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ANALYSIS OF JAPANESE AIRBORNE

RADAR EQUIPMENT CAPTURED AT HOLLANDIA ON 22 APRIL 1944

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14 August 1944 NRL Report No. R-2347

NAVY DEPARTMENT

Report on

Analysis of Japanese Airborne Radar Equipment Captured at Hollandia on 22 April 1944

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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1 Office of the Air Communication Officer, Army Air Forces, Project Status Section, Room 5D176, Pentagon Building, Washington, D.C.
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4 Royal Air Force Delegation, Room 717, 1424 - 16th Street, N.W., Washington, D.C. Attn: Director of Signals (For transmission 1 copy to TRE, London; 3 copies to RCM Board, London.)
1 British Army Staff, Grafton Hotel, Room 528, 1139 Connecticut Avenue, N.W., Washington, D.C. Attn: Col. A.J. Fisher, for transmission to A.D.RDE
1 Joint Intelligence Committee, Canadian Joint Staff, 2222 S Street, N.W., Washington, D.C.

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1 NDRC, Division 15, 1 River Road, Schenectady, New York
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1 Navy Liaison Office, Radio Research Laboratory, Harvard University, Cambridge, Massachusetts

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AUTHORIZATION FOR TESTS

1. These tests were authorized by Bureau of Aeronautics letter, reference (a). Additional pertinent information is listed in reference (b). The Laboratory released advance information of these tests in references (c) and (d).

References:
- (a) BuAer ltr. to NRL, Aer-E-3143-MBP, EF37/F42-5, dated 9 June 1944.
- (b) Secret report to NRL from JEIA, "Captured Japanese Radar Equipment at Tanahmera Bay, Hollandia" - NRL file No. S-A9-8, Serial 007805.
- (c) NRL Confidential ltr., "Measurements on Japanese Radio Receiver Mark III No. IV, Serial No. 178", dated 17 June 1944. NRL file No. C-A6-1 - Serial 6-19-1 (S) to CINPAC.
- (d) NRL Confidential ltr. "Tentative Characteristics of Captured Japanese Radar", dated 29 June 1944 to CINPAC Conference.

ABSTRACT

2. A Japanese Radar receiver type 3, Mark VI Model 4 No. 178 and its associated indicator unit, captured at Tanahmera Bay, Hollandia, have been thoroughly investigated with respect to mechanical and electrical characteristics. Schematic circuit diagrams, circuit descriptions, performance data, curves and photographs are included herein.

3. As the equipment received does not constitute a complete Airborne Radar system this report covers the operational characteristics of the receiver and indicator only.

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CONCLUSIONS

4. a. The receiver and indicator units tested are undoubtedly part of a complete radar system.

b. The weight and size of these units indicate the possibility of their use in aircraft. Information contained in reference (b) substantiates this supposition; however, the construction of the receiver R.F. circuit is such as to give poor performance under the conditions of vibration encountered in aircraft.

c. These units might be used more effectively as a search radar for land or ship installations. Reference (b) states that similar units have been captured operating in this capacity.

d. The indicator is capable of giving both "A" type presentation (i.e., signals appear on only one side of a straight line trace) or "L" type presentation in which signals appear on both sides of the trace. When the indicator is used in conjunction with the receiver, the presentation is type "A". However, a minor wiring change within the indicator permits "L" type presentation of signals fed to a separate front panel connector.

e. The receiver tuning range shows the operating frequency to be approximately 150 mc/s.

f. The video bandwidth indicates that the pulse used is at least 10 microseconds in duration. Several similar equipments discussed in reference (b) use pulse lengths of 10 microseconds.

g. The indicator has a single range of 150 kilometers.

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RECOMMENDATIONS

5. It is recommended that a complete Japanese Radar system of this type, if and when obtained, be delivered to this Laboratory for a complete investigation of operational characteristics, and electrical and mechanical design in order that the Navy Department may be more thoroughly advised as to the exact nature of enemy equipment.

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MECHANICAL CHARACTERISTICS

6. a. Receiver

(1) The receiver and its case weigh 18.5 pounds. The case measures 6 3/8" x 9 7/8" x 18 3/4" and is divided into two parts. In the front part is the receiver proper, which measures 6 3/8" x 9 7/8" x 9 1/4". The rear part of the case is not used.

(2) The receiver proper is divided into two sections of equal volume. The R.F. circuits are located in the front section while the IF amplifier, detector, and video amplifier occupy the rear section. Each section is a complete unit in itself and can be removed from the box without disturbing the other section. Plates 1 and 2 show the top and bottom views of the receiver.

(3) Much hand work is used in the manufacture of the receiver. Its case is constructed by screwing aluminum covers to an angle-aluminum frame. Brass blocks, which are riveted to the angle aluminum frame, are tapped to hold the screws. The cross-sectional dimensions of the angle aluminum used in the frame are 3/8" x 3/8" x 1/16". The screws mentioned above are 3mm. in diameter and have 0.6 threads per mm.

(4) The following undesirable characteristics in mechanical construction were noted. All grid and plate connections to the type 954 tubes in the R.F. section are soldered directly to the tube pins. Detuning of the R.F. circuits would occur under vibration because of the non-rigid R.F. coil construction. The two R.F. trimmers on the right hand side of the receiver, as shown on Plate 6, turn freely and will not maintain their settings under vibration. The doubler-buffer tube must be removed before the oscillator tube can be removed.

(5) Six tuning controls, a gain control, and a voltmeter are mounted on the front panel of the receiver. The antenna connectors, the antenna trimmers, the power input connector, and the video output terminals are located on the right hand side of the receiver. A view of the front and right hand side of the receiver can be seen in Plate 6. The receiver name plate is fastened to the top cover of the receiver and its translation, as given in reference (b), is shown below.

Type 3 Air Mark VI Wireless Set
Model 4
Receiver No. 178
Manufactured December 1943
Weight 8.4 KG
Navy Air Technical Depot

b. Indicator

(1) The indicator unit is constructed on an aluminum chassis which measures 3 3/4" x 8 1/2" x 18", and is housed in an aluminum case whose dimensions are 10" x 10 1/4" x 18 1/2". The weight of the indicator

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with its case is 48 pounds. The top and bottom covers of the case are held in position by captive type fasteners and may be removed to provide access to the tubes and wiring. Top and bottom views of the indicator chassis are shown by Plates 4 and 5.

(2) The construction of the unit is not suitable for the conditions of vibration encountered in aircraft for several reasons: resistors are mounted perpendicular to the chassis by a bolt running longitudinally through the resistors and supported at only one end; no lock washers are used in the unit; and no friction locks are used on the internal calibration potentiometers.

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ELECTRICAL CHARACTERISTICS

7. a. Power Requirements

(1) The power for the receiver and indicator units is obtained from an external source, probably a separate power supply unit. No unit of this type was received with this equipment and reference (b) indicates that only the receiver and indicator units were captured.

(2) Tests on the receiver and indicator show that the power required is as listed below.

(a) 12 volts d.c. at 2.5 amperes for filaments.

(b) 500 volts d.c. at 80 ma. for "B" supply.

(c) 110 volts, 60 cps at 0.5 amperes for indicator high-voltage rectifier circuit.

This power reaches the subject units through a connector on the front panel of the indicator. The power for the receiver is obtained through a cable from a second connector on the indicator front panel. The 500 volt input is stabilized at 300 volts in the indicator by a German type STV280/40 cold cathode regulator tube. The indicator circuit and regulator tube require 30 ma. of the input "B" current and the remaining 50 ma. is consumed by the receiver.

(3) The filaments of the receiver tubes are fed directly from the 12 volt supply, while those for the indicator sweep tubes are supplied through a ballast lamp from the 12 volt input. The 2,800 volt cathode voltage for the cathode ray tube is obtained through a transformer and rectifier from the 110 volt 60 cps input using a type DC 762A tube for the high voltage rectifier. This tube is similar to, and may be replaced by, an American type 2X2 rectifier.

b. Receiver Description

(1) Figure 8 shows the receiver schematic diagram. The tube line up is as follows: two 954 R.F. amplifiers; a 955 oscillator; a 954 doubler-buffer; a 954 mixer; and four IF amplifiers, a diode detector, and a video amplifier employing a Japanese tube (shown on Plate 3) which has the same connections and mutual conductance as the American 12J7G type tube.

(2) There are six R.F. tuning adjustments plus two antenna trimmers for the balanced input antenna coil. The tuning adjustments on the front panel (see Plate 6 and Figure 8) are as follows;

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Top left	Second R.F. grid tuning
Top center	First R.F. grid tuning
Top right	Antenna primary tuning
Bottom left	Mixer grid tuning
Bottom center	Doubler-Buffer plate tuning
Bottom right	Oscillator tuning

The electrical characteristics of the receiver are as follows:

(a)	Filament supply voltage	12 volts
(b)	Plate supply voltage	300 volts d.c.
(c)	Plate supply current	50 ma. d.c.
(d)	Maximum tuning range (see Figures 1 and 2)	135 to 171 Mc/s
(e)	Tuning range within 6 db of maximum sensitivity	146 to 163 Mc/s
(f)	Signal equivalent to noise at 150 Mc/s (measured from 1st R.F. grid)	3.8 microvolts
(g)	Image rejection over band (The image frequency is 20 Mc/s below the signal frequency)	See Figure 2
(h)	Overload characteristics	See Figure 4
(i)	Video bandwidth at 3 db points (Figure 5)	50 Kc/s
(j)	IF bandwidth at 3 db points (Figure 6)	400 Kc/s
(k)	Overall bandwidth at 3 db points (not including video)	350 Kc/s
(l)	Overall pulse response: Time required for pulse to reach 90% of maximum amplitude	12 microseconds
	Time required for pulse to reach 95% of maximum amplitude	20 microseconds

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(m)	R.F. Gain	22.5 db.
(n)	IF Gain	76.5 db.
(o)	Video Gain	41.4 db.
(p)	Overall Gain	140.4 db.
(q)	Range of Gain Control	See Figure 7
(r)	IF Frequency	10 Mc/s
(s)	Minimum probable pulse width	10 microseconds

(2) Signal equivalent to noise and RF gain were measured from the first R.F. grid. Some signal gain can be expected from the antenna or antennas, but since these were not received and their characteristics are not known, no allowance can be made for the antennas.

