Flight trials of cascode preamplifier for MZPI

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FLIGHT TRIALS OF CASCODE PREAMPLIFIER FOR MZPI

BY

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OTTAWA

NOVEMBER 1950

ABSTRACT

Flight trials of the MZPI (A.A. No.4 Mk.VI) have been carried out to evaluate the performance of the cascode preamplifier and to investigate qualitatively the nature of the radar echo from a jet aircraft. The predicted improvement of 23 per cent in range has been confirmed within the limits attainable when using aircraft as targets. Charts are presented which illustrate the characteristics of the echo from a Vampire and a Dakota aircraft under various conditions.

CONTENTS

ILLUSTRATIONS

FLIGHT TRIALS OF CASCODE PREAMPLIFIER FOR MZPI

I. INTRODUCTION

As reported previously[1] an experimental preamplifier has been designed to reduce the over-all noise figure of the Canadian MZPI (A.A. No.4, Mk.VI) from about 14 to 10.4 decibels.

A range improvement of 23 per cent would be expected under certain simplifying assumptions. These are, first, that the target remain at a constant angle of elevation from the radar, and, second, that the effective echoing area of the target remain constant. Neither of these assumptions is valid for an aircraft flying at constant altitude, and hence flight trials were undertaken in conjunction with the Directorate of Armament Development to determine to what extent the expected increase in range would be realized in practice. A further objective of the trials was to obtain information on the strength and reliability of the radar echoes received from a typical jet fighter (Vampire) at various altitudes.

This report describes the results of these trials. The work was done on behalf of the Directorate of Armament Development. The Directorate was responsible for liaison with the Royal Canadian Air Force, and for over-all direction of the flight trials. Captain D.C. Badenoch was the official observer from D.A.D.

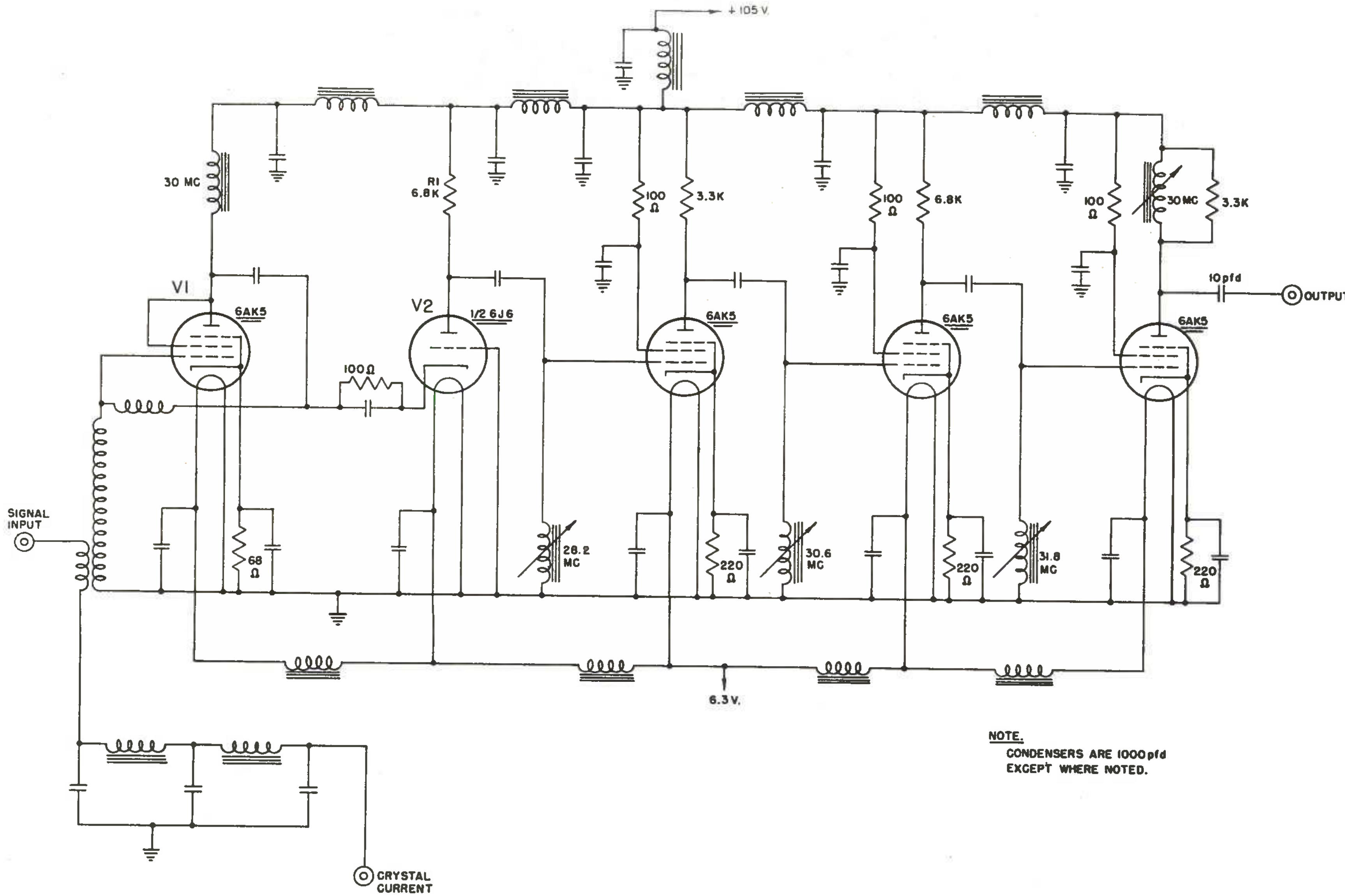
II. BRIEF DESCRIPTION OF NEW PREAMPLIFIER

(1) General

Fig.1 is a schematic of the cascode preamplifier. V_1 and V_2 comprise the cascode input stage, essentially as described by Wallman, MacNee and Gadsen[2]. The input coil resonates below 30 megacycles for best noise factor. The remainder of the amplifier is a flat-staggered triple which has been modified to compensate for the frequency characteristics of the input circuit. The measured frequency response of the preamplifier is given in Fig.2, while Fig.3 shows the over-all frequency response of the preamplifier plus the original main amplifier. The broken line in Fig.3 is the measured over-all characteristic using the original preamplifier. The difference is not significant.

(2) Comparison of Staggered and Synchronous Single-tuned Design

The schematic of the earlier cascode preamplifier is shown in Fig.10 of Reference (1). No staggering was used, and the 6-decibel bandwidth of the preamplifier was 1.9 megacycles. (Research Enterprises, Limited, test specification TI-1114 requires that the 6-decibel bandwidth be between 2.7 and 3.3 megacycles.) The bandwidth may be increased to 3 megacycles by the use of 1.8K load resistors, adequate gain being available.



CASCODE PREAMPLIFIER SCHEMATIC

FIG. 1

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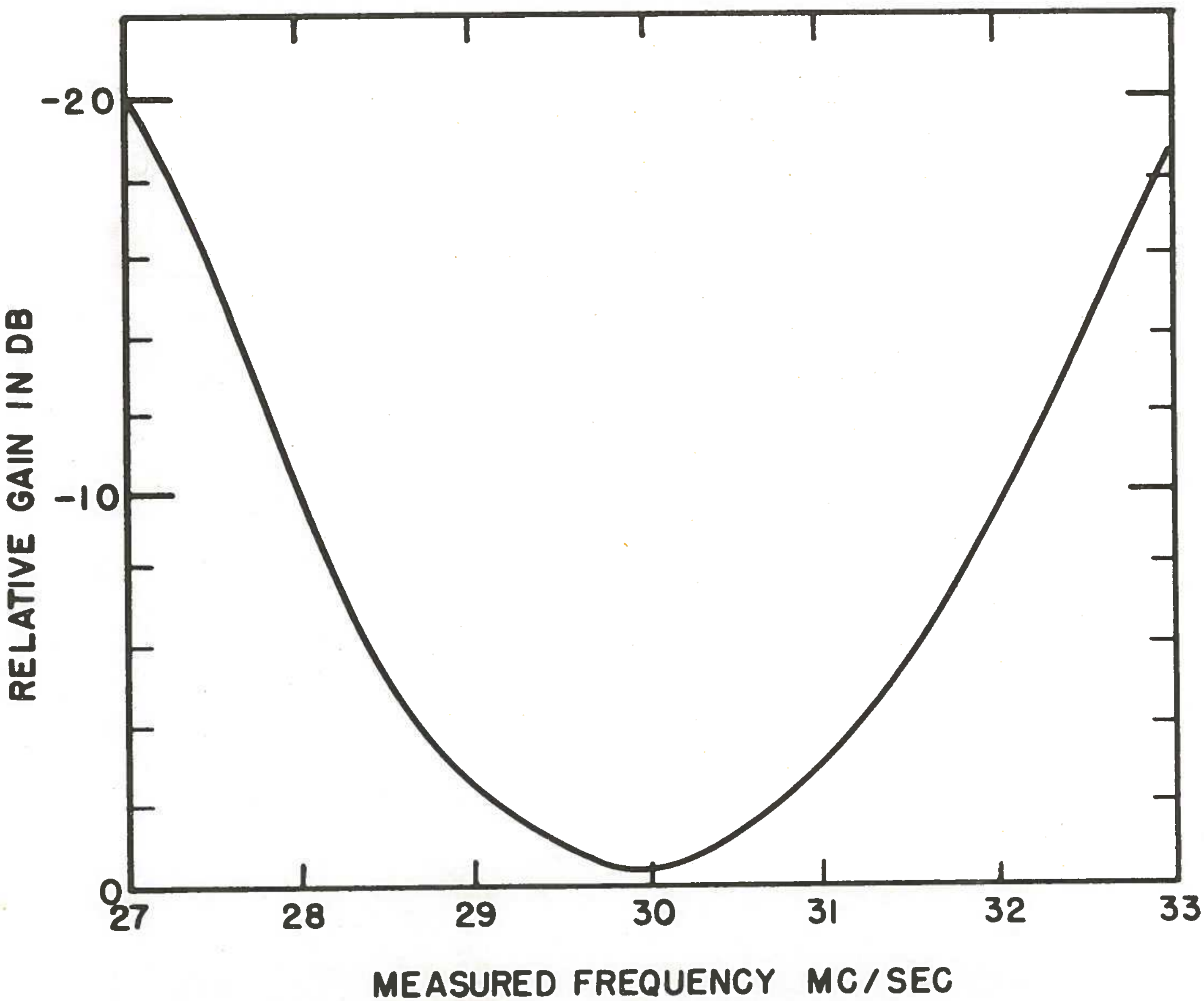

