DES 8100/1

College of Aeronautics

AIRCRAFT DESIGN

A LARGE ADVANCED FREIGHT AIRCRAFT

F-81

Dr. J.P. Fielding NOVEMBER 1981

INDEX

TABLES

FIGURES

1. Introduction

Commercial air freight operations have grown in importance in recent years, due mainly to cost reductions caused by increasing aircraft and freight-terminal efficiencies. The bulk of this traffic is carried in the underfloor holds of wide-body passenger aircraft, but there is a significant sector of the market served by 'dedicated' freighters such as the 747F and DC8-63F. These aircraft are often equipped with standard containers and pallets which are loaded at factories or freight depots. The largest and most efficient container is the 8 ft x 8 ft x 20 ft size

NASA felt the need to study the air-freight market and commissioned the extensive C.L.A.S.S. study (Ref.1). This report suggested that significant operating cost savings would be required, together with improved ground interfaces, to make more inroads into the surface transport market.

It studied the economics of aircraft derived from current types, together with new designs. The former was more immediately attractive, but a market existed for new aircraft from the mid 1990's.

The most attractive new type would be a long range aircraft with payload in the 75 to 165 ton range. The lower size aircraft was slightly more economic, but would pose grave airport frequency saturation problems and therefore a larger aircraft was preferable. Aircraft much above the 165 ton class however, would lead to development costs higher than the market could stand.

An aircraft of about 165 tons payload seemed to be a good solution which could be made more attractive if it were designed to satisfy both civil and military requirements, thus spreading development costs. This philosophy was aimed at during the design of the Lockheed C-141 but too much emphasis was placed on military properties and no civil versions were sold. This should be avoided on a new design which should be capable of augmenting and partially replacing current fleets of 747F, DC10 CF and Lockheed C-5A aircraft.

It was decided to study such an aircraft with the main emphasis being on civil operations with modifications such as a kneeling undercarriage as military options. A specification was derived from refs. 1 and 2 together with information about current freighter aircraft which is shown in section 2 below:-

2. Specification

a) The Range with maximum payload should be 4,000 n. miles with reserves.

b) The Payload should be in the range 330-390,000 lb (150-175,000 kgs) Civil operators would use 8 x 8 x 20 ft containers with provision for a height extension to 10 ft.

Military payloads would include most of the major equipment. Typical extremes in size and weight are:-

1)	Weight.	Chieftain Main battle tank	(52.3 tonnes)
2)	Length	175 mm self propelled gun	(11.3)m
3)	Height	Puma helicopter rotor to retracted undercarriage (13.2 ft {4 metres})	

c) Field Performance in the civil version should be similar to that of the 747F:-

Take off to 35 ft = 11,000 ft (3350 m)
Landing = 7,000 ft (2130 m)

The runway load classification number should be 87 on a 20 in pavement. To meet commercial engine-out climb gradient.

d) Speed

Cruise Mach numbers in the 0.75-0.8 range

e) Technology

Technology that is likely to be available by the mid 1990's is to be used which should include:-

i) Advanced wing sections
ii) "Active" controls.
iii) Some composite materials
iv) More fuel efficient engines
v) Lighter weight systems.

f) Noise

To achieve current noise requirements.

g) Costs

The aircraft first costs should be \$132 x 10^6 (US) in 1994 with direct operating costs 30% below those of 747 Fs.

3. Configuration and Design Requirements

A general arrangement drawing is shown in Fig.F81-1 and some points are discussed below:-

3.1 Wing

A moderate sweepback combined with a relatively thick supercritical wing section enable cruise Mach numbers in the region of 0.75 to be achieved. The aspect ratio is 11 and there is sufficient fuel tankage in the wing for a range of 4000 n. miles with reserves. The very high aspect ratio improves fuel burn and airfield performance. The large bending moments produced by such a wing are alleviated by "active" ailerons which modify the airload distribution. Single-slotted Fowler flaps, moderate wing loading, spoilers and the high aspect ratio give adequate field performance which may be augmented by leading-edge slats for military operations.

3.2 Fuselage

The aircraft uses an extremely large fuselage. The main freight hold has a parallel section wide enough to accommodate three 8' x 8' x 20' containers side by side together with two walk ways. The elliptical section gives a maximum height of 10 ft at the corners of the compartment but 13.5 ft at the centre for bulky loads. The upper deck includes the flight deck, rest station, wing centre section and two compartments which can be used for LD-7 "igloo" containers or passengers. The normal freight loading is by means of the large nose 'visor' door. In military versions this may be augmented by nose ramps which when combined with a kneeling undercarriage, give an 11° drive on ramp. Provision is also made for a rear ramp door for the air-dropping of military supplies.

If the aircraft were used in an all passenger role, high density capacity 1000 passengers on three floors.

3.3 Engines

The aircraft uses four wing-pod mounted RB211 - 524D engines which have good fuel consumption, performance and noise characteristics. It is envisaged that by the mid 1990's these engines or their derivatives should have their fuel consumption improved by 13%.

3.4 Design requirements

The aircraft is to be designed to meet BCAR requirements at the normal take off mass of 435840 kg. The design value of cruise speed V_C is 173 m/s EAS or M = 0.75, whichever is the lesser. The corresponding values of the design diving speed V_D = 187 m/s EAS and M = 0.81 and these values are shown in fig.6
Av.P. 970 requirements are to be used where appropriate.

The airframe life is to be 60,000 hours with average flight duration of 5.75 hours . The cabin differential pressure of 0.58 bar ensures that the cabin altitude need never exceed 2.1 km. The range performance depends on the flight pattern used and is summarised in fig. 7.

The undercarriage design vertical velocity of descent is 3.05 m/s. The aircraft mass associated with particular flight patterns for fatigue loading purposes must be calculated as appropriate. A typical distribution of flight profiles is given in table 3.

Where appropriate the design of components should allow for the reliability requirements shown in table 4.

4. Geometry

4.1 Wing (See Fig. 3)

Gross area	688.9 m
Span	87.2 m
Aspect ratio	11.04
Root chord (centreline)	11.3 m
Tip chord (nominal)	4.5 m
Leading edge sweepback	27°
Sweep of 0.25c line	25°
Standard mean chord $\bar{c}$	7.90 m

Aerofoil section:-

root 15% thickness supercritical
tip 12.2% thickness supercritical

(See Figure 4)

Wing body setting angle, rel. to chord line	2°
Anhedral on 0.25c line	5°
Location of 0.25 $\bar{c}$ aft of nose	34.29 m
Location of 0.25 $\bar{c}$ line, at centreline above datum	2.55 m

4.2 Ailerons (See Fig. 3)

Type:- Round nose

Aileron chord/wing chord	0.25
Movement	±20°
Inboard end from aircraft centreline	33.48 m
Outboard end from aircraft centreline	42.28 m

4.3 Trailing edge flaps (See Fig. 4)

Type:- Single slotted Fowler

Flap chord/wing chord	0.30
Take off flap angle	25°
Landing flap angle	40°
Inboard end of flap from ℄	6.52 m
Outboard end of flap from ℄	33.48 m
Wing chord flap extended/wing chord	1.15

4.4 Wing spoilers (See Fig. 3)

Chord 10% of local chord

Movement max. relative to local top surface	60°
Inboard end relative to aircraft ℄	6.52 m
Outboard end relative to aircraft ℄	33.48 m
Distance of spoiler leading edge from wing trailing edge	35% of chord

4.5 Tailplane (See Fig. 3)

Gross area	73.8 m^2
Span	18.0 m
Aspect ratio	4.39
Root chord (centreline)	5.8 m
Tip chord (nominal)	2.4 m
Sweepback of leading edge, approx.	31°
Sweep of 0.25 c line	25°
Aerofoil section:- 10% thickness symmetrical (See Fig. 4)	
Dihedral	Zero
Movement	$+8^{\circ}$ -13°
Location of apex line aft of fuselage nose.	73.27 m
Vertical location above fuselage datum	12.0

4.6 Elevator (See Fig. 3)

Type:- Round nose	
Elevator chord/tailplane chord	0.30
Movement	$+20^{\circ}$ -25°

4.7 Fin (See Fig. 3)

Nominal area above fuselage datum (ignoring tip fairing)	114.66 m^2
Net area, above fuselage	80.44 m^2
Height above datum	12.6 m
Nominal height above fuselage	9.4 m
Aspect ratio, based on nominal area	1.385
Aspect ratio, based on net area	1.098
Root chord, on fuselage datum	11.0 m
Tip chord (nominal)	7.2 m
Sweepback of leading edge, approx.	33°
Aerofoil section:- 12% thickness symmetrical (See Fig. 4)	
Distance of intersection of leading edge with fuselage datum, aft of fuselage nose.	66.73 m

4.8 Rudder (See Fig. 3)

Type: Round nose

Rudder chord/fin chord	0.25
Height of rudder root at trailing edge, above datum	3.2 m
Height of rudder tip at trailing edge above datum	10.7 m
Movement	$\mp 20^{\circ}$

4.9 Fuselage (See Fig. 2)

Overall length	78.6 m
Maximum width overall	10.4 m
Internal width on main hold floor	8.6 m
Internal width on upper deck floor	3.6 m
Maximum height of main hold	3.94 m
Maximum length of main hold	57.2 m

4.10 Undercarriage (See Fig. 2)

Type:- Nosewheel with four main legs.

Wheelbase, to centre of main units	26.54 m
Track, to centre of outboard main bogie	8.1 m

Main undercarriage units

6 wheel bogie

Tyres: 1.245 m diameter by 0.432 m wide

Tyre pressure	10.34 bar
Wheel track	1.28 m
Bogie wheelbase between adjacent axles	1.5 m
Static tyre closure	0.11 m
Maximum tyre closure	0.324 m
Centre of bogie aft of fuselage nose	37.34 m
Distance to centre of inboard bogie from ℄	1.0 m

Nose undercarriage

Four wheels in line, rearwards retracting	
Tyres 1.245 m diameter x 0.432 m wide	
Tyre pressure	10.34 bar
Track of outer wheels	2.9 m
Location of leg aft of fuselage nose	10.8 m

5. Powerplants

Type: Rolls Royce RB211-524D bypass turbojet

Sea level static rating 235.75 kN

Installation: 4 underslung wing pods

Inboard powerplants

Distance of engine centreline below datum at front face	0.15 m
Distance of engine centreline from aircraft centreline at front face	14.85 m
Location of engine front face aft of fuselage nose	27.1 m
Maximum pod diameter	2.45 m
Total length of pod	5.1 m
Angle of pod datum	2.0° nose in
Sweepback of pylon leading edge relative to fuselage datum	17°
Sweepback of pylon trailing edge relative to fuselage datum	13.5°
Inclination of pylon to vertical	0°
Pylon chord at engine centreline	5.7 m
Pylon chord at wing datum	6.5 m
Pylon aerofoil section Symmetrical 12% thickness at 50%c	

Outboard powerplants

Distance of engine centreline below datum at front face	1.1 m
Distance of engine centreline from aircraft centreline at front face	25.3 m
Location of engine front face aft of fuselage nose	32.17 m

Remainder of powerplant information as for the inboard powerplants

5.1 Auxiliary power unit

Type:- Garrett Airesearch

APU datum below fuselage datum	3.2 m
APU position from fuselage nose	30.09 m

6. Masses, Centres of Gravity and Moments of Inertia

Design normal take off mass	435840 kg
Design maximum landing mass	414048 kg
Minimum flying mass	139368 kg
Operating empty mass	139005 kg
Maximum payload	155690 kg
Maximum fuel load	167980 kg

Mass breakdown - see Table 1.

Centres of Gravity at APS mass, relative to $0.25\bar{c}$ and datum (Freight role)

Undercarriage retracted	0.31 m fwd 0.32 m above
Undercarriage extended	0.07 m fwd 0.024 m above
Centres of gravity range in flight	$0.2\bar{c}$ to $0.43\bar{c}$

Moment of Inertia - see Table 2.

7. Aerodynamic Information

7.1 Lift characteristics

Maximum lift coefficient:-

Basic wing	1.34
Flaps at take-off setting	2.04
Flaps at landing setting	2.31

Slope of wing-body lift curve

Basic	4.917/rad
Flaps deployed	5.045/rad.

7.2 Drag characteristics

Drag polar:-

Cruise condition M = 0.75 and 10,670 m

$$C_D = 0.0194 + 0.034\ C_L^2$$

Take off at sea level, undercarriage and flaps extended

$$C_D = 0.0425 + 0.034C_L^2 + 0.053\Delta C_L^2$$

Landing at sea level, undercarriage and flaps extended

$$C_D = 0.0715 + 0.034\ C_L^2 + 0.053\ \Delta C_L^2$$

Where ΔC_L is increment in C_L due to flap deflection.

7.3 Pitching Moment Characteristics (low speed)

Pitching moment coefficient at zero lift	
Wing alone, C_{M_0}	-0.06
Increment due to body and nacelles, ΔC_M	-0.011
Pitching moment increment due to flaps:-	
Take off setting, ΔC_M	-0.17
Landing setting, ΔC_M	-0.233
Location of overall wing-body aero centre from fuselage nose, clean	33.84
(Forward shift due to basic fuselage	0.123 $\bar{c}$
(Forward shift due to engine nacelles	0.02 $\bar{c}$
Spanwise variation of basic wing aero centre	Fig.

7.4 Control and Stabiliser Characteristics

Location of mean tailplane aero centre aft of fuselage nose	76.67 m
Spanwise variation of tailplane aero centre - see Fig. 11	
Location of mean fin aerocentre aft of fuselage nose	71.17 m
Rolling moment coefficient due to aileron, ℓ_ξ - see Fig.13	
Yawing moment coefficient due to aileron, n_ξ	-0.011

Aileron hinge moment coefficient due to wing incidence, b_1	-0.3706
Aileron hinge moment coefficient due to aileron angle, b_2	0.699
Slope of tailplane lift curve variation with M, a_{1T} - see Fig. 9	
Ratio of elevator lift curve slope, a_{2T}/a_{1T}	0.652
Elevator hinge moment coefficient due to tailplane angle, b_{1T}	-0.178
Elevator hinge moment coefficient due to elevator angle, b_{2T}	-0.634
Slope of fin lift curve variation with M, a_{1F} - see Fig. 9	
Ratio of rudder lift curve slope, a_{2F}/a_{1F}	0.429
Rudder hinge moment coefficient due to fin angle, b_{1F}	-0.083
Rudder hinge moment coefficient due to rudder angle, b_{2F}	-0.501
Yawing moment coefficient due to rudder, n_ζ, approx.	-0.1133
Rolling moment coefficient due to rudder ℓ_ζ	-0.0166

7.5 Stability Characteristics

Downwash at tailplane - see Fig. 14

Rolling moment coefficient due to:-

Rolling moment, ℓ_p - see Fig. 13	
Sideslip, ℓ_v	$0.0252 - 0.0054\, a_{1F} - 0.078 C_L - 0.0147 C_{LF}$
Yawing, ℓ_r.	$0.0023\, a_{1BT} + 0.1605 C_L - 0.0119$

Yawing moment coefficient due to:-

Rolling, n_p	-0.054
Sideslip, n_v, tail off	-0.108
n_v overall	$0.067\, a_{1BT} - 0.108$
Yawing, n_r	$-0.0288\, a_{1BT} - 0.0031 - 0.0044\, C_L^2$

Tailplane rolling moment coefficient due to sideslip, K_β	0.16

(NOTE all derivatives are based on the reference areas and dimensions quoted in paragraph 4. Hinge moment coefficients are based on control surface chord and area aft of the hinge line. All angular measurements are in radians unless otherwise stated).

