DECLASSIFIED

R-2095

FR-2095

DECLASSIFIED by NRL Contract
Declassification Team
Date: 19 Jun 2016
Reviewer's name(s): H. Do, P. HANNA

Declassification authority: NAVY DECLASS MANUAL, 11 DEC 2012, DE SERIES

DISTRIBUTION STATEMENT A APPLIES
Further distribution authorized by UNLIMITED only.

DECLASSIFIED

30 June 1943

DECLASSIFIED

[redacted]

NRL Report No. R-2095

NAVY DEPARTMENT

Report on

The Design and Development of an Effective Wide-Range Airborne Radar Jamming Equipment

Classification changed from SECRET
To UNCLASSIFIED
By authority of Lab. Memo 117/46
File No. .... Dated 7-1-46

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 12 Tables - 5 Plates - 13

Authorization: BuShips ltr. S-S67/36(485-j) Ser. 2562, dated 22 June 1942, Problem A-248.

Date of Tests: July, 1942, to January, 1943.

Prepared by:

H. M. Bryant, Contract Employee, Aircraft Radio

R. E. White, Contract Employee, Aircraft Radio

Reviewed by:

M. H. Schrenk, Principal Engineer, Aircraft Radio

A. Hoyt Taylor, Superintendent, Radio Division.

Approved by:

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

Distribution:
BuShips (1)
BuAer (1)

REW:RBO

[redacted]

DECLASSIFIED

OCT 17 1946

TABLE OF CONTENTS

APPENDICES

INTRODUCTION

AUTHORIZATION

1. This development was undertaken by authority of the Bureau of Ships letter, S-S67/36(485-j), Serial 2562, dated 22 June 1942, Problem A-24S.

STATEMENT OF PROBLEM

2. The object of this development was to prepare an experimental model of an equipment suitable for use in the Naval aircraft service for jamming enemy radar signals within the frequency range 375-600 megacycles. The equipment was to consist of a receiver unit for monitoring and a transmitter unit or units, modulated if necessary, for jamming transmission. Power sufficient to jam enemy radar signals at a distance of ten miles was specified.

KNOWN FACTS BEARING ON THE PROBLEM

3. An equipment to fulfill the stated requirements should consist of the following sections:

(a) An ultra-high frequency transmitter with an output sufficient to jam enemy radar signals in the range 375-600 Mc/s at a distance of 10 miles. Tuning should require only one control.

(b) A monitoring receiver of 1 or 2 millivolts sensitivity to cover the range 375 to 600 megacycles with a single control.

(c) An antenna system to suitably radiate the transmitter signal over the range 375-600 Mc/s.

(d) If necessary, a modulation system for the transmitter.

(e) Suitable power supplies for the above sections working from power sources available in standard military aircraft.

4. A power oscillator rather than a master oscillator-power amplifier was indicated for the transmitter because of its simplicity and the saving in size, weight, and power consumption. Several types of available tubes were known to oscillator at the required frequencies, but their power output at these frequencies was indefinite. Among the tubes available for this purpose were WE 316A, HY 615, RCA 8025, RCA 8012 and a few magnetrons. Oscillator circuits of the grounded grid type were capable of covering the necessary range. Standard tuning circuits such as coil and condenser, tuned parallel and coaxial transmission lines, and tuned cavity resonators had been used at frequencies within this range but their complete range with the tubes available was indefinitely known. The "butterfly" resonating circuit as used by the General Radio Company in their type P521A signal generator was considered capable of covering the range.

5. Receivers of the super-regenerative, super-heterodyne, double-heterodyne, and autodyne types, as well as simple diode and crystal detectors had been used at the frequencies mentioned. Because of its simplicity, the super-regenerative type was thought to be adequate for a monitoring receiver of the type mentioned.

6. The antenna for this equipment should be either tunable with the transmitter or have a sufficiently wide-band characteristic to cover the whole range.

7. Since almost no data was available on radar jamming when this problem was initiated, it was not known whether a carrier alone was the best means of jamming radar or whether a modulation of some sort was indicated.

8. A power source of 110 volts and variable frequency between 400 and 2000 cycles is available on most military aircraft. Proper rectifier and filter circuits used with suitably designed transformers can be made to provide commonly used plate voltages. These voltages can be stabilized by the use of regulator tubes. It is practical to have motors and relays operate on direct current supplied from the aircraft source of 12 or 24 volts.

THEORETICAL CONSIDERATIONS

9. The first problem was the determination of the output power necessary to give the required jamming range. Preliminary calculations indicated that a radiated power of approximately ten watts would be sufficient to jam radar signals at ten miles. Since ten watts was considered to be the approximate limit of the available tubes at the required frequencies, the power of the transmitter was arbitrarily set at this value.

10. Later a formula was derived for approximating a receiver input voltage when the power and distance of an airborne transmitter is known.

$$E_r = \frac{k\lambda\sqrt{PG_t\,G_r}}{2\pi D}$$

where E_r = microvolts input to the receiver

k = a constant = 3.915×10^5

λ = wavelength in meters

P = power radiated from transmitter in kilowatts

G_t = gain in the transmitting antenna

G_r = gain in the receiving antenna

[redacted]

D = distance in statute miles

11. If we now substitute $P = 0.01$, $D = 10$, $\lambda = 0.58$ (515 Mc/s), $G_t = 1$, we have $E_r = 360$ µv when $G_r = 1$, and $E_r = 1800$ µv when $G_r = 25$. Thus when the enemy receiver antenna is aimed at the jammer, a strong CW signal is fed to the receiver, depending on the antenna gain.

12. A carrier alone, however, has several disadvantages. It has a relatively narrow bandwidth as compared to a radar signal and thus might be filtered out, and anti-jam circuits can be introduced in the radar receiver to prevent blocking at higher input voltages. It has been found, however, that by modulating the carrier in several different ways, interference was introduced on the indicator tube although the power was insufficient to block the receiver. Two general types of modulation were considered feasible: random noise and waves of a low radio frequency.

13. Random noise can be furnished by various methods, the inherent "electron" noise in vacuum tubes furnishing a convenient source. For jamming use the transmitter carrier is modulated heavily with random noise in a standard manner. The wide frequency range of the noise would produce many sidebands and effectively broaden the transmitted signal. When such a jammer is on the same frequency as a radar receiver within jamming range it would have the effect of increasing the amount of "grass" on the indicator tube tending to envelop the echo indication.

14. The time sweep on a radar indicator varies from about 0.5 to 20 kilocycles per second, depending on the range in use. Therefore, if a frequency somewhat higher, say 200 kc/s, is fed to a radar receiver by modulation of a jamming transmitter, a wave is produced along the time axis that appears as a "ladder" or "railing" and interferes with the "blip" indication. This "railing" modulation was chosen for the equipment described for two reasons. First, it was found that good "blips" displaced the grass on the indicator tube and were thus identified through ordinary noise. Second, it was possible to obtain "railing" modulation by adding pulses on a straight CW carrier, thus obtaining a considerable saving in modulator power.

15. The sharpness of the pulse also effectively increases the bandwidth of the jamming signal.

16. A formula for approximating the power reflected from a radar target is given below:

$$P_r = \frac{k^2 APG_t}{2Z_oD^2} \times 10^{-15}$$

where P_r = peak reflected power

$k = 3.915 \times 10^5$

A = effective area of target in square meters

P = peak radiated power from transmitter in KW

21. A parallel line resonator was next tried, using RCA type 8012 tubes. The plates of two tubes were grounded through a condenser and tunable resonant lines used on the grids and filaments. An oscillator capable of tuning from 300 to 525 Mc/s with an output of 8-10 watts was the result. Attempts to stretch the frequency range to 600 Mc/s resulted in sporadic oscillations and loss of power. By changing the circuit to a grounded grid type and using parallel lines to resonate the plates, the output was raised and the range slightly increased. In its final form, the parallel line oscillator delivered from 14 to 30 watts over the range 375 to 540 megacycles. The physical characteristics of the tubes combined with lines made higher frequency operation impractical. It was therefore decided to use two transmitter units to cover the required range, a tuned line oscillator to cover from 375 to 540 megacycles/second and a tuned cavity oscillator to cover from 520 to 600 Mc/s.

22. Single dial control for adjusting the oscillator frequency was the next problem. In the case of the tuned line oscillator two different shorting bars had to be moved at varying rates. Curves were drawn for length-of-line versus frequency. Kinks in the original curves were rounded out by careful adjustment of the distance between the lines. The final curves were straight lines, the filament lines $(\frac{\lambda}{4})$ having twice the slope of the plate lines $(\frac{\lambda}{2})$. Tuning was then accomplished by moving the shorting bars by spiral screws that were suitably geared to the dial. This is shown in Plates 7 and 8.

23. The best means of tuning the resonant cavity was found to be by means of a plunger type condenser between top and bottom at the center of the cavity. A curve was drawn for condenser plate separation versus frequency. This was found to be a logarithmic curve and a cam and plunger mechanism were designed to tune the condenser with a single dial calibrated linearly in frequency. The filaments of the tubes were resonated by large coaxial lines that were adjusted for best power output over the range and locked. Plate 9 shows the tuning mechanism for the cavity resonator.

24. Antenna coupling into the parallel line oscillator was a simple problem. A small loop on the end of a 50 ohm coaxial transmission line was coupled inductively to the plate, grid and filament circuits respectively. Sufficient power was obtained in each case. The final coupling was made to the fixed end of the half-wave plate line. This can be seen in Plate 7.

25. A good means of coupling an antenna transmission line to the resonant cavity was more difficult to find. Small loops were tried in the electrostatic field at the middle and the electro-magnetic field at the sides but insufficient coupling was obtained. A small open-ended tuned coaxial transmission line was placed so as to reach the electro-static field at the center. Sufficient coupling was obtained but the tuning was so critical as to necessitate a complicated linkage to the main dial. After many trials, a small loop in the electro-magnetic field was found acceptable.

[redacted]

26. Modulation on the transmitter had been decided to be in the form of positive pulses of about 500 volts applied to the plates of the oscillator tubes. These pulses would occur from 50 to 200 kilocycles per second constantly varying to prevent synchronization by the enemy.

27. To produce these pulses, a varying D.C. voltage was applied to one control grid of a multivibrator circuit and the resulting square wave of varying frequency was converted to pulses by suitable circuits.

28. The output of the modulator consists of strong positive pulses which are fed directly to the oscillator plates through a condenser. The schematic diagrams in Plates 1 and 2 show the modulation circuit.

29. In the cavity transmitter the capacity between the oscillator plates and ground was found to shunt the modulator signal to ground. This was remedied by resonating this capacity in a low Q parallel resonant circuit at approximately 150 kc. to keep the impedance high.

30. The first experimental receiver for this equipment was built using a standard super-regenerative circuit, self-quenched, with a "butterfly" resonating circuit covering the complete range 375-600 Mc/s. Regeneration was controlled by varying the plate voltage to the type 955 triode used as detector-oscillator. This receiver was unsatisfactory for several reasons. First, an extra operation would be required to control the regeneration; second, the antenna coupling was very critical, although a very loosely coupled "link" worked well in coupling the "butterfly" to the coaxial transmission line. Also, strong signals tended to detune the receiver while very strong signals would block it.

31. An autodyne type receiver was next tried, which developed into the final model. The type 955 tube is quite well adapted to use with the "butterfly" circuit because leads can be kept very short by mounting the tube directly on the "butterfly".

32. By using an IF amplifier at a frequency considerably less than the bandwidth of the received signal, an oscillator circuit tuned to the median frequency of an incoming signal will beat with the sideband components.

33. An I.F. frequency of 120 kc. was chosen mainly because circuit elements for this frequency were obtainable. The schematic diagram is shown in Plate 3.

34. Some difficulties were encountered in maintaining oscillation of the "butterfly" circuit over the entire range. Dead spots were removed by careful adjustment of R.F. chokes, bypass condensers, and lead lengths. Still, the receiver sensitivity was not constant over the whole range. In an attempt to remedy this, an r.f. gain control was geared to the main tuning control in such a manner as to keep the sensitivity fairly constant, but it was found to be too noisy to be practical. A voltage regulator on the oscillator improved the stability greatly. Using the 955 as a non oscillating detector resulted in a fairly constant sensitivity but of too low a value.

35. Two methods of signal indication were available, audible or visual. Because an operator customarily has headphones on for intercommunications and other equipment, it was deemed advisable to include some visual indication. Oscilloscope circuits are prohibitive because they require additional size and weight. For these reasons, both a tuning eye indicator and a headphone jack were supplied.

DESCRIPTION OF MATERIAL

36. The equipment consists of three main units plus cables and accessories. The main units consist of one receiver to cover the range 375 Mc. to 600 Mc., and two transmitter units, one covering from 375 to 530 Mc. and the other from 515-600 Mc. These units are shown in Plate 4.

37. Plates 5 and 6 picture the receiver unit while its schematic circuit is shown in Plate 1. It utilizes a 955 triode in an autodyne detector circuit using an intermediate frequency of 120 kc. A "butterfly" tuning device acting as a variable inductance-capacitance covered the wide range in the oscillator circuit. A diode second detector is employed. The resulting audio signal, at the repetition rate of the pulse transmitter, is applied to a tuning eye indicator and to headphones.

38. Plate power of 250 volts is furnished by a conventional rectifier circuit operating from 110 V., 800 c.p.s. The tube heaters are operated from the 24 V. D.C. supply to avoid 800 cycle hum.

39. The low range transmitter unit (375-530 Mc.) utilizes type 8012 tubes in a push pull oscillator circuit using parallel lines with adjustable shorting bars for the resonant circuit. The schematic diagram is shown on Plate 2 and pictures of the equipment are shown in Plates 7, 8, and 9.

