MARCH 1956

A PROPOSAL

FOR

A LONG RANGE JET TRANSPORT

AVRO AIRCRAFT LIMITED

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LIST OF ILLUSTRATIONS

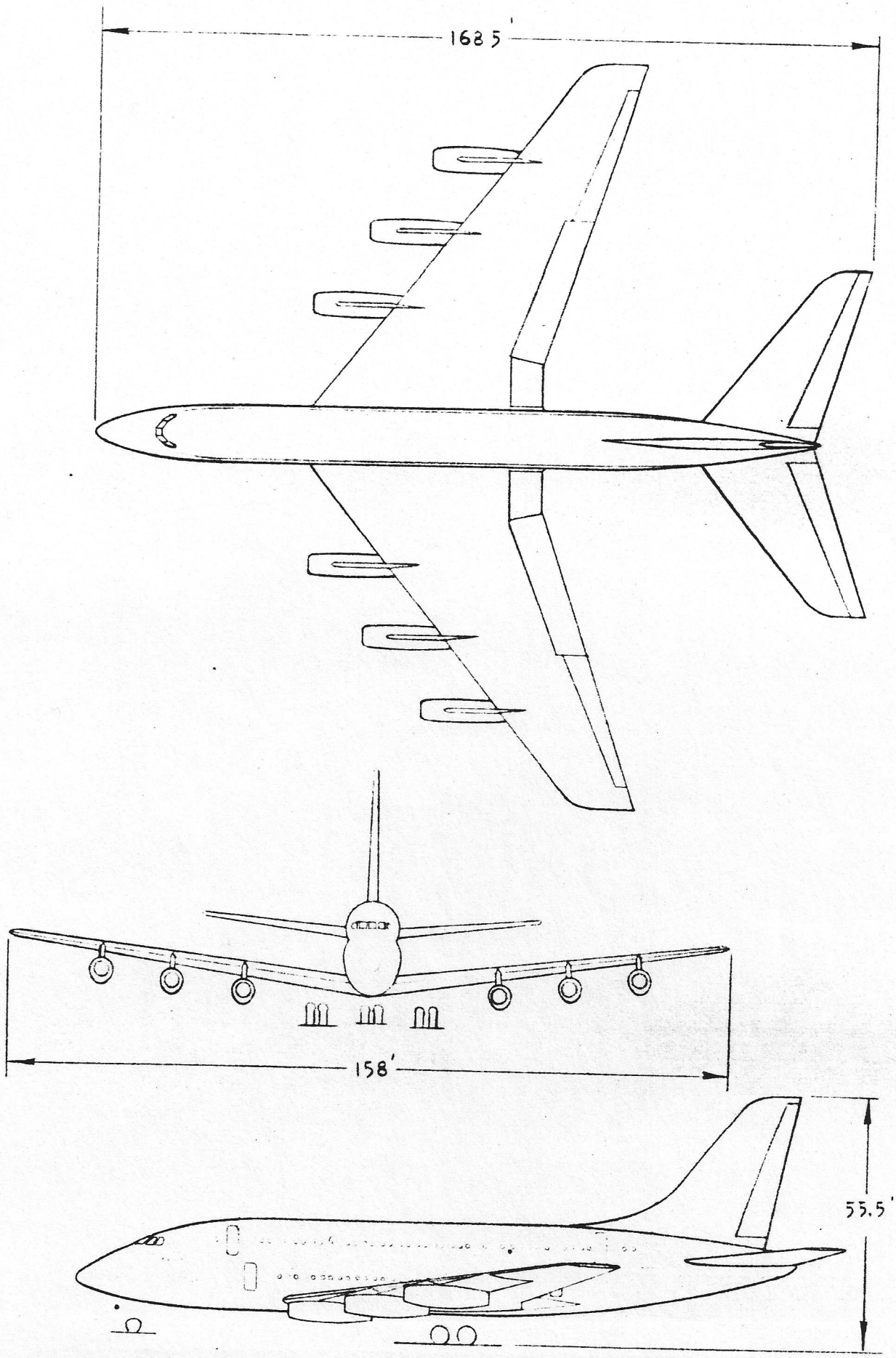
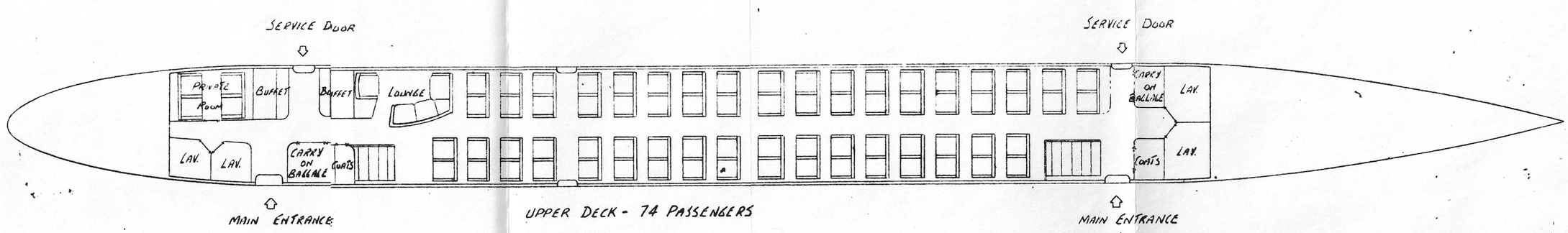


FIGURE 1 - 3 VIEW GENERAL ARRANGEMENT

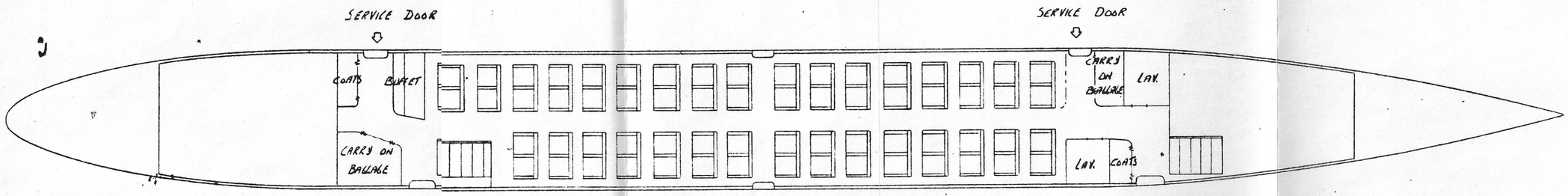
DESCRIPTION

This Brochure is revised from the preliminary one dated January, 1956, to bring the aircraft into line with requirements laid down as the result of discussions with T.W.A.

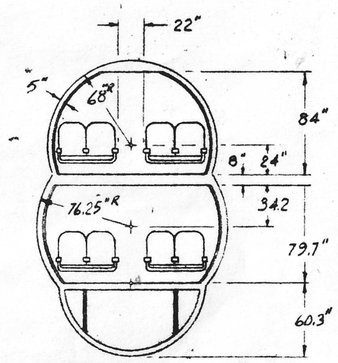
The aircraft is a low wing configuration with a gross weight of 422,000 lbs. It is powered by six jet engines of equivalent thrust to the Pratt & Whitney J.75 civil engine.



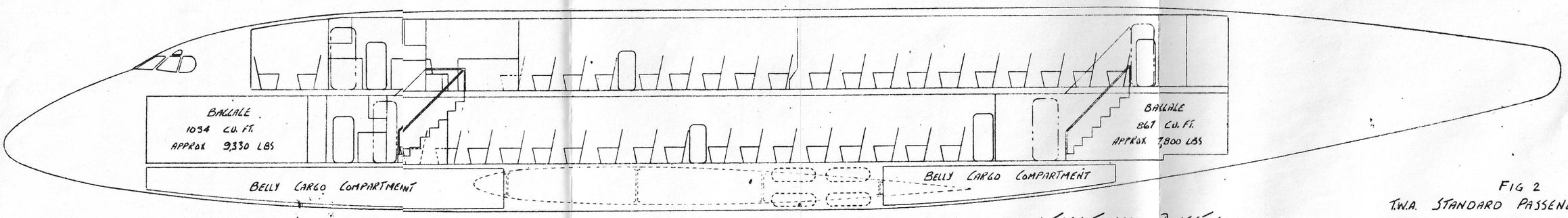
UPPER DECK - 74 PASSENGERS



LOWER DECK 64 PASSENGERS

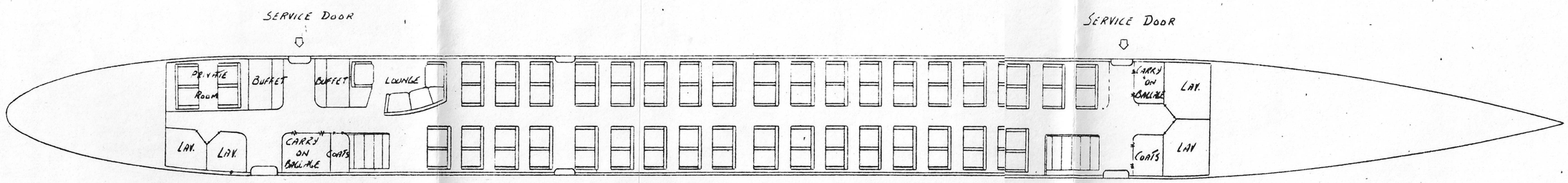


MAXIMUM SECTION



		INTERNATIONAL	DOMESTIC
VOLUMETRIC PAYLOAD	138 PASSENGERS	29,670 LBS	26,910 LBS
	CARGO	25,700 LBS	25,700 LBS
		55,370 LBS	52,610 LBS

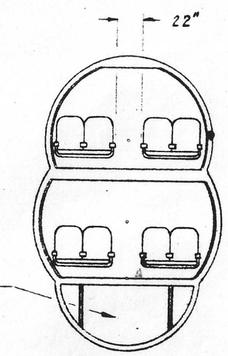
FIG 2
T.W.A. STANDARD PASSENGER ARRANGEMENT
20" WIDE SEATS AT 40" PITCH
SCALE 1/8" = 12"



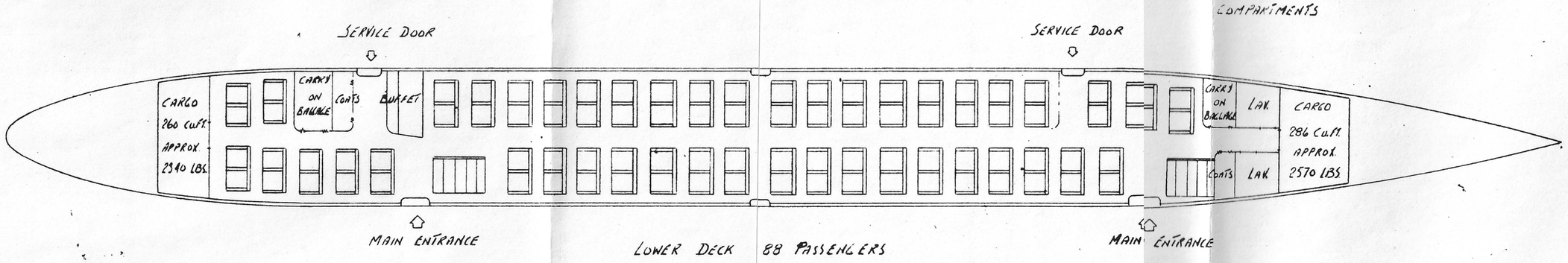
UPPER DECK - 74 PASSENGERS

NOTE: FOR MIXED STANDARD & COACH SEATING THE UPPER DECK IS AS SHOWN ABOVE AND THE LOWER DECK AS SHOWN IN FIG. 4

		INTERNATIONAL	DOMESTIC
THEN VOLUMETRIC PAYLOAD WOULD BE	179 PASSENGERS	37,435 LBS	34,905 LBS
	CARGO	14,400 LBS	17,400 LBS
		51,835 LBS	52,305 LBS



NOTE: IN THIS CABIN ARRANGEMENT MOST OF THE CARGO IS CARRIED IN THE BELLY COMPARTMENTS

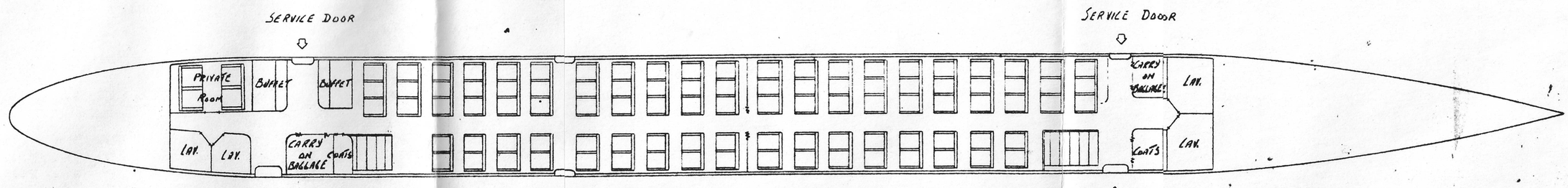


LOWER DECK 88 PASSENGERS

		INTERNATIONAL	DOMESTIC
VOLUMETRIC PAYLOAD	162 PASSENGERS	34,830 LBS	31,590 LBS
	CARGO	14,200 LBS	17,400 LBS
		49,030 LBS	48,990 LBS

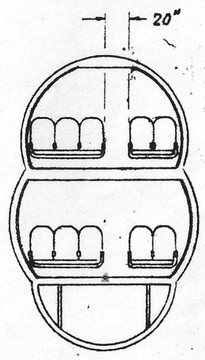
FIG 3

PROPOSED STANDARD CABIN ARRANGEMENT
162 PASSENGERS, 20" WIDE SEATS AT 40" PITCH
SCALE 1/8" = 12"

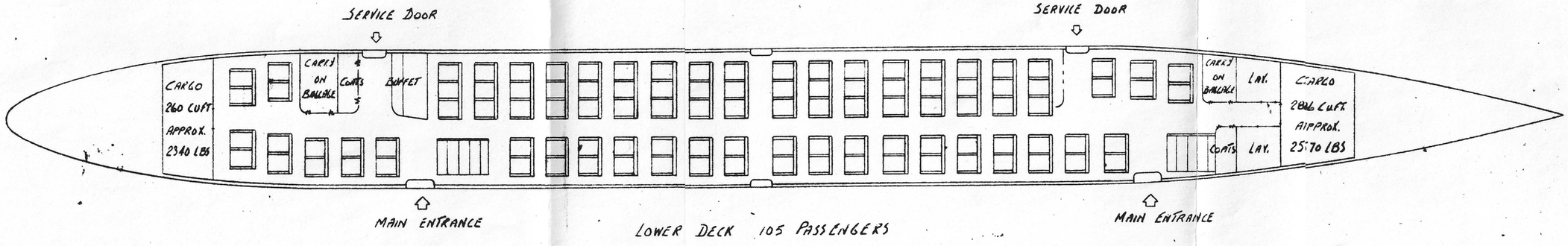


UPPER DECK - 101 PASSENGERS

NOTE: WITH SEAT PITCH REDUCED TO 38" FOR THE COACH ARRANGEMENT INSTEAD OF 40" AS DRAWN ADDITIONAL SPACE WOULD BE AVAILABLE FOR COATS & CARRY ON BAGGAGE



NOTE: IN THIS CABIN ARRANGEMENT MOST OF THE CARGO IS CARRIED IN THE BELLY COMPARTMENTS



LOWER DECK 105 PASSENGERS

		INTERNATIONAL	DOMESTIC
VOLUMETRIC PAYLOAD	206 PASSENGERS	42,230 LBS	40,170 LBS
	CARGO	14,000 LBS	16,100 LBS
		56,230 LBS	56,270 LBS

FIG 4
PROPOSED COACH CABIN ARRANGEMENT
206 PASSENGERS, 18" WIDE SEATS AT 40" PITCH
SCALE 1/8" = 12"

GEOMETRIC DATA

Overall Dimensions

Span	158'
Length	168.5'
Height	55.5'

Wing

Area (Gross)	5000 sq. ft.
Span	158'
Aspect Ratio	5
Taper Ratio	.264
Root Chord	50'
Tip Chord	13.2'
M.A.C.	35.2'
Sweep 25% c	35°
Thickness Ratio	8%
Dihedral	6°
Incidence	1

Tailplane

Area (Gross)	1400 sq. ft.
Span	74'
Aspect Ratio	3.9
Taper Ratio	.357
Root Chord	28'
Tip Chord	10'
Sweep 25% c	35°
Thickness Ratio	8%

Fin and Rudder

Area (Net)	606 sq. ft.
Span	30.75'
Sweep 25% c	35°
Thickness Ratio	8%

Fuselage

Length	157'
Depth	20'
Maximum Diameter	
Upper Deck	11' - 4"
Lower Deck	12' - 8.5"

Undercarriage

Track	24'
Base	69.5'

SUMMARY OF ASPECT RATIO STUDY

It was required to determine the effect of Aspect Ratio on the mission profile for this configuration.

In our earlier studies we had taken an Aspect Ratio of 3.75, based on the volume required for the large amounts of fuel to be carried, and also because there appeared to be evidence that the drag rise was delayed by decreasing Aspect Ratio.

As a result of further studies on the first and second segment climb criteria, and the fact that we have been unable to establish any proof of the drag rise delay (some NACA reports show that there is considerable benefit on drag rise from low Aspect Ratio while others show exactly the opposite) we have now established an Aspect Ratio of 5.0 as the optimum, considering take-off distances, climb after take-off, fuel capacity, wing weight, fuel consumption, etc.

Effect of Aspect Ratio on Fuel Required

The transatlantic route (Paris - N.Y.) was chosen for study with the associated winter conditions (giving the greatest headwinds). On this route the fuels required from take-off to destination were 173,700, 165,500 and 166,300 lb. for Aspect Ratios 3.75, 5.0 and 7.0, respectively. Taking into account the full reserves required on this route by TWA gave total fuel loads of 216,900, 206,900 and 205,800 lb., respectively.

Since the operating costs are a function of fuel consumed, Aspect Ratio 5.0 gave the best results. It also appears to be the best compromise based on the increased complexity of the structure and increased weight of the higher Aspect Ratio aircraft.

From the point of view of take-off and climb conditions (see Figs. 5 to 8), Aspect Ratio 5.0 is satisfactory.

It will be noted also that Fig. 7 shows a wing area of 4500 sq.ft. for an A.R. = 3.75 whereas our original submissions were based on 4200 sq.ft. at this Aspect Ratio. This is because we had previously assumed that 10,000 ft. take-off distance was adequate without water injection.

We have now provided sufficient wing area for take-off in a 9000 ft. C.A.R. field length (one engine cut) under standard conditions (T_s) without the use of water injection. Water injection, or the equivalent in higher thrust engines, has however still to be used to achieve 9000 ft. C.A.R. field length at extreme temperatures (see page 29).

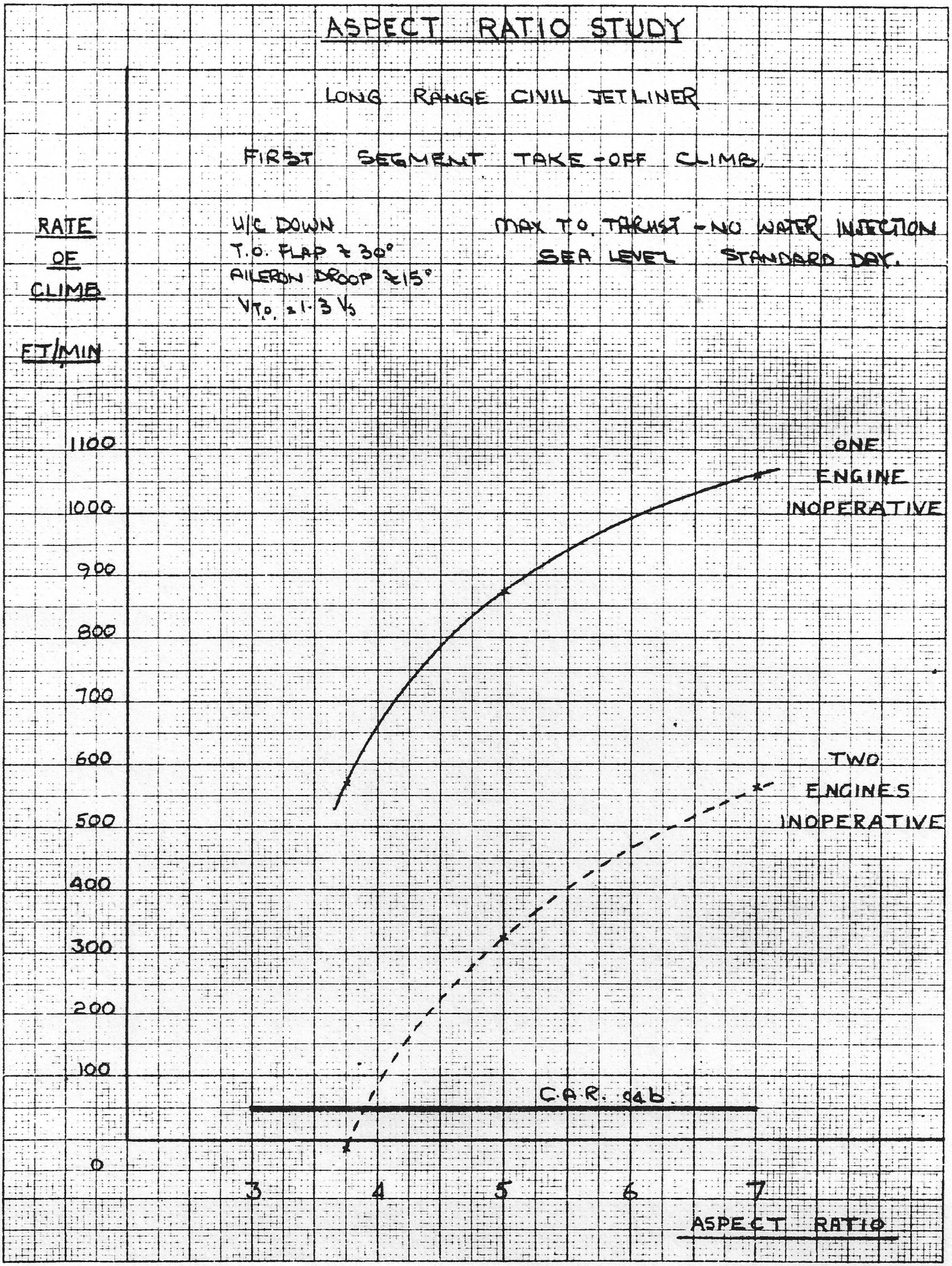


FIGURE 5

Feb 24/80.

