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REPORT NO. R-2254

DATE 22 March 1944

DECLASSIFIED by NRL Contract
Declassification Team
Date: 8 Aug 2016
Reviewer's name(s): A. Thompson, P. Hanna
Declassification authority: Navy Declass Guide, 11 Dec 2012, Pgs 6-7, Para 3(

SUBJECT

Test of Radio Sets SCR 608-A, SCR 609, and SCR 610

U. S. Army F-M Equipment

Confidential
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CNO ltr Op413B23 cvk
Ser 203P413 11/20/45

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WASHINGTON 20, D. C.

Mar 17 1944

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From: Director.
To: Chief of BuShips.

Subj: Radio - Test of Radio Sets SCR 608-A, SCR 609, and SCR 610 - U. S. Army F-M Equipment - Problem S471T-C - Priority "A".

Ref: (a) BuShips ltr. (938) of 1 October 1943 to NRL.

1. Under authorization contained in reference (a) the Model SCR 608-A, SCR 609, and SCR 610 frequency modulated radio sets were subjected to tests to determine the technical suitability of the equipments for Naval service. The performance of the equipments under Naval service conditions, and the desirable changes in the equipments which were revealed by the tests are discussed in the complete report of these equipments accompanying this letter as Enclosure A.

Encl:
A. NRL Report R-2254 (10 copies) dated 22 March 1944.

J. L. REINARTZ
COMDR. USNR
BY DIRECTION OF DIRECTOR
NAVAL RESEARCH LABORATORY

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NRL Report No. R-2254
BuShips Prob. S471T-C

NAVY DEPARTMENT

Report on
Test of Radio Sets SCR 608-A, SCR 609, and SCR 610
U. S. Army F-M Equipment

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 27 Tables - 26 Plates - 34

Authorization: BuShips ltr. (938) of 1 October 1943.

Date of Test: November 19, 1943 to February 15, 1944.

Tests conducted by: C. C. Pfitzer, Contract Employee

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

Reviewed by: C. B. Davis, Radio Engineer

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Approved by: for A. H. VanKeuren, Real Admiral, USN
Director, Naval Research Laboratory

Distribution: BuShips (10)

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APPENDICES

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SECTION 1

AUTHORIZATION

1-1. The tests herein reported were authorized by Bureau of Ships letter of 5 October 1943 requesting assignment of problem. NRL Problem Number S471T-C Priority A to cover tests of the SCR 608, 609, and 610 equipments was assigned.

OBJECT OF TESTS.

1-2. The object of the tests was:

(a) To determine the ability of the equipment to withstand the rigors of Naval usage.

(b) To determine the performance of the equipment when subjected to the various conditions likely to be encountered in Naval service.

(c) To determine what changes or modifications would make the equipments more capable of performing satisfactorily under Naval service conditions.

ABSTRACT OF TESTS.

1-3. The tests herein reported were conducted with a view of determining the potentialities of the equipment under Naval operating conditions. Inspection and tests were conducted as follows:

General examination of equipment.

(1) Check of vacuum tubes employed and method of mounting.

(2) Inspection of panel controls.

(3) Investigation of tuning methods.

(4) Accessibility and ease of adjustment.

(5) Wiring.

(6) Insulation.

(7) Weights and dimensions.

(8) General physical construction.

[redacted]

(9) Transmitter components. Meters, switches, resistors, fuses and capacitors.

(10) Mounting and shockproofing methods.

(11) Connection facilities.

(12) Power equipment.

Operational Data and Tests.

(1) Power output and operation into actual antenna.

(2) Frequency stability under locked-carrier conditions.

(3) Effect of temperature variations.

(4) Effect of humidity variations.

(5) Effect of inclination.

(6) Effect of vibration.

(7) Effect of shock.

(8) Effect of input voltage variation.

(9) Frequency deviation capabilities.

(10) Deviation sensitivity.

(11) Power input requirements.

(12) Power supply ripple.

(13) Fuses.

(14) Tube operating conditions.

(15) Susceptibility to damage from spray.

(16) Spare parts.

(17) Instruction books.

[redacted]

CONCLUSIONS

The SCR 608-A, 609, and 610 equipments have been designed to meet Army requirements and consequently do not have some of the features considered desirable in equipment designed specifically for Naval use. Deficiencies in antenna coupling facilities of all three equipments, the difficulty of changing operating channels to other than those originally installed in the SCR 609 and 610 equipments, the susceptibility of the SCR 608-A to corrosion, and the deleterious effects of shock and vibration have been described in this report. The equipments in their present form cannot be considered wholly acceptable for Naval service.

[redacted]

RECOMMENDATIONS

The recommendations made in this report are contingent upon the possibility of incorporating the changes after procurement. It is understood that no manufacturing changes can be effected in the production models which are now being obtained for Naval use.

On this premise, it is recommended:

(a) That the use of phenolic tube sockets be confined to the audio stages of the SCR 608-A transmitter. Par. 2-2(a).

(b) That friction tape binding for transmission line be eliminated in the SCR 608-A transmitter. Par. 2-2(a).

(c) That non-inflammable and fungus resistant hook-up wires be used in the BC 659-A and 659-B units. Par. 2-2(b).

(d) That symbol numbers be marked on the chassis instead of on the components in the SCR 609 and SCR 610 equipments. Par. 2-2(b).

(e) That consideration be given to further protecting the steel chassis and component cases in the SCR 608-A equipment. Par. 2-10.

(f) That further waterproofing of the SCR 609 and SCR 610 equipments be instituted. Par. 2-12.

(g) That supplementary rubber buffers be incorporated in the existing shock mounts for the SCR 608-A and SCR 610 equipments to prevent metal-to-metal bottoming under shock. Par. 2-15.

(h) That the spring tension on the push-button locking plate be increased. Par. 2-15.

(i) That the design of the locking device used to retain the BC 684-A transmitter in the mounting rack be improved. Par. 2-15.

(j) That 12 or 24 volt operation of the SCR 608-A be accomplished by means of suitable circuit switching without the necessity of changing dynamotors. Par. 2-20.

(k) That the noise produced by the Type DM 35-D

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MATERIAL UNDER TEST

1-4. The material under test consisted of the following:

Item (1) 1 - Type BC 684-A transmitter, a unit of U.S. Army Signal Corps Radio Set SCR 608-A, Western Electric Co., mfgr. Serial No. 9307.
Frequency Range: 27.0 to 38.9 mc.
Power Supply: Dynamotor, 12 volts d-c input.

(2) 1 - Mounting Rack FT-237.

(3) 1 - Remote Control Unit RM 29-A and canvas carrying case.

(4) 1 - Cabinet CH74-A.

(5) 1 - Mounting Rack FM-43.

(6) 1 - Antenna Mast Base MP-48.

(7) 6 - Sections of Antenna, 2 each of MS-51, 52 and 53.

(8) 1 - Microphone T-17.

(9) 1 - Headset P-23.

(10) Vacuum tubes as follows:
21 - VT 164 (RCA 1619)
3 - VT 165 (RCA 1624)

(11) 2 - Instruction books.

(12) Miscellaneous accessories including 60 additional Type FT-241 crystals.

(13) 1 - BC 659-B transmitter-receiver, a unit of U.S. Army Signal Corps Radio Set SCR 609, Galvin Manufacturing Corp., mfgr. Serial No. 216.
Frequency Range: 27.0 to 38.9 mc.
Power Supply: Dry-battery packs or vibrator power supply.

(14) 1 - Antenna - Type AN29-C.

(15) 2 - Type BA39 dry batteries.

(16) 2 - Type BA40 dry batteries.

(17) 2 - Type BA41 dry batteries.

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(18) Vacuum Tubes as follows:
4 - VT182 (Sylvania 1291)
2 - VT183 (Sylvania 1294)
8 - VT185 (Sylvania 1299)

(19) 1 - Remote Control Unit RM-29 and canvas carrying case.

(20) 2 - Technical Manuals

(21) 1 - Battery Case CS 79-C.

(22) Miscellaneous accessories including 118 type FT-243 crystals.

(23) 1 - BC 659-A transmitter-receiver, a unit of U.S. Army Signal Corps Radio Set SCR 610, Galvin Manufacturing Corp., mfgr., Serial No. 5068.
Frequency Range: 27.0 to 38.9 mc.
Power Supply: Dry-battery packs or vibrator power supply.

(24) 2 - Handsets, Type TC-13.

(25) 1 - Headset, Type HS-30F.

(26) 2 - Antennas, Type AN 29-C.

(27) 8 - Antenna Sections, 2 each of MS 50, 41, 52 and 53.

(28) 1 - Mast base bracket MP-50.

(29) 1 - Mast base MP-48.

(30) 1 - Remote Control Unit RM-29A and canvas carrying case.

(31) 2 - Technical Manuals.

(32) 1 - Mounting FT 250-C.

(33) 1 - Plate Supply Unit PE 117-C Serial No. 4863.

(34) 2 - Type BA39 dry batteries.

(35) 2 - Type BA40 dry batteries.

(36) 2 - Type BA41 dry batteries.

(37) Vacuum tubes as follows:
4 - VT182 (Sylvania 1291)
2 - VT183 (Sylvania 1299)
8 - VT185 (Sylvania 1299)

[redacted]

(38) 1 - Battery Case CS 79-C.

(39) 1 - Microphone T-17.

(40) 1 - Frame FM-43.

(41) Miscellaneous accessories including 118 Type FT-243 crystals,

1-5. Plates 101 to 130 are photographs of the SCR 608-A, 609 and 610 equipments which illustrate the above listed components and constructional features of the various units comprising the Radio Sets. The BC 659-A and 659-B are identical in construction and operation and differ only in the type of accessories furnished.

1-6. The equipments listed above were received at the Naval Research Laboratory on November 19, 1943.

METHOD OF TEST.

1-7. The equipments were well crated in wooden cases when received and the individual units were adequately packed in corrugated cartons inside the cases. All units were examined on receipt and found to be undamaged. The equipments were placed in operation with the aid of the information furnished in the instruction books.

1-8. The general construction of the transmitters was examined, and the component parts were inspected as completely as possible without destroying the various parts.

1-9. The BC 684-A transmitter was adjusted for operation at the 10 channels originally set up in the crystal holder in accordance with the procedure outlined in the instruction book. Measurements of carrier power were made by means of a lamp load and a photronic cell. A special lamp having approximately 40 ohms resistance at 16 watts dissipation was used for this load. The antenna tuning capacitors in the transmitter were left as originally received, and a 100 micromicrofarad variable capacitor was placed in series with this lamp to resonate the circuit at each of the operating frequencies. Precautions were taken to minimize the possibility of error in adjusting and maintaining the spacing and temperature of photronic cell when substituting the calibrating voltage.

1-10. Because the BC 659-A and 659-B transmitter-receivers are identical, only the BC 659-A transmitter was subjected to the majority of the tests described in this report. The Instruction Book for this equipment does not specify the characteristics of the dummy antenna into which the transmitter should

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be loaded for power output measurements. The antennas into which the equipment operate are designated however, and attempts were made to determine their characteristics by bridge measurements. Inasmuch as the antennas are not operated as grounded radiators, bridge measurements did not give conclusive results on the reactive components. The type AN29-C antenna resistance measured approximately 200 ohms over the frequency range of the equipment, and the 3-section whip antenna with a 3-foot feed line measured approximately 400 ohms. These resistances could be checked reasonably well by the substitution method of antenna characteristic determination.

1-11. Both the SCR 608-A and the SCR 610 equipments were placed inside a test chamber and subjected to controlled variations in ambient temperature and relative humidity. The SCR 608-A equipment was operated for five minutes during every 15 minute period during the test. The transmitter portion of the SCR 610 equipment was operated for 10 minutes during each 15 minute period and the receiver was continuously in operation. The frequency changes were measured with an LM-11 Heterodyne Frequency Meter. The lamp load was used as a dummy antenna for the SCR 608-A equipment, and a 30 ohm, non-inductive resistor was used to obtain the relative power output of the BC 659-A transmitter. The ambient temperature was varied between the limits of $+50^{\circ}C$ and $-30^{\circ}C$. The relative humidity was varied between the limits of approximately 30 percent and 95 percent at a temperature of $40^{\circ}C$.

1-12. The ability of the equipment to withstand pitch-roll, vibration, and shock was determined by mounting the BC 684-A transmitter and two BC 683-A receivers in the FT-237 mounting on a test platform which can produce these effects in controllable amounts. The BC 659-A transmitter-receiver and the PE 117-C supply were mounted in the FT 250-C mounting. The unmodulated carriers were monitored on a Type NC 200 receiver by means of the beat frequency oscillator in it. The quality of voice modulation was also observed on an f-m receiver at intervals throughout the test.

1-13. Tests of the audio fidelity and deviation capabilities of the equipments were made by applying the necessary audio signal across a 100 ohm resistor which was substituted for the microphone. The overall fidelity and deviation measurements were made by means of a linear f-m detector built at the Laboratory which was based on a circuit described by Seely, Kimball and Barco in RCA Review Vol. VI, Jan. 1942. This unit permits a qualitative determination of carrier shift and provides a low-distortion detector for use with an RCA 69-C Noise and Distortion Meter.

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1-14. The equipments were loaded into the antennas furnished with each, and in addition, the equipments were connected to the antennas through 5 and 15 foot lengths of RG8/U flexible coaxial transmission line and the loading characteristics of the equipments observed.

SECTION II

GENERAL DESCRIPTION

2-1. The SCR 608-A equipment comprises a Type BC 684-A crystal-controlled frequency modulated transmitter, two Type BC 683-A frequency modulation receivers, and a Type RM-29A remote telephone unit. The antenna insulators, microphones and accessories necessary for operating this equipment, with the exception of the storage batteries, are also supplied. The SCR 609 and 610 equipments are quite similar to each other electrically and mechanically, differing chiefly in the accessories provided for the different tactical operations in which the units are used. The equipments consist of a combined transmitter-receiver with associated power supplies and antennas. The SCR 609 is designed to be used as semi-portable equipment, and may be readily separated to make two units of approximately equal size and weight which can be carried by means of a shoulder strap and a leather handle attached to each. One unit is the BC 659-B transmitter-receiver, and the second is a metal case type CS-79 in which the dry batteries for operating the BC 659-B are carried. The thirteen-foot telescoping antenna collapses to a length of 13.5 inches and is carried on the top of the transmitter-receiver. In the operating position, the transmitter-receiver is placed on top of the battery case and the two units are held together by clamps attached to the outside of the cases. A short length of rubber-covered eight-conductor cable serves to connect the battery supply to the transmitter-receiver unit through a Type 97-5103-20-7S connector. A similar length of cable from the transmitter terminates in a type AN 3106-20-7P connector. The SCR 610 equipment is also comprised of a transmitter-receiver unit, with either a dry battery or a storage battery-vibrator power supply. This equipment is designed for use in vehicles, and has auxiliary equipment to adapt it for permanent mounting in them. Type RM 29A remote telephone units have been supplied with each of the above equipments. These remote telephone units are used with regular Army field telephone circuits, and have a three-position toggle switch which permits the f-m transmitter-receiver installation to be used by personnel located at a distant point. The services of the transmitter operator are necessary however to permit such remote operation.

2-2. Components and Mounting.

(a) The components of the BC 684-A transmitter

(SCR 608-A equipment) are well mounted and appear to be of good quality. The capacitors, resistors, and switches are commercial types and are available from several manufacturers. Three relays are used in the transmitter to control application of plate power, transfer the antenna from the receivers to the transmitter, and to energize the h-v dynamotor. The latter relay, S102, is rather inaccessible for replacement and the design of the receiver disabling relay S103 makes examination of the contacts very difficult. Connection facilities to the transmitter consist of a special multi-prong male connector, which is mounted to permit a small amount of lateral motion as a means of self-alignment with the associated outlet on the mounting FT-237. Tube sockets are of ceramic material, except for the first audio and crystal oscillator stages (Sockets VS 105 and VS 107) which are of phenolic material. The parts list in the instruction book indicates that all sockets except for the p-a tube are identical. It is recommended that wherever it becomes necessary in production to replace ceramic with phenolic sockets, the substitutes be confined to audio stages. Interconnecting leads have been kept reasonably short. Only small capacitors and resistors have been mounted directly on the tube socket prongs and all larger components have been secured to terminal boards or are bolted to the chassis. The power wiring has been done with stranded wire having glass braid insulation. Where feasible, groups of wires have been cabled and the general appearance is fair. Lacquered cotton tape has been wrapped around some of the cabled wires as protection against damage from chafing and as additional support for the cable. Shielded coaxial conductors have been used between the output tank circuit and the two antenna terminals. This cable is made up of brown phenolic beads inside of a tinned braid shield which is covered by a black cotton wrapper. The two cables have been bound together with friction tape, a practice which is not generally acceptable in Navy equipment. It is suggested that type RG-8/U or a similar type cable be substituted if possible. The general accessibility is reasonably good, although accessibility to the tube sockets, especially the r-f doubler (V 103) is not as good as is desirable. More careful marking of the symbol numbers on the chassis adjacent to the components would expedite the location and replacement of defective units. As protection against the effects of humidity, some of the phenolic materials such as coil forms and mica capacitor cases have been waxed. Terminal boards are of a phenolic material which does not appear to have been waxed, but since they have a hard, glazed finish, it is believed they will be satisfactory as now protected. Many of the features discussed in this paragraph can be seen in Plate 107.