8. Load Distribution

8.1 Aerodynamic loads

The wing spanwise load distribution due to incidence, flap, spoiler andtailplane load distribution due to both incidence and elevator deflection is given in Fig15-17.Whilst the corresponding information for the fin and rudder is to be found in Fig. 18. Fig.19 shows a typical lift distribution along the fuselage. The shape of the distribution is dependent upon incidence and the diagram given is a means for initial loading calculations.

Chordwise load distributions vary substantially with Mach number and lift coefficient. The curves given should only be used for local design of the various components and not for overall balance calculations. Typical wing chordwise loading due to incidence is shown in Fig.20whilst distributions due to flaps, control surface, are given in DES 8041. The chordwise loading on the tailplane and rudder may also be derived from DES 8041.

9. References

1. NASA CR 158950. Cargo logistics airlift systems study VOL.IV.

2. Article - Heavy lift aircraft studied by Air Force.
Aviation Week and Space Technology. February 23rd 1981

TABLE 1

MASS BREAKDOWN

COMPONENT	CIVIL MASS KG	% AUM	MIL.MASS KG	% AUM
Wings	42190	9.68	42190	9.68
Fuselage (including freight handling equipment)	40697	9.34	45527	10.45
Tailplane	1950	0.45	1950	0.45
Fin	1950	0.45	1950	0.45
Main Undercarriage	13152	3.02	16748	3.84
Nose Undercarriage	2320	0.52	2956	0.67
STRUCTURE	102259	23.46	111321	25.54
Engines - Dressed (+Fore Prot.)	20430	4.69	20430	4.69
Powerplant Structure (Pylons, Cowlings)	2683	0.61	2683	0.61
POWERPLANT	23113	5.30	23113	5.30
Fuel System	1044	0.24	1044	0.24
Flying Control System	2506	0.57	2506	0.57
Hydraulics	1911	0.44	1911	0.44
Electrical System	1634	0.37	1634	0.37
Instrument and Avionics	1453	0.33	1453	0.33
De-Ice System	227	0.05	227	0.05
Paint	363	0.08	363	0.08
Furnishings (Crew Compartment only)	1634	0.37	1634	0.37
Air Conditioning System	1998	0.44	1998	0.44
Auxiliary Power Unit	863	0.2	863	0.2
SYSTEMS AND EQUIPMENT	13633	3.13	13633	3.13
Basic Operating Empty Mass	139005	31.89	148067	33.97
Crew (4)	363	0.08	363	0.08
As prepared for service mass	139368	31.97	148430	34.06
Payload (Both decks)	155696	33.73	146634	33.64
Fuel at Max. Payload	140776	32.3	140776	32.3
ALL UP MASS.	435840	100.0	435840	100.0

TABLE 2

MOMENTS OF INERTIA - CIVIL VERSION

(Relative to wing 0.25 mean chord line)

CONFIGURATION	MOMENT OF INERTIA 10^3 kg - m^2			
	PITCH	ROLL	YAW	PRODUCT
As prepared for service 139368 kg	30709	29749	40358	1321
Increment due to 140776 kg fuel	3147	61330	64123	-187
Increment due to 155696 kg payload	46865	574	46291	-675

TABLE 3

PROPOSED FLIGHT PATTERN DISTRIBUTION - CIVIL

Stage Length km	Mach No.	Average Altitude km	% of Total Flights
500	0.75	10.06	9.15
1000	0.75	10.06	7.63
1500	0.75	10.06	1.04
2000	0.75	10.06	2.5
2500	0.75	10.06	2.4
3000	0.75	10.06	2.08
3500	0.75	10.06	0.88
4000	0.75	10.06	0.9
4500	0.75	10.06	1.0
5000	0.75	10.67	2.77
5500	0.75	10.67	2.64
6000	0.75	10.67	39.76
6500	0.75	10.67	15.95
7000	0.75	10.67	1.04
7500	0.75	10.67	2.5
8000	0.75	10.67	3.84
8500	0.75	10.67	3.88

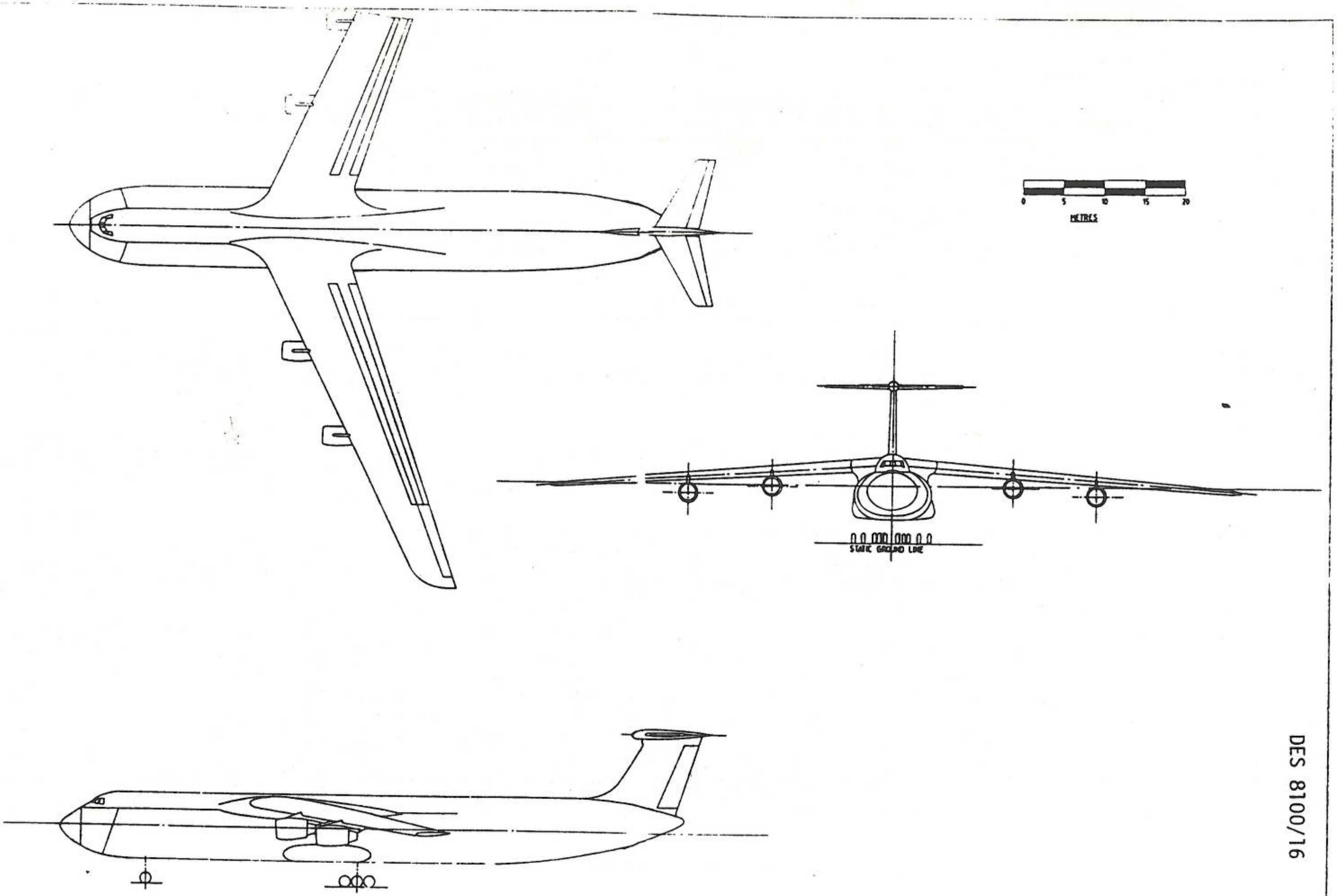
TABLE 4

DELAY RATE TARGETS FOR INDIVIDUAL SYSTEMS

(Civil Role)

ATA CHAPTER NO.	DESCRIPTION	DELAY RATE
21	Air Conditioning	0.047
22	Auto. Flight	0.04
23	Communications	0.099
24	Elec. Power	0.095
25	Furnishings	0.02
26	Fire Protection	0.106
27	Flying Controls	0.157
28	Fuel System	0.125
29	Hyd. Power	0.284
30	Ice Protection	0.046
31	Instruments	0.035
32	Landing Gear	0.803
33	Lights	0.073
34	Navigation	0.2
35	Oxygen	0.019
38	Water/Waste	0.01
49	A.P.U.	0.039
52-57	Structures	0.533
71-80	Powerplant Systems	1.375
TOTAL		4.306

$$\text{Delay Rate} = \frac{\text{No. of delays } > 15 \text{ min + cancellations}}{100 \text{ departures.}}$$

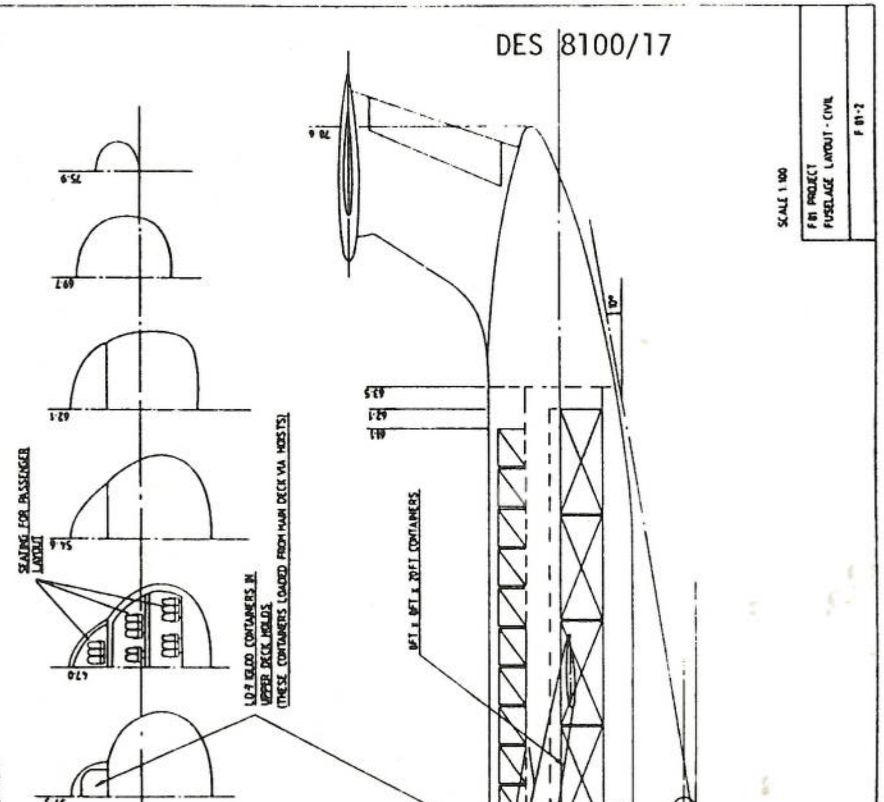


DES 8100/16

F 01 PROJECT
GENERAL ARRANGEMENT

F 01-1

DES 8100/17



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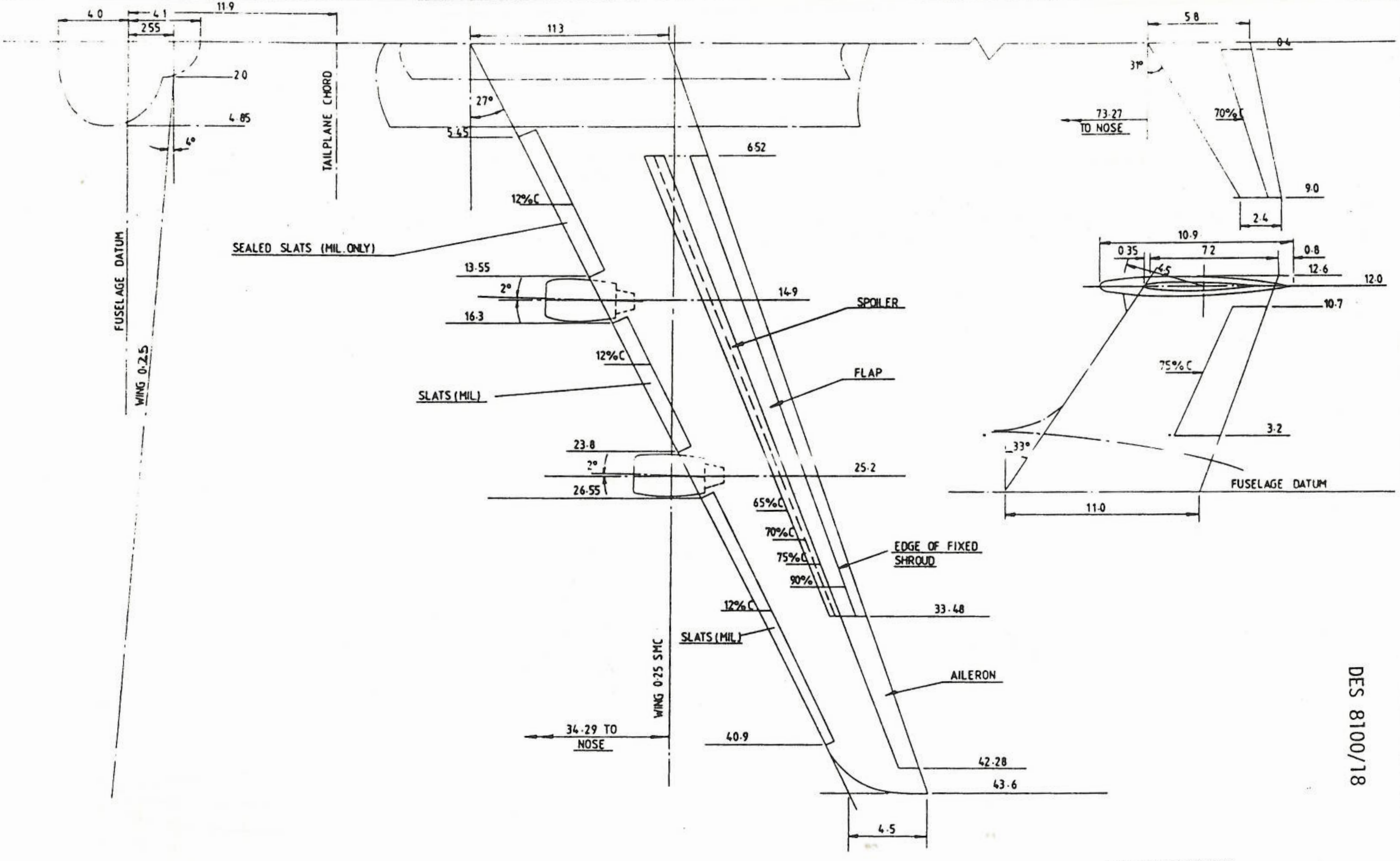
F81 PROJECT
FUSELAGE LAYOUT - CIVIL

