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Problem T5-34C

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SUBJECT

Test of Western Electric Type 226C

25 watt radio telephone equipment

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NAVAL RESEARCH LABORATORY

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25 watt radio telephone equipment
See also R-1685

December 18, 1940

NRL Report No. R-1672
BuShips Prob. No. T5-34C

NAVY DEPARTMENT

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Report on

Test of Western Electric Type 226C 25 watt radio telephone equipment

FR-1672

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Authorization: BuShips let. S67/43 (10-19-DR6) of 23 Oct. 1940.

Date of Test: November, 1940

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SECTION I

AUTHORIZATION

1-1. The tests herein reported were authorized by Bureau of Ships letter S67/43 (10-19-DR6) of 23 October 1940. The above letter assigned Bureau of Ships Problem T5-34C, Priority A, to cover the tests of the Western Electric Type 226C, 25 watt radio telephone equipment.

OBJECT OF TEST

1-2. The object of the test was:

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

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

(c) To ascertain what changes or modifications are necessary or desirable in the equipment to insure satisfactory operation under Naval service conditions.

ABSTRACT OF TESTS

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

(a) Transmitter.

General examination of equipment.

(1) Check of vacuum tubes employed and method of mounting.
(2) Inspection of panel controls.
(3) Investigation of tuning methods.
(4) Accessibility, ease of adjustment, and protective features.
(5) Wiring.
(6) Insulation.
(7) Weight and dimensions.
(8) Physical construction, ventilation, corrosion resisting measures.
(9) Check of meters, switches, resistors, fuses, capacitors, etc.
(10) Mounting and shock proofing methods.
(11) Handset, controls and mounting.
(12) Connection facilities.
(13) Power equipment.

[redacted]

Operational data and tests.

(1) Power output determination.
(2) Effect of temperature variations.
(3) Effect of humidity.
(4) Effect of vibration.
(5) Locked key operation.
(6) Local and remote control features.
(7) Modulation characteristics.
(8) Break-in method.
(9) Power required for operation.
(10) Instruction book.

(b) Receiver

General examination of equipment.

(1) Electrical inspection of circuits, etc.
(2) Mechanical inspection of components, controls,
(3) Instruction Book.
(4) Spare Parts.

Operational Data and Tests

(1) Listening tests on antenna
(2) Laboratory measurements in shielded room.

A. Sensitivity and Noise Output
B. Image Ratio
C. I. F. Response
D. Selectivity
E. Resonant Overload
F. Effect of Modulation Depth
G. Gain Control Range.
H. Radiation of Oscillator Frequency.

(3) Effects of temperature variations.
(4) Effects of humidity variations.
(5) Effects of vibration.

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CONCLUSIONS

(a) The general appearance and construction of the Model 226C equipment are good. Component parts of good quality are employed, although not all parts would comply with the usual requirements of Naval specifications. Standard tubes of a minimum number of types are used.

(b) The tuning and antenna adjustments provided for placing the transmitter into operation are simple in character and afford a means of obtaining compromise adjustments for operation on four frequencies. If the equipment is intended for use in a manner where original adjustments are made and permitted to remain fixed for long periods of time, the method provided is suitable. However, should the equipment be used under conditions requiring frequent adjustment of the circuits the present adjustment means would be found to be laborious if not entirely inadequate.

(c) A number of minor modifications are indicated to improve operation and maintenance of the transmitter circuits; and, if the equipment is intended for use where severe vibration exists, an improved method of mounting should be provided.

(d) The receiver has good sensitivity, selectivity, image ratio, etc.

(e) The receiver has exceptionally good AVC characteristics for its designed service.

(f) The receiver apparently is not affected to any great extent by exposure to high humidity; it can be started cold under such conditions with a relatively small loss of gain, which is restored very rapidly.

(g) Variations in temperature do not have any serious effect on receiver gain, except for a tendency toward instability at low temperatures. Controls seem to operate satisfactorily at all temperatures tested.

(h) While precision measurements could not be made on changes in receiver frequency during the temperature and humidity tests, there were no apparent changes in frequency of maximum response that were outside of signal generator error.

(i) In most instances, relatively slight changes in components would bring the receiver much closer to meeting the requirements of Naval service.

[redacted]

(j) The relatively poor performance of the receiver during listening tests on weak signals in the presence of strong local electrical noise is a serious defect in an otherwise excellent receiver. This may possibly be a defect of the individual unit tested.

(k) The necessity of tuning the signal in "by ear" with a tuning knob, in addition to setting the receiver oscillator frequency by means of the band or frequency switch, complicates operation of the equipment, particularly in the presence of strong local acoustical noise.

(l) The quality of reproduction on voice was excellent at all signal levels. Modulation measurements indicate linear response up to high modulation levels.

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RECOMMENDATIONS

It is recommended:

(1) That pilot lights or similar power indicators should be provided on the front panel for receiver and transmitter power circuits. Par. 2-2.

(2) That the necessary consideration be given to supplying suitable auxiliary power equipment in the event the Model 226C equipment is used in locations where 110 volts, 60 cycles is not available (Par. 2-8-f).

(3) That, if frequent tuning operations are contemplated, a more suitable means of making necessary tuning adjustments be provided. (Par. 2-3-b).

(4) That necessary steps be taken to provide adequate meters and auxiliary tuning apparatus to insure satisfactory adjustment and maintenance of equipment. (Par. 2-3-c).

(5) That suitable stranded wire be used in locations where leads and cables are subjected to repeated bending. (Par. 2-5).

(6) Taped wire power cable should be replaced by rubber sheathed cable. (Par. 3-9-(b)).

(7) It is recommended that flame proof wire of an approved type, insulated for at least 300 volts continuous operation, be used for wiring throughout the receiver circuits. (Par. 3-9-(m)).

(8) That all connection terminals be protected against corrosion; that suitable methods for clamping the power leads be provided and that a more satisfactory location for bringing the power leads into the cabinet be provided. (Par. 2-12).

(9) All terminal strips and boards should be wax treated against moisture. (Par. 3-9 (l)).

(10) Bakelite wafer-type tube and crystal sockets should be replaced by an approved ceramic type or else suitably wax-treated against moisture. (Par. 2-6, 3-9 (g)).

(11) That, in the interests of corrosion prevention, the type MW resistors be equipped with plated brass rather than plated steel mounting clamps and lugs. (Par. 2-9-c).

(12) Potting in an approved compound, or otherwise suitably protecting the loud-speaker input transformer, is recommended. (Par. 3-9 (e)).

[redacted]

(13) All unpotted choke coils should be protected by an appropriate wax treatment. (Par. 3-9 (i)).

(14) That precautions be taken to prevent leakage of compound from Transformer T-2. (Par. 2-8-d).

(15) That the Station Selector switch be more securely fastened to the shaft, either by use of two set-screws or by means of a taper pin. (See par. 2-2).

(16) That the necessary provision be made to insure that the antenna binding post grips the antenna wire securely. (Par. 2-9-f).

(17) That a means for suitably shock mounting the equipment be provided. (Par. 2-10).

(18) That suitable means for securing the handset against pitch and roll be provided; that the tension of the hook switch spring be increased and that provision be made for servicing the push-to-talk switch in the hand set. (Par. 2-11).

(19) Receiver and transmitter crystal frequencies should be plainly identified on the crystal holders. (Par. 3-9 (a)).

(20) "Goat"-type tube shields should be replaced by an approved well-grounded type. (Par. 3-9 (h)).

(21) It is recommended that approval be given the use of a 25 MF, 25 volt electrolytic condenser in a metal case for cathode by-passing. (Par. 3-9 (j)).

(22) All toggle switches should be of the same approved type and manufacture, preferably enclosed in a molded case, with heavy silver contact surfaces. (Par. 3-9-(k)).

(23) It is recommended that all controls that are lubricated in use shall employ a suitable lubricant which will not change its viscosity, in the temperature range of $+50^{\circ}$ to -15° C., sufficiently to affect operation of the control to any considerable extent. (Par. 3-7-b).

(24) The cause of the receiver's tendency to operate poorly under strong local electrical noise conditions should be determined and corrected, if readily possible. (Par. 3-9 (n)).

(25) Steps should be taken to reduce the radiation voltages appearing at the antenna terminal. (Par. 3-9 (o)).

[redacted]

(26) The tendency toward receiver instability at low temperatures should be corrected, if readily possible. (Par. 3-9 (p)).

(27) While the use of steel for cabinet and chassis is undesirable, it may be desirable to waive this requirement in the present instance for reasons of availability. (Par. 3-9(d)).

(28) That consideration be given to providing sufficient and suitable spare parts with the Model 226C equipment. (Par. 2-24).

[redacted]

MATERIAL UNDER TEST

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

1 - Model 226C, 25 Watt, Radio Telephone Equipment.
Western Electric Company
Serial No. 1110
equipped with following vacuum tubes:

2 - 807
2 - 6L6
1 - 5Z3
1 - 6L7G
2 - 6K7G
1 - 6C5G
1 - 6Q7G
1 - 6K6G

1 - 9D Quartz Plate, Ser. No. 657
1797.000 kc
2182.000 kc

1 - 9D Quartz Plate, Ser. No. 539
2137.000 kc
2126.000 kc

1 - 5D Quartz Plate, Ser. No. 3409
2115 kc
2500 kc

1 - Instruction Bulletin #962P

1-5. Plates TR-1, TR-2 and TR-3 are views showing the construction of the Model 226C equipment.

1-6. The Model 226C equipment was received at the Naval Research Laboratory on September 24, 1940.

METHOD OF TEST

1-7. The equipment, when received, was carefully unpacked and examined. Adequate precautions had been taken in preparing the equipment for shipment and no damage had occurred during transit. With the aid of the instruction bulletin furnished the equipment was placed into commission.

Transmitter

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

[redacted]

1-9 The transmitter was adjusted in accordance with the directions contained in the instruction pamphlet to operate at several frequencies, governed by the crystals furnished. Measurements of power output (carrier power) were made by means of a lamp load and a photronic cell. Two 15 watt, 32 volt lamps, connected in parallel were used as a load resistance. A capacitor of 300 µµf was connected in series with this load. The bases of the lamps were removed to minimize capacity losses. A photronic cell, rigidly anchored at a definite distance from the lamp load, and a microammeter were used to determine the power dissipated. A quick acting, low capacity switch was used to transfer the lamp load from the R.F. source to a 60 cycle calibrating source in order that the various parts of the load and measuring circuit might be maintained at temperature equilibrium. A precision type wattmeter (Weston Model 310, Ser. 7966) was used to determine the exact power required to produce the same photronic cell deflection which was obtained from the output of the transmitter.

1-10. The complete equipment was placed within a test chamber and subjected to variations in ambient temperature and relative humidity. A Model LK crystal controlled drift indicator was used to monitor the output frequency of the transmitter under test. The Model 226C transmitter was loaded into a dummy antenna consisting of a 300 µµf capacitor and a 25 ohm low inductance plaque resistor. Provision was made to check the power output of the transmitter under test at stated intervals during the course of the various tests conducted in the test chamber. The ambient temperature was varied between the limits of plus 50 degrees Centigrade and approximately minus 15 degrees Centigrade. The relative humidity was varied between the limits of approximately 30% and 95% at a temperature of 40 degrees Centigrade.

1-11. The ability of the equipment to withstand vibration was determined by mounting the unit on a vibration platform which was capable of producing vibration of varying degrees of amplitude and frequency. The equipment under test was kept under constant observation and voice signals were monitored and observed by means of a nearby receiver.

1-12. The Model 226C equipment was operated into an actual antenna whose quarter wave resonance point was approximately 2900 kc. The resistance of this antenna ranged between 5 ohms at 2100 kc and 9 ohms at 2800 kc. The capacity of the antenna fell between the limits of 550 µµf at 2100 kc and approximately 2000 µµf at 2700 kc. When operating into this antenna a 300 µµf series condenser was used.

Receiver

1-13. The receiver section of the equipment was examined; first, from the electrical viewpoint, with most of the information being derived from the circuit schematic diagram and other parts of the instruction book; second, from the mechanical and structural viewpoint by direct visual inspection. The results of these examinations are given in paragraphs 3-1 and 3-2.

[redacted]

1-14. The equipment was operated on an antenna (described in paragraph 1-12) for listening tests. A controllable standard signal was provided from an antenna about 1000 feet away and tests were made at various levels, with and without modulation. The results of these tests are described in paragraph 3-5 and are shown in Tables R-1, R-2 and R-3.

1-15. The receiver characteristics were measured in a shielded room, using a standard signal generator (Measurements, Inc. Model 65 Ser. 70) and a standard dummy antenna (General Radio Type 418G). The audio output was measured by means of an output meter (General Radio Type 583A, Serial 64). The sensitivity of the receiver was measured at full gain, since the noise level on loud-speaker operation was very low. A value of signal plus noise output of 40 milliwatts was chosen as being far enough below the AVC threshold point at 30% modulation. Noise output was also measured, both with modulation off and carrier off. Selectivity was measured at the same constant output level, with the input frequency varied at various input levels to give the same output reading on both sides of the frequency of maximum response. Image ratio was determined by measurement of the input at the image frequency necessary to give 40 milliwatts output This value of input was divided by the input for 40 milliwatts output at the desired frequency to give the image ratio.

A resonant overload characteristic measurement was made, with inputs from 0.1 microvolt to 2 volts. Noise level with modulation off was measured at each point. The effect of various carrier modulation percentages was determined in terms of A.F. output at 400 cps. The attentuation of the gain control was measured at the point of minimum output.

The voltage appearing at the antenna binding post due to the receiver oscillator was measured by substitution. The output caused by this undesired voltage in another receiver, coupled to the antenna post of the Western Electric equipment through 5000 ohms resistance, was measured. The standard signal generator was then substituted for the Western Electric receiver, and the input necessary to give the same output from the measuring receiver was determined. This measurement was made at the fundamental, second harmonic, third harmonic, etc., of the oscillator frequency.

The results of the above measurements are described in paragraph 3-6 (a to f) and are shown on Plates R-1, R-2 and R-3, and Tables R-4, R-5, R-6, R-7.

