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JULY 1965

CALCULATED HEAT TRANSFER AND COOLING SYSTEM PERFORMANCE, VOLUME II

XV-5A

LIFT FAN FLIGHT RESEARCH AIRCRAFT PROGRAM

CONTRACT NUMBER DA44-177-TC-715

GENERAL ELECTRIC

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CALCULATED HEAT TRANSFER AND COOLING SYSTEM PERFORMANCE

Volume II

XV-5A LIFT FAN

FLIGHT RESEARCH AIRCRAFT PROGRAM

Contract DA 44-177-TC-715

June 1965

ADVANCED ENGINE AND TECHNOLOGY DEPARTMENT
GENERAL ELECTRIC COMPANY
CINCINNATI, OHIO 45215

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PREFACE

This report presents calculated heat transfer and cooling system performance for the U.S. Army XV-5A Lift Fan Research Aircraft. The report is submitted in two volumes, and this is Volume II.

Volume I contains the results of analysis and presents heat transfer and cooling performance characteristics. Volume II contains supporting data including test results providing the basis for estimates of external airframe heating, methods used in calculation of cooling system performance and an analysis of structural protection systems.

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9.1 REFERENCES

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9.2 SYMBOLS AND ABBREVIATIONS

Symbol	Description
A	Heat Transfer Area Normal to Direction of Flow
A_{DUCT}	Cross-Sectional Area of Duct Branch in Question
A_f	Radiative Heat Transfer Area Factor
A_F	Wing Fan Area
A_{fF}	Area of Duct Facing Floor of Engine Bay
$A_{Flapper}$	Area of Boundary Layer Bleed Duct Flapper
A_{fp}	Area of Duct Facing Honeycomb Panel
A_{fw}	Area of Duct Facing Inside Vertical Firewall
A_m	Cross-Sectional Area at Station m of Duct
A_{m+1}	Cross-Sectional Area at Station m+1 of Duct
A_{m+2}	Duct Area at 2nd Section From Section n
A_p	Inside Area Honeycomb Panel
A_R	Duct Area of the R^{th} Section of Duct
A_S	Tailpipe Shroud Area
A_T	Heat Transfer Area of Duct or Turbine Casing
$A_{T'}$	Area of Tailpipe

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Symbol	Description
A_W	Area of Vertical Firewall
A_3	Heat Transfer Area of Power Distribution Ducting
A_4	Heat Transfer Area of Fiberglass Shroud
BL	Butt Line: - Lateral Distance from Aircraft Centerline
CG	Center of Gravity
c_p	Specific Heat of Hot Duct Gases
c_{p_a}	Specific Heat of Air at Constant Pressure
c_{p_b}	Specific Heat at Bulk Temperature
c_{p_i}	Specific Heat of Insulation at Constant Pressure
c_{p_m}	Specific Heat of Metal at Constant Pressure
c_{p_o}	Specific Heat of Hydraulic Oil at Constant Pressure
CTOL	Conventional Take-off and Landing
d	Characteristic Duct Diameter
D	Duct Diameter or Shroud Diameter
D_H	Hydraulic Diameter of Section n
D_{Hn}	Hydraulic Diameter of Section n of Duct
D_p	Tailpipe Nozzle Exit Diameter
D_S	Tailpipe Shroud Exit Diameter
D_1, D_2	Fan Diameter Designations
E	Hydraulic Oil Cooler Effectiveness Factor or a constant

Symbol	Description
EGT	Exhaust Gas Temperature J85-5B Gas Generator
$(EGT)_L$	Exhaust Gas Temperature Left J85-5B Gas Generator
$(EGT)_R$	Exhaust Gas Temperature Right J85-5B Gas Generator
f	Friction factor
F	Force Acting on Flapper of Boundary Layer Bleed Duct or a Constant
$F_{A, 3-4}$	Radiative Shape-Emissivity Factor
$F_{A, 5-6}$	Radiative Shape-Emissivity Factor
$F_{A\epsilon}$	Radiative Heat Transfer Coefficient
F_B	Radiative Shape-Emissivity Factor Flow Engine Bay to Center Fuselage
F_F	Radiative Factor Duct to Engine Bay Floor
F_O	Radiative Shape-Emissivity Factor Outside Honeycomb Panel to Environment or Fuselage to Environment
F_P	Radiative Shape-Emissivity Factor Duct to Honeycomb Panel
F_S	Radiative Shape-Emissivity Factor for Tailpipe Shroud
F_T	Radiative Shape-Emissivity Factor Tailpipe to Shroud
F_W	Radiative Shape-Emissivity Factor Duct to Vertical Firewall
F_X	Radiative Shape-Emissivity Factor Turbine Casing to Engine Bay
F_1	Force Acting on Flapper of Boundary Layer Bleed Duct Due to Boundary Layer Bleed Airflow
F_2	Force Acting on Flapper of Boundary Layer Bleed Duct Due to Airflow from Large Cooling Fan

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Symbol	Description
g	Acceleration of Gravity
G	Flow Rate per Unit Area, or a Constant
Gr	Grashof's Number
G.W.	Gross Weight
h	Convective Heat Transfer Coefficient, Height of Wing Fan Above Ground
h_a	Heat Transfer Coefficient Fuselage to Ambient
h_{ac}	Convective Component of h_a
h_{ar}	Radiative Component of h_a
h_B	Convective Heat Transfer Coefficient Engine Bay Floor to Center Fuselage Air
h_c	Convective Heat Transfer Coefficient
$h_{c_{3-4}}$	Convective Heat Transfer Coefficient Between Duct and Shroud
$h_{c_{5-6}}$	Convective Heat Transfer Coefficient at Fuselage
h/D	Ratio of Lift Fan Height Above Ground Level to Fan Diameter
h_F	Convective Heat Transfer Coefficient Engine Bay Floor to Engine Bay Air
h_g	Convective Heat Transfer Gases Pitch Fan Gases to Insulation
h_{gi}	Convective Heat Transfer Coefficient at the Insulation Surface
h_G	Convective Heat Transfer Rate Hot Gas to Tailpipe Wall

Symbol	Description
h_o	Convective Heat Transfer Coefficient Outside Honeycomb Panel to Outside Air
h_p	Convective Heat Transfer Coefficient; Inside Honeycomb Panel Surface to Air
h_r	Radiative Heat Transfer Coefficient
$h_{r_{3-4}}$	Radiative Heat Transfer Coefficient Between Duct and Shroud
$h_{r_{5-6}}$	Radiative Heat Transfer Coefficient at Fuselage
h_{s_i}	Convective Heat Transfer Coefficient Shroud to Cooling Air
h_{s_1}	Convective Heat Transfer Coefficient Shroud to Fuselage Air
h_T	Convective Heat Transfer Coefficient Shroud to Cooling Air
$h_T{}^1$	Convective Heat Transfer Coefficient Tailpipe to Cooling Air
h_w	Convective Heat Transfer Coefficient Vertical Firewall to Air
h_{w_i}	Convective Heat Transfer Coefficient Fuselage to Fuselage Air
h_{w_1}	Convective Heat Transfer Coefficient Fuselage to Outside Air
h_{1-2}	Heat Transfer Coefficient
h_2	Heat Transfer Coefficient Between Fuselage Walls
h_{2c}	Convective Component of h_2
h_{2r}	Radiative Component of h_2
h_{3-4}	Total Heat Transfer Coefficient Between Duct and Shroud

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Symbol	Description
h_{5-6}	Heat Transfer Coefficient
i	Ficticious Slab Interface
j	Time Increment
k	Ratio Specific Heat
K	General Pressure Loss Coefficient
k_b	Thermal Conductivity at Bulk Temperature
$k_{c_{3-4}}$	Thermal Conductivity of Air Between Duct and Shroud
K_G	Geometrical Pressure Loss Coefficient
$K(G)$	Geometrical Pressure Loss Coefficient
K_{Gn}	Geometrical Pressure Loss Coefficient
k_i	Thermal Conductivity of Insulation
K_n	Pressure Loss Coefficient for Section n of Duct
K_{n+1}	Pressure Loss Coefficient for the Section of Duct Following Section n of the Duct
K_{n+2}	Pressure Loss Coefficient for the Second Section of Duct Following Section n of the Duct
K_P	Effective Thermal Conductivity of Honeycomb Panel
K_R	Pressure Loss Coefficient for the R^{th} Section of a Duct
K_T	Total Value of Pressure Loss Coefficient
K_{T_n}	Total Value of Pressure Loss Coefficient at Cross-Section n of Duct
k_{2-3}	Thermal Conductivity Power Distribution Ducting

Symbol	Description
k_{4-5}	Thermal Conductivity Fiberglass Shroud
l	Length of Duct Under Consideration or Thickness of Honeycomb Panel
L	Length Used for Convective Heat Transfer Coefficient
L_n	Length of Section n of duct
M	Mach Number
M_A	$M_A = c_{p_2} - \gamma_i(\Delta X_i)^2 / k_i \Delta \theta$
Mach	Mach Number: - Ratio of Actual Speed to Speed of Sound
N_A	Defined by Equation $N_A = h_{g_i} \Delta X_i / k_i$
N_F	RPM or % RPM of Wing Fans
N_{FL}	RPM or % RPM of Left Wing Fan
N_{FR}	RPM or % RPM of Right Wing Fan
N_{Gr}	Grashof's Number
N_P	RPM or % RPM of Pitch Control Fan
P	Local Pressure
P_a	Ambient Pressure
P_{amb}	Ambient Pressure
P_i	Cooling Fan Inlet Pressure
P_o	Ambient Air Temperature
P_p	Total Pressure of Primary Air in Ejector
P_r	Prandt'ls Number

Symbol	Description
P_{REF}	Reference Pressure
P_S	Static Pressure at Flapper, Total Pressure Secondary Airflow in Ejector, Static Surface Pressure
P_{S1}	Static Pressure Boundary Layer Bleed Duct at Flapper
P_{S2}	Static Pressure Large Cooling Fan Duct at Flapper
P_{S3}	Static Pressure Following Mixing of Boundary Layer Bleed Air and Large Cooling Fan Air Downstream of Flapper
P_T	Total Pressure
P_{T1}	Total Pressure Boundary Layer Bleed Duct at Flapper
P_{T2}	Total Pressure Large Cooling Fan Duct at Flapper
PTI	Inlet Total Pressure
PTI_m	Total Pressure at Inlet of Section m of Duct
PTI_n	Inlet Total Pressure at Cross-Section n of Duct
PTI_{n+1}	Inlet Total Pressure at Cross-Section n+1 of Duct
PTO	Outlet Total Pressure
PTO_n	Outlet Total Pressure at Cross-Section n
PTO_{n+1}	Outlet Total Pressure at Cross-Section n+1 of Duct
P_1	Absolute Pressure of Inlet Air to Blower
P_2	Absolute Pressure of Outlet Air From Blower
q	Dynamic Pressure, or Rate of Heat Flow
Q	Volume Rate of Air Flow
q_{AIR}	Heat Transfer Rate to Hydraulic Oil Cooler Cooling Air

Symbol	Description
$q_{C_{B-W}}$	Convective Heat Transfer Rate Fuselage Air to Fuselage
$q_{C_{F-A}}$	Convective Heat Transfer Rate Engine Bay Floor to Engine Bay Air
$q_{C_{F-B}}$	Convective Heat Transfer Rate Engine Bay Floor to Center Fuselage Air
q_{CO}	Convective Heat Transfer Rate Outside Aircraft Surface
$q_{C_{P-A}}$	Heat Transfer Rate Honeycomb Panel to Engine Bay Air
q_{crew}	Rate of Heat Addition Due to Heat Load From Crew
$q_{C_{S-A}}$	Convective Heat Transfer Rate Shroud to Cooling Air
$q_{C_{S-B}}$	Convective Heat Transfer Rate From Shroud to Fuselage Air
$q_{C_{T-A}}$	Heat Transfer Rate From Turbine Casing or Wall to Engine Bay Air
$q_{C_{T-S}}$	Convective Heat Transfer From Shroud to Cooling Air
$q_{C_{T'-S}}$	Convective Heat Transfer From Tailpipe to Cooling Air
$q_{S_{W-A}}$	Convective Heat Transfer Vertical Firewalls to Engine Bay Air
q_{g-a}	Net Convective Heat Transfer Hot Gases to Outside Air
q_{g-1}	Convective Heat Transfer Hot Gases to Insulation
q_G	Heat Addition Rate from Generator to Cooling Air; or Hot Gas Heat Transfer Rate to Tailpipe

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Symbol	Description
q_{G_i}	Total Energy Input to Generator
q_i	Rate of Heat Transfer from Hot Gases to Turbine or Duct Wall
q_{KP}	Heat Transfer Rate Across Honeycomb Panel
q_m	Dynamic Pressure at Duct Station m
q_o	Free Stream Dynamic Pressure at Aircraft Speed
q_{oil}	Heat Transferred from Hydraulic Oil in Cooler
q_N, q_{N_1}, q_{N_2}	Wing Lift Fan Stream Dynamic Pressures
q_{NP}	Pitch Fan Stream Dynamic Pressure
q_{RB}	Radiative Heat Transfer Rate Engine Bay Floor to Center Fuselage
q_{RF}	Radiative Heat Transfer Turbine Casing or Duct to Engine Bay Floor
q_{RO}	Radiative Heat Transfer Outside Aircraft Surface to Environment
q_{RP}	Radiative Heat Transfer Turbine Casing or Duct Wall to Honeycomb Panel
$q_{R_{S-W}}$	Radiative Heat Transfer Shroud to Fuselage
q_{RT}	Radiant Heat Transfer Rate Tailpipe to Shroud
$q_{R_{T-S}}$	Radiative Heat Transfer Tailpipe to Shroud
q_{RW}	Radiative Heat Transfer Rate Turbine Casing or Duct to Vertical Firewall
q_{RX}	Radiative Heat Transfer Rate Turbine Casing Axially Along Engine Bay

Symbol	Description
q^s	Effective Fan Stream Dynamic Pressure
q_s	Dynamic Pressure of Air Stream Running Along the Ground
q_{Solar}	Rate of Heat Addition Due to Solar Heat Load
q_1	Dynamic Pressure Boundary Layer Bleed Duct Air at Flapper
q_{1-2}	Heat Transfer Rate Across Insulation
q_2	Dynamic Pressure Large Cooling Fan Duct Air at Flapper
q_{2-3}	Heat Transfer Rate Across Fuselage Wall
q_{3-a}	Heat Transfer Rate Fuselage Wall to Environment
r	Recovery Factor
R	Gas Constant
R_{e_d}	Reynolds Number for Flow Inside Ducting
R_e	Reynolds Number for Flow Over Flat Plate
RE	Arithmatic Mean Reynolds Number
RPM	Revolution per Minute
S	Distance fromTailpipe Nozzle Plane to Shroud Exit Plane
STA	Aircraft Station
S_1 S_2	Distance Between Fans
t	Temperature
T	Absolute Temperature
t_a	Ambient or Outside Air Temperature

Symbol	Description
T_A	Engine Bay Air Absolute Temperature
$T_{air\ in}$	Inlet Air Temperature to Hydraulic Oil Cooler
$T_{air\ out}$	Outlet Air Temperature from Hydraulic Oil Cooler
T_{AM}	Mean Shroud Air Temperature
t_{AMB}	Ambient Air Temperature
t_{AMB_1}	Ambient Air Temperature During Test
t_{AMB_2}	100° F
T_{AMB}	Absolute Ambient Air Temperature
t_B	Temperature Boundary Layer Bleed Air
T_B	Absolute Temperature Engine Bay
t_c	Temperature Cockpit Air to Cooling Fan Plenum
TC	Thermocouple
TC_{MAX}	Thermocouple Number With the Maximum Reading
T_c^s	Fan Stream Thrust Coefficient
T_D	Absolute Temperature Gas Power Distribution Ducting
t_F	Temperature Air from Large Blower at Flapper
T_F	Fuselage Air Temperature, Absolute Temperature Engine Bay Floor
t_g	Pitch Fan Exhaust Gas Temperature
$t_{g,j}$	Gas Temperature at Time Increment j
$t_{g,j+1}$	Gas Temperature at $j+1^{th}$ Time Increment

Symbol	Description
t_{g_1}	Wing Fan Exhaust Gas Temperature During Test
t_{g_2}	Wing Fan Exhaust Gas Temperature at 100% Power
t_G	Generator Outlet Air Temperature
T_g	Absolute Total Temperature of Gas Stream in Duct
T_G	Absolute Temperature Duct Gases
t_H	Hot Gas Temperature from Wing or Diverter Valve Leakage
t_i	Temperature of Air to Engine Bay from Flapper
$t_{i,j}$	Temperature at i^{th} interface at j^{th} Time Increment
$t_{i,j+1}$	Temperature at i^{th} Interface at $j+1^{th}$ Time Increment
$t_{i-1,j}$	Temperature at $i-1^{th}$ Interface at j^{th} Time Increment
$t_{i+1,j}$	Temperature at $i+1^{th}$ Interface at j^{th} Time Increment
t_L	Temperature of Duct Leakage
t_m	Mean or pitch fan Temperature of Cooling Fan Plenum Air or Wing Air
T_m	Absolute Mean Temperature of Cooling Fan Plenum Air
t_{MAX}	Maximum Landing Gear Environmental Temperature
t_{M_1}	Measured Temperature of Landing Gear Environment During Test
$t_{n,j}$	Temperature at Insulation-Metal Plate Interface at j^{th} Time Increment
$t_{n,j+1}$	Temperature at Insulation-Metal Plate Interface at $j+1^{th}$ Time Increment
t_o	Outside Air Temperature

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Symbol	Description
T_o	Absolute Temperature Outside Air
$T_{oil\ in}$	Temperature Inlet Oil to Hydraulic Oil Cooler
$T_{oil\ out}$	Temperature Outlet Oil from Hydraulic Oil Cooler
$t_{o,j}$	Temperature Gas-Insulation Interface at j^{th} Time Increment
$t_{o,j+1}$	Temperature Gas-Insulation Interface at $j+1^{th}$ Time Increment
T_{ooo}	Wing Fan Lift at $\beta_v = O$, $M = O$, and $\beta_s = O$
t_p	Temperature Inlet Air at Fuselage Port or Pitch Fan Inlet Air
T_p	Absolute Temperature of Primary Air of Ejector
T_{P_I}	Absolute Temperature Inside Surface Honeycomb Panel
$t_{p,j+1}$	Assumed Temperature Insulated Plate Temperature at $j+1^{th}$ Time Increment
T_{P_O}	Absolute Temperature Outside Surface Honeycomb Panel
T_{REF}	Reference Temperature
T_s	Absolute Temperature of Secondary Air of Ejector, Fiberglass Shroud or Cooling Air Temperature
T_{SO}	Absolute Temperature of Outside Fiberglass Shroud
T_T	Absolute Temperature Turbine Casing or Duct or Shroud Temperature
$T_{T'}$	Tailpipe Temperature
T_W	Absolute Temperature Vertical Firewall
T_X	Absolute Temperature Honeycomb Panel Aft of Turbine Casing

Symbol	Description
t_{oo}	Hot Gas-Insulation Interface Temperature
t_1	Temperature Gases to Fan Scrolls
T_1	Absolute Temperature Insulation Surface
t_2	Temperature Surface q
T_2	Absolute Temperature Air Leaving Blower, or Absolute Temperature of Surface 2
t_3	Temperature of Fuselage Surface
T_3	Absolute Temperature of Fuselage Surface
$t_{5.1}$	X353-5B Gas Generator Exhaust Gas Temperature
t_6	Temperature Fuselage Air
U_i	Overall Heat Transfer Coefficient Hot Gases to Turbine Case or Duct Surface
U_o	Overall Heat Transfer Coefficient Across Insulation and Fuselage
V_D	Velocity of Boundary Layer Bleed Air
V_F	Wing Lift Fan Air Velocity
V_g	Pitch Fan Exhaust Gas Velocity Over Insulation
V_m	Mean Velocity in Duct
V_o	Aircraft Free Stream Velocity
V_p	Aircraft Flight Speed
W	Weight Rate of Airflow From Flapper to Engine Bay
W_a	Weight Rate of Airflow

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Symbol	Description
W_B	Weight Rate of Boundary Layer Bleed Air to Flapper
W_c	Weight Rate Airflow Out of Cockpit
W_F	Weight Rate of Large Blower Cooling Air to Flapper or in Fuselage
W_g	Weight Rate of Hot Gas Flow
W_G	Weight Rate Airflow Through Generator
W_H	Weight Rate of Hot Gas Flow from Wing or Diverter Valve Leakage
W_L	Weight Rate of Duct Leakage
W_o	Weight Rate Oil Flow Through Hydraulic Oil Cooler or Outside Airflow
W_P	Weight Rate of Flow of Ejector Primary Air, Weight Rate of Air to Cooling Fan Plenum Through Fuselage Ports; or Weight Flow from Pitch Fan Area
W_S	Weight Rate of Flow of Ejector Secondary Air
W_1	Weight Rate of Airflow in Boundary Layer Bleed Duct at Flapper
W_2	Weight Rate of Airflow in Large Cooling Fan Duct at Flapper
W_3	Weight Rate of Airflow Downstream of Flapper
WL	Aircraft Water Line
X	Distance
X_i	Thickness of Insulation
X_m	Thickness of Metal

Symbol	Description
X_s	Ground Distance From Lift Fan Center
X_t	Correlating Temperature Difference Ratio
X_{2-3}	Thickness Power Distribution Ducts
X_{4-5}	Fiberglass Shroud Thickness
Y	$= \gamma^2 g \beta C_p / \mu k$ For Air
α	Aircraft Angle of Attack
β	Volumetric Expansion Factor
β_{AP}	Apparent Turning Angle of Fan Turbine Exhaust
β_s	Stagger Angle of Lift Fan Louvers
β_v	Vector Angle of Lift Fan Louvers
β_{V_1}	Louver Vector Angle of Lift Fan No. 1
β_{V_2}	Louver Vector Angle of Lift Fan No. 2
γ	Density of Duct Gases
γ_i	Density of Insulation
γ_m	Density of Metal
γ_{REF}	Reference Specific Weight
δ	Air Gap Thickness of Fuselage Section
Δ	Difference Symbol
δ_F	Flap Angle Setting
ϵ	Surface Emissivity
ϵ_B	Surface Emissivity of Center Fuselage Bay
ϵ_F	Emissivity of Engine Bay Floor

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Symbol	Description
ϵ_{pi}	Inside Surface Emissivity Honeycomb Panel
ϵ_{po}	Outside Surface Emissivity Honeycomb Panel
ϵ_{si}	Surface Emissivity of Inside of Shroud
ϵ_{sl}	Surface Emissivity of Outside of Shroud
ϵ_{t}	Surface Emissivity Turbine Casing or Duct
ϵ_{w}	Surface Emissivity of Vertical Firewall
ϵ_{wi}	Surface Emissivity of Inside Fuselage Skin
ϵ_{wl}	Surface Emissivity of Outside of Fuselage Skin
ϵ_{3}	Emissivity of Power Distribution Ducting
ϵ_{4}	Emissivity of Inside Shroud Surface Gold Plated
ϵ_{5}	Emissivity of Outside Shroud Surface
ϵ_{6}	Emissivity of Fuselage Inside Surface
θ	Angle of Boundary Layer Bleed Duct Flapper With Respect to Airflow; Time
μ	Viscosity of Duct Gases
μ_{b}	Viscosity of Air at Bulk Temperature
μ_{wsi}	Viscosity of Cooling Air at Inside Shroud Temperature
μ_{wt}	Viscosity of Cooling Air at Outside Tailpipe Temperature
ρ	Density of Hot Gases in Ducts
σ	Stephan-Boltzman Constant 1730×10^{-12} as Used in This Report
Σ	Summation of Terms Symbols

Symbols	Description
Φ	Summation of Pressure Loss Coefficients Related to a Given Section of a Duct
ΔP	Pressure Difference
ΔP_{DUCT}	Pressure Loss at Duct of Varying Shape, Cross-Section, etc.
ΔP_f	Pressure Drop Due to Wall Friction
ΔP_G	Pressure Drop Due to Geometrical Factors
ΔP_n	Pressure Drop Across Section n of Duct
ΔP_{total}	Sum of ΔP_f and ΔP_G
ΔP_T	Incremental Total Pressure
Δq_G	Rate of Heat Rejection by Generator
Δt	Temperature Rise Across Cooling Fan Blowers
ΔT	Temperature Difference Shroud to Fuselage Air
ΔT_A	Temperature Rise of Air Across Hydraulic Oil Cooler
Δt_{AH}	Incremental Temperature Due to Aerodynamic Heating
ΔT_{AH}	Incremental Absolute Temperature Due to Aerodynamic Heating
Δt_{FusAir}	Temperature Rise Due to Air Recirculation Between Shroud and Duct
Δt_G	Temperature Rise of Generator Cooling Air
Δt_M	Incremental Temperature of Landing Gear Environment
ΔT_{oil}	Temperature Change

Symbol	Description
Δt_p	Temperature Drop Across Metal Plate
Δt_{sc}	Cockpit Air Temperature Rise Due to Solar and Crew Heat Loads
ΔT_T	Total Temperature Increment $\Delta t_T = \Delta t_{AH} + \Delta t_{sc}$
ΔX_i	Thickness of Slab of Figure 13.2 Defined as $X_{i/n}$
$\Delta\theta$	Time Increment Defined from Equation for M_A

9.3 COOLING SYSTEM ANALYSIS

9.3.1 Method of Approach

The cooling system analysis of this section establishes the balanced cooling air flow rates through the various flow passages of the aircraft. Thermal performance of the cooling system is considered in Section 9.4. The general procedure to establish the balanced flow rates consists of the following steps:

1. Definition of flow passages and their geometrical factors affecting flow rates; (See Tables 9.1 through 9.10 and Figures 9.1 through 9.9.)

2. Selection of pressure loss factors for the flow path components at the appropriate ranges of geometrical factors and estimated flow rates from Reference 12, (See Tables 9.1 - 9.10.)

3. Establishment of terminal conditions for each flow passage in terms of aircraft operation.

4. Calculation of pressure losses in each flow passage by a digital computer program for a matrix of input-output conditions of flow rate, inlet pressure and outlet pressure. This program is presented in Section 9.3.2.3.

5. Establishment of cooling fan performance at off-design conditions based on vendor and unpublished test data using conventional equations and procedures derived from fan similarity laws.

6. Generally balanced flow was established by a series of iterations in three steps: (a) the upper fuselage section was balanced assuming a series of lower fuselage compartment pressures; (b) the lower fuselage section was balanced based on the same series of compartment pressures used in 6(a); and (c) the upper and lower fuselage sections were balanced at the compartment pressure-flow rate interface.

7. The above steps were carried out for specific conditions of the aircraft speed-altitude envelope, operating mode, and

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for ARDC standard and ANA Bulletin 421 hot day conditions. Although somewhat lengthy and tedious, once the procedure was established, balanced flow rates were established in a routine manner.

8. Since point by point coverage of the wide range of aircraft operating conditions was impractical, approximate methods were developed by analysis, which were verified by spot checks at terminal and mid-point conditions, and used to establish intermediate data by interpolation.

9.3.2 Pressure Loss Analysis

9.3.2.1 General

Since the airflow rate in a given duct is established only when the pressure drop available for flow is equal to the pressure drop required for the given flow, detailed knowledge of those factors affecting pressure loss estimates is needed. In the subject studies, compressible flow equations were used, unless otherwise specified. Pressure loss may be considered in two parts: frictional and geometrical components. The frictional component is expressed as

$$\Delta P_f = \left(\frac{4fl}{D}\right) q$$

The geometrical component (effective for changes in duct direction, shape, or cross-section) is given by:

$$\Delta P_G = K_G q$$

where K_G may be the product or sum of several factors depending upon the methods of data correlation. The total loss in pressure is the sum of these two components, or

$$\Delta P_{Total} = \Delta P_f + \Delta P_G = (4f^1/D + K_G)\, q$$

9.3.2.2 Incompressible Flow

An attractive advantage of incompressible flow is the ease with which ducting losses are analyzed and related in terms of one section of a duct passage. For example, in the equation

$$\Delta P_{Duct} = \Phi\, q_n$$

where

$$\Phi = K_n + K_{n+1}\left(\frac{A_m}{A_{m+1}}\right)^2 + K_{n+2}\left(\frac{A_m}{A_{m+2}}\right)^2 + \ldots . K_R\left(\frac{A_m}{A_R}\right)$$

both frictional and geometrical effects can be included in K without significant error and the study is referenced to any convenient cross-section n.

Incompressible flow was assumed for the following three branches - cockpit to cooling fan compartment, fuselage ports to cooling fan compartment, and the small cooling fan to the generator.

Flow from Cockpit to Cooling Fan Compartment

Standard Day, Sea Level

$$Q = 589 \sqrt{\Delta P_{in} H_2O} \quad Ft^3/min.$$

Hot Day, 2500 feet

$$Q = 633 \sqrt{\Delta P_{in} H_2O} \quad Ft^3/min.$$

The plots of Q vs ΔP for various day and altitudes are presented in Figures 9.10 and 9.11

Flow from Fuselage Ports to Cooling Fan Compartment

Standard Day, Sea Level

$$Q = 868 \sqrt{\Delta P_{in} H_2O} \quad Ft^3/min.$$

Hot Day, 2500 feet

$$Q = 934 \sqrt{\Delta P_{in} H_2O} \quad Ft^3/min$$

The plots of Q vs ΔP for various days and altitudes are presented in Figures 9.12 and 9.13.

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Flow from Small Cooling Fan to Generator

Standard Day, Sea Level

$$Q = 60.9 \sqrt{\Delta P_{in} H_2O} \quad Ft^3/min$$

Hot Day, 2500 feet

$$Q = 65.7 \sqrt{\Delta P_{in} H_2O} \quad Ft^3/min$$

The plots of Q vs ΔP for various days and altitudes are presented in Figures 9.14 and 9.15.

9.3.2.3 Compressible Flow

All ducts except those mentioned in Section 9.3.2.2 were analyzed with compressible flow. The duct characteristics are presented in Figures 9.1 - 9.9 and Tables 9.1 - 9.9. Pressure loss analysis of the various ducts utilized an IBM 704 computer program requiring information on the following fluid and duct characteristics: temperature, viscosity, specific heat ratio, molecular weight, geometric K-factor, length, hydraulic diameter, duct station areas, and weight flow. An option was available to include a table of geometric K-factor vs Reynolds No. for any section where the Reynolds Number demonstrated a large effect.

The computer calculated and printed out the following:

1. Reynolds Number, RE

$$RE = \frac{12 D_{H_n} W}{\left(\frac{A_m + A_{m+1}}{2}\right) M}$$

2. Mach Number, M

M was obtained by iteration of the following equation

$$\frac{W\sqrt{T_g}}{A_m \; PTI_m} = Mg\left(\frac{k}{R}\right)^{1/2}\left[1 + \frac{k-1}{2}M^2\right]^{-\frac{k+1}{2(k-1)}}$$

3. Flow Velocity, V ~ Ft/sec.

$$V = M\left[\frac{1}{1 + \frac{k-1}{2}M^2}\right]^{1/2}(kRT_g)^{1/2}$$

4. Total K - factor, K_T

$$K_T = 4\frac{L_n}{D_{H_n}}\left(0.0014 + \frac{0.125}{R_E \cdot 32} + K_{G_n}\right)$$

5. Pressure Ratio, P_{S}/P_{T}

$$P_S/P_T = \left[1 + \frac{k-1}{2}M^2\right]^{-k/k-1}$$

6. Section Outlet Total Pressure, PTO ~ lb/in^2

$$PTO_n = PTI_n\left[1-K_{T_n}\left(1-{}^{P}S/_{P_T}\right)\right]$$

7. Section Inlet Total Pressure, PTI ~ lb/in^2

PTI_m is given

$$PTI_{n+1} = PTO_n, \; PTI_{n+2} = PTO_{n+1}, \text{ etc.}$$

8. Static Pressure, P_S ~ lb/in^2

$$P_S = \left(\frac{P_S}{P_T}\right) PTO$$

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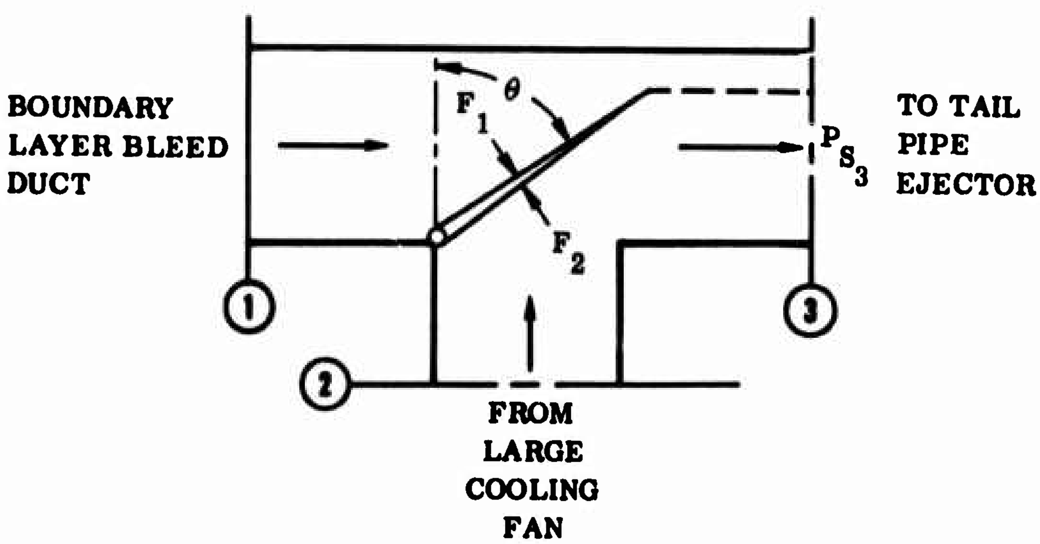
9. Pressure Drop, $\Delta P \sim lb/in^2$

$$\Delta P_n = PTI_n - PTO_n$$

The results of the computer analysis for the various duct flows at various altitudes and days are presented in Figures 9.16 through 9.26. In some instances the effects of changes in pressure, temperature, and density with changes in altitude and type of day can be handled with simple ratios. Thus, some systems or branches may be calculated at standard day, sea level conditions and adjusted to various altitudes by the relationship between the pressure temperature, and/or density. Representative values of these ratios are presented in Table 9.10.

9.3.3 Boundary Layer Bleed Duct Aft Flapper Position



A description of the aft flapper operation was presented in Section 3.0. Since the flapper is a free hinged door, the position is a function of the forces developed on each side by the two air flows from each duct branch. The system is analyzed as two ducts branching into a single duct by setting the flapper at any fixed position.

The method of approach is as follows:

1. Set the flapper position and treat the flapper as part of the ducts 1 and 2.

2. Using the duct characteristics of ducts 1 and 2 at each flapper setting, place into the computer program as described in Section 9.2.

3. From the computer program, obtain the values at a given condition for the following: q_1, q_2, P_{S_1}, P_{S_2}, W_1, W_2, P_{T_1} and P_{T_2} (see sketch).

4. Balance the forces on the flapper at various flow rates

$$F = A_{FLAPPER} P_S + 2 A_{DUCT} q \sqrt{2(1-\cos\theta)}$$

where θ is the angle of flapper with respect to the flow

<u>@ θ = 0°</u>

$$\frac{F_1}{17.6} = P_{S_1} + 1.435q_1 \qquad \frac{F_2}{17.6} = P_{S_2} + .395q_2$$

@ θ = 22.5°

$$\frac{F_1}{17.6} = P_{S_1} + 2.52q_1 \qquad \frac{F_2}{17.6} = P_{S_2} + .305q_2$$

<u>@ θ = 45°</u>

$$\frac{F_1}{17.6} = P_{S_1} + 1.74q_1 \qquad \frac{F_2}{17.6} = P_{S_2} + .773q_2$$

<u>@ θ = 67.5°</u>

$$\frac{F_1}{17.6} = P_{S_1} + .886q_1 \qquad \frac{F_2}{17.6} = P_{S_2} + 1.125q_2$$

5. With P_{S_3}, W_3 and Mach number, compare with duct system ΔP to the tailpipe exhaust and the tailpipe ejector performance at the given Mach number.

6. When the flapper system flow balances with the tailpipe ejector performance, the flapper is balanced at that Mach number.

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Figure 9.27 shows the estimated flapper position at various Mach numbers. Its position is not significant beyond the fact that the division of flow is a unique function of flapper position, which in turn is a function of Mach number and power setting conventional flight mode.

9.3.4 Tailpipe Ejector Analysis

The tailpipe ejector augments cooling airflow in the engine bay, tailpipe, and shroud during turbojet mode operation. The ejector is a simple, conical extension of the shroud past the tailpipe (Figure 3.6), with the following design characteristics:

$$\frac{D_s}{D_p} = \frac{\text{Shroud Exit Diameter}}{\text{Tailpipe Exit Diameter}} = 1.10$$

$$\frac{S}{D_p} = \frac{\text{Shroud Extension}}{\text{Tailpipe Exit Diameter}} = 0.40$$

A full scale ejector with nearly identical design characteristics was experimentally tested and recorded in Reference 13 showing the relationship between P_{p/P_o}, P_{s/P_o}, and $\frac{W_s\sqrt{T_s}}{W_p\sqrt{T_p}}$, see Figures 9.28 and 9.29.

The values of W_p, $\sqrt{T_p}$, and P_{p/P_o} are known for any altitude, day and engine setting, therefore a plot between P_{s/P_o} and W_s can be made at various temperatures. A plot can also be made of P_{s/P_o} vs W_s for ducting system forward of the ejector. When the values of P_{s/P_o} and W_s for the ejector equal the values of P_{s/P_o} and W_s, respectively, for the ducting, then the ejector is in balance. This cross plot of balance flow is presented in Figures 9.30 through 9.42.

9.3.5 Cooling Air Flow Between the Nose Fan and Wing Fan Cavities During Conventional Flight

During CTOL flight mode, the doors are closed at the wing and nose fan, but air gaps exist around the doors. In flight relatively high positive pressures develop at the nose fan doors; and relatively low negative pressures develop at the wing fan (see Figures 9.43 and 9.44).

Cooling air will flow into the nose fan cavity, through the hot gas supply ducts, into the wing fan cavity, and then out the wing fan closures to the outside. See Figures 9.45 and 9.46 for cavity pressure vs flow in or out, and Figure 9.47 for a flow rate vs Δp between the cavities.

9.3.6 Cooling Fan Outlet Total Pressure

The outlet total pressure of the small and large cooling fan is a function of the chamber pressure, fan speed, air density, flow rate and static pressure rise across the fans. The large fan outlet total pressure vs Q and P_1 is presented in Figures 9.48 through 9.55. The small fan outlet total pressure vs flow rate and inlet pressure is presented in Figures 9.56 through 9.63.

9.3.7 Cooling Air Weight Flow

The cooling air weight flow from the upper fuselage to the lower fuselage and from the lower fuselage to the outside is a function of the fuselage pressure. The weight flow through each branch as a function of fuselage pressure in the lift fan mode is presented in Figures 9.64 through 9.74, and in the conventional mode is presented in Figures 9.75 through 9.103. A balanced total flow into the center and lower forward fuselage with the balanced total flow out will give a balanced system through each branch such as presented in Figures 9.74, 9.83, 9.102, and 9.103.

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TABLE 9.1
COOLING AIR DUCT DEFINITION - BOUNDARY LAYER BLEED DUCT TO ENGINE BAY
(See Figure 9.1)

STATION NO.	AREA IN^2	SECTION SHAPE	SECTION NO.	K(G)	L IN.	D_H IN.
0	10.8					
1	12.3	STRAIGHT - RECTANGULAR	1	0.10	2.44	2.3
2	14.5	EXPANSION	2	0.02	0.	2.3
3	14.8	STRAIGHT-RECTANGULAR	3	0.	1.66	3.1
4	9.1	CONTRACTION	4	0.03	5.40	3.2
5	15.7	EXPANSION	5	0.05	10.13	4.3
6	19.2	CURVING-RECTANGULAR	6	0.14	7.13	5.7
7	19.2	SPLITTER	7	0.32	0.	5.7
8	19.3	CURVING RECTANGULAR	8	0.08	2.20	3.9
9	18.6	STRAIGHT-RECTANGULAR	9	0.	4.20	3.9
10	18.2	CURVING	10	0.04	4.00	4.0
11	20.4	CURVING-CIRCULAR	11	0.09	4.30	4.4
12	20.4	STRAIGHT-CIRCULAR	12	0.01	8.00	4.9
13	20.4	BELLOWS	13	0.04	3.15	4.9
14	20.9	STRAIGHT	14	0.	16.10	4.9
15	399.0	EXPANSION	15	0.90	0.	4.9

TABLE 9.2
COOLING AIR DUCT DEFINITION - LARGE COOLING FAN TO BOUNDARY LAYER BLEED DUCT
(See Figure 9.2)

STATION NO	AREA IN^2	SECTION SHAPE	SECTION NO	K(G)	L IN.	D_H IN.
0	8.15					
1	8.15	CURVING - RECTANGULAR	1	0.91	3.9	2.74
2	8.15	CURVING RECTANGULAR	2	0.01	0.4	2.74
3	8.15	STRAIGHT - RECTANGULAR	3	0.	2.3	2.74
4	8.15	CURVING - RECTANGULAR	4	0.09	12.3	2.74
5	9.23	EXPANSION - RECTANGULAR	5	0.01	4.2	2.88
6	8.92	CURVING - RECTANGULAR	6	0.02	3.6	2.96
7	8.92	CURVING - RECTANGULAR	7	0.13	2.5	2.96
8	8.92	STRAIGHT RECTANGULAR	8	0.	4.0	2.96
9	8.92	RECTANGULAR 90°- BEND	9	1.87	5.2	3.36

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TABLE 9.3
COOLING AIR DUCT DEFINITION - ENGINE BAY TO TAIL PIPE EJECTOR
(See Figure 9.3)

STATION NO.	AREA IN^2	SECTION SHAPE	SECTION NO.	K(G)	L IN.	D_H IN.
15	399.0					
16	284.0	ANNULUS	16	0.	27.0	9.1
17	379.0	ANNULUS	17	0.	26.9	8.9
18	394.0	ANNULUS	18	0.	3.0	10.2
19	92.6	CONTRACTION	19	0.11	0.	3.0
20	92.6	CURVING ANNULUS	20	0.05	13.5	3.2
21	84.8	CONTRACTION	21	0.02	0.	3.2
22	84.8	ANNULUS	22	0.	85.6	3.2
23	84.8	CURVING ANNULUS	23	0.06	17.0	3.2
24	92.6	EXPANSION-ANNULUS	24	0.	5.6	3.4
25	92.6	EXPANSION	25	1.0	0.	3.4

TABLE 9.4
COOLING AIR DUCT DEFINITION - SMALL COOLING FAN TO ELECTRONIC COMPARTMENT
(See Figure 9.4)

STATION NO	AREA IN^2	SECTION SHAPE	SECTION NO	K(G)	L IN	D_H IN.
0	11.2					
1	28.4	CURVING RECTANGULAR	1	0.16	5.1	5.8
2	28.4	HYDRAULIC OIL COOLER	2	18.6	0.	5.8
3	16.0	DIFFUSER	3	0.04	5.1	4.8
4	16.0	STRAIGHT-CIRCULAR	4	0.	4.5	4.5
5	16.0	CURVING-CIRCULAR	5	0.31	21.1	4.5
6	16.0	STRAIGHT-CIRCULAR	6	0.	1.0	4.5
7	438.0	EXPANSION	7	0.95	0.	4.5
8	438.0	STRAIGHT-RECTANGULAR	8	0.	14.5	23.9
9	203.0	CONTRACTION	9	0.34	0.	23.9
10	660.0	EXPANSION	10	0.48	0.	23.9
11	660.0	STRAIGHT-RECTANGULAR	11	0.	18.5	32.5
12	28.3	CONTRACTION & EXPANSION	12	2.88	0.	32.5

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TABLE 9.5
COOLING AIR DUCT DEFINITION - L.H. LARGE COOLING FAN TO CENTER FUSELAGE
(See Figure 9.5)

STATION NO.	AREA IN^2	SECTION SHAPE	SECTION NO.	K(6)	L IN.	D_H IN.
0	9.7					
1	9.7	STRAIGHT-RECTANGULAR	1	0.	1.75	3.02
2	9.7	CURVING-RECTANGULAR	2	0.09	1.70	3.02
3	9.7	STRAIGHT-RECTANGULAR	3	0.	.85	3.02
4	9.7	ANGLE	4	0.08	0.	3.02
5	15.0	EXPANDING RECTANGLE	5	0.12	12.0	9.41
6	15.0	EXPANSION	6	1.0	0.	9.41

TABLE 9.6
COOLING AIR DUCT DEFINITION - R.H. LARGE COOLING FAN TO CENTER FUSELAGE
(See Figure 9.6)

STATION NO	AREA IN^2	SECTION SHAPE	SECTION NO	K(G)	L IN	D_H IN
0	9.7					
1	9.7	STRAIGHT-RECTANGULAR	1	0.	1.75	3.02
2	9.7	CURVING-RECTANGULAR	2	0.09	1.70	3.02
3	9.7	STRAIGHT-RECTANGULAR	3	0.	.85	3.02
4	9.7	ANGLE	4	0.06	0.	3.02
5	14.6	EXPANSION	5	0.11	9.8	8.01
6	12.2	STRAIGHT-RECTANGULAR	6	0.	2.0	12.20
7	12.2	ANGLE	7	0.08	0.	12.20
8	15.9	EXPANSION	8	0.05	11.4	8.84
9	15.9	STRAIGHT-ELLIPSE	9	0.	22.8	4.25
10	15.9	ANGLE-ELLIPSE	10	0.02	0.	4.25
11	15.9	STRAIGHT-ELLIPSE	11	0.	16.7	4.25
12	15.9	EXPANSION	12	1.0	0.	4.25

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TABLE 9.7
COOLING AIR DUCT DEFINITION - ELECTRONIC COMPARTMENT TO PITCH FAN AIR EJECTOR
(See Figure 9.7)

STATION No	AREA IN^2	SECTION SHAPE	SECTION NO	K(G)	L IN	D_H IN
0	253.0					
1	55.0	CONTRACTION	1	0.46	0.	—
2	253.0	EXPANSION	2	0.63	0.	—
3	253.0	STRAIGHT	3	0.	9.3	10.5
4	96.0	CONTRACTION	4	0.39	0.	—
5	253.0	EXPANSION	5	0.39	0.	—
6	253.0	STRAIGHT	6	0.	11.0	10.5
7	96.0	CONTRACTION	7	0.39	0.	—
8	253.0	EXPANSION	8	0.39	0.	—
9	253.0	STRAIGHT	9	0.	22.0	10.5
10	96.0	CONTRACTION	10	0.39	0.	—
11	253.0	EXPANSION	11	0.39	0.	—
12	253.0	STRAIGHT	12	0.	9.5	10.5
13	99.0	CONTRACTION	13	0.38	0.	—
14	414.0	EXPANSION	14	0.59	0.	—
15	414.0	90°-BEND [illegible]	15	0.37	32.1	13.3
16	7.0	90°-BEND [illegible]	16	0.01	0.	—
17	4.7	STRAIGHT- [illegible]	17	0.	2.0	1.1
18	4.3	90° BEND- [illegible]	18	8.40	2.6	1.1
19	4.3	EXPANSION	19	1.0	0.	—

TABLE 9.8

COOLING AIR DUCT DEFINITION - CENTER FUSELAGE TO FLAP ACTUATOR COMPARTMENT

(See Figure 9.8)

STATION NO	AREA IN²	SECTION SHAPE	SECTION NO	K(C)	L IN.	D_H IN.
0	14.0					
1	14.0	CONTRACTION	·	0.48	0.	—
2	480.0	EXPANSION	2	1.0	0.	—
3	48.0	STRAIGHT-RECTANGULAR	3	0.	10.5	16.1
4	9.0	CONTRACTION	4	0.48	0.	—
5	480.0	EXPANSION	5	1.0	0.	—
6	48.0	STRAIGHT-RECTANGULAR	6	0.	11.0	16.1
7	16.0	CONTRACTION	7	0.48	0.	—
8	16.0	EXPANSION	8	1.0	0.	—

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TABLE 9.9
COOLING AIR DUCT DEFINITION - CENTER FUSELAGE TO WING FAN AIR EJECTORS
(See Figure 9.9)

STATION NO	AREA IN^2	SECTION SHAPE	SECTION NO	K(G)	L IN.	D_H IN.
0	86.6					
1	86.6	CONTRACTION	1	0.43	0.	—
2	234.0	EXPANSION	2	0.40	0.	—
3	159.0	STRAIGHT	3	0.01	4.4	16.6
4	85.0	CONTRACTION	4	0.30	0.	—
5	159.0	EXPANSION	5	0.21	0.	—
6	123.0	STRAIGHT	6	0.01	3.2	10.6
7	71.0	CONTRACTION	7	0.27	0.	—
8	123.0	EXPANSION	8	0.17	0.	—
9	91.0	STRAIGHT	9	0.01	3.4	9.4
10	50.0	CONTRACTION	10	0.29	0.	—
11	91.0	EXPANSION	11	0.20	0.	—
12	75.0	STRAIGHT	12	0.01	4.3	7.8
13	44.0	CONTRACTION	13	0.27	0.	—
14	75.0	EXPANSION	14	0.16	0.	—
15	46.0	STRAIGHT	15	0.01	7.4	6.2
16	26.0	CONTRACTION	16	0.28	0.	—
17	46.0	EXPANSION	17	0.18	0.	—
18	35.0	STRAIGHT	18	0.01	7.3	5.3
19	18.0	CONTRACTION	19	0.32	0.	—
20	35.0	EXPANSION	20	0.23	0.	—
21	24.0	STRAIGHT	21	0.01	4.0	4.5
22	10.1	CONTRACTION	22	0.37	0.	—
23	5.0	STRAIGHT	23	0.32	0.	—
24	3.2	FLOW BEND	24	1.43	5.0	1.8
25	8.0	STRAIGHT	25	0.68	6.0	2.2
26	4.2	90° BEND	26	0.60	6.0	2.5
27	4.2	EXPANSION	27	1.00	0.	—

TABLE 9.10

ARDC STANDARD DAY AND ANA BULLETIN 421 HOT DAY ALTITUDE CONDITIONS REFERENCED TO ARDC STANDARD DAY SEA LEVEL

ALTITUDE - FEET & DAY	$\frac{P}{P_{REF}}$	$\sqrt{\frac{T_{REF}}{T}}$	$\frac{P}{P_{REF}}\sqrt{\frac{T_{REF}}{T}}$	$\frac{\gamma}{\gamma_{REF}}$
STANDARD DAY				
SEA LEVEL	1.0	1.0	1.0	1.0
5,000	.8321	1.0176	.8467	.8612
10,000	.6878	1.0362	.7127	.7379
20,000	.4579	1.0766	.4571	.5321
30,000	.2975	1.1222	.3338	.3736
40,000	.1858	1.1532	.2143	.2461
HOT DAY				
SEA LEVEL	1.0	.9600	.9600	.9229
2,500	.9193	.9680	.8899	.8628
5,000	.8439	.9763	.8239	.8057
10,000	.7081	.9933	.7033	.7002
20,000	.4890	1.0302	.5038	.5195
30,000	.3279	1.0715	.3513	.3774
40,000	.2125	1.1216	.2383	.2662

REFERENCE : STANDARD DAY
SEA LEVEL

PRESSURE P = 2116.2 #/FT^2
TEMPERATURE T = 518.69 °R
SPECIFIC WEIGHT γ = .07647 #/FT^3

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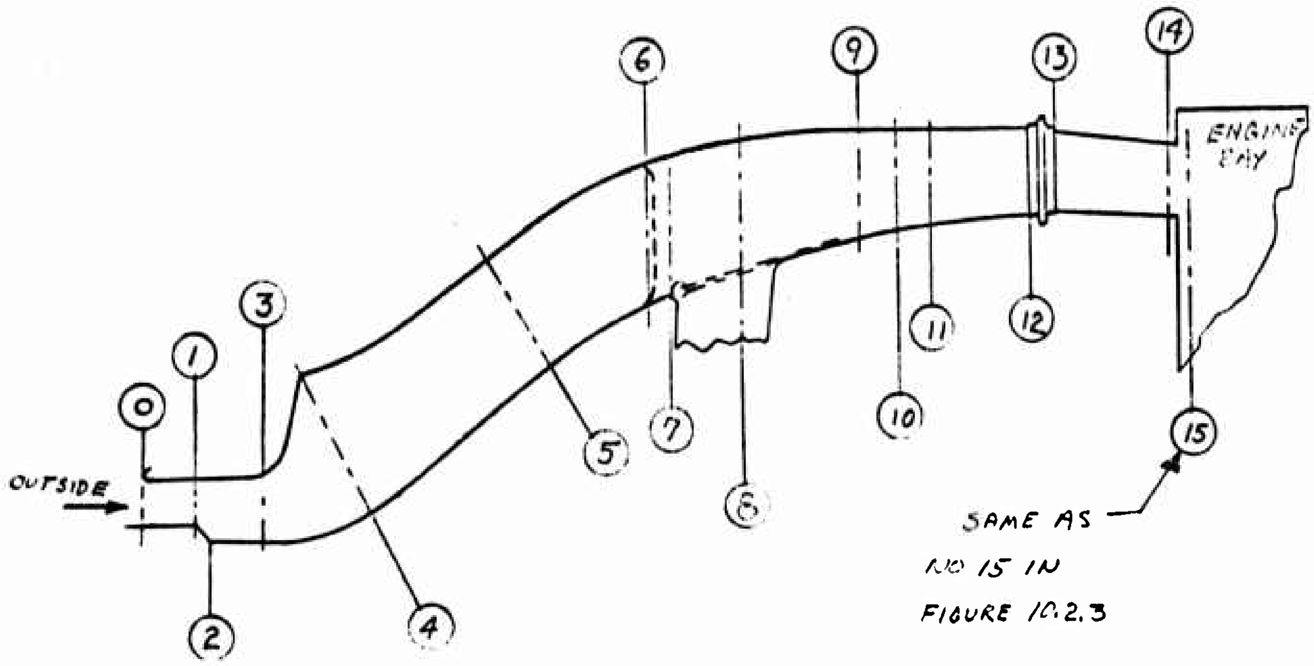

Figure 9.1 **Cooling Air Duct Definition - Boundary Layer Bleed Duct to Engine Bay**

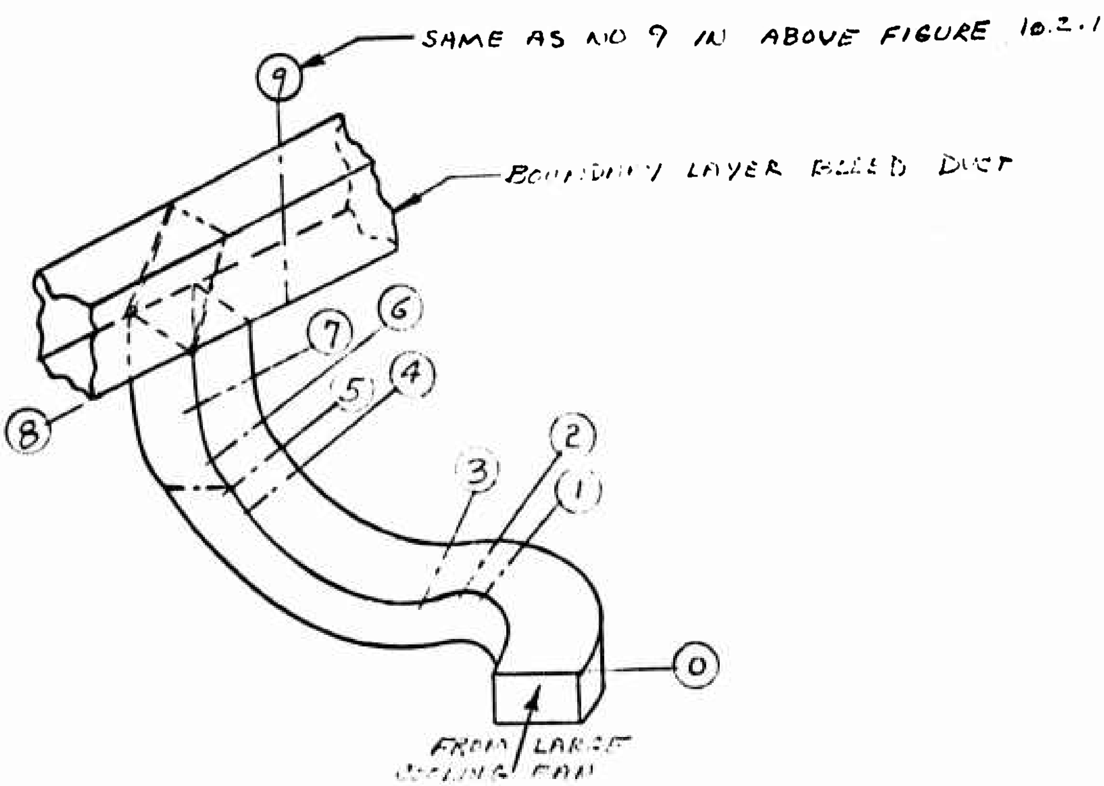

Figure 9.2 **Cooling Air Duct Definition - Large Cooling Fan to Boundary Layer Bleed Duct**

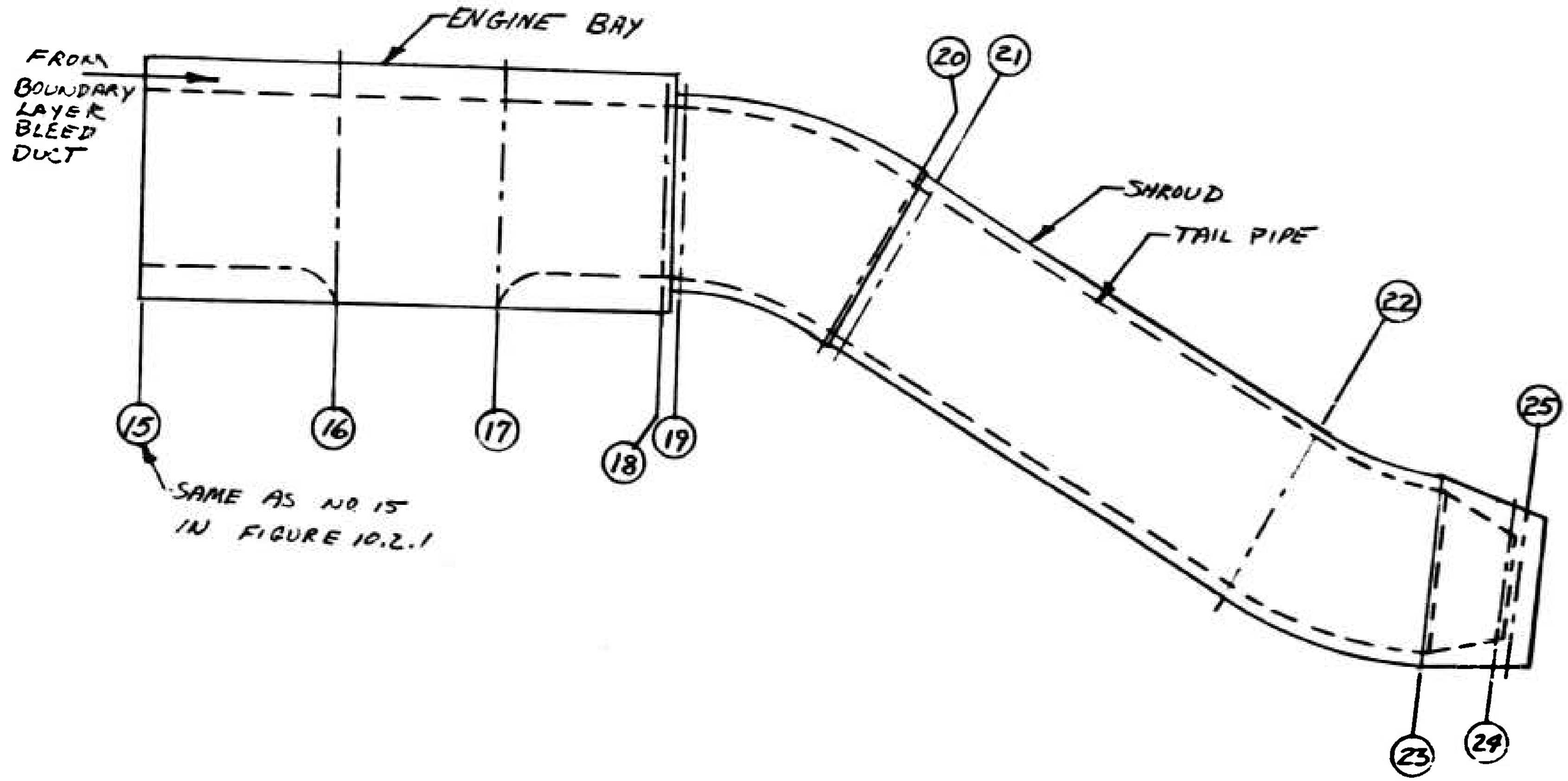

Figure 9.3 Cooling Air Duct Definition - Engine Bay to Tailpipe Ejector

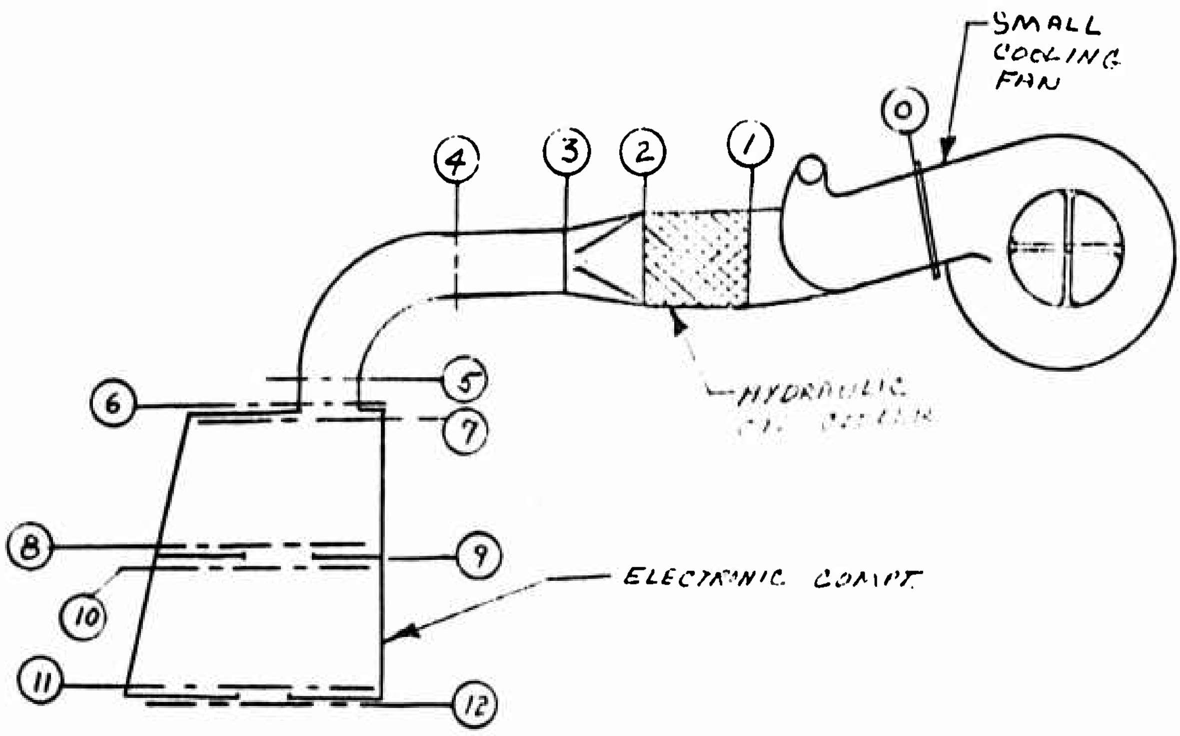

Figure 9.4 Cooling Air Duct Definition - Small Cooling Fan to Electronic Compartment

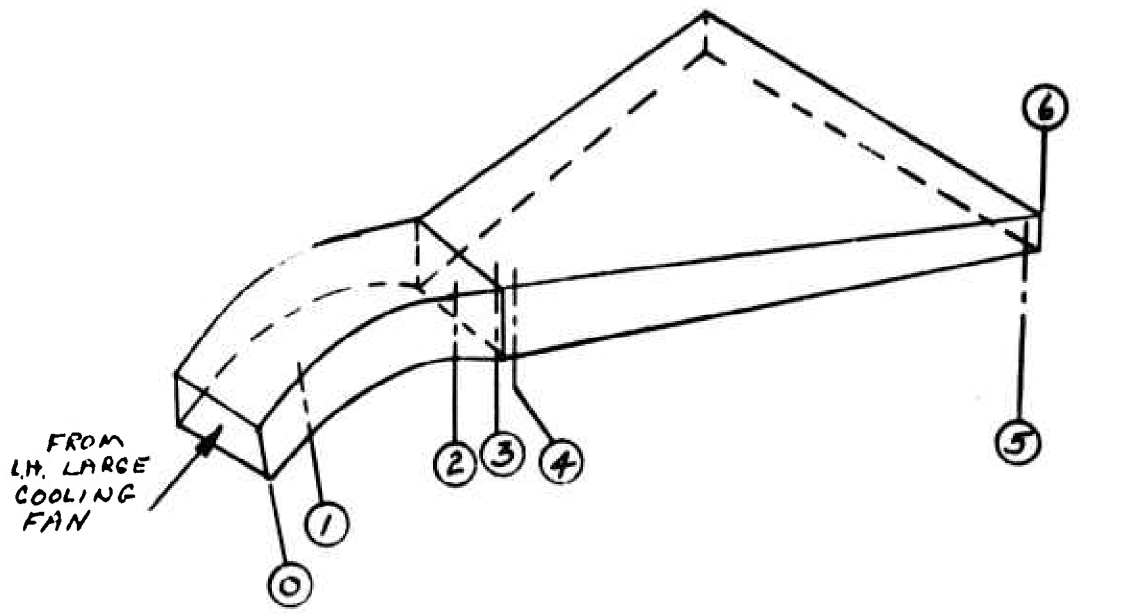

Figure 9.5 Cooling Air Duct Definition - L.H. Large Cooling Fan to Center Fuselage

