APPENDIX 1

Ref: GT/Occ 02456

Civil Aviation Authority

Airworthiness Division

Boeing 727-46 G-BAEF

Take-off accident at Luton Airport on 21st June 1974

Analysis of Flight Recorder Data

(Occurrence No. 02456)

CAA-AD Research Note No. 14
B.727 G-BAEF. Take-Off
accident on 21 6 74:
Analysis of F.R. Data
Issue 3 : February 1975

CONTENTS

1. INTRODUCTION

On the 21 June 1974 a Boeing 727-46, G-BAEF of Dan Air, taking off from Runway 26 at Luton struck a fence, an ILS monitor, the Localiser array and approach lights at the end of the runway. Some damage was sustained by the aircraft which subsequently made a successful landing at Gatwick Airport. The accident is being investigated by the Accidents Investigation Branch of the D of T who have carried out a read-out of the Flight Data Recorder. This note summarises an analysis, made by the CAA at the request of the AIB, of the data recovered from the FDR;

(See also CAA Form 700, ref no. DR/SOU 1935).

2. FLIGHT DATA RECORDER

The aircraft was equipped with a United Controls Data Division Flight Recorder, Type FB 542 Serial No. 3639 and a post-accident calibration was carried out at Fields Aircraft Services Ltd on 3 July 1974. A read-out of the data recorded on the foil during the accident was obtained by the AIB using the equipment of the AQD (Aircraft Quality Directorate).

The purpose of this read-out was to generally cover the period from start of roll to the scheduled altitude for flap retraction. A further read-out was then made by the CAA for a shorter time period, but in more detail, covering the lift-off and initial climb, using photographs of the foil lent by the AIB.

The data recovered from the foil record by the original AIB read-out is shown on Fig 1 and uses a time-scale and time-zero datum based on the distance along the foil from a single arbitrary reference line assuming a constant foil speed. Pitch attitude (which appears on the reverse side of the foil and displaced along the foil relative to the other parameters) has been aligned by assuming the FDR manufacturers' nominal linear displacement. Later work by the AIB (not included in this Research Note) has slightly modified the alignment between some of the recorded parameters.

In the CAA read-out (Fig 2) the individual parameters have been adjusted to give what is believed to be a true synchronisation and are referenced to a time-scale which allows for the observed small variations in foil speed. The synchronisation obtained by the CAA read-out is in good agreement with the later alignment work carried out by the AIB and referred to above.

The time-zero datum of the CAA read-out is at a point shortly before the aircraft was lined up with the runway. The time-zero datum for the AIB read-out occurs at time 47 seconds on the CAA time-scale.

All references to time in this note (unless otherwise stated) are to the CAA datum and time-scale shown on Fig 2.

3. ACCURACY AND CORRECTIONS TO THE DATA

The post-accident calibration of the Flight Data Recorder itself showed it to be functioning within the manufacturer's tolerances except for the recording of normal acceleration. This was found to exhibit an error in datum but not slope, when compared with the required calibration line. When recovering normal acceleration data from the foil this error has been allowed for by first finding a definite lg line on the record and then, with this as datum, using the calibration slope to obtain acceleration increments about this datum line. The calibration did not include a check for possible errors in the transducer fitted to the aircraft and these could, if present, affect the calibration slope. However, the normal acceleration variations were not found to be significant in the analysis of the data and the conclusions would be unaltered even if a constant value of lg were assumed for the whole period of the analysis.

The Flight Recorder obtains pitch data from a Sperry 300 Series Vertical Gyro (Part No. 2587 335/10); the signal first being fed from the gyro to a Collins Flight Director and then via a 'boot-strap' synchro to the Flight Recorder. Pitch Erection cut-off operates when the longitudinal acceleration exceeds 0.039 min to 0.048 max g and this is equivalent to the resultant 'g' vector being tilted $(2\frac{1}{2} \pm \frac{1}{4})^{\circ}$. Variable errors due to Gyro Free Drift and Earth rate are small for the time period of the incident. Since the signal from the gyro is not fed directly to the Flight Recorder, but via the Flight Director, it is possible that other errors of unknown quantity may also be present but it is considered that these would be small and constant rather than variable.

An adjustment for pitch attitude datum errors has been made by first comparing the ground attitude obtained from the record when the aircraft was turning on to the runway prior to the take-off run with the ground attitude given in the Boeing 727 Flight Manual (-0.75° nose down). The pitch attitude record has then been adjusted to give -0.75° nose down at the start of the read-out. Engine thrust and local runway slope could affect the ground attitude and therefore it is considered that a margin of about $+0.5^{\circ}$ should be taken into account when using pitch attitude values given in this note.

A height datum has been obtained using the recorded height when the aircraft was at the beginning of the runway. The variation of local runway height above the datum with time is also shown on Fig 2.

The airspeed records shown on Figs 1 and 2 were obtained from the FDR using a detailed calibration carried out at Fields Aircraft Services Ltd. However, for speeds below about 60 knots it is not possible to use the calibration with accuracy and therefore some care must be taken when using the record at these low speeds. This is further dealt with in paragraph 5.

Where airspeed has been used in the analysis IAS has been corrected for position error to obtain EAS by two methods. Firstly, when the aircraft was airborne and out of ground effect, the appropriate PE corrections given in the Flight Manual have been applied. Secondly, when the aircraft was on the ground the difference between recorded height and runway height has been used to give a static pressure correction and hence correction to the indicated airspeed.

4. ADDITIONAL DATA USED IN THE ANALYSIS

Details of the runway and damaged approach facilities have been obtained from drawings prepared for the AIB by the Luton Borough Engineer. Certain performance data relating to the Boeing 727 has been obtained from the Boeing Company, Airplane Division, and is shown on Figs 3 and 4.

It is understood that all three engines were set at 1.95 EPR (rather than the maximum permitted settings of 1.98 EPR on the pod engines and 1.955 EPR on the centre engine) and therefore the analysis has been based on thrust and accelerations for that setting. All reference to Boeing data in this note implies data related to a setting of 1.95 EPR on each engine.

5. ANALYSIS OF THE FLIGHT RECORDER DATA

The purpose of the analysis has been to provide further information to aid the investigation into the cause of the accident. The analysis falls conveniently into two parts; firstly dealing with the take-off run to lift-off and secondly dealing with the flight path after lift-off.

The take-off was scheduled to be with flaps 15° and the crew statements confirm this. However, the analysis also considers the implications of take-off with flaps 5° but assuming that the crew thought the flaps were correctly set at 15°.

The acceleration data obtained from the Boeing Company is for a flap setting of 15° and the analysis has been based on these data. If the flaps were in fact set at 5° then the acceleration would be slightly better due to the lower drag. It is estimated that the improvement could be of the order of 5 per cent for speeds near the rotation speed. However, the drag reduction due to the lower flap setting is proportional to the square of the airspeed. Therefore the improvement in acceleration would be less for lower airspeeds and insignificant for most of the speed range considered in the analysis.

5.1 Take-Off run

The aircraft made a rolling start on runway 26 with the surface wind reported to be '150°/less than 5 knots'. Because of this reported wind the analysis has given consideration to the implications of both a zero wind and a light, possibly variable, tailwind.

5.1.1 The variation of airspeed (corrected for Position Error) with time as given by the Flight Recorder is plotted on Fig 5. The Boeing acceleration data (Fig 3) has been used to compute the predicted variation of airspeed with time (assuming still air conditions) and this is also shown on Fig 5. At airspeeds below about 60 knots the implied acceleration is seen to be considerably greater than the maximum achievable according to the Boeing estimates. This is assumed to be due to difficulties in the retrieval of airspeed data from the Flight Recorder at low speeds (see paragraph 3). (A changing wind strength would produce the same effect but the magnitude would be completely inconsistent with the reported conditions). It has therefore been assumed that for airspeeds equal to or less than 60 knots the true variation of airspeed with time is as derived from the Boeing data. (Although this assumes still air conditions, the speed time relationship between zero and 60 knots is to a good approximation linear, and therefore there would be little error if in fact there was a steady wind at the time). This then gives, at zero airspeed, an effective still air start of roll at time = 1 sec.

A comparison of a mean line through the Flight Recorder airspeed points with the line predicted from the Boeing data (still air), shows a possible lack of aircraft apparent acceleration of up to 5 per cent. This could imply reduced thrust or some unexpected drag (eg wheel brake drag). The Boeing acceleration data is based on a minimum engine thrust corresponding to an EPR setting of 1.95 on all engines. Permitted engine thrust tolerances are such that the actual thrust per engine could be up to 250 lbs greater but not less. Aircraft EPR gauge errors, however, could result in the achievement of a lower thrust than scheduled.

Alternatively the Flight Recorder data can be made to fit the Boeing variation of airspeed with time by assuming a varying tailwind during the take-off run. The implied tailwind is shown on Fig 5 where, for the purposes of analysis, a mean line has been drawn through the points. This corresponds to a tailwind, building up to about 6 knots in 14 secs and then becoming constant, starting to affect the aircraft at about time 20 secs. In this case there would be no implication of reduced thrust or unexpected drag.

It is not possible from the data available to determine which of the two possibilities (reduced acceleration or build-up of tail-wind) is the more likely nor is it possible to establish whether the wind at the start of roll was either zero, a head or a tailwind.

The three variations of airspeed with time have been integrated to give the corresponding variations of distance with time and airspeed and these are shown on Figs 6 and 7.

5.1.2 *Lift-Off Speed*

An assessment of the Flight Recorder time at lift-off has been made using the data available. Although an indication of lift-off can be obtained from the normal acceleration record, a more reliable method is to estimate where incidence and airspeed combine to first give lift equal to weight using the airspeed and pitch attitude records. (Note: The airspeed/pitch attitude variation will depend on which of the airspeed variations discussed in paragraph 5.1.1 is used).