40. Tuned circuits are used in plate and filament circuits with short fixed grid lines tuned about 500 Mc. and grounded through a grid leak at the center of this fixed line. The plate and filament line lengths are varied by sliding the shorting bars with threaded rods suitably geared to the tuning crank. The plate line is effectively half wave in length and is the frequency control. The filament lines are quarter wave in length and act as filament chokes and as a control on excitation of the oscillator.

41. Output is loop coupled from the fixed end of the plate line. Plate voltage of 700 volts and filament power are obtained from a conventional transformer and rectifier fed from 110 V. 800 cycles. Plate modulation is employed.

42. The high range transmitter (510 to 600 Mc.) shown in schematic by Plate 3, and in pictures by Plates 9 and 10, utilizes a resonant cavity as a tuned circuit. The cavity resonator is 7" x 7" x 7/8" inner dimensions with the tubes mounted 1-3/8" out from the center.

43. The filaments project through holes in the bottom of the cavity and are enclosed by coaxial lines which resonate in the tuning range. These lines act as RF chokes and raise the efficiency of the circuit.

[redacted]

44. Tuning of this circuit is accomplished by varying a disc type condenser shunting the top and bottom of the cavity at the midpoint between tubes. Movement of the condenser plate is controlled by a gear driven cam which is designed to give a straight line frequency characteristic.

45. Plate modulation is applied through a condenser. The modulation employed in both transmitters consists of positive pulses of approximately 250 V. amplitude. The repetition rate of these pulses varies between about 80 and 220 kc. at an 800 cycle rate. This modulation is developed by applying a varying D.C. voltage to one control grid of a multivibrator circuit and by suitably clipping and peaking the output wave form.

46. The transmitted wave then, consists of an ultra high frequency carrier modulated with pulses occurring at a low varying radio frequency rate (80-220 kc.).

47. The wave form is radiated from a non-directional antenna at the frequency of an enemy radar transmitter. If the plane bearing the jamming equipment is being ranged upon, it is necessary for the jamming transmitter to radiate a signal stronger than the reflected pulse of the enemy transmitter. The jamming signal will then be accepted by the enemy receiver along with the returning echo reflected from the airplane. The sweep of the enemy's range indicator will depend on the range of the equipment. For example, the sweep would have a duration of 133.4 microseconds for a total range of 20 kilometers. During that time 26.7 cycles of a 200 kilocycle per second modulation would have passed and appeared on the indicator scope as a "railing ladder". Since the modulation frequency is varying, the "ladder" would appear to vibrate up and down on the screen at a rate of 800 cycles per second, thus effectively smearing the "blip" indication.

48. The tuning procedure consists of locating a signal with the receiver which indicates both audibly in headphones and visibly on the tuning eye and then switching to transmit position and tuning the transmitter until a second indication is given by the tuning eye. The transmitter is then on frequency and jamming.

49. A rough calibration of the dials allows the transmitter to be brought to frequency very quickly. To determine whether the plane is still being ranged upon, the receive-transmit switch must be thrown to receive position momentarily. Sensitivity controls on the receiver make it possible to search for other signals while the transmitter is in operation.

50. For this procedure, the receiver must be located at the operator's position while the transmitter may be installed at a remote point and a remote tuning dial used.

TEST PROCEDURE

51. Power Input

Weston Model 301 ammeters and RCA Junior Voltohmists were used in measurement of currents and voltages, respectively.

[redacted]

52. **Power Output**

R.F. energy was loop coupled into standard 70 ohm PT-5 cable which was terminated in a slotted line. Across this slotted line a photometric power measuring device consisting of a load lamp and photocell was connected.

53. The photocell reading was calibrated in terms of power by feeding known amounts of d.c. power into the load lamp and observing the corresponding photocell reading.

54. When any standing waves in the PT-5 cable had been eliminated by means of the slotted line, the power delivered to the load lamp should be the same as on d.c. calibration.

55. It was recognized that at high frequencies long filaments in load lamps become unevenly heated along their lengths, i.e. they develop hot spots and give false indications of power. To avoid this, special load lamps with short filaments were employed.

56. **Transmitter Stability**

Since this equipment is to be constantly monitored, stability is not of prime importance, and these tests were run only at room temperature to determine the characteristics of the early warm-up period and the effect of variable input voltages.

57. The equipment was turned on and the frequency measured immediately and at intervals of one minute thereafter for twenty minutes. After allowing a warm-up of two minutes, the frequency was checked as input voltage was varied. An NRL type LAB frequency meter was used to measure frequency.

58. This test was run only on the line transmitter since time was at a premium and it was known to be the least stable of the two transmitters.

59. **Receiver Sensitivity**

To measure IF sensitivity, a signal from a Model 160 Ferris Signal generator was fed to the I.F. section and the amount of signal necessary to maintain 50 milliwatts output into 600 ohms was noted.

60. Overall sensitivity was determined similarly by feeding a carrier modulated 30% from RCA UHF signal generator type 710A, Serial 012, to the RF input. This test was run only to 540 Mc. because calibrated signal generators were not available above that frequency.

61. **Wide Band Antenna**

The wide band antenna was tested by Mr. Ringwalt in Special Development Section.

[redacted]

62. **Performance Tests**

For reasons of security, field tests of this equipment were considered inadvisable. It was therefore decided to confine the jamming radiations to a single shielded room, where the following test procedure was followed. (See block diagram, Plate 1)

63. The complete jamming equipment was placed in a large double-screened box within the shielded room and all power leads were carefully filtered so as to obtain at least 50 db attenuation of the ultrs high frequency field present within the box. An adjustable r.f. attenuator was built into the shielded box, the outside end feeding a coaxial transmission line. The inside end of the attenuator was link-coupled to the transmitter antenna terminals. A jamming signal, variable over 50 db, was then available at the end of the transmission line. A radar receiver and indicator were set up in the shielded room to represent the equipment to be jammed. An artificial return echo was then produced on the indicator screen. This was done by means of a double pulse generator whose delayed pulse triggered a pulse signal generator, which, in turn, produced an r.f. pulse at the radar frequency whose amplitude could be controlled by adjusting an r.f. attenuator.

64. The output from this attenuator was carried to the radar receiver by a coaxial transmission line, producing a blip on the indicator screen which was variable in position, amplitude, width and repetition frequency. Since adjustable signals from both the jammer and echo generator are fed together to the radar receiver, the relative power necessary for jamming can be determined. In a typical test, the echo is set to the approximate indication of an airplane at fairly close range. The jamming signal is then turned on and gradually increased until the blip has been entirely smeared. This point is noted and the relative amplitudes of the two signals measured.

65. Because a bolometer was not available for this measurement, the signal was compared with a known CW signal in a General Radio Type 621A receiver.

DATA OBTAINED

66.

Size and weight of units:	Table 1
Power input requirements:	2
Power output:	3
Transmitter stability:	4
Receiver sensitivity:	5

67. Simulated operational test.

In a test set-up to simulate actual operating conditions, the following results were obtained:

On XAT Radar Receiver

(1) Receiver blocked with 150 uv CW input.
(2) Receiver was jammed with 50 uv input from XBM.

On ASB-3 radar receiver

(1) Signal was obliterated at 130 uv input from XBM.
(2) Jamming signal from XBM has approximately twice the bandwidth of echo.

CONCLUSIONS AND RECOMMENDATIONS

68. Recommendations

Recommendations will here take the form of suggestions for improvement in future models.

69. For the low frequency transmitter:

(1) Tuning rods should be made of some heat resistant, hard, insulating materials.

(2) Shorting bars should employ some spring type, wiping contact.

(3) Some form of tube clip which would allow motion and yet maintain contact should be used.

(4) A rigid coupling loop should be employed.

(5) A better arrangement of parts should be found. For instance: fan should be mounted behind lines to cool lines and tubes rather than at the front blowing hot air from the tubes over the lines.

70. For high frequency transmitter:

(1) Cavity might be silver plated.

(2) Some form of tube clips which allow motion and yet maintain position and contact should be used.

(3) Fixed filament lines may be used.

71. For receiver:

(1) A tuning circuit with a smoother output curve than the "butterfly" should be used.

(2) A lower i.f. should be used.

(3) The i.f. amplifier might employ one stage of impedance coupled amplification and the two following resistance coupled stages.

72. **Conclusions**

The tests described in paragraphs 63, 64, and 65 indicate that this equipment is capable of obscuring the echo from an aircraft viewed on an ASB type equipment at a distance of 10 miles or less. Since flight tests are prohibited by reasons of security, more detailed conclusions are impossible.

SUMMARY AND DISCUSSION

73. This equipment is designed to jam enemy radar installations operating against aircraft on frequencies between 375 mc/sec. and 600 mc/sec. The equipment is airborne and of low power and consequently its use is limited to jamming echoes of the type returned from aircraft and cannot be expected to operate successfully against echoes from large surface craft or land. Its effectiveness is a function of the type of radar receiver and the power of the transmitter.

Table 1

List of Complete XBM-XBO Equipment

Experimental Model

	Name of Unit	Approximate Dimension in Inches. Height	Width	Depth	Approx. Weight in Lbs.
1	XBM Transmitter Low Range Unit	7-1/2	10	19-1/2	38
2	XBM Transmitter High Range Unit	7-1/2	10	19-1/2	43
3	XBO Receiver Unit	7-1/2	5	19-1/2	22
4	Wide Band Antenna	10	8 TEARDROP	25	5
5	Receiver Antenna	5	ROD		2
6	Remote Tuning Unit	6	3	2	2
7	Flexible Cable for Remote Tuning				
8	Antenna Cables and Plugs	50 Ohm Coaxial Transmission Line			
9	Transmitter-Receiver Connecting Cable and Plugs	9 Conductor			
10	Power Cable to 110 V. 800 cps	2 Conductor			
11	Power Cable to 24 V. D.C.	2 Conductor			

DECLASSIFIED

Table 3

XBM TRANSMITTER

Frequency Versus Power Output
For Plate Power Input = 112 Watts

Low Range Unit		High Range Unit	
Freq. in Mc/s.	Output Power in Watts	Freq. in Mc/s.	Output Power in Watts
375	14.3	490	9.0
380	14.6	500	10.5
390	16.0	510	11.4
400	18.1	520	12.2
410	20.0	530	14.1
420	Greater than 20*	540	14.5
430	20	550	14.2
440	20	560	13.6
450	20	570	11.4
460	20	573**	10.8
470	20	580	12.2
480	20	590	10.8
490	20	600	10.0
500	20		
510	20		
520	20		
530	20		
540	20		

* Measuring device indicates only up to 20 watts power.

** Minimum of dip in curve

DECLASSIFIED

Table 4

Stability of Line Oscillator

Time in Mins.	Freq. deviation in Mc/Sec. from 497 Mc/Sec.
0	0
1	0.63
2	0.77
3	0.87
4	0.90
5	0.90
6	0.92
7	0.94
8	0.95
9	0.96
10	0.97
15	0.99
20	0.99

Line Voltage Volts	Freq. Deviation in Mc/Sec. from 497 Mc/Sec.
90	0
95	0.070
100	0.126
105	0.342
110*	0.540
115	0.955
120	1.26

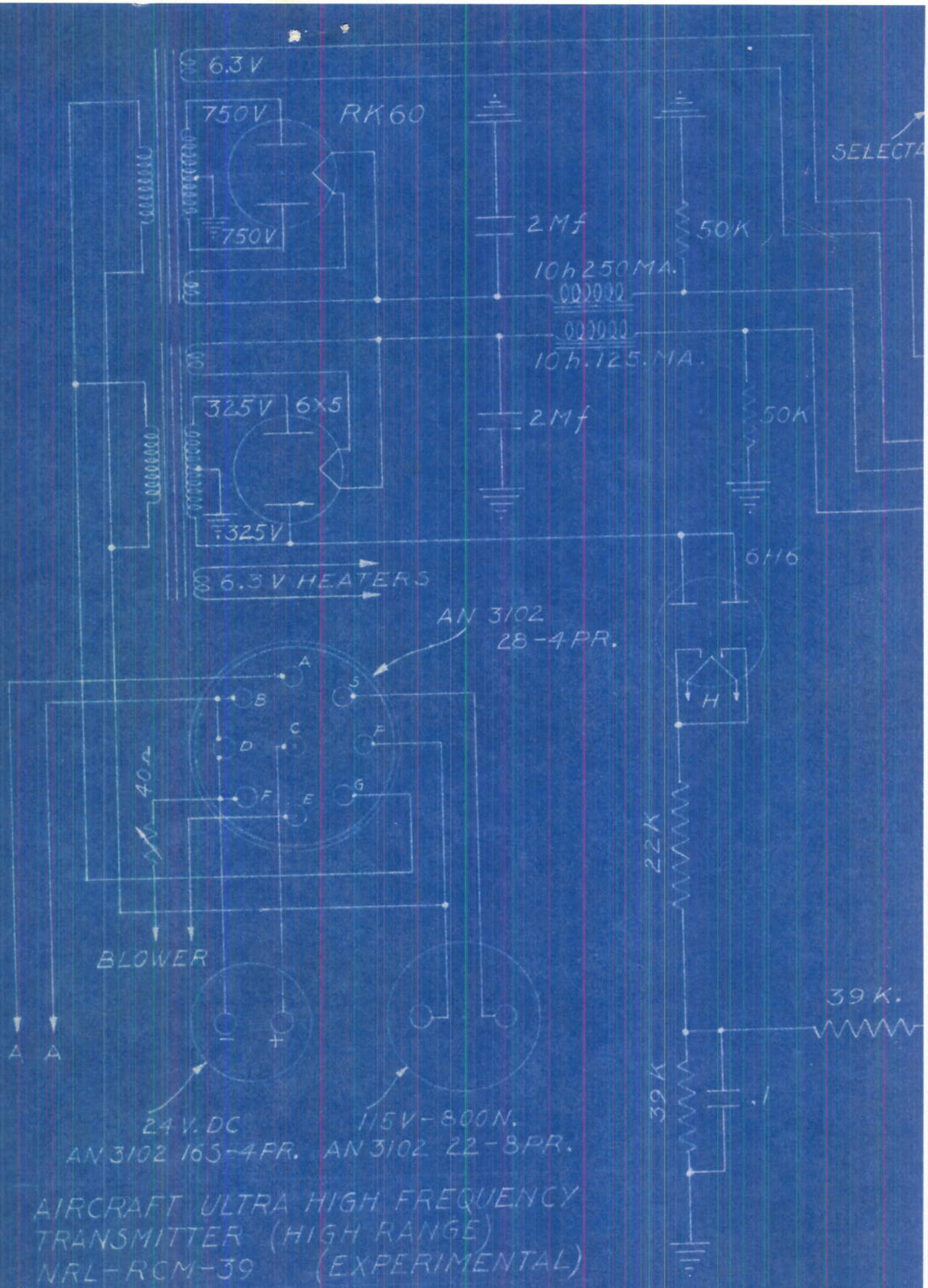
* Normal operating voltage.

