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Reviewer's names: A. THOMPSON,  
P. HANNA

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Report on Model XAZ

Radio Transmitting Equipment.

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BELLEVUE, D. C.

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10 February 1944

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Problem No. S121R-C

Navy Department

Report on

Model XAZ

Radio Transmitting Equipment

Naval Research Laboratory  
Anacostia Station  
Washington, D. C.

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Prepared by:

*F. T. Powles*

F. T. Powles, Radio Engineer

*W. E. Withrow*

W. E. Withrow, Radio Engineer

Submitted by:

*C. H. Fraser*

C. H. Fraser, Head of Special  
Development Section

Reviewed by:

*A. Hoyt Taylor*

A. Hoyt Taylor, Supt. of Radio Div.

Approved by:

*A. H. VanKeuren*

A. H. VanKeuren, Rear Admiral, U.S.N.  
Director

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### 1. General

The Model XAZ radio transmitting equipment is designed to provide communication between ship stations using either voice modulation or keyed mcw emission. Connections for standard remote control units are provided so that operation of the power and keying circuits can be controlled either at the transmitter or from a point remotely located on shipboard.

The transmitter provides a minimum of 38 watts of radio frequency power into the coaxial transmission line at any frequency in the range from 225 to 400 megacycles.

A power source of 115 volts, 60 cycles, 1 phase is required for operation of the equipment.

### 2. Specifications

Frequency range	225 to 400 megacycles
R. F. power output	38 watts at 400 Mc. 62 watts at 225 Mc.
Supply voltage	110 volts, 60 cycle, 1 phase
Supply line input power	800 watts
Modulation capability	80% at audio input level of 0.6 to 6.0 milliwatts
Audio frequency response	±1 D.B. from 300 to 3500 cycles
Overall harmonic distortion with 70% mod.	8.5% at 225 Mc., 12.5% at 400 Mc.
Noise level	42 D.B. below 70% modulation
Noise level with vibration	34 D.B. " " "
Audio level control	65 to 70% modulation with 10 D.B. input change
Dimensions: Transmitter Antenna	24" wide x 40" high x 20" deep 34½" wide x 24-¾" high
Weight: Transmitter Antenna	535 pounds 35 pounds
Overall frequency stability:	.228% at 400 Mcs. .231% at 300 Mcs. .192% at 225 Mcs.

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The following factors are included in calculating the overall frequency stability:

- Ambient temperature change 0 to 50° C.
- Relative humidity change 30 to 95%.
- Line voltage change  $\pm 10\%$ .
- Cold start (filaments on for one hour before plate).
- Vibration and shock.
- Wavemeter dial backlash and reset.

A complete tabulation of frequency stability figures is included in the appendix.

Curves showing further characteristics of the transmitter and antenna are shown in Figures 1, 2, and 3. Frequency calibration curves are given in Figure 1. Power output and efficiency measured at the transmitter are shown in Figure 2. In Figure 3 are shown the impedance of the antenna and the percentage reflection over the frequency range.

### 3. Description of Transmitter

- (a) The transmitter is contained in a metal frame which is mounted on four shock mountings attached to a base plate which can be bolted to a deck. Removable side, back, and front panels provide shielding of radio circuits and protection to operating personnel. A door at the bottom of the front panel gives access to the main terminal board and to those power controls which are used infrequently. All other controls and all indicating devices are mounted on the front panel. A receptacle on top of the transmitter provides a connection for a coaxial transmission line to the antenna. Provision is also made for coupling to the receiver.
- (b) The transmitter housing contains a radio frequency unit, an audio amplifier and modulator unit, a high voltage plate rectifier, a low voltage plate rectifier, a dry disk rectifier for control purposes, and such relays and components as are necessary for control of power and keying circuits. The audio unit and the low voltage rectifier unit are mounted on angles and held in place by thumb screws so that they can be easily removed by taking off a side panel. The radio frequency unit is made accessible by removing the front panel.
- (c) The radio frequency unit consists of a self-excited oscillator having concentric lines as tuning elements and using three type 8025 triode tubes connected in parallel. Tuning controls are provided for varying the length of the grid-plate line which is the main frequency determining element and the length of the grid-filament line which serves as a feedback control. The antenna coupling is geared to the main oscillator tuning control providing proper coupling to the antenna over the frequency range. The resonant lines are made up of three concentric sections, the inner section being connected to the filament through bypass condensers C40, C41, and C42, the intermediate section to the grids and the outer section to the plates of the tubes through bypass condenser C43. This connection puts the outer cylinder at ground potential with respect to both D.C. and R.F. voltages. A shorting plunger between the grid and the

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plate cylinders provides the main frequency control and a second plunger shorting the grid and filament cylinders provides a means of adjusting the excitation. The bias voltage for the tubes is obtained from combined grid leak and cathode resistors, R11 and R57, which are connected to the center tap of the filament transformer, T5, thus putting this winding above ground potential by a voltage equal to the grid bias. The filaments of the tubes are bypassed to the top of the filament line, and the filament leads are brought down inside the line through close fitting brass tubing, which holds the lead in position as well as providing additional bypassing action. The plate voltage connection is made to a terminal on top of the cap, the terminal connecting to a metal plate which serves as one side of the plate bypass condenser. This plate holds the tube plate clips and is underneath the cap and insulated from it so that plate voltage is exposed only at the terminal and the tube clips.

(d) The frequency determining elements are constructed of Invar. Invar has a very low linear coefficient of thermal expansion, and these parts, when silver plated, provide a low resistance path for the radio frequency currents. The use of Invar reduces frequency drift, caused by temperature change, to a minimum.

(e) A blower mounted in the top of the transmitter frame provides forced air cooling for the three oscillator tubes.

(f) Power output from the oscillator is obtained from a coupling loop mounted on the grid-plate shorting plunger and connecting to a 50 ohm coaxial transmission line. This line comes out of the bottom of the oscillator and is connected to an antenna change-over switch to which the receiver also connects. The output fitting accommodates a 7/8 inch 50 ohm solid dielectric transmission line which connects to the antenna. Coupling is varied automatically with the grid-plate tuning.

(g) A wavemeter is built into the unit for use in setting the oscillator on the desired frequency. Its tuning element is a quarter-wave concentric line adjustable over the frequency range by means of a front panel control. A probe inserted through the outer cylinder of the transmitter oscillator into its grid-plate cavity, at the end of a short length of coaxial transmission line, provides radio frequency pickup for the wavemeter. This voltage is rectified by a type 955 acorn tube, V14, and the current is measured on a wavemeter indicator M4. The wavemeter elements are constructed of silver plated Invar. A dessicator is provided to minimize effects of humidity changes.

(h) The oscillator is plate modulated by two type 845 triode tubes, V9 and V10, connected in parallel and operating as Class A amplifiers. The modulator tubes are preceded by three amplifier stages using a type 1612 tube, V6, as first audio amplifier and a type 6SN7 double triode tube, V8, as the intermediate and driver stages. A second type 6SN7 tube, V7, provides a voltage which is applied to the grid of the first amplifier tube for automatic level control to prevent excessive modulation. Part of the voltage from the audio amplifier is fed into an auxiliary amplifier tube, V13, which is a type 6AC7, which in turn feeds a second stage, V12, using a type 6V6 tube to provide sidetone voltage.

(i) A type 6SN7 tube, V11, is used as an audio oscillator for MCM transmission and as a delay tube in the keying circuit. The delay tube

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keeps the carrier on for about five seconds after the key is up.

(j) The voltage for the plate and screen of all low power stages is obtained from a single phase, full wave rectifier using a 5U4G high vacuum tube, V1. The plate voltage for the modulator and oscillator tubes is provided by a rectifier using 4 type 1616 tubes, V2, V3, V4, and V5, in a single phase full wave circuit.

(k) Photographs of the transmitter are shown in Plates 1 to 5.

### 4. Antenna

(a) A broad band antenna is provided which covers the entire range of 225 to 400 Mc. without adjustment. In fact, its characteristics are suitable for transmission and reception over the frequency range of 150 to 800 Mc. Over the 225-400 Mc. band, the antenna will terminate the 50 ohm transmission line in an impedance ranging from 40 to 63 ohms. This causes a reflection on the line of not more than 17 percent at any frequency in the 225-400 Mc. band.

(b) The antenna consists of a combination of a cone and a cylindrical radiator above a conical groundplane. The solid dielectric transmission line is coupled to an expanded section of 50 ohm air dielectric line. This expanded section provides a mounting for the complete antenna as well as the radiator. The outside conductor of the expanded section of line folds back on itself in the form of a cone, thus forming the groundplane. The center conductor, after passing through an insulator, flares out in the form of another cone and then extends vertically to form the cylindrical portion. The included angle between the two conical sections is 45°.