(b) The BC 659-A and BC 659-B transmitters-receivers have identical components, the majority of which are commercially available from several manufacturers. Some of the bakelite cased mica capacitors used in these equipments do not appear to be of as high quality as those used in the BC 684-A transmitter but no failures of units of this type occurred during the tests. No relays have been used in this equipment. Connection facilities to the transmitter-receiver have been described in Par. 2-1. Tube sockets are of phenolic material. Waxed cotton-covered magnet wire, rubber covered stranded hook-up wire, and bare tinned No. 14 solid wire have been used for interconnecting leads between the various stages. Spaghetti insulation has been used around the r-f leads at a number of places. These types of insulation are all inflammable and susceptible to fungus attach. It is recommended that wire having non-inflammable insulation and suitable fungus resistant qualities be used in this equipment. Radio frequency leads have been kept short but it is believed some improvement could be made in the mounting of r-f choke coils, which are in many cases supported on pigtail leads longer than one-half inch. Plate 124 shows the below-chassis arrangement of BC 659-A components. General accessibility is good and the appearance of the wiring is fair. Symbol numbers are marked indiscriminately on the components or on the chassis adjacent to the component, which will cause confusion when one of the components on which the symbol is marked has been replaced with an unmarked spare unit. It is recommended that the symbol numbers be marked on the chassis adjacent to the position of the component instead of as now marked. As protection against the effects of humidity, r-f chokes, ceramic capacitors, and some phenolic capacitor cases have been waxed. A heavy white wax has been used on the r-f chokes, and a transparent type has been used on the capacitors. The receiver r-f tuning coil form and p-a tank coil form have been lacquered to seal the surface of the unglazed ceramic. A light coating of protective varnish has been applied to the phenolic coil forms used in both the receiver and transmitter portions of the unit.

(c) The power supply (PE 117-C) wiring and mounting of components are much the same as in the BC 659-A unit. An improvement could be made in the multi-conductor rubber covered power cable, in which an excessively long wire has been folded upon itself several times and bound with a bit of adhesive paper. One ten-watt resistor (R-6) in a group of three is supported on pig-tail leads longer than one-half inch. Such defects as these can be corrected by the insistence of the inspection forces upon proper techniques.

(d) One multi-range meter has been provided in each equipment to facilitate operation. A four position rotary selector switch connects the meter provided in the SR 609 and 610 equipments into four different circuits to give a relative indication of power amplifier plate and grid current, plate voltage, and filament voltages. The required shunt and multiplier resistors have been so chosen that the meter pointer deflects to the same position on the scale each time. This position is marked with a spot of radioactive phosphorescent paint. This simplification in metering makes rapid checking of operating conditions easy for inexperienced personnel. In the BC 684-A transmitter, a multirange milliameter has been provided to indicate the grid current on each of the r-f stages. A double pole 6-position rotary switch is used to transfer the meter connections from one circuit to another. The meter scale is calibrated from 0 to 100 and full-scale deflection requires from 1.2 ma to 15.2 ma depending on the circuit in which it is used. The meter is also connected to a double-pole double-throw toggle switch which transfers it from the rotary switch circuit to the output of a thermocouple which is capacitively coupled through the coaxial transmission line to the antenna. By this expedient, an indication of the antenna current is available to the operator for initial channel tuning and incidental checking of operation. Tables 23 and 24 are calibrations of these meters.

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2-3. Installation.

The SCR 608-A equipment comprises a relatively high-powered mobile communications facility and consequently requires permanent installation in a motor vehicle or a ship. The mounting racks, cabinet, and spring-base self-supporting vertical whip antenna required for installing the transmitter and receivers in a motor vehicle have been furnished as part of the SCR 608-A equipment. The procedure for vehicular installation outlined in the instruction book for the equipment is brief but adequate and can possibly be applied to shipboard installations without extensive modification. The SCR 609 equipment is designed for semi-portable applications and therefore the preparations necessary for putting the equipment into operating condition are few and simple. The SCR 610 equipment is intended for vehicular operation and more detailed installation directions appear in the joint instruction book for these equipments.

2-4. Power Supplies.

The SCR 608-A equipment is powered by individual 12 or 24 volt d-c dynamotors incorporated in the BC 684-A transmitter and BC 683-A receivers. The storage battery of the vehicle in which the equipment is installed is used to supply the required power for these components. The transmitter dynamotor is rated only for intermittent duty and although it continued operating for a period of 1 hour and 30 minutes under key-locked operation, the heating was considerable and would damage the windings with repetition. All bias and filament voltages necessary for operation of the SCR 608-A equipment are provided by the storage battery and dynamotors. The SCR 609 equipment is operated from dry battery packs which are carried in a metal case approximately the same size as the BC 659-B transmitter-receiver cabinet, to which it can be readily attached. An Army type BA40 dry battery pack supplies power for the receiver portion of the BC 659-B, and a type BA39 dry battery pack furnishes the transmitter power. These batteries are required in addition to the type BA-41 bias pack used for the automatic frequency stabilizing circuit in the transmitter portion of the equipment. To supply power for the BC 659-A equipment (SCR 610) a vibrator power unit has been provided. It is designated as "Plate Supply Unit PE 117-C" and operates from a six or twelve volt vehicle storage battery. The PE 117-C can be used interchangeably with the dry battery supply for operating the SCR 609 equipment although its output voltages are lower than those obtainable with the dry battery packs.

2-5. Frequency Range and Operation.

(a) A group of ten crystals can be selected from the 120 supplied with the SCR 608-A equipment and

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installed in a heat-insulated compartment in the BC 684-A transmitter. A snap-type thermostat controls approximately 30 watts of heating power supplied to this compartment when the inside temperature drops below 21 degrees centigrade. This provision tends to limit the range of ambient temperatures to which the crystals are subjected but the heating does not provide the degree of heat control found in the heated m-o compartments of Navy transmitters. After the initial adjustments have been made, which consist chiefly of resonating the antenna circuits by means of trimmer capacitors, operating procedure is simple. A push-to-talk switch in the microphone applies power to the transmitter dynamotor and operates the antenna transfer relay which connects the transmitter output to the antenna. Selection of a crystal controlled channel is made by depressing the proper push button in a bank of ten on the front of the transmitter. These pushbuttons are mechanically interlocked so that only one can be operated at a time. To the channel selector push buttons are connected the tuning capacitors of the various r-f stages of the transmitter, so that tuning to the desired operating frequency is simultaneously accomplished when a pushbutton is depressed. This method of transmitter operation permits rapid change of frequency to any one of the ten previously selected channels. Channels have been spaced 100 kc apart between 27 and 38.9 mcs. The flexibility and surety afforded by crystal control and pushbutton tuning should be advantageous in services where attempts are made by the enemy to jam communications nets.

(b) The SCR 609 and 610 equipments are designed to operate in the same frequency spectrum as the SCR 608-A, and presumably in conjunction with the latter equipment as well as independently. Consequently, a total of 120 crystals has been furnished as necessary spares in each of these equipments to correspond with those furnished for the SCR 609-A. Only two channels are available at any one time, however. Selection of the desired operating channel is effected by means of a two-position rotary switch which connects preset variable capacitors across the tank circuit inductance in each stage of the transmitter and each stage of the receiver ahead of the mixer tube. Plate and filament power are continuously supplied to the receiver during operation. Plate power is also continuously applied to the transmitter but filament power is controlled by the press-to-talk switch in the carbon microphone. The receiver is capacitively coupled to the transmitter p-a tank circuit and a portion of the transmitter energy is thus fed into the receiver. This signal is rectified in the discriminator detector and is used to control the frequency of the transmitter by means of a direct coupled amplifier which determines the operating bias on the reactance modulator. In this manner a good approximation of crystal controlled frequency stability can be maintained in the transmitter.

(c) Changing the selection of crystals in the SCR 608-A transmitter requires the retuning of all the radio frequency stages. The correct procedure has been adequately described in the instruction book and can be readily performed by moderately skilled operating personnel without the use of any additional equipment except a screw driver.

(d) To change to an operating frequency other than that afforded by either of the crystals originally supplied in the SCR 609 and 610 equipments is a rather involved procedure which cannot be performed in the field. A vacuum tube voltmeter is necessary for the alignment, and a signal generator is also desirable. A total of 14 variable capacitors must be adjusted to resonate the r-f stages of the receiver and transmitter to the frequencies determined by the choice of crystals plugged into the receiver. Detailed instructions have been included in the Instruction Book for the steps necessary to change frequencies. Adjustment of the transmitter oscillator was found to be the most critical step in the alignment process although the interaction between the multiplier stages, and between the receiver and transmitter, complicates the entire operation. These conditions require, therefore, that the frequency adjustment be made by an experienced man who has the proper facilities available for the work.

RESULTS OF TESTS.

2-6. Weights and Dimensions.

The weights and dimensions of the equipments are shown in Table 1. It can be seen that the SCR 609, although portable, is in no sense a "Walkie Talkie" or back pack equipment and cannot

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be operated while being carried. Views of the complete equipments appear in Plates 101, 111, and 117 which show respectively the SCR 608-A, SCR 609, and SCR 610 Radio sets.

2-7. Measurement of Power Output.

The Instruction Book for the SCR 608-A equipment specifies a dummy antenna of 40 ohms resistance to be used when measuring the power output obtainable from the BC 684-A transmitter. The transmitter was therefore loaded into a lamp bulb having approximately 40 ohms resistance at 16 watts dissipation. The antenna tuning controls of the transmitter were left as originally received. To effect resonance, a 100 uuf variable capacitor was connected in series with the load lamp and adjusted to produce maximum antenna current at each of the operating frequencies provided. The data obtained in this test appear in Table 2. There was an appreciable difference in the power outputs obtained on the various channels despite the external variable capacitor having been tuned to produce maximum antenna current at each of the frequencies shown. It is stated in the Instruction Book that the transmitter may be operated into an antenna which is a quarter wavelength long at some midband frequency; it may be operated into a half-wave antenna over a limited range of frequencies depending on the coupling adjustment in the transmitter. The transmitter must be connected to the antenna by a 2-foot length of stranded wire which has been provided with the equipment. A fitting has also been provided in the antenna mast base to terminate a flexible coaxial transmission line if the antenna must be located more than 2 feet from the transmitter. A line of this type is listed as a part of the SCR 608-A equipment, but none was furnished for test. To determine the operation of this transmitter into the quarter and half-wave antennas, a five-foot and a fifteen-foot length of RG-8/U flexible transmission line were used to connect the transmitter to the antenna. Measurements of the antenna current at the base of the antenna were made at each operating frequency and these data appear in Table 3. It may be noted that changing the length of the transmission line had more effect on the antenna current than changing the length of the antenna. It was observed that the longer transmission line did not permit tuning the transmitter at the low and high ends of the band with the degree of coupling set by the manufacturer. The position of the coupling inductance in the antenna circuit can be changed by means of a sliding adjustment provided on the ceramic forms which support the p-a tank inductance and the antenna coupling coil. Although the instruction book indicates that this inductance is calibrated for 3 positions, no such calibration appears on the control. The instruction book for the SCR 609 and 610 equipments does not specify the characteristics of the dummy antenna into which the transmitter should be loaded for power output measurements. The antennas, however, are designated, the attempts were made to determine their

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characteristics by bridge measurements. Inasmuch as the antennas are not operated as grounded radiators, bridge measurements did not give conclusive results on the reactive component of the antenna impedance but reproducible values were obtained for the resistive components. The type AN 29-C antenna resistance measured approximately 200 ohms over the frequency range of the equipment and the 3-section whip antenna, with a 3-foot feed line, measured approximately 400 ohms. These resistance values could be checked reasonably well by the substitution method of antenna characteristic determinaltion. The power output obtainable in a 203 ohm load is shown in Table 4. Although the instruction book indicates that the transmitter power output is 2 watts, the power obtained at the Laboratory with either a low resistance or high resistance antenna was usually less than one watt. Table 5 contains data showing the operation of the BC 659-A transmitter into the two types of antennas with open wire and concentric transmission lines.

2-8. Locked Carrier Operation.

The BC 684-A (SCR 608-A) transmitter is not intended for continuous operation. However an attempt was made to obtain data on frequency drift under continuous key-locked operation and the equipment was operated a total of one and one half hours before excessive heating occurred. The data obtained appear in Table 6. The decrease in power observed is attributable chiefly to the heating of the dynamotor and the consequent reduction of output voltage. Table 7 is comprised of the data for a similar test conducted on the BC 659-A (SCR 610) transmitter with which the vibrator power unit PE 117-C was used. It will be noted that although the plate power input exhibited a random variation tendency, the frequency stability of the transmitter was not measurably affected.

2-9. Temperature Variations.

The SCR 608-A and SCR 610 equipments were subjected to temperatures ranging from +50°C to -30°C. Arrangements were made to operate the BC 684-A transmitter for the first five minutes of each fifteen minute period during the test and the BC 659-A transmitter operated during the remaining ten minutes of each period. This permitted frequency measurements to be made on each unit without interference and provided the intermittent operating conditions for which the BC 684-A transmitter is designed. Table 8 contains the data indicative of the changes observed in the operation of the BC 684-A transmitter. Table 9 is comprised of data obtained during the same tests on the SCR 610 equipment. The better stability of the crystal controlled SCR 608-A equipment is evident when a comparison between the data of the two tables is made. In either case however, the frequency change is a very small percentage of the carrier frequency.

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2-10. Humidity Variations.

The SCR 608-A and SCR 610 equipments were subjected to the usual high humidity tests which standard Navy equipment undergo. These data appear in Tables 10 and 11. The sealed construction of the SCR 610 shows to advantage in the performance of the BC 659-A transmitter under high humidity conditions, for no frequency changes attributable to the high humidity were observed. There was some change in frequency observed in the BC 684-A transmitter during this test however. The high humidity conditions seriously affected the plating on the majority of metal-cased components in the SCR 608-A equipment. The steel chassis and component cases have been zinc plated, which, under the high humidity conditions, formed a heavy deposit of zinc oxide on the interior surfaces of the equipment. The painted steel outer surfaces of the SCR 608-A equipment were not noticeably affected. It is believed that the moist salt atmosphere encountered in tropical countries would rapidly destroy the serviceability of this equipment unless more adequate protection is given to the plated steel surfaces. It is recommended that consideration be given to applying a waterproof varnished finish to all steel and zinc plated surfaces not required for electrical bonding. No corrosion was observed in the SCR 610 equipment. A plating resembling cadmium has been used on the chassis and shielded component cases.

2-11. Cold Start Test.

The equipments were subjected to a cold start test in which they were shut down completely for two and one-half hours in an ambient temperature of minus thirty degrees centigrate. At the end of this period, the dynamotors in the SCR 608-A equipment started satisfactorily, all pushbuttons operated without undue stiffness and normal power output was obtained on all ten channels. All controls in the SCR 610 equipment were also satisfactorily operative.

2-12. Effects of Prolonged High Humidity on Idle Equipment.

The equipments remained off for a two hour period during which the relative humidity in the test chamber was maintained in excess of 95 percent at an ambient temperature of 40°C. When the BC 684-A transmitter (SCR 608-A) was turned on, no r-f power was obtained, and reversed grid current was observed in the doubler and power amplifier stages. It was necessary to shut down the transmitter because of the overload present on the last two transmitter stages. Inspection of the equipment revealed small amounts of condensed moisture on various components and arc-over between rotor and stator plates of C-113 in the plate circuit of the tripler stage. This capacitor is one portion of the ganged main tuning capacitor. Twelve hours later the

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equipment had dried out and it was found to operate normally without requiring any servicing. The BC 659-A transmitter was less affected by this test but for approximately fifteen minutes after it was turned on instability was observed in the p-a plate current and power output. This cleared itself however and no further difficulty was encountered. The open construction of the SCR 608-A equipment would nullify the effects of any dessicator unit which might be installed to prevent the failure encountered in this test. The use of ceramic coil forms to replace the bakelite one now used in the low frequency stages, non-hygroscopic insulation on hookup wiring and terminal boards, together with the precaution of waxing of components should minimize failures from this cause. A glass-fiber bag filled with a dry chemical dessicator has been incorporated in the SCR 609 and SCR 610 equipments to absorb what moisture seeps through the rubber-gasketed openings into the interior. The erratic operation noted in this equipment after the comparatively short duration of this test indicates the inadequacy of the protection now provided. It is recommended that further waterproofing in both types of equipment be instituted. In this connection it is suggested that the Bureau review the work being undertaken by the Signal Corps on this equipment in addition to what has been done along parallel lines by this Laboratory.

2-13. Effect of Inclination.

The SCR 608-A and SCR 610 equipments were secured on a special test platform by means of the mounting bases provided with each unit for inclination, vibration, and shock tests. The equipments were subjected first to a 30 minute period of side-to-side inclination during which the unmodulated carrier was monitored on a receiver by means of a beat oscillator. There was inappreciable frequency change in the beat note as the SCR equipments were inclined through an angle of 45° each side of the vertical. Front-to-back inclination of the equipments for 30 minutes likewise caused inappreciable changes in beat note frequency. No mechanical difficulties arose during this test.

2-14. Effect of Vibration.

The equipments mounted as described in paragraph 2-13 were subjected to vibration frequencies ranging from 300 to 1900 cycles per minute for a total period of one hour. The modulated signals from both transmitters were monitored on the associated receivers. The carrier alone was monitored on an amplitude modulation receiver by means of the beat note method previously mentioned. An audio noise modulation was evident in the signal from the BC 659-A (SCR 610) transmitter which followed the changing vibrating frequencies of the platform. The frequency deviation produced by this modulation was rather low, and would consequently be unnoticeable with the normal deviation produced by voice

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modulation. A vibration frequency of approximately 500 cycles per minute produced a resonance effect in the BC 659-A transmitter which caused a maximum of 0.14 inches displacement of the unit. At all other vibration frequencies the shock mounts were effective in attenuating the vibrational acceleration satisfactorily. The SCR 608 equipment has a natural resonance period at approximately 450 cycles per minute, which produced a displacement of 0.16 inches. No damage resulted in either equipment from this test.