1-16. The equipment was set up in the temperature and humidity chamber, as described in par. 1-10, 2-15, and 2-16. Signal generator and output meter connections were made as shown in Plate TR-4. Since the transmitter output load was left connected to the antenna post of the equipment throughout the temperature-humidity tests, a 1000 ohm non-inductive resistor was used to isolate the equipments under test from each other, and also to protect the signal generator from the transmitter antenna voltage during operation of the transmitter. Changes in gain and noise level were meas-

[redacted]

ured during the course of the tests described in the above mentioned paragraphs and as given in par. 3-7. Results of the tests are shown on Plates R-4, R-5, and R-6, and Tables R-8, R-9, and R-10.

1-17. The equipment was set up for vibration test, as described in par. 1-10 and 2-17. The receiver was checked for changes in gain or functioning, with the results given in par. 3-8.

1-18. No receiver frequency measurements were made during the temperature, humidity, and vibration tests, other than the signal generator dial settings, due primarily to lack of time and the unavailability of precision frequency measuring equipment during the test period.

DATA RECORDED

1-19. The data recorded during the test are shown in the appended tables and plates. Tables or plates with the prefix TR refer to the equipment as a whole; the prefix "T" refers to the transmitter, while the prefix "R" covers receiver data.

TRANSMITTER - MECHANICAL DESIGN AND CONSTRUCTION

2-1. Vacuum Tubes. The Model 226C Western Electric Radio Telephone employs the following tubes in the transmitter section of the equipment:

(a) One 807 crystal oscillator .
(b) One 807 power amplifier.
(c) Two 6L6's as push-pull modulators.
(d) One 5Z3 rectifier, which is used to supply both transmitter and receiver.

The tube sockets are the bakelite wafer type commonly used in radio receivers. No shock mounting is employed, and tube base clamps are not used. However, tube base pins are gripped tightly by the socket contacts, and no trouble or damage resulted during the vibration test to which the equipment was subjected. Uninsulated clips are used to make contact to tube caps. All tubes employed in the transmitter section of the equipment are types which have received Navy type approval.

2-2. Panel Controls. The following controls are provided on the front panel of the equipment:

(a) Station selector switch, 4-position. The bakelite knob, one inch in diameter, is secured to the shaft with a single set screw.

(b) "Power-Off" switch. 2-position nickel plated toggle switch.

(c) "Speaker-Off" switch. 2-position nickel plated toggle switch.

[redacted]

(d) "Tuning" control for receiver.

(e) "Sensitivity" control for receiver.

No indicator lights are used. In addition to the above controls, which are mounted on the front panel, a push button "press-to-talk" switch is built into the handset grip. This push button cannot be locked in the "on" position. The above controls appear adequate in size and ease of manipulation and are so spaced and shaped that they can be operated even when conditions require the operator to wear gloves or mittens. However, it is considered advisable to either pin the control knobs, or at least use two set screws 120° apart rather than depend on the single screw employed at present.

2-3. Tuning. Tuning is accomplished by the following:

(a) Crystal Oscillator. This circuit is untuned.

(b) Power Amplifier Tank, Antenna Tuning and Coupling.

The tuning of these elements is accomplished by use of a common rotatable coil having four adjustable roller contacts. A screwdriver may be used to rotate the coil,and a hole in the top of the cabinet allows this to be done with the equipment operating. Three of the roller contacts are used for tuning the antenna, while the fourth roller secures proper plate impedance for the power amplifier tube. The station selector switch places various combinations of these taps in the circuit, depending on its position.
In positions one and two of the selector switch, which are normally used for ship to shore stations, no change in the roller circuits is made. Hence tuning to these two frequencies must be a compromise, and optimum conditions cannot be attained simultaneously on both channels. In position three of the selector swtich, one portion of the tuning coil is shorted out, and antenna tuning for this channel is therefore independent of the other channels. Tuning of band three is accomplished by moving the number three roller along the coil to short out the proper number of turns. Position four of the selector switch is tuned in the same manner as position three, a separate roller being used to short out part of the tuning coil. To summarize the above:

(1) Tuning of antenna positions one and two is accomplished by using the rotating feature of the tuning coil.

(2) Positions three and four of the selector switch are tuned by moving the proper shorting rollers along the coil. The rotating feature of the coil is not used.

[redacted]

(3) Power amplifier loading is adjusted for only one frequency. The same setting must serve for all four channels.

From this summary it is apparent that the rotating feature of the coil is used only once in tuning up all four bands, after which all subsequent adjustments are made by moving the coil roller contacts. These rollers are difficult to adjust in the present design, and it is necessary to remove the P. A. vacuum tube in order to reach the plate roller. It is suggested that some easier method of making adjustments be sought and if possible, a more independent method of coupling and tuning be provided.

(c) No meters are supplied with the equipment. As stated on Page 16 of the instruction book, the following apparatus is required for tuning the antenna:

1 - 500 μμf variable air condenser (calibrated)
1 - Simple wavemeter capable of tuning from 2 to 6 mc.
1 - 1.5 ampere R.F. ammeter

In addition, the following fixed condensers should be available:

2 - 100 μμf condensers
2 - 150 μμf condensers
2 - 200 μμf condensers
2 - 250 μμf condensers
2 - 300 μμf condensers
2 - 500 μμf condensers

In order to determine the proper plate loading, a 0-200 ma. meter and a plug to fit jack J1 are also required.

2-4. <u>Accessibility and Protection of Personnel.</u>

After the initial tuning adjustment, using the rotating feature of the tuning coil, further adjustments are accomplished by tilting the front panel forward. All components except the power supply are mounted on a shelf welded to the rear of the front panel. Hence, when in the tilted position, tank coil adjustments, and tube and crystal changes can be readily accomplished. The front panel is equipped with a sturdy continuous hinge along its lower edge and a catch holds the panel at 35° from the vertical when in the forward position. This catch may be released to allow greater opening, but in that case care must be taken that panel controls are not damaged by the supporting table. All components of the transmitter become accessible for servicing when the panel is in this near-horizontal position. Line fuses, rectifier tube and relays are also accessible, but several components of the rectifier, including wire-wound resistors, still cannot be serviced unless the rectifier chassis, mounted in the cabinet itself, is completely removed. This operation

[redacted]

requires unbolting the equipment from its support, if the bottom of the cabinet is inaccessible, and removal of six retaining screws. Protection of personnel is provided by the inclusion of an inter-lock switch at the rear of the panel shelf which acts to cut off the line supply voltage to the equipment when the front panel is tilted forward. A blocking condenser C1 prevents d-c from reaching the antenna. However, due to the common plate and antenna tuning coil, the P.A. voltage is present on this component.

2-5. Wiring. In general, the wiring of the Model 226C equipment is very well done.

(a) Unstranded, 22-gauge, tinned, color-coded, braid-insulated wire is used for wiring most of the circuits. Stranded, braid-insulated wire is used for vacuum tube cap connections and for leads to the hand-set hook switch mounted on the side of the cabinet.

(b) Leads from transmitter-receiver to rectifier are cabled together, taped, and led through two holes cut in the rectifier sub-base. These holes were originally fitted with grommets to prevent chafing the insulation, but these have moved out of position and are no longer effective. The wire used in the cabled leads is the solid, 22-gauge type described above. This wire is not considered suitable for applications where movement or bending of the wire in operation will take place, and it is therefore recommended that stranded flexible wires be employed for these cables.

(c) Solder is not depended upon for mechanical strength. Soldering lugs are crimped to wires.

2-6. Insulation. Ceramic insulation, apparently Isolantite, has been used in the antenna post insulator, P. A. tank coil form, and station selector switch parts. Phenolic insulation has been employed in terminal strips, relay parts, switches, tube sockets, crystal holders, and fixed condensers. Micalex is used for P.A. tank coil and plates. No condensers of the paper-cased type are used. A fiber grommet is used where the antenna lead passes through the metal shelf of the transmitter, and choke coil forms are also of fiber. As can be observed in the above list, non-ceramic insulation has been employed in some applications where its use is prohibited in standard Naval equipment. These are its use in the antenna transfer relay, tube sockets, crystal holders, antenna grommet, and choke coil forms.

2-7. Weights and Dimensions. The weight and dimensions of the Model 226C transmitter-receiver are given in Table Tr-1.

[redacted]

2-8. General Physical Construction.

(a) Both transmitter and receiver are assembled together on a plated steel shelf welded to and supported by the front panel. The rectifier is located in the cabinet itself and is assembled on a sub-base secured by six screws to the bottom of the cabinet. The cabinet itself encloses the entire equipment with the exception of the handset and hook switch, which are mounted on a bracket on the left side of the cabinet. The cabinet is of steel finished in gray-wrinkle on the exterior and plain gray on the interior. The front panel is of aluminum backed by a steel panel painted gray on the exposed inner surface. The front panel itself exhibits a pleasing appearance with the raised plain aluminum lettering on a glossy black background. The front panel is hinged as described in Paragraph 2-4 and is retained in the closed position by means of two plated-steel thumbscrews 5/8 inches in diameter, which engage self-aligning units fastened to the cabinets. The two thumbscrews are of the non-detachable type; and since they remain fastened to the panel, may be used as handles in opening the set. The continuous type hinge along the lower edge of the front panel is of nickel plated brass, mounted in a concealed manner.

(b) Steel has been employed in several instances where it has been the practice in Navy apparatus to use other materials. However, where steel has been used, a protective coating has been applied to prevent corrosion. The hinge along the lower edge of the front panel is of nickel plated brass. The materials used in construction have apparently been carefully selected by the manufacturer, and in general the choice is very good.

(c) Thumbscrews holding the front panel in the closed position are described above in paragraph 2-8-(a). Other screws holding components to the chassis, and the six screws which fasten the rectifier unit to the cabinet, are of stainless steel or nickeled brass.

(d) Ventilation has been accomplished by the provision of louvers on top and sides of the cabinet. The only evidence of overheating noted during the test period was the leakage of compound from T2, the modulator stage input transformer. Since the component is mounted adjacent to the modulator and rectifier tubes, it is quite likely that heat radiated by the tubes cuased the trouble. Failure of the transformer did not occur.

(e) The presence of the ventilation louvers in the top of the cabinet makes the equipment incapable of withstanding conditions where water may drip upon it.

[redacted]

(f) No rotating equipment is included in the set tested, since it operates directly from a 110-volt, 60-cycle source. Additional equipment will be necessary to operate the transmitter-receiver if sources other than 110-volt, 60-cycles are contemplated.

2-9. Component Parts.

(a) No meters whatever are provided with the equipment. As pointed out in paragraph 2-3-C, certain meters (not supplied) are necessary in order to tune the set initially.

(b) Switches employed in the transmitter are as follows:

1 - DPST nickel plated toggle switch (Power-Off).
1 - SPDT nickel plated toggle switch (Speaker-Off).
1 - SPST momentary, nickel plated push-to-close switch (interlock).
1 - Handset hook switch.
1 - Two-section, 4-position station selector switch.

The first three switches listed above are of Hart and Hegeman manufacture. The station selector switch is made by Yaxley. All switches are standard types.

(c) All resistors employed in the Model 226C are manufactured by IRC. Composition type resistors are used in ratings up to 2 watts, while power resistors are Type MW, wire-wound. The MW resistors are provided with plated steel mounting clamps and soldering lugs. Since these resistors are obtainable with brass clamps and lugs, it is recommended that this substitution be made in the interest of greater reliability. No ferrule type resistors are employed. Except in the case of composition resistors, which are provided with pigtail leads, wiring is not depended upon for mechanical support.

(d) The only fuses supplied in the equipment are the two line fuses rated at 5 amps. These are Littel-fuse No. 5AG of the non-renewable, glass body type. The dimensions are: overall length - 1-1/2"; diameter of ferrules 13/32". These are replaceable by Type M, midget Navy standard fuses. The phenolic fuse block is located on the rectifier chassis and may be reached by tilting the front panel of the transmitter-receiver forward to a nearly horizontal position. The fuse positions are not marked in any way to indicate the fuse rating required.

(e) Capacitors used in the transmitter section of the equipment include small bakelite-cased mica condensers and metal-cased by-pass and filter condensers manufactured by Cornell-Dubilier.

[redacted]

A 25-mfd., 25-volt dry electrolytic capacitor, metal-encased, is used as a filter for the microphone current supply. Replacement of all condensers in the transmitter-receiver portion of the equipment may be readily accomplished without disassembly. Filter condensers are located on the rectifier chassis and the unit must be removed from the cabinet in the manner previously described if these components require replacement.

(f) The antenna terminal is located at the top of the cabinet near the edge of the front panel. A spring binding post is used which will accommodate wires up to #8 B&S gauge. The clamp has rounded edges which do not retain the antenna wire securely, and the wire may be pulled out of the terminal post without difficulty. Since it is necessary to disconnect the antenna in order to tilt the front panel of the set forward (as in tuning up the circuits) it is desirable that a quick, convenient method of making the antenna connection be provided, but one which grips the wire in a more satisfactory manner than in the present design.

2-10. <u>Mounting and Shock-proofing</u>. No shock-proofing of any kind is employed in the equipment. It is apparently intended for mounting on a flat horizontal surface, since six felt pad feet are provided on the base. Four slotted bolt holes in the rear of the cabinet permit attachment to a vertical support.

2-11. <u>Handset</u>. A Western Electric Type F3 handset and hook switch is provided with the equipment. The handset merely hangs in the hook switch, no retaining spring or clamp being used. This arrangement is considered unsatisfactory, and it is recommended that some device be provided which will prevent loss of the handset due to pitch and roll or vibration. During vibration tests to which the equipment was subjected, it was noted that excessive vibration of the hook switch occurred at some frequencies with the handset off the hook. Although this vibration did not cause the switch contacts to operate, it is believed that under some conditions this might result. This switch is in the microphone circuit, and its intermittent opening would make transmitted speech unintelligible. It is therefore recommended that a stronger switch spring be employed. The button switch of the handset cannot be removed without special tools; and since this switch is in more constant use than any other in the equipment, it is believed that such construction is undesirable.

