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ENGINEERING REPORT NO. RESTRICTED

R107B-800

SUBJECT

GROUND HANDLING LOADS CRITERIA

MODEL:
XC-120

FAIRCHILD AIRCRAFT

Division of

FAIRCHILD ENGINE & AIRPLANE CORPORATION

HAGERSTOWN, MARYLAND

Date: 12 July 1949

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REFERENCES

1. Specification AN-J-5 "Army-Navy Aeronautical Specification Jack Pad Design and Installation of (for Aircraft)" 2 November 1945

2. ANC-2a "Ground Loads Bulletin" - March 1948

3. Fairchild Report R107-000A - "Model Specification M-107-B"

4. Army Air Force Specification C-1803-E "Stress Analysis Criteria" - Amendment #2 16 April 1945

5. Fairchild Report 107B-011 "Landing Ground Loads Criteria M107B"

6. Fairchild Report 107B-004 "Mass Moments of Inertia - M-107-B"

7. Fairchild Report R-107-B-014"Basic Flight Criteria M-107-B"

FAIRCHILD REFERENCE DRAWINGS

Drawing 78 - 136007 - Ring - Wing Outer Panel, Sta. 378.096
107 - 110001 - Center Section Assembly - Wing
107 - 820260 - Release Mech. - Installation Locking Fittings, Crew Nacelle
110 - 110026 - Jack Point Installation - Rear Spar Sta. 126.0
110 - 133070 - Bracket Installation - Sta. 378.096
110 - 320011 - Mooring Ring Boom Sta. 344.06
110 - 320015 - Mooring Ring Ass'y - Boom

107 - 500003 - Data Sheet Engine Nacelle

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GROUND HANDLING LOADS CRITERIA - MODEL XC-120

W.J. DEADY 12 JULY '49 22PP. TABLES, DRWGS

STRUCTURES (7) LOADS, GROUND
LOADS AND CRITERIA (1) AIRPLANES - GROUND HANDLING C-120

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INTRODUCTION

This report presents all the loads imposed on the airplane due to ground handling which includes jacking, towing, hoisting, mooring, and cargo loading.

The Model XC-120 airplane has a detachable cargo section (pack) which is hoisted from the ground to the airplane (carrier) and locked in place to make a complete flying unit. The pack has detachable ground handling gears on which it may be towed about the airport and also off the airport. Ground handling may therefore involve the carrier alone, the carrier plus pack, or the pack alone.

In the hoisting condition, the hoisting of the pack, from the ground to the carrier will be considered, but hoisting the airplane as a complete unit (with or without pack) will not be required on this airplane.

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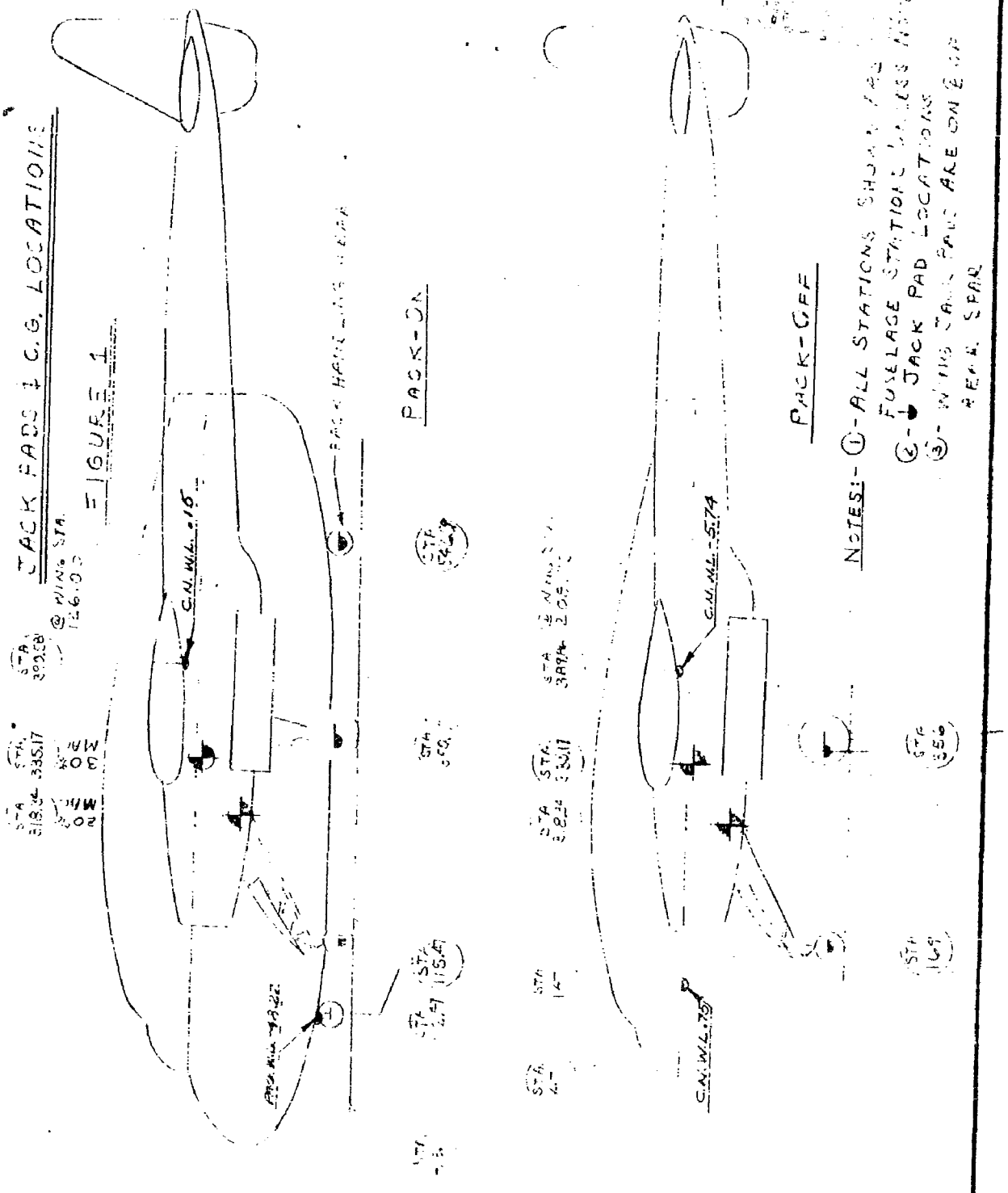

