

REPORT NO. FR-1628

DATE 27 June 1940

SUBJECT

FR-1628

Report on

Test of Preliminary Model MU-1

Radio Direction Finder Equipment

(Lendix Radio Corporation)

DECLASSIFIED by NRL Contract

Declassification Team

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Reviewer's name(s): A. THOMPSON,

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by

W. A. Gordon

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27 June 1940

NRL Report No. R-1628  
BuEng. Prob. A8-11C

NAVY DEPARTMENT

  
Report on

Test of Preliminary Model XDU-1  
Radio Direction Finder Equipment  
(Bendix Radio Corporation)

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NAVAL RESEARCH LABORATORY  
ANACOSTIA STATION  
WASHINGTON, D. C.

Number of Pages:      Text - 8              Tables - 10              Plates - 10

Authorization:      BuEng-C&R let. C-NOs 72173 (5-23-DR) of 7 June 1940.

Date of Test:      3 June 1940 to 18 June 1940.

Prepared by:      \_\_\_\_\_  
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H. G. Bowen, Rear Admiral, U.S.N. Director.

Distribution:      BuShips (10)  
                                 NAS Anacostia (2)

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Ser. 40082 of 21 June 1940 to NRL

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## AUTHORIZATION FOR TEST

1. The tests herein reported were authorized by reference (a) and other additional references pertinent to this problem are listed as references (b) and (c).

Reference: (a) BuEng & BuC&R let. C-NOs 72173 (5-23-DR) of 7 June 1940.  
(b) RINM let. L4+3/72173 (30) of 23 May 1940 to BuEng. encl. Bendix let. G530 of 22 May to RINM.  
(c) BuEng Conf. Specification RE 13A 546B.

Enclosures: (A) Photographs of Equipment, 2 plates.  
(B) Plates Containing Data, 8 plates.

Appendices: Report of Naval Air Station, Anacostia.

## OBJECT OF TEST

2. The object of these tests was to determine the suitability of the Model XDU-1 Direction Finder Equipment for use in Naval Aircraft.

## ABSTRACT OF TEST

3. The tests include measurement of efficiency over a temperature range of  $-30^{\circ}$  to  $50^{\circ}$  C with a relative humidity in excess of 95%. Measurement of loss due to coupler unit. Observation of general field operation. Ability of equipment to withstand an acceleration of 8g. Ability of equipment to operate during vibration. Measurements of weights and dimensions.

## DESCRIPTION OF EQUIPMENT UNDER TEST

4. The Model DU-1 Equipment was manufactured by the Bendix Radio Corporation of Baltimore, Maryland. The equipment is designed to provide unilateral and bilateral bearings when using the Model RU receivers over a frequency range of 200 to 1600 kcs. It is intended to be used on scouting and observation type aircraft.

5. The equipment provides for complete operation at the coupler unit location since the coupler unit, azimuth scale, rotating mechanism and loop antenna comprise a single mechanical assembly.

6. The equipment utilizes the cardioid principle for unilateral operation which gives an indication of the station bearing and then reverts to the bilateral loop operation for accurate determination of the bearing. This equipment is similar to the Model DW-1 equipment with the exception of the loop being mounted upon an extension shaft of required length.

7. The equipment consists of the following major components:

- 1 - Coupler Unit - Type CRR
- 1 - Receiver Coupling Cable - Type AC 56725-1
- 1 - D.C. Power Cable - Type AC 56603-1
- 1 - Coupler Mounting Base, Type CRR
- 1 - Loop and Azimuth Unit, Type CRR.

## METHOD OF TEST

8. The tests herein reported were conducted as nearly as possible in accordance with the governing specifications, reference (c). A visual inspection of workmanship was made, the component parts were examined, and the separate units measured and weighed.

9. In determining the effect of temperature and humidity upon the efficiency of the equipment the coupler unit was placed in a temperature controlled cabinet. A standard signal generator was used to supply a constant R.F. voltage to a transmission line erected within the cabinet so that a constant field strength was provided within the cabinet. A Model RU-6 receiver was used for output observation, being located outside the temperature cabinet. The output was recorded at room temperature, the cabinet sealed and the temperature then varied from  $-30^{\circ}$  to  $50^{\circ}\text{C}$ , the changes in output being recorded. The effect of humidity was noted by the above operation except that the temperature was maintained at  $50^{\circ}\text{C}$  while the relative humidity was varied from 40% to 95%. The unilateral and bilateral ratios and relations were obtained by field observation on broadcasting stations and by the use of the field from

a transmission line. The bilateral directional sensitivity was measured by the use of a transmission line whose radiated field strength was known at a given distance from the line. Acceleration test was made on an accelerometer. Effect of vibration was noted with the equipment mounted upon a vibrating platform.

#### DATA RECORDED DURING TEST

10. Data recorded during the tests in the form of tables, charts and photographs are appended to this report. Data were recorded on the following:

- (a) Unilateral Maximum to Minimum Ratio
- (b) Unilateral Maximum to Bilateral Maximum
- (c) Bilateral Operation
- (d) Power consumption
- (e) Loss due to coupler unit
- (f) Effect of Temperature Variation
- (g) Effect of Humidity Variation
- (h) Frequency Range and Overlap
- (i) Field Operation
- (j) Weights and Dimensions
- (k) Bilateral Directional Sensitivity.

#### DISCUSSION OF PROBABLE ERRORS

11. The accuracy of the bilateral directional sensitivity measurements are within 10%. The measurements of efficiency loss due to temperature and humidity are within 5%. The acceleration recordings are within 25%. All other measurements are within 2%.

#### RESULTS OF TEST

12. In the following paragraphs of the report reference is made to the governing specifications (RE 13A 546B) under which this equipment was constructed. Where no specific reference is made to any particular paragraph it is understood that the equipment under test complies with this paragraph and that no further explanatory remarks are considered necessary.

2-9(1) The equipment performed satisfactorily after being subjected to an acceleration of 8g.

2-9(2) The equipment operated satisfactorily after being subjected to continuous vibration for 4 hours, vibration amplitude from  $1/32''$  to  $3/32''$  at frequencies from 700 to 2200 vibrations per minute.

- 2-9(3) The total loss in efficiency due to a temperature change from  $-30^{\circ}\text{C}$  to  $50^{\circ}\text{C}$  was 13%. The total loss due to variations of relative humidity from 40 to 95% was 17%. The equipment resumed normal operation upon return of temperature and humidity to initial values. Data is contained in Tables 5 and 6.
- 2-9(4) Results of flight tests are contained in report of Naval Air Station, Anacostia, appended to this report.
- 2-13(1) The equipment when operated in the field and in a transmission line radiated field gave no evidence of reverse directional indication.
- 2-13(2) It is not necessary to select the sense antenna.
- 2-15 Excellent Unilateral operation was observed when using various fixed antennas. Results are contained in Table No. 1.
- 2-16 Relatively inexperienced personnel have obtained good practical operation of this equipment.
- 2-17 Two Type 12F7 vacuum tubes are employed.
- 2-18(1) The frequency range 200 to 1600 kcs. is covered by three bands selected by a three point switch located on the front panel. Data on frequency range and frequency band overlap are contained in Table No. 9.

#### CONSTRUCTION

13. The overall height of the equipment exceeds the specifications by  $5/16$  inch; this height should be reduced to conform with that of existing equipment. All other dimensions are within those specified. The weight of the equipment is within that specified.

Table No. 7 contains all dimensions and weights.