(3) The bandwidth up to the video amplifier is very large in comparison with the narrow video bandwidth. Therefore, the video amplifier bandwidth limits the pulse to a comparatively wide pulse. Probably the R.F. and IF circuits are comparatively broad in order to compensate for frequency instability in the system.

c. <u>Indicator</u>

(1) The indicator uses a 4 inch electrostatic cathode-ray tube, Japanese type SSE120G, which has the deflection plate terminals and second anode connection brought out to side caps on the neck of the tube. The deflection sensitivity of this tube is 85 volts per inch. The tubes used in the sweep circuits are American type 76 tubes.

(2) A schematic circuit diagram is shown in Figure 9 and reference is made to this Figure in the following circuit description. A saw tooth wave is generated by V2 in a free running blocking oscillator circuit. A large part of this signal is capacity coupled to one horizontal deflection plate. The remainder is fed through the transformer T2 to V3 where it is inverted, amplified, and applied to the other horizontal deflection plate. The sweep is synchronized by a negative pulse fed to the grid of V1 and injected into the oscillator circuit through T1. The phase shifting network across the secondary winding of T1 allows the start of the sweep to be varied slightly in time with respect to the synchronizing pulse, thus assuring that the sweep will start at the instant the synchronizing pulse reaches the cathode ray tube. It is assumed that the synchronizing pulse will be coincident with the transmitter pulse.

(3) The video signal may be applied to the vertical deflection plates in two ways: either directly from the receiver through the binding posts on the side of the case, (see Plate 6) one of which is grounded, or through a connector on the front panel which

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allows both plates to be above ground and provides for vertical centering. An internal wiring change is required to change from one input to the other suggesting that the unit is made to be part of either of two different systems.

(4) The front panel controls are as follows:

Top left	Horizontal centering
Top right	Vertical centering
Left center	Phase Shifting control
Right center	Sweep amplitude
Bottom left	CRT focus
Bottom right	CRT brilliance
Bottom center	Input AC voltage

(5) The following two controls are located on the sides of the chassis:

Left side - Calibration control, in cathode circuit of V2

Right side - Calibration control, in cathode circuit of V3

(6) The face of the cathode ray tube is marked with a 0-150 km. scale. This corresponds to a time of 1,000 microseconds, and since the sweep is continuous this demands a sweep frequency of 1,000 cps. The blocking oscillator should therefore be adjusted by means of the potentiometer in the cathode circuit of V2 to run free at a sweep frequency of about 800 cps. It can then be synchronized by externally supplied negative pulses which have a recurrence frequency of from 800 to 1200 cps. With the required recurrence rate of 1,000 cps. the phasing control works effectively. The sweep is slightly exponential and the scale on the cathode ray tube correlates well with the sweep.

(7) The indicator unit was inoperative upon arrival at this laboratory and several repairs had to be made. The most significant repair was made on the variable auto-transformer, T3. This variable auto-transformer was originally connected as shown in Figure 10B. It was changed to the connection shown in Figure 9 and Figure 10A. Two resistors, R19 and R34, were found to be open and were replaced. Also, the rectifier filament winding of T5 had an internal short circuit which was repaired prior to testing the unit.

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8. A more complete analysis of this type of Japanese Radar Equipment should be made when the presently missing units of the complete system are obtained and made available to the Laboratory for characteristic tests. The following units would probably complete this radar system:

(a) Power Rectifier (Supply) unit.

(b) Transmitter unit.

(c) Duplexer unit.

(d) Antenna and video switching unit (if any is used for the "L" scan)

(e) Antenna or antennas.

(f) Control boxes, cables, test equipment, etc.

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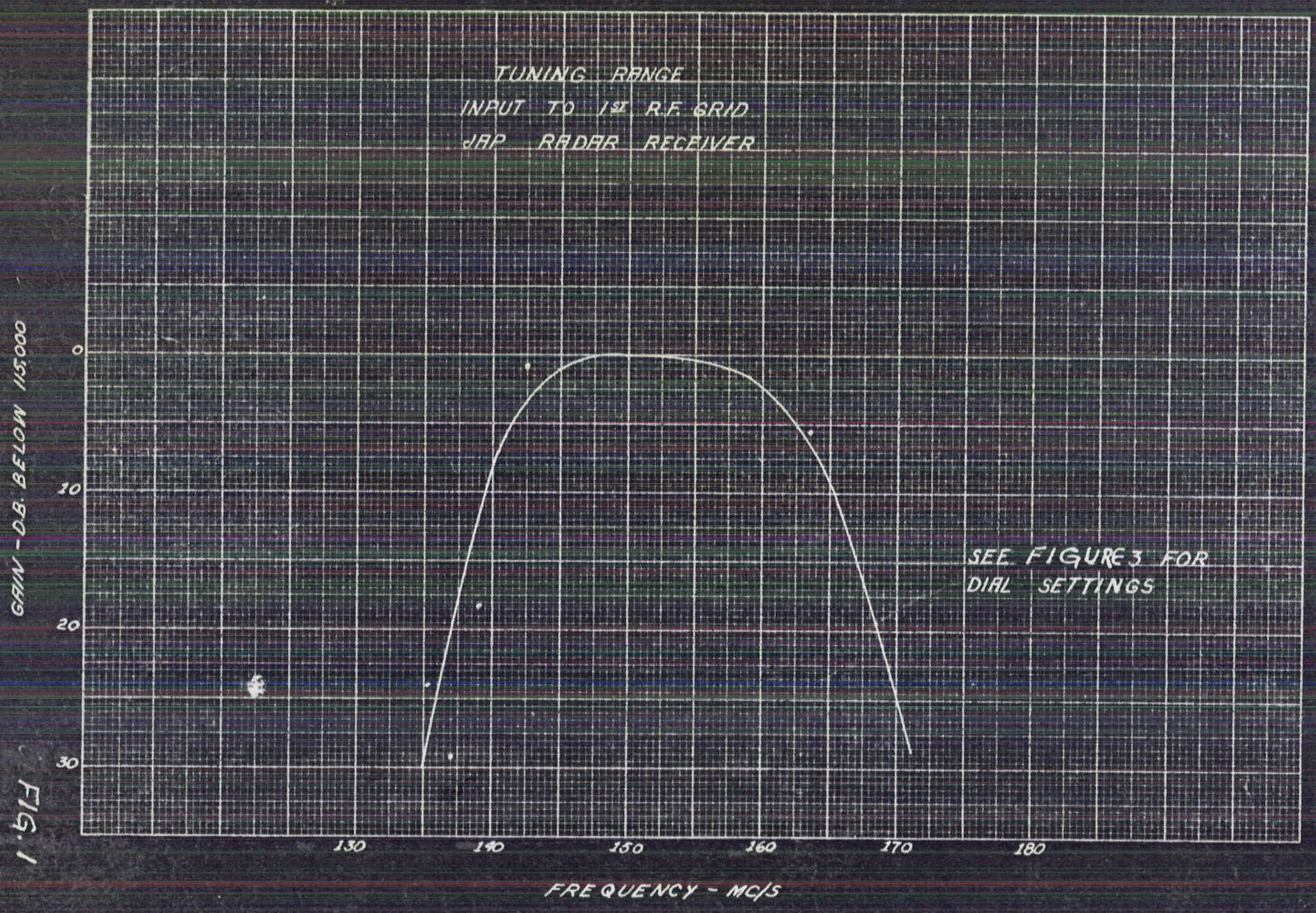

FIG. 1

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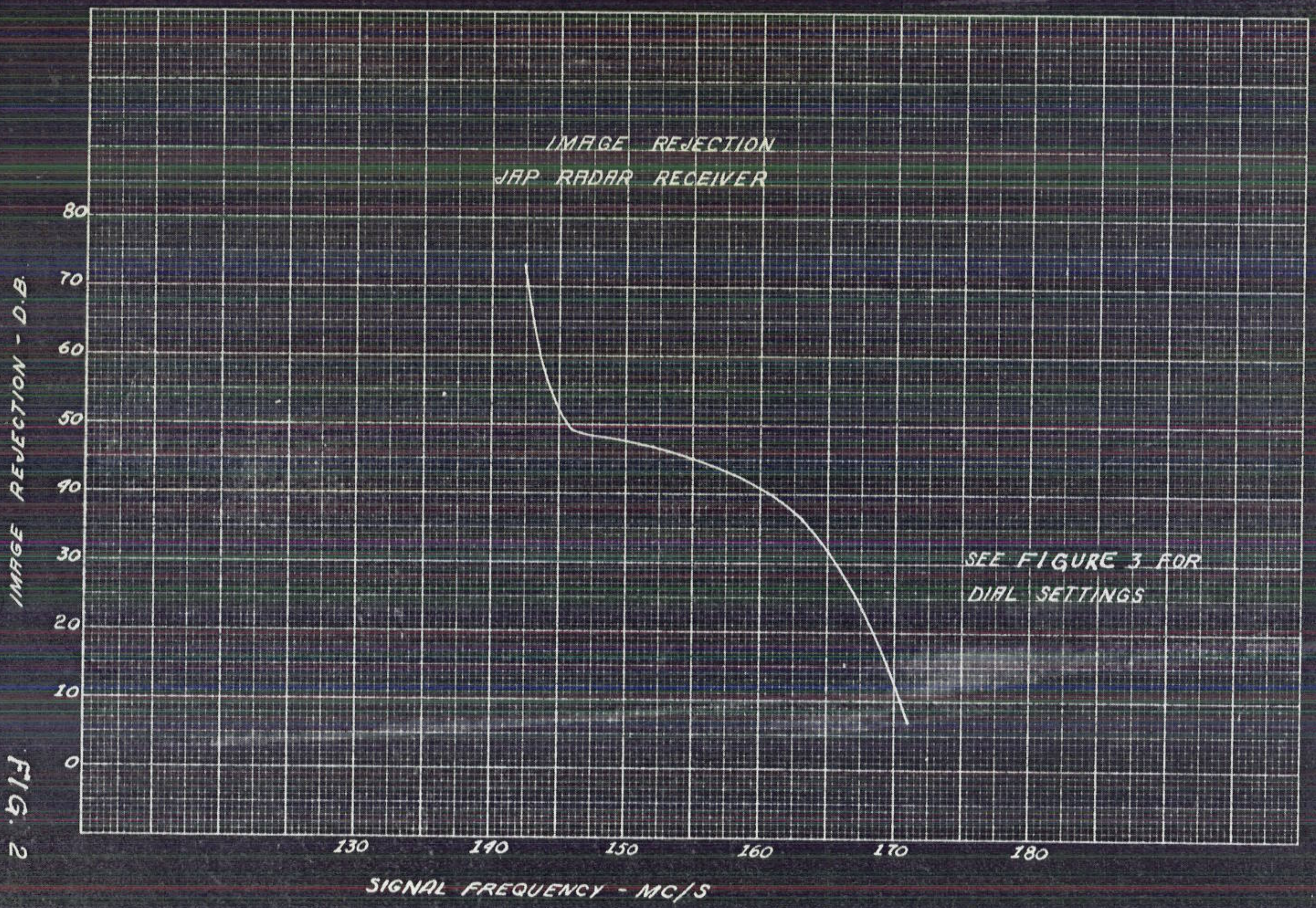

