AD 346020

Report No. AAEE/Tech/242/Arm.

MINISTRY OF AVIATION

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

SEA VIXEN Mk.1 AIRCRAFT

THE RELATIONSHIP BETWEEN AIRSTREAM DIRECTION DETECTOR POSITION AND AIRCRAFT INCIDENCE

[U]

BY

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RESTRICTED

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A. & A.E.E. Ref: Arm.G.3
M.O.A. Ref: AV/170/05
Period of Trial: June 1962 - May 1963

Summary

This report deals with an investigation into the feasibility of using the Airstream Direction Detector as a means of measuring aircraft incidence in normal flight, with a view to its use in the weapons sighting system. As a result of this investigation it is recommended that this system of measuring aircraft incidence in flight be brought to the notice of all interested parties, especially those conerned with Weapon Sighting Systems.

This Report is issued with the authority of

Air Commodore,
Commandant, A. & A.E.E.

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/1. Introduction

1. Introduction

Current Sighting systems for air-to-air unguided weapons ignore changes in aircraft all-up weight, Mach Number and aircraft configuration when computing aircraft attitude. The sighting errors thus produced are not always insignificant. A simple method has long been sought whereby measurement of a single parameter might be directly related to aircraft incidence during flight, and such information passed directly to the sight computing system. To this end it was considered that certain components of the Airstream Direction Detector could be utilised.

2. Object of Trial

The trial was carried out to ascertain whether the Airstream Direction Detector probe incidence could be simply related to aircraft incidence in normal flight.

3. Description of Installation

In order to obtain fine readings, the A.D.D. probe of Sea Vixen Mk.1 XJ.564 was connected to a 30° potentiometer in place of the standard 50° item. Movements of the probe were reproduced on the photographic trace of a C.I.D. recorder, together with time scale, altitude, 'g' and indicated airspeed traces. Control of the recorder was effected by the camera button and firing trigger on the pilot's control column.

4. Derivation of the Test Method

It was necessary to establish the wing incidence of the aircraft over a wide range of airspeeds, altitudes and all-up weights in order that it might be compared with the A.D.D. reading.

Two sources of information were available:-

(a) From results of previous A. & A.E.E. trials, the incidence of the Sea Vixen Mk.1 aircraft had been established with reasonable accuracy (inclinometer method - Figures 1(a), (b) and (c)) for the following limited conditions:-

(i) All-up weights:- 31,000 lb. and 35,000 lb.

(ii) Altitudes:- Sea Level, 20,000 ft. and 40,000 ft.

(iii) Configuration:- launchers. Aircraft fitted with four, twenty-four tube

These incidence plots (see Figure 1) are referred to in later paragraphs and tables as the A. & A.E.E. curves.

(b) Wind tunnel lift/incidence/Mach Number curves for the Sea Vixen Mk.1 aircraft supplied by De Havilland Aircraft Co. Ltd., (no flight results were available to confirm the accuracy of the curves).

A Pegasus digital computer was programmed to give aircraft incidence from a knowledge of equivalent airspeed, altitude and all-up weight, using De Havilland data. Conditions of equivalent airspeed, altitude and all-up weight corresponding to those known from the A. & A.E.E. curves were fed into the computor, and incidence of figures were obtained. The differences between the A. & A.E.E. curves and the computed incidence figures were found to vary from 7 to 9 milliradians ($17\frac{1}{2}$ milliradians = 1 degree approx.) for all heights and speeds where comparison was possible (see Table 1).

The following assumptions were then made:-

(a) The A. & A.E.E. curves which were derived from flight tests correct.

(b) Figures from the Pegasus computer do not agree with the A. & A.E.E. figures by 7 to 9 milliradians under certain conditions, therefore the computed figures have a "zero shift" under all conditions, (see Figure 2). Hence "True Incidence" for any condition can be obtained from "Computed Incidence" corrected for the zero shift.