(c) The field pattern of the antenna taken at 300 Mc. shows one wide lobe with maximum at 42° above the horizontal. In a plane perpendicular to the axis, the field intensity is about one half the maximum noted. The field pattern is vertically polarized.

(d) A photograph of the antenna is shown on Plate 6.

### 5. Operation

(a) A supply voltage of 115 volts, 60 cycles, 1 phase is connected to the terminals on the main board. The emergency switch, S1, is in the main line and controls the 110 volt 60 cycle input. The push button switch, S3, operates the relay which turns the filaments on and off. About 20 seconds are required after the start button is pushed for the tubes to heat. Filament voltage is indicated by the voltmeter, V1, and can be adjusted by rheostat R10 on the panel behind the door at the bottom of the front transmitter panel.

(b) If voice communication is desired, it is only necessary to remove the hand set from the hook and press the hand set switch when talking. If mcw is desired, the hand set is not used. Operation of either the transmitter test key or the hand telegraph key connected externally, turns on the carrier. The modulation level in either case can be set by means

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of control R28, as shown on modulation indicator M3.

(c) Additional front panel controls and indicators include a local-remote switch, S4, a power output switch, S5, a relay shorting switch, S2, a power indicator lamp, P1, a carrier indicator lamp, P2, oscillator plate current meter, M2, sidetone volume control, R39.

### 6. Tuning

(a) To set the oscillator on a given frequency, a built-in calibrated wavemeter coupled to the oscillator is provided. The wavemeter dial is first set to the desired frequency as read on a calibration curve. The oscillator cathode-grid tuning dial is set to the reading shown on its curve for the same frequency. The oscillator grid-plate tuning dial is then adjusted until the maximum reading of the wavemeter indicator meter is obtained. The grid-plate tuning control is also geared to the output coupling loop so that the proper loading is obtained automatically at the given frequency. An approximated calibration curve for the grid-plate tuning dial is given so that it is possible to set this control with plate power off; then only a slight trimming is required when power is applied.

(b) To prevent excessive plate current while tuning the transmitter or to reduce the power output, a tap switch is provided which allows steps of approximately 25, 50, 75, or 100% of full output.

### 7. Conclusions and Recommendations

(a) The equipment described meets the requirements set up for it in most respects and should prove satisfactory for Naval Service. The following recommendations, however, are made for improvement of the equipment if commercial production is contemplated.

(1) Better internal regulation of the filament voltage and plate voltage of the oscillator should be provided. At present, an external regulating transformer is used.

(2) The antenna coupling loop should be tuned by means of a stub to provide optimum input to the antenna. The oscillator filament tuning control can be eliminated, and this adjustment geared to the oscillator tuning, thus providing single dial control of frequency. A second dial may be required for the antenna tuning stub.

(3) The use of D.C. instead of A.C. for the coil of the antenna change-over relay will give quieter operation.

(4) The shock mounts on the transmitter should be stiffened, unless a clearance of 3 inches or more can be allowed on all sides of the frame.

(5) The weight should be reduced as much as possible by the substitution of aluminum for steel, particularly in the framework.

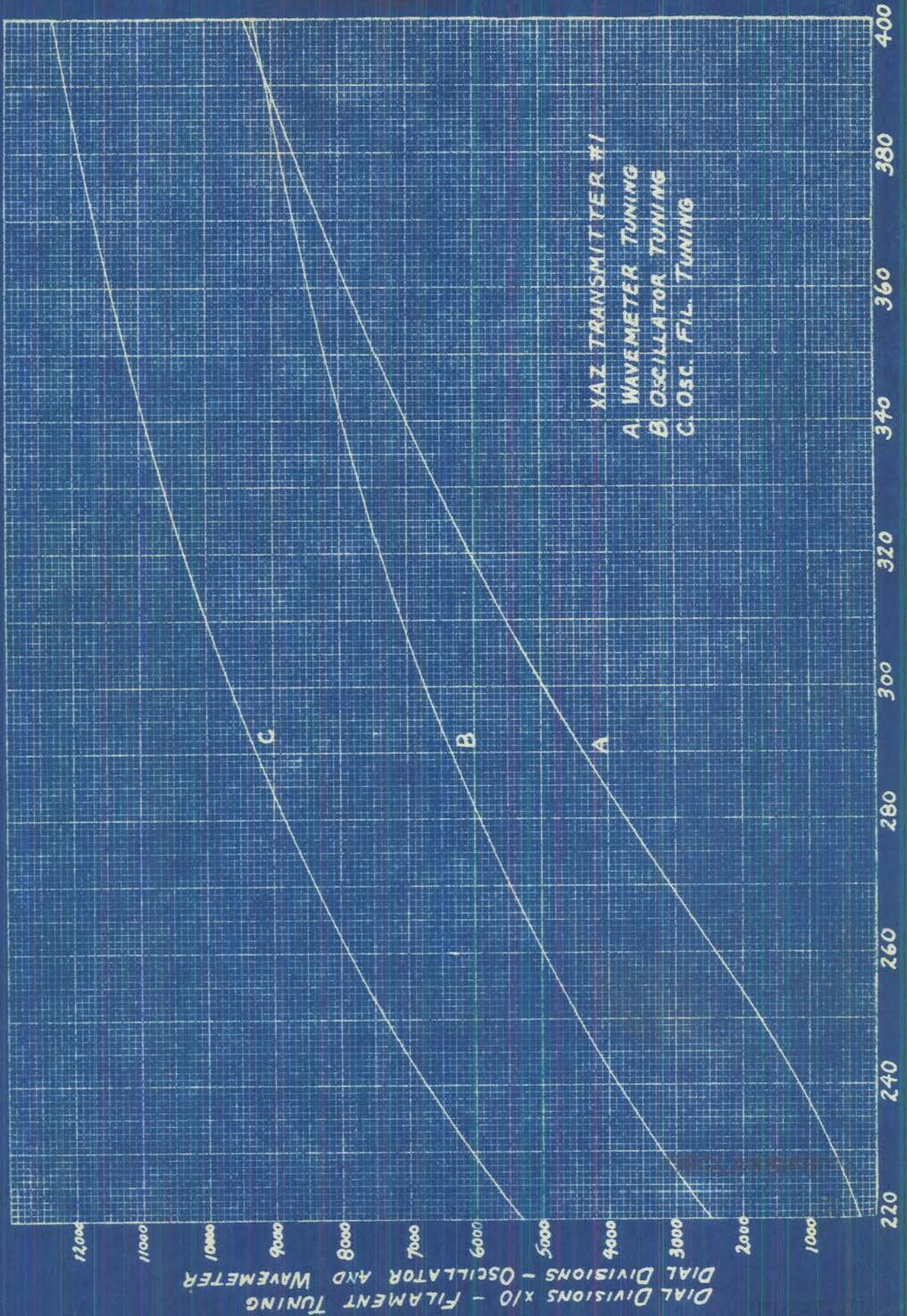
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(b) It is believed that the frequency stability figures given for the temperature, cold start, and line voltage variations could be materially improved by further development.

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IF SHEET IS READ THIS WAY (HORIZONTAL) IT MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICAL) THIS MUST BE LEFT-HAND SIDE.

S. B. L. 35A



XAZ TRANSMITTER #1  
A. WAVEMETER TUNING  
B. OSCILLATOR TUNING  
C. OSC. FIL. TUNING

DIAL DIVISIONS x 10 - FILAMENT AND WAVEMETER TUNING

FREQUENCY IN MEGACYCLES

FIGURE 1

IF SHEET IS SPREAD THIS WAY (HORIZONTAL) THIS MUST BE TOP. IF SHEET IS READ THE OTHER WAY (VERTICALLY) THIS MUST BE LEFT HAND SIDE.

