

PREPARED BY: <b>L. J. Schneider</b>	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. <b>1</b>
CHECKED BY: <b>N. E. Ehlers</b>		REPORT NO.
DATE: <b>11-1-63</b>		TITLE

**BEDE AIRCRAFT, INC.**

REPORT NO. 1-0000-001

AIRPLANE MODEL BD-1

**"BASIC LOADS ANALYSIS"**

W = 1375 lb.

P = 115 hp.

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PREPARED BY: <b>L. J. Schneider</b>	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. <b>3</b>
CHECKED BY: <b>N. E. Ehlers</b>		REPORT NO.
DATE: <b>11-1-63</b>	TITLE <b>SUMMARY</b>	MODEL NO. <b>BD-1</b>

### SUMMARY

This report presents calculated loads necessary for substantiation of the structural integrity of the Bede Model BD-1 airplane for the 1375 lb. version powered by a 115 hp. engine.



PREPARED BY: <b>L. J. Schneider</b>	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 4
CHECKED BY: <b>N. E. Ehlers</b>		REPORT NO.
DATE: 11-1-63	TITLE REFERENCES	MODEL NO. BD-1

REFERENCES


1. Civil Aeronautics Manual 3 Federal Aviation Agency, as amended to, May 15, 1956, and amendments 3-1 through 3-7.
2. National Advisory Committee for Aeronautics, report No. TR-824, "Summary of Airfoil Data" 1945.
3. National Advisory Committee for Aeronautics, report No. TR-427, "Effect of Multiple Fixed Slots on the Lift and Drag of a Clark Y Airfoil" 1932.
4. "Airplane Performance Stability and Control" Perkins & Hage, John Wiley & Sons, Inc. 1956.
5. "Aircraft Structures" D.J.Perry, McGraw-Hill Inc. 1950.
6. National Advisory Committee for Aeronautics, report No. TR 633, "Pressure Distribution over an N.A.C.A. 23012 airfoil with flaps", 1938.
7. National Advisory Committee for Aeronautics report No. TR 554 "Ordinary and Split Flaps on Airfoils of different Profile", 1936.
8. National Advisory Committee for Aeronautics, report No. 574 "Pressure Distribution over an Airfoil Section with a flap and tab" 1936.



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 66
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-1-63	TITLE SYMBOLS CONTINUED	MODEL NO. BD-1

**q** DYNAMIC PRESSURE (psf)  
**R<sub>n</sub>** NOSE WHEEL FORCE (lb)  
**R<sub>m</sub>** MAIN WHEEL FORCE (lb)  
**S** DESIGN WING AREA (ft<sup>2</sup>)  
**S<sub>a</sub>** AILERON AREA (ft<sup>2</sup>)  
**S<sub>t</sub>** HORIZONTAL TAIL AREA (ft<sup>2</sup>)  
**S<sub>tt</sub>** TRIM TAB AREA (ft<sup>2</sup>)  
**S<sub>v</sub>** VERTICAL TAIL AREA (ft<sup>2</sup>)  
**T** TORQUE (ft-lb)  
**t** INCRIDENTAL TAIL LOAD (lb)  
**U** GUST VELOCITY (fps)  
**V<sub>c</sub>** DESIGN CRUISING SPEED (mph)  
**V<sub>d</sub>** DESIGN DIVING SPEED (mph)  
**V<sub>f</sub>** DESIGN FLAP SPEED (mph)  
**V<sub>h</sub>** MAXIMUM LEVEL FLIGHT SPEED OBTAINABLE (mph)  
**V<sub>p</sub>** DESIGN MANEUVER SPEED (mph)  
**V<sub>s</sub>** STALL SPEED WITH FLAPS RETRACTED (mph)  
**V<sub>sf</sub>** STALL SPEED WITH FLAPS EXTENDED (mph)  
**V<sub>si</sub>** INVERTED STALL SPEED (mph)  
**W** WEIGHT (lb)  
**w** UNIT LOADING (lb/in)  
**w<sub>d</sub>** UNIT DEAD WEIGHT LOADING (lb/in)  
**X** LONGITUDINAL DISTANCE PARALLEL TO WATER LINES (in)  
**X<sub>ac</sub>** HORIZONTAL DISTANCE WING L.E. to a.c. (in)  
**X<sub>cg</sub>** HORIZONTAL DISTANCE WING a.c. to C.G. (in)  
**Y** LATERAL DISTANCE PARALLEL TO STATION LINES (in)  
**y** DISTANCE WING L.E. TO RESULTANT FORCE (ft)  
**Y<sub>c</sub>** LATERAL DISTANCE PERPENDICULAR TO WING CHORD LINE (in)  
**Z<sub>cg</sub>** VERTICAL DISTANCE a.c. to C.G. (in)  
**α'** ANGLE-OF-ATTACK WITH RESPECT TO FUSLAGE REF. LINE (deg.)  
**α<sub>0</sub>** ANGLE OF ZERO LIFT (deg.)  
**α<sub>x</sub>** LATERAL ANGULAR ACCELERATION (Rad/Sec<sup>2</sup>)  
**α<sub>y</sub>** LONGITUDINAL ANGULAR ACCELERATION (Rad/Sec<sup>2</sup>)  
**α<sub>z</sub>** DIRECTIONAL ANGULAR ACCELERATION (Rad/Sec<sup>2</sup>)  
**ρ** AIR DENSITY = .002378 @ SEA LEVEL



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 5
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-1-63	TITLE SYMBOLS	MODEL NO. BD-1

**A** ASPECT RATIO  
**a** WING LIFT CURVE SLOPE (Per Degree)  
**a<sub>o</sub>** AIRFOIL LIFT CURVE SLOPE (Per Degree)  
**a<sub>ot</sub>** HORIZONTAL TAIL AIRFOIL LIFT CURVE SLOPE (Per Degree)  
**a<sub>ov</sub>** VERTICAL TAIL AIRFOIL LIFT CURVE SLOPE (Per Degree)  
**a<sub>t</sub>** HORIZONTAL TIAL LIFT CURVE SLOPE (Per Degree)  
**A<sub>tt</sub>** TRIM TAB ASPECT RATIO  
**A<sub>v</sub>** VERTICAL TAIL ASPECT RATIO  
**a<sub>v</sub>** VERTICAL TAIL LIFT CURVE SLOPE (Per Degree)  
**b** WING SPAN (ft)  
**b<sub>t</sub>** HORIZONTAL TAIL SPAN (ft)  
**c<sub>a</sub>** AILERON CHORD (ft)  
**c<sub>m</sub>** WING MEAN AERODYNAMIC CHORD (ft)  
**C<sub>c</sub>** WING CHORDWISE FORCE COEFFICIENT  
**C<sub>l</sub>** WING LIFT COEFFICIENT  
**C<sub>l<sub>tt</sub></sub>** TRIM TAB LIFT COEFFICIENT  
**C<sub>na</sub>** WING NORMAL FORCE COEFFICIENT  
**C<sub>mac</sub>** WING MOMENT COEFFICIENT  
**C<sub>mf</sub>** FUSELAGE MOMENT COEFFICIENT  
**C.G.** CENTER OF GRAVITY (Abbreviation)  
**C.P.** CENTER OF PRESSURE ( Abbreviation)  
**c<sub>r</sub>** RUDDER CHORD (ft)  
**c<sub>ra</sub>** RUDDER CHORD AFT OF HINGE LINE (ft)  
**c<sub>rf</sub>** RUDDER CHORD FORWARD OF HINGE LINE (ft)  
**c<sub>t</sub>** HORIZONTAL STABILIZER CHORD (ft)  
**c<sub>v</sub>** VERTICAL STABILIZER CHORD (ft)  
**d** HORIZONTAL DISTANCE a.c. TO TAIL c.p. (in)  
**F<sub>a</sub>** AILERON LOAD (lb)  
**F<sub>cw</sub>** CHORDWISE WING FORCE (lb)  
**F<sub>na</sub>** NORMAL FORCE AT THE AIRPLANE C.G. (lb)  
**F<sub>t</sub>** TAIL FORCE (lb)  
**F<sub>tt</sub>** TRIM TAB LOAD (lb)  
**H** HINGE MOMENT (ft-lb)  
**h** DROP HEIGHT (in)  
**H<sub>e</sub>** ELEVATOR HINGE MOMENT (ft-lb)  
**H<sub>r</sub>** RUDDER HINGE MOMENT (ft-lb)  
**i** WING INCIDENCE ANGLE (Degree)  
**I<sub>x</sub>** LATERAL MOMENT OF INERTIA (in-lb-sec<sup>2</sup>)  
**I<sub>y</sub>** LONGITUDINAL MOMENT OF INERTIA (in-lb-sec<sup>2</sup>)  
**I<sub>z</sub>** DIRECTIONAL MOMENT OF INERTIA (in-lb-sec<sup>2</sup>)  
**K** GUST LOAD FACTOR  
**l** FUSELAGE LENGTH (ft)  
**L** WING LIFT LOAD FACTOR  
**M<sub>ac</sub>** MOMENT ABOUT WING AERODYNAMIC CENTER (ft-lb)  
**M<sub>cg</sub>** MOMENT ABOUT AIRPLANE C.G. (ft-lb)  
**M<sub>f</sub>** FUSELAGE MOMENT (ft-lb)  
**m** WING LIFT CURVE SLOPE (Per Radian)  
**m<sub>v</sub>** VERTICAL TAIL LIFT CURVE SLOPE (Per Radian)  
**N** ENGINE SPEED (rpm)  
**n** LOAD FACTOR  
**P** POWER (hp)



PREPARED BY: <b>L. J. Schneider</b>	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. <b>7</b>
CHECKED BY: <b>N. E. Ehlers</b>		REPORT NO.
DATE: <b>10-7-63</b>	TITLE <b>INTRODUCTION</b>	MODEL NO. <b>BD-1</b>

### INTRODUCTION

The Bede BD-1 is an aerodynamically conventional, two place, single engine, low wing airplane. This report presents calculated airloads, ground loads, and related data necessary for substantiation of the structural integrity of the airplane. Reference is made in each section of this report to the appropriate Civil Air Regulation of CAM-3.

The loads are calculated for the 1375 lb. maximum weight version in the acrobatic category. In addition the landing gear loads are calculated for 1418 lb. gross weight at its center of gravity position.



PREPARED BY: J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 8
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-7-63	TITLE BASIC DATA	MODEL NO. BD-1

MAXIMUM DESIGN WEIGHT (CAM 3.74)

$W = 1375 \text{ lb.}$

MINIMUM DESIGN WEIGHT (CAM 3.75)

$W_m = 930 \text{ lb.}$

EMPTY WEIGHT (CAM 3.73)

$W_e = 832.7 \text{ lb.}$

DESIGN WING AREA

$S = 93.3 \text{ ft.}^2$

DESIGN WING LOADING

$W/S = 14.8 \text{ lb./ft.}^2$

MINIMUM WING LOADING

$W/S = 9.97 \text{ lb./ft.}^2$

WING SPAN

$b = 23.3 \text{ ft.}$

WING MEAN AERODYNAMIC CHORD

$\bar{c} = 4.0 \text{ ft.}$

WING ASPECT RATIO

$A = 5.83$

WING AIRFOIL SECTION

NACA 64<sub>2</sub>-415



PREPARED BY: L. J. Schneider		PAGE NO. 9
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-7-63	TITLE WEIGHT AND CENTER OF GRAVITY SUMMARY	MODEL NO. BD-1

**EMPTY WEIGHT**

ITEM	Wt. (lb)	FUSELAGE STATION (in)	WATER LINE (in)	X MOMENT	Y MOMENT
FUSELAGE	211.8	107.4	42.2	22,747	8,938
WINGS	135.2	91.5	35.9	12,370	4,851
EMPENNAGE	32.6	212.0	51.9	6,902	1,687
LANDING GEAR	94.1	75.9	15.3	7,135	1,443
FURNISHINGS & CONTROLS	51.0	91.0	36.0	4,641	1,835
POWER PLANT (115 hp.)	308.0	34.2	45.3	10,540	13,941
<b>EMPTY WEIGHT</b>	<b>832.7</b>	<b>77.3</b>	<b>39.2</b>	<b>64,335</b>	<b>32,695</b>

\*NOTE: The fuselage zero station is 50 in. forward of the firewall.  
The zero water line is 25 in. below the bottom of the cabin floor.

