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FR-2358

REPORT NO. R-2358

DATE 4 September 1944

SUBJECT

Test of Model TDO Transmitting Equipment

by

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NAVAL RESEARCH LABORATORY

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DECLASSIFIED by NRL Contract
Declassification Team
Date: 1st AUG 2012
Reviewer's name(s): A. THOMPSON, P. HANNA
Declassification authority: DIAN DECLASS MANUAL, IIDEC 2012, 06 SERIES

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SERIAL No.

Encl. (A) of NRL ltr.
C-S67/52(380-ALG) Ser. C-381-421

4 September 194[redacted]

Classification changed from Confidential
to Unclassified
By authority of Let. Memo 117-46 ltr.
Dated
File No.

NRL Report No. R-2358
Problem No. S520T-R

NAVY DEPARTMENT

Report on
Test of Model TDO Transmitting Equipment

Contractor:
Collins Radio Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 52 Tables - 55 Plates - 42

Authorization: BuShips ltr Serial No. 763(925B) of 4 November 1943 to NRL.

Dates of Test: 12 November 1943 to 17 January 1944

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Distribution: BuShips (10)

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AUTHORIZATION OF TESTS

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

Reference:
(a) BuShips ltr. Serial No. 763(925B) of 4 November 1943 to NRL.
(b) "Summary of Requirements Applicable to Model TDO and BC-460 300 Watt Radiotelegraph and Radiotelephone Equipments" of 7 June 1943.
(c) Contractor's Descriptive Specification for 300 Watt Radiotelegraph and Radiotelephone Transmitting Equipments of 21 October 1943.
(d) BuShips ltr. NXs-20834(926) Serial No. 316 of 12 June 1943 to Collins Radio Co.
(e) BuShips ltr. NXs-20834(926) Serial No. 439 of 21 July 1943 to Collins Radio Co.
(f) Collins Radio Co. ltr. of 14 July 1943 to BuShips.
(g) BuShips ltr. NXs-20834(926) Serial 555 of 26 August 1943 to Collins Radio Co.
(h) Collins Radio Co. ltr. of 24 Aug. 1943 to BuShips.
(i) BuShips ltr. NXs-20834(926) Serial No. 619 of 20 Sept. 1943 to Collins Radio Co.
(j) NRL ltr. Serial No. S67/52(380-ALG) of 26 November 1943 to BuShips.
(k) NRL ltr. Serial No. S67/52(380-ALG) of 4 December 1943 to BuShips.
(l) NRL ltr. Serial No. S67/52(380-ALG) of 21 December 1943 to BuShips.
(m) NRL ltr. Serial No. S67/52(380-ALG) of 3 February 1943 to BuShips.
(n) BuShips Specification RE 13A 554D.
(o) JAN 1A Army-Navy Tube Specifications.

OBJECT OF TESTS

2. The objects of the tests were to determine the extent to which this equipment complies with the specifications, references (b) and (c) and the revisions and supplements of these specifications, references (d), (e), (g), (i), (n), and (o).

3. Tests were performed to obtain sufficient data to permit the submission of recommendations regarding desirable changes and to aid in the preparation of specifications required in the purchase of additional equipment.

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ABSTRACT OF TESTS

4. The tests herein reported were conducted to determine the degree of compliance of the TDO transmitting equipment with the mechanical and electrical requirements set forth in general Naval Specifications.

5. Specifically tests were conducted to determine the following:

(a) Packaging and ability of the equipment to withstand shipment and movement from one location to another.

(b) Check of the general mechanical and physical construction and assembly, general workmanship, materials employed, corrosion resisting measures employed, and the adequacy of electrical circuits to withstand service under normal operating conditions.

(c) Power output, power input, and flexibility of the antenna coupling network.

(d) Quality of emitted signals, lilt, and keying speeds.

(e) Check of dimensions and weights of the units.

(f) Determination of frequency overlap, limiting frequencies of various circuits, and cycles per dial division of the tuning controls.

(g) Check of the operation of the temperature control circuits employed in the equipment.

(h) Check of the fuse and overload relay protection of the circuits.

(i) Check of the frequency stability and accuracy under certain conditions.

(j) Check of the audio circuit operation.

(k) Check of the power equipment to determine voltage regulation and performance under a variety of conditions.

(l) Check of the operation of the remote control unit.

(m) Check of the operation and reliability of the autotune system.

(n) Check of the operation of the relays which provide remote control operation.

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CONCLUSIONS

(1) In general, the Model TDO transmitting equipment is suitable for Naval Service. Certain exceptions have been noted and recommendations have been made regarding corrective action which, if taken, will make the transmitter suitable for use in the Naval Service.

(2) Satisfactory power output in excess of specification requirements has been provided throughout the entire frequency range using A-1, A-2, or A-3 emission.

(3) A high degree of flexibility is obtained by means of the auto-tune system, which automatically tunes the transmitter to any one of eleven channel frequencies. Automatic selection of type A-1, A-2, or A-3 emission is afforded.

(4) Remote control operation of the transmitter may be accomplished from one or more remote locations with the same flexibility of operation as with local transmitter control.

(5) In general, the mechanical and electrical construction is satisfactory. Minor changes have been recommended to improve the operation and increase the reliability of the transmitter.

(6) The frequency stability of the master oscillator is satisfactory except with changes of the ambient temperature and humidity. Recommendations regarding the improvement of the thermal stability of the heater compartment have been outlined in this report.

(7) If the necessary action be taken as outlined in this report, the TDO transmitting equipment will then be considered suitable for use in the Naval Service.

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RECOMMENDATIONS

It is recommended:

(1) That all component parts be adequately protected against the effects of corrosion. (Par. 27)

(2) That improved type fuse holders be used which do not depend upon solder for mechanical strength. (Par. 30)

(3) That a protective thermostat be provided to afford protection, should the thermostat S102 fail to open. (Par. 33)

(4) That Navy Type numbers be affixed to the component parts. (Par. 35)

(5) That the master oscillator frequency determining circuits and heater be made more accessible. (Par. 36)

(6) That special tools required for assembly and repairs be provided. (Par. 37)

(7) That adequate protection of the personnel be provided by an interlock system which will not allow the personnel to be exposed to high voltage. (Par. 40)

(8) That the interlock seats be fully adjustable to allow for any misalignment of the front or rear door of the transmitter. (Par. 41)

(9) That Navy approved tubes be used throughout the equipment. (Par. 43)

(10) That the potentials applied to all tubes be maintained in conformance with the tube ratings. (Par. 44)

(11) That the resistor clips be carefully positioned so that the proper spacing between clips will be obtained. (Par. 47)

(12) That certain resistors be removed from the transmitter and shipped separately. (Par. 48)

(13) That an improved type of overload relay be used which is capable of being tripped at any preset value between the full load and 25 per cent overload. (Par. 52)

(14) That the conditions which cause arc-over across the contacts of the phone-cw relay K117 be corrected. (Par. 53)

(15) That the rotary switch relay be of more suitable design

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and capable of holding its adjustments through many cycles of operation. (Par. 56)

(16) That anti-glare type glass be incorporated in all meters. (Par. 59)

(17) That an antenna ammeter having a greater range be incorporated in the equipment. (Par. 62)

(18) That a more rigid inspection be given the metering switches to insure reliable operation. (Par. 63)

(19) That an accurate means of measuring the 2.5 volt filament potential be provided. (Par. 63)

(20) That separate plate current indicators be used for the modulator and the final power amplifier. (Par. 64)

(21) That the meters, multipliers, and shunts be carefully inspected to insure accuracy. (Par. 65)

(22) That a clear glass indicator be used instead of green to indicate when the filament circuit is energized. (Par. 67)

(23) That an amber indicator lamp be used to indicate when the m-o heater circuit is energized. (Par. 68)

(24) That insulated wire be used for the filament circuits of the high voltage rectifier. (Par. 70)

(25) That larger holes be provided in the antenna ammeter connecting lugs. (Par. 72)

(26) That ceramic insulator supports be substituted for the bakelite strip which insulates C132 from ground. (Par. 75)

(27) That captive nuts be used to secure the screws holding the steel side panels to the cabinet. (Par. 78)

(28) That the door catches be more adequately secured to the transmitter cabinet. (Par. 80)

(29) That greater care be taken to tighten the screws which hold the m-o shelf in place. (Par. 81)

(30) That a larger terminal board be used for the supply line wires. (Par. 82)

(31) That the controls located inside the transmitter cabinet be made accessible for tuning without the necessity of opening the front door. (Par. 85)

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(32) That the markings of control dials be changed so that in all cases an increase of the final controlled effect is obtained with an increase in the dial setting. (Par. 87)

(33) That greater care be taken to provide sufficient clearance between the m-o dial and the movable vernier plate. (Par. 88)

(34) That the primary power switch S120 be made accessible without the necessity of opening the front door of the transmitter. (Par. 89)

(35) That greater care be taken in the fastening of the "local-remote" switch to the front panel. (Par. 92)

(36) That an interlock switch be provided to remove the plate voltage when rotary switch S101 is manually operated. (Par. 93, 135)

(37) That labels be provided for all fuse holders to designate the voltage and current rating of the fuse employed. (Par.97)

(38) That all transformers bear nameplates showing the terminal designations. (Par. 98)

(39) That suitable tags and labels be provided to facilitate in the unpacking and assembly of the transmitter. (Par. 99)

(40) That lubrication instructions be provided on each of the motors. (Par. 100)

(41) That a balanced output network be incorporated. (Par.111)

(42) That the parasitic oscillations existing in the final power amplifier be investigated particularly with regard to the characteristics of the operation of the plate feed choke. (Par.114)

(43) That shaft couplers having less flexibility be used to eliminate the torque lash of the m-o tuning circuit. (Par. 119)

(44) That adequate compensation be provided in the frequency determining circuits for changes in humidity. (Par. 124)

(45) That the excessive frequency drift during the first five minutes of operation be corrected. (Par. 125)

(46) That the temperature controlling circuits provide greater thermal stability. (Par. 126)

(47) That the frequency range of the master oscillator circuits be increased. (Par. 136)

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(48) That a tuning data card be provided on the front of the transmitter. (Par. 139)

(49) That the coils in the exciter circuits which are tuned by a slug be capable of either an increase or a decrease in the effective inductance. (Par. 136)

(50) That an outlet box or similar means be provided for the entrance of the audio and control lines from the remote control unit into the transmitter. (Par. 145)

(51) That all test cables be carefully and correctly labeled. (Par. 148)

(52) That a means of measuring the modulation level be provided. (Par. 161)

(53) That a splined shaft and sleeve be used to couple the auto-tune motor to the drive shafts. (Par. 165)

(54) That the manufacturer investigate the possibility of providing a more accurate means of setting and locking the auto-tune controls to a desired dial setting. (Par. 167 and 119)

(55) That the reliability of the auto-tune relay control system be improved. (Par. 183 and 184)

(56) That permanently connected handsets be provided. (Par. 186)

(57) That the style of the remote units conform with reference (d). (Par. 187)

(58) That a tap-switch be provided on the input auto-transformer to allow correction for abnormal line voltages. (Par. 192)

(59) That the "Tune" position of the "L.V.-Tune-Op." switch be used only for tuning the transmitter. (Par. 192)

(60) That a multi-range voltmeter be incorporated so that either the high voltage or low voltage power supply potentials may be determined. (Par. 202)

(61) That a heater be used to provide for operation of the mercury vapor rectifier at low ambient temperatures. (Par. 204)

(62) That the spare parts required be provided. (Par. 205)

(63) That the errors or omissions in the instruction book be corrected. (Par. 206 to 222, incl.)

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MATERIAL UNDER TEST

6. The material under test consisted of one Model TDO transmitter, Serial 1, complete with one set of tubes, two instruction books, and one case of spare parts. Two Type COL-23377 remote control units, Serial 1 and 2, complete with one telegraph key and one microphone each, were provided. The transmitter was designed to operate from a 230 or 115 volt single-phase 50-60 cycle power source and the remote control units operate from a 115-volt single-phase power source. The equipment was received at the Naval Research Laboratory under Contract NXss-20834 on November 6, 1943 from the Collins Radio Co., Cedar Rapids, Iowa.

7. The transmitter is rated at 400 watts output using type A-1 emission and 250 watts output using either type A-2 or A-3 emission. This equipment is designed for shore station operation using the frequency range of 2.0 to 18.1 mc.

METHOD OF TEST

8. The equipment when received was carefully examined to determine whether adequate precautions had been taken in preparing the material for shipment and whether any damage had occurred during transportation.

9. Power output measurements were made by measuring the current flowing through a resistive water-cooled load. Care was taken to use an r-f ammeter having accurate calibration throughout the frequency range. The resistors used in the load were of the non-inductive type and voltage and resistance measurements were made to insure the maximum degree of accuracy.

10. Frequency changes and drift were checked by means of a Model LK frequency drift indicator.

11. The frequency range, overlap, end tolerance, kilocycles per division of dial marking, adequacy of the frequency determining circuits, and accuracy of automatic frequency adjustment were determined by means of the Types LD-4 and LM frequency meters.

12. Measurements of ripple voltage in the output of the power supplies were made by the use of high impedance voltmeters of Daven manufacture.

13. A Model RBG receiver was used to determine the quality of the emitted signals.

14. Measurements of fidelity and noise and distortion of the audio equipment were made with an RCA Model 69C noise and distortion meter.

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15. The equipment was subjected to variations of ambient temperature and relative humidity in the Naval Research Laboratory test chamber. The variation in ambient temperature ranged from minus 10 to plus 50 degrees C. The relative humidity was varied between the limits of 30 and 97 per cent at an ambient temperature of 40°C. During these tests the output frequency and power output were kept under constant observation. In addition the power-amplifier plate potential and plate current were recorded.

DATA RECORDED

16. Complete data were recorded during all the tests conducted and are shown in Tables 1 to 55 and Plates 1 to 42, inclusive.

PROBABLE ERRORS IN RESULTS

17. Precautions were taken to minimize the errors in the results obtained during the tests; where necessary and desirable, duplicate tests were conducted to insure accuracy.

18. Meters of the precision type of verified accuracy were employed under conditions which insure maximum accuracy.

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SECTION I -- INTRODUCTORY

19. The Model TDO transmitting equipment is intended for cw, mcw, and voice operation over a continuous frequency range of 2000 to 18,100 kc and is so designed that it may be operated on any one of eleven preset frequencies. These frequencies may be selected automatically, either locally or at a remote point by means of telephone dials.

20. The transmitting equipment described is complete except for interconnecting wires for the remote control units and leads to the source of primary power.

21. The complete equipment consists of the transmitter, modulator, power supply, one set of vacuum tubes (excluding spare tubes), two remote control units, and the auto-transformer necessary to provide either 115 or 230 volt operation of the equipment.

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SECTION II -- GENERAL FEATURES

22. Workmanship. The equipment in general has been constructed in a workmanlike manner. Certain defects due to poor workmanship have been noted. Those requiring corrective action are included under the listing of "RECOMMENDATIONS" of this report.

23. Temperature and Humidity. The TDO transmitter and remote control unit were subjected to ambient temperature changes ranging from 0 to 50 degrees C. and to 97 per cent relative humidity at an ambient temperature of 50 degrees C. In addition to the usual tests, the transmitter was subjected to a cold temperature test during which the ambient temperature was lowered to minus 20 degrees C. The operation of the transmitter and remote control unit was also investigated following a three-hour saturation of the units at an ambient temperature of 40 degrees C. and 95 per cent or greater relative humidity. Certain difficulties experienced during these tests are discussed under paragraphs 123, 124, and 185 of this report.

24. The individual components were not tested for flow or softening of compounds at 75 degrees C. Following the temperature tests at 50 degrees C. the components were inspected and no evidence of flow or leakage of compounds could be detected.

25. A ventilating system aids in maintaining a safe operating temperature within the unit. The details of the ventilating system are discussed under paragraph 26 of this report.

26. Ventilating and Cooling. Ample ventilation is supplied by a blower which is driven by a 1/20 horsepower single-phase motor. This blower is located in the lower rear section of the transmitter. Air enters through the lower rear louvers and then is filtered by a spun-glass dust filter. Louvers at the top of the rear panel of the transmitter permit the escape of hot air. The manufacturer recommends a minimum clearance of 18 inches at the rear of the transmitter, to insure free circulation of air.

27. Corrosion. Corrosion resisting measures have been taken in the TDO equipment to protect the metals against corrosion. The steel cabinet of the transmitter is finished with a zinc chromate primer with a final coat of black crinkle finish on the outside and flat gray paint on the inside. Certain component parts have been noted where protection was entirely lacking or inadequate. Following the humidity tests, it was noted that the mounting bolt of the dry disc rectifier CR101 had rusted. Transformers T112, T115, and T116 showed signs of rust where the paint was inadequate. The plunger of relay K118 showed signs of corrosion. As

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far as could be observed, brass and copper parts are plated with the exception of the brass contactor assembly on relays K112, K113, and K118 and the fuse clips holding fuses F114 and F115. It is recommended that adequate protection against corrosion be provided for all the exposed metal parts.

28. General Design. In general, it may be stated that the design of electrical circuits and controls is liberal. The parts which are likely to carry a heavy overload, due to poor adjustment or tube casualty are proportioned to care for such an overload or devices have been included to protect them.

29. Parts in the final amplifier which are likely to carry a heavy overload due to improper adjustment or opening or short-circuiting the antenna, are protected by overload relay K101. When this relay is tripped by excessive current, the holding circuit for the plate auxiliary relay K115 is opened, removing plate voltage from the low and high-voltage rectifiers. Certain difficulties which were experienced with this relay are discussed under paragraph 52. Table 6 shows the effect of opening or short-circuiting the antenna while operating at full power output. Shorting the antenna while operating at a frequency of 2000 kc resulted in severe overload of the power amplifier tubes; however, no satisfactory method of protection against overloads of this type has been devised.

30. The fuses employed in the equipment are listed in Table 3. These fuses are primarily of the non-renewable "instrument" type and are secured in extractor-type fuse holders. Difficulty was experienced with these holders due to loosening of the lugs which are soldered to the fuse receptacle. It is recommended that an improved type holder be used which does not depend upon solder for mechanical strength. Table 4 shows the effect of fuse failures on the operation of the equipment. This table shows that all fuses are effective in providing protection in the circuit in which they are located. Fuses of the slow-blowing type are used in circuits which are subjected to high instantaneous currents in excess of the normal operating current.

31. The 110/220 volt supply line is protected against short-circuit or heavy overload by two renewable 25 ampere fuses. Additional protection is provided by the magnetic type line switch, which is designed to trip at approximately 10 amperes. Investigation of the operation of this switch is shown in Table 5.

32. The master oscillator and subsequent driving stages of the equipment are not provided with overload relay protection; however, adequate protection of the tubes is provided by the use of cathode bias.

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33. No protection has been provided for the master oscillator heater compartment in the event that the heater thermostat, S102, should fail to open. It was found that with the thermostat shorted, the temperature within the heater compartment reached a temperature of 120 degrees C. within 50 minutes. It is recommended that a protective thermostat be provided to afford protection should the thermostat S102 fail to open.

34. Shock and Vibration. No provision has been made for this equipment to withstand shock and vibration. Transporting the transmitter as a single assembled unit should not be attempted since large components, such as transformers, are held by positioning-studs and only small size Phillips screws are employed to secure the transformer mounting brackets to these studs. Machine screws are secured by lock washers of non-corrosive material. Fiber washers have been used to absorb stress set up on ceramic insulators. With the exception of the fuse holders mentioned in paragraph 30, solder has not been relied upon for mechanical strength. Soldering lugs are of a type which crimp firmly upon the wire and insulation.

35. Interchangeability and Numbering of Parts. In general, the essential parts employed in the equipment are accessible and interchangeable with types employed in similar Navy equipments. The general design requirements of the governing specifications require the use of certain special parts; most of these parts being used in conjunction with the automatic channel selection system. Navy Type numbers have not been affixed to the component parts; however, with certain exceptions, symbol numbers and nameplates have been suitably affixed.

36. The m-o unit does not readily lend itself to disassembly and repair, due to the inaccessibility of certain parts. During the investigation of the subject equipment, the m.o. was completely dismantled to determine the accessibility of such parts as the m-o thermostat and heater elements. Plate 39 shows the m-o compartment with the bottom coverplate removed and the puffed mica packed around the heater elements. This mica must be removed, disclosing the heater elements underneath. See Plate 40. In order that the heater unit may be removed from the compartment, the four connecting wires must be released from their terminals. After the shaft couplers and insulator supports had been released, it was found that insufficient clearance is provided to allow this unit to be lifted out of the compartment. Consequently, it was necessary to move the wall of the compartment which separates the heater unit from the m-o tube socket and adjacent parts to provide the needed clearance. Examination of Plate 40 shows that this wall is held in place by screws at the side which are inaccessible, thus necessitating the partial removal of the entire compartment by removing the two bolts running through the cast-aluminum supports. The head of one of these bolts is inaccessible and therefore the multi-turn unit must be removed. With the removal of the

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multi-turn unit, the two front mounting bolts can be removed. Choke L133 must be released and the entire unit may then be lifted up so that the screws at the side can be removed, thus allowing sufficient clearance for the removal of the heater unit. See Plate 41. The heater unit can then be disassembled, and the thermostat will be found within the container in a separate tubular compartment as shown in Plate 42. In reassembling the entire unit, not only must the m.o. be calibrated, but removal of the multi-turn unit requires re-synchronization of this unit with the other units of the auto-tune system. It is evident that a greater degree of accessibility is necessary and it is recommended that the component parts of the oscillator circuit, including the heater and heater thermostat be mounted so as to facilitate repairs and replacements.

37. Special parts, not ordinarily used in Navy Type equipment, necessitate the use of special tools. Adjustment of the auto-tune unit requires the use of a 0.005-inch feeler gauge. A telephone relay spring-bender is necessary to make adjustments on the limiting switch S110. To adjust condenser C126, a 1/4-inch spin type wrench is required. For assembly and disassembly, a set of Bristo wrenches is required. Since Phillips type screws are used, a complete set of Phillips screwdrivers of the standard and off-set type are necessary. Since these tools are of a special nature, it is recommended that they be included with each transmitting equipment.

38. Materials. Reinforced sheet steel has been used primarily for the construction of the transmitter cabinet. Steel, aluminum, copper, and brass have been used throughout the transmitter. Insulating material is primarily of ceramic or bakelite. In general, the kind and quality of the materials are consistent with the intended used. Certain exceptions have been noted in paragraph 75.

39. Safety. All external panels and frame are at ground potential. The front and rear access doors are equipped with self-aligning interlocks. Bleeder resistors are used to protect personnel against capacitor discharge.

40. When the interlock system is operated or the transmitter is shut down in the normal manner, the primary circuits of the power supplies are opened. However, when the "L. V.-Tune-Op." switch is in the "L.V." position, the front door interlock is shorted out. Under these conditions, the low voltage power supply is energized, thereby exposing the operator to potentials of 500 volts. It is recommended that the interlock system be altered so that the operating personnel is protected from potentials dangerous to life.

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41. Trouble was experienced with interlock S121 on the front transmitter door which failed to seat properly and make positive electrical contact. It was found that there is insufficient adjustment for the correct placement of the interlock seat. It is recommended that future equipments be equipped with interlocks capable of sufficient adjustment.

42. Installation. As shown in Plate 12 the transmitter may be secured to the deck by means of feet attached to the sides of the transmitter. Each foot has two 1/2-inch diameter holes suitable for accommodating the mounting bolts. The remote control units are designed to mount in standard 19-inch racks. Table 10 lists the overall dimensions and weights of the units.

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SECTION III -- GENERAL ELECTRICAL FEATURES

43. Tubes. The tube complement of the TDO equipment includes certain types which have not received Navy approval. Specific non-approved tubes in this equipment include types 6A8, 6C8G, 2A3, 805, and 249C. It is recommended that only Navy approved tubes be used in this equipment so that replacements can be readily obtained.

44. Table 7 list the potentials applied to the vacuum tubes under various operating conditions. The tube potentials have exceeded the limitations of reference (c) in the following instances:

(a) The potentials applied to grids 3 and 5 of the type 6A8 calibration oscillator exceeded the specification ratings.

(b) The plate voltage of the type 6AG7 buffer amplifier exceeded the specification ratings under key-up conditions.

(c) The rated screen voltage of the type 807 first intermediate amplifier is exceeded under the key-open conditions.

(d) The rated screen voltage of the type 807 second intermediate amplifier is exceeded under the key-open conditions.

(e) The rated screen voltage of the type 813 final amplifier tubes is exceeded under the key-open conditions with all types of emission. It is also exceeded under A-1 emission with the key closed. The plate potential to these tubes is exceeded under both key-open and key-closed conditions when using type A-1 emission and is also exceeded under the key-up conditions when using A-2 and A-3 emission.

(f) With no modulation using type A-2 or A-3 emission the plate potentials of the type 805 class B modulator tubes exceed the specification limit.

(g) The potential applied to the screen grid of the type 6SJ7 audio amplifier was excessive.

It is recommended that all vacuum tubes used in this equipment be operated within the ratings of reference (c).

45. In an emergency, the manufacturer recommends the use of 866-A tubes to replace the type 249-C high voltage rectifier tubes. Operation in this manner was satisfactory although the tube life is probably shortened.

46. Resistors. Table 1 lists the resistors used in the

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TDO transmitter and the measured current and voltage values at which they operate. Ferrule type resistors have been used where dissipation of more than one watt is present, and carbon or metalized resistors have been used where there is less than one watt of dissipation. All carbon resistors have been suitably color-coded, to denote their ohmic resistance. The wire-wound resistors comply with the requirements of specification RE 13A 372.

47. Resistor clips which hold resistors R181, R199, R203, R204, and R205 were loose and improperly spaced for correct accommodation of the resistors. It is recommended that greater care be taken to properly position the resistor clips.

48. Resistors R203, R204, and R205 were not packed separately but shipped in their respective clips in the transmitter power supply unit. It is recommended that these resistors be removed from the transmitter and shipped separately with the other resistors.

49. Capacitors. Foil paper capacitors have been employed in this equipment, and hermetically sealed metal cases are used as containers. A suitable finish has been given the container to protect the metal against corrosion. Electrolytic capacitors have not been employed in this equipment. No specific tests of the capacitors was undertaken since it is assumed that such tests were made by the Inspector at the point of manufacture.

50. Transformers and Reactors. No specific tests were applied to the transformers or reactors; however, satisfactory operation was obtained throughout the test without any undue heating.

51. Relays. Relays have been used as switching devices throughout the equipment. The operation of the overload relay K101 has been discussed under paragraphs 29 and 52.

52. The overload relay K101, which provides protection of the final amplifier circuits against excessive currents, has a knurled knob to provide adjustment of the current required to trip it. No calibration of this adjustment has been provided so that the operator must guess at the proper setting. Table 5 shows the current required to trip this relay at various settings of the adjusting knob. It was found that this relay is incapable of being adjusted to trip at any value between full load and 25 per cent overload. It is recommended that a calibrated relay be incorporated which will readily function at any preset value between full load and 25 per cent overload.

53. The phone-cw relay, K117 showed evidence of arcing across the set of contacts used to throw the high voltage on and

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off the modulator tubes. It was noticed that when the transmitter was keyed under mcw conditions, arc-overs occurred across the open pair of contacts (i.e., between the contacts attached to terminals 4 and 5 of modulation transformer T116). Although these contacts were cleaned and adjusted, arc-overs persisted.

54. Certain relays were found to be quite inaccessible to repair or replacement. Relays K115, K116, and K117 were particularly inaccessible.

55. Relay K112 was found to be faulty in operation, chattered and made poor contact. This trouble was remedied by thoroughly cleaning the pole-piece and applying a thin film of oil to the moving parts.

56. Telephone type relays are used primarily as a means of operating the various control circuits in conjunction with the auto-tune system. As shown in Plates 29 and 30 these relays are grouped in the auto-tune control chassis and are protected by a cover. Trouble free operation was obtained with all but the rotary switch relay, K107. This relay was found to be faulty in operation when the equipment was received. The rotary switch relay failed to follow the electrical impulses supplied by the telephone dial of the auto-tune system; consequently the wrong channel was obtained. Although careful adjustment of this relay remedied the situation, it was found that these adjustments would not hold for any length of time. It is recommended that future equipments employing the auto-tune system incorporate a more suitable rotary switch relay.

57. A time delay relay, K114, is energized upon the operation of the filament relay, K112. This relay prevents the application of plate power until sufficient time has elapsed to allow all the tubes in the transmitter to warm up to the proper operating temperature.

58. Meters: The meters used in the TDO equipment are listed in Table 2. These indicating instruments are the equivalents of the Weston type 301, 476, and 425 as required by paragraph C-2 of reference (c). The accompanying data list all the meters including those in the remote control unit together with measurements of their accuracy. All meters are of the 3.5-inch diameter flush mounted type with dull black bakelite cases. These meters are the standard Navy approved type except that square cases are used in lieu of the standard 3.5-inch diameter round case. If a round case meter is used to replace any of these square-case meters, additional holes will have to be drilled for the mounting screws.

59. The meters present a pleasing appearance as shown in Plate 12. They are mounted on a bakelite meter panel and are

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viewed through the glass window of the front door. The meters have not been equipped with anti-glare type glass and it is recommended that this type glass be included in future equipments.

60. A self-contained thermo-couple type antenna current ammeter is used in this equipment. It is located in the high potential side of the antenna output circuit.

61. The d-c high-voltage voltmeter is equipped with a hermetically sealed multiplier resistor so that a range of 0 to 3 kv is provided. This and other meters in the circuit have been suitably by-passed to protect them against damage due to stray r-f potentials.

62. The range of the antenna ammeter was found to be inadequate for all modes of operation. When the maximum c-w power output of 594 watts is attained and an antenna load resistance of 50 ohms at zero degrees is used, it is evident that the antenna ammeter must read 3.45 amperes. Since this reading is 0.45 ampere beyond the range of the present meter, it is recommended that an ammeter having greater range be installed.

63. Two multiple-purpose meters are used in this equipment. The grid current meter is provided with two scales and a suitable shunt so that the double-pole, double-throw switch S103 may be operated to provide measurement of either the intermediate or final amplifier grid current. Trouble was experienced with the metering switch when it was thrown in the "807" position. On numerous occasions, no reading could be obtained because of the failure of the switch to make positive contact. It is recommended that a more rigid inspection be given these switches to insure satisfactory operation in future equipments. The a-c filament-line switch is also equipped with two ranges, one being from 0 to 15 volts and the 0 to 300 volts. The 0 to 15 volt range is used to measure all filament potentials in the transmitter by means of a long rubber covered wire which is shown in the foreground of Plate 38. By plugging this cord into the various metering outlets, the filament voltages may be measured. Although this system was satisfactory, the readable accuracy of the meter when measuring the 2.5 volt filament voltages was unsatisfactory. It is recommended that a more accurate means of making these measurements be supplied.

64. Under mcw and radiotelephone operating conditions, the plate current meter reads the combined modulator and power-amplifier plate currents. This condition is confusing to the operator, since there is no definite indication of the actual power amplifier plate current. It is recommended that separate instruments be supplied for these circuits.

65. Table 2 shows the accuracy of calibration of the various

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meters. The line-filament voltmeter, plate current milliammeter, grid current milliammeter (0-5 ma scale) and the antenna ammeter displayed errors in excess of specification limits. It is, therefore, recommended that the meters, multipliers, and shunts be more carefully inspected to insure necessary accuracy.

66. Control Circuits. The general design of the control circuits is considered to be as simple as possible under the requirements of reference (b). Since control of the circuits may be accomplished both manually or automatically from a remote location, the control circuit design is of necessity rather complex. Details of the auto-tune control system are discussed under appropriate paragraphs of this report.

67. The indicating lamps used in this equipment are listed in Table 8. It is recommended that the filament indicator be changed from a green to a clear indicator lamp to indicate when the filament circuit is energized.

68. There are no means of knowing when the m-o compartment heater thermostat is functioning. It is recommended that an amber colored indicator be mounted on the front panel to indicate when the heater is energized.

69. Wiring. In general, the wiring of the transmitter is accomplished in neat manner. As may be seen in Plates 25, 28, and 36, the wiring is laced and supported wherever necessary. Flexible stranded leads have been used in most cases except in the r-f circuits where bare bus wire is used. The soldering of the wires to components has been effected in a very neat and workmanlike manner. In no case could evidence be found of excessive stripping of the insulation on the wires in order to affect a connection.

70. A short-circuit developed in the high-voltage power supply during the tests, blowing the supply-line fuses, F114 and F115. Examination revealed that the wire to the primary (terminal 1) of the high-voltage rectifier filament transformer T113 had shorted to the bare bus-bar filament lead of the type 249-C rectifier tube (V122). Since the filament circuits of the rectifier tubes are carrying a high positive potential, it is recommended that suitably insulated wire be employed.

71. A short-circuit developed during the tests in the bias power-supply circuit, blowing fuse F106. The reason for this short-circuit was not determined since after three successive fuse failures, the short circuit cleared itself. It is possible that the cause of this short circuit was due to faulty wiring in the bias power supply.

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72. The lugs supplied on the bus wires to the r-f ammeter were too small to accommodate the terminals of the replacement meter provided in the spare parts. It is recommended that terminal lugs with larger holes be provided.

73. Shielding. The equipment is housed in a steel cabinet which effectively provides shielding of the separate units. Each tube in the r-f stages, except for the final power-amplifier tubes is shielded by a small can which fits down over the tube and is held in place by two thumb nuts. The entire bottom of the radio-frequency amplifier chassis is covered by a shield. When operation was attempted without this shield in place, spurious oscillation took place on the high frequency ranges of the transmitter.

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SECTION IV -- GENERAL MECHANICAL FEATURES

74. Materials. In general, the materials used throughout the equipment are adequate for the intended use.

75. The insulation used throughout the transmitter is mainly of phenolic or ceramic material. Ceramic insulation is used in most instances where radio-frequency circuits are substantially above ground potential. Bakelite has been used, however, to insulate capacitor C132 at a d-c potential of 580 volts above ground. The rotor of this capacitor is coupled to the rotor of tuning capacitor, C125, by a cloth inserted bakelite shaft coupler, requiring the coupler to provide insulation for potentials of 580 volts. It is recommended that ceramic insulator supports be provided for capacitor C132 and that high-grade ceramic couplers be used throughout the equipment. Wood and other less suitable insulating materials have not been employed as insulation in this equipment.

76. Liberal use of steel has been made throughout this equipment. Reinforced sheet steel has been used in the construction of the transmitter cabinet. Steel has also been used for the chassis as well as the individual containers for the components. In all cases suitable protection against corrosion is provided except as discussed in paragraph 27. Since the overall weight of the units is not a prime consideration, the use of steel is considered satisfactory.

77. Finishes and Platings. The exterior of the transmitter cabinet and the remote control panel have a zinc chromate primer and a black crinkle finish which provides suitable protection against corrosion and presents a pleasing appearange. The interior surfaces of the cabinet are finished with a zinc chromate primer and a flat gray paint. The cases for the various components are either tin-dipped or suitably painted with flat gray paint. All chassis except the r-f unit are also protected with paint on the inside and outside. The r-f chassis appears to be cadmium-plated steel. The finishes used provided adequate protection for the equipment during the temperature and humidity tests. Certain exceptions were noted where smaller components showed signs of corrosion as discussed in paragraph 27.

78. Screws and Nuts. Screws used in the assembly of the units are of the Phillips head type. They are suitably secured by the use of lock washers. Screws of this type are used to assemble the sheet steel side panels of the transmitter cabinet. It is recommended that captive nuts be used to secure these screws rather than tapped holes in the sheet steel.

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79. Fiber washers have been used to relieve any stress in ceramic insulators, where screws are used to secure the insulator to a metal surface.

80. Two door catches are provided to secure the front door of the transmitter when it is closed. Each catch is secured by but one small screw which continually loosened during the tests. It is recommended that more than one screw be used to fasten the catch.

81. The shelf within the m-o unit which holds tube socket X101 and its associated components loosened. Examination revealed that two Phillips type screws hold this shelf in place and provide a ground connection for the m-o circuit. It is recommended that greater care be taken to tighten all screws used in the assembly of the components.

82. The screws which provide the terminal connection for the supply line wires are not large enough to accommodate the connecting lugs. It is recommended that a terminal board of more adequate size be incorporated.

83 Controls. The transmitter is capable, by means of a minimum number of controls, of being adjusted for operation on any frequency in the range of 2 to 18.1 mc. As shown in Plates 12 and 34, the controls of both the transmitter and the remote control unit present a pleasing appearance. The operator may obtain either automatic tuning or manual tuning as he desires.

84. All control shafts have been grounded for the protection of the operating personnel. Bakelite has been used to insulate the knobs and switch handles to prevent burns due to stray r-f fields. The locking-bars of the auto-tune dials and the telephone dial channel selector are made of metal. No trace of r-f potentials could be detected on these parts and since they were used only during the preliminary steps of tuning, they are considered to be satisfactory for the purpose intended.

85. Plate 13 shows the controls, indicating instruments and indicator lights. As can be seen in Plate 12, the auto-tune controls and the lower sub-panel protrude through the openings in the front door of the transmitter when the door is closed. Access to the C.F.I. unit, or to the audio unit controls can only be attained with the door open. Since the transmitter must be operated in the "L.V." position to check the output frequency, the operator is exposed to potentials of 500 volts. This interlock system has been discussed under paragraph 40. Adjustments of the audio unit can only be made with the door open and opening the door will immediately open the interlock and shut down the power if the "L.V.-Tune-OP." is in the "Tune" or "Op." position. Since accurate

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settings of these controls cannot be easily accomplished without shorting out the front-door interlock, it is recommended that these controls be made accessible in a manner similar to that provided for the auto-tune controls.

86. The remote control unit is shown in Plate 34. The indicators are neatly arranged and present a pleasing appearance. Two control knobs have been placed at the rear of the chassis. One control is the channel indicator adjustment and the other is the relay adjustment. Both of these controls are provided so that the functioning of these circuits can be adjusted for various operat- conditions.

87. The m-o unit is provided with a dial control which is properly marked so that a numerical increase in setting causes an increase in the output frequency. The exciter tuning control and band switch, the power-amplifier tuning control and band switch, and the antenna tuning control, have been improperly marked. In each case the final controlled effect is increased with a decrease in the numerical dial setting. It is recommended that these markings be changed so that in all cases an increase of the final controlled effect is obtained with an increase in the dial marking. No dial locking devices have been included with the tuning units. When the controls are operated by the auto-tune mechanism, the friction of the clutches holds these dials securely in place. This method is considered satisfactory.

