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DATE 24 December 1941

## SUBJECT

Report on Hallicrafter Model S27 Receiver

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NAVY DEPARTMENT

Report

on

# Hallicrafter Model S27 Receiver

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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## AUTHORIZATION FOR TEST

1. This problem was authorized by Bureau of Ships letter C-S67/46 (485) Serial C-485-244 of 29 October 1941.

## OBJECT OF TEST

2. The object of this test was to determine the suitability of the subject equipment for shipboard use as intercept Radar equipment.

3. A further object was to determine the changes that would be necessary so that the equipment would more closely approach the standards set for standard Naval equipment.

## ABSTRACT OF TEST

4. The receiver was given a general inspection of mechanical construction and wiring. The following electrical tests were made:

(a) Sensitivity
(b) Selectivity
(c) Audio Fidelity
(d) Input Impedance
(e) Output Impedance
(f) AVC Characteristics
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[redacted]

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(dd) Overload Selectivity
(ee) Cross-Modulation Selectivity
(ff) Audio Power Output

[redacted]

## CONCLUSIONS

(a) The Hallicrafter's Model S27 Receiver is the only commercially available receiver known to the Laboratory that will cover the range from 28 to 140 mcs.

(b) This receiver possesses good sensitivity, fair selectivity, and good I-F signal rejection. The radiation from the receiver oscillators is excessive. The receiver has poor image rejection ratio, poor oscillator stability, and poor overload and cross-modulation selectivity.

(c) With mechanical and electrical improvements as noted herein, the receiver will more closely approach the standards set for equipment to withstand the rigors of naval usage.

(d) The 6 db selectivity is not broad enough to permit reliable communication without operator attendance in view of the instabilities from temperature humidity and other causes incidental to normal service operation.

[redacted]

RECOMMENDATIONS

(a) All the changes listed herein are desirable and it is recommended that as many be acted upon as consistent with the amount of time available.

(1) That Navy approved tube types be used in the receiver.

(2) That the noise limiter be changed to a more effective type such as the Karr Series Noise Limiter.

(3) That non-ferrous substitutes or suitable corrosion-resistant surfaces on iron, steel, or brass parts be employed. In view of the scarcity of non-corrosive materials, it is probable that a specification requiring their use would be out of order. However, in lieu of their use, particular emphasis should be placed upon the importance of suitably treating ferrous and brass materials to avoid corrosion and rust. It is not believed that this has been successfully accomplished in the Hallicrafter Model S27 recievers tested.

(4) That the calibration and rotation of the main tuning dial be such that a clockwise rotation of the main tuning dial control will effect an increase in both frequency and calibration on the arbitrary scale, and that a crank be used on main tuning control to facilitate tuning.

(5) That the arbitrary logging scale markings on the main tuning dial be printed in a different color or otherwise distinguished to avoid confusion with the marking of 'megacycles' just above it.

(6) That maximum controlled effect for both the A-F and R-F gain controls be obtained with the gain controls rotated clockwise toward an increase in the magnitude of the calibration.

(7) That provision be made for locking the tuning control in any desired position. While it is recognized that there is no need for this improvement for intercept work, it is believed to be desirable from the point of view of possible use of the receiver for communications purposes in which a fixed tuning adjustment must be maintained without disturbance due to accidental contact with the tuning control knob or its crank.

(8) That a more sturdy material be used in front-panel windows. This recommendation is prompted by the use of celluloid window which gives objectionable glare and high lights partly because its rigidity is insufficient to insure maintenance of a flat surface.

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[redacted]

(9) That a stop be provided to prevent insertion of the dial lamp too close to the scale of the tuning meter.

(10) That the detent action of the band switch should be made more positive.

(11) That the accessibility of components in the converter and oscillator section be improved.

(12) That the chassis and cabinet design be changed to permit ready removal of the chassis from the cabinet after loosening captive screws on the front panel. Rails or similar means should be provided to allow the chassis to slide readily to a partially removed position at which it may be secured for servicing, or to permit the chassis to be withdrawn completely from the cabinet when necessary for more extensive repair. In practice, the receiver will be permanently mounted as recommended in the following paragraph.

(13) That means be provided for securing the receiver to a table through the medium of suitable shock mounts, such as four Lord mounts. The chassis should not be secured to the bottom of the cabinet.

(14) That handles be provided on the front panel to facilitate withdrawal of the chassis from the cabinet.

(15) That hook-up wire be used which will meet Naval requirements relative to moisture, spray and heat resistance. In particular, that rubber (or equivalent homogeneous) covering be incorporated as a part of the insulation on all wiring carrying direct currents or radio-frequency voltages of any amounts. What appears to be a satisfactory substitute for rubber is provided in the so-called 'Aeroglass' wire produced by the Lenz Company.

(16) That a wax treatment be applied to the terminal strips, fixed resistors, fixed condensers, tube sockets, and radio-frequency as well as intermediate-frequency coil assemblies.

(17) That electrolytic and paper covered condensers be eliminated, impregnated paper condensers in sealed cans being substituted.

(18) That ceramic insulation or equal be provided instead of phenolic, fiber or bakelite insulation in R-F and I-F stages.

(19) That transformers, filter reactors, and paper condensers be impregnated and sealed in cans in such a way that compound is not lost during normal operation which may be at ambient temperatures between 0 and 60 degrees Centigrade.

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(20) That trimmers of the compression type be avoided if feasible, the air dielectric trimmer condensers being preferable. The cadmium used as plating for these trimmers has been found to have a tendency to 'grow'.

(21) That ceramic forms be used for I-F coil assemblies.

(22) That solid silver contact surfaces be provided in lieu of electro-deposited silver at all locations where radio-frequency or intermediate-frequency currents must be passed between relatively moving contacts. This refers particularly to band switches, selectivity switches, and tuning condenser rotor contacts. All wafer switches should be replaced by switches having solid silver contacts similar to the newly developed Oak or Yaxley Mallory switches which have solid silver contacts and would be preferable to those employed in the receivers tested.

(23) That the mechanical design be improved to provide better rigidity and orderliness in mounting components and in laying out and securing wiring.

(24) That vacuum tube sockets and other components which may be subject to removal, be secured to the chassis by machine screws and nuts rather than by rivets.

(25) That the use of self-tapping screws be avoided.

(26) That acorn type vacuum tube sockets of improved design as to contacting grips be provided.

(27) That care be taken to insure that no undue strain is placed on the power on-off switch as would cause the case to crack.

(28) That ground lugs be soldered to the chassis.

(29) That a clip designed to receive a protective gap across the antenna input circuit be mounted in the receiver. It would then be readily possible to install such a gap if this proves desirable when working near powerful transmitters.

(30) That the tuning control fiducial mark be mounted rigidly with respect to the tuning dial and not depend for support on the window material.

(31) That the input be designed to receive transmission lines of 70 ohms surge impedance with smaller mismatching.

[redacted]

(32) That the output transformer be chosen so as to provide maximum power output conditions when the nominal loads are inserted across the output terminals on the rear of the receiver chassis.

(33) That the AVC characteristics be improved.

(34) That the audio harmonic distortion be reduced if possible.

(35) That the image rejection ratio be increased if possible.

(36) That the receiver be compensated for changes in temperature and humidity.

(37) That the A-F and R-F gain controls be designed so as to offer a linear attenuation throughout the range of the control, to about 100 decibels.

(38) That the cause of severe vibration modulation be determined and corrected if possible.

(39) That the cause of excessive radiation from the receiver oscillators be determined and corrected if possible.

(40) That more gain be incorporated into the design of the first R-F stage.

(41) That means be taken to improve the performance of the receiver as regards overload and cross-modulation selectivity.

[redacted]

MATERIAL UNDER TEST

5. The material under test consisted of the Model S27 receivers, Serials 112905 and 112956 manufactured by the Hallicrafters Company of Chicago, Illinois. These receivers cover the range from 28 to 140 Mcs. in three bands and are provided with means for AM, FM, or CW reception.

METHOD OF TEST

Sensitivity

6. Sensitivity to amplitude modulated signals was measured with the aid of a General Radio type 804B signal generator. For this test the receiver was operated with the audio gain at maximum, AVC off, noise limiter off, and the tone control at normal. The beat frequency oscillator was also off, and the selectivity control was operated on broad condition. For measurements of sensitivity, the radio-frequency gain control was used to set up for standard noise conditions. Tests were made setting the antenna compensator for maximum output at the high frequency end of each band, and repeated with the antenna compensator set for maximum response at each frequency under test. Ratios of signal to noise of 5:1 (6 MW.: 1.2 MW.) were measured across 600 ohms resistance in the 500 ohm termination, with the aid of a 20,000 ohm voltmeter. The input to the receiver was fed to one antenna post and ground, with the other antenna post grounded, through a General Radio type 774 x 1 insertion unit and 10:1 attenuator. Since this combination gave an effective signal generator. output impedance of 75 ohms, no dummy antenna was used. The input signal was modulated 30% at 1,000 cycles. Measurements were made throughout the range of the receiver, at convenient intervals.

Selectivity

7. Selectivity measurements were taken of the intermediate-frequency amplifier of the receiver. The input was fed to the converter grid, and readings were taken of the input off resonance necessary to give the same output as readings at resonance. Input was modulated 30% at 1,000 cycles. The receiver was kept in AM operation, with noise limiter and AVC off.

Audio Fidelity

8. Fidelity characteristics were taken through the converter and intermediate-frequency amplifier to the audio. For this measurement, the receiver was first set up for a convenient output across 600 ohms in the 500 ohm termination with the input modulated at 30%. Readings of output voltage were then taken for different audio frequencies, with the tone control at each of its positions. All measurements were taken below the point of overload for either the I-F or the A-F stages of the receiver.

Input Impedance

9. Input impedance was measured by setting up the receiver for standard output (standard sensitivity) and recording the value of input voltage. A resistor, non-inductive, of the same order of magnitude as

[redacted]

the input impedance of the receiver was then placed in series with the receiver, and the input to the receiver from the signal generator at the frequency under test was varied until the same output was obtained. Assuming the impedance of the input to be a pure resistance, the impedance of the input was calculated from the above data. This measurement was repeated at suitable intervals throughout the range of the receiver.

### Output Impedance

10. Output impedances from the receiver were measured at the three output terminals, - phone jack, the 500 ohm termination, and the 5,000 ohm termination. The test was made with a General Radio power output meter with variable impedance. For each measurement the impedance was varied for maximum output, and the impedance noted at that point. Measurements were made with 30% modulation at 1,000 cycles. The test was conducted at both low and high power output levels.

### AVC Characteristics

11. Automatic volume control characteristics were taken with the audio gain reduced to prevent the audio amplifier from overloading. With AVC on, the receiver was adjusted with the R-F gain control at the same position as for standard sensitivity. Readings were taken of both signal plus noise and carrier noise alone, for different values of input signal. The modulation used was 30% at 1,000 cycles.

### Audio Harmonic Distortion

12. The audio output harmonic distortion was measured with the input held constant. A wave analyzer was connected across 600 ohms in the 500 ohm output termination, and used to obtain the harmonic voltages across the output. The input for this test was fed directly to the mixer grid, at the intermediate-frequency, and distortion measured as a function of the percentage of modulation of a 400 cycle tone. The same test was repeated, but this time the audio frequency modulation was kept at 30% and the frequency varied. Another distortion measurement was made with 30% modulation at 400 cycles, but the input voltage to the intermediate-frequency amplifier varied.

### Image Rejection

13. For image signal rejection determinations, the receiver was set up as for standard MCW AM sensitivity, and the output noted. The signal generator frequency was then shifted to the corresponding image frequency and the input adjusted to give standard output from the receiver. This value of input divided by the sensitivity input and expressed in decibels was recorded as the image rejection ratio. Readings were taken at 20 MC. intervals throughout the range.

### I-F Signal Rejection

14. Measurements of intermediate-frequency signal rejection were taken with the receiver set as for standard MCW AM sensitivity. A low

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frequency signal generator, at the intermediate frequency was then substituted for the ultra-high frequency signal generator, and the input to the receiver varied until the standard output was obtained. For this test, both signal generators were modulated 30% at 1,000 cycles. The input from the low frequency generator, divided by the input from the high frequency generator, for standard output conditions, expressed in decibels, is the intermediate-frequency signal rejection. For measurements with the low frequency signal generator, a 68 ohm non-inductive resistor was used as a dummy antenna. Readings were taken at convenient increments throughout the band.

### Variation of Oscillator Frequency with Line Voltage and Line Frequency

15. Variation of oscillator frequency with line voltage was measured at 200 MC. with the aid of a heterodyne frequency calibrator, loosely coupled to the oscillator of the receiver. At each measurement the heterodyne frequency oscillator was tuned to zero beat with the output from the receiver oscillator, and the frequency of the signal noted. Checks were made at frequency intervals, of the calibration of the heterodyne frequency oscillator, with the aid of the self-contained standard crystal. The line voltage was shifted in small increments, and after the receiver had stabilized, readings were taken of the oscillator frequency. Changes in line voltage were made both above and below the 115 volts standard line voltage used for all other measurements. The same measurement was made with variation of line frequency and fixed line voltage.

### Variation of Oscillator Frequency with Humidity

16. Oscillator frequency stability against changes in ambient humidity was determined as follows: the receiver was set up in the temperature-humidity control room at the Naval Research Laboratory, and the oscillator output loosely coupled to the heterodyne frequency calibrator and monitored. While the ambient humidity was undergoing change, frequent checks were made of the receiver oscillator frequency by tuning to zero beat with the heterodyne frequency calibrator. The signal was monitored continually to notice any change in oscillator frequency that may have been due to moisture. Checks were also made of the receiver gain during the test.

### Variation of Oscillator Frequency with Temperature

17. Temperature tests were made in the temperature control room of the Laboratory shop in order to determine changes in receiver gain and oscillator frequency in the presence of varying ambient temperatures. A modulated signal was applied to the receiver through a flexible concentric cable from an ultra-high frequency signal generator. The output from the receiver was measured by an output meter and monitored by headphones. An auxiliary receiver was used to pick up the beat note between the oscillator in the receiver under test and the heterodyne oscillator of a heterodyne calibrator made in this Laboratory. The heterodyne calibrator frequency was adjusted to zero beat against the receiver oscillator for each frequency drift reading. The heterodyne calibrator was also checked against

[redacted]

its standard crystal oscillator before readings. The receiver oscillator drift was calculated from the heterodyne calibrator dial readings by use of the slope of the calibrator frequency calibration curve.

### Oscillator Drift During Warm-Up

18. The oscillator frequency drift during warm-up, and change with variations of controls were checked as follows: The receiver was set up as for standard sensitivity at a desired frequency, and the heterodyne calibrator, loosely coupled to the oscillator, used to receive the oscillator signal. Readings were taken of the oscillator frequency during warm-up by obtaining a zero beat with the oscillator of the heterodyne frequency calibrator. After this test had been completed, the controls of the receiver were varied and note was made of the shift in frequency of the oscillator with variation of the controls.

### Oscillator Frequency Variation with Change of Oscillator Tubes

19. The oscillator frequency shift on replacing oscillator tubes was determined in the following way: After the receiver had been warmed up for a considerable length of time, readings were taken of the oscillator frequency. The original oscillator tube was then replaced by another tube of the same type, and readings were taken of the oscillator frequency at suitable intervals after replacing the oscillator tube. This was repeated with several other tubes. During these measurements, no other controls were varied.

### 'S'-Meter Calibration

20. In order to calibrate the 'S' meter, the signal generator was connected directly to the receiver. With the R-F gain switch full on, and with AVC on, the input to the receiver was varied and note made of the values of input which caused the 'S' meter to read at one of the calibrated points.

### R-F Gain Control Characteristics

21. Radio-frequency gain control characteristics were measured by first setting up the receiver as for standard sensitivity. Readings were then taken of the input necessary to give standard output with different settings of the R-F gain control. The results were expressed in terms of decibels attenuation from the input necessary to give standard output at maximum position of the gain control.

### A-F Gain Control Characteristics

22. Audio-frequency gain control characteristics were measured by first setting up the receiver as for standard AM sensitivity, and then increasing the R-F gain control to a point just below the overload of the audio amplifier. Readings were then taken of the output for different settings of the gain control. With the output at maximum gain taken as standard, the attenuation of the control was expressed in decibels.

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### Temperature Rise

23. The temperature rise of the interior of the receiver was measured by first setting up the receiver with both R-F and A-F gain controls full on, with AVC and noise limiter off, and with a 500 ohm load on the 500 ohm termination at the back of the receiver. Thermometers were then strapped on to suitable portions of the receiver chassis, and another suspended outside of the cabinet to record the ambient temperature. The test was continued until it was evident that an equilibrium had been reached.

### Vibration Test

24. Vibration tests were carried out on the shake table belonging to the Radio Transmitter Section of this Laboratory. As furnished the receiver could not be secured to a table. In order to mount it for vibration testing, the four rubber mounting feet furnished by the manufacturer were removed from the cabinet and for them were substituted four Lord shock mounts, each being rated at 25 pounds. These shock mounts were secured by machine screws to a stiff plywood board which in turn was bolted to the vibration table. A modulated signal from an ultra-high frequency signal generator was applied to the receiver through a concentric cable. The output from the receiver was observed by an output meter and monitored by headphones. In conducting the test, attention was given to changes in the signal generator frequency dial setting for maximum output from the receiver and to the input required from the generator for a standard output over the available range of vibration frequencies, and for some time at each of the observed critical mechanical frequencies.

### Rocking Tests

25. Rocking tests were carried out with the aid of the equipment described in the preceding paragraph. The receiver was rocked through angles up to plus or minus 45 degrees from the vertical while signal generator readings were made for standard receiver output as in the vibration test.

### Radiation of Receiver Oscillators

26. The radiation voltage from the receiver oscillator appearing at the antanna terminals was measured by substitution. A receiver that covered the same range as the oscillator of the receiver under test was coupled through a 1,000 ohm resistor to the receiver under test. Both receivers were loaded with 68 ohms of pure resistance to represent a dummy antenna. The receiver used for measurement, was tuned to the oscillator frequency and the output noted by means of the beat note produced in the receiver by the local beat frequency oscillator. This reading of signal generator output voltage was recorded as the oscillator voltage appearing at the antenna terminals. The controls of the receiver were also varied to determine any interdependence of oscillator output voltage with control position. This test was repeated at suitable frequency intervals throughout the band.

[redacted]

### Backlash

27. Backlash was measured by first setting up the receiver to a given input frequency from the standard signal generator, and noting the reading of the the linearly calibrated scale on the receiver at the position of maximum audio output, as the signal is approached first in a clockwise, then counter-clockwise direction. The input signal was modulated 30% at 1,000 cycles. The difference between the readings so obtained is the backlash. This test was repeated with another observer in an attempt to minimize personal error of observation.

### Calibration Accuracy

28. Calibration accuracy was measured by first allowing the receiver to stabilize after about four hours of operation. The receiver was then set to each of the frequencies at which the check was to be made, and the output loosely coupled into a heterodyne frequency calibrator which had also warmed up. Checks were made of the calibration of the heterodyne frequency oscillator at each frequency of test, by means of the standard 5 MC. crystal incorporated therein. Reset accuracy was determined by setting the receiver to a given frequency and noting the oscillator frequency at each setting. To the oscillator frequency was added the intermediate frequency, dependent on whether the oscillator was above or below the received signal.

### Power Requirements

29. The power requirements of the receiver were measured with a wattmeter in the A-C supply, and noted with each change of switch or control positions that affected the power consumed by the receiver. The power factor was measured at the same time, by comparing the results obtained with a wattmeter, against the results obtained by the use of ammeters and voltmeters.

### Check for Magnetic Materials

30. A check was made throughout the assembly of the receiver, using magnets, in order to ascertain if iron or ferric alloys had been used in places where it was not necessary for electrical purposes, as required in applicable naval specifications.

### Tuning Time

31. A check was made of the length of time necessary to tune to a given signal of 50 microvolts strength, with a knowledge of the frequency of the desired signal. This was done by setting a standard signal generator with 30% modulation at 1,000 cps and 50 microvolts output to the receiver, with the generator frequency somewhere in the band and noting the time required for tuning to the signal.

### Depth of Modulation Characteristics

32. Depth of modulation characteristics were taken to determine the linearity of the audio detector for different levels of modulation. The

[redacted]

input for this test was fed to the I-F amplifier to avoid errors due to frequency modulation resulting from the use of the U-H-F signal generator. With input to the converter grid, the R-F gain control was adjusted for a given output across 600 ohms in the 500 ohm output terminal, with 20% modulation. The AVC and the noise limiter were rendered inoperative for this test. The tone control was at normal. After the initial adjustment, readings were taken of output for different percentages of modulation of the signal input. Readings were taken with both AVC and noise limiter off, with AVC on and noise limiter off, and with AVC off and noise limiter on.

### Resonant Overload Characteristics

33. Resonant overload characteristics were taken with the same set up as for the AVC characteristics, paragraph 11, but with the AVC off. The receiver was first adjusted for standard sensitivity at the frequency of test, and readings were taken of increased values of input and resulting signal plus noise output and carrier noise output. For this test the standard modulation of 30% at 1,000 cps was used.

### Limiter Characteristics

34. The charactertistics of the limiter of the frequency modulation part of the receiver were measured by feeding to the second I-F amplifier control grid, a signal at the intermediate frequency modulated 30% at 1,000 cps, and measuring the output across the load in the limiter circuit with a vacuum tube voltmeter, the receiver being set for F-M operation. Readings were taken of the drop across the load resistor for increased values of the input signal.

### Discriminator Characteristics

35. Frequency-modulation discriminator characteristics were measured in the I-F amplifier by applying a signal at the intermediate frequency amplitude modulated at 30% at 400 cycles, and with the receiver set as for F-M operation, reading the voltage at the output terminals, for variations of the signal generator frequency above and below that of the center of the I-F band pass region.

### Reserve Gain

36. Reserve gain was determined after setting up the receiver for standard A-M sensitivity, with the tubes as furnished with the receiver, the R-F gain control was advanced to maximum, and readings taken of the noise output at that point. This value of noise output divided by standard noise and expressed in decibels is the reserve gain.

### Overload Selectivity

37. Overload selectivity tests were conducted with the aid of the XTBT transmitter which was installed with its antenna on the same horizontal plane with a vertical dipole used as receiving antenna for the S27 receiver. The antennas were separated about 65 feet. In this test a desired modulated signal was introduced into the receiver

from a local signal generator. The effect of an unmodulated signal from the model XTBT transmitter, operating at suitable power levels, in reducing the desired signal output was observed.

### Cross-Modulation Selectivity

38. Cross-modulation selectivity tests were carried out with the set-up described in the previous paragraph. The local desired signal was adjusted to give a standard output; its modulation was then removed and a modulated undesired signal received from the model XTBT transmitter operating at full power. The frequency separation between desired and undesired signals was determined under the condition of standard output from the desired modulation.

### Audio Power Output

39. Maximum power output was measured from all three terminals on the receiver first by measuring the voltage across standard resistances in the output of the receiver, and second by means of a General Radio output power meter with variable impedance. The maximum power output was measured at 1,000 cycles.

## DATA RECORDED DURING TEST

40. Complete data were recorded for all tests conducted, and this information is contained in Tables 1 to 12 inclusive, and Plates 1 to 21 inclusive. Photographs and wiring diagram are contained in Plates 101 to 109 inclusive.

41. Tabulated below are estimates of the probable errors in the results of the various tests. These estimates are based on the assumption that the equipment has been operated for sufficient time to permit stabilization to take place prior to test and include the advertised errors for the instruments employed. Included also are errors resulting from line-voltage fluctuation, radio-frequency leakage, frequency modulation, and errors due to resetting of instruments and receiver controls. The latter errors were reduced to a minimum by frequent checking of line voltage, the location of the ground connections for maximum reduction of stray field influences, and care in the adjustment of all instruments and receiver controls.

| Name of Test | | Estimated Overall Accuracy |
|---|---|---|
| Sensitivity | | 40% |
| Selectivity | (Attenuation | ± 1 DB |
| | (Frequency Setting | ± .05% |
| Oscillator Frequency Stability | | ± .005% |
| AVC and Resonant Overload Characteristics | | ± 5% |
| Audio-Frequency Fidelity | | ± .5 DB |
| Audio Output Harmonic Distortion (Per Cent Error in Per Cent Distortion) | | ± 10% |
| A.C. Power Consumption | | ± 3% |

[redacted]

## RESULTS OF TEST

### General Description of Receiver

42. The receiver employs a superheterodyne circuit having one stage of tuned radio-frequency amplification, a heterodyne oscillator, a converter, two stages of intermediate frequency amplification (at 5.25 mc.) common to the amplitude-modulation and frequency-modulation channel, intermediate frequency limiter amplifier for the frequency-modulation channel and audio beat frequency oscillator, second detector for amplitude-modulation and discriminator for frequency-modulation reception, and a stage of audio amplification and frequency inversion, with an output of push-pull pentodes, with output from the first audio stage for headphone reception, and two pairs of terminals labeled 500 and 5,000 ohms for driving a loud speaker. A power supply system is built into the receiver chassis; it is designed to operate on a 115 volt, 60 cycle line.

### Frequency Range

43. The receiver has a rated frequency range of 27.5 to 145 mc. covered in three tuning bands, from 27.5 mc. to 47 mc., from 46 mc. to 82 mc., and from 82 mc. to 145 mc.