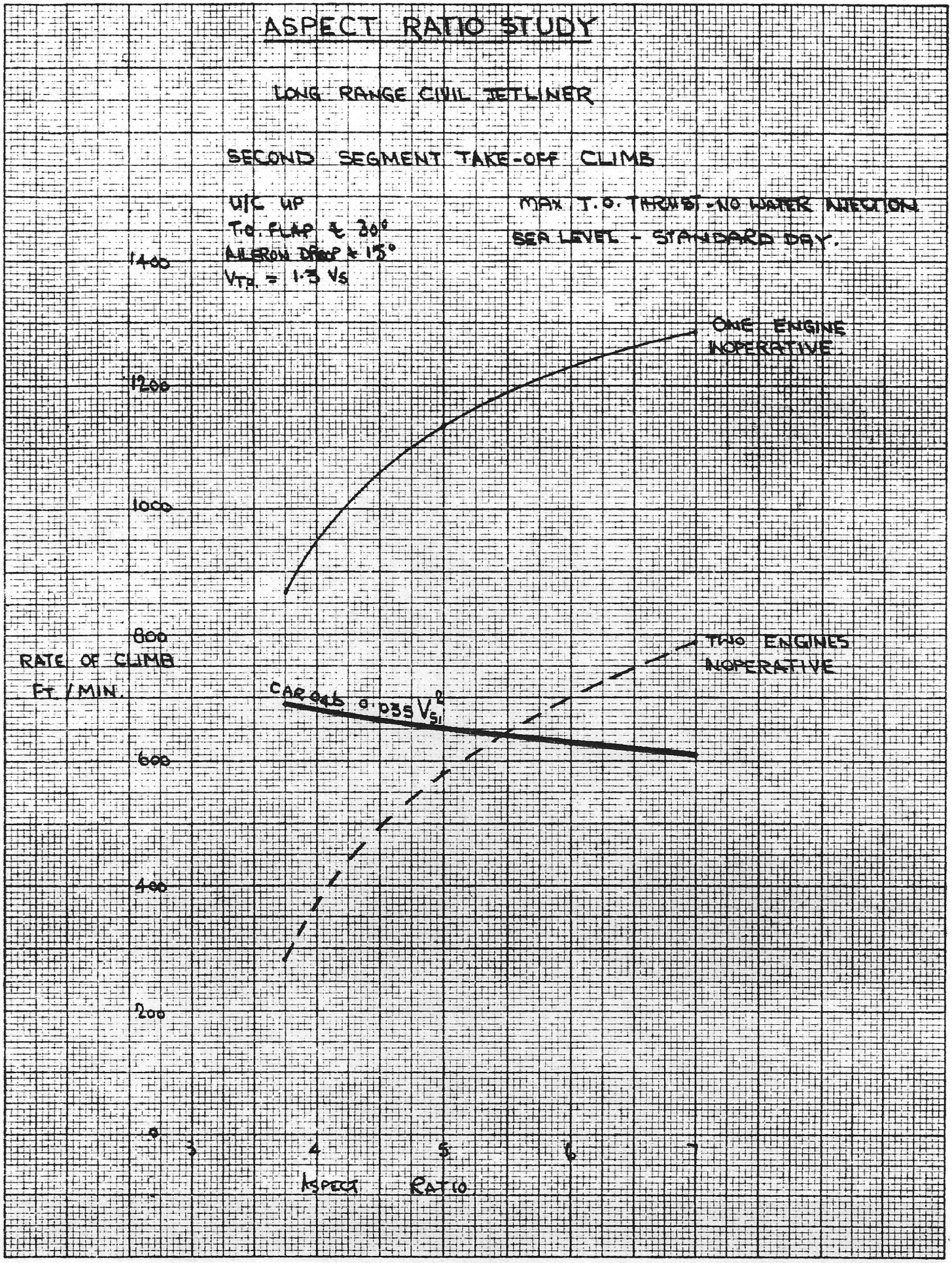


FIG. 6

Feb 24/56.

ASPECT RATIO STUDY

LONG RANGE CIVIL JET LINER

WING AREA VS ASPECT RATIO BASED ON
TAKE-OFF IN 5000 FT. WITH 202,500 lb FUEL.

TAKE-OFF TO CAR 04b

MAX. T.O. THRUST - NO WATER INJECTION.
SEA LEVEL - STANDARD - ZERO WIND.

$V_{UNSTICK} = 1.3\ V_{STALL}$.

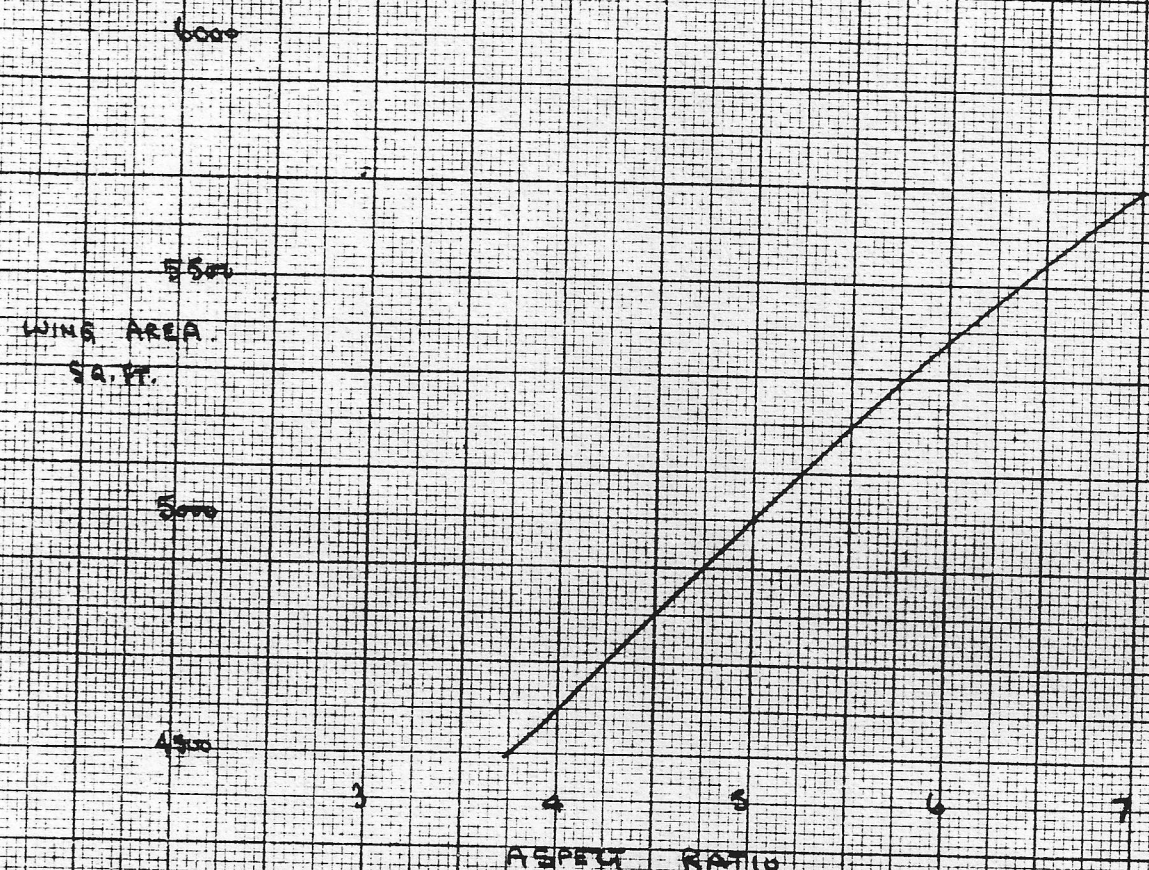


FIG. 7

Feb 24/56

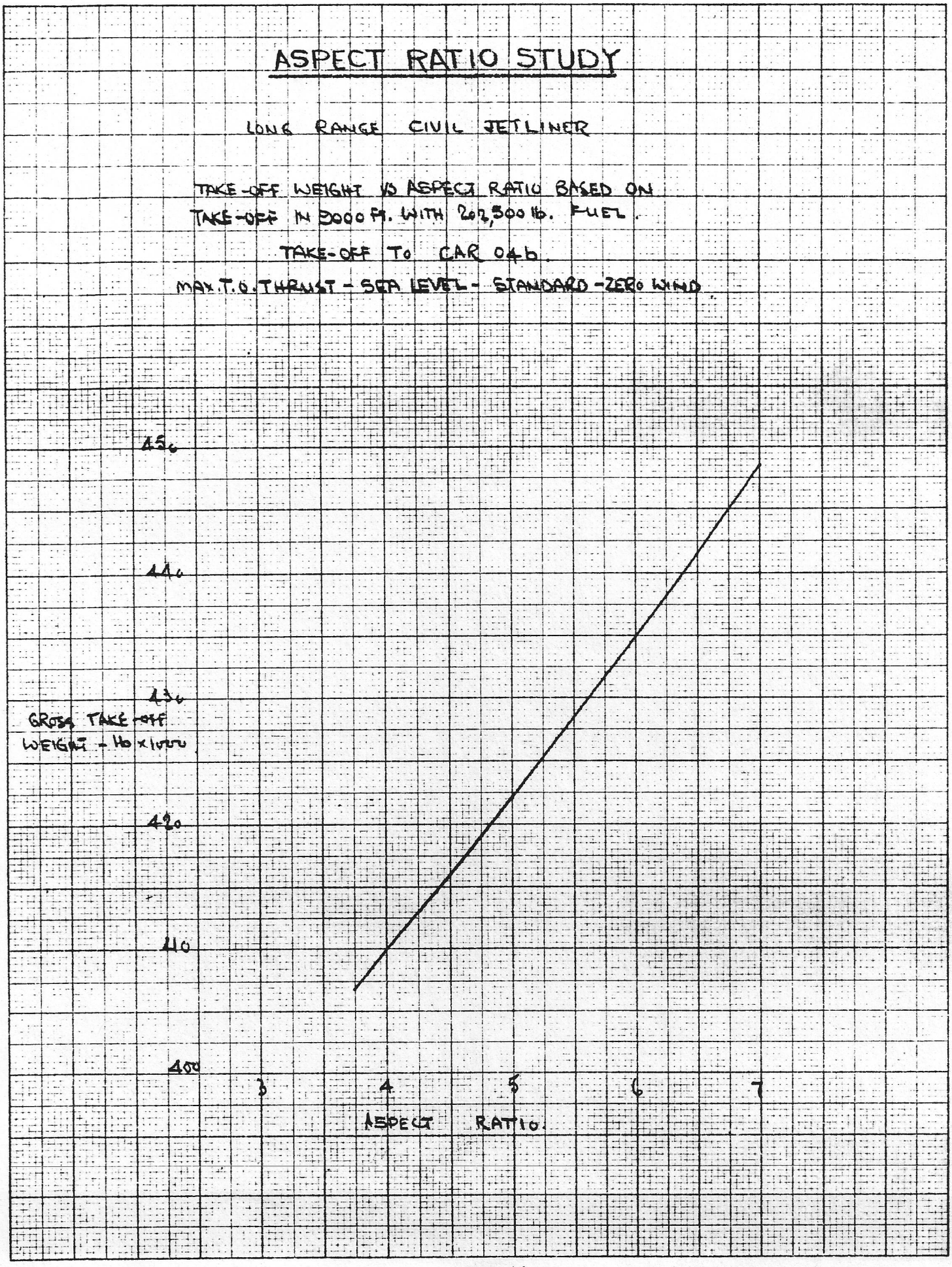


FIG. 8

STABILITY AND CONTROL

In this preliminary stage of design proposal, the aircraft stabilizing surfaces and control surfaces were obtained by appropriate non-dimensional comparison with existing similar designs such as Boeing 707 Tanker and Douglas DC-8. A comparison of relevant parameters is shown below. It is not expected that any large changes in control sizes may result from a thorough aerodynamic investigation.

Rudder size was investigated more fully than other controls. It was established that with the rudder of 30% local fin chord and 30° deflection, the minimum safe speed is 131 knots for the case of the outer and middle engine cut on one side and all others developing maximum thrust.

In the case of outer engine cut and all the others at maximum thrust the minimum control speed is 99 knots.

	707(TANKER)	DC-8	AVRO TRANSPORT
WING			
Area (Gross)	2400 sq.ft.	2680 sq.ft.	5000 sq.ft.
Span	129.667'	134.75'	158'
Aspect Ratio	7.0	6.76	5
M.A.C.	20.2'	21.7'	35.2'
Sweepback c/4	35°	30°	35°
TAIL			
Area (Gross)	510 sq.ft.	555 sq.ft.	1400sq.ft.
Span	39.667'	47.5'	74'
Aspect Ratio	3.09	4.07	3.9
M.A.C.	13.65'	12.6'	20.4'
Sweepback c/4	35°	34°	35°
Tail Arm	55.25'	63.42'	70'
Ratio-Tail Area/Wing Area	.212	.207	.28
Tail Volume	.581	.61	.557
FIN AND RUDDER			
Area (Net)	317 sq.ft.	284 sq.ft.	606 sq.ft.
Span	21.5'	22.5'	30.75'
Aspect Ratio	1.46	1.785	1.56
M.A.C.	15.9'	13.5'	21.25'
Sweepback	33°	34°	35°
Fin and Rudder Arm	53.9'	59'	61.25'
Ratio-Fin & Rudder Area/Wing Area	.132	.106	.121
Fin and Rudder Volume	.0523	.0464	.0470
Position on Body of Wing M.A.C. 1/4 Chord	45.5%	46.7%	48.8%

$$\text{Tail Volume} = \frac{\text{Tail Area}}{\text{Wing Area}} \times \frac{\text{Tail Arm}}{\text{Wing M.A.C.}}$$

$$\text{Fin and Rudder Volume} = \frac{\text{Fin \& Rudder Area}}{\text{Wing Area}} \times \frac{\text{Fin \& Rudder Arm}}{\text{Wing Span}}$$

MISSION PROFILE SUMMARY

MISSION	PAYLOAD Lb.	BLOCK			RESERVE		
		Dist. N.M.	Time Hr.	Fuel Lb.	Dist. N.M.	Time Hr.	Fuel Lb.
NEW YORK - PARIS							
Winter	44,127	3228	6.49	145,916	238	2.79	45,800
Summer	44,127	3228	6.59	149,356	238	2.79	46,050
PARIS - NEW YORK							
Winter	33,632	3228	7.56	166,906	87	2.35	35,600
Summer	33,632	3228	7.32	160,246	87	2.37	35,330
NEW YORK - ROME							
Winter	27,310	3719	7.26	161,016	295	3.05	49,200
ROME - NEW YORK							
Winter	18,583	3719	8.68	187,316	87	2.40	33,600
NEW YORK - SAN FRAN.							
Winter	56,270	2259	5.60	120,596	142	1.75	27,300
Summer	56,270	2259	5.34	112,796	142	1.76	27,880
SAN FRAN. - NEW YORK							
Winter	56,270	2259	4.54	94,876	83	1.62	24,540
Summer	56,270	2259	4.74	99,276	83	1.61	24,040
NEW YORK - CHICAGO							
Winter	56,270	688	2.09	41,296	151	1.76	27,630
Summer	56,270	688	2.08	39,896	151	1.78	27,910
CHICAGO - NEW YORK							
Winter	56,270	666	1.71	33,676	83	1.62	24,540
Summer	56,270	666	1.76	34,286	83	1.61	24,140

Note: The Mission Profiles for the Domestic Routes were calculated assuming 9,000 lb. for the Operator's Service Items as calculated for the International Route and noted in the brochure of January 1956. The calculation on Page 41 shows that these items actually total 4,367 lb. for the Maximum Gross Weight Domestic Version (Sky Tourist). The Gross Weights incorporating this correction are noted on Page 45. Thus, the results quoted above for Domestic Routes are conservative.

MISSION PROFILE

NEW YORK TO PARIS (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (422,000 lb.)	-	.22	3,816	418,184	-
Climb (40,000 ft.)	356	.75	27,700	390,484	+15.0
Cruise (40,000 ft.)	2788	5.09	111,825	278,659	+30.0
Descend (15,000 ft.)	84	.25	1,325	277,334	+21.25
Hold (15,000 ft.)	-	2.00	33,400	243,934	-
Cruise (15,000 ft.)	208	.61	12,400	231,534	+1.0
Descend (S.L.)	30	.18	1,250	230,284	-
Totals	3466	9.10	191,716		

Cruise Speed	M = .90 = 595 mph
Block Fuel	145,916 lb.
Reserve Fuel	45,800 lb.
Block Time	6.49 hrs.
Block Distance	3720 s.m.
Block Speed	573 mph
Payload	44,127 lb.

Alternate is Geneva - 238 n.m. away.

MISSION PROFILE

PARIS TO NEW YORK (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (422,000 lb.)	-	.22	3,816	418,184	-
Climb (40,000 ft.)	322.5	.75	27,700	390,484	-30
Cruise (40,000 ft.)	971	2.11	50,000	340,484	-59
Cruise (b)	1090	2.37	50,000	290,484	-59
Cruise (c)	785.5	1.71	33,000	257,484	-59
Descend (15,000 ft.)	59	.23	1,220	256,264	-43
Hold (15,000 ft.)	-	2.00	31,400	224,864	-
Cruise (15,000 ft.)	63	.18	4,200	220,664	-50
Descend (S.L.)	24	.17	1,170	219,494	-25
Totals	3315	9.74	202,506		

Cruise Speed	M = .90 = 595 mph
Block Fuel	166,906 lb.
Reserve Fuel	35,600 lb.
Block Time	7.56 hrs.
Block Distance	3720 s.m.
Block Speed	492 mph
Payload	33,632 lb.

Alternate is Philadelphia - 87 n.m. away.

MISSION PROFILE

NEW YORK TO PARIS (70% SUMMER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (425,690 lb.)	-	.22	3,816	421,874	-
Climb (40,000 ft.)	367.5	.78	29,000	392,874	+9
Cruise (40,000 ft.)	2780	5.17	114,000	278,874	+18
Descent (15,000 ft.)	80.5	.25	1,320	277,554	+12
Hold (15,000 ft.)	-	2.00	33,500	244,054	-
Cruise (15,000 ft.)	209	.62	12,550	231,504	-2
Descent (S.L.)	29	.17	1,220	230,284	-1
Totals	3466	9.21	195,406		

Cruise Speed	M = .90 = 595 mph
Block Fuel	149,356 lb.
Reserve Fuel	46,050 lb.
Block Time	6.59 hrs.
Block Distance	3720 s.m.
Block Speed	565 mph
Payload	44,127 lb.

Alternate is Geneva - 238 n.m. away.

MISSION PROFILE

PARIS TO NEW YORK (70% SUMMER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (415,076 lb.)	-	.22	3,816	411,260	-
Climb (40,000 ft.)	284	.65	25,000	386,260	-21
Cruise (40,000 ft.)	2882	6.05	129,000	257,260	-42
Descent (15,000 ft.)	62	.23	1,220	256,040	-33
Hold (15,000 ft.)	-	2.00	31,450	224,590	-
Cruise (15,000 ft.)	61	.20	3,880	220,710	-28
Descent (S.L.)	26	.17	1,210	221,500	-14
Totals	3315	9.52	195,576		

Cruise Speed	M = .90 = 595 mph
Block Fuel	160,246 lb.
Reserve Fuel	35,330 lb.
Block Time	7.32 hrs.
Block Distance	3720 s.m.
Block Speed	508 mph
Payload	33,632 lb.