MEASURED FREQUENCY RESPONSE, CASCODE PREAMPLIFIER

FIG. 2

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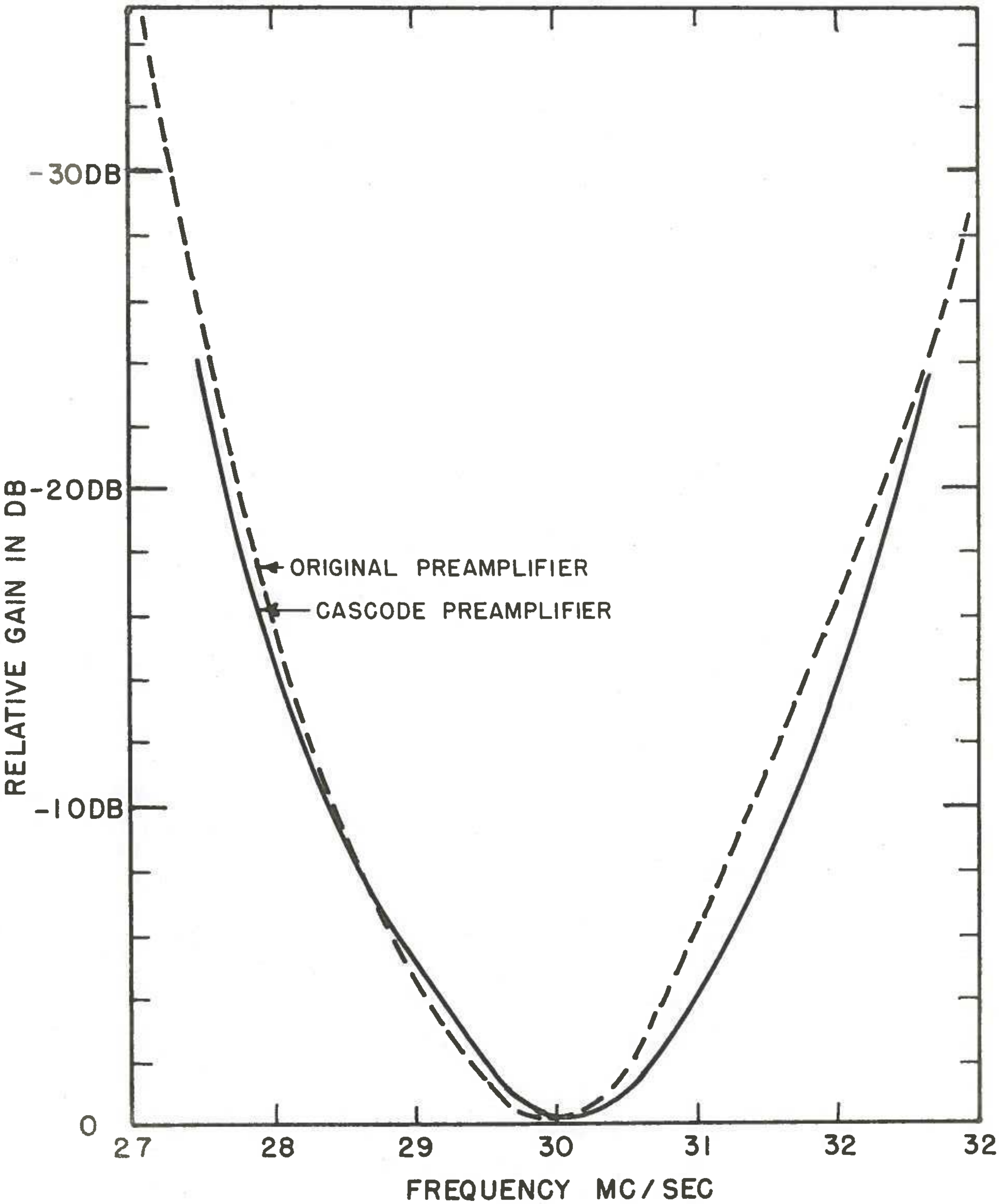

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MEASURED OVERALL FREQUENCY RESPONSE
PREAMPLIFIER PLUS MAIN AMPLIFIER

FIG. 3

Slightly better performance was apparently obtained with the staggered design. This has not been established definitely, but the staggered circuit has been adopted in order to save time. It will have slightly better performance under conditions of jamming.

It will be noted from Fig.1 that the gain control circuit has been eliminated. All flight trials were made with this control set at zero bias, and this has confirmed that the original method of control is satisfactory for the new preamplifier.

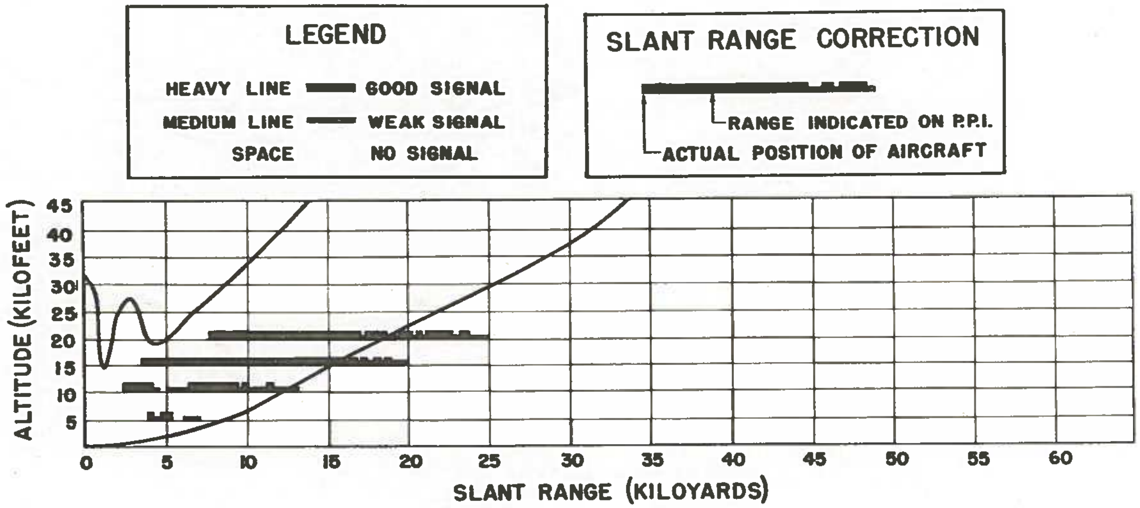
III. PROCEDURE

A site at the Metcalfe Road Field Station of the National Research Council was chosen for the trials. This site was flat and reasonably free from obstructions. Most of the flights were made to the south where the angle of elevation to the tops of the trees is approximately 1.5°.

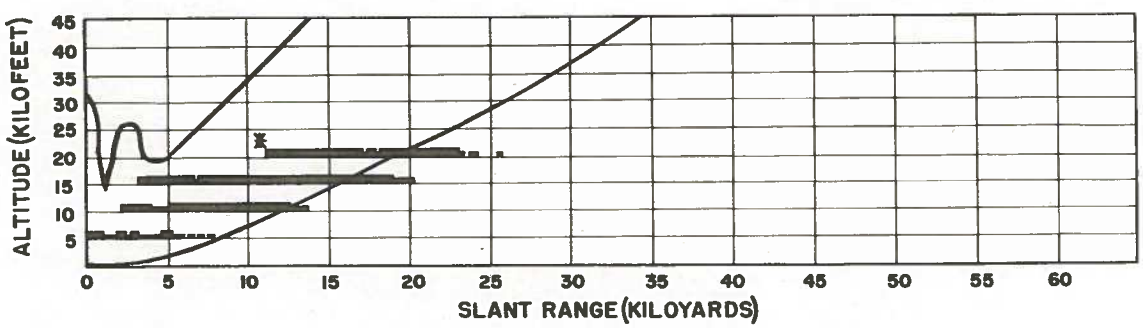
The flight trials were carried out in three stages. For the first series of tests the pilot was instructed to fly over the site at the chosen altitude and the aircraft was tracked on the MZPI with the new preamplifier installed. The returned signal from the aircraft for each revolution of the antenna was recorded as "strong", "weak", or "no signal". (The method of recording is described in Appendix I.) When radar contact was lost the pilot was instructed to return towards the radar and the signal was recorded in the same way for the return flight. Flights with a Dakota aircraft were made at altitudes of 5, 10, 15, and 20 thousand feet using the high and medium beams. The results of these trials are plotted in Figs. 4 and 5. They are also presented in tabular form (Tables II and III) and summarized in the histogram of Fig. 14(b). Fig.6 and Fig.7 illustrate similar trials made with the old preamplifier during the work described in Reference (4).

For the second group of trials the pilot of the aircraft was instructed to fly over the site at a selected altitude and tracked as before on both the outward and return trip with the old preamplifier in the MZPI. Immediately on the conclusion of the flight the new preamplifier was substituted for the original and the flight was repeated. In this way the conditions for the two preamplifiers were made as nearly identical as possible. The results of these trials are plotted in Figs. 8, 9, and 10. They are presented in tabular form in Tables IV to VI, and summarized in histogram Figs. 12(a), 12(b) and 13(a).

