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REPORT NO. R-2318

DATE [illegible] June 1944

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Comparison of Model [illegible] and Model [illegible]

Portable Radio [illegible] Transmitting-Receiving Equipments

[illegible]

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NAVAL RESEARCH LABORATORY

WASHINGTON, D.C.

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SERIAL No. 8

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30 June 1944

NRL Report No. R-2318
Prob. S116.2T-C

NAVY DEPARTMENT

Comparison of Model CXCR and Model CXCR-1 Portable Radio Transmitting-Receiving Equipments

NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

Number of Pages: Text - 43 Tables - 49 Plates - 61

Authorization: BuShips ltr NXs-18316-NXs-20859(925A) Ser. No. 240(925Ac) of 13 Jan 1944 to NRL.

Dates of Tests: 24 January 1944 through 25 April 1944.

Tests conducted by: Ralph D. Epperson
Ralph D. Epperson, Contract Employee
Samuel M Rice
Samuel M. Rice, Contract Employee

Report prepared by: M. F. Hodges
M. F. Hodges, Assistant Radio Engineer

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R. B. Meyer, Principal Radio Engineer
Chief, Transmitter Section
A. Hoyt Taylor
A. Hoyt Taylor, Head Physicist
Superintendent, Radio Division

Approved by: A H Van Keuren
A. H. Van Keuren, Rear Admiral, USN
Director, Naval Research Laboratory

Distribution: BuShips (10)

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auxiliaries are essential to satisfactory performance of this type equipment in the field, it is suggested that the hand generator and battery charger be submitted by the contractor for tests at the earliest possible date.

C.H.S.Murphy

C.H.S.Murphy
Commander U.S.N.
By direction of the Director
Naval Research Laboratory

[redacted]

REPLY IN DUPLICATE
AND REFERENCE TO
C-S67/43(380-MFH)
WILL BE APPRECIATED

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NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

sdt

JUL 8 - 1944

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To: Chief, BuShips.
Attn: Radio Div., Code 925Ac.

Subj: Radio - Comparative Tests of Model CXCR and Model CXCR-1 Portable Transmitting and Receiving Equipment - BuShips Problem S116.2T-C, Priority A-2.

Ref: (a) BuShips ltr NXs-18316-NXs-20859(925A) Ser. No. 240(925Ac) of 13 Jan 1944.

Encl: (H.W.)
(A) NRL report R-2318 dated 30 June 1944 (10 copies).

1. Under authorization contained in reference (a) the Model CXCR and Model CXCR-1 portable transmitting and receiving equipments were subjected to tests to determine their operating characteristics, suitability for the intended application in the Naval service, and to obtain data for changes necessary to insure safe and reliable operation. Enclosure (A) is a complete report on the comparative tests and investigation of the transmitter portions of the equipments.

2. It should be noted that neither contractor submitted dry batteries of the type proposed to be used with these equipments under emergency conditions and, in the case of the CXCR equipment, no provision for using them was made in the units submitted for test. Attention is directed to the description of the battery life tests in enclosure (A) where an analysis of the power requirements of these equipments has been made. In view of the high current requirements in both equipments, it is the conclusion of the Laboratory that the use of dry batteries as a source of power for either the Model CXCR or Model CXCR-1 equipment, except during the most extreme emergencies, will be impractical and entirely unsatisfactory under service conditions.

3. Hand generator and battery charging equipment were not furnished by the Howard Manufacturing Company for tests as part of the Model CXCR equipment. Inasmuch as these

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LIST OF PLATES (CONT'D)

[redacted]

LIST OF PLATES (CONT'D)

[redacted]

SECTION I

AUTHORIZATION

1-1. The comparison of the CXCR and CXCR-1 equipments was authorized by reference (a). Other pertinent data are listed in references (b) and (c).

Reference: (a) BuShips ltr NXS-18316-NXs-20859(925A) Ser. No. 240(925Ac) of 13 Jan 1944 to NRL.
(b) Specifications for Portable Pack Type Transmitting-Receiving Equipment, BuShips specification RE-9136-A.
(c) NRL ltr C-S67/52(380-MFH) of 6 Dec 1943 to BuShips Code 925A.

OBJECT OF TEST

1-2. The object of the tests was to compare the electrical and mechanical characteristics of the CXCR and CXCR-1 transmitters on a point-to-point basis to determine their suitability in the intended application in Naval service.

ABSTRACT OF TESTS

1-3. Tests were conducted to determine the following:

(a) Check of mechanical construction and assembly, general workmanship, materials used, corrosion, humidity, and fungus resisting measures taken, portability, and suitability of carrying harnesses.

(b) Power output.

(c) The frequency coverage of the transmitters.

(d) The accuracy of dial calibration.

(e) Frequency stability under the following conditions:

(1) Change of vacuum tubes.

(2) Locked-key operation.

(3) Effect of reduction in battery voltage.

(4) Change from transmit to receive conditions.

(5) Effects of temperature variations, -20°C to +60°C.

[redacted]

(6) Effects of humidity variations, 30% to 95%.

(7) Effects of vibration.

(8) Effects of shock.

(f) Percentage modulation capabilities on mcw and phone; audio distortion; overall frequency characteristics; frequency of mcw tone; and noise level.

(g) Quality of emitted signal, lilt, key clicks, and extraneous radiated signals.

(h) Dimensions and weights.

(i) Accuracy of reset; accuracy of detent positions.

(j) Vacuum tube operating conditions.

(k) Submergence capabilities.

(l) Battery operating life.

(m) Capabilities of battery charging devices.

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CONCLUSIONS

The comparative tests show the superiority of the Model CXCR equipment over the Model CXCR-1 equipment as now designed in meeting the demands of the Naval Service. The modifications recommended in this report for the Model CXCR equipment can be incorporated in the equipment without major modification, whereas extensive redesign of the Model CXCR-1 equipment will be necessary to provide an equipment suitable for the intended service.

[redacted]

RECOMMENDATIONS

In the CXCR equipment, it is recommended:

(1) That exterior fittings be of stainless steel or other noncorroding metal. (Par. 2-3(a))

(2) That the antenna terminal be of noncorroding material. (Par. 2-3(a))

(3) That a suitable warning nameplate be attached to the outside of the cabinet. (Par. 2-3(a))

(4) That accessibility to the tuning indicator lamp be improved. (Par. 2-5(a))

(5) That a Mazda type 51 lamp be used as a tuning indicator. (Par. 2-5(a))

(6) That a "cinch" type of octal socket be used as interconnecting terminal. (Par. 2-5(a))

(7) That a separate terminal board be used in conjunction with the interconnecting terminal socket. (Par. 2-5(a))

(8) That the instruction book include directions for disassembly of the transmitter and receiver subchassis. (Par. 2-5(a))

(9) That no obstruction of the tube socket center holes be permitted. (Par. 2-5(b))

(10) That noninflammable insulation be used on all hookup wiring. (Par. 2-6(a))

(11) That additional insulation be applied to the antenna loading coil. (Par. 2-6(a))

(12) That all wiring be suitably cabled where practicable. (Par. 2-6(a))

(13) That the means provided for removing the batteries be improved. (Par. 2-7(a))

(14) That consideration be given to a slight modification of the calibrate control and shaft. (Par. 2-7(a))

(15) That the marking of the mcw key switch be changed. (Par. 2-7(a))

[redacted]

(16) That a clip be provided to hold the spare vibrator. (Par. 2-8(a))

(17) That a recessed metal batten be provided on the bottom of the cabinet. (Par. 2-8(a))

(18) That the height of the handles on the top panel be increased. (Par. 2-8(a))

(19) That a guard rail around the controls be provided. (Par. 2-8(a))

(20) That bronze cable be used to retain the jointed segments of the antenna. (Par. 2-9(a))

(21) That provision be made for replacing any individual section of the antenna. (Par. 2-9(a))

(22) That the locking device on the antenna mounting be improved. (Par. 2-9(a))

(23) That consideration be given to incorporating a flexible coil spring in the antenna. (Par. 2-9(a))

(24) That further consideration be given to the design of the carrying harness. (Par. 2-11(a))

(25) That the detent markings be improved. (Par. 2-13(a))

(26) That the Contractor advise the Bureau regarding the durability and suitability of the cabinet finish. (Par. 2-14)

(27) That permanent fixtures for mounting renewable dehydrating material be incorporated in the equipment. (Par. 2-15)

(28) That provision be made to eliminate the necessity of retuning the antenna circuit when transferring from "Send" to "Receive." (Par. 3-9)

(29) That gasket cement less affected by temperature and prolonged humidity be used. (Par. 3-11(b))

(30) That efforts be made to reduce the frequency dispersion occurring during vibration. (Par. 3-12(a))

(31) That a clamp be provided on capacitor C-8. (Par. 3-13(a))

[redacted]

(32) That the backlash in the tuning control be reduced. (Par. 3-14(c))

(33) That the method of attaching the antenna case to the cabinet be improved. (Par. 3-21(c))

(34) That a valve be incorporated in the battery vents. (Par. 3-21(c))

(35) That preshrunk canvas be used in the carrying harness. (Par. 3-21(c))

(36) That closer tolerances be adopted and maintained between top panel and cabinet and battery compartment covers and compartment. (Par. 3-21(c))

(37) That the battery charging terminals be protected by a removable watertight cover. (Par. 3-21(g))

(38) That noncorrosive material be used for the battery clips. (Par. 3-23(b))

(39) That better contact between the batteries and the clips be provided. (Par. 3-23(b))

(40) That the operating current requirements of the relays be reduced. (Par. 3-23(d))

(41) That Navy type CUP-49215 "wafer" style headphones be used instead of the type HS-30-F now furnished. (Par. 5-2(a))

(42) That the mcw key be modified. (Par. 5-2(a))

(43) That suitable warning nameplate be provided at the p-a grid current pin jack. (Par. 5-3(a))

[redacted]

In the CXCR-1 equipment, it is recommended:

(1) That a warning nameplate be attached to the outside of the cabinet. (Par. 2-3(b))

(2) That contact between dissimilar metals be eliminated. (Par. 2-4(b))

(3) That further use of captive nuts or nut plates be made. (Par. 2-4(b))

(4) That terminal boards and individually replaceable units be used instead of "cup" assemblies. (Par. 2-5(b))

(5) That no obstruction of the tube socket center holes be permitted. (Par. 2-5(b))

(6) That the terminal board mounting be improved. (Par. 2-5(b))

(7) That the shaft alignment between the main tuning control and the main variable capacitor be improved. (Par. 2-5(b))

(8) That the design of the antibacklash drive gear be improved. (Par. 2-5(b))

(9) That the design and mounting of the 24-microhenry choke in the power supply be improved. (Par. 2-5(b))

(10) That a material improvement in the layout of the wiring be made. (Par. 2-6(b))

(11) That greater contrast between colors used in the color coded hookup wires be made. (Par. 2-6(b))

(12) That a larger control shaft be used on the calibrator capacitor. (Par. 2-7(b))

(13) That greater clearance be provided for the calibrate control shaft. (Par. 2-7(b))

(14) That suitable stops be provided for the "On-Off" switch. (Par. 2-7(b))

(15) That the position of the detent indicator flags be rotated to afford better visibility. (Par. 2-7(b))

(16) That the lettering on the top panel be modified. (Par. 2-7(b))

[redacted]

(17) That the top panel guard rail be modified and improved. (Par. 2-8(b))

(18) That battery ventilation be improved. (Par. 2-8(b))

(19) That consideration be given to incorporating a flexible coil spring in the antenna. (Par. 2-9(b))

(20) That a suitable ground terminal be provided for the "gooseneck" antenna. (Par. 2-9(b))

(21) That the carrying harness be attached to the cabinet by suitable hinged toggle bolts. (Par. 2-11(b))

(22) That material other than magnesium or aluminum be used for the toggle bolts and carrying harness hardware. (Par. 2-11(b))

(23) That the volume control be located in the head harness. (Par. 2-12)

(24) That the visibility of the tuning dial hairline indicator be increased. (Par. 2-13(b))

(25) That the detent adjustment screws be made adjustable under blackout conditions. (Par. 2-13(b))

(26) That the Contractor advise the Bureau regarding the durability and suitability of the cabinet finish. (Par. 2-14)

(27) That permanent fixtures for mounting renewable dehydrating material be incorporated in the equipment. (Par. 2-15)

(28) That interaction between the crystal-controlled and variable oscillators be eliminated. (Par. 3-3(a))

(29) That further efforts be made to secure uniformity of power output over the frequency range. (Par. 3-3(a))

(30) That efforts be made to reduce the frequency dispersion occurring during vibration. (Par. 3-12(a))

(31) That the backlash in the tuning dial be reduced. (Par. 3-14(c))

(32) That the carrier ripple be reduced. (Par. 3-19)

(33) That the battery vent system include a suitable valve. (Par. 3-21(d))

(34) That further efforts be made to make the equipment watertight. (Par. 3-21(e))

(35) That a removable watertight cover be devised for the battery charging terminals. (Par. 3-21(g))

(36) That spurious radiations from the transmitter be reduced. (Par. 3-22)

(37) That the hand generator be made submergence proof. (Par. 4-5)

(38) That more reliable overload protection be provided in the battery charger. (Par. 4-6)

(39) That screws more readily removable than those now used be employed in assembling the battery charger. (Par. 4-7)

(40) That Navy type CUP-49215 headphones be furnished with the equipment instead of the type now furnished. (Par. 5-2(b))

(41) That the mcw key be modified. (Par. 5-2(b))

(42) That a plastic box be used to contain spare tubes and tuning accessories.

(43) That a suitable alignment tool be furnished. (Par. 5-2(b))

[redacted]

As general standards for portable equipment of the CXCR-CXCR-1 type, it is recommended:

(1) That the accuracy of dial calibration be maintained within 0.5 per cent. (Par. 3-5(b))

(2) That a limit of 0.05 per cent frequency change for change of the variable oscillator tube and 0.005 per cent for change in any other stage be imposed for this equipment. (Par. 3-6(c))

(3) That the limit of permissible carrier frequency drift in the first five minutes of locked-carrier operation be 0.02 per cent, and 0.05 per cent during any subsequent period up to two hours. (Par. 3-7)

(4) That the frequency change per degree Centigrade not exceed 0.001 per cent. (Par. 3-10)

(5) That the frequency change with change of relative humidity not exceed 0.01 per cent. (Par. 3-11(a))

(6) That the accuracy of reset for nondetent positions be within 0.015 per cent, and within 0.02 per cent for detent positions.

(7) That the limit for average overall frequency stability be set at 0.5 per cent. (Par. 3-15)

(8) That minor defects in the equipments be eliminated. (Par. 5-2)

(9) That consideration be given by the Bureau to the various suggestions for improvements and modifications mentioned in the text of the report but not specifically referred to in these recommendations.

[redacted]

MATERIAL UNDER TEST

1-4(a). The following Model CXCR radio transmitting-receiving equipment, manufactured by the Howard Radio Company, Chicago, Ill., was received 24 January 1944 for test on the transmitting portion of the equipment.

(1) One Model CXCR transmitter-receiver, Serial No. 6.

(2) One wooden shipping chest.

(3) One type T-45 lip microphone.

(4) One type HS30F headphone and harness assembly.

(5) One set of canvas carrying harness.

(6) One segmented whip antenna in canvas carrying case.

(7) One instruction book.

1-4(b). The following Model CXCR-1 radio transmitting-receiving equipment, manufactured by the Galvin Manufacturing Corporation, Chicago, Ill., was received 30 December 1943 for test.

(1) One battery charger.

(2) One mounting bracket for charger.

(3) One book of schematic diagrams and drawings of the CXCR-1 equipment.

The following were received from the Galvin Manufacturing Corporation 3 January 1944 for tests on the transmitter portion of the equipment.

(1) One Model CXCR-1 transmitter-receiver, Serial No. 4.

(2) One type T-45 lip microphone.

(3) One headset type CTE-49016.

(4) One canvas headset helmet.

(5) One segmented whip antenna, type AN-131-A.

(6) One spare AN-131-A antenna.

[redacted]

(7) One flexible spring joint for AN-131-A antenna.

(8) One "gooseneck" antenna, type AN-130-A.

(9) One reel of rubber-covered antenna wire.

(10) One type SW-141-Q transfer switch.

(11) One hand generator, Serial No. 4, with two rubber-covered charging cables.

(12) One canvas carrying case for small accessories and antennas.

(13) One instruction book for Model CXCR-1 equipment.

METHOD OF TEST

1-5. The equipments when received were examined for possible damage incurred in shipment.

1-6. The CXCR equipment was placed in operation by following the instructions contained in the preliminary instruction book furnished. The CXCR-1 equipment was placed in operation by following accepted tuning procedure, inasmuch as preliminary instruction books were not furnished at the time of delivery of the equipment.

1-7. The power output measurements were made by means of a noninductive resistor and an r-f ammeter. A variable capacitor was inserted in series with the resistor and ammeter to simulate the characteristics of the whip antennas used with these equipments. The characteristics of the antennas were determined by the substitution method, and the dummy antenna constants thus determined were used for the power output measurements.

1-8. Frequency changes were measured on a Model LK frequency drift indicator and a Model LM-11 heterodyne frequency meter with the transmitter operating at full carrier power.

1-9. Modulation percentages were determined with a cathode-ray oscillograph. Distortion and noise level measurements were made with an RCA Model 69-C noise and distortion meter.

1-10. Audio signals for modulation percentage determinations, distortion, and overall audio response were obtained from a Boonton beat-frequency generator.

[redacted]

1-11. The CXCR-CXCR-1 equipments were placed in a test chamber in which the ambient temperature and relative humidity can be adjusted to simulate the range of operating conditions encountered in Naval service. The performance of the equipments was observed under temperature variations from -20°C to +60°C at a relative humidity maintained below 30 per cent, and under humidity variations between 30 per cent and 90 per cent at a constant temperature of 40°C.

1-12. The ability of the equipments to withstand the effects of vibration and shock was determined by mounting them on a test platform capable of producing these effects in controllable amounts.

1-13. The quality of the signals from these equipments was observed on the associated receivers, and on standard Navy type receivers set up at various distances from the transmitters.

1-14. The capability of the equipments to withstand submergence was determined by immersing the equipments in a tank of fresh water to a depth of one inch over the surface of the top panel. Since these equipments normally float upright, it was necessary to secure the equipments under the surface in this position for the test. The equipments remained submerged for 24 hours.

1-15. The operating life of the batteries was determined by automatically transferring the equipments from receive to transmit for one minute out of every four minutes. A portion of the r-f output was rectified and measured by a recording meter to determine the total operating time. Fully charged batteries were used at the start of the test.

1-16. The capabilities of the battery charging devices were determined by applying resistive loads and determining voltage and current output. The units were also connected to the discharged batteries and the restoration to the charged condition determined by observation of the indicators on the batteries.

<u>DATA RECORDED</u>

1-17. Complete data recorded during all tests accompany this report as Tables 1 to 49 and Plates 1 to 15, inclusive. Photographs of the two equipments are included as Plates 101 to 146, inclusive.

SECTION II--RESULTS OF TESTS

Introductory

2-1. The CXCR and CXCR-1 equipments tested for comparative performance at this Laboratory are developmental models of portable back-pack equipments designed to supplant or complement existing Naval equipment in this class of service. Although tentative specifications for such equipments have been written (reference (b)), the Laboratory tests were not conducted with the view of determining the degree of compliance of the two equipments to the requirements of these specifications due to the many changes which have been made since the developmental contracts were granted. However, provisions of reference (b) are considered indicative of the Bureau's desires for the basic mechanical, electrical, and operational characteristics of these equipments, and the comparative tests were conducted along the lines indicated in reference (b) as well as those specifically requested in reference (a).

Workmanship

2-2(a). The general workmanship in the Model CXCR equipment is excellent. The internal and external appearance is clean, orderly, and for the most part carefully arranged for serviceability and functional sequence in operation. Plates 123 to 131 and 135 to 146, inclusive, show many of the details of the mechanical construction and physical appearance of the equipment.

2-2(b). The exterior appearance of the Model CXCR-1 equipment is good and looks not unlike similar back-pack equipment devised by the Contractor for the military services. However, the workmanship and mechanical layout of components inside the case is not comparable with that usually found in Navy equipments. Plates 101 to 111, inclusive, show many of the details of mechanical features of this unit. Attention is directed to Plates 106 through 109, which show the top and bottom of the chassis and arrangement of components. Defects due to mechanical weaknesses in the equipments will be discussed in the paragraphs describing the test in which they were first observed.

Materials Used

2-3(a). The majority of materials used in the Model CXCR equipment are reasonably corrosion resistant in themselves. Most of the exterior metal surfaces are of aluminum alloy and

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have been painted with an olive drab enamel which appears to be of durable quality. Hold-down clamps, battery compartment cover hinges, carrying harness attachment buttons, and part of the antenna mounting are of steel which is, with the exception of the antenna terminal itself, paint protected. Inasmuch as paint is not ordinarily completely waterproof, it is recommended that these metal fittings be of stainless steel or the equivalent, and the paint relied upon merely to dull the surface and prevent reflections. Rust has been observed on the antenna terminal on several occasions; it is also recommended that a suitable noncorroding metal be used in this application, since electrical contact between antenna and this terminal is effected only by pressure between it and the bottom section of the fishpole antenna. Steel or magnetic material also has been used in the following applications in the interior of the equipment which are not in accordance with usual Naval practice:

(1) Drum dial and detent mechanism.

(2) Drive shaft for drum dial.

(3) Tube clamps.

(4) Power supply lifting bail.

(5) Relay mounting brackets.

In each of these applications the steel has been plated for corrosion protection. The chassis and shields are of aluminum alloy, with a sand blasted surface, lacquer protected. Inasmuch as the equipment is enclosed in a watertight case with a desiccator unit, the use of properly protected magnetic materials in the above applications is not considered objectionable. It is recommended that a warning nameplate be affixed to the exterior surface of the case bearing the legend, "Open case only when absolutely necessary," or the equivalent, to assure keeping the humidity as low as possible inside the case.

2-3(b). The exterior metal surfaces of the CXCR-1 are protected by olive-drab wrinkle-finish enamel. Hardware has been plated with black nickel. Aside from the magnetic applications, steel has been used in the following components of the CXCR-1:

(1) Main tuning capacitor frame.

(2) Tubular capacitor cases.

(3) Relay mounting brackets.

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Inasmuch as the watertight type of construction employed in this equipment is designed to minimize the effects of moisture and humidity on the components, and because these items have been plated with corrosion resisting metals, the use of properly protected magnetic material in these applications is not considered objectionable. As in the case of the CXCR, however, it is recommended that a warning nameplate be affixed to the exterior surface of the case bearing instructions to keep the case securely closed as much as possible.

Component Mounting

2-4(a). Machine screws used in the CXCR are of plated brass. Extensive use has been made of elastic stop-nuts secured to the chassis, which facilitates removing and replacing components. No tapped holes were observed in the aluminum alloy chassis. Some use has been made of steel rivets on structural members, but no component subject to replacement has been so secured.

2-4(b). Machine screws used in the CXCR-1 are of plated brass. Some use has been made of nut plates for securing structural members and large components on the chassis. It is recommended that further use of these anchored nuts or nut plates be made to facilitate replacement of components. A small number of rivets have been used to assemble structural members, but no rivets have been used for mounting components subject to replacement. No tapped holes were noted in the magnesium alloy chassis. An unplated brass bushing has been used to assemble the aluminum drive gears of the dial mechanism. Contact of dissimilar metals susceptible to corrosion and electrolytic action is prohibited in Naval equipment. It is recommended that contact between dissimilar metals be eliminated in this equipment.

Accessibility of Components

2-5(a). The arrangement of the majority of components of the CXCR is such that accessibility is good despite the extreme space limitations imposed on equipment of this type. The main tuning capacitor is completely enclosed by the subchassis of the receiver and transmitter and is inaccessible without major disassembly. The stator terminals of the various sections of this component are accessible for connection through suitable openings in the chassis. By placing the main tuning capacitor in this position, the accessibility to all other components is materially improved over what it otherwise would be. The tuning indicator lamp cannot be readily replaced due to the completely closed side plate, the close proximity of the antenna trimmer capacitor, top panel, and tube clamps. These components are so arranged that it is possible to insert only

[redacted]

one finger into the space adjacent to the bulb, and a special technique must be used to replace the bulb unless the top panel or side panel is completely removed. Some difficulty was experienced using this bulb to indicate resonance when the equipment was out of doors in full sunlight, due to the comparatively low brilliance of the lamp at the operating current obtainable from the equipment. A Mazda No. 51 bulb was substituted for the Mazda 55 furnished with the equipment and was found to be more suitable. There is a small danger of overloading this lamp if the mcw key is pressed while it is in the circuit, but for carrier conditions it has ample current carrying capacity. It is recommended that a type 51 bulb be used in this equipment. Plates 142 and 143 show the excellent accessibility to components such as tubes, relays, resistors, and capacitors, which are most liable to require replacement or other servicing. The power input socket, however, has such a large number of wires connected to it that it is difficult to service. One of these sockets developed defective contacts during the tests; this flat type of contact is particularly liable to become misaligned and completely pushed out of the phenolic socket when the male connector is inserted. It is recommended that a "cinch" type socket be used in this application. It is also recommended that a separate terminal board be used for the many wires now connected directly to the socket terminals in order that single leads may be brought to the contacts of the socket to facilitate replacement. The subchassis type of construction employed in the CXCR has distinct advantages from the standpoint of production. It is recommended that the instruction book for the final equipment include a description of the method by which these subchassis can be disassembled and servicing of the main tuning capacitor and drum dial mechanism effected.

2-5(b). Plates 106, 107, 108, and 109 show the components of the CXCR-1 equipment. Although the single unit chassis places the majority of units "out in the open," it is difficult to perform any servicing on the equipment other than replacing tubes. Metal-cased paper capacitors, which have been extensively used, are mounted on a short metal pedestal and secured to the chassis by a machine screw. Many of these screws are completely buried under resistors, capacitors, and circuit wiring which considerably hinders removal of the component. Several of these screws were found to have worked loose during the tests and could not be tightened. Accessibility to tube socket terminals for the most part is poor due to the large number of components compressed into the area surrounding the sockets. Small circular discs of cloth-inserted bakelite on which terminal lugs have been riveted serve as "cups" in which small quarter-watt resistors and ceramic capacitors are mounted. These assemblies have been

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used by the manufacturer in other portable equipments designed for the Army. In those applications, the components have been potted in a heavy wax, to be replaced as a unit if repairs are necessary. It is assumed that the same technique can be applied to these units in the CXCR-1 equipment. The use of the cup assemblies does not simplify servicing, however, inasmuch as several leads must be unsoldered to replace them, as contrasted to two for a single resistor or capacitor which might be defective in the group. In view of the doubtful advantage of these cup assemblies in facilitating servicing and the necessity for stocking additional special replacement units, it is recommended that consideration be given to using terminal boards and individually replaceable components instead of these cup assemblies. These cup assemblies are supported on metal rods soldered to the center of the tube socket. The manufacturer of the miniature type tubes used in the CXCR-CXCR-1 equipments specifically recommends that no obstruction be placed in the center of the tube socket because of the possibility that the miniature type tubes may be manufactured with the exhaust tip in the base of the tube. In the CXCR equipment several of the center holes in the sockets have also been obstructed by solder and wires to form a ground connection. It is recommended that no obstruction of the center hole in the tube socket be permitted in either equipment. A terminal board in the CXCR-1 indicated by the figure 1 in Plate 107 is flimsily mounted on an "L-shaped" bracket secured to the front panel by the volume control locking nut. It is recommended that a better method of mounting this terminal board be devised. The main tuning capacitor is mounted on the chassis by two machine screws through an angle bracket on the gear end of the frame, and by one machine screw through a rubber grommet shock mount on the opposite end. There is a misalignment between the worm gear on the main tuning capacitor and the tuning dial, part of which is compensated for by a yoke-and-crank coupler. The uncorrected portion of this misalignment produces a stress on the capacitor which rocks it back and forth as the dial is turned. This to-and-fro motion of the capacitor twists the chassis on which it is mounted, and adjacent components including IF transformers follow the motion. It is recommended that the shaft alignment be improved, and that the main tuning capacitor mounting be improved. The drive gear on the main tuning control is a split type of fiber and metal construction. The spring tension on the bakelite gear is insufficient to retain it in its proper position with respect to the metal gear and the anti-backlash capabilities of this combination are not fully utilized. It is recommended that the design of the gear be improved. The 24-microhenry choke used in the positive lead from the storage battery to the primary of the vibrator transformer is poorly designed and badly mounted. The coil is mounted in an

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insulated metal cylinder by means of a single bolt running through the center of the bakelite form on which it is wound. One terminal of the inductance is brought through the can to an insulated lug on the bottom, and the other is brought out the top to a similar insulated lug. The wires connecting this inductance into the circuit pass through ungrommeted holes in the chassis, which have been drilled so close to the mounting screw that the coil form presses down on the wires and will damage the insulation in time. The mounting screw of an adjacent filter capacitor also is underneath the coil form and interferes with proper mounting of the coil. This coil is so loosely mounted that it can easily turn under vibration and shock and short the battery to ground. It is recommended that the design and mounting of this coil be improved.

Wiring

2-6(a). The wiring of the CXCR presents a workmanlike appearance and has been done with well-insulated stranded hook-up wiring in the power circuits. Rather extensive use has been made of solid-conductor insulated bus-wire in the r-f circuits. An attempt to bring out these features has been made by means of the close-up views of Plates 142 and 144. The rough surface spaghetti insulation used in this equipment has been found by the Laboratory to support fungus growth. The cotton-wrapped hook-up wire has a smooth glazed surface and does not usually support fungus growth. No trouble from fungus should be experienced if moderate care is exercised to keep the chassis inside the case as much as possible. The stranded hook-up wire does not support combustion but the spaghetti insulation on some of the wiring is inflammable. It is recommended that noninflammable insulation be used on all wiring. The wiring has been neatly cabled, kept short, and all wires passing through the chassis have been protected by rubber grommets. Color coding of the hook-up wires facilitates circuit tracing and servicing. The antenna loading coil has been wound on a bakelite form and is so designed that the tank circuit end of the coil is brought back along the entire winding to a terminal near the base of the coil. The full r-f potential across this inductance exists between the turns of the coil and this wire, and only the silk insulation and insulating varnish prevents breakdown. Although no failures occurred during the tests, it is recommended that additional insulation be applied to this portion of the inductance. One lead in the battery charging circuit was found unsecured and it occasionally interfered with inserting the chassis in the cabinet. It is recommended that all lead wires be secured in a fixed position wherever possible.

2-6(b). The wiring of the CXCR-1 in general is unsatisfactory. Stranded vinylite insulated wire, which has been used exclusively, has definite merit for its fungus resistant and noninflammable characteristics. Color coding of these wires facilitates servicing and circuit checking, but more contrast between the various colors should be obtained by suitable choice of wires. The wiring does not present a workmanlike appearance and is far below the standards maintained in Naval equipment. Leads are indiscriminately too long or too short for the span between the components involved; wires passing through the chassis have no insulating grommets; insulation has been squeezed on wires wedged between components; numerous long single leads and the few groups of cabled leads are unsupported. Very little attempt appears to have been made to properly lay out the wiring in the design of this equipment, and servicing of the various components will be needlessly difficult because of this. An examination of Plates 107 and 109 will reveal other undesirable features in the wiring not specifically mentioned in this paragraph. It is recommended that a very material improvement be made in the wiring of this equipment.

Constructional Features

2-7(a). The chassis assembly of the CXCR is designed as a separate unit from the power supply, both of which may be completely removed from the cabinet. A six-conductor cable equipped with terminal plugs is used to connect the vibrator power supply and the transmitter-receiver unit. The arrangement of the components in either the transmitter-receiver or the power supply is such that no perceptible unbalance exists in the weight distribution when the equipment is carried as a pack load. The lead-acid type storage cells are mounted in separate compartments, accessible only through doors in the bottom of the cabinet. Plates 128 and 139 show the location of these compartments. Further description of the cabinet construction will be given in paragraph 2-8(a). The four cells can be withdrawn from the two compartments without necessitating the removal of the transmitter-receiver or power supply from the cabinet. This withdrawal is effected by means of rubberized cotton tapes which slip over the individual cells as shown in Plates 128 and 139. It was found that these tapes are attacked by the battery fluid and break after a short time. It is recommended that a better method of removing these batteries be devised. Tuning controls are shown in Plate 120. They are grouped for convenience in operation, and are of a size sufficient to permit gloves to be worn by the operating personnel while tuning. The frequency corrector control is accessible under the screw cap shown in Plate 124, and it also has a large and easily operated knob. Inasmuch as the calibrating circuit has been modified in these

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equipments from what it was in the previously submitted units, it is recommended that consideration be given to bringing the calibrate control shaft directly through the panel by means of a watertight gland to eliminate the screw cap now used. A locking device should be provided on the control if this is adopted. All controls necessary to the operation of the equipment, except the battery "on-off" switch and headset volume control, are located on this top panel, which is integral with the chassis. There is some possibility of confusion in the use of the mcw key switch shown in Plate 124. It is recommended that the marking be changed as follows:

"On" to "MCW On"
"Key" - Eliminated
"Off" to "Receive-Phone"

The "on-off" switch is located on the center of the right end panel as shown in Plate 127. The volume control is in the headset harness for convenience of the operator. This is shown in Plate 132.

2-7(b). The chassis assembly of the CXCR-1 equipment can be removed from the cabinet as a complete unit. The vibrator power supply also forms a part of the assembly, extending below the r-f portion of the transmitter-receiver chassis. This may be seen in Plates 105 and 106. The arrangement of the components of the chassis assembly is such that no perceptible unbalance exists when the equipment is carried as a pack load. The two lead-acid storage cells comprising the battery supply are mounted on the bottom plate of the cabinet, which is completely removable to afford access to the batteries. This feature appears in Plates 110 and 111, which also show the spare tubes and the battery connection facilities. The spare tubes, carried in a small wooden box, the exterior of which has been heavily painted with acid resisting paint, are locked under the terminal plate with the batteries during operation. Provision has been made in the connections on this terminal board for substituting dry batteries for the storage cells in emergencies. The battery compartment is completely isolated from the r-f portion of the equipment and can be opened without necessitating the removal of the chassis assembly from the cabinet. Tuning and operating controls have been placed on the top panel, as may be seen in Plate 101. The main tuning control and volume control knobs are of a sufficiently large size that they can be readily manipulated by an operator while wearing heavy gloves. The calibrate control is a screw-cap with a small screwdriver on the top which is inserted in the slotted end of the calibrating capacitor shaft when adjustments are necessary. It is recommended that a larger shaft be used on the calibrator capacitor, inasmuch as the screwdriver is at present much wider than the slot into which it fits and damage to the slot is probable. It is also recommended that this control be moved to a position which will provide greater clearance between it and the guard rail on the top panel. The "on-off" switch is controlled by a lever attached to a shaft approximately 9 inches long and 3/32 inch in diameter which is visible in Plate 109. Sufficient torque can be developed accidentally by means of the switch lever to twist this shaft materially. It is recommended that suitable stops be applied to this control to confine the travel of the lever to safe limits. Although the action of the detent mechanism on the main tuning dial is indicated by a definite drag on the tuning control and an audible click as it engages, a right-handed operator is obliged to remove his hand from the vicinity of the control in order to ascertain which detent he has engaged. It is therefore recommended that the position of the indicator flags be rotated approximately 180 degrees to facilitate rapid shifting from one detent position to another. The location of some of the panel lettering with respect to the associated control is for the most part good. It is recommended, however, that the word "Tuning" be moved closer to the tuning control knob (See Plate 101), and that the designation of the mcw switch be changed to read "MCW" and "Receive-Phone."

Cabinet Construction

2-8(a). The cabinet of the CXCR, exclusive of the top panel and battery compartment covers, is of plywood which has been treated to minimize the effects of humidity, temperature, and fungus. During the tests the contractor at his own request substituted a modification of the original cabinet, the chief changes in the final model being confined to the method of securing the top panel to the cabinet. Photographs of both style cabinets are included with this report and the majority of the constructional features of each type are revealed in Plates 124 through 129 and 135 through 140. In the original model, the top panel on the transmitter-receiver chassis was drawn down against the top of the cabinet by means of a large knurled knob located in a depression in the bottom of the cabinet. To this knob was attached a threaded shaft which engages a tapped opening in an "H-shaped" structural member on the bottom of the transmitter-receiver chassis. This drew the chassis vertically downward against the rubber-gasketed rim of the cabinet opening. The knob and H-frame can be observed in Plates 128 and 129. The openings to the battery compartments were closed by hinged metal covers having rubber gaskets for watertight seals. A special latch secured the free ends of these cover plates and exerted a force on the covers to compress the gaskets. On

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the final cabinet, the same style latch is also used on the top panel to effect a watertight seal instead of the drawbar arrangement of the originally submitted model. The force exerted by these clamps can be individually adjusted if necessary without voiding the watertight seal of the cabinet. This change slightly reduced the overall height of the equipment, but no changes in basic design were involved. Battery vents are brought out through the sides of the cabinet approximately half-way up from the bottom; in this position they will be protected against accidental fouling when the equipment is placed on the ground. The vents consist of horizontal bakelite tubes having a bore of approximately one-sixteenth inch. They are located inside the transmitter-receiver compartment. The battery compartment is arranged so that connection between the battery vent and the vent tube is assured when the battery is inserted. A small separate compartment has been provided in the back panel of the cabinet for the headset and spare vibrator of the equipment. The vibrator is not secured in this compartment; it is recommended that a clip be provided to hold the spare vibrator. The antenna is carried in a detachable canvas bag which is secured to the cabinet by means of "Dot" type fasteners. All corners and edges on the cabinet have been rounded with the exception of the bottom between the battery compartment covers. Since this portion of the cabinet will receive the greater part of the wear, it is recommended that a recessed metal batten strip be placed along the outer edges of the cabinet at these points. Two metal handles have been provided on the top panel which act as supports.for the chassis and keep its weight off the panel controls when the equipment is placed upside down. It is recommended that the height of these handles be increased to provide better clearance for the main tuning control knob than is now afforded. It is also recommended that these handles be extended to form a guard rail around the entire top of the control panel to further safeguard the controls from possible damage by low hanging branches and vines. The general design of the cabinet appears mechanically strong, and, with these changes, should successfully withstand severe abuse.