- 3-2 The equipment successfully withstood an acceleration of 8g.
- 3-3(4) No evidence of insulation failure occurred during this test.
- 3-4 Commented upon in paragraph 3-2.
- 3-18 The total current drain does not exceed that specified by contract note. Data are contained in Table No. 8.
- 3-19 No protective slip covers were supplied with the equipment.

3-20 The performance of the equipment was within that specified when subjected to conditions of condensation.

3-23 Provision has been made for readily changing the equipment for either 12 or 24 volt operation. A link connection connects the heaters of the two tubes in parallel for 12 volt operation and in series for 24 volt operation. The equipment was received connected for 12 volt operation.

#### Detail Requirements

4-1 The general layout and arrangement of the equipment complies with NAF drawing 214084 except for overall height. The overall height exceeds the specified limit of 17-3/16 inches by 5/16 inch.

4-2 Satisfactory operation over the frequency range 200 to 1600 kcs. was obtained.

4-3 The bilateral directional sensitivity of the equipment is within the specified limits. Data are contained in Table No. 10 and Plate No. 3. The operation of this equipment is decidedly improved over that of the previous Model DU equipment, especially below 500 kcs. where the usable sensitivity of the Model DU-1 is approximately 3 times that of the Model DU. Comparison of sensitivity of the Model DU and DU-1 are contained on Plate No. 4.

4-4 The sensitivity does not vary more than 30% from 600 to 1600 kcs. which is a desirable condition. The decrease in sensitivity below 600 kcs. is due to circuit conditions necessary to cover the low frequency range of 200 kcs.

4-4(1) The overall sensitivity of the equipment over the frequency range 200 to 1600 kcs., measured at the coupler unit is not more than three times that measured at the receiver terminal. Data are contained in Table No. 4.

4-5(1) This specification is complied with when operating in a field strength up to 200,000 microvolts per meter.

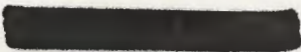
4-5(2) The bilateral signal input to the receiver shows no evidence of antenna effect or stray pick-up, the input being essentially sinusoidal as shown on Plate No. 5.

4-6 Unilateral performance was obtained over the frequency range 200 to 1600 kcs. using antennas as specified.

- 4-6(3) Excellent unilateral operation was obtained over the entire frequency band using antennas whose capacity ranged from 50 to 200 mmf. Unilateral voltage output maximum to minimum ratios in excess of 8 to 1 were readily obtained with but slight readjustment of the gain control. The unilateral ratio could be improved at the extreme ends of the frequency range when using an initial phasing adjustment at 1000 kcs. by slightly detuning the loop circuit. The detuning of the loop circuit to obtain optimum unilateral ratio was not of such magnitude as to effect the sensitivity of the equipment when reverting back to bilateral operation. Data on Unilateral operation are contained in Table 1 and Plates 6 and 7.
- 4-6(4) Unilateral operation is satisfactory without retuning the loop circuit after an initial tuning on bilateral maximum.
- 4-6(5) The relation of the unilateral maximum to the bilateral maximum averages 70%. Data is contained in Table No. 2.
- 4-7 The weight of the equipment complete with detachable mounting base, receiver coupling and power cable is 9 lbs., 10 oz. The weight exclusive of cables is 7 lbs. 8 oz. Weights and dimensions are contained in Table 7.
- 4-8 The dimensions of the equipment are in accordance with NAF drawing 214084 except for height, the equipment exceeding the required height of 17-3/16" by 5/16". This additional height must be reduced to the required height of 17-3/16" so as to allow for installation and rotation of the loop in the type aircraft for which the equipment is intended.

14. Comments are herein made covering reference (b); paragraphs are lettered in accordance with those of reference (b).

- (a) Contractor's vibration test complies with specification.
- (b) Naval Inspector's production inspection. No evidence of warping due to vibration was observed following this test.
- (c) Nickle plated brass rivets are desirable.
- (d) Nickle plated rivets are desirable.
- (e) The equipment operated satisfactorily on either 12 or 24 volt supply. It is necessary to change and resolder connections on four terminals located on bottom of coupler unit. Terminals are properly identified in accordance with instruction book.



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- (f) All weights are contained in letter.
- (g) The use of two pointed cup set screws are adequate for properly securing the control knobs to shaft.
- (h) The present chain appears to be satisfactory.
- (i) A binding post with all metal cap will be satisfactory; the post should incorporate the feature of providing positive contact in event the securing nut becomes loose.
- (j) Present cable marking is considered adequate.
- (k) Lengthening of the phenolic insert should be increased so that the securing holes in the cable's braid will be at least 1/4" from end of cable.
- (l) The INM recommendation is desirable.
- (m) It appears that the loop construction is satisfactory.
- (n) A three conductor cable similar to that used on the equipment is listed on NAF drawing 47024-304.
- (o) The receiver to coupler cable is satisfactory for its intended use provided the phenolic cap used at the receiver end of the cable is modified as previously requested.
- (p) Final instruction books should be supplied with production equipment.
- (q) Circuit symbols must be affixed to production equipment.
- (r) The specifications requiring that the band overlap shall be 5% has been interpreted correctly by the manufacturer and provided for in the equipments frequency bands.
- (s) The wording of the instruction plate for R-B-D operation is considered correct with the exception that the word "indicator" be changed to "arrow."
- (t) The INM recommendation is desirable.
- (u) All electrical joints must be mechanically secured before soldering and the soldering shall be properly made.
- (v) The INM suggestion is practicable as this will prevent unnecessary breakage of contacts.
- (w) The use of spaghetti is permissible provided the type used is non-inflammable.

(x) The painting of the loop appears to be in accordance with existing equipment and is therefore satisfactory.

### CONCLUSIONS

The Model DU-1 Equipment having satisfactorily met the requirements of reference (c) with but few exceptions, is considered suitable for use in Naval Aircraft provided the following exceptions are corrected.

(a) The power switch does not function properly at temperatures below  $-10^{\circ}\text{C}$ .

(b) The overall height of the equipment exceeds the specifications by  $5/16$  inch.

(c) The termination of the receiver coupling cable at the receiver end is unsatisfactory.

" The equipment satisfactorily met the requirements of reference (c) on the following:

Bilateral Directional Sensitivity.

Frequency Range and Overlap.

Efficiency Loss Due to Humidity Variations.

Efficiency Loss Due to Temperature Variations.

