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Lab NRL Report No. R-2225
BuShips Prob. S347T-C
(X-108C)

NAVY DEPARTMENT

FR-2225

Report on
TESTS OF MODEL SC-2 RADAR EQUIPMENT

Contractor:
General Electric Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Date of Tests: 5 January 1943 to 15 April 1943

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R. C. Guthrie, Head of Ship and Shore Radar Research Section

Section II submitted by: R B Meyer
R. B. Meyer, Head of Transmitter Section

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Approved by: R H Gibbs for A.H. VanKeuren, Rear Admiral, U.S.N.
Director.

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U. S. Naval Academy, Post-graduate School	(1)
Navy Radio and Sound Lab., San Diego	(1)

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REPORT ON MODEL SC-2 RADAR EQUIPMENT

INTRODUCTION

0-1. AUTHORIZATION.

The tests on Model SC-2 Radar equipment, serial No. 2, were authorized by a letter from the Bureau of Ships C-NOs-84613 (916-2) Serial #C-916-6301 of 2 January 1943 assigning Problem X-108C.

0-2. OBJECT OF TESTS.

The tests on the SC-2 Radar equipment, Serial No. 2, were made to determine its suitability for Naval use.

0-3. PERIOD OF TESTS.

The PPI unit for the Model SC-2 Radar equipment, Serial No. 2, was received at the Chesapeake Bay Annex on 5 January 1943. The remainder of the system arrived on 11 January 1943. A PPI repeater unit was delivered on 4 February 1943. The operational tests were concluded on 15 February 1943. From 15 February 1943 to 15 April 1943 the equipment was at the Naval Research Laboratory, where it underwent detailed mechanical and electrical tests. Later, the SC-2 system was permanently installed at the Chesapeake Bay Annex.

0-4. CONTENTS.

The report of the tests on SC-2 Radar equipment, Serial No. 2, is divided into three sections. The table of contents for each section is given on the first page of that section. Section I covers the operational tests. Section II covers an investigation of the mechanical construction and electrical operation of the transmitting units. Section III covers mechanical and electrical tests on the receiving units.

0-5. CONCLUSIONS: SECTION I

The tests and observations given in Section I of this report lead to the following conclusions.

0-5-1. The maximum range for consistent following of small planes was 16 miles for a plane flying at 200 feet altitude, 25 miles for a plane flying at 1000 feet altitude, and 70 miles for a plane flying at 10000 feet altitude. A YP boat was followed consistently to 9550 yards and the Norfolk Boat was consistently followed to 21700 yards. These ranges are satisfactory for this type of radar equipment.

0-5-2. The mechanical operation of the PPI unit is not satisfactory. An effort should be made to improve the mechanical features.

0-5-3. The tests on the SC-2 system show that the absolute range accuracy is not better than 0.5 mile on the 75 mile scale and 40 yards on the 30000 yard scale, that the variation with line voltage is as high as 500 yards on the 30000 yard scale, that the effect of warmup is 300 yards on the 30000 yard scale and 0.2 mile on the 75 mile scale, and that the range reset accuracy is 60 yards for the A scope and 300 yards for the P scope. The variation with line voltage is considered excessive. Otherwise, the range accuracy is satisfactory.

0-5-4. There was a difference of $0^\circ 43'$ between bearing readings on the A and P scopes, a static bearing backlash on the A scope of $0^\circ 19'$, and a dynamic bearing backlash on the P scope of $0^\circ 42'$. There was a mean deviation for bearing accuracy of 2.1° when following a moving ship. These bearing accuracies are satisfactory.

0-5-5. The General Electric PPI repeater unit operated satisfactorily when connected to the SC-2 system.

0-5-6. The SC-2 antenna has a beam width of 17° at 200 mc; its side lobes measure only 11% of the field strength of the main beam. This is a result of unequal current distribution among the radiator elements. In general, the electrical features of this antenna appear to be entirely satisfactory. It was observed, however, that a heavy coating of ice makes two of the side lobes very prominent and reduces the maximum range and sensitivity of the system.

0-6. CONCLUSIONS: SECTION II

The tests and observations given in Section II of this report lead to the following conclusions.

0-6-1. The equipment operated satisfactorily over a wide range of ambient temperature and relative humidity. In the absence of specifications governing the permissible variation in emitted frequency and power output with temperature and humidity no conclusions relative to these variations can be included.

0-6-2. The transmitter suffered only slight damage when subjected to vibration. The antenna, however, was severely damaged by vibration and must be strengthened or otherwise modified before satisfactory service can be expected.

0-6-3. The equipment suffered only minor damage when subjected to shock. If the conditions leading to these difficulties are corrected, the equipment can be expected to withstand shock. This conclusion assumes that the equipment will be installed correctly, especially with respect to the top shock mount of the transmitter.

0-6-4. A number of component parts require improvement either mechanically or electrically. Particular attention should be given to the following transmitter components: the oscillator tube sockets, the high voltage filter capacitor, the filament and high voltage transformers of the high voltage rectifier.

0-6-5. The Model SC-2 Transmitter and Control Unit differs only slightly in construction from the corresponding units of the Model SC-1 Equipment.

0-7. CONCLUSIONS: SECTION III.

The tests and observations given in Section III of this report lead to the following conclusions.

0-7-1. The equipment, in general, fulfills its purpose, and is considered with exceptions stated below, to be satisfactory for Naval shipboard service.

0-7-2. The variation in range accuracy with line voltage variation is considered excessive. Reference paragraph (3-18).

0-7-3. The shock mounts are considered unsatisfactory for the purpose, and the use of either U. S. Rubber type 401C or Portsmouth shock mounts is recommended. Reference paragraph (3-6). Reference (G).

0-7-4. Further defects are stated in paragraph (3-21), and in reference (c) of Section III.

0-8. SUMMARY OF DEFECTS AND RECOMMENDATIONS.

The following defects were noted and recommendations made in Sections I, II and III of this report. The numerals in parentheses refer to the paragraph under which these items are discussed in detail. These defects are not arranged in the order of their importance.

0-8-1. PEDESTAL TERMINAL STRIPS (1-20-1). The internal wiring in the pedestal should be connected to the top row of terminals on terminal board TB52.

0-8-2. PEDESTAL LABEL (1-20-2). A label should be attached to the pedestal adjacent to the safety pull-out plug, to explain the purpose of this plug.

0-8-3. CONTROL UNIT VARIAC (1-22-6). An arrangement should be used to prevent the variac on the control panel from being turned below or past zero.

0-8-4. CABLE CLEARANCE (1-23-1). Sufficient clearance to the cables going to terminal boards TB60 and TB61 should be provided.

0-8-5. CONNECTION DIAGRAM (1-23-2). Connection diagram PP-7762550 should show a four-wire cable running from the receiver-indicator unit to the control unit.

0-8-6. (2-4-2a, 2-4-2b) When the antenna was subjected to vibration, various parts oscillated excessively as a result of mechanical resonance. Breakage occurred at several points as a result of vibration. It is recommended that the antenna be so modified to prevent these failures. It was not determined whether the large displacements resulting from the mechanical resonance will change the antenna pattern sufficiently to interfere with the operation of the equipment.

0-8-7. NAME PLATES (1-22-1). Proper nameplates should be attached to the amplidyne and line step-down transformer.

0-8-8. AMPLIDYNE WIRES (1-22-2). The wires coming out of the amplidyne unit should be correctly labelled.

0-8-9. CONTROL UNIT TERMINAL BOARD (1-22-3). The preliminary installation book should show complete wiring instructions for the control unit terminal boards.

0-8-10. CONTROL UNIT CABLES (1-22-4). The cables from the control unit to the terminal boards on the rear of the cabinet should be lengthened about six inches.

0-8-11. ANTI-HUNT CONTROL (1-22-5). The anti-hunt control should be placed closer to the front panel of the control unit, or provision should be made to adjust it without removing the chassis from the cabinet.

0-8-12. (2-8a) It was found that the antenna rotation control system has 35 minutes backlash. This amount is not considered excessive.

0-8-13. (2-9-4b) Base clamps should be provided for the vacuum tubes in the Control Unit to hold them firmly in their sockets.

0-8-14. (2-11-3c) The fuse holders in the line switch box should be marked with the current and voltage ratings of the fuses to be employed and with appropriate "Symbol Designations".

0-8-15. (2-11-3d) A number of "Symbol Designations" have been omitted and others are illegible. More care should be exercised in applying these markings.

0-8-16. (2-12, a, b, c, d, e, f) There are a number of discrepancies in the Instruction Book. These should be corrected.

0-8-17. (2-10-1f) The threads in one of the bolt holes in the line switch box became stripped during the tests. The metal into which these holes are tapped should be made of sufficient thickness to prevent the threads from stripping.

0-8-18. (2-10-1h) The excess thermostat tubing in the antenna pedestal should be either eliminated or adequately supported and clamped.

0-8-19. (2-10-1i) Oil was found to be leaking out of the antenna pedestal around the oil gauge fittings. Care should be taken during manufacture to tighten these fittings securely.

0-8-20. (2-10-1j) The antenna control system gears in the Control Unit were found to lack lubrication. Proper lubrication should be applied to the gears during manufacture of the equipment.

0-8-21. (2-10-1k) The bolts holding capacitors C101 and C102 should be made sufficiently long to extend completely through the "Elastic Stop Nuts" by which they are secured.

0-8-22. (2-11-2e) Suitable lubrication instruction labels should be fastened to the antenna pedestal and antenna drive motor.

0-8-23. (2-11-2f) A label should be fastened to the antenna pedestal to warn operators to open the interlock switch before working on the antenna.

0-8-24. (2-11-2g) Attention is directed to the ease with which the "Sling Here" marking on the antenna can be obliterated.

0-8-25. (2-10-3a) Lock washers should be provided on the terminal screws of the terminal board TB31.

0-8-26. (2-10-3b) It is suggested that guards be provided to protect the interconnecting cable in the Control Unit against the abrasion that occurs when the Control Unit chassis is withdrawn from its cabinet.

0-8-27. (2-11-1) The line switch should be provided with a suitable Navy-type nameplate.

0-8-28. (2-11-2a) Several resistors in the equipment are not marked with resistance value or type number. Appropriate marking should be provided.

0-8-29. (2-10-1d) Attention is directed to the fact that certain stand-off insulators which form a part of the switch S102 in the Control Unit were found broken. It is possible that anti-stress washers of a more effective type are needed to protect the ceramic parts of this switch.

0-8-30. (2-10-1l) The unplated steel gears in the Control Unit should be replaced by gears that will be resistant to the corrosive action of a moist sea atmosphere.

0-8-31. (2-8b) The label "RR" for control "J" on the front panel of the Control Unit should be replaced by the label "IFF".

0-8-32. (2-9-1a, 2-9-1b) Several non-Navy type resistors are used in the Control Unit. These should be replaced by resistors that conform to Navy specifications.

0-8-33. (2-9-1e) There is a discrepancy between the actual power dissipation rating of the resistors R171 and R172 and the power dissipation rating listed in the instruction book. The discrepancy should be corrected.

0-8-34. (2-9-1d) Resistor R102c, which is now supported on V-shaped clips, should be adequately supported. A more satisfactory modification would be to substitute a ferrule type wire-wound resistor for the present non-Navy resistor.

0-8-35. (2-9-4g) The base on the pulse indicator oscilloscope tube was found to be loose. This condition indicates either that the bases of these tubes are not cemented in a durable manner or that the inspection of the completed tubes is faulty. The situation should be called to the attention of the tube manufacturer with the request that he make whatever improvement is necessary.

0-8-36. (2-9-5) Refillable fuses are used in the equipment. These should be replaced by non-refillable fuses to conform with the latest decision of the Bureau of Ships.

0-8-37. (2-9-6) The oscillator plate voltage variac in the transmitter unit should be modified in a manner necessary to prevent its brush holder from slipping on its shaft. The use of set-screws alone to secure this brush holder has not proved satisfactory.

0-8-38. (2-9-7a, 2-9-7b) The oscillator plate voltage supply transformer of the transmitter does not have insulation of a sufficiently high voltage rating to satisfy Navy specifications. The insulation rating of the rectifier is not clearly stated. Both transformers should be provided with adequate insulation.

0-8-39. (2-9-7c) The case of the transformer T104 should be made leak-proof. Oil was found to be leaking out of the transformer.

(2-10-1a) The mycalex arm of the transmitters output coupling bar rubs against the Pulse Indicator. Ample clearance should be provided.

0-8-40. (2-10-1b) One of the clips for the resistor R307 in the transmitter unit is mounted on one of the stand-off insulators which forms part of the terminals of the capacitor C301. This method of support is not satisfactory since the bearing surface provided by the terminal on the insulator is insufficient and the clip is difficult to tighten. The resistor clip should be mounted on a separate support.

0-8-41. (2-10-1c) The grid inductors for the transmitter oscillator should be packed for shipment in a manner that will prevent their being damaged during shipment and storage.

0-8-42. (2-3-2) When power was applied to the equipment after it had been allowed to remain idle in an atmosphere of high humidity, arcing occurred inside the transmitter. Because of this arcing, normal operation could not be obtained until three minutes had elapsed. Three minutes elapsed time was also required for the Model SC-1 equipment before normal operation was obtained after the equipment was exposed to approximately the same conditions.

0-8-43. (2-4-1b) The coupling jack J303A became loose when the transmitter was subjected to vibration. Steps should be taken to prevent this jack from being loosened by either shock or vibration.

0-8-44. (2-4-1c) The overload relay rattled when the transmitter was subjected to vibration. This noise is likely to be annoying and it is recommended that the relay be modified to prevent it from rattling.

0-8-45. (2-4-1d) Several of the tabs holding the center of the oscillator grid inductors in the transmitter broke during the course of the tests. This damage was the result either of the vibration test to which the equipment was subjected or of normal handling incident to the installation or replacement of the grid inductors. These inductors should be modified in such a manner that they will not be disrupted when subjected to the rigors of the Naval Service.

0-8-46. (2-4-1e, 2-5-2b, 2-9-4c, 2-9-4d, 2-9-4e, 2-9-4f) The tube sockets provided for the type 327A tubes used in the transmitter oscillator are not mechanically satisfactory. The present type of socket should be replaced by a type which will prevent the tube from shifting its position in the socket and which will permit the tubes to be installed and removed without damage to their electrode seals.

0-8-47. (2-4-1g) The top of the case of the transmitters high-voltage-supply filter capacitor C301 should be made more rigid. At present, the ceramic insulators mounted on the top of the capacitor are not adequately supported and therefore oscillate with respect to each other when the equipment is subjected to vibration. It is probable that this oscillation will cause failures of this capacitor.

0-8-48. (2-4-1h) The variable transformer by which the oscillator tube filament voltages of the transmitter are controlled should be modified to reduce the excessive play in the brush rigging.

0-8-49. (2-9-2b) The case of the capacitor C302 in the transmitter is leaking oil. This case should be made oil tight.

0-8-50. (2-9-2c) One section of filter capacitor C301 in the transmitter unit developed an internal short circuit during the course of the tests. The other section subsequently failed when subjected to a d-c test potential of a lower value than Naval specifications require it to withstand. It is recommended that further investigations be made to determine the suitability of this type of capacitor for use in the Model SC-2 equipment.

0-8-51. (2-9-2d) The common terminal of capacitor C303 should be marked to indicate that it is the common terminal. The capacitor should be provided with an oil-tight case.

0-8-52. (2-9-4a) With the primary voltage adjusted so that the front panel filament voltmeter indicated the specified value, the rectifier filament voltage was found to be less than the five per cent tolerance specified by the tube manufacturer. It is recommended that the filament transformer be replaced by one that will provide the correct rectifier filament voltage.

0-8-53. (2-11-2b) There is a discrepancy between the capacity marking on the capacitor C350 and the capacity listed in the instruction book. This discrepancy should be corrected.

0-8-54. (2-11-2c) Nameplates have been omitted from several transformers in the equipment. Suitable nameplates should be provided on all transformers.

0-8-55. (2-11-2d) The terminals on the transformer T151 should be numbered. These numbers should also appear on the schematic diagram.

0-8-56. (2-10-1e) The terminal studs on the transmitter overload relay loosened when an attempt was made to disconnect the relay leads. Steps should be taken to prevent these studs from loosening.

0-8-57. (2-10-1g) The studs for the transmitter side shield should be staked or otherwise secured to prevent them from being accidentally unscrewed from the transmitter frame.

0-8-58. (2-10-2a) The shield cover on the type 5U4G vacuum tube in the Pulse Indicator Unit should be made more conveniently removable.

0-8-59. (2-11-3a) There is a discrepancy in the chassis markings for resistors R326 and R318 of the Pulse Indicator. This discrepancy should be eliminated.

0-8-60. (2-11-3b) Resistor R328 should be eliminated from the Pulse Indicator schematic diagram since no such resistor appears in the unit.

0-8-61 (2-5-2a) The angle brackets holding the transmitter jacks J301A and J303A became loose when the equipment was subjected to shock. These jacks should be secured in a manner that will preclude their loosening during shock.

0-8-62. (2-5-2c) Because of the large deflection of the top of the transmitter unit which occurs when this unit is subjected to shock, care should be taken to provide three inches of clearance around this unit when it is installed. The installation drawings should indicate that this amount of clearance is required.

0-8-63. (2-5-2d) The thumb nuts by which the side and back shields are held on the transmitter loosened when the equipment was subjected to shock. It is recommended that the thumb nuts be replaced by a more effective type and that the auxiliary bolts be eliminated.

0-8-64. MATCHING CONTROL (1-21-2). The full 100° scale on the transmitter matching control should be used.

0-8-65. OUTPUT COUPLING CONTROL (1-21-1). The full 100° scale on the transmitter output coupling control should be used.

0-8-66. FILAMENT VOLTAGE ADJUSTING TRANSFORMER (1-21-3). Filament voltage adjusting transformers should be carefully inspected at the factory for proper operation.

0-8-67. PULSE INDICATOR (1-21-4). The preliminary installation book should include instructions pertaining to the installation of the pulse indicator.

0-8-68. TRANSMITTER SPARKOVER (1-21-5). An investigation should be made to eliminate sparkover on the transmitter along the mycalex coupling bar support.

0-8-69. PPI CABINET MOUNTING HOLES (1-24-2). The mounting holes on the top of the PPI cabinet should be located more accurately.

0-8-70. PPI SPARE PARTS PACKING SLIP (1-24-3). A packing slip should be included in the PPI spare parts box as well as in other boxes.

0-8-71. PPI CABLES (1-24-4). Proper connectors should be used and firmly soldered to all coaxial cables.

0-8-72. PPI CABLE ROUTE (1-24-5). A safe route should be found for the three coaxial cables coming from the video unit.

0-8-74. PPI TERMINAL CABLES (1-24-6). The lengths of the laced cables connecting to terminal boards TB74-TB75-TB78-TB79 should be increased sufficiently to permit the withdrawal of the scope and video units for simultaneous servicing.

0-8-75. CABLE CLAMPS (1-24-6). Some sort of clamps should be provided to hold the laced cables connecting to terminal boards TB74-TB75-TB78-TB79 clear of the release mechanism.

0-8-76. SECTOR SWEEP (1-24-7). The sector sweep should be tested for proper operation before leaving the factory.

0-8-77. SECTOR BEARING CONTROLS (1-24-8). The shafts for the sector and bearing controls should be better centered so the gears will mesh properly.

0-8-78. CENTERING CONTROL (1-24-9). The centering control should be designed to permit the PPI trace to have a margin of movement on each side of the center.

0-8-79. CENTERING CONTROL LOCK (1-24-9). A lock should be provided on the PPI centering control.

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0-8-80. MARKER PIP (1-24-10). An effort should be made to reduce the length of the marker pip on all ranges of the PPI scope.

0-8-81. RELAY (1-24-11). Better workmanship should be used on PPI relay K2200 and on all soldered wire connections.

0-8-82. PPI RANGE SWITCH (1-24-12). A more reliable range switch should be used on the PPI unit.

0-8-83. PPI RELEASE HARDWARE (1-24-13). The spring action on all release arrangements should be checked for proper operation before leaving the factory.

0-8-84. (3-19-51). A cable rested on a sharp corner of a metal power supply shield.

0-8-85. (3-19-52). Wiring to resistors and condensers most of which were on terminal strips was generally accessible, but some of the wiring to components not on terminal strips was quite inaccessible.

0-8-86. (3-19-53). Two leads longer than 1 foot each were unsupported except at their ends.

0-8-87. (3-19-54). The mounting fingers for the selsyns were not counter balanced, and tightening the mounting bolts resulted in a flexing force on the bolt. The flexing force on the bolt was not present for the finger between the two selsyns, but this finger was not of sufficient strength, and was bent by force applied to tighten the mounting bolt.

0-8-88. (3-19-55). Defects found in the plan position indicator were described in reference (c) of Section III.

0-8-89. RECTIFIER PLATE LEADS (1-23-3). A means of identification should be used to identify the plate cap connections of the 2X2 tubes in the receiver-indicator power supply.

0-8-90. PREAMPLIFIER (1-23-4). A misprint should be corrected on Page 9 of the preliminary installation book.

0-8-91. INSTRUCTION BOOK (1-23-5). No instruction book was furnished with the SC-2 equipment. An instruction book should be provided before SC-2 equipment is installed.

0-8-92. JUNCTION BOX BUSHING (1-23-6). The outer bushings in the junction box should each be increased 3/16 inch in length.

0-8-93. HOODS (1-23-7) Provision should be made to mount a hood on the A scope and a hood on the P scope.

0-8-94. BACK TRACE (1-23-8). The return trace on the A scope should be completely suppressed.

0-8-95. GROUND STRAP (1-23-9). A more reliable ground strap should be used from the receiver chassis to the receiver sliding track.

0-8-96. CONNECTION DIAGRAM (1-23-10). The preliminary installation book should include a connection diagram for the junction box.

0-8-97. INSTALLATION BOOK (1-23-11). No mention should be made of the range of the SC-2 equipment in a "restricted" installation book.

0-8-98. SHORT ITEMS (1-23-12). A complete set of spare parts should be furnished with the SC-2 equipment.

0-8-99. SWITCH (1-24-10). The "mark-IFF" switch should be modified to have a neutral position.

0-8-100. (3-19-3). No primer coating appears to have been provided on the aluminum panel to afford protection against corrosion.

0-8-101. (3-19-4). No stops are provided for either of the two threaded rods driven by the trimmer knobs, and the cathode trimmer variable condenser rotor plate was forced off its mounting on the rod by rotation of the knob. The plate trimmer has a pair of nuts on the threaded rod which may have been tightened together to prevent excessive withdrawal of the threaded rod, but these nuts were separated from each other, and did not function. There are two other trimmer condensers in the unit, and these, likewise, are not provided with stops. All four rotor plates are provided with sheets of mica glued on to prevent electrical contact between rotor and stator plates, but it was observed that two of the trimmers could be turned so far that the rotor plates touched the stator plates, and the force thus applied placed a strain on the contact fingers provided for the type GL-446 tube.

0-8-102. (3-19-5). The lock knobs provided on the two main tuning dials are not well placed, and interfere with rapid operation of the dials.

0-8-103. (3-19-6). The ground connection for the rotor plate of each trimmer depends upon the electrical contact of the threaded rod in a tapped hole. An adjustment is provided for each trimmer to maintain firm ground contact, but the cathode and plate trimmers with knobs on the front panel have oil on the threads and on the rods, which gives no assurance of good electrical contact.

0-8-104. (3-19-7). The circular laminated molded phenolic coupler used to transmit rotation from the main tuning dials to the tuning condensers shows a tendency to warp.

0-8-105. (3-19-8). The power transformer is not potted and sealed and is in such a position that the covering of the windings makes contact with the inside surface of the case of the preamplifier unit.

0-8-106. (3-19-9). The shielded power cable to the preamplifier is supported by the conductors at both ends. Excessive strain is placed on the conductors, because of the weight of the cable, and other transmitted force. Provision of cable clamps would relieve the strain on this cable.

0-8-107. (3-19-10). The following paragraphs represent the results of an inspection of the subject receiver-indicator to determine whether or not the recommendations of the Naval Research Laboratory submitted in reference (a) of Section III have been effective in this, the subsequent model. The numbers in parentheses refer to paragraph numbers in reference (a) of Section III.

0-8-108. (3-27-1) Locks have not been mounted further from controls so as to prevent them from interfering with operation of the control.

0-8-109. (3-27-2). There was no regrouping of controls.

0-8-110. (3-27-4) Single set screws are still used on control knobs on many of the controls.

0-8-111. (3-27-5) Dial knobs have not been changed as suggested.

0-8-112. (3-27-8) Brass gears have some grease on them, but this may not be adequate to prevent corrosion.

0-8-113. (3-27-10) Loctal type tubes have not been replaced by octal or other approved types.

0-8-114. (3-27-11) The acorn sockets used in the r-f section are not approved.

0-8-115. (3-27-12) Only one tube clamp has been used in the receiver-indicator. This is on the 5U4-G.

0-8-116. (3-27-13) Tube sockets are not identified on both sides.

0-8-117. (3-27-14) One cable includes wires having the same color coding.

0-8-118. (3-27-15) Switch shaft is used as a cable support.

0-8-119. (3-27-17) Paper markers are used on the wires.

0-8-120. (3-27-18) Interlock has not been provided.

0-8-121. (3-27-19) Method of mounting dial light appears to be satisfactory.

0-8-122. (3-27-20) No holes have been provided for easy removal of the three screws on the under side of the receiver chassis.

0-8-123. (3-27-21) No clamp is used on the 164 kilocycle crystal, and the mounting is considered unsatisfactory.

0-8-124. (3-27-24) Shields over transformers are not secured at the top except by bowing pressure.

0-8-125. (3-27-25) Not all components are marked.

0-8-126. (3-27-26) Transformers and chokes are not potted.

0-8-127 (3-27-27) The tank coils L703 and L704 have not been wax coated.

0-8-128. (3-27-28) Resistors and condensers have been waxed.

0-8-129. (3-27-29) Condenser and resistor leads have been bent and soldered too close to the respective components.

0-8-130. (3-27-30) No side plates have been fastened by wedging.

0-8-131. (3-27-32) No temporary clamping has been used on permanent parts.

0-8-132. (3-27-33) No burned wires were noted, however, soldering was not of the highest quality.

0-8-133. (3-27-34) The intermediate frequency slugs were arranged to prevent short circuiting to the windings.

0-8-134. (3-27-35) Mica condensers have been used extensively.

0-8-135 (3-19-40) Resistor R634 has been removed from the circuit. Connection is made to only one terminal of this resistor.

0-8-136. (3-19-41) There was insufficient clearance between one terminal board and chassis. Clearance is desirable to prevent accumulations of moisture.

0-8-137. (3-19-42) Wires were soldered to ends of threaded rods.

0-8-138. (3-19-43) Many components in i-f stages were inaccessible.

0-8-139. (3-19-44) A pigtail on one resistor in an i-f stage is longer than 1/2 inch.

0-8-140. (3-19-45) Pigtails on some components are shorter than 1/8 inch.

0-8-141. (3-19-47) Mica condensers are used extensively.

0-8-142. (3-19-48) Soldering has been done so close to components that the solder actually touched the component.

0-8-143. (3-19-49) Wiring to some tube sockets was inaccessible.

0-8-144. (3-19-50) At several points wires were placed so that they rested on sharp corners of terminal boards.

0-8-145. PPI HOLDING SCREWS (1-24-1). The number of screws holding the PPI chassis to its cabinet should be increased and care should be taken so they will screw into place easily without the aid of tools.

0-9. <u>GENERAL COMMENTS.</u> Almost all of the recommendations made in this report on the SC-2 Radar equipment have already been discussed with representatives of the Bureau of Ships. Some of the recommendations have been acted upon in the SC-3 and SK radar equipments.

0-9-1. In paragraph 2-13-5 it was noted that Westinghouse 327-A transmitting tubes gave superior performance to Eimac 327-A tubes. Another sampling of Westinghouse and Eimac tubes tested in a NRL oscillator gave a slightly larger pulse power output from the Eimac tubes. There are variations in tubes made by the same manufacturer, but on the average both Eimac and Westinghouse type 327A tubes give essentially the same pulse power output.

SECTION I

OPERATIONAL TESTS ON SC-2 RADAR EQUIPMENT, SERIAL NO. 2

TABLE OF CONTENTS

	Paragraph	Page
Object of Operational Tests	1-1	1
Abstract of Tests	1-1-1	1
Conclusions	1-2	1
Description of Equipment	1-3	2
Period of Tests	1-4	2
Installation	1-5	2
Maximum Range on Planes	1-6	3
Maximum Range on Ships	1-7	3
Minimum Range	1-8	3
Line Voltage Test	1-9	4
Warm-up Test	1-10	4
Input Power	1-11	4
Iced Antenna Test	1-12	4
Range Accuracy	1-13	4
Bearing Accuracy	1-14	5
System Sensitivity	1-15	6
Pulse Characteristics	1-16	6
Antenna Tests	1-17	6
Duplexer	1-17-6	8
Interference	1-18	8
PPI Repeater	1-19	8
Antenna System Defects	1-20	9
Transmitter Defects	1-21	9
Control System Defects	1-22	10
Receiver-Indicator Defects	1-23	11
PPI Defects	1-24	13
Summary of Defects and Recommendations	1-25	15
Conclusions	1-26	18

Line Voltage Test	Tables 1 and 2
Summary of Range Data	Table 3
Maximum Range Comparisons with Other Systems	Table 4
Bearing Reset Accuracy	Table 5
Bearing Backlash A Scope	Table 6
Bearing Backlash P Scope	Table 7
Range Reset Accuracy	Table 8
Comparative Test with SH System	Table 9
Range and Bearing Variations with Time	Table 10
Noise Measurements	Table 11
Summary of Antenna Tests	Table 12
Results of Antenna Tests	Plates 1-10
Rough Antenna Patterns	Plate 11
Photographs of Equipment	Plates 12-14
Antenna Under Iced Conditions	Plate 15

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1-1. OBJECT OF OPERATIONAL TESTS. The object of the tests which are covered in this section is to determine the operational characteristics of the Model SC-2 Radar system with reference to its suitability for use by the Navy. These tests are concerned primarily with the performance of the system with regard to maximum range on planes and boats, range and bearing accuracy, system sensitivity, and the comparison of this performance with that of other systems. Tests are also made to determine the effect of line voltage change, of supply frequency change, of tuning over the RF band, and of warmup on the performance of the system. Detailed tests on the components are not a part of the operational tests but are covered by other sections of this report. Only those defects and failures are noted in Section I which interfered with either the installation or the operation of the system.

1-1-1. ABSTRACT OF TESTS. Operational tests were made on the SC-2 Radar equipment at an antenna height of 110 feet. The maximum range on planes and boats, as well as range and bearing accuracies, were determined. Tests were made to determine the effect of line voltage change and warmup. Measurements were made to find the system sensitivity, the noise radiated from the system, and a rough antenna pattern.

1-2. CONCLUSIONS. The operational tests on the SC-2 equipment lead to the following conclusions.

1-2-1. The maximum range for consistent following of small planes was 16 miles for a plane flying at 200 feet altitude, 25 miles for a plane flying at 1000 feet altitude, and 70 miles for a plane flying at 10,000 feet altitude. A YP boat was followed consistently to 9,550 yards and the Norfolk Boat was consistently followed to 21,700 yards. These ranges are satisfactory for this type of radar equipment.

1-2-2. The mechanical operation of the PPI unit is not satisfactory. An effort should be made to improve the mechanical features.

1-2-3. The tests on the SC-2 system show that the absolute range accuracy is not better than 0.5 mile on the 75 mile scale and 40 yards on the 30,000 yard scale; that the variation with line voltage is as high as 500 yards on the 30,000 yard scale; that the effect of warmup is 300 yards on the 30,000 yard scale and 0.2 mile on the 75-mile scale, and that the range reset accuracy is 60 yards for the A scope and 300 yards for the P scope. The variation with line voltage is considered excessive; otherwise, the range accuracy is satisfactory.

1-2-4. There was a difference of $0^\circ 43'$ between bearing readings on the A and P scopes, a static bearing backlash on the A scope of $0^\circ 19'$, and a dynamic bearing backlash on the P scope of $0^\circ 42'$. There was a mean deviation for bearing accuracy of 2.1° when following a moving ship. These bearing accuracies are satisfactory.

1-2-5. The General Electric PPI repeater unit operated satisfactorily when connected to the SC-2 system.

1-2-6. The SC-2 antenna has a beam width of 17° at 200 mc.; its side lobes measure only 11% of the field strength of the main beam. This is a result of unequal current distribution among the radiator elements. In general the electrical features of this antenna appear to be entirely satisfactory. It was observed, however, that a heavy coating of ice makes two of the side lobes very prominent and reduces the maximum range and sensitivity of the system.

1-3. DESCRIPTION OF EQUIPMENT. The SC-2 Radar equipment is a medium-power, general-purpose search radar for use by Naval vessels. The equipment is intended for use in long range aircraft detection, moderate range surface craft detection, detection of land and other objects for navigational purposes, and to furnish sufficiently accurate range and bearing data to put a fire-control radar on a target. The transmitter pulse power is over 150 KW with a 3 to 5 microsecond pulse length, a repetition rate of 60 pulses per second and a frequency band from 175 to 225 mc. A single antenna is used to cover a band of 10 mc. for both transmitting and receiving. There are four such bands: red (175 to 185 mc.), green (185 to 195 mc.), yellow (195 to 205 mc.) and blue (215 to 225 mc.). The antenna and duplexer furnished with this equipment were for the yellow band from 195 to 205 mc. The equipment is similar to the SC-1 system with a new antenna, the addition of a master PPI unit and provision for IFF equipment. Plate 12 of Section I shows the SC-2 interior installation with a BL-1 receiver-transmitter unit on the far right. Plate 13 shows the complete antenna. The PPI repeater unit is shown on Plate 14.

1-4. PERIOD OF TESTS. The PPI unit for the model SC-2 Radar equipment, Serial No. 2, was received at the Chesapeake Bay Annex on January 5, 1943. The remainder of the equipment arrived on January 11, 1943. A PPI repeater unit was delivered on February 4, 1943. The operational tests were concluded on February 15, 1943 after 112 hours of operation. The equipment was then dismantled and shipped to NRL on February 16, 1943 for detailed electrical and mechanical tests on components. The results of these tests are covered in Sections II and III of this report. Subsequently, the equipment was permanently installed at the Chesapeake Bay Annex.

1-5. INSTALLATION. The SC-2 equipment was installed in Building 1 at the Chesapeake Bay Annex according to the "Preliminary Installation Book." The approximate height of the center of the antenna was 110 feet above water. The installation book was not entirely adequate because of certain omissions and misprints. These defects are discussed later in paragraphs 1-21-4, 1-22-3, 1-23-2, 1-23-4, 1-23-10 and 1-24-5. The only instruction books supplied were those for the master PPI and the PPI repeater units.

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1-6. MAXIMUM RANGE ON PLANES. A summary is given in Table 3 of Section I of the runs which were made to determine the maximum range at which the SC-2 system will follow planes. The maximum range for consistent following of small planes was 16.1 miles for a plane flying at 200 feet altitude, 25.0 miles for a plane flying at 1000 feet and 69.6 miles for a plane flying at 10,000 feet altitude. Some "step-ladder" runs were made, in which a plane increased its altitude one mile every ten miles of flight. For this type of run a plane was followed consistently to 36.0 miles.

1-6-1. RANGE COMPARISONS ON PLANES. A summary of the consistent ranges of the SC-2 and some other radar systems is given in Table 4 of Section I. At the Chesapeake Bay Annex, the performance of the SC-2 system was inferior to that of the MA and CXCA #2 systems and was superior to that of the CXCA #1 and CXAZ systems on planes flying at 200 feet altitude. For planes flying at 10,000 feet altitude, the SC-2 system outperformed the MA, CXCA #1 and CXCA #2 systems.

1-6-2. ADVANTAGES OF P SCOPE FOR SEARCH. During the operational tests it was found that rapidly fluctuating echoes and echoes that were too weak to be noticed on the A scope sometimes could be discerned on the P scope. This was true even for targets following a fixed course. The P scope is far superior to the A scope for the initial detection of a target coming in from an unknown bearing. Using the P scope, it is also much easier to pick up a plane after passing through a null point. Having located a target on the P scope, the antenna rotation can be stopped and the A scope can be used to obtain the range and bearing.

1-7. MAXIMUM RANGE ON SHIPS. A summary of the maximum range on ships is given in Table 3 of Section I. The Norfolk Boat was followed consistently to 21,700 yards, an armed freighter to 21,650 yards, and a YP boat to 9,550 yards. With an average thickness of 1/4 inch of ice on all parts of the antenna, the Norfolk Boat was followed to 14,000 yards.

1-7-1. RANGE COMPARISONS ON SHIPS. The SC-2 system consistently followed the Norfolk Boat to 10.9 miles. The MA system consistently followed it to 12 miles, the CXCA #1 system to 7.5 miles, the CXCA #2 system to 15 miles, and the CXAZ system to 7.8 miles. The performance of the SC-2 system was superior to that of the CXCA #1 and CXAZ systems but was inferior to that of the MA and CXCA #2 system when using the Norfolk Boat as a target.

1-8. MINIMUM RANGE. Echoes could be followed in to about 1800 yards but could not be ranged accurately because the outgoing pulse and the foreground echoes did not reach the base line on the display until the 3,000-yard position was reached. Echoes from low-flying planes could be seen beating with foreground echoes up to the outgoing pulse at an estimated range of 1,000 yards. High-flying planes at 10,000 feet altitude could be followed in as close as 6,200 yards, corresponding to an elevation angle of 32°.

1-9. LINE VOLTAGE TEST. The rated line voltage is 115 volts at 60 cycles. As a regular practice, a line voltage of 110 volts was used for the tests in this report unless otherwise mentioned. Tables 1 and 2 of Section I give performance data for line voltages from 95 to 125 volts both with and without the preamplifier for variations in range reading, transmitter frequency, duty cycle and signal-to-noise ratio. The results will be discussed in paragraphs 1-13-3, 1-15-1, and 1-16.

1-10. WARMUP TEST. The SC-2 equipment was turned on and range bearing readings on two stationary targets were noted at one-hour intervals over a four-hour period. The data are given in Table 10 of Section I. The results will be discussed in paragraph 1-13-4.

1-11. INPUT POWER. The input power to the SC-2 system was measured, using line voltages of 110 volts and 115 volts. The transmitter plate voltage was adjusted to 12 kilovolts and the antenna was rotated near its highest speed. At 110 volts the line current was 24.7 amps, the power 2.12 kw and the power factor 0.78. At 115 volts, the line current was 26 amps, the power 2.3 kw and the power factor 0.77.

1-12. ICED ANTENNA TEST. During a brief period of the operational tests, there was an ice storm which caused a coating of ice to be deposited on the SC-2 antenna. This ice completely covered all exposed parts of the antenna. The thickness varied from a half inch to an eighth inch. Plate 15 of Section 1 shows the ice-covered antenna. The ice caused a detuning of the antenna which resulted in side lobes. The P scope trace of the Annapolis Radio Towers showed a main trace and a smaller trace at each end of the main trace. The main trace extended from 358° to 29°, and the two side traces extended respectively from 333° to 358° and from 29° to 56°. After the ice had been removed, the normal single trace returned. The signal-to-noise ratio of the "Towers" echo was 3 with the ice covering and 8 after removal of the ice from radiators and feed lines; the normal ratio is over 20. No echo was received from Sharps Island Light before the ice was removed. A run was made on the Norfolk Boat when the antenna was partially iced. It was followed to a maximum consistent range of 14,800 yards. The normal range is about 21,700 yards.

1-13. RANGE ACCURACY. The SC-2 equipment has three range scales for the A scope: 30,000 yards, 75 miles, and 375 miles. The P scope ranges are: 20, 75, and 200 miles. Observations were made to determine the absolute range accuracy, range reset accuracy and the effect of line voltage variation and warmup on range reading.

1-13-1. ABSOLUTE RANGE ACCURACY. After the equipment had warmed up for several hours the range calibration was checked and the range readings were taken. The range was 21.0 on the Annapolis Radio Towers and 14,800 yards on Sharps Island Light. There was an error of 0.5 mile in range on the Towers and an error of 40 yards in range on the Light. These errors in range are not excessive for meter wave search radar equipment.

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1-13-2. RANGE RESET ACCURACY. Ten readings by each of two observers on both the A and P scopes were made to determine the range reset accuracy. The data are tabulated in Table 8 of Section I. Using the A scope the average reset range was 14,810 yards. The maximum deviation from this average value was 60 yards, and the mean deviation was 24 yards. On the P scope, using the range marker, the average reset range was 14,850 yards. The maximum deviation from this average value was 300 yards and the mean deviation was 110 yards.

1-13-3. LINE VOLTAGE. As noted in Tables 1 and 2 of Section I, a variation of line voltage from 95 to 125 volts caused a decrease in range readings as high as 500 yards on a target at 14,760 yards. This is considered excessive.

1-13-4. WARMUP. As noted in Table 10 of Section I, the range reading on a target at 14,760 yards decreased 200 yards in the first hour of operation. The total decrease in range reading over a four-hour period was 300 yards. This is rather large, but should not seriously affect the usefulness of the equipment.

1-13-5. COMPARATIVE RANGE ACCURACY. Table 9 of Section I gives comparative range data for the SC-2 A and P scopes and the SH, using a moving ship as the target. The mean deviation between the SC-2 and SH range readings was 59 yards, the maximum deviation was 186 yards, and the zero correction was 79 yards. The mean deviation between the A and P scope readings on the SC-2 was 39 yards, the maximum deviation was 54 yards, and the zero correction was 46 yards. This is satisfactory.

<u>1-14. BEARING ACCURACY.</u> The following tests were made to determine the bearing accuracy.

1-14-1. BEARING RESET ACCURACY. The data in Table 5 of Section I show that the mean deviation in bearing reading is 0°22' on the A scope and 0°26' on the P scope when using a stationary target. The maximum deviations were 0°52' on the A scope and 1°40' on the P scope. The difference between the average bearing readings on the A and P scopes was only 0°43'. This is satisfactory.

1-14-2. BEARING BACKLASH. As noted in Table 6 of Section I, the static bearing backlash is 0°19' when using the A scope. Table 7 of Section I gives the results of the dynamic backlash test when using the P scope. The dynamic bearing backlash based on the general average of the bearings at the beginning and the end of the echo arc was 0.5° or 0°30'. The dynamic bearing backlash based on the observed echo maximum bearing was 0.7° or 0°42'. This is satisfactory for search radar purposes.