5. Method of Trial

For each flight the aircraft was prepared to the standard configuration (four twenty-four tube launchers, two on each wing) with full fuel tanks. On reaching a pre-determined altitude, the aircraft was flown straight and level at a selected indicated air speed, and the fuel state was noted. The C.I.D. recorder was then operated by the pilot, for approximately ten seconds. At the end of the run the fuel state was again noted. This procedure was repeated for various speeds at the altitude selected for that flight. In this way, a total of 13 successful flights was made, covering altitude, indicated airspeed, and all-up weight ranges of:-

(a) 1,000 to 45,000 feet

(b) 200 to 500 knots

(c) 31,600 to 36,150 pounds

6. Results of Trials

The results of trials, given in table 2, suggested that the simple relationship - A.D.D. reading equals True Incidence* - was relevant. In fact, as shown in Table 2 and Figure 3, there was a maximum inequality of 5 milliradians. Examination of the figures in column 2 of Table 3 shows that correlation exists between altitude and the mean value of the "difference", (see Table 4). This may be attributed to many sources including slight inaccuracies in the A. & A.E.E. curves and/or the De Havilland data. However, the inequalities found are small, and it is considered that for all practical purposes the assumptions made in para 4 above have been substantiated, and that the function quoted above* has been shown to apply.

7. Conclusions

It is concluded that:-

(a) In the four twenty-four tube launchers configuration, an Airstream Direction Detector probe, fitted in the normal position on the Sea Vixen Mk.1 aircraft, is capable of giving an accurate indication of aircraft incidence.

(b) The damped output from the Airstream Direction Detector could be fed to a suitably modified sight computor to increase the accuracy of the Pilot Attack Sight System.

8. Recommendations

It is recommended that this system of measuring aircraft incidence in flight be brought to the notice of all interested parties, especially those concerned with Weapon Sighting Systems.

Reference

De Havilland Aircraft Co. Ltd., Report Number AD 110/03/16, Figure 3, Issue 2, dated 17th March, 1960, "D.H.110 Mk.20 Sea Vixen Lift Carpet".

/Circulation list ...

Circulation List

D.A. Arm	8	Copies
A.D.P.An.	1	Copy
R.D.T.2	1	"
R.D.T.3	1	"
T.I.L.	70	Copies
R.A. . Farnborough	5	"
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Table 1

Zero Shift

E.A.S. (Knots)	Altitude (Feet)	All-Up Weight (Pounds)	Incidence (Milliradians)		
			A. & A.E.E. Curves	Computed	Zero Shift
250	Sea Level	35,000	67.0	74.12	7.12
275	" "	"	54.5	62.04	7.54
300	" "	"	46.0	53.14	7.14
325	" "	"	39.0	46.03	7.03
350	" "	"	32.5	40.05	7.55
375	" "	"	27.5	35.06	7.56
400	" "	"	23.1	31.0	7.9
450	" "	"	17.0	24.82	7.82
500	" "	"	11.0	19.62	8.62
350	" "	31,000	27.8	36.09	8.29
400	" "	"	20.1	28.04	7.94
500	" "	"	9.1	17.95	8.85
301	20,000	35,000	43.3	50.97	7.67
346.5	"	"	28.0	35.94	7.94
408.5	"	"	18.0	25.71	7.71
301	"	31,000	37.5	45.5	8.0
346.5	"	"	24.5	32.3	7.8
408.5	"	"	15.6	23.0	7.4
173.5	40,000	35,000	141.0	148.32	7.32
200	"	"	102.5	109.51	7.01
240	"	"	58	65.0	7.0
250	"	"	53.5	60.96	7.46
254	"	"	52.5	59.97	7.47
173.5	"	31,000	123.0	130.97	7.97
200	"	"	90.0	97.36	7.36
250	"	"	47.0	54.55	7.55