Table 5

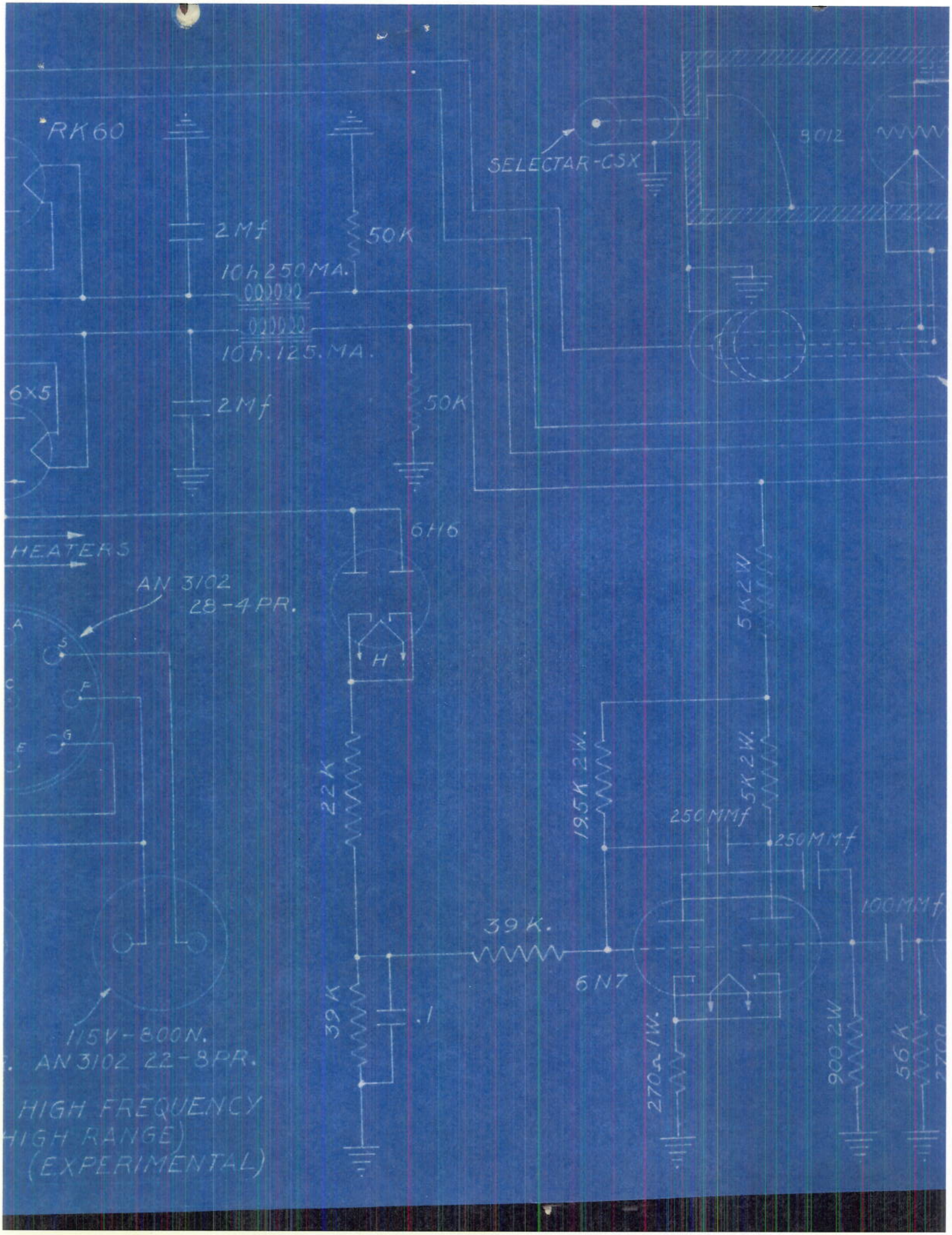
Receiver Sensitivity

Frequency in Mc/Sec.	Sensitivity in Microvolts *
380	70
390	100
400	60
410	30
420	20
430	50
440	50
450	50
460	50
470	40
480	20
490	20
500	25
510	25
520	40
530	40
540	40
550	50

* Input voltage necessary to maintain 50 mw output.



AIRCRAFT ULTRA HIGH FREQUENCY
TRANSMITTER (HIGH RANGE)
NRL-RCM-39 (EXPERIMENTAL)


RK60
2Mf
50K
10h 250 MA.
10h.125.MA.
6X5
2Mf
50K
SELECTAR-CSX
9012
HEATERS
6H6
AN 3102
28-4PR.
A
S
C
F
G
E
H
5K 2W.
19.5K 2W.
5K 2W.
250MMf
250MMf
100MMf
22K
39K.
6N7
39K
.1
270Ω 1W.
900 2W
56K
270
115V-800N.
AN 3102 22-8PR.
HIGH FREQUENCY
HIGH RANGE)
(EXPERIMENTAL)

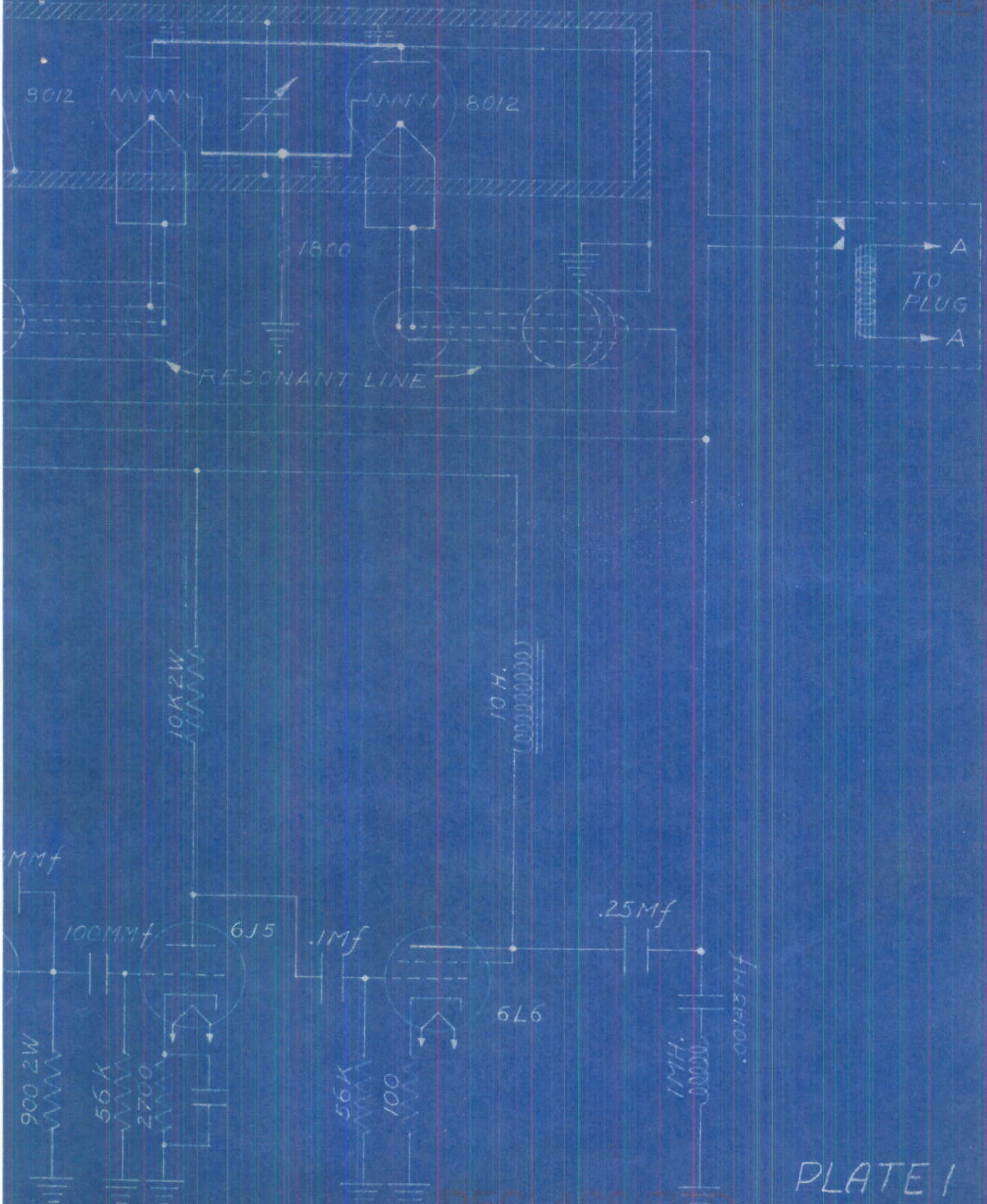
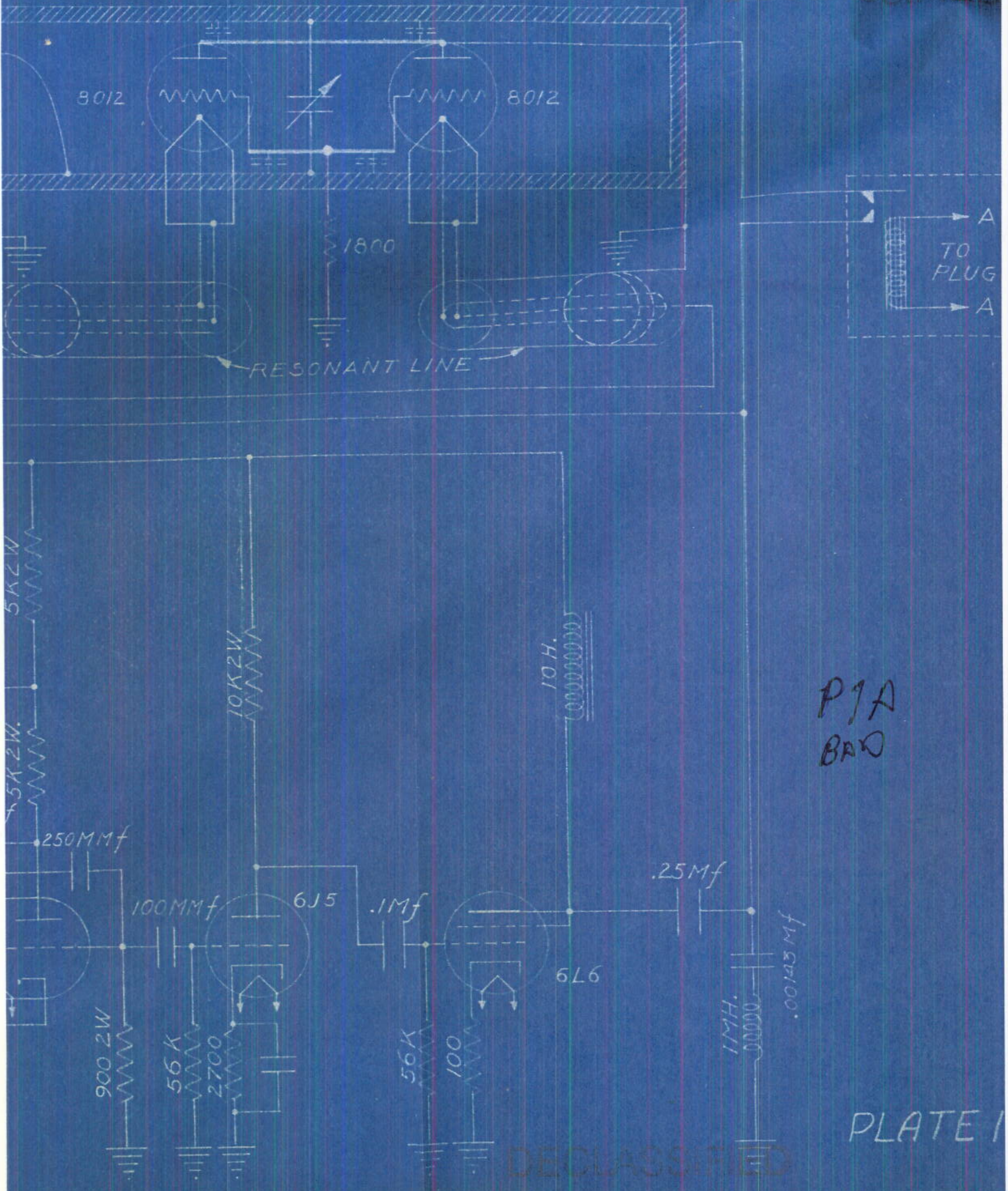
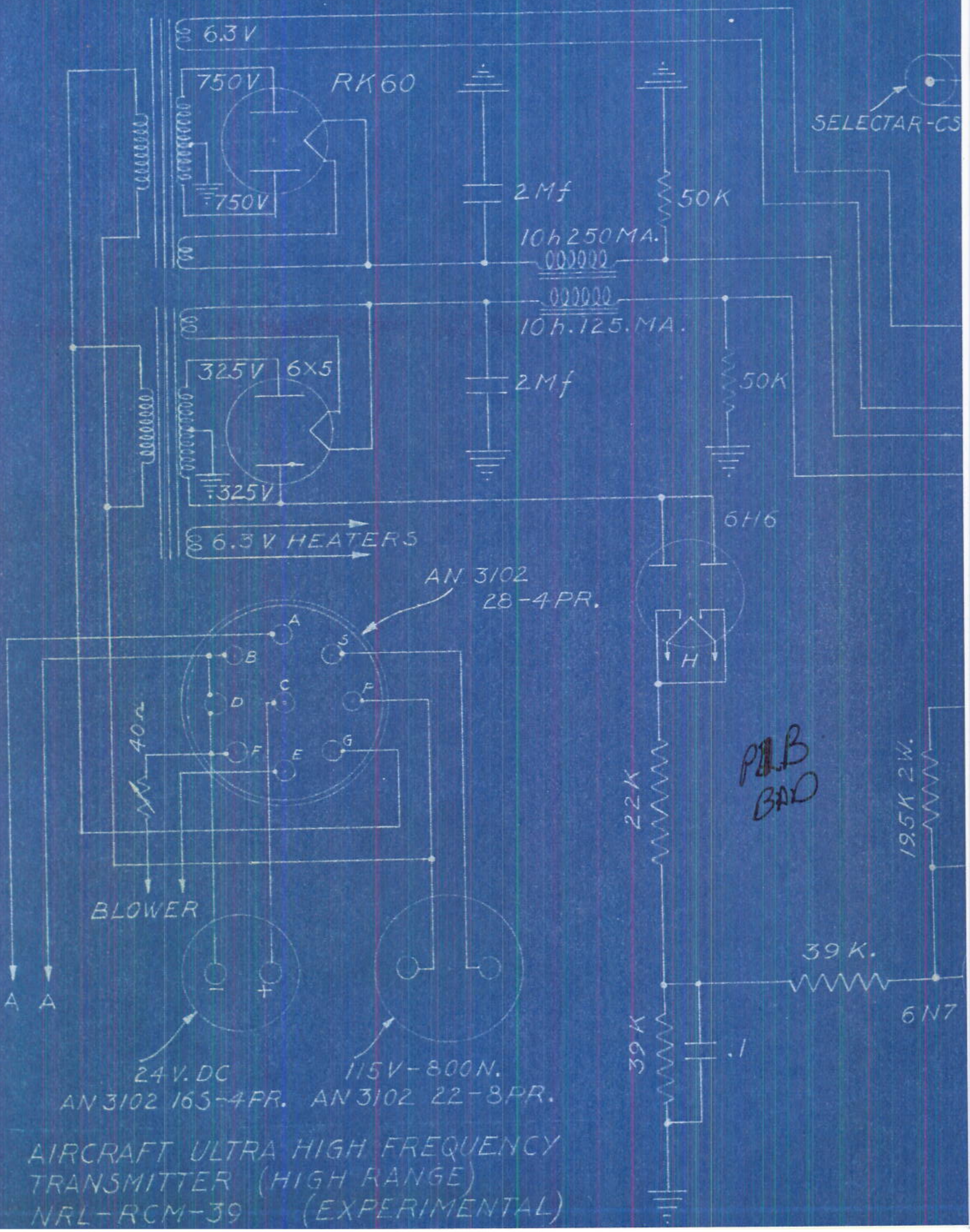