1-14-3. ADVANTAGES OF P SCOPE FOR SEARCH. During the operational tests it was found that better bearing accuracy could be obtained from the P scope than from the A scope on rapidly moving targets. Due to rapid change of bearing and rapid fluctuation of echo height from rapidly

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moving targets, such as planes, it is very difficult to rotate the antenna quickly enough to obtain the true bearing at any time on the A scope. But, the true bearing can be read from the middle of the echo trace on the P scope for any position of a plane. A fluctuating echo, although annoying on the A scope will still produce a legible trace on the P scope.

1-14-4. DYNAMIC ACCURACY. The Norfolk Boat was followed with the SC-2 system and with the SH system. The bearing data are tabulated in Table 9 of Section I. The bearing readings of the A scope on the SC-2 followed very closely the bearing readings of the SH systems. The mean deviation from SH readings was 2.1° and the maximum deviation was 7.8°.

1-15. SYSTEM SENSITIVITY. Signal-to-noise measurements were made on the echo pip which was observed when using Sharps Island Light as the target. As given in Table 4 of Section I, the measured signal-to-noise ratio was 8 for SC-2, 5 for MA and 2 for CXCA #1. It was 6 for SA and 9 for XAR-2. These results agree qualitatively with those obtained from maximum ranges on ships, as given in paragraph 1-7-1.

1-15-1. EFFECT OF LINE VOLTAGE. The results of the line voltage test are given in Tables 1 and 2 of Section I. A variation of line voltage from 95 to 125 volts caused a maximum increase in signal-to-noise ratio from 3.6 to 7.0 with the preamplifier connected in the system. With the preamplifier disconnected, the maximum increase in signal-to-noise ratio was from 2.7 to 7.

1-15-2. EFFECT OF FREQUENCY. In Tables 1 and 2 of Section I data are given for the signal-to-noise ratio for the echo from a stationary target at 194 mc., 200 mc. and 206 mc. These show that the performance is better at the extremes of the band, being best at 206 mc.

1-15-3. EFFECT OF PREAMPLIFIER. The data in Tables 1 and 2 of Section I show that the use of the preamplifier unit resulted in about a 3 db increase in the signal-to-noise ratio, taking the average of the 110-volt readings.

1-16. PULSE CHARACTERISTICS. Using the duty cycle readings in Tables 1 and 2 of Section I, the over-all pulse length was found to decrease from 9 to 3 microseconds as the line voltage was increased from 95 to 125 volts. This change in pulse length is normal in a self-quenched radar oscillator.

1-16-1. BANDWIDTH MEASUREMENTS. A "pulse transmission spectrometer" was used to find the bandwidth of the transmitted pulse measured at half maximum voltage. Two runs were made, giving pulse bandwidths of 306 kc and 280 kc, or an everage of 293 kc.

1-17. ANTENNA TESTS. Tests were made to find the antenna patterns of the SC-2, BL, and BG antennas. Standing wave ratio variations with frequency were found for each separate antenna.

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1-17-1. DESCRIPTION OF ANTENNA. The SC-2 antenna consists of a main screen 4' high by 15'2" wide, made of 1" square steel box tubing and faced with 2" diamond mesh screening. This is surmounted by a smaller screen for the BL portion of the antenna, measuring 24" by 10'6". This sub-screen is also constructed of 1" square steel tubing, but is faced with 5/16" copper-clad steel rods strung vertically and so spaced as to subtend equal angles at the BL radiators. The upper screen is detachable from the lower and is held in place by 4 brackets which bolt the lower edge to the top of the main screen, which is in turn braced to the pedestal with ½" round steel tubing. A general layout of the antenna is shown in Plates 1 and 2 of Section I. The SC-2 antenna proper comprises 2 rows of three voltage-fed pairs of horizontal dipoles. These pairs are fed with a current distribution of 1 to 1.45 to 1. The BL antenna consists of 4 vertically polarized current-fed dipoles, so constructed as to be integral with the line balance converters on the 7/8" coaxial line. These radiators carry equal currents. The BG array is fitted in between the SC-2 radiators and feed lines. It is made up of 4 bays, each of which contains three vertically polarized pairs of dipoles. The current distribution between bays if 1 to 1.32 to 1.32 to 1.

1-17-2. ELECTRICAL TESTS OF SC-2 ANTENNA. Plates 3, 4, and 5 of Section I are radiation patterns obtained with a slide back type field strength meter at a distance of 120 feet and at frequencies representing the two ends and center of the yellow band. The beam width at half power is 18.5° at 195 mc., 17° at 200 mc., and 16° at 205 mc. Side lobes were observed 30° and 60° on either side of the main beam, with relative field strengths averaging 11 and 8 per cent respectively. Back radiation did not exceed 3 per cent at any of these frequencies. The pattern is considered quite satisfactory for an array of this type. Plate 6 of Section 1 represents the variation of standing wave ratio (i.e., E_{min}/E_{max}) with frequency. It is better than 50% from 195 to 205.5 mc., which is an acceptable band width. This particular antenna is aligned for 203 mc., where the standing wave ratio is 87%. It is interesting to note that it could also be used in the red band, since it matches the line sufficiently well in the region 173 to 190 mc.

1-17-3. ELECTRICAL TESTS OF BL RECOGNITION ANTENNA. The pattern of the BL antenna for 183 mc. is shown in Plate 7 of Section 1. The beam width is 27°. Side lobes at 45° had a relative field strength of 13%, while back radiation amounted to 12%. The BL also puts out a horizontally polarized signal of considerable magnitude, which results from excitation of the SC-2 elements through their vertical feed wires. Except for a possible loss in gain, however, this effect is not considered to be serious. Plate 8 of Section I shows standing wave ratios as a function of frequency for the BL section. By the usual criterion, E_{min}/E_{max} larger than 0.50, the band width is 174.5 to 201 mc. While showing a satisfactory alignment, this antenna is peaked for 196 rather than 183 mc. Undoubtedly the operation of the antenna could be improved by the incorporation of a matching stub in the main feeder so that optimum match could be obtained at mid-band.

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1-17-4. ELECTRICAL TESTS OF BG ANTENNA. Plate 9 of Section I is a pattern, taken at 480 mc., of the BG recognition array. The beam width is 8.5°. Side lobes at 16° and 38° show amplitudes of 12% on the right side and 6% on the left side of the forward direction. A 12% lobe appears directly backwards. Some rather sketchy measurements (Plate 10) show that the BG is well matched over its entire band, 460 to 500 mc.

1-17-5. ROUGH ANTENNA PATTERN. During the operational tests, rough antenna patterns were made with the Annapolis Radio Towers and with Sharps Island Light as the targets. Plate 11 of Section I shows the curves which were obtained when relative echo heights were plotted against bearing readings. At the half-maximum points the beam-width was 18.5° for the Annapolis Towers and 20° for Sharps Island Light. As noted in paragraph 1-8, a plane flying at 1,000 feet altitude was followed in to 6,200 yards. This corresponds to an elevation angle of 32°.

1-17-6. DUPLEXER. No tests were made on the SC-2 duplexing unit. However, this duplexer is identical to that used in the SC-1 system. The results of the tests on the SC-1 duplexer are included in the SC-1 report, NRL Report No. R-1937, BuShips Problem X75S, dated 16 October 1942.

1-17-7. SUMMARY OF ANTENNA TESTS. The results of the antenna tests are summarized in Table 12 of Section I. There do not seem to be any serious defects in the electrical characteristics of the SC-2 antenna system. As mentioned in paragraph 1-17-3, it might be worth-while to provide for a more careful alighment of the BL recognition section.

1-18. INTERFERENCE. During the operational tests on the SC-2 equipment, other radars were also being used. The only interference noticed on the SC-2 system was from the Japanese radar system. This interference was not sufficient to interrupt SC-2 operation. Only one complaint was received on interference caused by the SC-2 system. The Mark 10 radar system could not be operated successfully when the SC-2 was being used. However, the Mark 10 and SC-2 systems were almost side-by-side in a building and the respective antennas were only about 15 feet apart.

1-18-1. NOISE MEASUREMENTS. Measurements were taken on the noise radiated from the SC-2 system at 200 kc. These data are presented in Table 11 of Section I. The RF leakage was greatest around the upper right-hand door on the transmitter front panel.

1-19. PPI REPEATER. A General Electric pre-production PPI Repeater unit was connected to the master PPI unit of the SC-2 equipment and tested for general operation. It was operated merely to find out if it would perform satisfactorily before undergoing mechanical and electrical tests at NRL. No comparison tests were made with any other parts of the SC-2 system.

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1-19-1. DESCRIPTION. Plate 3 of Section I shows the PPI repeater unit. There are four ranges: 7.5 miles, 20 miles, 75 miles and 200 miles. A four-position switch enables the unit to accept pulse repetition rates of 60, 200, 400 or 800-1000 pulses per second. The power, synchronizing and video voltages are obtained from the master PPI unit.

1-19-2. INSTALLATION. The PPI repeater unit was installed according to the "Advance Instruction Book" furnished with the unit. The instructions were adequate. For convenience, the unit was located adjacent to the SC-2 system, with short cables between the PPI repeater and the master PPI units.

1-19-3. DEFECTS. Because of the limited scope of tests on the PPI repeater, no investigation was made of defects. It was noticed, however, that none of the range scales lined up with the range circles on the cover over the face of the scope. In one case, for the 20-mile range, the range-adjusting potentiometer control did not have enough variation to properly adjust the range.

1-19-4. PPI REPEATER SUMMARY. The PPI repeater unit worked satisfactorily when connected to the master SC-2 PPI unit, except for adjustment of range scales.

<u>1-20. ANTENNA SYSTEM DEFECTS</u>. Those defects in the antenna system which hindered the installation or the operation of the SC-2 system, and those noted during the antenna tests, are listed below.

1-20-1. PEDESTAL TERMINAL STRIPS. It was found very difficult to connect the antenna cable to terminal strip #52 in the pedestal, due to the proximity of the drive motor. It is recommended that the internal wiring be connected to the top row of terminals on terminal board #52, leaving the lower row of terminals available for external connections.

1-20-2. PEDESTAL LABEL. On the antenna pedestal is a plug which, if removed, prevents rotation of the antenna. It is recommended that a warning label be placed on the pedestal adjacent to this plug. This label should caution the operator to remove the plug before working on the antenna.

<u>1-21. TRANSMITTER DEFECTS</u>. Very little trouble was experienced with the transmitter unit. The few defects are listed below.

1-21-1. OUTPUT COUPLING CONTROL. The output coupling control covers only 96° out of a possible 100° on the scale. It is recommended that this control be adjusted or modified so the full 100° can be used.

1-21-2. MATCHING CONTROL. The matching control dial on the transmitter covers but 94° out of a possible 100° on the scale. It is recommended that this control be adjusted or modified so the full 100° can be used.

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1-21-3. FILAMENT VOLTAGE ADJUSTING TRANSFORMER. Fluctuating filament voltage was observed when the transmitter was turned on for the first time. The trouble was caused by insufficient pressure of a brush on the winding of the filament voltage adjusting transformer. This brush was chipped on one corner. There were no spare brushes. The brush holder stuck slightly in the support hole. It is recommended that adjusting transformers be carefully inspected at the factory to insure proper operation.

1-21-4. PULSE INDICATOR. There was no mention of the pulse indicator in the preliminary installation book. Inexperienced personnel would not know what tubes, if any, should be installed in this unit. It is recommended that the installation book be modified to include instructions pertaining to the installation of the pulse indicator.

1-21-5. TRANSMITTER SPARKOVER. Some trouble was experienced with sparkover from the screwheads on the coupling bar along the mycalex support to the filament frame shield. It is recommended that an investigation be made with regard to eliminating this source of sparkover.

1-22. CONTROL SYSTEM DEFECTS. During the installation and operational tests of the SC-2 equipment, various defects were noted in the control unit and associated units. These defects are listed below with appropriate recommendations.

1-22-1. NAME PLATES. Both the amplidyne unit and the line step-down transformer had temporary name plates. These two items were probably shipped before the proper name plates were available. It is recommended that the proper name plates be attached to amplidynes and transformers before shipment is made.

1-22-2. AMPLIDYNE WIRES. The wires in the amplidyne unit were incorrectly labelled. The induction motor leads were supposed to be marked L_1 and L_2 but were marked T_1, T_2, T_3 and T_4. Since these four wires were connected in pairs, it was assumed that the two resultant lead combinations were equivalent to L_1 and L_2. It is recommended that the amplidyne wires be correctly labelled before shipment.

1-22-3. CONTROL UNIT TERMINAL BOARD. The instructions in the preliminary installation book did not mention all wiring to be installed. Trouble was experienced in obtaining pedestal operation. Finally, a jumper wire was put from terminal 16-6 to 16-7, thus supplying line voltage to the control amplifier unit. It is recommended that the installation book show complete wiring instructions.

[redacted]

1-22-4. CONTROL UNIT CABLES. The cables from the control unit to the terminal boards on the rear of the cabinet are not long enough to permit the withdrawal of the unit from the cabinet for servicing. When the unit is pulled out and balanced precariously on the front edge of the cabinet, the selenium rectifier is likely to short to the cabinet. It is recommended that these cables be lengthened about six inches.

1-22-5. ANTI-HUNT CONTROL. The anti-hunt control is located in the rear of the control unit. In order to adjust it the operator must reach far into the unit, incurring probable contact with "live" circuits. It is recommended that the anti-hunt control be placed closer to the front panel of the control unit or that provision be made for adjusting it without removal of the control unit from its cabinet.

1-22-6. CONTROL UNIT VARIAC. The plate voltage control knob can be turned below zero setting on the scale. The transmitter power goes on when the knob is turned to either side of zero. The brush contact on the variac broke off once when the knob was turned below zero. It is recommended that some arrangement be used to prevent the control knob from going below zero.

<u>1-23. RECEIVER-INDICATOR DEFECTS.</u> A number of defects in the receiver-indicator unit were noted during the installation and operational tests. These are listed below. Other defects will be found in Section III of this report.

1-23-1. CABLE CLEARANCE. The cables connecting to terminal boards TB60 and TB61 were found to have insufficient clearance on the right side of the receiver-indicator assembly. The insulation on the cable was scraped every time the unit was pulled out of or pushed into the cabinet. It is recommended that sufficient clearance be given these cables.

1-23-2. CONNECTION DIAGRAM. A four-wire cable from the receiver-indicator to the control unit was not shown on connection diagram PP-7762550, although it was mentioned in the text of the preliminary installation book. As this diagram was used almost exclusively during the installation procedure, there was a delay in getting power to the receiver-indicator unit. It is recommended that the connection diagram include this four-wire cable.

1-23-3. RECTIFIER PLATE LEADS. The two leads which are attached to the plate caps of the 2X2 tubes in the receiver-indicator power supply were interchanged during the installation. This resulted in no DC output voltage from the power supply. It is recommended that a means of identification be used to properly identify the leads to the tubes.

[redacted]

1-23-4. PREAMPLIFIER. When first installed, there was no power to the preamplifier unit. This trouble was due to a misprint on Page 9 of the preliminary installation book. It was necessary to change a lead terminal from board TB61-5 to board TB62-5 in the receiver-indicator unit. It is recommended that the installation book be corrected to show the proper termination of this lead.

1-23-5. INSTRUCTION BOOK. No instruction book was furnished with the SC-2 equipment. Considerable delay resulted from lack of information on control "QQ" on the front panel of the receiver-indicator unit. By elimination of controls, "QQ" was found to control the step on the display. There were many other needs for an instruction book. It is recommended that an instruction book be available before an SC-2 installation is made.

1-23-6. JUNCTION BOX BUSHING. The outer bushing in junction box connector J-901 was found to be about 3/16 inch too short. Consequently, the outer braid of the cable could not be clamped as per the instructions in diagram K7889274 of the installation book. The other six cable connectors on the box were in the same condition. It is recommended that the outer bushings be increased 3/16 inch in length.

1-23-7. HOODS. No provision was made for mounting a hood on the A scope or a hood on the P scope. Although normally used in dark surroundings, there will be occasions when the SC-2 equipment will be used in lighted areas. It is recommended that provisions be made for mounting a hood on the A scope and a hood on the P scope.

1-23-8. BACK TRACE. On the 375 mile range of the A scope the back trace was not completely suppressed. Approximately one-third of the return trace could be seen. It is recommended that the return trace be completely suppressed.

1-23-9. GROUND STRAP. There is a grounding strap from the receiver chassis to the receiver sliding track. This strap was found to be broken during the operational tests. It is recommended that a more reliable strap be used.

1-23-10. CONNECTION DIAGRAM. The installation book does not show the connections inside the junction box. It is recommended that the installation book include a connection diagram for the junction box.

1-23-11. INSTALLATION BOOK. The installation book, which is only "Restricted," mentions "15 mile range synchro," "75 mile range synchro," etc. No mention should be made of the range of the SC-2 equipment in a restricted book.

[redacted]

1-23-12. SHORT ITEMS. A large number of tubes were missing from the regular and spare parts boxes. There was no spare quartz crystal for the receiver-indicator. In some cases, the quantities of some items were just sufficient for those required in some of the units. It is recommended that a complete set of spare parts be furnished with the equipment.

1-24. PPI DEFECTS. Those defects in the PPI unit which interferred with the installation and operation of the unit are listed below.

1-24-1. PPI HOLDING SCREWS. The screws holding the PPI unit to its cabinet do not properly engage. The knurled heads turn so hard that pliers are necessary to secure the unit in its cabinet. There was an insufficient quantity of these holding screws to withstand the shocks encountered in service. It is recommended that the number of these holding screws be increased and that care be taken so they will screw into place easily without the aid of tools.

1-24-2. PPI CABINET MOUNTING HOLES. The mounting holes on the top of the PPI cabinet were slightly misaligned. Consequently, the inter-unit mountings could not be used with the bolts furnished. Smaller sized bolts were used. It is recommended that these mounting holes be located more accurately.

1-24-3. PPI SPARE PARTS PACKING SLIP. There was no packing slip for the PPI spare parts box. It is recommended that packing slips be included in all parts boxes.

1-24-4. PPI CABLES. Two coaxial cables (P2004 - P2601 and P2005 - P2602) for the PPI unit were furnished with male connectors instead of the necessary female connectors. Only two connectors were in the spare parts box. While preparing to replace the connector on P2005, the center conductor slipped out freely from its soldered connection. It is recommended that the proper connectors be used and that they be firmly soldered to the cables.

1-24-5. PPI CABLE ROUTE. There was an indefinite route for the three coaxial cables from the video unit. To bring them out at the top would cause damage to the cables due to the small clearance at the cabinet opening. To bring them out through a small hole in the rear of the unit would cause the cables to rest on the rectifier tubes. The route finally used was between the bank of condensers and the ventilation shield. It is recommended that a safe route be found for these cables, rearranging the parts of the chassis if necessary. The installation book should give instructions as to the route to be used.

[redacted]

1-24-6. PPI TERMINAL CABLES. The laced cables connecting to terminal boards TB74 - TB75 - TB78 - TB 79 often were caught in front of the release hardware on the sliding track. These cables are not long enough to permit the withdrawal of both the scope and video units at the same time. It is recommended that some sort of clamps be provided to hold the cables clear of the release mechanism. It is further recommended that the cable lengths be increased sufficiently to allow the withdrawal of the scope and video units for simultaneous servicing.

1-24-7. SECTOR SWEEP. The sector sweep would not operate until about 120° beyond the index line. It was necessary to remove the dial cover, disengage the sector and bearing control gears, and to remove a small gear which engaged the dial. The index line was moved to bisect the sector angle. Then the engaging gear was replaced. It is recommended that the sector sweep be tested for proper operation before shipment.

1-24-8. SECTOR-BEARING CONTROLS. The meshing gears on the sector and bearing controls required too much force to engage or disengage them. It is recommended that the shafts of these two controls be better centered so the gears will mesh properly.

1-24-9. CENTERING CONTROL. The centering control barely permitted centering of the PPI trace. No lock was provided for this control. It is recommended that the centering control be designed to permit the PPI trace to have a margin of movement on each side of center. It is further recommended that a lock be put on the centering control.

1-24-10. MARKER PIP. The marker pip was about a mile long on all PPI ranges. It was most noticeable on the 20 mile range. The pip did not entirely disappear when the marker switch was turned off thus interfering with faint echoes. It was impossible to turn the marker pip off without turning the IFF on. It is recommended that an effort be made to reduce the length of the marker pip and that means be found to completely eliminate it from the trace when the marker switch is off. It is further recommended that the Mark-IFF switch be modified to have a neutral position.

1-24-11. RELAY. The two holding contact wires on PPI relay K2200 were covered with large blobs of solder on the terminals. Intermittent shorts between the solder blobs resulted in unpredictable changes of sector sweep angle, position and direction. It is recommended that better workmanship be used on soldered wire connections.

1-24-12. PPI RANGE SWITCH. The range switch contact on the 75 mile range became defective, resulting in an erratic scope trace. It is recommended that a more reliable switch be used.

[redacted]

1-24-13. PPI RELEASE HARDWARE. There was insufficient spring action on the release hardware arrangement which prevents the PPI sweep unit from slipping entirely out of the cabinet. It was possible to pull this unit from the cabinet without pressing the release. It is recommended that the spring action on all release arrangements be checked for proper operation before shipment.

1-25. SUMMARY OF DEFECTS AND RECOMMENDATIONS. The following defects were noted, and recommendations made, as a result of the operational tests on the SC-2 equipment. The numerals in parentheses refer to the paragraph in the main body of the report in which this item is discussed. The defects are not arranged in the order of their importance.

1-25-1. PEDESTAL TERMINAL STRIPS (1-20-1). The internal wiring in the pedestal should be connected to the top row of terminals on terminal board TB52.

1-25-2. PEDESTAL LABEL (1-20-2). A label should be attached to the pedestal adjacent to the safety pull-out plug, to explain the purpose of this plug.

1-25-3. MATCHING CONTROL (1-21-2). The full 100° scale on the transmitter matching control should be used.

1-25-4. OUTPUT COUPLING CONTROL (1-21-1). The full 100° scale on the transmitter output coupling control should be used.

1-25-5. FILAMENT VOLTAGE ADJUSTING TRANSFORMER (1-21-3). Filament voltage adjusting transformers should be carefully inspected at the factory for proper operation.

1-25-6. PULSE INDICATOR (1-21-4). The preliminary installation book should include instructions pertaining to the installation of the pulse indicator.

1-25-7. TRANSMITTER SPARKOVER (1-21-5). An investigation should be made to eliminate sparkover in the transmitter along the mycalex coupling bar support.

1-25-8. NAMEPLATES (1-22-1). Proper nameplates should be attached to the amplidyne and line step-down transformer.

1-25-9. AMPLIDYNE WIRES (1-22-2). The wires coming out of the amplidyne unit should be correctly labelled.

1-25-10. CONTROL UNIT TERMINAL BOARD (1-22-3). The preliminary installation book should show complete wiring instructions for the control unit terminal boards.

[redacted]

1-25-11. CONTROL UNIT CABLES (1-22-4). The cables from the control unit to the terminal boards on the rear of the cabinet should be lengthened about six inches.

1-25-12. ANTI-HUNT CONTROL (1-22-5). The anti-hunt control should be placed closer to the front panel of the control unit, or provision should be made to adjust it without removing the chassis from the cabinet.

1-25-13. CONTROL UNIT VARIAC (1-22-6). An arrangement should be used to prevent the variac on the control board from being turned below or past zero.

1-25-14. CABLE CLEARANCE (1-23-1). Sufficient clearance to the cables going to terminal boards TB60 and TB61 should be provided.

1-25-15. CONNECTION DIAGRAM (1-23-2). Connection diagram PP7762550 should show a four-wire cable running from the receiver-indicator unit to the control unit.

1-25-16. RECTIFIER PLATE LEADS (1-23-3). A means of identification should be used to identify the plate cap connections of the 2X2 tubes in the receiver-indicator power supply.

1-25-17. PREAMPLIFIER (1-23-4). A misprint should be corrected on Page 9 of the preliminary installation book.

1-25-18. INSTRUCTION BOOK (1-23-5). No instruction book was furnished with the SC-2 equipment. An instruction book should be provided before SC-2 equipment is installed.

1-25-19. JUNCTION BOX BUSHING (1-23-6). The outer bushings in the junction box should each be increased 3/16 inch in length.

1-25-20. HOODS (1-23-7). Provision should be made to mount a hood on the A scope and a hood on the P scope.

1-25-21. BACK TRACE (1-23-8). The return trace on the A scope should be completely suppressed.

1-25-22. GROUND STRAP (1-23-9). A more reliable ground strap should be used from the receiver chassis to the receiver sliding track.

1-25-23. CONNECTION DIAGRAM (1-23-10). The preliminary installation book should include a connection diagram for the junction box.

1-25-24. INSTALLATION BOOK (1-23-11). No mention should be made of the range of the SC-2 equipment in a "Restricted" installation book.

[redacted]

1-25-25. SHORT ITEMS (1-23-12). A complete set of spare parts should be furnished with the SC-2 equipment.

1-25-26. PPI HOLDING SCREWS (1-24-1). The number of screws holding the PPI chassis to its cabinet should be increased and care should be taken so they will screw into place easily without the aid of tools.

1-25-27. PPI CABINET MOUNTING HOLES (1-24-2). The mounting holes on the top of the PPI cabinet should be located more accurately.

1-25-28. PPI SPARE PARTS PACKING SLIP (1-24-3). A packing slip should be included in the PPI spare parts box as well as in other boxes.

1-25-29. PPI CABLES (1-24-4). Proper connectors should be used and firmly soldered to all coaxial cables.

1-25-30. PPI CABLE ROUTE (1-24-5). A safe route should be found for the three coaxial cables coming from the video unit.

1-25-31. CABLE ROUTE INSTRUCTIONS (1-24-5). The preliminary installation book should give instructions as to the route to be used for the three coaxial cables coming from the video unit.

1-25-32. PPI TERMINAL CABLES (1-24-6). The lengths of the laced cables connecting to terminal boards TB74-TB75-TB78-TB79 should be increased sufficiently to permit the withdrawal of the scope and video units for simultaneous servicing.

1-25-33. CABLE CLAMPS (1-24-6). Some sort of clamps should be provided to hold the laced cables connecting to terminal boards TB74-TB75-TB78-TB79 clear of the release mechanism.

1-25-34. SECTOR SWEEP (1-24-7). The sector sweep should be tested for proper operation before leaving the factory.

1-25-35. SECTOR BEARING CONTROLS (1-24-8). The shafts for the sector and bearing controls should be better centered so the gears will mesh properly.

1-25-36. CENTERING CONTROL (1-24-9). The centering control should be designed to permit the PPI trace to have a margin of movement on each side of the center.

1-25-37. CENTERING CONTROL LOCK (1-24-9). A lock should be provided on the PPI centering control.

1-25-38. MARKER PIP (1-24-10). An effort should be made to reduce the length of the marker pip on all ranges of the PPI scope.

[redacted]

1-25-39. RELAY (1-24-11). Better workmanship should be used on PPI relay K2200 and on all soldered wire connections.

1-25-40. PPI RANGE SWITCH (1-24-12). A more reliable range switch should be used on the PPI unit.

1-25-41. PPI RELEASE HARDWARE (1-24-13). The spring action on all release arrangements should be checked for proper operation before leaving the factory.

1-25-42. SWITCH (1-24-10). The "mark-IFF" switch should be modified to have a neutral position.

1-26. <u>CONCLUSIONS.</u> The operational tests on the SC-2 equipment lead to the following conclusions.

1-26-1. The maximum range for consistent following of small planes was 16 miles for a plane flying at 200 feet altitude, 25 miles for a plane flying at 1000 feet altitude, and 70 miles for a plane flying at 10000 feet altitude. A YP boat was followed consistently to 9550 yards and the Norfolk Boat was consistently followed to 21700 yards. These ranges are satisfactory for this type of radar equipment.

1-26-2. The mechanical operation of the PPI unit is not satisfactory. An effort should be made to improve the mechanical features.

1-26-3. The tests on the SC-2 system show that the absolute range accuracy is not better than 0.5 mile on the 75 mile scale and 40 yards on the 30000 yard scale, that the variation with line voltage is as high as 500 yards on the 30000 yard scale, that the effect of warmup is 300 yards on the 30000 yard scale and 0.2 mile on the 75 mile scale, and that the range reset accuracy is 60 yards for the A scope and 300 yards for the P scope. The variation with line voltage is considered excessive. Otherwise, the range accuracy is satisfactory.

1-26-4. There was a difference of $0^\circ 43'$ between bearing readings on the A and P scopes, a static bearing backlash on the A scope of $0^\circ 19'$, and a dynamic bearing backlash on the P scope of $0^\circ 42'$. There was a mean deviation for bearing accuracy of 2.1° when following a moving ship. These bearing accuracies are satisfactory.

1-26-5. The General Electric PPI repeater unit operated satisfactorily when connected to the SC-2 system.

[redacted]

1-26-6. The SC-2 antenna has a beam width of 17° at 200 mc; its side lobes measure only 11% of the field strength of the main beam. This is a result of unequal current distribution among the radiator elements. In general, the electrical features of this antenna appear to be entirely satisfactory. It was observed, however, that a heavy coating of ice makes two of the side lobes very prominent and reduces the maximum range and sensitivity of the system.

[redacted]

TABLE I

SC-2 SYSTEM

Pre-amplifier in

Target: Sharp's Island - Observed Range 14,900 yds. at Start of Run

Line Voltage Volts	Range yds.	Freq. mc.	S/N Ratio	Duty Cycle %
		194mc.		
110	14,900	194	4.0	.021
95	15,300	195	3.3	.028
99	15,200	195	5.0	.026
121	14,900	194	6.0	.019
125	14,900	194	6.3	.019
		200mc.		
110	14,900	200	3.6	.023
95	15,300	200	5.0	.0325
99	15,200	200	6.0	.028
121	14,900	200	6.5	.0215
125	14,900	200	7.0	.021
		206mc.		
110	14,900	206	8.3	.038
95	15,000	206	6.7	.054
99	14,950	206	8.0	.045
121	14,900	205.5	8.0	.035
125	14,900	205.5	11.5	.038

NOTE: After adjusting the equipment for optimum performance at the given frequency at a line voltage of 110 volts, the readings at the other line voltages were taken without making any tuning adjustments. The S/N ratio, as used for these tests, is defined in Table 4 of Section I.

[redacted]

TABLE 2

SC-2 SYSTEM

Pre-amplifier out

Target: Sharp's Island - Observed Range 15,000 yds. at Start of Run

Line Voltage Volts	Range Yds.	Freq. mc.	S/N Ratio	Duty Cycle %
		194 mc.		
110	15,000	194	4.0	.0215
95	15,200	194.5	3.0	.034
99	15,080	194.5	3.0	.028
121	14,850	194	5.0	.019
125	14,800	194	5.5	.018
		200 mc.		
110	15,000	200	2.0	.0245
95	15,175	200.5	1.5	.0335
99	15,100	200	1.7	.030
121	14,800	200	3.0	.023
125	14,700	200-	3.7	.023
		204 mc.		
110	14,800	204	5.5	.030
95	15,200	203.5	2.7	.0425
99	15,100	204+	2.7	.037
121	14,800	203.5	7.0	.0265
125	14,700	204	7.0	.0265

NOTE: See note in Table 1 of Section I

[redacted]

TABLE 3

Summary of Range Data

Target (Elevation in feet)	Aspect	Consistent Observed Range	Maximum Observed Range	Maximum Distance Travelled (yds.)
Norfolk Boat	Stern-on	8600-14800	14800	-- (ice on antenna)
	Stern-on	8550-15600	16600	---
	Stern-on	8800-17050	19650	---
	Stern-on	8100-21700	21700	---
	Stern-on	9000-16600	24000	---
	Bow-on	6800-15000	15000	---
	Stern-on	6800-16900	17600	---
Armed Freighter	Stern-on	10000-21650	23400	---
YP Boat	Stern-on	2350-9550	11200	---
	Bow-on	3900-8300	8300	---
SBD Plane				
200 ft.	Tail-on	5300-32200	32200	60000
200 ft.	Head-on	1800-16800	16800	60000
1,000 ft.	Tail-on	2300-22400	55400	60000
1,000 ft.	Head-on	3700-50000	50000	60000
9,000 ft.	Head-on	5600-62000	114400	180000
10,000 ft.	Tail-on	6550-66800		
		86400-139200	139200	160000
10,000 ft.	Head-on	45200-63400	95600	160000
1,000 ft. to 10 mi., then increasing 1,000 ft. every 10 mi.	Tail-on	6200-74800	74800	74800
Same as above	Tail-on	6700-47600	63400	180000
3,700 ft.	Head-on	6700-76800	82800	82800

[redacted]

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TABLE 4

MAXIMUM RANGE COMPARISONS WITH OTHER SYSTEMS

Maximum Consistent Range in Miles

Target Elevation (feet)		SC-2	CXCA #1	CXCA #2	CXAZ	MA
Norfolk Boat		10.9	7.5	15	7.8	12
SBD Plane	200	16.1	10.5	20	14.5	21
	1000	25.0	--	--	--	--
	2000	--	12.5	24.5	13	22
	6000	--	21	33	20.5	23
	10000	69.6	10	29	--	0
Signal-to-Noise Ratio (Sharps Island Light)		8	2			5

Antenna Heights at NRL Annex: 110 ft. for SC-2, 141 ft. for CXCA #1 and CXCA #2, 110 ft. for CXAZ, and 117 ft. for MA.

Signal-to-Noise Ratio: Obtained from measurements on the echo pip when using Sharps Island Light as the target. For this measurement, the "Signal" is defined as the distance from center of base-line noise to center of noise at the top of the echo. Similarly, the "Noise" is defined as the distance from the top of the semi-persistent base-line noise to the bottom of the semi-persistent base-line noise. The receiver gain control was set so that video-limiting did not limit the echo height.

[redacted]

TABLE 5

Bearing Reset Accuracy

Target: Sharp's Island

Static Test

A Scope		P Scope	
Run 1	Run 2	Run 1	Run 2
103° 45'	104° 15'	104° 30'	105°
104°	103° 15'	104°	103°
103° 30'	103° 30'	105°	104°
103°	104°	103° 30'	105°
103° 15'	104°	104° 30'	104°
104°	104°	103° 30'	104°
103°	103° 45'	105° 30	106°
104°	103° 30'	104°	104° 30'
104°	103° 45'	104°	104° 30'
102° 45'	103° 15'	104°	104°
Average = 103° 31'	Average = 103° 43'	Average = 104° 15'	Average = 104° 24'

A Scope	P Scope
General Average = 103° 37'	General Average = 104° 20'
Mean Deviation = 0° 22'	Mean Deviation = 0° 26'
Maximum Deviation = 0° 52'	Maximum Deviation = 1° 40'

Table 5 of Section I

[redacted]

TABLE 6

Bearing Backlash A Scope

Target: Sharp's Island

Static Test

Clockwise			Counter Clockwise		
Left Bearing	Right Bearing	Computed Average	Right Bearing	Left Bearing	Computed Average
95° 30'	109° 30'	102° 30'	110° 30'	97°	103° 45'
95° 15'	110° 45'	103°	110° 30'	96° 30'	103° 30'
95°	111° 15'	103° 7'	111°	97°	104°
95° 30'	111° 30'	103° 30'	112° 15'	95° 30'	103° 53'
95°	111° 45'	103° 23'	112°	95° 30'	103° 45'
95° 45'	111° 45'	103° 45'	112°	95° 30'	103° 45'
95° 15'	111° 45'	103° 30'	111° 30'	96°	103° 45'
95°	111° 30'	103° 15'	112° 30'	95°	103° 45'
95°	111° 30'	103° 15'	111°	96° 30'	103° 45'
94° 30'	112°	103° 15'	110° 45'	96° 15'	103° 30'

General Average - 103° 25'

General Average - 103° 44'

NOTE: The following procedure was used to determine the static bearing backlash accuracy using the A scope. Using the echo from Sharps Island Light, a line was marked on the face of the A scope at a height corresponding to 2/3 the maximum height of this echo. After rotating the antenna in a counter-clockwise direction until the echo disappeared, the antenna was rotated in a clockwise direction until the top of the echo pip came up to the marked line. The "Left Bearing" reading was noted. The antenna was then rotated further, passing through the maximum echo height, until the top of the echo pip again coincided with the marked line. The "Right Bearing" reading was then noted. Then the same readings were repeated, rotating the antenna counter-clockwise.

[redacted]

TABLE 7

Bearing Backlash P Scope

Target: Sharp's Island

Dynamic Test

Clockwise			Counter Clockwise		
	Observed			Observed	
Min. Bearing	Echo Max. Bearing	Max. Bearing	Max. Bearing	Echo Max. Bearing	Min. Bearing
90°	103°	116°	117°	105°	92°
92°	103°	116°	118°	104°	90°
92°	105°	117°	116°	105°	94°
92°	107°	122°	117°	105°	93°
92°	105°	117°	115°	105°	92°
93°	103°	115°	118°	105°	92°
92°	104°	116°	117°	105°	93°
92°	104°	118°	118°	106°	94°
93°	103°	116°	117°	104°	92°
91°	104°	117°	116°	104°	93°
	General Average			General Average	
91.9°	104.1°	117°	116.9°	104.8°	92.5°
	Computed Echo Max. Bearing				
	104.2°			104.7°	

NOTE: The following procedure was used to determine the dynamic bearing accuracy when using the P scope. The antenna was rotated slowly in a clockwise direction and the bearing readings corresponding to the beginning, middle and the end of the echo on the P scope were noted; similar readings were recorded with the antenna rotating counter-clockwise.

[redacted]

TABLE 8

RANGE RESET ACCURACY

Target: Sharps Island Light at 14760 yards

	A Scope		P Scope	
	Run 1	Run 2	Run 1	Run 2
	14850	14750	15150	15050
	14800	14800	14800	14850
	14850	14800	14900	14750
	14850	14800	15100	14850
	14850	14800	14900	14650
	14850	14800	14800	14800
	14800	14850	15000	14800
	14800	14800	14900	14750
	14800	14750	14800	14650
	14800	14800	14900	14600
Average	14825	14795	14925	14775

General Average for A scope — 14810 yards

Mean Deviation for A scope — 24 yards

Maximum Deviation for A scope — 60 yards

General Average for P scope — 14850 yards

Mean Deviation for P scope — 110 yards

Maximum Deviation for P scope — 300 yards

[redacted]

TABLE 9

Comparative Test

Large Surface Craft (Norfolk Boat)

Range			Bearing		S/N Ratio (Est.)	
SC-2			SC-2		SC-2	
A Scope (yards)	P Scope (yards)	SH (yards)	A Scope (degrees)	SH (degrees)	A Scope	P Scope
12,900	12,800	12,790	38°	37°	6	R3
12,400	12,350	12,300	40°	39°	6	R3
11,950	11,850	11,735	41°	40.5°	7	R4
11,200	11,150	11,230	43°	43°	7	R4
10,800	10,700	10,690	44°	46°	12	R5
10,300	10,200	10,200	50°	49°	12	R5
9,900	9,800	9,790	51°	52°	12	R5
9,400	9,400	9,335	52°	55.5°	12	R5
8,700	8,600	8,810	58°	61°	10	R4
8,400	8,400	8,385	63°	67°	10	R4
8,100	8,100	8,060	72°	73°	10	R4
7,900	7,850	7,870	83°	81.5°	12	R5
7,850	7,850	7,810	93°	92°	Sat.	R5
8,000	7,900	7,910	103°	103°	Sat.	R5
7,200	7,200	7,170	107°	110°	Sat.	R5
6,800	6,750	6,800	107°	109°	Sat.	R5
6,800	6,800	6,800	104°	107°	Sat.	R5
7,400	7,300	7,327	105°	105.5°	Sat.	R5
7,600	7,600	7,580	112°	115°	Sat.	R5
7,800	7,700	7,718	129°	121°	Sat.	R5
8,650	8,600	8,550	133°	128°	Sat.	R5
9,250	9,250	9,170	134°	134°	Sat.	R5
9,950	9,900	9,820	141°	138°	Sat.	R5
10,300	10,300	10,180	141°	140.5°	10	R4
10,800	10,800	10,535	·145°	141°	10	R4
11,700	11,700	11,440	147°	144.5°	8	R3

For A scopes on SC-2 and SH: Assuming 79 yd. zero correction:
- Mean range deviation: 59 yards
- Maximum range deviation: 186 yards

For SC-2 A and P scopes: Assuming 46 yd. zero correction:
- Mean range deviation: 39 yards
- Maximum range deviation: 54 yards

For A scopes on SC-2 and SH: Assuming 0.2 degree zero correction:
- Mean bearing deviation: 2.1 degrees
- Maximum bearing deviation: 7.8 degrees

[redacted]

TABLE 10

Range and Bearing Variations with Time

(Receiver-Indicator tuned properly at start. No re-adjustments until finish of run.)

TIME (hours)	ANNAPOLIS TOWERS Bearing	ANNAPOLIS TOWERS Range	SHARP'S ISLAND LIGHT Bearing	SHARP'S ISLAND LIGHT Range
0	11	21.2 mi.	103	15,100 yds.
1	12	21.2	103	14,900
2	13	21.2	104	14,800
3	14	21.2	104	14,850
4	13	21.0	103	14,800

Calibration checked o.k. at conclusion of run

Range of Annapolis Towers is 20.5 miles

Range of Sharp's Island Light is 14760 yards

[redacted]

TABLE 11

NOISE MEASUREMENTS AT 200 KC

MODEL SC-2 RADAR EQUIPMENT

Position of Locator	Field strength in microvolts/meter
Radiation Measurements	
5 ft. in front of transmitter	
Amplidyne only	18
Amplidyne, indicator, and transmitter filaments	300
Complete system running	1800
5 ft. in back of transmitter (whole system)	400
10 ft. in front of transmitter (whole system)	800
20 ft. in front of transmitter (whole system)	36
Over trench containing transmission line	300
25 ft. in rear of antenna	160
Line Measurements Across Input Variac	
Line to line measurements	
Amplidyne only	85
Amplidyne, indicator and transmitter filaments	2000
Whole system running	1500
Line to ground measurements	
Amplidyne only	8
Amplidyne, indicator and transmitter filaments	225
Whole system running	300

NOTE: These measurements were made with a Model "OF" #40 Interference Locator. Corrections for the residual noise were made for all readings.