N. 4. L. 31A

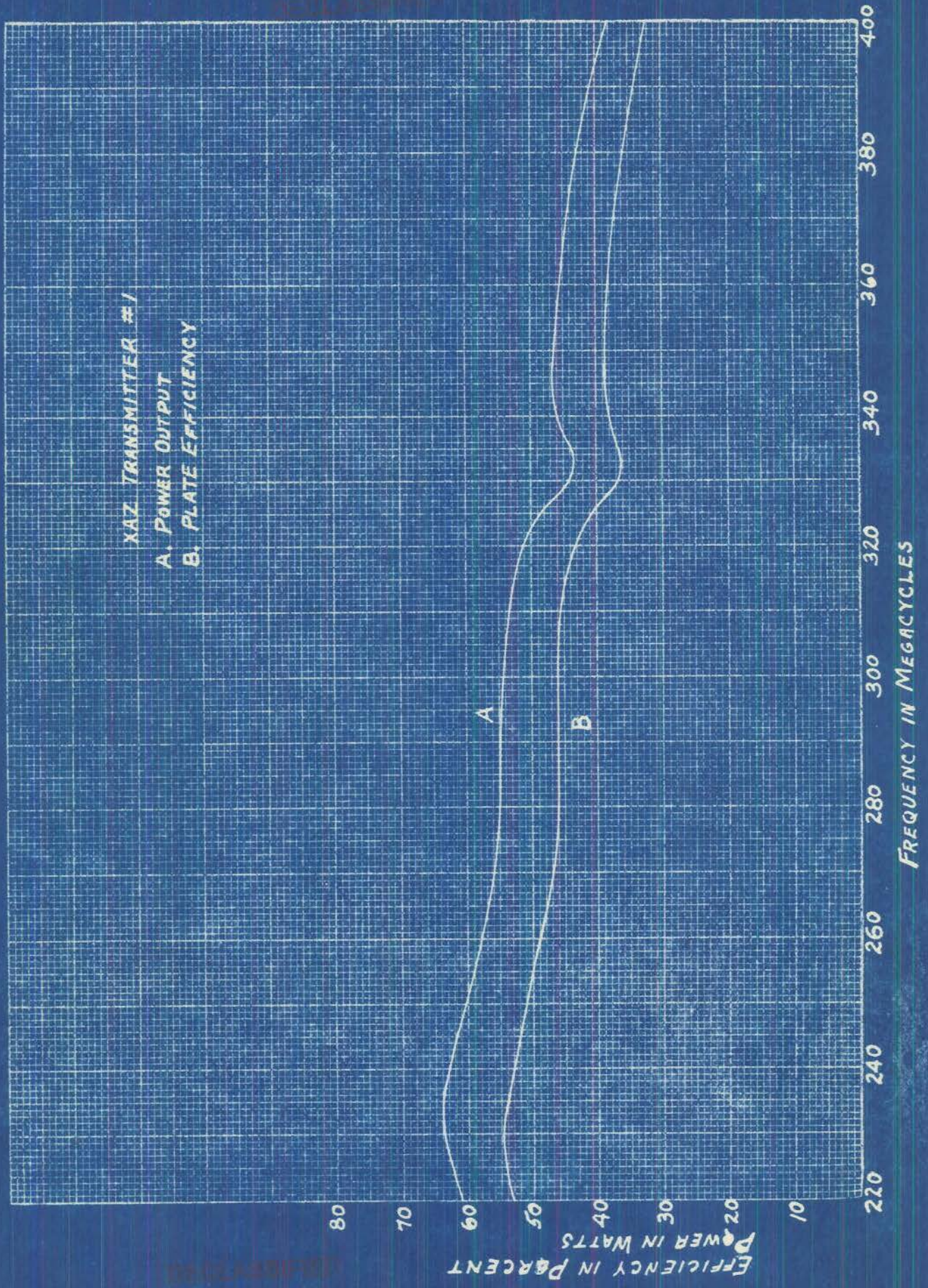


FIGURE 2

IF SHEET IS READ THIS WAY HORIZONTALLY IT MUST BE TOP. IF SHEET IS READ THE OTHER WAY VERTICALLY, THIS MUST BE LEFT-HAND SIDE

N. K. L. 31A

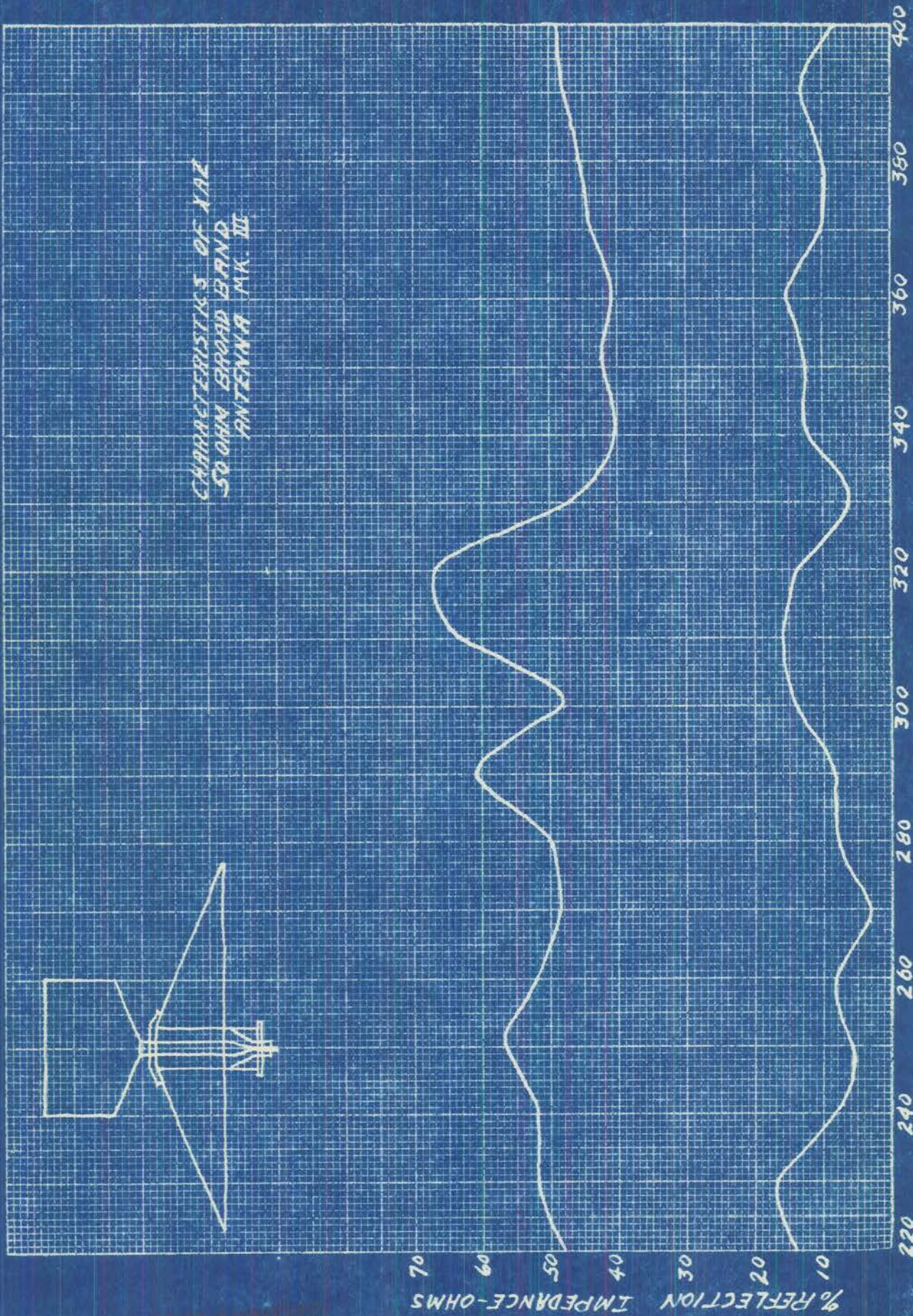
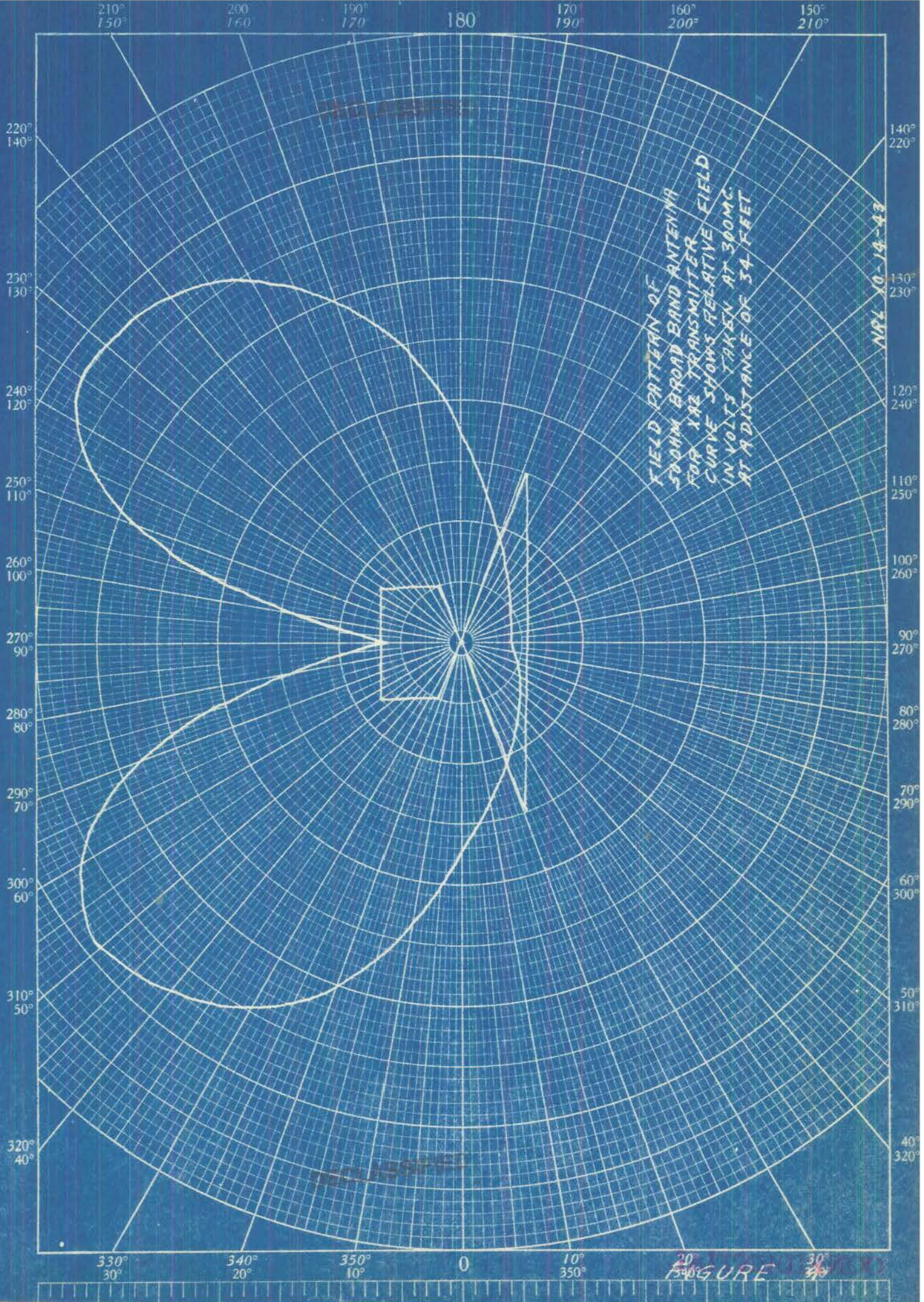