Firstly the Boeing data of Fig 4 has been analysed to give the predicted variation of lift-off incidence with airspeed. This is plotted in Fig 8 for the two flap angles of 15° and 5°.

Secondly, aircraft incidence has been obtained from the recorded pitch attitude by allowing for the down-hill slope of the runway of about –0.5° in the region of lift-off. This has then been plotted against airspeed in Fig 8 to give lift-off airspeeds at the points of intersection with the Boeing lines for flaps 5° and 15°, of 155.4 knots EAS and 153.3 knots EAS respectively. There is some tolerance in this method of determining the lift-off airspeed since:

(a) the pitch could be in error by perhaps about 0.5°, and

(b) the airspeed depends on which line is put through the Flight Recorder points (ie either the mean line or the Boeing line with a 6 knot tailwind).

Although Fig 8 is based on airspeed according to the mean line through the Flight Recorder points it can be seen from Fig 5 that, for airspeeds in the region of lift-off, the alternative line assuming a tailwind gives very similar speeds.

For the estimated lift-off airspeeds the distances and times at lift-off are tabulated below for the various airspeed-time and flap angle assumptions. (See also the comments on the effect of reduced drag due to a lower flap setting at the start of paragraph 5).

(i) *Mean Line through Flight Recorder points (implied thrust reduction or drag increase)*

	Flaps 15°	Flaps 5°
Flight Recorder time at Lift-Off*: Secs.	46	47
Airspeed at Lift-Off*: Knots EAS	153.3	155.4
Distance from start of roll to Lift-Off*. Feet	6,450	6,720

(ii) *Boeing predicted airspeed-time variation with tailwind (scheduled thrust for 1.95 EPR on all engines).*

	Flaps 15°	Flaps 5°
Flight Recorder time at Lift-Off*: Secs.	46	46.9
Airspeed at Lift-Off*: Knots EAS	153.3	155.4
Distance from start of roll to Lift-Off*: Feet	6,650	6,880

(iii) *Boeing predicted airspeed-time variation, still air (scheduled thrust for 1.95 EPR on all engines).*

	Flaps 15°	Flaps 5°
Flight Recorder time at Lift-Off*: Secs.	44	44.8
Airspeed at Lift-Off*: Knots EAS	153.3	155.4
Distance from start of roll to Lift-Off*: Feet	6,080	6,320

*ie To the airspeed value at lift-off estimated from the Flight Recorder data (Fig. 8).

Thus, relative to the Boeing still air data with scheduled thrust, the distance from start of roll to lift-off is increased by about,

(a) 370-400 feet if there was a small reduction in thrust or some unexpected drag with either zero or constant tailwind,

or (b) 560-570 feet if there was a build-up of a tailwind of about 6 knots shortly before lift-off and the thrust was as scheduled at 1.95 EPR on all engines,

and (c) 230†-270 feet of the flaps were inadvertently set at 5° instead of 15° († This could be reduced if the lower drag with flaps at 5° is taken into account).

Allowing for an effective start of roll point about 200-300 feet in from the beginning of the runway and the possibility of an additional constant tailwind (5 knots would add about 380 feet to the distances) the distances derived from the Flight Recorder data confirm an eye-witness report that lift-off occurred near the end of the stop-way (Fig. 6) whatever assumptions are made with regard to thrust, drag, tailwind or flap angle.

5.1.3 *Delay in Lift-Off*

There is, however, a large discrepancy between the Boeing scheduled lift-off airspeed of 145 knots EAS (Fig 4) and that estimated from the Flight Recorder data. With the thrust as scheduled for 1.95 EPR set on all engines and either the acceleration implied by the Boeing data for still air or with a tailwind increasing to 6 knots shortly before lift-off, the distance to and times at the *scheduled* lift-off speed of 145 knots EAS with flaps set at 15° are as given in the following table:

		Boeing acceleration with:	
		(Still air)	Tailwind (compatible with FR data)
Flight Recorder Time at scheduled Lift-Off:	Secs.	40.8	42.8
Airspeed at scheduled Lift-Off:	Knots EAS	145	145
Distance from start of roll to scheduled Lift-Off:	Feet	5,270*	5,800

**Note:* The distance given by the Boeing Company (see Fig 3) is 5,216 ft. The difference is probably due to small inaccuracies resulting from the computation of speed and distance from acceleration (see paragraph 5.1.1).

These distances are considerably less than those apparently achieved and reflect the discrepancy in lift-off speed. Comparisons of the distances and times from start of roll to the scheduled V_R (132 knots IAS, 131 knots EAS) and from the scheduled V_R to lift-off, for the various thrust or drag, tailwind and flap angle assumptions, are tabulated below.

(i) *Mean line through Flight Recorder points (implied thrust reduction or drag increase)*

Flight Recorder time at scheduled V_R:	Secs.	36.9
Distance from start of roll to scheduled V_R:	Feet	4,250

Hence:	Flaps 15°	Flaps 5°
Time from scheduled V_R to estimated Lift-Off speed: Secs.	9.1	10.1
Distance from scheduled V_R to estimated Lift-Off speed: Feet	2,200	2,470

(ii) *Boeing predicted airspeed-time variation with tailwind (scheduled thrust for 1.95 EPR on all engines).*

Flight Recorder time at scheduled V_R:	Secs.	37.8
Distance from start of roll to scheduled V_R:	Feet	4,580

Hence:	Flaps 15°	Flaps 5°
Time from scheduled V_R to estimated Lift-Off speed: Secs.	8.2	9.1
Distance from scheduled V_R to estimated Lift-Off speed: Feet	2,070	2,300

(iii) *Boeing predicted airspeed-time variation, flaps 15° and scheduled thrust for 1.95 EPR on all engines*

	Still air	Tailwind (compatible with FR data)
Flight Recorder time at scheduled V_R: Secs	35.8	37.8
Distance from start of roll to scheduled V_R: Feet	4,120	4,580
Hence:		
Time from scheduled V_R to scheduled Lift-Off speed (145 knots EAS): Secs.	5	5
Distance from schedule V_R to scheduled Lift-Off speed (145 knots EAS): Feet	1,150	1,220

Although Flight Recorder times and distances are not exact because of the tolerances on the basic data (see (a) and (b) in paragraph 5.1.2) this comparison does show that the achieved time from the scheduled rotation speed to lift-off was considerably slower than that assumed in the performance data. This was due to firstly the achieved rotation speed being higher than that scheduled and secondly due to the rate of rotation being slow. It is difficult to determine where rotation actually commenced but if it is assumed to be at time 40 secs (ie about 3 secs late) then the increase in distance due to the higher (about 8 knots) rotation speed is approximately 700 feet. The pitch attitude record on Fig 2 shows that the initial pitch rate was about 3°/Sec but the mean rate during the rotation to lift-off was about 1.3°/Sec. If the initial higher rate of rotation had been maintained then the time and distance to lift-off would have been reduced by approximately 2 secs and 500 feet respectively.

5.1.4 *Summary of the analysis of the Take-Off run*

The analysis of the Flight Recorder data for the take-off run shows that the contributions to the late lift-off are approximately as follows:

Assuming thrust reduction or drag increase

	Flaps 15°	Flaps 5°
Increase in distance due to Thrust/Drag change: Feet	370	400
Increase in distance due to slow rotation: Feet	810	1,050
Total increase in distance: Feet	1,180	1,450

or *Assuming an increase of tailwind to 6 knots*

	Flaps 15°	Flaps 5°
Increase in distance due to tailwind: Feet	570	560
Increase in distance due to slow rotation: Feet	810	1,050
Total increase in distance: Feet	1,380	1,610

If these increments in distance are added to the calculated Boeing still air distance to lift-off of 5,270 feet (paragraph 5.1.3) then the cause of the extended take-off distances as derived from the Flight Recorder data can be quantified subject to the accuracy of the analysis. The major contribution to the late lift-off appears to be the late and slow rotation. The implications of possible thrust reduction, drag increase or reduce flap setting and tailwind are of secondary importance.

5.2 *Flight Path after Lift-Off*

From Fig 6 and the drawings supplied by the Luton Borough Engineer it is probable that the aircraft did not fly clear of the approach lights etc until about time 52 secs. The damage trail shows that the flight path of the aircraft was about 0.5° down. Thus it was possible to calculate fuselage incidence from the flight path angle and the pitch attitude record for the time period from lift-off to time 52 secs. The implied C_L (including the thrust vector effect) was then calculated from the known weight and recorded airspeed and normal acceleration. The result is shown in Fig 4 where it can be seen that the C_L is considerably less than that given by the Boeing data for flaps 15° at the same incidence. This could imply that either the flaps were not at 15° or that the pitch attitude record was some 3° to 4° too positive. Although, as described in paragraph 3 an attempt has been made to remove constant errors by referencing the pitch data to the aircraft's static ground attitude, it is possible that small variable errors may be present. However, it is anticipated that these would be less than 1° and therefore insignificant for the purposes of the analysis.

The implied flap angle was also similarly assessed over the time period 59-65 secs where pitch attitude, speed and rate of climb were reasonably constant. In this case the flight path angle was calculated from the rate of climb and speed; assuming that the latter was ground speed. Again the calculated C_L and incidence as shown on Fig 4 imply a flap angle at this time of less than 15°, or that the pitch attitude was about 2° too positive.

Forces acting along the flight path of the aircraft are given by the equation:

$$T \cos \alpha_B = D + W \sin \gamma + \frac{W}{g} \dot{V}$$

where T = net engine thrust

α_B = body incidence

D = drag

W = weight

γ = flight path angle

V = true ground speed

Assuming the Flight Recorder speed is ground speed to obtain V and using the Boeing drag for flaps 15°, the implied thrust is about 32,400 lbs ie about 5 per cent down on the value given by the Boeing data. It is possible that the aircraft's drag was greater than the Boeing value due to the nature of the damage (landing gear doors but not flaps). In this case the thrust discrepancy would be reduced.