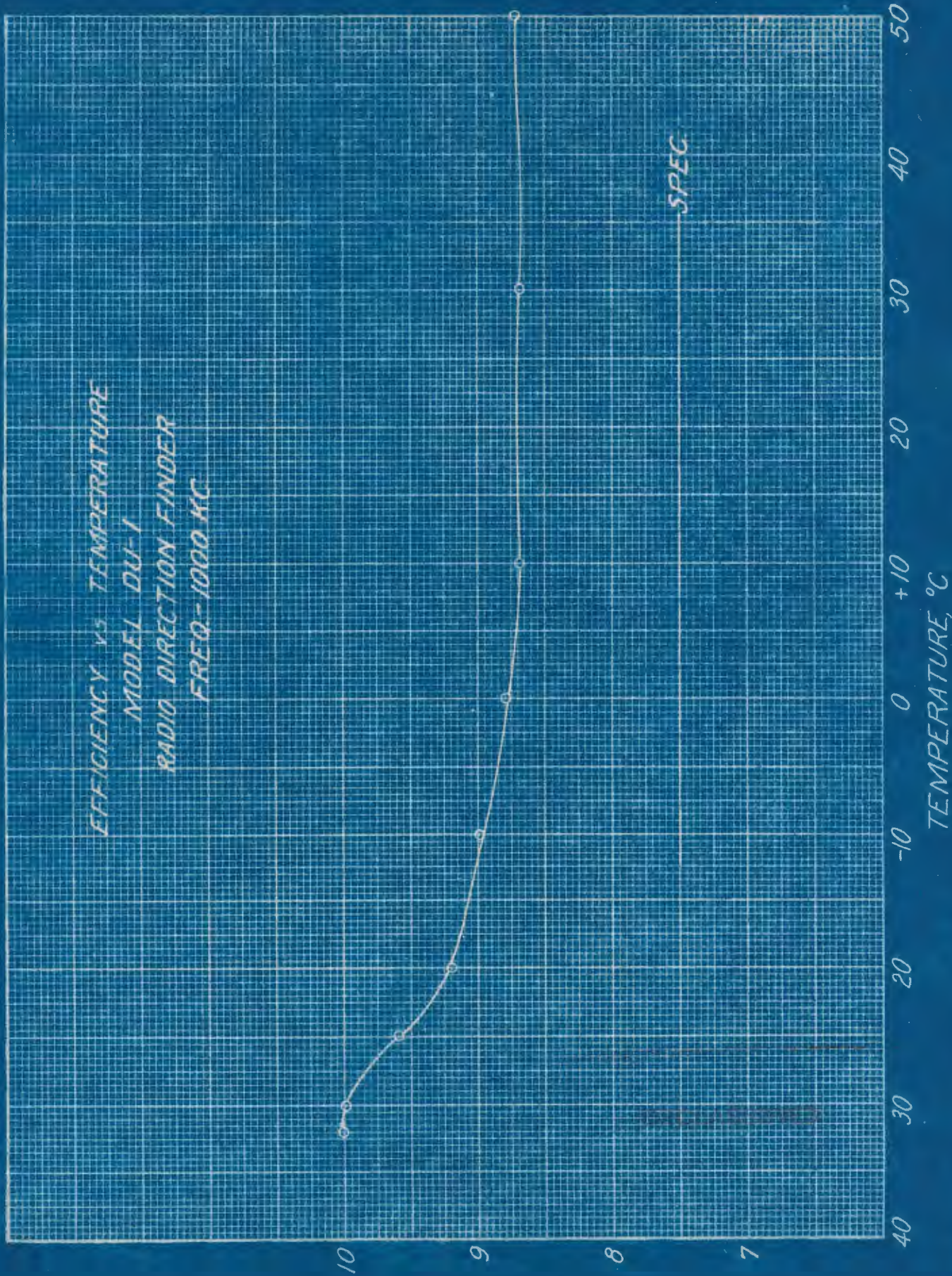
Power Consumption.

Sensitivity Loss Due to Coupler Unit.

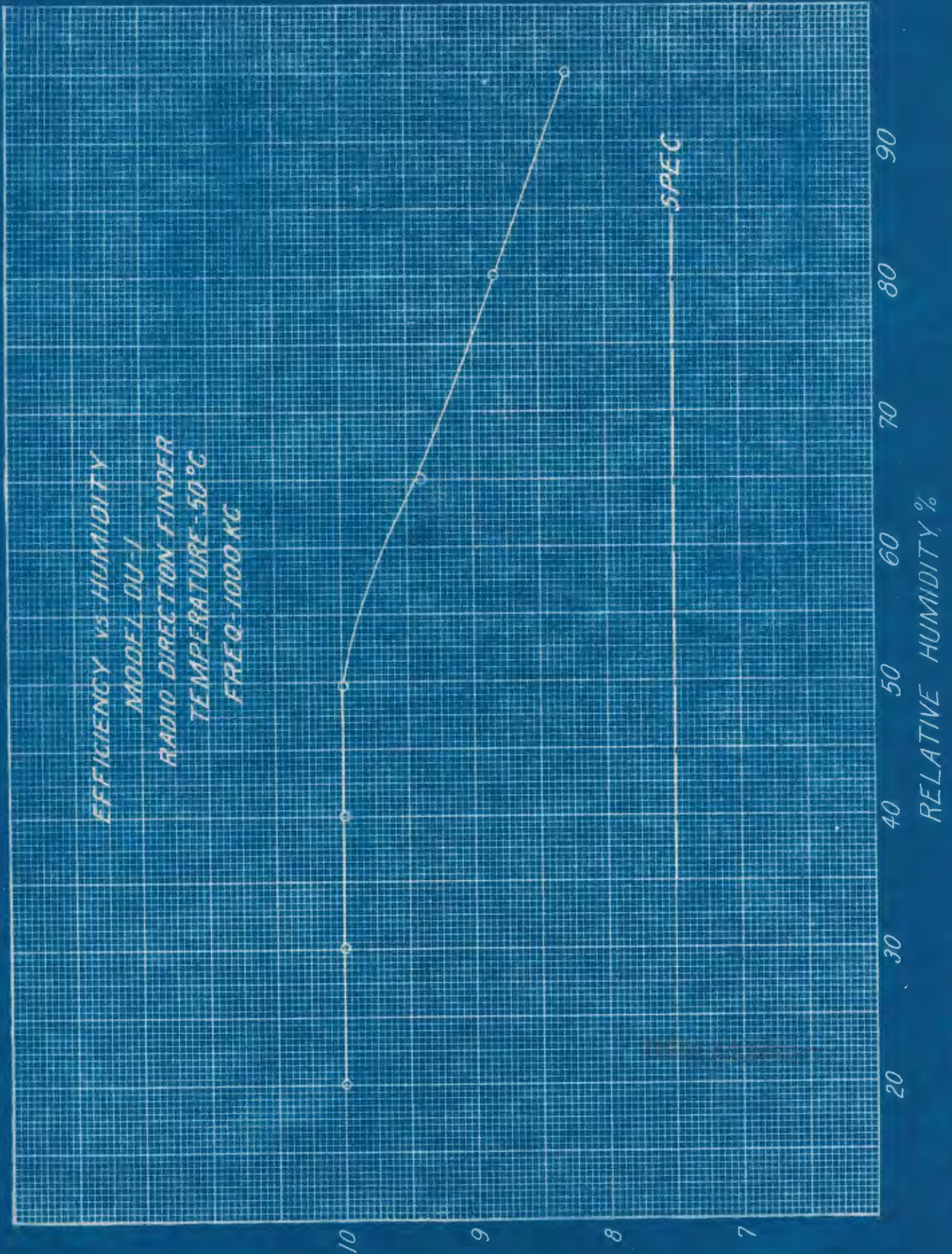
Unilateral Operation.

Bilateral Operation.