FIGURE 3

KEUFFEL & ESSER CO., N. Y. NO. 359-37  
Polar Co-ordin  
MADE IN U.S.A.

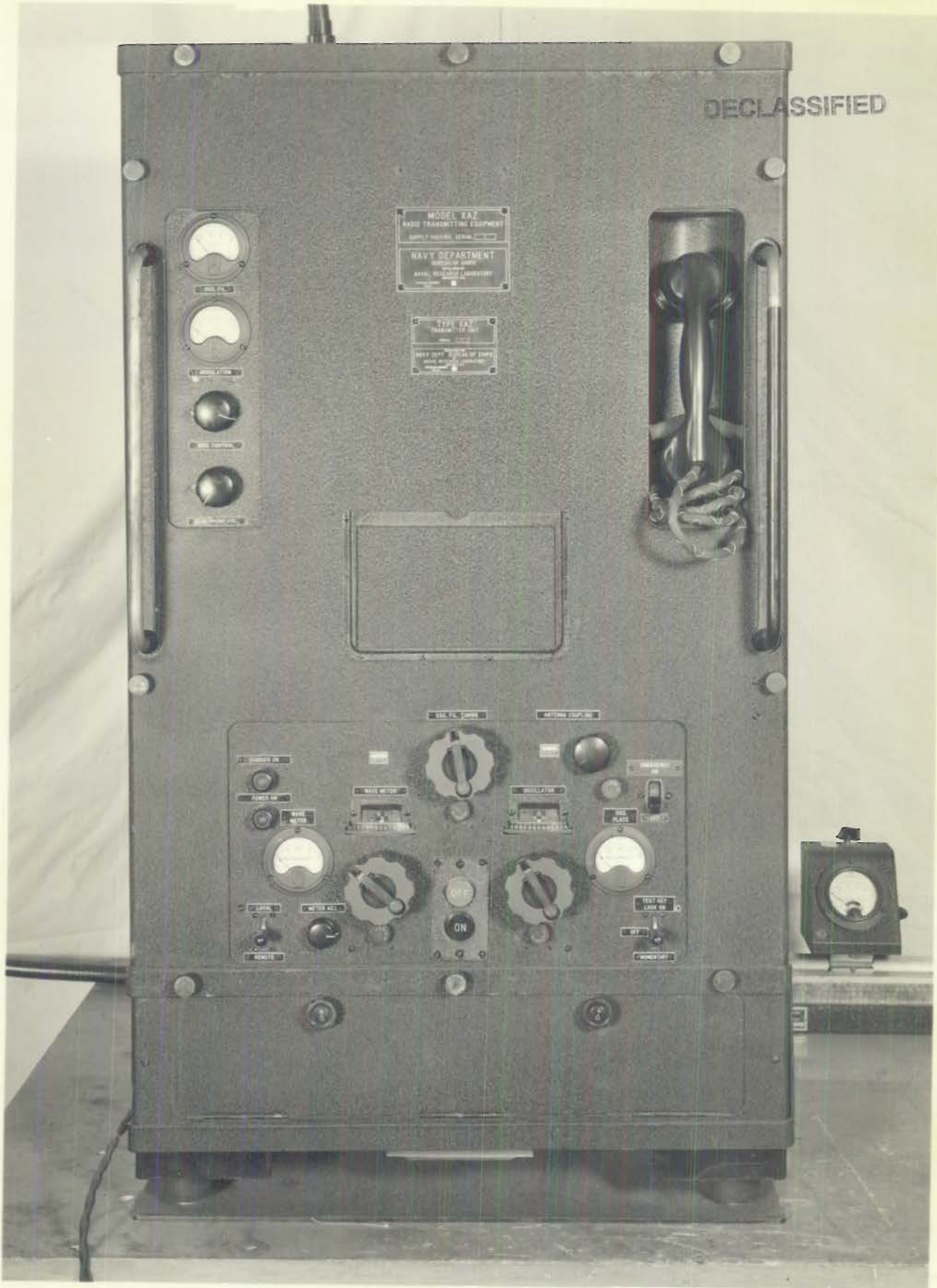


FIELD PATTERN OF  
500M BROAD BAND ANTENNA  
FOR XAZ TRANSMITTER.  
CURVE SHOWS RELATIVE FIELD  
IN VOLTS TAKEN AT 300M.  
AT A DISTANCE OF 34 FEET.