Table 2

Difference between "True Incidence" and A.D.D. Readings

Flight No.	Date	Altitude Feet	All-up Weight Pounds	E.A.S. Knots	Incidence (Milliradians)				
					Computed	Zero Shift	True	A.D.D.	Diff.
1	28. 6.62	30,200	34,900	239	78.2	7.2	71.0	68.5	-2.5
		30,300	34,600	282.5	50.1	7.4	42.7	42.7	0
		30,200	34,200	326	38.0	7.5	30.5	28.4	-2.1
		30,200	33,300	339.5	37.0	7.5	29.5	27.0	-2.5
		30,250	33,100	241.5	72.5	7.3	65.2	67.0	+1.8
		5,000	32,900	250	69.7	7.3	62.4	62.8	+0.4
		5,250	32,750	296.5	51.0	7.4	43.6	44.0	+0.4
		5,000	32,500	346.5	37.7	7.5	30.2	32.2	+2.0
		5,050	32,250	396	28.9	7.7	21.2	21.9	+0.7
		5,000	32,000	444.5	23.0	7.8	15.2	15.0	-0.2
		5,010	31,850	495.5	17.4	8.0	7.4	10.0	+0.6
2	17. 7.62	11,000	34,650	228.5	87.8	7.2	80.6	77.4	-2.8
		10,500	34,400	275	61.0	7.3	53.7	55	+1.3
		11,000	35,400	296	54.3	7.4	46.9	46	-0.9
		10,500	34,100	325.2	43.8	7.5	36.3	36	-0.3
		11,000	35,100	343.2	40.4	7.5	32.9	33	+0.1
		11,000	33,900	363.2	34.9	7.6	27.3	26	-1.3
		11,000	34,950	400.8	28.6	7.7	20.9	21	+0.1
		10,500	33,645	420	24.9	7.7	17.2	18	+0.8
		11,000	34,750	438.2	22.6	7.7	14.9	16	+1.1
3	26. 7.62	40,250	31,800	229	66.3	7.2	59.0	55.0	-4.0
		40,250	31,600	229	65.5	7.2	58.3	53.5	-4.8
4	8. 8.62	20,000	35,300	245	77.1	7.3	69.8	66.8	-3.0
		20,000	33,200	271.5	59.3	7.3	52.0	49.5	-2.5
		20,000	35,100	298	52.2	7.4	44.8	44.0	-0.8
		20,000	33,450	319	42.7	7.4	35.3	35.5	+0.2
		20,000	34,900	346.5	35.9	7.5	28.4	29.7	+1.3
		20,000	[illegible],600	363.5	30.6	7.6	23.0	23.5	+0.5
		20,000	[illegible],500	384.5	27.0	7.7	19.3	21.0	+1.7
		20,000	33,800	407	24.8	7.7	17.1	15.1	-2.0
5	9. 8.62	15,000	33,850	277	58.8	7.3	51.5	55	+3.5
		15,000	34,000	318	45.1	7.4	37.7	38	+0.3
		15,000	35,450	343	40.2	7.5	32.7	34	+1.3
		15,000	34,150	364	33.6	7.6	26.0	27	+1.0
		15,000	35,100	398	27.5	7.7	19.8	22.5	+2.7
		15,000	34,350	404	25.9	7.7	18.2	19	+0.8
		15,000	34,900	440	21.5	7.8	13.7	14	+0.3
		15,000	33,200	455	20.4	7.8	12.6	12	-0.6
6	15. 8.62	45,100	34,000	228	70.2	7.2	63.0	59.5	-3.5
		45,050	33,950	228	70.2	7.2	63.0	59.0	-4.0
		44,750	33,850	228	70.1	7.2	62.9	59.5	-3.4
		44,800	33,800	228	70.1	7.2	62.9	60	-2.9
7	3. 9.62	30,250	35,500	247	74.1	7.3	66.8	66.2	-0.6
		30,500	35,300	265.2	60.6	7.3	53.3	50.3	-3.0
		30,750	35,050	284.2	49.5	7.4	42.1	45.0	+2.9
		30,250	34,800	305.8	41.3	7.4	33.9	35.5	+1.6
		30,500	34,600	326.5	39.0	7.5	31.5	28.8	-2.7

8. ...