2-8(b). The entire cabinet of the CXCR-1 equipment is of light-weight metal construction. The various features of the cabinet can be seen in Plates 102, 103, 104, and 110. The top and bottom panels are gasketed with soft rubber to effect a watertight seal and are clamped in place by screw-type draw-bolts secured to the cabinet. A failure of one of these draw-bolts occurred during the tests. It is suggested that more careful inspection of the draw-bolts be made by the manufacturer. The controls on the top panel have been protected by a guard railing around the outer edges, with an additional cross brace across the approximate center. To

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improve the appearance of this panel, it is recommended that this cross brace be eliminated and that the guard rail on front and back edges be supported in the center of the span by a suitable post. This guard rail takes the weight off all projecting surfaces on the panel except the antenna terminal when the equipment is placed upside down. The antenna terminal is mechanically strong enough, however, to support the equipment in this position without danger of being damaged. The battery vent hole is in the removable bottom panel of the cabinet. It has a rubber cover which acts as a breather valve for battery gases and at the same time prevents dirt and foreign matter fouling the opening. The exhaust gases from the batteries are conducted to this vent through a hollow metal post of magnetic material used also as a part of the battery clamp. Despite the liquid trap built into the battery cells, it is entirely probable that the exhaust gases will be corrosive and this post will become blocked by corrosive action. It is recommended that a better method of battery ventilation be devised. Plate 110 shows the battery compartment of the CXCR-1; Plates 101 through 105, inclusive, show other features of the cabinet construction. The canvas antenna and accessory carrying cases are attached to the cabinet by two tabs which fit into slots on the draw-bolt fixtures and are securely held when the draw-bolts are in place. The general construction of the cabinet appears mechanically strong, and, with the changes recommended in this paragraph, should prove capable of withstanding severe abuse.

Antennas

2-9(a). The CXCR equipment has been provided with a jointed fish-rod type of antenna approximately 10 feet long. A stranded cable which passes through each of the sections prevents losing portions of the antenna when it is disassembled. A spring in the bottom section of the antenna is connected to the cable and aids the rapid assembly of the antenna. The individual sections of the antenna furnished with this equipment cannot be readily replaced. It has been found that the cable is susceptible to rust. It is recommended that bronze cable be used in its place, and that provision be made for replacing any individual section of the antenna. The mounting base of the antenna appears in Plates 124, 126, and 132. It consists of a spiral spring inside of a cylindrical housing with an insulated feed-through bushing which makes contact with a flexible leaf-type spring on the antenna loading coil assembly. The spring device permits 90-degree backward rotation of the antenna when the equipment is carried past an obstruction and returns the antenna to a vertical position when the obstruction is cleared. A push pin has been provided in this mounting to retain the antenna at 45 and 90 degrees

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from the vertical if it is necessary that the equipment be operated by personnel in a prone position. The locking device on this pin should be provided with wider flanges to afford better grip for the fingers when it is operated. Previously it has been pointed out in connection with the Model TBY equipment that this type of antenna mounting base does not prevent damage to the antenna should the equipment be carried sideways or backwards past obstructions. In the TBY equipments a flexible coil spring was incorporated in the whip antenna in addition to the rotating antenna mounting base to overcome this defect. It is recommended that a similar device be considered for this equipment.

2-9(b). Three types of antennas were furnished with the CXCR-1 equipment. The first type consisted of a jointed fish-pole approximately 10 feet long similar to that furnished with the CXCR equipment. The cable used in this antenna is larger in diameter than that furnished in the CXCR equipment and appears to be the more suitable of the two. Provision has been made to allow replacement of the individual segments of the antenna by securing the free end of the cable in the tip section of the antenna under a removable screw cap. The mounting base for this antenna is indicated by the figure 1 in Plate 114. This unit is attached to the antenna terminal by a knurled threaded ring, and is prevented from turning by a projecting pin which engages a suitable hole in the antenna terminal. The mounting consists of a double coil spring placed inside a protective cylinder at right angles to the axis of the antenna which permits backward rotation of the antenna to clear an obstruction and returns the antenna to a vertical position when the obstruction is cleared. The antenna may be locked at an angle of 90 degrees if desired. This mounting has the same limitations with respect to sideways and backward movements discussed in connection with the CXCR equipment and it is recommended that a suitable coil spring assembly be incorporated in this antenna. Fifty feet of stranded rubber-covered wire have been furnished as an auxiliary antenna into which satisfactory loading can be effected. A third whip-type antenna was furnished with this equipment. In Plate 113 this antenna is shown attached to the antenna terminal. It is approximately three feet long, with a short "gooseneck" section near the base for flexibility. A small capacitor, one end of which must be grounded to allow the transmitter to load into this antenna, has been permanently mounted inside the base of the antenna and connected to it. As the equipment was supplied, the ground connection is made with a short length of wire by slipping its terminal lug under one of the draw-bolts. The paint under these latches prevents obtaining a good connection. It is recommended that a suitable ground terminal be provided if this antenna is to be used with this equipment.

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Battery Charge Indicators

2-10. The condition of charge of the storage batteries of both equipments can be observed at all times without necessitating removal of the chassis or the batteries from the cabinet.

Carrying Harnesses

2-11(a). The carrying harnesses for both the original and modified CXCR cabinets are shown in Plates 123, 125, and 136. It can be completely removed from the cabinet. Due to the necessarily tight fit of the lower band, it is rather difficult to remove from the studs without the aid of tools. It is recommended that some provision be made to enable this band to be removed without the use of tools. An additional length of canvas strap attached to the band at a point toward its middle is suggested. The equipment can be readily slipped off the shoulders without detaching the harness from the cabinet. This harness, however, is not considered entirely satisfactory for carrying the equipment as a back pack. Plates 132, 133, and 134 show a Marine carrying the equipment. It will be observed that there is a forward thrust exerted by the weight of the equipment toward the "small" of the man's back. This must be countered by additional pull with his shoulders which accelerates fatigue and is undesirable. It is believed that the point of attachment of the top ends of the carrying straps should be placed in the center of the edge of the top panel, inasmuch as the total pull exerted by the shoulders in maintaining the equipment upright is inversely proportional to the cosine of the angle between the strap and a line parallel to the ground. The more nearly horizontal the top portion of the strap can be maintained, the smaller the difference between the required horizontal force and the actual force exerted on the strap. Similarly, the more nearly vertical the lower portion of the strap can be maintained, the more effective the force on the strap will be in supporting the equipment. This indicates the desirability of attaching the lower ends of the carrying harness well down toward the bottom of the cabinet. It is believed that a packboard arrangement or the equivalent would distribute the weight of the equipment more uniformly between the shoulders and hips and materially reduce fatigue. A good feature of packboard methods of carrying equipment is that the equipment does not rest directly on the back, permitting air circulation and minimizing perspiration and the attendant possibility of chafing. The pack board also serves as a partial buffer to reduce the possibility of injury to the operator if he should fall while carrying the equipment. It is therefore recommended that further consideration be given to the design of a light

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weight detachable packboard type of carrying harness for this equipment.

2-11(b). The carrying harness of the CXCR-1 equipment is shown in Plate 102. It consists of webbed canvas straps combined with a hinged padded metal plate attached to the cabinet by threaded bolts. The harness can be detached from the case by removing two threaded bolts. These bolts are of rather soft material and the slot for the screwdriver is easily damaged. It is recommended that the carrying harness be attached to the cabinet by hinged toggle bolts to permit more ready disengagement than is afforded by the machine bolts now used. It is also recommended that magnesium or aluminum not be used for the toggle bolts and carrying harness hardware. In Plates 112 and 113 a Marine is shown wearing the complete equipment as a pack load. It will be observed that the equipment is supported equally on the shoulders and hips and the weight is easily held in a vertical position over the legs and feet. This harness achieves the equivalent of pack-board load distribution and will cause a minimum of fatigue for the operator.

Volume Control

2-12. The volume control for the CXCR receiver is located in the headphone harness assembly and is suitably marked to indicate increase or decrease in volume. The volume control for the CXCR-1 is located on the top panel of the equipment, and is suitably marked to indicate increase or decrease in volume. It is recommended that, for operational convenience, this control be located in the headset harness.

Tuning Dials

2-13(a). The figures on the tuning dial and detent position indicators of the CXCR have been painted with radioactive phosphorescent material. The size of these figures on the tuning dial is sufficient for good readability without the use of the indirect dial light incorporated in the equipment, but that of the detent positions is not. It is recommended that the latter figures be turned 90 degrees and that an elongated style of figure be used to increase the amount of radioactive luminous material and improve visibility. No illumination of the controls has been provided. The small number of controls and their distinctive individual size and location obviates the necessity for such auxiliary illumination.

2-13(b). The figures on the tuning dial and the detent indicator flags of the CXCR-1 have been painted with a radioactive phosphorescent pigment to facilitate operation under

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blackout conditions. The position indicating hairline on the dial is very difficult to see against the faint illumination afforded by the luminous material. It is recommended that this condition be improved. It is not possible to change the detent setting under blackout conditions because the position of the corresponding detent adjustment screw cannot be ascertained without the aid of external illumination. It is recommended that the detent adjustment screws be indicated by suitably large figures of radioactive phosphorescent material. An auxiliary dial light provides satisfactory illumination of the tuning dial when blackout conditions need not be maintained. The tuning controls are sufficiently identifiable by touch that it is not believed advantageous to indicate them by luminous lettering.

2-13(c). Type 3A4 and 1T4 miniature tubes have been used in the CXCR equipment. These tubes are contained in the "Army-Navy Preferred List of Radio Electron Tubes," dated 15 Feb. 1944.

2-13(d). Type 1R5, 1S5, 1T4, and 3A4 miniature tubes have been used in the CXCR-1 equipment. These tubes are contained in the "Army-Navy Preferred List of Radio Electron Tubes," dated 15 Feb. 1944.

Cabinet Finishes

2-14. The exteriors of the cabinets and operating panels of the CXCR and CXCR-1 equipments have been finished in green color similar to that used on Marine Corps equipment. It is recommended that the contractors advise the Bureau regarding the fungus resistant capabilities, water proofness, and durability of the individual finishes used by them. The finishes are sufficiently flat to preclude light reflections from the surfaces of the cabinets.

Dehydrating Units

2-15. A small bag of nonrenewable desiccator material is packed in the cabinet of the CXCR equipment, but no container for dehydrating material has been incorporated in the design of either the CXCR or CXCR-1 equipment. A glass-cloth bag of silica gel was furnished with the CXCR-1 equipment, but no suitable location for placing the bag could be ascertained. It is recommended that a permanent fixture be devised for mounting a capsule of renewable dehydrating material in each equipment.

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SECTION III--ELECTRICAL PERFORMANCE

3-1. The basic equipments when assembled for operation can be carried by a man as a back pack and can be operated on A-3 emission by him either while walking or lying prone.

3-2. Field tests were not conducted to determine the operational distance in miles obtainable with either equipment.

Power Output

3-3(a). The CXCR and CXCR-1 transmitters are based on the master-oscillator power-amplifier principle, and are capable of producing either A-2 or A-3 emission. The power output obtained into a resistance-capacitance load of approximately 45 ohms and 25 μμf appears in Table 3 and Plate 1. The higher carrier power output of the CXCR results from using three type 3A4 tubes in parallel as a power amplifier. Two such tubes in parallel comprise the power amplifier of the CXCR-1. The data in Plate 1 were obtained at 100-kc dial intervals throughout the frequency ranges of the equipment, and show the output capabilities of the equipments into similar dummy antennas. The pronounced dips in power output of the CXCR-1 occur at frequencies close to the second and third harmonics of the crystal oscillator. Actual measurement of the CXCR-1 transmitter frequency in these regions indicates that there is a strong tendency for the variable oscillator to "pull in" and synchronize with the crystal oscillator. For approximately 100 kc in the vicinity of 3800 kc, changes in dial setting produce no change in output frequency. The reduction in power is produced by the detuning of the high Q antenna and p-a tank circuit which occurs when the variable oscillator synchronizes with the crystal oscillator. A somewhat similar change in output power was observed in the CXCR at 4000 kc where the frequency relationship between the crystal harmonics and the variable oscillator is the same as obtain in the CXCR-1 at 3800 kc. No tendency of the two oscillators to synchronize was observed in the CXCR, although a nonuniformity in output power present at 4000 kc is absent at 6000 kc. Any tendency of the variable oscillator to synchronize with a harmonic of the crystal oscillator is increased in the CXCR-1 equipment by the direct capacitive coupling between the plates of the two oscillator tubes. This close coupling produces a large number of undesired beat frequencies in the mixer tube and results in radiation of a carrier having a large number of side bands in the vicinity of 3800 kc and 5700 kc. It is recommended that the manufacturer of the CXCR-1 equipment eliminate these undesirable operating conditions caused by oscillator interaction at frequencies close to crystal harmonics and improve the uniformity of power output from the transmitter.

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3-3(b). Both equipments produce an appreciable increase in power during A-2 emission; the increase in the output of the CXCR is greater proportionally than that of the CXCR-1. The audio tone of the CXCR was found to be 1300 cycles; that of the CXCR-1 was 1275 cycles.

Frequency Coverage

3-4. The frequency coverages of the two equipments appear in Table 4. The highest calibrated frequency of the CXCR-1 is 7100 kc, as compared with 6500 kc in the CXCR. The high harmonic content of the CXCR-1 output makes a two-to-one frequency coverage disadvantageous unless the harmonic radiation is appreciably reduced.

Accuracy of Dial Calibration

3-5(a). The accuracy of dial calibration of the two equipments appears in Table 5. The average accuracy of calibration of the CXCR is somewhat better than that of the CXCR-1. Provision has been made in each equipment to use the third harmonic of the crystal oscillator as a calibration check point, and small trimmer capacitors have been placed across the variable oscillator inductances in each equipment. Satisfactory calibration can be effected in the CXCR equipment. It was found, however, that the tendency of the variable oscillator in the CXCR-1 to synchronize with the crystal oscillator made it very difficult to adjust for zero beat. The beat note frequency can be changed gradually by manipulation of the calibrator control only to within one or two kilocycles of zero beat, and then an abrupt stopping of the beat note occurs as the variable oscillator synchronizes. A reduction of the interaction between these oscillators, as recommended in paragraph 3-3(a) will undoubtedly eliminate this operating condition. As now designed, the trimmer has little effect at the calibrate point, and it is doubtful that the trimmer has sufficient range of capacity to correct for tube or circuit changes.

3-5(b). It is recommended that the accuracy of dial calibration be maintained within 0.5 per cent in these equipments.

Frequency Variation with Change of Tubes

3-6(a). A group of four type 3A4 tubes was substituted in the various stages of the CXCR transmitter and the resulting changes in frequency recorded. These data appear in Table 6. The frequency variations observed in this test are low and within acceptable limits for equipment of this type.

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3-6(b). A similar test was performed on the CXCR-1 and the measurements appear in Table 7. Higher deviations were observed in this equipment than in the CXCR equipment. Negligible frequency changes resulted from changes of p-a tubes in either equipment.

3-6(c). It is recommended that a limit of 0.05 per cent frequency change for change of the variable oscillator tube and 0.005 per cent for change in any other stage be imposed for this equipment.

Locked-Carrier Frequency Stability

3-7(a). Three two-hour locked-carrier tests were conducted on the CXCR transmitter for which the data appear in Tables 8, 10, and 12. The largest frequency changes during the first five minutes were observed at 3500 kc, but the greatest subsequent changes occurred at 6500 kc. This condition is probably due to the decreased effectiveness of the compensating capacitor in producing a change in total circuit capacitance when the tank capacitance is a maximum. The extent of compensation afforded by a negative coefficient capacitor can be shown to be dependent on the operating frequency and on the ratio of L to C which determines the operating frequency. Thus, in any given oscillator circuit in which the frequency is changed by a variable capacitor a small change in capacitance will produce a larger change in frequency at the high end of the band than the same change will produce at the low end of the band. This results in over-compensation at the higher frequencies under prolonged locked-carrier conditions. Inasmuch as this equipment will not be in the transmit position for such extended periods as these tests impose, the drift during the first five minutes may be considered representative of actual operating conditions. Although twice the drift shown in these tables would possibly occur between two CXCR equipments, the total drift would undoubtedly be within the band-pass limits in the receiver portion of the equipment.

3-7(b). Tables 9, 11, and 13 comprise data for similar locked-carrier tests conducted on the CXCR-1. A series and a shunt compensating capacitor have been used in this equipment which appear slightly more effective at 3500 kc in controlling the frequency during the first five minutes than the single shunt capacitor used in the CXCR. However, this circuit is materially less effective at 6500 kc and the total frequency drift at the end of two hours exceeds that in the CXCR at both ends of the band.

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3-7(c). It is recommended that the carrier frequency drift of these equipments not exceed 0.02 per cent during the first five minutes and 0.05 per cent during any subsequent period up to two hours.

Effect of Reduction of Battery Voltage

3-8(a). The battery voltage of the CXCR was reduced by operating the transmitter on locked carrier for approximately two hours using only two storage cells. The frequency change and the change in output power shown in Table 16 therefore reflect the combined effects of circuit heating as well as the decrease in battery voltage. Throughout the range of input voltages appearing in Table 14, A-2 and A-3 emission was effected and the send-receive relay operated normally.

3-8(b). The same test was conducted on the CXCR-1, permitting its batteries to run down under continuous locked-carrier load. The power output fell to zero when the battery voltage reached 2.9 volts, although the vibrator was still operating. The send-receive relay failed to hold in at this potential, and failed to pull in as the send-receive switch was operated. It will be observed that very nearly the same power output can be obtained from the CXCR at 2.6 volts battery potential as is obtainable from the CXCR-1 at 3 volts. The frequency change observed in the CXCR-1 is appreciably greater than that of the CXCR, due chiefly to the normally poorer performance of the CXCR-1 under locked-carrier operation.

Frequency Change - Send to Receive - Simultaneous Tuning.

3-9. The standard key-locked to intermittently-keyed test conducted on Navy transmitters was considered applicable to the equipments for determining the frequency change occurring when the equipment is transferred from send to receive. The data appear in Table 15. The frequency change observed in this portion of the test was negligible. Another test was devised for determining how the audio output of the receiver was affected by frequency change occurring under these conditions. The equipment, on transmit, was tuned exactly to zero beat with a Model LM-11 heterodyne frequency meter at the frequency shown in Table 15. Then the equipment was transferred to receive, audio modulation was applied to the signal from the LM-11 heterodyne frequency meter, and this audio output of the receiver detecting this signal was measured. Then the frequency of the incoming r-f signal was varied until a maximum audio voltage appeared in the output of the receiver. The change in frequency of the incoming signal corresponded to the changed resonant frequency of the CXCR or CXCR-1 transmitter-receiver. The CXCR equipment shows appreciably more change in characteristics in this operation than the

[redacted]

CXCR-1 does, particularly in its requirement that the antenna circuit be retuned for maximum response. It is recommended that an effort be made to effect this retuning automatically by switching in or out the necessary means of retuning after the CXCR equipment has been initially resonated for maximum power output on transmit. The dial of the Model CXCR-1 equipment was set at 3700 kc and the output frequency of the transmitter was found to be 3800 kc, due to the lock-in action between the crystal and variable oscillators. When the equipment was transferred to receive and a modulated 3800 kc signal was applied to the antenna, no audio output was obtained, and it was necessary to retune the signal generator to 3696 kc for maximum audio output from the CXCR-1 receiver. This condition is very undesirable and will cause considerable difficulty in establishing communication between equipments. Recommendations have been made in other paragraphs of this report that improvement be effected in this regard.

Variation in Ambient Temperature

3-10(a). The CXCR and CXCR-1 equipments were subjected to concurrent temperature tests insofar as possible. However, irregularities in the performance of each equipment required shutting down one or the other to investigate the difficulty, with the result that the test on the remaining unit was continued alone. This is the reason that variations occur in the curves of relative humidity shown in Plates 2 to 5, inclusive. Data obtained during the temperature test of the CXCR appear in Tables 16 and 17. The performance of the CXCR-1 under similar test conditions is indicated by the data in Tables 18 and 19. The greatest frequency change per degree Centigrade in both equipments occurred at the upper end of the range. The provisions for temperature compensation in the CXCR produce at 3500 kc an effect markedly different from what occurs at 6500 kc. This effect cannot readily be explained on the basis of over or under compensation for temperature changes, because other variables including plate voltages also influence the stability of the transmitter. The performance of the two equipments is similar at the high end of the band, but the CXCR-1 is decidedly inferior at the low end of the band.

3-10(b). It is recommended that a limit of 0.001 per cent frequency change per degree Centigrade be set for these equipments.

Variation in Relative Humidity

3-11(a). Variations in relative humidity had very little effect on the operation of either the CXCR or CXCR-1 equipment. The data obtained in the tests appear in Tables 20, 21, and 22

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and in Plates 6, 7, and 8. The frequency changes which occurred in both equipments are due to the effects of locked-carrier operation rather than any humidity effects. This is observable in the graphs, which show no abrupt changes in frequency to correspond with the abrupt changes in relative humidity.

3-11(b). The equipments were subjected to a seven-hour high humidity test to determine if there would be any undesirable effects not disclosed in the short tests previously conducted. While the ambient temperature and relative humidity in the temperature chamber were being brought to the test conditions, the equipments were operated under locked-carrier conditions. The transmitters initially were tuned to resonance and maximum power output at an ambient temperature of 20°C and no further tuning was done during the test. When conditions in the temperature chamber reached 40°C and 97 per cent relative humidity, the power output and frequency of each transmitter was recorded and the equipments turned off. They remained shut down for the seven-hour test period during which the ambient conditions obtaining at the start of the test were maintained constant. At the conclusion of this period, the frequency and power output were again measured, following which the equipments were examined for possible damage. The data for the CXCR are:

Time	Frequency (Kc)	Frequency Change (%)	Power Output (Watts)	Power Change (%)
0840	3502.200	--	0.76	--
1545	3502.100	0.0029	0.82	+21.1
1600	3502.550	0.010	0.65	-14.5

It will be noted that the power output at the start of the test is much lower than is shown in Table 3 or Table 20, but this is believed due primarily to the effect of moisture on the dummy antenna and the antenna insulator. The reduced power after the 15-minute locked-carrier period at the end of the test may be attributed chiefly to low plate voltage due to vibrator transformer heating. The frequency change is considered negligible. The prolonged humidity, however, had softened the adhesive used under the gaskets of several of the fixtures on the top panel of the CXCR and had started to rust the antenna mounting assembly and carrying harness attachment buttons. It is recommended that corrosion resisting materials be used for these applications and that a gasketing compound less affected by humidity be employed. No evidence of corrosion appeared on the case of the CXCR-1. The data on frequency and output power of the CXCR-1 are:

[redacted]

Time	Frequency (Kc)	Frequency Change (%)	Power Output (Watts)	Power Change (%)
0840	5930.6	--	0.68	--
1545	5931.3	0.012	0.57	-16.2
1600	5927.9	0.046	0.90	+32.4

The power output of the CXCR-1 at the beginning of the test is lower than that shown in Table 3 or Table 22, due to the effect of moisture on the dummy antenna and antenna insulator. The reduction in power observed at the end of the seven-hour period is believed due to the effects of detuning occasioned by the change in oscillator frequency. The increased power at the end of the 15-minute locked-carrier period may also be attributed to the tuning of the antenna circuit and possible drying of the antenna terminal. When the equipments were opened for inspection at 1600 no trace of moisture or evidence of humidity effects were observed in either equipment.

3-11(c). It is recommended that a limit of 0.01 per cent frequency change with humidity be set for these equipments.

Frequency Dispersion During Vibration

3-12(a). The CXCR and CXCR-1 equipments were mounted on a test platform by means of heavy steel clamps. Wooden buffers were placed between these clamps and the top panels of the equipments to eliminate the possibility of damaging the controls. Vibration frequencies between 600 and 1900 cycles per minute produced carrier frequency dispersions as shown in Table 23. Mechanical resonance effects appeared at 1200 and 1700 cycles per minute which produced the maximum dispersion observed in the CXCR equipment. Monitoring voice and mew signals of the CXCR on a stationary receiver showed inappreciable effects of this dispersion at 3500 kc, but both transmission and reception were affected at 6500 kc. The distortion introduced by vibration at 6500 kc was not sufficient to destroy intelligibility, however. In view of the possibility that these equipments may be adapted for shipboard or vehicular use, it is recommended that efforts be made to reduce the dispersion occurring at the high end of the band.

3-12(b). The maximum frequency dispersion resulting from vibration of the CXCR-1 occurred between 1200 and 1700 cycles per minute. The extent of the deviation was in most cases greater than those occurring in the CXCR. When the equipment was operating at 6500 kc, the quality of voice transmission

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was adversely affected between vibration frequencies of 1000 and 1300 cycles per minute, although greater dispersions were measured at higher vibration frequencies. The voice modulation remained intelligible, although considerable audible background noise appeared in the signal. Presumably this effect was produced by combined vibration of the audio and r-f portions of the CXCR-1, inasmuch as it was not observed when the equipment was operated at 3500 kc and the carrier-frequency dispersion was appreciably less. The same effect was observed with the CXCR-1 in the receive position at 6500 kc.

Effects of Shock

3-13(a). The equipments, mounted as described in paragraph 3-12, were subjected to a total of 43 shocks by means of a pneumatic shocking device. All but the first three shocks were imparted by the machine operating with 150 pounds per square inch air pressure, which imparts a minimum of 250 g acceleration to the test platform. The frequency before and after shock was recorded and the data appear in Table 24. The CXCR equipment was checked at the low end and the high end of the band as a series of 10 shocks directed toward a given side of the equipment was applied. The rather high changes in output frequency are believed to be caused chiefly by movement of the tuning control knob during shock because it was found, on shock number 23 at least, that applying a restraining pressure on the knob reduced the frequency shift. No tube failures were experienced during this series of shocks and no mechanical difficulty arose. When examined at the completion of the test, capacitor C-8 in the power pack was found to have been jarred loose from its socket. A clamp is recommended for securing this capacitor.

3-13(b). The effects of shock on the frequency of the CXCR-1 appear in Table 25. In making a comparison between the two equipments the per cent change corresponding to a given shock is the only fair basis of comparison. The direction of the shock with respect to the particular equipment should not be used as a reference, because uncontrollable variations in acceleration occur from one shock to the next, although for a constant air pressure the pneumatic device delivers in excess of 250 g on each shock. There is no consistency about the amount of frequency change produced by shock in either equipment. In the CXCR-1, however, it was noted that the amount of frequency change could be partially controlled by properly choosing the direction a given frequency setting was approached. This indicates backlash in the tuning dial. No mechanical failures occurred in either equipment, and no tube failures were experienced.

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Accuracy of Reset; Backlash and Torque Lash

3-14(a). Reference (a) outlined a procedure for determining the accuracy with which the equipments could be reset to a given calibrated frequency. The method described was very similar to the standard test for backlash, torque lash, and lost motion and the results appear in Tables 26 through 29 under this title. Greater accuracy of reset for both detent and non-detent positions was obtained at the high ends of the band in the CXCR. The data appear in Tables 26 and 27. The accuracy obtainable with the detent device compares favorably with that of the non-detent settings. The data obtained from the test of the CXCR-1 appear in Tables 28 and 29. Appreciable backlash appears at the high end of the band. It is probable that much of the frequency change observed during vibration and shock can be attributed to the backlash in the tuning mechanism.

3-14(b). The data in Tables 30 and 31 were abstracted from Tables 26 and 28 to show the accuracy of reset of the equipments when a calibrated dial position is approached in a clockwise direction. These data indicate that somewhat better reset accuracy is possible with the CXCR-1 equipment than is obtainable in the CXCR, which is assumed attributable to the greater band spread afforded by the cylindrical cam dial of the CXCR-1. It is probable that a reduction in backlash as recommended in paragraph 3-14(c) will materially improve the accuracy of reset of these equipments.

3-14(c). It is recommended that the backlash in these equipments be reduced, and that a permissible limit of 0.015 per cent be set for non-detent and 0.02 per cent frequency change be set for detent positions.

Summary of Frequency Stability Tests

3-15(a). Table 32 comprises a summary of the results of frequency stability tests conducted on the CXCR and CXCR-1 equipments. The data in the table represent the highest average deviations for the particular test irrespective of the operating frequency. The maximum deviations also are tabulated irrespective of the operating frequency. The overall stability of the CXCR appears decidedly superior to that of the CXCR-1.

3-15(b). It is recommended that the limit for average overall frequency stability of these equipments be set at 0.5 per cent.

[redacted]

Percentage Modulation Capability

3-16(a). The modulation capabilities of the equipments appear in Table 33 and Plate 9. Although 90 per cent modulation of the CXCR carrier could be obtained, the response for input signals above 0.15 volt is nonlinear and a high percentage of distortion is produced. The 95 per cent modulation level required by reference (b) is only 2 decibels higher than the 75 per cent modulation level obtainable with the CXCR as now designed. Since this change in level is less than the 3-decibel minimum which can be perceived by the average person, it is questionable that the circuit changes necessary to effect the required increase in modulating power would be justified.

3-16(b). The CXCR-1 equipment is capable of producing more than 90 per cent modulation of its carrier with nominal input voltages. The linearity of the curves in Plate 9 shows that relatively low distortion may be expected up to approximately 80 or 85 per cent modulation.

Audio Distortion and Overall Fidelity

3-17(a). The audio distortion produced in the output of the CXCR equipment when a constant modulation percentage is maintained is shown in Table 34. Data for both 90 per cent and 75 per cent modulation were obtained, and these data also appear graphically in Plate 10. In conjunction with Plate 9, it can be seen that 90 per cent modulation can be effected only by relatively high input voltages, which would be unobtainable from a carbon microphone, especially at low audio frequencies with the present circuit. At such high modulation percentages the distortion is excessive. However, the equipment is capable of 75 per cent modulation with less than 15 per cent distortion for audio frequencies between 500 and 5000 cycles per second. From 300 to 500 cycles, the distortion tends to be somewhat higher than the 15 per cent limit, but the increase cannot be detected by ear.

3-17(b). The audio distortion appearing in the output of the CXCR-1 is shown in Table 35 and in Plate 11. Appreciably higher percentages of distortion were obtained after the equipment had been operating for some time than were obtained immediately after the set had been turned on. At 3500 kc it was also noted that the distortion was unusually high for 75 per cent modulation. The grid drive to the final amplifier was found to be low and retuning the buffer stage slightly effected a material reduction in the amount of distortion in the output. At frequencies above 3500 kc the distortion was quite low, even for 90 per cent modulation,

[redacted]

regardless of the length of the time the equipment had been operated, indicating that insufficient drive at the low end of the band contributes materially to the distortion measured there.

3-17(c). The overall audio fidelity of the equipments appears in Tables 36 and 37 and Plates 12 and 13. The response of the CXCR is more uniform than that of the CXCR-1 between 300 and 3000 cycles, having a flat maximum response between approximately 600 and 1500 cycles. The maximum response of the CXCR-1 appears at 2000 cycles and is not flat at any point.

Power Supply Ripple

3-18. The ripple appearing in the various output voltages of the power supplies is shown in Table 38. The magnitude of the ripple is considered within acceptable limits in both equipments.

Carrier Ripple

3-19. The amount of ripple appearing on the carriers of the CXCR and CXCR-1 equipment is shown in Table 39. An appreciable increase in carrier ripple occurs at harmonics of the crystal frequency in each equipment. The ripple in the CXCR-1 carrier at 3800 kc is in excess of the 2 per cent limit usually imposed on Navy transmitters, and is appreciably higher than the CXCR at other frequencies. It is recommended that the carrier ripple in the CXCR-1 be reduced.

Tube Operating Conditions

3-20(a). The tube operating conditions in the CXCR were found to be as shown in Table 40. It will be noted that A-2 emission introduces the unbalanced screen current conditions discussed in reference (c). From a study of the mcw modulation characteristics, the grids of the modulator tubes are driven considerably positive by the vigorous oscillations of the tone generator and the screens attract the largest proportion of the filament emission. However, due to the discontinuous nature of mcw operation, it is probable that tube life will not be appreciably affected by this overload.

3-20(b). The tube operating conditions in the CXCR-1 were found to be as shown in Table 41. No overload conditions were observed in the transmitter portion of the equipment.

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Submergence Tests

3-21(a). The CXCR No. 5 equipment was subjected to several submergence tests in order to isolate specific deficiencies in the waterproof provisions. The calibrate control cover and tuning dial cover were turned on hand-tight, the batteries removed from the battery compartments and equivalent weights substituted therein. The equipment was submerged in a tank of fresh water to a depth of one inch below the surface. Bubbles of air were observed rising from the battery vent holes and the calibrator control cover within 15 minutes after submergence, so the equipment was removed from the water and examined. A small amount of water was found in both battery compartments, in the vibrator power supply well, and inside the calibrator control cover. Evidence of a leak appeared around one of the cover clamps. The equipment was carefully dried and suffered no damage from this test.

3-21(b). After adding an extra soft rubber gasket to the calibrate control opening and blocking three of the battery vent holes, the equipment was again submerged as in the first test and left for 24 hours in the water. One storage cell was placed in the compartment not having its vent hole blocked to determine if pressure differentials might keep water from running into the battery cell. Examination at the end of this test revealed:

(1) No water in the transmitter-receiver and power supply portion of the equipment.

(2) A small amount of water inside the storage cell.

(3) Water inside the battery compartment having leaked in around the edge of the covers.

(4) No water inside the spare parts compartment.

3-21(c). The CXCR No. 5 equipment, complete with accessories and with its antenna in the canvas carrying case, was thrown into the Potomac from about two feet above the surface of the water. The force exerted on the equipment as it passed below the surface tore the antenna case free of the "dot" fasteners on the cabinet and, in service, would have been lost. It is recommended that a different method of attaching the carrying case to the cabinet be devised. At the completion of this test the inspection revealed:

(1) Water had entered all battery cells.

(2) Water was found in battery compartment.

[redacted]

(3) Water had leaked in around the front center clamp on the top panel.

(4) Water was found inside power supply well.

(5) Some shrinkage occurred in the size of the canvas carrying harness which made it difficult to remove.

(6) The various tests have produced a gradual wearing of the paint on the cabinet.

These tests indicate that further improvement in the watertight provisions of the cabinet must be made to render the CXCR equipment capable of complete submergence in salt water. Specifically, it is recommended that a valve device be incorporated in the battery vents, that the closure of the battery compartments be improved, and that preshrunk canvas be used in the carrying harness. In addition, a general recommendation is made that closer tolerances between the top panel and the cabinet be adopted and adhered to.

3-21(d). The CXCR-1 No. 3 equipment was subjected to the same type submergence tests as conducted on the CXCR. At the conclusion of the first submergence test an examination revealed:

(1) Approximately one pint of water in the power supply well.

(2) A small amount of water in the battery compartment.

(3) Water in a small flask attached to the battery vent tube, which had been substituted for the storage battery.

(4) Battery vent rod rusted.

(5) A few drops of water inside the rubber phone jack housing.

3-21(e). When the equipment was thrown into the Potomac River, much the same conditions were noted except that water had been prevented from entering the batteries by pinching together the rubber battery vent tube. It was possible to operate the CXCR-1 equipment despite approximately one-half pint of water in the vibrator well of the cabinet. In none of these tests could the point of entry of the water be definitely located, but the volume of water found inside the cabinet suggests the possibility of a faulty seam in the metal cabinet as well as incomplete closure of the top gaskets. It is

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recommended that further efforts be made to make the CXCR-1 equipment watertight.

3-21(f). Both the CXCR and CXCR-1 equipments will float with the top panel above the surface of the water.

3-21(g). On both equipments the battery charging terminals are exposed and rapid discharge of the batteries and corrosion of the terminals may be expected if these equipments are carried through fresh or salt water. To determine this leakage current the Navy Standard Sea Water Solution was made up and the terminals from a Model CXCR equipment were immersed in it. Measures were taken to prevent the solution from coming into contact with the back side of the terminals and the wires leading to them so that only the surfaces of the terminals which would normally come into contact with sea water were exposed. A potential of 4.1 volts was applied to the terminals and the following currents were measured when the terminals were held in a vertical position similar to what it would occupy while floating or being carried in surf.