2-15. Effects of Shock.

A total of forty-eight shocks were applied to the table on which the equipments were mounted, twelve shocks being directed toward each of the four sides of the transmitters. These shocks produced inappreciable frequency changes in the two transmitters. On the first shock directed toward the left side of the BC 684-A transmitter the crystal oscillator tube (Type 1619) failed and was replaced. On the 25th shock, which was directed toward the right side of the equipment, the high voltage plate supply fuse blew, due to a momentary short in the Type 1624 p-a tube. No tube failures occurred in the SCR 610 equipment. The shock mounts now furnished with these equipments tend to bottom under the shocks administered by the Laboratory shock device. It is recommended that additional rubber buffers be incorporated in the existing shock-mount design to prevent mètal-to-metal contact and consequent high impact shocks from this cause. It is believed that such provision will reduce the number of tube failures which will occur from this contributory cause. The hold-in latches on the push-button mechanisms of the BC 683-A receivers and BC 684-A transmitter are inadequate to retain a selected channel in its operating position when shocks are directed toward the front or rear of the equipment, A spring loaded locking plate is used to latch the individual pushbuttons. It is recommended that the spring tension be increased on this locking plate to prevent the undesired release of these pushbuttons under shock. The shocks applied toward the left side of the SCR 608-A equipment bent one of the two bolts securing the BC 684-A transmitter to the mounting base. It is recommended that suitable provision be made to prevent movement of the transmitter under shock and eliminate the possibility of shearing these bolts by the heavy transmitter unit.

2-16. Effects of Input Voltage Variation. The effects of varying the input voltage to the transmitters appear in Tables 12 and 13. No frequency changes were observed in either equipment as a result of the reduction or increase in the input voltage to the equipments. The battery voltage for the BC 684-A transmitter was decreased from its normal value of 12 volts to approximately 4.5 volts before the control relays in the equipment ceased to hold in, so it may be assumed that the reduction

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in output power is attributable to reduced emission and plate voltage in the transmitter. The negligible output power obtained at the lower battery voltages with the BC 659-A transmitter can likewise be attributed to low plate and filament potentials, inasmuch as there no relays in the transmitter circuit.

2-17. Battery Life Test.

A battery life test was conducted on the SCR 609 equipment using the dry battery supply which consists of a Type BA 39 pack for the transmitter, and a Type BA 40 for the receiver. The transmitter was operated 1 minute in every 5 minutes. The test continued for a total of 102 hours before the transmitter battery became exhausted. During this time it was necessary to replace the type BA 40 receiver battery twice due to low filament voltage. This indicates that the two packs have not been designed to become exhausted at approximately the same time. Neither of these battery packs are listed as standard U. S. Navy Dry Battery types as of 1942.

2-18. Frequency Deviation Capabilities. The instruction book for the SCR 608-A equipment indicates that a peak deviation of plus and minus 110 kc is obtainable; the nominal value of the transmitter deviation is plus and minus 40 kc. The BC 683-A receivers are designed for a nominal band pass of 80 kc. The instruction booklet for the SCR 609-SCR 610 equipment contains no information as to the receiver band pass characteristics and the transmitter deviation capabilities. Preliminary measurements of the BC 683-A receiver indicates that it has a band pass of approximately 40 kc on the low frequency channels, and 50 kc on the higher frequency channels. The BC 684-A transmitter deviation capabilities are shown in Table 14 and appear graphically in Plate 1. Preliminary measurements of the band pass characteristics of the BC 659-A receiver show that it is considerably less than the BC 683-A receiver on the lower frequency channels, being approximately 25 kc, and increasing to 40 kc on the higher frequency channels. The deviation capabilities of the BC 659-A transmitter appear in Table 15 and graphically in Plate 2. The increased deviation resulting from the higher modulating frequencies is a desirable characteristic in f-m transmitters, inasmuch as it produces a more favorable signal-to-noise ratio in the receiver. Such accentuation normally requires a de-emphasizing circuit in associated receivers to restore the relative amplitudes present in the original modulating signal. It will be observed that the SCR 610 transmitter is incapable of producing as much deviation as is obtainable with the SCR 608-A. This fact coupled with the comparatively narrow band pass of the SCR 610 receiver imposes a limitation on operation when communication is to be effected between the SCR 608-A and 610 equipments. The SCR 608-A equipment may be arbitrarily classed as wide-band f-m in comparison to the SCR 610, although this classi-

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fication is not in accordance with Federal Communications Commission definitions. A wide-band f-m transmitter can be received on a narrow-band f-m receiver if the transmitter operator reduces the audio level of the modulating signal. In the case of the BC 684-A transmitter this would simply amount to holding the microphone slightly away from the lips instead of close up as would normally be done inasmuch as no provision has been made for controlling the output of the modulator. It is also pointed out that the low-deviation signals can be satisfactorily monitored on an amplitude modulation receiver whereas wide-band f-m cannot be as successfully intercepted. The signals of both the SCR 608-A and the SCR 610 transmitters were received with understandable clarity on a Navy type RBG receiver and a National type NC 200 receiver although the SCR 608-A produced some distortion in the receiver output when the transmitter deviation was increased.

2-19. Deviation Sensitivity.

The deviation sensitivity of the SCR 608-A and SCR 610 transmitters appear in Tables 16 and 17, and graphically in Plates 3 and 4. The data show that the response of the BC 684-A transmitter is rather poor at the low frequencies, and requires more modulating signal voltage than the BC 659-A unit. The deviations of both transmitters are reasonably linear with modulating voltage, however.

2-20. Power Input Requirements.

The power input requirements of the SCR 608-A equipment are shown in Table 18 for a number of test conditions. The combination of two receivers and the transmitter imposes a very heavy drain on the storage battery supply for the SCR 608-A equipment and will require ample charging facilities in addition to heavy duty types of batteries for satisfactory operation. To operate the SCR 608-A equipment from a 24-volt dc input requires the installation of a 24-volt dynamotor in the receiver and transmitter instead of the 12-volt units now furnished in each. It is recommended that consideration be given to providing greater flexibility than is now afforded in accommodating either 12 or 24 volt d-c inputs for this equipment when used in Naval service. The power input requirements for 6 and 12 volt operation of the SCR 610 equipment using the PE 117-C vibrator power supply appear in Table 19. Changeover links on the vibrator transformer and dropping resistors provide flexibility for 6 or 12 volt operation. The efficiency of the power supply is not as high on 12 volt operation as it is when a 6 volt supply is used, although somewhat higher output voltages are obtainable.

2-21. Power Supply Ripple.

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(a) The ripple voltages measured in the output of the dynamotor supply of the BC 684-A Serial No. 9307 transmitter are as follows:

Dynamotor No.	Output Volts	Peak Ripple Volts	Percent Ripple
4163	570	8.35	1.5
4334	590	46.6	7.9

The No. 4163 dynamotor was obtained for comparison purposes from the Serial No. 9590 transmitter supplied to the Laboratory but which was not under test. This ripple produced both frequency and amplitude modulation of the carrier which appeared as an objectionable background noise whenever the transmitter was turned on. These percentages are very much higher than are tolerated in standard Naval communications equipment. All attempts to bypass the ripple with capacitors were futile. The source of the noise was found to be the motor, and the noises produced by commutation of the motor are conducted by the input leads back to the battery and from there distributed to all the tubes in the transmitter through the filament circuits. This condition suggests improper commutation and misalignment of the brushes. The brush rigging is not adjustable in this type of dynamotor. In an attempt to isolate the source of the noise, an iron core inductance was placed in the positive battery lead at the motor input terminal and it was found to be effective in eliminating the objectionable noise. The following data shows the operating conditions before and after insertion of the inductance.

Point of Measurement	*Measured Voltage*	
	Without Series Inductance	*With Series Inductance*
MG Input	*12 d-c*	*11.9 d-c*
Noise Voltage on MG input	*0.32 rms*	*0.005 rms* (on battery side of filter)
Dynamotor Output Volts	595.0 d-c	575.0 d-c
Noise Voltage on Dyn. Output	10.8 rms	7.7 rms
Noise Measured Across L104 in BC 684-A	0.09 rms	0.014 rms

The noise voltage across L104 produces frequency

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modulation and does not appear on the carrier as a ripple voltage as the term is commonly used in connection with amplitude modulated carriers. Actual amplitude carrier ripple amounted to only 0.74 percent in the SCR 608-A equipment. It is recommended that the noise produced by the dynamotor supply be eliminated, because, from a security standpoint, such an identifiable signal is a definite hazard.

(b) The ripple voltage appearing in the output of the PE 117-C Power Unit was measured and appeared as follows:

Input		Output	Peak Ripple	Percent
Volts	Amps.	Volts	Volts	Ripple
6	3.4	95	0.05	0.15
12	2.8	123	Less than 0.01 volts	Negligible

The amplitude ripple voltage appearing in the carrier was in the order of 0.1 percent; negligible carrier deviation was observed. As mentioned in Par.2-21(a),the ripple voltage appearing on an f-m carrier as a result of inadepuate transmitter power supply filter does not have the same significance that it has in connection with an amplitude modulated carrier. It has been found that a 2 percent ripple voltage is not objectionalbe in the latter, but from the observations made of the signal from the SCR 608-A, only a very small deviation voltage can be tolerated if the carrier noise is not to be objectionable.

2-22. Fuses.

A Littelfuse type 4AG 1/2-ampere fuse has been placed in the positive side of the DM 35-D dynamotor output in the BC 684-A transmitter. This is held in a Littelfuse type 1212 holder. A spare fuse is carried in a second holder mounted adjacent to the active fuse. Full load operating current through the fuse is 190 milliamperes. The type 4AG fuse has a maximum voltage rating of 500 volts, but in this equipment, the fuse is used in a 600 volt circuit. It is recommended that the fuse be changed to one having a current rating of 250 ma. It is believed that this reduction will permit the use of a 4AG fuse with greater safety in the 600 volt circuit and will not necessitate changing to high voltage types which would be physically larger. A Western Electric Type 66B, 75-ampere link

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type fuse is connected in the positive battery lead in the Model FT 237D Mounting. This fuse is not contained in an insulated cartridge but is simply mounted on a piece of bakelite by means of two wing nuts. A clearance of approximately 1 inch is provided between the fuse and the metal cover of the fuse compartment. The maximum operating current measured through this fuse was 33 amperes. It is recommended that a standard insulated 40-ampere fuse be inserted in place of the one now provided inasmuch as the 75-ampere fuse will provide no material protection for the equipment. A 1/4-ampere Littelfuse instrument type fuse has been supplied in the BC 659-A and B units in the transmitter high voltage supply. The maximum operating current measured through this fuse was approximately 40 milliamperes. The input of the PE 117-C Power Unit has a 6-ampere type 3AG fuse for protection of the battery. The maximum input current measured in this unit was 3.5 amperes with a 6 volt supply. It is recommended that a 5-ampere fuse be used in this application.

2-23. Tube Operating Potentials.

A total of eight Navy Type 1619 and 1624 tubes have been used in the BC 684-A transmitter; one 1624 serves as the final p-a, and the remaining seven 1619 tubes function as radio frequency and audio frequency amplifiers. Loktal type tubes manufactured by Sylvania have been used in the BC 659-A and 659-B equipments, (SCR 610 and SCR 609 sets respectively). The potentials and operating currents of the vacuum tubes in the BC 684-A transmitter appear in Table 20. Similar data for the BC 659-A transmitter and the PE 117-C power supply appear in Tables 21 and 22. The operating potentials in the BC 684-A transmitter are within JAN-1A specification limits except for the filament voltages of V-101, V-104 and V-107 which are in excess of the limits. The filaments of V-101 and V-107 are in series with those of V-105 and V-106 which have potential drops across them within specification limits. The filament of V-104 is connected in series with V-102, V-103 and V-108 which also have potential drops across them that are within specification limits. It is probable that individual differences in filament resistances of the tubes cause this overload condition, and no correction can be made. In the BC 659-A transmitter, the filament potential of the p-a stage is in excess of specification limitations. The filament power for all four transmitting tubes is identical, but as the circuit is now arranged, so-called filament potential equalizing resistors are connected across the reactance modulator and the buffer filaments. Therefore it is recommended that a similar resistor be provided for the p-a filaments in order to equalize the potential drops across all transmitter tubes and eliminate the overload which now exists. The two tubes in the PE 117-C Power Supply are operated within specification limits. However, it was noted that the VR-90 is erratic in operation due to insufficient voltage to maintain ionization. When the SCR 610 equipment

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is first turned on, with a storage battery potential either 12.2 volts or 6.2 volts, the VR-90 ionizes properly at approximately its ionization potential of 127 volts, and the tube regulates the voltage drop across it to approximately 90 volts. A 1000-ohm 10-watt resistor (R-7) in series with the tube limits the current through the tube to approximately 25 milliamperes. When the transmitter is turned on by means of the microphone switch, the additional current drawn by the transmitter reactance modulator and r-f oscillator through this resistor lowers the potential applied to the tube sufficiently to stop ionization. When the operating condition is again restored to receive, the maximum voltage which is then applied to the VR-90 is 110 volts, which is 17 volts less than the minimum required for ionization of the tube, and the tube fails to ignite. Since this regulated voltage is desirable to aid in maintaining the frequency stability of the transmitter reactance modulator and r-f oscillator, it is recommended that the necessary changes be made to insure continuous ionization of the VR-90 tube during transmission and reception.

2-24. <u>Spray Test.</u>

To ascertain the protection against saltspray afforded by the cabinet, CH 74A, of the SCR 608-A equipment, it was subjected to spray from a hose for 15 minutes. During this test the canvas cover flap was buttoned over the cabinet opening by the fasteners provided along its edge. The BC 683-A receivers and the BC 684-A transmitter were not installed in the cabinet during this test. It was found that water splashed inside the cabinet sufficiently to wet the bottom approximately two-thirds of the total cabinet depth. Auxiliary holes have been punched in the cabinet to bring the antenna transmission line through, and to pass mounting bolts for the cabinet. Unless these openings are used in an installation they should be closed by a suitable plug. The SCR 609 and SCR 610 equipments were also sprayed for 15 minutes each and were satisfactorily free of moisture at the end of this period. Waterproof canvas covers (BG 153) have been furnished to cover the SCR 609 and SCR 610 equipments when set up in the field. These were found to withstand the spray satisfactorily. These covers supplement the nearly watertight construction of the equipment and serve chiefly to keep rain off the front panel controls and antenna terminal when the equipment is not in use but remains on the ground exposed to weather.

2-25. <u>Field Tests and Portability.</u>

No field tests were conducted with any of the SCR equipments by the Laboratory inasmuch as it is felt that the Signal Corps has much more comprehensive data on the performance of the various units than would be possible to obtain from the comparatively few conditions which could be set up in the time and space available to the Laboratory for the purpose. However, the

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following comments are based on observations made to determine the suitability of the equipments for portable and night operation.

(a) The SCR 608-A equipment cannot be carried as a pack load, and is designed only for vehicular transportation. It can be operated from such transportation either when in motion or when stationary. Simplicity of operation is assured by the push-button tuning provisions, and no difficulty is anticipated in setting up and maintaining communications nets on any of the ten channels. Since there are no tuning controls or calibrated dials on this equipment which must be adjusted when changing frequencies once the equipment has been initially tuned with the antenna, no illumination is necessary for these operations to permit using the equipment under blackout conditions. No dial lights or luminous markings have been provided, either on the receivers or the transmitter. It is recommended, however, that the push-button channel numbers on all units be painted with radioactive phosphorescent paint, to facilitate location of the desired push-button in the dark. Indicator lamps on the transmitter and receivers can be removed from the front panels to maintain black-out conditions while the equipment is being operated.

(b) The SCR 609 equipment may be classed as semi-portable, inasmuch as it can be carried as a pack load by one or two men and set up in any convenient location and operated. Individual webbed canvas carrying straps have been furnished for the BC 659-B transmitter-receiver and for the CS 79-C Battery Case. The unit is carried with the weight bearing on one shoulder and the opposite hip. A leather handle on each of the units also permits carrying the equipment for short distances without the use of the removable carrying straps. Although these provisions for carrying the equipment will permit transportation of the units, a man is considerably hampered in his movements by the unbalanced distribution of weight, and the fact that the unit tends to swing independently of his body movements unless it is steadied with one hand is a definite limitation which will be decidedly disadvantageous in the contemplated service. It is recommended that consideration be given to providing a suitable carrying harness so that the equipment can be placed on a man's back and worn like a knapsack. The individual weights of the

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units are sufficient to justify the use of two men to carry an SCR 609 equipment.

(c) The RM 29-A Remote Control Unit, which is associated with all three equipments, is also carried over one shoulder in a leather-reinforced canvas case. This unit is rather light, however, and this method of carrying is satisfactory.

(d) The operation of the SCR 609 and SCR 610 is simple. There are no tuning dials, charts, or variable controls other than switches, which must be manipulated during operation. A two-position rotary switch controlled by a lever on the front panel of the equipment selects the operating channel. A four-position rotary switch, controlled by a similar lever, switches a meter provided in the equipment to read filament voltage, plate voltage on p-a and buffer stages, p-a grid current, and p-a plate current. The meter has a single luminous spot to indicate the proper operating condition for each of the meter scales; no other illumination has been provided to facilitate night operations with the equipment. It is recommended that the positions of the Meter Switch and Band Change Switch be painted with radioactive luminous paint, and that suitable arrows or other identifying marks be applied to the switch levers to indicate their position in darkness.

