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Report on

Test of Model TAJ-4 Transmitting Equipment

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WASHINGTON, D. C.

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AUTHORIZATION OF TEST

1. The tests herein reported were authorized by reference (a). Other pertinent data used in connection with these tests are listed as references (b) to (e).

Reference: (a) BuEng let.NOs-31197(6-13-W8) of 18 June 1934.
(b) Specifications RE 13A 328G.
(c) RCA Victor Company descriptive specification AS-GL-27A
(d) Contract NOs-31197 of 3 March 1933.
(e) RCA Type Test Data Report on TAJ-4 Transmitter, Serial No. 1.

OBJECT OF TEST

2. The object of the test was to determine detailed compliance with the requirements of the applying contract specifications and the presence of desirable features over and above specific requirements.

ABSTRACT OF TEST

3. The tests herein reported were conducted to determine the degree of compliance of the Model TAJ-4 transmitting equipment with the mechanical and electrical requirements set forth in reference (b). Tests to determine frequency stability and accuracy under the following conditions were undertaken:

(a) Variation due to "Adjust-Tune-Operate" Switch.

(b) Effect of detuning P.A. and Antenna Coupling circuits.

(c) Effect of varying antenna constants 25%.

(d) Reset accuracy.

(e) Effect of changing tubes.

(f) Variation of line voltage.

(g) Test for lost motion and back lash.

(h) Variations in ambient temperature.

(i) Control of power output.

(j) Emergency operation.

4. Power output determinations were made at various frequencies within the range of the equipment with various combinations of antenna constants.

5. The power required from the supply lines was determined for various conditions of operation and the efficiency and character of the output of the rectifier equipment was checked.

6. The quality of emission was observed locally and particular attention was given to the various types of emergency operation of which the equipment is capable.

CONCLUSIONS

(a) The Model TAJ-4 is a rugged set which displays good workmanship. Good materials have been used in its construction and adequate shielding has been provided. The appearance is neat and symmetrical and the operation is simple. Parts have been marked in a legible manner to simplify servicing operations and adequate access has been provided to tubes and other items needing frequent inspection.

(b) Certain items of construction could be improved. Variable controls should be provided with stops to limit motion; the use of steel could be reduced by constructing such items as hinges, cap screws and covers from non-ferrous metal and additional protection would result from the use of tube protective relays which would operate on currents of smaller magnitude, and the addition of an interlock on the frequency range switch.

(c) The frequency stability of the equipment suffers mainly from the fact that the master oscillator is subjected to varying potentials simultaneously with the power amplifier. The use of a fixed plate potential on the master tube would improve this condition.

(d) The requirement of uninterrupted service is very likely to be interferred with due to the fact that main line fuses in the rectifier have blown repeatedly for some undiscovered reason.

(e) The power output in the low frequency end of the range in the neighborhood of 175 and 200 kilocycles is somewhat limited. Special tuning precautions must be taken in order to cause the power amplifier to draw full power and in order to obtain the output power required by the governing specifications.

(f) The modifications to reference (d) which incorporated certain provisions with respect to the control circuits of the rectifier unit have been complied with in all details. The result is an exceedingly flexible power source which enables an operator to shift from one rectifier to another in about eight minutes. In order to meet these requirements an additional unit is necessary, namely a junction box, containing the necessary number of terminals, connection links and contactors. This assembly requires 76 separate leads or cables to complete the wiring of the combination TAJ-4 - TBF-1 equipments, and the complete control and protective circuits employ 45 relays and contactors.

(g) There are eleven paragraphs of the specifications which have not been complied with. These are listed in par. 91 of this report.

RECOMMENDATIONS

It is recommended:

(a) That the manufacturer be required to overcome the difficulty which manifests itself in the repeated blowing of the main line fuses to the rectifier unit.

(b) That at least two spare door interlock switches be provided.

(c) That future specifications be so modified as to definitely require hand rails on the rectifier unit.

(d) That future specifications be clarified with regard to the operation desired in connection with the "local-remote" controls.

(e) That future specifications require that provision be made for the immediate availability of a "conditioned" rectifier tube for replacement purposes.

(f) That the Bureau consider the advisability of making provision in existing rectifier equipment for having available a "conditioned" rectifier tube for replacement purposes.

(g) That future specifications require that equipment be provided with fuses of the "refillable" type.

(h) That in future equipment the power amplifier plate voltmeter be so connected that it indicates the actual voltage on the power amplifier tube in the various positions of the "tune","adjust","operate" switch.

(i) That the Model TAJ-4 equipment, Serial No. 8, be considered satisfactory for use in the Naval Service provided the defects as noted in par.91 of this report be corrected by the manufacturer. Of these defects the fault of the rectifier which manifests itself by blowing of main line fuses is the most important.

MATERIAL UNDER TEST

7. The material under test consisted of one complete Model TAJ-4 Transmitting Equipment, Serial No. 8, and Rectifier Unit, Serial No.8. This equipment is so designed that through the medium of a Junction Box (Serial No.8) it is capable of being operated in conjunction with Model TBF-1 transmitting equipment. Normally the TAJ-4 transmitter is operated from its own rectifier unit and the TBF-1 transmitter is operated from its own rectifier unit. For emergency operation it is possible to select the following modes of operation:

(a) TAJ-4 and TBF-1 transmitters both operated from the TAJ-4 rectifier.
(b) TAJ-4 and TBF-1 transmitters both operated from the TBF-1 rectifier.
(c) TAJ-4 transmitter operated from the TBF-1 rectifier.
(d) TBF-1 transmitter operated from the TAJ-4 rectifier.

8. The Model TAJ-4 equipment was manufactured by the RCA Victor Company under Contract NOs-31197 and covers the frequency range of 175 kilocycles to 600 kilocycles. The equipment operates on a 230 volt, 60 cycle, 3 phase supply and is nominally rated at 500 watts output. The equipment was received at the Naval Research Laboratory on 14 June 1934.

METHOD OF TEST

9. 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.

10. 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.

11. Power output determinations were accomplished at various frequencies through the use of dummy antennas.

12. Frequency changes and drifts were checked by means of the Model LH visual frequency indicating equipment, the transmitter being operated at full power output whenever the governing specifications required this method of operation.

13. Determinations of the effect of change in ambient temperature were made at full power output over the temperature range of zero to 50°C. The temperature control facilities of the U.S. Bureau of Standards were utilized for these tests; frequency observations being taken on the Model LH equipment. The key of the transmitter was opened during the period while the temperature was being changed, the key being locked for one hour and ten minutes in order to permit the apparatus under test to reach temperature equilibrium.

14. Input power checks were made by the two wattmeter method. The efficiency of conversion was determined from input measurements made by the two wattmeter method and output measurements calculated from d.c. voltmeter and ammeter readings.

15. Keying records and ripple determinations were made through the use of a recording oscillograph.

16. Model RAA receivers were used in the tests for determining the quality of emission.

17. The K/C change per division of master oscillator dial marking and the frequency range and overlap determinations were accomplished through the use of a crystal controlled calibrator.

DATA RECORDED

18. Complete data was recorded on all tests conducted and this information is contained in Tables 1 to 25 and Plates 1 to 6 appended hereto.

PROBABLE ERROR IN RESULTS

19. Every effort was made to eliminate errors in the results obtained during the tests recorded herein. The visual frequency measuring equipment used to determine shifts or changes in frequency has been repeatedly checked and has been shown to be accurate to within 1 or 2 cycles in 1,000,000.

20. The kilocycles per division of marking of the master oscillator circuit were determined through the use of a crystal controlled calibrator whose accuracy is greater than 0.001%.

21. Power output determinations were made with extreme care. The dummy antenna resistors used were carefully measured at radio frequencies and it was determined that the value of the resistors does not vary over 1% in the frequency range covered by the TAJ-4 equipment. Low loss condensers were used whose resistance was found to be negligible at the frequencies involved. Rechecks of power determinations were made in order to coincide with suggestions made by the manufacturer of this equipment. The manufacturer suggested a slightly different method of tuning than that usually employed in the Naval Service. The results of both methods were recorded.

22. The r.f., 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.

23. Before making tests to determine the ripple voltage in the output of the rectifiers, the recording oscillograph was carefully calibrated by means of an accurate audio oscillator and output voltmeter. A check of this nature was made previous to each test.

24. Due to the difficulty in making radio frequency measurements of resistance and capacity of absolute accuracy, power output determinations which fell within 10% of the specification requirements are considered as meeting the specifications. A factor of this magnitude is believed to cover any discrepancies which might result from r.f. measurements whose accuracy cannot be guaranteed closer than 5% and will also take into account the fact that an ammeter placed in the ground side of the dummy antenna does not record absolutely all the current which is doing useful work in the dummy antenna.

RESULTS OF TESTS

25. Upon receipt of the Model TAJ-4 equipment it was noted that extreme care had been exercised in packing to safeguard the material during shipment. Special provisions were made to facilitate withdrawal of heavy units from the packing cases. These units were bolted to skids and could thus be removed from the case without difficulty. Extremely heavy items, such as transformers, reactors, etc., had been removed from the rectifier and boxed separately. Items, such as capacitors and inductors which are mounted in the transmitter by means of Isolantite insulators had been protected during shipment by removing the insulators and substituting therefore wooden blocks with through bolts. Complete instructions were provided as to the proper methods to be used for reinstalling each item in its respective location.

26. The only evidence of breakage noted was in connection with one of the interlock switches on the junction box. The metal tab by means of which this switch is secured to the frame had been broken off and the porcelain insulation within the switch had been cracked. It is possible that this injury resulted during the process of packing rather than during actual shipment, since the packing itself revealed no signs of injury. It was necessary to repair the switch by welding and cementing, since no spare switches were provided. The TBF-1 - TAJ-4 equipment is provided with ten of these interlock switches and it is believed that at least two spares should be provided as breakage can and is likely to occur as demonstrated when this shipment was received. Upon placing the transmitter into commission it was found that one of the flexible leads to the rotor of the P.A. variometer had not been connected. This apparently was an oversight which may have occurred at the time the equipment was being prepared for shipment.

27. In the following paragraphs of this report, reference is made to the governing specifications RE 13A 328G 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 fully with this paragraph and that no further explanatory remarks are considered necessary.

28. Section I. The Model TAJ-4 transmitting equipment meets the general scope of the introductory section of the specifications.

29. Par.2-3. The Model TAJ-4 transmitter is of rugged construction, and good materials have been used in its construction. Certain details of construction, however, can be improved and these are referred to in paragraphs 33, 36, 37, 61, and 62 below.

30. Par.2-4. The equipment reflects the results of good workmanship, but again it is desired to point out that improvements are possible, as listed in paragraphs 33, 36, 37, 61 and 62 below.

31. Par.2-5. The equipment operates over the range of temperatures from zero to 50°C without any signs of breakdown. The Model TAJ-4 equipment was subjected to variations in ambient temperature between the limits of zero and 50°C. The changes were made in steps of 5, 10, 15 and 25°. Tables 15 and 16 list the actual data obtained during these tests. Plates 1 and 2 show this data in graphic form, while Table 17 summarizes the information listed in Tables 15 and 16. It will be noted that frequency change per degree change in ambient temperature varies considerably. In the temperature range of 30 to 35° the temperature coefficient per degree is 0.0018% while in the range between 10 and 5°C the temperature coefficient per degree is 0.011%. In general, larger frequency changes occur in the temperature ranges below 25°C than in the ranges above 25°. All measurements were made at a frequency of 500 kilocycles. It should be remembered that the Model TAJ-4 equipment is not provided with temperature control facilities. The governing specifications do not state the permissible shift in frequency due to temperature changes. It is required that a change of 5° in ambient temperature when added to the frequency changes resulting from all the other factors listed under paragraph 3-9 of reference (b), shall not cause a frequency shift greater than 350 cycles. The actual frequency change per five degrees change in temperature varies over the temperature range, running from 223 cycles to as low as 45 cycles.

32. Par.2-6. Precautions have been taken to prevent corrosion; all exposed metal parts have been painted black or have been provided with a metallic plating of corrosion resisting qualities.

33. Par.2-7. Steel or iron has been used in certain items of construction where it would have been possible to utilize other metals such as brass or aluminum. Transmitter panels have been secured to the frame by means of steel cap screws and steel hinges were used to secure the door of the rectifier, although brass hinges were used on the transmitter unit. The enclosing covers of the interlock switches are steel and the junction box is constructed from sheet steel.

34. Par.2-8. Liberal use has been made of Isolantite and Micalex insulation, while phenolic insulation has been used only in such applications where its use does not constitute a hazard.

