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Report on Test of Model TCQ Transmitting and Receiving Equipment

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Report on Test

of

Model TCQ Transmitting and Receiving Equipment

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SECTION I

AUTHORIZATION

1-1. The tests herein reported were authorized by Bureau of Ships Problem T4-8, Priority "A," to cover the tests of the Model TCQ Transmitter-Receiver Equipment.

OBJECT OF TESTS

1-2. The object of the tests was

(a) To examine the equipment for the purpose of determining its ability to withstand the rigors of Naval usage.

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

(c) To ascertain what changes or modifications are necessary to insure satisfactory operation under Naval Service conditions.

ABSTRACT OF TESTS

1-3. The tests herein reported were conducted with a view of determining the performance of the equipment under Naval conditions of operation. Briefly, inspection and tests were conducted as follows:

(a) Transmitter.

General Examination of Equipment

(1) Vacuum tubes and methods of mounting.
(2) Controls.
(3) Investigation of tuning methods.
(4) Accessibility and protection of personnel.
(5) Wiring.
(6) Insulation.
(7) Weights and dimensions.
(8) General physical construction.
(9) Components.
(10) Mounting and shock proofing methods.
(11) Connection facilities.
(12) Power equipment.
(13) Antenna unit.

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Operational Data and Tests

(1) Power output and operation with actual antenna.
(2) Keying tests.
(3) Antenna circuit.
(4) Modulation and distortion.
(5) Carrier hum and ripple.
(6) Detuning of circuits.
(7) Change of tubes.
(8) Check for backlash, torque lash, and lost motion.
(9) Variation of ambient temperature.
(10) Variation of humidity.
(11) Locked key for two hours.
(12) Change from key-locked to intermittently-keyed condition.
(13) Change from continuously-keyed to intermittently-keyed condition.
(14) Inclination.
(15) Vibration.
(16) Shock.
(17) Calibration of the master oscillator and overlap.
(18) Antenna short circuited and open circuited.
(19) Vacuum tube operating conditions.
(20) Power required from supply lines.
(21) Ripple and regulation of generators.
(22) Instruction book.

(b) Receiver. The receiver was given a general inspection of mechanical construction and wiring. The following electrical tests were made:

(1) CW and MCW sensitivity.
(2) I-F and R-F selectivity.
(3) CW and MCW resonant overload.
(4) R-F gain control characteristics.
(5) Audio amplifier characteristics.
(6) Frequency stability for changes of supply voltage.
(7) Radio-frequency radiation.
(8) Image rejection.
(9) Output load variation.
(10) Squelch characteristics.
(11) Ambient temperature variation.
(12) Relative humidity variation.
(13) Vibration, roll, and shock.

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CONCLUSIONS

(a) The performance of the Model TCQ and an inspection of its mechanical features reveal that the equipment is unsuitable for Navy use in the service for which it was intended. Very extensive redesign would be required to remedy the many deficiencies which exist at present.

(b) The frequency stability of the transmitter and receiver is not satisfactory under many conditions of operation which will be encountered in service.

(c) The transmitter antenna tuning circuit does not provide sufficient flexibility and the power output is less than the specified 30 watts over much of the frequency range.

(d) Erratic shifts in output frequency occur when the transmitter is subjected to changes in ambient temperature while operating at 8000 kilocycles.

(e) Many components in the transmitter are quite inaccessible and difficult to service or replace.

(f) The chassis of the power unit is easily distorted by vibration and shock. The method of mounting this unit is not considered satisfactory.

(g) The receiver's cw sensitivity, its selectivity, its stability with supply voltage changes, and the quality of many of its components are about its only good points.

(h) The receiver chassis and shielding are so weak that stiffening them appears impracticable.

(i) The receiver radiation is sufficient to constitute a serious security hazard.

(j) The blocking from relatively low strength cw signals combined with the lack of r-f attenuation range, seriously limits the usefulness of the receiver.

(k) Satisfactory receiver operation under conditions of vibration and shock cannot be expected, and nothing short of complete redesign could correct this serious difficulty.

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RECOMMENDATIONS

It is recommended:

(1) That improved packing methods be used to prevent damage to the equipment during shipment (par. 1-7 - Trans.-Rec.)

(2) That the chassis of the power unit and receiver be strengthened and the method of mounting the unit be improved (par. 1-7-a and 2-10-b - Transmitter) (par. 3-66 - Receiver).

(3) That all vacuum tubes be provided with suitable base clamps to withstand vibration and shock; and that the method of mounting the modulator tube sockets be improved (par. 2-1-c - Trans.-Rec.).

(4) That leads of suitable length be used to connect to tube cap clips; that leads be properly fastened to lugs before soldering; and that insulated cap clips be employed (par. 2-1-d and 2-4-a - Transmitter).

(5) That spade bolts used to secure shields be equipped with two rivets to facilitate alignment; that vacuum tubes be made more accessible and that the time necessary to make tube changes be reduced to a minimum (par. 2-1-e and 2-4-a - Transmitter

(6) That the size of the channel control knob be increased to facilitate manipulation; that all control knobs be pinned to the control shafts; that the detent mechanism of the oscillator gang switch be relocated and adequately supported; that preloaded gears be employed in dial drives in order to take up wear and eliminate backlash; and that end stops on the oscillator and final tuning controls be relocated to prevent unnecessary strain on the capacitors and their driving mechanisms (par. 2-2-a - Transmitter) (par. 3-77 and 3-78 - Receiver).

(7) That taper pins be used to fasten elements of driven devices together; and that coupling sleeves fit the shafts with which they are used (par. 2-2-b - Transmitter).

(8) That indicator lamps be furnished to indicate the condition of the receiver and transmitter (par. 2-2-e - Transmitter).

(9) That oscillator temperature compensation capacitors be correctly adjusted at the point of manufacture and that adjustment holes be covered to prevent accidental movement during service (par. 2-3-a - Transmitter).

(10) That the cabinet construction be changed to eliminate the necessity of partially withdrawing the transmitter chassis when adjusting buffer tracking capacitors (par. 2-3-b); and

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that care be taken in fabricating the transmitter chassis to properly align capacitor adjustment access holes (par. 2-3-c - Transmitter).

(11) That antenna tuning capacitor dials be provided with index marks to facilitate resetting; and that interaction between the capacitors be eliminated (par. 2-3-d - Transmitter).

(12) That the accessibility of the antenna tuning capacitors be improved; and that the oscillator, buffer, and power amplifier variable capacitors be secured in such a manner that servicing can be more easily accomplished (par. 2-4-a - Transmitter).

(13) That a suitable nameplate warning of the presence of high voltage be affixed to the power unit in a prominent location (par. 2-4-b - Trans.-Rec.).

(14) That wiring be improved; that suitable wire be employed for each application, particularly where r.f. must be carried; that care be taken to keep r-f and general power leads separated; that coil forms be provided with lead-through holes large enough to accommodate the wire used in winding the coils; that insulation on all wires be non-inflammable and suitable for use under conditions of high humidity; that solder be used only for electrical connection and not for mechanical strength; and that a flexible wire be used between R-140 and R-147 and the resistors anchored to prevent rotation on their holders (par. 2-5-a - Transmitter).

(15) That rubber covered cable be employed for interunit connections (par. 2-5-b - Trans.-Rec.).

(16) That high voltage supplies to the transmitter be provided with r-f by-pass capacitors in the transmitter unit (par. 2-5-c - Transmitter).

(17) That crystal mountings be of ceramic material; and that the Bureau take under advisement the use of Amphenol interunit plugs at voltages above the specified maximum (par. 2-6 and 2-11 - Transmitter).

(18) That captive screws attached to the covers be used to secure cabinet side and top shields (par. 2-8-a - Trans.-Rec.).

(19) That transmitter and receiver chassis be treated [redacted] to prevent corrosion if this has not already been done (par. 2-8-b - Trans.-Rec.).

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(20) That all threaded parts be made of some corrosion-resisting material; and that care be taken to adequately protect steel against corrosion (par. 2-8-c - Transmitter) (par. 3-67 and 3-74 - Receiver).

(21) That the Bureau determine whether drip-proof construction of the transmitter-receiver unit is desirable or necessary; that a drip-proof shield be used to protect dynamotors mounted on the power unit; that the remote control be made waterproof and supplied for flush mounting (par. 2-8-e and 2-10-c - Trans.-Rec.).

(22) That better workmanship be used in constructing the equipment (par. 2-8-g - Transmitter) (par. 3-68 - Receiver).

(23) That a suitable multi-range meter be furnished to read transmitter currents in circuits not provided with meters; that meter jacks be properly marked and that the range of the meter required be given in each designation; and that necessary changes in construction be made to eliminate any possibility of the master-oscillator meter jack's becoming grounded (par. 2-9-a - Transmitter).

(24) That the method of mounting R-103 be changed to prevent vibration of the resistor (par. 2-9-c - Transmitter).

(25) That fuses of correct rating be furnished; that a 60-ampere fuse cartridge be employed for the transmitter dynamotor input line; that fuse mountings be marked with the symbol number and rating of each fuse; that high-voltage fuses be provided in the dynamotor output leads; and that fuse clips be nickel plated to prevent corrosion (par. 2-9-d - Trans.-Rec.).

(26) That the accessibility of trimmer capacitors located in the oscillator-buffer compartment be improved (par. 2-9-e - Transmitter).

(27) That the Bureau investigate the present or proposed installations and determine whether it is desirable to relocate the antenna terminal on top of the transmitter (par. 2-9-f - Transmitter).

(28) That keying relay shock mounts be eliminated; that suitable locks be applied to all controls, tubes, and plug-in coils (par. 2-10-a - Transmitter).

(29) That dynamotor shock mounts be eliminated (par. 2-10-b - Trans.-Rec.).

(30) That the antenna mast be properly drilled; and that two mast securing bolts be used if possible (par. 2-10-d - Trans.-Rec.).

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(31) That suitable ground terminals be provided on each unit (par. 2-11 - Trans.-Rec.).

(32) That the method recommended for changing the equipment to operate from a source having a negative ground be simplified (par. 2-12 - Trans.-Rec.).

(33) That the antenna mast sections be provided with stops to automatically prevent less than the recommended overlap between sections; and that care be taken to assemble the mast correctly during manufacture (par. 2-13 - Trans.-Rec.).

(34) That necessary redesign be accomplished to provide a power output equal to or in excess of the specified 30 watts; that carrier shift be eliminated; and that adjustable contacts be provided on the keying relay (par. 2-15 - Transmitter).

(35) That the use of plug-in coils be eliminated (par. 2-16 - Transmitter).

(36) That a more flexible and satisfactory antenna tuning circuit be employed (par. 2-16 - Transmitter).

(37) That the audio tone provided for mcw operation be changed to 1000 cycles; that steps be taken to eliminate the possibility of simultaneous tone and voice modulation (par. 2-17-a - Transmitter).

(38) That the peak limiter be pre-set by the manufacturer to provide 95 per cent maximum modulation and that the control be locked to prevent accidental manipulation during normal adjustment procedure; and that steps be taken to eliminate the voltage surge caused when the microphone press-to-talk switch is closed; that the manufacturer investigate the presence of oscillations observed in the speech amplifier and modulator (par. 2-17-a - Transmitter).

(39) That adequate shielding be provided on the buffer stage to prevent oscillation in the absence of excitation from the oscillator (par. 2-20 - Transmitter).

(40) That backlash and lost motion in the oscillator drive mechanism be reduced (par. 2-21 - Transmitter).

(41) That output frequency irregularities which occurred during ambient temperature variations be investigated by the manufacturer and eliminated (par. 2-22-a - Transmitter).

(42) That the effect of humidity on the output frequency be reduced (par. 2-23 - Transmitter) (par. 3-89 - Receiver).

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(43) That frequency drift during two-hour locked key operation be reduced (par. 2-24 - Transmitter).

(44) That the effect of inclination on the output frequency be reduced (par. 2-27 - Transmitter).

(45) That the effect of vibration on the emitted frequency be reduced (par. 2-28 - Transmitter).

(46) That the effect of shock on the output frequency be reduced (par. 2-29 - Transmitter).

(47) That the master-oscillator dial assembly be improved; that more accurate direct calibration be provided or calibration charts furnished; that a linear scale be supplied on the oscillator dial; and that overlap be increased to a minimum of 3 per cent (par. 2-30 - Transmitter).

(48) That consideration be given to properly protecting the power-amplifier tubes in case the antenna is open-circuited or short-circuited (par. 2-31 - Transmitter).

(49) That the overload of the VR-75 regulator tube be eliminated (par. 2-32 - Transmitter).

(50) That necessary switching be incorporated to turn off the speech amplifier and modulator except when these stages are actually in use; that momentary overloads to which the modulator tubes are subjected be eliminated (par. 2-33 - Transmitter).

(51) That the regulation of the dynamotors be improved (par. 2-34 - Trans.-Rec.).

(52) That the instruction book be expanded and necessary installation drawings furnished (par. 2-35 - Trans.-Rec.)

(53) That the use of ferrous parts in the receiver be reduced, and, where essential, that these parts be suitably treated to prevent rust (par. 3-67 - Receiver).

(54) That more solid mechanical mounting be given many receiver components, especially r-f coil inductance trimmers and negative temperature coefficient trimmers (par. 3-69 - Receiver).

(55) That the receiver be so made that no components strike a flat surface upon which it is set in its usual position (par. 3-69 - Receiver).

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(56) That the number of low-voltage electrolytic capacitors employed in the receiver be reduced (par. 3-70 - Receiver).

(57) That closer production inspection be given the metal-case paper capacitors to prevent repetition of the oil leakage which occurred during the temperature cycle (par. 3-71 - Receiver).

(58) That no brown bakelite-case mica capacitors be employed in the receiver (par. 3-72 - Receiver).

(59) That the r-f coils in the receiver be treated to withstand high humidity (par. 3-73 - Receiver).

(60) That a more secure method of inductance trimming be employed in the receiver r-f coils (par. 3-73 - Receiver).

(61) That external tooth lockwashers be employed under all nuts, and that all screws and nuts employed in the receiver be properly plated (par. 3-74 - Receiver).

(62) That a more rugged type of Navy approved band switch be employed in the receiver (par. 3-75 - Receiver).

(63) That Navy approved ceramic tube sockets be employed and properly mounted in the receiver (par. 3-76 - Receiver).

(64) That receiver control knobs have two set screws of the Allen head type (par. 3-32 - Receiver).

(65) That the receiver dial drive have provision for wear takeup to eliminate backlash, that it be enclosed to prevent entrance of dust, and that it be properly lubricated (par. 3-78 - Receiver).

(66) That the speaker frame and cone be treated to withstand moisture (par. 3-79 - Receiver).

(67) That the receiver wiring be improved. This includes elimination of spaghetti, use of protective grommets where wires pass through metal partition, anchoring of long leads, and elimination of tube sockets as supports for components (par. 3-80 - Receiver).

(68) That a better system of shock mounting the receiver tuning condenser be employed (par. 3-81 - Receiver).

(69) That the cause of the receiver's blocking immediately after it reaches maximum output on cw be removed (par. 3-82 - Receiver).

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(70) That the receiver r-f gain control range be extended to at least 100 decibels (par. 3-83 - Receiver).

(71) That the excessive high-frequency oscillator radiation of the receiver be reduced to a safe level from a security standpoint (par. 3-84 - Receiver).

(72) That the receiver audio output system be revised so that speaker output is not obtained when phones are in use (par. 3-86 - Receiver).

(73) That the receiver squelching action be greatly improved (par. 3-87 - Receiver).

(74) That the receiver frequency drift with temperature variation be considerably reduced (par. 3-88 - Receiver).

(75) That the cause of receiver beat-frequency oscillator superregeneration be removed (par. 3-90 - Receiver).

(76) That the receiver chassis be completely redesigned to provide greater rigidity and strength; this being necessary before considering any of the preceding recommendations, and that the metal workmanship be improved (par. 3-38, par. 3-40 and par. 3-66 - Receiver).

(77) That the receiver be completely redesigned with these recommendations in mind (Receiver).

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MATERIAL UNDER TEST

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

3 - Model TCQ Transmitter-Receiver
Type CHI-43012, Higgins Industries, Inc.
Transmitter output: 30 watts CW, MCW, Phone.
Frequency range: 2000 to 9050 kilocycles.
Serial Nos. 16, 17, and 36X.
Power Supplies: 24-v d.c., 24-v d.c., 110-v a.c.

1 - Set vacuum tubes for the above (tubes were shipped in place in the transmitter-receiver units).

2 - Dynamotor-Filter Units.
Type CHI-21575, Higgins Industries, Inc.
Input: 22 amps. at 24 volts d.c.
Output: 500/400 volts at 350/250 ma d.c.
Serial Nos.: 16 and 17.

1 - Special Rectifier-Filter Unit (tubes in place).
Input: 110 volts a.c.

2 - Remote Control Units.
Type CHI-23234.
Serial Nos.: 16 and 17.

2 - Antenna Masts.
Type CHI-66028.

2 - Antenna Base Insulators and Fittings.
Type CHI-66028.

3 - Bunnell Keys (9050-5-4).

3 - Universal Aircraft Microphones (Model AR-10) with holders.

3 - Sets of connection cables.

2 - Instruction books for the Serial No. 36X Equipment.

2 - Instruction books for the Serial Nos. 16 and 17 Equipments.

1-5. Plates TR-1 to TR-12, inclusive, are views showing the construction of the Model TCQ Equipment and its associated antenna. The power unit for the Serial No. 36X Equipment was submitted only to facilitate testing, and, since it is not a unit of the standard equipment, no photographs are included.

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1-6. The Serial No. 36X Equipment was received at the Naval Research Laboratory on October 20, 1941. The Serial Nos. 16 and 17 were received on December 12, 1941.

METHOD OF TEST

1-7.

(a) The TCQ equipments were carefully unpacked and examined for damage received in transit. The power unit of Serial No. 16 was found to have suffered the following damage:

(1) The unit had pulled loose from the bottom plate, which was bolted to the crate.
(2) Ends and sides of the chassis were buckled inward.
(3) Dynamotor end bells were crushed.
(4) Filter capacitors mounted on top of the chassis were bent out of line.
(5) Top of chassis was bent down in the center where the two dynamotors are mounted.

The Serial No. 17 Power Unit was found to be in essentially the same condition. These units were packed for shipment by fastening the base plate down to the packing box with four bolts. The motor-generator unit itself was inserted in this base plate, whose edges are bent over to form a slot into which the unit slides. During shipment the heavy chassis pulled loose from the base plate and normal handling in shipment thereafter caused the damage listed above. Previous correspondence received from the Bureau indicates that this trouble has occurred in all units received for installation. Since the chassis and base plate material are considered too soft and light to give satisfactory service, it is recommended that the difficulty be corrected by strengthening these members and by the employment of a sturdier method of fastening the chassis to the base plate. The method of packing should be improved also.

(b) The transmitter-receiver units (Serial Nos. 16 and 17) were examined and the following damage found:

(1) The glass and case of the antenna ammeter of each equipment was cracked.
(2) Rear corner of the Antenna Coupling Circuit Shield was bent in each unit by a bolt holding one of the Lord shock mounts to the frame.
(3) Felt pad inside the cover of the oscillator compartment was loose (Serial No. 16).
(4) Receiver tuning knob not secured to shaft (Serial No. 16).

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(5) Nuts holding the r-f, mixer, and h-f oscillator section of the receiver to the chassis had come off and the entire section could be moved about 1/8-inch by means of the front panel tuning knob (Serial No. 16).
(6) Type 1625 modulator tube gassy (Serial No. 16).

These units were packed for shipment in a sturdy wood crate. However, they are held to the crate by only two bolts, one in the bottom and one in the back of the mounting cradle. Very little padding was provided in these boxes, the equipment shock mounts being depended on to protect against shocks received in transit. The condition of the units as received indicates clearly the necessity for improved packing and securing. Two bolts are not sufficient to give the unit the necessary support it requires to successfully withstand rough handling. An inspection of the Serial No. 36X Transmitter-Receiver revealed the following:

(1) Type 38250 tube in receiver missing.
(2) Receiver temperature compensation capacitor C-220 (Band B) cracked.
(3) Master-oscillator coils of bands B and C shorted together in transmitter.
(4) Transmitter power-amplifier coil for band C shorted inside coil form.

(c) The remote control units, microphones, keys, connector cables, etc. were in good condition when unpacked. The packing of these items is considered to be satisfactory.

(d) Both antennas were received in good condition. The end of one box was found to be partially open due to splitting of the end board, but no damage to the antenna had resulted. A block at least two inches thick should be substituted for the end board used at present in order to minimize the possibility of trouble from this source.

Transmitter

1-8. The general construction of the transmitter and modulator was examined and the component parts were inspected as completely as possible without resorting to complete disassembly or destruction of the various parts.

1-9. The transmitters were adjusted in accordance with the directions contained in the instruction books furnished. Measurements of power output were made using dummy antennas simulating, as closely as available apparatus would permit, the measured characteristics of the whip antenna, furnished as a part of the equipment. Tables covering the various tests

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conducted also include a description of the antenna employed in each case.

1-10. The equipment was placed within a test chamber and subjected to variations in ambient temperature and relative humidity. A careful check was maintained on the output frequency of the transmitter by means of a Model LK Drift Indicator and a Model LM-2 Frequency Meter. During these tests, the ambient temperature was varied between the limits of +50°C and 0°C. The relative humidity was varied between the limits of approximately 20 per cent and 95 per cent at a temperature of 40°C. The ability of the equipment to start and operate after an idle period at temperatures between -10°C and -20°C was checked as well as its ability to start and operate after long subjection to high temperature and high humidity.

1-11. The ability of the equipment to withstand pitch, roll, vibration and shock was determined by mounting the complete equipment on a test platform capable of producing these effects in controllable amounts. The output frequency was kept under constant observation during these tests by means of an LK drift indicator. Voice signals were also transmitted and the quality observed on a suitable receiver.

1-12. Tests of modulation and distortion were made by means of an RCA Model 69-C Distortion Meter and a cathode-ray oscilloscope.

1-13. The transmitter was operated with the whip antenna forming a part of the equipment. Observations were made of the power output and ease of tuning.

1-14. Frequency range, overlap and end tolerances were determined by means of a Model LM-2 Frequency Meter.

1-15. Measurements of ripple voltage present in the outputs of the dynamotors were determined by means of high impedance voltmeters of the Ballantine type.

1-16. The degree of amplitude modulation present in the cw output was determined through the medium of a suitable rectifier, blocking capacitor and voltmeter.

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1-17. Battery and line voltages on the receiver and measuring instruments were maintained at rated values throughout each test.

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1-18. In making tests requiring antenna input, the output of the standard signal generator was connected to the receiver input terminals through an I.R.E. standard dummy antenna (General Radio 413-G) or through a 100 micromicrofarad capacitor in series with this dummy. The former dummy enables a comparison to be made with other receivers tested with this standard dummy. The latter dummy gives a better approximation to the actual 24 or 35-foot whip antenna supplied with this equipment. The receiver chassis was always grounded to the inside shield of the double copper screen booth in which the measurements were made.

1-19. The speaker voice coil was shorted out and output measurements were made using a 100,000-ohm output meter plugged into the phone jack. The output load was then an internal 1,000-ohm load provided in the receiver.

1-20. Measurement of the operating voltages was made on the complete equipment prior to disassembly. All voltages necessary for operation of the receiver proper were maintained at these values throughout the tests. They agree with the data given in the instruction book.

1-21. CW Sensitivity. The standard 20-decibel signal to noise ratio was maintained, with standard output as 6 milliwatts at 1,000 cycles in a 1,000-ohm load (2.45 volts) and standard noise as 60 microwatts (0.245 volts). Maximum audio gain was employed. The beat-frequency oscillator control was set at the center of its rotation and the beat note giving optimum output was employed. Measurements were made at five spaced frequencies in each band, including the last calibrated point at each end, and for each crystal controlled channel. Both the standard and "24-foot antenna" dummies were employed at each frequency.

1-22. MCW Sensitivity. The beat-frequency oscillator was turned off, and maximum r-f gain was employed. The carrier was modulated 30 per cent at 400 c.p.s. A 10-decibel ratio was maintained between the modulated carrier-on condition and the unmodulated carrier-on condition. This was obtained by adjustment of the audio gain control and the carrier input. Standard output was 6 milliwatts in 1,000 ohms (2.45 volts) and standard noise was 0.6 milliwatts (0.775 volts). This measurement was made at the same frequencies at which cw sensitivity measurements were made, and with the "24-foot" dummy only.

1-23. I-F Selectivity. The audio gain was set at maximum, and the beat-frequency oscillator was left off. The standard signal generator was connected between the signal grid of the mixer tube and ground. The original grid lead was removed.

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The signal generator was modulated 30 per cent at 400 c.p.s. and its frequency was adjusted to produce maximum output. The carrier level was set to as low a value as would still give a usable signal to noise ratio. The carrier level, signal generator dial setting and output voltage were observed. The input was increased in steps and at each step the signal generator was detuned on each side of resonance until the same output was obtained. The input and dial reading were obtained in each case. The signal generator calibration curve was used to obtain the deviation in kilocycles in each case.

1-24. R-F Selectivity. The plate of the mixer was fed through a 10,000-ohm resistor instead of through the first i-f transformer primary. The plate was by-passed to ground with a 0.005-microfarad capacitor, and was fed to the input of a General Radio 714-A Amplifier through a 10,000-ohm resistor and a 0.005-microfarad capacitor. The lead to the amplifier input was shielded. A General Radio 736-A Wave Analyzer was connected across the amplifier output. The high-frequency oscillator tube was removed from its socket. This made the first detector into a plate detector with r-f filtering in the output, and a means was provided to discriminate against the hum which was encountered. This allowed greater deviations from resonance to be measured with the available signal generator output. The beat-frequency oscillator was removed from the socket. Its switch then merely turned the AVC off or on. Maximum r-f gain was employed. The signal generator was modulated 40 per cent at 400 c.p.s. and was connected to the receiver input through the "24-foot" dummy. The measurement procedure was the same as for i-f selectivity, except that the wave analyzer was the output meter. This measurement was made at both ends of each band and for one crystal controlled channel; all with AVC on. Two measurements were repeated with AVC off.

1-25. CW Resonant Overload. The receiver was adjusted for cw sensitivity. The input was varied in steps from zero up to a level which resulted in blocking. The beat-frequency oscillator was then retuned to produce a beat even though it was not 1,000 cycles. The signal was then further increased in steps and the oscillator retuned where necessary until the receiver was blocked at all settings of its control. At each step, the input signal and output voltage were observed. This measurement was made at the center of each band.

1-26. MCW Resonant Overload. The receiver was adjusted for mcw sensitivity on the "24-foot" dummy. The input was varied in steps from zero to the maximum output (2 volts) of the signal generator. At each step, the carrier level and output voltage were observed. This measurement was made at only one frequency for comparison with the squelch characteristics.

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1-27. R-F Gain Control Characteristics. A paper disc having indications for every 20 degrees rotation was secured to the front panel around the r-f gain control shaft. The receiver was adjusted for cw sensitivity. The r-f gain control was then rotated in 20-degree steps from zero to 300 degrees (full on) and, at each step, the input required to produce standard output was observed. The noise level with no input signal was measured at each step. These measurements were made at the mid-frequency of bands A and C.

1-28. Audio Amplifier Characteristics. The diode plate lead from the second detector was removed from the last i-f transformer. Audio input from a General Radio 713-B Audio Oscillator was applied between the original plate end of the i-f transformer and the second detector cathode. The audio input voltage was read on an electronic voltmeter. This voltage was adjusted to a value which produced standard output at the frequency of greatest response. The input was then held constant at this value. The a-f gain control was set at maximum, and the squelch was left off. The audio-frequency was varied in steps from 20 to 10,000 c.p.s. and at each step the output voltage across a 1,000-ohm load was observed. This measurement was repeated with the squelch turned on. The squelch setting did not appear to affect the characteristic.

1-29. Frequency Stability for Changes of Supply Voltage. The receiver input was fed through the "24-foot" antenna dummy from a 100 kc standard frequency line. Harmonics up to 3.1 mc were usable as signals. The beat-frequency oscillator was turned on. The heater voltage was held constant at 24 volts d.c. A wave analyzer was connected across the output load so that the signal could be detected even below the noise level. The wave analyzer was used as a frequency measuring device. The optimum beat note was set in the vicinity of 1,000 cycles with a B voltage of 280 volts. The voltage was varied in steps from 320 to 90 volts, and, at each step, the voltage and output frequency were observed. The frequency deviation in per cent of the carrier frequency was determined using the frequency at 280 volts as a reference. This measurement was made at 2.0 mc and at 3.1 mc in band A. A note was made of the voltage at which the voltage regulator tube extinguished and the benefits from its use disappeared.

1-30. Radio-Frequency Radiations. The "24-foot" dummy antenna was connected between the receiver antenna and ground terminals. A 10,000-ohm resistance was connected from the antenna terminal of another receiver which was used as a voltmeter. An output meter was connected to the voltmeter receiver. The line voltage to this receiver and the heater and B voltages of the TCQ receiver were maintained at rated

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value throughout the measurement. The output from the TCQ high-frequency oscillator was tuned in on the voltmeter receiver and the output meter reading observed. The TCQ receiver was then replaced by a standard signal generator. The signal generator voltage was adjusted to give the same output meter reading, and the radiation microvolts were read from the signal generator attenuator. The same procedure was followed at oscillator harmonics with the voltmeter receiver and signal generator set to the proper harmonic of the TCQ oscillator. These measurements were made at the same receiver dial settings that were employed for sensitivity measurements.

1-31. Image Rejection. The receiver was adjusted for cw sensitivity with the "24-foot" dummy antenna. The sensitivity was recorded. Without changing any receiver adjustments, a signal was fed in at the image frequency, care being taken to employ the optimum of the two audio beats obtainable. The image input was adjusted to give standard output. The image rejection ratio was taken as the ratio of this voltage to the sensitivity input voltage. The image frequency was also indicated on the r-f selectivity curves to show the extent to which it deviated from the signal frequency.

1-32. Output Load Variation. The receiver was adjusted for mcw reception, but with reduced gain. A constant level carrier modulated 30 per cent at 400 c.p.s. and of such level as to produce standard output in a 1,000-ohm load was fed into the receiver through the "24-foot" dummy antenna. The external load was varied from 100,000 ohms to 2.5 ohms in steps. At each step, the resistance and output voltage were measured. The output power and decibels relative to the maximum output were computed.

1-33. Squelch Characteristics. The receiver was adjusted for mcw sensitivity. The squelch was then turned on and set to give maximum squelching action. The measurement procedure was the same as for mcw resonant overload. This was repeated for the squelch control set at half scale, and for minimum squelching action. These results were plotted on the same sheet with the mcw resonant overload curve.

1-34. Ambient Temperature Variation. The receiver was operated from the dynamotor unit with provision for charging the battery to maintain the voltage at 24.0 volts. The battery voltage was recorded at the same time all other readings were taken. The receiver and dynamotor were placed in the temperature room with two leads coming out from the phone jack, and a shielded lead coming from the dummy antenna to a switch. The shielded lead was terminated with a 39-ohm resistor at the input to the dummy. The dummy was connected to a plug which fitted the transmitter antenna receptacle. The antenna relay was left in the "receive" position.

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1-35. The external switch connected the center conductor to either the standard signal generator or the Model LR Heterodyne Frequency Meter, their connecting leads all being shielded. All shielding was tied together and grounded.

1-36. The receiver was adjusted for cw sensitivity, except that the gain was reduced to allow for increases in the local noise level which were probable in this location.

1-37. The humidity was held as nearly as practicable to 30 per cent throughout the test. It was determined from the readings of a wet and a dry bulb thermometer taken every ten minutes.

1-38. The temperature was set to 50 degrees Centigrade and held for one hour. It was then dropped to 40 degrees and held for one hour, etc., down to zero degrees Centigrade.

1-39. Every ten minutes the signal generator input required to give standard output was recorded. The signal generator frequency was adjusted to give a 1,000-cycle beat note on the optimum beat. These voltage values were used as a measure of the receiver gain.

1-40. A signal from the LR heterodyne frequency meter was fed into the receiver and the frequency adjusted for zero beat. This frequency was determined as the overall receiver frequency every ten minutes.

1-41. The radiated oscillator voltage was sufficient to beat with the LR heterodyne frequency meter and give a zero beat at the receiver high-frequency oscillator frequency. This measurement was also made every ten minutes.

1-42. These measurements were made at both ends of the highest frequency band. One measurement was made in the lowest frequency band when the temperature was held at 50 degrees Centigrade until stabilization was reached, and then dropped to zero until stabilized there. Another measurement was made where the temperature was dropped from zero to minus 20 degrees Centigrade and stabilized there.

1-43. Humidity Variation. Connections and measurement technique were the same as for temperature variation measurements. The temperature was held as near as practicable to 40 degrees Centigrade, and was recorded every ten minutes. The humidity was held for one hour at about 95 per cent and then dropped to about 30 per cent for at least one hour. Readings of signal generator input, overall frequency, high-frequency oscillator frequency, and battery voltage were taken every ten minutes.

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1-44. Vibration, Roll, and Shock. The complete TCQ equipment minus batteries was mounted on the vibration table. The measuring instruments and the technique were the same as for the temperature variation tests.

1-45. The frequency and gain measurements were made prior to any movement. The equipment was rocked 45 degrees each way for 30 minutes, and the readings were repeated. This was repeated with the table revolved 90 degrees, and again when revolved 90 degrees more, etc., until the test had been made with the equipment facing each of the four quadrants.

1-46. The equipment was vibrated at all frequencies up to 30 c.p.s., and the frequencies giving maximum noise output were observed. The vibration was continued for 30 minutes. The frequency and gain measurements were again made. The signal microvolts necessary to give maximum noise output were determined. The equipment was vibrated and its behavior on actual signals during vibration was observed.

1-47. The equipment was subjected to shock up to a 150-pound pressure with an air hammer from the front and one side. Frequency and gain measurements before and after shock were made.

1-48. The receiver was removed and given a thorough mechanical inspection.

DATA RECORDED

1-49. The data recorded during the tests are shown in the appended tables and plates. Tables and Plates with the prefix TR refer to the equipment as a whole; the prefix T refers to the transmitter, while the prefix R covers receiver data.

PROBABLE ERRORS IN RESULTS (Receiver Tests)

1-50. Prior to each test, all equipment and measuring instruments incorporating tubes or other devices which are dependent upon temperature for stability were allowed to operate for a sufficient length of time to permit stabilization to take place. Periodic calibration of the wave analyzer and audio-frequency oscillator was made to assume consistent and reliable results. Tables R-1 and R-2 indicate the measuring instruments used, their rated accuracy, and their application to the tests. The estimated overall accuracy depends upon the accuracy of resetability of the measuring instruments, their calibration accuracy, and small factors over which accurate control is not practical. The estimate must take into consideration

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the probability of cumulative or corrective errors from the several instruments used.

Test		Estimated Overall Accuracy %*
(a) CW and MCW Sensitivity		10.
(b) I-F and R-F Selectivity	Sensitivity Frequency	10. 0.1
(c) CW and MCW Resonant Overload		10.
(d) R-F Gain Control Characteristics		10.
(e) Audio Amplifier Characteristics		0.3 db
(f) Frequency Stability for Changes of Supply Voltage		0.1
(g) Radio-Frequency Radiation		10.
(h) Image Rejection		10.
(i) Output Load Variation		5.
(j) Squelch Characteristics		10.
(k) Ambient Temperature Variation	Frequency Gain	0.1 10.
(l) Relative Humidity Variation	Frequency Gain	0.1 10.
(m) Vibration, Roll, and Shock	Frequency Gain	0.1 10.

* Values are values recorded, plus or minus above limits.

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SECTION II - TRANSMITTER

2-1. Vacuum Tubes.

(a) The TCQ transmitter employs seven tubes in the radio-frequency circuits, including two gaseous regulator tubes, and six tubes in the speech amplifier and modulator. The tubes in the r-f circuits are used in the following manner:

(1) One type 12A6 master oscillator in an electron coupled circuit. Capacitive tuning is employed.
(2) One type 12A6 crystal oscillator. A Pierce circuit is used to provide crystal control on four frequencies.
(3) One type 1625 buffer stage. The tuning capacitor of this stage is ganged to that of the master oscillator.
(4) Two type 1625 vacuum tubes in parallel which comprise the power-amplifier stage.
(5) One VR-75 voltage regulator.
(6) One VR-150 voltage regulator.

Tubes in the amplifier-modulator section are used as follows:

(7) One type 6SJ7 first audio stage.
(8) One type 6K6GT second audio amplifier.
(9) Two type 1625 modulators in class AB push-pull.
(10) One type 6H6 peak limiter.
(11) One type 12SR7 audio oscillator.

(b) All vacuum tubes employed in the transmitter and modulator have received Navy Type Approval, but the type 12SR7, used for an audio oscillator tube in this apparatus, is approved for replacement only and is not approved for inclusion in new equipment.

(c) All tube sockets are of ceramic material and are of the "replacement" type secured to the chassis by two screws through a metal ring surrounding the socket itself. None of the tubes is provided with a clamping device to retain the tube, and no shock mounting has been incorporated except that for the entire equipment. In view of the very severe vibration to which this apparatus is subjected in service, it is considered that suitable tube clamps should be employed. Each modulator tube socket is suspended about 5/8-inch below the chassis on two long machine screws, which employ nuts for spacers. The envelopes of the tubes protrude upward through chassis holes above the sockets. This construction permits an undesirable amount of motion in the tube envelope and should be altered to provide a more rigid support. All tube sockets may be serviced or replaced easily.

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(d) Connection to the tube caps is made with cotton-covered stranded wire covered with an insulating sleeve. National grid clips are used. The leads are not properly secured to their terminal lugs, solder providing the mechanical strength, and the plate leads to the modulator tubes were so short that the wires came loose after the tubes had been removed and replaced a few times.

(e) Buffer, power amplifier, and voltage regulator tubes located in the transmitter section may be replaced after removal of the top shield. The 12SR7 and 6K6GT tubes located in the modulator may be replaced after removal of the left side shield. All other tubes cannot easily be replaced without withdrawing the two units from the cabinet. Even after withdrawing the transmitter unit, access to the master and crystal oscillator tubes requires the removal of an additional shield over the oscillator compartment. Since this shield is held by 14 nuts and 3 screws, considerable time is lost in changing tubes. Spade bolts used to fasten the compartment covers are each secured by only one rivet and may therefore turn sufficiently to make it difficult to line up all 14 bolts and replace the cover. General specifications RE 13A 554D require the use of two rivets in each spade bolt in order to prevent this undesired motion. It is recommended that necessary changes in the design be made to increase the accessibility of all vacuum tubes. The time necessary to make tube changes should be reduced to a minimum.

2-2. Controls.

(a) Table T-1 lists all front panel controls which pertain to the transmitter and modulator. In addition, there are several amplifier and modulator controls on the receiver-modulator chassis which are accessible only when the left side shield is removed. Controls which require a screwdriver for operation will be discussed in paragraph 2-3. All knobs on the transmitter front panel are 1-5/8 inches in diameter and, except for the channel control, can be manipulated without difficulty by an operator wearing heavy gloves. It is recommended that all knobs be pinned to the shafts to assure more positive operation than is afforded by the single or double set screw fastening now employed. The channel control knob operates two sets of switch sections which are mechanically connected by means of two right-angle gear boxes and shaft interconnections. A total of fourteen ceramic-insulated wafer switch sections are actuated by this control. This constitutes a considerable mechanical load and makes manipulation of the control difficult with the size knob provided. Due to the location of the controls on the front panel, the size of the channel control knob cannot be materially increased without interference with adjacent controls. It is suggested that

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necessary redesign be undertaken to facilitate operation of this control. The detent mechanism on the oscillator gang switches controlled by the channel switch is insecurely supported and became loose during the test period. The mechanism should be moved closer to the wafer switch sections involved in order to correct this difficulty. The oscillator tuning and final tuning controls operate variable capacitors through a system of metal gears. The gear train is constructed of nonmagnetic material and is not preloaded to eliminate backlash and take up wear. The only end stops provided in these assemblies are those incorporated in the driven variable capacitors. This is a particularly undesirable design, since sufficient torque is applied even with normal operation to cause deflections in the capacitor mounting brackets and unnecessarily strain the entire tuning system. End stops should be a part of the dial mechanism. The excitation control knob operates a small variable capacitor capable of complete rotation; therefore, end stops are not provided.

(b) The controls listed in the preceding subparagraph are not considered to be satisfactorily coupled to the driven loads. No flexible couplings are employed to isolate tuning mechanisms from panel and chassis deflections or shaft misalignments. Sleeve type rigid couplings are used which are pinned to the shafts by means of brass escutcheon pins. These pins are too soft to provide satisfactory performance over long periods, and it is recommended that standard stainless steel taper pins be substituted. The coupling sleeves are also equipped with set screws. However, ordinary RH brass screws have been used for the purpose rather than the hardened, cup-ended type designed for the purpose, and the screws therefore carry very little load. The coupling sleeves are in some instances too large for the shafts on which they are used and bushings to correct the situation have not been employed in all cases. Set screws used in the dial mechanisms are plated steel oval-head screws which showed signs of rust during the short test period. Taper pins should be substituted in these applications also.

(c) The front panel is engraved adjacent to each control with a description of its function. All markings are easily readable at distances in excess of 24 inches.

(d) The receiver panel has a main "power" switch which turns on the receiver and which must be in the "on" position before the transmitter can be started; a "transmitter" switch which starts the high-voltage dynamotor if the main power switch is in the correct position; and an mcw switch. All switches are of the toggle variety and satisfactorily perform their duties. A similar mcw switch is included in the remote control unit and constitutes the only transmitter control in

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that unit except for the microphone press-to-talk switch.

(e) Indicator lamps are not furnished in the equipment, although dial lamps can be observed for this purpose. It is recommended, however, that suitable indicator lamps be incorporated to indicate the conditions of both the receiver and the transmitter.

2-3. Tuning. The means of adjustment of the various circuits and the procedure are given below.

(a) Oscillator. Separate crystal and master-oscillator tubes and circuits are employed. The crystal oscillator is of the Pierce type employing a type 12A6 vacuum tube. Four crystals were supplied to provide output frequencies of 2716, 3045, 4335 and 5335 kilocycles. After adjustment of internal controls, operation at any desired crystal frequency may be obtained by means of the channel-selector switch located on the front panel. Owing to the circuit used, no tuning is necessary in the crystal oscillator. The master oscillator also utilizes a type 12A6 vacuum tube. Electron coupling is used with the cathode of the oscillator tube operating at an r-f potential above ground. Three sets of coils and trimmer capacitors are used in conjunction with a single variable tuning capacitor to cover the two to nine-megacycle range, the selection being accomplished by the front panel channel-selector switch. Each tuned oscillator circuit has a temperature-compensator variable capacitor associated with it. These capacitors are in parallel with the respective padding capacitors, and, therefore, any change in their setting alters the frequency range of the circuit. Means has been provided for setting these temperature-compensator capacitors in service. However, it is not considered possible to correctly adjust devices of this sort after installation, and it is recommended that they be preset at the factory and the adjustment holes covered. Band setting trimmer capacitors provided for each of the three oscillator ranges may be adjusted to the calibration frequencies listed in the instruction book. Tuning of the master oscillator is accomplished by means of a variable capacitor controlled by the oscillator tuning dial located on the front panel.