8012
8012
1800
RESONANT LINE
A
TO PLUG
A
10K 2W
10 H.
MMf
100MMf
6J5
.1Mf
.25Mf
6L6
.00125 Mf
1MH.
900 2W
56K
2700
56K
100

PLATE I



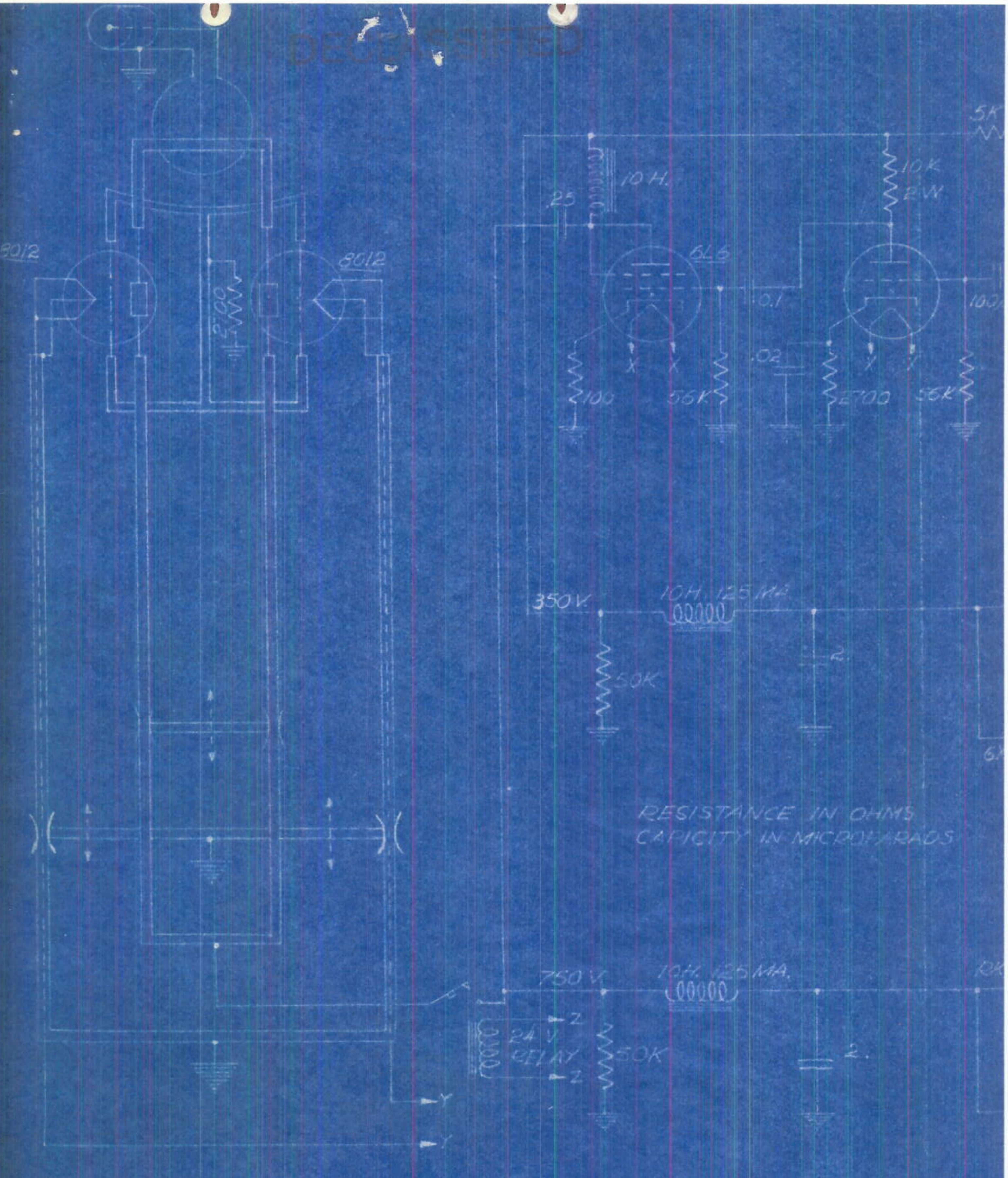
P1A
BAD

PLATE I



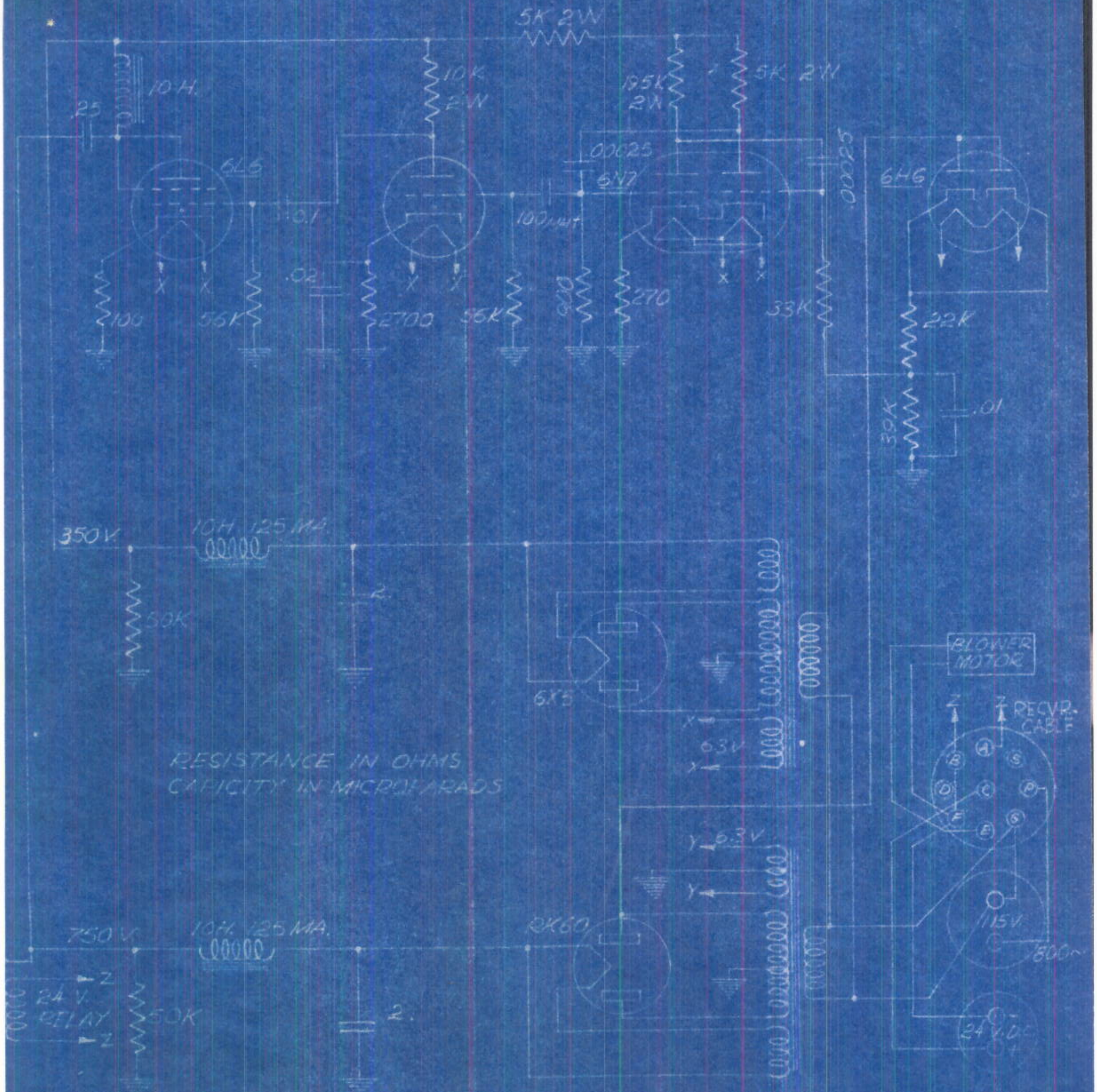
P1.B
BAD

AIRCRAFT ULTRA HIGH FREQUENCY
TRANSMITTER (HIGH RANGE)
NRL-RCM-39 (EXPERIMENTAL)