Time of Immersion (Minutes)	Leakage Current (ma)
0	65.0
1	69.0
2	70.0
3	71.0
4	71.5
5	72.0
6	72.5
7	72.5
8	72.5
9	72.5
10	72.5
15	72.5

Electrolytic action occurred with the passage of the above measured current with bubbles of hydrogen rapidly given off from the negative terminal. A white powder was formed on the positive terminal, which was assumed to be a compound of zinc from the brass terminals, inasmuch as a copper deposit was found on the surface of the terminal when the white solid was removed. It is recommended that a removable watertight cover be devised for protection of the charging terminals of both the CXCR and CXCR-1 equipment.

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Spurious Radiation

3-22. The two equipments were individually operated on 3500 kc and the frequency spectrum between 200 kc and 350 kc, and 500 kc and 20,000 kc explored with a Navy Type OF field strength meter. The dial calibration of this meter was found to be accurate only at one or two points in the several bands it is capable of covering. The meter was placed 22 feet from the transmitters and the field strength of the various radiations from the equipments determined. These data appear in Table 42. The field strength of 100,000 microvolts per meter chosen as a reference level was the carrier output of the CXCR-1. The data of Table 42 are presented graphically in Plates 14 and 15. It will be observed that the carrier frequency and some of the harmonic frequencies appear in the graphs at points on the "OF" dial other than in direct harmonic relation. Taking into consideration this probable dial error, the cause of the radiation at the various frequencies was determined for all but a very few of the signals, and appropriate designation of these signals has been made. There may be some question as to the correctness of the designation of "OF" image frequency responses, but the fact that they appeared at approximately the same point with either equipment justifies the assumption. The "OF" has an IF of 455 kilocycles. None of the other signals could be attributed to image response, however, The spurious radiation from the CXCR (neglecting the image response of the "OF") are more than 65 db below the carrier level. The maximum signal is produced by the second harmonic of the carrier, which, in the CXCR equipment, does not come within its tunable frequency range. One signal close to the CXCR carrier frequency could not be identified, but since it is 77 db below the carrier it will not be observed for any appreciable distance. In the CXCR-1, due to the method of coupling between the separate oscillators, between the oscillators and the mixer tube, and to the type of tank-antenna circuit, production and radiation of harmonics and beat frequencies is favored. Many of the possible combinations were actually of measurable magnitude and a particularly strong signal was picked up at 290 kc on the "OF" which was undoubtedly produced by the beat between the carrier and second harmonic of the crystal. This signal was only 29 db below the carrier level. The second harmonic of the 1900 kc crystal was only 37 db below the carrier level, and it is interesting to observe that the beat between the relatively strong second harmonic of the carrier and the second harmonic of the crystal produce an equally strong signal approximately 300 kc below the carrier frequency. The presence of high order of harmonics in the output of this equipment is undesirable and should be eliminated because of possible interference with other equipments in the vicinity; the tuning

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range of the CXCR-1 permits reception of the second harmonic of the carrier at 3500 kc, and unless the radiation is reduced, will cause confusion in operation. It would appear desirable also to reduce the spurious radiation as a means of increasing the carrier power of this equipment. Vibrator hash could be detected in the strongest signals of both equipments by slightly detuning the "OF" meter, but interference is to be expected only in the case of sensitive receivers working beside the equipments.

Battery Life Tests

3-23(a). Battery life tests were conducted with two and four storage cells in the CXCR equipment. The use of only two cells in series effects a 6-pound reduction in the weight of the equipment and will be useful for short patrol work. The equipment was operated alternately one minute on transmit and three minutes on receive; a monitoring detector and recording milliammeter indicated the relative power output of the transmitter during the transmission periods and the total operating time was determined from this record. The data for these tests appear in Table 43. With two cells a total of four hours operating time was obtained, although on two additional tests the equipment operated for five hours. These tests were conducted using the same set of batteries originally supplied with the CXCR equipment, which had undergone repeated cycling and considerable hard use. It is probable therefore that the average operating period of this equipment with one set of batteries will be nearer five hours than four. In a test when four cells were used the operating time obtained was eight and one-half hours. In a second test using four new, previously unused cells, a total operating time of nine and one-half hours was obtained.

3-23(b). In the course of the life tests, difficulty was experienced in establishing and maintaining contact with all four batteries in the CXCR. Spring Monel clips similar in style to small fuse clips are secured in small wells in the upper part of the CXCR battery compartment into which the battery terminals are pressed. Part of the pressure necessary to establish and maintain this contact is exerted by the battery compartment door and, as described in paragraph 3-21(a) (Submergence Tests), prevents good closure due to flexing of the cover plate. It was found that better contact with all eight battery terminals was obtained by lowering each of the Monel clips approximately one-eighth of an inch and removing a small amount of corrosion found chiefly on the negative terminal clips. It is recommended that non-corrosive material be used in this application if possible and that an improvement be made in the method of establishing contact. The use of a suitable clamp adjustable from the

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spare vibrator compartment has been considered, and several other possibilities will suggest themselves.

3-23(c). The same type of test was conducted with the CXCR-1 equipment, the data for which appear in Table 44. Eleven hours of operation were obtained from the two storage cells used in this equipment.

3-23(d). A study of the data in Tables 43 and 44 shows a considerable difference in the power input requirements of the CXCR and CXCR-1 equipments. Tables 45 and 46 comprise an analysis of the power output from the storage battery, and the operating efficiency of the vibrator power supply of each equipment. The filament drain was not measured in either equipment, the data being compiled from the tube manufacturer's ratings. Relay currents and vibrator supply inputs and outputs were directly measured, however. The efficiency of the CXCR vibrator supply is approximately 15 per cent better on transmit than on receive; that of the CXCR-1 is 10 per cent better on receive than on transmit. The chief difference in the current requirements of the two equipments on transmit is due to the higher filament heating requirements of the 10 type 3A4 tubes used in the CXCR, although a very considerable difference in relay power requirements exists also. The relays used in the CXCR equipment are smaller than the one used in the CXCR-1, and consequently require more current, but it appears desirable that a material decrease in relay operating current be effected. It is suggested that the mcw relay (RE-2) be supplanted by a suitable switch to conserve battery power. It would also be possible, by suitably designing the mcw key, to eliminate the necessity for using a keying relay. These two relays, however, are inoperative during phone transmission and consequently do not require operating power except when mcw operation is desired. The additional battery power saved by these changes may not justify the required circuit modifications at this time. It is recommended, however, that the operating current requirements of the relays in the CXCR, particularly relays RE-1 and RE-4, be reduced.

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SECTION IV--BATTERY CHARGING EQUIPMENT

Hand Generator

4-1. Battery chargers were furnished only with the CXCR-1 equipment; the contractor for the CXCR equipment has stated that their chargers will be submitted at a later date. The hand generator for the CXCR-1 is shown in Plates 115 to 120. The unit is designed to be worn on a cartridge belt or attached to a tree and may be operated for charging the battery in either position.

Charging Capability

4-2. The performance of the charger into batteries having different degrees of initial charge appears in Table 47. It will be noted that the condition of the battery has a small effect on the output of the generator, requiring somewhat higher crank speeds for a given charging rate as the internal resistance of the battery increases.

Audible Noise Output

4-3. The audible noise output of the generator at various crank speeds also appears in Table 47. This unit is markedly quieter in operation than the TBX hand generators and should not be as difficult to use where quietness is essential to security of personnel.

Hand Generator Ripple Voltage

4-4. The ripple voltage produced by the generator was measured at various crank speeds under receive and transmit condition; the data for this test comprise Table 48. It will be observed that the vibrator action produces an appreciable ripple across the battery terminals and that the additional ripple introduced by the generator is of negligible magnitude. It is believed that no change in the performance of the transmitter or receiver will occur when the hand generator is used and the CXCR-1 is in operation.

Submergence Test

4-5. Submergence tests of this unit revealed that it is not waterproof as submitted. Water was found inside the chain drive housing, and a few drops were observed around the assembly bolts in the generator portion of the unit. Although the operation was unimpaired after 24 hours submersion in fresh water, it is recommended that further efforts be made to render this unit water proof.

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Battery Charger

4-6. The CXCR-1 battery charger, shown in Plates 121 and 122, was used throughout the tests to charge both the CXCR and CXCR-1 batteries. The charger functioned satisfactorily and is capable of completely restoring the charge of the Willard Type BB-54-A storage cells furnished with the CXCR-1 equipment. Data on the performance of the charger with 6, 12, 24, and 32 volts d-c.and 110 volts a-c input appear in Table 49. A protective overload switch has been incorporated in the output circuit of this unit. The operation of this switch was checked and the data also appear in Table 49. The performance is not very consistent and it does not appear to give sufficient protection to the charger. It is recommended that this device be given further consideration to assure a uniform release time on overload.

4-7. Access can be gained to components below the chassis of the battery charger only with great difficulty, due to the use of a type of screw for which no suitable screwdriver could be located. It was found that the components below the chassis are well arranged for servicing. It is recommended that standard slotted, Allen, or Phillips type screws be used in assembling this charger and, if other than slotted screws are used, that a suitable screwdriver or wrench be furnished.

SECTION V--GENERAL CRITICISM

5-1. The main advantages and disadvantages of the Model CXCR-CXCR-1 equipments have been discussed at length in the previous sections of this report. The following paragraphs will cover briefly various defects and good points of a minor nature which could not be mentioned specifically in the earlier discussions.

Defects

5-2(a). The following defects in the CXCR equipment appear in the models submitted for test:

(1) The original adjustment of the antenna tuning slug in the No. 6 unit did not give proper tracking over the band. Comparison with the No. 5 unit, which did give proper tracking, showed it to have been improperly set by the contractor.

(2) Circuit diagrams for the power supply, interconnecting power cable, and cabinet wiring were not included in the instruction book.

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(3) Several errors were noted in the diagrams furnished on the equipment.

(4) The diagrams cemented to the cover shields should be arranged so that the openings left for access to the trimmer-capacitors do not break up the diagram and make them hard to follow.

(5) The power supply can be inserted in its well in the cabinet incorrectly and incorrect battery polarity can be applied to electrolytic capacitors. By interchanging the positions of C-8 and C-9, small blocks could be placed in the well so that the supply could be inserted correctly in but one direction.

(6) The banana plugs on the power supply are too small to maintain good contact, especially if the battery leads are a trifle short. Large size banana plugs should be substituted.

(7) Protruding nuts and bolts securing the "On-Off" switch to the cabinet scrape on the chassis when it is inserted in the cabinet.

(8) Only one set screw has been used on control knobs. Two are required in Navy equipment.

(9) The type HS-30-F headphones furnished with the CXCR equipment, while very light, become irritating when worn for even relatively short periods, due to the pressure exerted on the ear canal. It is recommended that Navy type CUP-49215 "wafer" style headphones be substituted. The adjusting strap on the canvas helmet used with these headphones should be detachable to facilitate putting the helmet on and taking it off.

(10) The mcw key was found to become inoperative if too much force was used in keying. This was remedied by pinning the center insulating bushing to the outer cylinder of the key assembly. It is recommended that this be done in all future equipments.

[redacted]

(11) An insulated "Two-in-One" aligning tool should be furnished and a suitable clip provided on the equipment for carrying it.

(12) No spare antenna tuning indicator lamp was furnished. Provision should be made for carrying one with the equipment.

(13) An Allen wrench should be provided for removing and tightening control knob set screws.

5-2(b). The following defects were noted in the Model CXCR-1 equipment:

(1) The minimum tension on the mcw key spring is too stiff to permit even moderate rates of keying. It is recommended that the design of this key be improved.

(2) The headphone and microphone cords are too long and may become entangled in dense undergrowth.

(3) The provision for side tone during transmission is too weak to be considered satisfactory.

(4) One T-45 lip microphone furnished with the equipment was defective when received.

(5) Magnesium alloy has been used for hardware which must have mechanical strength and it has failed to meet the requirements imposed on it in several places.

(6) A wooden box has been provided for carrying spare tubes, Allen wrenches, and aligning tool. It is recommended that a plastic box be substituted having spaces provided for each tube and accessory. It is also recommended that a suitable hex-head wrench required for aligning the equipment be provided in this box or a "Two-in-One" tool be provided to replace the present tool.

(7) Type CTE-49016 headsets furnished with the CXCR-1, although small in size, are still too heavy and bulky to be conveniently worn under a steel helmet. It is recommended that Navy type CUP-49215 headphones be substituted for those now furnished.

[redacted]

(8) Battery charger cables and output socket were not wired according to the circuit diagrams furnished.

(9) Several failures of the detent "click" mechanism occurred during the tests.

(10) Evidence of poor soldering techniques were noted on two resistors and tube sockets.

(11) Circuit diagrams furnished failed to show all wires found in equipment.

(12) When equipment operates near a crystal harmonic, a reduction of the blocking bias on the mcw oscillator occurs and the tone can be heard with the key up.

(13) One "gooseneck" antenna was found improperly wired inside its mounting and therefore could not be used with the CXCR-1 equipment.

(14) Some of the turns on the antenna loading coil became shorted during the tests due to abrasion of the insulation by the drum dial mechanism. Repairs and elimination of the cause were effected by a representative of the manufacturer.

(15) "Bristo" set screws on main control shaft loosened repeatedly.

(16) A sticky black adhesive, which has been used to aid in maintaining waterproofness, is annoying and undesirable because it comes off on the operator's hands and clothing.

(17) Power-amplifier grid drive is barely adequate at the high end of the band, and should be increased at the low end of the band for optimum performance over the frequency range.

<u>Desirable Special Features</u>

5-3(a). The Model CXCR equipment has a number of minor features which are considered good. They are as follows:

(1) The use of individual tube clamps which secure the miniature type tube envelope against vibration and shock. The hinged type clamps furnished in the No. 6 unit are preferable to those in the No. 5, which are not hinged. It is

[redacted]

more difficult to remove the tubes from the non-hinged clamp.

(2) The pin jacks for measuring the grid currents of the various transmitter stages are very convenient. Suitable directions for using the p-a grid current jack have been included in the instruction book, but it is recommended that a warning red label be attached to the jack to prevent possible damage to the meter if improperly inserted. In passing, it was found that the practice of turning the equipment off before each insertion of the ungrounded grid meter lead in these jacks is a simple way to avoid trouble from this cause.

(3) The combined headphone and microphone harness is preferable to having separate connecting cords for each unit.

5-3(b). The Model CXCR-1 equipment has several minor features which are considered good. They are as follows:

(1) The carrying harness, which has been mentioned before, is well designed.

(2) The provisions for inserting a meter in the transmitter mixer plate circuit and p-a plate circuit are a convenience when servicing the equipment.

(3) The use of r-f chokes at the microphone and headphone jacks minimizes interaction between the antenna and the microphone and headphone cords.

[redacted]

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TABLE 1

MODEL CXCR-CXCR-1 EQUIPMENT

LIST OF CONTROLS

Model CXCR Ser. No. 6

Control Marking	Dial Marking	Direction for Increase of the Controlled Effect
Tuning	3.5 to 6.5	Clockwise
Frequency Corrector	None	Not applicable
Antenna Adjust	None	Not applicable

MCW Key Switch (Toggle Type)
  Forward: On
  Back: Off
Crystal Oscillator Calibrate Switch (Momentary Contact Pushbutton Type). Normally open--push to close.
  Marking: Press to calibrate at 6 Mc.
Dial Light Switch. Same as Crystal Osc. Calibrate Switch.
Power Switch (Toggle Type).
  Up: On
  Down: Off
Headset-Microphone Connector. Four-prong male connectors--type unknown.
Headset-Microphone Send-Receive Switch (Momentary Contact Press-To-Talk Pushbutton Type).

(Continued)

[redacted]

TABLE 1 (CONT'D)

Model CXCR-1 Ser. No. 4

Control Marking	Dial Marking	Direction for Increase of the Controlled Effect
Tuning	3.4 to 7.1 Freq. in Mc	Clockwise.
Calibrate	None	Not applicable.
Antenna Trim	None	Resonant frequency increases with clockwise rotation of control.
Volume Control	Increase Output	Clockwise.

MCW-Rec. Switch. Two-position rotary.
Power Switch. Two-position rotary.
Forward: OFF
Back: ON

Dial Light Calibrate Switch (Momentary Contact Pushbutton Type).
Headset-Microphone Send-Receive Switch (Momentary Contact Press-To-Talk Lever Type).
Headset Jacks (Waterproofed Normally Open Single-Circuit Jack).
Microphone Jack (Waterproofed Normally Open Two-Circuit Jack).

[redacted]

TABLE 2

MODEL CXCR-CXCR-1 EQUIPMENT

DIMENSIONS AND WEIGHTS

Unit		CXCR Ser. No. 6	CXCR-1 Ser. No. 4
Shipping Chest (empty)	Height	18.75 inches	None furnished
	Width	15.0 inches	
	Depth	10.75 inches	
	Weight	8.0 pounds	
Transmitter-Receiver complete with batteries and accessories.	Height	15.88 inches	15.5 inches
	Width	14.25 inches	13.0 inches
	Depth	7.5 inches	7.25 inches
	Weight	37.0 pounds	34.5 pounds
	Height with antenna case attached	16.75 inches	18.0 inches
Batteries (each)	Type:	Willard ERH-25-2	Willard BB-54-A
	Height	6.4 inches	5.5 inches
	Width	2.5 inches	3.0 inches
	Depth	2.5 inches	4.0 inches
	Weight	3.0 pounds	4.5 pounds
	Number used	4	2
Charging Equipment		None furnished	Hand Generator
	Height		7.88 inches
	Width		7.75 inches
	Depth		6.0 inches
	Weight		8.25 pounds
	Overall width with crank handles extended		15.5 inches
		None furnished	Battery Charger complete with cable and mounting brackets
	Height		14.0 inches
	Width		7.0 inches
	Depth		6.75 inches
	Weight		20.5 pounds

(Continued)

[redacted]

TABLE 2 (CONT'D)

Accessories	CXCR No. 6 Weight	CXCR No. 6 Cord Length	CXCR-1 No. 4 Weight	CXCR-1 No. 4 Cord Length
Lip Microphone	(Microphone and Headset combined)		8 oz.	107 in.
Headset Unit	13 oz.	75.6 in.	12 oz.	64 in.
Charging Cord	4 oz.	33.6 in.	--	36 in.
Carrying Harness	16 oz.	--	Included with equipment	
Antenna Case	4 oz.	16.75 in.	--	18 in.
Antenna (8 sections)	8 oz.		8 oz.	
Length of each section	16 in.		17 in.	
Total assembled length	121 in.		128.5 in.	
"Gooseneck" Antenna	--		5 oz.	
Assembled	--		32.5 in.	
Collapsed	--		17 in.	
Emergency Wire Antenna	--		4 oz.	50 ft.

Carrying Harness Strap Lengths

	CXCR No. 6 Min.	CXCR No. 6 Max.	CXCR-1 No. 4 Min.	CXCR-1 No. 4 Max.
Waist Belt	28 in.	40.5 in.	28 in.	40.5 in.
Shoulder Straps	11 in.	28 in.	20.5 in.	26.5 in.

[redacted]

TABLE 3

MODEL CXCR-CXCR-1 EQUIPMENT

POWER OUTPUT

	Frequency (Mc)	Input Volts	Input Amps.	P-A Plate Volts	P-A Plate ma	R-F Watts
Model CXCR Serial No. 6						
Carrier	3.5	4.0	12.1	148	35	1.38
MCW	3.5	4.0	13.0	143	40	2.94
Carrier	4.0	4.0	12.1	148	36	1.55
MCW	4.0	4.0	13.0	144	41	3.30
Carrier	4.5	4.0	12.1	148	36	1.60
MCW	4.5	4.0	13.0	145	40	3.30
Carrier	5.0	4.0	12.2	148	36	1.55
MCW	5.0	4.0	13.0	144	40	3.32
Carrier	5.5	4.0	12.2	149	36	1.55
MCW	5.5	4.0	13.0	145	40	3.41
Carrier	6.0	4.0	12.1	148	33	1.50
MCW	6.0	4.0	13.0	145	38	3.41
Carrier	6.5	4.0	12.2	149	32	1.53
MCW	6.5	4.0	12.8	145	36	3.41

Dummy Antenna = 45.1 ohms, 25 μμf.

	Frequency (Mc)	Input Volts	Input Amps.	P-A Plate Volts	P-A Plate ma	R-F Watts
Model CXCR-1 Serial No. 4						
Carrier	3.5	4.0	8.6	162	23	0.93
MCW	3.5	4.0	9.0	160	25	1.34
Carrier	3.7	4.0	8.6	160	22	0.47
MCW	3.7	4.0	9.0	158	24	1.06
Carrier	3.8	4.0	9.6	138	38	0.076
MCW	3.8	4.0	10.1	137	39	0.118
Carrier	4.0	4.0	8.7	158	25	0.99
MCW	4.0	4.0	9.1	155	27	1.49
Carrier	4.5	4.0	8.5	156	26	0.98
MCW	4.5	4.0	8.9	153	28	1.42
Carrier	5.0	4.0	8.6	155	28	0.88
MCW	5.0	4.0	9.0	152	29	1.31
Carrier	5.5	4.0	8.6	155	26	1.05
MCW	5.5	4.0	9.0	152	28	1.61
Carrier	6.0	4.0	8.5	156	27	1.09
MCW	6.0	4.0	8.9	153	29	1.60
Carrier	6.5	4.0	8.5	155	27	1.06
MCW	6.5	4.0	8.9	152	29	1.60
Carrier	7.0	4.0	8.5	154	28	1.06
MCW	7.0	4.0	8.9	152	29	1.61

Dummy Antenna = 47.19 ohms, 25 μμf.

[redacted]

(Continued)

TABLE 3 (CONT'D)

Summary

Carrier Only

Frequency (Mc)	CXCR P-A Volts	CXCR P-A ma	CXCR R-F Output (Watts)	CXCR Per Cent Efficiency	CXCR-1 P-A Volts	CXCR-1 P-A ma	CXCR-1 R-F Output (Watts)	CXCR-1 Per Cent Efficiency
3.5	148	35	1.38	27	162	23	0.93	25
4.0	148	36	1.55	29	158	25	0.99	25
4.5	148	36	1.60	30	156	26	0.98	24
5.0	148	36	1.55	29	155	28	0.88	20
5.5	149	36	1.55	29	155	26	1.05	24
6.0	148	38	1.50	27	156	27	1.09	26
6.5	149	36	1.53	28	155	27	1.06	25
7.0	--	--	--	--	154	28	1.06	25

[redacted]

TABLE 4

MODEL CXCR-CXCR-1 EQUIPMENT

FREQUENCY COVERAGE OF TRANSMITTER

Position of Dial	Frequency (Kc)
Model CXCR Serial No. 6	
Dial stop (low side)	3400.600
First dial number (3500 kc)	3492.430
Last dial number (6500 kc)	6510.900
Dial stop (high side)	6787.000
CXCR-1 Serial No. 4	
Dial stop (low side)	3403.000
First dial number (3400 kc)	3405.000
Last dial number (7100 kc)	7097.000
Dial stop (high side)	7095.000*

* There is a drop in frequency between the last dial number and the dial stop.

[redacted]

TABLE 5

MODEL CXCR-CXCR-1 EQUIPMENT

ACCURACY OF DIAL CALIBRATION

Dial Setting (Kc)	CXCR Ser. No. 6 Measured Output Frequency (Kc)	CXCR Ser. No. 6 Per Cent off Calibration	CXCR-1 Ser. No. 4 Measured Output Frequency (Kc)	CXCR-1 Ser. No. 4 Per Cent off Calibration
3500	3489.75	0.29	3512	0.34
4000	4000.90	0.022	4007	0.18
4500	4497.70	0.051	4521	0.47
5000	4990.00	0.20	4999	0.020
5500	5482.19	0.32	5501	0.018
6000	6001.30	0.022	5992	0.13
6500	6508.57	0.13	6508	0.12
7000	--	--	6985	0.21
Average Deviation		0.148		0.186

Dummy Antenna 45.1 ohms, 25 μμf.

Note: (1) Model CXCR calibrated at 6000 kc at beginning of test.
(2) Model CXCR-1 calibrated at 5700 kc at beginning of test.

[redacted]

TABLE 6

MODEL CXCR SERIAL NO. 6

FREQUENCY VARIATION WITH CHANGE OF TUBES

Tube	Frequency (Kc)	Deviation from Mean Frequency Kc	Deviation from Mean Frequency Per Cent
	Variable Oscillator		
Orig.--RCA	3502.800	--	---
1--RCA	3504.800	2.714	0.0774
2--RCA	3502.300	0.214	0.0061
3--Tung-Sol	3501.000	1.086	0.0310
4--Tung-Sol	3500.630	1.456	0.0416
Orig.--RCA	3501.700	0.386	0.0110
Mean Freq.	3502.086	Average: 1.171	0.0334
Orig.--RCA	6432.500	--	--
1--RCA	6444.700	13.320	0.207
2--RCA	6433.100	1.720	0.0268
3--Tung-Sol	6420.600	10.780	0.168
4--Tung-Sol	6426.400	4.980	0.0775
Orig.--RCA	6432.100	0.720	0.0112
Mean Freq.	6431.380	Average: 6.304	0.0981
	Crystal Oscillator		
Orig.--RCA	3502.800	--	--
1--RCA	3502.300	0.370	0.0105
2--RCA	3502.600	0.070	0.0020
3--Tung-Sol	3502.850	0.180	0.0052
4--Tung-Sol	3502.800	0.130	0.0037
Orig.--RCA	3502.800	0.130	0.0037
Mean Freq.	3502.670	Average: 0.176	0.0050
	Buffer Tube		
Orig.--RCA	3502.250	--	--
1--RCA	3502.350	0.340	0.0097
2--RCA	3502.650	0.040	0.0011
3--Tung-Sol	3502.900	0.210	0.0060
4--Tung-Sol	3502.800	0.110	0.0031
Orig.--RCA	3502.750	0.060	0.0017
Mean Freq.	3502.690	Average: 0.152	0.0043

(Continued)

[redacted]

TABLE 6 (CONT'D)

Tubes	Frequency (Kc)	Deviation from Mean Frequency	
		Kc	Per Cent
	P-A Tubes		
Orig.--RCA's	3502.150	--	--
1 to 3--RCA's	3501.850	0.020	0.00057
4 to 6--Tung-Sol's	3501.900	0.030	0.00086
Orig.--RCA's	3501.850	0.020	0.00057
Mean Freq.	3501.870	Average: 0.023	0.00067

Note: (1) Frequencies read five minutes after power applied.

[redacted]

TABLE 7

MODEL CXCR-1 SERIAL NO. 4

FREQUENCY VARIATION WITH CHANGE OF TUBES

Tube	Frequency (Kc)	Deviation from Mean Frequency Kc	Deviation from Mean Frequency Per Cent
	Variable Oscillator		
Orig.--Tung Sol	3465.55	--	--
1--Tung Sol	3459.55	2.20	0.063
2--Ken Rad	3452.82	4.53	0.131
3--Tung Sol	3460.20	2.85	0.082
4--Gen. Elec.	3451.70	5.65	0.163
Orig.--Tung Sol	3462.45	5.10	0.147
Mean Freq.	3457.35	Average:. 4.07	0.117
Orig.--Tung Sol	6432.7	--	--
1--Tung Sol	6421.7	11.6	0.180
2--Ken Rad	6392.6	17.5	0.274
3--Tung Sol	6420.7	10.6	0.166
4--Gen. Elec.	6385.2	24.9	0.389
Orig.--Tung Sol	6430.4	20.3	0.317
Mean Freq.	6410.1	Average: 16.98	0.265
	Crystal Oscillator		
Orig.--Tung Sol	3503.000	--	--
1--Tung Sol	3503.500	0.048	0.0014
2--Ken Rad	3502.950	0.502	0.014
3--Tung Sol	3503.550	0.098	0.0028
4--Gen. Elec.	3503.700	0.248	0.0071
Orig.--Tung Sol	3503.760	0.308	0.0088
Mean Freq.	3503.452	Average: 0.241	0.0069

(Continued)

[redacted]

TABLE 7 (CONT'D)

Tube	Frequency (Kc)	Deviation from Mean Frequency Kc	Per Cent
		Kc	Per Cent
	Mixer-Buffer		
Orig.--RCA	3502.500	--	--
1--RCA	3502.800	3.620	0.10
2--RCA	3498.450	0.730	0.021
3--RCA	3497.750	1.430	0.041
4--Tung Sol	3497.900	1.280	0.037
Orig.--RCA	3499.000	0.180	0.0051
Mean Freq.	3499.180	Average: 1.448	0.041

Note: (1) Substitution in power amplifier produced negligible change.
(2) Frequencies read five minutes after power was applied.

[redacted]

TABLE 8

MODEL CXCR SERIAL NO. 6

TWO-HOUR LOCKED-CARRIER FREQUENCY STABILITY--3500 KC

Time (Minutes)	Frequency (Kc)	Battery Volts	P-A Plate Volts	P-A Plate ma	Power Output (Watts)
0	3502.500	3.95	155	37	1.60
5	3503.600	3.95	150	36	1.38
10	3504.000	3.95	145	34	1.31
15	3504.200	3.95	142	34	1.23
30	3504.150	3.95	135	32	1.09
45	3504.100	3.95	133	31	1.02
60	3504.150	3.95	133	32	1.02
75	3504.200	3.95	133	32	1.02
90	3504.200	3.95	133	32	1.02
105	3504.200	3.95	133	32	1.02
120	3504.200	3.95	133	32	1.02

Change during the first five minutes = 1100 cycles, 0.031 per cent.

Change during remainder of test = 600 cycles, 0.017 per cent.

Equipment operated from a cold start.

[redacted]

TABLE 9

MODEL CXCR-1 SERIAL NO. 4

TWO-HOUR LOCKED-CARRIER FREQUENCY STABILITY--3500 KC

Time (Minutes)	Frequency (Kc)	Battery Volts	P-A Plate Volts	P-A Plate ma	Power Output (Watts)
0	3504.700	4.0	144	26.5	1.12
5	3504.000	4.0	144	26.0	1.01
10	3503.900	4.0	144	26.5	1.01
15	3504.000	4.0	143	26.0	0.99
30	3504.500	4.0	140	26.0	0.98
45	3504.850	4.0	135	25.5	0.90
60	3505.185	4.0	135	25.5	0.88
75	3505.265	4.0	134	26.0	0.88
90	3505.625	4.0	135	26.0	0.89
105	3505.900	4.0	135	26.0	0.88
120	3506.030	4.0	134	26.0	0.86

Change during the first five minutes = 700 cycles, 0.02 per cent.

Change during remainder of test = 2030 cycles, 0.058 per cent.

Equipment operated from a cold start.

[redacted]

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TABLE 10

MODEL CXCR SERIAL NO. 6

TWO-HOUR LOCKED-CARRIER FREQUENCY STABILITY--5000 KC

Time (Minutes)	Frequency (Kc)	Battery Volts	P-A Plate Volts	P-A Plate ma	Power Output (Watts)
0	5002.500	4.05	150	36	1.63
5	5002.000	4.05	148	36	1.63
10	5001.400	4.05	148	36	1.63
15	5000.850	4.05	146	35	1.50
30	4999.850	4.05	145	34	1.46
45	4999.250	4.05	142	34	1.43
60	4999.000	4.05	145	34	1.46
75	4998.750	4.05	145	34	1.46
90	4998.750	4.05	145	34	1.46
105	4998.750	4.05	145	34	1.46
120	4998.750	4.05	145	34	1.46

Change during the first five minutes = 500 cycles, 0.010 per cent.

Change during remainder of test = 3250 cycles, 0.065 per cent.

Equipment operated from a cold start.

[redacted]

TABLE 11

MODEL CXCR-1 SERIAL NO. 4

TWO-HOUR LOCKED-CARRIER FREQUENCY STABILITY--5000 KC

Time (Minutes)	Frequency (Kc)	Battery Volts	P-A Plate Volts	P-A Plate ma	Power Output (Watts)
0	5004.400	4.05	138	31.1	0.80
5	5002.800	4.05	138	31.5	0.79
10	5001.850	4.05	137	31.0	0.78
15	5001.050	4.05	136	31.0	0.75
30	4999.600	4.04	134	30.5	0.74
45	4998.500	4.05	134	30.5	0.74
60	4997.450	4.05	136	30.5	0.75
75	4996.700	4.05	135	30.5	0.75
90	4996.100	4.06	133	30.2	0.74
105	4995.400	4.05	134	30.2	0.74
120	4995.000	4.05	128	29.0	0.68

Change during the first five minutes = 1600 cycles,
0.032 per cent.

Change during remainder of test = 7800 cycles, 0.16 per cent.

TABLE 12

MODEL CXCR SERIAL NO. 6

TWO-HOUR LOCKED-CARRIER FREQUENCY STABILITY--6500 KC

Time (Minutes)	Frequency (Kc)	Battery Volts	P-A Plate Volts	P-A Plate ma	Power Output (Watts)
0	6501.500	3.90	158	34	1.80
2	6502.400	3.90	158	34	1.72
5	6501.100	3.90	155	33	1.55
10	6500.000	3.90	150	31	1.43
15	6499.000	3.90	146	31	1.32
30	6497.700	3.85	142	30	1.27
45	6497.200	3.85	140	29	1.27
60	6496.600	3.85	138	29	1.17
75	6496.300	3.85	136	28	1.16
90	6496.100	3.85	135	28	1.13
105	6496,000	3.85	134	28	1.13
120	6495.900	3.85	133	28	1.13

Change during the first five minutes = 400 cycles, 0.0061 per cent

Change during remainder of test = 5200 cycles, 0.080 per cent.

Equipment operated from a cold start.

[redacted]

TABLE 13

MODEL CXCR-1 SERIAL NO. 4

TWO-HOUR LOCKED-CARRIER FREQUENCY STABILITY--6500 KC

Time (Minutes)	Frequency (Kc)	Battery Volts	P-A Plate Volts	P-A Plate ma	Power Output (Watts)
0	6434.6	4.0	155	33.5	1.53
5	6431.1	4.0	152	31.5	1.45
10	6430.1	4.0	150	31.0	1.43
15	6428.6	4.0	148	31.0	1.38
30	6425.9	4.0	143	29.5	1.27
45	6423.9	4.0	143	29.5	1.27
60	6422.6	4.0	143	30.0	1.27
75	6421.6	4.0	143	29.0	1.25
90	6420.6	4.0	144	29.0	1.24
105	6419.8	4.0	143	29.0	1.22
120	6419.6	4.0	140	28.5	1.15

Change during the first five minutes = 3500 cycles, 0.055 per cent.

Change during remainder of test = 11,500 cycles, 0.18 per cent.

Equipment operated from a cold start.

[redacted]

TABLE 14

MODEL CXCR-CXCR-1 EQUIPMENT

EFFECT OF REDUCTION IN VOLTAGE INPUT

Battery		Frequency	P-A Plate		Power
Volts	Amps.	(Kc)	Volts	ma	Output (Watts)
		Model CXCR Serial No. 6			
4.0	12.0	5002.500	147	33	1.38
3.8	11.0	5001.100	130	29	1.16
3.6	9.5	5001.150	120	26	0.89
3.4	8.5	5001.500	110	24	0.76
3.2	7.4	5001.800	98	21	0.55
3.0	6.4	5002.400	90	20	0.45
2.8	5.5	5003.200	80	18	0.29
2.6	4.5	5004.400	70	15	0.11
		Model CXCR-1 Serial No. 4			
4.1		5005.000	140	32.5	0.81
4.0		4998.850	130	29.5	0.65
3.8		4996.200	124	26.9	0.52
3.6		4995.850	118	24.0	0.40
3.4		4996.400	110	20.0	0.31
3.2		4997.100	104	19.0	0.18
3.0		4997.600	95	16.0	0.12
2.9		4997.300	75	14.0	0.+

Note: (1) Frequency change CXCR = 1900 cycles, 0.038 per cent.
Frequency change CXCR-1 = 7700 cycles, 0.15 per cent.

[redacted]

TABLE 15

MODEL CXCR-CXCR-1 EQUIPMENT

CHANGE FROM LOCKED-CARRIER
TO INTERMITTENT OPERATION AND SIMULTANEOUS TUNING

Frequency at End of 10-Minute Locked-Carrier Operation		Frequency at End of 10-Second Dash 20 Minutes Later		Change in Frequency			
CXCR	CXCR-1	CXCR	CXCR-1	CXCR		CXCR-1	
(Kc)	(Kc)	(Kc)	(Kc)	Cycles	Per Cent	Cycles	Per Cent
3502.850	3503.200	3502.150	3503.900	-700	0.020	+700	0.020
5002.500	5002.300	5002.200	5003.000	-300	0.006	+700	0.014
6501.600	6501.300	6502.400	6502.100	+800	0.012	+800	0.012

CHECK OF SIMULTANEOUS TUNING

	CXCR	CXCR-1	CXCR	CXCR-1	CXCR	CXCR-1	CXCR-1
Transmitter Freq. (Kc)	3500	3500	5000	5000	6500	6500	3800
Frequency of maximum audio output on Receive.	3507.3	3499.5	5000.8	5000.8	6506.0	6501.2	3696.0
Per Cent Frequency Change.	0.21	0.014	0.016	0.016	0.092	0.018	27.4
Output voltage at nominal transmitter frequency without retuning antenna.	1	1	1	1	1	1	0
Output voltage at frequency of maximum response without retuning antenna.	1.25	1.1	1.1	1.15	1.15	1.2	1.2
Output voltage at frequency of maximum response after retuning antenna.	1.9	1.1	2.0	1.15	1.4	1.2	1.2

(Continued)

[redacted]

TABLE 15 (CONT'D)

Note: (1) During 10-minute locked-carrier period, transmitter was on unmodulated phone operation. During 20-minute wait, equipment was on receive, transferring again to transmit for the 10-second dash.