Table 11 of Section I

[redacted]

TABLE 12

SUMMARY OF ANTENNA TESTS

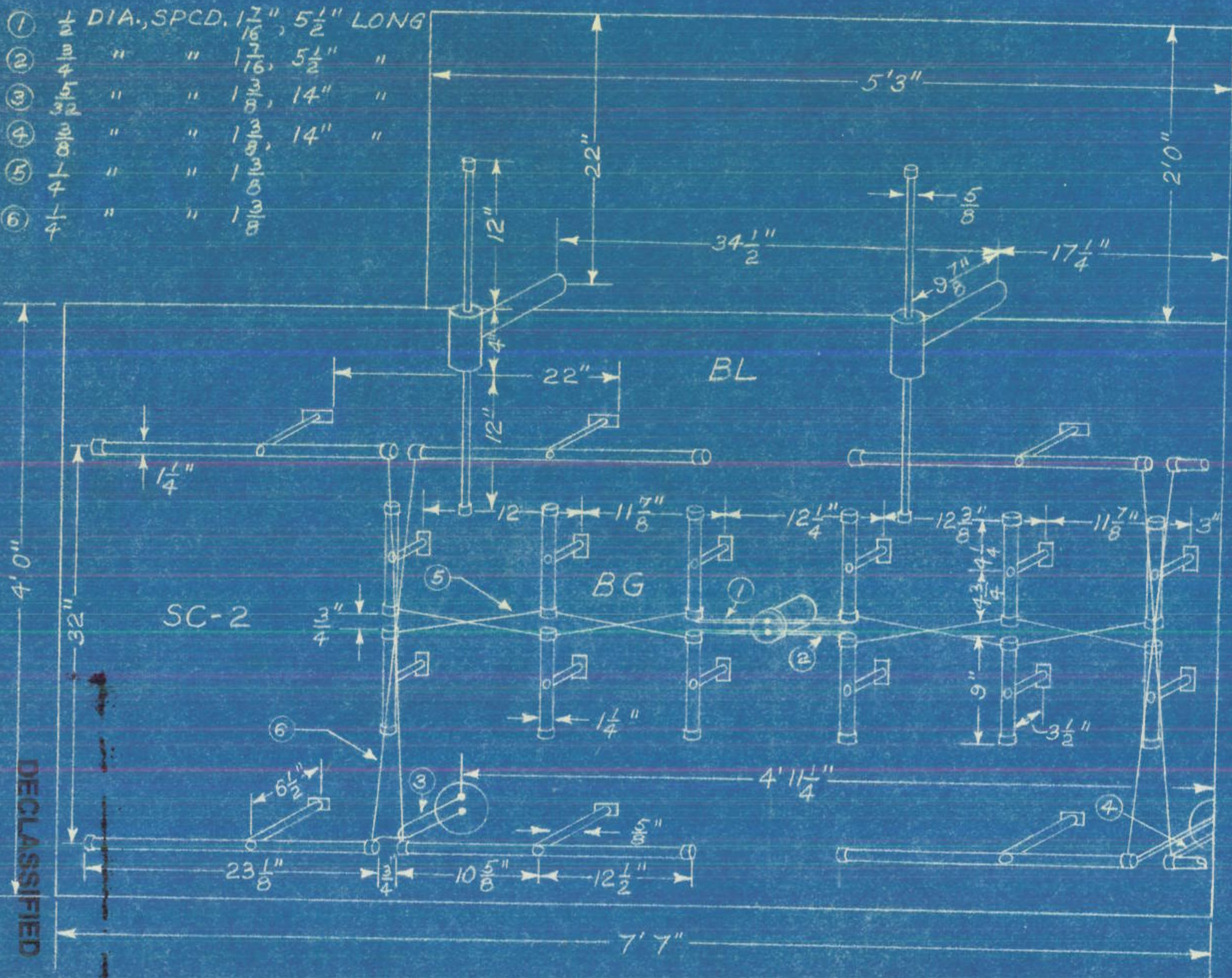
	SC-2 Section			BL Section	BG Section
Frequency, mc	195	200	205	183	480
Beam Width, Degrees	18.5	17.0	16.0	27	8.5
First Side Lobe					
Position, Degrees	31	30	30	45	16
Amplitude, per cent	10	12	11	13	12
Second Side Lobe					
Position, Degrees	60	62	60	--	38
Amplitude, per cent	8	9	10	--	12
Back Radiation, per cent	2	3	3	12	12
Standing Wave Ratio, E_{min}/E_{max}	50	75	54	56	82
Band Width, mc	195 to 205.5 and 173 to 190			175 to 201	Exceeds 460 to 500
Calculated Gain over Dipole, db	13.5			11	17

Table 12 of Section I

[redacted]

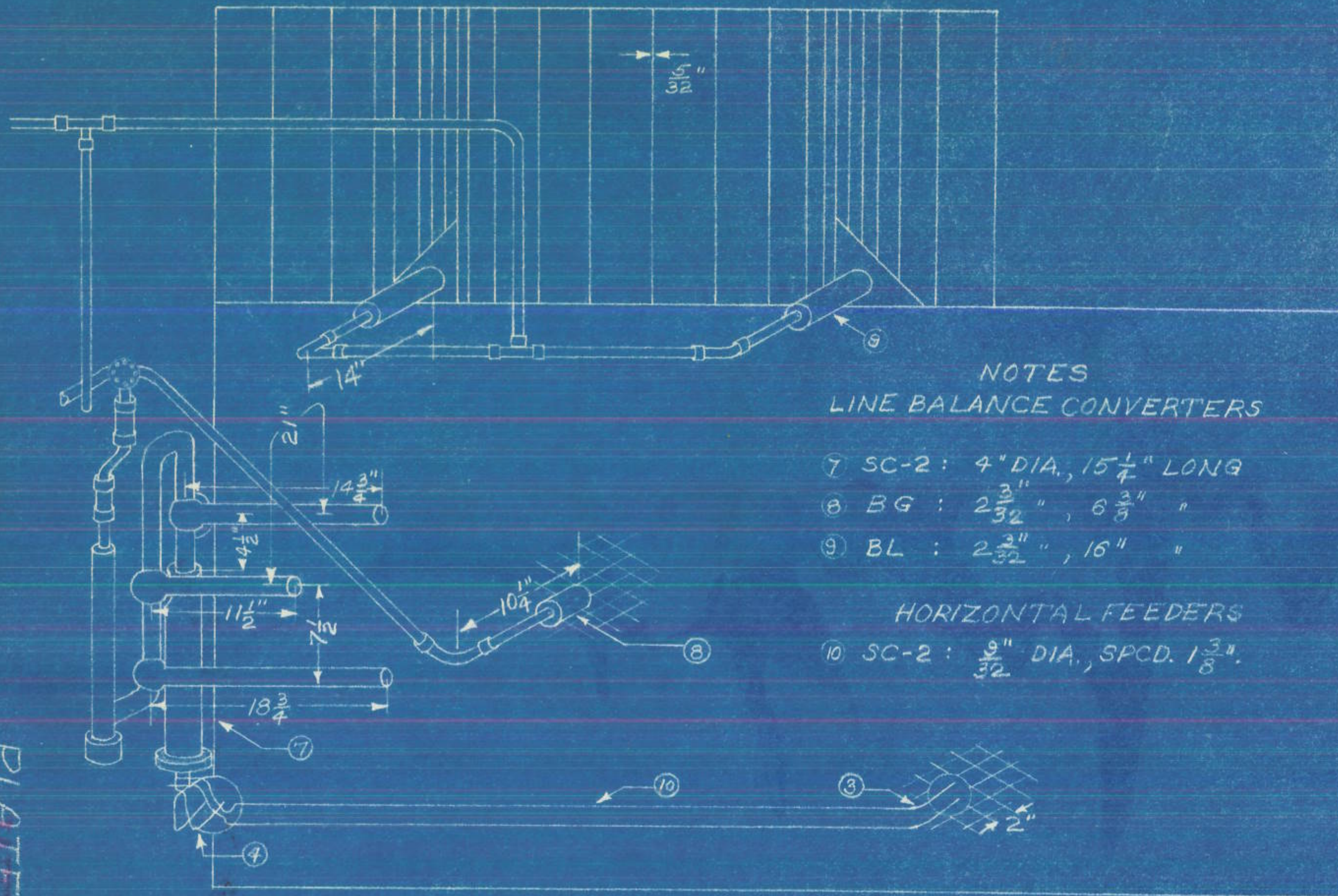
NOTES: TRANSFORMERS

①	$\frac{1}{2}$ DIA.,	SPCD. $1\frac{7}{16}$",	$5\frac{1}{2}$"	LONG
②	$\frac{3}{4}$ "	"	$1\frac{7}{16}$, $5\frac{1}{2}$"	"
③	$\frac{5}{32}$ "	"	$1\frac{3}{8}$, 14"	"
④	$\frac{3}{8}$ "	"	$1\frac{3}{8}$, 14"	"
⑤	$\frac{1}{4}$ "	"	$1\frac{3}{8}$	
⑥	$\frac{1}{4}$ "	"	$1\frac{3}{8}$	



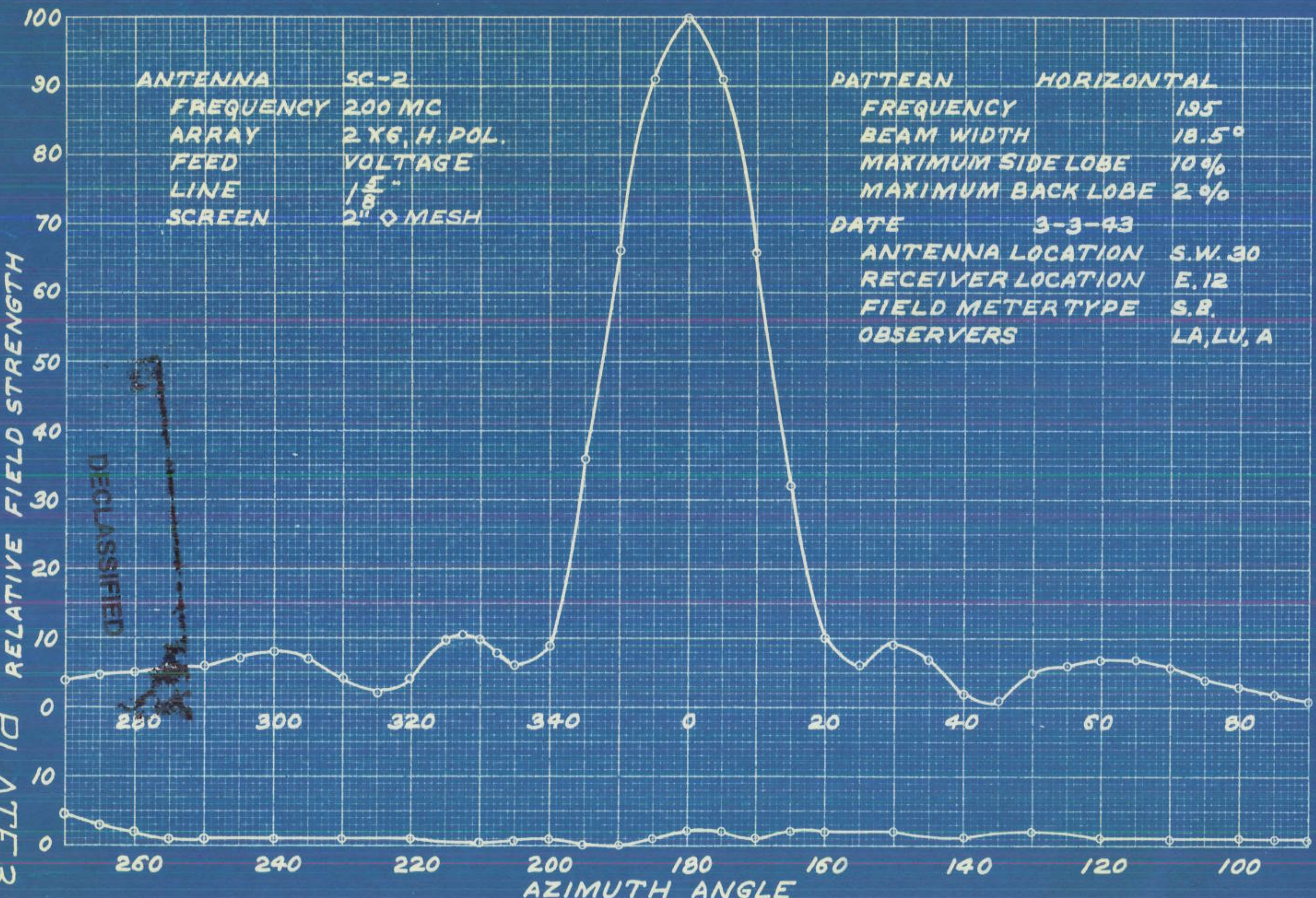
FRONT OBLIQUE OF SC-2 ANTENNA
PROJECTION ANGLE 30°
SHORTENING 0.866:1:1

PLATE 1 SEC



BACK OBLIQUE OF SC-2 ANTENNA
PROJECTION ANGLE 30°
SHORTENING 0.866:1:1

PLATE 2 SEC 1



ANTENNA SC-2
FREQUENCY 200 MC
ARRAY 2 X 6, H. POL.
FEED VOLTAGE
LINE 1 5/8"
SCREEN 2" ◇ MESH
PATTERN HORIZONTAL
FREQUENCY 195
BEAM WIDTH 18.5°
MAXIMUM SIDE LOBE 10%
MAXIMUM BACK LOBE 2%
DATE 3-3-43
ANTENNA LOCATION S.W. 30
RECEIVER LOCATION E. 12
FIELD METER TYPE S.B.
OBSERVERS LA, LU, A
RELATIVE FIELD STRENGTH
AZIMUTH ANGLE
DECLASSIFIED

PLATE 3. SEC. 1

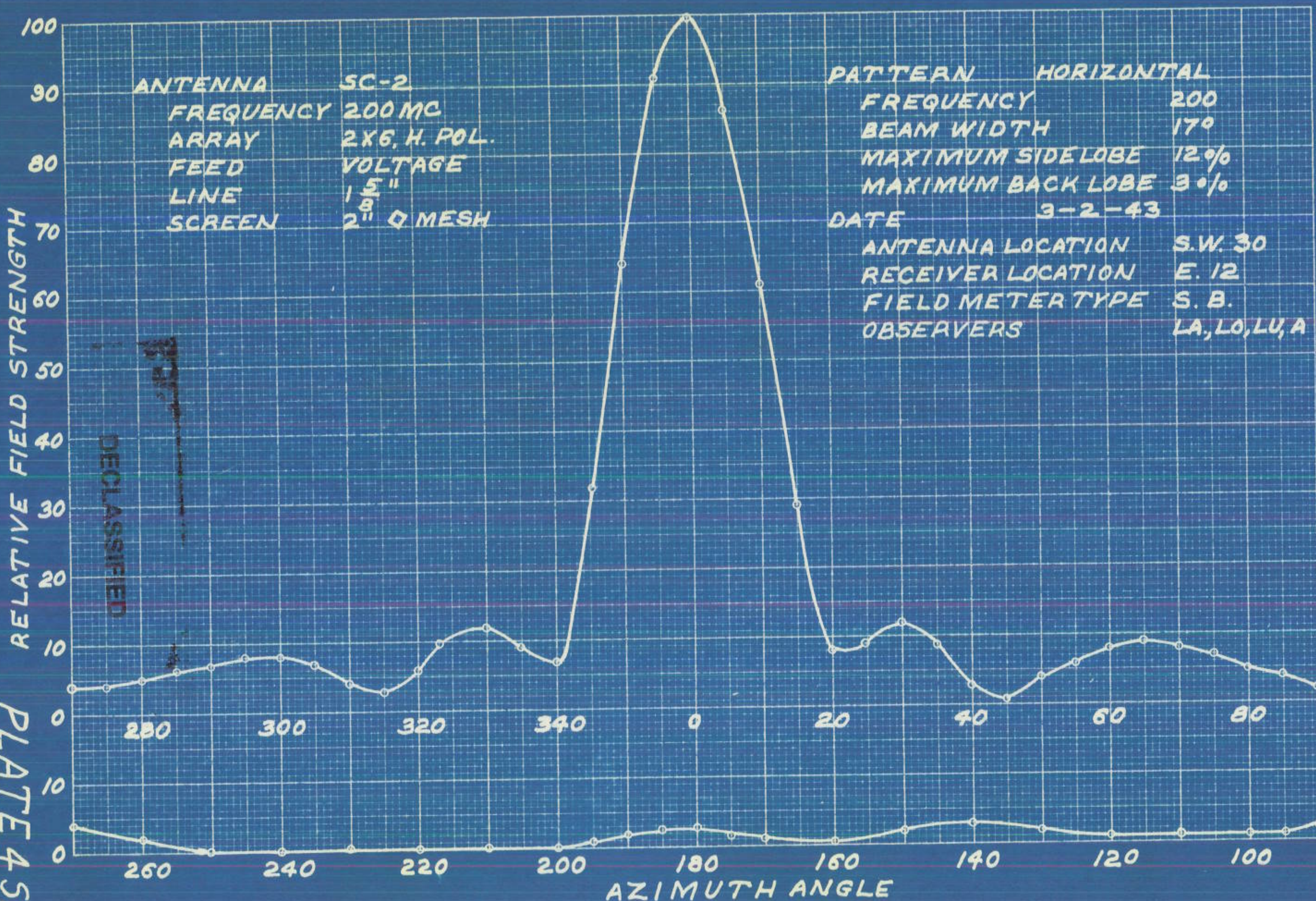
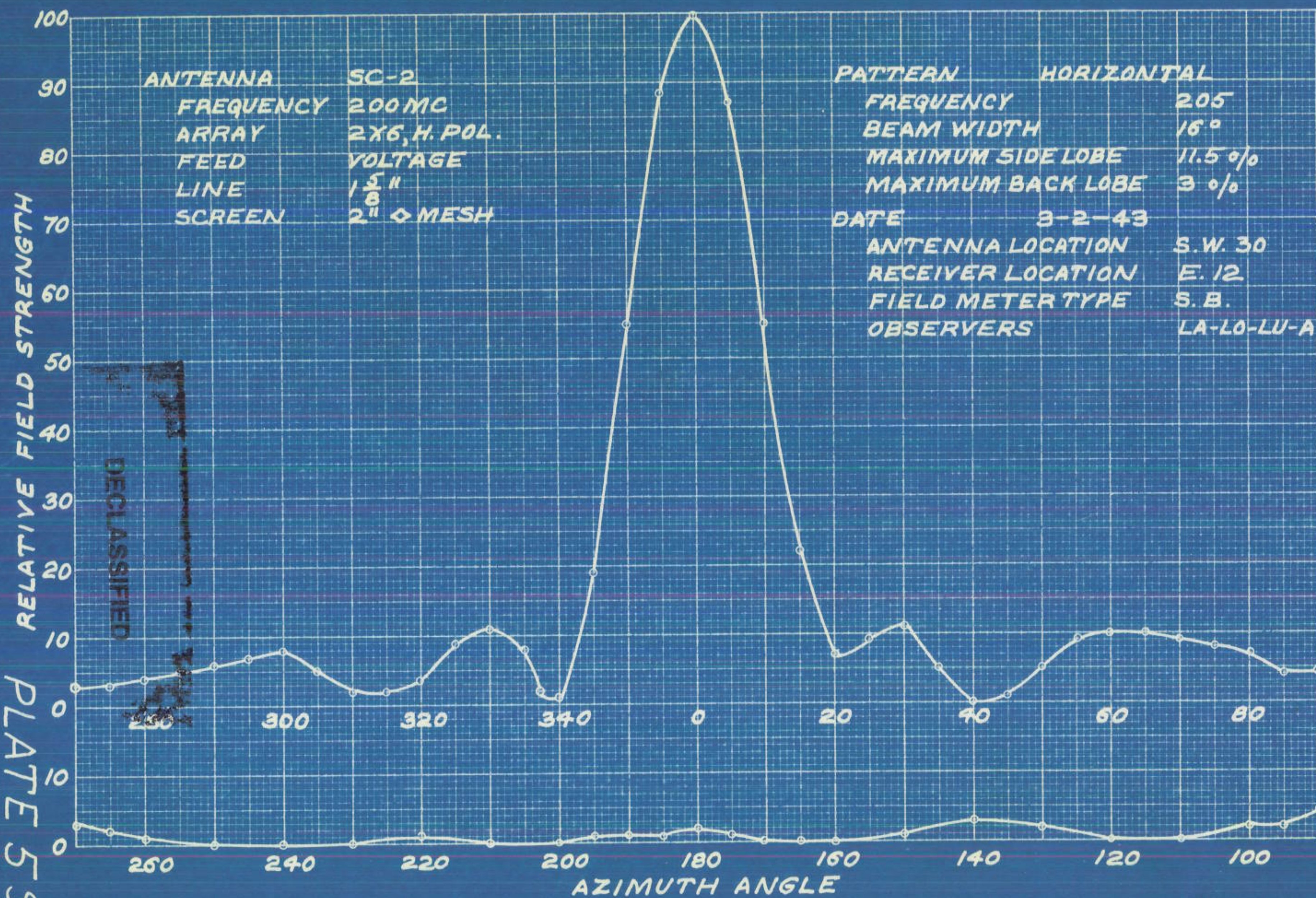
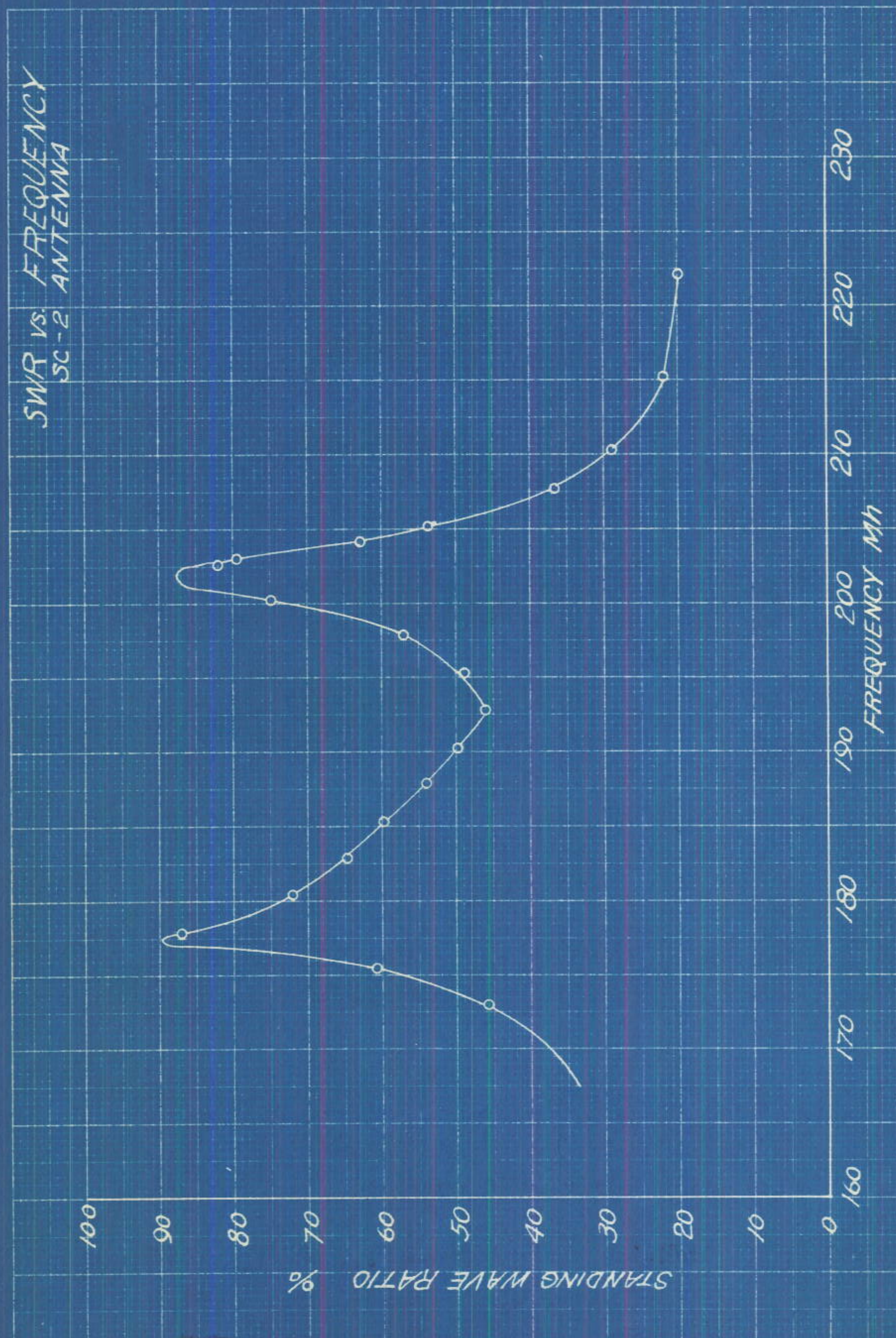

ANTENNA SC-2
FREQUENCY 200 MC
ARRAY 2X6, H. POL.
FEED VOLTAGE
LINE 1 5/8"
SCREEN 2" ◇ MESH
PATTERN HORIZONTAL
FREQUENCY 200
BEAM WIDTH 17°
MAXIMUM SIDE LOBE 12%
MAXIMUM BACK LOBE 3%
DATE 3-2-43
ANTENNA LOCATION S.W. 30
RECEIVER LOCATION E. 12
FIELD METER TYPE S. B.
OBSERVERS LA, LO, LU, A
RELATIVE FIELD STRENGTH
AZIMUTH ANGLE
DECLASSIFIED

PLATE 4 SEC. 1



ANTENNA SC-2
FREQUENCY 200 MC
ARRAY 2X6, H. POL.
FEED VOLTAGE
LINE 1 5/8"
SCREEN 2" ◇ MESH
PATTERN HORIZONTAL
FREQUENCY 205
BEAM WIDTH 16°
MAXIMUM SIDE LOBE 11.5 %
MAXIMUM BACK LOBE 3 %
DATE 3-2-43
ANTENNA LOCATION S.W. 30
RECEIVER LOCATION E. 12
FIELD METER TYPE S.B.
OBSERVERS LA-LO-LU-A
RELATIVE FIELD STRENGTH
100
90
80
70
60
50
40
30
20
10
0
300
320
340
0
20
40
60
80
10
0
260
240
220
200
180
160
140
120
100
AZIMUTH ANGLE

PLATE 5 SEC. I



DECLASSIFIED

PLATE 6 SEC. I

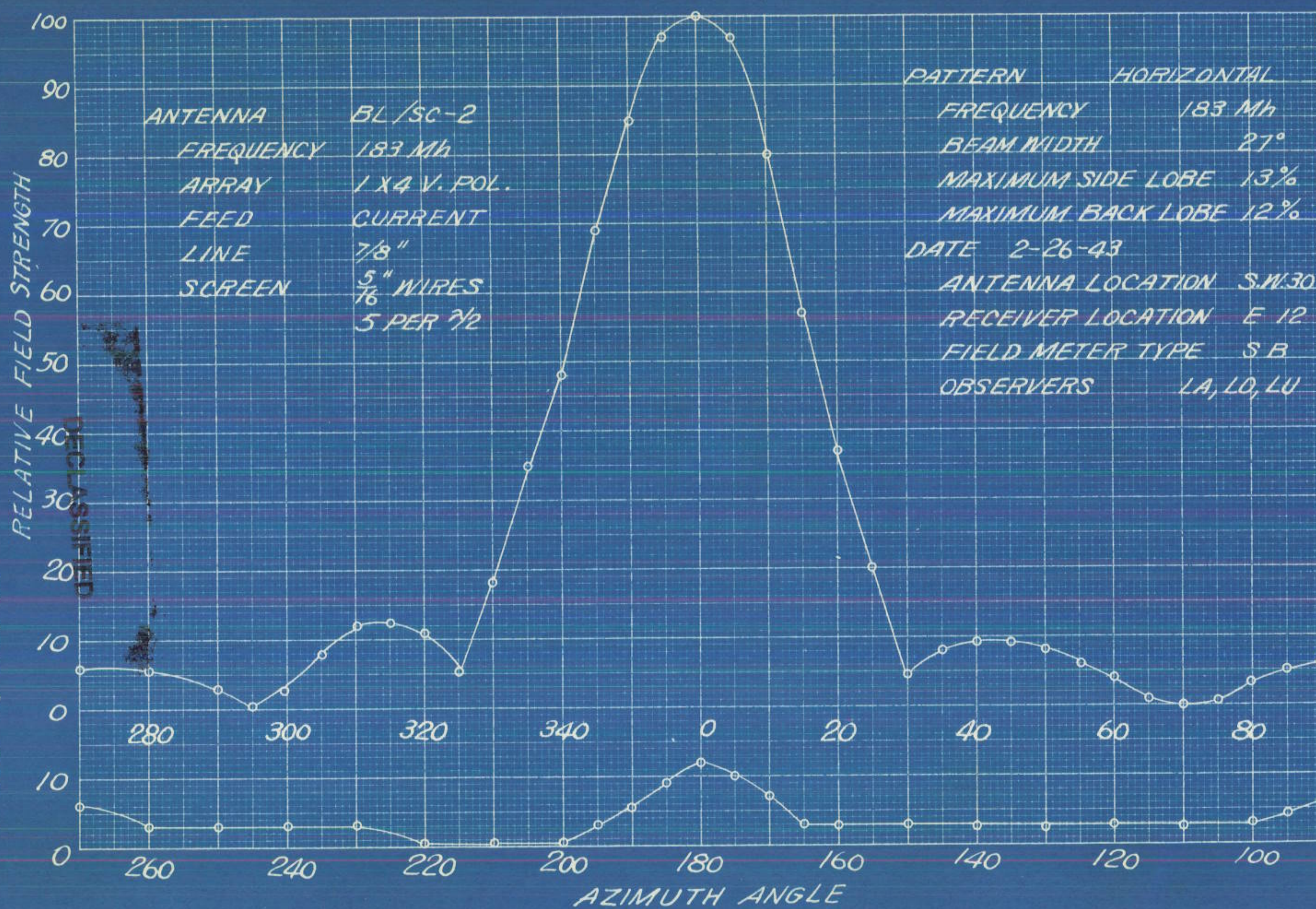

ANTENNA BL/SC-2
FREQUENCY 183 Mh
ARRAY 1 X 4 V. POL.
FEED CURRENT
LINE 7/8"
SCREEN 5/16" WIRES
5 PER 2 1/2
PATTERN HORIZONTAL
FREQUENCY 183 Mh
BEAM WIDTH 27°
MAXIMUM SIDE LOBE 13%
MAXIMUM BACK LOBE 12%
DATE 2-26-43
ANTENNA LOCATION S.W.30
RECEIVER LOCATION E 12
FIELD METER TYPE S B
OBSERVERS LA, LO, LU
RELATIVE FIELD STRENGTH
AZIMUTH ANGLE
100
90
80
70
60
50
40
30
20
10
0
10
0
280
300
320
340
0
20
40
60
80
260
240
220
200
180
160
140
120
100
DECLASSIFIED

PLATE 7 SEC. 1

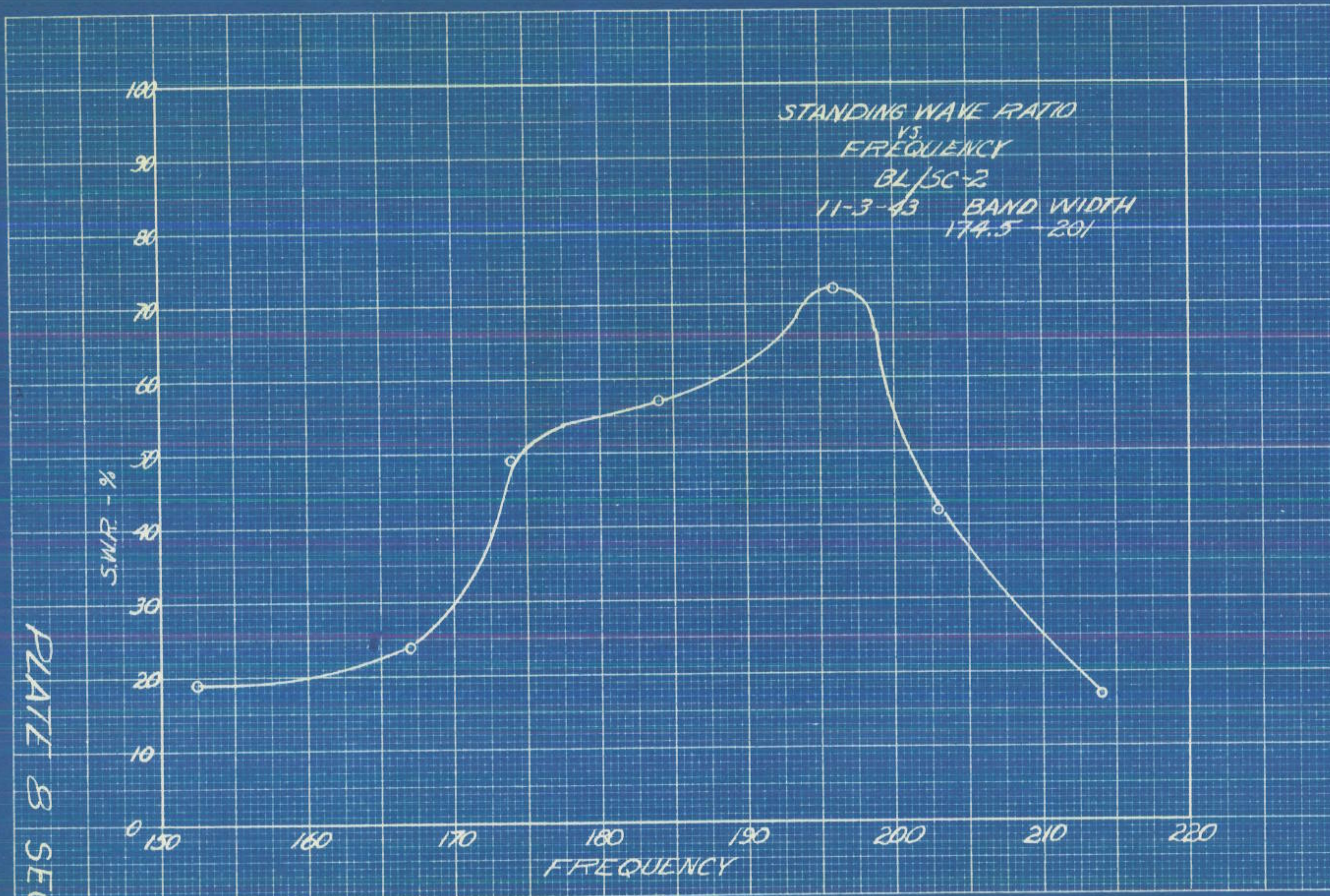

STANDING WAVE RATIO
VS.
FREQUENCY
BL/SC-2
11-3-43
BAND WIDTH
174.5 - 201
SWR - %
0
10
20
30
40
50
60
70
80
90
100
150
160
170
180
190
200
210
220
FREQUENCY

PLATE 8 SEC. 1

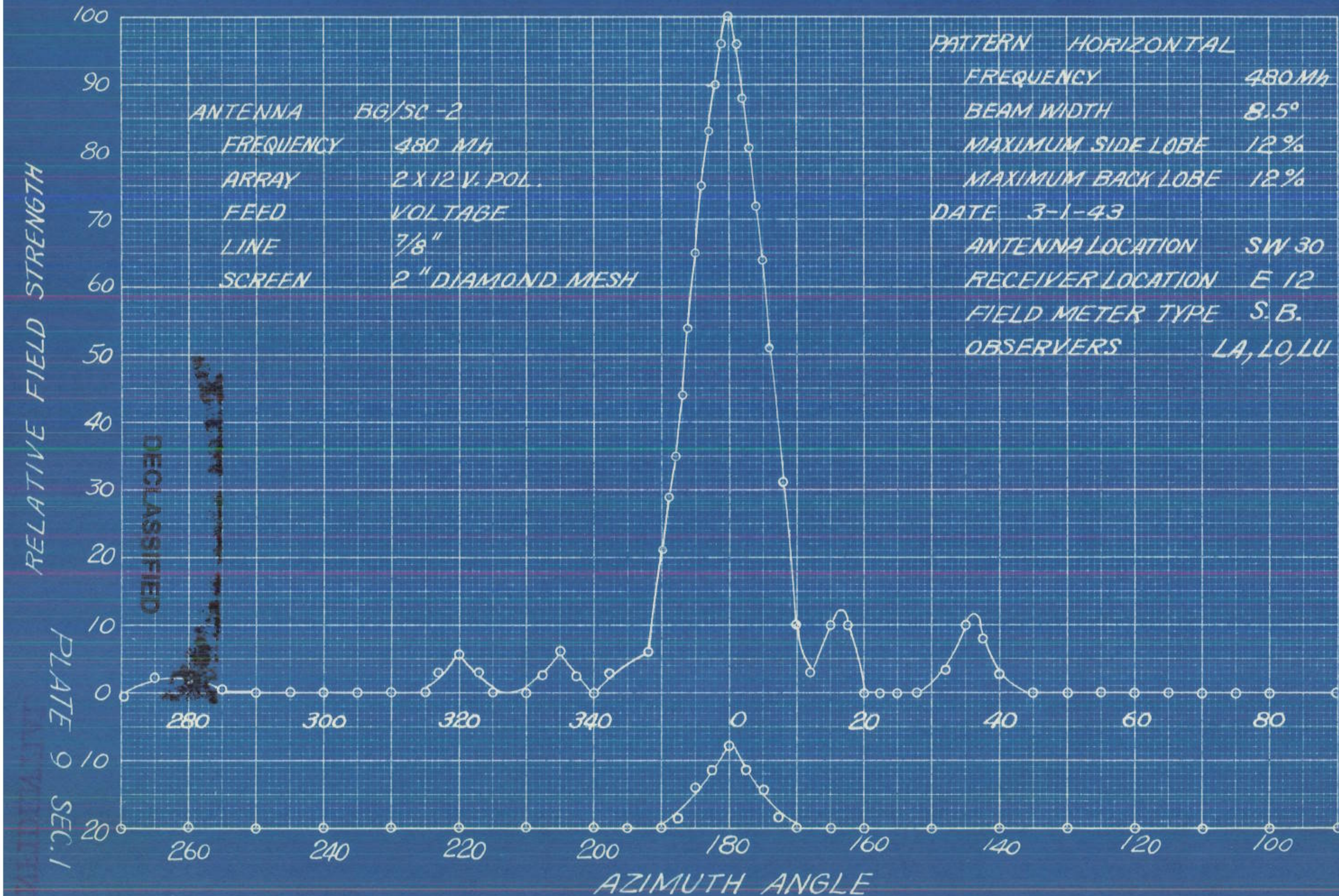

ANTENNA BG/SC-2
FREQUENCY 480 Mh
ARRAY 2 X 12 V. POL.
FEED VOLTAGE
LINE 7/8"
SCREEN 2" DIAMOND MESH
PATTERN HORIZONTAL
FREQUENCY 480 Mh
BEAM WIDTH 8.5°
MAXIMUM SIDE LOBE 12%
MAXIMUM BACK LOBE 12%
DATE 3-1-43
ANTENNA LOCATION SW 30
RECEIVER LOCATION E 12
FIELD METER TYPE S.B.
OBSERVERS LA, LO, LU
RELATIVE FIELD STRENGTH
100
90
80
70
60
50
40
30
20
10
0
10
20
280 300 320 340 0 20 40 60 80
260 240 220 200 180 160 140 120 100
AZIMUTH ANGLE

PLATE 9 SEC. I

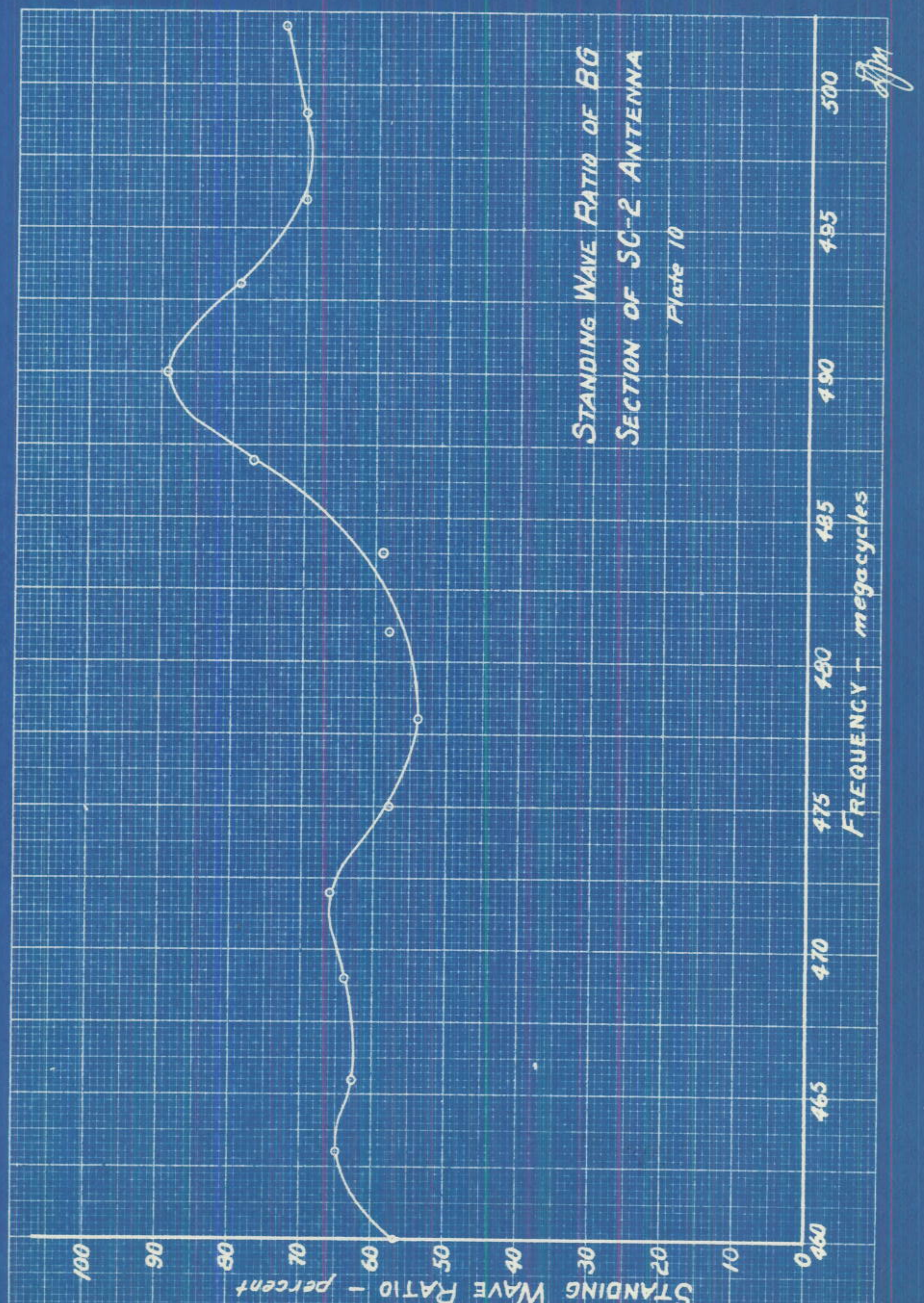


Plate 10 SEC. 1

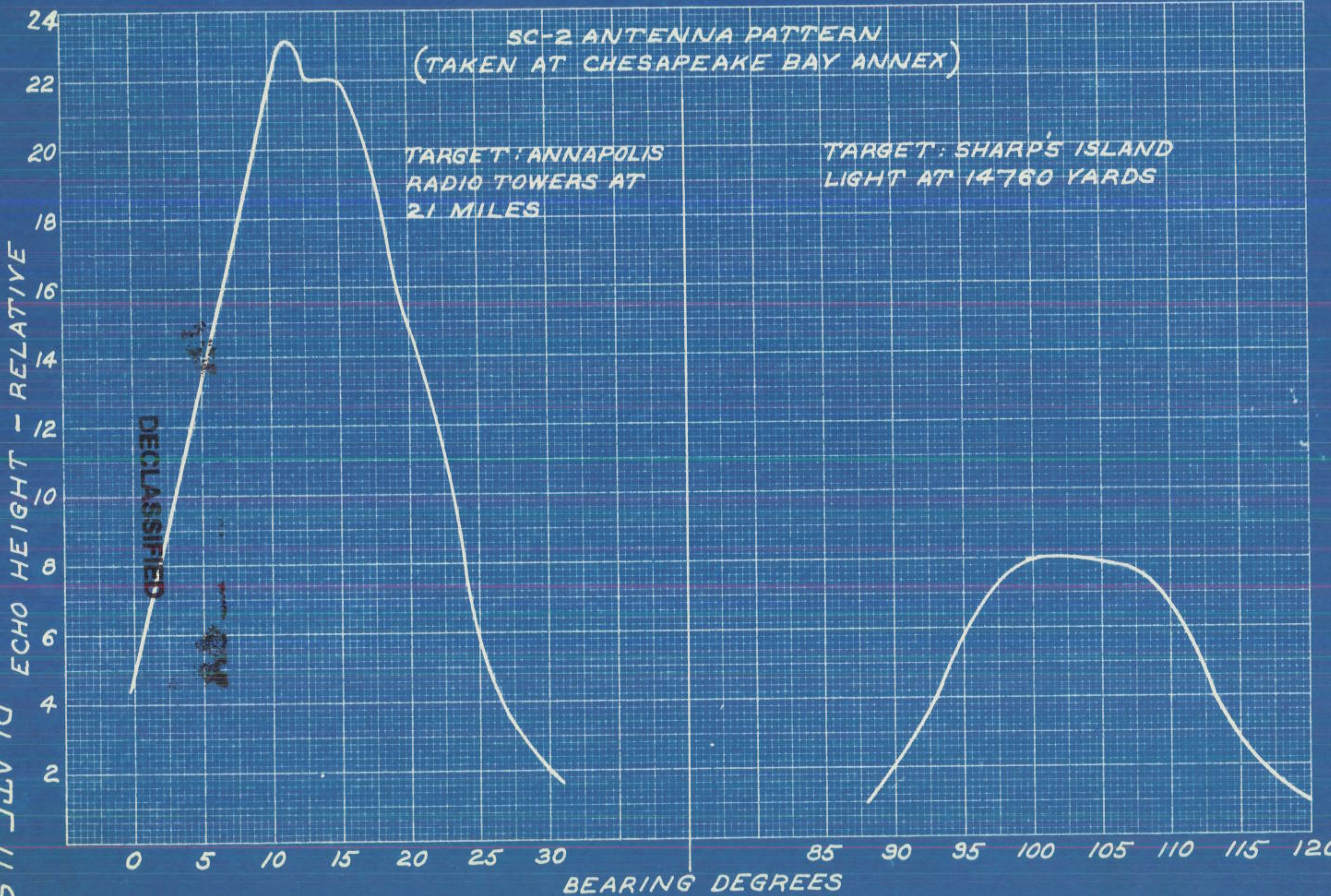

SC-2 ANTENNA PATTERN
(TAKEN AT CHESAPEAKE BAY ANNEX)
TARGET: ANNAPOLIS RADIO TOWERS AT 21 MILES
TARGET: SHARP'S ISLAND LIGHT AT 14760 YARDS
ECHO HEIGHT - RELATIVE
24
22
20
18
16
14
12
10
8
6
4
2
0
5
10
15
20
25
30
85
90
95
100
105
110
115
120
BEARING DEGREES

PLATE 11 SEC.