Energy Height was calculated for the time period 44-119 secs and is shown plotted on Fig 9. Thrust can be derived from the Energy Height slope by the equation:

$$\frac{dH}{dt} = \frac{V_T}{W} \quad (T-D)$$

where V_T = true airspeed

$\frac{dH}{dt}$ = rate of change of Energy Height

For the period 55-75 secs flight conditions are reasonably steady and the Energy Height slope gives an implied thrust that is about 6 per cent less than that given by the Boeing data. Again this discrepancy would be reduced if drag was increased as a result of the damage to the landing gear doors.

Energy Height, using the AIB read-out of Fig 1, was calculated and is shown in Fig 10. An increase in the slope of the line at time 197 secs is an indication of a change in the (Thrust-Drag) relationship. Assuming no thrust change then the implied drag change is consistent with a flap retraction from 15° to 5°. However, if there were no flap change then it is doubtful if the implied thrust change would be possible especially if the total drag had been increased by damage to the landing gear doors.

A reported engine power reduction at about Flight Recorder time 110 is not confirmed by the Energy Height plot.

6. CONCLUSIONS

Although inaccuracies in the recording equipment preclude absolute accuracy in the data recovered from the flight recorder, the analysis of that data implies the following:

6.1 The data and analysis is consistent with the known facts of the incident.

6.2 The rate of increase of airspeed during the take-off run implies an effective thrust of up to 5 per cent lower than the correct value, though this could equally be accounted for by a build-up in the tailwind component to about 6 Knots.

6.3 The take-off distance is either increased by about 370 feet if the effective thrust is reduced by 5 per cent, or by about 570 feet if the tailwind component builds up to about 6 Knots.

6.4 A late and slow rotation to lift-off occurred which increased the take-off distance by 810 feet.

6.5 The distance to lift-off could be increased by up to 270 feet if the take-off flap was inadvertently set at 5° rather than 15°.

6.6 Although the estimated aircraft incidence after take-off is higher than that which is compatible with flaps 15° for the weight and airspeed (and could therefore imply that the flaps were at 5°), uncertainties in the Flight Recorder data make this evidence suspect.

6.7 The estimated thrust after take-off is about 5 per cent less than the scheduled value assuming the drag of an undamaged aircraft with flaps 15°. However, a possible increase in drag due to damage to the landing gear doors would imply a reduction in the thrust discrepancy.

7. SUMMARY

Summarising the Flight Recorder data and analysis, the implications are that:

(a) A late and slow rotation delayed unstick and the stage at which a positive rate of climb was achieved.

(b) There are some indications of a slower rate of increase of airspeed than would be expected. This could be due to a shortfall in total engine thrust and/or a tailwind component occurring during the take-off run. (This is in addition to a small thrust shortfall that would already be expected from the stated use of 1.95 EPR on all engines, instead of the maximum permitted setting available).

(c) There is no reliable evidence to suggest that other than flaps 15° was used during the take-off.

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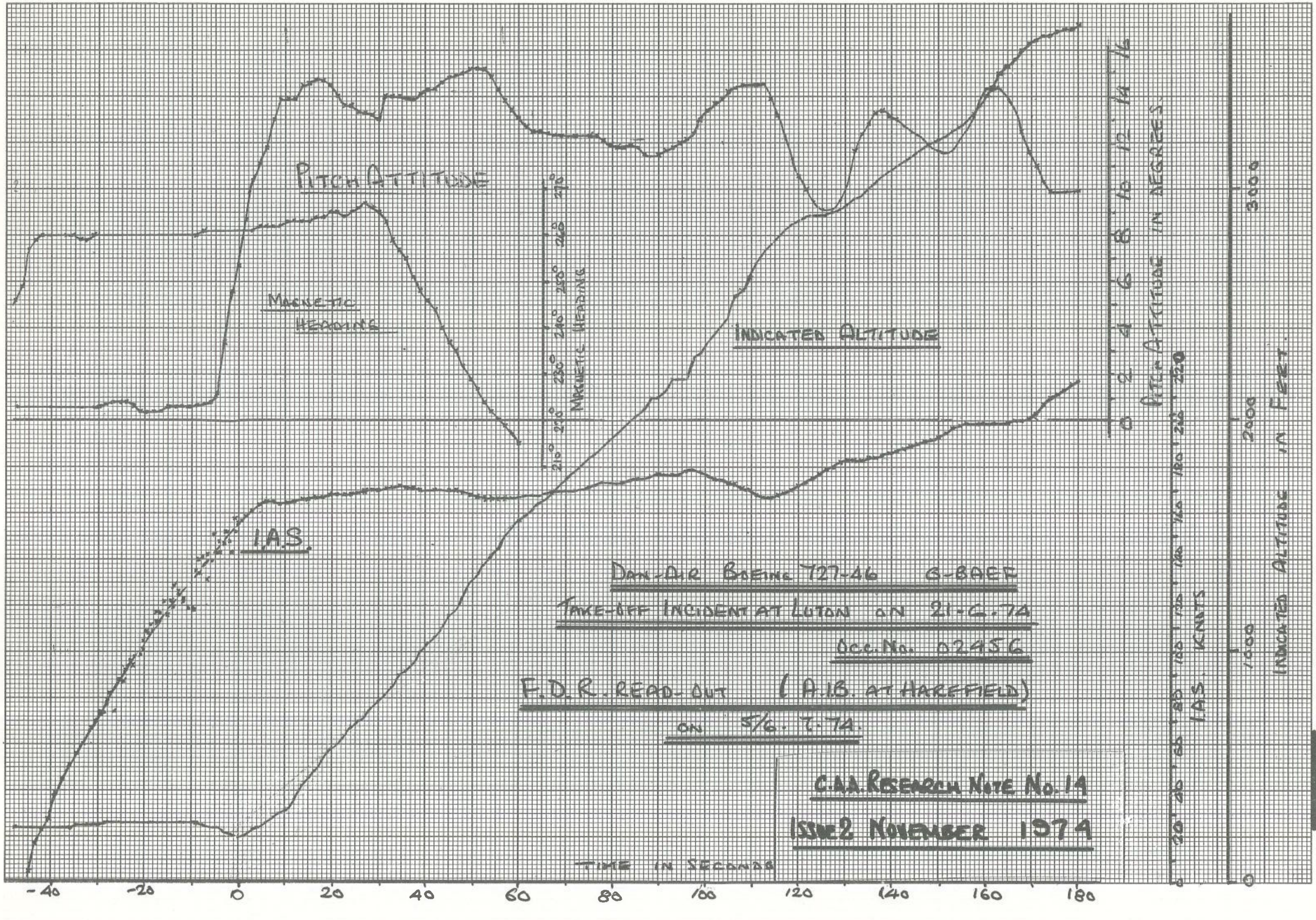


Dan-Air Boeing 727-46 G-BAEF

Take-off Incident at Luton on 21-6-74

Occ. No. 02456

F.D.R. Read-out (A.I.B. at Harefield)

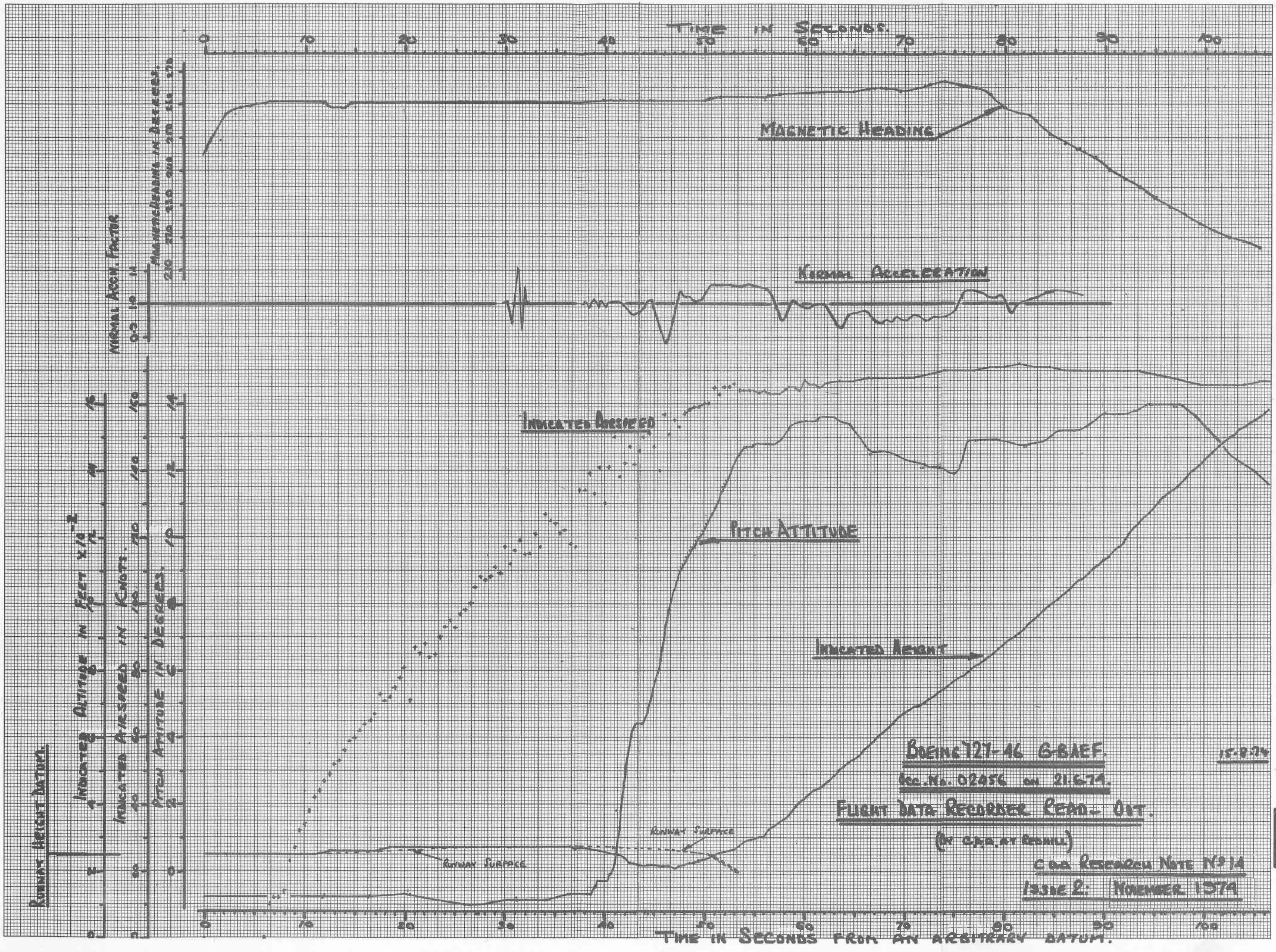
on 5/6. 7. 74.