2-12. <u>Method of Connection</u>. A terminal strip provided with nickel-plated screw terminals is mounted on the top of the filter choke to serve for connections to the handset or handsets. The 110-volt, 60-cycle supply lines are connected directly to the fuse clips located on the rectifier chassis. Unplated brass screws and terminals not provided with lock washer or soldering lugs are employed at these fuse clips. It is recommended that parts properly protected against the effects of corrosion be substituted in this service. No clamps or other devices

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are provided to prevent the power leads from exerting a pull on the terminals themselves, and in view of the absence of lock washers mentioned above, trouble with poor contacts may develop. Wires are brought through grommeted holes in the sides of the cabinet. It is considered desirable that these holes be relocated to provide more convenient entry of the wires, since their present position near the rear necessitates a right angle bend of the entering wires just inside the cabinet. Wire for connection of the equipment to the 110-volt lines was not supplied. All terminals described above may be reached without difficulty by tilting the front panel forward until nearly horizontal.

2-13. Power Supply. The power supply is integral with the receiver-transmitter unit, being mounted on a separate chassis in the lower part of the cabinet as described in paragraph 2-8-(a). This portion of the equipment is composed of the main power transformer which supplies all filament, plate, and bias voltages for both receiver and transmitter, a suitable filter, and relays to perform the circuit functions described below. No radio-frequency filter is used in the supply line. A Type 5Z3 rectifier is used followed by a conventional single section filter. Since the same rectifier is used for both receiver and transmitter, a relay (S2) is included, which serves to transfer the output of the rectifier from receiver to transmitter, depending on which is being used. In addition, one contact of this relay inserts a capacitor in the filter circuit when in the "transmit" position to provide increased voltage. In the "receive" position, the filter is inductive input. Also included in the rectifier-filter unit is the keying relay (S3), which is actuated by the push button of the handset and which controls the action of the voltage transfer relay (S2) and antenna transfer relay (S1). Voltage for operation of this relay (S3) is obtained from the bias supply, hence keying the transmitter is impossible until bias voltage is available.

OPERATIONAL DATA AND TESTS

2-14. Power Output. Table T-1 illustrates the power output obtainable from the Western Electric Model 226C radio telephone. Three crystals were available and the outputs listed were obtained with the equipment tuned up on each of the three channels, so that operation on any one frequency could be selected by manipulation of the station selector switch only. It is pointed out that no crystal was used in position two, and it was therefore unnecessary to make a compromise adjustment between positions one and two as explained in paragraph 2-3-(b). Compromise adjustment on all three bands was still required as far as antenna coupling is concerned. The dummy antenna constants are given in the same table, while the method of measurement has been described in paragraph 1-9. Outputs varied from 21.1 to 24 watts, depending on the frequency as compared to the manufacturer's nominal rating of 25 watts. Operation on an actual antenna, described in paragraph 1-12, was also accomplished. Adjustment and performance were found to be satisfactory,and emitted signals of good quality were obtained.

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2-15. Variation of Ambient Temperature. Table T-2 shows information obtained during the course of this test. The temperature was held at 50° C. for a period of approximately two hours, while readings were taken at about 15-minute intervals of output power and frequency. The humidity was maintained at a low value throughout the test. At the end of the two-hour period the ambient temperature was reduced to -15° C. and was held between -15 and -17.5° C. for the remainder of the test. After a period of about 1-1/2 hours at this low temperature, the receiver, which up to this time had been operating continuously, was shut down and the entire equipment allowed to stand idle for 20 minutes. At the end of the idle period the equipment was started and the test proceeded as shown in Table T-2. An examination of the data listed in this table reveals that except for an increase in carrier frequency of about 200 cycles, no definite effect of the change of temperature was observed. The equipment could be started and all controls operated without difficulty at the lowest ambient temperature attained.

2-16. Variation of Humidity. Two humidity tests were conducted on the Western Electric radio telephone equipment. The data obtained in the first test are shown in Table T-3. The receiver was operated continuously during the entire test, while the transmitter was on only long enough to obtain readings. This humidity test followed the usual pattern of such tests to which standard Navy apparatus is subjected. The humidity was held at a low value for one hour, raised to 97%, where it was maintained for one hour, then dropped to less than 30% for the remaining hour of the test. No difficulties of any kind were encountered during the test, the equipment performing satisfactorily at all times. In the second of the humidity tests, conducted to determine the ability of the equipment to operate after subjection to severe humidity conditions, the humidity was raised to 97% at a temperature of 40° C. and maintained at this point for two hours, 43 minutes. The entire equipment was idle during this period. At the end of this time the equipment was started and its performance checked against that observed under the low humidity conditions existing previous to the test. It was found that no serious change had occurred due to the high humidity, and operation was satisfactory in every respect.

2-17. Vibration Test. The complete Western Electric equipment was subjected to a vibration test. The transmitter-receiver was permitted to rest on a flat horizontal surface and securely bolted to a vertical support by means of the four slotted bolt holes in the rear of the cabinet. The data obtained during this test are listed in Table T-4. The emitted signal was checked to determine frequency stability and in addition the quality of transmission was observed at frequent intervals on a Navy Type RAB receiver. No damage due to vibration was observed during the test period, and an inspection of the equipment after the test revealed no injury to components. During the 30-minute vibration test the transmitter was in operation continuously. While no damage or faulty operation was noted during the test, this does not constitute definite assurance that failure of parts will not occur if

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the equipment is subjected to lengthy periods of vibration in actual service.

2-18. Locked Key for One Hour. Table T-5 shows the results obtained when the Model 226C radio telephone was operated for one hour under full power output conditions. During the test the ambient temperature was maintained at 40° C. and the relative humidity held below 30 per cent. The frequency drift was recorded on a Model LK drift indicator, a total frequency change of 50 cycles being observed during the one-hour period. No evidence of damage or faulty operation in the transmitter was noted during the test, and an examination of the transmitter components revealed no injury had resulted. However, heat from the adjacent Type 6L6 modulator tubes and the Type 5Z3 rectifier caused some flow of impregnating compound from transformer T2, the input transformer for the push-pull modulator stage.

2-19. Control. No remote control unit was furnished with the Model 226C transmitter. Directions for the connection of additional handsets and hook-switches are included in the instruction book so that operation from a remote point becomes possible. The receiver must be turned on from the front panel in any case; and no station selector, receiver tuning, or volume control would be provided at the remote point. The equipment is primarily designed for local control.

2-20. Modulation. Quantitative tests of the modulation capabilities of this transmitter were not conducted. However, listening tests on a Type RAB Navy receiver revealed that transmitted speech was at all times clear and intelligible.

2-21. Break-in. Break-in operation is accomplished by means of Relay S1, which acts to transfer the antenna from receiver to transmitter. This relay is controlled by keying Relay S3, which in turn is actuated by the handset push-to-talk-switch. At the same time relay S3 controls relay S2, which transfers the plate voltage from receiver to transmitter and changes the voltage output in the manner described in paragraph 2-13.

2-22. Power Input. The power input as given by the manufacturer on Page 9 of the instruction book is 100 volt-amperes at 115 volts, 60-cycles for the "receive" condition and approximately 300 volt-amperes for the "transmit" condition. The power factor is given as 85-90 per cent.

2-23. Instruction Book. The instruction book which was supplied with the Western Electric equipment provides fairly complete information on the operation and maintenance of the apparatus. Installation, adjustment, and servicing are also covered in an adequate manner. The book is provided with both schematic and color-coded wiring diagrams. All components in the schematic diagram are identified by symbol numbers corresponding to a parts list included in the instruction book. The parts list gives the manufacturer of each part and ordering information. However, since the ordering information in most cases is useful only

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when the parts are obtained from Western Electric, it is suggested that more complete descriptions of the components be given, so that other sources of supply may also be utilized.

2-24. Spare Parts. No spare parts accompanied the Western Electric equipment. Since numerous component parts are of such design and manufacture that they are not likely to be available within the Naval organization, it is deemed advisable that some definite provision be made to permit repairs by operating personnel. It may be pointed out that many of the parts used would fail to comply with Navy standards, and hence disruptions and failures under the rigors of Naval Service will undoubtedly occur. It is suggested that the manufacturer be consulted to determine which parts are most subject to failure based on service records of the Model 226-C equipments, or equipments of similar construction.

2-25. Summary of defects and suggested changes. Such items as appear definitely defective, together with suggestions for improvement and modification, are listed below. At the end of each of the statements there appears the paragraph number in the body of the report wherein each matter is discussed in detail.

(1) Station Selector Switch is held by means of a single set screw. (2-2).

(2) No "power on" indicator is provided. (2-2).

(3) Difficulty is experienced in making tuning adjustments (2-3-b).

(4) No meters or auxiliary tuning devices are provided. (2-3-c).

(5) Solid wire cabled leads subjected to bending and consequent danger of damage. (2-5).

(6) Phenolic insulation used in applications where normally prohibited in standard Naval equipment. (2-6).

(7) Leakage of compound occurred from Transformer T-2. (2-8-d).

(8) No auxiliary power equipment was provided with the Model 226C submitted for test. (2-8-f).

(9) Steel mounting clamps and soldering lugs used in type MW resistors. (2-9-c).

(10) Antenna binding post does not grip wire securely. (2-9-f)

(11) No shock-proofing employed in the equipment. (2-10).

(12) Hand-set is not secured against pitch and roll of vessel; hook switch spring lacks sufficient tension; servicing or repairs to handset push-to-talk switch would be difficult. (2-11)

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(13) Connection terminals not protected against corrosion; no method for clamping power leads provided; location of entrance holes unsatisfactory. (2-12).

(14) No spares are provided with the Model 226C equipment. (2-24).

III. RECEIVER SECTION OF EQUIPMENT

Electrical Inspection

3-1. The equipment was given an electrical inspection and the following information obtained, in large part from the schematic circuit diagram and the instruction book.

(a) Type of Circuit: Superheterodyne.

(b) Frequency range: 2000 to 2800 kc, (not continuously variable)

(c) Number of Bands: 4 fixed crystal frequencies on switch.

(d) Crystals: Crystal oscillator control at each frequency.

(e) Crystal Mounting: Common holder with transmitter crystal for each frequency. Each crystal frequency marked on holder but not identified, so that it is impossible to determine which is receiver crystal frequency.

(f) Total Number of Tubes: 6

(g) Tube Types Used: 6C5G, 6K6G, 6K7G, 6L7G, 6Q7G, 5Z3.

(h) Power Supply Required: 110 volts, 60 cps; 100 VA drain.

(i) Type of B Supply and Max. B+. Voltage at Receiver: Transformer-rectifier (5Z3); max. B+ = 200V.

(j) Antenna Required: Less than 60 feet.

(k) Antenna Input Circuit: Single tuned circuit, no primary; capacity coupling to antenna.

(l) Radio-Frequency Amplifier: 1 stage (6K7 G); single tuned circuit, with primary in plate circuit of tube.

(m) Radio-Frequency Tuning: R.F. circuits (except oscillator) continuously variable on panel dial; oscillator on bandswitch, not ganged with other circuits.

(n) Converter: Pentagrid mixer (6L7G).

(o) Oscillator: Simple crystal controlled triode circuit (6C5G); oscillator frequency below signal frequency.

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(p) Intermediate-Frequency Amplifier: 1 Stage (6K7G);
Tuning frequency = 385 kc.
2 transformers = 4 tuned circuits.

(q) Second Detector: Conventional diode; 1 plate of 6Q7G diode section.

(r) AVC System: Separate from 2nd detector; other plate of 6Q7G diode section.
Tubes on control = R.F. amplifier and converter.

(s) C. W. Oscillator: None.

(t) Noise Suppressor: None evident.

(u) Audio-Frequency Amplifier:
1st stage = Diode-biased triode section of 6Q7G cathode resistance coupled to
2nd stage = 6K6G output pentode.

(v) Audio Output Circuit: Output transformer, with 200 ohms secondary feeding loud-speaker input transformer and hand-set phone.

(w) Gain Control: R.F. gain, by variation of cathode bias of R.F. amplifier, converter, and I.F. amplifier tubes.

(x) Safety Devices: Interlock switch at rear of chassis disconnects power when equipment is opened for servicing.

(y) Changeover Means: Handset push-button, actuating power and antenna transfer relays.

(z) Remote Control: Remote handset and ringer stations obtainable.

(aa) Receiver Sensitivity: (from instruction book):
1 microvolt for .06 watt output, input modulated 30% at 400 cps.
Noise level with modulation off carrier = .019 watt.

(bb) Miscellaneous: Operation requires separate switching of band switch (oscillator) and tuning of R.F. amplifier circuits with continuously variable tuning control.
Handset phone is on at all times, regardless of position of loudspeaker switch.
Receiver designed for continuous operation.

3-2. Mechanical Inspection.

The equipment was given a mechanical inspection and the following information obtained:

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(a) Number of Units Comprising Equipment: 1.

(b) Size: Shown in Table TR 1.

(c) Weight: Shown in Table TR 1.

(d) General Type of Construction: Par. 2-8 applies. In addition, the loudspeaker unit is mounted behind grill work on front panel.

(e) Number of Front Panel Controls and Function: Par. 2-2 applies.

(f) Other Controls: Lifting handset off hook connects hand-set circuits to transmitter and receiver (and switches remote control circuits, if used). Hand-set push-button switches from receiver to transmitter operation.

(g) General Layout and Accessibility of Controls: Symmetrical layout; accessibility good.

(h) Ease of Control and Operation: All controls work easily; operation similar to normal types of broadcast receiver (except for the use of the handset in transmission).

(i) Accessibility for Servicing: Very accessible; receiver-transmitter chassis and front panel tilt forward as a unit on a hinge at the bottom of the front panel, exposing power chassis at bottom of cabinet. All tubes and trimmer adjustments readily accessible in this position. Power and receiver-transmitter chassis interconnected with taped power cable. Tape loosening. (Par. 2-4 applies)

(j) Accessibility for Repair: Good.

(k) Power Indicator: No indicator for power ON, except marking of power switch on panel.

(l) Materials Used and Finishes: All chassis parts and cabinet of steel, primer coated and lacquer covered. Cable clips nickel plated, variable condensers cadmium plated. Anti-corrosion protection generally good.

(m) General Insulation to Moisture: Appears reasonably good; loud speaker input transformer should be moisture proofed.

(n) General Protection against High Temperatures: Appears good.

(o) Ability to Withstand Vibration and Shock: No shock mounting provided; components appear to be well mounted.

(p) General Ruggedness: Appears excellent.