**MINIMUM FLYING WEIGHT**

ITEM	Wt. (lb)	FUSELAGE STATION (in)	WATER LINE (in)	X MOMENT	Y MOMENT
EMPTY WEIGHT	832.7	77.3	39.2	64,335	32,695
PILOT	170.0	90.0	36.0	15,300	6,120
FUEL	20.0	56.0	47.0	1,120	940
OIL	10.0	39.0	35.0	390	350
<b>MINIMUM Wt.</b>	<b>1032.7</b>	<b>78.7</b>	<b>38.8</b>	<b>81,145</b>	<b>40,105</b>

Selected Minimum Weight: Since lighter power plant installations are anticipated a minimum weight of 930.0 lb. will be conservatively used.



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 10 <i>10</i>
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-7-63	TITLE WEIGHT AND C.G. SUMMARY - (CONT'D)	MODEL NO. BD-1

**MOST FORWARD CENTER OF GRAVITY**

ITEM	Wt. (lb)	(IN) FUSELAGE STATION	(IN) WATER LINE	X MOMENT	Y MOMENT
EMPTY WEIGHT	832.7	77.3	39.2	64,335	32,695
PILOT	170.0	90.0	36.0	15,300	6,120
FUEL	26.0	56.0	47.0	1,456	1,222
OIL	12.0	39.0	35.0	468	420
OPTIONAL EQUIP.	43.3	84.1	32.8	33,643	1,386
<b>Fwd. C.G. Wt.</b>	<b>1084.0</b>	<b>78.6</b>	<b>38.6</b>	<b>85,202</b>	<b>41,843</b>

Select most forward position: W = 1190 @ Sta. 78.6 in. = 17% mac.

**MOST AFT CENTER OF GRAVITY**

ITEM	WEIGHT (lb.)	FUSELAGE STATION (IN)	WATER LINE (IN)	X MOMENT	Y MOMENT
EMPTY WEIGHT	832.7	77.0	39.2	64,146	32,695
PILOT	170.0	90.0	36.0	15,300	6,120
PASSENGER	170.0	190.0	36.0	15,300	6,120
BAGGAGE	40.0	107.5	37.0	4,300	1,480
OIL	10.0	39.0	35.0	390	350
OPTIONAL EQUIP.	43.3	84.1	32.8	3,643	1,386
<b>MOST AFT. C.G.</b>	<b>1266.0</b>	<b>81.5</b>	<b>38.0</b>	<b>103,079</b>	<b>48,151</b>

Select most Aft position: W = 1375 @ Sta. 84.9 in. = 30% mac.



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 11
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-7-63	TITLE WEIGHT AND C.G. SUMMARY - CONT'D	MODEL NO. BD-1

**MAXIMUM GROSS WEIGHT CENTER OF GRAVITY**

ITEM	WEIGHT (lb)	FUSELAGE STATION (IN)	WATER LINE (IN)	X MOMENT	Y MOMENT
EMPTY WEIGHT	832.7	77.0	39.2	64,146	32,695
PILOT	170.0	90.0	36.0	15,300	6,120
PASSENGER	170.0	90.0	36.0	15,300	6,120
BAGGAGE	40.0	107.5	37.0	4,300	1,480
OIL	12.0	39.0	35.0	468	420
FUEL	150.0	81.5	38.0	12,220	5,700
OPTIONAL EQUIP.	43.3	84.1	32.8	3,643	1,386
<b>MAX. GROSS</b>	<b>1418.0</b>	<b>81.4</b>	<b>38.0</b>	<b>115,377</b>	<b>53,921</b>

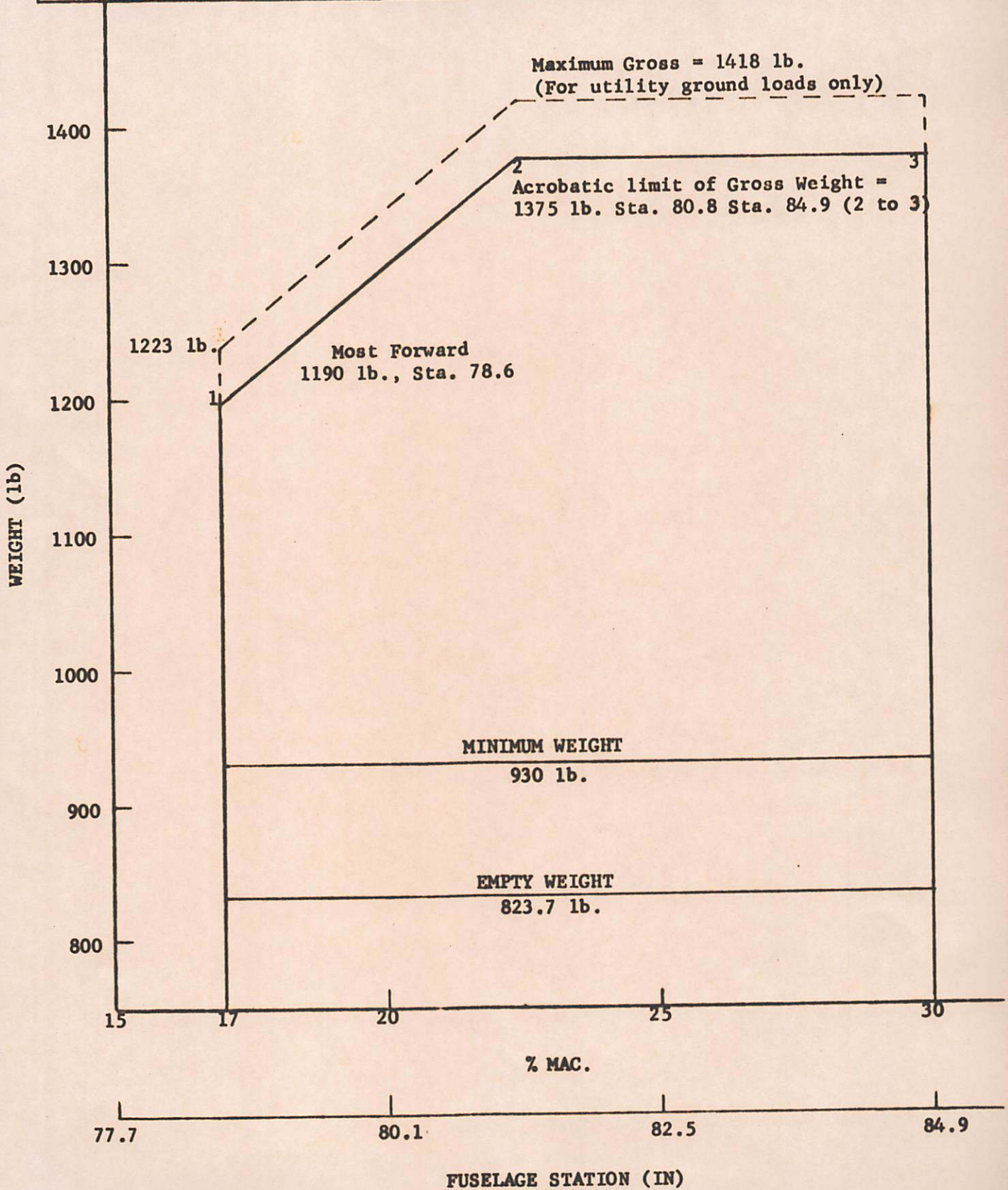
Select Maximum Gross Weight: The acrobatic weight will be limited to 1375 lb. (See the weight and C.G. diagram on the following page) However, in anticipation of flying the BD-1 in a utility configuration at higher weights. The ground loads will be based on a gross weight of 1418 lb. @ Sta. 81.4 in. and C.G. 38.0 in.

**TYPICAL ACROBATIC LOADING**

ITEM	WEIGHT (lb)	FUSELAGE STATION (IN)	WATER LINE (IN)	X MOMENT	Y MOMENT
EMPTY WEIGHT	832.7	77.3	39.2	64,335	32,695
PILOT	190.0	90.0	36.0	17,100	6,750
PASSENGER	190.0	90.0	36.0	17,100	6,750
FUEL	150.0	81.5	38.0	12,220	5,700
<b>ACROBATIC Wt.</b>	<b>1362.7</b>	<b>81.2</b>	<b>38.1</b>	<b>110,755</b>	<b>51,895</b>



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 12
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-1-63	TITLE WEIGHT AND C.G. SUMMARY	MODEL NO. BD-1





PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 13
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE REQUIRED MINIMUM DESIGN AIRSPEEDS (CAM 3.184)	MODEL NO. BD-1

MAXIMUM DESIGN WEIGHT OF 1375 lb.

$V_c$  = Minimum Design Cruising Airspeed:

$$V_c = 42 (W/S)^{1/2} = 42 (14.8)^{1/2} = \underline{161.8 \text{ mph. or}}$$

$$V_c = 0.9 V_h = 0.9 (160 \text{ est.}) = \underline{144.0 \text{ mph.}}$$

$V_d$  = Minimum Design Dive Airspeed:

$$V_d = 1.55 V_c = 1.55 (161.8) = \underline{250.4 \text{ mph. or}}$$

$$= 1.55 (144.0) = \underline{223.2 \text{ mph.}}$$

$V_s$  = Stalling Speed, Flaps Retracted:

Airplane  $C_{lmax} = 1.5$  (Ref. 2)

$$q_s = (W/S) / C_l = 14.8 / 1.5 = 9.87 \text{ psf}$$

$$V_s = (2 q / \rho)^{1/2} = (2 \times 9.87 / .002378)^{1/2} = 92.2 \text{ fps}$$

$$V_s = \underline{63.0 \text{ mph.}}$$

$V_{sf}$  = Stalling Speed, Flaps Deflected:

Airplane  $C_{lmax} = 1.8$  (Ref. 3)

$$q_{sf} = (W/S) / C_l = 14.8 / 1.8 = 8.22 \text{ psf}$$

$$V_{sf} = (2 q / \rho)^{1/2} = (2 \times 8.22 / .002378)^{1/2} = 84.1 \text{ fps}$$

$$V_{sf} = \underline{57.3 \text{ mph.}}$$

$V_{si}$  = Stalling Speed Inverted:

Airplane  $C_{lmax} = 1.0$  (Ref. 2)

$$q_{si} = (W/S) / C_l = 14.8 / 1.0 = 14.8 \text{ psf}$$

$$V_{si} = (2 q / \rho)^{1/2} = (2 \times 14.8 / .002378)^{1/2} = 112.6 \text{ fps.}$$

$$V_{si} = \underline{76.9 \text{ mph.}}$$

$V_p$  = Minimum Design Maneuvering Speed

$n = 6.0$  (CAM 3.186)

$$V_p = V_s n^{1/2} = 63.0 (6.0)^{1/2} = \underline{154.0 \text{ mph.}}$$

$V_{pi}$  = Minimum Design Maneuvering Speed, (Inverted):

$n = -3.0$  (CAM 3.186)

$$V_{pi} = V_{si} n^{1/2} = 76.9 (3.0)^{1/2} = \underline{133.0 \text{ mph.}}$$

$V_f$  = Minimum Design Flap Speed (CAM 2.190)

$$V_f = 1.4 V_s = 1.4 \times 63.0 = \underline{88.1 \text{ mph. or}}$$

$$V_f = 1.8 V_{sf} = 1.8 \times 57.3 = \underline{103.1 \text{ mph.}}$$

MINIMUM DESIGN WEIGHT OF 930 lb.

$V_s$  = Stalling Speed, Flaps Retracted:

Airplane  $C_{lmax} = 1.5$  (Ref. 2)

$$W/S = 930 / 93.3 = 9.97 \text{ psf.}$$

$$q_s = (W/S) / C_l = 9.97 / 1.5 = 6.64 \text{ psf.}$$

$$V_s = (2 q / \rho)^{1/2} = (2 \times 6.64 / .002378)^{1/2} = 74.7 \text{ fps.}$$

$$V_s = \underline{51.0 \text{ mph.}}$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 14
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: September 17, 1963	TITLE REQ'D MIN. DESIGN AIRSPEEDS - CONT'D	MODEL NO. BD-1

MINIMUM DESIGN WEIGHT OF 930 lb. CONT'D.

$V_{sf}$  = Stalling Speed, Flaps Deflected:

Airplane  $C_{lmax}$  = 1.8 (Ref. 3)

$q_{sf} = (W/S)/C_l = 9.97/1.8 = 5.54$  psf.

