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TESTS ON EXPERIMENTAL UNIT  
PROJECTION PLAN POSITION INDICATOR  
REPEATER, MODEL VG-2, SERIAL NO.X2,  
TYPE CG-55AFL.

BY

C. C. Mezger  
E. N. Munzer

FR-2547

Radio Division-Special Development  
Report No. R-2547-Problem S802T-C  


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## ABSTRACT

On 4 September 1944, the experimental Model VG-2, Serial No. X2, Projection Plan Position Indicator Repeater, made by the General Electric Company of Bridgeport, Connecticut was delivered to this Laboratory for type test.

In general, the electrical performance of the VG-2 meets Naval requirements and indicates good design. However, considerable improvement should be made in the mechanical construction. Particular attention is called to the optical assembly. The dark trace cathode ray tube is not readily accessible and its replacement requires a difficult task of re-alignment of the optical system.

The replacement of the power transformers, chokes, and condensers can be accomplished only by the removal of the complete electrical compartment which is not only bulky but has weight requiring two men to handle.

With high humidity the high voltage circuits and insulated component boards support a very bad case of corona. With proper corrective measures as indicated under Recommendations, the unit should give reliable shipboard service.

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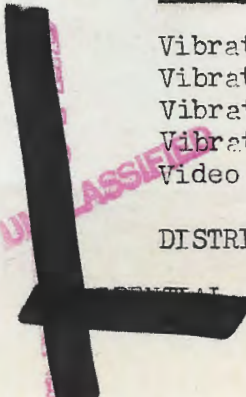
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### INTRODUCTION:

1. The Model VG-2 is a Projection Plan Position Indicator Repeater. It incorporates the Schmidt Optical System which magnifies the display of a 4-inch dark trace cathode ray tube to an overall diameter of 24 inches on the top viewing screen. The display is a magenta color on a white background.
2. The design adaptor itself for the installation of a standard Navy Dead Reckoning Tracer (DRT) at a level which is equal to that of the flat horizontal surface of the top viewing screen. This provides the observer with a magnified picture on a plotting board on which the actual map is portrayed and on which the tactical calculations are made directly.
3. Type test of this unit was authorized by BuShips ltr. C-MXsr - 5194 (916-1) Serial C-916-8601 of 12 July 1944, Model VG-2, Serial No. X2, Type CG-55AFL, BuShips Problem S-802T-C.

On 13 September 1944, the type test was authorized by BuShips ltr. C-MXsr-51594 Serial C-916-9159 of 13 September 1944, to include electrical measurements. Electrical tests were performed to determine whether the equipment conformed to the specifications of BuShips Specifications RE-9518A for Projection Plan Position Indicator, Model VG-2, and BuShips General Specifications RE-13A-659D for Plan Position Indicators and Plan Position Indicator Repeaters.

4. Temperature, humidity, vibration, shock, and mechanical tests were conducted. Electrical tests were again performed to determine whether any of the unit's electrical characteristics had changed after being submitted to temperature, humidity, shock and vibration. The last of the necessary measurements were completed on 19 January 1945.

### TEMPERATURE TEST

5. The subject equipment was placed in the temperature, humidity control room of NRL, Building 16, and prepared for test. The signal voltages which are required to operate the equipment were supplied from test apparatus. The NRL crystal calibrator, Serial No. 314, supplied the synchronizing pulse and the video signal; and a motor-driven synchro generator supplied the synchro voltages. With the equipment's range switch set to the four mile range, the calibrator's markers were adjusted until they coincided with the unit's internal markers as viewed on the sweep of the NRL servoscope, Type B, Serial No. 6. The range to which it was necessary to set the markers was then read from the calibrator. If the internal markers failed to indicate the correct range, the error could easily be detected. A similar procedure was followed on the ten, twenty, eighty, and two hundred mile ranges. During the test, the motor-driven

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synchro generator which furnished the synchro voltages was rotated at approximately 10 R.P.M.

6. The equipment was operated for two hours at 50 degrees Centigrade and one hour at each of the following temperatures: 35 degrees, 20 degrees, and 0 degrees Centigrade, respectively. The oscilloscope picture was normal under these conditions. The deflection coil correctly followed the motor-driven synchro and the range marks on all the scales indicated the correct range.

7. To determine the ability of the equipment to begin operation after several hours at a low temperature, the circuits were switched off; the space heaters automatically came on, and the temperature of the Control Room was held at minus 29 degrees Centigrade. Three hours later, the circuits were again energized. All the controls functioned normally and the range marks indicated the correct range. However, the deflection coil yoke would not follow the motor-driven synchro generator which was rotating at approximately 10 R.P.M.; instead, the yoke hunted through sectors of about 30 degrees. The unit was left turned on one and one half hours at this temperature, and during this time the deflection coil yoke still would not follow. The temperature of the box was raised to determine at what temperature the yoke drive would follow the motor-driven synchro generator. When the temperature box reached minus 4 degrees Centigrade, the yoke drive system followed normally up to speeds of 18 R.P.M.

8. During all the temperature tests, the relative humidity was kept below 30 per cent so that any observed effects would be a function of temperature alone.

### HUMIDITY TEST

9. The problem next investigated was the effect of high humidity on the operation of the equipment. With sync., video, and synchro signals supplied by test gear as in the temperature test (Reference Paragraph 5), the unit was energized and initial readings were taken. The accuracy of the internal markers was checked with the NRL crystal calibrator, Serial No. 314. The yoke drive system was following at 10 R.P.M. The circuits were then switched off including the strip heaters, and the unit was left in the temperature controlled box at 40 degrees Centigrade with a relative humidity of 95 per cent for six hours. At the end of this time, the unit's circuits were again energized and the operation of the equipment checked. The unit would not function due to the high voltage

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fuse being blown. The failure was caused by corona which was observed at the following places: various points of the high voltage leads in the high voltage compartment; condensers, (C6311, C6312, and C6313), insulated terminal posts; bakelite base for (V6021) tube socket; stand off insulator supports for (V6022) tube socket. Once the humidity was lowered, the unit functioned normally and the markers indicated the correct range.

### VIBRATION TEST:

10. The equipment was prepared for the vibration test in the following manner. It was firmly secured to the vibration-shock test table in NRL Building 16, by means of three 1/2 inch boiler plates. The equipment's shock mounts were fastened to these plates and sync., video, and synchro voltages were supplied from test apparatus used as in previous tests, (Reference Paragraph 5).