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(q) Tube Mounting, Sockets, etc: Tubes vertical, in bakelite wafer sockets. Sockets replaceable but will require disturbing of wiring and some resistors.

(r) Tube Shields: Two of "Goat" type used. These are constructed of several parts, fitting the tube envelope. Generally unreliable, with poor, indirect grounding to chassis.

(s) Transformers, Chokes, etc: Well encased, sturdy appearance, potting unknown. Universal wound choke coils varnished; wax would be preferable.

(t) Crystal mounting: Each crystal mounted in common molded bakelite holder with transmitter crystal; holder plugs into bakelite wafer tube socket. Very accessible.

(u) R.F. Transformer Structure: Hammerlund units in aluminum can shields; air trimmers.

(v) I. F. Transformer Structure: Hammarlund units in aluminum can shields; air trimmers.

(w) Variable Condensers: Hammarlund 2 gang, construction similar to air trimmer condensers; ceramic insulation; plate spacing small but probably satisfactory; cadmium plated.

(x) Fixed Condensers: Molded mica or metal-clad paper types, except for one 25 MF, 25 V electrolytic in metal can.

(y) Switch Construction: Band-switch is of ceramic wafer type, with silver-plated contacts; flat wipe. Power switch is of toggle type with bakelite housing. Speaker switch is of toggle type, with laminated housing.

(z) Resistors: Mostly 1/4 watt pigtail type; rigidly mounted, generally accessible but haphazard as to arrangement.

(aa) Terminal Strips: Sturdy, .115 inch thick terminals, with .1 inch creepage path, in power unit. Tinned lugs on .065 in. impregnated bakelite in receiver chassis; light but appear sufficiently strong. May be satisfactory for creepage if properly impregnated.

(bb) Mounting of Components: No rivets found; screws, nuts, and lock washers used throughout. Many resistors and condensers mounted on pigtails between other components, but in no case in an objectionable manner and well locked against rotation.

(cc) Wiring: Generally neat, arrangement good, with no long leads except cabled and taped leads from power unit. Excessive flexing of this power lead appears to have damaged taping. Wire size very small, with thin synthetic or rubber insulation covered with colored fabric outer braid. (Par. 2-5 also applies.)

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(dd) Miscellaneous: Antenna connection (or stand off insulator,) located above top of front panel. (Par. 2-9 (f) applies.)

3-3. Examination of Instruction Book
The comments in paragraph 2-23 apply to the receiver as well as to the transmitter portion of the equipment.

3-4. Spare Parts
The comments in paragraph 2-24 apply.

3-5. Listening Tests.
The equipment was set up in the Transmitter building and connected to an outside antenna. A standard signal generator was set up in the Laboratory Annex building about 1000 feet away, and its output connected to an outside antenna for the purpose of radiating a readily controllable field at the frequency of test. Tests were made with and without 30% modulation at various carrier levels, and voice modulation was also made available by means of a suitable microphone and audio amplifier modulating the signal generator.

The presence of a strong variable noise field in the transmitter building location made it difficult to get consistent results at the lower levels of signal generator input. The results tabulated in Table R-1 were obtained in the first listening test.

Due to the relatively poor showing of the equipment under test, as compared to similar equipments of other manufacture also tested at the same time in the same way, the test was repeated on the following day. The results are shown in Table R-2.

As shown in Table R-2, the results obtained in the second test were similar to those in the first.

It was also observed during all the listening tests that the receiver seemed to block on strong instantaneous noise pulses, such as similar to ignition noise. This blocking effect did not persist for any great length of time, but, in the presence of a continuous series of pulses, was enough to interfere seriously with the reception of relatively weak signals, which could, however, be readily understood on the other equipments under test. It is believed that the relatively poor showing of the Western Electric receiver on the listening tests, despite the superiority indicated by the Laboratory measurements in a noise-free shielded room, was due primarily to this tendency to block instantaneously in the presence of noise. This may possibly be an abnormal characteristic of the particular receiver tested.

The Western Electric equipment was tested at 2500 KC, as this was the crystal frequency nearest to 2738 KC provided in the group of crystals sent with the set. The other equipments tested were provided with crystals for the 2738 KC Intership channel. In order to determine possible differences due to the antenna at 2500 KC as compared to

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2738 KC, the field intensity from the transmitter portion of each equipment was measured at an arbitrary distance of about 750 feet. The same antenna was used in each case, and the antenna current was approximately the same on each equipment (about 1.0 ampere). The results are tabulated in Table R-3.

From Table R-3, and in view of other tests made by the Transmitter Section of the Laboratory on a dummy antenna, it seems probable that the frequency employed in testing the Western Electric Receiver was unfavorable for the antenna used, and it is believed that the receiver might have made a better showing on this antenna if it could have been tested at the same frequency as the other equipments.

3-6. Laboratory Measurements.

The receiver section of the Western Electric equipment was measured in a shielded room, (as per par. 1-15), with the following results.

(a) Sensitivity, Noise Output, Image Ratio and I. F. Response.
These are shown in Table R-4.

(b) Selectivity
The selectivity characteristic of the receiver is shown on Plate R-1. Tabulation R-5 summarizes this characteristic.

(c) Resonant Overload and Carrier Noise.
The resonant overload characteristics are shown in graph form on Plate R-2. The data for Table R-6 have been derived from this graph.

The graphs on Plate R-2 show an exceptionally flat AVC characteristic over a large range of input values, with a very sharp threshold at which AVC action begins. The input range necessary to decrease the carrier noise to the minimum value is small compared to the other makes of receivers tested, minimum carrier noise being obtained at 100 microvolts input.

(d) Effect of Modulation Depth on Output
Plate R-3 shows the effect of varying the signal modulation depth on the audio output from the receiver. The curve departs from linearity above about 70% modulation.

(e) Gain Control Range
The maximum attenuation of the sensitivity or gain control of the receiver is approximately 62 DB.

(f) Radiation of Oscillator Frequency.
The voltages appearing at the antenna terminal due [illegible] local crystal oscillator of the receiver were measured in terms of the microvolts input from a standard signal

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generator required to give the same output from a receiver tuned to the oscillator frequency. Both the receiver under test and the standard signal generator were connected, in turn, to the input terminals of the measuring receiver. The resulting data are shown in Table R-7.

3-7. <u>Temperature and Humidity Tests</u>
The equipment was set up in the large Temperature-Humidity chamber and was tested under the conditions described in par. 2-15 and 2-16. The circuit arrangement is shown schematically in Plate TR-4.

(a) <u>Effect of Humidity on Gain and Noise Level of Receiver</u>

The receiver noise output level was set, by means of the gain control, at 0.4 MW prior to beginning of test, with no carrier input. A drop in the local noise level, however, brought this output down to about 0.03 MW by the time the test was actually started and this lower noise level was obtained throughout most of the test.

The change in receiver gain with variation of humidity was measured in terms of the carrier input voltage required to maintain an arbitrary standard output of 10 MW (signal and noise), with the standard signal generator modulated 30% at 400 cps. Noise outputs with modulation off, and with carrier off, were also measured. Readings were taken at approximately 15 minute intervals.

The results of the test are shown on Plate R-4. Tabulation R-8 was derived from these graphs.

(b) <u>Effect of Temperature on Gain, Noise Level, and Control Operation.</u>
The change in receiver gain with variation of temperature was measured, in a way similar to that in the previous test. In this test, however, the signal generator was modulated 90% at 400 cps. Due to better local noise conditions (i.e. lower electrical interference noise.) during this test, the receiver gain was raised to maximum, and the input for a constant output of 100 milliwatts measured at about 15 minute intervals. Noise outputs were also checked, as well as signal generator dial settings. The equipment was operated continuously. The controls were checked at -17° C. for operation and found to be somewhat stiff but otherwise satisfactory. It was noted that the receiver showed signs of regeneration and instability upon operation of the tuning knob on either side of resonance, with the signal generator input on.

Plate R-5 shows the results of these tests. Tabulation R-9 was derived from these graphs.

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During the temperature test, it was noted that the output termination for maximum output from the receiver changed from 200 to 250 ohms at the higher temperatures. This value came back to 200 ohms at room temperature at the end of the test.

(c) <u>Effect of Humidity on Cold-Start Gain and Noise Characteristics.</u> For this test, the signal generator was modulated 90% at 400 cps. The input for 100 MW output, with gain control on maximum, was measured at 40° C. and 23% humidity. Noise was also measured and signal generator dial readings noted. The receiver was then turned off and the humidity increased to 97% at the same temperature, as described in par. 2-16. The receiver was turned on after 2 hours, 43 minutes, and the input for 100 MW. output and noise, immediately measured. The same measurements were then made at suitable short intervals to show the variations occurring after starting up. These readings are shown in graph form on Plate R-6.
The values shown in Table R-10 are derived from the above graphs.

3-8. <u>Effects of Vibration</u>
The equipment was subjected to a vibration test, as described in paragraph 2-17. The receiver was measured for changes in gain, whenever possible, between the intervals of vibration and transmitter operation. Very little usable data was obtained, however, due to the extremely high variable noise level in the transmitter building, where the tests were conducted. The receiver appeared to function well during the test, with no apparent damage or abrogation of performance. Reception of voice modulated signals was good during vibration. The few figures obtained in the course of the test indicate, if anything, a possible increase in gain after vibration, but the results are not definite.

3-9. <u>Summary of Defects</u>
The following defects were found as a result of the examinations and tests listed in paragraphs 3-1 to 3-8.

(a) Receiver and transmitter crystal frequencies are marked on each common crystal holder, but there is no way to determine from the markings which one is the receiver crystal frequency and which the transmitter. (Par. 3-1(e)).

(b) Taped wires interconnecting the power and receiver-transmitter chassis are unsatisfactory and should preferably be rubber sheathed cable. (Par. 3-2 (i)).

(c) Pilot lights or similar power indicators are not provided to indicate when receiver and transmitter sections of equipment are in operation. (Par. 3-2 (k)).

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(d) Use of steel for cabinet and chassis is undesirable, although these parts seem to be adequately protected by primer and lacquer coats (Par. 3-2 (l)).

(e) The loudspeaker input transformer (mounted on the loudspeaker frame) apparently is not moisture-proofed. (Par. 3-2 (m)).

(f) No shock mounting is provided for the entire equipment. (Par. 3-2 (o), 2-10).

(g) Tube and crystal sockets are of a bakelite wafer type, apparently not wax-treated. (Pars. 3-2 (q) and (t).

(h) Tube shields of the "Goat" type are used. These depend on a rather insecure method of assembly and are grounded through a series of consecutive contacts which are not dependable. (Par. 3-2 (r)).

(i) Universal wound choke (retard) coils are used, which appear to be varnish impregnated. Wax would be preferable. (Par. 3-2 (s)).

(j) One 25 MF, 25 V electrolytic condenser is used, mounted in a metal can. (Par. 3-2 (x)).

(k) Toggle switches are used, reliability unknown. Two different types provided; these should preferably be of the same type for replacement purposes (Par. 3-2 (y)).

(l) Terminal strips apparently are not wax-treated for creepage. (Par. 3-2(aa)).

(m) Wire size used in wiring is small, with thin insulation. (Par. 3-2 (cc)).

(n) Receiver appears to be affected by local noise to a much greater extent than similar equipments tested at the same time under similar conditions. (Par. 3-5).

(o) Radiation voltages appear to be excessive, particularly on switch position 1. (Par. 3.6 (f); Table R-7).

(p) Signs of regeneration and instability have been observed at -17° C. (Par. 3-7(b)).

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TABLE TR-1
Model 226C Western Electric Radio Telephone
Weight and Dimensions

Dimensions:	H - 15 3/4 inches overall
	D - 8 3/4 inches
	W - 19 inches with handset mounting
Weight:	65 lbs. 12 oz.

TABLE T - 1
Model 226C Western Electric Radio Telephone
Power Output

Antenna: 300 mmf + two 32 volt, 15 watt lamps in parallel.

	2126 KC	2182 KC	2500 KC
Ip (ma)	120	117	126
Irf (amps external)	1.05	1.04	1.01
E (Volts- line)	119	117.5	118
Selector Switch Position	1	3	4
Watts Output	24.0	23.3	21.1

[redacted]

TABLE T – 2
Model 226C Western Electric Radio Telephone
Variation of Ambient Temperature-2500 KC

Time	Ambient Temp. °C.	Relative Humidity %	Irf External Amps.	Frequency Kilocycles	Output Watts
0	50	17	0.93	2500.228	21.6
20	50	16	.90	.217	20.2
35	49	17	.91	.213	20.7
50	49	17	.92	.213	21.2
1:05	49.5	17	.90	.195	20.2
1:27	50	16	.90	.195	20.2
1:37	49.5	16	.88	.192	19.4
1:52	49.5	16	.88	.192	19.4
2:06	50.	15	.88	.194	19.4
2:21	46.	17.5			
2:36	28.	19		.187	
2:51	8.5		.87	.210	18.9
3:06	-0.5		.88	.257	19.4
3:21	-5.0		.86	.283	18.5
3:36	-9.0		.90	.305	20.2
4:00	-12.5		.90	.332	20.2
4:15	-14.5		.90	.352	20.2
4:32	-15.5		.90	.358	20.2
4:50	-17.0		.92	.363	21.2
5:05	-17.5		.92	.373	21.2
5:26	-17.0		.94	.380	22.1
5:44	-16.5	Equipment idle from 5:40 to 6:05			
6:00	-17.0				
6:05	-17.0		.93	.403	21.6
6:20	-16.5				
6:35	-16.5				
6:50	-17.5		.99	.395	24.5
7:05	-16.0		.98	.370	24.0
7:25	-15.5		1.02	.351	26.0

[redacted]

TABLE T - 3
Model 226C Western Electric Radio Telephone
Variation in Humidity -2500 KC

Time Minutes	Ambient Temp. °C.	Relative Humidity %	Irf External Amps.	Frequency Kilocycles	Output Watts
0	40	19	0.97	2500.246	23.5
20	39	14.5	.97	.241	23.5
35	40	13	.97	.241	23.5
50	40	13	.96		23.0
80	39	90.5	.93	.225	21.6
107	39	97	.94	.227	22.1
122	39	97	.94	.236	22.1
140	39	97	.93	.211	21.6
155	39	97	.92	.221	21.2
170	39.5	97	.92	.218	21.2
185	39	56.5	.91	.223	20.7
200	40	27	.91	.219	20.7
215	39.5	26.5	.91	.221	20.7
230	40	29	.89	.218	19.8
245	40	29	.89	.211	19.8
260	40	29	.89	.211	19.8

Antenna: 300 µµf in series with 25 ohms plaque resistors.