Alternate is Philadelphia - 87 n.m. away.

MISSION PROFILE

NEW YORK TO ROME (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (422,000 lb.)	-	.22	3,816	418,184	-
Climb (40,000 ft.)	360	.75	27,700	390,484	+19.5
Cruise (40,000 ft.)	3279	5.89	127,100	263,384	+39.0
Descent (15,000 ft.)	80	.24	1,260	262,124	+29.75
Hold (15,000 ft.)	-	2.00	32,000	230,124	-
Cruise (15,000 ft.)	271	.89	17,200	212,924	-27.5
Descent (S.L.)	24	.16	1,140	211,784	-13.75
Totals	4014	10.15	210,216		

Cruise Speed	M = .90 = 595 mph
Block Fuel	161,016 lb.
Reserve Fuel	49,200 lb.
Block Time	7.26 hrs.
Block Distance	4285 s.m.
Block Speed	590 mph
Payload	27,310 lb.

Alternate is Milan - 295 n.m. away.

MISSION PROFILE

ROME TO NEW YORK (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (422,000 lb.)	-	.22	3,816	418,184	-
Climb (40,000 ft.)	322	.75	27,700	390,484	-31
Cruise (40,000 ft.)	3345	7.34	153,580	236,904	-62
Descent (15,000 ft.)	52	.22	1,120	235,784	-49
Hold (15,000 ft.)	-	2.00	29,100	206,684	-
Cruise (15,000 ft.)	67	.25	4,500	202,184	-50
Descent (S.L.)	20	.15	1,100	201,084	-25
Totals	3719	10.93	220,916		

Cruise Speed	M = .90 = 595 mph
Block Speed	187,316 lb.
Reserve Fuel	33,600 lb.
Block Time	8.68 hrs.
Block Distance	4285 s.m.
Block Speed	494 mph
Payload	18,583 lb.

Alternate is Philadelphia - 87 n.m.

MISSION PROFILE

NEW YORK TO SAN FRANCISCO (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (389,166 lb.)	-	.22	3,816	385,350	-
Climb (40,000 ft.)	209	.49	20,170	365,180	-35.5
Cruise (40,000 ft.)	1987	4.45	94,030	271,150	-71.0
Descent (15,000 ft.)	63	.25	1,290	269,860	-52.0
Hold (15,000 ft.)	-	1.25	20,900	248,960	-
Cruise (15,000 ft.)	109	.31	6,400	242,560	+7.5
Descent (S.L.)	33	.19	1,290	241,270	+3.75
Totals	2401	7.16	147,896		

Cruise Speed	M = .90 = 595 mph
Block Fuel	120,596 lb.
Reserve Fuel	27,300 lb.
Block Time	5.60 hrs.
Block Distance	2600 s.m.
Block Speed	465 mph
Payload	56,270 lb.

Alternate is Fresno - 142 n.m. away.

MISSION PROFILE

SAN FRANCISCO TO NEW YORK (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (360,686 Lb.)	-	.22	3,816	356,870	-
Climb (40,000 ft.)	187	.39	16,600	340,270	+24
Cruise (40,000 ft.)	1991	3.51	72,000	268,270	+49
Descent (15,000 ft.)	81	.24	1,270	267,000	+33
Hold (15,000 ft.)	-	1.25	20,650	246,350	-
Cruise (15,000 ft.)	56	.19	3,890	242,460	-46
Descent (S.L.)	27	.18	1,190	241,270	-23
Totals	2342	5.98	119,416		

Cruise Speed	M = .90 = 595 mph
Block Fuel	94,876 lb.
Reserve Fuel	24,540 lb.
Block Time	4.54 hrs.
Block Distance	2600 s.m.
Block Speed	572 mph
Payload	56,270 lb.

Alternate is Philadelphia - 83 n.m. away.

MISSION PROFILE

NEW YORK TO SAN FRANCISCO (70% SUMMER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (381,946 lb.)	-	.22	3,816	378,130	-
Climb (40,000 ft.)	202	.43	19,150	358,980	-19.5
Cruise (40,000 ft.)	1988	4.15	87,250	271,730	-39
Descent (15,000 ft.)	69	.25	1,290	270,440	-27.25
Hold (15,000 ft.)	-	1.25	20,950	249,490	-
Cruise (15,000 ft.)	111	.32	6,930	242,560	-11
Descent (S.L.)	31	.19	1,290	241,270	-5.5
Totals	2401	6.81	140,676		

Cruise Speed	M = .90 = 595 mph
Block Fuel	112,796 lb.
Reserve Fuel	27,880 lb.
Block Time	5.34 hrs.
Block Distance	2600 s.m.
Payload	56,270 lb.
Block Speed	487 mph.

Alternate is Fesno - 142 n.m. away.

MISSION PROFILE

SAN FRANCISCO TO NEW YORK (70% SUMMER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (364,586 lb.)	-	.22	3,816	360,770	-
Climb (40,000 ft.)	185	.39	17,020	343,750	+12
Cruise (40,000 ft.)	1997	3.69	75,880	267,870	+23
Descent (15,000 ft.)	77	.25	1,270	266,600	+13.75
Hold (15,000 ft.)	-	1.25	20,600	246,000	-
Cruise (15,000 ft.)	53	.17	3,440	242,560	-25.5
Descent (S.L.)	30	.19	1,290	241,270	-12.75
Totals	2342	6.16	123,316		

Cruise Speed	M = .90 = 595 mph
Block Fuel	99,276 lb.
Reserve Fuel	24,040 lb.
Block Time	4.74 hrs.
Block Distance	2600 s.m.
Block Speed	549 mph
Payload	56,270 lb.

Alternate is Philadelphia - 83 n.m. away.

MISSION PROFILE

NEW YORK TO CHICAGO (70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (310,196 lb.)	-	.22	3,816	306,380	-
Climb (40,000 ft.)	117	.28	12,300	294,080	-39.0
Cruise (40,000 ft.)	507	1.15	22,600	271,480	-78.0
Descent (15,000 ft.)	64	.25	1,290	270,190	-49.5
Hold (15,000 ft.)	-	1.25	20,900	249,290	-
Cruise (15,000 ft.)	117	.32	6,730	242,560	+17.5
Descent (S.L.)	34	.19	1,290	241,270	+8.75
Totals	839	3.66	68,926		

Cruise Speed	M = .90 = 595 mph
Block Fuel	41,296 lb.
Reserve Fuel	27,630 lb.
Block Time	2.09 hrs.
Block Distance	792 s.m.
Block Speed	379 mph
Payload	56,270 lb.

Alternate is Fort Wayne - 151 n.m. away.

MISSION PROFILE

CHICAGO TO NEW YORK(IDL.)(70% WINTER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (299,486 lb.)	-	.22	3,816	295,670	-
Climb (40,000 ft.)	126	.26	11,800	283,870	+25
Cruise (40,000 ft.)	458	.81	15,600	268,270	+50
Descent (15,000 ft.)	82	.24	1,270	267,000	+37
Hold (15,000 ft.)	-	1.25	20,650	246,350	-
Cruise (15,000 ft.)	56	.19	3,890	242,460	-46
Descent (S.L.)	27	.18	1,190	241,270	-23
Totals	749	3.15	58,216		

Cruise Speed	M = .90 = 595 mph
Block Fuel	33,676 lb.
Reserve Fuel	24,540 lb.
Block Time	1.71 hrs.
Block Distance	766 s.m.
Block Speed	448 mph
Payload	56,270 lb.

Alternate is Philadelphia - 83 n.m. away.

MISSION PROFILE

NEW YORK (IDL.) TO CHICAGO (70% SUMMER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (309,076 lb.)	-	.22	3,816	305,260	-
Climb (40,000 ft.)	113	.26	12,000	293,260	-29
Cruise (40,000 ft.)	508	1.10	21,500	271,760	-57
Descent (15,000 ft.)	67	.29	1,290	270,470	-42
Hold (15,000 ft.)	-	1.25	20,900	249,570	-
Cruise (15,000 ft.)	113	.32	7,010	242,560	+10
Descent (S.L.)	38	.21	1,290	241,270	+5
Totals	839	3.65	67,806		

Cruise Speed	M = .90 = 595 mph
Block Fuel	39,896 lb.
Reserve Fuel	27,910 lb.
Block Time	2.08 hrs.
Block Distance	792 s.m.
Block Speed	381 mph.
Payload	56,270 lb.

Alternate is Fort Wayne - 151 n.m. away.

MISSION PROFILE

CHICAGO TO NEW YORK (70% SUMMER)

Operation	Dist. n.m.	Time hrs.	Fuel lb.	Weight lb.	Wind kts.
T.O. (299,696 lb.)	-	.22	3,816	295,880	-
Climb (40,000 ft.)	127	.27	11,800	284,080	+16.5
Cruise (40,000 ft.)	459	.83	16,100	267,980	+33.0
Descent (15,000 ft.)	80	.25	1,280	266,700	+22.25
Hold (15,000 ft.)	-	1.25	20,700	246,000	-
Cruise (15,000 ft.)	53	.17	3,440	242,560	-25.5
Descent (S.L.)	30	.19	1,290	241,270	-12.75
Totals	749	3.18	58,426		

Cruise Speed	M = .90 = 595 mph
Block Fuel	34,286 lb.
Reserve Fuel	24,140 lb.
Block Time	1.76 hrs.
Block Distance	766 s.m.
Block Speed	435 mph
Payload	56,270 lb.

Alternate is Philadelphia - 83 n.m. away.

AERODYNAMIC DATA

Mean Cruise C_D = .019

Mean Cruise C_L = .291

Mean Cruise L/D = 15.3

It is estimated that the drag rise is above .9 Mach Number at the cruise C_L for a wing of 8% t/c and 35° c/4 sweep with leading edge camber.

ENGINE DATA (Assumed)

Installed Thrust:

- Sea Level Static (Maximum)	15,300 #/engine
- 40,000 ft. at .9 Mach Number (Normal Rated)	4,210 #/engine
Specific Fuel Consumption (Cruise) at .9 Mach Number and 40,000 ft. at weight of 324,000 lb.	1.004 #/hr/# *

* Includes allowances for accessories and conservation.

TABLE OF TAKE-OFF FIELD LENGTHS

MISSION	TAKE-OFF WEIGHT	C.A.A. TAKE-OFF FIELD LENGTH - FT.					
		Take-Off Power			Take-Off Power + Water Injection		
		T_s	T_s+15°F	T_s+30°F	T_s	T_s+15°F	T_s+30°F
NEW YORK - PARIS							
Winter	422,000	9,000	10,100	11,600	7,730	8,250	8,930
Summer	425,690	9,180	10,300	11,840	7,870	8,400	9,100
PARIS - NEW YORK							
Winter	422,000	9,000	10,100	11,600	7,730	8,250	8,940
Summer	415,076	8,670	9,700	11,130	7,440	7,950	8,600
NEW YORK - SAN FRAN.							
Winter	389,166	7,500	8,350	9,500	6,450	6,900	7,440
Summer	381,946	7,250	8,050	9,130	6,240	6,660	7,160
SAN FRAN. - NEW YORK							
Winter	360,686	6,400	7,100	7,950	5,530	5,920	6,300
Summer	364,586	6,550	7,250	8,150	5,650	6,040	6,450
NEW YORK - CHICAGO							
Winter	310,196	4,520	4,920	5,350	4,000	4,220	4,380
Summer	309,076	4,490	4,900	5,300	3,960	4,190	4,350
CHICAGO - NEW YORK							
Winter	299,486	4,140	4,490	4,820	3,680	3,880	4,000
Summer	299,696	4,140	4,490	4,820	3,680	3,880	4,000
NEW YORK - ROME							
Winter	422,000	9,000	10,100	11,600	7,730	8,250	8,940
ROME - NEW YORK							
Winter	422,000	9,000	10,100	11,600	7,730	8,250	8,940

NOTE: INCREASED TEMPERATURES

At TWA's request take-off field lengths for standard temperatures plus 30°F were investigated for our configuration. From available meteorological data, however, the following facts are apparent. Examining New York and Paris, the hottest month of the year is July in both cases. The average daily maximum temperatures for this month are 82°F and 73°F respectively.

On the basis of these temperatures the figure of standard plus 30°F is quite high and therefore Avro has also presented field lengths for standard temperature plus 15°F.

Again take-off field lengths are given for power with water injection. Although Pratt & Whitney may not be prepared to supply this on the J.75, it is assumed that Orenda Engines could develop this system in co-operation with Pratt & Whitney if required for this aircraft.