(e) The SCR 610 equipment is designed for vehicular mounting, and can be operated while the vehicle is in motion. The transmitter-receiver portion of the equipment comprises a BC 659-A unit which is identical with the SCR 609 equipment, so the recommendations made in Par. 2-25(d) are also applicable to this equipment.

2-26. Spare Parts.

No spare parts other than complete replacements of vacuum tubes have been furnished with any of the subject equipments. It is recommended that the Bureau take the necessary action to obtain the requisite complement of spare parts for these equipments in accordance with the policy adopted for standard Navy equipment.

2-27. Instruction Books.

The preliminary instruction book for the SCR 608-A Radio Sets contains 39 pages of descriptive text, 16 pages listing

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components, and 19 plates of drawings and schematics, in much the same form as is used in Naval instruction books. It was found to be reasonably free from errors and technically accurate in its descriptive paragraphs. Instructions for changing frequencies in the transmitter and receiver are arranged in logical sequence, and should be capable of being correctly interpreted by service personnel. No photographs of the SCR 608-A equipment have been included in this book and this lack causes some difficulty and inconvenience in using the book when the equipment is not available. A different type of instruction book has been furnished for the SCR 609 and SCR 610 equipments. It is classed by the War Department as a Technical Manual, and is written in the popular vein for personnel having a limited technical background. There are 38 pages of descriptive text, interspersed liberally with plates, photographs, tables, cartoons, and sketches illustrating and emphasizing the point being discussed in an adjacent paragraph. This informal presentation of instructions has merit and could well be adopted for small portable Naval radio equipment. The organization of the material in the Technical Manual is not too good, and separation of the various aspects of operation, servicing, and maintainance would improve the usefulness of the book. The presentation of the technical information is brief but comprehensive. The lack of description of the antenna characteristics, and of information regarding the use of transmission line feed between the transmitter and antenna are considered the chief deficiencies of this book.

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Table 1

Radio Sets SCR 608-A - 609 - 610

U. S. Army F-M Equipment

WEIGHTS AND DIMENSIONS

Unit	Depth Inches	Width Inches	Height Inches	Weight Pounds
SCR 608 Equipment				
Transmitter - BC 684-A	10-3/8	18	11-7/16	64.0
2 Receivers - BC 683-A (each)	12-3/4	6-3/4	11-7/16	38.5
Mounting FT-237-D	13-3/8	33-1/2	5-1/16	40.0
Microphone T-17	Cable length five feet.			1.0
Headset P-23	3-1/2	5-3/4	7-1/2	0.6
Remote Control RM-29-A	6-1/4	9-3/8	6-1/4	14.5
Canvas Carrying Case for RM-29-A	----	----	----	2.0
Antenna Mast Base MP-48	3-1/4	3-3/8	17-7/8	11.5
6 Antenna Sections (each)	Dia. 11/16	------	40	3.5
Canvas case for Ant. Sections	----	9	44	1.5
Weather protecting Cabinet CH-74-A	17-1/2	35-1/2	16	86.0
Metal Table for Mounting Equipment FM-43	15-3/8	40-1/2	15-5/8	44.0
Battery Cable	Length 8 feet			1.5
		Total		308.6

Unit	Depth Inches	Width Inches	Height Inches	Weight Pounds
SCR 609 Equipment for Portable Operation				
Transmitter-Receiver BC 659-B	17-1/2	15-1/8	8	27.25
Case CS-79-C less Batteries BA 39 and BA 40	17	15-1/2	4-3/4	10.25
Battery BA 39	3-3/4	6-3/8	7-9/16	8.75
Battery BA 40	----	----	----	7.75
2 Carrying Straps	Adjustable		----	1.50
Handset TS 13 E	3-1/4	9-1/4	2-5/8	1.50
Antenna AN 29-C	Folded, 13-1/2";		Extended, 13 feet	1.50
Canvas Cover BG 153	----	----	----	2.25
		Total		60.8

[redacted] (Continued)

Table 1 (Cont'd)

Unit	Depth Inches	Width Inches	Height Inches	Weight Pounds
SCR 610 Equipment for Vehicular Operation				
Transmitter-Receiver	17-1/2	15-1/8	8	27.25
Power Supply Unit PE 117-C	17	15-1/2	4-7/8	28.50
Mounting FT 250-C	19-7/8	12-1/2	4-7/8	11.00
Antenna Mast Base MP 48	3-1/4	3-3/8	17-7/8	11.50
6 Antenna Sections (each)	Dia. 11/16	----	40	3.50
Canvas Case for Ant. Sections	----	9	44	1.50
Handset TS 13-E	3-1/4	9-1/4	2-5/8	1.50
Remote Control RM-29-A	6-1/4	9-3/8	6-1/4	14.50
Carrying Case for RM-29-A	----	----	----	2.00
Total				101.25
Miscellaneous Parts SCR 608-A				
Transmitter Dynamotor DM 35D	4-5/16	8-1/4	4-1/16	10.00
Receiver Dynamotor DM 34D	3	6-3/8	4-1/2	4.5
Battery BA 27 (in remote unit)	1-1/2	4-1/16	3-3/8	1.0
Crystal Box BX 40	8-3/8	11-1/16	2-1/8	3.5
Miscellaneous Parts SCR 609 - 610				
Headset HS 30F	Cord length 31 inches			12 oz.
Microphone T-17	Cord length 5 feet			1.0
Crystal Box BX 40	8-3/8	11-11/16	2-1/8	3.5
Chest CH 96	10	30	10	17.5

[redacted]

Table 2

Radio Set SCR 608-A
U.S. Army F-M Equipment

R-F POWER OUTPUT
INTO
LOW RESISTANCE ANTENNA

Channel No.	Frequency Kc	Battery Supply Amps.	Battery Supply Watts	P-A Plate Input Volts	P-A Plate Input Ma.	R-F Output Watts
272	27202.4	18.0	222	590	70.0	16.8
281	28100.8	18.1	223	600	76.0	19.5
289	28900.0	18.0	223	600	70.5	19.5
304	30400.8	18.0	223	600	69.0	18.2
328	32795.0	17.8	220	600	69.0	14.5
340	34005.5	18.0	223	600	71.0	12.6
352	35200.5	18.1	224	600	73.0	11.8
364	36403.0	18.1	224	600	68.0	15.2
377	37702.5	17.8	221	600	62.0	15.7
386	38597.0	17.5	217	600	57.0	17.6

Note 1. Battery voltage maintained at 12.35 $\pm$ 0.05 volts.

Note 2. Antenna: $40\,\Omega$ lamp (at 16 watts dissipation) series tuned by 100 $\mu\mu$f variable capacitor.

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Table 3

Radio Set SCR 608-A
U.S. Army F-M Equipment

OPERATION INTO REAL ANTENNAS

Channel No.	Equipment Meter Deflection		External R-F Amperes	
	P-A Grid	Antenna		
Antenna sections MS 52, MS 53 and Mast Base MP 48 connected by 5 feet of RG-8/U coaxial cable.				
272	27	32	0.72	
281	27	15	0.76	
289	30	11	0.76	
304	30	12	0.74	
328	28	11	0.72	
340	28	11	0.72	
352	30	20	0.94	
364	26	33	0.94	
377	30	18	0.54	Note 1
386	27	8	0.30	Note 1
Antenna same as above; 15 feet of RG-8/U coaxial cable.				
272	24	26	0.30	Note 2
281	25	98	0.70	Note 2
289	25	85	0.79	
304	30	40	0.88	
328	28	4	1.25	
340	27	30	1.40	
352	30	47	1.10	
364	25	10	0.30	Note 1
377	25	5	0.10	Note 1
386	25	5	0.05	Note 1
Antenna sections MS 50, MS 51, MS 52, MS 53, Mast Base MP 48 connected by 5 feet of RG-8/U coaxial cable.				
272	27	19	0.63	
281	27	11	0.56	
289	30	17	0.48	
304	28	17	0.50	
328	30	7	0.62	
340	30	2	0.74	
352	29	10	0.76	
364	25	19	0.73	
377	25	25	0.61	
386	25	30	0.51	Note 1

[redacted]

(Continued)

Table 3 (Cont'd)

Channel No.	Equipment Meter Deflection		External R-F Amperes	
	P-A Grid	Antenna		
Antenna same as above; 15 feet of RG-8/U coaxial cable.				
272	26	32	0.34	Note 2
381	25	82	0.68	Note 2
289	25	65	0.77	
304	26	17	0.74	
328	25	5	0.49	
340	27	5	0.44	
352	25	15	0.54	
364	24	24	0.50	Note 1
377	25	10	0.20	Note 1
386	25	6	0.10	Note 1

Note 1: Antenna padding capacitor at minimun; no further tuning possible.

Note 2: Antenna padding capacitor at maximum; no further tuning possible.

Note 3: External R.F. Antenna Current measured at bottom of MP 48.

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Table 4

Radio Set SCR 610
U.S. Army F-M Equipment

R-F POWER OUTPUT
INTO
HIGH RESISTANCE ANTENNA

Frequency Channel No.	R-F Frequency Kc	Battery Supply		P-A Plate Input		R-F Output	
		Amps.	Watts	Volts	MA.	Current Ma.	Power Watts
272	27206.4	2.78	33.4	127.5	20.2	50.0	0.506
281	28102.8	2.82	33.7	127.0	23.5	44.0	0.394
289	28903.2	2.74	32.9	126.0	22.3	48.0	0.469
304	30404.2	2.77	33.2	126.0	23.3	50.5	0.519
328	32802.5	2.76	33.1	125.5	23.6	59.0	0.710
340	33999.0	2.77	33.2	125.5	23.1	60.0	0.731
352	35201.5	2.77	33.2	125.0	23.1	66.0	0.885
364	36404.5	2.78	33.3	125.5	24.8	68.0	0.940
377	37701.5	2.73	32.8	125.5	21.6	63.0	0.810
386	38601.9	2.77	33.2	124.8	23.1	62.0	0.780

Note 1: Battery voltage maintained at 12 volts into PE 117-C Supply.

Note 2: R-F load resistor, 203 ohms.

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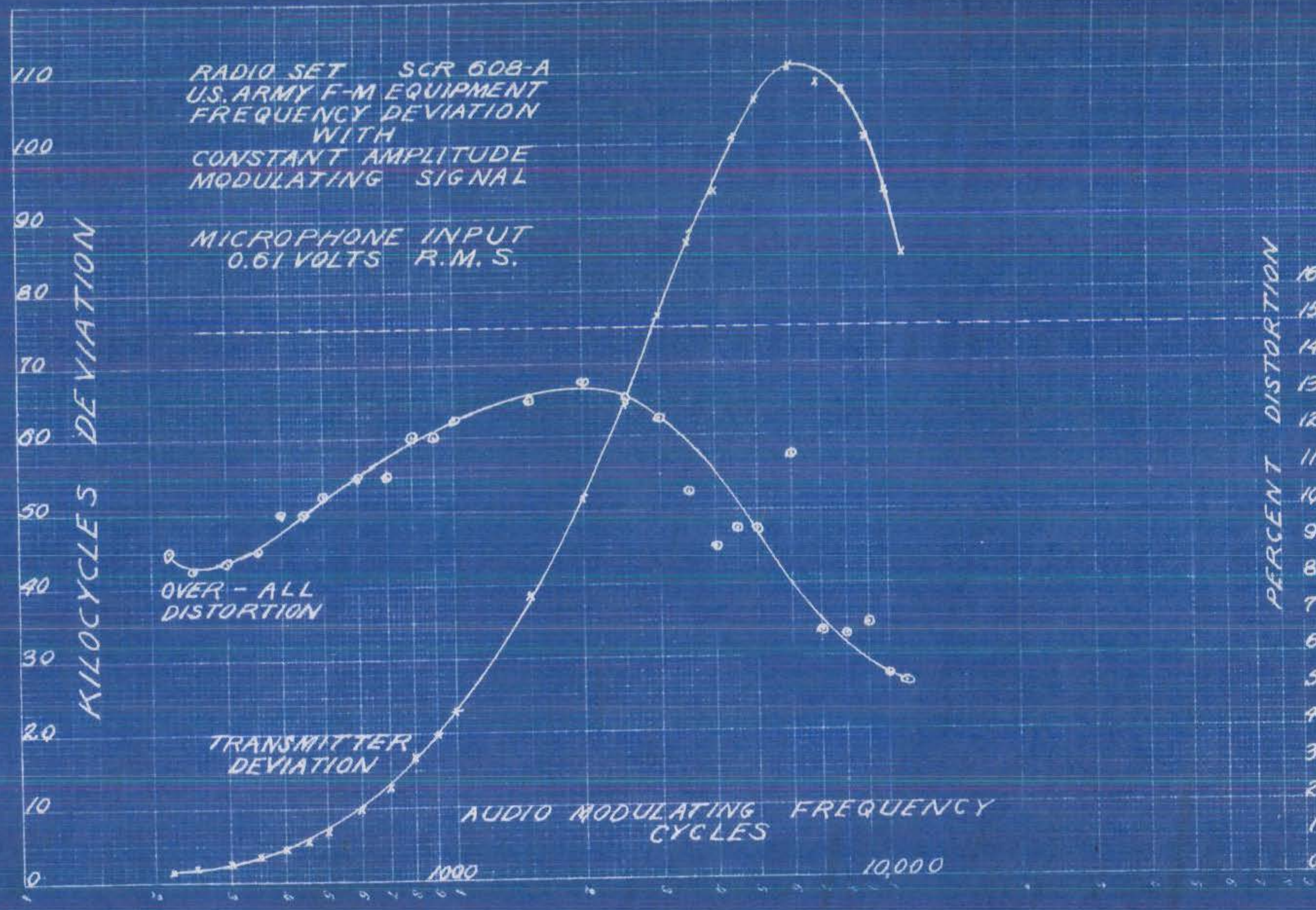

RADIO SET SCR 608-A
U.S. ARMY F-M EQUIPMENT
FREQUENCY DEVIATION
WITH
CONSTANT AMPLITUDE
MODULATING SIGNAL
MICROPHONE INPUT
0.61 VOLTS R.M.S.
OVER - ALL
DISTORTION
TRANSMITTER
DEVIATION
KILOCYCLES DEVIATION
PERCENT DISTORTION
AUDIO MODULATING FREQUENCY
CYCLES
1000
10,000
0
10
20
30
40
50
60
70
80
90
100
110
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 1