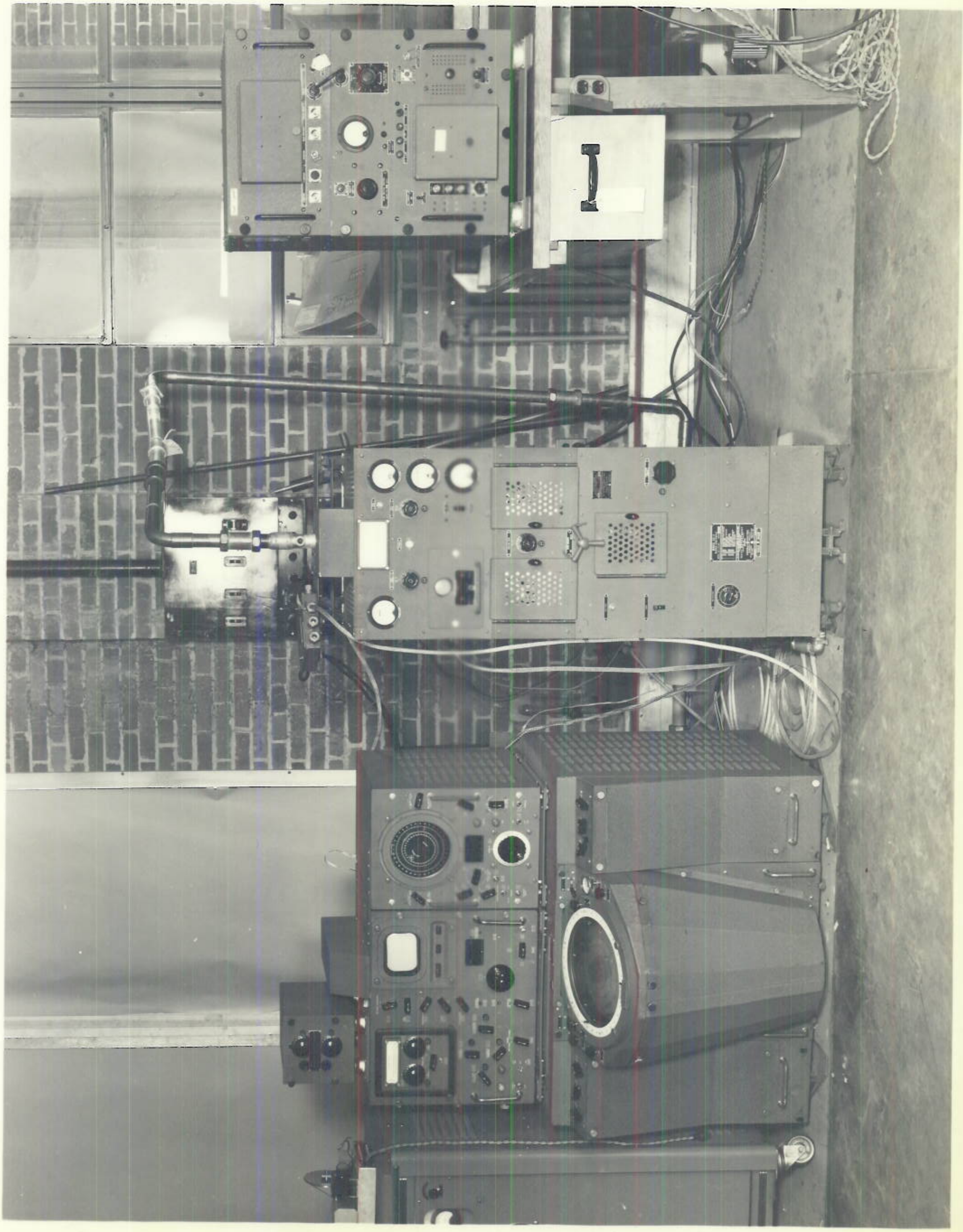
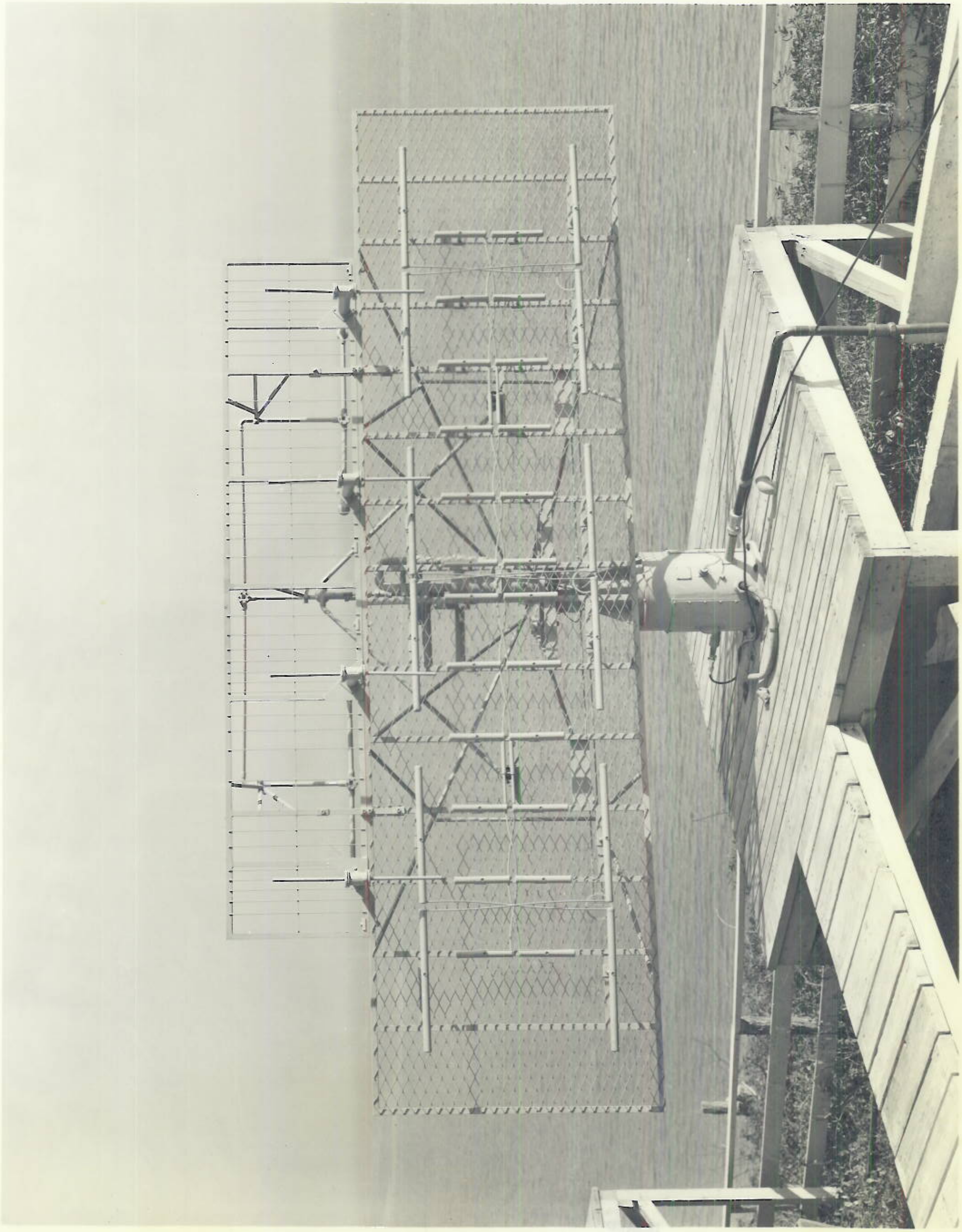


PLATE 12 SEC. I



CONFIDENTIAL DECLASSIFIED PLATE 13 SEC. I

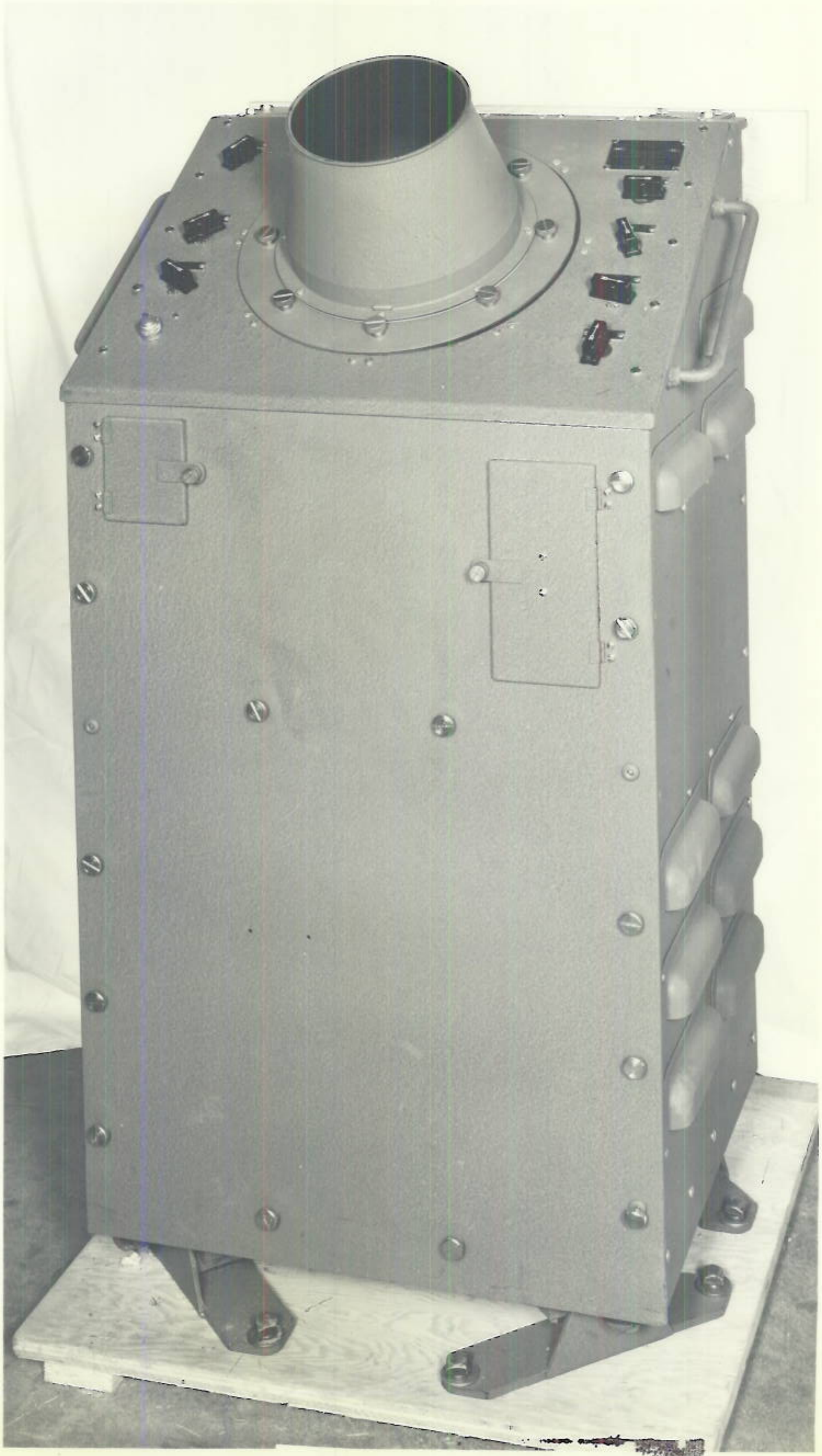


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PLATE 14 SEC. I

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PLATE 15 SEC. 1

SECTION 2

MODEL SC-2 RADAR TRANSMITTING EQUIPMENT
ELECTRICAL AND MECHANICAL TESTS

2-1. INTRODUCTION

During the period of 17 February to 6 April 1943 the mechanical construction and electrical operation of the Model SC-2 Radar Transmitting Equipment were investigated to determine the suitability of this equipment for use in the Naval Service. The following units were involved in these tests.

Unit	Navy Type	Serial No.
Radar Transmitter	CG-52ABH	13
Control	CG-23ACD	9
Motor-Dynamo Amplifier	CG-21ABU	--
Transformer	None	--
Switch	None	--
Antenna	----	--
Instruction Book - Vol. 2	----	968

The results of these investigations are discussed below.

2-1-1. Contents. For convenient reference the results of the investigations are divided as follows:

	Page	Paragraph
INTRODUCTION	1	2-1
Contents	1	2-1-1
List of Tables	2	2-1-2
List of Plates	3	2-1-3
List of References	3	2-1-4
EFFECTS OF AMBIENT TEMPERATURE	4	2-2
Variation in Ambient Temperature	4	2-2-1
EFFECTS OF HUMIDITY	5	2-3
Variation in Relative Humidity	5	2-3-1
Starting at a High Relative Humidity	5	2-3-2
EFFECTS OF VIBRATION	6	2-4
Transmitter Unit	6	2-4-1
Antenna Assembly	7	2-4-2
EFFECTS OF SHOCK	8	2-5
Shock Testing Apparatus	8	2-5-1
Transmitter Unit	8	2-5-2
Antenna	9	2-5-3

	Page	Paragraph
EFFECTS OF INCLINATION	9	2-6
PRIMARY POWER CONTROL AND SUPPLY CIRCUITS	9	2-7
Power Required From Supply Line	10	2-7-1
Variation in Line Voltage	10	2-7-2
CONTROLS	10	2-8
COMPONENT PARTS	11	2-9
Resistors	11	2-9-1
Capacitors	12	2-9-2
Meters	13	2-9-3
Vacuum Tubes	13	2-9-4
Fuses	14	2-9-5
Variac	15	2-9-6
Transformers	15	2-9-7
GENERAL PHYSICAL CONSTRUCTION	16	2-10
Mechanical	16	2-10-1
Accessibility	17	2-10-2
Wiring	18	2-10-3
Weights and Dimensions.	18	2-10-4
MARKING	18	2-11
Nameplates	18	2-11-1
Component Part Labels	18	2-11-2
Symbol Designations	19	2-11-3
INSTRUCTION BOOK	20	2-12
RADIO FREQUENCY POWER OUTPUT	20	2-13
SUMMARY OF DEFECTS AND RECOMMENDATIONS	22	2-14
CONCLUSIONS	26	2-15

2-1-2. List of Tables. The following tables are appended to Section 2 of this report.

Title	Table No.
Variation in Ambient Temperature	1
Variation in Relative Humidity	2
Starting at High Humidity	3
Resonant Points Noted During Vibration Test	4
Variation in Line Voltage	5
List of Controls	6
List of Meters	7
List of Vacuum Tube Potentials	8
List of Fuse Currents	9

Title	Table No.
List of Transformers	10
List of Relays	11
List of Weights and Dimensions	12
Nameplates	13
Radio Frequency Power Output	14
Variation in R-F Output with Coupling Control Setting. .	15
Variation in Power Output of Transmitter with Oscillator Plate Voltage	16
Effect of Oscillator Tube Replacement upon R-F Power Output	17

2-1-3. List of Plates. The following plates are appended to Section 2.

Title	Plate No.
Variation in Ambient Temperature	1
Variation in Relative Humidity	2
Transmitter: View of Front and Left Side	3
" : " " Left Side; Shield Off.	4
" : " " " " ; " " and Pulse Indicator Removed	5
Transmitter: View of Rear; Shield Off.	6
" : View of Right Side; Shield Off	7
" : Closeup View of Oscillator	8
Control Unit: View of Front and Left Side	9
" " : " " Rear and Right Side	10
" " : Chassis Removed from Cabinet	11
" " : View of Portion of Chassis	12
Duplexer	13
Amplidyne Motor-Generator	14
Line Transformer	15
Line Switch	16
Flexible Joint for Transmission Line	17
Antenna: Front View Showing Resonant Points and Point at Which Vibration Caused Damage	18
Antenna: Rear View	19
" : Side View	20
" : Showing Effect of Vibration	21
" : " " " "	22
" : " " " "	23
" : " " " "	24
" : " " " "	25
" : " " " "	26

2-1-4. List of References. Reference is made in this report to the documents listed below. For convenience, such reference is made by the alphabet letter rather than by full title.

Reference	Title
(a)	Shipboard Radar Component Failures--For Period Ending January, 1943. These are enclosures A to G, inclusive, of BuShips ltr. to NRL S67-5(982M) Serial R-982-1280 of March 4, 1943.
(b)	BuShips Spec. RE13A554D.
(c)	BuShips Spec. RE13A372J.

2-2. EFFECTS OF AMBIENT TEMPERATURE.

A test was made to determine the ability of the equipment to perform satisfactorily when subjected to wide variations in ambient temperature. As a preliminary to this test, the equipment was installed in a temperature test chamber and measuring instruments were connected to permit monitoring of appropriate circuits. In addition to the usual instruments such as ammeters and voltmeters, the following arrangement was also used:

(a) The radio frequency power output of the transmitter was conducted into a dummy load which consisted of a special type of load lamp. This lamp was installed external to the temperature room. The average power dissipated in the load lamp was determined by means of a calibrated photocell.

(b) The ratio t/T = duty cycle, where
t = pulse duration.
T = 1/ pulse repetition rate
was measured by means of an NRL type "Duty-Cyclometer". The peak power output of the transmitter was calculated from the ratio:

Average Power in Load Lamp/Duty Cycle

2-2-1. Variation in Ambient Temperature. With the equipment in operation, the ambient temperature was increased to 50°C. This value was maintained for one hour after which the ambient temperature was reduced first to 35°C, then to 20°C and finally to 0°C. Each of these temperatures was maintained for approximately one hour. The data recorded are listed in Table 1 and are presented graphically in Plate 1. The results of the test were as follows:

(a) The frequency of the emitted power varied between the limits 214.2 and 214.6 megacycles during this test. No correlation was obtained between the changes which were made in the ambient temperature and the observed changes in frequency.

(b) The peak power output varied between the limits of 46 and 51 kilowatts. There was no definite correlation between the

[redacted]

changes noted in power output and the changes which were made in ambient temperature. The change in power is not considered excessive.

2-3. EFFECTS OF HUMIDITY.

Tests were made to determine the ability of the equipment to perform satisfactorily when subjected to wide variations in relative humidity. Two different tests were made, namely, Variation in Relative Humidity and Starting at High Humidity. As a preliminary to these tests the equipment was installed in a humidity test chamber and provided with measuring apparatus as described in paragraph 2-2.

2-3-1. Variation in Relative Humidity. The data recorded during this test are listed in Table 2 and are presented graphically in Plate 2. The procedure during this test was as follows. With the equipment in operation, the ambient temperature was raised to 40°C and the relative humidity was adjusted to 20%. After these conditions had been maintained for one hour, the relative humidity was increased to 97%. This value was maintained for one hour and the relative humidity was restored to 20%. The results of this test were as follows:

(a) At the end of the initial period of operation in an atmosphere of 20% relative humidity, the transmitter's frequency was 214.4 megacycles. At the end of the period of operation in an atmosphere of 97% relative humidity, the transmitter's frequency was 214.25 megacycles. Thus, increasing the humidity resulted in a frequency change from 214.40 mcs. to 214.25 mcs. This represents a change of 0.15 megacycle or 0.07%. After the relative humidity was restored to 20%, the frequency gradually returned to 214.4 megacycles.

(b) The peak power output varied over a range of from 45.1 to 47.7 kilowatts. No correlation was noted between the changes which were made in the relative humidity and the changes which occurred in the peak power output.

2-3-2. Starting at a High Relative Humidity. A test was made to determine whether or not the equipment would start promptly and operate satisfactorily after it had been allowed to remain idle in an atmosphere of high relative humidity. The data for this test are listed in Table 3. The procedure in this test was as follows. Following the test described in paragraph 2-3-1, the equipment was de-energized, thus automatically applying power to the anti-humidity resistor in the transmitter. The relative humidity was adjusted to 97% at 40°C, and the equipment allowed to remain idle in this atmosphere for one hour. At the end of this period the equipment was energized. Upon applying plate voltage, arcing occurred in the transmitter. To eliminate this arcing, it was necessary to operate the transmitter for 3 minutes at a plate potential (7KV) lower than normal. At the end of 3 minutes the normal plate voltage (10.1 KV) could

[redacted]

be applied without arcing and stable operation could be obtained. This is equal to the performance obtained with the Model SC-1 Radar Transmitter when that unit was subjected to similar conditions which prevailed during the present test.

2-4. EFFECTS OF VIBRATION.

The equipment was subjected to vibration simulating insofar as possible conditions encountered aboard Naval vessels. For this test the equipment was secured to a vibration test stand by means of its normal hold-down fittings and was subjected to vibration at frequencies between 600 and 2000 cycles per minute. Care was taken to provide a rigid support for the upper shock mount assembly of the transmitter. The procedure and results of these tests are described below.

2-4-1. Transmitter Unit. The transmitter unit was subjected to vibration for a period of 5.5 hours with the following results:

(a) At vibrational frequencies in the range of from 700 to 900 cycles per minute, the top of the transmitter oscillated sideways. The maximum overall displacement was about 3/16 inch. While it is not desirable to have the transmitter cabinet oscillate in this manner, it is not deemed necessary to take steps to eliminate this effect.

(b) The coupling jack J303A at the bottom left side of the transmitter (visible on Plate 4) became loose in its mounting as a result of vibration. This permitted the jack to oscillate so that the plug P303A which fits into it struck against the deck on which the transmitter was mounted. It is recommended that this jack be secured in a manner that will prevent it from being loosened by shock or vibration.

(c) The overload relay K302 generated a loud rattling noise at a vibrational frequency of 900 cycles per minute. This noise will be annoying when the equipment is in service and should, therefore, be eliminated.

(d) During the vibration test, it was found that one of the tabs which support the center point of the oscillator grid inductance had partly broken away from the inductance. A more satisfactory method of supporting the center of the grid inductances should be provided.

(e) During the vibration test, one of the type 327A oscillator tubes gradually moved upward in its socket. The total displacement was 1/8 inch. This caused the plate connector pin to pull part way out of the socket. Although sufficient contact surface remained in the socket to maintain contact it is recommended that the mechanical design of the entire tube socket be improved.

[redacted]

(f) During a portion of the vibration test, the shock mount assembly at the top of the transmitter was removed and a special type of shock mount assembly was installed in its place. This substitute assembly was furnished by the Contractor and was installed at the request of the Contractor's representatives. The assembly was designed to act as a vibration limiter. The equipment was subjected to vibration for one hour using this substitute assembly. It was concluded that the substitute mounting did not provide additional protection against vibration. The design of this mounting is such that during shock the top of the transmitter is permitted to become displaced without any means of restoring it to its original position.

(g) The feed-through insulators which form part of the terminals of the filter capacitor C301 are supported on the top of the case of this unit. However, it was found that the case is too thin to support these insulators properly since the insulators oscillated considerably with respect to each other when the equipment was subjected to vibration. The portion of the case upon which these insulators are mounted should be made sufficiently sturdy to support them properly.

(h) There is an undesirable amount of clearance between the brush holding strip and its guide-track in the variable autotransformer T309 in the transmitter. This clearance makes the adjustment of the transformer difficult and also permits the adjustment to change when vibrated. It is recommended that this variable transformer be modified to eliminate this excessive clearance. It is suggested that this be done by providing the brush rigging with two guide tracks instead of the single one now used.

2-4-2. Antenna Assembly. The data obtained during the vibration test of the antenna are listed in Table 4. The results of the test were as follows:

(a) A number of points on the antenna resonated at certain of the applied vibration frequencies and developed considerable amplitudes of motion. The maximum aplitudes obtained were measured and are listed in Table 4. Reference to Plates 18 and 19 will reveal the location of the various points.

(b) The excessive amplitude of motion induced in the structure caused a number of the antenna components to become disrupted, namely:

The frame at point A on Plates 18 and 21;
The clamp bolt at point B on Plates 19 and 22;
The weld between two struts at point C on Plates 19 and 23;
The weld securing one of the feeder lines to the end of a radiator as shown at point D on Plates 18 and 24;

The outer conductor of the main concentric line at the point at which it connects to the rotating joint as shown at E on Plates 19 and 25;

The threads on the studs at the bottom of one of the matching sections. These threads became stripped. The loss of the threads caused the sleeves which thread on these studs to loosen at F on Plates 19 and 26.

The large amplitudes of motion described in item (a) and the damaged parts described in item (b) indicate that the antenna is of unsatisfactory design. During the vibration test additional struts or braces were fastened temporarily between various points on the antenna in an effort to determine experimentally whether any reduction could be effected in these amplitudes of motion. None of these attempts resulted in sufficient overall improvement to cause them to be recommended. It was concluded that there was no simple method by which the antenna could be made satisfactory.

2-5. EFFECT OF SHOCK.

The transmitter and antenna were subjected to a series of shocks simulating, insofar as possible, conditions encountered aboard Naval vessels. The procedure of this test was as follows. The units were fastened to a shock-test stand by means of their normal hold-down fittings. A rigid framework secured to the table was provided to support the upper shock mount assembly of the transmitter unit. The transmitter was connected to a dummy antenna consisting of a special load lamp. The r-f power dissipated in this lamp was measured by means of a calibrated photocell.

2-5-1. Shock Testing Apparatus. The shock testing apparatus consists of a platform to which a horizontal acceleration of relatively short duration can be imparted by means of a pneumatic shock device. The construction of the platform permits it to be rotated about its center axis so that any of its four edges may be presented to the pneumatic device. Thus, by mounting the apparatus under test with its sides parallel to those of the platform, shocks can be applied toward any of the four sides of the equipment. The peak acceleration imparted to the shock platform by the discharge of the pneumatic device is dependent upon the air pressure used. For most of the shocks in the present tests, the air pressure was 150 pound/sq. in. which corresponds to a maximum acceleration of the platform of approximately 250 g.

2-5-2. Transmitter Unit. A total of 48 shocks were applied to the transmitter unit; twelve shocks being applied toward each side. These shocks resulted in the following conditions:

(a) The screws holding the angle brackets upon which the jacks J301A and J303A are mounted loosened as a result of shock. It was found difficult to retighten the screws holding the bracket for J303 since the heads of these screws are accessible only from the bottom of the base plate. It is probable that the screws in these brackets were not sufficiently tightened

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during assembly. More care should be exercised both during construction and inspection.

(b) One of the thumb nuts by which the plate prongs of the oscillator tubes are held in their socket clips loosened. These thumb screws are similar to those used in the Model SC-1 Equipment. The Contractor should be required to modify these screws so as to prevent them from loosening.

(c) The top of the transmitter was displaced about one inch when the unit was subjected to shock. This displacement indicates that sufficient circumambient space must be provided to prevent the equipment from striking nearby objects. It is recommended that a clearance of 3 inches be provided at the right and left sides and the back. It should be noted that more clearance than three inches would be desirable to permit removal of shields and access to components.

(d) The thumb nuts by which the sides and back shields are held on the transmitter loosened as a result of shock. The auxiliary machine bolts prevented the side shields from being dislodged. The desirability of a change in the type of shield securing screws and the elimination of the auxiliary bolts has been pointed out previously in the report of the tests made at the Naval Research Laboratory on the Model SC-1 Radar Equipment.

2-5-3. Antenna. Fifteen shocks were applied to the antenna. No damage resulted. The antenna was not rotating when these shocks were applied so that no statement can be made relative to the effect of shock upon the rotation of the antenna.

2-6. EFFECTS OF INCLINATION.

Tests were made to determine the ability of the equipment to withstand inclination simulating the roll and pitch of a vessel. The unit was mounted on an inclination test stand by means of its normal hold-down fittings. Care was taken to insure that the top mounting was adequately supported. The transmitter was then placed in operation using a special type of dummy load lamp and was inclined from side to side for a period of thirty minutes. Following this, the unit was inclined from front to back for an additional period of 35 minutes. The transmitter was inclined 45 degrees to the right and left of the vertical at a rate of five cycles per minute. No damage or failure of operation resulted from this during this test.

2-7. PRIMARY POWER CONTROL AND SUPPLY CIRCUITS.

A number of tests and measurements were made of the primary power control and supply circuits. The results of these tests are described below under appropriate headings.

2-7-1. Power Required From the Supply Line. The power input to the transmitter and pulse indicator was measured and was found to be 1046 watts. This was measured on the primary side of the line transformer. The corresponding current and voltage were 5.4 amperes and 230 volts, respectively. This was measured with the transmitter operating at 211.2 megacycles. Attention is directed to the fact that the power input stated above does not include the power required by the receiver, the control unit, the indicator or the antenna drive.

2-7-2. Variation in Line Voltage. A test was made to determine whether or not the performance of the transmitter would be adversely affected if the supply voltage was varied over wide limits. The data recorded during this test are listed in Table 5. The procedure in this test was as follows. With the transmitter and pulse indicator in operation, the line voltage was reduced to 10% below normal. Measurements were made of the current or voltages in various circuits. The line voltage was then increased in small steps until a line voltage 10% above normal was obtained. The circuits measurements were repeated at each step. The results of this test were as follows:

(a) The equipment sustained no damage either at voltages below normal or above normal.

(b) It was found possible, by adjustment of the variacs, to restore the plate and filament voltages of the transmitter to their normal values when the line voltage was 10% below or 10% above normal. It is pointed out that, although this adjustment satisfactorily compensates for slow changes in line voltage, sudden changes in line voltage may result in an undesirable fluctuation in the power output.

2-8. CONTROLS.

Table 6 lists the controls of the transmitter unit and pulse indicator. Observations and use of the controls revealed the following:

(a) When the manual antenna position control on the control unit was brought to a desired position by moving it in a counter-clockwise direction the antenna would not rotate if the control was thereafter rotated clockwise until the control had been rotated through an arc of 35 minutes as indicated by the calibration on the manual control dial. The same situation existed if the initial approach was clockwise. Thus, there is a back-lash of 35 minutes in azimuth between the antenna and the antenna rotation control. This amount of back-lash was not considered excessive for this type of equipment.

(b) The marking "RR" on toggle switch "J" on the front panel of the control unit should be replaced by the marking "IFF". The switch has two positions (up and down), which are marked "on" and "off", respectively. It is recommended that the Bureau of

Ships determine whether or not this arrangement is in conformity with the latest specifications for IFF switches and if it is found that it is not, that the Bureau of Ships require the Contractor to make the changes necessary to obtain conformity.

2-9. COMPONENT PARTS.

Where circumstances permitted, measurements were made of the component parts in the equipment to determine whether they were operating within their ratings. In addition, visual inspection was made of the component parts to determine whether they were of the quality, type of construction, and workmanship which is required of equipment intended for the Naval Service. The results of these measurements and inspections are discussed below.

2-9-1. Resistors. The following items were noted concerning the resistors in the transmitting equipment:

(a) Resistors R102C, R105, and R108 (Plate 12) in the control unit are of the wire wound type with a vitreous enamel covering. A portion of the resistance wire has been left exposed to permit the use of a clamp band around the resistor as a variable tap. The terminals on these resistors are in the form of tabs. Paragraph 3-2-3A of reference (b) requires the use of ferrule type wire wound resistors in Naval radio equipment and states that these resistors shall meet the requirements of reference (c). Paragraph 7-1 of reference (c) requires that the coating completely cover the exterior of the resistor. It is recommended therefore that the present resistors be replaced by ferrule type resistors having a completely coated surface. The instruction book lists CAO-63639F as the Navy type number of the resistors R-105, R-108. The suffix "F" indicates that these are grade 1 class 1 resistors. It is considered highly improbable that a resistor having a portion of its wire exposed in the manner described would successfully withstand the Navy tests required for classification as grade 1 class 1. It is, therefore, recommended that the Bureau of Ships require the Contractor to justify the use of this type number.

(b) The wire wound resistors R-111 and R-112 in the control unit have tab type terminals. Reference (b) requires the use of ferrule type resistors. It is recommended that the Contractor be required to comply with this requirement.

(c) The resistors R-171, R-172 in the control unit have a power dissipation rating of 1 watt. The instruction book indicates that these resistors have a 2 watt rating. This discrepancy should be corrected.

(d) The resistor R-102C is supported by its V-shaped clips. This type of support is undesirable since vibration of the resistor may cause the leads to break. If the use of this type of resistor is continued, it should be more satisfactorily supported.

2-9-2. Capacitors. The following items were noted concerning the capacitors in the equipment:

(a) The capacitor C-302 in the transmitter was found to be leaking oil. It is recommended that the case of this capacitor be made oil tight.

(b) The filter capacitor C-301 in the transmitter unit bears a nameplate which contains the following information:

> General Electric Pyranol Capacitor,
> Cat. 26F415, CG481524, 0.4-0.4 mfd,
> 7500V-DC operating, M-746754-PT1.

At normal line voltages, each section of this capacitor operates at a maximum d-c potential of 7500 volts. One section of the capacitor became shorted out during the course of the tests presumably as the result of an internal insulation breakdown. When the remaining section was subsequently subjected to high d-c test potentials, its insulation broke down when the test potential reached 11.2 kilovolts. The case of this capacitor was subsequently cut open to permit an inspection of the foil-paper capacitor units contained therein. It was found that each section, C-301A and C-301B, consisted of two capacitors in series, that is, the case contained four units. This type of construction leads to difficulties since the applied potential does not divide equally between the two units forming each half of the capacitor. It divides in a ratio that depends upon the ratio of the leakage resistances of the two units. Thus, if the leakage resistances are not equal, one unit may have applied to it a voltage greater than it can withstand even though the total voltage does not exceed the sum of the voltage ratings of the two units. This difficulty could be overcome by replacing the present capacitor by one in which both the A section and the B section consisted of a single capacitor of the proper capacity and voltage rating. Although a single failure does not, of course, indicate that the capacitors in all Model SC-2 transmitters will become defective, it is pointed out that a similar capacitor in the Model SC-1 equipment has been a source of many failures. In reference A, it is shown that 11 capacitors (C301) failed in the Model SC-1 equipment between May, 1942, and January, 1943, inclusive. It is suggested that the Bureau of Ships require the Contractor to show in what manner, if any, the capacitor C-301 in the Model SC-2 transmitter has been improved as

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compared to the capacitor C-301 in the Model SC-1 transmitter. Alternately, it is suggested that the Bureau of Ships require the Contractor to submit one or more capacitors of the type CG-481524 to the Naval Research Laboratory for such tests as the Bureau may deem necessary.

(c) The capacitor C-303 in the transmitter unit does not have the common terminal marked to show that it is the common terminal. It is recommended that an appropriate marking be provided. The metal case of the capacitor should be made oil-tight since it is now leaking oil.

2-9-3. Meters. Table 7 lists the meters employed in the equipment. Attention is called to the fact that Navy type meters have been employed.

2-9-4. Vacuum Tubes. Table 8 lists certain of the static potentials applied to the vacuum tubes in the transmitter. The following information was noted concerning the vacuum tubes.

(a) The proper value for the filament voltage of the type 327A oscillator tubes in the transmitter is 10.5 volts. In order to obtain this value, it was found necessary to adjust the voltage to a value that resulted in a reading of 10.8 volts on the filament voltmeter on the front panel of the transmitter. That 10.8 is the required setting is indicated on a paper sticker on the inside of the front panel. However, it was found that the voltage which was applied to the rectifier filaments under these conditions was 4.59 volts rather than the rated value of 5.0 volts. Since the applied voltage differs from the rated value by more than 5%, it is recommended that the ratio of the rectifier filament transformer T304 be changed in a manner necessary to insure that the correct filament voltage will be applied to the rectifier filaments when the filament voltage for the oscillator tubes are adjusted to the correct value.

(b) The vacuum tubes in the control unit, 1 type 6N7and 2 type 6L6, are insecurely held in their sockets. It is recommended that clamps be provided to hold these tubes firmly in their sockets.

(c) The grid prongs on the oscillator tubes act as supports for the ends of the grid tuning inductances. The only other support afforded these inductors is by the stand-off insulators at their mid-point. This type of construction causes the grid inductance to place an undesirable stress on the tube and tends to cause the tube to shift in its socket. It has been previously pointed out in this report that during the vibration test one of these oscillator tubes moved upward in its socket about 1/8 inch. This caused the plate connector pin to pull part way out of its binding post. It is probable that this movement resulted from the lifting stress introduced by the grid inductance.

(d) In general, the filament prongs on the oscillator tubes do not fit properly into the filament jacks. It is necessary to distort the filament prongs when placing a tube in the socket. This places an undesirable stress on the electrode seals during and after installation.

(e) During removal of the type 327A oscillator tubes, a grid seal on each of two tubes became broken. This occurred when the grid seal was subjected to the strong steady pull necessary to remove the pin jack from the grid prong.

(f) Items (c), (d), and (e) immediately above indicate the existence of two difficulties, namely, that the electrode seals on the type 327A vacuum tube are too fragile and that the type of tube socket used for these tubes in the Model SC-2 equipment is mechanically unsatisfactory. It is suggested that the Bureau of Ships give consideration to the feasibility of providing the type 327A tube with sturdier external filament, plate, and grid connector pins. While it would not be possible to use tubes embodying such a modification in the Model SC-2 equipment, future equipments of the SC series could be designed to accommodate them. Referring to the sockets provided for these tubes, it is pointed out that sockets very similar to the present type have proved unsatisfactory. According to reference (a) the transmitter oscillator tube socket (X305) in the Model SC-1 equipment was responsible for 115 failures between June 1942 and the end of January 1943. An inspection of photographs reveals that the only apparent difference between the sockets of the Model SC-1 and Model SC-2 equipments is that a different type of contact-maintaining spring is used on the filament connectors. While the statement that there were 115 failures attributable to these sockets does not give a complete picture of the situation, it seems unlikely that a change in the filament contact springs alone will completely eliminate all the difficulties encountered with these sockets. Further improvement of the socket is considered necessary.