(b) Buffer. The buffer employs a type 1625 vacuum tube with three separate tuned circuits, corresponding to the oscillator ranges, the grid circuit is untuned and all tuning is accomplished in the plate. This stage is also tuned by means of a variable capacitor in conjunction with tracking capacitors equipped with screwdriver slots and shaft locks. These tracking controls are located on the left side of the transmitter chassis, but the chassis must be drawn forward slightly to permit complete accessibility and allow adjustment. The frame should be changed in shape to eliminate the necessity for such withdrawal. A

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separate adjustment is provided for tuning the buffer in each of the four crystal controlled bands. The master oscillator ranges are tuned by a variable capacitor ganged to the master-oscillator tuning capacitor. A single tracking capacitor is provided for the bands from 2 to 3.5 and 3.6 to 6.2 megacycles, while a separate capacitor is provided for the 6.25 to 9 megacycle band.

(c) As previously stated, many of the oscillator and buffer controls are located on the left side of the transmitter chassis. These controls are as follows (see Plate TR-2):

A	Master-Oscillator Tracking Capacitor	2.0 to 3.5 Mc
B	Master-Oscillator Tracking Capacitor	3.6 to 6.2 Mc
C	Master-Oscillator Tracking Capacitor	6.25 to 9.0 Mc
1	Buffer Tuning Capacitor	Crystal Channel 1
2	Buffer Tuning Capacitor	Crystal Channel 2
3	Buffer Tuning Capacitor	Crystal Channel 3
4	Buffer Tuning Capacitor	Crystal Channel 4
AB	Buffer Tracking Capacitor	2.0 to 6.2 Mc
C	Buffer Tracking Capacitor	6.25 to 9.0 Mc

Three holes just above oscillator adjustments A, B, and C provide access for setting the oscillator temperature compensation capacitors.

With the exception of the temperature-compensation capacitors, all the above controls are equipped with screwdriver slots and shaft locks consisting of a nut on a split sleeve. Holes through which adjustment of oscillator trimmers A and B is accomplished are off center and do not permit introduction of a wrench by which the lock may be tightened. It is recommended that holes be correctly placed to facilitate adjustment.

(d) Power Amplifier and Antenna. The power amplifier and antenna tuning system consists of a pi section made up of a series coil and two shunt capacitors. The channel switch located on the front panel effects changes in capacitor and coil combinations to cover the required range. No separate power-amplifier tank is provided, the pi section serving simultaneously as a tank, antenna tuning, and antenna coupling system. Only the variable capacitor associated with the power-amplifier end of the pi can be controlled from the front panel; all the other capacitors are grouped at the rear top of the transmitter assembly as shown in Plate TR-4 and are preset on installation. Due to the switching arrangement employed, it is not possible to adjust the capacitor for the low-frequency band without disturbing the settings for the other bands. Each of the variable capacitors is equipped with a bar knob and a small dial engraved from zero to ten. However, no index marks are provided and it is therefore impossible to log the

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capacitor settings. Suitable clamps have been furnished for locking the capacitors after completion of the adjustments.

2-4. Accessibility and Protection of Personnel.

(a) Transmitter-Receiver Unit. Access to any component in the transmitter unit recuires the removal of top and side shields and may require withdrawal of the transmitter from the mounting case. No access doors are provided on the front panel. Power-amplifier, buffer, and voltage-regulator tubes are accessible if the top shield of the case is removed. Access to the oscillator tubes involves removal of the transmitter from the frame and removal of the oscillator-buffer compartment top shield, as pointed out in paragraph 2-1(e). Most of the tubes in the amplifier-modulator section are inaccessible even though the main side shields are removed, and the receiver-modulator chassis must be withdrawn before they can be replaced. Since some transmitter tuning is accomplished at the left side and top of the transmitter, as described in the previous paragraph, sufficient space must be provided for these operations to be carried out after installation. The transmitter chassis may be withdrawn from the frame by disconnecting the receiver-transmitter interconnection cable, which is fitted with an Amphenol Type AN3102-28-4P Plug Connector. The socket for this cable is located beneath the left front corner of the transmitter chassis. After the transmitter unit is removed from the frame, almost all parts are accessible for servicing without any further disassembly except as noted below. The antenna tuning capacitors are enclosed in a shielded compartment which offers unusual difficulties in disassembly and which must be reassembled with self-tapping screws because of the impossibility of using the screw and nut construction originally supplied. Variable tuning capacitors in the oscillator, buffer, and power amplifier are so mounted as to be extremely difficult to remove. Simplification of this construction and increased accessibility to parts mounted in the shielded oscillator, power-amplifier, and antenna compartments are highly desirable in order that servicing may be more easily accomplished. The various by-pass and coupling capacitors, resistors, and chokes associated with each stage are readily accessible from beneath the chassis. No interlocks are provided on the transmitter-receiver unit. Tuning of the antenna circuit must be performed with the top shield removed. This exposes the operator to the possibility of contact with the plate caps of the buffer and power-amplifier tubes which are located in close proximity to the antenna controls. To eliminate this danger, it is recommended that insulated tube cap clips be provided for these three tubes.

(b) Power Equipment. As shown in Plate TR-3, the power unit has all terminals and parts operating at high voltage

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completely enclosed. Removal of the unit from its base plate exposes all components for necessary servicing or replacement. The line fuses and starting relays operate at low voltage and are enclosed in a shielded compartment on top of the power chassis. Interlocks have not been provided in the power unit and are not considered necessary. However, a suitable warning nameplate should be affixed in a prominent position on this unit to warn of the presence of high voltages when the unit is removed from its base plate.

(c) Remote Control Unit. The components located in this unit are completely accessible if the rear shield is removed. This is readily accomplished by taking out the retaining screws at the top and bottom without detaching the rear shield from the bulkhead upon which it is normally mounted.

2-5. Wiring.

(a) Wiring in the Model TCQ Equipment is not up to the usual standard encountered in Naval apparatus and, in general, is not considered to be satisfactory in quality or workmanship. Several varieties of hook-up wire are employed with little regard for the electrical and mechanical suitability. Cotton covered, tinned, stranded wire, of approximately 18 or 20 B and S gauge has been used for most applications, even where considerable r-f current must be handled, such as in the power-amplifier tank circuit. During the tests performed at the Laboratory, severe overheating occurred in this wire in the tank circuit. Heating was of sufficient degree to completely carbonize the cotton insulation and fill the compartment with smoke. Replacement of the wire was complicated by the difficulty encountered in removing the shield from the antenna capacitor compartment as described in paragraph 2-4(a) and by the fact that the tank lead had been cabled together with a ground wire. The wire was eventually replaced with a solid uninsulated wire and no further trouble occurred. Plug-in coils in the oscillator, buffer, and amplifier stages are wound with heavy enamelled wire. However, lead-through holes in the ceramic form do not accommodate wire of this size and a much smaller wire has been spliced to the coil wire in order to make connections to the coil prongs. When received, the p-a coil of band "C" was found to have the lead wires inside the form shorted together, rendering the equipment inoperative on the 6.25 to 9.0 mc range. The grades of hook-up wires used differ between the various stages, and the same type of wire is not used for the same application in different stages. A considerable amount of spaghetti tubing has been employed as additional insulation in the transmitter. The desirability of this practice is questioned, in view of the moisture and humidity conditions which are encountered in service. During humidity tests conducted in the Laboratory

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test chamber, the cotton covering of the wires absorbed considerable moisture and became quite damp. This condition persisted even an hour after the humidity had been brought down to a low level, and the wiring was very slow in drying out. Leads have been cabled together in many instances where this is possible; however, r-f leads are not kept separated from general power leads and the possibility of breakdown and insulation trouble is therefore increased. Solder is very often depended on for mechanical strength in connecting wires to terminal lugs. Wiring in the amplifier-modulator section is subject to the same criticisms. The wires to the modulator tube plate caps broke off due to improper soldering, as mentioned in paragraph 2-1(d). The wire between R140 and R147 snapped during vibration tests. Service reports indicate that this same trouble occurred in actual installations. Anchoring of the resistors and the use of a flexible wire at this point will eliminate the difficulty. It is pointed out that the service reports show several failures due to poor soldering, improperly insulated wires, or bad wiring practice. Breakdowns of the type encountered, which produced smoke and flame, may result in considerable danger of fire when the equipment is operated in confined spaces in which gasoline fumes may be present.

(b) The interconnections between the transmitter, receiver, and power supply are made with cabled wires enclosed in a cotton covered enamelled sleeve, which did not permit additional examination. It is recommended that a multi-wire cable insulated with a heavy rubber covering be used in place of the cabled wires now employed in order to reduce trouble due to contact of the cable with the wet deck.

(c) Neither of the high-voltage dynamotor inputs to the transmitter is provided with an r-f by-pass in the transmitter unit. During tests with the Serial No. 36X Equipment, which employed a rectifier plate supply, three filter capacitors in the power unit were successively destroyed by r.f. carried from the transmitter by the high-voltage cable. Although no trouble of this sort was encountered with the equipments using dynamotor supplies, it is not considered good practice to leave the supplies without proper r-f by-passing, and such by-passing is required by usual Naval specifications.

2-6. Insulation. Both ceramic and phenolic materials have been used as insulation in the Model TCQ Transmitter. Ceramic material has been used for tube sockets, stand-off insulators, multiposition switch sections, variable capacitor insulation, and coil forms. The keying relay insulation is Mycalex, while the antenna connector is insulated with polystyrene. Phenolic insulation is employed for resistor bank mountings, meter cases, capacitor cases, crystal holders, and

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interunit connectors. In general, the correct type of insulation has been chosen for each application. However, crystal mountings should be ceramic, and the advisability of using up to 500 volts on the pins of the Amphenol interunit connection plugs is questioned, since this exceeds the Naval voltage rating for this type plug.

2-7. Weights and Dimensions. The weight of the entire equipment is 151-3/4 pounds. Individual weights and overall dimensions of the separate units are given in Table TR-1.

2-8. General Physical Construction.

(a) The transmitter and the receiver are both contained in a common frame from which they are individually removable. The outward appearance is illustrated in Plate TR-1. The receiver chassis also contains the speech amplifier, modulator, and peak limiting components, which are arranged along the rear of this deck. The transmitter and receiver chassis each slide into metal guides when inserted in the frame and are secured by means of four oval-head screws passing through the edges of the front panel. The case is fabricated from nonmagnetic sheet metal approximately 5/64-inch thick. Spot welding has been employed in its construction and no signs of weakness appeared during the test period. Removable covers, which fit flush with the surface, are provided on the top and sides of the case. Each cover is fastened by four RH nickeled brass screws, which fit elastic stop nuts riveted to the case. It is recommended that captive screws attached to the covers be used in this application to prevent loss. The entire frame is mounted in an L shaped cradle covering the bottom and rear. The cradle is constructed in the same manner as the frame. The transmitter-receiver frame is supported in this cradle by means of six Lord shock mounts, four at the bottom and two at the top rear. This constitutes the only effective shock mounting in the equipment. The transmitter and the receiver chassis are each made of 3/64-inch aluminum and internal shielding is of the same gauge material. Covers to the oscillator and power amplifier compartments are slightly heavier, being approximately 3/32-inch in thickness. The vertical internal shielding in the transmitter adds considerably to the rigidity of the chassis and prevents the severe vibration noted in the receiver.

(b) The outside of the transmitter and receiver case, the cradle, the outside of the power unit, and the outside of the remote control unit are all finished in black wrinkle finish. The interior of each unit is painted a flat black. The transmitter and receiver chassis are not finished and it was impossible to determine whether any protective coating had been applied.

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(c) Steel has been used to some extent in the construction of the Model TCQ Equipment. Plated steel has been used in the transmitter in the following applications: elastic stop nuts, bolts securing the shock mounts to the frame, spade bolts used to fasten oscillator and power-amplifier compartment shields, shafts of band-selector switches, securing nuts for the keying relay, screws securing vertically mounted resistors, meter jack frames and tube socket retaining rings. In the power unit, plated steel is employed for capacitor cases and brackets, capacitor pal nuts, and transformer cases and securing screws. Corrosion of several of these parts was noted after subjection of the complete equipment to high humidity. It is recommended that all threaded parts mentioned in the above listing be constructed of corrosion resisting material, since the use of steel will eventually cause difficulty in servicing, even though a protective coating is initially present. The dynamotor frames and end bells are of steel. Considerable corrosion was noted in these units, particularly the interior surface of the frames and around the screened ventilation holes near the ends of the frames. It is suggested that particular care be taken to adequately protect these parts against the effects of a salt sea atmosphere by the application of a suitable protective coating. The cadmium plated screws which secure the end bells show evidence of corrosion and are subject to the criticism concerning threaded steel parts above.

(d) The means by which access to the transmitter and modulator chassis is gained has been discussed in previous paragraphs. The access panels on the sides of the transmitter-receiver frame are each perforated with 16 louvers 2-3/8 inches long. This provides a reasonable amount of ventilation for components mounted on the receiver chassis, but, owing to the enclosed construction at each end of the transmitter chassis, the side openings are practically blocked off from parts located on top of the transmitter chassis. The top removable shield is not perforated and no louvers are provided in the rear panel of the mounting frame. In spite of the apparent lack of ventilation in the transmitter, no difficulty attributable to overheating due to lack of ventilation was noted during the test period.

(e) The transmitter-receiver unit is not drip-proof. Very extensive redesign of the unit would be required to satisfy a condition of this sort. It is suggested that the Bureau determine the proposed method of installation and the conditions which will be encountered under service conditions with a view of deciding whether drip-proof construction is necessary. The power unit is also of a non-drip-proof design. Owing to the installation conditions which may be anticipated, it is recommended that a drip-proof shield be supplied to adequately

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protect the dynamotors mounted on this unit. The dynamotor construction includes screened openings in the frame and end bells which will admit water unless protection is afforded by a suitable cover. The remote control unit is similar in construction to the transmitter-receiver unit and is illustrated in Plate TR-7. Service reports indicate that this unit is unsuitable for use in the cockpit of PT boats, due to the spray normally present in this location. Complete redesign will be required to provide satisfactory operation under such conditions. An essentially water-tight construction must be employed with a weatherproof speaker, gasketed box, and waterproof switches and controls. Service reports show that waterproof jacks and plugs for microphone, headset and key are a necessity. Covers should be supplied which will protect the jacks when the plugs are not in place. A weatherproof power plug and rubber covered cable must also be employed.

(f) Ball bearings are employed in the dynamotors. Bearings are accessible without difficulty and without any disassembly other than the removal of the end bells and gasketed bearing cover plates.

(g) The general workmanship employed in building the Model TCQ Equipment does not meet the minimum requirements necessary to assure safe and satisfactory performance. Deviations from standard or accepted practice are pointed out in appropriate paragraphs of this report. A few instances not mentioned elsewhere are listed below;

(1) Felt pads which limit motion of plug-in coils in the master-oscillator compartment were not securely cemented to the compartment covers.
(2) Power-amplifier cathode by-pass capacitor not properly soldered.
(3) Brass filings and chips were found on control shafts, bearings and assemblies.
(4) Capacitor C-305 was not wired correctly in the dynamotor power supply units.

2-9. Components.

(a) Meters. Meters are provided on the front panel to indicate power-amplifier grid current, power-amplifier cathode current, and antenna current. All are standard Navy meters manufactured by Weston. The range and model of each meter is included in Table T-1. In addition to the meters mounted on the front panel, additional meters for servicing and adjustment are required as follows:

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Crystal Cathode Current or Master Oscillator Plate Current:	0-15 milliamperes.
Buffer Cathode Current:	0-100 milliamperes.
Modulator Cathode Current:	0-250 milliamperes.
Driver Cathode Current:	0-30 milliamperes.

These meters are not furnished with the equipment. It is recommended that a suitable multi-range meter equipped with plug be supplied. Jacks for the connection of the additional meters are located on the sides of the transmitter chassis and on the left top of the receiver chassis. Each jack is marked with the stage involved, but the range of the meter required and whether the cathode or plate current is measured is not indicated. It is suggested that this information be marked adjacent to each jack. The designations on the master-oscillator and crystal-oscillator current jacks were interchanged on Serial No. 16 Equipment. Care should be taken to verify all markings before release of the apparatus for service. The master-oscillator plate current jack is insulated from the chassis by a fiber washer. Due to the inaccurate punching of the side chassis brace, previously mentioned in paragraph 2-3(c), the spacing between the metal nut of the jack and the edges of the clearance hole in the brace differed in each of the equipments examined and in Serial No. 36 amounted to only about 0.02 inch. It is recommended that the construction be changed to eliminate any possibility of a short circuit developing at this point.

(b) Switches used in the transmitter are listed in Table T-1. The power, transmitter, and mcw switches mounted on the receiver panel are rated as follows: MCW, 3-a, 250-v; Transmitter, 1-a, 250-v; Power, 5-a, 250-v. No trouble with these switches was encountered at any time during the test period. The only switch included in the transmitter chassis is the multiposition channel switch previously discussed in paragraphs 2-2(a) and 2-2(b).

(c) Resistors. A number of one-half, one, and two-watt composition resistors have been employed in the construction of the transmitter. All are equipped with pigtails which serve for electrical connection and mechanical support. With the exception of R-103, the buffer grid resistor, all appear to be adequately supported. A better method of mounting R-103 is suggested in order to prevent vibration of the resistor. Wire-wound resistors of 10 and 20-watt ratings are also used. Two types of these resistors are used and two types of terminals have been provided on the resistors. The first type of resistor is the parasitic suppressor used in the grid and

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plate circuits of the buffer and power amplifier. These resistors are protected by vitreous enamel and have a heavy r-f choke connected across the terminals. The terminals are sturdy tabs which provide good mechanical support, as well as serving as an electrical connection. The remaining wire-wound resistors are mounted vertically underneath the chassis by means of a single axial bolt. Fiber insulating washers are used at both ends of each bolt. These resistors have either tab or pigtail terminals. Except for the parasitic suppressors which are manufactured by Ohmite, all wire-wound resistors are made by Clarostat. The resistance wire of Clarostat resistors is covered with a light green ceramic coating and the resistance rating is stamped with paint on the coating. Two variable-tap resistors are included in the modulator unit. These are also manufactured by Clarostat and are similar in construction to the resistors described above, with the exception of the unprotected contact path along one side of the body. Four potentiometer type resistors are included in the modulator for the control of mcw tone, mcw gain, audio gain, and peak limiter adjustment. Two of these, rated at 1,000 and 50,000 ohms, are wire wound, while the other two, both rated at 500,000 ohms, have carbon elements.

(d) Fuses. The only fuses included in the equipment are the dynamotor line fuses located on the top of the power unit as shown in Plate TR-8. One of these fuses protects each of the dynamotors, the grounded input side of the line not being fused in either case. The fuse for the receiver dynamotor is a 30-ampere, lag-link, renewable cartridge type mounted in standard 30-ampere fuse clips. The transmitter dynamotor fuse is similar but, according to the instruction book, parallel 30-ampere lag-links should be employed in the cartridge. The equipments received for test were fitted with single 30-ampere links and the fuses were marked 30 amperes. Several fuses were blown in this position before reference to the parts list of the instruction book disclosed the above instruction. The normal full-load current flowing through the transmitter fuse is considerably less than 30 amperes, as is apparent from an examination of Table T-32, and the double links are necessary only because of the high starting current. The use of parallel links in the 30-ampere cartridge is not considered good engineering practice and it is recommended that a 60-ampere cartridge be employed in this position. Fuse positions are not marked in any way and an examination of the wiring must be made before each fuse can be identified. Fuse mountings should be marked with the symbol number and rating of each fuse. High-voltage fuses in the dynamotor output lines have not been provided. Service reports indicate that high-voltage fuses must be supplied to reduce damage after the failure of a component and to insure safe operation.

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Unprotected copper fuse clips have been employed in the fuse mounting. It is recommended that nickel plated clips be substituted to prevent corrosion.

(e) Capacitors. Molded bakelite cased mica capacitors have been employed in the construction of the Model TCQ Transmitter. All are manufactured by Solar and are types which are commercially available from several manufacturers. Variable capacitors employed in the transmitter are made by Hammarlund, Bud Radio, F. W. Sickles, and Radio Condenser Corporation. Negative temperature coefficient capacitors used in the master-oscillator circuits are manufactured by Centralab. All variable capacitors and trimmers are equipped with ceramic insulation. Due to the method of construction and assembly, the trimmer capacitors located in the oscillator and buffer compartments and in the antenna tuning assembly are very difficult to replace. It is suggested that necessary changes in the design be accomplished to increase the accessibility and facilitate replacement. Three electrolytic capacitors are used in the modulator section of the equipment. All are of the cardboard-cased cartridge type and are located so as to be readily replaced without additional disassembly. Other by-pass capacitors in the modulator and power units are of the paper dielectric, metal-cased type.

(f) The antenna connection is provided on the front panel of the transmitter as shown in Plates TR-1 and TR-4. An Amphenol type 93M cable connector is provided for connection to the chassis jack. It is suggested that the Bureau investigate the present or proposed installations and determine the feasibility of locating the antenna terminal on top of the transmitter to reduce the danger to personnel.

2-10. Mounting and Shock Proofing.

(a) The common frame which holds the transmitter and receiver chassis is supported in the L shaped cradle by means of six No. 20 Lord Shock Mounts. The arrangement used is shown in Plate TR-2. Four of these shock mounts are used at the bottom of the frame and two at the top rear. The cradle itself is intended for mounting to a table and bulkhead to which it may be secured by means of bolts through 3/8-inch holes provided in the bottom and back of the cradle. The Lord shock mounts which support the frame can be replaced without difficulty if the transmitter and receiver chassis are removed. With the exception of the keying relay, no additional shock mounting is provided for components in the transmitter and modulator sections of the apparatus. The keying relay is supported on a small metal plate mounted on four soft rubber grommets. The securing nuts have been drawn down so tightly on the rubber as to nullify the effect of shock mounting

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almost completely. It is therefore recommended that the rubber be eliminated. No trouble with this relay was noted during the severe vibration and shock tests to which the equipment as a whole was subjected. Although no damage or mechanical difficulties were apparent during these tests, the absence of locks on controls, tubes, and coils will inevitably cause trouble in service and corrective measures should be applied.

(b) Power Unit. The power unit is not shock mounted. Rubber grommets have been used to shock mount the dynamotors, but the mounting bolts have been drawn up so tightly as to nullify their effect. It is therefore recommended that the rubber be eliminated. The method of mounting the power unit is not satisfactory. The removable bottom plate is first bolted to the deck by means of bolts through the bolt holes provided for the purpose. The power unit chassis is then slid into the lip which has been formed on the edges of the bottom plate. A retaining strip is finally fastened to the bottom plate to secure the unit and prevent withdrawal. During vibration and shock tests, the soft metal from which the chassis is formed bent inward until the chassis was very nearly free from the retaining lip. Additionally, the vibration caused the center of the chassis to sag quite appreciably. The power unit was mounted for shipment in its packing case in the above manner. The two units received for test had pulled loose from the base plate after severely distorting the sides of the chassis. Subsequently, additional damage had been caused to the unit because of the absence of any packing material such as excelsior in the packing case. It is recommended that a much more sturdy chassis be employed and that the method of mounting be changed to eliminate the above difficulties.

(c) Remote Control. The remote control is shown in Plate TR-7. The top, bottom, and rear shields are formed from one sheet and may be removed by taking out several screws. The unit is mounted by bolting the rear shield to the bulkhead, utilizing the four bolt holes punched in the shield, and then reassembling the unit. It is recommended that provision be made for flush mounting the remote control unit to eliminate the danger of injury of personnel or damage to the equipment when the apparatus is installed in confined quarters, such as the cockpit of the PT boats, where a great deal of vibration, rolling and pitching are normally encountered.

(d) Antenna. The antenna is provided with a heavy ceramic base-insulator which may be mounted on the deck by use of the mounting rings and gaskets provided. Six 1/2-inch bolts are used to secure the insulator to the deck. The hollow lower section of the antenna is then slipped over the bronze post on the upper end of the insulator, and is secured with a 1/4-inch bolt passing through both antenna tubing and

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post. A bolt hole has been provided in the insulator post, but only one side of the antenna tubing was drilled in each of the units supplied. Two bolt holes are indicated in drawing R-2021 accompanying the antenna insulator, whereas on drawing R-2022, and as supplied in fact, only one hole is present. It is recommended that the two securing bolts be used as indicated in drawing R-2021 if the holes do not weaken the antenna post unduly.

2-11. Method of Connection. Interconnections between the transmitter, receiver and power unit are accomplished by means of Amphenol AN3102-28-1P, 1S, 4P and 4S plugs and sockets. A connector is also supplied for the battery cable (AN-3106-32-1S) which accommodates No. 0 AWG cable. The use of this type connector has eliminated all terminal boards from the construction. The connectors are of sturdy design and plugs are locked to the sockets by means of a threaded captive sleeve secured to the plug. Eighteen threads per inch are used in the locking ring. It is pointed out that connector AN-3102-28-4P is marked 110-v - 24-v on the phenolic insulating insert. The maximum voltages permitted between pins and ground for this connector under Army-Navy Specifications 9534 are 350 volts d.c. for the 110-volt section and 70 volts for the 24-volt section. These ratings are exceeded in the Model TCQ Equipment and voltages of from 435 to 500 volts are present from pins to ground. A more complete description of this type of connector is given in NRL Report R-1718, in which it is recommended that the voltage rating of these connectors be increased for the present spacings. In view of this, it is concluded that the voltages to which the connectors are subjected in the TCQ equipment will not be detrimental from an operating standpoint. Ground connection terminals have not been provided on any unit of the equipment. It is recommended that a suitable terminal for grounding each unit be included in the design.

2-12. Power Unit. Plates TR-8 and TR-9 show the power unit provided with the TCQ equipment. Components are provided in this unit for taking power from a 24-volt d-c. source and converting it into the proper input voltages required by the receiver and transmitter. The mechanical construction of the power unit has been previously discussed in paragraphs 1-7(a) and 2-10(b). As received, the equipments were wired to operate from a source having the positive line grounded. During the course of the tests, it became necessary to operate with the negative line grounded. The method for conversion described on pages 9 and 10 of the instruction book was found to be unnecessarily difficult, involving the splicing of a wire. Instead, the input end bells of the dynamotors were removed and the leads therein reversed. This can be accomplished easily and provides satisfactory operation. It is therefore

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recommended that the instructions concerning the change be altered to include this procedure. An r-f filter is used in the ungrounded input line, and the power unit also contains smoothing filters for the dynamotor outputs. No electrical trouble was encountered in the power unit during the course of the tests, with the exception of the fuse discussed in paragraph 2-9(d).

2-13. Antenna. The antenna furnished with the Model TCQ Equipment consists of a sectional telescoping mast and a base insulator which also serves as a support. The mast is made up of five sections of oxidized monel tubing, each length being approximately seven feet long. The bottom section is 1-1/16 inches in diameter, while the top is slightly less than 1/2 inch in diameter. Sections are joined together by means of threaded sleeves containing movable wedges which clamp securely on the antenna tubing. The sleeve nuts are knurled and have no provision for using a wrench. Instructions accompanying the antenna state that sections should be overlapped by at least a foot. Stops are already provided to prevent the sections from pulling out or coming apart when the antenna is extended, and it is therefore recommended that the stops be modified to automatically prevent section overlaps of less than one foot. In the units received, it was noted that several of the wedges inside the threaded sleeve clamps were inserted incorrectly. It is suggested that a careful inspection of the items be made during assembly. The bottom section of the antenna is covered with a heavy rubber tube, as may be seen in Plate TR-12. The insulation thus provided was tested at 2, 4, 6 and 8 megacycles. An arc could not be drawn through the dry rubber with the transmitter operating at full power output. The antenna insulator is shown in Plate TR-12, while the complete insulator-antenna assembly is illustrated in Plate TR-11. The antenna and its mounting appear to be commercially available from Premax as antenna type MM-435 and base insulator type 6P-30.

OPERATIONAL DATA AND TESTS

2-14. Electrical tests were conducted along the lines followed in testing standard Navy apparatus where the procedure was applicable. Tests were made with master-oscillator operation for the most part, although data were also taken with crystal operation during a few tests. Listening tests were conducted for both types of operation. The results of the tests are illustrated in Tables T-2 to T-34 and are discussed in the following paragraphs.

2-15. Power Output and Operation with Actual Antennas.

(a) Measurements of the power output were made as

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outlined in paragraph 1-9 with the results shown in Tables T-2 and T-3. Table T-2 lists the maximum power obtainable at various frequencies throughout the frequency range of the transmitter. These were obtained by readjusting all circuits at each frequency. It will be noted that, with the antenna used, very little output was obtained at frequencies from 2000 to 3000 kilocycles. The dummy antenna used in this range consisted of a 5.07-ohm resistor in series with a 150 μμf capacitor, and approximates the constants of the thirty-foot vertical antenna provided with the equipment. The maximum output in this region was found to be 8.2 watts. Three different dummy antennas were used to cover the entire frequency range in order to more closely simulate the changing constants of an actual antenna. Above 3000 kilocycles, a higher resistance dummy antenna was employed with a corresponding improvement in the power output. The cw power remained fairly constant from 3600 to 8500 kilocycles, falling off at 3500 and 9000 kilocycles. The maximum power output at any frequency was 34 watts, while the minimum was 4.3 watts. It is emphasized that these data were obtained with all circuits tuned to give maximum output at each frequency, and hence do not give a true picture of what will occur in actual operation where a single compromise adjustment of the internal controls must serve over the frequency range covered by each band. Table T-3 was made up to show the effects of this type of operation. The transmitter controls were set for maximum power output at the lowest frequency in each band, and no subsequent changes of internal controls was made. A much wider variation in power output will be observed than appears in Table T-2. At 11 of the 17 points at which measurements were made, the cw output is less than 30 watts. The minimum power output occurred at 9000 kilocycles, approximately one watt being obtained at this point. Since crystal channels are provided with their own tuning controls, no compromise adjustment is necessary on these bands.

(b) Tests were also conducted of the operation of the Model TCQ Transmitter when used with the whip antenna furnished as a part of the equipment. The results of these tests are tabulated in Tables T-5 and T-6. The data contained in Table T-5 were obtained with the Serial No. 36X TCQ Equipment, which employed a rectifier power supply. The plate supply voltage was maintained at 435 volts throughout the test. Table T-6 lists data taken with the Serial No. 16 TCQ. This test was repeated using the Serial No. 17 Equipment with very little difference in the results obtained. In all cases, the transmitter circuits were tuned to provide maximum output at one point in each band, and no subsequent change of internal controls was made. The power outputs shown in each table were determined from the measured characteristics of the antennas employed. The antenna resistance at the low-frequency end of

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the range is in the neighborhood of 4 or 5 ohms in the case of the 24-foot antenna, and is about 6 or 8 ohms with the 30-foot antenna. It is apparent from the data contained in the two tables that the power-amplifier-antenna tuning system is incapable of supplying the antenna with any substantial amount of r-f power under these conditions. This is particularly true when operating with the 24-foot antenna, which is only 0.048 wavelength at 2000 kilocycles, and which has a theoretical radiation resistance of but 0.92 ohm at this frequency. As installed for test, the measured resistance of the 24-foot antenna and its lead was 5 ohms. With the better ground available on shipboard and with less possibility of dielectric in the field of the antenna, the resistance encountered in practice will probably range between 1.5 ohms and 5 ohms. Considerable improvement in the antenna tuning and coupling circuit must be made in order to provide the required 30 watts output with these short antennas. Attention is directed to the use of wire having a high r-f resistance in the antenna circuit, as discussed in paragraph 2-5(a), and to the use of a very simplified antenna feed system, as described in paragraph 2-3(d). The power output of the TCQ is shown by Tables T-5 and T-6 to be considerably below the rated output of 30 watts for all frequencies at which power measurements could be made.

(c) Table T-4 contains data on the mcw and phone power output from the TCQ transmitter. This test was performed with the Serial No. 36X Equipment. The plate voltage was maintained at 435 volts at all times. It will be noted that the output is very nearly the same with either mcw or phone emission. Although the output was modulated 95 per cent when phone emission was employed, the comparatively small increase in power output over that obtained with cw emission (Table T-2) indicates the presence of carrier shift. This effect was also noted when using the Serial Nos. 16 and 17 Equipments, which have dynamotor plate supplies. It is recommended that necessary steps be taken to eliminate this undesirable condition of operation. As with cw operation, the power output with either mcw or phone is less than the specified 30 watts at the low-frequency end of the band.

(d) Keying tests were conducted with both cw and mcw emission. The signal was observed on an oscilloscope and monitored with a Model RAB Receiver. The note exhibited no trace of key clicks, chirp, or other objectionable characteristics. A small amount of relay bounce became evident at keying speeds approaching 100 words per minute. This effect was not present at speeds below 60 words per minute. Keying at 50 words per minute was satisfactory when using mcw. During the keyed output tests, it was noted that the contacts of keying relay K-101 did not open in the proper sequence, and

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as a result the antenna circuit was opened while the power amplifier was still operating. This resulted in severe sparking at the antenna contacts. The relay contacts are not adjustable. In this class of service, adjustable contacts are considered a necessity, since cleaning the contacts may disturb the original adjustment. It is therefore recommended that a relay be furnished with adjustable contacts and that care be taken to correctly adjust the contacts during assembly.

2-16. Antenna Circuit. The antenna circuit provided in the TCQ equipment is a part of the power-amplifier tank circuit, and consists of a pi network using series inductance and variable shunt capacitors. The network is isolated from the d-c plate voltage by a blocking capacitor, C-133, rated at 0.0005 µf and 5000 volts test. Although the coils used in this circuit are of the plug-in type, it is not necessary to change coils at any time, and no spare coils or forms are furnished. It is therefore recommended that permanently mounted coils be substituted in order to reduce losses and eliminate the possibility of contact trouble. The capacitor at the power-amplifier end of the pi is variable from the front panel when master-oscillator operation is used, whereas, with the crystal oscillator, preset capacitors are employed in this position. The antenna end capacitors are preset in both cases and are located at the rear top of the transmitter chassis as shown in Plate TR-4. Since the only control brought out to the front panel controls the capacitor at the power-amplifier end of the pi network, this must serve as both power-amplifier tuning and coupling control. The circuit does not provide adequate flexibility, and, when used with the whip antennas provided with the equipment, resonance cannot be attained under some conditions, although some power is delivered to the antenna at all frequencies.

2-17. Modulation and Distortion.

(a) The Model TCQ Equipment provides cw, mcw, and voice emission. A microphone jack and a key jack have been provided on the receiver panel for operating the transmitter, and mcw may be selected by means of a toggle switch on the front panel. The degree of modulation on mcw and voice is variable by means of potentiometers in the modulator equipment on the rear of the receiver chassis. It is necessary to remove the left side shield from the cabinet to reach these controls. Plate modulation of the power-amplifier stage is employed with either type of emission. The audio oscillator necessary for mcw operation is incorporated in the speech amplifier and a potentiometer in the cathode circuit is provided to vary the audio tone. The measured audio frequency of the oscillator in the Serial No. 16 Equipment was 470 cycles, while that in the Serial No. 17 was 355 cycles. A variation of ±20 cycles

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was possible by use of the tone control in the Serial No. 16, with a corresponding ±25 cycles in the Serial No. 17. These mcw frequencies do not agree with the standard Navy frequencies of 800 and 1000 cycles to which many of the receivers are peaked. It is recommended that the modulating frequency be changed to conform with the usual Navy standard of 800 cycles. If the mcw switch on the front panel is accidentally left closed, the carrier may be modulated with tone and voice simultaneously. Necessary contacts on the mcw switch should be provided to preclude this undesirable operation. The power outputs obtained under modulation conditions are listed in Table T-4 and have been discussed in paragraph 2-15(c). The character of the modulation provided is shown in Table T-7, which also shows the effect of the peak limiter. Modulation percentages in excess of 100 per cent could easily be obtained when the limiter was inoperative, while, with the limiter in the circuit and set to a maximum, the modulation was less than 92 per cent at any frequency. It is pointed out that the limiter is double acting, since it is applied to the push-pull modulator output stage and, hence, limitation of both positive and negative peaks is accomplished. Since no method of determining the depth of modulation is incorporated in the equipment and it is unlikely that suitable apparatus will be available at the point of installation, it is recommended that the peak limiter be preset and locked by the manufacturer at a point which will provide not over 95 per cent modulation. Considerable difficulty was encountered in testing the Serial 36X Equipment, due to the high audio peaks which were present in the modulator output. These occurred when the microphone circuit was closed, and were caused by the transient voltage which appeared across the input transformer secondary. These surges of about 250 volts were impressed on the grid of the type 6SJ7 first audio tube and resulted in very high peaks in the following stages. Voltage breakdowns occurred in the power-amplifier - antenna capacitors and in the modulation transformer. Thereafter, oscillations of 40 to 65 kilocycles were noted in the modulator when high peaks of either voice or tone were present, even though the peaks were not sufficient to cause overmodulation. The cause of the oscillations was not determined. It was necessary to replace voice level potentiometer R-131 before completion of the tests, since the original unit was destroyed by the surges appearing across the secondary of the microphone transformer.

(b) Table T-8 shows the results of distortion measurements on the Serial No. 16 TCQ Modulator and Transmitter. Tests were conducted with an audio input of 800 cycles at modulation levels of 50 and 95 per cent. The maximum distortion occurred at 9000 kilocycles and 95 per cent modulation and amounted to 8.5 per cent. Listening tests using a suitable

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receiver indicated that the quality is satisfactory with this amount of distortion present.

2-18. Carrier Hum and Ripple. The amount of hum and ripple present in the cw carrier of the Serial No. 16 Equipment is shown in Table T-9. At the frequencies at which the test was conducted, the usual Naval limit of 2 per cent was not exceeded.

2-19. Detuning of Circuits. Table T-10 shows the effect of detuning the power-amplifier control, the only circuit which can be detuned from the front panel. The control was detuned in each direction until a change of 25 per cent was observed in the p-a cathode current. Tests were performed at 2500, 4500, and 9000 kilocycles, and, as will be observed from the table, the maximum variation of 0.0197 per cent occurred at 9000 kilocycles.

2-20. Change of Tubes. Table T-11 illustrates the effect of changing tubes in the various stages. In the master-oscillator stage, the average deviation caused by tube changes was less than 0.0106 per cent at the three frequencies at which the test was conducted. Tube changes in the following stages produced only small effects of 0.003 per cent or less. During these tests, it was found that the transmitter can be operated without the oscillator tubes in their sockets, the buffer tube acting as an oscillator in this case. It is recommended that shielding be improved to prevent the feedback which causes this effect.

2-21. Backlash, Torque Lash, and Lost Motion. The amount of backlash present in the master- oscillator control was investigated as shown in Table T-12. The maximum average variation in frequency was 0.0795 per cent. This is considerably higher than is normally present in standard Navy equipment and it is not considered that the construction of the oscillator control drive mechanism is satisfactory in this respect. It was found that frequency jumps of a kilocycle or more could be caused by touching the control. Since no dial locks are provided, this feature would be particularly objectionable in service where the equipment is subjected to severe vibration and shock. Suitable precautions to assure the mechanical stability and rigidity of this control should be taken during manufacture.

2-22. Variation of Ambient Temperature.

(a) The effect of changes in ambient temperature on the emitted frequency is shown in Tables T-14 and T-15 and is also presented graphically in Plates T-6 and T-7. During the

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tests, the relative humidity was held as low as practicable. The summary forming a part of each table indicates the per cent change of frequency per degree of temperature. Reference to the summary of Table T-14 will show that the maximum frequency change was 0.004 per cent at 2500 kilocycles, while Table T-15 shows that the maximum variation at 8000 kilocycles was 0.0046 per cent per degree. These variations are not considered to be unduly large. However, during the 8000-kilocycle test, the frequency did not vary smoothly, but changed in a series of sharp jumps. These sudden changes varied from a few cycles to two kilocycles and occurred on an average of about twice a minute. Since this effect was apparent only at 8000 kilocycles, it is probable that some component such as the temperature compensating capacitor was at fault. Care should be taken during production tests of the equipment to eliminate effects of this type. The signal emitted by the equipment during the temperature run at 8000 kilocycles would have been practically unreadable if keyed.

(b) Table T-16 shows the results of tests conducted to determine the ability of the equipment to start and operate after extended idle periods at high and low ambient temperatures. It will be noted that the plate voltage and power output rose as the temperature decreased. When attempting to start the equipment at minus 20 degrees Centigrade, the main starting relay did not close sufficiently to make contact. After several manipulations of the main power switch, this difficulty cleared itself and the relay closed properly. All controls could be rotated or operated at this low temperature. The extra load caused by stiff lubricant caused the transmitter channel-switch knob to loosen on its shaft. This may be remedied by pinning the knob as suggested in paragraph 2-2(a).

2-23. Variation of Humidity. Tables T-17 and T-18 list the results of tests conducted at 2500 and 8000 kilocycles to determine the effect of humidity on the Model TCQ Equipment. The test shown in Table T-17 was conducted in two parts, between which the transmitter remained shut down overnight in a humidity of 85 per cent. The equipment was started without difficulty and the run continued as shown. The frequency change of 0.07 per cent shown in the table is calculated from results obtained during the first part of this test. A variation of 0.081 per cent was observed during the test at 8000 kilocycles. These changes are considered to be excessive, and it is recommended that steps be taken to improve the performance in this respect. Sudden frequency jumps were observed during the run at 8000 kilocycles similar to those noted in the test involving changes in ambient temperature described in paragraph 2-22.

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2-24. Locked-Key Operation for Two Hours. Two-hour locked key runs at full power were conducted at frequencies of 2000, 4500, and 9000 kilocycles, as shown in Tables T-19, T-20 and T-21, respectively. The data are also presented graphically in Plates T-9, T-10 and T-11. All tests were performed on the Serial No. 36X Equipment. Since this apparatus was supplied voltage by a rectifier rather than by a dynamotor unit, the plate supply voltage to the transmitter was maintained at a constant 435 volts. The following frequency drifts were found (excluding the drift during the first five minutes).

2000 kilocycles:	0.08 per cent
4500 kilocycles:	0.05 per cent
9000 kilocycles:	0.30 per cent

It may readily be observed that the frequency drift encountered exceeds that normally permitted in standard Navy equipment and that the drift at 9000 kilocycles is very definitely objectionable. This may be due to poor selection or adjustment of the temperature compensator capacitors utilized in the master-oscillator circuit. In this connection, it is pointed out that the frequency climbed steadily upward during the locked-key run at 9000 kilocycles, whereas at 2000 and 4500 the drift was downward. No attempt was made to reset the compensator to obtain improved performance. It is recommended that the situation be investigated by the manufacturer with a view of correcting the deficiencies now present. Compensators should be set correctly at the factory and no further adjustment in the field should be necessary.

2-25. Change from Key-Locked to Intermittently-Keyed Condition. Table T-22 shows the change in frequency resulting from a twenty-minute idle period after operating with locked key for thirty minutes. At 2000 and 4500 kilocycles, tests were conducted in two different ways, one in which the filaments remained lighted during the inactive period and one in which the filaments were not lighted. As may be expected, the frequency change when the filaments were left on was found to be less than with the filaments off. The maximum change with the filaments lighted was 0.018 per cent, while that with the filaments unlighted was 0.025 per cent.