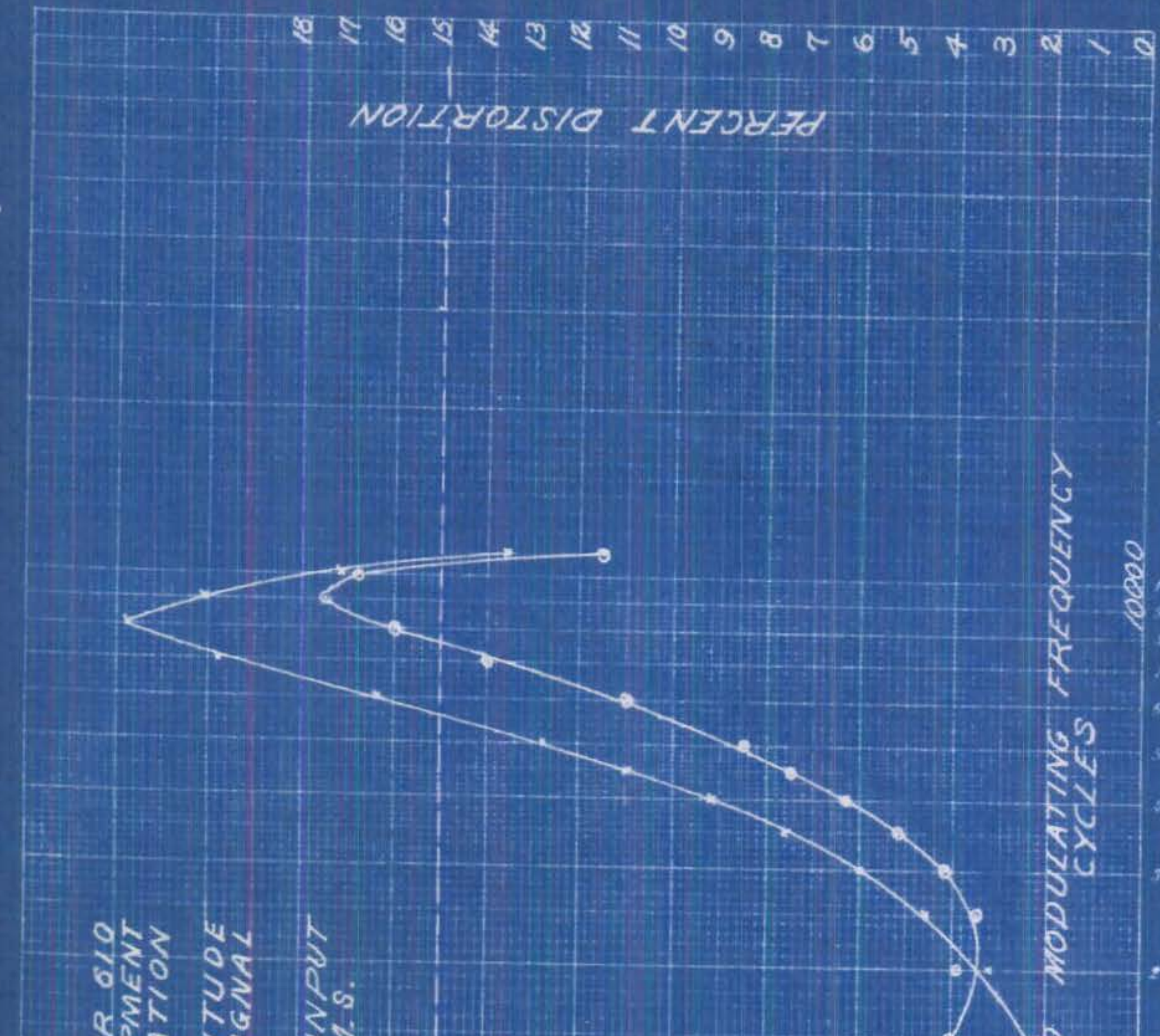
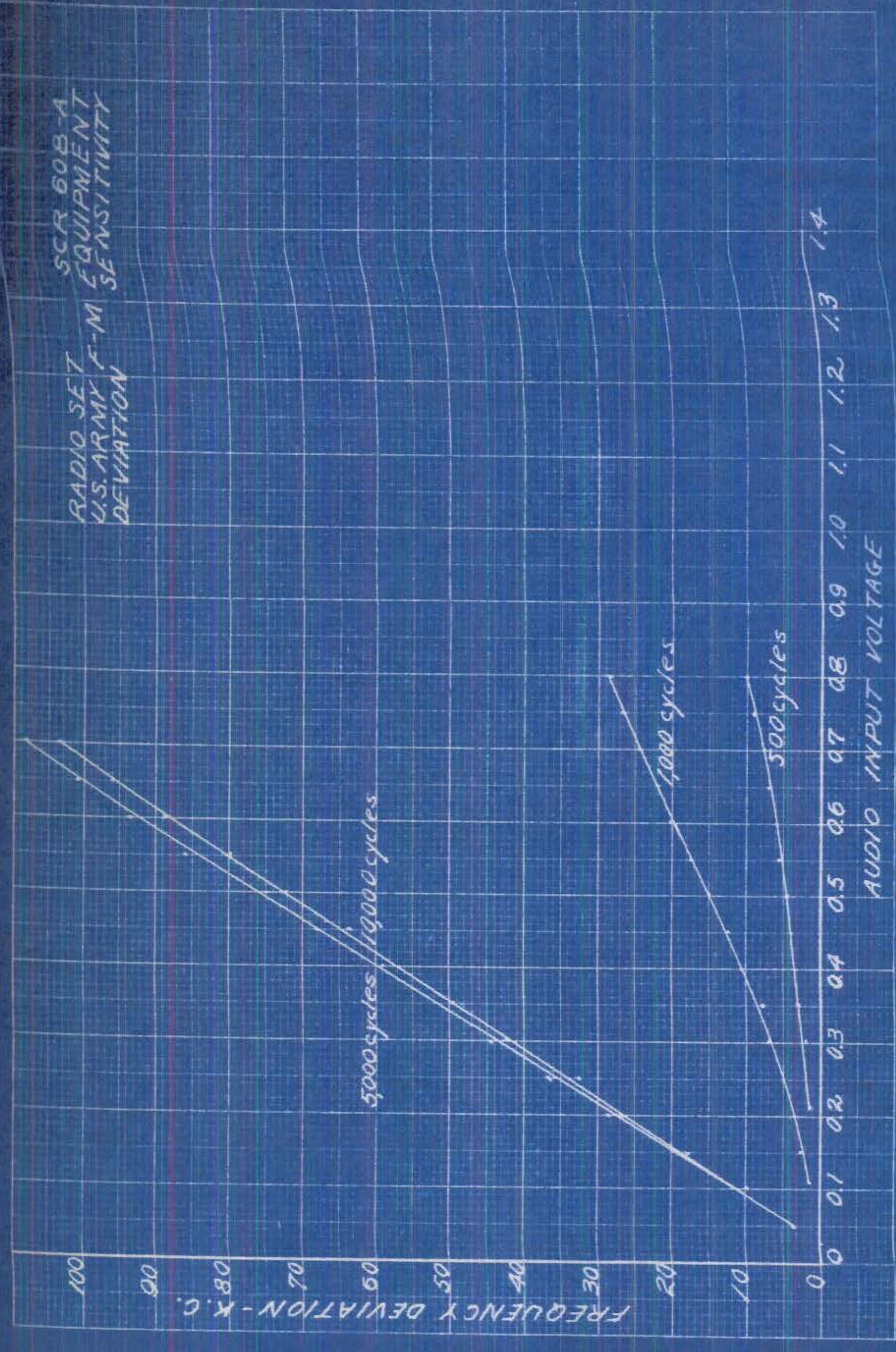

RADIO SET SCR 610
U.S. ARMY F-M EQUIPMENT
FREQUENCY DEVIATION
WITH
CONSTANT AMPLITUDE
MODULATING SIGNAL
MICROPHONE INPUT
0.155 VOLTS R.M.S.
OVER-ALL
DISTORTION
TRANSMITTER
DEVIATION
PERCENT DISTORTION
KILOCYCLES DEVIATION
AUDIO MODULATING FREQUENCY
CYCLES
1000
10000
0
10
20
30
40
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

PLATE 2



RADIO SET SCR 608-A
U.S. ARMY F-M EQUIPMENT
DEVIATION SENSITIVITY
FREQUENCY DEVIATION - K.C.
AUDIO INPUT VOLTAGE
5000 cycles
10,000 cycles
1,000 cycles
500 cycles
0
10
20
30
40
50
60
70
80
90
100
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4

PLATE 3

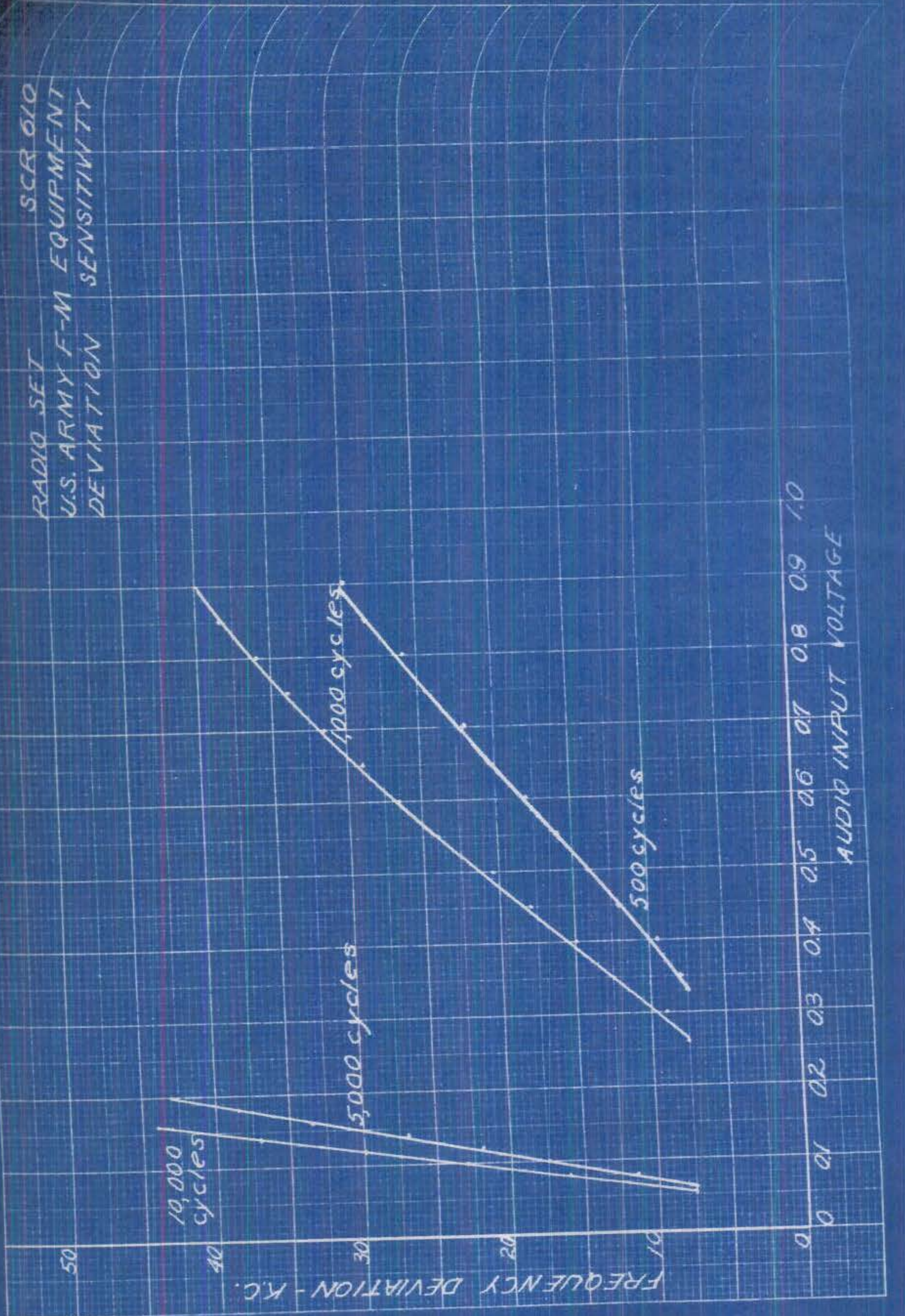

RADIO SET SCR 610
U.S. ARMY F-M EQUIPMENT
DEVIATION SENSITIVITY
FREQUENCY DEVIATION - K.C.
AUDIO INPUT VOLTAGE
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0 10 20 30 40 50
10,000 cycles
5000 cycles
1000 cycles
500 cycles