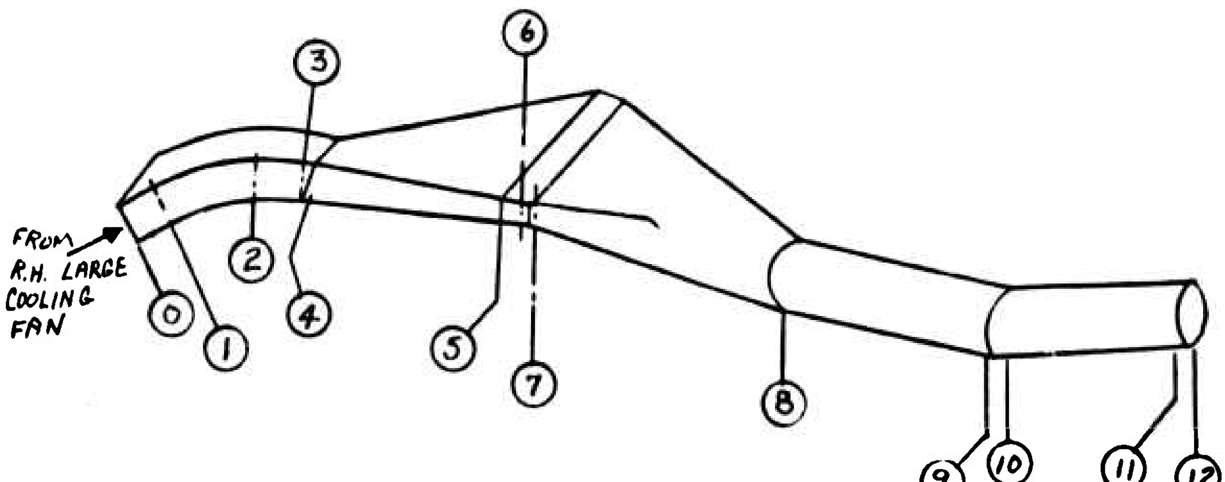

Figure 9.6 Cooling Air Duct Definition - R.H. Large Cooling Fan to Center Fuselage

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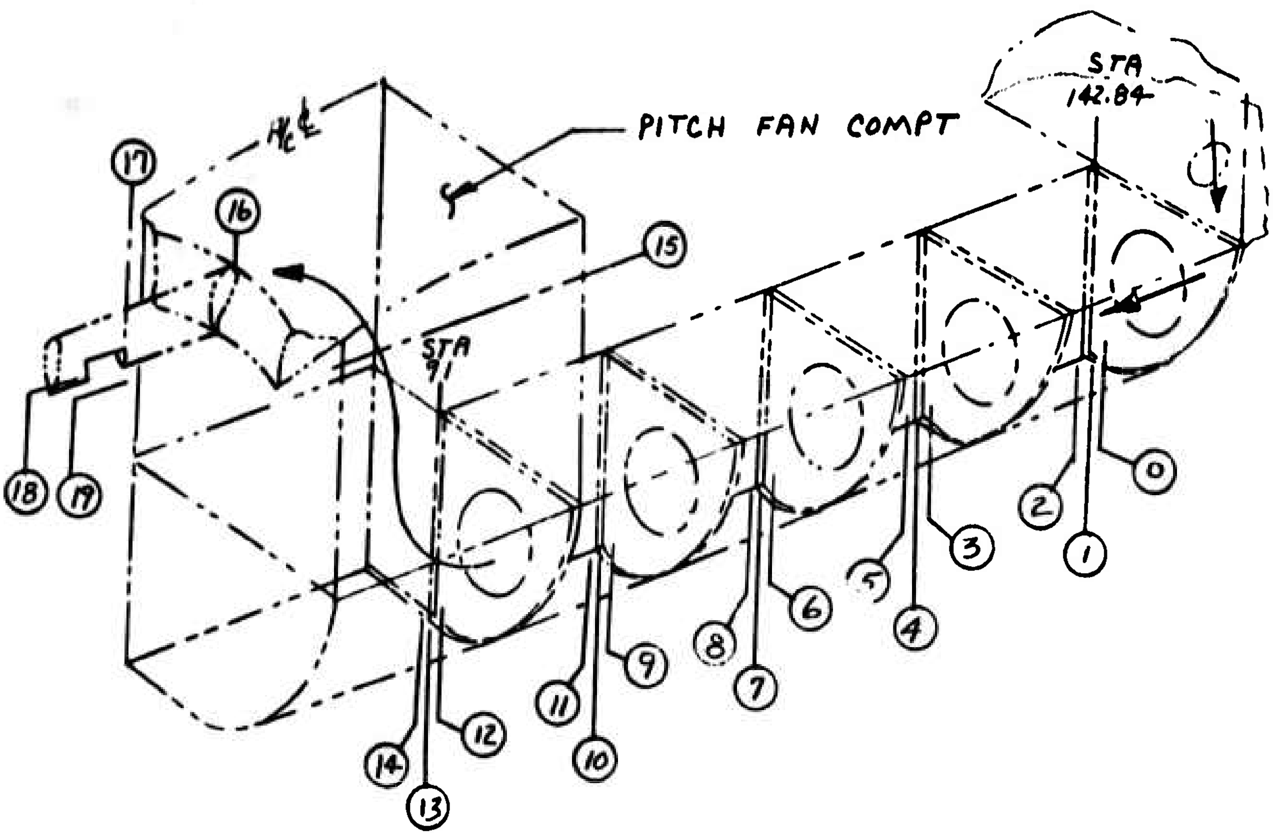

Figure 9.7 Cooling Air Duct Definition - Electronic Compartment to Nose Fan Air Ejectors

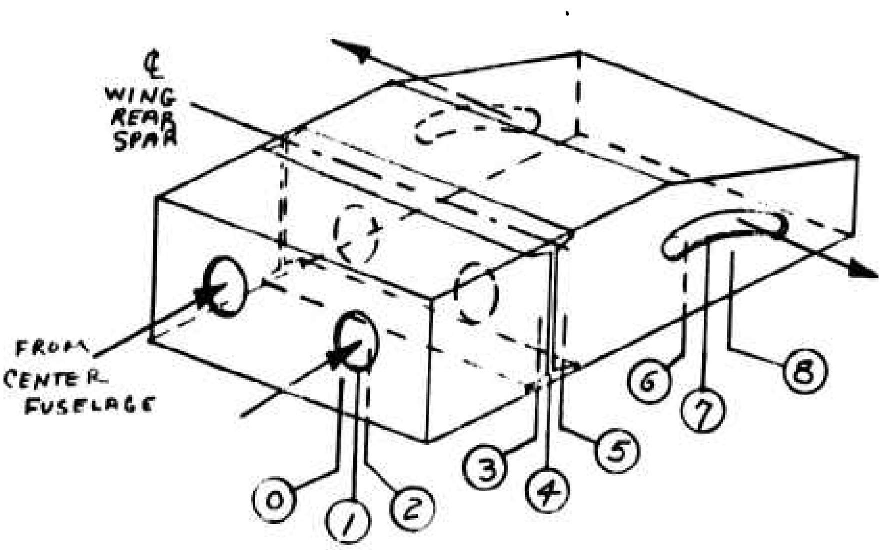

Figure 9.8 Cooling Air Duct Definition - Center Fuselage to Flap Actuator Compartment

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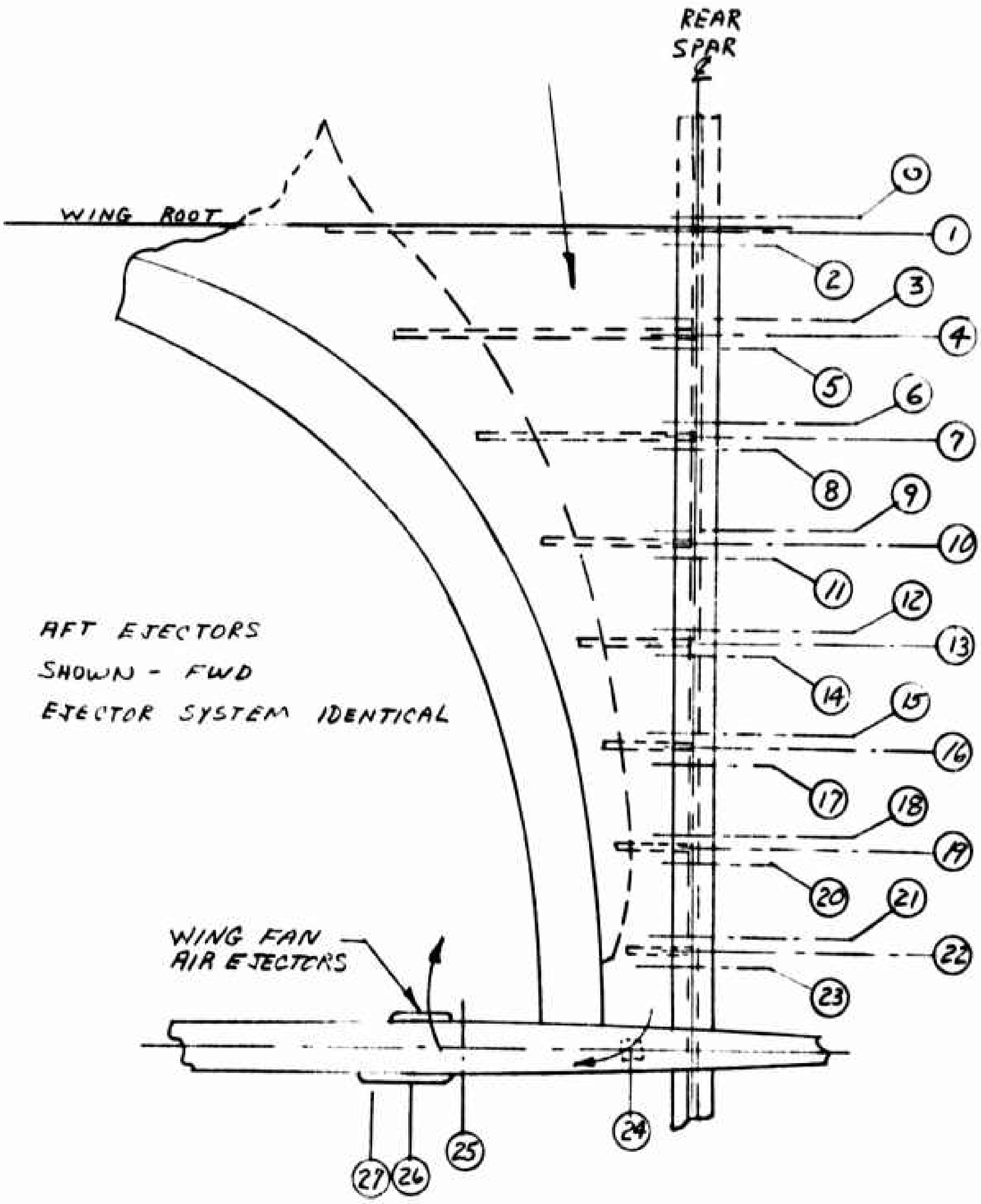

Figure 9.9 Cooling Air Duct Definition - Center Fuselage to Wing Fan Air Ejectors

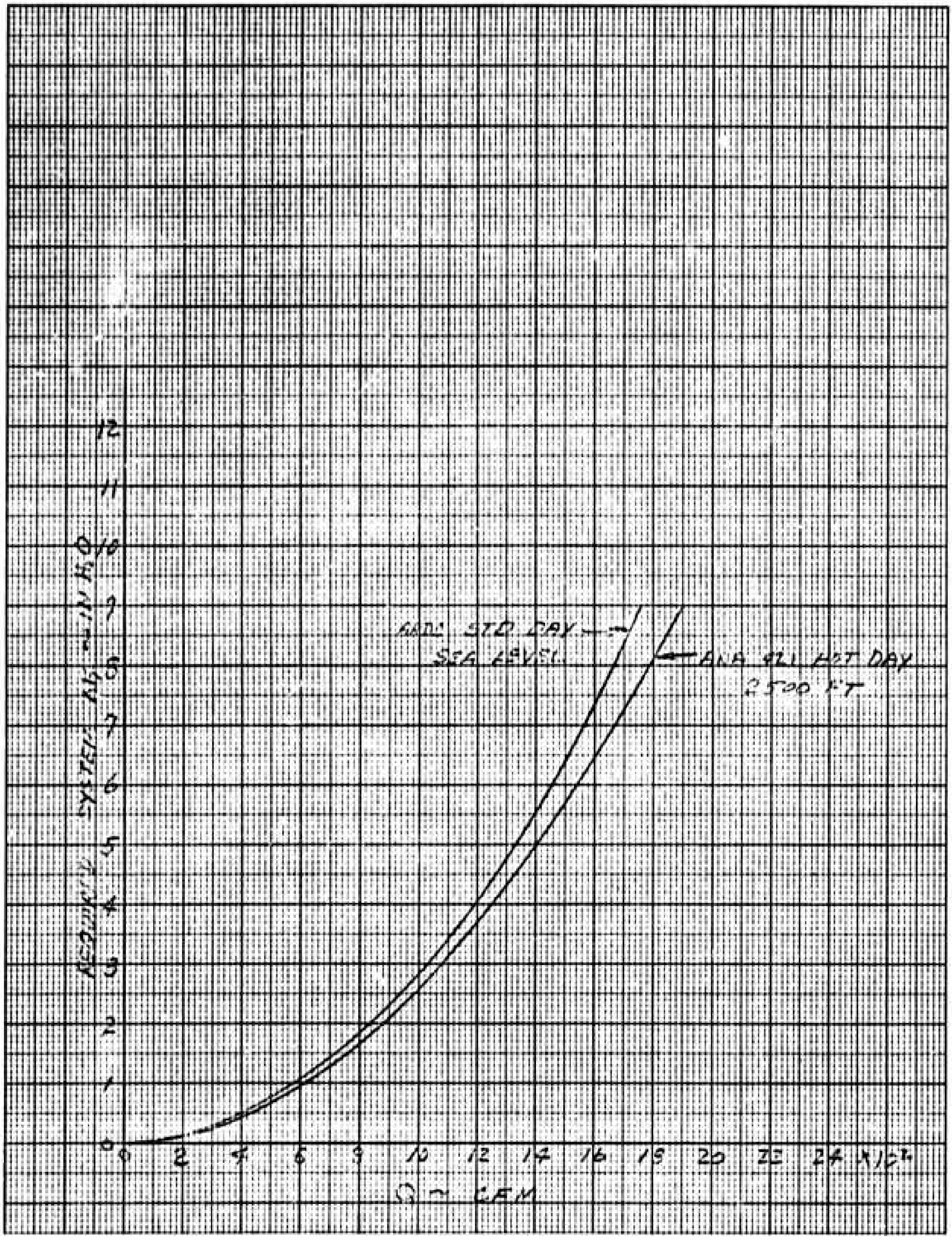

Figure 9.10 **Duct Pressure Loss - Cockpit to Cooling Fan Compartment Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.**

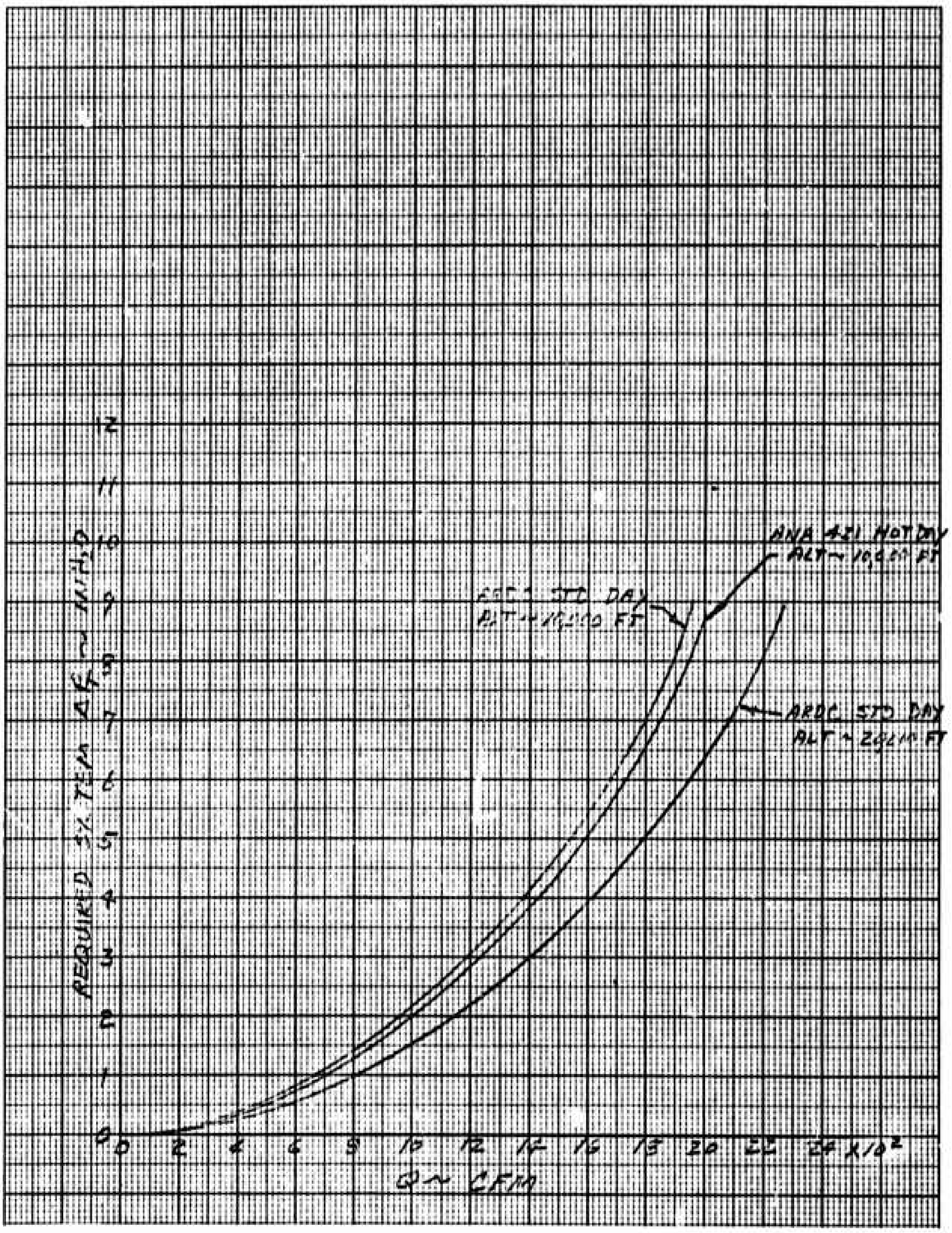

Figure 9.11 Duct Pressure Loss - Cockpit to Cooling Fan Compartment Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft., and Hot Day 10,000 Ft.

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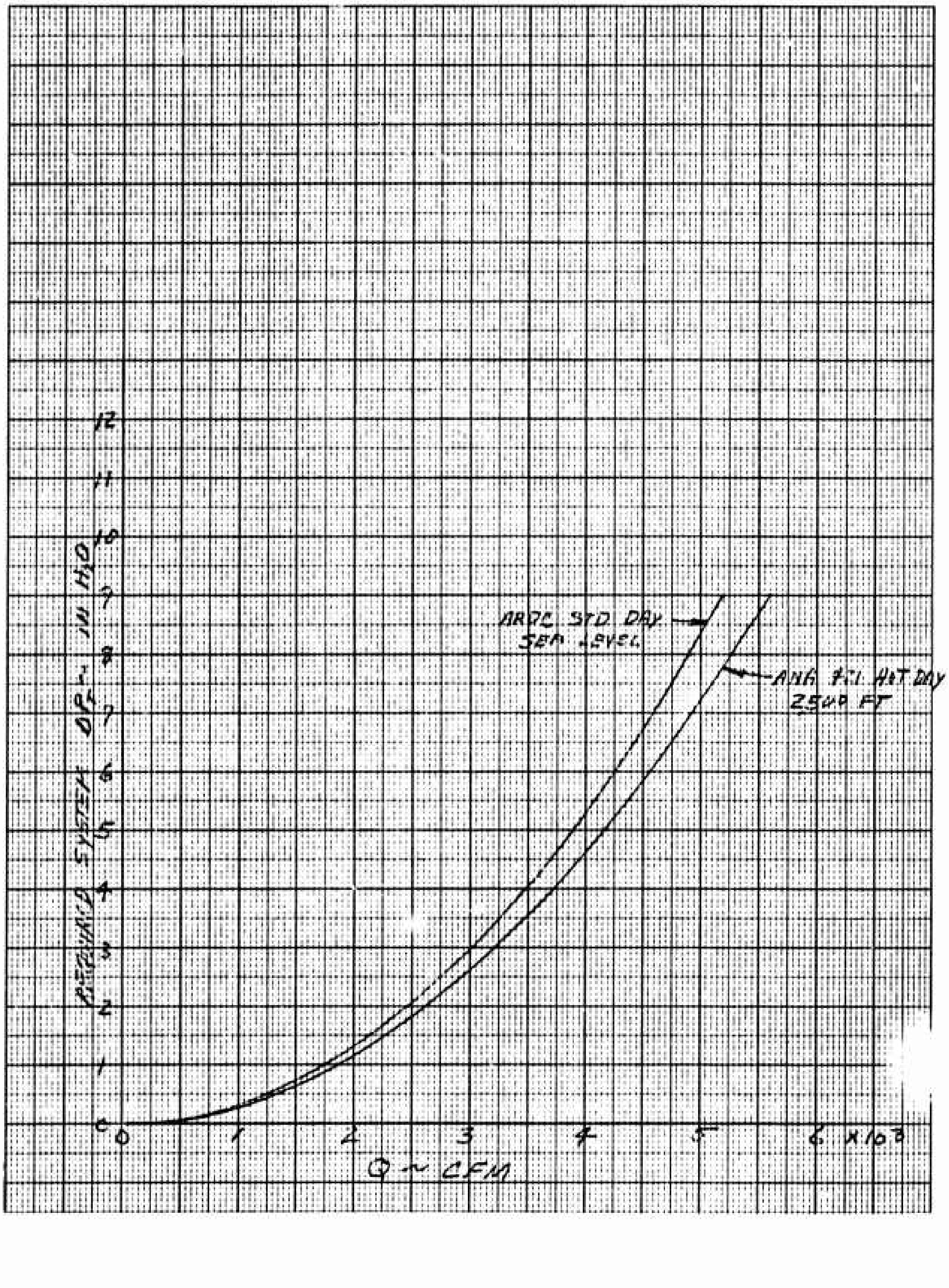

Figure 9.12 Duct Pressure Loss - Fuselage Ports to Cooling Fan Compartment Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

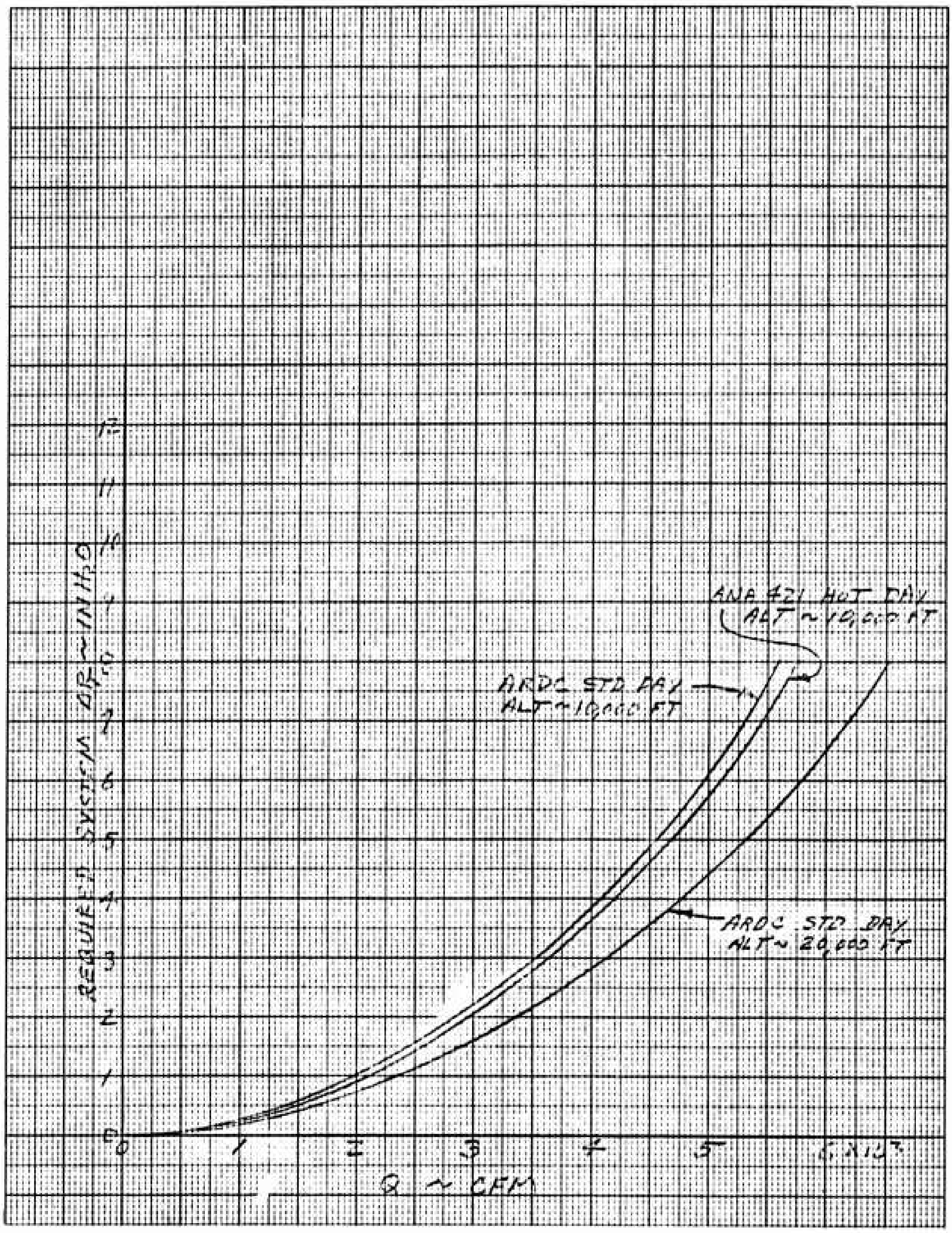

Figure 9.13 Duct Pressure Loss - Fuselage Ports to Cooling Fan Compartment Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft, and Hot Day 10,000 Ft.

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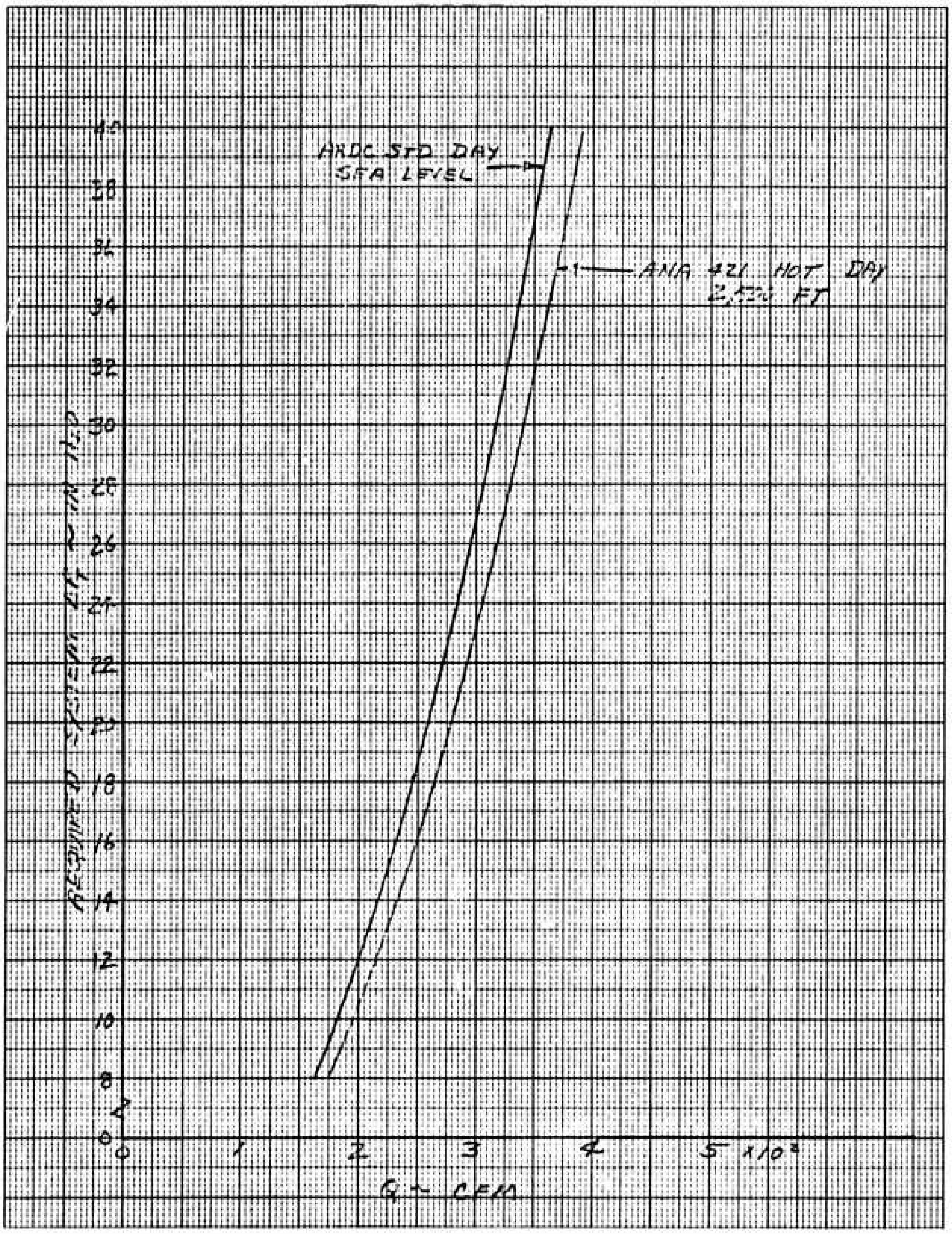

Figure 9.14 Duct Pressure Loss - Small Cooling Fan to Generator Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

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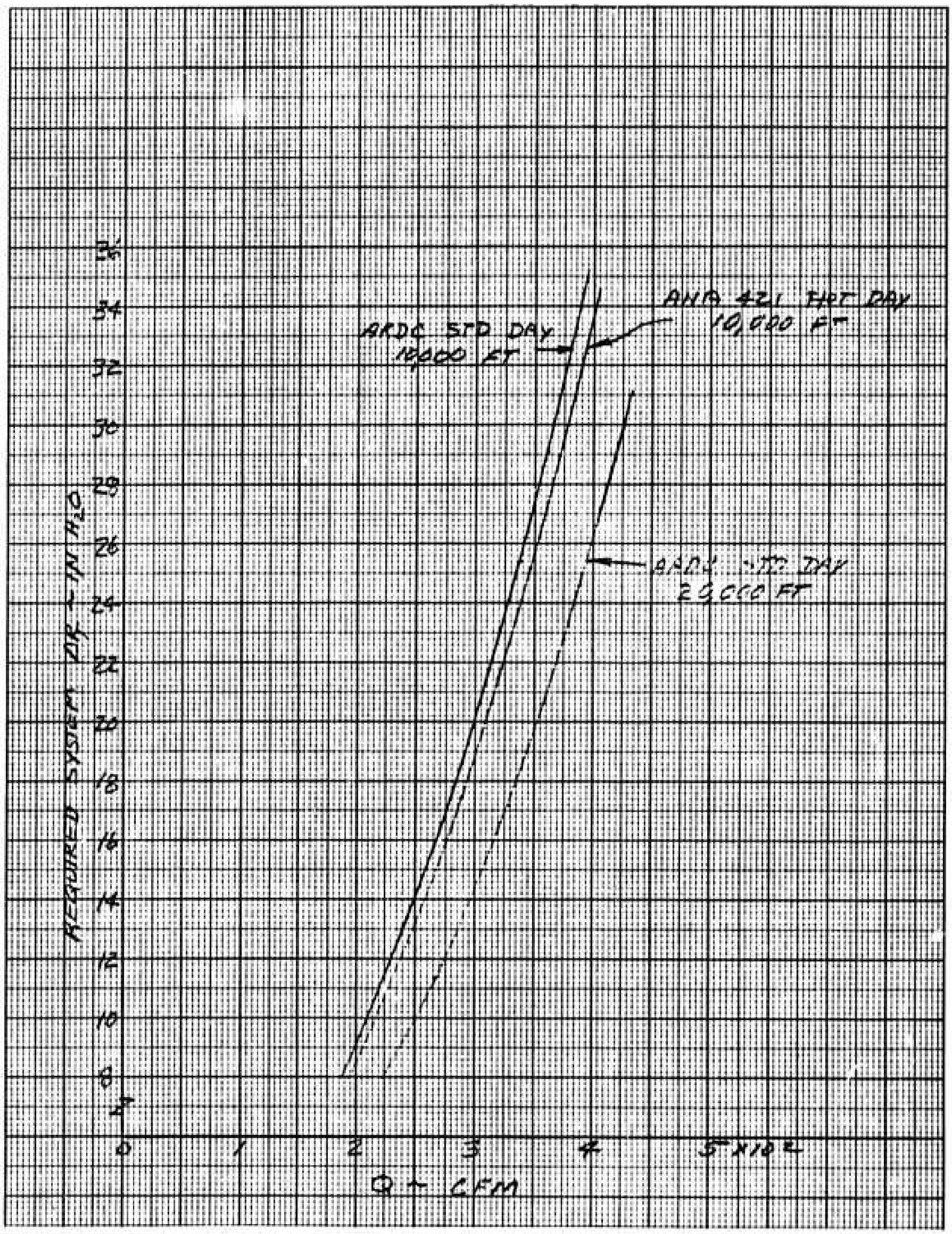

Figure 9.15 **Duct Pressure Loss - Small Cooling Fan to Generator Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft., and Hot Day 10,000 Ft.**

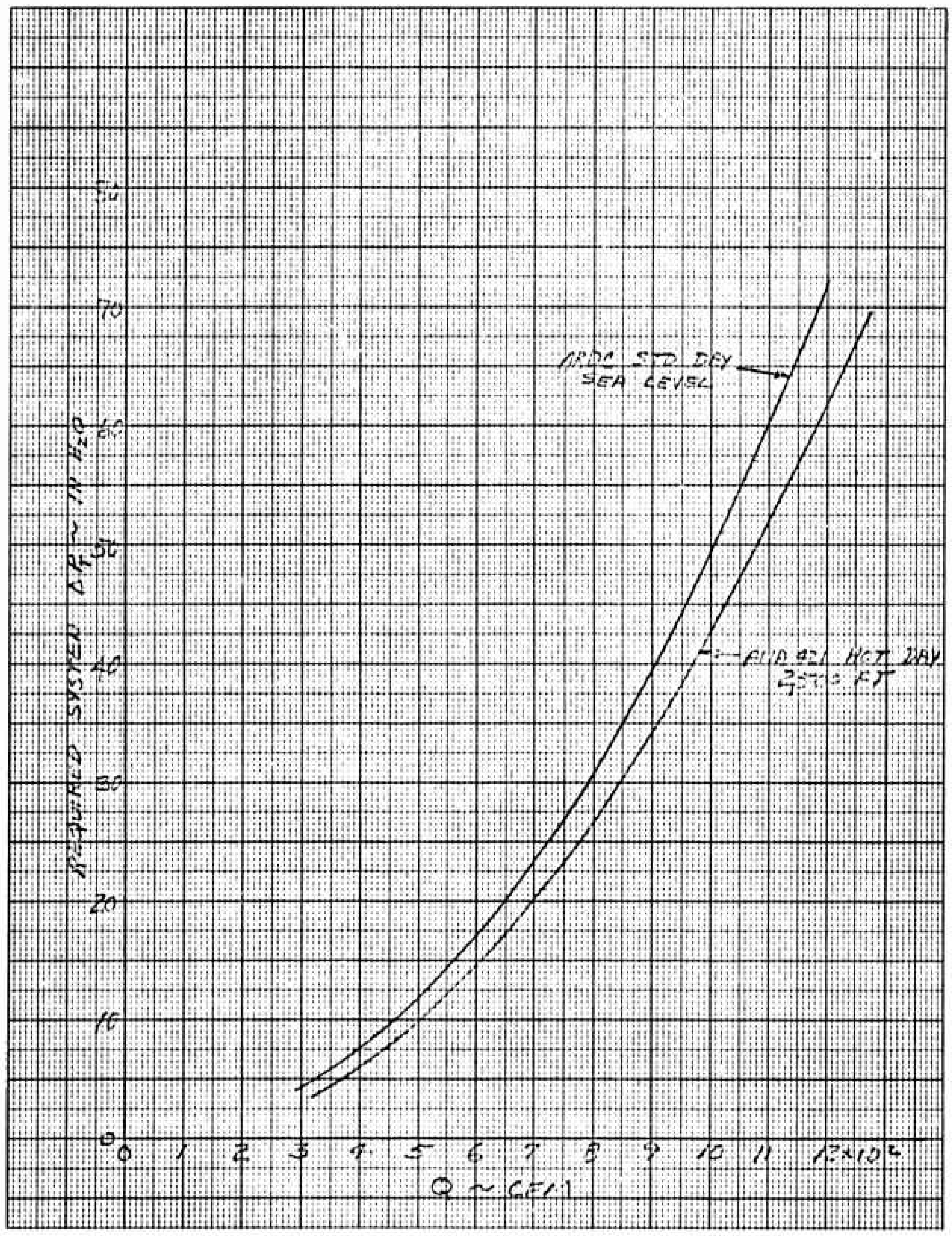

Figure 9.16 Duct Pressure Loss - Small Cooling Fan to Electronic Compartment Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

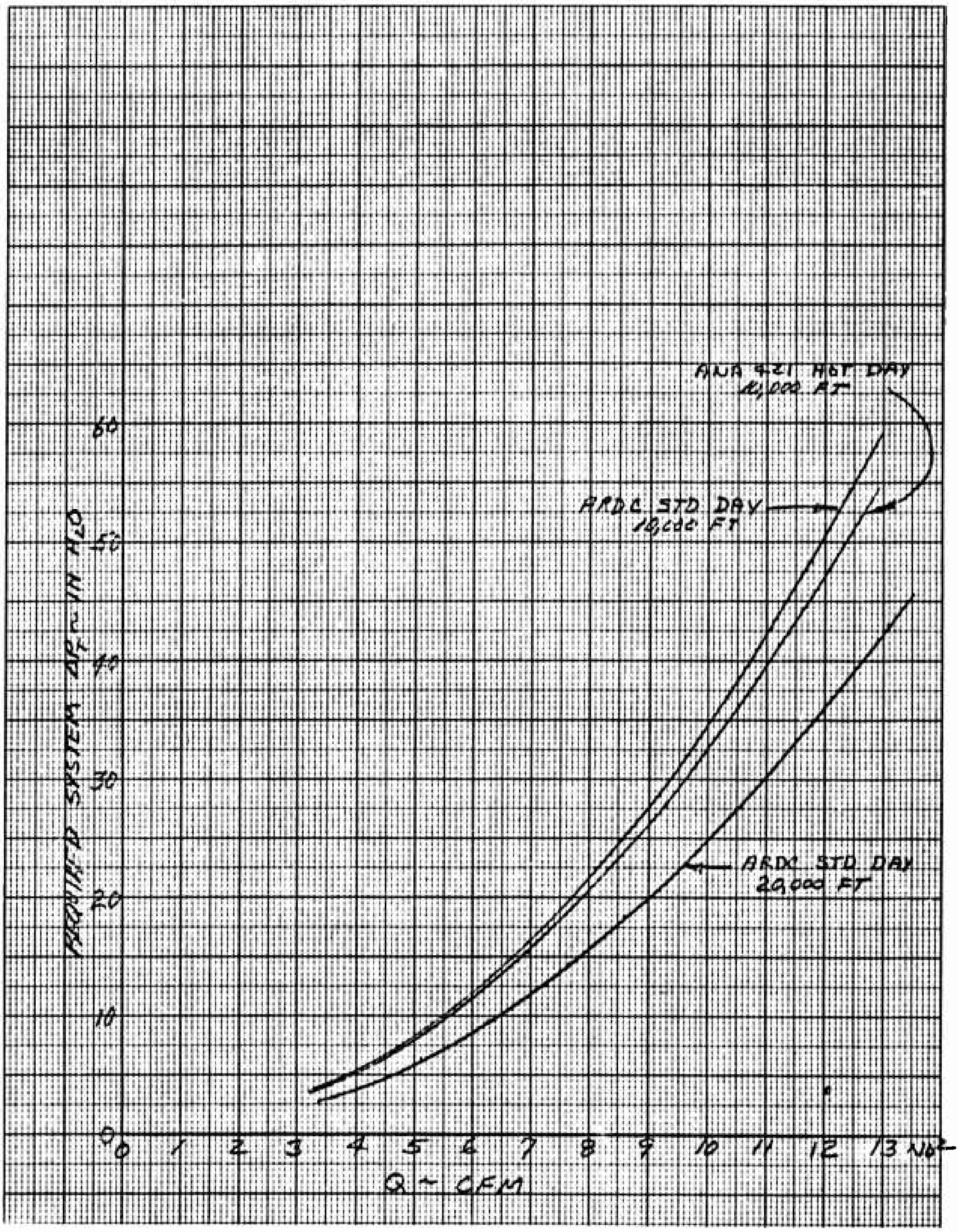

Figure 9.17 Duct Pressure Loss - Small Cooling Fan to Electronic Compartment Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft., and Hot Day 10,000 Ft.

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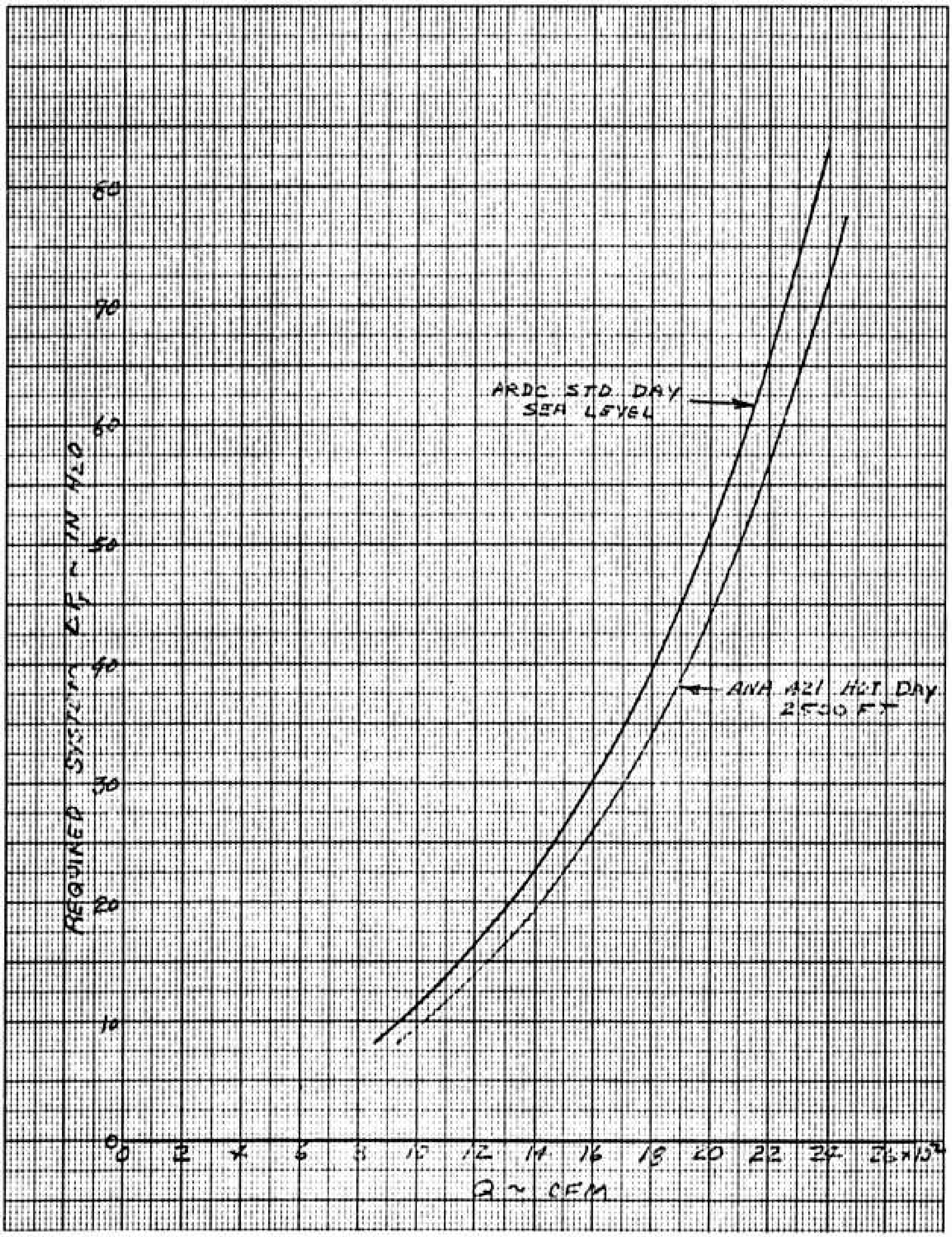

Figure 9.18 Duct Pressure Loss - L.H. Large Cooling Fan to Center Fuselage Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

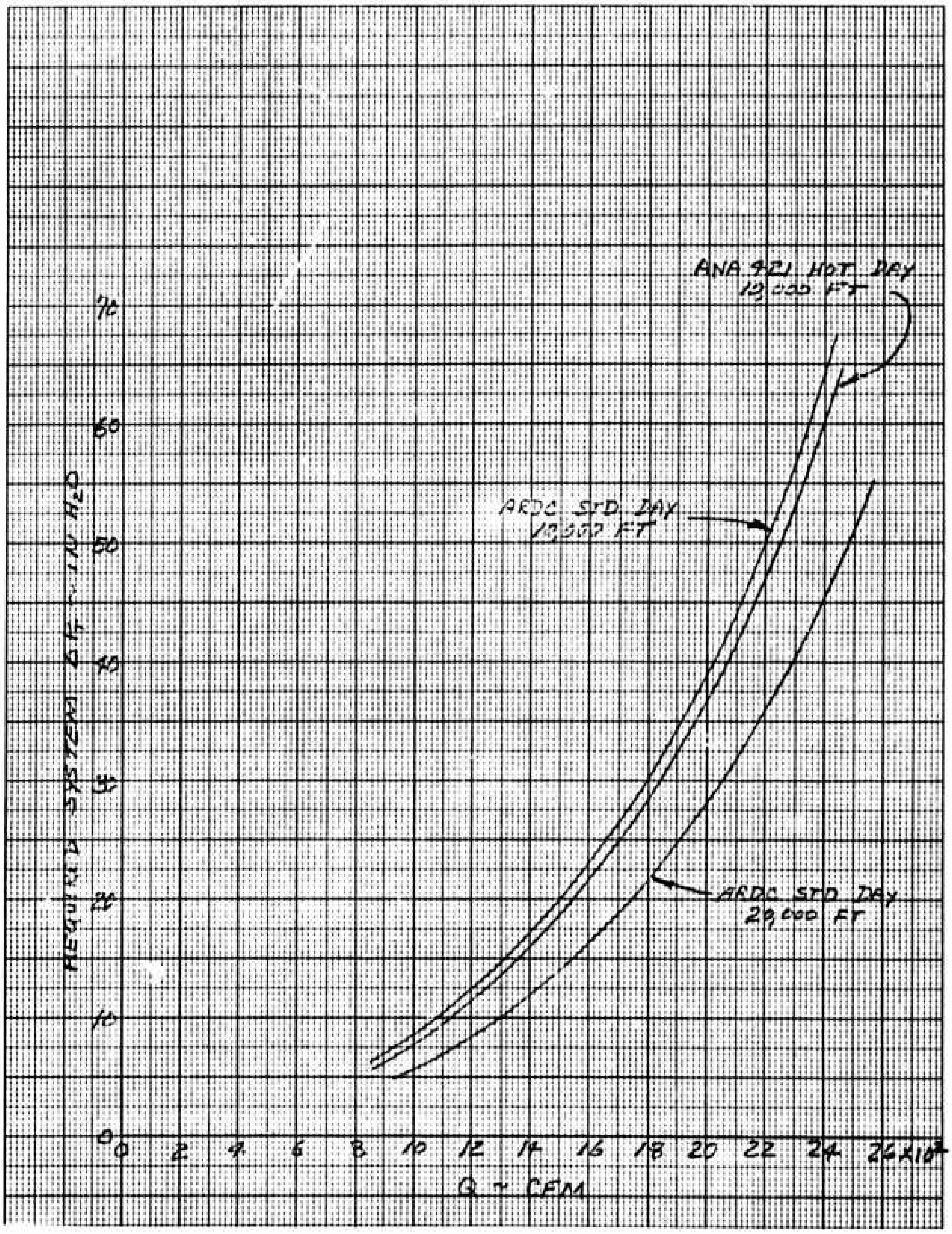

Figure 9.19 Duct Pressure Loss - L.H. Large Cooling Fan to Center Fuselage Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft., and Hot Day 10,000 Ft.

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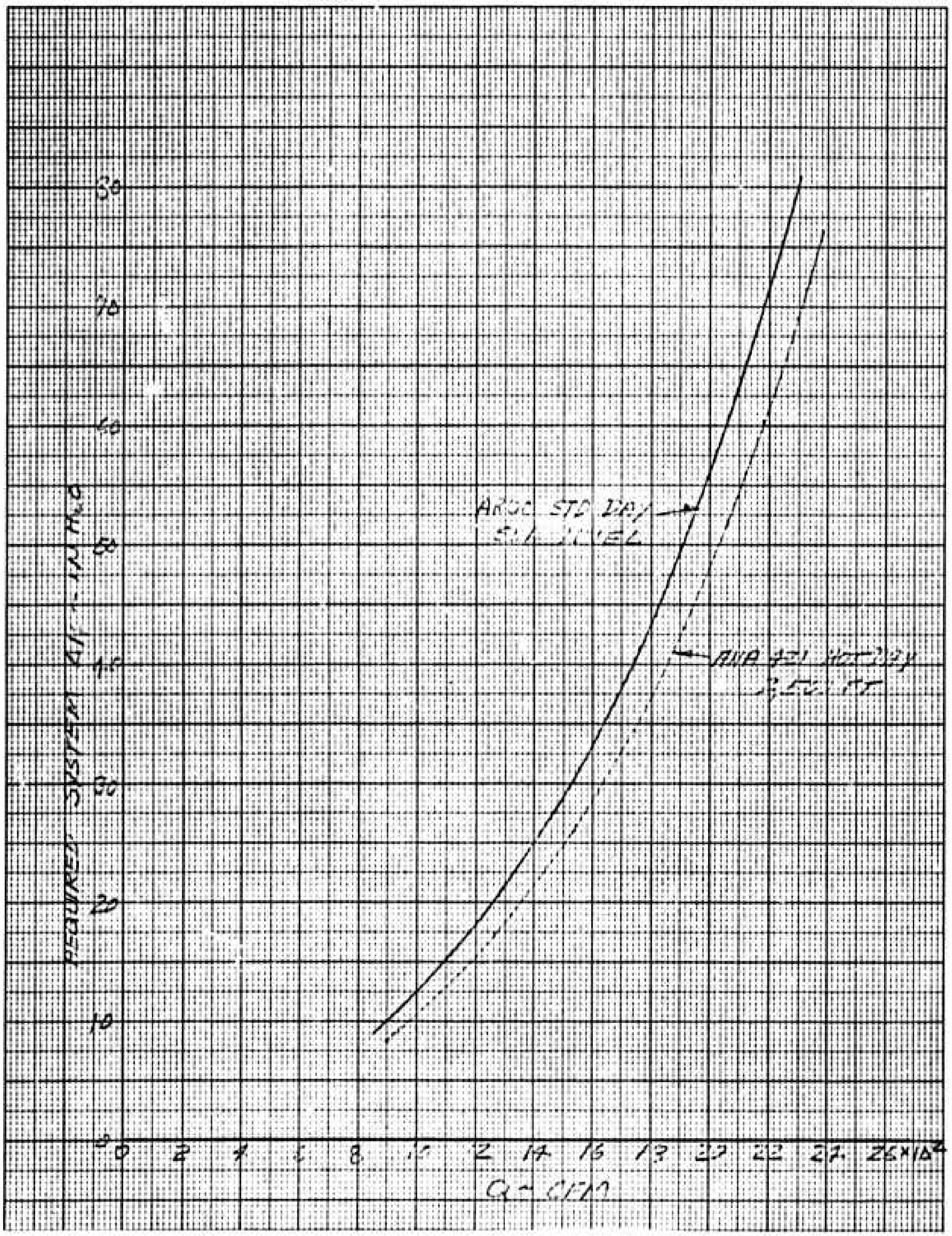

Figure 9.20 Duct Pressure Loss - R.H. Large Cooling Fan to Center Fuselage Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

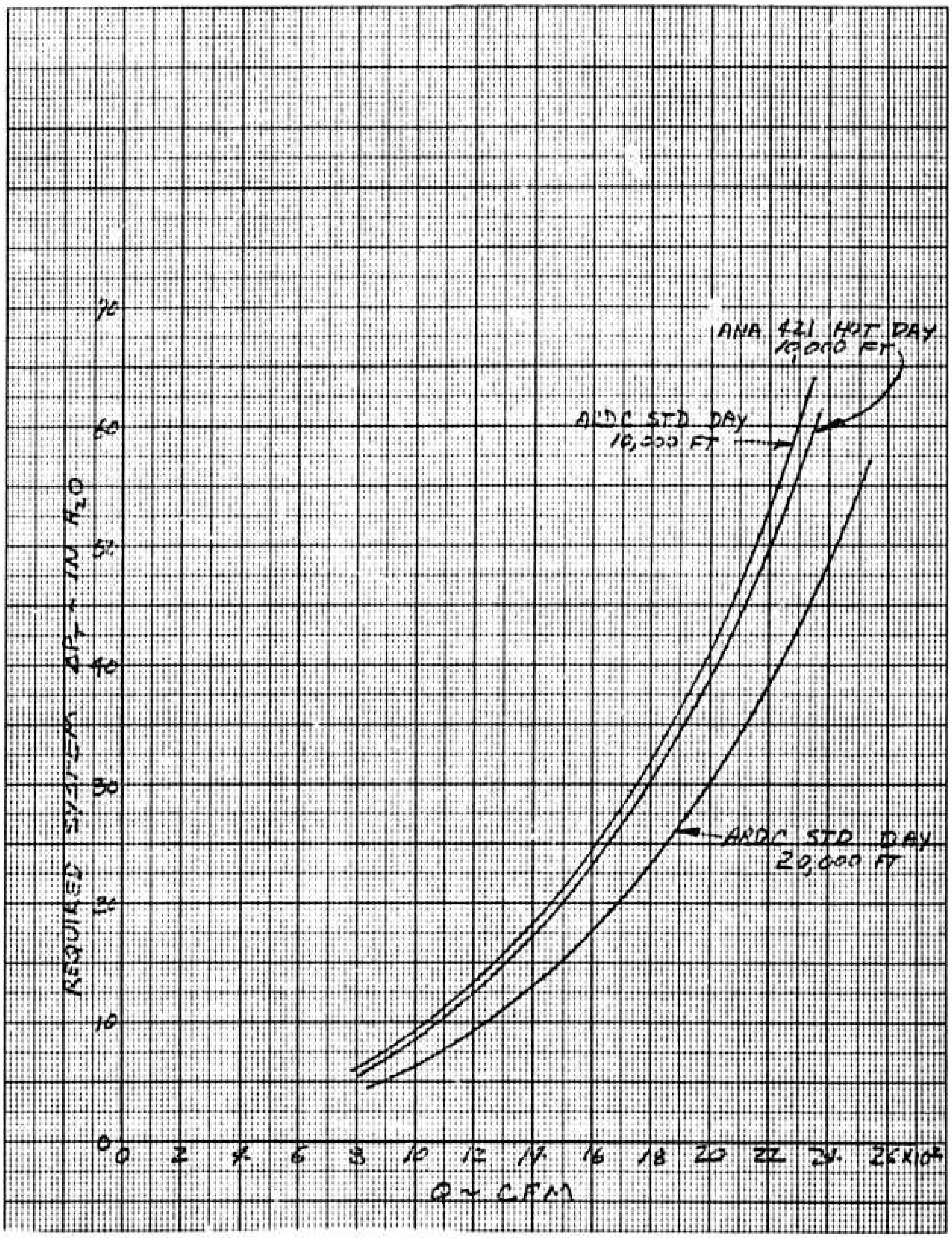

Figure 9.21 Duct Pressure Loss - R.H. Large Cooling Fan to Center Fuselage Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft., and Hot Day 10,000 Ft.

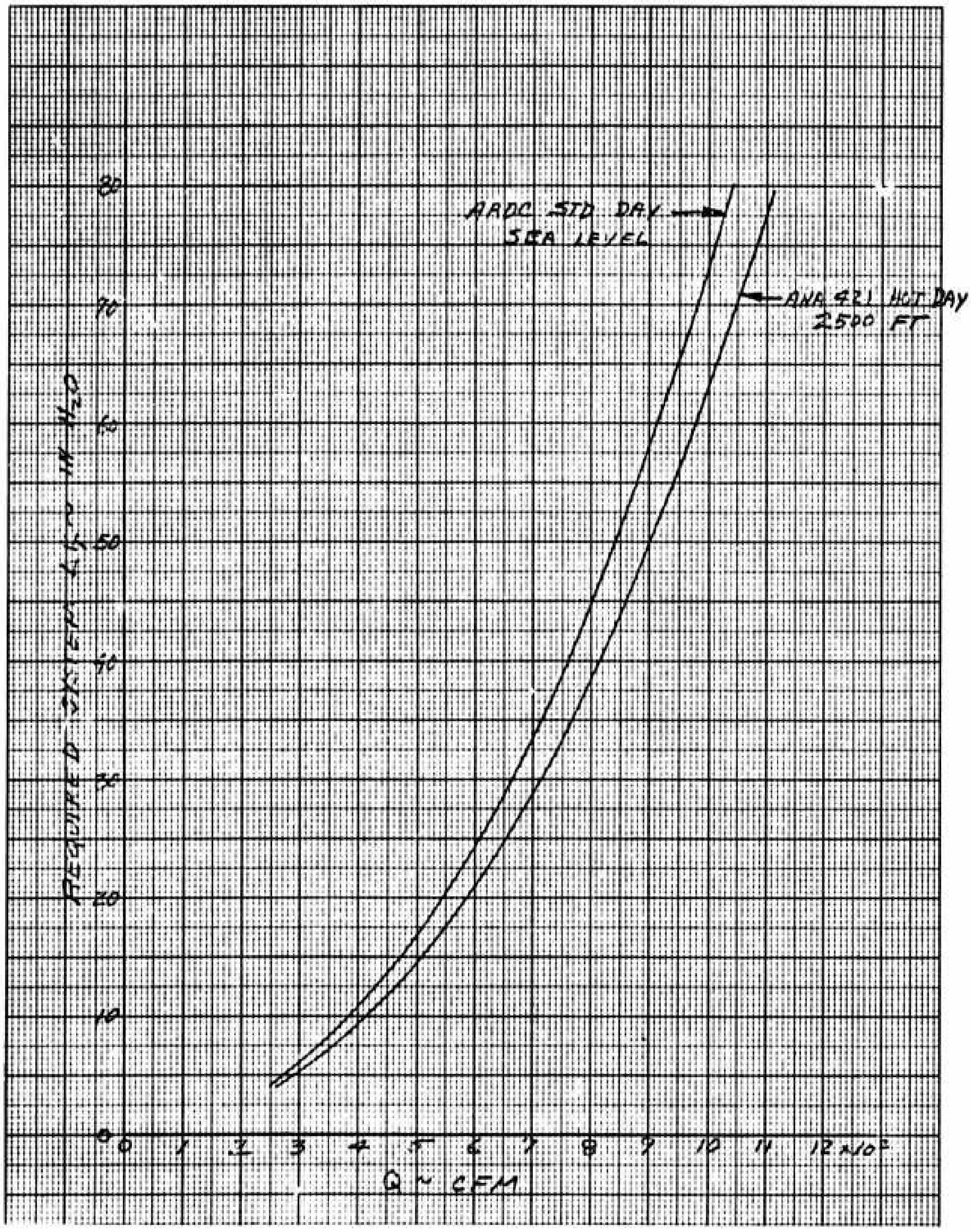

Figure 9.22 Duct Pressure Loss - Large Cooling Fan to Tailpipe Ejector Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

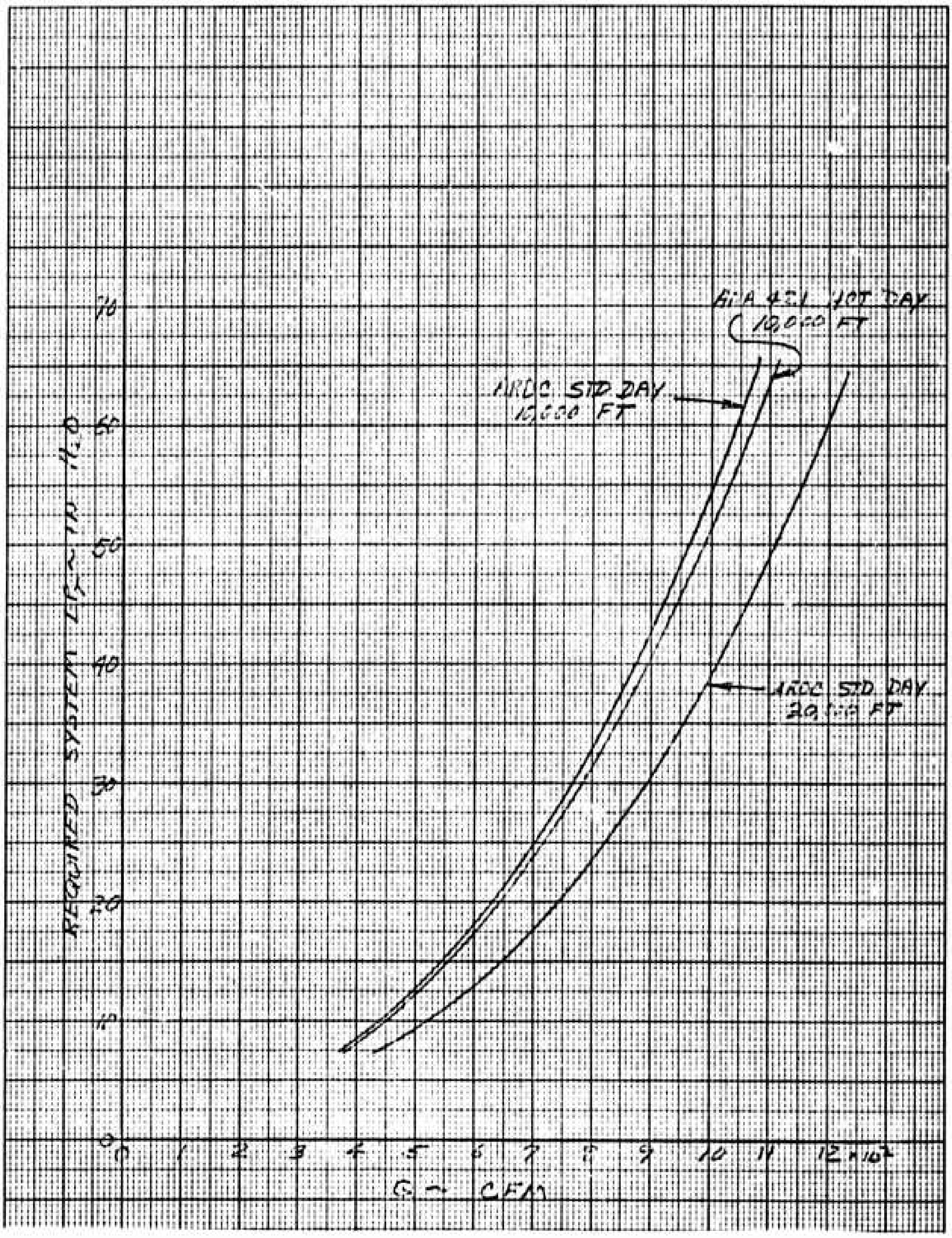

Figure 9.23 Duct Pressure Loss - Large Cooling Fan to Tailpipe Ejector Vs Cooling Air Flow - Standard Day 10,000 and 20,000 Ft., and Hot Day 10,000 Ft.