2-26. Change from Continuously-Keyed Condition to Intermittently-Keyed Condition. Table T-23 illustrates the effect on the output frequency caused by a twenty-minute pause in keying. All filaments were left on during the idle period. The test was conducted at output frequencies of 2000, 4500, and 9000 kilocycles. The maximum change in frequency was 0.0113 per cent.

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2-27. Inclination Test. The entire TCQ equipment was subjected to the standard inclination tests and the effect on the output frequency carefully observed. The transmitter-receiver cradle was secured at bottom and back during these tests and it was noted that only slight motion of the cabinet was apparent even at inclinations of 45 degrees from the vertical. The effect of inclination on the frequency is shown in Tables T-24 and T-25, which cover tests at 2500 and 8000 kilocycles, respectively. At 2500 kilocycles, the maximum frequency change during the test was 0.011 per cent. The results given include the frequency drift, although an attempt was made to stabilize the transmitter before starting each test. In the tests at 8000 kilocycles, shown in Table T-25, separation of the effects caused by inclination and drift is more difficult, since a very rapid drift was present at this frequency, even after a reasonable stabilization period. The frequency change during the test was a maximum of 0.041 per cent, while the maximum change observed in any single inclination cycle was 0.014 per cent. The effect of inclination on the output frequency exceeds that normally encountered in Navy equipment, and improvement in this respect can undoubtedly be accomplished by making the master-oscillator assembly more rigid.

2-28. Vibration. The entire equipment was secured to the test table by the means provided. The cradle of the main unit was bolted to the deck and additionally braced with a vertical support at the rear. The power unit was fastened by bolting the removable bottom panel to the table and then slipping the chassis into the lips provided on the plate. It was necessary to straighten the power unit chassis before this could be accomplished, since it had been received in a damaged condition, as described in paragraph 1-7(a). With the equipment secured in this manner, it was subjected to varying degrees of vibration, both in amplitude and frequency, for a period of one-half hour. Information obtained during the test, which was performed at 8000 kilocycles, is contained in Table T-26, and the same data are shown graphically in Plate T-5. It will be noted that, although considerable variation in frequency took place during the run, the maximum set in frequency was only 50 cycles or 0.00063 per cent. The emitted signal was monitored with a suitable receiver during the vibration period and later tests were conducted with voice emission. The cw signal was found to be badly modulated by the movement of parts due to vibration, but the signal was readable. The quality of the signal emitted with voice operation was satisfactory. The transmitter controls, which are not equipped with locks, were not observed to move during vibration, but it is pointed out that movement of this sort has been noted in service. It is therefore recommended that suitable locks be provided and that the construction be made

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more rigid, particularly in the oscillator stage, in order to decrease the modulating effect of vibration.

2-29. Shock. The pneumatic shock test equipment was used to administer shocks to the apparatus mounted as described in the preceding paragraph. The results of this test are shown in Table T-27. The maximum change in frequency was 0.0425 per cent. This is considerably higher than desirable, and necessary steps should be taken to reduce the effect. The transmitter remained in operation throughout the shock tests and the equipment suffered no mechanical damage other than that described in paragraph 2-10(b).

2-30. Calibration of the Master Oscillator and Overlap. Table T-28 contains a comparison of the actual output frequency and the master-oscillator dial reading. The oscillator dial is provided with three direct calibrated scales covering ranges A, B and C, but no linear scale is furnished for independent calibration. It is apparent from the data presented in the table that considerable error will result if the direct calibrations are employed in an attempt to set to a desired frequency. This error is a maximum of 0.736 per cent on band A, 0.663 per cent on band B, and 0.811 per cent on band C. The smallest division on the dial for band A is 50 kilocycles, while on bands B and C the smallest division is 100 kilocycles. All data in Table T-28 were taken on main dial divisions, and the difficulty of setting between divisions will add to the error when operation on unmarked frequencies is required. It is recommended that a suitable master-oscillator dial assembly be provided which will permit setting accurately to frequency and that a linear scale be provided in addition to the direct calibrated scales. The overlap between bands in the master-oscillator stage is listed in Table T-29. It will be observed that the overlap with respect to the lower limiting frequency of 2000 kilocycles and the overlap between bands B and C are both less than the usual Navy minimum of 3 per cent. Unless assurance is given by the manufacturer that the manufacturing tolerances can be held to necessary low limits, it is suggested that the overlap in all cases be increased to above 3 per cent. Ample overlap has been provided between bands A1 and A2, B1 and B2, and C1 and C2.

2-31. Antenna Open Circuited and Short Circuited. Tests were conducted to determine the effect of short circuiting and open circuiting the antenna, as shown in Table T-30. At both the output frequencies used, the power-amplifier tubes were subjected to destructive overheating under these conditions.

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2-32. Vacuum Tube Operating Conditions. The measured voltages and currents applied to the electrodes of vacuum tubes used in the Model TCQ Transmitter and Modulator are shown in Table T-31. Comparison of the values listed with the maximum limits imposed by applicable Navy specifications and the manufacturer's CCS ratings reveals no case of overload except in the VR-75 voltage regulator. This tube carries 33 milliamperes with the key up, or 10 per cent more than the maximum rated current. The minimum current of 20 milliamperes which flows through this tube with the key closed indicates that R-105, the series dropping resistor, can be increased to limit the key-up current through the tube to less than 30 milliamperes. The currents listed in the table for the type 1625 power-amplifier tubes include both tubes, since they are in parallel.

2-33. Power Required from Supply Lines. The power input to the equipment was measured under several conditions of operation, with the results shown in Table T-32. A maximum starting power of 1570 watts was recorded, but this can be reduced by starting the receiver and transmitter dynamotors separately by means of the switches provided. In this case, the starting power required is 968 watts, as indicated in the table. It will be noted that, even with the transmitter unkeyed, a line input of 408 watts is required at normal line voltage. This is chiefly due to the fact that the entire speech-amplifier and modulator unit is in operation at all times even though the transmitter is unkeyed or being operated with cw emission. In addition, even if only the receiver is in use and the transmitter dynamotor is off, the mcw audio-oscillator and speech-amplifier tubes continue to draw normal current, since these stages are supplied from the receiver dynamotor output. The modulator stage is supplied screen voltage from the receiver dynamotor and plate voltage from the transmitter dynamotor. The two-pole switch used to start the transmitter dynamotor closes the cathode circuit to the modulators at the same time that voltage is applied to the transmitter dynamotor. For a short period, therefore, while the dynamotor is attaining full speed, screen voltage is applied to the modulator tubes in the absence of plate voltage, causing a severe overload. To conserve tube life and battery power, these undesirable features should be eliminated by means of proper switching facilities or relays. In case this is done, however, the regulation of the power-amplifier plate voltage must be improved, since, without the steady modulator load, which now acts as a bleeder, the regulation of the high-voltage dynamotor is very poor. Table T-13 lists the power input required with line voltages 10 per cent above and below normal. The maximum input to the equipment under these conditions was 523 watts.

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2-34. Ripple and Regulation of Generators. The ripple present in the dynamotor outputs is shown in Table T-34. It will be noted that ripple has been held to a satisfactory minimum, the highest ripple being 1.55 per cent. Table T-33 shows the regulation of the generators. "No-load voltage" refers to a key-up condition. The regulations of the low and high-voltage dynamotors were 12 and 17.8 per cent, respectively. This is higher than is considered desirable in Navy equipment, and it is therefore recommended that the performance be improved to comply with the 5 per cent limitation usually imposed by Naval specifications.

2-35. Instruction Book. A preliminary instruction book was furnished with the Serial Nos. 16 and 17 Equipments, but one in final form was furnished with the Serial No. 36X and this one will be discussed below. The instruction book was carefully inspected and the following changes or additions are recommended.

(a) A complete description of the circuits should be included in the equipment with reference to diagrams. The discussion should be confined to the simplest terms possible, but completeness is of primary importance to facilitate servicing operations. The present instruction book has almost no mention of the circuits involved.

(b) Since parts in the equipment are not identified by symbol numbers, although each is assigned a number in the parts list of the instruction book, it is recommended that photographs of the under side of each chassis be included. All photographs should bear marginal notations with indicating arrows identifying the components. Photographs of the interior of the remote control unit should also be furnished.

(c) More complete winding data should be presented to permit the replacement or rebuilding of coils, chokes, transformers, reactors, and dynamotors included in the equipment.

(d) Installation drawings for each unit should be included. Installation drawings for the antenna were packed with the base insulator. All drawings and instructions should be a part of the instruction book.

2-36. Summary of Defects and Suggested Changes. Such items as appear definitely defective, together with suggestions for improvement and modification, are listed below. At the end of each of the statements there appears the paragraph number in the body of the report wherein each item is discussed in detail.

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(1) The equipment suffered severe damage during shipment. (1-7)

(2) The chassis of the power unit is light, soft, and easily deformed. The method of mounting does not provide sufficient strength to withstand vibration and shock. (1-7(a) and 2-10(b))

(3) Vacuum tubes are not clamped to withstand vibration and shock; type 1625 modulator tubes are not rigidly mounted. (2-1(c))

(4) Leads to tube cap clips are of insufficient length and are improperly fastened to soldering lugs. (2-1(d))

(5) Spade bolts used to fasten compartment covers have only one rivet and therefore may shift their positions, making replacement of the shields difficult. (2-1(e))

(6) Vacuum tubes cannot be changed easily. Shield covers must be removed to reach some tubes. (2-1(e), 2-4(a))

(7) The channel control knob is too small for the load driven; control knobs are not pinned to their shafts; detent mechanism of the oscillator gang switch is not properly supported; preloaded gears are not employed in dial drives; end stops on the oscillator and final tuning controls are located improperly. (2-2(a))

(8) Controls are not satisfactorily coupled to driven loads. (2-2(b))

(9) Indicator lamps are not provided. (2-2(e))

(10) Adjustment of the buffer-stage tracking capacitors requires partial withdrawal of transmitter from the cabinet (2-3(b)); access holes in the transmitter chassis do not line up with tracking capacitor shafts, therefore interfering with proper adjustment (2-3(c)).

(11) Antenna capacitor knobs are not provided with an index mark, hence settings cannot be logged; changing the capacitor for one band may effect the settings for the other two. (2-3(d).

(12) Antenna tuning capacitors are inaccessible; oscillator, buffer, and power-amplifier variable capacitors are secured in such a manner as to be very difficult to remove. (2-4(a))

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(13) No warning nameplate is affixed to the power unit. (2-4(b))

(14) Wiring and workmanship are not considered satisfactory; stranded, cotton-covered wire used where considerable r-f current is handled; r-f leads cabled with ground wires and general power leads; connections in plug-in coil made with lighter wire than is used for the coils themselves; p-a coil for band C shorted; insulation used on wires is not considered suitable for conditions where high humidity is encountered; solder is often depended on for mechanical strength; wire between R-140 and R-147 subjected to excessive mechanical stress and broke while under test. (2-5(a))

(15) The cable used for connections between units is not moisture proof. (2-5(b))

(16) High voltage supplies to the transmitter are not provided with r-f by-pass capacitors. (2-5(c))

(17) Crystal mountings are phenolic; voltage between pins of the Amphenol interunit plugs exceeds specifications. (2-6 and 2-11)

(18) Screws holding the top and side shields of the cabinet are subject to loss. (2-8(a))

(19) Steel has been used for some applications where it is not normally permitted and where difficulty in servicing may result. Inadequate protection of steel parts was noted. (2-8(c))

(20) The equipment is not drip-proof. The remote control is not waterproof and cannot be flush mounted. (2-8(e) and 2-10(c))

(21) General workmanship used in the Model TCQ is not up to Naval standards. (2-8(g))

(22) Additional meters, not furnished, are required in order to properly adjust the transmitter. Meter jacks are not marked with the range meter required. Markings on master and crystal-oscillator meter jacks in Serial No. 16 Equipment were reversed. The master-oscillator meter jack is not properly insulated from ground. (2-9(a))

(23) The mounting of R-103 permits undesirable movement. (2-9(c))

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(24) The transmitter-dynamotor input line fuse was not of the correct rating; fuse ratings call for use of parallel 30-ampere links in a 30-ampere cartridge; fuse mountings are not marked in any way; high-voltage fuses are not provided in the design; fuse clips are unprotected copper. (2-9(d))

(25) Trimmer capacitors in the oscillator-buffer compartment are inaccessible. (2-9(e))

(26) Shock mounting of the key relay is ineffective; locks have not been provided on controls, tubes, and coils (2-10(a)). Shock mounting of the dynamotors is ineffective; power unit chassis is of inadequate strength and rigidity; power unit mounting is unsatisfactory. (2-10(b))

(27) The antenna mast was not properly drilled to accommodate the securing bolt; two securing bolts are indicated in drawing R-2022, whereas only one is actually used. (2-10(d))

(28) Ground connection terminals have not been provided on any unit. (2-11)

(29) The method recommended for converting the equipment to operate with a supply having the negative grounded is unnecessarily complicated. (2-12)

(30) Stops are not provided to prevent overlapping antenna sections by less than the specified amount; antenna wedges were assembled incorrectly. (2-13)

(31) Power output is deficient at many frequencies (2-15(a) and (b)); carrier shift occurs during modulation (2-15(c)); the keying relay contacts are not adjustable (2-15(d)).

(32) Plug-in coils are used, although it is not necessary to change coils under any conditions; the antenna tuning and coupling circuit does not provide satisfactory flexibility. (2-16)

(33) Audio tone employed for mcw is not of the same frequency to which Navy receivers are peaked; voltage surges occur when the microphone circuit is closed; spurious oscillations were present in the speech amplifier and modulator (2-17(a))

(34) Buffer stage is capable of oscillating in the absence of excitation from the oscillator. (2-20)

(35) The amount of backlash and lost motion in the oscillator drive mechanism is excessive. (2-21)

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(36) The output frequency at 8000 kilocycles was very irregular during ambient temperature tests. (2-22(a))

(37) The effect of humidity on the emitted frequency was excessive. (2-23)

(38) The frequency drifts during the two-hour locked key tests were excessive. (2-24)

(39) The frequency variations caused by inclination were excessive. (2-27)

(40) Vibration caused severe modulation of the output frequency. (2-28)

(41) Shock caused excessive change in the output frequency. (2-29)

(42) Calibration facilities of the master oscillator are inadequate and unsatisfactory; a linear scale which can be used for independent calibration has not been furnished; overlap between bands is less than 3 per cent. (2-30)

(43) Power output tubes are not protected from overload in case the antenna is opened or shorted. (2-31)

(44) The VR-75 regulator tube is slightly overloaded. (2-32)

(45) The speech amplifier is in operation when only the receiver is in use, and the speech amplifier and modulator operate continuously during cw operation of the transmitter; the modulator tubes are subjected to severe overloads. (2-33)

(46) The regulation of the dynamotors is higher than usually considered desirable. (2-34)

(47) The instruction book is incomplete. (2-35)

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SECTION III - RECEIVER

DESCRIPTION OF RECEIVER

3-1. The Model TCQ Receiver is a part of a unit of the complete TCQ Radio Transmitting and Receiving Equipment. It is a superheterodyne with one stage of tuned radio-frequency amplification. Continuous coverage can be had from 1.95 to 9.35 megacycles with the single dial control and three sets of coils. The proper set is selected with a band switch. Four fixed frequency channels are also available using the same switch. Provision is made for either cw, mcw, or voice reception on either loudspeaker or phones.

3-2. The elements of the circuit are as follows, noted in order from the input:

(a) Antenna circuit.
(b) First tuned circuit.
(c) Radio-frequency amplifier tube.
(d) Second tuned circuit.
(e) Mixer tube.
(f) High-frequency oscillator tube and circuit.
(g) Intermediate-frequency amplifier tube and circuits.
(h) Second detector.
(i) Beat-frequency oscillator.
(j) First audio-frequency amplifier.
(k) Second audio amplifier (output stage).
(l) Squelch circuit.
(m) Control circuits.

3-3. Antenna Circuit. The antenna lead enters the receiver through the transmitter cable from the antenna relay. A 50-ohm resistance is in series with this lead and a section of the band switch. This switch section connects the antenna to the high-potential side of the selected primary of the first r-f transformer. There are three of these primaries for the three frequency bands used for continuous coverage. All fixed frequency channels employ the same primary as the lowest frequency continuous coverage band, and all fixed channel frequencies must be within this range. The low-potential ends of all three primaries are grounded to the chassis.

3-4. First Tuned Circuit. The secondary associated with the primary connected to the antenna is selected by another section of the band switch, which also connects it to the grid of the r-f amplifier tube. An air dielectric trimmer capacitor is connected between each secondary high-potential side and ground. For the three general coverage bands, another band switch section also connects the high-potential side of the

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secondary to one section of the main ganged tuning capacitor. This same switch section connects the high-potential side of the lowest frequency secondary to a pretuned air trimmer for each fixed channel. The low-potential side of all tuning capacitors is grounded to the chassis. The low-potential side of all secondaries is common and is returned through a resistance to the AVC return.

3-5. Radio-Frequency Amplifier Tube. The r-f amplifier is a 12SK7 with its heater in series with that of the 12K8 mixer tube across the 24-volt supply. The cathode and suppressor are connected and by-passed to the chassis. The cathode returns through a minimum bias resistor and the r-f gain control rheostat to ground. The screen is connected to the screen of the mixer tube, and both are fed from a voltage divider. A section of the band switch connects the plate to the high-potential side of the proper primary of the second r-f transformer. The low-potential ends of all primaries are by-passed to ground and fed from the high-voltage supply through a decoupling resistor.

3-6. Second Tuned Circuit. This is similar in connection and switching to the first tuned circuit, except that provision is made to short circuit the lowest frequency secondary when the two higher-frequency general coverage bands are in use, and the signal (no. 3) grid of the mixer is connected to the proper secondary.

3-7. Mixer Tube. A 12K8 tube is used as a mixer, but the oscillator section is not used. The oscillator section plate is grounded. Bias is obtained by the drop in a cathode to ground resistor which is by-passed. The low-potential end of the second tuned circuit is grounded so that this tube is not controlled by the AVC. The no. 1 grid is returned to the cathode through a resistance. It is capacitively coupled to the high-frequency oscillator.

3-8. High-Frequency Oscillator Tube and Circuit. This circuit employs a 6J5 triode with its heater in series with the beat-frequency oscillator tube heater and the heaters of two 6-volt tubes of the modulator unit. The cathode is grounded. The grid is returned to ground through a grid leak, and is capacitively coupled to either one of the tuned circuits employed for general coverage, or to one of the crystals employed for fixed channel operation. The plate is fed through an r-f choke from the 150-volt regulated supply, and is coupled to the mixer grid through a capacitor. It is also connected through a section of the band switch to the high-potential side of one of the three oscillator primaries or to one of the four crystals. The Pierce crystal-oscillator circuit is employed.

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3-9. The low-potential side of all primaries is connected to the 150-volt regulated supply and is by-passed to ground. The next lowest frequency band secondary is shorted to ground on general coverage. The low-potential end of each secondary is grounded through a series padder capacitor. The trimmer for band A consists of an air dielectric variable capacitor in parallel with a negative temperature coefficient ceramic capacitor across the secondary. For bands B and C, an air trimmer and a negative coefficient ceramic capacitor are in series across the secondary. A section of the main tuning capacitor is switched to the high-potential side of the general coverage secondary in use. The other side of the tuning capacitor is grounded.

3-10. Intermediate-Frequency Amplifier Tube and Circuits. The tuned primary of the first 456 kc i-f transformer is connected between the mixer plate and the high-voltage supply. The high-potential side of the tuned secondary is connected to the i-f amplifier tube grid. The low-potential side is by-passed to ground and returned to the AVC line through a decoupling resistor. The 12SK7 i-f amplifier tube cathode is by-passed to ground and has a minimum bias resistor returning through the r-f gain control rheostat to ground in common with the r-f amplifier cathode. The screen is fed from an individual voltage divider and is by-passed to ground. The plate is connected to the second i-f transformer tuned primary. The low-potential side of this primary is by-passed to ground and fed from the high-voltage supply through a decoupling resistor.

3-11. Second Detector. The high-potential side of the second i-f transformer tuned secondary is connected to the two paralleled diode plates of the 12SQ7 second detector tube. The detector cathode has a radio-frequency by-pass to the low-potential side of the transformer of 350 μμf. The cathode is grounded through a bias resistor, which is heavily by-passed for audio frequencies. The audio load resistor is a divider consisting of a 50,000-ohm resistor from the low-potential side of the i-f transformer, connected to one end of a 1-megohm potentiometer, the other end being connected to the cathode. The junction of these resistors is by-passed with 50 μμf, and is coupled through an 0.05 μf capacitor to the audio-amplifier gain control potentiometer, and through a filter resistor to the AVC line.

3-12. Beat-Frequency Oscillator. The beat oscillator employs a 6J5 triode with grounded cathode. The grid is returned to ground through a grid leak, and is capacitively coupled to the high-potential side of the tuned oscillator circuit. The low-potential side is grounded. An adjusting padder and a trimmer are connected across the inductance

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and an external air trimmer is mounted on the front panel with a control knob to give fine control of the cw beat note. A tickler winding is provided as a continuation of the tuned inductance, and is capacitively coupled to the plate. The plate is fed through a series resistor from the high-voltage supply when the oscillator switch is thrown ON. Another section of this switch disables the AVC at the same time. The plate is capacitively coupled to the low-potential side of the last i-f transformer secondary to provide injection into the second detector.

3-13. First Audio-Frequency Amplifier. The audio output from the second detector is impressed between the upper end of the a-f gain control potentiometer and ground. The arm of this potentiometer is capacitively coupled to the grid of the first a-f amplifier, a 6SQ7. The diode plates of this tube are left unconnected. The cathode is positively biased with respect to ground by a voltage divider from the high-voltage supply. It is by-passed to ground for audio frequencies. The grid returns to ground through an 0.5 megohm resistance in series with the plate resistor of the squelch tube, and a squelch network resistor if the squelch is ON. If the squelch is OFF, the latter resistor is shorted to ground. The audio-amplifier plate is supplied from the high-voltage supply through the plate load resistor. It is by-passed to ground with an 0.0005 µf capacitor and is coupled to the grid of the output stage through an 0.1 µf capacitor.

3-14. Audio Output Stage. The input from the first audio stage is capacitively coupled to the grid of the tube, a 6K6GT. The grid leak returns to ground during reception. During transmission, a large bias is applied to the lower end of this resistor and through a series resistor to the AVC line, to disable the receiver. The cathode of this tube is grounded through a by-passed bias resistor. The screen is fed from the high-voltage supply. The plate is connected to the high-potential side of the output transformer primary. This primary is tuned to resonate at 1000 c.p.s. with a fixed capacitor. The low-potential side of this primary is connected direct to the incoming 280-volt d-c input. All the rest of the receiver is fed through a 1250-ohm dropping resistor. One side of the output transformer secondary is grounded. The other side is connected to the speaker voice coil and to the remote unit plug. The other voice coil lead is wired to a single-pole single-throw toggle switch which either opens the local speaker or connects it through a 1000-ohm resistor to ground. This resistor is normally shorted. The phone jack is so wired that plugging in phones places them in parallel with this resistor and removes the short across it.

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3-15. Squelch Circuit. The squelch tube is the triode section of the 12SQ7 second detector. Its plate voltage is obtained from a voltage divider between the first audio tube cathode and ground. The squelch is disabled by throwing a single-pole single-throw toggle switch which shorts out the grounded resistor and removes all plate voltage from this tube. Voltage is fed to the grid from the center arm of a potentiometer which forms most of the second detector diode load. This voltage is filtered with a resistance capacitance filter to remove the audio variations before it is applied to the grid. The polarity of this voltage is negative with respect to ground, the same as the AVC voltage, so that an increase in signal will produce a decrease in squelch-tube plate current. The drop across the plate resistor is in such a direction as to add to the bias on the first audio tube when no carrier is present. This greatly reduces the audio-amplifier gain. A strong signal places a negative bias on the squelch tube and reduces its plate current. This in turn reduces the bias on the first audio amplifier and increases its gain, permitting the audio to be heard. The squelch control varies the voltage taken from the diode load potentiometer from which the squelch tube bias is taken. It can be set to open the squelch over a range of carrier levels.

3-16. Control Circuits. The switching for the transmitter, modulator and receiver is done from the receiver unit panel. It also contains jacks for the telegraph key and microphone. The main power, transmitter, tone modulation, and filament switches are mounted on the receiver front panel. Leads from these switches are run to the transmitter unit cable or the power input plug so that the desired switching results are accomplished when the complete equipment is assembled.

Major Component Parts of Receiver Only

Condensers - Variable

3-17. Main Tuning. The shaft, end and spacer plates, soldering lugs, and some assembly screws are of plated steel. Considerable rust has appeared. The rotor grounding fingers are of plated phosphor bronze. The aluminum plates are swedged or staked to lock them in place. The insulation is ceramic. The stators are secured to their mounting bolts by soldering.

3-18. Trimmers. All r-f air trimmers have plated soldered brass plates and ceramic insulation. They are provided with screwdriver adjustments and locking devices. Many of them were not locked as received. The beat-oscillator vernier is of similar construction, but has a shaft for a knob, and a

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stop mechanism to limit rotation to 180 degrees. This condenser has been cut down from a larger unit, and its appearance could be improved.

3-19. There are two ceramic trimmers employed. They are insecurely supported only by thin leads, and they project so far below the chassis that they strike a flat surface, if the receiver is set on it with the front panel over the edge. This has cracked one of these condensers.

Condensers - Fixed

3-20. Electrolytic. Six low-voltage electrolytic condensers are employed. They are of tubular type in waxed cardboard-covered metal cases with pigtail leads.

3-21. Paper. All paper condensers are completely enclosed in cadmium plated steel cases. One of these leaked oil after the temperature tests. The solder lug terminals are riveted and solder sealed. The bakelite insulation employed at the terminals appears to have no impregnation on some units, and to be wax or varnish treated on others. Some of these units are stacked two and three deep with long through-bolts securing all units in the stack.

3-22. Mica. Most of the mica condensers used have low loss bakelite cases. A few have brown bakelite cases.

Resistors

3-23. Fixed. The 1/2, 1, and 2-watt resistors are sealed in ceramic tubes with axial pigtail leads in each end. One 2-watt composition insulated resistor is used for the audio load shunt for phone operation. The larger wattage resistors are wire wound on ceramic tubes with a heat resistant green enamel surface. Most of these are mounted with through-bolts, one of which loosened during vibration. Some of these resistors have exposed wire for sliding taps, which is undesirable. The resistors are not Navy standard types.

3-24. Variable. The r-f gain control is a wire-wound potentiometer. The audio gain and squelch controls are of the composition type. The audio control became very stiff at minus 20 degrees Centigrade.

3-25. R-F Transformers. The r-f transformers are close wound with enameled-wire on low-loss bakelite forms. Terminal lugs are riveted to the forms.

The forms are riveted to the chassis with angle brackets. Apparently the cores have not been treated to withstand high humidity. The low-frequency primaries are universal wound and

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apparently have been treated to some extent with a material similar to collodion. Inductance trimming is done with cotton-covered wire unevenly wound and pushed inside the coil forms. These coils are wrapped with what appears to be cellulose acetate type and have been coated with a material similar to collodion. They appear slipshod and insecure in the forms. Each group of coils is enclosed in a compartment shielded from the other groups.

3-26. I-F Transformers. A ceramic coil form is used which is screwed to the bottom low-loss bakelite terminal panel and supports a metal structure which holds the air trimmer and padder capacitors and acts as a shield between them. The coils are universal wound with litz wire. Stiff bus wire runs from the terminal panel to the trimmer condensers. The condenser ceramic insulation and the bottom terminal plate are the only solid insulation employed except for the form itself. The coil leads are short and direct. The coils appear to be collodion treated. Substances of this type, such as polystyrene or duco, have not shown themselves as moisture-proof coil coatings. The aluminum cans are flimsy and somewhat out of shape. The can is extremely difficult to remove because the securing nuts are covered by wiring and the ends of the spade bolts have been clipped off, ruining the threads. Internal-tooth lockwashers are used on these nuts. No lockwashers are employed under the tap securing screws.

3-27. The beat-frequency oscillator coil is similar in construction to the i-f transformers. It has three litz-wound universal coils on a ceramic form with the same type of bottom terminal plate. The air padder and trimmer are mechanically held by solder only. A bakelite insulating strip is employed to secure the coil leads. The same considerations as to the can and difficulty of its removal apply as for the i-f transformers.

Switches

3-28. Control. All control switches are standard toggle types with steel sides and laminated bakelite housings. Wafer wiping type switches are to be preferred to toggle switches.

3-29. Band Switch. The band switch is a ganged unit employing ceramic insulation for rotor and stator sections. The contacts are of silver plated brass of a self wiping type. The clamps securing the stator contacts are of unplated brass. The shaft and front plate appear to be of cadmium plated steel. The spacers are of cadmium plated brass. The supporting front shield panel is of 0.039-inch aluminum alloy. This is too flimsy and is noticeably distorted. Rust appeared on the shaft after the humidity tests.

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3-30. Tube Sockets. All tube sockets are of ceramic material. Some are secured directly to the chassis by spring washers on the under side (this is not according to Navy specifications), and others are similarly secured to plated rings which are screwed to the chassis. Some of these rings are rusting. The clearance holes are so large that the rings are not solidly supported except at the ends.

3-31. Tubes. The tube complement of the receiver consists of a 12SK7 r-f amplifier, a 12K8 converter, a 6J5 h-f oscillator, a 12SK7 i-f amplifier, a 12SQ7 second detector and squelch tube, a 6J5 beat-frequency oscillator, a 12SQ7 first a-f amplifier, and a 6K6GT output audio stage. One 12SQ7 developed an intermittent contact in the triode section.

3-32. Knobs. Small bakelite bar knobs having a single set screw are used for all controls requiring rotation except the main tuning control. This control has a larger single set-screw knob with smooth indentations to permit a good finger grip. All set screws are of the slotted type.

3-33. Tuning Dial Drive. The drive is mounted on a cast brass support, and employs three brass spur gears with no provision for wear takeup. The dial indicator is a translucent disc attached to the condenser shaft, but considerable backlash exists between the tuning knob and the condenser, with the probability that it will increase with use. The dial aperature is covered with a magnifying window which is apparently of lucite. The dial indicator disc is also apparently of lucite. This indicator has been damaged at the edges, apparently due to accidental contact with a soldering iron. The gears are accessible for lubrication, but are also exposed to dust. There is very little, if any, lubrication. The drive is pinned to the condenser shaft. A set screw employed here dropped out during the vibration tests.

3-34. Crystal Sockets and Holders. The sockets are of polystyrene with spring wiper contacts. The holders are of black bakelite with plated contact prongs. The holders are secured in the sockets with a felt padded metal strip screwed to the chassis.

3-35. Output Transformer. The transformer has potted windings in a lacquered steel case. The case has rusted considerably since the humidity tests. The bottom bakelite terminal panel has riveted-on solder lug terminals. The leads come through the hollow rivets and wrap around the lugs prior to soldering.

3-36. Speaker. The speaker is a steel-frame permanent magnet type. The frame shows considerable rust. The grill

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is woven of unplated copper screen and cloth. The cone does not appear to have any waterproof treatment.

3-37. Wiring. Several different types of wire are used. Extensive use is made of varnished spaghetti. The tube sockets are used to hold many components, and some sockets are quite inaccessible. Many leads pass through metal partitions without protecting grommets. Most leads are cabled when this appears desirable. Most of the soldering has been neatly done. Leads are wrapped around or hooked to terminals prior to soldering. Several spans of excessively great unsupported length are employed.

3-38. Chassis. The chassis is made of 0.050-inch lacquered aluminum. The bending, welding, and drilling workmanship is not of the best. Several holes have rough edges. The panel is of 1/8-inch aluminum with a black crackle front finish and a smooth black rear finish. Lacquered aluminum shields are employed around three sides of each coil group. These shields are spot welded at the ends. The shields have a "patched plate" construction around the band switch to enable its removal. The lower screws on the plates are rather inaccessible, which defeats the purpose of this type of construction.

3-39. General. The pilot lamp socket rotates readily about its single screw mounting, greatly decreasing the dial illumination, striking a tuning drive set screw, and leading to the possibility of lead breakage. The dial lamp burned out during the vibration test. The grid cap of the converter tube is of plated steel. Many screws are clipped off, ruining the threads and leaving the unplated brass or steel ends exposed. The receiver cannot be set on a flat surface with the front panel over the edge without damage occurring to some sub-chassis components. The shock mounting consists of sponge rubber pads bolted between the mounted part and the chassis. Either there is no shock mounting, due to too much tension, or the screws will work loose. They worked loose during the vibration test.

RESULTS OF TESTS

3-40. Mechanical Construction and Wiring. Most of the reported difficulty with this receiver appears to be the result of the excessive weakness of the chassis. The oscillator frequency is greatly affected by the slightest vibration due to the physical movement of its circuit components. The metal employed in the chassis, coil shields, and i-f transformer cases is of too thin a gauge for the intended purpose.

3-41. The majority of the components are of excellent quality.

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3-42. Two components project below the bottom of the chassis and are subject to damage if the receiver is set on a flat surface with the panel over the edge.

3-43. The band switch is not ruggedly built. It gave some contact trouble during the tests, and its steel parts are rusting badly.

3-44. Many components are difficult to remove because of damaged screw threads or inaccessible locations.

3-45. Better support is needed for some of the longer leads. There is no apparent need for so many kinds of wire or for the use of so much spaghetti.

3-46. The internal shock mounting is of very poor design. This mounting should be either improved or eliminated. Most of the nuts worked loose during vibration.

3-47. The tuning dial drive should have some provision for backlash elimination and wear takeup which is not now present. It should be properly lubricated.

3-48. The inductance trimming method is insecure and demonstrates poor design. Some more solid and permanent method should be employed. More solid anchoring of the ceramic trimmers should be provided. One of these trimmers broke during the tests, and the oscillator failed to oscillate after 16 hours exposure to 97 per cent humidity.

3-49. After vibration, the mounting nut and washer had dropped off one lug strip. The nuts on a long threaded r-f choke supporting rod were loose. One vertical resistor bolt was loose. Several shock mount nuts were halfway off. The beat-frequency oscillator tuning condenser was loose on the front panel. The dial lamp was burned out. A set screw was gone from the main tuning dial.

3-50. After the humidity and temperature runs, oil leaked out of a paper capacitor and got into the phone jack. Rust appeared on the tuning condenser shaft and frame, the band switch shaft, the speaker frame, several bolt ends, and some tube socket rings. Cadmium growth appeared on the metal capacitor cases. Some wax dripped off the fixed resistors.

3-51. Sensitivity. The cw and mcw sensitivity for both standard and special dummy antennas is shown in Plate R-1. The cw sensitivity averages about 5 microvolts and is not greatly affected by changing from one type of dummy antenna to the other. The mcw sensitivity appears poor, possibly because a 400-cycle modulation was used, while the audio

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amplifier was quite peaked at 1000 cycles. The difference in audio response between 400 cycles and 1000 cycles is about 15 db.

3-52. Selectivity. The selectivity of the i-f amplifier is shown in Plate R-2. This is sharp enough to seriously affect response to high modulation frequencies.

3-53. The selectivity of the r-f section of the receiver is shown in Plates R-3-4-5-6 for each end of each general coverage band for one fixed channel. This selectivity is typical of most ordinary communication receivers having two tuned circuits at signal frequency. There is evidence of leakage around the r-f stage in the highest-frequency band.

3-54. Resonant Overload. CW resonant overload for each band is shown in Plate R-7. The receiver blocked almost immediately after reaching maximum output. The curves were extended beyond this point by detuning the beat oscillator and accepting a beat note other than 1000 cycles. When the receiver was blocked for any setting of the beat-frequency oscillator control, the curves were stopped. It was then necessary to either detune the tuning dial or reduce the r-f gain to obtain a beat note. MCW resonant overload is shown in Plate R-8.

3-55. R-F Gain Control Characteristics. R-F gain control characteristics are shown in Plates R-9-10 for the mid-frequency of bands A and C. The range in each case is less than 45 db, which is much too small. This control merely provides self bias for the r-f and i-f stages, which explains its lack of range. The noise level drops approximately with the signal when the r-f gain control is varied, as shown in Plates R-9-10.

3-56. Audio-Amplifier Characteristics. The audio-amplifier response as shown in Plate R-11 has a pronounced peak at 1000 cycles. This is produced by tuning the output transformer primary. It is accentuated by shunt capacity and small series coupling capacitors in the amplifier. The small change produced by turning on the squelch is shown. The peak is sufficient to cause speech to sound "tinny." No means is provided for improving the response to voice signals.

3-57. Frequency Stability for Changes of Supply Voltage. The overall cw frequency stability for two frequencies in band A is shown in Plate R-12. The stability is excellent up to the point where the regulator tube extinguishes.

3-58. Radio-Frequency Radiation. The high-frequency fundamental oscillator voltage appearing across the 418-G

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dummy antenna in series with 100 μμf is shown in Plate R-13. This voltage is many times greater than is found in many ordinary broadcast receivers. In many cases, harmonics up to the sixth produce voltages of over 1000 microvolts across this dummy antenna. Apparently no effort has been made to reduce the high radiation output present.

3-59. Image Rejection. The image rejection in decibels is shown in Plate R-14. The values found from the selectivity curves are also shown. The decrease at the low-frequency end of each band is apparently due to misalignment, as the sensitivity is also lower at these points. The rejection is poor at the higher frequencies, as would be expected with the intermediate frequency employed.

3-60. Output Load Variation. The variation of output power with change of output load across the phone terminals is shown in Plate R-15. Maximum power output occurs with a load of about 9 ohms. A 600-ohm load is down about 14 db. A 20,000-ohm load is down about 30 db. Maximum output produces about 100 milliwatts in 600-ohm phones and about 3 milliwatts in 20,000-ohm phones. This is adequate for 600-ohm phones, but somewhat weak for high impedance phones in an extremely noisy location. The manufacturer recommends use of high impedance phones without giving any explanation. No advantage is apparent in the method of switching from speaker to phones. Appreciable speaker output is heard at high signal levels when phones are in use.

3-61. Squelch Characteristics. Squelch characteristics at maximum, minimum, and intermediate settings are shown in Plate R-8, and are compared with the corresponding "squelch off" mcw resonant overload curve. There is some squelching action at all settings, but considerably less than the circuit employed is capable of giving. In its present form, the squelch is little more than a gain control.

3-62. Ambient Temperature Variation. The effect of ambient temperature variation on high-frequency and overall frequency and gain is shown in Plates R-16-17-18-19. The gain is affected very little by temperature changes, but the high-frequency oscillator and overall drift is considerable. The negative temperature capacitors employed are inadequate, as the drift is always toward higher frequencies with temperature decreases. This corresponds to a resultant positive temperature coefficient capacitor. The drift averages about four times that permitted in Naval receiver specifications.

3-63. Relative Humidity Variation. The effect of relative humidity variation on high-frequency oscillator and overall frequency and gain is shown in Plates R-20-21-22. Plate R-20

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shows the freedom from drift of the crystal oscillator. The overall drift is then due to the beat-frequency oscillator. After operation for 16 hours in 97 per cent humidity, the high-frequency oscillator would not oscillate on any of the variable frequency bands. The crystal oscillator operated on both fixed channels, but the gain was down about 40 db. The gain returned to nearly normal after four hours exposure to 25 per cent humidity. The gain is affected greatly by humidity changes. The frequency stability is very poor, being about ten times the drift allowed in Naval receiving equipment specifications.

3-64. Vibration, Roll, and Shock.

(a) The following mechanical changes were noted: The B band ceramic trimmer was broken in two pieces. The mounting nut and washer dropped off one long strip. Several trimmer locknuts were loose. The nuts holding the r-f choke on its long vertical bolt were loose. One vertical resistor through-bolt was loose. Several shock-mount nuts were part way off. The beat-frequency oscillator panel condenser mounting nut was loose. The dial lamp was burned out, and its socket was loose. A set screw was gone from the tuning dial. A loose rivet head was found.

(b) The effects of vibration, roll and shock on frequency and gain are shown in Table R-1. Roll has little effect. No one individual shock has any great effect. Continued vibration has serious effect, and the noise peaks due to vibration occur at 15 cycles (6 microvolt equivalent signal) and at 21 cycles (5.5 microvolt equivalent signal).

(c) At any vibration of over an 11-cycle frequency, it was impossible to copy a cw signal when keyed at a very slow rate. At any vibration frequency of over 14 cycles, mcw signals could not be copied. The signals degenerated into noise, varying in intensity at the vibration frequency. The i-f transformers knocked together violently at frequencies between 15 and 21 cycles.

SUMMARY OF DEFECTS

3-65. The following summary is intended to show the major respects in which this receiver is unsatisfactory from a Naval standpoint.

3-66. The gauge of the chassis, shield protection, and shield-can metal is entirely too light. These parts bend and flex under the slightest vibration and are the chief cause of the lack of stability during vibration.

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3-67. Iron and steel have been used to an excessive extent. Practically all ferrous parts show signs of rust.

3-68. The mechanical workmanship is not of the best. Holes frequently have jagged edges, bends are not smooth, and welds are not neat. Bolts are frequently clipped off and the beat-frecuency oscillator condenser has been cut down from a larger size, leaving a long projecting shaft.

3-69. Many parts are insecurely mounted. One ceramic trimmer was cracked and broken; an r-f choke, a wire-wound resistor, and a lug strip became loose. Two components are mounted so that they strike a flat surface upon which the receiver is set if the front panel projects over the edge.

3-70. Six low-voltage electrolytic capacitors are employed.

3-71. One of the metal-case paper capacitors leaked oil after the temperature run.

3-72. Some brown bakelite-case mica capacitors are employed.

3-73. The r-f coils apparently have not been treated to withstand high humidity and the inductance trimming method is sloppy, insecure and subject to moisture aosorption.

3-74. Many nuts are not secured with lockwashers, and most of the lockwashers are of the internal-tooth type. Many unplated brass nuts are employed.

3-75. The band switch is not rugged. It has unplated brass parts, and considerable rust has appeared on the shaft.

3-76. Tube sockets have too large clearance holes and some of their steel rings are rusting.

3-77. Control knobs all have only one set screw and it is of the slotted head type.

3-78. The dial drive has no provision for wear takeup or dust protection and appears to be inadequately lubricated. Some backlash appears in the drive.

3-79. The speaker frame is badly rusted. The cone does not appear to be treated to withstand moisture. There is considerable "blotter" effect when the cone is moistened.

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3-80. Varnished spaghetti is used extensively. Many wires pass through metal partitions without protecting grommets. Many long unsupported wire spans are employed. Tube sockets are used to hold many small components.

3-81. The tuning condenser and r-f tube shock mounting method is poor. If the screws are tight, there is no shock mounting. If loose, they work still looser until the unit bounces around badly.

3-82. The receiver blocks almost as soon as it reaches maximum output for cw reception.

3-83. The r-f gain control range is inadequate.

3-84. The high-frequency oscillator radiation is excessive, being worse than most ordinary broadcast receivers. Excessive outputs are obtained on harmonics beyond the sixth.

3-85. The alignment appears poor at the low-frequency end of all bands.

3-86. Considerable speaker output is heard on strong signals when phones are in use.

3-87. The squelch has little effect at any setting.

3-88. The frequency drift with temperature change is about four times that permitted in usual Naval receiver specifications.

3-89. The frequency drift with humidity change is about ten times that permitted in usual Naval receiver specifications. The gain change averages about three times the usual permitted value.