PLATE 4

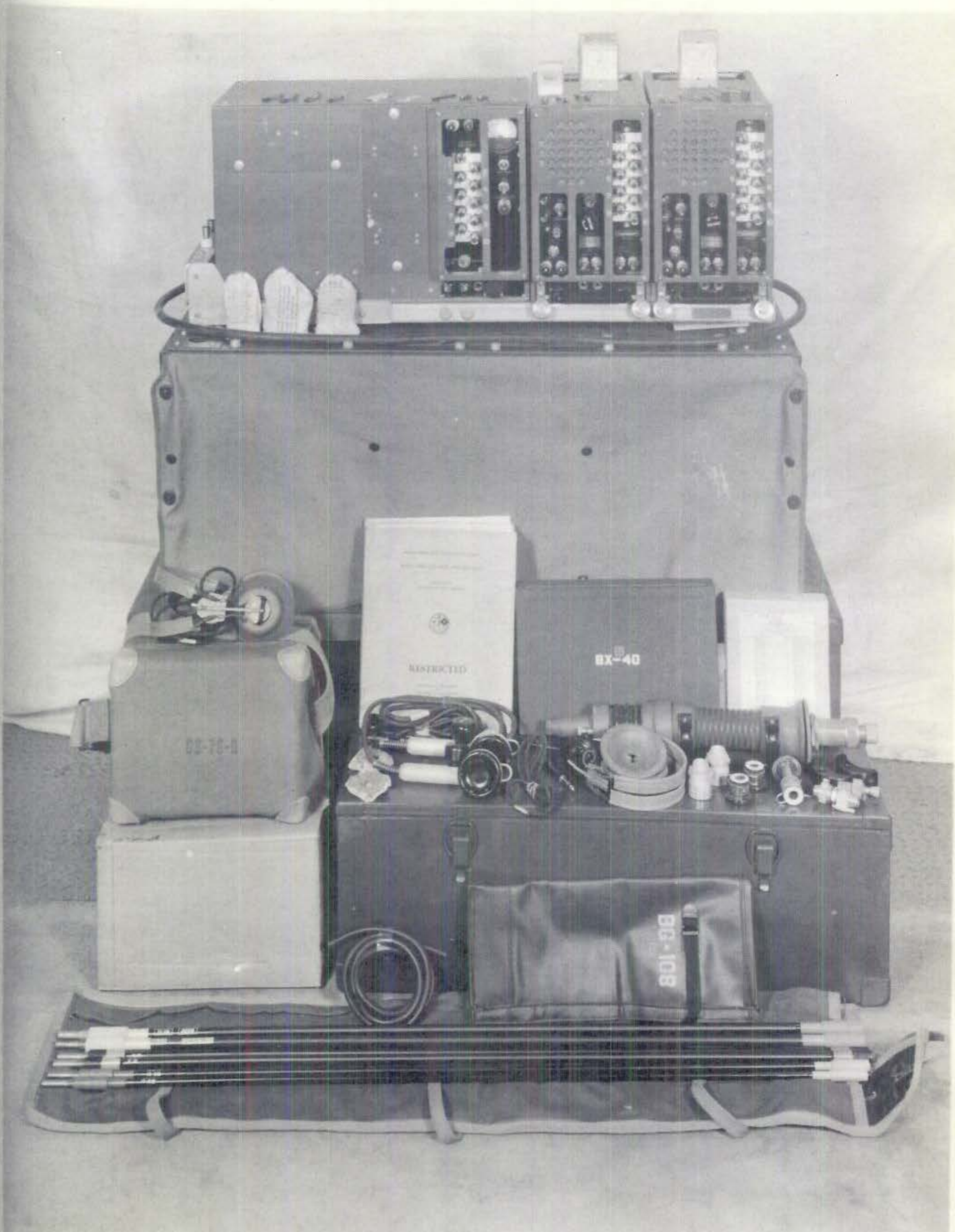


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PLATE 101

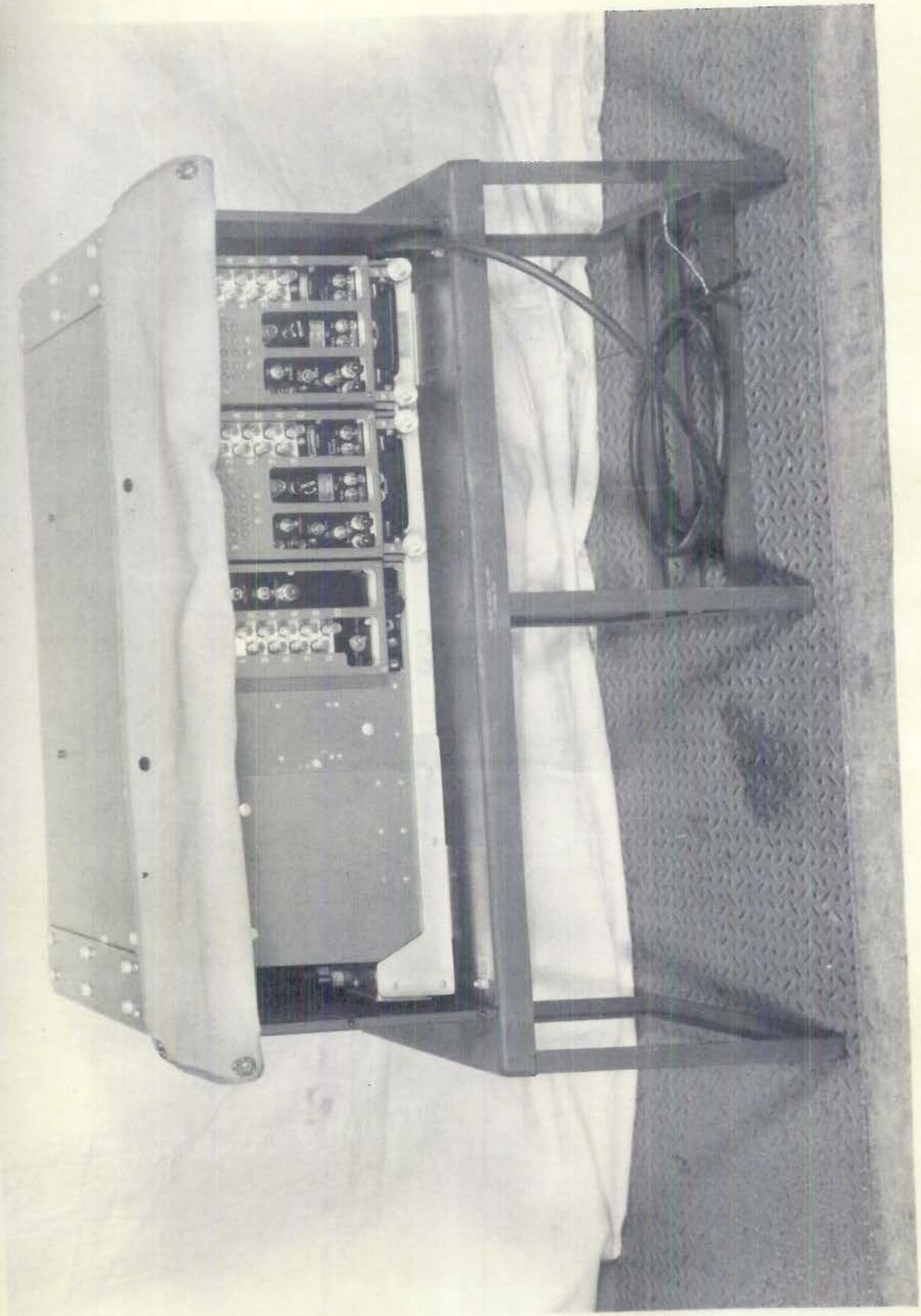

PLATE 102

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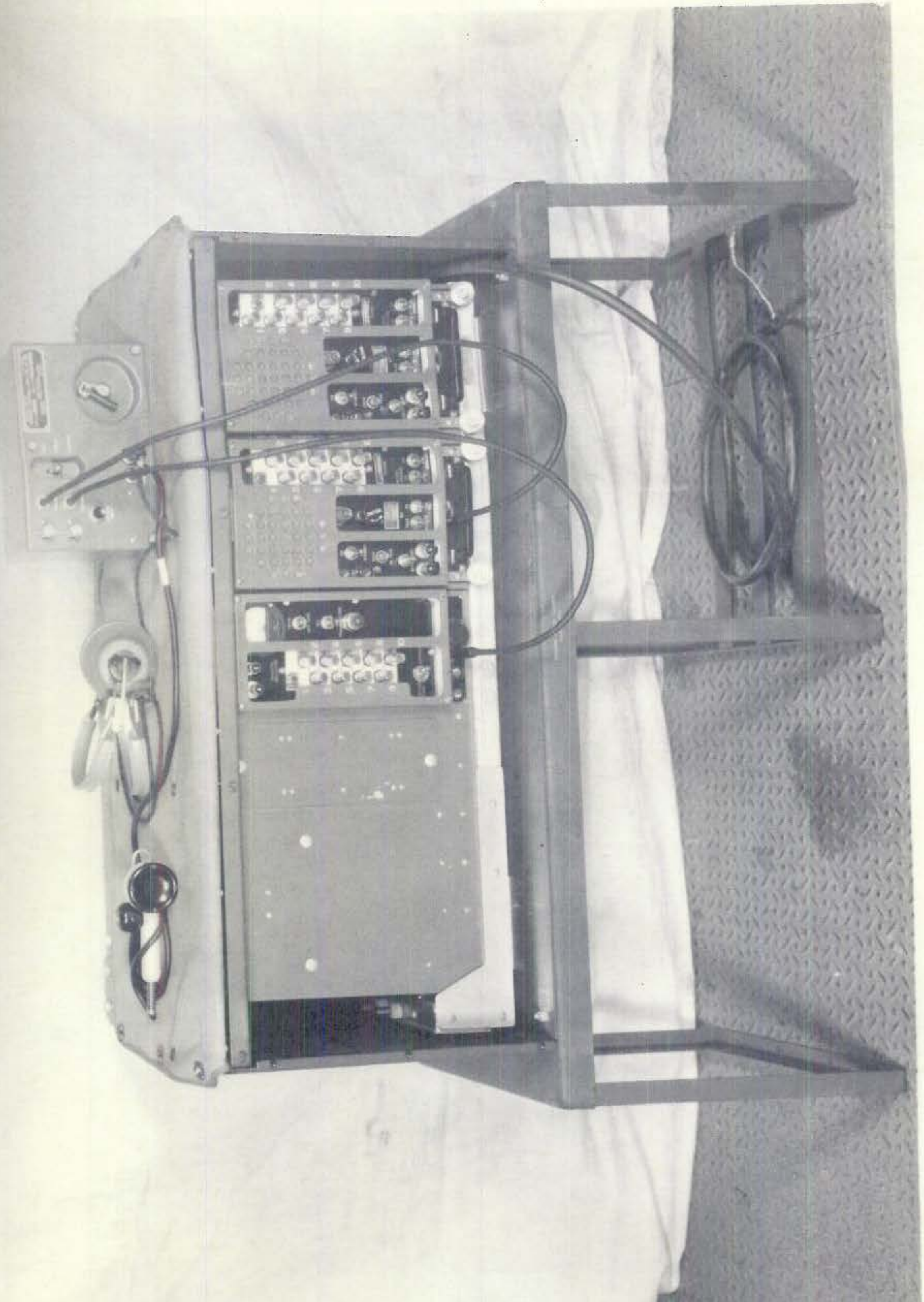