C.A.A. Research Note No. 14

Issue 2 November 1974

Fig: 1.

FIG: 2.



BOEING 727-46 G-BAEF.

ACC. No. 02456 ON 21.6.74.

FLIGHT DATA RECORDER READ-OUT.

(BY C.R.A. AT REDHILL)

15.8.74

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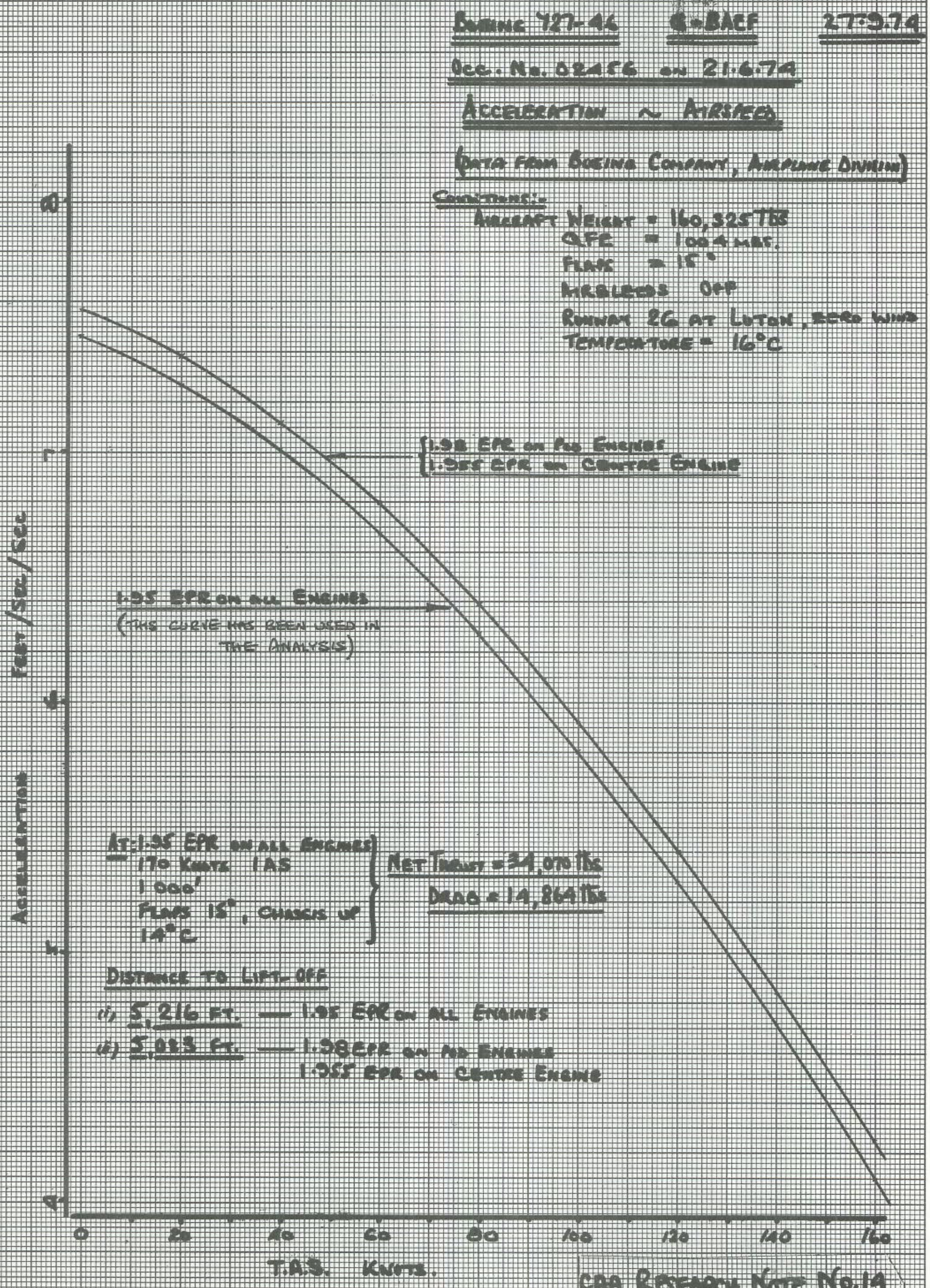
FIG: 3



BOEING 727-46 G-BAEF 27.9.74

OCC. NO. 02456 ON 21.6.74

ACCELERATION ~ AIRSPEED

(DATA FROM BOEING COMPANY, AIRPLANE DIVISION)

CONDITIONS:-
AIRCRAFT WEIGHT = 160,325 LBS
QFE = 1004 MBS.
FLAPS = 15°
AIRBLEEDS OFF
RUNWAY 26 AT LUTON, ZERO WIND
TEMPERATURE = 16°C

1.98 EPR ON POD ENGINES
1.955 EPR ON CENTRE ENGINE

1.95 EPR ON ALL ENGINES
(THIS CURVE HAS BEEN USED IN THE ANALYSIS)

AT: 1.95 EPR ON ALL ENGINES
170 KNOTS IAS
1 000'
FLAPS 15°, CHASSIS UP
14°C
NET THRUST = 34,070 LBS
DRAG = 14,864 LBS

DISTANCE TO LIFT-OFF

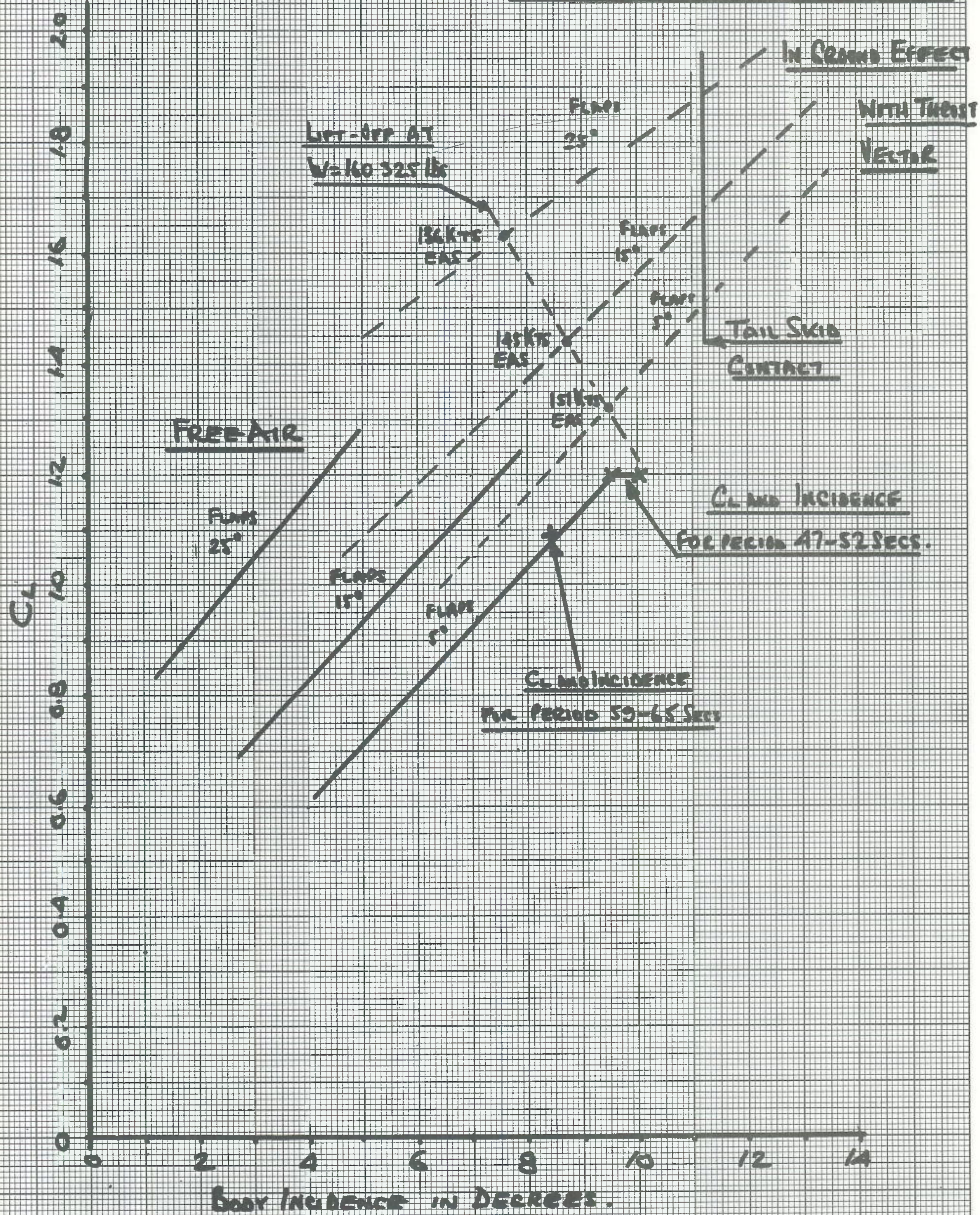
(i) 5,216 FT. — 1.95 EPR ON ALL ENGINES
(ii) 5,083 FT. — 1.98 EPR ON POD ENGINES
1.955 EPR ON CENTRE ENGINE

Fig: 4.