88. A movable vernier dial escutcheon plate is mounted directly behind the m-o tuning dial to provide a means of calibrating the m-o output frequency against the C.F.I. unit crystal frequency standard. During the tests it was found that turning the m-o dial caused the vernier plate to slip due to insufficient clearance between these units. It is recommended that greater care be taken in the assembly of these units.

89. The primary power switch, S120, is not accessible without opening the front door of the transmitter. Since this switch provides complete shut-down of all potentials, it is recommended that it be made accessible without opening the front door.

90. Switches. The switches employed in the units are satisfactory for their intended use. Both rotary and toggle type switches have been employed.

91. Erratic operation was experienced in conjunction with the "Local" keying circuit. At times it was impossible to key the transmitter locally when the "Local-Remote" switch S114 was switched to the "Local" position. This switch was removed and examination revealed that the pair of contacts which connect the test key failed to make contact. This trouble was corrected by

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bending the contact leaves into the proper position.

92. It was found that the "L.V.-Tune-Op." switch was insecurely mounted to the panel. It is recommended that greater care be taken in the fastening of the switch unit to the front panel in all future equipments.

93. Rotary switch S101 showed signs of arcing when manually tuned with the plate voltage applied. It is recommended that an interlock system be provided to remove the plate voltage when this switch is operated.

94. Metering switch S103 failed to make positive contact at all times. This condition is discussed under paragraph 63.

95. Adjacent to each control is a suitable marking descriptive of the purpose of the control. These markings are easily readable at a distance of 24-inches in poor light.

96. The operation and control of the primary power switch S120 is discussed under paragraph 89.

97. Marking. Appropriate nameplates have been supplied on the major units as shown in Table 9. In certain instances, necessary nameplates have not been provided on components. The fuse holders are not labeled as to the voltage and current rating of the fuse required. It is recommended that labels be attached giving the current and voltage ratings of each fuse.

98. Transformer T112 has not been given an appropriate nameplate. In addition, this transformer and transformer T117 should be provided with a nameplate bearing terminal designations of the unit. It is recommended that the manufacturer incorporate the labels on future units.

99. Warning labels and wiring labels have been attached to aid in the proper assembly of the units. In a number of instances it was found that the labels was either entirely lacking or in error. Wires to meters M102, M103, and M104 were not labeled. Wires to terminals 1 and 2 of terminal board E109 were not labeled. No warning label was affixed to the take-off couplers of the autotune units to insure that care will be taken to prevent accidental turning before the units are assembled. In addition, the link terminal board which connects padding capacitor C106 in parallel with C105 should be marked to denote the function of each link. It is recommended that suitable labels and tags be included in the aforementioned instances.

100. Lubrication nameplates should be supplied for the autotune drive motor and the blower motor, giving directions as to the

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lubrication required. It is recommended that these nameplates be provided and mounted on the side of each motor.

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SECTION V -- TRANSMITTER R-F CIRCUITS

101. R-f Circuits. The design of this transmitter is based upon the master-oscillator, power-amplifier principle of operation. It is intended for automatic frequency and emission selection from a remote or local position throughout the 2 to 18.1 mc frequency range. Provisions have been made for either A-1 emission or A-2 and A-3 emission employing high-level modulation. To accomplish this, various r-f circuits have been employed.

102. A master-oscillator circuit is employed which uses the negative transconductance characteristic of a type 6A8 pentagrid tube in a transitron oscillator circuit. A tuning slug provides accurate adjustment of the output frequency of this stage between the range of 1000 and 1510 kc. The frequency determining components are housed within a temperature controlled heater compartment.

103. An untuned r-f amplifier utilizes a 6AG7 pentode tube to provide r-f driving voltage for the frequency multiplier.

104. A type 807 beam pentode tube is used as a frequency multiplier, the output circuit being used either as a frequency doubler, tripler, or quadrupler depending upon the output frequency desired. The exciter band switch which is actuated in conjunction with the auto-tune dial mechanism selects the proper type of operation for this circuit.

105. A second type 807 beam pentode tube operates as a straight radio-frequency amplifier when the transmitter is operating within the 2.0 to 6.0 mc frequency range. For operation of the transmitter in the 6.0 to 18.1 mc range, this tube operates as a frequency tripler. The exciter band switch also operates to select the proper type of operation of this stage and is actuated by the auto-tune mechanism.

106. The final power-amplifier utilizes two type 813 tubes in a parallel-connected circuit. The output of these tubes is fed into a pi-network which acts as a combination power-amplifier plate circuit and antenna-coupling network. Proper values of inductance and capacitance in the output network are selected by the power amplifier band switch and the power amplifier tuning condenser.

107. Calibration Frequency Indicator. In order to provide accurate adjustment of the transmitter to any predetermined frequency, a crystal-controlled calibrator unit is supplied. This unit employs a Type 6A8 tube as an oscillator, a Type 6SN7GT tube as a converter and a Type 6SN7GT as an audio amplifier. A low temperature-coefficient 200-kc crystal provides an audible audio

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beat of the m-o output against the crystal frequency every 50 kc. These crystal check points allow the m-o tuning to be calibrated directly at these points, and for frequencies between the check points proper m-o dial settings may be obtained from the tuning chart provided.

108. Keying Tube. A Type 6SJ7 tube is used as a keyer tube. High speed keying is accomplished by varying the grid bias voltage of the master-oscillator tube. When the key is closed, a negative voltage is applied to the control grid of the keyer tube, stopping the flow of plate current. The voltage which is developed by the flow of plate current through the keyer tube load resistor is used to bias the master oscillator tube to cut-off; hence, when the plate current flow of the keyer tube stops, bias voltage is removed from the m-o tube and the circuit then oscillates.

109. Audio Frequency Circuits Within the Transmitter. The audio frequency system utilizes a Type 6SL7GT twin triode as a preamplifier, a Type 6C8G twin triode as a volume limiter, a Type 6C8G twin triode as an audio squelch tube, a Type 6SJ7 tube as an audio amplifier, a Type 6X5GT full wave rectifier as a limiter control tube, a pair of 2A3 triodes as audio drivers and a pair of 805 transmitting triodes as Class B modulators. In order to provide mcw operation a Type 6SN7 tube is utilized. This circuit is equipped with a switch which provides a choice of seven different audio modulation frequencies as shown in Table 48.

110. Audio Frequency Circuits Within the Remote Unit. Two stages of audio amplification are employed in the remote unit. A Type 6SJ7 tube is employed as the first preamplifier and a Type 6SN7GT is employed in the second stage of preamplification. These two stages of audio amplification provide sufficient power output to overcome up to 25 db loss in the control line between the transmitter and the remote control unit. A Type 6X5 rectifier tube is used as a high-vacuum rectifier to supply the d-c potentials required in the remote unit.

111. Antenna Matching Network. The antenna matching network acts as a power amplifier tank and antenna-tuning circuit. Reference (i) specifies that the equipment be capable of operation into a balanced or unbalanced load, either in the equipment itself or by means of an external coupling unit. No provision was made in the Model TDO equipment for balanced load operation and it is recommended that all future equipments of this type incorporate both balanced and unbalanced output networks. The circuit incorporated in the transmitter under test provides unbalanced operation as follows: 50 to 1200 ohms impedance at zero degrees; 50 to 850 ohms at plus or minus 45 degrees and 50 to 600 ohms at

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plus or minus 60 degrees. Table 11 shows the operating conditions when operating into various load resistors which presented an impedance of approximately zero degrees. Resistance values ranging from 55 to 552 ohms were used with satisfactory loading and operating conditions. It was necessary to connect capacitor C106 in parallel with C105 in order to load into a 58 ohm resistor at an output frequency of 2 mc. Table 55 shows the operation of the transmitter into a 164.5 foot antenna. It was found that loading into the antenna was impossible at frequencies which are multiples of the natural half-wave resonant frequency of the antenna. For this reason two antenna lead-in terminals are provided at the top of the transmitter so that either one of two antennas may be selected for each channel. The antenna so selected depends upon the connections made on the link terminal board, as shown in Plate 19. Antenna lengths should be selected when installing the transmitter, so that the natural half-wave frequency of the antenna or multiples thereof will avoid any of the operating channel frequencies.

112. The manufacturer suggests the use of a ground system composed of approximately 60 radials of 8 or 10 gauge bare copper wire. During the above tests, normal operation was obtained using the ground system of the Laboratory test room. A terminal is provided at the top of the transmitter for the ground connection as shown in Plate 15.

113. Harmonics, Key Clicks, and Lilt. Harmonics have been kept to a practical minimum; however, the single-ended power-amplifier circuit in conjunction with the antenna coupling pi-network has a tendency to emit a high second harmonic output. No attempt was made to measure the strength of this harmonic. Key clicks and lilt were found to be negligible when observed on a Model RBG receiver located approximately 10-feet from the transmitter. Certain instances of overloaded tubes were noted during the tests and are discussed under paragraph 44. The design of the equipment is such that no continuously oscillating master oscillator circuits are employed. Although the fundamental character of the signal is substantially pure, spurious side band emission was noted due to parasitic oscillations.

114. At frequencies between 2 and 4 mc it was found that the power output was somewhat lower than would normally be expected. As shown in Table 12 the power output measured at 2 mc was found to be 553 watts when using Type A-1 emission. Under the same conditions the power output was found to be 594 watts at a frequency of 8 mc. Investigation of the character of the emitted signal revealed spurious sidebands which were close to the fundamental frequency whenever the transmitter was operated in the 2 to 4 mc range. At higher frequencies of operation the sidebands disappeared; consequently the presence of parasitic oscillation

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was suspected. These sidebands were apparent regardless of the resistance value of the load used or the method used to tune the transmitter. The plate feed choke L103 which feeds the plate voltage to the final power amplifier in a shunt fed circuit was suspected of acting as a resonant plate circuit. In order to change the characteristics of this choke, a small amount of inductance (approximately 2 mh) was added in series with it. The addition of this choke produced a noticeable increase in the power output. At 2 mc the power output increased from 553 to 570 watts and the objectionable spurious sideband emission completely disappeared. The operation of the transmitter was normal at the higher frequencies; however, it was found that the additional r-f choke was unsatisfactory throughout the range of frequencies tuned by the transmitter. High r-f voltages were developed across the choke causing it to burn out. It is recommended that investigation be made to determine whether it is feasible to use a single r-f choke in this circuit throughout the 2-18.1 mc range. If this is not possible, a switching arrangement should be provided which will insert the correct amount of inductance in the plate feed system for the appropriate output frequencies.

115. Tests were conducted to determine the extent of amplitude modulation present in the carrier due to hum, ripple, or other audio frequency disturbances while the transmitter was adjusted for cw operation. The results of the tests are shown in Table 15. The percentage of ripple voltage was found to be considerably lower than that which is generally allowed in similar Navy Type equipments.

116. Mcw Emission. The TDO equipment has provisions for 100 per cent modulated mcw emission. When operating under these conditions the plate voltage to the final amplifier tubes is reduced to approximately 1500 volts. As shown in Tables 12, 13, and 14, the power output obtained is in excess of the rated power of 250 watts throughout the frequency range of the equipment.

The modulation frequency is variable in seven steps from 350 to 1205 cycles as shown in Table 48. Mcw emission can be automatically or manually selected.

FREQUENCY STABILITY TESTS

117. In accordance with the tests outlined in reference (b), the equipment was subjected to various tests to determine its frequency stability. These tests were conducted at various frequencies within the specified range to determine the variation in frequency or power output as shown in paragraphs 118 to 130.

118. Accuracy of Manual Frequency Adjustment. The TDO equipment is provided with a C.F.I. unit and a calibrated m-o dial to

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facilitate the adjustment of the transmitter to any predetermined frequency. As explained in paragraph 107, a crystal check-point is provided every 50 kc throughout the 1000 to 1510 kc range of the oscillator. A tuning chart is provided so that interpolated dial settings of the oscillator may be obtained for frequencies lying between the crystal check points. It is evident that the most accurate frequency adjustment will be obtained at frequencies at or near a crystal check-point. Table 16 shows the frequency deviations from the desired frequency when this method of tuning is used. A high degree of accuracy was obtained at 2003 and 2998 kc using the 2000 and 3000 kc check points respectively. When frequencies lying mid-way between the crystal check-points were tuned, a higher percentage of frequency deviation resulted.

119. Accuracy of Automatic Reset. After having locked the auto-tune system to a desired frequency, the transmitter was then retuned to another frequency and then returned to the initial frequency by using the auto-tune system. The difference between the original locked frequency and the frequency obtained automatically by the use of the auto-tune system was measured. This deviation of frequency as shown in Table 17 was found to be small on two of the channels tested and much greater on two others. This condition was partly attributed to the degree of technique and skill of the operator in adjusting and locking the auto-tune dials. The positioning pawl of each dial is locked against the stop ring drum. The degree of rotation and accuracy of dial setting is dependent upon the positioning pawl resting firmly in place against the stop ring. This positioning must be accurate or all subsequent auto-tune operations to this frequency will be inaccurate. Although there was a small deviation in frequency each time the transmitter was retuned to a channel, it was found that the greatest deviation existed between the original "manually locked-in setting" and the "automatically-tuned setting". Great care was taken to try to obtain an accurate adjustment of the auto-tune system; however, a rather wide range of frequency deviations were obtained. Inasmuch as these results could not be duplicated, it is believed that the human element becomes the limiting factor. After practicing the correct method of auto-tune adjustment, it is possible to lock the auto-tune system to the frequency desired with a reasonable degree of accuracy. Another source of frequency deviation resulted from the use of two universal type fiber shaft couplers between the auto-tune dial and the shaft of the m-o tuning slug. The flexibility of these couplings introduce a small amount of torque lash. This torque lash is sufficient to cause considerable frequency deviation. It is recommended that the manufacturer investigate the possibility of eliminating this condition by the use of more suitable couplers. It is desirable that the operator employ an external frequency measuring device to determine whether the transmitter is accurately tuned by means of the auto-tune system to the frequency desired.

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120. Operation of Tune-Operate Control. The change in frequency due to operation of the "Tune-Operate" control is shown in Table 18. At the frequencies investigated the deviation in frequency was small.

121. Detuning of Circuits. Circuits in the transmitter was detuned so that a 25 percent change in plate current was effected and the variation in output frequency measured. The plate tuning circuits of the exciter unit are ganged to a single control, consequently the frequency variation listed in Table 19 as "exciter tuning" represents the simultaneous detuning of two circuits. The frequency variation was found to be well within the specification limits.

122. Change of Tubes. A change of tubes in any of the r-f circuits was found to produce but little change in the output frequency when using full power and type A-1 emission. The results are shown in Tables 20 to 24.

123. Variation in Ambient Temperature. Pertinent data are shown in Tables 25 and 26 and Plates 1 and 2. The average variation in frequency per degree Centigrade in the ambient temperature range of 0 to 50 degrees C. was found to be within the limits imposed by reference (b). The test was conducted by operating first at an ambient temperature of 50 degrees C. and gradually lowering to 0 degrees C. in 10 degree steps. Normal power output was obtained; however, in subsequent tests it was found to be impossible to start the mercury-vapor rectifier tubes at the lower ambient temperatures. Further details of the effects of low ambient temperature operation are discussed under paragraph 185.

124. Variation in Humidity. Pertinent data are shown in Tables 27 and 28 and graphically in Plates 3 and 4. It may be seen that compliance with the specifications of reference (b) is obtained at 18100 kc but not at 2000 kc. In this case the frequency change was 0.00325 per cent whereas the specification allows 0.003 per cent. By referring to the data shown in Plate 3 it can be seen that the output frequency has not stabilized and it is recommended that more adequate compensation be provided for sudden changes in the relative humidity.

125. Locked Key Operation for Two Hours. With normal room ambient temperature the TDO equipment was operated under full power, A-1, locked-key conditions. The filaments were energized for a period of five minutes. Previous to operating the transmitter, the temperature control circuits were allowed to attain thermal stability. The pertinent data are shown in Tables 29, 30, and 31. At 2000 and 18100 kc output, the frequency change was within the requirements of reference (b). The initial frequency drift during the first five minutes of operation at 8000 kc was

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found to be 0.00125 per cent. During the remainder of this test, the frequency change was within the specification limits. It is recommended that the reasons for excessive initial frequency drift be investigated and corrected in future equipments.

126. Thermal stability has not been maintained in this equipment. The frequency change due to variation of temperature in the heater compartment is large as noted in the data of Tables 29, 30, and 31. This frequency change of the master oscillator due to cycling of the heater was found to range from 0.00032 per cent at a frequency of 8000 kc to 0.0005 per cent at a frequency of 2000 kc. The variation at 18.1 mc was found to be 60 cycles. This change caused an audible shift in the audio beat note when using type A-1 emission. This frequency variation is shown graphically in Plate 5. It is recommended that the temperature controlling thermostat be placed nearer the heater element so that the frequency determining components will not be subjected to wide variations of temperature.

127. A locked-key test was conducted at an output frequency of 2000 kc from a cold start, i.e. with the filaments and heater turned off for 24 hours before the tests. It was found that the frequency drift continued for a period of one and one-half hours. This indicates that thermal stability is slowly attained. The heater compartment is surrounded by "puffed" mica insulating material. This material as well as the surrounding metal compartment walls must reach thermal stability before the frequency determining components will reach a stable temperature. Consequently the heater compartment must be heated at least two hours before suitable frequency stability can be attained.

128. Change from Key-Locked to Intermittently-Keyed Condition. The change in frequency between the full power key-locked condition and the intermittently-keyed condition is shown in Table 33. Tests were conducted with and without the filament energized during the intervening period at 2000 and 18100 kc. It was found that the frequency variation was much less than is required in similar Navy Type transmitters.

129. Change from Continuously-Keyed to Intermittently-Keyed Conditions. Pertinent data are shown in Table 34. The percentage variation in frequency was found to be less than that permitted in similar Navy Type equipments.

130. Variation in Supply Line Voltage. The results of this test are shown in Table 35. With full power locked-key operation, the supply line voltage was varied from 10 per cent below to 10 per cent above normal line voltage. In all cases the frequency shift was small.

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131. Summary of Frequency Stability Tests. For purposes of comparison and information, a summary of all frequency comparison tests is shown in Table 36.

132. Stand-by Operation. Operation of the transmitter in the normal stand-by condition allows the filaments of all tubes to remain lighted. It is impossible to operate the filament of the master oscillator tube without operating all the other tube filaments. With the filament and plate power control switches turned off, only the m-o heater and the relay power transformer T114 remain energized.

133. Neutralization. The r-f amplifiers in this transmitter employ screen grid type tubes; however, it was found necessary to neutralize the Type 813 power amplifier tubes. These tubes are provided with a neutralizing capacitor consisting of a vertical metal plate placed parallel to the tubes as shown in Plate 21. This external capacitance feeds a small out-of-phase voltage to the grids of the tubes. Neutralization was made at the factory and no readjustments were required.

134. Keying. Keying the transmitter is accomplished by means of a keyer tube whose action is described under paragraph 108. When the key is opened all tubes cease to oscillate. Satisfactory operation is obtained with keying speeds up to approximately 100 w.p.m. As mentioned in paragraph 113 no trace of lilt or click was observed. The mcw keying was found to be satisfactory when tested at 25 w.p.m.

135. Frequency Switching and Overlap. Switching is empolyed in all tuned r-f power amplifier circuits. As can be seen in Plates 19 and 25, ganged rotary-switches are employed to switch to the various frequency ranges. Interlocks have not been provided to protect the contacts of these switches from excessive arcing. When automatic auto-tune operation is used, the plate power is removed when the switches are turned; however, when manual operation is used, the switches are unless the operator remembers to remove the plate power. It is recommended that all switch contacts subject to excessive arcing be protected by interlocks.

136. Switching is provided to adjust the first frequency multiplier, the intermediate amplifier, and the final amplifier plate tuning circuits. Pertinent data are shown in Tables 38 and 39. It may be noted that the end limits of the "Exciter Tuning" control are limited by the frequency range of the master oscillator. The range of the "PA Tuning" control varies according to the antenna impedance since this circuit acts as a combined plate tuning and antenna tuning network. For the data shown in Table 39, a load resistance of 300 ohms was used. The amount of frequency overlap and end-point tolerance appears to be adequate with the

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exception of the master-oscillator end-point tolerance, shown in Table 37. It was found that the end tolerances of the master oscillator tuning circuit were 1.16 and 0.85 per cent. Comparable Navy Type equipments are required to have an end-point tolerance of not less than 3 per cent. It is recommended that the frequency range of the master oscillator tuning be increased so that an end-point tolerance in excess of 3 per cent will be obtained. During the tests the grid current to the final amplifier tubes was found to be below the recommended minimum of 15 ma. at an output frequency of 14 mc. Adjustment of the tuning slug of the plate tank inductor L118 was indicated. It was found that the factory adjustment of this control was at the full counter-clockwise setting and additional adjustment of this tuned circuit was impossible. It is recommended that these circuits be designed so that additional adjustment of these circuits can be obtained with either an increase or decrease in the effective inductance being available.

137. Ease of Tuning. The transmitter unit is capable of being tuned to a pre-set channel frequency by means of the auto-tune system in 10.5 seconds. Manual adjustment of the controls to predetermined settings can be accomplished in approximately 45 seconds. The auto-tune system can be adjusted and locked to a predetermined dial setting in approximately one and one-half minutes. This time may vary considerably depending upon the dexterity and skill of the operator. Adjustments of the mcw or audio gain controls and the limiter control require additional time. These controls are mounted behind the front door, and as mentioned in paragraph 85, they are not easily adjusted.

138. Markings on the Panel. Each control is designated by means of an engraved marking which denotes the function of each control. The list of controls is shown in Table 8.

139. Tuning Data Cards. No tuning data chart has been provided for recording dial reset data. A small instruction book was provided in a compartment on the inside of the front door. Additionally, the fuses and their functions were listed on a small chart inside the front door. It is recommended that a calibration card suitable for the listing of ten frequencies be mounted on the outside of the front door of the transmitter.

140. A small calibration card was provided on the front of the remote control unit which provides for the listing of the frequency output of each of the ten channels available. This chart is shown in Plate 34.

141. Variation of Frequency per Dial Division. The variation in frequency per division of dial marking of the master-oscillator tuning control is shown in Table 40. All tuning capacitors are provided with 180 degree rotation with the dials calibrated from 0 to 100. This provides no vernier action for these

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controls and precise adjustment is difficult. The use of the auto-tune system makes it necessary to omit the use of vernier dial controls since this would complicate the auto-tune system.

142. Crystal Frequency Calibrator Unit. In order to expedite the adjustment of the transmitter to a desired frequency, the C.F.I. unit is provided. To check the frequency of the transmitter, the operator must plug his earphones into the receptacle and throw the C.F.I. power switch. An audible beat note is heard when the master-oscillator output beats with one of the harmonic frequencies of the crystal. The audio power output was measured and found to be 2.28 to -8.6 db. (6 mw. into 500 ohms as the zero db reference level).

143. Operation of the L.V.-Tune-Operate Switch. The "L.V.-Tune-Operate" switch provides three steps for tuning the transmitter. The "L.V." position places plate power on the master-oscillator and subsequent r-f exciter circuits. This permits the tuning of these circuits before applying plate voltage to the final power amplifier. When this switch is operated in the "Tune" position, voltage is applied to the plates of the final amplifier tubes; however, this plate potential is reduced to a safe value by a series voltage dropping resistor in the primary of the high-voltage power transformer, T115. In the "Operate" position, this dropping resistor is shorted out and full plate potential is applied to the final amplifier tubes. When the type of emission is changed from A-1 to A-2 or A-3, the power is reduced. This is accomplished by the power change relay, K118, which switches the connections of the primary taps of the power transformer so that a lower secondary voltage is obtained. The d-c plate potentials applied to the tubes using A-1, A-2, and A-3 emission are shown in Table 41. A continuously variable power output control was not considered to be necessary.

144. Test Key. A test key is provided on the lower control panel. This key is of the lever type providing either momentary contact or key-locked control.

145. Connecting Cables. Lines from a 110 or 230-volt a-c source are connected to terminal strip E109 at the lower rear floor of the transmitter. These lines enter through a standard outlet box located at the base of the transmitter as shown in Plate 17. No outlets have been provided for feeding the remote control lines into the transmitter. It is recommended that an outlet box similar to the one used for the a-c power line be provided for entrance of the remote control lines.

146. Accessibility. Access to the interior of the transmitter is accomplished either by opening the front door or removing the rear door. The rear door is provided with two knurled

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thumb screws at the top of the door to release the latches. The bottom is held in place with pins. The front door is prevented from swinging by means of a door stop.

147. All tubes are capable of being removed and replaced from the front of the transmitter. For major repair and maintenance, each unit is capable of being removed as shown in Plates 18, 21, 26, 29, and 32. This affords excellent accessibility to all components except those located in the modulator and power supply unit shown in Plate 32. This unit is bulky, and difficult to remove from the cabinet; however, after it has been removed, the component parts are accessible.

148. Ease of servicing is provided by two test cables shown in Plate 38. These test cables allow the units to be removed from the cabinet, so that the operating conditions may be observed. One of the cable connectors was labeled "Top" on both sides and caused considerable difficulty. It is recommended that these cables be correctly labeled and that a warning label be placed on each connector so that the operator will be aware that he is exposed to high voltages when operating the units outside the cabinet.

149. Antenna Connections. Two antenna terminals are provided at the top of the transmitter. These terminals are mounted on glass, bowl-type insulators. The antenna system is isolated from the high d-c plate potential by the plate coupling capacitor C109. A static drain choke is provided in the antenna matching network, but the manufacturer recommends the use of a horn-gap to protect the equipment from damage due to electrical storms and disturbances.

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SECTION VI -- AUDIO CIRCUITS

150. Electrical Tests of the Audio Circuits. The audio system of the TDO equipment was designed to provide high-level modulation using either voice or mcw emission. The audio system is capable of modulating the r-f carrier 100% with full power output when operated with either type A-2 or A-3 emission. The overall frequency response response was designed to be uniform within 3 db from 150 to 3500 cps.

151. The audio frequency system utilizes a Type 6SL7GT twin triode pre-amplifier, a Type 6C8G twin triode as a volume limiter, a Type 6C8G twin triode as an audio squelch tube, a 6SJ7 tube as an audio amplifier, a Type 6X5GT full wave rectifier as a limiter control tube and a pair of 805 triodes as Class B modulators.

152. A type 6SN7 tube is used to provide the audio oscillations for type A-2 emission. The pertinent data showing the operating potentials of these tubes are shown in Table 7.

153. Two stages of audio amplification are employed in the remote control unit. A Type 6SJ7 is employed as the first pre-amplifier and a Type 6SN7GT is employed in the second stage of pre-amplification. These two stages of audio amplification provide enough power output to overcome the permissible 25 db loss in the control line between the transmitter and the remote control unit.

154. Audio Fidelity. Audio fidelity measurements were made to determine the audio characteristics of the TDO equipment, with and without the use of the remote control audio unit. A distortion and noise meter was used to measure the audio output level in the manner outlined in paragraphs 155 and 156. Examination of the data in Tables 42, 43, 44, and 45 shows a discrepancy between the percentage of modulation observed on an oscilloscope and the output level measured by the distortion and noise meter. This discrepancy is possibly due to carrier shift; however, the overall fidelity measurements obtained by the use of the distortion and noise meter most nearly represent the actual audio levels obtained at the receiver.

155. Overall Fidelity of the Transmitter. With a constant 10 db audio input level supplied to the microphone terminal on the front panel of the transmitter, the carrier output level relative to 100 per cent modulation at 1000 cps was measured. This test was performed at a frequency of 2000 kc with the limiter gain turned off. The pertinent data are shown in Table 42 and graphically in Plate 6. From these data it can be seen that the audio response is flat within 3 db over the audio range of 100 to 4000 cps. Table 43 and Plate 7 show data for a similar test

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which was conducted with the limiter gain advanced to provide the maximum limiting action from the limiter circuit. The audio response appeared to be the same with and without the limiter action.

156. Overall Fidelity of the Transmitter and the Remote Unit. With a constant 0 db level audio input applied to the microphone terminals of the remote control unit, the carrier output level relative to 100 per cent modulation was measured. This test was performed at an output frequency of 2000 kc with limiter gain turned off. The pertinent data are shown in Table 44 and graphically in Plate 8. A similar test was conducted with the limiter gain advanced to provide maximum limiting action. The results of this test are shown in Table 45 and graphically in Plate 9. These data show that the results are similar regardless of the position of the limiter gain control, and that the frequency response is flat within 3 db over a range of 150 to 5000 cps.

157. Fidelity of the Remote Control Unit. The fidelity of the remote control unit only is shown in Table 46 and Plate 10. A constant input level of 0 db was applied to the microphone input terminals and the output level relative to 0 db at 1000 cps was measured. This frequency response was greater at high frequencies and the output level was flat within 3 db from 150 to 5000 cps. The capacity effects of a long audio line were simulated by terminating the output with a 500 ohm resistor shunted by a 0.5 mfd condenser. From Plate 10, it can be seen that under these conditions the high frequency response is considerably less.

158. Operation of the Limiter. The limiter action is shown in Table 47 and graphically in Plate 11. With various input levels, the output level was measured under conditions with and without the limiter action. From these data it can be seen that a change of 10 db in input level does not produce more than 3 db change in the modulation level.

159. Mcw Audio Frequency. The mcw oscillator is adjustable from 350 to 1205 cps in seven steps. The frequencies obtained are shown in Table 48.

160. Noise and Distortion. Measurements of noise and distortion relative to 100% modulation of the carrier were undertaken at output frequencies of 2000 and 18100 kc. Tables 49 and 50 show the results obtained using a -15 db input level with 10 db of compression. Direct audio input to the transmitter and audio input through the remote control unit were used with similar results. The noise level was somewhat higher with the audio input supplied to the remote control unit. In all instances, the noise level was more than -40 db below 100% modulation.

161. Audio Circuit Adjustment. The audio circuit must be

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adjusted so that approximately 100 per cent modulation of the carrier is obtained. This requires the use of an oscilloscope to observe the pattern of the modulated carrier and a db meter to indicate the input and output levels of the audio system. It is recommended that the audio system be provided with a db meter. This meter should be capable of being plugged into appropriate receptacles to indicate the input level to transformer T103 and the output level applied to the grids of the modulator tubes, V118 and V119. In addition it is recommended that this meter indicate 0 db output level when 100 per cent modulation of the carrier is obtained. This will then provide a means of obtaining approximately 100 per cent modulation of the carrier without the use of an oscilloscope.

162. Audio Squelch System - A Type 6SN7 tube, V115, protects the modulator tubes when the transmitter is in the stand-by condition. On stand-by telephone operation, filament and plate voltages are on with the push-to-talk button on the microphone released. Under these conditions there would be danger of damaging the modulator tubes with the class C load removed. The audio squelch tube acts to prevent this condition by removing the audio excitation voltage from the windings of transformer T104.

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SECTION VII -- TRANSMITTER CONTROL

163. Auto-tune System. The auto-tune system is a combination of mechanical and electrical devices which accurately position the switches and variable capacitors of the TDO equipment. An electric motor drives a positioning mechanism which provides precise angular adjustment of each control knob. These control knobs are manually set and locked with respect to the positioning mechanism, the setting for each control being entirely independent of the other controls. Accurate positioning of all controls is a prime requisite and is dependent upon the mechanical and electrical operation of the system.

164. Mechanical Features. A one-fifth horsepower single-phase, 230-volt motor drives the auto-tune shafts as shown in Plate 13. This motor is of the capacitor reversible type. The drive shafts couple the auto-tune assemblies to the motor. Bristol type set screws secure the shafts to the couplers.

165. Since the set screws continually loosened, it is recommended that a splined shaft and sleeve be used to couple the shaft to the motor. The small boxes shown at the left on Plates 20 and 24 marked "19" and "20" house the line shaft drive gears. As can be seen, the line shaft extends the entire length of the casting. The power is supplied to each positioning unit by means of worm gears.

166. The positioning units are known as single-turn and multi-turn units. The multi-turn unit, as its name implies, provides for positioning at any point within the range of ten revolutions of the control. A small counter on the lower part of the control indicates the hundreds and the main dial knob indicates the units. Thus, any setting between zero and 1000 is obtainable on this unit; only the master oscillator uses the multi-turn positioning unit. The rest of the elements are positioned by the single-turn units which provide a range of 360 degrees rotation.

167. Each control after having been manually adjusted to the proper setting is locked into place by means of a locking bar. The locking bar locks the tuning element to the mechanism for each predetermined setting of the control. The entire system may be dialed and reset to any one of 11 desired channels by means of the auto-tune system in 10.5 seconds. Since the dials are firmly held in place by the positioning mechanism, no dial locks are used. Each control knob has grooves to provide a good hand-hold. These were found to be sharp and made manual adjustments difficult and uncomfortable for the operator. The locking bars do not extend far enough from the dial to allow easy locking. These factors

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made it difficult to lock the auto-tune accurately to the desired frequency as mentioned in paragraph 119. It is recommended that the manufacturer investigate the possibilities of providing a more accurate means of setting and locking the tuned elements to the auto-tune positioning mechanisms. Except for the loosening of the drive shaft set screws, no mechanical difficulties were encountered.

168. Electrical Features. An electrical control system is used in conjunction with the auto-tune system. This control system requires two wires to operate the control relays from a remote operating position. By means of a telephone type dial, operation can be selected on any one of eleven channels. Manual operation of the dials can be obtained by dialing AA2. Type A-1, A-2, or A-3 emission may be automatically selected or may be obtained by dialing the type emission desired. In addition, the transmitter may be turned either on or off by means of the telephone dial. For this reason, various relays and switches are employed.

169. Mcw Relay K102. This relay connects the circuits for mcw emission and is operated by dialing A-2.

170. Transmitter Off Relay K103. This relay operates when A-0 is dialed, and turns the transmitter off. Any dialing operation also releases this relay so that the transmitter plate potentials are turned off while the transmitter is being tuned.

171. Auto-tune Motor Reversing Relay K104. The operation of this relay reverses the rotation of the electric motor which drives the auto-tune system.

172. Auto-tune Motor Starting Relay K105. This relay causes forward rotation of the auto-tune units by closing the circuit to the 220-volt single-phase power line.

173. Emission Selection Relay K106. By dialing A-1, the rotary relay, K107, is actuated to position 12 which in turn operates relay K106.

174. Rotary Switch K107. This relay is of the 25 position telephone type having four banks. The impulses supplied by the telephone dial through K108 actuate this relay so that the switch contact selected corresponds with the number which is dialed.

175. Impulse Relay K108. This relay is a quick acting telephone type and is actuated by the telephone dial. This relay in turn operates to actuate the rotary switch K107.

176. Homing Relay K109. This relay closes when the auto-

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tune has completed its cycle and the motor has come to rest.

177. Timing Relay K110. This relay prevents the starting of the auto-tune motor during dialing operations.

178. Timing Relay K111. This relay is of the slow release characteristic type and is actuated until the last dial impulse is received. When the last impulse has been received the relay opens and allows the auto-tune mechanism to go through its cycle.

179. Auto-tune Positioning Switch S109. This switch is operated by the channel indicator assembly. When the switch reaches the contact which corresponds to the channel that has been dialed, the motor reversing relay is then actuated.

180. Auto-tune Limit Switch S110. This switch is mounted on the multi-turn unit and operates in such a manner as to cause the motor to reverse at the appropriate time.

181. Local-Remote Switch S114. The local-remote switch is located on the control panel and provides for switching control of the system from the local position to the remote control position.

182. Telephone Dial. A telephone dial is provided on both the remote or local control positions. The dial will transmit a maximum of eleven impulses.

183. During the tests certain troubles occurred which were attributed to faulty switch or relay action. One of the contacts of the local-remote switch failed to make contact. This condition was corrected by bending one of the spring contact leaves. Several times during the tests, the homing relay failed to operate. The cause was undetermined because this condition appeared to be erratic; however, it is believed that it was caused by the failure of the limiting switch S110 to make positive contact. The rotary switch K107 was faulty at various times during the tests. When the TDO equipment was first placed in operation, it was found that this switch would not follow the impulses of the telephone dial. For example, when channel 10 was dialed, channel 8 would be actuated. When A-1 emission was dialed, the modulator would not turn off. Rotary switch, K107, and its associated relay as shown in Plates 30 and 31 were carefully readjusted. These adjustments would hold for several hundred dialing operations, then a readjustment would be required. This relay appears to be of poor quality. The stamped metal parts and adjustments appear to be capable of withstanding reasonable usage and although adjustments are provided, they are not capable of being firmly secured for any length of time. Later, during the tests, the contact arm would make several revolutions before coming to rest at the end

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of the auto-tune cycle.

184. None of the above listed conditions were consistent enough to allow the difficulty to be accurately determined. The erratic operation was easily observed but would generally correct itself before the exact source of the trouble could be located. The rotary switch K107 was the most common source of trouble and it is recommended that a more reliable relay be provided. In addition it is recommended that the manufacturer investigate the possibility of improving the relaibility of the entire relay control system.

185. Effects of Temperature Variations. Tests were made to determine the lowest ambient temperature at which the auto-tune would operate. With the power turned off, the transmitter was subjected to an ambient temperature of 0 degrees C for a period of 2-1/2 hours. All channels were operative at the end of this time although the operation was sluggish. At an ambient temperature of minus 10 degrees C the telephone dial failed to operate. The mechanical system continued to function; however, 15 seconds were required for tuning instead of 10.5 seconds.

186. Remote Control Unit. The remote control unit consists of a two-stage audio amplifier as described in paragraph 110 and shown in Plate 35. A dynamic type microphone as shown in Plate 38 is used. This microphone is provided with a push-to-talk switch and a cable connector at the end of the microphone cable allows it to be plugged into the front panel of the remote control unit. Although the omission of a permanently connected handset is permissible in early deliveries of the Model TDO equipment, it is recommended that permanently connected handsets be provided in accordance with paragraph 3 of reference (g). A telegraph key and cord permit plugging the key into the key jack on the front panel of the control unit.

187. Table 10 shows the size of this unit which is designed to be mounted in a standard 19-inch rack. Although rack mounting is acceptable, it is recommended that steps be taken to provide units which conform with the requirements outlined in reference (d).

188. Power Requirements. The remote control unit operates from a 110-volt single-phase power source. The power required is shown in Table 51.

189. Cable Connections. As shown in Plate 35, a terminal strip is provided to make the necessary connections from the transmitter to the remote unit. For normal operation, one line is required for a common ground circuit for the carrier control and dialing circuit. One dial line and one carrier control line are necessary and two wires are required for the audio circuit.

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During the tests a shielded four-wire cable was used. In addition, provision has been made for an external source of audio input to a 500-ohm or 75-ohm transformer winding. A pair of contacts are also provided for a separate push-to-talk control of the carrier. A relay is utilized and the contacts are brought to terminals in the rear of the transmitter. These contacts may be used in conjunction with the operating receiver to turn the receiver power off during the time the transmitter is being operated. A time delay feature is provided for this relay and its adjustment is accomplished with a control knob at the rear of the chassis.