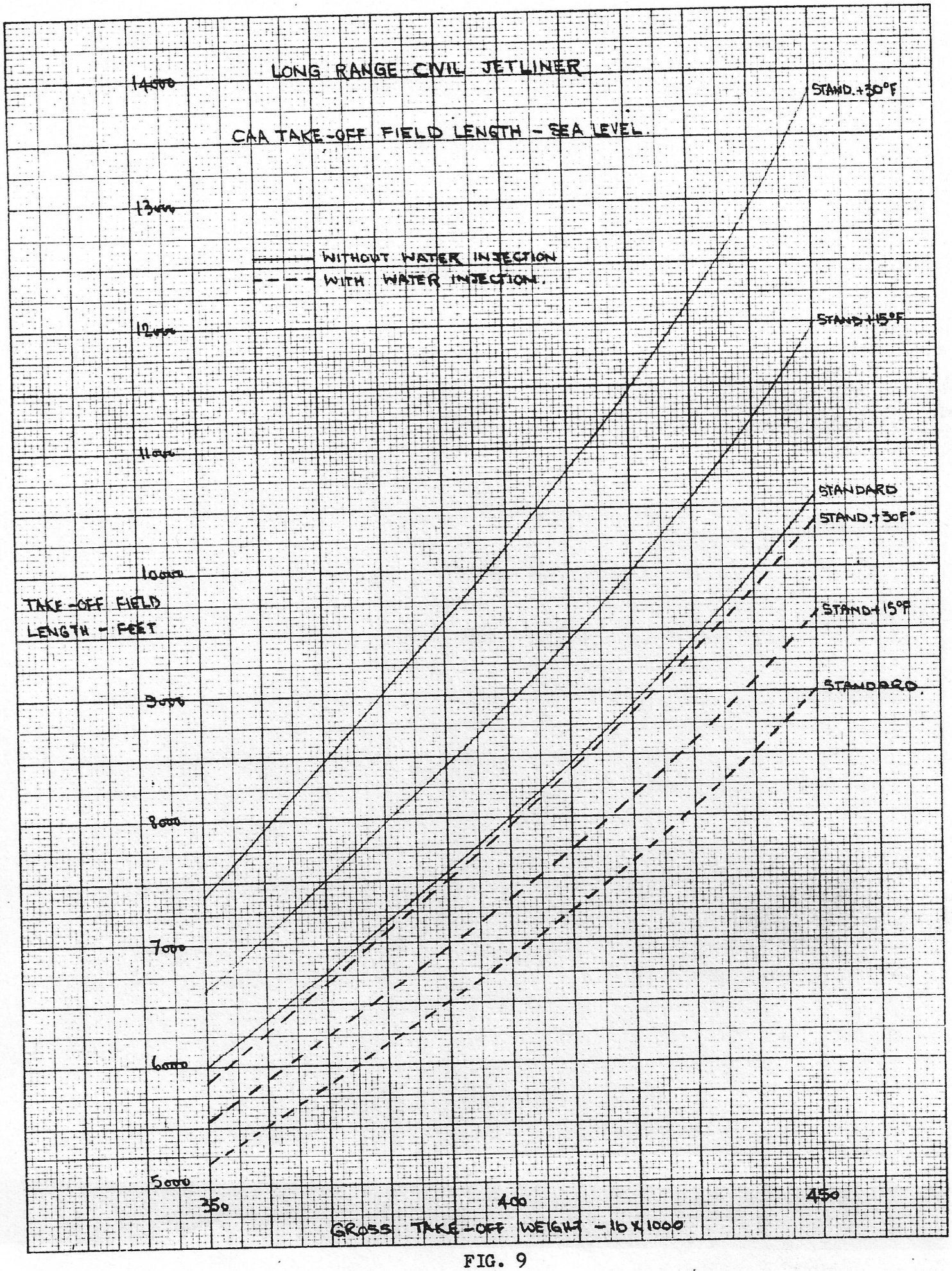


FIG. 9

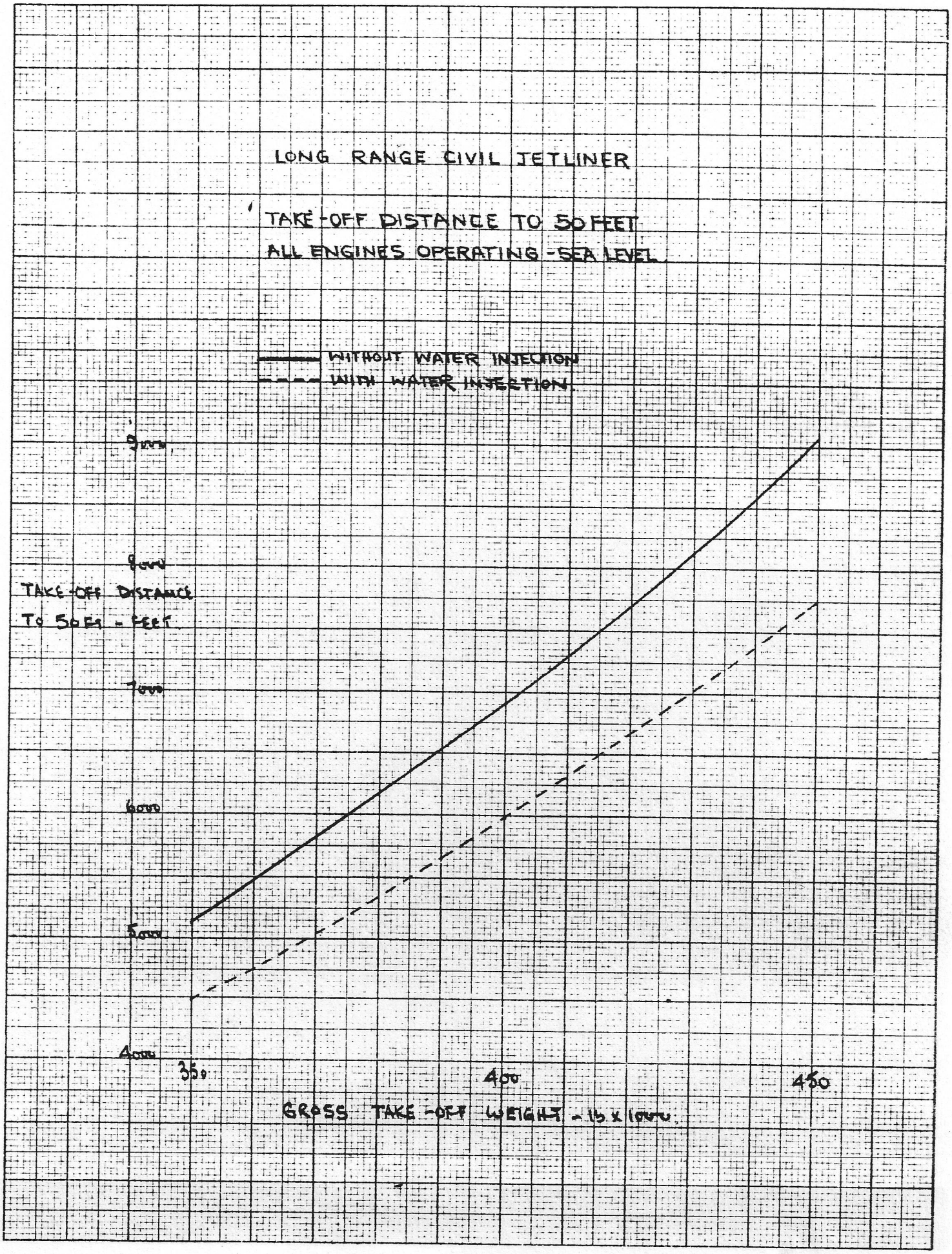


FIG. 10

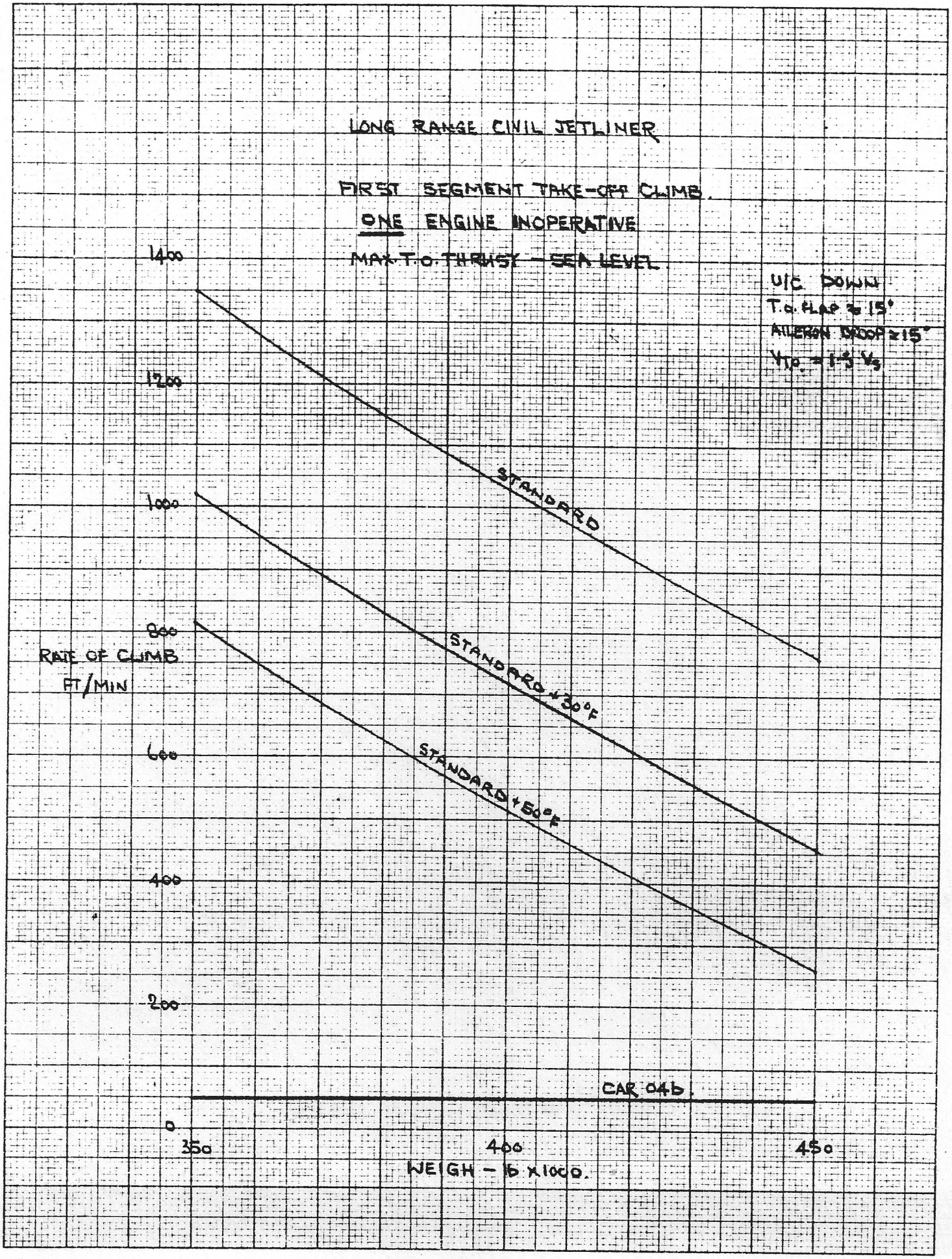

LONG RANGE CIVIL JETLINER
FIRST SEGMENT TAKE-OFF CLIMB.
ONE ENGINE INOPERATIVE
MAX. T.O. THRUST — SEA LEVEL
U/C DOWN
T.O. FLAP ≈ 15°
AILERON DROOP ≈ 15°
$V_{TO} \approx 1.3\ V_S$
1400
1200
1000
800
600
400
200
0
RATE OF CLIMB
FT/MIN
STANDARD
STANDARD +30°F
STANDARD +50°F
CAR 04b
350
400
450
WEIGH — lb x1000.

FIG. 11

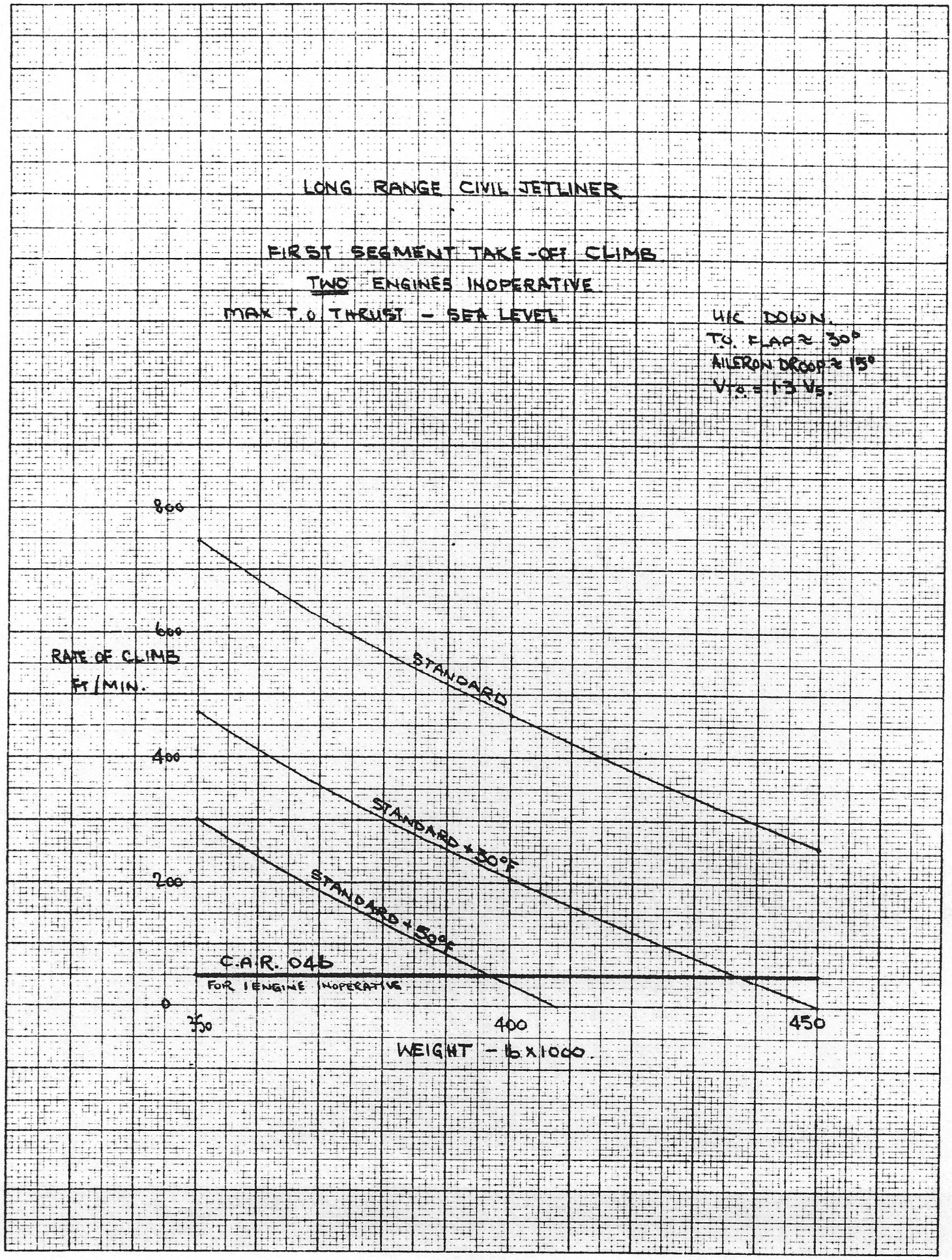

LONG RANGE CIVIL JETLINER
FIRST SEGMENT TAKE-OFF CLIMB
TWO ENGINES INOPERATIVE
MAX T.O THRUST - SEA LEVEL
U/C DOWN.
T.O. FLAP ≈ 30°
AILERON DROOP ≈ 15°
VTO = 1.3 VS.
800
600
400
200
0
RATE OF CLIMB
FT/MIN.
STANDARD
STANDARD + 30°F
STANDARD + 50°F
C.A.R. 04b
FOR 1 ENGINE INOPERATIVE
350
400
450
WEIGHT - lb x 1000.