Boeing 727-46 G-BAEF 15-8-74

Occ. No. 0205G on 21.6.74

C_L ~ Incidence



From Boeing Company, Airplane Division

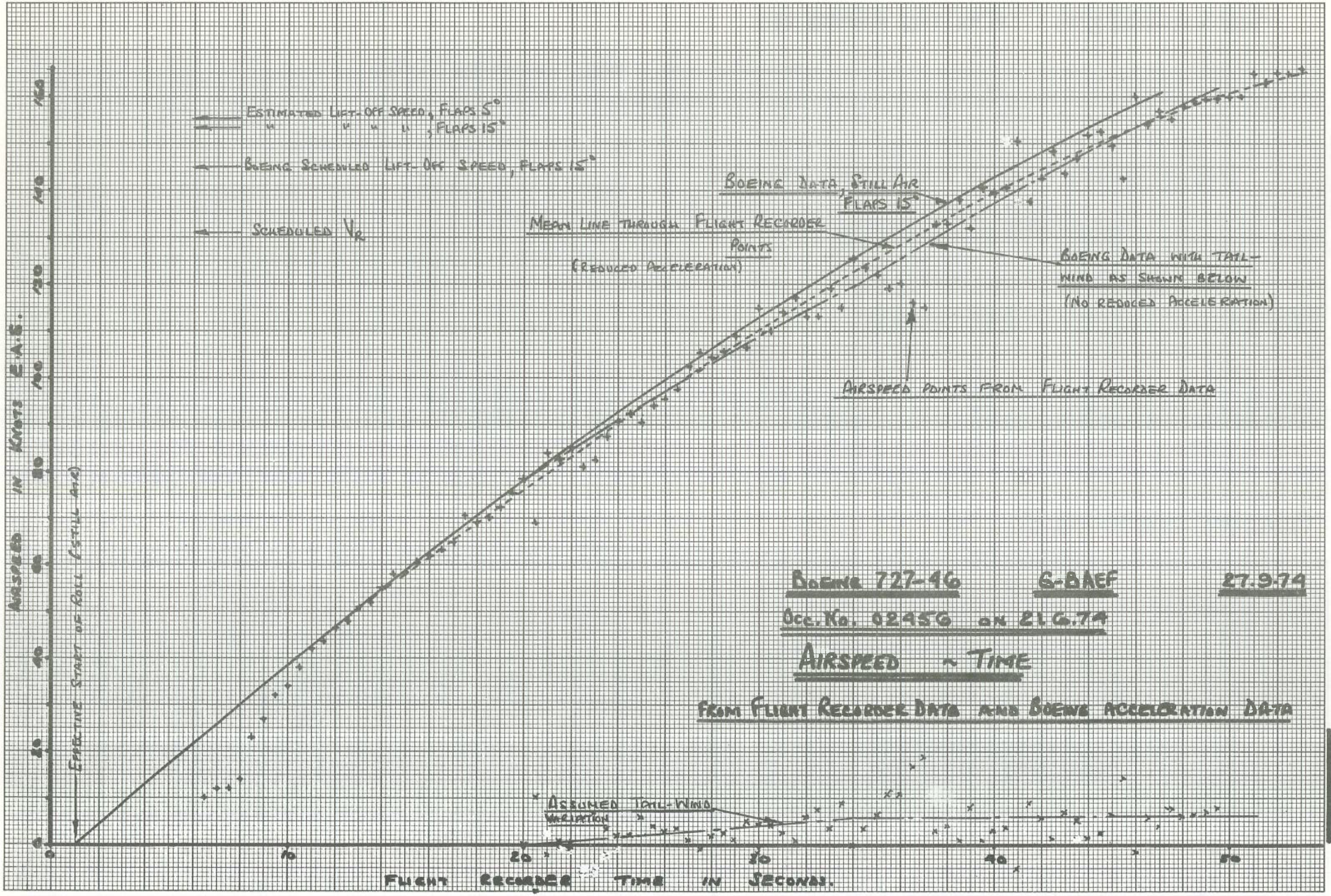
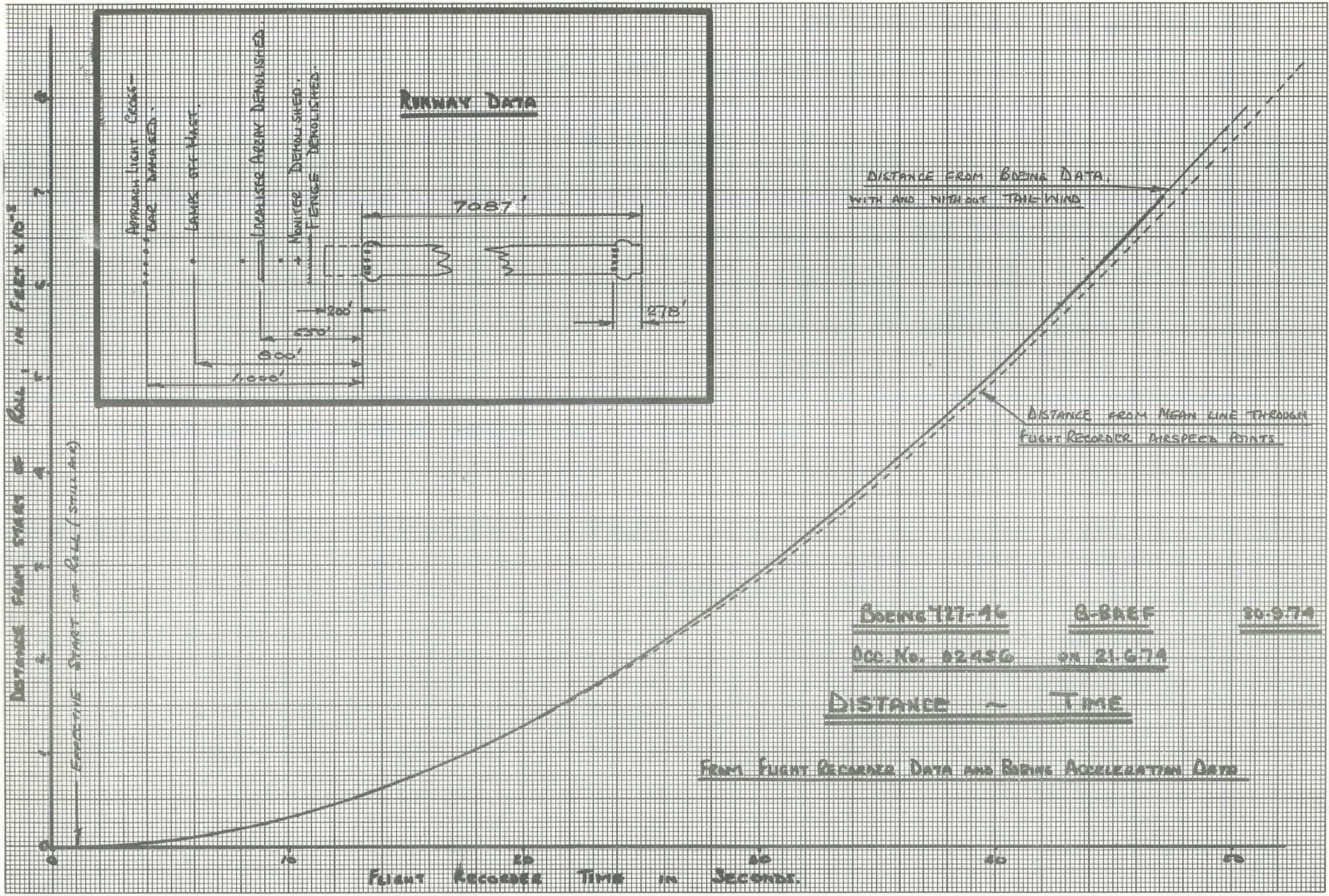

ESTIMATED LIFT-OFF SPEED, FLAPS 5°
" " " " , FLAPS 15°
BOEING SCHEDULED LIFT-OFF SPEED, FLAPS 15°
SCHEDULED V_R
BOEING DATA, STILL AIR FLAPS 15°
MEAN LINE THROUGH FLIGHT RECORDER POINTS
(REDUCED ACCELERATION)
BOEING DATA WITH TAIL-WIND AS SHOWN BELOW
(NO REDUCED ACCELERATION)
AIRSPEED POINTS FROM FLIGHT RECORDER DATA
BOEING 727-46
G-BAEF
27.9.74
OCC. No. 02456 ON 21.6.74
AIRSPEED ~ TIME
FROM FLIGHT RECORDER DATA AND BOEING ACCELERATION DATA
EFFECTIVE START OF ROLL (STILL AIR)
ASSUMED TAIL-WIND VARIATION
AIRSPEED IN KNOTS E.A.S.
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
FLIGHT RECORDER TIME IN SECONDS.