35. Par.2-9. The use of wood has not been employed in the construc- of this equipment.

36. Par.2-10. The design of the electrical circuits and controls is liberal. Overload protection has been provided in the main line supply to the rectifier, in addition to fuses. In this connection it is pointed out, however, that during the tests the main line fuses blew frequently and in several instances the main line circuit breakers opened. The overload relays are set to take care of the load which results when both the TAJ-4 and TBF-1 transmitters are operated from a single rectifier. The maximum current drawn from any one terminal of the 3-phase line under this condition is approximately 22 amperes. The main line switch is fused for 30 amperes. However, these fuses would blow when only the TAJ-4 transmitter was acting as a load and in some instances the fuses failed while the key of the transmitter was open. The failure of the fuses was of such a spasmodic and irregular nature that no reasons for these failures could be discovered. Rectifier tubes were tested since it was believed that these tubes might be causing the difficulty, but all tubes tested appeared to be normal and satisfactory. Inspection revealed no faulty insulation or defective items, such as capacitors, reactors or resistors. This action was observed by representatives of the manufacturer, but at the time they could offer no solution of the difficulty. The fuses supplied with the equipment are of the non-refillable type. It is recommended that future specifications require that refillable fuses be supplied, accompanied by an adequate number of spare fuse links.

37. Par.2-11. The vacuum tube protective relay would not function on any value of plate current obtainable by detuning the power amplifier. By means of an external rheostat and 110 volts, d.c., it was determined that the current necessary to trip the overload is 700 milliamperes. Investigation showed that no further adjustment beyond about one turn was possible and at this setting the relay tripped at slightly less than 700 milliamperes. It was noted that the five second drop out relay fails to restore the transmitter to an operative condition immediately after opening the key. A momentary wait is necessary to allow this relay to return to its normal position after it has operated.

38. Par.2-12. Satisfactory provision has been made to prevent personnel from accidentally coming in contact with dangerous potentials. The only difficulty experienced in this connection was the fact that one of the interlock switches in the junction box was received in a damaged condition and no spares had been provided to meet such a contingency.

39. Par.2-13. Numerous tests indicate that the ventilation of the TAJ-4 is adequate both in the rectifier and in the transmitter, although no fan is provided, dependence being placed upon natural circulation through the perforated shields.

40. Par.2-15. The equipment was subjected to a two hour locked key test at full power without overheating or any damage occurring. In addition, the equipment was keyed at the rate of 100 words per minute without showing any signs of brush discharge, corona, or sparking. An oscillographic record of the keying is shown in Plate 3. Table 1 is a record of the two hour locked key test.

41. Par.2-16. Table 2 shows the results of short circuiting and open circuiting the antenna. At 600 kilocycles there was a slight rise in plate current both when the antenna was opened and when it was shorted, but it was not of dangerous proportions. At 175 kilocycles the plate current fell off slightly from the normal value when the antenna was opened and shorted. The equipment meets the requirements of this test.

42. Par.2-17. The vacuum tubes incorporated in this equipment operate within the limits laid down in Navy tube specifications.

43. Par.2-19. No facilities were available to conduct this test but it is believed that the equipment will operate satisfactorily afloat when subjected to the roll and pitch of a vessel.

44. Par.2-20. Although no definite test could be conducted to simulate the vibration and shock encountered afloat, it is believed the equipment will satisfactorily operate under such conditions. Lock washers have been provided where their use is desirable and necessary.

45. Par.2-21. All vacuum tubes and other delicate devices are cushioned with "Lord" flexible mountings.

46. Par.2-23. All indicating devices and controls are located on the front panel and are suitably marked for identification and operation.

47. Par.2-24. The requirements of this paragraph are complied with except that the lever of the test key is bare metal and it would be possible for an operator to receive a burn from stray high frequency fields.

48. Par.2-32 and 2-33. The dimensional and weight limitations of these paragraphs have been complied with.

49. Par.2-35. All resistor mountings have been suitably marked to indicate Navy type number and value of resistance. All relays have been similarly marked with the exception of the key relay and the contactors in the junction box.

50. Par.2-36. The use of "Lord" mountings makes it easy to quickly substitute new mountings for the old should this action become necessary.

51. Par.3-1. The tubes and circuits used in the Model TAJ-4 transmitter comply with the requirements of this paragraph.

52. Par.3-2. This paragraph specified the type of antennas into which the equipment must operate satisfactorily. Tests were conducted to determine the power output under these conditions and the results are shown in Tables 3 to 8 inclusive. Subsequent to the tests listed in Tables 3, 4, and 5, the Laboratory was advised by representatives of the RCA Victor Company that if a somewhat different method of tuning

were employed, the power output of the transmitter could be increased. This suggestion is based on theoretical considerations which indicate that when resonating a circuit by means of inductive tuning it does not necessarily follow that resonance is indicated by the plate current "dip". but that actual resonance may occur on one side of the plate current "V" or "dip". It was also pointed out to the Laboratory that since a resistor is employed in the TAJ-4 transmitter, connected in the negative plate return for biasing purposes, that the potentials indicated on the voltmeters supplied with the transmitter and rectifier units do not indicate the actual voltage applied to the power amplifier tube, since these meters fail to take into account the drop across the biasing resistor. The drop across this biasing resistor was measured at full power output and was found to be 57 volts. Therefore, the plate voltage indicated by the voltmeters is actually 50 to 60 volts in excess of the actual voltage.

53. Taking these points into consideration, a second series of power output tests were conducted. The results of these tests are listed in Tables 6, 7, and 8. It will be noted that in each case two tests were conducted on each frequency, one test being conducted on Rectifier Tap 5 and the other on Rectifier Tap 6. The line voltage available at the Naval Research Laboratory generally runs between 220 and 222 volts, while the normal voltage for the equipment is specified as 230 volts. Thus Tap 5 generally produces a potential somewhat less than 3,000 volts, and approximately normal voltage, 3,000 volts, is obtained on Tap 6, taking into account the drop over the bias resistor. Therefore, the tests conducted on Tap 6 coincide more accurately with maximum operating conditions.

54. Referring to Table 3, Column 1, and Table 4, Columns 1, 2, and 3, it will be seen that full amplifier plate current of 350 milliamperes could not be drawn, even on Tap 6 of the rectifier, when the dip in power amplifier plate current was used as the guide for resonance. Referring to Table 6, it will be noted that 350 milliampere plate current was drawn under all conditions, either on Tap 5 or 6, when the power amplifier was resonated slightly off the plate current dip. At frequencies above 300 kilocycles, 350 milliampere plate current can be drawn when either method of tuning is utilized; i.e., when the plate current dip is utilized for indicating resonance or when resonance is assumed to occur slightly to one side of the plate current dip.

55. In summarizing the results of the power output determination tests it may be stated that if the assumption advanced in paragraph 24 of this report is allowed; namely, that power output measurements which fall within 10% of the specified amount are accepted as meeting the requirements of the specifications, that if tuning at the lower frequencies may be accomplished by resonating the circuit slightly off the plate current dip, and if the drop across the biasing resistor is subtracted from the voltmeter readings, the Model TAJ-4 transmitter meets the requirements of paragraphs 3-2 and 3-3 of reference (b) and also complies with the output guaranteed by the manufacturer in reference (c).

56. Par.3-4. No attempt was made to measure harmonic output since with the measuring equipment available only comparative results could be obtained which would hold only for a particular frequency and at a given angle and distance from one particular antenna. Key clicks were observed and appear to be of the same nature as those observed in connection with other transmitters of similar characteristics. Tests were conducted to determine the quality of emission of the TAJ-4 transmitter and to determine the interaction of the TBF-1 when both sets were operated from one rectifier. With the key locked on the TAJ-4 a slight interaction from the TBF-1 could be detected when the latter was keyed, but in all cases the interaction was so slight that the keyed signals of the TAJ-4 were entirely satisfactory for communication purposes. The TAJ-4 produces an excellent note, free from lilt and spurious oscillations. Table 9 covers the results of tests conducted in conformity with this paragraph.

57. Par.3-5. Table 10 gives a summary of the operation of the TAJ-4 transmitter on MCW. It will be noted that the equipment meets the requirements of this paragraph with the exception that the power output at 175 kilocycles when operating MCW is reduced 52% from the CW condition, while the specifications limit the reduction in power to 40%.

58. Par.3-8 and 3-9. The results of tests conducted in conformity with these paragraphs are contained in Tables 11, 12, 13, 14, 15, and 16, while Table 18 summarizes the tests. Table 17 is a summary of the temperature tests, the results of which are listed in detail in Tables 15 and 16. The specifications require that a frequency shift of 350 cycles shall not be exceeded from the causes enumerated in paragraph 3-9. No limit is placed upon the frequency shift resulting from a single cause, but as will be seen from Table 18, the total variation from all the causes listed exceeds the limits of the specifications. The total overall shift noted is 440 cycles. The greatest shift occurs when the power output was varied between the limits of 100% and 25%, the frequency shift recorded being 246 cycles. This shift is due to the fact that the voltage applied to the master oscillator is supplied by the main rectifier and when the voltage of the power amplifier circuit is varied the voltage of the master circuit varies also.

59. Par.3-11. All tubes cease oscillation when the key is open and satisfactory operation is secured at keying speeds up to 100 words per minute, as is shown in Plate 3 appended hereto.

60. Par.3-12. The frequency range of the transmitter has been divided into three bands and the overlap is satisfactory. It is also possible to make adjustments for frequencies within any band not requiring shifting of the selector switch, with power on the transmitter. However, the band selector switch is not provided with an interlock which will momentarily remove power from the transmitter during operation of the switch. If the switch is changed while the key is locked the contacts of the selector switch arc.

61. Par.3-16. Table 19 is a calibration of the master oscillator circuit which shows that the frequency per division of marking does not exceed 0.05% and that the smallest change is substantially 0.02%. The overlap is satisfactory and the width of any scale division is greater than that required by the specifications. This control, however, does not comply with the requirements of "positive gearing". A form of Geneva movement is employed which operates in such a manner that at certain dial settings it is possible for the coarse adjustment indicator to move without a coincident shift in frequency. If this occurs, the calibration of the circuit is destroyed. In this connection it is also pointed out that controls "B", "C", and "E" are not provided with stops to limit the useful motion of these controls.

62. Par.3-17. Locking devices have been provided on all continuously variable tuning controls. However, the locking device which operates on the master oscillator control is not considered satisfactory. This locking device presents sharp corners and is so located that an operator's hand is subject to injury.

63. Par.3-18. It is possible to reset the transmitter to a previously calibrated setting in less than one man minute and within the limits of accuracy specified. See Table 11. In this connection attention is invited to Table 13-A. This table shows the results of a test conducted at 500 kilocycles in order to determine the amount of lost motion and back lash present in the master oscillator control. It will be noted that the frequency difference between clockwise and counter-clockwise settings is approximately 800 cycles which is greater than the total permitted from all causes listed under paragraph 3-9 of reference (b). It should be pointed out that the major portion of this back lash effect is eliminated if settings are always arrived at from the same direction.

64. Par.3-19. The design of the equipment is such that it is possible to shift from one frequency to any other frequency or from CW to ICW transmission without readjusting the voltages applied to the transmitter.

65. Par.3-20. A three position switch has been incorporated in the design of this equipment to facilitate frequency shifting. The three positions are appropriately marked "Adjust", "Tune", and "Operate".

66. Par.3-21. The test key provided on the panel of the TAJ-4 equipment does not comply with the requirements of this paragraph. A lever type key is provided for the "lock" position, while the momentary contact keying is accomplished by means of a push button. The lever key is fabricated from metal, uninsulated, and is liable to cause burns from stray high frequency fields.

67. Par.3-22. All radio frequency circuits cease to operate when the key is open, so signals which are readable with the transmitter shut down remain readable with power on the transmitter when the key is open.

68. Par.3-24. A three pole, six position switch is provided on the rectifier unit by means of which it is possible to vary the power output of the transmitter while it is in operation. Table 14 covers the details of this test. The requirements of this paragraph are complied with.

69. Par.3-25, 3-26, 3-27. The requirements of these paragraphs are complied with.

70. Par.3-28. Table 20 lists the dimensions of this equipment. The requirements of the specification are complied with, since the fractional excesses noted are due to projecting members which can be removed while the equipment is being handled and should cause no difficulty when the equipment is installed in its alloted location.

71. Par.3-26. The transmitter complies with these requirements. The distance from the lower edge of the terminal board to the deck is 5.75 inches. The specifications require 4 inches and request 6 inches.

72. Par.3-40. A suitable insulated hand rail has been provided on each side of the transmitter, but no hand rails have been provided on the rectifier units. The specifications do not require hand rails on the rectifier, but it is suggested that future specifications be modified to require the use of hand rails on the rectifier units as well as on the transmitter.

73. Par.5-7. The control circuits of this equipment operate in such a manner that the keying relay cannot be energized until the rectifier is in an operating condition, as is required by the specifications.

74. Par.5-8. The keying relay operates satisfactorily up to speeds of 100 words per minute. The current drawn by the key relay is 200 milliamperes. Specifications require less than 1 ampere.

75. Par.5-9. An indicator light is provided and connections are provided on the transmitter for connection of an external monitor light as called for. It is pointed out, however, that with the "local-remote" switch on "local" and the local "start-stop" switch on "off" position, if the remote start-stop switch is closed, the remote indicator lamp lights although the transmitter is actually shut down. It is suggested that the specifications be clarified on this point since it is believed undesirable to have the remote indicator lamp light under conditions where the transmitter is not actually available to the remote operator. Drawing RE 43AA 216 should probably be modified to show the connection of the "remote-local" switch in the transmitter in such a manner that the remote indicator will light only when the transmitter is actually available for operation.