(g) The base of the type 902 oscilloscope in the pulse indicator unit was found to be loose. This situation should be called to the attention of the tube manufacturer for corrective action.

2-9-5. Fuses. Table 9 lists the fuses used in the equipment. It is pointed out that the current listed in the tables includes the requirement only of the transmitter, control unit and pulse indicator. All of the fuses are refillable. It is understood that the latest decision of the Bureau of Ships requires the use of non-refillable fuses in Radar equipment. If this is the present requirement, these fuses should be replaced by a non-refillable type.

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2-9-6. Variac. A variac located in the control unit is used to control the plate voltage applied to the oscillator tubes in the transmitter. The shaft of this variac is composed of bakelite covered steel. The brush-holding arm is held in place on this shaft by means of set-screws. However, it was found that these set-screws are not sufficient to prevent the brush arm from slipping on its shaft whenever the control is turned to its extreme positions. It is recommended that a taper pin be provided to secure the brush arm to the shaft.

2-9-7. Transformers. Table 10 lists the nameplates on the transformers in the transmitter and control units. The following items were observed concerning these transformers:

(a) The transformer T302 supplies plate voltage to the oscillator tubes in the transmitter. The nameplate on this transformer indicates that the transformer is insulated for 12.5 kilovolts. It is assumed that this rating indicates the peak voltage (dc or ac) that can be applied to the insulation if conservative operation is desired. However, calculations reveal that when a d-c plate potential of 15 kilovolts is applied to the oscillator tubes, the instantaneous potential difference between the high voltage winding and the core of the transformer is approximately 15 kilovolts. This potential is composed of a 7500 volts d-c component in series with a peak a-c component of approximately 7500 volts. Thus, under these circumstances the voltage rating of the insulation is exceeded. Attention is invited to the fact that transformers of this same type (CG-30872) are used in the Model SC-1 equipment under conditions almost identical to those present in the Model SC-2 equipment. Reference (a) reveals that no failures of these transformers were reported between May 1942 and January 1943 although a considerable number of Model SC-1 equipments were in service during this period. It is nevertheless recommended that the Contractor be required to provide the transformer with insulation of the proper voltage rating.

(b) A potential of 15 kilovolts is applied between the filament windings of the rectifier filament transformer T-304 and the grounded core of this transformer. The nameplate on the transformer contains the notation: INSULATION KV 0.75. It appears from this notation that the transformer does not have insulation of a sufficiently high rating to satisfy the requirements of Navy specifications. The Contractor should be required to explain this situation and, if necessary, provide the transformer with insulation of the proper rating.

(c) It was found that oil was leaking from the transformer T-104. The case should be made oil tight to prevent this leakage.

2-9-8. Relays. Table 11 lists the relays employed in the equipment.

2-10. GENERAL PHYSICAL CONSTRUCTION.

A number of items of a mechanical nature were noted during the course of the investigations made on the Model SC-2 equipment. These items are discussed below under appropriate headings.

2-10-1. Mechanical. The following items were noted concerning the construction of the equipment:

(a) The micalex arm on the output coupling bar in the transmitter unit rubs against the right side of the Pulse Indicator. A clearance of at least 1/4 inch should be provided.

(b) The nut holding the clip for resistor R307 on the terminal of the transmitter high voltage supply capacitor C-301 was found to be loose. This method of mounting the resistor clip is unsatisfactory mechanically since the stud on the capacitor terminal does not provide sufficient bearing surface for the clip. The resistor, when being inserted or removed, will, if moved sideways, act as a lever and cause the clip to loosen. It is difficult to tighten the nut since it is inaccessible. After the nut is finally tightened the clip may or may not be in correct alignment since the resistor cannot be in place during the process. It is recommended that the clip be removed from the capacitor terminal and mounted on a separate insulated support.

(c) More care should be taken in packing the transmitter oscillator grid inductors for shipment. Upon receipt of the present equipment, one coil in the green band and one coil in the blue band were so badly bent that upon installation they were found to touch the aluminum tuning disc.

(d) Some of the cylindrical stand-off insulators which form part of the Remote-Relative Switch S102 in the control unit were found to be cracked. The cause of this damage was not discovered.

(e) The studs which form the terminals of the overload relay K302 became loose in their mounting base when an attempt was made to disconnect the external interconnecting leads from the relay. This occurred because the entire terminal including the stud rotated when the nuts holding the external leads to the studs were tightened. These terminals should be modified to prevent this condition.

(f) The plate upon which the fuse clips are mounted is secured to the inside back of the supply line switch box by means of three screws which are tapped into the box. The threads on the upper of the three holes became stripped. The metal into which these holes are tapped should be made thicker to preclude further stripping of the threads.

(g) The side and back shields of the transmitter are secured by means of captive thumb nuts. The nuts fit on threaded studs which are screwed into the frame of the transmitter. The inner ends of the studs are staked. However, the staking proved ineffective in one instance since one of the studs unscrewed when the thumb nut was loosened. The staking should be improved.

(h) There is an excessive amount of tubing in the thermostat circuit in the base of the antenna. The excessive tubing has been formed into a coil and is without proper support. Vibration will cause fatigue and eventual breakage. If this excess tubing is essential to the operation of the thermostat, adequate support should be provided.

(i) Oil is leaking out of the antenna pedestal through the oil gauge. Care should be taken during manufacture to tighten the oil gauge fittings properly.

(j) The gears which drive the antenna control system in the control unit should be lubricated. These gears are at present unlubricated and showed considerable wear.

(k) "Elastic Stop Nuts" are used on the bolts which fasten the capacitors C101, C102 to the chassis of the control unit. These bolts extend only part way through their nuts and since this type of nut depends for its locking action upon the fibre insert at the exit side of the nut, it is imperative that the bolt pass completely through. The bolts holding these capacitors should be made at least 1/4 inch longer.

(l) A number of the gears in the control unit are made of unplated steel. Since this material is subject to severe corrosion, it is recommended that these gears be made of a suitable corrosion resisting material.

2-10-2. Accessibility. The following items were noted concerning the accessibility of the component parts for replacement or servicing:

(a) It was found impossible to remove the shield cover over the type 5U4G rectifier tube in the pulse indicator unit without first removing the oscilloscope interlock switch. This inconvenience can be eliminated by suitable relocation of the switch or modification of the shield.

(b) The capacitor C301 is difficult to replace because the resistor clip mounted on one of the terminals cannot be readily aligned after a new capacitor is installed.

2-10-3. Wiring. The following items were noted concerning the wiring in the equipment:

(a) Lock washers should be used on the terminal screws on the terminal board TB31.

(b) The interconnecting cables between the control unit chassis and the terminal boards at the back of the cabinet tend to catch on the panel securing brackets while the chassis is being withdrawn from the cabinet. The brackets referred to are those located near the inside front edge of the cabinet. The abrasion of the insulation due to this action will cause damage to the cable. It is suggested that guards be provided to prevent this chafing.

2-10-4. Weights and Dimensions. Table 12 lists the weights and dimensions of the transmitter, control unit and certain auxiliary apparatus.

2-11. MARKING.

An examination was made to determine the suitability of the nameplates and component markings. The results of these examinations are discussed below.

2-11-1. Nameplates. Table 13 lists the information found on the nameplates of the various units. The nameplate on the line switch is not in the form required by Naval specifications and does not state that this unit is a part of the Model SC-2 Radar Equipment. An appropriately worded Navy type nameplate should be provided.

2-11-2. Component Part Labels. A number of the component parts were found to be labelled in an incomplete or unsatisfactory manner. The following items were noted:

(a) There are no markings on the resistors R105, R108, R111, R112 in the control unit to indicate the type number or resistance value. Appropriate markings should be provided in accordance with reference (b).

(b) The color code markings on the capacitor C350 indicate 2000 mmfd. The instruction book states that the capacity of this component is 100 mmfd. This discrepancy should be corrected.

(c) The transformers T310 and T311 in the transmitter, T151 and T152 in the control unit and the plate voltage transformer in the pulse indicator do not have nameplates. Nameplates should be provided containing the information required by paragraph 2-7-(1) of reference (b).

(d) The terminals on the transformer T151 are not numbered. This omission makes it difficult to connect this transformer and also increases the difficulty of servicing the equipment. These terminals should be numbered.

(e) The points at which the antenna pedestal is filled with or drained of oil and the points at which the pedestal and drive motor bearings are to be greased should be marked. A label on the antenna drive motor should specify the Navy type number of the grease that is to be used.

(f) An interlock is provided on the antenna pedestal which, when opened, prevents the antenna from being rotated by an operator at the control unit. The purpose of this interlock is to permit repairs to or adjustments of the antenna to be made in safety. A nameplate should be placed on the antenna pedestal adjacent to this plug to indicate its purpose and to warn personnel to open the interlock before working on the antenna. The nameplate should be conspicuous and of such a nature that it will not be obscured by weathering or when the pedestal is repainted.

(g) The points on the antenna to which lines are to be fastened for lowering or hoisting operations are marked "Sling Here". These markings have been applied by stencilling them in black paint over the grey paint with which the antenna is finished. Attention is invited to the fact that the markings will be obscured when the antenna is repainted.

2-11-3. Symbol Designations. A number of instances were noted where the marking of component parts required by paragraph 4-5-(1) of reference (b) had either been omitted or had been incorrectly accomplished. The following items were noted:

(a) There is a discrepancy in the marking of two potentiometers in the pulse indicator. The condition is as follows:

Symbol Designation on Chassis	R326	R318
Resistance Marked on Potentiometer (ohms)	15000	22000
Resistance Listed in Instruction Book	22000	15000

In addition, the circuit diagram P776457 shows R326 and R318 as fixed resistors. The resistor R327, however, is shown variable and in series with R326. Likewise the resistor R319 is shown as variable and in series with R318. These discrepancies should be eliminated.

(b) The resistor R328 is shown on the circuit diagram of the pulse indicator unit but is not present in the equipment or listed in the parts list. This discrepancy should be corrected.

(c) Markings showing the symbol designation and the voltage and current rating of the fuses should be placed adjacent to the corresponding fuse holder in the supply line switch box.

(d) A number of symbol designation in the transmitter and pulse indicator units are omitted and others are illegible. These are not enumerated since such defects are likely to vary from one equipment to the next. More care should be taken in applying the markings.

2-12. INSTRUCTION BOOK.

An examination of the instruction book revealed the following items:

(a) The switch S307 on the schematic diagram P7764757 is shown as normally open. It should be shown as normally closed.

(b) The switch S313 is listed in the parts list but is not present in the equipment or shown on the schematic diagrams. The switch S312 is listed in the parts list as a power switch but is shown on schematic P7764757 as a door interlock switch. These discrepancies should be corrected.

(c) The switches S105 and S106 in the control unit are marked with the Navy type number CG-24066. The parts list specifies switches of Navy type CG-24013. This discrepancy should be corrected.

(d) The switch S111 in the control unit is marked 1 ampere, 125 volt. The parts list specifies 3 amperes, 125 volts. The discrepancy should be corrected.

(e) The schematic diagram TT-7661911 indicates that the fuses in the line switch box are ahead of the switch. Since it would be difficult and dangerous to change fuses with the specified connection, it is recommended that the diagram be changed to show the fuses following the switch.

(f) It was found that Pages 39 and 40 had been omitted from the instruction book.

2-13. RADIO FREQUENCY POWER OUTPUT.

Measurements were made of the radio frequency power output of the transmitter. The procedure and results of the measurements are discussed below.

2-13-1. Measuring Equipment. The measurement of the power output involved the determination of various quantities as follows:

(a) Average Power. A special type of resistor which formed the inner conductor of a concentric transmission line was used as a dummy antenna for these power measurements. This was connected to the output terminals of the transmitter through a section of slotted transmission line and an additional section (approximately 10 feet) of 1-5/8 inch 50 ohm concentric transmission line. The slotted line was placed at the load end of the transmission line. The slot in the line permitted the measurement of the standing wave ratio. A tuning stub located between the load and the slotted line permitted adjustment of the mismatch at the load. The resistor was water cooled and the power being dissipated in it could be determined by measurement of the quantity of water flowing and the temperature difference between the water entering and leaving the load. Comparison of these results with those obtained by calibrating the resistor with known values of 60 cycle power then revealed the average r-f power.

(b) Peak Power. The peak power was determined by dividing the figure obtained for the average power by the duty cycle. This quantity, which is equivalent to "Pulse length X Pulse Repetition Rate" was measured by means of an NRL type "Duty Cyclometer".

2-13-2. Power Output at Various Frequencies. Table 14 lists the power obtained from the transmitter at various frequencies. The following is a summary of this table:

Freq Mc/s	Band	Peak Power KW
182.8	Red	216
192.2	Green	186
197.9	Yellow	200
215.8	Blue	225

2-13-3. Effect of Coupling Control. The control "B" on the front panel of the transmitter is labelled "Output Coupling". Table 15 lists the data obtained during a test that was made to determine the effect upon power output by varying the setting of this control. Varying the setting of this control had relatively little effect upon the peak power since the maximum value was 222 kw and the minimum value was 206 kw. It is to be noted that for each setting of control "B", the setting of the control "C", the "Output Matching" control, was adjusted to obtain the maximum possible output.

2-13-4. Effect of Oscillator Plate Voltage Variation. Table 16 lists the data obtained when the plate voltage applied to the oscillator tubes was varied. The peak power output varied from 81 kw at 7.5 kv to 216 kw at 15 kv.

2-13-5. Effect of Oscillator Tube Replacement. The power output measurements were made with Westinghouse type 327A tubes in the oscillator sockets. Table 17 shows the power output obtained from a set of Eimac tubes as compared with the power output obtained from the Westinghouse tubes. It will be seen that the average power outputs obtained from the two sets did not differ substantially but that the peak power output of the Westinghouse tubes was 19% greater than that obtained from the Eimac tubes.

2-14. SUMMARY OF DEFECTS AND RECOMMENDATIONS.

The defects encountered during the tests of the Model SC-2 equipment are summarized below. The numerals in parenthesis preceding each item refer to the paragraph of this report in which the item is discussed at greater length. The relative order of listing is not indicative of the relative importance attached to the item.

2-14-1. (2-3-2) When power was applied to the equipment after it had been allowed to remain idle in an atmosphere of high humidity, arcing occurred inside the transmitter. Because of this arcing, normal operation could not be obtained until three minutes had elapsed. Three minutes elapsed time was also required for the Model SC-1 equipment before normal operation was obtained after the equipment was exposed to approximately the same conditions.

2-14-2. (2-4-1b) The coupling jack J303A became loose when the transmitter was subjected to vibration. Steps should be taken to prevent this jack from being loosened by either shock or vibration.

2-14-3. (2-4-1c) The overload relay rattled when the transmitter was subjected to vibration. This noise is likely to be annoying and it is recommended that the relay be modified to prevent it from rattling.

2-14-4. (2-4-1d) Several of the tabs holding the center of the oscillator grid inductors in the transmitter broke during the course of the tests. This damage was the result either of the vibration test to which the equipment was subjected or of normal handling incident to the installation or replacement of the grid inductors. These inductors should be modified in such a manner that they will not be disrupted when subjected to the rigors of the Naval Service.

2-14-5. (2-4-1e, 2-5-2b, 2-9-4c, 2-9-4d, 2-9-4e, 2-9-4f) The tube sockets provided for the type 327A tubes used in the transmitter oscillator are not mechanically satisfactory. The present type of socket should be replaced by a type which will prevent the tube from shifting its position in the socket and which will permit the tubes to be installed and removed without damage to their electrode seals.

2-14-6. (2-4-1g) The top of the case of the transmitter's high-voltage-supply filter capacitor C301 should be made more rigid. At present, the ceramic insulators mounted on the top of the capacitor are not adequately supported and therefore oscillate with respect to each other when the equipment is subjected to vibration. It is probable that this oscillation will cause failures of this capacitor.

2-14-7. (2-4-1h) The variable transformer by which the oscillator tube filament voltages of the transmitter are controlled should be modified to reduce the excessive play in the brush rigging.

2-14-8. (2-4-2a, 2-4-2b) When the antenna was subjected to vibration, various parts oscillated excessively as a result of mechanical resonance. Breakage occurred at several points as a result of vibration. It is recommended that the antenna be so modified to prevent these failures. It was not determined whether the large displacements resulting from the mechanical resonance will change the antenna pattern sufficiently to interfere with the operation of the equipment.

2-14-9. (2-5-2a) The angle brackets holding the transmitter jacks J301A and J303A became loose when the equipment was subjected to shock. These jacks should be secured in a manner that will preclude their loosening during shock.

2-14-10. (2-5-2c) Because of the large deflection of the top of the transmitter unit which occurs when this unit is subjected to shock, care should be taken to provide three inches of clearance around this unit when it is installed. The installation drawings should indicate that this amount of clearance is required.

2-14-11. (2-5-2d) The thumb nuts by which the side and back shields are held on the transmitter loosened when the equipment was subjected to shock. It is recommended that the thumb nuts be replaced by a more effective type and that the auxiliary bolts be eliminated.

2-14-12. (2-8a) It was found that the antenna rotation control system has 35 minutes backlash. This amount is not considered excessive.

2-14-13. (2-8b) The label "RR" for control "J" on the front panel of the Control Unit should be replaced by the label "IFF".

2-14-14. (2-9-1a, 2-9-1b) Several non-Navy type resistors are used in the Control Unit. These should be replaced by resistors that conform to Navy specifications.

2-14-15. (2-9-1c) There is a discrepancy between the actual power dissipation rating of the resistors R171 and R172 and the power dissipation rating listed in the instruction book. The discrepancy should be corrected.

2-14-16. (2-9-1d) Resistor R102c,which is now supported on V-shaped clips,should be adequately supported. A more satisfactory modification would be to substitute a ferrule type wire-wound resistor for the present non-Navy type resistor.

2-14-17. (2-9-2b) The case of the capacitor C302 in the transmitter is leaking oil. This case should be made oil tight.

2-14-18. 2-9-2c) One section of filter capacitor C301 in the transmitter unit developed an internal short circuit during the course of the tests. The other section subsequently failed when subjected to a d-c test potential of a lower value than Naval specifications require it to withstand. It is recommended that further investigations be made to determine the suitability of this type of capacitory for use in the Model SC-2 equipment.

[redacted]

2-14-19. (2-9-2d) The common terminal of capacitor C303 should be marked to indicate that it is the common terminal. The capacitor should be provided with an oil-tight case.

2-14-20. (2-9-4a) With the primary voltage adjusted so that the front panel filament voltmeter indicated the specified value, the rectifier filament voltage was found to be less than the five per cent tolerance specified by the tube manufacturer. It is recommended that the filament transformer be replaced by one that will provide the correct rectifier filament voltage.

2-14-21. (2-9-4b) Base clamps should be provided for the vacuum tubes in the Control Unit to hold them firmly in their sockets.

2-14-22. (2-9-4g) The base on the pulse indicator oscilloscope tube was found to be loose. This condition indicates either that the bases of these tubes are not cemented in a durable manner or that the inspection of the completed tubes is faulty. The situation should be called to the attention of the tube manufacturer with the request that he make whatever improvement is necessary.

2-14-23. (2-9-5) Refillable fuses are used in the equipment. These should be replaced by non-refillable fuses to conform with the latest decision of the Bureau of Ships.

2-14-24. (2-9-6) The oscillator plate voltage variac in the transmitter unit should be modified in a manner necessary to prevent its brush holder from slipping on its shaft. The use of set-screws alone to secure this brush holder has not proved satisfactory.

2-14-25. (2-9-7a, 2-9-7b) The oscillator plate voltage supply transformer of the transmitter does not have insulation of a sufficiently high voltage rating to satisfy Navy specifications. The insulation rating of the rectifier is not clearly stated. Both transformers should be provided with adequate insulation.

2-14-26. (2-9-7c) The case of the transformer T104 should be made leak-proof. Oil was found to be leaking out of the transformer.

(2-10-1a) The micalex arm of the transmitter's output coupling bar rubs against the Pulse Indicator. Ample clearance should be provided.

2-14-27. (2-10-1b) One of the clips for the resistor R307 in the transmitter unit is mounted on one of the stand-off insulators which forms part of the terminals of the capacitor C301. This method of support is not satisfactory since the bearing surface provided by the terminal on the insulator is insufficient and the clip is difficult to tighten. The resistor clip should be mounted on a separate support.

2-14-28. (2-10-1c) The grid inductors for the transmitter oscillator should be packed for shipment in a manner that will prevent their being damaged during shipment and storage.

2-14-29. (2-10-1d) Attention is directed to the fact that certain stand-off insulators which form a part of the switch S102 in the Control Unit were found broken. It is possible that anti-stress washers of a more effective type are needed to protect the ceramic parts of this switch.

2-14-30. (2-10-11) The unplated steel gears in the Control Unit should be replaced by gears that will be resistant to the corrosive action of a moist sea atmosphere.

2-14-31. (2-10-2a) The shield cover on the type 5U4G vacuum tube in the Pulse Indicator Unit should be made more conveniently removable.

2-14-32. (2-10-3a) Lock washers should be provided on the terminal screws of the terminal board TB31.

2-14-33. (2-10-3b) It is suggested that guards be provided to protect the interconnecting cable in the Control Unit against the abrasion that occurs when the Control Unit chassis is withdrawn from its cabinet.

2-14-34. (2-11-1) The line switch should be provided with a suitable Navy-type nameplate.

2-14-35. (2-11-2a) Several resistors in the equipment are not marked with resistance value or type number. Appropriate markings should be provided.

2-14-36. (2-11-2b) There is a discrepancy between the capacity marking on the capacitor C350 and the capacity listed in the instruction book. This discrepancy should be corrected.

2-14-37. (2-11-2c) Nameplates have been omitted from several transformers in the equipment. Suitable nameplates should be provided on all transformers.

2-14-38. (2-11-2d) The terminals on the transformer T151 should be numbered. These numbers should also appear on the schematic diagram.

2-14-39. (2-10-1e) The terminal studs on the transmitter overload relay loosened when an attempt was made to disconnect the relay leads. Steps should be taken to prevent these studs from loosening.

2-14-40. (2-10-1f) The threads in one of the bolt holes in the line switch box became stripped during the tests. The metal into which these holes are tapped should be made of sufficient thickness to prevent the threads from stripping.

2-14-41. (2-10-1g) The studs for the transmitter side shields should be staked or otherwise secured to prevent them from being accidentally unscrewed from the transmitter frame.

2-14-42. (2-10-1h) The excess thermostat tubing in the antenna pedestal should be either eliminated or adequately supported and clamped.

2-14-43. (2-10-1i) Oil was found to be leaking out of the antenna pedestal around the oil gauge fittings. Care should be taken during manufacture to tighten these fittings securely.

2-14-44. (2-10-1j) The antenna control system gears in the Control Unit were found to lack lubrication. Proper lubrication should be applied to the gears during manufacture of the equipment.

2-14-45. (2-10-1k) The bolts holding capacitors C101 and C102 should be made sufficiently long to extend completely through the "Elastic Stop Nuts" by which they are secured.

2-14-46. (2-11-2e) Suitable lubrication instruction labels should be fastened to the antenna pedestal and antenna drive motor.

2-14-47. (2-11-2f) A label should be fastened to the antenna pedestal to warn operators to open the interlock switch before working on the antenna.

2-14-48. (2-11-2g) Attention is directed to the ease with which the "Sling Here" marking on the antenna can be obliterated.

2-14-49. (2-11-3a) There is a discrepancy in the chassis markings for resistors R326 and R318 of the Pulse Indicator. This discrepancy should be eliminated.

2-14-50. (2-11-3b) Resistor R328 should be eliminated from the Pulse Indicator schematic diagram since no such resistor appears in the unit.

2-14-51. (2-11-3c) The fuse holders in the line switch box should be marked with the current and voltage ratings of the fuses to be employed and with appropriate "Symbol Designations".

2-14-52. (2-11-3d) A number of "Symbol Designations" have been omitted and others are illegible. More care should be exercised in applying these markings.

2-14-53. (2-12, a, b, c, d, e, f) There are a number of discrepancies in the Instruction Book. These should be corrected.

2-15. CONCLUSIONS.

The results of the tests conducted on the Model SC-2 equipment lead to the following conclusions.

2-15-1. The equipment operated satisfactorily over a wide range of ambient temperature and relative humidity. In the absence of specifications governing the permissible variation in emitted frequency and power output with temperature and humidity no conclusions relative to these variations can be included.

2-15-2. The transmitter suffered only slight damage when subjected to vibration. The antenna, however, was severely damaged by vibration and must be strengthened or otherwise modified before satisfactory service can be expected.

2-15-3. The equipment suffered only minor damage when subjected to shock. If the conditions leading to these difficulties are corrected, the equipment can be expected to withstand shock. This conclusion assumes that the equipment will be installed correctly, especially with respect to the top shock mount of the transmitter.

2-15-4. A number of component parts require improvement either mechanically or electrically. Particular attention should be given to the following transmitter components: the oscillator tube sockets, the high voltage filter capacitor, the filament and high voltage transformers of the high voltage rectifier.

2-15-5. The Model SC-2 Transmitter and Control Unit differs only slightly in construction from the corresponding units of the Model SC-1 Equipment.

Table 1 - Section 2

Model SC-2 Radar Equipment
Variation in Ambient Temperature

Time Hour	Amb Temp (°C)	Rel Hum (%)	Freq. (Mc)	Power Output Aver. (Watts)	Power Output Peak (Kw)	Oscillator I_p (Ma)	Oscillator E_p (Kv)	Duty Cycle (%)	Fil. (Volts)
0845	25	30	214.2	13.5	48.2	10.30	10.10	.0280	10.80
0900	50	8	214.2	13.1	46.0	10.29	10.20	.0285	10.79
0915	50	8	214.2	13.3	46.7	10.28	10.20	.0285	10.70
0930	50	8	214.2	13.4	47.4	10.28	10.10	.0283	10.70
0945	50	8	214.2	13.3	47.4	10.25	10.10	.0281	10.65
1000	50	8	214.2	13.4	47.8	10.22	10.10	.0280	10.62
1015	35	10	214.2	13.4	47.8	10.25	10.10	.0280	10.62
1030	34.5	11.5	214.2	13.4	48.7	10.25	10.10	.0275	10.70
1045	35	10	214.2	13.5	49.1	10.25	10.25	.0275	10.70
1100	35	10	214.2	13.5	48.2	10.25	10.25	.0280	10.70
1115	35	10	214.2	13.6	48.6	10.25	10.25	.0280	10.70
1130	20	23	214.6	13.6	48.6	10.28	10.25	.0280	10.75
1145	20	23	214.6	13.6	48.4	10.28	10.25	.0281	10.79
1200	20	16	214.6	13.9	49.6	10.3	10.25	.0280	10.80
1215	20	16	214.2	13.7	48.9	10.29	10.25	.0280	10.79
1230	20	16	214.2	13.7	48.3	10.29	10.25	.0285	10.79
1300	0.0	--	214.3	14.1	47.0	10.31	10.25	.0300	10.81
1315	0.0	--	214.4	14.0	49.4	10.32	10.30	.0282	10.85
1330	0.0	--	214.4	14.0	50.1	10.30	10.30	.0280	10.90
1345	0.0	--	214.4	14.0	50.1	10.25	10.40	.0280	10.90
1400	0.0	--	214.4	13.5	50.1	10.20	10.40	.0270	10.90
1415	0.0	--	214.5	13.2	51.0	10.15	10.40	.0260	10.90
1430	20	16	214.5	13.2	51.0	10.15	10.45	.0260	10.90
1445	20	16	214.4	13.9	49.7	10.25	10.40	.0280	10.82
1500	20	16	214.4	14.0	50.0	10.30	10.30	.0280	10.81
1515	20	16	214.4	14.0	50.0	10.30	10.30	.0280	10.81
1530	20	16	214.4	14.1	48.7	10.30	10.25	.0290	10.80
1545	20	16	214.4	14.2	50.0	10.30	10.30	.0285	10.79
1600	20	16	214.4	14.5	50.0	10.30	10.30	.0290	10.80

Supply voltage applied to equipment was maintained constant at 115 volts. The transmitter, control unit and line transformer were included in this test.

[redacted]

Table 2 - Section 2

Model SC-2 Radar Equipment
Variation in Relative Humidity
Transmitter Unit: Type CG-52ABH
Control Unit: Type CG-23ACD
Transformer

Time Hour	Amb Temp (°C)	Rel Hum (%)	Freq. (Mc)	Power Output Aver. (Watts)	Power Output Peak (Kw)	Osc. I_p (Ma)	Duty Cycle (%)	Fil (Volts)
1015	40	20	214.2	13.1	45.2	10.22	.0290	10.80
1030	40	20	214.6	13.0	45.6	10.20	.0285	10.80
1045	40	20	214.4	13.1	47.0	10.20	.0280	10.79
1100	40	20	214.4	13.3	47.7	10.18	.0280	10.79
1115	40	20	214.4	13.0	46.4	10.18	.0280	10.79
1130	40	58	214.4	12.9	47.1	10.18	.0275	10.70
1145	40.5	97	214.4	12.5	46.4	10.18	.0270	10.70
1200	40	97	214.3	12.2	45.2	10.18	.0270	10.70
1215	40	96	214.3	12.5	46.4	10.18	.0270	10.65
1230	40	96	214.3	12.4	45.1	10.15	.0275	10.61
1245	40	96	214.25	12.5	45.1	10.15	.0272	10.62
1300	40	48	214.25	12.4	45.9	10.15	.0270	10.70
1315	40	21	214.3	12.6	46.7	10.17	.0270	10.70
1330	40	20	214.3	12.5	45.5	10.17	.0275	10.70
1345	39	20	214.4	12.8	47.0	10.17	.0275	10.73
1400	40	20	214.4	12.7	47.6	10.17	.0270	10.70
1415	40	20	214.4	12.6	46.5	10.17	.0275	10.70

Oscillator plate voltage: 10.1 Kv.
Voltage applied to equipment: 115 volts.

[redacted]

Table 3 - Section 2

Model SC-2 Radar Equipment
Starting at High Humidity

Time	Amb Temp (°C)	Rel Humid (%)	Oscillator I_p (Ma)	Oscillator E_p (Kv)	Line Current (Amps)	Average Power Output (Watts)
Equipment not energized. Heaters in transmitter energized.						
1418	40	20				
1430	40	95				
1445	40	97				
1500	40	95				
1515	40	97				
1530	40	95				
Equipment was switched on at 1545.						
1545	40	97	10.2	10.1	9.1	
1548	40	97	10.2	-----	----	12.5

On applying plate voltage at 1545, arcing occurred in transmitter. It was necessary to operate 3 minutes at a reduced plate voltage (7 kv) before 10.1 kv could be applied without sparking.

Line voltage = 115 volts.

[redacted]

Table 4 - Section 2

Model SC-2 Radar Equipment
Resonant Points Noted During Vibration Test

Vibration Frequency (Cpm)	Part Vibrating	Corresponding Point on Plates No. 18 & 19.	Amplitude (Inches)
690	Top Center of Screen.	G	3/16
820	BG Matching Section and BL Antenna.	I H	1/8 3/16
900	Bottom Center of Main Frame	J	1/8 horizontally 1/16 vertically
1000	Ends of Main Reflector	K, L	1-1/4
	2/3 Distance from End of Main Reflector	M, N	1/4
1200	Ends of Main Reflector	K, L	1/2
	2/3 Distance from End of Main Reflector	M, N	1/4
1310	Top Center of Main Reflector	O	1/4
	Ends of Tuning Stubs for SC	P. Q	3/16
	BL Transmission Line	R	1/4
1675	Center of BL Reflector	S	3/16
	Top of Two Center BL Radiators	G	1/2

[redacted]

Table 5 - Section 2

Model SC-2 Radar Equipment
Variation in Line Voltage

Line Voltage Deviation	Line Volts	Freq. (Mc)	Duty Cycle (%)	Fil. Volts	R-F Osc. I_p (Ma)	R-F Osc. E_p (Kv)	Line Curr. Amps	Watts Input
-10%	207	210.6	.045	9.6	14.3	11.4	4.59	878
	210	210.65	.041	9.75	13.0	12.0	4.75	888
	215	210.72	.035	10.0	12.8	12.25	4.82	901
	220	210.65	.030	10.25	12.8	12.6	4.96	904
	225	210.7	.025	10.53	12.8	13.0	5.13	918
Normal Value	230	210.7	.0216	10.79	12.8	13.4	5.28	1001
	235	210.64	.019	11.0	13.0	13.6	5.45	1056
	240	210.62	.017	11.2	12.7	13.6	5.62	1090
	245	210.6	.015	11.5	13.1	14.1	5.83	1132
	250	210.61	.014	11.7	13.2	14.4	6.08	1168
+10%	253	210.61	.014	11.87	13.2	14.5	6.23	1196

Note: Plate and filament voltages can be returned to correct value with variac adjustments even when line voltage is either 10% below or 10% above normal.

List of Units Included in the Above Test

Unit	Model	Type	Serial
Transmitter	SC-2	CG-52ABH	13
Transformer	SC-2	Cat.#7467100	FX
Line Switch DPST	SC-2	A	Cat.#72261
Pulse Indicator	SC-2	-----	13

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Table 6 (Cont'd)

Control Designation	Control Marking	Circuit Controlled	Control Calibration or Positions. Type of Control
		PULSE INDICATOR	
R317	Intensity	Grid Bias Pulse Indicator	Potentiometer
S312	Off -- On	115 Volt Circuit Pulse Indicator	Off -- On SPST Switch
R327	Focus	Accelerating Anode Voltage Pulse Indicator	Potentiometer
		CONTROL UNIT CG-23ACD	
E	Bearing Mark	Controls Horn for Signalling	SPST
K	Local PPI Sweep	Polarity of Armature Voltage of Slewing Motor	DPDT
D	Off -- On Remote Bearing	Parallels Remote Ind. with PPI	6P ST
C	Relative True	Determines Source of Energy for Differential Gen. B104	5 Pole 2 Throw
	Increase Dial Lights	Brilliance of V103, V104, V105, V106	R109 Potentiometer
B	0--130 Trans. Plate Voltage	Primary of Power Transformer in Transmitter	
L	Relay Reset	Controls Relay K303	Momentary Push Button
H	0' - 10' Manual	Controls Position of Rotor of Diff. Gen.	Hand Wheel
J	R.R. On--Off	Relay in IFF.	SPST
F	Auto Manual	Slewing Motor Field Excitation	SPST
G	CCW Off CW Antenna Rotation	Controls Polarity of Slewing Motor Armature. R102A, R102B(2), R102C	3 Ganged Potentiometer Continuously Variable
A	Off On Power	Controls Line Voltage & Strip Heaters, RCVR-Ind.&Ant.Ped.	3P DT
	Increase Indicator Lights	Brilliance of I101, I102	R110 Potentiometer

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Table 6 - Section 2

Model SC-2 Radar Equipment
List of Controls

Control Designation	Control Marking	Circuit Controlled	Control Calibration or Positions. Type of Control
		TRANSMITTER	
S308 A & B	Grid Resistance	Osc. Grid Resistance	1-8 Ganged Switches
S301	Power	115V AC Input	On Off Double Pole ST
S305	Relay Reset	Controls Relay K303	Momentary Push Button Switch
C	Output Matching	Impedance of Compensating Stub	0-100 Dial
This controls the length of the compensating stub.			
A	Oscillator Tuning	Osc. Grid Inductance	0-100 Dial
This varies the inductance of the osc. cir. by rotating aluminum discs with respect to the grid coils.			
	Plate Shorting	Osc. Plate Circuit	Switch and Mechanical Linkage Safe--Operate
This shorts the osc. plate circuit to ground in safe position and locks front doors closed and sides and back on when in the operate position; opens interlock switch S311 in safe position.			
T309	Filament Voltage	Voltage on Transmitter Tubes	Increase
This dial controls position of brushes on auto transformer.			
S302	Test--Operate	Interlock Circuit	Test Operate
This DPST switch makes interlock circuit independent of E_p in test position.			
B	Output Coupling	Coupling Between Filament and Transmission Line	0-100 Dial
This varies position of filament coupling connector.			

[redacted]

Table 7 - Section 2

Model SC-2 Radar Equipment
List of Meters

Circ. Sym.	Meter Range	Meter Circuit	Meter Dial Marking
M301	0-15 AC Volts	Filament Voltage	AC Volts U.S.N. Type CG-22080 General Electric made in U.S.A. Type AO-22 Model 8A022 Cycles 25-133 No. 4023 N.P.60705
M302	D-C Milliamperes 0-25	Plate Current	D-C Milliamperes U.S.N. Type CG-22054 General Electric Made in U.S.A. Type DO-41 Model 8D041 No. S6514 N.P. 63807
M303	D-C Milliamperes 0-5	Grid Current	D-C Milliamperes U.S.N. Type CG-22050 General Electric Made in U.S.A. Type DO-41 Model 8D041 No. V3108 N.P. 63807
M304	Hours 0-99999	Filament Circuit	Hours General Electric Time Meter Model 8KT8E3 110 Volts 60 Cycles U.S.N. Type CG-22289 Made in U.S.A.

[redacted]

Table 8 - Section 2

Model SC-2 Radar Equipment
List of Vacuum Tube Potentials

Circuit Symbol	Tube Type	Filament Voltage-Volts Actual	Filament Voltage-Volts Panel Meter	Rated	Circuit
V301	GL8020	4.59	10.8	5.0	Transmitter Rectifier
V302	GL8020	4.59	10.8	5.0	" "
V305	327A	10.49	10.8	10.5	R-F Oscillator
V306	327A	10.50	10.8	10.5	" "
V307	327A	10.50	10.8	10.5	" "
V308	327A	10.49	10.8	10.5	" "

The filament voltages were measured with zero plate voltage.

Table 9 - Section 2

Model SC-2 Radar Equipment
List of Fuse Currents

		Fuse Mount Marking			Size Inch		Rating on Fuse		Operating Conditions			
Cir. Symb.	#	Cir. Symb.	Amps	Volt	Dia.	Leng.	Amp.	Volt	Volt	Amps Surge	Amps Nor.	Fuse Circuit
						TRANSMITTER						
F301	R	F301	20	250	9/32	2	20	250	112	14.0	8.35	Transmitter Line Fuse
F302	R	F302	20	250	9/32	2	20	250	112	14.0	8.35	Transmitter Line Fuse

Note: Transmitter stops operating when F301 or F302 are removed.

						CONTROL UNIT						
F101	R	F101	40	250	13/16	3	40	250	115	13.8	*7.75	Line Fuse
F102	R	F102	40	250	13/16	3	40	250	115	13.7	*7.90	Line Fuse

Note: Transmitter stops operating when F101 is removed.
Transmitter stops operating when F102 is removed.

Main Line Switch - No Cir. Symb.

	R	----	--	---	13/16	5	20	600	440	3.6	*2.6	Main Line
	R	----	--	---	13/16	5	20	600	440	3.6	*2.6	Main Line

Note: Transmitter stops operating when either fuse is removed.

* Does not include current requirement of receiver, antenna, or indicator unit.
\# N in this column indicates non-refillable type fuse. R indicates refillable type fuse.

Table 10 - Section 2

Model SC-2 Radar Equipment
List of Transformers

Circuit Symbol T302

General Electric
Transformer Primary Connections

Line Volts	Lines On	Sec. Volts	Sec. Amp.
115	1 & 2	6250	.056 RMS
115	1 & 3	3050	.056 RMS
115	1 & 4	2600	.056 RMS

Schenectady, N.Y. Made in USA

General Electric
Transformer
Cat. 686NO KVA .350
12.5 KV INS. CYC. 60
Volts 115 PRI. 6250 3850/2600 Sec.
Diagram M7466143PTI Pat. CG 30872

T304

General Electric
Filament Transformer
Cat. 68G112
PRI.V. 115 Sec. V. 11.5 CYC. 60
KV-A. .130 Insulation KV .75
M-7465928-1 CG-30869
NP52986 Schenectady, N.Y. Made in USA

T305 Nameplate Inaccessible

T306

General Electric
1 Filament Transformer
Cat. 68G117 CG-30873
PRI. V. 115 Sec. V. 11.5 CYC. 60
KV-A. .130 Insulation KV. .75
M-7465928-1
Schenectady, N.Y. Made in USA FX

T307

General Electric
G Filament Transformer EX
Cat. 68G117 CG-30873
PRI. V. 115 Sec. V. 11.5 CYC. 60
KV-A .130 Insulation KV. .75
M-7465928-1
Schenectady, N. Y. Made in USA

[redacted]

Table 10 - Section 2 (Cont'd)

T308 General Electric
O Filament Transformer EX
Cat. 68G117 CG-30873
PRI. V. 115 Sec. V. 11.5 CYC. 60
KV-A. .130 Insulation KV. .75
M-7465928-1
Schenectady, N.Y. Made in U.S.A.

T309 General Electric
Auto Transformer
Cat. 68G245 7.5 Amp Output
CG-308730 CYC. 60
Output .860 KV-A. Equiv.---KV-A.
Volts. 115 90-130
Diagram U.S. Pat. 2009013

T310 No Nameplate.

T311 No Nameplate

T151 No Nameplate

T152 No Nameplate

T101 The Adjustable Transformer
VARIAC
Trademark Reg. U.S. Pat 2009013
GR
GENERAL RADIO CO. CAMBRIDGE, MASS. U.S.A.

T102 General Electric
Auto Transformer AX
Cat. 67G997
Serial Cont 84613 CYC. 60
Output .0234 KV-A EQUIV. .00754 KV-A
Volts 115 Input 78 Output
Diagram M7465908 U.S. Pat.