FIG: 5.

FIG: 6.



Distance from Boeing Data, with and without tail-wind

Distance from mean line through Flight Recorder airspeed points

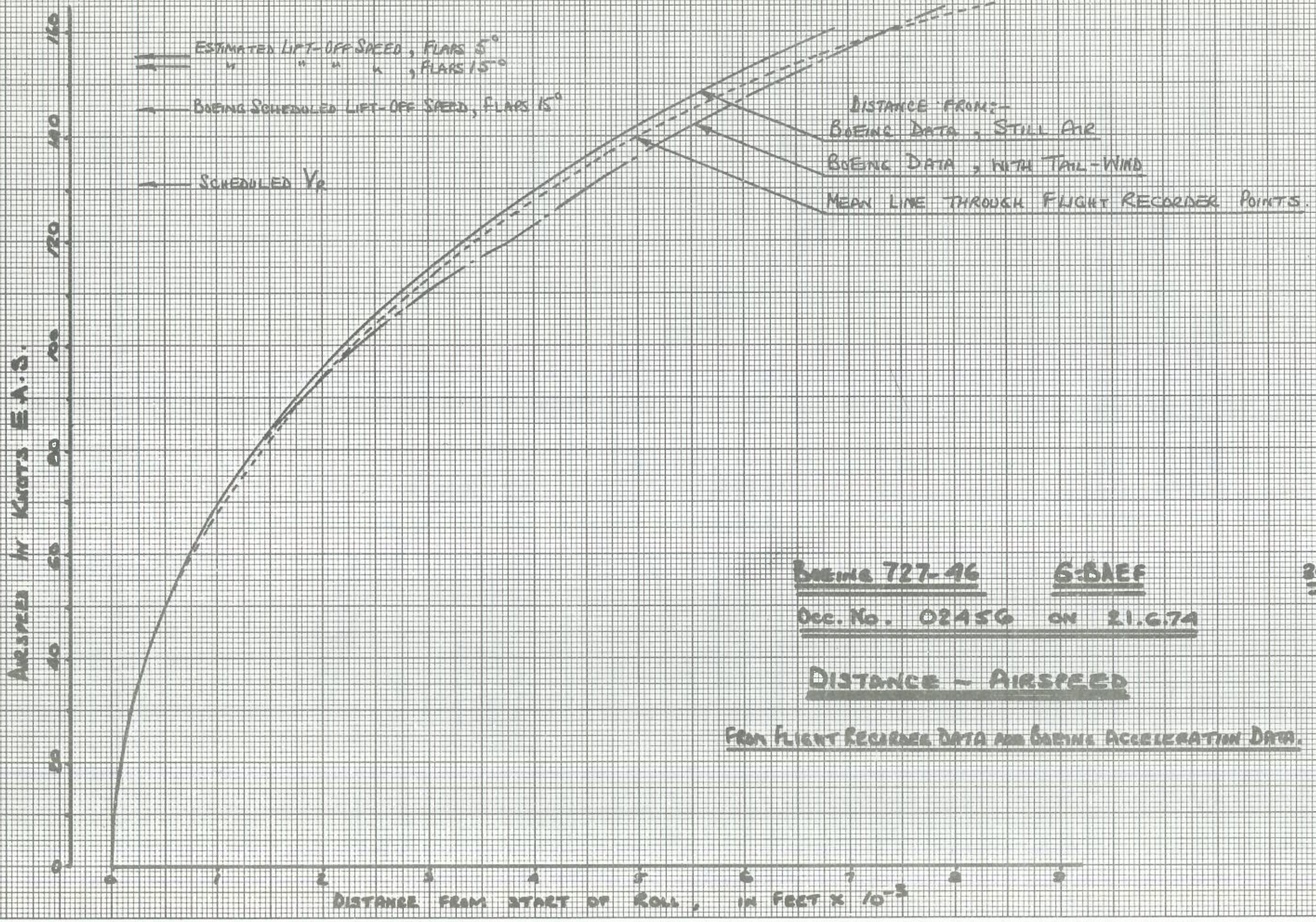
Boeing 727-46 G-BAEF 30.9.74

Occ. No. 02456 on 21.6.74

Distance ~ Time

From Flight Recorder Data and Boeing Acceleration Data

Fig: 7.



Boeing 727-46 G-BAEF

Occ. No. 0245G on 21.6.74

Distance – Airspeed

From Flight Recorder Data and Boeing Acceleration Data.