$V_{sf} = (2 q / )^{1/2} = (2 \times 5.54 / .002378)^{1/2} = 68.3$  fps

$V_{sf} = \underline{46.6}$  mph.

$V_{si}$  = Stalling Speed Inverted:

Airplane  $C_{lmax}$  = 1.0 (Ref. 2)

$q_{si} = (W/S)/C_l = 9.97/1.0 = 9.97$  psf.

$V_{si} = (2 q / )^{1/2} = (2 \times 9.97 / .002378)^{1/2} = 91.5$  fps.

$V_{si} = \underline{62.4}$  mph.

$V_p$  = Minimum Design Maneuvering Speed:

$n = 6.0$  (CAM 3.186)

$V_p = V_s n^{1/2} = 51.0 (6.0)^{1/2} = \underline{125.0}$  mph.

$V_{pi}$  = Minimum Inverted Design Maneuvering Speed:

$n = -3.0$  (CAM 3.186)

$V_{pi} = V_{si} n^{1/2} = 62.4 (3.0)^{1/2} = \underline{108.0}$  mph.

$V_f$  = Minimum Design Flap Speed (CAM 3.190)

$V_f = 1.4 V_s = 1.4 \times 51.0 = \underline{71.4}$  mph. or

$V_f = 1.8 V_{sf} = 1.8 \times 46.6 = \underline{83.9}$  mph.

MOST FORWARD C.G. WEIGHT OF 1190 lb.

$V_s$  - Stalling Speed, Flaps Retracted:

Airplane  $C_{lmax}$  = 1.5 (Ref. 2)

$W/S = 1190/93.3 = 12.8$  psf.

$q_s = (W/S)/C_l = 12.8/1.5 = 8.53$  psf.

$V_s = (2 q / )^{1/2} = (2 \times 8.53 / .002378)^{1/2} = 84.6$  fps.

$V_s = \underline{57.7}$  mph.

$V_{sf}$  = Stalling Speed, Flaps Deflected:

Airplane  $C_{lmax}$  = 1.8 (Ref. 3)

$q_{sf} = (W/S)/C_l = 12.8/1.8 = 7.12$  psf

$V_{sf} = (2 q / )^{1/2} = (2 \times 7.12 / .002378)^{1/2} = 77.4$  fps

$V_{sf} = \underline{52.7}$  mph.

$V_{si}$  = Stalling Speed, Inverted:

Airplane  $C_{lmax}$  = -1.0 (Ref. 2)

$q_{si} = (W/S)/C_l = 12.8/1.0 = 12.8$  psf

$V_{si} = (2 q / )^{1/2} = (2 \times 12.8 / .002378)^{1/2} = 103.8$  fps.

$V_{si} = \underline{70.8}$  mph.



PREPARED BY: L. J. Schneider		PAGE NO. 15
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE REQ'D MIN. DESIGN AIRSPEEDS-CONT'D	MODEL NO. BD-1

MOST FWD. C.G. WT. OF 1190 lb. - CONT'D.

$V_p$  = Minimum Design Maneuvering Speed:

$$n = 6.0 \text{ (CAM 3.186)}$$

$$V_p = V_g n^{\frac{1}{2}} = 57.7 (6.0)^{\frac{1}{2}} = \underline{141.2 \text{ mph.}}$$

$V_{p1}$  = Minimum Inverted Design Maneuvering Speed:

$$n = -3.0 \text{ (CAM 3.186)}$$

$$V_{p1} = V_{g1} n^{\frac{1}{2}} = 70.8 (3.0)^{\frac{1}{2}} = \underline{122.6 \text{ mph.}}$$

$V_f$  = Minimum Design Flap Speed: (CAM 3.190)

$$V_f = 1.4 V_g = 1.4 \times 57.7 = \underline{80.7 \text{ mph or}}$$

$$V_f = 1.8 V_{gf} = 1.8 \times 52.7 = \underline{94.8 \text{ mph.}}$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 16
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE SELECTED DESIGN AIRSPEEDS	MODEL NO. ED-1

MAXIMUM DESIGN WEIGHT OF 1375 lb.

$V_c$ (Design Cruising Speed)	162	mph.
$V_d$ (Design Dive Speed)	251	mph.
$V_p$ (Design Maneuvering Speed)	154	mph.
$V_{pi}$ (Design Inverted Maneuvering Speed)	133	mph.
$V_f$ (Design Flap Speed)	104	mph.

MINIMUM DESIGN WEIGHT OF 930 lb.

$V_c$ (Design Cruising Speed)	162	mph.
$V_d$ (Design Dive Speed)	251	mph.
$V_p$ (Design Maneuvering Speed)	125	mph.
$V_{pi}$ (Design Inverted Maneuvering Speed)	110	mph.
$V_f$ (Design Flap Speed)	84	mph.

MOST FORWARD C.G. WEIGHT OF 1190 lb.

$V_c$ (Design Cruising Speed)	162	mph.
$V_d$ (Design Dive Speed)	251	mph.
$V_p$ (Design Maneuvering Speed)	142	mph.
$V_{pi}$ (Design Inverted Maneuvering Speed)	123	mph.
$V_f$ (Design Flap Speed)	95	mph.



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CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: September 17, 1963	TITLE SLOPE OF LIFT CURVE, COMPLETE WING	MODEL NO. BD-1

AIRFOIL = 64<sub>2</sub>-415

AIRFOIL LIFT CURVE SLOPE =  $a_0$  = .114 PER DEGREE (Ref. 2)

WING SPAN =  $b$  = 23.3 ft.

WING MAC =  $\bar{c}$  = 4.0 ft.

ASPECT RATIO =  $b/\bar{c}$  = 23.3/4.0 = 5.83

$$a = \frac{f a_0}{1 + (57.3 a_0 / \pi A)} \quad (\text{Ref. 4 p. 84})$$

WHERE:  $f$  = .989 For Rectangular Planform (Ref. 4 p. 85)

$$a = \frac{.989 \times .114}{1 + 57.3 \times .114 / \pi \times 5.83}$$

$a$  = .0833 Per Degree

CONVERTING TO RADIAN:

$$m = 57.3 a = 57.3 \times .0833$$

$m$  = 4.77 Per Radian



MAXIMUM DESIGN WEIGHT CONDITION OF 1375 LB.

PREPARED BY: L. J. Schneider	CHECKED BY: N. E. Ehlers	DATE: 10-8-63
		TITLE: V-n DIAGRAM (CAM 3.185)
 <b>BEDE AIRCRAFT, INC.</b>		REPORT NO.
		PAGE NO. 18
MODEL NO. BD-1		

POINT "A"

$n = 6.0$

(CAM 3.186)

$V_p = 154 \text{ mph.}$

(page 16)

POINT "C"

GUST LOAD FACTOR

(CAM 3.188)

$K = \frac{1}{2} \text{ (W/S)}^{\frac{1}{2}}$

WHERE  $W/S = 14.8 \text{ psf}$

$K = \frac{1}{2} \text{ (14.8)}^{\frac{1}{2}}$

$K = .980$

$n = 1 + \frac{K U V m}{575 \text{ (W/S)}}$

WHERE  $m = 4.77$  (page 17)

$V = V_c = 162 \text{ mph.}$

$U = 30 \text{ fps}$

$n = 1 + \frac{.980 \times 30 \times 162 \times 4.77}{575 \times 14.8}$

$n = 3.67$

POINT "D"

GUST LOAD FACTOR

(CAM 3.188)

$n = 1 - \frac{K U V m}{575 \text{ (W/S)}}$

WHERE  $V = V_p = 251 \text{ mph.}$

$U = 15 \text{ fps}$

$n = 1 + \frac{.980 \times 15 \times 251 \times 4.77}{575 \times 14.8}$

$n = 3.07$

POINT "E"

GUST LOAD FACTOR

(CAM 3.188)

$n = 1 - \frac{K U V m}{575 \text{ (W/S)}}$

WHERE  $V = V_p = 251 \text{ mph.}$

$U = 15 \text{ fps}$

$n = -1.07$

POINT "F"

GUST LOAD FACTOR

(CAM 3.188)

$n = 1 - \frac{K U V m}{575 \text{ (W/S)}}$

WHERE  $V = V_c = 162 \text{ mph.}$

$U = 30 \text{ fps.}$

$n = -1.67$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 19
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE V-n DIAGRAM - CONT'D	MODEL NO. BD-1

MAX. WEIGHT OF 1375 lb. - CONT'D


POINT "G"       $n = -3.0$       (CAM 3.186)

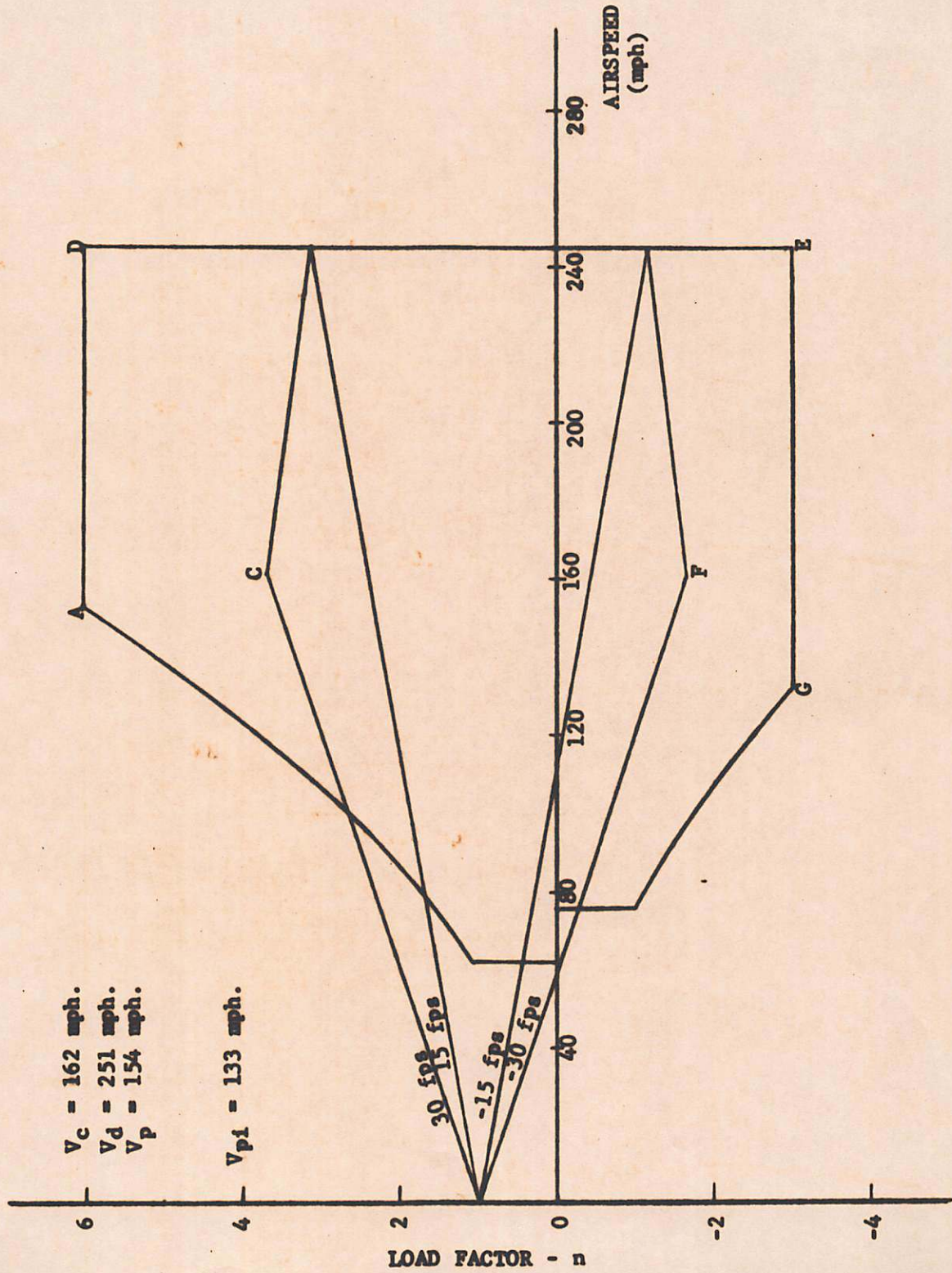
$V_{pi} = 133$  mph. (page 16)

STALL CURVES

$V_S = 63.0$ mph.		$V_{Si} = 76.9$ mph.	
V	n	V	n
80	1.67	80	-1.11
100	2.60	100	-1.74
120	3.75	120	-2.49



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 20
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-6-63	TITLE V-n DIAGRAM MAXIMUM DESIGN WEIGHT (1375 lb)	MODEL NO. BD-1





PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 21
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE V-n DIAGRAM - CONTINUED	MODEL NO. BD-1

MINIMUM DESIGN WEIGHT OF 930 lb.