3-90. The beat-frequency oscillator superregenerates for about 10 minutes after the receiver is first turned on and set for cw reception.

Table TR-1

Model TCQ Transmitting Equipment

DIMENSIONS AND WEIGHTS

Transmitter-Receiver Unit

Height = 20"
Width = 19-7/8"
Depth = 20" Weight = 86 lbs.

Transmitter Unit

Height = 9-1/4"
Width = 19"
Depth = 15" Weight = 31 lbs.

Receiver Unit

Height = 8-1/2"
Width = 19"
Depth = 17-7/8" Weight = 32 lbs.

Frame and Cradle

Height = 20"
Width = 19-7/8"
Depth = 16-1/2" Weight = 23 lbs.

Dynamotor-Filter Unit

Height = 8"
Width = 18-1/2"
Depth = 15" Weight = 54-1/2 lbs.

Remote Control Unit

Height = 6-3/8"
Width = 12-1/2"
Depth = 4-1/4" Weight = 3-1/2 lbs.

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Table TR-1 (Cont'd)

Cables

Function	Length	Weight
Receiver to Remote Unit	19-1/4'	5-1/4 lbs.
Power Unit to Receiver	9-1/2'	2-1/2 lbs.
Microphone	5-3/4'	-------
Key	6-1/3'	-------

Total Weight = 151.75 lbs.

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Table TR-2

Model TCQ Transmitting Equipment

NAMEPLATE DATA

Transmitter Unit

1. (Size - 4-1/2" x 5-3/4") (Top Panel)

Radio Transmitting and Receiving Equipment

Model TCQ Serial 16

Output	Emission	Frequency Range
30 Watts	CW (A1)	2000 to 9050 KC
30 Watts	MCW (A2)	2000 to 9050 KC
30 Watts	Phone (A3)	2000 to 9050 KC

Supply 24 Volts D.C.

Equipment Consists of Following Units

CHI-43012 Radio Transmitter-Receiver
CHI-21575 Dynamotor-Filter Unit
CHI-23234 Remote Control Unit
CHI-66028 Whip Antenna

See License Notice Inside

Navy Department
Bureau of Ships

Contractor
Higgins Industries, Inc.
New Orleans, La.

Contract NOs 83068 Contract Date 17 March 1941

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Table TR-2 (Cont'd)

2. (Size - 3" x 3-1/8") (Front Panel)

Radio Transmitter-Receiver
Type CHI-43012
Frequency: 2000 to 9050 KC
Weight 84 Lbs. Serial 16
A Unit of Model TCQ Radio Equipment
Manufactured For
Navy Department - Bureau of Ships
By
Higgins Industries, Inc.
Santa Monica, Cal.
Contract NOs 83068
Contract Date: 17 March 1941

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Dynamotor-Filter Unit

3. (Size - 3" x 3-3/8") (Top Cover)

Dynamotor-Filter Unit
Type CHI-21575
Input: 22 Amps. at 24 Volts DC
Output: 500/400 Volts at 350/250 MA DC
Weight: 60 LBS. Serial 16
A Unit of Model TCQ Equipment
Manufactured For
Navy Department - Bureau of Ships
By
Higgins Industries, Inc.
Santa Monica, Cal.
Contract NOs 83068
Contract Date: 17 March 1941

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Table TR-2 (Cont'd)

4. (Size - 2-9/16" x 1") (H-V Dynamotor) (Serial 17 Equipment)

Code No. E5135
Input: 24 dc
Output: 515 dc, 0.350 amps.
Serial No.: 15569
Carter Motor Co., Chicago, Ill., Made in U.S.A.

- -

5. (Size - 2-9/16" x 1") (L-V Dynamotor) (Serial 17 Equipment)

Code No. E4125
Input: 24 dc
Output: 415 dc, 0.250 amps.
Serial No.: 15607
Carter Motor Co., Chicago, Ill., Made in U.S.A.

- -

Remote Unit

6. (Size - 3" x 3-1/8") (Side Panel)

Remote Control Unit
Type CHI-23234
Weight 4 lbs. Serial 16
A Unit of Model TCQ Radio Equipment
Manufactured For
Navy Department - Bureau of Ships
By
Higgins Industries, Inc.
Santa Monica, Cal.
Contract NOs 83068
Contract Date: 17 March 1941

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Table T-1

Model TCQ Transmitting Equipment

LIST OF CONTROLS AND METERS
(Transmitter Unit)

Control Marking	Dial Marking	Type and Description
Channel	A_1, A_2; B_1, B_2; C_1, C_2; 1,2,3,4	10-position rotary switch. Black bakelite knob 1-5/8" diameter.
Excitation	None	Continuously variable capacitor. Black bakelite knob. 1-5/8" diameter.
Osc. Tuning	A, 2 to 3.5 mc B, 3.6 to 6.2 mc C, 6.2 to 9.2 mc	Variable capacitor directly calibrated in frequency from 2 to 9.2 mc in 3 bands. Black bakelite knob 1-5/8" diameter.
Final Tuning	100 Divisions	Variable capacitor. Black bakelite knob 1-5/8" diameter.
1	0 to 10	Continuously variable ant. tuning capacitors mounted inside trans. unit. Black bakelite bar knobs with locking bars.
2	"	
3	"	
4	"	
A_1	"	
A_2	"	
A_3	"	
A_4	"	
A_5	"	

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(Continued)

Table T-1 (Cont'd)

Control Marking	Type	Function
A	Screwdriver adjustment	M-O Band Set Capacitor
B	" "	" " " " "
C	" "	" " " " "
1	" "	Buffer Tuning Cap. Channel 1
2	" "	Buffer Tuning Cap. Channel 2
3	" "	Buffer Tuning Cap. Channel 3
4	" "	Buffer Tuning Cap. Channel 4
AB	" "	Buffer Tuning Cap. Channel A and B
C	" "	Buffer Tuning Cap. Channel C
None	" "	M-O Temp. Compensator Band A
None	" "	M-O Temp. Compensator Band B
None	" "	M-O Temp. Compensator Band C

Meters

P.A. Grid Current	CV-22132	0-15 ma d.c.
P.A. Plate Current	CV-22065	0-250 ma d.c.
Antenna Current	CV-22019	0-2 amps. r.f.

In addition, there are three single-circuit, normally-closed jacks on the sides of chassis for reading M.O., C.O., and Buffer Plate Currents.

All meters are located on front panel of transmitter unit.

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(Continued)

Table T-1 (Cont'd)

Controls in the Receiver-Modulator Unit
Which Pertain to the Transmitter.

Front Panel Controls

Control Marking	Type	Function
Power On	Toggle SPST	Energizes all filaments and starts L-V Generator.
Trans. On	Toggle DPST	Starts H-V Generator.
MCW On	Toggle SPST	Turns on Audio Oscillator.
Key	Single-Circuit Jack	Key jack.
Microphone	Two-Circuit Jack	Microphone input.

Other Controls

Control Marking	Type	Function
MCW Tone	Rheostat 1-1/4" Bar Knob	Changes tone of Audio Osc.
MCW Level	Potentiometer 1-1/4" Bar Knob	Controls MCW level.
Voice Level	Potentiometer 1-1/4" Bar Knob	Controls voice level.
A.P.L.	Potentiometer 1-1/4" Bar Knob	Automatic peak limiter to prevent over modulation.

No dials or dial markings are provided for these controls.

Two single-circuit jacks are accessible on the side of the receiver-modulator chassis for reading Modulator Plate Current and Driver Plate Current. These are marked "Mod. Plate" and "Driver Plate."

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Table T-2

Model TCQ Transmitting Equipment

MAXIMUM POWER OUTPUT - CW

Frequency Kc	Band	PA Ig	PA Ic	Line Voltage	Output Watts	Note
2000	A1	2.6	140	24.0	8.2	1
2500	A1	7.9	149	24.0	4.3	1
3000	A2	7.7	153	24.0	7.6	1
3000	A2	4.2	163	24.0	32.0	2
3500	A2	7.2	157	24.0	17.0	2
3600	B1	4.4	163	24.0	34.0	2
4000	B1	4.1	151	24.0	31.0	2
4500	B1	5.9	154	24.0	27.0	2
5000	B2	4.8	164	24.0	31.0	2
5500	B2	4.2	149	24.0	32.0	2
6000	B2	5.0	158	24.0	31.0	2
6500	C1	2.3	142	24.0	33.4	3, 4
7000	C2	2.3	148	24.0	34.0	3
7500	C2	2.3	145	24.0	33.8	3
8000	C2	2.1	147	24.0	33.5	3
8500	C2	1.8	145	24.0	33.5	3
9000	C2	1.4	157	24.0	20.0	3
2716	1	3.2	162	24.0	10.2	1
3405	2	6.6	154	24.0	25.0	2
4385	3	3.2	169	24.0	26.0	2
5335	4	5.6	150	24.0	31.5	2

NOTE: (1) Antenna: 5.07-ohm non-inductive resistor in series with 150 µµf.

(2) Antenna: 32-volt, 25-watt lamp in series with 150 µµf.

(3) Antenna: 32-volt, 25-watt lamp.

(4) Due to heating of the transmitter, this output is less than obtained at the same frequency with a compromise adjustment (see following table). The power output with a compromise adjustment was taken with the transmitter comparatively cold.

(5) Transmitter tuned for maximum output at each frequency.

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Table T-3

Model TCQ Transmitting Equipment

OPTIMUM POWER OUTPUT - CW

Frequency Kc	Band	PA Ig	PA Ic	Line Voltage	Output Watts	Note
2000	A1	2.4	130	23.8	8.2	1
2500	A1	10.9	140	23.8	4.5	1
3000	A2	4.1	130	23.8	6.7	1
3000	A2	3.5	135	23.8	21.0	2
3500	A2	1.5	93	23.8	12.0	2
3600	B1	5.6	173	24.0	30.5	2
4000	B1	5.0	155	24.0	34.0	2
4500	B1	5.0	150	24.0	29.0	2
5000	B2	3.6	169	24.0	32.5	2
5500	B2	3.3	152	24.0	36.0	2
6000	B2	4.5	150	24.0	29.0	2
6500	C1	2.0	153	24.0	38.0	3
7000	C2	2.2	153	24.0	35.5	3
7500	C2	2.8	138	24.0	27.5	3
8000	C2	3.2	123	24.0	17.0	3
8500	C2	3.2	128	24.0	10.5	3
9000	C2	2.3	112	24.0	1.0	3
2716	1	3.2	162	24.0	10.2	1
3405	2	6.6	154	24.0	25.0	2
4385	3	3.2	169	24.0	26.0	2
5335	4	5.6	150	24.0	31.5	2

NOTE: (1) Antenna: 5.07-ohm non-inductive resistor in series with 150 μμf.

(2) Antenna: 32-volt, 25-watt lamp in series with 150 μμf.

(3) Antenna: 32-volt, 25-watt lamp.

(4) Transmitter tuned for maximum output at the lowest frequency of each band.

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Table T-4

Model TCQ Transmitting Equipment

MAXIMUM POWER OUTPUT - MCW and PHONE

Frequency Kc	Band	PA Ic		Output - Watts		Note
		MCW	Phone	MCW	Phone	
2000	A1	138	136	10.0	9.7	1
2400	A2	152	152	6.5	6.3	1
3000	A2	156	158	36.0	35.0	2
3600	B1	163	167	37.0	37.0	2
4000	B1	155	150	41.5	42.5	2
4500	B1	149	149	35.0	35.0	2
5000	B2	173	172	46.5	42.0	2
5500	B2	155	157	41.8	42.0	2
6000	B2	144	151	38.0	38.2	2
6500	C1	148	148	43.0	42.0	3
7000	C1	131	132	43.4	41.5	3
7500	C1	129	132	39.2	39.0	3
8000	C1	121	122	36.0	36.0	3
8500	C2	128	133	37.0	36.2	3
9000	C2	123	122	32.0	31.8	3
2716	1	126	124	11.1	10.3	1
3045	2	151	150	33.0	31.2	2
4385	3	148	150	36.9	33.5	2
5335	4	133	138	31.5	31.2	2

NOTE: (1) Antenna: 5.1-ohm non-inductive resistor in series with 150 μμf.

(2) Antenna: 32-volt, 25-watt lamp in series with 150 μμf.

(3) Antenna: 32-volt, 25-watt lamp.

(4) Plate supply voltage maintained at 435 volts. Buffer plate voltage maintained at 280 volts,

(5) Transmitter tuned for maximum output at each frequency.

(6) A 600-cycle input sufficient to cause 95 per cent modulation was used during phone tests.

(7) Peak limiter set to a minimum during the above tests.

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Table T-5

Model TCQ Transmitting Equipment

OPERATION WITH A 24-FOOT WHIP ANTENNA

Frequency Kc	Band	PA I_g	PA I_c	R-F Amps.	Output Watts
2000	A1	7.6	150	0.71	2.0
2500	A2	8.8	149	0.82	2.7
3000	A2	9.3	143	0.65	2.0
3500	A2	9.6	118	0.55	1.9
3600	B1	6.3	156	0.98	6.5
4000	B1	6.8	125	0.82	6.1
4500	B2	3.4	134	1.09	13.3
5000	B2	5.0	163	0.94	12.7
5500	B2	5.2	150	0.82	12.1
6000	B2	6.7	157	0.77	----
6500	C1	3.7	105	0.98	----
7000	C2	3.0	132	1.27	----
7500	C2	2.8	140	1.28	----
8000	C2	1.8	140	1.28	----
8500	C2	1.0	137	0.84	----
9000	C2	1.4	128	0.71	----

NOTE: (1) Transmitter tuned to maximum output at one frequency on each band. No internal adjustments made at other frequencies.

(2) Antenna extended to 24 feet. A four-foot open wire lead was used from the base of the antenna to the transmitter terminal.

(3) Antenna characteristics were not measured above 5800 kilocycles.

(4) Plate supply voltage maintained at 435 volts throughout the above test.

(5) Serial No. 36X TCQ Transmitter employed.

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Table T-6

Model TCQ Transmitting Equipment

OPERATION WITH A 30-FOOT WHIP ANTENNA

Frequency Kc	Band	PA Ig	PA Ic	Line Voltage	R-F Amps.	Output Watts	Note
2000	A1	6.0	164	24	1.3	10.1	1
2500	A1	9.2	143	24	0.88	5.3	
3000	A2	7.5	158	24	1.15	16.0	
3500	A2	10.0	141	24	0.88	9.0	
3600	B1	6.0	159	24	1.25	19.2	1
4000	B1	6.5	153	24	1.09	18.6	
4500	B2	4.3	150	24	1.32	----	1
5000	B2	4.2	148	24	1.17	----	
5500	B2	4.0	148	24	0.99	----	
6000	B2	3.6	138	24	1.04	----	
6500	C1	2.2	157	24	0.90	----	1
7000	C2	2.2	144	24	0.80	----	1
7500	C2	2.1	140	24	0.83	----	
8000	C2	2.9	137	24	0.60	----	
8500	C2	3.2	122	24	0.40	----	
9000	C2	1.0	166	24	0.	----	
2716	1	5.3	158	24	1.33	12.8	1
3405	2	6.5	162	24	1.11	9.4	1
4385	3	3.8	133	24	0.97	----	1
5335	4	5.5	144	24	1.00	----	1

NOTE: (1) Transmitter tuned to maximum output at this frequency. No internal readjustments made at other frequencies except as noted.

(2) Antenna extended to 30 feet. A 4-1/2-foot open wire lead was used from the base of the antenna to the transmitter terminal.

(3) Serial No. 16 TCQ transmitter employed.

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Table T-7

Model TCQ Transmitting Equipment

MODULATION CHARACTERISTICS

Frequency Kc	Mod. I_c		R-F Current		Per Cent Mod.	
	MCW	Phone	MCW	Phone	MCW	Phone
			Peak Limiter Set on Minimum			
2000	185	181	1.38	1.40	100.	100
3000	210	196	1.00	0.98	100.	100
4000	195	195	1.00	1.00	100.	100
5000	210	206	1.09	1.09	100.	100
6000	180	182	1.20	1.17	100.	100
7000	183	170	1.15	1.11	100.	100
8000	180	178	1.13	1.13	100.	100
9000	190	183	0.78	0.78	100.	100
			Peak Limiter Set on Maximum			
2000					87.	88
3000					87.	88
4000					84.5	86
5000					92.	90
6000					83.	83
7000					83.	83
8000					83.	78
9000					85.	86

NOTE: (1) Per cent modulation determined with an RCA 69-C Distortion and Noise Meter and a cathode-ray oscilloscope.

(2) Line voltage held constant at 24 volts.

(3) Modulating frequencies: MCW - 450 cycles
Phone - 800 cycles

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Table T-8

Model TCQ Transmitting Equipment

AUDIO DISTORTION

Frequency Kc	Mod. I_p	PA I_p	Internal R-F Amps.	Per Cent Modulation	Per Cent Distortion
2000	170	118	1.14	95	6.0
2000	130	120	1.03	50	7.3
4500	200	163	1.08	95	6.7
4500	137	158	0.97	50	3.5
9000	189	142	0.73	95	8.5
9000	147	147	0.70	50	5.5

Percentage modulation determined by use of oscilloscope.
Percentage distortion determined by use of R.C.A. Distortion Meter.

Line voltage held constant at 24 volts.
Modulation frequency: 800 c.p.s.

Antennas: On 2000 kc: 5.07-ohm resistor and 150 μμf capacitor.
On 4500 kc: 32-volt 25-watt lamp and 150 μμf capacitor.
On 9000 kc: 32-volt 25-watt lamp.

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Table T-9

Model TCQ Transmitting Equipment

PERCENTAGE RIPPLE IN CARRIER

Frequency Kc	Carrier Volts	Ripple Volts	Per Cent Ripple
2000	300	1.65	0.55
4500	300	3.00	1.00
9000	200	1.50	0.75

Transmitter operated at full cw power output.
Supply line voltage held constant at 24 volts.

Antennas: On 2000 kc: 5.07-ohm resistor and 150 μμf capacitor.
On 4500 kc: 32-volt 25-watt lamp and 150 μμf capacitor.
On 9000 kc: 32-volt 25-watt lamp.

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Table T-10

Model TCQ Transmitting Equipment

DETUNING OF CIRCUITS

Circuit Detuned	Frequency Kc	Change in Frequency Cycles	Change in Frequency Per Cent
Normal	2500.270		
c Final Tuning	2500.276	6	0.00024
cc Final Tuning	2500.250	20	0.00080
Normal	4500.360		
c Final Tuning	4500.345	15	0.00033
cc Final Tuning	4500.385	25	0.00056
Normal	9000.525		
c Final Tuning	9000.750	225	0.00250
cc Final Tuning	9002.300	1775	0.01972

NOTE: (1) Each control detuned in both a clockwise and counter-clockwise direction as shown by the letters "c" and "cc."

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Table T-11

Model TCQ Transmitting Equipment

CHANGE OF TUBES

Manufacturer and Serial No.	Frequency Kc	Deviation from Mean Frequency	
		Cycles	Per Cent
	M-O Stage		
RCA 1	2002.350	94	0.00470
RCA 2	2002.300	144	0.00720
Hygrade-Sylvania 7	2002.615	171	0.00855
Hygrade-Sylvania 8	2002.350	94	0.00470
Hygrade-Sylvania 9	2002.600	156	0.00780
Hygrade-Sylvania 10	2002.490	46	0.00230
Hygrade-Sylvania 12	2002.400	44	0.00220
Mean	2002.444	107	0.00535
RCA 1	4503.920	1096	0.02430
RCA 2	4502.750	74	0.00016
Hygrade-Sylvania 7	4503.250	426	0.00946
Hygrade-Sylvania 8	4502.575	249	0.00554
Hygrade-Sylvania 9	4502.975	151	0.00334
Hygrade-Sylvania 10	4502.350	474	0.01050
Hygrade-Sylvania 12	4501.950	874	0.01940
Mean	4502.824	478	0.01064
RCA 1	9002.325	829	0.00922
RCA 2	9000.900	596	0.00662
Hygrade-Sylvania 7	9002.250	754	0.00835
Hygrade-Sylvania 8	9000.750	746	0.00820
Hygrade-Sylvania 9	9002.500	1104	0.01225
Hygrade-Sylvania 10	9001.000	496	0.00550
Hygrade-Sylvania 12	9000.750	746	0.00550
Mean	9001.496	753	0.00834

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(Continued)

Table T-11 (Cont'd)

Manufacturer and Serial No.	Frequency Kc	Deviation from Mean Frequency	
		Cycles	Per Cent
	Buffer Stage		
RCA 1	2001.650	67	0.00334
RCA 4	2001.550	33	0.00165
RCA 5	2001.550	33	0.00165
Mean	2001.583	44	0.00220
RCA 1	4502.650	33	0.00073
RCA 4	4502.700	17	0.00038
RCA 5	4502.700	17	0.00038
Mean	4502.683	22	0.00049
RCA 1	9001.550	8	0.000089
RCA 4	9001.450	108	0.00120
RCA 5	9001.675	117	0.00130
Mean	9001.558	77	0.00085
	P-A Stage		
RCA 2, 3	2001.575	50	0.0025
RCA 4, 5	2001.475	50	0.0025
Mean	2001.525	50	0.0025
RCA 2, 3	4502.650	13	0.00029
RCA 4, 5	4502.625	12	0.00026
Mean	4502.637	12.5	0.00028
RCA 2, 3	9002.900	263	0.00293
RCA 4, 5	9002.375	262	0.00291
Mean	9002.637	262.5	0.00292

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Table T-12

Model TCQ Transmitting Equipment

TEST FOR LOST MOTION, BACKLASH, AND TORQUE LASH

Trial No.	Frequency When Approached From A Counterclockwise Direction Kc	Clockwise Direction Kc	Backlash Cycles	Backlash Per Cent
1	2495.000	2496.500	1500	0.060
2	2495.000	2497.100	2100	0.083
3	2495.000	2497.425	2425	0.097
4	2495.000	2496.300	1300	0.052
5	2495.000	2496.850	1850	0.074
			Average:	0.0732
1	1996.750	1998.000	1650	0.0925
2	1996.775	1998.125	1350	0.0675
3	1996.500	1998.300	1800	0.0900
4	1997.100	1999.150	2050	0.1025
5	1997.150	1998.050	900	0.0450
			Average:	0.0795
1	3995.000	3996.500	1500	0.0375
2	3995.000	3995.750	750	0.0187
3	3995.000	3996.300	1300	0.0325
4	3995.000	3995.300	300	0.0075
5	3995.000	3996.950	1950	0.0488
			Average:	0.0290
1	6002.175	6000.650	1525	0.0254
2	6002.625	6000.950	1675	0.0279
3	6002.300	6000.300	2000	0.0333
4	6000.600	6001.800	1200	0.0200
5	6001.900	6000.750	1150	0.0192
			Average:	0.0252
1	7001.500	7004.075	2575	0.0368
2	7001.075	7002.725	1650	0.0236
3	7000.275	7001.840	1565	0.0223
4	7003.675	7003.750	75	0.0001
5	7003.425	7004.575	1150	0.0164
			Average:	0.0198

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(Continued)

Table T-12 (Cont'd)

Trial No.	Frequency When Approached From A Counterclockwise Direction Kc	Clockwise Direction Kc	Backlash Cycles	Backlash Per Cent
1	9001.050	9003.700	2650	0.0294
2	9001.800	9003.325	1525	0.0169
3	9002.810	9004.300	1490	0.0166
4	9001.870	9003.350	1480	0.0165
5	9001.325	9002.240	915	0.0102
			Average:	0.0179

Frequency measured with Lw-2 Frequency Indicator.

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Table T-13

Model TCQ Transmitting Equipment

VARIATION OF SUPPLY LINE VOLTAGE

Condition	Frequency Kc	Watts Output	Line Voltage	Line Current	Watts Input
CW	5000	22.5	21.6	18.0	390
CW	5000	30.0	24.0	19.8	476
CW	5000	37.0	26.4	21.8	523

NOTE: Antenna: 32-volt, 25-watt lamp in series with 150 μμf.

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Table T-14

Model TCQ Transmitting Equipment

VARIATION OF AMBIENT TEMPERATURE - 2500 KC

Time	Amb. Temp. °C	Rel. Hum, %	Frequency Kc	P.A. Ep	P.A. Ip	Output Watts	Line Volts
0925	50	30	2499.550	466	135	8.05	24.2
0940	48	29	2500.010	467	130	8.05	24.2
0955	48	29	2502.150	465	125	7.45	24.1
1010	49	28	2502.350	467	124	7.50	24.2
1025	49	28	2502.500	455	119	6.90	23.7
1035	40	32	2502.700	468	122	7.5	24.2
1050	40	25	2502.850	455	117	7.08	23.7
1105	40	27	2502.900	467	122	7.65	24.2
1120	40.5	27	2502.900	460	120	7.30	24.0
1135	40.5	28	2502.750	466	121	7.65	24.2
1145	30	39	2503.000	470	122	7.65	24.3
1200	28.5	33	2503.250	460	121	7.5	24.0
1215	28.5	30	2503.350	462	123	7.65	24.1
1230	30	31	2503.350	464	124	7.65	24.2
1245	30	31	2503.250	465	122	7.5	24.3
1310	18	57	2503.350	466	126	8.05	24.2
1325	20	36	2503.750	470	128	8.3	24.2
1340	20	36	2503.740	468	130	8.3	24.0
1355	20.5	32	2504.500	471	128	8.4	24.0
1410	19	44	2504.300	470	130	8.4	24.0
1415	10	--	2504.400	470	130	8.6	24.0
1430	11	--	2504.650	468	130	8.6	24.0
1445	10	--	2504.700	470	130	8.7	23.9
1500	10	--	2504.900	470	132	8.85	23.9
1510	10	--	2505.000	465	133	8.95	23.8
1530	0	--	2505.200	470	143	9.20	24.0
1545	0	--	2505.500	473	145	9.50	24.2
1600	-1	--	2505.650	474	145	9.50	24.1
1615	+2	--	2505.700	470	145	9.50	24.0
1630	+1	--	2505.675	471	146	9.50	24.0

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Table T-14 (Cont'd)

Summary

Temperature Change Degrees C	Cycles Change per 10°C	Per Cent Change per One Degree C
50 to 40	250	0.0010
40 to 30	500	0.0020
30 to 20	1050	0.0040
20 to 10	700	0.0028
10 to 0	675	0.0027

Antenna: 5.07 ohms resistance and 150 μμf.

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Table T-15

Model TCQ Transmitting Equipment

VARIATION OF AMBIENT TEMPERATURE - 8000 KC

Time	Amb. Temp. °C	Rel. Hum.	Frequency Kc	P.A. Ep	P.A. Ip	Output Watts	Line Volts
0840	48.9	28	8000.500	485	118	9.25	24.7
0855	49.4	26.5	8001.500	480	115	9.10	24.6
0910	48.3	27	8003.000	476	114	9.00	24.6
0925	48.5	29	8002.600	476	116	9.00	24.6
0940	48.3	29	8004.000	474	115	8.85	24.6
0950	38.9	26	8004.500	473	112	8.85	24.5
1005	38.9	26	8004.000	471	116	9.00	24.6
1020	40.0	27	8003.200	470	115	8.85	24.6
1035	40.5	25	8003.500	470	116	8.85	24.6
1050	39.5	25	8004.000	470	115	8.85	24.5
1055	29.5	32.5	8004.000	470	118	9.00	24.5
1110	27.2	32	8004.700	465	117	8.85	24.4
1125	28.9	29	8004.000	466	120	9.10	24.4
1140	28.5	29	8005.200	470	120	9.10	24.4
1155	30.0	28	8005.550	470	121	9.25	24.4
1157	20.0	36	8005.300	475	122	9.55	24.4
1210	19.5	41	8007.750	476	125	9.65	24.6
1225	22.0	28	8008.400	470	125	9.55	24.2
1245	19.0	32	8008.200	470	125	9.55	24.2
1300	20.5	32	8008.750	470	126	9.55	24.2
1315	11.0	40	8009.200	470	126	9.65	24.0
1330	11.0	40	8008.000	470	124	9.65	24.0
1345	11.6	47	8008.100	472	125	9.65	24.0
1400	10.5	--	8008.300	470	126	9.55	24.0
1415	11.6	--	8008.700	468	125	9.65	24.0
1425	0.0	--	8008.400	470	128	9.80	24.0
1440	0.0	--	8009.900	470	130	9.95	24.0
1455	0.0	--	8011.050	472	132	9.95	24.1
1510	0.0	--	8012.150	474	133	10.1	24.1
1525	0.0	--	8012.400	475	132	10.1	24.1

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(Continued)

Table T-15 (Cont'd)

Summary

Temperature Change Degrees C	Cycles Change per 10°C	Per Cent Change per One Degree C
50 to 40	0000	0.00000
40 to 30	1550	0.00194
30 to 20	3200	0.00400
20 to 10	50	0.00006
10 to 0	3700	0.00463

Antenna: 5.07 ohms resistance and 150 μμf.

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Table T-16

Model TCQ Transmitting Equipment

OPERATION AFTER IDLE PERIODS AT
HIGH AND LOW AMBIENT TEMPERATURES

Time	Amb. Temp. °C	Rel. Hum.	Frequency Kc (Note 1)	P.A. Ep	P.A. Ip	Power Output Watts	Line Volts
0825	49.5	23	2007.000	465	141	27	23.8
0855	50.0	26	Entire equipment shut down.				
0925	50.0	31	Entire equipment shut down.				
0955	50.0	26	Entire equipment shut down.				
1025	49.0	28	2006.720	468	140	29	24.0
1115	0.0	--	2010.520	485	138	33	24.5
1145	0.0	--	Entire equipment shut down.				
1215	0.5	--	Entire equipment shut down.				
1245	1.0	--	Entire equipment shut down.				
1315	1.3	--	2010.000	480	132	33	24.2
1345	-10.	--	Entire equipment shut down.				
1415	-16.	--	Entire equipment shut down.				
1445	-19.	--	Entire equipment shut down.				
1450	-20.	--	Entire equipment shut down.				
1520	-20.	--	2012.130	480	134	35	24.2

NOTE: (1) Frequency changes cannot be calculated from the data given, since it was necessary to readjust the frequency of the transmitter before taking each reading in order to bring the frequency within range of the measuring equipment.

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Table T-17

Model TCQ Transmitting Equipment

VARIATION OF HUMIDITY - 2500 KC

Time	Amb. Temp. °C	Rel. Hum.	Frequency Kc	P.A. Ep	P.A. Ip	Output Watts	Line Volts
1415	38.	30	2500.930	448	125	6.4	23.0
1430	39.	28	2500.900	445	125	6.4	23.0
1445	39.2	28	2500.850	445	120	6.4	22.8
1500	39.	28	2500.825	445	122	6.1	22.8
1515	39.	28	2500.875	445	121	6.1	22.8
1530	38.	65	2500.500	444	120	6.1	22.8
1545	42.	97	2499.520	440	118	5.8	22.8
1600	41.	97	2499.270	440	115	5.5	22.7
1615	40.8	97	2499.120	440	120	5.8	22.7
			Entire Equipment Idle Overnight				
0815	41.	97	Transmitter turned on.				
0915	40.	97	2502.000	460	112	6.3	23.6
0930	40.	97	2503.250	455	111	6.1	23.6
0945	40.5	97	2504.190	455	108	6.1	23.5
1000	41.5	97	2504.550	452	106	5.9	23.4
1015	41.8	97	2505.000	452	105	5.8	23.3
1030	42.5	47	2505.000	450	104	5.7	23.2
1045	39.	29	2505.000	450	115	5.9	23.2
1100	40.	27	2505.450	449	115	6.0	23.2
1115	38.8	24	2506.180	450	116	6.1	23.2
1130	39.	24	2506.280	450	115	6.1	23.1
1145	39.	23	2506.180	445	116	6.1	23.1

Frequency at end of first test period: 2500.875 kc.
Frequency of greatest subsequent change (during second test period): 2499.120 kc.
Maximum frequency change: 1755 cycles; 0.0702 per cent.

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Table T-18

Model TCQ Transmitting Equipment

VARIATION OF HUMIDITY - 8000 KC

Time	Amb. Temp. °C	Rel. Hum.	Frequency Kc	P.A. Ep	P.A. Ip	Output Watts	Line Volts
1215	40.	23	8001.000	436	140	24	22.9
1230	39.5	23	8001.725	435	140	24	22.8
1245	40.	25	8002.500	435	140	23	22.8
1300	44.	93	8002.000	432	136	23	22.8
1315	41.	97	8001.000	430	135	22	22.7
1330	40.	87	8002.750	430	134	22	22.6
1345	40.	87	8003.500	430	136	19	22.5
1400	40.	93	8004.650	430	133	19	22.5
1415	40.2	93	8002.750	460	143	23	24.0
1430	40.2	27	8005.000	460	145	24	24.0
1445	39.5	23	8007.500	464	147	24	24.1
1500	39.5	23	8008.900	461	147	24	24.1
1515	39.	26	8006.800	462	147	25	24.1
1530	39.5	27	8009.000	460	148	25	24.2

Frequency at end of first test period: 8002.500 kc.
Frequency of greatest subsequent change: 8009.000 kc.
Maximum frequency change: 6500 cycles; 0.081 per cent.

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Table T-19

Model TCQ Transmitting Equipment

LOCKED KEY OPERATION FOR TWO HOURS - 2000 KC

Time	Ambient Temp. °C	Frequency Kc	Plate Volts	P.A. Ip	Output Watts
1325	21.5	2003.960	435	139	7.95
1330	21.5	2003.660	435	138	7.95
1335	21.5	2003.450	435	133	7.72
1340	21.6	2003.310	435	132	7.72
1345	21.7	2003.150	435	131	7.59
1350	21.9	2003.075	435	131	7.59
1355	22.0	2002.950	435	130	7.59
1400	21.9	2002.875	435	130	7.59
1405	21.8	2002.740	435	128	7.45
1410	21.6	2002.610	435	128	7.45
1415	21.6	2002.510	435	129	7.45
1420	21.6	2002.490	435	129	7.45
1425	21.6	2002.390	435	128	7.32
1430	21.6	2002.305	435	128	7.45
1435	21.6	2002.260	435	128	7.45
1440	21.8	2002.270	435	128	7.32
1445	21.9	2002.195	435	127	7.32
1450	21.9	2002.160	435	127	7.32
1455	21.9	2002.125	435	127	7.21
1500	22.4	2002.100	435	127	7.32
1505	22.2	2002.090	435	127	7.45
1510	22.0	2002.060	435	121	7.21
1515	22.0	2002.060	435	121	7.21
1520	21.8	2002.050	435	121	7.21
1525	21.7	2002.050	435	120	7.21

Antenna: 150 μμf + 5.1 ohms.

Frequency change in first 5 minutes: 300 cycles, 0.0149 per cent.
Maximum frequency change during remainder of test: 1610 cycles, 0.0805 per cent.

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Table T-20

Model TCQ Transmitting Equipment

LOCKED KEY OPERATION FOR TWO HOURS - 4500 KC

Time	Ambient Temp. °C	Frequency Kc	Plate Volts	P.A. Ip	Output Watts
1000	22.6	4503.090	435	157	29.5
1005	22.6	4502.705	435	156	29.5
1010	22.5	4502.450	435	155	29.5
1015	22.5	4502.240	435	156	29.5
1020	22.5	4502.090	435	155	30.0
1025	22.5	4501.941	435	155	30.0
1030	22.5	4501.730	435	155	30.0
1035	22.5	4501.550	435	155	30.5
1040	22.4	4501.365	435	156	30.5
1045	22.4	4501.230	435	155	30.0
1050	22.4	4501.150	435	154	30.0
1055	22.6	4501.030	435	154	30.0
1100	22.7	4500.960	435	155	30.5
1105	22.8	4500.855	435	155	30.0
1110	22.8	4500.750	435	155	30.0
1115	22.7	4500.705	435	154	30.0
1120	22.8	4500.664	435	155	30.0
1125	22.8	4500.610	435	155	30.0
1130	22.8	4500.589	435	155	30.0
1135	22.8	4500.559	435	155	30.0
1140	22.8	4500.556	435	155	30.0
1145	22.7	4500.521	435	155	30.0
1150	22.6	4500.501	435	155	30.0
1155	22.6	4500.506	435	155	30.0
1200	22.5	4500.475	435	156	30.0

Antenna: 32-volt, 25-watt lamp + 150 μμf.

Frequency change in first 5 minutes: 385 cycles, 0.00856 per cent.
Maximum frequency change during remainder of test: 2230 cycles, 0.0495 per cent.

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Table T-21

Model TCQ Transmitting Equipment

LOCKED KEY OPERATION FOR TWO HOURS - 9000 KC

Time	Ambient Temp. °C	Frequency Kc	Plate Volts	P.A. Ip	Output Watts
1400	22.5	9000.975	435	134	26.4
1405	22.6	9000.800	435	134	26.4
1410	22.5	9000.825	435	134	26.4
1415	22.5	9001.500	435	133	26.8
1420	22.5	9002.670	435	133	26.4
1425	22.5	9003.975	435	133	26.8
1430	22.5	9005.000	435	132	26.8
1435	22.8	9007.825	435	133	26.8
1440	22.8	9009.200	435	132	26.8
1445	23.0	9010.000	435	132	26.8
1450	23.0	9012.310	435	132	26.8
1455	23.0	9013.550	435	132	26.8
1500	22.9	9015.000	435	132	26.8
1505	23.0	9017.300	435	132	26.4
1510	22.9	9018.600	435	133	26.8
1515	22.9	9020.000	435	133	26.8
1520	22.8	*9022.975	435	131	26.4
1525	22.8	9023.770	435	132	26.8
1530	22.7	9024.335	435	132	27.4
1535	22.8	9025.000	435	132	27.4
1540	22.8	9026.425	435	132	27.4
1545	23.0	9026.760	435	132	26.8
1550	23.0	9027.150	435	132	26.8
1555	23.2	9027.505	435	132	27.8
1600	23.5	9027.760	435	132	27.8

* Frequency suddenly shifted 850 cycles.

Antenna: 32-volt, 25-watt lamp.

Frequency change in first five minutes: 175 cycles, 0.00194 per cent.
Maximum frequency change during remainder of test: 26,960 cycles, 0.300 per cent.

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Table T-22

Model TCQ Transmitting Equipment

CHANGE FROM KEY-LOCKED TO INTERMITTENTLY-KEYED CONDITION

Test Condition	Freq. at End of 10 Min. Key-Locked	Freq. at End of 10-Sec. Dash 20 Min. Later	Change in Freq. Cycles	Change in Freq. Per Cent
Fil. Lighted	2002.700	2003.060	360	0.018
Fils. Not Lighted	2002.150	2002.650	500	0.025
Fils. Lighted	4502.004	4502.250	246	0.00547
Fils. Not Lighted	4501.875	4502.925	1050	0.0233
Fils. Lighted	9002.425	9001.775	650	0.00722

Table T-23

Model TCQ Transmitting Equipment

CHANGE FROM CONTINUOUSLY-KEYED TO INTERMITTENTLY-KEYED CONDITION

Test Condition	Freq. at End of 30 Min. Continuous Keying Kc	Freq. at End of 10-Sec. Dash After 20-Min. Pause Kc	Change in Freq. Cycles	Change in Freq. Per Cent
Fils. Lighted	2002.575	2002.800	225	0.0113
Fils. Lighted	4502.050	4502.275	225	0.0050
Fils. Lighted	9003.650	9003.810	160	0.00177

Antennas: 2 Mc: 5.07 ohms resistance and 150 μμf.
4.5 Mc: 32-volt, 25-watt lamp and 150 μμf.
9.0 Mc: 32-volt, 25-watt lamp.

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Table T-24

Model TCQ Transmitting Equipment

INCLINATION TEST - 2500 KC

Time	Maximum Frequency Kc	Difference Cycles	Minimum Frequency Kc	Test Condition
		Inclination - Side to Side		
1509	2502.350	---	--------	Stationary
1510	2502.300	---	--------	Inclination
1520	2502.250	---	--------	Inclination
1530	2502.150	---	--------	Inclination
1540	2502.075	---	--------	Inclination
1541	2502.100	---	--------	Stationary

Frequency change during test from frequency at start of test:
275 cycles; 0.011 per cent.

Inclination - Front to Back

1600	2502.025	---	--------	Stationary
1601	2502.025	---	--------	Inclination
1610	2502.050	---	--------	Inclination
1620	2502.050	125	2501.925	Inclination
1628	2502.000	100	2501.900	Inclination
1629	2501.900	---	--------	Stationary

Frequency change during test from frequency at start of test:
125 cycles; 0.005 per cent.

Maximum frequency change at any two points in inclination cycle (max. to min.): 125 cycles; 0.005 per cent.

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Table T-25

Model TCQ Transmitting Equipment

INCLINATION TEST

Time	Maximum Frequency Kc	Difference Cycles	Minimum Frequency Kc	Test Condition
		Inclination - Front to Back		
0855	8001.700	---	--------	Stationary
0856	8002.950	1100	8001.850	Inclination
0905	--------	---	--------	Inclination
0915	Off Scale	---	8004.150	Inclination
0925	Off Scale	---	8004.850	Inclination
0926	Off Scale	---	Off Scale	Stationary

Frequency change during test from frequency at start of test:
3300 cycles; 0.041 per cent.

Maximum frequency change at any two points in inclination cycle (max. to min.): 1100 cycles; 0.014 per cent.

		Inclination - Side to Side		
0940	8001.700	---	--------	Stationary
0941	8002.050	750	8001.300	Inclination
0950	8003.175	675	8002.500	Inclination
1000	8003.250	700	8002.550	Inclination
1010	8003.850	400	8003.450	Inclination
1011	8003.900	---	--------	Stationary

Frequency change during test from frequency at start of test:
2200 cycles; 0.0275 per cent.

Maximum frequency change at any two points in inclination cycle (max. to min.): 750 cycles; 0.009 per cent.

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Table T-26

Model TCQ Transmitting Equipment

VIBRATION TEST

Time	Frequency Kc	P.A. Ep	P.A. Ip	Int. R-F Amps.	Line Volts	Test Condition
1025	8002.100	400	116	0.82	24.3	Stationary
1026	8001.500	395	---	----	24.0	Vibration
1035	8001.500	395	---	----	24.0	Vibration
1045	8001.750	405	120	0.83	24.4	Vibration
1055	8002.050	395	120	0.83	24.0	Stationary

Maximum set in frequency (difference between start and end of test): 50 cycles; 0.00063 per cent.