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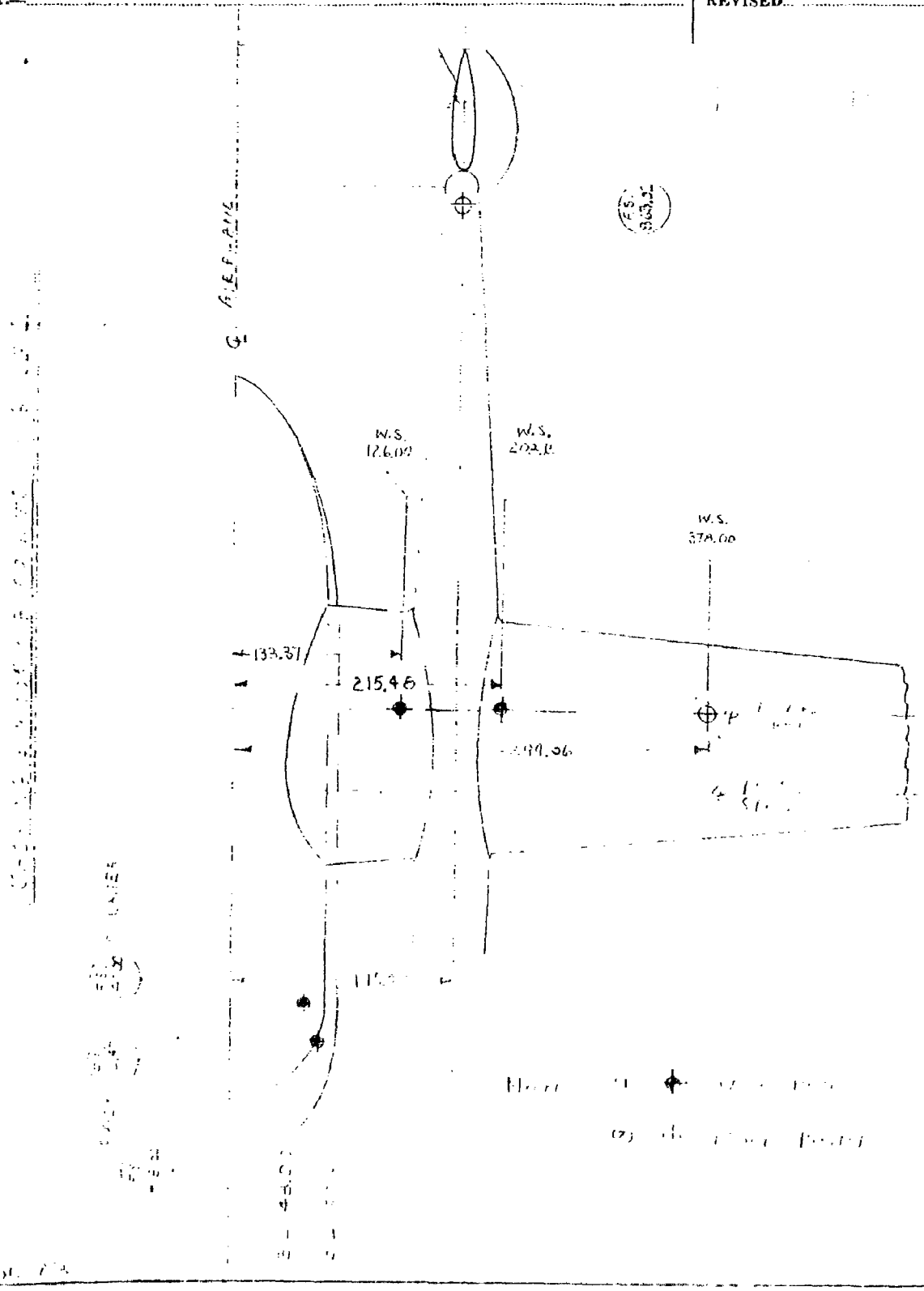

JACKING

The jack pad locations are shown in figures 1 and 2 (Ref pgs 4 and 5).

There are seven jack points per side (fourteen total) located on the Model XC-120 airplane. Two are located on the wing, one outboard and one inboard of the tail boom, one on each set of landing and pack handling gears, and one mounted in the pack lock fitting when the pack is removed.

The airplane gear jacks will be used only to change tires, and the jack point on the aft pack ground handling gear at Fuselage Sta. 542.59 will be used to jack the pack only. Jacking the complete airplane with pack will be accomplished by jacks at the rear spar (wing) jack points and at the jack point located on the pack at Fuselage Sta. 112.47. In jacking the complete airplane with the pack off, the rear spar (wing) jack point, and the jack pad fitting mounted in the pack lock fitting on the crew nacelle at Fuselage Sta. 147.0 are utilized.