(2) Each transmitter initially tuned to zero beat with a Model LM-11 Heterodyne Frequency Meter at the frequency shown; then the CXCR or CXCR-1 equipment was switched to "receive" and the data shown above were recorded.

[redacted]

TABLE 16

MODEL CXCR SERIAL NO. 6

VARIATION IN AMBIENT TEMPERATURE--3500 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Battery Volts	Battery Amps.	P-A Plate Volts	P-A Plate ma	R-F Output (Watts)	Frequency (Kc)
1300	60.0	24	4.00	11.5	137	31	0.86	3504.200
1315	60.0	24	4.00	11.1	135	31	0.81	3504.300
1330	60.0	24	4.00	11.2	134	30	0.76	3504.300
1345	54.0	24	4.10	10.5	127	29	0.76	3504.100
1400	58.0	26	4.10	9.5	122	27	0.70	3503.700
1415	39.0	28	4.02	10.0	126	28	0.70	3503.500
1430	40.0	20	4.01	10.1	127	28	0.82	3503.450
1445	40.0	16	4.00	10.1	125	29	0.76	3503.450
1450	20.0	23	4.00	10.1	126	29	0.76	3503.200
1500	20.0	23	4.00	10.2	124	28	0.76	3502.900
1510	20.0	23	4.00	10.0	124	28	0.82	3502.750
1520	21.0	21	4.00	10.5	128	29	0.86	3502.750
1530	0.0	--	4.00	10.7	130	29	0.86	3502.400
1545	0.0	--	4.00	10.8	131	29	0.99	3502.100
1600	0.0	--	4.00	11.0	131	29	1.02	3501.950
1615	0.0	--	4.00	12.0	135	30	1.08	3502.100
1630	0.0	--	4.00	11.6	135	29	1.08	3502.100
1640	-20.0	--	4.00	11.2	134	30	1.08	3501.100
1655	-19.5	--	4.00	11.4	134	29	1.13	3500.750
1710	-20.0	--	4.00	11.8	135	29	1.16	3500.650
1725	-20.5	--	4.00	11.5	134	28	1.16	3500.600
1740	-20.5	--	4.00	11.7	136	29	1.16	3500.600

Summary

Temperature Change (°C)	Frequency Change (Kc)	Per Cent Change per °C
60 to 40	0.250	0.00036
40 to 20	0.700	0.00100
20 to 0	0.650	0.00093
0 to -20	1.500	0.00214
Total Change:	3.100	
Average per cent change per °C:		0.00111

[redacted]

TABLE 17

MODEL CXCR SERIAL NO. 6

VARIATION IN AMBIENT TEMPERATURE--6500 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Battery Volts	Battery Amps.	P-A Plate Volts	P-A Plate ma	R-F Output (Watts)	Frequency (Kc)
1300	60.5	20	4.00	11.0	135	29	0.89	6495.900
1315	60.5	21	4.05	10.5	133	28	0.89	6493.900
1330	60.5	20	4.02	10.0	130	28	0.89	6492.200
1345	60.0	20	4.02	10.2	128	28	0.91	6491.400
1400	60.0	20	4.00	10.9	135	29	0.91	6490.500
1415	40.0	20	4.00	10.7	133	29	0.89	6491.200
1430	40.0	20	4.00	10.8	134	29	0.91	6493.100
1445	40.0	20	4.00	10.8	132	28	0.91	6494.200
1500	40.0	20	4.00	10.8	132	29	0.91	6494.900
1515	40.0	20	4.00	10.6	132	29	0.91	6495.300
1530	20.5	21	4.02	11.0	134	29	0.99	6496.900
1545	20.5	21	4.02	11.0	136	30	1.02	6498.900
1600	20.5	21	4.06	10.5	130	29	0.89	6500.000
1615	20.5	21	4.05	10.4	132	29	1.02	6501.400
1630	20.0	20	4.00	11.0	133	29	1.02	6502.400
1645	0.0	--	4.00	10.5	133	29	1.02	6504.500
1700	0.0	--	4.00	10.9	134	30	1.16	6507.000
1715	0.0	--	4.00	11.0	134	30	1.16	6508.800
1730	0.0	--	4.00	11.0	135	30	1.16	6510.100
1745	0.0	--	3.95	11.5	139	31	1.24	6511.200
1800	-19.5	--	3.95	11.5	139	31	1.23	6512.900
1815	-20.0	--	4.00	12.0	142	32	1.31	6515.100
1830	-20.0	--	4.00	12.0	143	32	1.38	6517.100
1845	-20.0	--	4.00	12.0	142	32	1.38	6518.400
1900	-20.0	--	4.00	11.7	144	32	1.38	6519.600

(Continued)

TABLE 17 (CONT'D)

Summary

Temperature Change (°C)	Frequency Change (Kc)	Per Cent Change per °C
60 to 40	4.800	0.0037
40 to 20	7.100	0.0055
20 to 0	8.800	0.0068
0 to -20	8.400	0.0065
Total Change:	29.100	
Average change per degree C.:		0.0056

[redacted]

TABLE 18

MODEL CXCR-1 SERIAL NO. 4

VARIATION IN AMBIENT TEMPERATURE--4000 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	R-F Output (Watts)	Frequency (Kc)
1300	60.5	20	0.91	3996.650
1315	60.0	21	0.91	3996.100
1330	60.0	21	0.87	3995.000
1345	60.0	21	0.87	3994.100
1400	60.0	21	0.87	3992.900
1415	40.0	21	0.86	3991.950
1430	40.0	20	0.87	3992.050
1445	40.0	18	0.87	3992.300
1500	40.0	18	0.86	3992.300
1515	40.0	16	0.85	3992.500
1530	21.0	19	0.84	3993.000
1545	20.0	16	0.74	3993.300
1600	20.0	16	0.74	3993.550
1615	20.0	16	0.86	3994.050
1630	20.0	23	0.92	3994.300
1645	0.5	--	0.99	3994.950
1700	0.0	--	1.06	3995.200
1715	0.0	--	1.06	3995.200
1730	0.0	--	1.09	3995.100
1745	0.0	--	1.13	3995.250
1800	-16.5	--	1.18	3995.500
1815	-20.5	--	1.33	3995.600
1830	-20.0	--	1.40	3995.550
1845	-20.0	--	1.40	3995.550
1900	-20.0	--	1.36	3995.450
1950	-20.0	--	1.36	3995.350

(Continued)

[redacted]

TABLE 18 (CONT'D)

Summary

Temperature Change (°C)	Frequency Change (Kc)	Per Cent Change per °C
60 to 40	0.400	0.00050
40 to 20	1.800	0.00225
20 to 0	0.950	0.00119
0 to -20	0.100	0.00012

Total change: 3.250

Average per cent change per °C: 0.0010

[redacted]

TABLE 19

MODEL CXCR-1 SERIAL NO. 4

VARIATION IN AMBIENT TEMPERATURE--6000 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	R-F Output (Watts)	Frequency (Kc)
1300	60.5	20	0.87	6001.000
1315	60.5	21	0.99	5996.650
1330	60.5	20	0.96	5992.450
1345	60.0	20	0.95	5989.550
1400	60.0	20	0.95	5987.350
1415	40.0	20	0.95	5988.050
1430	40.0	20	0.99	5991.050
1445	40.0	20	0.98	5993.050
1500	40.0	20	0.98	5994.700
1515	40.0	20	0.96	5995.600
1530	20.5	21	0.92	5997.800
1545	20.0	21	0.80	6000.300
1600	20.0	21	0.92	6002.750
1615	20.0	21	1.00	6004.500
1630	20.0	20	1.10	6005.500
1645	0.0	--	1.21	6007.800
1700	0.0	--	1.27	6010.200
1715	0.0	--	1.21	6012.000
1730	0.0	--	1.36	6013.700
1745	0.0	--	1.30	6014.600
1800	-19.5	--	1.46	6015.700
1815	-20.0	--	1.52	6018.400
1830	-20.5	--	1.56	6020.100
1845	-20.0	--	1.58	6021.200
1900	-20.0	--	1.58	6021.800

(Continued)

[redacted]

TABLE 19 (CONT'D)

Summary

Temperature Change (°C)	Frequency Change (Kc)	Per Cent Change per °C
60 to 40	8.250	0.0069
40 to 20	9.900	0.0083
20 to 0	9.100	0.0076
0 to -20	7.200	0.0060
Total change:	35.450	
Average per cent change per °C:		0.0074

[redacted]

TABLE 20

MODEL CXCR SERIAL NO. 6

VARIATION IN RELATIVE HUMIDITY--3500 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Battery Volts	Battery Amps.	P-A Plate Volts	P-A Plate ma	R-F Output (Watts)	Frequency (Kc)
1300	40.0	25	3.95	11.2	134	30.0	1.04	3503.150
1315	40.0	25	3.95	11.2	134	29.5	1.04	3503.250
1330	40.0	25	3.95	11.2	134	29.5	1.04	3503.350
1345	43.0	73	3.95	11.2	134	29.5	1.02	3503.600
1400	43.0	90	4.00	10.4	132	29.0	0.96	3503.550
1415	41.5	97	3.95	10.9	132	29.5	1.03	3503.550
1430	41.5	97	4.00	10.5	132	29.5	0.95	3503.600
1445	41.5	97	4.00	11.0	132	29.5	1.00	3503.700
1500	40.0	27	3.95	10.5	132	29.5	0.95	3503.600
1515	40.0	27	3.95	10.5	132	29.0	1.00	3503.700
1530	40.0	27	3.95	11.0	134	30.0	1.02	3503.650

Frequency at end of initial 30-minute low humidity period = 3503.350 kc.

Frequency at greatest subsequent change = 3503.700 kc.

Frequency change = 0.350 kc, 0.01 per cent.

[redacted]

TABLE 21

MODEL CXCR SERIAL NO. 6

VARIATION IN RELATIVE HUMIDITY--6500 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	Battery Volts	R-F Output (Watts)	Frequency (Kc)
1300	40.0	25	4.00	0.76	6504.500
1315	40.0	25	4.00	0.82	6503.300
1330	40.0	25	4.00	0.79	6502.200
1345	40.0	90	4.00	0.76	6501.200
1400	40.0	97	4.03	0.76	6500.300
1415	40.0	93	4.02	0.67	6499.600
1430	40.0	97	4.01	0.64	6499.100
1445	40.5	97	4.01	0.64	6498.800
1500	40.0	97	4.01	0.65	6498.300
1515	40.0	97	4.01	0.65	6498.200
1530	40.5	97	4.00	0.66	6497.900
1545	40.0	97	4.00	0.65	6497.900
1600	40.5	97	4.00	0.69	6497.800
1615	40.0	31	4.00	0.66	6497.700
1630	40.0	27	4.00	0.68	6497.900
1645	40.0	25	4.01	0.71	6498.000

Frequency at end of initial 30-minute low humidity period = 6502.200 kc.

Frequency at greatest subsequent change = 6497.700 kc.

Frequency change = 4.500 kc, 0.069 per cent.

[redacted]

TABLE 22

MODEL CXCR-1 SERIAL NO. 4

VARIATION IN RELATIVE HUMIDITY--4000 KC

Time	Amb. Temp. (°C)	Rel. Hum. (%)	R-F Output (Watts)	Frequency (Kc)
1300	40.0	25	0.92	4004.000
1315	40.0	25	0.92	4003.950
1330	40.0	25	0.92	4003.850
1345	43.0	73	0.92	4003.650
1400	43.0	90	0.92	4003.500
1415	41.5	97	0.92	4003.300
1430	41.5	97	0.90	4003.160
1445	41.5	97	0.92	4003.050
1500	40.0	27	0.94	4003.060
1515	40.5	27	0.92	4003.050
1530	40.0	27	0.92	4003.025

Frequency at end of initial 30-minute low-humidity period = 4003.850 kc.

Frequency of greatest subsequent change = 4003.025 kc.

Frequency change = 0.825 kc, 0.0206 per cent.

[redacted]

TABLE 23

MODEL CXCR-CXCR-1 EQUIPMENTS

FREQUENCY DISPERSION DURING VIBRATION

Vib. Freq. (CPM)	CXCR Dispersion				CXCR-1 Dispersion			
	3500 Kc		6500 Kc		3500 Kc		6500 Kc	
	Cycles	Per Cent	Cycles	Per Cent	Cycles	Per Cent	Cycles	Per Cent
0	24	0.00068	37	0.00057	66	0.0019	140	0.0021
600	46	0.0013	50	0.00077	90	0.0026	160	0.0025
700	58	0.0016	90	0.0014	84	0.0024	180	0.0028
800	200	0.0057	700	0.011	240	0.0069	800	0.012
900	160	0.0046	640	0.0098	245	0.0070	350	0.0054
1000	160	0.0046	350	0.0054	160	0.0046	270	0.0041
1100	380	0.011	640	0.0098	260	0.0074	900	0.014
1200	750	0.021	1000	0.015	420	0.012	1350	0.021
1300	600	0.017	650	0.010	600	0.017	1670	0.026
1400	420	0.012	500	0.0077	370	0.010	1650	0.025
1500	410	0.012	500	0.0077	460	0.013	1850	0.028
1600	270	0.0077	650	0.010	700	0.020	2500+	0.038
1700	700	0.020	1450	0.022	700	0.020	2500+	0.038
1800	500	0.014	750	0.011	600	0.017	2150	0.033
1900	300	0.0086	750	0.011	410	0.011	1600	0.025

[redacted]

DECLASSIFIED

TABLE 24

MODEL CXCR SERIAL NO. 6

EFFECT OF SHOCK

Shock No.	Frequency (Kc)		Frequency Change	
	Before Shock	After Shock	Cycles	Per Cent
	Shock Directed Toward Right End of CXCR***			
1	3503.3	3505.+	*	
2	3500.7	3504.1	3400	0.097
3	3501.0	3497.0	4000	0.11
4	3501.0	3505.5	4500	0.13
5	3501.0	3506.0	5000	0.14
6	3497.8	Not recorded	----	----
7	3496.5	3503.0	6500	0.19
8	3496.3	Not recorded	----	----
9	6501.7	Not recorded	----	----
10	6495.8	6497.0	1200	0.018
11	6495.8	6495.8	0	----
12	6500.0	6500.0	0	----
13	6500.0	6504.2	4200	0.065
	Shock Directed Toward Rear of CXCR			
14	6498.5	6505.+	*	
15	6496.2	6505.+	8800+	0.13
16	6496.0	6505.+	9000+	0.14
17	6496.2	6505.+	8800+	0.13
18	6496.2	6504.5**	8300	0.13
19	3496.6	3505.+	*	
20	3495.5	3495.0	500	0.014
21	3495.0	3505.+	*	
22	3496.0	3499.0	3000	0.086
23	3496.2	3496.7**	500	0.014

(Continued)

[redacted]

DECLASSIFIED

TABLE 24 (CONT'D)

Shock No.	Frequency (Kc) Before Shock	Frequency (Kc) After Shock	Frequency Change Cycles	Frequency Change Per Cent
		Shock Directed Toward Left End of CXCR		
24	3496.8	3504.0	7200	0.21
25	Not recorded		----	----
26	Not recorded		----	----
27	Not recorded		----	----
28	3496.0	3504.5	8500	0.24
29	6496.1	Not recorded	----	----
30	6496.5	6495.0	1500	0.023
31	6495.8	6495.-	800+	0.012+
32	6504.0	6505.+	1000+	0.015+
33	6495.5	6495.-	500+	0.0077+
		Shock Directed Toward Front of CXCR		
34	6496.0	6495.0	1000	0.015
35	6500.0	6495.0	5000	0.077
36	6497.0	6504.0	7000	0.11
37	6496.5	6495.-	1500+	0.023
38	6500.0	6496.0	4000	0.061
39	3500.0	3498.5	1500	0.043
40	3500.0	3505.0	5000	0.14
41	3500.0	3495.-	5000+	0.14
42	3500.0	3505.+	5000+	0.14
43	3500.0	3505.+	5000+	0.14

Note: *(1) Plus or minus signs indicate frequency changes greater than could be recorded on scale of LK Frequency Drift Indicator.

**(2) Applied slight pressure to tuning control knob to prevent movement.

***(3) The sides of the CXCR cabinet were designated as follows:

Right end. Side on which antenna terminal is located. (See Plate 133).

Back. Side in which the headset compartment is located. (See Plate 134).

Left end. Side on which the headset terminals are located. (See Plate 134).

Front. Side to which the carrying harness is attached. (See Plate 132).

[redacted]

TABLE 25

MODEL CXCR-1 SERIAL NO. 4

EFFECT OF SHOCK

Shock No.	Frequency (Kc) Before Shock	After Shock	Frequency Change Cycles	Per Cent
	Shock Directed Toward Left End of CXCR-1***			
1	6501.700	6499.750	1950	0.030
2	6503.600	6502.500	1100	0.017
3	6502.500	6503.600	1100	0.017
4	6502.050	6501.200	850	0.013
5	6501.800**	6505.+ *	3200	0.049
6	6502.200**	6505.+	2800	0.043
7	6497.500	6497.500	0	0.0
8	6497.500	6497.000	500	0.0077
9	3501.300**	3505.+	3700	0.11
10	3497.400	3498.000	600	0.017
11	3498.000	3498.500	500	0.014
12	3498.000	3498.300	300	0.0086
13	3497.250	3497.500	250	0.0071
	Shock Directed Toward Front of CXCR-1			
14	3502.200**	3505.+	2800	0.080
15	3498.100	3498.600	500	0.014
16	3498.000	3498.600	600	0.017
17	3498.100	3498.000	100	0.0031
18	3497.900	3497.650	250	0.0071
19	6500.900	6500.000	900	0.014
20	6500.000	6499.000	1000	0.015
21	6500.000	6498.900	1100	0.017
22	6500.000	6498.800	1200	0.018
23	6500.000**	6505.+	5000	0.077

(Continued)

[redacted]

TABLE 25 (CONT'D)

Shock No.	Frequency (Kc) Before Shock	Frequency (Kc) After Shock	Frequency Change Cycles	Frequency Change Per Cent
	Shock Directed Toward Right End of CXCR-1			
24	6496.000**	6505.+ *	9000	0.14
25	6500.000	6497.500	2500	0.038
26	6500.000	6498.800	1200	0.018
27	6500.000	6499.000	1000	0.015
28	6495.500	6505.+	9500	0.15
29	3500.000	3501.000	1000	0.029
30	3500.000	3500.500	500	0.014
31	3500.000	3500.250	250	0.0071
32	3496.000**	3501.200	5200	0.15
33	3496.000**	3498.600	2600	0.075
	Shock Directed Toward Back of CXCR-1			
34	3500.000	3499.550	450	0.013
35	3500.000	3500.400	400	0.011
36	3500.000	3500.200	200	0.0057
37	3500.000	3500.100	100	0.0029
38	3497.500**	3503.000	5500	0.16
39	6500.000	6500.450	450	0.0069
40	6495.500**	6505.+	9500	0.15
41	6500.000	6500.100	100	0.0015
42	6500.000	6500.900	900	0.014
43	6495.000**	6505.+	10000	0.15

Note: *(1) Plus signs indicate frequency changes greater than could be recorded on scale of LK Frequency Drift Indicator.

**(2) At this frequency, the dial setting was approached in a clockwise direction. At all other frequencies not so marked, the setting was approached in a counterclockwise direction.

***(3) The sides of the CXCR-1 cabinet were designated as follows:

- Left end. Side nearest antenna terminal (See Plate 103).
- Front. Side to which the carrying harness is attached (See Plate 102).
- Right end. Side on which battery charging receptacle is located (See Plate 104).
- Back. Side on which battery indicator windows are located (See Plate 103).

[redacted]

TABLE 26

MODEL CXCR SERIAL NO. 6

CHECK FOR LOST MOTION, BACKLASH, AND TORQUE LASH
(NON-DETENT POSITIONS)

No.	Frequency when Approached from		Deviation	
	High Side	Low Side	Cycles	Per Cent
1	3496.900	3497.300	400	0.0115
2	3497.300	3496.500	800	0.0230
3	3497.800	3496.700	1100	0.0315
4	3499.770	3498.900	870	0.0248
5	3496.200	3496.700	500	0.0143
		Average:	734	0.0210
1	4500.150	4500.300	150	0.0033
2	4500.800	4496.600	4200	0.0933
3	4500.250	4500.200	50	0.0011
4	4498.850	4498.750	100	0.0022
5	4500.250	4498.550	1700	0.0378
		Average:	1240	0.0276
1	5500.400	5499.600	800	0.0145
2	5500.270	5499.640	630	0.0114
3	5500.400	5499.900	500	0.0091
4	5500.450	5501.350	900	0.0164
5	5499.690	5500.000	310	0.0056
		Average:	628	0.0114
1	6503.000	6503.800	800	0.0123
2	6503.100	6502.700	400	0.0062
3	6500.200	6501.250	1050	0.0162
4	6500.940	6500.290	650	0.0100
5	6501.400	6500.500	900	0.0138
		Average:	760	0.0117

[redacted]

TABLE 27

MODEL CXCR SERIAL NO. 6

CHECK FOR LOST MOTION, BACKLASH, AND TORQUE LASH
(DETENT POSITIONS)

Trial No.	Frequency when Approached from		Deviation	
	High Side	Low Side	Cycles	Per Cent
1	3502.600	3501.500	1100	0.0312
2	3503.100	3502.000	1100	0.0312
3	3502.900	3501.200	1700	0.0486
4	3501.600	3501.700	100	0.0029
5	3501.500	3500.000	1500	0.0428
		Average:	1100	0.0312
1	4501.600	4500.430	1170	0.0260
2	4501.500	4500.650	850	0.0189
3	4501.900	4500.400	1500	0.0334
4	4500.000	4501.600	1600	0.0355
5	4501.500	4500.350	1150	0.0256
		Average:	1254	0.0279
1	5501.800	5502.200	400	0.0073
2	5502.500	5503.000	500	0.0091
3	5502.500	5503.300	800	0.0145
4	5502.700	5501.000	1700	0.0310
5	5501.250	5501.000	250	0.0046
		Average:	730	0.0133
1	6499.900	6499.000	900	0.0138
2	6499.200	6500.610	1410	0.0217
3	6499.200	6501.000	1800	0.0277
4	6498.350	6500.150	1800	0.0277
5	6499.860	6500.150	290	0.0045
		Average:	1240	0.0191

[redacted]

TABLE 28

MODEL CXCR-1 SERIAL NO. 4

CHECK FOR LOST MOTION, BACKLASH, AND TORQUE LASH
(NON-DETENT POSITIONS)

Trial No.	Frequency when Approached from		Deviation	
	High Side	Low Side	Cycles	Per Cent
1	3503.050	3501.900	1150	0.033
2	3503.000	3501.750	1250	0.036
3	3503.450	3501.650	1800	0.051
4	3503.000	3501.450	1550	0.043
5	3502.000	3501.000	1000	0.029
		Average:	1350	0.039
1	4501.700	4499.150	2550	0.057
2	4501.600	4500.000	1600	0.036
3	4501.650	4500.100	1550	0.034
4	4501.400	4498.900	2500	0.055
5	4501.500	4499.000	2500	0.055
		Average:	2140	0.047
1	4988.410	4988.010	400	0.0080
2	4988.620	4988.210	410	0.0082
3	4988.610	4987.830	780	0.0156
4	4988.510	4987.820	690	0.0138
5	4988.400	4987.710	690	0.0138
		Average:	594	0.0119
1	6500.910	6494.910	6000	0.092
2	6500.610	6495.520	5090	0.078
3	6500.710	6494.810	5900	0.091
4	6500.900	6495.400	5500	0.085
5	6500.500	6494.810	5690	0.088
		Average:	5636	0.087

Note: Measurements made at approximately 5 Mc instead of 5.5 Mc because of spurious signals present at the latter frequency.

[redacted]

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TABLE 29

MODEL CXCR-1 SERIAL NO. 4

CHECK FOR LOST MOTION, BACKLASH, AND TORQUE LASH
(DETENT POSITIONS)

Trial No.	Frequency when Approached from: High Side	Low Side	Deviation: Cycles	Per Cent
1	3501.900	3496.800	5100	0.146
2	3501.900	3496.900	5000	0.143
3	3502.100	3497.000	5100	0.146
4	3502.050	3496.950	5100	0.146
5	3502.050	3497.200	4850	0.139
		Average:	5030	0.144
1	4504.700	4496.000	8700	0.193
2	4504.550	4496.300	8250	0.183
3	4504.700	4496.200	8500	0.189
4	4504.750	4496.400	8350	0.185
5	4504.750	4496.700	8050	0.179
		Average:	8370	0.186
1	4954.400	4942.100	12300	0.249
2	4954.500	4942.300	12200	0.247
3	4954.700	4942.400	12300	0.249
4	4954.900	4942.500	12400	0.251
5	4954.700	4942.900	11800	0.239
		Average:	12200	0.247
1	6535.300	6519.700	15600	0.240
2	6535.100	6519.600	15500	0.238
3	6535.500	6519.600	15900	0.244
4	6535.200	6519.500	15700	0.242
5	6535.300	6519.500	15800	0.243
		Average:	15700	0.242

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TABLE 30

MODEL CXCR SERIAL NO. 6

ACCURACY OF RESET TO CALIBRATED FREQUENCIES
(NON-DETENT POSITIONS)

Trial	Frequency (Kc)	Deviation Cycles	Deviation Per Cent
Original	3497.300	----	----
1	3496.500	800	0.023
2	3496.700	600	0.017
3	3498.900	1600	0.045
4	3496.700	600	0.017
	Average:	900	0.026
Original	4500.300	----	----
1	4496.600	3700	0.082
2	4500.200	100	0.0022
3	4498.750	1550	0.034
4	4498.550	1750	0.039
	Average:	1800	0.040
Original	5499.600	----	----
1	5499.640	40	0.00073
2	5499.900	300	0.0054
3	5501.350	1750	0.032
4	5500.000	400	0.0073
	Average:	622	0.011
Original	6503.800	----	----
1	6502.700	1100	0.011
2	6501.250	2550	0.039
3	6500.290	3510	0.054
4	6500.500	3300	0.051
	Average:	2615	0.040

Note: Frequencies approached in a clockwise direction.

[redacted]

TABLE 31

MODEL CXCR-1 SERIAL NO. 4

ACCURACY OF RESET TO CALIBRATED FREQUENCIES
(NON-DETENT POSITIONS)

Trial	Frequency (Kc)	Deviation Cycles	Deviation Per Cent
Original	3501.900	---	---
1	3501.750	150	0.0043
2	3501.650	250	0.0071
3	3501.450	450	0.013
4	3501.000	900	0.027
	Average:	437	0.012
Original	4499.150	---	---
1	4500.000	850	0.019
2	4500.100	950	0.021
3	4498.900	250	0.0055
4	4499.000	150	0.0033
	Average:	550	0.012
Original	4988.010	---	---
1	4988.210	200	0.0040
2	4987.830	170	0.0034
3	4987.820	190	0.0038
4	4987.710	300	0.0060
	Average:	215	0.0043
Original	6494.910	---	---
1	6495.520	610	0.0094
2	6494.810	100	0.0015
3	6495.400	490	0.0075
4	6494.810	100	0.0015
	Average:	325	0.0050

Note: Frequencies approached in a clockwise direction.

[redacted]

TABLE 32

MODEL CXCR-CXCR-1 EQUIPMENT

SUMMARY OF FREQUENCY STABILITY TESTS

Test	CXCR		CXCR-1	
	Average Deviation (%)	Maximum Deviation (%)	Average Deviation (%)	Maximum Deviation (%)
Change of Tubes:				
Variable Oscillator	0.098	0.21	0.26	0.39
Crystal Oscillator	0.0050	0.010	0.0069	0.014
Buffer	0.0043	0.006	0.041	0.10
Power Amplifier	0.00067	0.00086	Not recorded	
Locked Carrier--3500 Kc:				
First 5 Minutes	--	0.031	--	0.020
Remainder	0.017	--	0.058	--
Locked Carrier--6500 Kc:				
First 5 Minutes	--	0.006	--	0.055
Remainder	0.080	--	0.18	--
Reduction of Battery Voltage	--	0.038	--	0.15
Change from Key-locked to Intermittently Keyed Operation	0.012	0.02	0.015	0.020
Variation in Ambient Temp.	0.0056	0.0068	0.0074	0.0083
Variation in Relative Humidity	--	0.069	--	0.021
Frequency Dispersion during Vibration	--	0.022	--	0.038
Shock	--	0.24	--	0.16
Lost Motion, Backlash				
Non-Detent	0.028	0.093	0.087	0.092
Detent Positions	0.031	0.049	0.25	0.25
Accuracy of Reset	0.040	0.082	0.012	0.021
Totals:	0.321+	0.883+	0.917+	1.34-

Note: Readings are highest values recorded under individual column headings.

[redacted]

TABLE 33

MODEL CXCR-CXCR-1 EQUIPMENT

PERCENTAGE MODULATION CAPABILITY--1000 C.P.S.

Modulation (%)	Input (Volts)	Antenna Current (ma)
	CXCR Ser. No. 6	
	3500 Kc	
0	0.	165
10	0.010	165
20	0.030	165
30	0.045	165
40	0.058	168
50	0.078	171
60	0.100	180
70	0.120	183
80	0.170	190
90	0.340	210
92 maximum	0.520	210
	6000 Kc	
0	0.	165
10	0.012	165
20	0.023	165
30	0.044	166
40	0.058	170
50	0.070	175
60	0.090	182
70	0.100	190
80	0.170	200
90	0.300	220
92 maximum	0.470	228

(Continued)

[redacted]

TABLE 33 (CONT'D)

Modulation (%)	Input (Volts)	Antenna Current (ma)
	CXCR-1 Ser. No. 4	
	4000 Kc	
12	0.010	Not recorded
15	0.015	Not recorded
39	0.030	Not recorded
58	0.045	Not recorded
74	0.060	Not recorded
91	0.090	Not recorded
95	0.100	Not recorded
	5700 Kc	
20	0.023	130
30	0.038	130
40	0.045	131
50	0.053	131
60	0.060	131
70	0.080	131
80	0.100	131
90	0.125	133
98	0.180	134

[redacted]

TABLE 34

MODEL CXCR SERIAL NO. 6

DISTORTION VERSUS AUDIO FREQUENCY

3500 Kc

Audio Frequency (C.P.S.)	90% Mod.		75% Mod.	
	Audio Input (Volts)	Distortion (%)	Audio Input (Volts)	Distortion (%)
300	0.62	29	0.20	16
400	0.46	26	0.17	14
500	0.37	24	0.15	12
600	0.39	25	0.15	11
750	0.38	25	0.13	10
1000	0.34	23	0.13	10
1500	0.34	22	0.13	9
2000	0.30	20	0.13	10
2500	0.30	21	0.12	10
3000	0.30	22	0.13	11
4000	0.28	21	0.11	11
5000	0.25	18	0.10	11
10000	0.32	12	0.16	5

- - -

6000 Kc

Audio Frequency (C.P.S.)	75% Mod.	
	Audio Input (Volts)	Distortion (%)
300	0.14	19
400	0.13	16
500	0.12	15
600	0.12	14
750	0.11	13
1000	0.10	12
1500	0.10	12
2000	0.10	12
2500	0.11	12
3000	0.10	12
4000	0.10	14
5000	0.10	13
10000	0.16	8

[redacted]

TABLE 35

MODEL CXCR-1 SERIAL NO. 4

DISTORTION VERSUS AUDIO FREQUENCY

3500 Kc--75% Modulation

Audio Frequency (C.P.S.)	Before Retuning Buffer: Audio Input (Volts)	Before Retuning Buffer: Distortion (%)	After Retuning Buffer: Audio Input (Volts)	After Retuning Buffer: Distortion (%)
300	0.076	20.0	0.055	11.0
400	0.073	18.5	0.054	9.5
500	0.080	20.0	0.054	9.5
600	0.075	18.0	0.058	9.5
750	0.084	20.0	0.062	10.0
1000	0.088	20.0	0.069	9.6
1500	0.105	19.0	0.087	9.0
2000	0.115	19.0	0.105	8.6
2500	0.125	17.5	0.125	9.0
3000	0.175	18.0	0.135	8.5
4000	0.250	17.5	0.200	9.0
5000	0.480	17.0	0.325	9.0

\- - -

3500 Kc--90% Modulation

Audio Frequency (C.P.S.)	Set Cold: Audio Input (Volts)	Set Cold: Distortion (%)	Set Hot: Audio Input (Volts)	Set Hot: Distortion (%)
300	0.075	8.5	0.06	12.0
400	0.075	7.0	0.064	11.0
500	0.075	6.0	0.070	11.0
600	0.083	6.0	0.067	9.5
750	0.090	5.6	0.078	10.0
1000	0.105	5.5	0.09	10.0
1500	0.110	5.3	0.11	11.0
2000	0.13	5.1	0.12	10.5
2500	0.15	5.4	0.14	10.0
3000	0.18	6.0	0.15	10.0
4000	0.27	6.5	0.27	11.0
5000	0.42	8.0	0.37	11.0

\- - -

(Continued)

[redacted]

TABLE 35 (CONT'D)

5700 Kc--75% Modulation

Audio Frequency (C.P.S.)	Set Hot or Cold	
	Audio Input (Volts)	Distortion (%)
300	0.070	7.5
400	0.068	6.0
500	0.070	5.0
600	0.078	5.0
750	0.086	5.0
1000	0.10	4.5
1500	0.11	4.0
2000	0.13	3.5
2500	0.14	3.5
3000	0.18	3.0
4000	0.27	4.0
5000	0.70	16.0

- - -

[redacted]

TABLE 36

MODEL CXCR SERIAL NO. 6

OVERALL FIDELITY FROM MICROPHONE TO CARRIER

Audio Frequency (C.P.S.)	Microphone Input Voltage (Volts)		Modulation (%)		Db Relative to 75% Mod. at 1000 CPS		Antenna Current (ma)	
	3500 Kc	6000 Kc	3500 Kc	6000 Kc	3500 Kc	6000 Kc	3500 Kc	6000 Kc
1000	0.17	0.17	75	75	0.0	0.0	220	220
100	0.05	0.04	24	27	-9.9	-8.9	185	185
200	0.08	0.08	43	47	-4.8	-4.1	198	200
300	0.12	0.11	55	64	-2.7	-1.4	200	210
400	0.13	0.13	65	65	-1.2	-1.3	209	215
500	0.15	0.15	69	70	-0.72	-0.6	210	218
600	0.16	0.16	72	75	-0.36	0.0	212	225
750	0.17	0.17	73	75	-0.24	0.0	217	225
1000	0.17	0.17	75	76	0.0	+0.12	217	226
1500	0.15	0.15	74	75	-0.12	0.0	212	220
2000	0.12	0.12	67	69	-1.0	-0.72	202	215
2500	0.11	0.10	62	64	-1.7	-1.4	201	218
3000	0.08	0.08	57	61	-2.4	-1.8	192	205
4000	0.06	0.06	51	50	-3.4	-3.5	190	200
5000	0.05	0.05	43	48	-4.7	-3.9	190	195
10000	0.06	0.06	32	35	-7.4	-6.6	185	190

Note: Audio voltage applied across a 200-ohm resistor. Total audio input current to parallel combination of resistor and microphone transformer held constant.

[redacted]

TABLE 37

MODEL CXCR-1 SERIAL NO. 4

OVERALL FIDELITY FROM MICROPHONE TO CARRIER

Audio Frequency (C.P.S.)	Microphone Input Voltage (Volts)		Modulation (%)		Db Relative to 75% Mod. at 1000 CPS		Antenna Current (ma)	
	3500 Kc	5700 Kc	3500 Kc	5700 Kc	3500 Kc	5700 Kc	3500 Kc	5700 Kc
1000	0.07	0.110	75	75	0.0	0.0	136	143
100	0.028	0.042	11	22	--	-10.6	129	134
200	0.033	0.049	40	45	-5.4	-4.4	129	135
300	0.038	0.060	43	59	-4.8	-2.1	129	135
400	0.043	0.065	67	64	-0.9	-1.4	130	135
500	0.049	0.072	68	64	-0.8	-1.4	130	135
600	0.054	0.080	72	72	-0.3	-0.36	131	136
750	0.06	0.093	70	71	-0.5	-0.48	130	137
1000	0.072	0.115	77	76	+0.3	+0.12	131	137
1500	0.092	0.140	79	81	+0.5	+0.68	132	137
2000	0.11	0.165	79	81	+0.5	+0.68	133	137
2500	0.12	0.180	76	77	+0.2	+0.22	133	136
3000	0.13	0.195	72	70	-0.3	-0.60	133	136
4000	0.15	0.215	59	56	-2.0	-2.5	131	135
5000	0.16	0.225	45	46	-4.4	-4.4	130	135

Note: Audio voltage applied across 200-ohm resistor. Total audio input current to parallel combination of resistor and microphone transformer held constant.