The third group of tests was undertaken to ensure that the results did not depend on a particular property of the receiver crystal employed — e.g., an abnormally low noise temperature ratio. The tests were conducted in the same manner as the second group, except that the target aircraft flew only at an altitude of 20,000 feet. After each pair of comparative flights the receiver crystal was changed. Four



DAKOTA AIRCRAFT RECEDING



DAKOTA AIRCRAFT APPROACHING

COVERAGE OF MZPI ON HIGH BEAM WITH NEW PREAMPLIFIER

* OFF COURSE — AIRCRAFT DID NOT APPROACH CLOSER THAN 11,000 YARDS

Fig. 4

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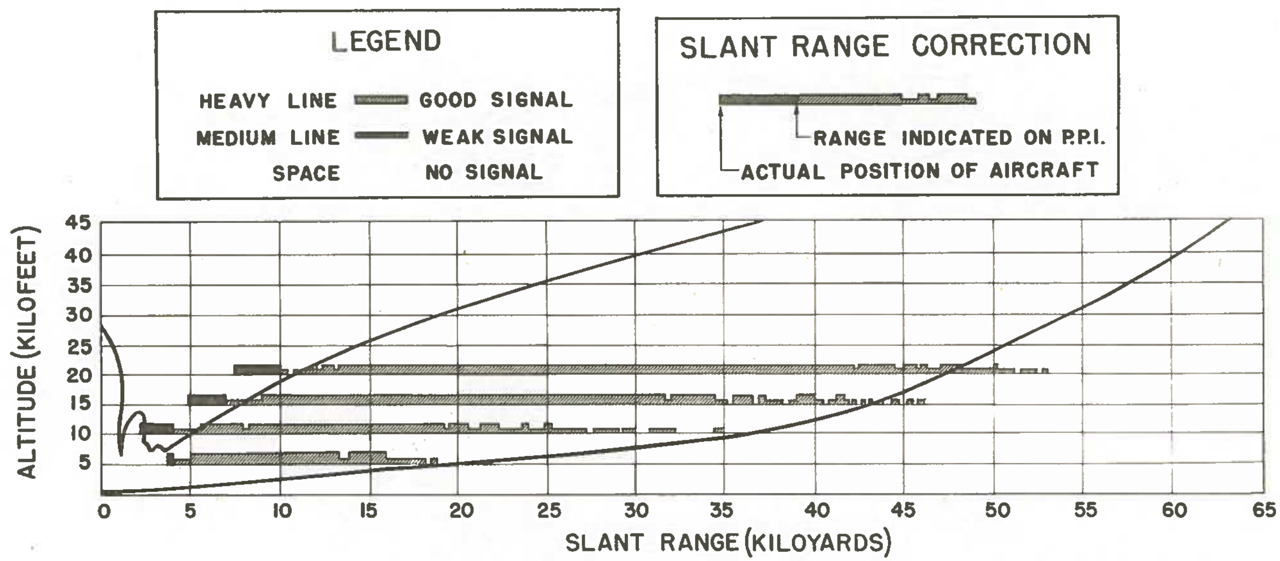
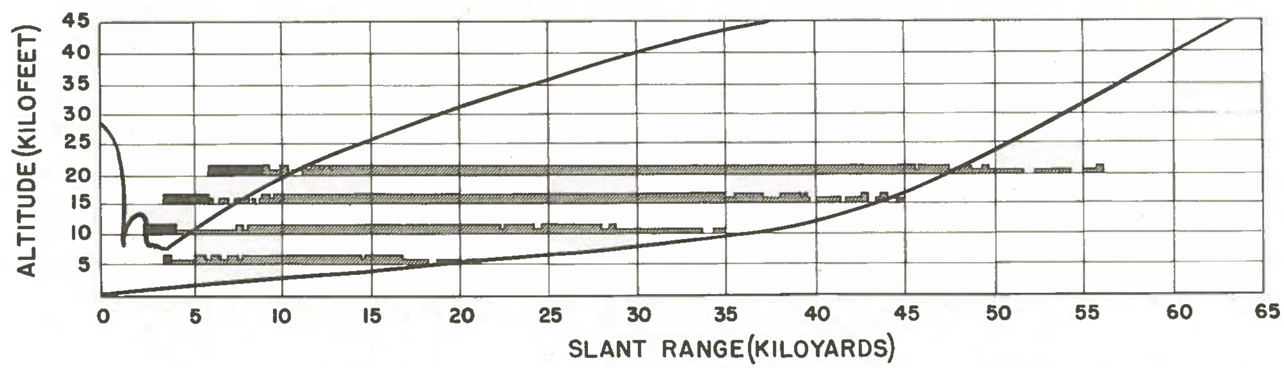


COVERAGE OF M Z P I MEDIUM BEAM WITH NEW PREAMPLIFIER

DAKOTA AIRCRAFT RECEDING



COVERAGE OF M Z P I MEDIUM BEAM WITH NEW PREAMPLIFIER

DAKOTA AIRCRAFT APPROACHING

Fig. 5

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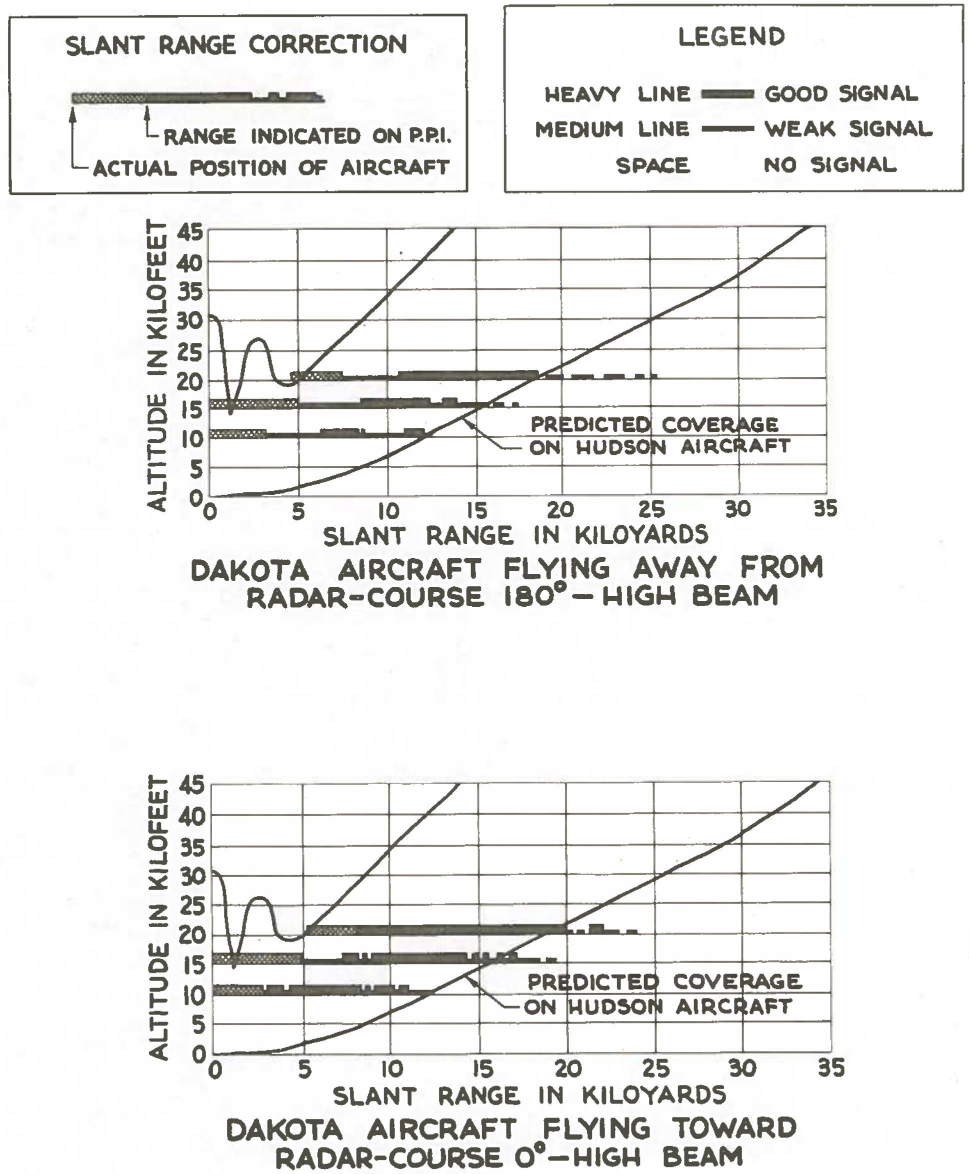

COVERAGE OF MZPI ON HIGH BEAM WITH OLD PREAMPLIFIER

Fig. 6

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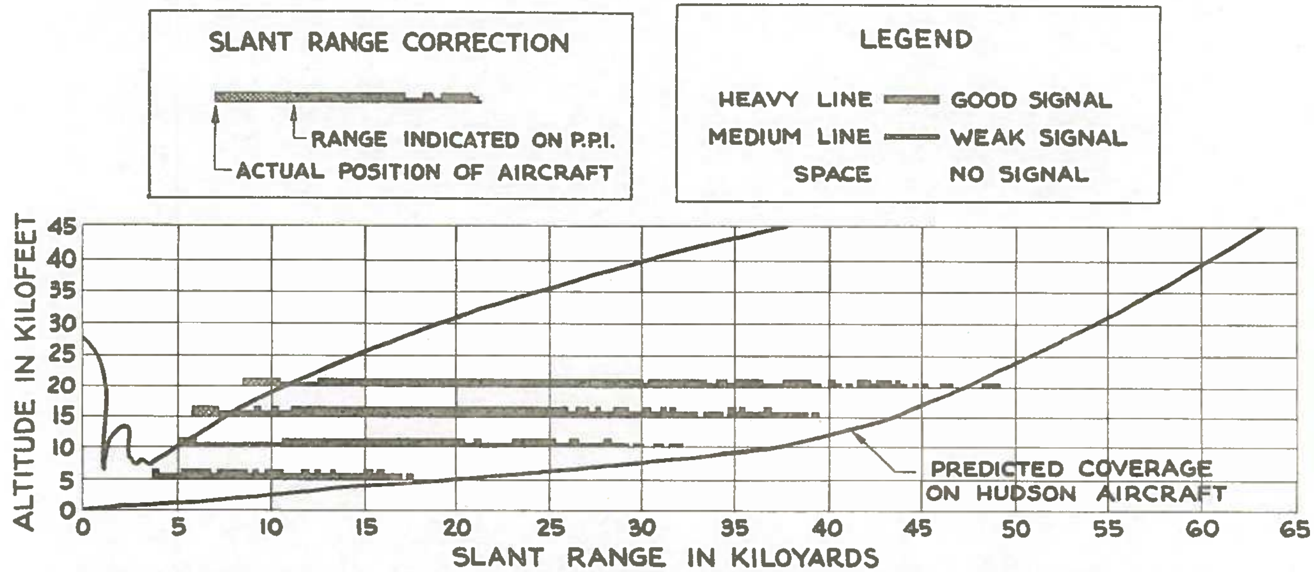
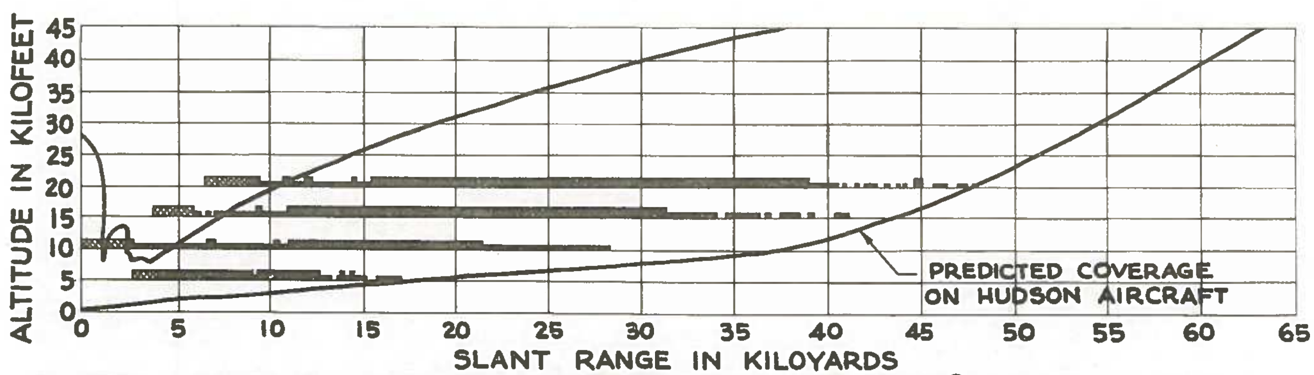