### 44. Vacuum Tube Complement

| Type | Number | Function | Navy Status* |
|---|---|---|---|
| 956 | One | R.F. Amplifier | Preferred |
| 954 | One | Converter | Preferred |
| 955 | One | Oscillator | Preferred |
| 1852 | One | I-F Amplifier | For replacement only |
| 1853 | One | I-F Amplifier | Preferred |
| 6SK7 | One | I-F Amplifier (AM operation) | Preferred |
| 1852 | One | I-F Limiter-Amplifier (FM Operation) | For replacement only |
| 6H6 | One | Diode Detector, Noise limiter (AM) | Preferred |
| 6H6 | One | FM Discriminator | Preferred |
| 6J5 | One | Audio Beat Frequency Oscillator | Preferred |
| 6C8G | One | First Audio Amplifier-Inverter | Replacement only |
| 6V6 | Two | Output Power Stage | Unapproved# |
| VR-150 | One | Voltage Regulator | Preferred |
| 5Z3 | One | Power Rectifier | For replacement only |

* As of date of completion of report
\# 6V6 GT Preferred

### Circuit Elements

45. The circuit elements, noted in order from input, are as listed below. They are also indicated in the wiring diagram given on Plate 109.

(a) Input circuit
(b) First radio-frequency circuit
(c) Radio-frequency amplifier tube
(d) Second radio-frequency circuit
(e) First detector tube
(f) Oscillator citcuit
(g) Oscillator tube
(h) First intermediate transformer and circuit
(i) First intermediate-frequency amplifier tube
(j) Second and third intermediate-frequency transformers and circuits
(k) Second intermediate frequency amplifier tube
(l) Third intermediate-frequency amplifier-AM operation
(m) Third intermediate-frequency amplifier tube - AM operation
(n) Third intermediate-frequency amplifier-limiter - FM operation
(o) Third intermediate-frequency limiter-amplifier tube - FM operation
(p) AM second detector circuits
(q) AM detector tube
(r) Audio beat frequency oscillator circuits
(s) Audio beat frequency oscillator tube
(t) FM detector circuit
(u) FM detector tube
(v) Automatic volume control circuits and switch - FM and AM operation
(w) First audio amplifier-inverter circuit
(x) First audio amplifier-inverter tube
(y) Output circuit
(z) Output tube
(aa) Band switch
(bb) Selectivity Switch
(cc) Tone Control Circuit
(dd) FM-AM Operation Switch
(ee) Automatic noise limiter switch
(ff) Power supply and voltage regulator
(gg) Power rectifier and voltage regulator tubes
(hh) Tuning meter circuit

## Input Circuit

46. The antenna input is inductively coupled to the first tuned circuit. The coupling loop is designed to match transmission line impedances of 75 to 100 ohms. A clip designed to receive a protective gap across the input circuit would protect the receiver when working in fields near powerful transmitters.

## First Radio-Frequency Circuit

47. The first radio-frequency circuit consists of a coil wound on phenolic forms. Selection of the desired frequency is accomplished by tuning a variable capacitor which is mounted with the other tuning capacitors, in broadcast receiver fashion, along the depth of the cabinet.

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### First Radio-Frequency Amplifier Tube

48. This tube is a 956 acorn pentode having its suppressor grid and cathode tied together and grounded through a resistor, by-passed by a capacitor. The control grid does not receive any AVC bias. The screen is returned through a resistance-capacity filter to a positive tap in the power supply.

### Second Radio-Frequency Circuit

49. This circuit also contains a transformer wound on a phenolic form. The coupling to the grid of the next stage is capacitive as well as inductive on one of the bands. The input to the grid contains the tuned circuit, tuned by means of a ganged variable capacitor.

### First Detector Tube

50. This tube is a type 954 acorn pentode with the suppressor grid connected cirectly to ground, and no AVC bias voltage to the grid. The cathode is connected through a resistor to ground for bias and isolation of the voltage injected to the cathode by a series inductance and capacitor from the oscillator circuit. The screen is returned to a positive potential in the power supply by means of a resistance, by-passed capacitatively to ground. The heater of this tube is also by-passed to ground.

### Oscillator Circuit

51. The oscillator circuit consists of a tuned plate oscillator with shunt feed. The grid is inductively coupled to the tuned plate circuit, through a series condenser, with a grid leak to ground.

### Oscillator Tube

52. The oscillator tube consists of a 955 acorn type triode. The plate voltage is fed through resistance-capacity, and resistance-choke filters, from the 'B' supply voltage, the cathode of the tube is connected directly to ground. The heaters of the tube are by-passed to ground, and further isolation of the tube is assured by a radio-frequency choke in series with the ungrounded side of the filament.

### First Intermediate-Frequency Transformer and Circuit

53. The first intermediate-frequency transformer consists of an iron-core transformer, with both primary and secondary tuned. The grid of the first intermediate-frequency amplifier tube is connected through suitable resistive-capacity networks to the AVC circuit.

### First Intermediate-Frequency Amplifier Tube

54. The first intermediate-frequency amplifier is an 1852. The cathode is connected through series resistors to a potentiometer connected to ground, to vary the bias on the tube. The cathode is by-

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passed over part of the cathode load. The suppressor of the tube is tied directly to ground. The screen is fed from a resistor from the high voltage supply, and by-passed to ground. The plate is fed through the primary of the next tuned circuit, through a resistance, with the other side of the primary of the transformer by-passed to ground.

### Second and Third Intermediate-Frequency Transformers and Circuits

55. The second and third intermediate-frequency transformers and circuits are similar to those just described for the first intermediate-frequency transformer and circuits. In addition, however, the third transformer's secondary is capacitatively coupled to the next two stages, the AM amplifier and the FM limiter-amplifier, only one of which is used during reception.

### Second Intermediate-Frequency Amplifier Tube

56. The second intermediate-frequency amplifier tube is a type 1853 pentode, connected in a manner similar to the first intermediate-frequency amplifier tube, including the AVC control to the control grid, and the control of the bias to the cathode by means of the potentiometer arrangement. Both cathodes of the first and second intermediate-frequency amplifiers are connected to the same tap on the potentiometer.

### Third Intermediate-Frequency Amplifier - AM Operation

57. The third intermediate-frequency amplifier is capacitively coupled to the secondary of the third intermediate frequency transformer. The output of this stage is coupled to the diode detector through the fourth intermediate-frequency transformer.

### Third Intermediate-Frequency Amplifier Tube - AM Operation

58. The third intermediate-frequency amplifier tube is a 6SK7 pentode in a conventional amplifier circuit, with suppressor connected to the cathode, and the cathode connected to ground through a bias resistor, also by-passed. The screen of the tube is fed through a series resistor from the high voltage, and is by-passed to ground. The plate is fed through the primary of the intermediate-frequency transformer and a resistor to the 'B' supply, with a by-pass capacitor from the 'cold' side of the primary to ground.

### Third Intermediate-Frequency Amplifier Circuit - FM Operation

59. The third intermediate-frequency amplifier is fed from the secondary of the third intermediate-frequency transformer. There is no cathode bias on the tube, allowing the grid to draw current, supplying an AVC voltage to be described later. The output of the tube is fed through a conventional FM transformer to the next stage.

### Third Intermediate-Frequency Amplifier Tube - FM Operation

60. The third intermediate-frequency amplifier tube, FM operation, is a pentode 1852 with the screen fed through a series resistor from the

[redacted]

supply voltage. In series with the screen resistor is another resistor to the last intermediate-frequency transformer primary, and thence to the plate, causing the plate to be at a lower D-C potential than the screen, and so deriving its limiting abilities. The suppressor of the tube and the cathode are grounded. In series with the grid is a grid leak whose action is such that the grid biases itself negatively when drawing current providing another means for limiting in the tube.

### AM Second Detector Circuits

61. The AM detector consists of a simple diode detector in a conventional circuit, feeding a shunt type of noise limiter. The AVC voltage is derived from part of the diode load. The noise limiter diode is connected across part of the load, and when operative is biased by the current flowing through the load due to the signal voltage. When instantaneous peaks, such as noise, **are** impressed across the secondary of the last intermediate-frequency transformer, the noise limiter tube is made conductive, causing the audio voltage due to the peak of noise to pass through the tube and a condenser to ground. The time constant of the noise limiter circuit, affecting the operation of the limiter on pulses of different width, is determined by the resistance and capacity in the plate circuit of the noise limiter diode. It has been the experience of the Laboratory that this type of noise limiter, involving a shunt action on the undesired audio voltage, is relatively ineffective, except on certain types of noise. It has been found that a series type of noise limiter, such as the Karr noise limiter circuit, has greater capabilities and effectiveness.

### AM Detector Tube

62. The detector tube is a 6H6 duo-diode, with cathode grounded. The tube is self-biased by the current flowing through the load.

### Audio Beat Frequency Oscillator Circuits

63. The audio beat frequency oscillator circuit consists of a standard Hartley oscillator, with the output coupled by virtue of the field around the oscillator, to the I-F circuits.

### Audio Beat Frequency Oscillator Tube

64. The audio beat frequency oscillator tube is a 6J5 triode, with the plate voltage fed through a resistance-capacity filter. In this tube, the plate is at R-F ground potential.

### FM Detector Circuit

65. The FM detector circuit consists of a standard type of frequency discriminator, such as is commonly used for automatic frequency control of broadcast receivers, - a transformer that is both inductively (mutual) and capacitatively coupled. The input is fed from the limiter stage preceding. The output from the detector circuit is taken through a resistor to a condenser and potentiometer arrangement to the next stage.

[redacted]

### FM Detector Tube

66. The FM detector tube is a type 6H6 duo-diode with plates connected across opposite ends of the secondary of the last intermediate frequency transformer, and returned through the center tap of the transformer secondary, to the center tap of a resistance between both cathodes.

### Automatic Volume Control Circuits and Switch - FM and AM Operation

67. For AM operation the automatic volume control bias is taken off part of the resistive load of the AM detector diode, and fed through suitable resistive-capacitive networks to the control grid circuits of the first and second intermediate-frequency amplifier tubes. The automatic volume control operation is optional with AM reception. A switch connecting from the automatic volume control bias to ground provides means for grounding the automatic volume control bias, or applying it to the control grids of the tubes under control. When the receiver is put into FM operation, automatic volume control bias is put on the same tubes under control, by taking part of the voltage appearing in the grid circuit of the limiter tube caused by the flow of current through the grid resistor. There is no optional use of this automatic control bias, it being connected at all times for FM reception.

### First Audio Amplifier - Inverter Circuit

68. The first audio amplifier-inverter circuit utilizes two triodes, one for audio amplification and the other for phase inversion. The plate supply voltage is obtained from the 'B' supply voltage through a resistor.

### First Audio Amplifier - Inverter Tube

69. The first audio-amplifier-inverter tube is a 6C8G, duo-triode. The grid of one of the triodes is fed from the plate circuit of the other to provide the proper phase relationships for the output voltage.

### Output Circuit

70. The output circuit of the push pull output tubes is transformer coupled to the output terminals. The phone jack provides output for the phones from the preceding audio stage, when the phone plug is inserted, and shorts the output transformer of the last stage through a resistor to ground. When the phone plug is removed, the resistor is taken off from across the secondary of the output transformer, and power output becomes available for the 500 ohm or 5000 ohm terminal. The 5,000 ohm terminal is connected across the entire secondary of the output transformer, while the 500 ohm terminal is connected across part of the output transformer.

### Output Tubes

71. The output tubes are 6V6 beam power tetrodes. Plate voltage is fed through the primary of the output transformer. The cathodes are connected to ground through a resistor, and by-passed. The screen voltage is supplied directly from the power supply.

[redacted]

### Band Switch

72. The band switch has three positions. In each of the positions different sets of primaries and secondaries are switched in the R-F transformers.

### Selectivity Switch

73. The selectivity switch provides two positions of selectivity. For sharp selectivity, the circuits are conventional. For broad selectivity, resistances are added in the secondaries of the I-F transformers, and more coupling is added between the primaries and secondaries of the transformers. The switch also changes the bias on the last I-F amplifier of the AM stage by shorting out part of the cathode resistor load in that stage.

### Tone Control Circuit

74. The tone control circuit consists of a switch with four positions to switch different circuits containing resistance-capacity circuits.

### FM-AM Operation Switch

75. To switch from FM to AM operation, the single control does the following: (1) switch output of detectors from FM detector to AM detector; (2) change insertion point of the tuning meter, and (3) change the automatic volume control bias source, from the grid circuit of the limiter tube in FM operation to the load circuit of the diode detector.

### Tuning Meter Circuit

76. The tuning meter circuit consists of a tuning meter, 80-0-20 microamperes. For AM operation, the meter derives its current from the second intermediate-frequency amplifier tube plate current, shunted with 10 ohms. The variations in plate current to operate the meter are caused by the automatic volume control grid bias on the tube, which changes the plate current. The meter therefore, is effective only with AVC. It is made to operate only with the gain at maximum position, so that the calibration of the scale can be relied upon to a greater degree of accuracy for comparison of signal strengths. For FM operation, the meter is grounded where it formerly was connected to the plate supply voltage. The other end of the meter, then connects to a series resistance to the ungrounded cathode of the FM detector diodes. When the receiver is tuned to the center frequency of the incoming signal, the voltage drop across the cathode of that tube to ground, or cathode to cathode, is zero, so that no current will flow from the cathode to ground through the meter. On either side of the center frequency, however, the voltage from that cathode to ground, or to the other cathode, will be proportional to the deviation of the receiver frequency from the center frequency of the desired signal, being one value for an increase of receiver frequency, and the negative value for a decrease in frequency of the same amount, so that the meter needle will vary about a center position when tuning through a carrier, and would remain at zero when tuned to the center frequency. The swing of the needle, however, is limited by the pass band of the preceding stages.

[redacted]

### Automatic Noise Limiter Switch

77. The automatic noise limiter switch connects the noise limiter diode to the appropriate points in the diode detector circuit.

### Power Supply and Voltage Regulator

78. The power supply consists of a transformer-rectifier-filter, operating from a 115 volt, A-C source. The input is fused in both leads to the primary of the input transformers, and has in series with each lead to ground, a pi-network of capacity by-passes and R-F chokes, to reduce the feed-back of oscillator voltage to the line, and prevent disturbances from reaching the receiver power supply. A switch is provided in series with one of the leads. Separate transformers are used for plate and filament supplies. One side of the receiver filament supply is grounded. The output from the rectifier passes to a socket at the back of the receiver. With the proper type of shorting plug in the octal socket, the power supply can be made to work with either A-C or D-C, for D-C input, however, connection must be made to the socket instead of through the line cord. An external switch is placed in the center tap of the high voltage transformer, to permit switching of the receiver from send to receive, by means of an external contacting device, instead of the send-receive switch on the front panel. The rectified D-C, or the D-C from the external source, is then filtered through two pi-sections of chokes and condensers. Power for the output tube is taken from the first section. The second section feeds all the other tubes, with the exception of those elements or tubes, fed from the voltage regulator. The voltage regulator circuit is connected across the output of the second filter section and is used to supply voltage to the plate of the oscillator tube, the screen and plate of the converter tube, and the screen of the second intermediate-frequency amplifier tube.

### Power Rectifier and Voltage Regulator Tubes

79. The power rectifier is a 5Z3 full wave rectifier, with plate voltage supplied by the high voltage transformer, and filament voltage supplied by a separate winding on the filament transformer. The voltage regulator is a VR-150.

### Mechanical Inspection

80. The receiver was given a mechanical inspection to determine the extent to which the equipment is suitable for Naval service, with the results given in the following paragraphs.

### Number of Units Comprising Equipment

81. The receiver is complete in one cabinet, together with power supply. Terminals for speaker or headphones are provided at the rear of the receiver. A phone jack on the front panel may alternatively be used for head phone operation at lower power levels.

[redacted]

General Type of Construction

82. The receiver chassis is mounted in a cabinet of the following dimensions:

Height: 9"
Length: 19"
Depth: 12-1/4"

The front panel is attached by 6 screws of the self-tapping type, and is about 1/8" thick. The cabinet is ferrous with a black crackle finish. The panel is also ferrous. The top of the cabinet is a hinged cover which swings open, allowing replacement of tubes and dial lamps without disassembly. The cabinet bottom is integral with the rest of the cabinet, making it necessary to take the receiver out of the cabinet in order to service the underside. The receiver is not provided with rails to allow the chassis to slide out readily. The receiver chassis is also held on to the bottomside of the cabinet by 12 slotted-head detachable screws. The screws holding the chassis to the cabinet fit into tapped holes. No handles are provided on the cabinet or front panel. The sides are slotted, the bottom has louvers, and the cover top has holes for ventilation of the chassis. All lettering on the front panel has been done in silver. One of the receivers used for test purposes had been subjected to salt water atmosphere for several months. Part of the front panel and chassis had rusted.

Main Tuning Dial

83. The main tuning dial varies the tuning of the R-F and high frequency oscillator circuits. This dial is calibrated directly in megacycles, with a linear scale for calibration purposes. A series of brass gears, including five split gears, are used as the driving mechanism. A small vernier dial carries the small linear divisions, while the large dial carries the direct calibration and the large linear divisions. Both dials operate from the single control. The fiducial marks for both dial scales consist of black lines drawn on the celluloid coverings for the dial apertures. With such an arrangement errors in reading due to parallax can be very large. The celluloid used as front panel covering is unsturdy and gives objectionable glare and high lights because its rigidity is insufficient to maintain a flat surface. The vernier action is such that 52 turns of the tuning dial covers the complete range of the receiver. The tuning control is not provided with a crank to facilitate rotation of the tuning dial without fatigue to the operator. Calibration of the dial on the different bands varies from every half megacycle to every megacycle point. The dial itself is a celluloid translucent disc, with the numbers painted in black. The arbitrary scale markings are indistinguishable from the frequency markings. No provision is made for locking the control.

Antenna Compensator

84. This control varies the tuning of the radio-frequency tuned circuit in the first tuned circuit, to compensate for changes in antennas. The knob has numerals from 0 to 9 for calibration purposes.

[redacted]

## Band Switch

85. The band switch changes the tuning inductances of the R - F and oscillator circuits. The knob carries a triangular shaped index which rotates past the band numerals on the front panel. The switch has three positions corresponding to the arbitrary band designations appearing on the celluloid transparent covering over the main tuning dial aperture.

## R-F Gain

86. The R-F gain control is a potentiometer in the cathode circuits of the first two I-F stages. The knob is numbered around the periphery from 0 to 9 and rotates past a fixed index on the front panel. The control has a switch position at maximum R-F gain which switches in the "S" meter on AM operation.

## AVC Switch

87. The AVC switch is a two position toggle switch, labeled 'on-off' on the front panel. This switch applies AVC bias to the tubes under control.

## Selectivity Switch

88. The selectivity switch is a three position switch. The knob has a triangular shaped index on its surface which rotates past the three positions, titled 'A.C. Off' - 'Sharp' - 'Broad'. On the 'A.C. Off' position, power is removed from the receiver. On either of the other two positions the A-C power is applied to the receiver. With the switch on broad position, the I-F bandwidth is increased to a greater bandwidth than with the switch on sharp position.

## A-F Gain

89. The A-F gain control is a potentiometer in the input circuit to the grid of the first audio tube. The control knob is also numbered from 0 to 9 in a manner similar to that of the R-F gain control.

## Automatic Noise Limiter

90. The automatic noise limiter switch is titled 'A.N.L.' and is a toggle switch of the same general type of construction as the 'AVC On-Off' switch.

## AM-FM Switch

91. The AM-FM switch is a rotary wafer switch similar to the band switch, with the triangular index on its surface. The front panel is titled 'AM-FM' in accordance with the two positions of the switch.

### Beat Frequency Oscillator

92. The beat frequency oscillator switch is a toggle switch similar in type to that of the AVC on-off switch. The front panel is titled 'on-off' corresponding to the two positions of the switch. The switch controls the power to the beat frequency oscillator tube.

### Tone Control

93. The tone control switch is a four position switch with the designations 'Bass Boost', 'High Fid.', 'Normal', and 'Low', on the knob, rotating past a fixed index. This switch changes filter networks in the audio system.

### Send-Receive

94. The send-receive switch is a two position toggle switch controlling the 'B' voltage to the receiver stages.

### Other Panel Instruments and Devices

95. The front panel also contains the outlet for the phone jack, which delivers output from the first audio stage. The signal strength meter is also on the front panel. This meter is operative with the reception switch on FM operation, or with the R-F gain control turned up to the switch position on AM operation. On the front panel there is also a cover over a hole which permits alignment of the S-Meter by varying a potentiometer inside the cabinet. As per instructions, the S-Meter is aligned by setting the receiver in the AM position with power applied, and with the AVC on and the antenna disconnected, the R-F gain control is increased until the switch position is reached, at which point the 'S'-Meter potentiometer is varied until the 'S'-Meter reads zero.

### Dial and Knob Calibrations

96. Contrary to standard Navy practice, the main tuning knob has to be rotated counter-clockwise for a numerical increase in the linear calibration scale. The frequency, however, decreases as the linear scale numerically increases. In addition, the maximum controlled effect for both the R-F and A-F gain, is attained with the controls rotated toward a numerical decrease in the calibration. The rotation, however, is in the clockwise direction for maximum controlled effect.

### Panel Lighting

97. The scales of the main tuning dial, the Vernier tuning dial, and the 'S'-Meter are illuminated from inside the cabinet by small dial lamps, of the Mazda 44, 6-8 volts, blue bead type, with bayonet base. The dial lamp for the main tuning scale is mounted on an angle bracket to the top of the R-F section cover, held with one self-tapping screw. The dial lamp for the small Vernier scale is fastened in like manner to the rear panel of the gear assembly, with screw and lock-washer tapped into the

panel. The dial lamp for the 'S'-Meter consists of just the socket assembly, making tight fit through a rubber grommet in a hole in the back of the meter. This arrangement is capable of vibration. In addition, in one of the receivers tested, the dial lamp had been inserted too close to the meter scale, probably touching, so that part of the scale was burnt from the heat of the dial lamp. There is no provision for a stop to prevent the dial lamp from being inserted again in like manner.

98. Illumination of panel by one foot candle of light was found to be sufficient for reading all scales and control positions from at least a distance of about three feet, with the receiver power on and all dial lights on.

## Layout of Controls

99. The layout of controls, although not symmetrical, is pleasing, and accessibility is good. All controls work easily. On several of the models tested, it was found that the detent action of the band switch was not positive enough to preclude stoppage of the band switch at positions other than the designated ones. There is sufficient flywheel action of the main tuning dial to permit of rapid traversing of the entire band without fatigue to the operator. Each knob is fastened to its shaft with only one slotted head screw.

## Accessibility for Servicing

100. Accessibility for servicing of the receiver is generally good. Most of the tubes are available for replacement by lifting the hinged cover of the cabinet. The acorn type tubes in the R-F assembly can be reached by unscrewing the thumb screw and the five knurled nuts that hold the R-F section cover. Most trimmers are made accessible by lifting the hinged cover. In this position, the trimming adjustments are found on top of the I-F transformer cans for the I-F section, and through two holes in the R-F cover shield for the R-F oscillator. Some tuning adjustments can be reached through the holes in the Gusset plates.

## Accessibility for Repair

101. Accessibility for repair is generally good. After removing the chassis from the cabinet, the underside of the chassis is available for most types of repair work. The R-F assembly for the most part is accessible for repair after the cover shield has been removed, but the converter and oscillator section has several resistors and condensers which might not be replaced without considerable difficulty. I-F transformers are generally accessible with a minimum amount of work required to replace them. Some R-F chokes and other assemblies mounted on the sides of the chassis may be removed by means of a screwdriver, through holes provided in the Gusset plates for that purpose. The tuning controls and devices mounted on the front panel cannot be removed until the front panel has been removed. However, since the front panel is held to the Gusset plates with six slotted-head screws, it is believed that removal of the front panel would not present any major difficulty. Replacement

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of the bandswitch would involve the disassembly of the R-F section of the receiver. However, in view of the nature of the equipment it is believed that improvement in the accessibility of the bandswitch could be accomplished only with complete redesign, which might affect the operation of the equipment. The gear assembly driving the tuning dials can be removed as a unit by screws provided for that purpose. Due to the use of rivets instead of screws to hold the tube sockets and terminal strips, the replacement of these items would be greatly hampered. The front panel screws are not of the captive thumb screw type.

## Power Indicators

102. Indication of power 'on' is obtained by the markings of the selectivity switch, and the illumination of both the tuning dials and the 'S'-Meter.

## General Construction

103. The front panel is of magnetic material, and is finished in a relatively smooth black wrinkle finish. One of the receivers, subjected to salt water atmosphere, showed signs of rust on the front panel. The back of the panel has a smooth black finish. The gussets and chassis are also of ferrous materials, the gussets having a black wrinkle finish, and the chassis a plating of cadmium. The ferrous cabinet is finished in black wrinkle, with the exception of the underside of the cabinet and the underside of the hinged cover, which are finished in smooth black. Aluminum cans are used for the I-F transformers and the R-F chokes in the power leads. The R-F assembly, including cover shield, and sectionalizing shields, are also of cadmium-plated magnetic materials. Many screws, lockwashers, and shafts are of cadmium-plated magnetic materials. Other screws are of nickel-plated brass. Unplated materials are to be found in the brass coupling unit of the antenna compensator, the binding post screws, the meter terminals, a nut and coupling unit in the tuning condenser assembly, the springs on the main tuning dial clutch, and many gears and parts of the gear assembly. Two of the gears seem to be plated, or are of another material than the other gears. The grid cap of the 6C8G is also of cadmium plated magnetic material.