Table 1 (Ref pg 6) gives the static ground reaction per side and the name and location of the forward and aft support points. Table 2 (ref pg 7) shows the limit load factors (specified in ANC-2a, Table 2.46) and the ultimate jack loads per side for a symmetrical loading condition.

For the jacking conditions, a design gross weight of 64,000# with pack-on and 54,000# with pack-off will be used with the airplane c.g. at 20% M.A.C. or 30% M.A.C., which are the maximum forward and aft c.g. positions permitted (ref 3 & 4). The pack, when jacked alone, consists of 20,000 #. cargo plus 5,121# structural weight with the most aft c.g. position (ref 6) to give the critical jack loads on the aft jack points. The forward jack point loads are critical for jacking the complete airplane plus pack.

The pack is attached to the carrier by four lock fittings, two at Fuselage Sta. 147.0 and two at Fuselage Sta. 394.0. The two forward fittings carry only vertical load so that the side load component and the fore and aft load component due to jacking the airplane with pack on are resisted at the aft lock fittings. The pack inertia loads will relieve part of this load on the aft fittings.

TABLE I - JACKING STATIC GROUND REACTIONS PER SIDE

Cond.	Gross Weight = P	Ref.	Pack	c.g. Location (Airp.)	Name and Location of Fwd. Support	Name and Location of Aft Support	l Inches	d Inches	p x d (In.Lbs.)	Reactions per Side (Lbs.) Aft Sup't.	Reactions per Side (Lbs.) Fwd. Sup't
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	64000	7	On	318.34	Fwd. Gear 169.00	Main Gear Tire 356.00	187.00	149.34	9557760	25556	6444
2	64000	7	On	335.17	Fwd. Gear 169.00	Main Gear Jack 350.17	181.17	166.17	10634880	29351	2649
	54000		Off	318.34	Carrier 147.0	Wing 390.58	243.58	171.34	9252360	18992	8008
	54000		Off	335.17	Carrier 147.0	Wing 390.58	243.58	188.17	10161180	20858	6142
1	64000	7	On	318.34	Pack 112.47	Wing 389.86	277.39	205.87	13175680	23749	8251
2	64000	7	On	335.17	Pack 112.47	Wing 389.86	277.39	222.70	14252800	25691	6309
*2A	74000	6	Off	317.04	Pack 112.47	Pack 542.59	430.12	204.57	5139003	5974	6591
					Ref. Fig. 1	Ref. Fig. 1	(7) - (6)	(5) - (6)	(2) x (9)	(10) ÷ (2 x (8)	(2)/2 - (11)

NOTE: 1. Columns (5), (6), and (7) are fuselage stations.
2. l = Distance between forward and aft support points.
3. d = Distance from c.g. to forward support point.

* Jacking Pack Only - P = 25,121# (Cargo + Pack) - Pack c.g. F. S. 317.04
l = 430.12, d = 317.04 - 112.47 = 204.57 p x d = 25,121 x 204.57 = 5,139,003

FAIRCHILD

JACKING

Table 2 - Ultimate Jacking Loads Per Side

* Air Force Letter MCREOA5/RMC/cjc dated 12/12/49.

Cond.	Jack Point	Component	Limit Load Factor	Ultimate Load Factor	V (Lbs.)	Ultimate Load Per Side (Lbs.)
1	2	3	4	5	6	7
Pack Off G. W. = 54,000#	Crew Nacelle	Vertical	2.00	3.000	8008	24024
	Pack Lock	Fore and Aft	.50	.750		6006
	Fitting (F. S. 147)	Lateral	.50	.750		6006
Pack-On G. W. = 64,000# Gear Jacking	Main Gear (F. S. 350.17)	Vertical	1.35	2.025	29351	59436
		Fore and Aft	.40	.60		17611
		Lateral	.40	.60		17611
	Fwd. Gear (F. S. 164)	Vertical	1.35	2.025	6444	13049
		Fore and Aft	.40	.60		3866
		Lateral	.40	.60		3866
Pack-On G. W. = 64,000# Airplane Jacking	Wing Jack Point (F. S. 389.86)	Vertical	2.00	3.000	25691	77073
		Fore and Aft	.33 *	.500		12845
		Lateral	.50	.750		19268
	Fwd. Jack Pack Fitting (F. S. 112.47)	Vertical	1.35	2.025	8251	16904
		Fore and Aft	.40	.60		5008
		Lateral	.40	.60		5008
Pack Alone G. W. = 25,121#	Fwd. Jack Pack Fitting (F. S. 112.47)	Vertical	1.35	2.025	6591	13338
		Fore and Aft	.40	.60		3955
		Lateral	.40	.60		3955
	Aft Jack Pack Fitting (F. S. 542.59)	Vertical	1.35	2.025	5974	12097
		Fore and Aft	.40	.60		3584
		Lateral	.40	.60		3584
Ref.	Figs. 1 and 2		ANC-2a Table 2.16	1.5 x (4)	Table 1 Col. 11, 12	(5) x (6)