RESISTANCE IN OHMS
CAPICITY IN MICROFARADS

MODEL XBM AIRCRAFT TRANSM

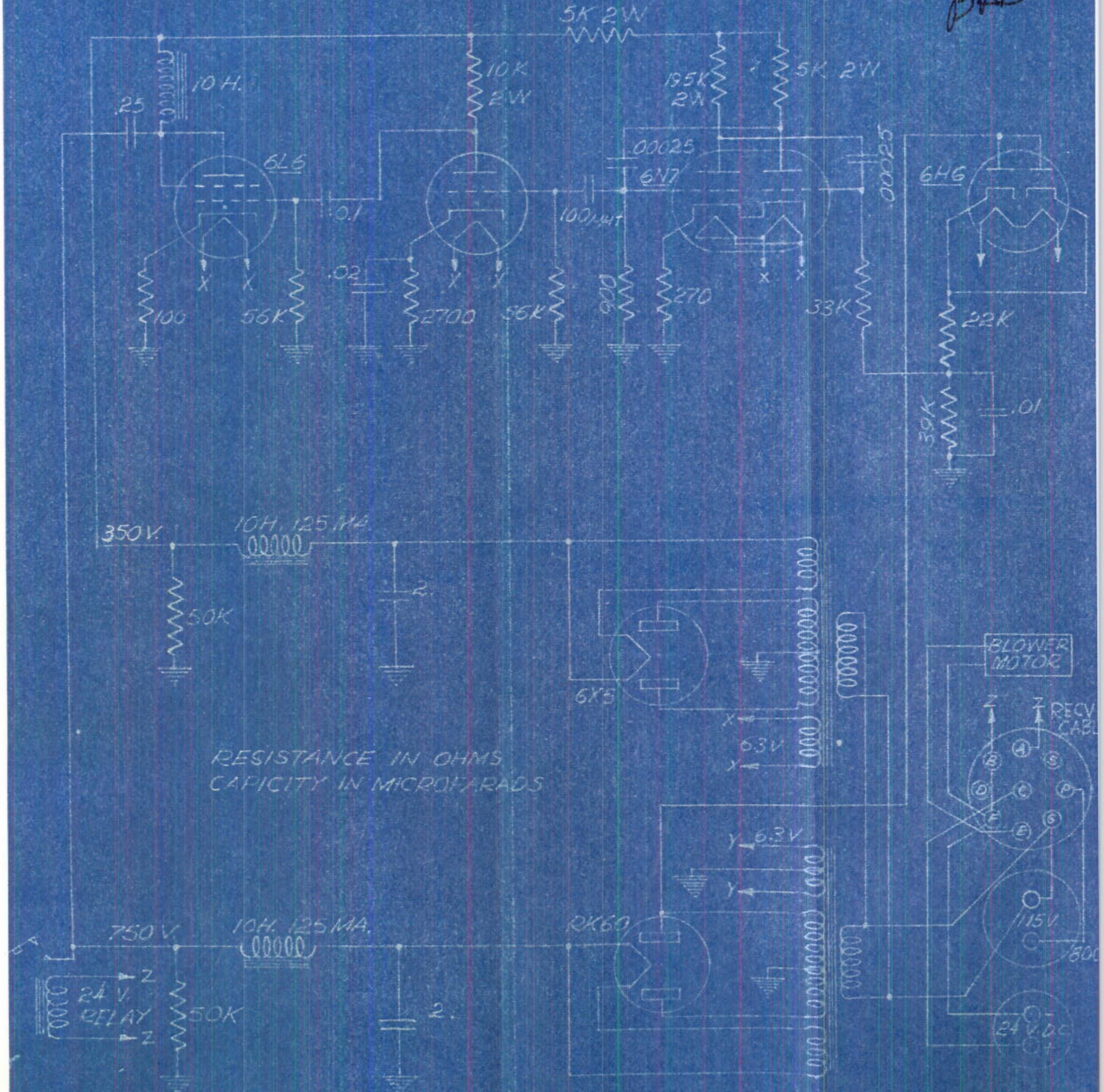


RESISTANCE IN OHMS
CAPICITY IN MICROFARADS

MODEL YBM AIRCRAFT TRANSMITTER

PLATE 2

P2B
BRD

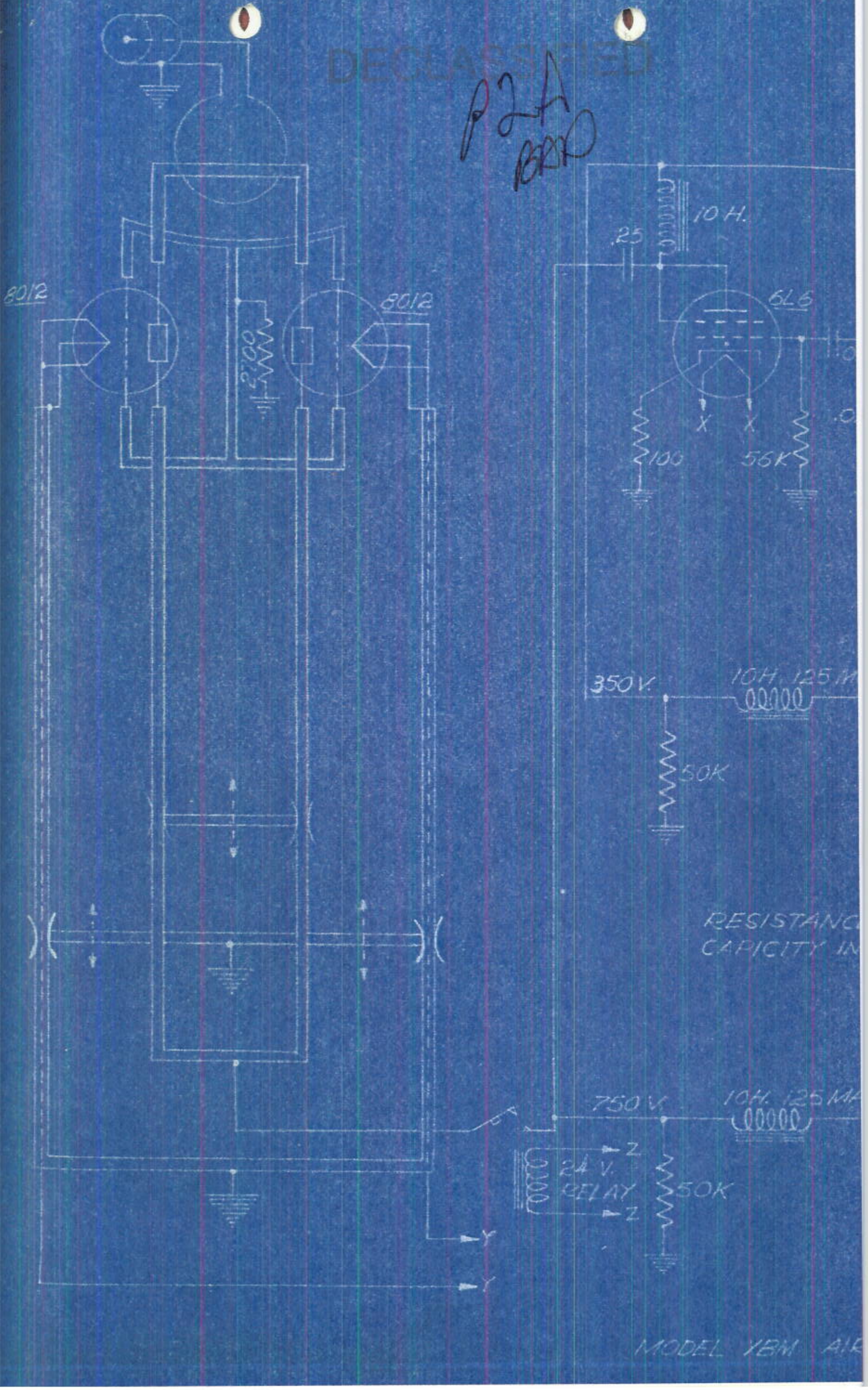


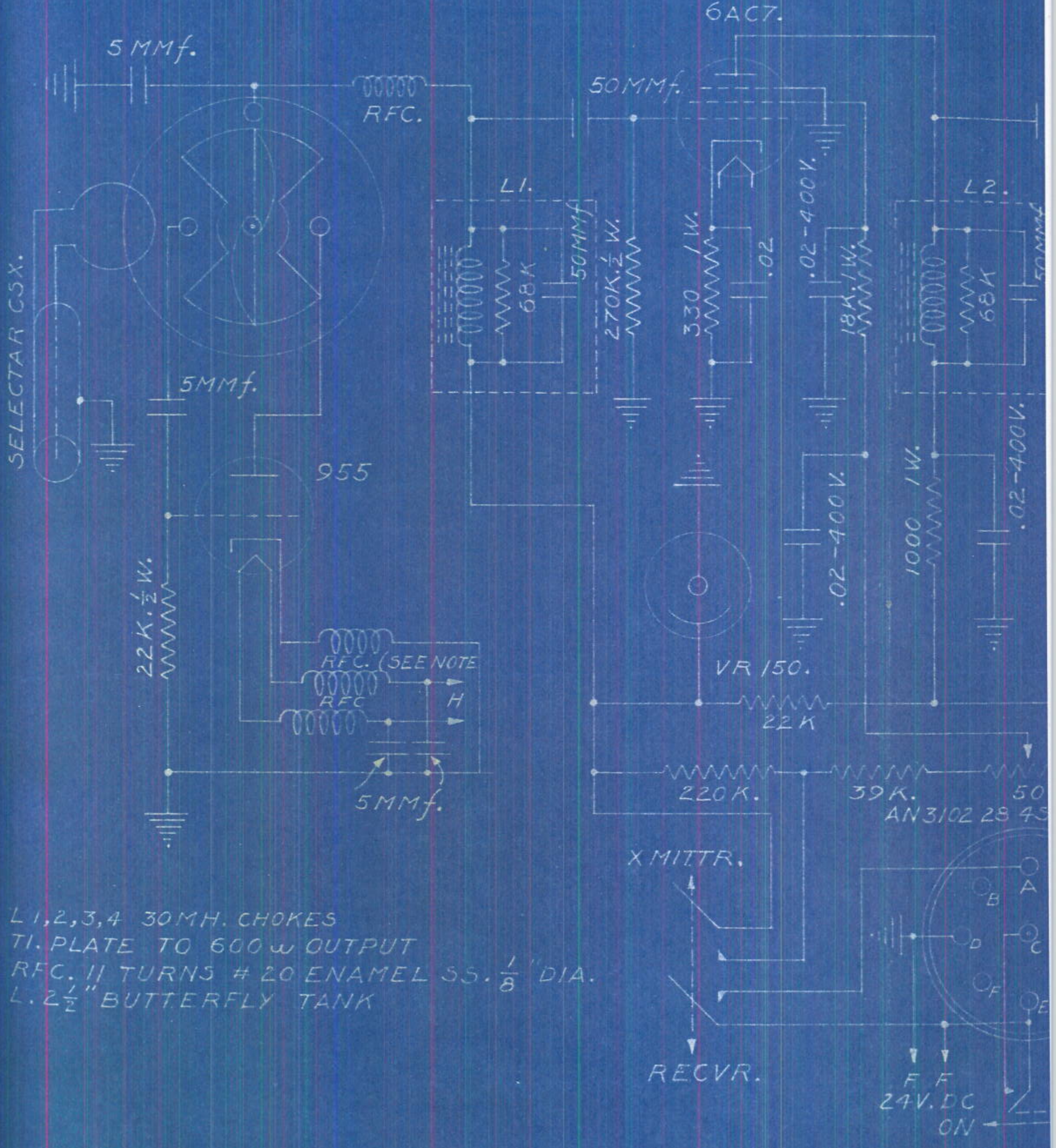
RESISTANCE IN OHMS
CAPICITY IN MICROFARADS