[redacted]

TABLE 38

MODEL CXCR-CXCR-1 EQUIPMENT

POWER SUPPLY RIPPLE

D-C Voltage (D-C Volts)	A-C Ripple (Volts RMS)	Ripple (%)
	CXCR Ser. No. 6	
150 (Pin 6)	0.7	0.47
125 (Pin 5)	0.2	0.16
-13 (Pin 2)	0.0+	--
4 (Pin 1)	0.04	1.00
	CXCR-1 Ser. No. 4	
150	0.28	0.18

Note: Measurements made at full battery potential.

[redacted]

TABLE 39

MODEL CXCR-CXCR-1 EQUIPMENT

CARRIER RIPPLE

Frequency (Kc)	Rectified Carrier Voltage (Volts DC)	A-C Ripple Voltage (Volts RMS)	Ripple (%)
	CXCR Ser. No. 6		
3500	210	0.50	0.24
4000*	225	1.50	0.67
6000*	240	1.50	0.63
6500	200	0.50	0.25

Noise level relative to 75 per cent modulation by 1000 cycles at 3500 kc = -39 db.

Frequency (Kc)	Rectified Carrier Voltage (Volts DC)	A-C Ripple Voltage (Volts RMS)	Ripple (%)
	CXCR-1 Ser. No. 4		
3500	40	0.6	1.5
3800*	38	10.0	26.0
5700*	40	0.6	1.5
6500	95	1.5	1.6

Noise level relative to 75 per cent modulation by 1000 cycles at 3500 kc = -27 db.

Note: *(1) These frequencies are crystal harmonic points.

(2) Measurements are for carrier conditions only.

[redacted]

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TABLE 40

MODEL CXCR SERIAL NO. 6

TUBE OPERATING CONDITIONS ON TRANSMIT--3500 KC

Tube Operation	Condition	Fil. Volts	Grid Volts	Grid ma	Screen Volts	Screen ma	Plate Volts	Plate ma
Crystal Osc.	Phone Carrier	2.94	-7.8	0.088	68	2.8	124	10.0
	Phone Mod.	2.94	-7.8	0.089	68	2.8	124	10.2
	MCW	2.85	-7.6	0.083	67	2.7	119	10.6
Variable Osc.	Phone Carrier	2.85	-18.0	0.190	90	3.76	76	12.5
	Phone Mod.	2.85	-18.0	0.185	90	3.46	77	12.5
	MCW	2.75	-17.0	0.180	87	3.46	75	11.7
Trans.-Mixer-Buffer	Phone Carrier	2.94	-19.5	0.210	114	4.55	143	20.45
	Phone Mod.	2.94	-19.5	0.210	114	4.55	143	19.95
	MCW	2.94	-19.0	0.200	109	4.55	138	18.45
Final Amp. Totals of 3 tubes.	Phone Carrier	2.99	-48.0	0.360	125	11.2	137	32.0
	Phone Mod.	2.99	-47.0	0.350	123	11.2	133	35.0
	MCW	2.90	-43.0	0.200	119	9.6	128	36.0
1st A.F.	Phone Carrier	2.76	-14.7	0.	114	2.6	114	11.4
1st A.F.	Phone Mod.	2.76	-15.7	0.	114	2.2	114	10.3
A-F Osc.	MCW	2.66	-34.0	1.95	109	7.0	109	7.4
Modulator No. 1	Phone Carrier	2.85	-14.2	0.	138	3.9	138	21.1
	Phone Mod.	2.85	-15.2	0.6	138	5.2	138	19.8
	MCW	2.76	-34.2	7.0	133	18.5*	133	7.5
Modulator No. 2	Phone Carrier	2.85	-14.2	0.	138	3.7	138	20.3
	Phone Mod.	2.85	-15.2	0.7	138	5.0	138	19.0
	MCW	2.76	-33.2	5.5	133	17.5*	133	10.0
Bias Rectifier	Phone Carrier	2.85	(Grid-plate-screen connected together)				-42	13.0
	Phone Mod.	2.85					-43	12.5
	MCW	2.80					-45	8.6

Type 3A4 tubes used throughout transmitter.
Phone modulation: 75 per cent at 1000 cycles.

* JAN-1A rating exceeded; total current input within rating for tube, however.

[redacted]

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TABLE 41

MODEL CXCR-1 SERIAL NO. 4

TUBE OPERATING CONDITIONS ON TRANSMIT--5000 KC

Tube			Fil.	Grid		Screen		Plate	
Type	Function	Condition	Volts	Volts	ma	Volts	ma	Volts	ma
1T4	Crystal Osc.	Phone Carrier	1.68	-51.0	0.65	--	--	95	4.0*
		Phone Mod.	1.68	-48.0	0.65	--	--	89	4.0*
		MCW	1.68	-48.0	0.65	--	--	88	3.9*
1T4	Variable Osc.	Phone Carrier	1.5	-5.4	0.06	--	--	95	4.0*
		Phone Mod.	1.5	-5.1	0.055	--	--	89	4.0*
		MCW	1.5	-4.9	0.052	--	--	88	3.9*
3A4	Trans.-Mixer-Buffer	Phone Carrier	3.1	-36.0	0.06	95	--	138	5.0
		Phone Mod.	3.1	-34.0	0.05	89	--	130	4.5
		MCW	3.1	-33.0	0.05	88	--	129	4.5
3A4	Final Amp. Totals of 2 tubes.	Phone Carrier	3.1	-31.0	0.79	100	20	138	28.0
		Phone Mod.	3.1	-28.0	0.70	99	20	129	28.5
		MCW	3.1	-27.0	0.70	85	20	128	29.0
1S5	Microphone Amplifier	Phone Carrier	1.34	-1.6	0.0	70	0.16	49	0.88
		Phone Mod.	1.34	-1.6	0.0	66	0.15	50	0.78
		MCW	1.34	-1.6	0.0	64	0.15	48	0.78
1T4	MCW Osc.	Phone Carrier	1.5	-1.7	0.0	68	1.75	--	--
		Phone Mod.	1.5	-1.7	0.0	65	3.15	--	--
		MCW	1.5	-1.7	0.001	62	1.75	--	--
3A4	Modulator No. 1	Phone Carrier	3.1	-18.0	0.0	128	1	142	9.5
		Phone Mod.	3.1	-17.0	0.0	117	2.9	138	12.0
		MCW	3.1	-23.5	0.0	108	3.	136	10.0
3A4	Modulator No. 2	Phone Carrier	3.1	-18.0	0.0	128	2	142	12.0
		Phone Mod.	3.1	-17.0	0.0	117	3.3	138	13.0
		MCW	3.1	-23.5	0.0	108	4.2	136	8.0
3A4	Modulator No. 3	Phone Carrier	3.1	-18.0	0.0	128	1	142	6.0
		Phone Mod.	3.1	-17.0	0.0	117	2	138	7.5
		MCW	3.1	-23.5	0.0	108	2.9	136	11.0
3A4	Modulator No. 4	Phone Carrier	3.1	-18.0	0.0	128	1.5	142	11.0
		Phone Mod.	3.1	-17.0	0.0	117	2	138	11.5
		MCW	3.1	-23.5	0.0	108	3.1	136	13.0

* Values shown are total for screen and plate.

[redacted]

TABLE 42

MODEL CXCR-CXCR-1 EQUIPMENT

SPURIOUS RADIATION
(NOMINAL OUTPUT FREQUENCY--3600 KC)

Frequency of Interfering Signal (Mc)	Field Strength (Microvolts/Meter)		Relative Field Strength (Decibels)*	
	CXCR	CXCR-1	CXCR	CXCR-1
0.29	---	3,600	--	-29.0
0.575	---	140	--	-57.0
1.63	---	100	--	-60.0
1.92	---	40	--	-68.0
2.00	100	---	-60.0	--
2.20	---	140	--	-57.0
2.64	140	86	-57.0	-61.5
3.00	---	60	--	-64.5
3.10	38	---	-68.5	--
3.30	---	1,400	--	-37.0
3.60	200,000	100,000	6.0	0.0
3.62	30	---	-70.5	--
3.90	---	1,400	--	-37.0
4.10	80	40	-62.0	-68.5
5.50	---	160	--	-56.0
5.75	---	40	--	-68.0
7.00	---	60	--	-64.5
7.24	110	1,000	-59.0	-39.5
7.50	---	80	--	-65.0
8.75	12	---	-78.0	--
8.90	---	12	--	-78.0

Note: *(1) Reference level 100,000 microvolts per meter.

(2) These field strengths measured at a distance of 22 feet from the transmitter with a Model OF Field Strength Meter.

[redacted]

TABLE 43

MODEL CXCR EQUIPMENT

BATTERY LIFE TESTS

Elapsed Time (Hours)	Operating Condition	Battery Output		Transmitter Output	
		Volts	Amps.	RF ma	Watts
		Two Cells			
0.0	Receive	4.15	2.4	---	---
0.05	Transmit	3.90	12.2	180	1.48
1.0	Receive	4.02	2.5	---	---
1.05	Transmit	3.85	11.5	168	1.39
2.0	Receive	3.93	2.4	---	---
2.05	Transmit	3.75	11.0	160	1.16
3.00	Receive	3.8	2.2	---	---
3.05	Transmit	3.61	10.5	152	1.06
4.00	Receive	3.61	2.1	---	---
4.05	Transmit	3.35	9.2	135	0.86
4.50	Receive	2.7	1.6	---	---
4.55	Transmit	2.2	3.5	0	0.
		Four Cells			
0.0	Receive	4.15	2.5	---	---
0.05	Transmit	4.00	12.6	188	1.61
1.00	Receive	4.12	2.5	---	---
1.05	Transmit	4.00	12.1	180	1.48
2.00	Receive	4.08	2.5	---	---
2.05	Transmit	3.98	11.5	173	1.36
3.00	Receive	4.02	2.4	---	---
3.05	Transmit	3.92	11.4	170	1.32
4.00	Receive	4.00	2.4	---	---
4.05	Transmit	3.90	11.2	168	1.28
5.00	Receive	3.97	2.4	---	---
5.05	Transmit	3.86	10.9	164	1.22
7.00	Receive	3.81	2.2	---	---
7.05	Transmit	3.69	10.4	156	1.11
8.00	Receive	3.68	2.1	---	---
8.05	Transmit	3.40	9.2	140	0.89
8.5	Transmit	---	--	130	0.77
8.6	Transmit	---	--	0	0.

[redacted]

TABLE 44

MODEL CXCR-1 EQUIPMENT

BATTERY LIFE TEST

Elapsed Time (Hours)	Operating Condition	Battery Output		Transmitter Output	
		Volts	Amps.	RF ma	Watts
0.0	Receive	4.2	1.1	---	---
0.05	Transmit	4.0	7.7	136	0.87
1.0	Receive	4.15	1.1	---	---
1.05	Transmit	3.96	7.9	130	0.80
2.0	Receive	4.11	1.0	---	---
2.05	Transmit	3.95	7.9	128	0.77
3.0	Receive	4.10	1.0	---	---
3.05	Transmit	3.40	7.9	122	0.70
4.0	Receive	4.07	1.0	---	---
4.05	Transmit	3.89	7.8	121	0.69
5.0	Receive	4.01	1.0	---	---
5.05	Transmit	3.85	7.8	120	0.68
6.0	Receive	4.0	1.0	---	---
6.05	Transmit	3.8	7.6	120	0.68
11.05	Transmit	---	---	55	0.14
11.10	---	---	---	0	0.0

[redacted]

TABLE 45

MODEL CXCR-CXCR-1 EQUIPMENT

NOMINAL FILAMENT DRAIN

Model CXCR Equipment

Receive

Variable Oscillator	3A4	100 ma
Audio Frequency Oscillator	3A4	100 ma
Audio Output Stage	3A4 (2)	200 ma
Bias Rectifier	3A4	100 ma
Receiver R-F Amplifier	1T4	50 ma
First IF and Mixer	1T4 (2 in series)	50 ma
Second IF and Detector	1T4 (2 in series)	50 ma
	Total	650 ma

Transmit-Phone Carrier

Variable Oscillator	3A4	100 ma
Crystal Oscillator	3A4	100 ma
Buffer-Mixer	3A4	100 ma
Power Amplifier	3A4 (3)	300 ma
Audio Oscillator-Amplifier	3A4	100 ma
Modulators	3A4 (2)	200 ma
Bias Rectifier	3A4	100 ma
Relay Current	Two relays in parallel	500 ma
	Total	1500 ma

Model CXCR-1 Equipment

Receive

Rec. Osc. and Diode-Mike Ampl.	1T4 and 1S5 in series	50 ma
Converter and First IF Ampl.	1R5 and 1T4 in series	50 ma
Diode Driver and First RF Ampl.	1T4 (2 in series)	50 ma
Audio Ampl. and Second IF	1T4 (2 in series)	50 ma
	Total	200 ma

Transmit-Phone Carrier

Rec. Osc. and Diode-Mike Ampl.	1T4 and 1S5 in series	50 ma
Buffer Mixer	3A4	100 ma
Power Amplifier	3A4 (2)	200 ma
MCW Osc. and Crystal Osc.	1T4 (2 in series)	50 ma
Modulators	3A4 (4)	400 ma
Relay Current	(1)	60 ma
	Total	860 ma

TABLE 46

MODEL CXCR-CXCR-1 EQUIPMENT

VIBRATOR SUPPLY EFFICIENCY

Condition	Input from Battery Volts	Input from Battery Amps.	Output from Vibrator Volts	Output from Vibrator ma	Total Input (Watts)	Total Output (Watts)	Efficiency (%)
Model CXCR Equipment							
Receive	4.0	1.8	110	34	7.2	3.74	52
Phone Carrier	4.0	9.2	160	156	36.8	25.0	68
Model CXCR-1 Equipment							
Receive	4.2	0.8	104	20	3.36	2.08	62
Phone Carrier	4.0	6.5	146	93	26.0	13.6	52

[redacted]

TABLE 47

MODEL CXCR-1 EQUIPMENT

HAND GENERATOR CHARGING CAPABILITY

Generator Crank Speed (R.P.M.)	Condition 1		Condition 2		Condition 3		Audible Noise Output (Db)
	Output (Volts)	Output (Amps.)	Output (Volts)	Output (Amps.)	Output (Volts)	Output (Amps.)	
0	4.0	0.0	4.2	0.0	4.00	0.0	--
60	4.0	0.0	4.2	0.0	4.00	0.0	52.3
70	4.05	0.5	4.3	1.0	4.05	1.2	--
75	4.07	0.7	4.35	1.2	4.10	1.6	--
80	4.15	1.4	4.37	1.4	4.12	1.8	55.2
90	4.30	2.5	4.40	2.3	4.15	2.6	--
100	4.35	3.5	4.45	3.2	4.18	3.5	57.6
120	4.40	4.5	4.50	4.3	4.25	4.5	61.7
180	4.50	6.5	4.60	6.5	4.35	6.4	68

Condition 1: Batteries completely discharged; no indicator balls floating, equipment off.

Condition 2: Batteries partially discharged; two indicator balls floating, equipment off.

Condition 3: Batteries partially discharged; two indicator balls floating, equipment on transmit.

Note: (1) Noise output measured in an ambient level of 48 decibels with a General Radio Sound Level Meter Type 759-B. (Necessary corrections have been made.)

(2) Output voltage measured across battery terminals.

[redacted]

TABLE 48

MODEL CXCR-1 EQUIPMENT

HAND GENERATOR RIPPLE VOLTAGE

Generator Crank Speed (R.P.M.)	Transmit Conditions				Receive Conditions			
	Output Volts	A-C Ripple Volts	Effective Ripple Volts	Ripple (%)	Output Volts	A-C Ripple Volts	Effective Ripple Volts	Ripple (%)
0	4.00	0.031	0.	0.	4.1	0.004	0.	0.
60	4.00	0.031	0.	0.	4.1	0.004	0.	0.
70	4.05	0.032	0.0078	0.19	4.2	0.0045	0.0028	0.070
75	4.10	0.033	0.011	0.28	4.22	0.0050	0.0030	0.075
80	4.12	0.034	0.014	0.35	4.27	0.0055	0.0038	0.095
90	4.15	0.034	0.014	0.35	4.30	0.0070	0.0058	0.14
100	4.18	0.034	0.014	0.35	4.35	0.0090	0.0080	0.20
120	4.25	0.034	0.014	0.35	4.42	0.013	0.012	0.30
180	4.35	0.036	0.018	0.45	4.55	0.014	0.013	0.32

Note: (1) Effective ripple voltage produced by the generator equals $(V^2 - V_0^2)^{1/2}$ where V_0 is the measured voltage at zero crank speed.

[redacted]

TABLE 49

MODEL CXCR-1 EQUIPMENT

BATTERY CHARGER CAPABILITY

Input Voltage (Volts)	Input Current (Amps.)	Output Voltage (Volts)	Output Current (Amps.)	Efficiency (%)
6.0 d-c	3.2	4.3	2.0	45*
12.1 d-c	1.6	4.3	2.0	44.5
24.3 d-c	0.87	4.3	2.1	42.6
32.5 d-c	0.67	4.3	2.0	41.8**
110.0 a-c	0.26	4.32	2.8	42.4***

Notes: (1) Two Willard Type BB54-A batteries 90 per cent discharged used as charger load.

*(2) Overload switch release time 140 seconds
Input current on short circuit 9 amps.
Output current on short circuit 7 amps.

**(3) Overload switch release time 45 seconds
Input current on short circuit 2 amps.
Output current on short circuit 10 amps.

***(4) Overload switch release time 15 seconds
Input current on short circuit 0.65 amp.
Output current on short circuit 10 amps.

[redacted]

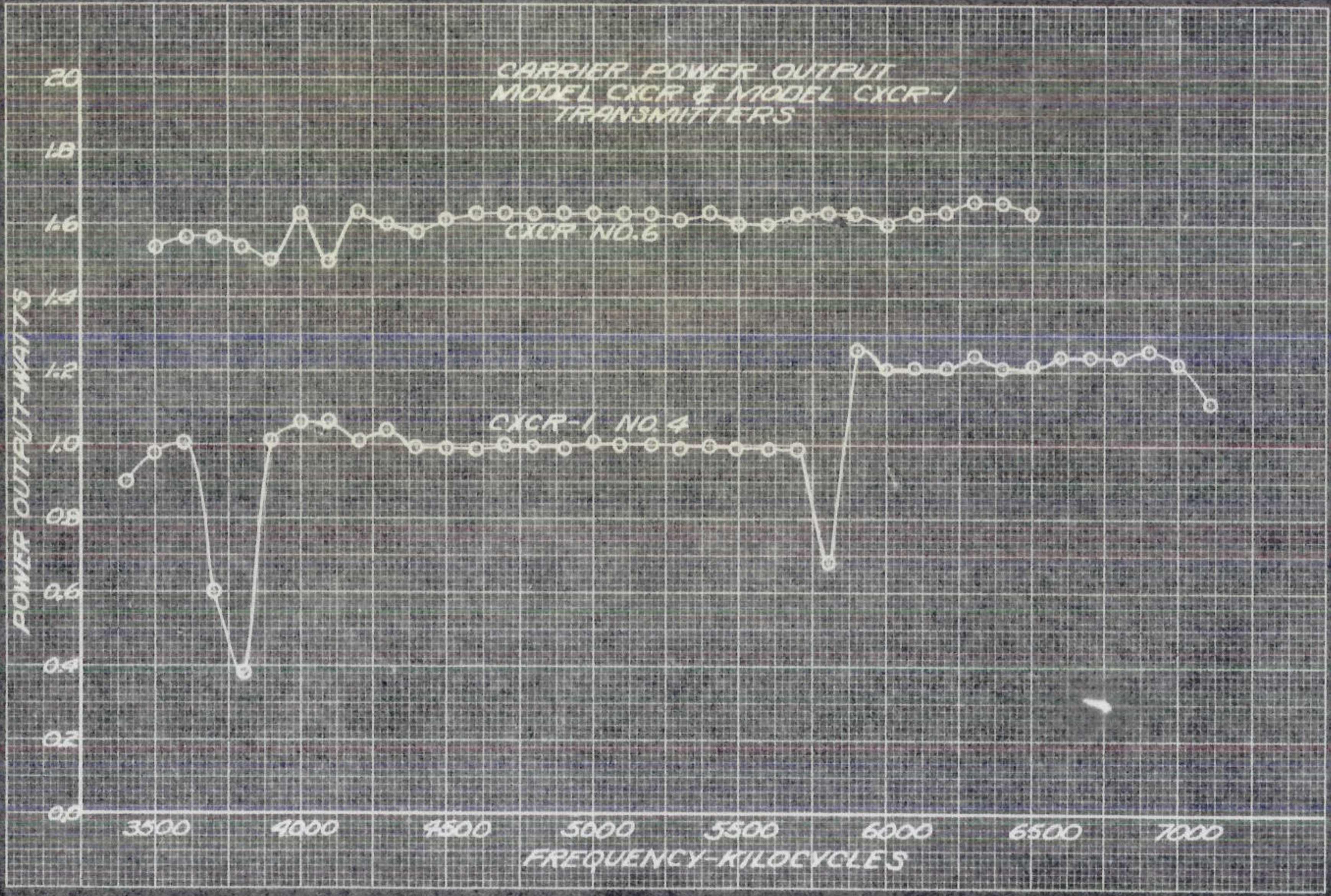

CARRIER POWER OUTPUT
MODEL CXCR & MODEL CXCR-1
TRANSMITTERS
CXCR NO.6
CXCR-1 NO.4
POWER OUTPUT-WATTS
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3500
4000
4500
5000
5500
6000
6500
7000
FREQUENCY-KILOCYCLES

PLATE I

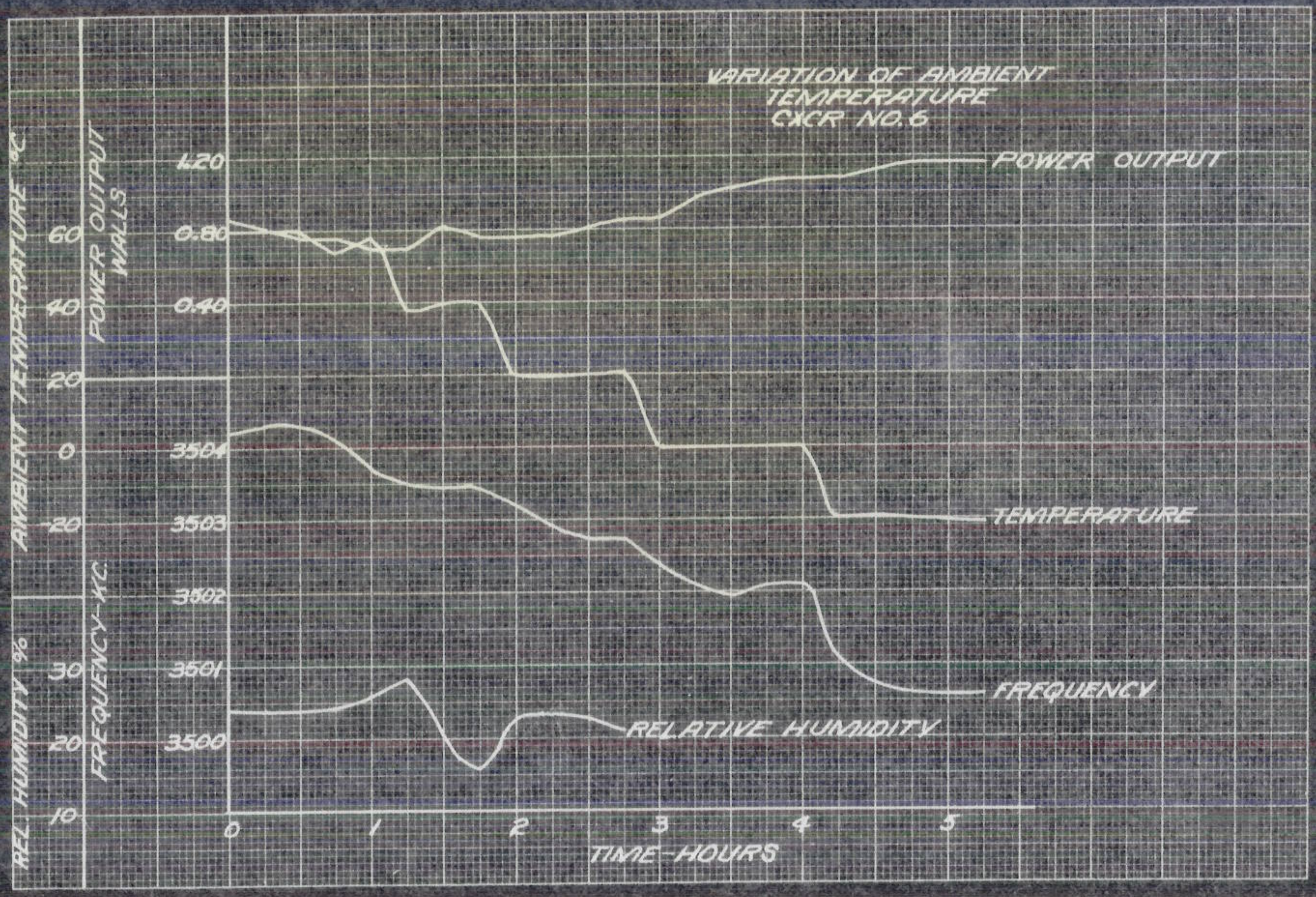

VARIATION OF AMBIENT
TEMPERATURE
CXCR NO.6
POWER OUTPUT
TEMPERATURE
FREQUENCY
RELATIVE HUMIDITY
AMBIENT TEMPERATURE °C
POWER OUTPUT
WATTS
FREQUENCY-KC.
REL. HUMIDITY %
60
40
20
0
-20
30
20
10
1.20
0.80
0.40
3504
3503
3502
3501
3500
0
1
2
3
4
5
TIME-HOURS

PLATE 2

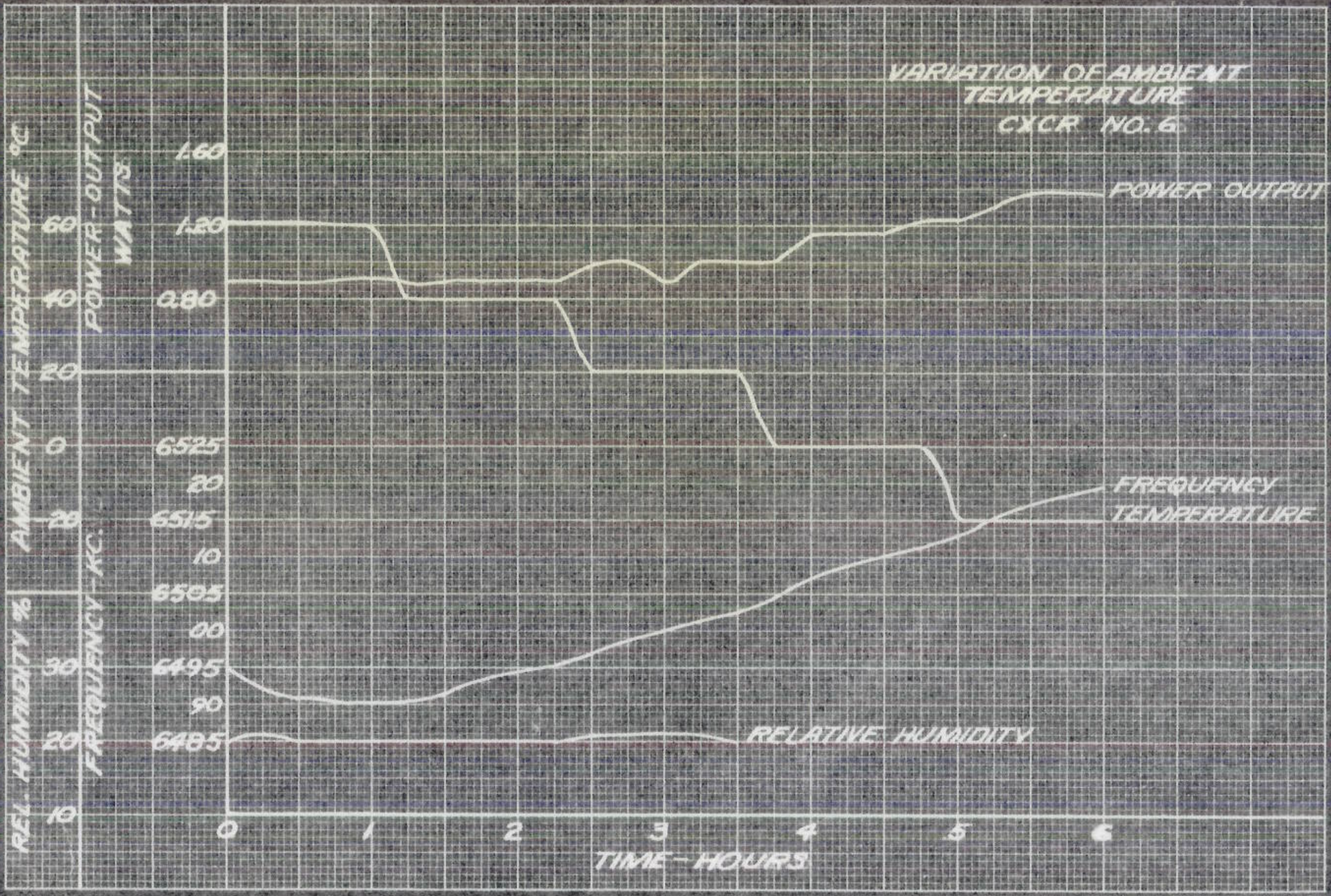


PLATE 3

DECLASSIFIED

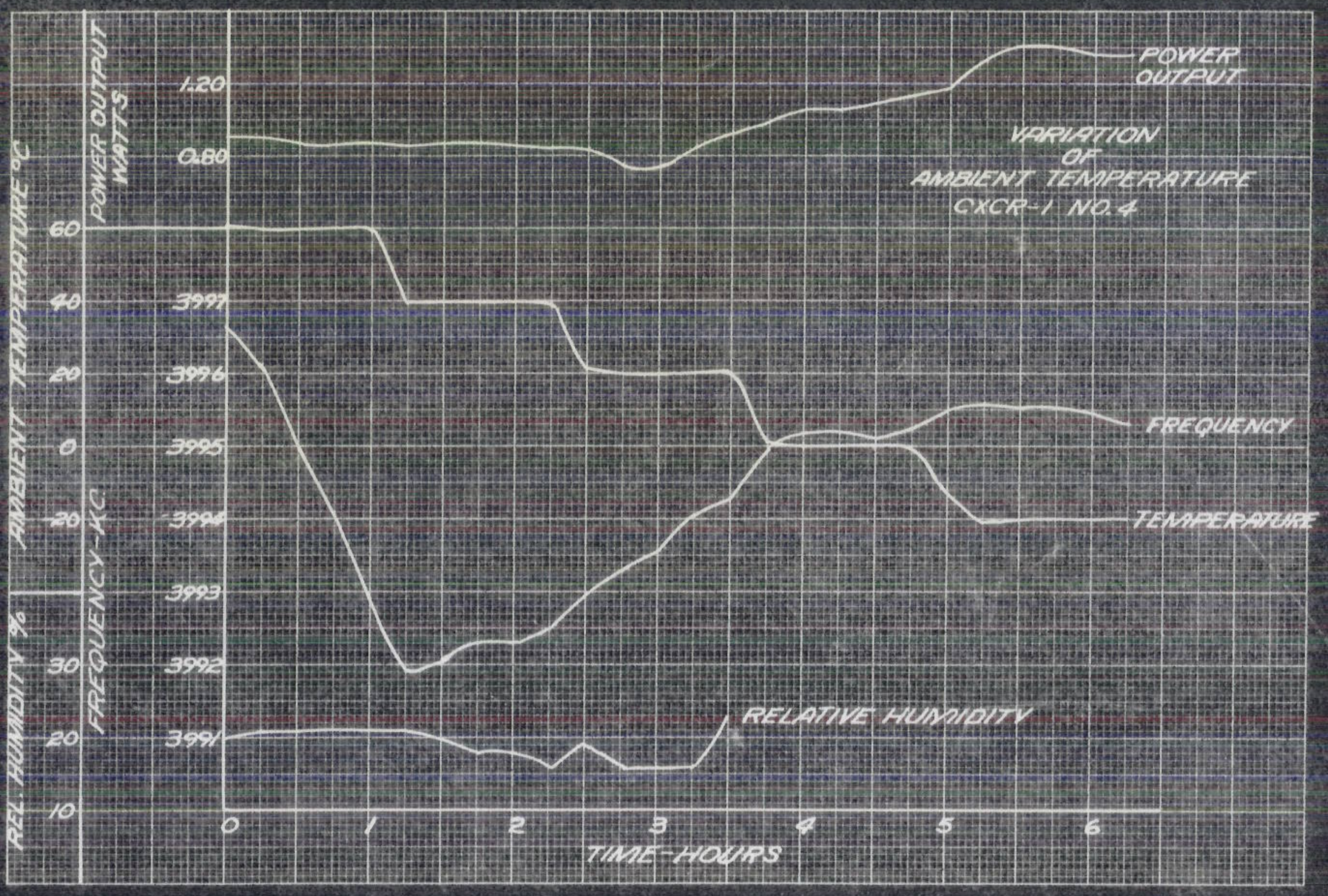

VARIATION
OF
AMBIENT TEMPERATURE
CXCR-1 NO. 4
POWER OUTPUT
FREQUENCY
TEMPERATURE
RELATIVE HUMIDITY
POWER OUTPUT WATTS
FREQUENCY-KC
AMBIENT TEMPERATURE °C
REL. HUMIDITY %
TIME-HOURS
1.20
0.80
60
40
20
0
-20
30
20
10
3997
3996
3995
3994
3993
3992
3991
0
1
2
3
4
5
6

PLATE 4

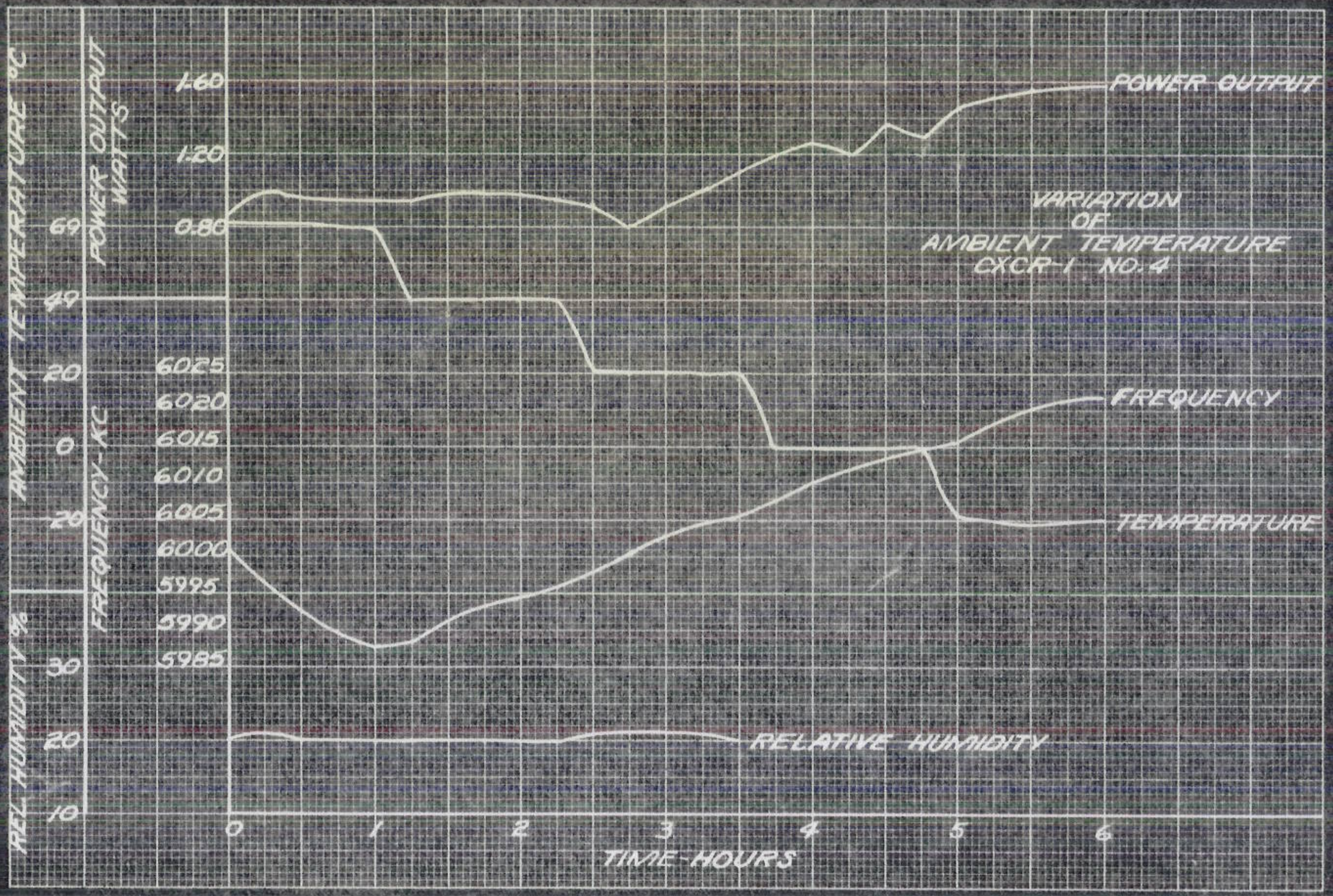

POWER OUTPUT
VARIATION
OF
AMBIENT TEMPERATURE
CXCR-1 NO. 4
FREQUENCY
TEMPERATURE
RELATIVE HUMIDITY
TIME-HOURS
AMBIENT TEMPERATURE °C
POWER OUTPUT WATTS
FREQUENCY-KC
REL. HUMIDITY %
1.60
1.20
0.80
69
49
20
0
-20
30
20
10
6025
6020
6015
6010
6005
6000
5995
5990
5985
0
1
2
3
4
5
6