## Wire

104. The wiring of the receiver is done with solid wire, with fabric wraps, which may have been impregnated. This type wire has been found to be unsatisfactory in the presence of moisture. Heavy bus bar has been used for some wiring in the R-F section.

## Insulation Against Moisture

105. All small fixed resistors and capacitors do not seem to have adequate coatings of wax to exclude moisture. The paper covered condensers have been waxed.

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106. Generally, the insulation of the receiver is poor. Further clarification will be given in following paragraphs on component parts.

### Tube Sockets

107. Acorn tubes are mounted horizontally in ceramic sockets fastened with screws, nuts, and lockwashers to the R-F sectionalizing shields. These sockets are not considered as having good contacting grips. The other tubes of the receiver are vertically mounted in black phenolic sockets. The sockets in the receiver do not appear to have been waxed to reduce surface leakage. The phenolic sockets are fastened with rivets to the chassis. Holes for mounting with rivets are spaced 1-1/2 inches apart, as required of standard Navy receivers. In addition, each phenolic socket has stamped on it the type number of the tube to be inserted. Sockets are of the octal type, with the exception of the power rectifier and the acorn tubes.

### Transformers and Chokes

108. The iron transformers and chokes of the receiver appear to be sturdily built. However, most of the construction does not leave the core protected against moisture. The transformers and chokes do not appear to have been potted.

109. The R-F transformers are wound on bakelite tubing for the two lower frequency bands, and on solid bakelite rod for the highest frequency range. The coils on the tubing are wound with both cotton covered wire of small diameter, and a wire with a fabric wrap, of about number 16. The large diameter wire is coated with a lacquer or other binder to hold it to the tubing or rods. No such binder is used for the thin wire to enable it to retain its shape. Trimmers for the coils are mostly of ceramic insulated compression type capacitors, with mica dielectric. Two trimmers used on the oscillator coils, are of unknown construction; however, they appear to be made of metal rods which vary their capacity to another plate by screw action. The condenser trimmers appear to be cadmium plated. Cadmium has been found to be undesirable for such plating, because of its tendency to 'grow'.

110. The I-F transformers are wound on fish paper forms with cotton covered wire. The coils appear to be universal wound and wax covered. The leads from the coils terminate on two bakelite sheets used to hold the transformer in position. Air dielectric trimmers of the movable plate type are used to vary the tuning capacity of these coils. These condensers are mounted on a ceramic block. The transformer presents a very sturdy construction despite the fish paper forms. The transformer is enclosed in an aluminum can. Between transformer assembly and can is placed a sheet of waxed paper. The assembly is fastened to the top of the aluminum can by two nuts.

### Variable Condensers

111. Variable tuning condensers are ganged as in conventional ganging systems. The plates of the condensers are of aluminum fastened

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mechanically by means of a tight fit on to the rotor shaft and the mounting side plates. The plates are of unconventional shape and the outer plates of each condenser section are serrated to facilitate proper alignment of the receiver. The rotor shaft appears to be of silver-plated brass. Short linen base bakelite segments, of approximately 3/32" thickness are used to isolate the rotor shaft of each section. For each section of the condenser, four contacts are made to the rotor shaft by means of two springs with their flat sides wiping the sides of the rotor shaft created by a groove around the circumference. These springs appear to be silver-plated phosphor bronze. The contact springs are mounted on bakelite strips and grounded on to the sectionalizing shields of the stage of the high-frequency assembly which they tune. The stator plates are mounted on a material similar to micalex, of about 1/16" thickness. The sectionalizing shields and supporting assembly of the condenser unit are of cadmium plated magnetic material. The thickness of the silver plating on both rotor and contact wipers is unknown, but is estimated at less than 2 mils. The antenna compensator is composed of four plates total. The condenser has aluminum plates and ceramic insulation. The rotor wiper contact is integral with the three-fingered spring that holds the rotor plates in shape. No silver plating is employed. The pitch control condenser is of similar construction.

### Fixed Condensers

112. Many small mica condensers are used in the receiver. These condensers do not appear to have been wax-treated to prevent excess leakage. Numerous paper-covered paper condensers are used. These condensers have been wax-dipped. Several low-voltage electrolytic capacitors are used in the equipment, in addition to high voltage electrolytic capacitors used in the power supply filter. Capacitors are mounted on their pigtails whenever possible. Many can vibrate due to their long leads.

### Fixed Resistors

113. With several exceptions, the resistors used in the equipment appear to have ceramic insulation, and are mostly of the 1/3 watt size. Other resistors are of carbon, and some are wire-wound ohmite resistors with vitreous enamel coatings. As in the case of the condensers, resistors are mounted wherever possible on their pigtails, and many can vibrate due to their long leads.

### Variable Resistors

114. Wire wound and composition-type potentiometers are employed.

### Switches

115. The switch that functions in the S-Meter circuit and is part of the R-F gain control, is mounted as part of the control on the back of the R-F gain control potentiometer. The AVC on-off, automatic noise limiter, beat frequency oscillator, and send-receive switches are all of the toggle type. The selectivity switch and A-C on-off switch are mounted on the same shaft. The selectivity switch consists of three bakelite wafers to

which have been soldered the terminal lugs and wiper contacts and are of cheap broadcast receiver construction. The silver plating on the contacts appears to have been wiped away by the contacts. The A-C line on-off switch is of the same type as used to mount on the back of the potentiometer controls. The switch is housed in a black bakelite case. On one of the receivers examined, this case had been cracked. The assembly rods and plates on the switch are of cadmium plated magnetic materials. This switch is considered inadequate to meet the demands of Naval service. The A-M - F-M switch is of the same type of construction, but consists of one wafer. The tone control switch is very similar to the A-M - F-M switch. The band-change switch is a seven-ganged switch with very little detent action. The switch consists of a series of ceramic wafers on which the contacts are mounted. The switch is silver-plated, but due to the cutting action of the wiper contacts, it is doubtful whether the silver plating would be evident after a little usage. This switch too is considered to be poor as compared to the type of switch necessary to give dependable service.

### Terminal Strips

116. The terminal strips used in the receiver are of bakelite construction, with terminals riveted to the bakelite. Some, but not all, of the strips appear to have been wax treated. Terminal spacing is good. The strips are mounted by means of angle brackets usually riveted to the chassis. This mounting is very poor, since many of the terminal strips in receivers examined showed comparative freedom of movement.

### Mounting of Components

117. Components are generally mounted haphazardly with some components mounted on terminal strips. Resistors and condensers are not adequately secured to prevent movement with vibration of the receiver chassis. Rivets are used for mounting tube sockets and terminal strips The larger components are fastened to the chassis by means of nuts, screws, and lockwashers. The larger components are well-secured. Some self-tapping screws are used.

### Wiring

118. Wiring of the receiver is accomplished mostly with solid wire, covered with spaghetti. Other wire is of the push-back variety, color-coded, but deemed unsafe in the presence of moisture. Some of the wire appears to have been waxed. Despite the fact that cabling is used throughout the receiver, several long leads are unsupported and would undoubtedly vibrate considerably under conditions of shock or vibration of the receiver chassis. Ground lugs are not soldered to the chassis. The wire used in the R-F section of the receiver is in most instances solid bus bar with a protective covering of spaghetti. Fiber grommets are used in most instances where wire is brought through the chassis. Due to the poor type of wire used and the hygroscopic qualities of most types of fiber grommets, this type of insulation might be unsafe in the presence of moisture.

[redacted]

### Instruction Book

119. The instruction book supplied with the equipment by the manufacturer contains a block diagram of the receiver and a general discussion of amplitude and frequency modulation with reference to the subject equipment. The instruction book also describes the installation of the receiver, the type of antenna suitable for its operation, operating instructions, aligning instructions, list of parts, chassis sketch and wiring diagram.

### Spare Parts

120. No spare parts are furnished with the receiver.

## Electrical Tests

### Sensitivity

121. Measurements made of the Mcw sensitivity of the receiver are shown on Plates 1 and 2. On Plate 1 is shown the sensitivity of the receiver with the antenna compensator set at the high frequency end of each band and untuned for the other frequencies in that range. Plate 2 shows the sensitivities for the case where the antenna compensator is set for maximum response at each frequency. The discrepancy of sensitivity at the high frequency end of the receiver between both tests may be due to the fact that a considerable time elapsed between tests. The total sensitivity variation on Plate 1 is about 20 db and about 6 db on Plate 2 over the whole range of the receiver.

### Selectivity

122. Selectivities of the receiver were only taken through the intermediate-frequency amplifier, since with the lack of adequate preselection, the selectivity of the intermediate-frequency amplifier is the determining selectivity. Plates 3 and 4 show the selectivity for both positions of the selectivity control. For the broad condition the ratio of 6:60 DB points is sbout 6 and the same ratio for the sharp position is about 4.03. On sharp position, the ratio is comparable to similar types of receivers.

### Audio Fidelity

123. Audio fidelity characteristics as measured through the I-F amplifier for the different positions of the gain control as shown on Plate 5 with output from the 500 ohm terminal. Plate 6 shows the fidelity obtainable with the tone control switch on high fidelity and output from the phone jack with a 10,000 ohm termination, to demonstrate the response of the system when used in conjunction with high impedance terminations, such as oscilloscopes.

### Input Impedance

124. The input impedance of the receiver for several frequencies in each band is given in Table 1. There is a considerable mismatch between

[redacted]

the input impedance as given in this table and the surge impedance of transmission lines commonly used for ultra-high frequencies (70 ohms).

### Output Impedances

125. Table 2 shows the optimum matching impedance from all three terminals of the receiver. Improvement of output would be obtained were the output impedances matched properly to the output terminals.

### AVC Characteristics

126. AVC characteristics are shown on Plate 7. These characteristics are very poor as compared to the AVC action of equipments designed to Navy specifications.

### Audio Harmonic Distortion

127. Audio harmonic distortion for different conditions are shown on Tables 3, 4, and 5. The distortion in all instances is far in excess of the distortion usually tolerated in equipment designed for the Navy.

### Image Rejection

128. Image rejection is tabulated in Table 6. As compared to similar receivers under test, this image rejection is poor.

### I-F Signal Rejection

129. I-F signal rejection was found to be greater than 90 db over the complete range of the receiver. Since no signal generators were available to provide sufficient output to the receiver to determine the actual rejection ratios, no data is tabulated.

### Variation of Oscillator Frequency with Line Voltage and Line Frequency

130. Variation of oscillator frequency with line voltage and line frequency are shown on Plate 8 and Table 7 respectively.

### Variation of Oscillator Frequency with Humidity

131. Plate 9 shows the variation of the oscillator frequency with variation of humidity. On the same sheet is plotted the gain of the receiver. The receiver is unprotected against changes in humidity, accounting for the wide variation of oscillator frequency. The drift is enough to completely lose any signal originally within the pass band of the I-F amplifier.

### Variation of Oscillator Frequency with Temperature

132. Plate 10 shows the variation of oscillator frequency with temperature. The gain of the receiver is also plotted on the same sheet. The oscillator of this receiver is not thermostatically controlled, nor is it thermally insulated. The extent of temperature compensation is not known.

[redacted]

The drift in frequency with changes in temperature is great enough so as to completely shift any signal originally within the pass band of the receiver to a point far removed.

### Oscillator Drift During Warm-Up

133. Plate 11 shows the drift of the oscillator of the receiver during warm-up. From the curve, it is seen that the receiver stabilized in approximately 40 minutes. The frequency drift for one hour after the first two minutes of warm-up is considerably greater than the drift for similar receivers under the same conditions, but the drift for the period of one hour after the first hour of warm-up is comparable to the drifts of other receivers for the same time.

### Oscillator Frequency Variation with Change of Oscillator Tubes

134. Table 8 shows the frequency variation of the oscillator with change of oscillator tube to tubes with normal transconductance.

### 'S'-Meter Calibration

135. Plate 12 shows the 'S'-Meter calibration plotted against input in microvolts. The calibration of the meter is reasonably linear.

### R-F Gain Control Characteristics

136. R-F gain control characteristics are shown on Plate 13. The attenuation of the control, although almost linear does not comply with the usual requirements for Navy receivers that the attenuation be about 100 db.

### A-F Gain Control Characteristics

137. The A-F gain control characteristics are shown on Plate 14. This control too does not attenuate linearly to 100 decibels.

### Temperature Rise

138. Table 9 shows the rise in temperature of several points within the cabinet due to warm-up of the receiver.

### Vibration Test

139. The receiver was vibrated for about three hours, at periods of about an hour at a time. There was very little variation in sensitivity of the receiver throughout the test. During the test, a severe vibration modulation was noted when the receiver was vibrated from 820 to 1700 vibrations per minute. No mechanical damage was inflicted on the receiver.

### Rocking Test

140. The receiver was rocked for about 15 minutes, with no noticeable variation of sensitivity.

Radiation from Receiver Oscillators

141. Table 10 shows the radiation from both ultra-high-frequency and beat frequency oscillators. The radiation voltages are excessive as compared to similar types of receivers.

Backlash

142. The backlash was measured as .3 of a linear scale division throughout the range of the dial.

Calibration Accuracy

143. The linearity of the receiver calibration is shown on Plate 15. Plate 16 shows the accuracy of calibration. It will be noted that the calibration conforms with the tolerance usually allowed for such devices of ± 1%.

Power Requirements and Power Factor

144. Table 11 shows the power drawn by the receiver under different conditions of operation. The power factor under normal operating conditions was 95%.

Tuning Time

145. Less than one minute is required to change from any frequency within the range of the receiver to any other frequency within the range of the receiver and to make the necessary adjustments for optimum sensitivity.

Depth of Modulation Characteristics

146. Plate 17 shows the depth of modulation characteristics under different conditions of operation with and without AVC or automatic noise limiter. Departure from linearity occurs sensibly only with AVC on. The departure from linearity starts at 80% modulation, which is good compared to other receivers tested.

Resonant Overload Characteristics

147. Mcw resonant overload characteristics are shown on Plate 18 for MCW-AM operation. The characteristic is good as compared to other receivers.

Limiter Characteristics

148. Limiter characteristics for F-M operation are given on Plate 19. The limiter characteristics are good.

Discriminator Characteristics

149. The discriminator characteristics are given on Plate 20. The discriminator characteristics would allow a deviation of ± 75 Kc. for linear output not taking into account the selectivity of the system.

[redacted]

### Reserve Gain

150. Reserve gain is given on Plate 21. The receiver does not have enough gain to satisfy the usual Naval requirements of at least 10 decibels reserve gain.

### Overload Selectivity

151. Overload selectivity measurements could not be determined satisfactorily due to the poor performance of the receiver. Numerous responses were noted. The receiver performed poorly over the range of plus or minus 6 megacycles from 144 megacycles, in the presence of a strong signal such as from the type XTBT transmitter.

### Cross-Modulation Selectivity

152. Cross-modulation selectivity measurements could not be determined satisfactorily also due to the poor performance of the receiver in the range of plus or minus 1 megacycle from 144 megacycles. In the presence of a strong signal such as from the XTBT transmitter. Monitoring of speech transmission when the transmitter was near, was found to be impractical.

### Audio Power Output

153. Maximum audio power output is given in Table 12.

## SUMMARY OF DEFECTS

154. Some of the tubes used in the equipment are not Navy approved types. Reference paragraph 44.

155. The noise limiter used in this receiver is relatively ineffective. Reference paragraph 61.

156. One of the receivers used for test purposes had been subjected to salt-water atmosphere for several months during which part of the front panel and chassis had rusted as a result. Paragraph 103.

157. Contrary to Navy practice, the main tuning knob has to be rotated counter-clockwise for a numerical increase in the linear calibration scale. The frequency, however, decreases as the linear scale increases numerically. Reference paragraph 96.

158. The arbitrary scale on the main tuning dial can be easily confused with the frequency scales. Reference paragraph 83.

159. Maximum controlled effect for both the R-F and A-F gain controls is obtained with the controls rotated toward a numerical decrease in the calibration. Reference paragraph 96.

160. No locking device is provided for the main tuning dial. Reference paragraph 83.

[redacted]

161. The celluloid used as main tuning dial windows is not considered sturdy enough. Reference paragraph 83.

162. In one of the receivers tested, the dial lamp had been inserted too close to the meter scale, so that part of the scale was burnt from the heat. Reference paragraph 97.

163. Detent action of the band switch is poor. Reference paragraph 99.

164. The converter and oscillator section has several resistors and condensers which could not be replaced without considerable difficulty. Reference paragraph 101.

165. The front panel screws are not of the captive thumb screw type. Reference paragraph 101.

166. The receiver is not provided with rails to allow the chassis to slide out readily. Reference paragraph 82.

167. The chassis is secured to the bottom of the cabinet with screws which must be removed to permit withdrawal of the chassis, and render it inconvenient to secure the receiver to a table through the medium of shock mounts. Reference paragraph 82.

168. No handles are provided on the front panel of the chassis. Reference paragraph 82.

169. Some brass and other corrosive materials have not been adequately plated. Reference paragraph 103.

170. The wire used in the receiver has been found to be unsatisfactory in the presence of moisture. Reference paragraph 104.

171. All small fixed condensers and resistors do not seem to have adequate coatings of wax to exclude moisture. Reference paragraph 105.

172. The receiver employs paper-covered condensers which have been found to be unsatisfactory for Naval use. Reference paragraph 112.

173. Tube sockets used for the I-F stage are not ceramic. Reference paragraph 107.

174. Tube sockets used in the equipment do not appear to have been wax-treated to reduce surface leakage. Reference paragraph 107.

175. The cores of the transformers and chokes are not generally protected against moisture and do not appear to have been potted. Reference paragraph 108.

176. Coil forms for the tuning coils are of bakelite instead of ceramic or styrene. Reference paragraph 109.

[redacted]

177. The turns of wire on the tuning coils do not appear to have been adequately fastened to the forms. Reference paragraph 109.

178. The cadmium plating of the type used on the small trimmer condensers has been found to have a tendency to 'grow'. Reference paragraph 109.

179. The compression type trimmers have been found to be unsatisfactory. Reference paragraph 109.

180. The I-F transformers are wound on fish paper forms. Reference paragraph 110.

181. The silver plating of the wipers and contacts on the main tuning condenser does not appear to be adequate. Reference paragraph 111.

182. Electrolytic capacitors are used for high voltage filtering. Reference paragraph 112.

183. Resistors and condensers are not mounted sturdily enough to prevent excessive movement with vibration or shock of the receiver. Reference paragraph 117.

184. The receiver employs self-tapping screws. Reference paragraph 117.

185. Bakelite insulation instead of ceramic is used for the selectivity switch. Reference paragraph 115.

186. The silver plating of the selectivity switch does not appear to be adequate. Reference paragraph 115.

187. On one of the receivers examined, the casing of the power on-off switch was cracked. Reference paragraph 115.

188. The band change switch is poor in construction and insulation as compared to the types of switches usually required for Naval equipment. Reference paragraph 115.

189. All the terminal strips used in the receiver have not been wax treated to prevent excess surface leakage. Reference paragraph 116.

190. The mounting of many of the terminal strips is poor. Reference paragraph 116.

191. Rivets have been used for mounting tube sockets and terminal strips. Reference paragraph 117.

192. Several long wires have not beenadequately secured to prevent vibration. Reference paragraphs 117 and 118.

193. Ground lugs have not been soldered to the chassis. Reference paragraph 118.

[redacted]

194. The use of fiber grommets is questionable in the presence of excess moisture. Reference paragraph 118.

195. There is a considerable mismatch between the input impedance of the receiver and the surge impedance of transmission lines commonly used for ultra-high frequencies. Reference paragraph 124.

196. The output impedance marked on the terminals of the receiver do not represent the optimum matching impedances. Reference paragraph 125.

197. The AVC characteristics are very poor as compared to the AVC characteristics of equipments designed to Navy specifications. Reference paragraph 126.

198. The distortion of the audio system is far in excess of the distortion usually tolerated in equipment designed for the Navy. Reference paragraph 127.

199. Image rejection is poor. Reference paragraph 128.

200. The drift in frequency due to changes of humidity and temperature is too great to retain a signal within the pass band of the receiver over the range of ambient conditions under which the receivers were tested. Reference paragraphs 131, 132.

201. Both A-F and R-F gain controls should have linear attenuation characteristics of about 100 decibels. Reference paragraphs 136, 137.

202. Severe vibration modulation was noted when the receiver was vibrated over a wide range of vibration frequencies. Reference paragraph 139.

203. The radiation voltages from the receiver oscillators are excessive as compared to similar types of receivers. Reference paragraph 141.

204. The receiver does not have enough gain to satisfy the usual Naval requirements of at least 10 decibels reserve gain throughout the range of the receiver. Reference paragraph 150.

205. Overload selectivity measurements and cross-modulation selectivity measurements, although not complete, adequately showed that the receiver was much inferior in performance to equipment which would be considered suited for Naval use. Reference paragraphs 151 and 152.

CONCLUSIONS

206. (a) The Hallicrafter's model S27 receiver is the only commercially available receiver known to the Laboratory that will cover the range from 28 to 140 mcs.

[redacted]

(b) This receiver possesses good sensitivity, fair selectivity, and good I-F signal rejection. The radiation from the receiver oscillators is excessive. The receiver has poor image rejection ratio, poor oscillator stability, and poor overload and cross-modulation selectivity.

(c) With mechanical and electrical improvements as noted herein, the receiver will more closely approach the standards set for equipment to withstand the rigors of Naval usage.

(d) The 6 db selectivity is not broad enough to permit reliable communication without operator attendance in view of the instabilities from temperature humidity and other causes incidental to normal service operation.

## RECOMMENDATIONS

207. All the changes listed herein are desirable, and it is recommended that as many be acted upon as consistent with the amount of time available.

(a) That Navy approved tube types be used in the receiver.

(b) That the noise limiter be changed to a more effective type such as the Karr Series Noise Limiter.

(c) That non-ferrous substitutes or suitable corrosion-resistant surfaces on iron, steel, or brass parts be employed. In view of the scarcity of non-corrosive materials, it is probable that a specification requiring their use would be out of order. However, in view of their use, particular emphasis should be placed upon the importance of suitably treating ferrous and brass materials to avoid corrosion and rust. It is not believed that this has been successfully accomplished in the Hallicrafter Model S27 receivers tested.

(d) That the calibration and rotation of the main tuning dial be such that a clockwise rotation of the main tuning dial control will effect an increase in both frequency and calibration on the arbitrary scale, and that a crank be used on main tuning control to facilitate tuning.

(e) That the arbitrary logging scale markings on the main tuning dial be printed in a different color or otherwise distinguished to avoid confusion with the marking of 'megacycles' just above it.

(f) That maximum controlled effect for both the A-F and R-F gain controls be obtained with the gain controls rotated clockwise toward an increase in the magnitude of the calibration.

(g) That provision be made for locking the tuning control in any desired position. While it is recognized that there is no need for this improvement for intercept work, it is believed to be desirable from the point of view of possible use of the receiver for communications purposes in which a fixed tuning adjustment must be maintained without disturbance due to accidental contact with the tuning control knob or its crank.

[redacted]

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(h) That a more sturdy material be used in front-panel windows. This recommendation is prompted by the use of celluloid windows which gives objectionable glare and high lights partly because its rigidity is insufficient to insure maintenance of a flat surface.

(i) That a stop be provided to prevent insertion of the dial lamp too close to the scale of the tuning meter.

(j) That the detent action of the band switch should be made more positive.

(k) That the accessibility of components in the converter and oscillator section be improved.

(l) That the chassis and cabinet design be changed to permit ready removal of the chassis from the cabinet after loosening captive screws on the front panel. Rails or similar means should be provided to allow the chassis to slide readily to a partially removed position at which it may be secured for servicing, or to permit the chassis to be withdrawn completely from the cabinet when necessary for more extensive repair. In practice, the receiver will be permanently mounted as recommended in the following paragraph.

(m) That means be provided for securing the receiver to a table through the medium of suitable shock mounts, such as four Lord mounts. The chassis should not be secured to the bottom of the cabinet.

(n) That handles be provided on the front panel to facilitate withdrawal of the chassis from the cabinet.

(o) That hook-up wire be used which will meet Naval requirements relative to moisture, spray and heat resistance. In particular, that rubber (or equivalent homogeneous) covering be incorporated as a part of the insulation on all wiring carrying direct currents or radio-frequency voltages of any amounts. What appears to be a satisfactory substitute for rubber is provided in the so-called 'Aeroglas' wire produced by the Lenz Company.

(p) That a wax treatment be applied to the terminal strips, fixed resistors, fixed condensers, tube sockets and radio-frequency as well as intermediate-frequency coil assemblies.

(q) That electrolytic and paper covered condensers be eliminates, impregnated paper condensers in sealed cans being substituted.

(r) That ceramic insulation or equal be provided instead of penolic fiber or bakelite insulation in R-F and I-F stages.

[redacted]

(s) That transformers, filter reactors, and paper condensers be impregnated and sealed in cans in such a way that compound is not lost during normal operation which may be at ambient temperatures between 0 and 60 degrees Centigrade.

(t) That trimmers of the compression type be avoided if feasible, the air dielectric trimmer condensers being preferable. The cadmium used as plating for these trimmers has been found to have a tendency to 'grow'.

(u) That ceramic forms be used for I-F coil assemblies.

(v) That solid silver contact surfaces be provided in lieu of electro-depositived silver at all locations where radio-frequency or intermediate-frequency currents must be passed between relatively moving contacts. This refers particularly to band switches, selectivity switches, and tuning condenser rotor contacts. All wafer switches should be replaced by switches having solid silver contacts similar to the newly developed Oak or Yaxley Mallory switches which have solid silver contacts and would be preferable to those employed in the receivers tested.