FIG. 2

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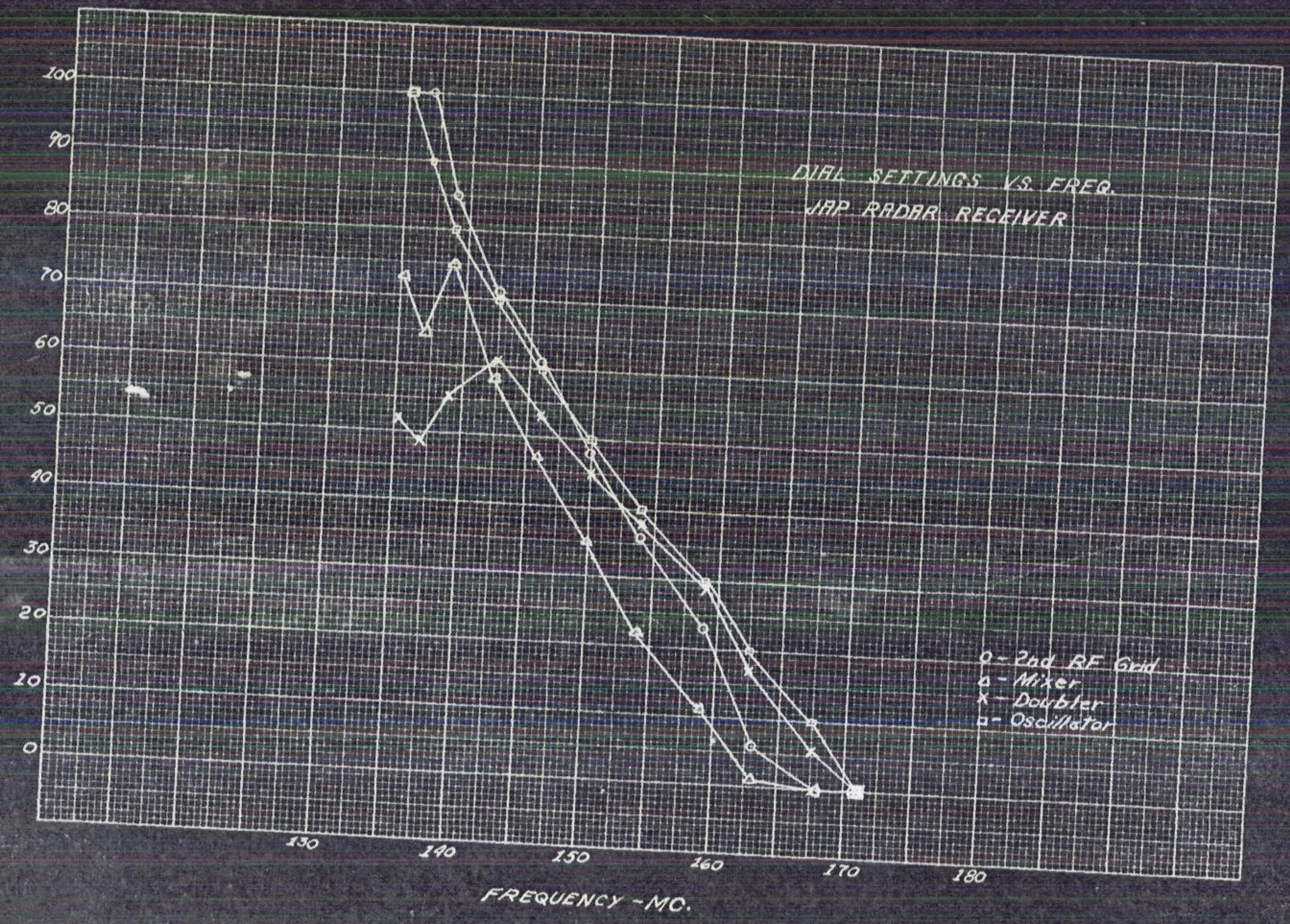

FIG. 3

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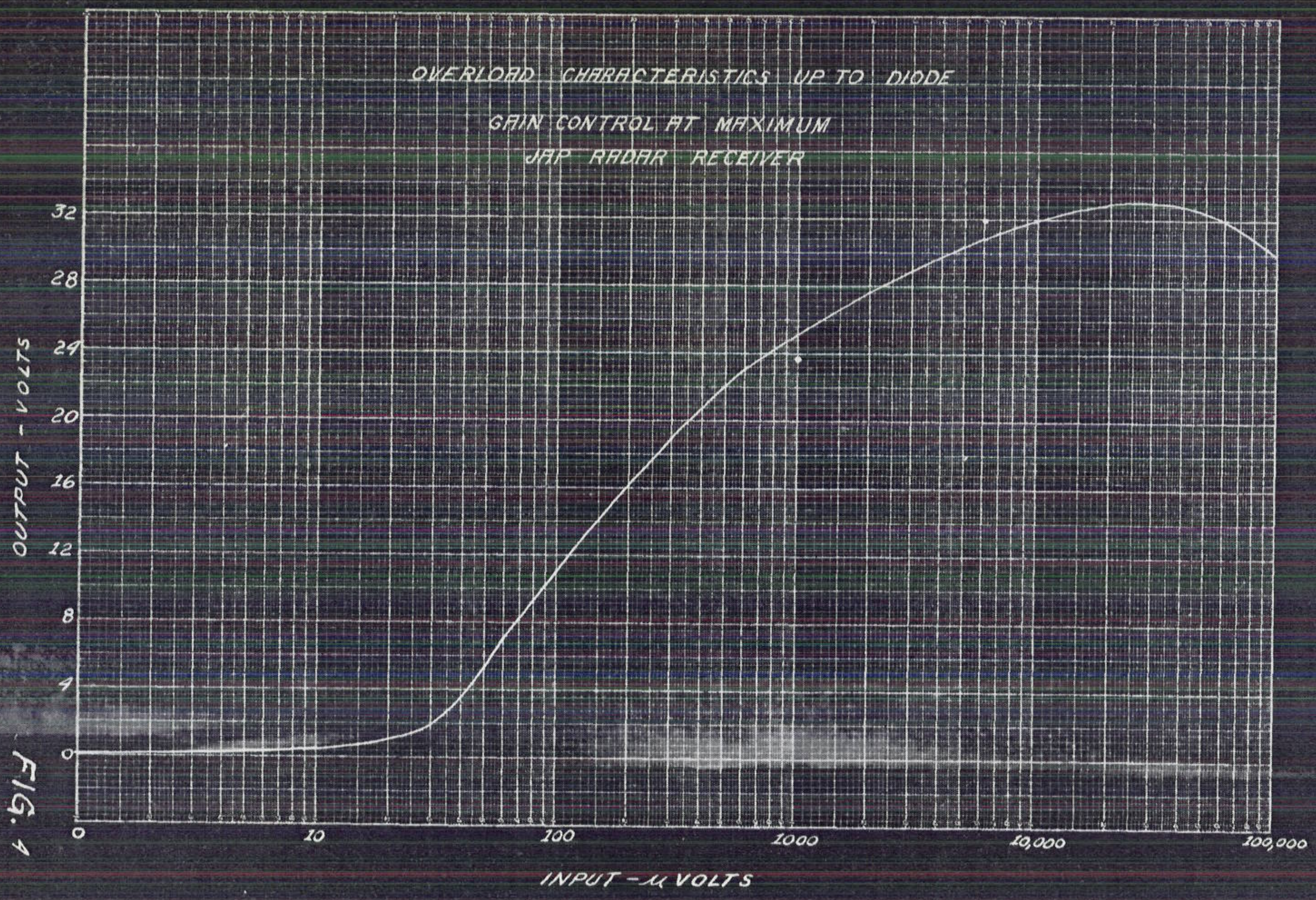