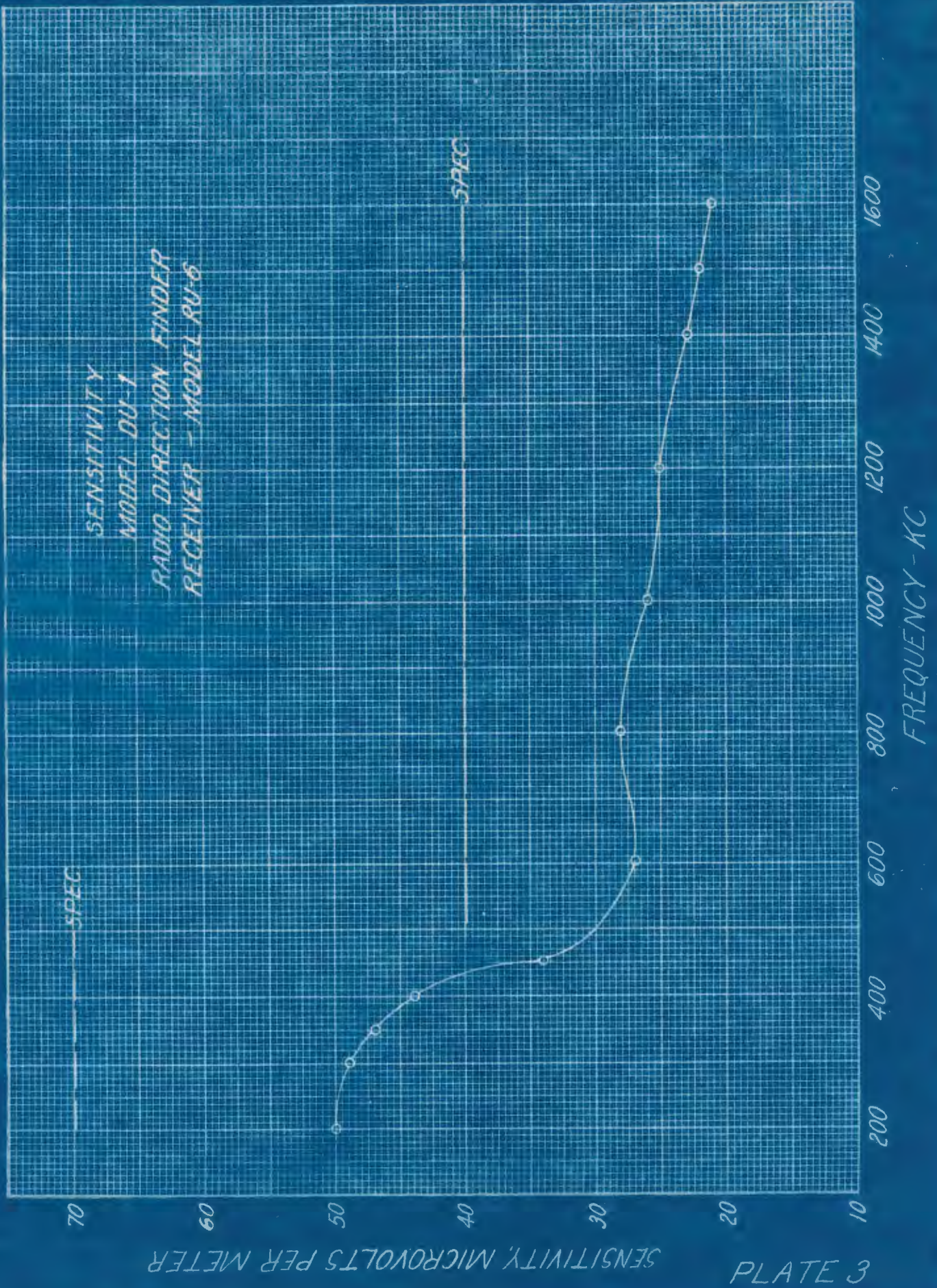
N. R. L. 84A



N. R. L. 34A



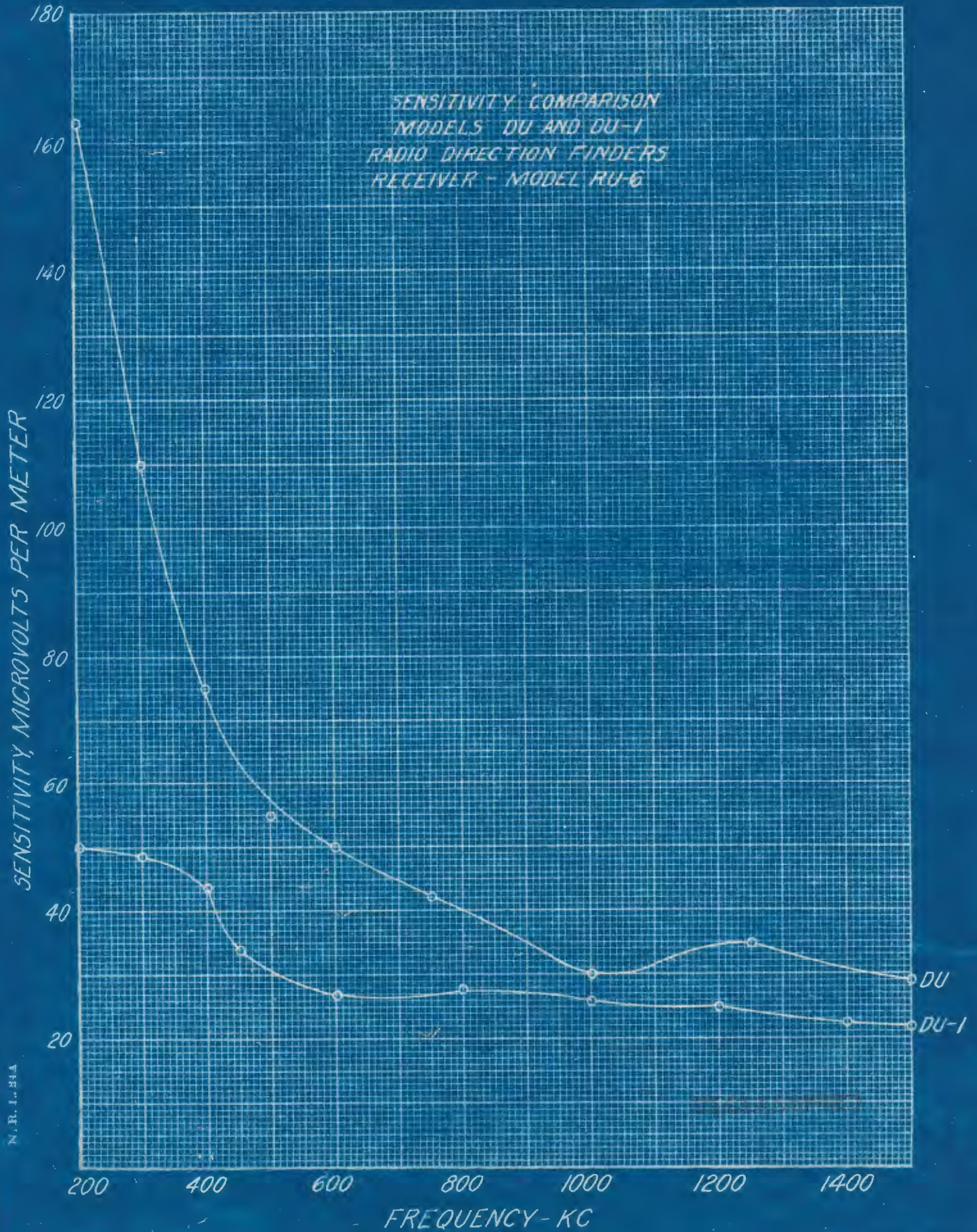
N R 1 344



SENSITIVITY, MICROVOLTS PER METER

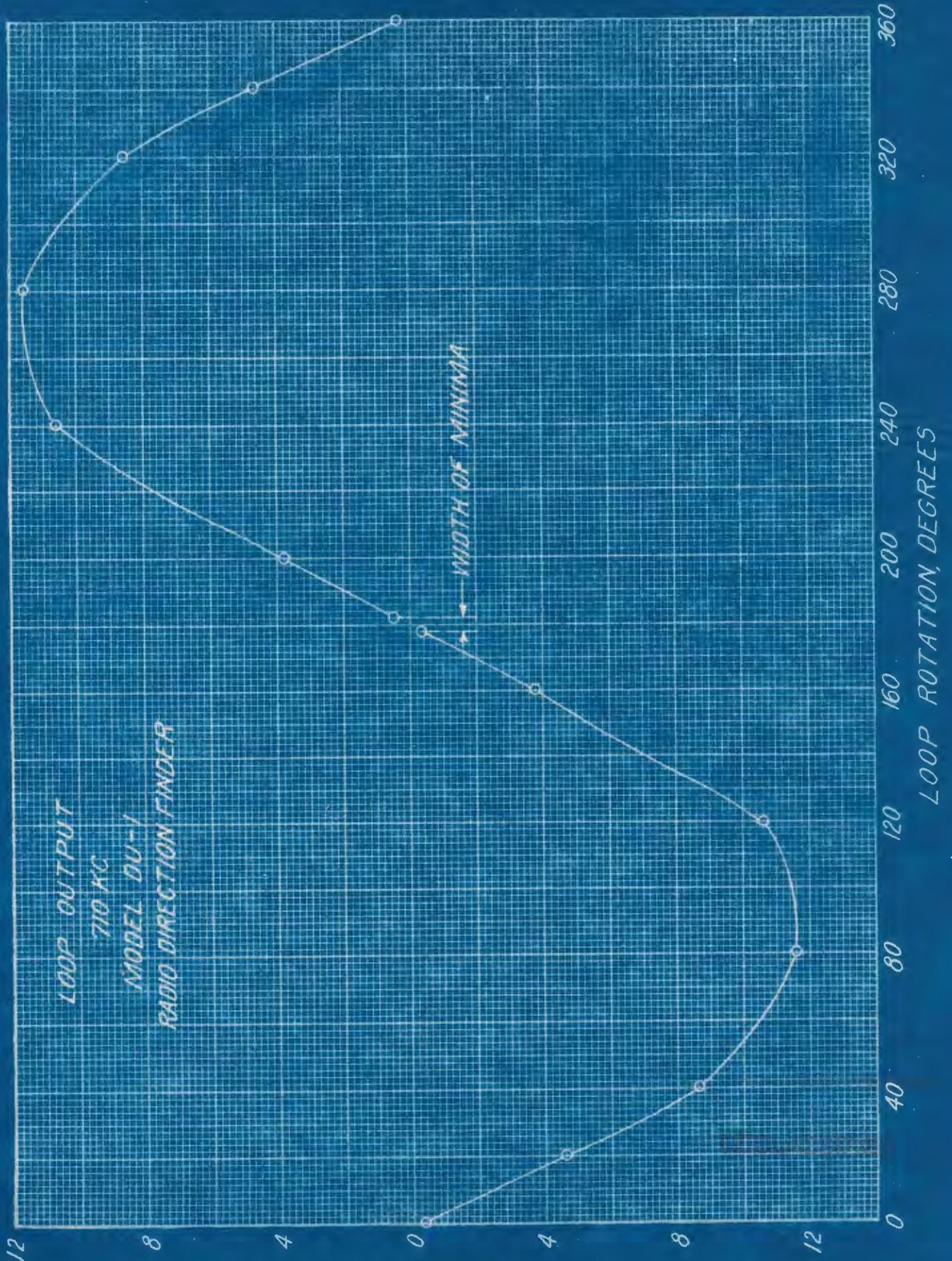
PLATE 3

FREQUENCY - KC



N. R. L. 34A

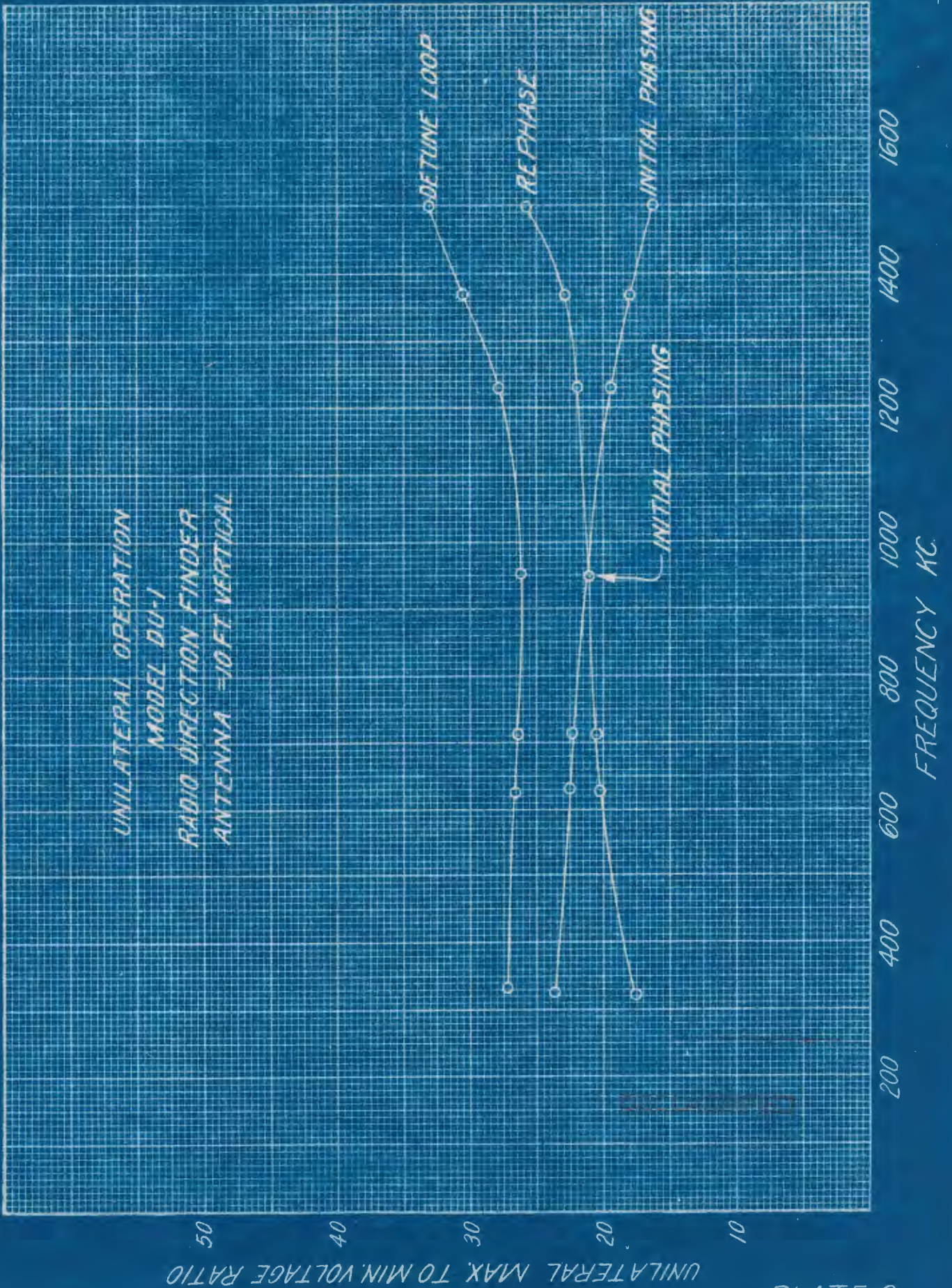
N. R. L. 34A



OUTPUT VOLTS

PLATE 5

N. R. L. 34A



30°  
330°

20°  
340°

10°  
350°



350°  
10°

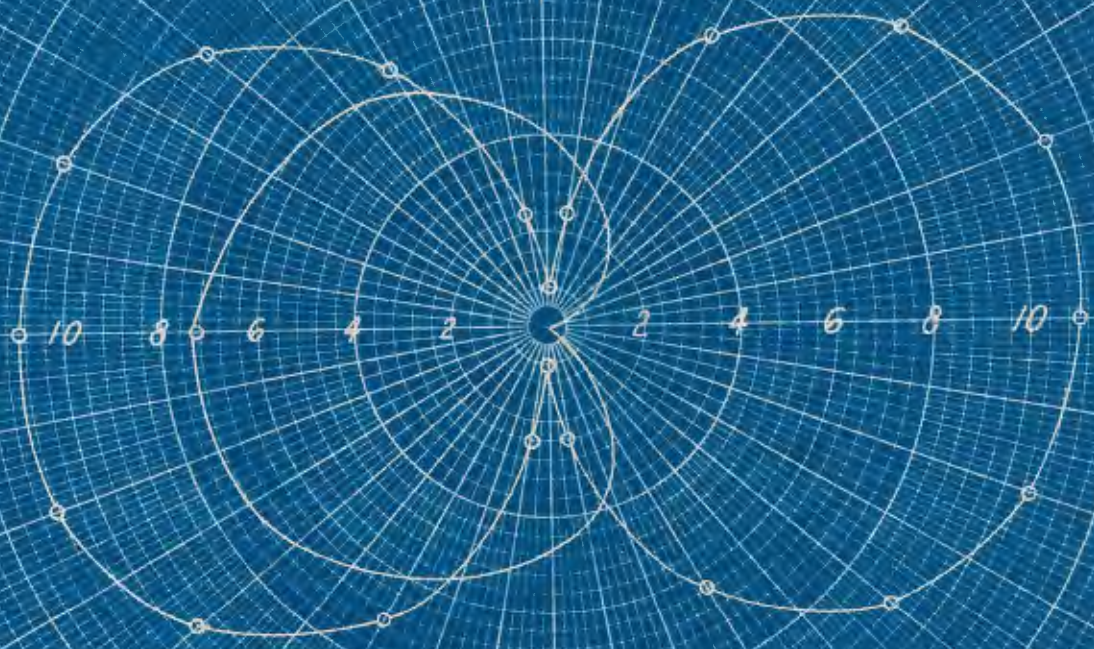
340°  
20°

330°  
30°

MODEL DU-1  
RADIO DIRECTION FINDER  
BILATERAL-UNILATERAL PATTERN  
710 KC

40°  
320°  
50°  
310°  
60°  
300°  
70°  
290°  
80°  
280°  
90°  
270°  
100°  
260°  
110°  
250°  
120°  
240°  
130°  
230°  
140°  
220°

320°  
40°  
310°  
50°  
300°  
60°  
290°  
70°  
280°  
80°  
270°  
90°  
260°  
100°  
250°  
110°  
240°  
120°  
230°  
130°  
220°  
140°