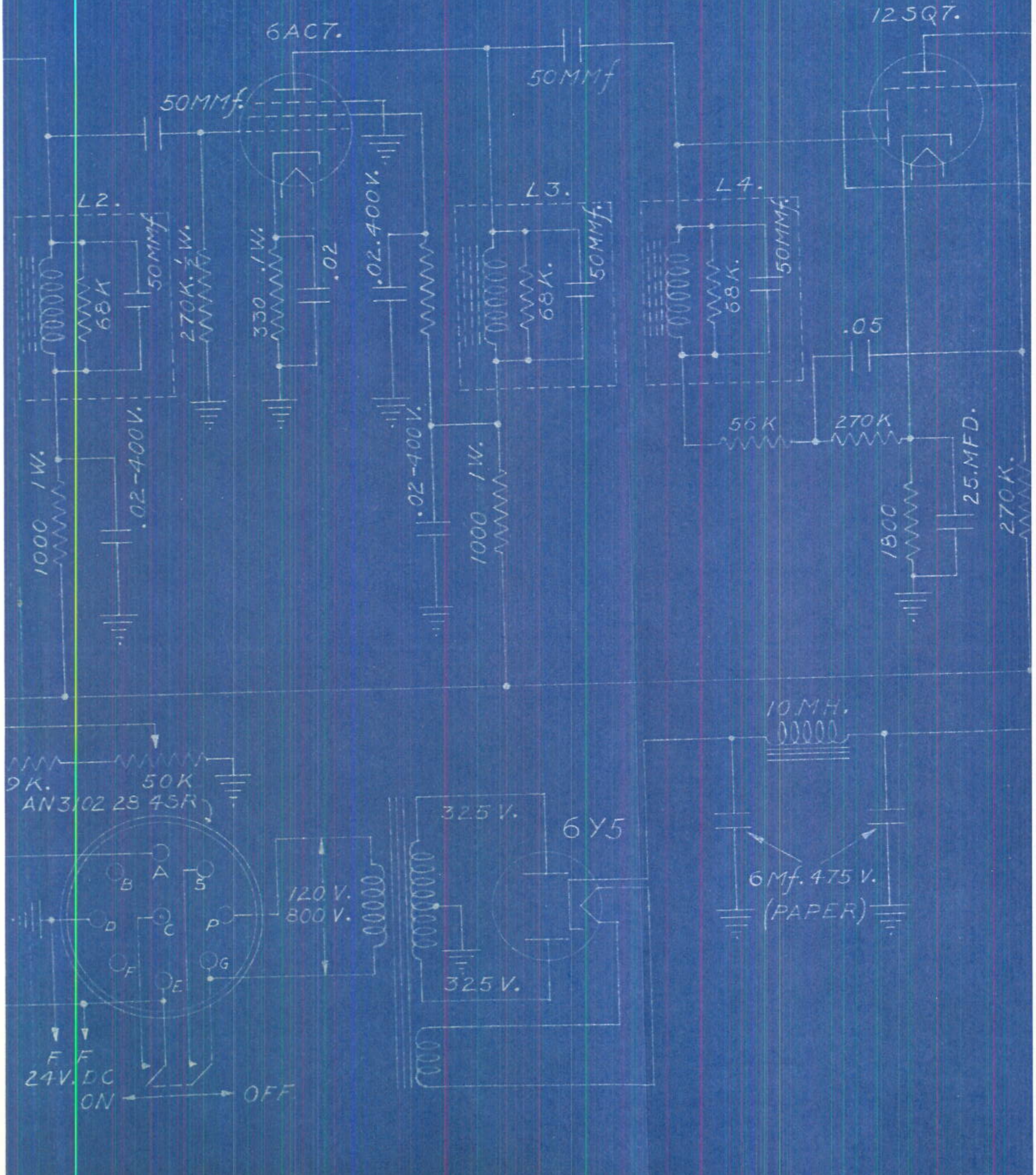
MODEL YBM AIRCRAFT TRANSMITTER

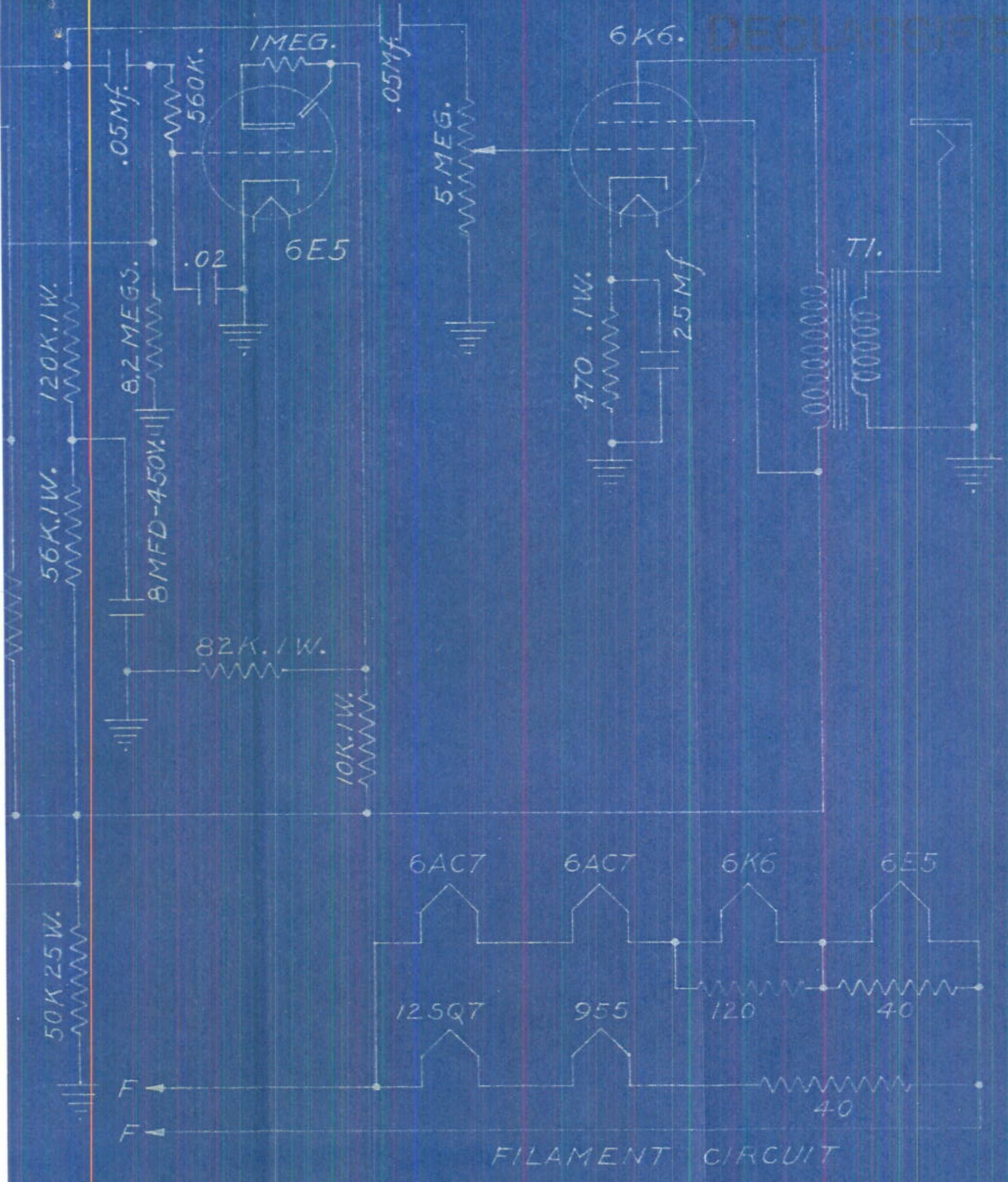
PLATE 2

P2A
BRD


8012
8012
2700
.25
10 H.
6L6
X
X
100
56K
350 V.
10H. 125 M
50K
RESISTANC
CAPICITY IN
750 V.
10H. 125 MA
24 V.
RELAY
Z
Z
50K
Y
Y
MODEL YBM AIR


L 1,2,3,4 30MH. CHOKES
TI. PLATE TO 600 ω OUTPUT
RFC. 11 TURNS # 20 ENAMEL SS. $\frac{1}{8}$" DIA.
L. 2$\frac{1}{2}$" BUTTERFLY TANK

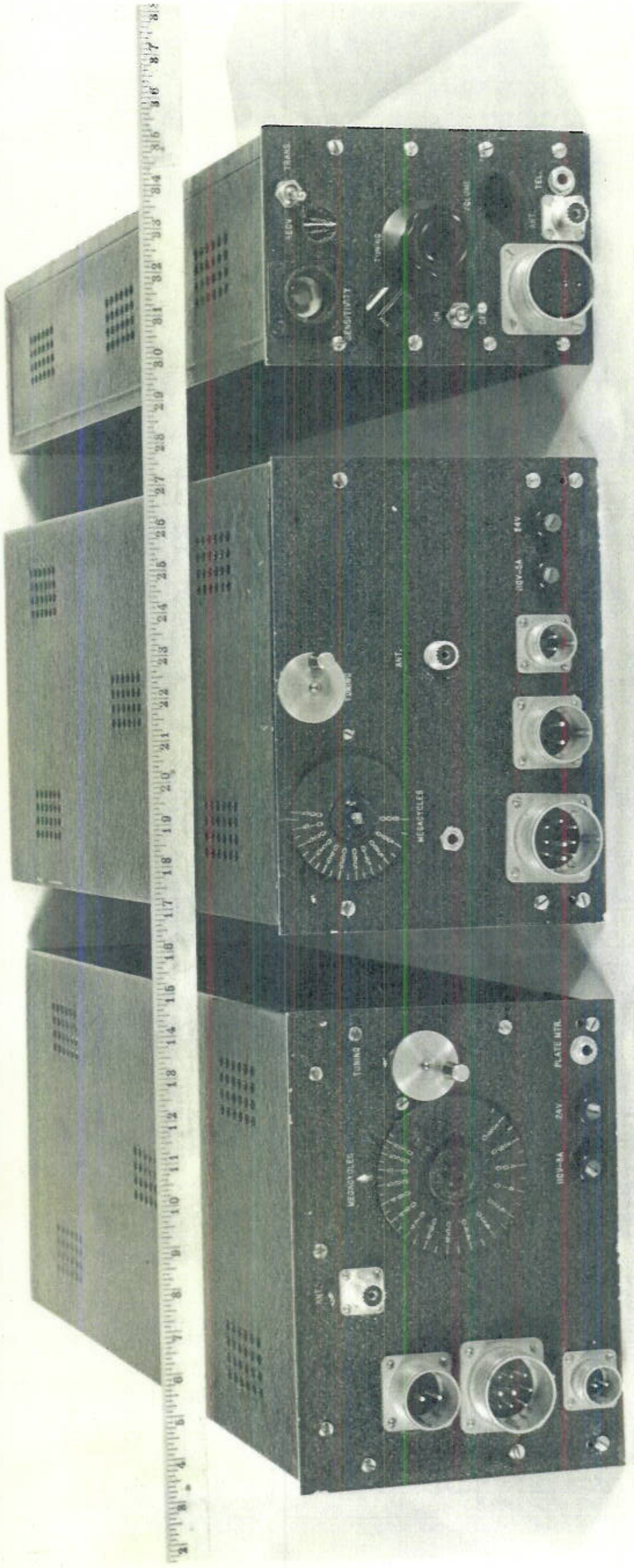

6AC7.
50MMf
50MMf.
12SQ7.
L2.
50MMf
68K
270K. ½W.
330 1W.
.02
.02. 400V.
L3.
50MMf.
68K.
L4.
50MMf.
68K.
.05
.02-400V.
1000 1W.
.02-400V.
1000 1W.
56K
270K
25.MFD.
1800
270K.
10.MH.
9K.
50K
AN3102 28 4SR
A
B
S
D
C
P
F
E
G
120 V.
800 V.
325 V.
325 V.
6Y5
6Mf. 475 V.
(PAPER)
F
F
24V. DC
ON
OFF



AIRCRAFT ULTRA HIGH FREQUENCY
RECEIVER. NRL.-RCM-39. (EXPERIMENTAL)

PLATE 3

DECLASSIFIED



DECLASSIFIED

PLATE 4

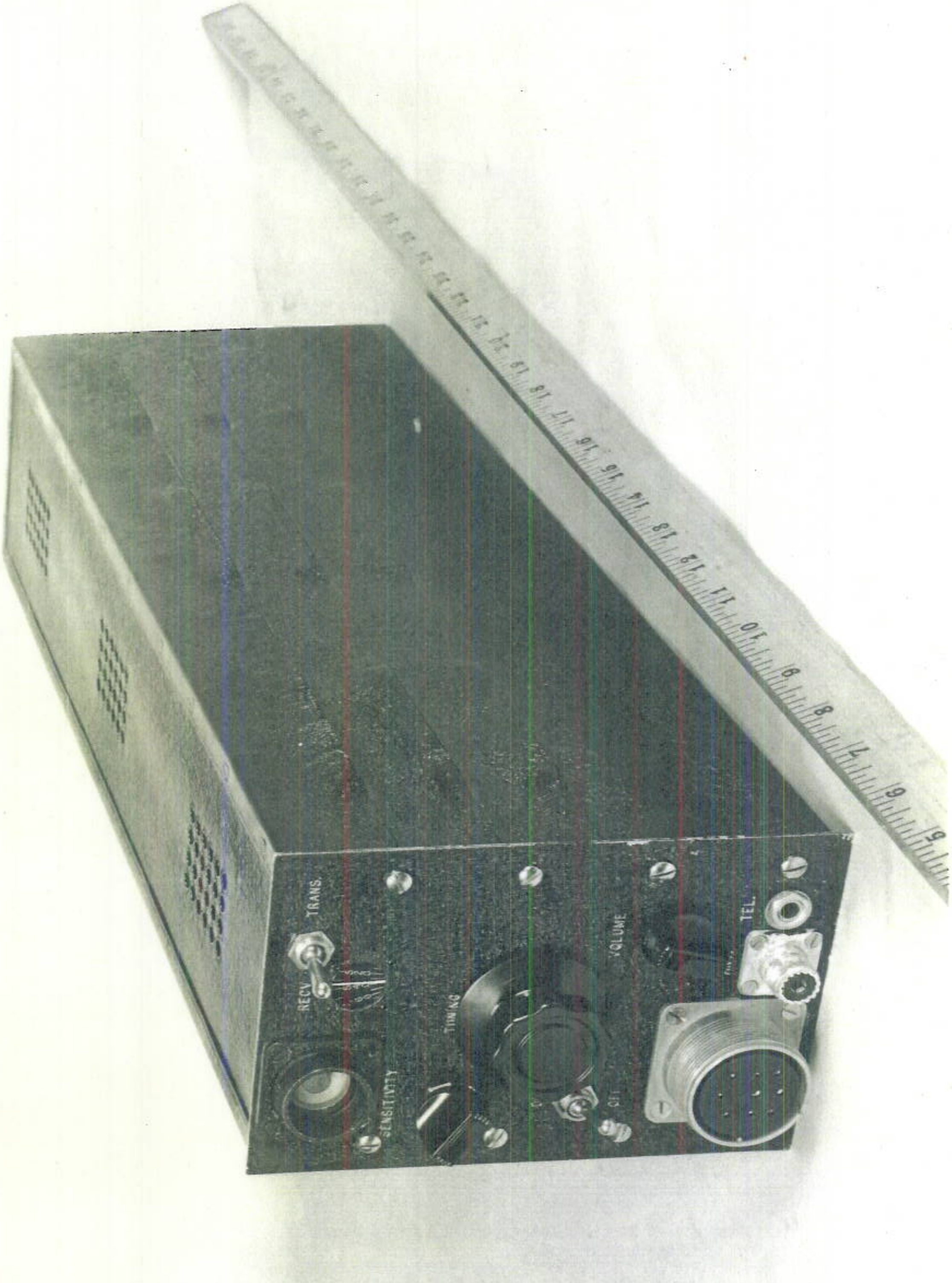
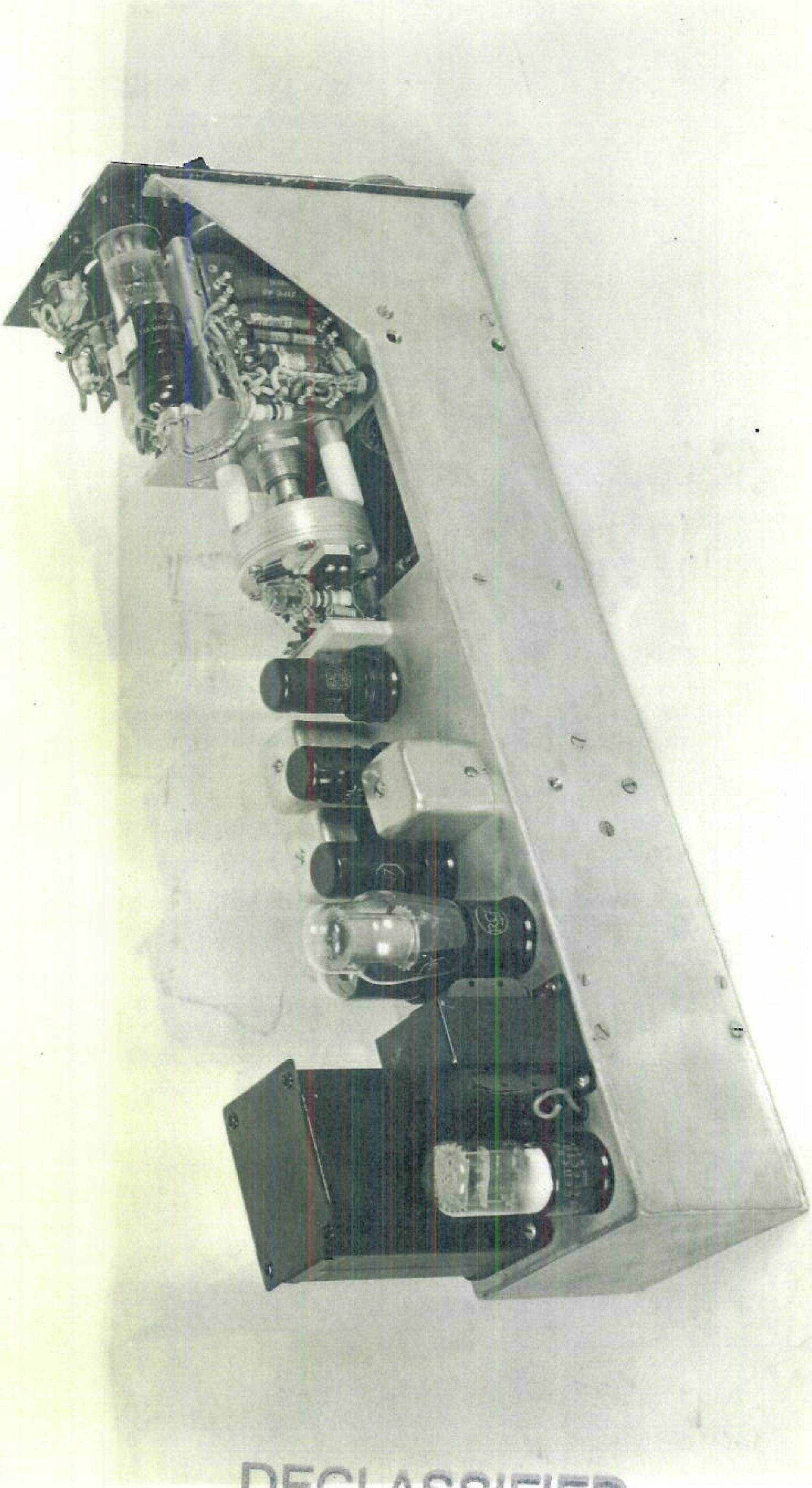