190. Controls and Indicators. The telephone dial provides selection of the channel and emission desired in the manner previously outlined in paragraph 182. The "on-off" switch controls the application of primary voltage and a red pilot lamp indicates the power "on" condition. The audio gain is controlled by a knob on the panel and the proper audio output level is obtained by observing the volume level meter. A chart shows the frequencies obtained by dialing each channel. The channel upon which the transmitter is set is indicated by the channel indicator. The meter indicates channels 1 through 10. An additional channel, channel 11, is provided on the transmitter. This channel is obtained by dialing AA1; however, no indication is provided on the remote control channel indicator when this channel is used.

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SECTION VIII -- POWER EQUIPMENT

191. General Description. The TDO transmitting equipment is designed to operate from either a 115-volt or a 230-volt 50/60-cps single-phase power source. This is accomplished by the use of an auto-transformer as shown in Plate 17. This equipment is designed for continuous, full-power, locked-key operation and during the tests no undue heating of any of the power supply components was observed. During the tests, 110-volt, 60-cps single-phase was used as the primary power source.

192. Variation of Supply Line. The supply voltage was varied from ten per cent above to ten per cent below the normal supply voltage of 110 volts. The operation of the transmitter is shown in Table 35. No tests were made except with a 60-cps source of power. No difficulty was experienced with the relays or r-f circuits with lower and higher values of voltage. The primary windings of all filament and plate power transformers are equipped with three to five taps which provide adjustment of the output voltage to the correct values; however, the inconvenience of changing these taps preclude their use except to correct for abnormal line voltage conditions which exist for long periods of time. The provision of a tap switch on the input auto-transformer to facilitate this operation is recommended. The regulation of the rectifiers is shown in Table 54. A resistor is used in series with the primary winding of the high voltage plate transformer when the "L.V.-Tune-Op." switch is in the "Tune" position. Under these conditions, the regulation of the high voltage power supply is very poor and prohibits using the transmitter in this manner for reduced power output. It may be noted that the regulation of the rectifiers under the "Operate" condition is also quite poor; however, the operation of the transmitter is not adversely affected by this condition.

193. Power Required From the Supply Line. The total power required from the supply line is shown in Table 52. The maximum power required from the power lines is 1.662 kw using 100% modulation and type A-2 or A-3 emission. The power factor ranged from 83.4 to 93.7 per cent.

194. High Voltage Power Supply. The high-voltage supply furnishes power for application to the plates of the power amplifier and modulator tubes. The rectifier is the single-phase full-wave type using two Type 249C mercury-vapor rectifier tubes. The filament voltage is supplied by a separate transformer. A two-section choke-input filter system is used.

195. Low Voltage Power Supply. The low voltage power supply furnishes power for the plates and screens of all the low-

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power transmitter tubes and the screens of the power amplifier tubes. The rectifier is a single-phase full-wave type using two Type 866A mercury-vapor rectifier tubes. The filament voltage is supplied by a separate transformer. A two-section choke-input filter system is used.

196. Bias Voltage Supply. The bias supply employs a Type 5U4G tube in a full-wave rectifier circuit. A two-section choke-input filter system is employed and a separate filament transformer is used to supply the filament voltage. This supply provides bias voltages necessary for the operation of the frequency multiplier, intermediate amplifier, power amplifier, limiter and keyer tubes.

197. Relay Power Supply. A selenium rectifier is used to supply 48-volts d-c necessary for the operation of the d-c relays in the transmitter. This power supply operates at all times when the main power switch S120 is closed.

198. Ripple Voltages. Pertinent data are shown in Table 53. The measured ripple voltage was found to be negligible in all cases.

199. Time Delay Protection. A time delay relay is incorporated which permits the filaments of the rectifier tubes to attain proper operating temperature before the plate voltage can be applied. The time delay relay is capable of adjustment and the manufacturer's adjustment afforded 30-second delay action.

200. Transformer Insulation. The insulation and other properties of the transformers were not investigated. It is assumed that these components have been subjected to type tests to determine their suitability for Naval usage.

201. Accessibility. The rectifier tubes are located in the lower section of the transmitter and are accessible from the front of the panel as shown in Plate 13. Insulating caps protect the personnel from accidently coming in contact with the high potentials existing on the caps of the mercury-vapor tubes.

202. Metering. A plate voltmeter, M-102, is used to measure the high-voltage power supply potential. No means of measurement has been provided for the low-voltage and bias power potentials. It is recommended that a multi-range voltmeter be used in conjunction with a metering switch so that either the high-voltage or the low-voltage power supply potentials may be read.

203. Switch and Relay Operation. The main power line switch removes all filament and plate power. The operation of this switch is discussed in paragraph 89. Overload relay, K101, is designed

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to provide protection for the r-f amplifier tubes. No overload relay protection is incorporated in the bias, low voltage, and high voltage power supplies.

204. Operating Temperatures. Satisfactory operation of the mercury vapor rectifier tubes was obtained at ambient temperatures ranging from 15 to 50 degrees C. At ambient temperatures lower than 15 degrees C the ionization of the mercury in the tubes became erratic. This condition makes it impossible to operate the transmitter at temperatures lower than approximately 15 degrees C unless tube heaters are installed. It is recommended that a heater compartment with provisions for circulating the air be used to enclose the Type 866A and 249C mercury vapor rectifier tubes.

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SECTION IX -- SPARE PARTS

205. General. Certain spare parts have been provided with this equipment; however, the parts supplied do not conform to the requirements of Section VI of reference (n). Numerous parts have been omitted and the additional parts required are as follows:

(a) Fifty per cent but not less than one each of the variable resistors and r-f chokes used in the equipment.

(b) Fifty per cent but not less than one each of each type audio transformer and inductor.

(c) Fifty per cent but not less than one each of each type of tube and lamp socket.

(d) Fifty per cent but not less than one each of each type of toggle switch.

(e) Two of each type vacuum tube, and current regulator.

(f) One coil for each type relay.

(g) Four sets of contacts for each relay.

(h) One motor for driving the auto-tune system.

(i) One complete set of the replaceable auto-tune parts. These are to include the line shaft assembly, with groove-pins, worm gears and main line shaft thrust bearings. The replaceable parts necessary in either a multi-turn of single-turn unit including all gears, and clutbh parts should be included.

(j) Fifty per cent or one each of each type plate transformer with a primary of less than 200-volt-amperes.

(k) Fifty per cent or one each of each type filament transformer having a primary of less than 100-volt-amperes.

It is recommended that the spare parts listed above be included with the spare parts now provided with the equipment.

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SECTION X -- INSTRUCTION BOOKS

206. The Model TDO transmitter was accompanied by a preliminary instruction book containing type test data, schematic diagrams, and pictures of the equipment. Certain omissions or errors have been noted and should be corrected.

207. The method of connecting the auto-transformer T117 for 110 or 220-volt operation is confusing. Reference is made on page 41 to the transmitter diagram, Figure 40, which should show the proper connections. The symbols for the terminals as shown on the diagram are not to be found on the transformer.

208. Information contained under the heading of circuit tests, paragraph 4.4, page 49, 50, and 51, is in error. Fuses F114 and F115 must be inserted before the control and power circuits can be checked. Fuse F101 should be inserted following the insertion of fuses F114 and F115. The steps listed a to j can then be accomplished. Step k is in error, since in order to provide for operation of the bias interlock, relay K116, not only must fuse F106 be inserted, but the rectifier tube V124 must be in operation. If V124 is installed, steps K to r can be followed. Following step r it will be necessary to include an additional step; that of installing the modulator fuse F113.

209. No instructions were given for adjustment of the overload relay K101.

210. The warning regarding the displacement of the auto-tune take-off couplers should be given on page 38, paragraph 3.3, part 1. This warning now appears on page 39.

211. On page 8, paragraph 2.3, the following statement is incorrect: "The operation of the filament relay also applies power to the filament pilot lamp, I-101, the master oscillator compartment heating resistors, R102 and R103 and the dry disc rectifier CR101". Examination of the circuit discloses that R102, R103, and the dry disc rectifier are energized from transformer T114. This transformer is energized when the main supply line switch, S120, is closed; consequently, the m-o heater and dry disc rectifier are not dependent upon the filament relay for their operation.

212. On page 67, paragraph 5.2, the operating power-amplifier plate voltage is stated as being 2140 volts. Again on page 93, typical operating voltages show the plate voltage to the type 813 tubes as 2140 volts. As pointed out previously, this voltage is in excess of the rated plate voltage (2000 volts) for type 813 tubes. These and other references in the instruction book to the power amplifier plate voltage should be amended to read 2000 volts.

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213. The correct operating plate voltages and plate currents for the final amplifier tubes are not listed. On page 70, under "Voice Emission" it is stated that the plate voltage (2140 volts) is applied. Actually the plate voltage is lowered to approximately 1500 volts for phone operation. The same error appears on page 71 under "M.C.W. Emission". The actual operating voltage under mcw conditions is also approximately 1500 volts. These and any other erroneous references to the plate voltages should be corrected. In addition, the correct p-a plate currents with 100 per cent modulation should be listed.

214. The instructions should include the fact that care should be taken that cables connect the proper plugs and that the cable connections are properly inserted. The marking "TOP" should appear on the upper side of each connector.

215. On page 90, paragraph 6.7, it is stated that when test cables are used, "The operation of the unit will be exactly the same as when in place in the transmitter". This condition does not exist in all cases since the r-f unit power-amplifier requires the associated output network for plate voltage connection and normal operation. Only the exciter stages will be operated normally; however, the operator should be warned that operation with the units removed from the cabinet involves the use of voltages which are dangerous.

216. On page 89, paragraph 6.2 and 6.2.1, reference is made to the maintenance of relays. In paragraph 6.2, it is stated that "some of these relays have critical adjustments and should not be tampered with". In paragraph 6.2.1, it is stated that the relay "....adjustment instructions will be found in the Appendix.." No such instructions could be found. During the tests it was necessary to make periodic adjustments of the rotary switch relay K107, overload relay, K101, filament relay K112, plate relay K113, and phone-cw relay K117. Instructions regarding the adjustment of all relays incorporated in the equipment should be included in the instruction book.

217. On page 89, paragraph 6.2.2, "washing with gasoline" is recommended for cleaning the pole faces of the a-c contactor relays. A non-inflammable solvent should be used rather than gasoline.

218. The schematic diagrams, Figures 39 and 40, show terminal 7 of transformer T102 grounded whereas terminal 9 is the grounded terminal.

219. No instructions have been given regarding the removal of the C.F.I. unit.

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220. Navy Type designation and Navy specification numbers have not been included in the list of parts.

221. Instructions have not been provided for the method of making repairs on the more inaccessible parts in the m-o heater compartment.

222. Detailed drawings of the power transformer, showing details of their windings and characteristics have not been provided.

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SUMMARY OF DEFECTS

223. There are summarized below the various defects encountered during the course of the test; also included are certain other features which, though not specifically required by the specifications, are of such a nature that a considerable improvement in operation or performance would result, provided the necessary steps are taken to overcome them. At the end of each of the following statements there appears the paragraph number in the body of the report wherein each matter is discussed in detail.

(a) The mounting bolt of the dry disc rectifier CR101, transformers T112, T115, and T116, and the plunger of relay K118 showed signs of corrosion. Par. 27.

(b) The fuse holders are of poor quality and depend upon solder for mechanical strength. Par. 30.

(c) No protection is afforded the m-o components in the heater compartment in the event that the heater thermostat S102 should stick. Par. 33.

(d) Navy Type numbers have not been provided on the component parts of the equipment. Par. 35.

(e) The m-o heater compartment thermostat and the components within the heater compartment are not accessible for repairs. Par. 26.

(f) Special tools required in the repair and adjustment of the transmitter have not been provided. Par. 37.

(g) Adequate protection of the personnel against electrical shock has not been provided by the interlock system. Par. 40.

(h) The seat of interlock S121 is incapable of sufficient adjustment. Par. 41.

(i) Vacuum tubes which have not received Navy Type approval are used. Par. 43.

(j) The screen voltage of the type 807 first intermediate amplifier is exceeded under certain conditions. Par. 44.

(k) The screen voltage of the type 807 second intermediate amplifier is exceeded under certain conditions. Par. 44.

(l) The screen and plate potentials are exceeded in the type 813 final amplifier tubes under certain conditions. Par. 44.

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(m) The plate potentials of the type 805 class B modulator tube is exceeded under certain conditions. Par. 44.

(n) Resistor clips have not been properly positioned. Par. 47.

(o) Resistors R203, R204, and R205 were not separately packed, but shipped in their respective clips. Par. 48.

(p) The overload relay K101, is incapable of accurate adjustment and fails to trip at the required current values. Par. 52.

(q) The phone-cw relay K117 showed signs of arc-over under certain conditions. Par. 53.

(r) Relays K115, K116, and K117 are quite inaccessible to repairs and replacements. Par. 54.

(s) Relay K112 was faulty in operation and made poor contact. Par. 55.

(t) The rotary switch relay, K107, was faulty in operation and was incapable of holding its adjustment. Par. 56.

(u) Anti-glare glass had not been provided for the meters. Par. 59.

(v) The range of the antenna current ammeter is inadequate. Par. 62.

(w) Metering switch S103 failed to make positive contact. Par. 63.

(x) The readable accuracy of the filament voltmeter is insufficient to provide accurate readings of the 2.5 volt filament potentials. Par. 63.

(y) The plate current meter reads the combined r-f amplifier and class B modulator tube plate currents. There are no means of reading these current values separately. Par. 64.

(aa) The line-filament voltmeter, plate current milliameter, grid current milliameter, and antenna current ammeter are inaccurate. Par. 65.

(ab) The filament indicator lamp shows green instead of clear when the filaments are energized. Par. 67.

(ac) There are no means of knowing when the m-o compartment

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heater thermostat is functioning. Par. 68.

(ad) The insulation of the high voltage power supply wiring was inadequate causing a short circuit to develope. Par. 70.

(ae) A short circuit developed in the bias power supply due to some undetermined cause. Par. 71.

(af) The lugs on the wires to the r-f ammeter are too small to accommodate the terminals of the replacement r-f ammeter. Par. 72.

(ag) Bakelite is used to insulate the capacitor C132 at d-c potential of 580 volts above ground. Par. 75.

(ah) Nuts have not been used to secure the screws which are used to hold the side panels to the cabinet. Par. 78.

(ai) The door catches continually loosened since only one screw is used to secure these latches to the transmitter cabinet. Par. 80.

(aj) The screws to the shelf holding the m-o tube socket and associated components were found to be loose. Par. 81.

(ak) The terminal board for the supply line wires, E109, is too small to accommodate the connecting lugs. Par. 82.

(al) The audio circuit controls cannot be readily adjusted with the transmitter carrier turned on. Par. 85.

(am) The exciter tuning, exciter band switch, p-a tuning and p-a band switch are marked so that a decrease in dial setting increases the final controlled effect. Par. 87.

(an) The vernier m-o dial plate moved with the tuning of the m-o dial due to insufficient clearance between the dial and the plate. Par. 88.

(ao) The primary power switch is not readily accessible. Par. 89.

(ap) The "Local-Remote" switch failed to make contact because the contact leaves had been bent out of position. Par. 91.

(aq) Rotary switch S101 arcs when the switch control is manually operated with plate potentials applied. Par. 93.

(ar) Fuse holders have not been labeled to denote the appropriate voltage and current rating of the fuses required. Par. 97.

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(as) Transformers T112 and T117 have not been provided with nameplates bearing the terminal designation and characteristics of the units. Par. 98.

(at) No warning label was attached to the auto-tune take-off couplers to prevent accidental turning when the units are uncrated and assembled. Par. 99.

(au) Lubrication nameplates have not been provided for the auto-tune drive motor and the blower motor. Par. 100.

(av) The transmitter is not provided with a balanced output network. Par. 111.

(aw) Parasitic operation occurred in the final power amplifier in the 2.0 to 4.0 mc. range. Par. 114.

(ax) The use of fiber shaft couplings to the m-o tuning shaft introduces torque lash. Par. 119.

(ay) Variations of humidity cause excessive frequency variations at output frequencies of 2000 kc. Par. 124.

(az) The initial frequency drift of the oscillator is excessive at 8000 kc. Par. 125.

(ba) Frequency variations due to the cycling of the m-o heater were excessive. Par. 126.

(bb) The m-o heater compartment is slow in obtaining thermal stability. Par. 127.

(bc) Insufficient end-tolerance has been provided by the tuning range of the m-o tuning and intermediate amplifier tuning slugs. Par. 136.

(bd) A tuning chart has not been provided on the front of the transmitter. Par. 139.

(be) No outlet is provided to feed the remote control lines into the transmitter. Par. 145.

(bf) Test cables were provided which were marked "top" on both sides of the connecting plug. Par. 148.

(bg) The proper modulation level cannot be obtained without the use of additional equipment. Par. 161.

(bh) The Bristol type set screws on the auto-tune drive shaft loosened. Par. 165.

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(bi) Permanently connected hand-sets have not been used in conjunction with the remote control unit. Par. 186.

(bj) No indication is provided on the remote control unit to show when the 11th channel is dialed. Par. 190.

(bk) No simple means of compensating for variation in line voltage has been provided. Par. 192.

(bl) There are no meters to indicate the d-c potential of the low voltage and bias power supplies. Par. 195.

(bm) The mercury vapor type rectifiers preclude the use of this equipment at ambient temperatures below 15 degrees C. Par. 204.

(bn) Certain spare parts have not been provided. Par. 205.

(bo) Numerous errors or omissions have been made in the instruction book. Par. 206 to 222.

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TABLE 1

MODEL TDO TRANSMITTING EQUIPMENT

CHECK OF RESISTORS USED IN EQUIPMENT

Tests as Per Paragraphs 3-2 and 3-3 of Specifications RE 13A 554D

Fixed Wire Wound Resistors

Symbol	Rated Ohms	Style	Permitted by Specs. Max. R	Max. V	Max. W	Measured Max. R	Max. V	Max. W
R113	510	F	4000	225	15	520	21	0.848
R115	2400	C	25000	775	70	2347	49	1.014
R123	10000	C	25000	775	70	10280	250	6.080
R129	5600	C	25000	775	70	5584	172	0.507
R147	8200	D	18000	625	60	7955	222	6.200
R181	750	D	18000	625	60	739	54	3.870
R195	240	D	18000	625	60	236	55	12.800
R196	130	D	18000	625	60	130	30	6.820
R197	43	E	6000	350	25	42	10	2.300
R198	82	E	6000	350	25	83	19	4.370
R199	1300	A	75000	1650	200	1299	175	24.500
R200	5100	D	18000	625	60	5177	170	5.580
R201	5100	D	18000	625	60	5145	168	5.480
R202	2400	B	50000	1200	150	2407	100	4.158
R203	20000	A	75000	1650	200	19994	630	19.860
R204	20000	A	75000	1650	200	20570	650	20.550
R205	20000	A	75000	1650	200	20260	645	20.630
R206	88Adjust Tune-Operate Res.				No.Specs.	92	158	27.290

Fixed Composition Resistors

Specified in Instruction Book Symbol	Rated Ohms	Rated Watts	Per Cent Tolerance	Resistor Code Watts	Tolerance	Measured Ohms	Volts	Watts
R104	100	0.5	20	2.0	20	97	----	-----
R105	10000	2.0	10	2.0	20	9870	0.64	0.0041
R106	200	2.0	20	2.0	20	200	0.76	0.0019
R107	30000	2.0	20	2.0	20	29630	166.0	0.930
R108	51000	2.0	20	2.0	5	50000	----	-----
R109	2400	2.0	20	2.0	20	2157	19.5	0.148
R110	2400	2.0	20	2.0	20	2176	20.5	0.193
R111**	47	1.0	20	0.5	20	11	----	-----

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TABLE 1 (Cont'd)

Miscellaneous Resistors

Symbol	Rated Ohms	Purpose	Permitted by Specs. Max. R	Max. V	Max. W	Measured Max. R	Max. V	Max. W
R101	3 Meg.	Multiplier	3 Meg.			3 Meg.	2370	1.872
R102	186	Heater	No Specs.		18	186.6	52.5	14.78
R103	186	Heater	No Specs.		18	187.2	52.5	14.72
R119	101	Meter Shunt	No Specs.			101	----	---
R120	1251	Meter Shunt	No Specs.			1251	----	---
R137	1000	Channel Ind. Res.	No Specs.			1000	7.1	.0504
R138	1000	" " "	No Specs.			999	7.1	.0505
R139	1000	" " "	No Specs.			999	7.1	.0505
R140	1000	" " "	No Specs.			1000	7.1	.0504
R141	1000	" " "	No Specs.			1001	7.1	.0504
R142	1000	" " "	No Specs.			998	7.1	.0505
R143	1000	" " "	No Specs.			1002	7.1	.0503
R144	1000	" " "	No Specs.			1005	7.1	.0502
R145	1000	" " "	No Specs.			1003	7.1	.0503
R146	1000	" " "	No Specs.			1000	7.1	.0504

Remote Control Unit

Symbol	Rated Ohms	Rated Watts	Per Cent Tolerance	Resistor Code Watts	Tolerance	Measured Ohms	Volts	Watts
R301	50000	Potentiometer		---	---	51000	---	---
R302	100000	2	20	2	20	108000	0	---
R303*	2700	2	20	2	20	3300	3.7	0.00415
R304	47000	2	20	2	20	43000	---	---
R305	270000	2	20	2	20	260000	---	---
R306	5600	2	20	2	20	6000	---	---
R307	1 Meg.	2	20	2	20	1 Meg.	---	---
R308	510000	2	20	2	20	550000	---	---
R309	820	2	20	2	20	706	4.2	0.025
R310	50000	Potentiometer				45000	---	---
R311	1 Meg.	2	20	2	20	900000	---	---
R312	1300	2	20	2	20	1420	---	---
R313	10000	2	20	2	10	9300	---	---
R314	1 Meg.	2	20	2	20	950000	---	---
R315	10000	Potentiometer				9600	---	---
R316	2400	2	20	2	20	2400	---	---
R317	2400	2	20	2	20	2000	---	---
R318	2400	2	20	2	20	2260	---	---

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TABLE 1 (Cont'd)

Specified in Instruction Book				Resistor Code		Measured		
Symbol	Rated Ohms	Rated Watts	Per Cent Tolerance	Watts	Tolerance	Ohms	Volts	Watts
R112	51000	2.0	20	2.0	5	51000	163.2	.523
R114	47	1.0	20	0.5	20	53	---	---
R116	1 Meg.	0.12	20	2.0	20	1 Meg.	---	---
R117	10000	2.0	10	2.0	10	11000	70.0	.445
R118*	22000	2.0	5	2.0	20	24600	30.0	.0366
R121	5100	2.0	20	2.0	20	5700	11.0	.0212
R122	5100	2.0	20	2.0	20	5560	---	---
R124	1500	2.0	10	2.0	10	1549	11.0	.0781
R125	1500	2.0	10	2.0	10	1484	10.54	.0748
R126*	1500	2.0	10	2.0	10	1688	11.98	.0852
R127	51000	2.0	20	2.0	20	47000	---	---
R128	100000	2.0	20	2.0	20	112000	---	---
R130	16000	2.0	20	2.0	10	16500	117.2	.832
R131	16000	2.0	20	2.0	10	15970	113.3	.806
R132	16000	2.0	20	2.0	10	15020	107.9	.767
R133	16000	2.0	20	2.0	10	16500	117.2	.832
R134	16000	2.0	20	2.0	10	15930	113.1	.804
R135	16000	2.0	20	2.0	10	16000	113.5	.807
R136	16000	2.0	20	2.0	10	15850	112.5	.800
R148	1 Meg.	2.0	20	2.0	20	1 Meg.	18.5	.003
R149	24000	2.0	10	2.0	10	25230	---	---
R150	36000	2.0	10	2.0	10	38300	9.9	.0027
R151	30000	2.0	20	2.0	5	32200	---	---
R152**	100000	2.0	20	2.0	20	21000	12.5	.0075
R153	1 Meg.	2.0	20	2.0	20	1 Meg.	11.5	.00013
R154	51000	2.0	20	2.0	20	51000	---	---
R155	1000	2.0	20	2.0	20	897	3.15	.0110
R156	1000	2.0	20	2.0	20	911	9.35	.0960
R157**	1 Meg.	2.0	20	2.0	20	118000	---	---
R158	51000	2.0	20	2.0	10	54000	---	---
R159	12000	2.0	10	2.0	10	13160	---	---
R160	12000	2.0	10	2.0	10	12970	---	---
R161	36000	2.0	10	2.0	10	36000	---	---
R163	1000	2.0	20	2.0	20	1143	7.5	.0483
R164	24000	2.0	10	2.0	10	24000	---	---
R165	24000	2.0	10	2.0	10	24400	---	---
R166	24000	2.0	10	2.0	10	25000	---	---
R167	24000	2.0	10	2.0	10	24800	---	---
R168**	25000	2.0	5	2.0	5	15400	30.0	.0584
R169	30000	2.0	5	2.0	5	29800	---	---
R170	43000	2.0	5	2.0	5	44000	---	---
R171	43000	2.0	5	2.0	5	43500	---	---
R172*	30000	2.0	5	2.0	5	32400	---	---

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TABLE 1 (Cont'd)

Specified in Instruction Book				Resistor Code		Measured		
Symbol	Rated Ohms	Rated Watts	Per Cent Tolerance	Watts	Tolerance	Ohms	Volts	Watts
R173**	25000	2.0	5	2.0	5	14870	30	.0600
R174	100000	2.0	20	2.0	20	113000	47	.0196
R175	1000	2.0	20	2.0	20	930	95	.975
R176	5100	2.0	20	2.0	5	5930	---	---
R177	5 Meg.	.05	20	--	20	5 Meg.	---	---
R179	100000	2.0	20	2.0	20	111000	---	---
R180	100000	2.0	20	2.0	20	119000	---	---
R182	100000	2.0	20	2.0	20	116000	---	---
R183	2000	2.0	20	2.0	5	2011	12	.0716
R184	5100	2.0	20	2.0	5	5120	---	---
R185	10000	2.0	20	2.0	20	9400	---	---
R186	10000	2.0	20	2.0	20	9070	---	---
R188	47000	2.0	20	2.0	20	41900	---	---
R189	1000	2.0	20	2.0	20	1145	7.5	.0491
R190	5100	2.0	20	2.0	5	5900	---	---
R191	5100	2.0	20	2.0	5	5280	---	---
R192	510	2.0	20	2.0	20	485	---	---
R193	510	2.0	20	2.0	20	494	---	---
R194	5100	2.0	20	2.0	20	5720	---	---
R207**	30000	2.0	20	2.0	10	16000	---	---
R208**	47000	2.0	20	2.0	20	530000	---	---
R209	10000	2.0	20	2.0	20	9366	---	---

Potentiometers

Symbol	Rated Ohms	Measured Ohms
R162A	100000	100000
R162B	100000	97000
R178A	100000	98000
R178B	100000	97000
R187	100000	105000

(Continued)

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TABLE 1 (Cont'd)

Symbol	Rated Ohms	Rated Watts	Per Cent Tolerance	Resistor Code Watts	Resistor Code Tolerance	Measured Ohms	Measured Volts	Measured Watts
R319	1100	2	20	2	20	1150	---	---
R320	1100	2	20	2	20	970	---	---
R321	1100	2	20	2	20	990	---	---

Resistors Not Rated As Shown In Instruction Book

Symbol	Instruction Book (Ohms)	Resistor Code (Ohms)
R111	47	10
R152	100000	20000
R157	1 Meg.	100000
R168	25000	15000
R173	25000	15000
R207	30000	16000
R208	47000	510000

Note: All resistors not having power ratings were inaccessible for measurement.

* Resistance value exceeds the instruction book or code marking tolerances.

** Resistor values do not conform with the ratings shown in the instruction book.

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TABLE 2

MODEL TDO TRANSMITTING EQUIPMENT

CALIBRATION OF METERS

Designation	Original TDO Meters	Precision Standard
Line-Fil. Voltage (0-15 Volt Scale)	*14.0 a-c volts	14.4 a-c volts
	*12.0	12.35
	10.0	10.20
	8.0	8.15
	6.0	6.10
	5.0	4.90
	4.0	3.85
	3.0	3.00
Line-Fil. Voltage (0-300 Volt Scale)	295.0 a-c volts	300.0 a-c volts
	260.0	258.0
	240.0	236.0
	220.0	217.0
	200.0	196.0
	180.0	177.0
	140.0	138.0
	120.0	120.0
	100.0	97.0
Plate Current (0-800 ma)	*740.0 milli-	715.0 milliamperes
	*600.0 amperes	555.0
	*500.0	455.0
	400.0	395.0
	300.0	289.0
	200.0	189.0
	100.0	98.0
Grid Current (0-50 ma. scale)	50.0 milli-	50.0 milliamperes
	40.0 amperes	40.0
	35.0	35.0
	30.0	30.0
	25.0	25.0
	20.0	21.0
	15.0	16.0
	10.0	10.0
Grid Current (0-5 ma. scale)	*5.0 milli-	4.8 milliamperes
	4.0 amperes	3.9
	3.0	2.9
	2.0	2.0
	1.0	1.0

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TABLE 2 (Cont'd)

Designation	Original TDO Meters	Precision Standard
Plate Voltage (0-3000 Volts)	2150.0 d-c volts	2150.0 d-c volts
	2000.0	2000.0
	1500.0	1500.0
	1000.0	1000.0
	500.0	500.0
Ant. Current (0-3.0 Amp.)	* 3.0 amperes	2.55 amperes
	* 2.5	2.30
	* 2.0	1.86
	* 1.5	1.41
	* 1.0	0.90
Volume Indicator (Unit Serial No. 1)	-10.0 db	-8.0 db
	- 6.0	-5.0
	- 4.0	-3.0
	- 0.3	0.0
	+ 2.8	+3.0
	+ 6.0	+6.0

* In excess of specification limits.

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TABLE 3

MODEL TDO TRANSMITTING EQUIPMENT

INVESTIGATION OF FUSES

Symbol	Rated Volts	Rated Amps.	Measured Volts	Measured Max. Amps.	Type
F101	250	0.375	115	0.29	"Slo-blo"
F102	250	0.250	230	0.12	"Slo-blo"
F103	250	0.75	230	0.48	"Slo-blo"
F104	250	0.375	230	1.6	"Slo-blo"
F105	250	0.250	230	0.1	"Slo-blo"
F106	250	0.250	230	0.25	"Slo-blo"
F107	250	0.500	230	0.11	"Slo-blo"
F108	250	3.0	230	1.0	Non-renewable Cartridge
F109	250	0.500	230	0.3	"Slo-blo"
F110	250	2.0	230	0.28	Non-renewable Cartridge
F111	250	2.0	62	0.04	Non-renewable Cartridge
F112	250	0.500	230	0.26	"Slo-blo"
F113	5000	0.500	1500	0.250	H.V. Cartridge
F114	240	25.0	115	14.5	Renewable Cartridge
F115	240	25.0	115	14.5	Renewable Cartridge
F301	250	0.25	115	0.18	Non-renewable Cartridge

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TABLE 4

MODEL TDO TRANSMITTING EQUIPMENT

EFFECT OF FAILURE OF FUSES

Symbol	Effect of Failure
F101	Removes voltage from heater elements.
F102	Removes voltage from filaments of V103, V104, and V107.
F103	Removes voltage from filaments of V105, V106, V109, V110, and V111.
F104	Removes voltage from filaments of V112, V113, V114, V115, V116, and V117.
F105	Removes voltage from filament of V124. Releases bias interlock which makes L.V. inoperative.
F106	Removes voltage from plate of V124.
F107	Removes voltage from filaments of V125 and V126.
F108	Removes voltage from plates of V125 and V126.
F109	Removes voltage from filaments of V120 and V121.
F110	Plate relay, filament relay, L.V. rectifiers shut off; modulator filaments come on.
F111	All elements connected to dry disc rectifier.
F112	Removes voltage from filaments of V122 and V123.
F113	Removes voltage from plates of V120 and V121.
F114	Removes the supply line voltage.
F115	Removes the supply line voltage.
F301	Removes voltage from primary of T303.

TABLE 5

MODEL TDO TRANSMITTING EQUIPMENT

OPERATION OF OVERLOAD DEVICES

Symbol	Designation	Normal Current Amperes	Relay Setting	Current Required To Trip Amperes	Time Required To Trip Seconds
K101	PA Overload Relay	0.360	Full clockwise	0.515	Instantaneous
			One turn counter clockwise	0.750	Instantaneous
			Full counter clockwise	Over 2.0	Failed to trip
S120	Supply Line Overload Switch	7.4	None	10.0	Failed to trip
			None	10.5	4
			None	11.0	3

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TABLE 6

MODEL TDO TRANSMITTING EQUIPMENT

ANTENNA SHORT CIRCUITED AND OPEN CIRCUITED

Frequency (Kc)	Antenna Condition	Antenna Current Amps.	PA Plate Ma.	PA Plate Volts	Approx. Output Watts
2000	Normal	1.85	360	2000	500
	Shorted	Off scale	400	2000	---
	Open	0.40	330	2000	---
18000	Normal	1.86	360	2000	500
	Shorted	PA Overload tripped			
	Open	PA Overload tripped			

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TABLE 7

MODEL TDO TRANSMITTING EQUIPMENT

POTENTIALS APPLIED TO ELECTRODES OF VACUUM TUBES
2000 Kc.

Element	Spec. Rating Volts	Emission	Key Up Volts	Key Down Volts
		Master Oscillator, Type 6A8		
Filament	6.3	A-1	5.9	5.9
Grid 1	---	A-1	-12.05	-0.57
Grid 2	330	A-1	156	154
Grid 3	110	A-1	-98	-45
Grid 4	---	A-1	0.05	0.60
Grid 5	110	A-1	-98	-45
Plate	330	A-1	157	155
		Buffer Amplifier, Type 6AG7		
Filament	6.3	A-1	5.9	5.9
Grid 1	---	A-1	-5.5	-9.6
Grid 2	330	A-1	189.5	289.0
Grid 3	---	A-1	-5.5	-6.0
Plate	330	A-1	*364.5	314.0
		First Frequency Multiplier, Type 807		
Filament	6.3	A-1	6.3	6.3
Grid 1	-200	A-1	120	-184
Grid 2	300	A-1	*370	163
Plate	600	A-1	570	503
		Second Frequency Multiplier, Type 807		
Filament	6.3	A-1	6.3	6.3
Grid 1	-200	A-1	-120	-240
Grid 2	300	A-1	*360	**(1)290 **(2)230 **(3),(4)200
Plate	600	A-1	570	535

(Continued)

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TABLE 7 (Cont'd)

Element	Spec. Rating Volts	Emission	Key Up Volts	Key Down Volts
		Final Power Amplifier, Type 813		
Filament	10.0	A-1	10.0	10.0
Grid 1	-300	A-1	-124	-170
	-300	A-2	-124	-175
	-300	A-3	-124	-175
Grid 2	400	A-1	*560	*420
	400	A-2	*560	385
	400	A-3	*565	380
Plate	2000	A-1	*2370	*2100
	1600	A-2	*1700	1540
	1600	A-3	*1700	1580
		Keyer, Type 6SJ7		
Filament	6.3	A-1	6.3	6.3
Grid 1	----	A-1	0	-16
Grid 2	140	A-1	30	32
Grid 3	----	A-1	0	0
Plate	330	A-1	18	32
		Voltage Regulator, Type VR-150/30		
Anode	150	A-1	156	154

Element	Spec. Rating Volts	Maximum Measured Volts
	Calibration Oscillator, Type 6A8	
Filament	6.3	6.2
Grid 1	---	-63
Grid 2	330	238
Grid 3	110	*136
Grid 4	---	-33.5
Grid 5	110	*136
Plate	330	253
	Converter, Type 6SL7GT	
Filament	6.3	6.2
Grid 1	---	-49
Plate 1	275	134
Grid 2	---	-44
Plate 2	275	168

(Continued)

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TABLE 7 (Cont'd)

Element	Spec. Rating Volts	100 Per Cent Modulation	No Modulation
Audio Preamplifier, Type 6SL7GT			
Filament	6.3	6.52	6.65
Grid 1	---	-1.85	-1.85
Plate 1	275	158	158
Grid 2	---	-1.85	-1.85
Plate 2	275	162	162
Volume Limiter, Type 6C8G			
Filament	6.3	6.52	6.65
Grid 1	---	-24	-24
Plate 1	275	135	135
Grid 2	---	-24	-24
Plate 2	275	135	135
Audio Squelch, Type 6C8G			
Filament	6.3	6.52	6.65
Grid 1	---	-14	-14
Plate 1	275	168	166
Grid 2	---	-14	-14
Plate 2	275	164	16
Audio Amplifier, Type 6SJ7			
Filament	6.3	6.52	6.65
Grid 1	----	-9.5	-9.5
Grid 2	140	*275	*273
Grid 3	----	275	273
Plate	330	275	273
Limiter Control, Type 6X5			
Filament	6.3	6.52	6.65
Plate 1	---	78	76
Plate 2	---	78	76
Audio Driver, Type 2A3			
Filament	2.5	2.5	2.5
Grid	---	-57	-57
Plate	360	288	288

(Continued)

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TABLE 7 (Cont'd)

Element	Spec. Rating Volts	Maximum Measured Volts
Audio Amplifier, Type 6SN7GT		
Filament	6.3	6.2
Grid 1	---	-9.3
Plate 1	330	285.7
Grid 2	---	-3.2
Plate 2	330	104.8
First Remote Amplifier, Type 6SJ7		
Filament	6.3	6.1
Grid 1	---	-3.7
Grid 2	140	77.3
Grid 3	---	0
Plate	330	106.3
Second Remote Amplifier, Type 6SN7GT		
Filament	6.3	6.1
Grid 1	---	-107
Plate 1	330	137
Grid 2	---	4.4
Plate 2	330	154.4
Rectifier, Type 6X5GT		
Filament	6.3	6.1
Cathode	450	176
Plate to Plate	1375 (max.inv.)	256

Element	Spec. Rating Volts	100 Per Cent Modulation	No Modulation
Mcw Oscillator, Amplifier, Type 6SN7GT			
Filament	6.3	6.52	6.65
Grid 1	---	-12	-12
Plate 1	330	308	308
Grid 2	---	-7.8	-7.8
Plate 2	330	214	214

(Continued)

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TABLE 7 (Cont'd)

Element	Spec. Rating Volts	100 Per Cent Modulation	No Modulation
	Audio Driver, Type 2A3		
Filament	2.5	2.5	2.5
Grid	---	-57	-57
Plate	360	288	288
	Modulator, Type 805		
Filament	10.0	9.9	10.0
Grid	---	-24	-20
Plate	1500	1500	1550
	Modulator, Type 805		
Filament	10.0	9.9	10.0
Grid	---	-24	-20
Plate	1500	1500	1550

Element	Spec. Rating Volts	Emission	Key Up Volts	Key Down Volts
	High Voltage Rectifiers, Type 249C			
Plate to Plate	***17500	A-1	4950	4800
Filament	2.5	A-1	2.5	2.5
	Bias Rectifier, Type 5U4G			
Plate to Plate	***1550	A-1	520	510
Filament	5.0	A-1	5.1	5.1
	Low Voltage Rectifiers, Type 866A			
Plate to Plate	***10000	A-1	1260	1230
Filament	2.5	A-1	2.5	2.5

* In excess of specification ratings.
** Exc. Band Switch
*** Rated maximum inverse peak voltage.