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Table T-27

Model TCQ Transmitting Equipment

SHOCK TEST

Shock Applied To	Frequency Before Shock	Frequency After Shock	Frequency Cycles	Difference Per Cent
Side	8002.500	8001.300	1200	0.0150
Side	8002.100	8003.400	1300	0.0163
Side	8003.500	8004.800	1300	0.0163
Side	8001.800	8004.900	3100	0.0388
Side	8002.000	8005.000	3000	0.0375
Side	8001.900	8002.850	950	0.0120
Front	8001.600	8005.000	3400	0.0425
Front	8002.100	8005.000	2900	0.0362
Front	8001.650	8005.000	3350	0.0420
Front	8003.050	8005.000	1950	0.0244
Front	8002.000	8004.100	2100	0.0263
Front	8002.400	8002.400	0000	0.0000

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Table T-28

Model TCQ Transmitting Equipment

CALIBRATION OF MASTER-OSCILLATOR DIAL

Band	M-O Dial Setting (Kc)	Actual Freq. (Kc)	Frequency Difference (Kc)	Per Cent Error
A1	2000	2003.0	+ 3.0	0.150
A1	2100	2107.0	+ 7.0	0.333
A1	2200	2209.2	+ 9.2	0.418
A1	2300	2314.9	+14.9	0.648
A1	2400	2413.9	+13.9	0.589
A1	2500	2518.4	+18.4	0.736
A1	2600	2607.6	+ 7.6	0.292
A2	2700	2702.4	+ 2.4	0.089
A2	2800	2799.8	- 0.2	0.0715
A2	2900	2900.8	+ 0.8	0.0276
A2	3000	3000.4	+ 0.4	0.0133
A2	3100	3114.6	+14.6	0.471
A2	3200	3201.8	+ 1.8	0.056
A2	3300	3302.8	+ 2.8	0.085
A2	3400	3398.8	- 1.2	0.035
A2	3500	3502.0	+ 2.0	0.057
B1	3600	3595.9	- 4.1	0.114
B1	3700	3692.7	- 7.3	0.197
B1	3800	3791.9	- 8.1	0.213
B1	3900	3895.9	- 4.1	0.105
B1	4000	4000.0	0.0	0.000
B1	4250	4258.1	+ 8.1	0.191
B1	4500	4470.2	-29.8	0.663
B1	5000	5012.6	+12.6	0.252
B1	5500	5503.8	+ 3.8	0.069
B1	6000	6003.5	+ 3.5	0.058
C1	6250	6273.1	+23.1	0.370
C2	7000	7045.4	+45.4	0.648
C2	7500	7544.8	+44.8	0.598
C2	8000	8059.3	+59.3	0.742
C2	9000	9073.0	+73.0	0.811

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Table T-28 (Cont'd)

Band	Crystal Freq. (Kc)	Actual Freq. (Kc)	Frequency Difference (Kc)	Per Cent Error
1	2716	2715.5	- 0.5	0.0184
2	3045	3045.3	+ 0.3	0.0098
3	4385	4383.0	- 2.0	0.0219
4	5335	5334.0	- 1.0	0.0187

Frequency measurements made with LM-2 Frequency Indicator.

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Table T-29

Model TCQ Transmitting Equipment

OVERLAP AND LIMITING FREQUENCIES OF MASTER OSCILLATOR

Band	M-O Dial Setting (Kc)	Actual Freq. (Kc)	Overlap Kc	Mean Freq. (Kc)	Percentage Overlap
Specification Limit		2000.0	41.5	1979.2	2.10
A1	2000	1958.5			
A2	3500	3548.3	163.1	3629.8	4.50
B1	3600	3485.2			
B2	6200	6239.3	63.3	6207.6	1.02
C1	6250	6176.0			
C2	9000	9280.0			
Specification Limit		9000.0	280.0	9140.0	3.06
		OVERLAP BETWEEN CHANNELS			
A1	3050	3049	467	2815.5	16.6
A2	2580	2582			
B1	5350	5369	996	4871.0	20.7
B2	4370	4373			
C1	6600	6573	397	6374.5	6.23
C2	6250	6176			

Frequency measurements made with LM-2 Frequency Indicator.

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Table T-30

Model TCQ Transmitting Equipment

ANTENNA OPEN CIRCUITED AND SHORT CIRCUITED

Frequency Kc	Antenna Condition	P-A Grid Current Ma	P-A Plate Current Ma	Internal R-F Amperes
2000	Normal	8.6	151	1.37
2000	Open	7.6	177	0.0
2000	Shorted	7.6	173	0.1
8000	Normal	1.9	147	1.23
8000	Open	1.3	155	0.0
8000	Shorted	1.3	155	0.0

Antenna: 2000 Kc: Two-wire flat top 35 feet long.
8000 Kc: 32-volt 50-watt lamp.

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Table T-31

Model TCQ Transmitting Equipment

VACUUM TUBE OPERATING CONDITIONS

Tube Type	Use	E_p	I_p	E_{sg}	I_{sg}	E_g	Key Position
			Transmitter Unit				
12A6	M.O.	74.0	0.0	145.0		-85.0	Up
		72.0	11.0	145.0		- 6.6	Down
12A6	C.O.	145.0	0.0	72.0		-85.0	Up
		143.0	11.0	72.0		- 4.8	Down
1625	Buffer	267.0	51.5	200.0	2.5	-13.0	Up
		267.0	53.1	187.0	2.85	-13.5	Down
1625	P.A.	460.0	7.6	460.0	0.41	-86.5	Up
		412.5	141.4	227.5	8.6	-39.5	Down
1625	P.A.	In parallel with above					Up
							Down
VR-75	V.R.	74.0	33.0	-----	---	-----	Up
		72.0	20.0	-----	---	-----	Down
VR-150	V.R.	145.0	15.0	-----	---	-----	Up
		145.0	13.0	-----	---	-----	Down
			Modulator Unit				
12SR7	Audio Osc.	107.5	2.8	-----	---	-24.4	Up
		103.0	2.7	-----	---	-24.0	Down
6SJ7	1st Amp.	83.5	0.46	56.5	0.14	-11.5	Up
		80.5	0.45	54.5	0.14	-11.4	Down
6K6GT	Driver	290.00	0.0	Tied to Plate		-88.0	Up
		250.0	15.0	-----	---	-25.0	Down
6H6	Limiter	0.0	0.0	(No signal input)			Up
		0.0	0.0	(No signal input)			Down
1625	Mod.	458.0	65.0	275.0	2.2	-22.8	Up
		400.0	105.0	260.0	8.6	-23.5	Down
1625	Mod.	458.0	57.0	275.0	2.6	-22.8	Up
		400.0	110.0	260.0	10.0	-23.5	Down

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(Continued)

Table T-31 (Cont'd)

NOTE: (1) Filament voltages (key down conditions) were as follows:

12A6 M.O.	11.0 volts	12SR7 A.O.	11.3 volts
12A6 C.O.	11.0 volts	6SJ7 1st Amp.	5.5 volts
1625 Buffer	11.6 volts	6K6GT Driver	5.6 volts
1625 P.A.	11.4 volts	6H6 Limiter	5.5 volts
1625 P.A.	10.8 volts	1625 Mod.	12.0 volts
		1625 Mod.	12.0 volts

(2) Modulator grid currents were 0.35 and 1.05 ma, respectively.

(3) Measurements were made with transmitter operating on 8000 kc, cw.

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Table T-32

Model TCQ Transmitting Equipment

POWER REQUIRED FROM SUPPLY LINES

Condition	Frequency Kc	Watts Output	Line Voltage	Line Current	Watts Input
Starting (Main switch only)	----	----	24.2	40.0	968
Starting (Both switches)	----	----	24.2	65.0	1570
Running Idle	----	----	24.0	17.0	408
CW	2000	9.0	24.0	19.8	476
MCW	2000	11.2	24.0	20.8	500
Phone	2000	10.4	24.0	20.7	497
CW	9000	17.0	24.0	19.6	470
MCW	9000	25.0	24.0	20.8	500
Phone	9000	23.5	24.0	20.2	490

NOTE: (1) Phone Condition: 95 per cent modulation at 800 cycles.

(2) Antenna: 2000 kc: 5.07-ohm resistor in series with 150 μμf.
9000 kc: 32-volt, 25-watt lamp.

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Table T-33

Model TCQ Transmitting Equipment

REGULATION OF GENERATORS

Generator	Voltage No Load	Voltage Full Load	Per Cent Regulation
Low Voltage	468	418	12.0
High Voltage	548	465	17.8

NOTE: (1) Line voltage held at 24 volts.

(2) Transmitter operated at 5 mc with cw emission.

[redacted]

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[redacted]

Table T-34

Model TCQ Transmitting Equipment

MEASUREMENT OF GENERATOR RIPPLE

Generator	Key Position	D-C Voltage	Ripple Voltage	Per Cent Ripple
High Voltage	Open	525	6.23	1.19
High Voltage	Closed	460	6.5	1.41
Low Voltage	Open	440	6.8	1.55
Low Voltage	Closed	400	5.75	1.43

NOTE: (1) Line voltage maintained at 24 volts.

(2) Transmitter operated at 5 mc with cw emission.

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Table R-1

Model TCQ Receiving Equipment

INSTRUMENTS USED IN TESTS

Instr. No.	Type No.	Serial No.	Description	Mfr's Rated Accuracy %
1	418-G	--	Standard Dummy Antenna - G.R. +100 μμf Antenna Capacitor	---
2	300	194	Electronic Voltmeter, Ballantine	3.0
3	300	195	Electronic Voltmeter, Ballantine	3.0
4	65-B	180	Standard Signal Generator - Voltage Measurements Corp. - Frequency	15.0 1.0
5	672-A	139	Power Supply, G.R. + four Storage Batteries	---
6	714-A	160-A	Audio Amplifier, G.R.	---
7	736-A	289	Wave Analyzer, G.R. - Voltage - Frequency	5.0 2.0
8	713-B	766	Audio Oscillator, G.R. - Frequency	2.0
9	RAS	X79	Radio Receiver and Power Unit, National	---
10	583-A	16	Output Power Meter, G.R. - Impedance	8.0
11	200-C	--	Variac, G.R.	---
12	433	29594	0-150 A-C Voltmeter, Weston	0.75
13	LR	Prelim. Model	Heterodyne Freq. Meter, G.R.	100 c.p.s.

[redacted]

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[redacted]

Table R-2

Model TCQ Receiving Equipment

APPLICATION OF INSTRUMENTS TO TESTS

Test \ Instrument No.:*	1	2	3	4	5	6	7	8	9	10	11	12	13
CW Sensitivity	x	x		x	x						x	x	
MCW Sensitivity	x	x		x	x						x	x	
I-F Selectivity		x		x	x						x	x	
R-F Selectivity	x			x	x	x	x				x	x	
CW Res, Overload	x	x		x	x						x	x	
MCW Res. Overload	x	x		x	x						x	x	
R-F Gain Characteristics	x	x		x	x						x	x	
A-F Amp. Characteristics		x	x		x			x			x	x	
B Voltage Variation	x				x		x				x	x	
Radiation	x	x		x	x				x		x	x	
Image Rejection	x	x		x	x						x	x	
Output Load Variation	x	x		x	x					x	x	x	
Squelch Characteristics	x	x		x	x						x	x	
Temperature Variation	x	x		x									
Humidity Variation	x	x		x									x
Vibration, Roll, Shock	x	x		x									x

* Refer to Table R-1.

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Table R-3

Model TCQ Receiving Equipment

ROLL, VIBRATION AND SHOCK

Roll--Band C

45-Degree Roll Each Way	H-F Osc. Freq. Mc	Overall Freq. Mc	Input Microvolts
Start Right-Side Roll	7,8156	7.3510	2800
After 30 Minutes	7,8077	7.3481	2300
Start Front Roll	7.8075	7.3475	2000
After 30 Minutes	7.8074	7.3470	1700
Start Back Roll	7.8215	7.3690	1060
After 30 Minutes	8,8152	7.3631	1060
Start Left-Side Roll	7,8155	7.3631	1060
After 30 Minutes	7,8140	7.3618	1060

Vibration--Band C

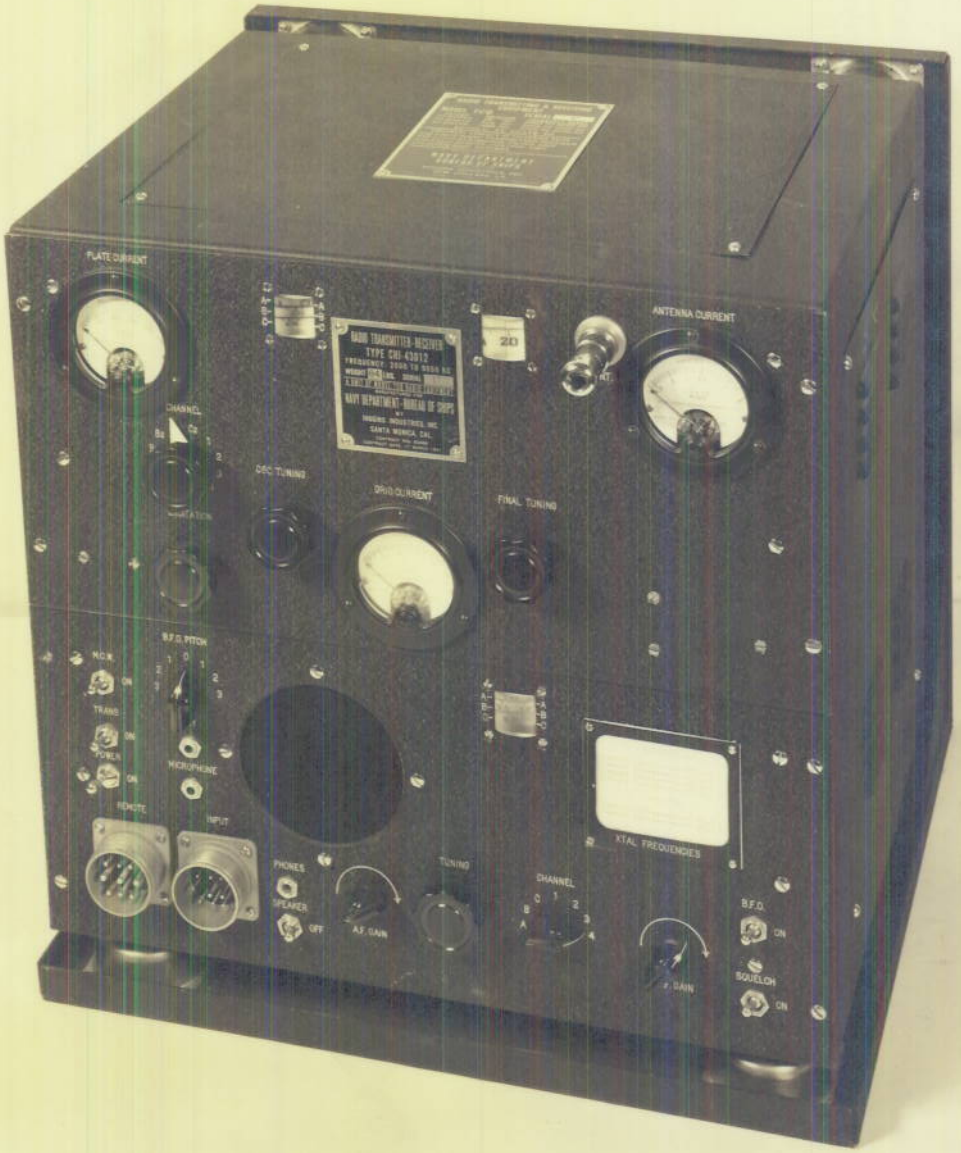
Before Vibration	7,8140	7.3618	1060
After 30 Minutes	7,1622	6.7098	980

Shock--Band A

Before Shock	3.068	2.614	12.0
After 90-Pound Shock	3.067	2,613	12.0
After 138-Pound Shock	3.065	2.612	12.5

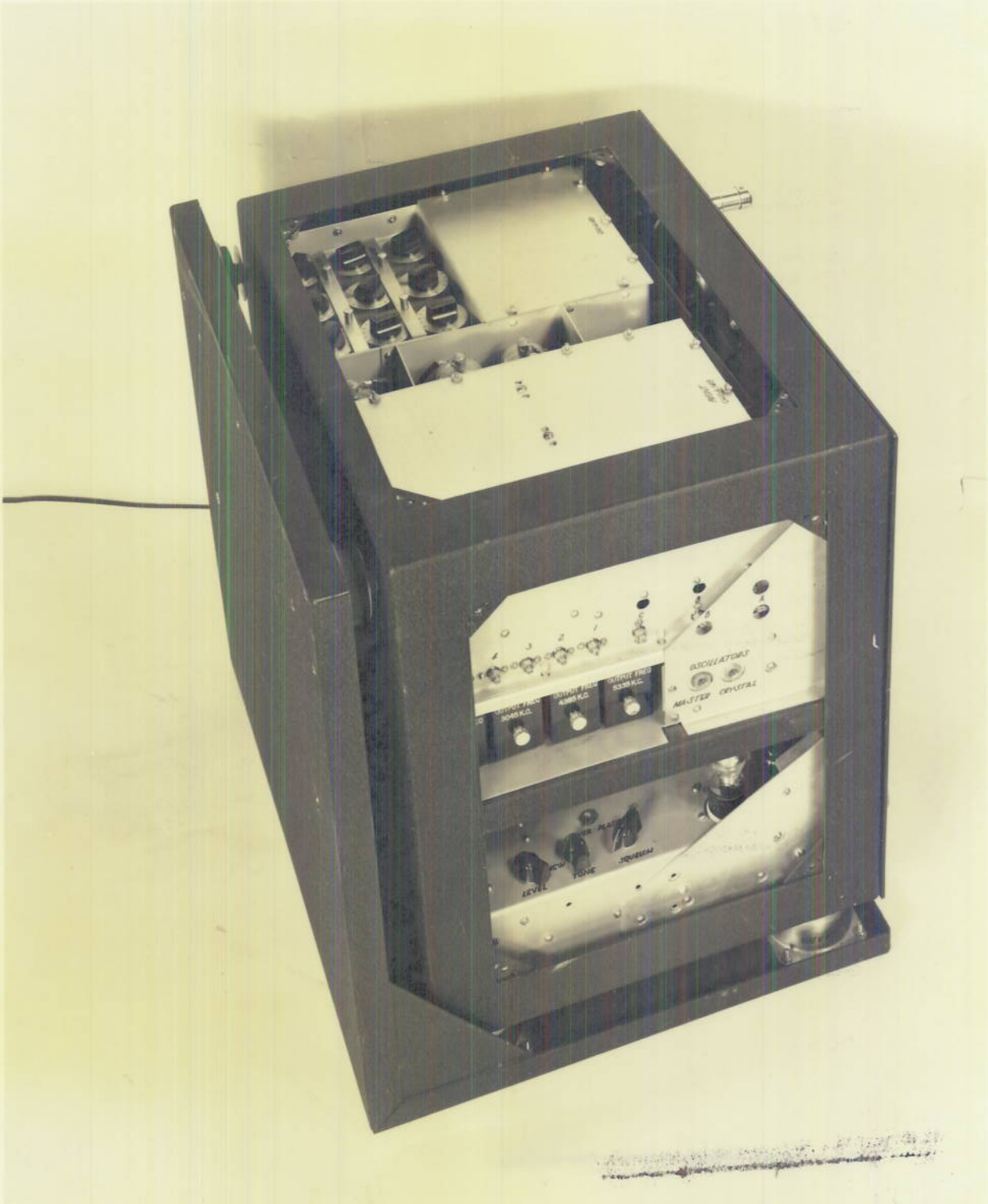
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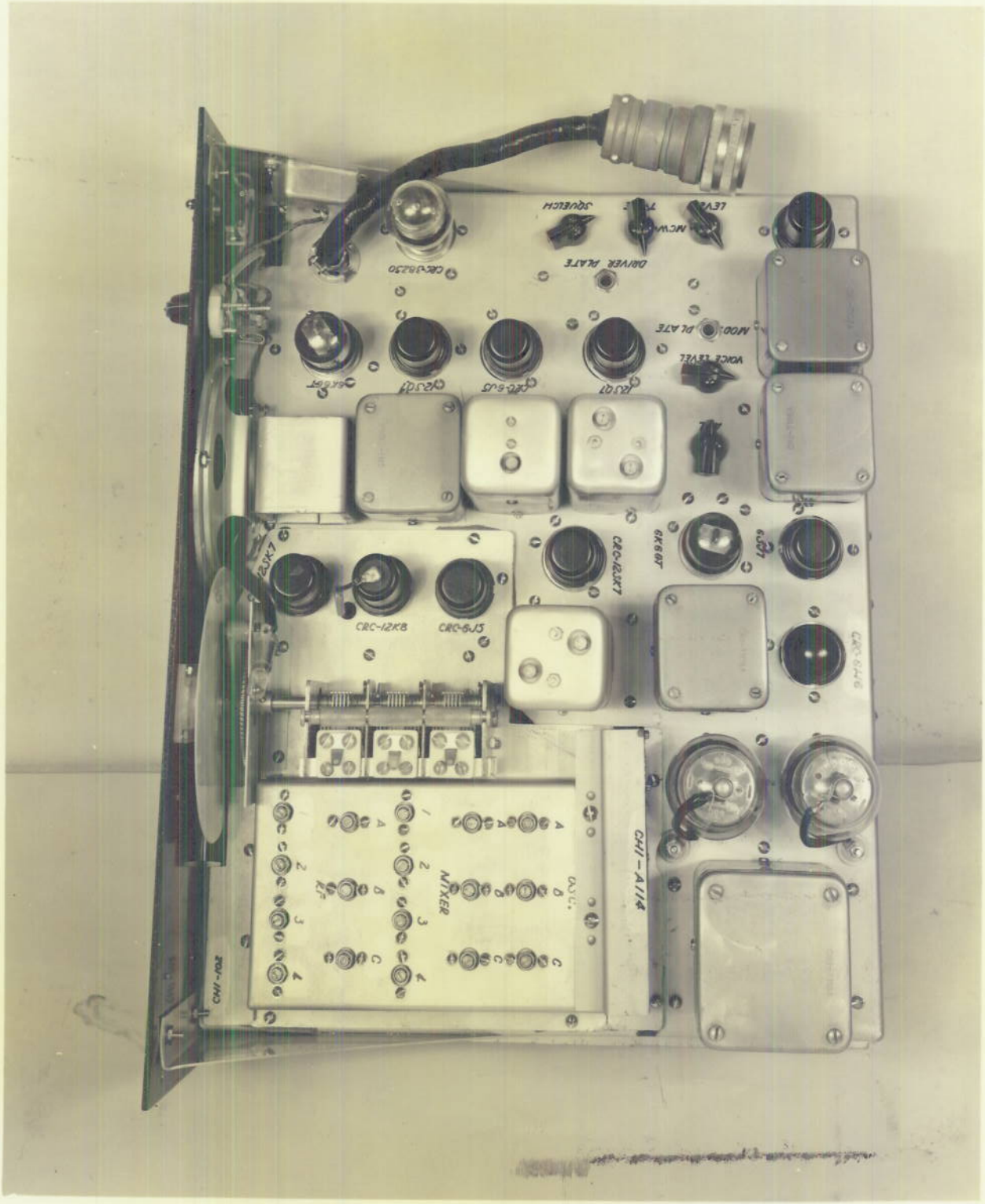
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PLATE TR I



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PLATE TR 2



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PLATE TR 3

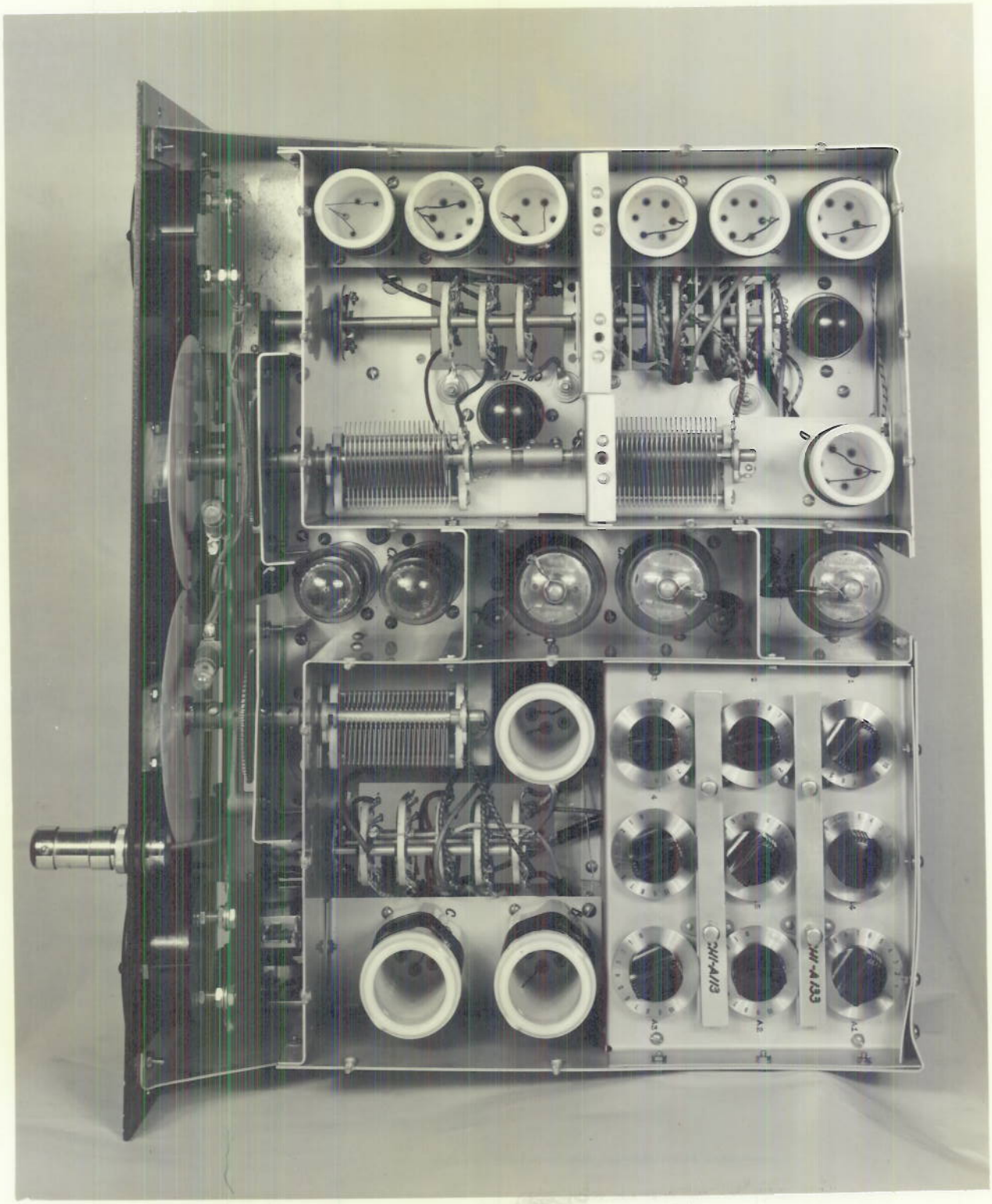


PLATE TR 4



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PLATE TR 5

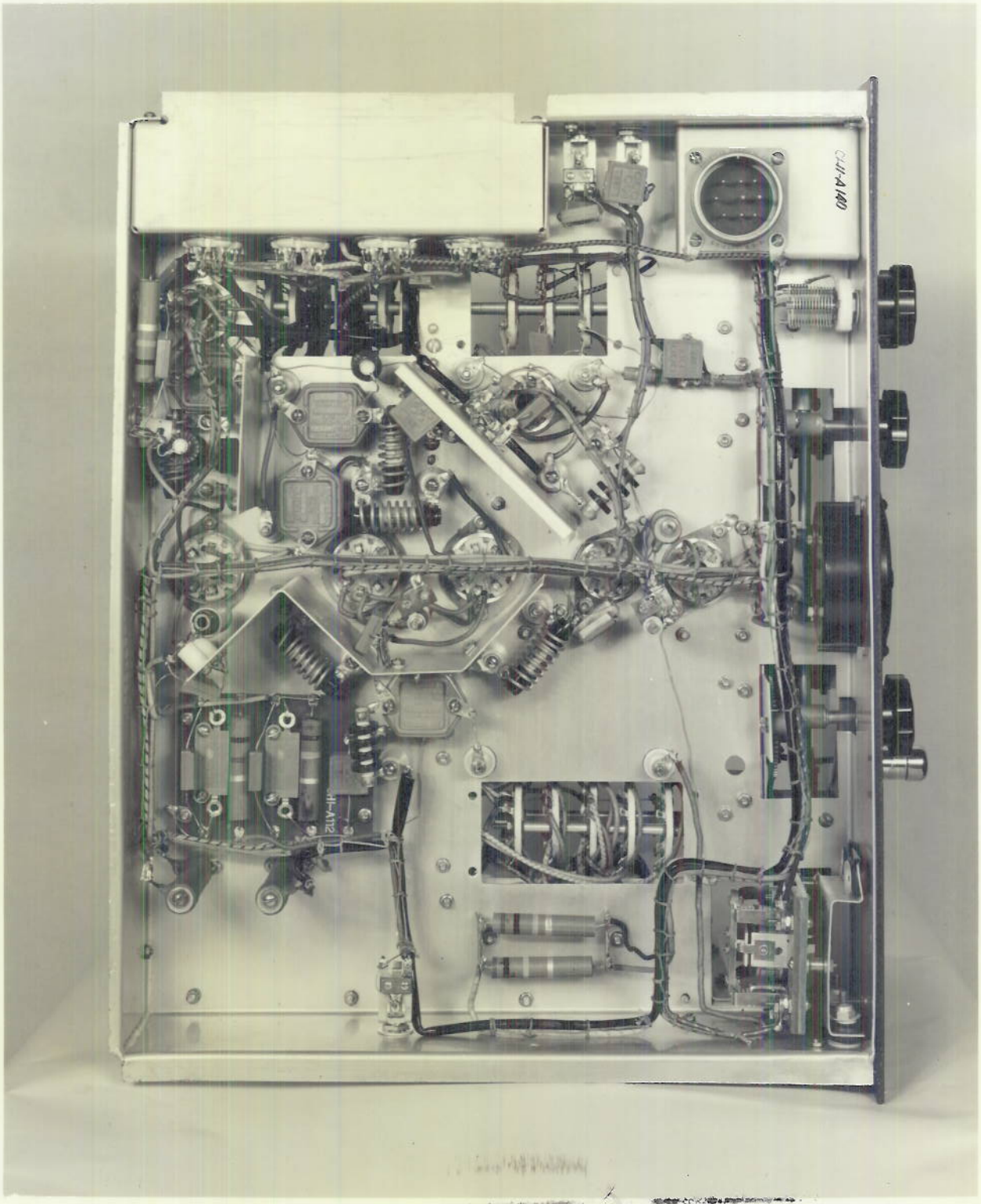
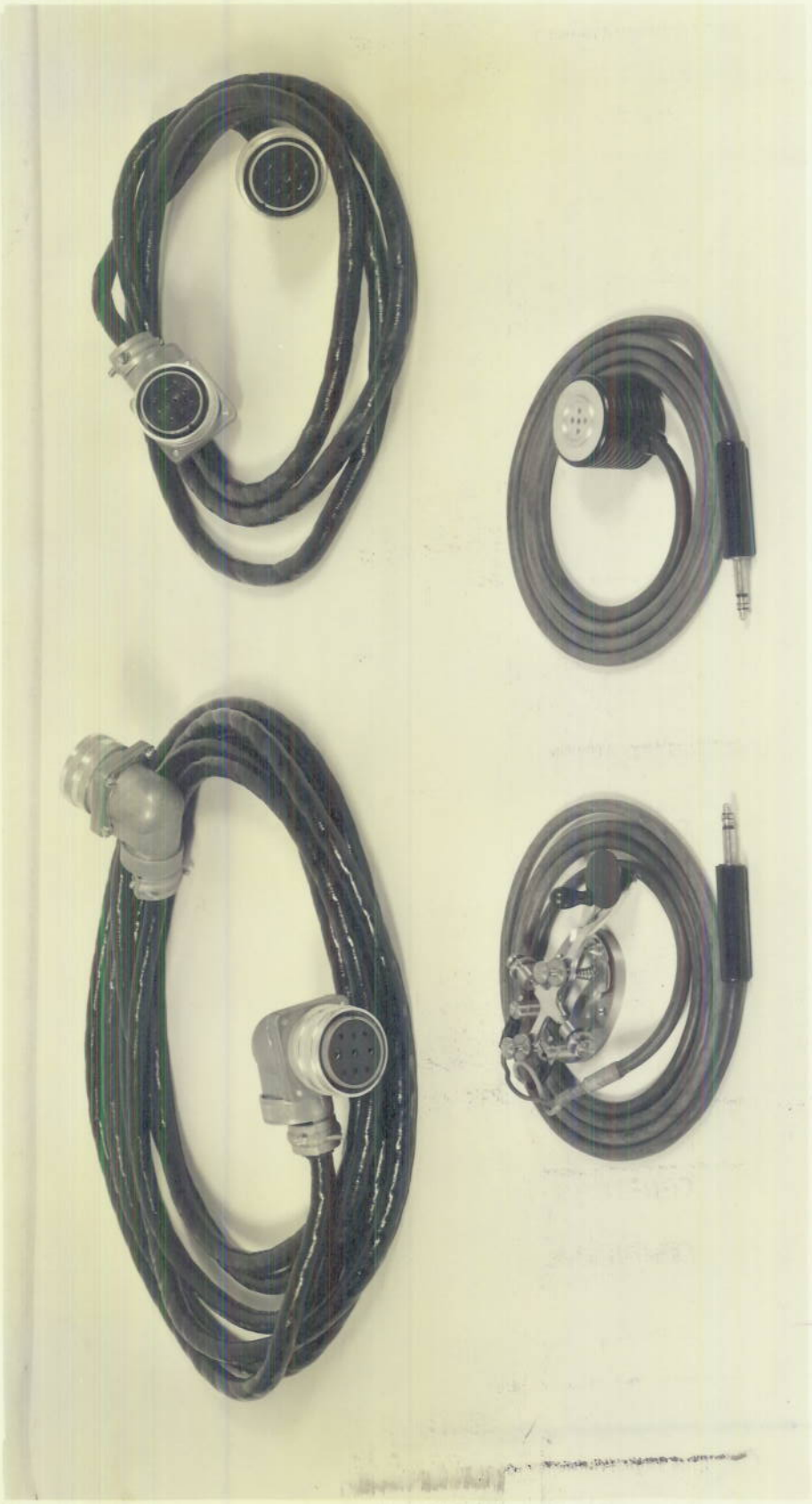


PLATE TR 6

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PLATE TR 7

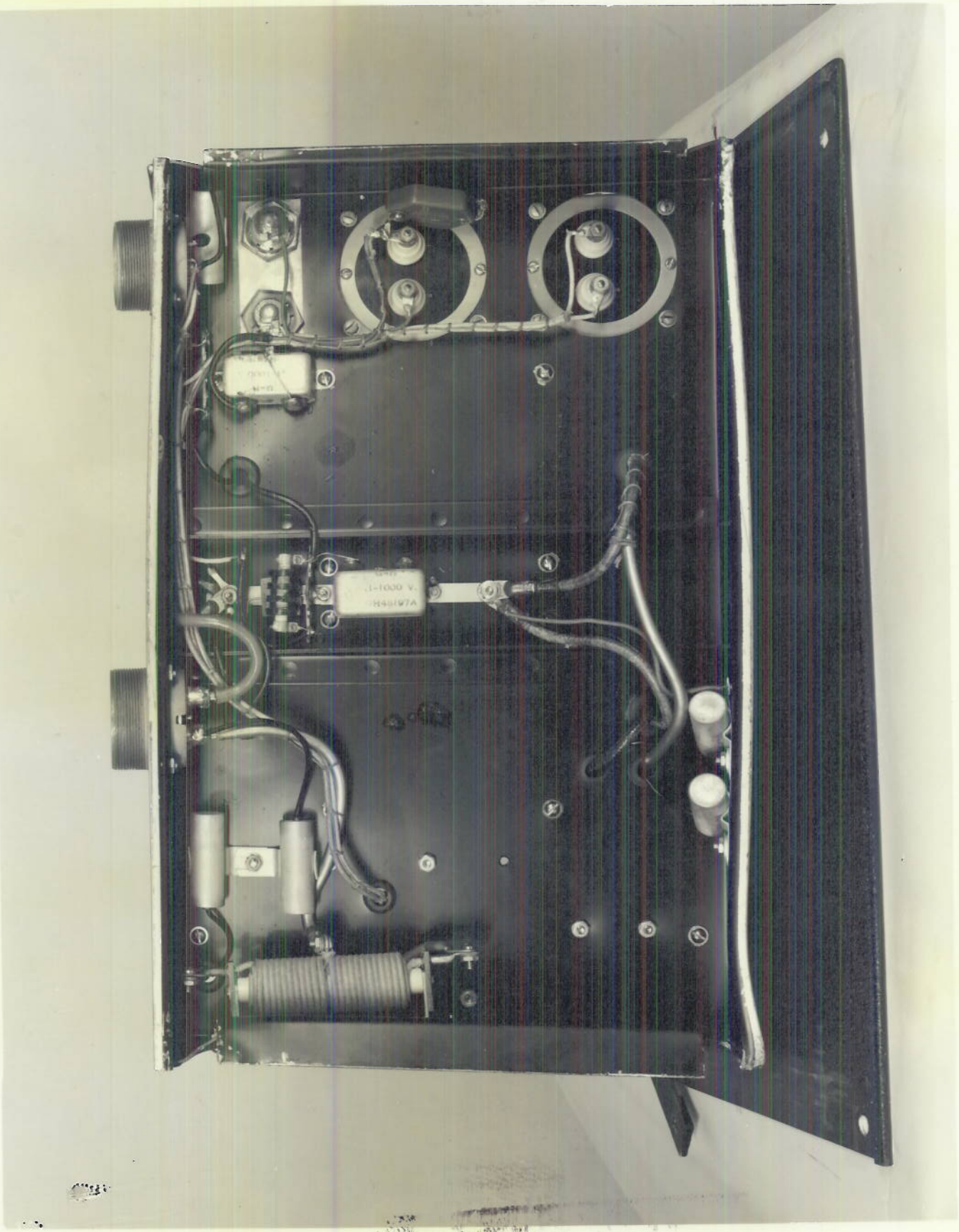


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PLATE TR 8

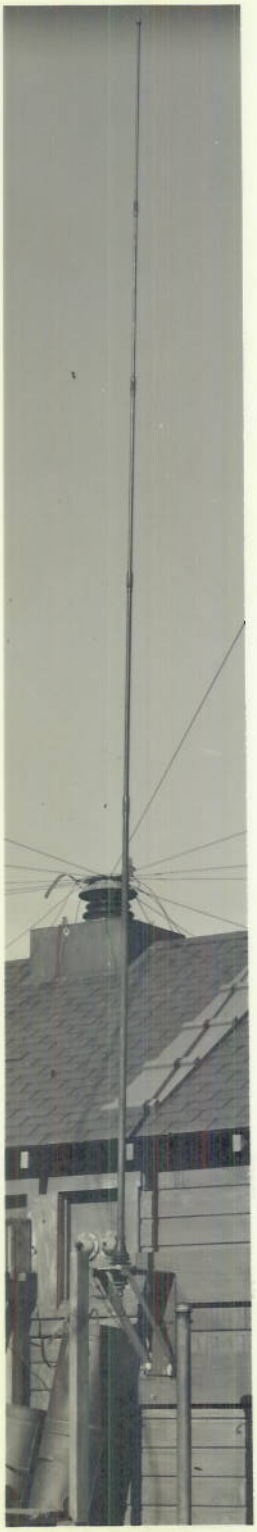
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PLATE TR 9



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PLATE TR 10



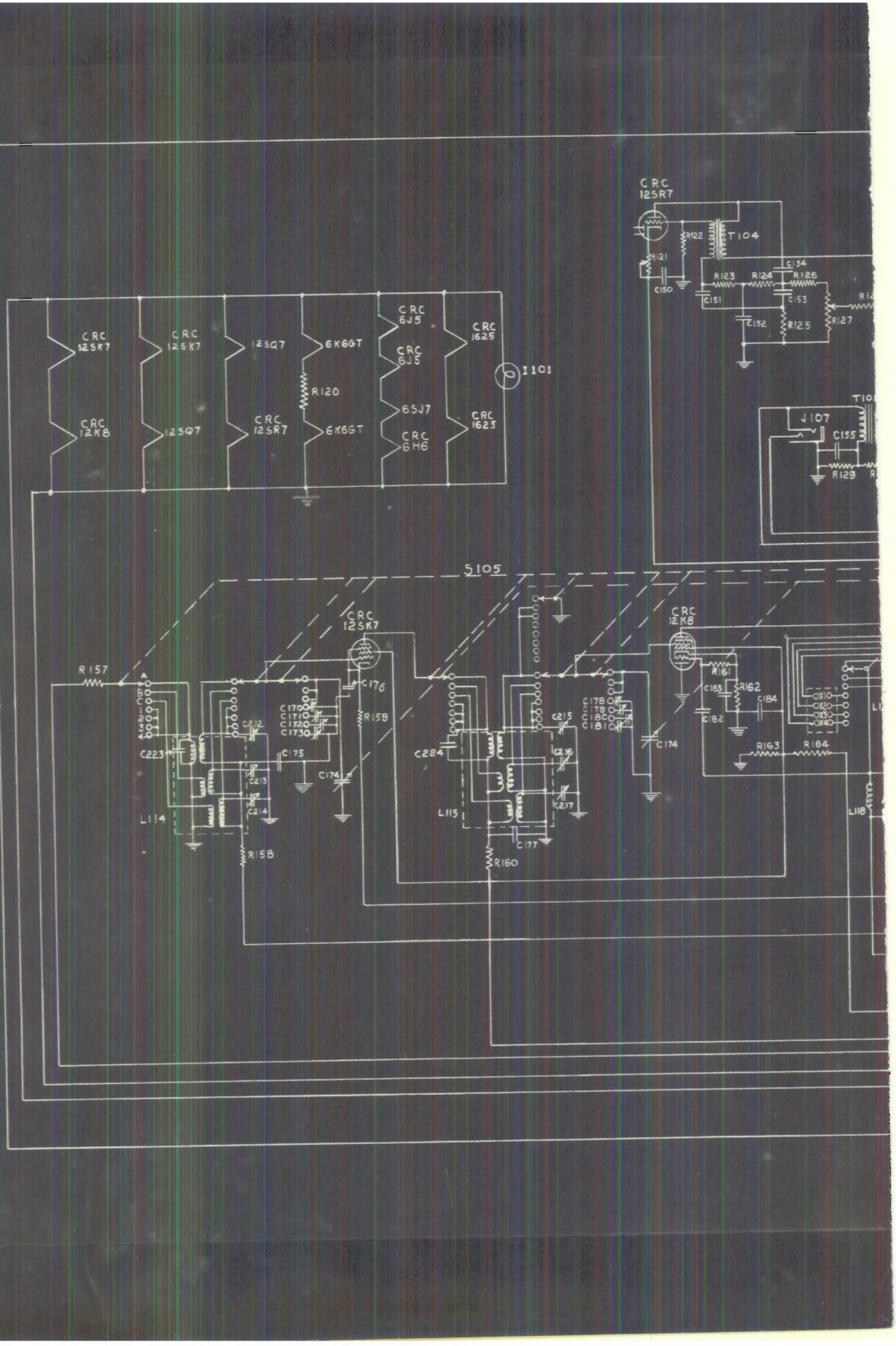
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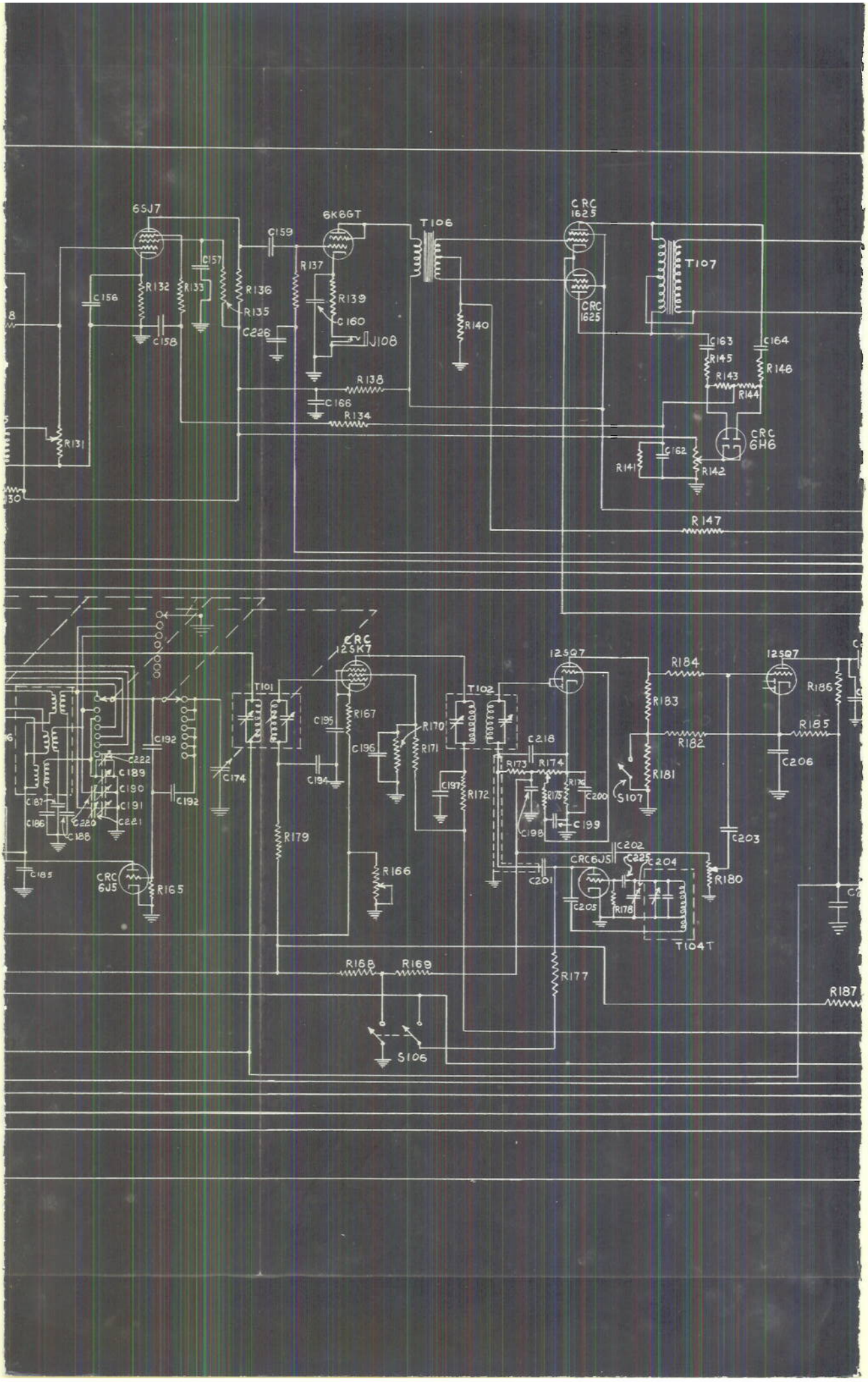
PLATE TR II