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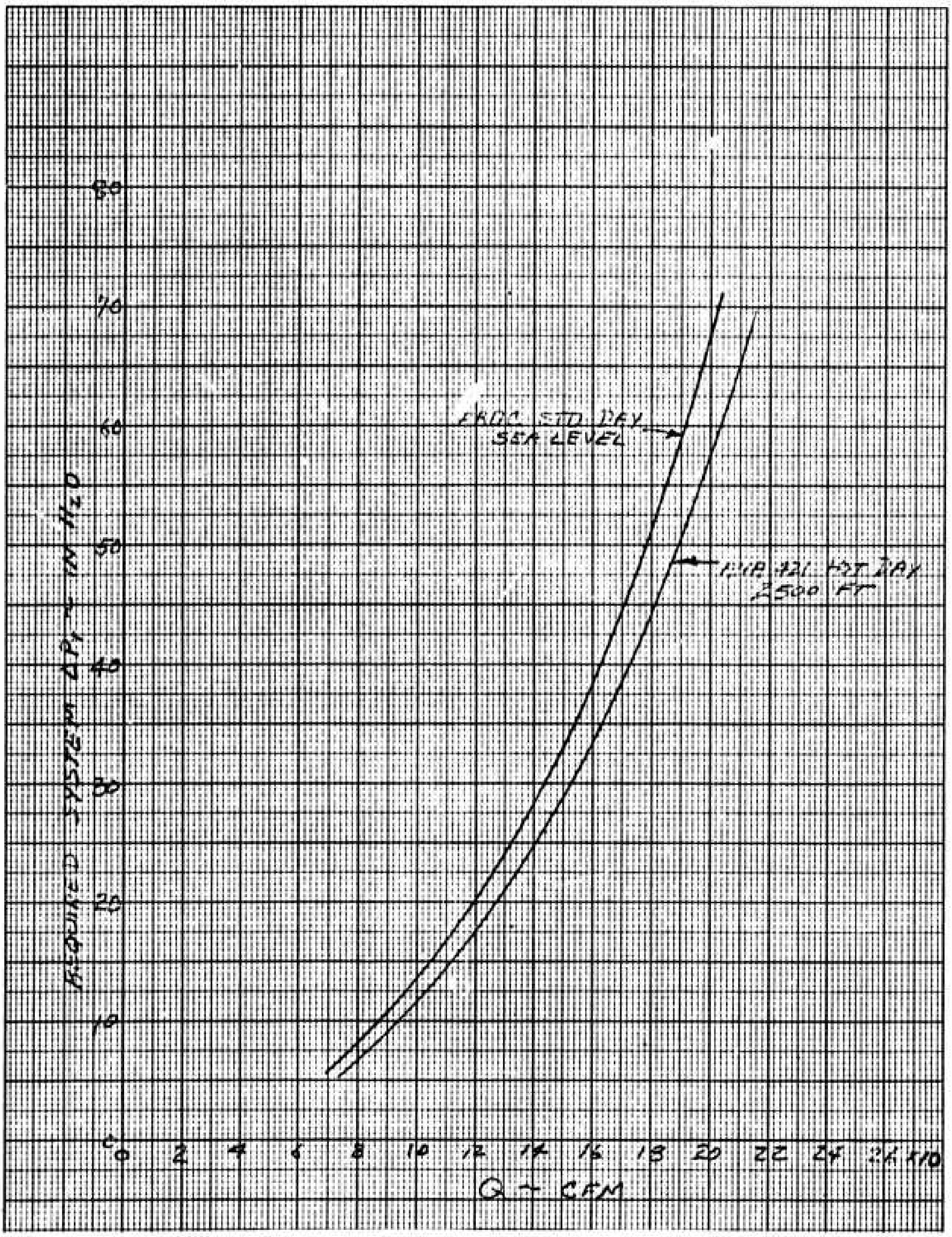

Figure 9.24 Duct Pressure Loss - Electronic Compartment to Nose Fan Ejector Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

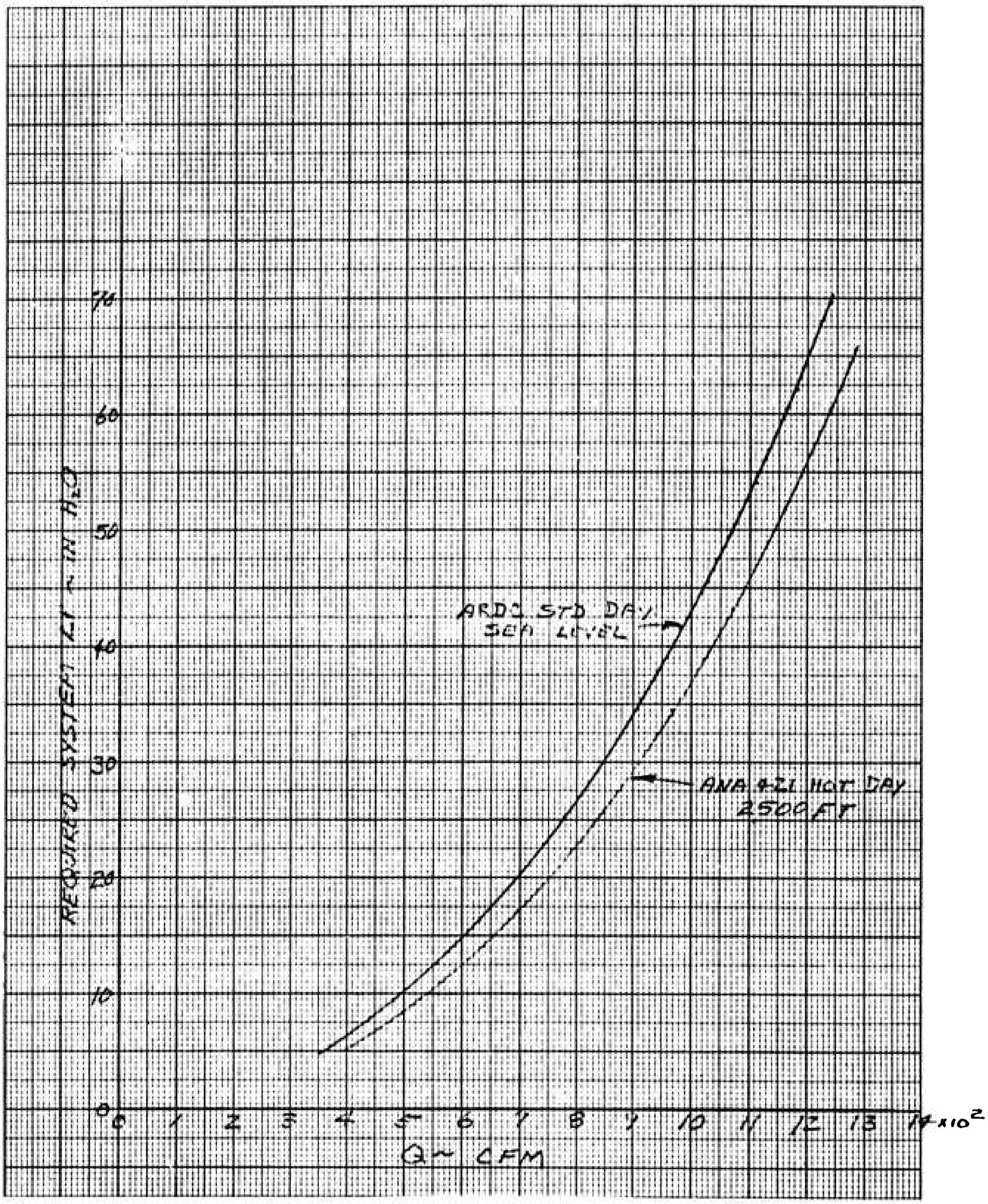

Figure 9.25 Duct Pressure Loss - Center Fuselage to Flap Actuator Compartment Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

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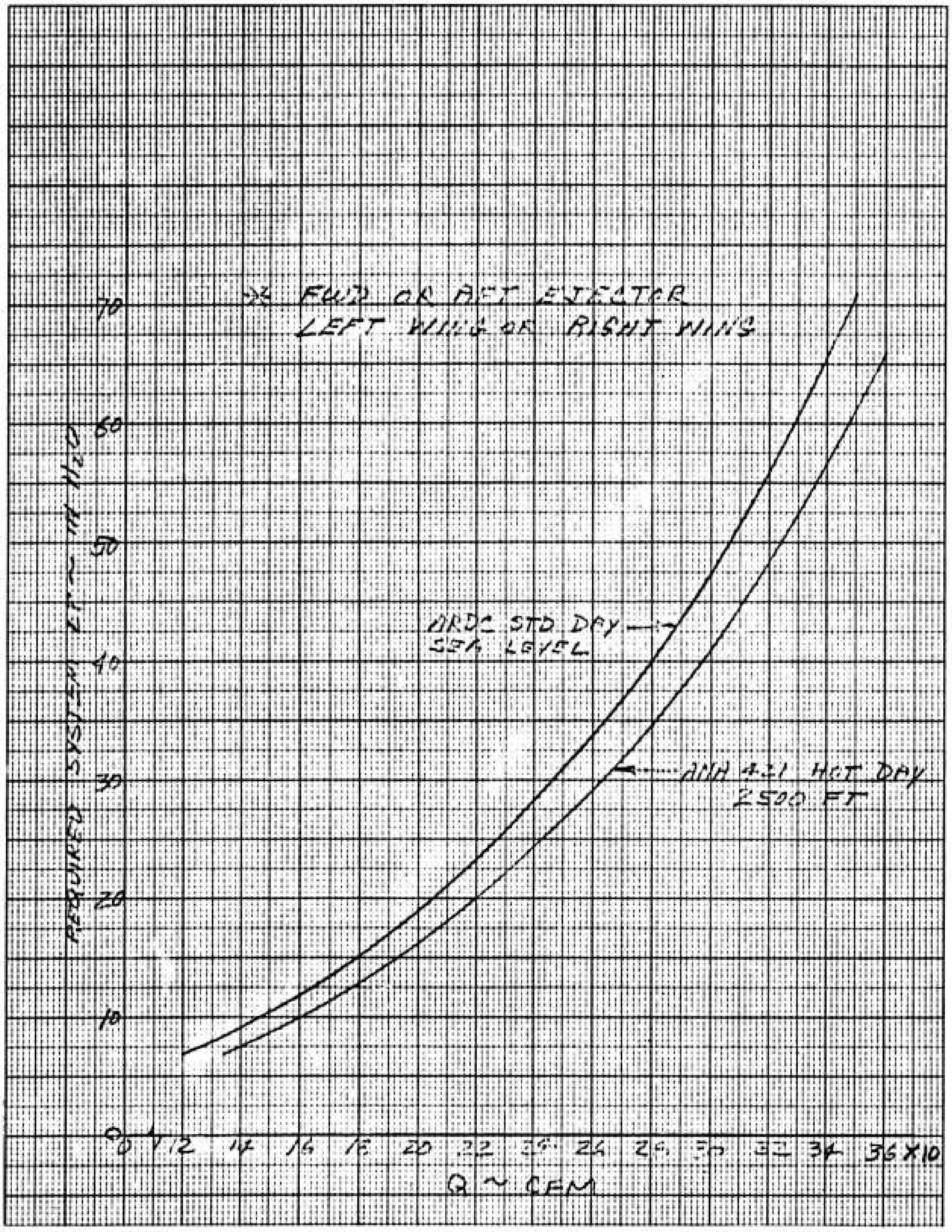

Figure 9.26 Duct Pressure Loss - Center Fuselage to Wing Fan Ejector Vs Cooling Air Flow - Standard Day Sea Level, and Hot Day 2,500 Ft.

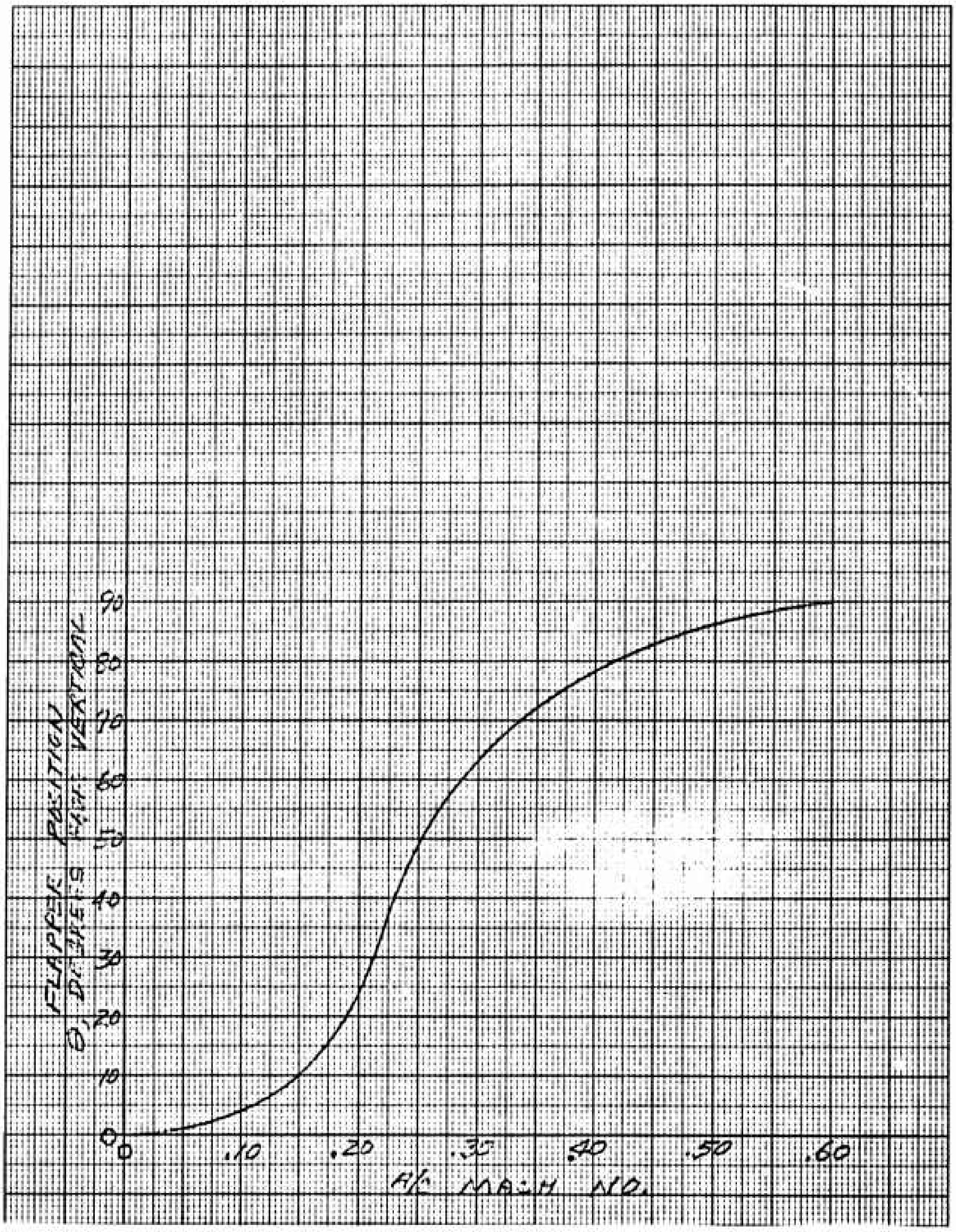

Figure 9.27 Boundary Layer Bleed Duct Aft Flapper Position Vs Aircraft Mach No. - Standard Day, Sea Level, 100% RPM

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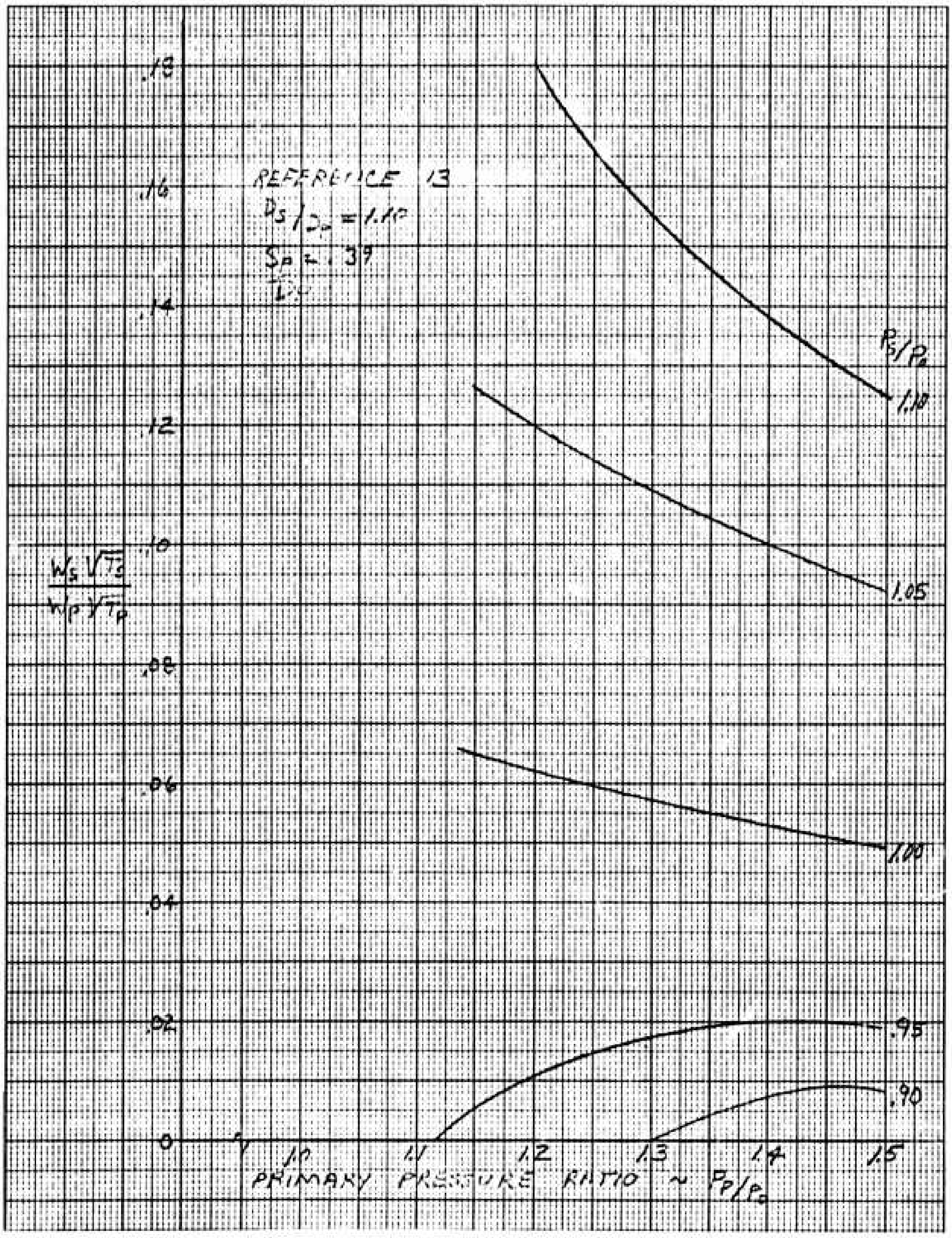

Figure 9. 28 Tailpipe Ejector Weight Flow Ratio Vs Primary and Secondary Pressure Ratio, P_p/P_o = 1.1 to 1.5

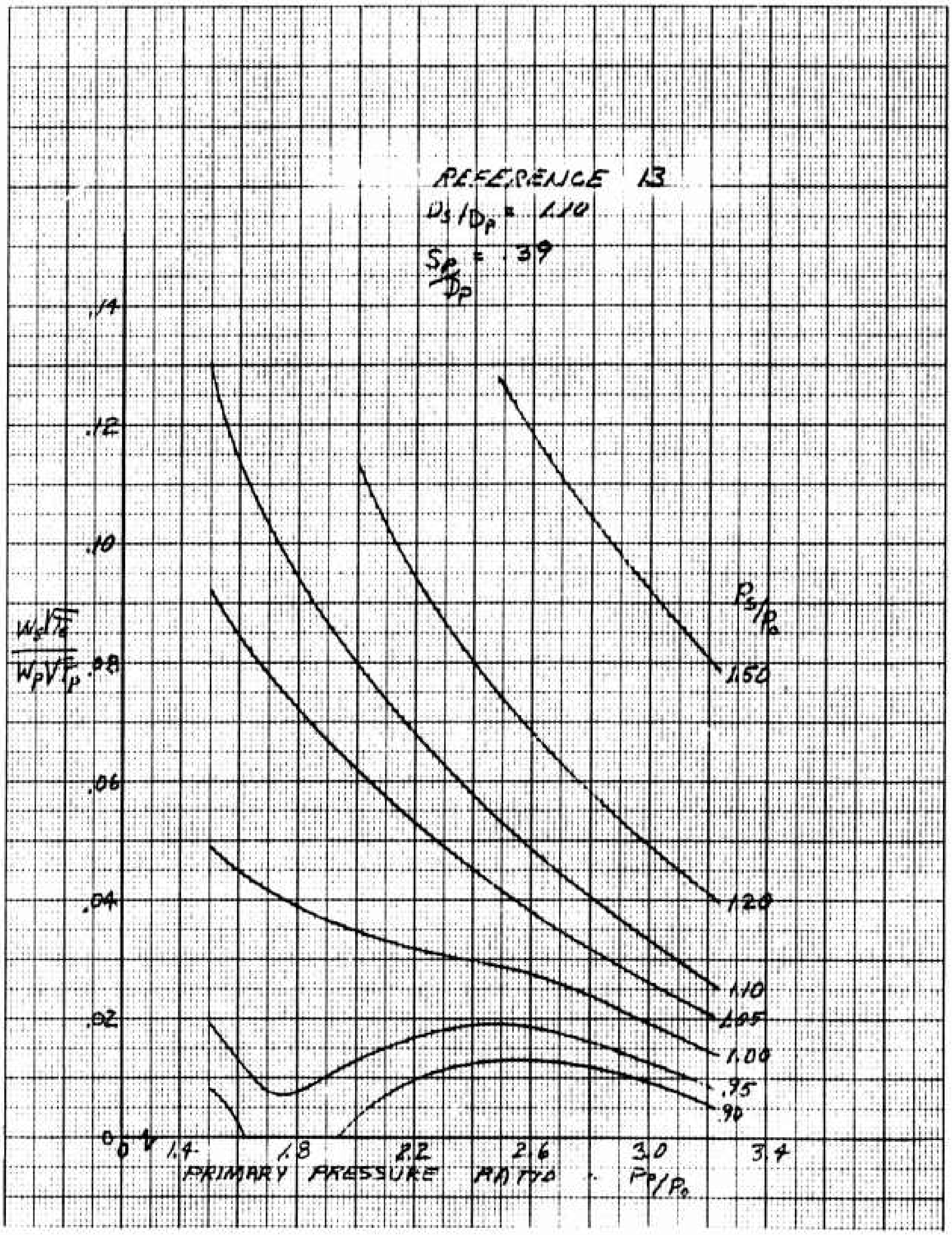

Figure 9.29 Tailpipe Ejector Weight Flow Ratio Vs Primary and Secondary Pressure Ratio, P_p/P_o = 1.5 to 3.2

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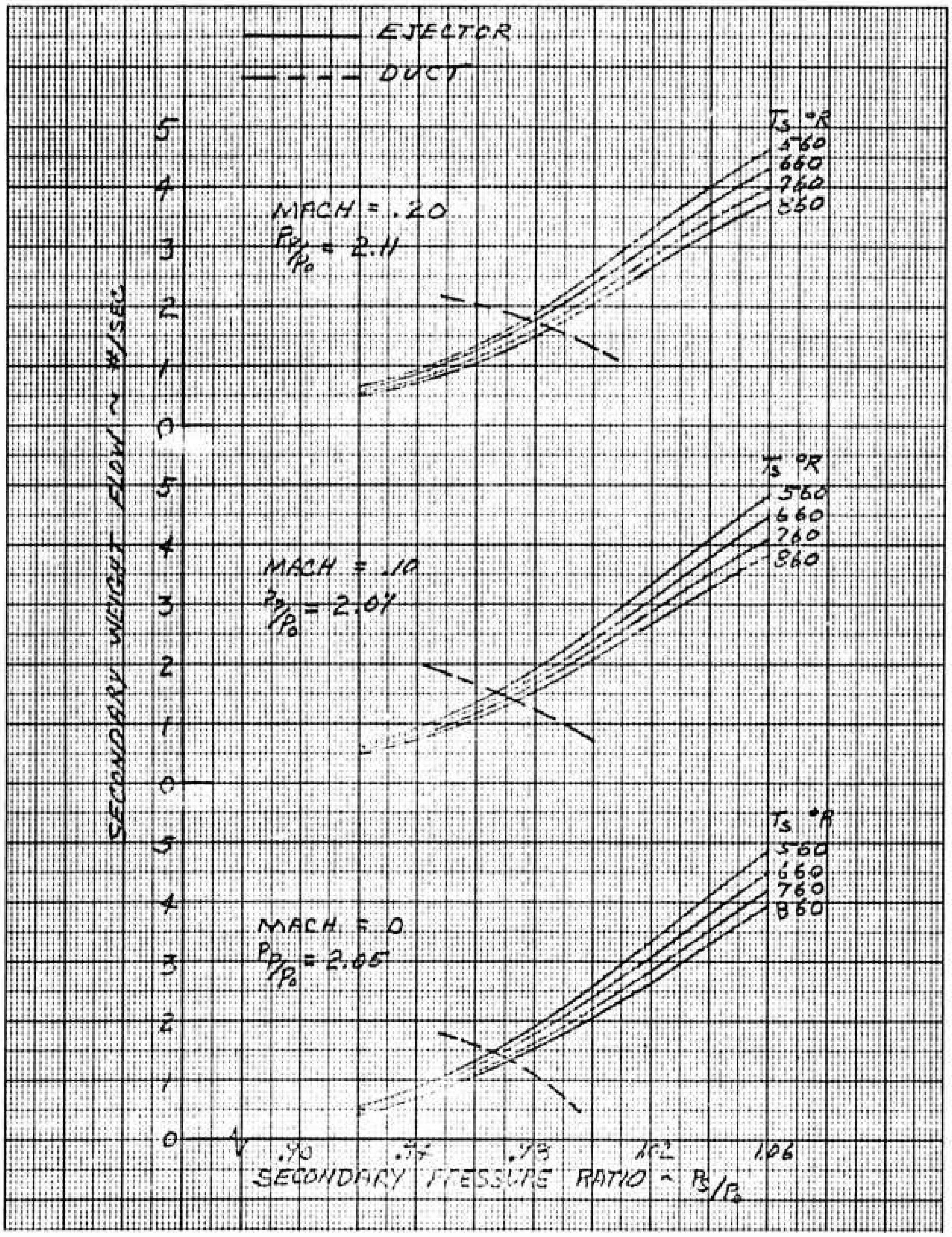

Figure 9.30 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 100% RPM and Mach No. = 0, 0.1 and 0.2

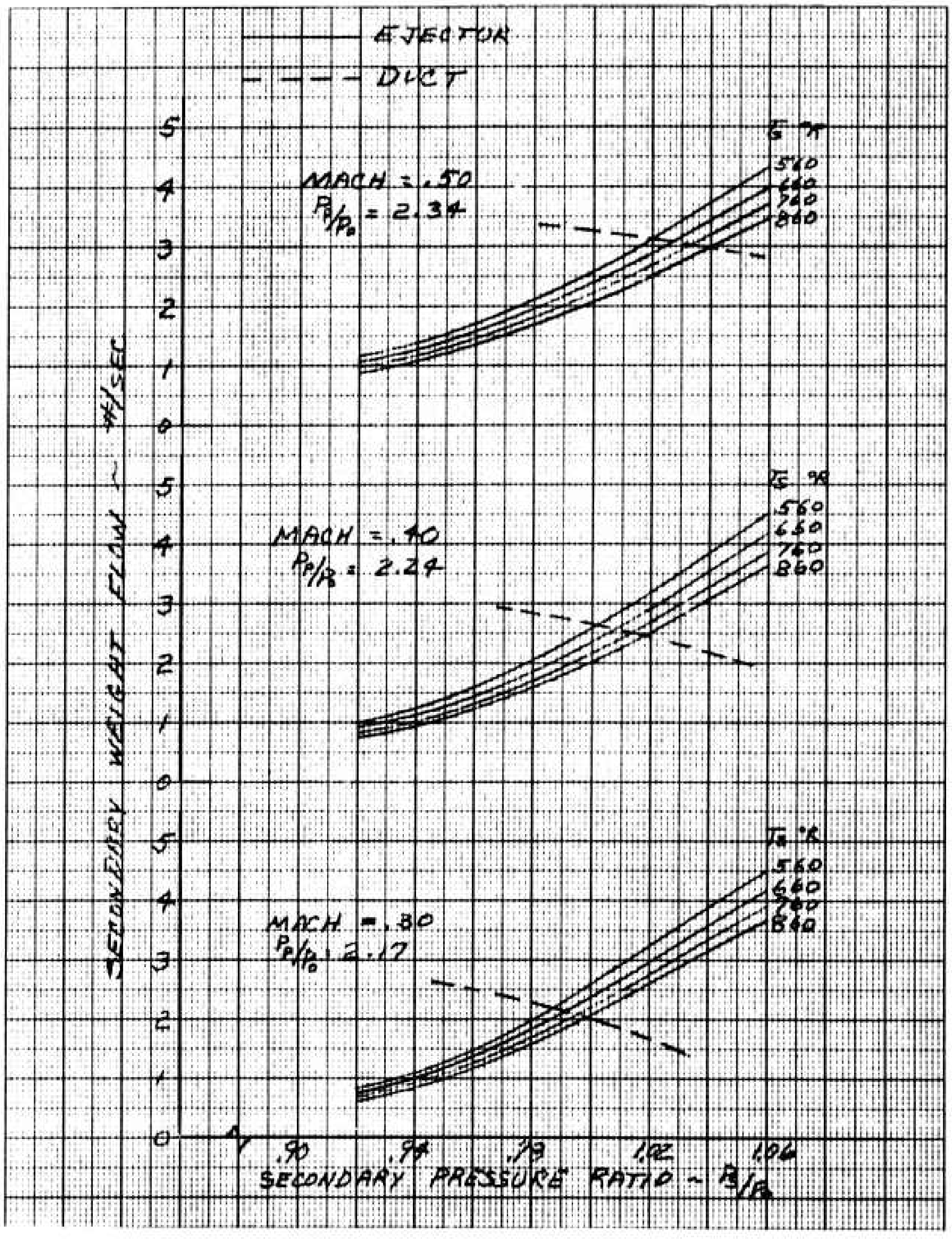

Figure 9.31 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 100% RPM and Mach No. = 0.3, 0.4 and 0.5

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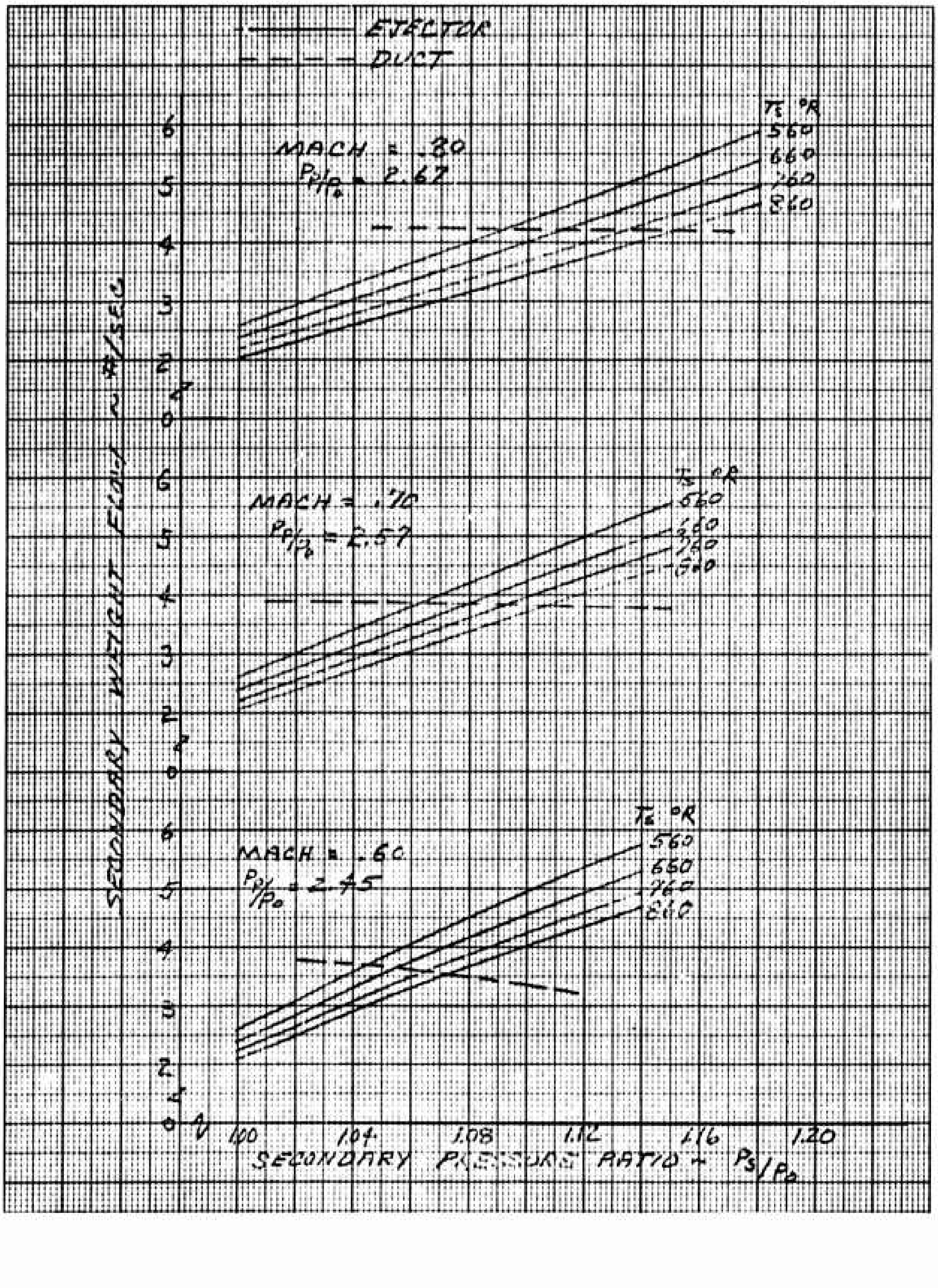

Figure 9.32 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 100% RPM and Mach No. = 0.6, 0.7 and 0.8

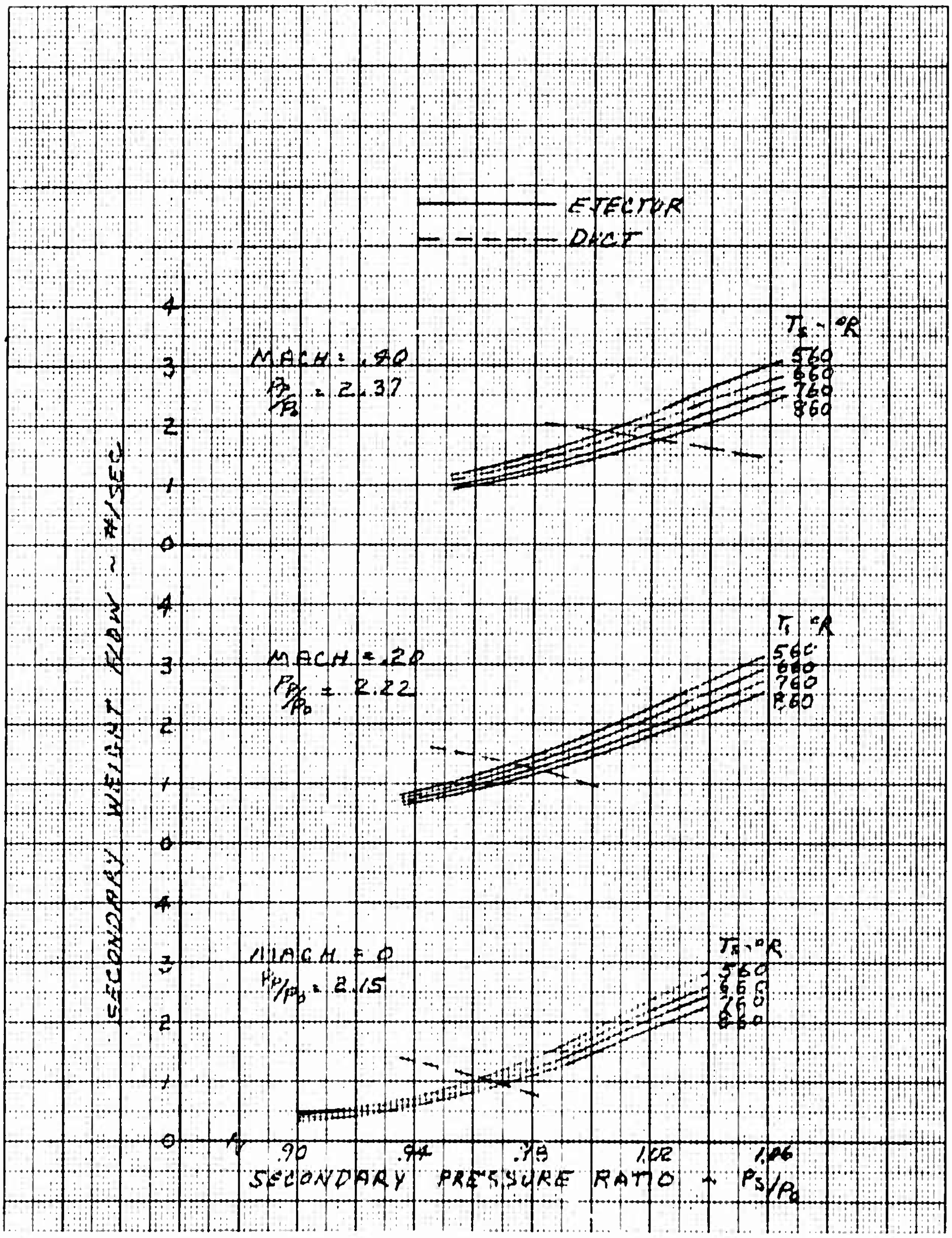

Figure 9.33 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day 10,000 Ft., 100% RPM and Mach No. = 0, 0.2 and 0.4

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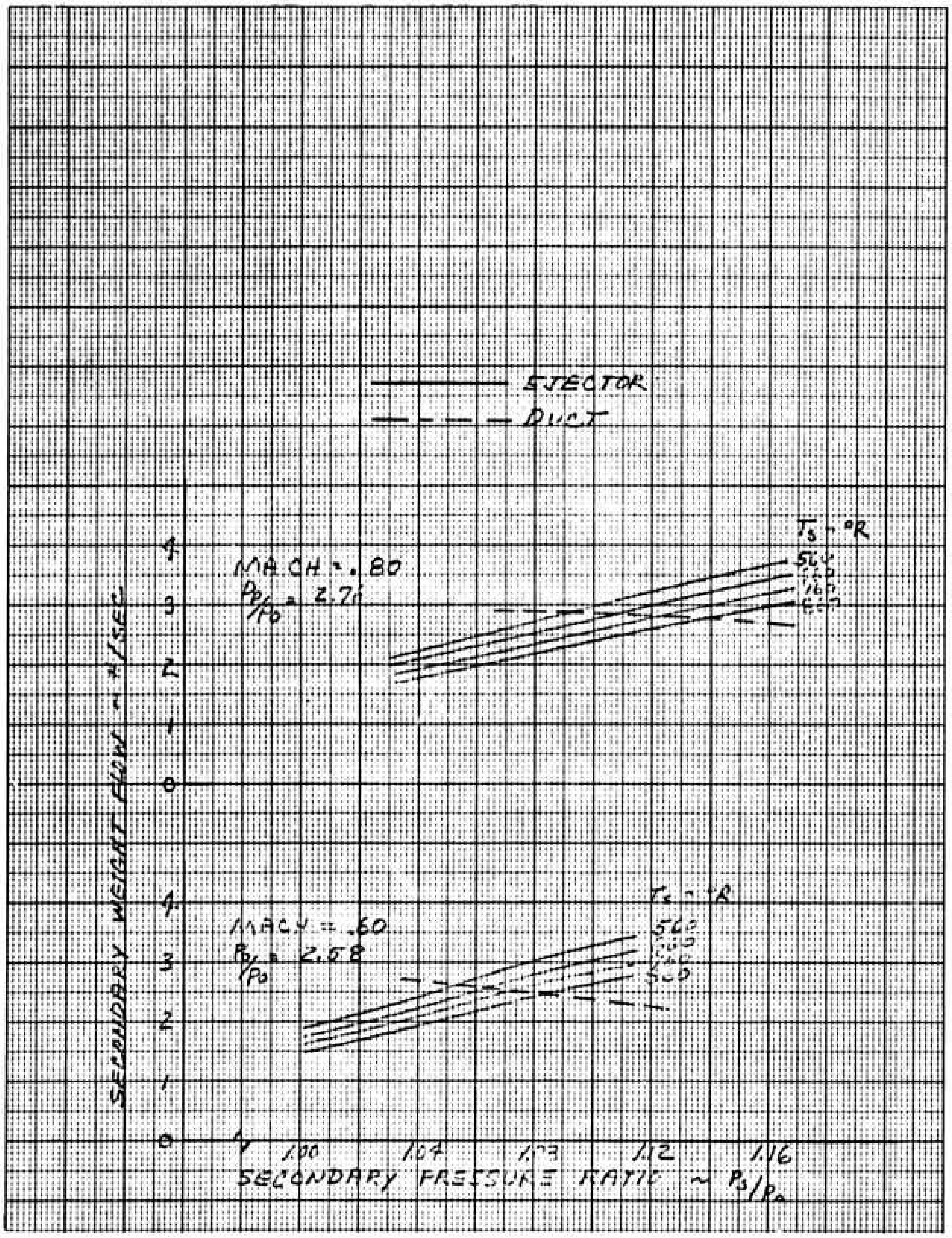

Figure 9.34 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day 10,000 Ft., 100% RPM and Mach No. = 0.6 and 0.8

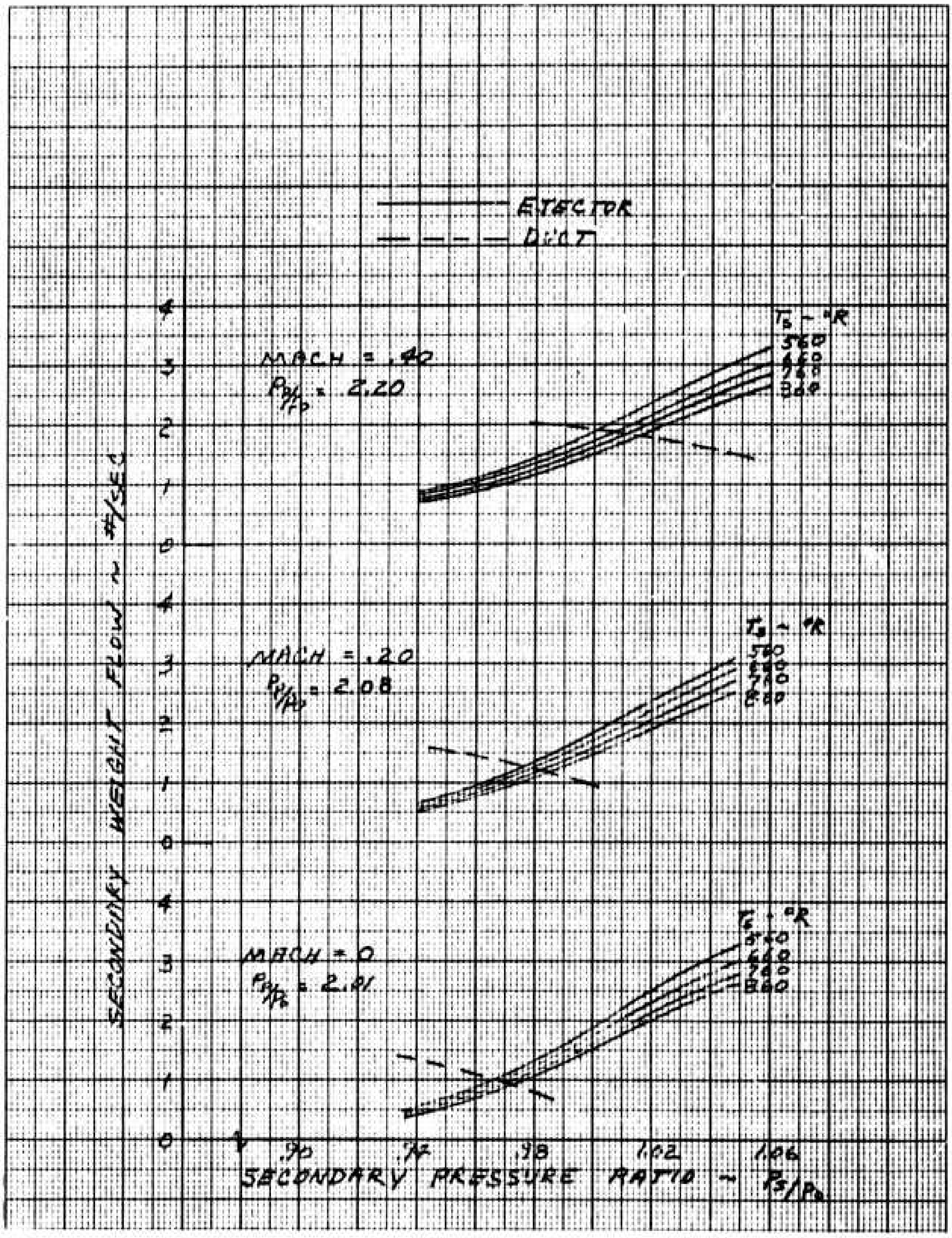

Figure 9.35 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Hot Day, 10,000 Ft., 100% RPM and Mach No. = 0, 0.2 and 0.4

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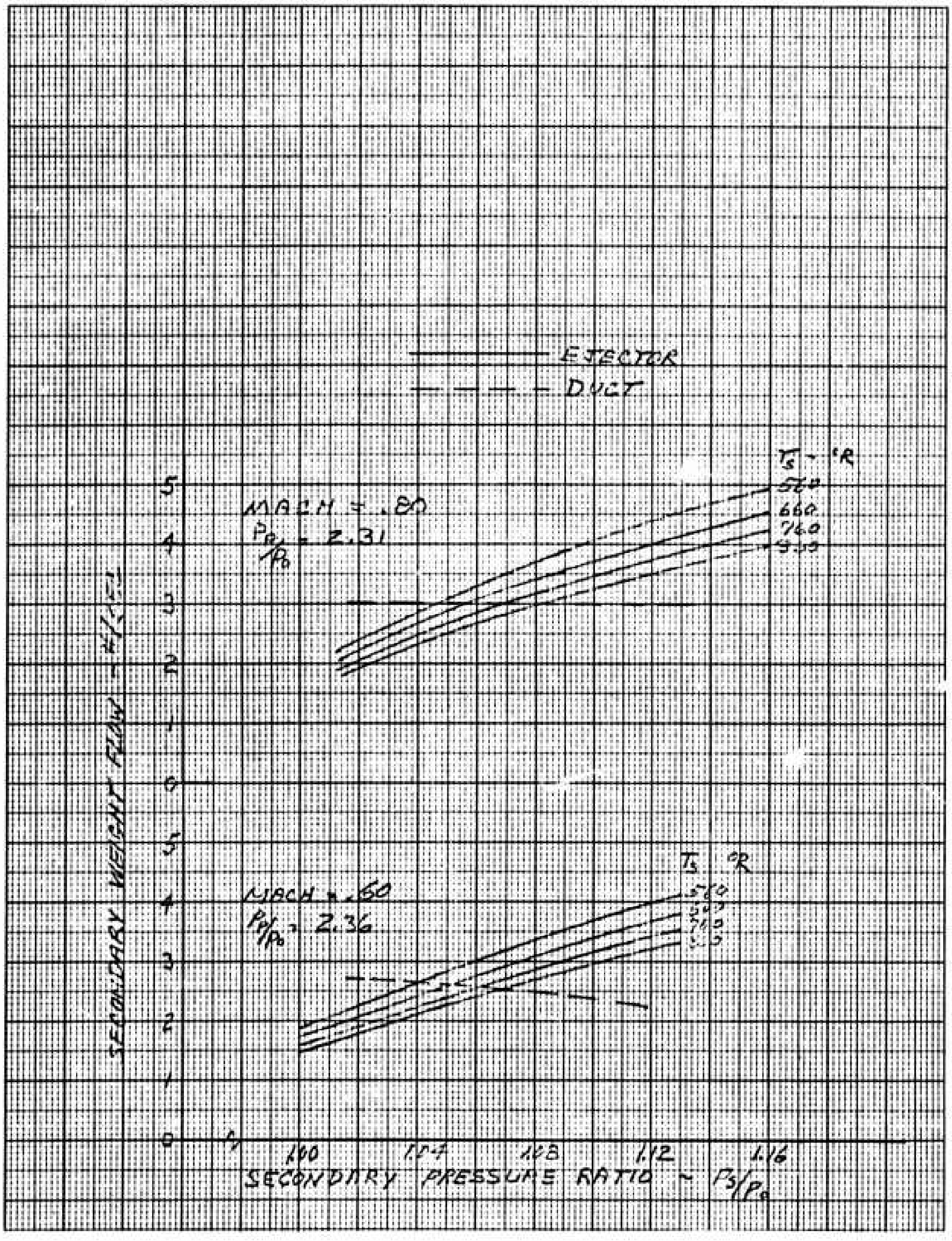

Figure 9.36 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Hot Day 10,000 Ft., 100% RPM and Mach No. = 0.6 and 0.8

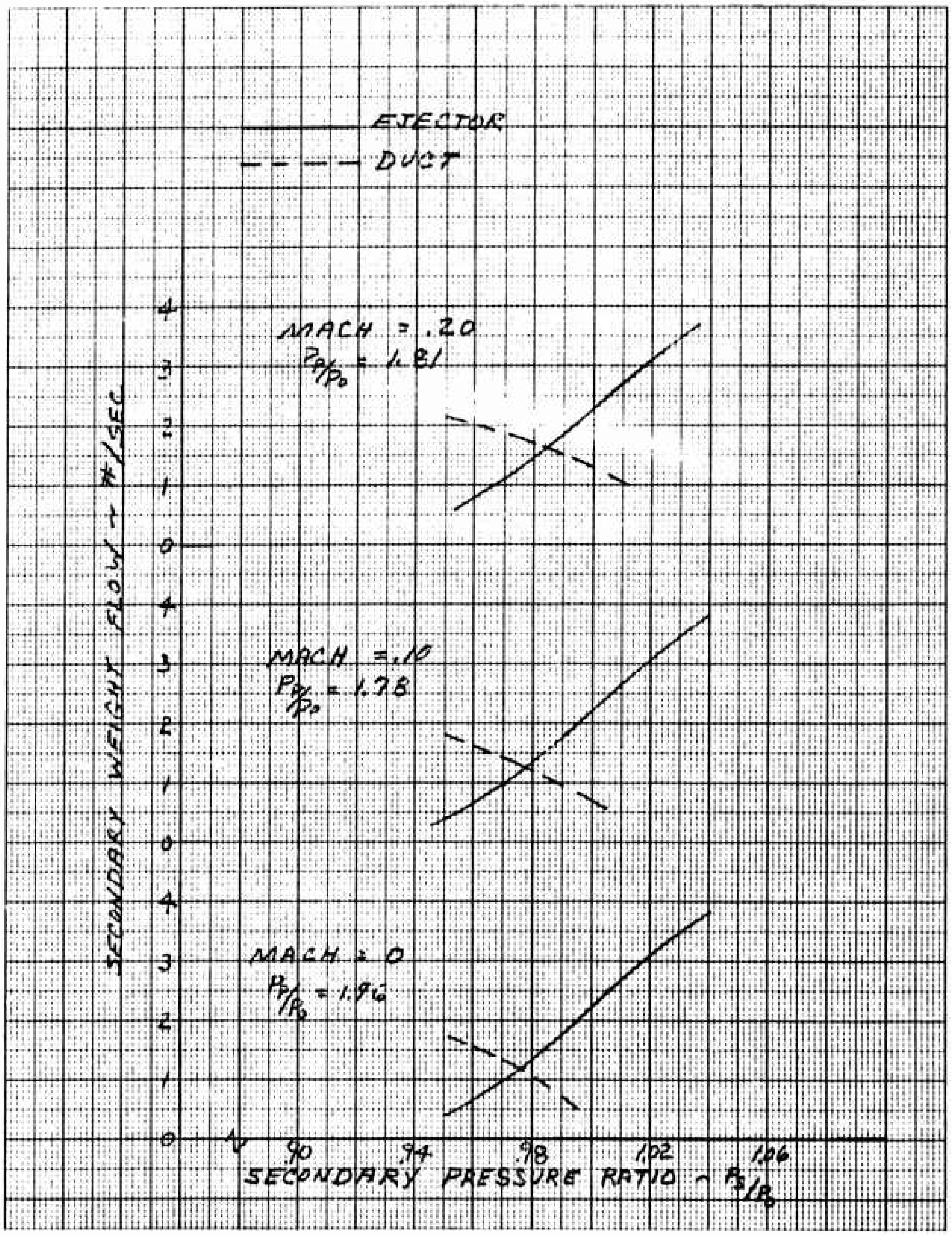

Figure 9.37 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 95% RPM and Mach No. = 0, 0.1 and 0.2

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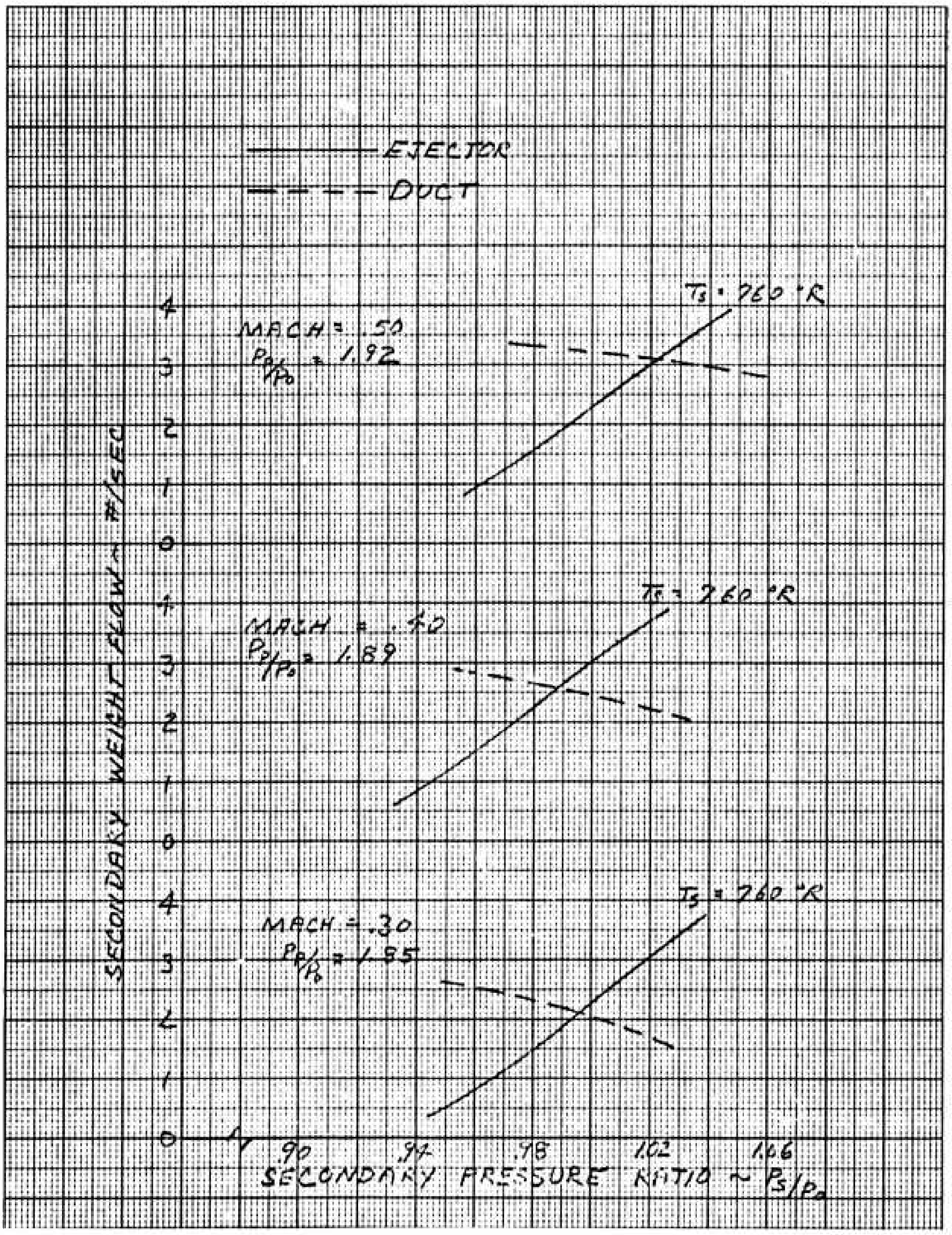

Figure 9.38 **Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 95% RPM and Mach No. = 0.3, 0.4 and 0.5**

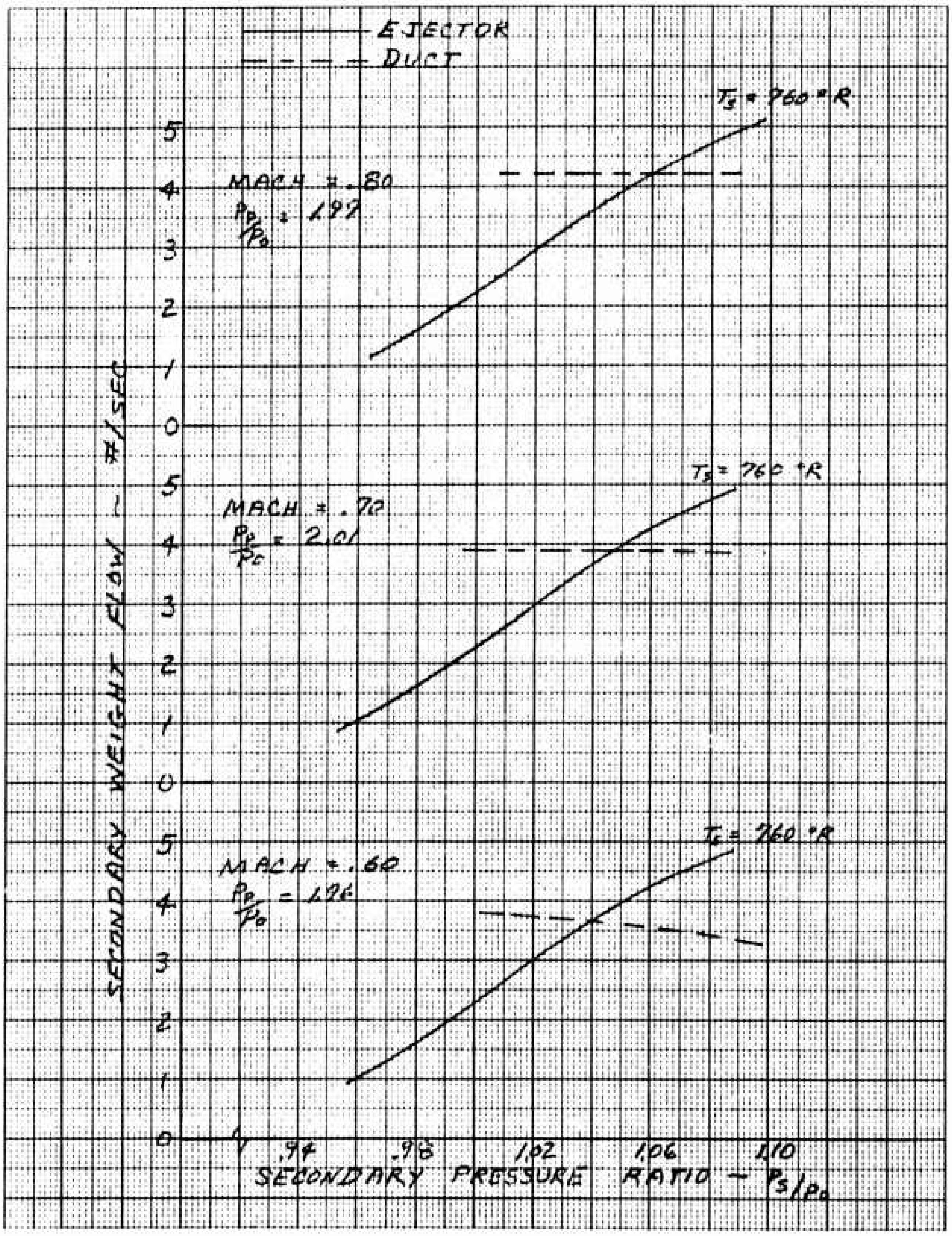

Figure 9.39 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 95% RPM and Mach No. = 0.6, 0.7 and 0.8

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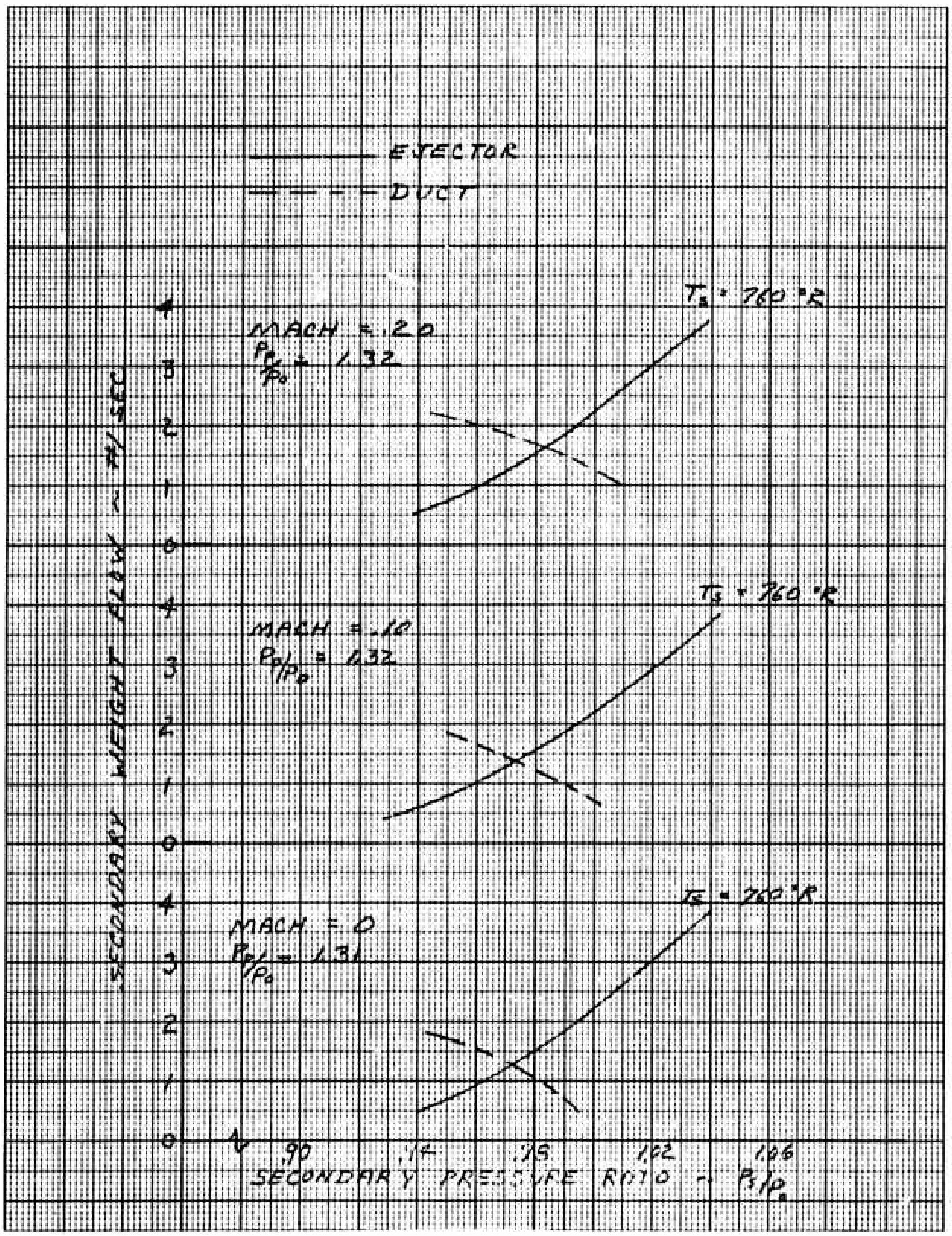

Figure 9.40 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 85% RPM and Mach No. = 0, 0.1 and 0.2

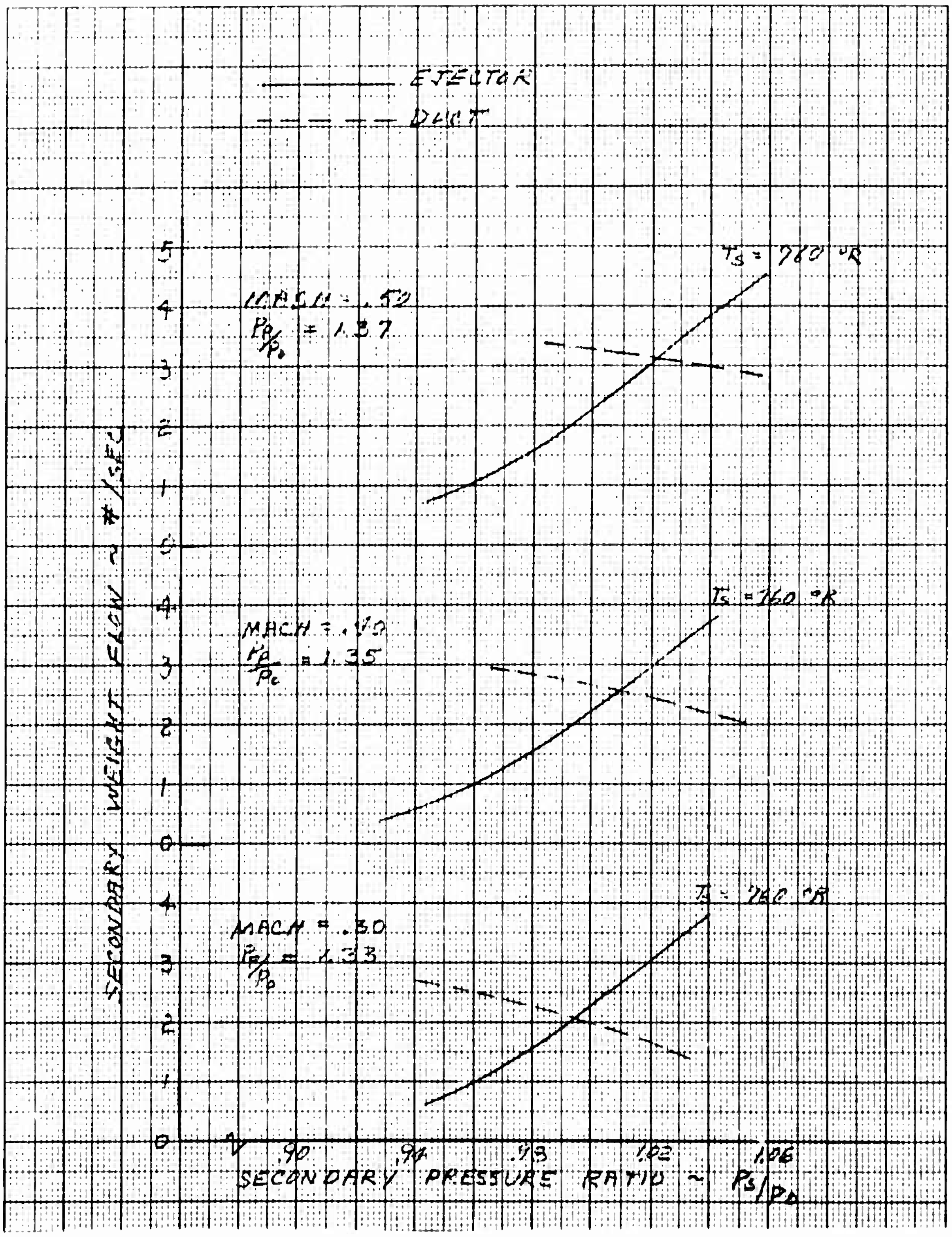

Figure 9.41 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 85% RPM and Mach No. = 0.3, 0.4 and 0.5