F 81-2

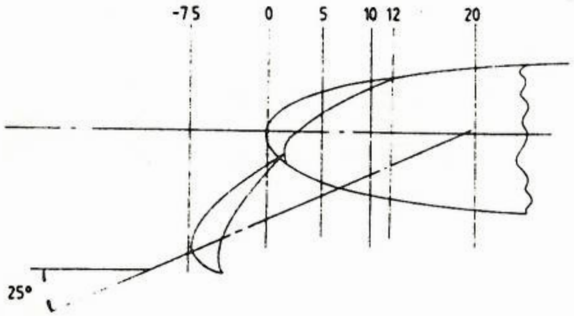


DIMENSIONS IN METRES
SCALE 1:100

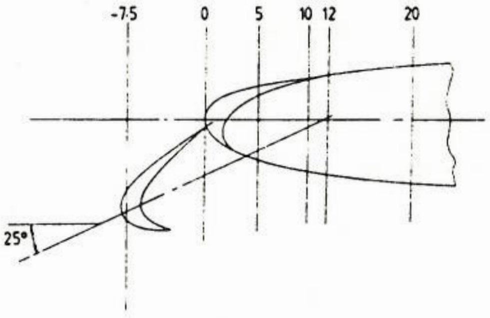
F 81 PROJECT
WING AND TAIL GEOMETRY

DES 8100/18

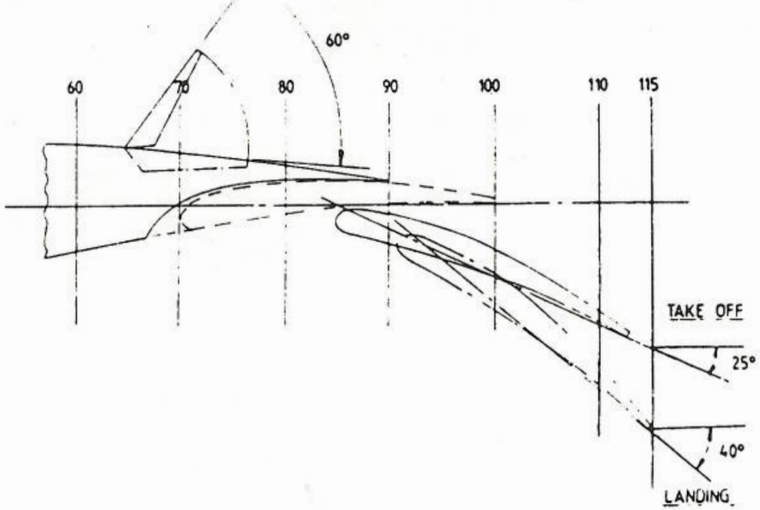
MILITARY VERSION SEALED WING SLAT
INBOARD OF INBOARD PYLON



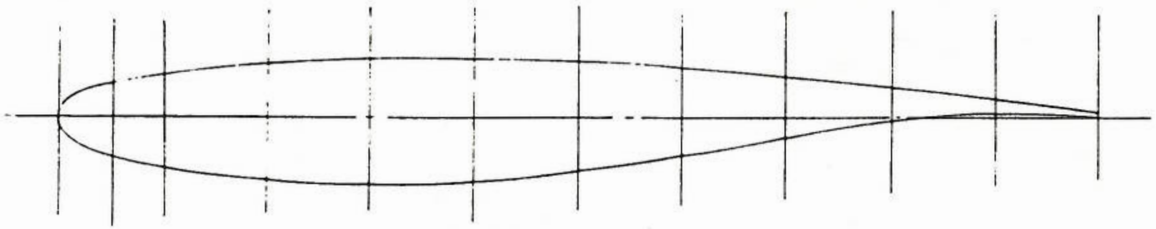
MILITARY VERSION WING SLAT
OUTBOARD OF INBOARD PYLON



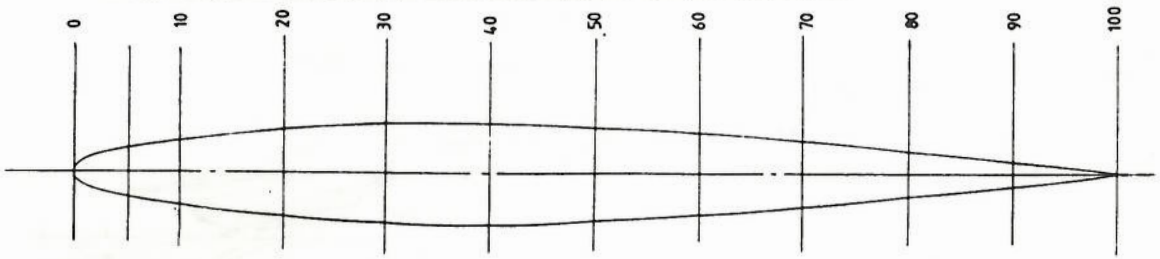
TRAILING EDGE FLAPS



WING TIP AEROFOIL SECTION RAE 9550 DRAWN NORMAL TO L.E. (SCALE UP FROM 12.2% t/c FOR INBOARD SECTIONS)



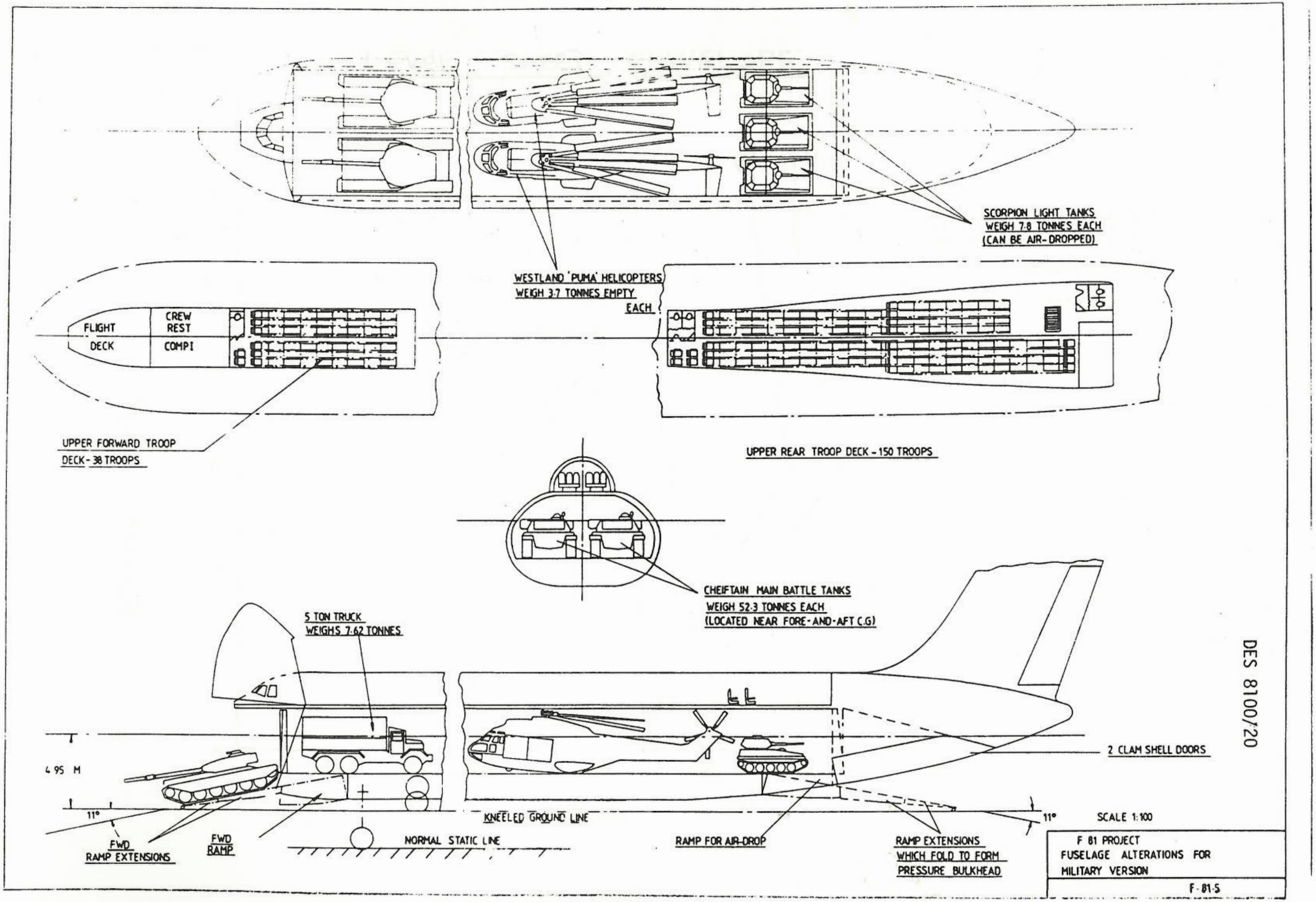
TAIL PLANE SECTION 10% THICKNESS AT 37.5% CHORD SYMMETRIC - SCALE UP TO 12% FOR FIN



DES 8100/19

F 81 PROJECT - AEROFOIL
AND CONTROL SECTIONS

F-81-



F 81 PROJECT
FUSELAGE ALTERATIONS FOR
MILITARY VERSION

F-81-5

DES 8100/20

LEVEL SPEED ENVELOPE

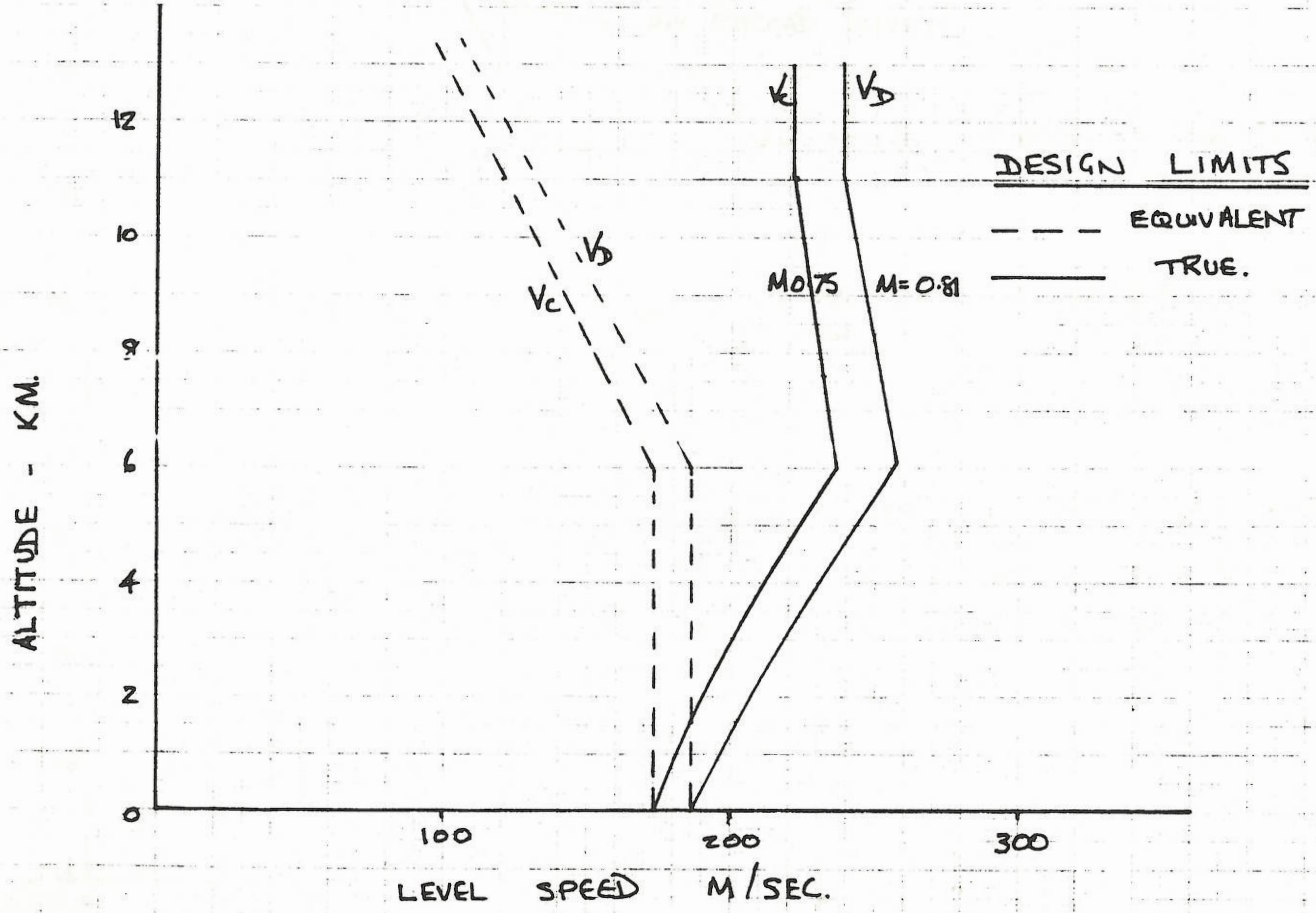
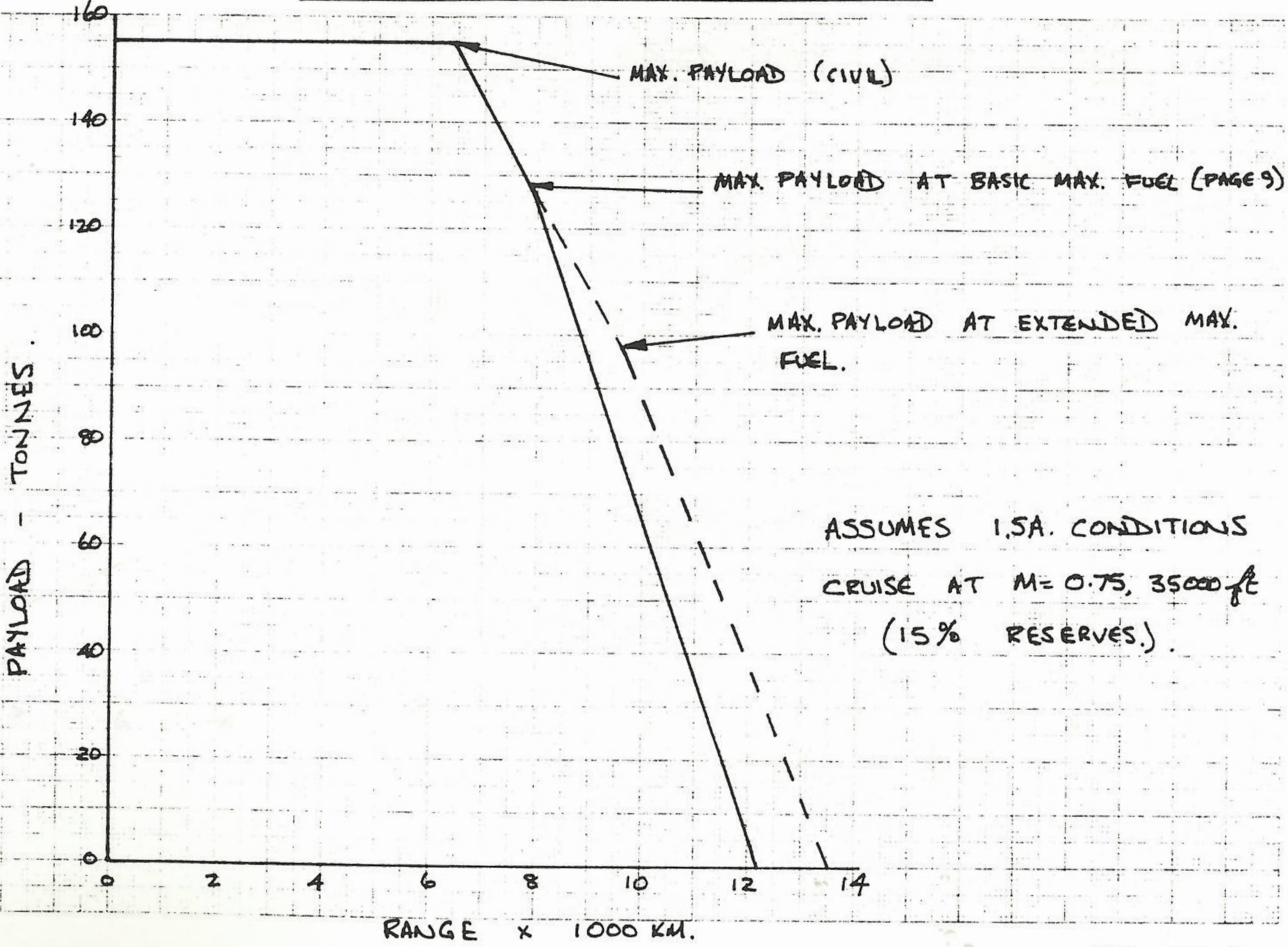