Output Frequency at end of first test period - 2500.241 KC
Frequency of maximum departure thereafter - 2500.211 KC
Difference - 30 Cycles or 0.0012 %

Power output at end of first test period - 23 watts
Maximum power decrease noted thereafter - 19.8 watts
Difference - 3.2 watts, or 13.9 %

[redacted]

TABLE T - 4
Model 226C Western Electric Radio Telephone
Vibration Test-2126 KC

Time	Irf External Amps.	Emitted Signal	Condition
13.44	1.01	Satisfactory	Stationary
13.49	1.01	"	Vibration
13.54	1.01	"	"
13.59	1.01	"	"
14.04	1.01	"	"
14.09	1.01	"	"
14.14	1.01	"	"
14.19	1.01	"	"
14.20	0.98	"	Stationary

TABLE T - 5
Model 226C Western Electric Radio Telephone
Locked Key Operation for One Hour-2500 KC

Time	Ambient Temp. °C.	Relative Humidity %	Irf External Amps.	Frequency Kilocycles	Output Watts
14:10	40	25	0.93	2500.216	21.6
14:20	39.5	24.5	0.92	.209	21.2
14:30	39.5	24.5	0.94	.205	22.1
14:40	39	26.0	0.92	.186	21.2
14:50	40	25.0	0.91	.181	20.7
15:00	39	29.0	0.93	.175	21.6
15:10	40	25.0	0.92	.165	21.2

Output frequency at beginning of test - 2500.216
Maximum frequency departure noted thereafter - 2500.165
Difference - 51 Cycles or 0.002 %

Power output at start of test - 21.6
Minimum power observed thereafter 20.7
Difference - 0.9 watts, or 4.16 %

[redacted]

TABLE R - 1

Listening Tests on Western Electric 226C

Radio-Telephone - October 4, 1940

\- - - - - - -

f = 2500 KC

(1)	Sig.Gen. Input to Antenna in Lab.Annex	2 volts	100,000 µv	10,000 µv	5,000 µv
(2)	Signal Plus Noise Output (30% modulation)	27 MW	38 MW	-	-
(3)	Noise: Carrier On	0.1 MW	13 MW	-	-
(4)	Noise: Carrier Off	100 MW	100 to 200 MW	-	-
(5)	Ratio in DB Signal plus Noise to Noise : (2)/(3)	24.3 DB	4.7 DB	-	-
(6)	Comments on Quality & Intelligibility	Excellent: AVC protects receiver from overload	Very understandable, but noisy background	Inaudible above noise	Inaudible above noise

[redacted]

TABLE R - 2

Listening Tests on Western Electric 226C

Radio-Telephone - October 7, 1940

- - - - - - - -

f = 2500 KC

(1)	Sig. Gen. Input to Antenna in Lab. Annex	2 volts	100,000 µv	50,000 µv	10,000 µv
(2)	Signal plus Noise Output (30% modulation)	30 MW	45 MW	60 MW	60 MW
(3)	Noise: Carrier On	0.1 MW	17 MW	60 MW	60 MW
(4)	Noise: Carrier Off	100 MW	100 MW	100 MW	100 MW
(5)	Ratio in DB: Signal plus Noise to Noise : $\frac{(2)}{(3)}$	24.9 DB	4.2 DB	0	0
(6)	Comments on Quality & Intelligibility	Excellent	Understandable; noise high. Quality good on handset.	Speech audible but not understandable	Unheard; Tone or speech.

TABLE R - 3

Field Intensity of Three Radio-Telephone Transmitters at a Point approximately 750 feet from the Antenna (Same antenna used for each)

Equipment	Frequency	Measured Field Intensity
Western Electric 226C	2500 KC	22,500 µv meter
B	2738	54,500
C	2738	51,000

(Above measurements made with Ferris portable Field Intensity Meter).

[redacted]

TABLE R - 4

Sensitivity, Noise Output, Image Ratio and I.F. Response

of Western Electric 226C Radio-Telephone Receiver

Gain control at maximum; input modulated 30% at 400 cps.

Output impedance: 200 ohms.

Selector Switch Position	1	2	3
Signal Frequency	2182 KC	2500 KC	2522 KC
Tuning Knob Position	87	38	36
Input through Standard Dummy Ant.	2.2 μv	2.0 μv	2.05 μv
A.F. Output in 200 ohms	40 MW	40 MW	40 MW
Noise Output - modulation off	1.3 MW	1.8 MW	1.8 MW
Noise Output - Carrier off	0.1 MW	0.15 MW	0.15 MW
Image Frequency	1412 KC	1730 KC	1752 KC
Image Ratio	4210	1785	1700
I.F. Response from Antenna for 40 MW output (385 KC)	over 100,000 μv	-	over 100,000 μv

DECLASSIFIED

[redacted]

TABLE R - 5

Selectivity of Western Electric 226C

Radio-Telephone Receiver

\- - - - - - - - -

Frequency - 2500 KC

Gain control at maximum; input, 30%
modulation at 400 cps; constant output - 40 MW

Ratio: $\frac{\text{Input off max. response}}{\text{Input at max. response}}$	Ratio in DB	Band Width	
		KC	%
1.4	3 DB	4.8 KC	.19%
2	6	6.5	.26
10	20	11.4	.47
100	40	19.3	.77
1,000	60	30.0	1.2
10,000	80	47.5	1.9

[redacted]

TABLE R - 6

Resonant Overload Characteristics of Western Electric

226C Radio-Telephone Receiver.

Gain control on max., input 30% modulated at 400 cps.

(1)	Threshold of AVC action:	Input - 2.6 µv Output - 62 MW
(2)	Maximum variation of output for +100 DB increase of input above AVC threshold:	60 to 72 MW (0.8 DB)
(3)	Input for 6 DB change in AVC threshold output:	1.10 volts
(4)	Range of linear detection below AVC threshold:	Input - 1.3 to 2.6 µv Output - 13 to 62 MW
(5)	Carrier noise output (modulation off):	Max. - 1.8 MW Min. - .04 MW Ratio - 16.5 DB
(6)	Range of input variation to decrease carrier noise from max. to min. value:	2.6 to 100 µv (+32 DB)
(7)	Max power output of receiver	460 MW

[redacted]

TABLE R – 9

Effect of Temperature on Gain and Noise Level of Western

Electric 226 C Radio-Telephone Equipment

- - - - - - - -

Gain control set at max.

Temperature	50° C (Start)	50° C (End)	–15° C (Start)	–15° C (End)
Time	0	120 mins.	255 mins.	410 mins.
Input for 100 MW output	76 µv	78 µv	21 µv	28 µv
Gain Ratio	1.0	0.975	3.61	2.71
DB change in initial gain	0	–0.2 DB	+ 11.2 DB	+ 8.7 DB
Carrier Noise Level – Mod. off	10 MW	13 MW	49 MW	60 MW
Carrier Noise Ratio	1.0	1.3	4.9	6.0
DB Change in Carrier Noise	0	+1.2 DB	+6.9 DB	+7.8 DB
Noise Output – Carrier Off	4 MW	5 MW	25 MW	60 MW
Noise Ratio – Carrier Off	1.0	1.25	6.25	15
DB change in noise output – carrier off.	0	+1.0 DB	+7.8 DB	+11.7 DB

[redacted]

TABLE R - 10

Effect of Humidity on Cold-Start Gain and Noise Characteristics of Western Electric 226C Radio-Telephone Receiver

- - -

Gain control on max. - Equipment turned off from 0 to 200 mins.

Condition	Initial Check (a)	Equipment turned on (b)	Reading (c)	Reading (d)	Final Reading (e)
Time	0	200 mins.	205 mins.	215 mins.	300 mins.
Humidity	23%	97%	97%	97%	26%
Input for 100 MW output	65 µv	375 µv	130 µv	117 µv	75 µv
Gain Radio	1.0	0.173	0.5	0.55	0.87
DB Change in Gain	0	-15.2 DB	-6 DB	-5.2 DB	-1.2 DB
Carrier Noise Level-Mod. Off	.6 MW	1.1 MW	1.1 MW	1.1 MW	8 MW
Carrier Noise Ratio	1.0	1.83	1.83	1.83	13.2
DB change in carrier noise	0	+2.6 DB	+2.6 DB	+2.6 DB	+11.2 DB
Noise Output - - Carrier Off	1.4 MW	.14 MW	.14 MW	.14 MW	8 MW
Noise Ratio - Carrier Off	1.0	0.1	0.1	0.1	5.7
DB Change in Noise - Carrier Off	0	-5 DB	-5 DB	-5 DB	+7.6 DB

[redacted]