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FIGURE 30 30

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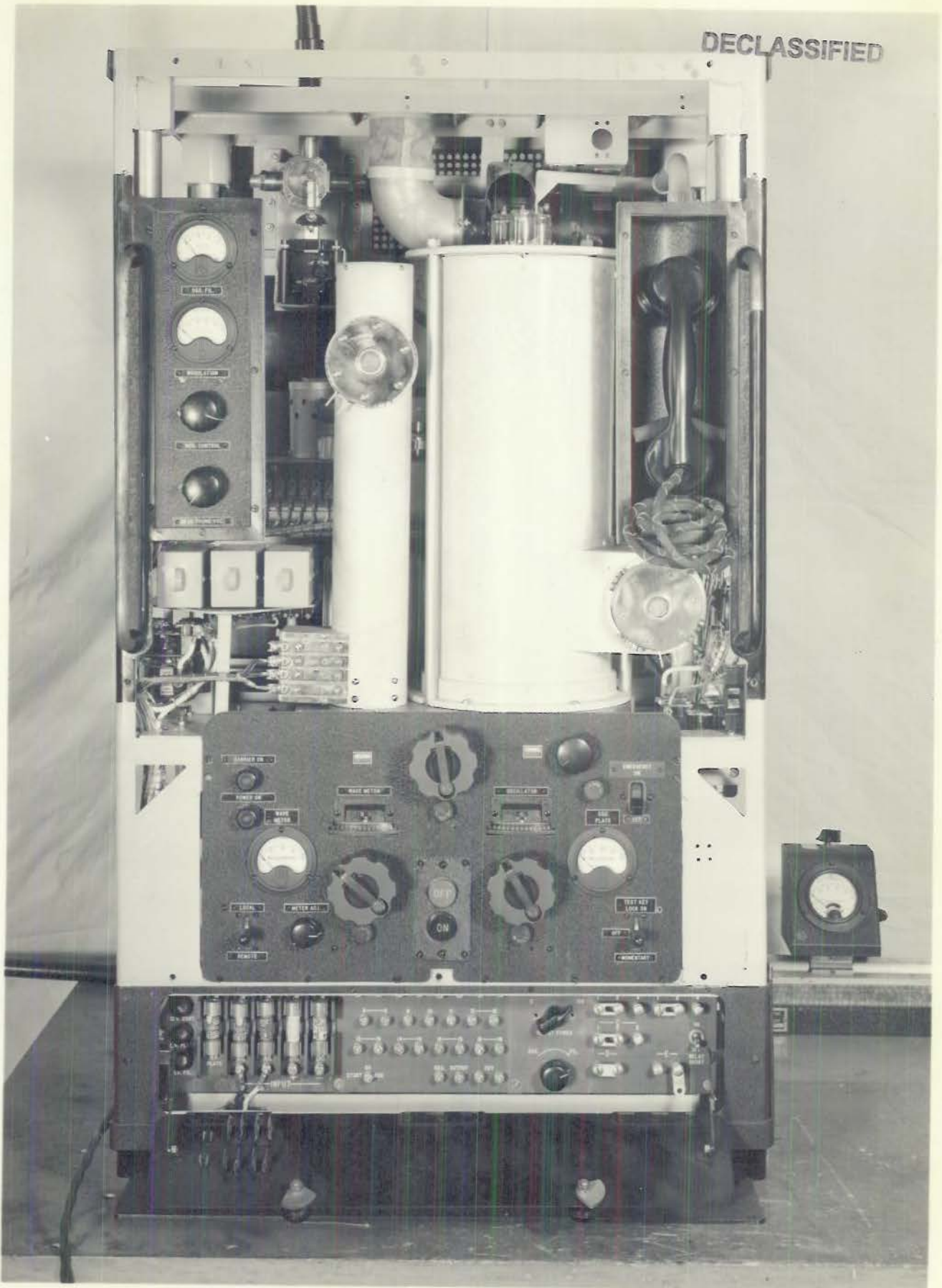
MODEL XAZ TRANSMITTER - FRONT VIEW

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PLATE I

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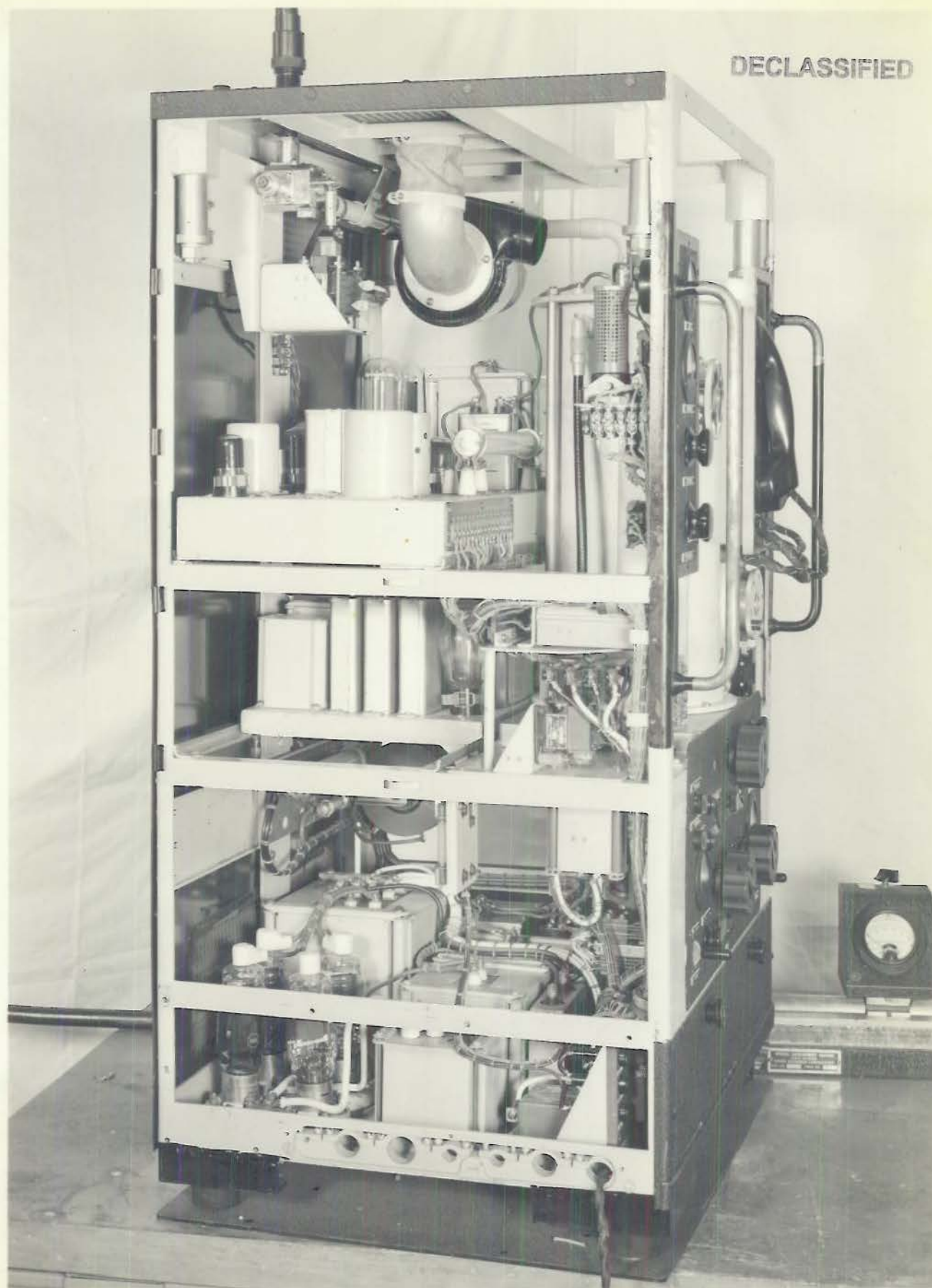
MODEL XAZ TRANSMITTER - FRONT VIEW PANEL REMOVED

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PLATE 2

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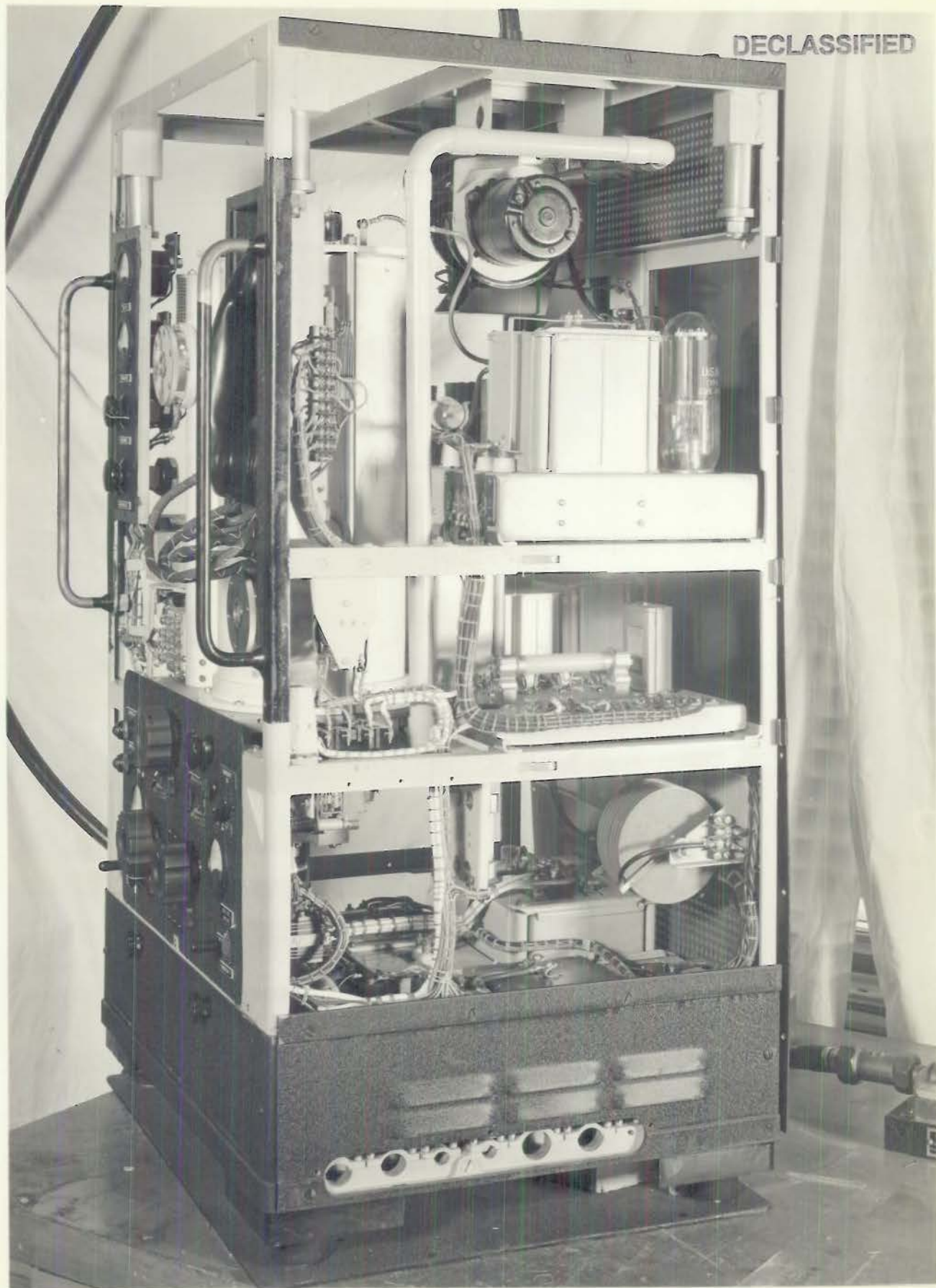
MODEL XAZ TRANSMITTER - LEFT SIDE VIEW