Flight No.	Date	Altitude Feet	All-up Weight Pounds	E.A.S. Knots	Incidence (Milliradians)				
					Computed	Zero Shift	True	A.D.D.	Diff.
8	20. 9.62	46,050	33,900	218	78.5	7.2	71.3	68.0	-3.3
		45,600	33,700	218	77.7	7.2	70.5	67.0	-3.0
9	2.10.62	19,000	35,900	231.2	88.7	7.2	81.5	83.6	+2.1
		19,000	35,700	245.5	77.8	7.3	70.5	70.3	-0.2
		19,000	35,500	272	62.9	7.3	55.6	54.2	-1.4
		19,000	35,300	303.7	50.6	7.4	43.2	43.7	+0.5
		19,000	35,150	311.2	48.0	7.4	40.6	38.0	-2.6
		19,000	35,050	338.5	38.8	7.5	31.3	29.8	-1.5
		19,000	34,900	358	33.6	7.6	26.0	26.6	+0.6
		19,500	34,550	391.7	26.2	7.7	18.5	18.0	-0.5
		19,500	34,250	419.2	19.8	7.7	12.1	10.5	-1.6
10	29.10.62	14,800	36,150	219	99.5	7.2	92.3	89.3	-3.0
		14,800	36,050	249.5	76.6	7.3	69.3	71.4	+2.1
		14,925	35,900	283	59.5	7.4	52.1	51.0	-1.1
		15,000	35,850	306	51.1	7.4	43.7	42.5	01.2
		15,100	35,800	316	47.9	7.4	40.5	39.1	01.4
		15,250	35,650	343.5	40.3	7.5	32.8	30.4	-2.4
		15,250	35,450	367	33.8	7.6	26.2	23.6	-2.6
		15,050	35,200	400	27.2	7.7	19.5	21.7	+2.2
		15,175	35,100	417.5	23.7	7.7	16.0	16.7	+0.7
		15,275	34,800	457.5	22.0	7.8	14.2	11.3	-2.9
11	29. 4.63	45,000	34,800	214	80.6	7.2	73.4	71.8	-1.6