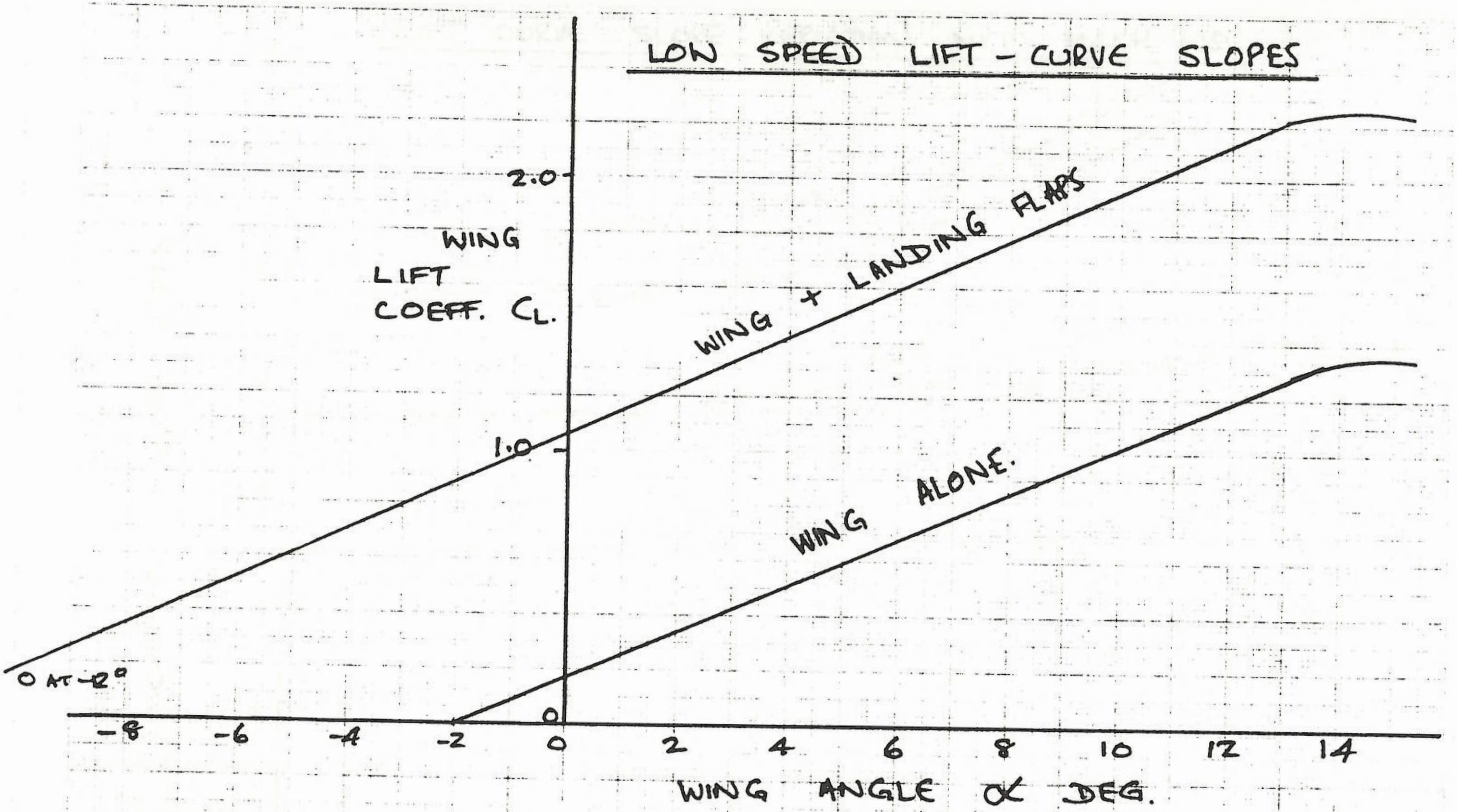
FIG. F81-6

PAYLOAD - RANGE ENVELOPE



ASSUMES I.S.A. CONDITIONS
CRUISE AT M= 0.75, 35000 ft
(15% RESERVES).

FIG. F81-7



LOW SPEED LIFT - CURVE SLOPES

FIG. F-81-8

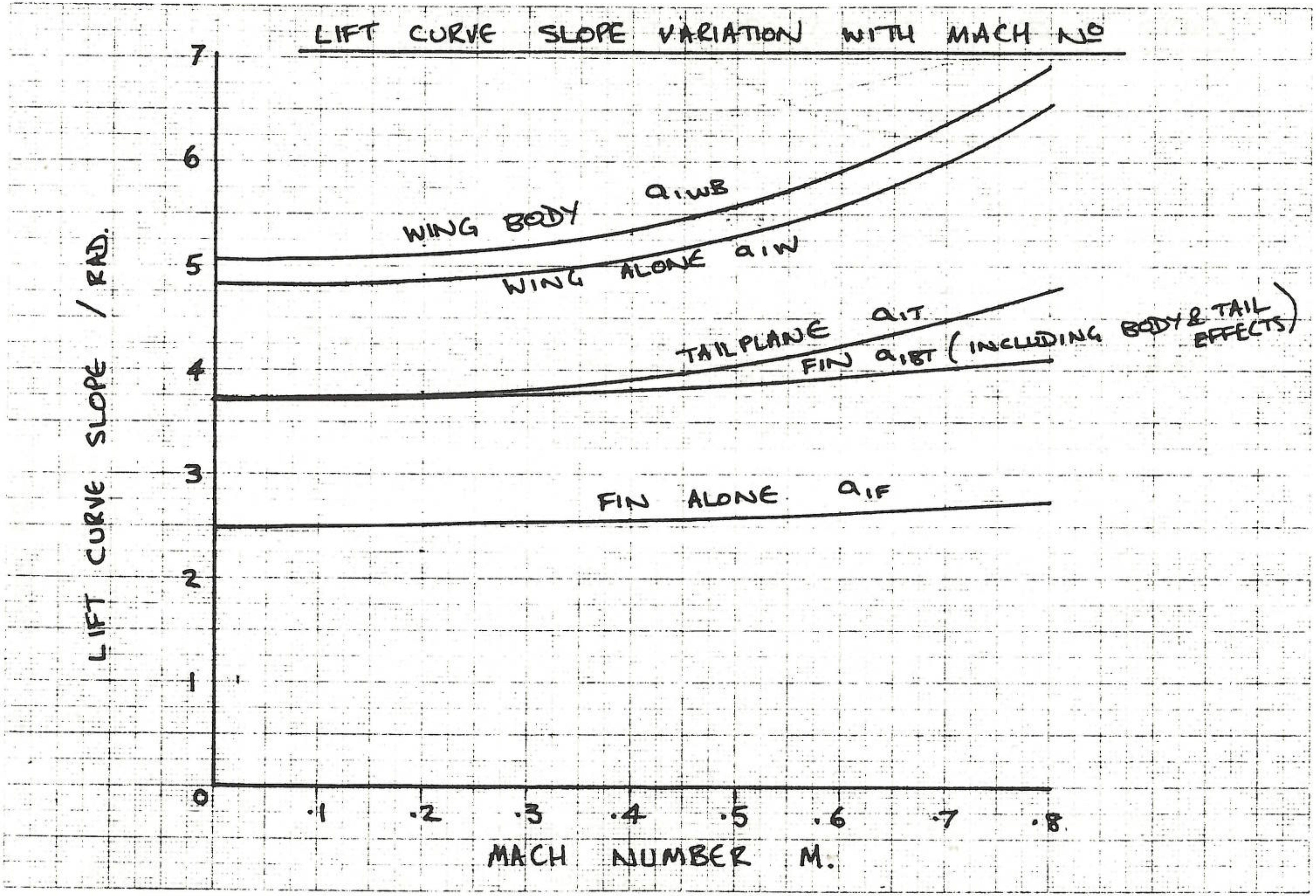

LIFT CURVE SLOPE VARIATION WITH MACH No
LIFT CURVE SLOPE / RAD.
7
6
5
4
3
2
1
0
·1
·2
·3
·4
·5
·6
·7
·8
MACH NUMBER M.
WING BODY a_{1WB}
WING ALONE a_{1W}
TAILPLANE a_{1T}
FIN a_{1BT} (INCLUDING BODY & TAIL EFFECTS)
FIN ALONE a_{1F}

FIG. F81 - 9.