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PLATE 3

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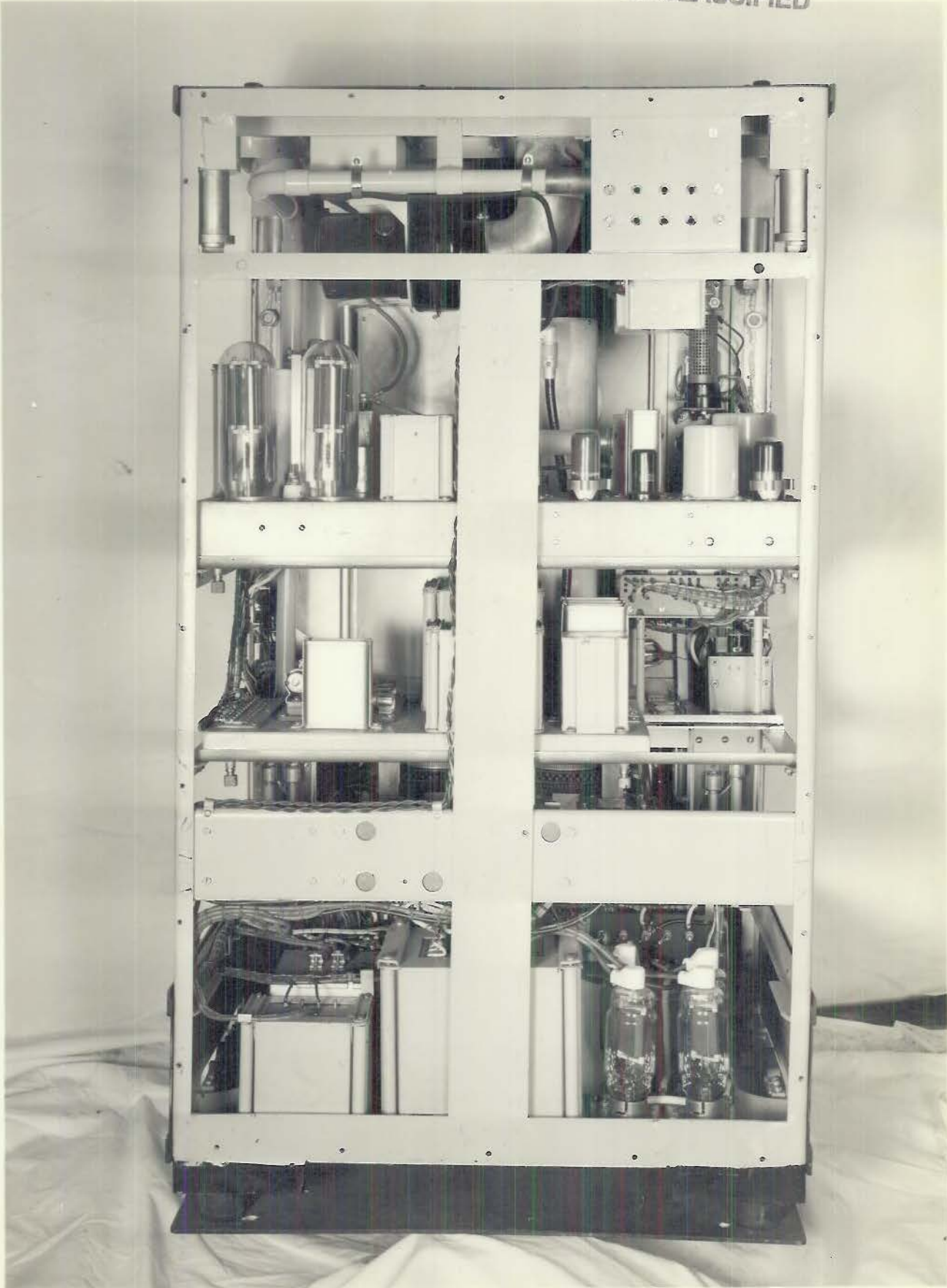
MODEL XAZ TRANSMITTER - RIGHT SIDE VIEW

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PLATE 4

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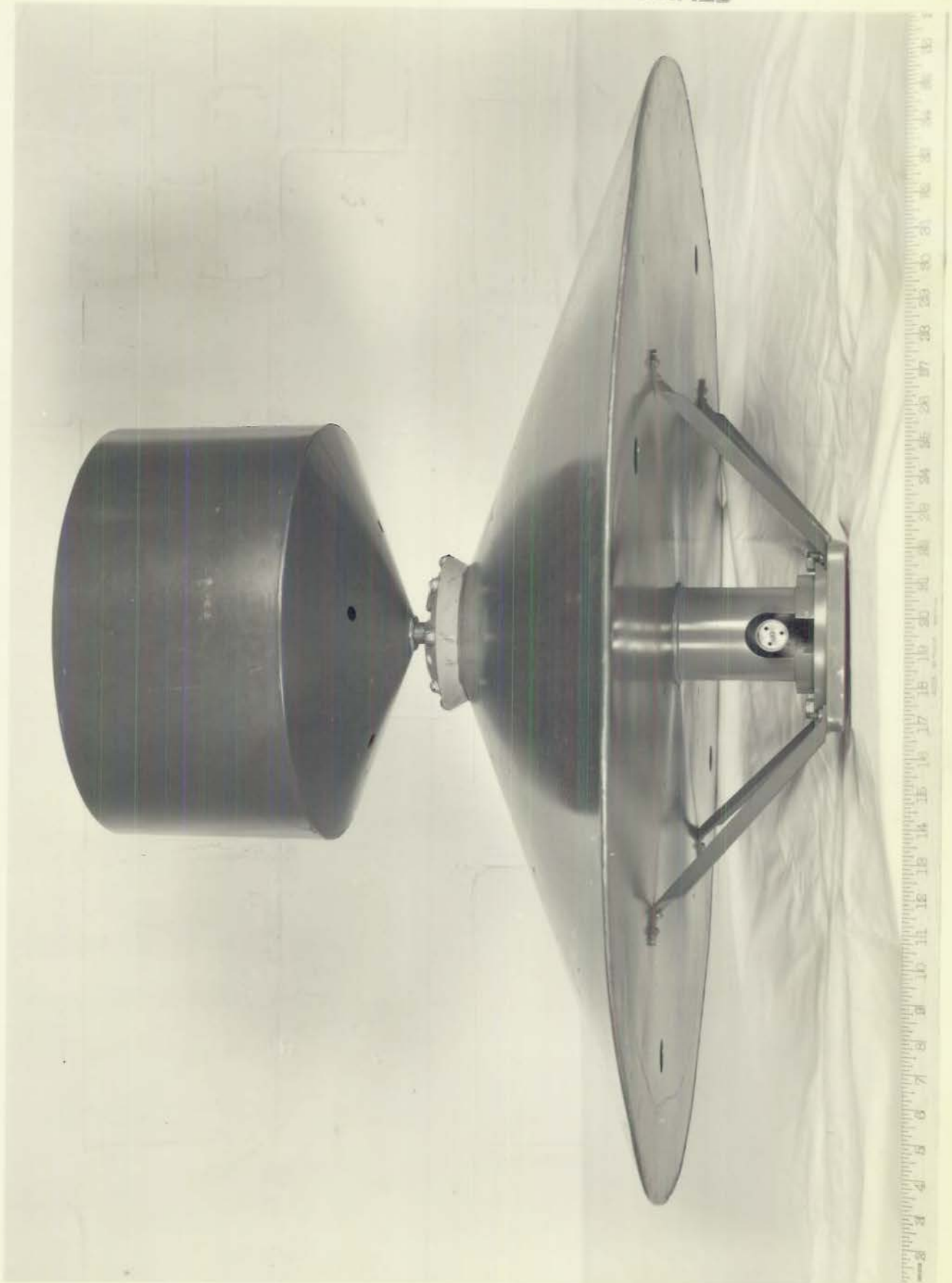
MODEL XAZ TRANSMITTER - REAR VIEW