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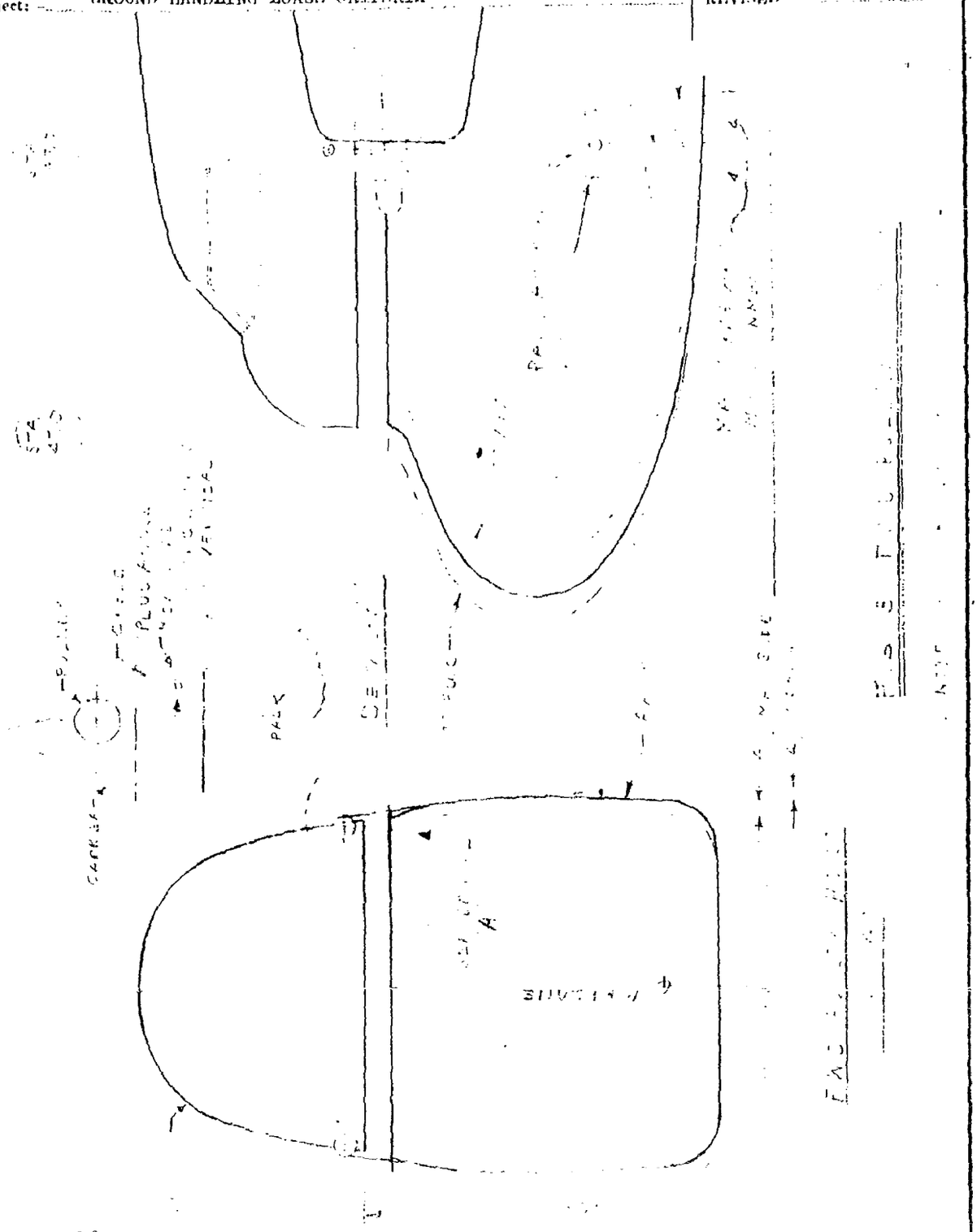


HOISTING - PACK TO CARRIER

The pack is hoisted from its ground position to the carrier by means of four cables, two on each side of the airplane at Fuselage Stations 147.0 and 394.8. The loading conditions are "1P" at 74,000# Gross Weight (Refpg.10), "2A" at 64,000# and 74,000# Gross Weight (Ref 6), and "6L" at 60,000# Gross Weight (Ref. 6) Condition "1P" at 74,000# Gross Weight is critical for the forward cables and condition 2A at 74,000 Gross Weight is critical for the aft cables. Table 7 shows the ultimate cable load per side for an ultimate load factor of 3.00. Figure 3 (pg 8) shows the maximum allowable cable misalignment due to pack hoisting for the forward cables and is similar for the aft cables. The maximum side misalignment between the pack and the airplane centerlines is four inches, and the maximum fore and aft misalignment is 7°. The critical cable loads are calculated assuming the side and fore and aft maximum misalignments occur simultaneously and are shown in Table 7.

HOISTING - PACK TO CARRIER

Condition 1P - Outer Panel Fuel Tank Full, Airplane C.G. @ 20% M.A.C. Gear Down, Cargo Fwd and High (60" above floor) - Gross Weight 64,000#

Item	Weight (LBS)	X	WX (in# x 10^{-3})	Z	WZ (in# x 10^{-3})
Basic Weight	41,842	340.5	14,247.20	168.42	7,047.03
ΔM (From Gear Extension)			-206.39		358.03
Fuel	9,744	372.5	3,629.64	154.0	1,501.55
Oil	547	475.0	259.83	151.0	82.60
Cargo	11,867	X	11.87x	204.0	2,420.87
	64,000	336.34	17,930.18 + 11.87x		11,410.08

$$X_{cargo} = \frac{64.00 \times 336.34 - 17,930.18}{11.87} = \frac{3595.58}{11.87}$$

$$= 302.91" \text{ (F.S. = 284.91)}$$

$$Z_{airplane} = \frac{11,410.08 \times 10^3}{64,000} = 178.28"$$

Cond 3P - Outer Panel Fuel Tanks Full, Airplane C.G @ 20% M.A.C. Gear Down, Cargo Fwd and Low (6" above floor) G.W. = 64,000# (same as Cond."1P" except Cargo 6.0" above floor)

$X_{airplane}$ = 336.14 (See Cond "1P" above)