76. Par.5-10. Local start-stop control of the transmitter is effected by a start-stop switch located on the front panel, and local control is effective regardless of the position of the remote control switch.

However, it is pointed out that in order to throw the control to the remote position it is necessary to do so by means of the "local-remote" switch on the panel of the transmitter. When this "local-remote" switch is in the "remote" position, the local key does not operate and the local "start-stop" switch is ineffective. It is believed that this type of operation is not desirable and it is suggested that the specifications be further clarified on this point.

77. Par.6-3. The equipment performed satisfactorily while the line voltage was varied between the limits of minus 5% to plus 5%. See Table 12. No facilities were available for shifting the frequency of the supply plus or minus 2%, but no reason is apparent why difficulty should be experienced from a shift of this magnitude.

78. Par.6-5. Table 21 shows that the total power under key locked conditions required for the operation of this equipment is 2620 watts; specifications permit 3500 watts.

79. Par.6-38. The equipment is so designed that if a proper motor generator equipment were substituted for the rectifier power unit, operation could be secured. Some modification of the control system might be necessary to accomplish this.

80. Par.6-39 and 6-40. The requirements of these paragraphs are complied with.

81. Par.6-41. The dimensional requirements of this paragraph are complied with as shown in Table 20.

82. Par.6-45. The efficiency of conversion, from the supply lines to direct current output, including filament energy, for the main plate rectifier is 85%. See Table 22. The specifications require that the efficiency of conversion shall be not less than 80%.

83. Par.6-46. The voltage regulation of the main plate rectifier is less than 2%; see Table 23. Specifications permit a regulation of 8%. The TAJ-4 equipment does not utilize the output of the bias rectifier, but this was measured and the regulation was found to be 2% whereas the specifications permit 12%.

84. Par.6-47. This paragraph of the specifications requires that the voltage ripple of the main plate rectifier shall not exceed one half of one percent and that the voltage ripple of the auxiliary plate rectifier shall not exceed one half of one percent. No requirements are stated for the bias and control rectifiers. Table 24 and Plates 4, 5, and 6 show the results of tests conducted to determine the percent of ripple present in the output of the various rectifiers under full load conditions. It will be observed that the specification requirements are complied with in all respects.

85. Table 25, appended hereto, shows the value of current flowing in each line of the 60 cycles, 3-phase supply, under various conditions of operation, including the simultaneous operation of the Model TBF-1 and the Model TAJ-4 transmitters.

86. Par.6-48 and 6-49. The requirements of these paragraphs are complied with.

87. Par.6-50. The spirit of this paragraph is complied with inasmuch as the power can be controlled within the limits specified as shown in Table 14. However, the actual voltage of the rectifier cannot be raised to 110% of normal as is illustrated in this same table.

88. Par.6-51 to 6-59. The requirements of these paragraphs have been complied with. The instruction book and tube data supplied with the equipment state that care must be exercised in placing the rectifier unit into commission. It is necessary to burn the filaments of the rectifier tubes for a sufficient length of time without the application of plate voltage in order to disperse the free mercury which coats the glass envelope and other parts of the tubes. It is felt, however, that some provision should be made for "conditioning" a tube which is to be used as a replacement during service. If an operator inserted a new tube directly from the carton without subjecting it to the proper conditioning, a short circuit is likely to result. It is believed, therefore, that a spare socket should be provided within the rectifier where a spare tube, properly conditioned, could be maintained in an upright position ready for instant use. Thus the ten or fifteen minutes delay incident to conditioning the tube would be avoided when a tube replacement had to be effected in an emergency.

89. Par.7-1. The list of spares actually furnished with the equipment is not in agreement with the list as indicated in the "Contract Note" of NOs-31197. However, the spares furnished agrees with the list shown in the preliminary instructions and appears to be adequate to meet the needs of the Service, with the following exception:

No spare inter-lock switches are provided.
(See paragraph 26 above.)

90. Par.9-4. The instruction books submitted with the transmitting equipment were adequate for placing the apparatus into commission. It is believed, however, that it would be helpful if the preliminary instruction books contained a more detailed description of the control circuits. The TBF-1 - TAJ-4 combination employs a total of 45 relays and contactors beside numerous switches. Since the control and protective circuits of this type of equipment is more complicated than in most previous equipment supplied to the Service, it is believed that operators would appreciate such detailed information.

91. A summary of the defects noted and such items as do not comply with the requirements of reference (b) are listed below:

(a) Upper door interlock switch on junction box was broken when received. Securing tab was broken off and porcelain buffer inside switch was also broken.

(b) Two lower terminals of left hand row of left hand bank in the junction box were both engraved "17-R". Next to bottom should be marked "17-T".

(c) Controls "B", "C" and "E" are not provided with stops to limit the motion.

(d) Main line fuses in the rectifier blew frequently.

(e) Par.3-16. Control "B" does not meet the requirement of "positive gearing".

(f) Par.5-10. Local start-stop switch and local key do not function when transmitter is being controlled from remote position.

(g) Par.5-9. With "local-remote" switch on "local" and local "start-stop" switch in "off" position, if remote "start-stop" switch is closed the remote indicator lamp lights although the set is shut down.

(h) Par.2-7. Steel cap screws were used for fastening the front panel of the transmitter and steel hinges were employed on the door of the rectifier. The enclosing covers of the interlock switches are of steel and the junction box is fabricated from sheet steel.

(i) Par.3-18. The locking device on control "B" is not satisfactory.

(j) Par.2-16. Plate overload relay will not function below 600 milliamperes.

(k) Par.3-9. Total variation of frequency due to causes listed is greater than the 350 cycles required by specifications.

(l) Par.3-5. Modulation reduces power output to less than 60% on 175 kilocycles.

(m) Par.-10-3-6. Backlash in master oscillator is more than twice as great as the total allowable shift due to all causes listed in par.3-9.

(n) Par.3-12. Frequency range selector switch is not equipped with interlock to open keying circuit when changing taps.

(o) Par.3-21. Test key does not comply with specifications.

(p) Tension spring of the master relay fell off while equipment was being installed.

(q) Power amplifier variometer was not connected when the equipment was received.

(r) One 38183 rectifier tube failed after approximately 200 hours of operation.

(s) The five second drop out relay does not immediately re-establish the keying circuit.

CONCLUSIONS

92. The Model TAJ-4 is a rugged set which displays good workmanship. Good materials have been used in its construction and adequate shielding has been provided. The appearance is neat and symmetrical and the operation is simple. Parts have been marked in a legible manner to simplify servicing operations and adequate access has been provided to tubes and other items needing frequent inspection.

93. Certain items of construction could be improved. Variable controls should be provided with stops to limit motion; the use of steel could be reduced by constructing such items as hinges, cap screws and covers from non-ferrous metal and additional protection would result from the use of tube protective relays which would operate on currents of smaller magnitude and the addition of an interlock on the frequency range switch.

94. The frequency stability of the equipment suffers mainly from the fact that the master oscillator is subjected to varying potentials simultaneously with the power amplifier. The use of a fixed plate potential on the master tube would improve this condition.

95. The requirement of uninterrupted service is very likely to be interferred with due to the fact that main line fuses in the rectifier have blown repeatedly for some undiscovered reason.

96. The power output in the low frequency end of the range in the neighborhood of 175 and 200 kilocycles is somewhat limited. Special tuning precautions must be taken in order to cause the power amplifier to draw full power and in order to obtain the output power required by the governing specifications.

97. The modifications to reference (d) which incorporated certain provisions with respect to the control circuits of the rectifier unit have been complied with in all details. The result is an exceedingly flexible power source which enables an operator to shift from one rectifier to another in about eight minutes. In order to meet these requirements an additional unit is necessary; namely, a junction box, containing the necessary number of terminals, connection links and contactors. This assembly requires 76 separate leads or cables to complete the wiring of the combination TAJ-4 - TBF-1 equipments, and the complete control and protective circuits employ 45 relays and contactors.

98. There are eleven paragraphs of the specifications which have not been complied with. These are listed in paragraph 91 of this report.

Table 1

Model TAJ-4 Transmitter, Serial Number 8

Two hour locked key test at 500 kilocycles

Test as per paragraph 10-3-8 of Specifications RE 13A 328G

Time	Frequency	Ambient Temperature	Plate Volts	Plate Current
1300	500.770	29.0	2960	350
1310	.590	29.6	2960	348
1320	.550	30.0	3000	348
1330	.538	30.2	2960	345
1340	.533	30.6	2980	345
1350	.531	30.8	2970	345
1400	.514	31.2	2990	348
1410	.490	31.4	2980	349
1420	.453	31.6	2990	350
1430	.413	31.6	2990	351
1440	.360	32.0	2990	352
1450	.330	32.2	2990	346
1500	.306	32.1	2990	344

Change in frequency: 464 cycles or 0.093%
Post trial inspection showed no signs of overheating.

Table 2

Model TAJ-4 Transmitter, Serial Number 8

Antenna short circuited and open circuited

Test as per paragraph 2-16 of Specifications RE 13A 328G

Frequency	Antenna	Plate Volts	Power Amp.Plate Curr.	Antenna Curr.
600 kcs	Normal	2960	350	9.2
600	Open	2960	360	0
600	Shorted	2960	370	1.0
175	Normal	2950	350	7.1
175	Open	2950	280	0
175	Shorted	2950	275	0

Table 3

Model TAJ-4 Transmitter, Serial Number 8

Determination of Power Output

Test as per paragraph 3-2 of Specifications RE 13A 328G.

Column No.	1	2	3	4	5
Control or Meter	200 kcs	300 kcs	400 kcs	500 kcs	600 kcs
"A"	1	2	3	3	3
"B"	1110	1769	1396	1890	2320
"C"	43	70	63	84	88
"D"	5	9	10	10	11
"E"	81	31	35	68	39
"F"	4	2	3	3	3
MO I_p	52	51	50	51	55
PA Ip	300	350	350	350	350
Plate Volts	3000	2900	2940	2940	2940
Ant I "Int"	5.7	7.9	9	10	11
Ant I "Ext"	5.4	7.2	8.4	9.3	9.9
Ant Cap	750	833	833	833	900
Ant Res	12	8	6	4.66	4
Watts "Int"	390	500	486	466	484
Watts "Ext"	350	415	423	404	391
Watts required by Specs.	475	475		460	445

Table 4

Model TAJ-4 Transmitter, Serial Number 8

Determination of Power Output

Test as per paragraph 8-2 of Specifications RE 13A 328G

Column No.	1	2	3	4	5	6
Control or Meter	175 kcs	175 kcs	200 kcs	355 kcs	500 kcs	600 kcs
"A"	1	1	1	3	3	3
"B"	610	610	1110	1064	1890	2320
"C"	23	23	42	32	85	89
"D"	1	1	3	10	11	11
"E"	65	65	82	11	34	72
"F"	4	4	4	3	2	2
MO Ip	52	56	54	50	52	56
PA Ip	270	305	330	350	350	350
Plate Volts	2900	3225	3000	2940	3000	2900
Ant I "Int"	6.1	7	6.9	10	13	15
Ant I "Ext"	5.9	6.3	6.2	9.1	12.2	13.2
Ant Cap	600	600	600	900	1225	1400
Ant Res	6	6	6	4	2.67	1.55
Watts "Int"	222	294	285	400	452	350
Watts "Ext"	208	238	230	331	398	270
Watts guaranteed by manuf'r	325		345	432	405	334
Watts obtained in type test of Trans.Ser. No.1	333		384	450	480	360

Table 5

Model TAJ-4 Transmitter, Serial Number 8

Determination of Power Output

Test as per paragraph 3-2 of Specifications RE 13A 328G

Column No.	1	2	3
Control or Meter	175 kcs	355 kcs	355 kcs
"A"	1	3	3
"B"	610	1064	1064
"C"	22	54	50
"D"	3	9	10
"E"	39	75	24
"F"	4	4	3
MO Ip	51	50	50
PA Ip	262	350	350
Plate Volts	2980	2940	3000
Ant I "Int	5.5	8	9.4
Ant I "Ext"	5.3	7.65	8.8
Ant Cap	750	833	975
Ant Res	12	7	4.2
Watts "Int"	364	448	370
Watts "Ext"	338	410	325

Table 6

Model TAJ-4 Transmitter, Serial Number 8

Determination of Power Output

Test as per paragraph 8-2 of Specifications RE 13A 328G

Column No.	1	2	3	4	5
Control or Meter	175 kcs	175 kcs	200 kcs	200 kcs	200 kcs
"A"	1	1	1	1	1
"B"	610	610	1110	1110	1110
"C"	29.5	26.9	46	47.5	46
"D"	1	1	3	5	5
"E"	62	62	78.6	62.5	61.8
"F"	4	4	4	4	4
MO Ip	50	55	50	51	56
PA Ip	350	350	350	350	350
Plate Volts	2890	3140	2900	2910	3160
Ant I "Int"	7.1	7.8	7.3	6.3	6.9
Ant I "Ext"	6.6	7.2	6.8	5.95	6.4
Ant Cap	600	600	600	750	750
Ant Res	6.1	6.1	6.1	12.2	12.2
Watts "Int"	307	371	325	485	582
Watts "Ext"	266	316	282	432	500
Watts guar. by mfgr	325	325	345		
Watts obtained in type test of Trans.Ser. #1	333	333	384		
Watts required by Specs.				475	475

Table 7

Model TAJ-4 Transmitter, Serial Number 8

Determination of Power Output

Test as per paragraph 8-2 of Specifications RE 13A 328G

Column No.	1	2	3	4	5	6
Control or Meter	300 kcs	300 kcs	355 kcs	355 kcs	400 kcs	400 kcs
"A"	2	2	3	3	3	3
"B"	1769	1769	1039	1039	1396	1396
"C"	75	71	40	57.6	64.2	67.2
"D"	9	9	10	10	10	10
"E"	40	37.8	13.5	17	38	38
"F"	2	2	3	3	3	3
MO Ip	52	56	49	53	50	55
PA Ip	350	350	350	350	350	350
Plate Volts	2800	3050	2820	3050	2800	3050
Ant I "Int"	7.75	8.4	10.7	11.2	8.9	9.6
Ant I "Ext"	7.2	7.6	10.0	10.6	8.1	8.95
Ant Cap	833	833	900	900	833	833
Ant Res	8.15	8.15	4.09	4.09	6.1	6.1
Watts "Int"	490	573	468	514	483	562
Watts "Ext"	423	471	409	460	400	489
Watts guar. by mfr.			432	432		
Watts obtained in type test of Trans. Ser. #1			450	450		
Watts req'd by Specs.	475	475				

Line voltage for above tests - 221 volts.