		45,000	34,700	191.5	109.0	7.2	101.8	98.8	-3.0
12	6. 5.63	1,100	34,300	491	19.8	8.0	11.8	13.8	+2.0
		1,200	34,100	451	24.1	7.8	16.3	19.0	+2.7
		950	34,000	392,5	31.3	7,7	23.6	24.1	+0.5
		970	33,900	352.5	38.3	7.6	30.7	33.5	+2.8
		1,100	33,850	298.5	52.1	7.4	44.7	47.1	+2.4
		1,100	33,800	253	69.9	7.3	62.6	63.4	+0.8
		1,000	33,750	300.5	51.2	7.4	43.8	43.8	0
		1,200	33,700	358	37.0	7.6	29.4	32.2	+2.8
		1,250	33,600	403	29.4	7.7	21.7	22.0	+0.3
		1,350	33,550	451.[illegible]	23.7	7.8	15.9	18.2	+2.3
		1,500	33,450	504.5	18.2	8.0	10.2	12.6	+2.4
13	20. 5.63	19,700	36,000	203.5	113.7	7.0	106.7	106	-0.7
		19,700	35,900	219.5	98.4	7.1	91.3	87.8	-3.5
		19,850	35,800	251	74.3	7.3	67.0	67.1	+0.1
		19,900	35,600	274.5	61.9	7.3	54.6	51.4	-3.2
		19,950	35,400	297.5	52.7	7.4	45.3	44.6	-0.7
		19,650	35,300	319	45.4	7.4	38.0	38.8	+0.8
		19,850	35,100	340.5	37.7	7.5	30.2	32.3	+2.1
		19,800	35,000	363	32.0	7.6	24.4	27.0	+2.6
		19,900	34,800	370.5	30.0	7.6	22.4	23.0	+0.6
		19,900	34,400	408	25.2	7.7	17.5	18.6	+1.3
		19,550	34,200	411	24.7	7.7	17.0	17.6	+0.6

Table 3

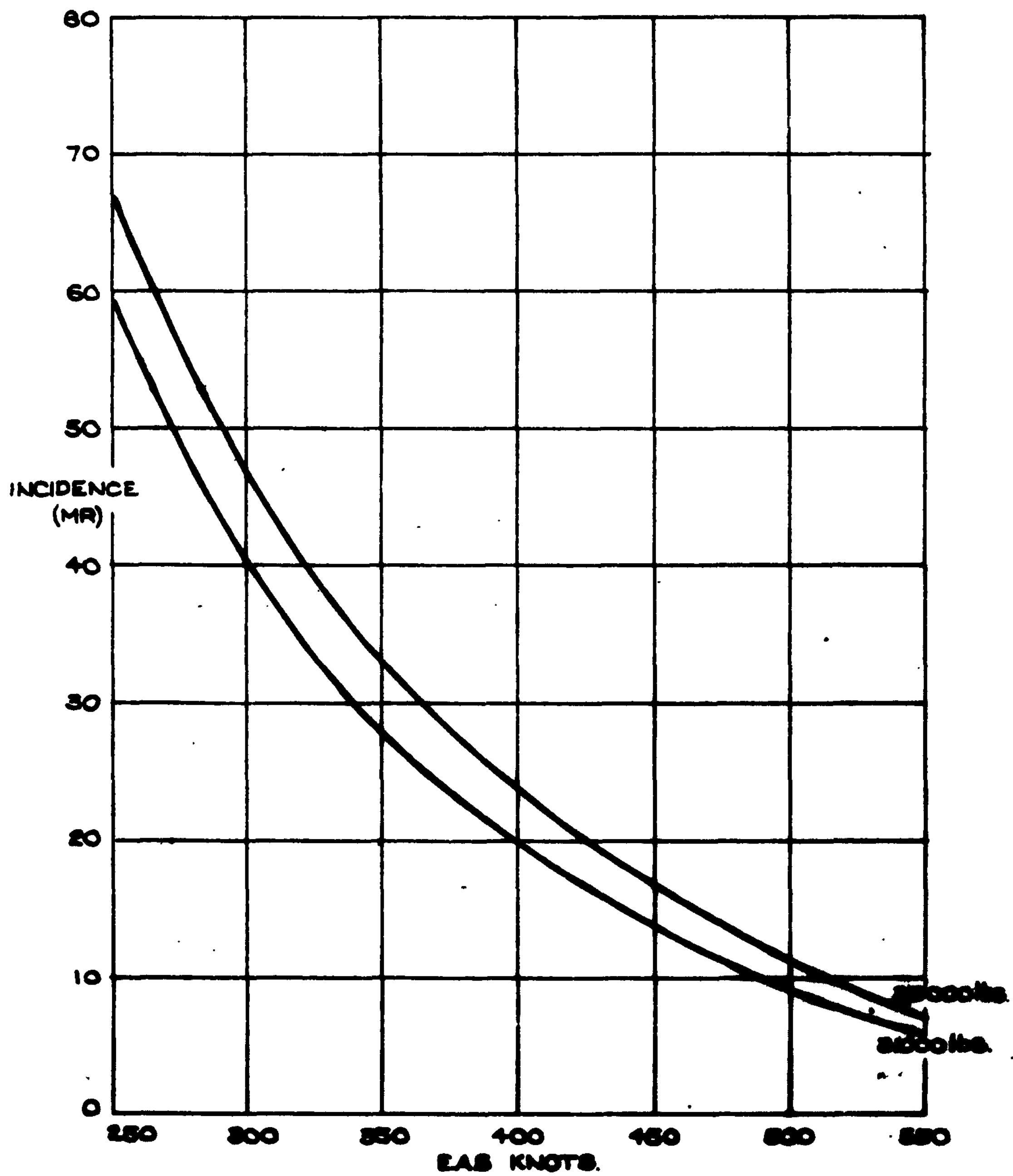
Standard Deviation and Means of "Differences"