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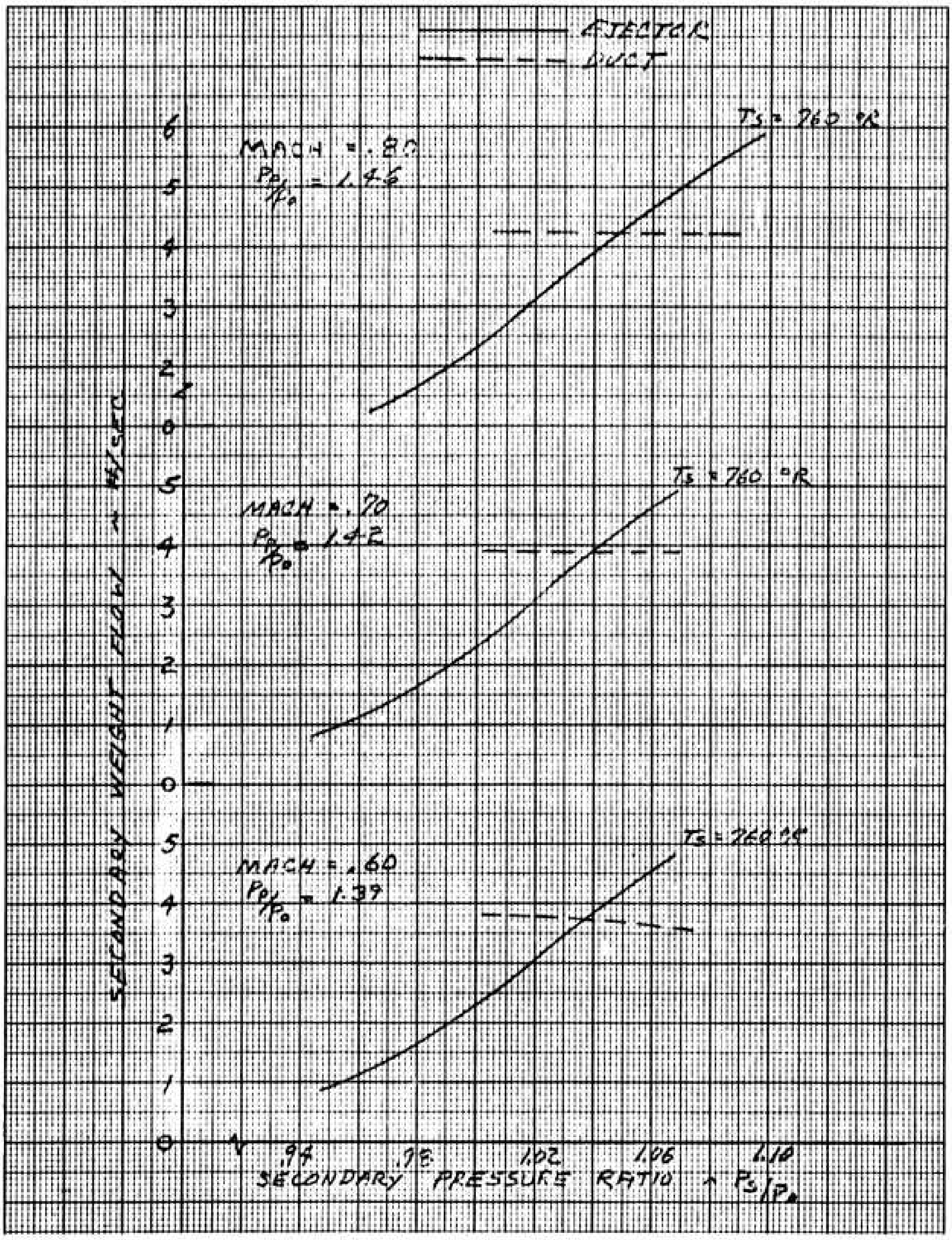

Figure 9.42 Tailpipe Ejector Secondary Weight Flow Vs Secondary Pressure Ratio - Standard Day Sea Level, 85% RPM and Mach No. = 0.6, 0.7 and 0.8

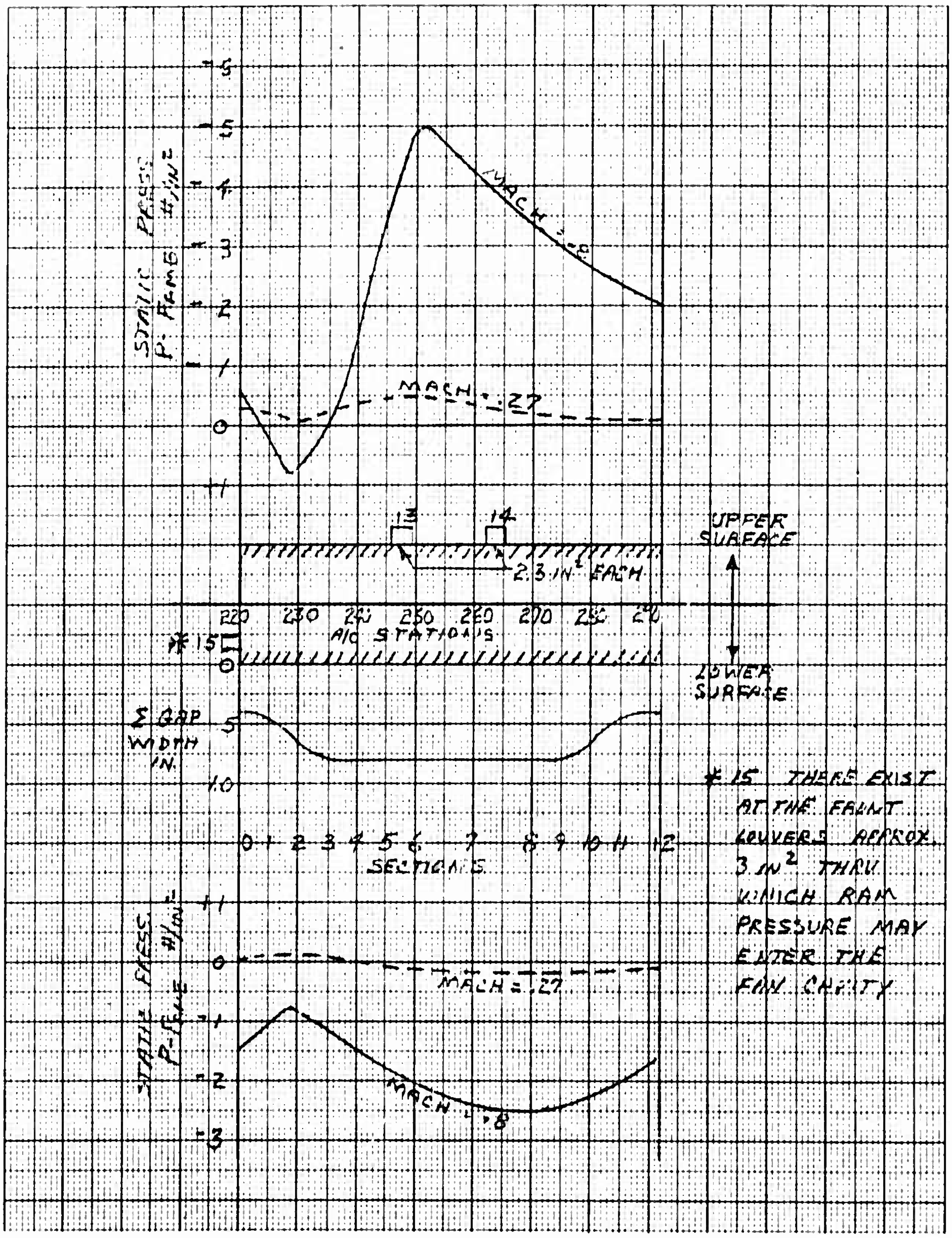

Figure 9.43 Wing Fan Region Chordwise Pressure Distribution and Leakage Area

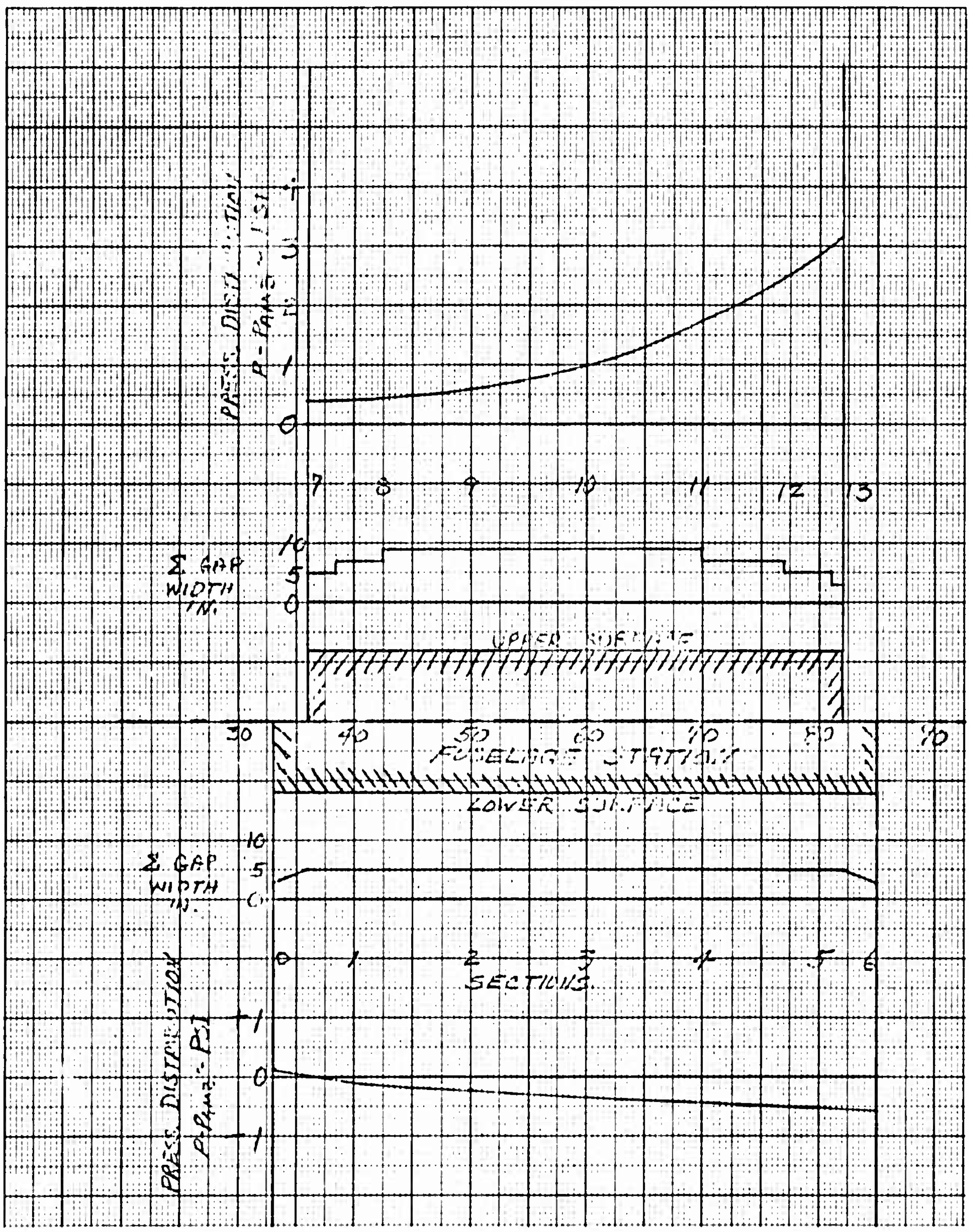

Figure 9.44 Nose Fan Doors - Pressure Distribution And Leakage Area - Mach No. = 0.8

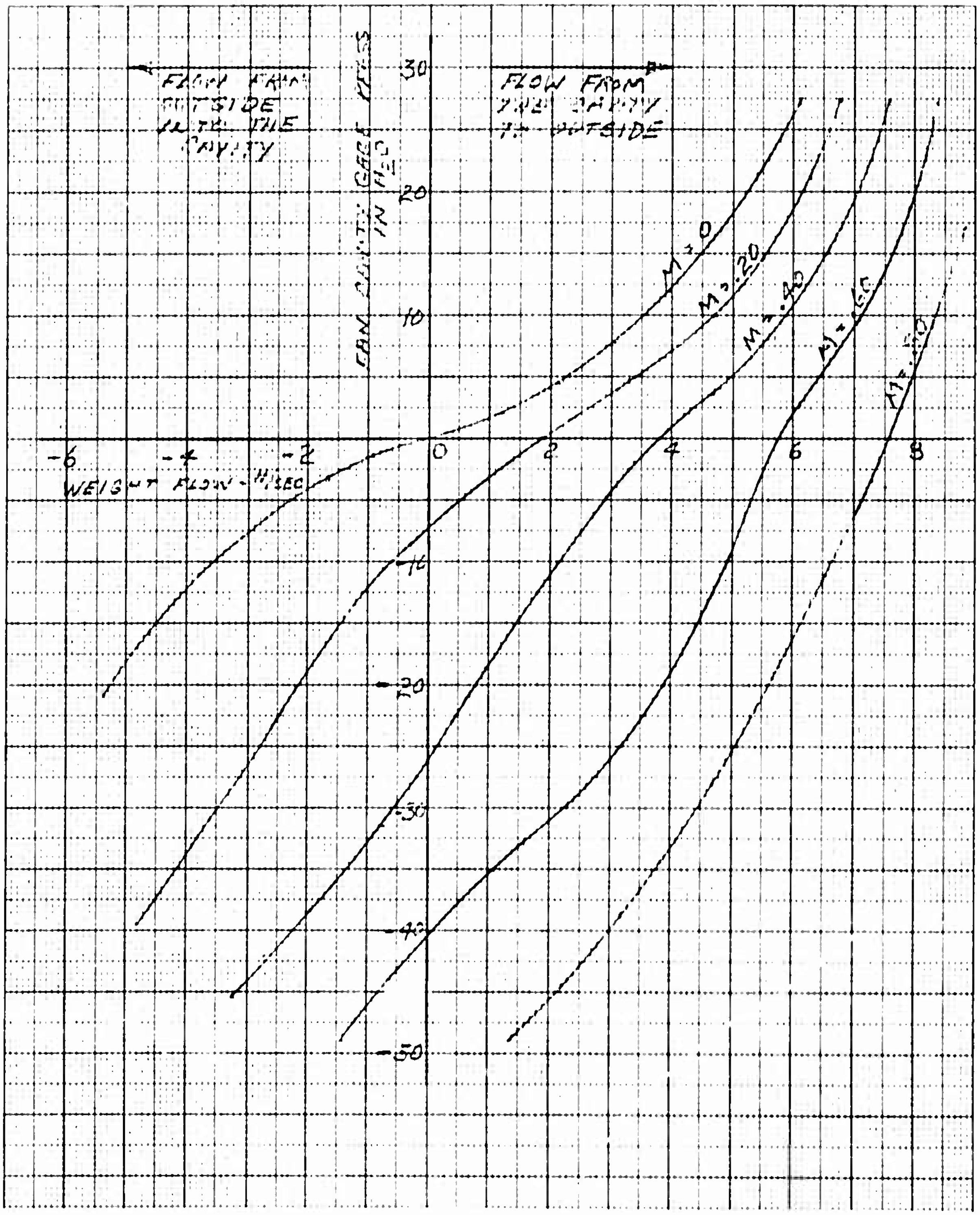

Figure 9.45 Wing Fan Cavity Pressure Vs Air Flow Between Fan Cavity And Outside and Mach No. - Standard Day, Sea Level

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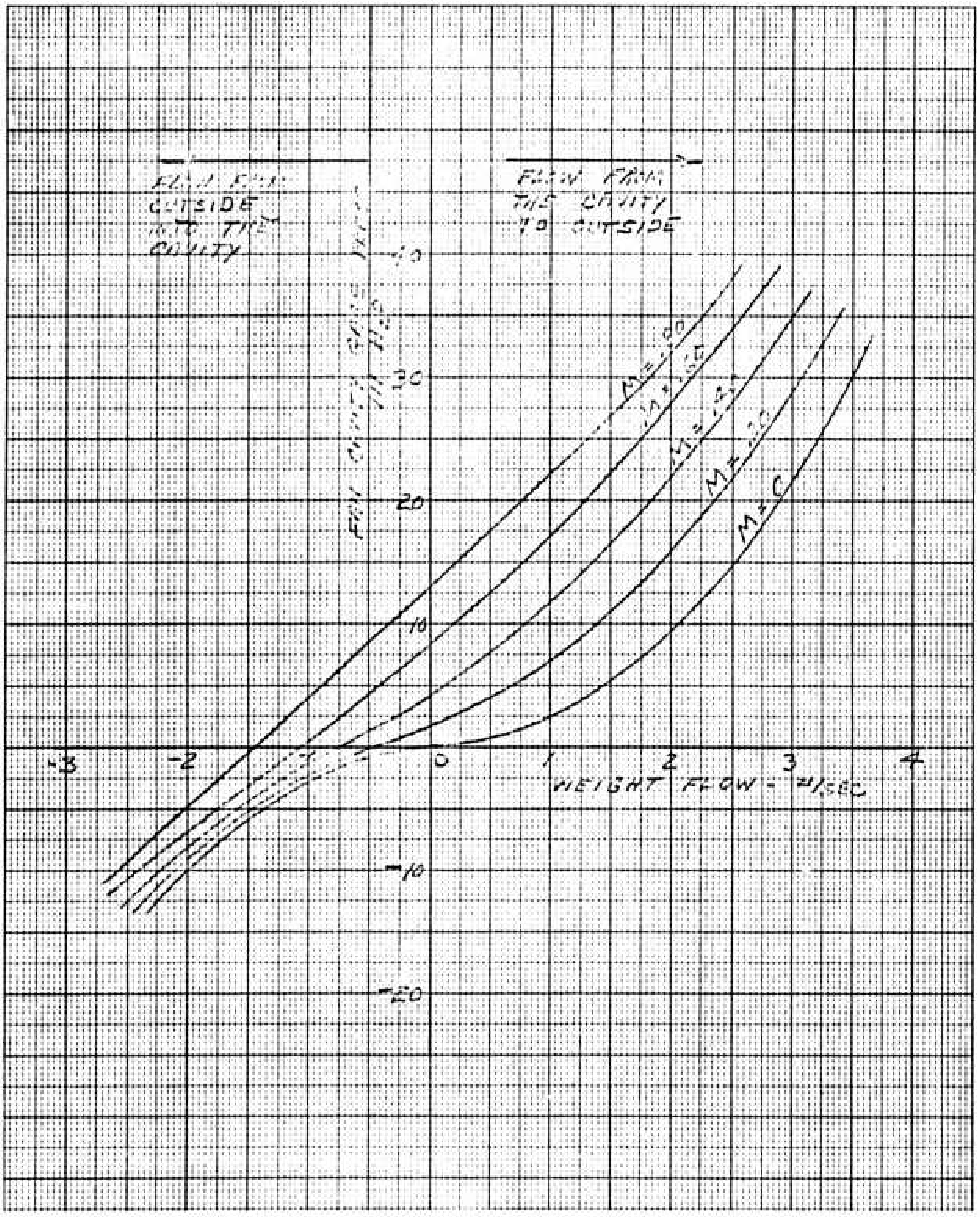

Figure 9.46 Nose Fan Cavity Pressure Vs Air Flow Between Fan Cavity And Outside, and Mach No. - Standard Day, Sea Level

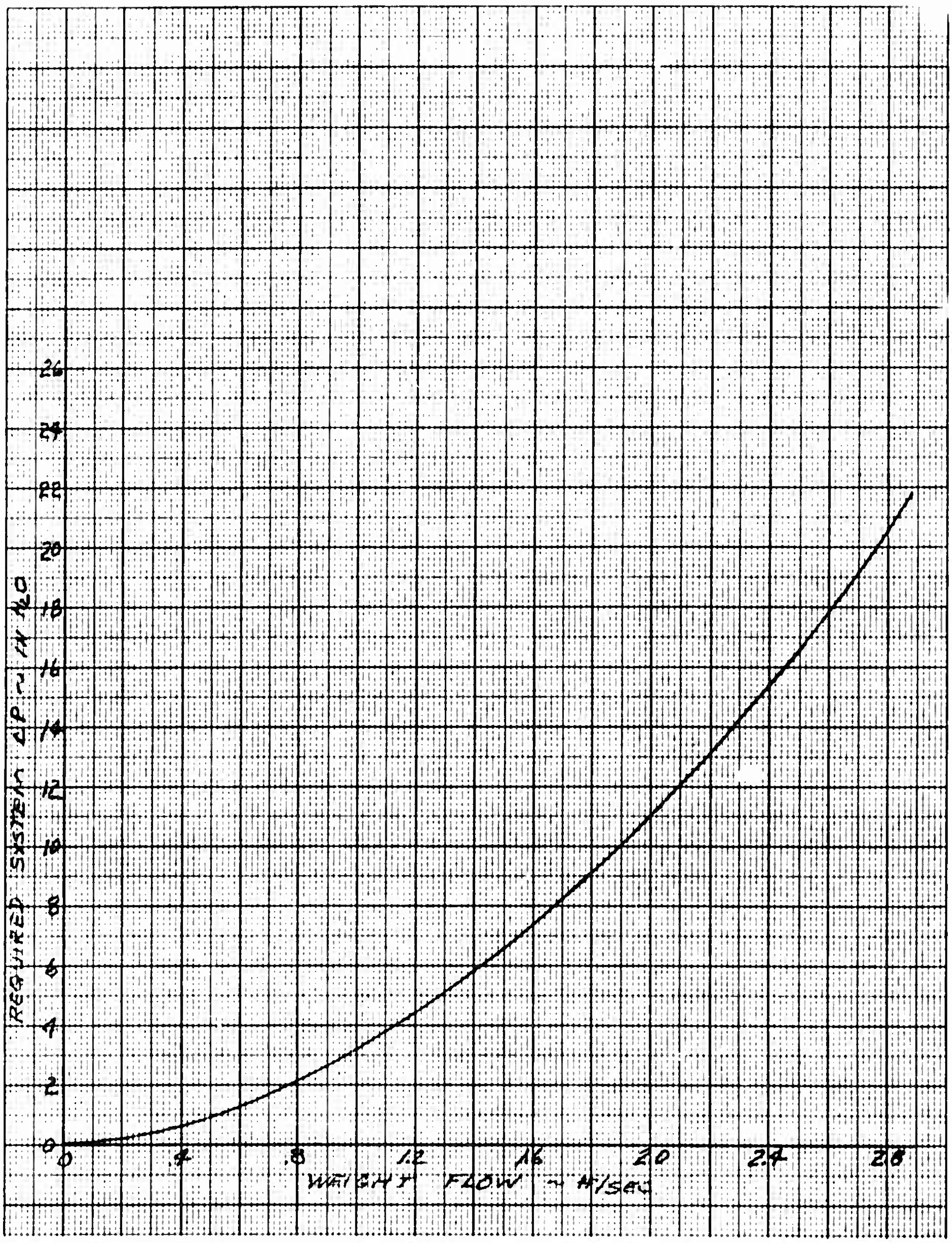

Figure 9.47 Pressure Loss Vs Weight Flow in the Lift Fan Supply Ducts from the Nose Fan Cavity to the Wing Fan Cavity - Standard Day Sea Level

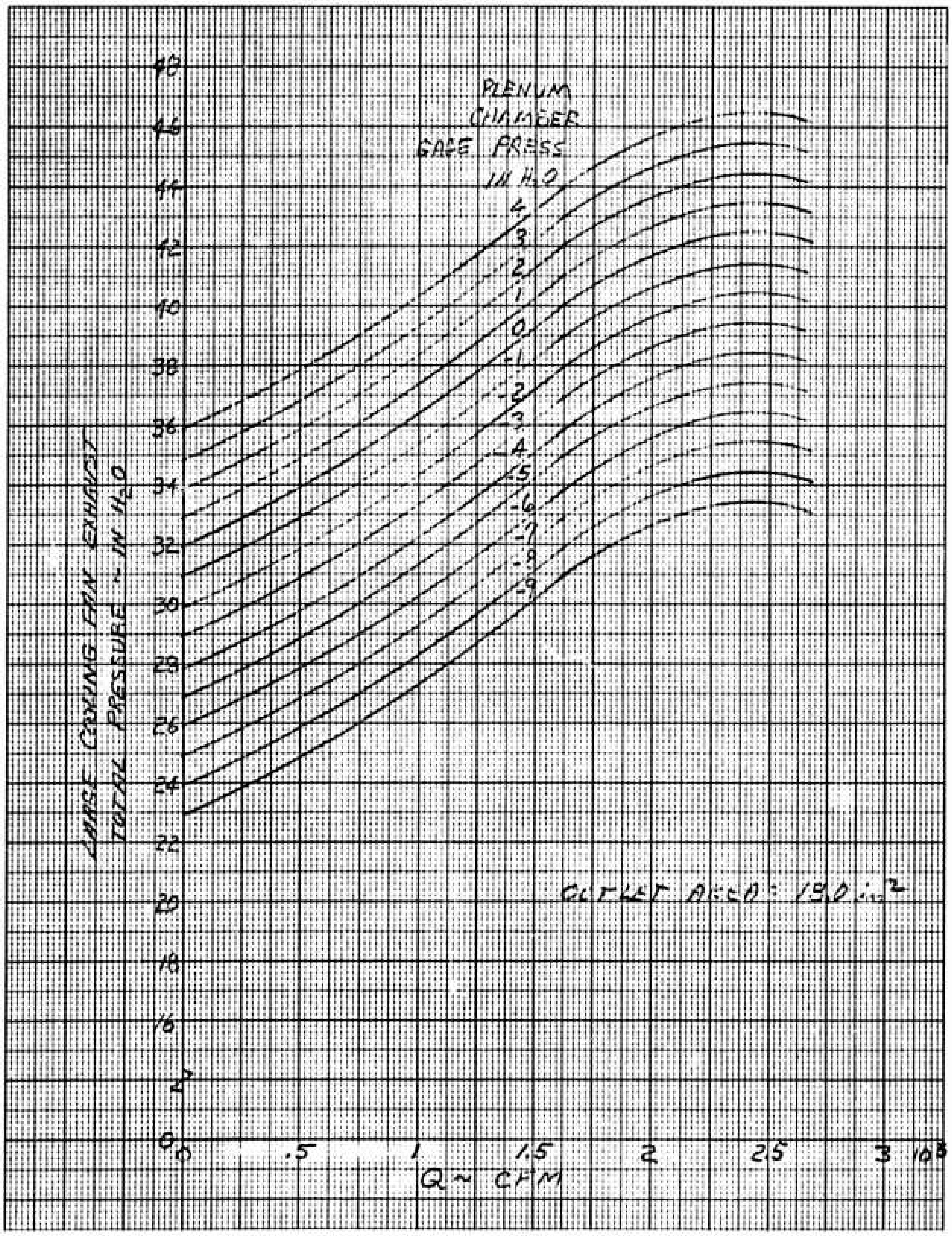

Figure 9.48 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 100% RPM

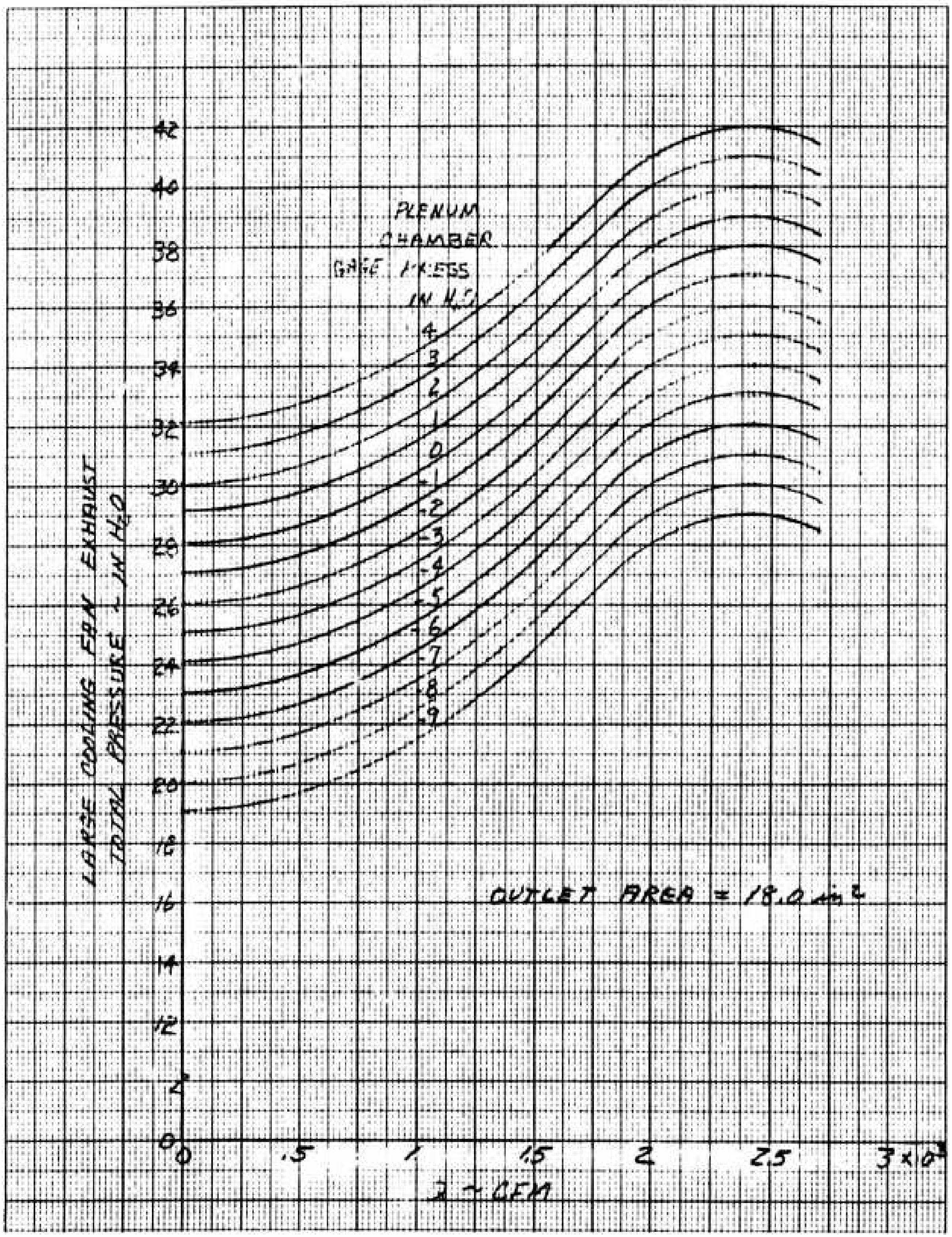

Figure 9.49 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Hot Day, 2,500 Ft., 100% RPM

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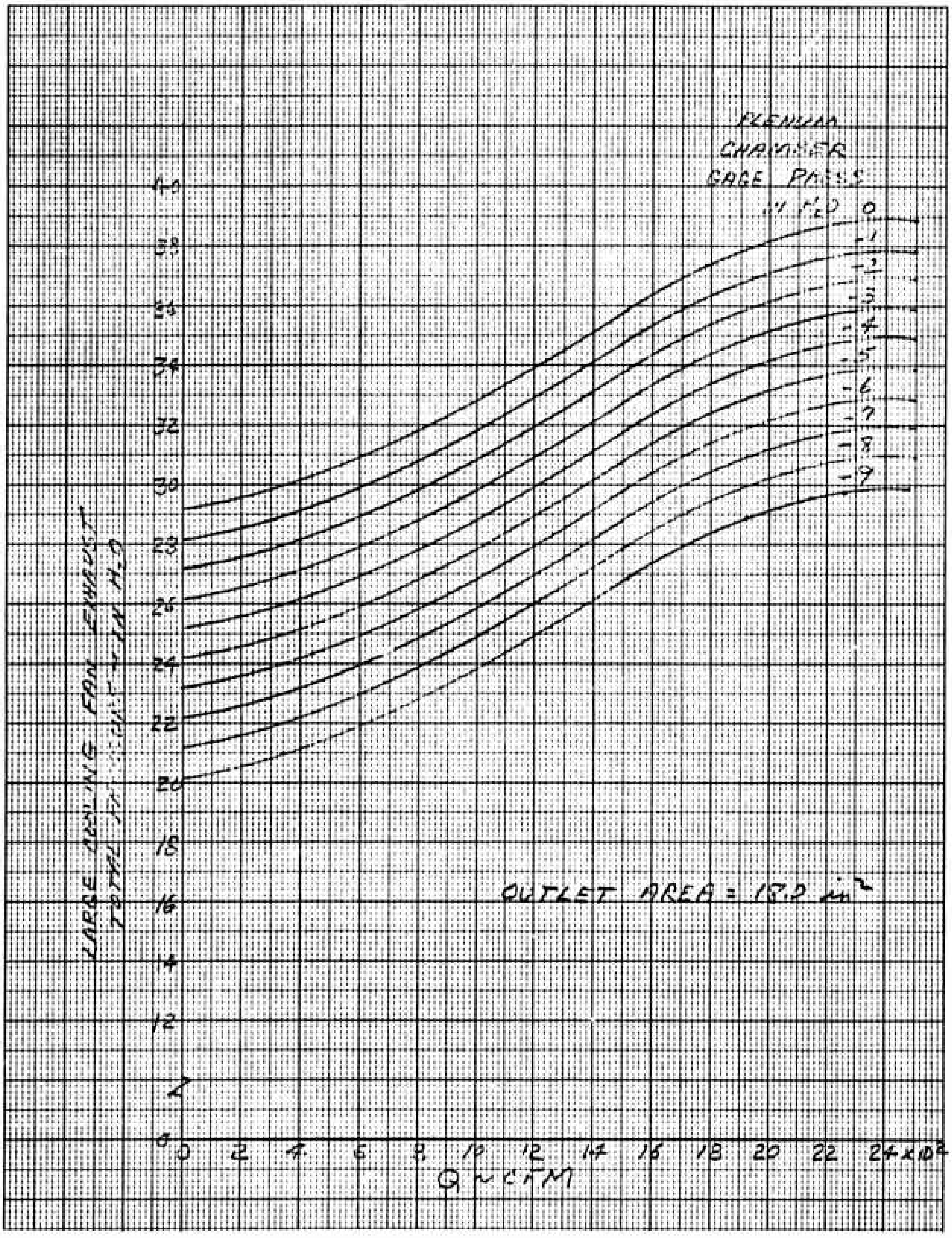

Figure 9.50 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 95% RPM

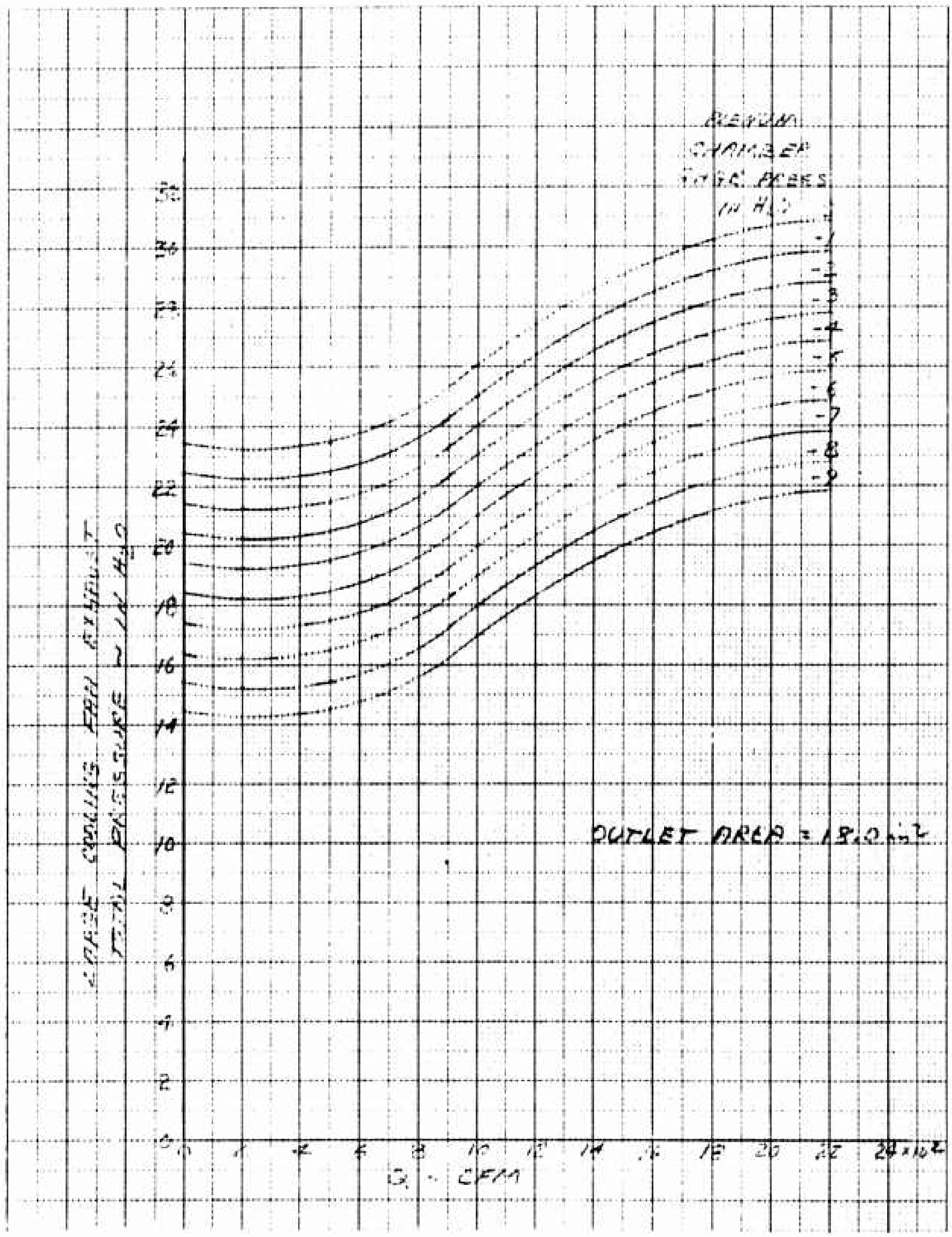

Figure 9.51 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 85% RPM

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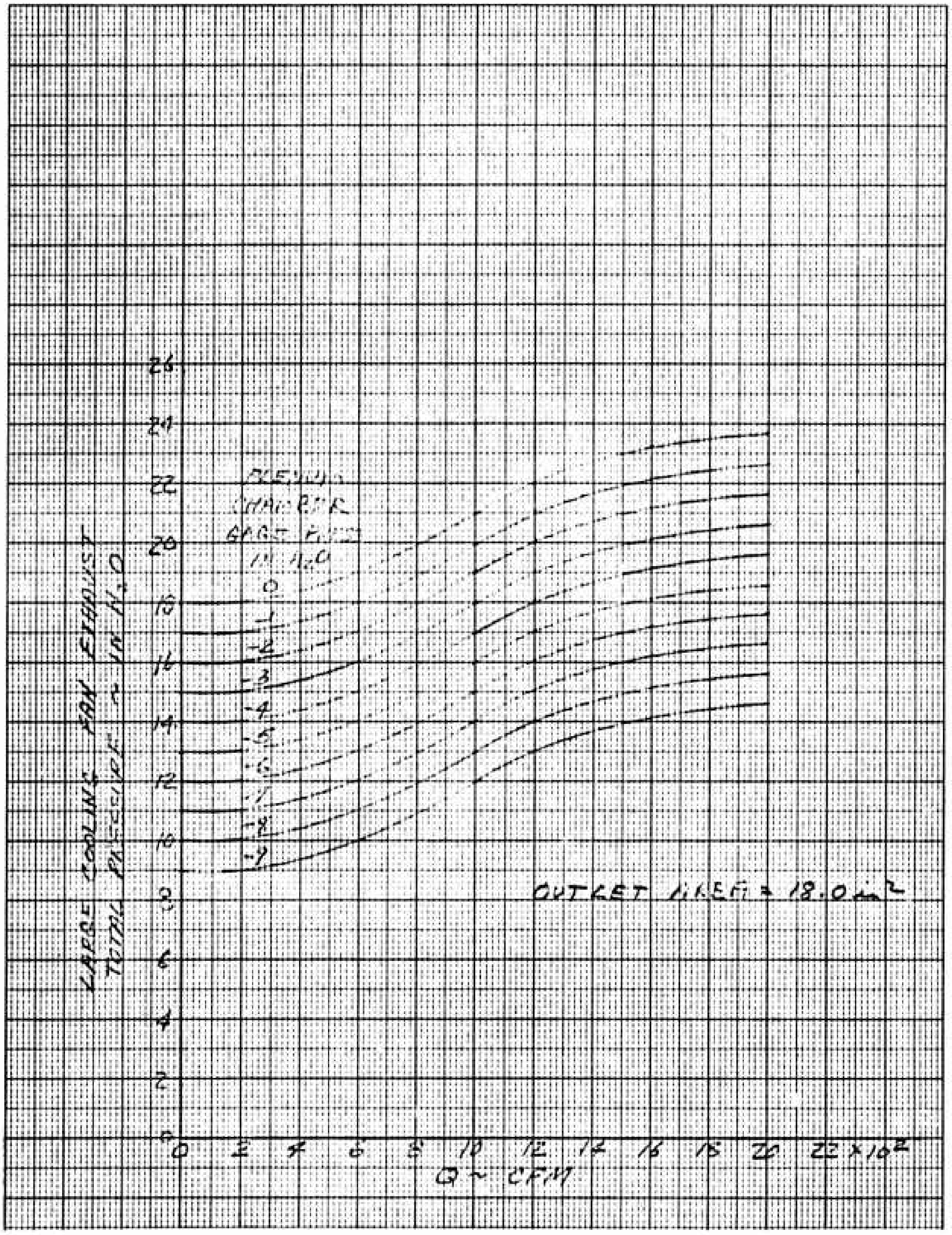

Figure 9.52 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 75% RPM

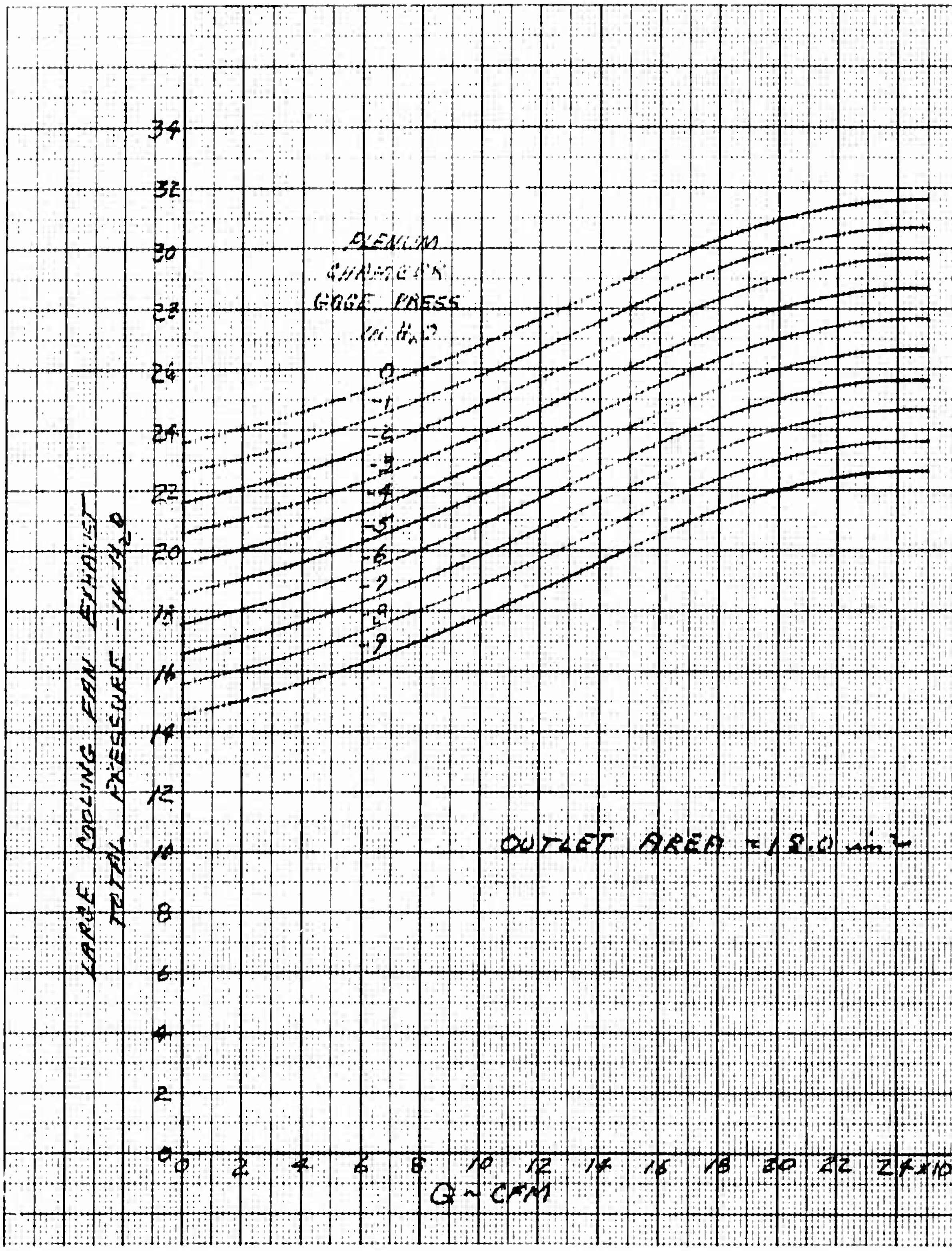

Figure 9.53 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, 10,000 Ft., 100% RPM

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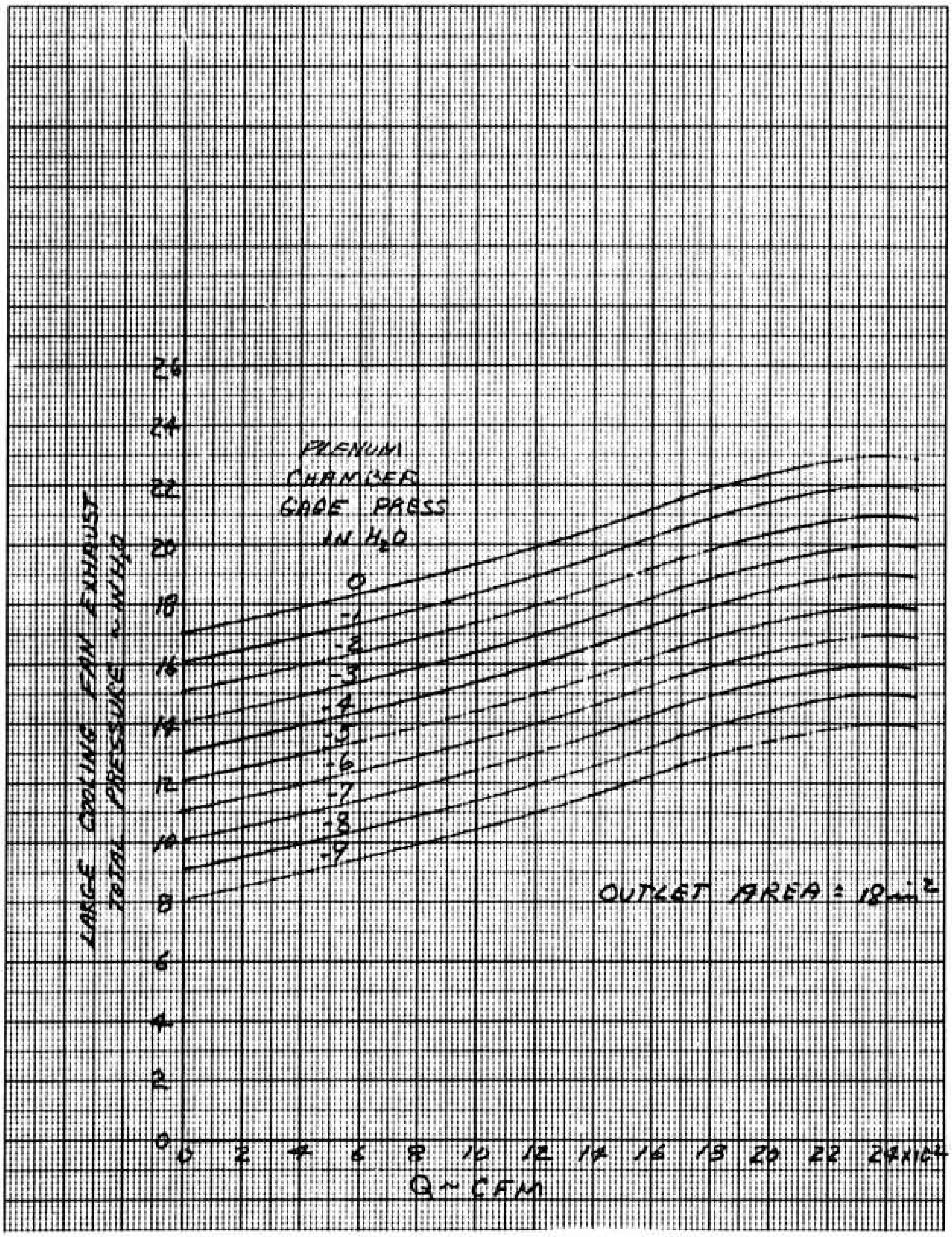

Figure 9.54 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, 20,000 Ft., 100% RPM

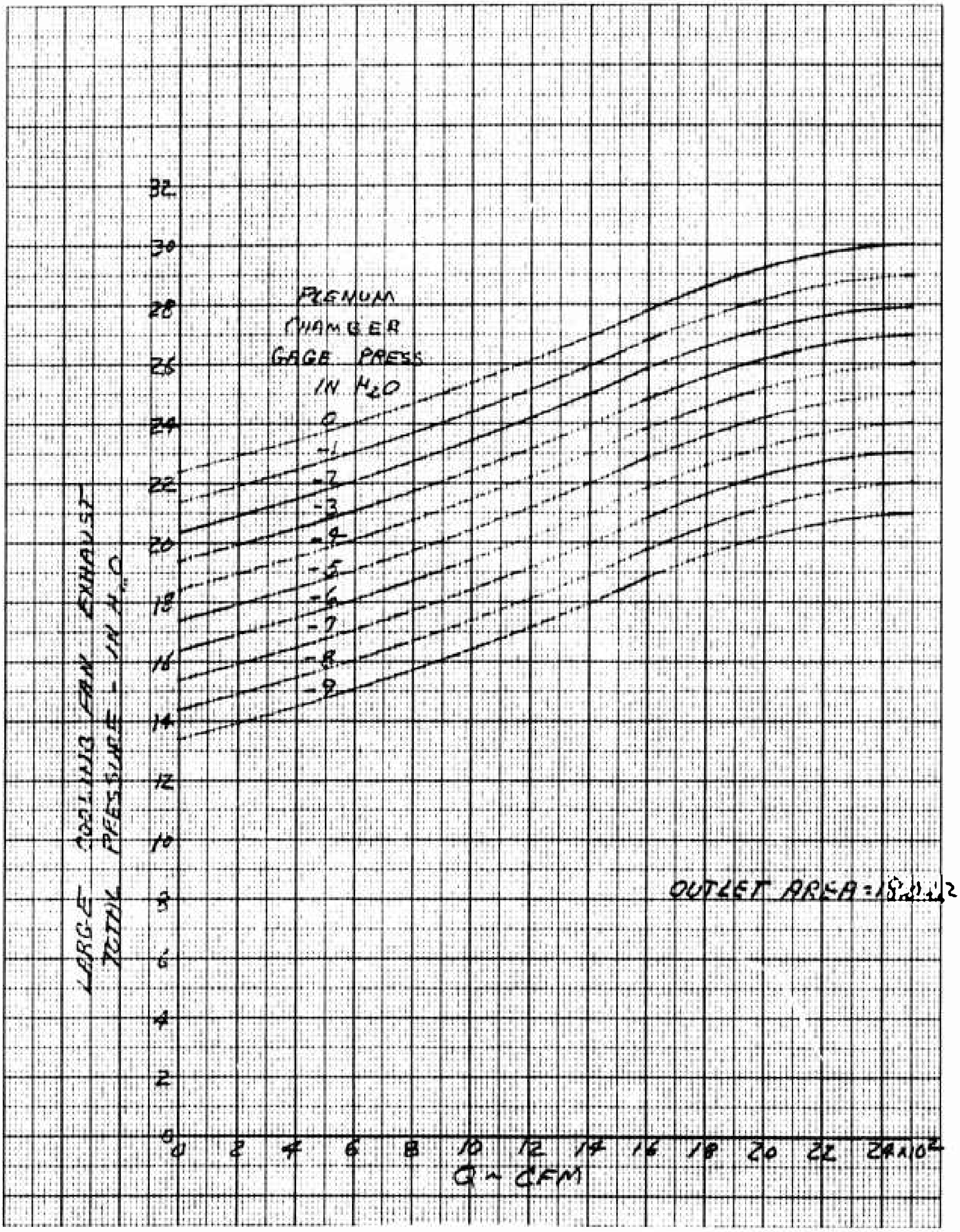

Figure 9.55 Large Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Hot Day, 10,000 Ft., 100% RPM

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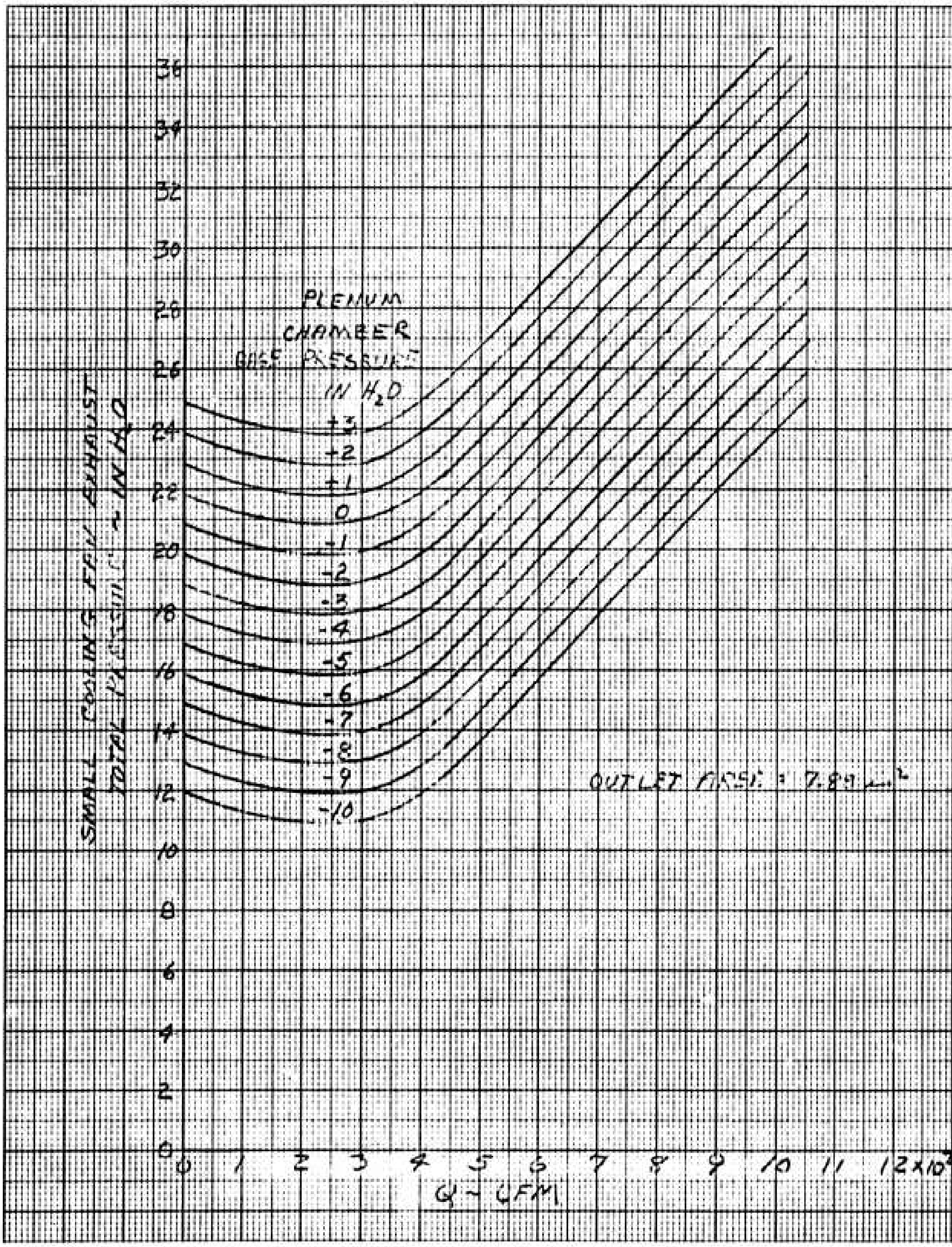

Figure 9.56 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 100% RPM

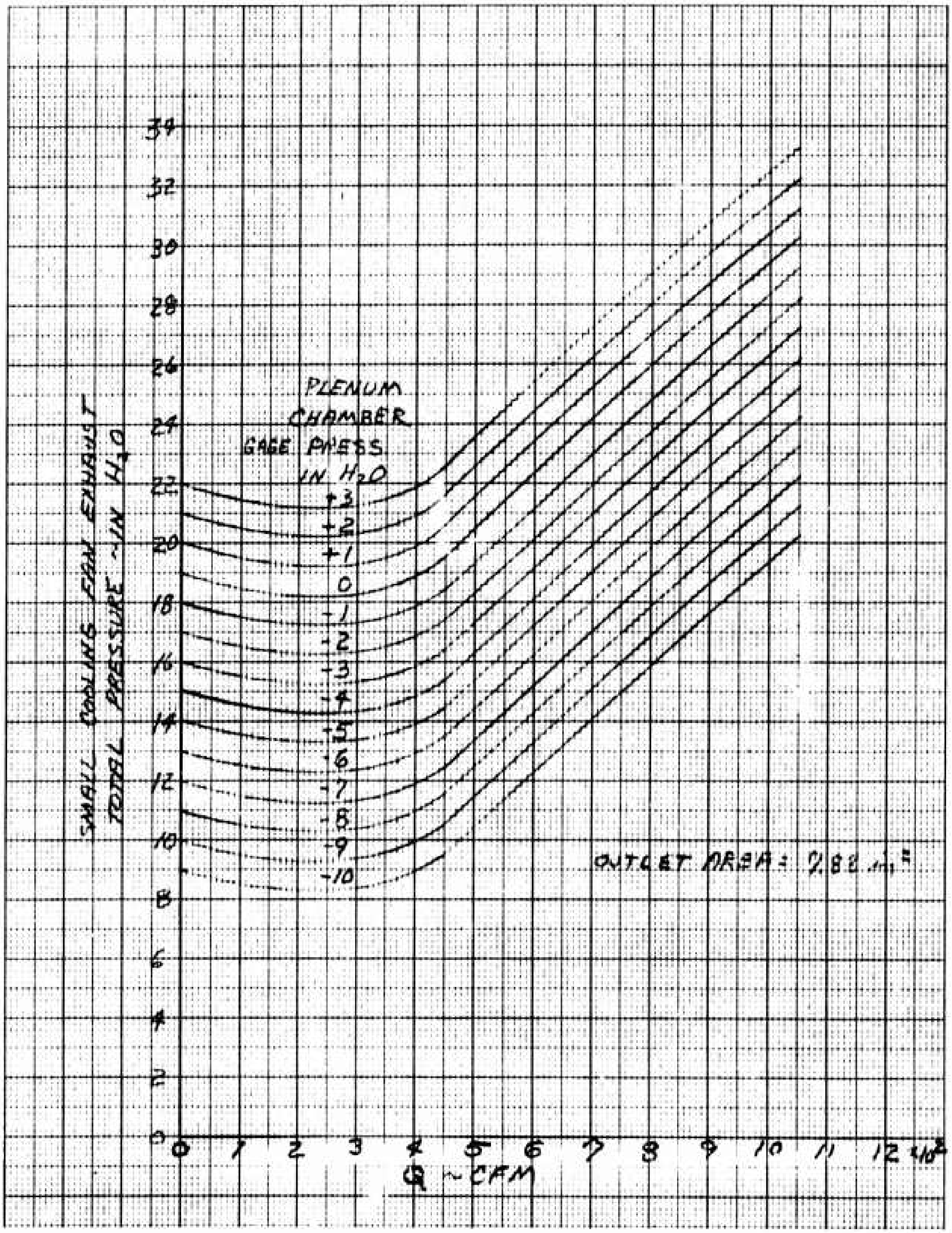

Figure 9.57 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Hot Day, 2,500 Ft., 100% RPM

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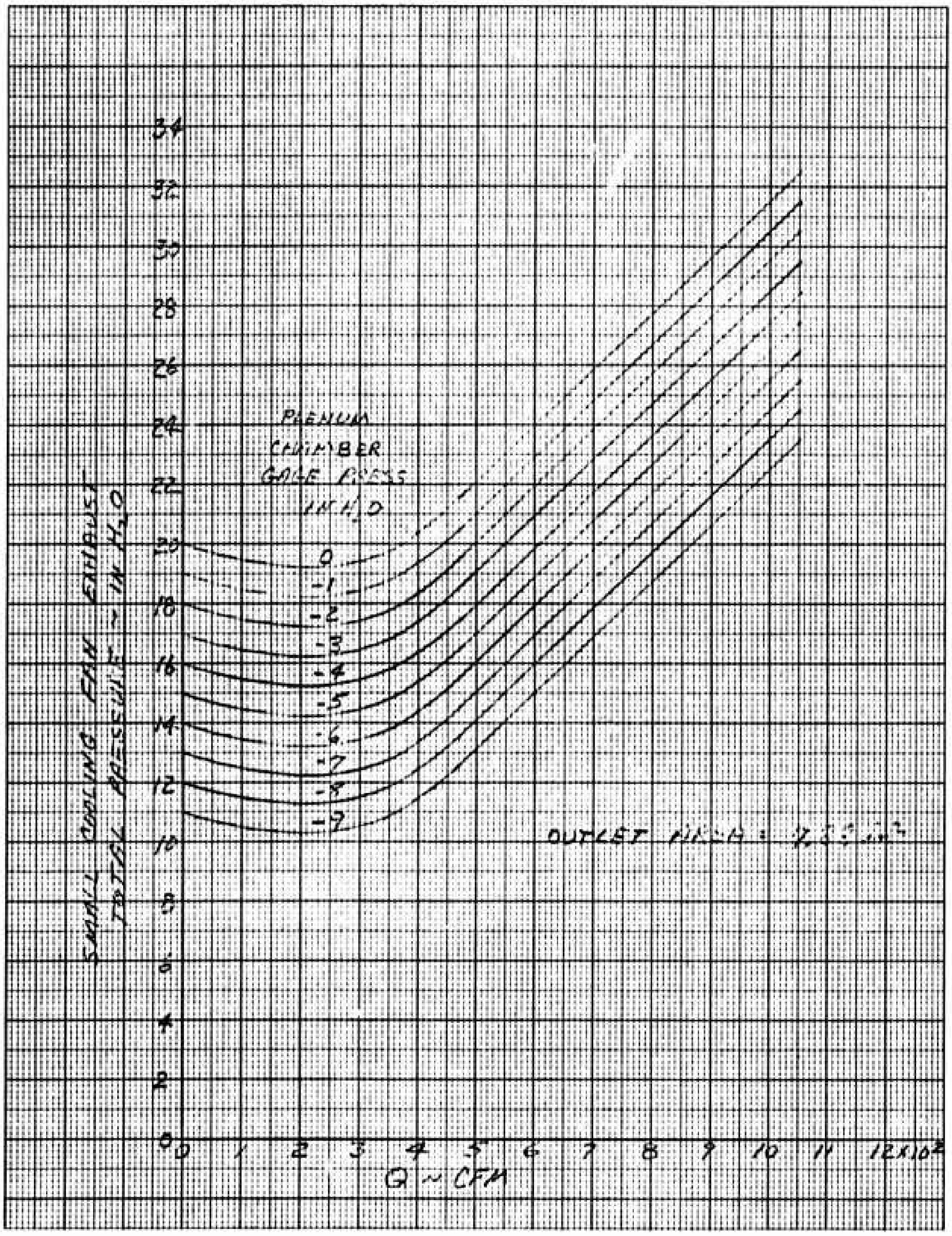