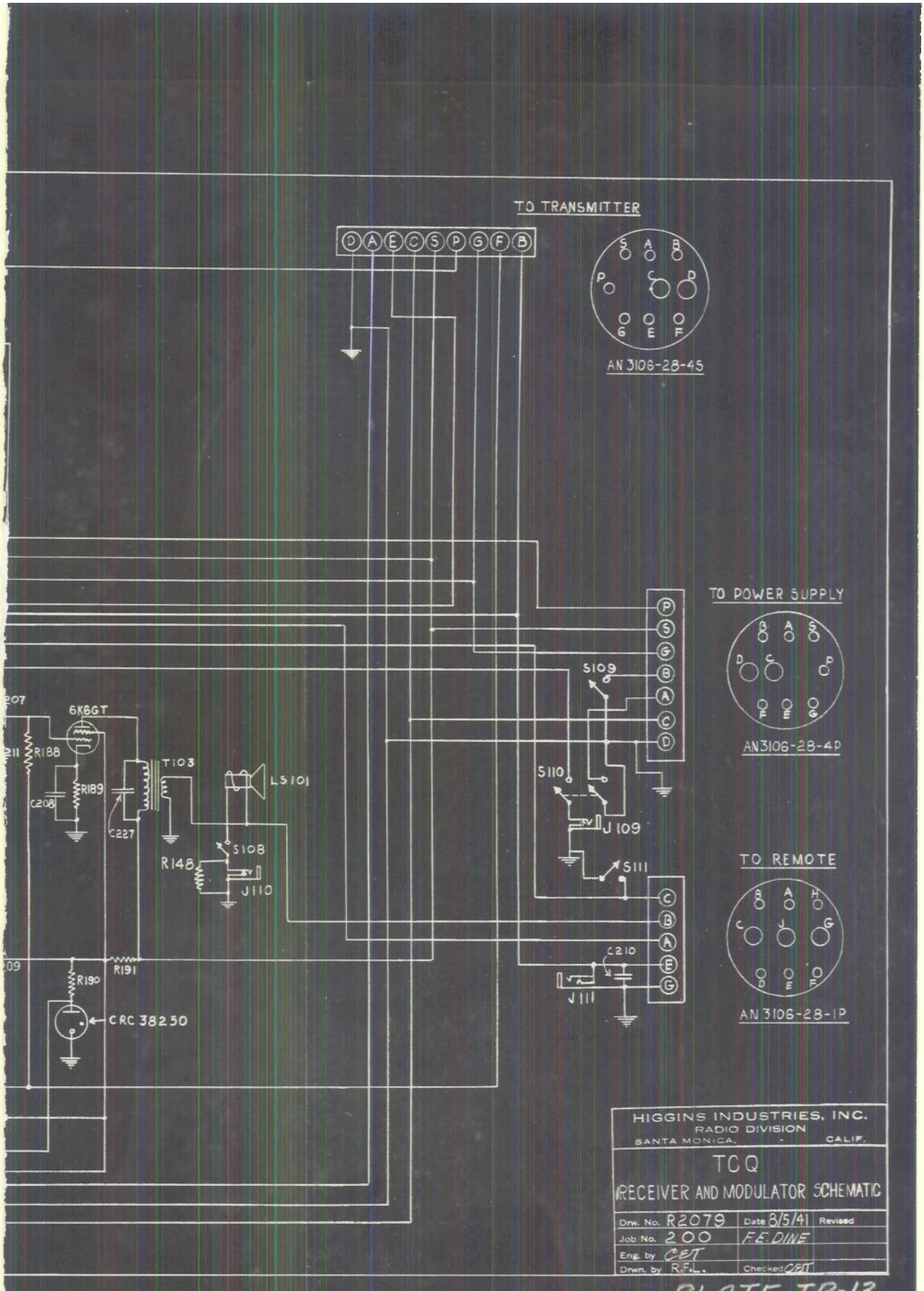


PLATE TR 12

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CRC 12SK7
CRC 12SK7
12SQ7
6K6GT
CRC 6J5
CRC 1625
I101
R120
CRC 12K8
12SQ7
CRC 12SR7
6K6GT
65J7
CRC 6H6
CRC 1625
CRC 12SR7
R122
T104
R121
C150
C154
R123
R124
R126
C151
C153
C152
R125
R127
J107
C155
R129
5105
CRC 12SK7
CRC 12K8
R157
A
B
C
1
2
3
4
C212
C170
C171
C172
C173
C176
R159
C223
C175
C213
C214
C174
L114
R158
C224
C215
C216
C217
C178
C179
C180
C181
C174
L115
C177
R160
R161
C183
R162
C184
C182
X10
X20
X30
X40
R163
R164
L118


6SJ7
6K6GT
T106
CRC 1625
CRC 1625
T107
C159
C157
R136
R135
C226
R137
R139
C160
J108
R140
C156
R132
R133
C158
C163
C164
R145
R146
R143
R144
R138
C166
R134
R131
CRC 6H6
C162
R141
R142
R147
CRC 12SK7
T101
T102
12SQ7
12SQ7
R184
R183
R182
R181
R185
R186
C206
S107
C195
R167
C196
R170
R171
C218
R173
R174
R175
C200
C199
C198
C197
R172
C194
C174
C192
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R179
R166
C201
C202
C225
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R180
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R165
R168
R169
R177
R187
S106



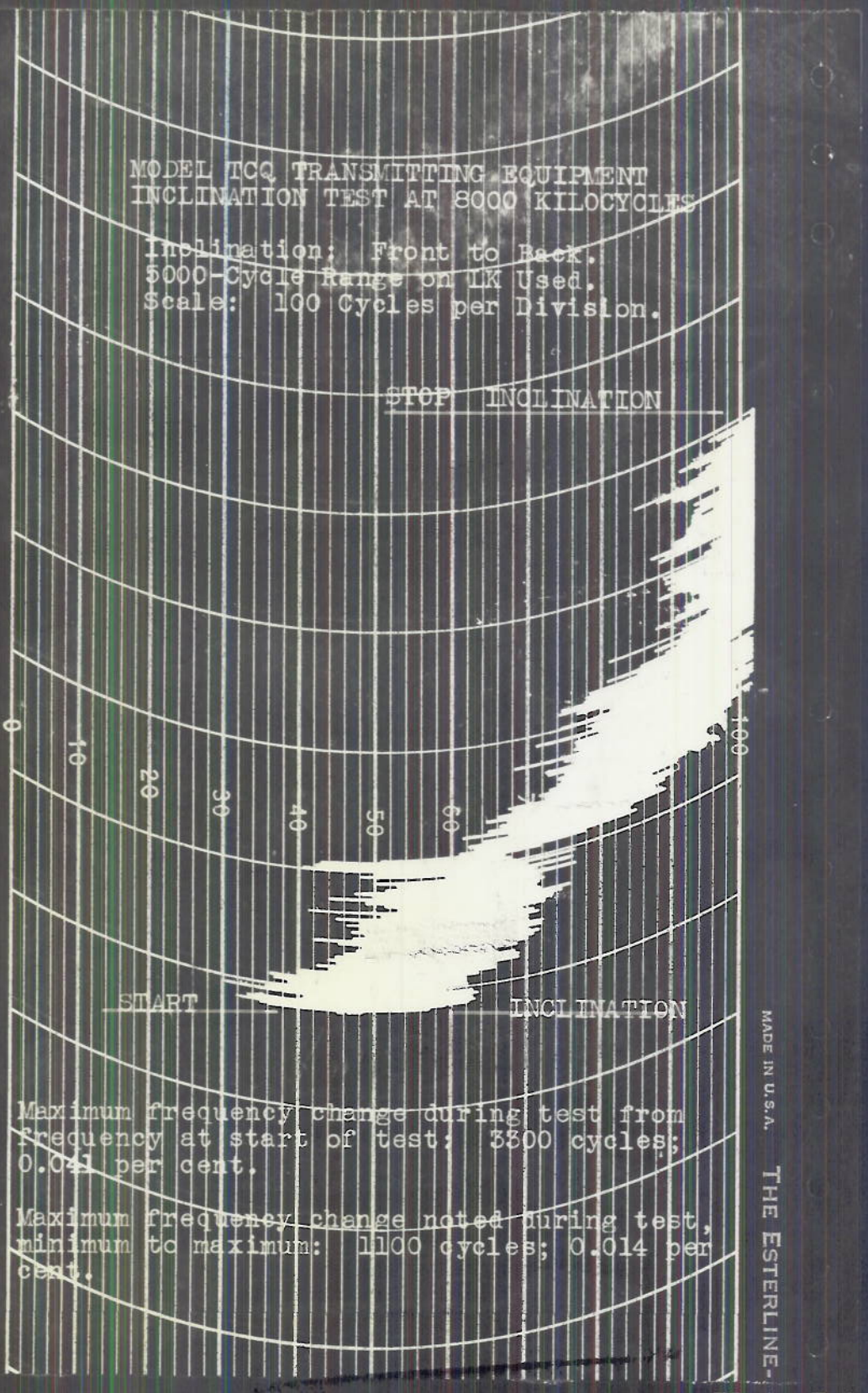
HIGGINS INDUSTRIES, INC.
RADIO DIVISION
SANTA MONICA, - CALIF.

TCQ
RECEIVER AND MODULATOR SCHEMATIC

Drw. No. R2079	Date 8/5/41	Revised
Job No. 200	F.E. DINE	
Eng. by C&T		
Drwn. by R.F.L.	Checked C&T	

PLATE TR-13

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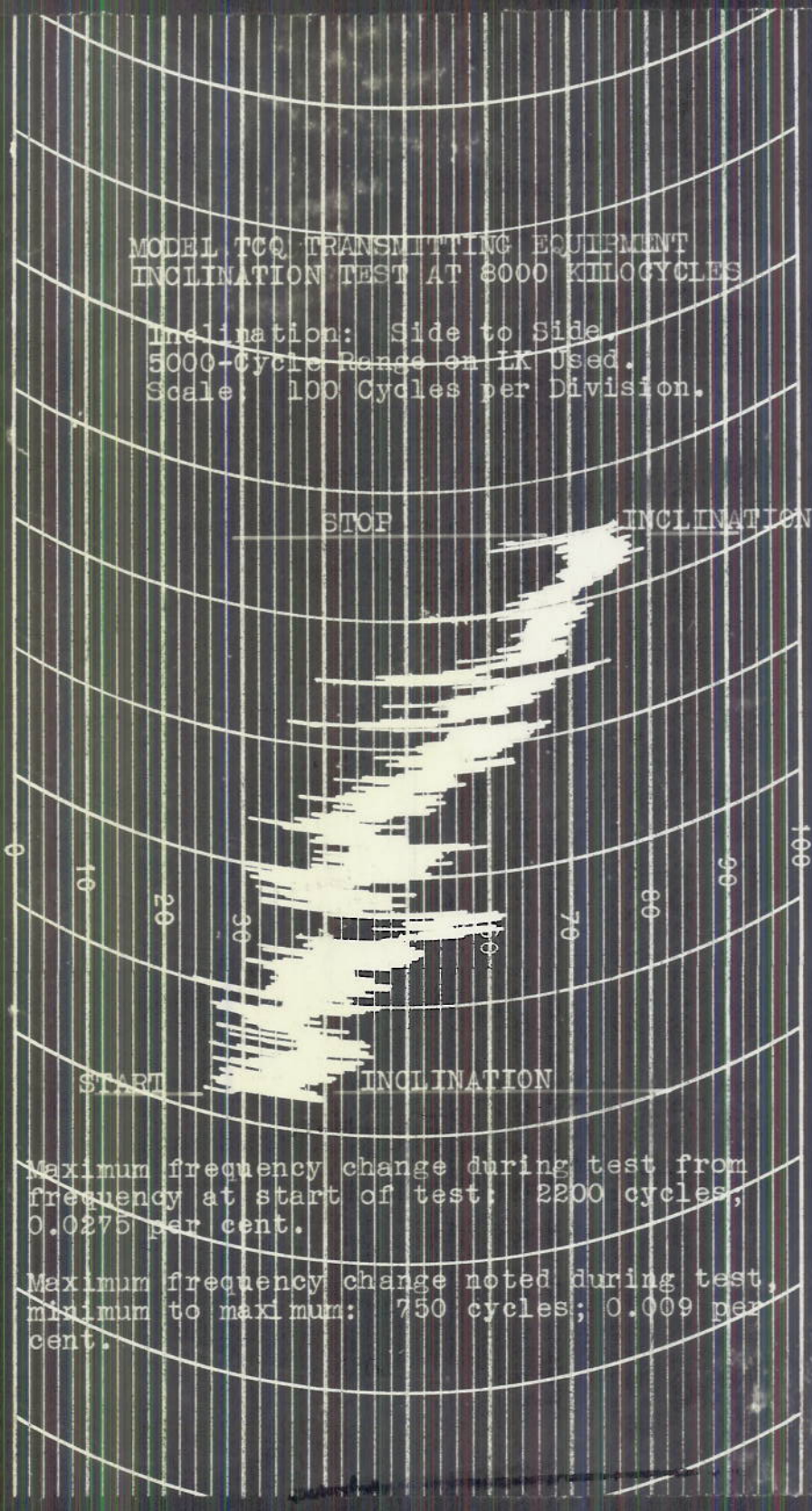


Maximum frequency change during test from frequency at start of test: 3300 cycles; 0.041 per cent.

Maximum frequency change noted during test, minimum to maximum: 1100 cycles; 0.014 per cent.

Plate T-1

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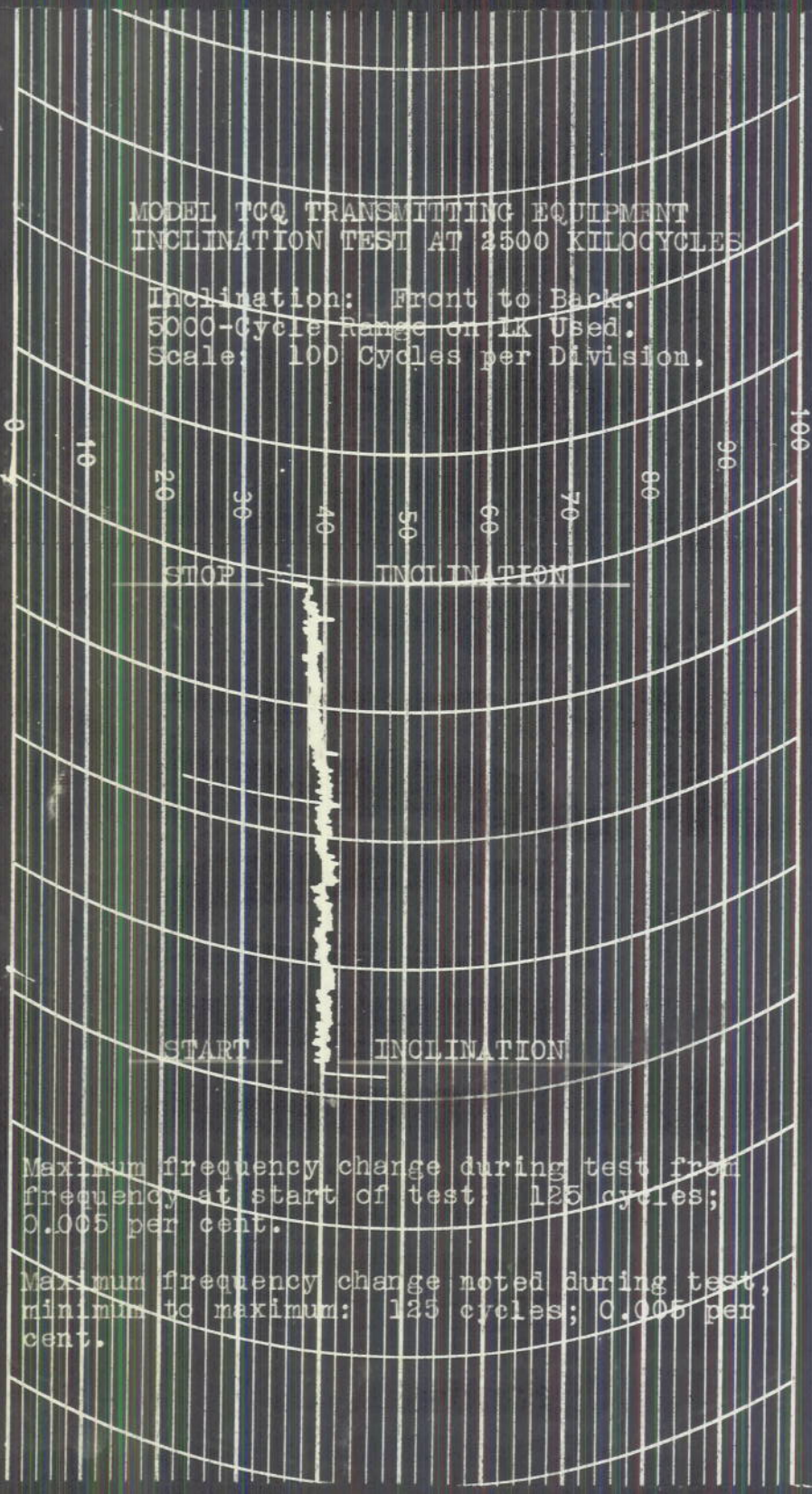


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10

Plate T-2

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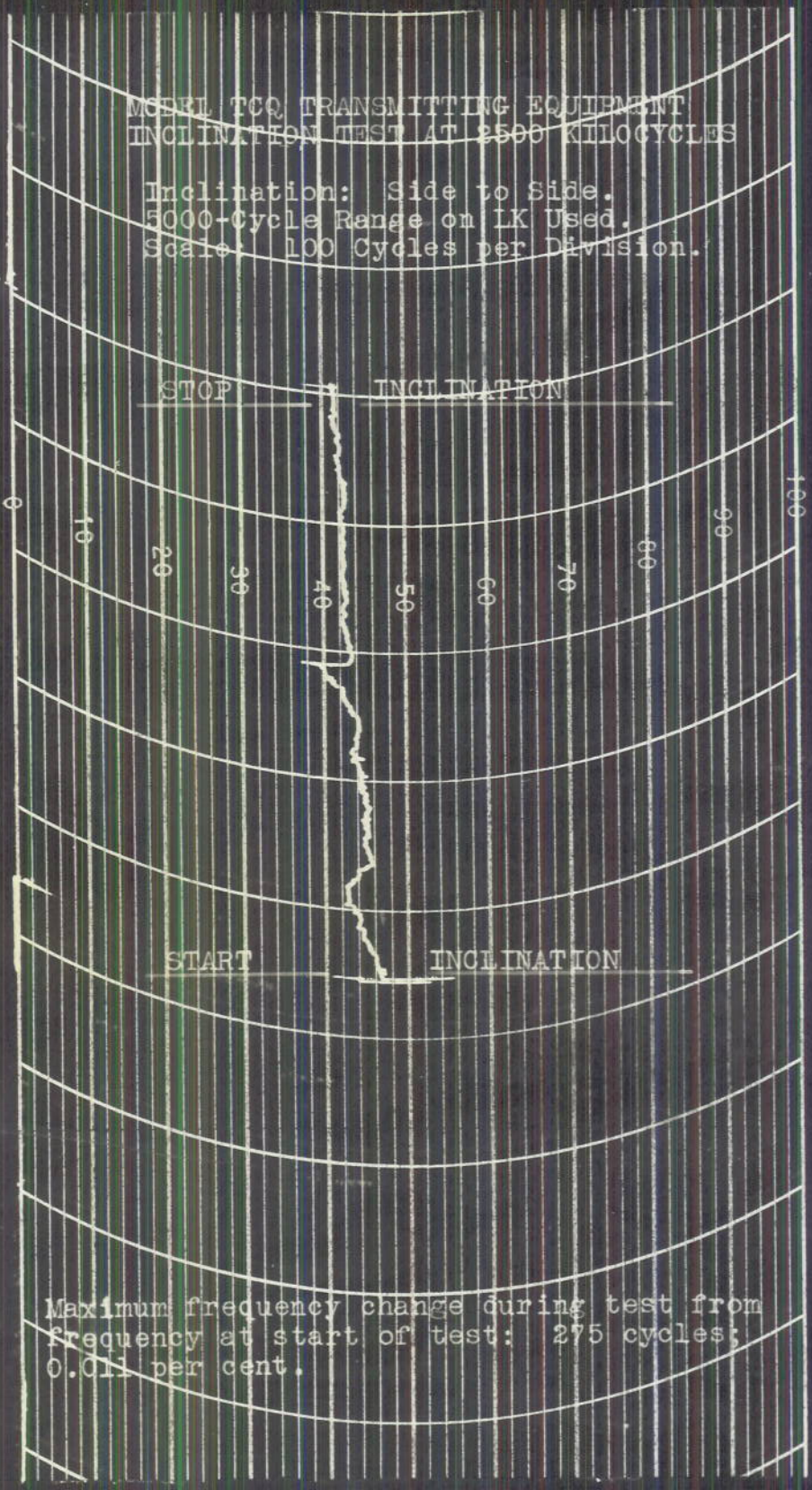


Maximum frequency change during test from frequency at start of test: 125 cycles; 0.005 per cent.

Maximum frequency change noted during test, minimum to maximum: 125 cycles; 0.005 per cent.

Plate T-3

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Plate T-4

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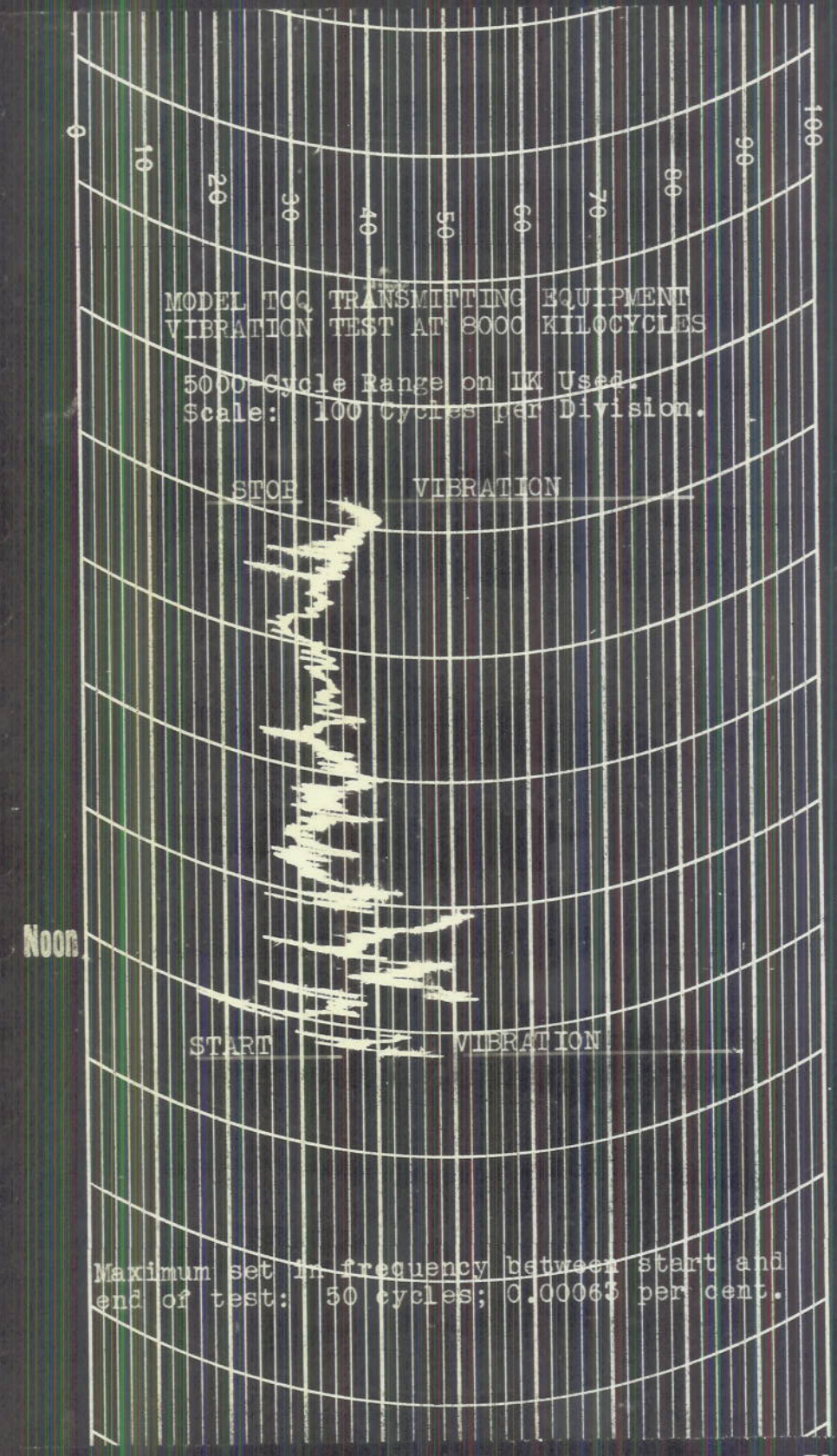


Plate T-5

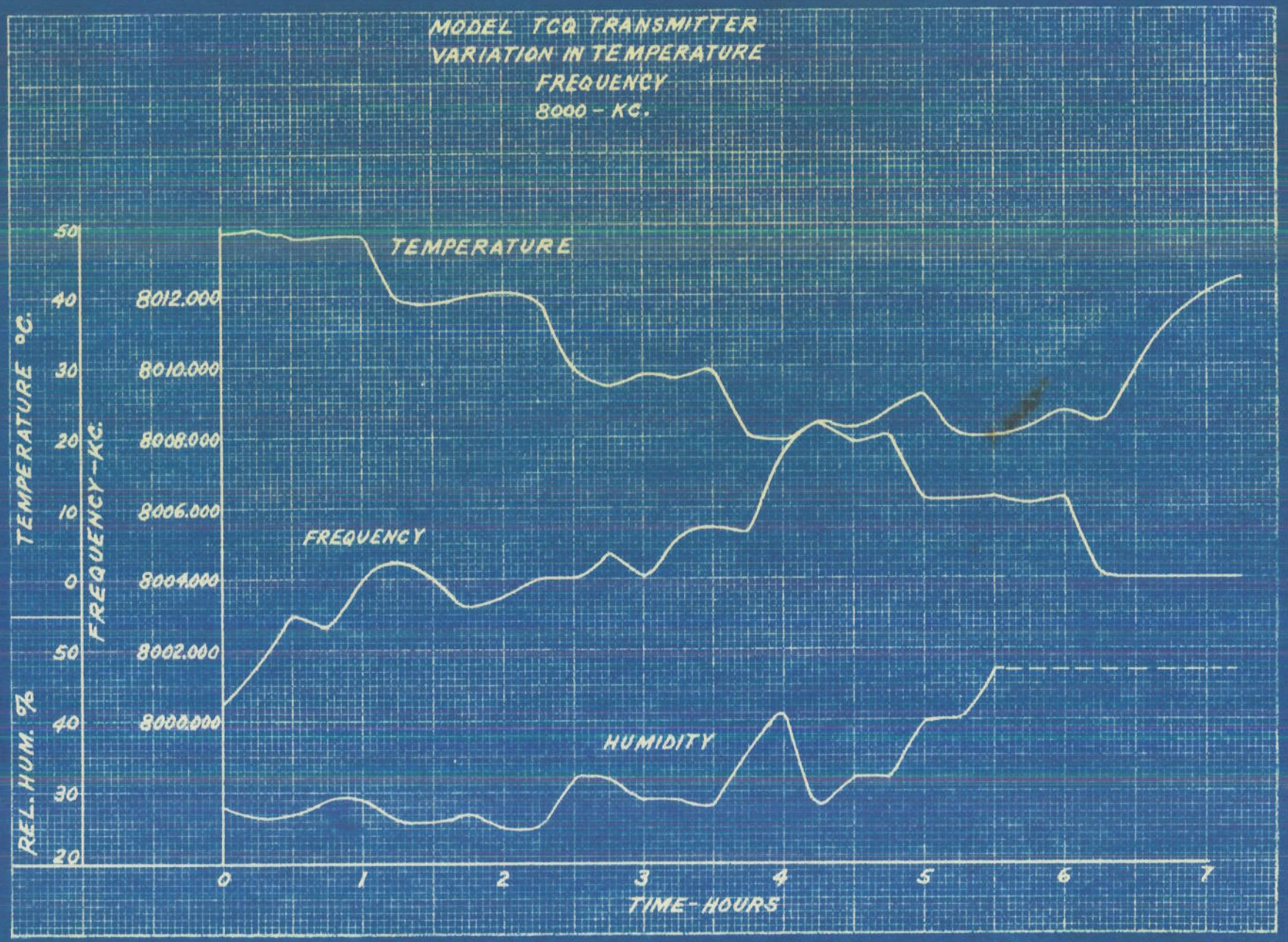
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PLATE T-6

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PLATE T-7.

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PLATE T-8

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BELLEVUE, D. C.

DATE

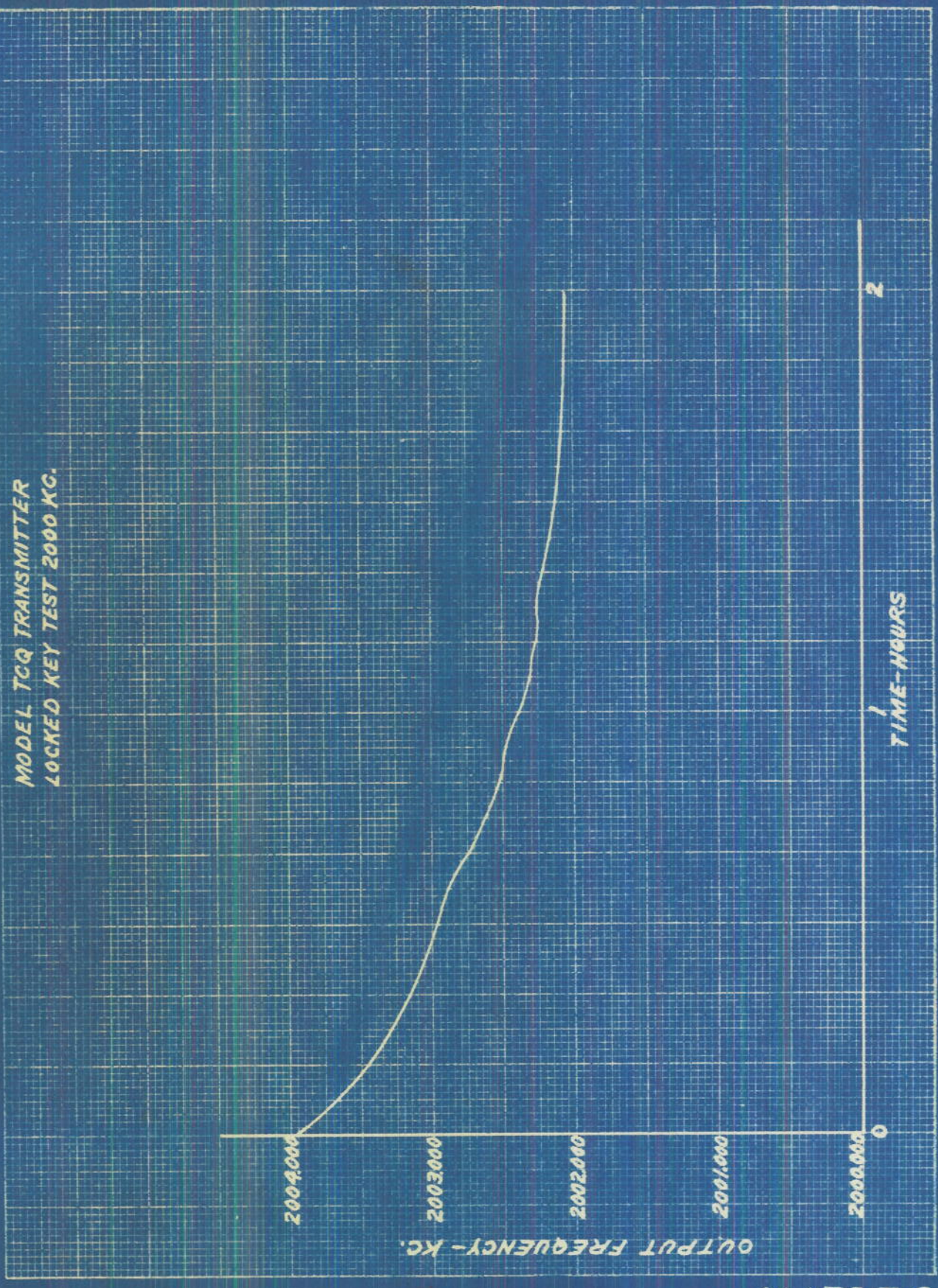


PLATE T-9

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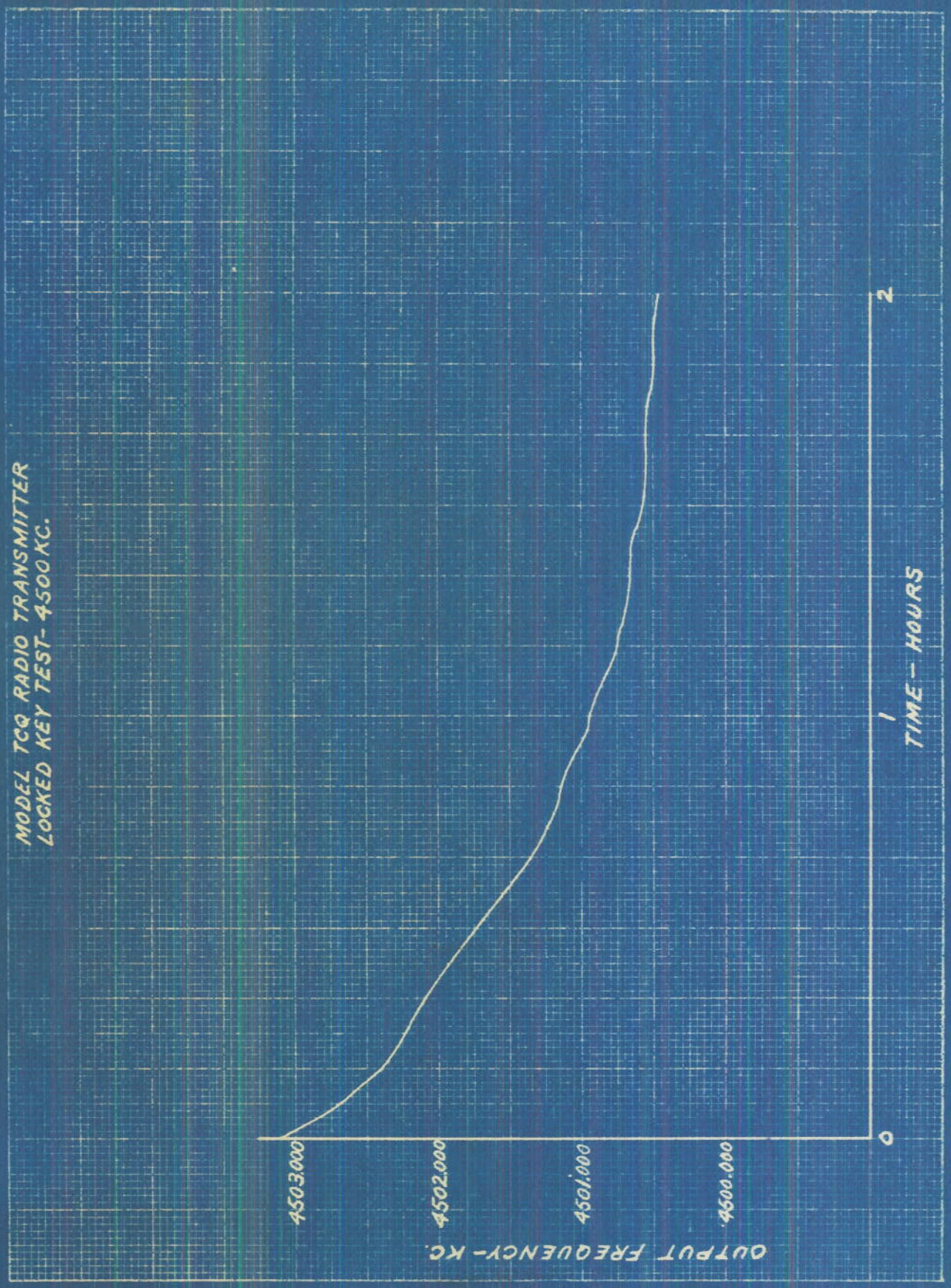


PLATE T-10

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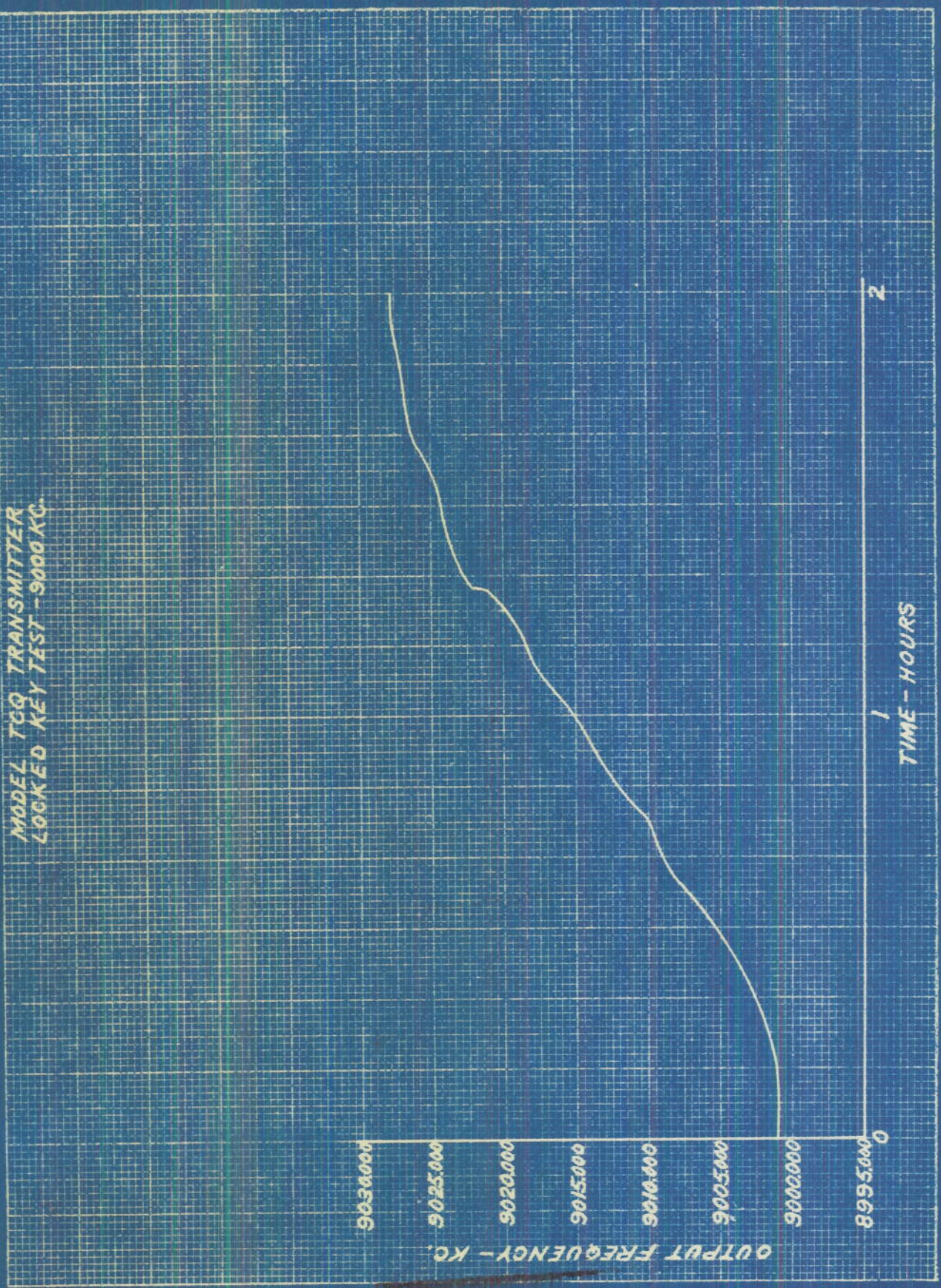