FIG. 4

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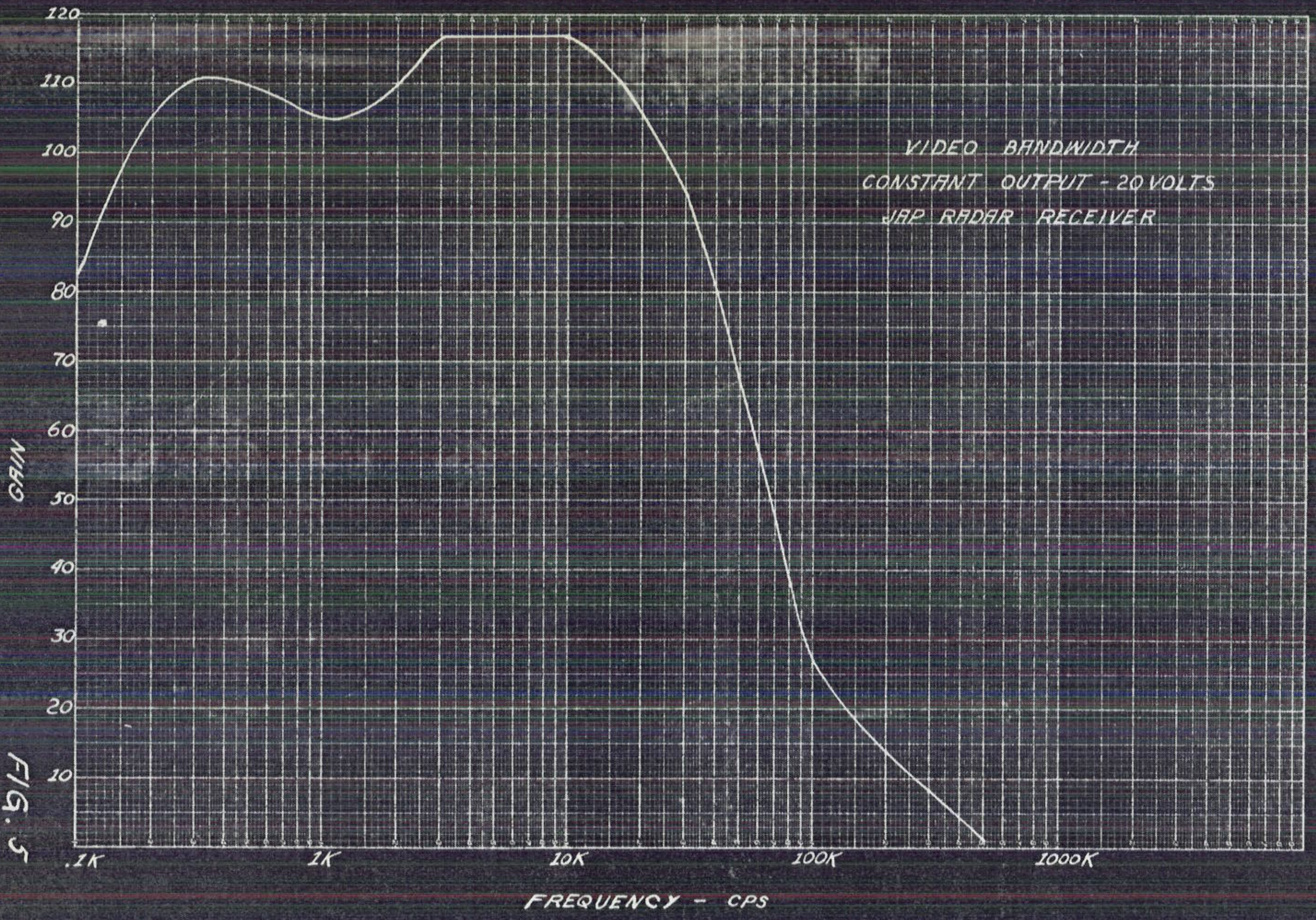

FIG. 5

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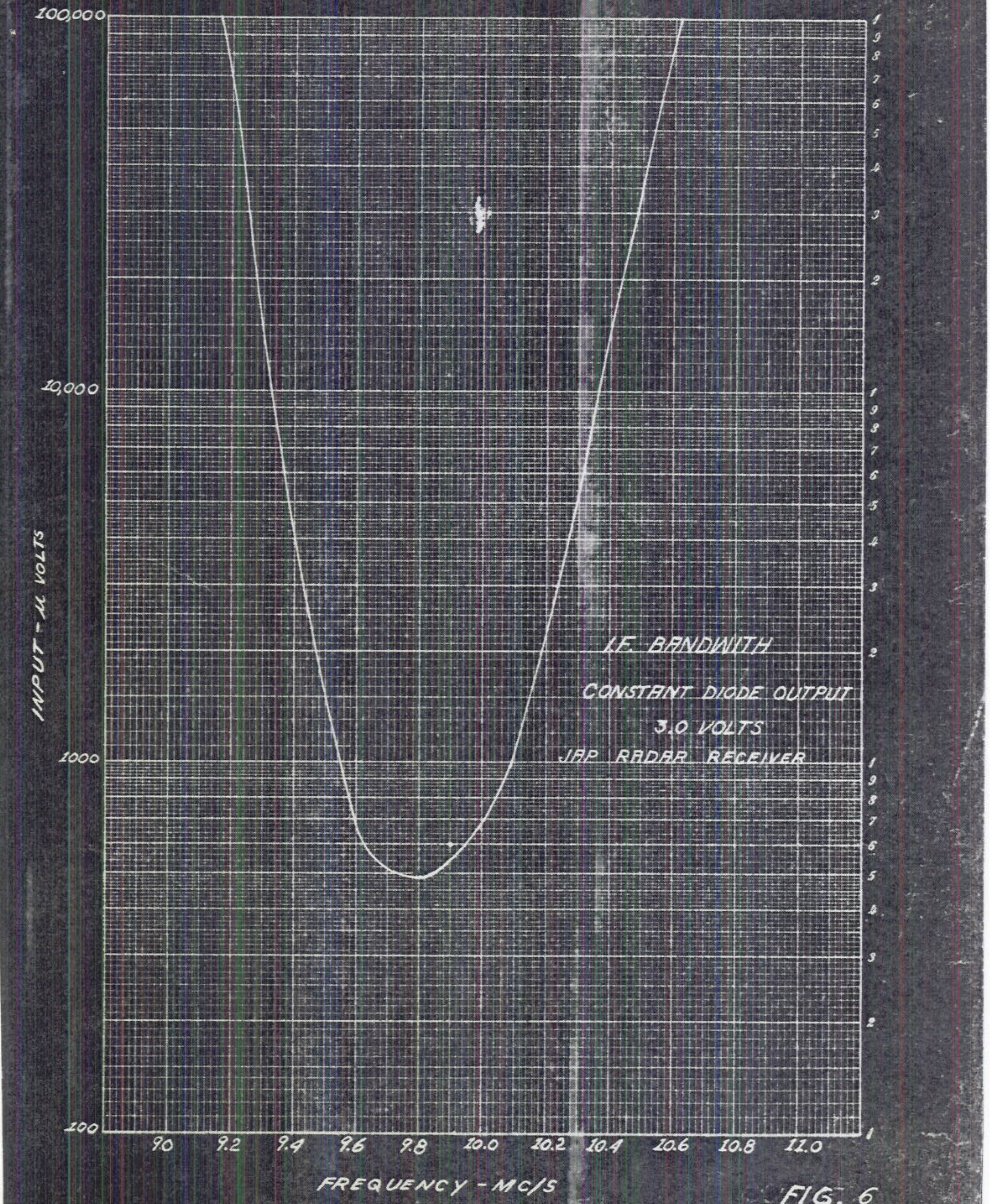

FIG. 6

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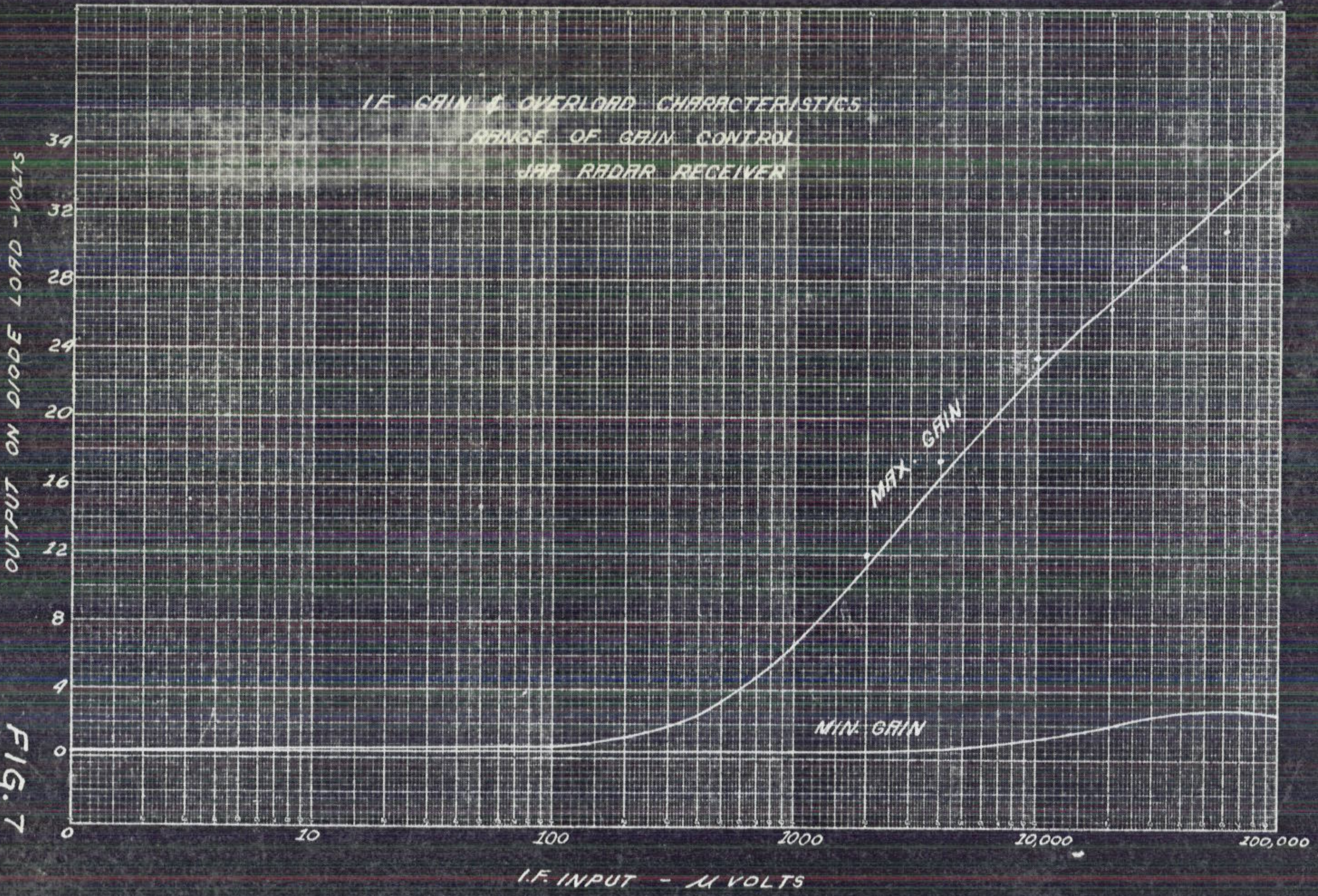