11. During the test, the overall operation of the equipment could be ascertained by viewing the pattern on the viewing screen.

12. At the beginning of the test, the table was vibrated throughout the available range of frequencies, 500 to 1900 C. .M. During this cycle of vibration, a General Radio vibration meter, Type 761, Serial No. 224 was used so that ratio curves (Reference Plates 1, 2, 3, and 4) of table to unit displacement could be plotted. By means of this curve, the most serious modes of vibration could easily be determined.

13. The most predominant vibration modes were at 600, 900, and 1000 C.P.M. This can be seen by examining Plates 1, 2, 3, and 4. At 900 C.P.M. the top viewing screen has an amplitude of vibration of approximately 1/8 inch side to side and 1/16 inch vertical. During the vibration test, the end chassis panel rattled excessively.

14. The equipment operated without failure during the test and the range markers on the four, ten, twenty, eighty, and two hundred mile sweeps continued to indicate correct range.

### SHOCK TEST

15. The equipment was left secured to the vibration-shock table as for the vibration test, and the table was adjusted to receive shocks from the pneumatic ram. The ram delivers shocks to the edge of the table of sufficient magnitude to give the table a maximum acceleration of approximately 250G. As the unit was mounted with its sides parallel to the table edges, shocks were delivered in the direction of the front, rear, and operator's right side of the equipment. The sync., video, and synchro signals necessary to give an intelligible display were supplied to the unit as in Paragraph 5.

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16. The unit received a total of ~~seventy~~ five shocks, twenty-five shocks being applied to each side mentioned in the preceding paragraph. The order in which the groups of twenty-five shocks were directed toward the equipment is as follows: The front, the rear, and operator's right. Throughout the test the focus control shifted causing the trace to be slightly out of focus. On the twenty-third shock toward the rear of the unit, the unit failed to function. Upon checking the equipment, the projection lamp filament wires were found to be broken. When the lamp was replaced the unit functioned normally. The internal markers on the four, ten, twenty, eighty, and two hundred mile ranges throughout the test indicated the correct range.

### TEMPERATURE RISE OF COMPONENTS

17. It was deemed necessary to determine the rise in temperature of the components when the equipment was operated continuously over a long period of time. Thermocouples were fastened on the high voltage transformer T6302; the low voltage transformer T6301; the low voltage reactor, L6303; the top of end chassis; the blower motor; the servo drive motor; the servo amplifier power transformer, T1506; the projection lamp spherical mirror; the 4AP10 tube face; the aspheric corrector lens; and the spherical projection mirror. The temperatures of the components were measured with a resistance bridge pyrometer, Lewis Eng. Co., Model T8P04, Serial No. 61T, which was connected to the thermocouples. The highest temperature rises are as follows: the high voltage transformer T6302, 36.0 degrees Centigrade; the low voltage transformer T6301, 39.5 degrees Centigrade; the low voltage reactor L6303, 41.25 degrees Centigrade; the top of end chassis, 40.5 degrees; the blower motor, 48.5 degrees Centigrade; the servo drive motor, 63.0 degrees Centigrade; the servo amplifier power transformer T1506, 43.0 degrees Centigrade; the projection lamp spherical mirror, 103.5 degrees Centigrade; the 4AP10 tube face, 53.25 degrees Centigrade; the aspheric corrector lens, 33.25 degrees Centigrade; the spherical projection mirror 38.5 degrees Centigrade. The total time of the test was approximately 24 hours. The ambient temperature during the test rose from 30.8 to 33.25 degrees Centigrade.

### SYNCHRONIZING TEST

18. To determine whether the equipment fulfills the requirements of Paragraph 4-1 of Reference (d) and Paragraph 3-1 (a) of Reference (c), the Colonial Radio pulse generator Model 700, Serial No. 12, was connected to the sync. input terminals of the unit. With the pulse generator being synchronized by the General Radio, wide range beat frequency oscillator, Type 700A, Serial No. 164, pulses with all the characteristics specified to initiate the timing circuits were simulated as close as possible.

19. Positive sync. pulses with a repetition rate of from 60 to 1100 cycles per second, 2 to 20 volts in amplitude, and of 1/2 to 14 microseconds width triggered the 4, 10, and 20 mile ranges satisfactorily although the range markers were dim on the 4 and 10 mile ranges at 60 cycles per second. On the 80 and 200 mile ranges at 650 and 225 cycles per second respectively the trace shortened in length but the time interval between the range markers remained the same. At 760 and 265 cycles per second on the 80 and 200 mile ranges respectively the circuits would not hold synchronization.

SYNCHRONIZING PULSE LINE AND VIDEO SIGNAL LINE REQUIREMENTS.

20. Terminals for both synchronizing pulse line and video signal line are provided on terminal boards TB6002 and TB6003 respectively. Also the synchronizing pulse and video signal lines can be operated either in a terminated or unterminated condition. All these conditions are necessary to comply with Paragraphs 4-2 and 4-5 of Reference (d). The 75 ohm resistors used to terminate these lines are mounted on a terminal board very close to the terminal board accommodating the incoming lines. Switches S6502 to S6506 inclusive are clearly marked "Final" and "Intermediate" which provides an easy means for changing from terminated to unterminate.

VIDEO SIGNAL REQUIREMENTS

21. To test the equipment in relation to the requirements of Paragraph 4-3 of Reference (d), the output of the Colonial Radio pulse generator, Model 700, Serial No. 12, was adjusted to give a one half microsecond pulse and then fed to the Video input of the unit. The one half microsecond, positive polarity pulses of either one or two and one half volts could easily be distinguished on all the ranges. The requirements of Paragraph 4-3 of Reference (d) are satisfactorily fulfilled.

VIDEO RESPONSE

22. The frequency response of the Video system was measured in the usual manner. A signal source and a vacuum tube voltmeter were used to supply voltages to the Video input terminals of constant amplitude at any of the necessary frequencies and a vacuum tube voltmeter measured the output of the amplifier. The General Radio beat frequency oscillator, Type 700A, Serial No. 164, delivered video signals from 100 cycles to 4 megacycles. General Radio vacuum tube voltmeters, Type 726A, (Serial Nos. 1804 and 1798) were employed to measure the input and output voltages.