X_{cargo} = 302.91 (F.S. = 284.91) (See Cond "1P" above)

Z_{cargo} = 204.00 + (60-6) = 258.00"

ΔWZ_{cargo} = (11,867)(54) = 640.82 x 10^3 in-#

$$Z_{airplane} = \frac{(11,410.08 + 640.82) \times (10^3)}{64,000} = 188.30"$$

Note:

(*) X = Fuselage Sta. + 18.00
(Δ) Z = Dist. below vertical ref. line
Vert. Ref. Line is 172.0" above thrust line

HOISTING - PACK TO CARRIER

Table 3 Hoisting - C.G. Determination

COND	AIRPLANE GROSS WT.	CARGO WT. = W_1	PACK EMPTY WT. = W_2	CARGO C.G.	PACK C.G.	W_1X_1	$W_2 \times {}_2$	TOTAL WX	PACK + CARGO C.G.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1P	74,000	20,000	5121	314.00	324.44	6280000	1,661,457	7941457	316.13
2A	74,000	20,000	5121	346.56	324.44	6931200	1,661,457	8592657	342.05
2A	64,000	11,867	5121	358.27	324.44	4251590	1,661,457	5913047	348.07
6L	60,000	17,132	5121	361.49	324.44	6193047	1,661,457	7854504	352.96
					Ref 6	(2) x (4)	(3) x (5)	(6) + (7)	(8) ÷ ((2) + (3))

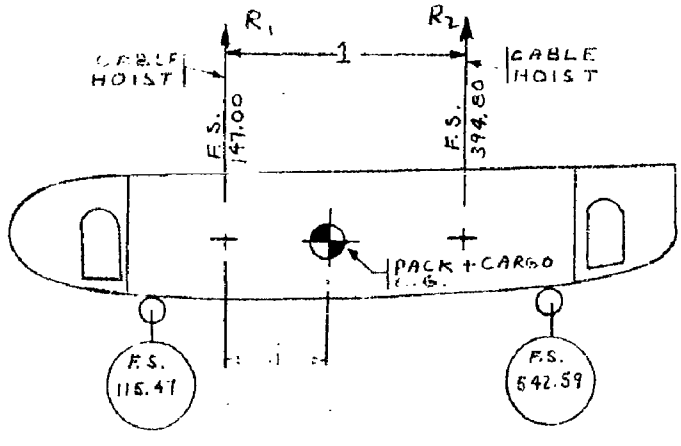


Table 4 Static Cable Hoist Loads

COND	AIRPLANE GROSS WT.	WEIGHT PACK + CARGO	d	l	Wd	$R_2 = \frac{Wd}{l}$	$R_1 = W - R_2$
	(1)	(10)	(11)	(12)	(13)	(14)	(15)
1P	74,000	25,121	169.13	247.80	4248715	17,146	7975
2A	74,000	25,121	195.05	247.80	4899851	19,773	5348
2A	64,000	16,988	201.07	247.80	3415777	13,784	3204
6L	60,000	22,253	205.96	247.80	4583228	18,496	3757
		(2) + (3)	(9) - 147.00	394.8 - 147.0	(10) x (11)	(13) ÷ (12)	(10) - (14)

Note: Columns (4), (5), and (9) are fuselage stations

HOISTING - PACK TO CARRIER

Table 5 Critical Ultimate Cable Hoist Loads

COND.	AIRPLANE GROSS WT.	ULT. CABLE LOADS PER SIDE FRONT CABLE	REAR CABLE
	(1)	(16)	(17)
1P	74,000	11,963	—
2A	74,000	—	29,660
		(3.00 (15)) ÷ 2	(3.00 x (14)) ÷ 2

Ultimate Load Factor = 3.00

Table 6 Cable Angles (Due to 4" Misalignment to Left) (REF FIG 3)

CABLE (Δ)	CABLE ANGLE θ	TAN θ
Left Front	-19°	.34433
Right Front	4°	.06993
Left Rear	-7.25°	.12722
Right Rear	0.83°	.01455