FIG. 12

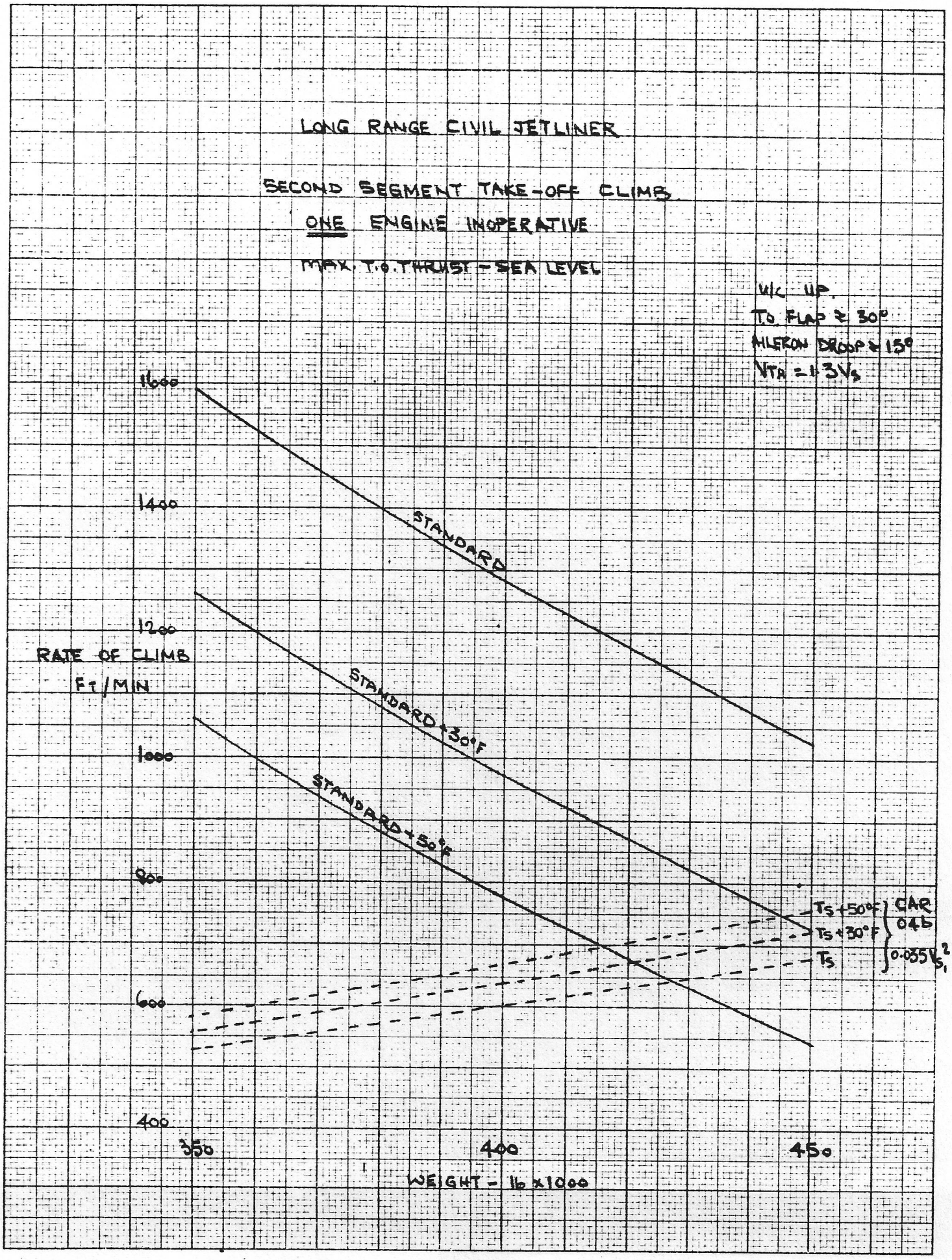


FIG. 13

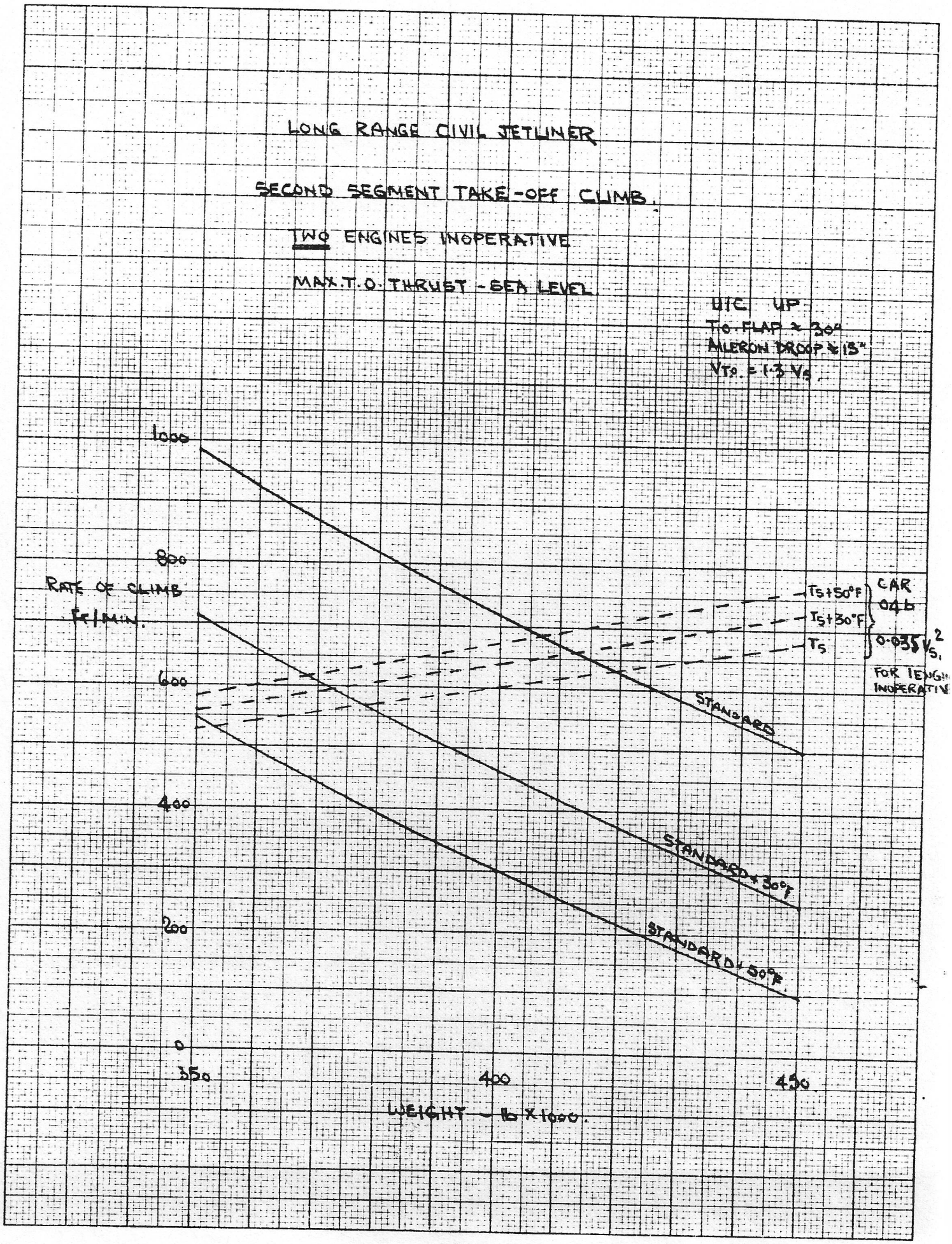


FIG. 14

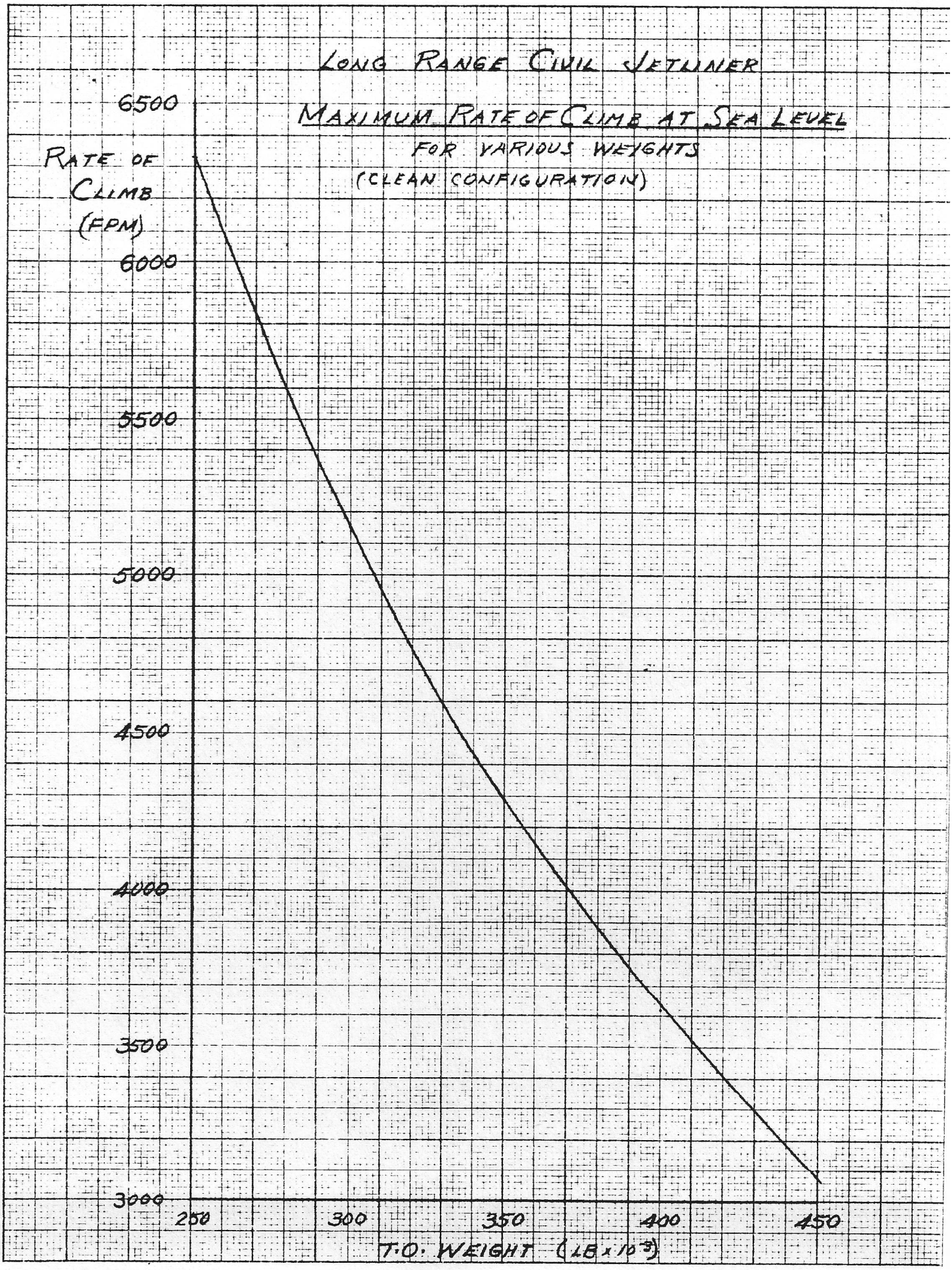


FIG. 15

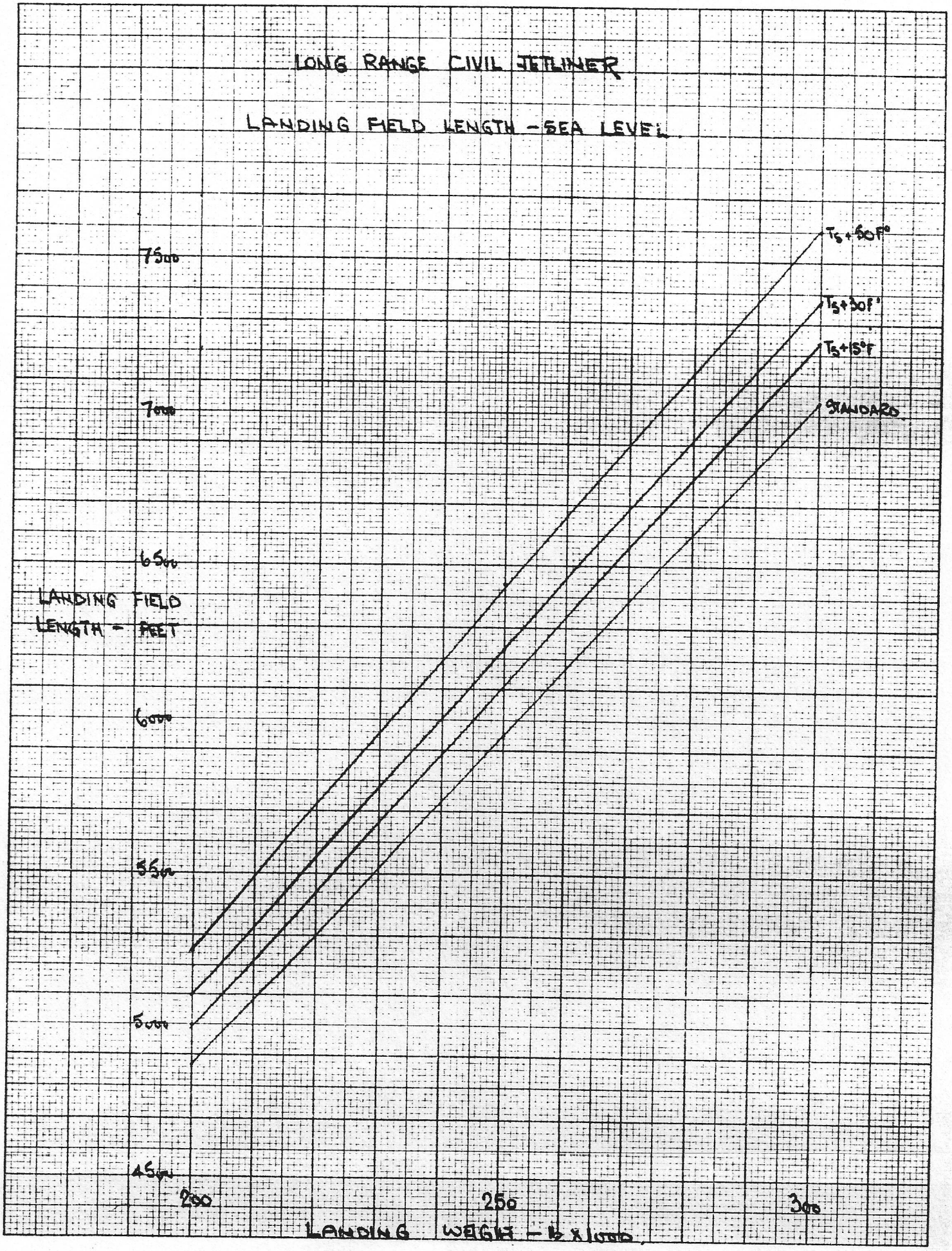


FIG. 16

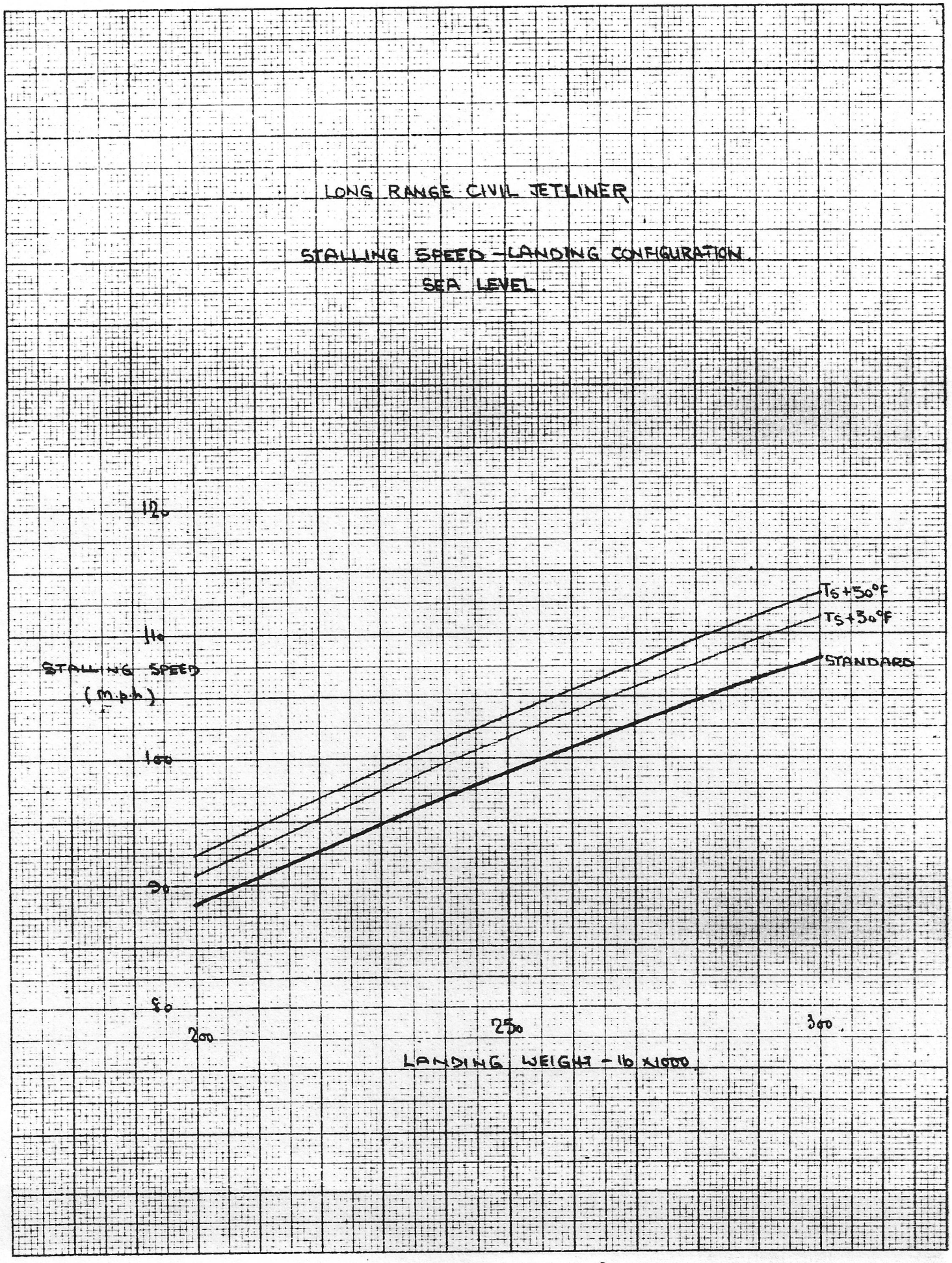


FIG. 17

SUMMARY

PAYLOAD AND GROSS WEIGHT

CLASS OF SERVICE	STANDARD FARE			SKY TOURIST			MIXED		
AVAILABLE PASSENGER SEATS	162			206			74 STANDARD FARE 105 TOURIST		
ROUTE	PAYLOAD CARRIED		GROSS WT. LB.	PAYLOAD CARRIED		GROSS WT. LB.	PAYLOAD CARRIED		GROSS WT. LB.
	Passengers	Cargo Lb.		Passengers	Cargo Lb.		Passengers	Cargo Lb.	
N.Y.- Paris (Winter)	162	9,297	422,000	206	1,904	422,000	74 Standard 105 Tourist	6,956	422,000
Paris - N.Y. (Winter)	156	92	422,000	169	104	422,000	74 Standard 89 Tourist	57	422,000
N.Y.- Paris (Summer)	162	9,297	425,690	206	1,904	425,690	74 Standard 105 Tourist	6,956	425,690
Paris - N.Y. (Summer)	156	92	415,076	169	104	415,076	74 Standard 89 Tourist	57	415,076
N.Y.- Rome (Winter)	127	5	422,000	137	157	422,000	74 Standard 57 Tourist	110	422,000
Rome - N.Y. (Winter)	86	93	422,000	93	140	422,000	74 Standard 13 Tourist	94	422,000
N.Y.-Chicago(Winter) Chicago-N.Y.(Winter)	162	17,400	Gross Weight less than Sky Tourist Version	206	16,100	305,653 294,853	74 Standard 105 Tourist	17,400	Gross Weight less than Sky Tourist Version
N.Y.-Chicago(Summer) Chicago-N.Y.(Summer)						304,443 295,063			
N.Y. - S.F. (Winter) S.F. - N.Y. (Winter)						384,533 356,053			
N.Y. - S.F. (Summer) S.F. - N.Y. (Summer)						377,313 359,953			

STATEMENT OF EMPTY WEIGHT

ITEM		WEIGHT-LB.	REFERENCE
Structure		107,000	
Wing	49,800		Driggs' Formula modified by Hyatt's Formula (U.S. Navy)
Fuselage	24,000		RAE/Structures/24 (Grinstead) RAE/Structures/93 (Ripley) RAND R-171 & rational
Tail	10,130		Avro Statistical Data
Undercarriage	14,070		RAE/Structures/80 (Burt)
Nacelles	9,000		RAND R-171 modified
Power Plant		36,700	
Engines (6)	28,800		Manufacturer's Data plus estimates for additional equipment.
Thrust Reversers (6)	1,200		
Controls, Starting System etc.	2,000		
Jet Pipe	500		
Fire Protection	200		
Fuel System	2,000		
Residual Fuel	2,000		
Fixed Equipment and Services		32,300	
Instruments	400		Avro Statistical Data and Rational Estimates.
Flying Controls	3,000		
Hydraulics	3,400		
Electrics	2,000		
Radio and Radar	1,000		
Furnishings	17,700		
Anti-Icing	2,500		
Pneumatics	1,500		
Fire Protection	300		
Gear Box	500		
WEIGHT EMPTY		176,000 Lb.	

STATEMENT OF WEIGHT FOR OPERATOR'S SERVICE ITEMS

(According to T.W.A. Flight Requirements)

Based on: A single crew consisting of Pilot, Co-Pilot, Flight Engineer, Steward-Purser and 3 Stewardesses for Domestic Flights and a Navigator added for International Flights.

ROUTE	INTERNATIONAL			DOMESTIC		
CLASS	STANDARD	SKY TOURIST	MIXED	STANDARD	SKY TOURIST	MIXED
NO. OF PASSENGERS	162	206	74 Standard 105 Tourist	162	206	74 Standard 105 Tourist
NO. OF CREW	8	8	8	7	7	7
ITEM:						
Buffet	3553	2939	3152	2113	603	1275
Emergency Equipment	1955	2440	2140	372	439	420
Passenger Service	2176	2121	2079	1099	1343	1188
Flight Equipment	255	300	270	51	43	45
Miscellaneous	238	320	272	254	114	174
Pilot, Co-Pilot, Flt. Eng'r. (170x3)	510	510	510	510	510	510
Navigator (170 x 1)	170	170	170	-	-	-
Steward-Purser (150 x 1)	150	150	150	150	150	150
Stewardesses (130 x 3)	390	390	390	390	390	390
Crew Baggage (35 lb. each)	280	280	280	245	245	245
Oil	480	480	480	480	480	430
TOTAL	10,157	10,150	9,893	5,664	4,367	4,877

NOTES: (1) No. of Seats for computation of weights = No. of Passengers + No. of Crew
(2) Standard Fare Buffet Weight assumed for Crew on both Standard Fare and Sky Tourist Versions.

STATEMENT OF PAYLOAD AND GROSS WEIGHT

INTERNATIONAL ROUTE (N.Y. - PARIS)

(Winter Conditions)

CLASS OF SERVICE		STANDARD	SKY TOURIST	MIXED
AVAILABLE PASSENGER SEATS		162	206	74 Standard 105 Tourist
CREW CARRIED		8	8	8
UNIT WEIGHT OF PASSENGERS (Including Baggage)		215	205	215 Standard 205 Tourist
(A) NEW YORK TO PARIS				
No. of Passengers (Space Limited)		162	206	74 Standard 105 Tourist
Passengers and Baggage	lb.	34,830	42,230	37,435
Cargo	lb.	9,297	1,904	6,956
Total Payload	lb.	44,127	44,134	44,391
Passenger Service Items	lb.	10,157	10,150	9,893
Empty Weight	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	230,284	230,284	230,284
Fuel	lb.	191,716	191,716	191,716
GROSS WEIGHT	lb.	422,000	422,000	422,000
(B) PARIS TO NEW YORK				
No. of Passengers (Weight Limited)		156	169	74 Standard 89 Tourist
Passengers and Baggage	lb.	33,540	34,645	34,155
Cargo	lb.	92	104	57
Total Payload	lb.	33,632	34,749	34,212
Passenger Service Items ★	lb.	9,868	8,751	9,288
Empty Weight	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	219,500	219,500	219,500
Fuel	lb.	202,500	202,500	202,500
GROSS WEIGHT	lb.	422,000	422,000	422,000

★ Adjusted for number of passengers carried.

STATEMENT OF PAYLOAD AND GROSS WEIGHT

INTERNATIONAL ROUTE (N.Y. - PARIS)

(Summer Conditions)

CLASS OF SERVICE		STANDARD	SKY TOURIST	MIXED
AVAILABLE PASSENGER SEATS		162	206	74 Standard 105 Tourist
CREW CARRIED		8	8	8
UNIT WEIGHT OF PASSENGERS (Including Baggage)		215	215	215 Standard 205 Tourist
(A) NEW YORK TO PARIS				
No. of Passengers		162	206	74 Standard 105 Tourist
Passengers and Baggage	lb.	34,830	42,230	37,435
Cargo	lb.	9,297	1,904	6,956
Total Payload	lb.	44,127	44,134	44,391
Passenger Service Items	lb.	10,157	10,150	9,893
Empty Weight	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	230,284	230,284	230,284
Fuel	lb.	195,406	195,406	195,406
GROSS WEIGHT	lb.	425,690	425,690	425,690
(B) PARIS TO NEW YORK				
No. of Passengers		156	169	74 Standard 89 Tourist
Passengers and Baggage	lb.	33,540	34,645	34,155
Cargo	lb.	92	104	57
Total Payload	lb.	33,632	34,749	34,212
Passenger Service Items ★	lb.	9,868	8,751	9,288
Empty Weight	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	219,500	219,500	219,500
Fuel	lb.	195,576	195,576	195,576
GROSS WEIGHT	lb.	415,076	415,076	415,076

★ Adjusted for number of passengers carried.

Note: Payload assumed identical to that calculated for Winter Conditions.

STATEMENT OF PAYLOAD AND GROSS WEIGHT
INTERNATIONAL ROUTE (N.Y. - ROME)
(Winter Conditions)

CLASS OF SERVICE		STANDARD	SKY TOURIST	MIXED
AVAILABLE PASSENGER SEATS		162	206	74 Standard 105 Tourist
CREW CARRIED		8	8	8
UNIT WEIGHT OF PASSENGERS (Including Baggage)		215	205	215 Standard 205 Tourist
(A) NEW YORK TO ROME				
No. of Passengers (Weight Limited)		127	137	74 Standard 57 Tourist
Passengers and Baggage	lb.	27,305	28,085	27,595
Cargo	lb.	5	157	110
Total Payload	lb.	27,310	28,242	27,705
Passengers Service Items *	lb.	8,474	7,542	8,079
Empty Weight	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	211,784	211,784	211,784
Fuel	lb.	210,216	210,216	210,216
GROSS WEIGHT	lb.	422,000	422,000	422,000
(B) ROME TO NEW YORK				
No. of Passengers (Weight Limited)		86	93	74 Standard 13 Tourist
Passengers and Baggage	lb.	18,490	19,065	18,575
Cargo	lb.	93	140	94
Total Payload	lb.	18,583	19,205	18,669
Passenger Service Items *	lb.	6,501	5,879	6,415
Empty Weight	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	201,084	201,084	201,084
Fuel	lb.	220,916	220,916	220,916
GROSS WEIGHT	lb.	422,000	422,000	422,000

* Adjusted for number of passengers carried.

STATEMENT OF PAYLOAD AND GROSS WEIGHT

DOMESTIC ROUTES (N.Y. - S.F.)
(N.Y. - CHI.)

(Summer and Winter)

CLASS OF SERVICE		STANDARD	SKY TOURIST	MIXED
NO. OF PASSENGERS ★		162	206	74 Standard 105 Tourist
NO. OF CREW		7	7	7
UNIT WEIGHT OF PASSENGERS (Including Baggage)		195	195	195
Passengers and Baggage ★	lb.	31,590	40,170	34,905
Cargo ★	lb.	17,400	16,100	17,400
Total Payload ★	lb.	48,990	56,270	52,305
Passenger Service Items	lb.	5,664	4,367	4,877
Empty	lb.	176,000	176,000	176,000
Zero Fuel Gross Weight	lb.	230,654	236,637	233,182

Gross Weights for Maximum Weight Version (Sky Tourist):

(A) NEW YORK - SAN FRANCISCO

ROUTE	N.Y. - S.F.	S.F. - N.Y.	N.Y. - S.F.	S.F. - N.Y.
CONDITION	Winter	Winter	Summer	Summer
Fuel -lb.	147,396	119,416	140,676	123,316
Gross Weight -lb.	384,533	356,053	377,313	359,953

(B) NEW YORK - CHICAGO

ROUTE	N.Y. - CHI.	CHI. - N.Y.	N.Y. - CHI.	CHI. - N.Y.
CONDITION	Winter	Winter	Summer	Summer
Fuel - lb.	68,926	58,216	67,306	58,426
Gross Weight- lb.	305,563	294,853	304,443	295,063

★ Payload is Space-Limited at these short ranges.

OPERATING COSTS

Reference: TWA Staff Engineering Report No. 3-2053, revised June 15, 1955.

The operating costs presented in this brochure are based on the method given in the above report. Agreement has been reached with TWA to deviate from some of the values quoted in the above report, and in such cases the revised assumptions are stated below.

Utilization

8 block hours per day assumed - 2920 hrs. per year.

Flight Crew

Composition - International, Four (Capt., 1st Off., F/E, Nav.)
Domestic, Three (Capt., 1st.Off., F/E)

Flight Crew Block Hours = 74 per month.

Salaries per A/C Block Hour:

Capt. & 1st Officer's Mileage Pay:

Block Speed - mph	300	400	500	600
International	$35.55	37.90	40.15	42.50
Domestic	$35.55	37.90	40.15	42.50

Capt. & 1st Officer's Base Pay:

International	$12.77
Domestic	$ 8.12

Flight Engineer's Mileage Pay

Block Speed - mph	300	400	500	600
International	$8.90	9.52	10.13	10.77
Domestic	$7.89	8.47	9.12	9.74

Flight Engineer's & Navigator's Base Pay

International	$11.93
Domestic (F/E only)	$ 3.61

Flight Crew Expenses per A/C Block Hour:

International = 4 x 1.25 = $5.00
Domestic = 3 x 1.25 = $3.75

Aircraft Insurance

$79.50 per aircraft block hour based on assumed aircraft purchase price of $7,100,000.

Gasoline & Oil

Cost per aircraft block hour:

$$\text{International} = \$18.90 + \$0.0335 \times \frac{\text{Block Fuel Wt.(lb.)}}{\text{Block Time (hrs.)}} \quad \text{- Westbound}$$

$$= \$18.90 + \$0.025 \times \frac{\text{Block Fuel Wt.(lb.)}}{\text{Block Time (hrs.)}} \quad \text{- Eastbound}$$

$$\text{Domestic} = \$18.90 + \$0.025 \times \frac{\text{Block Fuel Wt.(lb.)}}{\text{Block Time (hrs.)}}$$

Fuel for holding is not considered as consumed for cost purposes. The 5% increase in SFC required over the block distance is accounted for in the costs.

Maintenance

Airframe Labour per aircraft block hour = $49.40
based on $A_{f_{wt}}$ = 150,000 lb.

Airframe Material per aircraft block hour = $55.75
based on airframe cost assumed at $5,840,000

Engine Labour per aircraft block hour = $14.00
based on 800 hour overhaul period.

Engine Material per aircraft block hour = $325.00
based on 800 hour overhaul period and assumed cost per engine of $210,000.

Other Labour & Materials per aircraft block hour = $5.10.

Depreciation

Seven year depreciation period assumed. Effect of 10 year period is as follows:

		7 yrs.	10 yrs.
Direct Cost per 200 lb. mile	(standard)	1.54¢	1.43¢
	(coach)	1.60¢	1.50¢

Aircraft - per aircraft block hour $329.00
Engines - " " " " $ 35.10
Other Flight Equipment - per aircraft block hour $82.25

Passenger Service Expenses

Cabin Attendants

Composition, International & Domestic - Four (Purser + 3 Hostesses)

Cabin Crew Block Hour = 68 per month.

Salaries per aircraft block hour, International = $19.20
Domestic = $16.50.

Travel Expenses per aircraft block hour, International = $5.60
Domestic = $4.00

Passenger Liability Insurance (variable with passenger load factor)

Per Aircraft Block Hour:

Block Speed (mph)	300	400	500	600
No. Passengers				
162	$18.23	24.30	30.35	36.45
179	$20.15	26.85	33.55	40.25
206	$23.15	30.90	38.60	46.30

Passenger Food Supplies (variable with passenger load factor)

Per Aircraft Block Hour:

Block Speed (mph)	300	400	500	600
No. Passengers				
International				
162	$130.70	174.20	218.00	261.50
179	$144.40	192.70	240.50	289.00
206	$166.30	221.50	277.00	332.50
Domestic				
162	$ 97.80	130.40	163.00	195.50
179	$108.00	144.00	180.00	216.00
206	$124.40	166.00	207.00	248.00

These costs warrant review since it is implied that food costs increase with block speed, whereas the reverse should apply.

Indirect Operating Costs

1.10 x (Total Direct Flying Costs - Direct Passenger Flying Costs - Depreciation and Rental Costs).

Revenue Rates

As per TWA method. Wherever practical the proportions of mail, express and cargo have been adjusted to give an average revenue of $0.70 per ton mile international and $0.35 per ton mile domestic.

Routes

Analysis based on TWA method for 70% performance under Winter and Summer conditions. Holding and alternate allowances in accordance with TWA method. Altitude for holding and diversion assumed to be 15,000 ft. for all routes.