DAKOTA AIRCRAFT FLYING AWAY FROM RADAR-COURSE 180°—MEDIUM BEAM



DAKOTA AIRCRAFT FLYING TOWARD RADAR-COURSE 0°—MEDIUM BEAM

COVERAGE OF MZPI ON MEDIUM BEAM WITH OLD PREAMPLIFIER

Fig. 7

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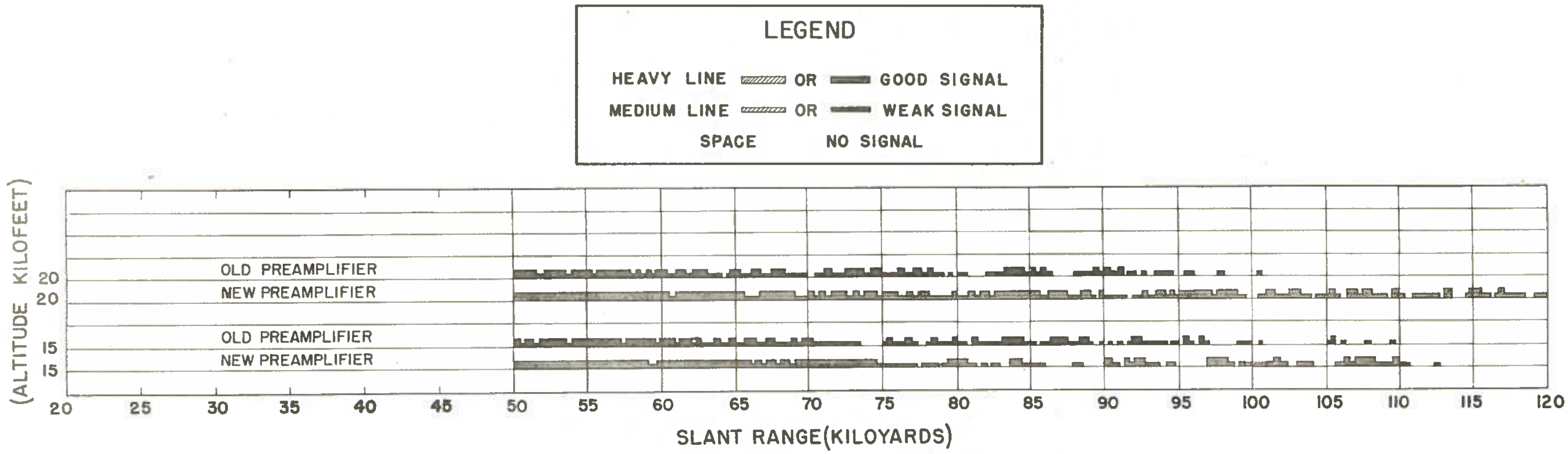
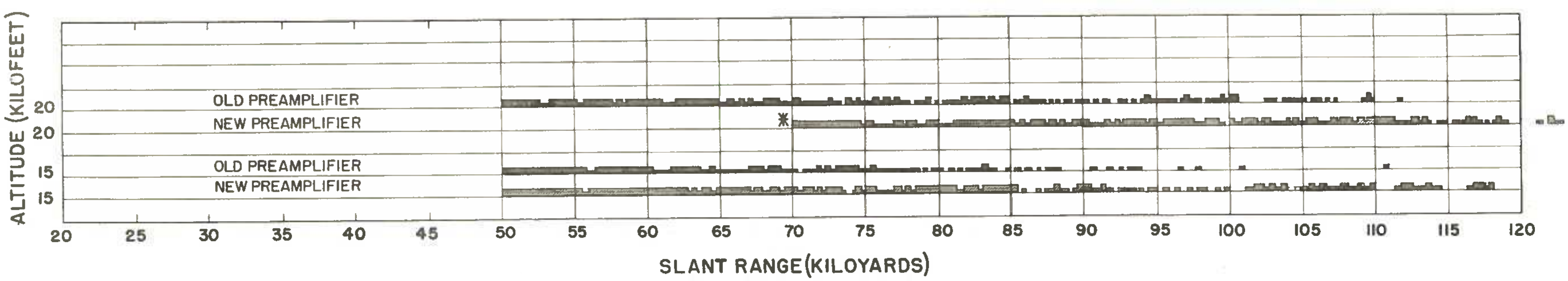


DAKOTA AIRCRAFT RECEDING



DAKOTA AIRCRAFT APPROACHING

COMPARISON OF RANGE OF M Z P I ON LOW BEAM WITH OLD AND NEW PREAMPLIFIER

* DISCONTINUED TO PREPARE FOR NEXT FLIGHT AS FUTHER TRACKING APPEARED UNNECESSARY

Fig. 8

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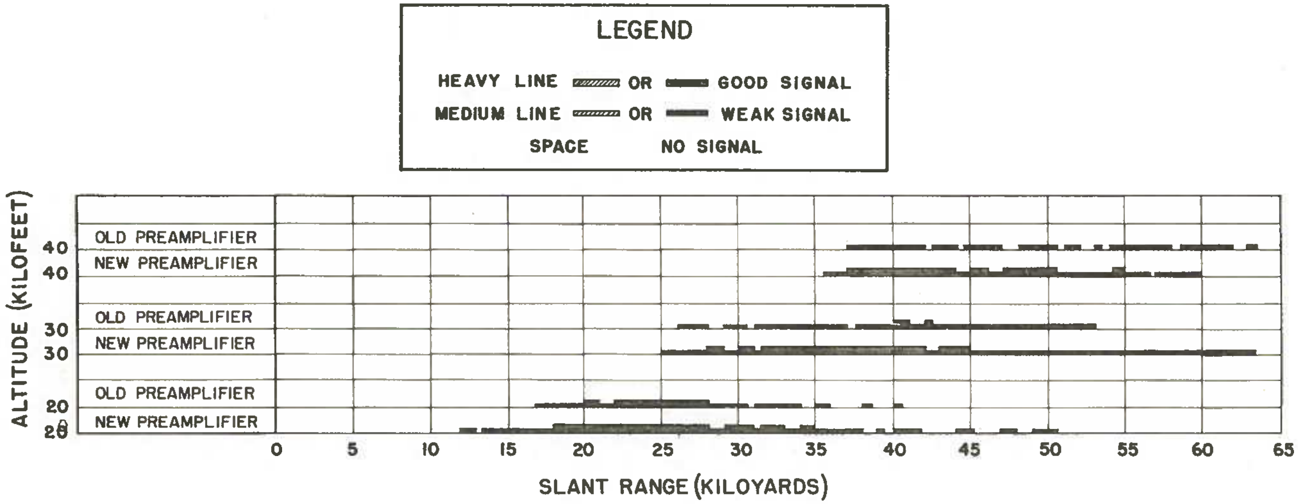
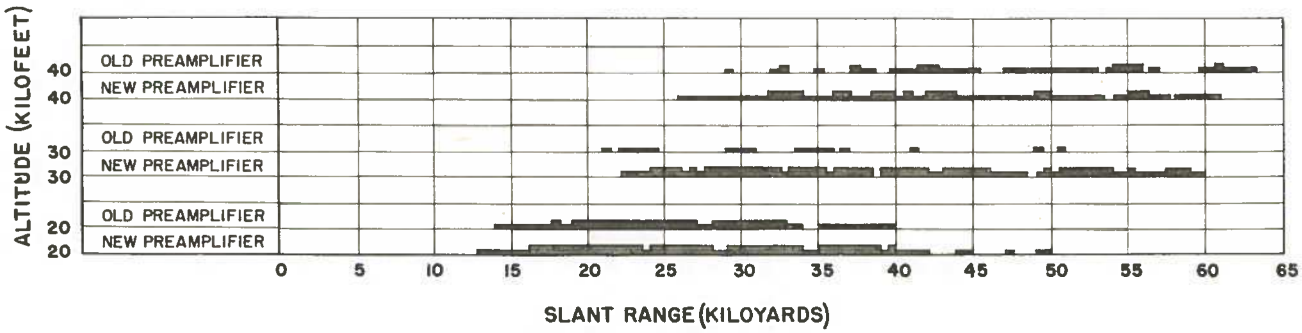