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TABLE 8

MODEL TDO TRANSMITTING EQUIPMENT

LIST OF PANEL CONTROLS, METERS AND OTHER INDICATING DEVICES

Dials

Designation	Purpose	Scale
Oscillator Tuning	M-o tuning.	0-100
	Geared with m-o tuning to indicate "hundreds".	0-10
Exciter Tuning	Tunes the frequency doubler and int. amp.	0-100
Exciter Band Switch	Switches the freq. doubler and int. amp.	1-4
Power Amp. Tuning	Tunes the p-a plate circuit	0-100
Power Amp. Band Switch	Switches the p-a plate circuit	1-12
Antenna Tuning	Controls the antenna loading	0-100
Mcw Frequency	Controls the modulation frequency	1-7
Audio Gain	Controls the audio output	0-10
Mcw Gain	Controls the mcw gain	0-10
Limiter Gain	Controls the limiter action	0-10

Switches

Marking	Purpose	Type
On-off	Main power line switch.	Toggle
Test key	Keys to transmitter	Toggle
L.V.-Tune-Op.	Applies the desired value of plate voltage	Knob
Local Remote	Selects either local or remote operation.	Toggle
Filament	Energizes the filaments	Push buttons
Plate	Energizes the plate transformers	Push buttons
Auto-Tune	Provides impulses for auto-tune channel selection	Telephone dial
C.F.I. Off-on	Turns plate power on or off the C.F.I. unit.	Two position knob

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TABLE 8 (Cont'd)

Indicators

Marking	Purpose	Type
Filament	Indicates when filaments are energized	Green glass
Plate	Indicates when plate voltage is applied	Red glass
Channel Indicator	Indicates the number of the channel to which transmitter is dialed or shows "M" for manual operation.	0-11 and "M"

Remote Control Unit

Designation	Purpose	Type or Scale
*Channel Indicator	Indicates channel to which transmitter is dialed or "off"	Off and 1-10
Gain	Controls audio input gain	Knob
On-Off	Throws 110 volt supply voltage on and off	Toggle
Dial Light	Shows "Power on" condition	Red glass
Auto-Tune	Provides impulses for the auto-tune channel selection.	Telephone Dial

* Fails to indicate channel 11.

Meters

Nameplate	Range	Manufacturer	Manufacturer Type
Line, Fil. Voltage	0-15 volts 0-300 volts	G.E.	A025
Plate Voltage	0-3 kv.	G.E.	D053
Plate Current	0-800 ma.	G.E.	D053
Grid Current	0-5 ma. 0-50 ma.	G.E.	D053
Antenna Current	0-3 amp.	Weston	425

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TABLE 9

MODEL TDO TRANSMITTING EQUIPMENT

LIST OF NAMEPLATES

1. Equipment nameplate: Front panel of transmitter.
Plastic, photo-etched. 3-1/8" x 4-1/16"

Model TDO
Radio Transmitting Equipment
Supply: 115/1/50 or 60 Serial 1
For complete list of units see Instruction Book

NAVY DEPARTMENT
Bureau of Ships

Contractor
Collins Radio Company
Cedar Rapids, Iowa

Contract NXss-20834

2. Acceptance nameplate: Front panel of transmitter.
Plastic, photo-etched. 5/8" x 4-1/16"

Accepted by Navy Placed in Service
Oct. 31, 1943

See Instruction Book regarding guarantee

(Continued)

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TABLE 9 (Cont'd)

3. Equipment nameplate: Front panel of transmitter. Plastic, photo-etched. 4-1/16" x 3-3/32".

Type COL-52318
Radio Transmitter
Serial 1

A Unit of Model TDO Radio Equipment
Manufactured For
Navy Department -- Bureau of Ships
By Contractor
Collins Radio Company
Cedar Rapids, Iowa
Contract NXss-20834

4. Equipment nameplate: Inside front door of transmitter. Metal, engraved. 2-5/8" x 4".

Radio Transmitting Equipment

COLLINS

Type 16F Model 8 Serial 95590
Output A1 400 W A2 250 W A3 250 W
Freq. 2.0-18 MC Ant. Unbalanced

Power Source

Volts 115/230 Amp. 16/8 Phase 1 Cycles 50/60

Audio Frequency

Input 5000 Level 0.1V Micr. Dynamic

COLLINS RADIO COMPANY
Cedar Rapids, Iowa

(Continued)

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TABLE 9 (Cont'd)

5. Warning nameplate: Front of lower shelf of the power unit. Metal, engraved. Size 2" x 1".

DANGER

High Voltage
Remove Metering Plug
Before Applying Plate Power

6. Remote Control Unit: Front of the panel. Plastic, photo-etched. 3" x 2".

Type COL-23377
Remote Control Unit
Serial 1
A unit of Model TDO Radio Equipment
Manufactured for
Navy Department -- Bureau of Ships
By Contractor
Collins Radio Company
Cedar Rapids, Iowa
Contract NXss-20834

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TABLE 10

MODEL TDO TRANSMITTING EQUIPMENT

DIMENSIONS AND WEIGHTS

Transmitter:	
Width	32"
Depth	30-1/2"
Height	80-1/2"
Weight	1167.5 pounds
Remote Unit:	
Width	19"
Depth	10-3/8"
Height	10-1/2"
Weight	31 pounds

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TABLE 11

MODEL TDO TRANSMITTING EQUIPMENT

OPERATION OF THE OUTPUT NETWORK

Indicator or Control	*2.0 Mc	18.1 Mc	2.0 Mc	18.1 Mc	2.0 Mc	18.1 Mc	2.0 Mc	18.1 Mc
Emission	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1
Oscillator Tuning	20	965	20	965	20	965	20	965
Exciter Band Switch	4	1	4	1	4	1	4	1
Exciter Tuning	48	10	45	10	48	10	45	10
P-A Tuning	40	32	2	30	63	14	32	10
P-A Band Switch	11	1	12	1	11	1	12	1
Antenna Tuning	90	25	67	27	82	50	46	65
Ant. Current (Amps.)	3.09	2.95	2.42	2.55	1.29	1.32	1.00	0.9
Power Output (Watts)	525	480	523	580	550	575	552	448
Load Resistance (Ohms)	58	55	89.1	89.1	330	330	552	552

* C106 was paralleled with C105 before it was possible to tune at 2 Mc with 55 ohm load.

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TABLE 12

MODEL TDO TRANSMITTING EQUIPMENT

DETERMINATION OF POWER OUTPUT

Control or Meter	1.977 MC	2 MC	3 MC	4 MC
A-1 Emission:				
Channel Indicator	-	1	2	3
Osc. Tuning	-30	20	950.6	685
Exciter Band Switch	4	4	4	3
Exciter Tuning	50	45	11	46
P.A. Band Switch	11	11	9	8
P.A. Tuning	63	32	38	13
Antenna Tuning	86	88	44	33
Line (Volts)	230	229	228	228
813 Grid (Ma.)	24.5	22.2	27.0	24.8
807 Grid (Ma.)	0.86	3.2	2.2	1.62
813 Plate (Ma.)	365	365	365	365
Plate Voltage (Kv.)	2.03	2.01	2.03	2.03
Antenna Current (Amp.)	1.35	1.35	1.35	1.38
Watts Output	553	553	553	578
A-2, A-3 Emission (No Modulation)				
813 Grid (Ma.)	26.0	23.2	28.5	26.0
813 Plate (Ma.)	340	342	330	345
Plate Volts (Kv.)	1.50	1.50	1.50	1.50
Antenna Current (Amp.)	1.05	1.05	1.02	1.05
Watts Output	334	334	316	334
A-2, A-3 Emission (100% Modulation)				
813 Grid (Ma.)	25.0	23.8	23.8	26.2
813 Plate (Ma.)	490	490	490	500
Plate Volts (Kv.)	1.48	1.46	1.46	1.50
Ant. Current (Amp.)	1.20	1.21	1.21	1.23
Watts Output	438	444	444	459

Note: Load Resistance - 303.6 ohms.

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TABLE 13

MODEL TDO TRANSMITTING EQUIPMENT

DETERMINATION OF POWER OUTPUT

Control or Meter	5 MC	6 MC	8 MC	10 MC
A-1 Emission:				
Channel Indicator	4	5	6	7
Osc. Tuning	585	950	683.2	318
Exciter Band Switch	3	3	2	1
Exciter Tuning	24	12	20	74
P.A. Band Switch	6	5	4	3
P.A. Tuning	29	38	49	61
Antenna Tuning	46	56	40	48
Line (Volts)	228	230	233	233
813 Grid (Ma.)	23.3	23.0	23.9	17.5
807 Grid (Ma.)	0.8	1.4	1.75	2.65
813 Plate (Ma.)	365	365	365	365
Plate Voltage (Kv.)	2.00	2.03	2.05	2.05
Antenna Current (Amp.)	1.38	1.38	1.40	1.36
Watts Output	578	578	594	561
A-2, A-3 Emission (No Modulation)				
813 Grid (Ma.)	23.3	25.0	25.0	18.1
813 Plate (Ma.)	358	350	345	360
Plate Volts (Kv.)	1.50	1.51	1.52	1.51
Antenna Current (Amp.)	1.08	1.08	1.08	1.10
Watts Output	354	354	354	368
A-2, A-3 Emission (100% Modulation)				
813 Grid (Ma.)	23.2	25.0	25.0	18.5
813 Plate (Ma.)	505	500	500	500
Plate Volts (Kv.)	1.46	1.48	1.50	1.50
Ant. Current (Amp.)	1.22	1.23	1.24	1.22
Watts Output	452	459	467	452

Note: Load Resistance - 303.6 ohms.

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TABLE 14

MODEL TDO TRANSMITTING EQUIPMENT

DETERMINATION OF POWER OUTPUT

Control or Meter	12 MC	14 MC	16 MC	18.1 MC	18.265 MC
A-1 Emission:					
Channel Indicator	8	9	10	11	-
Osc. Tuning	20	421	683	965	0
Exciter Band Switch	1	1	1	1	1
Exciter Tuning	47	30	18	10	10
P.A. Band Switch	2	2	1	1	1
P.A. Tuning	73	28	46	12	12
Antenna Tuning	57	42	60	48	46
Line (Volts)	233	232	232	232	230
813 Grid (Ma.)	17.0	16.0	19.9	22.2	22.5
807 Grid (Ma.)	2.2	1.45	2.18	1.60	1.35
813 Plate (Ma.)	365	365	365	365	365
Plate Voltage (Kv.)	2.05	2.04	2.04	2.05	2.02
Antenna Current (Amp.)	1.35	1.34	1.33	1.35	1.35
Watts Output	553	546	538	553	553
A-2, A-3 Emission (No Modulation)					
813 Grid (Ma.)	17.9	16.5	20.5	23.0	23.5
813 Plate (Ma.)	365	365	355	350	360
Plate Volts (Kv.)	1.51	1.50	1.52	1.52	1.50
Antenna Current (Amp.)	1.08	1.10	1.05	1.05	1.06
Watts Output	354	368	334	334	341
A-2, A-3 Emission (100% Modulation)					
813 Grid (Ma.)	17.8	16.1	20.5	23.0	23.2
813 Plate (Ma.)	495	500	520	530	540
Plate Volts (Kv.)	1.49	1.48	1.49	1.50	1.47
Ant. Current (Amp.)	1.18	1.21	1.20	1.23	1.25
Watts Output	423	444	438	4.59	475

Note: Load Resistance - 303.6 ohms.

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TABLE 15

MODEL TDO TRANSMITTING EQUIPMENT

MEASUREMENT OF CARRIER RIPPLE

Frequency (Kc)	Rectified Carrier (Volts)	Volts RMS Ripple on Carrier	Per Cent Ripple
2000	675	0.25	0.037
18000	660	1.45	0.220

Specification Requirements: Not to exceed 2.0 per cent.

TABLE 16

MODEL TDO TRANSMITTING EQUIPMENT

ACCURACY OF MANUAL FREQUENCY ADJUSTMENT

Test as per par. 1 of ref. (b)

Intended Frequency (Kc)	Nearest Crystal Check Point Frequency (Kc)	Interpolated M.O. Dial Setting	Manual Frequency Adjustment (Kc)	Frequency Deviation From Intended Freq. Cycles	Per Cent
2003	2000	26.1	2003.009	9	0.00045
2998	3000	948.6	2997.985	15	0.00050
3504	3450	423.6	3503.707	293	0.00836
4002	4050	684.2	4001.250	750	0.01870

Specification limit: Maximum frequency deviation - 0.02 per cent.

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TABLE 17

MODEL TDO TRANSMITTING EQUIPMENT

ACCURACY OF AUTOMATIC RESET

Test as per par. 2 of ref. (b)

Trial No.	Frequency When Auto-Tune is Dialed (Kc)	M-O Dial Reading	Frequency Deviation From Initial Freq. Cycles	Per Cent
Initial Freq.	2003.099	26.1		
1	2003.089	26.1	10	.00049
2	2003.089	26.1	10	.00049
3	2003.099	26.1	0	.00000
4	2003.089	26.1	10	.00049
5	2003.109	26.1	10	.00049
		Average Deviation	8	.00040
Initial Freq.	2998.188	948.6		
1	2998.188	948.6	0	.00000
2	2998.188	948.6	0	.00000
3	2998.188	948.6	0	.00000
4	2998.203	948.6	15	.00050
5	2998.203	948.6	15	.00050
		Average Deviation	6	.00020
Initial Freq.	3503.707	423.6		
1	3504.215	423.6	508	* .01450
2	3504.215	423.6	508	* .01435
3	2504.254	423.6	547	* .01560
4	2504.235	423.6	528	* .01505
5	3504.235	423.6	528	* .01500
		Average Deviation	524	* .01499
Initial Freq.	4000.389	684.3		
1	4001.365	684.3	976	* .02440
2	4001.514	684.3	1125	* .02815
3	4001.538	684.3	1149	* .02870
4	4001.562	684.3	1173	* .02935
5	4001.586	684.3	1197	* .02990
		Average Deviation	1124	* .02810

Specification limits: Average of five trials - 0.004 per cent.
Any one trial - 0.005 per cent.

Note: * In excess of specification limits.
Time required for automatic frequency reset - 10.5 sec.

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TABLE 18

MODEL TDO TRANSMITTING EQUIPMENT

OPERATION OF L.V.-TUNE-OPERATE CONTROL

Test as per par. 3 of ref (b)

Type Emission	Step One "L.V."	Step Two "Tune"	Step Three "Operate"	Maximum Frequency Change	
				Cycles	Per Cent
2.0 mc output					
CW	2000.449	2000.449	2000.450	1	0.00005
Phone	2000.454	2000.454	2000.454	0	0.00000
MCW	2000.452	2000.452	2000.452	0	0.00000
8.0 mc output					
CW	8000.500	8000.510	8000.525	25	0.00031
Phone	8000.538	8000.549	8000.555	17	0.00021
MCW	8000.535	8000.545	8000.550	15	0.00019
18.1 mc output					
CW	18100.608	18100.622	18100.700	78	0.00043
Phone	18100.568	18100.591	18100.665	97	0.00053
MCW	18100.800	18100.820	18100.890	90	0.00050

Specification limits: 0.001 per cent.

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TABLE 19

MODEL TDO TRANSMITTING EQUIPMENT

DETUNING OF CIRCUITS

Test as per par. 4 of ref. (b)

Circuit Detuned Designation		Frequency (Kc)	Change in Frequency Cycles	Per Cent
Normal		3000.510		
Exciter Tuning	C	3000.515	5	0.000166
Exciter Tuning	CC	3000.517	7	0.000212
Power Amp. Tuning	C	3000.510	0	0.000000
Power Amp. Tuning	CC	3000.510	0	0.000000
Antenna Tuning	C	3000.500	10	0.000333
Antenna Tuning	CC	3000.498	12	0.000399
Normal		2000.520		
Exciter Tuning	C	2000.522	2	0.000199
Exciter Tuning	CC	2000.519	1	0.000020
Power Amp. Tuning	C	2000.520	0	0.000000
Power Amp. Tuning	CC	2000.525	5	0.000249
Antenna Tuning	C	2000.522	2	0.000199
Antenna Tuning	CC	2000.518	2	0.000199

Specification Limit: 0.003 per cent.

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TABLE 20

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE OF TUBES -- MASTER OSCILLATOR

Tests as per par. 5 of ref. (b)

Manufacturer	Serial	Frequency (Kc)	Deviation from Mean Frequency	
			Cycles	Per Cent
Philips	1	2000.821	5	0.00024
Philips	2	2000.670	145	0.00724
Philips	3	2000.912	97	0.00484
Philips	4	2000.940	125	0.00624
Philips	5	2000.690	125	0.00624
Philips	6	2000.729	86	0.00429
Philips	7	2000.932	117	0.00584
Philips	8	2000.721	94	0.00469
Philips	9	2000.900	85	0.00424
Philips	10	2000.839	24	0.00119
Mean Frequency:		2000.815	90.3	0.00451
Philips	1	18100.280	554	0.00306
Philips	2	18101.110	276	0.00152
Philips	3	18100.482	352	0.00194
Philips	4	18100.825	9	0.00005
Philips	5	18101.000	166	0.00092
Philips	6	18100.535	299	0.00165
Philips	7	18101.305	471	0.00261
Philips	8	18100.420	414	0.00229
Philips	9	18101.500	666	0.00368
Philips	10	18100.888	54	0.00023
Mean Frequency:		18100.834	326	0.00180

Specification limits: Max. freq. change not to exceed 0.01 per cent.

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TABLE 21

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE OF TUBES - FIRST FREQUENCY MULTIPLIER

Tests as per par. 5 of ref. (b)

Manufacturer	Serial	Frequency (Kc)	Deviation from Mean Frequency	
			Cycles	Per Cent
National Union	1	2000.506	4	0.0002
National Union	2	2000.518	8	0.0004
National Union	3	2000.505	5	0.00025
National Union	4	2000.518	8	0.0004
National Union	5	2000.517	7	0.00035
National Union	6	2000.518	8	0.00040
National Union	7	2000.505	5	0.00025
National Union	8	2000.512	2	0.0001
National Union	9	2000.502	8	0.0004
National Union	10	2000.502	8	0.0004
Mean Frequency:		2000.510	6.3	0.00032
National Union	1	18102.490	6	0.000033
National Union	2	18102.490	6	0.000033
National Union	3	18102.490	6	0.000033
National Union	4	18102.490	6	0.000033
National Union	5	18102.500	4	0.000021
National Union	6	18102.500	4	0.000021
National Union	7	18102.500	4	0.000021
National Union	8	18102.500	4	0.000021
National Union	9	18102.500	4	0.000021
National Union	10	18102.505	9	0.000049
Mean Frequency:		18102.496	5.3	0.000029

Specification limits: Frequency change not to exceed 0.0005 per cent.

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TABLE 22

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE OF TUBES - SECOND FREQUENCY MULTIPLIER

Test as per par. 5 of ref. (b)

Manufacturer	Serial	Frequency (K_c)	Deviation from Mean Frequency	
			Cycles	Per Cent
National Union	1	2000.495	6	0.0003
National Union	2	2000.505	4	0.0002
National Union	3	2000.498	3	0.00015
National Union	4	2000.505	4	0.0002
National Union	5	2000.497	4	0.0002
National Union	6	2000.493	8	0.0004
National Union	7	2000.495	6	0.0003
National Union	8	2000.506	5	0.00025
National Union	9	2000.511	10	0.0005
National Union	10	2000.501	0	0.0000
Mean Frequency		2000.501	5	0.00025
National Union	1	18102.400	24	0.000132
National Union	2	18102.400	24	0.000132
National Union	3	18102.405	19	0.000105
National Union	4	18102.415	9	0.000049
National Union	5	18102.420	4	0.000022
National Union	6	18102.425	1	0.000005
National Union	7	18102.435	11	0.000061
National Union	8	18102.440	16	0.000088
National Union	9	18102.450	26	0.000144
National Union	10	18102.450	25	0.000138
Mean Frequency		18102.424	15.9	0.000088

Specification limits: Frequency change not to exceed 0.0005 per cent.

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TABLE 23

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE OF TUBES - POWER AMPLIFIER

Test as per par. 5 of ref. (b)

Manufacturer	Serial	Frequency (Kc)	Deviation from Mean Frequency Cycles	Per Cent
		Front Tube (V-105)		
Kenrad	31397	2000.541	3	0.00015
RCA	2	2000.542	4	0.00020
Kenrad	9357	2000.536	2	0.00010
National Union	90491	2000.533	5	0.00025
RCA	1	2000.545	7	0.00035
National Union	90915	2000.531	7	0.00035
Kenrad	9215	2000.530	8	0.00040
Sylvania	8	2000.543	5	0.00025
Sylvania	6	2000.534	4	0.00020
RCA	451	2000.547	9	0.00045
Mean Frequency:		2000.538	5.4	0.00027
		Rear Tube (V-106)		
Kenrad	31397	2000.535	3	0.00015
RCA	2	2000.542	4	0.00020
Kenrad	9357	2000.540	2	0.00010
National Union	90491	2000.539	1	0.00005
RCA	1	2000.539	1	0.00005
National Union	90915	2000.539	1	0.00005
Kenrad	9215	2000.541	3	0.00015
Sylvania	8	2000.540	2	0.00010
Sylvania	6	2000.531	7	0.00035
RCA	451	2000.531	7	0.00035
Mean Frequency		2000.538	3.1	0.00015

Specification Limits: Frequency change not to exceed 0.0005 per cent.

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TABLE 24

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE OF TUBES - VOLTAGE REGULATOR FOR MO

Tests as per par. 5 of ref. (b)

Manufacturer	Serial	Frequency (Kc)	Deviation from Mean Frequency	
			Cycles	Per Cent
National Union	1	18103.050	92	0.00051
RCA	2	18103.100	42	0.00023
National Union	3	18103.075	67	0.00037
National Union	4	18103.125	17	0.00009
RCA	5	18103.125	17	0.00009
Collins	6	18103.125	17	0.00009
RCA	7	18103.150	8	0.00004
RCA	8	18103.150	8	0.00004
RCA	9	18103.225	83	0.00046
*RCA	10	18103.300	158	0.00087
Mean Frequency:		18103.142	50.9	0.00028
National Union	1	2000.590	5	0.00025
RCA	2	2000.590	5	0.00025
National Union	3	2000.580	5	0.00025
National Union	4	2000.585	0	0.00000
RCA	5	2000.588	3	0.00015
Collins	6	2000.580	5	0.00025
RCA	7	2000.584	1	0.00005
RCA	8	2000.590	5	0.00025
RCA	9	2000.580	5	0.00025
RCA	10	2000.588	3	0.00015
Mean Frequency:		2000.585	3.7	0.00018

* Exceeds specification limits.

Specification Limits: Frequency change not to exceed 0.0005 per cent.

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TABLE 25

MODEL TDO TRANSMITTING EQUIPMENT

VARIATION OF AMBIENT TEMPERATURE - 2000 KC

Test as per par. 7 of ref. (b)

Time	Amb. Temp. C°	Rel. Humidity Per Cent	Frequency (Kc)	Line Volts	P-A I_p (Ma)	P-A E_p (Volts)	I_{ant} (Amps.)
0900	50	26	2000.432	232	360	2050	1.35
0915	50	26	2000.430	233	360	2050	1.35
0930	50	26	2000.430	232	360	2050	1.35
0945	50	26	2000.432	232	360	2050	1.35
1000	50	26	2000.430	233	355	2050	1.35
1015	40	31	2000.440	233	355	2050	1.35
1030	39	30	2000.440	232	355	2025	1.35
1045	39	29	2000.438	233	355	2025	1.35
1100	40	29	2000.439	233	355	2025	1.35
1115	40	29	2000.439	232	350	2025	1.35
1130	30	28	2000.443	231	350	2025	1.35
1145	30	28	2000.450	232	350	2025	1.35
1200	30	28	2000.450	233	350	2025	1.35
1215	30	28	2000.451	235	350	2050	1.35
1230	30	28	2000.451	236	355	2050	1.35
1245	20	27	2000.452	236	360	2050	1.35
1300	20	31	2000.458	236	360	2050	1.35
1315	20	33	2000.460	236	360	2050	1.35
1330	20	31	2000.461	235	360	2050	1.35
1345	20	31	2000.461	235	360	2050	1.35
1400	10	38	2000.469	234	360	2050	1.35
1415	9	38	2000.470	234	360	2050	1.35
1430	10	38	2000.468	232	360	2050	1.35
1445	10	38	2000.465	234	360	2050	1.35
1500	10	38	2000.465	236	360	2070	1.4
1515	0	--	2000.461	236	360	2070	1.4
1530	0	--	2000.462	236	360	2060	1.4
1545	0	--	2000.462	238	365	2100	1.4
1600	0	--	2000.461	238	365	2100	1.45
1615	0	--	2000.456	238	370	2100	1.4

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TABLE 25 (Cont'd)

SUMMARY

Temperature Change Degrees C.	Cycles Change per 10 Deg. C.	Per Cent Change per one Deg. C.
50 - 40	+ 9	0.000045
40 - 30	+ 12	0.000060
30 - 20	+ 10	0.000050
20 - 10	+ 4	0.000020
10 - 0	- 9	0.000045

Specification requirements: Max. frequency change per one degree C. - 0.00035%.

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TABLE 26

MODEL TDO TRANSMITTING EQUIPMENT

VARIATION OF AMBIENT TEMPERATURE - 18000 KC

Test as per par. 7 of ref. (b)

Time	Amb. Temp. C°	Rel. Humidity Per Cent	Frequency (Kc)	Line Volts	P-A I_p (Ma)	P-A E_p (Volts)	I_{ant} (Amps.)
0845	50	27	18002.470	224	360	1980	2.50
0900	50	26	18002.500	226	360	1980	2.50
0915	50	25	18002.501	224	355	1950	2.45
0930	50.5	25.	18002.605	224	355	1950	2.45
0945	50	25	18002.650	225	355	1950	2.45
1000	40	27	18002.750	224	355	1950	2.45
1015	40	23	18002.730	224	355	1950	2.45
1030	40	23	18002.750	224	355	1950	2.45
1045	40	23	18002.750	226	360	1980	2.48
1100	40	23	18002.830	226	360	1980	2.48
1115	30	26	18002.850	226	360	1950	2.48
1130	30	26	18002.895	226	360	1950	2.48
1145	30	23	18002.880	226	360	1950	2.48
1200	30	23	18002.860	226	360	1980	2.50
1215	30	23	18002.850	226	360	1980	2.50
1230	20	37	18002.820	226	360	1980	2.52
1245	20	33	18002.820	226	360	1890	2.52
1300	20	31	18002.820	226	360	1950	2.52
1315	20	31	18002.810	226	360	1950	2.52
1330	20	24	18002.860	226	360	1980	2.52
1345	10.5	34	18002.860	226	360	1980	2.52
1400	10	32	18002.850	226	360	1980	2.52
1415	10	32	18002.840	226	360	1980	2.52
1430	10	32	18002.800	226	360	1980	2.52
1445	10	32	18002.810	226	360	1980	2.52
1500	0	--	18002.800	226	360	1980	2.52
1515	0	--	18002.750	226	360	1980	2.52
1530	0	--	18002.680	226	360	1980	2.52
1545	0	--	18002.660	226	360	1980	2.52
1600	0	--	18002.700	226	365	1980	2.55

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TABLE 26 (Cont'd)

SUMMARY

Temperature Change Degrees C.	Cycles change per 10 Deg. C.	Per Cent change per one Deg. C.
50 - 40	+ 180	0.00010
40 - 30	+ 20	0.000011
30 - 20	+ 10	0.000005
20 - 10	- 50	0.000028
10 - 0	- 90	0.000050

Specification requirements: Max. frequency change per one degree C. - 0.00035%

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TABLE 27

MODEL TDO TRANSMITTING EQUIPMENT

VARIATIONS IN HUMIDITY - 2000 KC

Test as per par. 8 of ref. (b)

Time	Amb. Temp. C°	Rel. Humidity Per Cent	Frequency (Kc)	Line Volts	P-A I_p (Ma.)	P-A E_p (Volts)	I_a (Amp.)
0930	40	29	2000.490	228	360	2000	1.8
0945	40	27	2000.468	228	360	2000	1.8
1000	40	25	2000.462	228	360	2000	1.8
1015	40	95	2000.430	228	355	1980	1.8
1030	40	95	2000.420	230	350	2000	1.8
1045	40	97	2000.412	230	350	2000	1.78
1100	40	95	*2000.397	229	350	2000	1.78
1115	40	95	*2000.399	228	350	2000	1.78
1130	40	29	2000.410	228	350	2000	1.78
1145	40	29	2000.418	228	350	2000	1.78
1200	40	27	2000.426	228	350	2000	1.78
1215	40	27	2000.428	228	350	2000	1.79
1230	40	27	2000.435	230	355	2020	1.80

* In excess of specification requirements.
Max. frequency variation from that prevailing at end of first period 65 cycles, 0.00325%.
Max. change in power output. 4.0%

Specification requirements: Max. frequency change - .003%
Max. power output change 5.0%

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TABLE 28

MODEL TDO TRANSMITTING EQUIPMENT

VARIATION IN HUMIDITY - 18000 KC

Test as per par. 8 of ref. (b)

Time	Amb. Temp. C°	Rel. Humidity Per Cent	Frequency (Kc)	Line Volts	P-A I_p (Ma.)	P-A E_p (Volts)	I_a (Amp.)
1300	40	27	18002.890	228	360	2000	1.75
1315	40	27	18002.850	228	360	2000	1.75
1330	40	27	18002.850	228	350	2000	1.75
1345	40	93	18002.760	230	360	2000	1.78
1400	40	95	18002.620	230	360	2000	1.78
1415	40	97	18002.650	226	350	1970	1.72
1430	40	95	18002.560	229	355	2000	1.75
1445	40	97	18002.500	230	360	1980	1.75
1500	39.5	27	18002.680	228	355	1980	1.75
1515	40	27	18002.750	228	355	1980	1.75
1530	40	27	18002.810	228	350	1980	1.75
1545	40	27	18002.860	228	350	1980	1.75
1600	40	27	18002.860	230	360	2000	1.81

Max. frequency variation from that prevailing at end of first period: 350 cycles, 0.00194 per cent.
Max. change in power output: 4.2 per cent.

Specification requirements: Max. freq. change 0.003 per cent.
Max. power output change 5.0 per cent.

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TABLE 29

MODEL TDO TRANSMITTING EQUIPMENT

LOCKED KEY OPERATION FOR TWO HOURS - 2000 KC

Tests as per par. 9 of ref. (b)

Time	Frequency (Kc)	P-A I_g (Ma.)	P-A I_p (Ma.)	I_{ant} (Amps.)
1405	Filament energized.			
1410	2000.599	23.1	360	1.35
1415	2000.582	22.9	360	1.34
1420	2000.581	22.5	355	1.32
1430	2000.572	22.8	360	1.33
1445	2000.572	23.0	360	1.34
1500	2000.565	23.0	360	1.35
1515	2000.561	22.5	355	1.33
1530	2000.569	22.8	360	1.33
1545	2000.569	22.9	360	1.34
1600	2000.557	23.0	360	1.34
1610	2000.557	22.8	358	1.34

	Cycles	Per Cent
Freq. change during first five minutes	17	0.00085
Freq. change during balance of test	25	0.00125
Freq. change due to heater cycle	10	0.0005
Specification requirements:		
First five minutes		0.001
Balance of test		0.0025

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TABLE 30

MODEL TDO TRANSMITTING EQUIPMENT

LOCKED KEY OPERATION FOR TWO HOURS - 8000 KC

Test as per par. 9 of ref. (b)

Time	Frequency (Kc)	P-A I_g (Ma.)	P-A I_a (Ma.)	I_{ant} (Amps.)
1255	Filaments energized			
1300	8000.740	22.4	355	1.37
1305	8000.640	22.1	355	1.36
1310	8000.590	22.0	355	1.35
1315	8000.610	21.9	355	1.35
1330	8000.610	22.0	355	1.35
1345	8000.590	22.0	355	1.35
1400	8000.603	22.0	355	1.36
1415	8000.570	22.0	355	1.35
1430	8000.580	22.0	355	1.36
1445	8000.595	22.0	355	1.37
1500	8000.560	22.0	355	1.36

	Cycles	Per Cent
Freq. change during the first five minutes	100	0.00125
Freq. change during the balance of the test	80	0.001
Freq. change due to heater cycle	25	0.00032
Specification requirements:		
First five minutes		0.001
Balance of test		0.0025

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TABLE 31

MODEL TDO TRANSMITTING EQUIPMENT

LOCKED KEY OPERATION FOR TWO HOURS - 18100 KC

Test as per par. 9 of ref. (b)

Time	Frequency (Kc)	P-A I_g (Ma.)	P-A I_p (Ma.)	I_{ant} (Amps.)
925	Filaments energized.			
930	18100.913	20.2	360	1.34
935	18100.840	20.5	360	1.34
940	18100.722	20.8	360	1.34
945	18100.760	21.0	360	1.34
1000	18100.710	21.0	360	1.34
1015	18100.705	21.0	355	1.34
1030	18100.712	21.0	355	1.34
1045	18100.700	20.8	355	1.34
1100	18100.700	21.0	355	1.34
1115	18100.685	21.0	360	1.35
1130	18100.625	21.0	360	1.35

	Cycles	Per Cent
Freq. change during first five minutes	73	0.000403
Freq. change during balance of test	215	0.00194
Frequency change due to heater cycle	80	0.00044
Specification requirements:		
First five minutes		0.001
Balance of test		0.0025

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TABLE 32

MODEL TDO TRANSMITTING EQUIPMENT

LOCKED KEY OPERATION FOR TWO HOURS, COLD START - 2000 KC

Time	Frequency (Kc)	P-A I_g (Ma.)	P-A I_p (Ma.)	I_{ant} (Amps.)
0910	2002.465	32.1	360	1.0
0915	2002.540	31.2	360	1.0
0920	2002.620	31.0	360	1.0
0925	2002.695	30.8	360	1.0
0930	2002.685	31.0	365	1.0
0935	2002.670	30.8	365	1.0
0940	2002.675	30.8	365	1.0
0945	2002.685	30.7	365	1.0
0950	2002.690	30.2	365	1.0
0955	2002.695	30.4	365	1.0
1000	2002.700	30.3	365	1.0
1005	2002.710	30.3	360	1.0
1010	2002.730	30.2	360	1.0
1025	2002.775	30.0	360	1.0
1040	2002.800	30.2	360	1.0

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TABLE 33

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE FROM KEY LOCKED TO INTERMITTENTLY KEYED CONDITION

Test Condition	Freq. at end of 10 min. key Locked period (Kc)	Freq. at end of 10 second dash 20 min. later (Kc)	Change in Freq. Cycles	Change in Freq. Per Cent
Filament lighted	2000.485	2000.495	10	0.0005
Filaments off	2000.490	2000.540	50	0.00250
Filament lighted	18102.150	18102.300	150	0.000832
Filaments off	18102.620	18102.965	345	0.00192

Specification requirements of similar equipment: .0.01 per cent filament energized. 0.02 per cent filament not energized.

TABLE 34

MODEL TDO TRANSMITTING EQUIPMENT

CHANGE FROM CONTINUOUSLY KEYED CONDITION TO INTERMITTENTLY KEYED CONDITION

Freq. at end of 30 min. of Continuous Keying (Kc)	Freq. at end of 10 second dash after 20 minute pause (Kc)	Change in Freq. Cycles	Change in Freq. Per Cent
2000.490	2000.510	20	0.001
18002.325	18002.300	25	0.00014

Specification requirements of similar equipment: 0.01 per cent.

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TABLE 35

MODEL TDO TRANSMITTING EQUIPMENT

VARIATION OF SUPPLY LINE VOLTAGE

Test as per par. 6 of ref. (b)

Supply Line Volts	P-A E_p (Volts)	Output Watts	Frequency (Kc)	Frequency Change Cycles	Frequency Change Per Cent
Minus to Plus 10% in One Minute					
		A-1 Emission			
103.5	1750	446.0	2000.513		
115	2020	546.0	2000.520	7	0.00035
126.5	2220	558.0	2000.520	7	0.00035
		A-2, A-3 Emission			
103.5	1375	53.0	2000.519		
115.0	1520	324.5	2000.520	1	0.00005
126.5	1820	390.0	2000.522	3	0.00015
		A-1 Emission			
103.5	1850	439.0	3000.450		
115.0	2025	538.0	3000.457	7	0.00023
126.5	2220	630.0	3000.458	8	0.00027
		A-2, A-3 Emission			
103.5	1400	50.0	3000.455		
115.0	1550	343.0	3000.450	5	0.00017
126.0	1675	376.0	3000.445	10	0.00033
Minus to Plus 10% in Five Minutes					
		A-1 Emission			
103.5	1850	446.0	2000.520		
115.0	2025	555.0	2000.525	5	0.00025
126.5	2220	656.0	2000.528	8	0.00039

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TABLE 35 (Cont'd)

Supply Line Volts	P-A E_p (Volts)	Output Watts	Frequency (Kc)	Frequency Change Cycles	Frequency Change Per Cent
		A-2, A-3 Emission			
103.5	1375	55.5	2000.450		
115.0	1515	318.0	2000.450	0	0.00000
126.5	1675	383.0	2000.450	0	0.00000
		A-1 Emission			
103.5	1850	376.5	3000.449		
115.0	2050	539.0	3000.450	1	0.00003
126.5	2220	630.0	3000.453	4	0.00013
		A-2, A-3 Emission			
103.5	1400	52.9	3000.457		
115.0	1525	343.0	3000.462	5	0.00017
126.5	1730	376.0	3000.449	8	0.00027

Specifications: Max. deviation - 0.0015 per cent.