PLATE 5

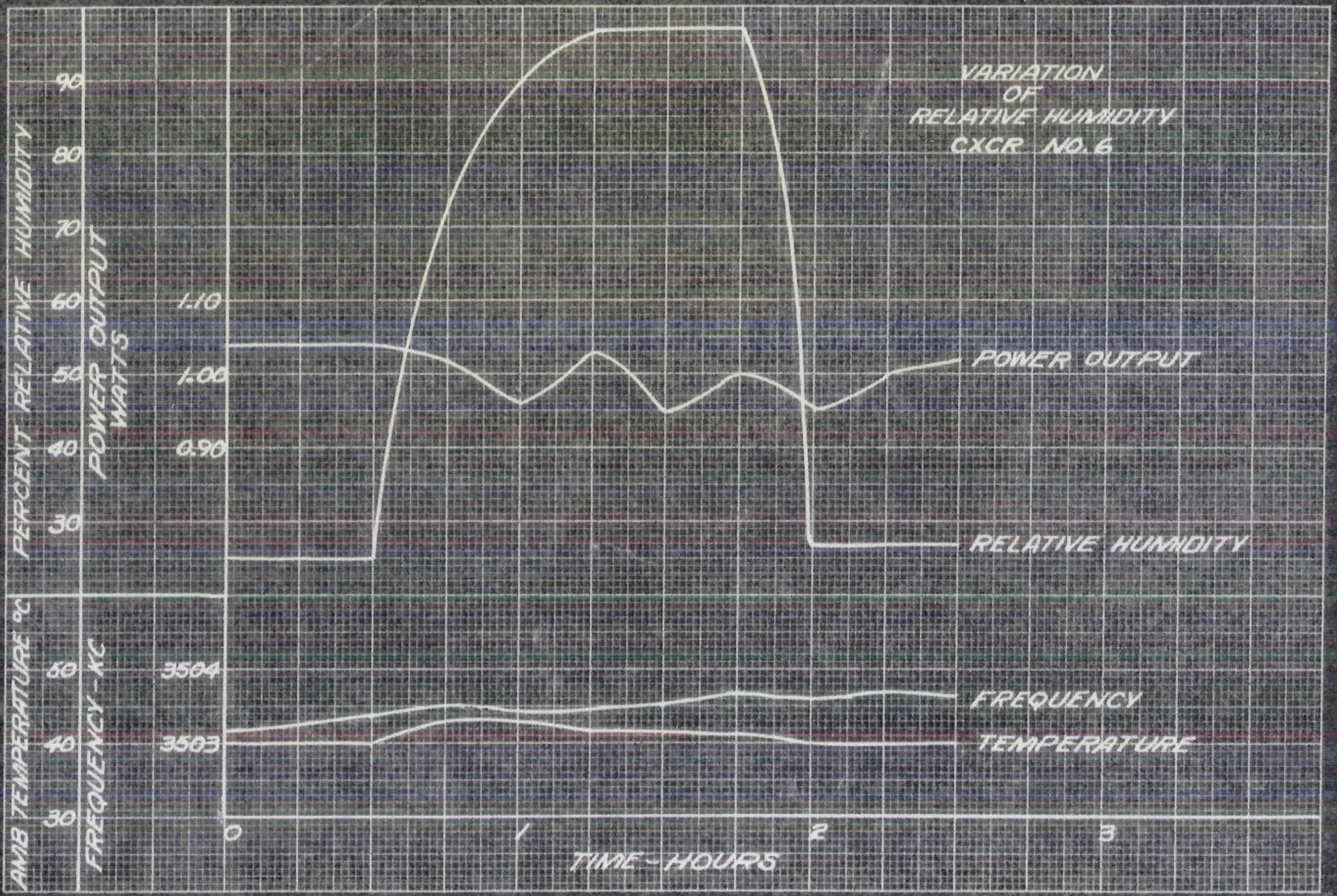

VARIATION
OF
RELATIVE HUMIDITY
CXCR NO. 6
PERCENT RELATIVE HUMIDITY
POWER OUTPUT
WATTS
90
80
70
60
50
40
30
1.10
1.00
0.90
AMB TEMPERATURE °C
FREQUENCY-KC
60
40
30
3504
3503
POWER OUTPUT
RELATIVE HUMIDITY
FREQUENCY
TEMPERATURE
0
1
2
3
TIME-HOURS

PLATE 6

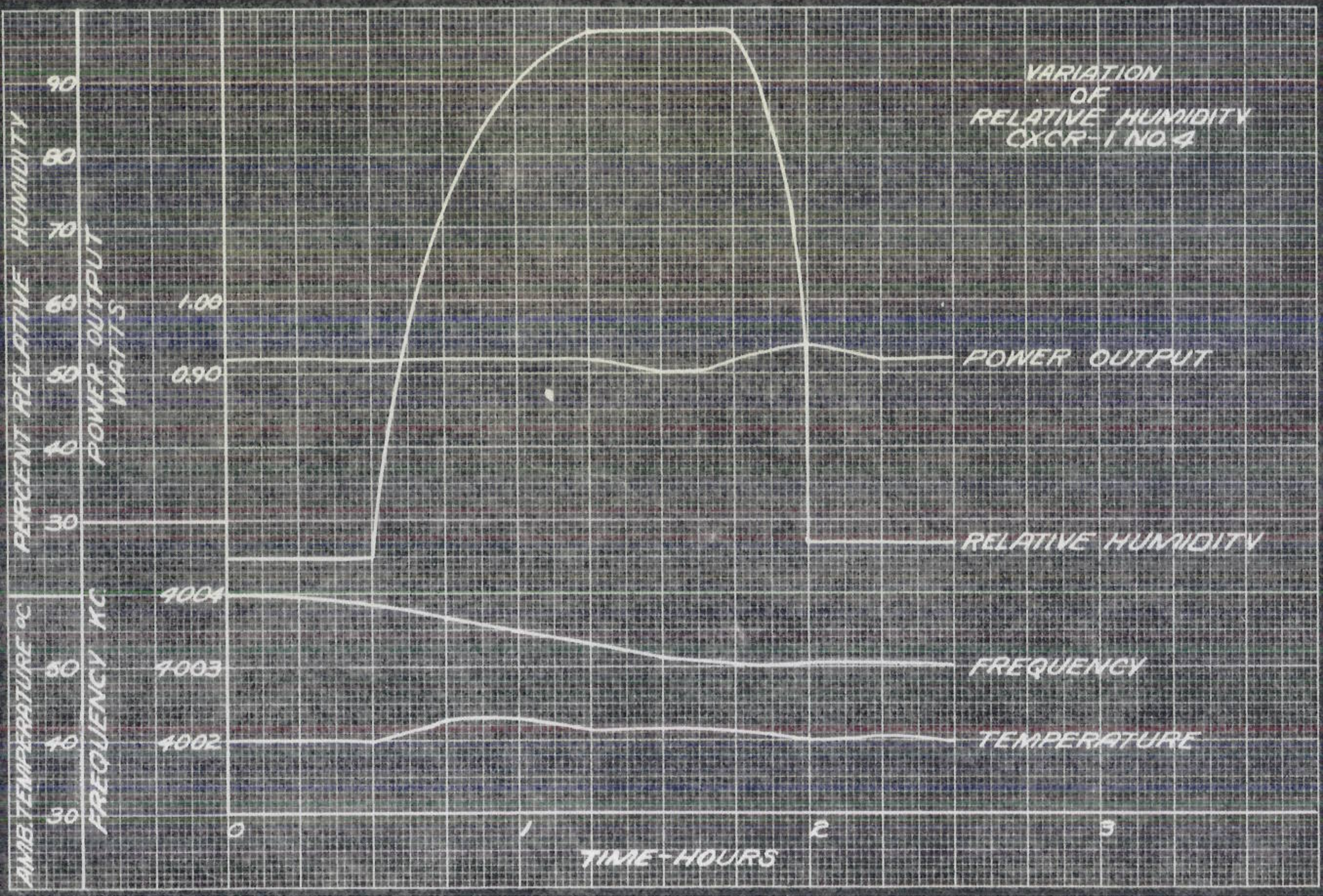

VARIATION
OF
RELATIVE HUMIDITY
CXCR-1 NO. 4
PERCENT RELATIVE HUMIDITY
POWER OUTPUT
WATTS
AMB. TEMPERATURE °C
FREQUENCY KC
90
80
70
60
50
40
30
1.00
0.90
4004
4003
4002
POWER OUTPUT
RELATIVE HUMIDITY
FREQUENCY
TEMPERATURE
0
1
2
3
TIME-HOURS

PLATE 7

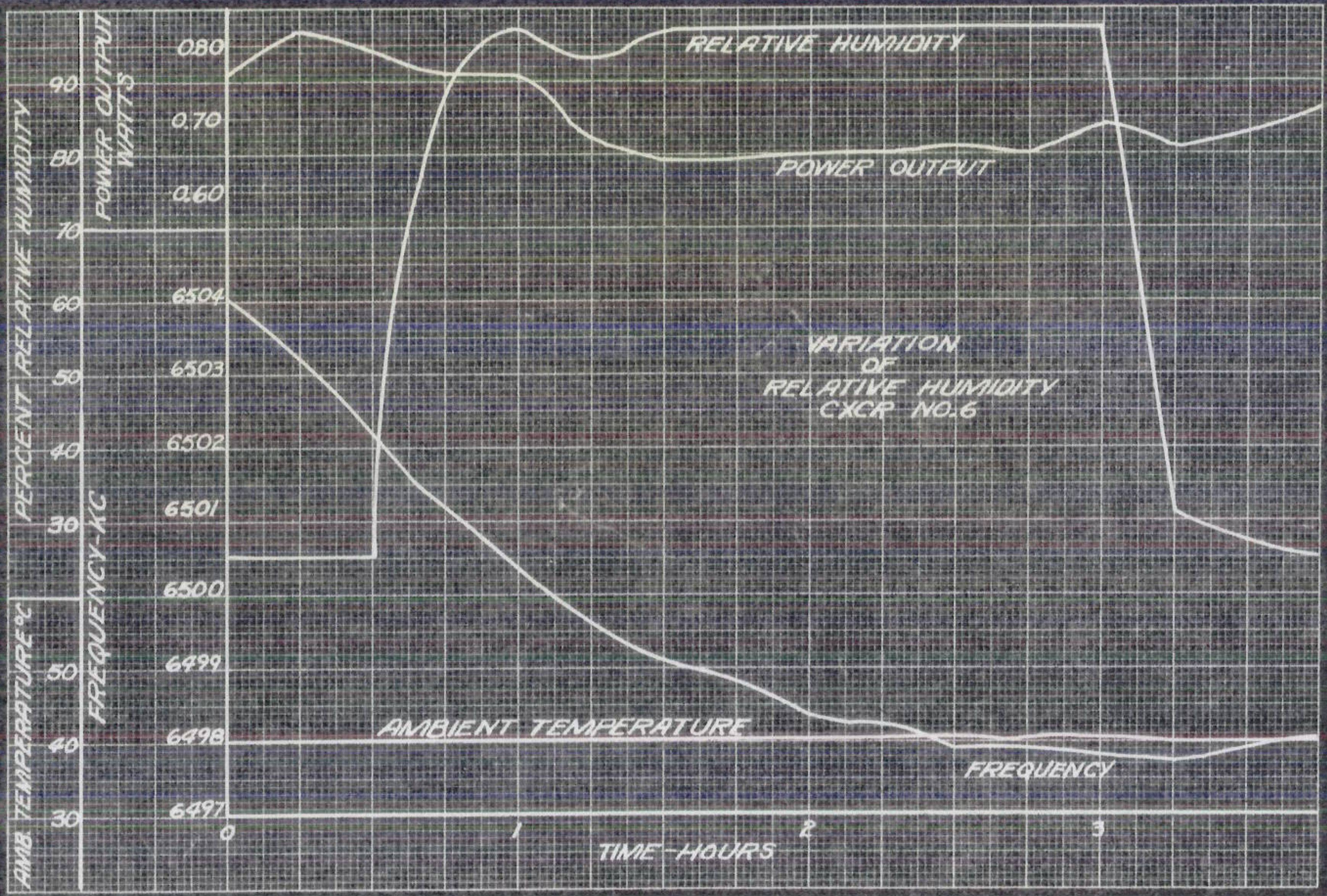

RELATIVE HUMIDITY
POWER OUTPUT
VARIATION
OF
RELATIVE HUMIDITY
CXCR NO.6
AMBIENT TEMPERATURE
FREQUENCY
PERCENT RELATIVE HUMIDITY
90
80
70
60
50
40
30
AMB TEMPERATURE °C
50
40
30
POWER OUTPUT WATTS
0.80
0.70
0.60
FREQUENCY-KC
6504
6503
6502
6501
6500
6499
6498
6497
0
1
2
3
TIME-HOURS

PLATE 8

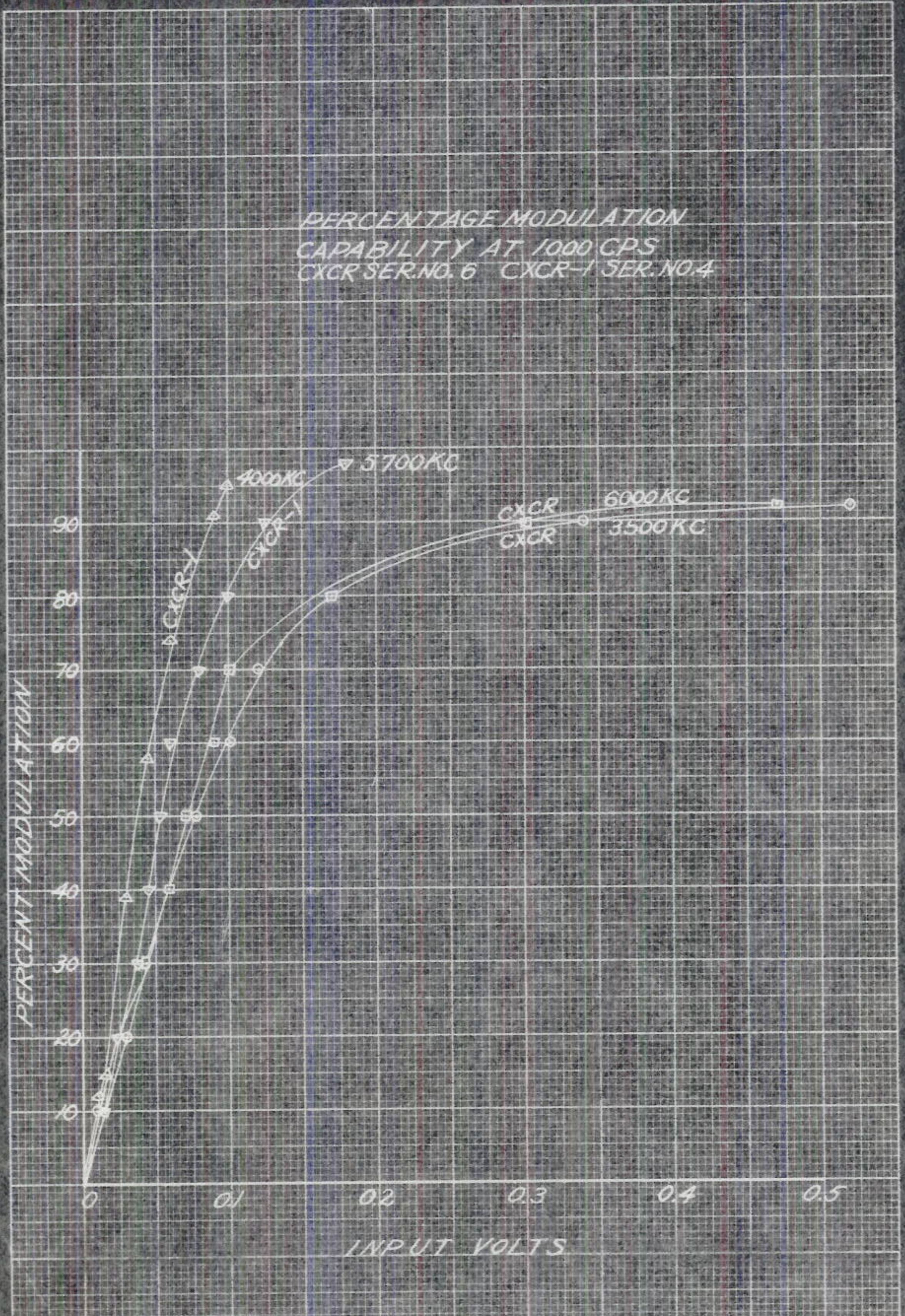

PERCENTAGE MODULATION
CAPABILITY AT 1000 CPS
CXCR SER. NO. 6 CXCR-1 SER. NO. 4
5700 KC
4000 KC
CXCR-1
CXCR-1
CXCR
6000 KC
CXCR
3500 KC
PERCENT MODULATION
INPUT VOLTS
10
20
30
40
50
60
70
80
90
0
0.1
0.2
0.3
0.4
0.5

PLATE 9

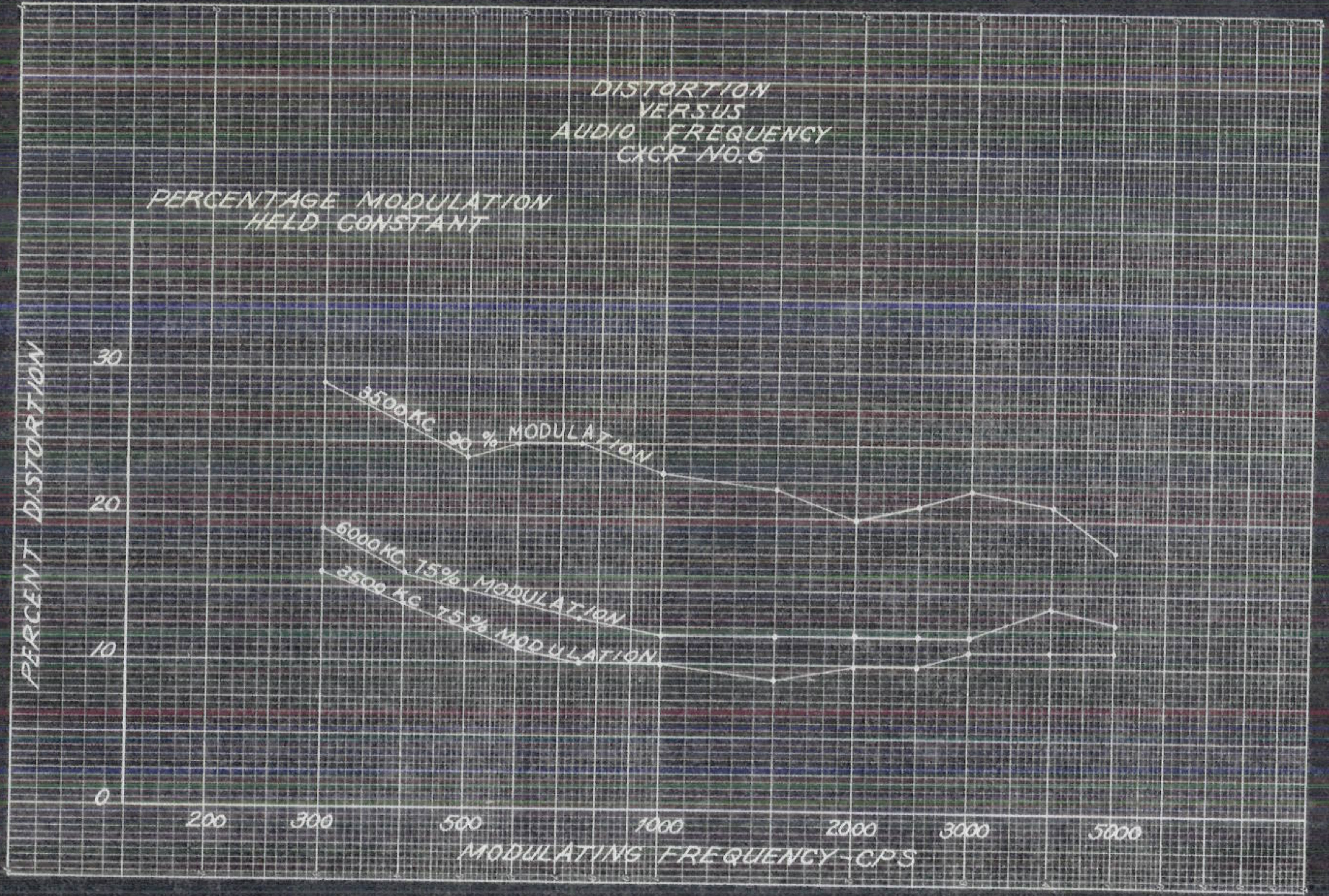
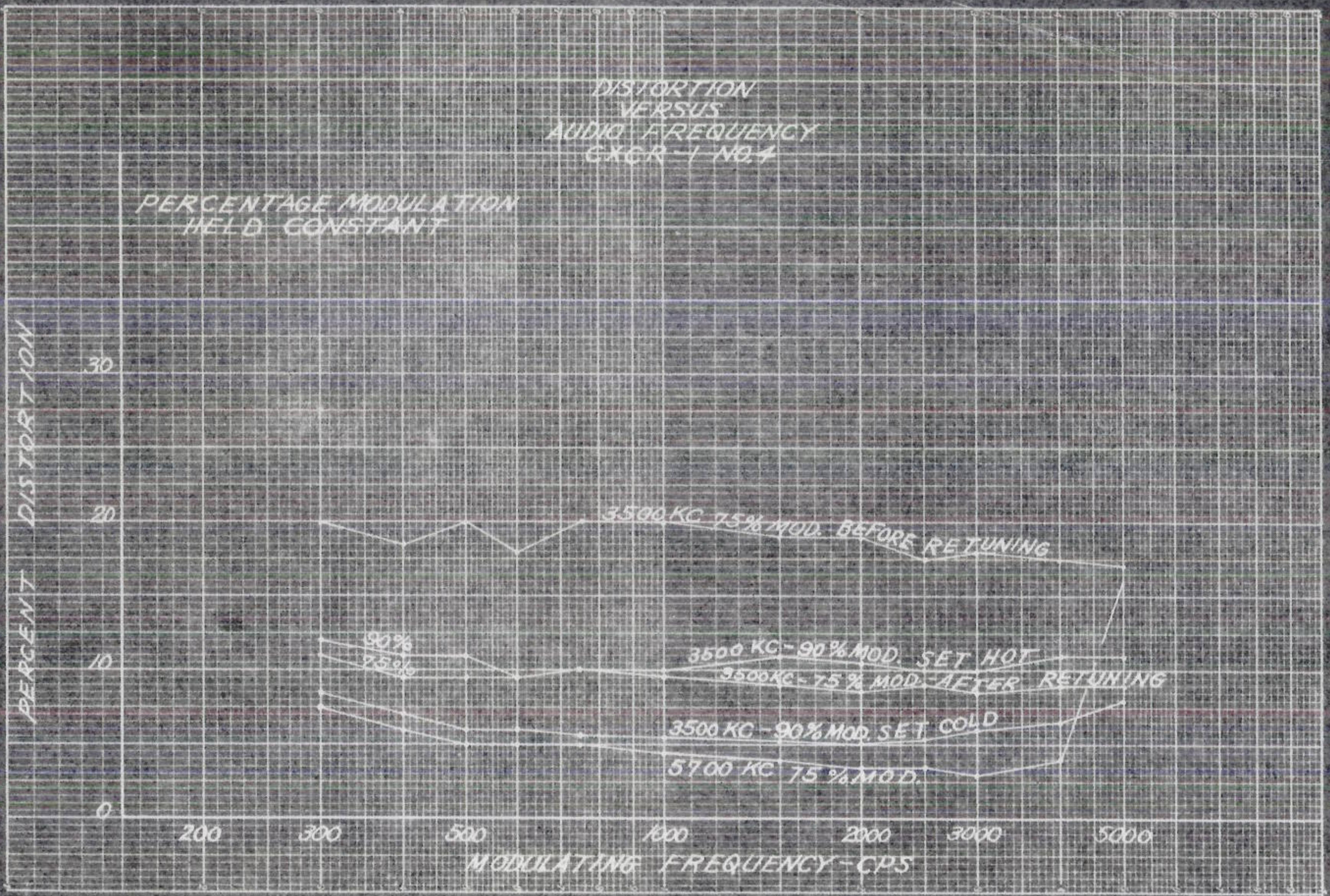

DISTORTION
VERSUS
AUDIO FREQUENCY
CXCR NO. 6
PERCENTAGE MODULATION
HELD CONSTANT
3500 KC 90 % MODULATION
6000 KC 75% MODULATION
3500 KC 75 % MODULATION
PERCENT DISTORTION
30
20
10
0
200
300
500
1000
2000
3000
5000
MODULATING FREQUENCY - CPS

PLATE 10



DISTORTION
VERSUS
AUDIO FREQUENCY
CXCR-1 NO.4
PERCENTAGE MODULATION
HELD CONSTANT
PERCENT DISTORTION
30
20
10
0
200
300
500
1000
2000
3000
5000
MODULATING FREQUENCY - CPS
3500 KC 75% MOD. BEFORE RETUNING
90%
75%
3500 KC - 90% MOD. SET HOT
3500 KC - 75% MOD. AFTER RETUNING
3500 KC - 90% MOD. SET COLD
5700 KC 75% MOD.

PLATE 11

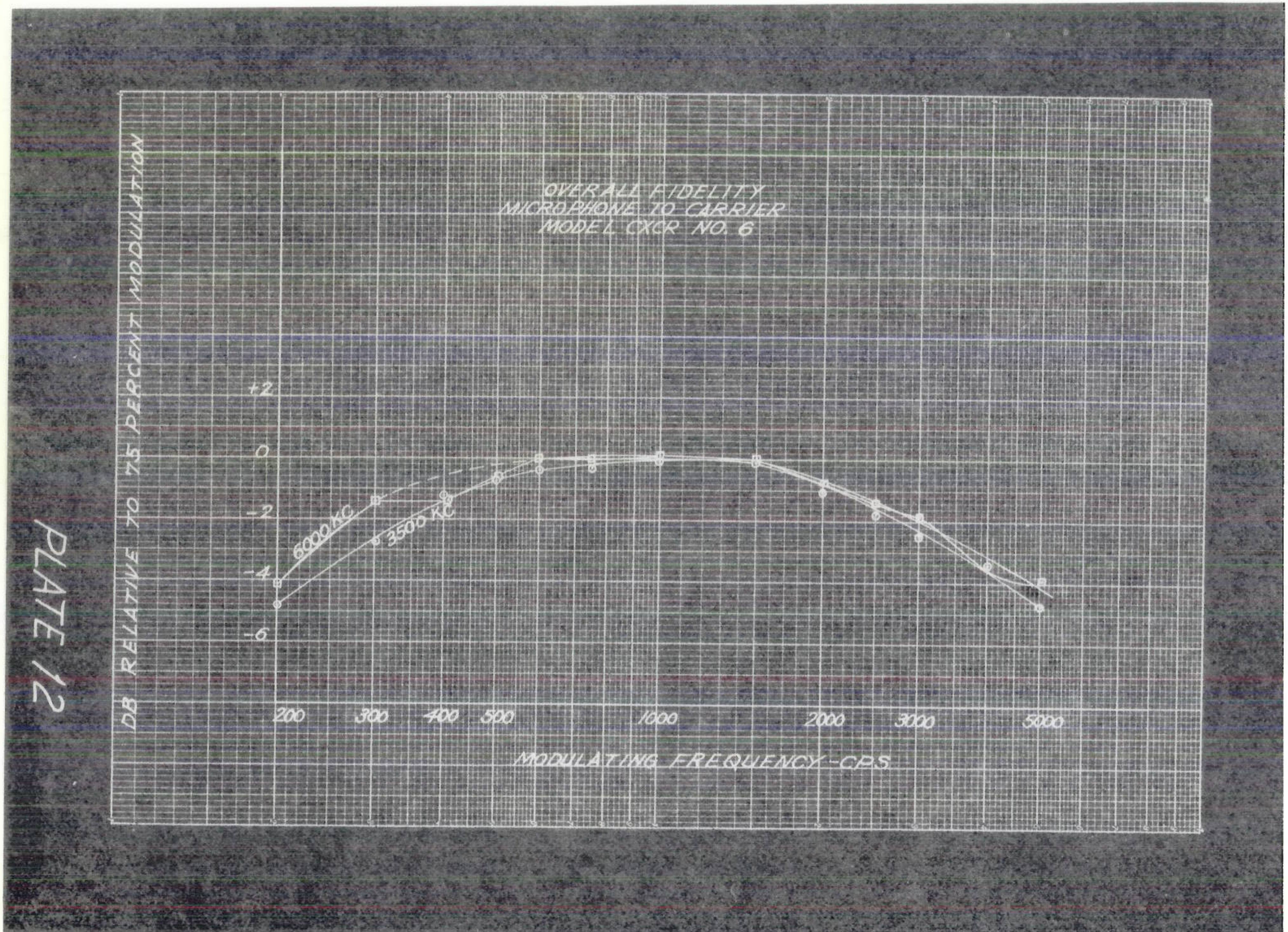

OVERALL FIDELITY
MICROPHONE TO CARRIER
MODEL CXGR NO. 6
DB RELATIVE TO 75 PERCENT MODULATION
+2
0
-2
-4
-6
6000 KC
3500 KC
200
300
400
500
1000
2000
3000
5000
MODULATING FREQUENCY-CPS

PLATE 12

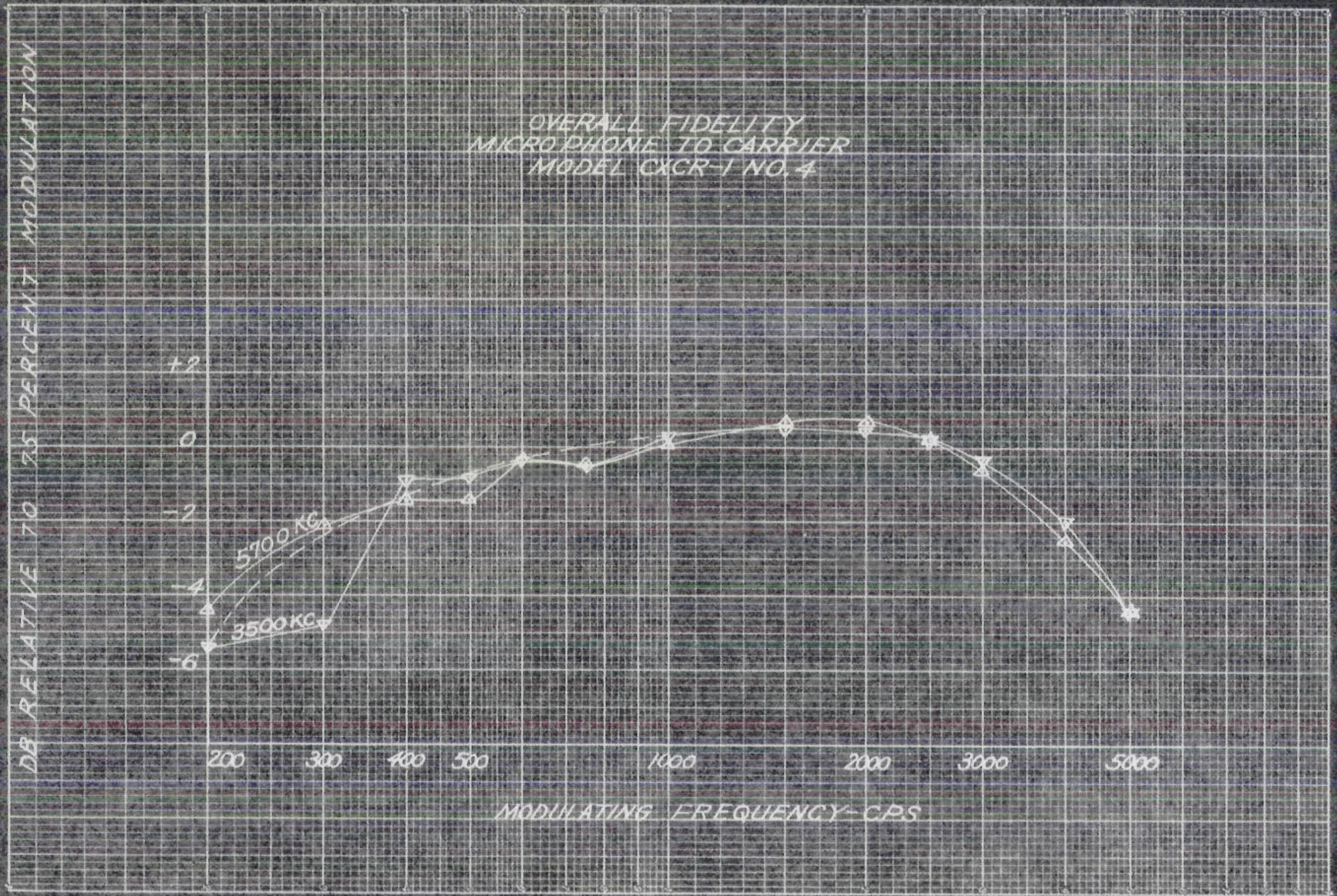

OVERALL FIDELITY
MICROPHONE TO CARRIER
MODEL CXCR-1 NO. 4
DB RELATIVE TO 75 PERCENT MODULATION
+2
0
-2
-4
-6
5700 KC
3500 KC
200
300
400
500
1000
2000
3000
5000
MODULATING FREQUENCY-CPS