(w) That the mechanical design be improved to provide better rigidity and orderliness in mounting components and in laying out and securing wiring.

(x) That vacuum tube sockets and other components which may be subject to removal, be secured to the chassis by machine screws and nuts rather than by rivets.

(y) That the use of self-tapping screws be avoided.

(z) That acorn type vacuum tube sockets of improved design as to contacting grips be provided.

(aa) That care be taken to insure that no undue strain is placed on the power on-off switch as would cause the case to crack.

(bb) That ground lugs be soldered to the chassis.

(cc) That a clip designed to receive a protective gap across the antenna input circuit be mounted in the receiver. It would then be readily possible to install such a gap if this proves desirable when working near powerful transmitters.

(dd) That the tuning control fiducial mark be mounted rigidly with respect to the tuning dial and not depend for support on the window material.

(ee) That the input be designed to receive transmission lines of 70 ohms surge impedance with smaller mismatching,

[redacted]

(ff) That the output transformer be chosen so as to provide maximum power output conditions when the nominal loads are inserted across the output terminals on the rear of the receiver chassis.

(gg) That the AVC characteristics be improved.

(hh) That the audio harmonic distortion be reduced if possible.

(ii) That the image rejection ratio be increased if possible.

(jj) That the receiver be compensated for changes in temperature and humidity.

(kk) That the A-F and R-F gain controls be designed so as to offer a linear attenuation throughout the range of the control, to about 100 decibels.

(ll) That the cause of severe vibration modulation be determined and corrected if possible.

(mm) That the cause of excessive radiation from the receiver oscillators be determined and corrected if possible.

(nn) That more gain be incorporated into the design of the first R-F stage.

(oo) That means be taken to improve the performance of the receiver as regards overload and cross-modulation selectivity.

[redacted]

## Table 1

## Input Impedance of Hallicrafter's Model S27 Receiver #112905

| Band | Frequency | Input Impedance |
|---|---|---|
| 1 | 28 MC | 185 ohms |
| | 38 | 141 |
| | 46 | 195 |
| 2 | 48 | 185 |
| | 64 | 104 |
| | 80 | 55 |
| 3 | 82 | 233 |
| | 110 | 124 |
| | 140 | 279 |

## Table 2

## Output Impedances of Hallicrafter's Model S27 Receiver #112905

| Terminal | Matching Optimum Impedance |
|---|---|
| 500 ohm | 200 ohms |
| 5000 ohm | 10,000 ohms |
| Phone Jack | > 20,000 ohms |

[redacted]

[redacted]

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## Table 3

### Harmonic Distortion as a Function of Depth of Modulation

Hallicrafter's Model S27 Receiver #112905

| Depth of Modulation at 400 cps. | Total Distortion |
|---|---|
| 20 % | 19.5 % |
| 30 | 21.5 |
| 40 | 22.8 |
| 50 | 26.2 |
| 60 | 22.6 |
| 80 | 24.0 |
| 100 | 25.8 |

## Table 4

### Harmonic Distortion as a Function of Input Hallicrafter's Model S27 Receiver #112905

| Input | 30% Modulation at 400 cps. Total Distortion |
|---|---|
| 5,000 μv | 21.8 % |
| 50,000 | 20.6 |
| 500,000 | 17.5 |

## Table 5

### Harmonic Distortion as a Function of Input Audio Frequency, Hallicrafter's Model S27 Receiver #112905

Input Modulation 30%

| Modulation Frequency | Total Distortion |
|---|---|
| 100 cps | 26.4 % |
| 400 | 19.6 |
| 700 | 19.3 |
| 1000 | 18.3 |
| 4000 | 8.5 |

[redacted]

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## Table 6

### Image Rejection of
### Hallicrafter's Model S27 Receiver #112905

| Band | Receiver Frequency | Image Rejection Ratio | DB Image Rejection Ratio |
|---|---|---|---|
| 1 | 28 MC | 5600 | 75 DB |
| | 36 | 1400 | 63 |
| | 47 | 360 | 51.1 |
| 2 | 47 | 190 | 45.6 |
| | 65 | 187 | 45.4 |
| | 82 | 333 | 50.4 |
| 3 | 83 | 210 | 46.4 |
| | 112 | 40 | 32 |
| | 140 | 280 | 49 |

## Table 7

### Change in Oscillator Frequency With
### Input Line Frequency
### Hallicrafter's Model S27 Receiver #112905

Receiver at 140 MC

| Order of Measurement | Line Frequency | Oscillator Frequency Variation |
|---|---|---|
| 1 | 57 | 0 |
| 2 | 63 | - 5.7 KC |
| 3 | 60 | + 4.3 KC |
| 4 | 57 | -.1.4 KC |
| 5 | 63 | - 8.5 KC |

## Table 8

### Oscillator Frequency Variation with
### Change of Oscillator Tubes
### Hallicrafter's Model S27 Receiver #112905

| Tube No. | Oscillator Deviation |
|---|---|
| 1 | 0 KC |
| 2 | +882 |
| 3 | +540 |
| 4 | +513 |
| 5 | +598 |
| 6 | +518 |

[redacted]

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## Table 9

## Temperature Rise of Interior of Cabinet Hallicrafter's Model S27 Receiver #112956

Receiver turned on at 0 minutes

| Time | Room Temperature | High Frequency Top Shield Temperature | Power Transformer Temperature |
|---|---|---|---|
| 0 min. | 26° C. | 26.5° C. | 26.5° C. |
| 30 | 26 | 31 | 34 |
| 60 | 26 | 34 | 40 |
| 90 | 25.5 | 35 | 43 |
| 120 | 25 | 36 | 46 |
| 150 | 25 | 36 | 47 |

## Table 10

## Radiation of Oscillators of Hallicrafter's Model S27 Receiver #112905

| | U-H-F Oscillator Radiation at Antenna Terminals | |
|---|---|---|
| Band | Receiver Frequency | Oscillator Radiation |
| 1 | 28 Mc | 4800 μv |
| 1 | 48 | 1200 |
| 2 | 48 | 5000 |
| 2 | 82 | 3500 |
| 3 | 82 | 2800 |
| 3 | 142 | 5000 |

Beat Freq. Osc. Radiation

| | |
|---|---|
| Across 500 Ω in 500 Ω Term. | 630 |
| Across 5000 Ω in 5000 Ω Term. | 8500 |
| Across 20,000 Ω in Phone Jack | 1000 |

[redacted]

[redacted]

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## Table 11

### Power Drawn Under Different Conditions by Hallicrafter's Model S27 Receiver #112905

| Conditions | Wattmeter | Power Factor |
|---|---|---|
| Normal | 90 watts | 95% |
| 'Send' Operation (Otherwise Normal) | 53.5 | |
| R-F Gain @ Maximum (Otherwise Normal) | 90 | |
| R-F Gain @ Minimum (Otherwise Normal) | 86.5 | |
| BFO Switch on (Otherwise Normal) | 91 | |

## Table 12

### Maximum Power Output from Receiver Under Optimum Load Conditions

| | 1000 cps. Output | | |
|---|---|---|---|
| Terminal | Load | Maximum Volts Across Load | Maximum Power Output |
| 500 ohms | 200 ohms | 14 V | 980 MW |
| 5000 ohms | 10,000 ohms | 29 V | 84 MW |
| Phone Jack | >20,000 ohms | >30 V | >45 MW |

[redacted]

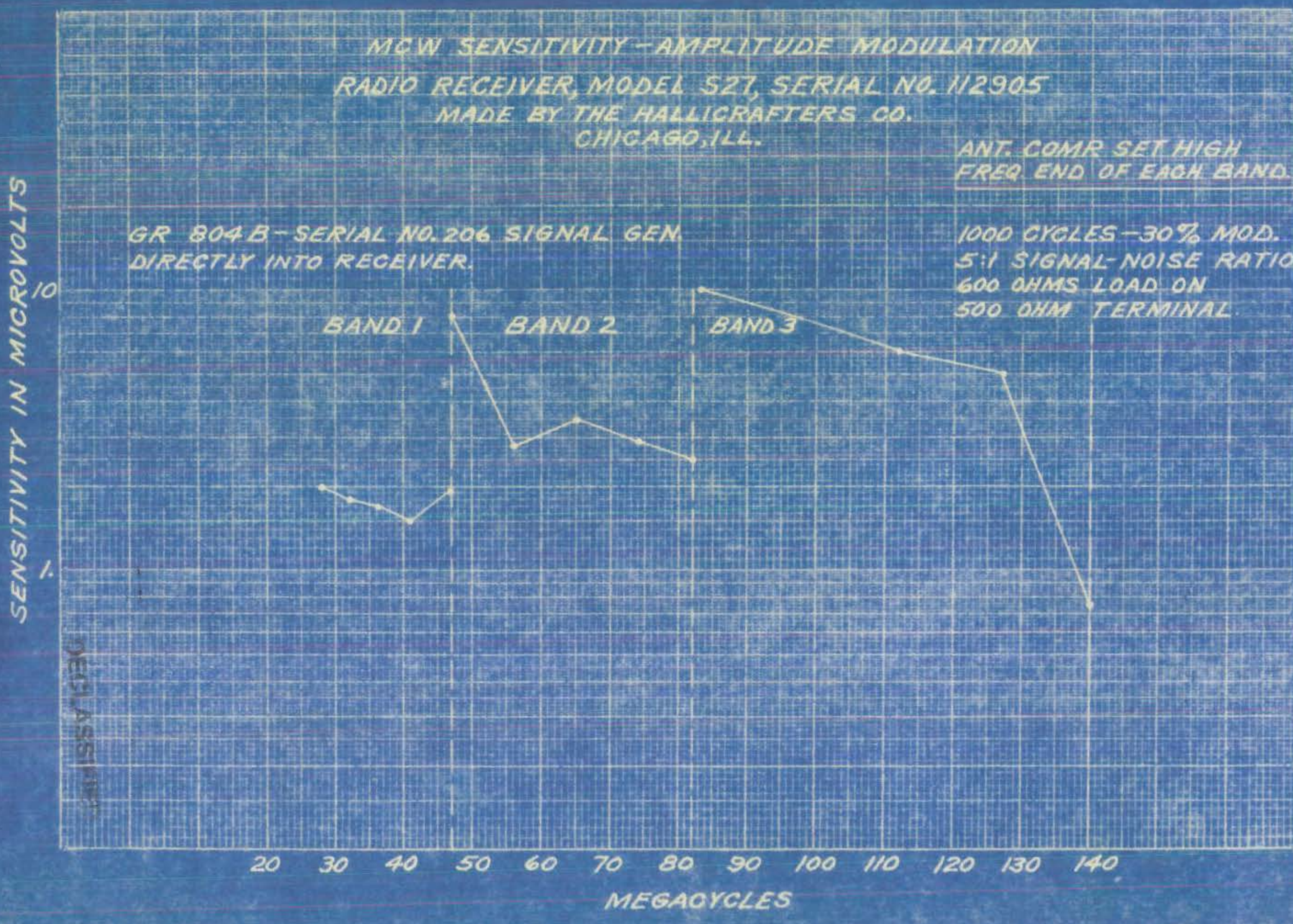
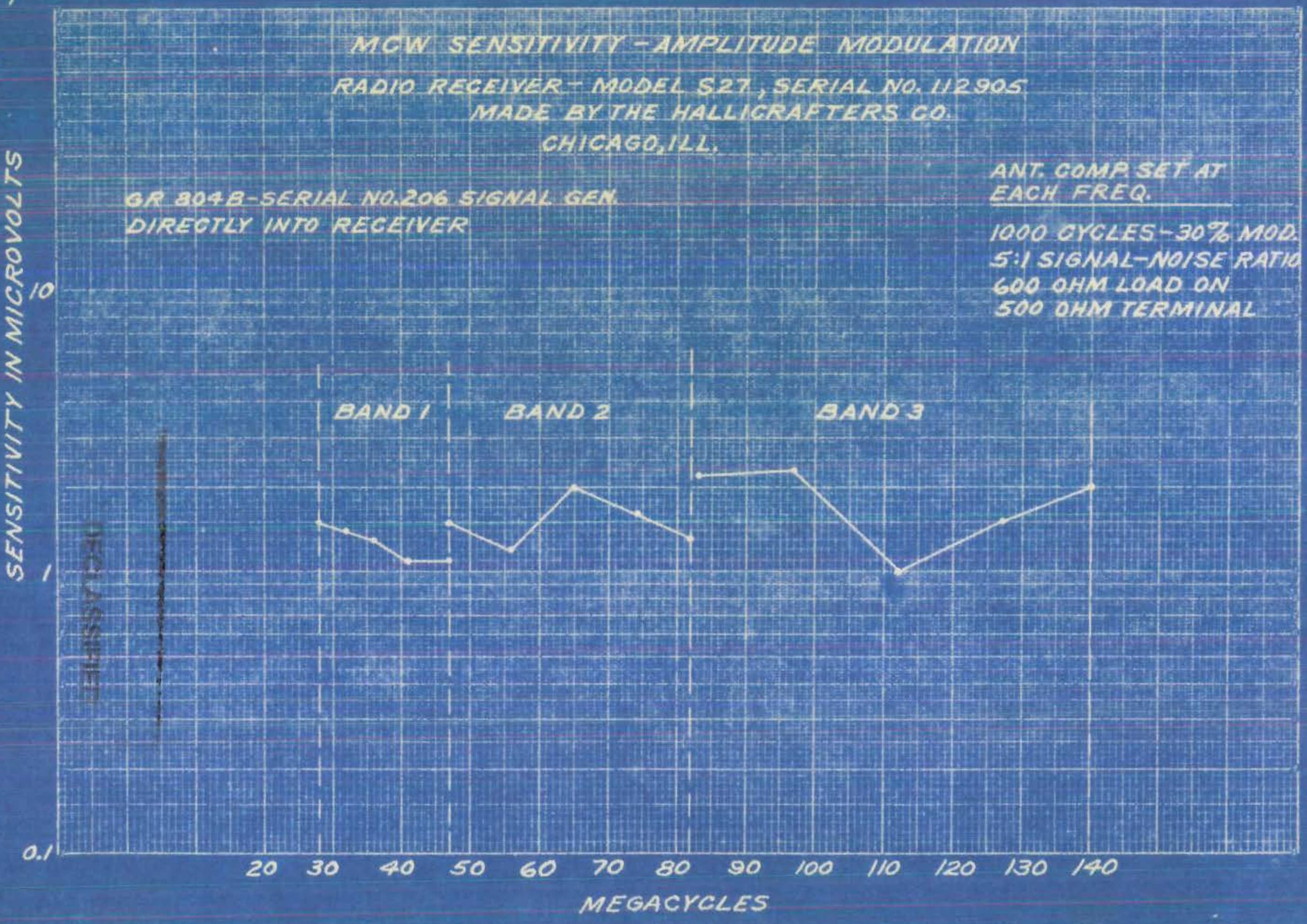

MCW SENSITIVITY-AMPLITUDE MODULATION
RADIO RECEIVER, MODEL S27, SERIAL NO. 112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.
ANT. COMP. SET HIGH FREQ. END OF EACH BAND
GR 804 B-SERIAL NO. 206 SIGNAL GEN. DIRECTLY INTO RECEIVER.
1000 CYCLES-30% MOD.
5:1 SIGNAL-NOISE RATIO
600 OHMS LOAD ON
500 OHM TERMINAL
BAND 1
BAND 2
BAND 3
SENSITIVITY IN MICROVOLTS
10
1.
20
30
40
50
60
70
80
90
100
110
120
130
140
MEGACYCLES

PLATE I


MCW SENSITIVITY - AMPLITUDE MODULATION
RADIO RECEIVER - MODEL S27, SERIAL NO. 112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.
GR 804B-SERIAL NO. 206 SIGNAL GEN.
DIRECTLY INTO RECEIVER
ANT. COMP. SET AT EACH FREQ.
1000 CYCLES-30% MOD.
5:1 SIGNAL-NOISE RATIO
600 OHM LOAD ON
500 OHM TERMINAL
BAND 1
BAND 2
BAND 3
SENSITIVITY IN MICROVOLTS
10
1
0.1
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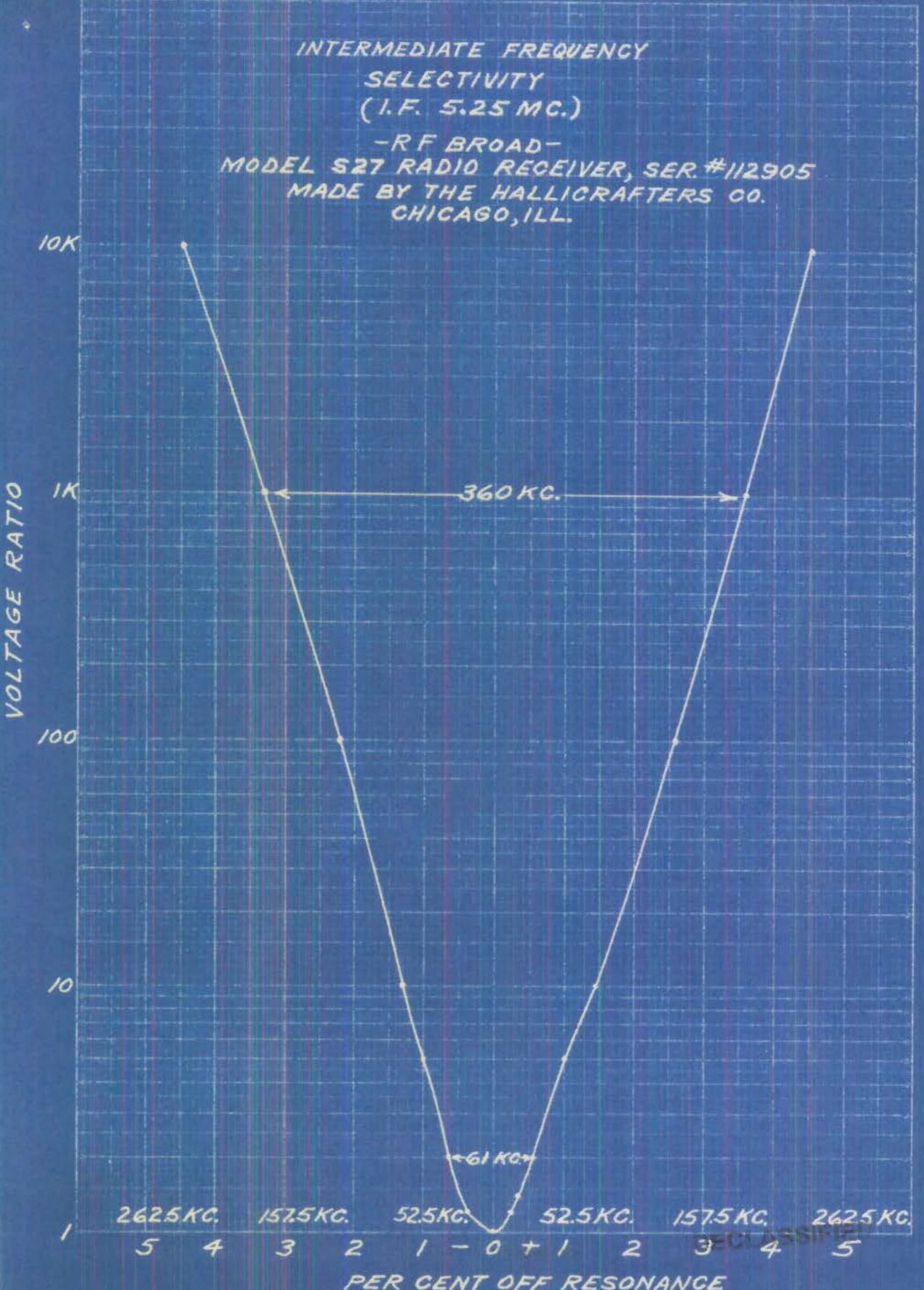
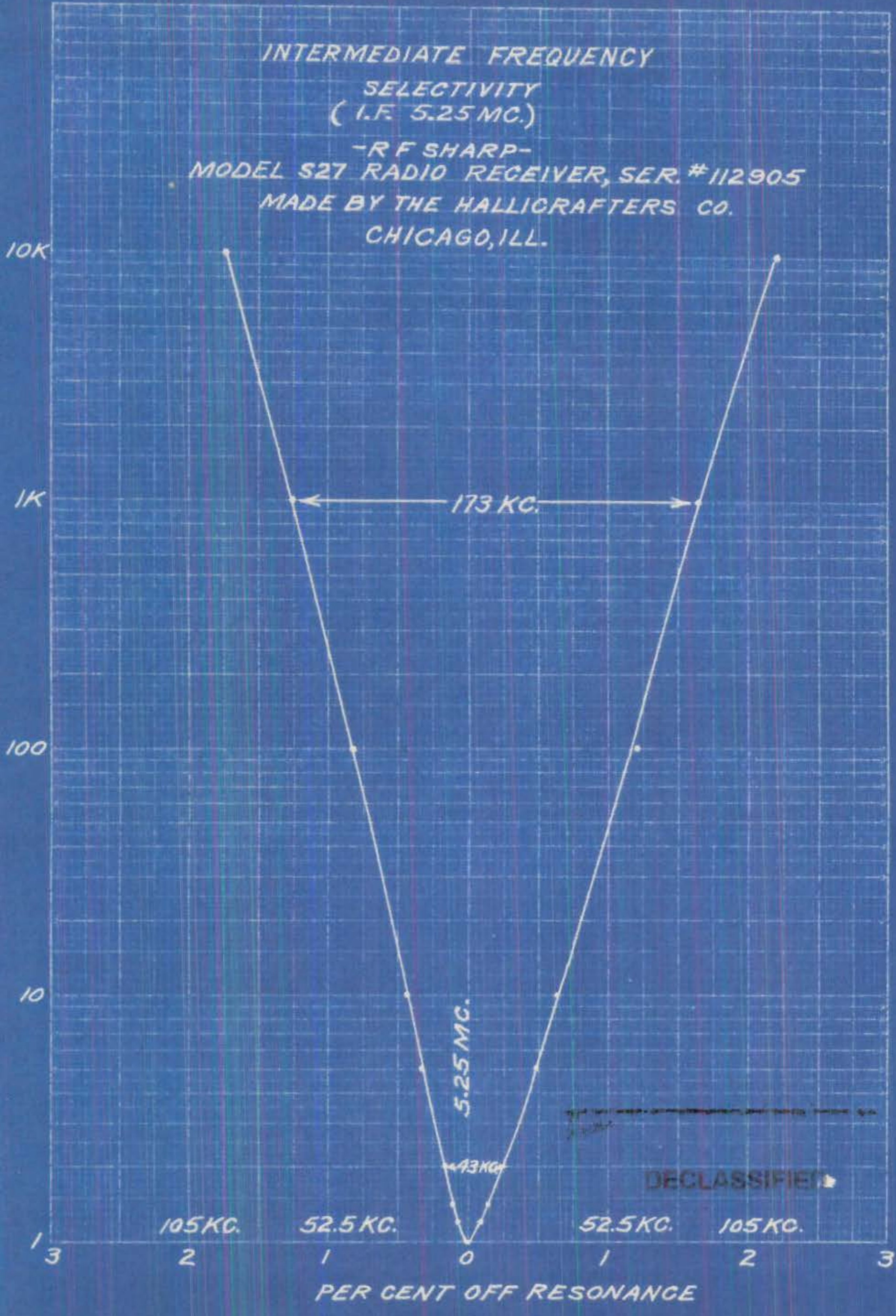
40
50
60
70
80
90
100
110
120
130
140
MEGACYCLES

PLATE 2



INTERMEDIATE FREQUENCY
SELECTIVITY
(I.F. 5.25 MC.)
-RF BROAD-
MODEL S27 RADIO RECEIVER, SER. #112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

PLATE 3



INTERMEDIATE FREQUENCY
SELECTIVITY
( I.F. 5.25 MC.)
-R F SHARP-
MODEL S27 RADIO RECEIVER, SER. #112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