Under Standard Temperature conditions, T_S, the 70% Winter performance conditions establish the economic boundaries, i.e. with high winter tail winds the block speed and payload are high with a corresponding low cost, with high winter headwinds the block speed and payload are low with corresponding high operating cost. Route economics for Summer operation lie between these two Winter extremes.

VOLUMETRIC PAYLOADS

	lb.
International Standard Class	
162 Passengers at 215 lb. (74 Upper with Lounge, 88 Lower)	34,830
Cargo at 10 lb./ cu.ft.	14,200
	49,030
International Coach Class	
206 Passengers at 205 lb. (101 Upper, 105 Lower)	42,230
Cargo at 10 lb./cu.ft.	14,000
	56,230
International Standard & Coach Class	
74 Passengers Standard (Upper) at 215 lb. = 15,910) 105 Passengers Coach (Lower) at 205 lb. = 21,525)	37,435
Cargo at 10 lb./cu.ft.	14,400
	51,835
Domestic Standard Class	
162 Passengers at 195 lb.	31,590
Cargo at 10 lb./cu.ft.	17,400
	48,990
Domestic Coach Class	
206 Passengers at 195 lb.	40,170
Cargo at 10 lb./cu.ft.	16,100
	56,270
Domestic Standard & Coach Class	
74 Standard + 105 Coach at 195 lb.	34,905
Cargo at 10 lb./cu.ft.	17,400
	52,305

The cargo loads quoted represent the volume remaining for revenue earning cargo and mail after deducting the volume required for carriage of passengers' baggage allowance.

For the route economics presented some of the payloads considered are below volumetric in order that a take-off weight of 422,000 lb. is not exceeded. With this limitation of 422,000 lb. a CAR field length of 9000 ft. is maintained under standard conditions at temperature Ts. Increases in this take-off weight may be obtained by increasing the allowable CAR field length or assuming engines of higher take-off thrust than presently envisaged.

VOLUMETRIC PAYLOAD WITH 20 FT. FUSELAGE EXTENSION

	lb.
International Standard Class	
210 Passengers at 215 lb. (98 Upper with Lounge, 112 Lower)	45,150
Cargo at 10 lb./cu.ft.	15,100
	60,250
International Coach Class	
266 Passengers at 205 lb. (131 Upper, 135 Lower)	54,530
Cargo at 10 lb./cu.ft.	14,900
	69,430
International Standard & Coach Class	
98 Passengers Standard (Upper) at 215 = 21,070)	48,745
135 Passengers Coach (Lower) at 205 = 27,675)	
Cargo at 10 lb./cu.ft.	15,300
	64,045
Domestic Standard Class	
210 Passengers at 195 lb.	40,950
Cargo at 10 lb./cu.ft.	19,300
	60,250
Domestic Coach Class	
266 Passengers at 195 lb.	51,870
Cargo at 10 lb./cu.ft.	17,600
	69,470
Domestic Standard & Coach Class	
98 Standard + 135 Coach at 195	45,435
Cargo at 10 lb./cu.ft.	19,100
	64,535

The above shows some of the potential stretch of the design by increasing the length of the fuselage 20 ft. - 10 ft. ahead of the wing and 10 ft. behind. No performance or economic analyses of this development have been made at this stage. Introduction of such a model awaits the development of higher thrust engines if the take-off and climb characteristics of the aircraft are not to be prejudiced.

DIRECT OPERATING COSTS (PER A/C BLOCK HOUR)

	70% WINTER, Ts	
	N.Y. - PARIS	PARIS - N.Y.
Salaries		
Captains & 1st Officers Mileage Pay	41.87	39.97
Captains & 1st Officers Base Pay	12.77	12.77
Flight Engineer's Mileage Pay	10.60	10.08
F/E & Navigator's Base Pay	11.93	11.93
Total Salaries	77.17	74.75
Gasoline & Oil	581.40	757.90
Flight Crew Expenses	5.00	5.00
Insurance - Aircraft	79.50	79.50
Sub-Total	665.90	842.40
Maintenance		
Aircraft - Labour	49.40	49.40
Aircraft - Materials	55.75	55.75
Engine - Labour	14.00	14.00
Engine - Materials	325.00	325.00
Other - Labour & Materials	5.10	5.10
Total Maintenance	449.25	449.25
Depreciation & Rental		
Aircraft	329.00	329.00
Engine	35.10	35.10
Other Flight Equipment	82.25	82.25
Total Depreciation & Rental	446.35	446.35
Total Aircraft Direct Operating Costs	1638.67	1812.75

Direct Passenger Flying Costs	Standard	Coach	Standard	Coach
Salaries - Cabin Attendants	19.20	19.20	19.20	19.20
Cabin Attendants' Expenses	5.60	5.60	5.60	5.60
Variable with Load Factor (Insurance - Passenger Liability	34.80	44.22	28.73	31.15
(Passenger Supplies & Food Expenses	249.75	317.50	206.50	224.00
Total Passenger Flying Costs	309.35	386.52	260.03	279.95
Total Direct Flying Costs	1948.02	2025.19	2072.78	2092.70

DIRECT OPERATING COST
(Including Passenger Flying Costs)
N.Y – PARIS – N.Y (70% WINTER, T_s)

T.O. GROSS WEIGHT = 422,000 LB.
UTILIZATION - 8 BLOCK HOURS/DAY

	N.Y. - PARIS		PARIS - N.Y.	
Cruise Speed M = .90	595 mph		595 mph	
Block Speed	573 mph		492 mph	
Payload	44,127 lb.		33,626 lb. (Standard 34,743 lb. (Coach)	
	Standard	Coach	Standard	Coach
Passengers	162	206	156	169
Mail	4000 lb.	1904 lb.	86 lb.	98 lb.
Cargo	5297 lb.	- lb.	- lb.	- lb.

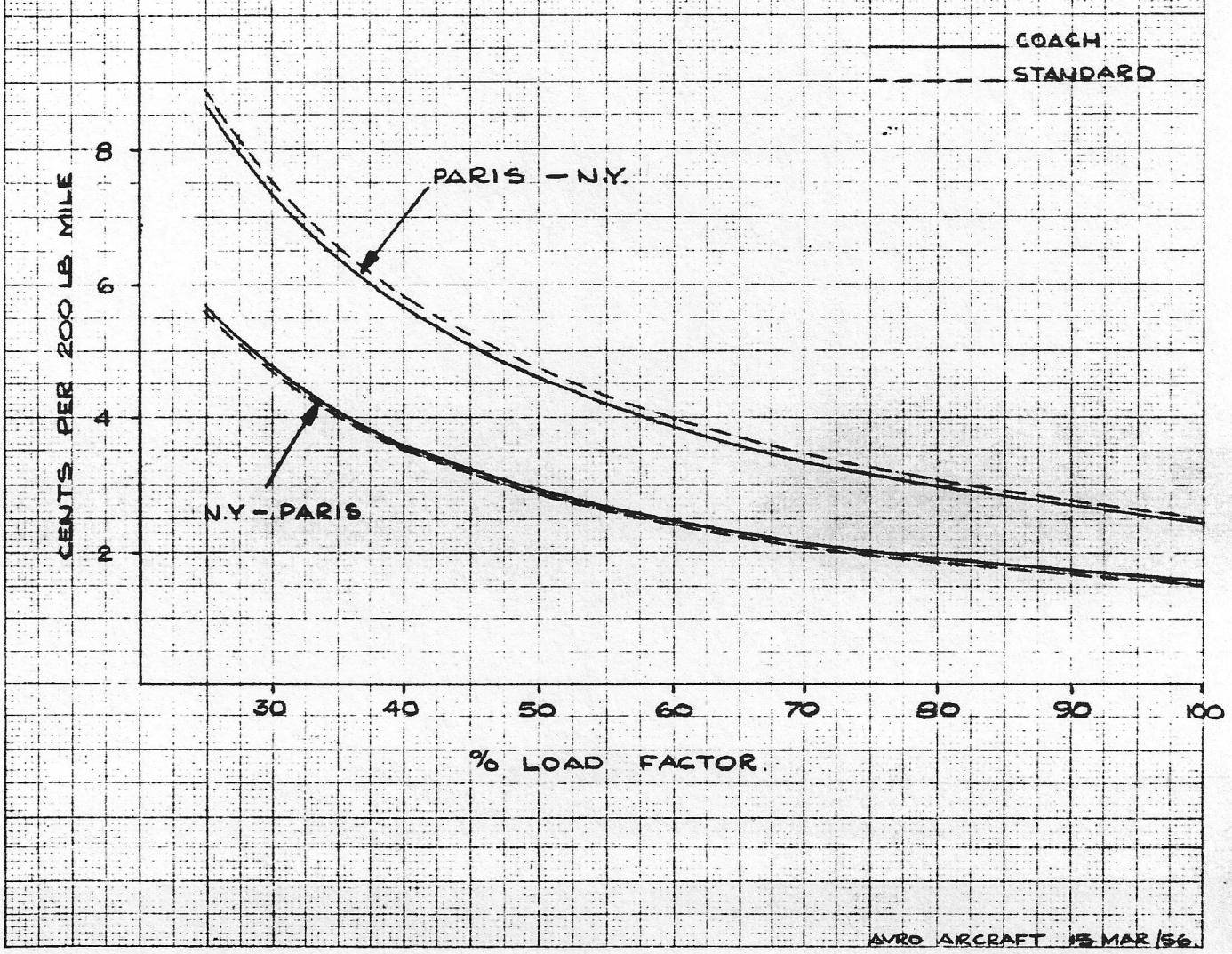


FIG. 18

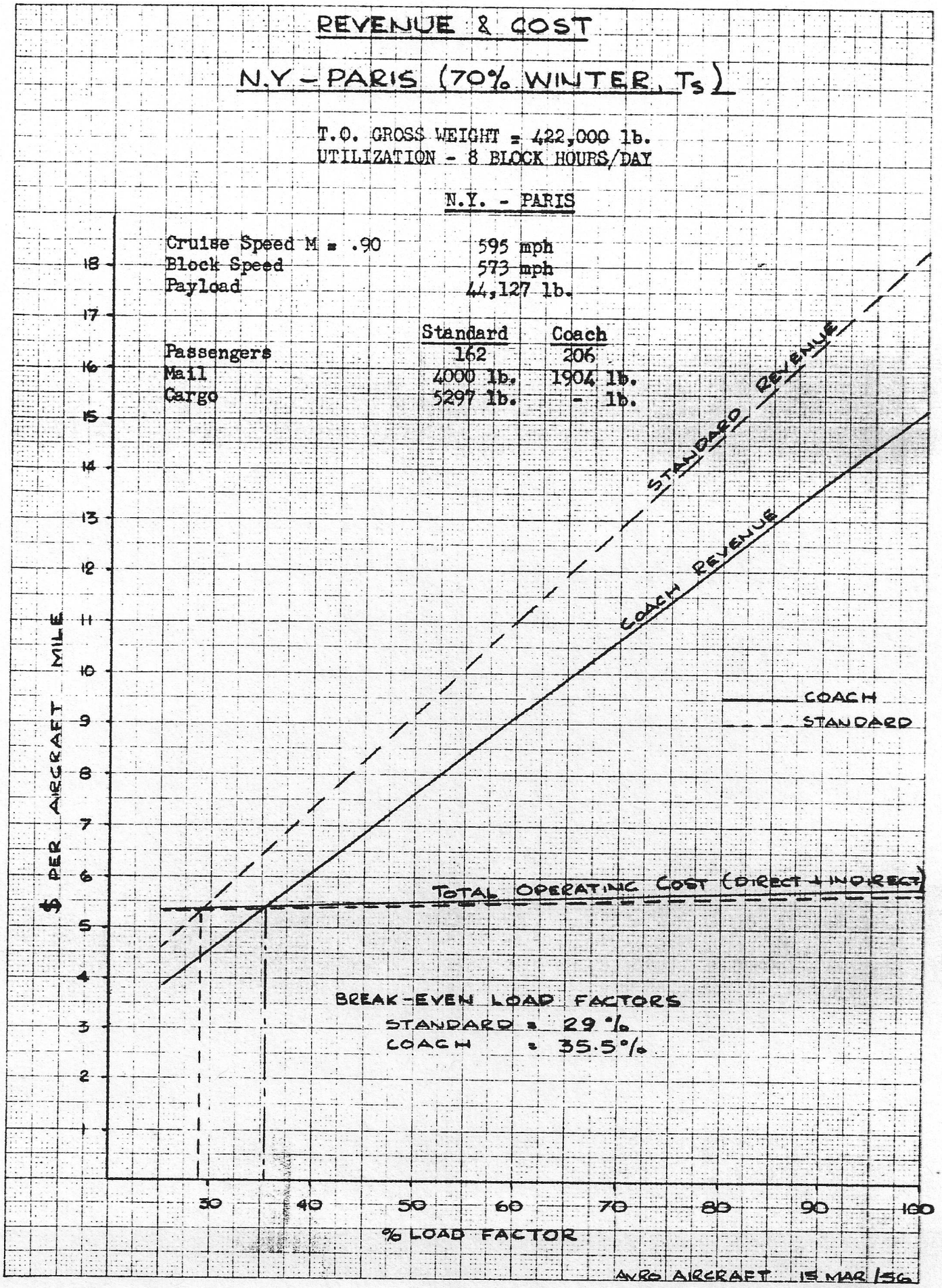

REVENUE & COST
N.Y - PARIS (70% WINTER, Ts)
T.O. GROSS WEIGHT = 422,000 lb.
UTILIZATION - 8 BLOCK HOURS/DAY
N.Y. - PARIS
Cruise Speed M = .90 595 mph
Block Speed 573 mph
Payload 44,127 lb.
Standard Coach
Passengers 162 206
Mail 4000 lb. 1904 lb.
Cargo 5297 lb. - lb.
STANDARD REVENUE
COACH REVENUE
COACH
STANDARD
TOTAL OPERATING COST (DIRECT + INDIRECT)
BREAK-EVEN LOAD FACTORS
STANDARD = 29 %
COACH = 35.5 %
$ PER AIRCRAFT MILE
% LOAD FACTOR
AVRO AIRCRAFT 15 MAR 1956

FIG. 19

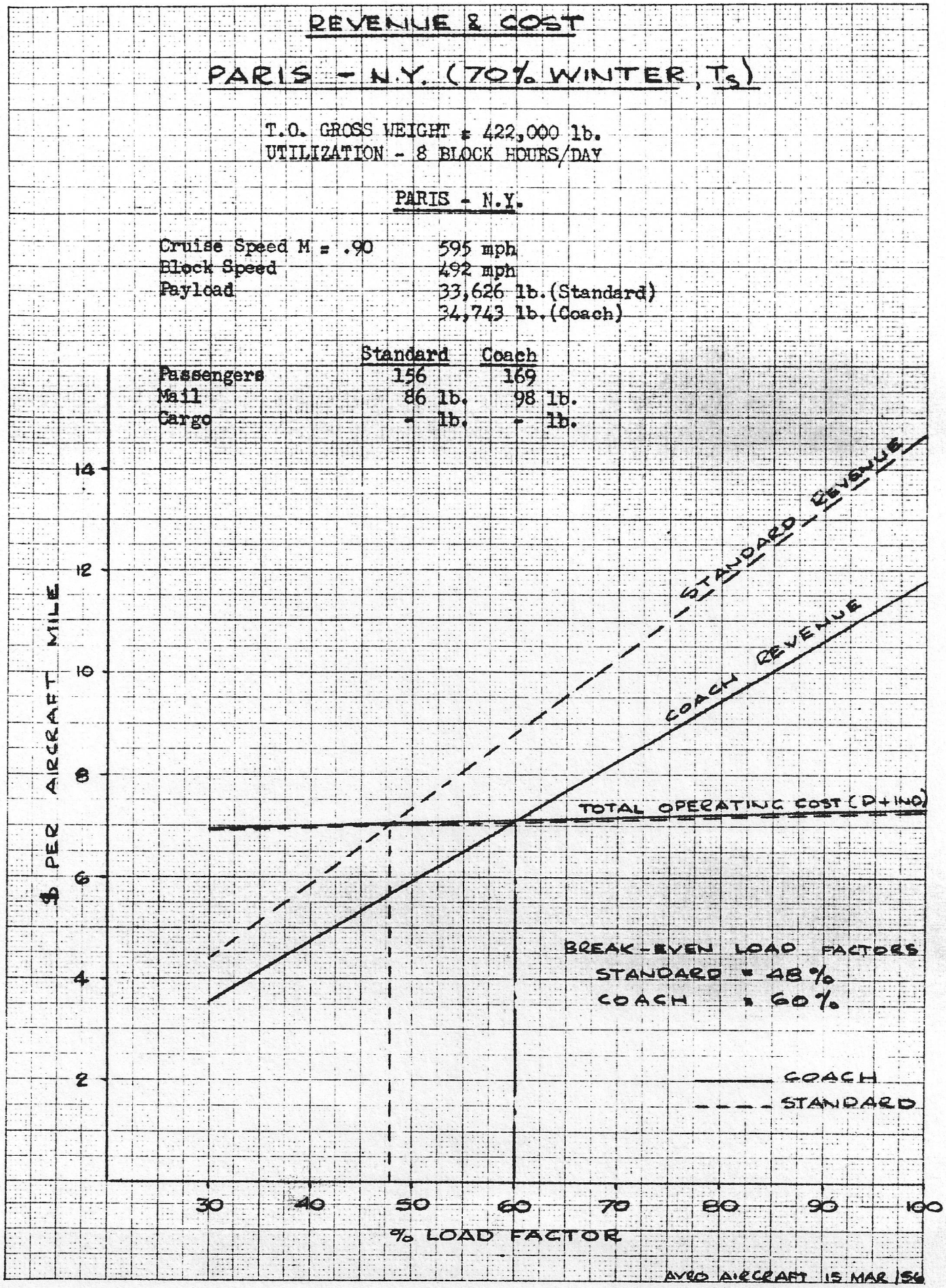

REVENUE & COST
PARIS - N.Y. (70% WINTER, Ts)
T.O. GROSS WEIGHT = 422,000 lb.
UTILIZATION - 8 BLOCK HOURS/DAY
PARIS - N.Y.
Cruise Speed M = .90 595 mph
Block Speed 492 mph
Payload 33,626 lb. (Standard)
34,743 lb. (Coach)
Standard Coach
Passengers 156 169
Mail 86 lb. 98 lb.
Cargo - lb. - lb.
$ PER AIRCRAFT MILE
14
12
10
8
6
4
2
STANDARD REVENUE
COACH REVENUE
TOTAL OPERATING COST (D+INO)
BREAK-EVEN LOAD FACTORS
STANDARD = 48%
COACH = 60%
COACH
STANDARD
30
40
50
60
70
80
90
100
% LOAD FACTOR
AVRO AIRCRAFT 15 MAR 56

FIG. 20

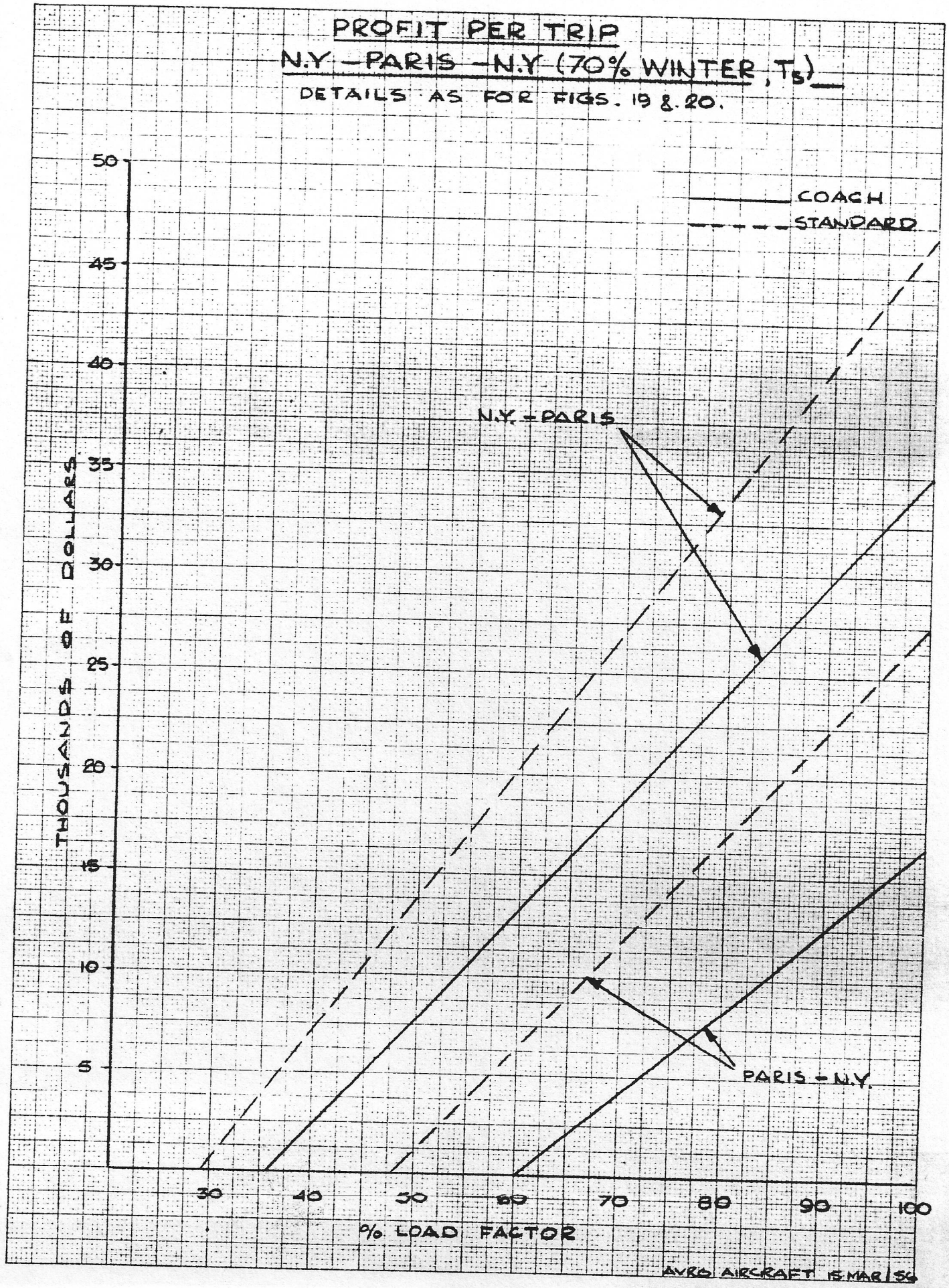

PROFIT PER TRIP
N.Y. – PARIS – N.Y. (70% WINTER, T_5)
DETAILS AS FOR FIGS. 19 & 20.
COACH
STANDARD
N.Y. – PARIS
PARIS – N.Y.
THOUSANDS OF DOLLARS
50
45
40
35
30
25
20
15
10
5
30
40
50
60
70
80
90
100
% LOAD FACTOR
AVRO AIRCRAFT 15 MAR 56