Figure 9.58 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 95% RPM

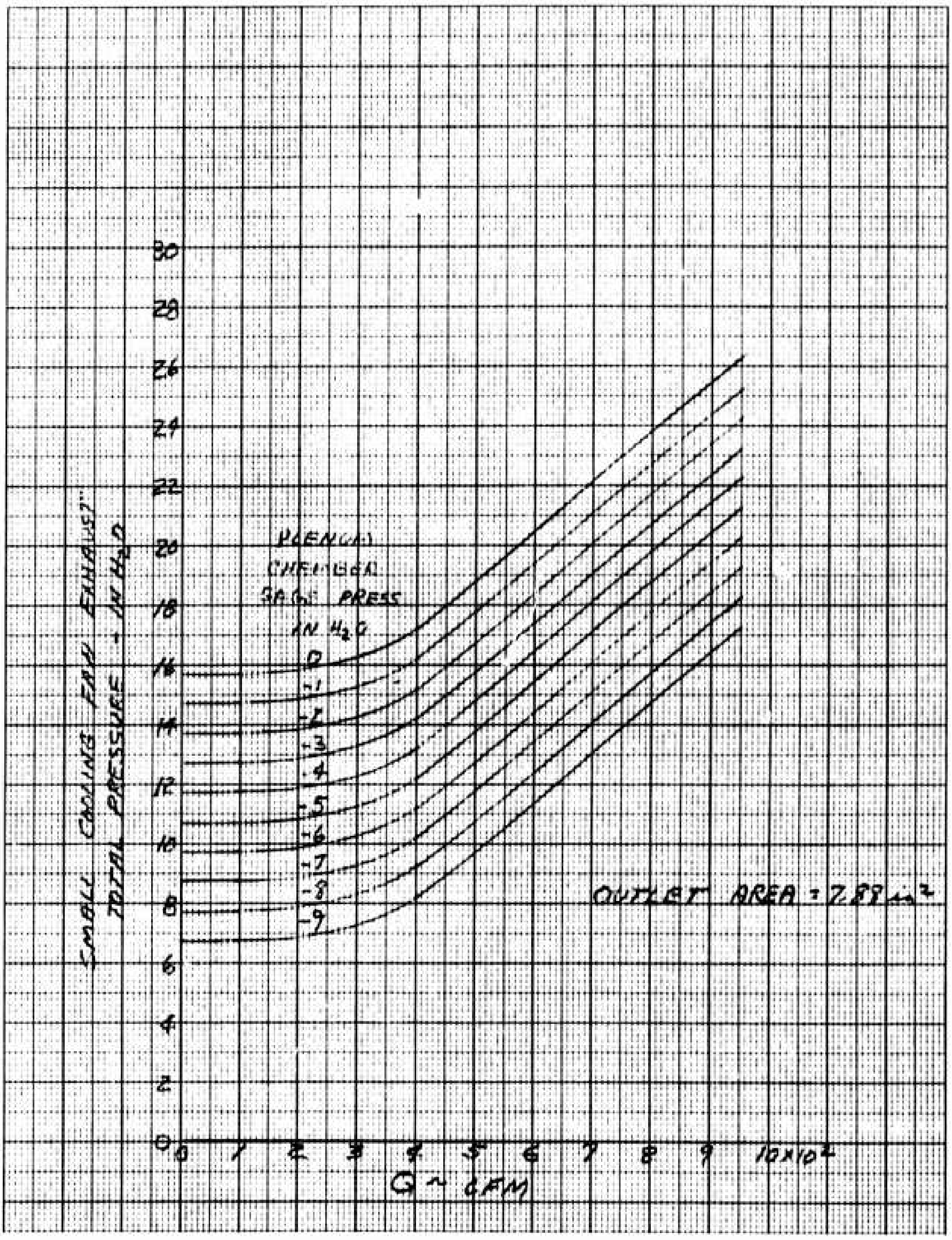

Figure 9.59 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 85% RPM

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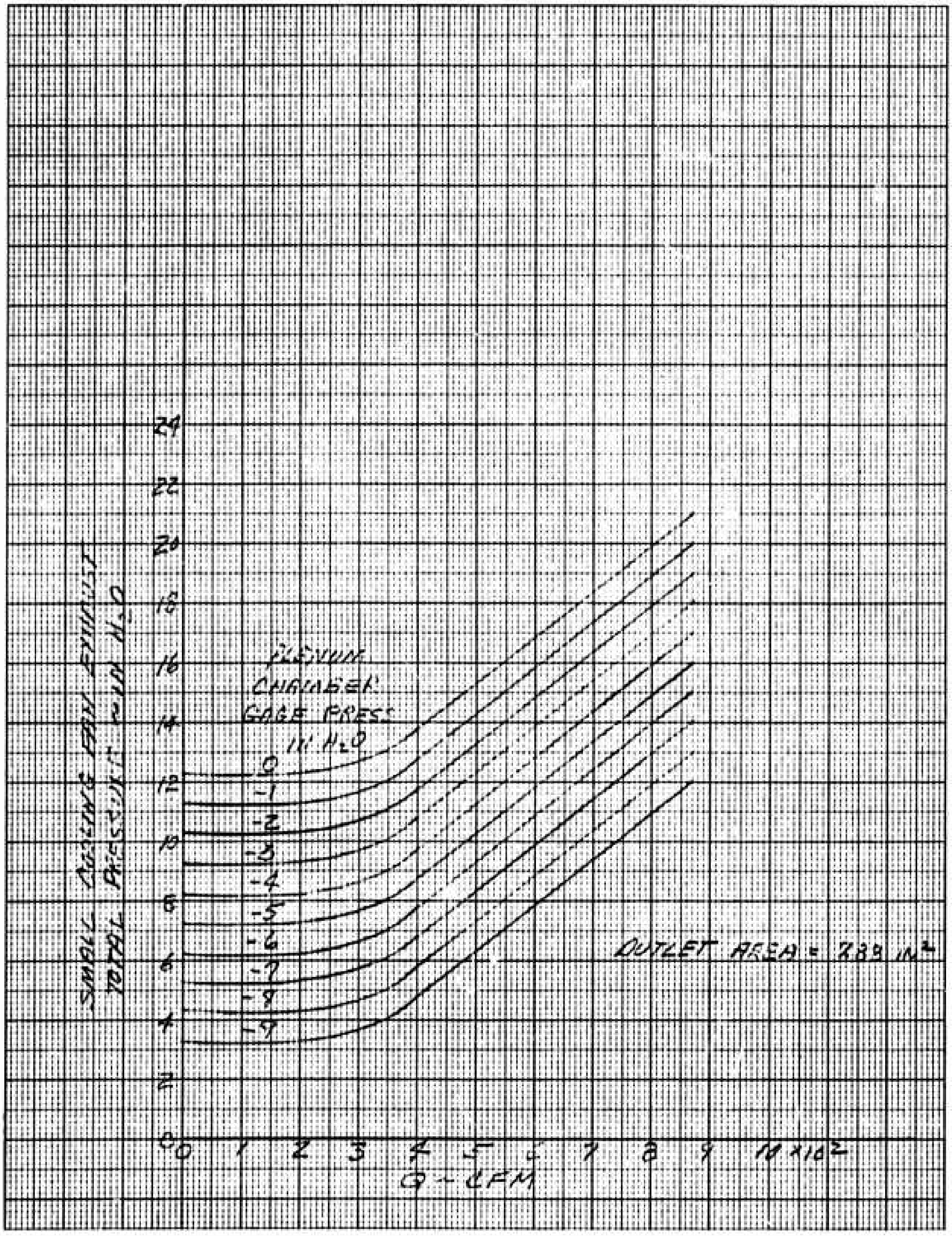

Figure 9.60 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, Sea Level, 75% RPM

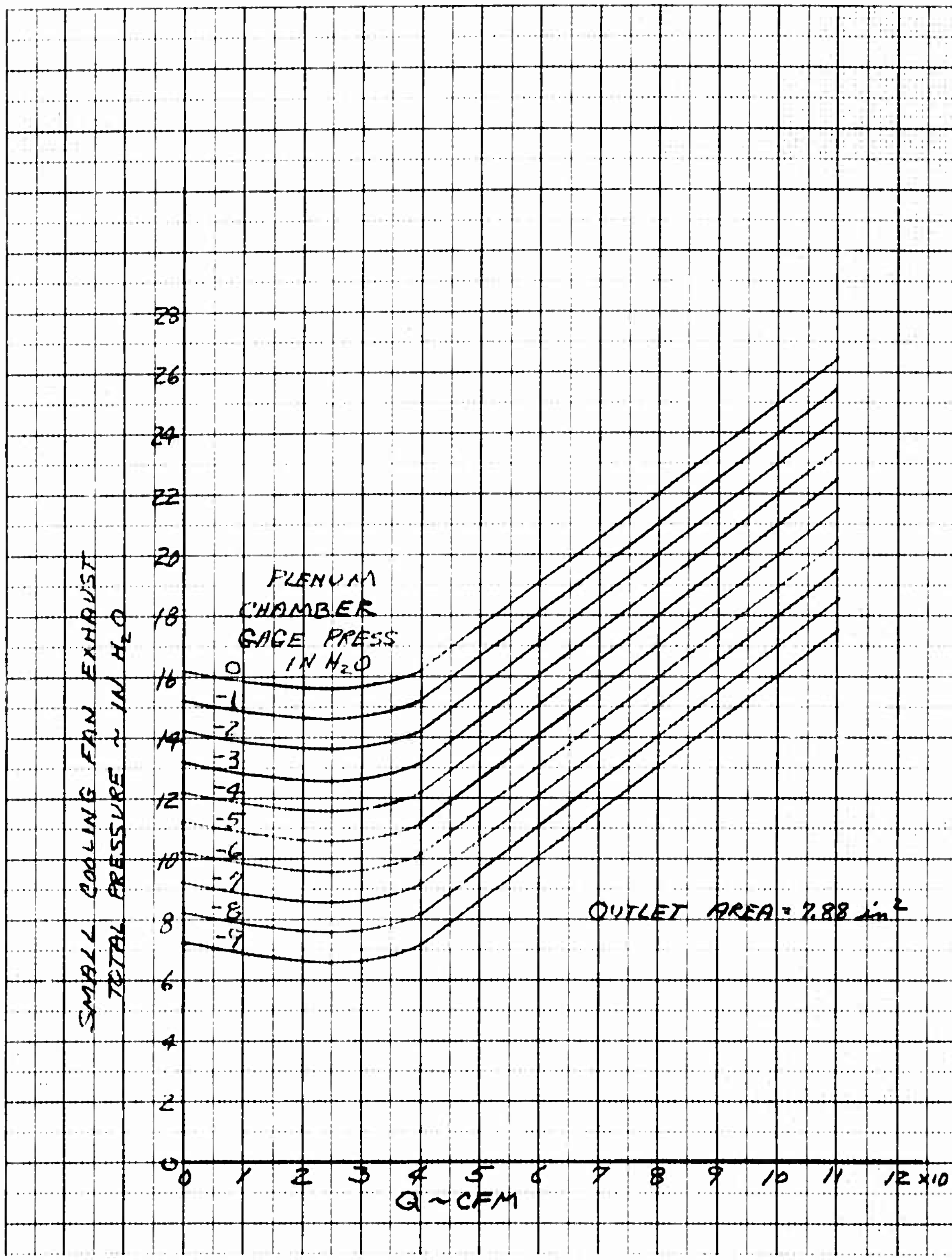

Figure 9.61 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, 10,000 Ft., 100% RPM

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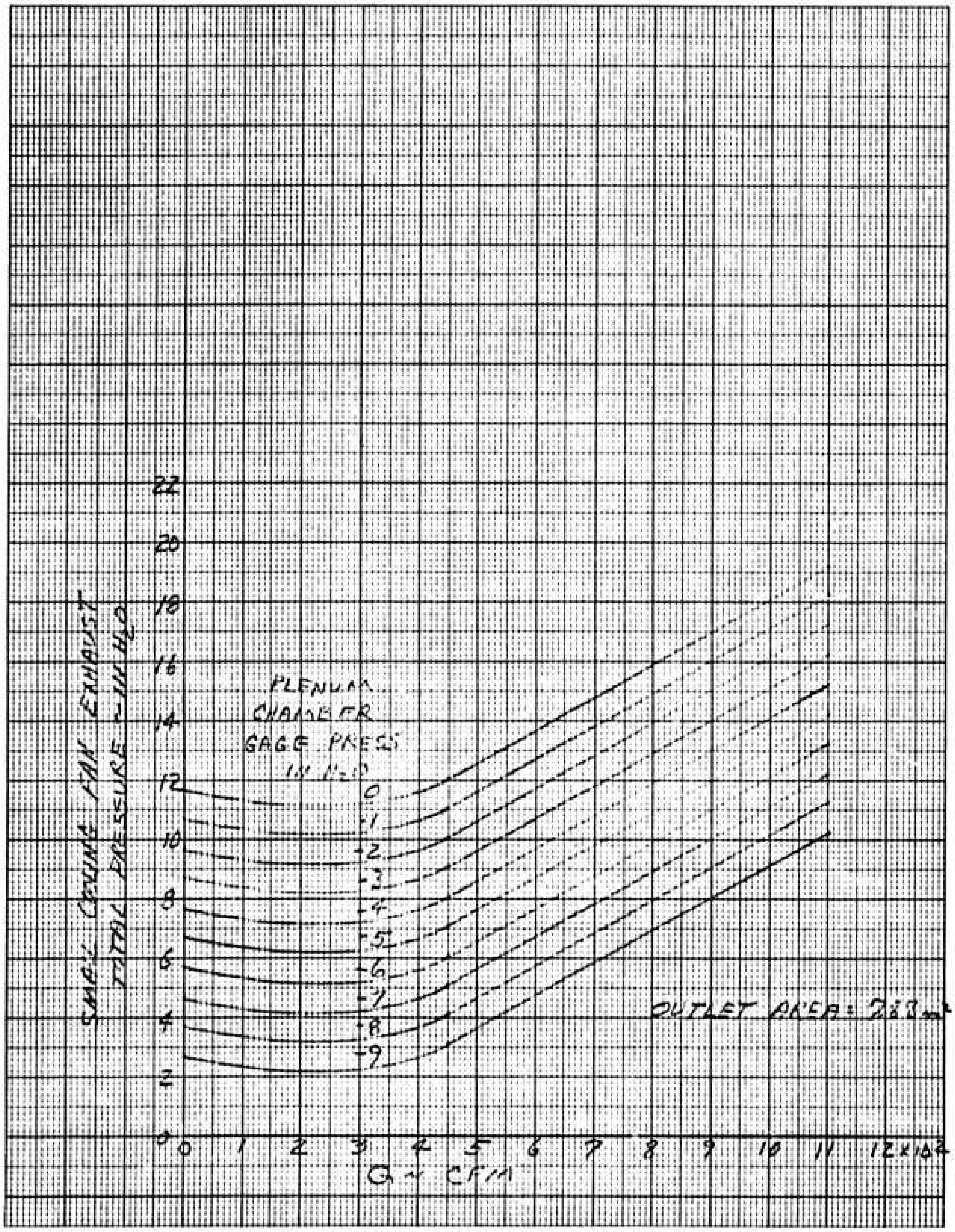

Figure 9.62 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Standard Day, 20,000 Ft., 100% RPM

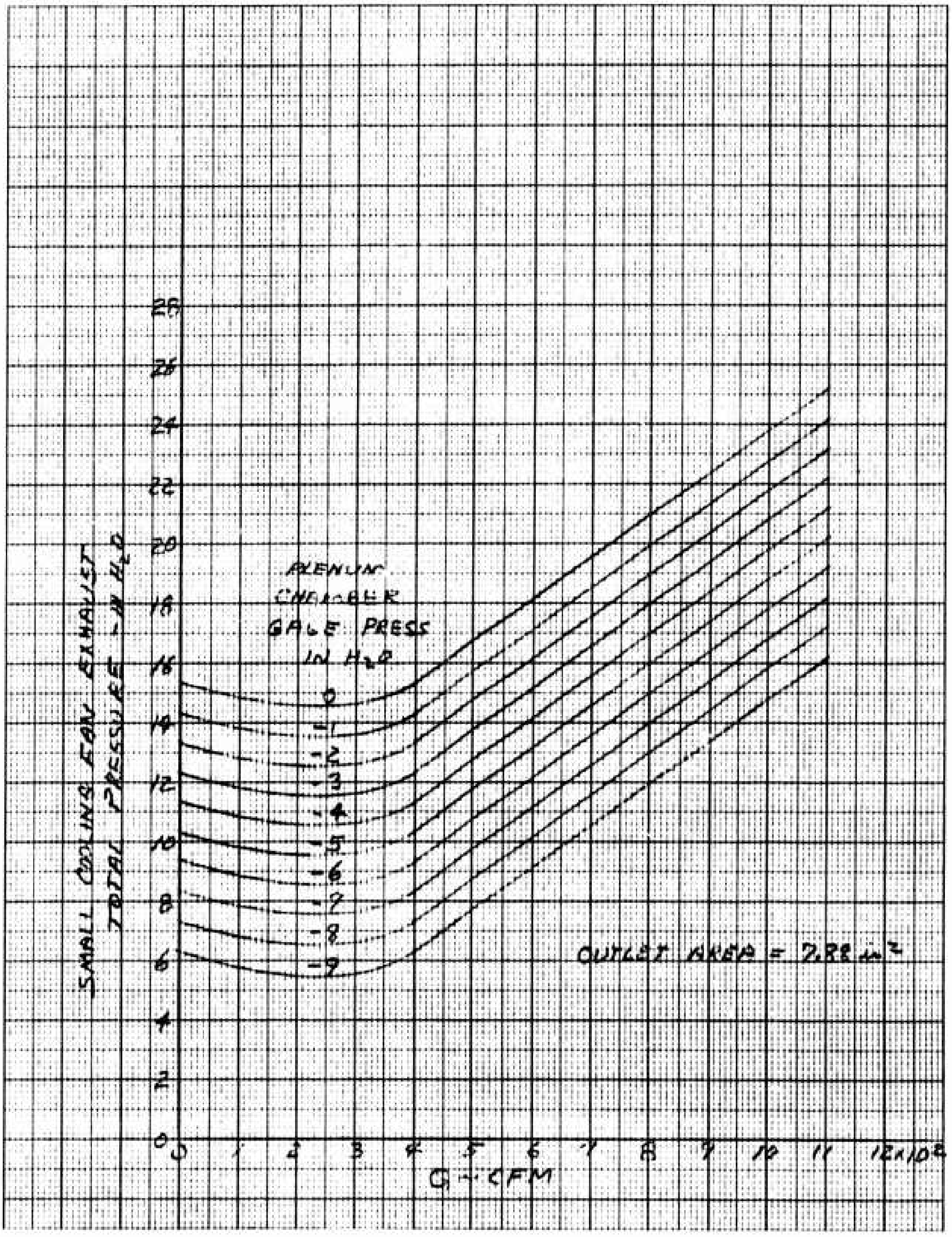

Figure 9.63 Small Cooling Fan Exhaust Total Pressure Vs Flow Rate and Plenum Chamber Pressure - Hot Day, 10,000 Ft., 100% RPM

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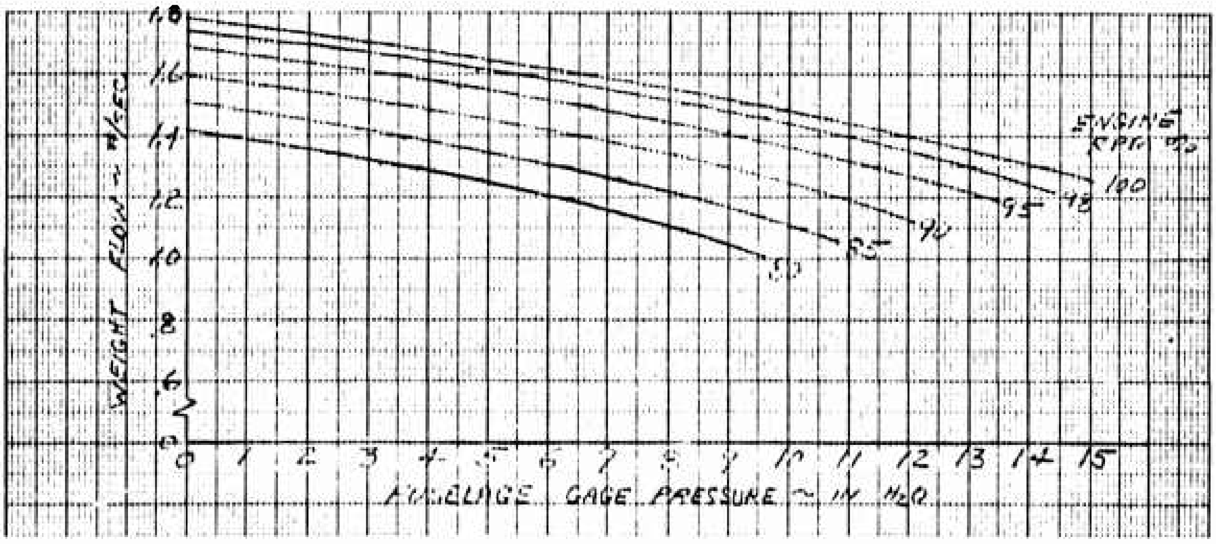

Figure 9.64 Cooling Air Weight Flow - Cockpit to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

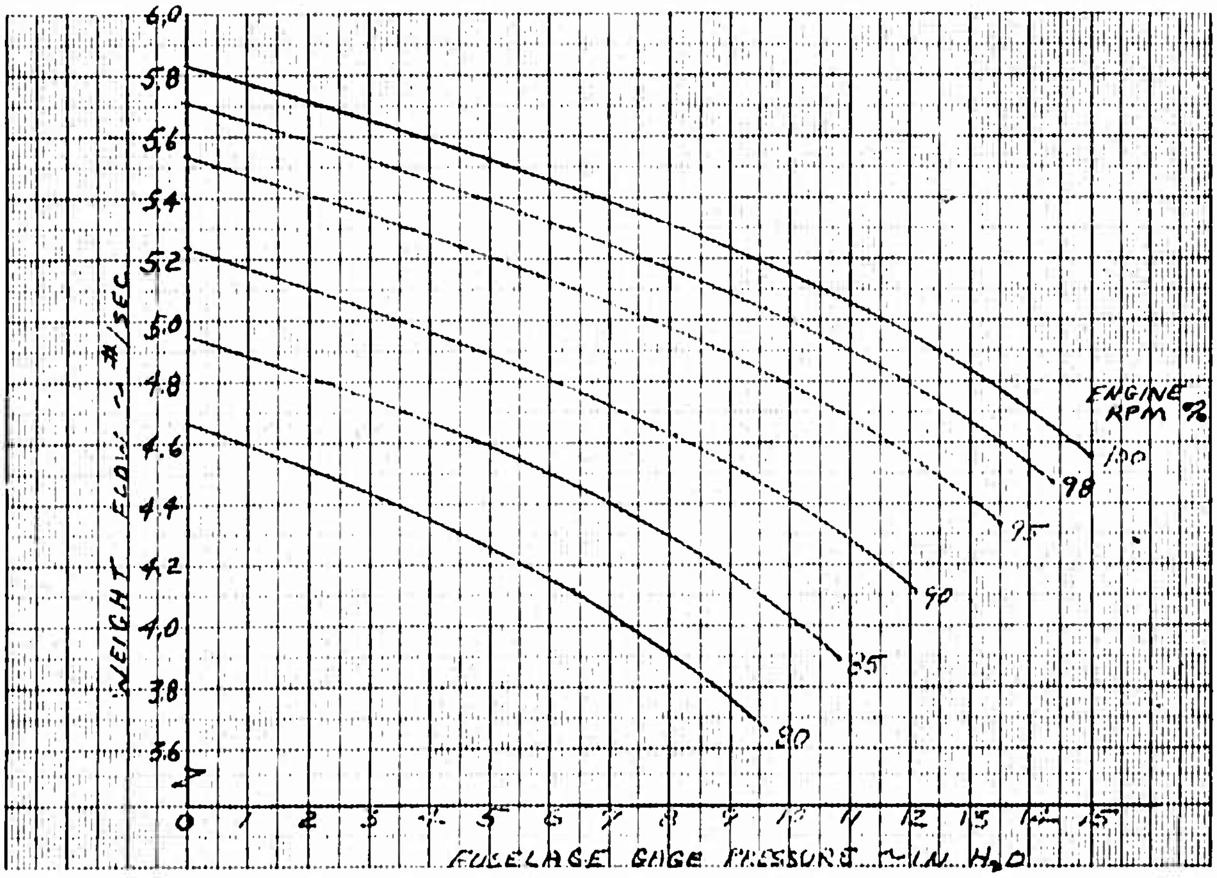

Figure 9.65 Cooling Air Weight Flow - Fuselage Ports to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

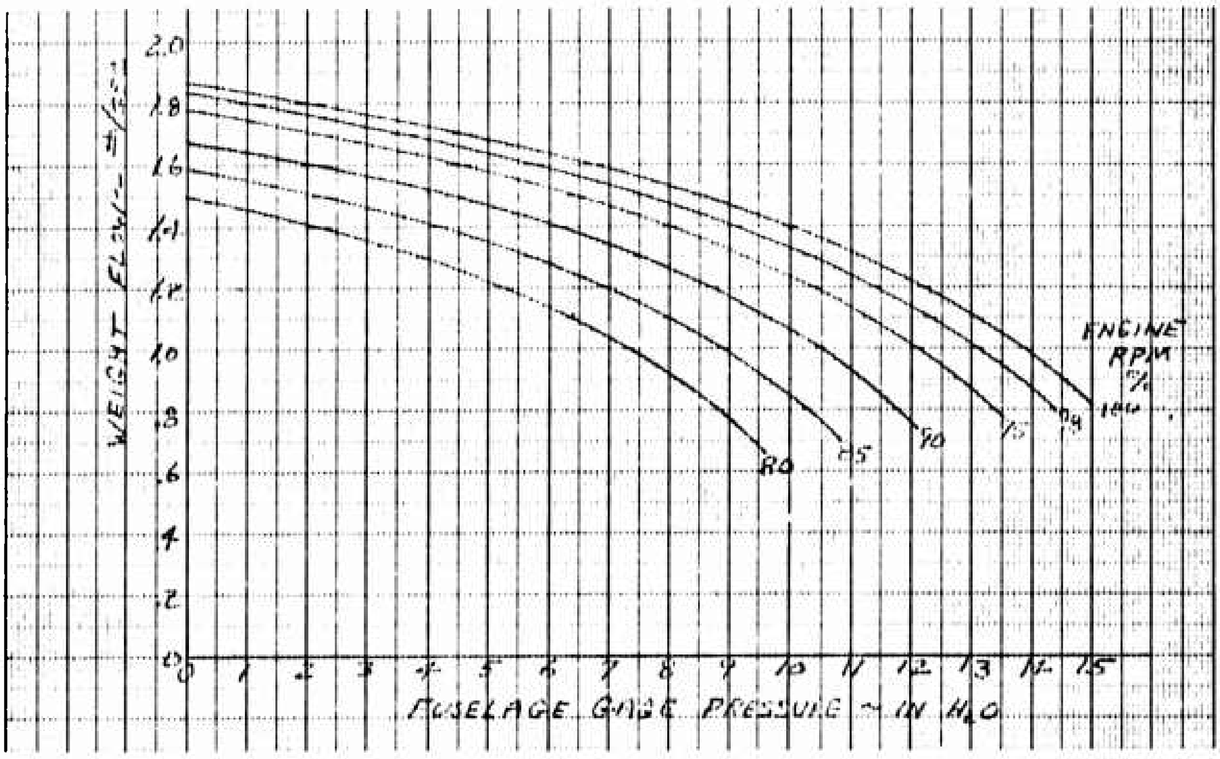

Figure 9.66 Cooling Air Weight Flow - Small Cooling Fan to Electronic Compartment Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

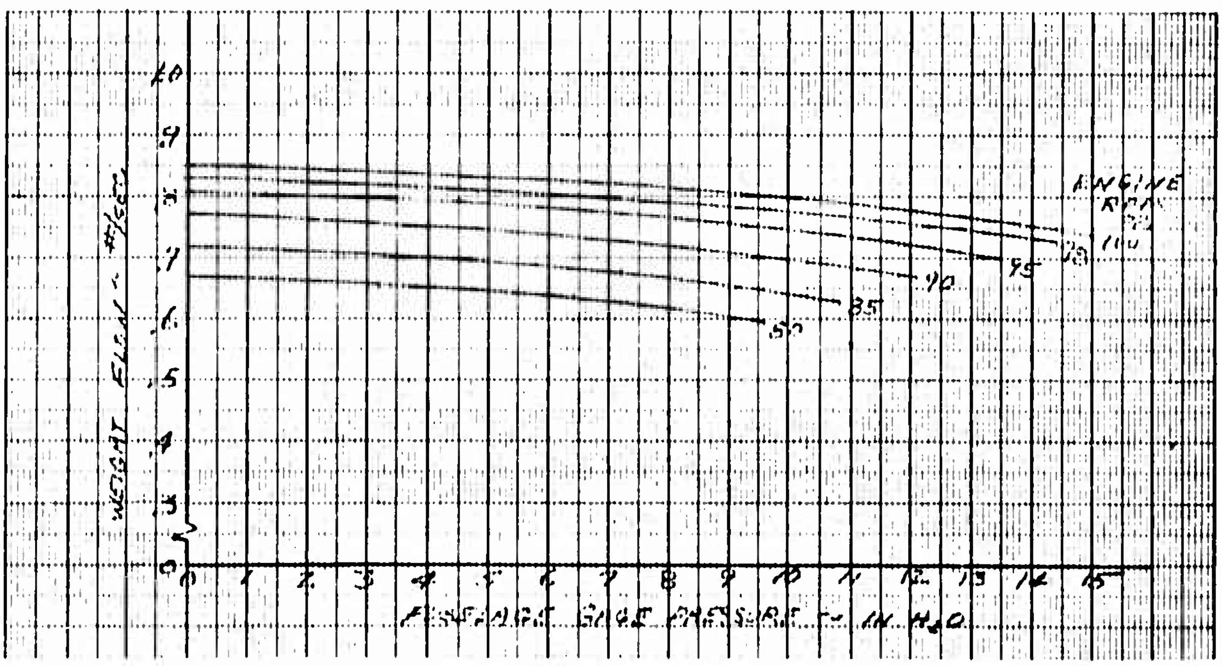

Figure 9.67 Cooling Air Weight Flow - Small Cooling Fan to Generator Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

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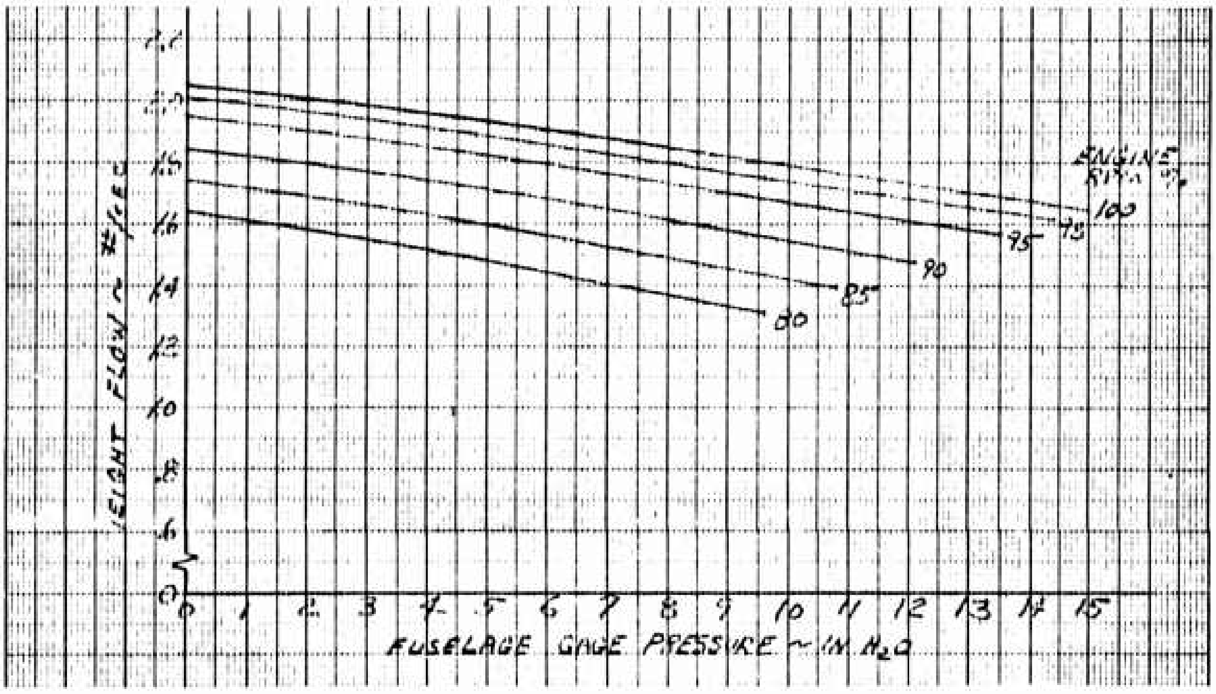

Figure 9.68 Cooling Air Weight Flow - L.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

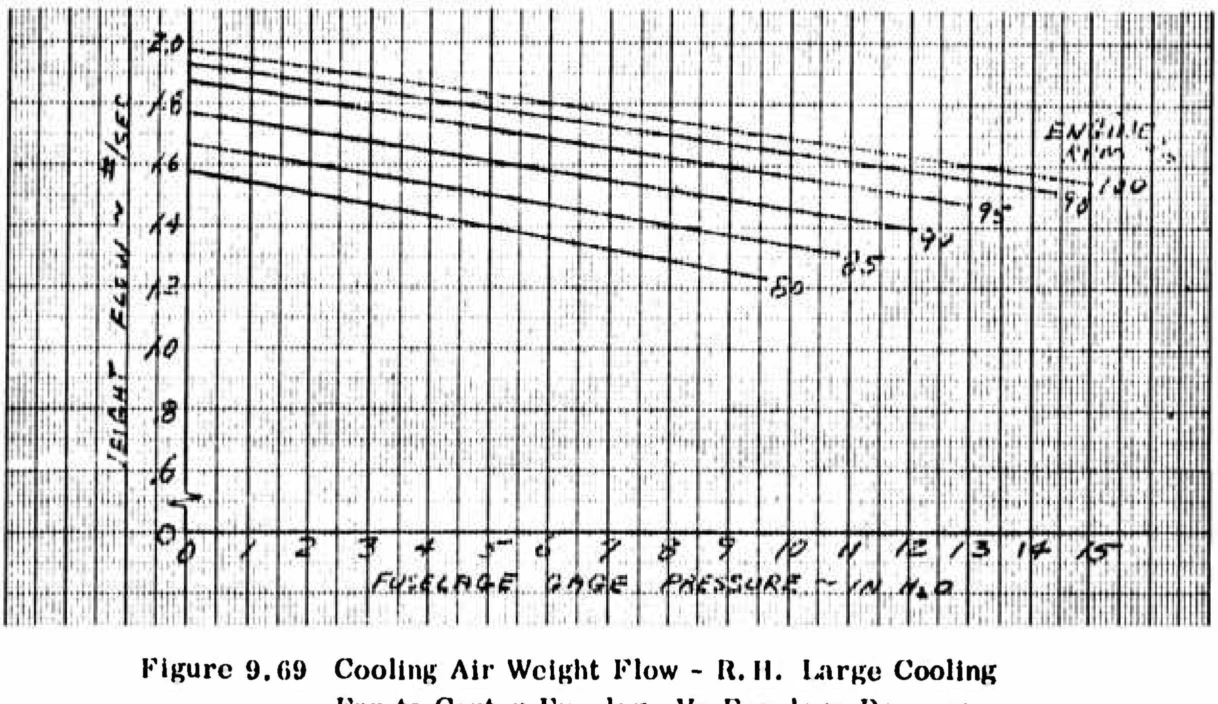

Figure 9.69 Cooling Air Weight Flow - R.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

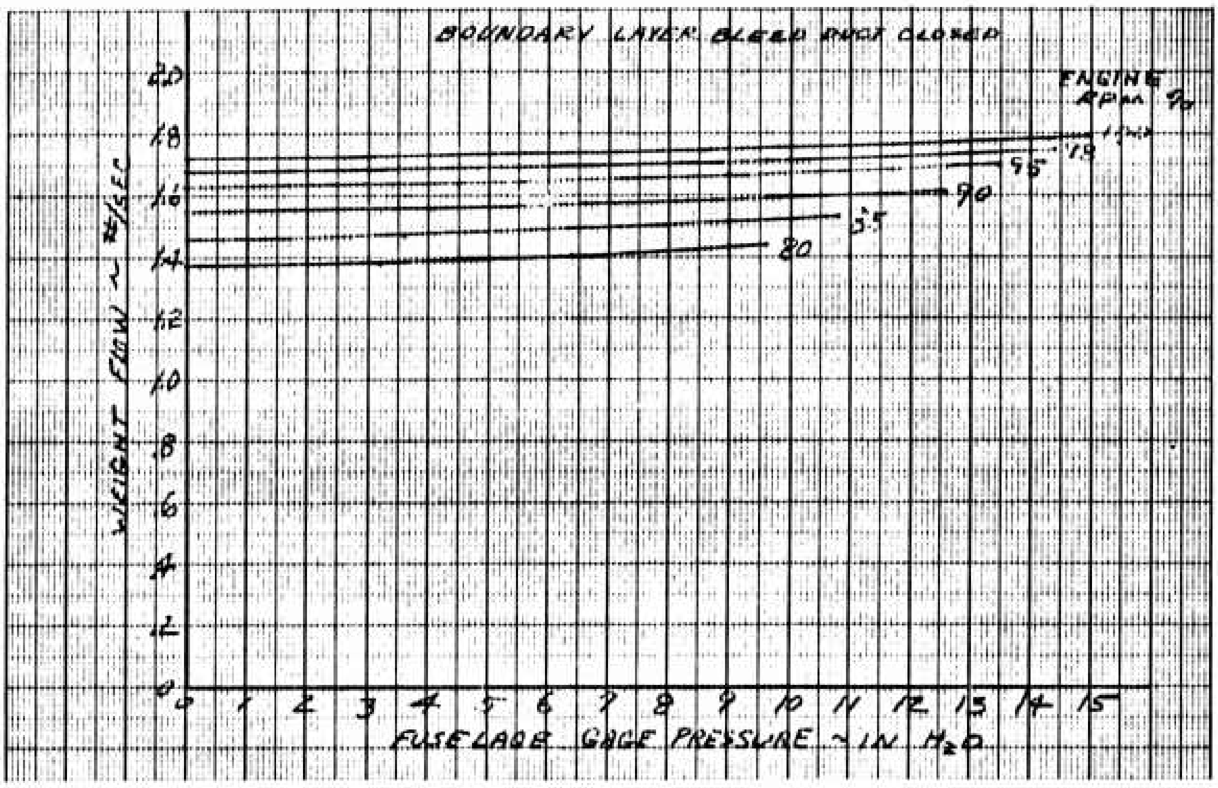

Figure 9.70 Cooling Air Weight Flow - Large Cooling Fan to Tailpipe Ejector Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

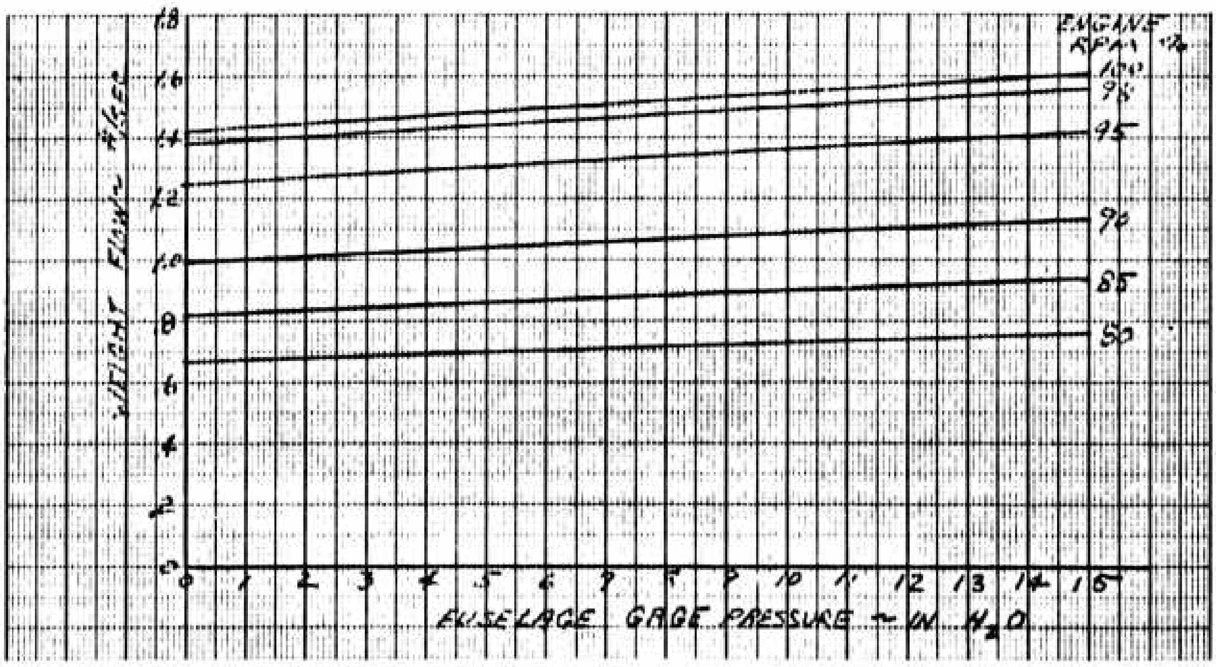

Figure 9.71 Cooling Air Weight Flow - Center Fuselage to Wing Fan Cavity Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

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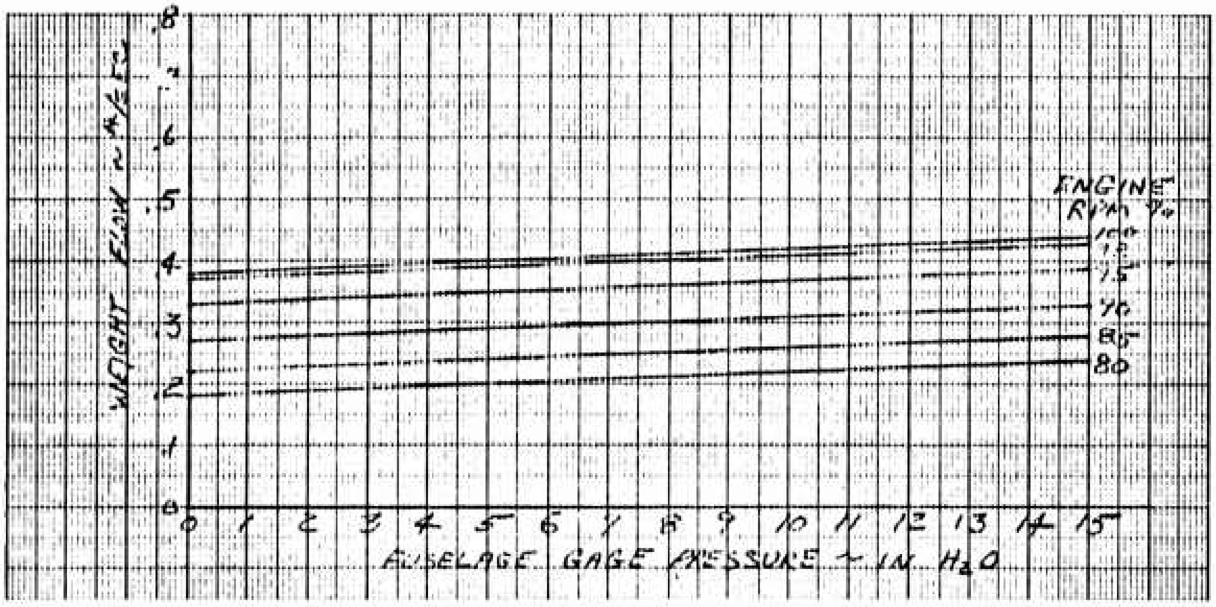

Figure 9.72 Cooling Air Weight Flow - Forward Fuselage to Nose Fan Cavity Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

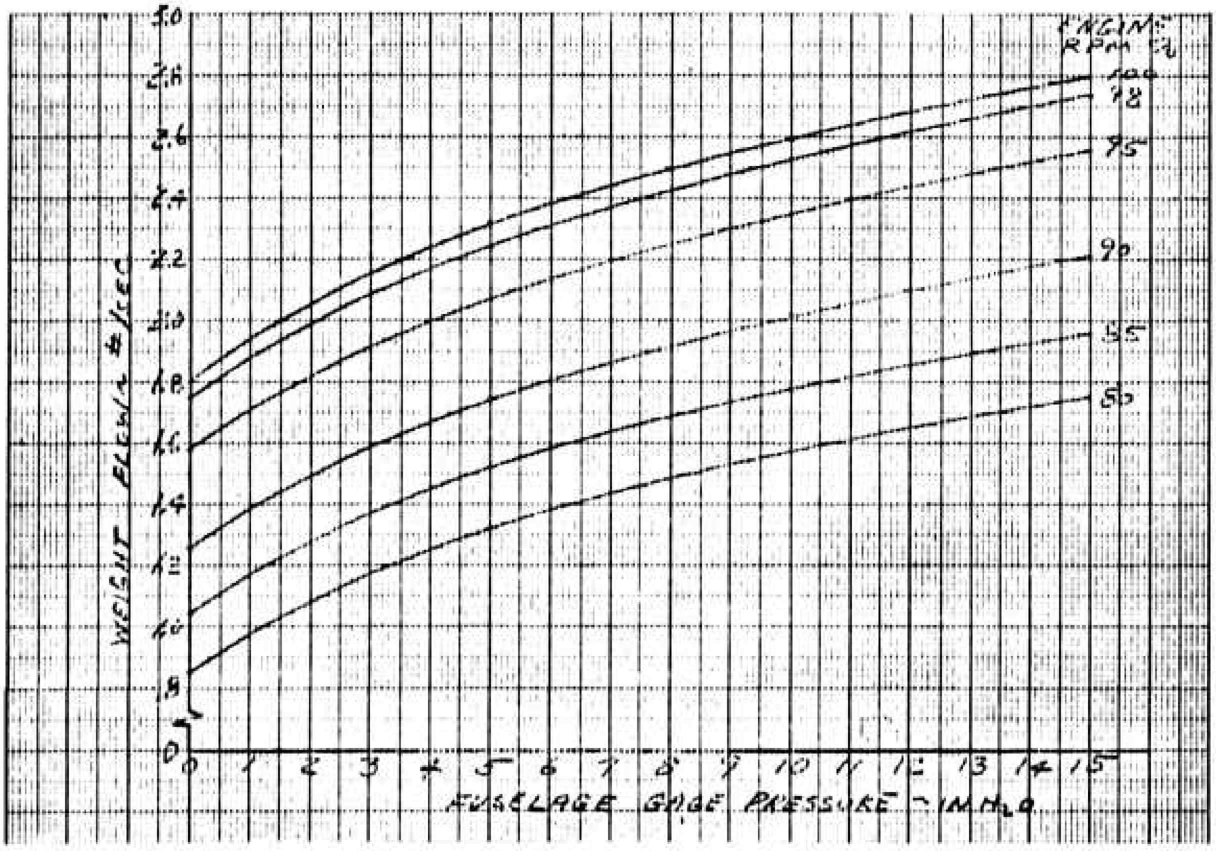

Figure 9.73 Cooling Air Weight Flow - Wing and Nose Fan Ejectors and Flap Actuator Slot to Outside Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

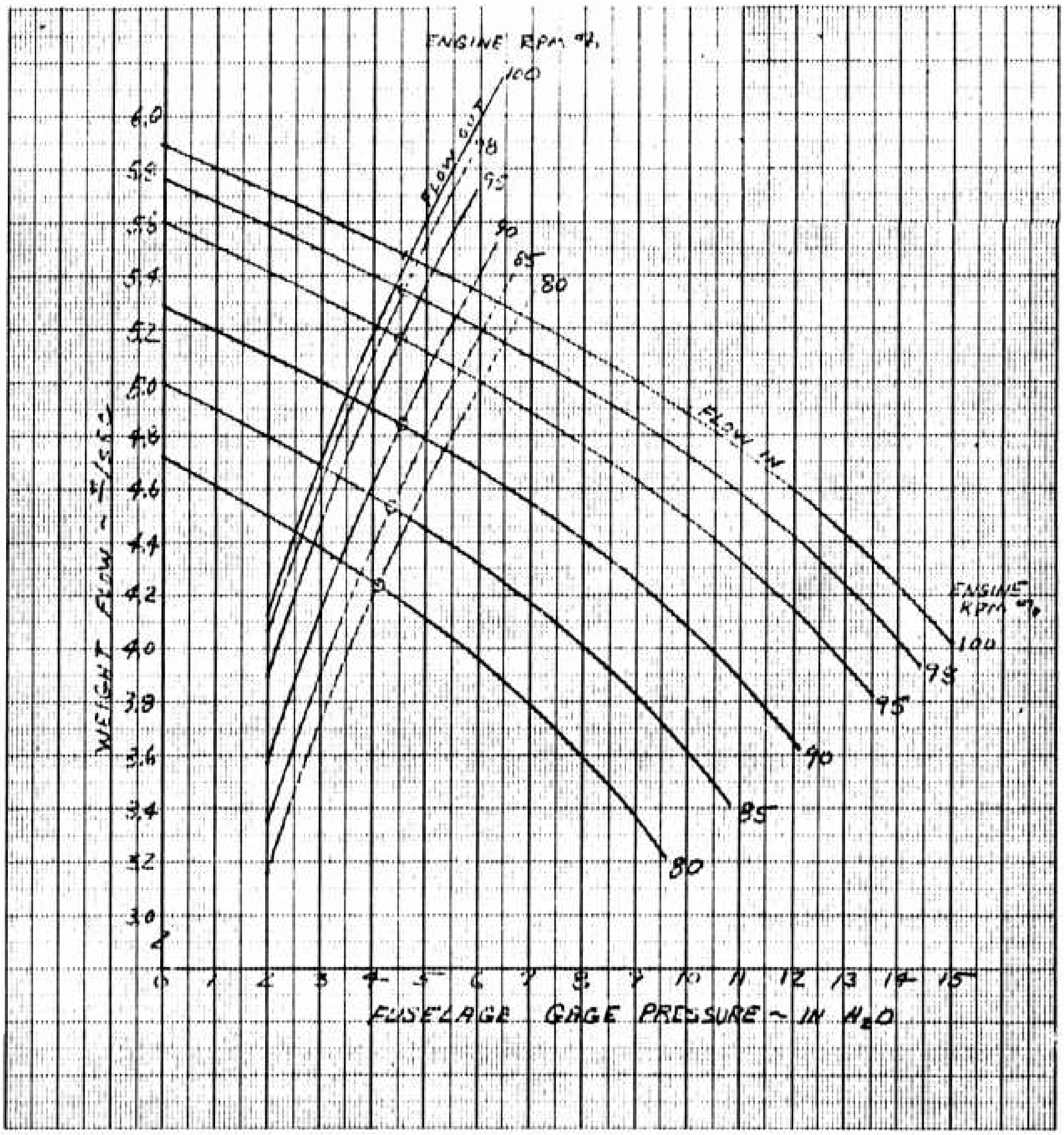

Figure 9.74 Cooling Air Weight Flow - Balance of Flow Thru The Lower Fuselage Vs Fuselage Pressure and % RPM - Fan Mode, Standard Day, Sea Level

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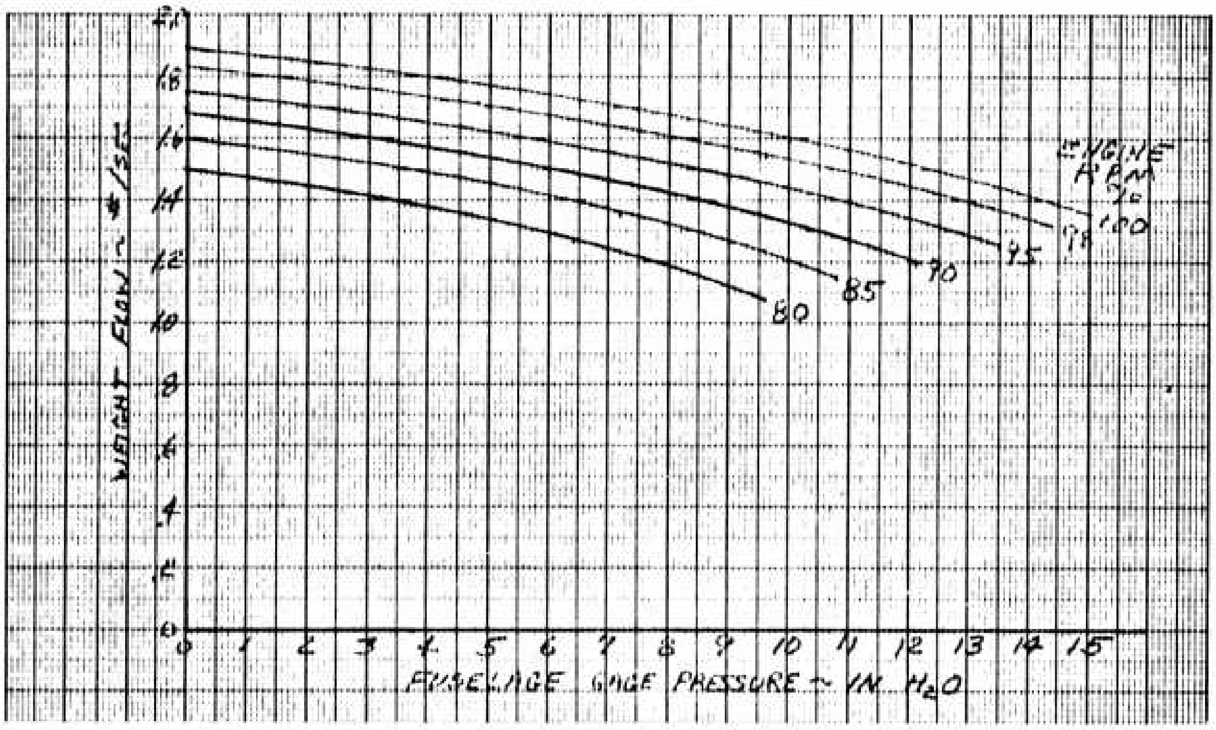

Figure 9.75 Cooling Air Weight Flow - Cockpit to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

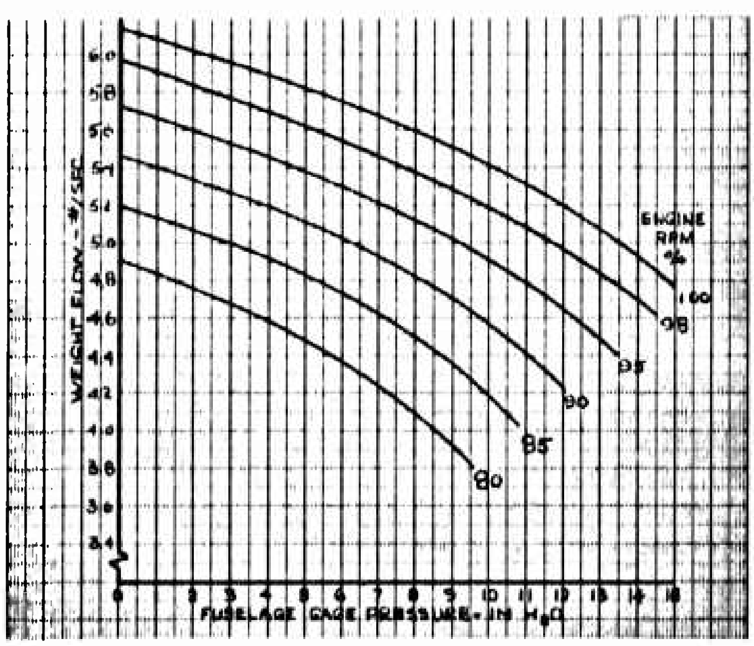

Figure 9.76 Cooling Air Weight Flow - Fuselage Ports to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

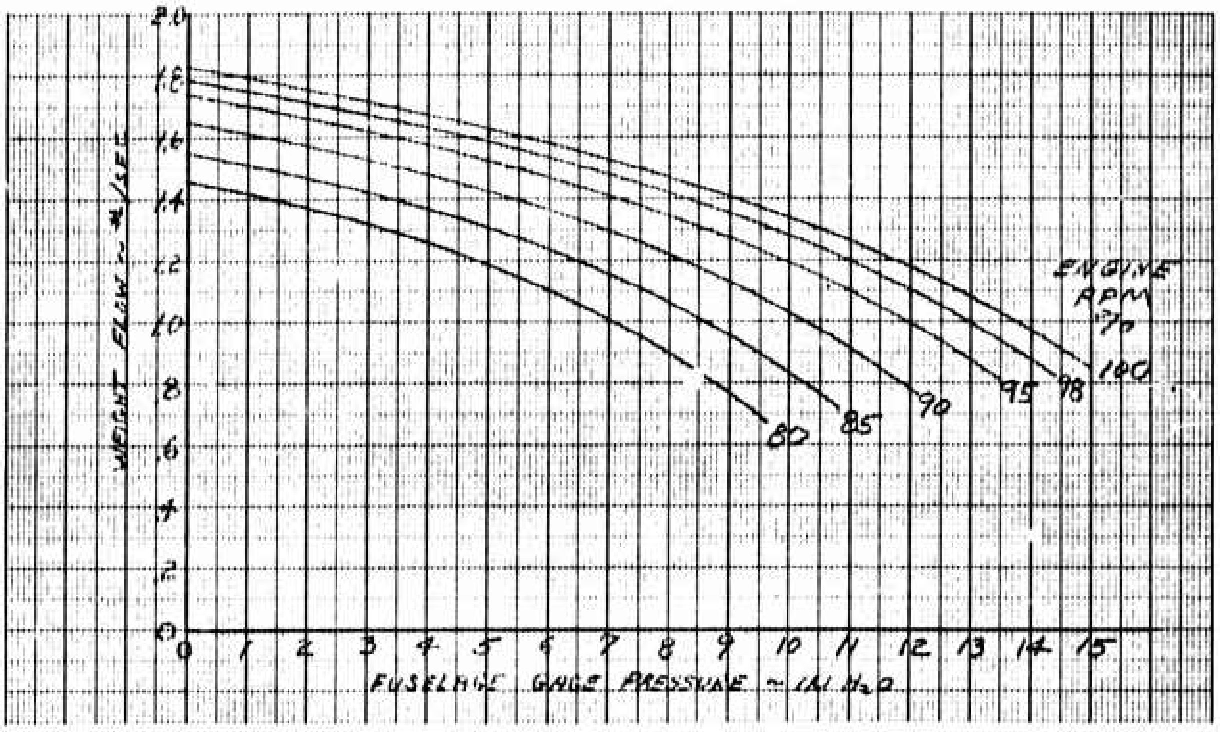

Figure 9.77 Cooling Air Weight Flow - Small Cooling Fan to Electronic Compartment Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

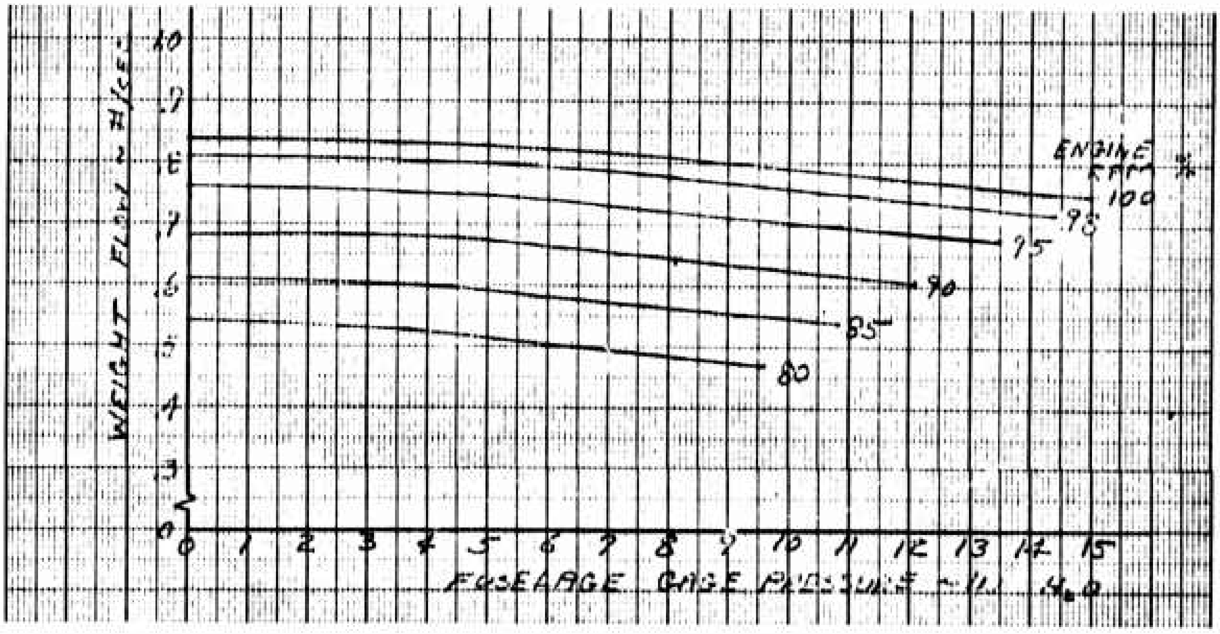

Figure 9.78 Cooling Air Weight Flow - Small Cooling Fan to Generator Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

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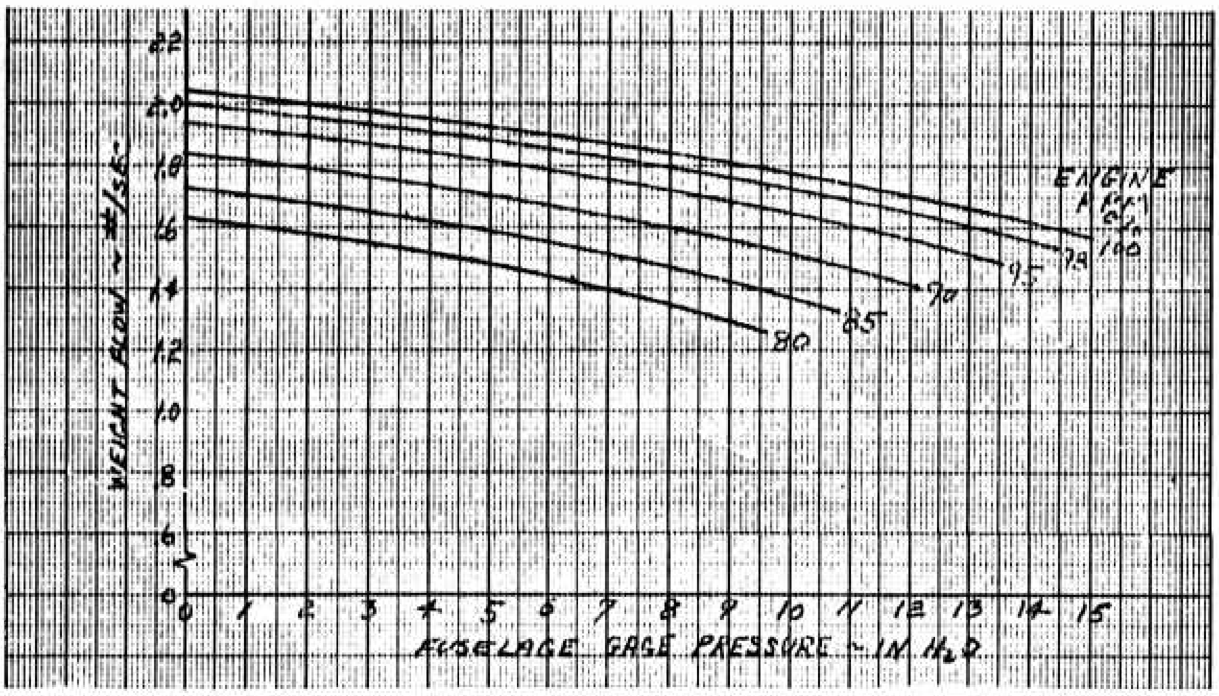

Figure 9.79 Cooling Air Weight Flow - L.H. Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

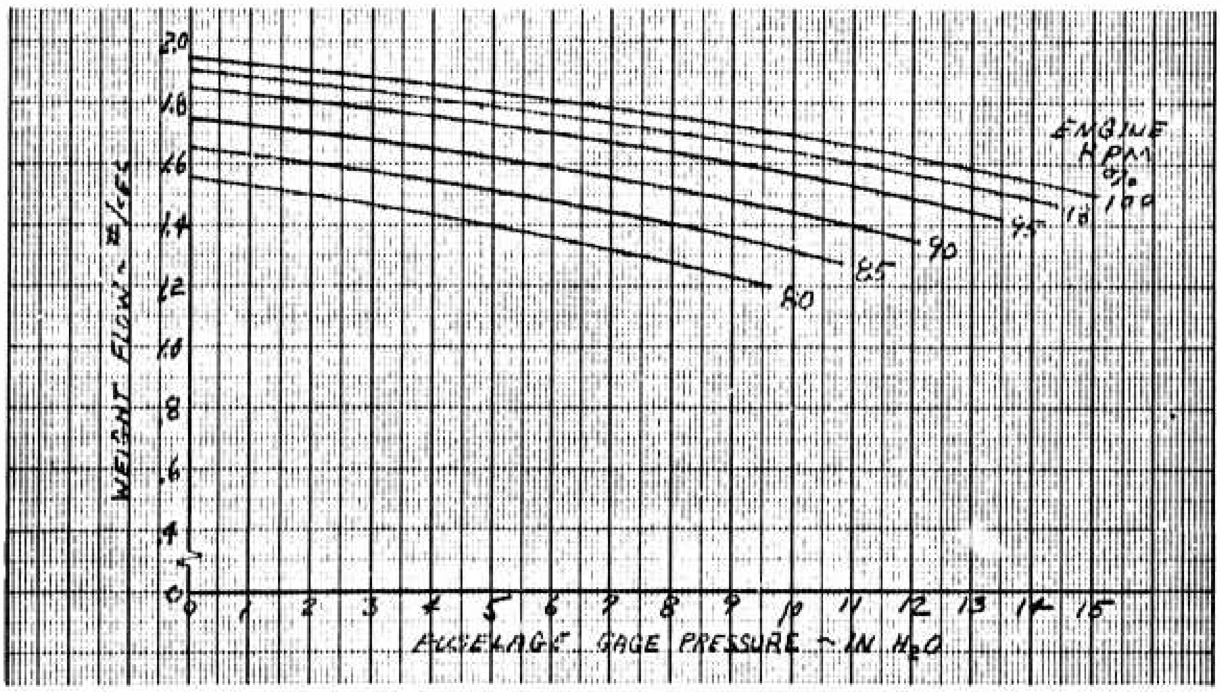

Figure 9.80 Cooling Air Weight Flow - R.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