PLATE 4

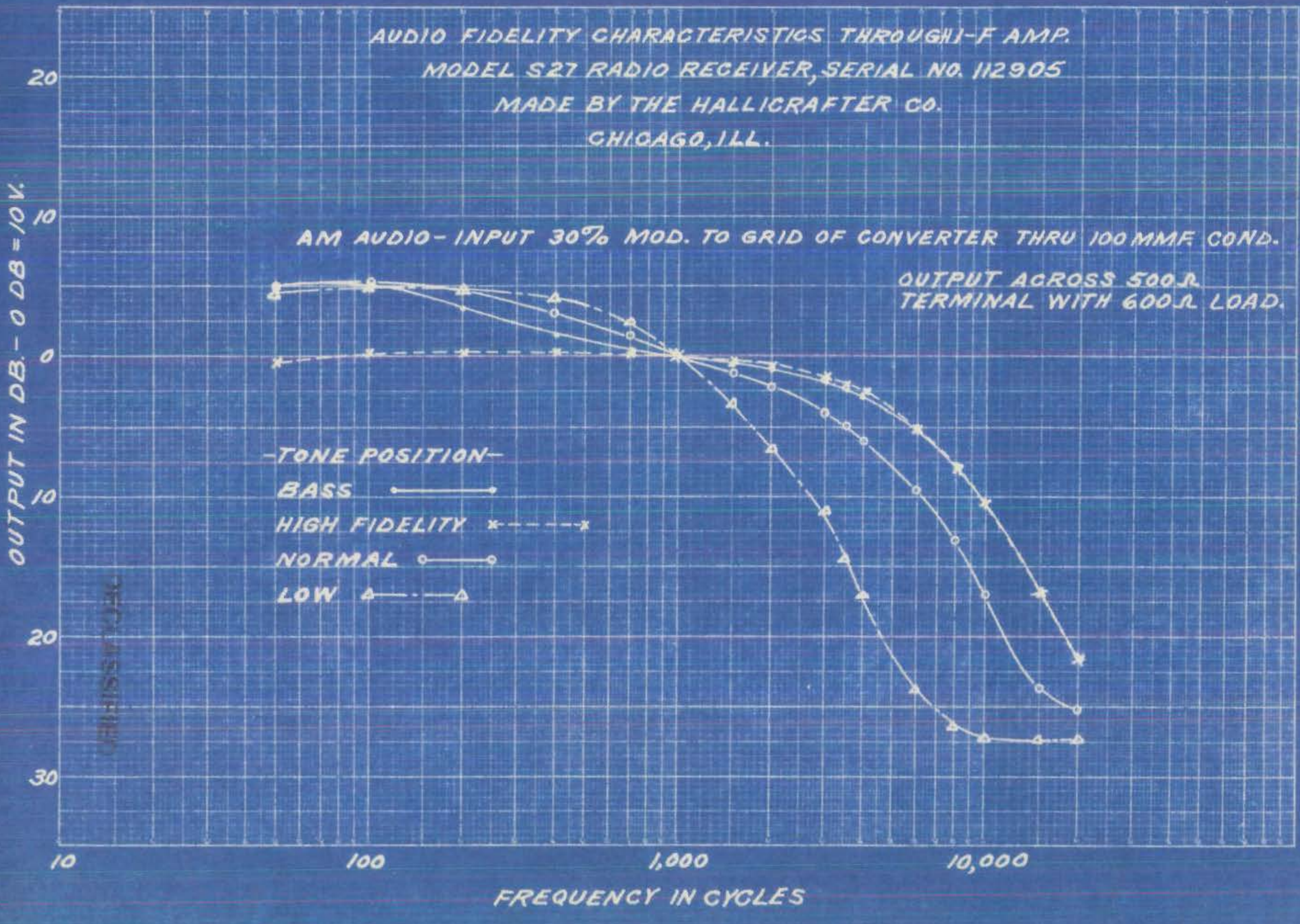
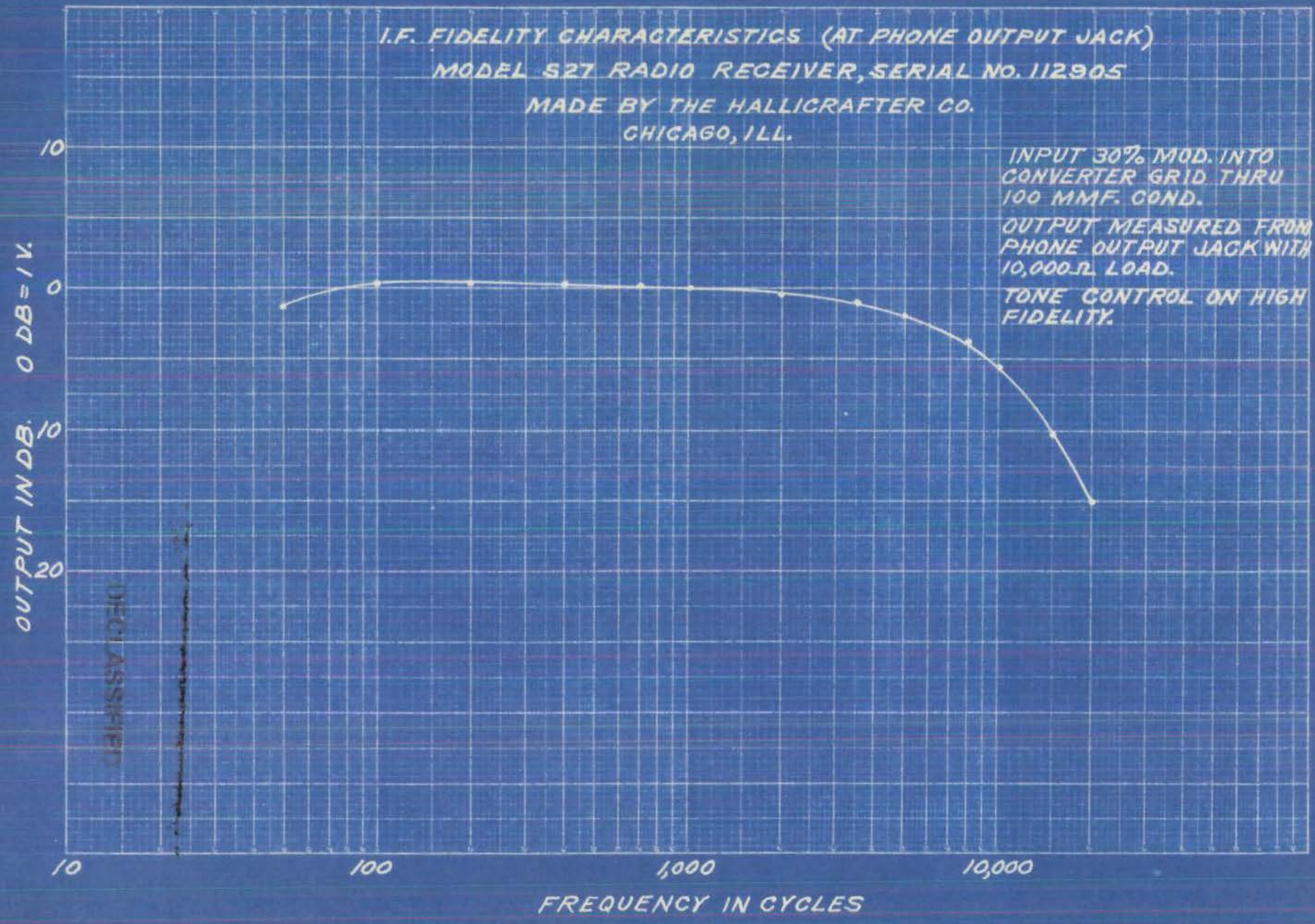

AUDIO FIDELITY CHARACTERISTICS THROUGH I-F AMP.
MODEL S27 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.
AM AUDIO-INPUT 30% MOD. TO GRID OF CONVERTER THRU 100 MMF. COND.
OUTPUT ACROSS 500Ω TERMINAL WITH 600Ω LOAD.
-TONE POSITION-
BASS
HIGH FIDELITY
NORMAL
LOW
20
10
0
10
20
30
OUTPUT IN DB. - 0 DB = 10 V.
10
100
1,000
10,000
FREQUENCY IN CYCLES

PLATE 5



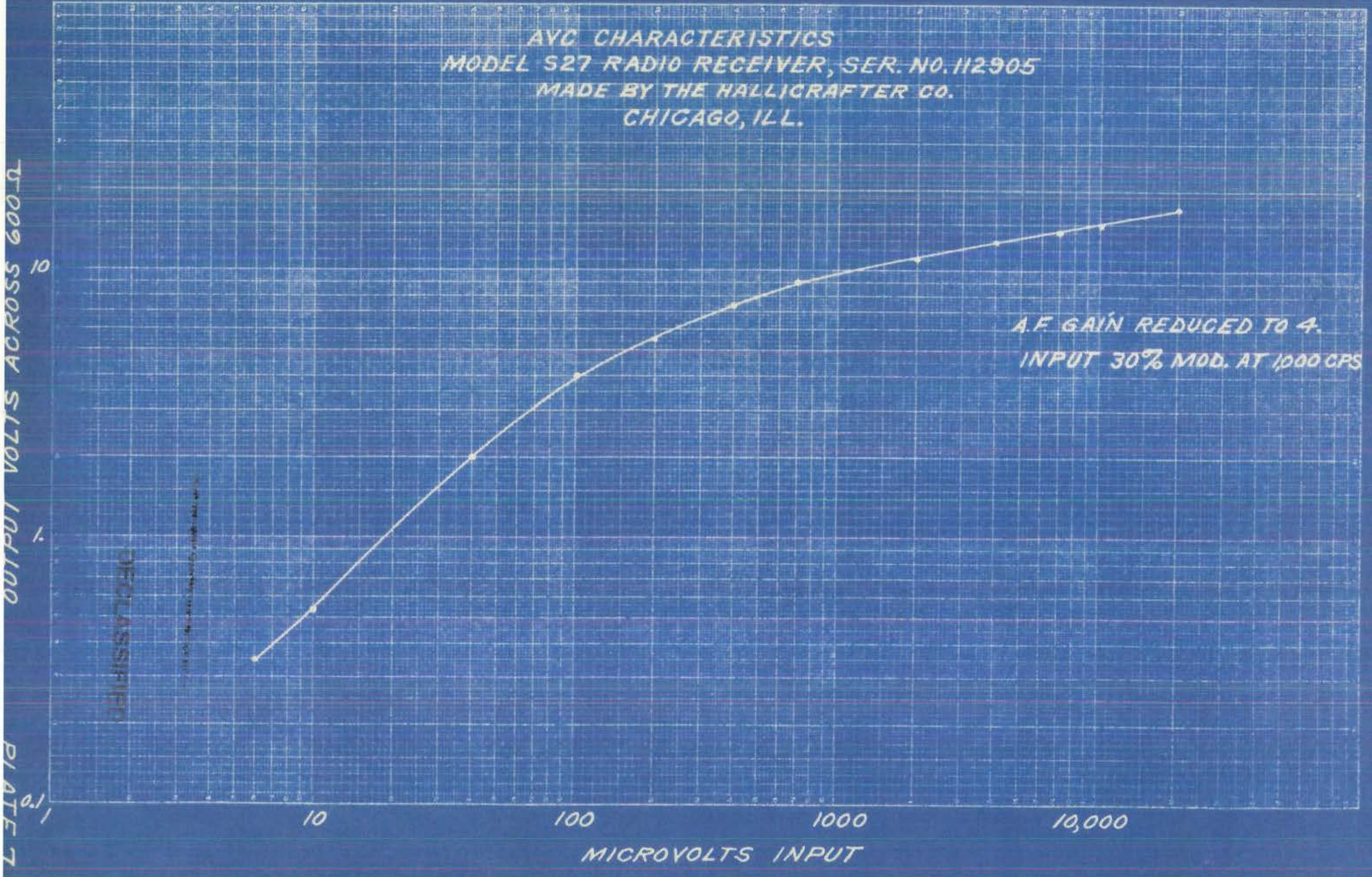
I.F. FIDELITY CHARACTERISTICS (AT PHONE OUTPUT JACK)
MODEL S27 RADIO RECEIVER, SERIAL No. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.

INPUT 30% MOD. INTO CONVERTER GRID THRU 100 MMF. COND.

OUTPUT MEASURED FROM PHONE OUTPUT JACK WITH 10,000Ω LOAD.

TONE CONTROL ON HIGH FIDELITY.

PLATE 6

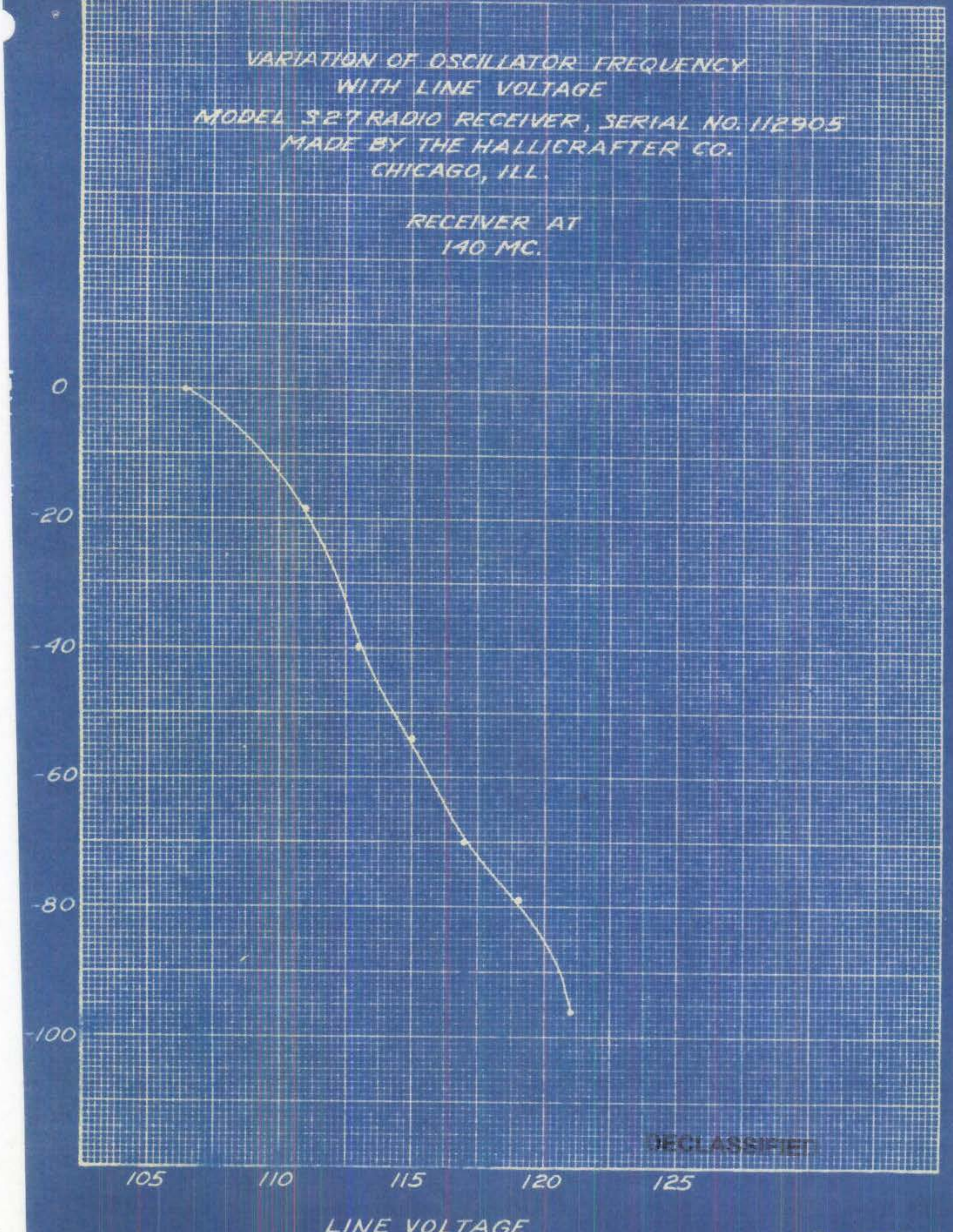


AVC CHARACTERISTICS
MODEL S27 RADIO RECEIVER, SER. NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.

A.F. GAIN REDUCED TO 4.
INPUT 30% MOD. AT 1,000 CPS

DECLASSIFIED

PLATE 7



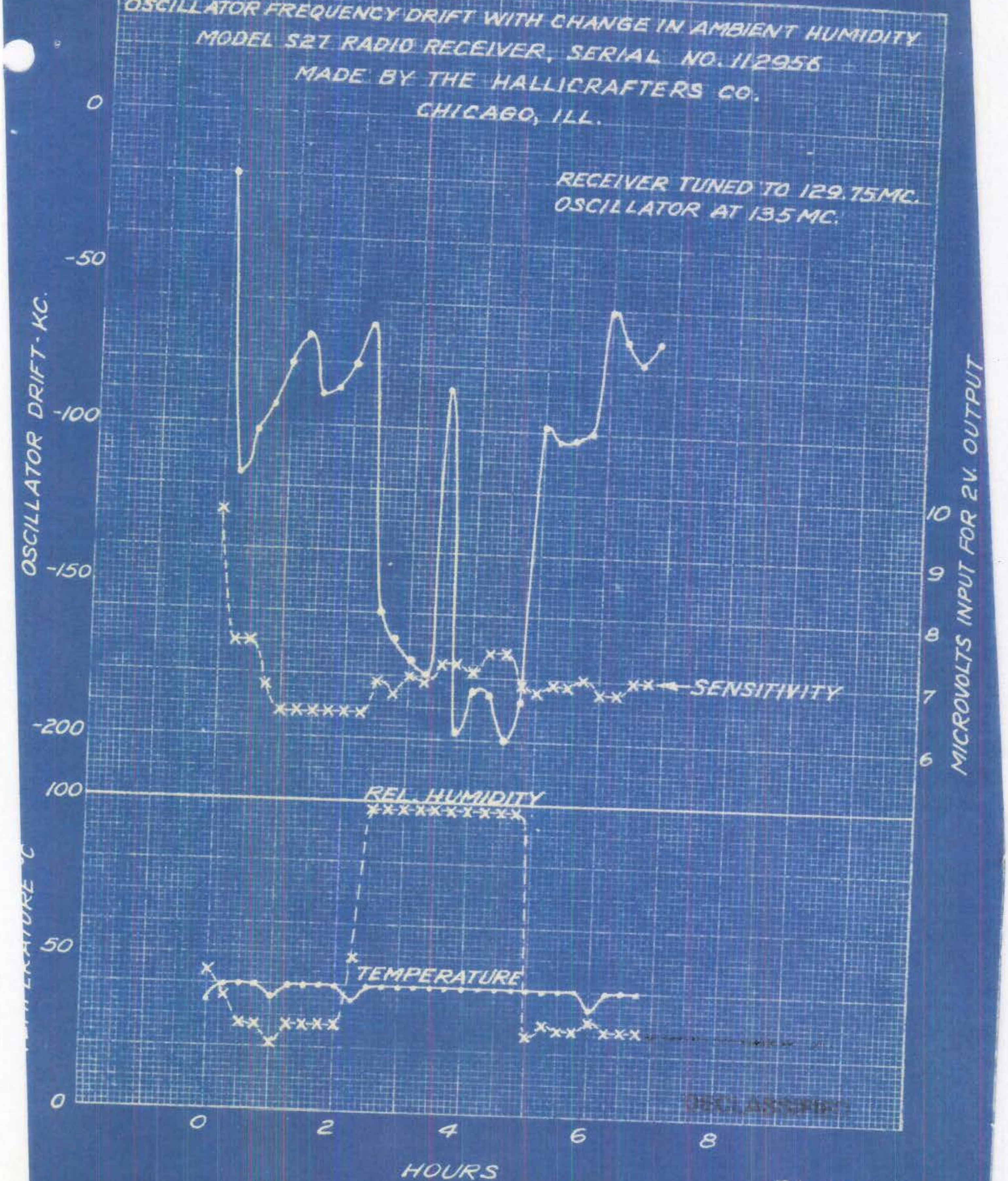
VARIATION OF OSCILLATOR FREQUENCY
WITH LINE VOLTAGE
MODEL S27 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.

RECEIVER AT
140 MC.

PLATE 8

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

DATE



OSCILLATOR FREQUENCY DRIFT WITH CHANGE IN AMBIENT HUMIDITY
MODEL S27 RADIO RECEIVER, SERIAL NO. 112956
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

RECEIVER TUNED TO 129.75 MC.
OSCILLATOR AT 135 MC.

PLATE 9

## OSCILLATOR FREQUENCY DRIFT WITH CHANGE IN AMBIENT TEMPERATURE
## MODEL S27 RADIO RECEIVER , SERIAL NO. 112956
## MADE BY THE HALLICRAFTERS CO.
## CHICAGO, ILL.

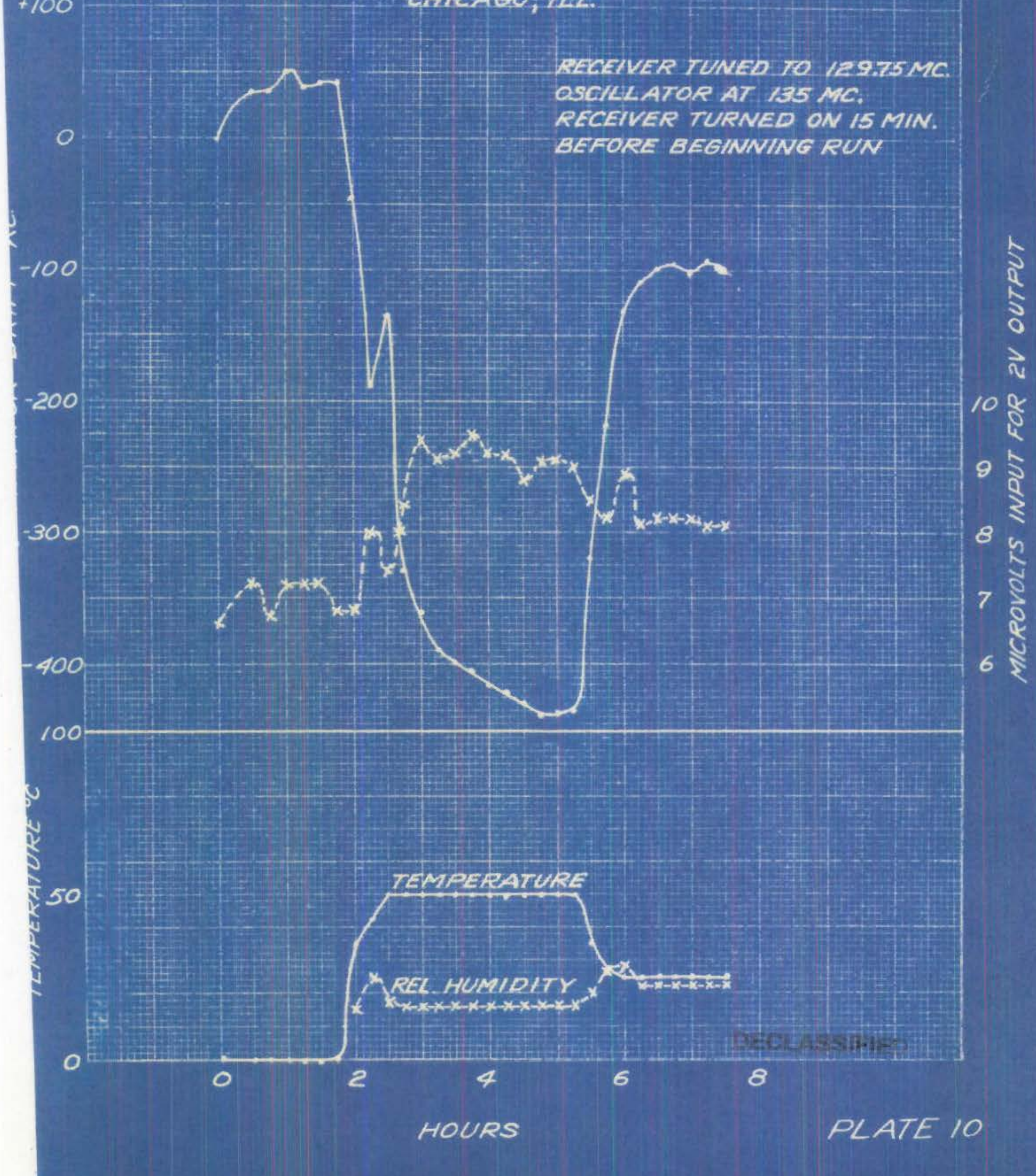
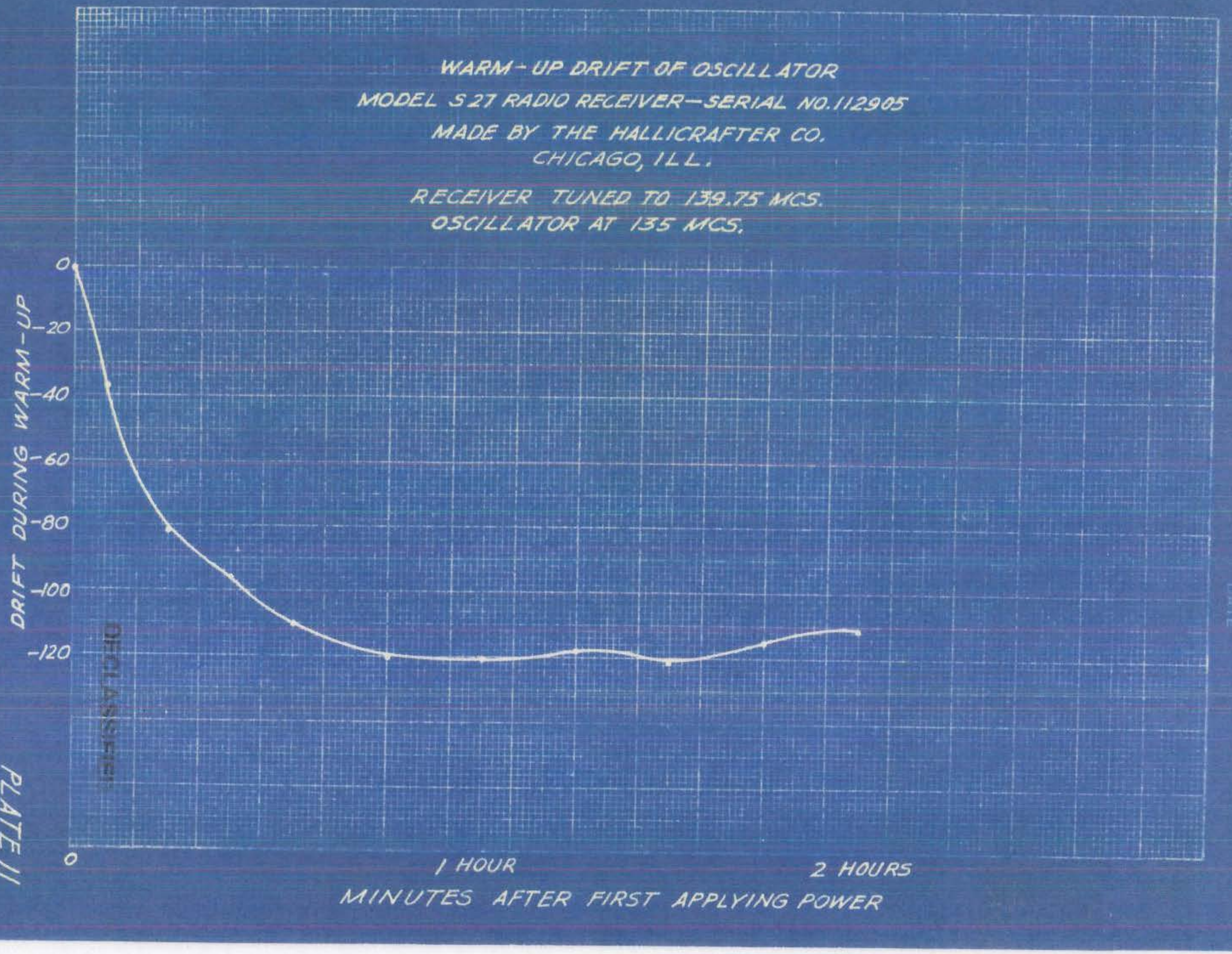


PLATE 10


WARM-UP DRIFT OF OSCILLATOR
MODEL S27 RADIO RECEIVER—SERIAL NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.