Table 8

Model TAJ-4 Transmitter, Serial Number 8

Determination of Power Output

Test as per paragraph 8-2 of Specifications RE 13A 328G

Column No.	1	2	3	4	5	6
Control or Meter	500 kcs	500 kcs	600 kcs	600 kcs	600 kcs	600 kcs
"A"	3	3	3	3	3	3
"B"	1890	1890	2320	2320	2320	2320
"C"	74	85	100	92.5	100	93.2
"D"	10	10*	11	11	11	11
"E"	70.8	73.5	46.1	44.5	72.1	71.7
"F"	3	2**	2	2	1	1
MO Ip	53	58	56	61	56	61
PA Ip	350	350	350	350	350	350
Plate Volts	2810	3060	2810	3060	2810	3060
Int I "Int"	10.1	10.8	10.6	11.5	15.3	16.4
Ant I "Ext"	9.1	9.6	9.6	10.2	14.8	15.5
Ant Cap	833	833	900	900	1400	1400
Ant Res	4.75	4.75	4.09	4.09	1.55	1.55
Watts "Int"	485	554	460	542	363	417
Watts "Ext"	394	438	377	426	340	373
Watts guar. by mfr					334	334
Watts obtained in type test of Trans.Ser. #1					360	360
Watts req'd by Specs.	460	460	445	445		

* Tap #3 gave same output as Tap No. 2
** Tap #11 would not reach resonance.

Line voltage for above tests - 221 volts

Table 9

Model TAJ-4 Transmitter, Serial Number 8

Transmission tests to determine reaction between transmitters, quality of emission and key clicks.

Test per paragraph 3-4 of Specifications RE 13A 328G

TEST NO.1

TBF-1 on 3000 kcs; TAJ-4 on 500 kcs, operated at full power and both transmitters operated on TAJ-4 rectifier. Key locked on TAJ-4 while TBF-1 was being keyed.

The 500 kc signal showed a slight frequency modulation or shift corresponding with the keying of the 3000 kc frequency.

NOTE: This modulation is apparently due to the drop in signal intensity because of lowered voltage when both transmitters are key closed. The frequency shift at keying speeds is also probably due to a voltage drop.

TEST NO.2

TBF-1 on 3000 kcs; TAJ-4 on 500 kcs; both transmitters operating simultaneously from TAJ-4 rectifier. Key locked on TBF-1 while TAJ-4 was being keyed.

The 3000 kc signal had "back wave" modulation of some intensity with very slight frequency change. (See "note" above regarding "back wave" modulation.)

TEST NO.3

TBF-1 on 3000 kcs; TAJ-4 on 500 kcs; both transmitter operating simultaneously from TAJ-4 rectifier. Both transmitters being keyed.

500 kcs; good d.c. note. 3000 kcs; note d.c. with marked keying lilt. Key clicks quite bad. There is no noticeable reaction when both transmitters are being keyed simutaneously.

TEST NO.4

TBF-1 on 3000 kcs; TAJ-4 on 500 kcs; both transmitters operating simultaneously from TBF-1 rectifier. TAJ-4 operated key locked while TBF-1 was being keyed.

Noticeable lilt in 3000 kc transmission; 500 kc has slight modulation from 3000 kc keying, mostly amplitude but with some frequency change. Key clicks observed on 500 kc frequency.

Table 9 (continued)

TEST NO.5

TBF-1 on 3000 kc; TAJ-4 on 500 kc; both transmitters operating simultaneously from TBF-1 rectifier. TBF-1 being operated key locked while TAJ-4 was being keyed.

500 kc frequency good d.c. note; 3000 kc frequency being modulated with both amplitude and frequency. Key clicks observed on locked frequency (3000 kcs).

TEST NO. 6

TBF-1 on 3000 kc; TAJ-4 on 500 kc; both transmitters operating simultaneously from TBF-1 rectifier. Both transmitters being keyed.

No objectionable interaction.

TEST NO. 7

TBF-1 on 4500 kc; TAJ-4 on 500 kc; both transmitters operating simultaneously from TBF-1 rectifier. TAJ-4 being operated key locked while TBF-1 was being keyed.

Lilt on 4500 kcs objectionable; seemed to be extra "chirps" in signal between keying periods.

TEST NO. 8

TBF-1 on 4500 kc; TAJ-4 on 500 kc; both transmitters operating simultaneously from TBF-1 rectifier. TBF-1 being operated key locked while TAJ-4 was being keyed.

500 kc note good; practically no reaction right on 4500 kcs but some noticed to one side.

TEST NO. 9

TBF-1 on 4500 kc; TAJ-4 on 500 kc; both transmitters operating simultaneously from TBF-1 rectifier. Both transmitters being keyed.

No objectionable inter-action.

TEST NO. 10

TBF-1 on 2000 kc; TAJ-4 on 400 kc; both transmitters being operated simultaneously from TBF-1 rectifier. TAJ-4 operated key locked while TBF-1 was being keyed.

Slight frequency and amplitude modulation noticed,with key thumps, when on ICW position. 2000 kc good d.c. note with no side frequencies noted.

Table 9 (continued)

TEST NO. 11

TBF-1 on 2000 kc; TAJ-4 on 400 kc; both transmitters being operated simultaneously from TBF-1 rectifier. TBF-1 being operated key locked with TAJ-4 was keyed.

Not much amplitude or frequency modulation noted. Could observe key thumps on ICW position.

TEST NO. 12

TBF-1 on 2000 kc; TAJ-4 on 400 kc; both transmitters being operated simultaneously from TBF-1 rectifier. Both transmitters being keyed.

No reaction.

TEST NO. 13

TBF-1 on 2000 kc; TAJ-4 on 400 kc. Each transmitter being operated on its respective rectifier. TAJ-4 being operated key locked while the TBF-1 was being keyed.

No interaction, good note, very little lilt on 2000 kc.

TEST NO. 14

TBF-1 on 2000 kc; TAJ-4 on 400 kc. Each transmitter being operated on its respective rectifier. TBF-1 operated key locked while TAJ-4 was being keyed.

Good d.c. note; no interaction.

Observations made on Model RAA and RAB receivers at distance of about 500 feet. Such interaction or reaction between transmitters as was observed when both transmitters were operating from one rectifier was not sufficient to interfere seriously with communications. No reaction, whatever, was observed when each transmitter was operated from its respective rectifier.

Table 10.

Model TAJ-4 Transmitter, Serial Number 8

MCW Operation

Test per paragraph 3-5 of Specifications RE 13A 328G

Comparison of CW and MCW Operation

Type of Emission	CW	MCW	CW	MCW	CW	MCW
Output Frequency	175	175	355	355	600	600
MO Ip	50	50	50	48	54	54
PA Ip	350	280	350	300	350	300
Plate Volts	2930	2930	2940	2940	2900	2900
Ant Cap	975	975	975	975	975	975
Ant Res	4.2	4.2	4.2	4.2	4.2	4.2
Ant Curr	7.6	5.3	9.0	7.3	10.1	8.2
Output Watts	242	116	340	224	428	282

Difference between CW and MCW at 175 kc - 136 watts
52%

" " " " " " 355 " - 116 watts
34%

" " " " " " 600 " - 146 watts
33%

Tolerance permitted by specifications - 40%

Percent Modulation

Frequency Kcs	Negative Peaks	Positive Peaks
600	100%	24%
300	100%	30%

Required by specifications - 50%

Frequency of Modulation

Measured - 895 cycles
Required - 800 cycles (approx)

Table 11

Model TAJ-4 Transmitter, Serial Number 8

Frequency Stability

Tests per paragraph 3-9 of Specifications RE 13A 328G

Variation due to "Adjust-Tune-Operate" Switch

Adjust - 500.680 kc
Tune - 500.690
Operate- 500.690

Difference - 10 cycles

- - -

Effect of detuning power amplifier and antenna coupling circuits. Plate current changed about 25% by the detuning.

Stage Detuned	Frequency at Resonance	Frequency below Resonance	Frequency above Resonance
PA	500.650	500.726	500.630
Ant	500.650	500.586	500.666

Effect of varying antenna constants - 25%

Antenna Capacity	Frequency
975 uuf	500.645
1300 uuf	500.628

Difference: 17 cycles

- - -

Reset accuracy within one-man-minute

Original Frequency	Reset Frequency	Difference	Time
500.594	500.710	116 cycles	45 sec.
500.710	500.520	190 cycles	50 sec.

Frequency shift with change of tubes.

Master Oscillator Circuit

Original Frequency - 500.835 kc

Tube No.	Frequency	Change
40344	500.900	+ 65 cycles
40347	500.895	+ 60
40112	500.710	-125

Average difference: 83 cycles

Table 11 (continued)

Power Amplifier Circuit

Original Frequency - 500.710 kc

Tube No.	Frequency	Change
15340	500.710	0
15247	500.710	0

Table 12

Model TAJ-4 Transmitter, Serial Number 8

Variation of Line Voltage

Test per paragraphs 3-9-4 and 6-3 of Specifications RE 13A 328G

Line Volts	Power Amp. Plate Curr.	Plate Volts	Column 1 Frequency	Column 2 Frequency	Column 3 Frequency
218.5	285	2800	783 cy	585 cy	585 cy
220.8	300	2850	678	588	
223.1	308	2880	677	592	
225.4	315	2910	675	596	
227.7	320	2950	672	600	
230.0	322	2960	667	608	
232.3	328	2990	664	617	
234.6	331	3000	662	620	
236.9	338	3040	658	630	
239.2	340	3050	656	640	
241.5	345	3090	653	650	614
	Frequency difference:		30 cy	65 cy	29 cy

Note: Columns 1 and 2 represent the frequency shift due to 1% per minute change in voltage. In column 1 the line voltage was varied from 218.5 to 241.5, while in column 2 the line voltage was varied from 241.5 down to 218.5 volts. Under column 3 the line voltage was varied as rapidly as possible from 218.5 to 241.5 volts.

The frequency change resulting from a line voltage variation (rapid) from minus 5% to plus 5% is 29 cycles or 0.006%, at 500 kcs.

Table 13

Model TAJ-4 Transmitter, Serial Number 8

Accuracy of Reset of Master Oscillator Circuit

Test as per paragraph 3-9-2 of Specifications RE 13A 328G

Starting Frequency - 500.648 kc

Trial	Frequency	Deviation
1	500.672	24 cycles
2	500.669	21
3	500.630	18
4	500.617	31
5	500.652	4

Average deviation - 20 cycles

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Table 13A

Test for Lost Motion and Back Lash

Clockwise setting of Control "B"	Frequency	Counter clockwise setting of Control "B"	Frequency Diff.
1894	500.620	1891.0	900 cycles
1894	500.620	1891.4	780
1894	500.620	1891.2	840
1894	500.620	1891.3	810
1894	500.620	1891.3	810

Average difference: 832 cycles

Note: The cycles per division of the master oscillator tuning was determined to be 300, at 500 kcs.
The control "B" was carefully rotated in a clockwise direction to give the same frequency, 500.620 kcs, on the "LH" frequency measuring equipment. Then control "B" was rotated in a counter clockwise direction until the same frequency, 500.620 kcs, was obtained. The difference between the two settings multiplied by 300 gives the degree of back lash in cycles.