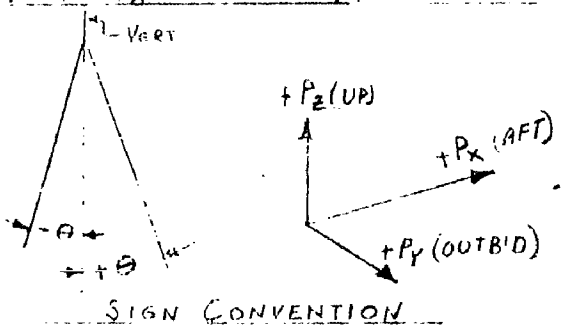
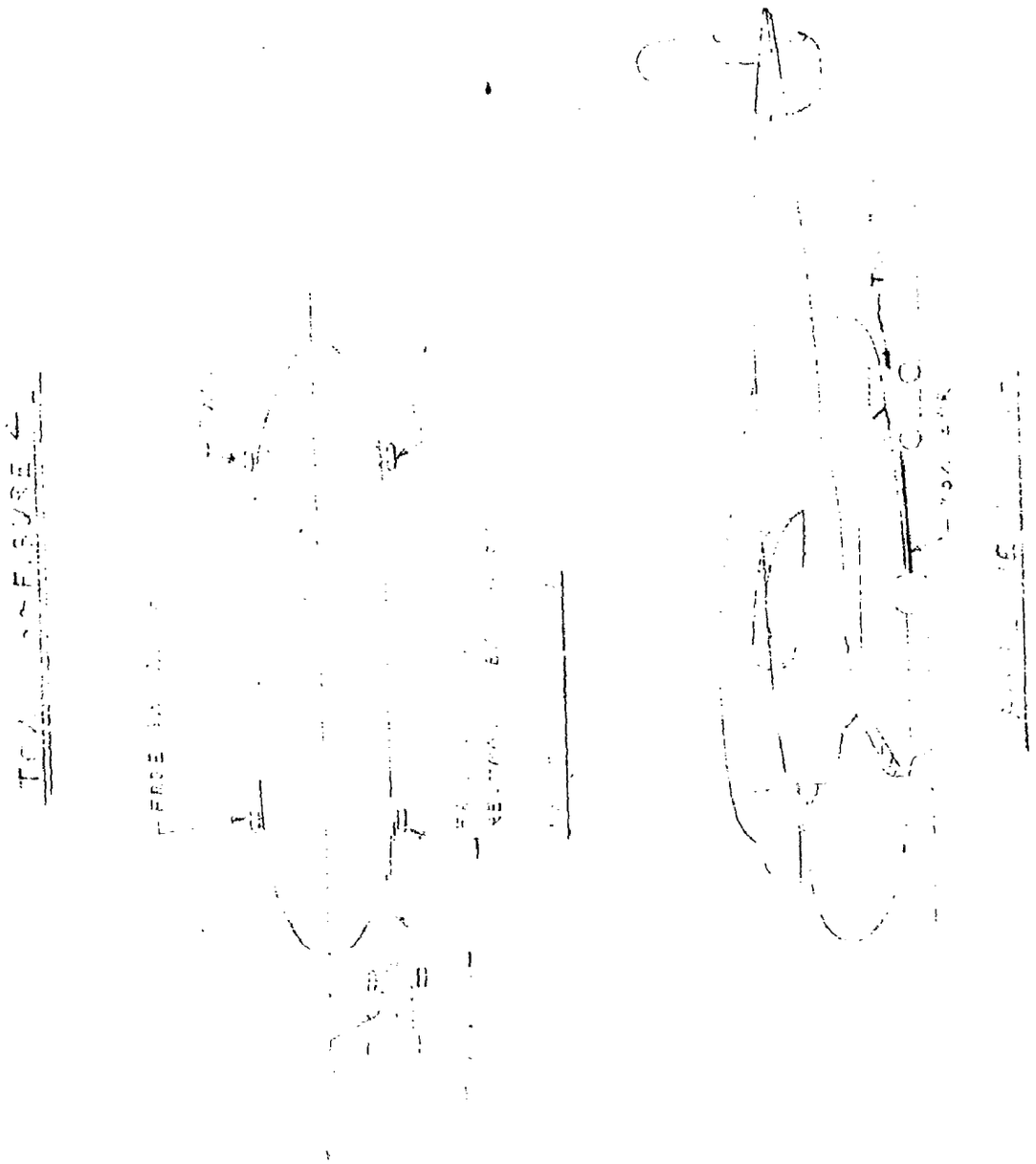


Table 7 Ultimate Hoist Cable Loads for Maximum Misalignment Cond.

CABLE (Δ)	Pz	Py = Pz Tan θ	Px = Pz Tan 7°	Resultant Cable Load $R = (P_z^2 + P_y^2 + P_x^2)^{1/2}$
	(18)	(19)	(20)	(21)
Left Front	11,963	4119	1469	12,737
Right Front	11,963	837	1469	12,082
Left Rear	29,660	3773	3642	30,120
Right Rear	29,660	432	3642	29,886
	(16) or (17)	(18) x (Tan θ)	(18) x tan 7°	

(Δ) AS Viewed from Rear Looking Forward



TOWING

(a) Towing Airplane

The airplane (with or without pack) is towed or pushed from a fitting on the aft side of the main gear by a tractor unit at each gear (left and right) as shown in Figure 4 (Ref pg 14). There is no tow point on the forward gear. The maximum towing gross weight for the complete airplane with pack is 74,000#. Section 2.45 of ANC-2a states the towing loads criteria.

$$\text{Limit towing load } P = \frac{6W_t + 450}{70} \text{ (Ref 2) where } W_t = 74 \text{ kips}$$

$$P = \frac{6 \times 74 + 450}{70} = 12{,}771\# \text{ (limit)}$$

$$\text{or } P = 19{,}157\# \text{ ultimate}$$

The main gear towing load acting parallel to the "D" axis or 30° from the the D axis equals 0.75P or 14,368#. The vertical load at the gear is equal to the static reaction. Since no towing will be done from the forward gear, the aft gear will be critical.

For a gross weight of 74,000# with the pack cargo high and aft the airplane c.g. is at Fuselage Station 332.38 (Ref 5) Conditions 2A and 4A Gear Down G.W. 74,000#.

$$\text{Vertical reaction on Main Gear} = \frac{74{,}000 \times 163.38 \times 1.5}{187} = 96{,}980\# \text{ (ult)}$$

Vertical Reaction on Fwd Gear = 111,000 - 96,980 = 14,020# ultimate

Towing Loads - Ultimate - Table 8

GEAR	HORIZONTAL LOAD MAGNITUDE	HORIZONTAL LOAD DIRECTION	VERTICAL LOAD	CONDITION	AIRPLANE GROSS WT.
Main	14,368#	Fwd or Aft Parallel to D Axis or at 30° to D Axis	96,980#	Pack Cargo High and Aft	74,000

TOWING

(b) Towing Pack

The pack may be towed from either forward pack gear as shown in Fig. 4 (Ref. pg 14). Both front gears are free swiveling while the aft gears are fixed. Two pack towing conditions, Normal Towing and Fast Towing, will be investigated. Normal towing is a very slow towing condition for maneuvering the pack about the airport and will conform to section 2.45 of ANC-2a. The Fast Tow condition is a towing condition off the airport at a slightly increased speed. Ultimate load factors of 3.0 g vertical and .75 g lateral will be assumed for the Fast Tow condition. The maximum pack gross weight for towing is 22,253# which includes a cargo weight of 17,132#.