RECEIVER TUNED TO 139.75 MCS.
OSCILLATOR AT 135 MCS.

PLATE 11

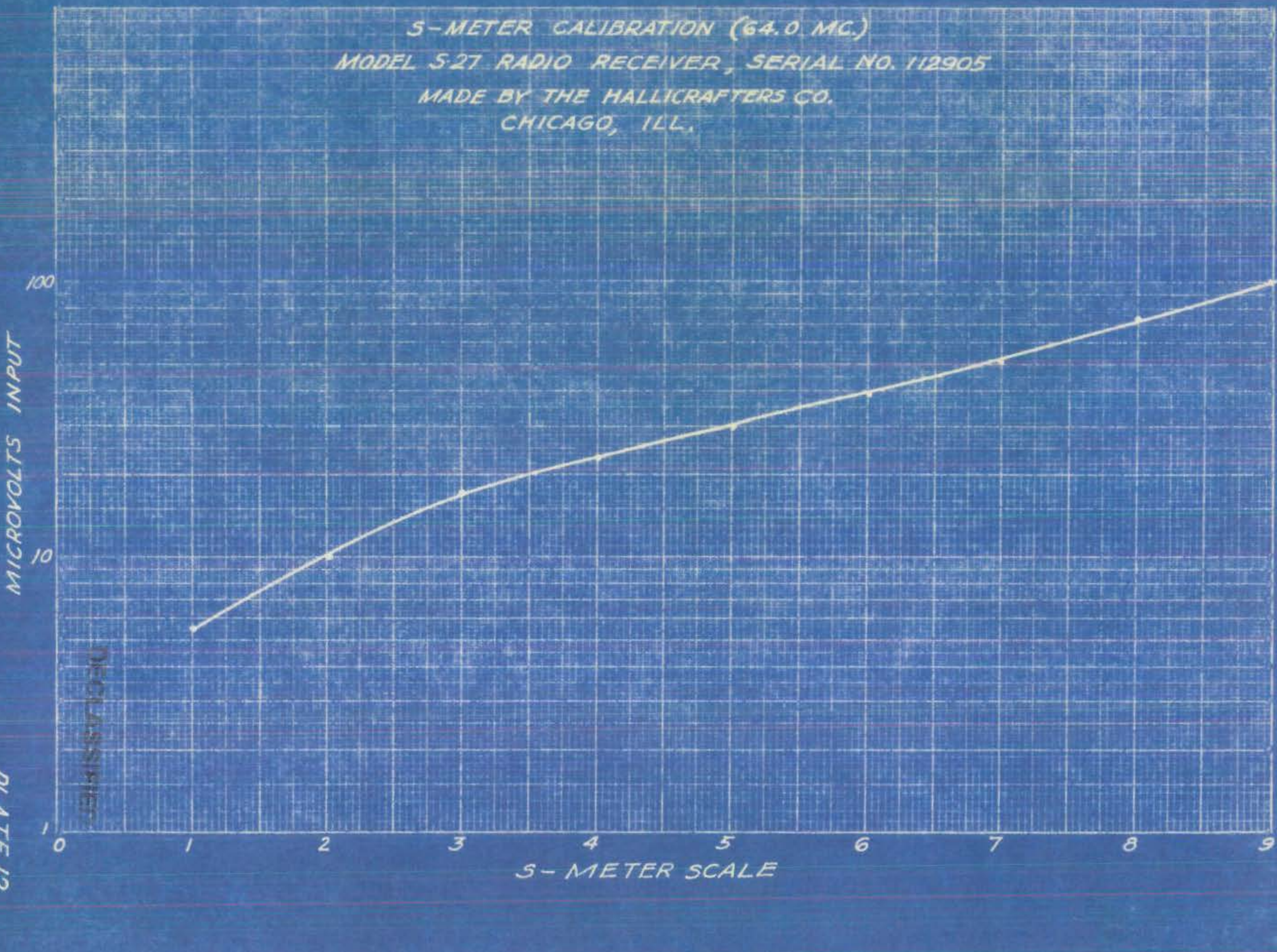
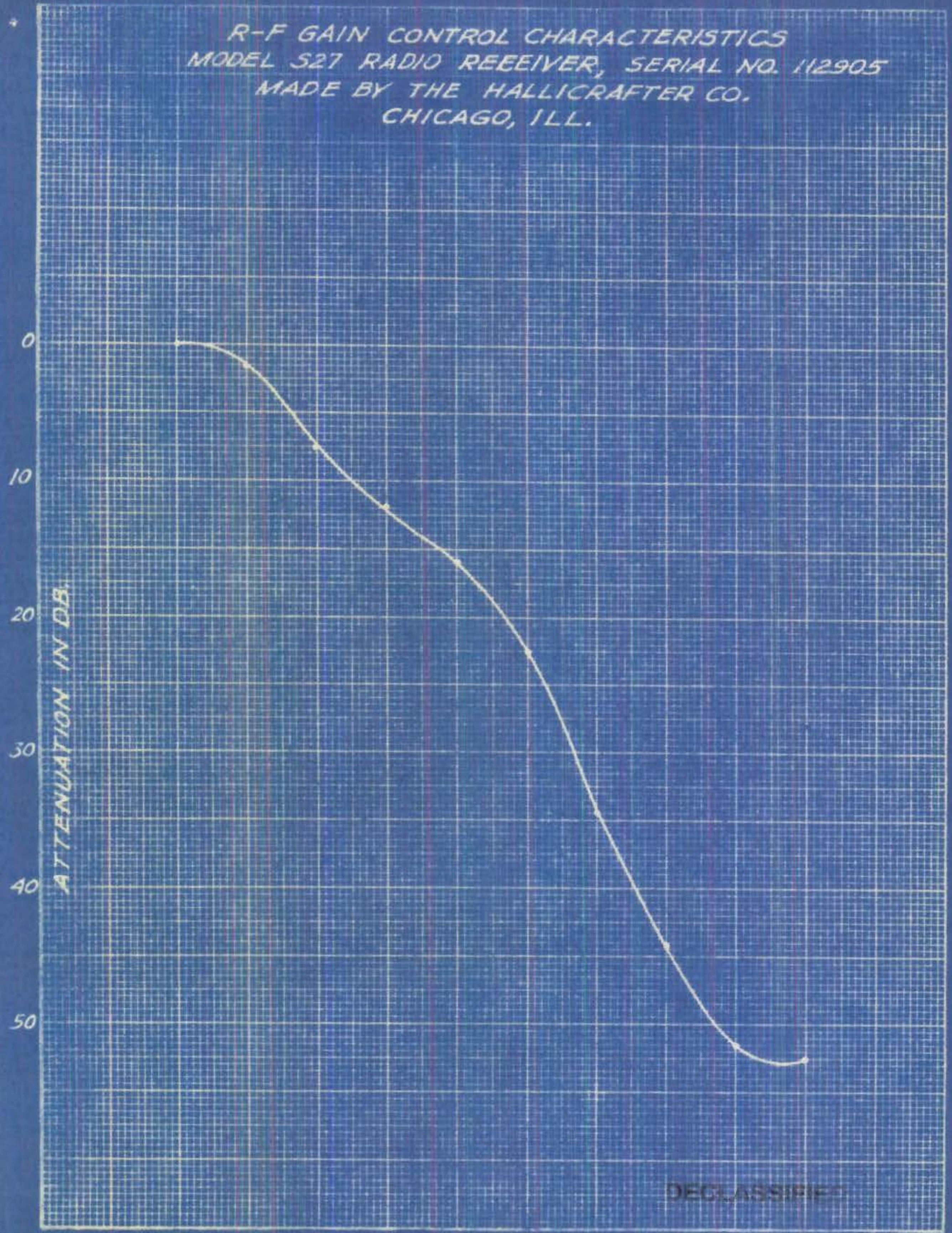

S-METER CALIBRATION (64.0 MC.)
MODEL S-27 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

PLATE 12

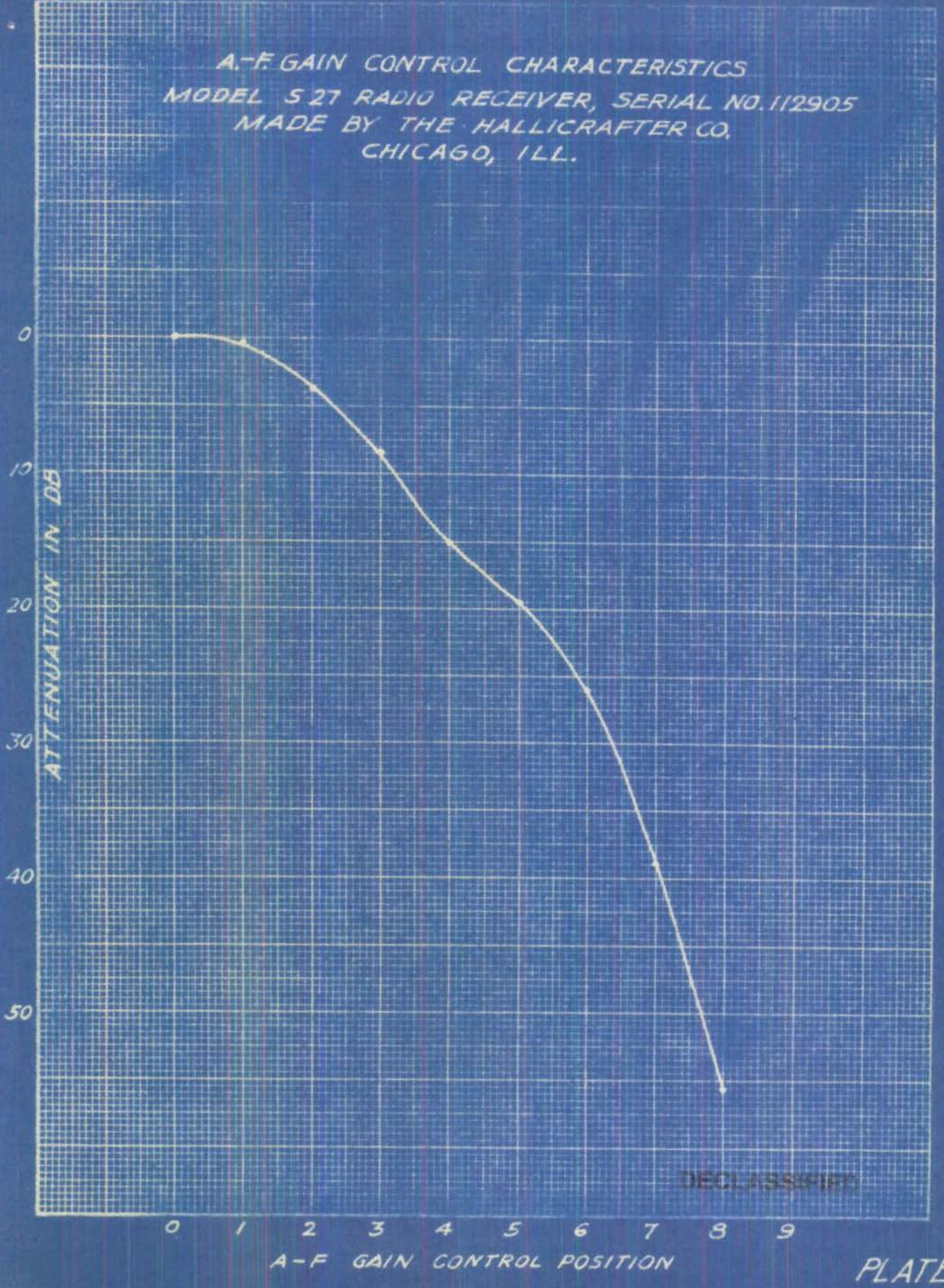
U.S. NAVAL RESEARCH LABORATORY
BELLEVUE, D.C.

DATE



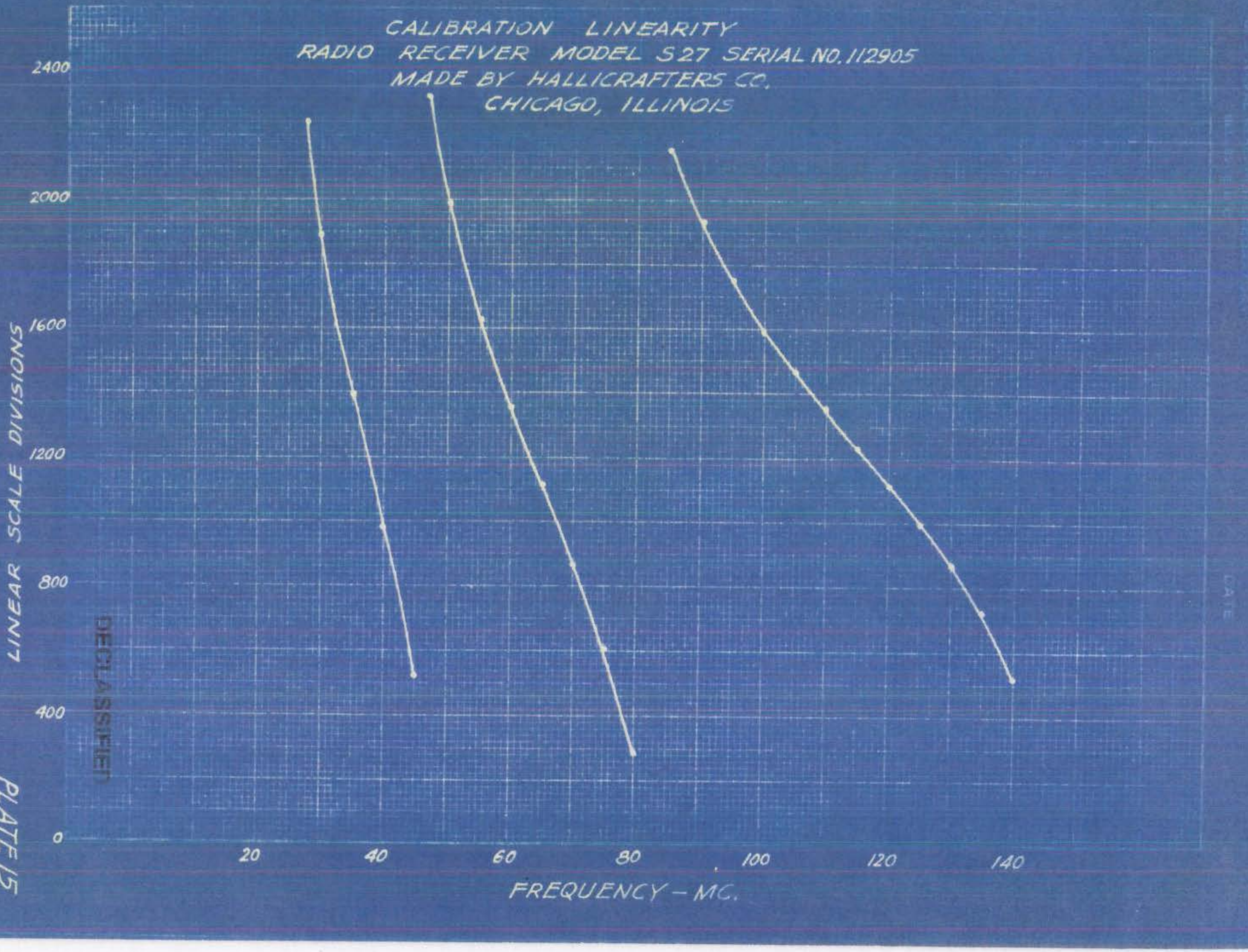
R-F GAIN CONTROL CHARACTERISTICS
MODEL S27 RADIO REEEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.

PLATE 13



A.-F. GAIN CONTROL CHARACTERISTICS
MODEL S 27 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.

PLATE 14



CALIBRATION LINEARITY
RADIO RECEIVER MODEL S27 SERIAL NO. 112905
MADE BY HALLICRAFTERS CO.
CHICAGO, ILLINOIS

PLATE 15

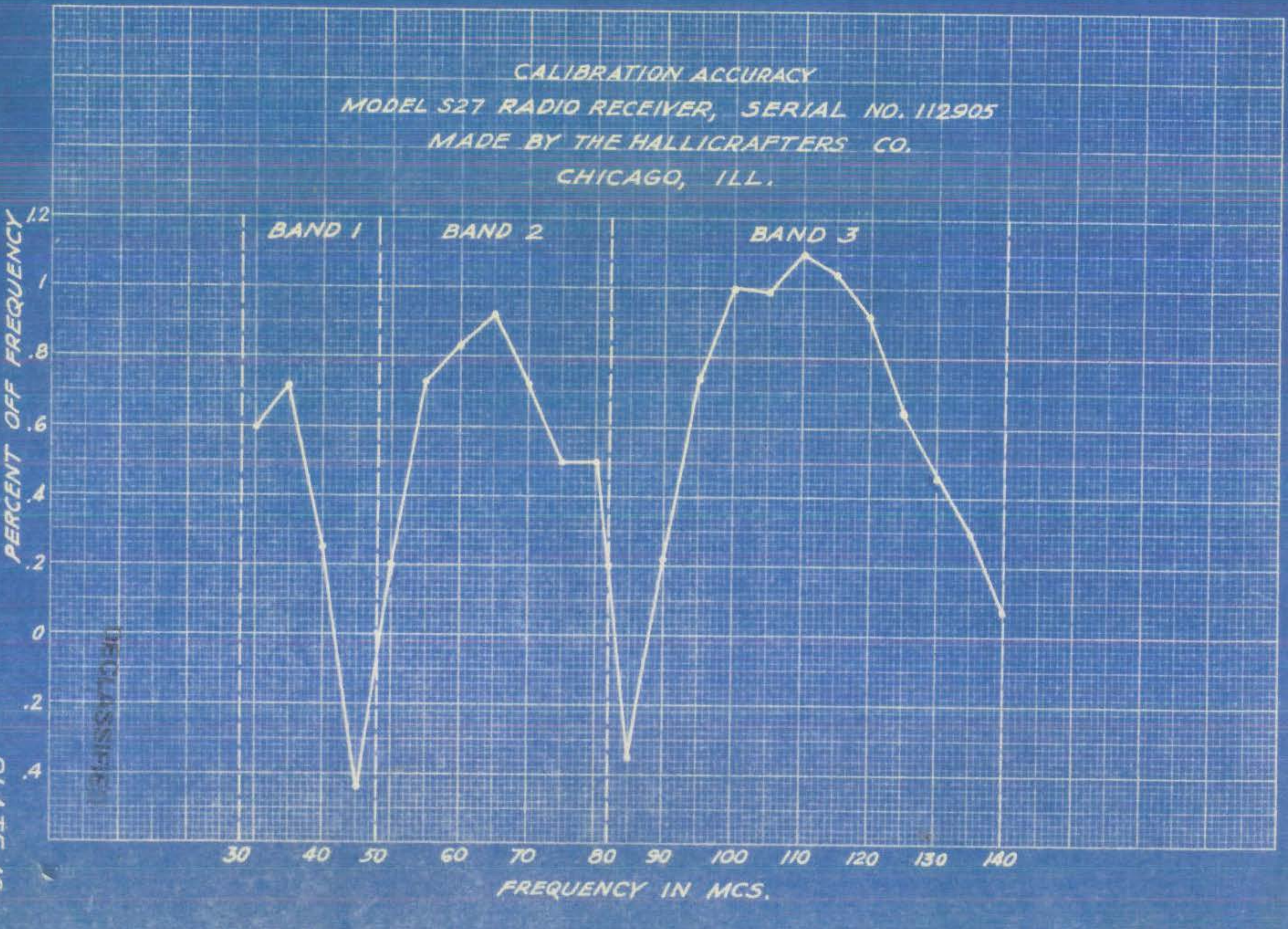

CALIBRATION ACCURACY
MODEL S27 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

PLATE 16

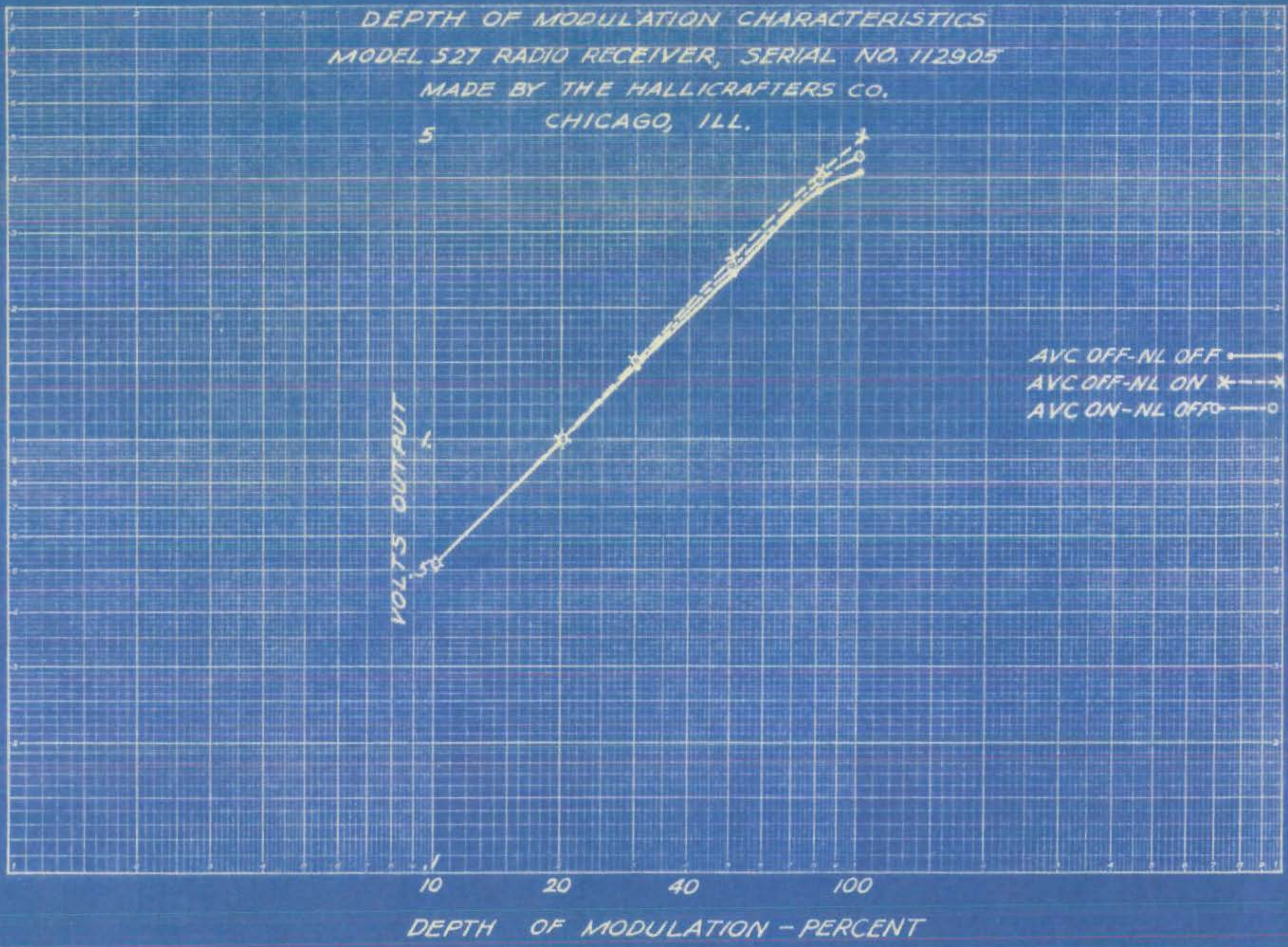
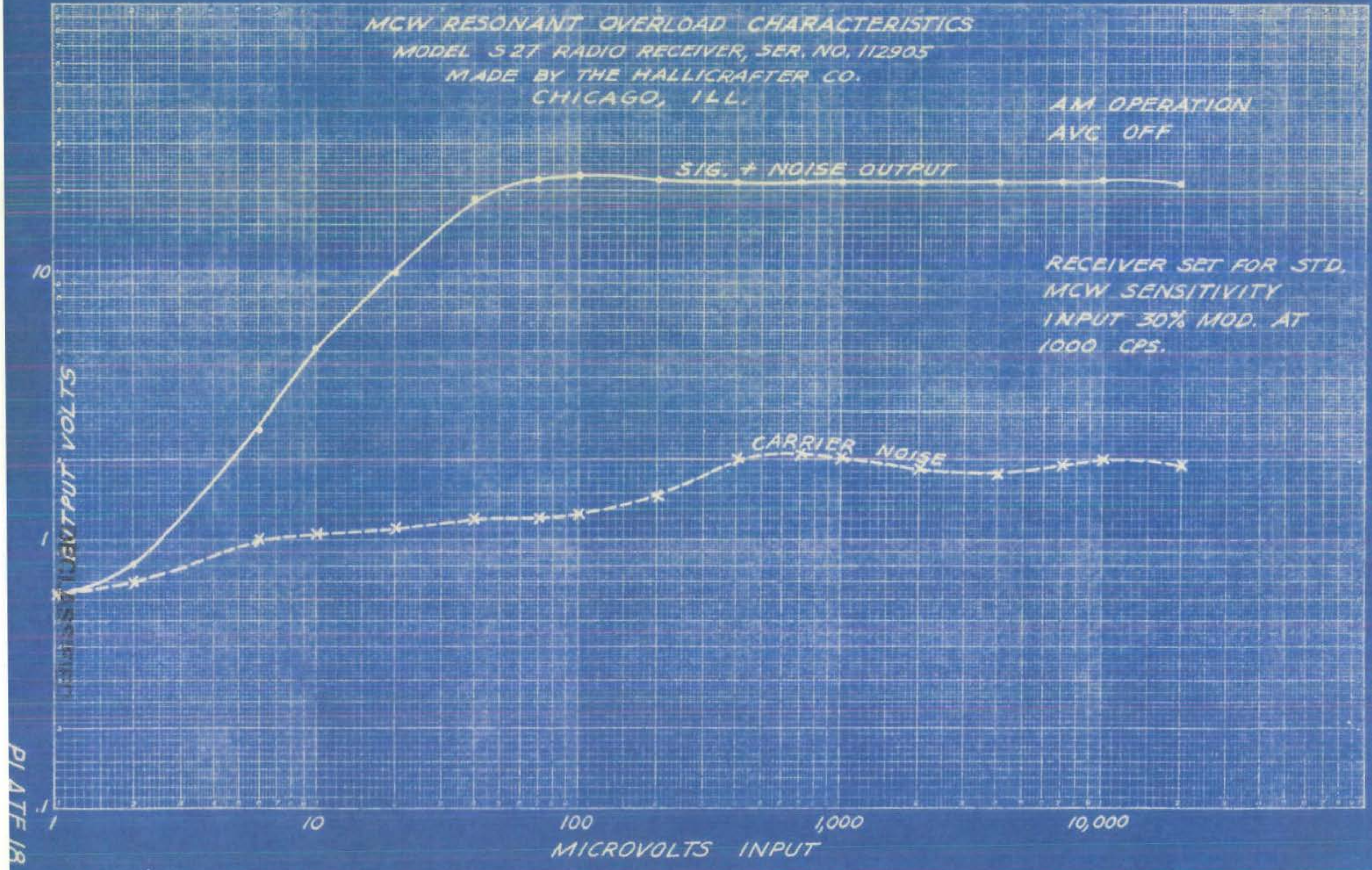
 