VAMPIRE AIRCRAFT RECEDING



VAMPIRE AIRCRAFT APPROACHING

COMPARISON OF RANGE OF M Z P I ON MEDIUM BEAM WITH OLD AND NEW PREAMPLIFIER

Fig. 9

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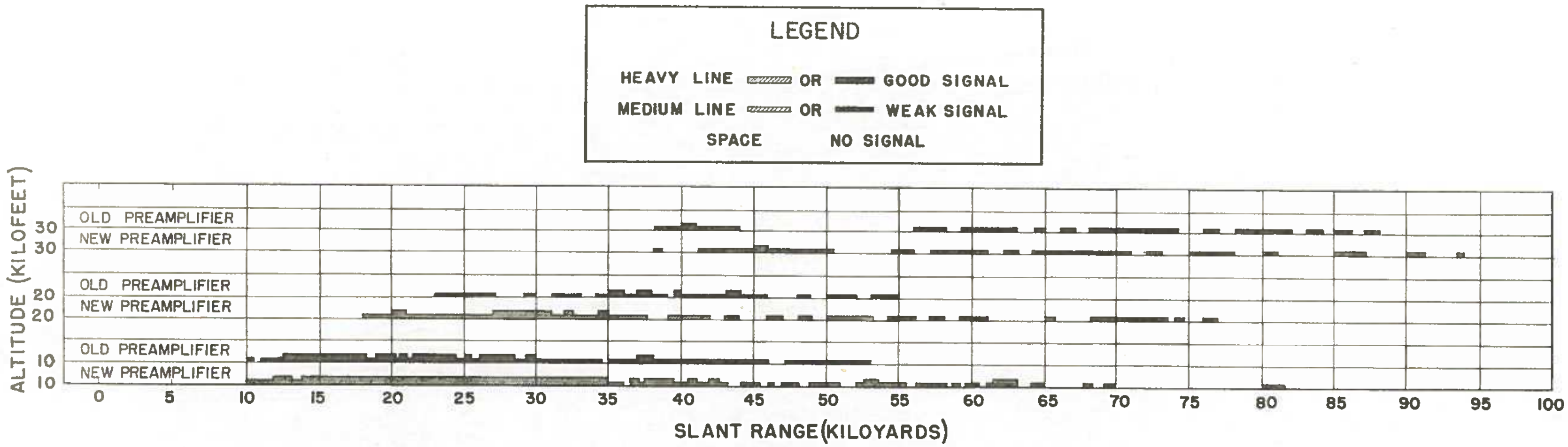
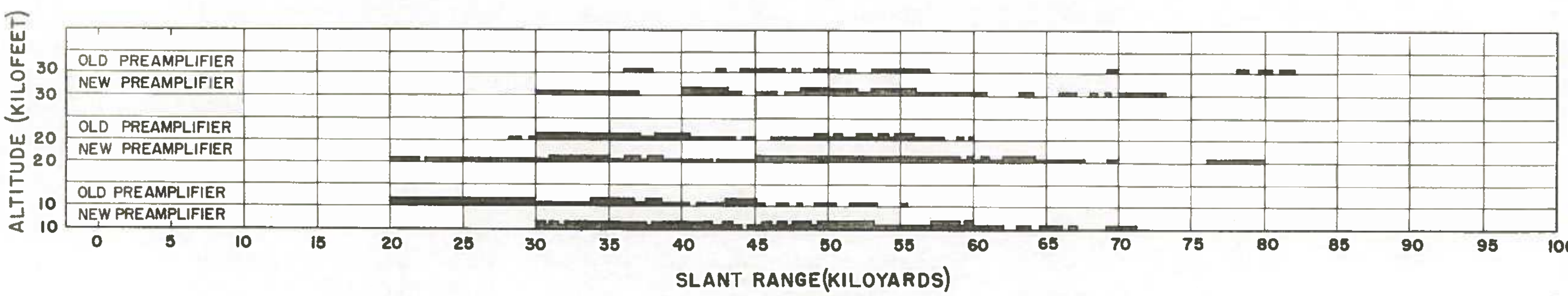


VAMPIRE AIRCRAFT RECEDING



VAMPIRE AIRCRAFT APPROACHING

COMPARISON OF RANGE OF MZPI ON LOW BEAM WITH OLD AND NEW PREAMPLIFIER

Fig. 10

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crystals were used. They were chosen from a box of ten new (war-surplus) Sylvania crystals. The crystals were selected to be typical by examination of the height of a fixed echo on the "A" scope, and graded "poor" (No.3), "fair" (No.4), "good" (No.1), and "excellent" (No.2). Fig. 11 shows the results of these tests.

IV. FACTORS AFFECTING CONSISTENCY OF OBSERVATIONS

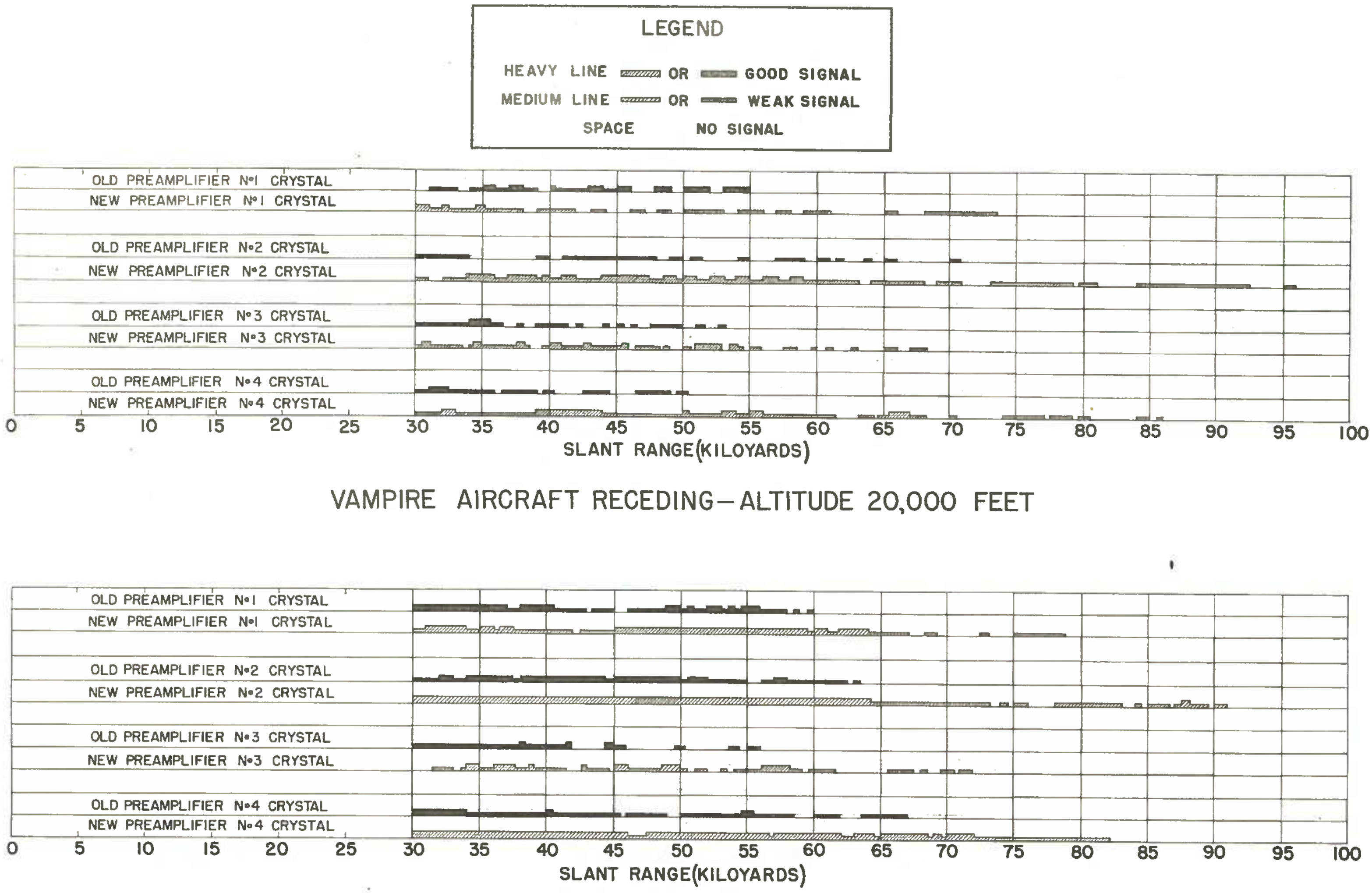
The following factors must be considered when interpreting radar flight trials:

(a) Alertness and skill of the operator are important, and it is impossible to ensure that these factors are constant during a trial. Even if the same operator were used throughout there would be an unknown factor due to fatigue. For the tests being described several operators were used at different times.

(b) The returned power from the aircraft will depend on the azimuth of the radar with respect to the aircraft. Changes of as much as 15 decibels in returned power for one-third of a degree change in azimuth are possible[3]. It is impossible to hold the aspect of an aircraft in flight sufficiently constant to eliminate this difficulty. Such an effect explains the intermittent nature of the returned signal from the aircraft at extreme range, and the inconsistency of the maximum ranges obtained on successive flights.

(c) The returned power from the aircraft will depend on the angle of depression of the radar with respect to the aircraft. This will be subject to continual small variations superimposed upon a continuous increase or decrease in the angle as the aircraft approaches or recedes.

(d) The tuning of the T/R cavity should have been readjusted when the preamplifiers were interchanged. It was impossible to do this for groups two and three of the flight trials. However, an attempt was made to determine the extent of the detuning by comparing the position of the T/R tuning slugs for maximum return from a fixed echo on the A-scope with the two preamplifiers installed alternately. It was found that the difference was barely detectable. The effect on the accuracy of the results is therefore negligible in comparison with the factors mentioned above.



VAMPIRE AIRCRAFT APPROACHING — ALTITUDE 20,000 FEET

COMPARISON OF RANGE WITH OLD AND NEW PREAMPLIFIER

USING LOW BEAM

Fig. 11

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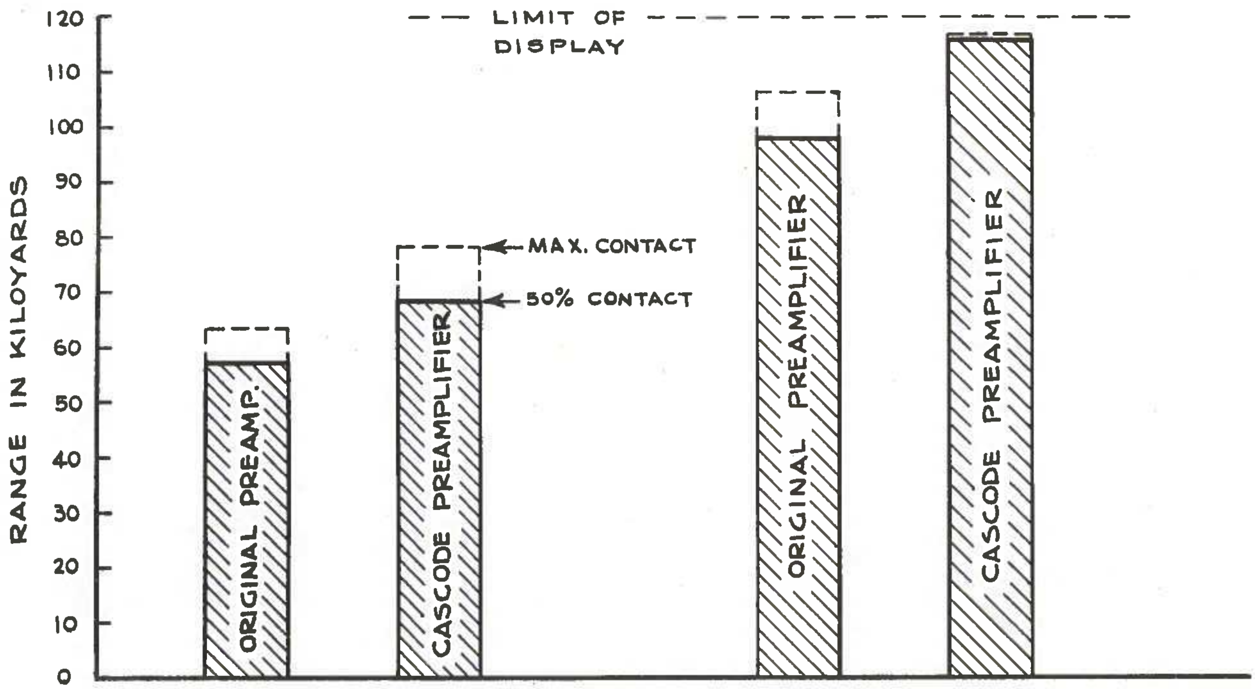
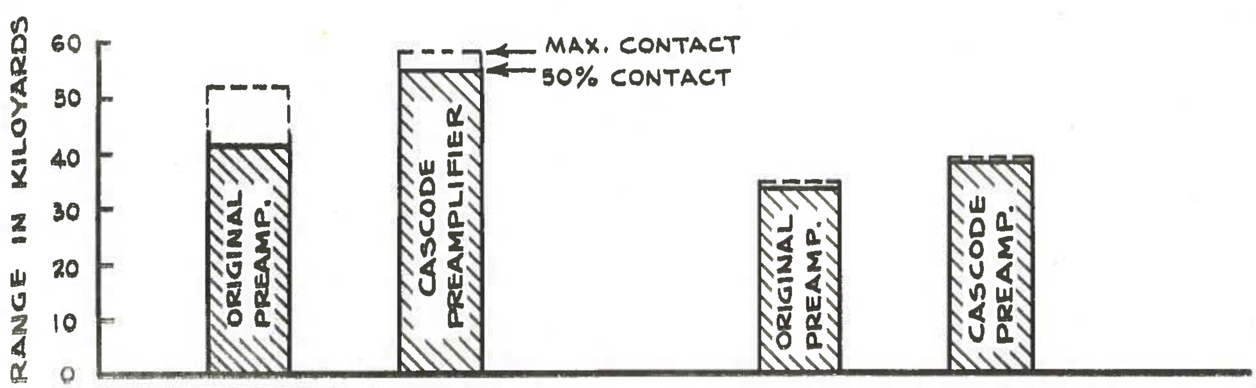