VARIATION OF WING AERO. CENTRE ACROSS SPAN

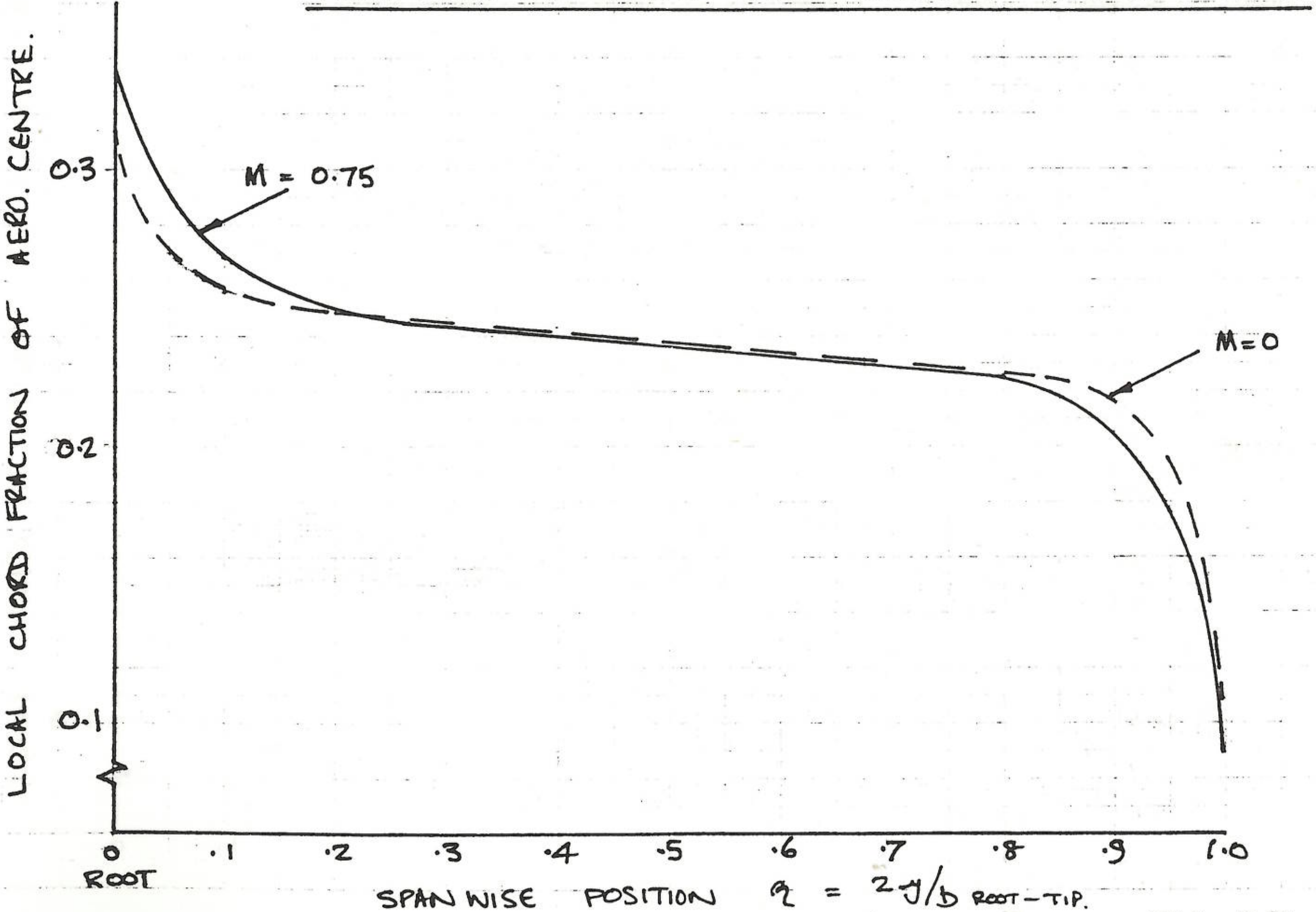


FIG. F81 –10

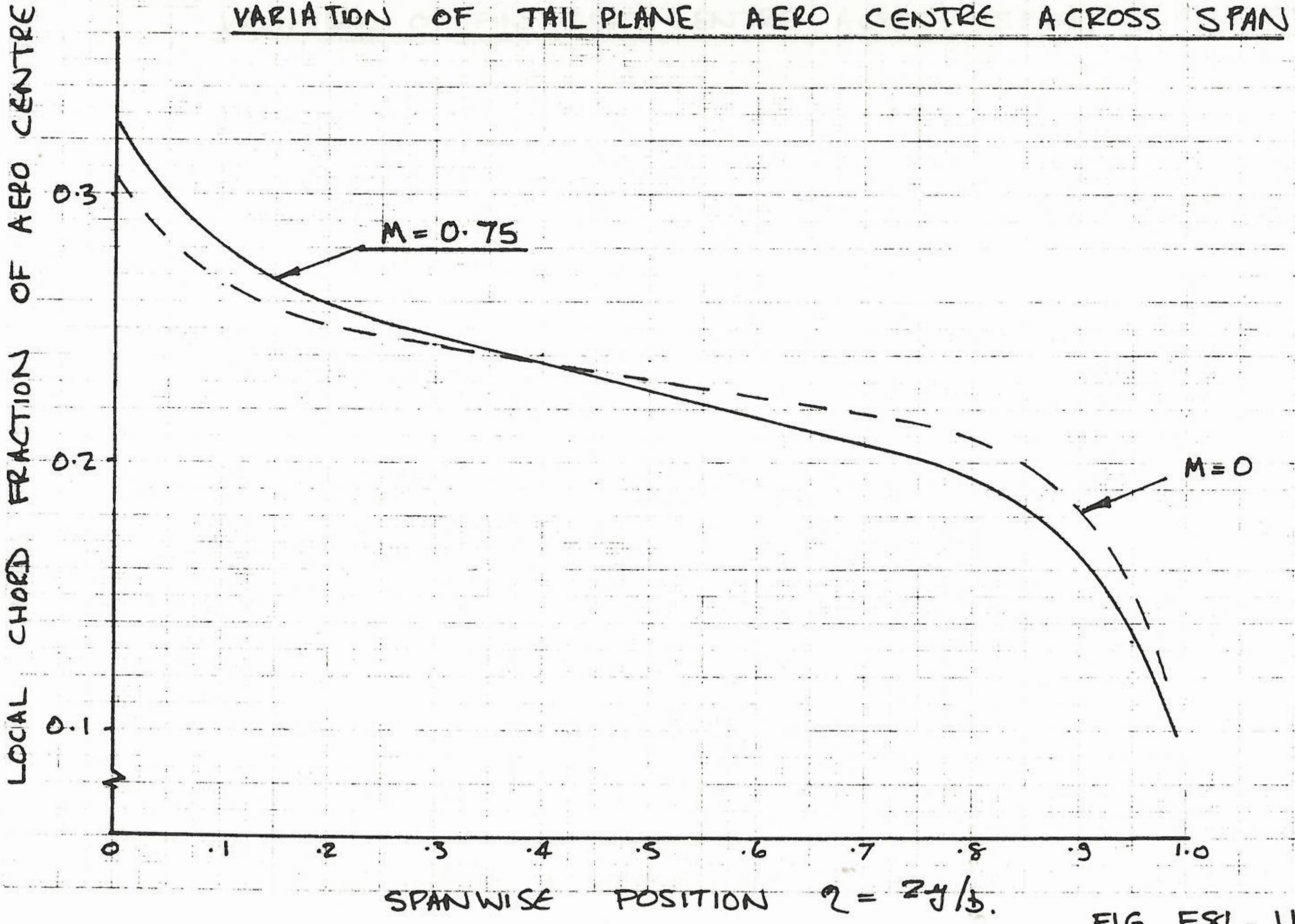

VARIATION OF TAIL PLANE AERO CENTRE ACROSS SPAN
LOCAL CHORD FRACTION OF AERO CENTRE
0.3
0.2
0.1
M = 0.75
M = 0
0
·1
·2
·3
·4
·5
·6
·7
·8
·9
1.0
SPANWISE POSITION η = 2y/b.

FIG. F81 - 11

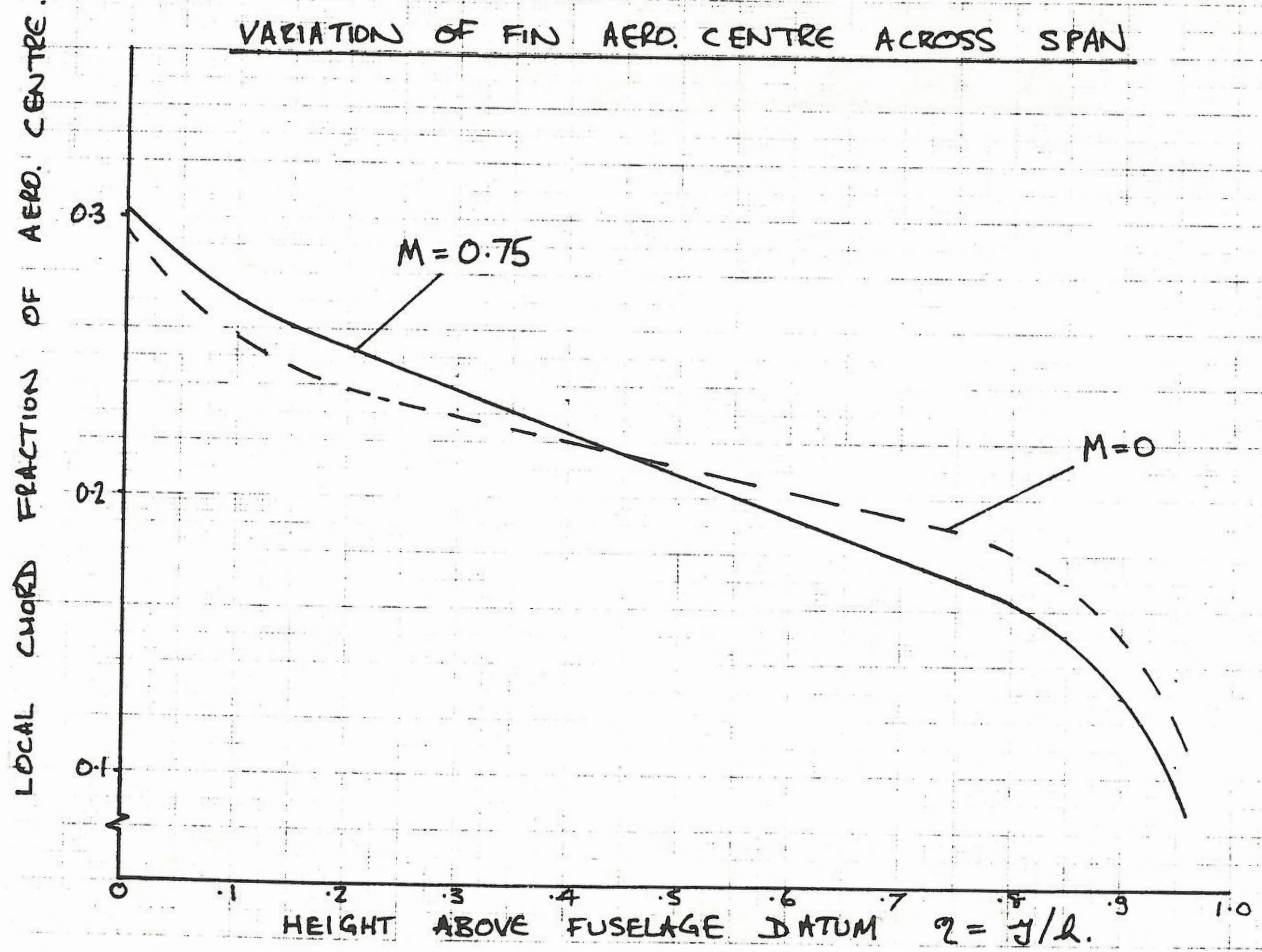
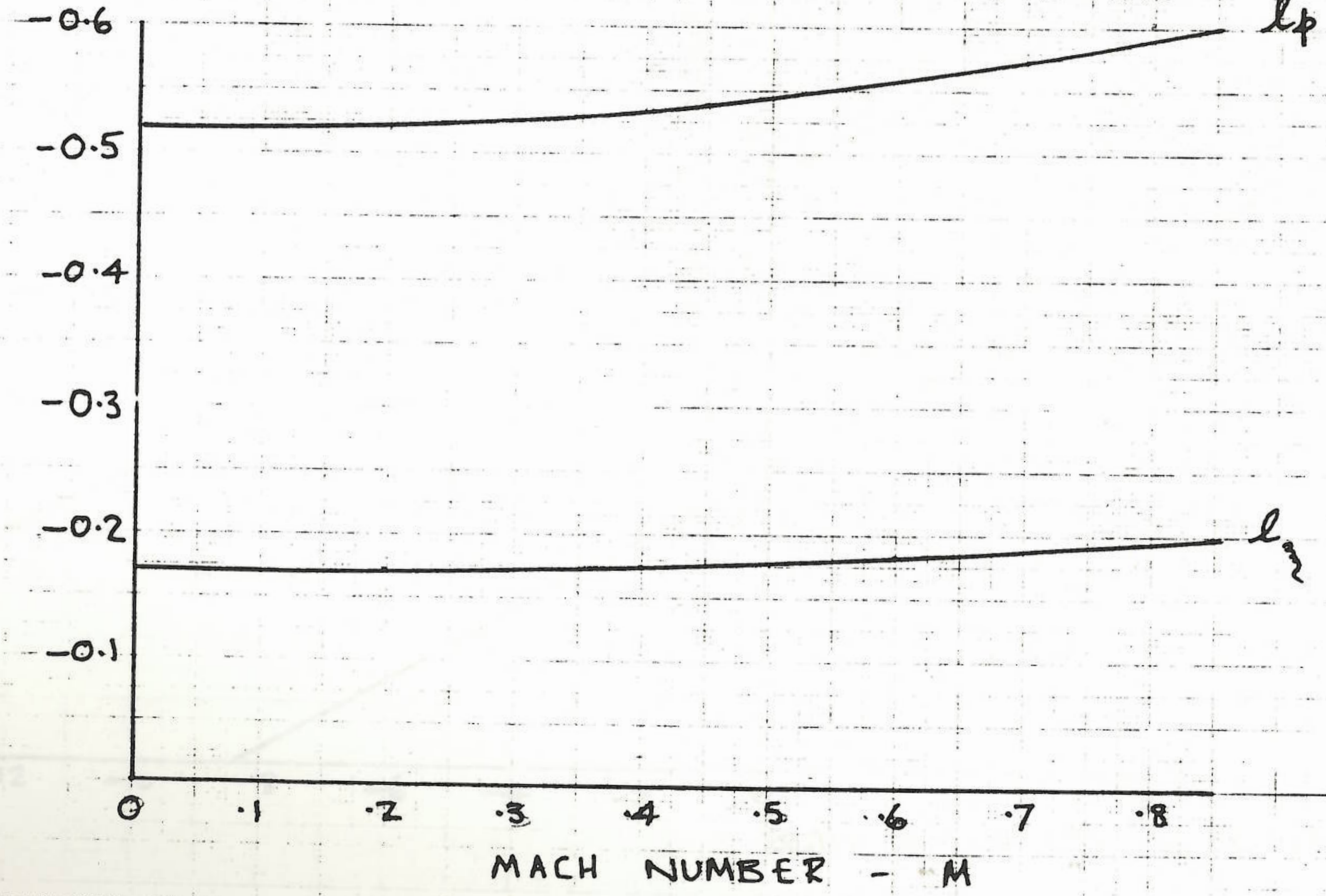