Table 14

Model TAJ-4 Transmitter, Serial Number 8

Control of Power Output

Test as per paragraph 3-24 of Specifications RE 13A 328G

Voltage Tap	Frequency	Plate Volts	Plate Curr.	Ant. Amps	Power Watts	Per Cent
6	500.807	3180	385	10.0	420	121
5	500.784	2930	350	9.1	346	100
4	500.728	2560	300	7.8	255	74
3	500.674	2210	250	6.4	172	50
2	500.610	1860	208	5.3	118	34
1	500.538	1500	160	4.1	71	22.5

Specifications require that the control of power shall be such that the power may be reduced to at least 25% of full power.

Frequency change between 22.5% and 100% - 246 cycles.

Table 15
Model TAJ-4 Transmitter, Serial Number 8

Effect of change in ambient temperature, 500 kilocycles

Time	Ambient °C	Actual Frequency	Line Volts
0940	24.8	501.070	228
50	25.0	500.855	228
1000	25.2	.885	228
10	25.0	.970	228
20	25.0	501.005	228
30	25.0	500.980	228
40	25.0	501.000	228
50	25.0	.065	227
Key open 10 minutes while temperature was changed.			
1100	30.0	501.102	227
10	30.0	.030	228
20	30.2	500.980	228
30	30.0	.940	228
40	30.0	.918	227
50	30.0	.910	226
1200	30.0	.912	227
10	30.0	.920	227
Key open 10 minutes while temperature was changed.			
1220	34.8	501.035	228
30	35.2	500.920	227
40	35.2	.890	228
50	35.0	.870	227
1300	35.2	.865	226
10	35.0	.860	227
20	34.8	.870	227
30	35.0	.875	227
Key open 10 minutes while temperature was changed.			
1340	50.8	500.875	227
50	50.4	.680	226
1400	50.0	.610	226
10	50.0	.582	226
20	50.0	.574	227
30	50.0	.580	225
40	50.0	.592	226
50	50.0	.614	226
Key open 10 minutes while temperature was changed.			
1500	24.8	500.915	226
10	25.0	501.005	228
20	25.0	.104	229
30	24.8	.200	229
40	25.0	.250	228
50	25.2	.275	228
1600	25.0	.285	229
10	25.0	.290	229

Table 15 (continued)

Difference between readings taken at 1050 and 1210
Ambient temperature - 5.0°C
Difference in frequency - 145 cycles
Difference in frequency per degree Centigrade - 29 cycles, .0058%

Difference between readings taken at 1210 and 1330
Ambient temperature - 5.0°C
Difference in frequency - 45 cycles
Difference in frequency per degree Centigrade - 9 cycles, .0018%

Difference between readings taken at 1330 and 1450
Ambient temperature - 15.0°C
Difference in frequency - 261 cycles
Difference in frequency per degree Centigrade - 17 cycles, .0034%

Difference between readings taken at 1450 and 1610
Ambient temperature - 25.0°C
Difference in frequency - 676 cycles
Difference in frequency per degree Centigrade - 27 cycles, .0054%

Difference between readings taken at 1050 and 1610
Ambient temperature - none
Difference in frequency - 225 cycles, .045%

Table 16
Model TAJ-4 Transmitter, Serial Number 8
Effect of Change in Ambient Temperature, 500 kilocycles

Time	Ambient °C	Actual Frequency	Line Volts
0820	24.8	501.000	230
30	25.0	500.850	229
40	25.0	.880	229
50	25.2	.920	227
0900	25.0	.935	228
10	25.0	.950	230
20	25.0	501.000	230
30	25.0	.035	228
Key open 10 minutes while temperature was changed.			
0940	10.8	501.340	228
50	10.0	.425	228
1000	9.8	.545	229
10	9.8	.594	227
20	10.2	.628	227
30	10.0	.644	227
40	10.0	.692	227
50	10.0	.704	227
Key open 10 minutes while temperature was changed.			
1100	5.8	501.905	226
10	5.4	.915	226
20	5.0	.955	225
30	5.0	.975	225
40	5.0	502.000	225
50	4.8	.000	226
1200	5.0	501.995	225
10	5.0	.990	226
Key open 30 minutes while temperature was changed.			
1240	0.4	502.225	225
50	0.1	.130	225
1300	0.4	.105	225
10	0.2	.090	225
20	0.2	.086	225
30	0.2	.082	225
40	0.0	.083	225
50	0.0	.084	225
Key open 10 minutes while temperature was changed.			
1400	25.2	501.980	226
10	25.0	.740	225
20	25.2	.604	225
30	25.2	.515	225
40	25.0	.450	225
50	25.0	.390	226
1500	24.8	.350	226
10	25.0	.310	226

Table 16(continued)

Difference between readings taken at 0930 and 1050
Ambient temperature - 15.0°C
Difference in frequency - 669 cycles
Difference in frequency per degree Centigrade - 44 cycles, .0088%

Difference between readings taken at 1050 and 1210
Ambient temperature - 5.0°C
Difference in frequency - 286 cycles
Difference in frequency per degree Centigrade - 57 cycles, .011%

Difference between readings taken at 1210 and 1350
Ambient temperature - 5.0°C
Difference in frequency - 94 cycles
Difference in frequency per degree Centigrade - 19 cycles, .0038%

Difference between readings taken at 1350 and 1510
Ambient temperature - 25.0°C
Difference in frequency - 915 cycles
Difference in frequency per degree Centigrade - 36 cycles, .0072%

Difference between readings taken at 0930 and 1510
Ambient temperature - none
Difference in frequency - 680 cycles, .136 %

Table 17
Model TAJ-4 Transmitter, Serial Number 8

Summary of Tables 15 and 16 inclusive.

Frequency	Temperature Range	% Frequency Change per °C
500 kcs	25 - 30	.0058
"	30 - 35	.0018
"	35 - 50	.0034
"	50 - 25	.0054
"	25 - 10	.0088
"	10 - 5	.011
"	5 - 0	.0038
"	0 - 25	.0072
	Average -	.0059

Table 18
Model TAJ-4 Transmitter, Serial Number 8

Summary of Test as per paragraph 3-9 of Specifications

Test Frequency - 500 kilocycles

(1)	Initial errors in calibration:	0
(2)	Errors in resetting to desired frequency: (See Table 13)	20 cycles
(3)	Variations of 5°C per hour: (See Tables 15 and 16)	45 cycles
(4)	Variations of supply line voltage: (See Table 12)	29 cycles
(5)	25% variation in antenna constants: (See Table 11)	17 cycles
(6)	Control of power output from 25% to full power: (See Table 14)	246 cycles
(7)	Replacement of vacuum tubes: (See Table 11)	83 cycles
	Total change	440 cycles

Permitted by specifications - 350 cycles

Table 19

Model TAJ-4 Transmitter, Serial Number 8

Variation of Resonant Frequency of Master Oscillator per Division of Marking
Test per paragraph 3-16 of Specifications RE 13A 328G

Frequency	Tap	MO Setting	KC per Division	% per Division
166	1	315		
175	1	610	0.030	0.017
200	1	1114	0.050	0.025
225	1	1455	0.073	0.032
250	1	1697	0.103	0.041
300	1	2084	0.129	0.039
325	1	2280	0.127	0.039
333	1	2370	0.092	0.028
200	2	535		
225	2	1005	0.053	0.023
250	2	1340	0.075	0.030
275	2	1581	0.104	0.038
300	2	1769	0.133	0.044
325	2	2097	0.076	0.023
300	3	230		
350	3	989	0.066	0.019
400	3	1396	0.123	0.031
450	3	1675	0.179	0.040
500	3	1890	0.232	0.048
550	3	2098	0.240	0.044
600	3	2320	0.225	0.037

Required by specifications: Not more than 0.05 nor less than 0.02 of one percent.

Table 20

Model TAJ-4 Transmitter, Serial Number 8

Physical Dimensions of Equipment

Test per paragraphs 3-28 and 6-41 of Specifications RE 13A 328G

Transmitter	Specification Requirements	Actual Dimensions of Frame	Actual Overall Dimensions
Height	72"	71-15/16"	72-3/16"
Width	27"	26"	26-3/4"
Depth	20"	16-3/4"	20-3/8"
Rectifier Unit			
Height	72"	71-7/8"	71-7/8"
Width	24"	20-1/8"	20-7/8"
Depth	24"	21-1/4"	24"

Table 21

Model TAJ-4 Transmitter, Serial Number 8

Power required from Supply Lines

Test per paragraph 6-55 of Specifications RE 13A 328G
(Determined by two wattmeter method)

Test No.	Wattmeter No. 1	Wattmeter No. 2	Total Watts
1	Rectifier main line switch only "closed"		
	40	0	40
2	Rectifier filaments and bias		
	50	560	610
3	Rectifier filaments, bias, and plate		
	670	190	860
4	Rectifier filaments, bias, and plate plus junction box controls.		
	1040	240	1280
5	Total load, full power, key locked. (Plate E - 3000 V; Plate 1 - 350 ma)		
	1740	880	2620

Permitted by specifications - 3500 watts

Table 22

Model TAJ-4 Transmitter, Serial Number 8

Efficiency of Conversion of Main Plate Rectifier

Test as per paragraph 6-45 of Specifications RE 13A 328G

Input watts: 1770
Output watts: 1508

Efficiency of conversion: 85%

Method: Main plate rectifier tubes were removed and rectifier turned on. Input power was recorded. Tubes were replaced and set turned on. Input power was again recorded. Difference in readings is input power to main plate rectifier. Output was determined from current and voltage meters on rectifier output.

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

Table 23

Model TAJ-4 Transmitter, Serial Number 8

Voltage Regulation of Rectifier

Test as per paragraph 6-46 of Specifications RE 13A 328G

Rectifier	No Load	Full Load	Per Cent Regulation
Main Plate (Over-all)	2990	2940	1.7
Main Plate (Center-Tap)	1400	1380	1.45

Permitted by Specifications - 8%

Table 24

Model TAJ-4 Transmitter, Serial Number 8

Voltage Ripple Determinations

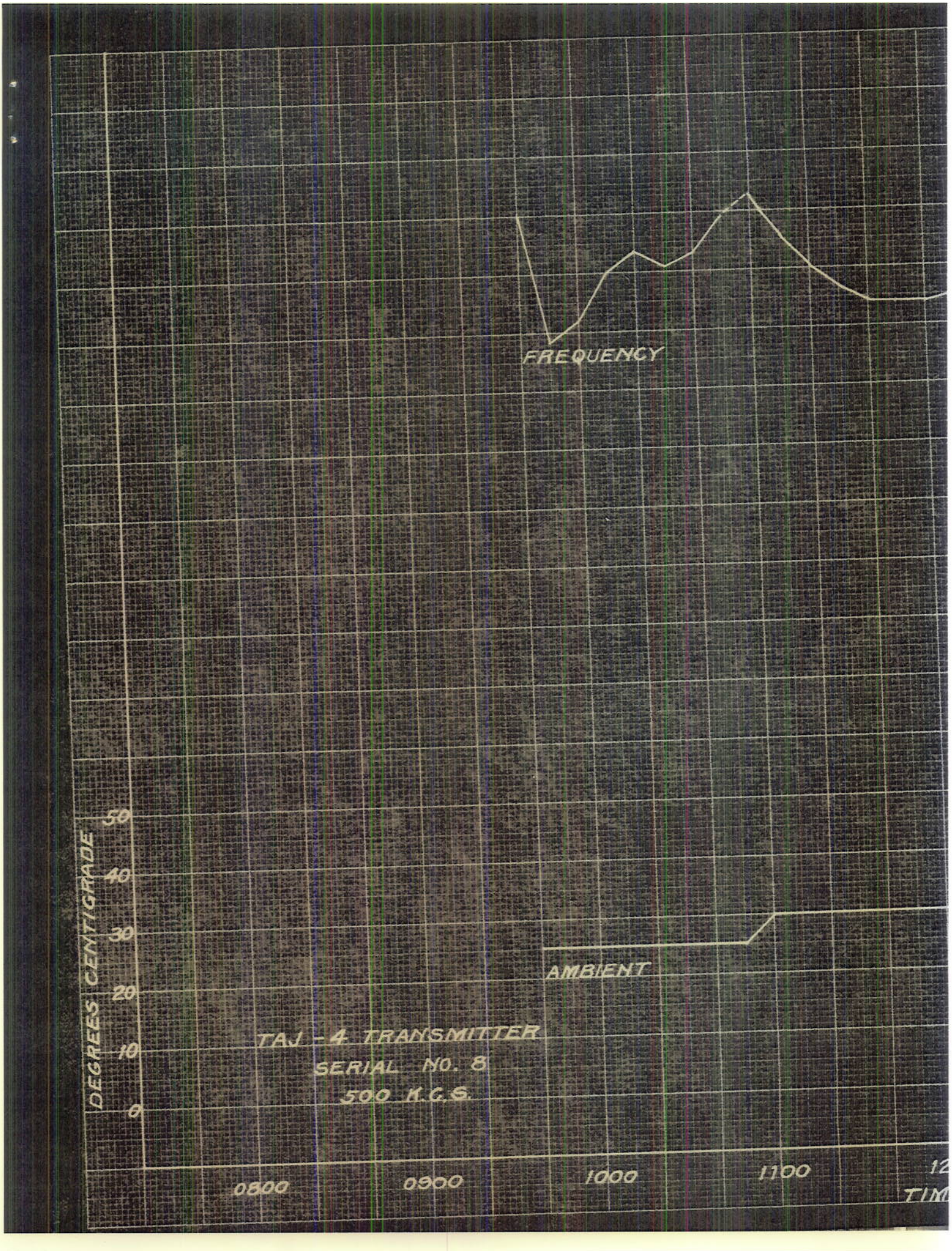
Rectifier	Ripple Voltage Peak	RMS	Specs	Actual Per Cent
Main Plate, 2940 Volts	17.0	12.0	0.5%	0.41%
Main Plate, Mid Tap, 1460 V	8.1	5.7	0.5%	0.39%
Auxiliary Plate, 1225 V	4.5	3.2	0.5%	0.26%
Grid Bias, 510 V.	2.8	2.0	-	0.39%
Control, 112 V.	9.0	6.4	-	5.70%