PLATE 5

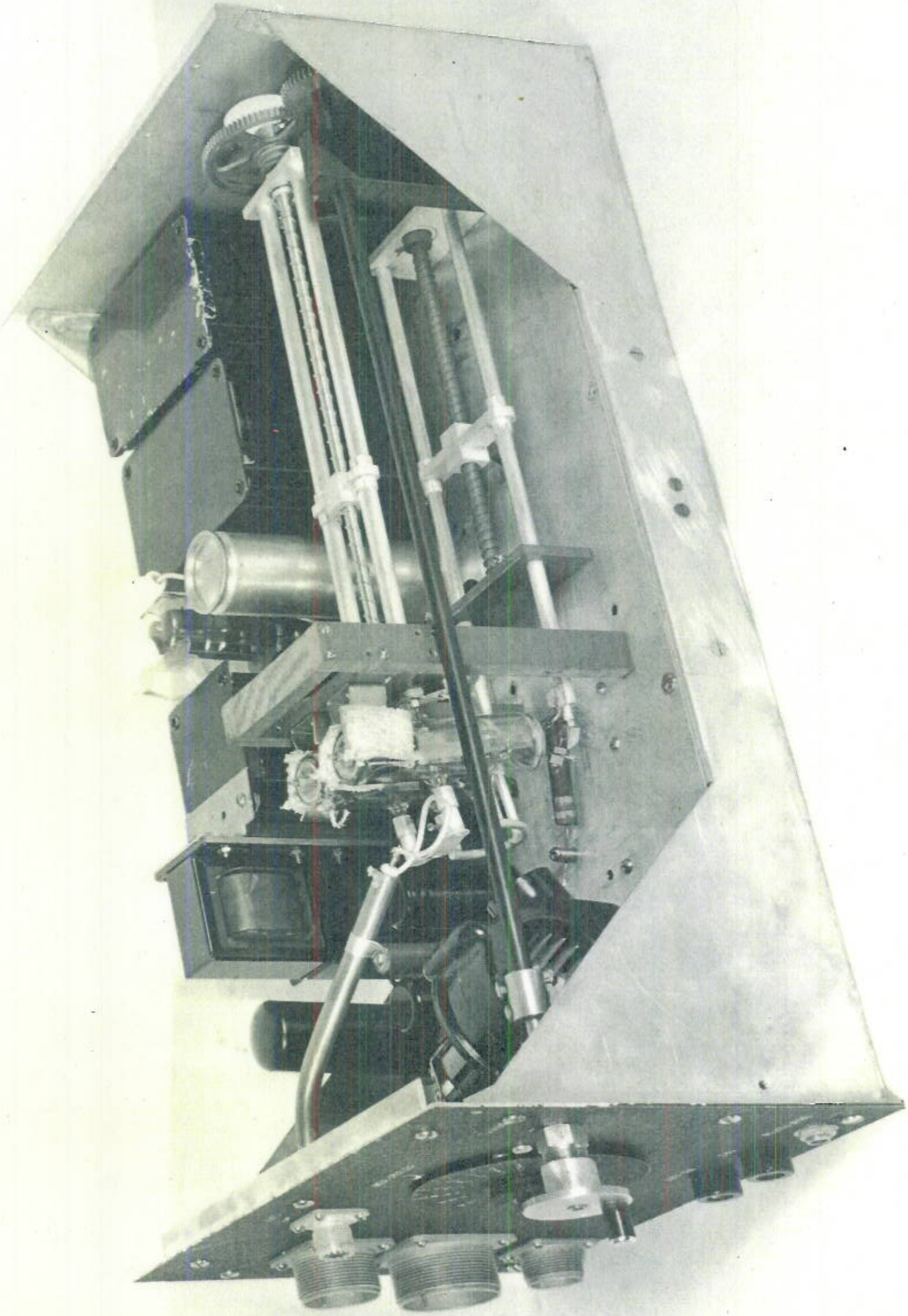
DECLASSIFIED



DECLASSIFIED

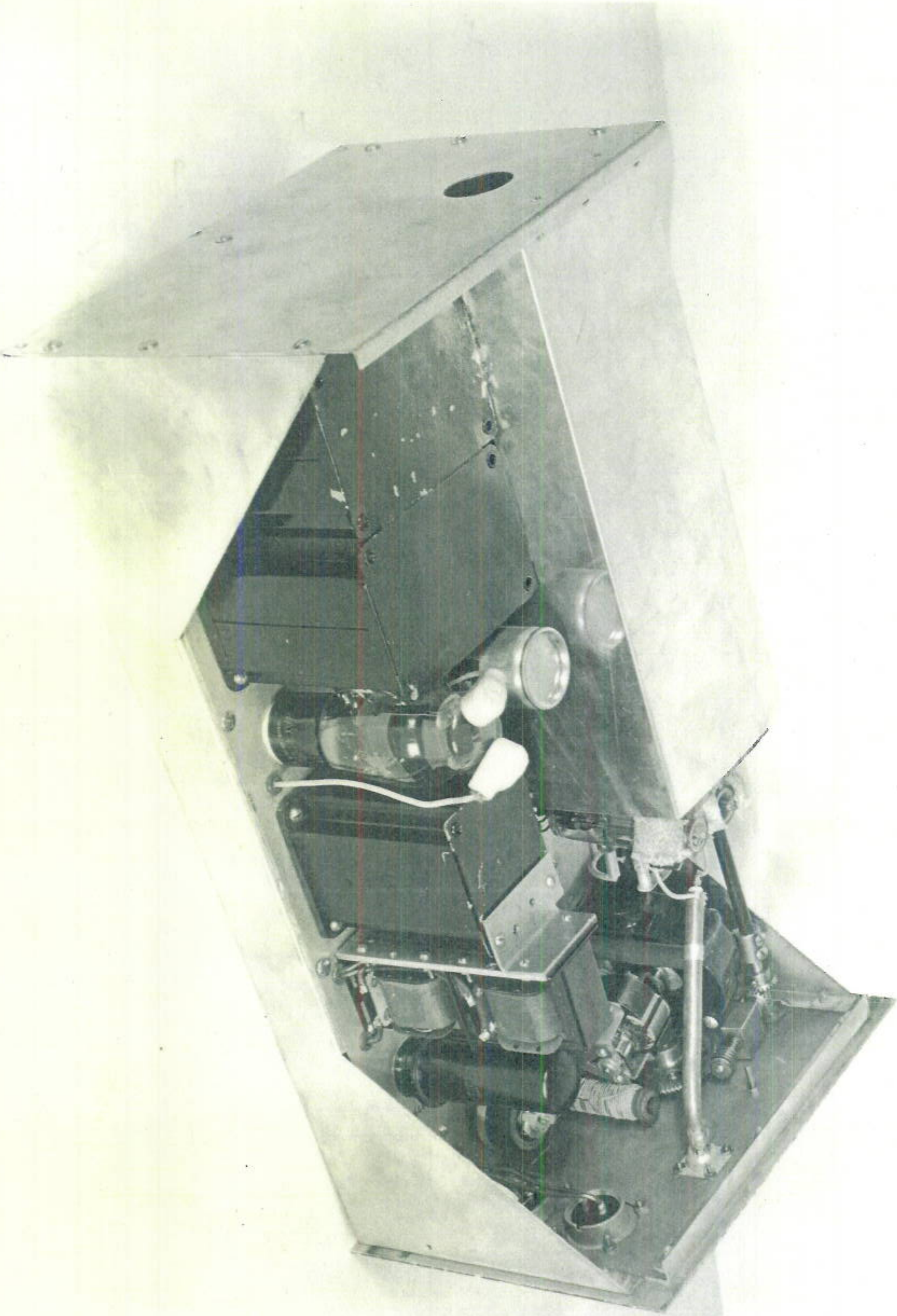
PLATE 6

DECLASSIFIED



DECLASSIFIED

DECLASSIFIED



DECLASSIFIED

PLATE 8

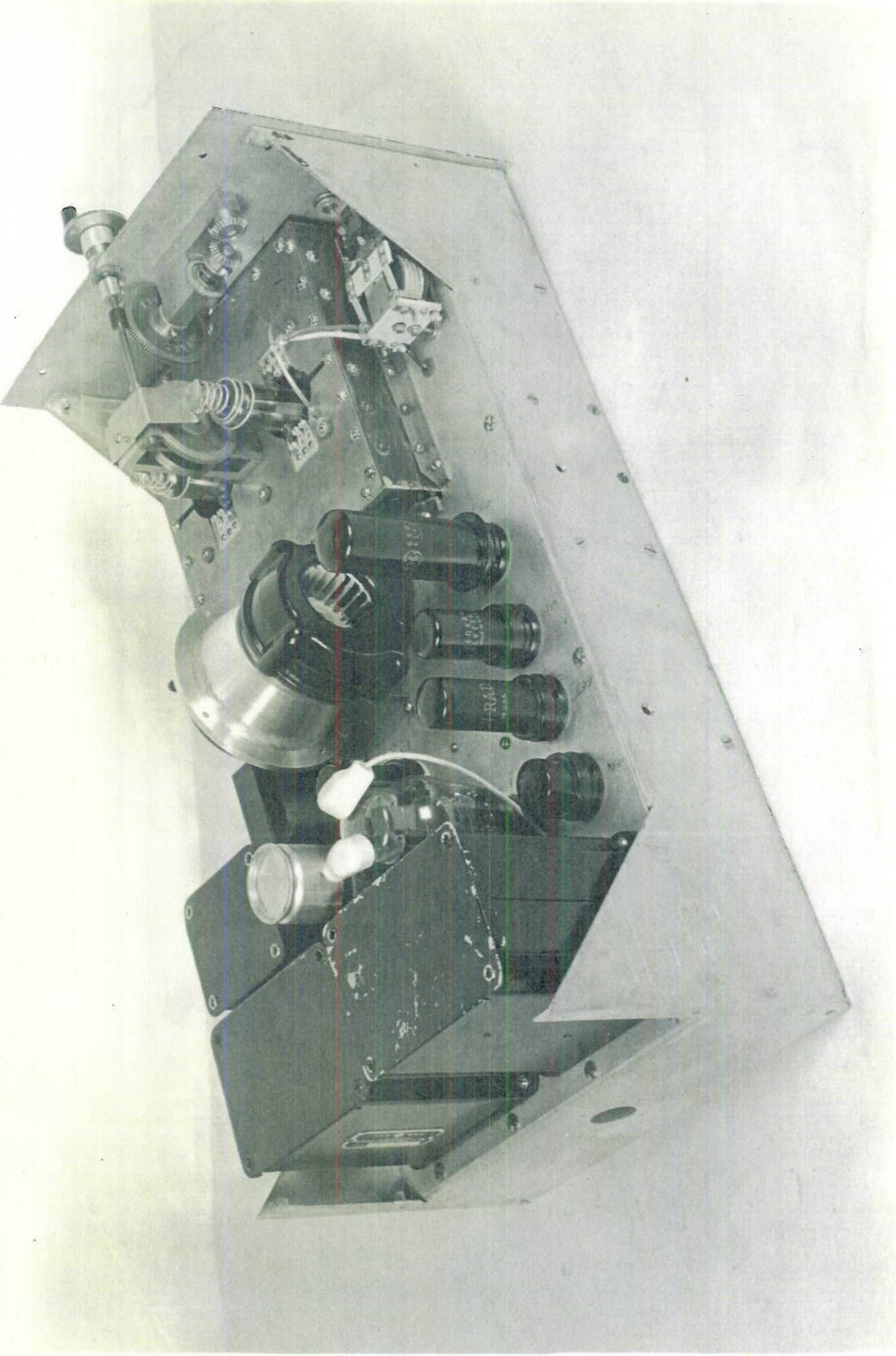
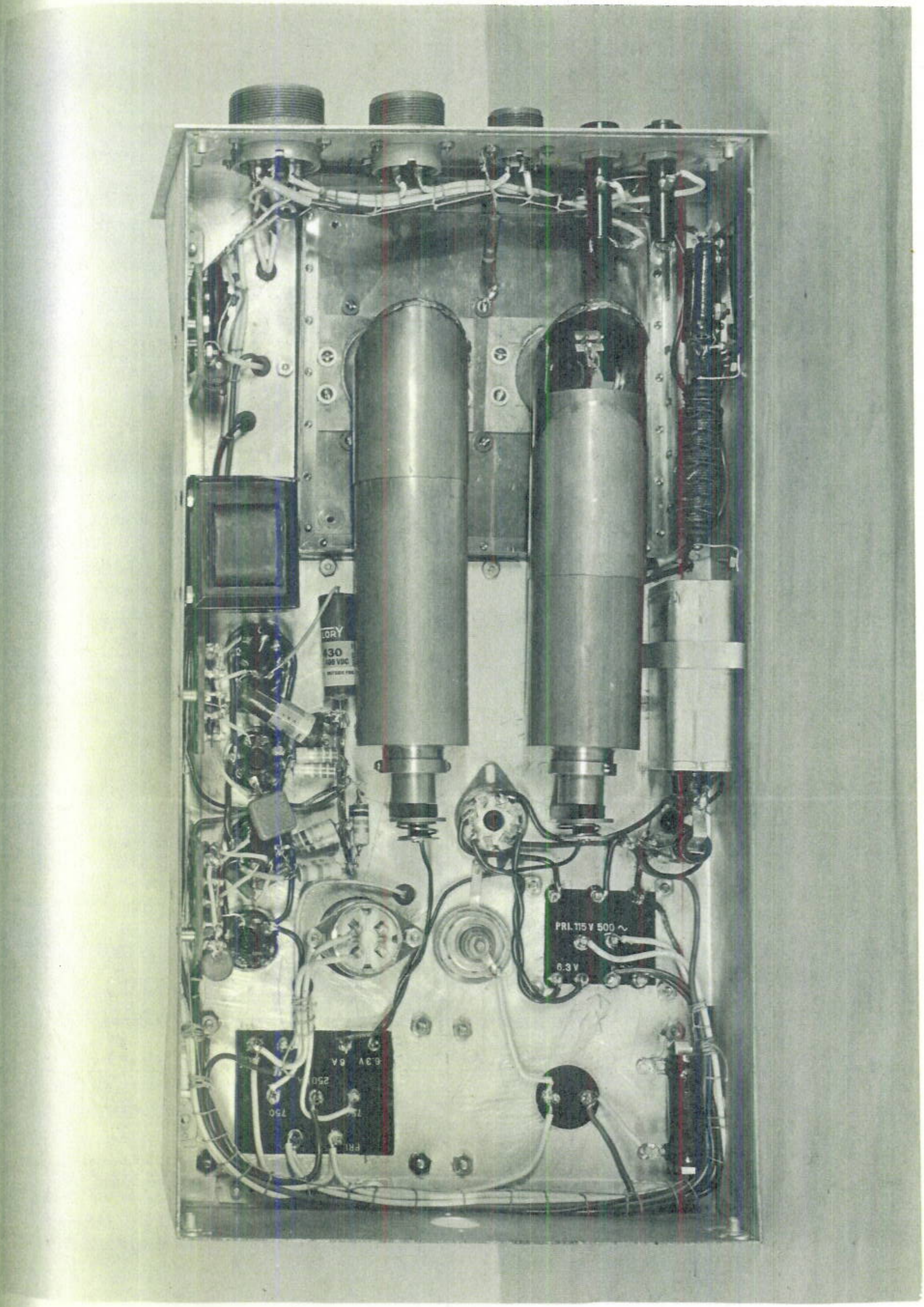


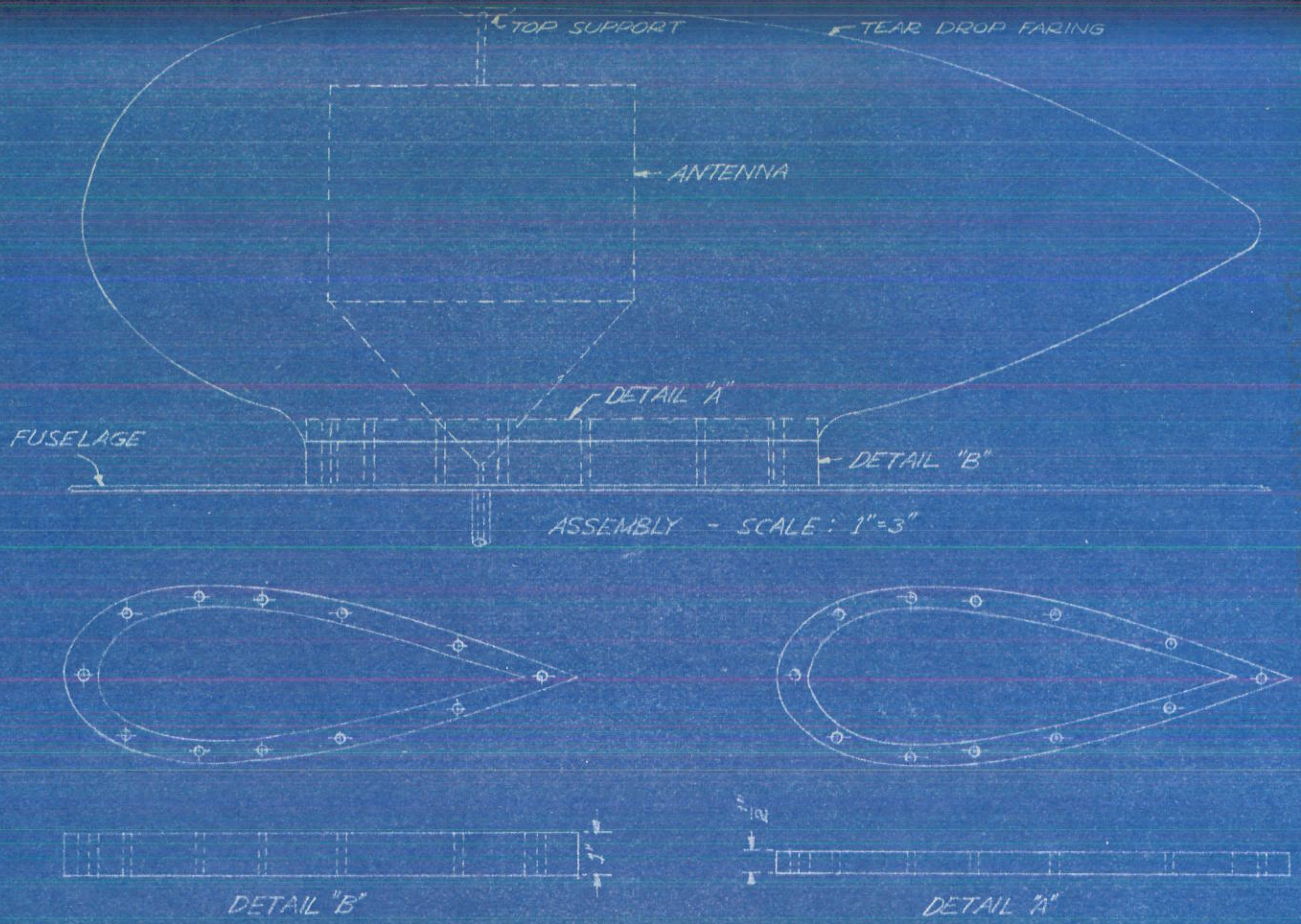