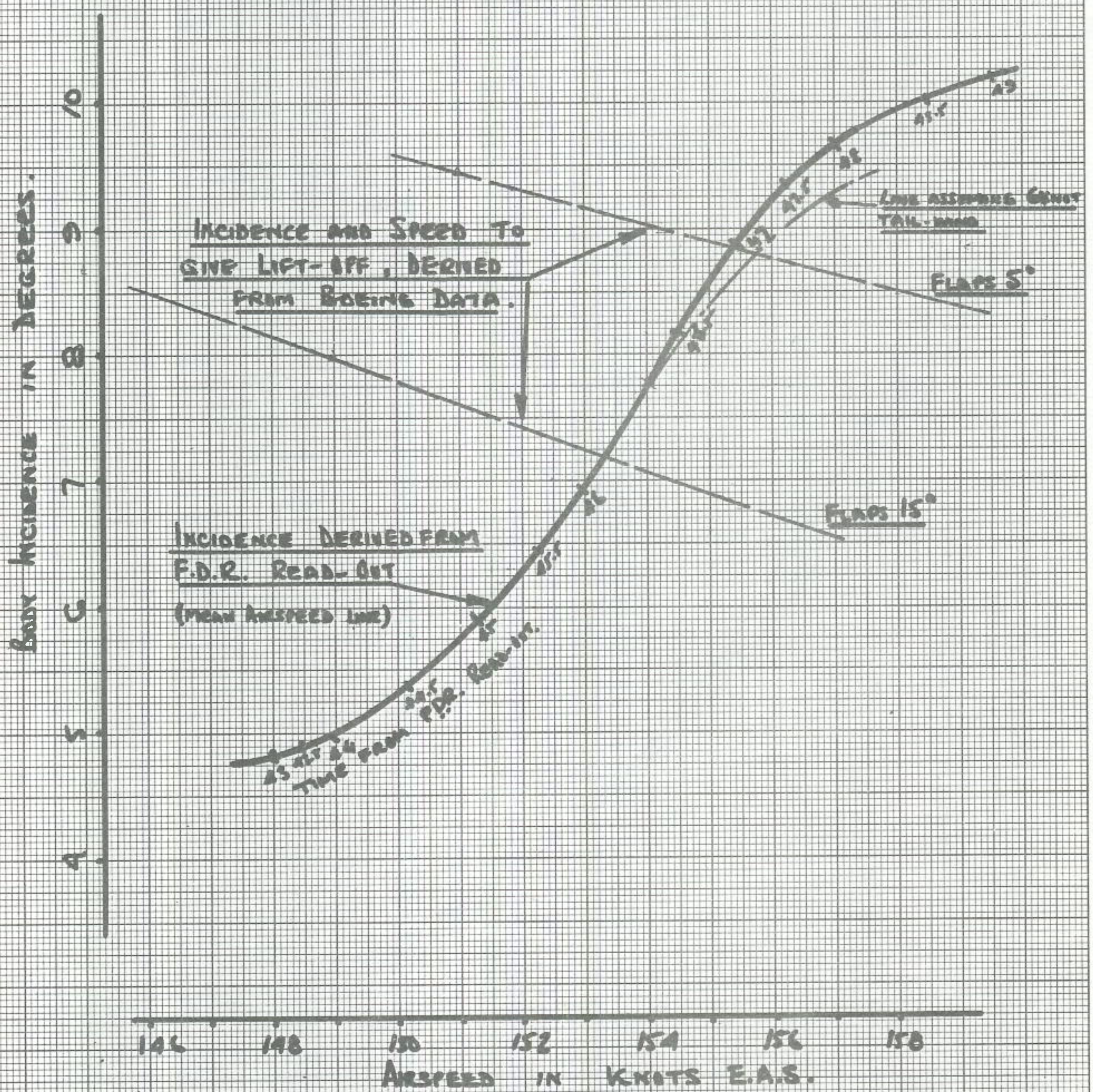
20.9.74

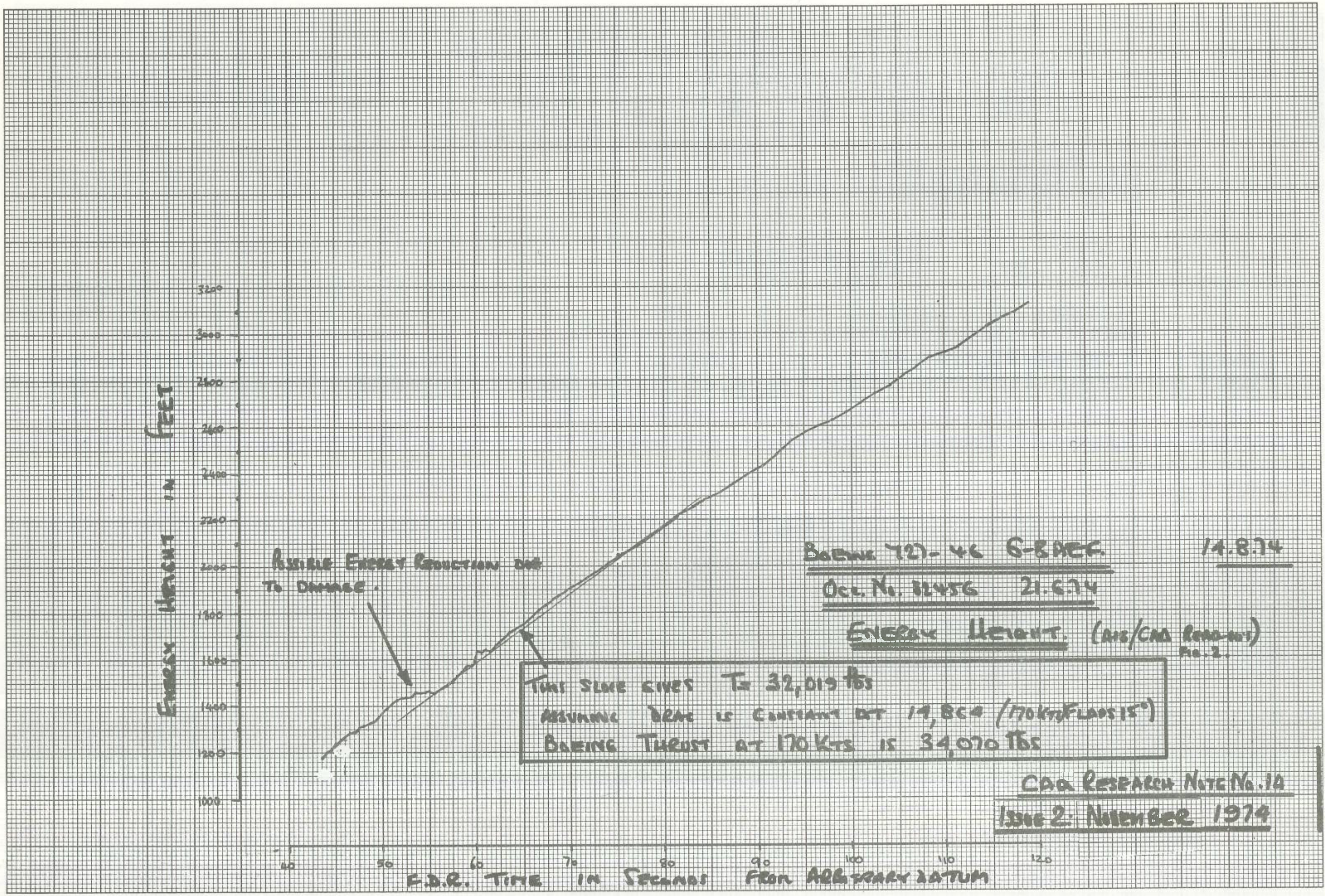
FIG: 8.

BOEING 727-46 15.8.74

OCC. No. 02056 ON 21.6.74

DERIVATION OF LIFT-OFF SPEED





POSSIBLE ENERGY REDUCTION DUE TO DAMAGE.

THIS SLOPE GIVES T= 32,019 lbs
ASSUMING DRAG IS CONSTANT AT 19,864 (170 Kts FLAPS 15°)
BOEING THRUST AT 170 Kts IS 34,070 lbs

BOEING 727-46 G-BDEF. 14.8.74
Occ. No. 32456 21.6.74
ENERGY HEIGHT. (AIB/CAA READ-OUT) FIG. 2.

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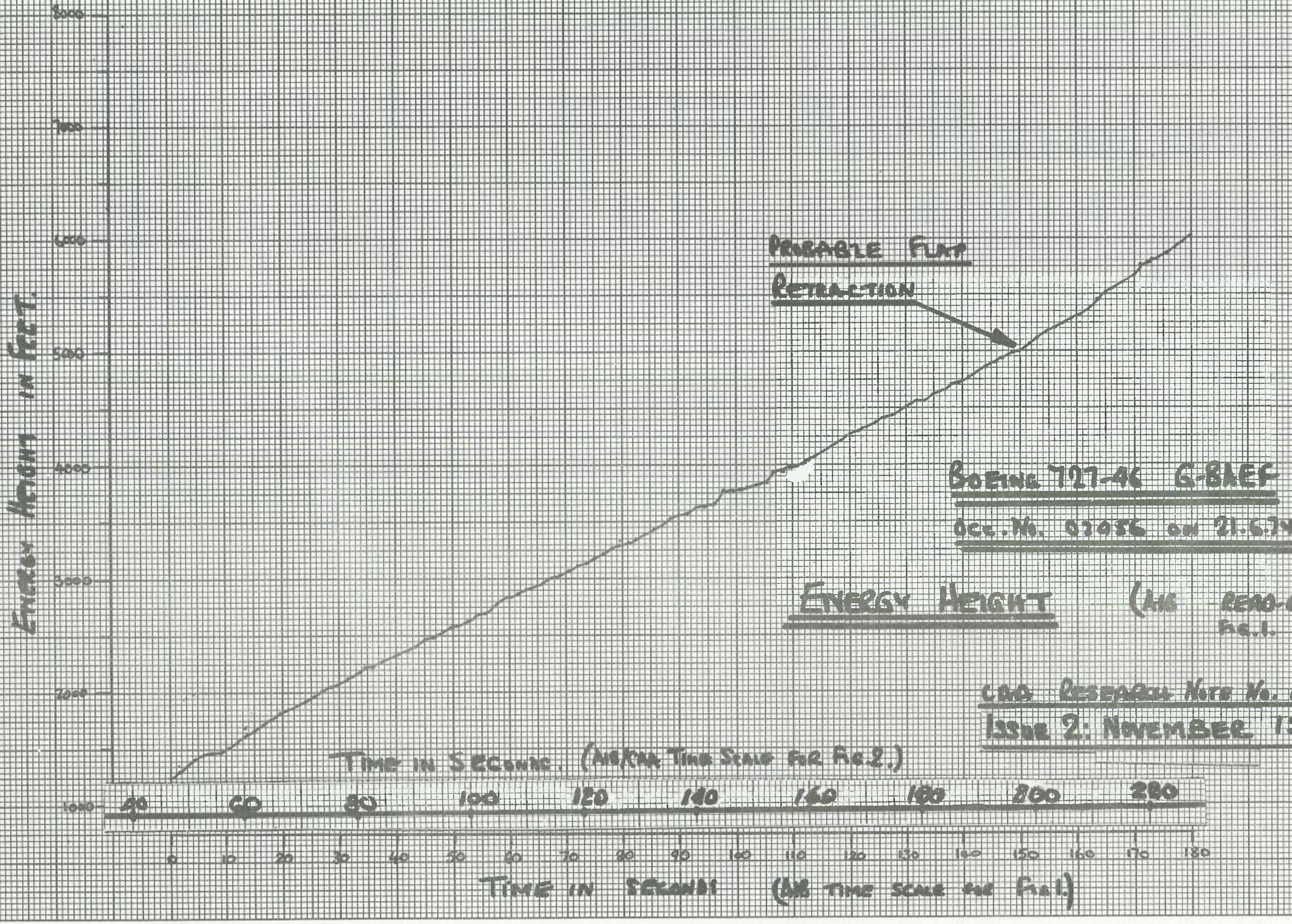
FIG: 9

FIG: 10



BOEING 727-46 G-BAEF

OCC. NO. 02056 ON 21.6.74

ENERGY HEIGHT (AIS READ-OUT FIG. 1.)