VARIATION OF FIN AERO. CENTRE ACROSS SPAN

FIG. F81-12

DES 8100/27

ROLLING DERIVATIVES l_p AND l_ξ



DES 8100/28

FIG. F81-13

DOWN WASH AT TAILPLANE

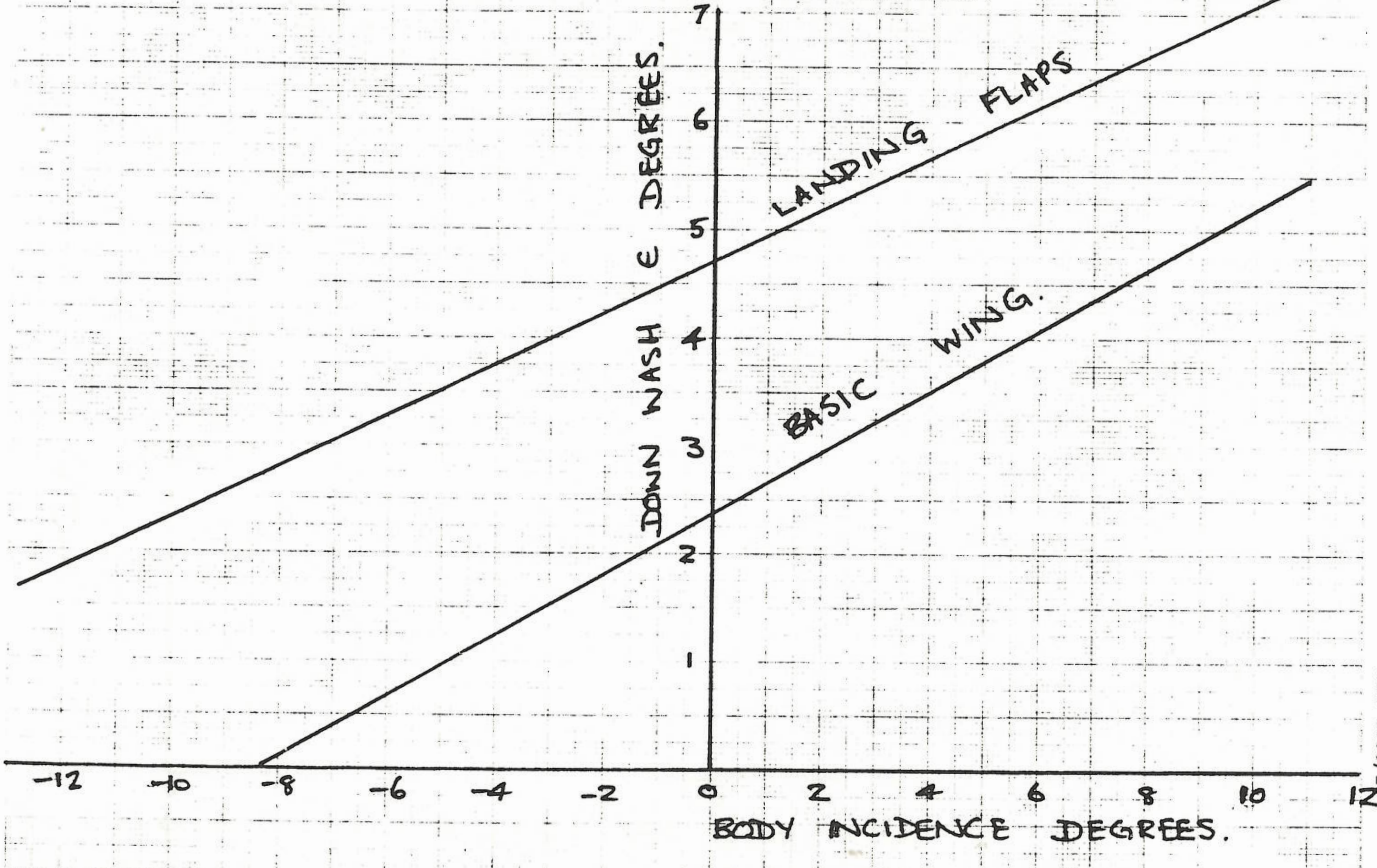


FIG.F·81 - 14

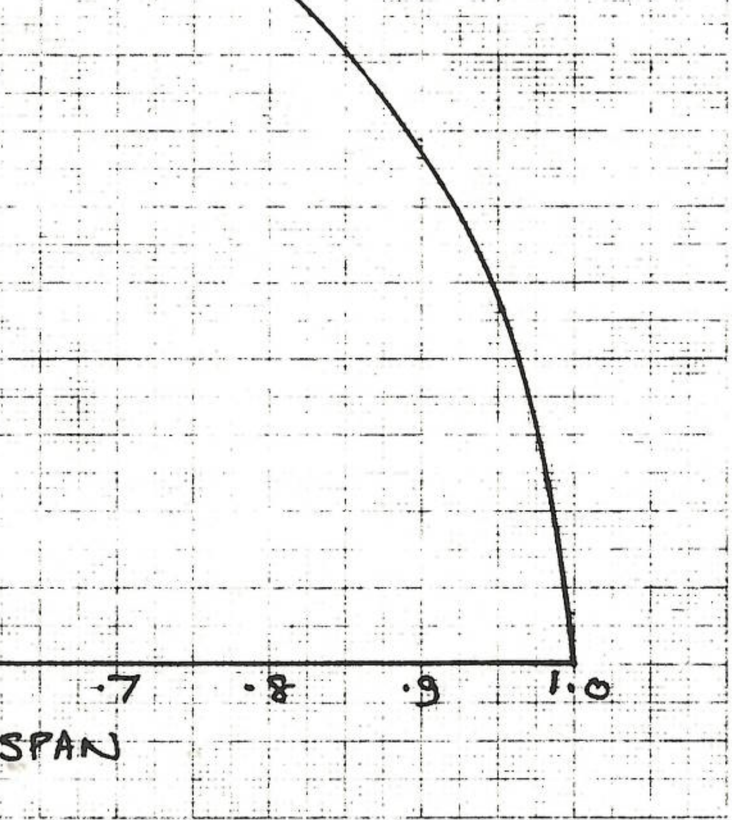


FIG. F81 -15.

DES 8100/30

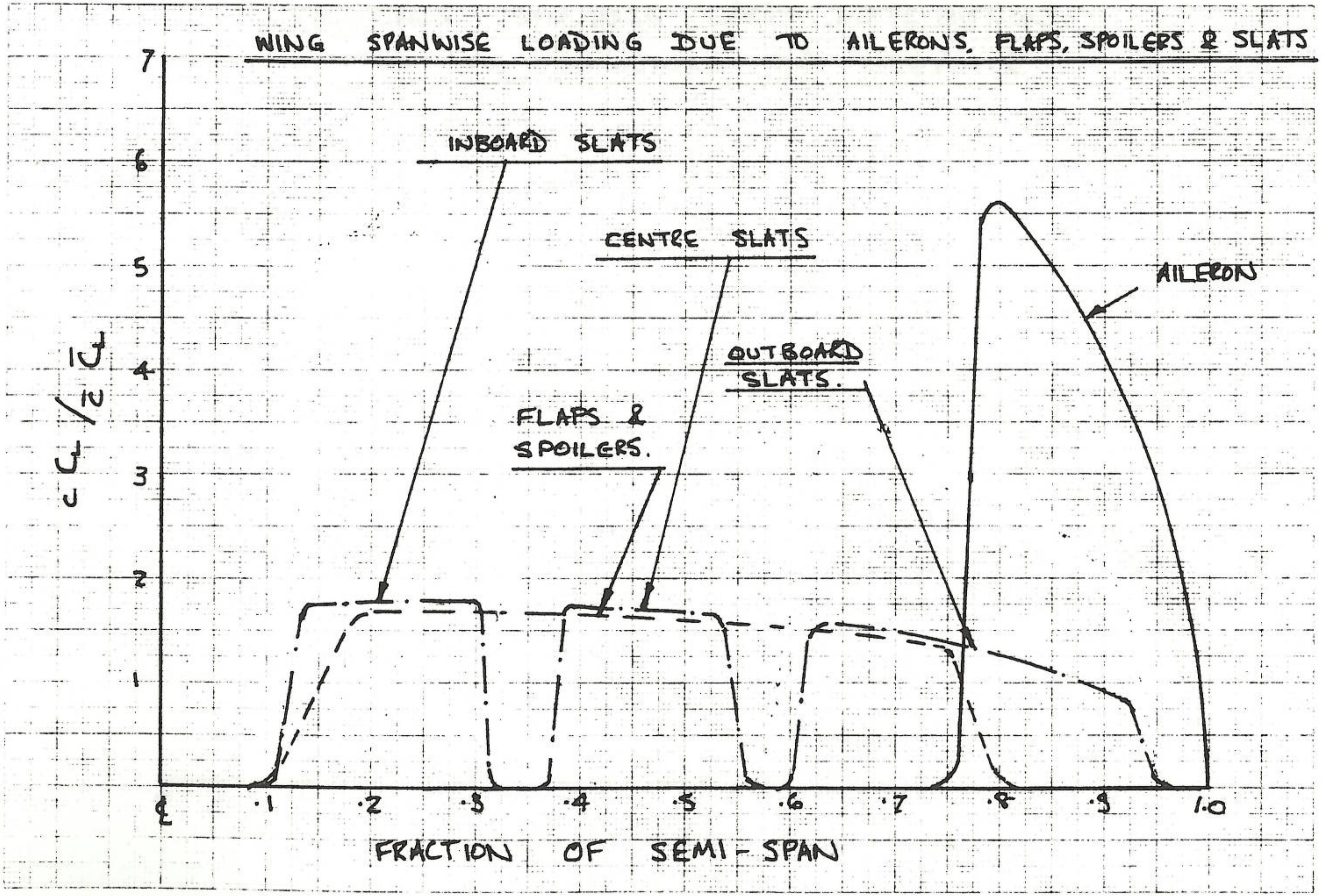

WING SPANWISE LOADING DUE TO AILERONS, FLAPS, SPOILERS & SLATS

FIG. F81-16.