FIG. 7

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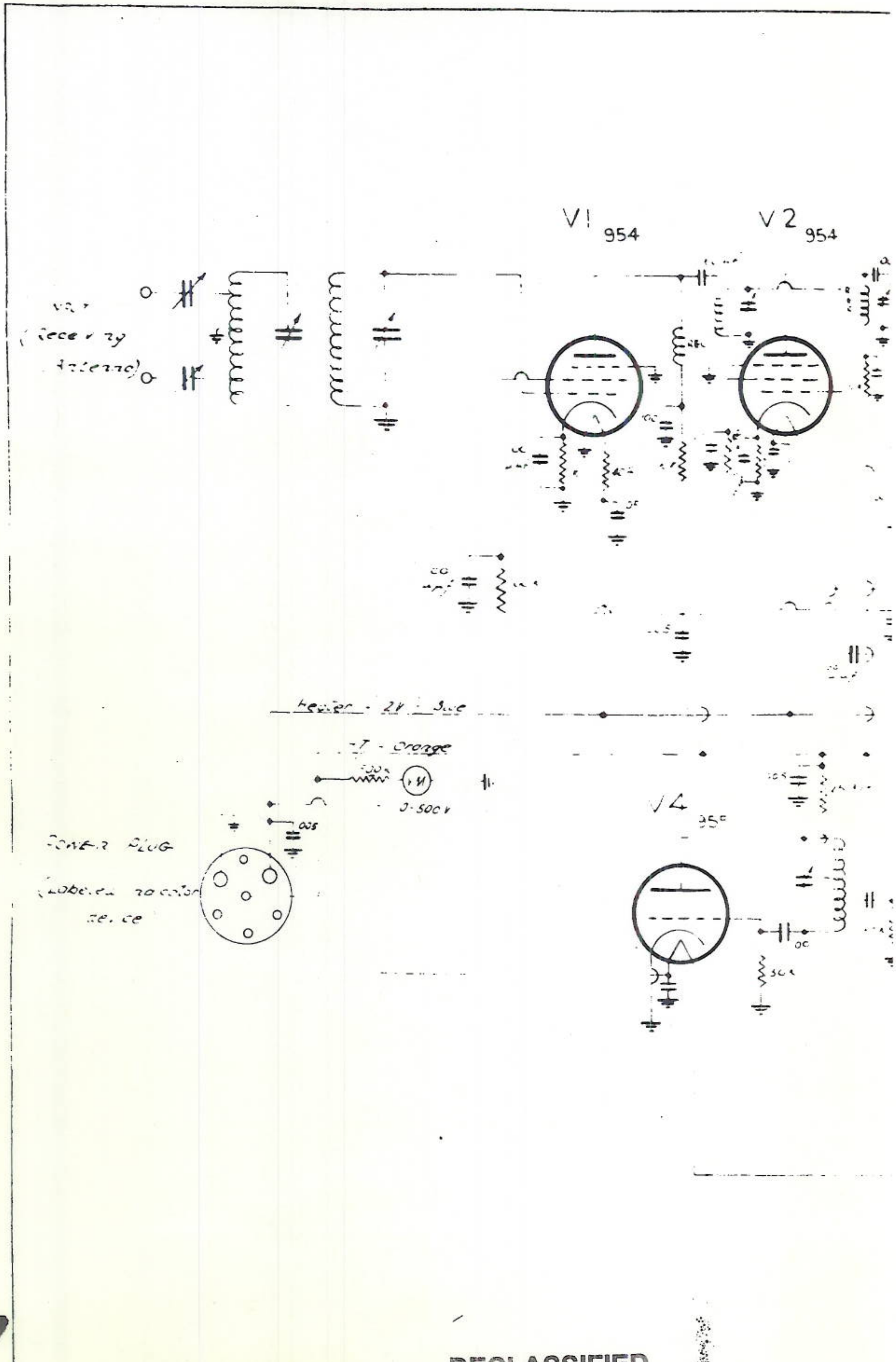

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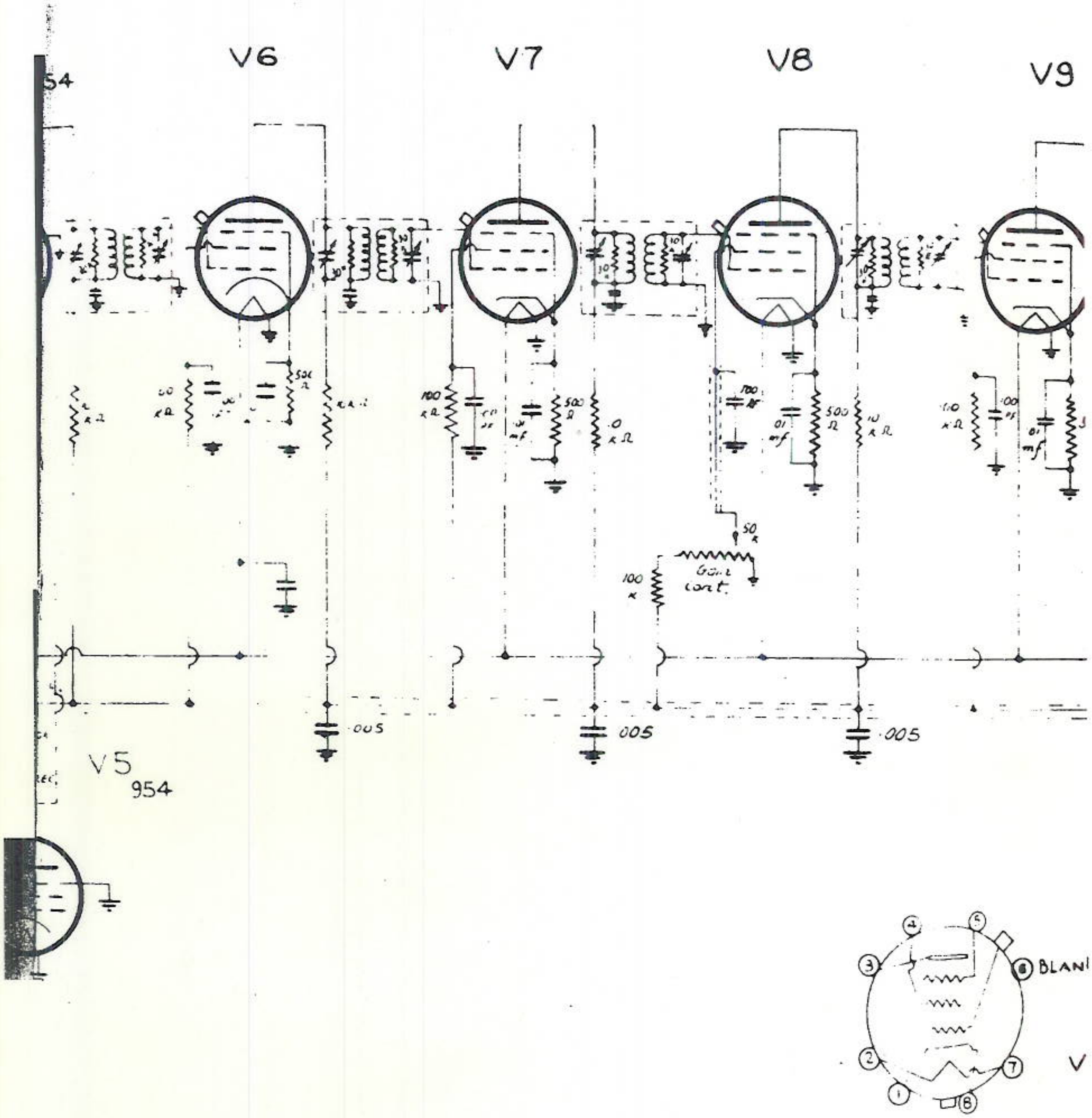