POINT "A"       $n = 6.0$       (CAM 3.186)  
 $V_p = 125 \text{ mph.}$       (page 16 )

POINT "C" GUST LOAD FACTOR      (CAM 3.188)

$$K = \frac{1}{2} (W/S)^k \quad \text{WHERE } W/S = 9.97$$

$$K = \frac{1}{2} (9.97)^k$$

$$K = .888$$

$$n = 1 + \frac{K U V m}{575 (W/S)} \quad \text{WHERE } m = 4.77 \quad (\text{page 17 } )$$

$V = V_c = 162 \text{ mph.}$   
 $U = 30 \text{ fps}$

$$n = 1 + \frac{.888 \times 30 \times 162 \times 4.77}{575 (9.97)}$$

$$n = \underline{4.59}$$

POINT "D" GUST LOAD FACTOR      (CAM 3.188)

$$n = 1 + \frac{K U V m}{575 (W/S)} \quad \text{WHERE } V = V_d = 251 \text{ mph.}$$

$U = 15 \text{ fps}$

$$n = 1 + \frac{.888 \times 15 \times 251 \times 4.77}{575 \times 9.97}$$

$$n = \underline{3.78}$$

POINT "E" GUST LOAD FACTOR      (CAM 3.188)

$$n = 1 - \frac{K U V m}{575 (W/S)} \quad \text{WHERE } V = V_d = 251 \text{ mph.}$$

$U = 15 \text{ fps}$

$$n = \underline{-1.78}$$

POINT "F" GUST LOAD FACTOR      (CAM 3.188)

$$n = 1 - \frac{K U V m}{575 (W/S)} \quad \text{WHERE } V = V_c = 162 \text{ mph.}$$

$U = 30 \text{ fps.}$

$$n = \underline{-2.59}$$



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CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE V-n DIAGRAM - CONTINUED	MODEL NO. BD-1

MINIMUM DESIGN WEIGHT OF 930 lb. - CONT'D.

POINT "G"       $n = -3.0$       (CAM 3.186)

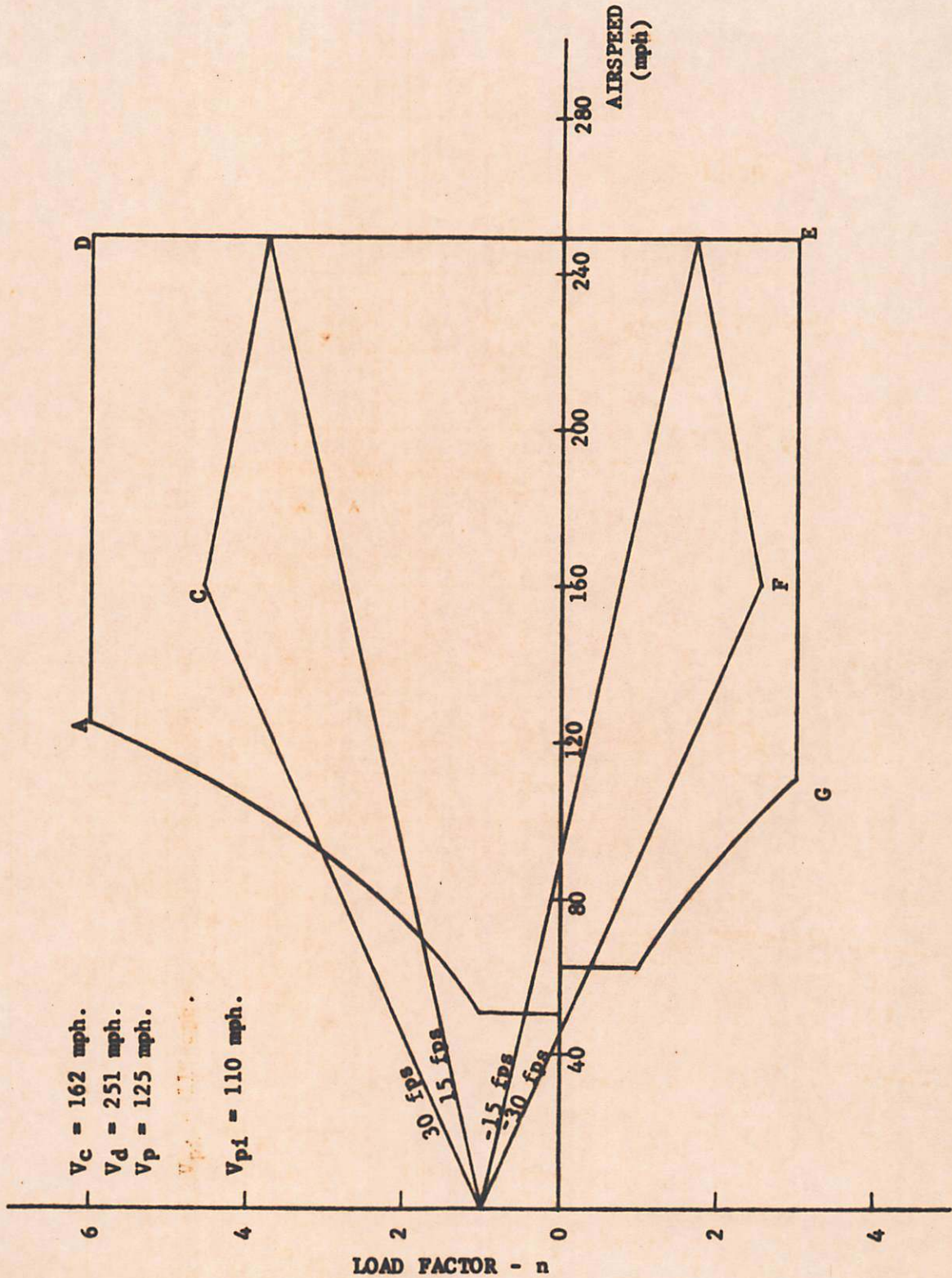
$V_{pi} = 110$  mph.      (page 16 )

STALL CURVES

$V_s = 51.0$ mph.		$V_{si} = 62.4$ mph.	
V	n	V	n
60	1.38	70	1.26
70	1.89	80	1.64
80	2.46	90	2.08



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 23
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-6-63	TITLE V-n DIAGRAM MINIMUM DESIGN WEIGHT (930 lb)	MODEL NO. BD-1





PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 24
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE V-n DIAGRAM - CONTINUED	MODEL NO. BD-1

MOST FWD. C.G. WEIGHT OF 1190 lb.

POINT "A"      $n = 6.0$      (CAM 3.186)

$V_p = 142$  mph.     (page 16 )

POINT "C"     GUST LOAD FACTOR (CAM 3.188)

$$K = \frac{1}{2} (W/S)^k \quad \text{WHERE } W/S = 12.8 \text{ psf.}$$

$$K = \frac{1}{2} (12.8)^k$$

$$K = .945$$

$$n = 1 + \frac{K U V m}{575 (W/S)} \quad \text{WHERE } m = 4.77 \quad (\text{page 17})$$

$$V = V_c = 162 \text{ mph.}$$

$$U = 30 \text{ fps.}$$

$$n = 1 + \frac{.945 \times 30 \times 162 \times 4.77}{575 \times 12.8}$$

$$n = 3.98$$

POINT "D" GUST LOAD FACTOR     (CAM 3.188)

$$n = 1 + \frac{K U V m}{575 (W/S)} \quad \text{WHERE } V = V_d = 251 \text{ mph.}$$

$$U = 15 \text{ fps.}$$

$$n = 1 + \frac{.945 \times 15 \times 251 \times 4.77}{575 \times 12.8}$$

$$n = 3.31$$

POINT "E" GUST LOAD FACTOR     (CAM 3.188)

$$n = 1 - \frac{K U V m}{575 (W/S)} \quad \text{WHERE } V = V_c = 251 \text{ mph.}$$

$$U = 15 \text{ fps.}$$

$$n = -1.31$$

POINT "F" GUST LOAD FACTOR     (CAM 3.188)

$$n = 1 - \frac{K U V m}{575 (W/S)} \quad \text{WHERE } V = V_c = 162 \text{ mph.}$$

$$U = 30 \text{ fps.}$$

$$n = -1.98$$



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CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE V-n DIAGRAM CONTINUED	MODEL NO. BD-1

MOST FORWARD C.G. WEIGHT OF 1190 lb. - CONT'D.

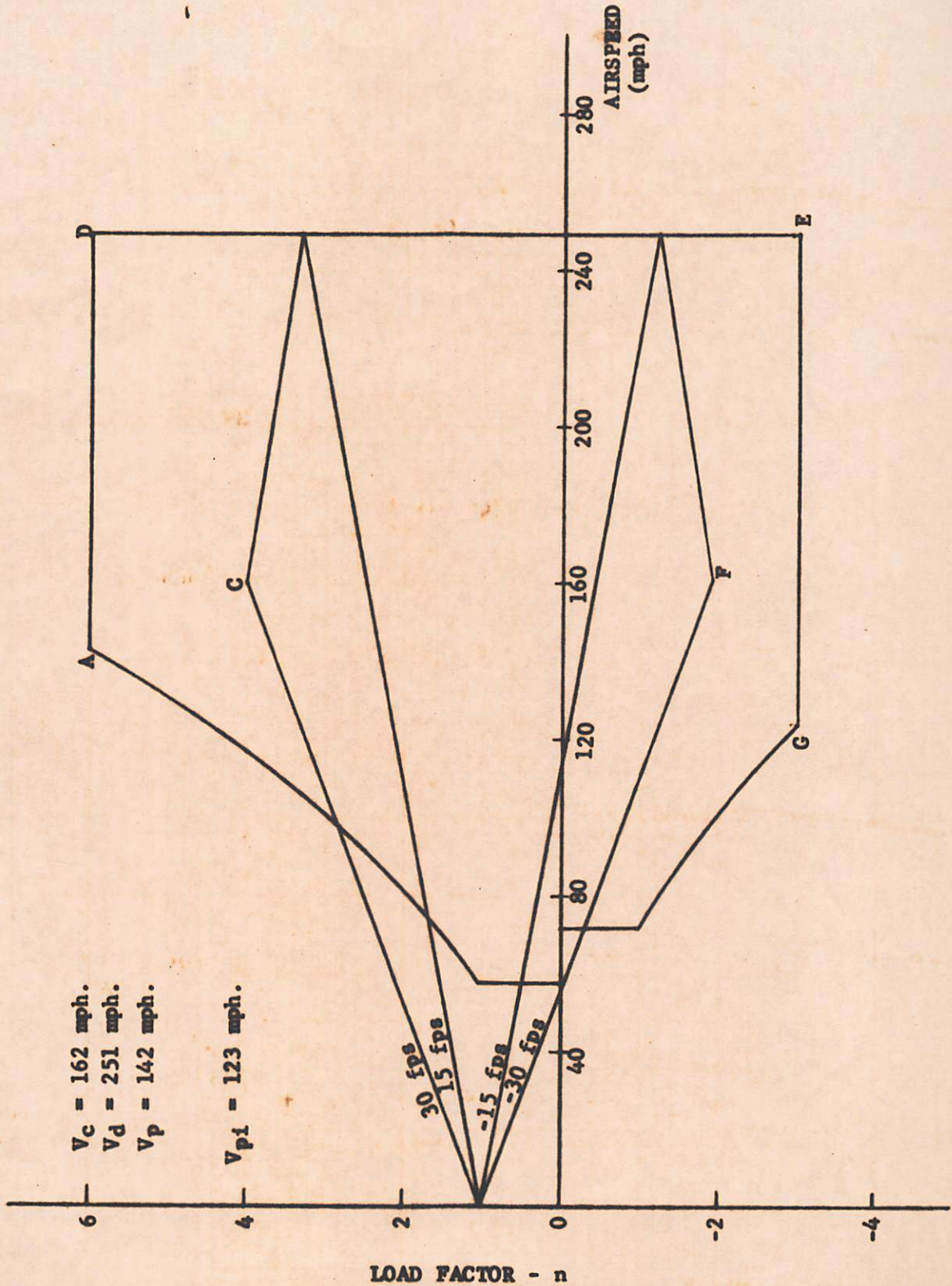
POINT "G"       $n = -3.0$       (CAM 3.186)  
 $V_{pi} = 123$  mph.      (page 16)

STALL CURVES

$V_s = 57.7$ mph.		$V_{si} = 70.8$ mph.	
V	n	V	n
70	1.47	80	-1.28
90	2.44	90	-1.62
110	3.63		



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CHECKED BY: <b>N. E. Ehlers</b>		REPORT NO.
DATE: <b>11-6-63</b>	TITLE <b>V-n DIAGRAM MOST FWD. C.G. WIEGHT (1190 lb.)</b>	MODEL NO. <b>BD-1</b>





PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 27
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63		TITLE BALANCING DIMENSIONS

CENTER OF GRAVITY (CAM 3.76):

AS TAKEN FROM WEIGHT AND BALANCE (pages 9 to 11)

LOADING CONDITION	WEIGHT (lb)	FUSELAGE STATION (IN)	WATER LINE (IN)
MOST FORWARD	1190	78.6	38.6
FORWARD GROSS	1375	80.8	38.4
REARWARD GROSS	1375	84.9	38.0
MINIMUM *	930	78.6	38.8

\* ASSUME MIN. WEIGHT STA. SAME AS MOST FWD.