The maximum allowable cargo for the pack towing condition is 17,132#. The most forward and aft pack c.g. limiting conditions are 5L and 6L (Ref 6)

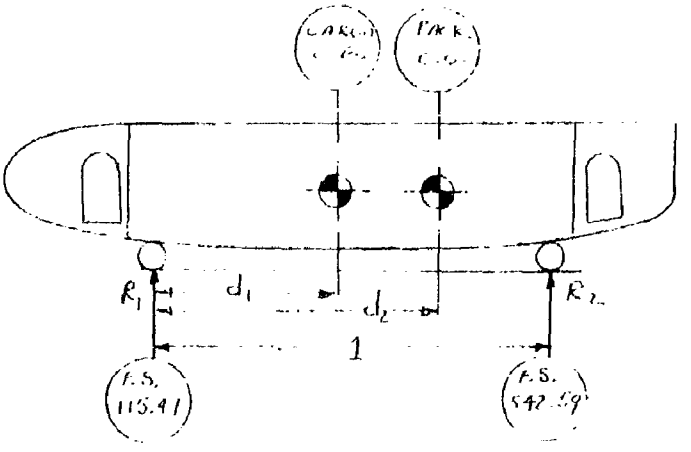


Table 9 Pack Static Ground Reactions

COND	CARGO $W_t = P_1$	PACK $W_t = P_2$	CARGO C.G.	PACK C.G.	d_1	d_2	l	$P_1d_1 = M_1 \times 10^{-3}$	$P_2d_2 = M_2 \times 10^{-3}$	$M_t = M_1 + M_2 \times 10^{-3}$	R_2	R_1
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
5L	17,132	5121	314.6	324.4	199.1	208.9	427.1	3411.5	1070.1	4481.6	10,493	11,760
6L	17,132	5121	361.5	324.4	246.0	208.9	427.1	4214.8	1070.1	5285.0	12373	9880
REF	REF 6	REF 6	REF 6	REF 6	(4) - 115.5	(5) - 115.5	(*)	(2) x (6)	(3) x (7)	(9) + (10)	(11)/(8)	(2)+(3) - (12)

(*) l = 542.59 - 115.47 = 427.12

TOWING

(b) Towing Pack

(1) Normal Tow

The loaded pack will be towed from one set of forward gears.

$P = 0.30\ W_t$ (Ref. Fig. 2.45 ANC-2a)

$W_t = 22,253\#$

$P = .030 \times 22,253 = 6676\#$

Tow is assumed to be 0.75P in all directions.

Tow load $= .75 \times 6676 \times 1.5 = 7511\#$ (ultimate)

Maximum Vertical load per forward gear $= \frac{11760}{2} \times 1.5$ (REF. TABLE 9 Pg. 16)

$= 5880 \times 1.5 = 8820\#$ (ultimate)

The balancing forces for pack towing will be translational and rotational inertia of pack (Ref. Condition "b' ANC-2a Table 2.45). Condition "a" will be ignored as it is a gear condition only.

(2) Fast Tow

For this condition a 3.0 g vertical and a $0.25 \times 3.0 = 0.75$ g lateral load in any position in 360° is assumed. Since the load analysis shown here includes Normal Towing, the loads shown will be considered for aft and side loads only (no forward loads) and is call "Fast Tow Condition.

The side load will be considered acting at the flat tire radius (6.70 " below ℄ of axle). This side load may occur even though the front gears are full swiveling because on the towed gear, the tow bar will restrain the swivel action.

Maximum front static reaction for one gear $= \frac{11760}{2} = 5880\#$ (Ref pg 16) TABLE 9

Ultimate $V_z = 5880 \times 3.0 = 17,640\#$

Ultimate $V_x = 5880 \times .75 = 4,410\#$

Ultimate $V_y = 5880 \times .75 = 4,410\#$

MOORING

Limit load is that load resulting from a 75 m.p.h. wind parallel to the ground in any direction to the airplane. (Ref 4) It is assumed that the only weathervane action will be that due to the wind acting on the vertical tail and on the tail boom. This design moment about the c.g. of the airplane is resisted by a couple applied at the main wheel blocks, and nose gear blocks, reactions applied at the eye at the end of each tail boom and a couple applied at the mooring fittings at wing station 378 on the outer panel.

It is further assumed that the wing mooring fittings and the tail boom mooring fitting each take 40% of the total moment.

Assume drag coefficient of boom = 1.20

Assume drag coefficient of tail = 1.28

For 75 m.p.h. wind (limit)

$q = 1/2\rho_o V^2 = 1/2\ (.002378)\ (1.467 \times 75)^2 = 14.39$ PSF

(ρ_o = standard density.)