DEPTH OF MODULATION CHARACTERISTICS
MODEL 527 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

PLATE 17

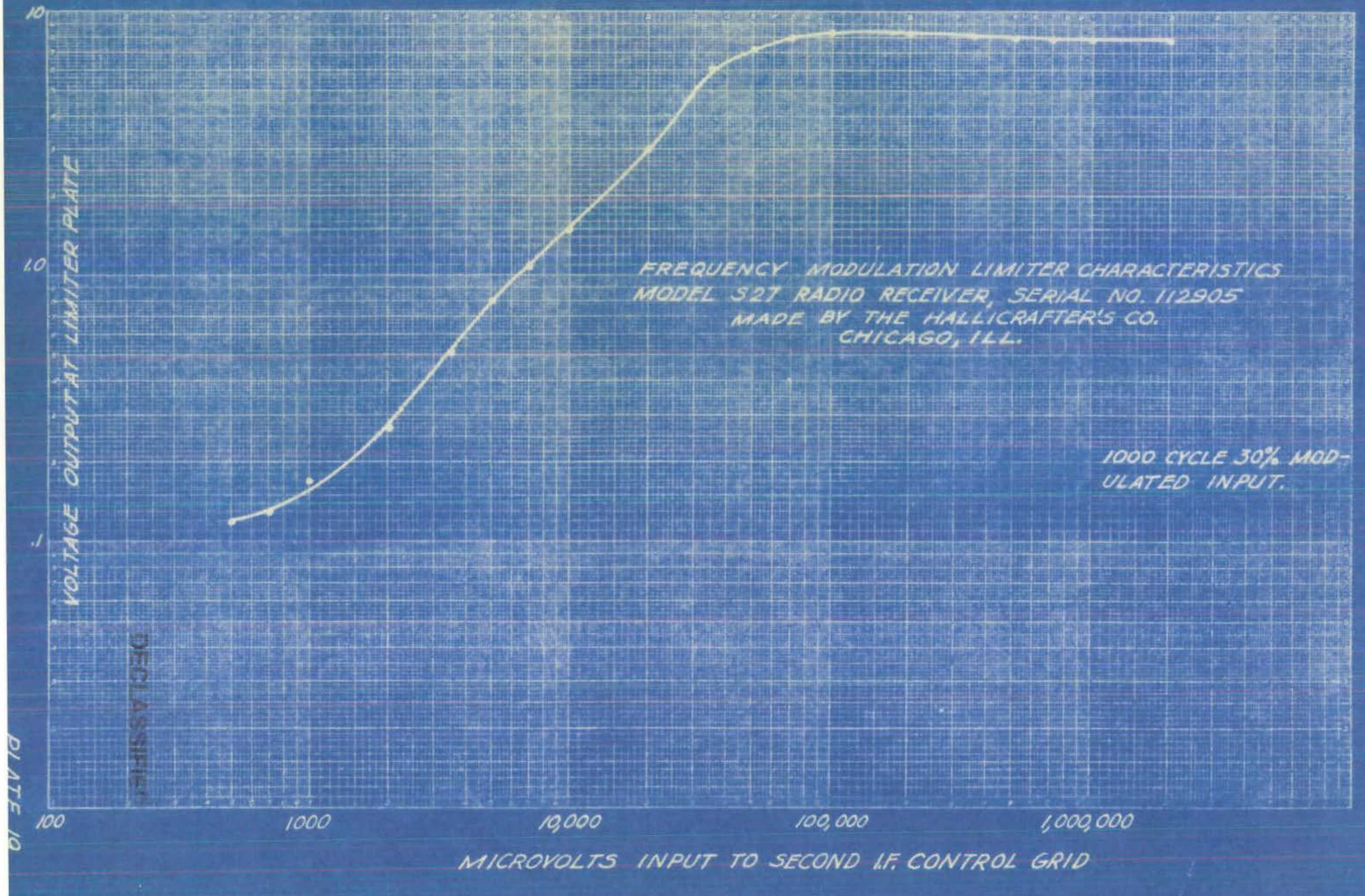
PLATE 18

## MCW RESONANT OVERLOAD CHARACTERISTICS

MODEL S27 RADIO RECEIVER, SER. NO. 112905
MADE BY THE HALLICRAFTER CO.
CHICAGO, ILL.



DECLASSIFIED



FREQUENCY MODULATION LIMITER CHARACTERISTICS
MODEL S27 RADIO RECEIVER, SERIAL NO. 112905
MADE BY THE HALLICRAFTER'S CO.
CHICAGO, ILL.

PLATE 19

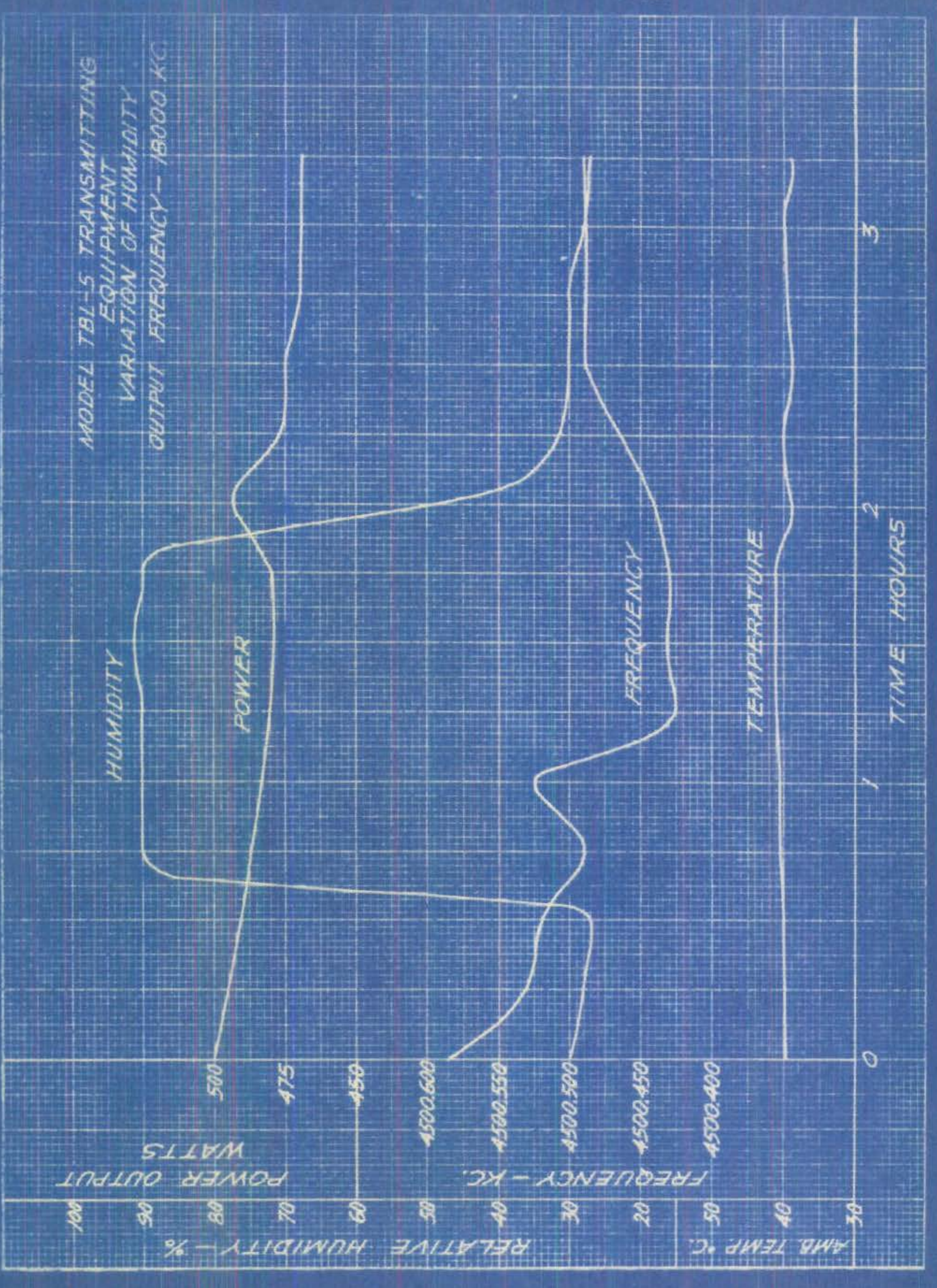
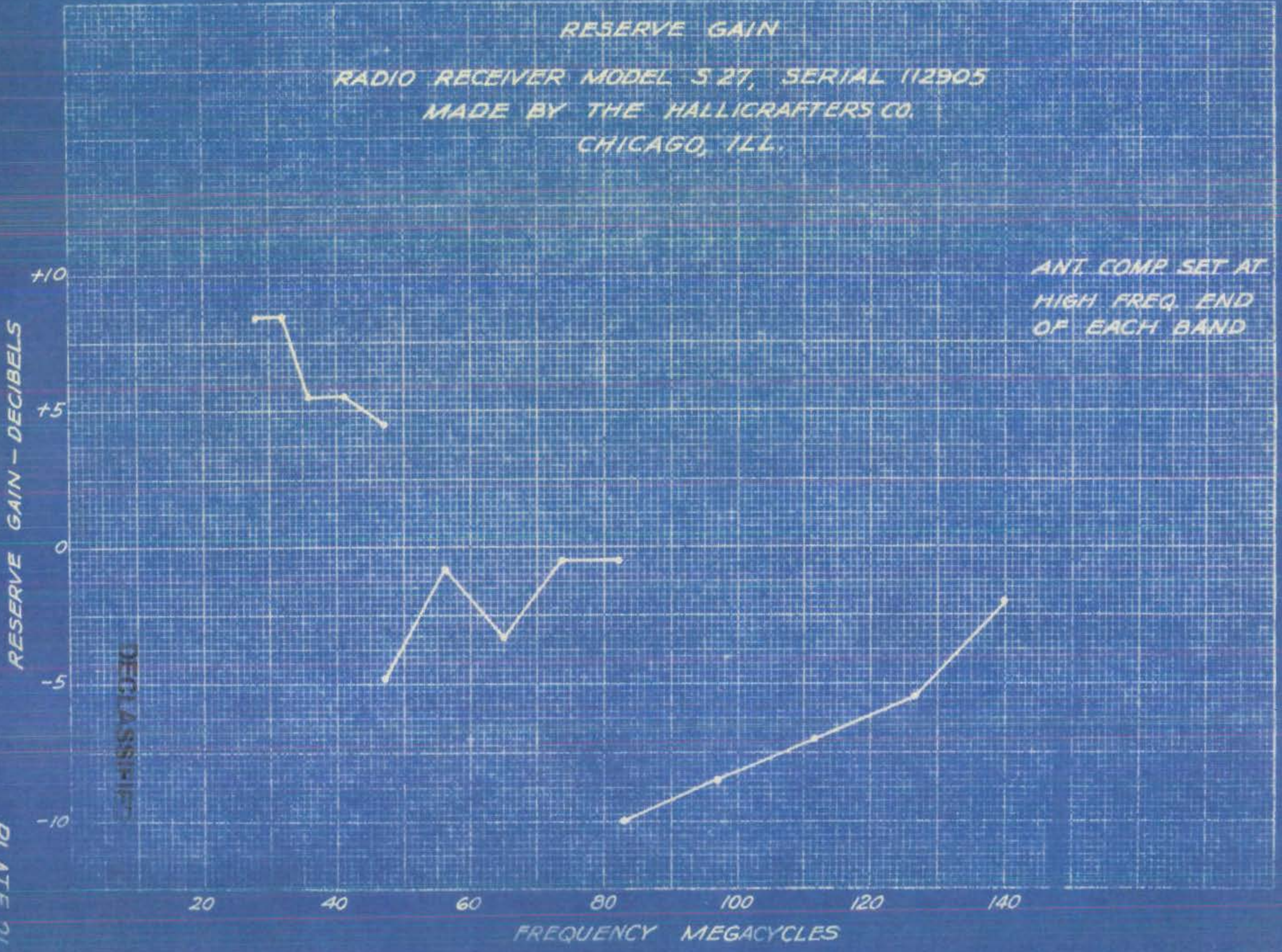

DATE
MODEL TBL-5 TRANSMITTING
EQUIPMENT
VARIATION OF HUMIDITY
OUTPUT FREQUENCY – 18000 KC
HUMIDITY
POWER
FREQUENCY
TEMPERATURE
TIME HOURS
0
1
2
3
RELATIVE HUMIDITY – %
100
90
80
70
60
50
40
30
20
POWER OUTPUT WATTS
500
475
450
FREQUENCY – KC.
4500.600
4500.550
4500.500
4500.450
4500.400
AMB. TEMP. °C.
50
40
30

PLATE 20



RESERVE GAIN

RADIO RECEIVER MODEL S 27, SERIAL 112905
MADE BY THE HALLICRAFTERS CO.
CHICAGO, ILL.

ANT. COMP. SET AT
HIGH FREQ. END
OF EACH BAND

PLATE 21

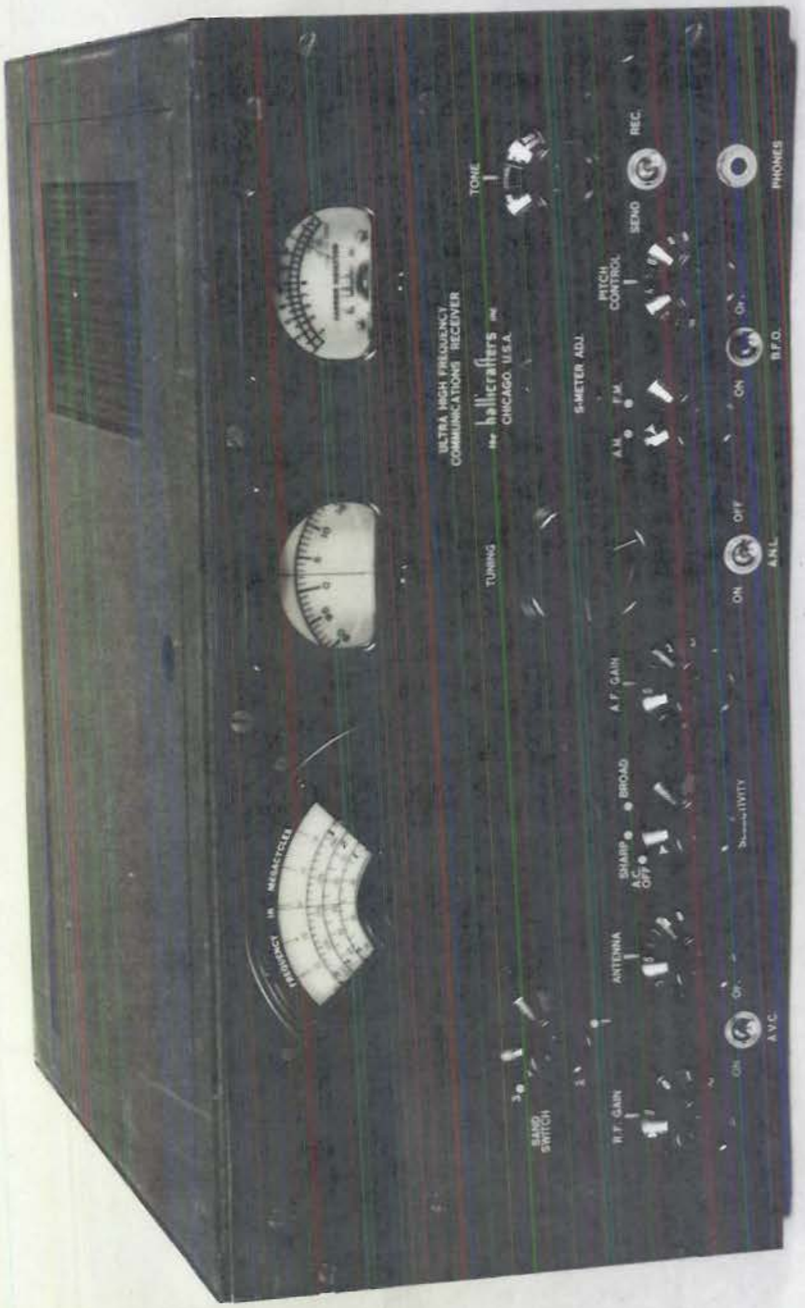

ULTRA HIGH FREQUENCY COMMUNICATIONS RECEIVER
the hallicrafters inc CHICAGO U.S.A.
FREQUENCY IN MEGACYCLES
BAND SWITCH
R.F. GAIN
ANTENNA
A.C. OFF
SHARP
BROAD
A.F. GAIN
TUNING
A.M.
F.M.
S-METER ADJ.
PITCH CONTROL
TONE
SEND
REC.
PHONES
ON
OFF
A.V.C.
SENSITIVITY
A.N.L.
B.F.O.