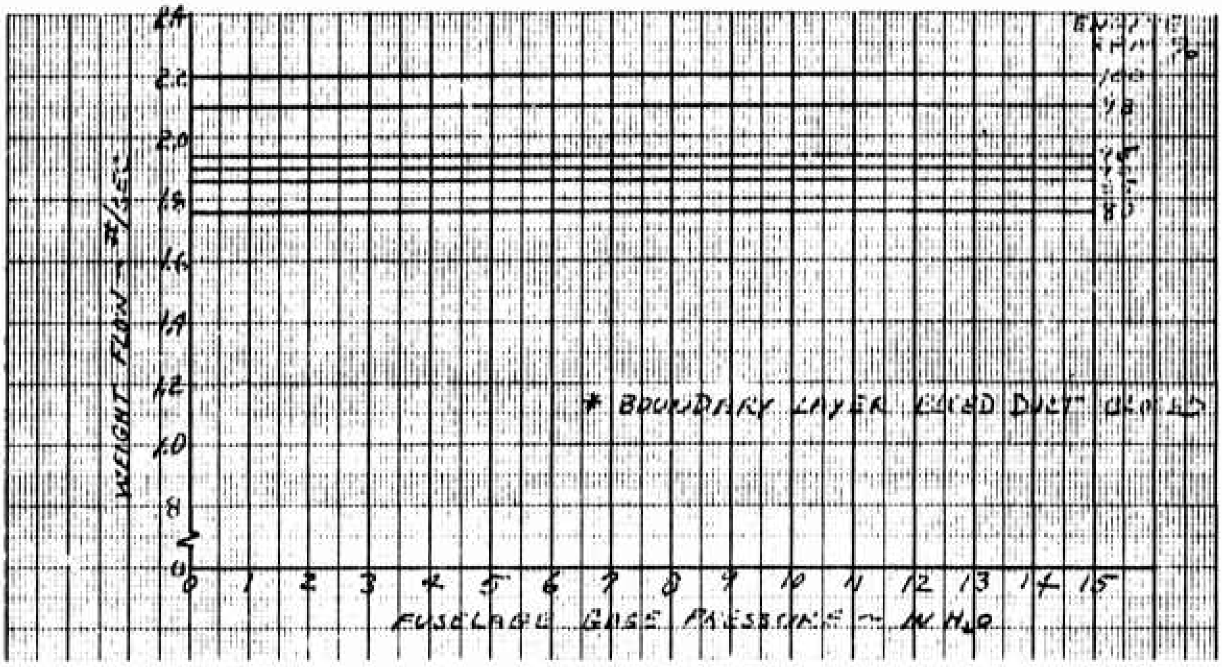

Figure 9.81 Cooling Air Weight Flow - Large Cooling Fan to Tailpipe Ejector Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

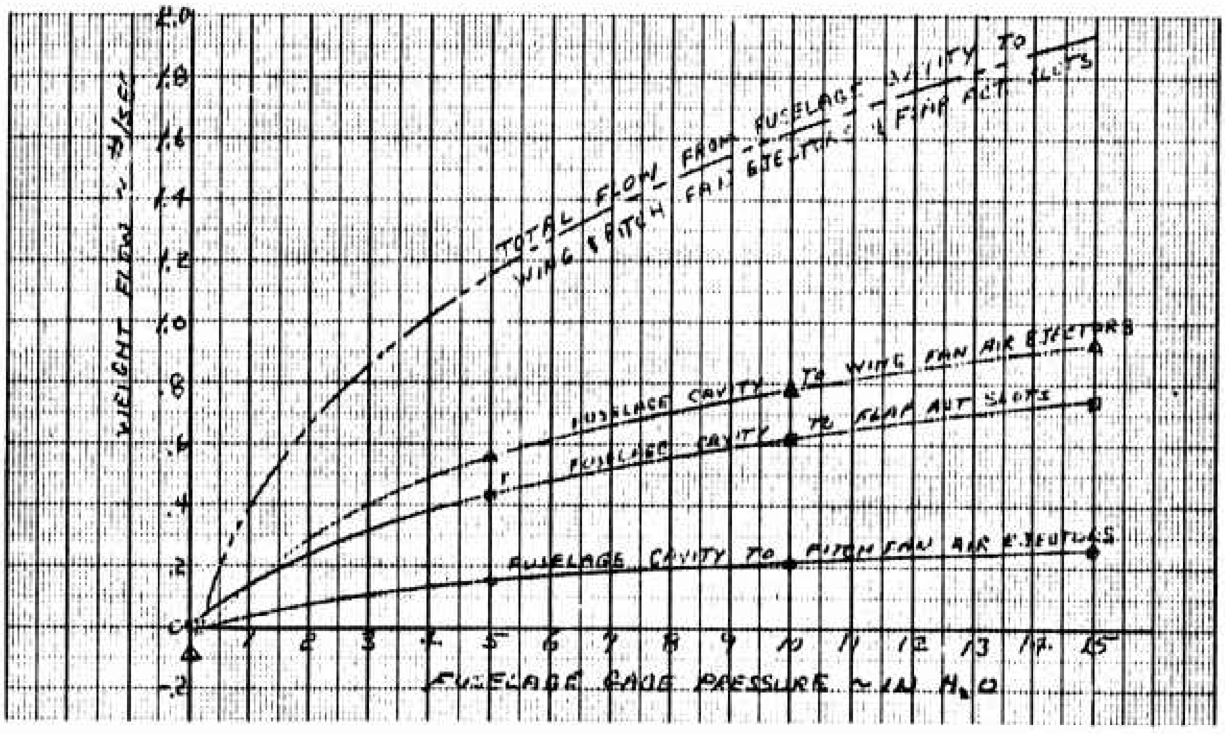

Figure 9.82 Cooling Air Weight Flow - Wing and Nose Fan Ejectors and Flap Actuator Slot to Outside Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

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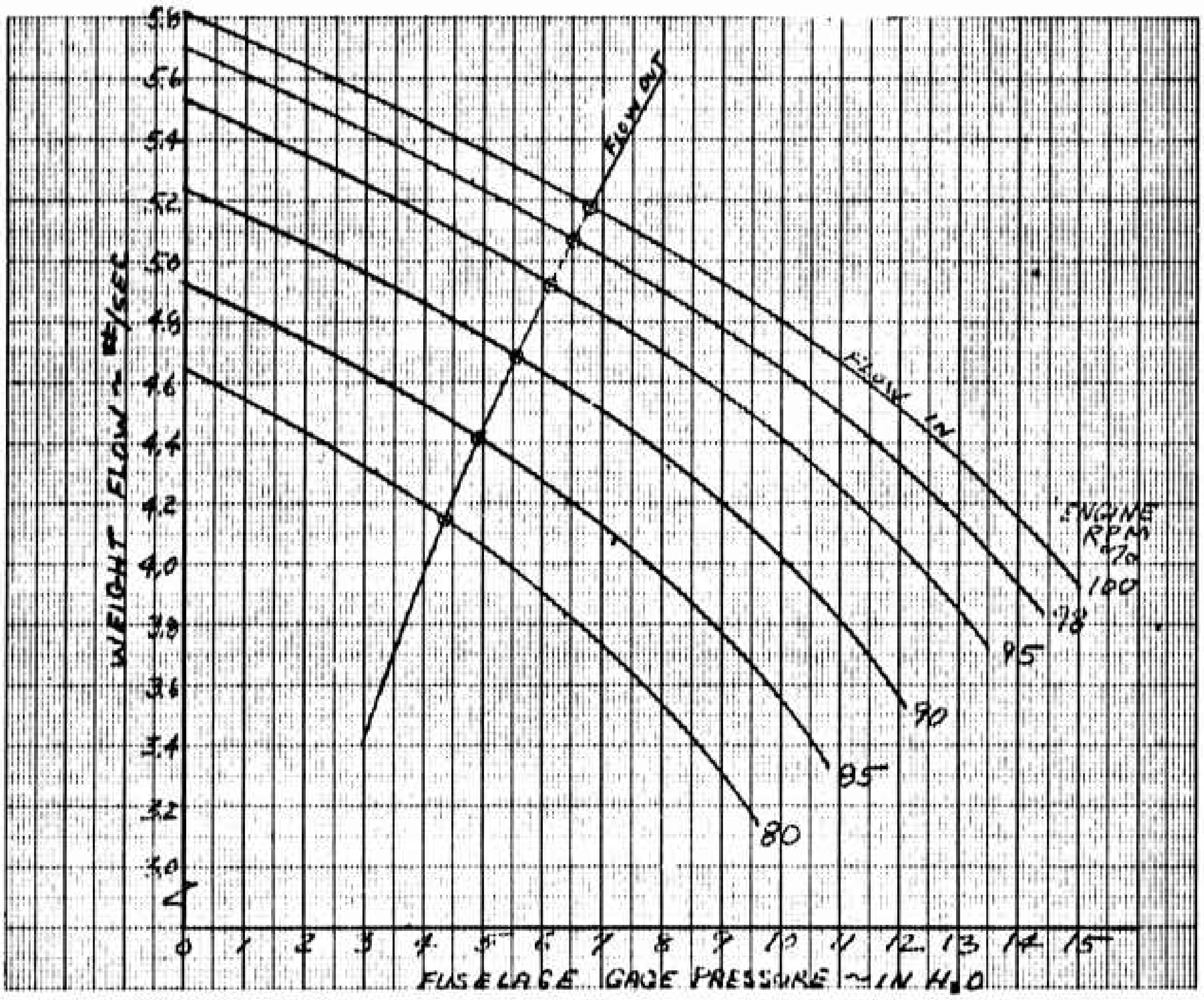

Figure 9.83 Cooling Air Weight Flow Balance of Flow Thru the Lower Fuselage Vs Fuselage Pressure and % RPM - Conventional Mode, Standard Day, Sea Level

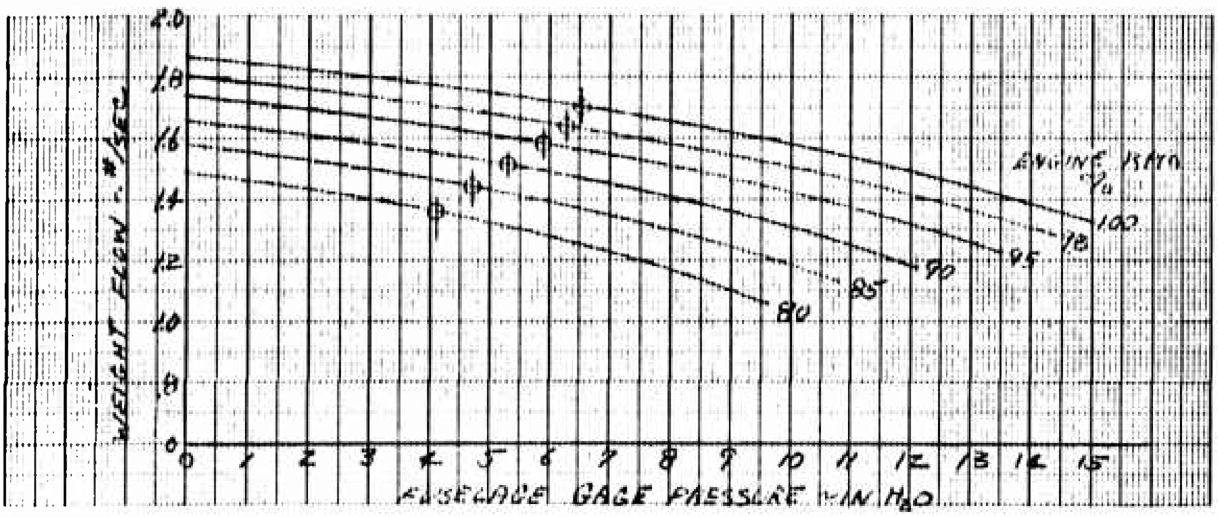

Figure 9.84 Cooling Air Weight Flow - Cockpit to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2

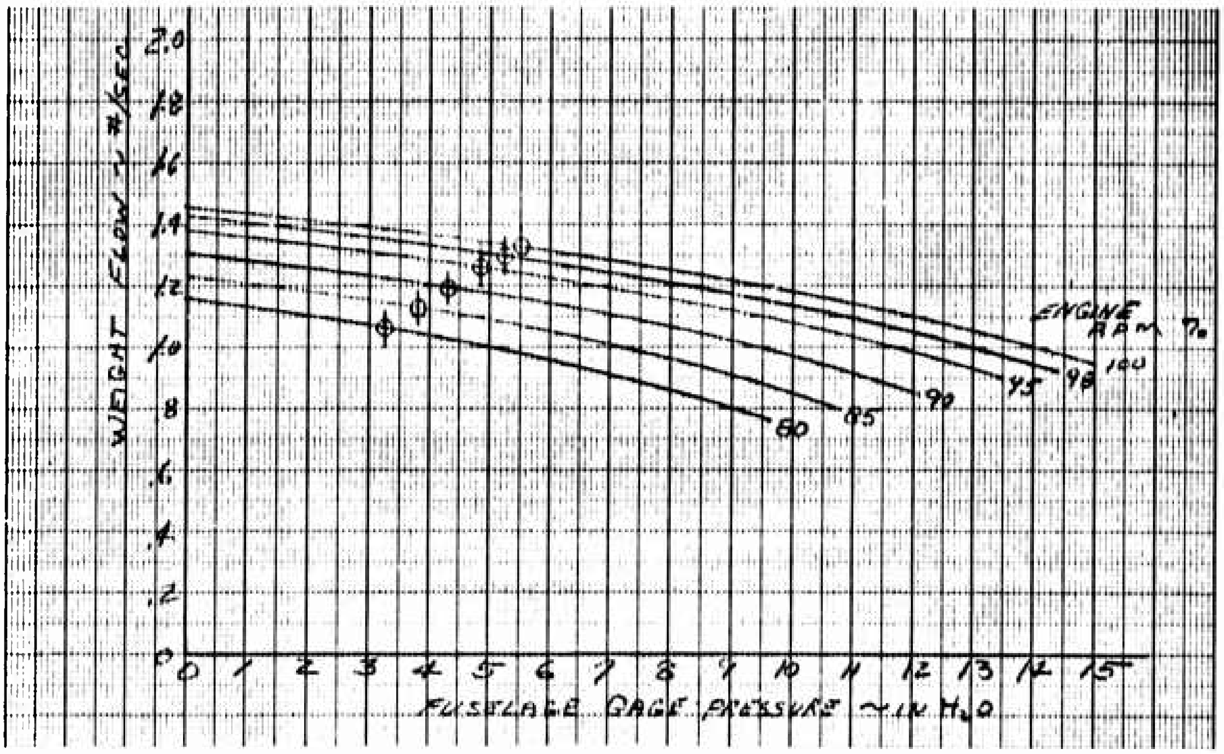

Figure 9.85 Cooling Air Weight Flow - Cockpit to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.4

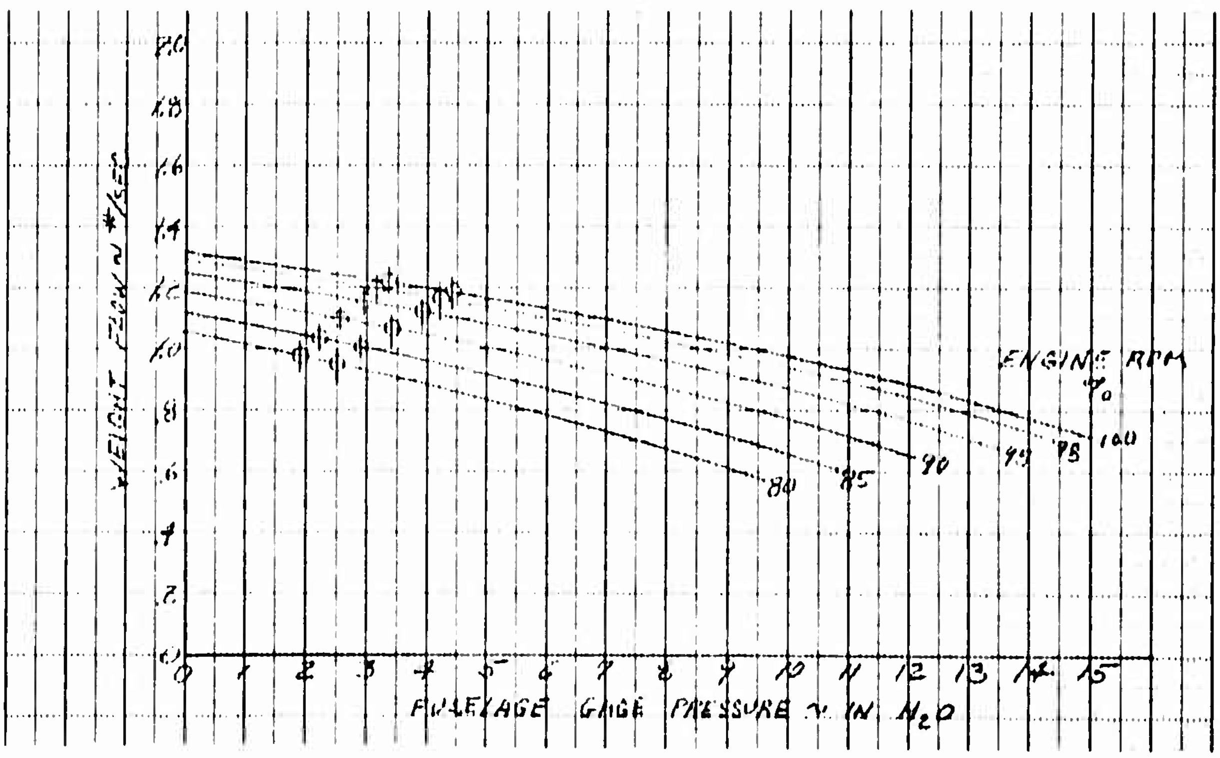

Figure 9.86 Cooling Air Weight Flow - Cockpit to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

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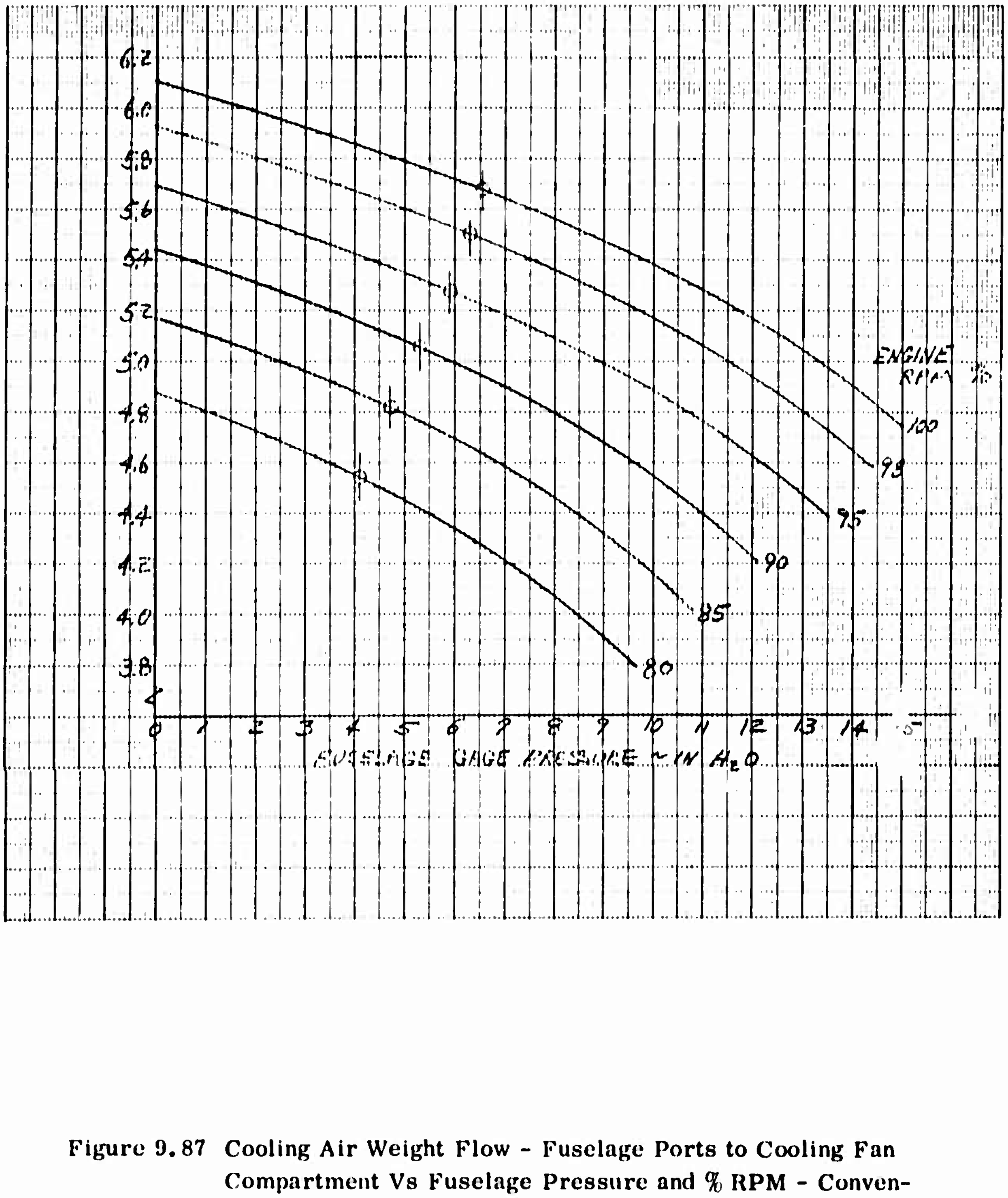

Figure 9.87 Cooling Air Weight Flow - Fuselage Ports to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2

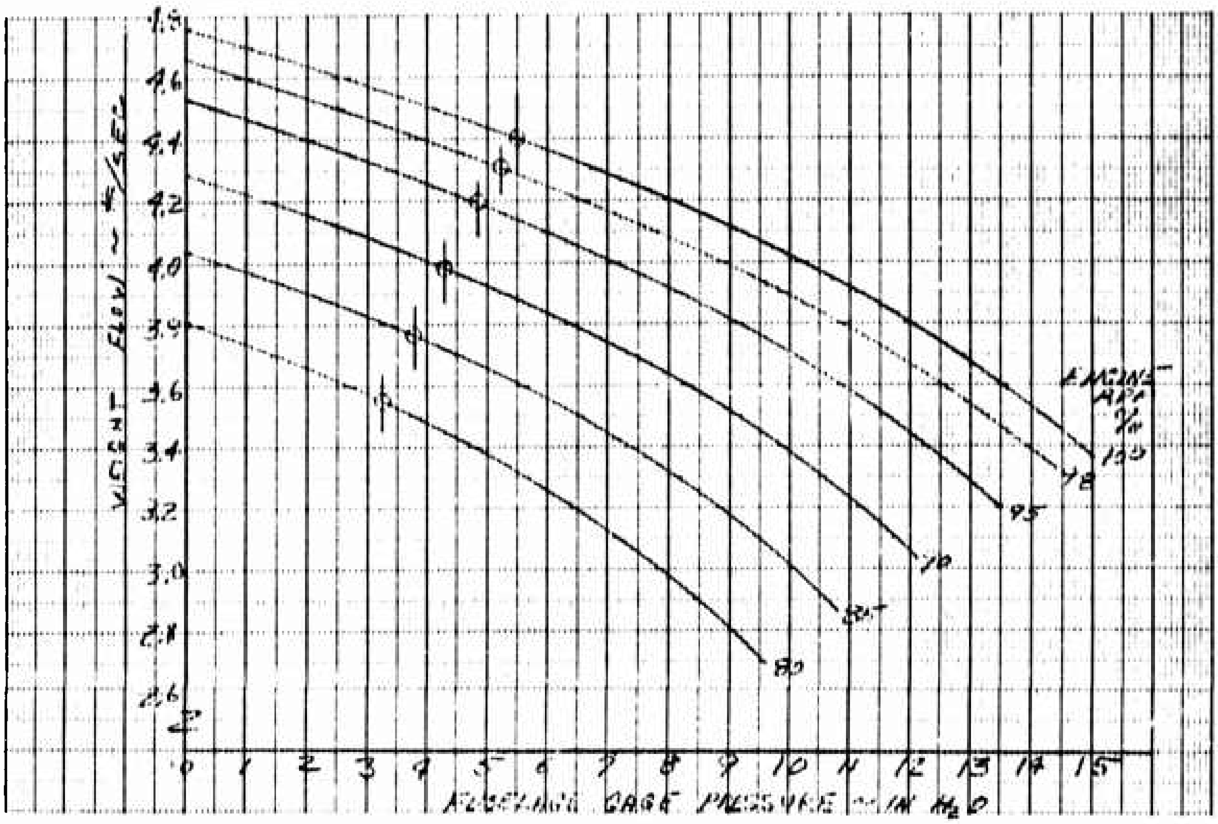

Figure 9.88 Cooling Air Weight Flow - Fuselage Ports to Cooling Fan Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.4

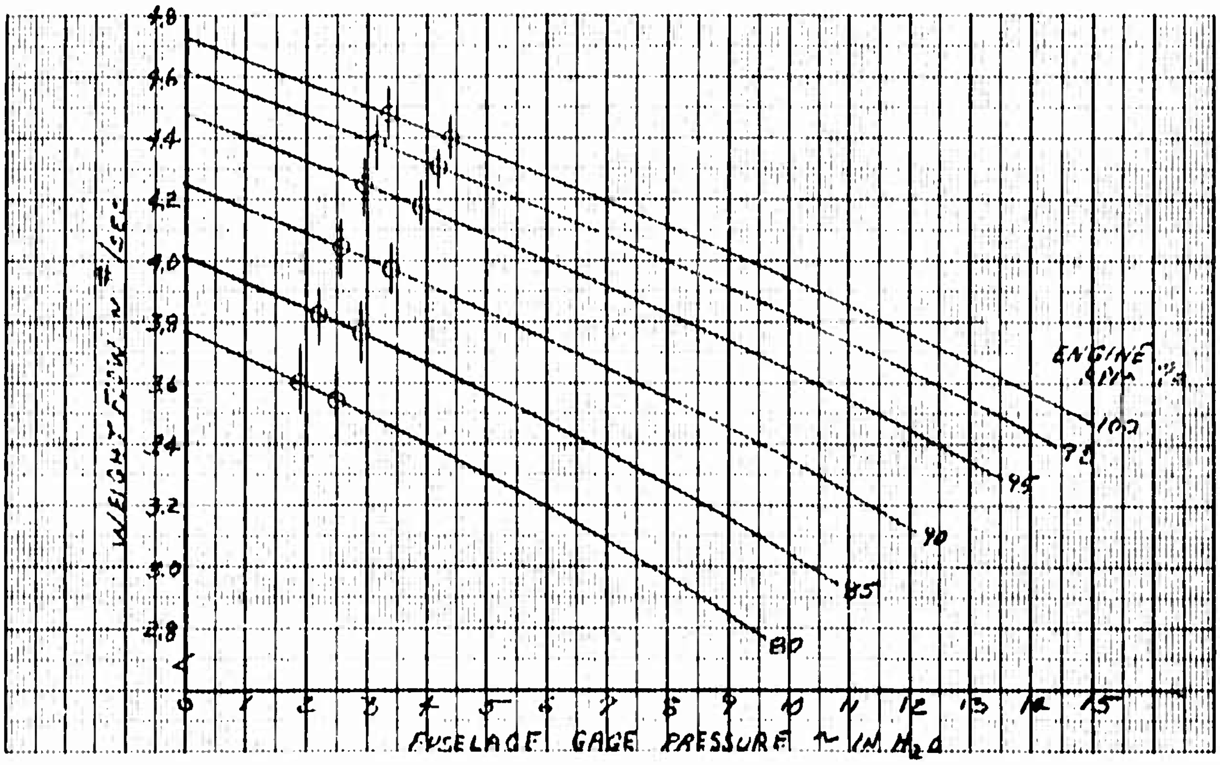

Figure 9.89 Cooling Air Weight Flow - Fuselage Ports to Cooling Fan Compartment Vs Fuselage Pressure % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

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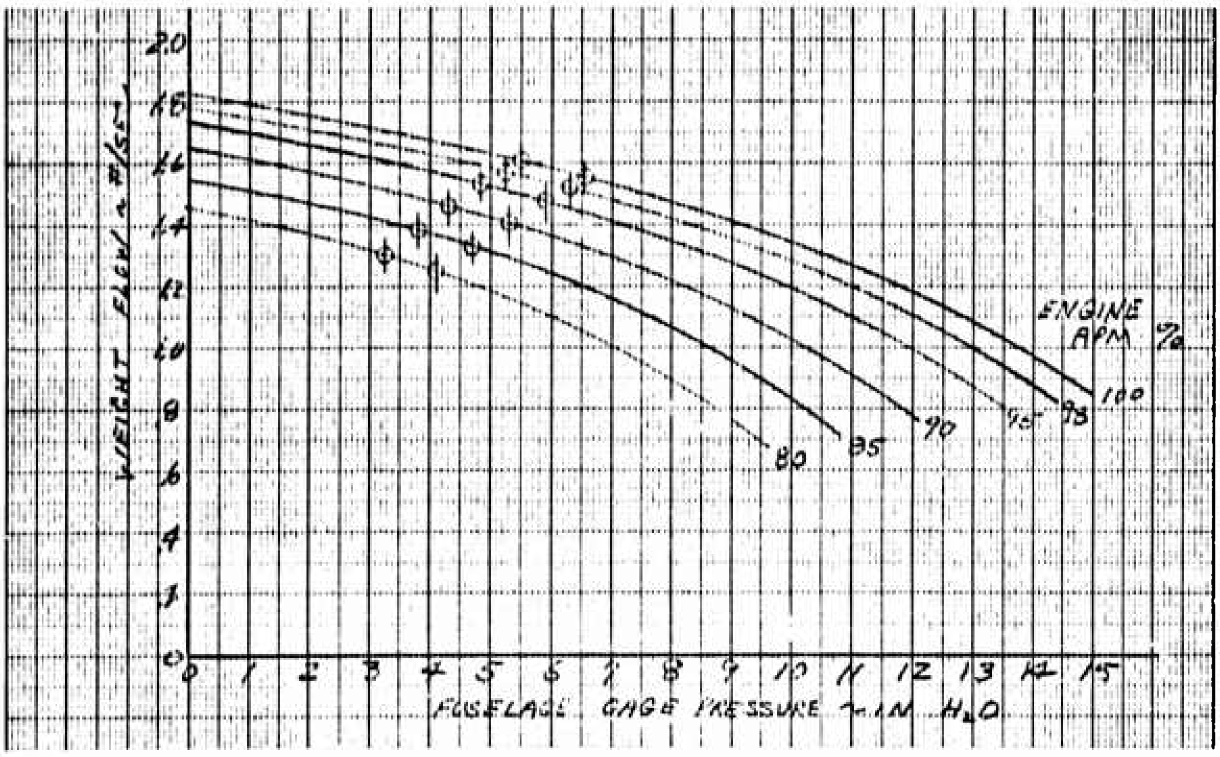

Figure 9.90 Cooling Air Weight Flow - Small Cooling Fan to Electronic Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2 and 0.4

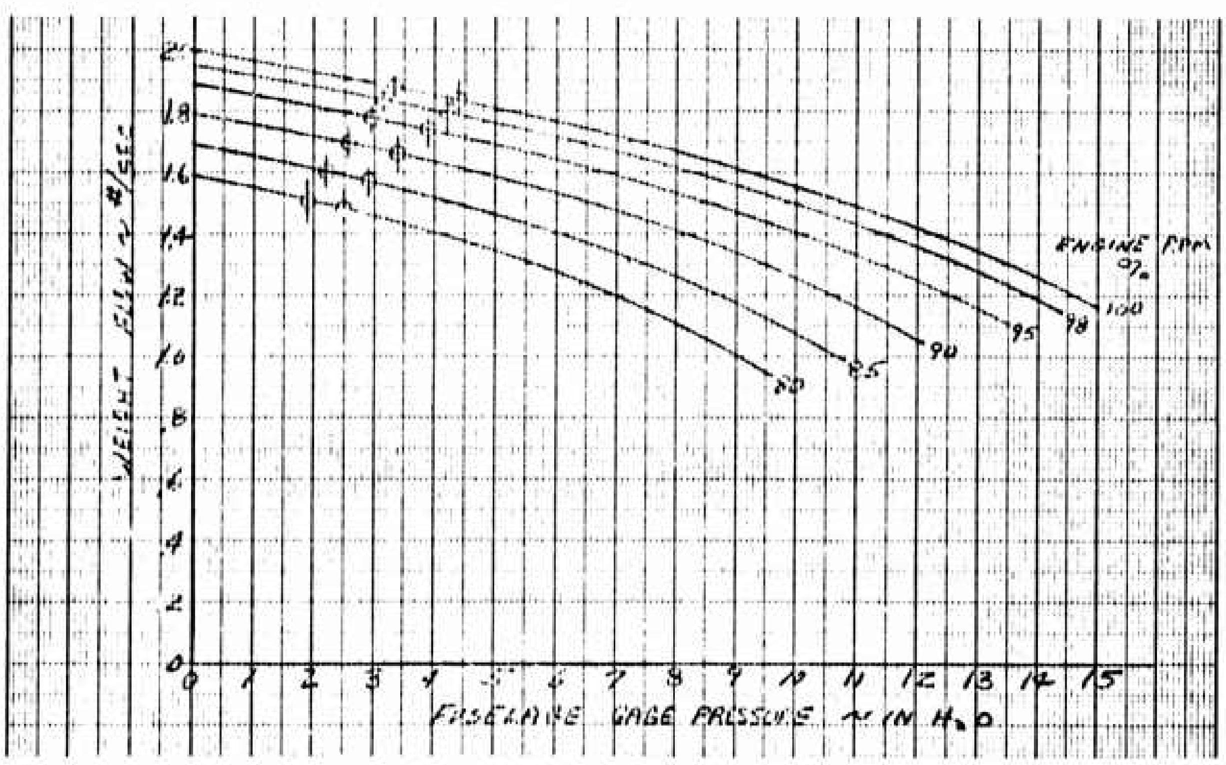

Figure 9.91 Cooling Air Weight Flow - Small Cooling Fan to Electronic Compartment Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

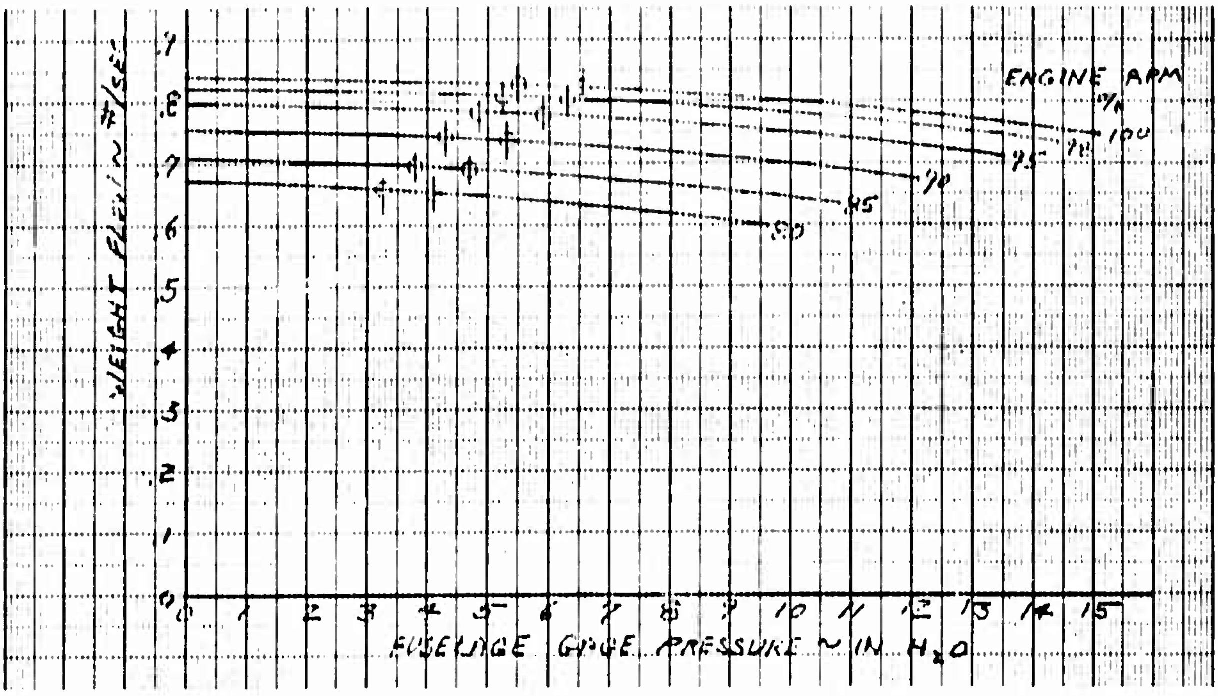

Figure 9.92 Cooling Air Weight Flow - Small Cooling Fan to Generators Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2 and 0.4

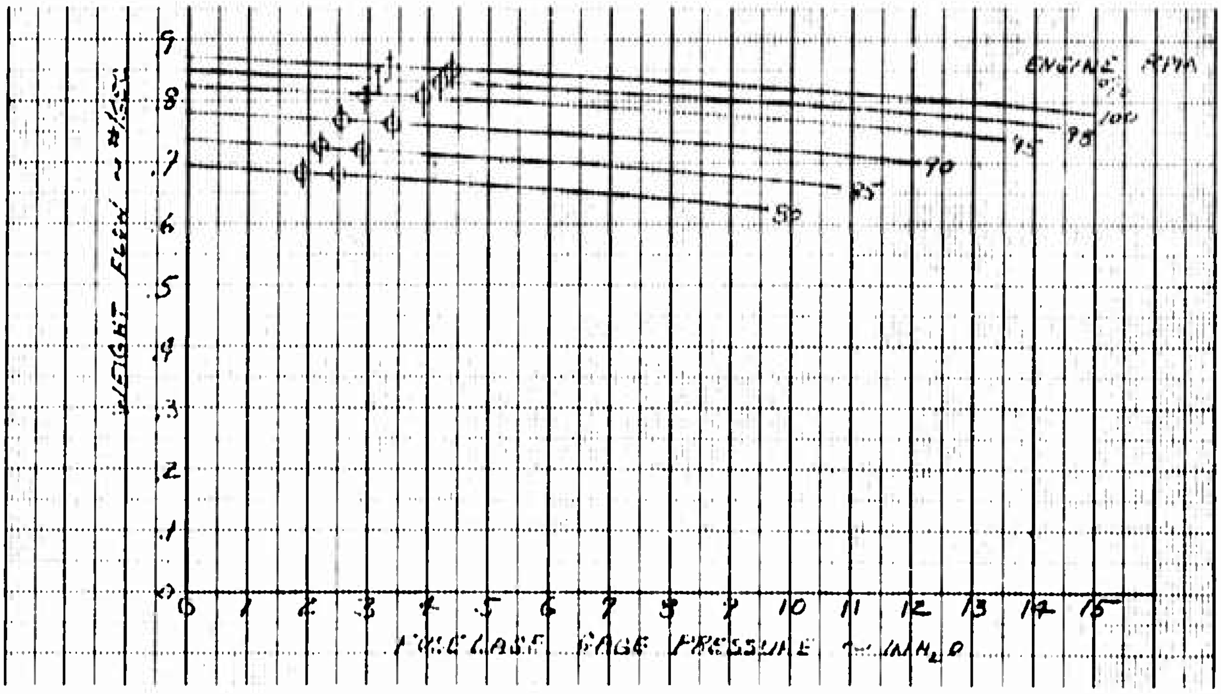

Figure 9.93 Cooling Air Weight Flow - Small Cooling Fan to Generators Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

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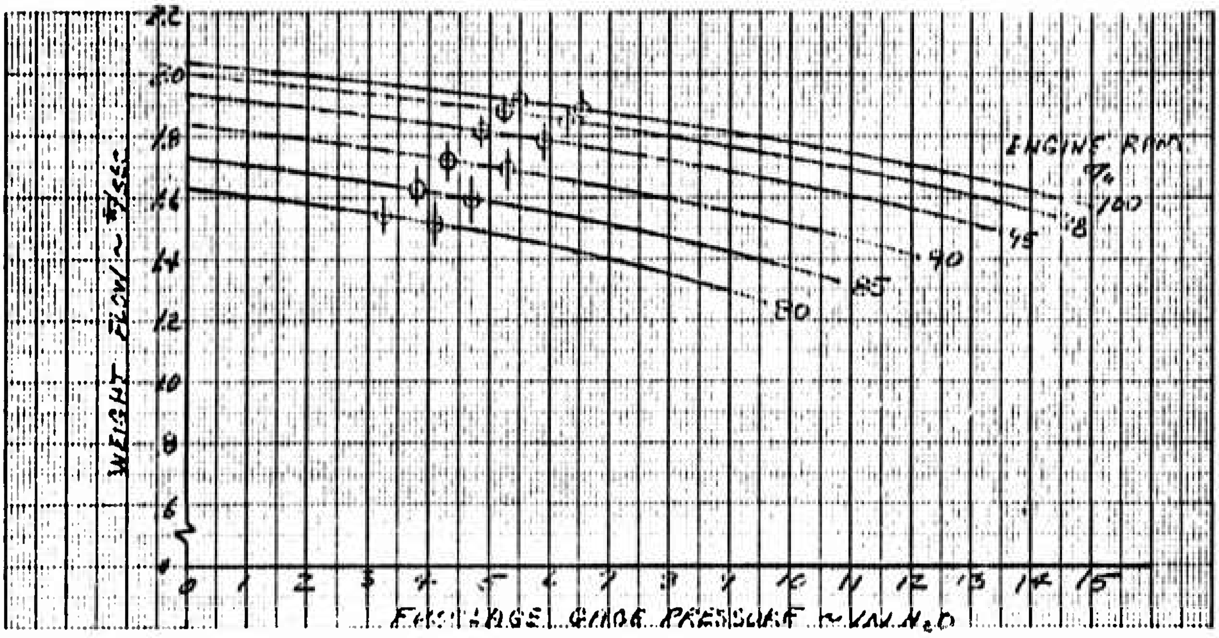

Figure 9.94 Cooling Air Weight Flow - L.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2 and 0.4

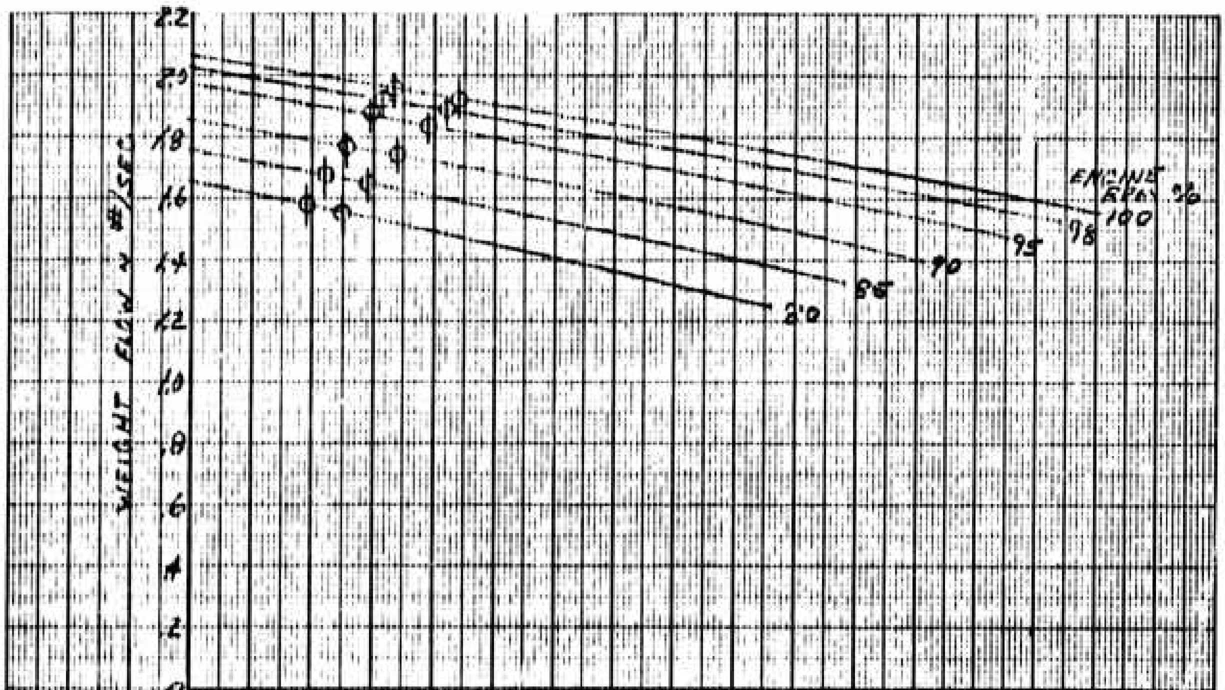

Figure 9.95 Cooling Air Weight Flow - L.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

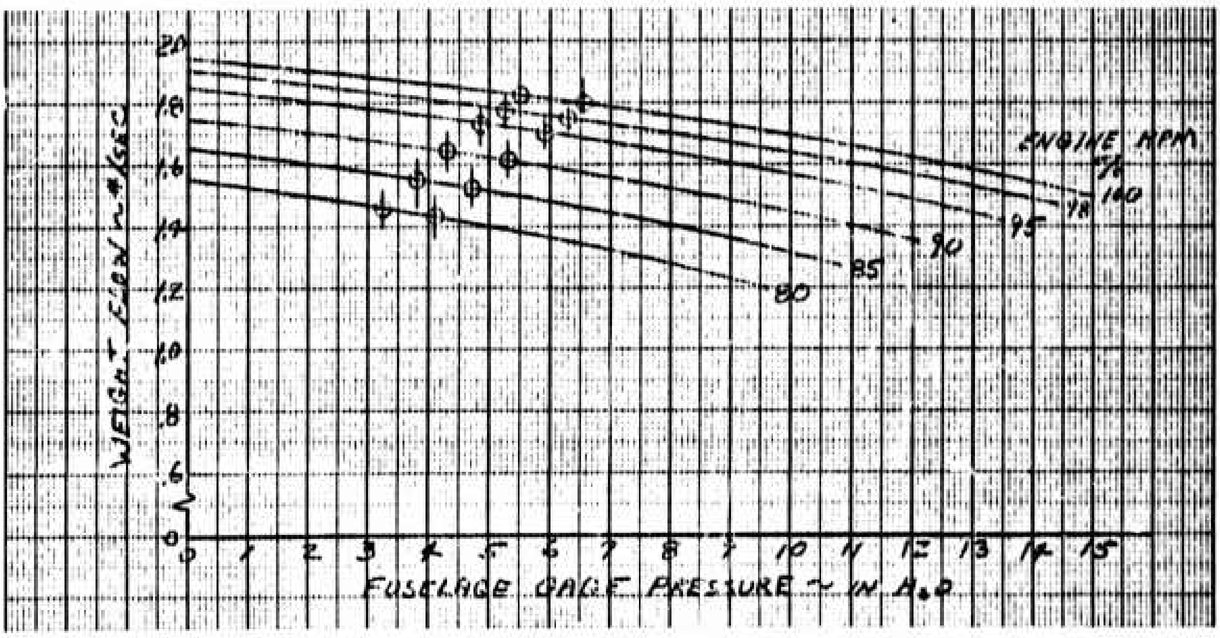

Figure 9.96 Cooling Air Weight Flow - R.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2 and 0.4

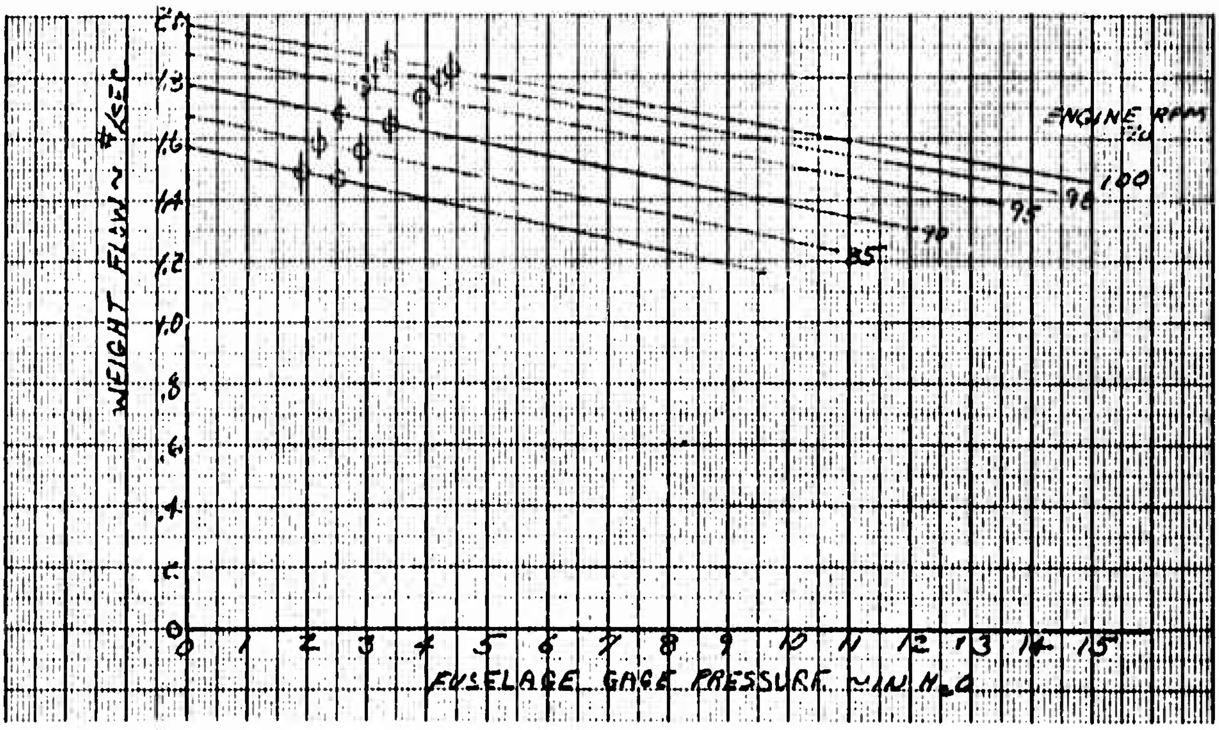

Figure 9.97 Cooling Air Weight Flow - R.H. Large Cooling Fan to Center Fuselage Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

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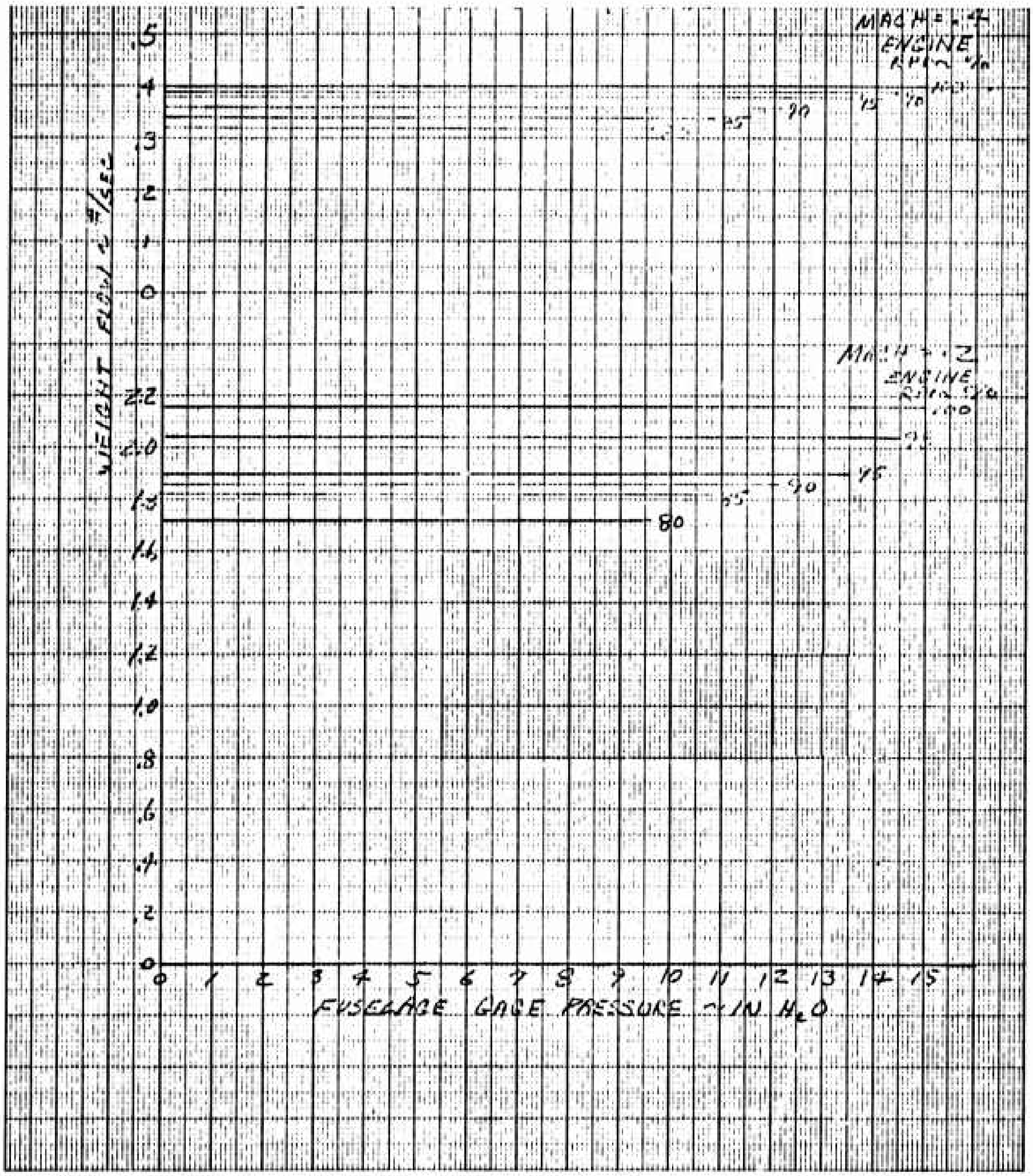

Figure 9.98 Cooling Air Weight Flow - Large Cooling Fans to Engine Bay Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2 and 0.4

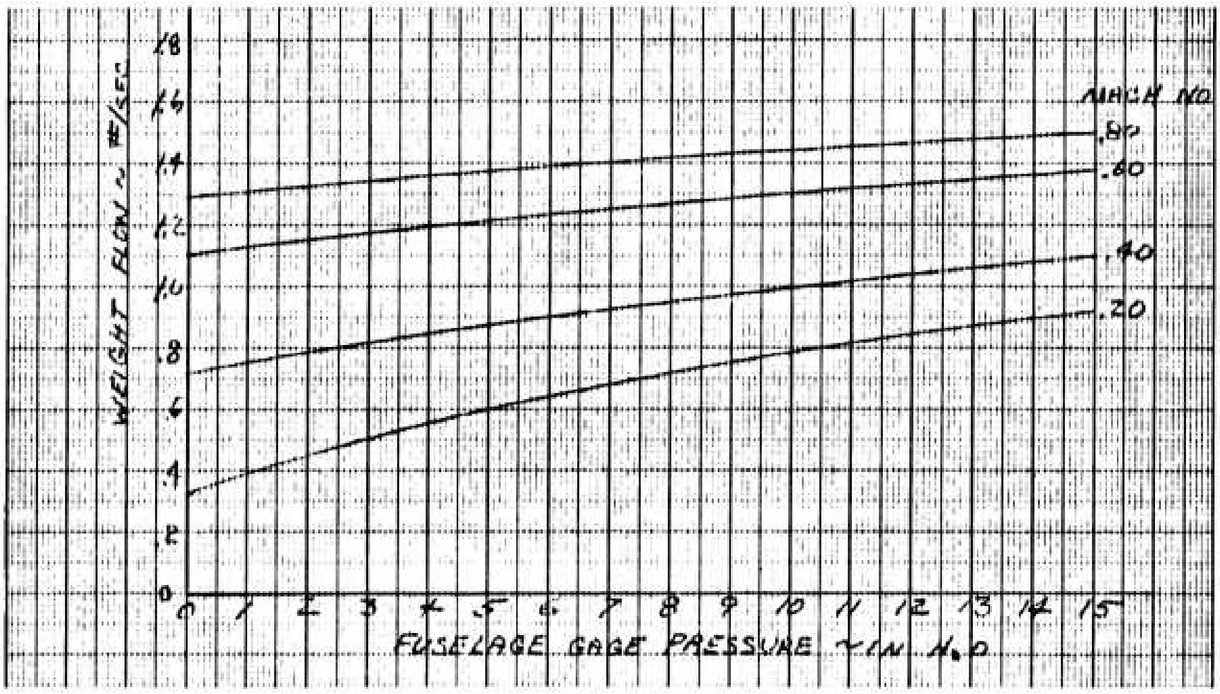

Figure 9.99 Cooling Air Weight Flow - Center Fuselage to Wing Fan Air Ejectors Vs Fuselage Pressure and Mach No. - Conventional Flight Mode, Standard Day, Sea Level

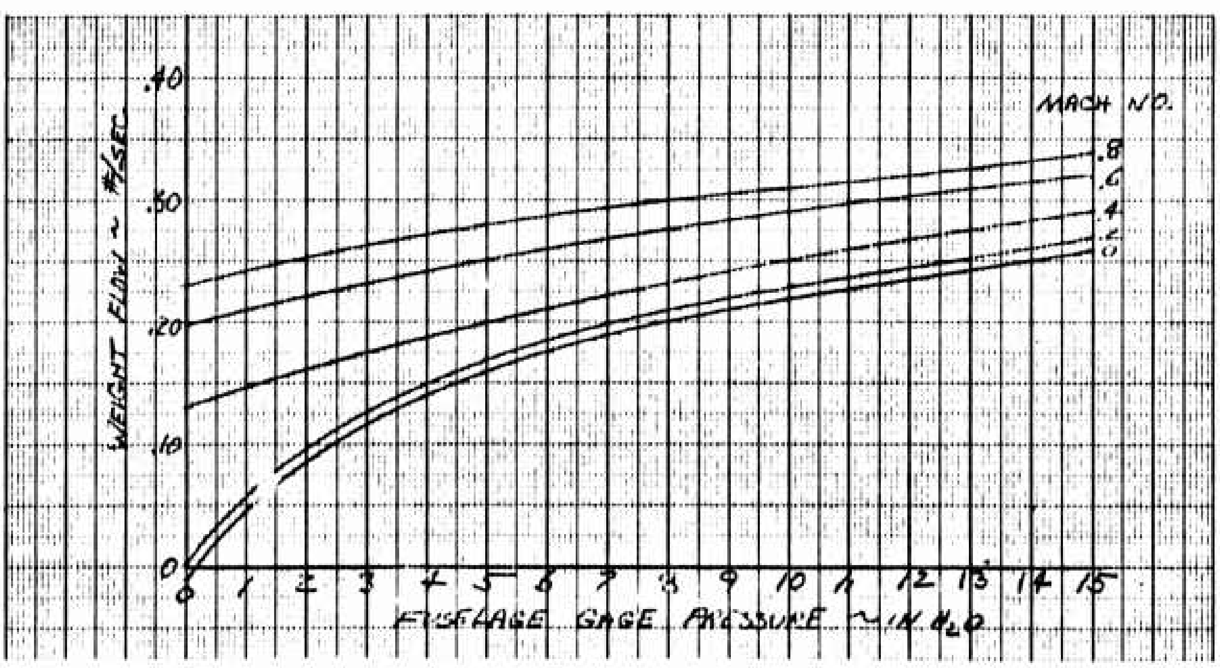

Figure 9.100 Cooling Air Weight Flow - Center Fuselage to Nose Fan Air Ejectors Vs Fuselage Pressure and Mach No. - Conventional Flight Mode, Standard Day, Sea Level

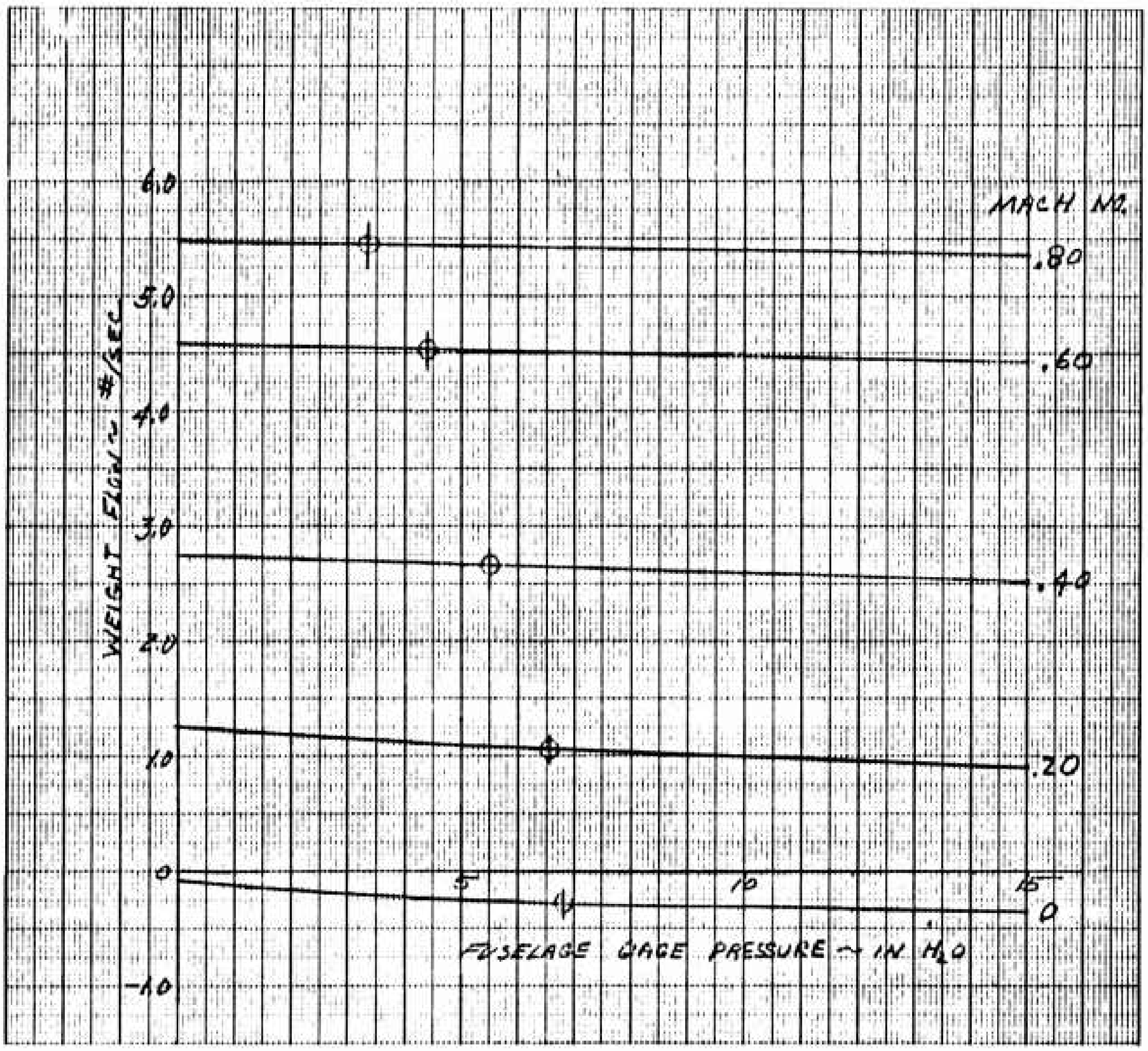

Figure 9.101 Cooling Air Weight Flow - Outside to Nose Fan Cavity Vs Fuselage Pressure and Mach No. - Conventional Flight Mode, Standard Day, Sea Level

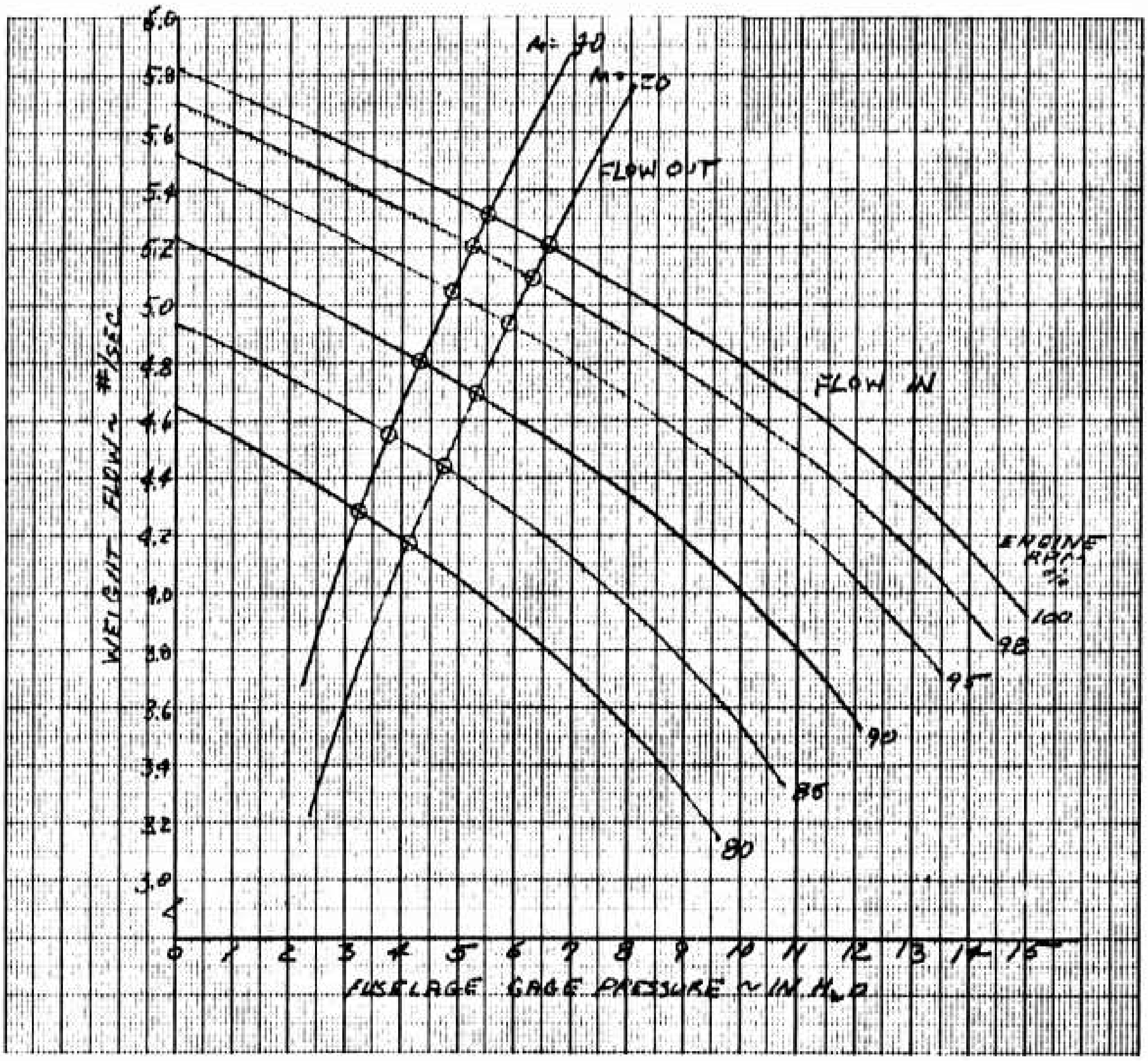

Figure 9.102 Cooling Air Weight Flow - Balance of Flow Into and Out of the Lower Fuselage Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.2 and 0.4

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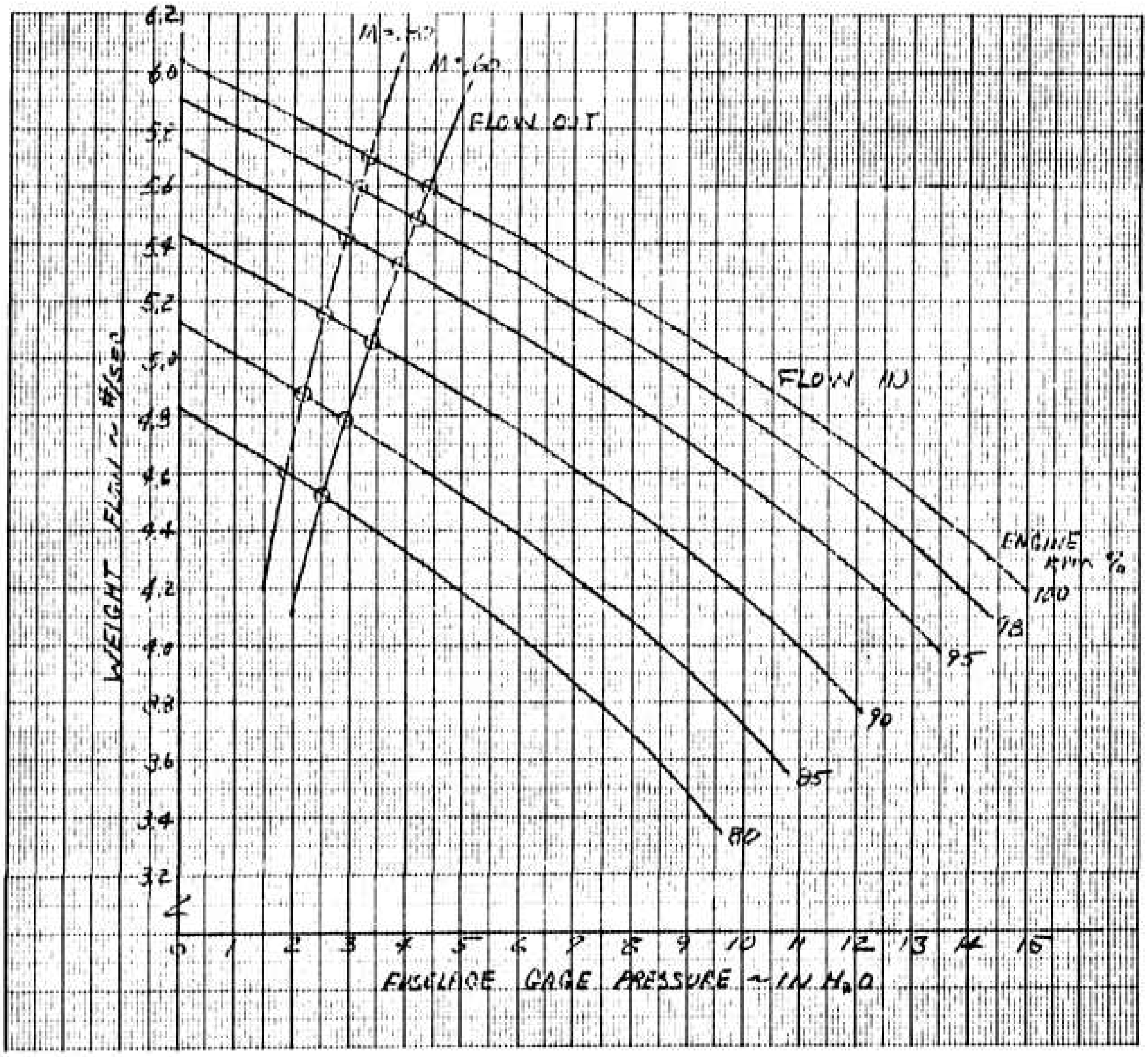

Figure 9.103 Cooling Air Weight Flow - Balance of Flow Into and Out of the Lower Fuselage Vs Fuselage Pressure and % RPM - Conventional Flight Mode, Standard Day, Sea Level, Mach No. = 0.6 and 0.8

9.4 THERMAL ANALYSIS

The structural boundaries, functions, and operation of the areas discussed in this section have been described in Section 3.0. The procedures used in this analysis were taken mainly from References 12, 14, and 15.