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TABLE 36

MODEL TDO TRANSMITTING EQUIPMENT

SUMMARY OF FREQUENCY STABILITY TESTS

Test	Per Cent Maximum Frequency Variation 2000 kc.	4000 kc.	8000 kc.	18000 kc.	Ref.(b) Limits Per Cent
Accuracy of Manual Frequency Adjustment	0.00045	0.0187			0.02
Accuracy of Automatic Reset	0.0004	<u>0.02810</u>			0.004
Operation of Tune-Operate Control	0.00005		0.00031	0.00053	0.001
Detuning of Circuits	0.000249				0.003
Change of Tubes	0.00451			0.00180	0.01
Variation of Temperature	0.00006			0.0001	0.00035
Variation of Humidity	<u>0.00325</u>			0.00194	0.003
Two Hour Locked Key:					
First 5 minutes	0.00085		<u>0.00125</u>	0.0004	0.001
Balance of test	0.00125		0.001	0.00194	0.0025
Change from Locked Key to Intermittently Keyed.					
Filaments Off	0.0025			0.00135	
Filaments On	0.00049			0.000832	
Change from Continuously Keyed to Intermittently Keyed	0.001			0.000414	

Note: Underlined values exceed the limits set forth in the specifications.

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TABLE 37

MODEL TDO TRANSMITTING EQUIPMENT

DETERMINATION OF LIMITING FREQUENCIES AND OVERLAP OF M. O.

M.O. Dial Setting	M.O. Output Frequency (Kc)	Mean Frequency (Kc)	Overlap Kc.	Overlap Per Cent
Specification Limit:	1000.0	994.25	11.5	1.16
-29	988.5			
1000	1521.3	1514.82	12.97	0.85
Specification Limit:	1508.33			

Specification requirements of similar equipments: 3.0 per cent.

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TABLE 38

MODEL TDO TRANSMITTING EQUIPMENT

DETERMINATION OF LIMITING FREQUENCIES AND OVERLAP OF THE EXCITER

M.O. Control Dial	Exciter Band Switch	Exciter Tuning Control	Exciter Output Frequency (Kc)	Mean Frequency (Kc)	Overlap Kc.	Overlap Per Cent	Frequency Limiting Circuit
Specification Limit:			2000.0				
				1988.5	23.0	1.16	
-29	4	49	1977.0				M.O.
1000	4	9	3042.5				M.O.
				3004.0	77.0	2.56	
-29	3	98	2965.5				M.O.
1000	3	10	6085.0				M.O.
				6008.0	154.0	2.56	
-29	2	49	5931.0				M.O.
1000	2	11	9132.0				M.O
				9059.3	145.5	1.61	
-29	1	98	8986.5				M.O.
1000	1	10	18255.0				M.O.
				18177.5	155.0	0.85	
Specification Limit:			18100.0				

Specification requirements of similar equipments: 3.0 per cent.

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TABLE 39

MODEL TDO TRANSMITTING EQUIPMENT

DETERMINATION OF LIMITING FREQUENCY AND OVERLAP OF PA

M.O. Control Dial	Exciter Band Switch	Exciter Tuning Control	P-A Band Switch	P-A Tuning Control	Output Freq. (Kc)	Mean Freq. (Kc)	Overlap Kc.	Overlap Per Cent	Freq. Limiting Circuit
Specification Limit:					2000.0				
						1988.5	23.0	1.16	M.O.
929	4	47	12	30	1977.0				P.A.
178	4	41	12	0	2095.0				P.A.
						2058.5	73	3.5	
252	4	38	11	100	2022.0				P.A.
478	4	28	11	0	2395.0				P.A.
						2282.5	225	9.85	
266	4	35	10	100	2170.0				P.A.
1000	4	10	10	0	3043.0				P.A.
						2764.5	557	20.0	
551	4	26	9	100	2486.0				P.A.
474	3	61	9	0	3580.0				P.A.
						3291.5	577	17.5	
31	3	95	8	100	3003.0				P.A.
733	3	45	8	0	4098.0				P.A.
						3771.5	653	17.3	
366	3	71	7	100	3445.0				P.A.
500	3	27	7	0	4838.0				P.A.
						4457.0	762	17.0	
93	3	44	6	100	4076.0				P.A.
948	3	11	6	0	5980.0				P.A.
						5507.0	946	17.1	
575	3	24	5	100	5034.0				P.A.
473	2	30	5	0	7156.0				P.A.
						6925.0	462	6.68	
362	3	34	4	100	669.4				P.A.
131	1	88	4	0	9276.0				P.A.
						9219.0	124	1.35	
190	1	91	3	100	9152.0				P.A.
702	1	46	3	0	12080.0				P.A.
						11794.0	572	4.85	
607	1	51	2	100	11508				P.A.
557	1	24	2	0	14932				P.A.
						14566.0	732	5.0	
456	1	29	1	100	14200				P.A.
*169	1	86	1	0	18770				P.A.
						18435.0	670	3.64	
Specification Limit:					18100				

Note: * Final amplifier operated as a doubler.
Antenna loading capacitor dial setting - 50.

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TABLE 40

MODEL TDO TRANSMITTING EQUIPMENT

VARIATION OF RESONANT FREQUENCY OF MASTER OSCILLATOR PER DIVISION OF DIAL MARKING

Setting of Oscillator Tuning Control	Frequency (Kc)	Division Change	K.C. per Division	Per Cent Per Division
-29	988.00			
0	993.79	29	0.1995	0.0201
50	1006.09	50	0.2460	0.0244
100	1021.00	50	0.2980	0.0292
150	1038.19	50	0.3440	0.0332
200	1057.15	50	0.3790	0.0359
250	1078.21	50	0.4220	0.0392
300	1101.62	50	0.4690	0.0425
350	1126.09	50	0.4900	0.0435
400	1153.03	50	0.5380	0.0467
450	1181.59	50	0.5720	0.0484
500	1211.07	50	0.5900	0.0487
550	1241.61	50	0.6110	0.0492
600	1275.49	50	0.6780	0.0528
650	1309.21	50	0.6750	0.0516
700	1343.37	50	0.6840	0.0508
750	1377.83	50	0.6900	0.0502
800	1410.37	50	0.6520	0.0463
850	1442.12	50	0.6350	0.0440
900	1472.42	50	0.6060	0.0412
950	1498.61	50	0.6020	0.0402
1000	1521.33	50	0.4540	0.0298

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TABLE 41

MODEL TDO TRANSMITTING EQUIPMENT

TEST OF L.V.-TUNE-OPERATE CONTROL

	Step 1 "L.V."	Step 2 "Tune"	Step 3 "Operate"
A-1 Emission			
Line Volts	232.	231	227
PA Grid Current	28.7	25.5	21.5
PA Plate Current	----	140	365
PA Plate Voltage	----	720	1990
Antenna Current	----	0.55	1.38
A-2, A-3 Emission (100% Modulation)			
Line Volts	232	229	227
PA Grid Current	28.7	26.0	23.0
PA Plate Current	----	200	490
PA Plate Voltage	----	500	1450
Antenna Current	----	0.5	1.19
A-2, A-3 Emission (No Modulation)			
Line Volts	232	230	228
PA Grid Current	28.5	25.2	22.8
PA Plate Current	----	140	335
PA Plate Voltage	----	710	1480
Antenna Current	----	0.55	1.04

Note: Voltage measured with key closed.

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TABLE 42

MODEL TDO TRANSMITTING EQUIPMENT

OVERALL FIDELITY OF THE TRANSMITTER WITHOUT LIMITING ACTION

Frequency c.p.s.	Per Cent Modulation	I_a Amps.	P-A E_p	P-A I_p	Output Level Db Relative to 100% Modulation at 1000 c.p.s.
50	60	1.050	1.500	430	- 5.0
100	90	1.120	1.470	465	- 1.9
200	100	1.160	1.480	480	- 1.1
400	100	1.160	1.470	475	- 0.4
600	100	1.160	1.470	475	- 0.2
1000	100	1.175	1.470	480	0
1500	100	1.160	1.470	470	- 0.3
2000	100	1.150	1.460	470	- 0.4
2500	100	1.140	1.470	475	- 0.7
3000	100	1.120	1.470	475	- 1.0
3500	100	1.100	1.480	480	- 1.6
4000	100	1.060	1.480	485	- 2.4
4500	100	1.040	1.480	495	- 2.7
5000	100	1.00	1.460	495	- 3.4
6000	100	1.00	1.470	510	- 4.5
8000	100	0.95	1.460	515	- 5.8
10000	100	0.95	1.450	530	- 7.0
15000	100	0.90	1.480	530	- 8.0

Test Conditions: Audio input level 10 db.
Limiter Gain turned off.
Output frequency - 2000 kc.

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TABLE 43

MODEL TDO TRANSMITTING EQUIPMENT

OVERALL FIDELITY OF THE TRANSMITTER WITH LIMITING ACTION

Frequency c.p.s.	Per Cent Modulation	I_a Amps.	P-A E_p	P-A I_p	Output Level Db Relative to 100 % modulation at 1000 c.p.s.
50	60	1.04	1.480	450	- 4.8
100	100	1.10	1.470	455	- 1.2
200	100	1.130	1.480	455	- 0.6
400	100	1.130	1.480	455	- 0.3
600	100	1.140	1 480	455	- 0.2
1000	100	1.140	1.480	450	0
1500	100	1.130	1.480	450	- 0.1
2000	100	1.130	1.480	455	- 0.2
2500	100	1.130	1.480	455	- 0.6
3000	100	1.100	1.480	460	- 0.9
3500	100	1.070	1.480	460	- 1.3
4000	100	1.050	1.480	460	- 2.0
4500	90	1.030	1.470	465	- 2.8
5000	90	1.010	1.480	475	- 3.4
6000	80	1.000	1.460	480	- 4.6
8000	75	0.970	1.470	490	- 5.8
10000	70	0.980	1.480	500	- 7.5
15000	60	0.940	1.500	438	- 8.0

Test conditions: Audio input level - 10 db.
Limiter gain set for maximum compression.
Output frequency - 2000 kc.

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TABLE 44

MODEL TDO TRANSMITTING EQUIPMENT

OVERALL TRANSMITTER FIDELITY THROUGH THE REMOTE UNIT WITHOUT LIMITER ACTION

Frequency c.p.s.	Per Cent Modulation	I_a Amp.	P-A E_p	P-A I_p	Db Output Relative to 100% Modulation at 1000 c.p.s.
50	10	1.00	1.500	350	- 14.0
100	70	1.06	1.480	425	- 3.8
200	100	1.13	1.475	460	- 1.2
400	100	1.15	1.480	465	- 0.5
600	100	1.16	1.480	470	- 0.2
1000	100	1.17	1.490	470	0
1500	100	1.16	1.480	470	0
2000	100	1.16	1.480	475	0
2500	100	1.15	1.480	480	- 0.1
3000	100	1.13	1.480	485	- 0.5
3500	100	1.10	1.480	490	- 0.8
4000	100+	1.08	1.480	500	- 1.2
4500	100+	1.05	1.480	515	- 1.6
5000	100+	1.03	1.480	525	- 2.0
6000	100+	1.0	1.470	560	- 2.8

Test conditions: Audio input level - 0 db.
Limiter gain turned off,
Output frequency - 2000 kc.

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TABLE 45

MODEL TDO TRANSMITTING EQUIPMENT

OVERALL TRANSMITTER FIDELITY THROUGH THE REMOTE UNIT WITH LIMITING ACTION

Frequency c.p.s.	Per Cent Modulation	I_a Amp.	P-A E_p	P-A I_p	Db Output Relative to 100% Modulation at 1000 c.p.s.
50	--	1.00	1.500	350	- 12.0
100	70	1.07	1.480	425	- 2.3
200	90	1.10	1.480	445	- 0.7
400	90	1.12	1.490	445	- 0.2
600	90	1.12	1.490	445	- 0.1
1000	90	1.12	1.490	445	0
1500	90	1.11	1.480	440	- 0.1
2000	90	1.10	1.480	440	- 0.3
2500	90	1.10	1.480	445	- 0.5
3000	90	1.09	1.480	445	- 0.9
3500	95	1.06	1.480	450	- 1.2
4000	95	1.05	1.480	455	- 1.8
4500	95	1.03	1.480	460	- 2.5
5000	95	1.04	1.480	465	- 3.0
6000	95	1.00	1.480	475	- 4.2

Test conditions: Audio input level.- 0 db.
Limiter gain adjusted for maximum compression.
Output frequency - 2000 kc.

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TABLE 46

MODEL TDO TRANSMITTING EQUIPMENT

FIDELITY OF THE REMOTE CONTROL UNIT

Audio Input Frequency c.p.s.	Db output level relative to 0 db at 1000 c.p.s.	
	500 ohm Resistor Termination	500 ohm Resistor and 0.5 mfd Shunt Condenser Termination
100	-2.3	-3.0
200	-0.4	1.0
400	-0.2	8.0
800	-0.2	2.0
1000	.0	0
2000	.0	-2.2
3000	0.2	-4.8
4000	0.7	-6.5
5000	1.02	-8.5
6000	2.60	-10.0

Note: 0 db - input level.

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TABLE 47

MODEL TDO TRANSMITTING EQUIPMENT

OPERATION OF THE AUDIO LIMITER CIRCUIT

Input Level Db	Audio output at Secondary of T106 volts	Output Level (With respect to 0 db input level) db
Limiter Gain On:		
-10	23.0	-6.91
- 5	37.5	-2.67
- 2	49.0	-0.35
0	51.0	0.0
5	52.0	0.18
10	53.5	0.43
15	53.5	0.43
20	54.5	0.57
25	54.5	0.57
Limiter Gain Off:		
-10	23.0	-6.91
- 5	37.5	-2.67
- 2	54.0	-0.9
0	67.0	0
5	93.0	2.86
10	97.5	3.26
15	100.0	3.50
20	105.0	4.0

Note: 400 c.p.s. audio input.

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TABLE 48

MODEL TDO TRANSMITTING EQUIPMENT

CALIBRATION OF MCW AUDIO OSCILLATOR OUTPUT FREQUENCY

MCW Switch Tap	Per Cent Modulation	Modulation Frequency c.p.s.
1	80	350
2	80	486
3	80	632
4	80	771
5	80	907
6	80	1030
7	80	1205

TABLE 49

MODEL TDO TRANSMITTING EQUIPMENT

MEASUREMENT OF NOISE AND DISTORTION
2000 KC

	*Direct Audio Input (c.p.s.)				Audio Fed through Remote Control Unit (c.p.s.)			
	100	400	1000	5000	100	400	1000	5000
Limiter Gain Control	8.2	8.2	8.2	8.2	8.1	8.1	8.0	8.0
Audio Gain Control	6.0	6.0	6.0	5.8	4.0	4.0	4.0	4.0
Distortion Per Cent	7.1	3.3	2.1	13.0	7.2	2.3	4.7	14.5
Noise Level Db	-54.0	-54.0	-51.0	-47.0	-44.0	-46.0	-46.0	-43.0

* Measurements made with -15 db audio input level, 10 db of compression 100% modulation.

Note: Distortion and noise measurements are with respect to 100 per cent modulation.

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TABLE 50

MODEL TDO TRANSMITTING EQUIPMENT

MEASUREMENT OF NOISE AND DISTORTION
18100 KC

	Direct Audio Input (c.p.s.)				Audio Fed through Remote Control Unit (c.p.s.)			
	100	400	1000	5000	100	400	1000	5000
Limiter Gain Control	8.3	8.4	8.3	8.1	7.5	8.1	8.3	8.0
Audio Gain Control	6.0	5.9	5.8	5.7	4.0	3.8	3.6	3.8
Distortion Per Cent	8.0	2.2	2.1	17.5	12.0	3.0	2.3	13.0
Noise Level Db.	-47.0	-50.0	-58.0	-49.0	-44.0	-47.0	-47.0	-41.0

Note: Distortion and noise measurements are with respect to 100% modulation.
Measurements made with -15 db audio input level, 10 db compression with 100 per cent modulation.

TABLE 51

MODEL TDO TRANSMITTING EQUIPMENT

POWER REQUIRED FOR OPERATION OF THE REMOTE UNIT

Condition	Volts	Amps.	Watts	Power Factor Per Cent
Key Up	114.0	0.205	22.0	94.2
Key Down	114.0	0.1858	20.1	95.0

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TABLE 52

MODEL TDO TRANSMITTING EQUIPMENT

POWER INPUT REQUIRED FROM SUPPLY LINE
2000 KC

Condition	Line Volts	Line Current (Amp.)	Power (k.w.)	K.V.A.	P.F. (Per Cent
Auto Transformer only	118.0		0.020		
M-O Heater and Trans.	118.0		0.060		
A-1 Emission					
Filaments only	116.5	5.1	0.500	0.594	84.2
Low Voltage	116.5	7.6	0.756	0.885	85.4
Tune	117.0	10.3	1.108	1.205	91.9
Operate	116.0	15.6	1.572	1.810	84.1
Stand-by (Operate)	118.0	8.2	0.808	0.967	83.4
A-2, A-3 Emission (100% Modulation)					
Filaments only	117.5	5.8	0.580	0.681	85.2
Low Voltage	117.5	8.0	0.820	0.940	87.3
Tune	117.0	10.9	1.168	1.275	91.5
Operate	116.0	16.5	1.662	1.914	86.9
Stand-by (Operate)	117.0	8.9	0.944	1.040	90.8
A-2, A-3 Emission (No Modulation)					
Filaments only	117.5	5.8	0.580	0.681	85.2
Low Voltage	118.0	7.9	0.832	0.932	89.3
Tune	117.0	10.0	1.096	1.170	93.7
Operate	116.5	13.6	1.416	1.585	89.3
Stand-by (Operate)	117.5	8.8	0.952	1.032	92.0

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TABLE 53

MODEL TDO TRANSMITTING EQUIPMENT

MEASUREMENT OF RECTIFIER RIPPLE

Rectifier Unit	Key Condition	D.C. Volts	A.C. Ripple Volts	A.C. Ripple Per Cent
H.V.	Closed	1975	1.4	0.071
	Open	2200	0.8	0.036
L.V.	Closed	505	1.5	0.297
	Open	527	0.1	0.019
Bias	Closed	116	0.0	0.0
	Open	110	0.0	0.0

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TABLE 54

MODEL TDO TRANSMITTING EQUIPMENT

REGULATION OF RECTIFIERS

Supply Unit and Operating Conditions	Volts Key Up	Volts Key Down	Regulation Per Cent
"Low Voltage"			
Bias	110	118	6.8
Low Voltage	527	510	3.2
High Voltage	---	---	---
"Tune"			
Bias	110	117	6.0
Low Voltage	527	510	3.2
High Voltage	1750	675	61.5
"Operate"			
Bias	110	116	5.2
Low Voltage	527	505	4.2
High Voltage	2200	1975	10.2

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TABLE 55

MODEL TDO TRANSMITTING EQUIPMENT

OPERATION INTO A 164.5 FOOT ANTENNA

Control or Indicator	2 MC	3 MC	4 MC	6 MC	8 MC	12 MC	14 MC	16 MC	18.1 MC
Osc. Tuning	20	950.6	685	950	682	20	420	683	965
Exciter Band Switch	4	4	3	3	3	1	1	1	1
Exciter Tuning	47	11	55	12	20	47	30	19	11
PA Band Switch	12	10	8	6	7	2	2	1	1
PA Tuning	57	45	15	27	25	70	41	63	3
Antenna Tuning	60	6	25	6	7	63	22	34	75
Type Emission	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1
PA Plate (Ma.)	360	360	360	360	360	360	200	360	360
PA Plate (Volts)	2080	2100	2080	2080	2070	2040	2100	2040	2100
Ant. Current (Amps.)	2.35	2.27	3.0	2.95	1.5	2.0	Off scale	2.8	Off scale

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PLATE 1

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PLATE 2

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PLATE 3

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PLATE 4

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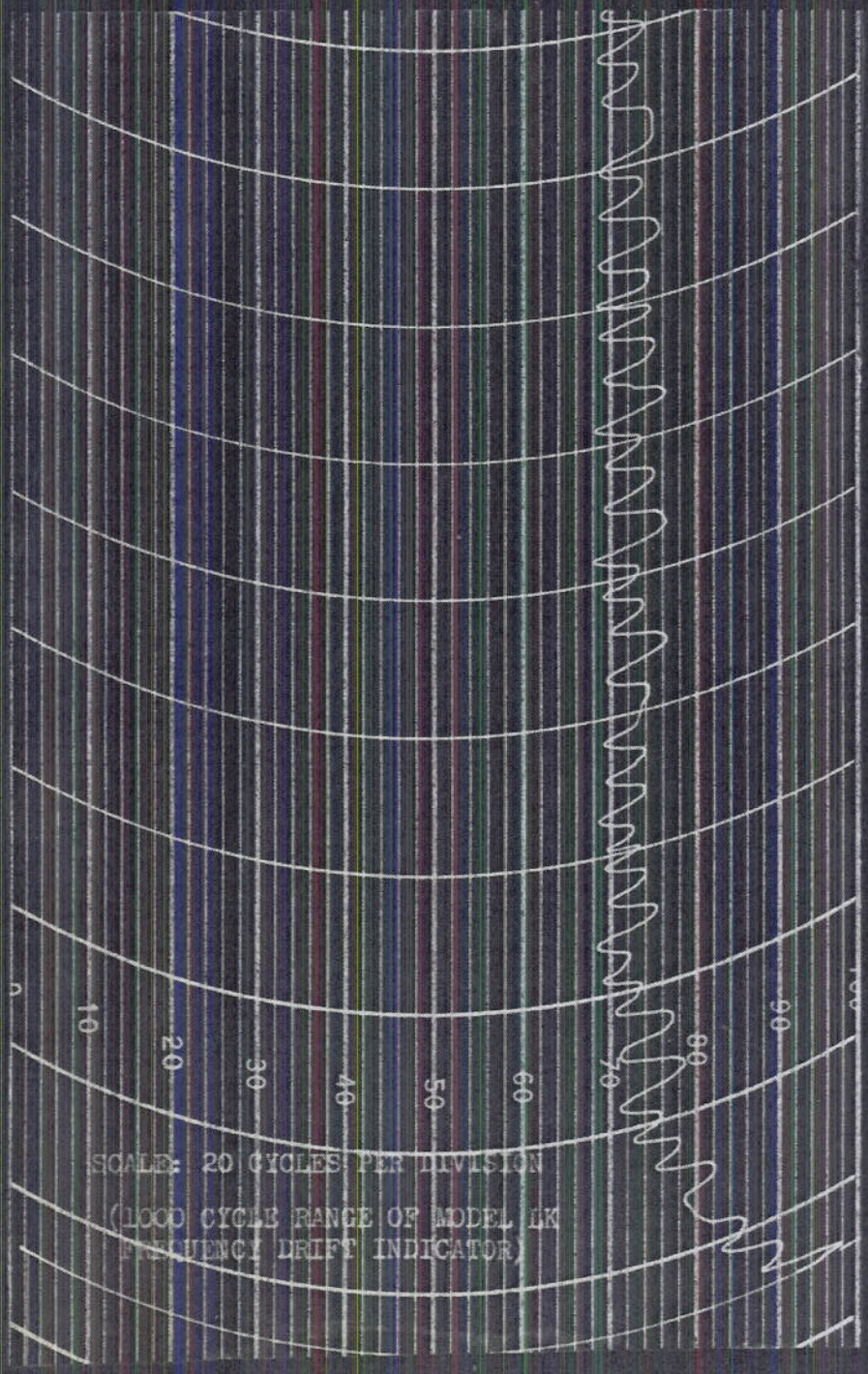
MODEL TDO TRANSMITTING EQUIPMENT

LOCKED KEY TEST 18100 KC



SCALE: 20 CYCLES PER DIVISION

(1000 CYCLE RANGE OF MODEL LK
FREQUENCY DRIFT INDICATOR)

MAXIMUM FREQUENCY CHANGE DUE TO HEATER CYCLE WAS

80 CYCLES OR 0.00044 PER CENT.

PLATE 5

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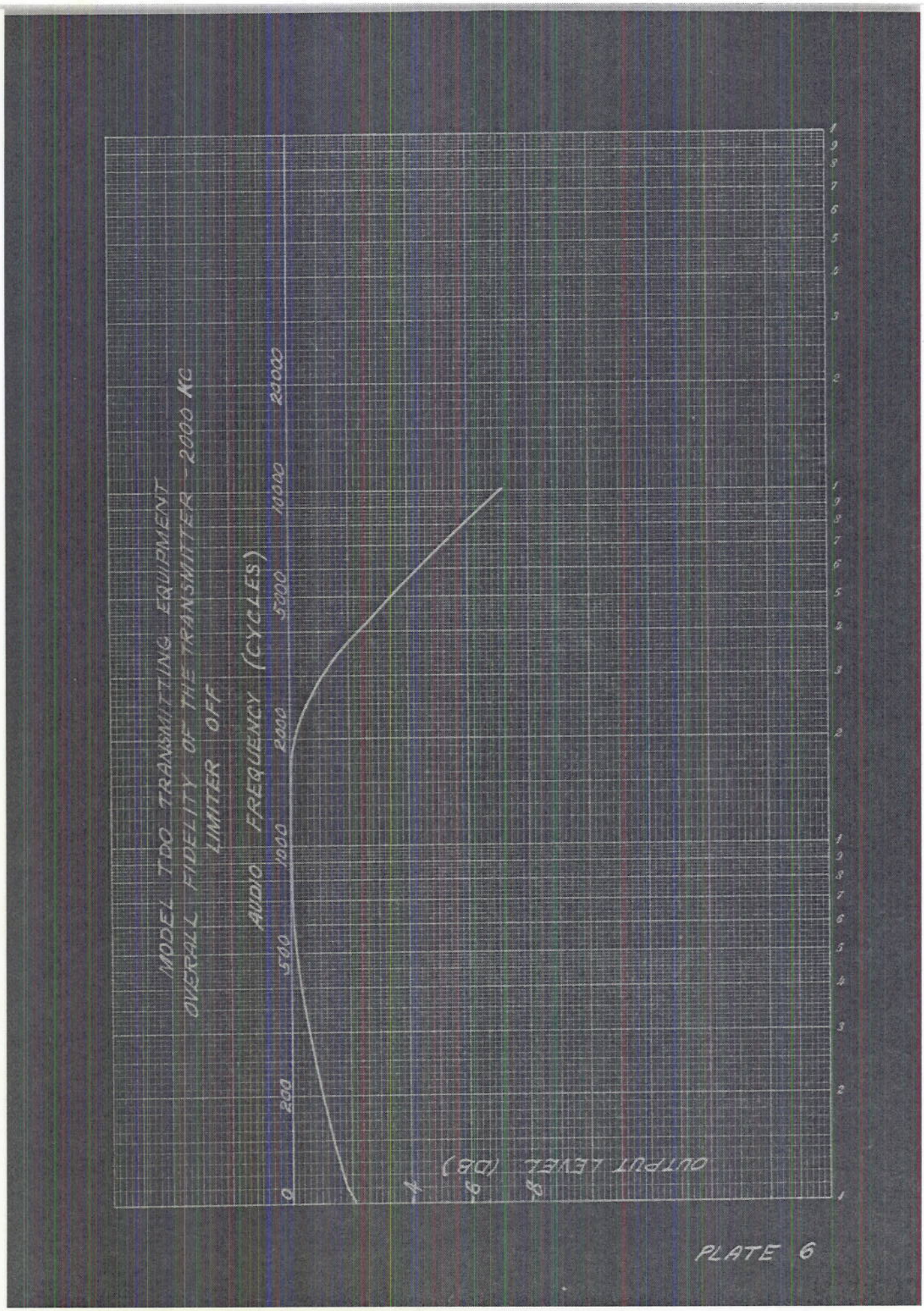

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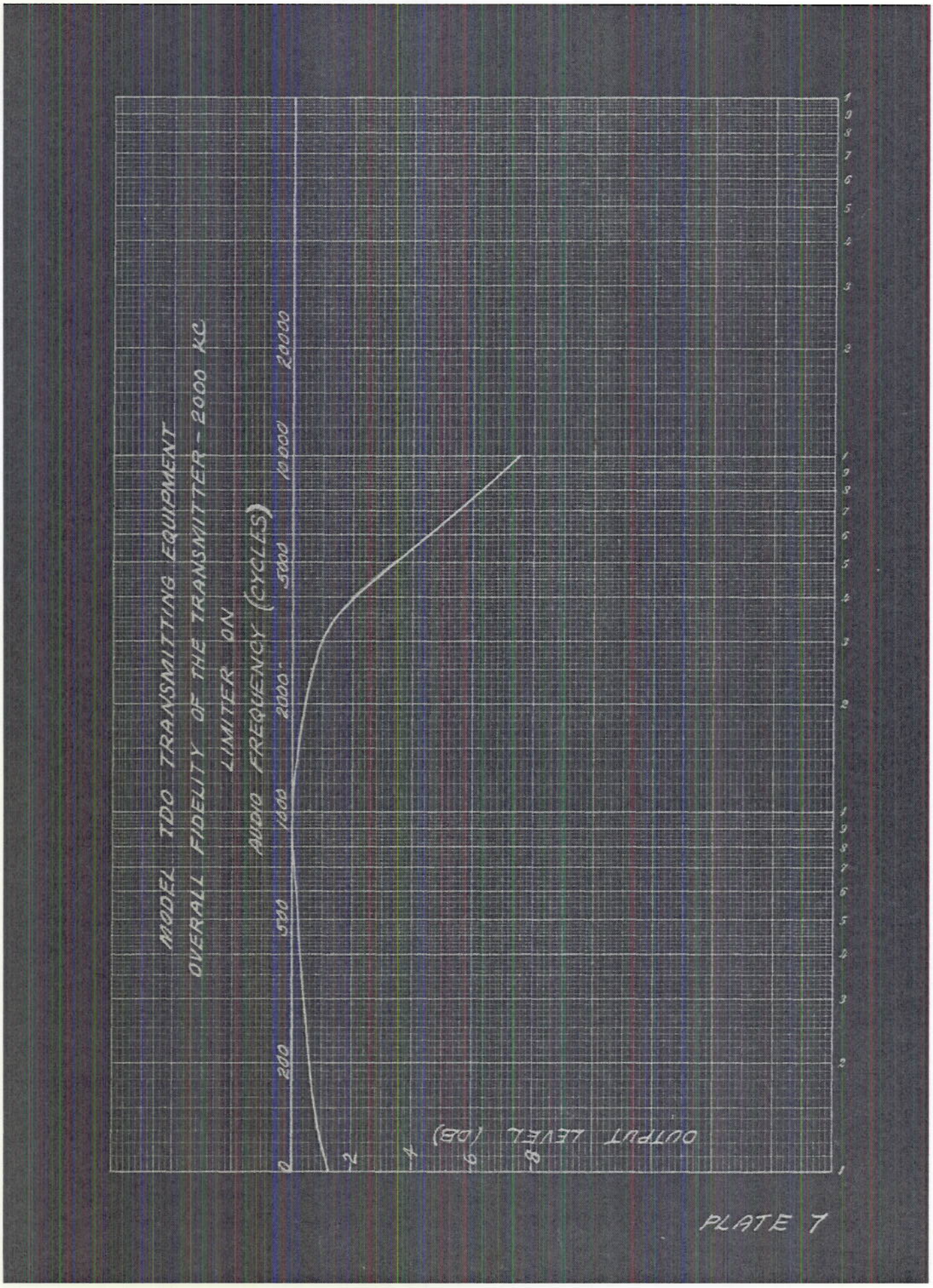

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PLATE 8

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PLATE 9

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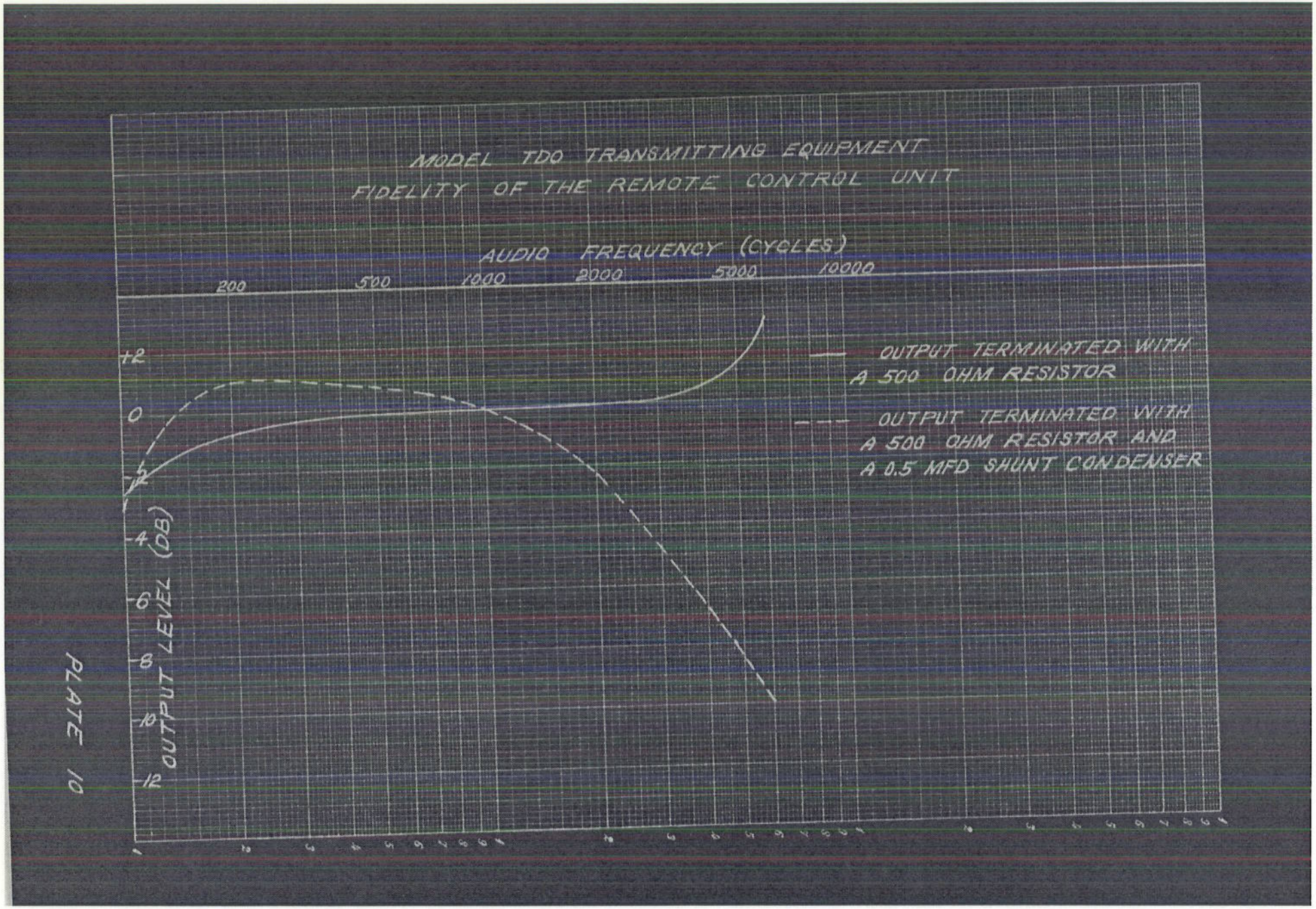
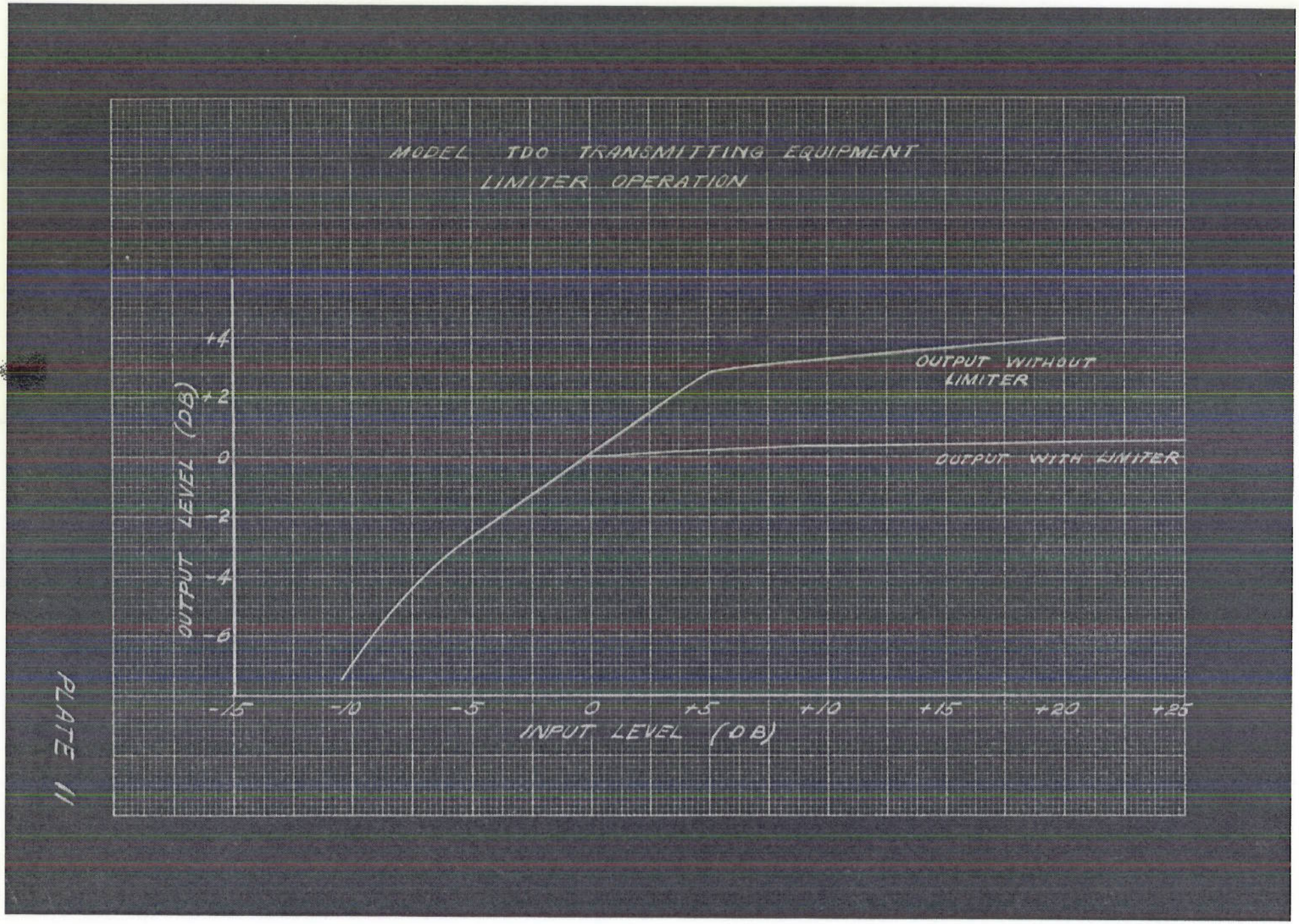
PLATE 10