PLATE 13

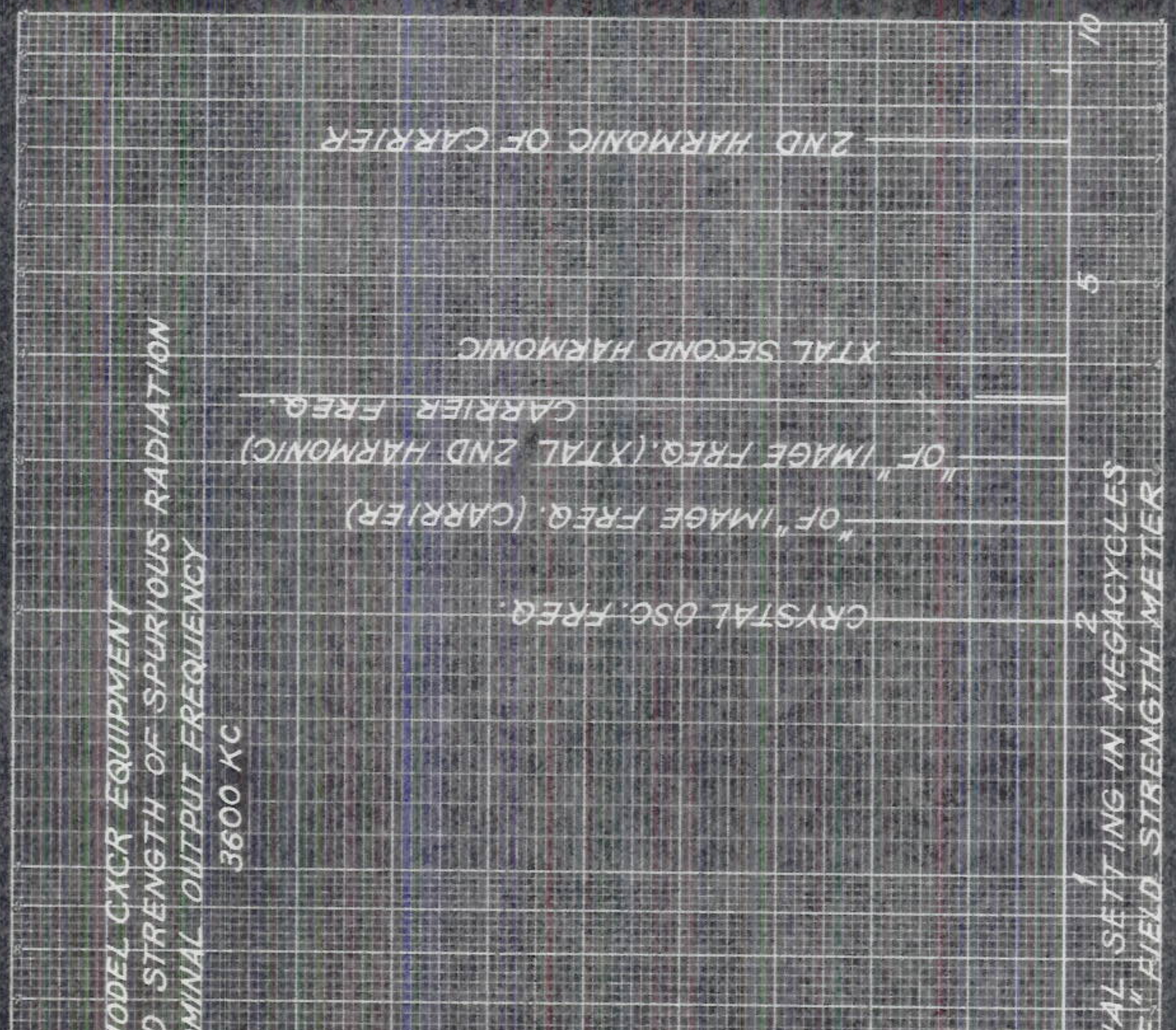


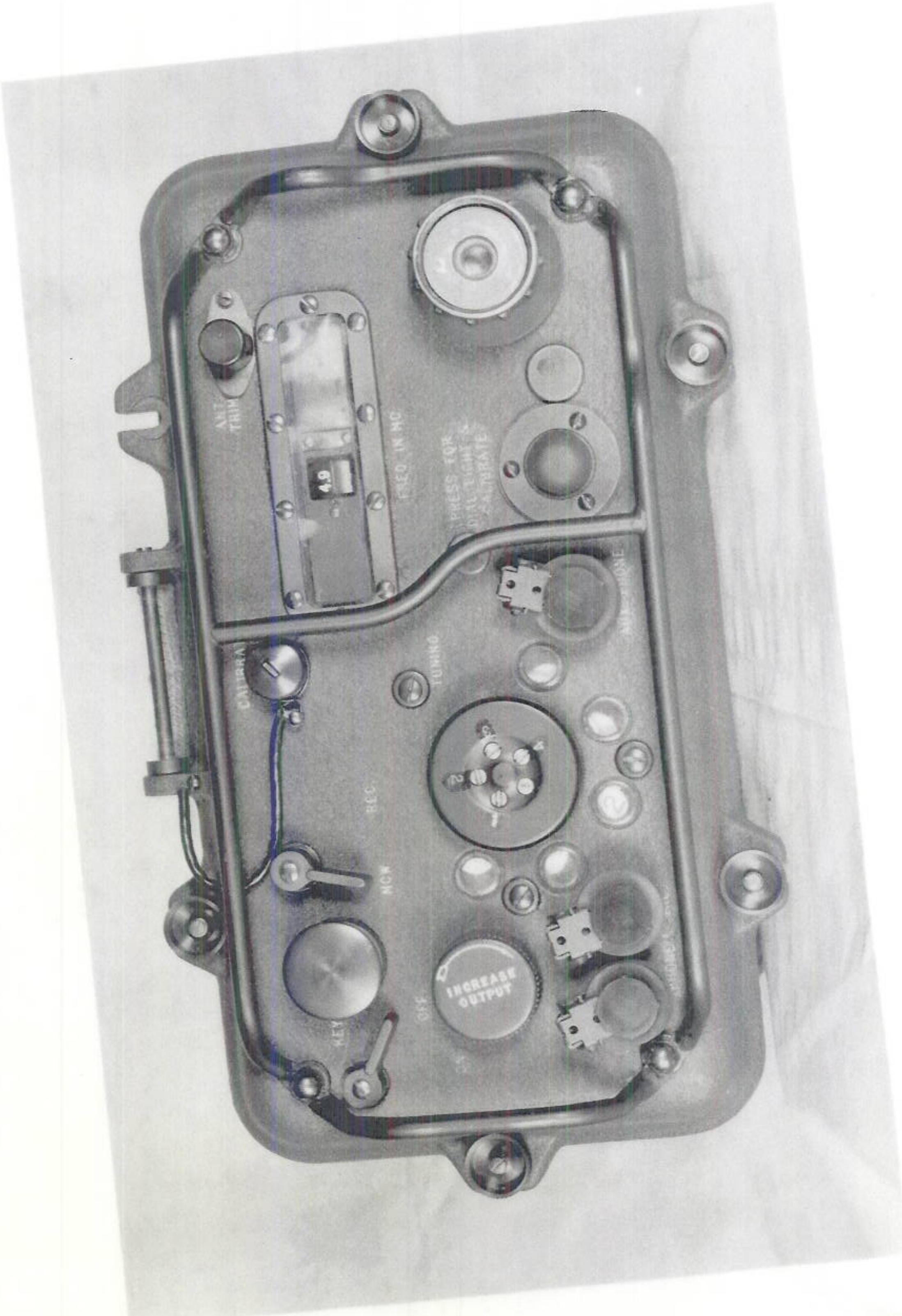
PLATE 14

DECLASSIFIED


MODEL CXGR-1 EQUIPMENT
RELATIVE FIELD STRENGTH OF SPURIOUS RADIATION
NOMINAL OUTPUT FREQUENCY
3600 KC
FIELD STRENGTH IN DECIBELS
100000 μV/M REFERENCE
0
-10
-20
-30
-40
-50
-60
-70
-80
0.2
0.5
1
2
5
10
DIAL SETTING IN MEGACYCLES
"OF" FIELD STRENGTH METER
BEAT FREQ. CARRIER AND XTAL 2ND HARM.
BEAT FREQ.-VAR. OSC. WITH
XTAL 2ND AND 4TH HARMONICS
CRYSTAL OSC. FREQ.
BEAT FREQ.-CARRIER AND
XTAL 3RD HARMONIC
"OF" IMAGE FREQ. (CARRIER)
"OF" IMAGE FREQ. (XTAL 2ND HARMONIC)
BEAT FREQ. BETWEEN 2ND HARM. OF CARRIER
AND 2ND HARM. OF XTAL
CARRIER FREQ.
XTAL SECOND HARMONIC
BEAT BETWEEN CARRIER
AND 4TH HARM. OF XTAL
VAR. OSC. FREQ.
XTAL THIRD HARM. OF XTAL
XTAL 4TH HARMONIC
CARRIER 2ND HARMONIC

PLATE 15

no plates
16 - 100



DECLASSIFIED

PLATE 101

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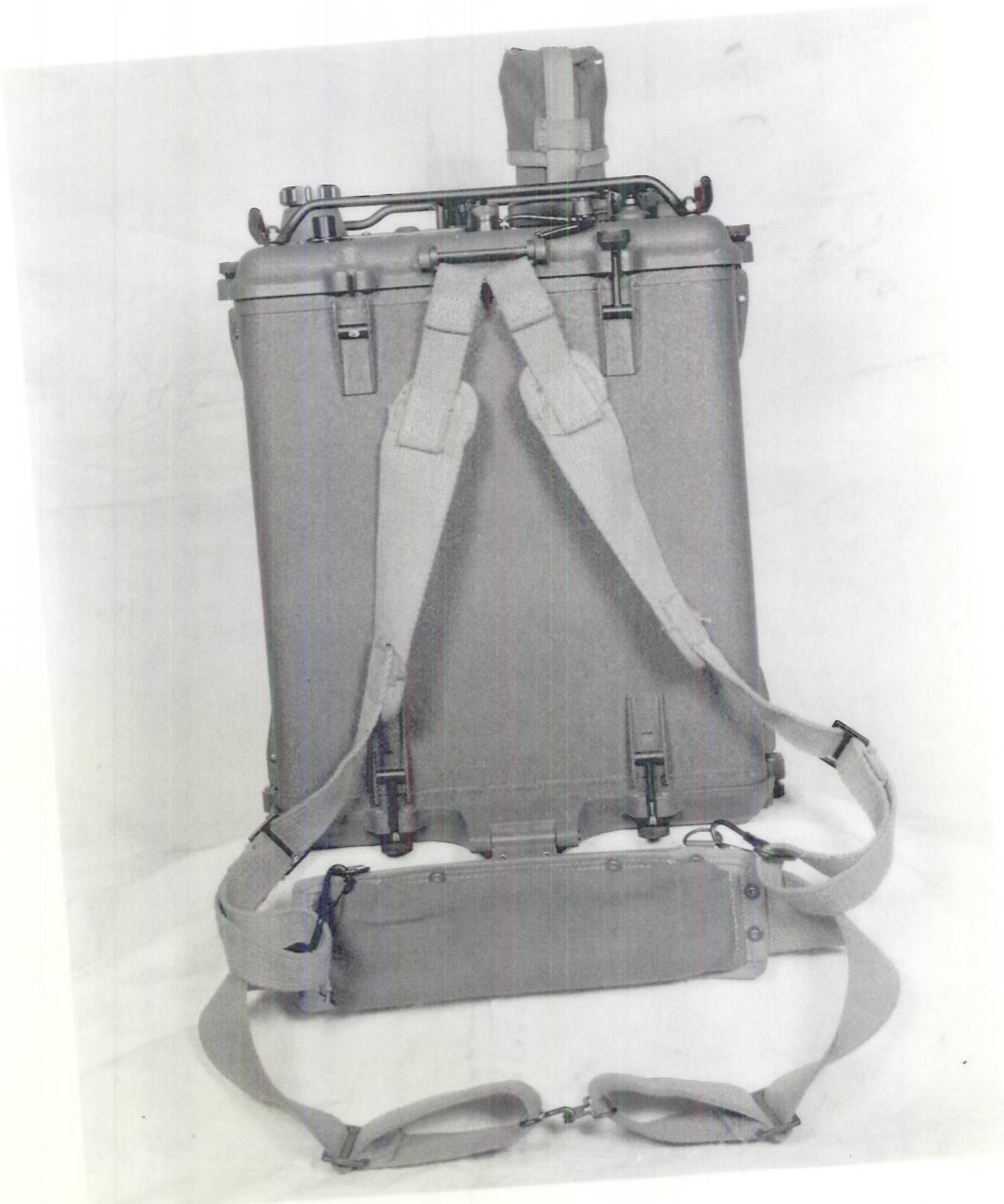
DECLASSIFIED



DECLASSIFIED

PLATE 102

[redacted]

DECLASSIFIED

DECLASSIFIED

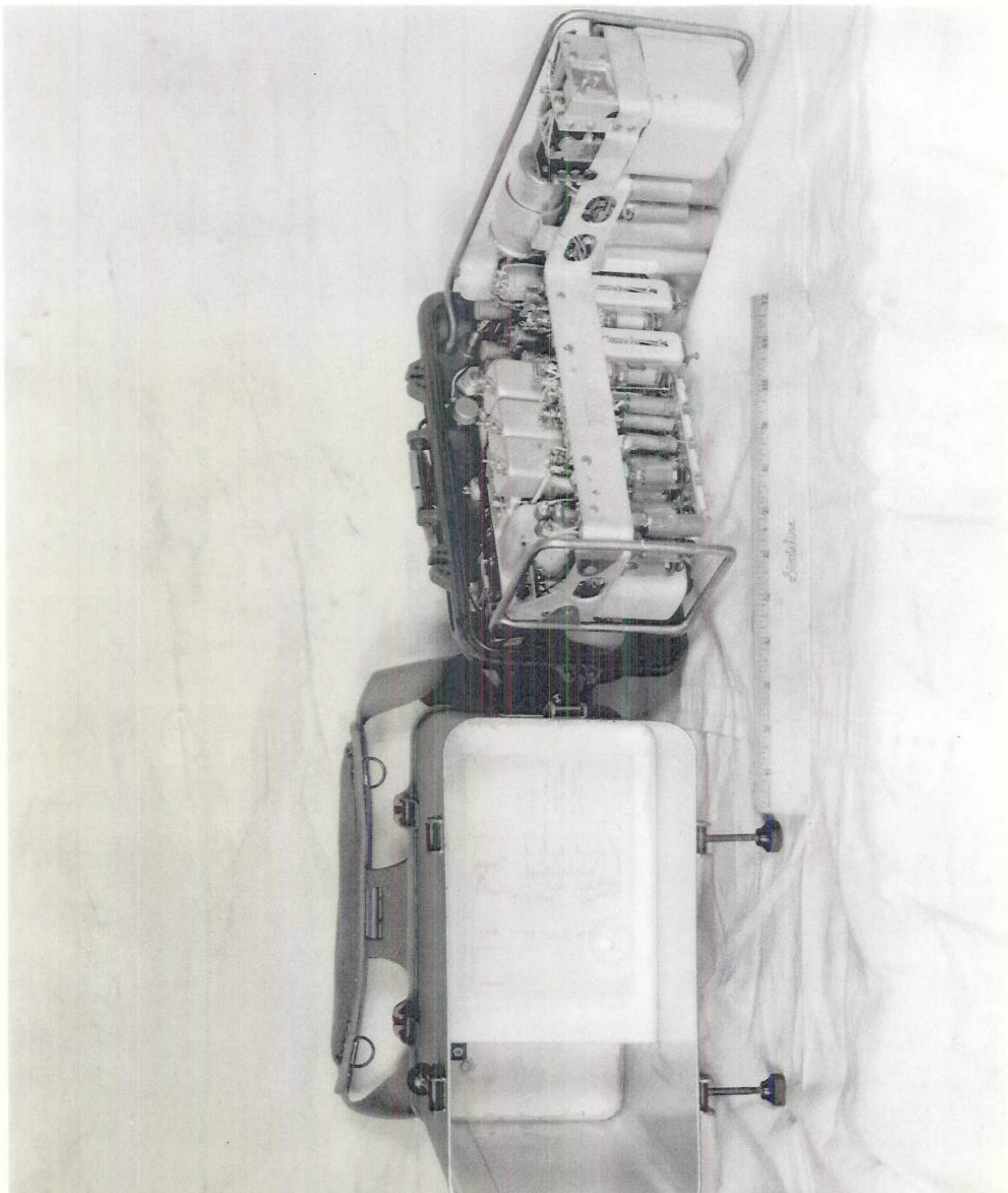
[redacted]

PLATE 103

[redacted]

PLATE 104

DECLASSIFIED



DECLASSIFIED

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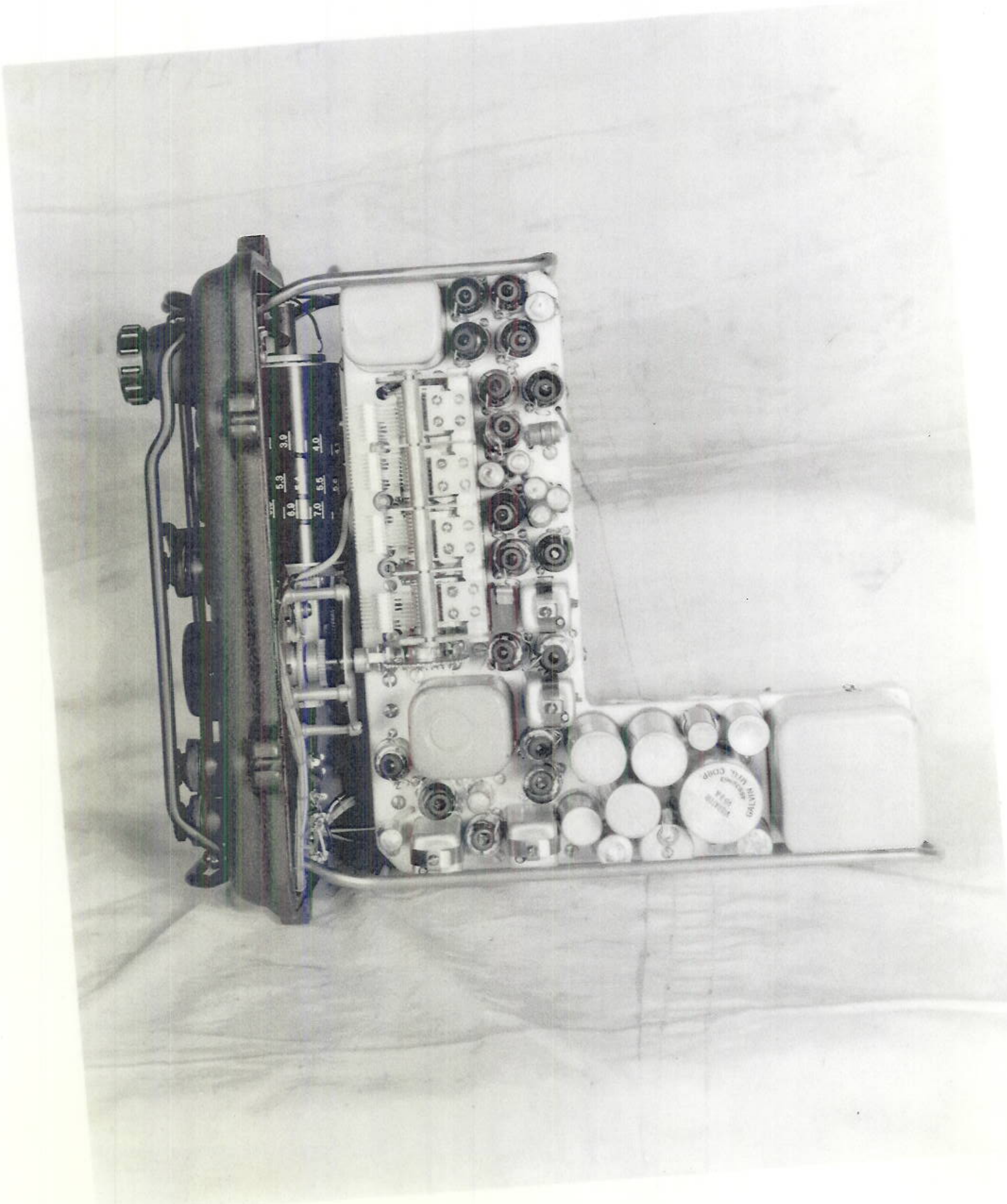
PLATE 105



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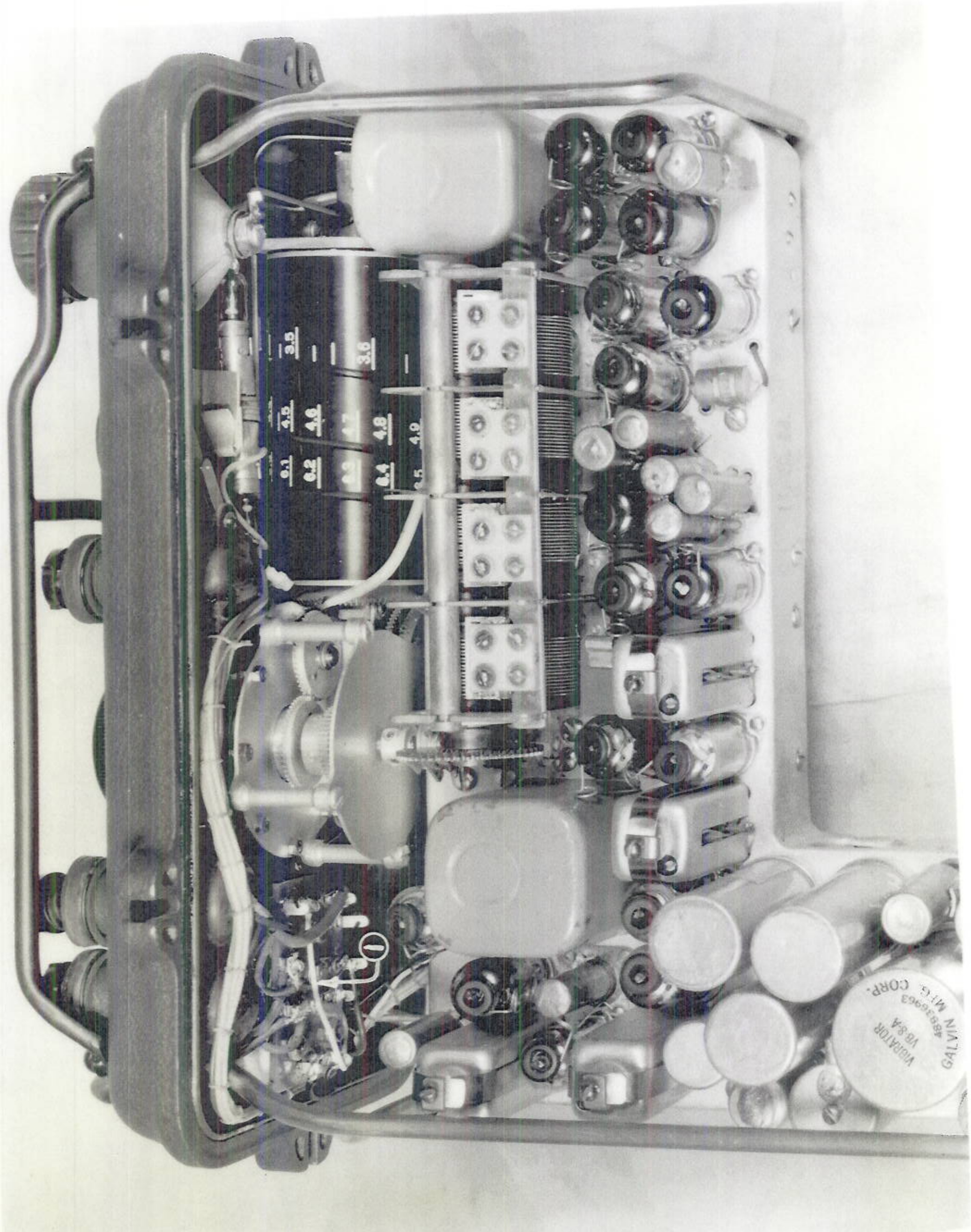
DECLASSIFIED

PLATE 106

DECLASSIFIED



[redacted] DECLASSIFIED PLATE 107

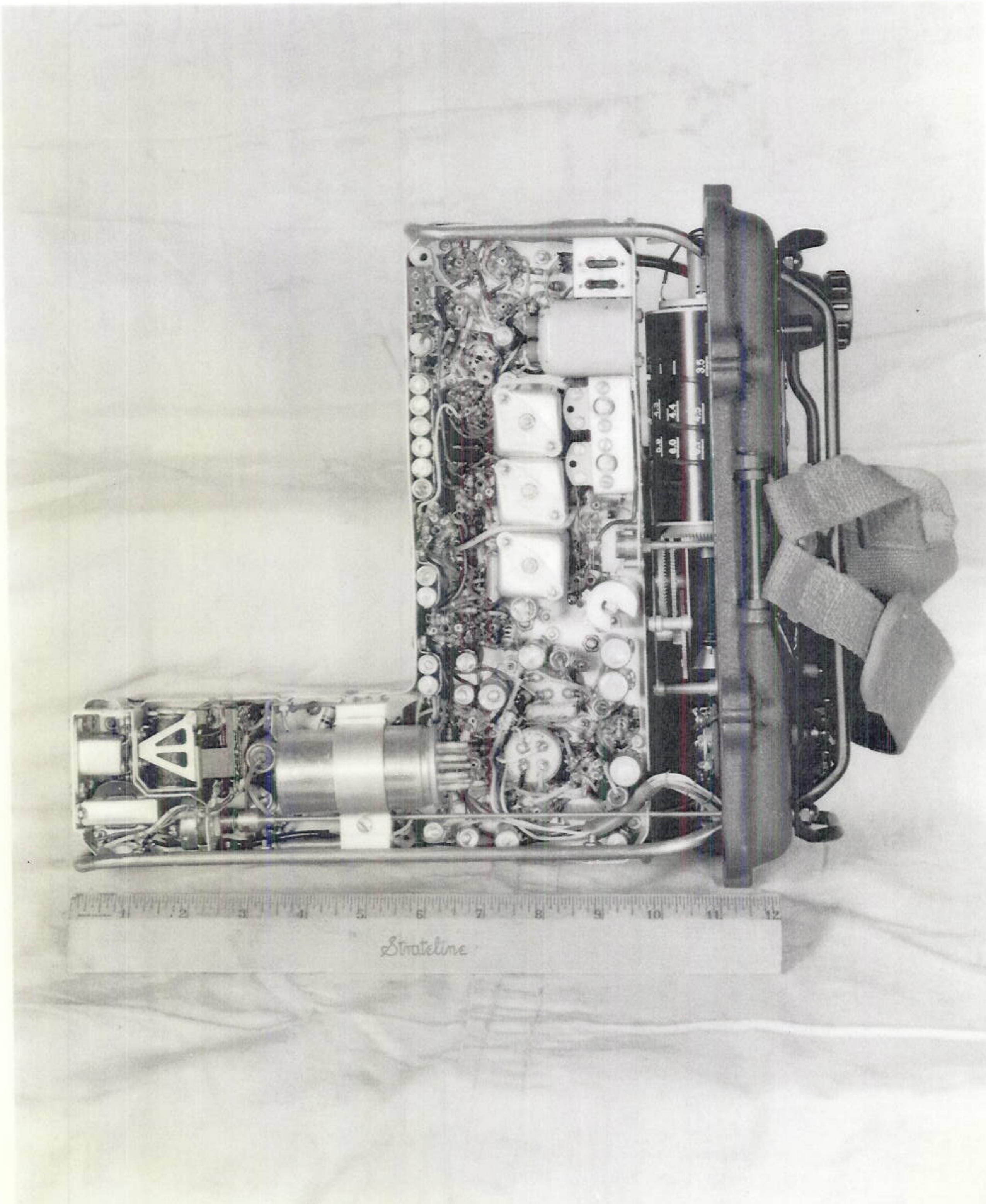


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PLATE 108

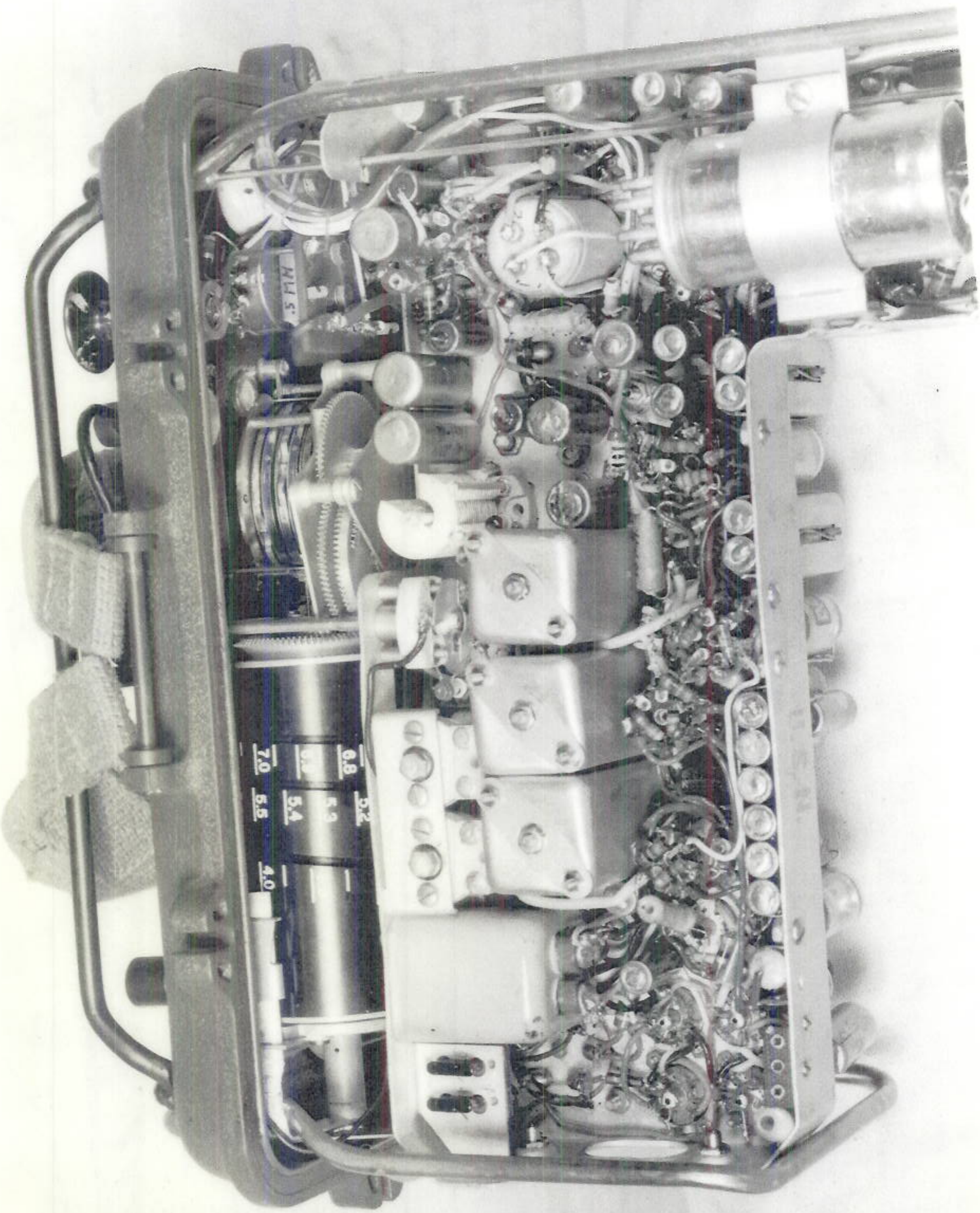
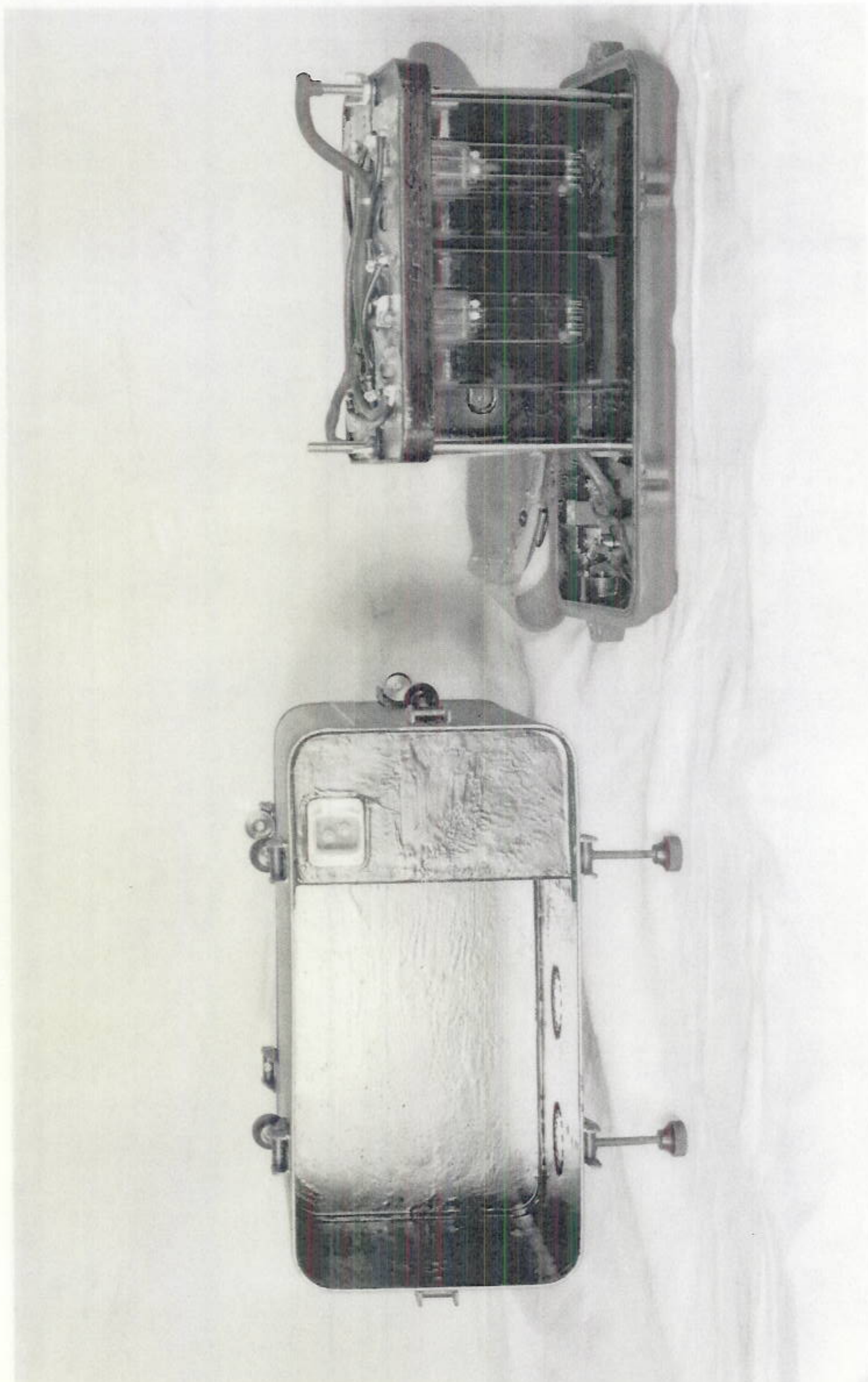


PLATE 109

[redacted]



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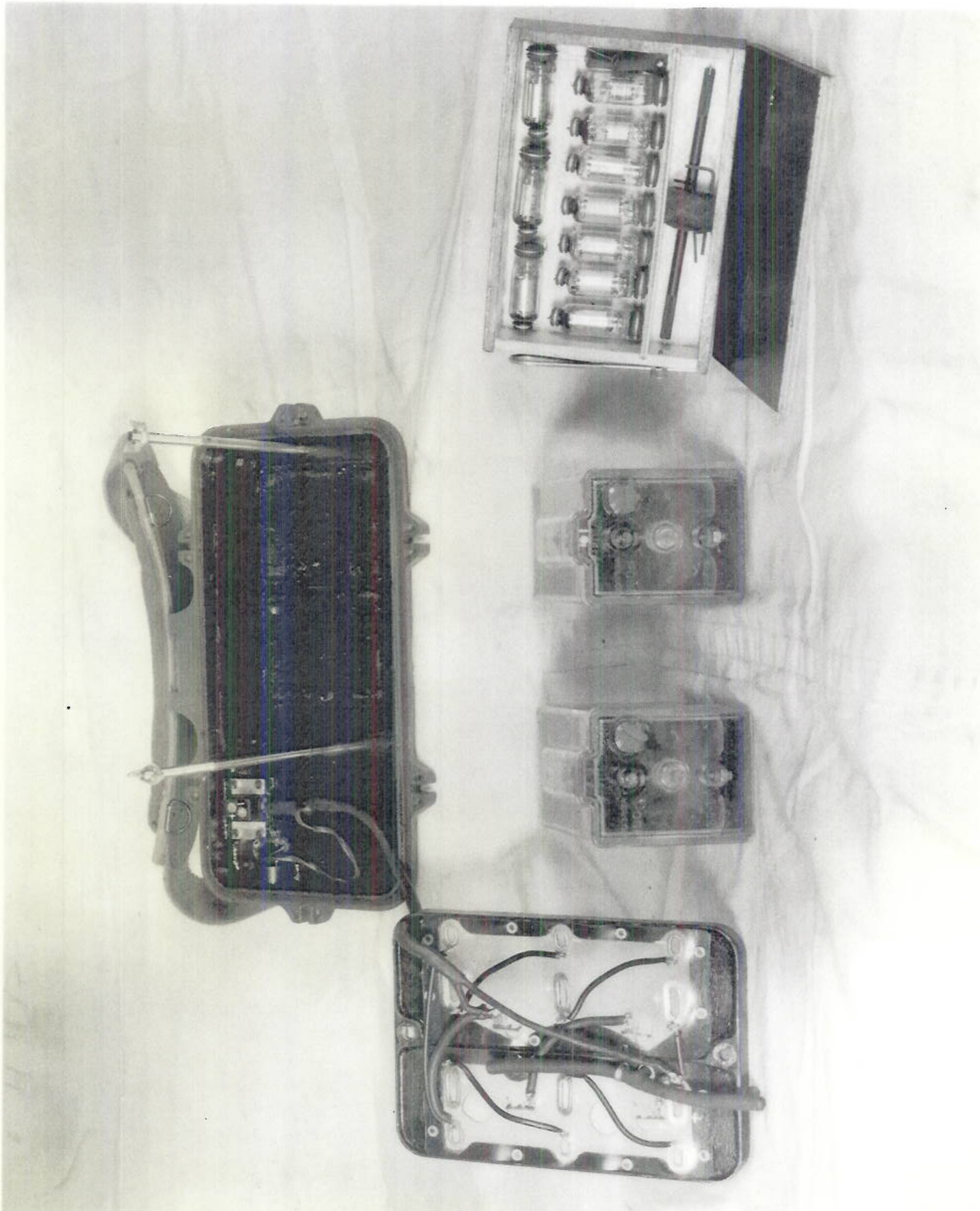


DECLASSIFIED

[redacted]