Area of vertical tail = 99.4 ft^2 (Ref. Dwg. 107-000000)

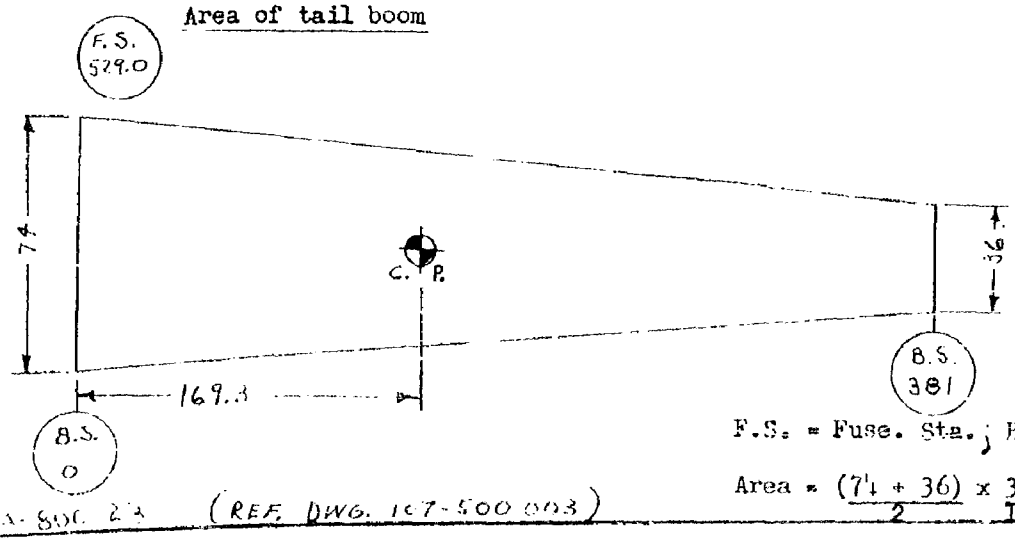
Design load on tail = 1.28 x 14.39 x 99.4 x 1.5 = 2746#

Vertical tail center of Pressure = 922.1 + 12.0 = 934.1 (Fus. Sta.)

Distance tail C.P. to forward c.g. of airplane = 934.1 - 318.34 = 615.76"

Design weathervane moment about c.g. = 2745 x 615.76 = 1,690,877 in-lb

Area of tail boom



F.S. = Fuse. Sta.; B.S. = Boom Sta.

Area = $\frac{(74 + 36)}{2} \times \frac{381}{144} = 145.2\ ft^{-2}$

(REF DWG. 107-500 003)

MOORING

Distance boom c.p. to forward c.g. of airplane = 738.3 - 318.34 = 419.96 in.

Design load on boom = 1.20 x 145.2 x 14.38 x 1.5 = 3761#

Design weathervane moment about c.g. = 3761 x 419.96 = 1,579,470 in-#

Total weathervane moment = 3,270,347 in lb

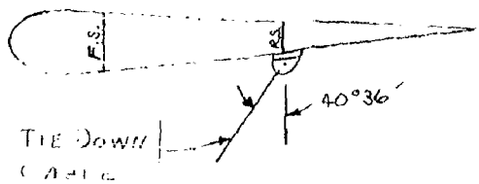
40% Total Moment = .40 x 3270,347 = 1,308,139 in lb

(a) Wing Mooring

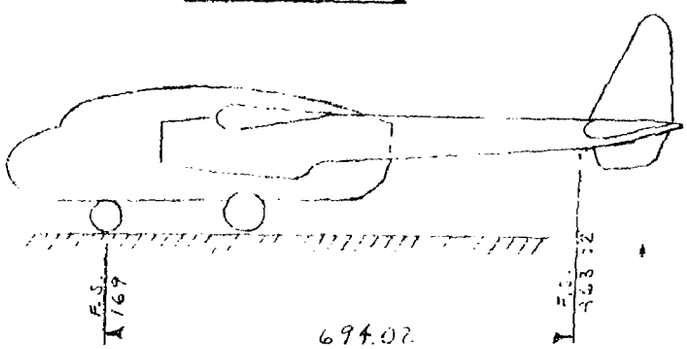
Distance between outer panel mooring points =
[222.56 + (378.10 - 216.94) (.9988)] / [2] = 767.06' in.

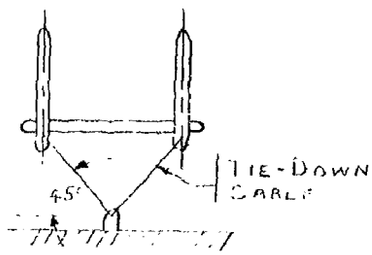
Drag component = $\frac{1,308,139}{767.06}$ = 1705#

Load in tie down cable = $\frac{1705}{\sin 40°36'}$ = 2620#



(b) Boom Mooring





couple = $\frac{1,308,139}{694.02}$ = 1885#

cable load = $\frac{1885}{\cos 45°}$ = 2666#

CARGO LOADING - PACK

The pack cargo will be loaded with the pack resting on its gears or in the jacked position. The pack has provisions for loading cargo thru the forward or aft ends by means of a loading ramp. The maximum cargo that may be loaded thru the fwd end of the pack is 10,000#, while thru the aft it is 20,000#. The maximum concentrated weight that may be applied to the frames at each set of gears is 10,000# for the forward frames and 15,000# for the aft frames. The ultimate load factor for loading is 2.00.

Ultimate load per forward gear = 10,000#

Ultimate load per aft gear = 15,000#

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FAIRCHILD ENGINE AND AIRPLANE CORP., FAIRCHILD AIRCRAFT DIV., HAGERSTOWN, MD. (REPORT NO. R107B-800)

GROUND HANDLING LOADS CRITERIA - MODEL XC-120 P1/3.5

W.J. DEADY 12 JULY '49 22PP. TABLES, DRWGS

STRUCTURES (7) / LOADS, GROUND FLIGHT LOADS
LOADS AND CRITERIA (1) AIRPLANES - GROUND HANDLING
C-120 & TRANSPORT AIRCRAFT

EO 10501 dd 5 NOV 1953

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C-120 Aircraft