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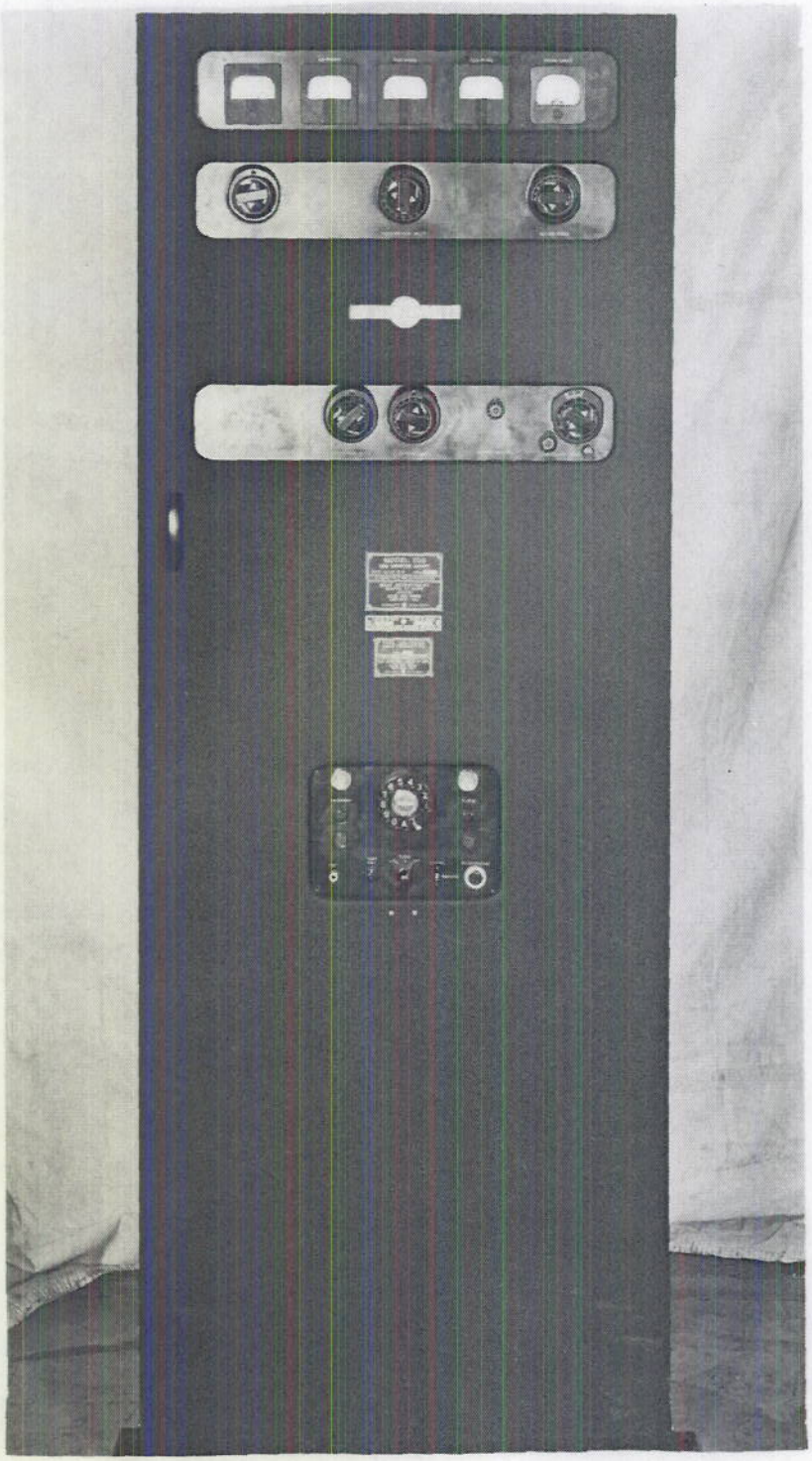

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PLATE 12

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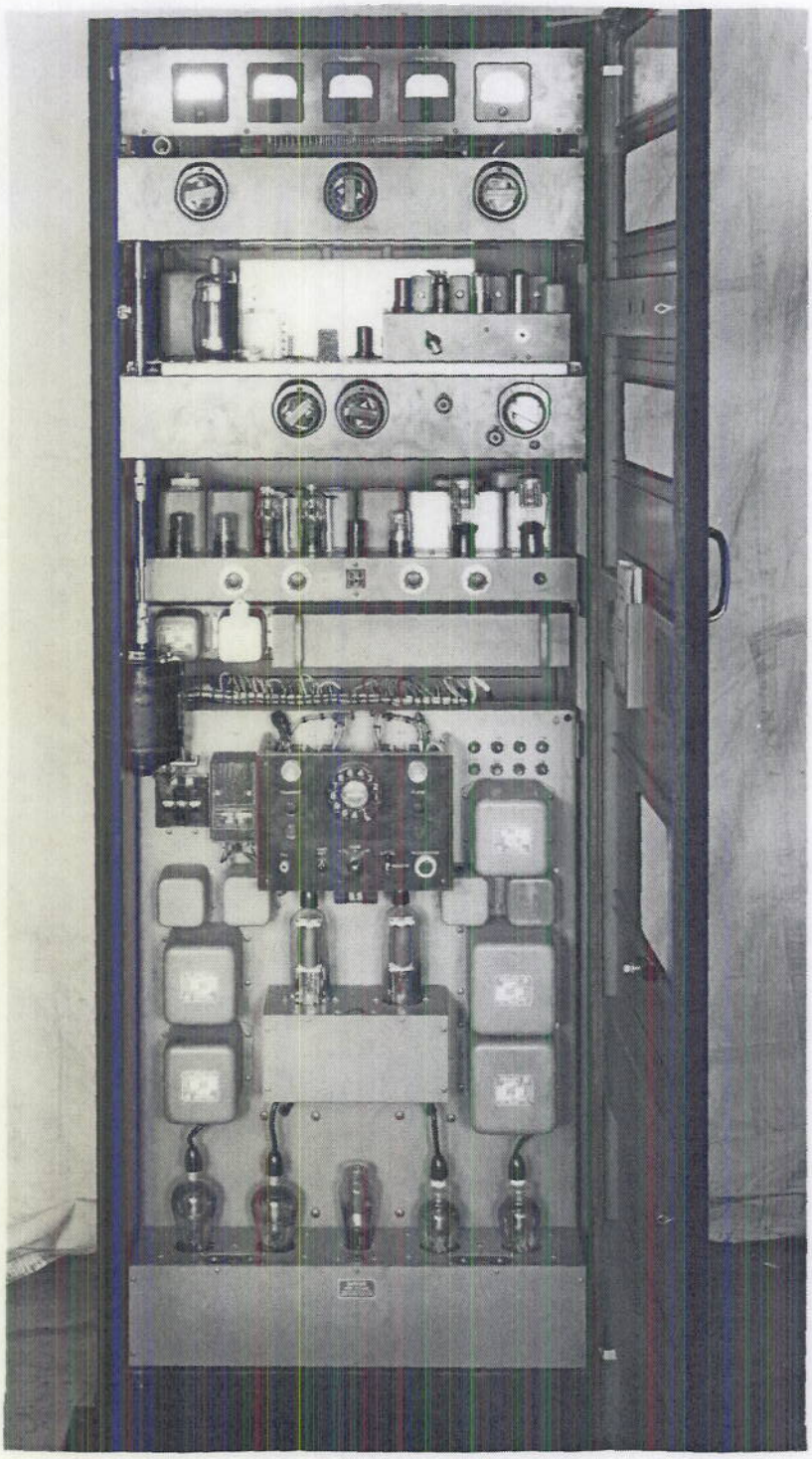

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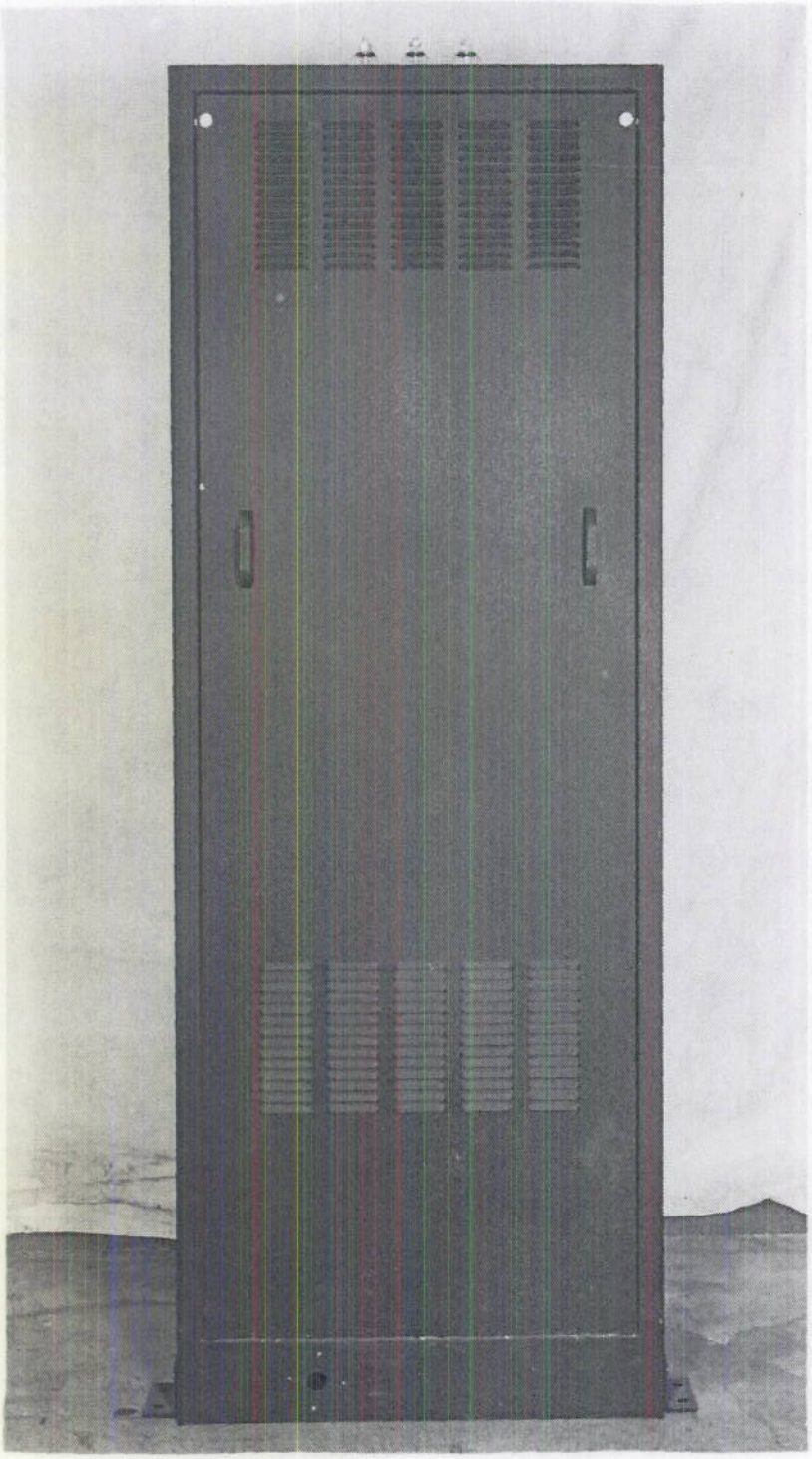

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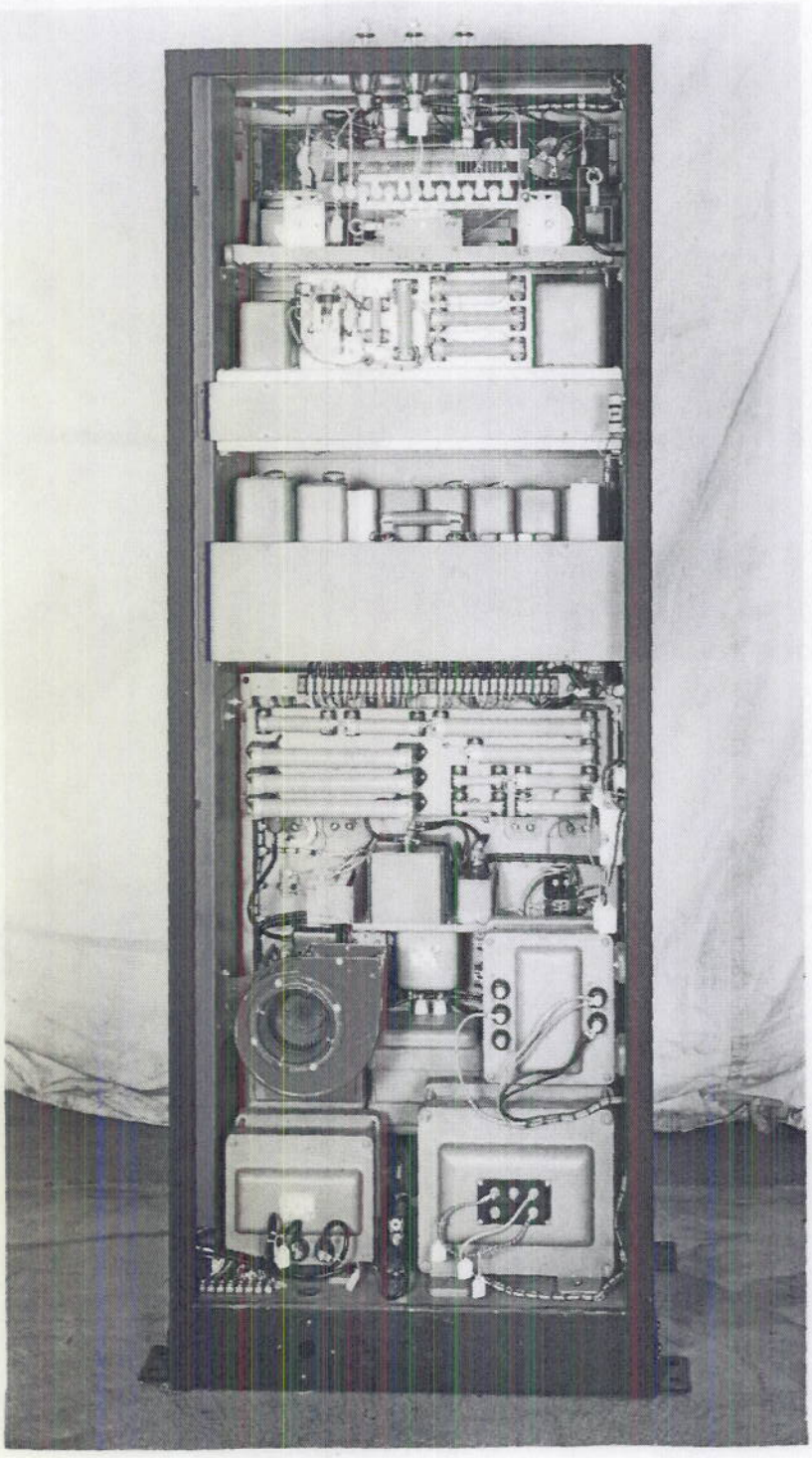

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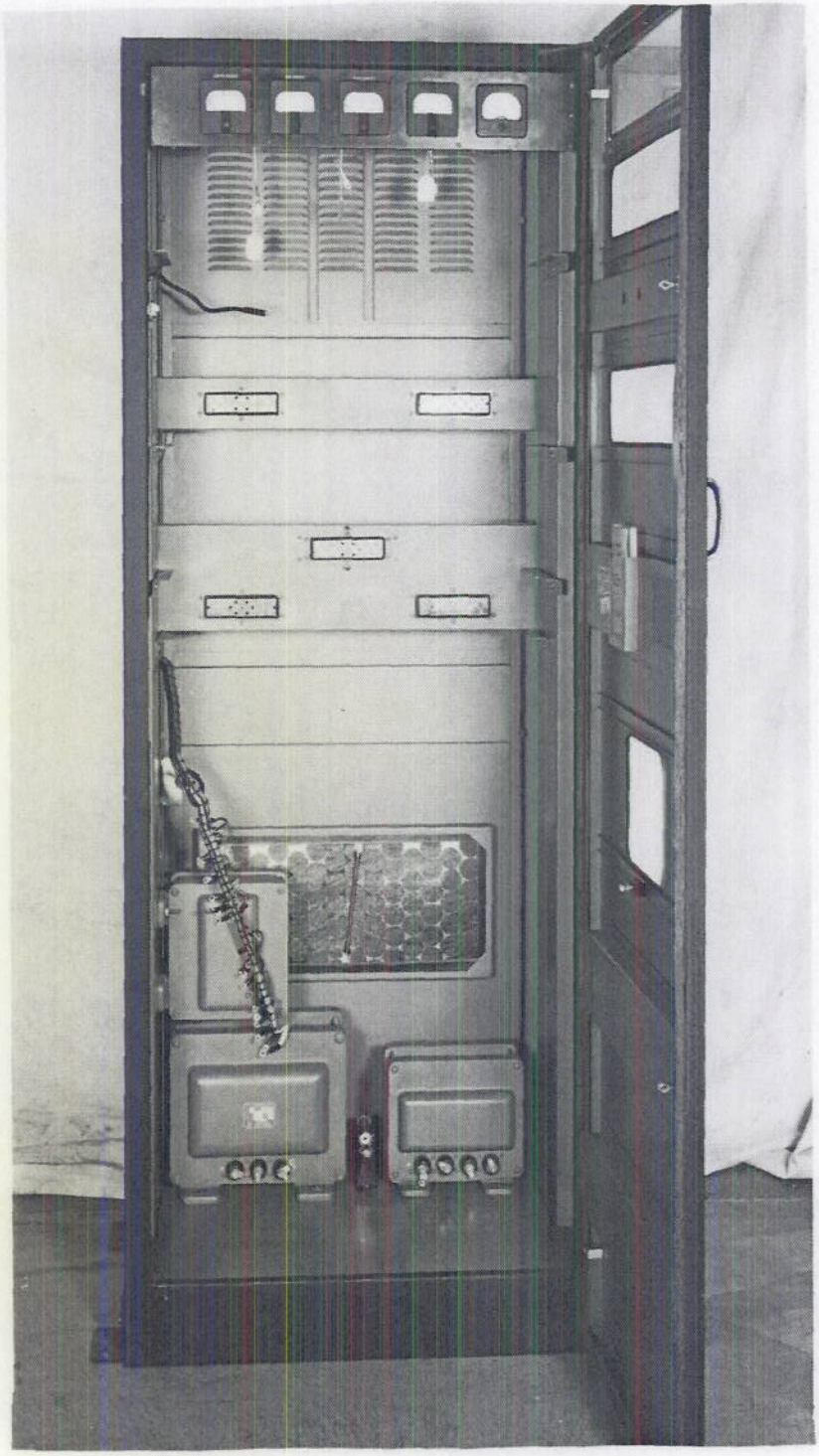

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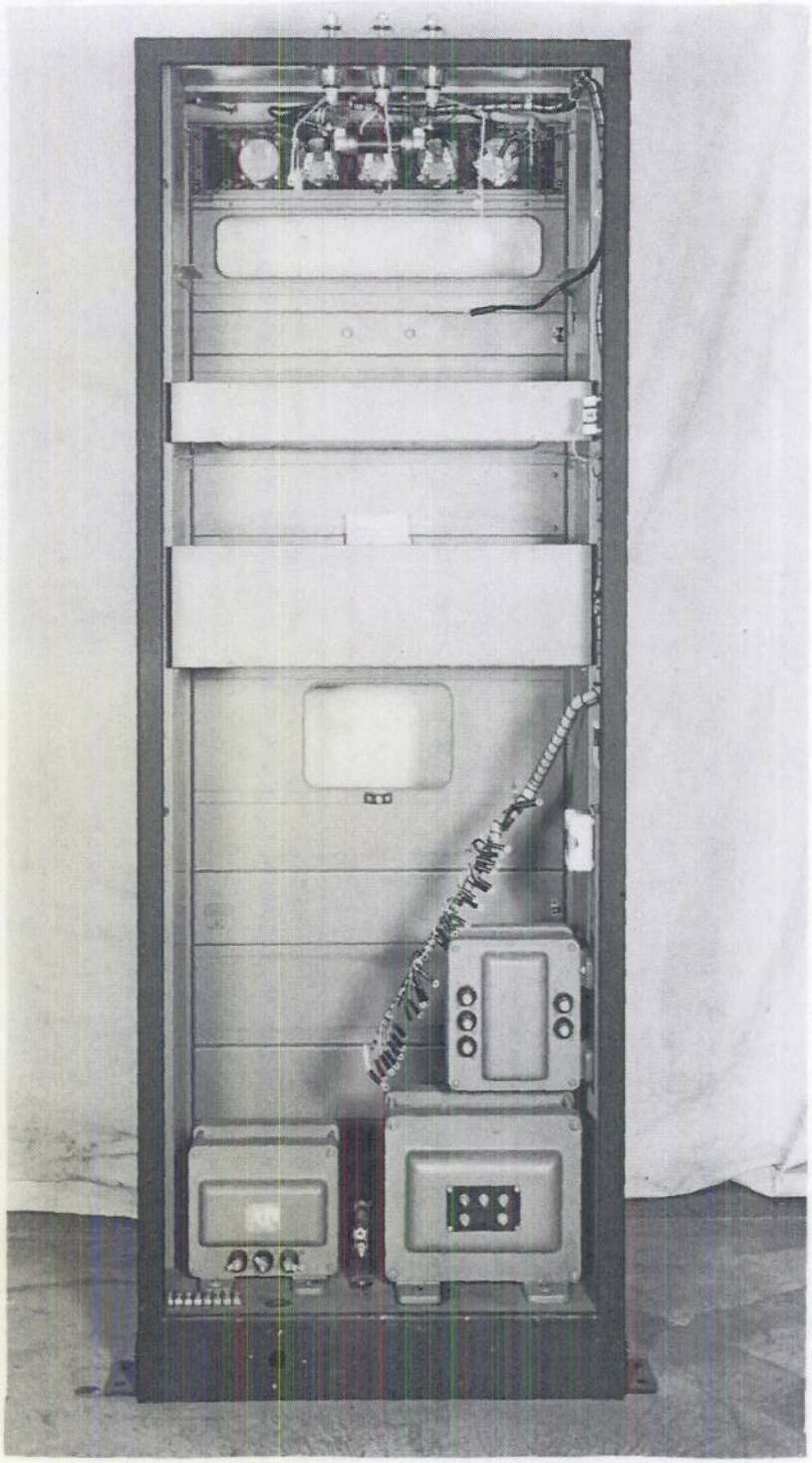

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PLATE 17

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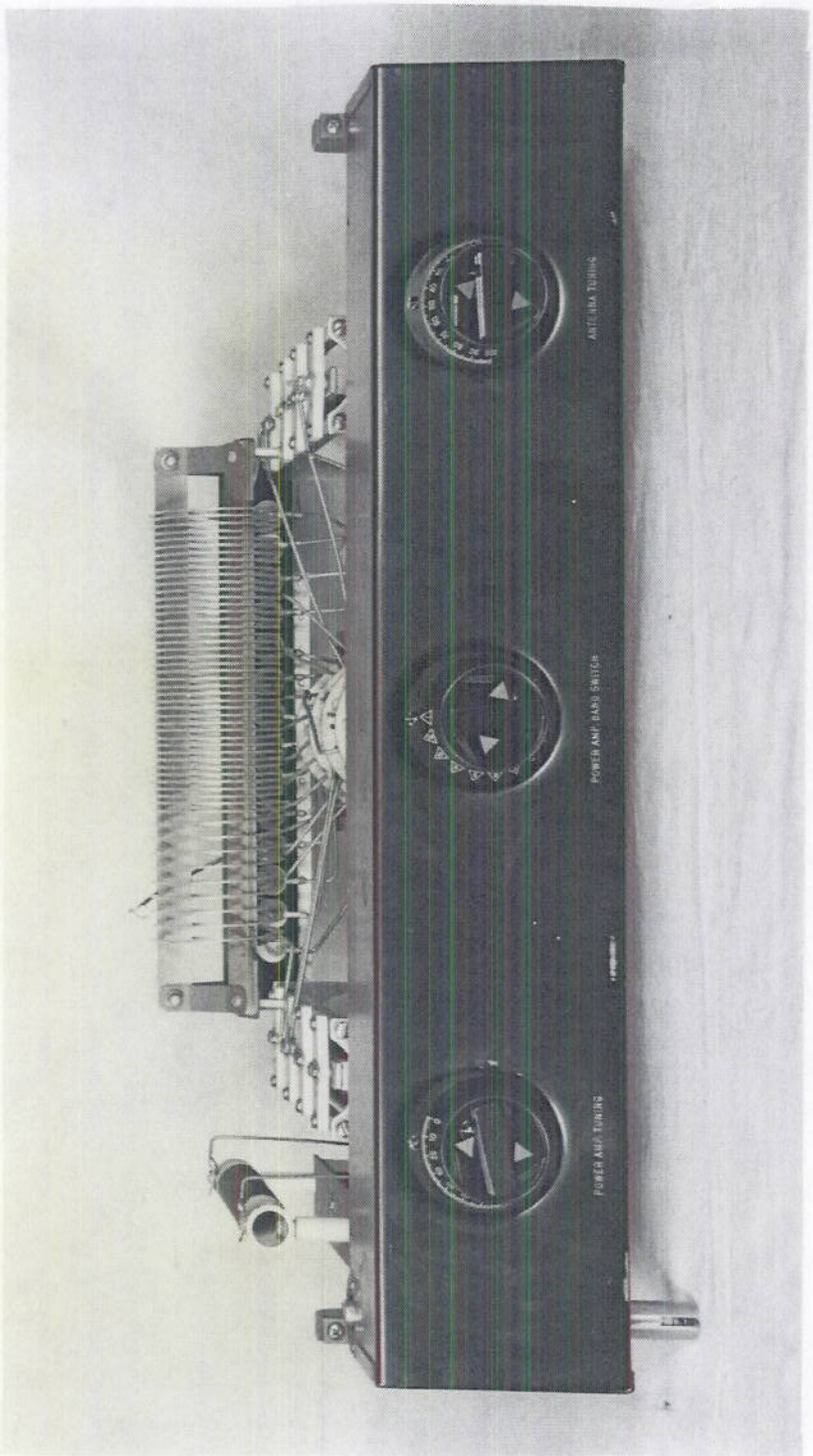

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PLATE 18

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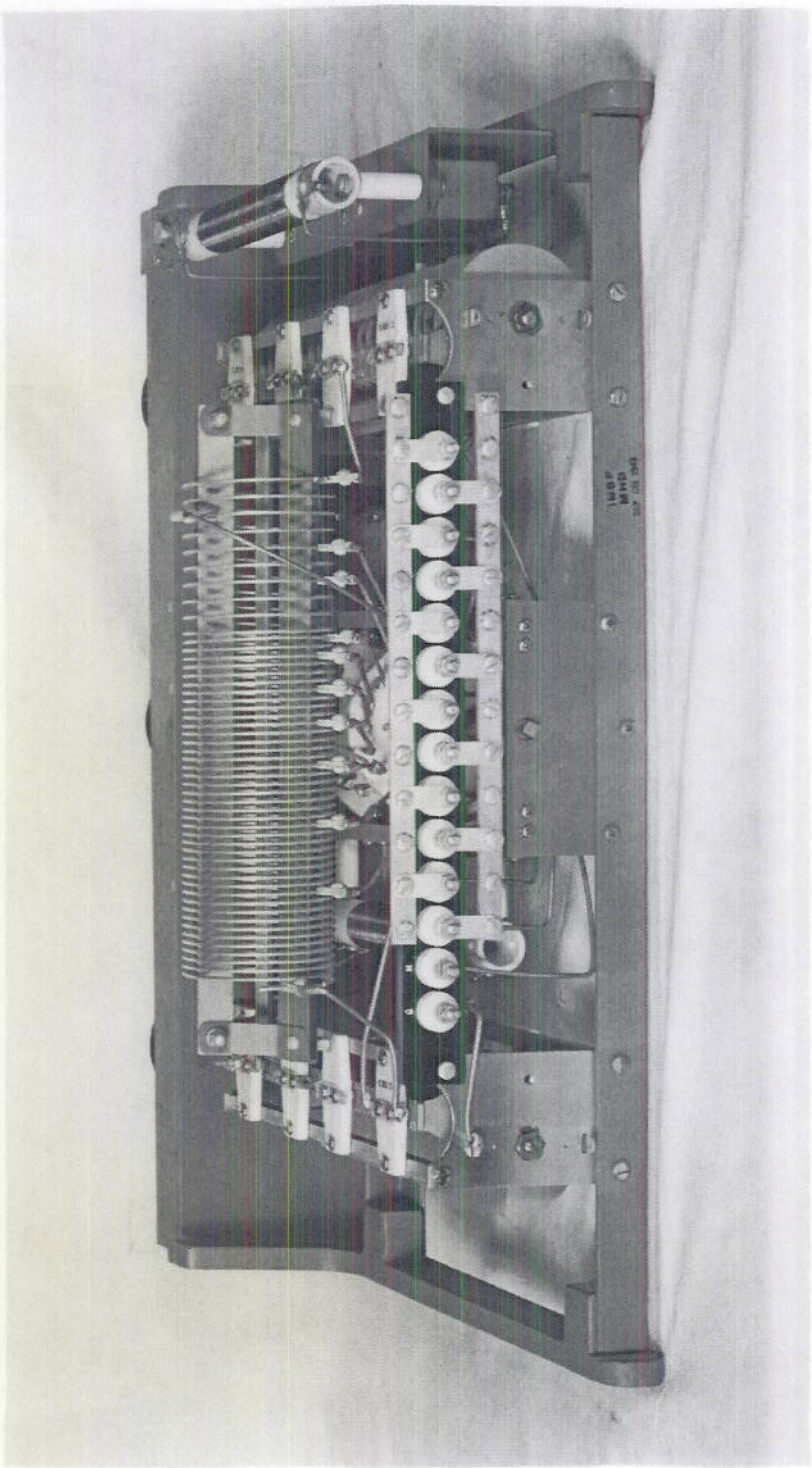

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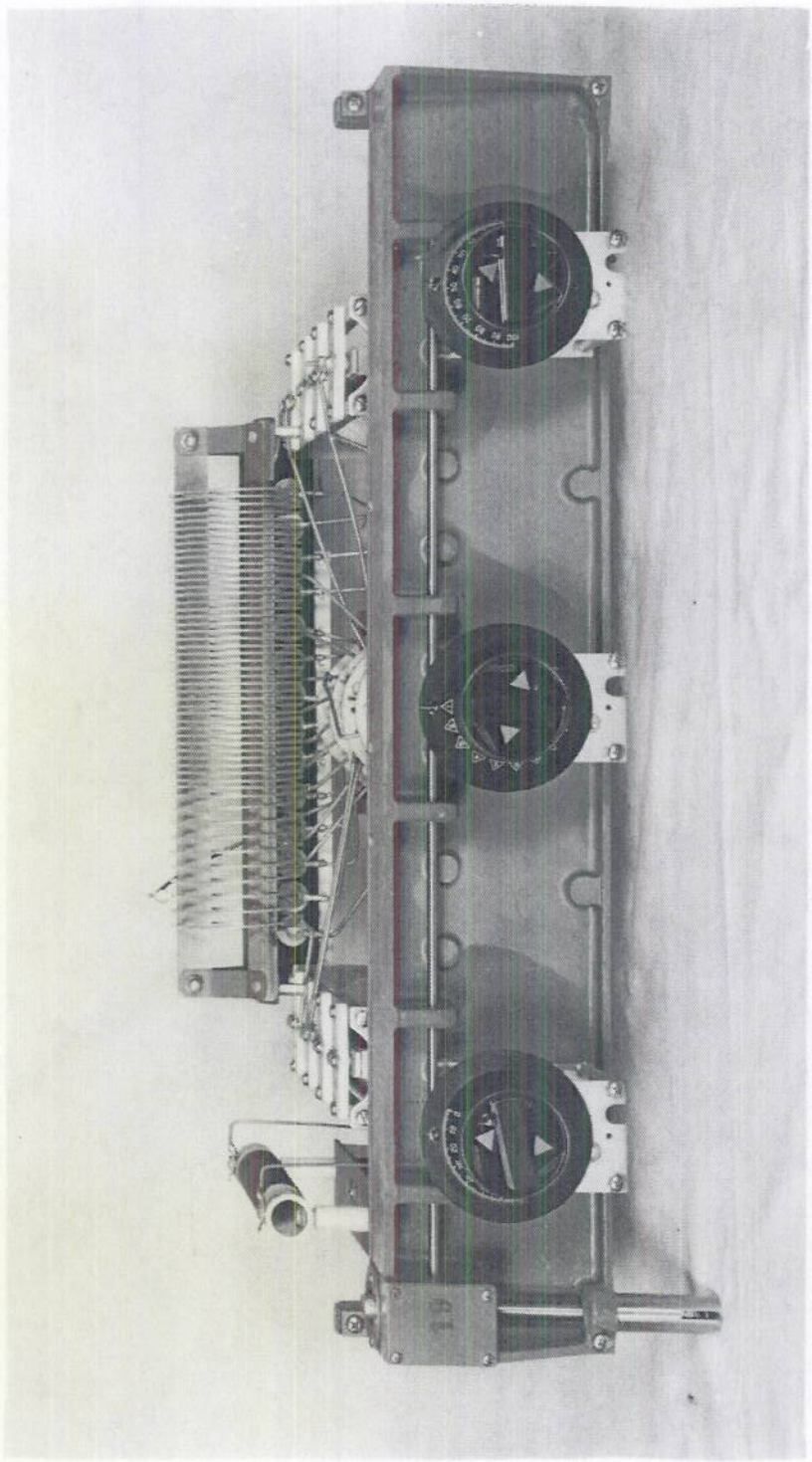

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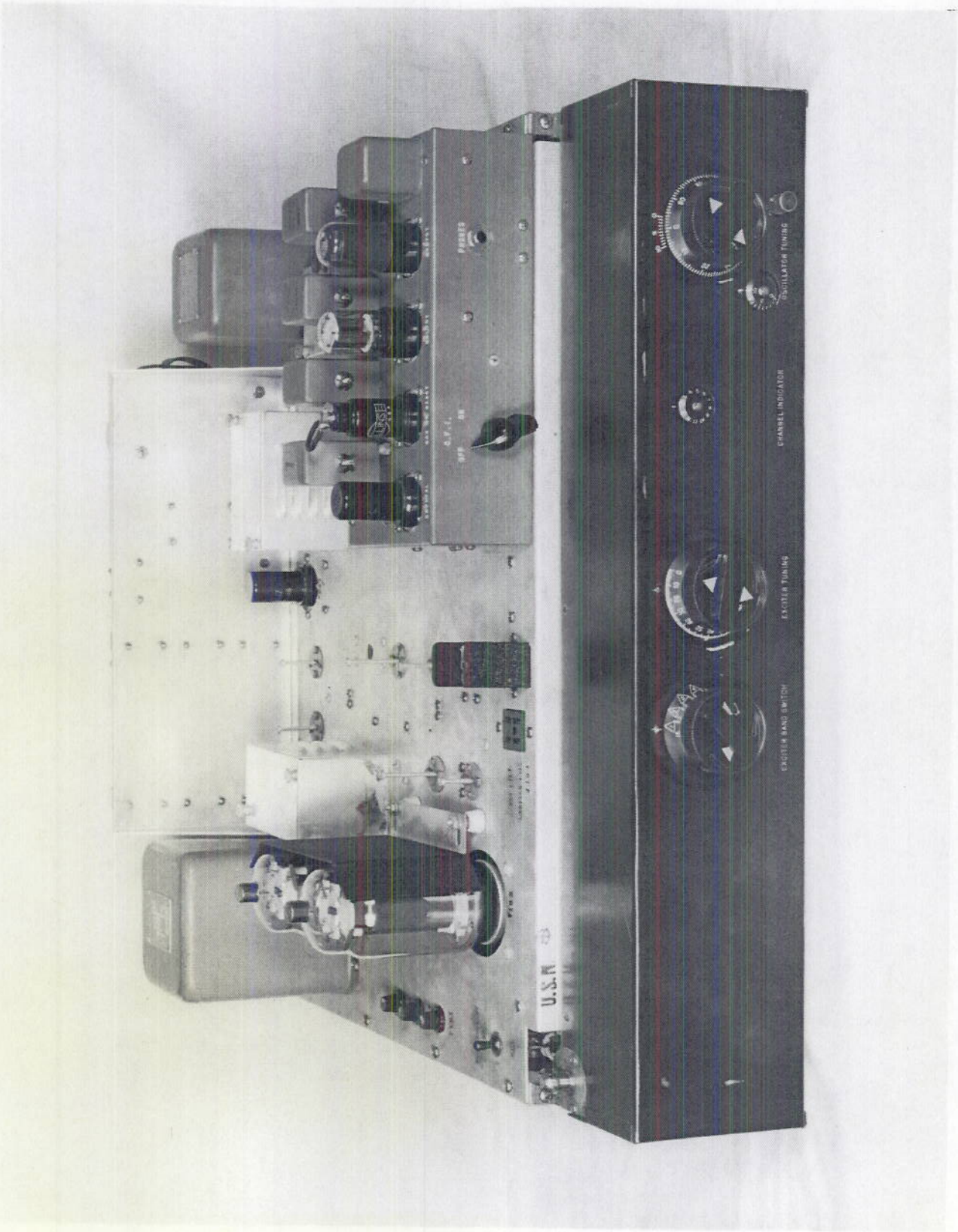