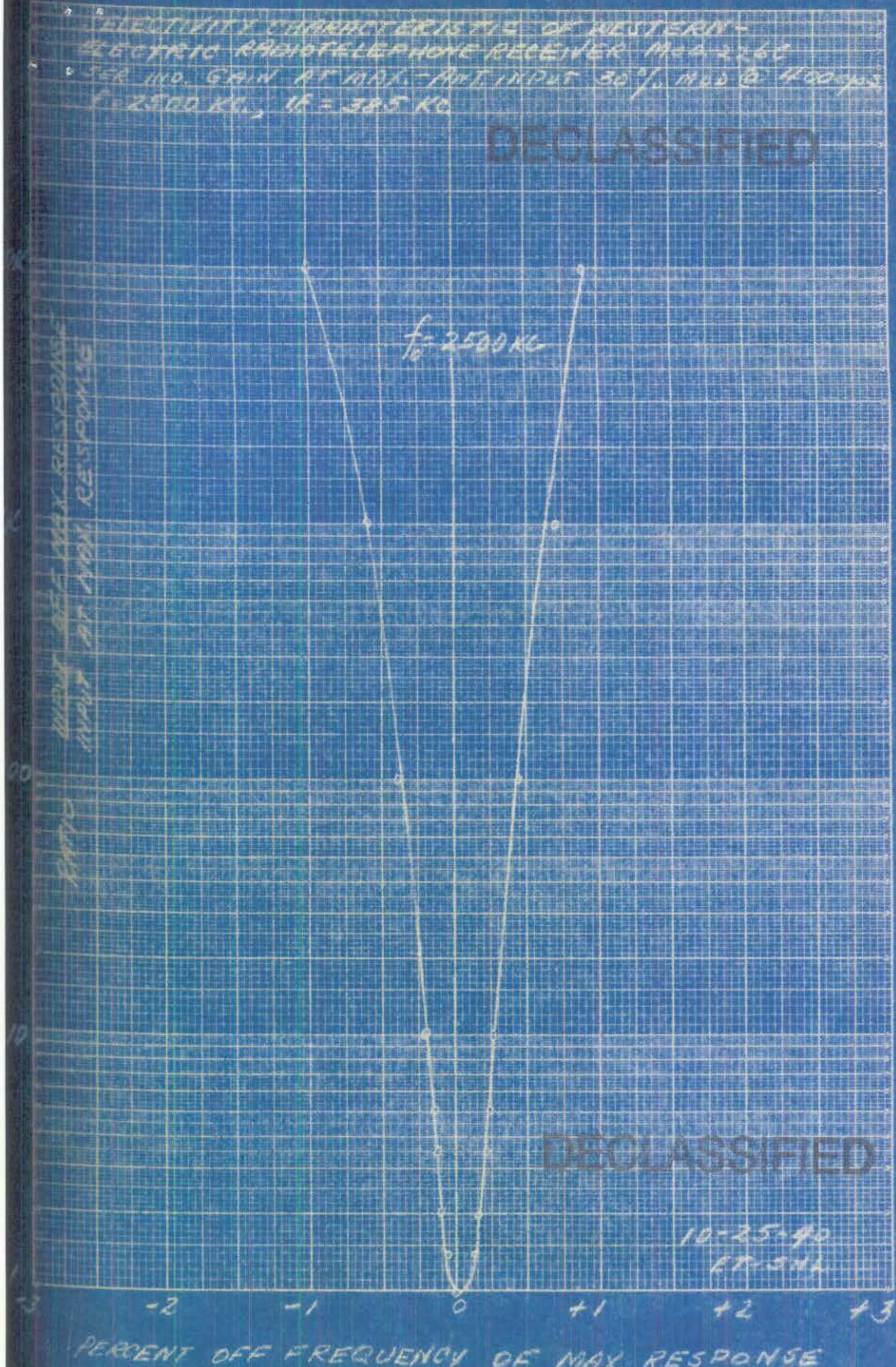
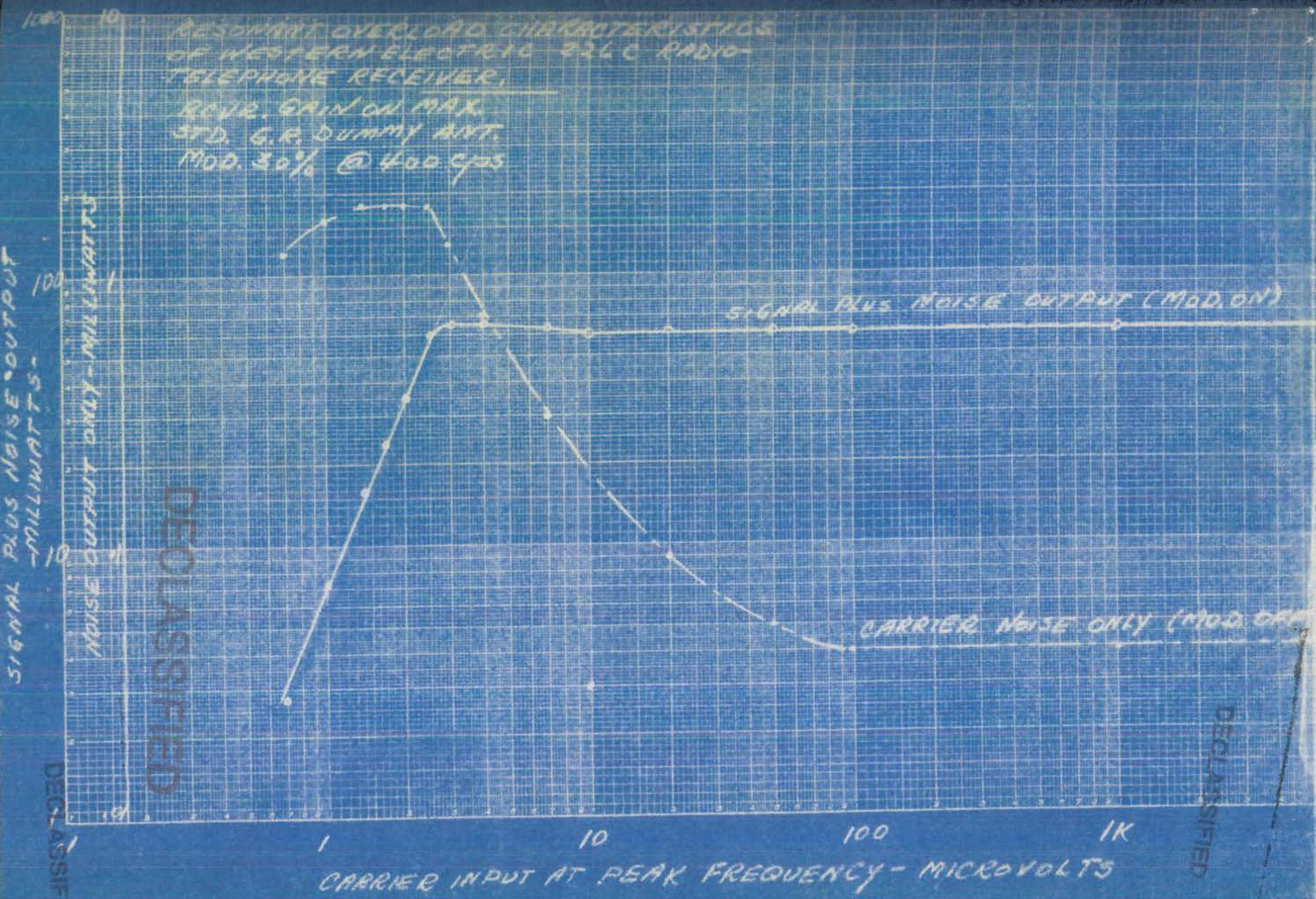
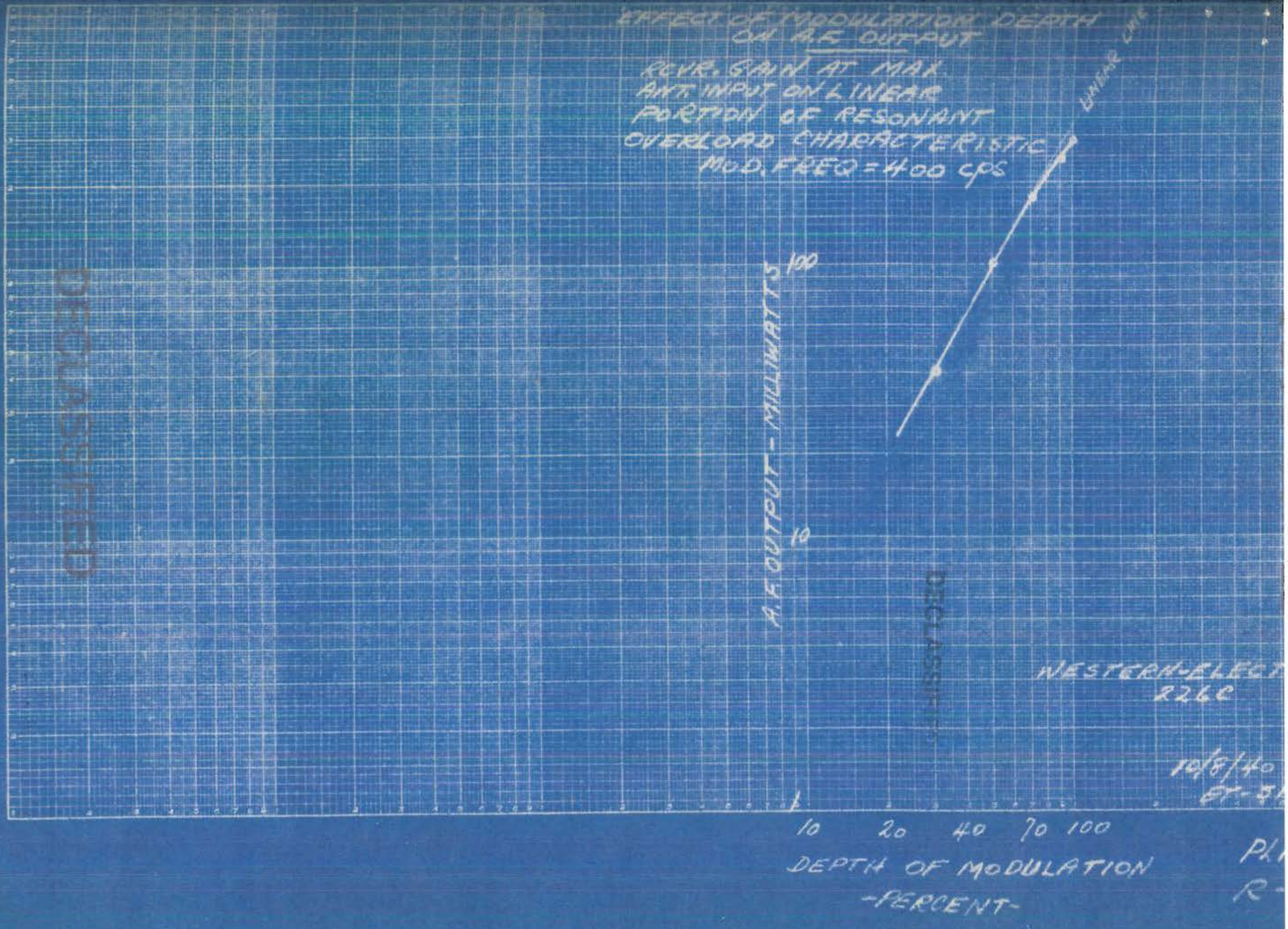

SELECTIVITY CHARACTERISTIC OF WESTERN-
ELECTRIC RADIOTELEPHONE RECEIVER
SER. NO. GAIN AT MAX. - ANT. INPUT 30% MOD @ 400cps
f = 2500 KC., IF = 385 KC
f_0 = 2500 KC
RATIO INPUT OFF MAX. RESPONSE / INPUT AT MAX. RESPONSE
10-25-40
-2
-1
0
+1
+2
+3
PERCENT OFF FREQUENCY OF MAX. RESPONSE

PLATE R-1



RESONANT OVERLOAD CHARACTERISTICS OF WESTERN ELECTRIC 226C RADIO-TELEPHONE RECEIVER.
RCVR. GAIN ON MAX.
STD. G.R. DUMMY ANT.
MOD. 30% @ 400 CPS
SIGNAL PLUS NOISE OUTPUT (MOD. ON)
CARRIER NOISE ONLY (MOD. OFF)
SIGNAL PLUS NOISE OUTPUT -MILLIWATTS-
NOISE OUTPUT ONLY - MILLIWATTS
1000
100
10
1
10
1
1
10
100
1K
CARRIER INPUT AT PEAK FREQUENCY - MICROVOLTS


EFFECT OF MODULATION DEPTH
ON A.F. OUTPUT
RCVR. GAIN AT MAX
ANT. INPUT ON LINEAR
PORTION OF RESONANT
OVERLOAD CHARACTERISTIC
MOD. FREQ = 400 CPS
LINEAR LINE
A.F. OUTPUT - MILLIWATTS
100
10
1
10 20 40 70 100
DEPTH OF MODULATION
-PERCENT-
WESTERN-ELECT
226C
10/8/40

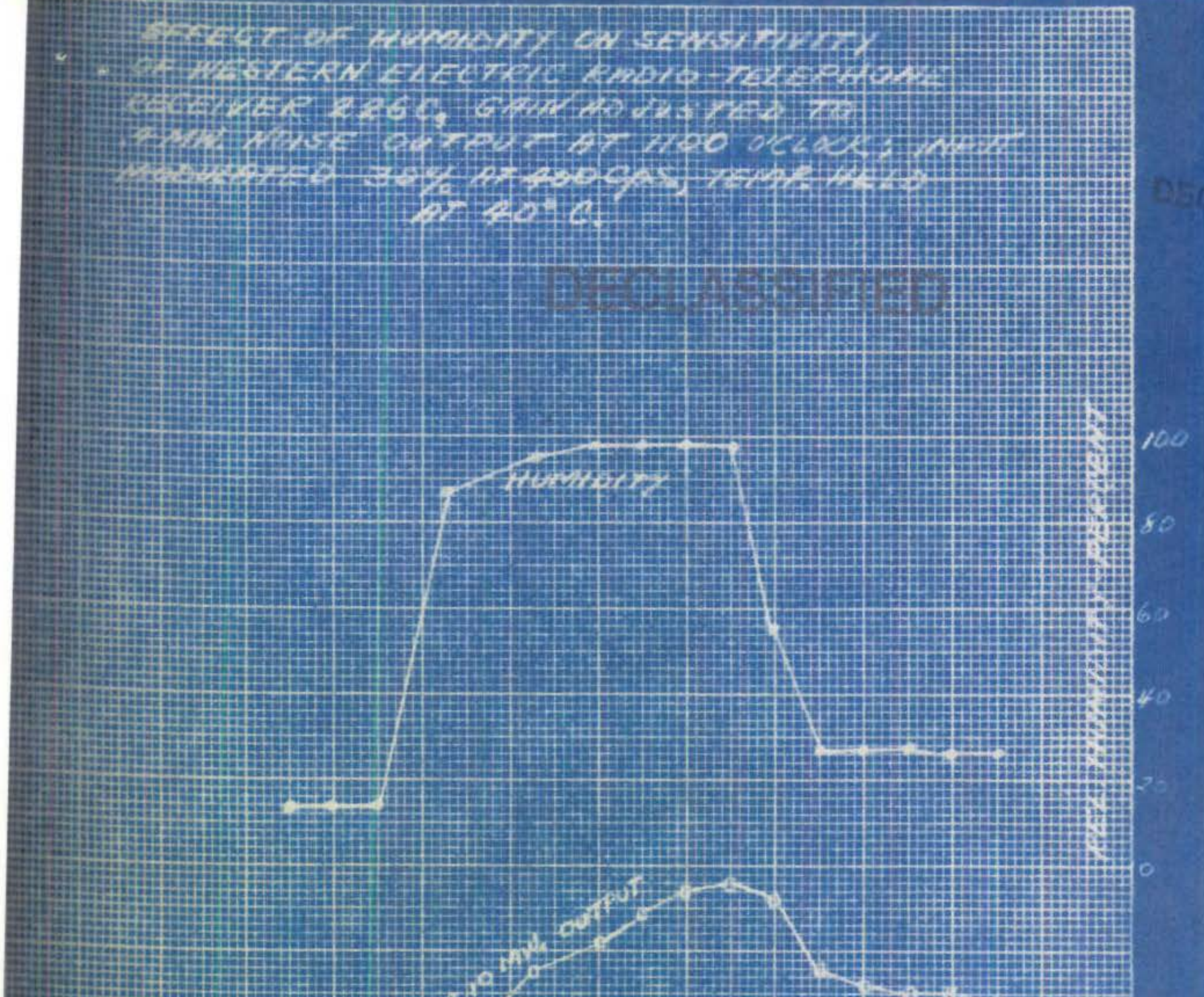

EFFECT OF HUMIDITY ON SENSITIVITY
OF WESTERN ELECTRIC RADIO-TELEPHONE
RECEIVER 226C, GAIN ADJUSTED TO
9 MW. NOISE OUTPUT AT 1100 O'CLOCK; INPUT
MODULATED 30% AT 400 CPS; TEMP. HELD
AT 40° C.
HUMIDITY
INPUT FOR 10 MW. OUTPUT
CARRIER NOISE — NO MOD.
NOISE — NO CARRIER
REL. HUMIDITY — PERCENT
100
80
60
40
20
0
11
12
13
14
15
TIME — O'CLOCK