9.4.1 Cockpit Air Temperatures

The cockpit is ventilated by air drawn through gaps at the canopy closure. In the turbojet mode, cockpit air is made up largely of boundary layer air. In lift fan mode, it is made up largely of locally induced environmental air. As a result, cockpit inlet air temperatures are affected by climatic conditions (day and altitude), by aircraft flight speed and/or ingestion effects. Short of some form of air conditioning, there is no practical way of reducing cockpit air temperatures in the conventional mode. In the fan mode, relocation of cockpit air inlet may permit cockpit inlet air to approach ambient air temperatures.

Cockpit heat loads include inputs from the following: solar irradiation, crew and equipment aerodynamic heating, hot gas ingestion, heat transfer from walls, floor, and bulkheads.

Figures 7.78 and 7.79 present estimated cockpit temperatures vs aircraft speed altitude and day for conventional operation. Estimated temperatures were calculated as follows:

$$\Delta t_{AH} = \Delta T_{AH} = \frac{k-1}{2} r M^2 T_{AMB}$$

where for r = 0.89 and k = 1.4

$$\Delta t_{AH} = 0.178 M^2 T_{AMB}$$

Additional Heating

Solar heat constant = 270 Btu/hr ft^2

Projected area of the canopy = 20 ft^2

q_{SOLAR} = 5400 Btu/hr

q_{CREW} = 600 Btu/hr

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Δt_{SC} = Temperature rise due to solar energy and the crew

$$\Delta t_{SC} = \frac{q_{SOLAR} + q_{CREW}}{W_a C_{p_a} 3600} = \frac{6.9}{W_a}$$

W_a = Cooling Air Flow rate; lb/sec

Total Temperature Rise, Δt_{SC}

$$\Delta t_T = \Delta t_{AH} + \Delta t_{SC}$$

$$t_c = t_{AMB} + \Delta T_t$$

Example:

Conditions: Hot Day, Sea Level, Mach = .6

$$T_{AMB} = 103° F + 460 = 563° R$$

$$W_a = 1.10 \text{ lb/sec}$$

$$\Delta t_{AH} = \left(\frac{1.4-1}{2}\right) (.89) (.6)^2 (103 + 460) = 36$$

$$\Delta T_t = \Delta T_{AH} + \Delta T_{SC} = 36 + 6.3 = 42.3$$

$$t_c = t_{amb} + \Delta T_T = 103 + 42.3 = 145.3° F$$

9.4.2 Cooling Fan Compartment Inlet Port Air Temperature - Turbojet Mode

The free stream air passing the inlet is sucked into the cooling fan compartment when the high speed stream is brought to near stagnation condition:

$$\Delta t_{AH} = 0.178 M^2 T_{AMB}$$

and for hot day sea level conditions at M = 0.6

Δt_{AH} = 36° F as above

9.4.3 Cooling Fan Compartment Air Temperature

The cooling air enters the cooling fan compartment from the cockpit, fuselage ports and generators. Assuming complete mixing of the air, the resultant temperature is a function of the weight flow and temperature of each flow. A plot of cooling fan compartment temperature vs aircraft speed is presented in Figure 7.82.

Setting C_{p_a} equal for all flows

$$W_G t_G + W_c t_c + W_p t_p = (W_G + W_c + W_p) t_m$$

since $t_G = f(t_m)$

$$(t_G - t_m) = \frac{q_G}{W_G C_{p_a}}$$

$$W_G t_G = W_G t_m + \frac{q_G}{C_{p_a}}$$

$$\frac{q_G}{C_{p_a}} + W_c t_c + W_p t_p = (W_c + W_p) t_m$$

$$t_m = \frac{q_G/C_{p_a} + W_c t_c + W_p t_p}{W_c + W_p}$$

Example:

Hot Day, sea level, M = .6

Cockpit Air

See cockpit air temperature analysis

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$t_c = 145.3°F \qquad W_c = 1.10$

Fuselage Port Air

See fuselage port inlet air analysis

$t_p = 139°F \qquad W_p = 3.62$

Generator Air Temperature

See Generator air temperature analysis

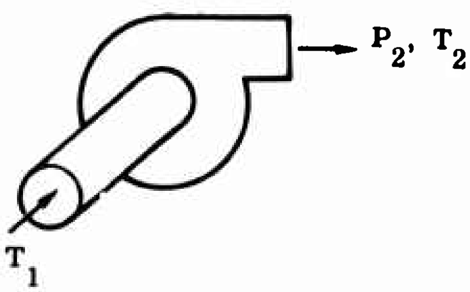
$$q_G/c_p = 5.05/.24 = 21.04$$

$$t_m = \frac{q_G/C_{p_a} + W_c t_c + W_p t_p}{W_c + W_p} = \frac{21.04 + 1.10\ (145.3) + 139\ (3.62)}{4.72}$$

$$t_m = \frac{21.04 + 159.83 + 503.14}{4.72} = 144.9°F$$

9.4.4 Temperature Rise Across the Cooling Fans

The minimum temperature rise across the fan is approximated by assuming a reversible adiabatic compression process. Thus



$$T_2 = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} T_m \ °R = \left(\frac{P_2}{P_1}\right)^{.285} T_m$$

This is a minimum value.

Small Cooling Fan

$$T_2 = \left(\frac{15.84}{14.69}\right)^{.285} T_m = 1.0216\ T_m$$

$$T_2 - T_m = .0216\ T_m$$

Large Cooling Fan

$$T_2 = \left(\frac{16.20}{14.69}\right)^{.285} T_m = 1.0283\ T_m\ .$$

$$T_2 - T_m = .0283\ T_m$$

Example:

Hot Day, Sea level, Mach = .6

Small Cooling Fan

$$\Delta t = \Delta T = .0216\ T_m = 13.03 \text{ since } T_m = t_m + 460$$

$$T_m = 460 + 144.9 = 604.9°R$$

$$t_2 = t_m + \Delta t = 144.9 + 13.0 = 157.9$$

Large Cooling Fan

$$\Delta t = .0283\ T_m = 17.08$$

$$t_2 = 144.9 + 17.1 = 162.0$$

A plot of the cooling fan exhaust temperature vs aircraft speed is presented in Figure 7.81.

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9.4.5 Generator Air Temperature

A constant power of 165 amps at 30 volts is available between 80% and 100% engine RPM per generator.

Generator Efficiency = 65%.

$$165 \times 30 = 4.95 \text{ KW/GEN} = 4.69 \text{ Btu/sec.} = q_G$$

$$q_G = 4.69 \text{ Btu/sec.}$$

$$q_{Gi} \; .65 = 4.69 \text{ Btu/sec.}$$

$$q_{Gi} = 7.22 \text{ Btu/sec.}$$

$$\Delta q_G = \text{Heat rejected} = (q_{Gi} - q_G) = 7.22 - 4.69 = 2.53 \text{ Btu/sec}$$

$$\Delta q_G = W_G C_{p_a} \Delta t$$

$$\Delta t_G = \frac{2.53}{W_G C_{p_a}} = \frac{10.52}{W_G}$$

Example:

Hot Day, sea level, M = .6

$$W_G = .70/2 = .35 \text{ lbs. air/generator}$$

$$\Delta t_G = \frac{10.52}{.35} = 30 \text{ deg.}$$

A plot of generator discharge temperature vs aircraft speed is presented in Figure 7.80.

9.4.6 <u>Temperature Rise Across the Hydraulic Oil Cooler</u>

From: Stewart-Warner Corporation 10-12-62
Performance - 8407C Oil Cooler

The effectiveness factor (E) is given by the relationship

$$\frac{T_{OIL\ IN} - T_{OIL\ OUT}}{T_{OIL\ IN} - T_{AIR\ IN}} = E$$

For $E = 0.9$, $\Delta T_{OIL} = T_{OIL\ IN} - T_{OIL\ OUT}$

$$= .90\,(T_{OIL\ IN} - T_{AIR\ IN})$$

$$q_{AIR} = q_{OIL}$$

$$W_a C_{p_A} (T_{AIR\ OUT} - T_{AIR\ IN}) = W_o C_{p_o} (T_{OIL\ IN} - T_{OIL\ OUT})$$

$$\Delta T_A = \frac{W_o}{W_a} \frac{C_{p_o}}{C_{p_a}} (.90)\,(T_{OIL\ IN} - T_{AIR\ IN})$$

$C_{p_o} = .455$ $\quad$ $C_{p_a} = .24$

$$\Delta T_A = 1.706 \frac{W_o}{W_A} (T_{OIL\ IN} - T_{AIR\ IN})$$

Example:

Hot Day, sea level, Mach = .6

W_o = 1 gal./min = 7.15 lb/min

W_a = .88 lb/sec/Hyd Oil Cooler

$T_{AIR\ IN}$ = 155° F from Temp Rise Across the Small Fans

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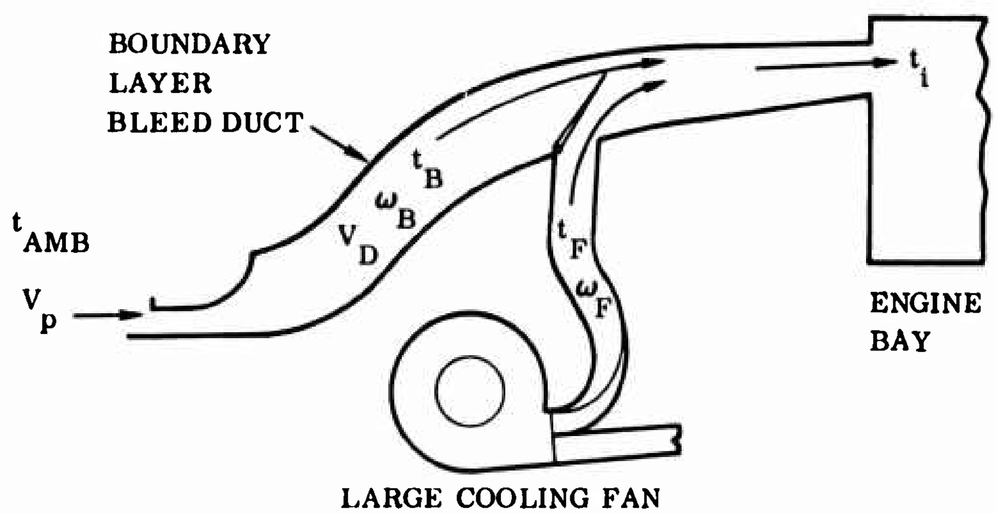
$$\Delta T_A = 1.706 \left(\frac{.119}{.88}\right) (T_{OIL\ IN} - 155) = .230\ (T_{OIL\ IN} - 155)$$

Set $T_{OIL\ IN}$	ΔT_A	$T_{AIR\ OUT}$
200	10	165
250	21	176
300	33	188

9.4.7 Engine Bay Inlet Air Temperature

The temperature of the engine bay inlet at the top, inboard, forward corner is a result of the mixed air from the boundary layer bleed duct and the large cooling fan as shown in the schematic below. A plot of engine bay inlet time vs aircraft speed is presented in Figure 7.87.



$$t_i = \frac{\sum wt}{\sum w} = \frac{W_B t_B + W_F t_F}{W_B + W_F}$$

For Large Cooling Fan exhaust temperature, t_F, see Section 9.4.4.

Boundary layer bleed duct, t_B

$$t_B = t_{AMB} + \Delta t_{AH} = t_{AMB} + 0.178M^2 \, T_{AMB}$$

Example:

Conditions: Hot Day, Sea Level, Mach = 0.6 at M = 0.6 $W_F = 0$

$$t_i = t_B$$

$$t_{AMB} = 103° \, F$$

$$t_B = 103 + 0.178 \, (.6)^2 \, (563)$$

$$= 103 + 36 = 139° \, F$$

9.4.8 <u>Center Fuselage Air Temperature Analysis - Lift Fan Mode</u>

During VTOL mode, hot gases flow through the fan supply ducts and leave the wing fans on the inboard quadrants. The hot gases leaving the fans impinge on the lower section of the center fuselage.

The center fuselage air will be heated by the following:

1. Heat Transfer from the supply ducts to the air.
2. Heat Transfer from the canoe to the air.
3. Mass transfer of the fuselage air recirculating between the duct and shroud.
4. Mass transfer of wing fan hot exhaust gas into the fuselage.
5. Mass transfer of hot gases from the supply duct joints.

Example:

Standard Day, Sea Level

100% RPM, Lift Fan Mode, Static Condition

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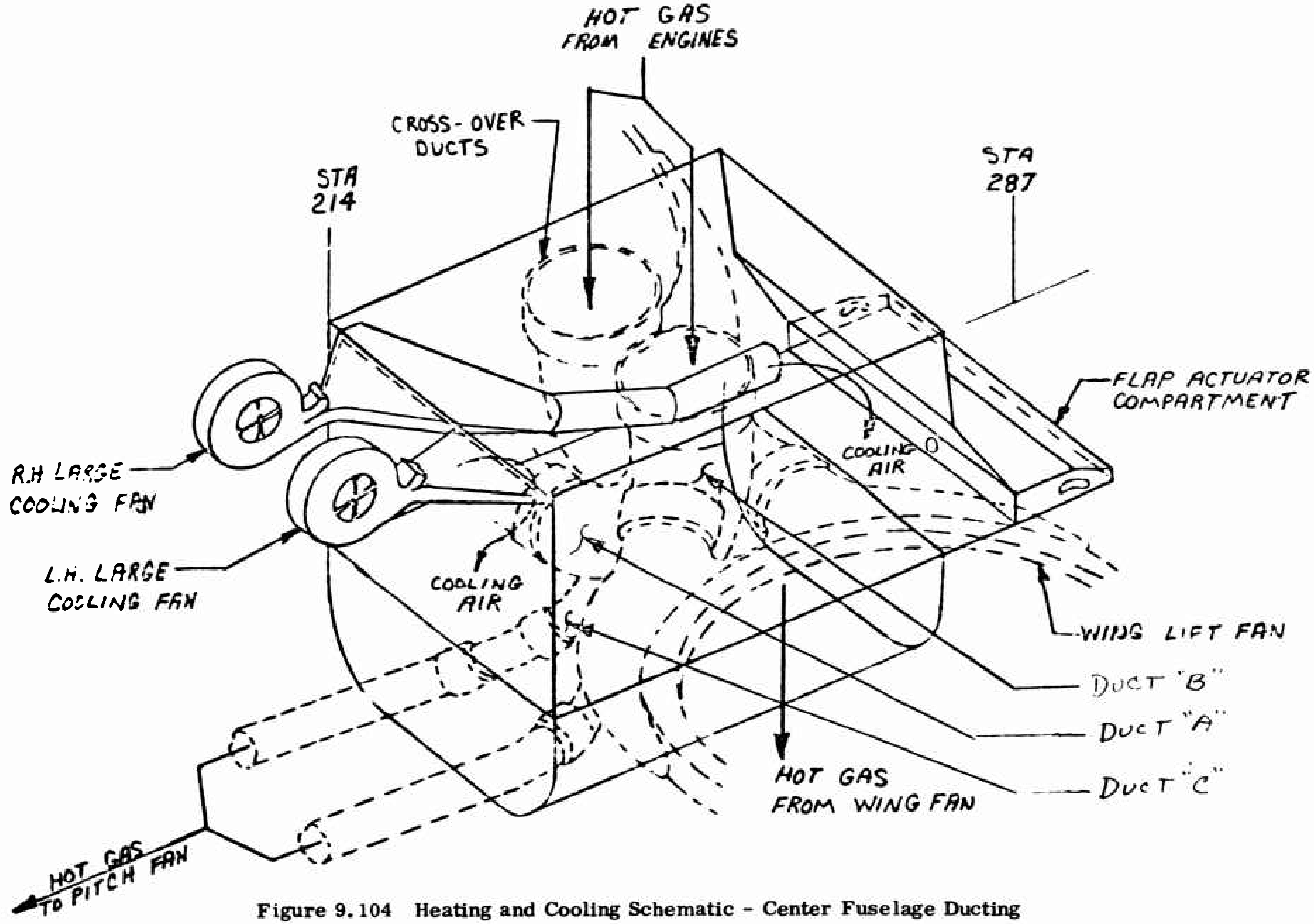


Figure 9.104 Heating and Cooling Schematic - Center Fuselage Ducting

Assume complete mixing of all gases.

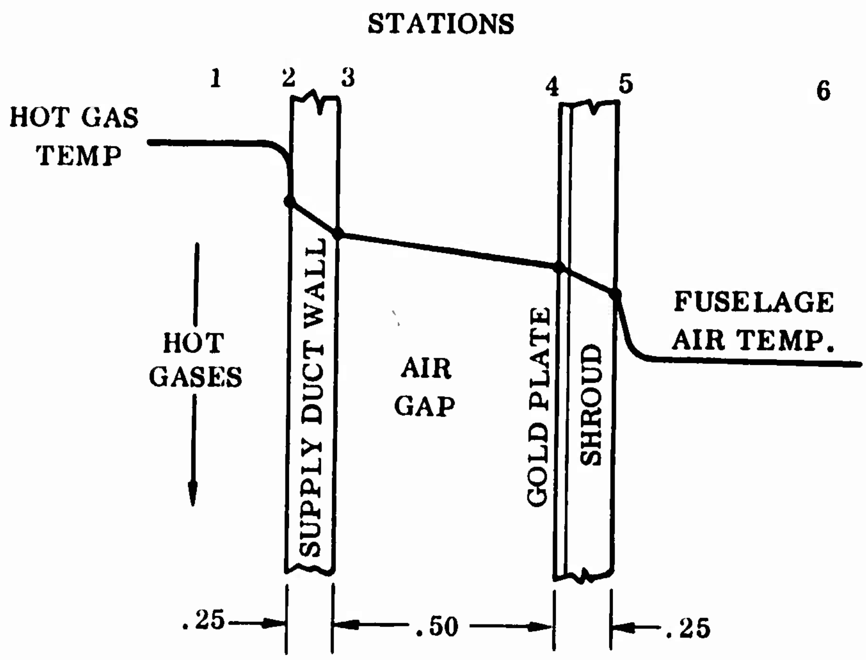
1. <u>Heat Transfer from the Supply Ducts to the Air</u>

Duct Area* $A = 23.6\ ft^2$/Both engines

$B = 9.0\ ft^2$/Both engines

$C = 21.0\ ft^2$/Both engines

*See Figure 9.104.



<u>Overall Heat Transfer</u>

$$\frac{q}{A} = \frac{t_1 - t_6}{\frac{1}{h_{1-2}} + \frac{X_{2-3}}{k_{2-3}} + \frac{1}{h_{3-4}} + \frac{X_{4-5}}{k_{4-5}} + \frac{1}{h_{5-6}}}$$

$$k_{4-5} = 2.1\ \frac{BTU\ IN}{HR\ ft^2\ °F}\quad \frac{X_{4-5}}{k_{4-5}} = \frac{.025}{2.1} = 1.19 \times 10^{-2}$$

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$$k_{2-3} = 135 \frac{\text{BTU IN}}{\text{HR PT}^2 \, °F} \quad \frac{X_{2-3}}{k_{2-3}} = \frac{.025}{135} = 1.84 \times 10^{-4}$$

$\underline{h_{1-2}}$

$$\frac{h}{\rho C_p V_m} = \frac{.0384 \left(R_{e_d}\right)^{-\frac{1}{4}}}{1 + \left(1.5 \, P_r^{-1/6}\right) \left(R_{e_d}\right)^{-1/8} (P_r - 1)}$$ Equation 814, Reference 16

$\rho = .047 \text{ lb/ft}^3$

$C_p = .27 \text{ BTU/lb} \, °F$

$P_r = .70$

$(P_r)^{-1/6} = 1.061$

$V_m = 645 \text{ ft/sec}$

$$R_{e_d} = \frac{D\rho V}{\mu} = \frac{.92 \, (.047) \, (645)}{2.68 \times 10^{-5}} = 1.037 \times 10^6$$

$\left(R_{e_d}\right)^{-1/4} = .0313$

$\left(R_{e_d}\right)^{-1/8} = .177$

$\rho C_p V_m = (.047) \, (.27) \, (645) = 8.18$

$$h_{1-2} = \frac{8.18 \, (3.84) \, (3.13)}{1 + 1.59 \, (.177) \, (-.3)} \left(3.6 \times 10^3 \frac{\text{SEC}}{\text{HR}}\right) = 38.5$$

$$\frac{1}{h_{1-2}} = \frac{1}{38.5} = .026$$

$\underline{h_{3-4}}$

$$h_{3-4} = h_{c_{3-4}} + h_{r_{3-4}}$$

h_c = Convective Heat Transfer Coeff.

h_r = Radiation Heat Transfer Coeff.

$$h_{r_{3-4}} = \sigma F_{A_{3-4}} \frac{\left[T_D^{\,4} - T_S^{\,4}\right]}{T_D - T_S} \quad \text{where } \sigma = 1730 \times 10^{-12}$$

$$F_{A_{3-4}} = \frac{1}{\frac{1}{\epsilon_3} + \frac{A_3}{A_4}\left(\frac{1}{\epsilon_4} - 1\right)} = \frac{1}{\frac{1}{.9} + .91\left(\frac{1}{.1} - 1\right)} = .107$$

$$h_{r_{3-4}} = 185 \frac{\left[(T_{D/1000})^4 - (T_{S/1000})^4\right]}{T_D - T_S}$$

Set T_D = 1610 °R

T_S = 1460 °R

$$h_{r_{3-4}} = 185 \frac{(6.72 - 4.54)}{150} = 2.69$$

$$\text{LOG} \frac{hc_{3-4}}{kc_{3-4}} = \Phi (N_{Gr})$$

$$N_{Gr} = \frac{\gamma^2 \beta g}{\mu^2} D_1^{\,3} (t_1 - t_2)$$

$$\beta = \frac{1}{T°R} = 7.8 \times 10^{-4}\ °R^{-1}$$

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$$\mu^2 = 5.86 \times 10^{-10} \text{ lb}^2/\text{sec}^2 \text{ ft}^2$$

$$\gamma^2 = 3.6 \times 10^{-3} \text{ lb}^2/\text{ft}^2$$

$$g = 32.2 \text{ ft/sec}^2$$

$$D_1{}^3 = 7.8 \times 10^{-1} \text{ ft}^3$$

$$\Delta T = 100$$

$$N_{Gr} = \frac{(3.6 \times 10^{-3})\ (7.8 \times 10^{-4})\ (3.22 \times 10)\ (7.8 \times 10^{-1})}{5.86} \times 10^{12}$$

$$= 1.20 \times 10^7$$

$$\text{LOG} \frac{h_{c3-4}}{k_{c3-4}} = .04$$

$$\frac{h_{c3-4}}{k_{c3-4}} = 1.10 \qquad h_{c3-4} = 1.10\ (.36) = .8$$

$$\frac{1}{h_{3-4}} = \frac{1}{2.69 + .8} = .286$$

$\underline{h_{5-6}}$

$$h_{5-6} = h_{c_{5-6}} + h_{r_{5-6}}$$

$$h_{c_{5-6}} = .27 \left(\frac{\Delta T}{D}\right)^{1/4} = .27\ (4.73) = 1.28$$

$$h_{r_{5-6}} = \sigma F_{A_{5-6}} \frac{\left[\left(T_{s_{o/1000}}\right)^4 - \left(T_{o_{/1000}}\right)^4\right]}{T_{s_o} - T_o}$$

$$F_{A_{5-6}} = \frac{1}{\frac{1}{\epsilon_5} + \frac{1}{\epsilon_6} - 1} = \frac{1}{\frac{1}{.36} + \frac{1}{.8} - 1} = .33$$

$$h_{r_{5-6}} = \frac{571\ (2.518 - .254)}{550} = 2.35$$

$$h_{5-6} = 1.28 + 2.35 = 3.63$$

$$\frac{1}{h_{5-6}} = .275$$

$$\frac{q}{A} = \frac{t_1 - t_6}{.026 + .0018 + .286 + .012 + .275} = \frac{t_1 - t_6}{.599}$$

$$t_1 - t_6 = 1150$$

$$A = 53.6\ ft^2$$

$$q = 102,912\ BTU/HR = 28.6\ BTU/SEC$$

$$\Delta t = \frac{q}{W_a C_{p_a}} = \frac{28.6}{3.78\ (.24)} = 32°\ F$$

where W_a = 3.78 from Figures 11.68 and 11.69, at Fuselage Press

= 5"H_2O

2. <u>Heat Transfer from Canoe Panel to Air</u>

Area of Canoe = 36 ft^2

$$h = .19\ (\Delta T)^{1/3} = 1.11$$

$$q = hA\Delta T = 8000\ Btu/HR = 2.2\ Btu/SEC$$

$$\Delta T = \frac{2.2}{3.78(.24)} = 3°$$

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3. Heat Transfer to Fuselage Air by Recirculation Between Ducts and Shroud

$$(q \text{ to fuse air}) = (W_{recirculation})\, C_{p_a}\, \Delta t_a$$

$$\Delta T = 900-137 = 763$$

$$\Delta t_a = \frac{(Q \text{ to Fuse Air})}{W_{\text{Fuse Air}}\, C_{p_a}}$$

at $W_{recirculation} = .1$ lb/sec assumed

$$q = .1\,(.24)\,(763) = 18.3 \text{ Btu/Sec}$$

$$\Delta t_{FusAir} = \frac{18.3}{3.78(.24)} = 20°$$

See Figure 9.105

4. Mass Transfer of Hot Wing Fan Exhaust Air Into The Center Fuselage

$$t_m = \frac{W_F\, t_F + W_H\, t_H}{W_F + W_H}$$

F = Fuse. Air
H = Hot Gas

at $T_F = 100°$ F $W_H = .3$

$W_F = 3.78$ $t_H = 300$

$t_m = 114°$

$\Delta t = 14°$

5. Duct Joint Leakage

The duct joint leakage rate cannot be predicted, therefore the fuselage air temperature must be plotted against duct joint leakage in % engine hot gas flow.

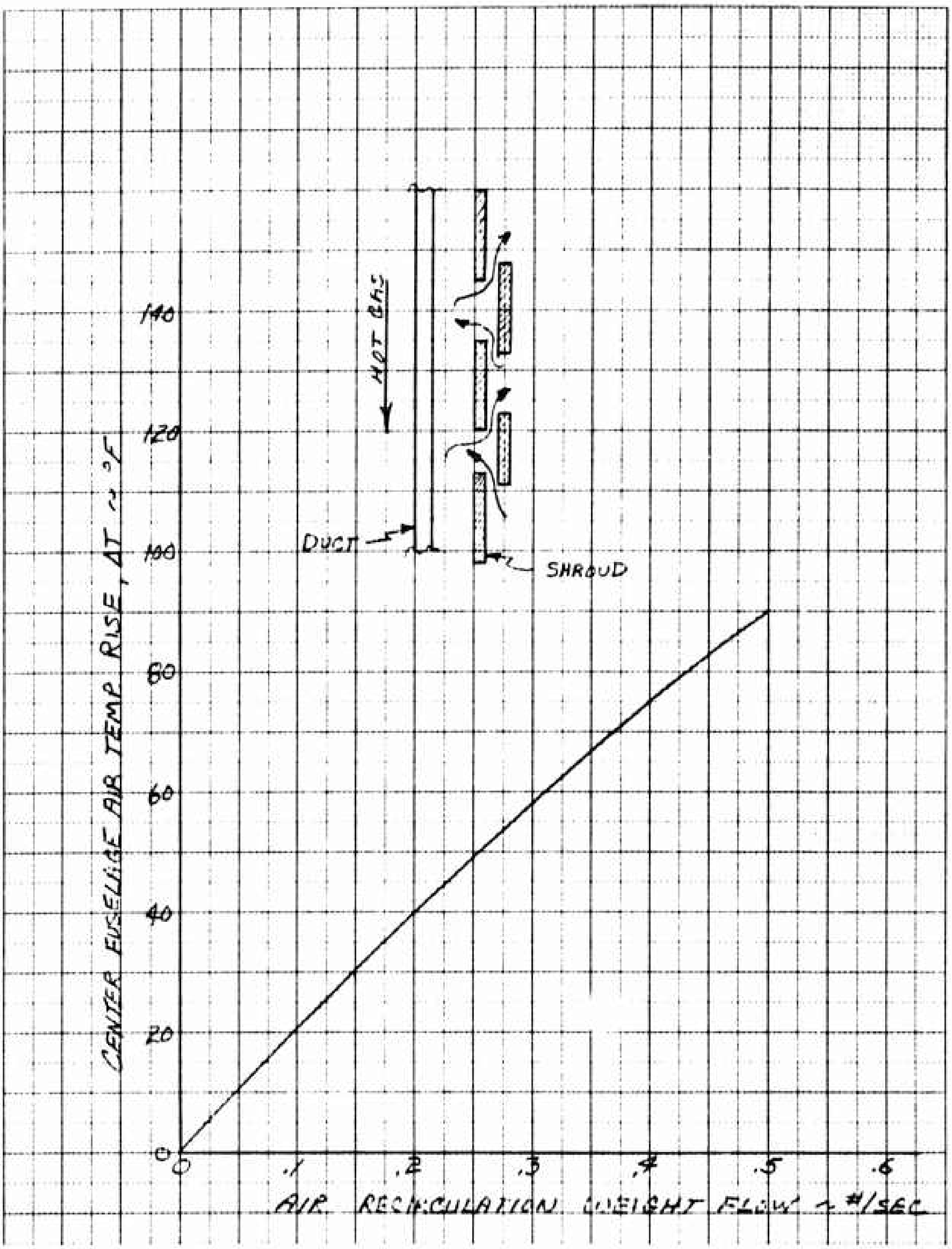

Figure 9.105 Center Fuselage Air Temperature Rise Vs Recirculation of Fuselage Air Between Supply Duct and Shroud - Fan Mode

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The temperature rise is a function of the temperature and weight flow of the hot gas leakage.

$$t_m = \frac{W_F t_F + W_L t_L}{W_F + W_L}$$

See Figure 7-77 for results.

9.4.9 Lift Fan Cavity Air Temperature - Turbojet Mode

Wing Fan

The wing cavity temperature is a function of the mixing of cooling air and hot diverter valve leakage. The cool air comes from the fuselage and pitch fan cavity.

$$t_M = \frac{\sum Wt}{\sum W} = \frac{W_p t_p + W_F t_F + W_H t_H}{W_p + W_F + W_H}$$

Example:

Standard Day, sea level, 100% RPM

M	W_H* lb/sec	t_H °F	$W_H t_H$	W_p** lb/sec	t_p °F	$W_p t_p$
0	.304	1240	377	0	60	0
.1	.354	1241	439	.28	60	16.8
.2	.361	1244	449	.63	60	37.8
.3	.370	1247	461	1.02	61	62.2
.4	.381	1247	475	1.45	62	89.9
.5	.396	1248	494	1.91	63	120
.6	.412	1247	514	2.39	64	153
.7	.435	1239	539	2.75	66	182
.8	.428	1230	526	2.87	68	195

*W_H = 0.8% of engine air flow at the diverter valve inlet.

**W_p = 0.5 sum of flow rates read from Figures 7.60 and 7.63.

M	W_F* lb/sec	t_F °F	$W_F t_F$	$\sum W$	$\sum Wt$	t_m
0	.32	90	28.8	.624	405.8	650
.1	.32	90	28.8	.954	484.8	508
.2	.33	90	29.7	1.321	516.5	391
.3	.37	90	33.3	1.760	556.5	316
.4	.45	90	40.5	2.281	605.4	265
.5	.54	90	46.6	2.846	660.6	232
.6	.60	90	54.0	3.402	721.0	312
.7	.64	90	57.6	3.825	778.6	203
.8	.67	90	60.3	3.968	781.3	197

*W_F = 0.5 value read from Figure 7.57.

Calculate and plot t_m vs Mach No. for various RPM's and terminate each RPM curve at stable flight condition.

Nose Fan

Calculate the pitch fan cavity temperature in the same manner as the wing fan.

$$t_m = \frac{W_o t_o + W_F t_F + W_H t_H}{W_o + W_F + W_H}$$

9.4.10 Wing Fan Ejector Air Temperature During Forward Fan Flight

The static pressure at the wing fan ejectors will vary with respect to the cross flow at the fan during forward flight as shown by the plots of $(P_s - P_a)/q^s$ vs $T_c{}^s$ and β_v in Figures 9.106 and 9.107 (Reference 17)

where

$$T_c{}^s = \frac{T_{ooo}/A_F}{T_{ooo}/A_F + q_o} = \text{Slip Stream Thrust Coefficient}$$

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and

$$q^s = \frac{T_{ooo}}{A_F} + q_o = \text{Slip Stream Dynamic Pressure}$$

At trimmed flight for any velocity and β_v value, $T_c{}^s$ and q^s are given, therefore P_s-P_a at the ejector is known. With a system pressure differential known, the weight flow of cooling air is obtained from the system performance.

During operation in the fan mode, a scroll leakage of .2% W_g may occur into the cooling air. The temperature of the mixed flow is a function of the weight flow and temperature of the two flows.

$$t_M = \frac{\sum wt}{\sum w} = \frac{W_c t_c + W_H t_H}{W_c + W_H}$$

Example:

Hot Day, 2500 feet

$\alpha = 0$

$\beta_s = 6°$

C. G. at Sta. 246

GW = 9200 lbs.

Trimmed Flight Conditions:

V_p Knots	β_v Deg.	$T_c{}^s$	q^s #/ft^2
0	0	1.0	210
35	10	.984	224
54	20	.965	243
70	30	.942	247
86	40	.922	278
95	45	.914	308

Scroll leakage

W_{gas} = 38.5 lb./sec.

13% To Pitch Fan = 5 lb./sec.

W_H To Wing = 33.5 lb./sec.

W_H / Side of Wing Fan = 16.7 lb./sec.

Leakage at .2% = 16.7 (.002) = .033 lb./sec. at 1140° F

$W_H t_H$ = 37.6

Set t_c = 150° F

AFT AIR EJECTOR

V_p Knots	W_c lb/sec.	$W_c t_c$	$\sum wt$	$\sum w$	t_m °F
0	.310	46.5	84.1	.343	245
20	.298	44.7	82.3	.331	249
40	.273	40.9	78.5	.306	256
60	.239	35.8	73.4	.272	269
80	.200	30.0	67.6	.233	290
95	.180	27.0	64.6	.213	303

FORWARD AIR EJECTOR

V_p Knots	W_c lb/sec.	$W_c t_c$	$\sum wt$	$\sum w$	t_M °F
0	.280	42.0	79.6	.313	254
20	.290	43.5	81.1	.323	251
40	.304	45.6	83.2	.337	246
60	.326	48.9	86.2	.359	240
80	.346	51.9	89.5	.379	236
95	.360	54.0	91.6	.393	233

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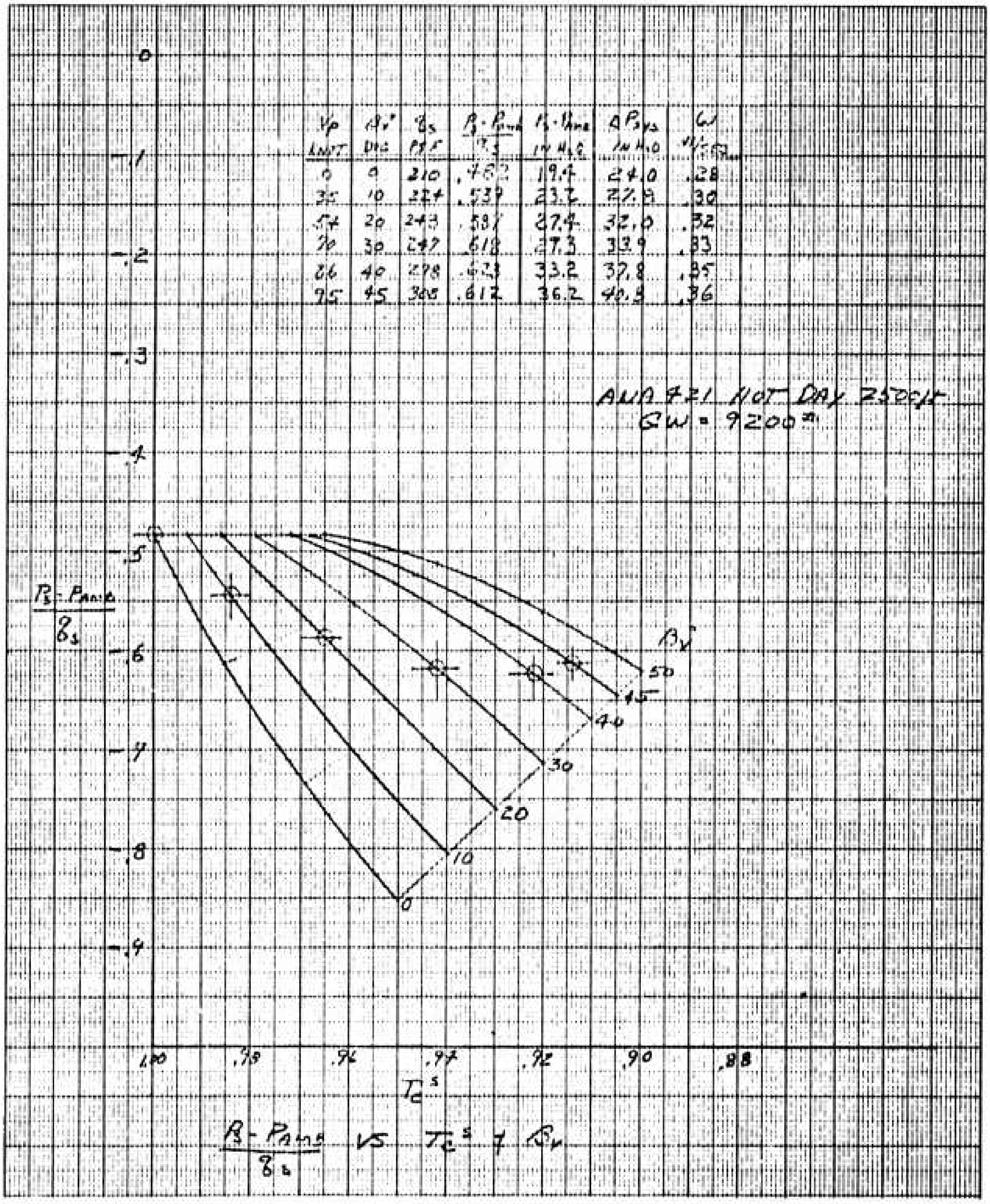

Figure 9.106 Wing Fan Forward Air Ejector - T_c^s Vs $\frac{P_s - P_a}{q_s}$

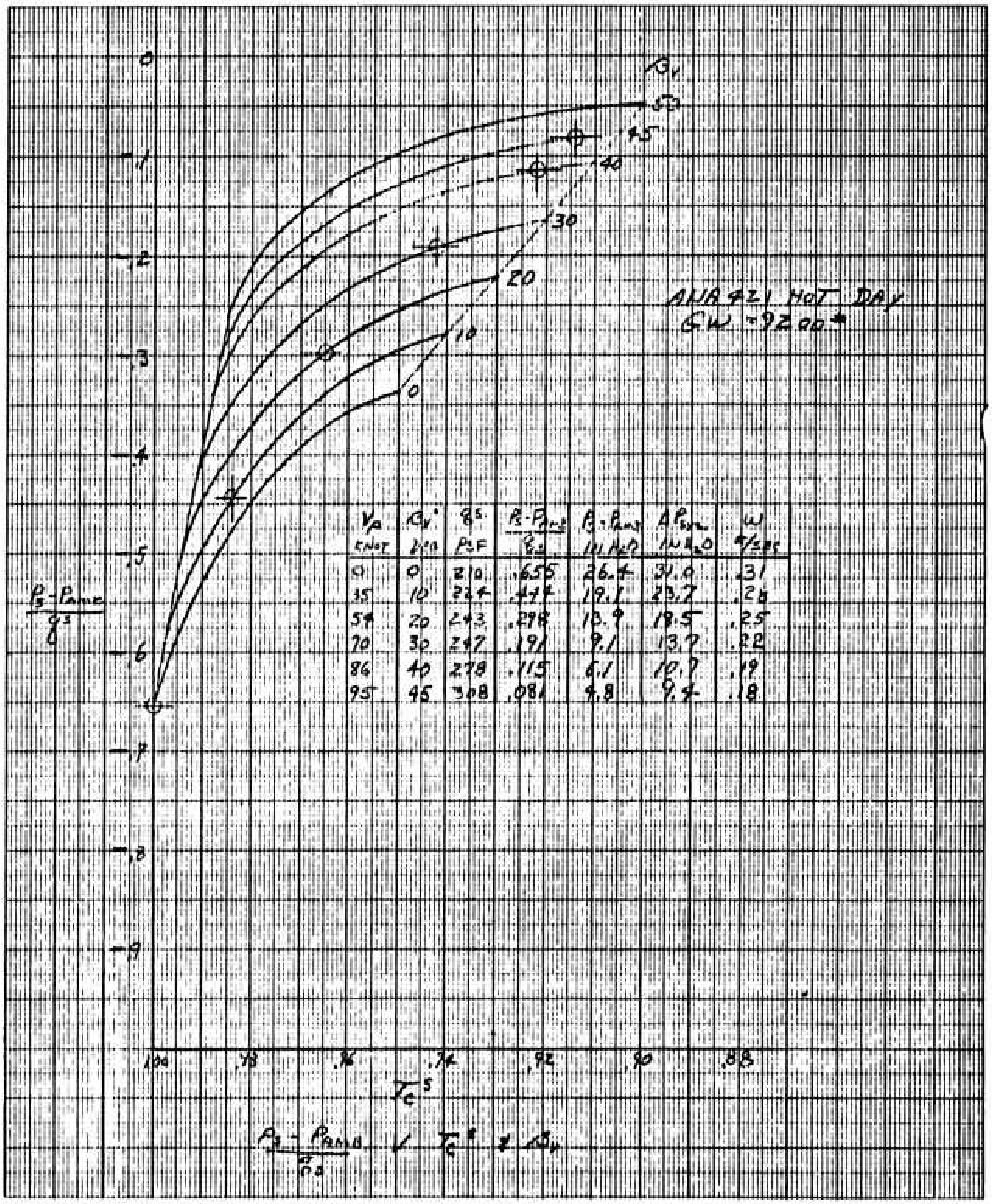

Figure 9.107 Wing Fan Aft Air Ejector - T_c^s Vs $\frac{P_s - P_a}{qs}$

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9.4.11 Engine Bay Heat Transfer Analysis

Each engine is enclosed by a bay from the turbine casing to the tailpipe (see Figure 9.108). The engine has three distinct components in the engine bay, the turbine casing, diverter valve, and bellows. The turbine casing has a step temperature drop at the turbine blades, therefore the turbine casing may be analyzed as two units.

Turbine Casting, Section 1 and 2

The heat balance schematic is shown in Figure 9.109. It is assumed that no heat flow occurs through the forward bay enclosure.

Basic Heat Transfer Equations

$$q_i = U_i A_T (T_G - T_T)$$

$$q_{c_{T-A}} = h_T A_T (T_T - T_A)$$

$$q_{R_P} = \sigma F_P A_{f_p} \left(T_T^4 - T_{P_i}^4\right)$$

$$q_{R_W} = \sigma F_W A_{f_w} \left(T_T^4 - T_W^4\right)$$

$$q_{R_F} = \sigma F_F A_{f_F} \left(T_T^4 - T_F^4\right)$$

$$q_{R_X} = \sigma F_X A_T \left(T_T^4 - T_X^4\right)$$

$$q_{C_{W-A}} = h_W A_W (T_W - T_A)$$

$$q_{C_{P-A}} = h_P A_P (T_F - T_A)$$

$$q_{C_{F-A}} = h_F A_F (T_F - T_A)$$

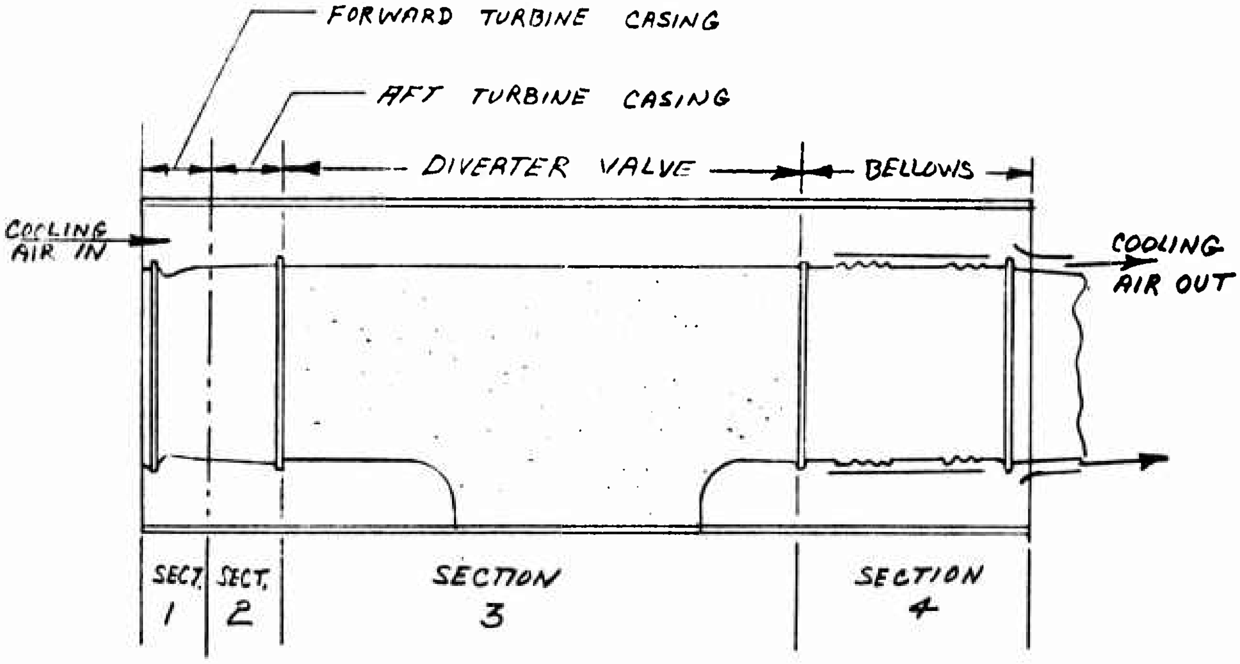

Figure 9.108 Heating and Cooling Schematic - Engine Bay

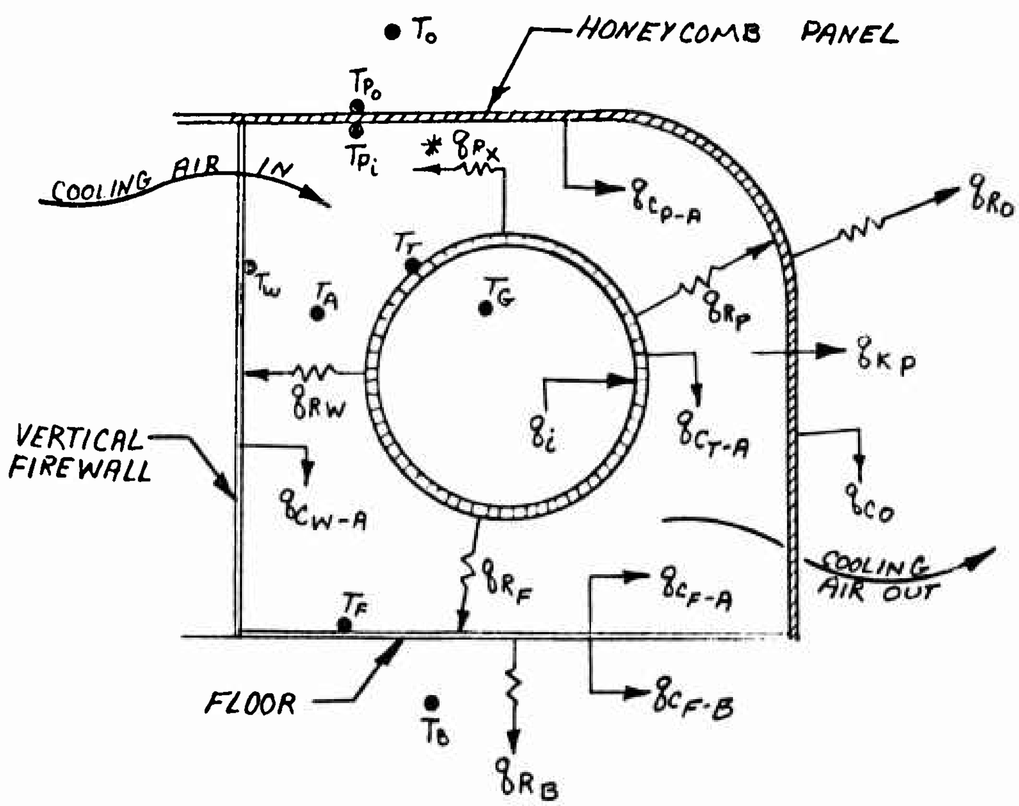

Figure 9.109 Forward and Aft Turbine Casing Heat Flow Schematic

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$$q_{K_P} = \frac{K_P}{l} A_P \left(T_{P_o} - T_{P_i}\right)$$

$$q_{R_B} = \sigma F_B A_F \left(T_F^4 - T_B^4\right)$$

$$qC_{F-B} = h_B A_F \left(T_F - T_B\right)$$

$$qC_O = h_O A_P \left(T_{P_o} - T_o\right)$$

$$q_{R_O} = \sigma F_O A_P \left(T_{P_o}^4 - T_o^4\right)$$

*q_{R_X} - Only 20 percent of the radiation leaving the turbine casing and reflecting from the walls will return to the turbine casing to be absorbed or reflected. The other 80 per cent will reflect from the walls to the diverter valve and bellow sections. See Figure 9.108.

Areas - ft^2:

	Section 1	Section 2
A_T	1.12	.93
A_W	.62	.51
A_F	.50	.42
A_P	.90	.74
A_{f_p}	.64	.64
A_{f_W}	.42	.42
A_{f_F}	.34	.34

Emissivities - Both Sections

$\epsilon_T = .80$

$\epsilon_{p_i} = .10$

$\epsilon_{p_o} = .80$

$\epsilon_w = .15$

$\epsilon_F = .15$

$\epsilon_B = .80$

Turbine Casing Overall Transfer Coefficients

Section 1 $\quad U_i = 40$

Section 2 $\quad U_i = 88$

<u>Example:</u>

Standard Day

Sea Level

Static Condition

100% RPM

$T_G = 1320° F = 1780 ° R$

$T_A = 70° F = 530 ° R$

$T_B = 150° F = 610 ° R$

$T_O = 60° F = 520 ° R$

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$$h_T = \frac{.0194\ (PV)^{.6}}{T^{.17}\ D^{.4}} = \frac{.0194\ [2116 \times 3]^{.6}}{(530)^{.17}(1.416)^{.4}} = 1.14$$

$$h_F = .27\left(\frac{\Delta T}{X}\right)^{1/4} = .27\left(\frac{430}{2.0}\right)^{1/4} = 1.03$$

$$h_w = .29\left(\frac{\Delta T}{X}\right)^{1/4} = .29\left(\frac{530}{2.47}\right)^{1/4} = 1.10$$

$$h_{p_i} = .29\left(\frac{\Delta T}{X}\right)^{1/4} = .29\left(\frac{330}{3.58}\right)^{1/4} = 1.01$$

$$h_B = .12\left(\frac{\Delta T}{X}\right)^{1/4} = .12\left(\frac{300}{2}\right)^{1/4} = .42$$

$$h_o = .29\left(\frac{\Delta T}{X}\right)^{1/4} = .29\left(\frac{90}{3.58}\right)^{1/4} = .65$$

$$F_X = .9\ (.80) = .72$$

$$F_o = .8$$

$$F_W = \frac{1}{\frac{1}{\epsilon_T} + \frac{1}{\epsilon_W} - 1} = \frac{1}{1.25 + 5.66} = .145$$

$$F_P = \frac{1}{\frac{1}{\epsilon_T} + \frac{1}{\epsilon_P} - 1} = \frac{1}{1.25 + 9.0} = .097$$

$$F_F = \frac{1}{\frac{1}{\epsilon_T} + \frac{1}{\epsilon_F} - 1} = \frac{1}{1.25 + 5.66} = .145$$

$$F_B = \frac{1}{\frac{1}{\epsilon_F} + \frac{1}{\epsilon_B} - 1} = \frac{1}{1.25 + 5.66} = .145$$

K_p for the Honeycomb Panel = .43 Btu/hr. ft^2 °F/in.

ℓ = 1 in.

$$\frac{K_p}{\ell} = .43$$

Set $T_x = 300°F = 760°R \left(\frac{T_x}{1000}\right)^4 = .334$

<u>Heat Transfer Equations</u>

q = heat flux BTU/HR

SECTION 1	SECTION 2
$q_i = 44.8\,(T_G - T_T)$	$q_i = 81.8\,(T_G - T_T)$
$q_{C_{T-A}} = 1.28\,(T_T - T_A)$	$q_{C_{T-A}} = 1.06\,(T_T - T_A)$
$q_{R_P} = 120\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_P}{1000}\right)^4\right]$	$q_{R_P} = 100\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_P}{1000}\right)^4\right]$
$q_{R_W} = 119\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right]$	$q_{R_W} = 93\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right]$
$q_{R_F} = 96\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_F}{1000}\right)^4\right]$	$q_{R_F} = 75\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_F}{1000}\right)^4\right]$
$q_{R_X} = 1395\left(\frac{T_T}{1000}\right)^4 - 466$	$q_{R_X} = 1158\left(\frac{T_F}{1000}\right)^4 - 387$
$q_{C_{W-A}} = .68\,(T_W - T_A)$	$q_{C_{W-A}} = .56\,(T_W - T_A)$

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SECTION 1	SECTION 2
$q_{CP-A} = .91 (T_{P_i} - T_A)$	$q_{CP-A} = .75 (T_{P_i} - T_A)$
$q_{CF-A} = .52 (T_F - T_A)$	$q_{CF-A} = .43 (T_F - T_A)$
$q_{KP} = .39 (T_{P_i} - T_{P_o})$	$q_{KP} = .32 \left(T_{P_i} - T_{P_o}\right)$
$q_{R_B} = 125 \left[\left(\frac{T_F}{1000}\right)^4 - \left(\frac{T_B}{1000}\right)^4\right]$	$q_{R_B} = 105 \left[\left(\frac{T_F}{1000}\right)^4 - \left(\frac{T_B}{1000}\right)^4\right]$
$q_{C_{F-B}} = .21 (T_F - T_B)$	$q_{C_{F-B}} = .18 (T_F - T_B)$
$q_{Co} = .58 (T_{Po} - T_o)$	$q_{Co} = .48 (T_{P_o} - T_o)$
$q_{R_o} = 1246 \left[\left(\frac{T_{P_o}}{1000}\right)^4 - \left(\frac{T_o}{1000}\right)^4\right]$	$q_{R_o} = 1024 \left[\left(\frac{T_{P_o}}{1000}\right)^4 - \left(\frac{T_o}{1000}\right)^4\right]$

Balanced Equations

Turbine Casing

$$q_i = q_{C_{T-A}} + q_{RP} + q_{Rw} + q_{R_F} + q_{RX}$$

Section 1

$$44.8\,(T_G - T_T) = 1.28\,(T_T - T_A) + 120\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_{P_i}}{1000}\right)^4\right]$$

$$+ 119\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right] + 96\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_F}{1000}\right)^4\right]$$

$$+ 1395\left(\frac{T_T}{1000}\right)^4 - 466$$

(Eq. 1)

$$120\left(\frac{T_{P_i}}{1000}\right)^4 + 119\left(\frac{T_W}{1000}\right)^4 + 96\left(\frac{T_F}{1000}\right)^4 = 1.28(T_T - T_A)$$

$$+ 1730\left(\frac{T_T}{1000}\right)^4 - 44.8(T_G - T_T) - 466$$

Section 2

$$81.8(T_G - T_T) = 1.06(T_T - T_A) + 100\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_{P_i}}{1000}\right)^4\right]$$

$$+ 93\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right] + 75\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_F}{1000}\right)^4\right]$$

$$+ 1158\left(\frac{T_T}{1000}\right)^4 - 387$$

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(Eq. 2)

$$100\left(\frac{T_{P_i}}{1000}\right)^4 + 93\left(\frac{T_W}{1000}\right)^4 + 75\left(\frac{T_F}{1000}\right)^4 = 1.06\,(T_T - T_A)$$

$$+ 1426\left(\frac{T_T}{1000}\right)^4 - 81.8\,(T_G - T_T) - 387$$

<u>**Vertical Wall**</u>

$$q_{R_W} = q_{C_{W-A}}$$

<u>**Section 1**</u>

$$119\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right] = .68\,(T_W - T_A)$$

(Eq. 3)

$$175\left(\frac{T_T}{1000}\right)^4 + 529 = 175\left(\frac{T_W}{1000}\right)^4 + T_W$$

<u>**Section 2**</u>

$$93\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right] = .56\,(T_W - T_A)$$

(Eq. 4)

$$166\left(\frac{T_T}{1000}\right)^4 + 530 = 166\left(\frac{T_W}{1000}\right)^4 + T_W$$

<u>**Floor**</u>

$$q_{R_F} = q_{C_{F-A}} + q_{R_B} + q_{C_{F-B}}$$

Section 1

$$96\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_F}{1000}\right)^4\right] = .52\,(T_F - T_A) + 125\left[\left(\frac{T_F}{1000}\right)^4 - \left(\frac{T_B}{1000}\right)^4\right] + .21\,(T_F - T_B)$$

(Eq. 5)

$$132\left(\frac{T_T}{1000}\right)^4 + 577 = 303\left(\frac{T_F}{1000}\right)^4 + T_F$$

Section 2

$$75\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_F}{1000}\right)^4\right] = .43\,(T_F - T_A) + 105\left[\left(\frac{T_F}{1000}\right)^4 - \left(\frac{T_B}{1000}\right)^4\right] + .18\,(T_F - T_B)$$

(Eq. 6)

$$123\left(\frac{T_T}{1000}\right)^4 + 577 = 295\left(\frac{T_F}{1000}\right)^4 + T_F$$

Honeycomb Panel - Inside

$$q_{R_P} = q_{K_P} + q_{C_{P-A}}$$

Section 1

$$120\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_P}{1000}\right)^4\right] = .39\left(T_{P_i} - T_{P_o}\right) + .91\,(T_{P_i} - T_A)$$

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(Eq. 7)

$$T_{P_o} = 2.33\left(T_{P_i} - T_A\right) + T_{P_i} - 308\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_P}{1000}\right)^4\right]$$

<u>Section 2</u>

$$100\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_P}{1000}\right)^4\right] = .32\left(T_{P_i} - T_{P_o}\right) + .75\left(T_{P_i} - T_A\right)$$

(Eq. 8)

$$T_{P_o} = 2.34\left(T_{P_i} - T_A\right) + T_{P_i} - 312\left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_P}{1000}\right)^4\right]$$

<u>Honeycomb Panel - Outside</u>

$$q_{K_P} = q_{C_o} + q_{R_o}$$

<u>Section 1</u>

(Eq. 9)

$$.39\left(T_{P_i} - T_{P_o}\right) = .58\left(T_{P_o} - T_o\right) + 1246\left[\left(\frac{T_{P_o}}{1000}\right)^4 - \left(\frac{T_o}{1000}\right)^4\right]$$

<u>Section 2</u>

(Eq. 10)

$$.32\left(T_{P_i} - T_{P_o}\right) = .48\left(T_{P_o} - T_o\right) + 1024\left[\left(\frac{T_{P_o}}{1000}\right)^4 - \left(\frac{T_o}{1000}\right)^4\right]$$

Heat Transfer Balance - Section One

$$\text{Assume } T_T = 1089.1\,^\circ F = 1549.1\,^\circ R, \quad T_T^4 = 5.760$$

(From Eq. 1)

$$120\left(\frac{T_{P_i}}{1000}\right)^4 + 119\left(\frac{T_W}{1000}\right)^4 + 96\left(\frac{T_F}{1000}\right)^4 = 1.28(1019.1)$$

$$+ 1730\,(5.76)$$

$$- 44.8\,(230.9) - 466$$

(Eq. 11)

$$120\left(\frac{T_{P_i}}{1000}\right)^4 + 119\left(\frac{T_W}{1000}\right)^4 + 96\left(\frac{T_F}{1000}\right)^4 = 459$$

(From Eq. 3)

$$175\,(5.76) + 529 = 175\, T_W^4 + T_W$$

$$1536 = 175\, T_W^4 + T_W$$

$$\text{Set } T_W = 1188\,^\circ R = 728\,^\circ F \quad \left(\frac{T_W}{1000}\right)^4 = 1.991$$

$$1536 = 1536$$

(From Eq. 5)

$$132\,(5.76) + 577 = 303\, T_F^4 + T_F$$

$$1337 = 303\, T_F^4 + T_F$$

$$\text{Set } T_F = 1016\,^\circ R = 556\,^\circ F \quad \left(\frac{T_F}{1000}\right) = 1.065$$

$$1337 = 1337$$

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(From Eq. 11)

$$120 \left(\frac{T_{P_i}}{1000}\right)^4 + 119\,(1.991) + 96\,(1.065) = 459$$

$$120 \left(\frac{T_{P_i}}{1000}\right)^4 = 120$$

$$T_{P_i} = 1000\ ^\circ R = 540\ ^\circ F$$

(From Eq. 7)

$$T_{P_o} = 2.33\,(470) + 1000 - 308\,(4.76)$$

$$T_{P_o} = 629\ ^\circ R = 169\ ^\circ F \quad \left(\frac{T_{P_o}}{1000}\right)^4 = .156$$

(From Eq. 9)

$$.39\,(371) = .58\,(109) + 1246\,(.083)$$

$$145 \approx 166$$

<u>Temperature Summary - Section One</u>

$$T_G = 1320\ ^\circ F$$

$$T_T = 1089.1\ ^\circ F$$

$$T_A = 70\ ^\circ F$$

$$T_{P_i} = 540\ ^\circ F$$

$$T_{P_o} = 169\ ^\circ F$$

$T_W = 728\ ^\circ F$

$T_F = 556\ ^\circ F$

$T_B = 150\ ^\circ F$

$T_o = 60\ ^\circ F$

<u>Heat Transfer Balance - Section Two</u>

$$\text{Assume } T_T = 1133.6\ ^\circ F = 1593.6\ ^\circ R,\ \left(\frac{T_T}{1000}\right)^4 = 6.449$$

(From Eq. 2)

$$100\left(\frac{T_{P_i}}{1000}\right)^4 + 93\left(\frac{T_W}{1000}\right)^4 + 75\left(\frac{T_F}{1000}\right)^4 = 1.06\ (1063.6) + 1426\ (6.449) - 81.8\ (116.4) - 387$$

(Eq. 12)

$$100\left(\frac{T_{P_i}}{1000}\right)^4 + 93\left(\frac{T_W}{1000}\right)^4 + 75\left(\frac{T_F}{1000}\right)^4 = 415$$

(From Eq. 4)

$$166\ (6.449) + 530 = 166\left(\frac{T_W}{1000}\right)^4 + T_W$$

$$T_W = 1226\ ^\circ R = 766\ ^\circ F\ \left(\frac{T_W}{1000}\right)^4 = 2.258$$

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(From Eq. 12)

$$100\left(\frac{T_{P_i}}{1000}\right)^4 + 93\ (2.259) + 75\ (1.143) = 415$$

$$100\left(\frac{T_{P_i}}{1000}\right)^4 = 119 \qquad \left(\frac{T_{P_i}}{1000}\right)^4 = 1.190$$

$$T_{P_i} = 1045\ ^\circ R = 585\ ^\circ F$$

(From Eq. 8)

$$T_{P_o} = 2.34\ (515) + 1045 - 312\ (5.259)$$

$$T_{P_o} = 609\ ^\circ R = 149\ ^\circ F \qquad \left(\frac{T_{P_o}}{1000}\right)^4 = .137$$

(From Eq. 10)

$$.32\ (436) = .48\ (89) + 1024\ (.064)$$

$$139 \approx 108$$

<u>Temperature Summary - Section Two</u>

$T_G = 1320\ ^\circ F$

$T_T = 1133.6\ ^\circ F$

$T_A = 70\ ^\circ F$

$T_{P_i} = 585\ ^\circ F$

$T_{P_o} = 149\ ^\circ F$

T_W = 766 °F

T_F = 574 °F

T_B = 150 °F

T_o = 60 °F

Diverter Valve - Section 3

The heat transfer analysis of the diverter valve section is similar to the turbine casing analysis. Only the value of the coefficients areas and temperatures are changed. The Diverter Valve is insulated and has an overall heat transfer coefficient of 1.2 Btu/hr.ft^2 °F. See Figure 9.110.