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PLATE 103

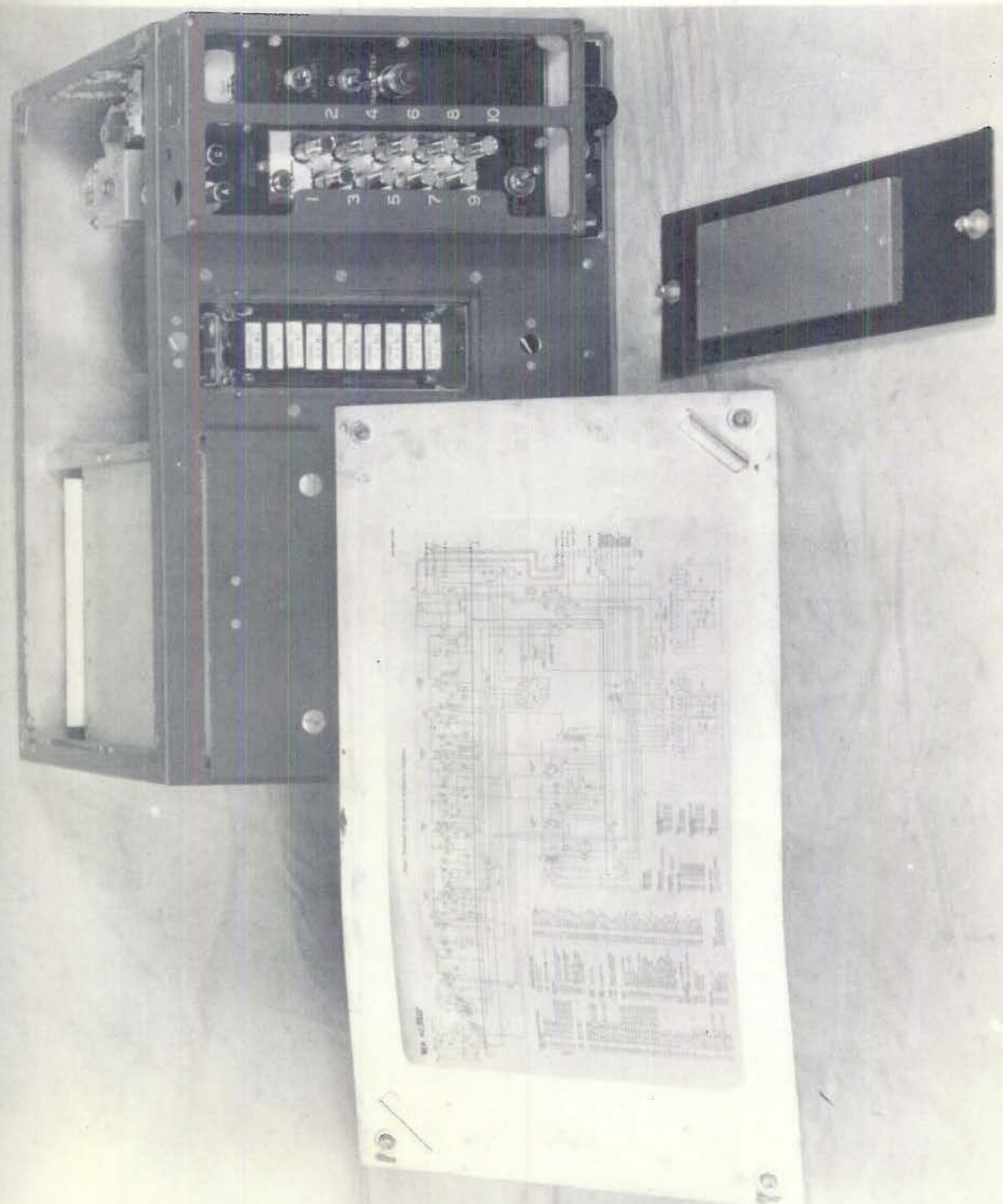

PLATE 104

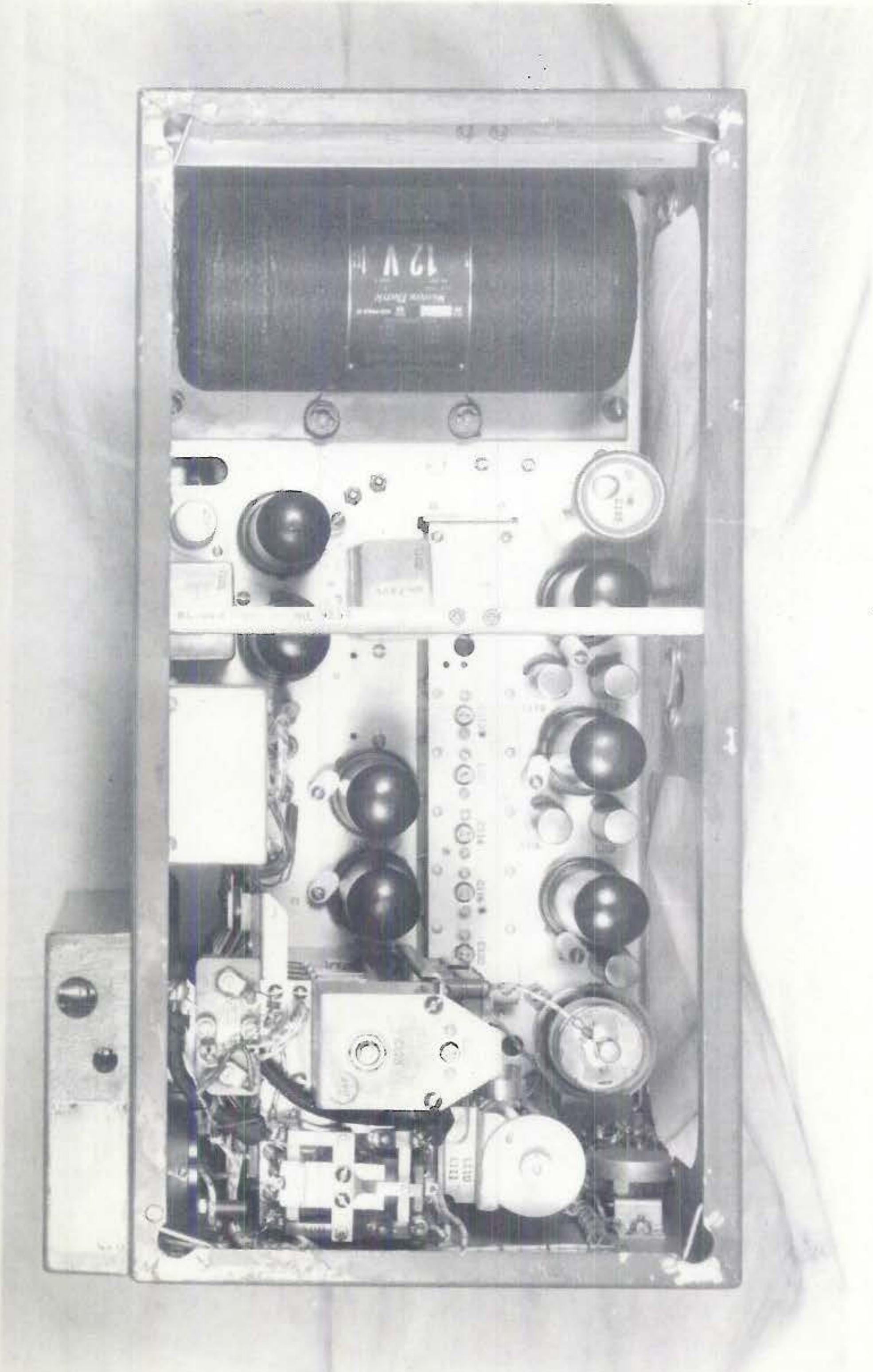

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PLATE 105

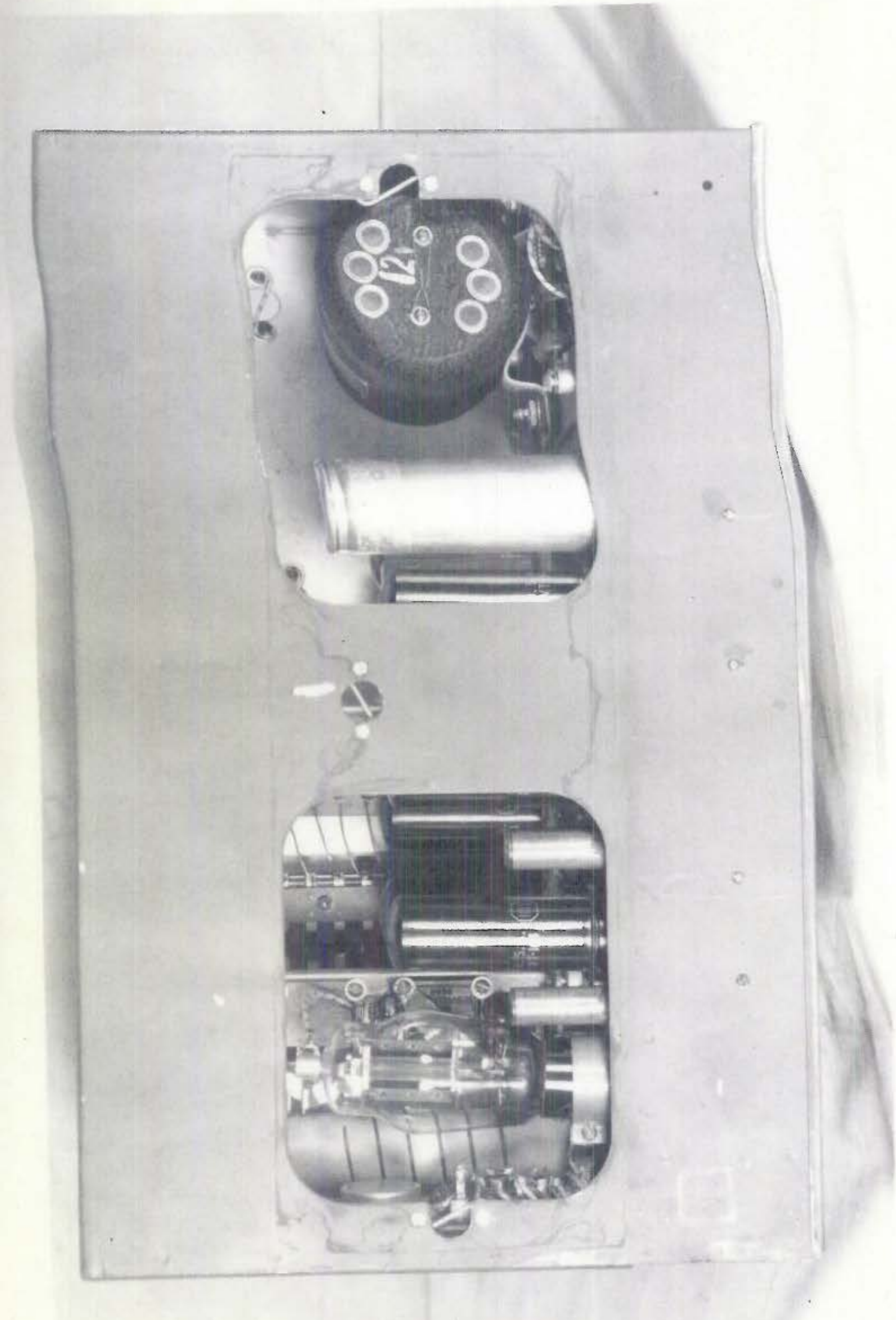

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PLATE 106

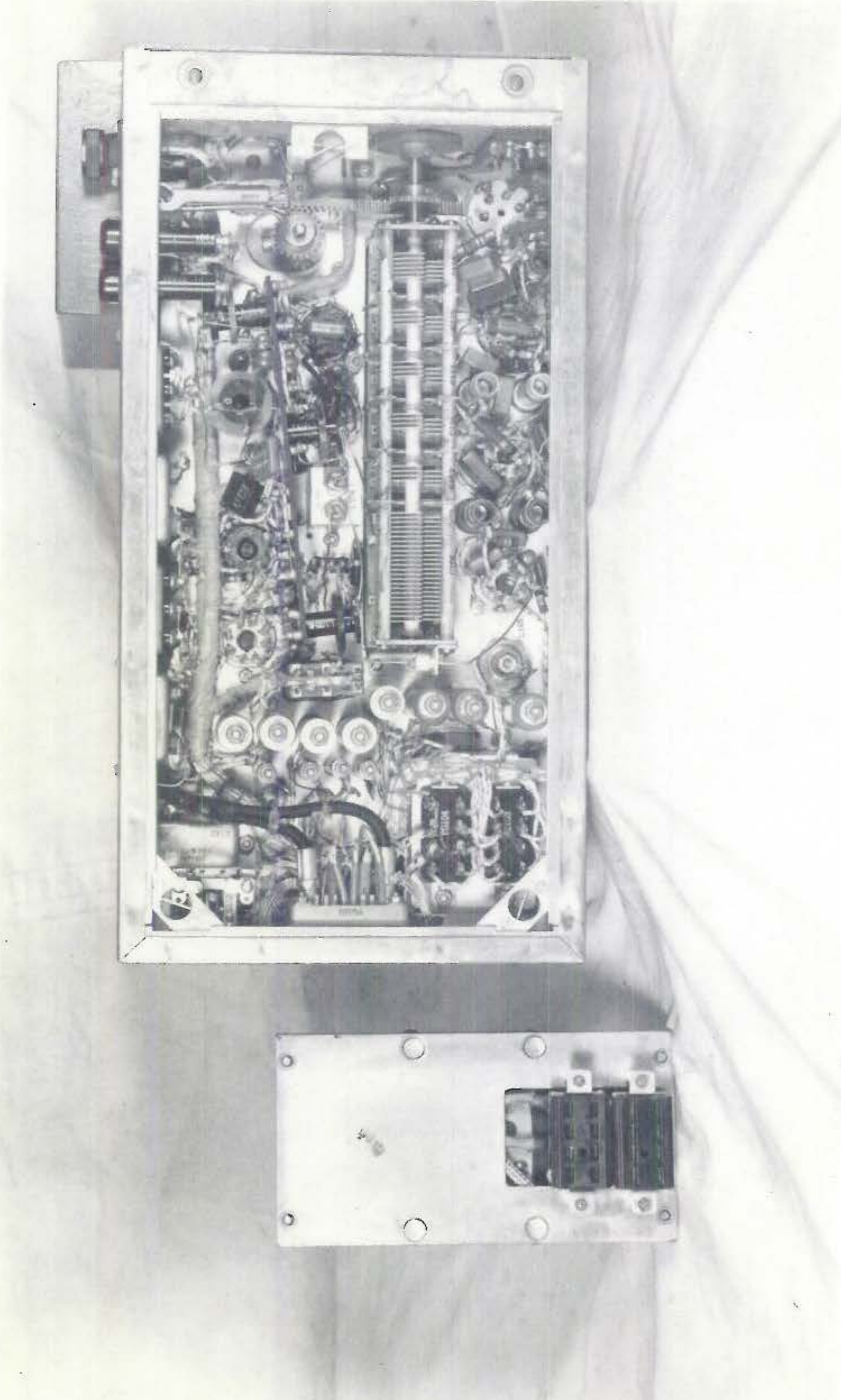

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PLATE 107

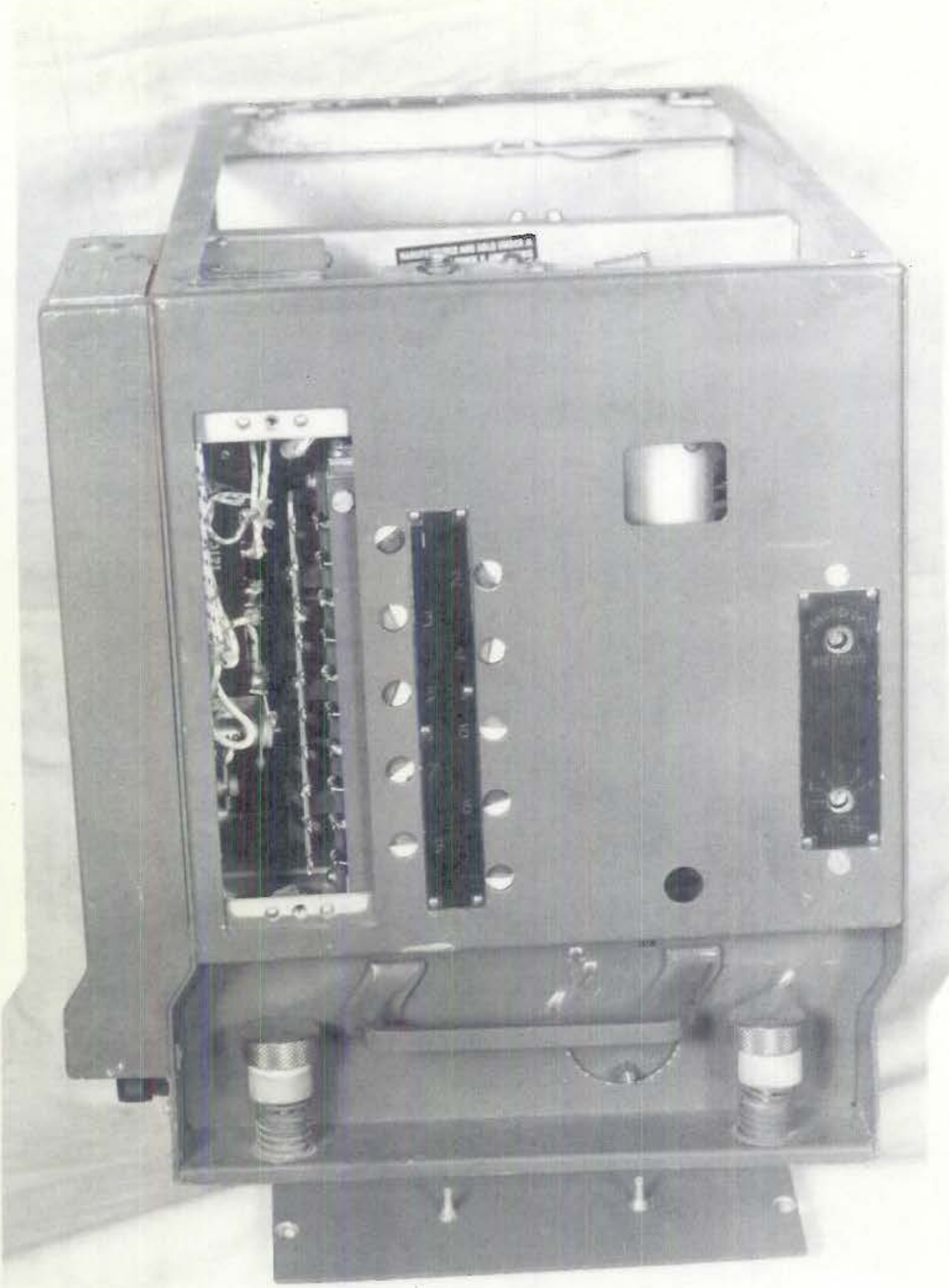

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PLATE 108

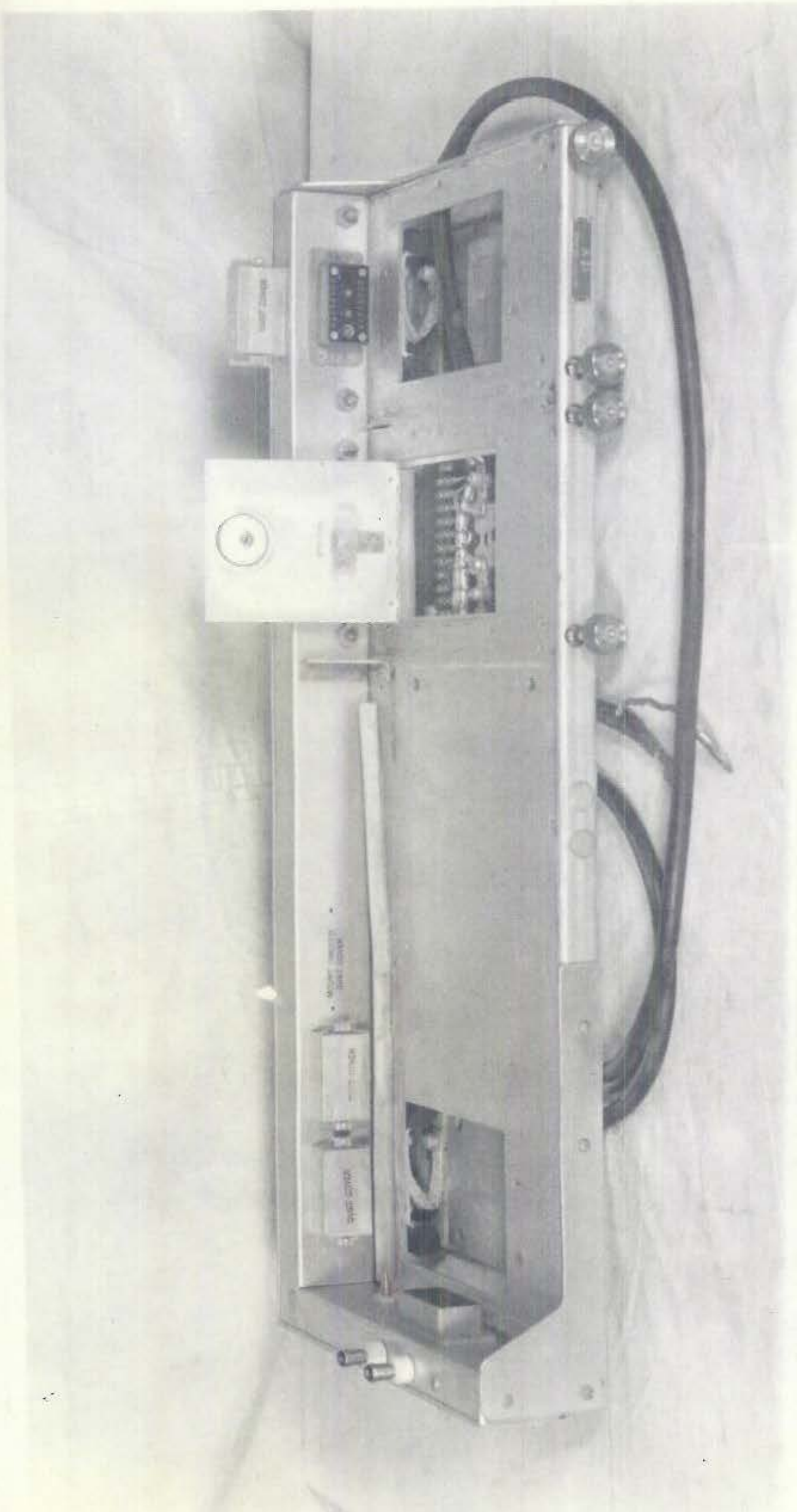

PLATE 109

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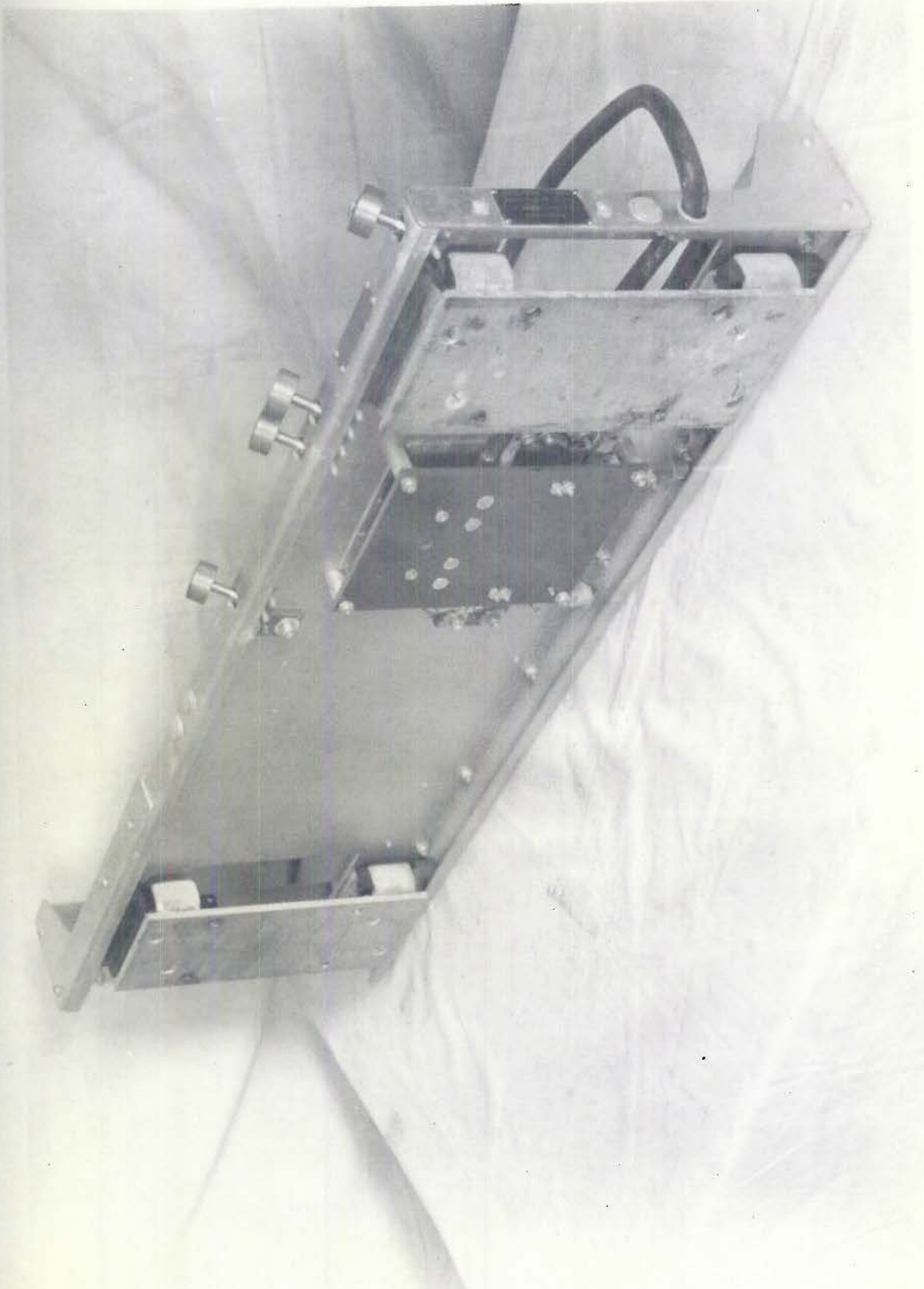

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[redacted]

PLATE 110

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PLATE III

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[redacted]

PLATE 112

PLATE 113

[redacted]

PLATE 114

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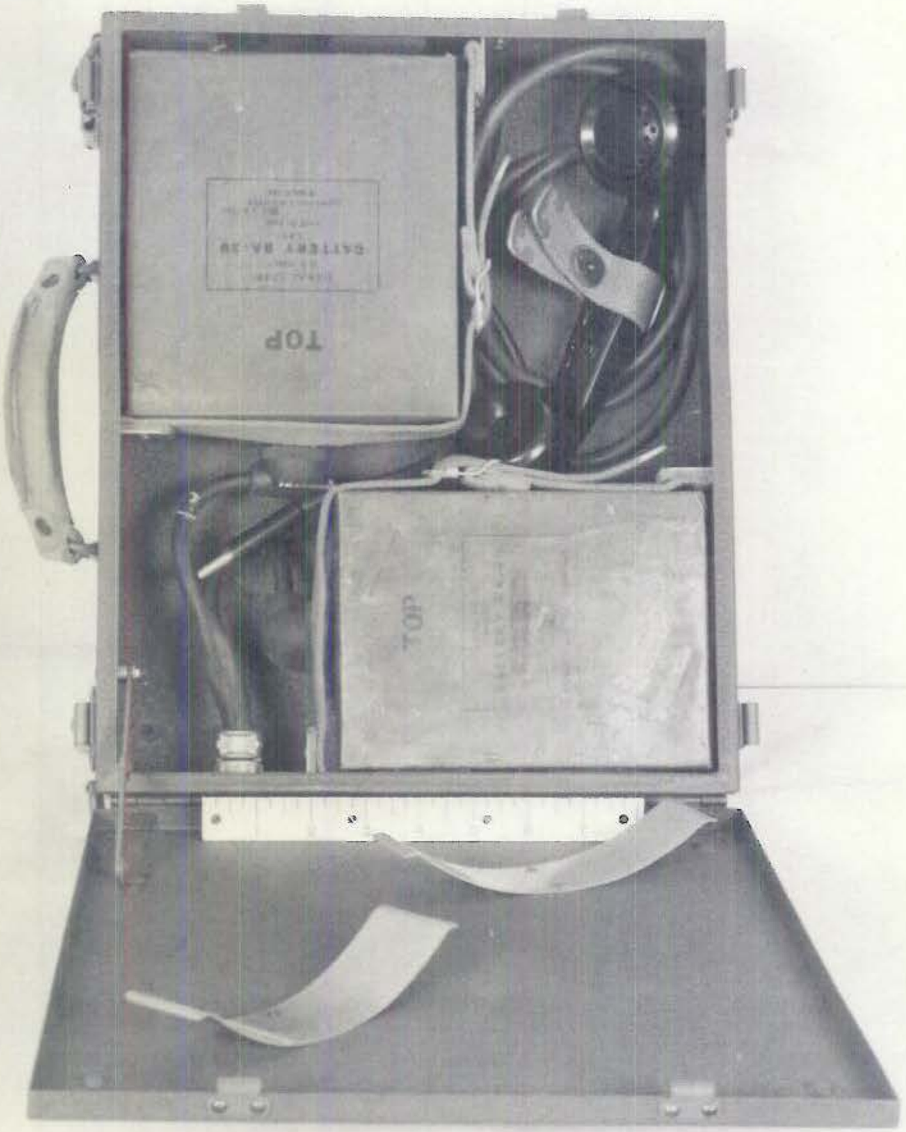