PLATE R-4

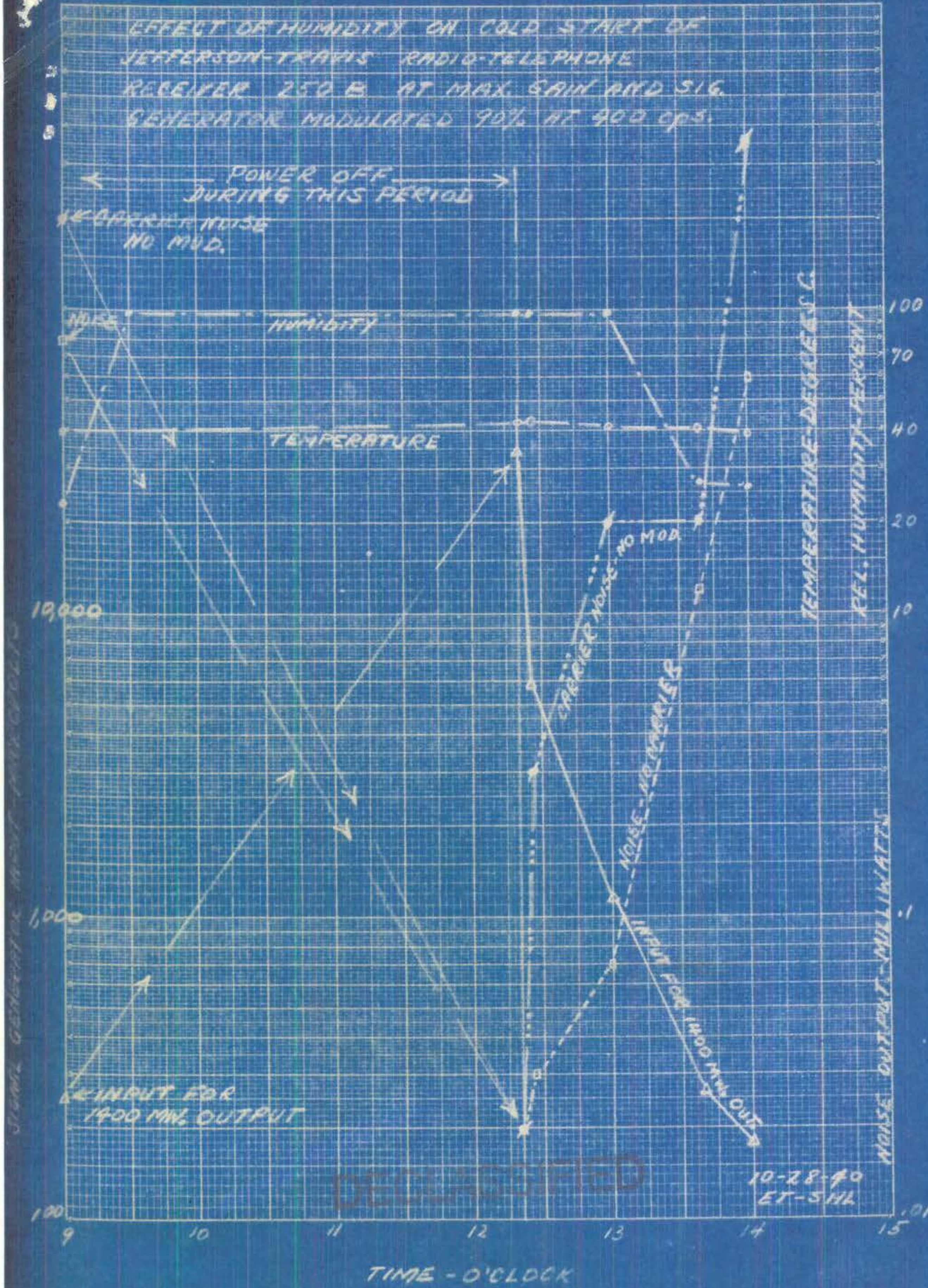

EFFECT OF HUMIDITY ON COLD START OF
JEFFERSON-TRAVIS RADIO-TELEPHONE
RECEIVER 250 B AT MAX. GAIN AND SIG.
GENERATOR MODULATED 90% AT 400 cps.
POWER OFF DURING THIS PERIOD
CARRIER NOISE NO MOD.
NOISE
HUMIDITY
TEMPERATURE
CARRIER NOISE - NO MOD
NOISE - NO CARRIER
INPUT FOR 1400 MW. OUT
INPUT FOR 1400 MW. OUTPUT
TEMPERATURE - DEGREES C.
REL. HUMIDITY - PERCENT
NOISE OUTPUT - MILLIWATTS
10-28-40
ET-SHL
10,000
1,000
100
100
70
40
20
10
.1
.01
9
10
11
12
13
14
15
TIME - O'CLOCK

PLATE R-5

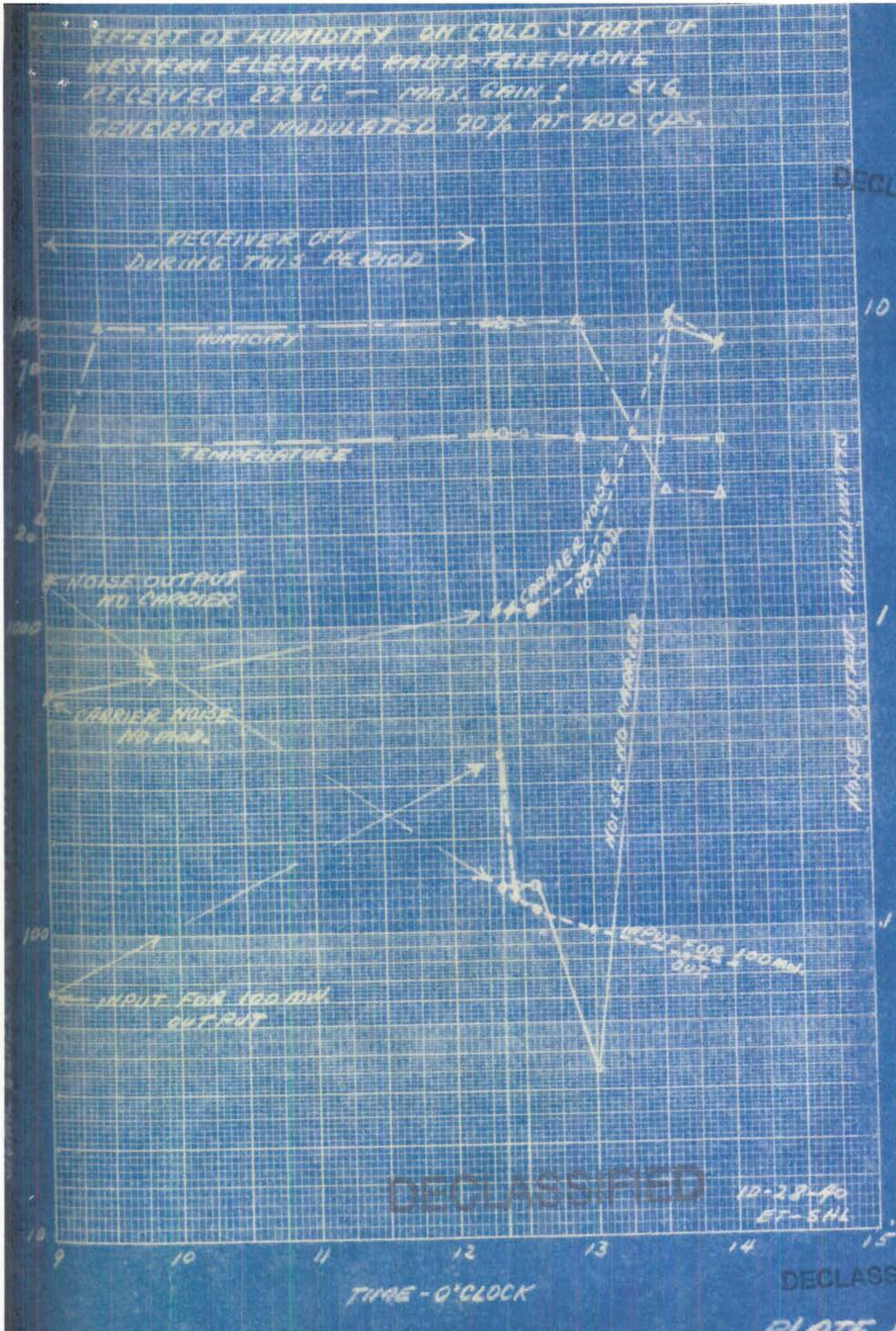
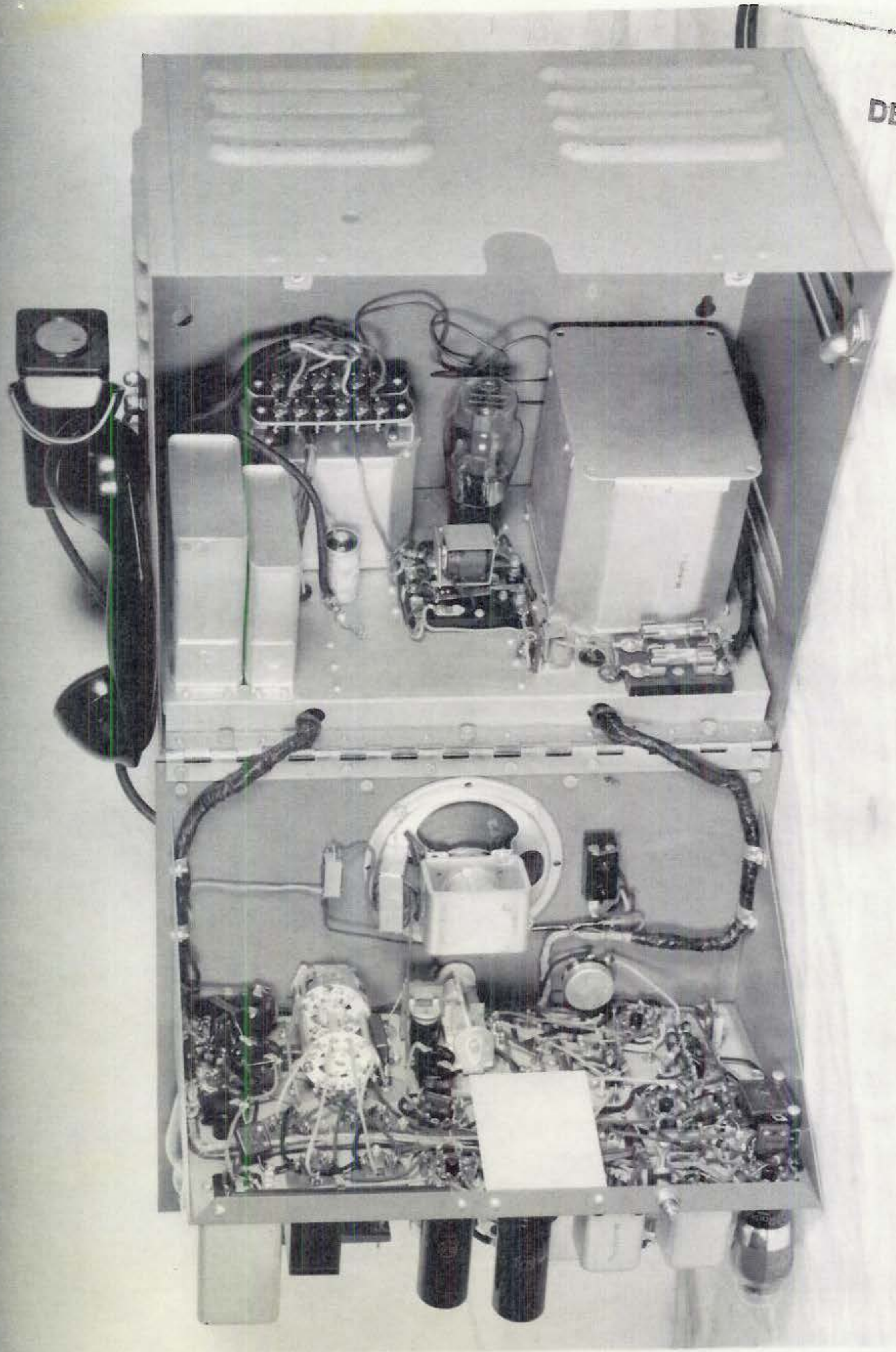

EFFECT OF HUMIDITY ON COLD START OF
WESTERN ELECTRIC RADIO-TELEPHONE
RECEIVER 226C — MAX. GAIN; SIG.
GENERATOR MODULATED 90% AT 400 CPS.
RECEIVER OFF
DURING THIS PERIOD
HUMIDITY
TEMPERATURE
NOISE OUTPUT
NO CARRIER
CARRIER NOISE
NO MOD.
CARRIER NOISE
NO MOD.
NOISE - NO CARRIER
INPUT FOR 100 MW.
OUTPUT
INPUT FOR 100 MW.
OUTPUT
NOISE OUTPUT - MILLIWATTS
100
70
40
20
1000
100
10
10
1
.1
.01
9
10
11
12
13
14
15
TIME - O'CLOCK
10-28-40
ET-SHL