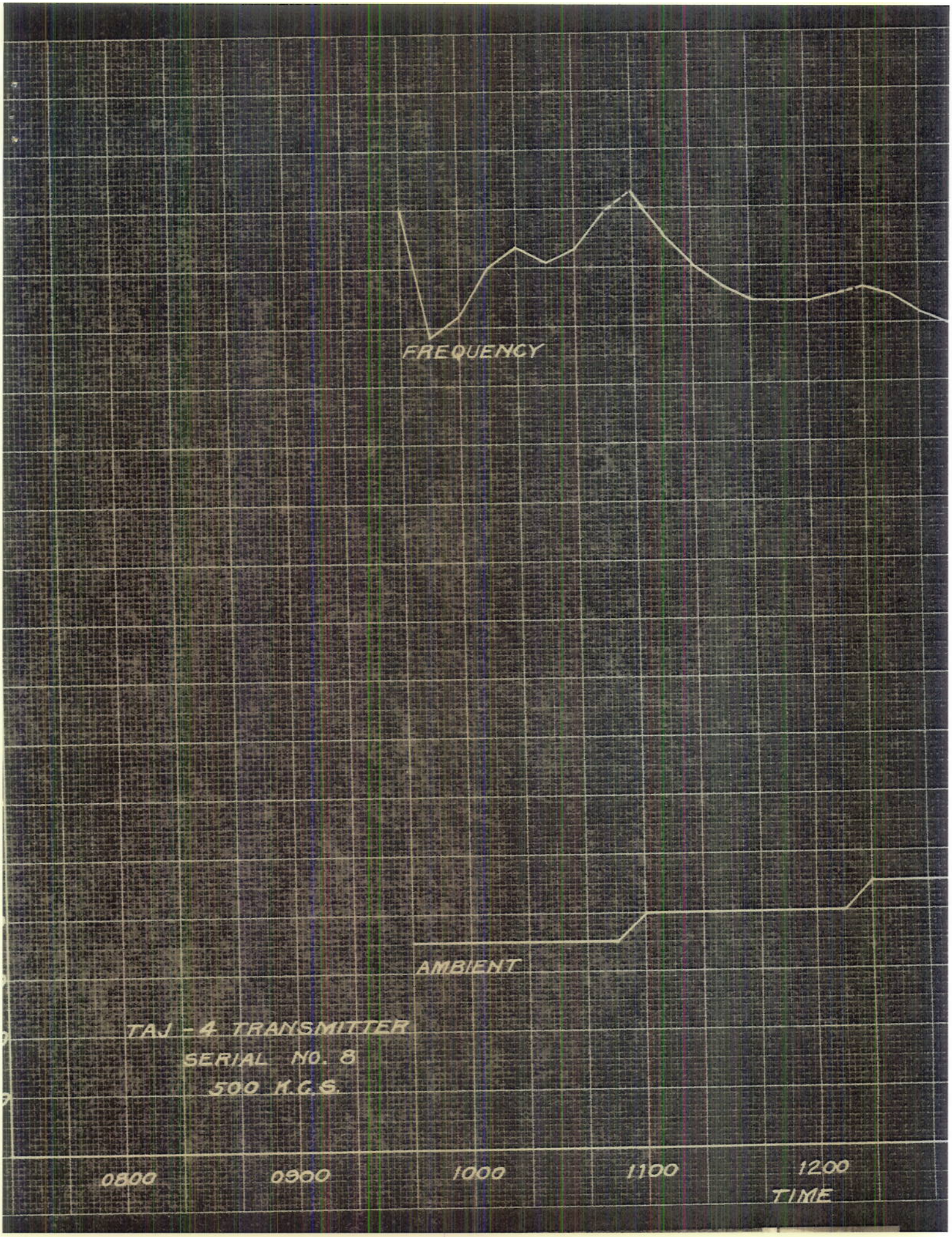
Table 25

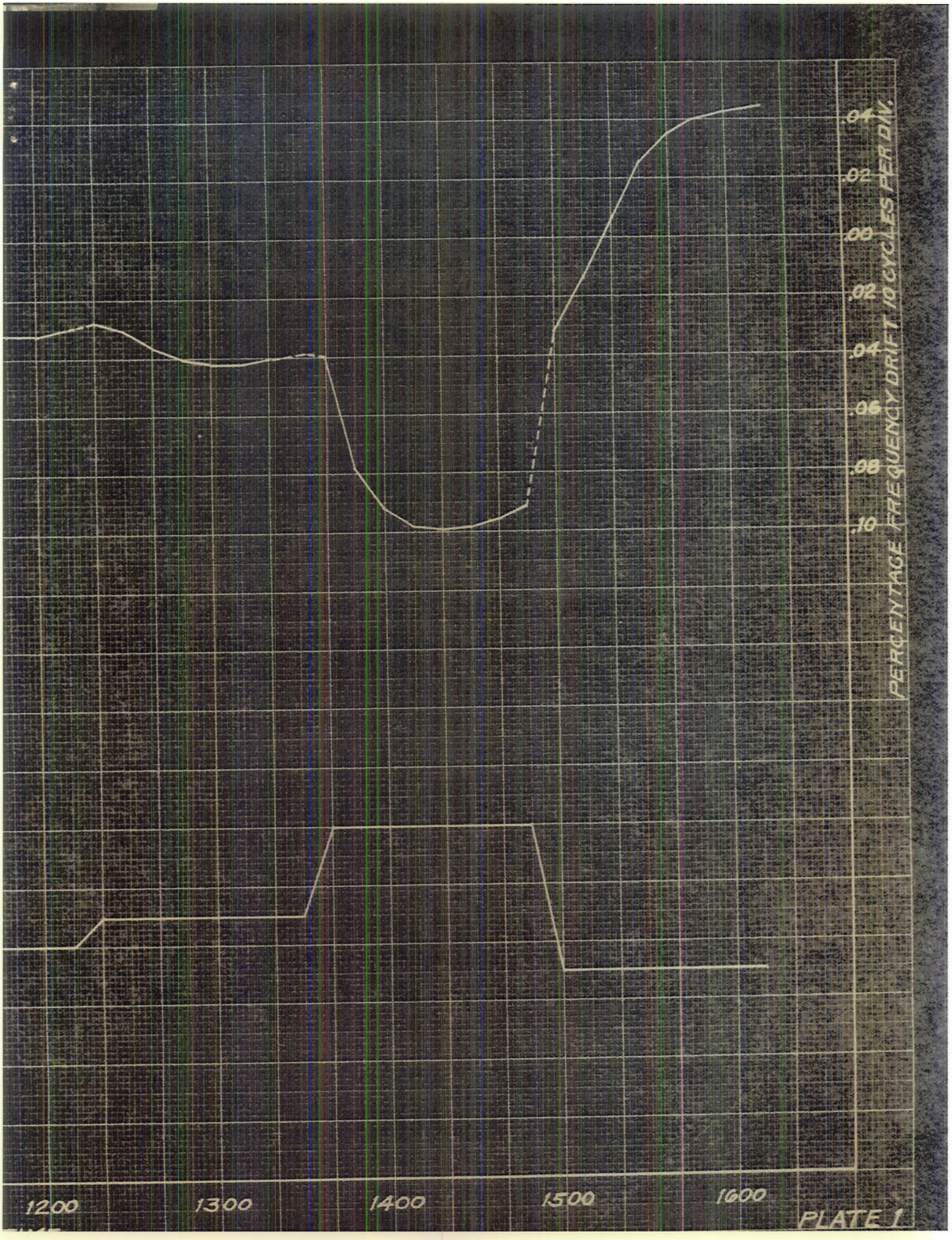
Model TAJ-4 Transmitter, Serial Number 8

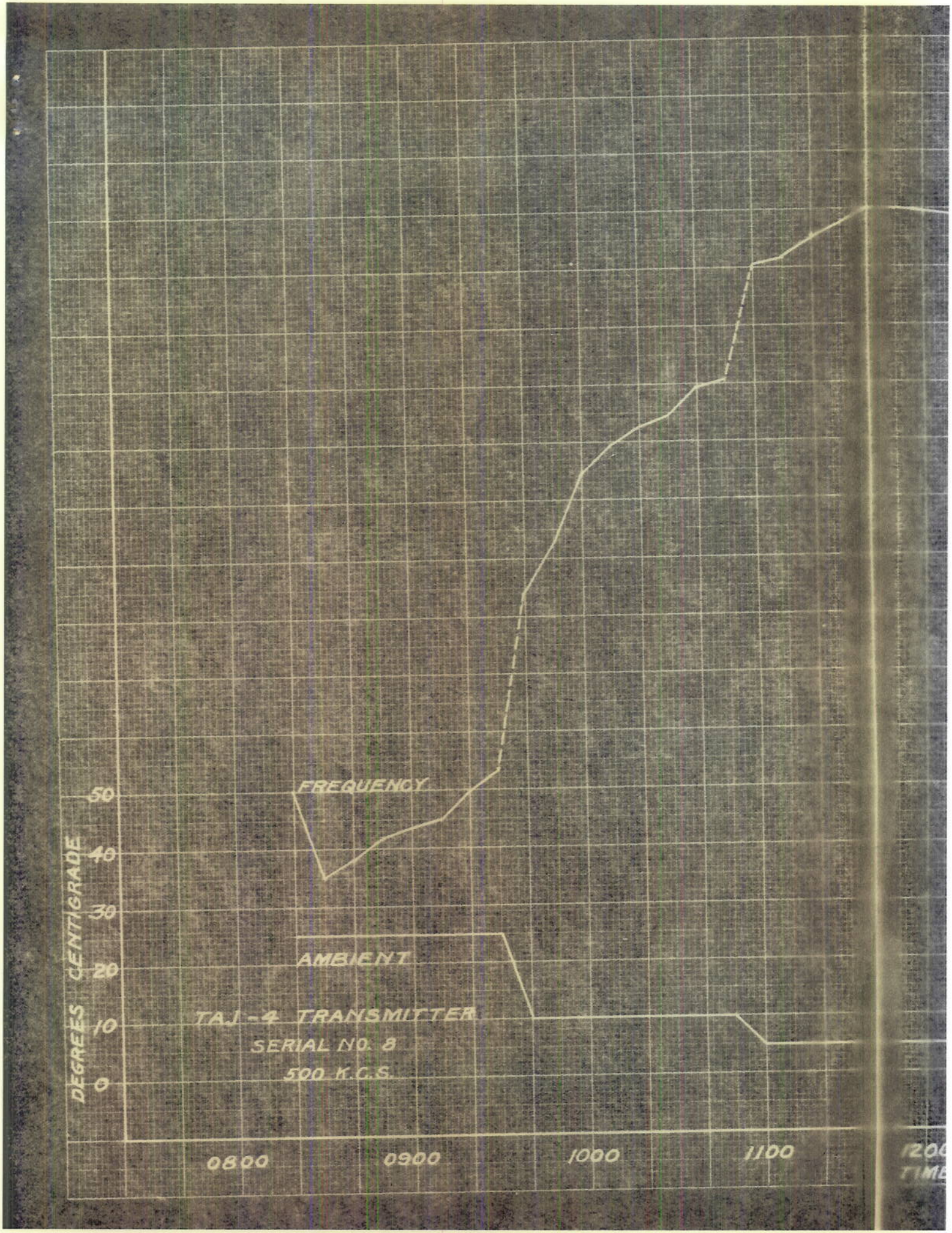
Check of Current in Rectifier Supply Lines