PLATE III

DECLASSIFIED

DECLASSIFIED

CONFIDENTIAL

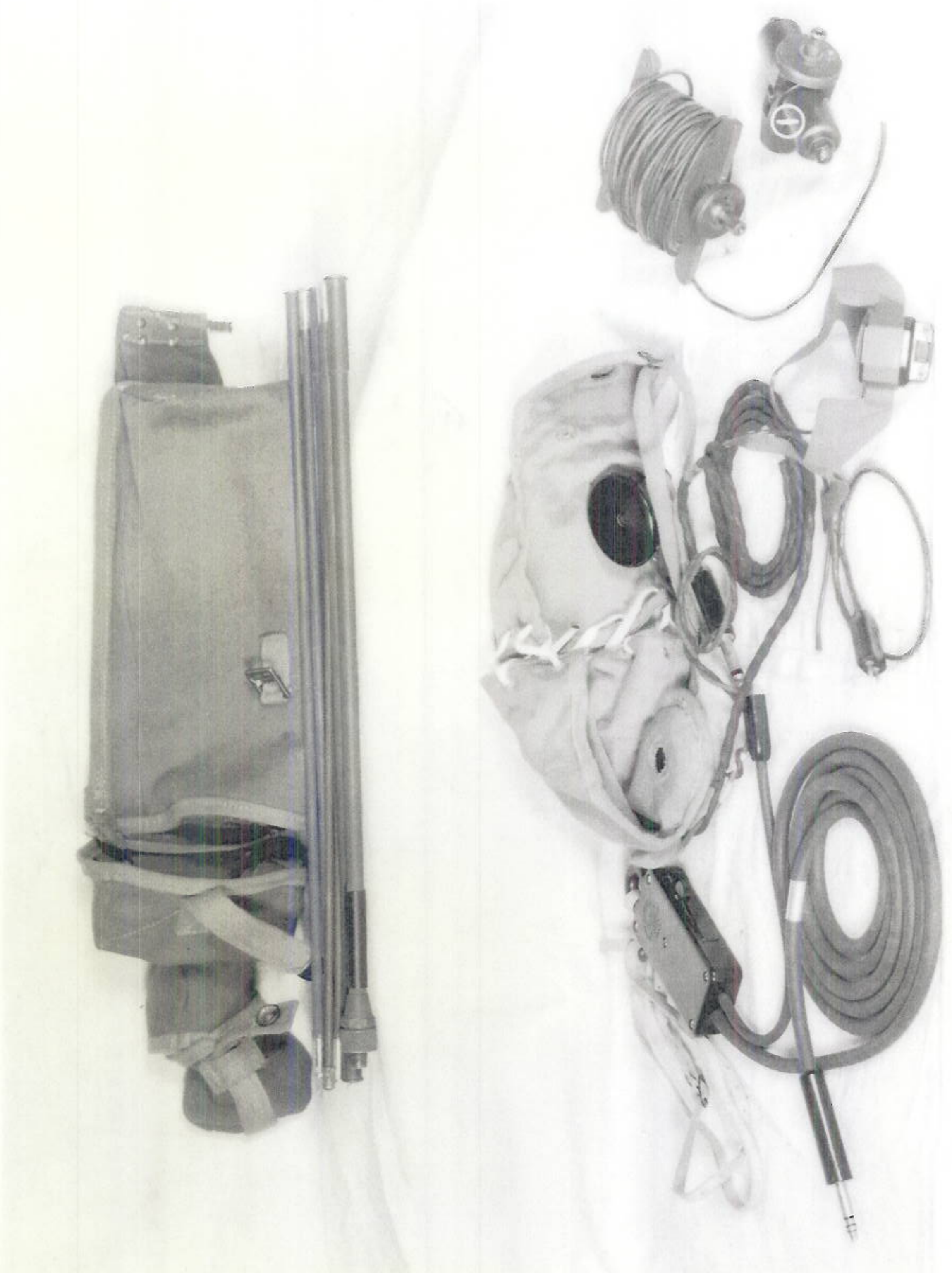
PLATE 112

DECLASSIFIED

[redacted]

PLATE 113

DECLASSIFIED



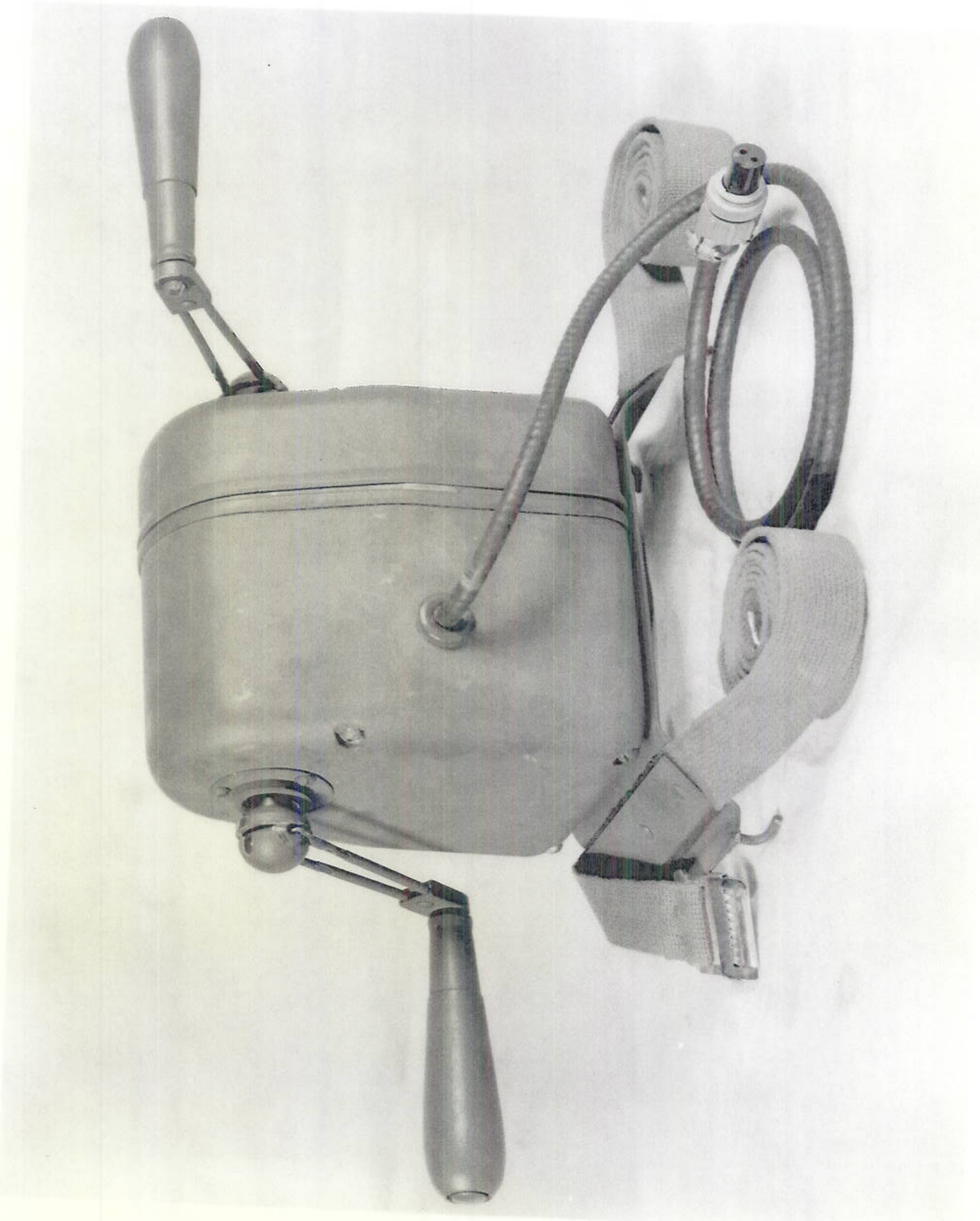
DECLASSIFIED

CONFIDENTIAL

PLATE 114

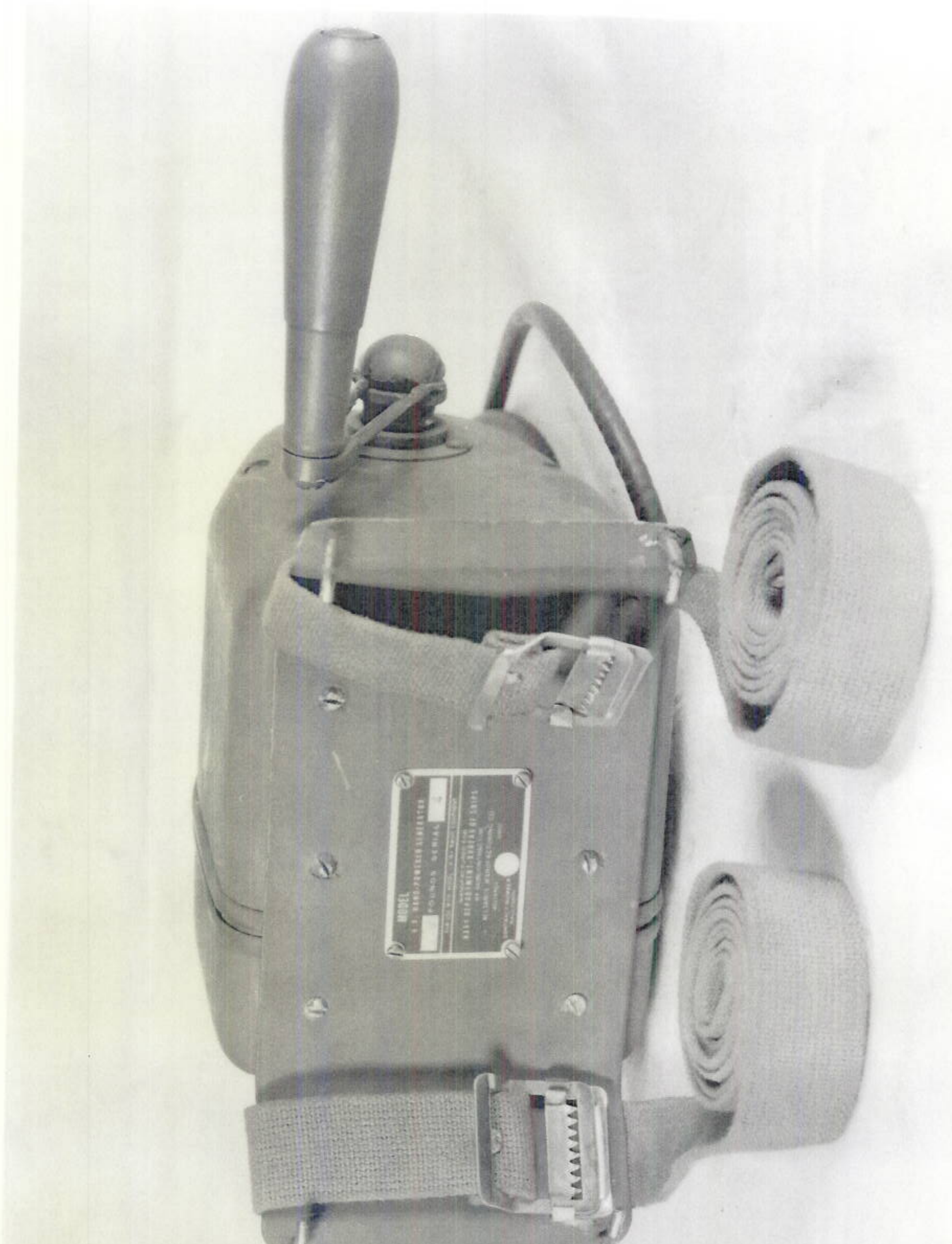
DECLASSIFIED

PLATE 115



DECLASSIFIED

PLATE 116



DECLASSIFIED

[redacted]

PLATE 117

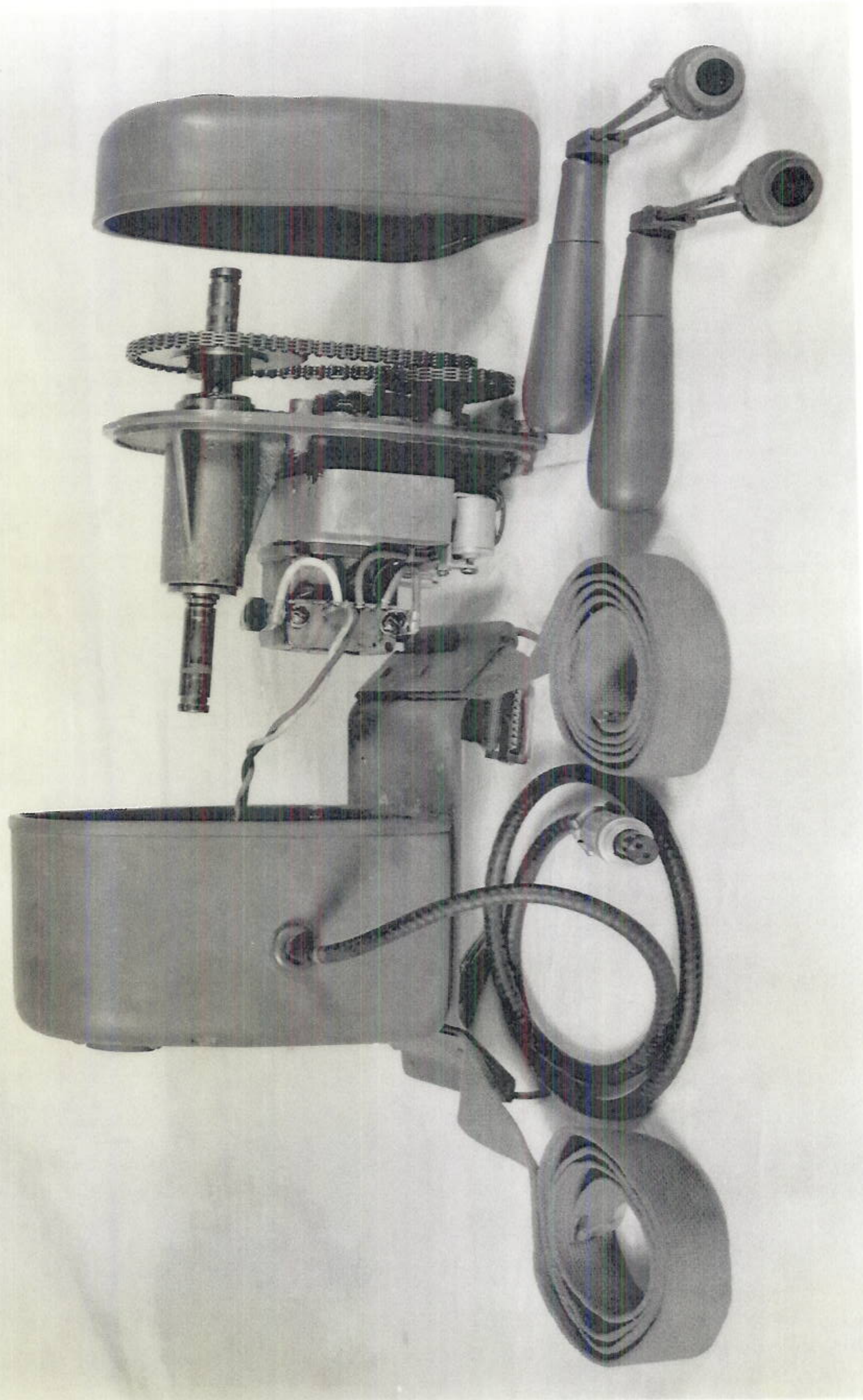


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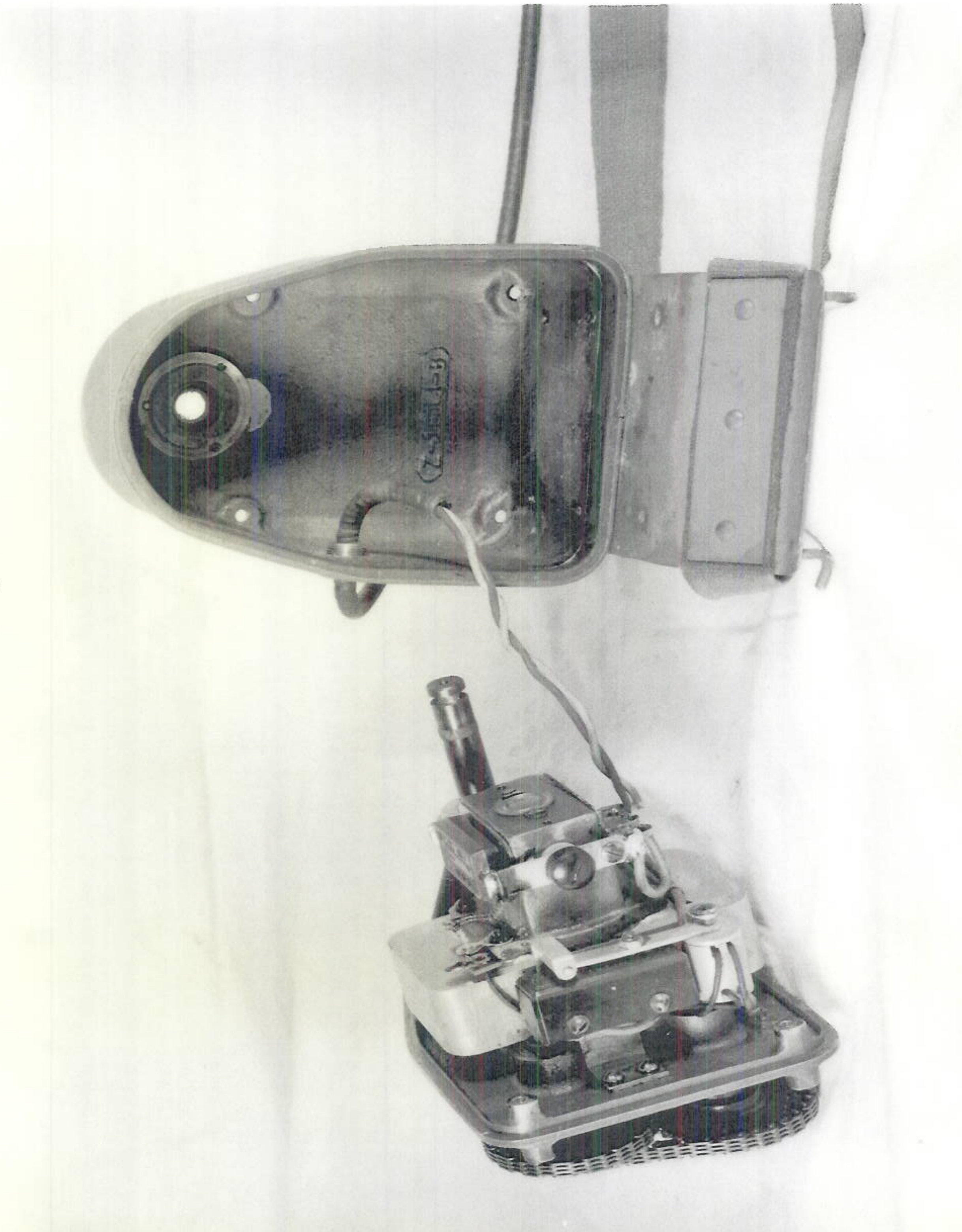
PLATE 118



DECLASSIFIED

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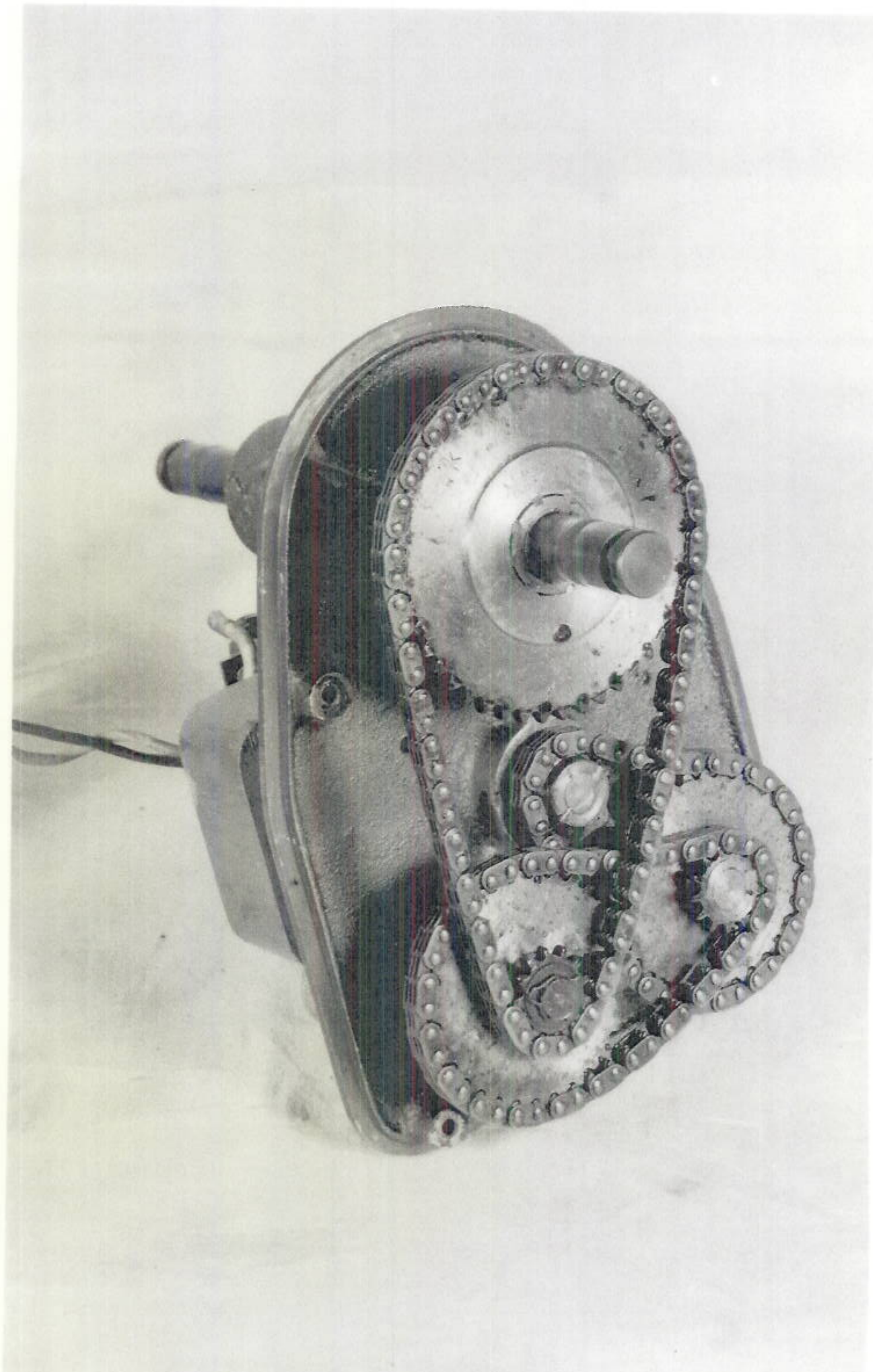
PLATE 119



DECLASSIFIED

PLATE 120

[redacted]

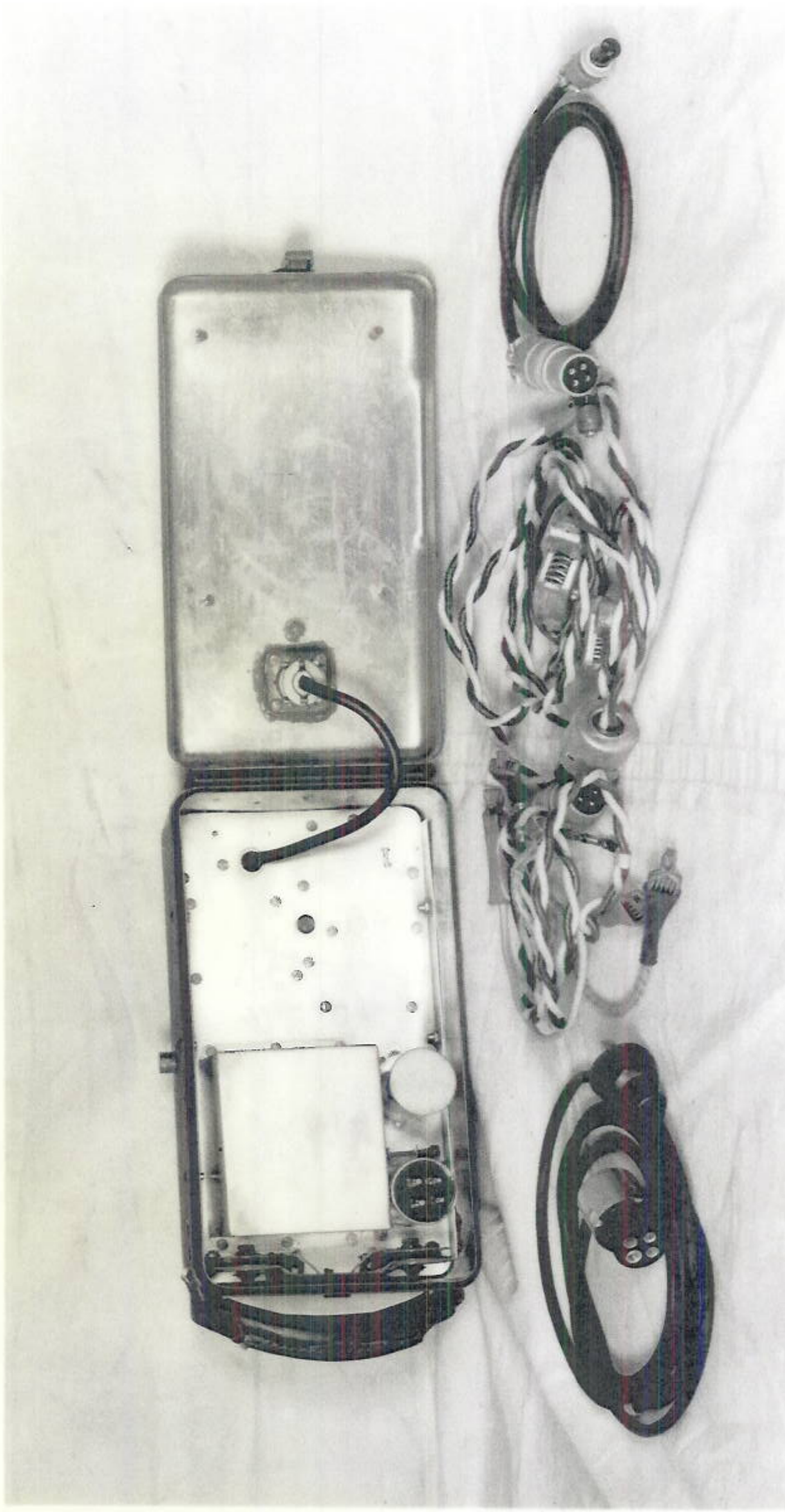
DECLASSIFIED

DECLASSIFIED

[redacted]

PLATE 121

DECLASSIFIED

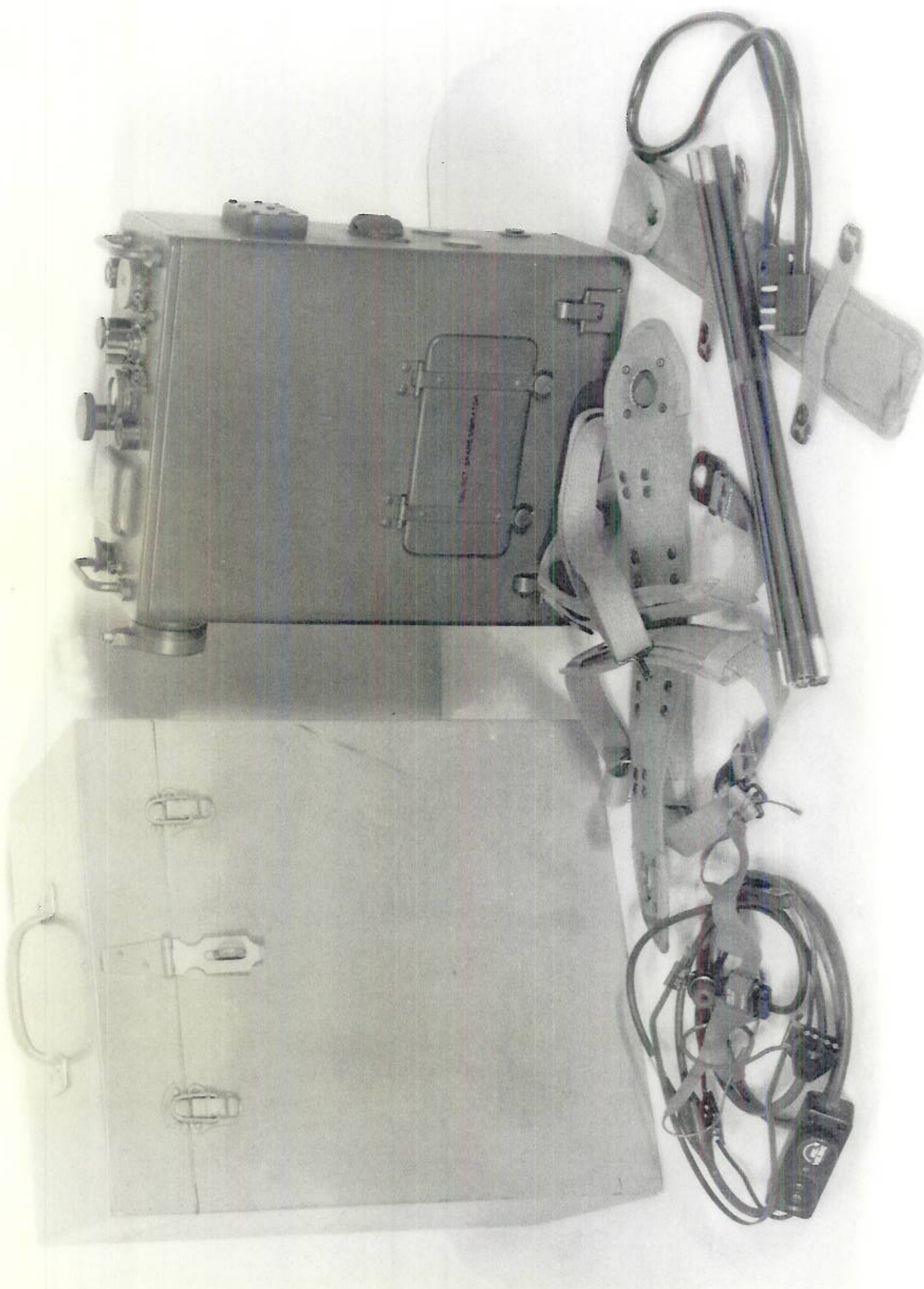


CONFIDENTIAL

DECLASSIFIED

PLATE 122

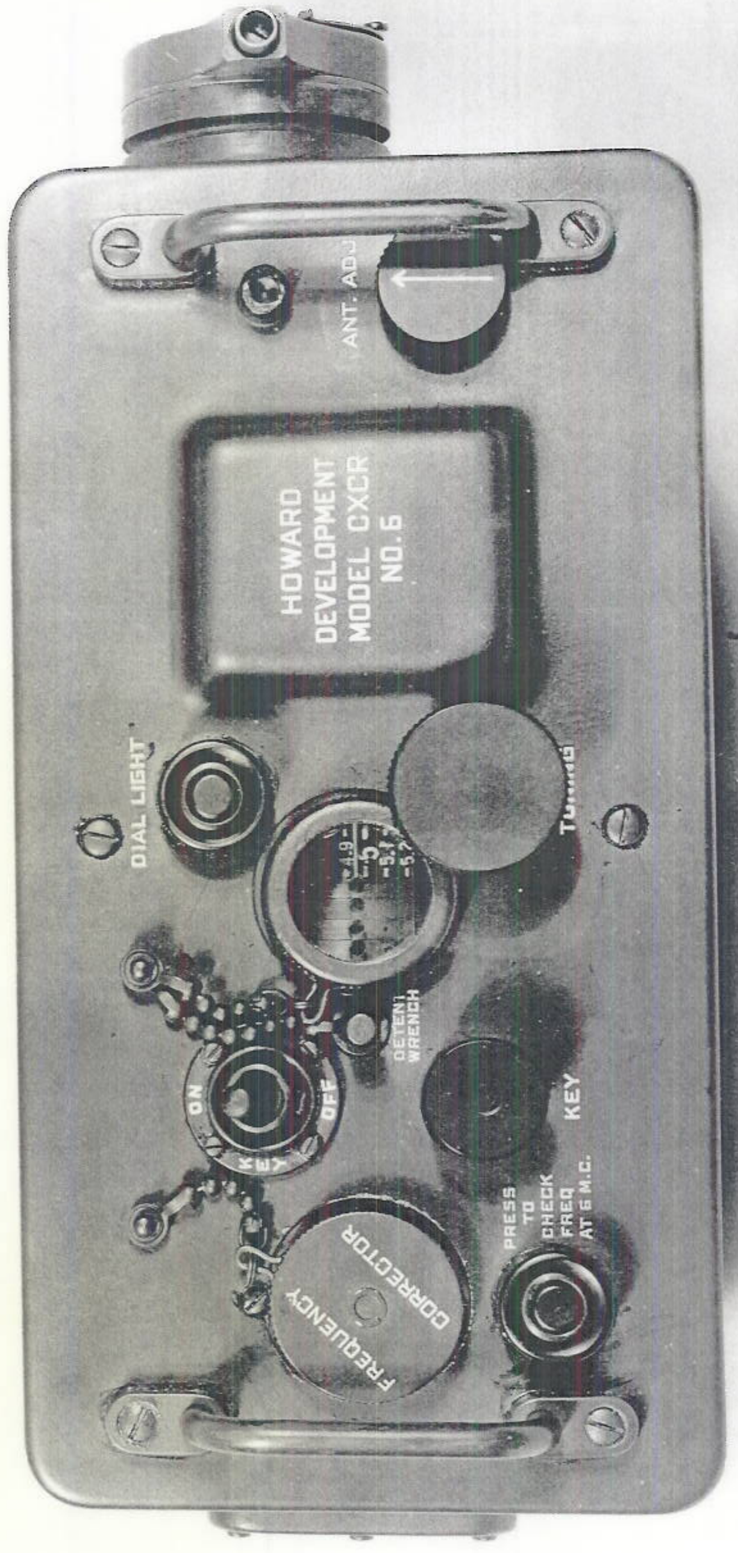
DECLASSIFIED



DECLASSIFIED

[redacted]

PLATE 123



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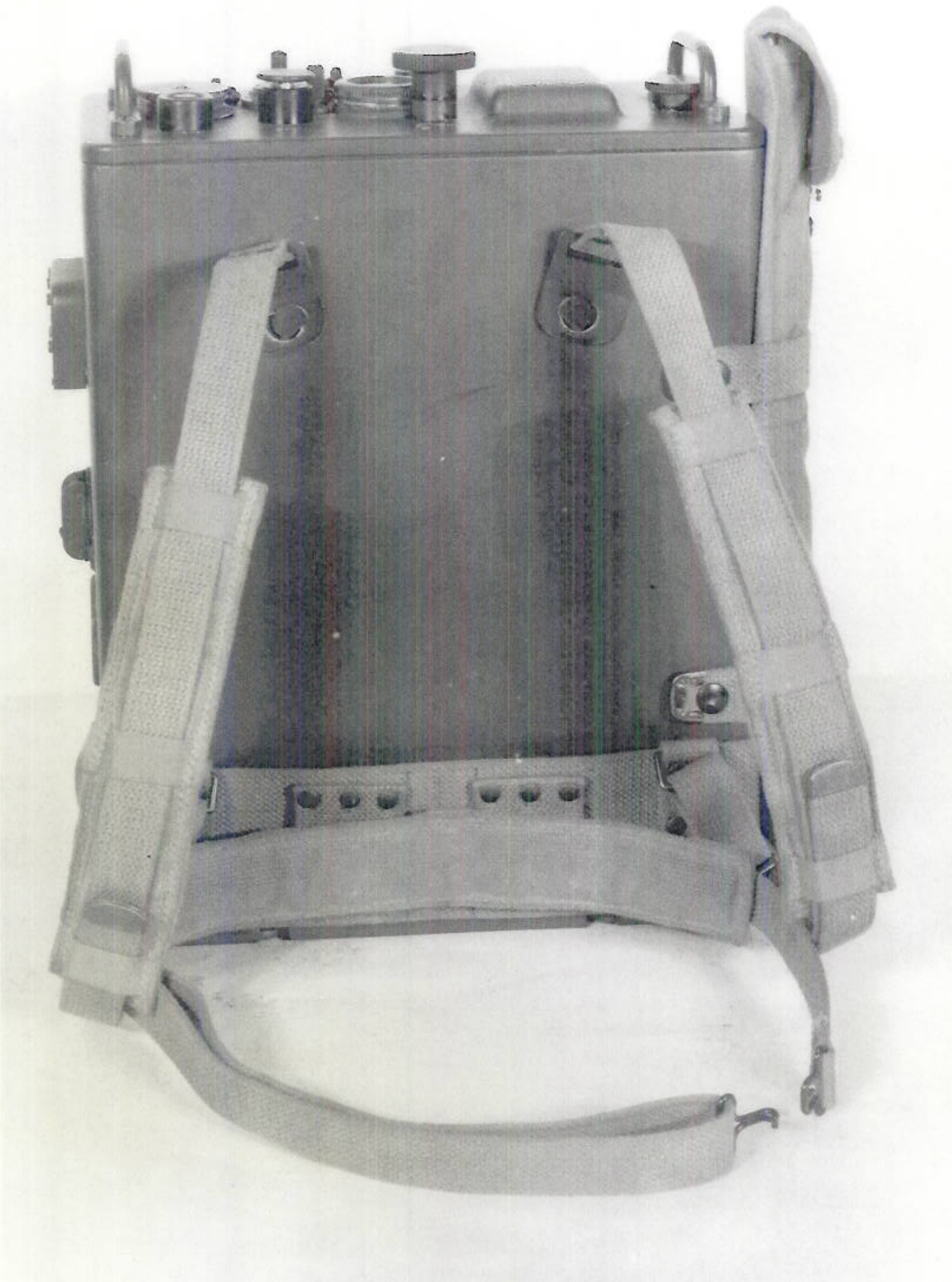
[redacted]



DECLASSIFIED