PLATE R-6

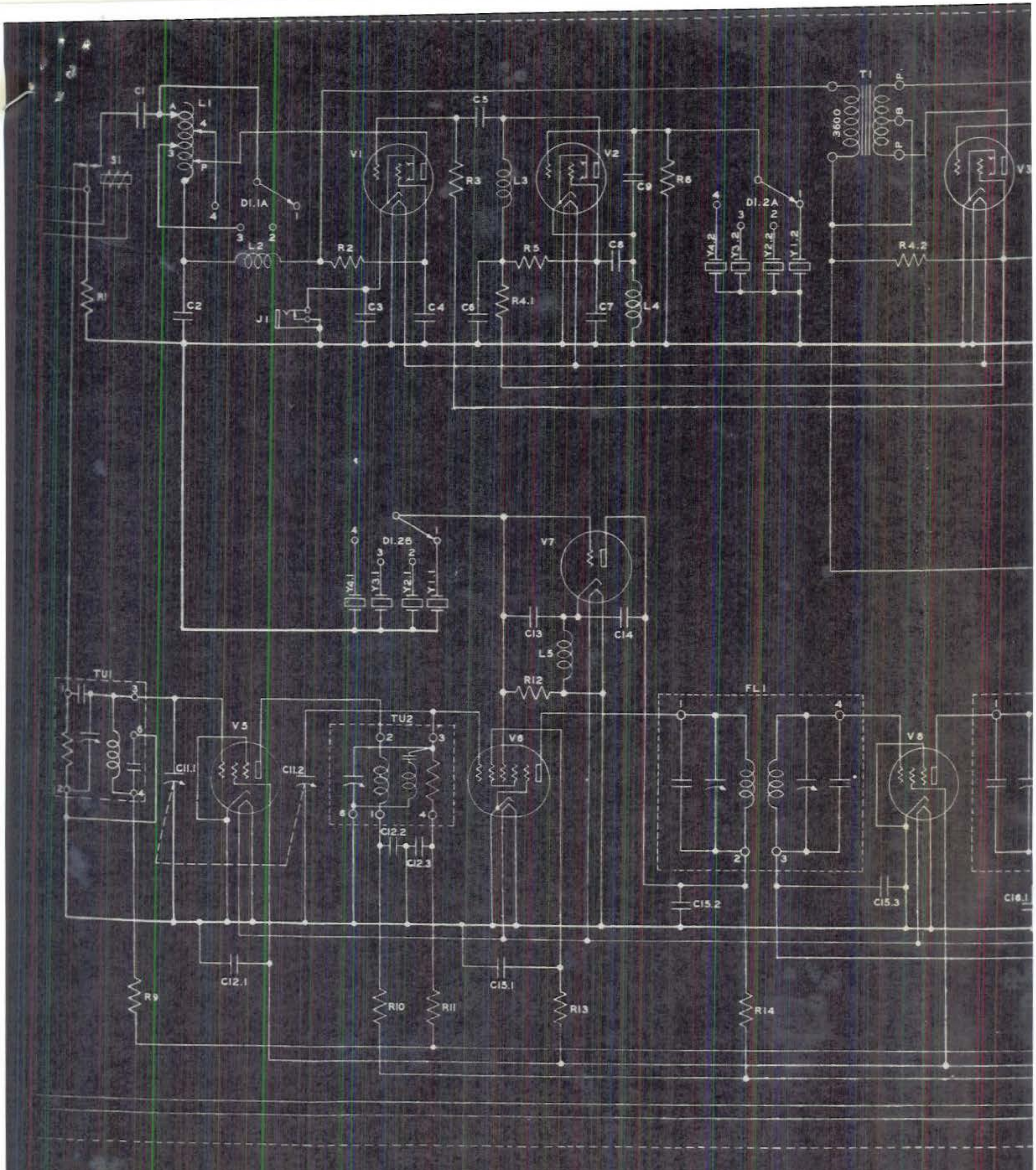
Western Elec. 226C - Front View

Plate TR-1



Western Elec. 226C - Inside View
Bottom of Chassis & Power Supply

Plate TR-3

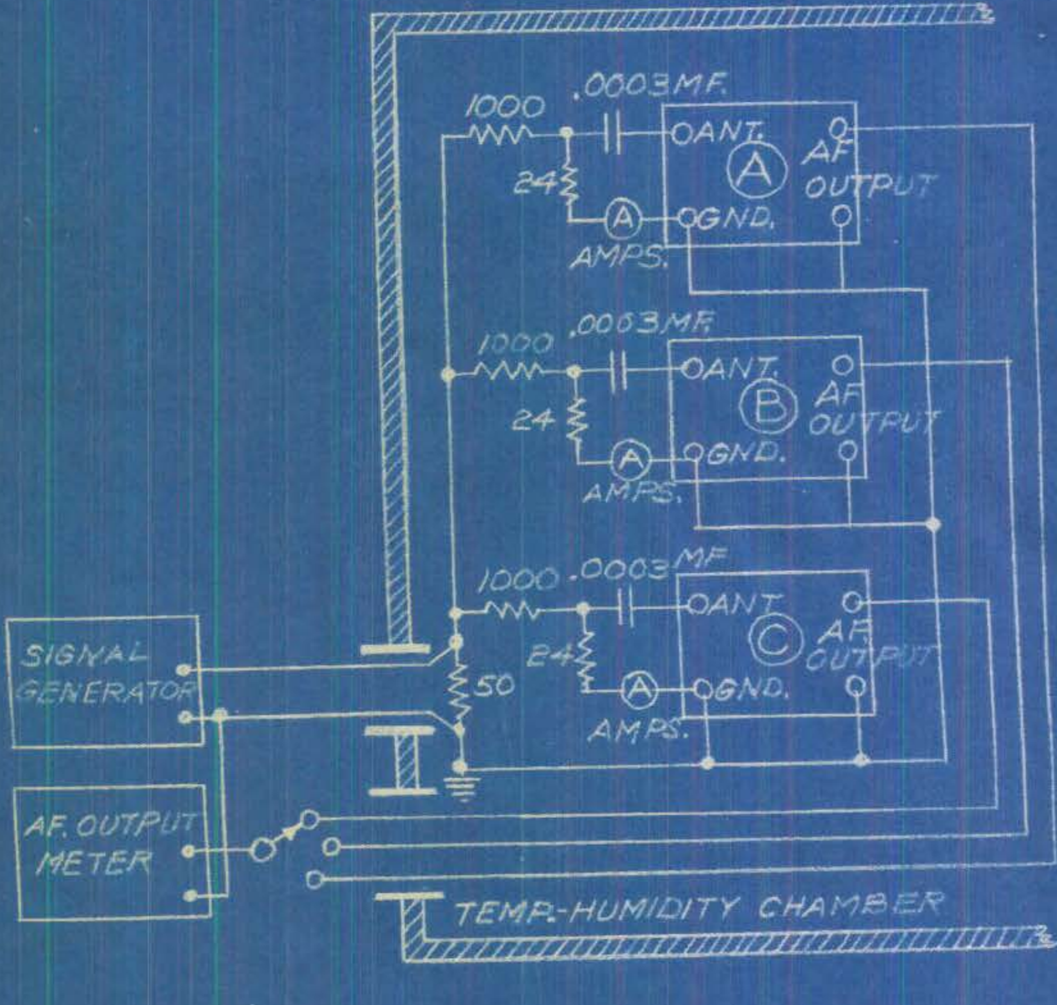


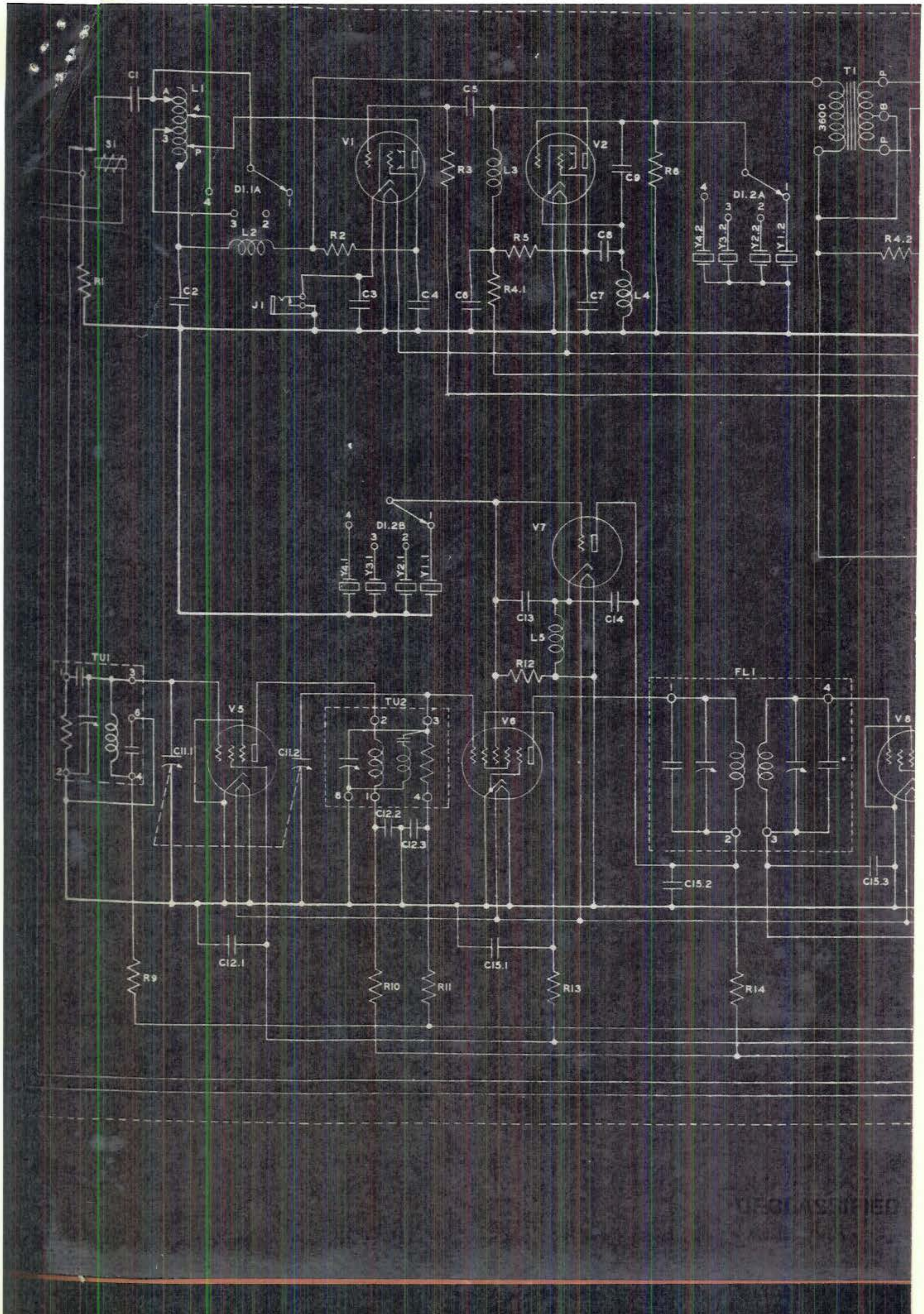
C1
L1
S1
R1
C2
L2
J1
D1.1A
V1
R2
C3
C4
C5
R3
L3
V2
R5
C6
R4.1
C7
C8
C9
L4
R6
D1.2A
Y4.2
Y3.2
Y2.2
Y1.2
T1
3600
V3
R4.2
D1.2B
Y4.1
Y3.1
Y2.1
Y1.1
V7
C13
C14
L5
R12
TU1
V5
C11.1
C11.2
TU2
C12.2
C12.3
V6
FL1
V8
C15.2
C15.3
C16.1
C12.1
R9
R10
R11
C15.1
R13
R14

METHOD OF CONNECTING RECEIVER MEASURING EQUIPTMENT FOR TEMPERATURE AND HUMIDITY TESTS

EXTERNAL POWER CONTROL CIRCUITS NOT SHOWN

.0003MFD. CONDENSER AND 24 OHM RESISTOR, TOGETHER WITH AMMETER, FORM TRANSMITTER DUMMY LOAD.





C1
L1
A
4
3
P
S1
DI.1A
L2
R1
C2
V1
C5
R2
R3
L3
J1
C3
C4
V2
C9
R6
R5
C8
C6
R4.1
C7
L4
DI.2A
Y4.2
Y3.2
Y2.2
Y1.2
T1
3600
B
R4.2
DI.2B
Y4.1
Y3.1
Y2.1
Y1.1
V7
C13
C14
L5
R12
TU1
V5
C11.1
C11.2
TU2
C12.2
C12.3
V6
FL1
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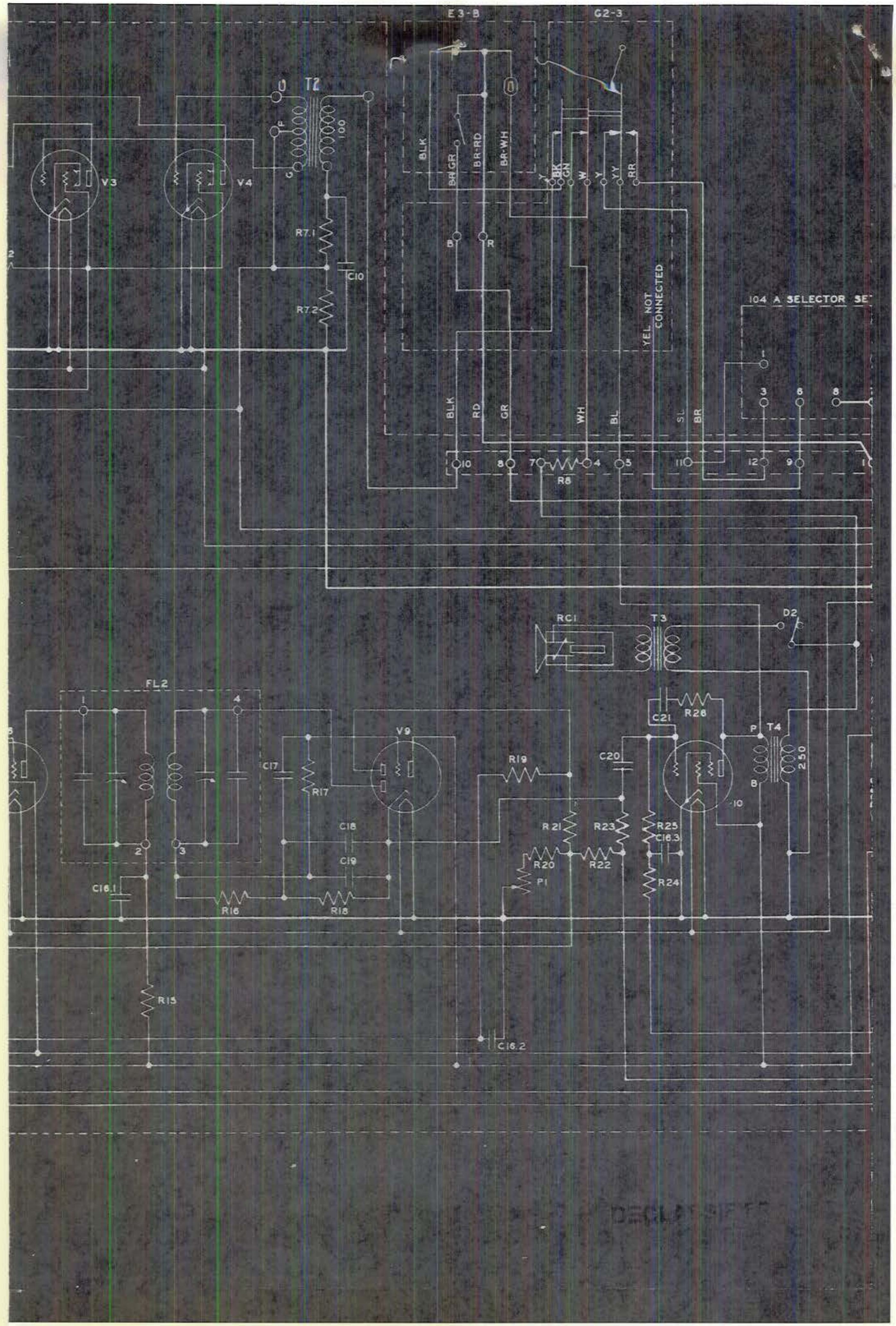
V8
C12.1
C15.1
R9
R10
R11
R13
R14


E3-B
G2-3
T2
100
V3
V4
R7.1
C10
R7.2
BLK
BR-GR
BR-RD
BR-WH
BK
GN
W
Y
YY
RR
B
R
YEL NOT CONNECTED
104 A SELECTOR SET
BLK
RD
GR
WH
BL
SL
BR
10
8
7
R8
4
5
11
12
9
1
3
6
8
RC1
T3
D2
FL2
1
4
2
3
V9
C17
R17
C18
C19
R16
R18
C16.1
R15
R19
R21
R20
P1
R22
R23
C20
C21
R26
R25
C16.3
R24
T4
P
B
250
C16.2