**AERODYNAMIC DIMENSIONS:**

WING AERODYNAMIC CENTER = a.c. = 26.4 % MAC. (Ref. 2)

FUSELAGE STATION = 83.2 IN.

WATER LINE = 36.3 IN.

**HORIZONTAL TAIL CENTER OF PRESSURE**

(ASSUME 25% OF TAIL MAC.)

FUSELAGE STATION = 204.4 IN.

WATER LINE = 44.5 IN.

The aerodynamic forces and dimensions are computed with respect to a line through the wing aerodynamic center parallel to the fuselage longitudinal axis, such that aerodynamic forces are obtained perpendicular and parallel to fuselage water lines. The wing chord line is at a 3.5 degree angle of incidence to the fuselage water lines.

ARM FROM WING a.c. to Tail c.p.

$$X = (204.4 - 83.2) = \underline{121.2 \text{ IN.}} = d \quad Z = (44.5 - 36.3) = \underline{8.2 \text{ IN.}}$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 28
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-8-63	TITLE BALANCING DIMENSIONS - CONT'D	MODEL NO. BD-1

BALANCING ARMS FROM AIRPLANE C.G. TO WING a.c.

LOADING CONDITION	X <sub>cg</sub> (IN)	Z <sub>cg</sub> (IN)
MOST FORWARD	-4.6	2.3
FORWARD GROSS	-2.4	2.1
REARWARD GROSS	1.7	1.7
MINIMUM	-4.6	2.5

ARM FROM WING a.c. TO THRUST LINE

The thrust line is parallel to the station lines at water line = 45.0 in.

The arm from the wing a.c. to the thrust line is:

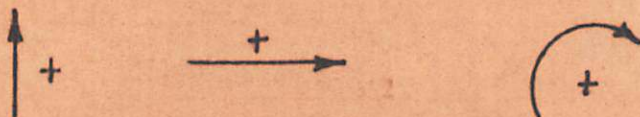
$$Z_t = 45.0 - 36.3 = 8.7 \text{ in.}$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 29
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: September 18, 1963	TITLE WING AERODYNAMIC CHARACTERISTICS	MODEL NO. BD-1

$$C_{na} = C_l \cos \alpha' + C_d \sin \alpha' \quad (\text{REF. 4, P. 217})$$

$$C_c = C_d \cos \alpha' - C_l \sin \alpha'$$



ASSUME:

AIRFOIL 64<sub>2</sub> - 415

$$\alpha_o = -3.0^\circ$$

$$i = 3.5^\circ$$

$$a = .0833 \quad (\text{page 17})$$

$$A = 5.83 \quad (\text{page 17})$$

$$\textcircled{1} 1/a = 1/.0833 = 12.0$$

$$\textcircled{2} \alpha_o - i = -3.0 - 3.5 = -6.5^\circ$$

$$\textcircled{3} 1/\pi A = 1/\pi 5.83 = .0546$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 30
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: September 18, 1963		TITLE WING AERODYNAMIC CHARACTERISTICS CONTINUED

4	$C_l$		-1.0	-.8	-.6	-.4	-.2	0	.2	.4
5	$\alpha$	(1) x (4)	-12.0	-9.6	-7.2	-4.8	-2.4	0	2.4	4.8
6	$\alpha'$	(5) + (2)	-18.5	-16.1	-13.7	-11.3	-8.9	-6.5	-4.1	-1.7
7	$C_{do}$	Ref. 2	.0162	.0132	.0110	.0091	.0079	.0067	.0056	.0058
8	$C_{di}$	(3) x (4) <sup>2</sup>	.0546	.0349	.0196	.0087	.0022	0	.0022	.0087
9	$C_d$	(7) + (8)	.0708	.0481	.0306	.0178	.0101	.0067	.0078	.0145
10	$\cos \alpha'$	$\cos (6)$	.948	.961	.972	.981	.988	.994	.997	1.000
11	$\sin \alpha'$	$\sin (6)$	-.317	-.277	-.237	-.196	-.155	-.113	-.072	-.030
12	$C_l \cos \alpha'$	(4) x (10)	-.948	-.769	-.583	-.392	-.198	0	-.199	.400
13	$C_d \sin \alpha'$	(9) x (11)	-.022	-.013	-.007	-.004	-.002	-.001	-.001	0
14	$C_n$	(12) + (13)	-.970	-.782	-.590	-.396	-.200	-.001	.198	.400
15	$C_l \sin \alpha'$	(4) x (11)	.317	.221	.142	.078	.031	0	-.014	-.012
16	$C_d \cos \alpha'$	(9) x (10)	.067	.046	.030	.017	.010	.007	.008	.014
17	$C_c$	(16) - (15)	-.250	-.175	-.112	-.061	-.021	.007	.022	.026

CONTINUED ON NEXT PAGE

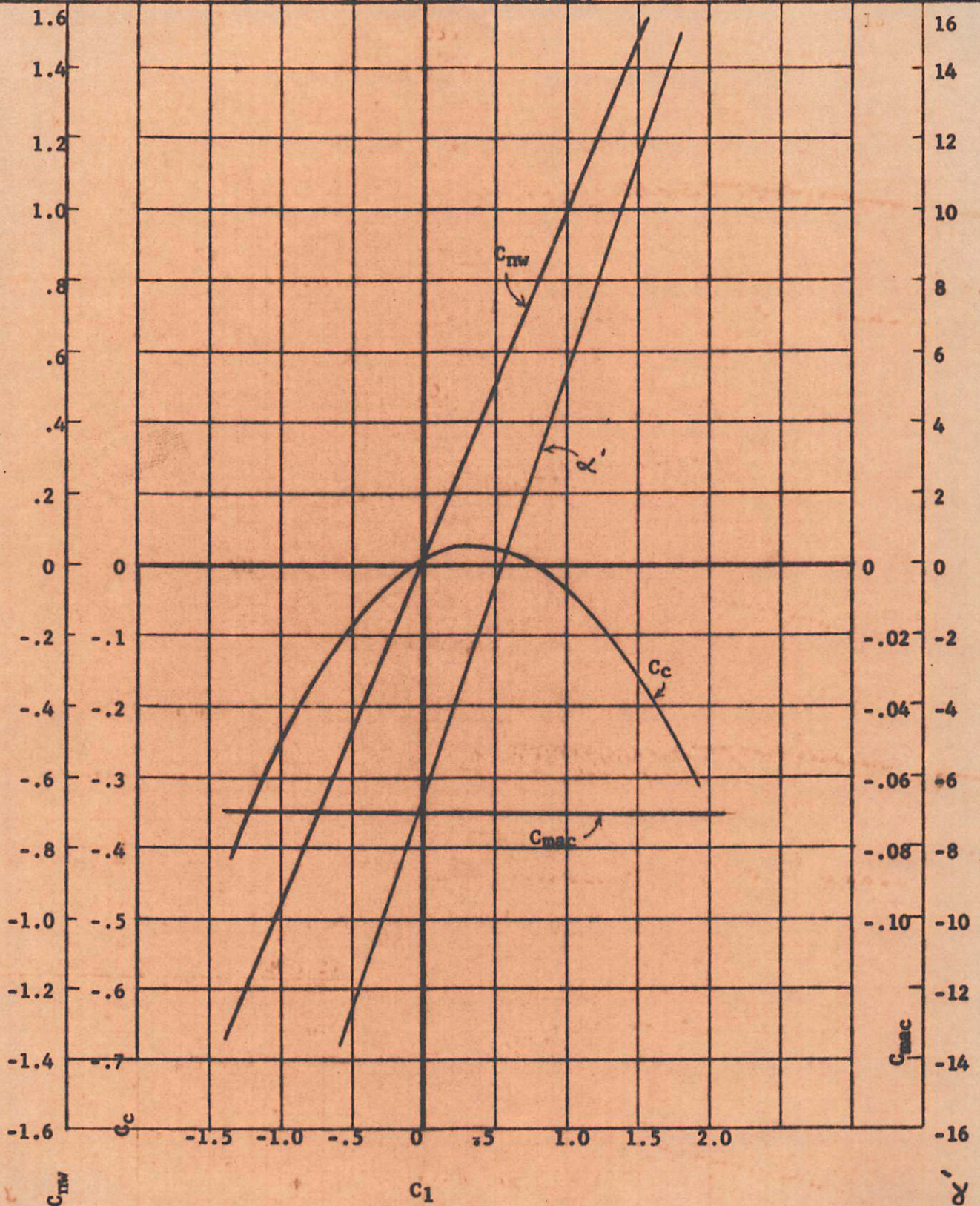


PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 31
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: September 18, 1963		TITLE WING AERODYNAMIC CHARACTERISTICS CONTINUED

4	$C_l$		.6	.8	1.0	1.2	1.4	1.6	1.8	2.0
5	$\alpha$	① x ④	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0
6	$\alpha'$	⑤ + ②	0.7	3.1	5.5	7.9	10.3	12.7	15.1	17.5
7	$C_{do}$	Ref. 2	.0059	.0063	.0117	.0146	.0205	.0280	.0335	.0375
8	$C_{di}$	③ x ④ <sup>2</sup>	.0196	.0349	.0546	.0786	.1070	.1398	.1770	.2182
9	$C_d$	⑦ + ⑧	.0255	.0412	.0663	.0932	.1275	.1678	.2105	.2557
10	$\cos \alpha'$	$\cos$ ⑥	1.000	.998	.995	.990	.984	.976	.965	.954
11	$\sin \alpha'$	$\sin$ ⑥	.012	.054	.096	.137	.179	.220	.260	.301
12	$C_l \cos \alpha'$	④ x ⑩	.600	.798	.995	1.188	1.379	1.561	1.739	1.910
13	$C_d \sin \alpha'$	⑨ x ⑪	0	.002	.006	.013	.023	.037	.055	.077
14	$C_n$	⑫ + ⑬	.600	.800	1.001	1.201	1.402	1.598	1.794	1.987
15	$C_l \sin \alpha'$	④ x ⑪	.007	.043	.096	.164	.251	.352	.468	.602
16	$C_d \cos \alpha'$	⑨ x ⑩	.026	.041	.066	.092	.126	.164	.204	.244
17	$C_c$	⑫ - ⑮	.019	-.002	-.030	-.072	-.125	-.188	-.264	-.358