JAPANESE RADAR RECEIVER

TYPE 3 - AIR

№6 WIRELESS SET

MARK IV

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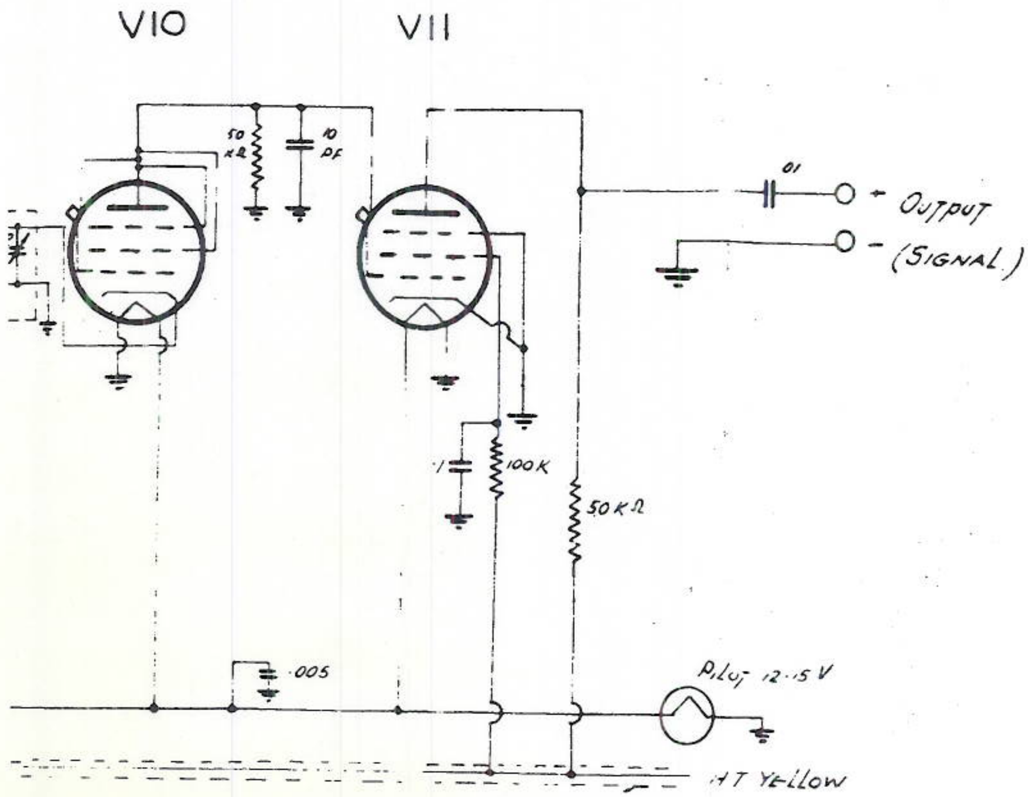
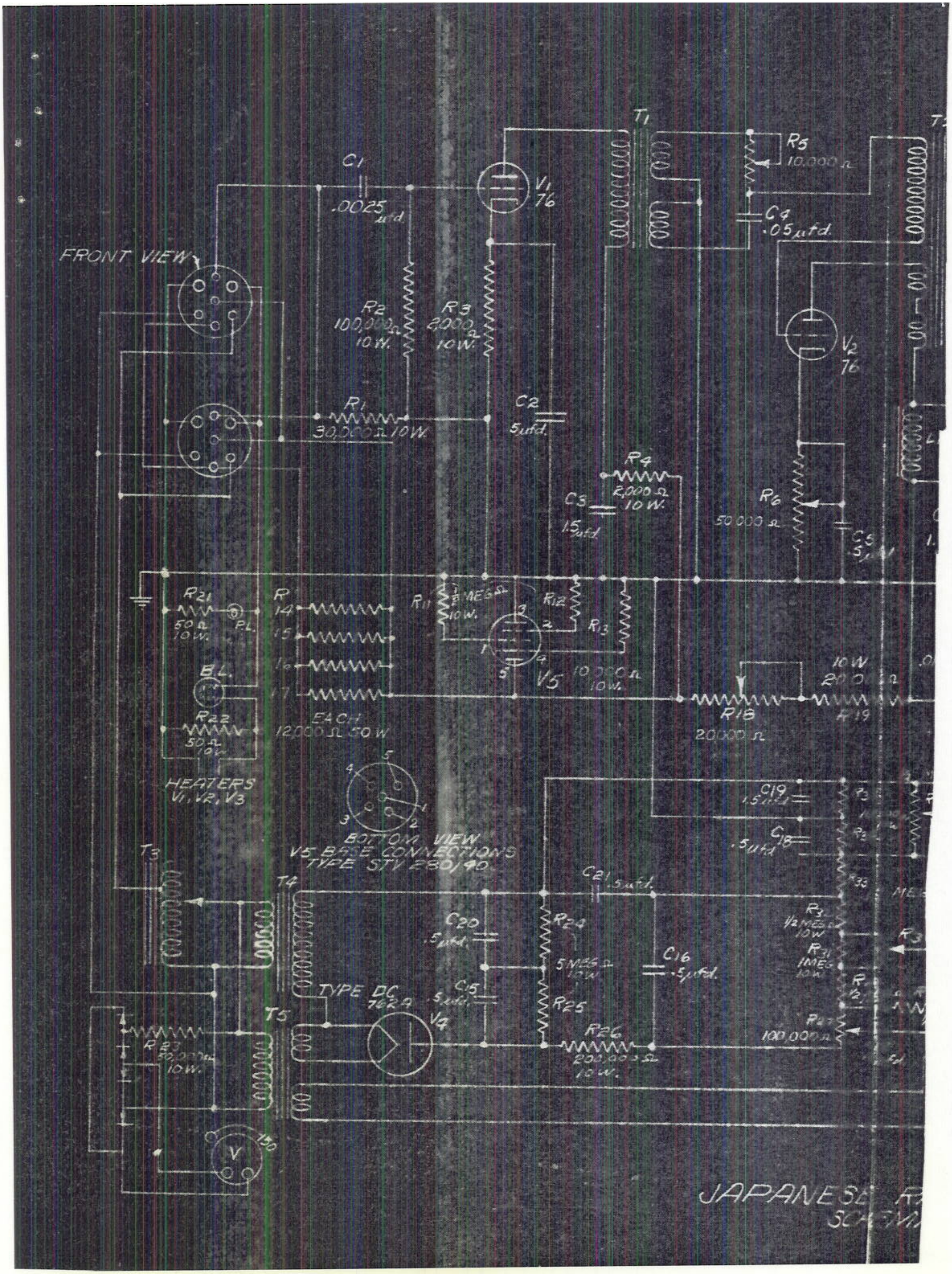

V10
V11
50 KΩ
10 PF
.01
+ OUTPUT
- (SIGNAL)
.1
100K
50KΩ
.005
Pilot 12.5V
HT YELLOW

INCL.

FIG. 8



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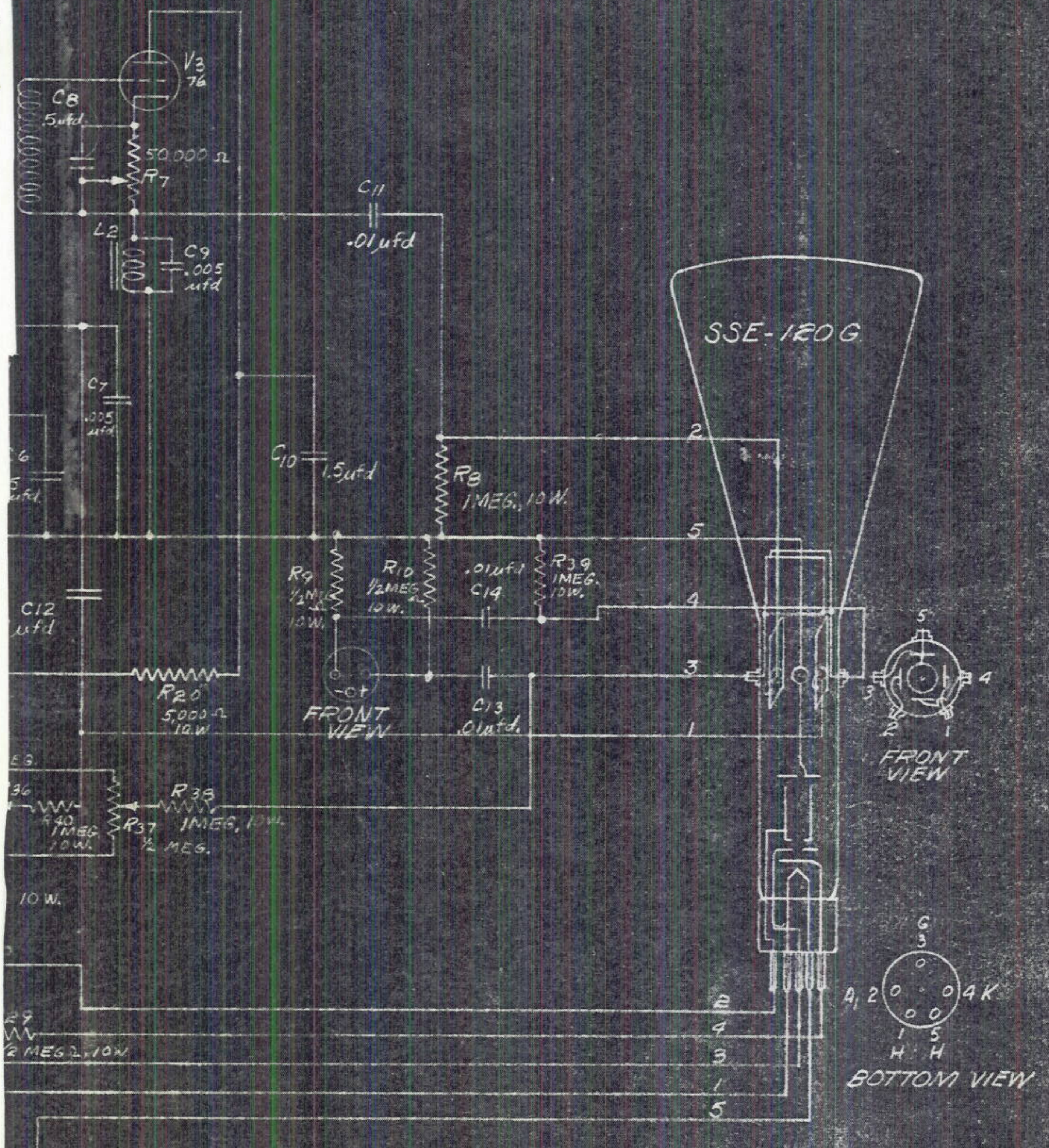