23. The magnitude of the output voltage delivered by the amplifier was measured when it operated with signal inputs of video frequency of an amplitude of one volt. Measurements were made with the video gain control set at maximum and midway with the intensity equalizer control set at maximum and minimum. The results obtained from the tests show that the output of the amplifier is not better than 1.0 megacycle wide at 3 db down but it is less than 3 db down at 10 kilocycles. (Reference Plate 5). The equipment does not fulfill all of the requirements of Paragraph 3-1(b) of Reference (c).

SWEEP STARTING TIME

24. For this test the NRL crystal calibrator, Serial No. 314 was used to synchronize the equipment and the NRL servoscope, Type B, Serial No. 6. The marker from the crystal calibrator was phase shifted from the leading edge of the synchronizing pulse to the beginning of the flat portion of the unblanking negative gate. This was viewed on the sweep of the servoscope. Testing all ranges by this method showed that the time elapsed was well within the limits required by Paragraph 5-2 of Reference (d).

SWEEP DEFLECTION

25. To test the equipment with regard to the sweep deflection requirement of Paragraph 5-3 of Reference (d), fixed markers from the United Cinephone Corporation, range calibrator, Model B, NRL No. 371 and variable markers from the NRL crystal calibrator, Serial No. 314, were applied to the video input terminals of the equipment. The crystal calibrator's markers were phase shifted until both sets of markers coincided with each other, as observed on the unit's trace. Rotating the crystal calibrator phase control moved its markers out along the trace. A measurement was made when the marker dots in the center of the trace appeared twice as far apart as the pair of dots at the start of the trace. These measurements, as noted on the phase control dial scale, met the requirements for all ranges of Paragraph 5-3 of Reference (d).

RANGE ACCURACY

26. The range of echoes on the top viewing screen must be estimated from four fixed marks of known ranges. For example, on the four mile scale, marks appear at one, two, three, and four miles. The space between markers on the screen is approximately 3 inches. If an echo lies between two markers, that increment of its range between the markers can be estimated to about plus or minus 10 percent of the distance between the markers. For example, an echo at 2.3 miles would be between the two and three mile markers on the four mile sweep and its range may be estimated to be between 2.2 and 2.4 miles. The error to be expected in determining the range of echos lying between markers depends on the operator's ability to estimate the range and not so much in the method of presentation.

27. The observations discussed above show that the unit should approximate the range accuracy specifications of Paragraph 5-4 of Reference (d). The unit fulfills all these specifications.

RECOVERY TIME OF SWEEP

28. In this report, recovery time is interpreted as that time from the instant the sweep voltage starts to return to zero, until it maintains itself at the base line of the trace. To measure the recovery time of the unit's sweep circuit, the voltage on the plate side of the sweep deflection coil was applied to the NRL servoscope, Type B, Serial No. 6, vertical deflection plate. The NRL crystal calibrator, Serial No. 314, furnished the synchronizing pulse at 200 cycles per second as well as markers which could be phase shifted, so that a very accurate electrical measurement could be made. On the 500 microsecond sweep of the servoscope, the recovery time of the four, ten, and twenty mile ranges measured 17, 22, and 53 microseconds respectively. The eighty and two hundred mile ranges were measured on the 5000 microsecond sweep of the servoscope. The recovery times measured were 180 and 480 microseconds respectively.

29. Attention is directed to the fact that the requirements of Paragraph 5-5 of Reference (d) are not fulfilled. The results obtained in the synchronization test shows that the 80 and 200 mile ranges lose synchronization at 760 and 265 cycles per second respectively. (Reference Paragraph 19).

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RANGE MARKERS

30. Provision has been made in the equipment for switching on four equally spaced markers which are generated within the unit itself, and for controlling their amplitude. These facilities are necessary to meet the specifications of Paragraph 5-6 of Reference (d).

31. The duration of the range marks at a voltage of 70 percent of the peak value of the range mark voltage was measured on the NRL calibrated servoscope, Type B, Serial No. 4 to find if they met the 3/4 microsecond duration specification of Paragraph 5-6 of Reference (d). The length of the range markers of the unit as received measured .66 microseconds on the four and ten mile ranges and .5 microseconds on the twenty, eighty and two hundred mile ranges. After the temperature, shock, and vibration tests were conducted, the marker length measured .48 microseconds on the four, ten, and twenty mile ranges and .61 microseconds on the eighty, and two hundred mile ranges.

32. All the requirements of Paragraph 5-6 of Reference (d) are satisfactorily fulfilled.

RANGE MARKER ACCURACY

33. The NRL crystal calibrator, Serial No. 314, was used to measure the accuracy of the range marks on the four, ten, twenty, eighty, and two hundred mile ranges in accordance with Paragraphs 5-7 and 5-8 of Reference (d). The calibrator furnished markers which could be phase shifted and a trigger pulse to initiate the NRL servoscope, Model B, Serial No. 6, and the unit's timing circuits. The calibrator's markers were applied to one of the vertical deflection plates of the servoscope, and the unit's internal markers were applied to the other vertical deflection plate. By phase shifting the calibrator's markers, until they coincided with the unit's internal markers and observing the dial reading, an accurate measurement could be made of the range markers in yards. The results of the test are tabulated below:

FOUR MILE RANGE

<u>Range Marker No.</u>	<u>As Received(Yards)**</u>	<u>After Tests(Yards)***</u>	<u>Limits(Yards)</u>
1	1880*	1860*	1920 - 2080
2	1970	1960	1960 - 2040
3	1990	2000	1940 - 2060
4	1980	2000	1920 - 2080

TEN MILE RANGE

1	4848	4720*	4800 - 5200
2	4860*	4950	4900 - 5100
3	5030	4970	4850 - 5150
4	5010	5070	4800 - 5200

TWENTY MILE RANGE

<u>Range Marker No.</u>	<u>As Received (Yards)**</u>	<u>After Tests (Yards)***</u>	<u>Limits (Yards)</u>
1	9820	9800	9600 - 10400
2	9900	9860	9800 - 10200
3	9850	9910	9700 - 10300
4	9990	10040	9600 - 10400

EIGHTY MILE RANGE

1	39460	39510	38400 - 41600
2	39360	39380	39200 - 40800
3	39440	39300	38800 - 41200
4	39260	39530	38400 - 41600

TWO HUNDRED MILE RANGE

1	99180	99480	96000 - 104000
2	99300	99690	98000 - 102000
3	99560	99550	97000 - 103000
4	99900	99880	96000 - 104000

\* These markers did not meet specifications.