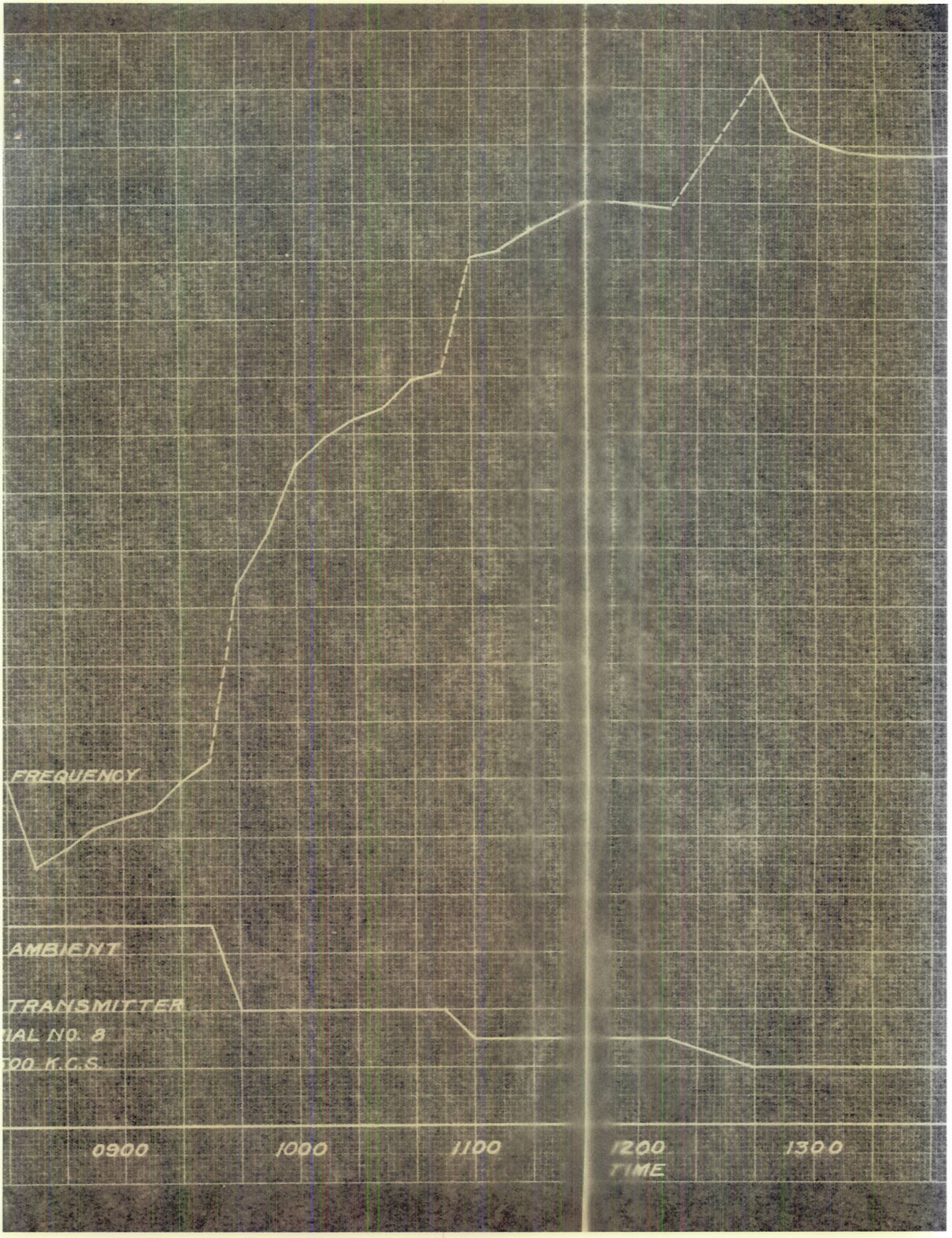
	Amperes Line 1	Line 2	Line 3
TBF-1 RECTIFIER			
TBF-1, Low Power, Key open	4.6	8.2	5.0
TBF-1, Low Power, Key closed	5.3	9.5	5.8
TBF-1, High Power, Key open	4.8	9.0	5.3
TBF-1, High Power, Key closed	8.2	11.9	8.9
TAJ-4 RECTIFIER			
TAJ-4 Transmitter, key open	3.0	7.0	3.0
TAJ-4 Transmitter, key closed	5.2	9.9	7.5
TBF-1 and TAJ-4 RECTIFIERS			
TBF-1 and TAJ-4, key open	9.5	17.5	10.8
TBF-1 and TAJ-4, keys closed	14.3	22.1	17.8

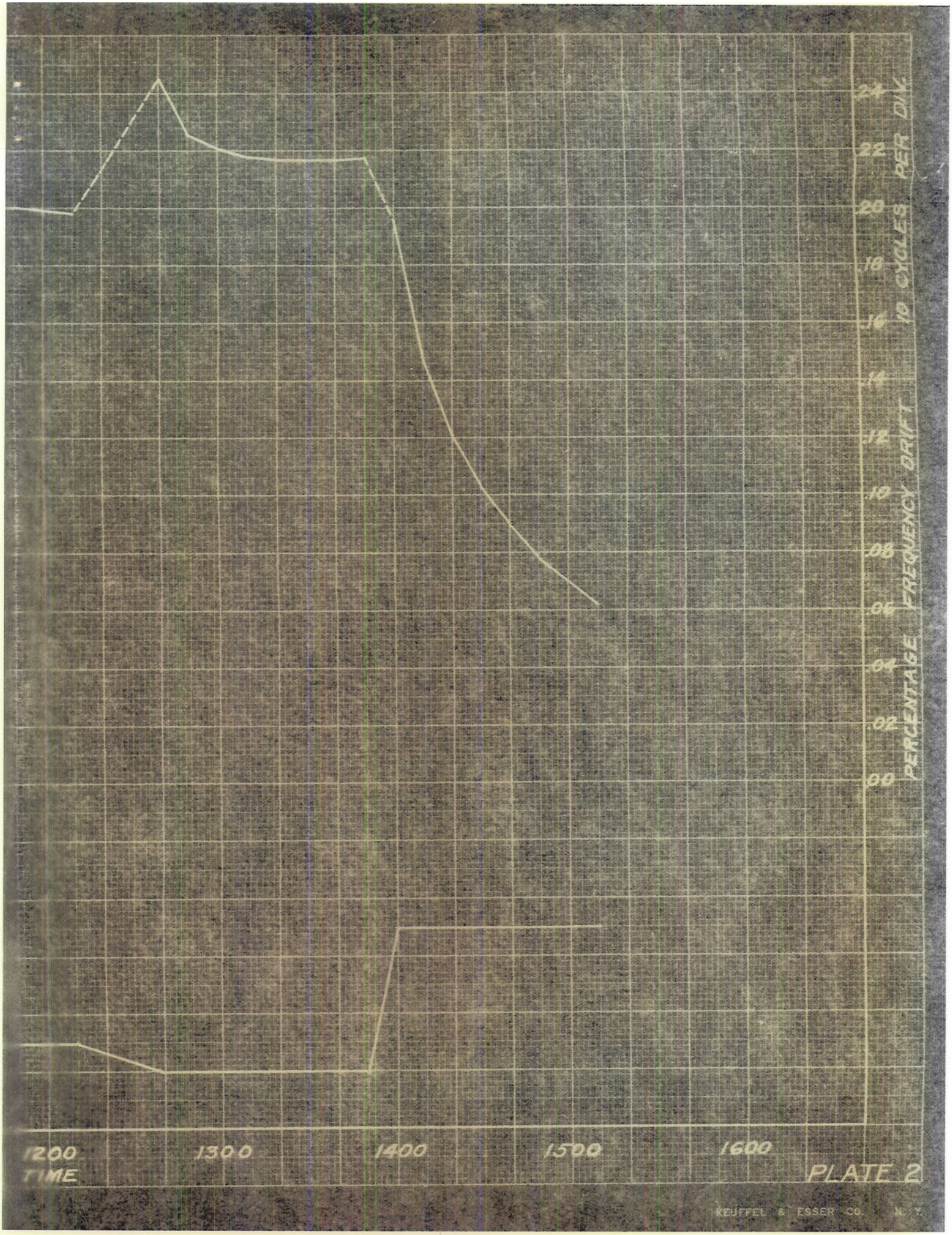

FREQUENCY
AMBIENT
DEGREES CENTIGRADE
50
40
30
20
10
0
TAJ - 4 TRANSMITTER
SERIAL NO. 8
500 K.C.S.
0800
0900
1000
1100
12
TIM

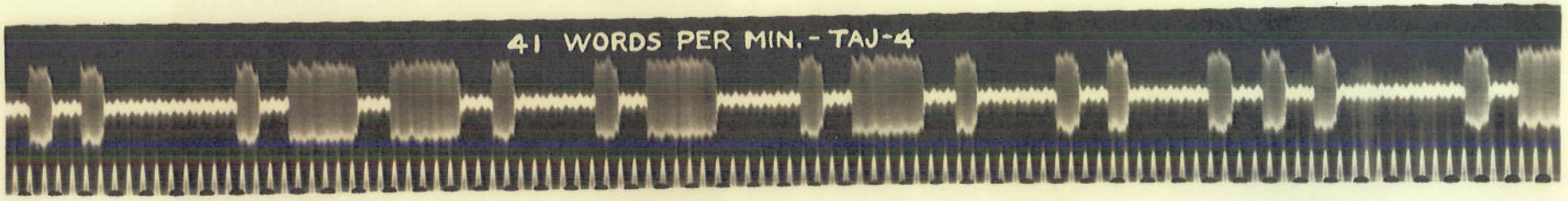

FREQUENCY
AMBIENT
TAJ - 4 TRANSMITTER
SERIAL NO. 8
500 K.C.S.
0800
0900
1000
1100
1200
TIME

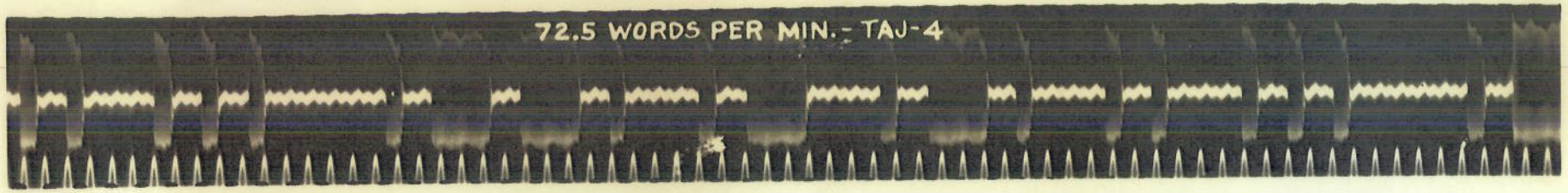

.04
.02
.00
.02
.04
.06
.08
.10
PERCENTAGE FREQUENCY DRIFT IN CYCLES PER DIV.
1200
1300
1400
1500
1600
PLATE 1


DEGREES CENTIGRADE
50
40
30
20
10
0
FREQUENCY
AMBIENT
TAJ-4 TRANSMITTER
SERIAL NO. 8
500 K.C.S.
0800
0900
1000
1100
TIME


FREQUENCY
AMBIENT
TRANSMITTER
IAL NO. 8
00 K.C.S.
0900
1000
1100
1200
1300
TIME


PERCENTAGE FREQUENCY DRIFT IO CYCLES PER D/C
.24
.22
.20
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
1200
TIME
1300
1400
1500
1600
PLATE 2
KEUFFEL & ESSER CO. N. Y.