ADAR INDICATOR
ATIC DIAGRAM

FIG. 9

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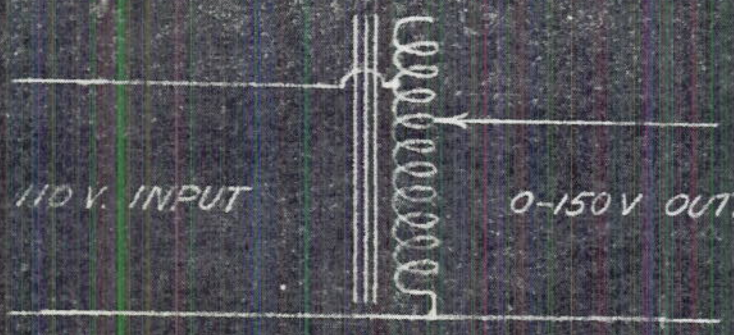
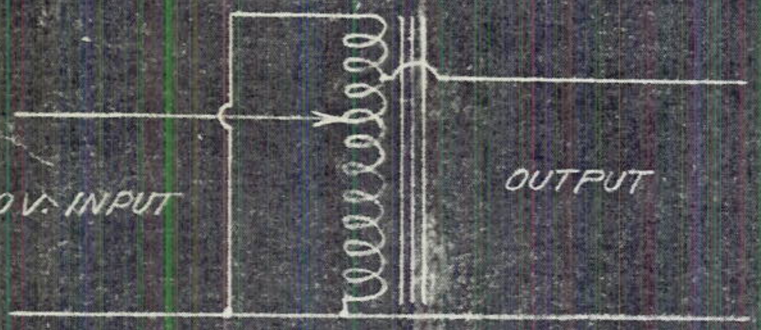
REPAIR OF AUTO-TRANSFORMER



A. Correct Connection



B. Connection as Received

FIG. 10

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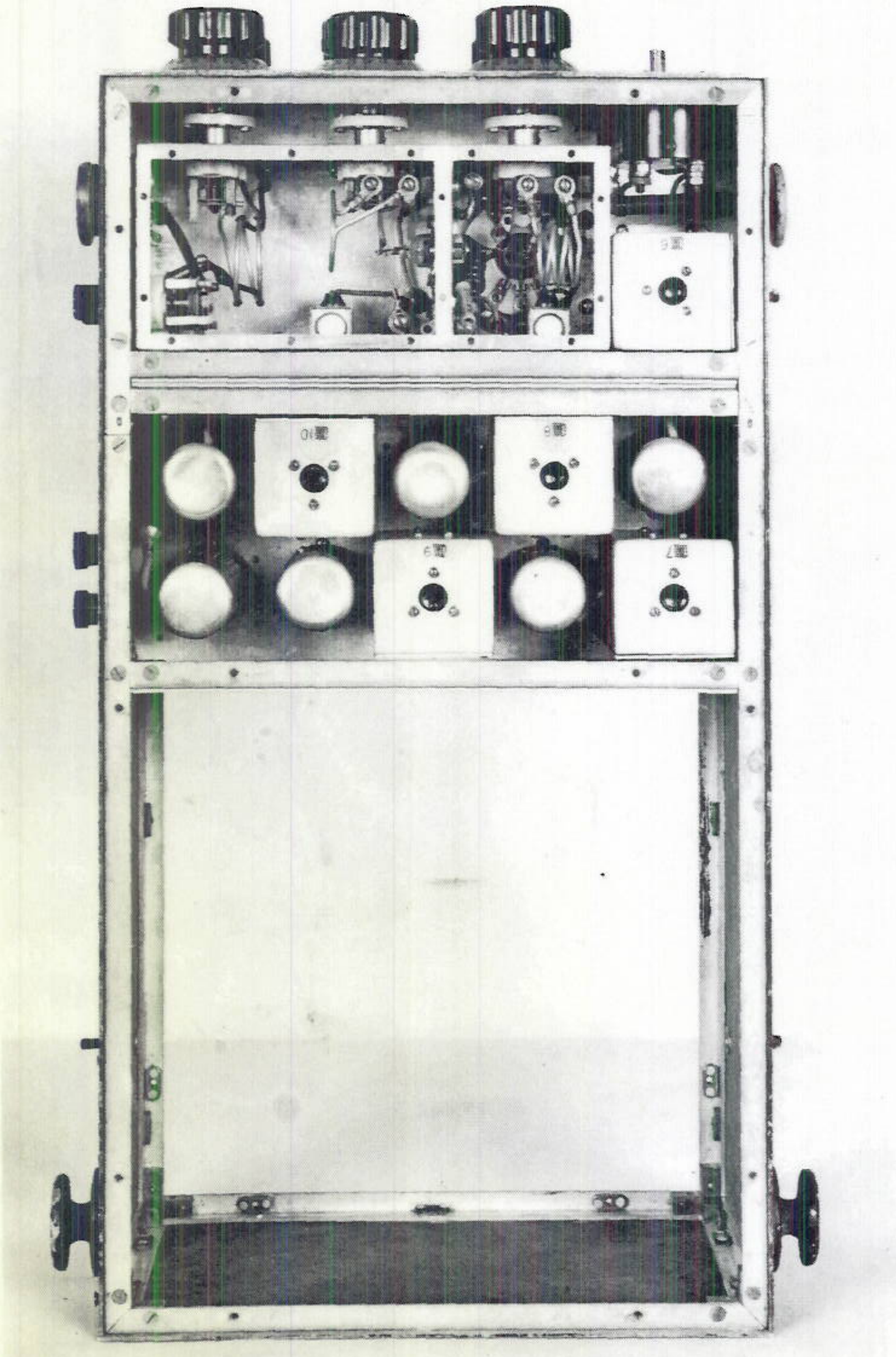

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PLATE I

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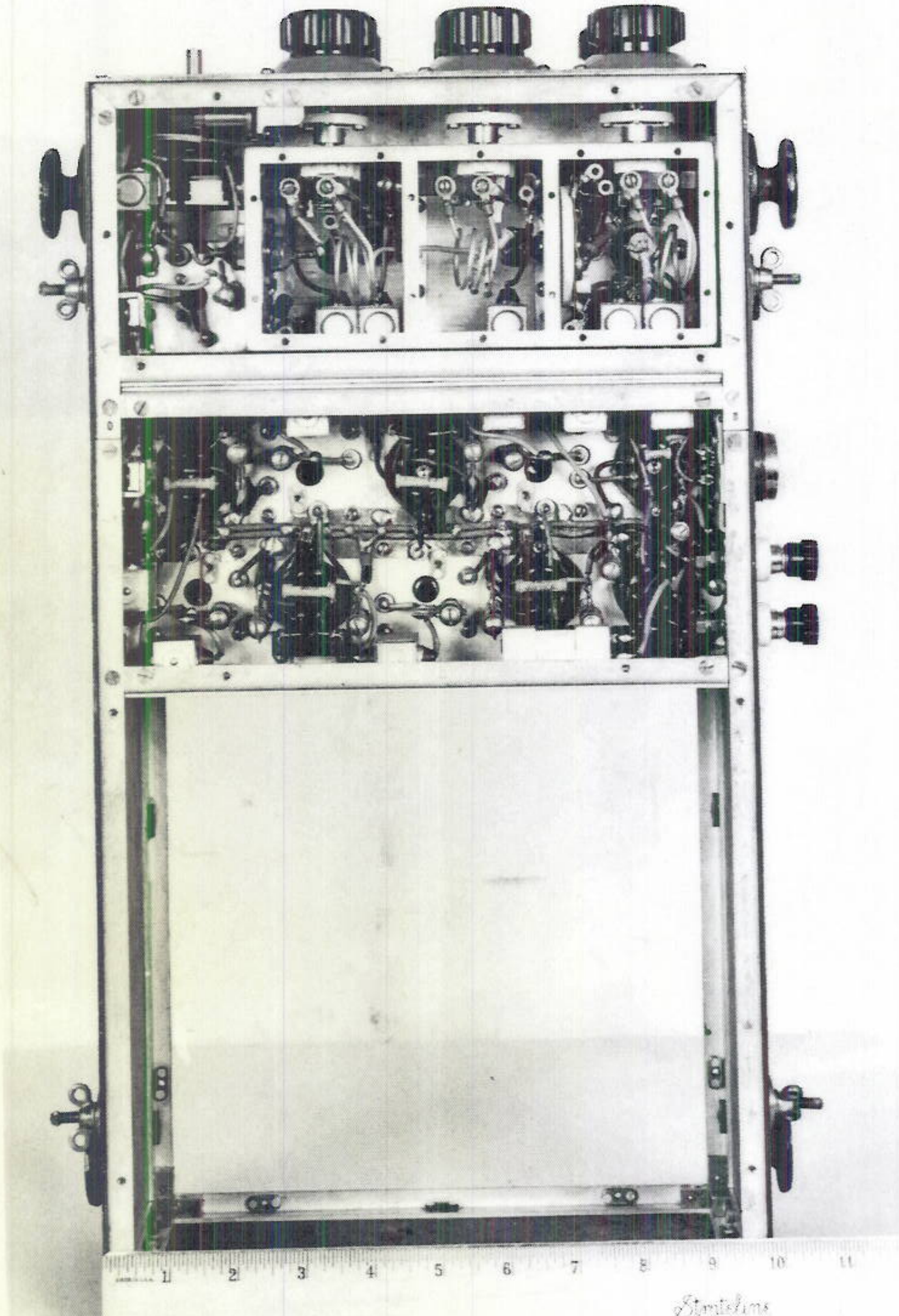