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PLATE 5

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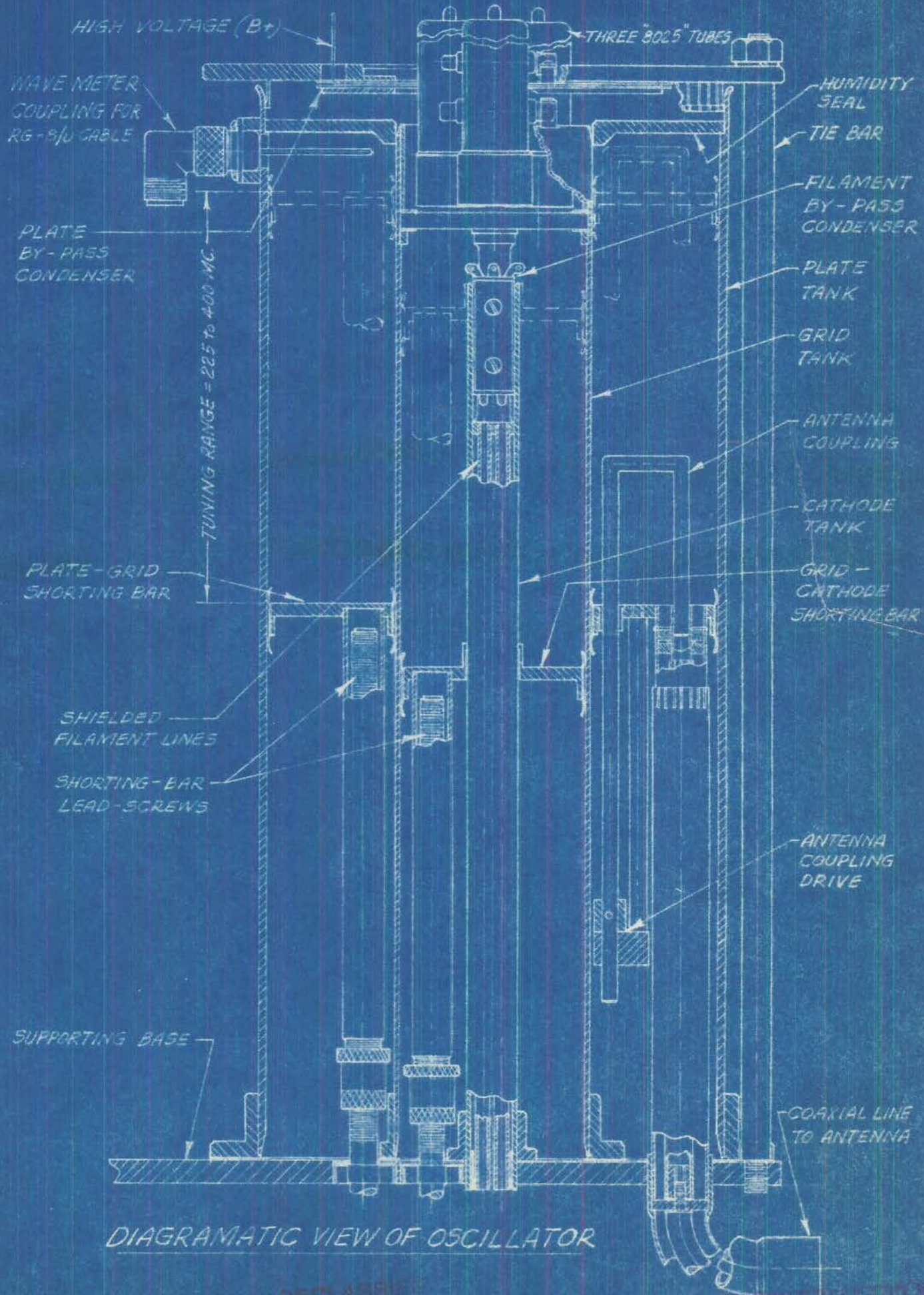


BROAD BAND ANTENNA MK. III FOR MODEL XAZ TRANSMITTER

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PLATE 6



DIAGRAMATIC VIEW OF OSCILLATOR

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APPENDIX

FREQUENCY STABILITY OF OSCILLATOR

	<u>Percentage Frequency Change</u>		
	<u>400Mcs.</u>	<u>300Mcs.</u>	<u>225Mcs.</u>
<u>Change of ambient temperature</u>			
0 to 50°C.	.053	-.025	-.055
-15° to 0°C.	.042	.012	.002
<u>Change of humidity</u>			
30% to 95%	.0061	.0045	.0065
<u>Line voltage variation</u>			
±10% (5 min. period)	.138	.090	.063
Same test with regulated input	.016	.010	.005
Same test with regulated filament voltage only	.044	.023	.016
<u>Cold start (filaments on for 20 seconds before plate)</u>			
Measured on heterodyne meter			
1st 20 seconds	.185	.166	.081
Delay of 1 or 2 seconds at start while tuning to signal.			
1st minute	.234	.222	.118
Total drift (1st 15 minutes)	.263	.251	.154
Using Recorder - Total drift (at 245Mc.)			.33
<u>Cold start (filaments on for 1 hour before plate)</u>			
(1st 20 seconds)	.107	.102	.061
1st minute	.119	.118	.073
Total drift (1st 5 min.)	.123	.120	.081
Using Recorder - Total drift (at 245Mc.)			.15
<u>Change of tubes</u>			
Set #1	1.66		1.09
Set #2	.16		.13
<u>Detuning of Circuits</u>			
Antenna Coupling ±5 div.	.077	.048	.028
Oscillator grid-cathode ±5 div.	.020	.009	.008
<u>Oscillator Tuning Control</u>			
Backlash	.054 (4.0 dial div.)	.023 (4.0 dial div.)	.012 (2.3 dial div.)