\*\* "As Received" - Tests made on unit immediately after delivery as received.

\*\*\* "After Tests" - Tests made after shock, vibration, temperature, and humidity tests.

DEFLECTION YOKE SPEED

34. For this test a motor-driven synchro generator was wired to the unit's servo system. The deflection coil was found to follow the synchro generator satisfactorily at speeds up to and including a maximum of 18 R.P.M. as required by the first part of Paragraph 6-1 of Reference (d).

BEARING ACCURACY

35. The motor-driven synchro generator was connected to the unit's servo 5 CT synchro as in the previous test. A DuMont oscilloscope, Type 241, Serial No. 929, was calibrated so that one degree yoke rotation corresponded to twenty small blocks on the oscilloscope calibration. This was accomplished by placing the oscilloscope across the output terminals of the unit's 5 CT synchro and observing the oscilloscope pattern when the yoke was displaced one degree from zero output of the 5 CT synchro.

36. The deflection coil was rotated from speeds of 1.5 to 18 R.P.M. and at no time did the error output voltage of the 5 CT synchro exceed 43 small blocks which shows that the deflection coil was following with less than 2.2 degree lag as required by Paragraph 6-1 of Reference (d).

37. On 10 January 1945; Mr. H. Lyman of General Electric Company made minor circuit changes in the servo amplifier. Another test was made similar to the procedure described in Paragraph 36. In this test the error output voltage of the 5 CT synchro did not exceed 15 small blocks which showed that the deflection coil followed with less than  $3/4$  degree lag.

#### SPOT RADIUS

38. During rotation of the deflection coil, the radius of the orbit of the undeflected spot on the cathode ray tube screen met the requirements of Paragraph 3-1 (d) of Reference (c).

#### CENTER EXPAND

39. A control to permit extension of the sweep origin to a point not less than one inch nor more than two inches from the center of rotation on the plotting screen is required by Paragraph 3-1 (e) of Reference (c). The function of S-6002, fulfills these requirements.

#### CENTERING

40. Electrical means have been provided on the equipment for centering the undeflected spot on the plan position indicator tube face. The undeflected spot on the tube face can be centered to any point within a circle of  $13/32$  of an inch radius where Paragraph 7-3 of Reference (d) requires a one inch radius. The unit does not fulfill this part of the specification; although, the centering means are sufficient to counteract the strength of a five gauss field normal to the electron beam.

#### POWER REQUIREMENTS

41. The unit was operated from 103.5 to 126.5 volts, to determine how much current is taken from the 60 cycle power line and the power factor of the unit. A Weston, a.c.-d.c. ammeter, Model 370, No. 5308; Weston, a.c.-d.c. wattmeter, Model 310, No. 7966; Weston, a.c.-d.c. wattmeter, Model 310, No. 7934; Westinghouse, a.c. voltmeter, Type PY-5, Serial No. 1466479; Westinghouse, ammeter, Type PY-5, Serial No. 1705303 were used. The results are tabulated below:

<u>Line Voltage</u>	<u>Line Amperes</u>	<u>True Power</u>	<u>Power Factor</u>
---------------------	---------------------	-------------------	---------------------

(Main power, operate and high voltages switches on)

103.5	12.4	1266.7	.985
115.0	13.2	1495.9	.985
126.5	14.0	1735.0	.978

(Main power switch on)

103.5	9.50	966.7	.982
115.0	9.95	1125.9	.982
126.5	10.40	1295.0	.982

## (Main power and operate switches on)

103.5	12.10	1246.7	.994
115.0	12.95	1460.0	.978
126.5	13.70	1703.0	.982

## (Blower motor on)

103.5	1.88	133.4	.685
115.0	1.91	142.4	.648
126.5	2.07	152.9	.584

## (Beacon lamp on)

103.5	8.38	860.9	.992
115.0	8.90	1025.0	1.000
126.5	9.40	1188.9	.997

## (Strip heaters on)

103.5	.735	70.4	.926
115.0	.818	88.0	.934
126.5	.890	106.2	.943

## (R1 and R2 connected to O.S.C. source)\*

103.5	.202	8.76	.415
115.0	.226	11.10	.426
126.5	.250	13.25	.418

## (R1 and R2 connected to O.S.C. source)\*\*

103.5	.198	7.06	.345
115.0	.225	9.10	.368
126.5	.250	10.95	.346

\* Motor-driven synchro generator rotating at 10 R.P.M.

\*\* Motor-driven synchro generator stationary.

42. A  $\pm$  10 percent variation in line voltage introduced no serious faults in the operation of the equipment; however, when the line voltage was down 10 percent, it was necessary to re-focus the trace on all ranges.

43. A transient variation in line voltage of  $\pm$  20 percent as required by Paragraph 8-2 of Reference (d) could not be obtained. However, a single phase, 1/3 H.P., Type SCS, Delta motor was used to simulate a transient voltage variation. The voltage surge caused by starting the motor which was placed across the unit's line introduced no serious effects to the equipment. Varying the line frequency as required by Paragraph 8-1 of Reference (d) could not be performed for lack of equipment.

RELATIVE BEARING WARNING SIGNAL

44. The subject equipment was found to meet the requirements of Paragraph 3-1 (c) of Reference (c).

PIN JACK OSCILLOGRAMS

45. For this test a United Cinephone range calibrator, Model B, NRL No. 371, was used to synchronize the unit and the NRL servoscope, Type B, Serial No. 6 was used for checking the patterns. The oscillograms as viewed on the sweep of the servoscope agreed closely with those shown adjacent to the pin jacks. The requirements of Paragraphs 4-34 and 4-35 of Reference (c) are fulfilled in the equipment.

DIMENSIONS

46. The physical outline of the unit is so constructed so that it fulfills the requirements of Paragraphs 4-5 and 4-6 Reference (c).

VIDEO EQUALIZER

47. The video equalizer circuit contained in the equipment does not fulfill the requirements of paragraphs 3-3 and 3-10 of Reference (c).