PLATE 9

DECLASSIFIED



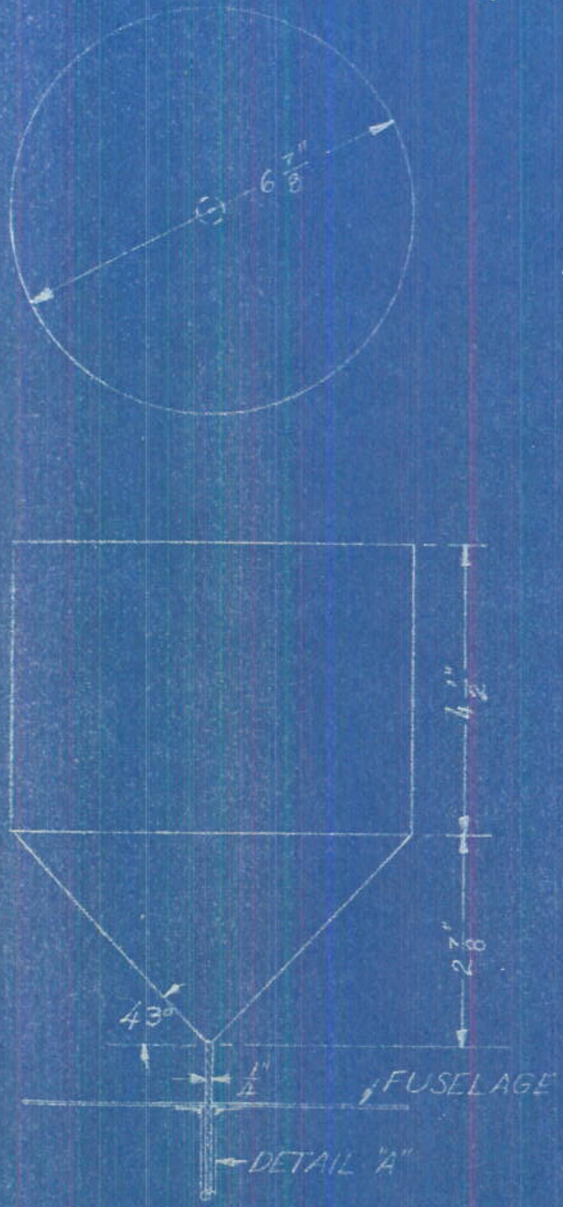
DECLASSIFIED

PLATE 10

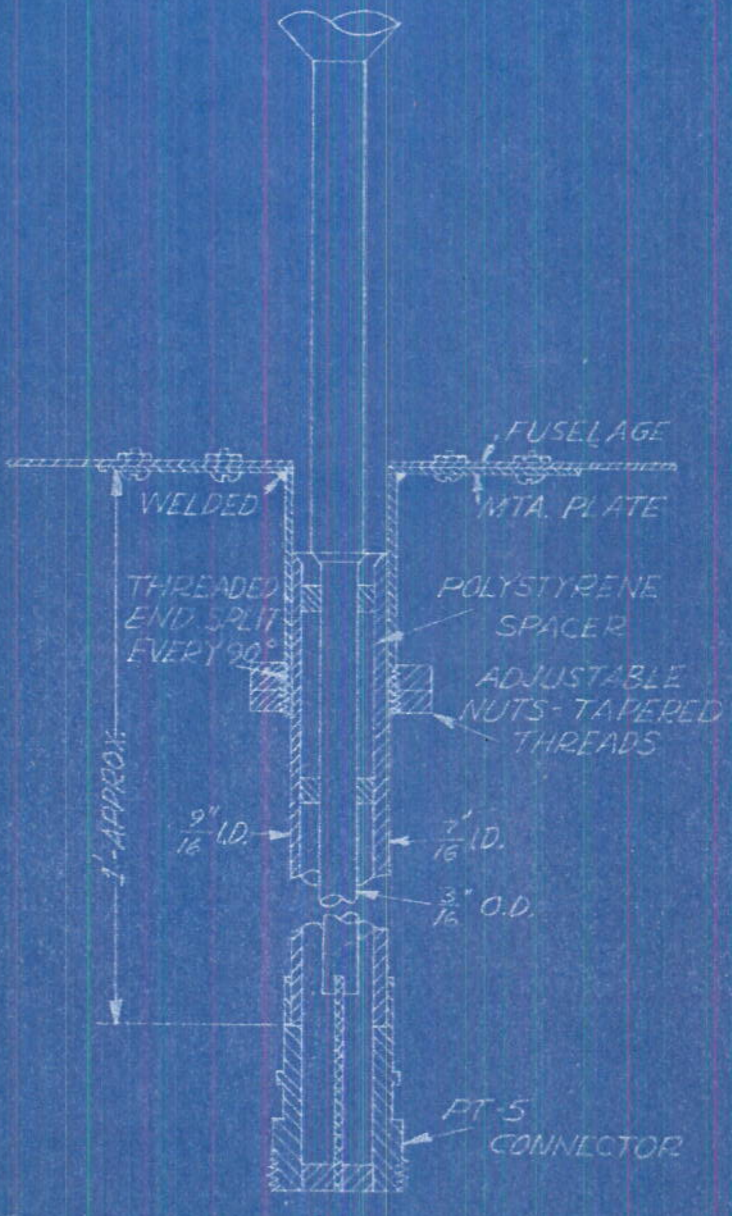


TYPE XBM TRANSMITTER WIDE BAND ANTENNA

PLATE 11



ANTENNA - SCALE: 1"=3"



DETAIL "A" - FULL SCALE

TYPE XBM TRANSMITTER WIDE BAND ANTENNA

PLATE 12