Nominal Altitude	Mean Value	Standard Deviation
1,000 ft	1.727	1.093
5,000 ft.	0.65	0.731
10,000 ft.	-0.211	1.118
15,000 ft.	-0.017	1.995
20,000 ft.	-0.329	1.695
30,000 ft.	-0.71	2.179
40,000 ft.	-4.4	-
45,000 ft.	-3.088	0.695
ALL	-0.316	2.015

Table 4

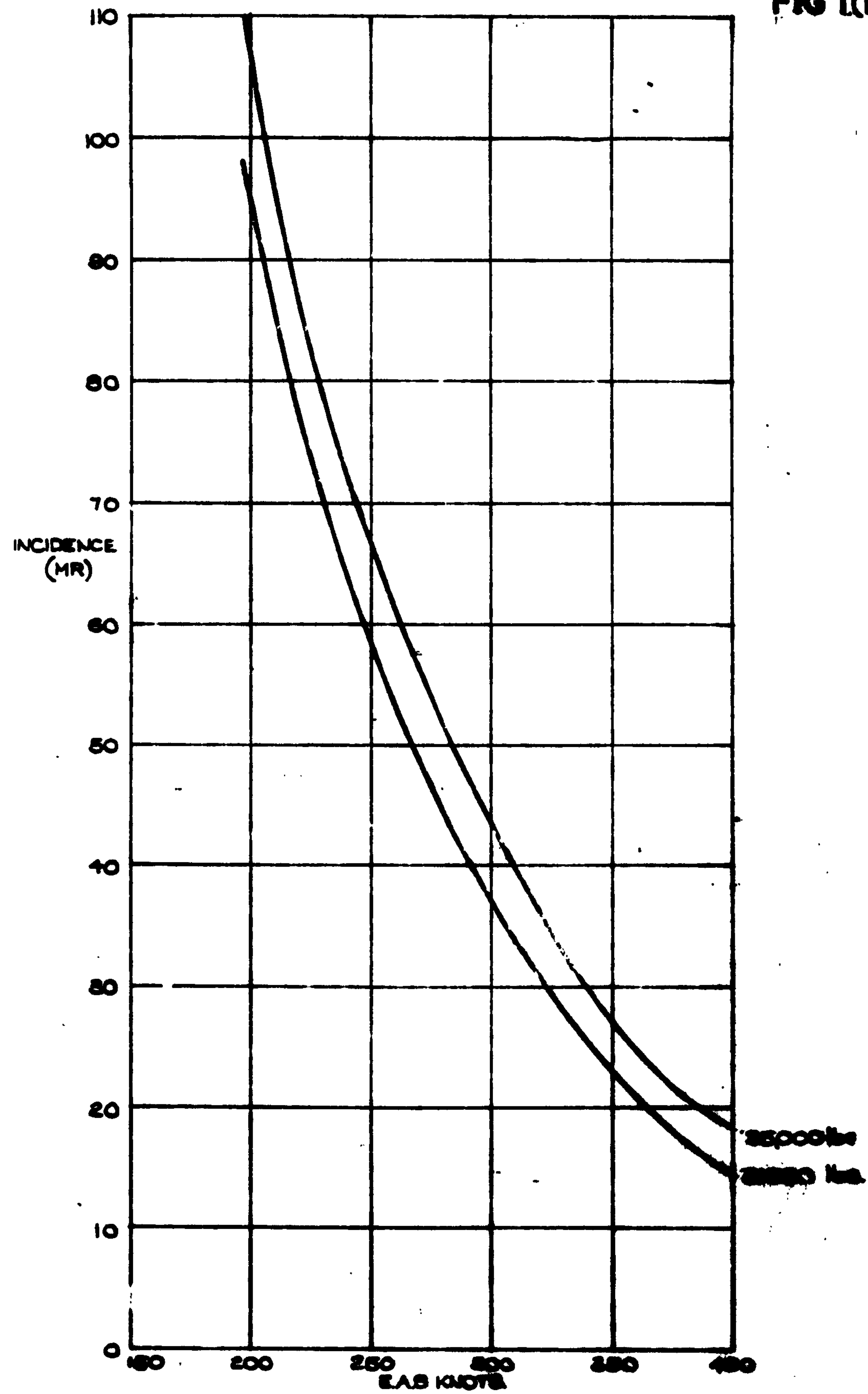
Coefficient of Correlation Between Altitude and "Difference"