COMPONENTS AND WIRING

48. During the test and inspection of the equipment, the following notes concerning the components and wiring were made:

- (a) The tube markings V6009, V6010, V6011, and V6012 are difficult to see and the wiring surrounding the tube sockets is congested.
- (b) There is no insulating grommet where the 4AP10 high voltage lead passes through the end chassis.
- (c) Condenser C6308 rubs against the cable connecting to TB6007 and TB 6008. A cable clamp should be utilized for holding it in position.
- (d) Identification of the essential tubes could be simplified if both sides of the chassis were marked.
- (e) A long piece of solid wire is used for grounding one side of condenser's C6313 and C6312. This is not considered good practice for general Navy use.
- (f) Flaws were noticed in the high voltage transformer insulated terminal.
- (g) The coupling for connecting the rotation indicator shaft to the gear box is not sufficiently rugged in design to withstand continuous use. After a short period of operation, the pin of coupling 06003 sheared and the slot of 06004 was worn approximately  $1/32$  of an inch.
- (h) Coupling 06004 was listed in the instruction book but was not included or listed in the spare parts boxes.
- (i) Terminal boards TB6002 to TB6005 inclusive in the equipment are not located in their respective position as shown in Figure 11 of the temporary instruction book.

- (j) The terminal board used for securing the termination resistors is not marked with a TB number.
- (k) The ground connections of the sync. and video cables on TB 6006 are not soldered. Paragraph 4-27 of Reference (c) requires that no solderless lugs be used.
- (l) Terminal boards in the end chassis were made using cloth inserted Bakelite. Paper inserted Bakelite is considered best for tropical conditions.

#### MECHANICAL INSPECTION

49. All parts of the cabinet and chassis were found to be sturdily constructed. However, some mechanical faults were found and these are listed below:

- (a) Corrosion was found on the following places:
  1. Plate holding the rear section of TB 6006.
  2. Mounting board supporting the sweep length potentiometers.
  3. Various points of the end chassis.
  4. Range marker coil brackets.
  5. Screws and springs of terminal boards 6006, 6007, and 6008.
  6. Bracket for holding down the 3B24 plate connector.
  7. Brackets for securing high voltage bleeder resistors terminal board.
  8. Low voltage rectifier tubes chassis.
  9. Practically all bracket mounting screw heads in end chassis.
  10. Conductor inside high voltage transformer insulated terminal.
  11. Air filter retaining plate captive screws.
  12. Blower motor fan housing and bracket.
  13. Blower motor grease cups.
  14. Blower motor end bell housing screw heads and nuts.
  15. Blower motor housing clamp.
  16. Screw heads which secure the small panel above blower motor.
  17. Machine screw heads holding the angular mirror bed plate.
  18. Machine screw heads that hold angular mirror to bed plate.
- (b) Rust was found on the following places:
  1. Case adjacent to the rear section of TB 6007.
  2. Angular adjustment screw head.
  3. Case where the "picture erase" and "fade out" controls are mounted.
  4. Throughout various spots on the welded seams of the shock mount pillars.
- (c) No guide rail on unit to protect controls as required by Paragraph 4-17 of Reference (c).
- (d) Interlock was broken on end chassis when unit was received.
- (e) No wrench was provided for tightening the potentiometer locks.

- (f) Difficulty was experienced in removing the servo amplifier chassis screws due to the nearness of the strip heater.
- (g) One Dzus fastener was missing on the air filter compartment panel.
- (h) The flatted shaft (bottom section of the yoke drive shaft) was installed upside down.
- (i) It was noticed that the welded seams of all the floor plate compartments were filled with putty. This putty came loose during the shock and vibration tests.
- (j) The top front edge of the paper clamp bar and its tabs have sharp edges and corners respectively.
- (k) The video gain, range marker intensity, focus, and C.R.T. bias front panel controls are not fitted with a simple locking device as required by Paragraph 4-16 (a) of Reference (c).
- (l) Controls on the end chassis are not labeled as required by Paragraph 4-19 of Reference (c).
- (m) The tube clamps on the servo amplifier chassis are not considered suitable to fulfill the requirements of Paragraph 4-30 of Reference (c).
- (n) A Navy approved coaxial connector to furnish trigger voltage for test equipment as required by Paragraph 806 of Reference (d) is not contained in the equipment.
- (o) The cover provided for the protection of the glass plotting surface when the equipment is not in use as required by Paragraph 4-40 of Reference (c) is made of wood.
- (p) Lock ring type tube sockets are used in the servo amplifier. This type of tube socket is not Navy approved.
- (q) The door on the recessed cabinet which contains spare fuses and tools does not have an identification label.
- (r) Felt gaskets used in the equipment are not considered good practice for general Navy use and fungus.
- (s) The spare part mirrors are contained in a wood storage box.

#### CONCLUSIONS

50. The tests and inspections of this equipment disclosed sturdy construction and stable electrical circuits. Some defects were uncovered. The most serious defects are as follows: The trouble encountered with the rotation indicator coupling 0-6003 and 0-6004; the loss of synchronization on the eighty and two hundred mile ranges; the failure of the unit when subjected to high humidity; and the corrosion found throughout the unit due to insufficient plating. Further information concerning these and other defects is summarized in Paragraph 52.

51. The equipment shows evidence of good engineering design and with improvement of the defects mentioned in this report, should give reliable operational results in the Naval shipboard use.

SUMMARY OF DEFECTS AND RECOMMENDATIONS

52. In the following paragraphs are summarized the defects and recommendations. Where possible, suggestions leading to the correction of these defects are given. The number in parenthesis at the beginning of each paragraph refers to that portion of the report in which the defect is more fully discussed. The defects are listed in the order of their appearance in the report and not in the order of their importance. It is recommended:

- (a) (7) That an investigation be conducted to find a lubricant that can be used in the gear reduction box which will allow the yoke to follow at temperatures from -30 degrees Centigrade to 50 degrees Centigrade. The present grease in the gear reduction box offers too much drag on the servo drive motor at -30 degrees Centigrade to permit correct yoke follow-up rotation.
- (b) (9) The failure of the unit when subjected to high humidity should be investigated and corrected.
- (c) (13) Some means of dampening the unit's resonant modes of vibration should be incorporated in the method of shock mounting the equipment. The vibration of the end chassis panel should be corrected.
- (d) (16) The front panel focus potentiometer should be incorporated with a lock as the adjustment shifted during the shock test. The failure of the projection lamp under shock should be investigated.
- (e) (19) The eighty and two hundred mile ranges do not meet the requirements of Paragraph 5-5 of Reference (d). This should be investigated and corrected.
- (f) (23) The response of the video amplifier should be improved so that it meets the requirements of Paragraph 3-1(b) of Reference (c).
- (g) (28) The recovery time between the finish and start of consecutive sweeps is not sufficiently rapid on the eighty and two hundred mile ranges to meet the repetition rate requirements of Paragraph 5-5 of Reference (d). This should be investigated and corrected.
- (h) (33) The inaccuracy of the four and ten mile ranges should be corrected.
- (i) (40) The electrical means is not sufficient to center the undeflected cathode ray tube spot to any point within a circle of one inch radius. This should be investigated and corrected.
- (j) (47) The video equalizer circuit should be investigated and corrected so that the intensity of the trace is more uniform from its center to the outer edge.
- (k) (48) The items noted in the components and wiring should be investigated and corrected.
- (l) (49) The troubles found in the mechanical inspection should be investigated and corrected.