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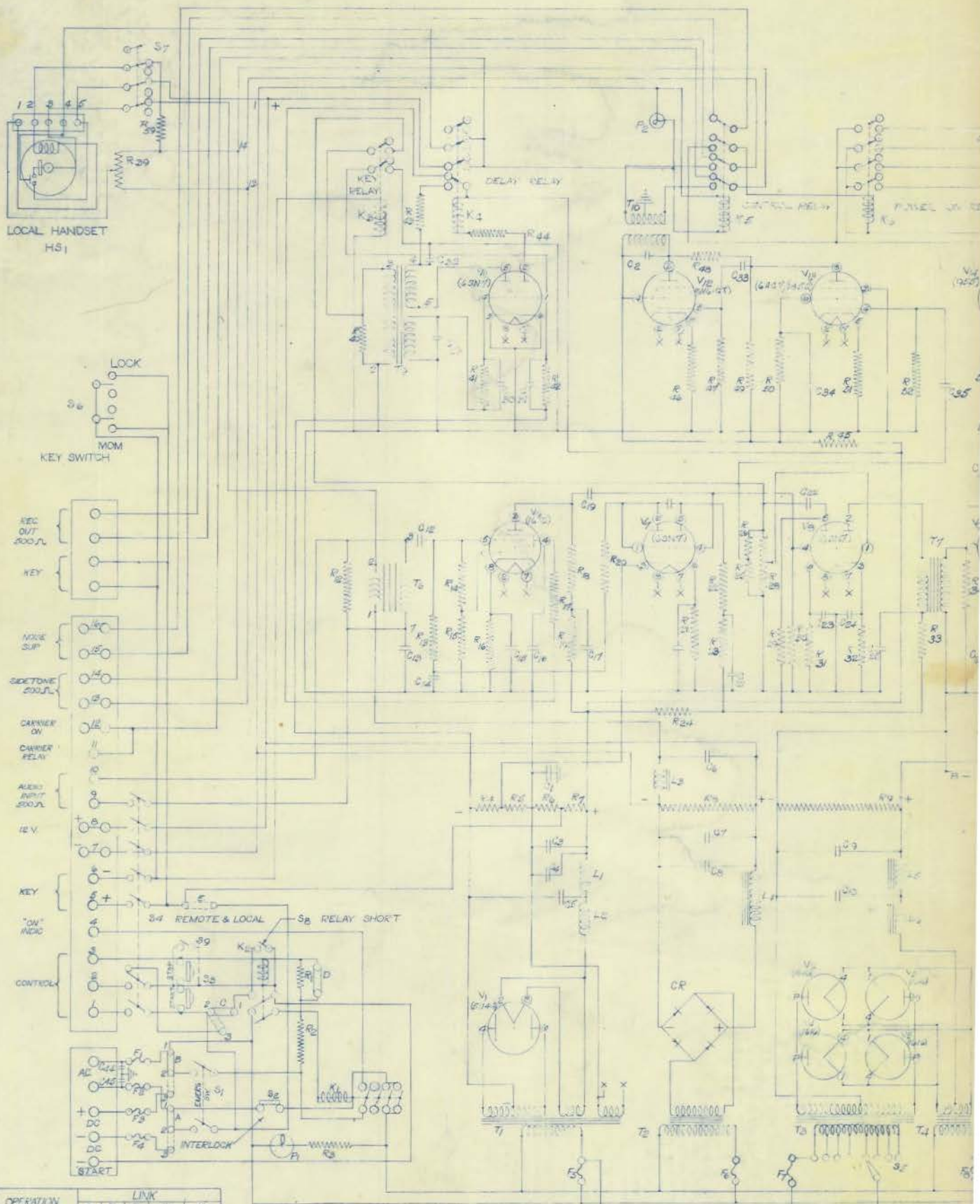
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		Percentage Frequency Change		
		<u>400Mcs.</u>	<u>300Mcs.</u>	<u>225Mcs.</u>
<u>Oscillator Tuning Control (Cont.)</u>				
Reset		.0013 (0.1 dial div.)	.0006 (0.1 dial div.)	0 0
<u>Power output switch</u>				
75% power		.049	.0185	.0054
50% "		.079	.030	.0047
25% "		.096	.027	.0020
<u>Inclination ±45°</u>				
Front to Back per cycle	Max.			<u>400Mcs.</u> .0026
	Av.			.002
Side to Side per cycle	Max.	.0017		.0073
	Av.	.0014		.0033
Front to Back ½ hr. period				.0004
Side to Side ½ hr. period		.0078		.0041
<u>Vibration</u>				
¼ hr. period		.021		.0069
<u>Shock</u>				
Applied at Rear			Shock #1)	.0012
			" 2)	.0024
			Av.)	.0018
Applied on Left Side	Shock #1)	.020	Shock #1)	.016
	" 2)	.010	" 2)	.002
	" 3)	.007	" 3)	.0016
	" 4)	.009	Av.)	.0065
	" 5)	0		
	" 6)	0		
	Av.)	.0081		

FREQUENCY STABILITY OF WAVEMETER

		Percentage Frequency Change		
		<u>400Mcs.</u>	<u>300Mcs.</u>	<u>225Mcs.</u>
<u>Wavemeter Tuning Control</u>				
Backlash		.014 (1.8 Dial Div.)	.013 (1.9 Dial Div.)	.0076 (1.3 Dial Div.)
Reset		.0008 (0.1 Dial Div.)	.0008 (0.1 Dial Div.)	.0003 (0.1 Dial Div.)
<u>Ambient Temperature Change</u>				
-15° to 50°C.		.034	.019	.021
<u>Humidity Change</u>				
30% to 95%		.010	.0091	.0027

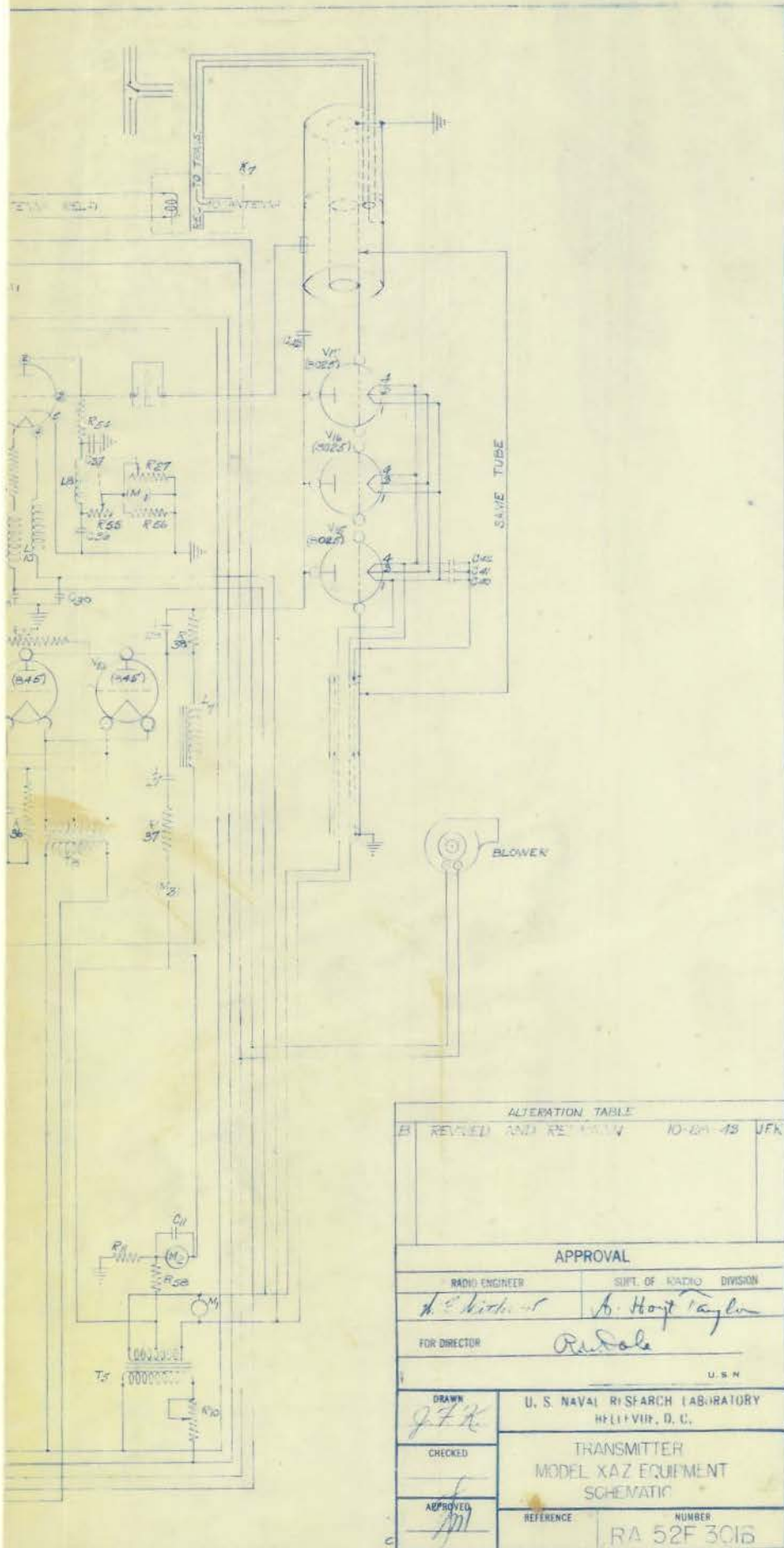
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OPERATION	LINK				
	A	B	C	D	E
15 V AC - 6 WIRE	1-2	1-2	1-2	CLOSED	OPEN
15 V AC - 4 WIRE	1-2	1-2	1-2	CLOSED	CLOSED
15 V DC - 6 WIRE	2-3	2-3	1-2	OPEN	OPEN
15 V DC - 4 WIRE	2-3	2-3	2-3	OPEN	CLOSED

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ALTERATION TABLE		
B	REVISED AND RE-DESIGNED	10-20-48 JFK

APPROVAL	
RADIO ENGINEER	SUPV. OF RADIO DIVISION
<i>H. E. Nichols</i>	<i>A. Hoyt Taylor</i>
FOR DIRECTOR	<i>Rudale</i>
U. S. N.	

DRAWN <i>JFK</i>	U. S. NAVAL RESEARCH LABORATORY HETTERVIEW, D. C.
CHECKED	TRANSMITTER MODEL XAZ EQUIPMENT SCHEMATIC
APPROVED <i>JFK</i>	NUMBER RA 52F 3016
REFERENCE	

PLATE 8