PLATE 101

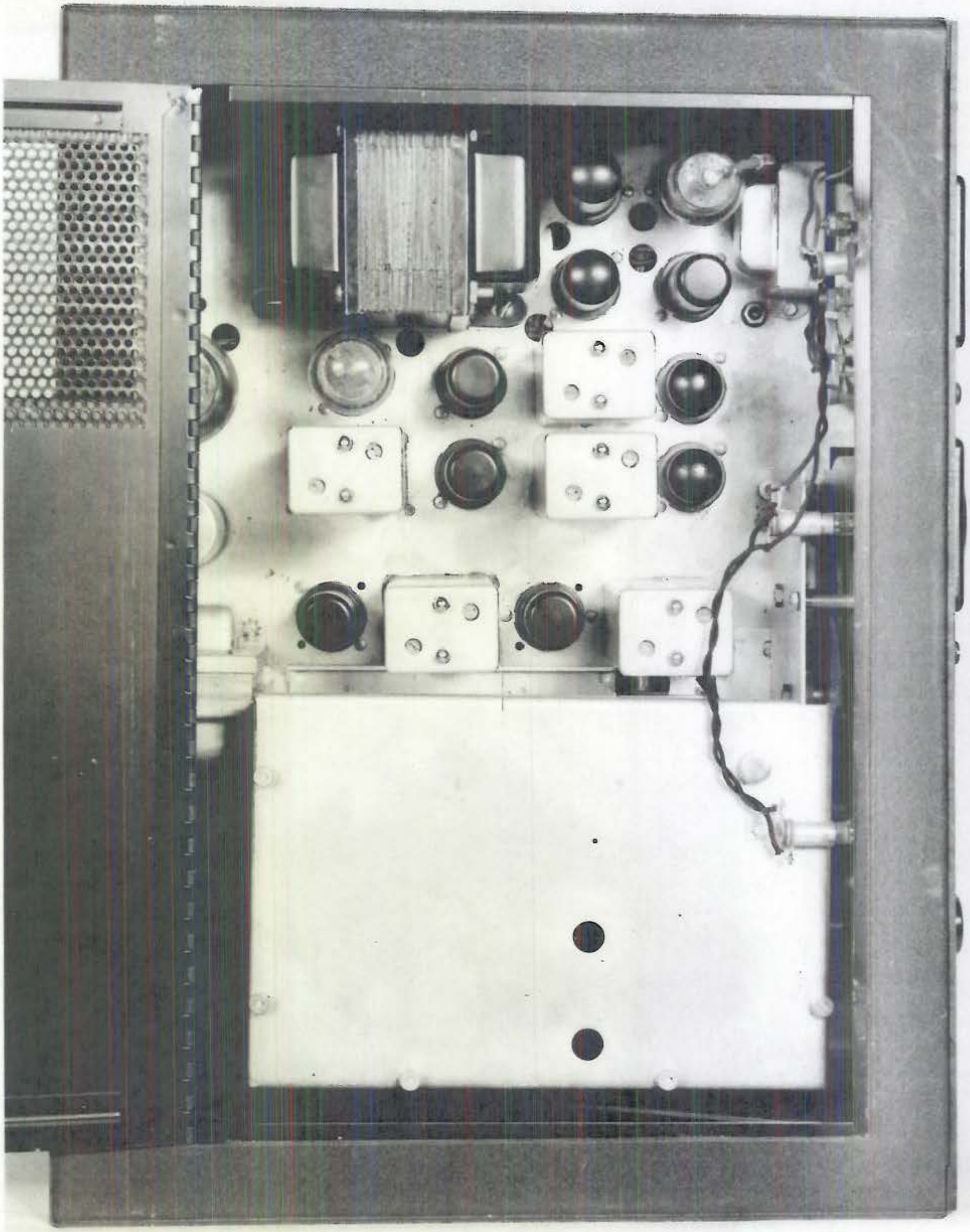


PLATE 102

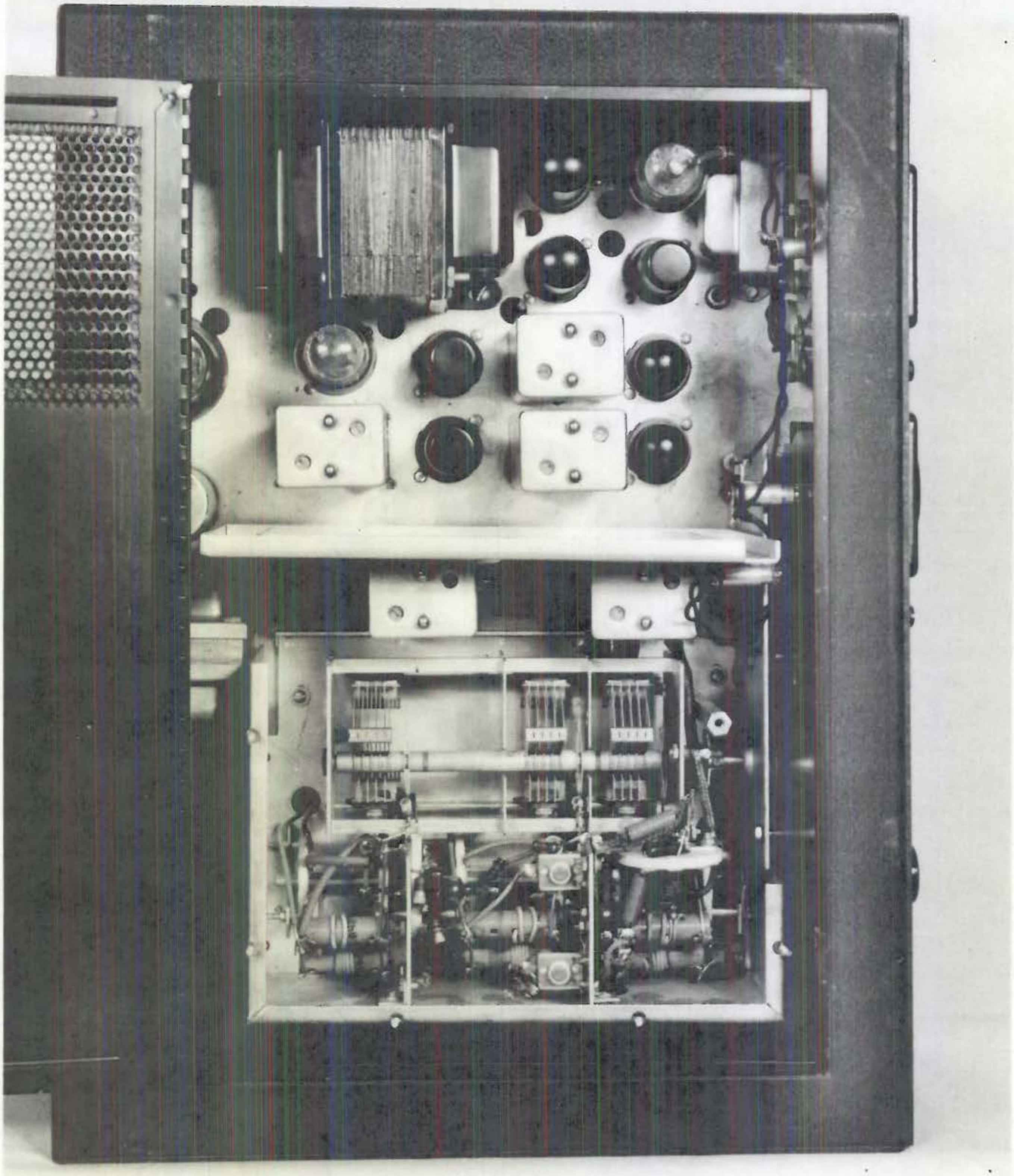


PLATE 103

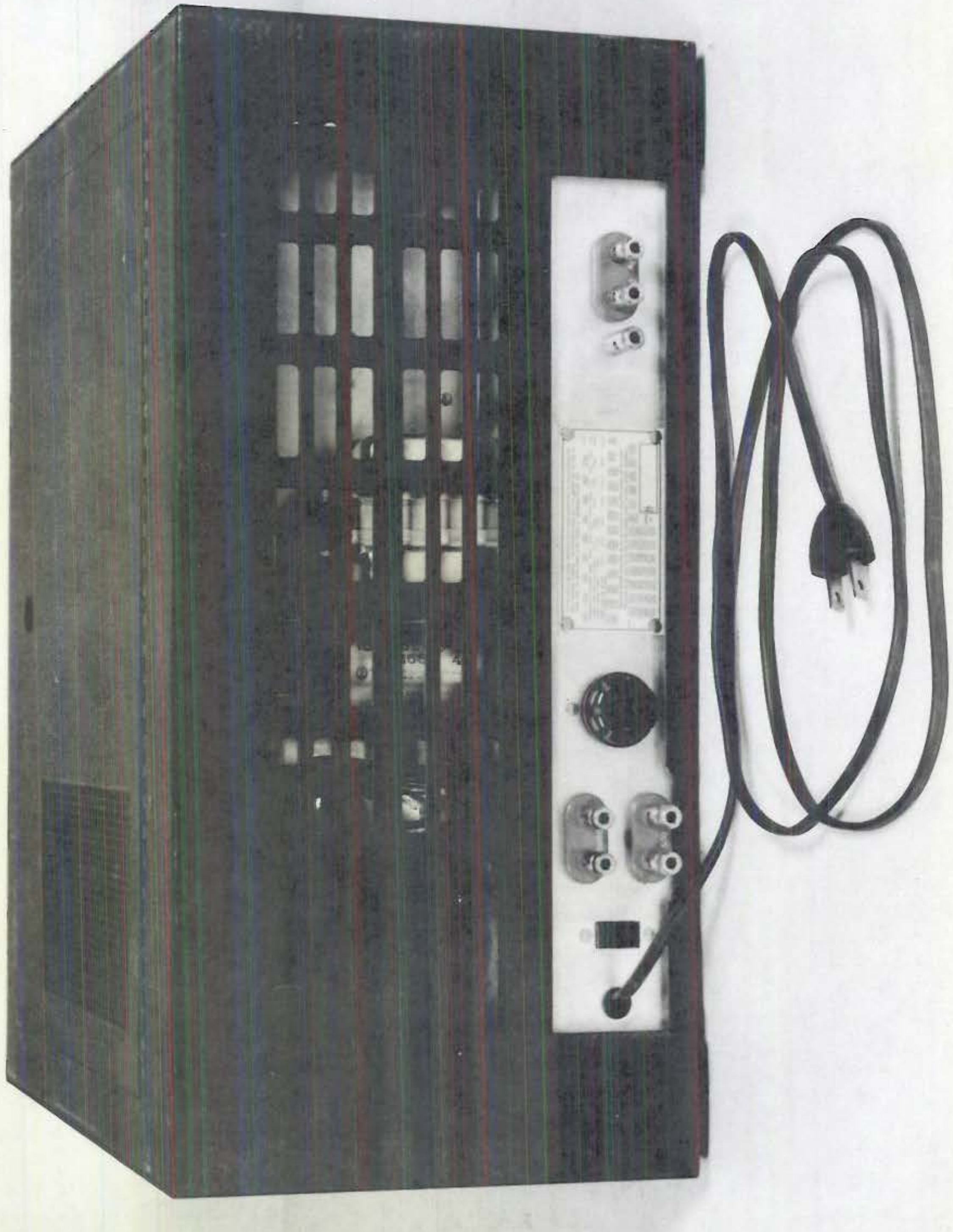


PLATE 104

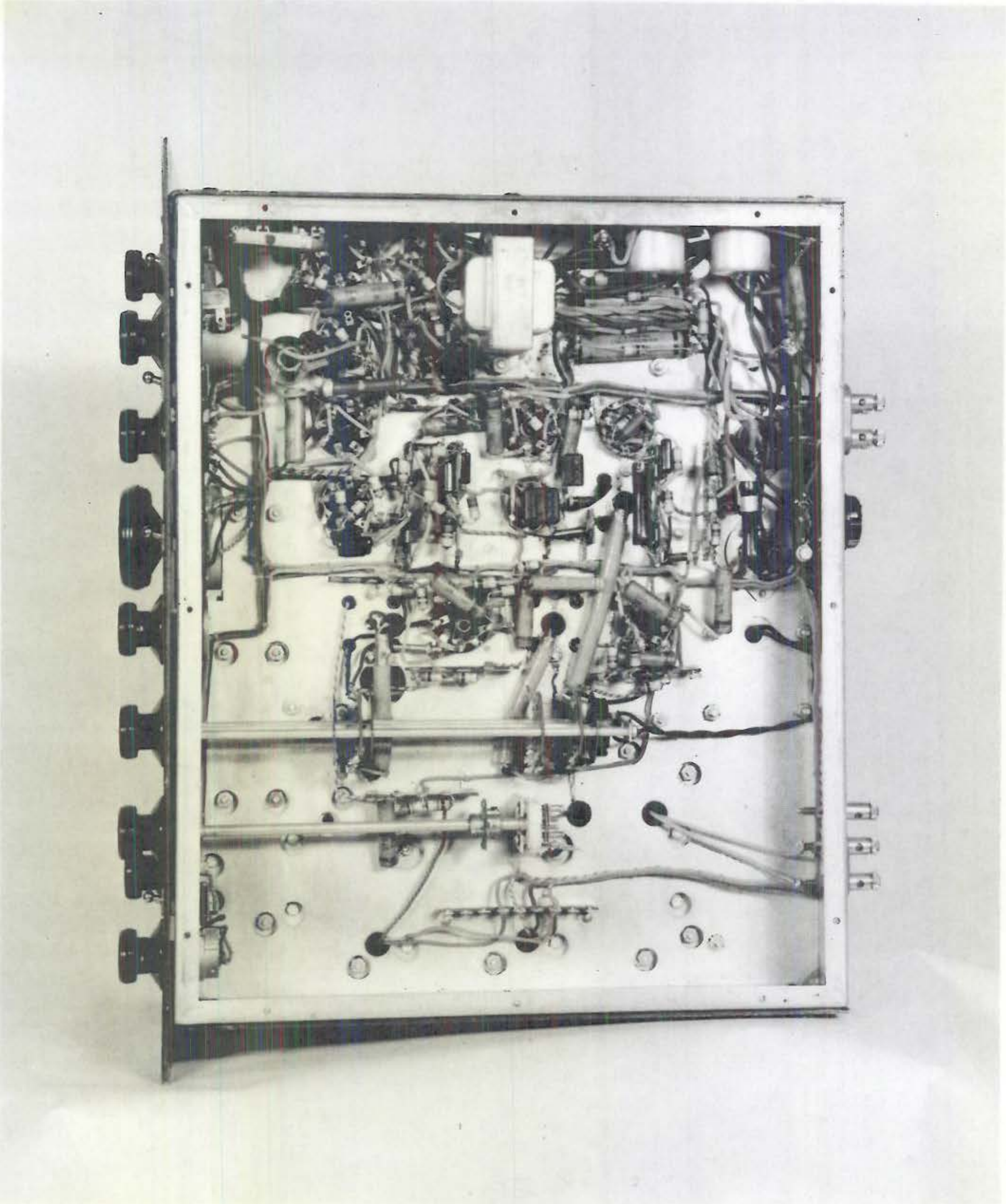


PLATE 105

DECLASSIFIED

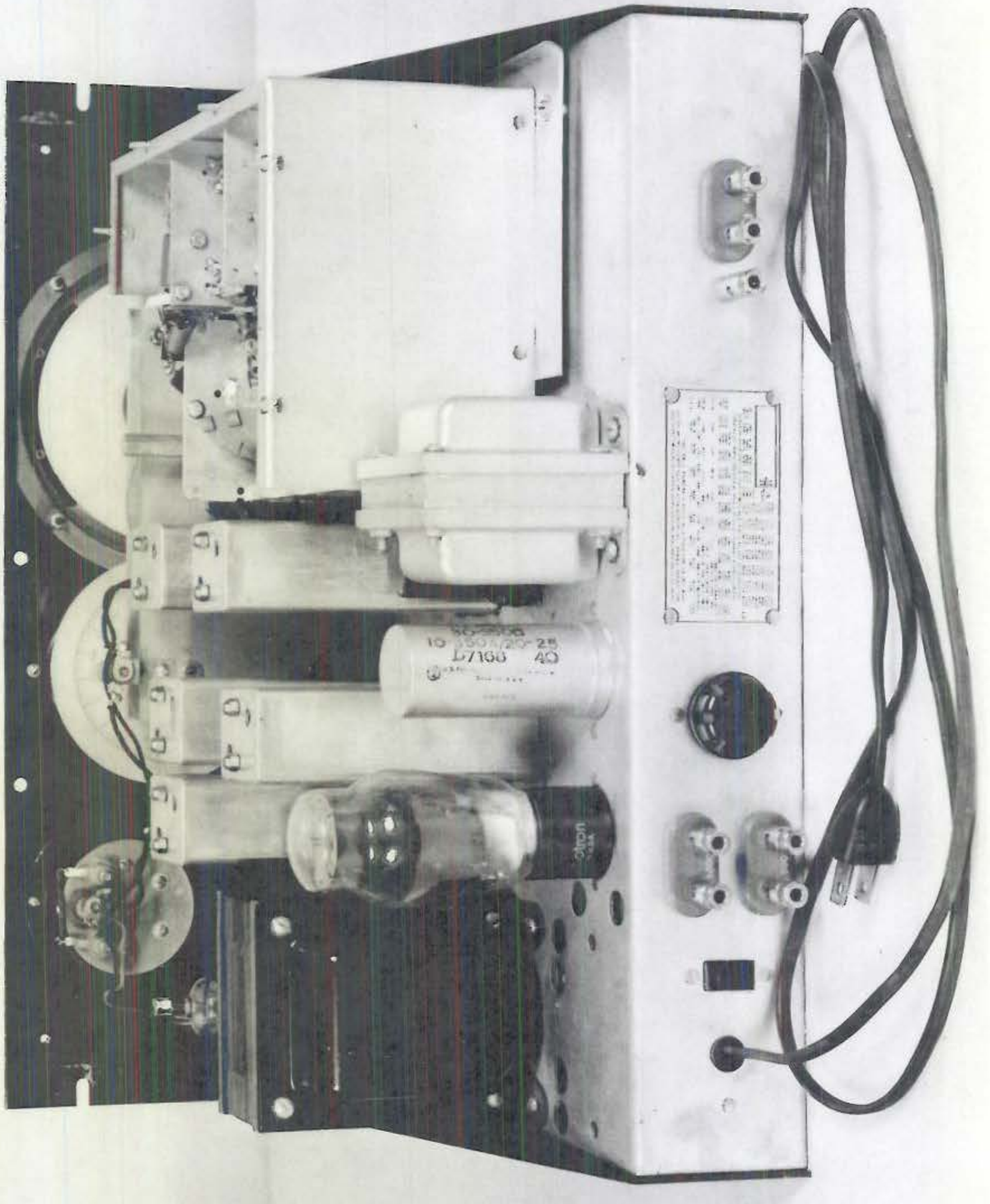


PLATE 106

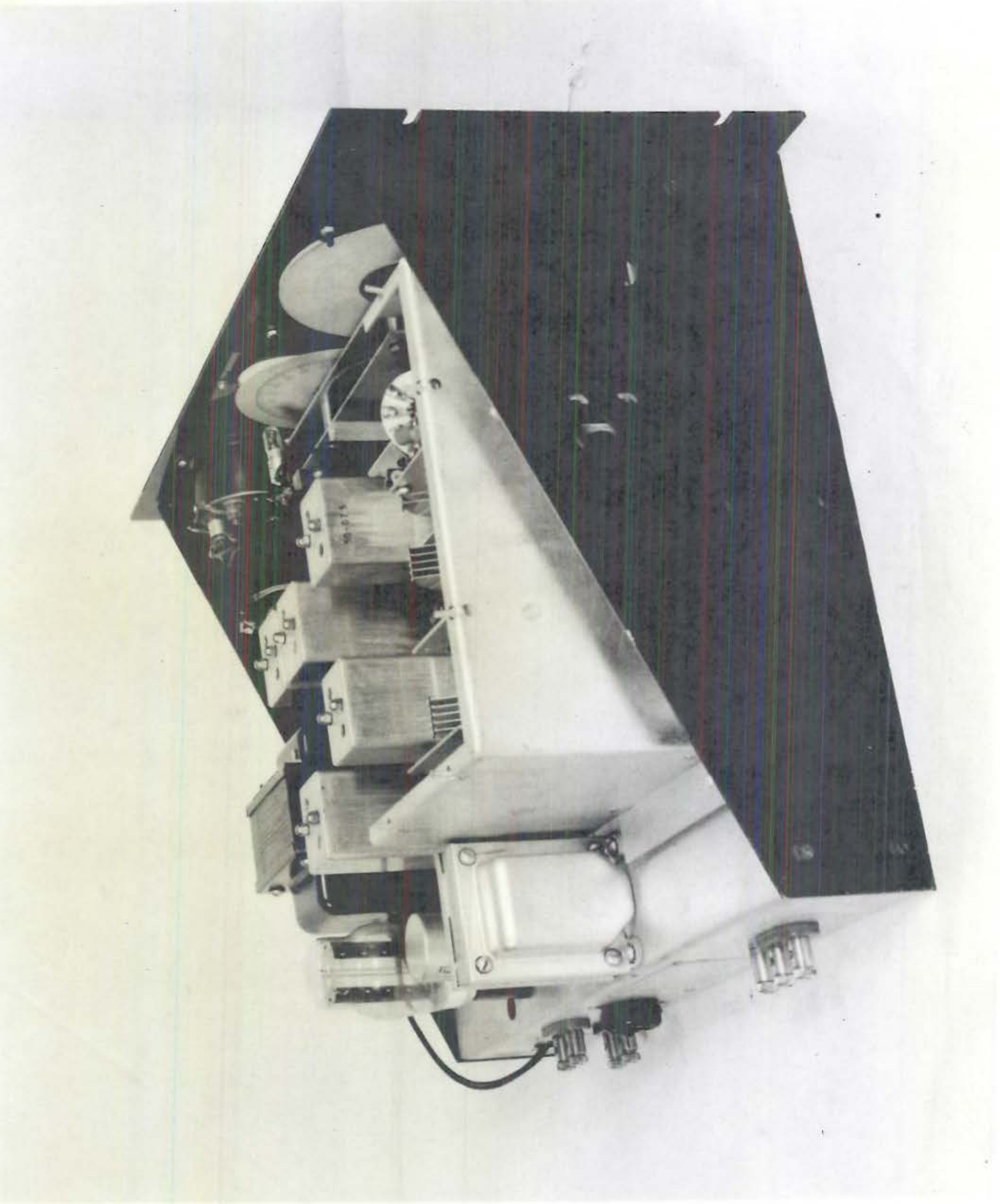


PLATE 107

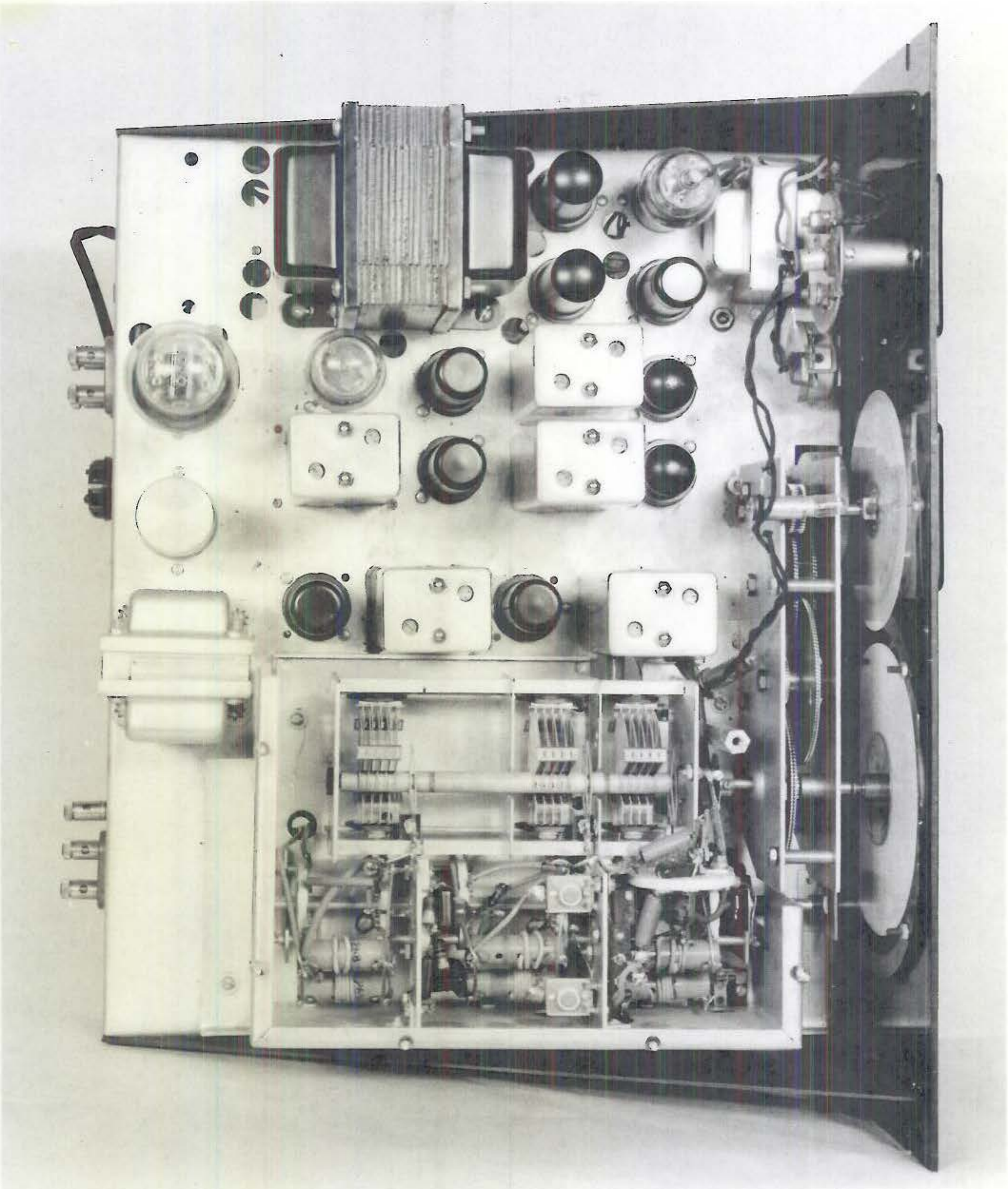
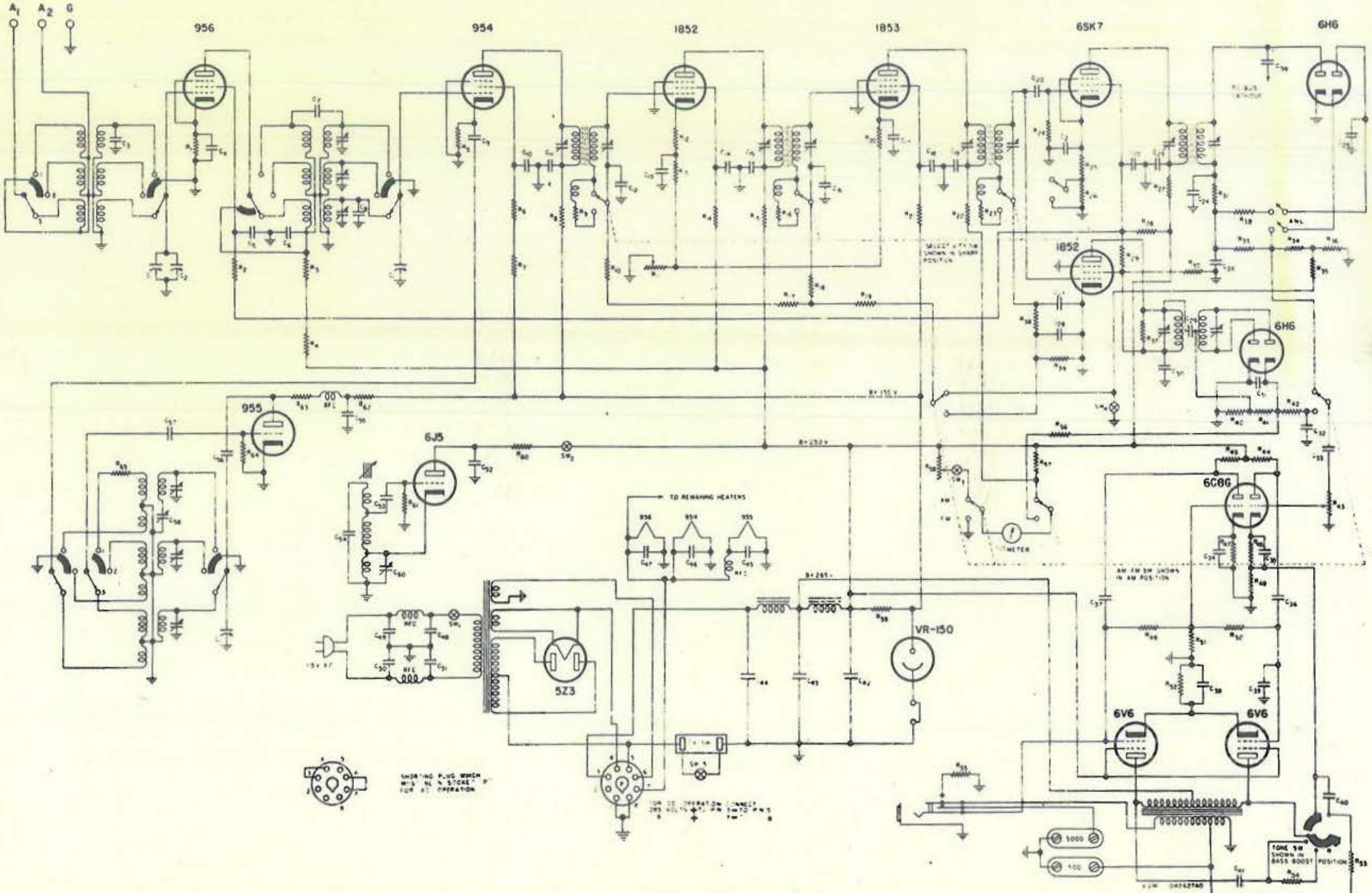


PLATE 108

SCHEMATIC DIAGRAM - ULTRA HIGH FREQUENCY FM-AM RECEIVER - MODEL S-27



**the hallicrafters inc.**
CHICAGO U.S.A.