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REFERENCES

- (a) BuShips ltr. C-NXsr-51594 (916-1) Serial C-916-8601 of 12 July 1944.
- (b) BuShips ltr. C-NXsr-51594 Serial C-916-9159 of 13 September 1944.
- (c) BuShips Specifications RE-9518A for Projection Plan Position Indicator, Model VG-2.
- (d) BuShips General Specifications RE-13A-659D for Plan Position Indicators and Plan Position Indicator Repeaters.

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TABLE I

TUBE ELECTRODE VOLTAGES

Conditions of Test: Selector Switch in the "Off" Position.

Note: All voltages were measured to ground with a Simpson voltmeter, Serial No. 4604 and are positive D.C. volts unless otherwise indicated.

F - 6.3 volts A.C.

G - Ground

N.C. No connection

\* Voltage varies with the total range of the C.R.T. bias fine adjustment.

Tube Symbol Designation	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
V6001 (6AC7)	G	G	G	0	3.7	142	F	270
V6002 (6SN7GT)	-16	280	G	15	300	27.5	G	F
V6003 (6L6G)	G	G	70	112	0.4	N.C.	F	G
V6004 (6SN7GT)	0.1	115	14.2	-0.25	0.1	G	G	F
V6005 (6SN7GT)	-67	-67	-62	0	70	G	G	F
V6006 (6L6G)	G	G	300	300	-62	N.C.	F	0.67
V6007 (6SN7GT)	0	156	16.15	-3.5	195	G	G	F
V6008 (6SN7GT)	-7	300	6.4	-16.5	-16.5	-9	F	
							Across Pins 7 & 8	
V6009 (6SN7GT)	-9	135	14.2	0	135	4.2	G	F
V6010 (6AC7)	G	F	-70	-2.5	G	140	G	280
V6011 (6AG7)	G	F	G	-0.4	0	6.3	G	295
V6012 (6AG7)	G	F	G	25	38	215	G	300
V6013 (6SN7GT)	-16	-16	-11	-67	-67	-67	G	F
	to*	to*	to*					
	-40	-40	27					
V6014 (6SN7GT)	8	46	8	-8	270	19	G	F
V6015 (6SN7GT)	8	258	17.5	0	270	17.5	G	F
V6016 (6SN7GT)	0	270	14	-8	-8	-8	G	F
V6017 (6SN7GT)	-11	-11	0	0	300	27	G	F
	to*	to*						
	-27	-27						



VG-2 RADAR  
PROJECTION PPI REPEATER  
OPERATORS RIGHT TOP OF UNIT

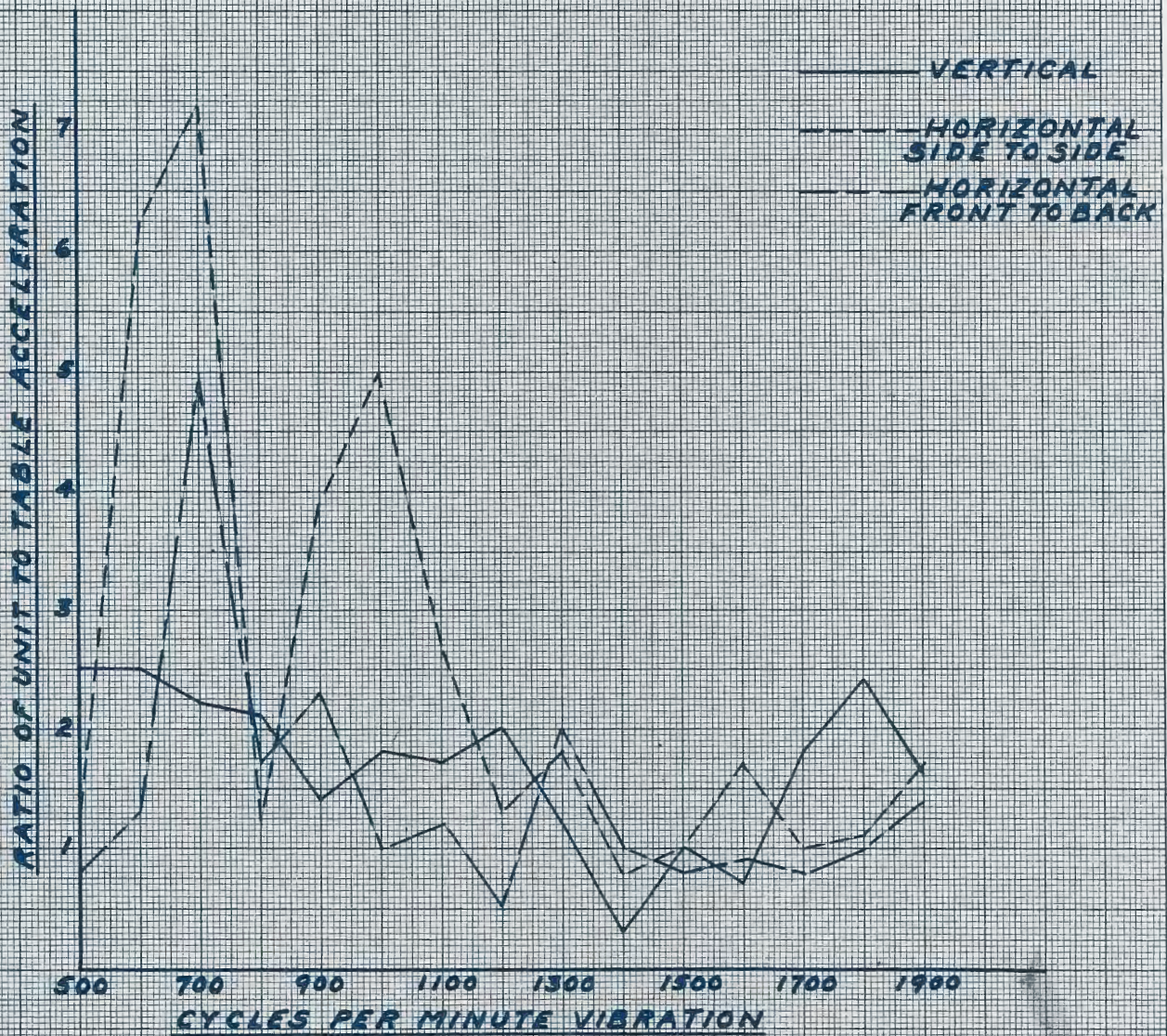


PLATE 1

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VG-2 RADAR  
PROJECTION PPI REPEATER  
OPERATORS LEFT BOTTOM OF UNIT