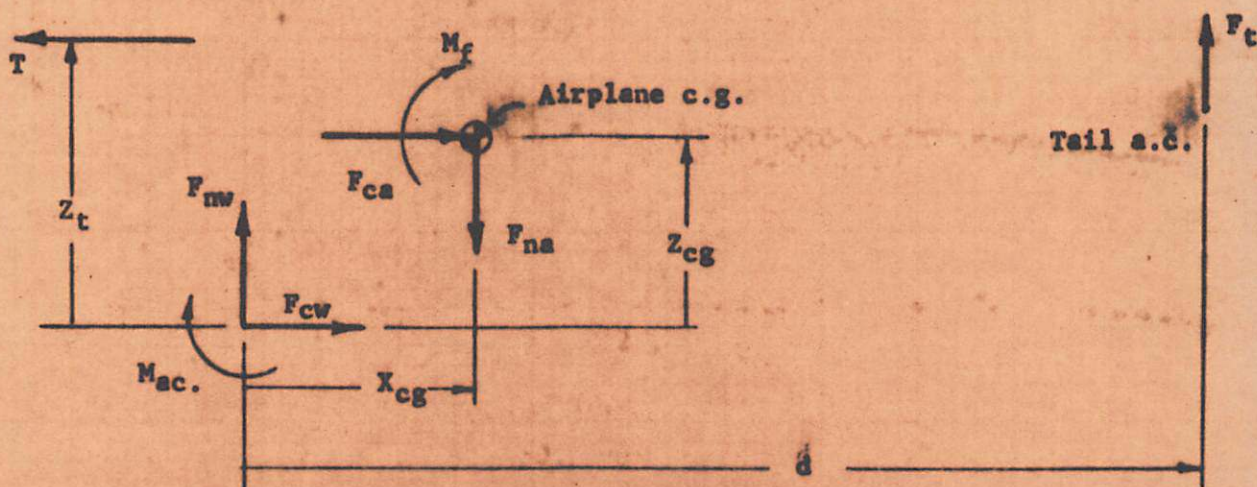
PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 32
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-6-63	TITLE WING AERODYNAMIC CHARACTERISTICS (FLAPS RETRACTED)	MODEL NO. BD-1





PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 33
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-11-63	TITLE WING LIMIT AIRLOADS	MODEL NO. BD-1

AIRPLANE EQUILIBRIUM (CAM 3.189)



1)  $\sum$  Horizontal Forces

$$F_{ca} + F_{ca} - T = 0$$

2)  $\sum$  Vertical Forces

$$F_{lw} - F_{na} + F_t = 0$$

3)  $\sum$  Moments About c.g.

$$M_{ac} + M_f - z_{cg} F_{cw} + x_{cg} F_{lw} - (z_t - z_{cg}) T - (d - x_{cg}) F_t = 0$$

EXPLANATION OF BALANCING TABLES (pages 35 to 36)

- ① V Design Speed Selected From Page 16 .
- ② n Limit Load Factor From V-n Diagrams
- ③  $q = .00256 v^2$
- ④ Estimate A Value For  $F_{lw}$
- ⑤  $C_{lw} = F_{lw} / q S = .0107 F_{lw} / q$
- ⑥ Select  $C_c$  From The Wing Characteristics Curve (p.32 )
- ⑦  $F_{cw} = C_c q S$
- ⑧  $M_{ac} = C_{mac} \bar{c} q S = (-.07) (4.0) q (93.3) = -26.2 q$
- ⑨  $M_f = C_{mf} \bar{c} q S = (-.01) (4.0) q (93.3) = -3.73 q$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 34
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-11-63	TITLE WING LIMIT AIRLOADS - CONT'D	MODEL NO. BD-1

$$\textcircled{10} T = 375 P n/v = 375 (108) (.85)/v = 31,300/v^*$$

$$\textcircled{11} \frac{F_t = -Z_{cg} F_{cw} - (Z_t - Z_{cg}) T + M_{ac} + M_f + X_{cg} F_{na}}{d - X_{cg}}$$

$$\textcircled{12} F_{na} = nW$$

$$\textcircled{13} F_{nw} = F_{na} - F_t \quad (\text{check } \textcircled{4})$$

\* NOTE: Thrust will be conservatively assumed to be at maximum continuous power for level flight and zero for inverted flight.



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 35
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-23-63	TITLE Wing Limit Airloads - Cont'd	MODEL NO. BD-1.

MOST FORWARD WEIGHT CONDITION

$W = 1190 \text{ lb.}$

$X_{cg} = 4.6 \text{ in.} = -.383 \text{ ft.}$

$d = 121.2 \text{ in.} = 10.1 \text{ ft.}$

$Z_{cg} = 2.3 \text{ in.} = .192 \text{ ft.}$

$Z_t = 8.7 \text{ in.} = .725 \text{ ft}$

$(Z_t - Z_{cg}) = .725 - .192 = .533 \text{ ft.} \quad (d - X_{cg}) = 10.1 + .4 = 10.5 \text{ ft.}$

No.	ENVELOPE POINT	A	D	E	G
1	V (mph.)	142	251	251	123
2	n	6.0	6.0	-3.0	-3.0
3	$q = .00256 \times (1)$	51.7	161.5	161.5	38.7
4	$F_{nw}$ (est.)	7558	7900	-3236	-3609
5	$C_{nw} = .0107 (4)(3)$	1.56	.523	-.214	-.998
6	$C_c$ (page 32)	-.188	.018	-.028	-.265
7	$F_{cw} = 93.3 (6) \times (3)$	-907	271	-422	-956
8	$M_{ac} = -26.2 \times (3)$	-1352	-4230	-4230	-1013
9	$M_f = -3.73 \times (3)$	-193	-602	-602	-144
10	$T = 34400 / (1)$	242	137	0	0
11	$F_t = \frac{-.192(7) - .533(10) + (8) + (9) - .383(4)}{10.5}$	-418	-760	-384	39
12	$F_{na} = 1190(2)$	7140	7140	-3570	-3570
13	$F_{nw} = (12) = (11)$ (check (4))	7558	7900	-3236	-3609



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 36
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-23-63	TITLE WING LIMIT AIRLOADS - Cont'd	MODEL NO. BD-1

FORWARD GROSS WEIGHT CONDITION

$$W = 1375 \text{ lb.}$$

$$X_{cg} = -2.4 \text{ in.} = -.200 \text{ ft.}$$

$$d = 121.2 \text{ in} = 10.1 \text{ ft.}$$

$$Z_{cg} = 2.1 \text{ in.} = .175 \text{ ft.}$$

$$Z_t = 8.7 \text{ in.} = .725 \text{ ft.}$$

$$(Z_t - Z_{cg}) = .725 - .175 = .550$$

$$(d - X_{cg}) = 10.1 + .2 = 10.3$$

No.	ENVELOPE POINT	A	D	E	G
1	V (mph)	154	251	251	133
2	n	6.0	6.0	-3.0	-3.0
3	$q = .00256 \times (1)$	60.7	161.5	161.5	45.3
4	$F_{nw}$ (est.)	8588	8903	-3737	-4090
5	$C_{nw} = .0107 (4) / (3)$	1.51	.591	-.248	-.965
6	$C_c$ (page 32)	-.174	.016	-.036	-.248
7	$F_{cw} = 93.3 (6) \times (3)$	-985	241	-542	-1048
8	$M_{ac} = -26.2 \times (3)$	-1590	-4230	-4230	-1188
9	$M_f = -3.73 \times (3)$	-226	-602	0602	-169
10	$T = 34400 / (1)$	224	137	0	0
11	$F_t = \frac{-.175(7) - .550(10) + (8) + (9) - .20(4)}{10.3}$	-338	-653	-388	-35
12	$F_{na} = 1375 (2)$	8250	8250	-4125	-4125
13	$F_{nw} = (12) - (11)$ (check (4))	8588	8903 <sub>q</sub>	-3737	-4090



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 37
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-23-63	TITLE WING LIMIT AIRLOADS - CONT'D	MODEL NO. BD-1

MOST AFT GROSS WEIGHT CONDITION

$$W = 1375 \text{ lb.}$$

$$X_{cg} = 1.7 \text{ in} = .141 \text{ ft.}$$

$$d = 121.2 \text{ in} = 10.1 \text{ ft.}$$

$$Z_{cg} = 1.7 \text{ in.} = .141 \text{ ft.}$$

$$Z_t = 8.7 \text{ in.} = .725 \text{ ft.}$$

$$(Z_t - Z_{cg}) = .725 - .141 = .584$$

$$(d - X_{cg}) = 10.1 - .1 = 10.0 \text{ ft.}$$

No.	ENVELOPE POINT	A	D	E	G
1	V (mph)	154	251	251	133
2	n	6.0	6.0	-3.0	-3.0
3	$q = .00256 \times (1)$	60.7	161.5	161.5	45.3
4	$F_{nw}$ (est.)	8315	8623	-3598	-3948
5	$C_{nw} = .0107 (4) / (3)$	1.47	.571	-.238	.933
6	$C_c$ (page 32)	-.160	.016	-.033	-.237
7	$F_{cw} = 93.3 (6) \times (3)$	-906	241	-497	-1002
8	$M_{ac} = -26.2 \times (3)$	-1590	-4230	-4230	-1188
9	$M_f = -3.73 \times (3)$	-226	-602	-602	-169
10	$T = 34400 / (1)$	224	137	0	0
11	$F_t = \frac{-.141 (7) - .584 (10) + (8) + (9) + .141 (4)}{10.0}$	-65	-373	-527	-177
12	$F_{na} = 1375 (2)$	8250	8250	-4125	-4125
13	$F_{nw} = (12) - (11) \text{ (check (4))}$	8315	8623	-3598	-3948



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 38
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-23-63	TITLE WING LIMIT AIRLOADS - CONT'D	MODEL NO. BD-1

### MINIMUM WEIGHT CONDITION

W = 930 lb.

Since both the weight and load factors at each of the Envelope Points are the same or less than those of the Most Forward Center of Gravity Condition, it is not possible for the wing airloads of the Minimum Weight Condition to be more than those of the Most Forward Center of Gravity Condition.

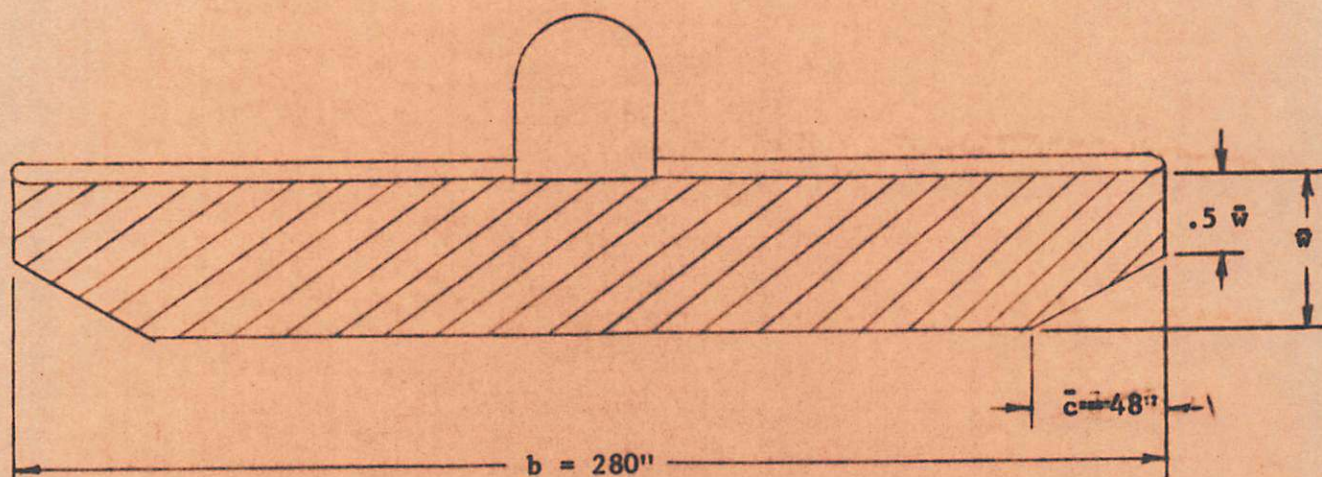
### SPANWISE LOAD DISTRIBUTION

- NOTES: 1) A detail weight analysis of the BD-1 wing structure shows a weight distribution ranging from 0.403 to 0.635 lb/in. A dead weight load distribution of a constant 0.4 lb/in will be conservatively used for this analysis. That is  $\bar{w}_d = 0.4$  lb/in.
- 2) A rectangular spanwise load distribution of  $\bar{w}_n$  (and  $\bar{w}_{ic}$ ) will be assumed to a point on the span where the distance from the tip equals the chord. From that point  $\bar{w}_n$  (and  $\bar{w}_c$ ) vary linearly to a value of  $.5 \bar{w}_n$  (and  $.5 \bar{w}_c$ ) at the tip.