(a) VAMPIRE AIRCRAFT
AVERAGE OF 8 FLIGHTS AT
10, 15, 20 & 30 KILOFEET ALTITUDE
AIRCRAFT APPROACHING & RECEDING

(b) DAKOTA AIRCRAFT
AVERAGE OF 4 FLIGHTS AT
15 AND 20 KILOFEET ALTITUDE
AIRCRAFT APPROACHING & RECEDING

Fig. 12. AVERAGED RANGE DATA ON LOW BEAM



(a) VAMPIRE AIRCRAFT
AVERAGE OF 6 FLIGHTS AT
20, 30 & 40 KILOFEET ALTITUDE
AIRCRAFT APPROACHING & RECEDING

(b) DAKOTA AIRCRAFT
AVERAGE OF 8 FLIGHTS AT
5, 10, 15 & 20 KILOFEET ALTITUDE
AIRCRAFT APPROACHING & RECEDING

Fig. 13. AVERAGED RANGE DATA ON MEDIUM BEAM

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V. COMPARISON OF INTERMEDIATE-FREQUENCY NOISE FIGURE

The entire improvement expected with the cascode preamplifier is, of course, attributed to the intermediate-frequency noise figure of 1.7 decibels, compared with 5.5 decibels for the original preamplifier (median values, various tubes). For this reason it was important to measure intermediate-frequency noise factor before and after the trials on both preamplifiers. This was done, with the results shown in Table I. The tubes in each amplifier were, of course, not changed.

TABLE I

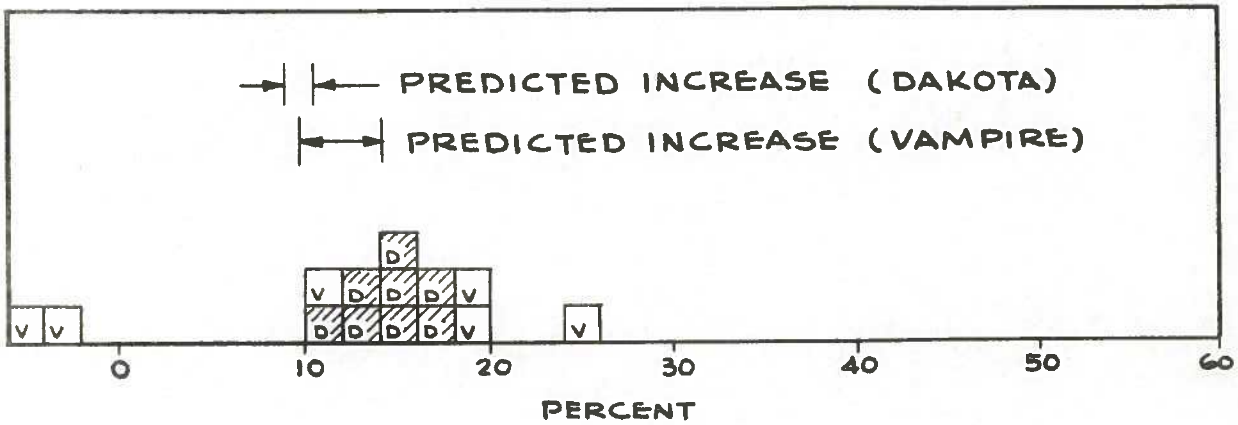
	I-F Noise Factor	
	Original Preamplifier	Cascode Preamplifier
Before flight trials	5.3 db	1.7 db
After flight trials	6.3 db	1.7 db

It may be seen that, unfortunately, the original preamplifier has deteriorated by one decibel during the tests. It may be assumed that 5.3 decibels is typical for the original preamplifier. It cannot be ascertained when the deterioration occurred; however, using the least favourable assumption, namely that it occurred early in the trials, the approximate effect may be estimated.

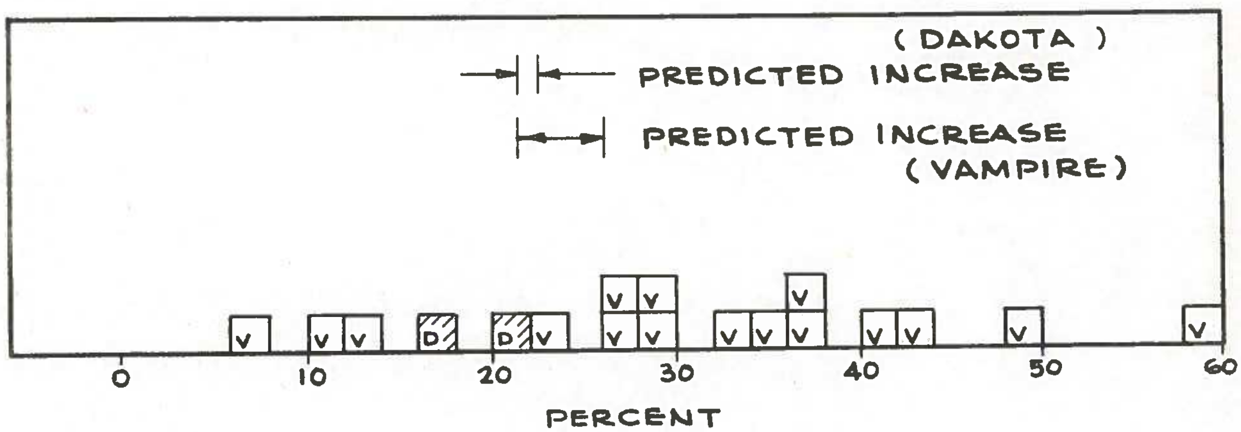
Typical crystals range from: $g = 5.6$ db, $t = 1.2$ (good crystal); to $g = 6.9$, $t = 2.8$ (poor crystal) — (see Table I, ref. (1)). Using these extreme values, the effect on over-all noise figure of the observed intermediate-frequency deterioration is found to be 0.94 decibel for the best crystals, and 0.66 decibel for the worst crystals, or an average of 0.8 decibel. This is equivalent to a reduction in range of about 4.5 per cent.

VI. METHOD OF PRESENTING RESULTS

To assess the increase in range obtained with the new preamplifier two criteria have been used: the maximum range at which any signal was received, and the maximum range at which a return was received for an average of at least 50 per cent of the time. Both of these criteria are arbitrary, but they do provide an adequate basis of comparison.



(a) MEDIUM BEAM



(b) LOW BEAM

Fig. 14 OBSERVED INCREASE IN RANGE WITH CASCODE PREAMPLIFIER (V = VAMPIRE D = DAKOTA)

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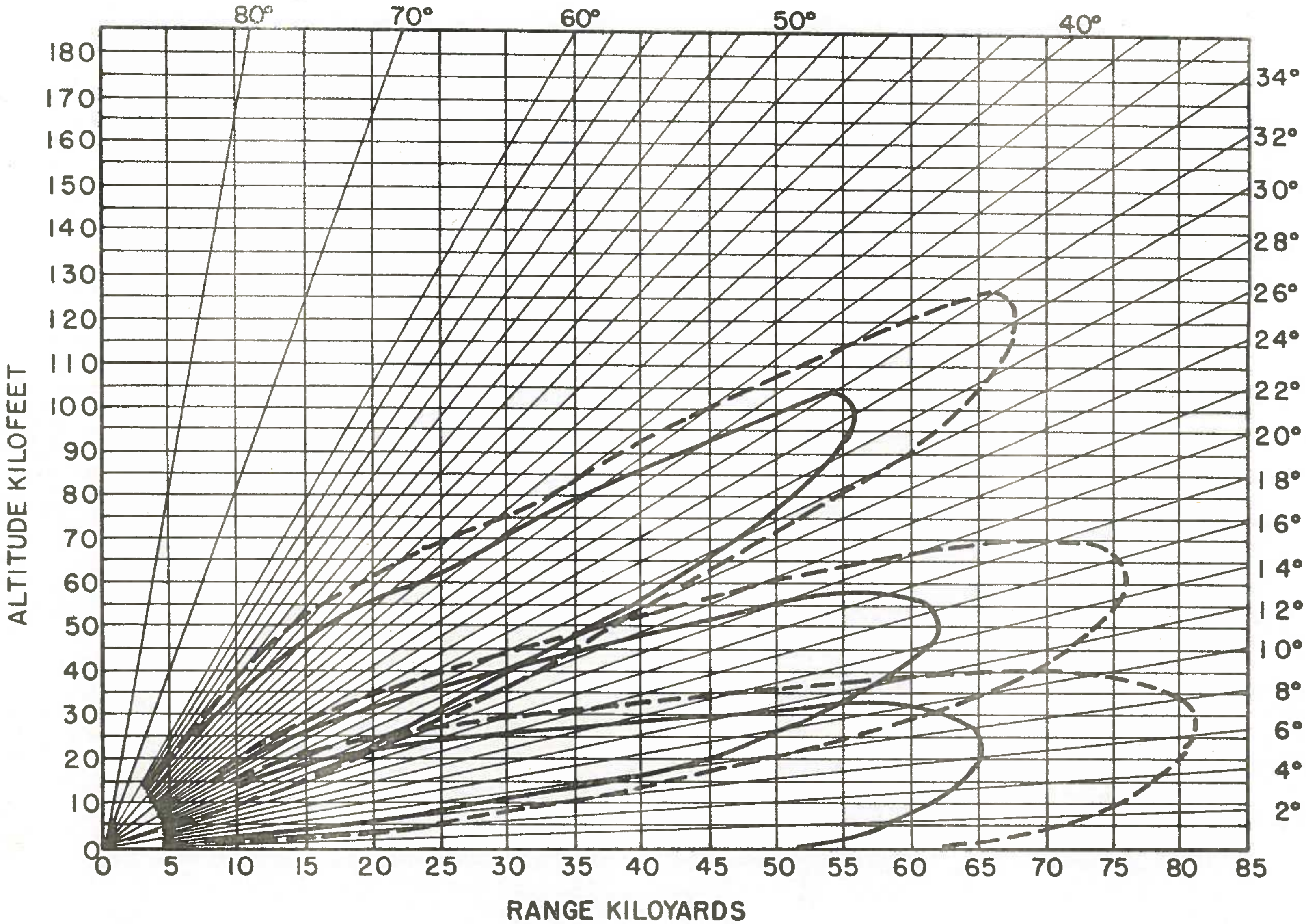