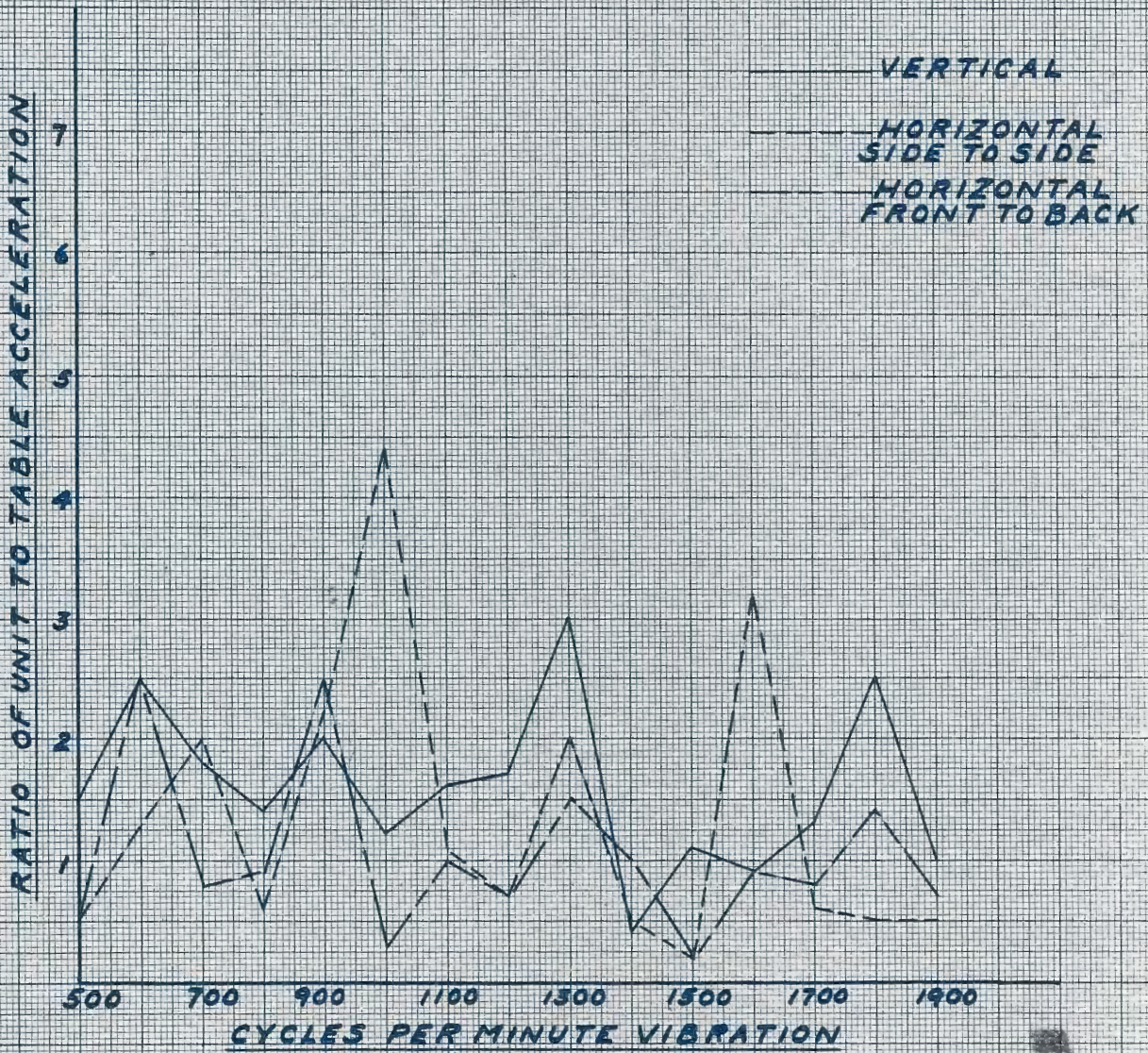


PLATE 2

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VG-2 RADAR  
PROJECTION PPI REPEATER  
OPERATORS LEFT TOP OF UNIT