TAILPLANE SPANWISE LOAD DISTRIBUTION
DUE TO INCIDENCE AND ELEVATOR

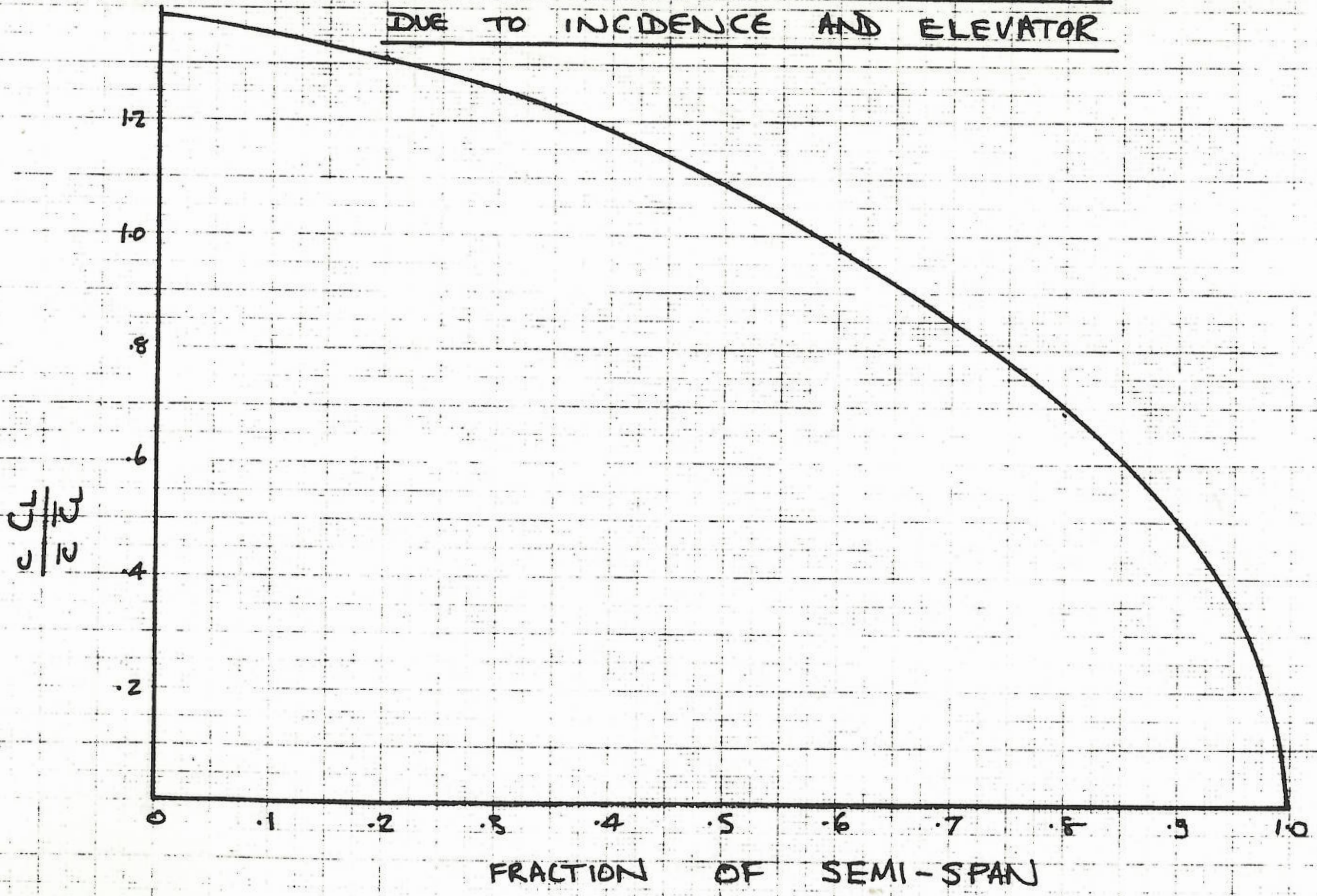


FIG F81 -17

FIN SPANWISE AIRLOAD DISTRIBUTION DUE TO INCIDENCE

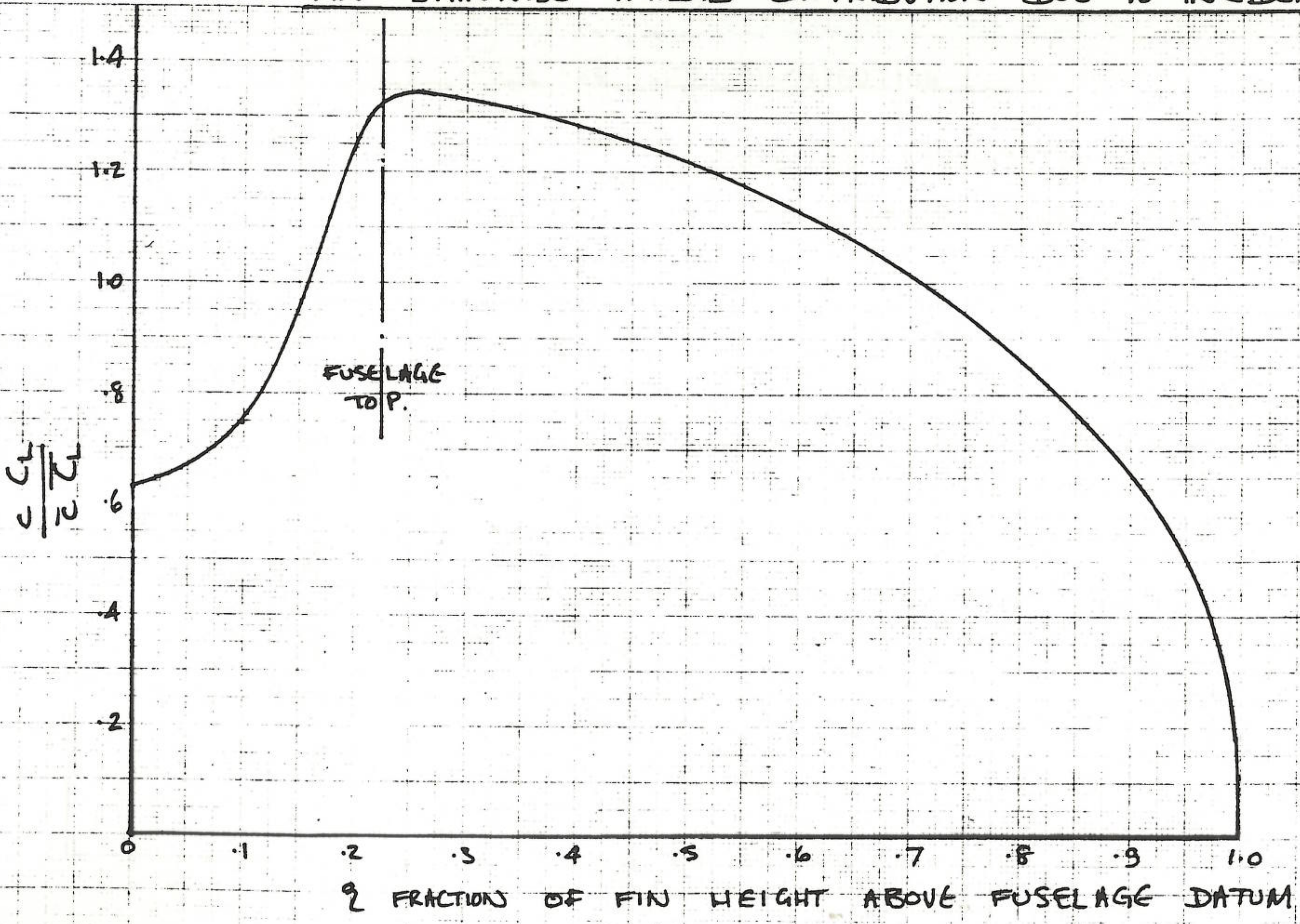


FIG. F81 -18

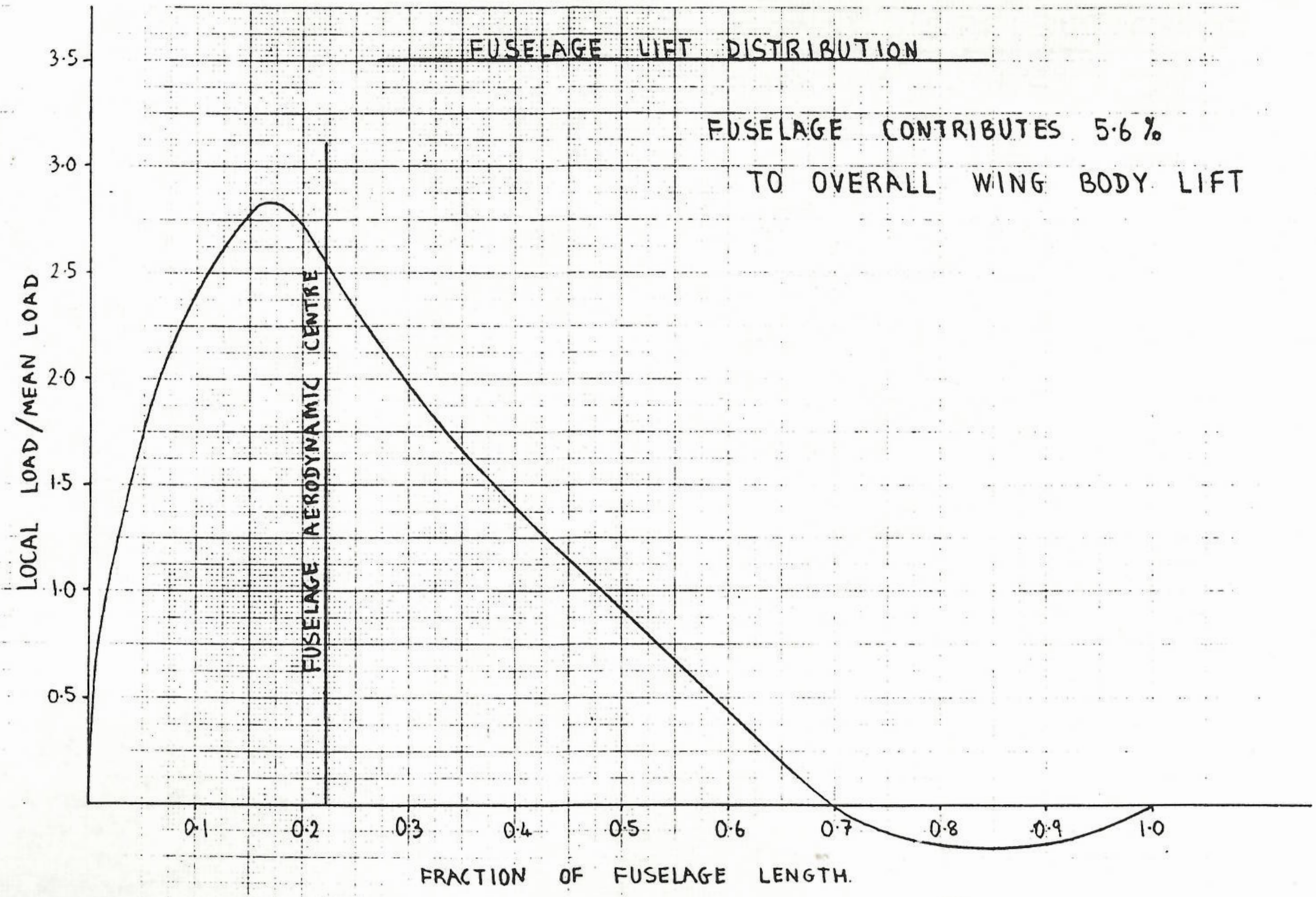

FUSELAGE LIFT DISTRIBUTION
FUSELAGE CONTRIBUTES 5·6 %
TO OVERALL WING BODY LIFT
FUSELAGE AERODYNAMIC CENTRE
LOCAL LOAD/MEAN LOAD
3·5
3·0
2·5
2·0
1·5
1·0
0·5
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
FRACTION OF FUSELAGE LENGTH.

FIG. F81-19

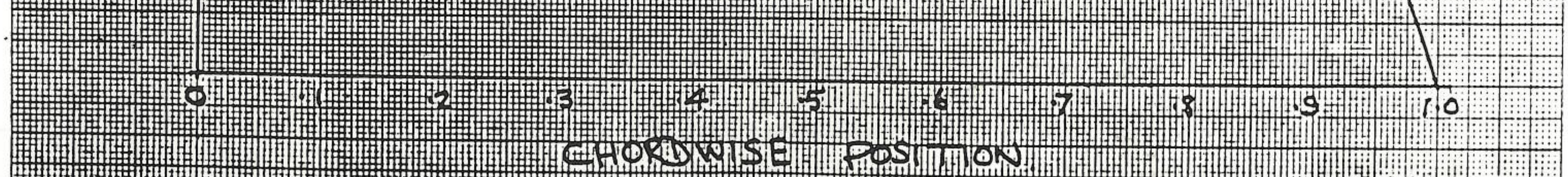
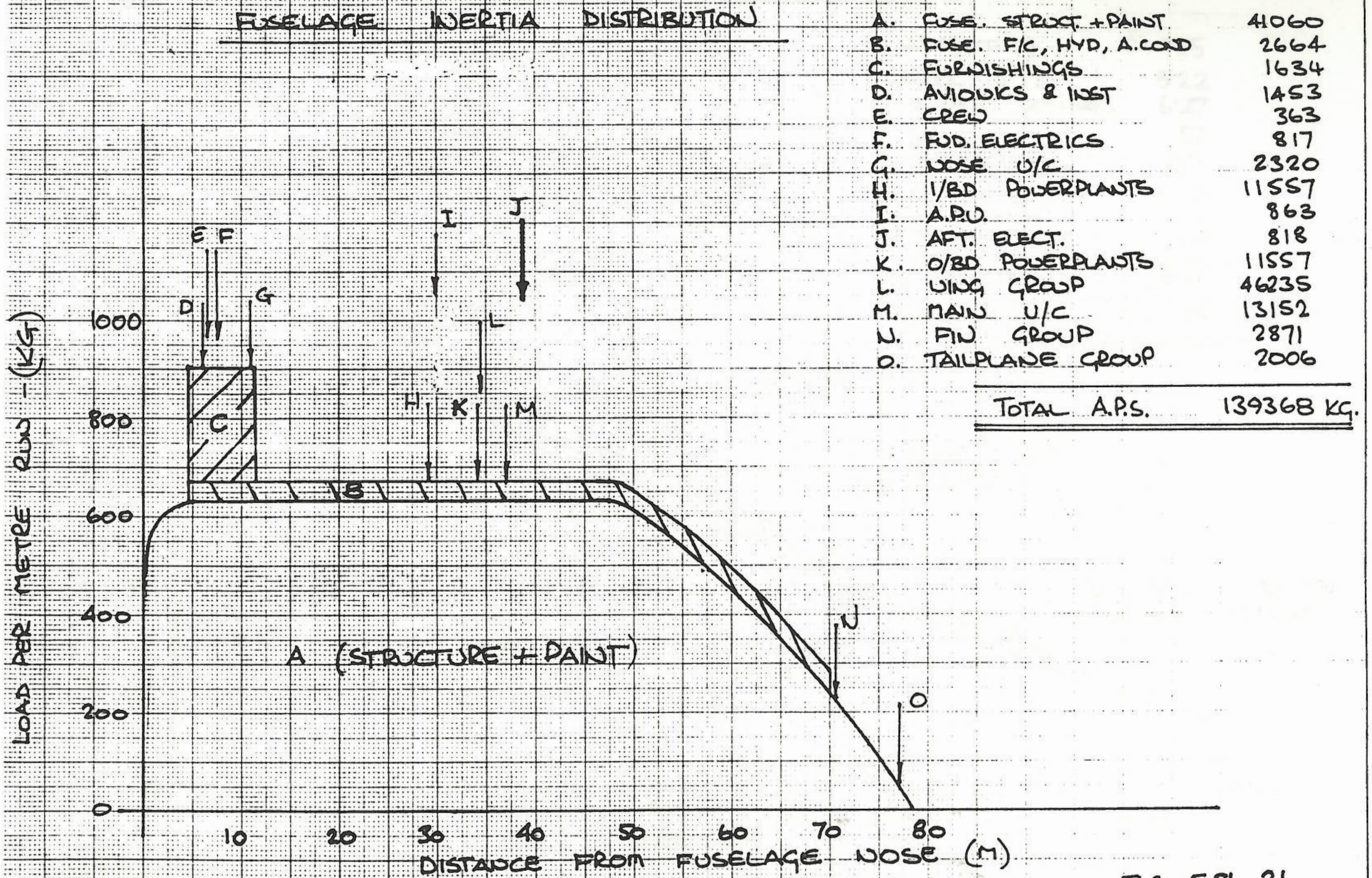


FIG. F81 -20

FUSELAGE INERTIA DISTRIBUTION



A.	FUSE. STRUCT. + PAINT	41060
B.	FUSE. F/C, HYD, A.COND	2664
C.	FURNISHINGS	1634
D.	AVIONICS & INST	1453
E.	CREW	363
F.	FWD. ELECTRICS	817
G.	NOSE U/C	2320
H.	I/BD POWERPLANTS	11557
I.	A.P.U.	863
J.	AFT. ELECT.	818
K.	O/BD POWERPLANTS	11557
L.	WING GROUP	46235
M.	MAIN U/C	13152
N.	FIN GROUP	2871
O.	TAILPLANE GROUP	2006
	TOTAL A.P.S.	139368 KG.

FIG. F81-21

WING INERTIA DISTRIBUTION

STRUCTURE	21095
FUEL SYS.	522
FLYING CONTROLS	627
DE-ICE	57
HYDRAULICS	717
AIR COND	100
TOTAL GRAPH	23118
2× POWERPLANTS	11 557
TOTAL / WING	34675 KG

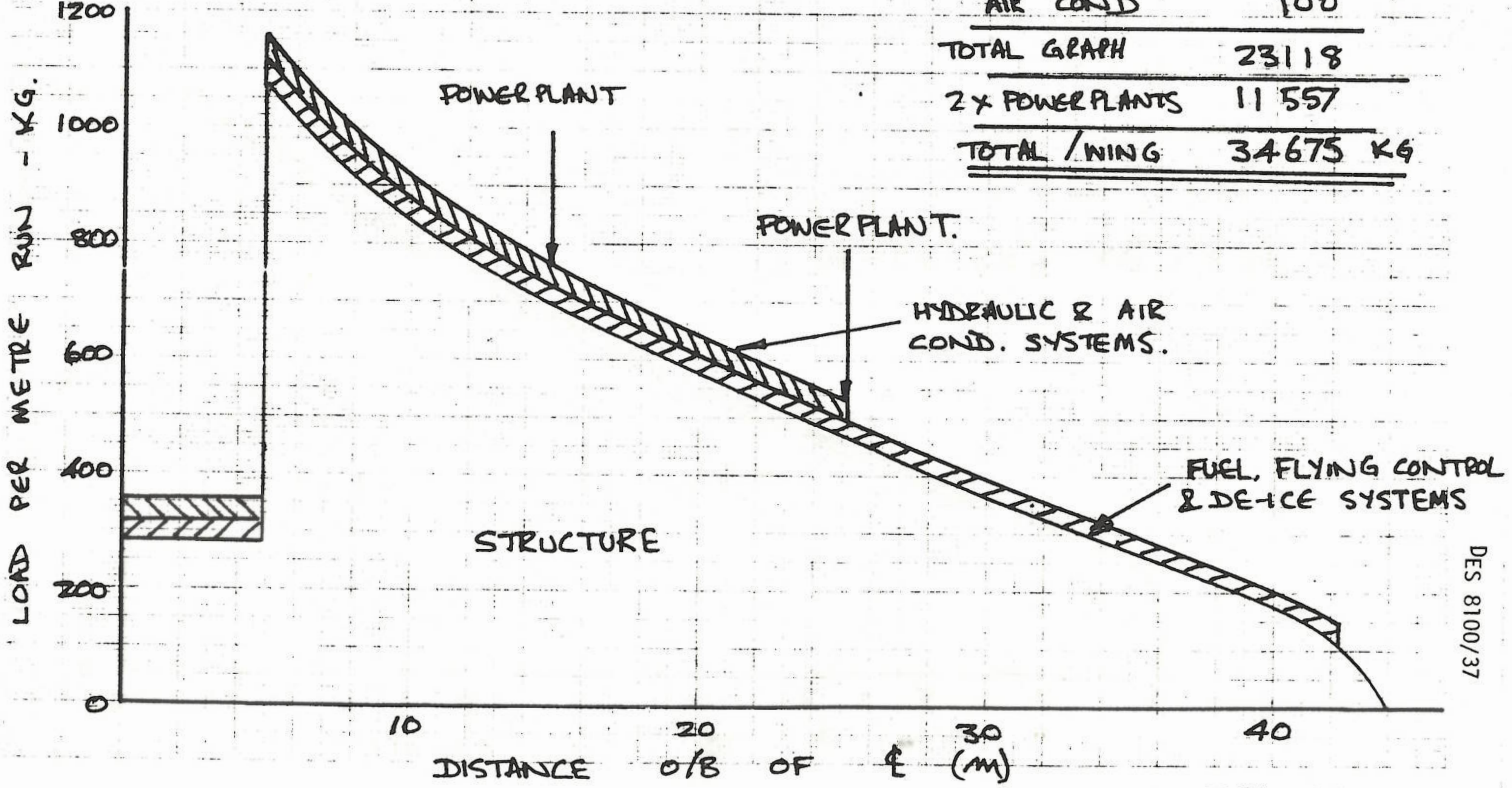


FIG. F81-22.