PLATE T-11

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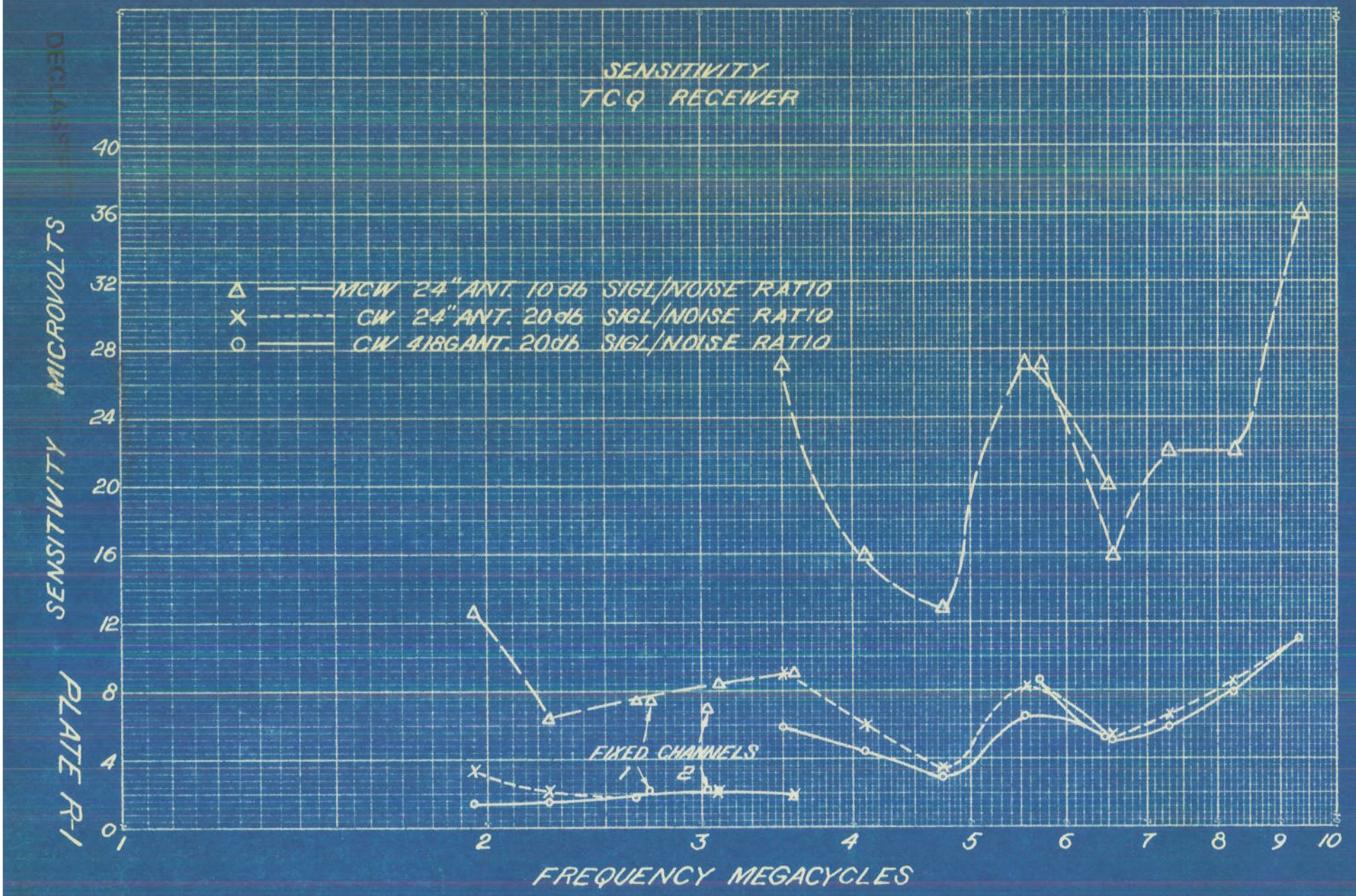
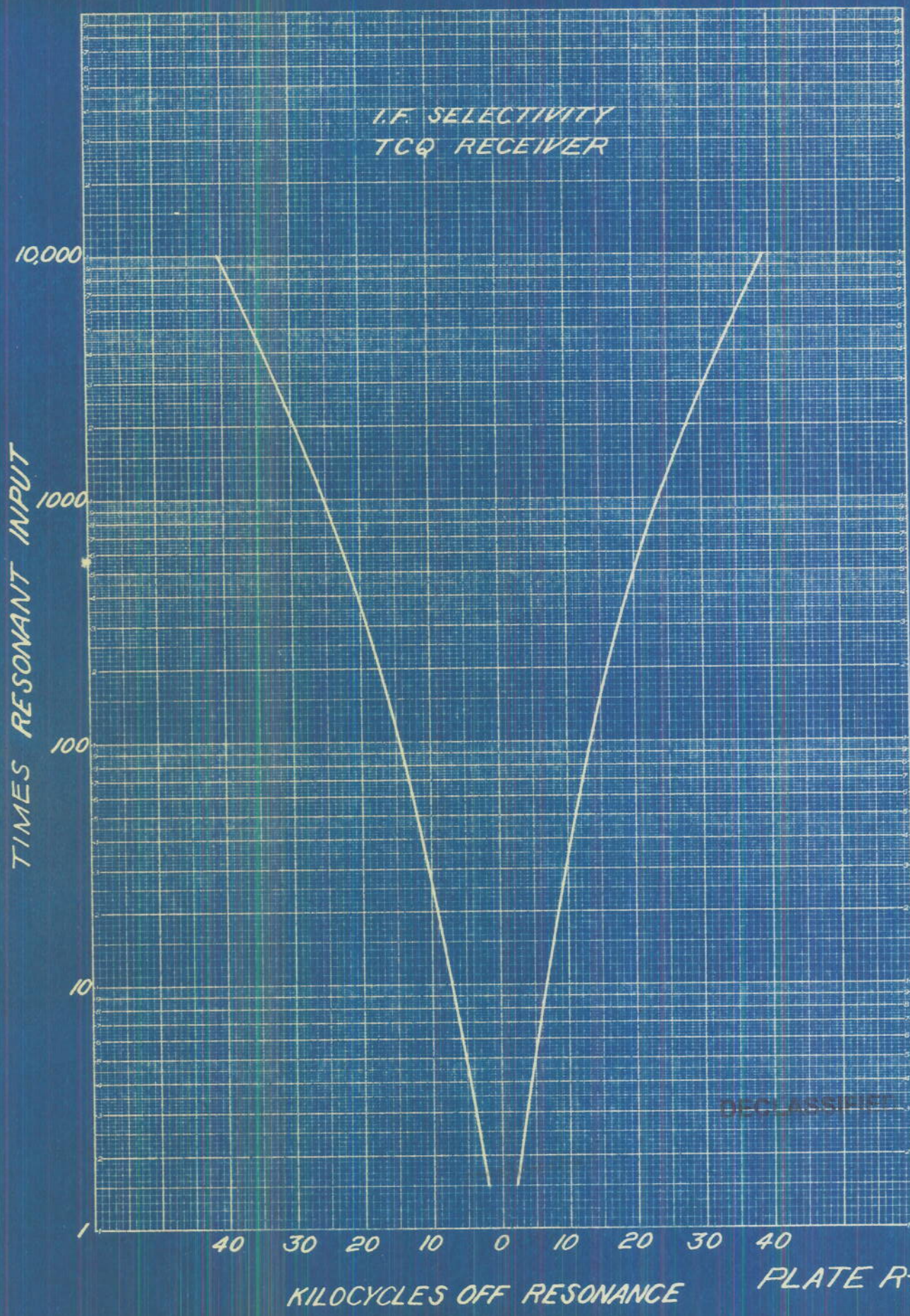

SENSITIVITY
TCQ RECEIVER
MCW 24" ANT. 10 db SIGL/NOISE RATIO
CW 24" ANT. 20 db SIGL/NOISE RATIO
CW 418G ANT. 20 db SIGL/NOISE RATIO
FIXED CHANNELS
1
2
SENSITIVITY MICROVOLTS
FREQUENCY MEGACYCLES
0
4
8
12
16
20
24
28
32
36
40
1
2
3
4
5
6
7
8
9
10

PLATE R-1



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PLATE R-2

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BELLEVUE, D. C.
DATE

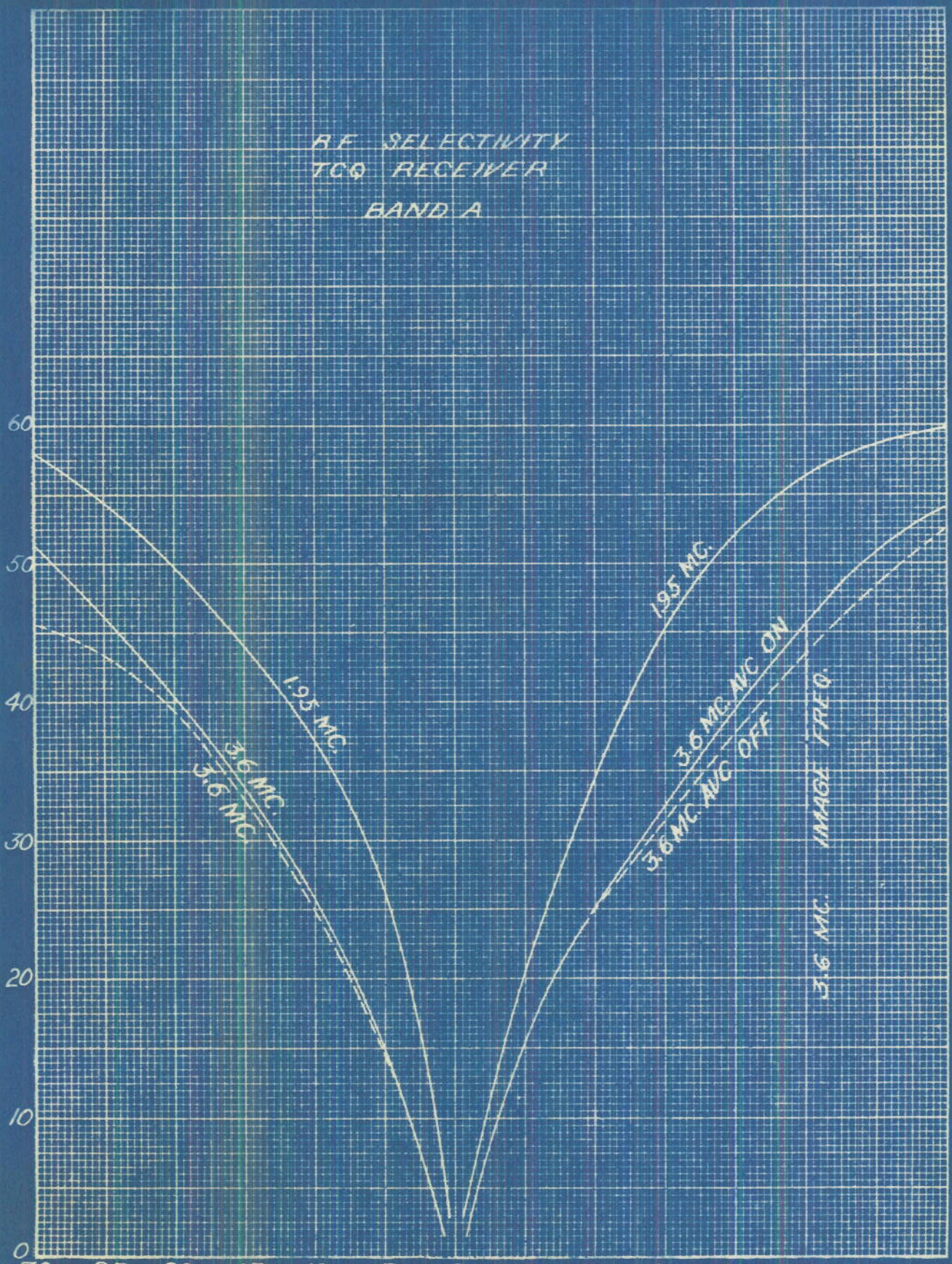
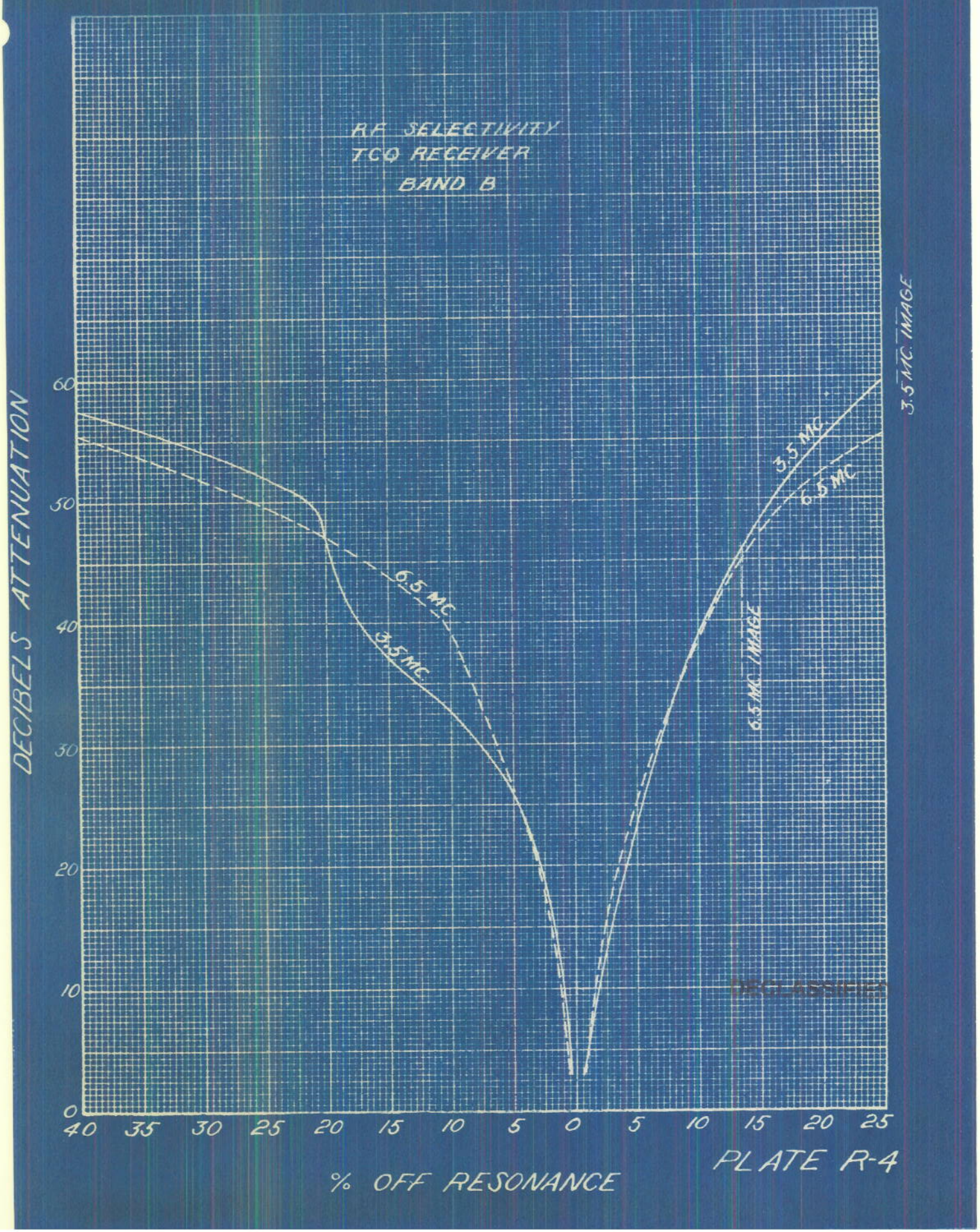


PLATE R-3

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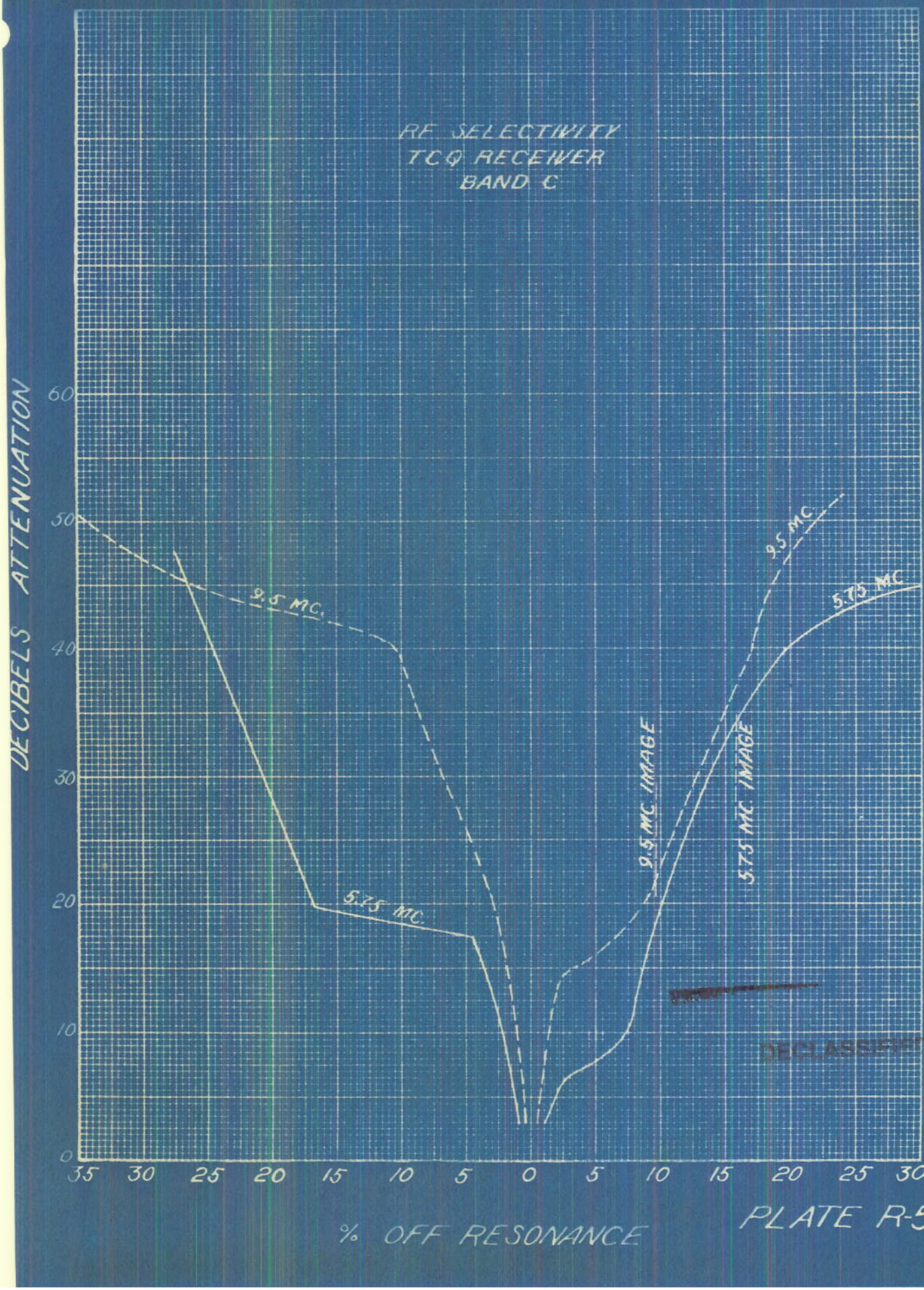
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BELLEVUE, D.C.
DATE



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PLATE R-4

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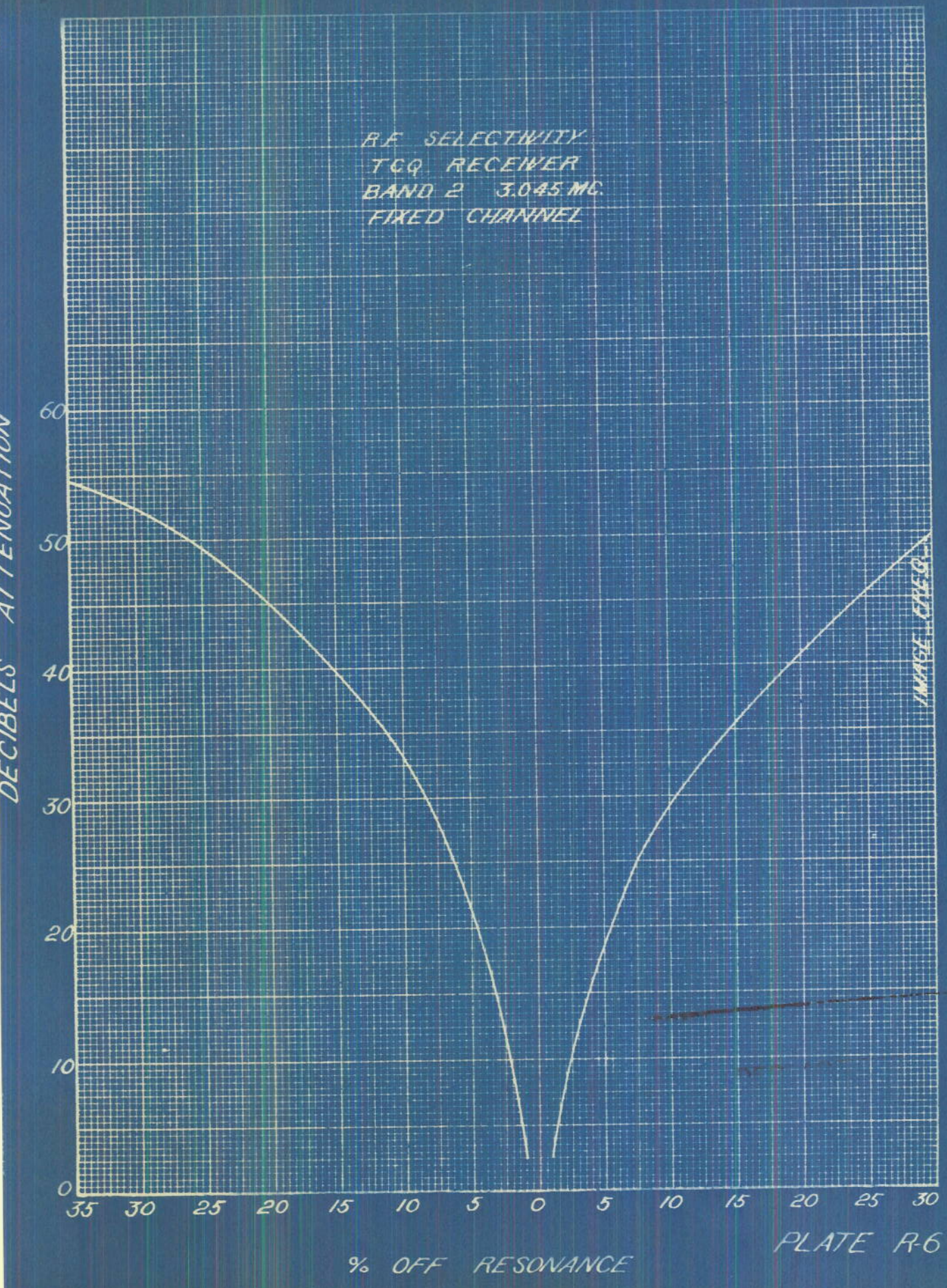
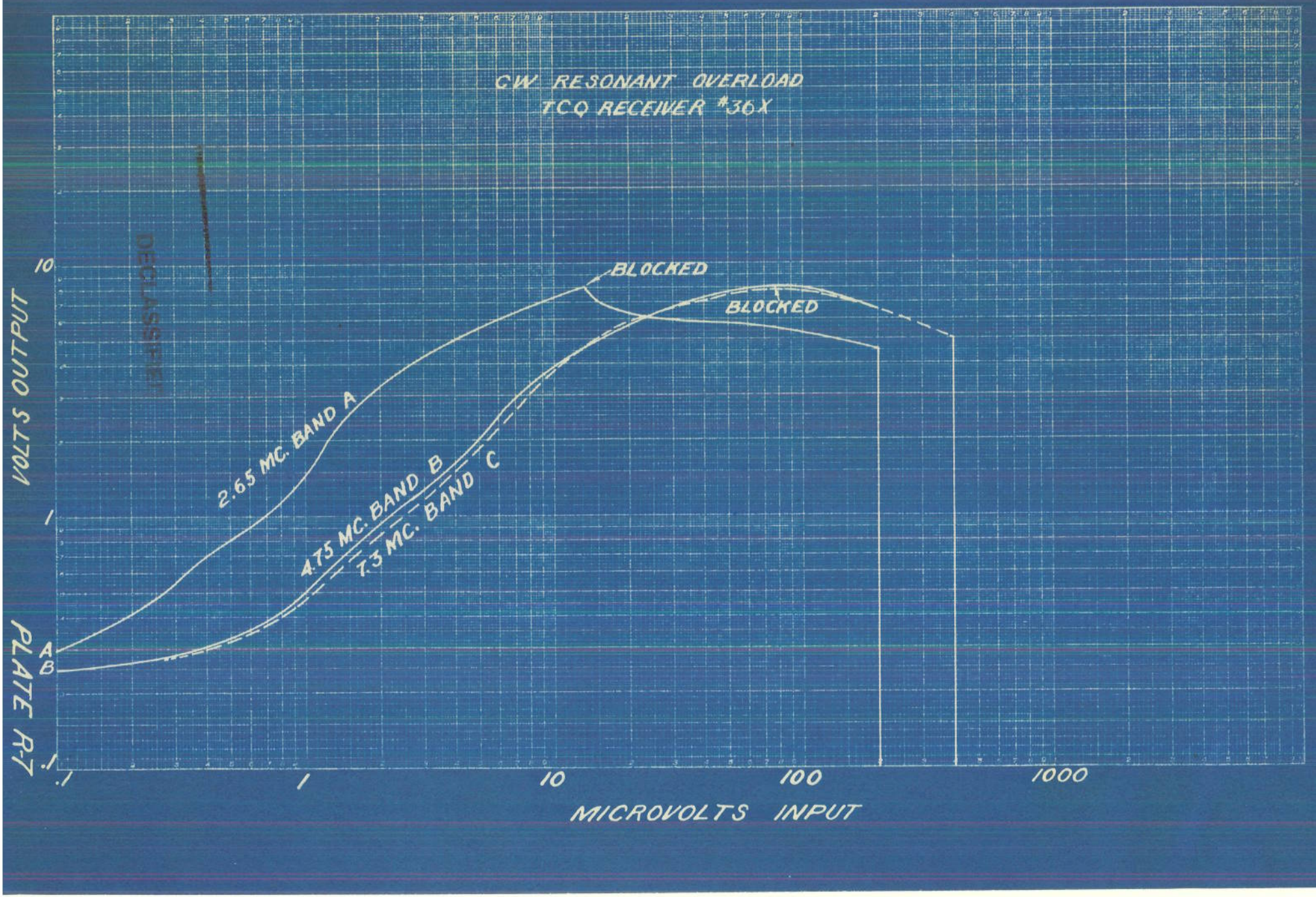
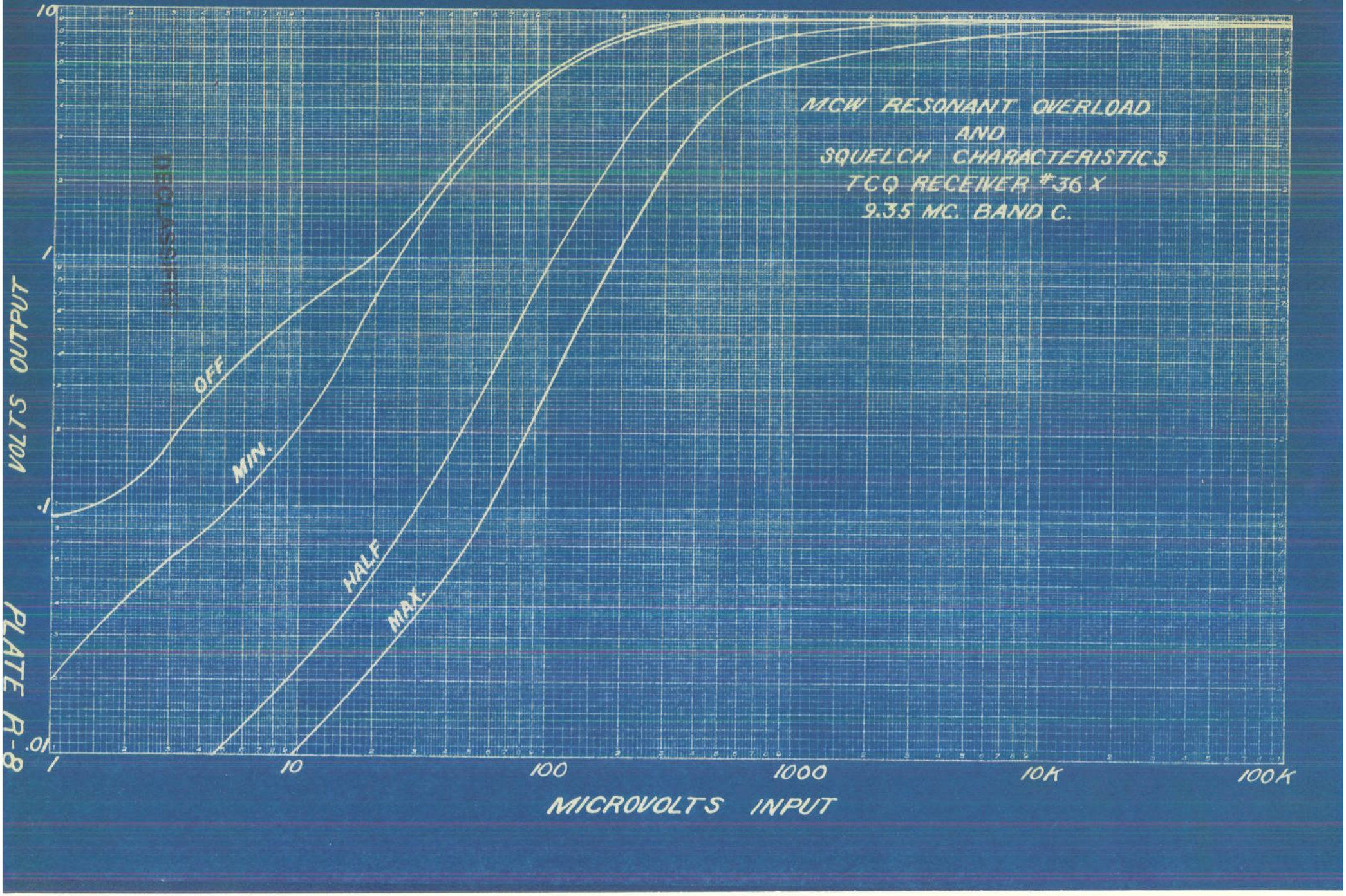
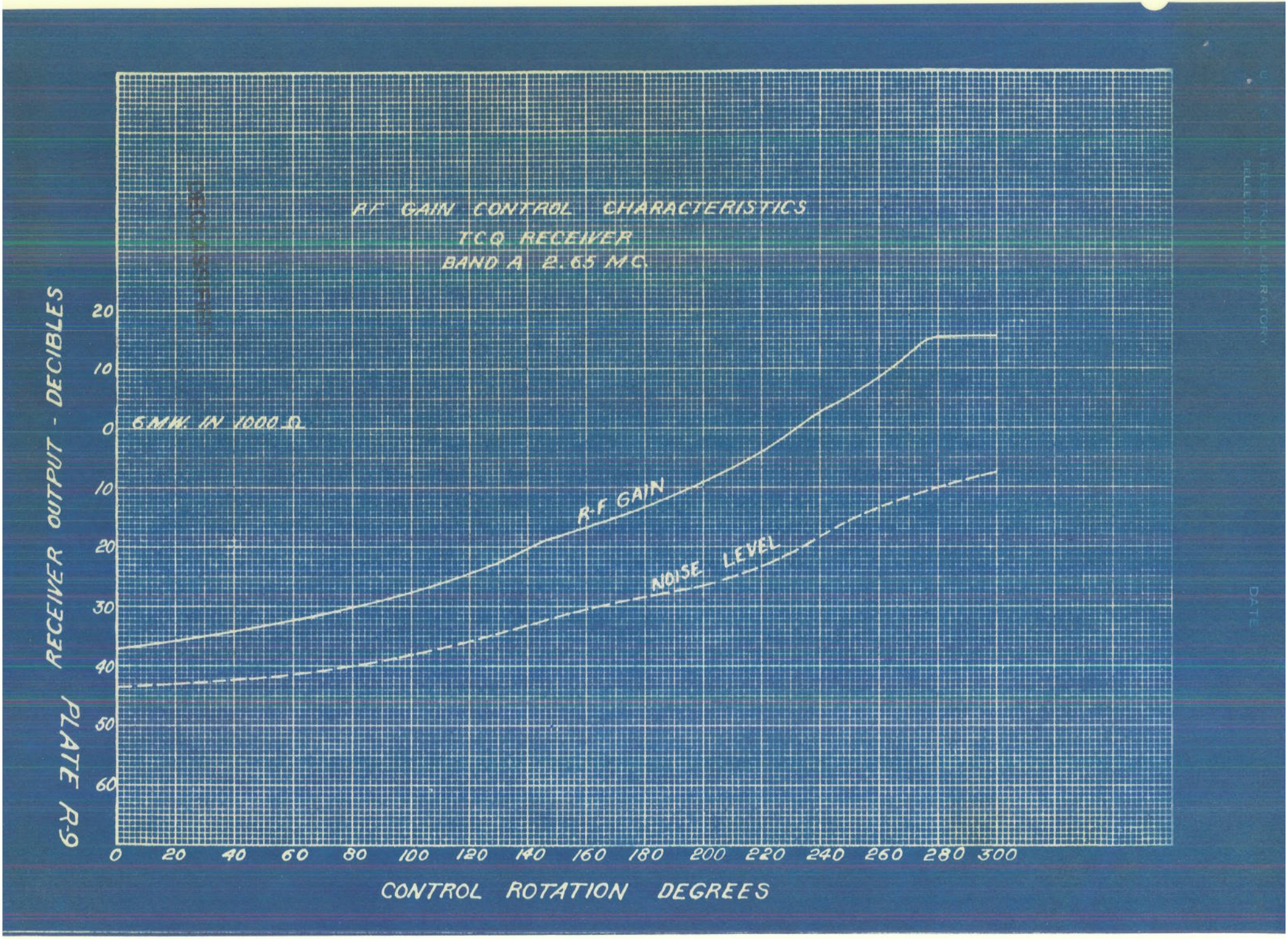


PLATE R-6


CW RESONANT OVERLOAD
TCQ RECEIVER #36X
DECLASSIFIED
BLOCKED
BLOCKED
2.65 MC. BAND A
4.75 MC. BAND B
7.3 MC. BAND C
A
B
10
1
.1
.1
1
10
100
1000
VOLTS OUTPUT
PLATE R-T
MICROVOLTS INPUT


MCW RESONANT OVERLOAD
AND
SQUELCH CHARACTERISTICS
TCQ RECEIVER #36 X
9.35 MC. BAND C.
OFF
MIN.
HALF
MAX.
10
1
.1
.01
VOLTS OUTPUT
PLATE R-8
1
10
100
1000
10K
100K
MICROVOLTS INPUT


RF GAIN CONTROL CHARACTERISTICS
TCQ RECEIVER
BAND A 2.65 M.C.
6 MW. IN 1000 Ω
R-F GAIN
NOISE LEVEL
PLATE R-9 RECEIVER OUTPUT - DECIBLES
20
10
0
10
20
30
40
50
60
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
CONTROL ROTATION DEGREES

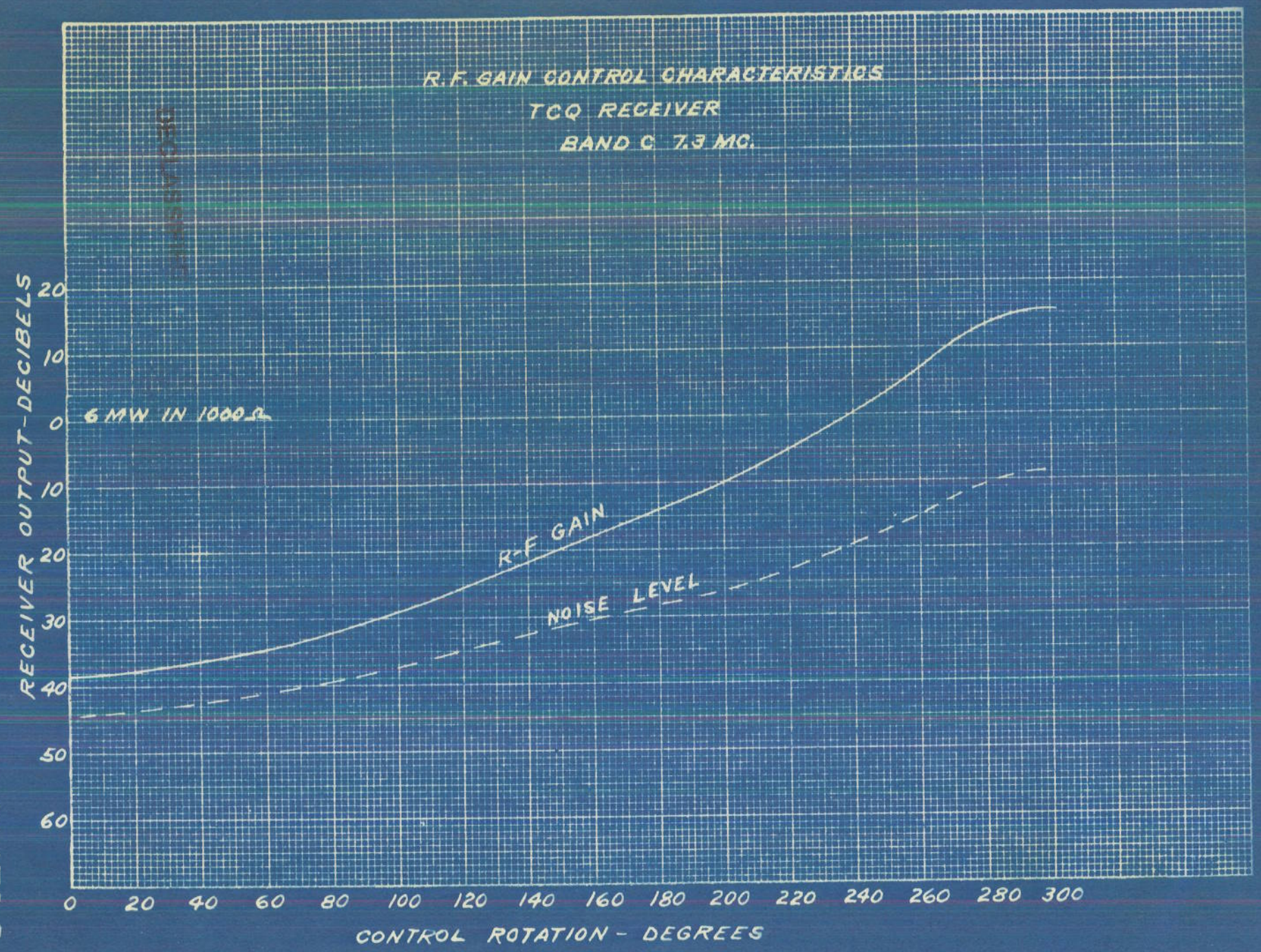

R. F. GAIN CONTROL CHARACTERISTICS
TCQ RECEIVER
BAND C 7.3 MC.
RECEIVER OUTPUT - DECIBELS
20
10
0
10
20
30
40
50
60
6 MW IN 1000Ω
R-F GAIN
NOISE LEVEL
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
CONTROL ROTATION - DEGREES