41 WORDS PER MIN. - TAJ-4


72.5 WORDS PER MIN. - TAJ-4

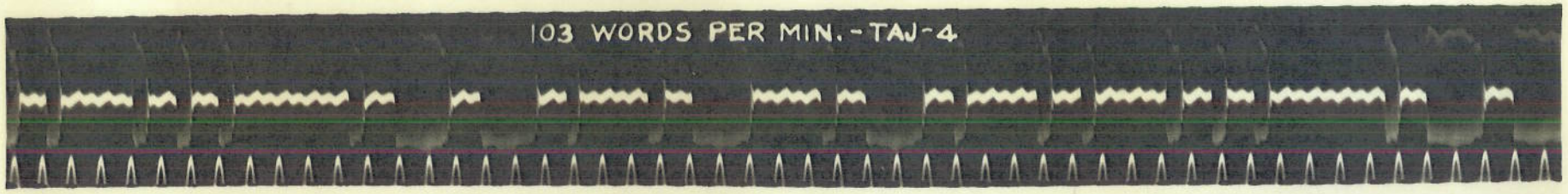
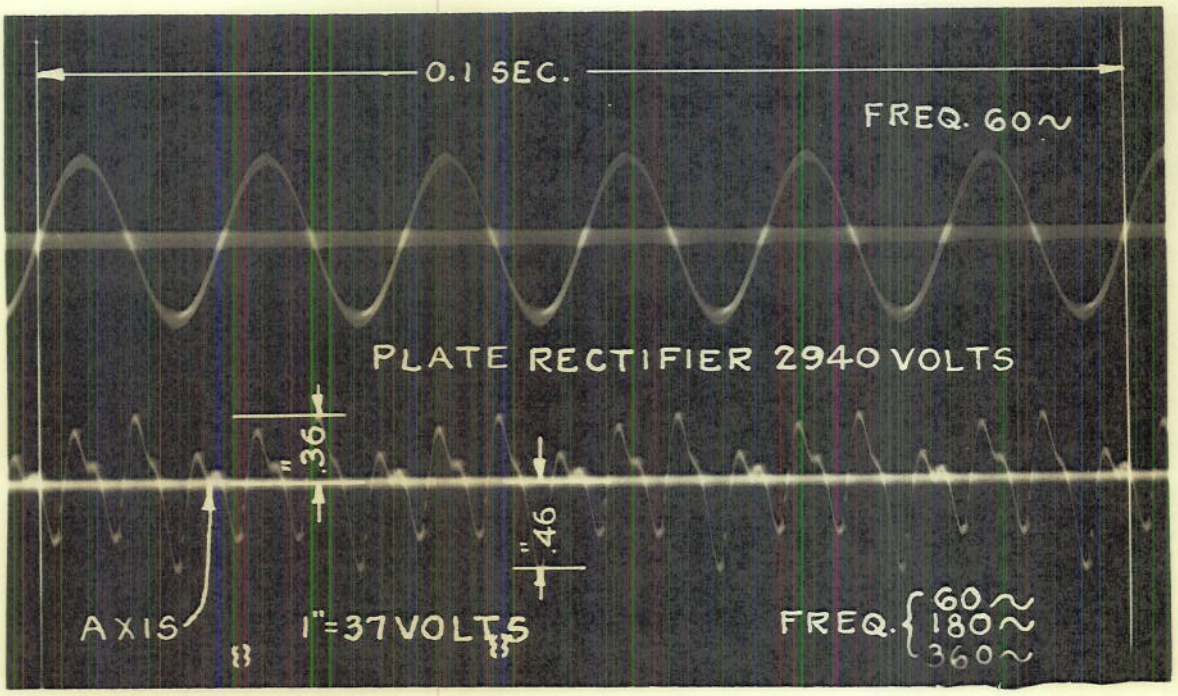

103 WORDS PER MIN. - TAJ-4

PLATE 3


0.1 SEC.
FREQ. 60~
PLATE RECTIFIER 2940 VOLTS
=.36
=.46
AXIS
1"=37 VOLTS
FREQ. { 60~ 180~ 360~

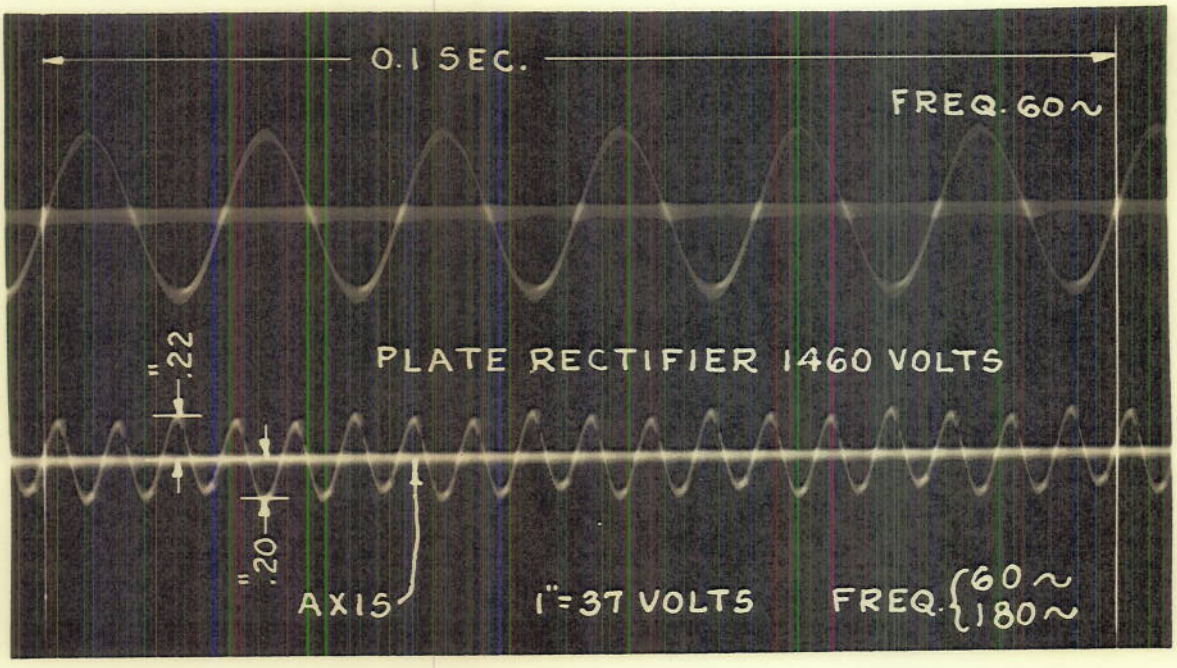
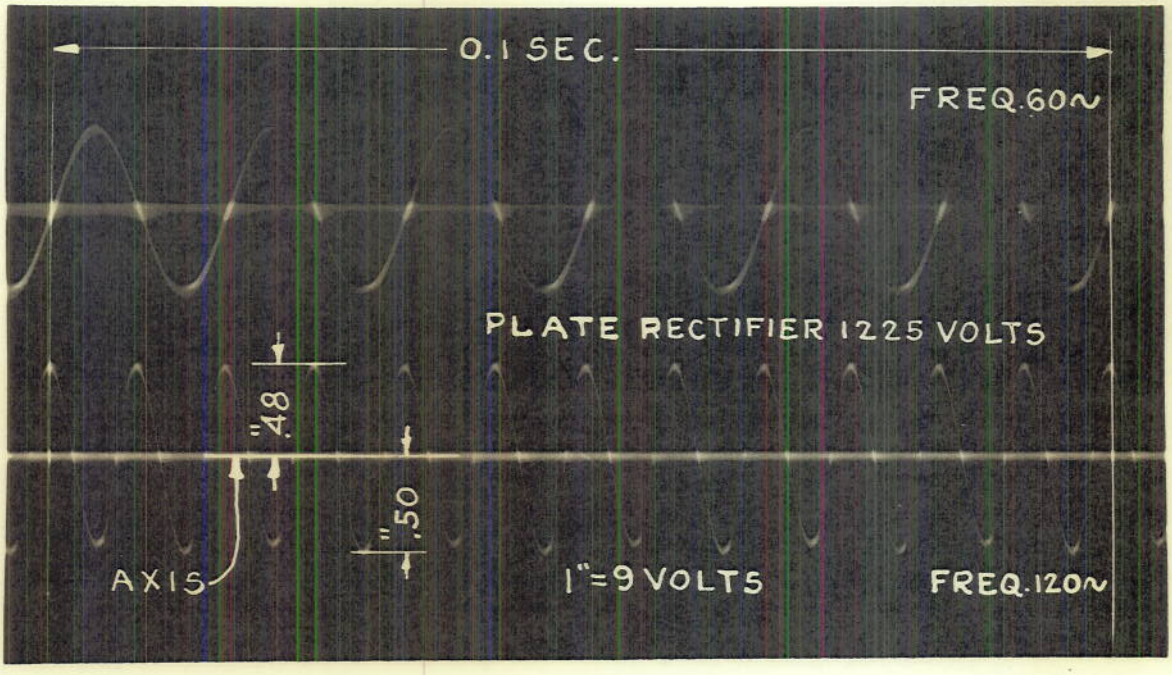

0.1 SEC.
FREQ. 60~
PLATE RECTIFIER 1460 VOLTS
=.22
=.20
AXIS
1"=37 VOLTS
FREQ. { 60~ 180~

PLATE 4


0.1 SEC.
FREQ. 60~
PLATE RECTIFIER 1225 VOLTS
.48"
.50"
AXIS
1"=9 VOLTS
FREQ. 120~

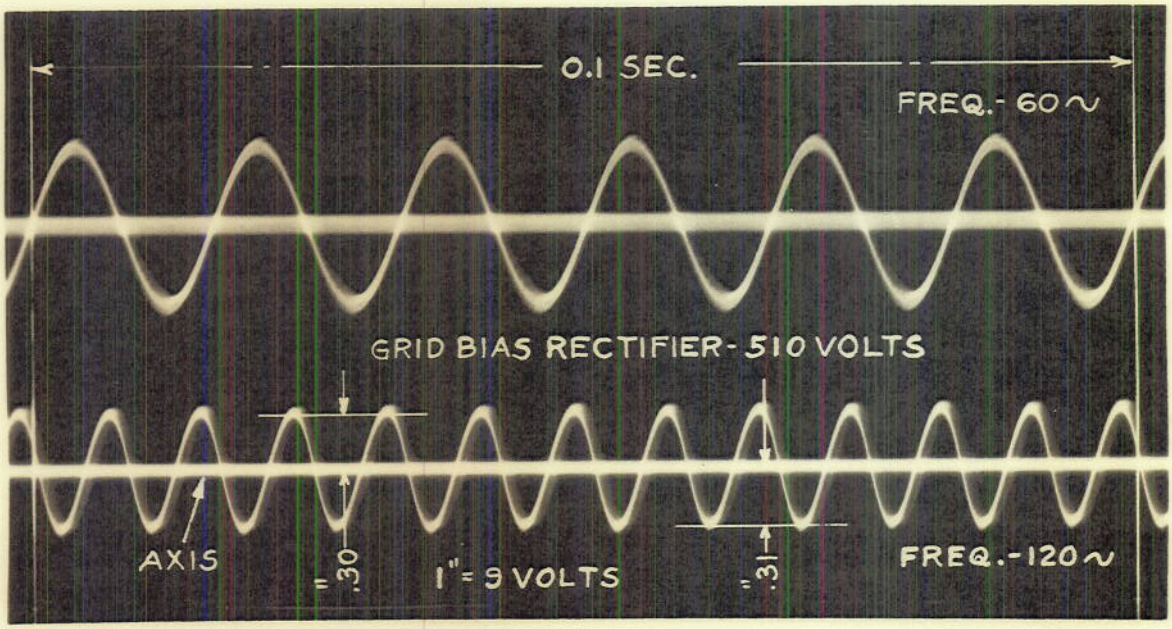

0.1 SEC.
FREQ.- 60~
GRID BIAS RECTIFIER- 510 VOLTS
AXIS
.30"
1"= 9 VOLTS
.31"
FREQ.- 120~

PLATE 5

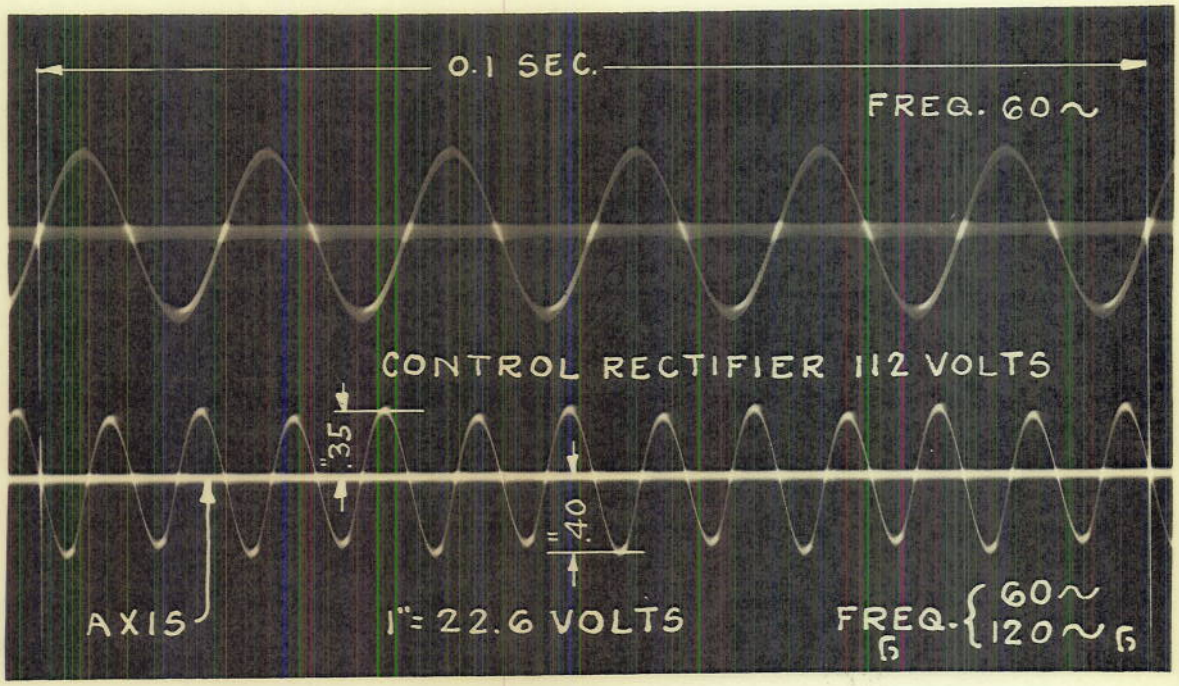

0.1 SEC.
FREQ. 60~
CONTROL RECTIFIER 112 VOLTS
.35
.40
AXIS
1" = 22.6 VOLTS
FREQ. 60~ 120~

PLATE 6