EFFECT OF 23 % INCREASE IN SLANT RANGE ON THEORETICAL COVERAGE OF MZPI

FIG. 15

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The data collected in this report may be examined from two points of view. From the operational standpoint it is of interest to determine the increase in range due to the cascode preamplifier. For this purpose the histograms of Figs. 12, 13 and 14 have been prepared. The other question of interest is to determine to what extent the theoretical improvement of 23 per cent, measured radially, is borne out by flight trials. For this purpose it is not permissible to average data at various altitudes because the expected horizontal range improvement is a function of altitude. To investigate this point the sixth and seventh columns in Tables II to VII have been determined, using a larger scale version of Fig.15. Column 6 gives the predicted improvement in range, and Column 7 gives the observed improvement. The method of calculating Column 6 is outlined in Appendix II.

The increase in range which may be obtained from use of the cascode preamplifier is more accurately indicated by the predicted results (Column 6) than by the observed results (Column 7). Since the calculated increase has on the average been confirmed by the flight trials it is reasonable to assume that at any particular altitude the calculated increase would be obtained if a large number of flights were averaged. Therefore it would be a better indication than any individual flight.

VII. CONCLUSIONS

(1) General

Fig. 14 shows the extent to which the predicted increase in horizontal range has been realized in the flight trials. The wide variation in the individual observations made it difficult to evaluate the increase numerically. However, it can be seen that the average of the increases is slightly greater than was expected. It has been assumed that this is due to the deterioration of one decibel in the original preamplifier during the flight trials, and that the actual performance of the new preamplifier agrees with the calculated performance.

Some tentative conclusions concerning the nature of the targets can be drawn. For example, it appears that the Dakota aircraft is a more reliable target than the Vampire, as indicated by smaller variations in the maximum ranges recorded. This might be at least partly attributed to the difference in the speed of the two aircraft. If the Vampire presents a less favourable aspect to the radar, and is lost, it will travel farther, and may even pass out of range before a more favourable aspect is again presented. The Dakota, on the other hand, does not travel as far during the periods when it is presenting an unfavourable aspect. This would tend to make the intermittent nature of the return less important in the case of the Dakota.

The moving propellers on the Dakota are probably also significant, as they will present a different aspect to each individual radar pulse, and hence could be expected to smooth out the radar response.

(2) Echoing Area

No values of the echoing area (σ) of aircraft can be calculated from these trials*. However, the ratio of equivalent area of a Dakota to that of a Vampire may be estimated as follows:

Range for 50 per cent Contact (Average of Approaching and Receding Flights, in Kiloyards)

		Old Receiver	New Receiver
DAKOTA:	Altitude 15,000'	92.5	112.5
	Altitude 20,000'	101.5	119.5
		D = 194.0	D' = 232.0
VAMPIRE:	Altitude 15,000'	48.0	65.5
	Altitude 20,000'	56.5	64.0
		V = 104.5	V' = 129.5

$$\frac{\text{Range (DAKOTA)}}{\text{Range (VAMPIRE)}} = \frac{D}{V} = 1.859 \qquad \frac{D'}{V'} = 1.791$$

$$\frac{\text{**Corrected Range (DAKOTA)}}{\text{**Corrected Range (VAMPIRE)}} = 1.859 \times 1.032 \qquad 1.791 \times 1.057$$

$$= 1.918 \qquad 1.892$$

Average = 1.905

$$\frac{\sigma \text{ Dakota}}{\sigma \text{ Vampire}} = (1.905)^4 = 13.2$$

* It will be possible later to deduce actual values of σ from the data of this report when tests with spherical targets of known echoing area have been made.

** The correction for the fact that the two aircraft are lost at different angles from the radar has been determined by a simple graphical construction on the antenna pattern and found to have the value (1.032) for the case of the old receiver, and the value (1.057) for the case of the new receiver.

In this calculation the fifty per cent figure rather than the extreme ranges has been used because the extreme ranges were limited by the display in the case of the Dakota. Altitudes of 15,000 and 20,000 feet have been chosen because the correction for the angle subtended at the radar is small. Equivalent echoing area is discussed briefly in Appendix III. This appendix gives a ratio of 17.6 for σ Dakota/σ Vampire compared with 13.2 in our trials. This discrepancy is not large for work of this nature, and when expressed in range it represents a discrepancy of $\sqrt[4]{17.6/13.2} = 1.074$, or a difference of 7.4 per cent in range.

TABLE II

Flights with Dakota Aircraft

HIGH BEAM MZPI

Extreme Range in Kiloyards

Altitude (feet)	Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
10,000	12	12	12	12	0*	0
15,000	17	17	19	19	0*	0
20,000	25	25	24	24	0*	0

Maximum Range for 50 per cent Contact (kiloyards)

Altitude (feet)	Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
10,000	12	12	12	12	0*	0
15,000	17	17	19	19	0*	0
20,000	23	24	24	24	0*	1/2

* too small to compute graphically

TABLE III

MEDIUM BEAM MZPI

Extreme Range in Kiloyards

Altitude (feet)	Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
5,000	17	18	17	21	1.5	2.5
10,000	32	35	28	35	3	5
15,000	39	46	41	45	4	5.5
20,000	49	53	48	56	5	6

Maximum Range for 50 per cent Contact (kiloyards)

Altitude (feet)	Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
5,000	17	18	17	21	1.5	2.5
10,000	32	32	28	35	3	3.5
15,000	39	46	39	45	4	6.5
20,000	46	53	48	56	5	7.5

TABLE IV

Flights with Dakota Aircraft

LOW BEAM MZPI

Altitude (feet)	Extreme Range in Kiloyards: Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
15,000	109	112	101	118*	22.5	10*
20,000	101	120*	112	119*	24	13*
Maximum Range for 50 per cent Contact (kiloyards)						
15,000	97	111	88	114	20.5	20
20,000	96	120*	107	119*	22	18

* Appreciably better performance would probably have been observed if the display had extended beyond 120,000 yards.

TABLE V

Flights with Vampire Aircraft

MEDIUM BEAM MZPI

Altitude (feet)	Extreme Range in Kiloyards: Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
20,000	41	51	40	50	4	10
30,000	53	63	51	60	6.5	9.5
40,000	63	60	63	61	9	-2.5
Maximum Range for 50 per cent Contact (kiloyards)						
20,000	36	42	40	42	4	4
30,000	53	63	0*	60*	6.5	10
40,000	63	60	63	61	9	-2.5

* These data not used.

TABLE VI

Flights with Vampire Aircraft

LOW BEAM MZPI

Altitude (feet)	Receding Old (preamp.)	Receding New	Approaching Old (preamp.)	Approaching New	Calculated Increase	Observed Increase
	Extreme Range in Kiloyards					
10,000	54	70	56	71	12	15.5
15,000	56	82	55	83	12.5	27
20,000	55	76	60	80	13	20.5
30,000	88	94	82	73	20	8.5
	Maximum Range for 50 per cent Contact (kiloyards)					
10,000	54	65	53	71	11.5	14.5
15,000	50	79	46	52	11	17.5
20,000	55	61	58	67	13	7.5
30,000	88	78	52	73	19.5	5.5

TABLE VII

Flights with Vampire Aircraft

LOW BEAM MZPI

Crystal	Receding Old	Receding New	Approaching Old	Approaching New	Calculated Increase	Observed Increase
	Extreme Range in Kiloyards					
No.1	55	73	60	78	14	18.5
No.2	71	96	63	91	15.5	26.5
No.3	53	68	56	72	13.5	15.5
No.4	51	86	67	82	14	25
	Maximum Range for 50 per cent Contact (kiloyards)					
No.1	55	73	60	69	14	13.5
No.2	52	92	63	91	14	34
No.3	50	56	42	62	13	13
No.4	51	80	67	82	14	22

REFERENCES

(1) "Noise Factor of MZPI Radar", A.C. Hudson, National Research Council of Canada, Radio and Electrical Engineering Division, ERA-186, (NRC Radio Doc.No.20845) SECRET

(2) "A Low-noise Amplifier", Henry Wallman, Alan B. Macnee, and C.P. Gadsden, Proc. I.R.E., vol.36, p.700, June,1948.

(3) "Radar System Engineering", L.N. Ridenour, Radiation Laboratory Series, vol.1, p.76, McGraw-Hill Book Co.

(4) "Trials of a New Antenna and Rotating Coupler for A.A.No.4, Mk.VI (MZPI)", F.V. Cairns, National Research Council of Canada, Radio and Electrical Engineering Division, ERA-193 SECRET

(5) "Equivalent Echoing Areas of Aircraft and Characteristics of Aircraft Echoes: A Critical Survey of the Literature", T.R.E. Tech. Note No.47 (NRC Radio Doc.No.20648) SECRET

APPENDIX I

Method of Recording Data

A semi-automatic method of recording data was used. When the operator had decided on the correct classification for the signal, he pressed one of three buttons which controlled typewriter keys. The keys printed code letters indicating "strong", "weak", or "miss", on a moving strip of paper. Other data such as range and altitude were recorded simultaneously. Fig. 16 is a photograph of the recording device.

This method allows the operator to devote his full attention to the PPI display.