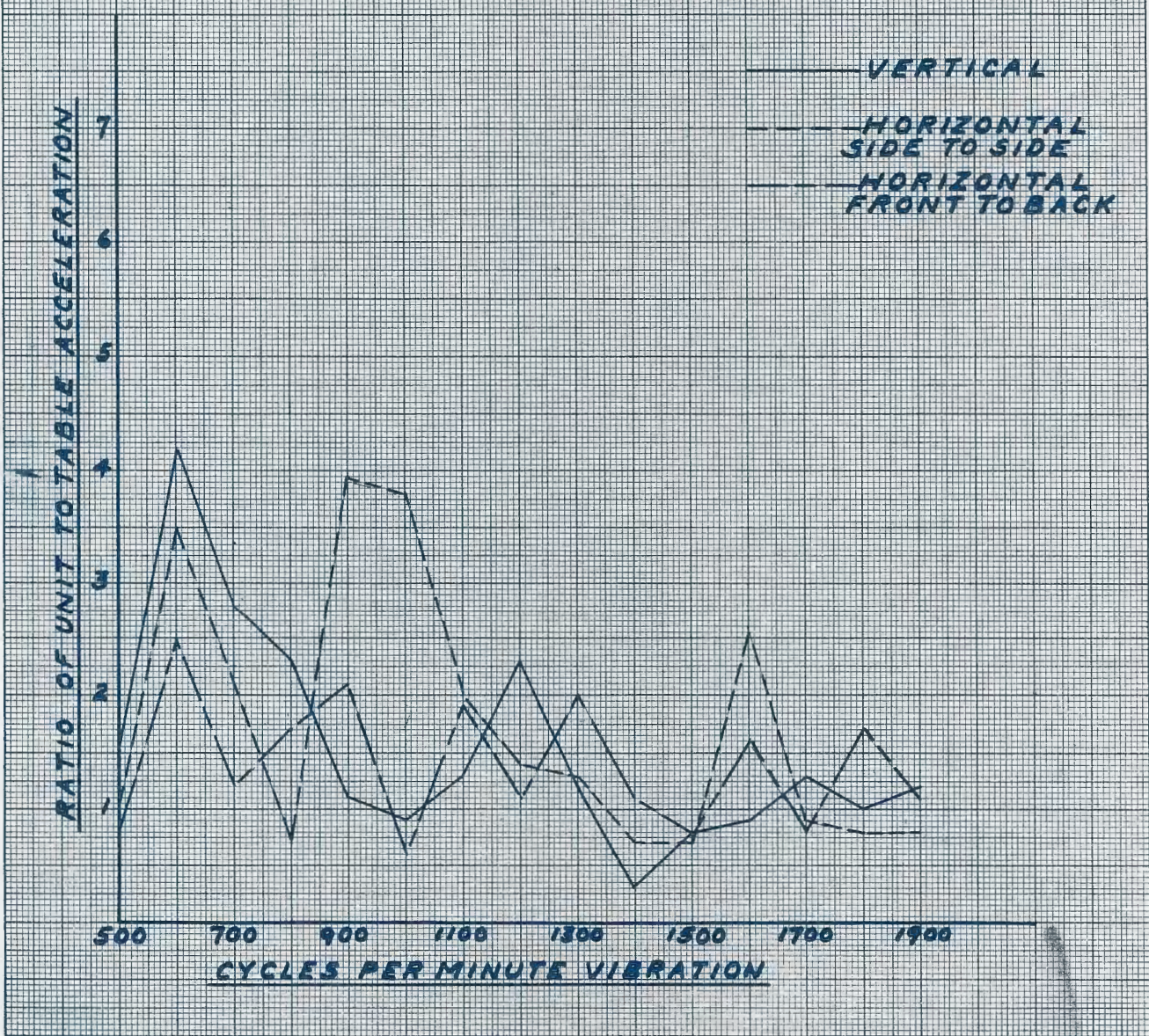
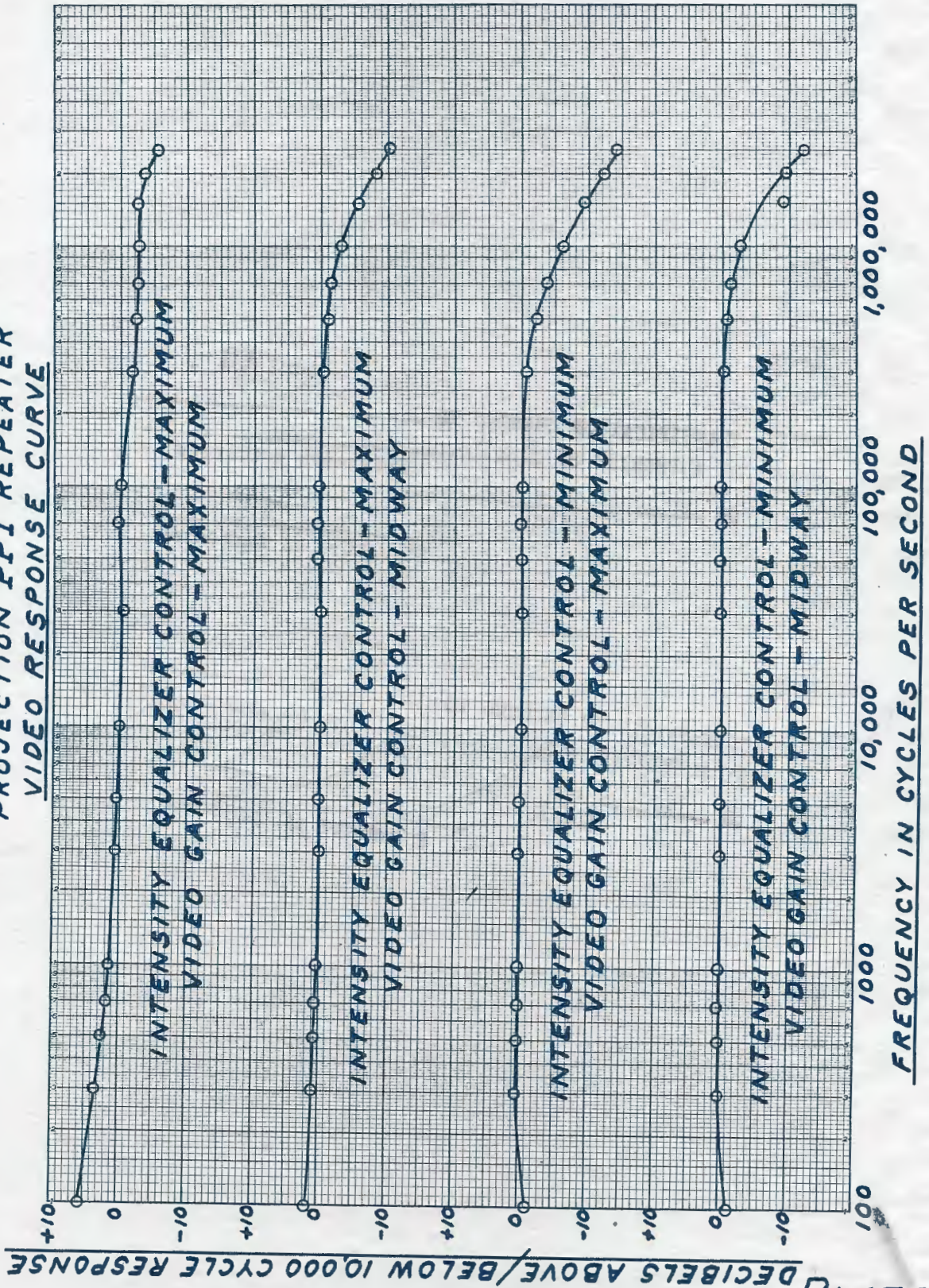


PLATE 4

VG-2 RADAR  
PROJECTION EPI REPEATER  
VIDEO RESPONSE CURVE



5 PLATE