LOOP ROTATION, DEGREES

150°  
10

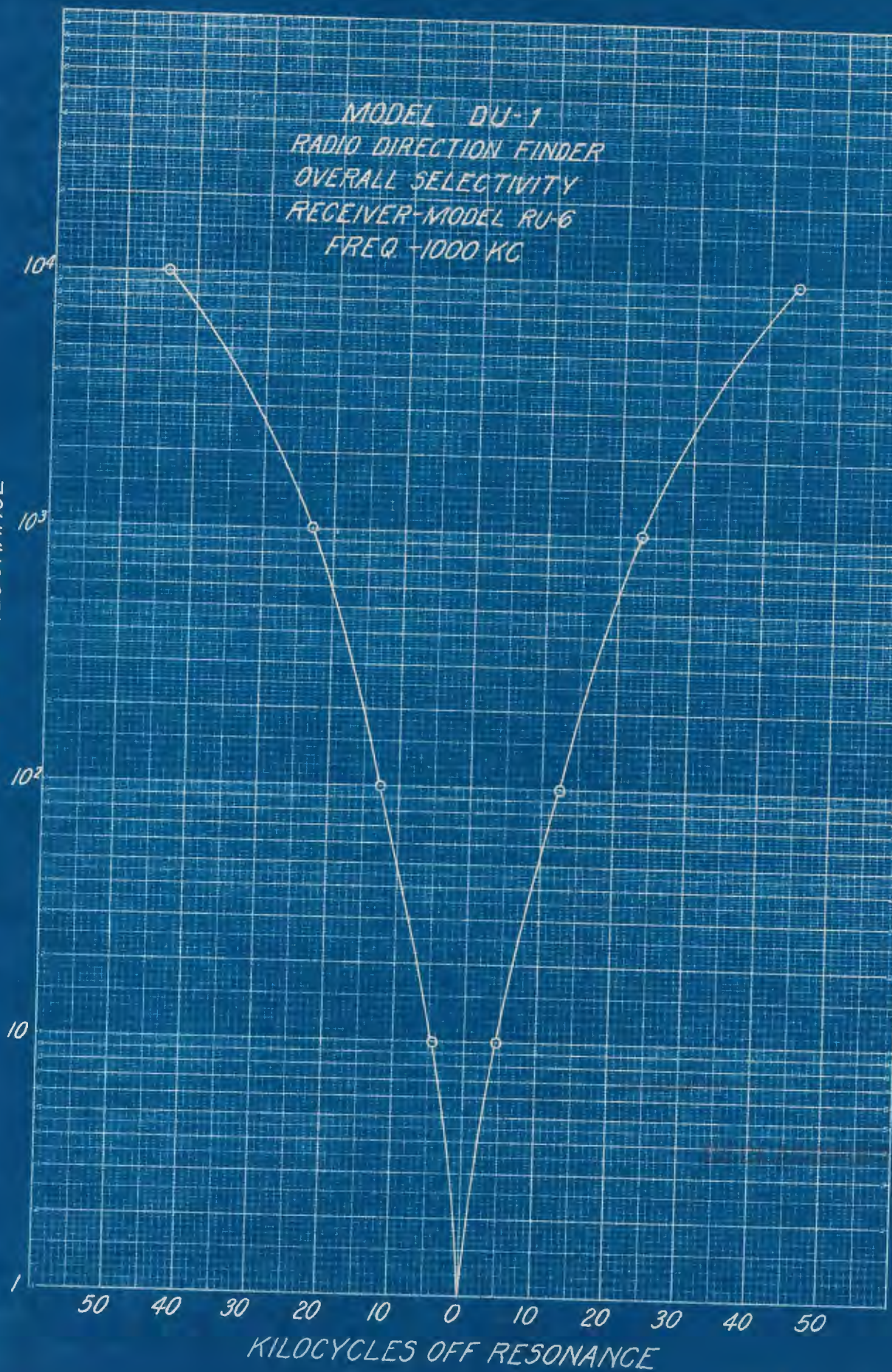
160°  
200

190°  
170

10°  
150°

MODEL DU-1  
RADIO DIRECTION FINDER  
OVERALL SELECTIVITY  
RECEIVER-MODEL RU-6  
FREQ. -1000 KC