PLATE R-10

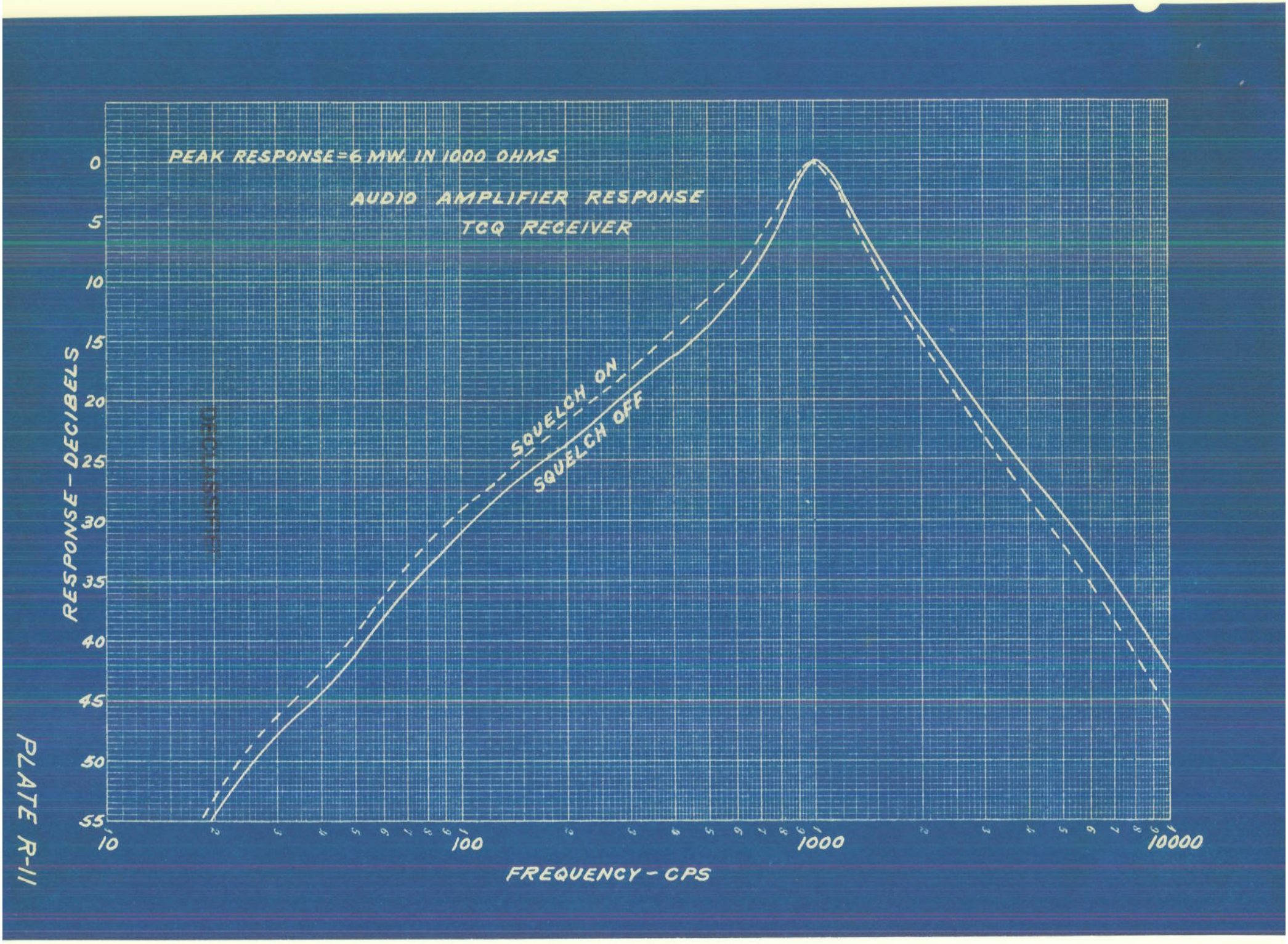
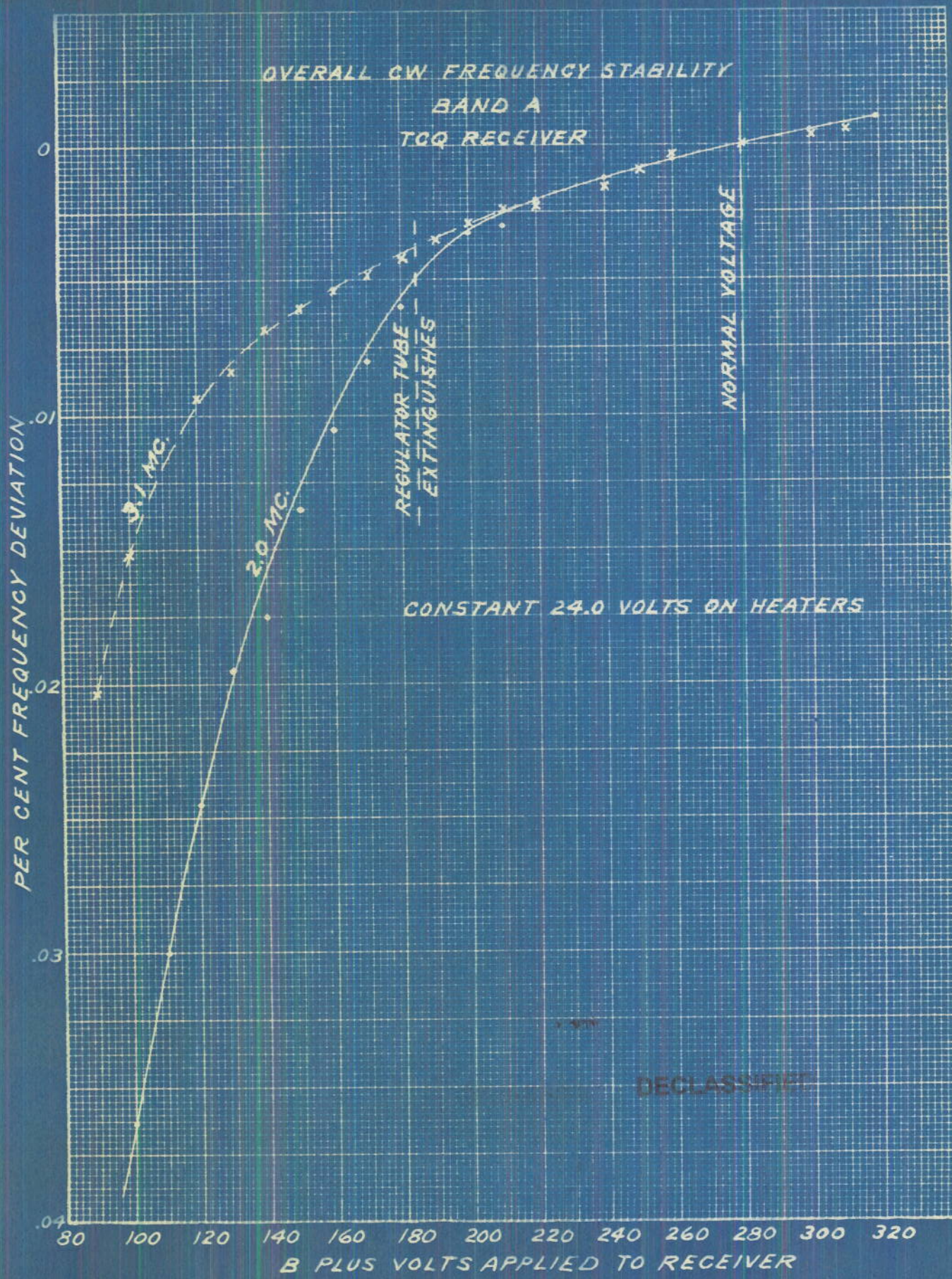

PEAK RESPONSE=6 MW. IN 1000 OHMS
AUDIO AMPLIFIER RESPONSE
TCQ RECEIVER
SQUELCH ON
SQUELCH OFF
RESPONSE - DECIBELS
0
5
10
15
20
25
30
35
40
45
50
55
10
100
1000
10000
FREQUENCY - CPS

PLATE R-11

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PLATE R-12

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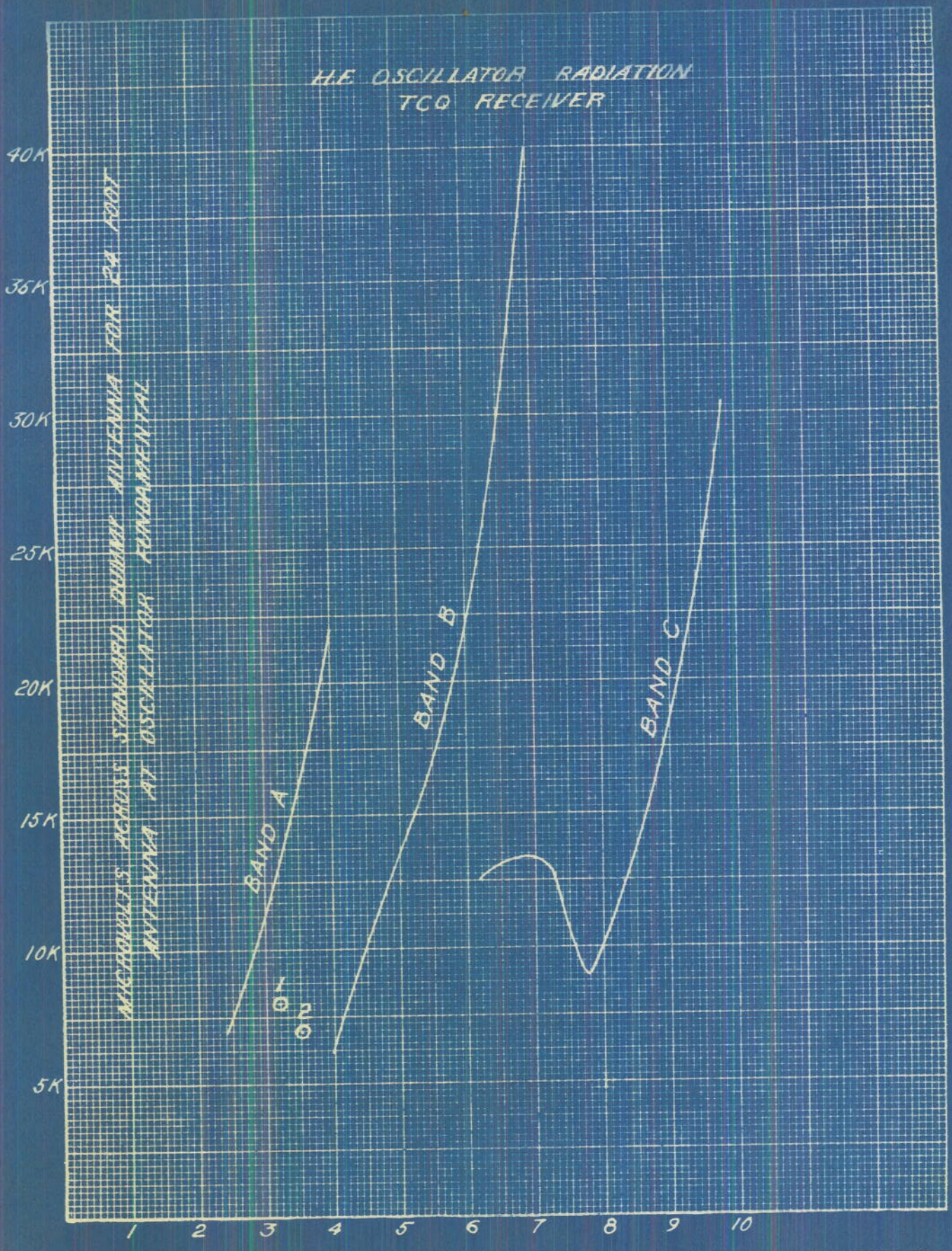


PLATE R-13

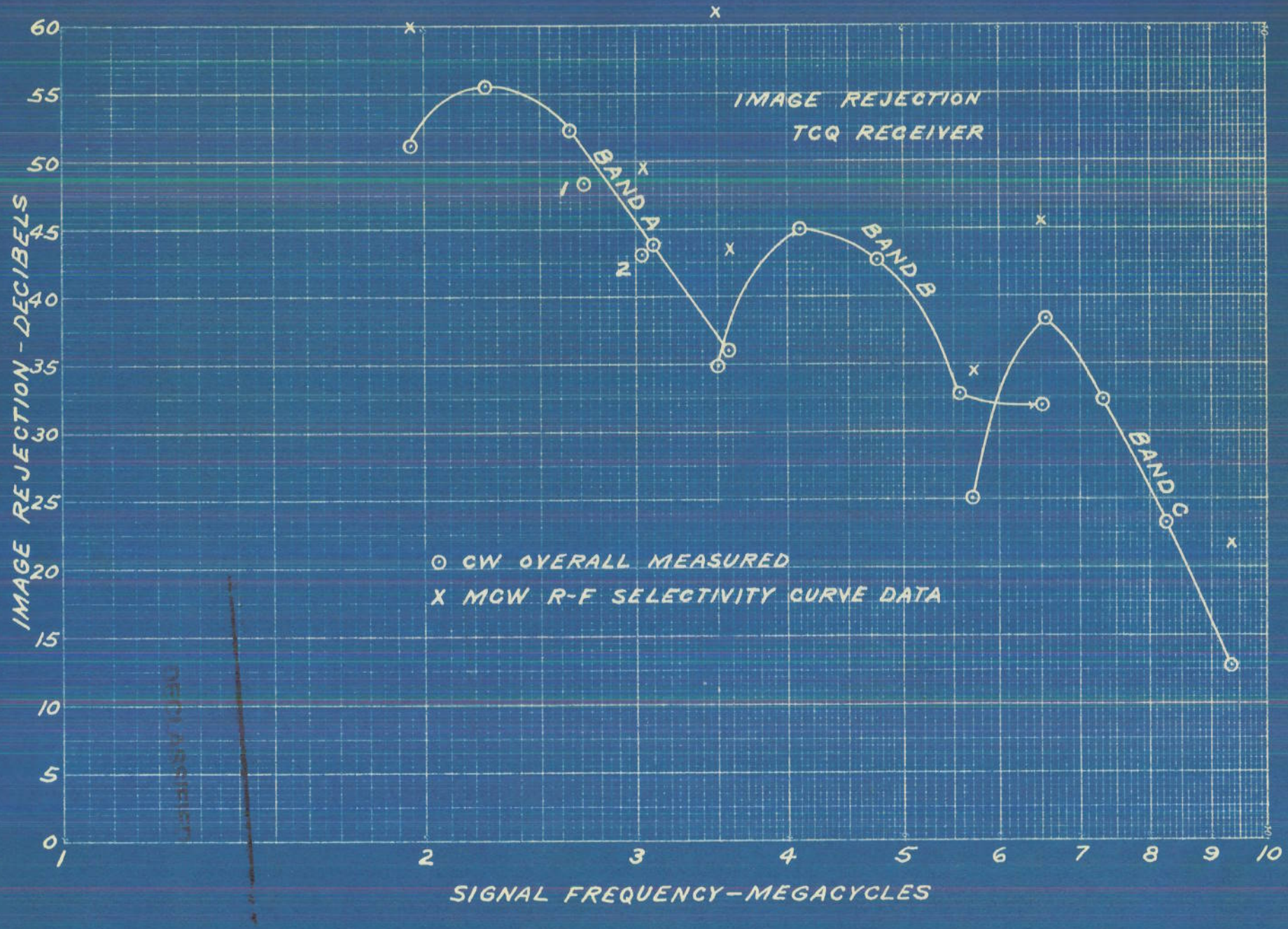

IMAGE REJECTION
TCQ RECEIVER
BAND A
1
2
BAND B
BAND C
⊙ CW OVERALL MEASURED
X MCW R-F SELECTIVITY CURVE DATA
IMAGE REJECTION - DECIBELS
SIGNAL FREQUENCY - MEGACYCLES
0
5
10
15
20
25
30
35
40
45
50
55
60
1
2
3
4
5
6
7
8
9
10

PLATE R-14

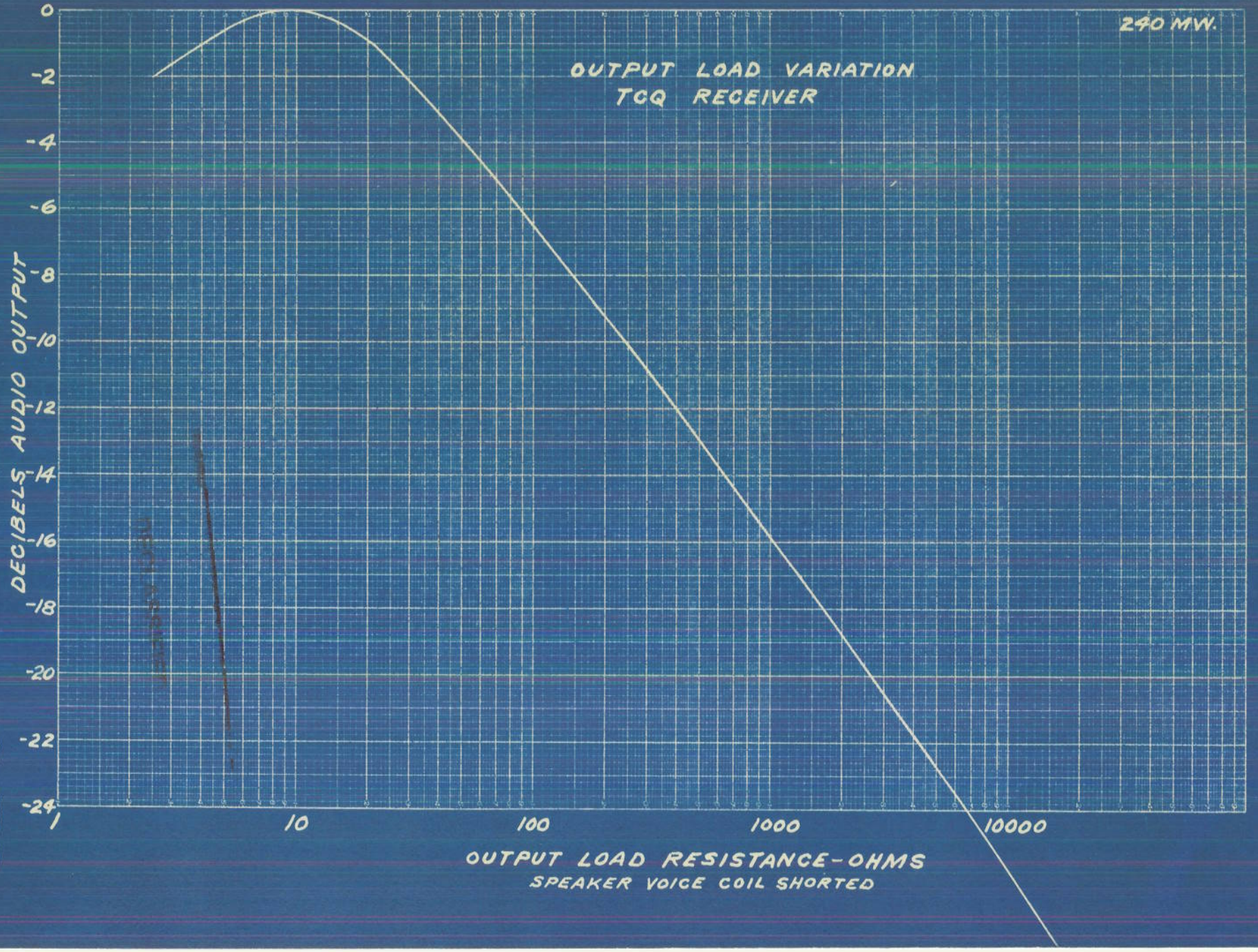

240 MW.
OUTPUT LOAD VARIATION
TCQ RECEIVER
DECIBELS AUDIO OUTPUT
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
1
10
100
1000
10000
OUTPUT LOAD RESISTANCE-OHMS
SPEAKER VOICE COIL SHORTED

PLATE R-15

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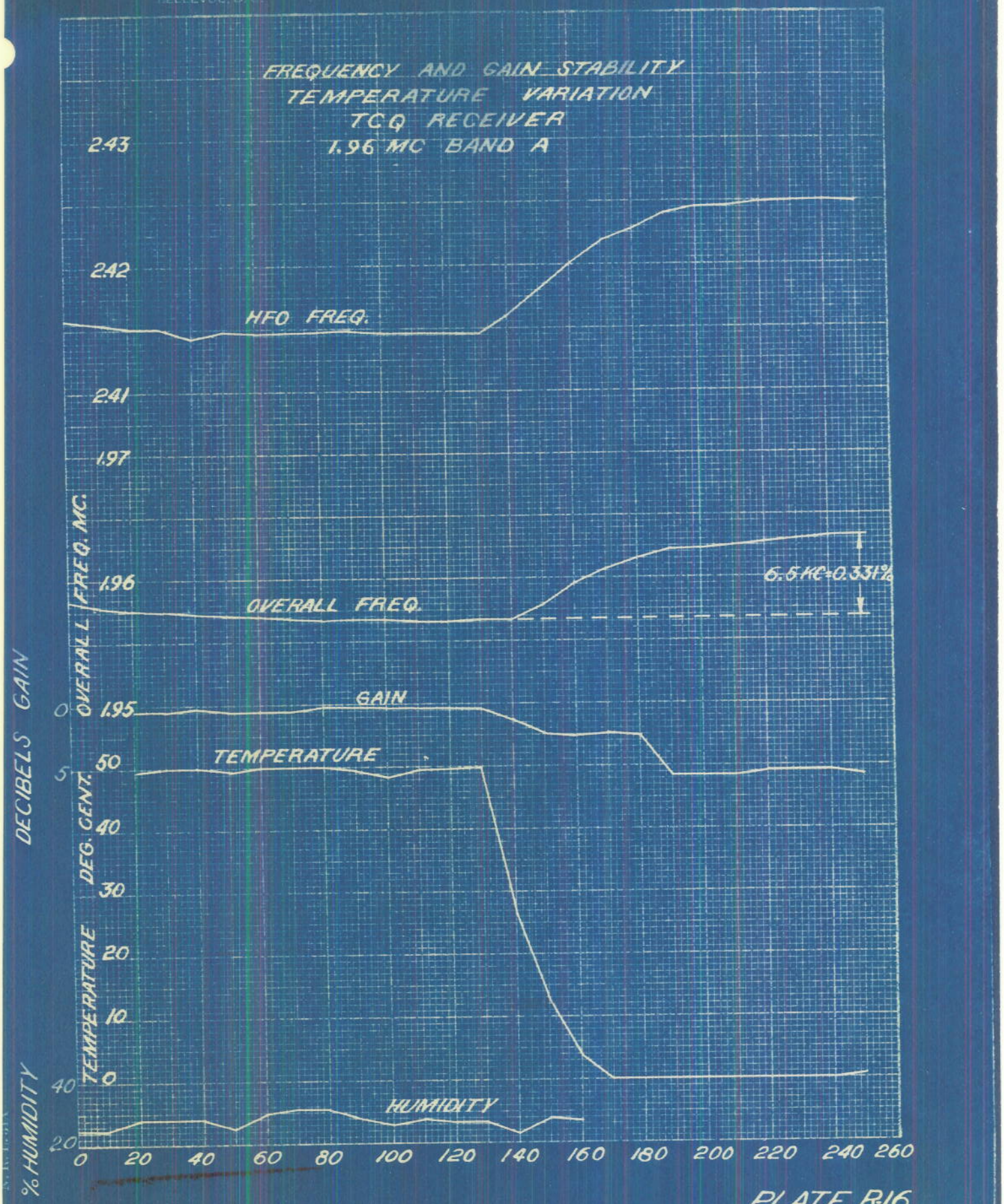


PLATE R-16

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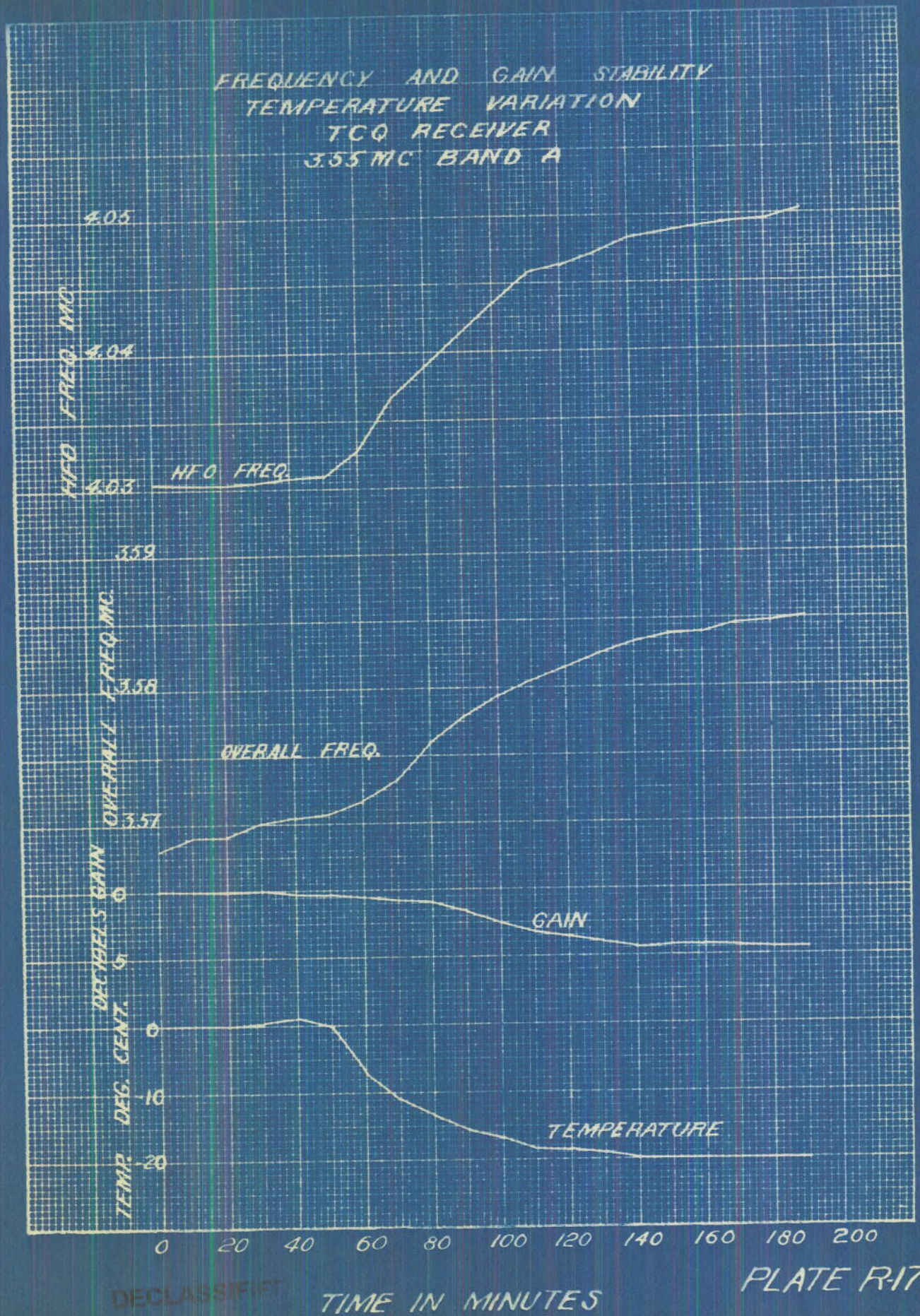
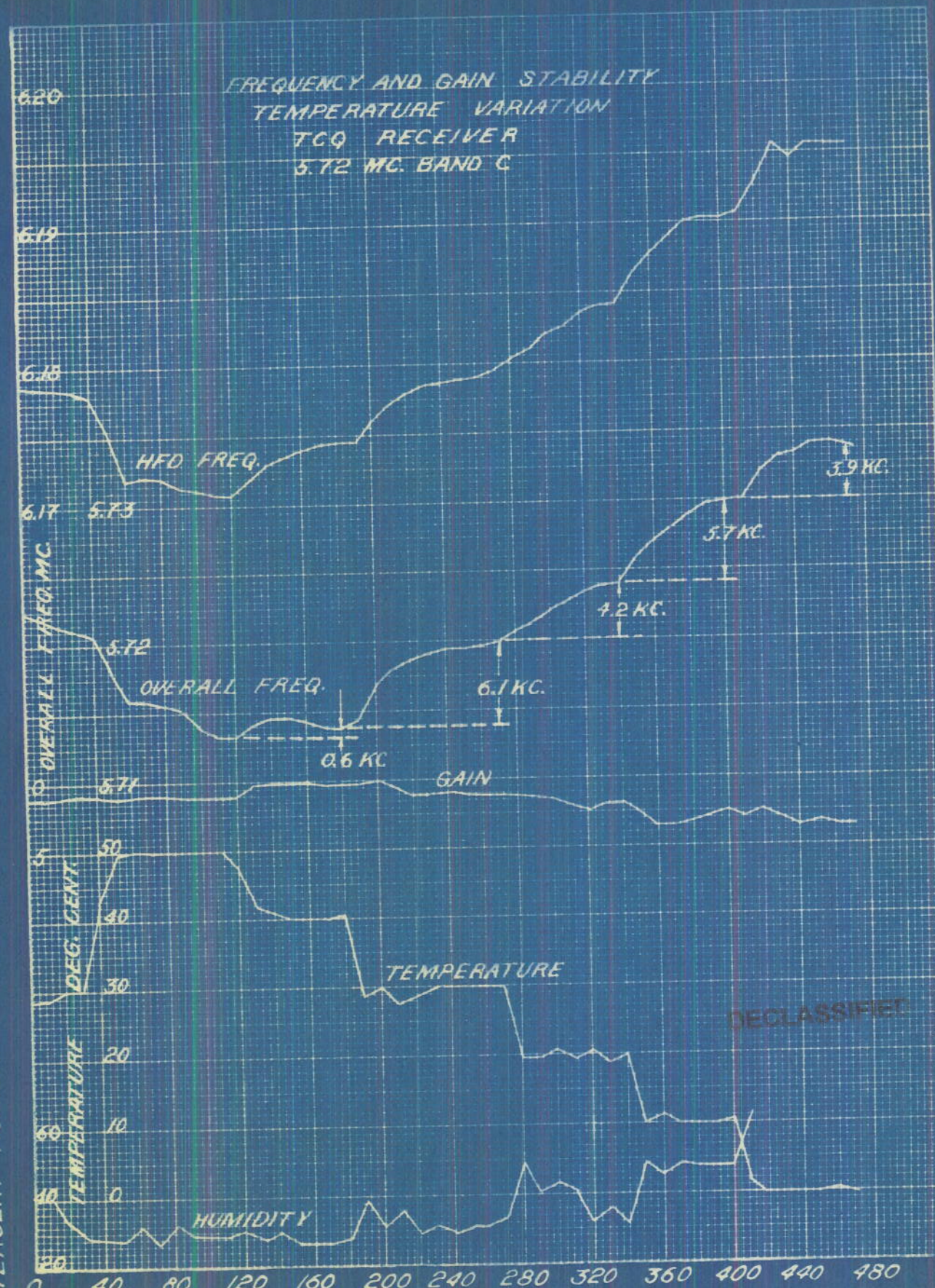


PLATE R-17

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DATE

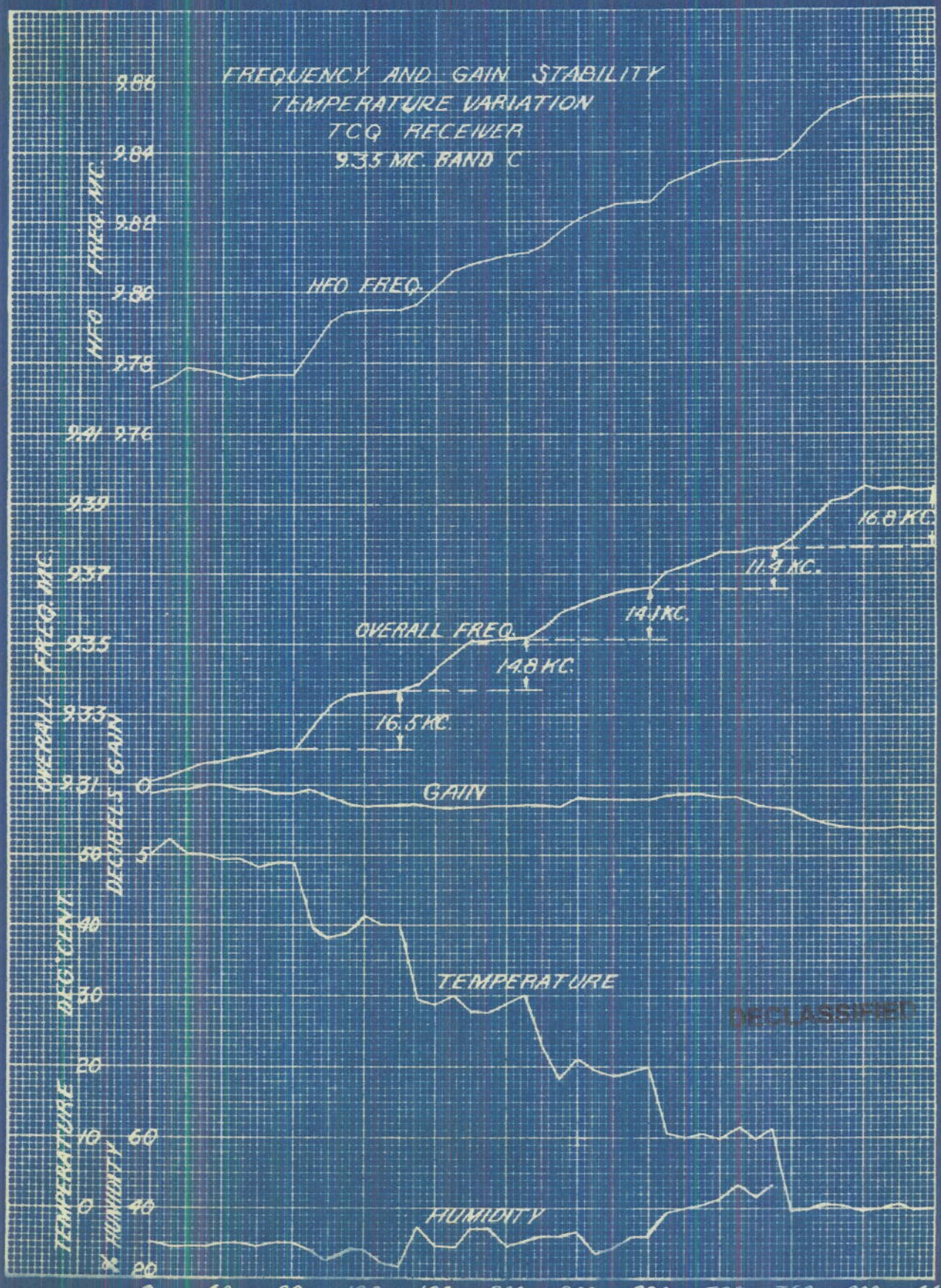


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PLATE R-18

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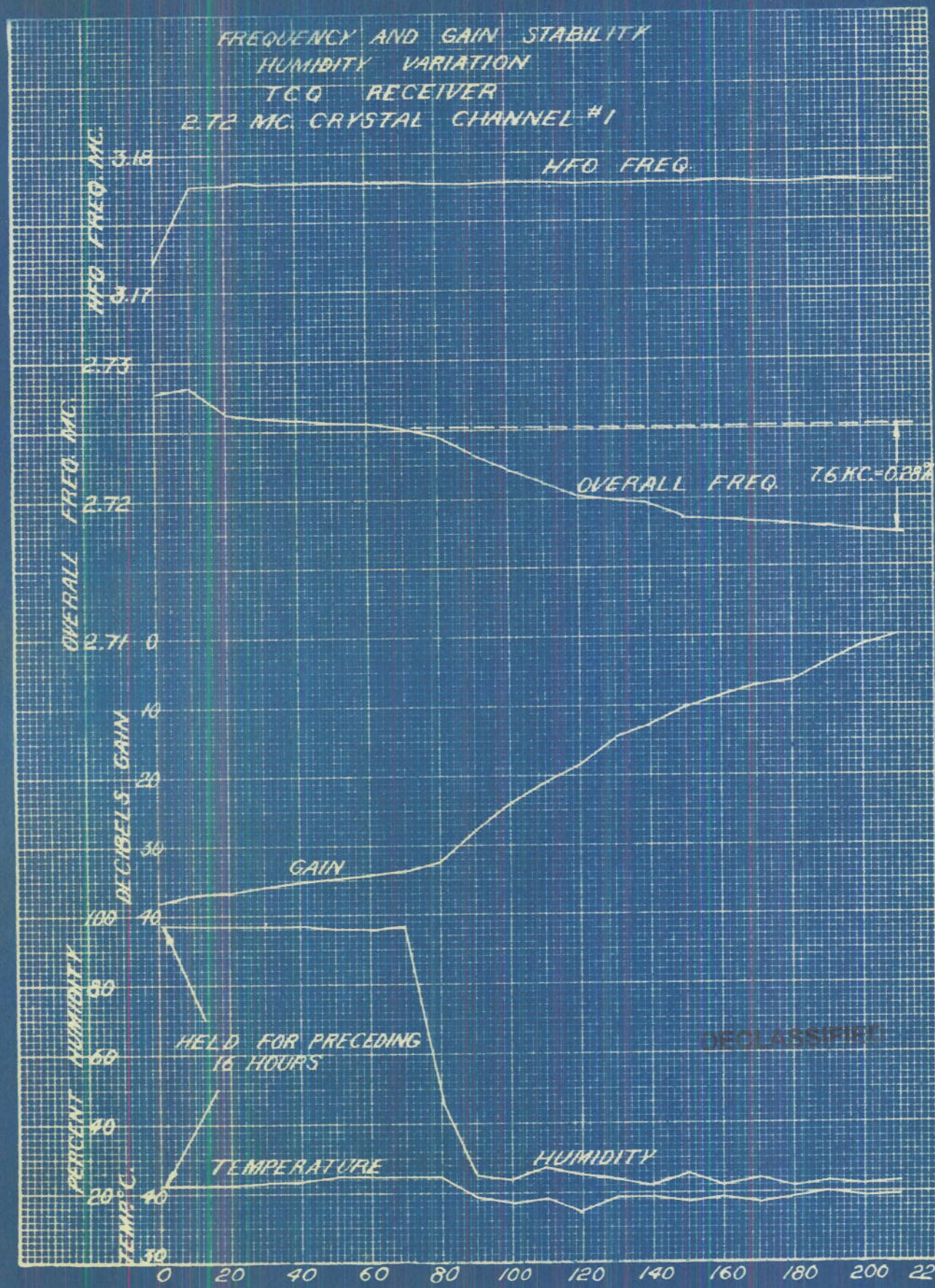


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PLATE R-19

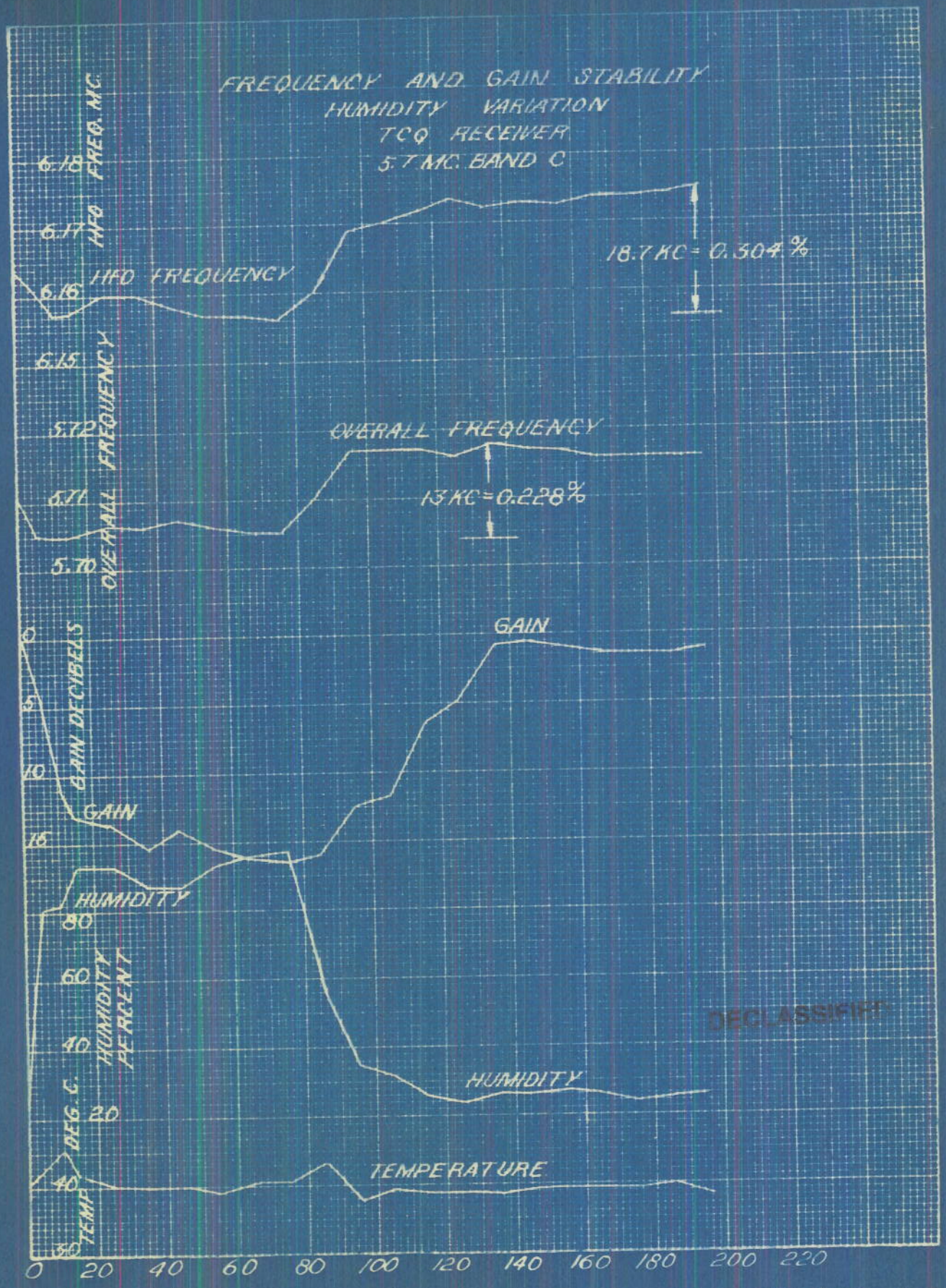
U.S. NAVAL RESEARCH LABORATORY
BELLEVUE, D.C.

DATE



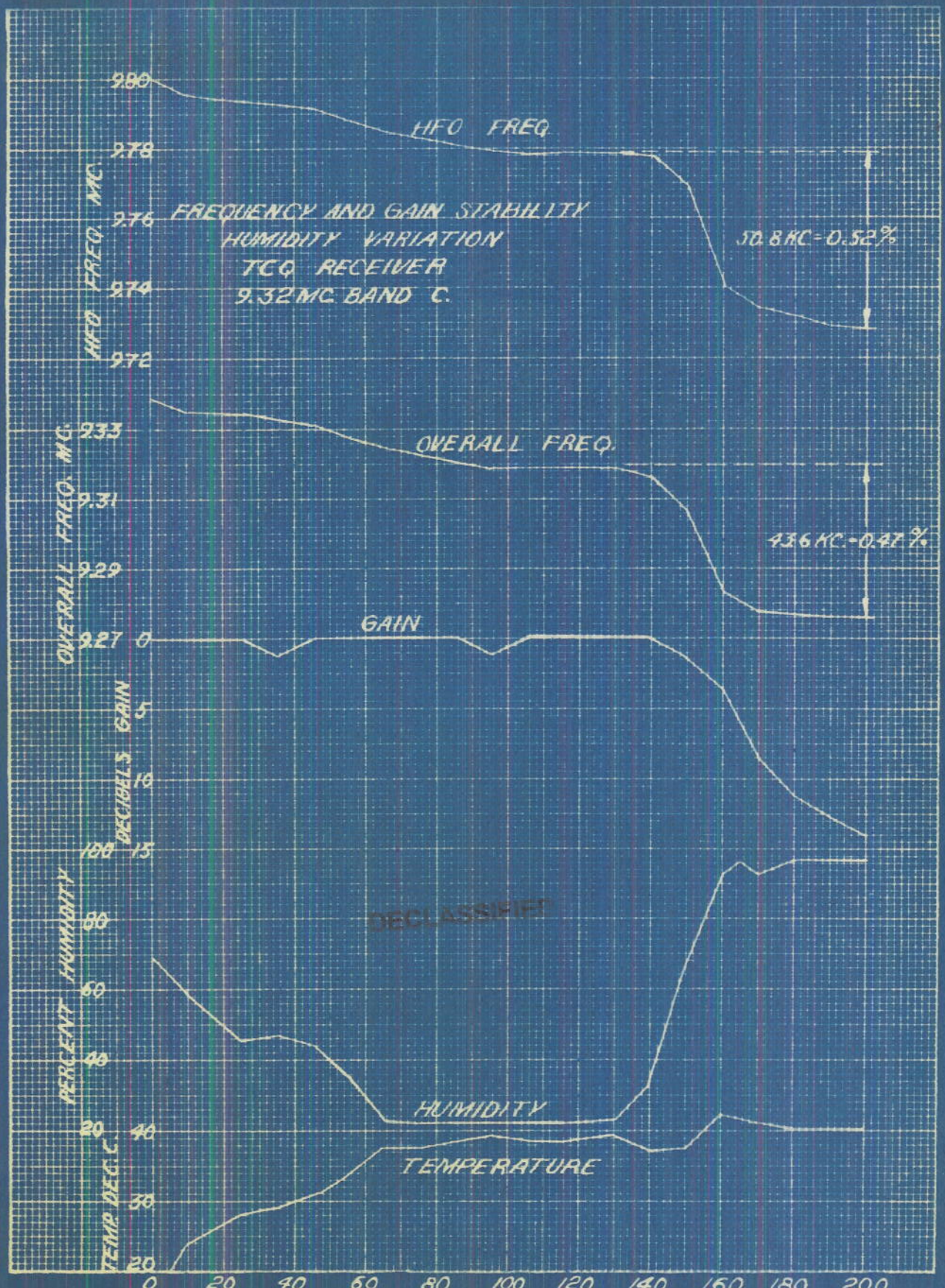
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PLATE-R20



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PLATE R-21



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PLATE R-22