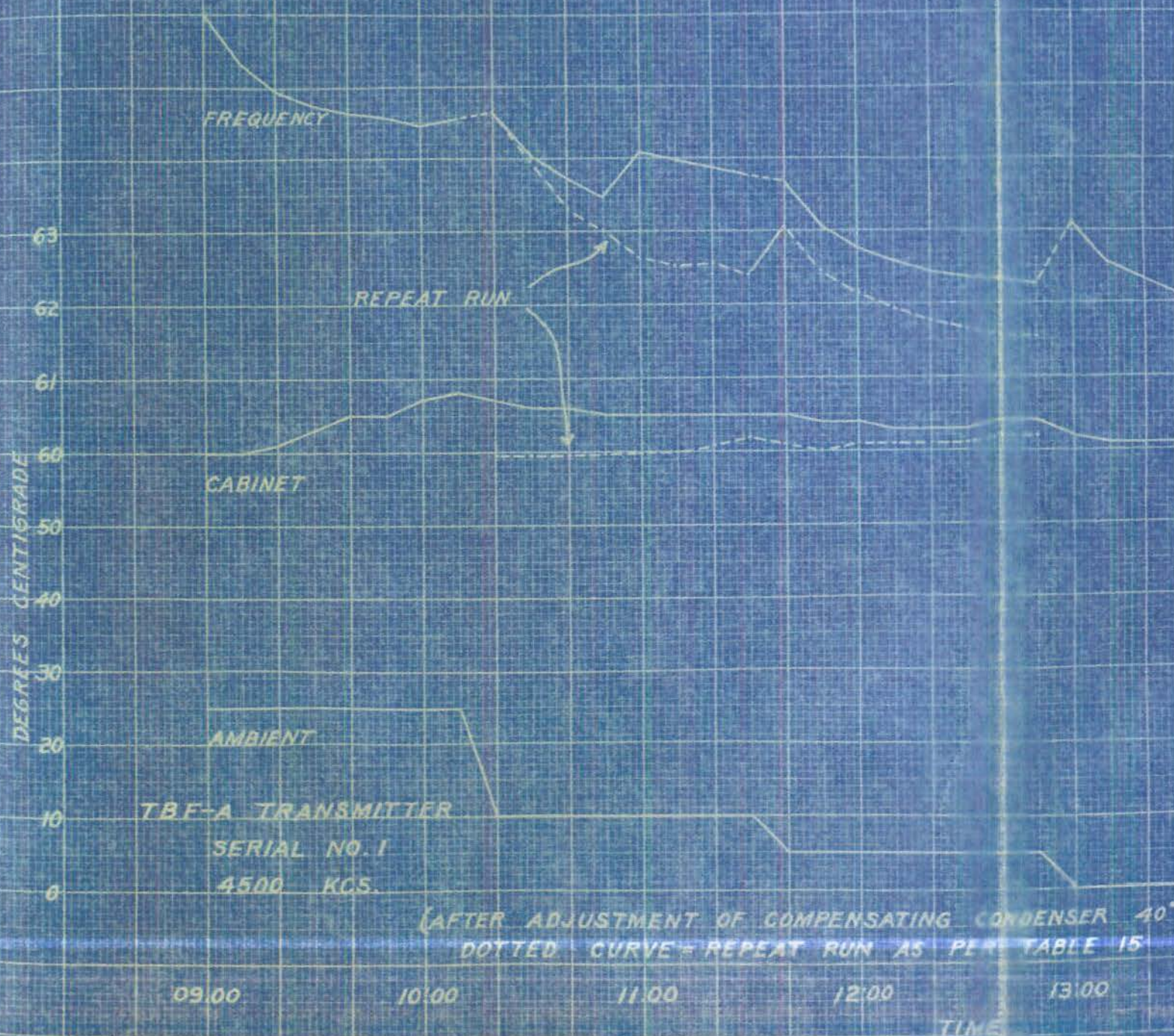
13:00

14:00

15:00

16:00

K-1



K-2

02

01
00
01
02
PERCENTAGE FREQUENCY DRIFT

02

SENSOR 40°
TABLE 15

13:00

14:00

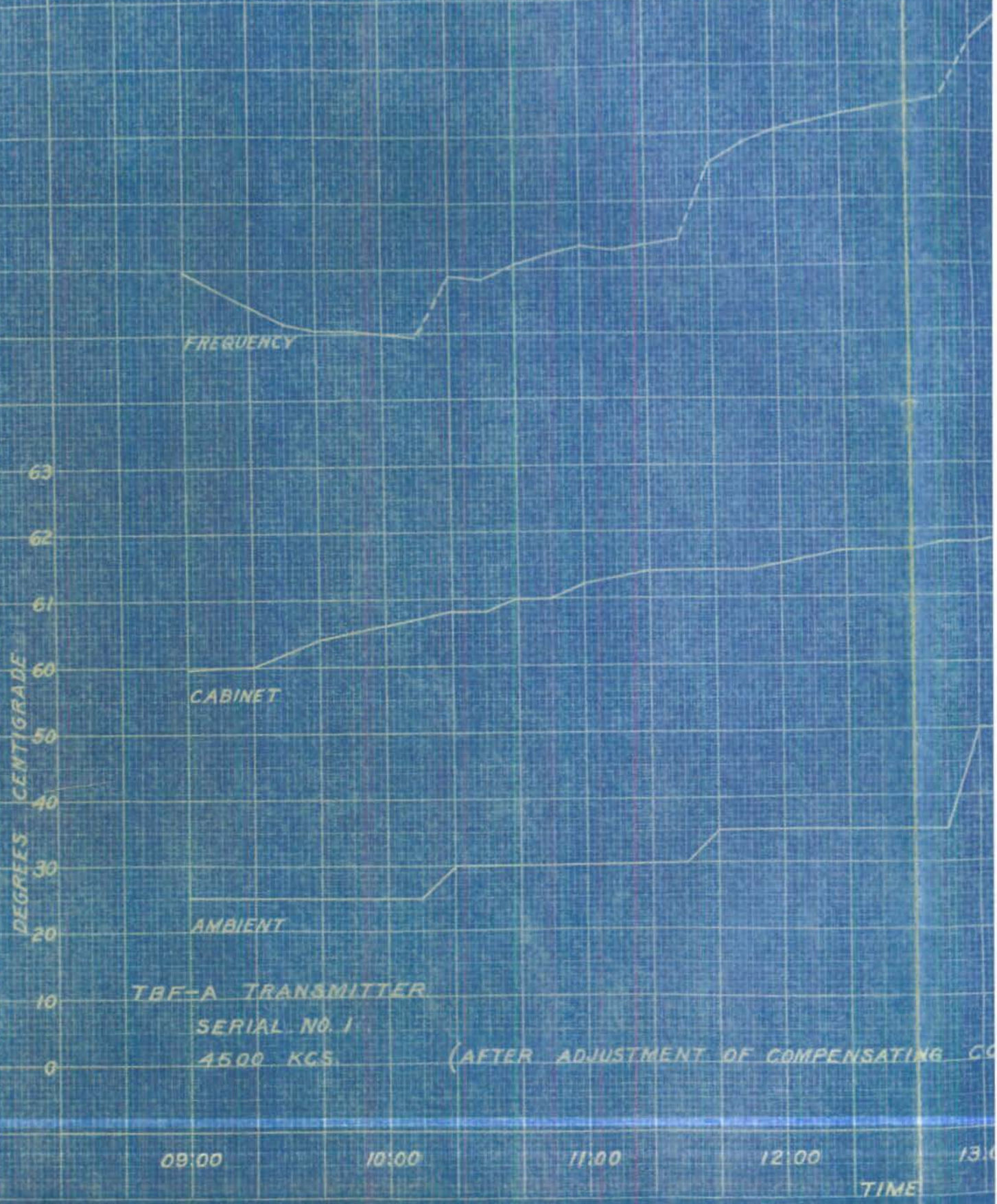
15:00

16:00

KEUFFEL & ESSER CO. N. Y.

PLATE 11

L-1



FREQUENCY

CABINET

AMBIENT

TBF-A TRANSMITTER

SERIAL NO. 1

4500 KCS.

(AFTER ADJUSTMENT OF COMPENSATING CO

09:00

10:00

11:00

12:00

13:00

TIME

L-2

PERCENTAGE FREQUENCY DRIFT

02

01

00

01

02

16 CONDENSER 40°

13:00

14:00

15:00

16:00

WEUFFEL & ESSER CO. N. Y.

PLATE 12