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 39
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-23-63	TITLE WING LIMIT AIRLOADS - CONT'D	MODEL NO. BD-1

SPANWISE LIFT DISTRIBUTION - CONT'D.



$$\bar{w}_{ni} = \frac{F_{nw}}{b - .5c} - \bar{w}_d = \frac{F_{nw}}{280 - .5 \times 48} - n \times .4 = \frac{F_{nw}}{256} - n \times .4$$

$$\bar{w}_c = \frac{F_{cw}}{b - .5c} = \frac{F_{cw}}{280 - .5 \times 48} = \frac{F_{cw}}{256}$$

FLAPS RETRACTED

ENVELOPE POINT	A	D	E	G
Critical Loading Condition	Fwd./Gross	Fwd./Gross	GFwd./Gross	Fwd./Gross
$F_{nw}$ (page 36) =	8588	8903	-3737	-4090
$F_{cw}$ (page 36)	-985	241	-542	-1048
n	6.0	6.0	-3.0	-3.0
$\bar{w}_n$ (lb/in)	31.2	32.4	-13.4	-14.8
$\bar{w}_c$ (lb/in)	-3.85	.94	-2.12	-4.09



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 40
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-14-63	TITLE FLAP DOWN WING CHARACTERISTICS	MODEL NO. BD-1

ASSUME:

$$\begin{aligned}
 i &= 3.5^\circ \\
 A &= 5.83 \\
 f &= .989 \quad (\text{Ref. 4, p. 85}) \\
 \alpha_o &= -3.0^\circ \\
 S_f &= 46.6 \text{ ft.} \\
 \Delta C_{L1} &= 1.0 \quad (\text{Ref. 4, Fig. 2-58}) \\
 K &= 6 \quad (\text{Ref. 4, Fig. 2-57})
 \end{aligned}$$

$$\begin{aligned}
 \delta_f &= 60^\circ \\
 c_f/\bar{c} &= 16\%
 \end{aligned}$$

$$\Delta \alpha_{of} = -K \Delta C_{L1} = -6 \times 1 = -6^\circ \quad (\text{Ref. 4, P. 86})$$

$$\alpha_{ow} = \alpha_o + \Delta \alpha_{of} = -3 - 6 = -9^\circ$$

ASSUME: LIFT CURVE SLOPE IS UNCHANGED WITH FLAP DEFLECTION.'

$$a = .0833 \text{ Per Degree} \quad (\text{page 17/})$$

$$\textcircled{1} \quad 1/a = 1/.0833 = 12.0$$

$$\textcircled{2} \quad \alpha_{ow} - i = -9^\circ - 3.5^\circ = -12.5^\circ$$

$$\textcircled{3} \quad 1/\pi A = 1/\pi 5.83 = .0546$$



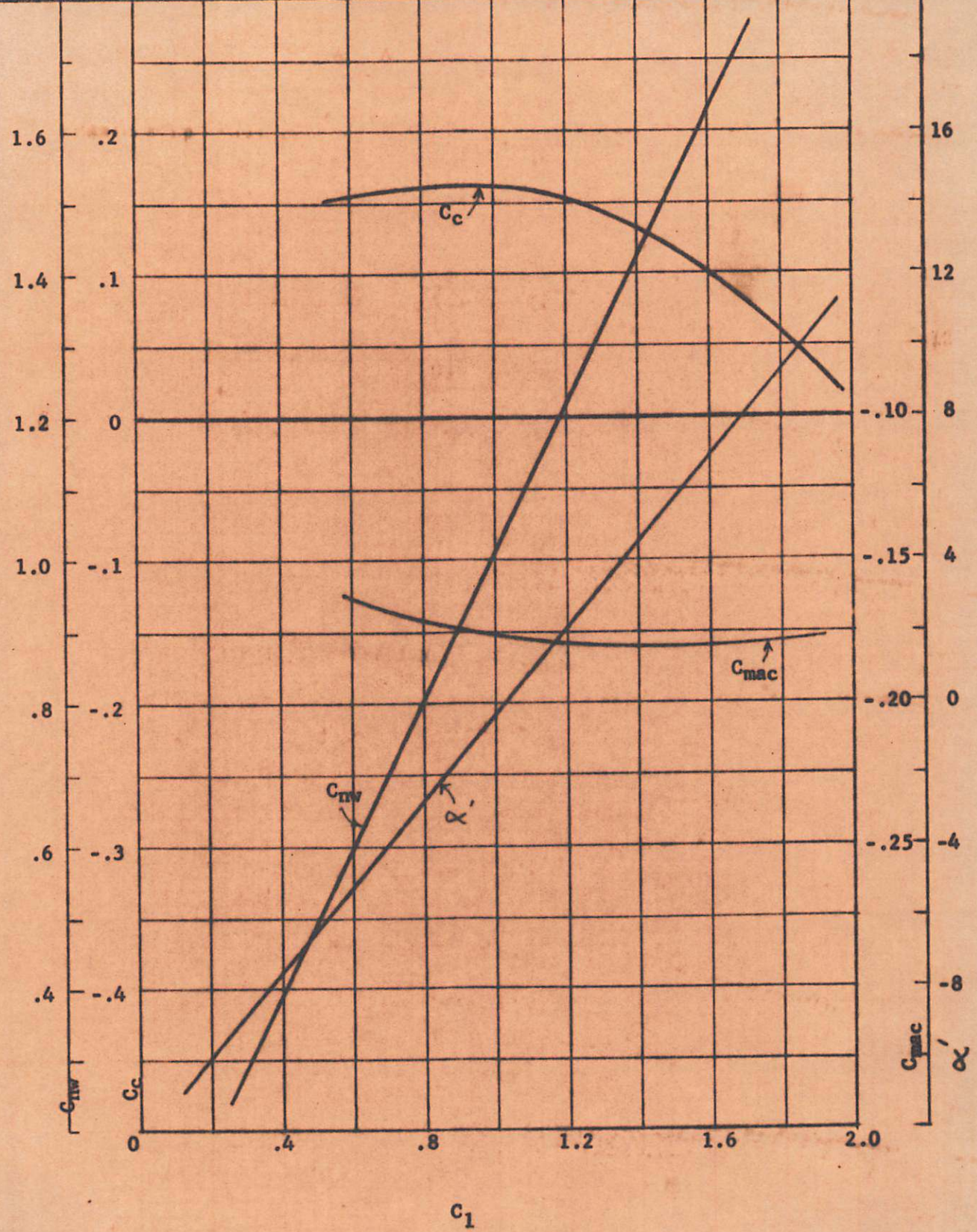
PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 41
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-14-63	TITLE FLAP DOWN WING CHARACTERISTICS	MODEL NO. BD-1

④	$C_l$		.6	.8	1.0	1.2	1.4	1.6	1.8	2.0
⑤	$\alpha$	① x ④	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0
⑥	$\alpha'$	⑤ + ②	-5.3	-2.9	-.5	1.9	4.3	6.7	9.1	11.5
⑦	$C_{do}^*$	Ref. 7	.078	.082	.096	.117	.130	.149	.167	.209
⑧	$C_{di}$	③ x ④	.020	.035	.055	.079	.107	.140	.178	.218
⑨	$C_d$	⑦ + ⑧	.098	.117	.151	.196	.237	.289	.345	.427
⑩	$\cos \alpha'$	$\cos$ ⑥	.996	.999	1.000	.999	.997	.993	.987	.980
⑪	$\sin \alpha'$	$\sin$ ⑥	-.092	-.051	-.009	.033	.075	.117	.158	.199
⑫	$C_l \cos \alpha'$	④ x ⑩	.598	.799	1.000	1.199	1.396	1.589	1.777	1.960
⑬	$C_d \sin \alpha'$	⑨ x ⑪	-.009	-.006	-.001	.006	.018	.034	.055	.085
⑭	$C_n$	⑫ + ⑬	.589	.793	.999	1.205	1.414	1.623	1.832	2.045
⑮	$C_l \sin \alpha'$	④ x ⑪	-.055	-.041	-.009	.040	.105	.187	.284	.398
⑯	$C_d \cos \alpha'$	⑨ x ⑩	.098	.117	.151	.196	.236	.287	.340	.418
⑰	$C_c$	⑯ - ⑮	.153	.158	.160	.156	.131	.100	.056	.020
⑱	$C_{mac}^{unflapd}$	Unflaped	-.07	-.07	-.07	-.07	-.07	-.07	-.07	-.07
⑲	$C_{mac}^f$	Ref. 7	-.26	-.27	-.28	-.28	-.28	-.28	-.28	-.27
⑳	$C_{mac}^*$	⑱ + ⑲/2	-.16	-.17	-.18	-.18	-.18	-.18	-.18	-.17

\* The profile drag coefficients and the pitching moment coefficient are the combination of the flap up and flap down coefficients proportional to the flaped and unflaped wing areas.



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 42
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 11-6-63	TITLE WING AERODYNAMIC CHARACTERISTICS (FLAP DOWN)	MODEL NO. BD-1





PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 4343
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-14-63		TITLE WING LIMIT AIRLOADS - CONT'D.

FLAPS EXTENDED FLIGHT CONDITION (CAM 3.190)

ASSUME:  $V_f = 104$  mph. - Fwd. Gross Weight (p. 16)

$V_f = 95$  mph. - Most Fwd. Weight (p. 16)

$C_{mac} = -.18$  (page 42)

$$M_{ac} = q C_{mac} \bar{c} S$$

$$M_{ac} = q (-.18) (4.0) (93.3)$$

$$M_{ac} = -67.2 q$$

GUST LOAD FACTOR: (CAM 3.188)

MOST FWD. WEIGHT:

$$n = 1 + \frac{K U V m}{575 (W/S)}$$

$$n = 1 + \frac{.945 \times 15 \times 95 \times 4.77}{575 \times 12.8}$$

$$n = 1.87$$

WHERE  $W = 1190$  lb.

$$W/S = 12.8 \text{ psf}$$

$$K = .945 \text{ (page 24)}$$

$$m = 4.77 \text{ (page 17)}$$

$$U = 15 \text{ fps (CAM 3.190)}$$

Fwd. Gross Weight:

$$n = 1 + \frac{K U V m}{575 (W/S)}$$

$$n = 1 + \frac{.980 \times 15 \times 104 \times 4.77}{575 \times 14.8}$$

$$n = 1.86$$

WHERE  $W = 1375$  lb.

$$W/S = 14.8 \text{ psf}$$

$$K = .980 \text{ (page 18)}$$

$$m = 4.77 \text{ (page 17)}$$

$$U = 15 \text{ fps (CAM 3.190)}$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 44
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-14-63	TITLE WING LIMIT AIRLOADS - CONT'D	MODEL NO. BD-1

MOST FORWARD WEIGHT CONDITION (FLAPS EXTENDED)

$$W = 1190 \text{ lb.}$$

$$X_{cg} = -4.6 \text{ in.} = -3383 \text{ ft.}$$

$$d = 121.2 \text{ in.} = 10.1 \text{ ft.}$$

$$Z_{cg} = 2.3 \text{ in.} = .192 \text{ ft.}$$

$$Z_t = 8.7 \text{ in.} = .725 \text{ ft.}$$

$$(Z_t - Z_{cg}) = .533 \text{ ft.}$$

$$(d - X_{cg}) = 10.5 \text{ ft.}$$

No.		MANEUVER	GUST
1	V (mph.)	95	95
2	n	2.0	1.87
3	$q = .00256 \times \textcircled{1}^2$	23.1	23.1
4	$F_{nw}$ (est.)	2657	2496
5	$C_{nw} = .0107 \textcircled{4} / \textcircled{3}$	1.23	1.16
6	$C_c$ (page 42)	.150	.155
7	$F_{cw} = 93.3 \textcircled{6} \times \textcircled{3}$	323	334
8	$M_{ac} = -67.2 \times \textcircled{3}$	-1550	-1550
9	$M_f = -3.73 \times \textcircled{3}$	-86	-86
10	$T = 34400 / \textcircled{1}$	362	362
11	$F_t = \frac{-.192 \textcircled{7} - .533 \textcircled{10} + \textcircled{8} + \textcircled{9}}{10.5} - .383 \textcircled{4}$	-277	-271
12	$F_{na} = 1190 \textcircled{2}$	2380	2225
13	$F_{nw} = \textcircled{12} - \textcircled{11}$	2657	2496