FIG. 21

AIRCRAFT DIRECT OPERATING COSTS (PER AIRCRAFT BLOCK HOUR)

	70% WINTER, Ts	
SALARIES	N.Y.-S.F.	S.F.-N.Y.
Captains and First Officers Mileage Pay	39.34	41.84
Captains and First Officers Base Pay	8.12	8.12
Flight Engineer's Mileage Pay	8.89	9.57
Flight Engineer's Base Pay	3.61	3.61
Total Salaries	59.96	63.14
GASOLINE & OIL	556.90	540.90
FLIGHT CREW EXPENSES	3.75	3.75
INSURANCE - AIRCRAFT	79.50	79.50
Sub-Total	640.15	624.15
MAINTENANCE		
Aircraft - Labour	49.40	49.40
Aircraft - Materials	55.75	55.75
Engines - Labour	14.00	14.00
Engines - Materials	325.00	325.00
Other - Labour & Materials	5.10	5.10
Total Maintenance	449.25	449.25
DEPRECIATION & RENTAL		
Aircraft	329.00	329.00
Engines	35.10	35.10
Other Flight Equipment	82.25	82.25
Total Depreciation & Rental	446.35	446.35
Total Aircraft Operating Costs	1595.71	1582.89

	DIRECT PASSENGER FLYING COSTS	STANDARD	COACH	STANDARD	COACH
	Salaries - Cabin Attendants	16.50	16.50	16.50	16.50
	Cabin Attendants Expenses	4.00	4.00	4.00	4.00
Variable with Passenger L.F.	Insurance - Passenger Liability	28.17	35.83	34.74	44.14
	Passenger Supplies & Food Expenses	151.25	192.25	186.40	236.50
	Total Passenger Flying Costs	199.92	248.58	241.64	301.14
	Total Direct Flying Costs	1795.63	1844.29	1824.53	1884.03

DIRECT OPERATING COST
(Including Passenger Flying Costs)
N.Y. – S.F – N.Y. (70% WINTER, T_S)

UTILIZATION = 8 BLOCK HOURS PER DAY

	N.Y. - S.F.		S.F. - N.Y.	
T.O. GROSS WEIGHT - STANDARD	378,550 lb.		350,070 lb.	
- COACH	384,533 lb.		356,053 lb.	
CRUISE SPEED M = .90	595 mph		595 mph	
BLOCK SPEED	464 mph		572 mph	
	Standard	Coach	Standard	Coach
PAYLOAD	48,990 lb.	56,270 lb.	48,990 lb	56,270 lb.
PASSENGERS	162	206	162	206
MAIL	5,000 lb.	5,000 lb.	5,000 lb.	5,000 lb.
EXPRESS	7,000 lb.	6,000 lb.	7,000 lb.	6,000 lb.
CARGO	5,400 lb.	5,100 lb.	5,400 lb.	5,100 lb.

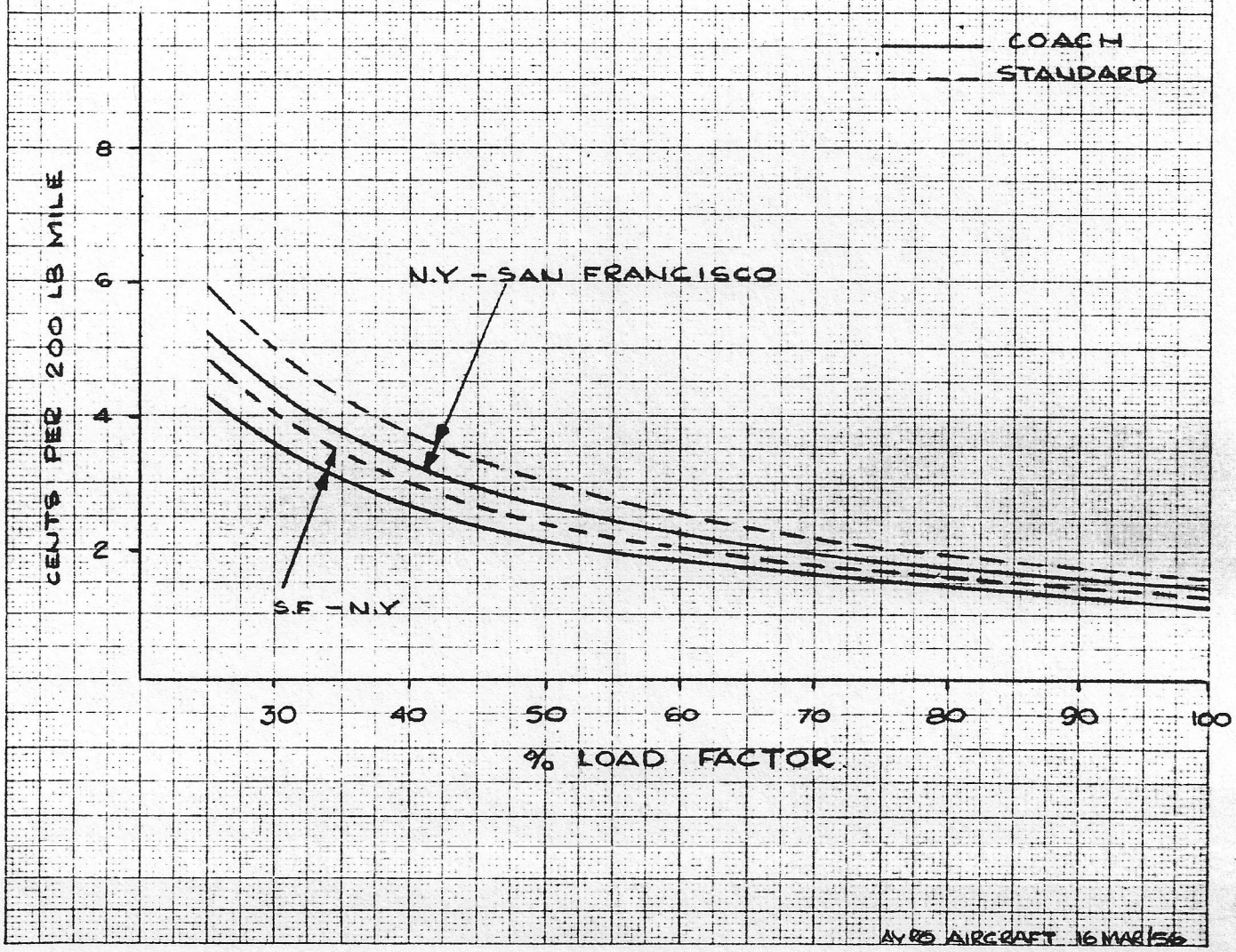


FIG. 22

REVENUE & COST

N.Y – SAN FRANCISCO (70% WINTER, T_S)

UTILIZATION = 8 BLOCK HOURS PER DAY

		N.Y. - S.F.
T.O. GROSS WEIGHT	- STANDARD	378,550 lb.
	- COACH	384,533 lb.
CRUISE SPEED M = .90		595 mph
BLOCK SPEED		464 mph

	Standard	Coach
PAYLOAD	48,990 lb.	56,270 lb.
PASSENGERS	162	206
MAIL	5,000 lb.	5,000 lb.
EXPRESS	7,000 lb.	6,000 lb.
CARGO	5,400 lb.	5,100 lb.

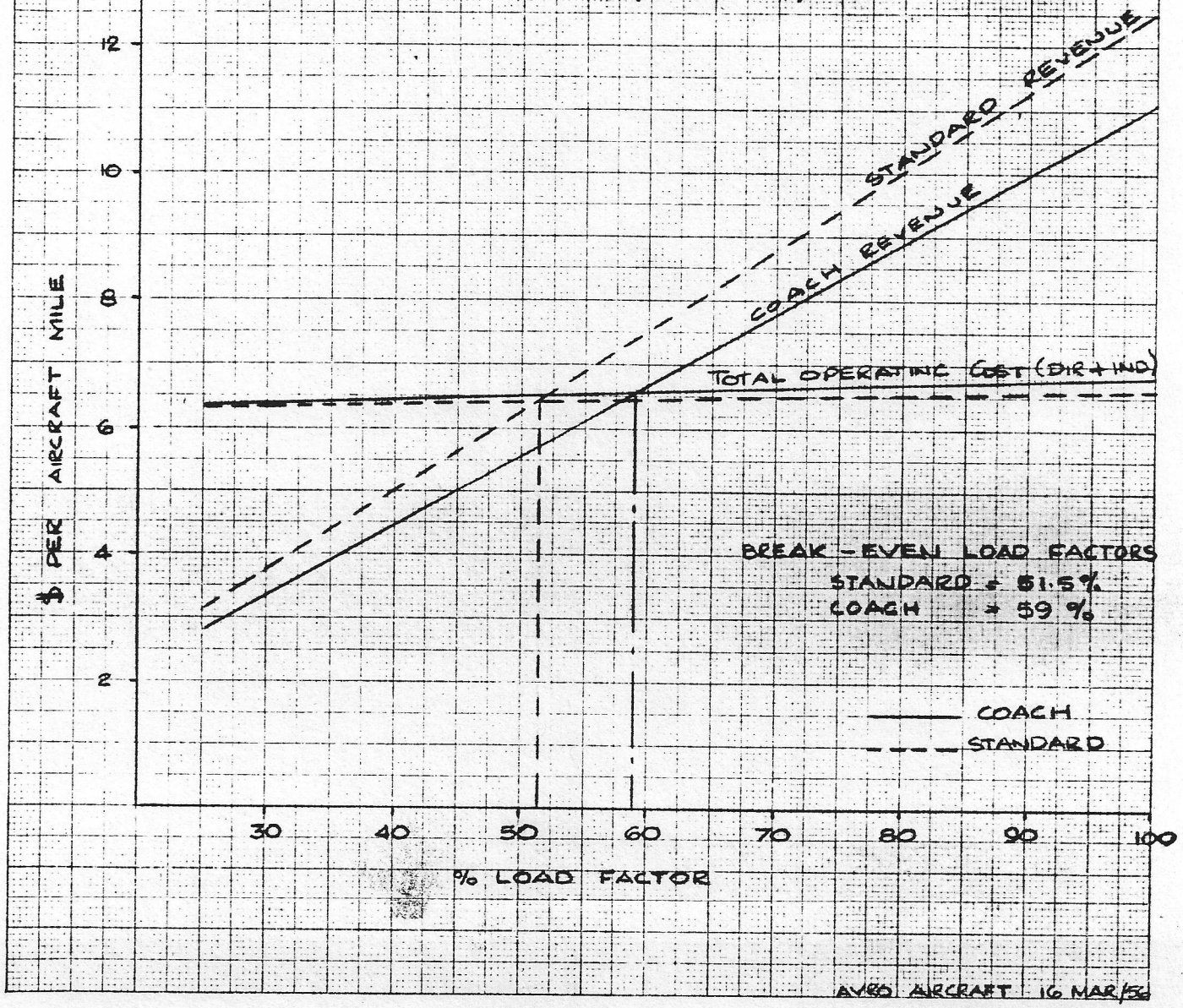


FIG. 23

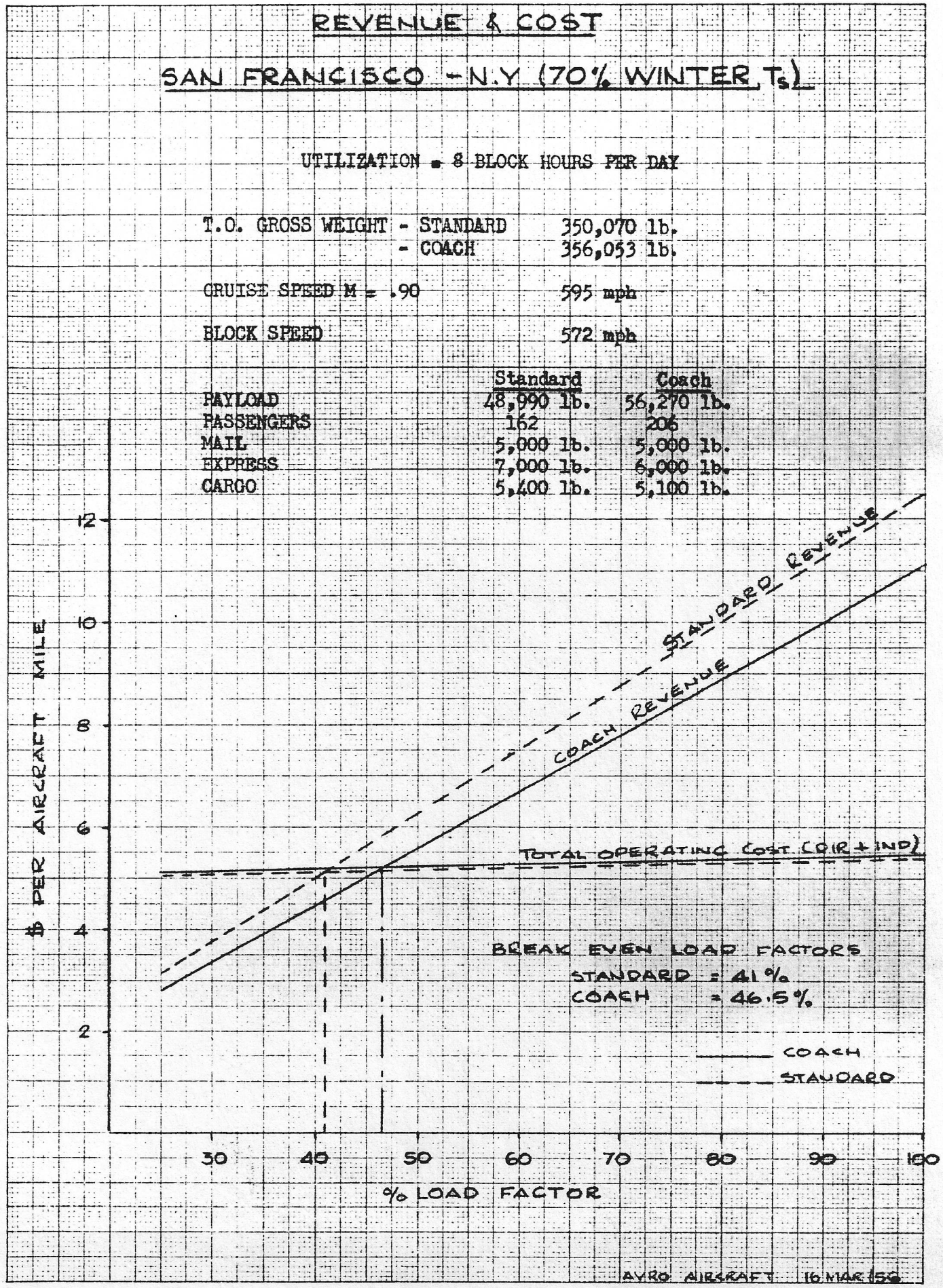

REVENUE & COST
SAN FRANCISCO - N.Y (70% WINTER Ts)
UTILIZATION = 8 BLOCK HOURS PER DAY
T.O. GROSS WEIGHT - STANDARD 350,070 lb.
- COACH 356,053 lb.
CRUISE SPEED M = .90 595 mph
BLOCK SPEED 572 mph
Standard Coach
PAYLOAD 48,990 lb. 56,270 lb.
PASSENGERS 162 206
MAIL 5,000 lb. 5,000 lb.
EXPRESS 7,000 lb. 6,000 lb.
CARGO 5,400 lb. 5,100 lb.
STANDARD REVENUE
COACH REVENUE
TOTAL OPERATING COST (DIR + IND)
BREAK EVEN LOAD FACTORS
STANDARD = 41%
COACH = 46.5%
COACH
STANDARD
$ PER AIRCRAFT MILE
2
4
6
8
10
12
30
40
50
60
70
80
90
100
% LOAD FACTOR
AVRO AIRCRAFT 16 MAR 56

FIG. 24

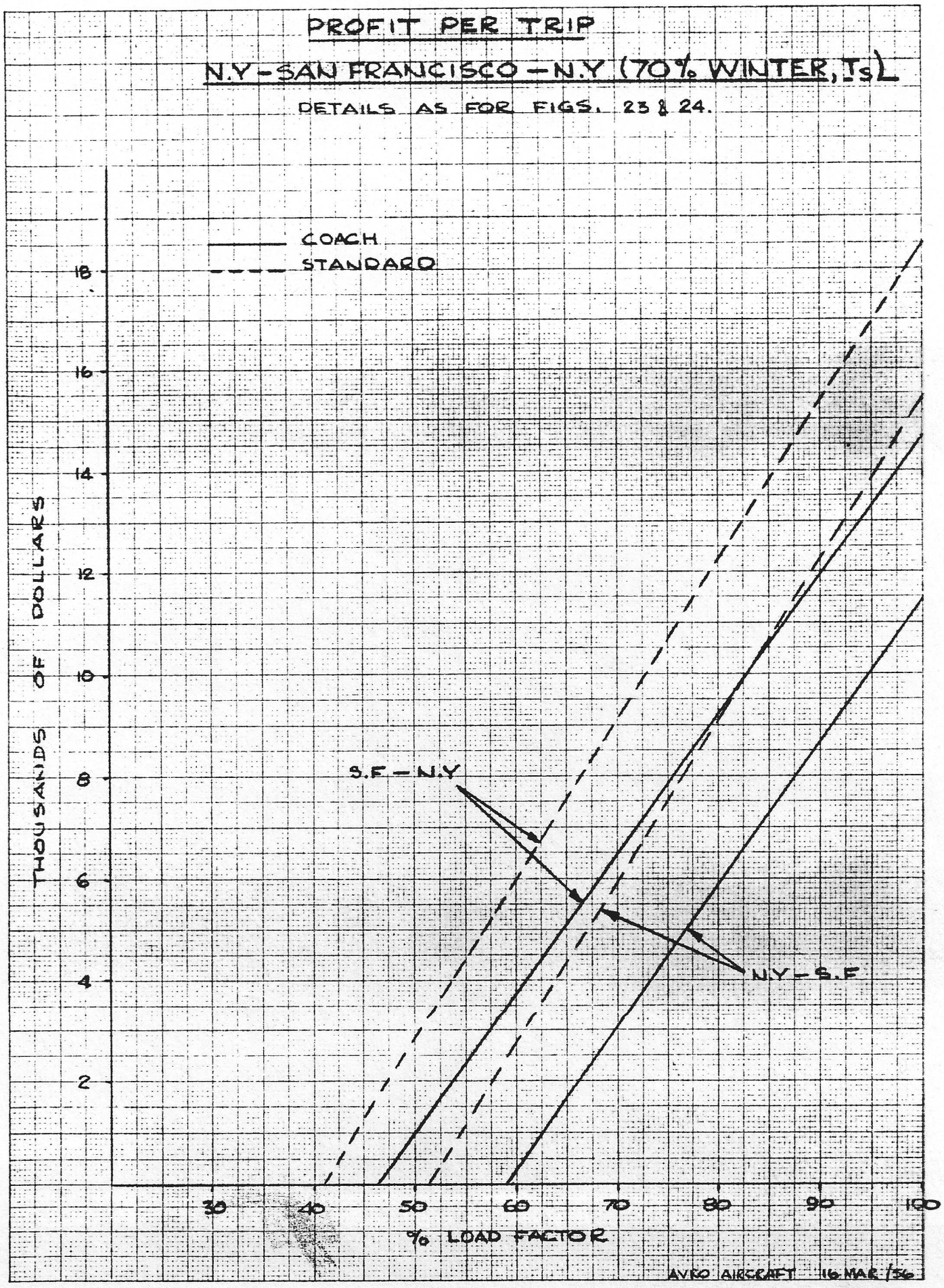

PROFIT PER TRIP
N.Y-SAN FRANCISCO-N.Y (70% WINTER, Ts)
DETAILS AS FOR FIGS. 23 & 24.
COACH
STANDARD
THOUSANDS OF DOLLARS
18
16
14
12
10
8
6
4
2
S.F-N.Y
N.Y-S.F
30
40
50
60
70
80
90
100
% LOAD FACTOR
AVRO AIRCRAFT 16 MAR. 1956