$$\text{RATIO} = \frac{\text{INPUT OFF RESONANCE}}{\text{INPUT AT RESONANCE}}$$



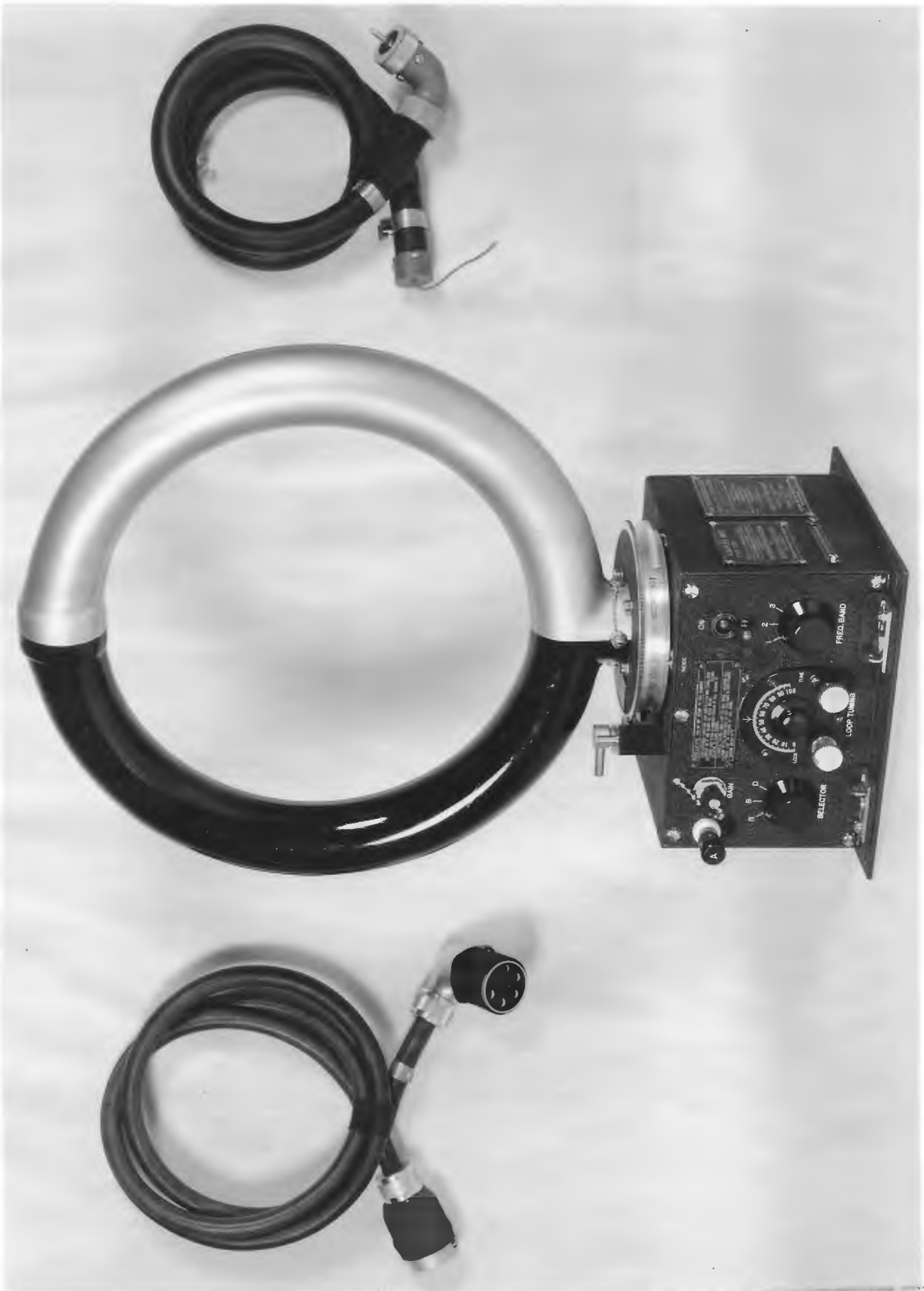
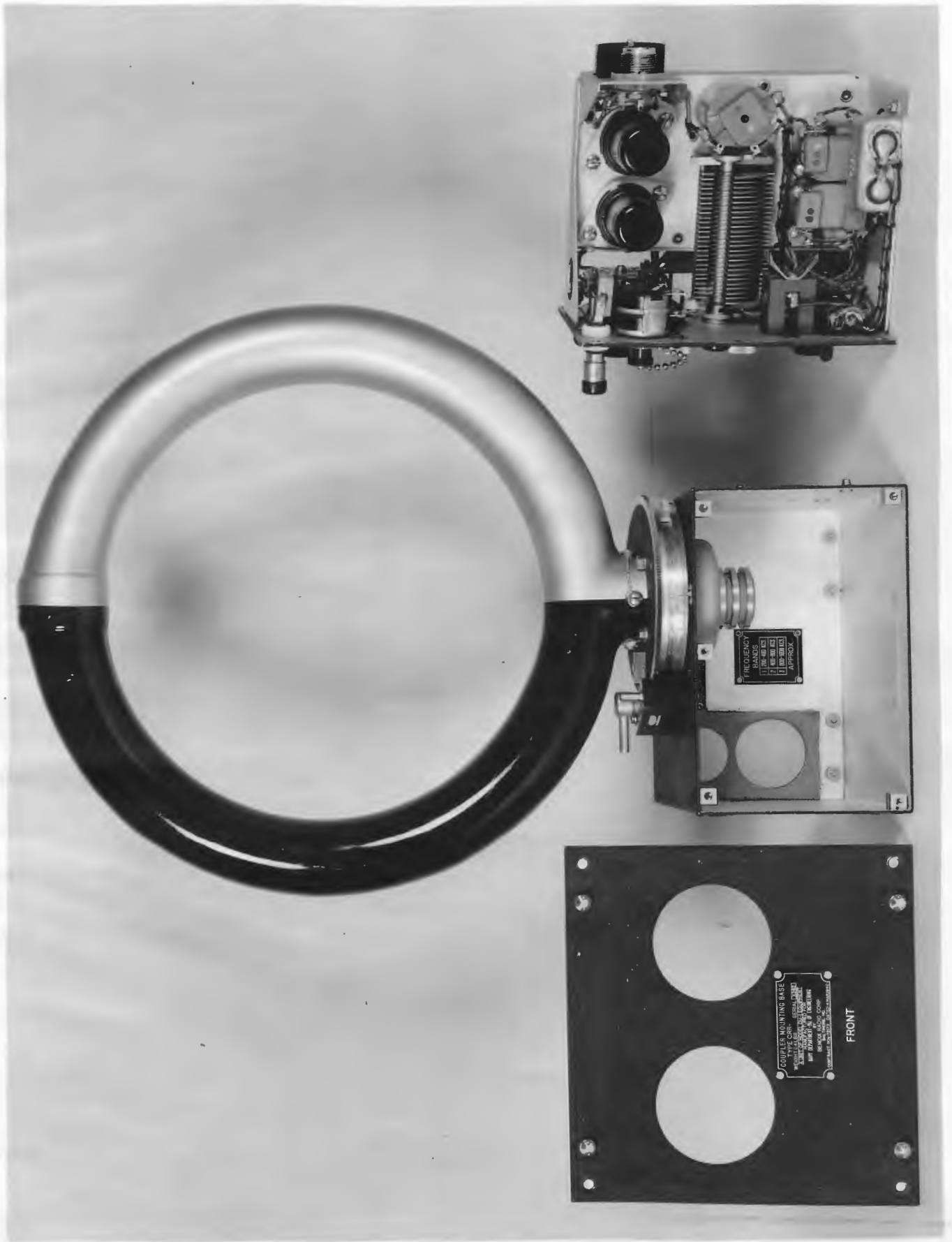


Plate 9

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FREQUENCY  
1.5-3.0 MC  
1.5-3.0 MC  
APPROX.