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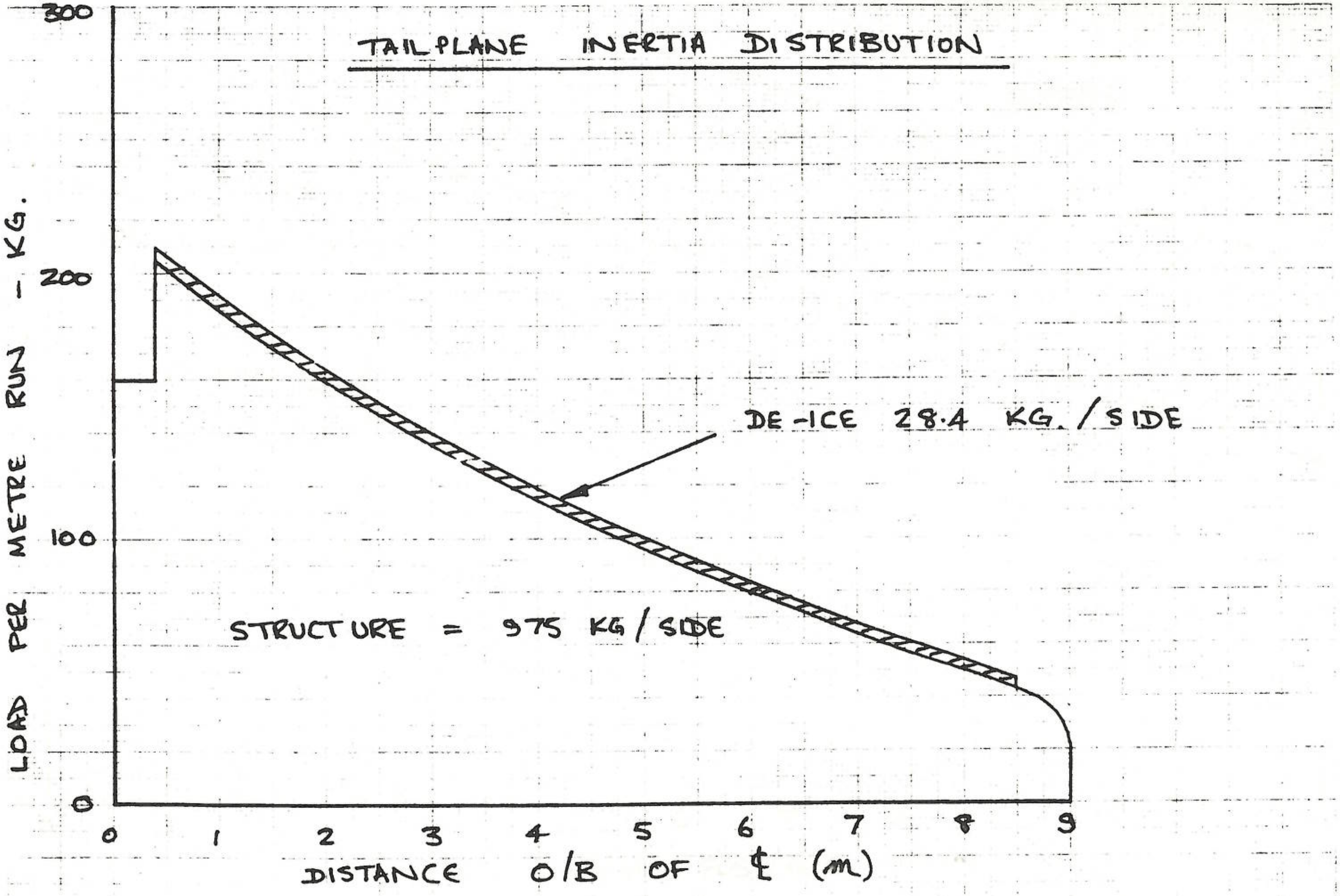
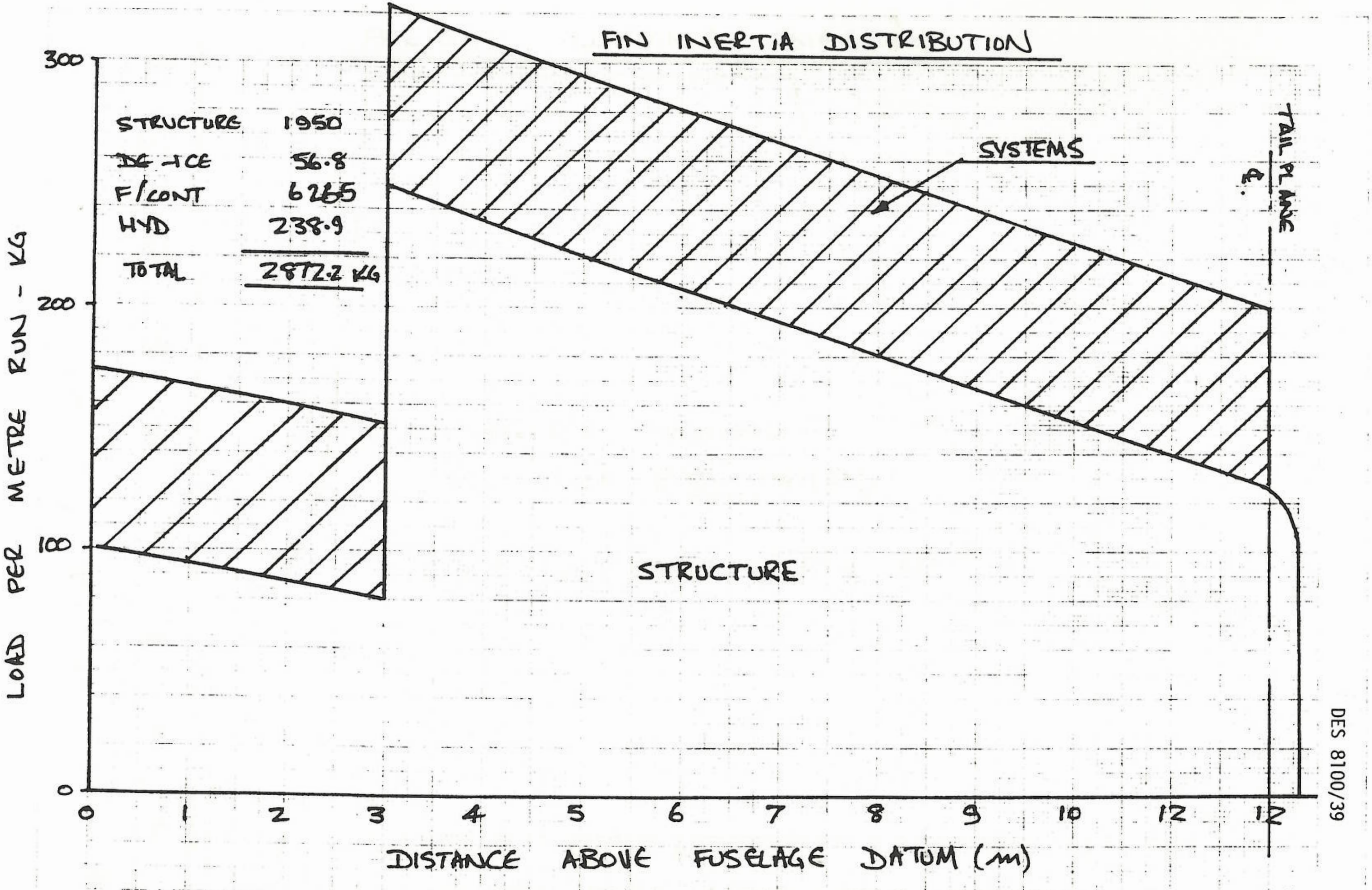

TAILPLANE INERTIA DISTRIBUTION

FIG. F81-23



STRUCTURE	1950
DE-ICE	56.8
F/CONT	626.5
HYD	238.9
TOTAL	2872.2 KG

FIG. F81-24.

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FREIGHT LOADING DIAGRAM

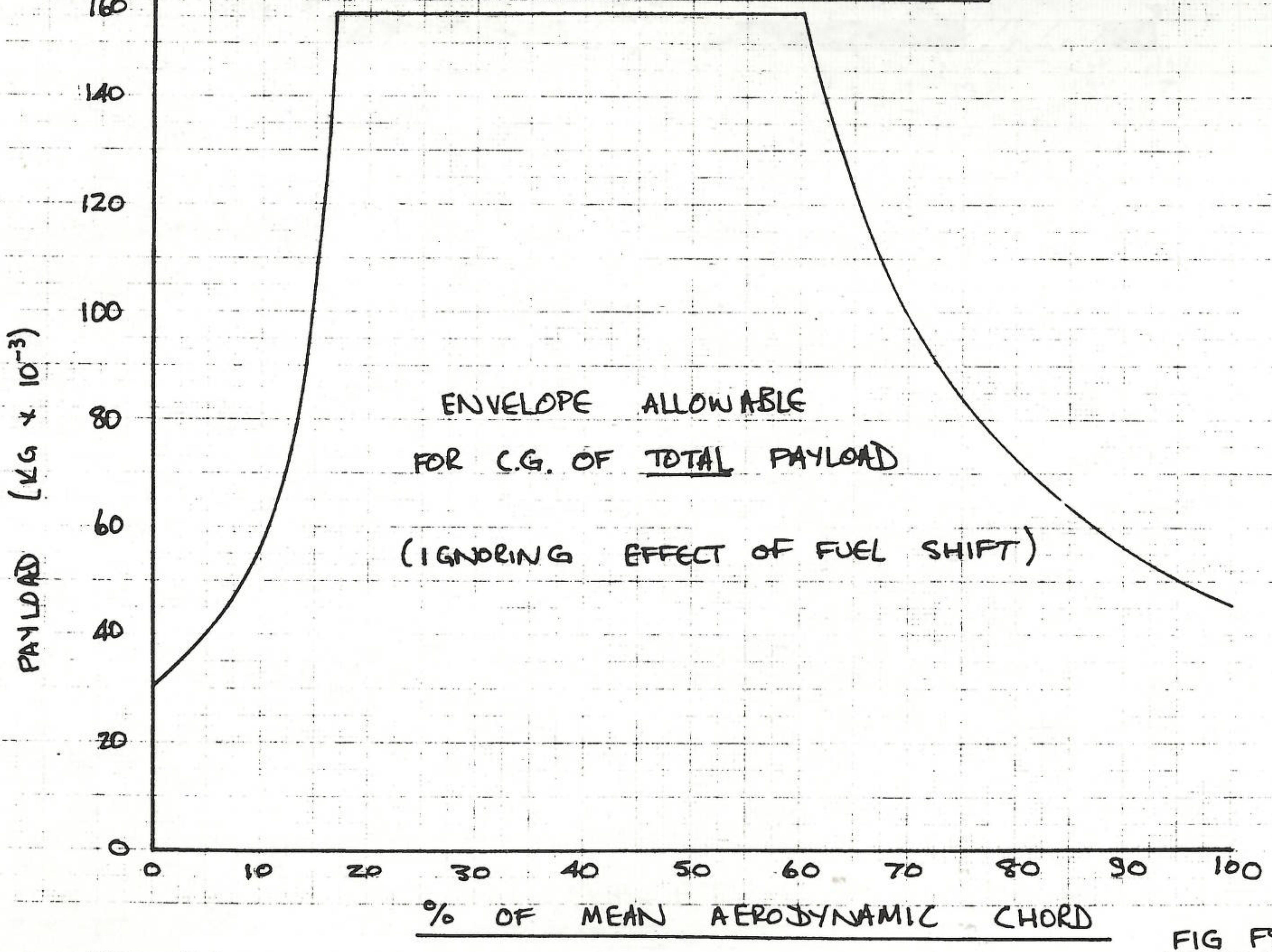
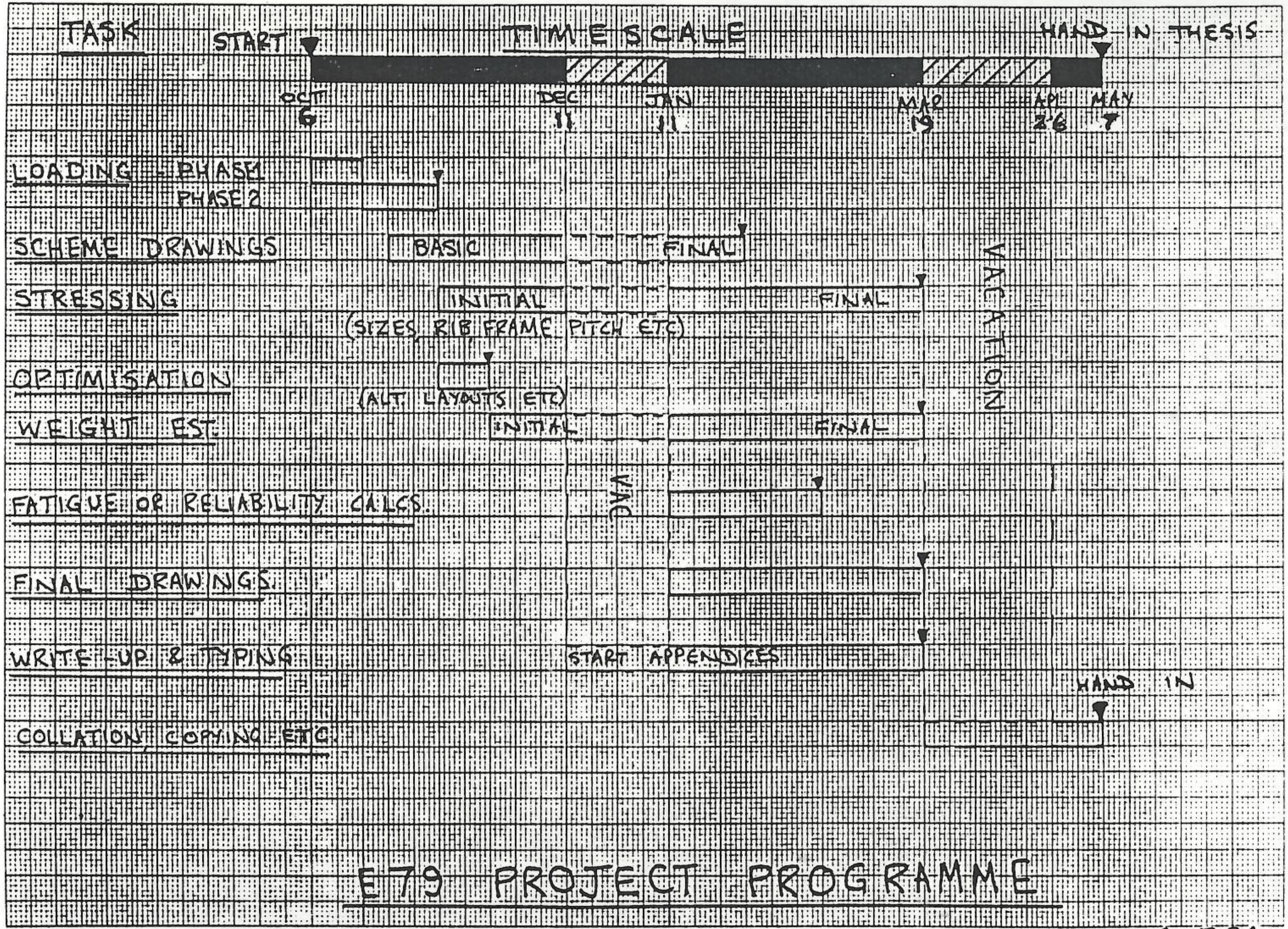


FIG F81 -25



DES 8100/41

FIG. F81-26