FIG. 25

AIRCRAFT DIRECT OPERATING COSTS (PER AIRCRAFT BLOCK HOUR)

	70% WINTER, Ts	
	N.Y.-Chicago	Chicago - N.Y.
SALARIES		
Captain's and 1st Officer's Mileage Pay	37.40	38.98
Captain's and 1st Officer's Base Pay	8.12	8.12
Flight Engineer's Mileage Pay	8.35	8.78
Flight Engineer's Base Pay	3.61	3.61
Total Salaries	57.48	59.49
GASOLINE & OIL	512.90	510.40
FLIGHT CREW EXPENSES	3.75	3.75
INSURANCE - AIRCRAFT	79.50	79.50
Sub-Total	596.15	593.65
MAINTENANCE		
Aircraft - Labour	49.40	49.40
Aircraft - Materials	55.75	55.75
Engines - Labour	14.00	14.00
Engines - Materials	325.00	325.00
Other - Labour and Materials	5.10	5.10
Total Maintenance	449.25	449.25
DEPRECIATION & RENTAL		
Aircraft	329.00	329.00
Engines	35.10	35.10
Other Flight Equipment	82.25	82.25
Total Depreciation & Rental	446.35	446.35
Total Aircraft Operating Cost	1549.23	1548.74

DIRECT PASSENGER FLYING COSTS	STANDARD	COACH	STANDARD	COACH
Salaries - Cabin Attendants	16.50	16.50	16.50	16.50
Cabin Attendants Expenses	4.00	4.00	4.00	4.00
Insurance - Passenger Liability	23.03	29.27	27.21	34.60
Passenger Supplies & Food Expenses	123.55	157.25	146.07	185.70
Total Passenger Flying Costs	167.08	207.02	193.78	240.80
Total Direct Flying Costs	1716.31	1756.25	1742.52	1789.54

DIRECT OPERATING COST

(including Passenger Flying Cost)

N.Y.-CHICAGO-N.Y (70% WINTER T_s)

UTILIZATION - 8 BLOCK HOURS PER DAY

	N.Y. - Chicago	Chicago - N.Y.
T.O. GROSS WEIGHT - STANDARD	299,570 lb.	288,870 lb.
- COACH	305,563 lb.	294,853 lb.
CRUISE SPEED M = .90	595 mph	595 mph
BLOCK SPEED	379 mph	448 mph

	Standard	Coach	Standard	Coach
PAYLOAD	48,990 lb.	56,270 lb.	48,990 lb.	56,270 lb.
PASSENGERS	162	206	162	206
MAIL	5,000 lb.	5,000 lb.	5,000 lb.	5,000 lb.
EXPRESS	7,000 lb.	6,000 lb.	7,000 lb.	6,000 lb.
CARGO	5,400 lb.	5,100 lb.	5,400 lb.	5,100 lb.

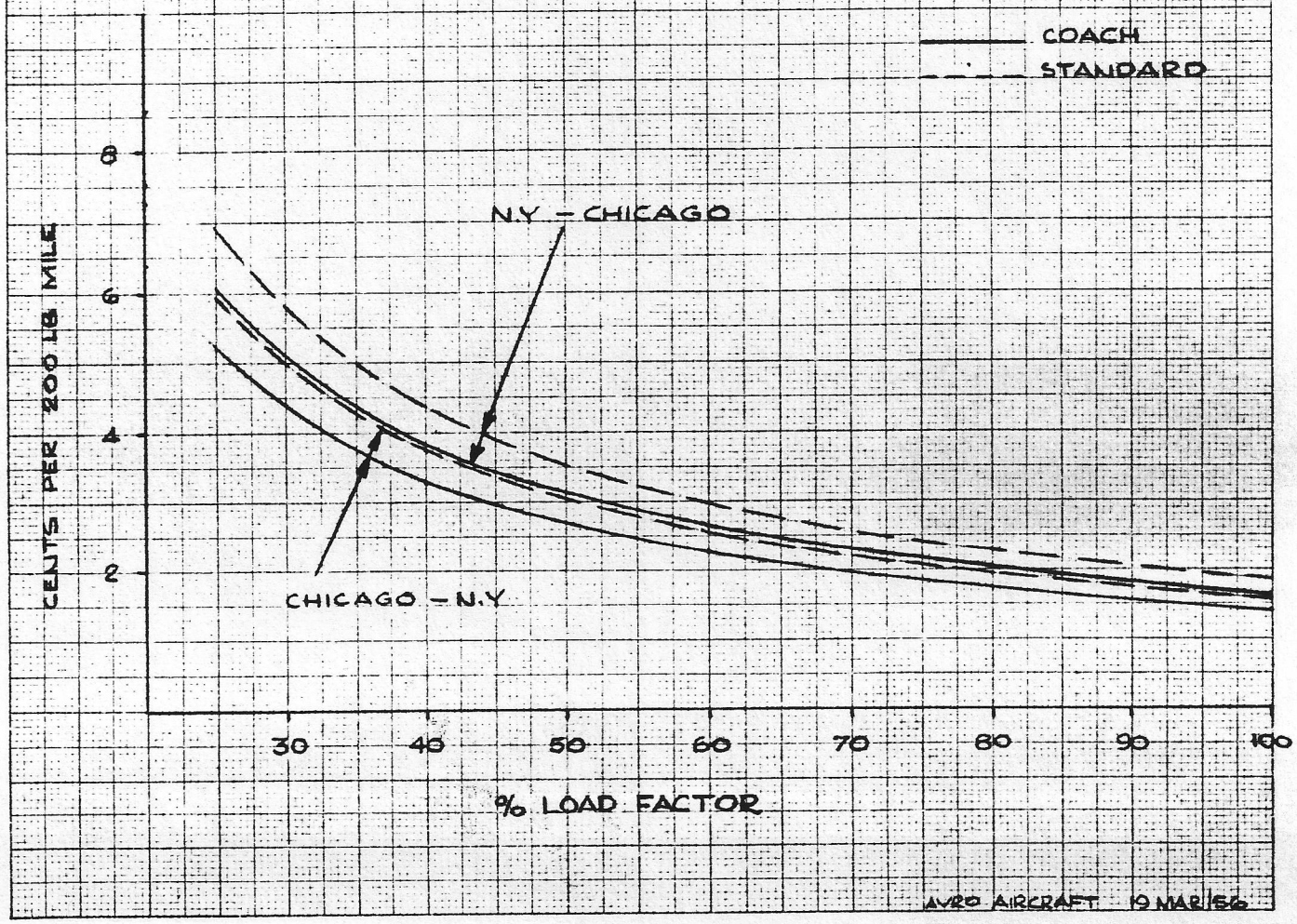


FIG. 26

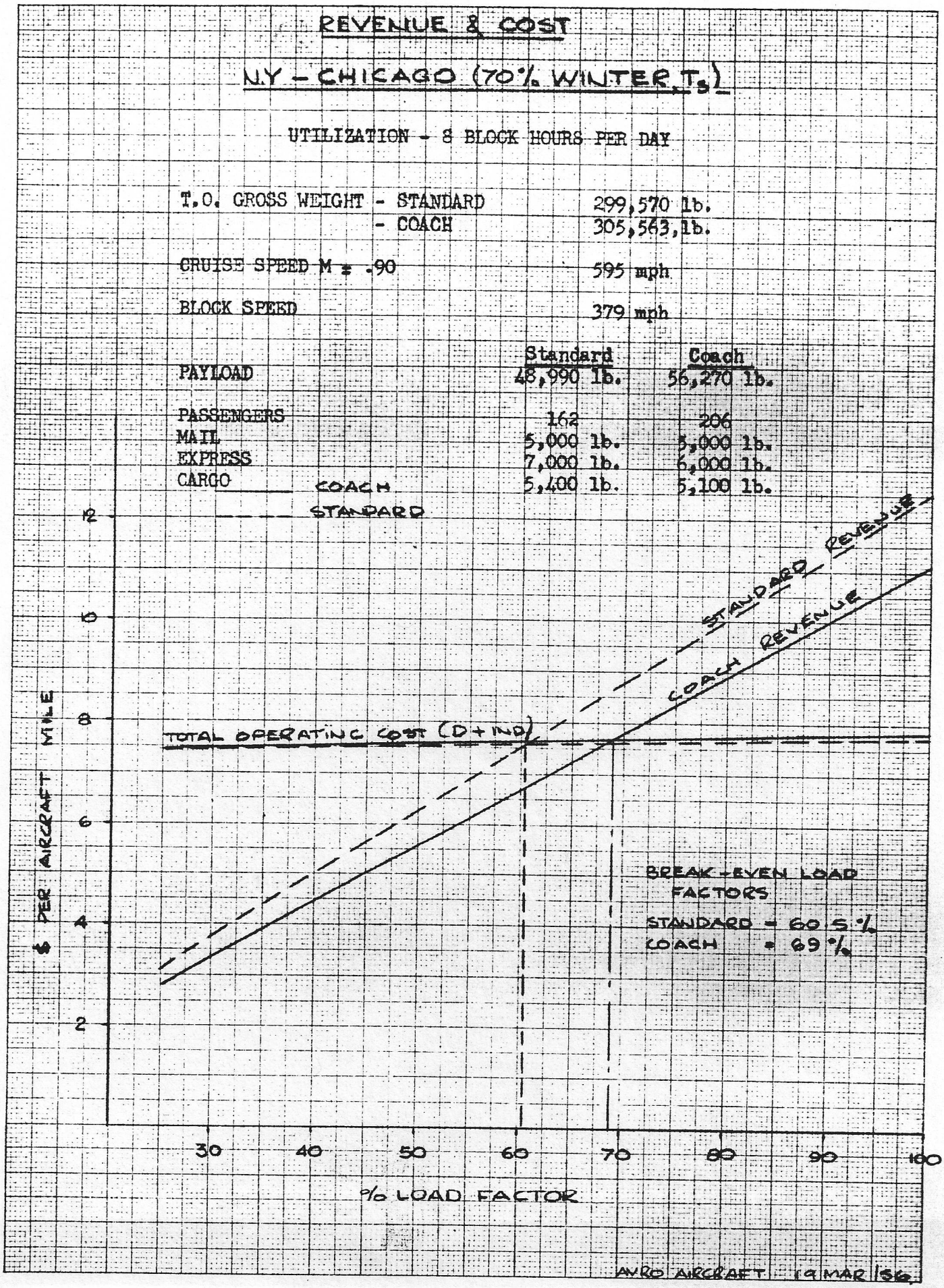

REVENUE & COST
N.Y - CHICAGO (70% WINTER T.)
UTILIZATION - 8 BLOCK HOURS PER DAY
T.O. GROSS WEIGHT - STANDARD 299,570 lb.
- COACH 305,563 lb.
CRUISE SPEED M = .90 595 mph
BLOCK SPEED 379 mph
Standard Coach
PAYLOAD 48,990 lb. 56,270 lb.
PASSENGERS 162 206
MAIL 5,000 lb. 5,000 lb.
EXPRESS 7,000 lb. 6,000 lb.
CARGO 5,400 lb. 5,100 lb.
COACH
STANDARD
STANDARD REVENUE
COACH REVENUE
TOTAL OPERATING COST (D + IND)
BREAK-EVEN LOAD FACTORS
STANDARD = 60.5 %
COACH = 69 %
$ PER AIRCRAFT MILE
2
4
6
8
10
12
30
40
50
60
70
80
90
100
% LOAD FACTOR
AVRO AIRCRAFT 19 MAR 1956

FIG. 27

REVENUE & COST

CHICAGO – N.Y (70% WINTER T_s)

UTILIZATION - 8 BLOCK HOURS PER DAY

T.O. GROSS WEIGHT - STANDARD	288,870 lb.	
- COACH	294,853 lb.	
CRUISE SPEED M = .90	595 mph	
BLOCK SPEED	448 mph	
	Standard	Coach
PAYLOAD	48,990 lb.	56,270 lb.
PASSENGERS	162	206
MAIL	5,000 lb.	5,000 lb.
EXPRESS	7,000 lb.	6,000 lb.
CARGO	5,400 lb.	5,100 lb.

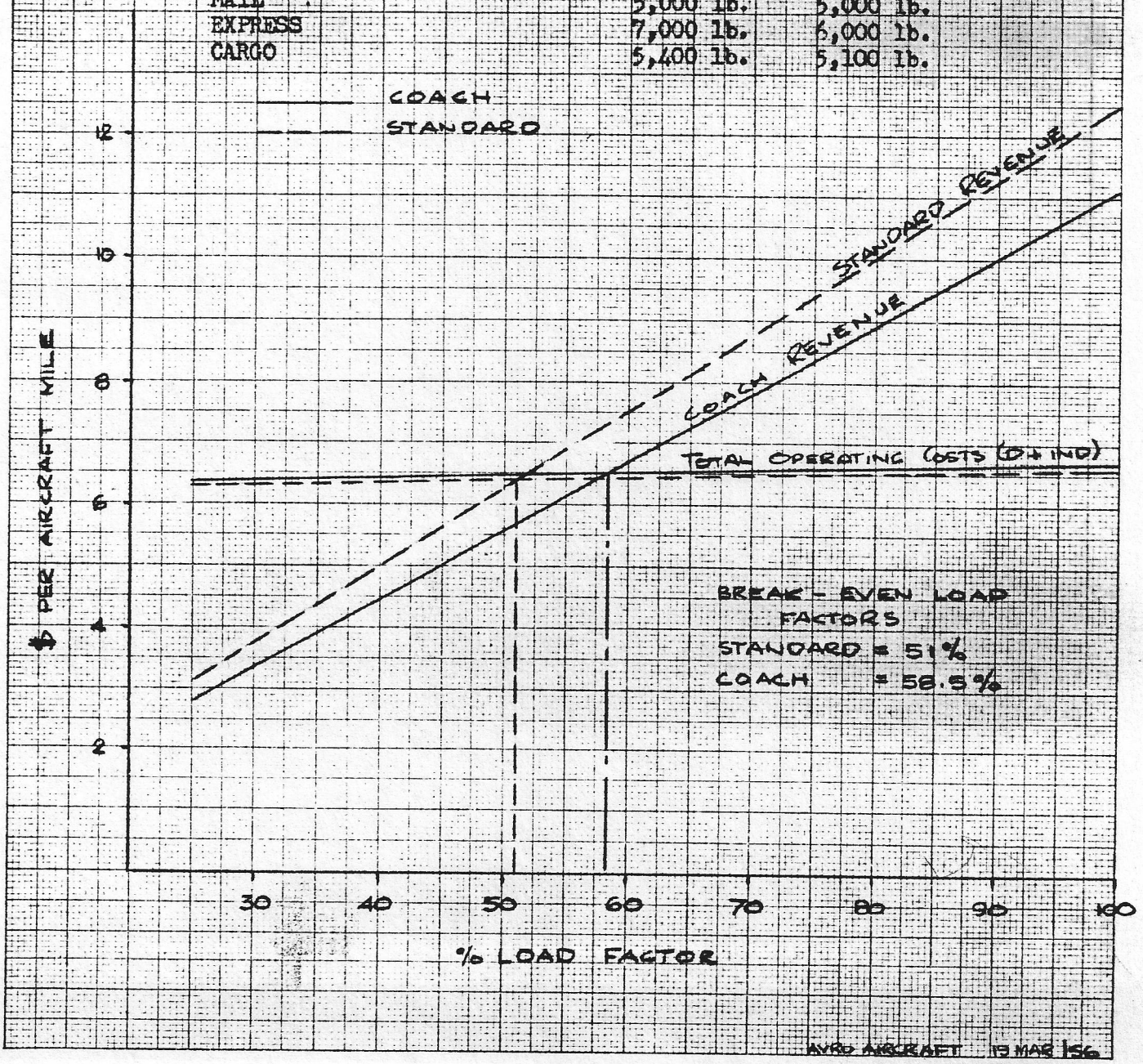


FIG. 28

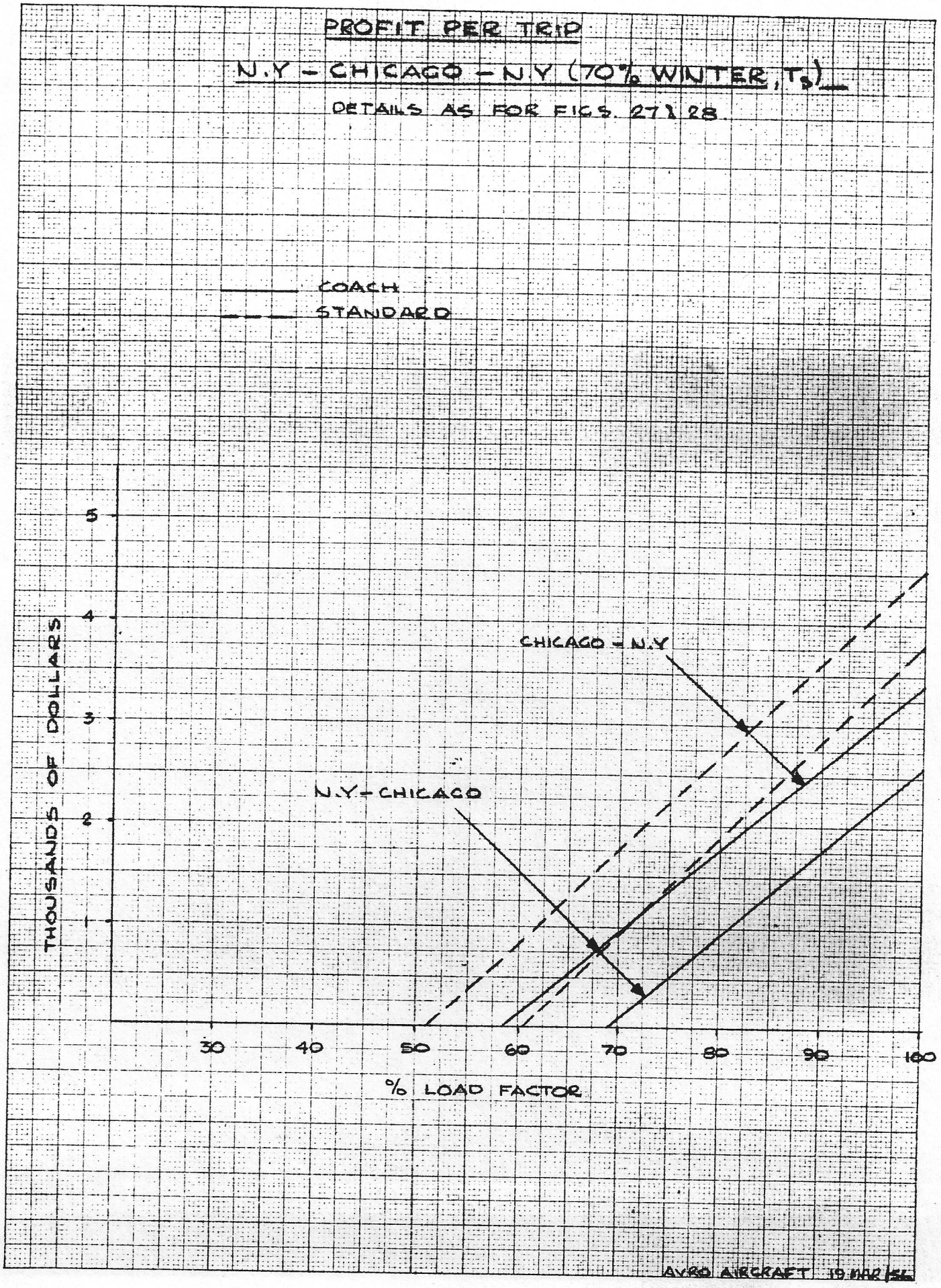

PROFIT PER TRIP
N.Y - CHICAGO - N.Y (70% WINTER, T_s)
DETAILS AS FOR FIGS. 27 & 28
COACH
STANDARD
THOUSANDS OF DOLLARS
5
4
3
2
1
CHICAGO - N.Y
N.Y - CHICAGO
30
40
50
60
70
80
90
100
% LOAD FACTOR
AVRO AIRCRAFT 19 MAR 56

FIG. 29