COUPLER MOUNTING BASE  
DESIGNED BY  
RADIO SHOCK COMPANY  
1000 W. 10TH ST. ST. LOUIS, MO.  
MFG. IN U.S.A.

FRONT

Refer to No. NAG/F42-1/69 U. S. NAVAL AIR STATION  
(1)(232) Anacostia, D. C.  
Serial 40082

JCL:cc

From: Commanding Officer.  
To: Director, Naval Research Laboratory.  
Subject: Aircraft Radio - Confidential Contract NOs 72173 with Bendix Radio Corp. for Model DU-1 and DW-1 Direction Finders - Test of Preliminary Model XDU-1 equipment - Report on.  
Reference: (a) BuEng ltr. C-NOs 72173 (5-23-DRI) of June 5, 1940.  
(b) BuEng Specifications RE 13A 546B.

1. Subject equipment arrived at this station on 5 June from the Naval Research Laboratory and flight tests were begun as soon as a plane was available. Six flights including one to an altitude of 22,000 feet were made in BT-1 airplane #0630. Tests were made in conjunction with both RU series and type K receivers.

2. DIMENSIONS and WEIGHTS.

The overall dimensions and weight of the subject equipment is as follows:

	<u>Height</u>	<u>Width</u>	<u>Depth</u>	<u>Weight</u>
Loop, Loop Azimuth scale, Coupler Unit and Mounting Base	17 13/32	12" (Loop Dia.)	6 13/16	7.4
Power Cable	60" long			1.3
Receiver Coupling Cable	36" long			0.9

Overall and mounting dimensions are in accordance with NAF drawing 214084 shown on page 38 B of reference (b) with one exception. The overall height of the model XDU-1 is 17 13/32 inches instead of the required 17 3/16 inches. Previous direction finders of this series are built with an overall height of 17 3/16 inches and the mounting restrictions in the various airplanes are such that this dimension must not be exceeded in production model DU-1 equipments.

3. PERFORMANCE.

Satisfactory bilateral and unilateral operation was obtained in flight throughout the frequency range. Satisfactory unilateral operation was obtained with the fixed antenna on the BT-1 airplane and also with trailing antennas up to 150 feet.

4. DEFICIENCIES.

(a) Overall height of loop and coupler unit is 17 13/32 inches instead of 17 3/16.

Refer to No. NA6/F42-1/69  
(1)(232)  
Serial 40082

JCL:cc

Subject: Aircraft Radio - Confidential Contract NOs 72173 with  
Bendix Radio Corp. for Model DU-1 and DW-1 Direction  
Finders - Test of Preliminary Model XDU-1 equipment -  
Report on.

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(b) The phenolic termination on the receiver end of the receiver coupling cable lacks the necessary depth to secure it properly to the cable.

(c) On the D.C. power cable, the method used to secure the straight plug to the cable is similar to that used on the model GQ equipment. Several instances of trouble have developed with this design during the service use of the model GQ equipment. The difficulty is that the shell of the plug can be stripped over the shoulder of the ferrule which secures the plug to the cable.

5. CONCLUSION.

Flight tests have indicated the equipment to be suitable for service use provided the deficiencies of the preceding paragraph are corrected.

(Signed) S. P. GINDER

Copy to: BuEng  
BuAero

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[REDACTED]

TABLE 1

Unilateral Operation  
Various Sense Antennas

<u>Freq. Kcs.</u>	50 Micromicrofarad Capacity		<u>Unilateral Max/Min Ratio</u>
	<u>Unilateral Maximum</u>	<u>Unilateral Minimum</u>	
250	10	.45	22
500	10	.35	28
750	10	.20	50
1000	10	.20	50
1250	10	.35	28
1500	10	.37	27

100 Micromicrofarad Capacity

250	10	.60	16
500	10	.45	22
750	10	.25	40
1000	10	.25	40
1250	10	.30	33
1500	10	.40	25

200 Micromicrofarad Capacity

250	10	.45	22
500	10	.40	25
750	10	.25	40
1000	10	.25	40
1250	10	.35	28
1500	10	.50	20

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TABLE 2

Unilateral Operation  
Unilateral Maximum to Bilateral Maximum

<u>Freq.</u>	<u>Unilat.Max.</u>	<u>Bilat.Max.</u>	<u>Unilat.Max. of Bilat.Max.</u>
250	7.1	10	71%
500	6.8	10	68%
750	8.4	10	84%
1000	7.3	10	73%
1250	6.2	10	62%
1500	6.7	10	67%

TABLE 3

Bilateral Operation  
Bilateral Maximum to Minimum

<u>Freq.</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Max/Min Ratio</u>
250	16.5	.25	66
500	4.0	.10	40
750	5.1	.30	17
1000	14.0	.39	36
1250	10.0	.35	28
1500	5.0	.11	45

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TABLE 4

Loss in Coupler Unit

<u>Freq.KCs.</u>	<u>Receiver Output</u>	<u>Receiver Input Sensitivity</u>	<u>Coupler Input Sensitivity</u>	<u>Coupler Receiver</u>
250	50 MW	10 MW	24 MW	2.4
500	50 "	6.5 "	11.7 "	1.8
750	50 "	5.3 "	8.5 "	1.6
1000	50 "	5.0 "	8.3 "	1.66
1250	50 "	4.7 "	8.4 "	1.78
1500	50 "	4.2 "	7.7 "	1.83

TABLE 5

Efficiency Loss Due to Temperature  
Frequency -1000 KCs.

<u>Temp. °C</u>	<u>Output Volts</u>	<u>Percent Loss</u>
- 30	10	0
- 25	9.6	4
- 20	9.2	8
- 10	9.0	10
0	8.8	12
10	8.7	13
20	8.7	13
30	8.7	13
40	8.7	13
50	8.7	13

Specification: Not more than 25%.

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TABLE 6

Efficiency Loss Due to Humidity  
Frequency - 1000 KCs.  
Temperature - 50°C

<u>Per Cent Relative Humidity</u>	<u>Output Volts</u>	<u>Per Cent Loss</u>
20	10	0
30	10	0
40	10	0
50	10	0
60	9.7	3
70	9.2	8
80	8.8	12
95	8.3	17

TABLE 7

Weights and Dimensions

(a) Weights

Loop Coupler Unit	7 lbs. 8 oz.
Receiver Coupling Cable	14 oz.
Power Cable	1 lb. 4 oz.
Total Weight	9 lbs. 10 oz.

(b) Dimensions

Overall Height	17 1/2 inches
Coupler Unit Width	6 7/8 inches
Coupler Unit Depth	6-13/16 inches
Coupler Unit Depth with Cables	8 inches
Length of Receiver Cable	36-1/2 inches
Length of Power Cable	63-1/2 inches

Specifications: Overall height requirement by NAF  
drwg. 214084 is 17-3/16 inches,  
equipment is 5/16 inch over.

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TABLE 8

Power Consumption

12 volts                      24 volts  
0.3 amperes                  0.15 amperes

200 volts  
14.3 Milliamperes

TABLE 9

Frequency Range and Overlap

Band	<u>Freq. KCs.</u>		Band Width KCs.	Overlap KCs.	Overlap %
	Min.	Max.			
1	193	412	219		
2	388	880	492	24	11
3	772	1720	948	108	22

TABLE 10

Bilateral Directional Sensitivity

<u>Freq. KCs.</u>	<u>Sensitivity Micro-</u> <u>volts per Meter</u>
200	50
300	47
400	44
500	31
600	27
700	27
800	28
900	27
1000	26
1100	25
1200	25
1300	24
1400	23
1500	22
1600	21

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