 [redacted]

Test 10 - Sec. 2 (Cont'd)

T103

General Electric
Filament Transformer
Cat. 68G64
Pri. V. 115/230 Sec. V. 6.3 CYC. 60
KV-A. .0095 Insulation KV .75
M-7465909
N.P. 52986 Schenectady, N.Y. Made in USA AZ

General Electric
Transformer Primary Connections

Line Volts	Lines On	Links Connect
115	1 & 4	1 to 3 & 2 to 4
230	1 & 4	2 to 3

N.P. 89621 Schenectady, N.Y. Made in USA

[redacted]

Table 11 - Section 2

Model SC-2 Radar Equipment
List of Relays

Circuit Symbol

K301

General Electric
Relay
Model No. 12HGA15FIN
Volts 115 Amps CY. 60
Ext--
U.S. Pat.
1576155 Made in
2184342 USA

GX 1083 Part Bulletin
INST. GEI 1093 GEF2623

K302

General Electric
Electric Reset
Coil
F. 3128881
Volts 1 Min.
115 cycles 60
Resistor Cat.

Ohms
Schenectady, N.Y. Made in USA

General Electric
Instantaneous
Overcurrent Relay
Model 12PBC14B2N
Type PBC Amps. 4
Part Bulletin
GEF 2337
U.S. Pat.
2029136 2029137 CX1500
Made in USA

K303

General Electric
Relay
Model No. 12HGA15FIN
Volts 115 Amps CY. 60
Amps Part Bulletin
INST GEI 10930 GEF2623
US Pat. 1576155 Made in
2184342 CX1287 USA

[redacted]

Table 12 - Section 2

Model SC-2 Radar Equipment
List of Weights and Dimensions

Unit	Overall Dimensions in Inches Height	Width	Depth	Length	Weight Pounds
ST DP Switch Cat. No. 72261 Type "A"	14-1/2	9-3/4	5-3/8		13.5
G.E. Transformer 60 cycles Ser. FX N.P. 79203 Cat. 7467100	7-13/16	8-7/8		20-3/8	139
Control Unit Type CG-23ACD	19-3/8	13-7/16	21-1/2		126
Transmitter Type CG-52ABH	62	20-3/4	20-5/8		345

[redacted]

Table 13 - Section 2

Model SC-2 Radar Equipment
Nameplates

On Radar Transmitter

Nameplate: 4" wide, 4-1/2" high:
MODEL SC-2 RADAR EQUIPMENT
Supply: 115V 1 ø 60 cycles Serial 2
Equipment Consists of Accessories and the Following:

1 CG-21ABU Motor-Dynamo Amplifier Unit
1 CG-23ACD Control Unit
1 CG-46ABJ Radar Receiver-Indicator
1 (*) Duplexing Unit
1 CG-50 ABM Pre-Amplifier Unit
1 CG-52 ABH Radar Transmitter
1 CG-55 ACC Plan Indicator
1 CG-55 ACD Plan Repeater Indicator
1 CG-62060 Receiver Junction Box
1 (*) Antenna Assembly

(*) For Navy Type Numbers see Instruction Book
See License Notice Inside
NAVY DEPARTMENT
Bureau of Ships
Contractor
GENERAL ELECTRIC
Schenectady, N.Y., Made in U.S.A.

Contract Number	Contract Date
NOs. -84613	April 21, 1941

Nameplate: 3" wide, 2" high
Type CG-52ABH
Radar Transmitter
Input 115/1/60 10 Amps 1100 Watts
345 Pounds Serial 13
A Unit of Model SC-2 Radar Equipment
Manufactured for
Navy Department -- Bureau of Ships
By Contractor
GENERAL ELECTRIC
Schenectady, N. Y., Made in U.S.A.

Contract Number	Contract Date
Nos. - 84613	April 21, 1941

[redacted]

Table 13 - Section 2 (Contd)

Model SC-2 Radar Equipment

Nameplate: 3-3/4" wide, 2-1/8" high
PULSE INDICATOR
FOR
SC-2
OFF ON
Intensity Focus
Serial #13

Nameplate: 3" wide, 1/2" high
Accepted by Navy Placed in Service
1-1-43
See Instruction Book Regarding Guarantee

On Control Unit
Nameplate: 3" wide, 2" high
Type CG-23ACD
Control Unit
125 Pounds Serial 9
A Unit of Model SC-2 Radar Equipment
Manufactured for
Navy Department - Bureau of Ships
By Contractor
GENERAL ELECTRIC
Schenectady, N.Y., Made in U.S.A.
Contract Number Contract Date
Nos. 84613 April 21, 1941

Nameplate: 2-3/4" wide, 1-5/8" high
GENERAL ELECTRIC
Transformer
Cat. 7467109
Cy. 60
KVA 3.5
Inst. GEI 710 Inside Wiring Compartment
Serial FX ___
U.S. Pat. ___

Table 13 - Section 2 (Contd)

Model SC-2 Radar Equipment

Main Line Switch A

Nameplate: 2-1/8" wide, 2-3/8" high (Irregular)

The		
Trumbell Elec.		Plainville
Mfg. Company		Conn., USA
Type		A
Cat. Number	72261	
30	Amp.	2 Pole
	600	Volts
Max. H.P.	7-1/2	600 D.C.
Max. H.P.	________	________
Max. H.P.	________	________

Table 14 - Section 2

Model SC-2 Radar Equipment
Radio Frequency Power Output

Freq. Mc/s	Power Output Aver. (Watts)	Power Output Peak (Kw)	Duty Cycle (%)	Standing Wave Ratio	Control Settings A	Control Settings B	Control Settings C	Band
215.8	31.5	225	.0140	0.51	50.0	76.5	49.0	Bl
215.9	26.1	186	.0140	0.59	50.0	33.0	75.5	"
212.4	26.9	174	.0160	0.59	50.0	0	83.8	"
196.8	44.2	196	.0225	0.82	50.8	72.0	16.5	Yel
197.0	43.3	196	.0220	0.81	50.8	74.0	16.5	"
197.9	37.0	200	.0185	0.81	58	41	9.2	"
197.9	39.1	190	.0205	0.69	58	60.6	3.5	"
192.2	43.9	186	.0235	0.94	50	72.5	53.5	Gr
182.8	43.3	216	.0200	0.90	84	66.5	43.5	Red
182.8	41.3	206	.0200	0.82	84	66.5	49.5	"

Oscillator plate voltage 15.0 kilovolts
Westinghouse Type 327A oscillator tubes

Table 15 - Section 2

Model SC-2 Radar Equipment
Variation in R-F Output with Setting of Transmitter
Coupling Control

Setting of Control		Power Output		Duty Cycle	Standing Wave	Freq.
B	C	Aver. (Watts)	Peak (Kw)	(%)	Ratio	Mc/s
0	53	44.0	220	.0200	0.87	182.4
5	55	43.2	216	.0200	0.87	182.0
10	53.5	43.3	216	.0200	0.87	182.3
20	53.5	41.6	208	.0200	0.87	182.4
30	54.0	41.1	206	.0200	0.87	182.4
40	53	41.5	207	.0198	0.87	182.4
50	49	41.8	210	.0199	0.86	182.8
60	48.5	42.4	217	.0195	0.89	182.8
70	47	43.0	215	.0200	0.86	182.8
80	43.9	43.3	222	.0195	0.85	182.9
90	41.5	43.1	221	.0195	0.86	182.8
96 Max	39.9	42.6	213	.0200	0.86	182.8

Oscillator Plate Voltage = 15 kilovolts
Control A Setting = 84
Band = Red
Westinghouse Type 327A tubes.

Table 16 - Section 2

Model SC-2 Radar Equipment
Variation in Power Output of Transmitter
with Oscillator Plate Voltage

Freq. Mc/Sec	Oscil. Plate Voltage (Kv)	Power Output Aver. (Watts)	Power Output Peak (Kw)	Duty Cycle (%)	Standing Wave Ratio
182.4	7.5	9.8	81	.0120	0.86
182.6	10.0	19.9	133	.0150	0.90
182.6	12.5	32.2	185	.0175	0.89
182.8	15.0	43.3	216	.0205	0.89

Control Settings A = 84; B = 66.5; C = 49.5
Red Band.
Westinghouse Type 327A tubes

[redacted]

Table 17 - Section 2

Model SC-2 Radar Equipment
Effect of Oscillator Tube Replacement Upon
R-F Power Output

Freq. Mc/S	Power Output Aver. (Watts)	Power Output Peak (Kw)	Duty Cycle (%)	Standing Wave Ratio	Control Settings A	Control Settings B	Control Settings C
Eimac Type 327A tubes in Transmitter: Serial Numbers of Tubes: J2-3229; J2-3225; J2-34833; H2-31529.							
189.0	42.7	152.8	.028	0.82	50	50	54
Westinghouse Type 327A tubes in Transmitter: Serial Numbers of Tubes: D25276P; D25617P; D26056P; D25948P.							
188.5	41.7	181.5	.023	0.81	50	50	54

Oscillator Plate Voltage = 15 Kilovolts
Green Band.

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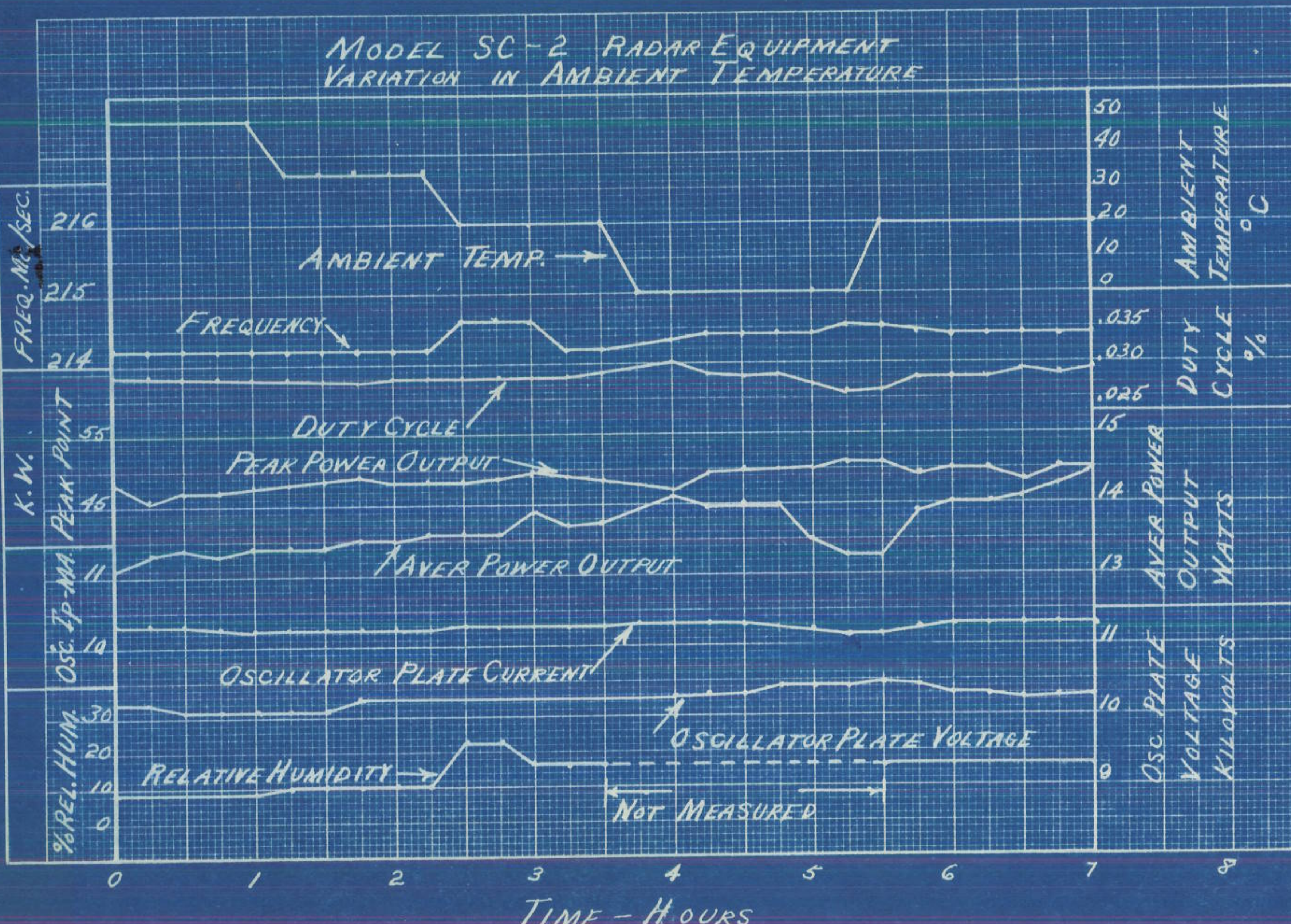

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PLATE 1-SEC. 2

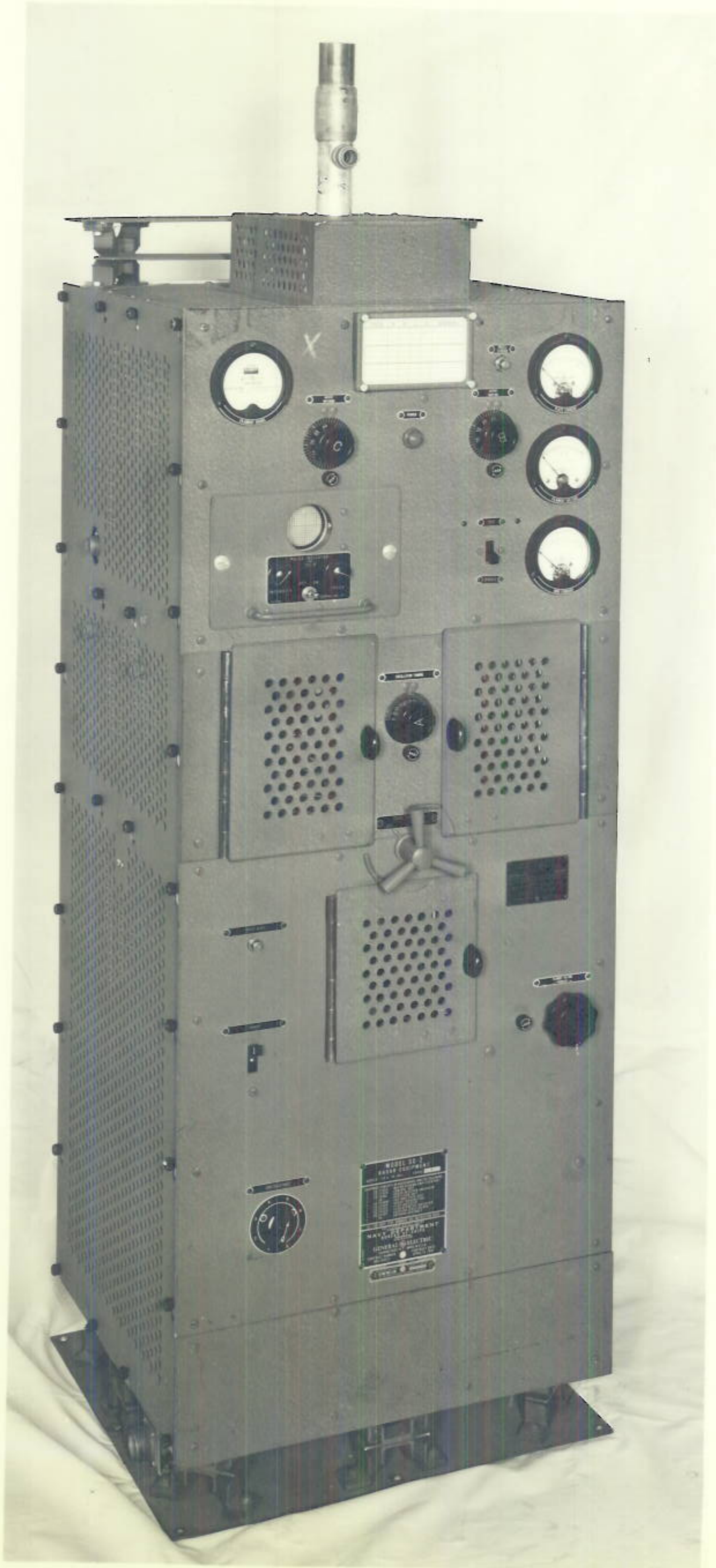

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PLATE 3 SEC.2

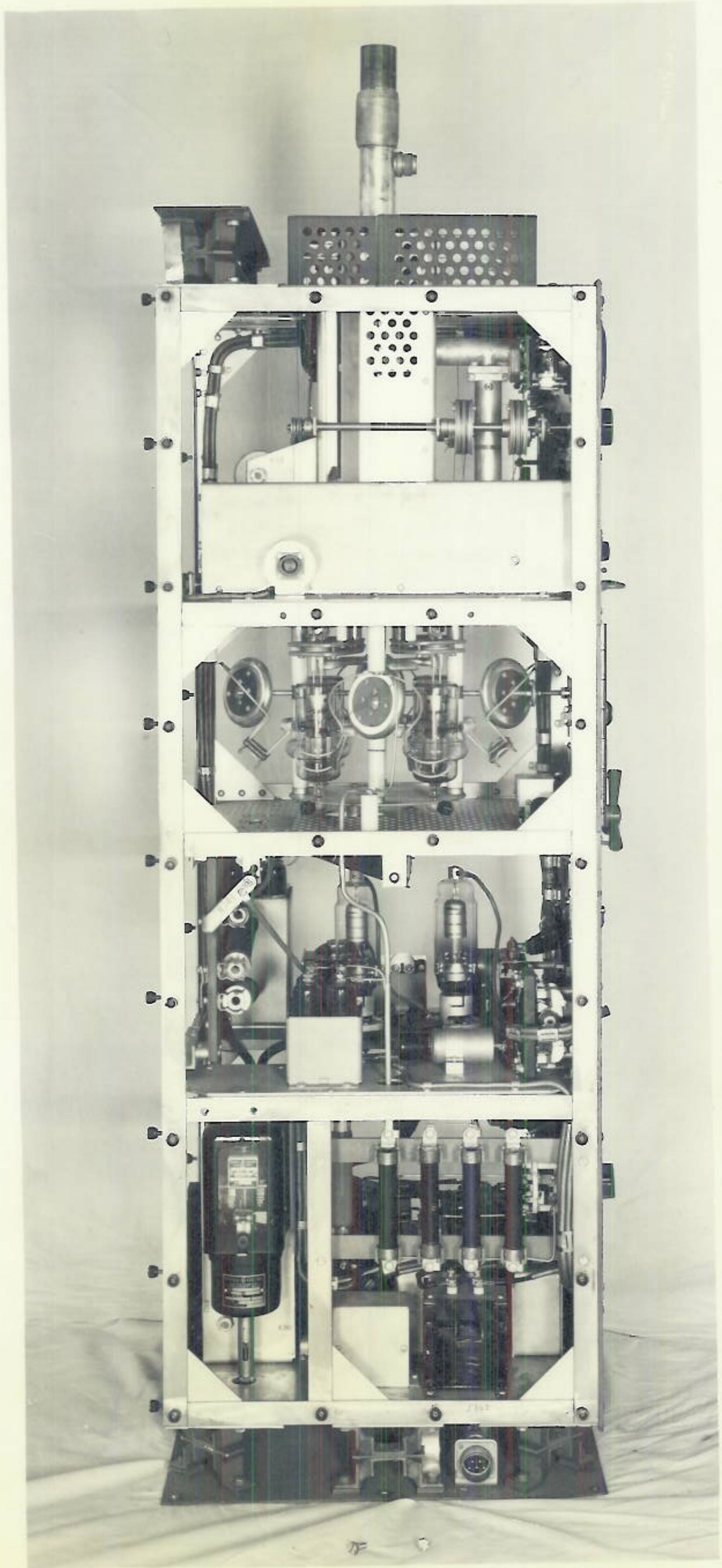

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PLATE 4 SEC. 2

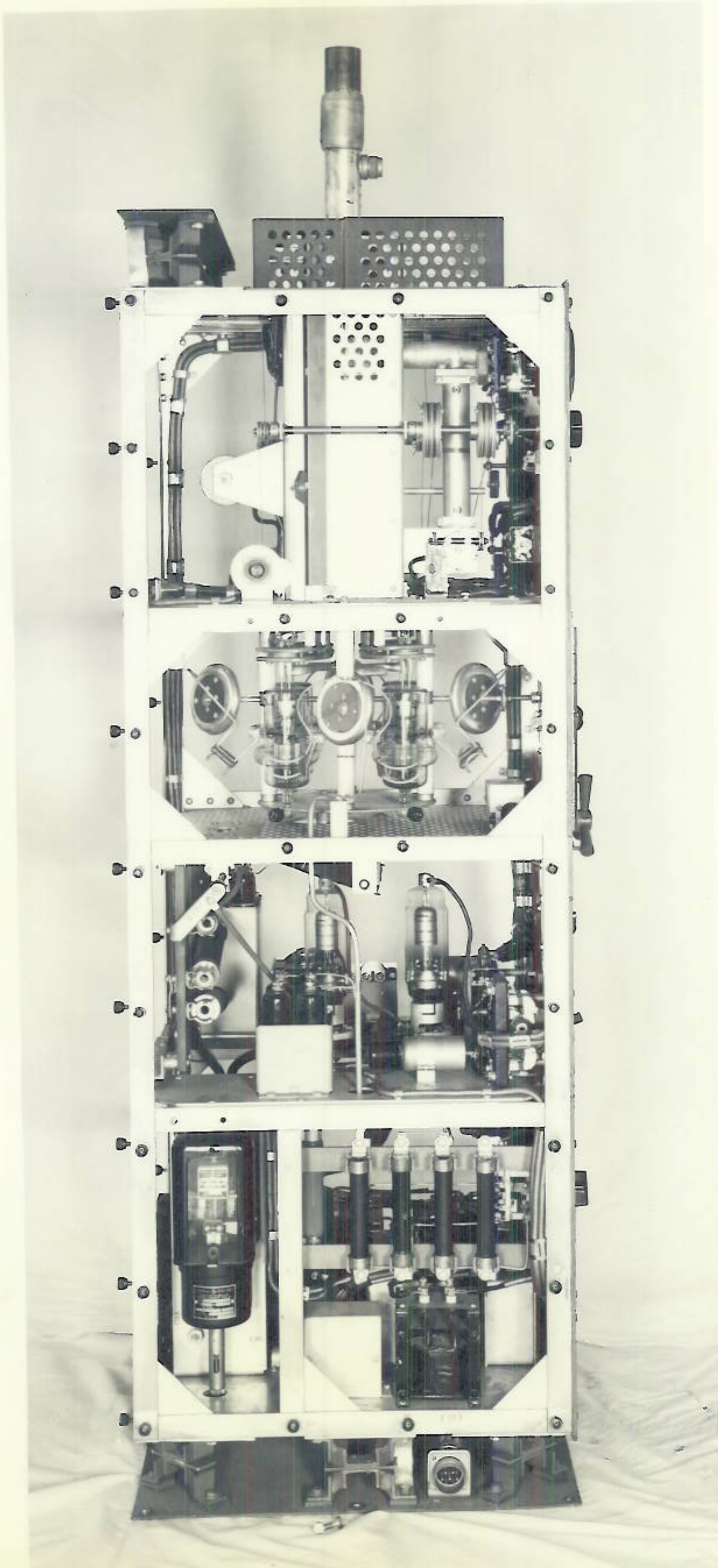

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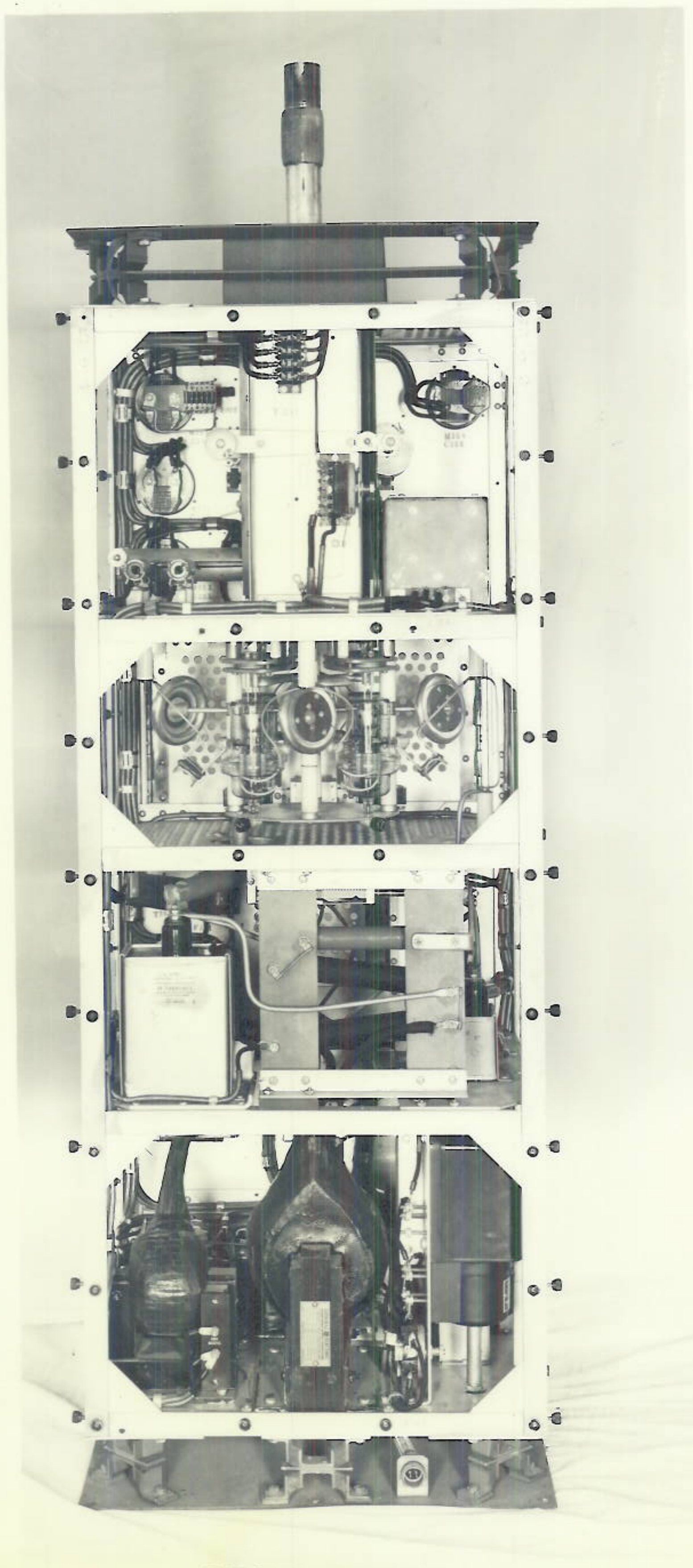
PLATE 5 SEC. 2



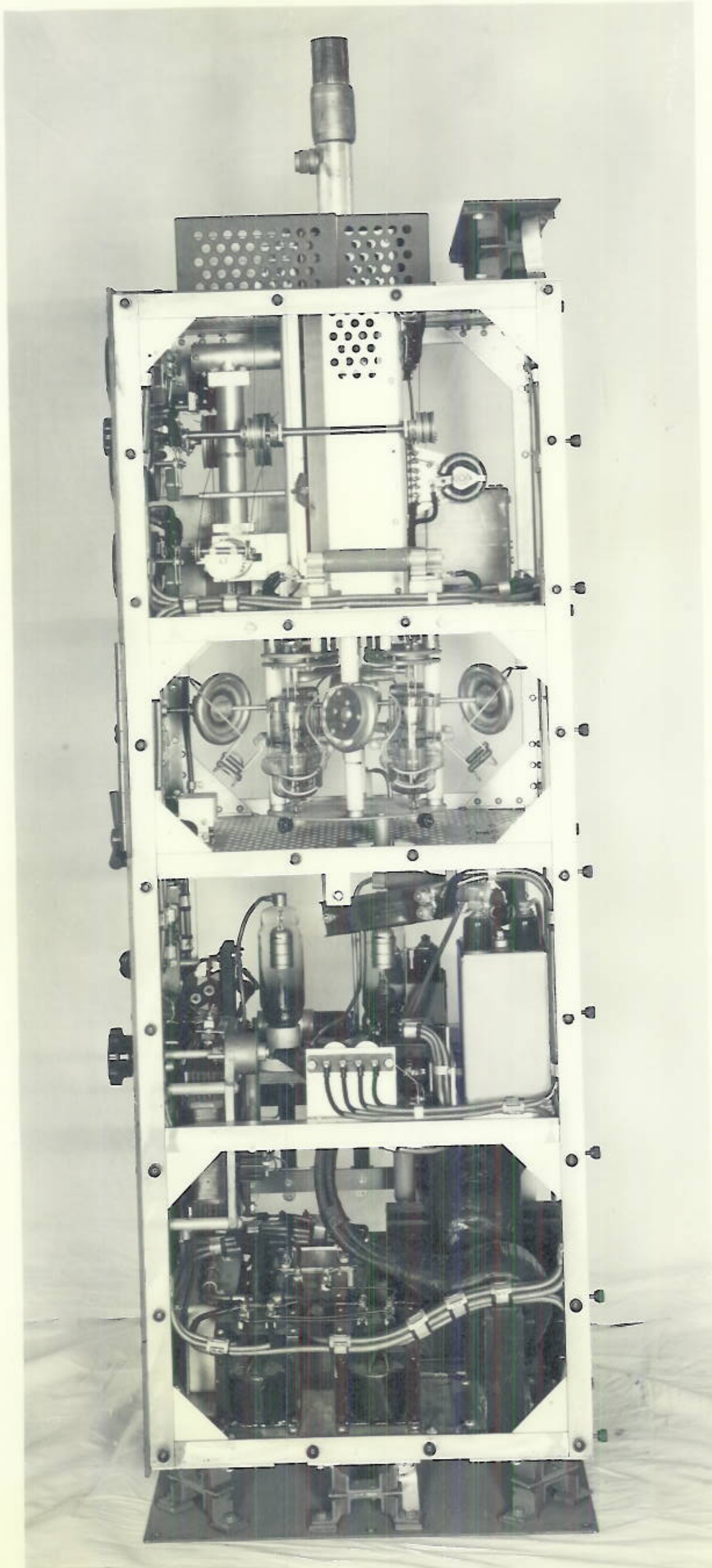


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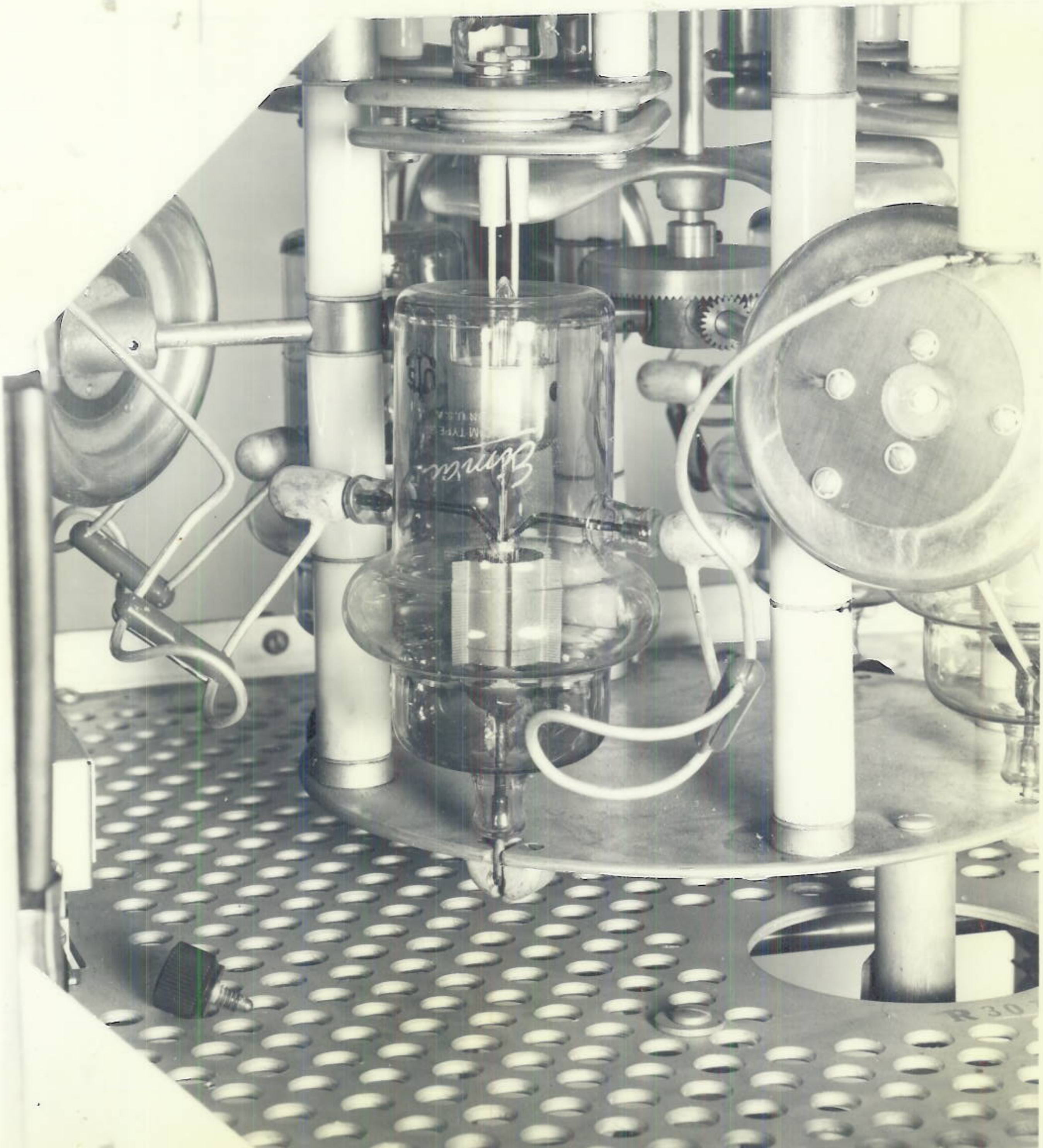
PLATE 7 SEC. 2