Mean Altitude Ft.	S.D. Altitude Ft.	Mean "Difference" Milliradians	S.D. "Difference" Milliradians	Coefficient of Correlation 'R'
18,545.16	12052.93	-0.316	2.015	-0.5926



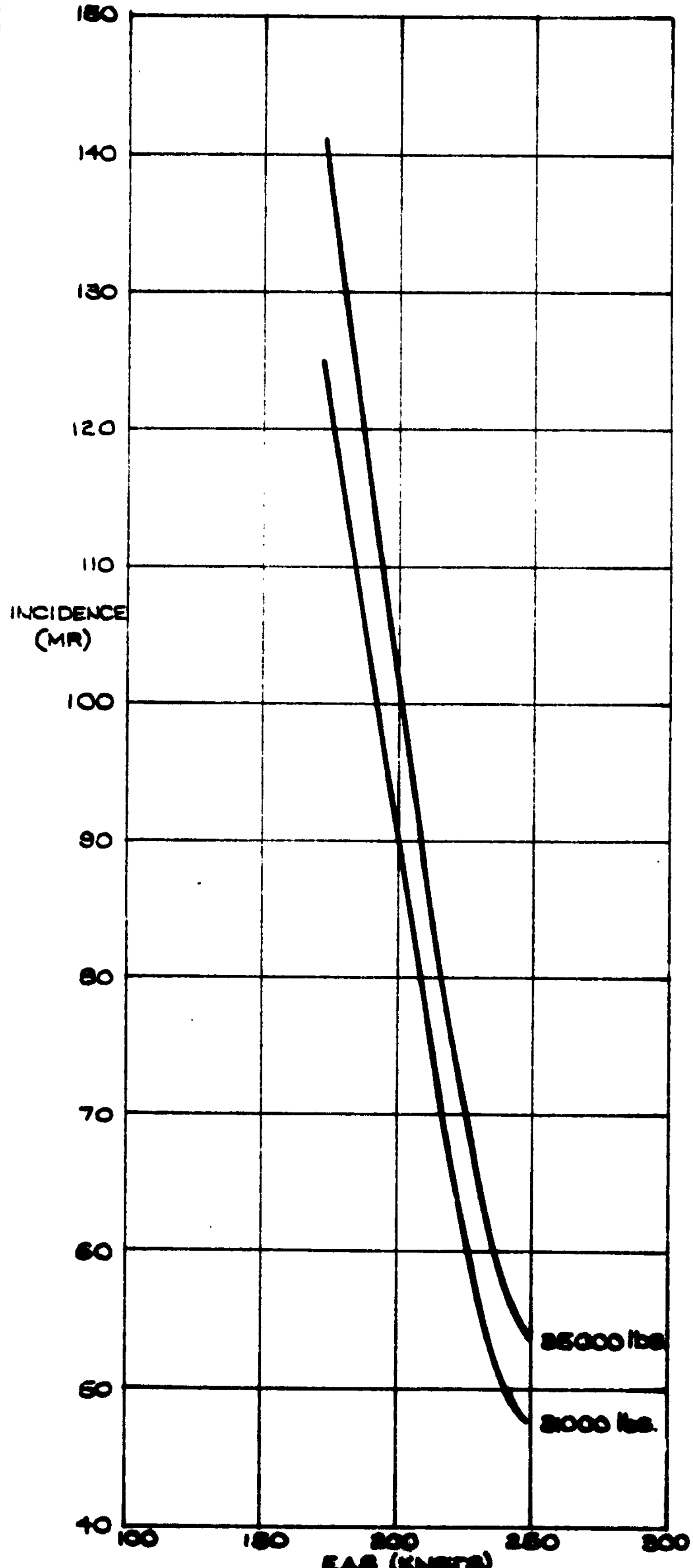
A&AEE. CURVES. SEA LEVEL.