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PLATE 2

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PLATE 3

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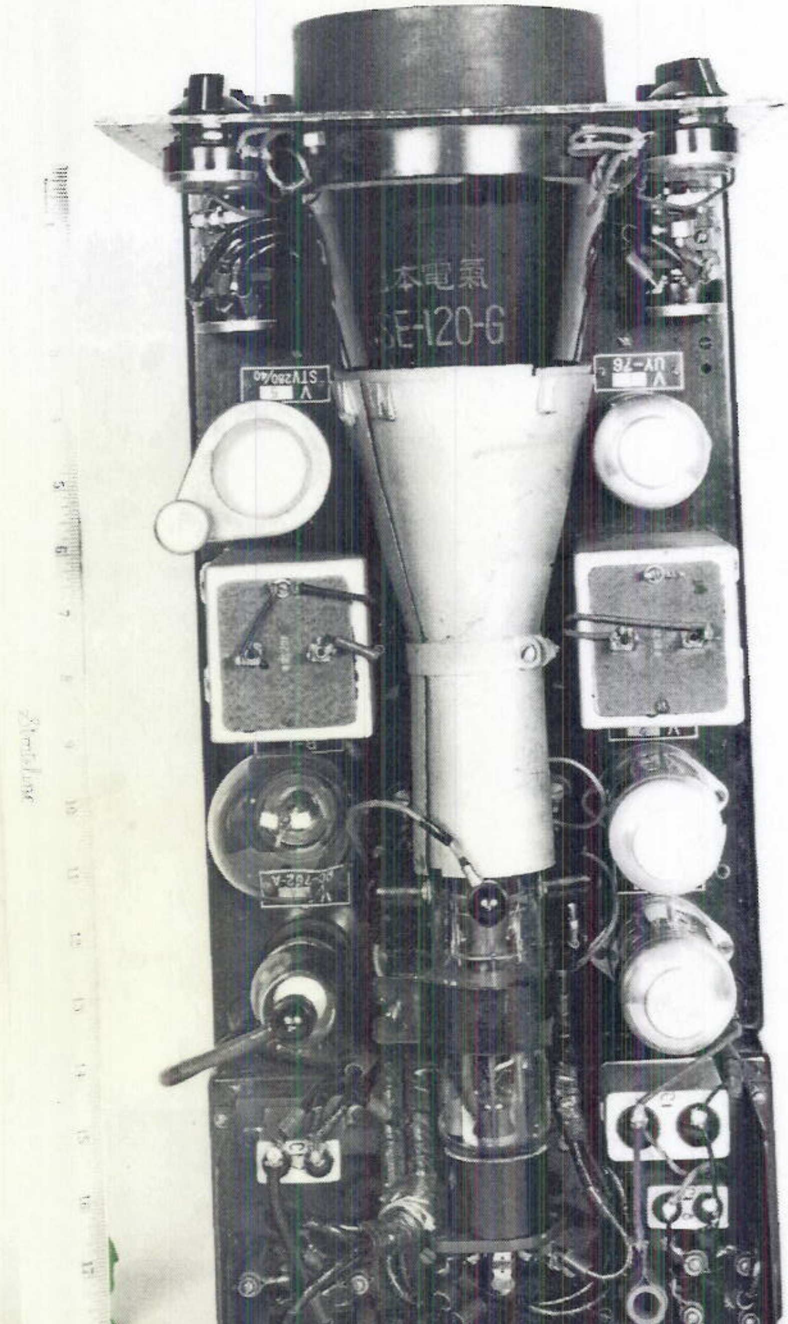

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PLATE 4

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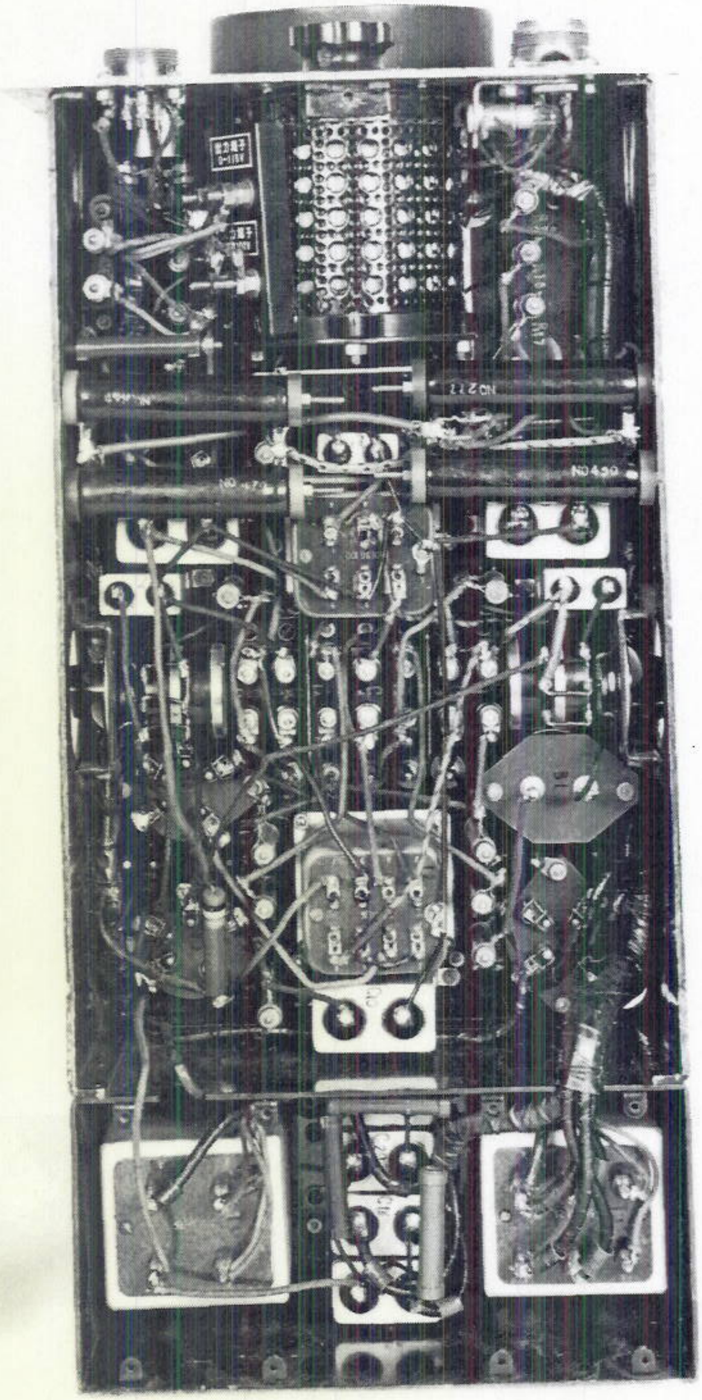

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PLATE 5

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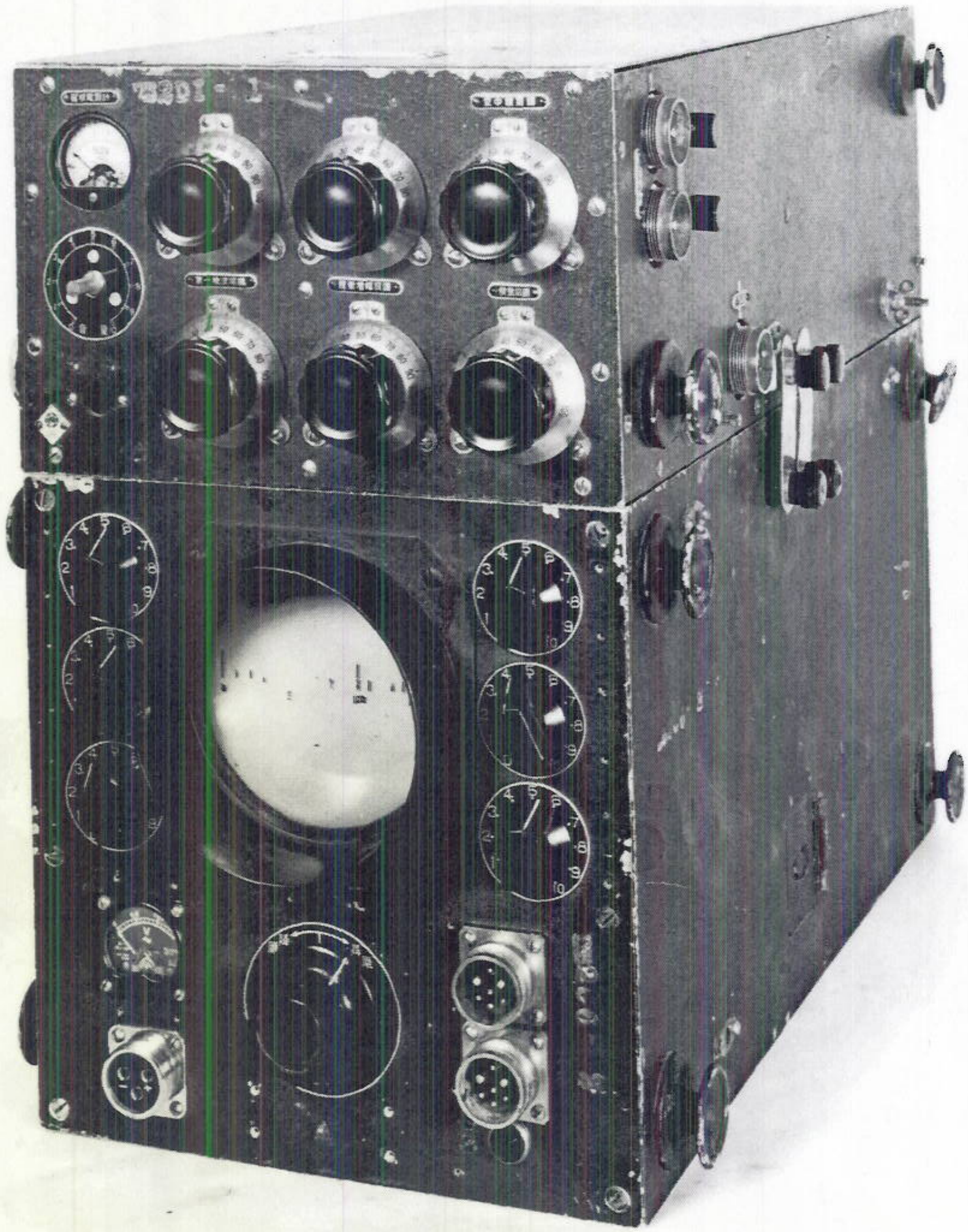

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PLATE 6