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 45
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-14-63	TITLE WING LIMIT AIRLOADS - CONT'D.	MODEL NO. BD-1

FORWARD GROSS WEIGHT CONDITION (FLAPS EXTENDED)

$$W = 1375 \text{ lb.}$$

$$X_{cg} = -2.4 \text{ in.} = -.200 \text{ ft.}$$

$$d = 121.2 \text{ in.} = 10.1 \text{ ft.}$$

$$Z_{cg} = 2.1 \text{ in.} = .175 \text{ ft.}$$

$$(Z_t - Z_{cg}) = .550$$

$$(d - X_{cg}) = 10.3$$

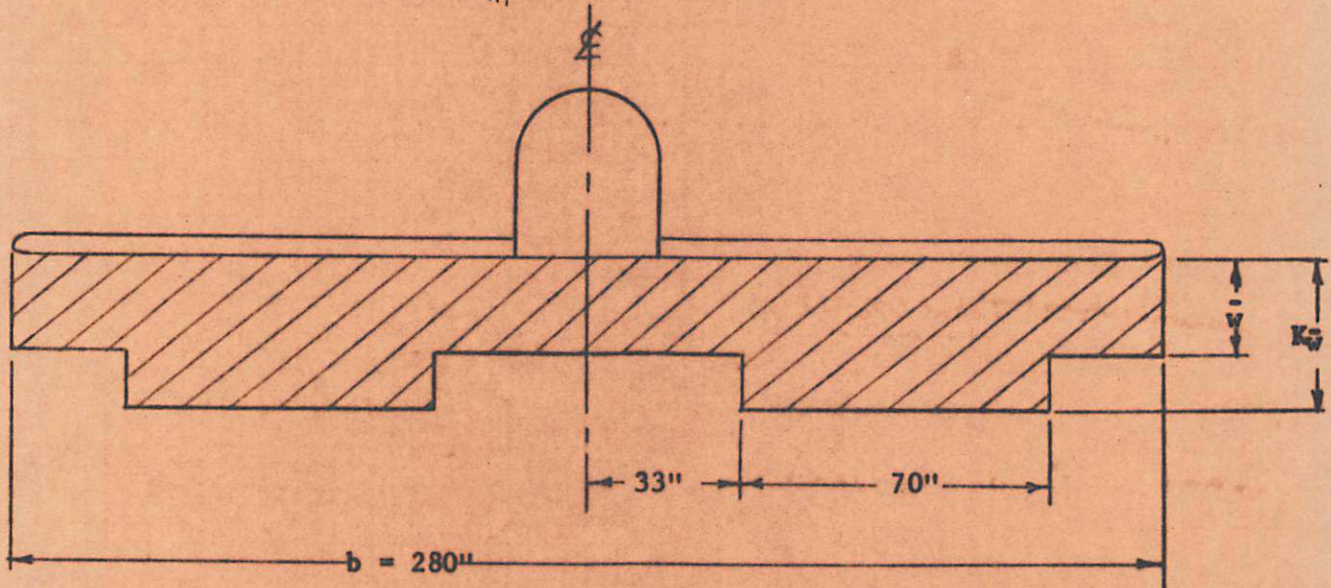
No.		MANEUVER	GUST
1	V (mph)	104	104
2	n	2.0	1.86
3	$q = .00256 \times \textcircled{1}^2$	27.7	27.7
4	$F_{nw}$ (est.)	3024	2828
5	$C_{nw} = .0107 \textcircled{4} / \textcircled{3}$	1.17	1.09
6	$C_c$ (page 42.)	.155	.158
7	$F_{cw} = 93.3 \textcircled{6} \times \textcircled{3}$	400	408
8	$M_{ac} = -67.2 \times \textcircled{3}$	-1863	-1863
9	$M_f = -3.73 \times \textcircled{3}$	-103	-103
10	$T = 34400 / \textcircled{1}$	331	331
11	$F_t = \frac{-.175 \textcircled{7} - .550 \textcircled{10} + \textcircled{8} + \textcircled{9}}{10.3} - .20 \textcircled{4}$	-274	-270
12	$F_{na} = 1375 \textcircled{2}$	2750	2558
13	$F_{nw} = \textcircled{12} - \textcircled{11}$	3024	2828



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CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-24-63	TITLE WING LIMIT AIRLOADS - CONT'D	MODEL NO. BD-1

SPANWISE LOAD DISTRIBUTION (FLAPS EXTENDED)

- NOTES: 1)  $\bar{w}_d = 0.40 \text{ lb/in}$  (page 38 )
- 2) A rectangular spanwise load distribution of  $\bar{w}_n$  (and  $\bar{w}_c$ ) will be assumed proportional to the flap up and flap down lift coefficients.
- 3) Flap up  $C_{lf} = 1.66$  (Ref. 2)
- 4) Flap down  $C_{lf} = 2.25$  (Ref. 6)



$$K = C_{lf}/C_l = 2.25/1.66 = 1.36$$

$$\bar{w}_n = \frac{F_{nw}}{b/2 (1 + K)} - n \bar{w}_d$$

$$\bar{w}_n = \frac{F_{nw}}{140 (1 + 1.36)} - n \times .4$$

$$\bar{w}_n = \frac{F_{nw}}{330} - .4n$$



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 47
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-25-63	TITLE WING LIMIT AIRLOADS - CONT'D.	MODEL NO. BD-1

SPANWISE LOAD DISTRIBUTION (FLAPS EXTENDED)

$$\bar{w}_c = \frac{F_c F_{cw}}{b/2 (1 + K)}$$

$$\bar{w}_c = \frac{F_{cw}}{140 (1 + 1.36)}$$

$$\bar{w}_c = \frac{F_{cw}}{330}$$

FLAPS EXTENDED - CRITICAL CONDITION = MANEUVER @ GROSS WEIGHT

$F_{nw}$ (page 45 )	3024
$F_{cw}$ (page 45 )	400
n (page 45 )	2.0
$\bar{w}_n$ (lb/in)	8.37
$\bar{w}_c$ (lb/in)	1.21



PREPARED BY: L. J. Schneider	 <b>BEDE AIRCRAFT, INC.</b>	PAGE NO. 48
CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-24-63	TITLE FLAP LIMIT LOADS CAM 3.223	MODEL NO. BD-1

$$c_f = .67 \text{ ft.}$$

$$b_f = 5.87 \text{ ft.}$$

$$V_f = 104 \text{ mph, therefore } q = 27.7 \text{ psf (page 45)}$$

$$\text{AREA/SIDE} = c_f \times b_f = .67 \times 5.87 = 3.93 \text{ ft.}^2$$

For the critical flap down condition of  $2.0g$ , Maneuvering,  $C_{nw} = 1.17$  (page 45), and  $\delta_f = 60^\circ = 1.045 \text{ Rad.}$

$$C_1 = 1.15 @ C_{nw} = 1.17 \quad (\text{page 42})$$

$$\text{For } C_{f/c} = 0.67/4.00 = .167$$

$$\left. \begin{aligned} \frac{\delta C_{hf}}{\delta C_1} &= -.072 \\ \frac{\delta C_{hf}}{\delta \delta_f} &= -.688 \\ C_{hfo} &= -.080 \end{aligned} \right\} (\text{Ref. 8})$$

$$C_{hf} = C_{hfo} + \left( \frac{\delta C_{hf}}{\delta C_1} \right) C_1 + \left( \frac{\delta C_{hf}}{\delta \delta_f} \right) \delta_f \quad (\text{Ref. 8})$$

$$C_{hf} = -.080 + (-.072)(1.15) + (-.688)(1.045)$$

$$C_{hf} = -.882^*$$

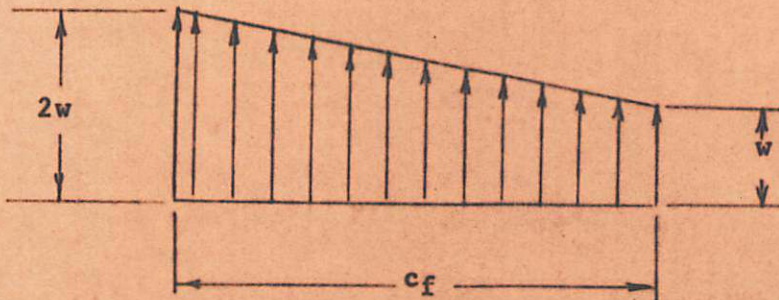
$$\text{WHERE } C_{hf} = \frac{HFC}{q b_f c_f^2}$$

\* This value is considered conservative since the flap tested in Ref. 8 was well sealed.



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CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-24-63	TITLE FLAP LOADS - CONT'D.	MODEL NO. BD-1

ASSUMING A TRAPEZOIDAL LOADING PER CAM 3.223-1



Conservatively neglecting aerodynamic balance gives:

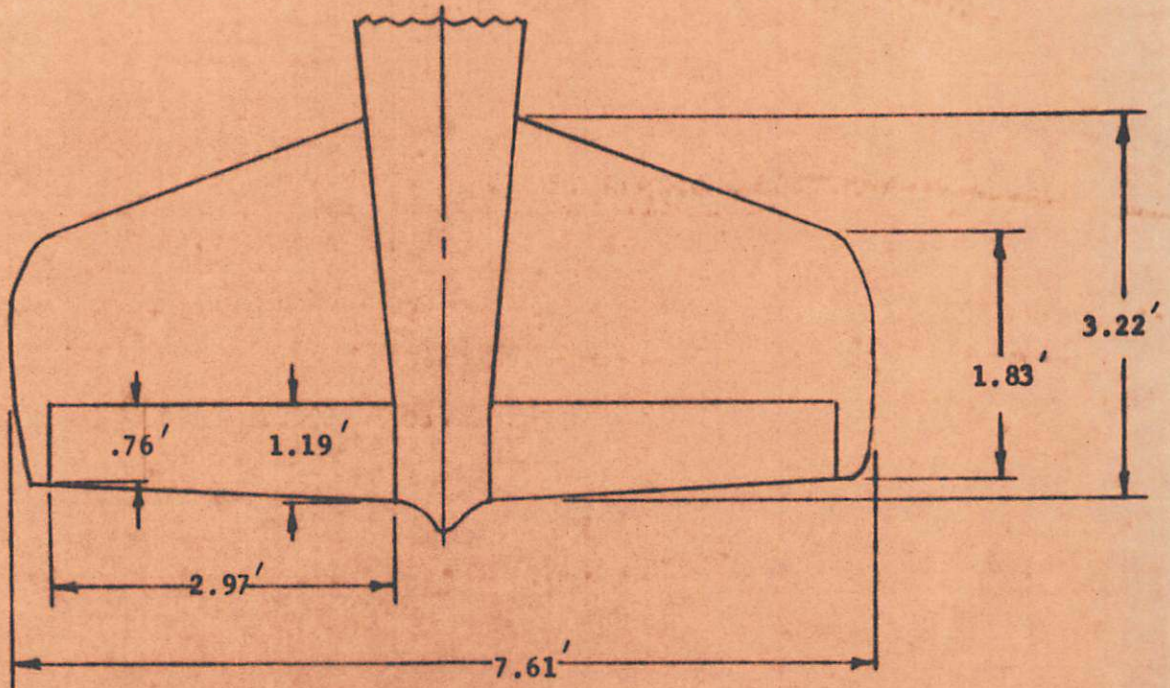
$$w = 3 C_{hf} q / 2 = 3 (-.882) (27.7) / 2 = \underline{36.6 \text{ psf}}$$

NOTE: Since the entire flap is outside of the propeller slipstream there will be no added load due to slipstream effects.



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CHECKED BY: N. E. Ehlers		REPORT NO.
DATE: 10-11-63		TITLE HORIZONTAL TAIL AIRLOADS

HORIZONTAL TAIL DIMENSIONS



$$\begin{aligned}
 \text{STABILIZER AREA} &= 13.4 \text{ ft.}^2 \\
 \text{ELEVATOR AREA} &= \frac{5.8 \text{ ft.}^2}{\phantom{=}} \\
 \text{TOTAL} &= 19.2 \text{ ft.}^2 = S_t
 \end{aligned}$$

BALANCING CONDITION (CAM 3.215)

MOST CRITICAL BALANCING TAIL LOADS (Flap Retracted)

- 760 lb. Down Load (page 35 )
  - + 39 lb. Up Load (Page 35 )
- (Loading Per. Fig. 3-7 CAM -3)