FIG 1(b)



A&A E.E CURVES 20,000 FT.

FIG. 1(c)



A&A.E.E. CURVES. 40,000 FT.

TR A.E.N | CH. S/LDR. WRIGHT | APP. | for S of A | 11.7.63

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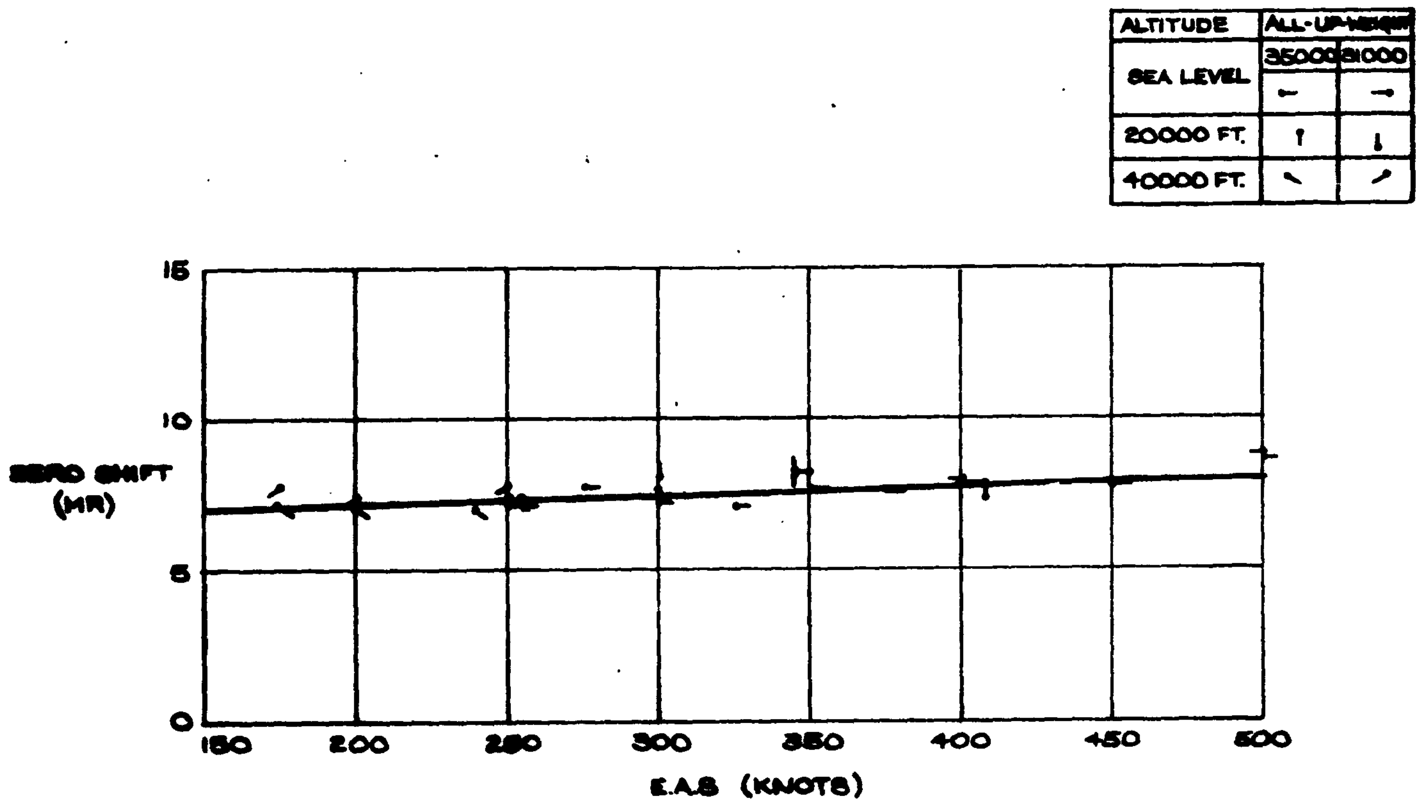
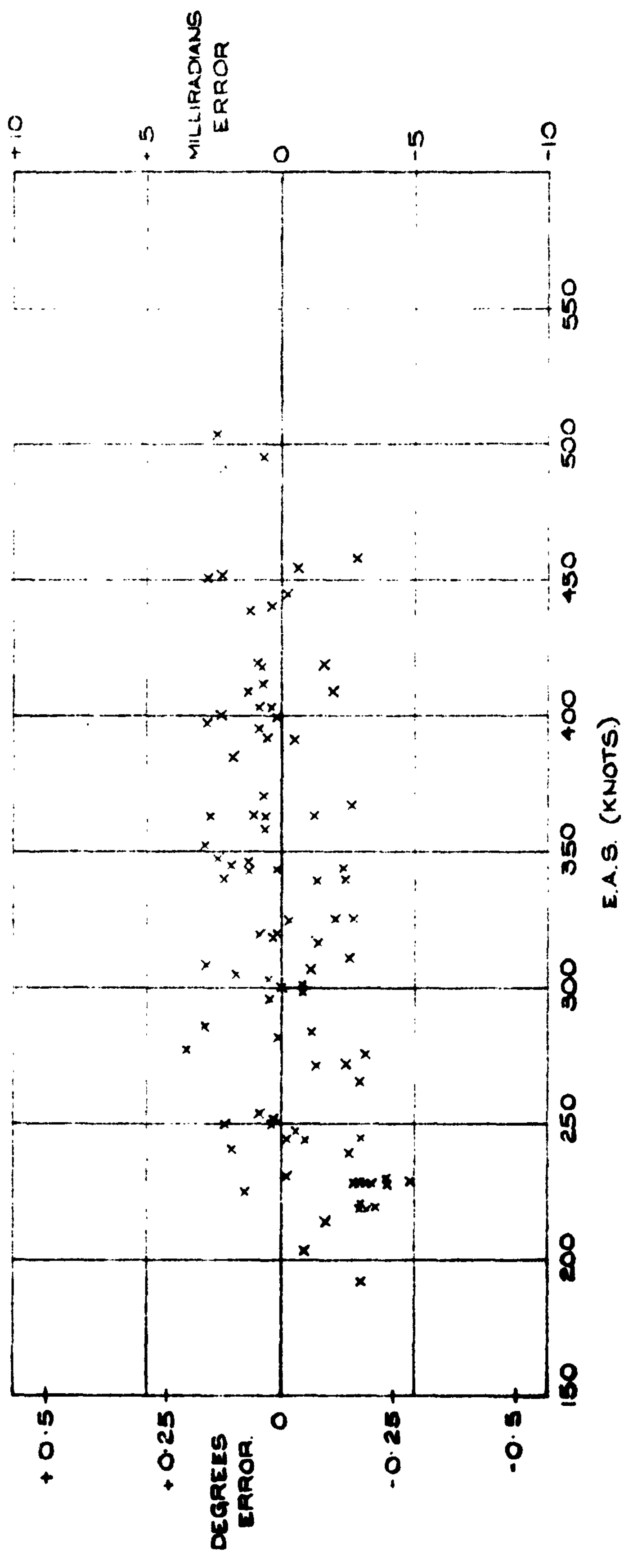
SKN°B1932 | TR A E N. | CH. S/LDR. WRIGHT | APP. Rlw: for S of A | 11·7·C3



ZERO SHIFT.

FIG 2.

FIG 3.



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DIFFERENCE BETWEEN 'TRUE' INCIDENCE AND A.D.D. READINGS.

[dstl]

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Date of Search: 15 July 2008

Record Summary: AVIA 18/2052
Title: Sea Vixen Mk I Aircraft the Relationship Between Airstream Direction Detector Position and Aircraft Incidence
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
Former reference (Department) AAEE/TECH 242/A
Held by The National Archives, Kew

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