CONFIDENTIAL DECLASSIFIED PLATE 8 SEC. 2

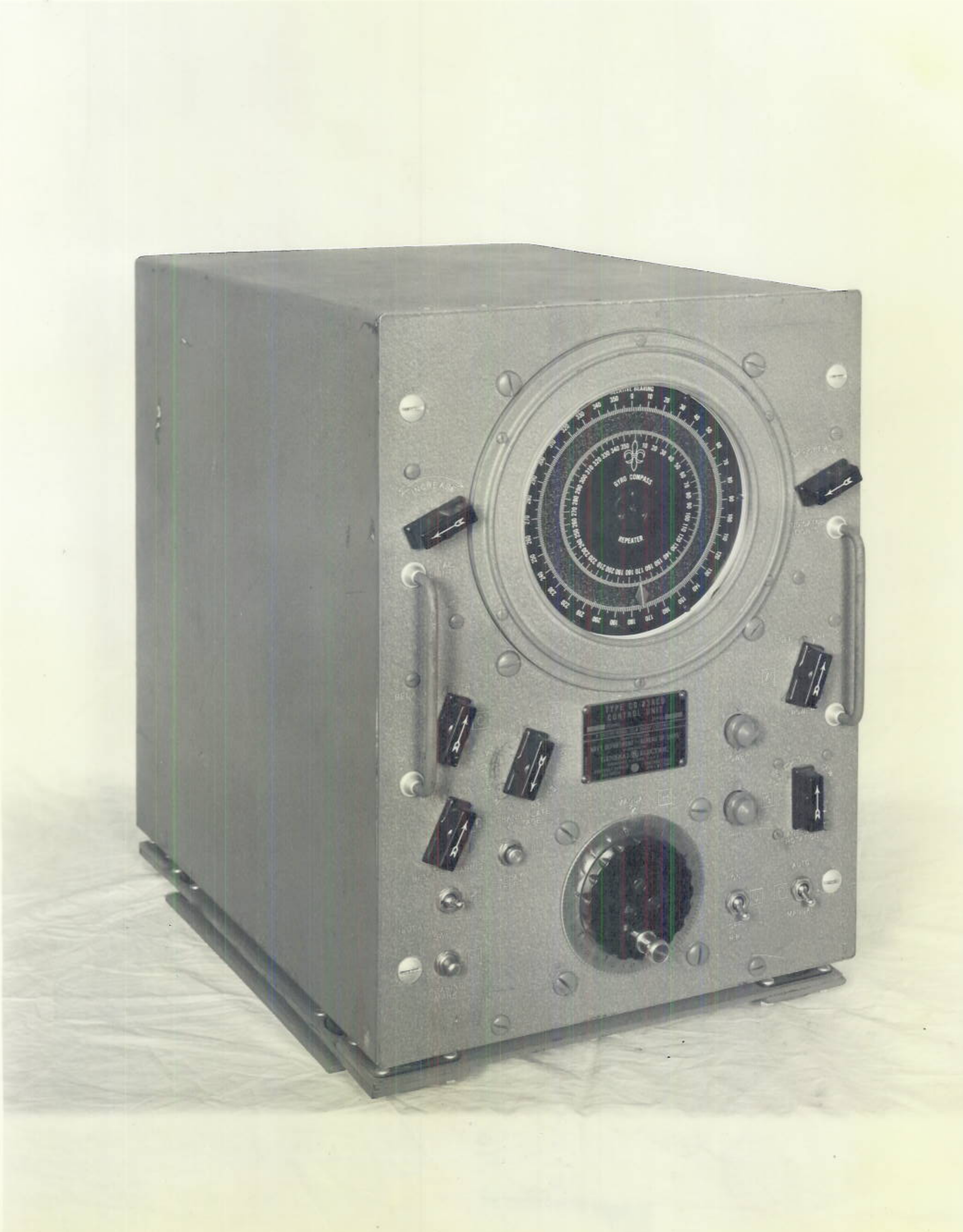


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PLATE 9 SEC. 2

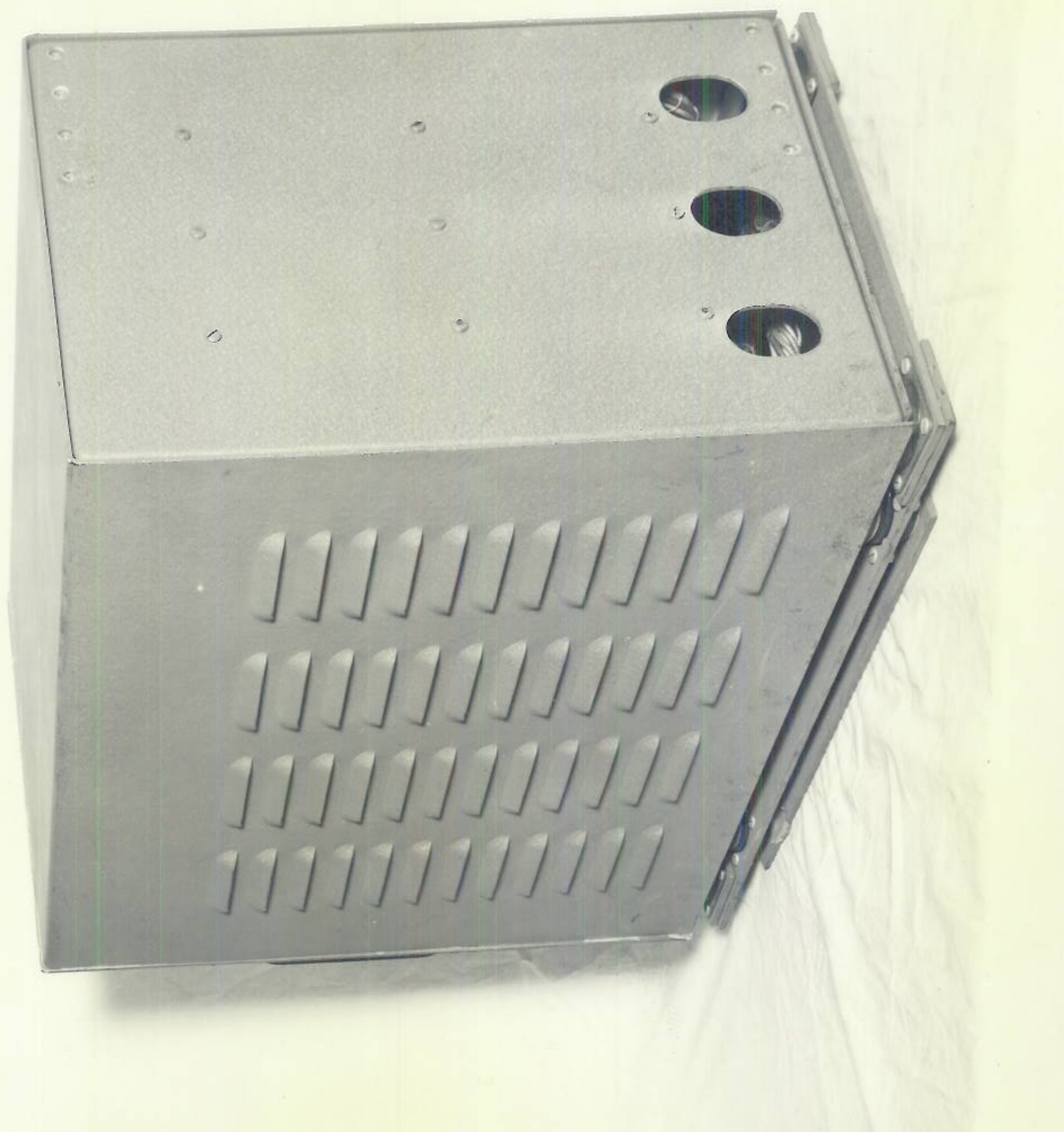

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PLATE 10 SEC. 2

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PLATE II SEC.2

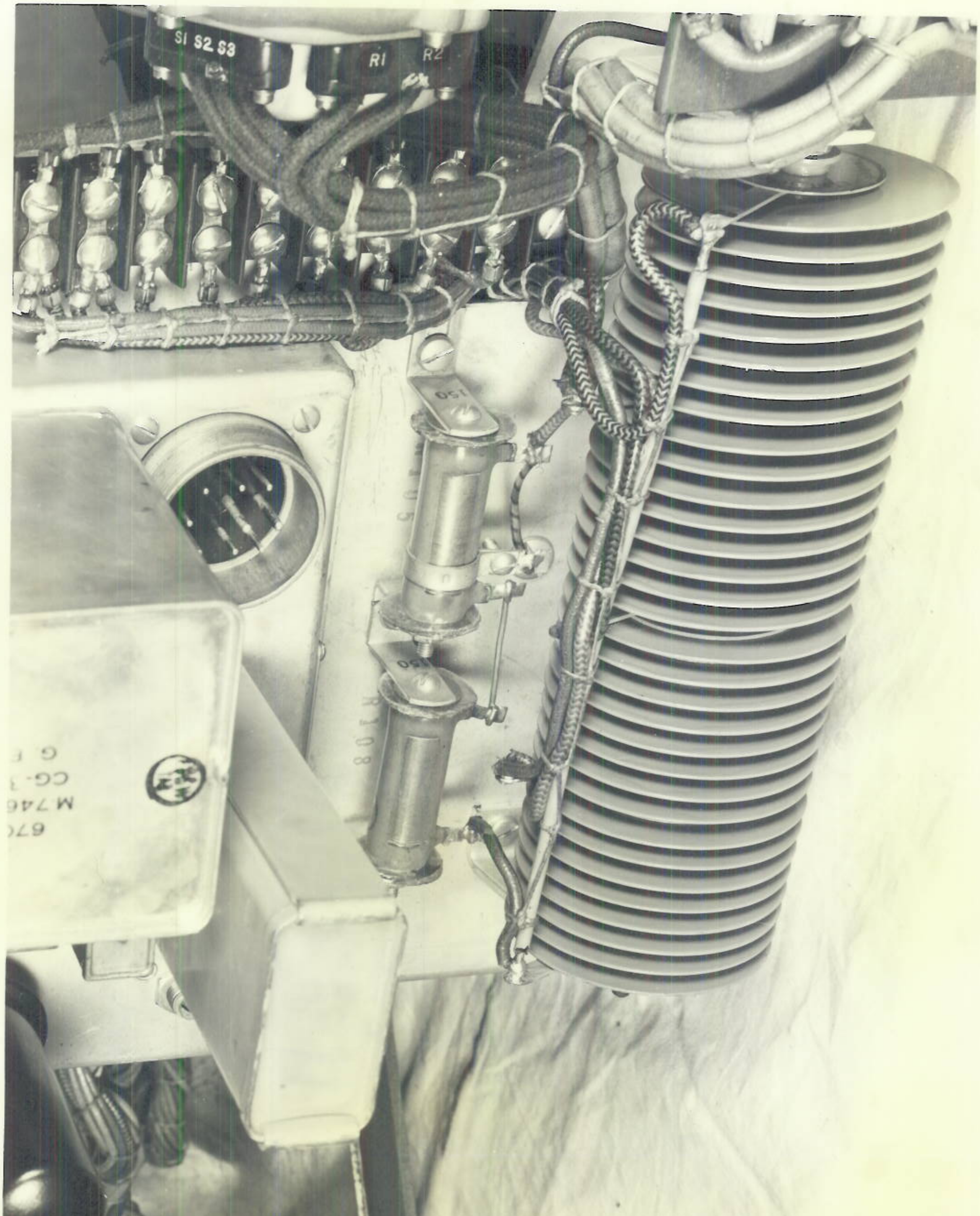

PLATE 12 SEC. 2

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PLATE 13 SEC. 2

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PLATE 14 SEC. 2

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PLATE 15 SEC. 2

PLATE 16 SEC. 2

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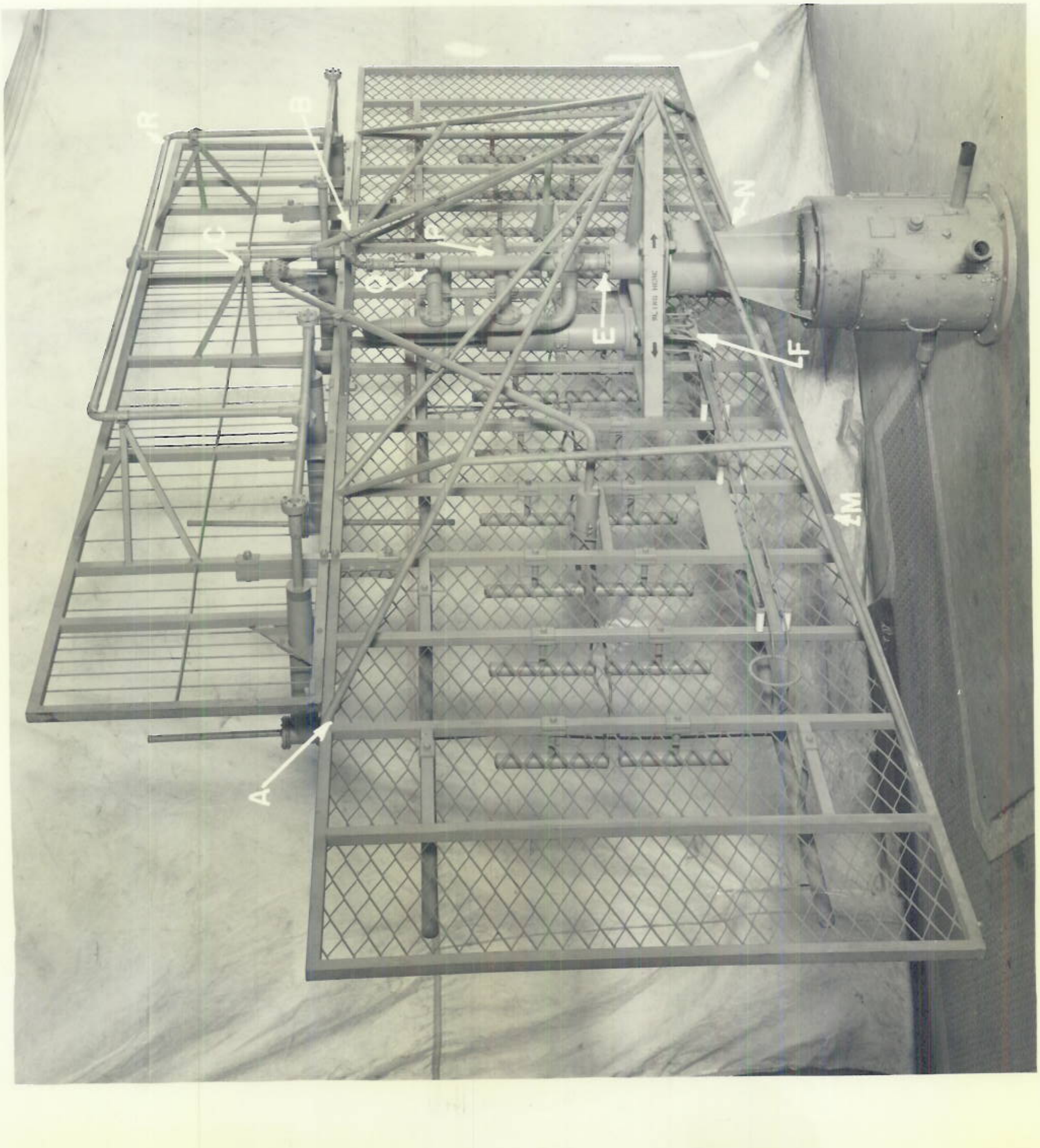
PLATE 17 SEC. 2

PLATE 18 SEC. 2



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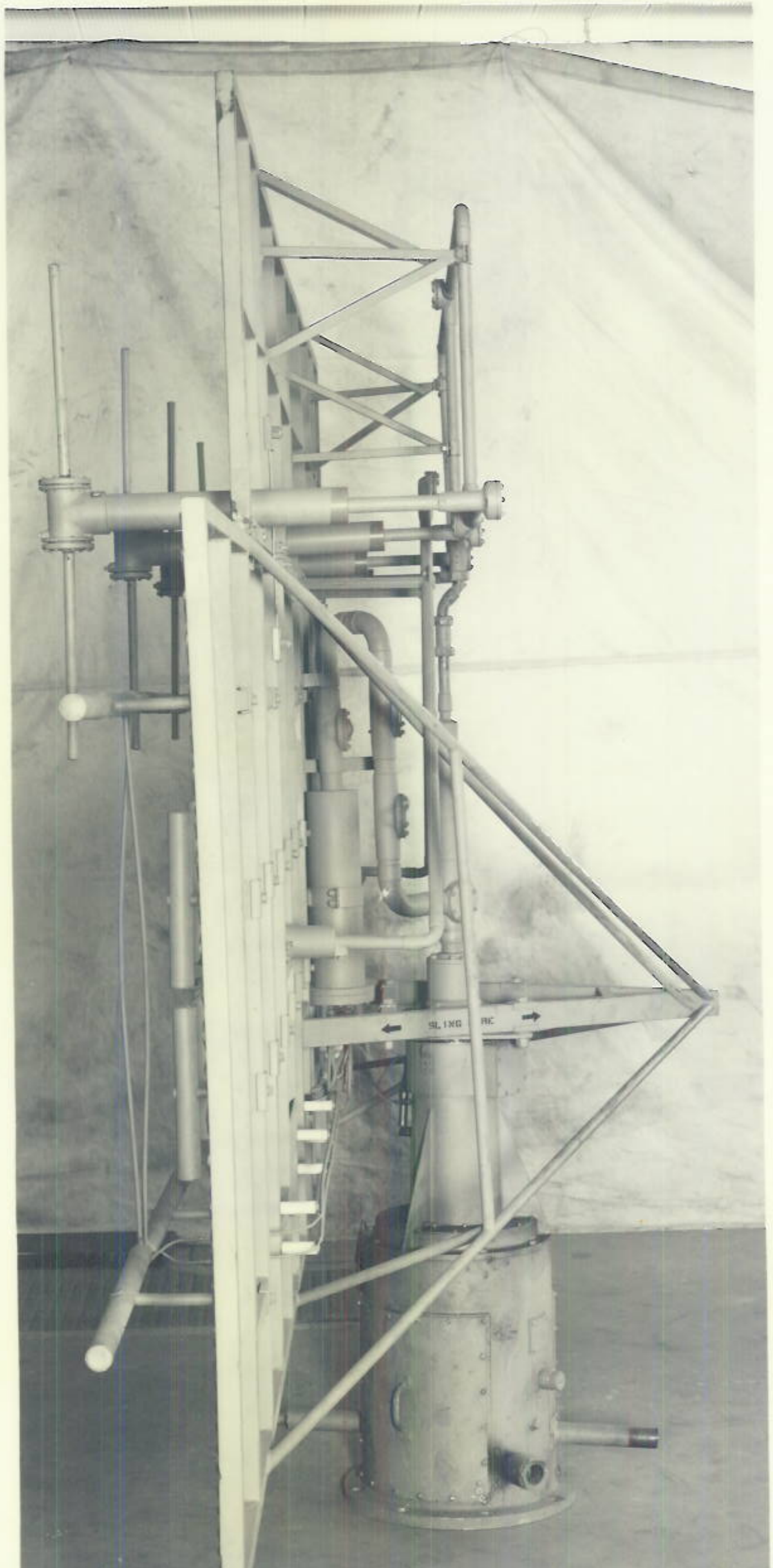

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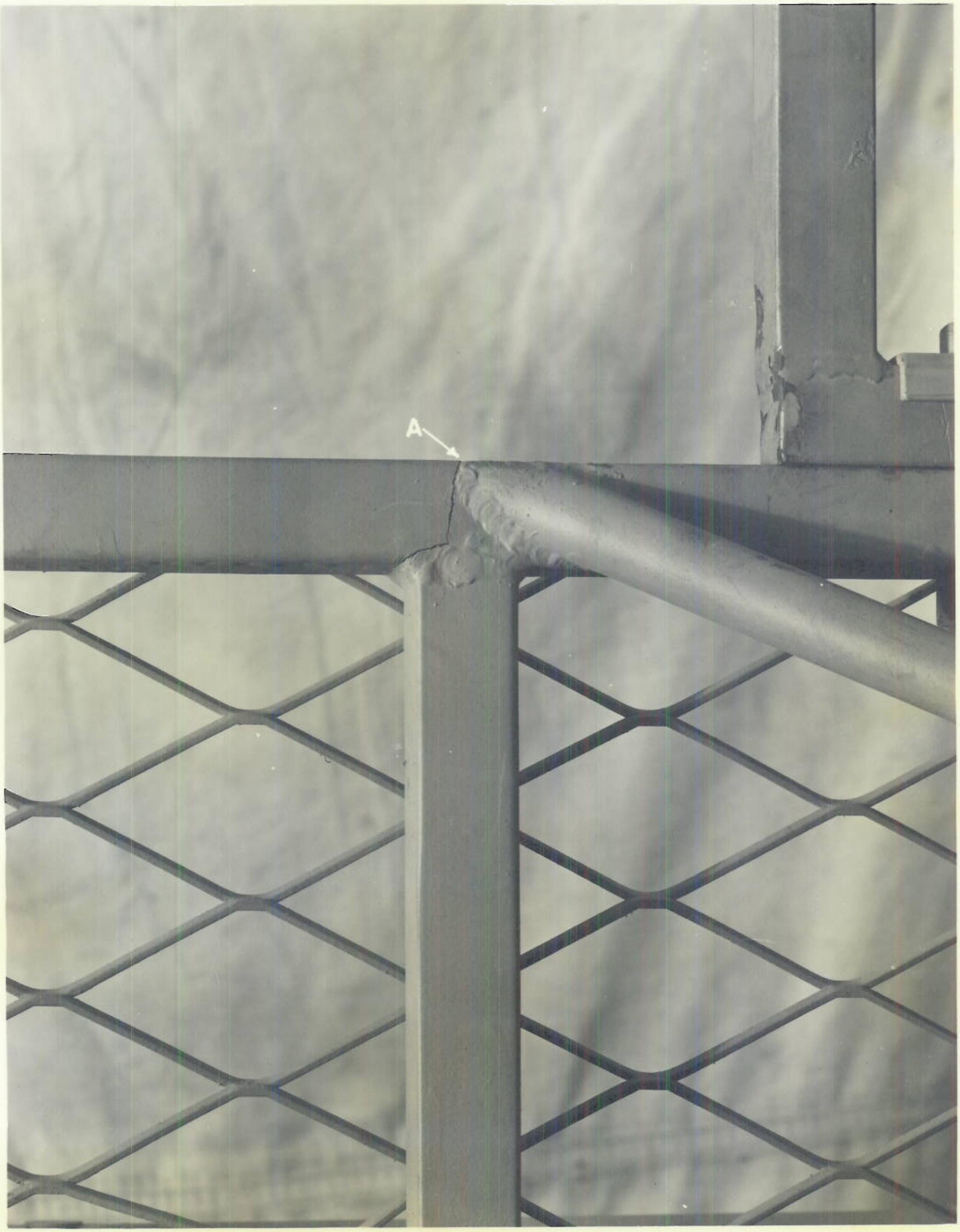

PLATE 21 SEC.2

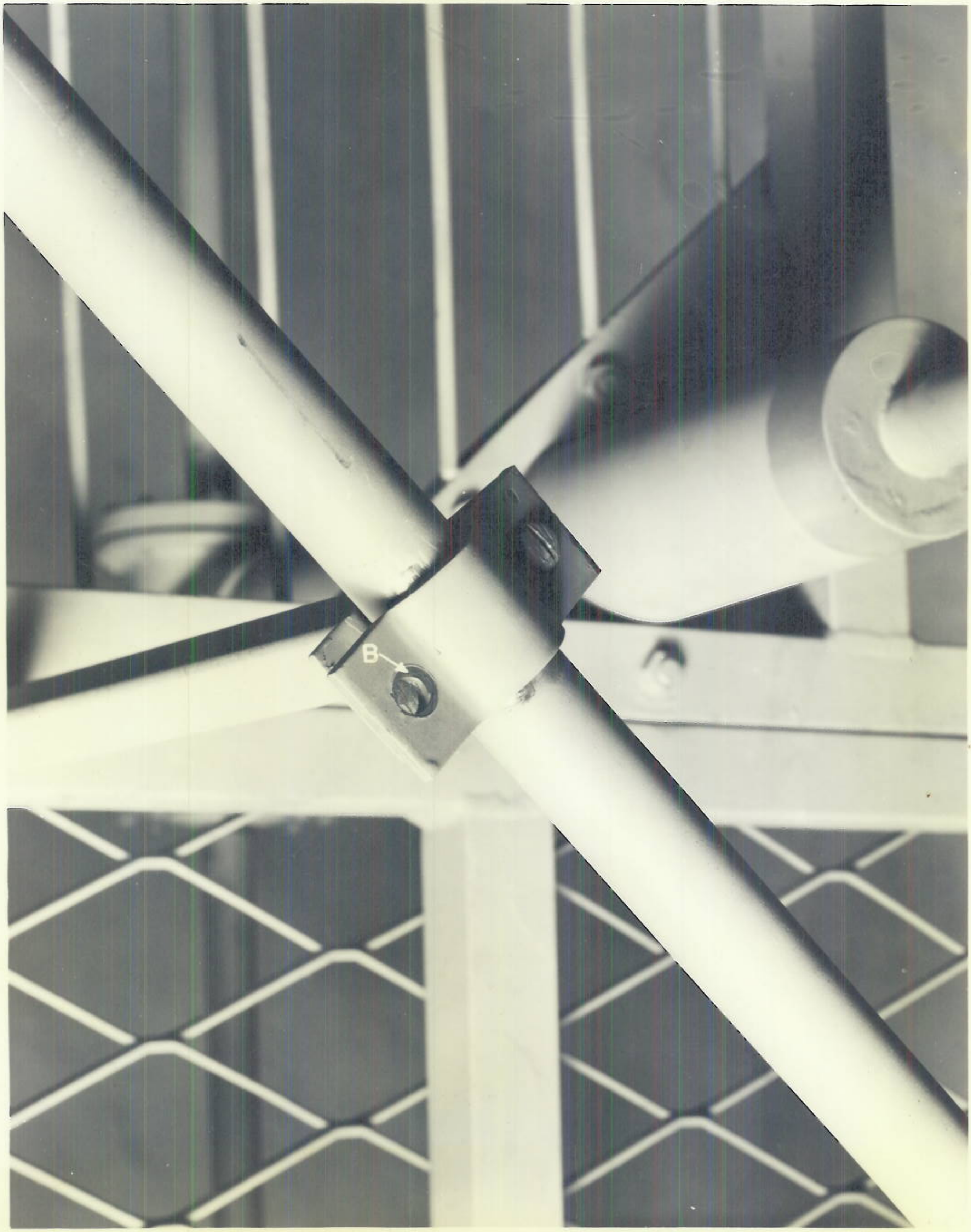

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PLATE 22 SEC.2

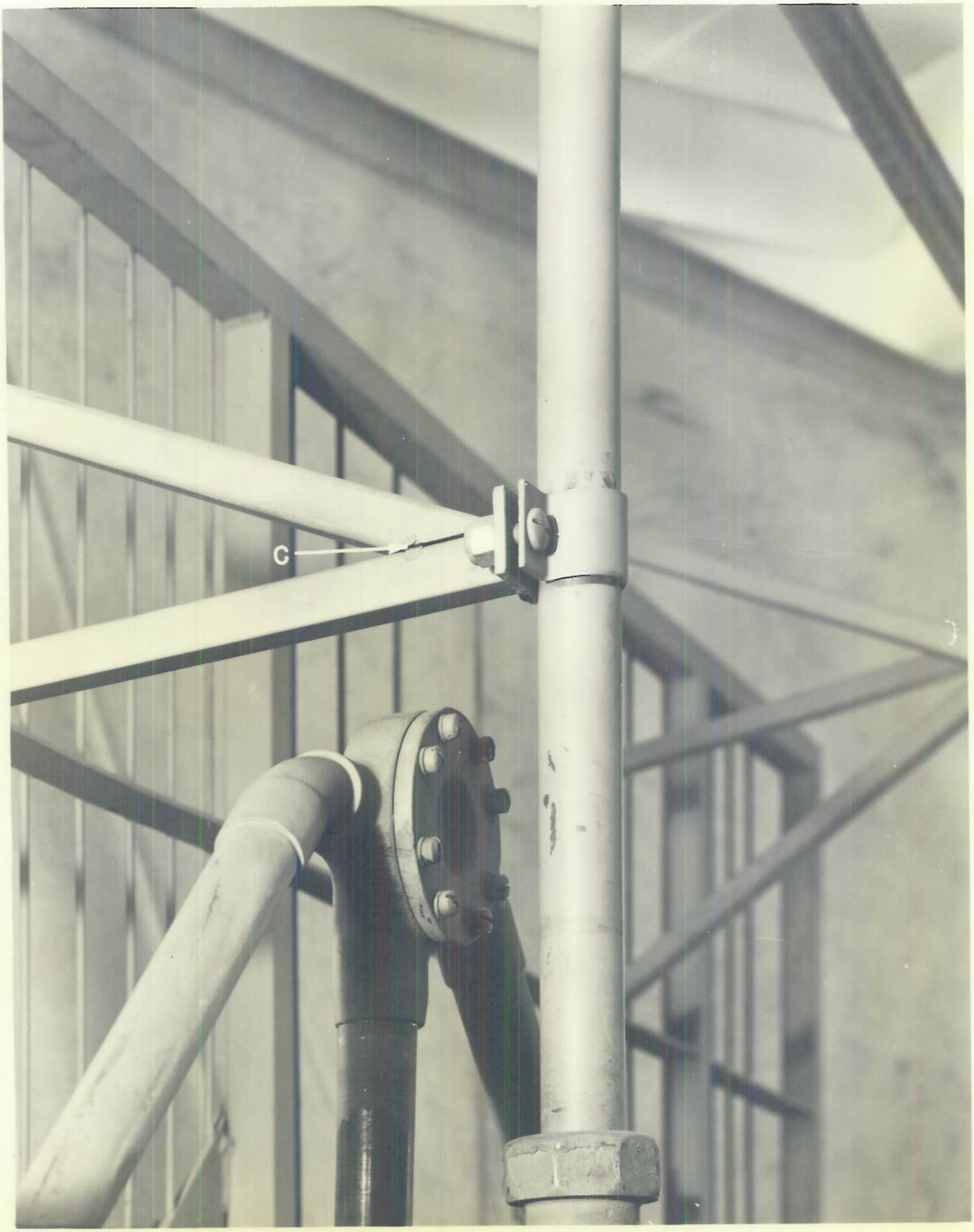

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PLATE 23 SEC. 2

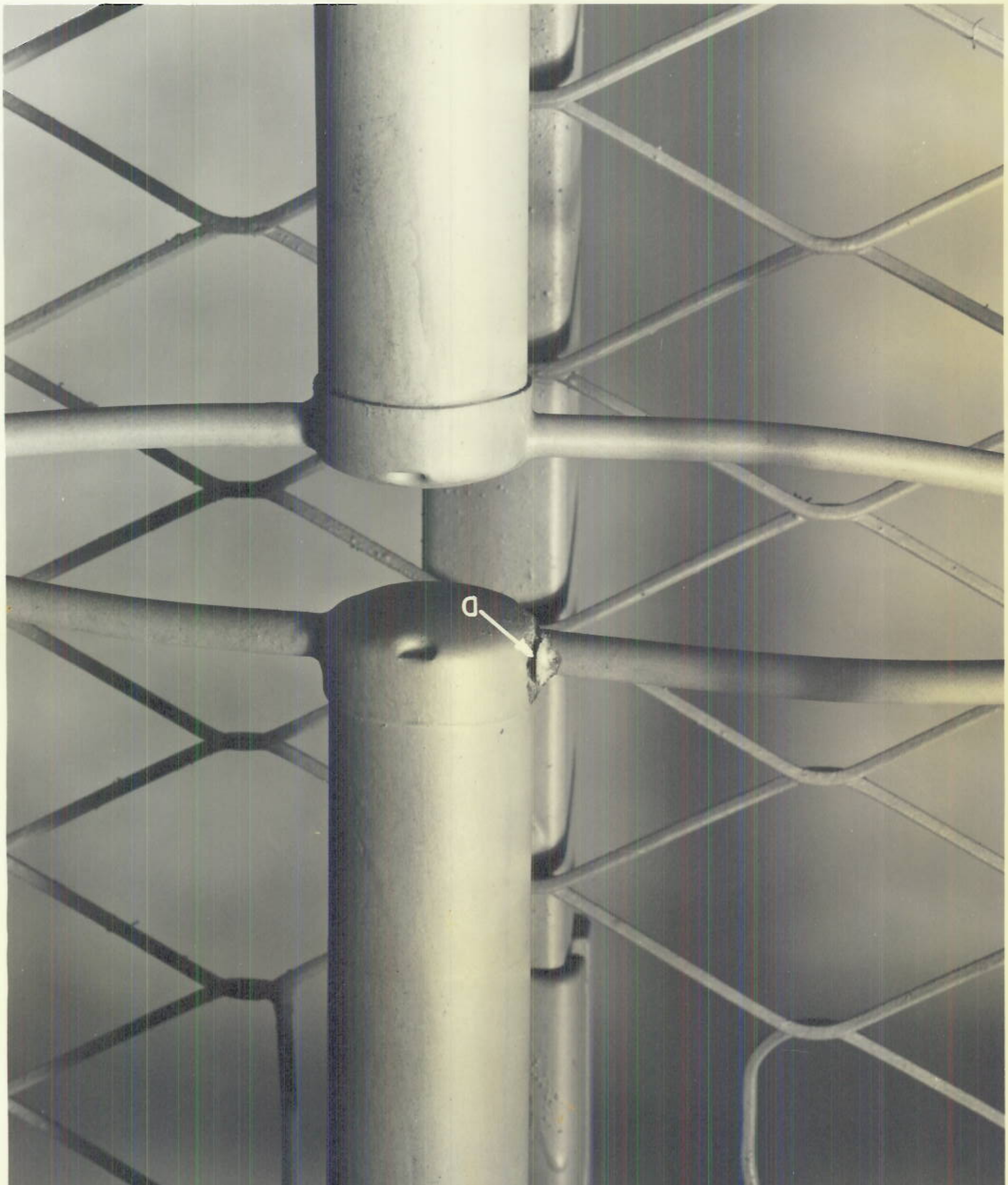

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PLATE 24 SEC.2

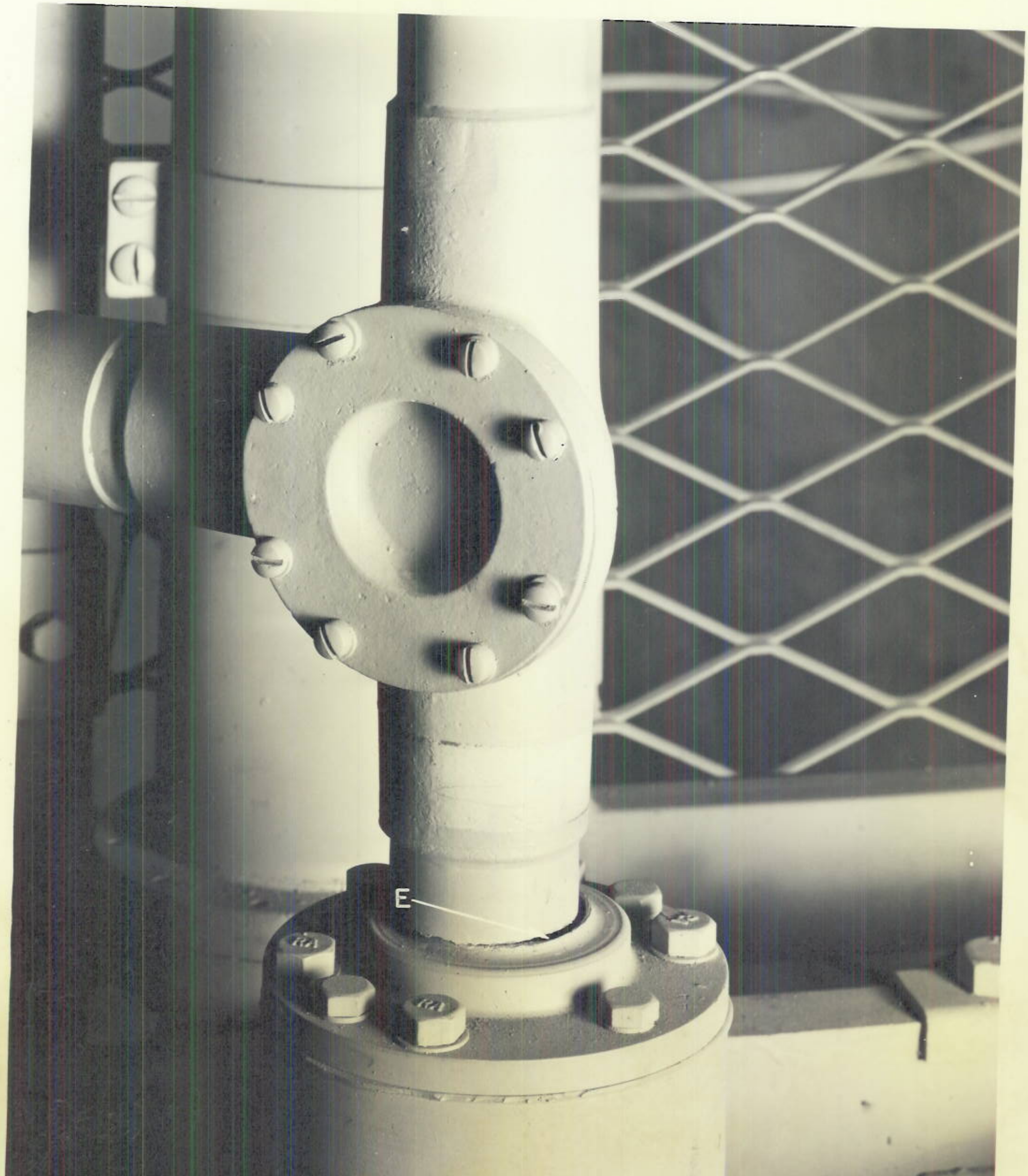
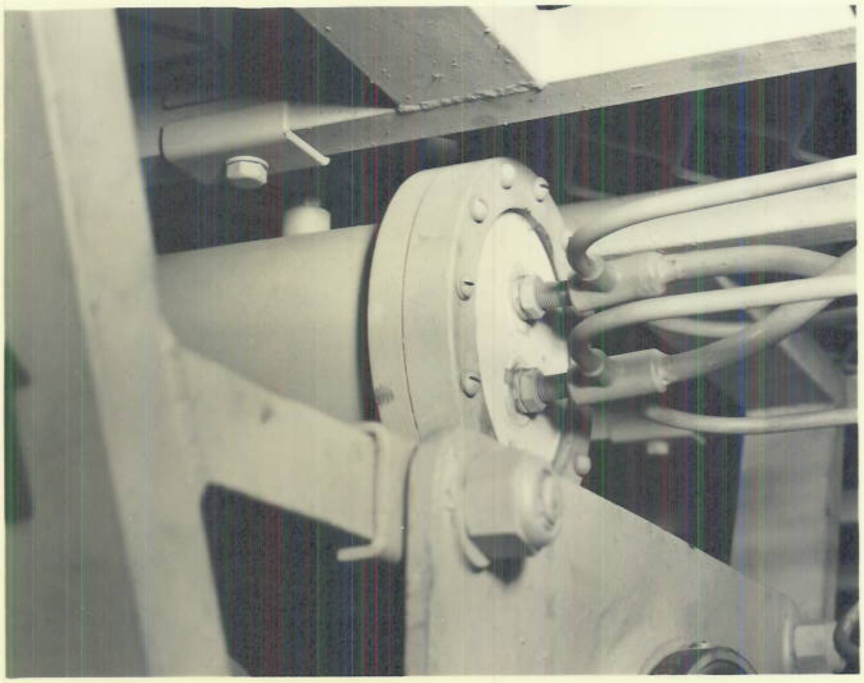


PLATE 25 SEC. 2



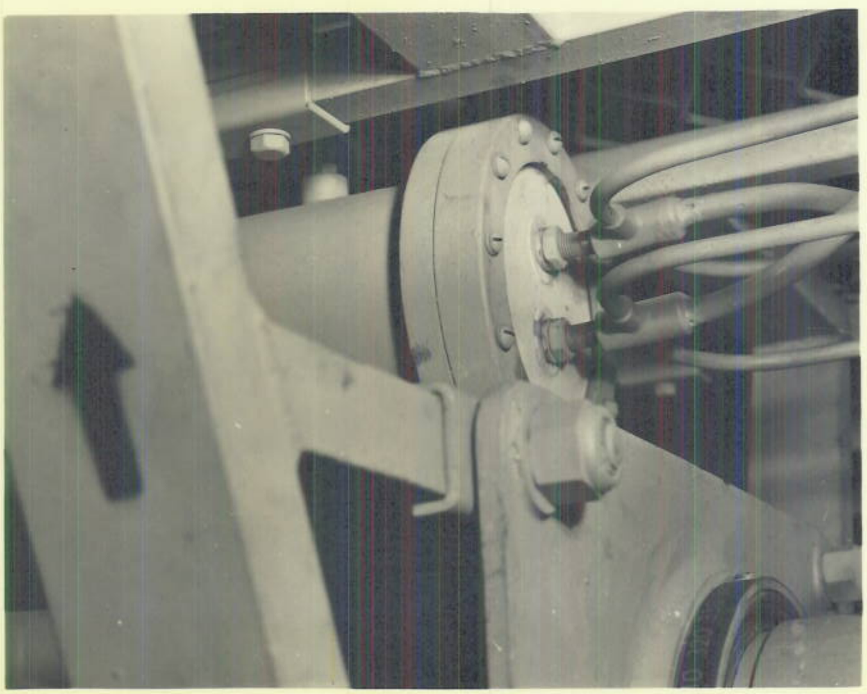


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PLATE 26 SEC.2

REPORT OF ELECTRICAL AND MECHANICAL TESTS OF THE MODEL SC-2 PLAN POSITION INDICATOR UNIT, PREAMPLIFIER UNIT, AND RECEIVER INDICATOR UNIT.

Supplements: Graphs Plates 1 to 6
Tables 1 to 4

Reference: (a) Section 3 NRL Report R-1937 of Oct. 16, 1942.
(b) NRL letter to BuShips C-S67/36(350 PER), of March 25, 1943.
(c) NRL letter to BuShips C-S67/36(350-PER) of April 8, 1943.
(d) BuShips specifications RE 13A 659B.
(e) Preliminary instruction book for SC-2 Radar equipment.
(f) BuShips letter C-S67/36(sc) of Jan. 2, 1943 to NRL.
(g) NRL letter C-S67-5(sc) (350-PER) of July 24, 1943.

3-1. Dates and Purposes of Tests.

3-1-1. The following tests were performed on the Model SC-2 Preamplifier Unit Type CG-50ABM serial No. 27, Receiver-Indicator Unit Type CG-46ABJ serial No. 97, and Plan Position Indicator Unit Type CG-55ACC serial No. 20 to ascertain compliance with Naval specifications and to determine its suitability for Naval Service.

3-1-2. All tests were conducted between February 15, 1943 and April 15, 1943.

3-2. Index to Section 3.

Subject	Paragraph No.	Page No.
Dates and Purposes of Tests	3-1	1
Index to Section 3	3-2	1
Weights and Dimensions	3-3	2
Overall Selectivity	3-4	2
Sensitivity	3-5	3
Effects of Shock	3-6	4
Effects of Vibration	3-7	7
Effects of Inclination	3-8	8
Video Fidelity	3-9	8
Image Rejection Ratio and Intermediate-Frequency Rejection Ratio	3-10	8
Nameplates and Component Marking	3-11	8
Controls and Tuning Systems	3-12	9
Effects of Temperature Variation	3-13	10
Effects of Humidity Variation	3-14	10
Tube List	3-15	10
Corrosion	3-16	11
Instruction Book	3-17	12
Effects of Line Voltage Variations	3-18	12
Summary of Defects	3-19	12
Conclusions	3-20	15

reference plates 4 and 5 respectively. The value of 0.5 volts of noise output was used as a standard output with reduced gain control setting because the noise output with full gain, and the preamplifier connected was 0.9 volts, and no appreciable noise output was observed with the gain control setting at the mid-position of angular rotation.

3-4-5. The following table gives the bandwidths at two levels and under the conditions described in the preceding paragraph:

Plate	Input voltage ratios db.	Bandwidth in Mc.
1	3	0.64
	6	0.94
2	3	0.76
	6	1.02
3	3	0.90
	6	1.08
4	3	0.78
	6	1.06
5	3	0.72
	6	1.04

3-5. Sensitivity.

3-5-1. The instruments, equipment, and connections used for the sensitivity measurement were similar to those of the over-all selectivity measurement. Reference paragraph (3-4). Measurements were made of the values of input voltage required to raise the output voltage to maintain a given ratio of total output voltage to noise output voltage, and noise factor also was measured. Specific values and conditions are given in the following paragraphs.

3-5-2. At 200 Mc the values of input voltage necessary to raise the output voltage to 1.4 times the value of noise voltage were observed with the preamplifier connected and with the gain at maximum as well as with the gain reduced as described in paragraph (3-4). Another measurement was made without the preamplifier and with the gain at maximum, as shown by the following table:

Preamp.	Gain Settings	Noise output volts	Signal output volts	Input microvolts
in	reduced	0.5	0.7	1.4
in	maximum	0.9	1.3	1.4
out	maximum	0.35	.5	2.4

3-4-3. Noise factor data was taken using a range of input values of from 0 to 18.5 microvolts at a frequency of 200 Mc using the preamplifier with the receiver gain reduced, and both with and without the preamplifier maintaining the gain at maximum.

3-5-4. The following values of noise factor were calculated:

Preamp.	Gain settings	Bandwidth Mc	Equivalent noise voltage microvolts	Noise factor db
in	reduced	0.90	1.2	7
in	maximum	0.76	1.2	8
out	maximum	0.64	2.0	14

3-6. Effects of Shock.

3-6-1. The receiver-indicator unit, and preamplifier unit mentioned in the sensitivity test, reference paragraph (3-5), as well as the plan position indicator serial No. 20 type CG-55ACC were tested while operating to determine the effects of shock. All units were mounted together in their conventional positions, using both bulkhead and deck shock mounts on the plan position indicator unit. The control unit was used for mechanical loading purposes only, and had no external electrical connections.

3-6-2. Insofar as practical the data on effects of shock is divided into two parts, the first consisting of effects observed in connection with the preamplifier and receiver-indicator units, and the second consisting of such observations of the plan position indicator. The discussion of the two parts is in paragraphs (3-6-3 to 3-6-15), and paragraphs (3-6-15 to 3-6-19) respectively. A discussion of shock mounts is included in paragraphs (3-6-20) and (3-6-21).

3-6-3. The output of a General Radio Company signal generator model 804-B serial No. 206 was fed to the antenna terminal of the preamplifier through 20 feet of packard cable. Thirty percent 400 cycle modulation was used with a carrier frequency of 200 Mc.

3-6-4. After tuning the preamplifier and receiver for maximum deflection of the trace on the receiver-indicator cathode ray tube, the tuning controls were locked in position. The calibrating frequency control was adjusted to give zero beat with the crystal, and this control was locked in position. The receiver gain control was adjusted to give a deflection of about 1/2 inch on the screen of the receiver-indicator cathode ray tube due to thermal agitation and other noise voltages, and the output of the signal generator was adjusted to cause the deflection of the trace to be twice the amount it was for noise. The "Calibrate minimum" control was adjusted at 2000 yards; the calibrate maximum control was adjusted at 28,000 yards, and these two controls were locked in position.

3-6-5. Shocks were delivered as follows: 12 from left, 12 from front, 2 more from left, 12 from back, 12 from right. Movement of the receiver-indicator was measured using a pencil mounted in such a way as to follow the motion of the shock table. A piece of paper was fastened to the top surface of the receiver-indicator unit, and readings were taken of the distance from a zero mark designating the position at rest. The distances measured are the lengths of pencil trace from the position at rest. After the twelfth shock, observations of the pencil trace indicated that the equipment had moved, at each blow, an average of 0.9 inch to the right, and 0.6 inch to the left relative to the table.

3-6-6. After the thirteenth shock, which was the first one from the front, the range step failed to operate. This failure occurred at the same time as the range mark corresponding to the step disappeared from the PPI unit cathode ray tube. The step was restored to the receiver-indicator cathode ray tube when the tubes in the receiver-indicator unit were firmly seated in their sockets. The trace was, at this time, observed to be intermittent in position. The deflection of the top surface of the receiver-indicator unit when struck from the front was found to be back about 1.3 inches and forward about 1.2 inches relative to the table.

3-6-7. The following points were observed to strike when shocks were delivered from the front: left front bolt supporting left shock mount of left front pair of shock mounts struck PPI unit. Right front bolt supporting right shock mount of right front pair of shock mounts struck PPI unit.

3-6-8. At the instant of the twenty fifth shóck, a transient increase in intensity was observed on the receiver-indicator cathode ray tube. At the same instant, a similar transient was noted on the plan position indicator cathode ray tube. After the twenty eighth shock it was observed that there had been a slight shift in the frequency of the transitron oscillator.

3-6-9. After the thirty-first shock, the trace on the receiver-indicator ray tube was distorted and shifted to the left edge of the cathode ray tube screen. The cathode ray tube was replaced, and the conventional trace was restored. Subsequent tests made by the Electronics Section of the Laboratory disclosed no discrepancies in the functioning of the tube. After the thirty-third shock the range step on the receiver-indicator cathode ray tube screen was observed to be intermittent. After the thirty-fifth shock the receiver-indicator trace moved down slightly.

3-6-10. After the thirty-sixth shock the trace was distorted and shortened to about a quarter of an inch. By striking V709, a 6AG7, the trace became normal. While the equipment was at rest, and before the thirty-seventh shock, the depth of the range step decreased.

3-6-11. A slight shift in the frequency of the transitron oscillator was observed after the thirty-seventh shock. After the thirty-eighth shock it was observed that a pencil trace on a sheet of paper fastened to the top surface of the control unit showed that the top surface had moved back about 1.2 inches, and forward about 0.6 inch relative to the table.

3-6-12. After shocks were delivered from the back of the equipment it was observed that bolts on the left shock mount of the left front pair of shock mounts had struck the PPI unit. The same condition was observed to exist for the right shock mount of the right front pair of shock mounts, the left one of the left rear pair and the right one of the right rear pair. Observations made after the forty-fourth shock indicated a movement of the top surface of the receiver-indicator unit of about 0.8 inch to the left and about one inch to the right relative to the table.

3-6-13. After the forty sixth shock, it was observed that the transitron oscillator frequency had again shifted slightly.

3-6-14. When the equipment was shocked from the right side two bolts on the left shock mount of the left rear pair of shock mounts struck the PPI unit.

3-6-15. A list of shocks with the direction of shock, acceleration of the shock table, and values of "calibrate minimum" and "calibrate maximum" with the values of output voltage of the signal generator required to maintain constant deflection of trace on the receiver-indicator cathode ray tube are given in table (1).