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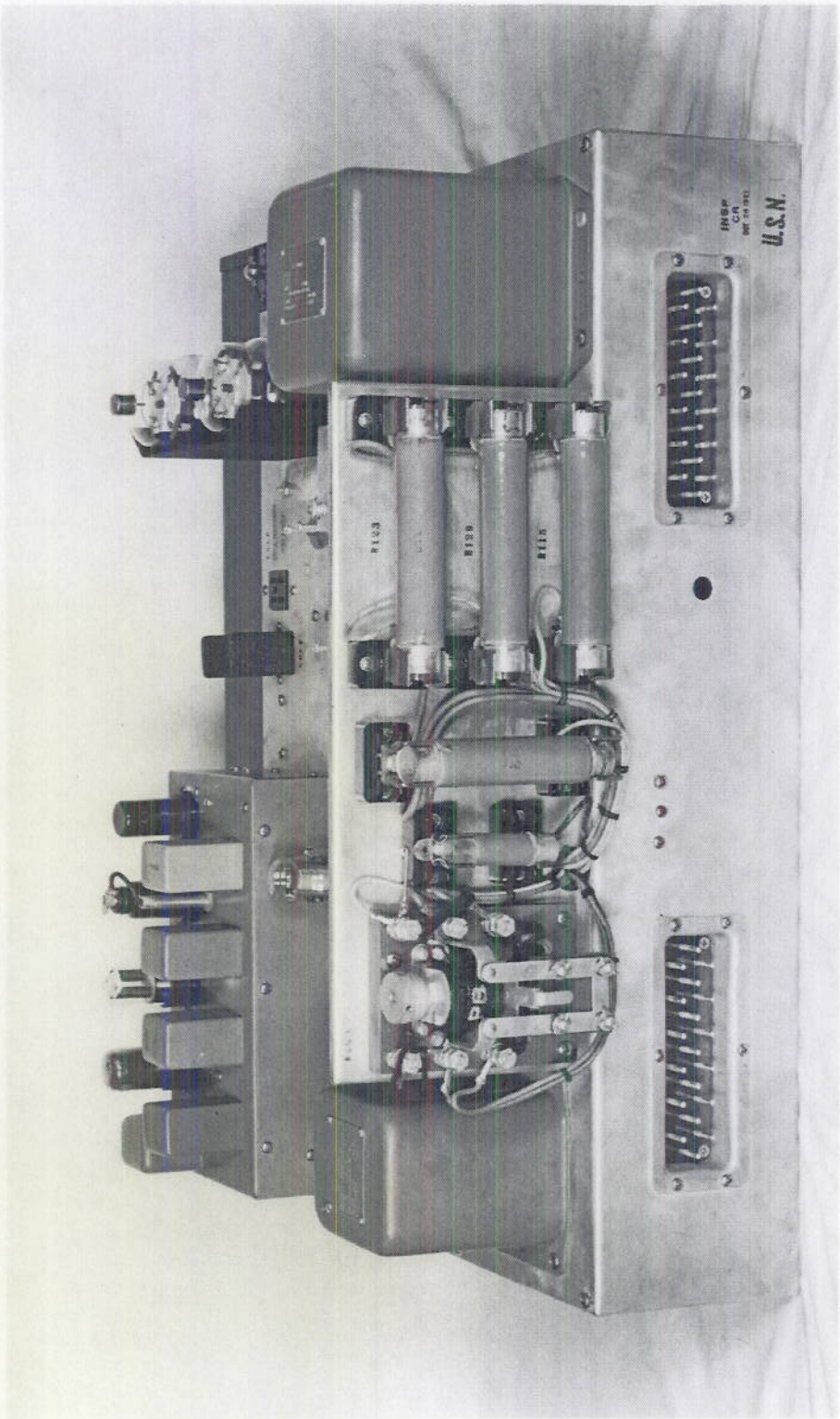

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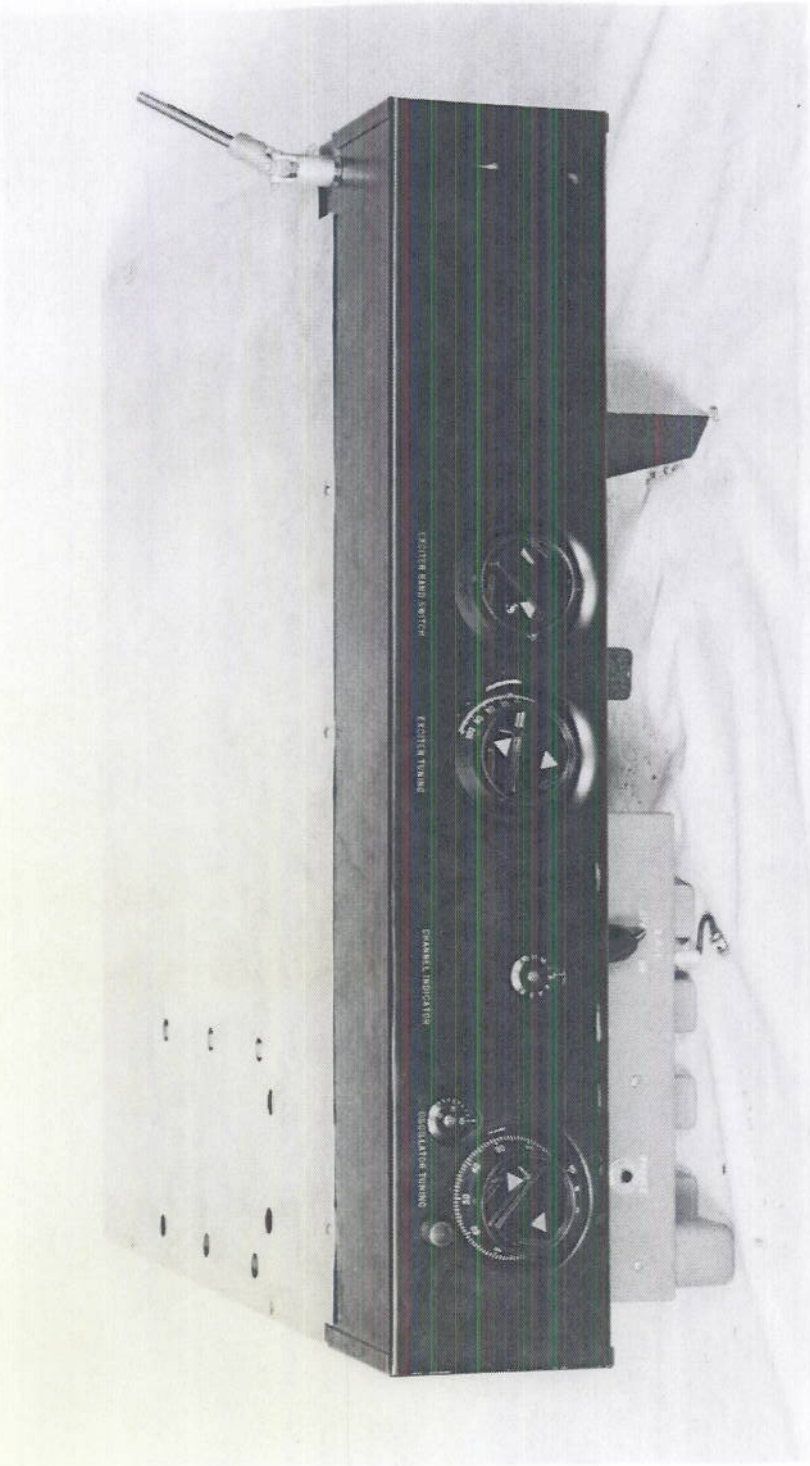

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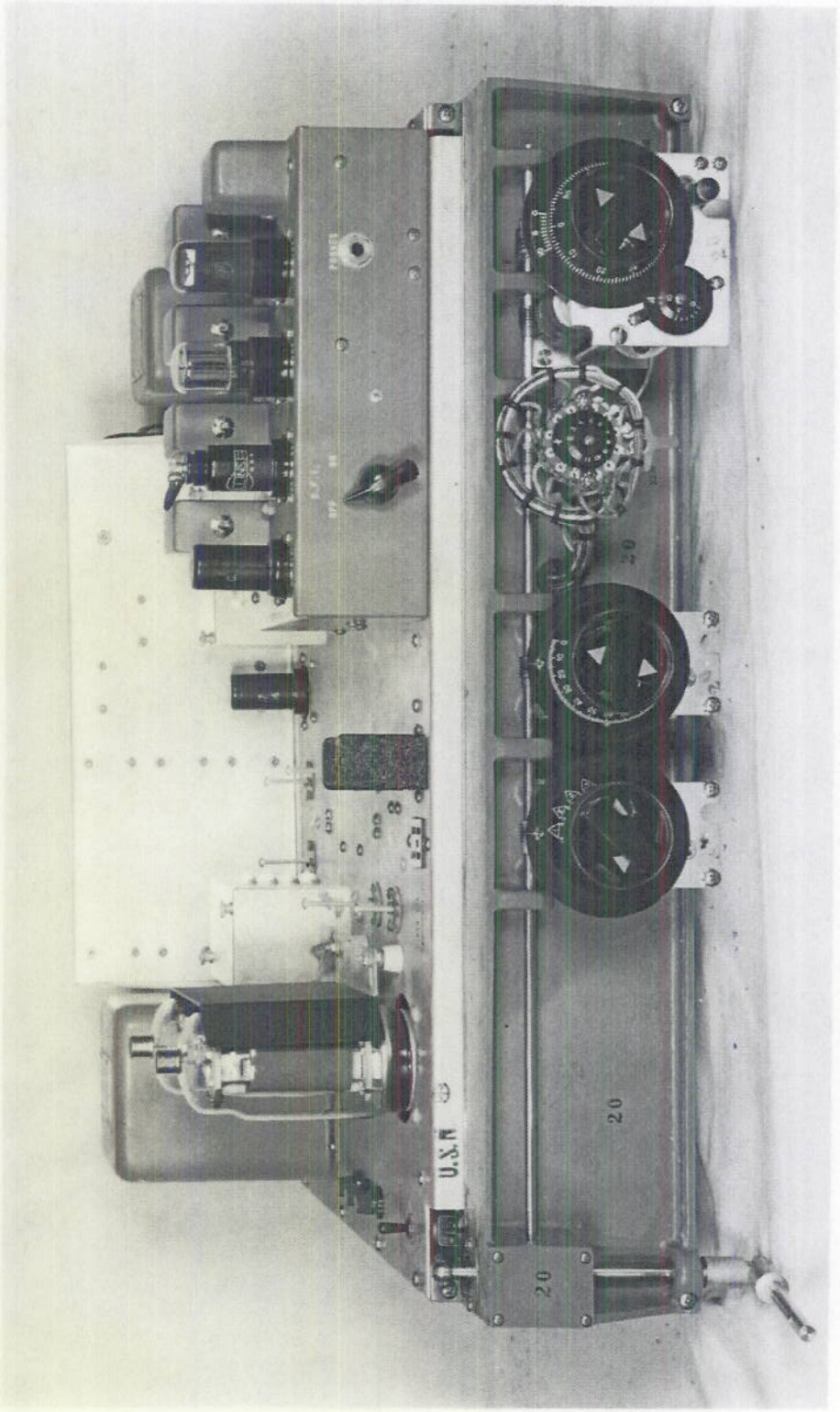

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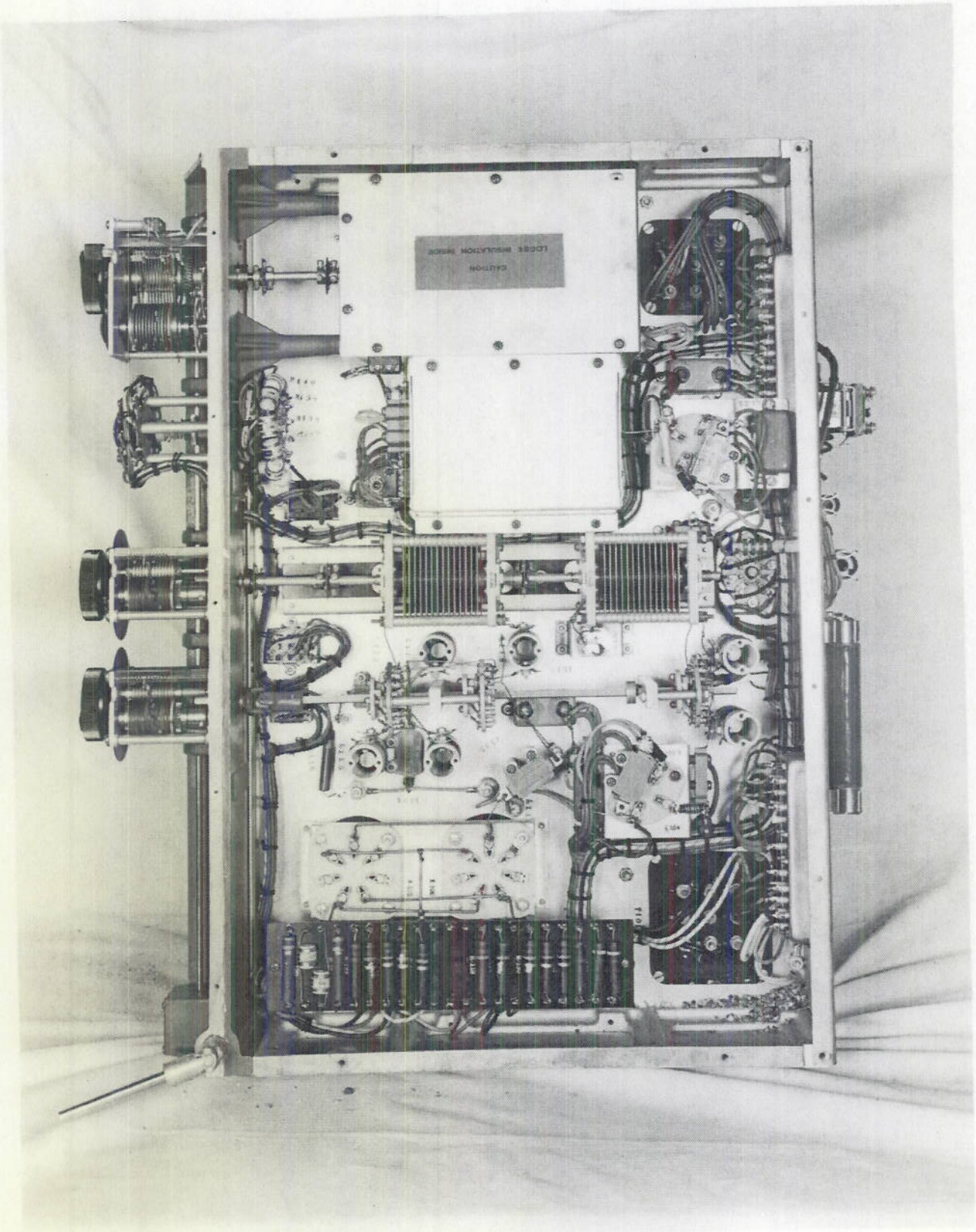

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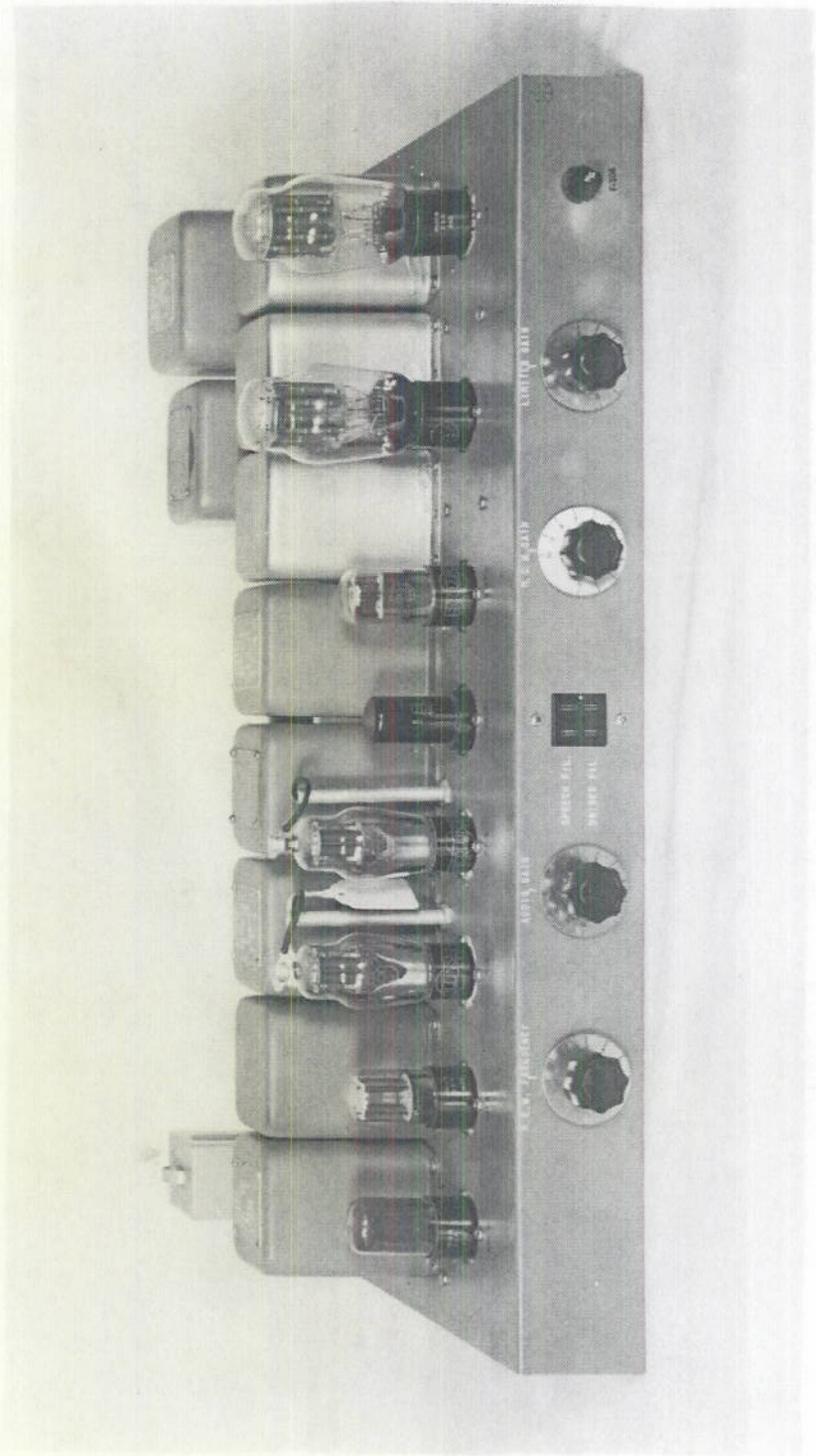

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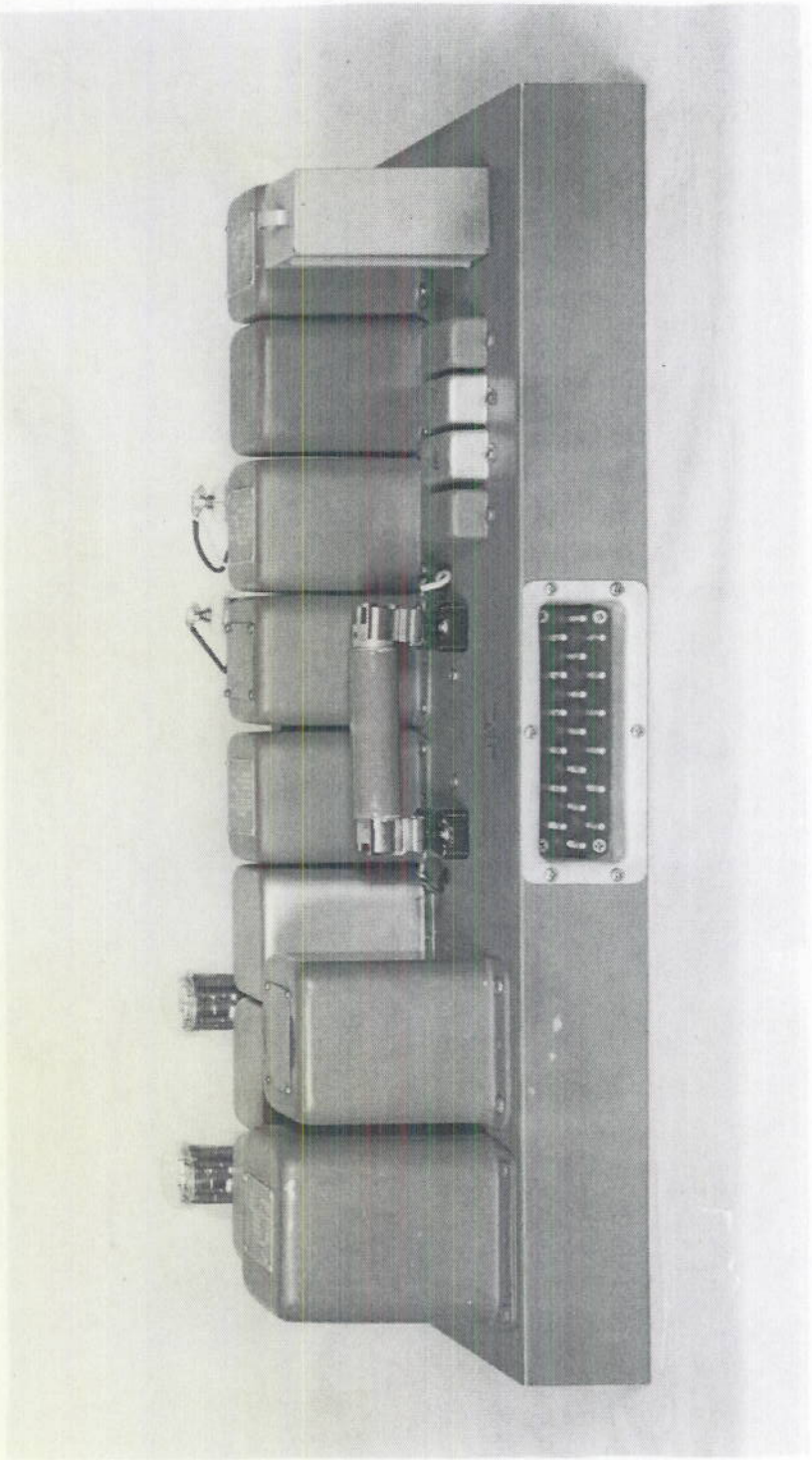

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PLATE 27

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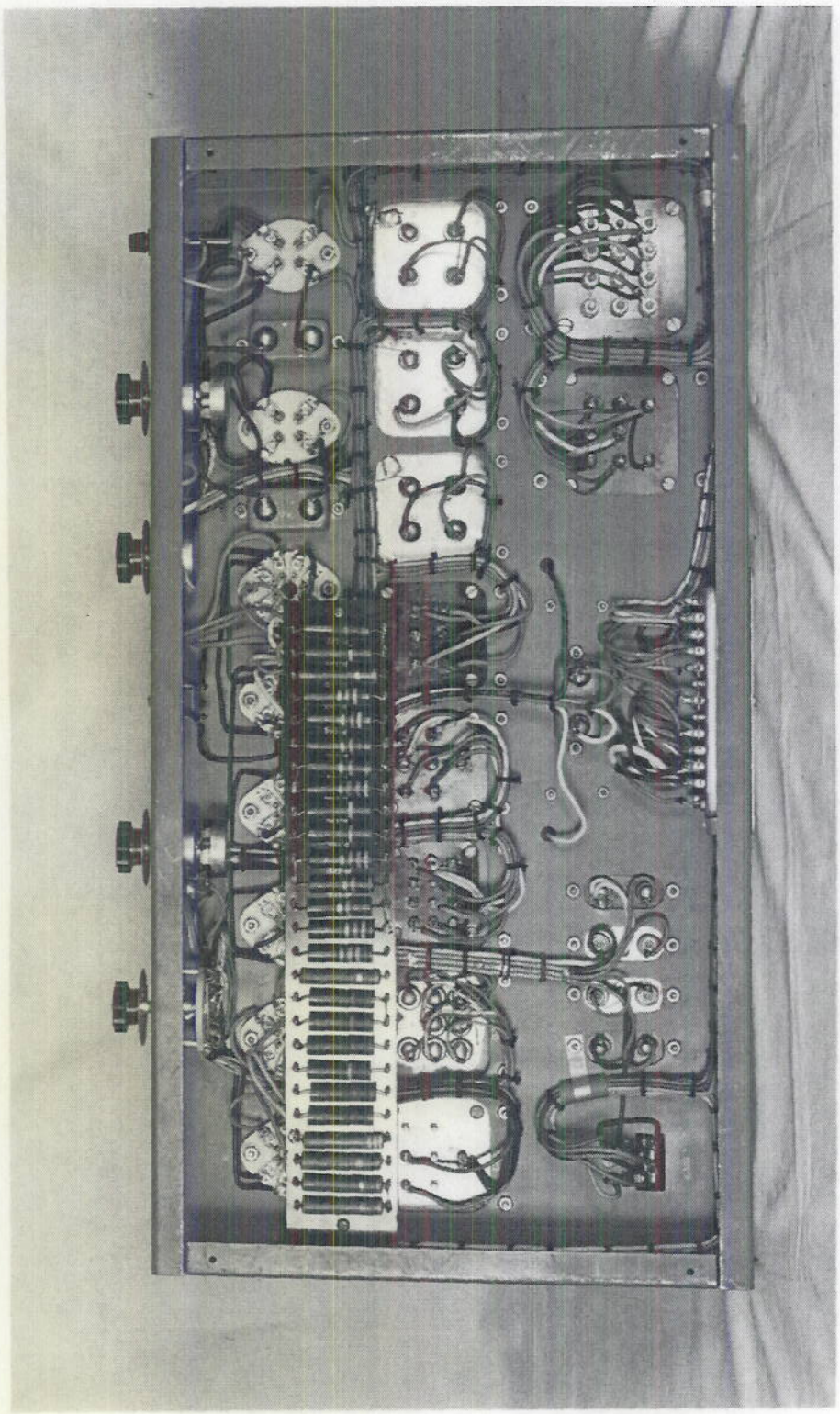

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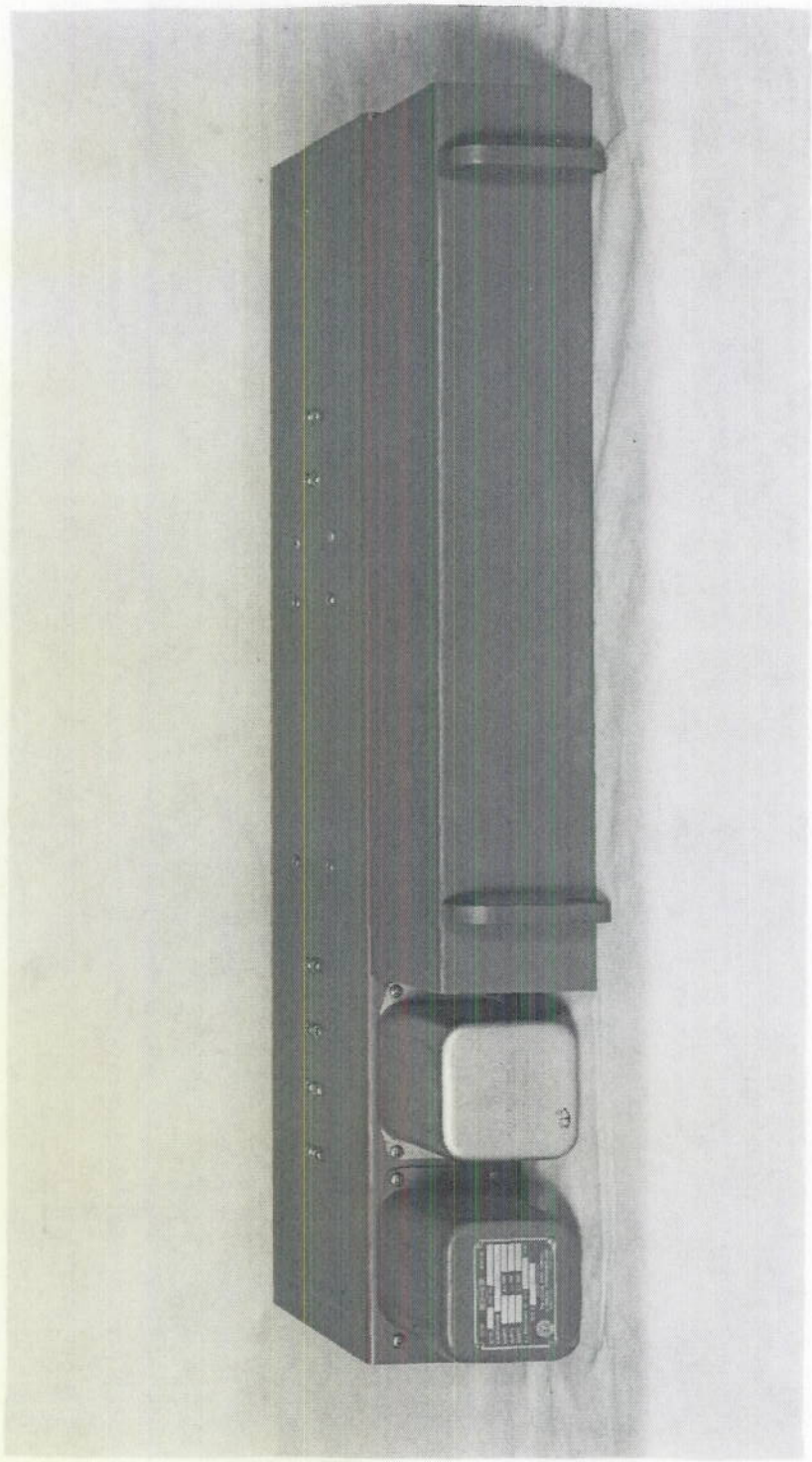

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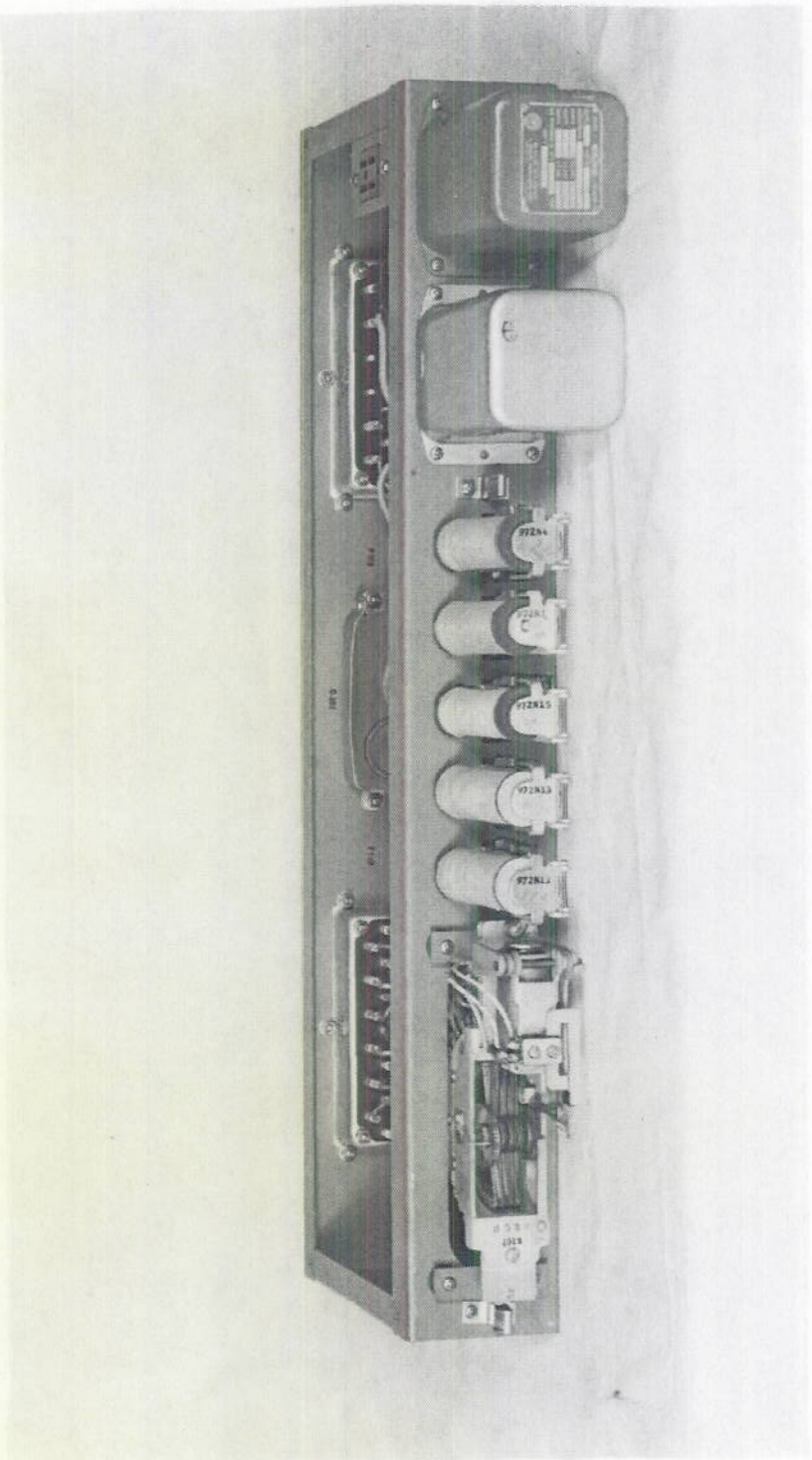

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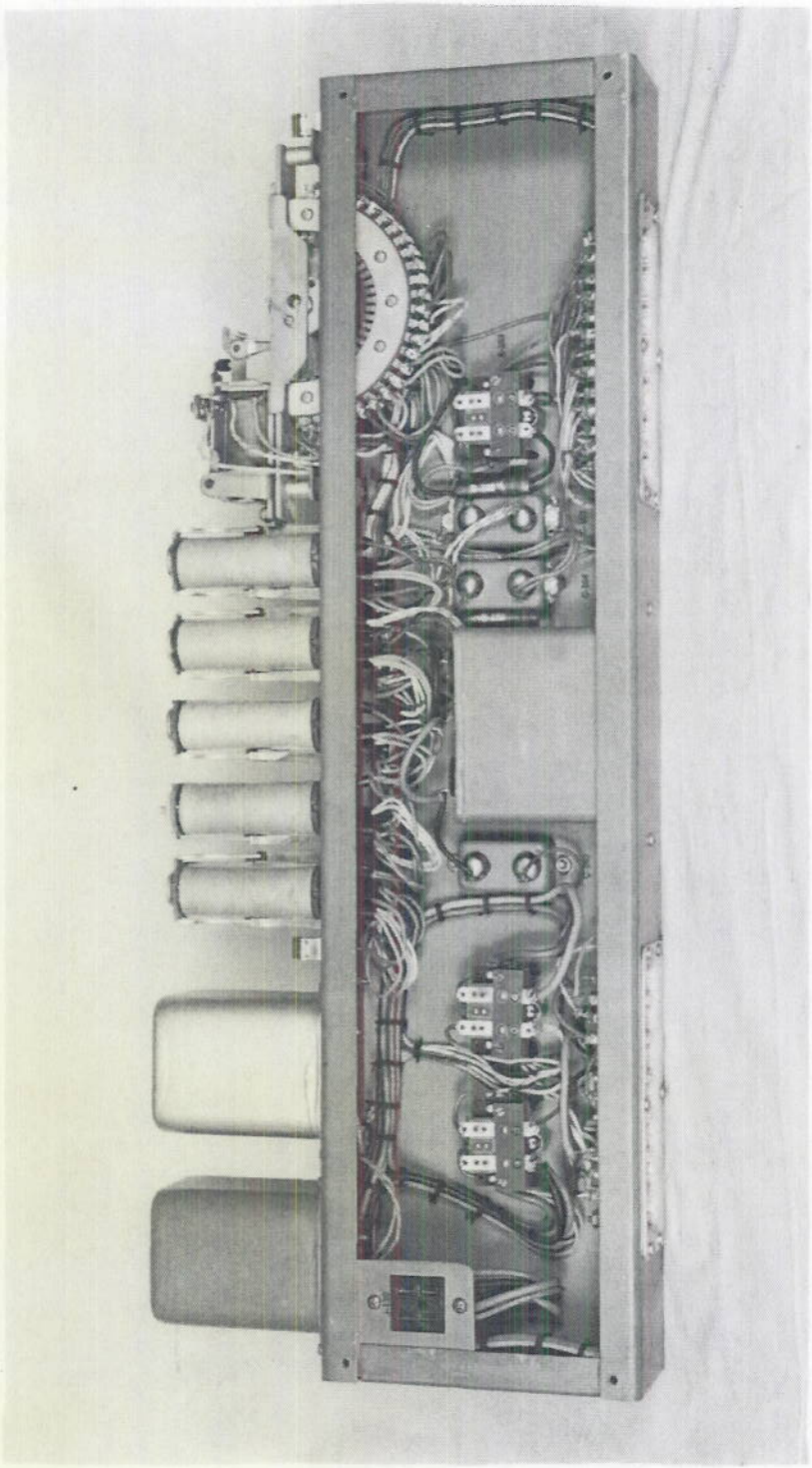

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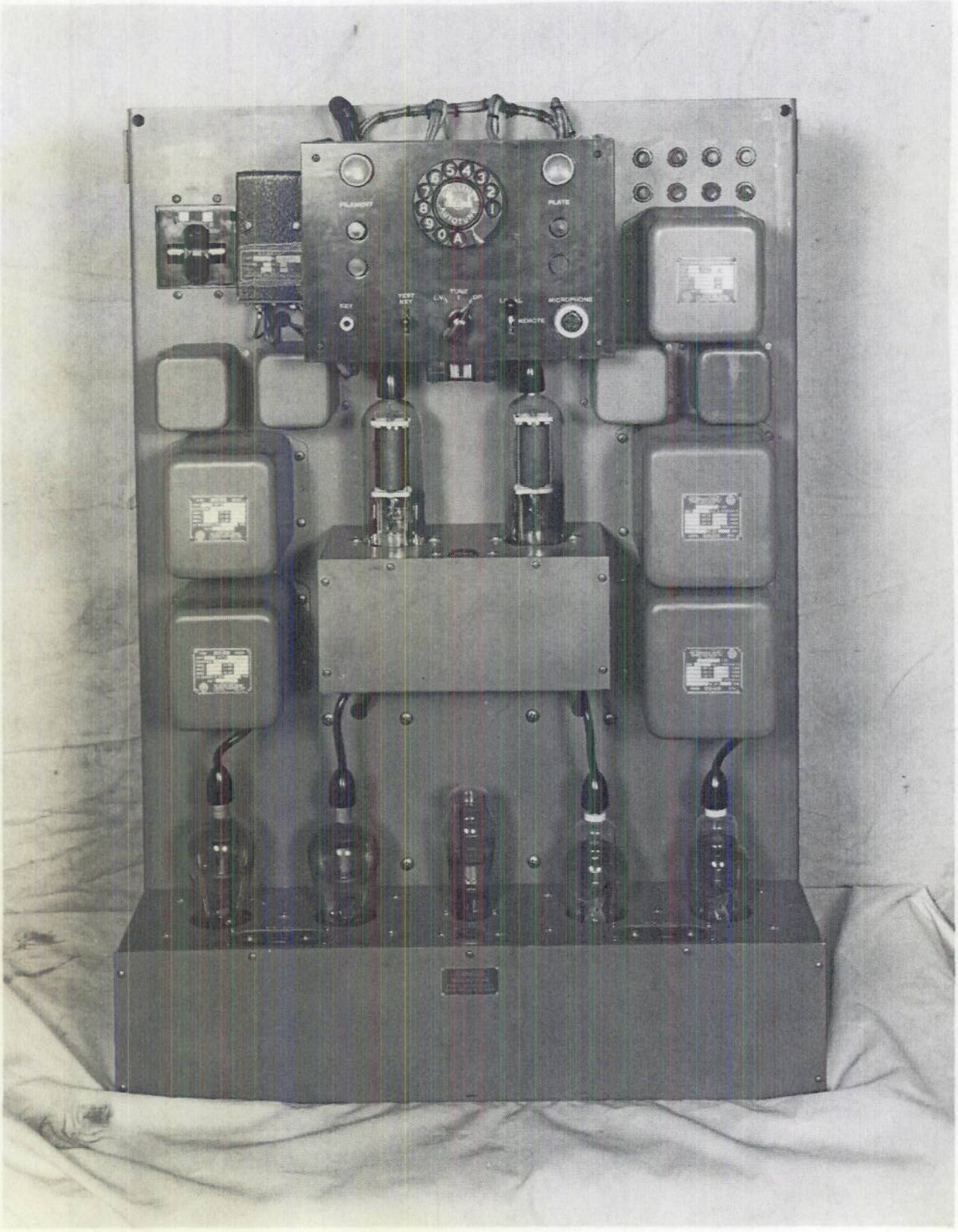