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PLATE 115

PLATE 116

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PLATE 117

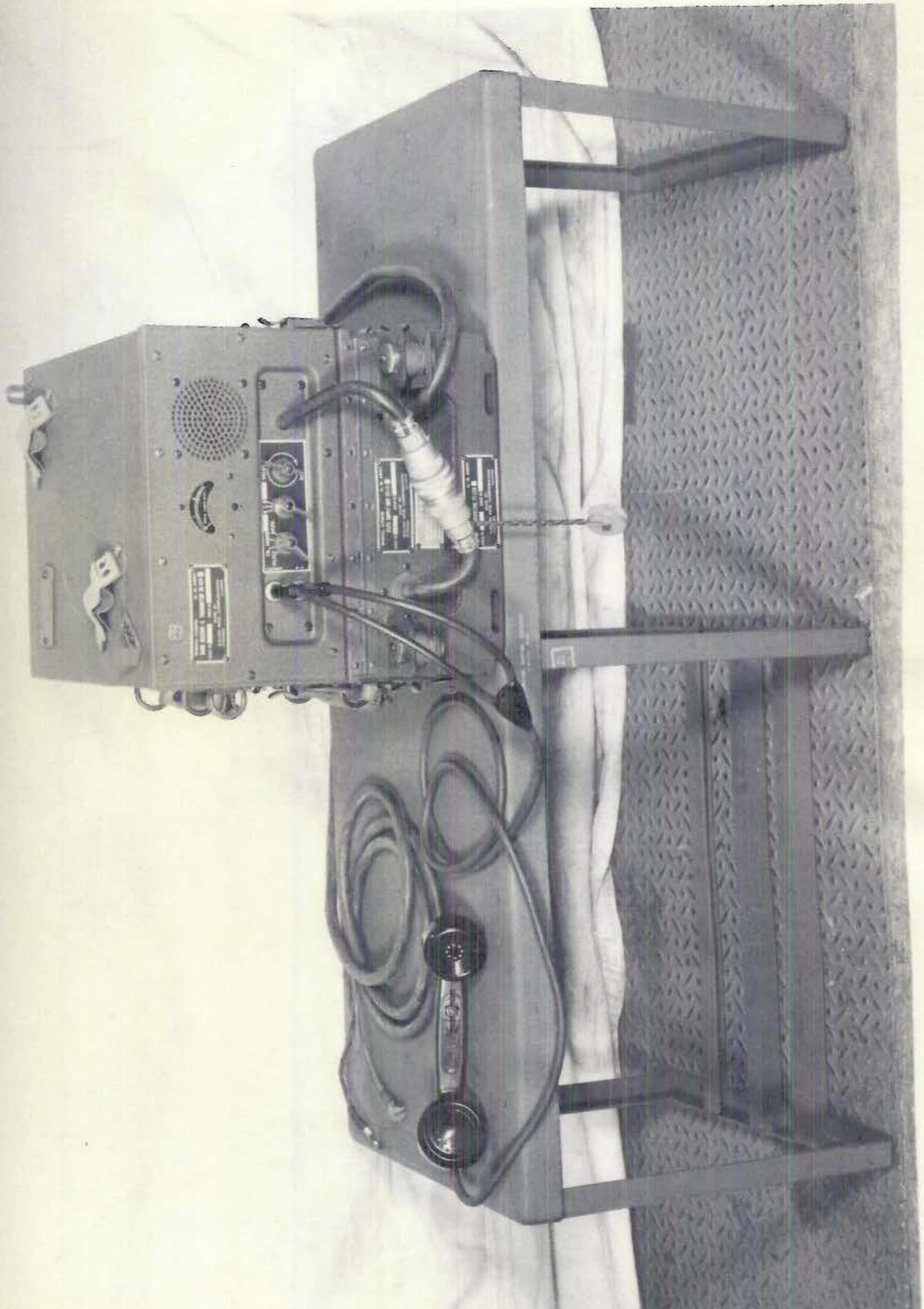

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PLATE 118

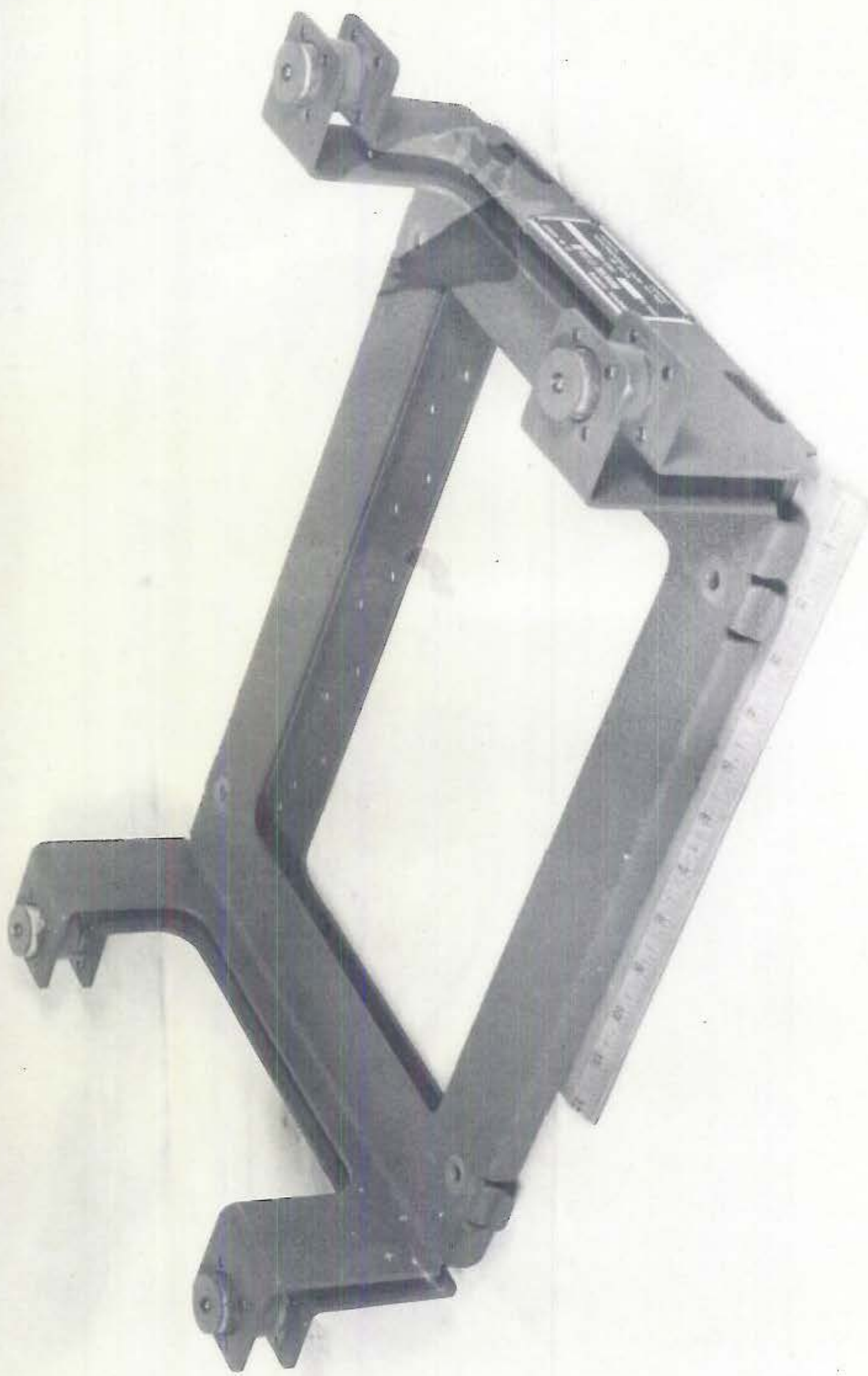

PLATE 119

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PLATE 120

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PLATE 121

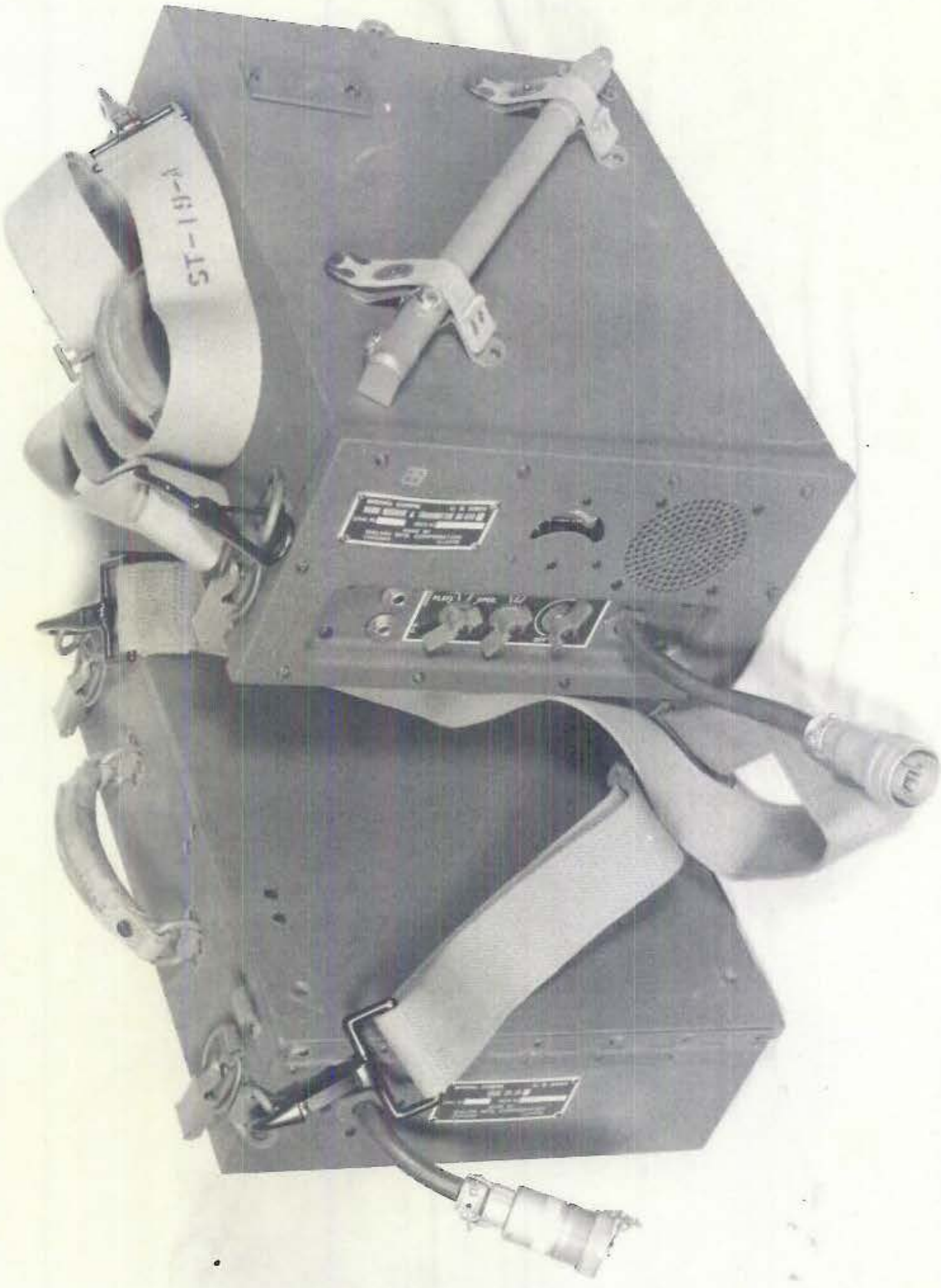

PLATE 122

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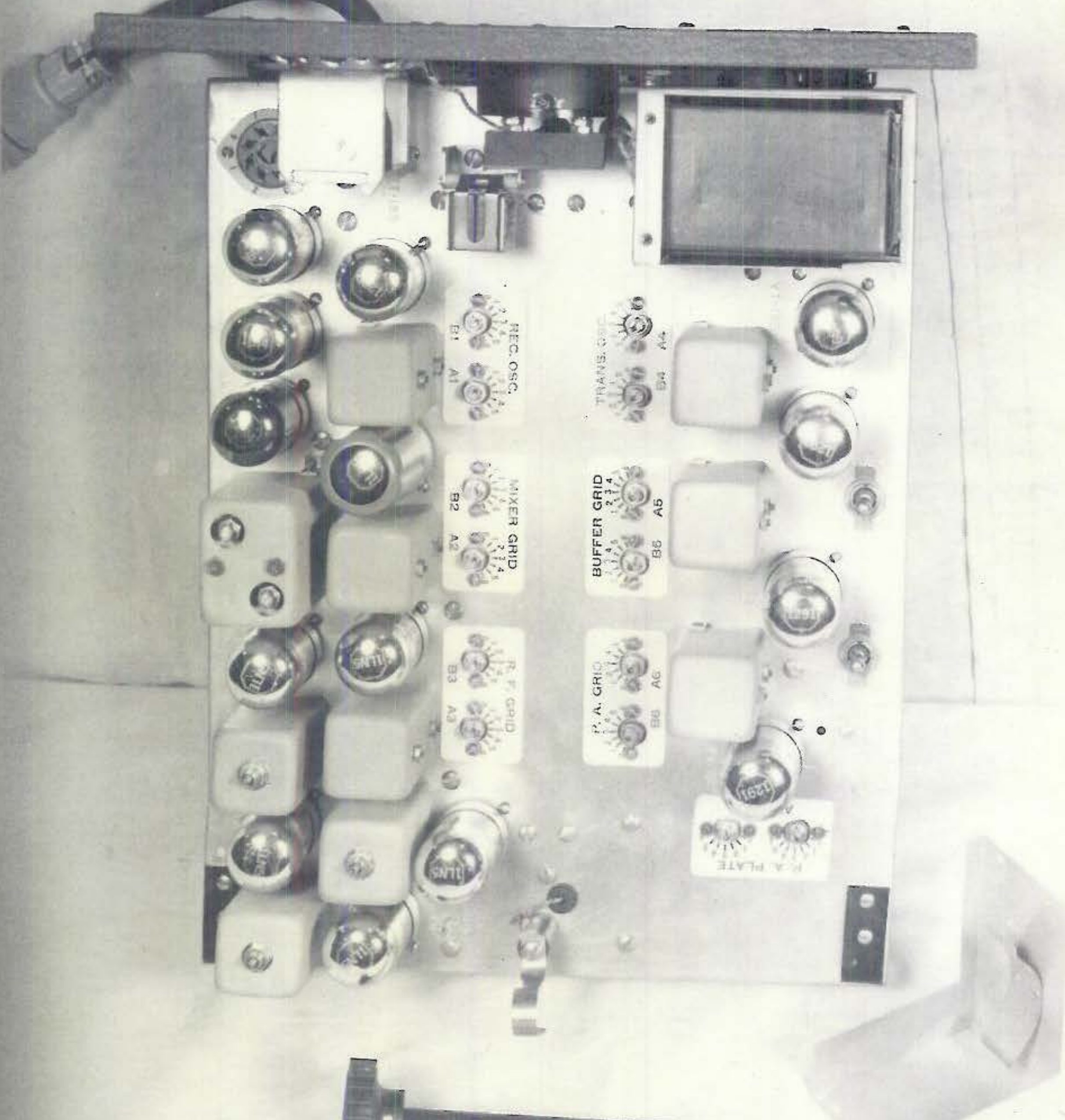

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PLATE 123

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PLATE 124

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PLATE 125

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PLATE 126

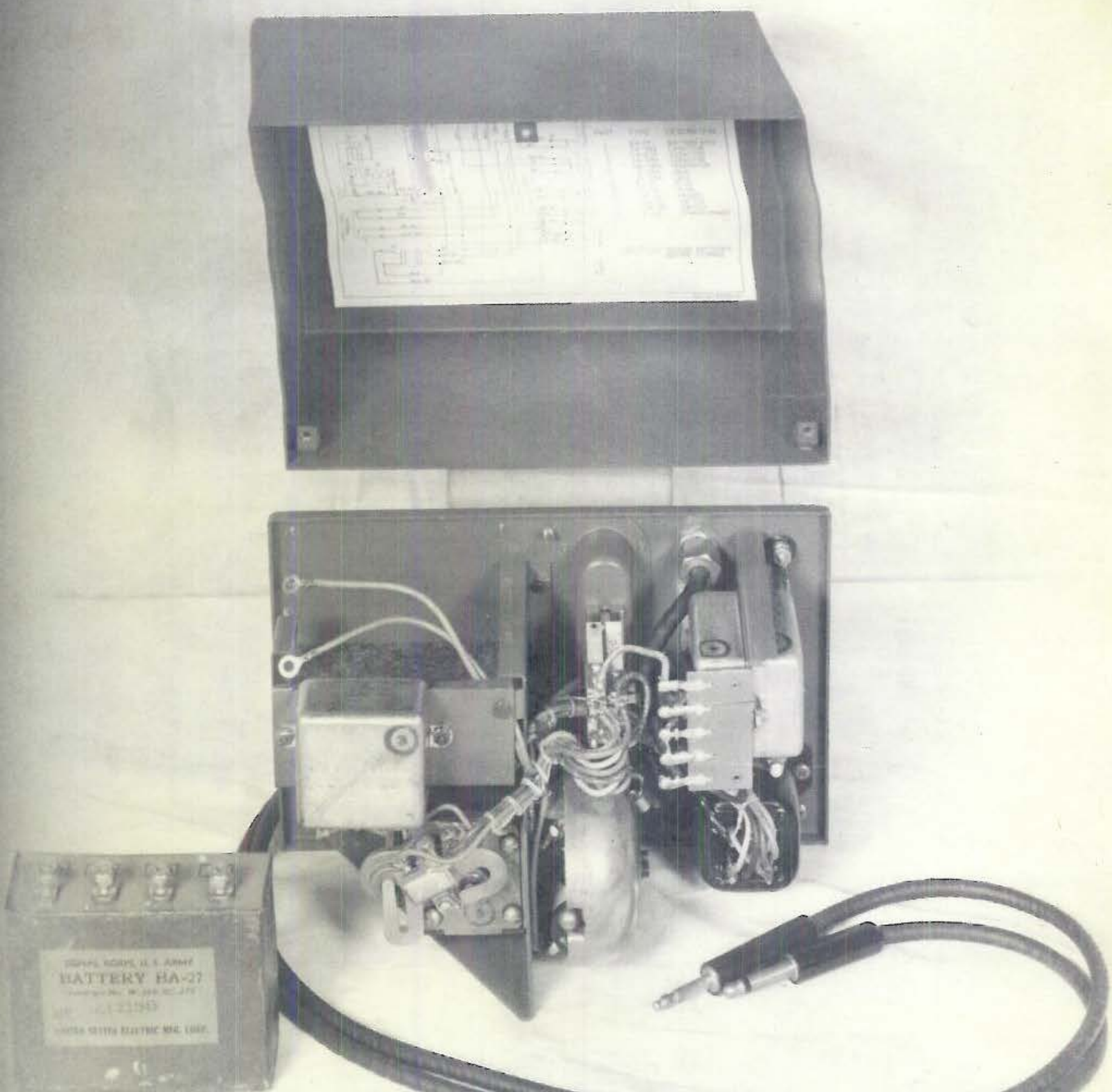

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PLATE 127

[redacted]

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PLATE 128

PLATE 129

DECLASSIFIED

PLATE 130