3-6-16. The following effects of shock were observed in connection with the plan position indicator, mounted as described in paragraph (3-6-1).

3-6-17. The unit "bottomed" with each shock, showing too great a resiliency of the shock mounts. Bright flashings were noted on the cathode ray tube nine times during the test, although the equipment recovered after each shock.

3-6-18. The equipment failed three times during the test, once due to a type 2X2 tube coming loose from its socket, the second time due to a plate cap coming off a 2X2 tube, and once due to the 6V6GT unblanking tube coming loose in its socket.

3-6-19. The pivot point of the trace moved six times during the test, in one case 3/8", and at least 1/8" the other five times. The intensity control became erratic after the 13th shock, but operated normally after the 15th.

3-6-20. Due to the "bottoming" of the equipment on shock it received an excessive amount of transmitted shock and the test was not indicative of its operation with more suitable shock mounts. Further shock and vibration tests with U.S. Rubber #401C and Portsmouth type shock mounts installed gave better results. Reference (g).

3-6-21. The test showed the present shock mounts to be unsatisfactory, and replacement of these mounts with some other type should be considered. Reference (g).

3-7. Effects of Vibration.

3-7-1. The equipment was tested to determine the effects of vibration, under conditions similar to those of the shock test. Reference paragraph (3-6).

3-7-2. Vibration test of the receiver-indicator unit was run at frequencies between 900 and 2200 cycles per minute. A metallic "clanking" was heard at frequent intervals at a frequency of 1280 cycles per minute. The frequency was lowered to 700 cycles per minute, and it was observed that there was no excessive vibration of the cathode ray tube.

3-7-3. The test was run for two hours at various rates of vibration between 500 cycles per minute and 1900 cycles per minute, running for the most part, on or near one of the two resonant frequencies of approximately 700 and 1100 cycles per minute. It was observed that at about 1100 cycles per minute the preamplifier unit was rocking violently back and forth. The preamplifier was observed to rock from side to side at about 750 cycles per minute.

3-7-4. The range settings did not vary appreciably during the test. The signal input voltage to the preamplifier required to maintain a constant value of trace deflection on the cathode ray tube was constant at 27 microvolts.

3-7-5. The plan position indicator, when subjected to vibration as described in paragraphs (3-7-2 to 3-7-4) was observed, as follows.

3-7-6. The resonant vibration frequency of 1100 cycles per minute, was maintained for a half hour to permit observations of the plan position indicator.

3-7-7. Operation was not completely satisfactory. It was noted that the trace became blurred, due presumably to vibration of the deflection coil or cathode ray tube. No electrical failures were noted during this test.

3-8. Effects of Inclination.

3-8-1. The arrangement was the same as that of the shock test. Reference paragraph (3-6).

3-8-2. The equipment was inclinded 45° to the front and rear, and 45° to the right and left at intervals of a few seconds over a period of about an hour.

3-8-3. No discrepancies in the functioning of the receiver-indicator were observed.

3-8-4. The shock mounts compressed so far as to almost "bottom" lacking but 1/32" in both directions of roll.

3-9. Video Fidelity.

3-9-1. The video fidelity characteristic of the Master Plan Position Indicator was measured using a General Radio Company vacuum tube voltmeter type 726A serial No. 319, across the input at jack designation J2004, and a General Radio Company vacuum tube voltmeter type 726A serial No. 628 was connected from the plate pin of vacuum tube of designation V2006 to ground.

3-9-2. Video response data was taken with gain at maximum and at one-half maximum over a range of frequencies from 50 cycles to 2 Mc. The data are plotted in plate 6.

3-10. Image Rejection Ratio and Intermediate Frequency Rejection Ratio.

3-10-1. Conditions were similar to those of the overall selectivity measurement. Reference paragraph (3-4).

3-10-2. No indication of output voltage change occurred with a signal of 20 millivolts at the image frequency, or at the intermediate frequency. The test was run at 200 Mc, and the results obtained with maximum gain control setting follow:

Preamplifier	Image frequency rejection	Intermediate frequency rejection
in	greater than 83 db	greater than 83 db
out	greater than 79 db	greater than 79 db

3-11. Nameplates and component marking.

3-11-1. The form of the following sample metal nameplate is duplicated on the receiver-indicator unit, and on the preamplifier unit:

Type CG-55ACC

Plan Position Indicator

Input 115/1/60 5.2 amps 380 watts

692 pounds serial 20

a unit of Model SC-2 Radar Equipment

Manufactured for

Navy Department Bureau of Ships

By Contractor

General Electric

Schenectady, New York

made in U.S.A.

Bridgeport Works

Contract Number	Contract Date
Nos 84613(NP9742)	April 21, 1941

3-11-2. Control labels and parts designations are provided by stenciling in some cases. The placement of designations is such as to facilitate visibility, but no panel illumination is provided.

3-12. Controls and Tuning Systems.

3-12-1. The locking knobs used with the controls operate but interfere with rapid manipulation of controls.

3-12-2. A discussion of details in the various units follows.

3-12-3. The tuning controls in the preamplifier unit operated properly, but the trimmers in it are unsatisfactory. Reference paragraph (3-19-4).

3-12-4. In the receiver-indicator unit it was observed that the following controls operated properly; tuning, gain, "cal. max.", "cal. min.", power switch, calibrating frequency, vertical centering, horizontal centering, crystal on-off switch, astigmatism, brightness, focus, receive-calibrate switch, range switch, range setting, and dial light intensity.

3-12-5. In the plan position indicator, the satisfactory operation of the following controls was established: Pilot light dim, brilliance, focus, range switch. It was observed that the mounting of the power switch was not secure, and the entire switch was free to rotate through an angle of approximately 60 degrees. The electrical characteristics of the switch seem satisfactory.

3-13. Effects of Temperature Variation.

3-13-1. The electrical arrangement for the temperature test was similar to that of the shock test. Reference paragraph (3-6).

3-13-2. At the start of the test the temperature was raised to 50 degrees centigrade and held at this value for 2 hours. No overheating or other detrimental effects were noted during this part of the test, and observations of the electrical operation of the preamplifier unit and the receiver indicator unit were made as in the shock test, reference paragraph (3-6), without noting appreciable change in functioning of equipment.

3-13-3. The equipment was subjected to a temperature of 0 degrees centigrade for two hours, with satisfactory operation.

3-13-4. A "cold start" test was conducted. The equipment was turned off and with the heaters operating the temperature was lowered to minus 30 degrees centigrade.

3-13-5. The equipment was turned on to check performance. A slight "drag" was noticed in the operation of the range crank on the receiver-indicator, but the electrical functioning of the receiver indicator and preamplifier was satisfactory.

3-13-6. The defects observed in connection with the plan position indicator follow.

3-13-7. The slewing motor would not operate the yoke mechanism due to the "stiffness" of the grease on the gears.

3-13-8. The focus and intensity controls were both "frozen", but all other controls operated satisfactorily and all electrical circuits functioned properly.

3-13-9. When the temperature had risen to minus 20 degrees centigrade, the slewing motor moved slowly. The equipment operated satisfactorily at minus 10 degrees centigrade.

3-14. Effects of Humidity Variation.

3-14-1. The electrical arrangement for the temperature test was similar to that of the shock test. Reference paragraph (3-6).

3-14-2. The equipment was subjected to a temperature of 40 degrees centigrade with a relative humidity of 95% for two hours.

3-14-3. Operation of all units seemed satisfactory during this test.

3-15. Tube List.

3-15-1. The vacuum tubes used in each unit are listed below

3-15-2. Preamplifier unit:

Type	Number
GL446	2
6X5GT	1
Total	3

3-15-3. Receiver-Indicator unit:

Receiver:		Indicator	
Type	Number	Type	Number
954	1	6SN7	5
955	1	6K6	1
956	2	6SK7	1
7H7	3	6J5	3
7E6	1	6AG7	2
6AG7	1	5U4G	1
6H6	1	5CP1	1 (cathode ray tube)
total	10	total	14

Receiver total 10
Indicator total 14
Receiver-Indicator total 24

3-15-4. Plan Position Indicator unit:

Type	Number
2X2	2
5U4G	4
6AG7	2
6H6	1
6J5	5
6L6G	2
6SL7-GT	1
6SN7-GT	1
6SQ7-GT	1
6V6-GT	7
807	1
12DP7	1 (Cathode ray tube)
total	28

Unit	Total number of tubes
Preamplifier	3
Receiver-Indicator	24
Plan Position Indicator	28
Total for all Units	65

3-16. Corrosion.

3-16-1. There was no evidence of excessive corrosion, slight traces being noticed on some of the bolt heads.

3-16-2. There is no assurance that there will be no excessive corrosion in time. Reference paragraph (3-17-15).

3-17. Instruction Book.

The instruction book, reference (e) is comprehensive, and is considered suitable for its purpose.

3-18. Effects of Line Voltage Variation.

3-18-1. The equipment was tested for effects of line voltage variation.

3-18-2. With voltage variations of plus and minus 5% and plus and minus 10% the receiver-indicator was observed to operate satisfactorily, and with a 30% transient shift of line voltage to recover satisfactorily in less than 10 seconds.

3-18-3. The functioning of the plan position indicator under conditions of varying line voltage is considered extremely unsatisfactory. See Reference (b), and Table 2.

3-18-4. The effects of line voltage variation on the electrode voltages of some of the tubes in the sweep unit are shown in table 3. The electrode voltages were measured with a Precision Apparatus Corporation vacuum tube voltmeter model EV-10 serial No. 5158, and the line voltage was measured with a Weston a.c. voltmeter model 433 serial No. 29594.

3-18-5. Further information regarding sweep lengths, focus, calibration, and intensity is given in table 4.

3-19. Summary of Defects.

3-19-1. The defects are presented in the following order: the preamplifier, receiver-indicator, and finally the plan position indicator.

3-19-2. The following information applies to the preamplifier.

3-19-3. No primer coating appears to have been provided on the aluminum panel to afford protection against corrosion.

3-19-4. No stops are provided for either of the two threaded rods driven by the trimmer knobs, and the cathode trimmer variable condenser rotor plate was forced off its mounting on the rod by rotation of the knob. The plate trimmer has a pair of nuts on the threaded rod which may have been tightened together to prevent excessive withdrawal of the threaded rod, but these nuts were separated from each other, and did not function. There are two other trimmer condensers in the unit, and these, likewise, are not provided with stops. All four rotor plates are provided with sheets of mica glued on to prevent electrical contact between rotor and stator plates, but it was observed that two of the trimmers could be turned so far that the rotor plates touched the stator plates, and the force thus applied placed a strain on the contact fingers provided for the type GL-446 tube.

3-19-5. The lock knobs provided on the two main tuning dials are not well placed, and interfere with rapid operation of the dials.

3-19-6. The ground connection for the rotor plate of each trimmer depends upon the electrical contact of the threaded rod in a tapped hole. An adjustment is provided for each trimmer to maintain firm ground contact, but the cathode and plate trimmers with knobs on the front panel have oil on the threads and on the rods, which gives no assurance of good electrical contact.

3-19-7. The circular laminated molded phenolic coupler used to transmit rotation from the main tuning dials to the tuning condensers shows a tendency to warp.

3-19-8. The power transformer is not potted and sealed and is in such a position that the covering of the windings makes contact with the inside surface of the case of the preamplifier unit.

3-19-9. The shielded power cable to the preamplifier is supported by the conductors at both ends. Excessive strain is placed on the conductors, beqause of the weight of the cable, and other transmitted force. Provision of cable clamps would relieve the strain on this cable.

3-19-10. The following paragraphs represent the results of an inspection of the subject receiver-indicator to determine whether or not the recommendations of the Naval Research Laboratory submitted in reference (a) have been effective in this, the subsequent model. The numbers in parentheses refer to paragraph numbers in reference (a).

3-19-11. (3-27-1) Locks have not been mounted further from controls so as to prevent them from interfering with operation of the control.

3-19-12. (3-27-2) There was no regrouping of controls.

3-19-13. (3-27-4) Single set screws are still used on control knobs on many of the controls.

3-19-14. (3-27-5) Dial knobs have not been changed as suggested.

3-19-15. (3-27-8) Brass gears have some grease on them, but this may not be adequate to prevent corrosion.

3-19-16. (3-27-10) Loctal type tubes have not been replaced by octal or other approved types.

3-19-17. (3-27-11) The acorn sockets used in the r-f section are not approved.

3-19-18. (3-27-12) Only one tube clamp has been used in the receiver-indicator. This is on the 5U4-G.

3-19-19. (3-27-13) Tube sockets are not identified on both sides.

3-19-20. (3-27-14) One cable includes wires having the same color codin

3-19-21. (3-27-15) Switch shaft is used as a cable support.

3-19-22. (3-27-17) Paper markers are used on the wires.

3-19-23. (3-27-18) Interlock has not been provided.

3-19-24. (3-27-19) Method of mounting dial lights appears to be satisfactory.

3-19-25. (3-27-20) No holes have been provided for easy removal of the three screws on the under side of the receiver chassis.

3-19-26. (3-27-21) No clamp is used on the 164 kilocycle crystal, and the mounting is considered unsatisfactory.

3-19-27. (3-27-24) Shields over transformers are not secured at the top except by bowing pressure.

3-19-28. (3-27-25) Not all components are marked.

3-19-29. (3-27-26) Transformers and chokes are not potted.

3-19-30. (3-27-27) The tank coils L703 and L704 have not been wax coated.

3-19-31. (3-27-28) Resistors and condensers have been waxed.

3-19-32. (3-27-29) Condenser and resistor leads have been bent and soldered too close to the respective components.

3-19-33. (3-27-30) No side plates have been fastened by wedging.

3-19-34. (3-27-32) No temporary clamping has been used on permanent parts.

3-19-35. (3-27-33) No burned wires were noted, however, soldering was not of the highest quality.

3-19-36. (3-27-34) The intermediate frequency slugs were arranged to prevent short circuiting to the windings.

3-19-37. (3-27-35) Mica condensers have been used extensively.

3-19-38. As shown by paragraphs (3-19-10) to (3-19-36) of the present report, the recommendations of the Naval Research Laboratory apparently have in many cases, not been effective in this, the subsequent model.

3-19-39. The following observations were made with regard to the subject receiver.

3-19-40. Resistor R634 has been removed from the circuit. Connection is made to only one terminal of this resistor.

3-19-41. There was insufficient clearance between one terminal board and chassis. Clearance is desirable to prevent accumulations of moisture.

TABLE 1

RESULTS OF SHOCK TEST

Shock No.	From	Acceleration	Calibration Minimum, Yards	Calibration Maximum, Yards	Microvolts Input
	(Initial Settings)		2000	28,000	27
1	Left	250 g	1900	27,700	27
2	"	250 g	1900	27,800	27
3	"	250 g	1900	27,700	27
4	"	250 g	1900	27,700	27
5	"	250 g	1900	27,700	27
6	"	250 g	1900	27,700	27
7	"	250 g	1900	27,700	27
8	"	250 g	1900	27,700	27
9	"	250 g	1900	27,700	18
10	* "	250 g	1900	27,700	18
11	"	250 g	1900	27,700	18
12	"	250 g	1900	27,700	18
13	Front	250 g	1900	27,700	18
14	"	250 g	2000	27,800	12
15	"	250 g	1950	27,700	12
16	"	250 g	2000	27,700	12
17	"	250 g	1950	27,700	12
18	"	250 g	1900	28,100	32
19	"	250 g	1900	27,900	32
20	"	250 g	1900	27,900	32
21	"	250 g	1900	27,800	32
22	"	250 g	1900	27,900	32
23	"	250 g	1900	27,700	32
24	"	250 g	1950	27,700	23
25	Left	250 g	1900	27,700	23
26	"	250 g	1900	27,000	23
27	Back	250 g	1900	27,700	23
28	"	250 g	1900	27,700	23
29	"	250 g	1900	27,500	23
30	"	250 g	1900	27,500	23
31	"	250 g	1900	27,900	32
32	"	250 g	1900	27,900	32
33	"	250 g	1900	27,900	32
34	"	250 g	1900	27,900	32
35	"	250 g	1900	27,900	32
36	"	250 g	1900	27,900	32
37	"	250 g	2000	27,900	32
38	"	250 g	2000	27,700	32
39	Rear	250 g	None	None	32
40	Right	250 g	1900	28,000	32
41	"	250 g	2000	28,000	32
42	"	250 g	2000	27,900	32
43	"	250 g	1900	27,900	32

[redacted]

TABLE 1 (Continued)

Shock No.	From	Acceleration	Calibration Minimum	Calibration Maximum	Microvolts Input
44	Right	250 g	1900	27,900	32
45	"	250 g	1900	27,900	32
46	"	250 g	2000	27,800	32
47	"	250 g	2000	27,800	32
48	"	250 g	1900	27,700	32
49	"	250 g	1900	27,700	32
50	"	250 g	1900	27,700	32
51	"	250 g	2000	27,800	32

TABLE 2

Variation of Sweep Length and Range Mark with Line voltage variation

Line Voltage	Sweep Length in in.	Range Mark in in.	% Variation of sweep length	% Voltage Variation
(20 Mile Range)				
104	4-1/32	3-9/16	-10.2	-9.6
109	4-7/32	3-3/4	-6.2	-5.2
115	4-1/2	3-15/16	0	0
121	4-3/4	4-1/8	+5.5	+5.2
126	4-13/16	4-1/4	+7.0	+9.6
75 Mile Range				
104	3-3/4	3-1/8	-9.0	-9.6
109	3-15/16	3-1/4	-4.5	-5.2
115	4-1/8	3-5/16	0	0
121	4-1/4	3-13/32	+3.0	+5.2
126	4-15/32	3-17/32	+8.2	+9.6
200 Mile Range				
104	3-5/8	3-5/32	-9.2	-9.6
109	3-27/32	3-9/32	-3.9	-5.2
115	4.0	3-13/32	0	0
121	4-7/32	3-1/2	+5.4	+5.2
126	4-3/8	3-5/8	+9.2	+9.6

[redacted]

3-19-42. Wires were soldered to ends of threaded rods.

3-19-43. Many components in i-f stages were inaccessible.

3-19-44. A pigtail on one resistor in an i-f stage is longer than 1/2 inch.

3-19-45. Pigtails on some components are shorter than 1/8 inch.

3-19-46. The following information applies to the subject indicator.

3-19-47. Mica condensers are used extensively.

3-19-48. Soldering has been done so close to components that the solder actually touched the component.

3-19-49. Wiring to some tube sockets was inaccessible.

3-19-50. At several points wires were placed so that they rested on sharp corners of terminal boards.

3-19-51. A cable rested on a sharp corner of a metal power supply shield.

3-19-52. Wiring to resistors and condensers most of which were on terminal strips was generally accessible, but some of the wiring to components not on terminal strips was quite inaccessible.

3-19-53. Two leads longer than 1 foot each were unsupported except at their ends.

3-19-54. The mounting fingers for the selsyns were not counter balanced, and tightening the mounting bolts resulted in a flexing force on the bolt. The flexing force on the bolt was not present for the finger between the two selsyns, but this finger was not of sufficient strength, and was bent by force applied to tighten the mounting bolt.

3-19-55. Defects found in the plan position indicator were described in reference (c).

3-20. Conclusions.

3-20-1. The equipment, in general, fulfills its purpose, and is considered with exceptions stated below, to be satisfactory for Naval shipboard service.

3-20-2. The variation in range accuracy with line voltage variation is considered excessive. Reference paragraph (3-18).

3-20-3. The shock mounts are considered unsatisfactory for the purpose, and the use of either U. S. Rubber type 401C or Portsmouth shock mounts is recommended. Reference paragraph (3-6). Reference (G).

3-20-4. Further defects are stated in paragraph (3-21), and in reference (c).

TABLE 4

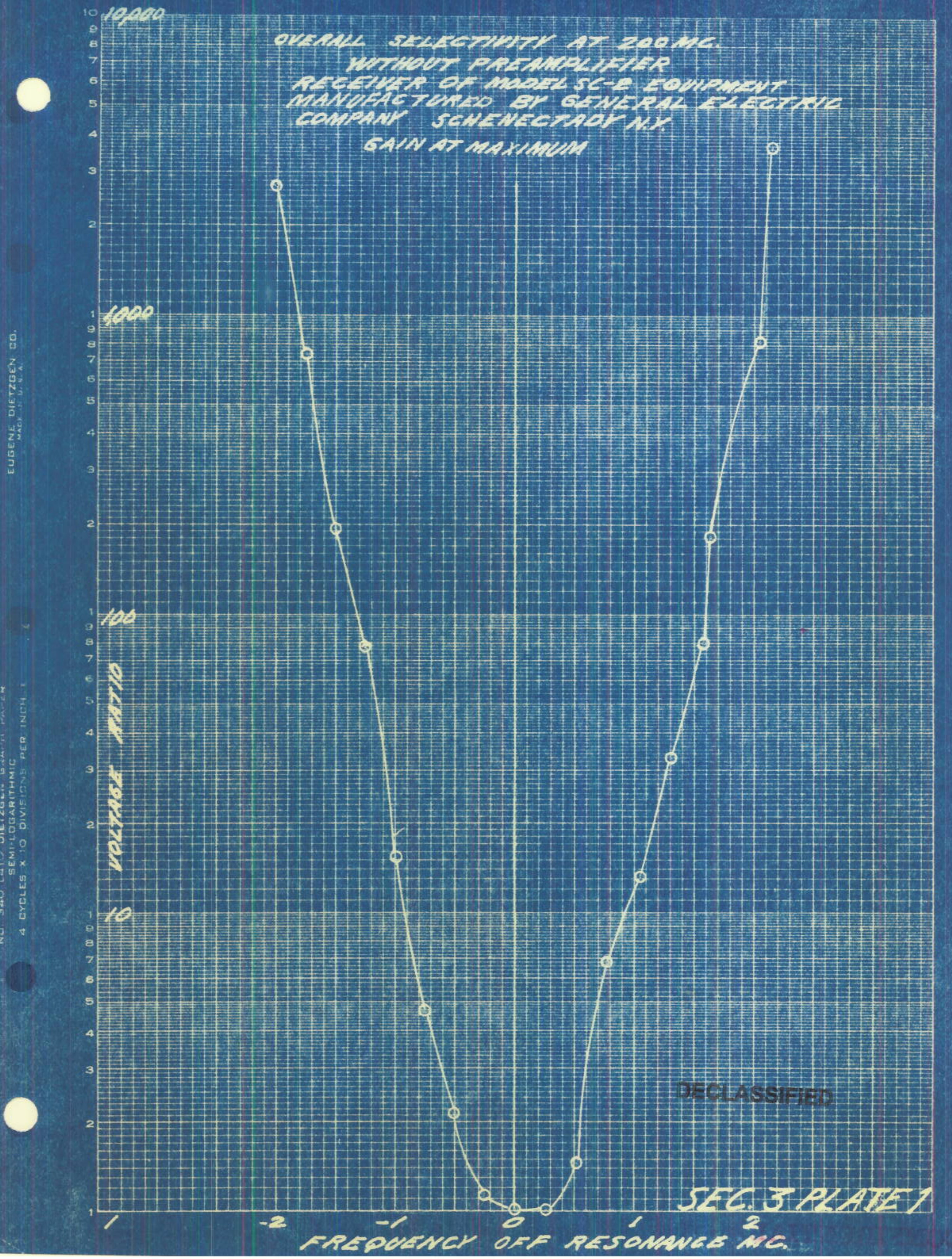
Effects of Line Voltage Variation on Length of Sweep, Focus, Calibration, and Intensity

Line Voltage	Sweep Length	Distance from start of sweep to Cal. Spot	Focus	Intensity	Distance from center of scope tube to sweep starting point
103	4.06	2.875	very poor	fair	1/16"
109	4.25	3.00	fair	lower	1/32"
115	4.5	3.12	good	good	Calibration point
121	4.75	3.15	fair	brighter	1/32"
126	4.93	3.37	no data	very intense	1/16"

Percentage variation from conditions at 115 v

Line Voltage	Sweep Length	Cal. Spot Distance
-10	-9,7	-8,0
-5	-5,6	-4.0
0	0	0
+5	+5,61	1,0
+10	+20,8	8,0

[redacted]



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SEC. 3 PLATE 1

<u>TABLE 3</u>

Tube Electrode Voltage Variation with Line Voltage

Master PPI Sweep Circuit

Applied Voltage	97	103	109	115	121	127
% Variation from 115 v	-15	-10	-5	0	5	10

Vacuum Tube:

Type 807 Sweep Amplifier Tube

Plate	297	320	340	357	380	400
Screen	297	320	340	357	380	400
Cathode	9.6	10.5	22	22	23	23.5
Grid	-27.5	-29.5	-31.5	-33	-35	-37

Type 6V6GT Sweep Forming Tube

Plate	-27.5	-29.5	-31.5	-33	-35	-37
Screen	26.5	27.5	28	30	31	50
Grid	-54	-58	-60	-62	-54	-73
Cathode	-42	-46	-48	-50	-52	-58

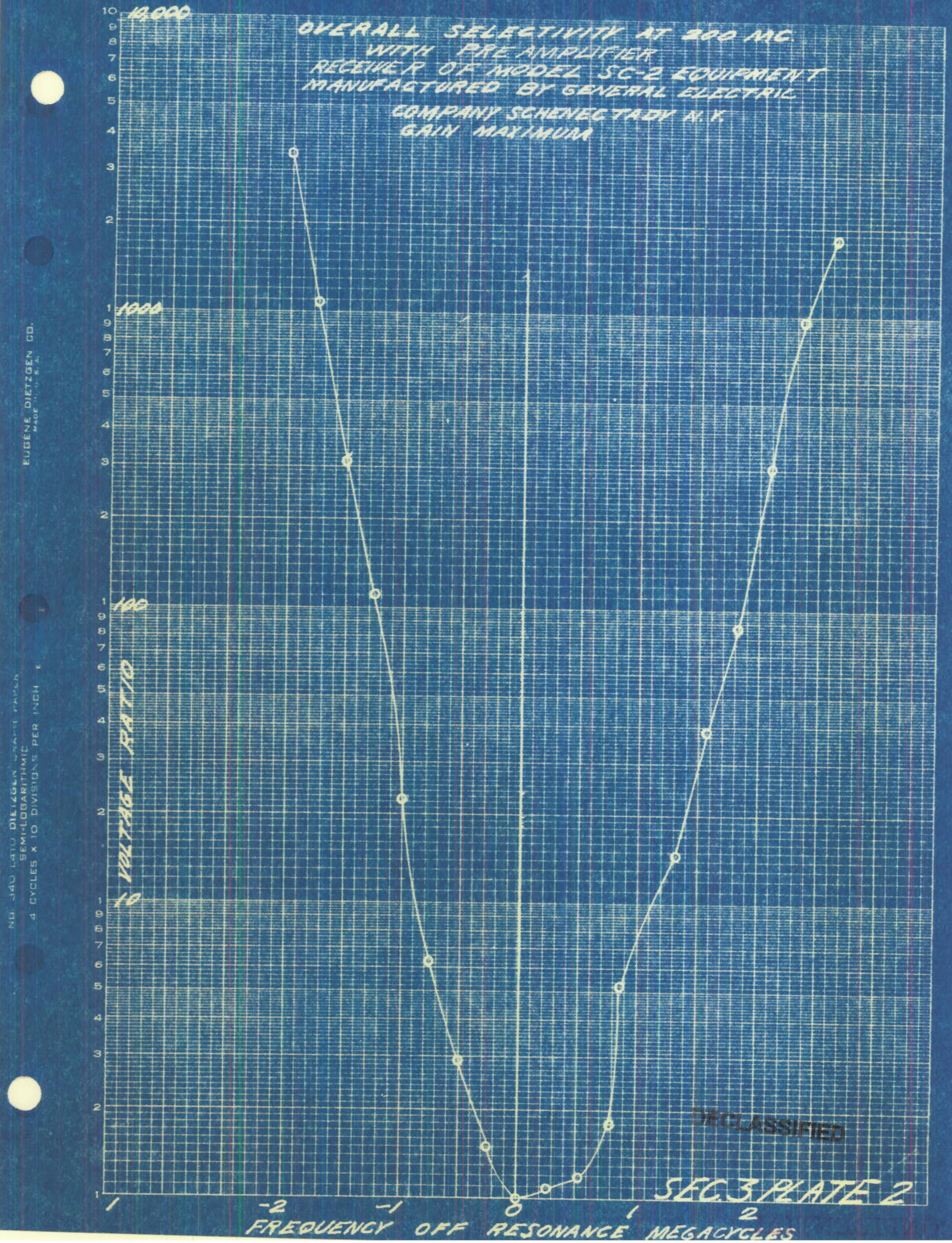
Type 6J5

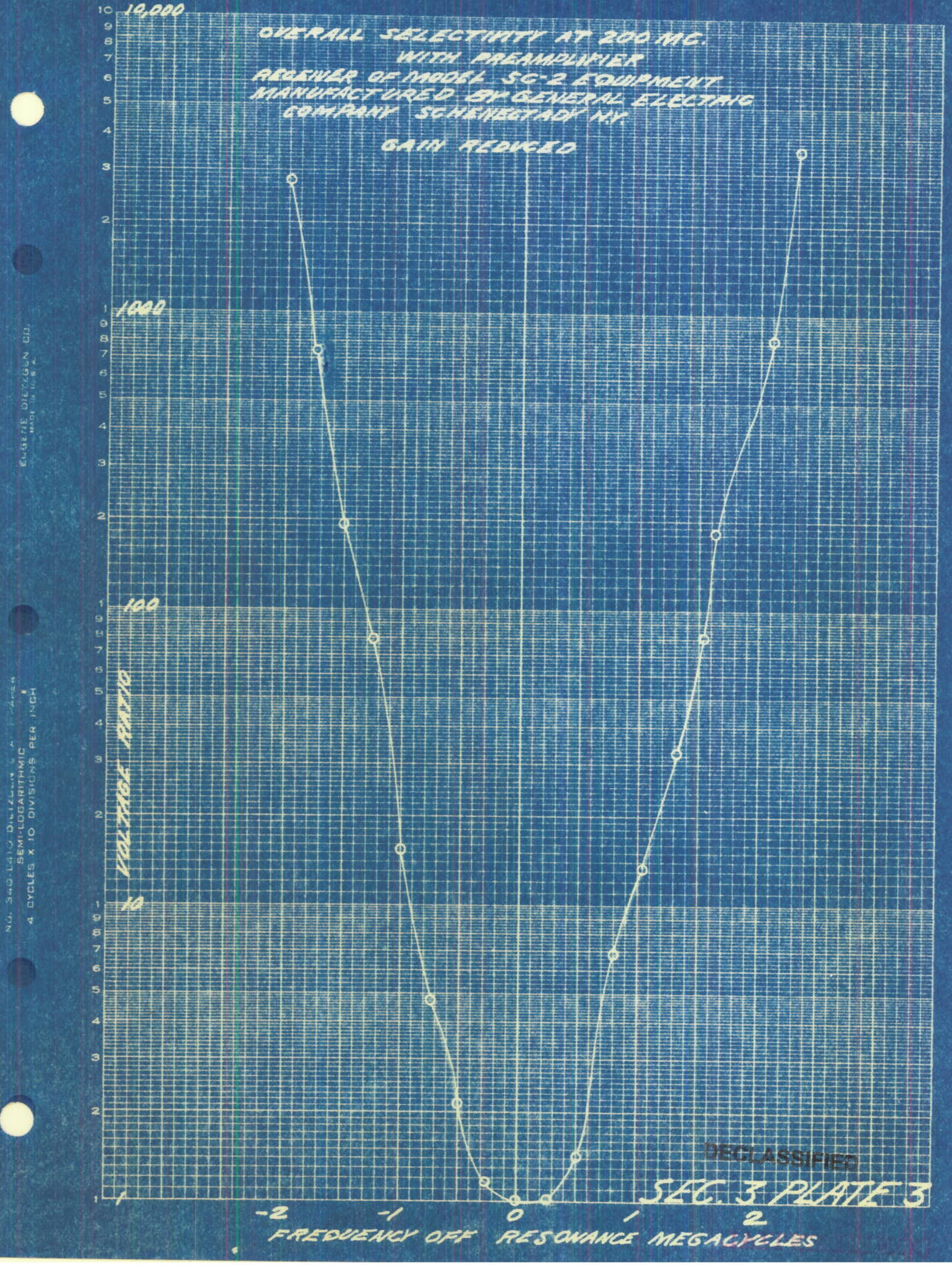
Plate	155	165	170	190	215	212
Grid	-16.5	-18.5	-20	-21.5	-23.5	-24.5
Cathode	2.85	3.0	3.6	3.7	3.8	3.95

Type 6V6GT Unblanking Tube

Plate	243	260	280	290	320	330
Grid	+1.1	+1.5	+2.3	+2.3	+2.6	+2.8
Cathode	26.5	27.5	30	33	36	38

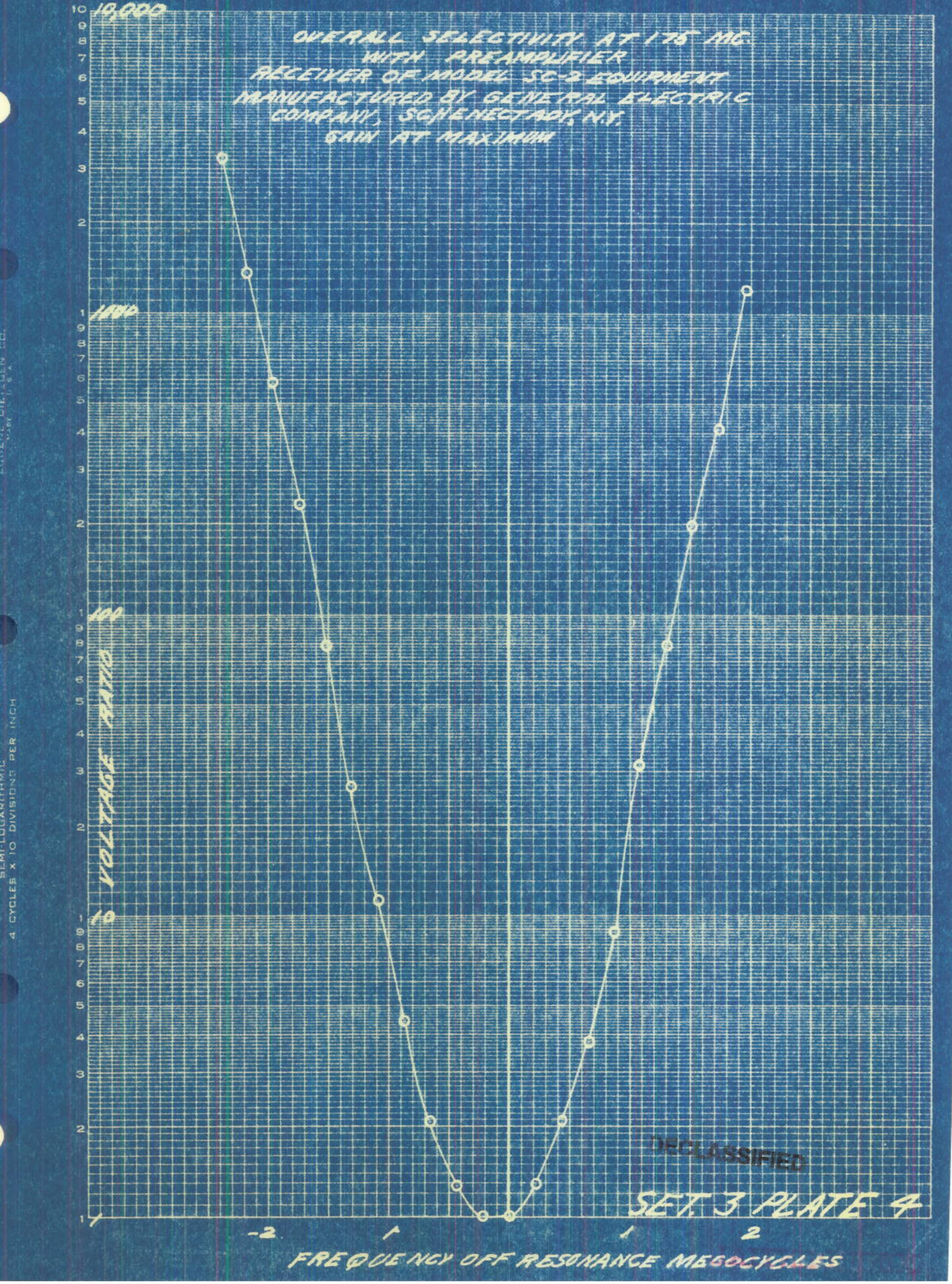
[redacted]


OVERALL SELECTIVITY AT 200 MC.
WITH PRE AMPLIFIER
RECEIVER OF MODEL SC-2 EQUIPMENT
MANUFACTURED BY GENERAL ELECTRIC
COMPANY SCHENECTADY N.Y.
GAIN MAXIMUM
10,000
1000
100
10
1
VOLTAGE RATIO
-2
-1
0
1
2
FREQUENCY OFF RESONANCE MEGACYCLES
DECLASSIFIED
SEC.3 PLATE 2
EUGENE DIETZGEN CO.
SEMI-LOGARITHMIC
4 CYCLES X 10 DIVISIONS PER INCH

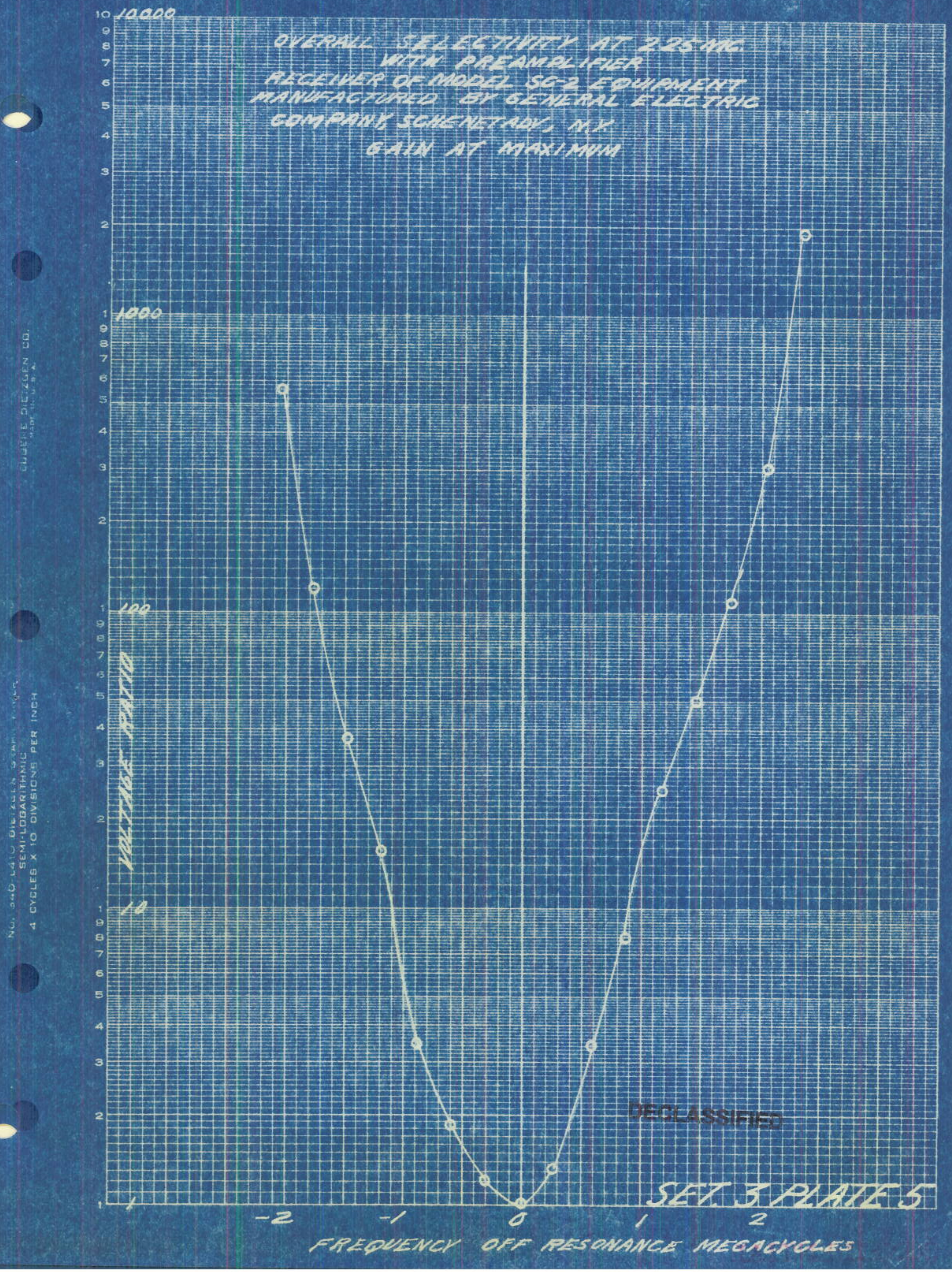


DECLASSIFIED

SEC. 3 PLATE 3


OVERALL SELECTIVITY AT 175 MC.
WITH PREAMPLIFIER
RECEIVER OF MODEL SC-2 EQUIPMENT
MANUFACTURED BY GENERAL ELECTRIC
COMPANY, SCHENECTADY, N.Y.
GAIN AT MAXIMUM
10,000
1000
100
10
1
VOLTAGE RATIO
-2
1
1
2
FREQUENCY OFF RESONANCE MEGOCYCLES
SEMI-LOGARITHMIC
4 CYCLES X 10 DIVISIONS PER INCH
DECLASSIFIED

SET. 3 PLATE 4



OVERALL SELECTIVITY AT 2.25 MC
WITH PREAMPLIFIER
RECEIVER OF MODEL SC-2 EQUIPMENT
MANUFACTURED BY GENERAL ELECTRIC
COMPANY, SCHENECTADY, N.Y.
GAIN AT MAXIMUM
10000
1000
100
10
1
VOLTAGE RATIO
-2
-1
0
1
2
FREQUENCY OFF RESONANCE MEGACYCLES
DECLASSIFIED
SET. 3 PLATE 5
NO. 340-L410 DIETZGEN GRAPH PAPER
SEMI-LOGARITHMIC
4 CYCLES X 10 DIVISIONS PER INCH
EUGENE DIETZGEN CO.
MADE IN U.S.A.