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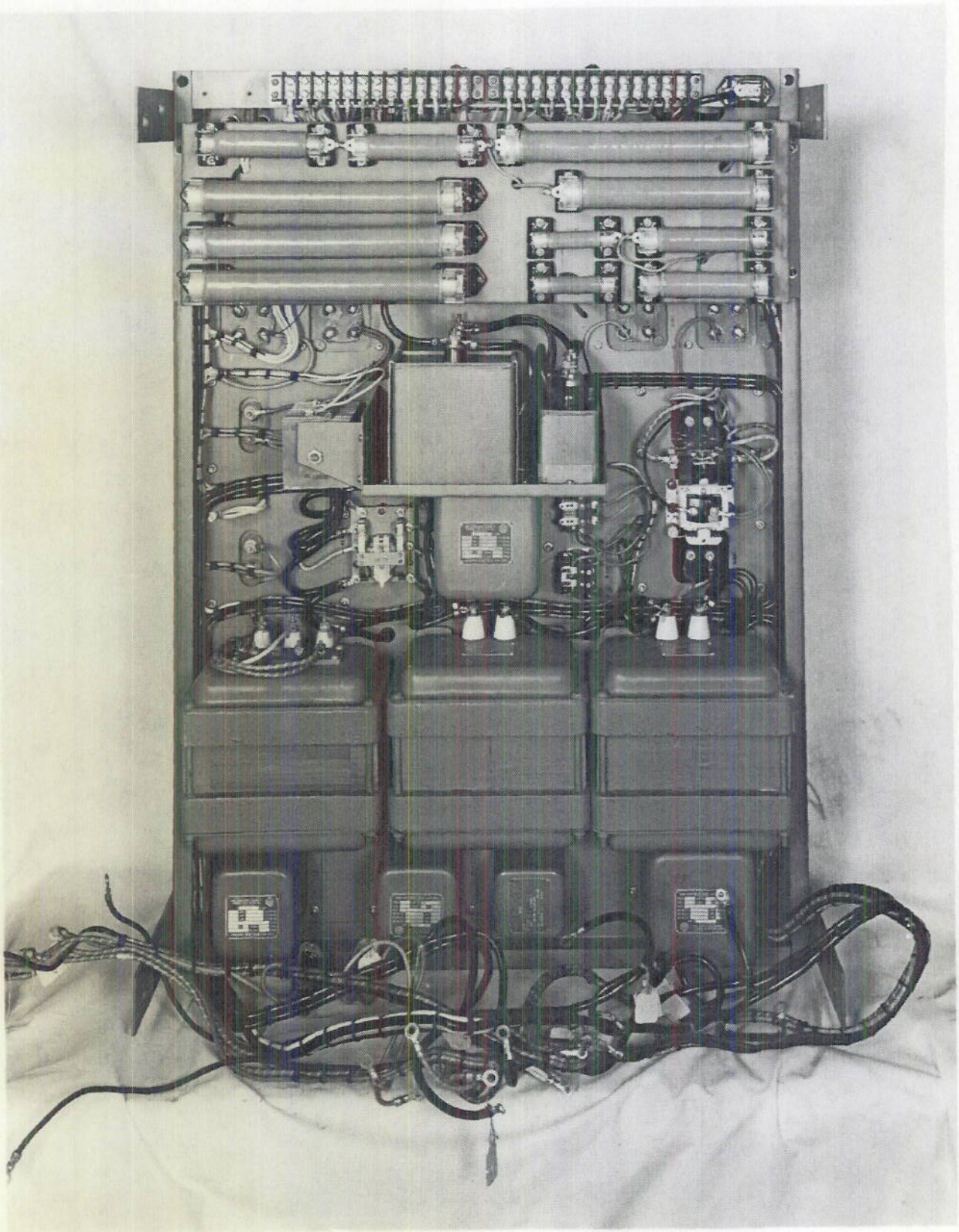

PLATE 33

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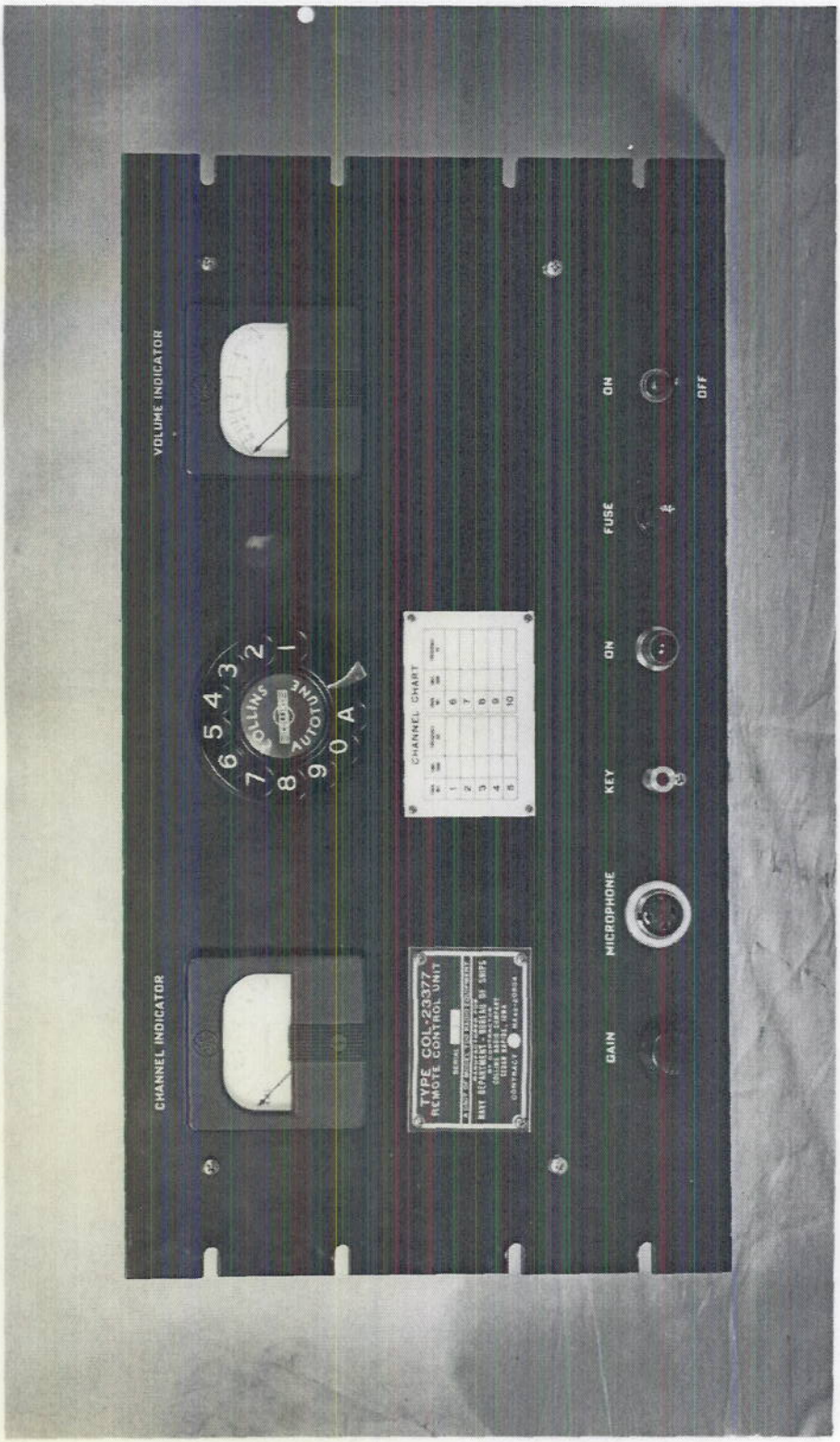

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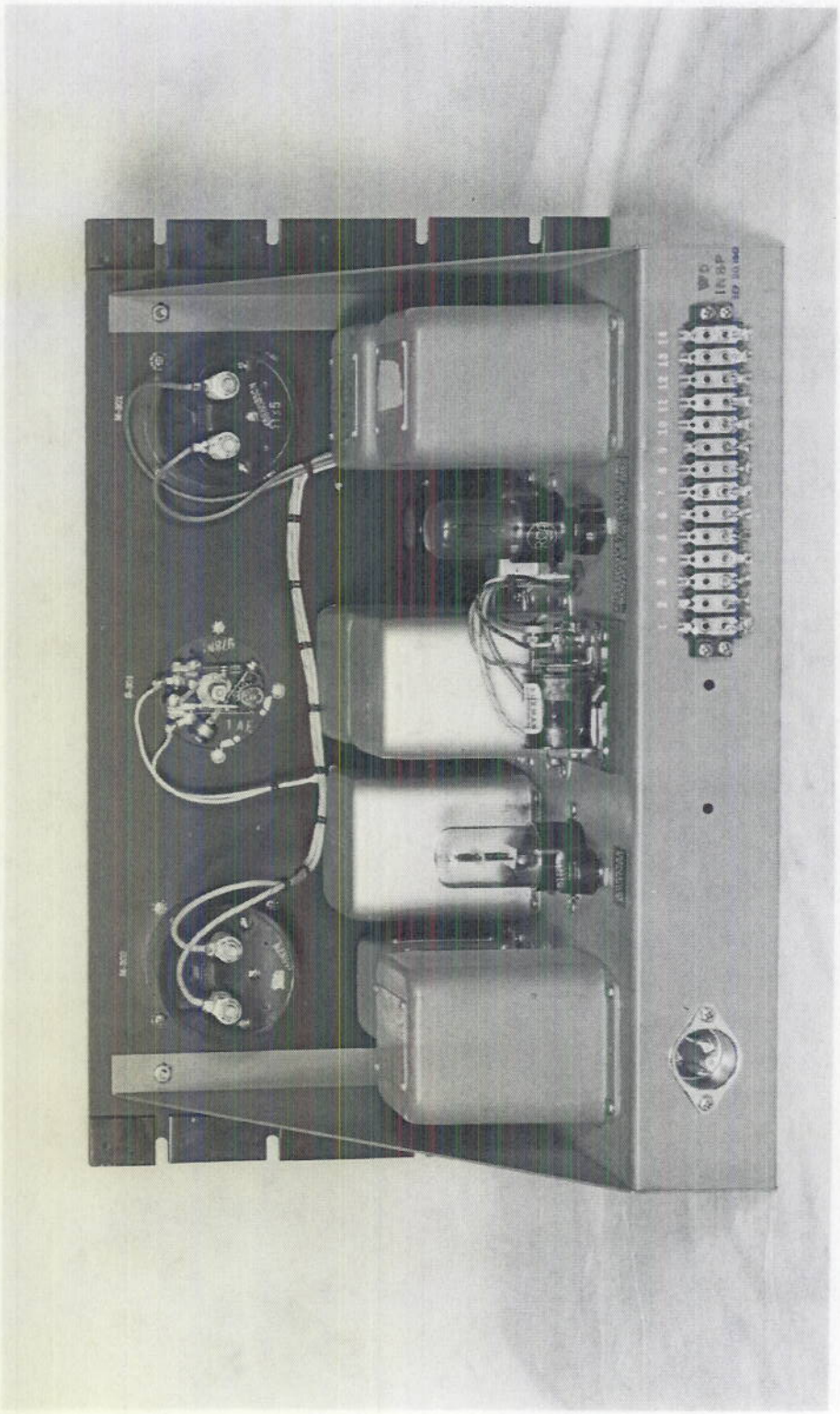

PLATE 35

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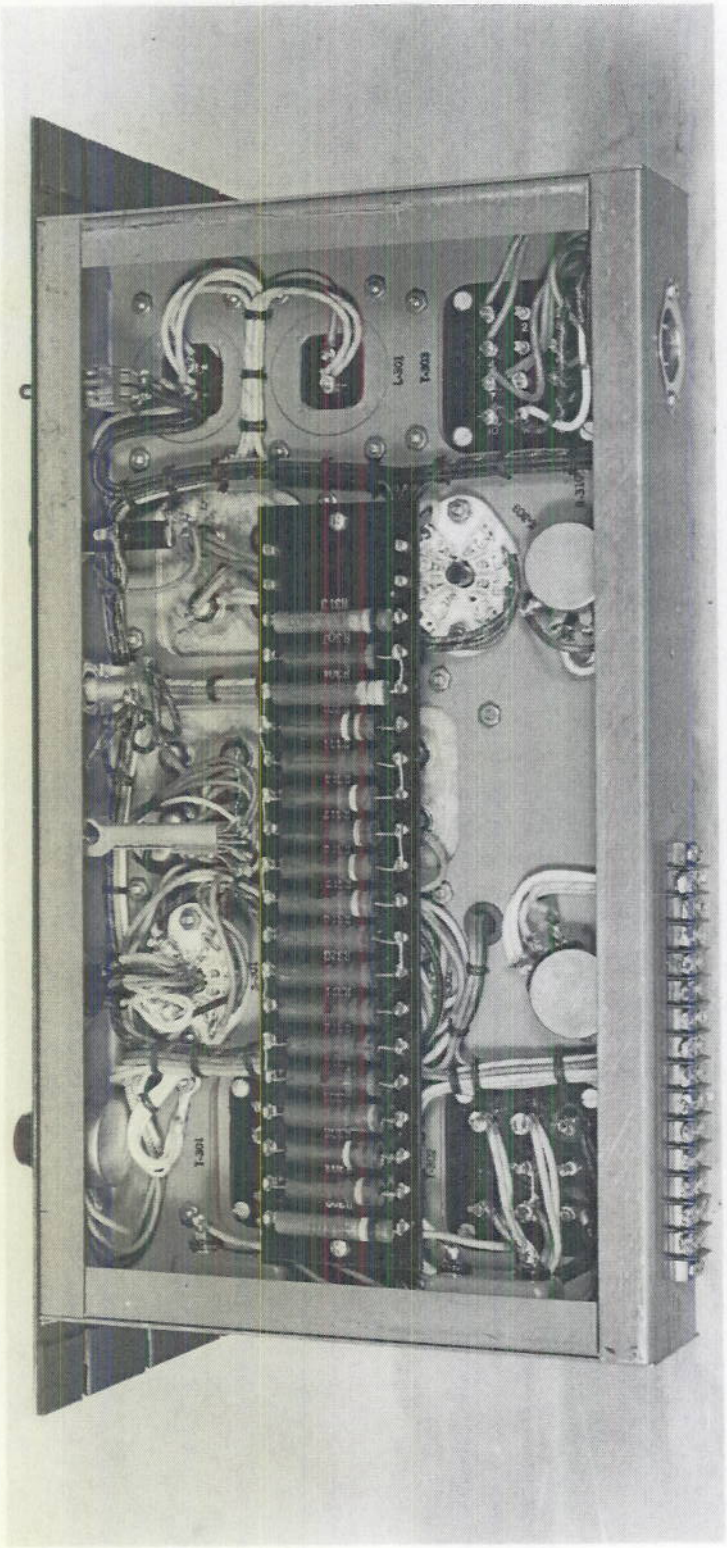

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PLATE 36

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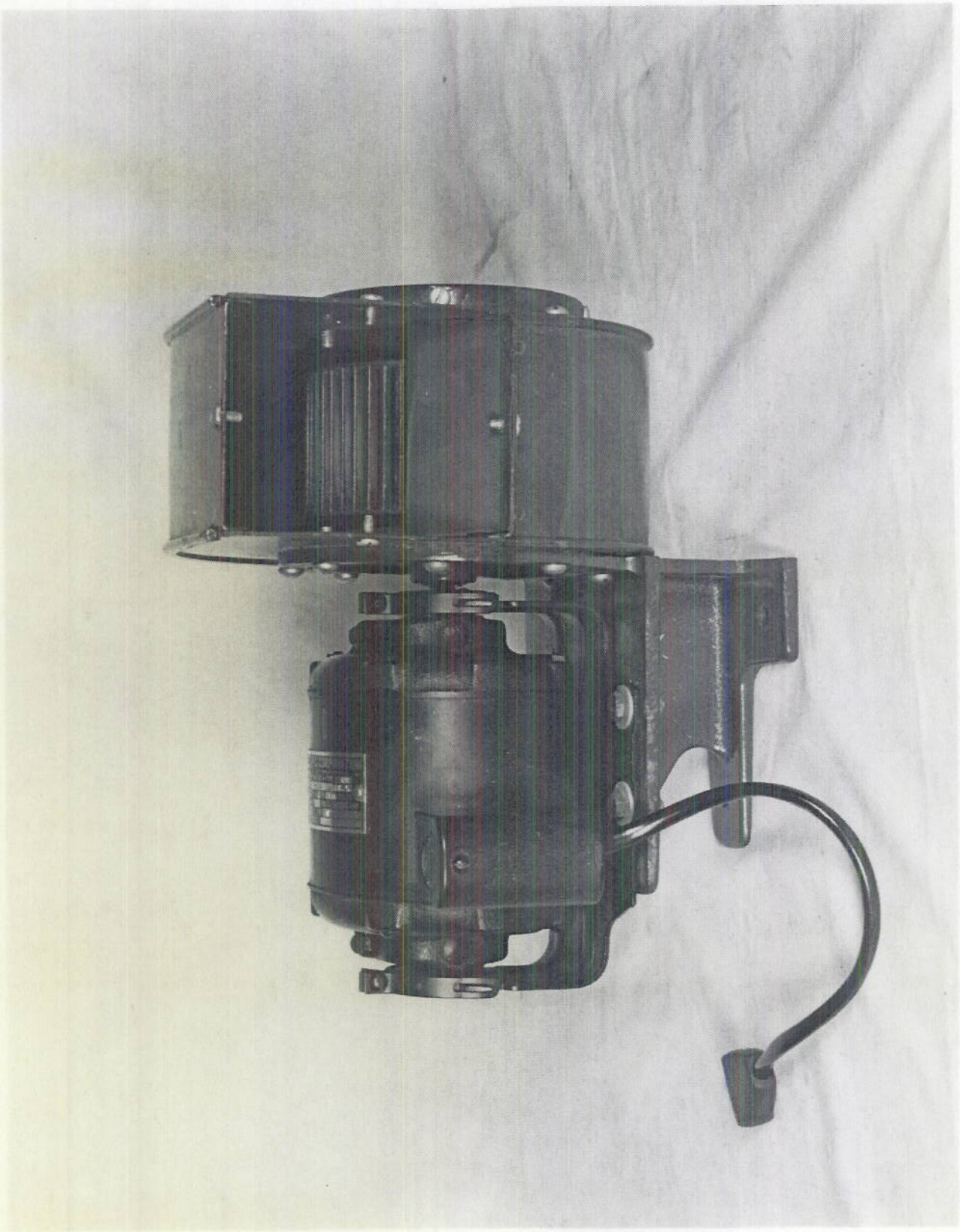

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PLATE 37

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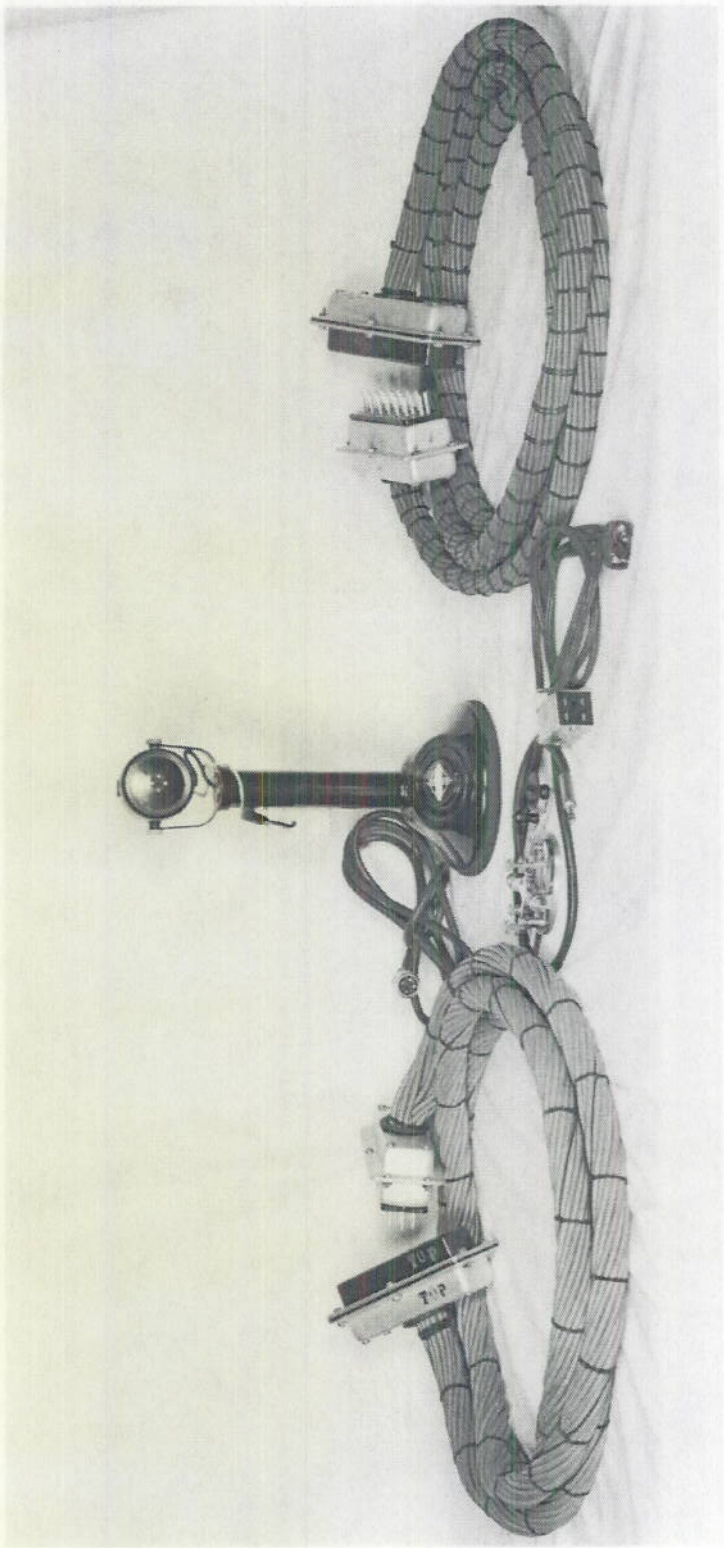

PLATE 38

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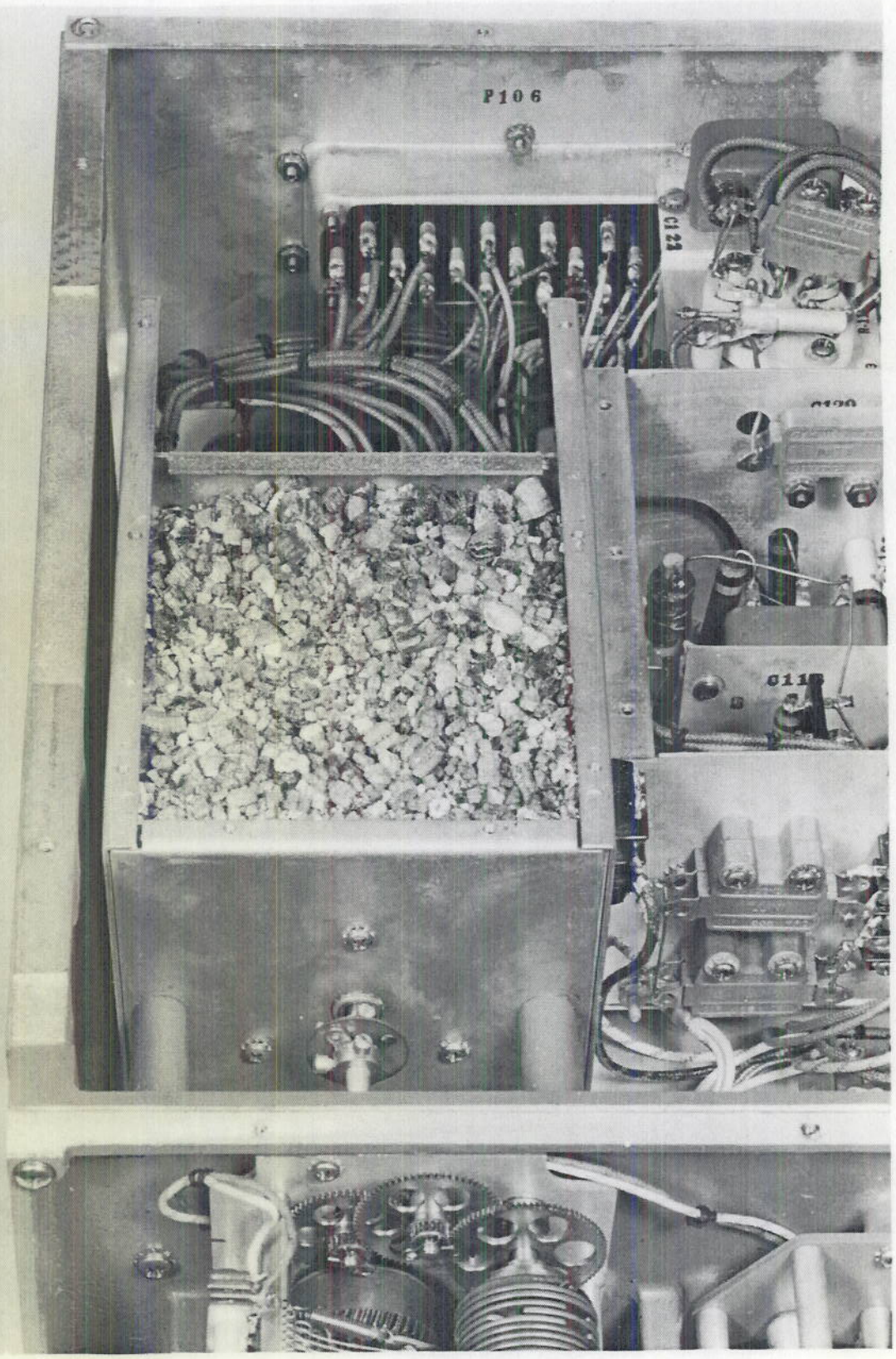

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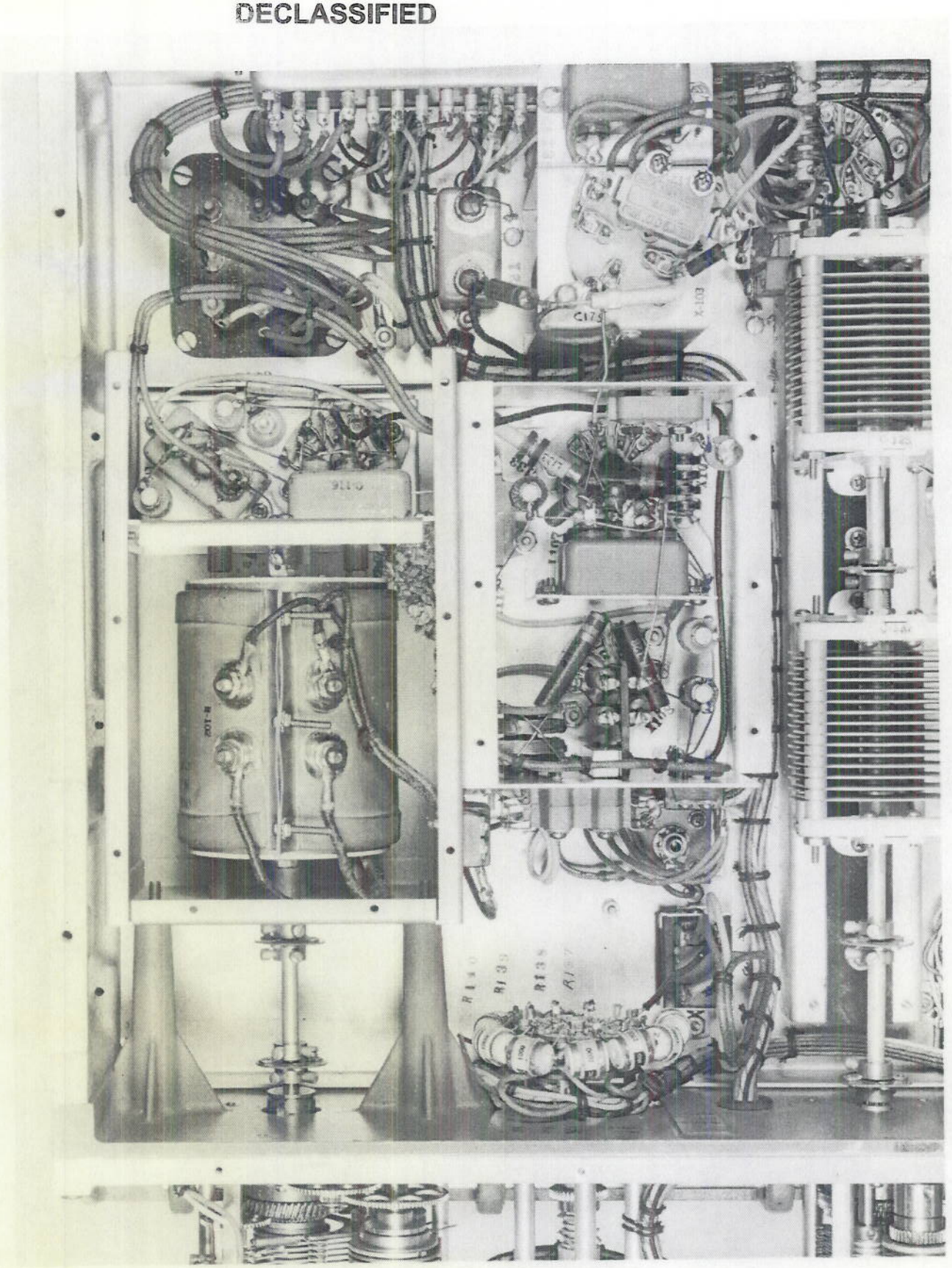

PLATE 40

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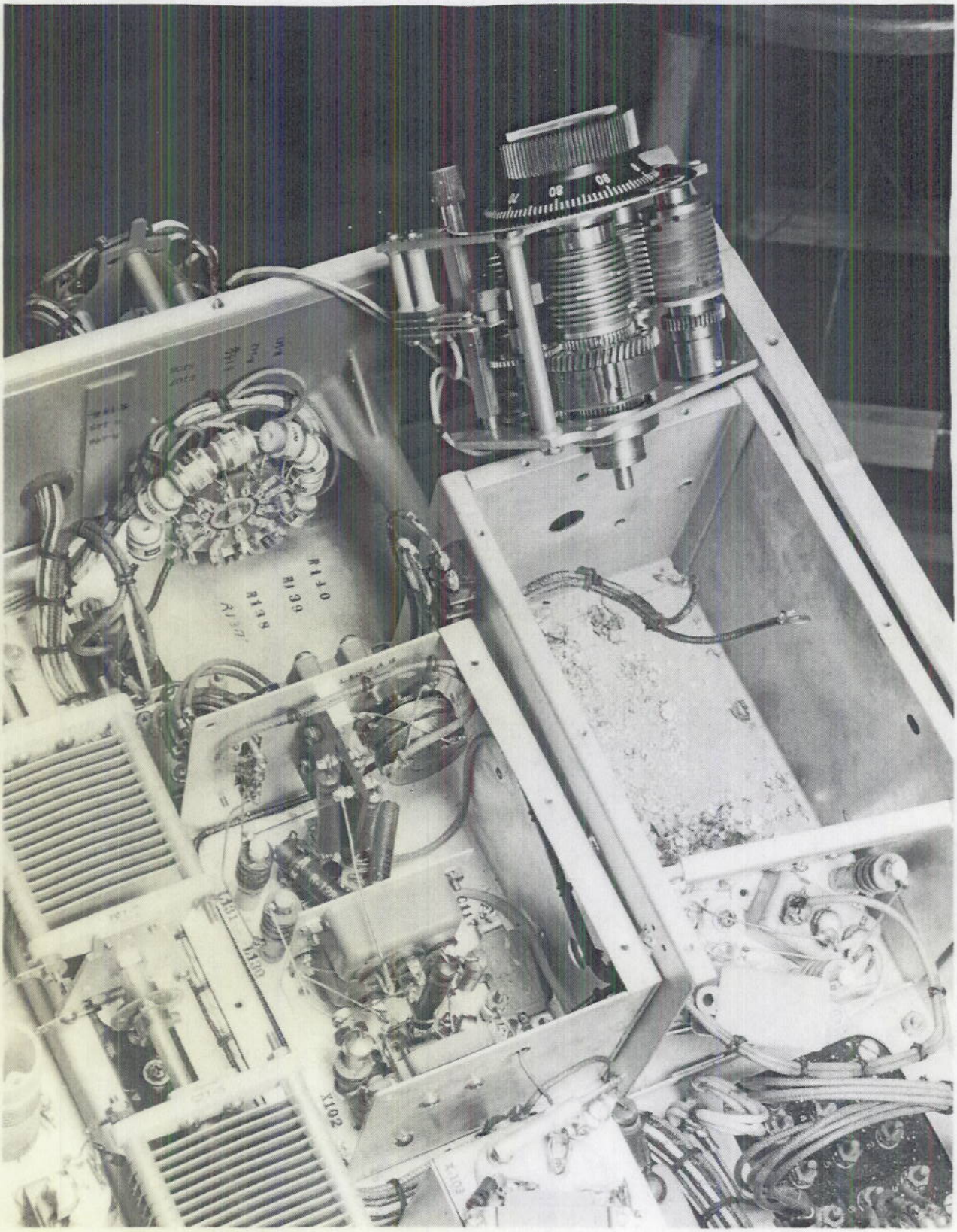

PLATE 41

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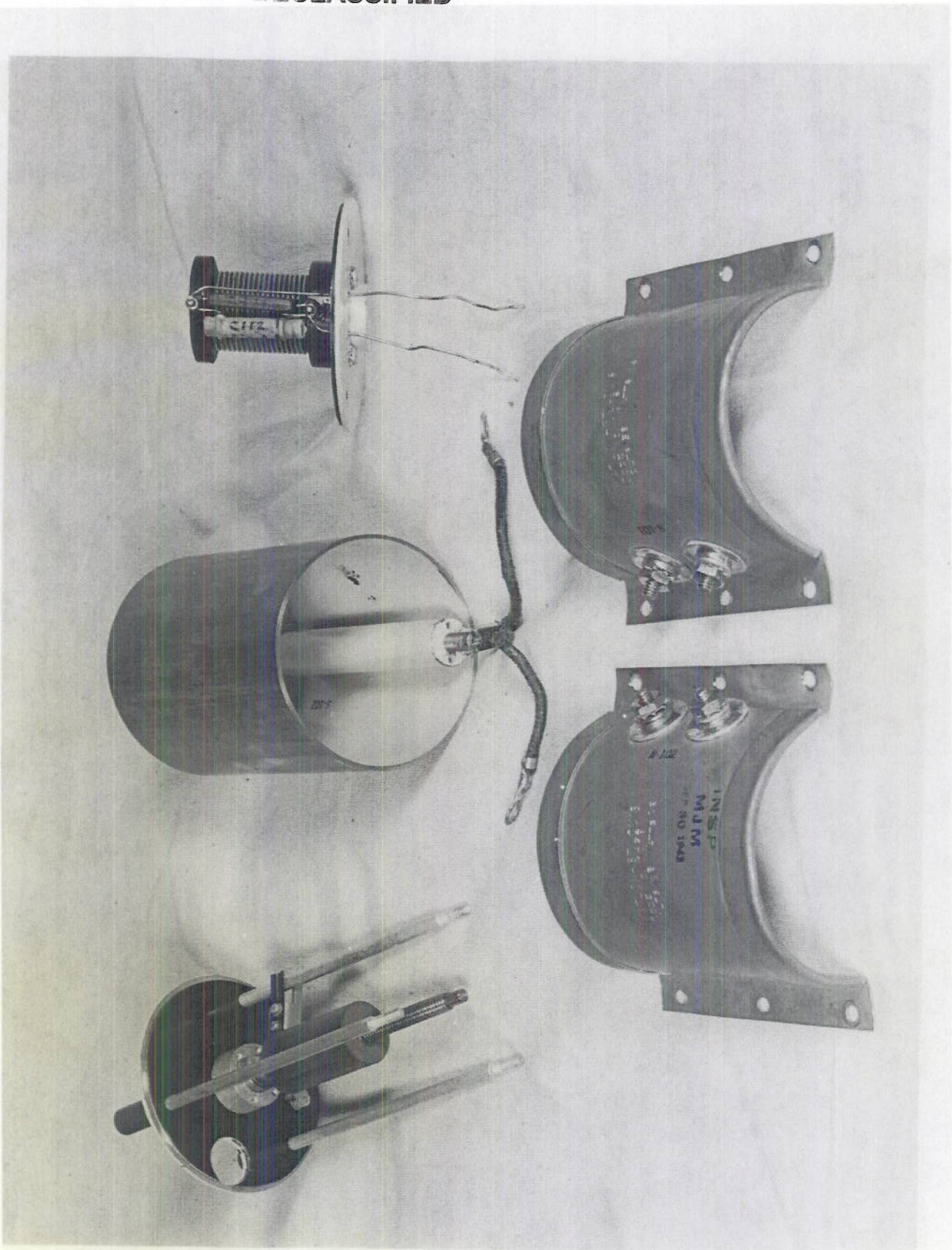

PLATE 42

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