16.8.74

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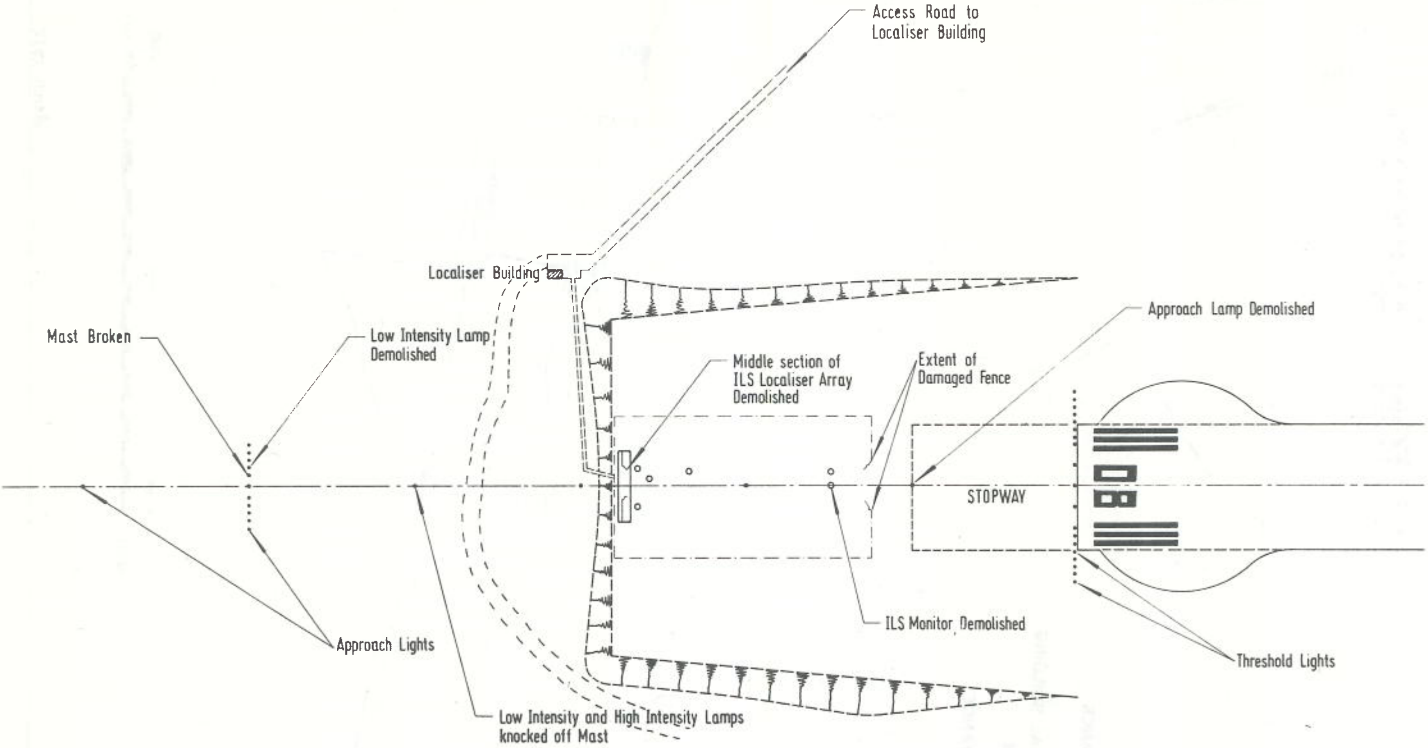
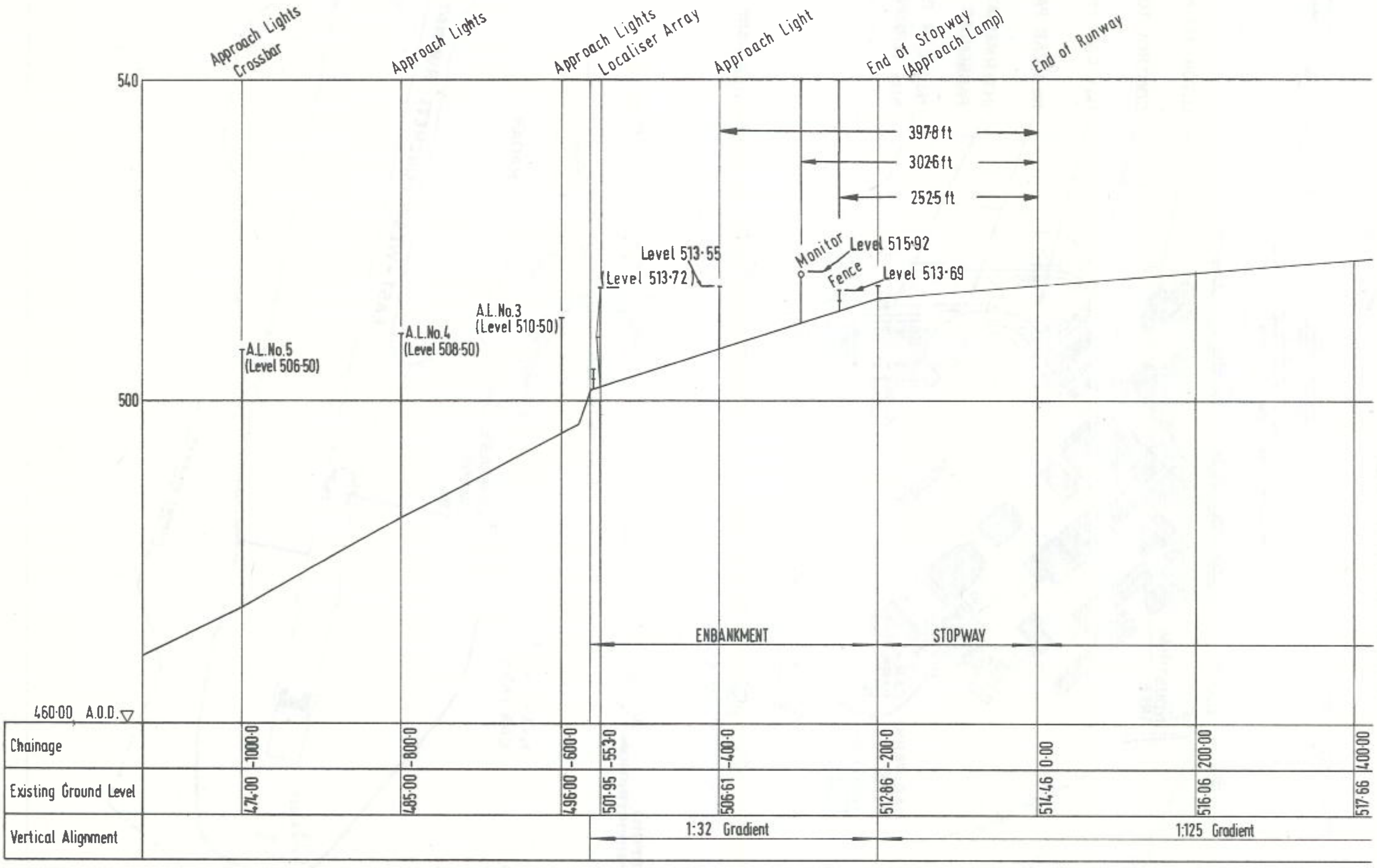
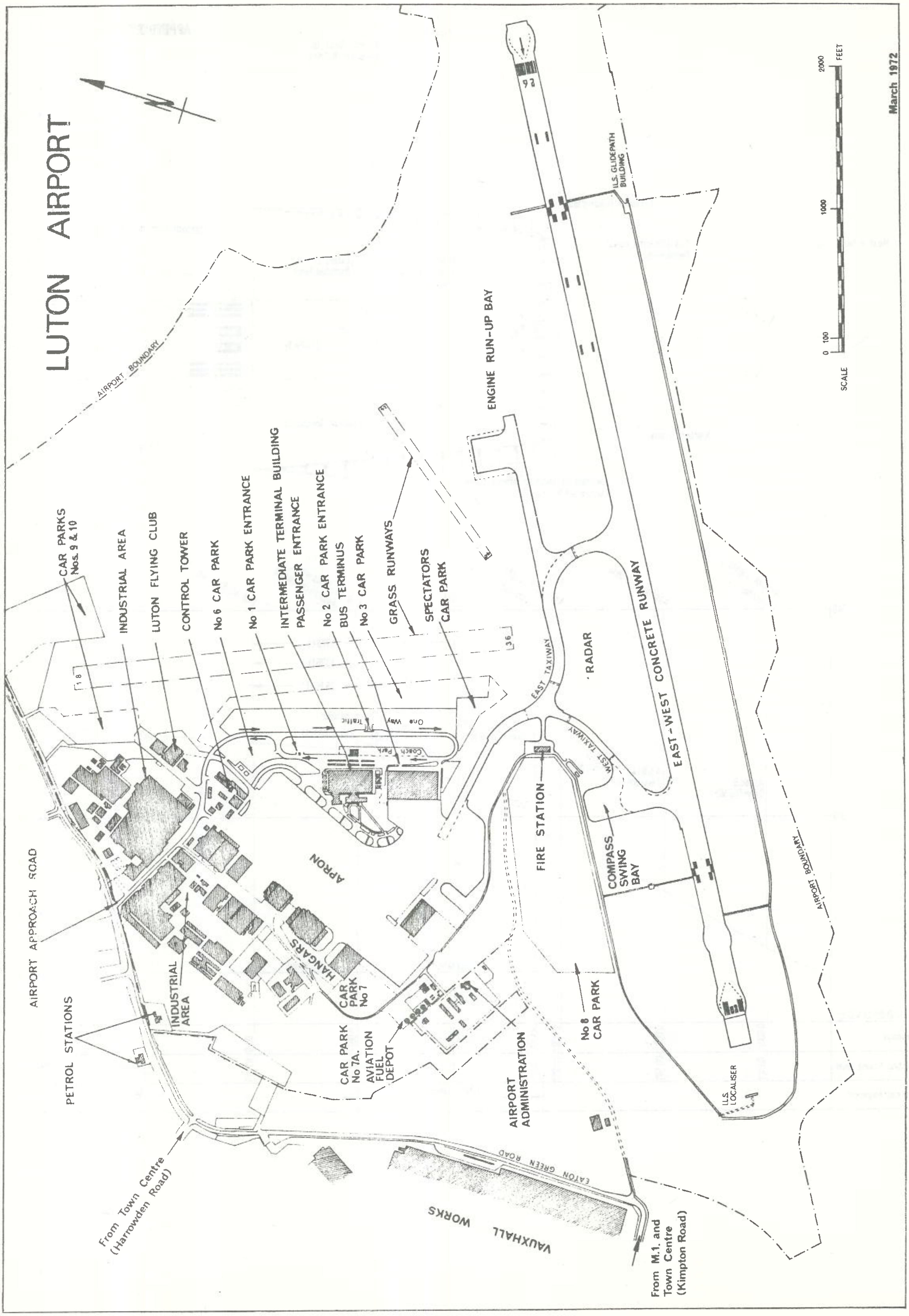
APPENDIX 2.


Access Road to Localiser Building
Localiser Building
Mast Broken
Low Intensity Lamp Demolished
Middle section of ILS Localiser Array Demolished
Extent of Damaged Fence
Approach Lamp Demolished
STOPWAY
Approach Lights
Approach Lights
ILS Monitor Demolished
Threshold Lights
Low Intensity and High Intensity Lamps knocked off Mast


Approach Lights Crossbar
Approach Lights
Approach Lights
Localiser Array
Approach Light
End of Stopway (Approach Lamp)
End of Runway
540
500
460·00 A.O.D.
397·8 ft
302·6 ft
252·5 ft
Level 513·55
(Level 513·72)
Monitor
Level 515·92
Fence
Level 513·69
A.L. No.5 (Level 506·50)
A.L. No.4 (Level 508·50)
A.L. No.3 (Level 510·50)
ENBANKMENT
STOPWAY
Chainage
-1000·0
-800·0
-600·0
-553·0
-400·0
-200·0
0·00
200·00
400·00
Existing Ground Level
474·00
485·00
496·00
501·95
506·61
512·86
514·46
516·06
517·66
Vertical Alignment
1:32 Gradient
1:125 Gradient

APPENDIX 3

LUTON AIRPORT



March 1972