RECORDER USED ON FLIGHT TRIALS

Fig. 16

APPENDIX II

Method of Predicting Improvement in Horizontal Range from a Given Improvement in Radar Performance

Given an improvement in radar performance of m decibels, the improvement in horizontal range is found as follows: (see Fig.17)

1. Let n be m expressed as a power ratio.

2. Calculate n:

$$n = 10^{m/10} \qquad (1)$$

3. Let p be the factor by which radial range is improved.

4. Calculate p:

$$p = \sqrt[4]{n}$$

5. Let A (Fig. 17) represent maximum contact on a given target plotted in range and altitude.

6. Let B be the intersection of straight line AO with the antenna coverage diagram (Pattern 1).

7. Draw BC at constant altitude to intersect Pattern 2 at C.

8. Project OC to D where OD:OC = OA:OB; or alternatively, find D by continuing OC to D which is at the same altitude as A.

9. D is at the predicted range for the improved radar performance.

This method, of course, does not allow for the non-uniformity of an aircraft echoing area with aspect.

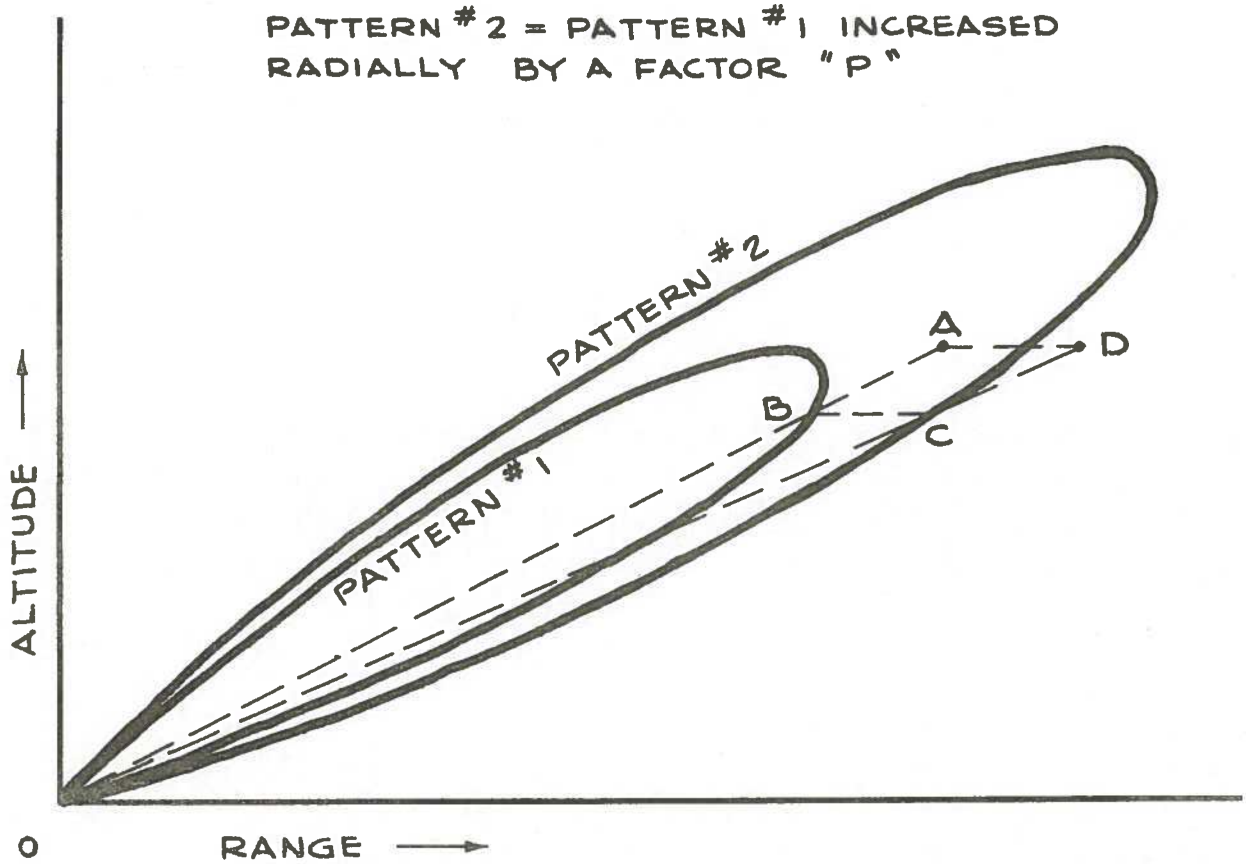

Fig. 17 METHOD OF DETERMINING INCREASE IN HORIZONTAL RANGE DUE TO AN IMPROVEMENT IN RADAR PERFORMANCE.

NOTE: THE ABOVE PATTERNS ARE FIELD STRENGTH PATTERNS AND HENCE ARE EQUIVALENT TO COVERAGE DIAGRAMS.

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APPENDIX III

Echoing Area of Various Aircraft

Reference (5) gives reliable values of echoing area for a Vampire, Spitfire, Meteor, Tempest, Mosquito, Havoc, Wellington and Lancaster. These values have been plotted against wingspread (see Fig.18) using semi-log paper. Straight lines have been drawn through the data, leading to the following approximate expression for echoing area as a function of wingspread:

$$\sigma = 10^{(W/52 + k)} \tag{1}$$

$$\text{or: } \log_{10} \sigma = (W/52 + k)$$

where σ = equivalent echoing area in square meters

W = wingspread in feet

and k is a parameter with the following values:

k = 0 (for propeller aircraft receding)

= + 0.33 (for propeller aircraft approaching).

As an example, consider a Hudson aircraft approaching:

$$W = \text{wingspread} = 66 \text{ feet}$$

$$\left(\frac{W}{52} + k\right) = \left(\frac{66}{52} + 0.33\right)$$

$$= 1.60,$$

then, $$\log_{10} \sigma = 1.60,$$

and $$\sigma = 40 \text{ square meters.}$$

The following limitations of this formula must be kept in mind:

(1) Errors in original data

(2) Dependence of the concept "equivalent echoing area" on aspect. The aspect is not given in Ref. (~~4~~ 5)

(3) Errors in the assumption that equivalent echoing area is a function of wingspread alone

APPENDIX III

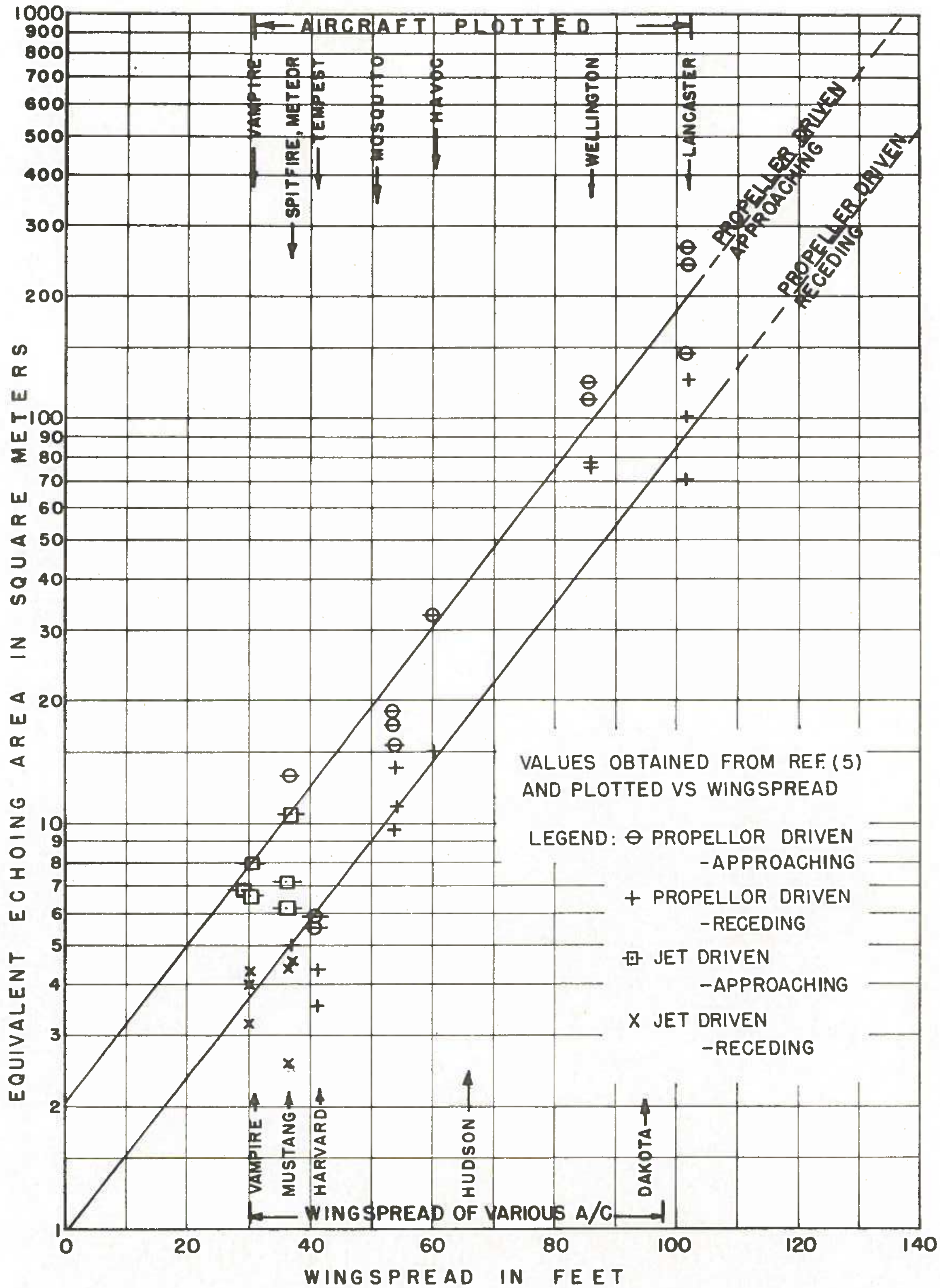
Echoing Area of Various Aircraft (Continued)

(4) Errors in the degree to which the given straight lines approximate the given data. (The "Tempest", for example, has only one-half the echoing area given by the straight-line approximation.)

(5) Possible serious error if the lines are extrapolated to aircraft of larger wingspread than that given in the data.

For jet aircraft, the Vampire is approximated by the above equation. However, a larger jet, the "Meteor", has a smaller echoing area.

Extrapolation of this data to a B-29 (wingspread = 141 feet) and a B-36 (wingspread = 230 feet) give equivalent echoing areas of 1100 and 60,000 square meters, respectively. It should be emphasized that no data is available at present to justify this extrapolation.



EQUIVALENT ECHOING AREA --- VARIOUS AIRCRAFT

FIG. 18

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