Emissivities

ϵ_T = .50

ϵ_{P_i} = .10

ϵ_{P_o} = .80

ϵ_W = .15

ϵ_F = .15

ϵ_B = .80

Bellows - Section 4

The bellow section is similar to the turbine casing section except for a shroud around the tailpipe that allows cooling air to flow between the shroud and tailpipe, see Figure 9.111. The heat flow from the shroud to the walls is the same as in the turbine casing section, q_i is equal to the total heat input into the shroud.

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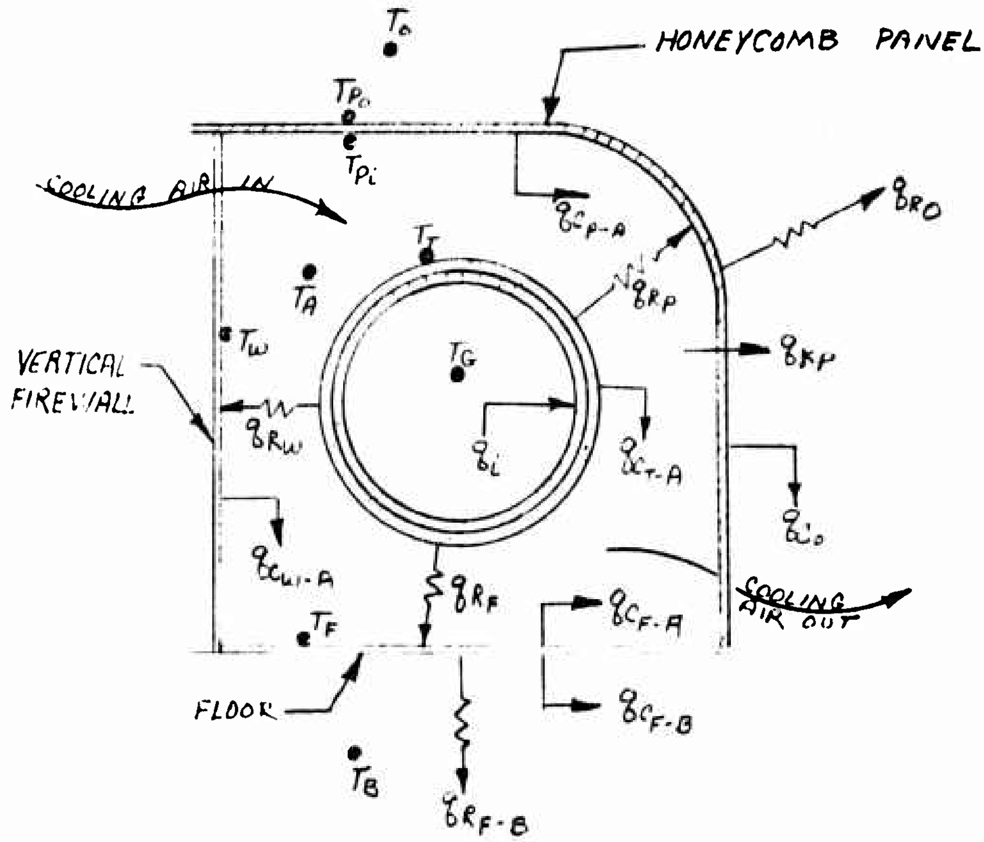

Figure 9.110 Diverter Valve Heat Flow Schematic

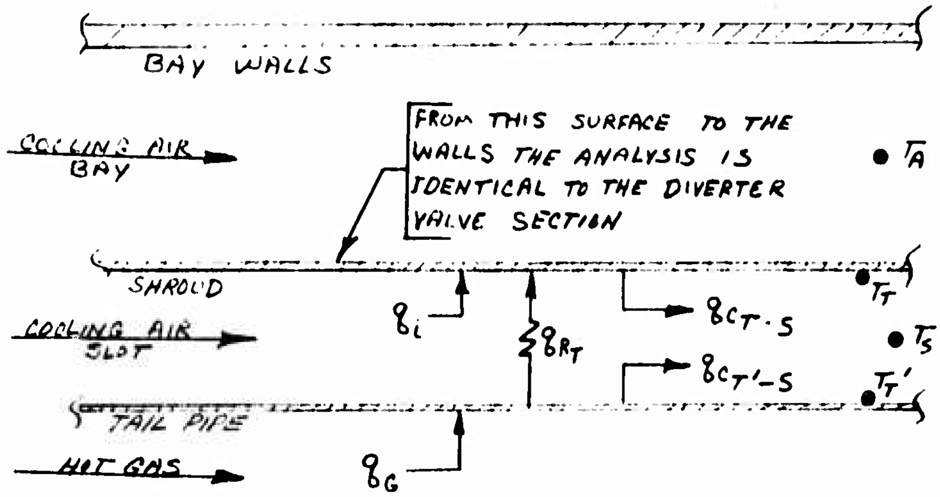

Figure 9.111 Bellows Heat Flow Schematic

$$q_G = q_{R_T} + q_{C_{T^1-S}}$$

$$h_G A_{T'} \left(T_G - T_{T'}\right) = \sigma F_T A_{F'} \left(T_{T'}^4 T_T^4\right) + h_{T'} A_{T'} \left(T_{T'} - T_S\right)$$

T_G and T_S are known

Set $T_{T'}$

Define coefficients and areas

Find T_T

$$q_i = q_{R_T} - q_{C_T}{}^{-S}$$

$$q_i = \sigma F_T A_{T'} \left(T_{T'}^4 - T_T^4\right) - h_T A_T \left(T_T - T_S\right)$$

Define coefficients and areas

$T_{T'}$, T_T, and T_S are known

Find q_i

With q_i and T_T known, analyze the whole system as outlined in the turbine sections. Pick various values of $T_{T'}$ until the whole system is balanced.

9.4.12 Aft Fuselage Heat Transfer Analysis

The aft fuselage is heated by two turbojet engine tailpipes passing diagonally through the section. The tailpipes are shrouded and cooling air is pumped through the annulus formed by the tailpipe and shroud. There is no cooling air flowing between the shrouds and fuselage skin, therefore the free convective heat transferred from the shrouds must enter the fuselage skin by free convection. The tailpipe, shroud, and fuselage skin materials are very thin, therefore the temperature across the material is assumed to be uniform. The aft fuselage is divided into

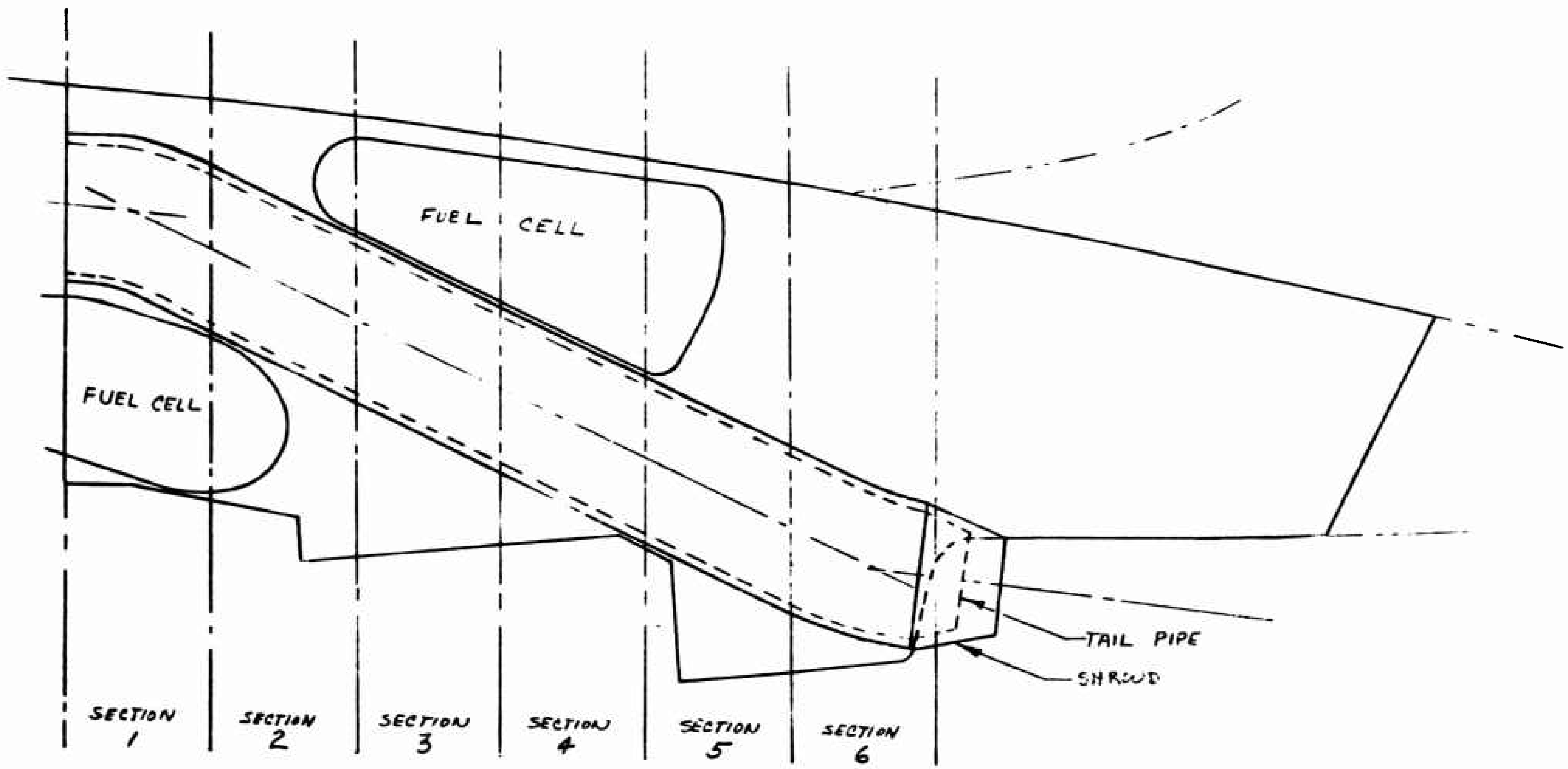

Figure 9.112 Heating and Cooling Schematic - Aft Fuselage

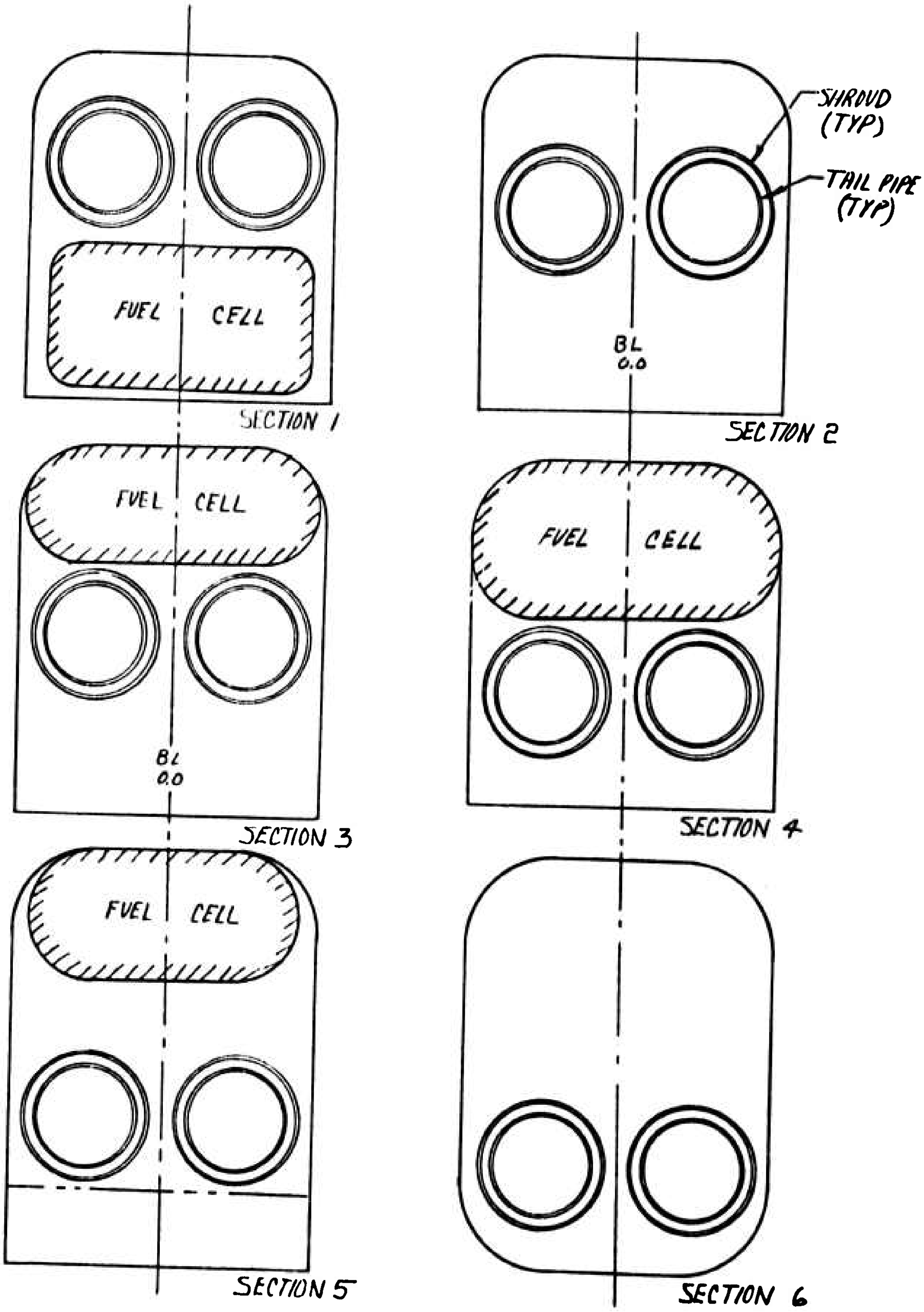

Figure 9.113 Heating and Cooling Schematic - Aft Fuselage Sections

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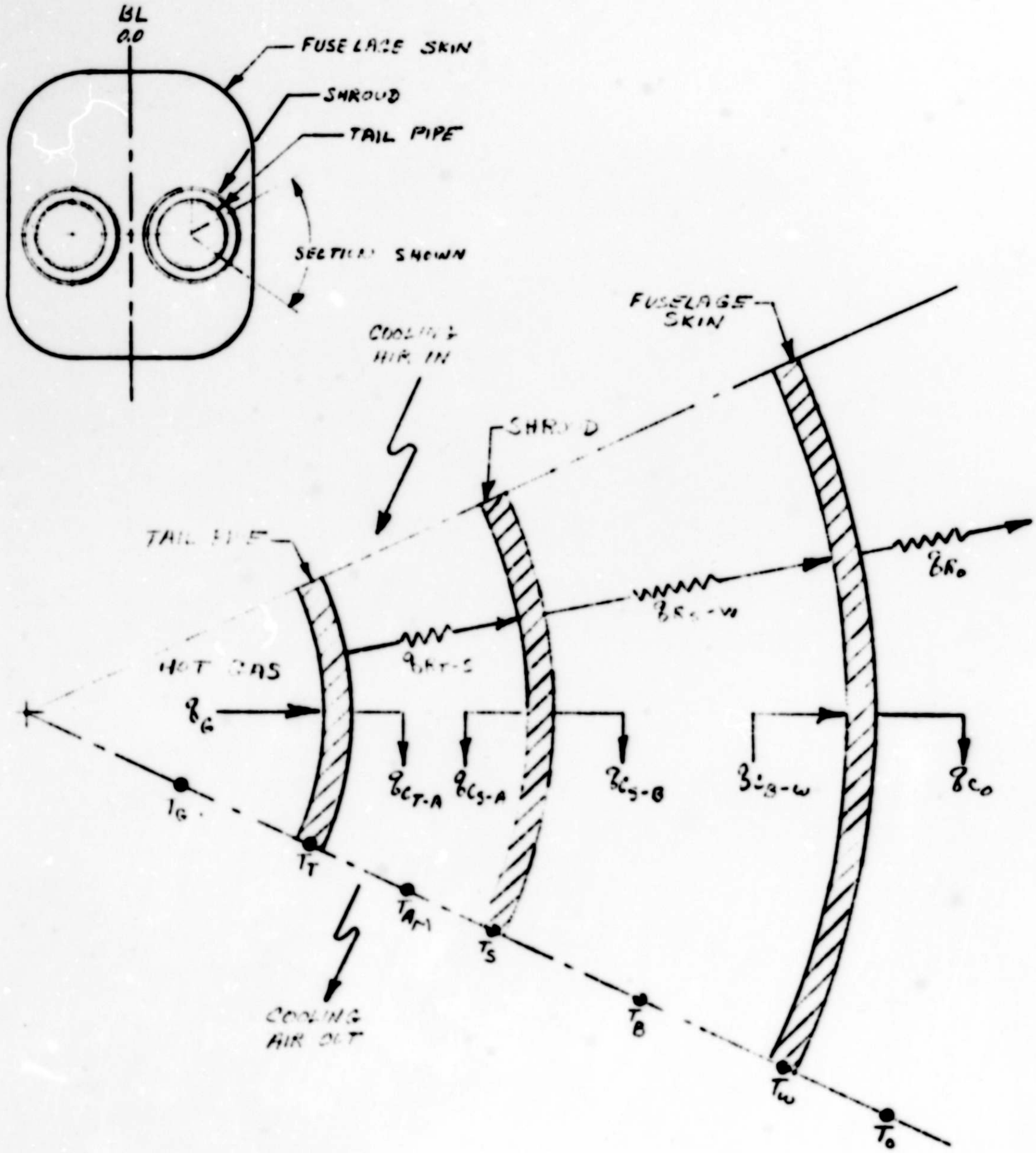

Figure 9. 114 Aft Fuselage Heat Balance Schematic

six sections as presented in Figures 9.112 and 9.113. The heat balance across a section is schematically shown in Figure 9.114.

Basic Heat Transfer Equations

$$q_G = h_G A_T \left(T_G - T_T\right)$$

$$q_{R_{T-S}} = \sigma F_T A_T \left(T_T^4 - T_S^4\right)$$

$$q_{C_{T-A}} = h_T A_T \left(T_T - T_{AM}\right)$$

$$q_{C_{S-A}} = h_{S_i} A_S \left(T_S - T_{AM}\right)$$

$$q_{R_{S-W}} = \sigma F_S A_f \left(T_S^4 - T_W^4\right)$$

$$q_{C_{S-B}} = h_{S_1} A_s \left(T_S - T_B\right)$$

$$q_{C_{B-W}} = h_{W_1} A_w \left(T_B - T_W\right)$$

$$q_{R_o} = \sigma F_o A_w \left(T_W^4 - T_O^4\right)$$

$$q_{c_o} = h_{w_1} A_W \left(T_W - T_O\right)$$

Balanced Equations

$$q_G = q_{R_{T-S}} + q_{C_{T-A}}$$

$$q_A = q_{C_{T-A}} + q_{C_{S-A}}$$

$$q_{R_{S-W}} + q_{C_{B-W}} = q_{R_O} + q_{C_O}$$

$$q_{C_{S-B}} = q_{C_{B-W}}$$

$$q_G = q_A + q_{R_O} + q_{C_O}$$

Example

The following example is an analysis of the heat transfer in section one for a condition at standard day, sea level, static operation, 100% RPM, and turbojet mode.

Known Conditions

$T_G = 1250°F = 1710°R$

$T_O = 60°F = 520°R$

Air Temp. into the section = 88° F = 548 ° R

$A_T = 6.48\ ft^2/section$

$A_S = 7.65\ ft^2/section$

$A_f = .863$

Wall Areas - ft^2

Section	A_w
1	9.0
2	13.0
3	11.0
4	9.7
5	11.0
6	13.5

Emissivities

$\epsilon_T = .40$ $\epsilon_S = .12$ $\epsilon_W = .90$

$\epsilon_{S_i} = .10$ $\epsilon_{W_i} = .90$

Calculations

h_G Tailpipe hot gas transfer coefficient

$$\frac{h_G}{\rho c_p V} = \frac{.0384 \left(R_{e_d}\right)^{-1/4}}{1 + 1.5 \left(P_r\right)^{-1/6} \left(R_{e_d}\right)^{-1/8} \left(P_r - 1\right)}$$

$\mu = 2.68 \times 10^{-5}$ lb/sec. ft

$\rho = .047$ lb ft^2

$P_r = .70$

$c_{p_a} = .27$ Btu/lb °F

$A = 1.48$ ft^2

$D = 1.375$ ft.

$W = 44$ lb/sec.

$V = \frac{W}{A\rho} = 632$ ft/sec.

$R_{e_d} = \frac{D\rho V}{\mu} = 1.523 \times 10^6$

$\left(R_{e_d}\right)^{-1/4} = .028$ $\left(R_{e_d}\right)^{-1/8} = .168$ $\left(P_r\right)^{-1/6} = 1.061$

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$$h_G = \frac{(.047)(.27)(632)(.0384)(.028)}{1 + 1.5\,(1.061)(.168)(-.3)} \left(3600\ \frac{\text{sec}}{\text{hr}}\right)$$

$$h_G = 34\ \frac{\text{Btu}}{\text{hr-ft}^2\text{-}^\circ\text{F}}$$

Annulus:

h_T = Outside surface of the tailpipe

h_{S_i} - Inside surface of the shroud

$$\frac{h}{c_{p_b} G} \left(\frac{c_p \mu}{k}\right)_b \left(\frac{\mu w}{\mu_b}\right)^{.14} = \frac{.023}{\left(\frac{D_H G}{\mu_b}\right)^{.2}}$$

Subscript b = bulk

c_{p_b} = .24 Btu/lb °F

G = 3390 lb/hr-ft^2

μ_b = 5.08 x 10^{-2} lb/hr-ft

μW_{S_i} = 5.01 x 10^{-2} lb/hr-ft

μW_T = 8.71 x 10^{-2} lb/hr-ft

D_H = .25 ft.

$$h = \frac{.023}{\left(\frac{D_H G}{\mu_b}\right)^{.2}} \quad \frac{c_{p_b} G}{\left(\frac{\mu_w}{\mu_b}\right)^{.14} \left(\frac{c_p \mu}{k}\right)^{2/3}}$$

$h_{s_i} = 3.43$ Btu/hr-ft^2 °F

$h_T = 3.18$ Btu/hr-ft^2 °F

h_{s_l} - Outside surface of shroud

$$h_{s_l} = .27 \left(\frac{P}{14.7}\right)^{1/2} \left(\frac{\Delta T}{D}\right)^{1/4} = .24\, \Delta T^{1/4}$$

h_{w_i} - Inside surface of the fuselage skin

h_{w_l} - Outside surface of the fuselage skin

In terms of ΔT, $h_{w_i} = h_{w_l} = .29 \left(\frac{P}{14.7}\right)^{1/2} \left(\frac{\Delta T}{D}\right)^{1/4}$

Section	h_{w_i} or h_w
1	$.452\, \Delta T^{1/4}$
2	$.499\, \Delta T^{1/4}$
3	$.478\, \Delta T^{1/4}$
4	$.461\, \Delta T^{1/4}$
5	$.478\, \Delta T^{1/4}$
6	$.501\, \Delta T^{1/4}$

$$F_T = \frac{1}{\frac{1}{\epsilon_T} + \left(\frac{A_T}{A_S}\right)\left(\frac{1}{\epsilon_{s_l}} - 1\right)} = .099$$

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$$F_S = \frac{1}{\frac{1}{\epsilon_{S_l}} + \left(\frac{A_S A_f}{A_T}\right)\left(\frac{1}{\epsilon_{w_i}} - 1\right)} = .118$$

$$F_O = .80$$

<u>Heat Transfer Equations</u>

$$q_G = 220\ (T_G - T_T)$$

$$q_{R_{T-S}} = 1110 \left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_S}{1000}\right)^4\right]$$

$$q_{C_{T-A}} = 20.6 \left(T_T\ T_{A_m}\right)$$

$$q_{C_{S-A}} = 26.6 \left(T_S\ T_{A_m}\right)$$

$$q_{R_{S-W}} = 1347 \left[\left(\frac{T_S}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right]$$

$$q_{C_{S-B}} = 1.84\ (T_S - T_B)^{1.25}$$

$q_{C_{B-W}}$: and q_{C_O}	SECTION	$q_{C_{B-W}}$	q_{C_O}
	1	$4.07\ (T_B - T_W)^{1.25}$	$4.07\ (T_W - T_O)^{1.25}$
	2	$6.48\ (T_B - T_W)^{1.25}$	$6.48\ (T_W - T_O)^{1.25}$
	3	$5.26\ (T_B - T_W)^{1.25}$	$5.26\ (T_W - T_O)^{1.25}$

$q_{C_{B-W}}$:	SECTION	$q_{C_{B-W}}$	q_{C_O}
and	4	$4.47\,(T_B - T_W)^{1.25}$	$4.47\,(T_W - T_O)^{1.25}$
q_{C_O}	5	$5.26\,(T_B - T_W)^{1.25}$	$5.26\,(T_W - T_O)^{1.25}$
(Cont)	6	$6.76\,(T_B - T_W)^{1.25}$	$6.76\,(T_W - T_O)^{1.25}$

q_{R_O} :	SECTION	q_{R_O}
	1	$1.40 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$
	2	$2.02 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$
	3	$1.71 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$
	4	$1.51 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$
	5	$1.71 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$
	6	$2.10 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$

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Balance for Section One

Using the Balance equations

(1) $q_G = q_{R_{T-S}} + q_{C_{T-A}}$

$$h_G A_T (T_G - T_T) = \sigma F_T A_T \left(T_T^4 - T_S^4\right) + h_T A_T (T_T - T_A)$$

$$200\ (T_G - T_T) = 1110 \left[\left(\frac{T_T}{1000}\right)^4 - \left(\frac{T_T}{1000}\right)^4\right] + 20.6\ \left(T_T - T_{A_m}\right)$$

(2) Set T_T = 1124.26 °F = 1584.26 °R

(3) Assume ΔT_a = 28° R

(4) Solve for T_S

q_G = 27,663 Btu/hr

qC_{T-A} = 21,058 Btu/hr

$q_{R_{T-S}}$ = 27,663 - 21,058 = 6,605 Btu/hr

$$1110 \left(\frac{T_S}{1000}\right)^4 = 110 \left(\frac{T_T}{1000}\right)^4 - 6,605$$

$$\left(\frac{T_S}{1000}\right)^4 = 6.300 - 5.950 = .350$$

T_S = 769 °R

(5) Solve for $q_{C_{S-A}}$

$$q_{C_{S-A}} = 26.6 \quad T_S - T_{A_m} = 5,506 \text{ Btu/hr}$$

(6) Solve for ΔT_a to check step (3)

$$q_A = q_{C_{S-A}} + q_{C_{T-A}} = 21,058 + 5,506 = 26,564 \text{ Btu/hr}$$

$$\Delta T = \frac{q_A}{WC_p} = \frac{26,560 \text{ Btu/hr}}{1.10 \text{ lb/sec } .27 \text{ Btu/lb °F}} \left(\frac{\text{hr}}{3600 \text{ sec}}\right) = 28 \text{ °F}$$

(7) Solve for T_W

$$q_{C_{S-B}} + q_{R_{S-W}} = q_{R_{T-S}} - q_{C_{S-A}} = 1099 \text{ Btu/hr}$$

$$q_{C_{S-B}} + q_{R_{S-W}} = q_{R_O} + q_{C_O}$$

$$1099 = 4.07 (T_W - T_O)^{1.25} + 1.40 \times 10^4 \left[\left(\frac{T_W}{1000}\right)^4 - \left(\frac{T_O}{1000}\right)^4\right]$$

$$T_W = 575 \text{ °R}$$

(8) Solve for T_B

$$q_{C_{S-B}} = q_{C_{B-W}}$$

$$1.84 (T_S - T_B)^{1.25} = 4.07 (T_B - T_W)^{1.25}$$

$$\left(\frac{T_S - T_B}{T_B - T_W}\right)^{1.25} = 2.21$$

T_B K 642 °R

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(9) Using T_W, T_B, and T_S, Solve for

$q_{C_{S-B}}$ and $q_{R_{S-W}}$ and check for the value obtained in step (7)

$$q_{C_{S-B}} = 1.84\,(T_S - T_B)^{1.25} = 786 \text{ Btu/hr}$$

$$q_{R_{S-W}} = 1347 \left[\left(\frac{T_S}{1000}\right)^4 - \left(\frac{T_W}{1000}\right)^4\right] = 324 \text{ Btu/hr}$$

$$q_{C_{S-B}} + q_{R_{S-W}} = 1110 \text{ Btu/hr}$$

This is close enough to the value 1099 Btu/hr obtained in step (7).

(10) Check overall system

$$q_G = q_A + q_{R_O} + q_{C_O}$$

$$27{,}663 \approx 27{,}659$$

(11) Summary of temperatures

$T_G = 1250\,°F$

$T_T = 1124.26\,°F$

$T_S = 309\,°F$

$T_{A_m} = 102\,°F$

$T_B = 182\,°F$

$T_W = 115\,°F$

$T_O = 60\,^\circ F$

The sections two thru six are analyzed in the same manner, using the values of q given in this section, decreasing T_B by the value of

$$\left(\frac{q_G}{W_G C_{p_o}}\right),$$

and obtaining T_{A_m} by using T_a in as T_a in + ΔT from the preceding section.

9.5 STRUCTURAL PROTECTION SYSTEM ANALYSIS

9.5.1 Insulation of Nose Fan Thrust Reverser Door

Upper Closure Longeron Assembly Part No. 143F003

A steady state heat transfer analysis of insulation requirements for Assembly Part No. 143F003 was made using the simplified model of Figure 9.115 below (see Figure 6.1 for reference).

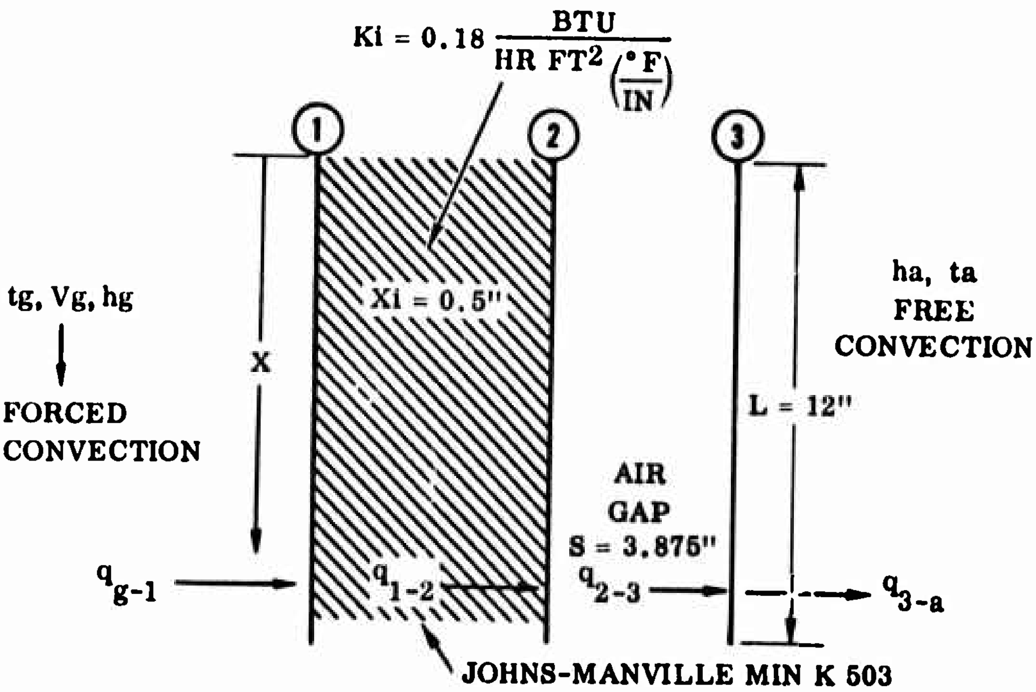

Figure 9.115 Part No. 143F003 Heat Transfer Model

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For steady state

$$q_{g-a} = q_{g-1} = q_{1-2} = q_{2-3} = q_{3-a}$$

From which

$$\frac{1}{U_o} = \frac{1}{h_g} + \frac{X_i}{k_i} + \frac{1}{h_2} + \frac{1}{h_a}$$

The heat transfer coefficient h_g is obtained from Equation 34 or 36 on Page I-25 of Reference 18; the choice depending upon whether or not

$$Re = 1.7 \times 10^5 \frac{V_g PX}{T_1^{1.75}} \lessgtr 5 \times 10^5$$

The heat transfer coefficient h_2 between walls 2 and 3 of Figure 9.115 accounts for both convection (h_{2c}) and radiation (h_{2r}).

The convective term h_{2c} may be read directly from Figure 1c-35 on Page 1-c-58 of Reference 12 at $\delta = 3.875''$ and an assumed Δt between the plates ($\Delta t = t_2 - t_3$).

The radiative term h_{2r} is determined from the equation

$$h_{2r} = \frac{1730 F_{A\epsilon} \left[\left(\frac{T_2}{1000} \right)^4 - \left(\frac{T_3}{1000} \right)^4 \right]}{(T_2 - T_3)}$$

where $T = t + 460$.

Since neither T_2 nor T_3 are known, trial and error is required.

The heat transfer coefficient h_a likewise includes convective (h_{ac}) and radiative (h_{ar}) components so that $h_a = h_{ac} + h_{ar}$.

The convective term h_{ac} is determined from either equations 104 or 105, Page 1-c-56, Reference 13, depending upon the value of Gr Pr which is easily obtained from the equation

$Gr\ Pr = Y \Delta t\, L^3$ where Y is read from Figure 1c-34 Page 1-c-55 of Reference 12 at the average temperature $(t_3 + t_a)/2$.

The radiative term h_{ar} is obtained from the equation

$$h_{ar} = \frac{1730\ F_{A\epsilon} \left[\left(\frac{T_3}{1000} \right)^4 - \left(\frac{T_a}{1000} \right)^4 \right]}{(T_3 - T_a)}$$

Since the solution is by trial and error, it is convenient to use the fact that the ratio of component temperature differences to the total temperature difference is equal to the ratio of component thermal resistance to total thermal resistance so that

$$\frac{t_g - t_2}{t_g - t_a} = \frac{\left[\frac{1}{h_g} + \frac{X_i}{k_i} \right]}{\left[\frac{1}{h_g} + \frac{X_i}{k_i} + \frac{1}{h_2} + \frac{1}{h_a} \right]}$$

and

$$\frac{t_g - t_3}{t_g - t_a} = \frac{\left[\frac{1}{h_g} + \frac{X_i}{k_i} + \frac{1}{h_2} \right]}{\left[\frac{1}{h_g} + \frac{X_i}{k_i} + \frac{1}{h_2} + \frac{1}{h_a} \right]}$$

Sample Calculation:

Initial Conditions

$V_g = 300$ ft/sec, $P = 2118$ lbs/ft^2, $t_g = 700°F$

$X_i = 0.5"$, $k_i = 0.18"$, $X = 3"$, $t_a = 100°F$

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Assume $t_1 = 685°F$, $t_2 = 244°F$, $t_3 = 174°F$ $F_{A\epsilon} = .9$

(Note $T = t + 460$)

$$R_e = 1.7 \times 10^5 (300)(2118)(3/12) \Big/ (685 + 460)^{1.75} = 1.17 \times 10^5 < 5 \times 10^5$$

Use Equation 34 Page I-25 Reference 18

$$h_g = 0.0077 \left(\frac{V_g P}{X}\right)^{1/2} = 0.0077 \left[\frac{(300)(2118)}{(3/12)}\right]^{.5}$$

$$= 12.2 \frac{\text{Btu}}{\text{hr. ft.}^2 \, °F}$$

h_{2c} = 0.43 from Figure IC-35 Page 1-c-58 Reference 12 at Δt = 70° F and δ = 3.875"

$$h_{2r} = (1730)(F_{A\epsilon})\left[\left(\frac{T_2}{1000}\right)^4 - \left(\frac{T_3}{1000}\right)^4\right] \Big/ (t_2 - t_3)$$

$$= (1730)(.9)\left[\frac{4}{.704} - \frac{4}{.634}\right] \Big/ (244-174) = 1.87$$

$$h_2 = h_{2c} + h_{2r} = 2.30$$

To obtain $h_a = h_{ac} + h_{ar}$ check (Gr) (Pr) first.

$$Y = 9.2 \times 10^5 \text{ at } t = (t_3 + t_a) \Big/ 2 = 137$$

Then

$$GrPr = Y (t_3 - t_a)(L)^3 = (9.2 \times 10^5)(74)(1) = 6.8 \times 10^7$$

Use Equation 104 Page 1-c-56 Reference 12

$$h_{ac} = 0.29 \left[\frac{P}{(144)(14.7)}\right]^{1/2} \left(\frac{\Delta t}{X}\right)^{1/4}$$

$$h_{ac} = (0.29)(74)^{1/4} = .85$$

$$h_{ar} = (1730)\,(F\Delta\epsilon)\left[\left(\frac{T_3}{1000}\right)^4 - \left(\frac{T_a}{1000}\right)^4\right]$$

$$= (1730)\,(.9)\left[\frac{4}{.634} - \frac{4}{560}\right]\Big/ 74 = 1.29$$

$$h_a = .85 + 1.29 = 2.14$$

$$\frac{1}{U_o} = \left[\frac{1}{h_g} + \frac{X_i}{k_i} + \frac{1}{h_2} + \frac{1}{h_a}\right]$$

$$= \left[\frac{1}{12.2} + \frac{.5}{.18} + \frac{1}{2.3} + \frac{1}{2.14}\right]$$

$$= .082 + 2.78 + .435 + .467 = 3.764$$

To check assumptions of $t_2 = 244$ and $t_3 = 174$

$$\frac{t_g - t_2}{t_g - t_a} = \frac{\frac{1}{h_g} + \frac{X_i}{}}{\frac{1}{U_o}} = \frac{2.862}{3.764} = .761 = \frac{700 - t_2}{700-100}$$

$t_2 = 700 - .761\ (600) = 700-456 = 244$ ok

$$\frac{t_g - t_3}{t_g - t_a} = \frac{\frac{1}{h_g} + \frac{X_i}{k_i} + \frac{1}{h_2}}{\frac{1}{U_o}} = \frac{3.297}{3.764} = .875 = \frac{700 - t_3}{700-100}$$

$t_3 = 700 - 525 = 175$ close enough

Conclusion

0.5" Johns Manville Min K 503 insulation will keep the longeron assembly below the design load limit of 250° F. Edges should be sealed to prevent "blow-by" of hot gases behind the insulation.

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9.5.2 Insulation Requirements for Local Aircraft Surface Areas

9.5.2.1 Method of Analysis

The following procedure is applicable to transient heat transfer analysis of aircraft surface insulation systems shown in Figure 2.3. It is based primarily on the numerical method of Dusinberre as presented in Reference 15. The one-dimensional heat transfer model, presented in Figure 9.116, consists of a thin metal plate protected by a relatively thick layer of insulation. The plate is assumed large enough that edge effects are negligible, assumes negligible contact resistance between the insulation and metal plate, and assumes that the metal plate is thin enough that it may be treated as if it had infinite thermal conductivity. Radiation from the hot and cold sides is neglected; thereby adding some conservatism to the method since more heat is added to the hot side and less heat is lost from the cold side than would be the case if it had been included.

The insulation of thickness X_i is divided into n slabs of thickness $\Delta X_i = X_i/n$. The general equation for determining the temperature t_i at the i^{th} interface for $1 < i \leq n-1$ at the $j+1^{th}$ time increment is

$$t_{i,j+1} = \frac{t_{i-1,j} + (M_A - 2)\, t_{i,j} + t_{i+1,j}}{M_A}$$

At the insulation surface where $t_i = t_o$, the equation

$$t_{o,j+1} = \frac{N_A}{N_A + 1}\, t_{g,j+1} + \frac{1}{N_A + 1}\, t_{1,j+1}$$

is used, except for the first time increment following the initial application of $t_{g,j+1}$ to the system, where the approximation $t_{o,j} = \left(t_{o,j} + t_{g,j}\right)/2$ is used. (Note the subscripts are correct.)

At the insulation-metal plate interface $i = n$ an iteration step is required as follows

Assume $t_{p,\,j+1} = t_{n,\,j}$

By a heat balance on the metal plate the temperature rise is given by

$$\Delta t_p = E\, t_{n-1,\, j+1} - F\, t_{p,\, j+1} + G\, t_a$$

and then a calculated value of $t_{p,\, j+1}$ is given by

$$t_{p,\, j+1} = t_{n,\, j} + \Delta t_p \, .$$

Obviously the first assumption of $t_{p,\, j+1}$ is incorrect; so the next trial assumes the value of $t_{p,\, j+1}$ just calculated. This procedure is repeated until the assumed and calculated value agree within some specified limit at which time the statement is made that $t_{n,\, j+1} = t_{p,\, j+1}$.

Values of M_A, N_A, E, F, and G are defined below.

$$M_A = \frac{c_{p_i}\, \gamma_i\, (\Delta X_i)^2}{k_i\, \Delta\theta}$$

$$N_A = \frac{h_{g_i}\, \Delta X_i}{k_i}$$

$$E = \frac{(\Delta\theta)\,(k_i)}{(60)\,(144)\,(X_m)\,(\rho_m)\left(C_{p_m}\right)(\Delta X_i)}$$

$$F = \left(\frac{\Delta\theta}{(60)\,(144)\,(X_m)\,(\rho_m)\left(C_{p_m}\right)}\right)\left(\frac{k_i}{\Delta X_i} + h_a\right)$$

$$G = \frac{(h_a)\,(\Delta\theta)}{(60)\,(144)\,(X_m)\,(\rho_m)\left(C_{p_m}\right)}$$

The above equations were programed for digital computer use. The term M_A is arbitrarily set at $M_A = 2$ or greater to obtain the time increment $\Delta\theta$. Time varying boundary conditions together with any initial temperature distribution in the insulation may be handled with

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TABLE 9.11
Insulation System Study Summary

CASE	Insulation * k_i	C_{p_i}	γ_i	X_i	Skin Mat'l.	C_{p_m}	γ_m	X_m	θ	Boundary Condition t_g	h_g	t_a	h_a	Initial Condition t_x, θ=0	See Figure
1	.22	.25	.00926	.25	T_i	.126	.1632	.025	5	1000	22	100	.8	100	13.5
2										800					
3										600					
4										400					
5				.375						1000					13.6
6										800					
7										600					
8										400					
9				.500						1000					13.7
10										800					
11										600					
12										400					
13	.22	.25	.00926	.675	Al	.25	.10	.040	35	1000	22	100	.8	100	13.9
14										500					
15										715					
16										600					

CASE	Insulation * k_i	C_{p_i}	γ_i	X_i	Skin Mat'l.	C_{p_m}	γ_m	X_m	θ	Boundary Condition t_g	h_g	t_a	h_a	Initial Condition t_x, θ=0	See Figure
17	.22	.25	.00926	.5	Al	.25	.10	.040	35	1000	22	100	.8	100	13.10
18										800					
19										715					
20										600					
21				.375						1000					13.11
22										800					
23										715					
24										600					
25				.25						1000					13.12
26										800					"
27										715					"
28										600					"

k = Btu/hr.ft.^{2} (^{o}F/in.); C_p = Btu/lb. ^{o}F; γ = lb./in.^{3}; X = inches

θ = Minutes; t = ^{o}F; h = Btu/hr.ft.^{2} ^{o}F

* Insulation: Johns Manville Min K

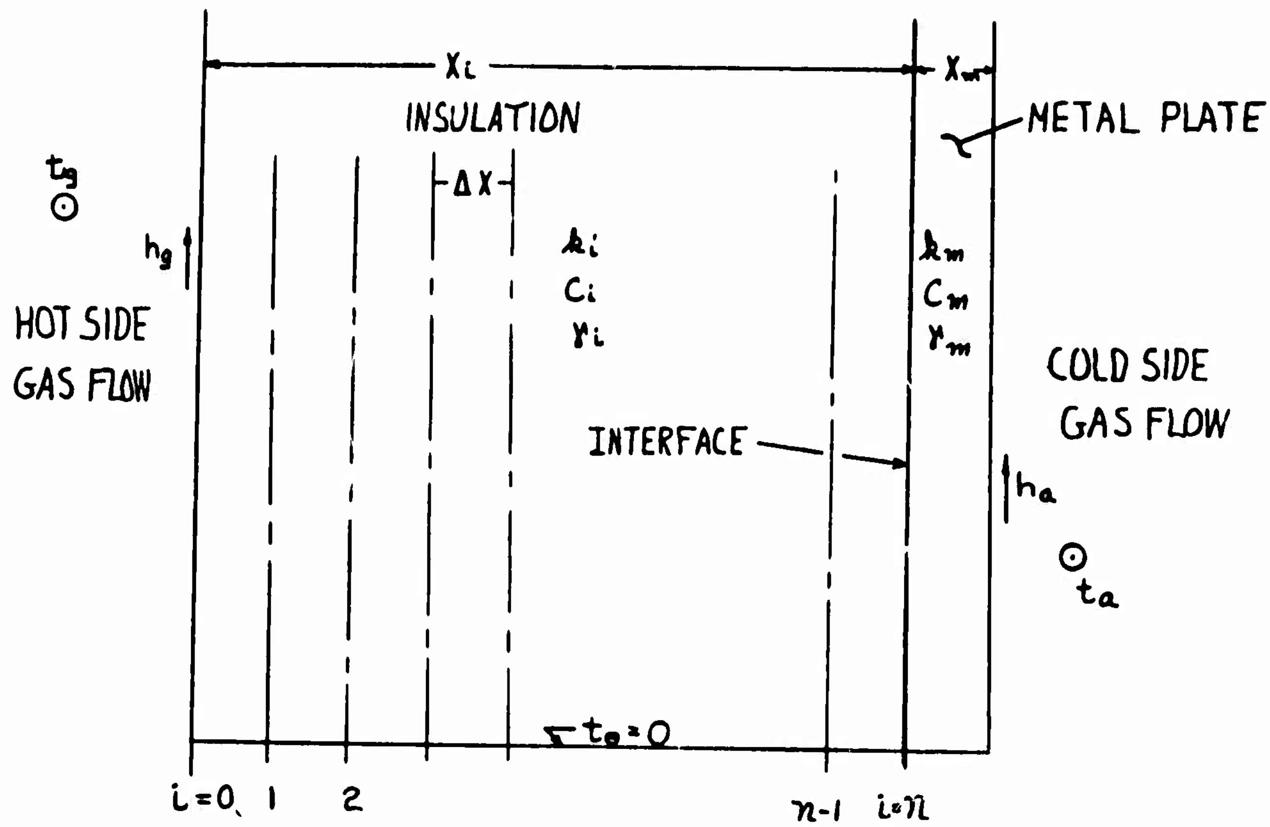

Figure 9.116 Heat Transfer Model for Insulated Metal Skin

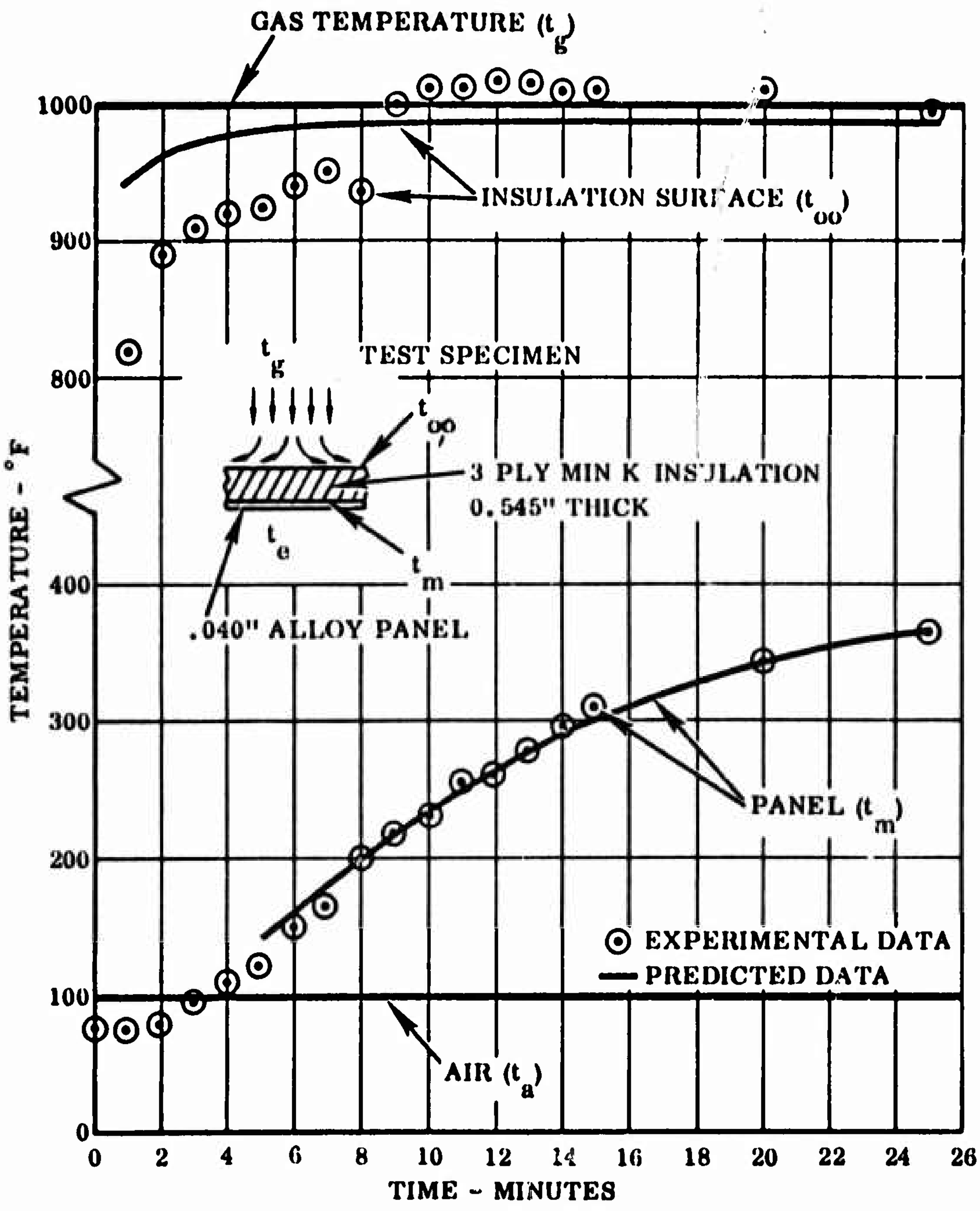

Figure 9.117 Comparison of Predicted and Experimental Insulated Panel Temperatures: 0.545" Min K Insulation on .025" Titanium

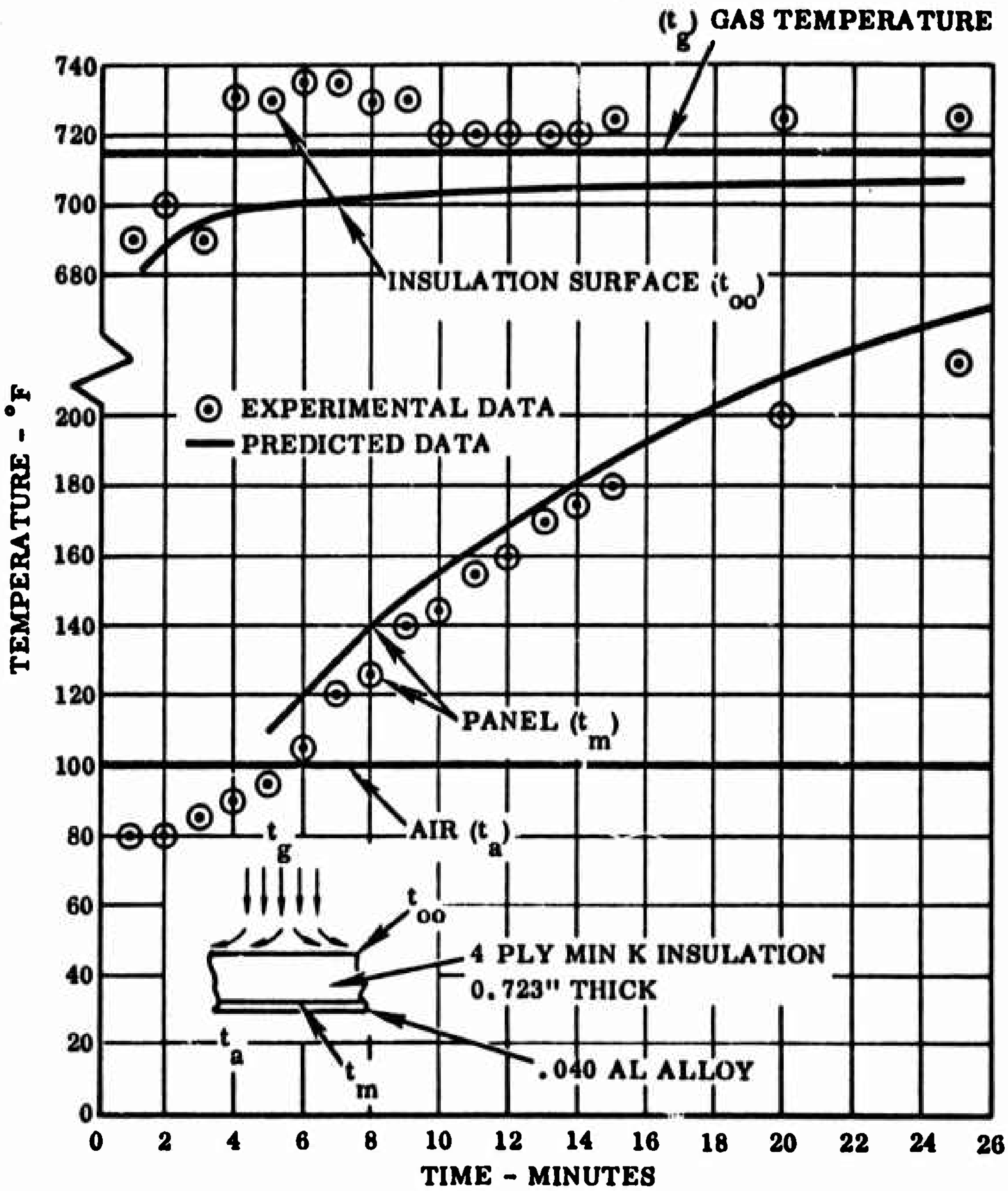

Figure 9.118 Comparison of Predicted and Experimental Insulated Panel Temperatures: 0.723" Min K Insulation on .025" Titanium

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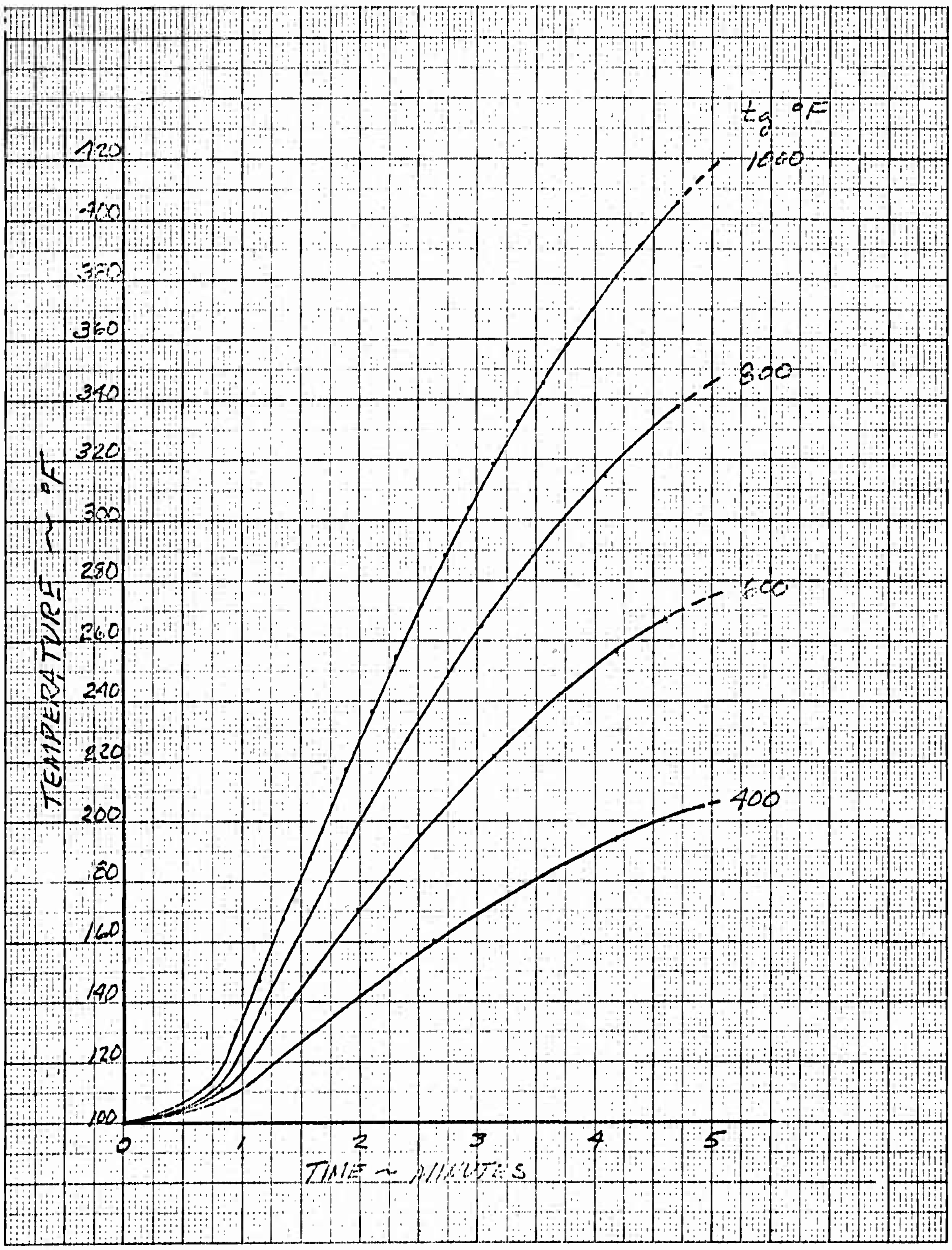

Figure 9.119 Skin Temperature-Time Profiles Vs Gas Temperature 0.25" Min K Insulation on .025" Titanium

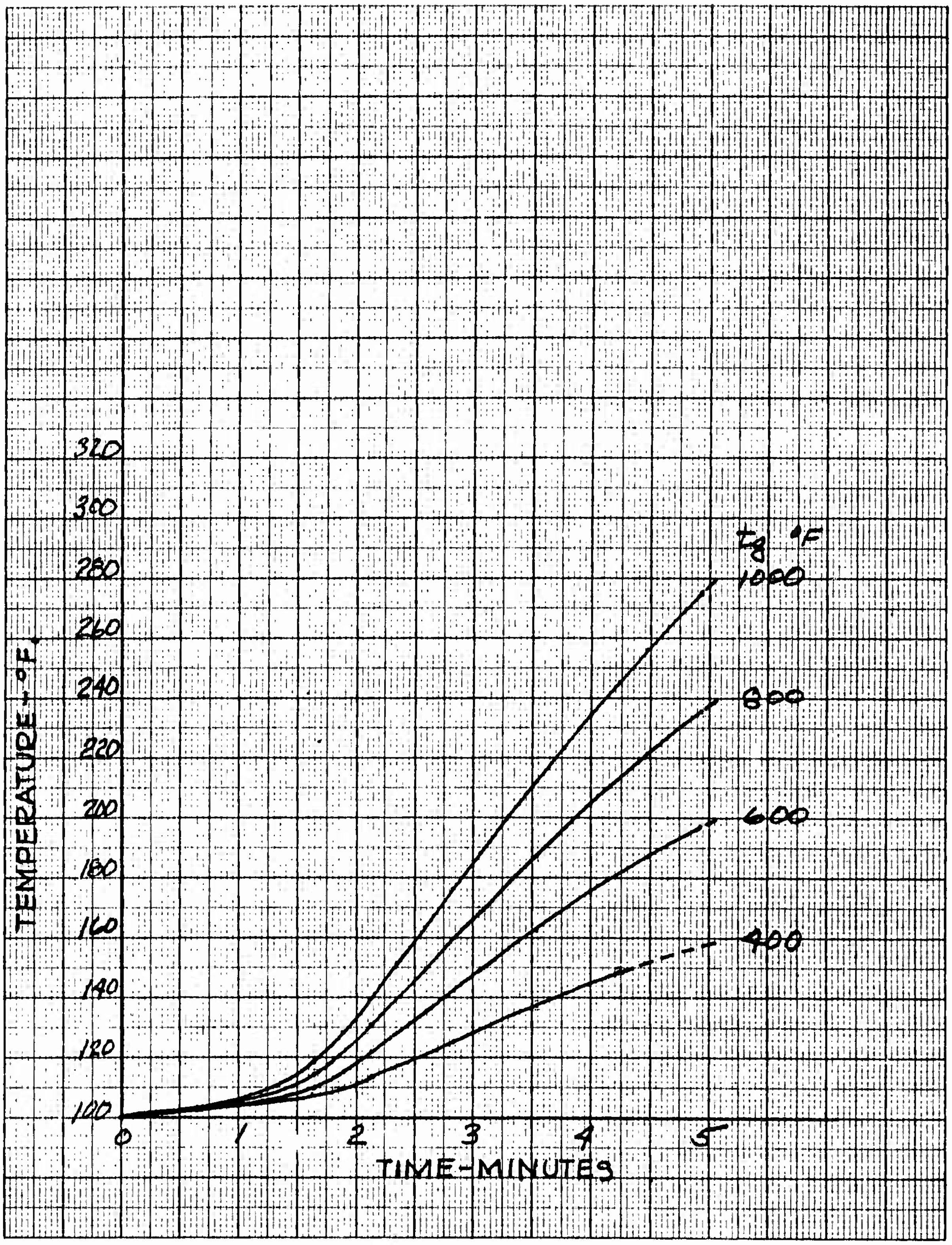

Figure 9.120 Skin Temperature-Time Profiles Vs Gas Temperature
0.375" Min K Insulation on .025" Titanium

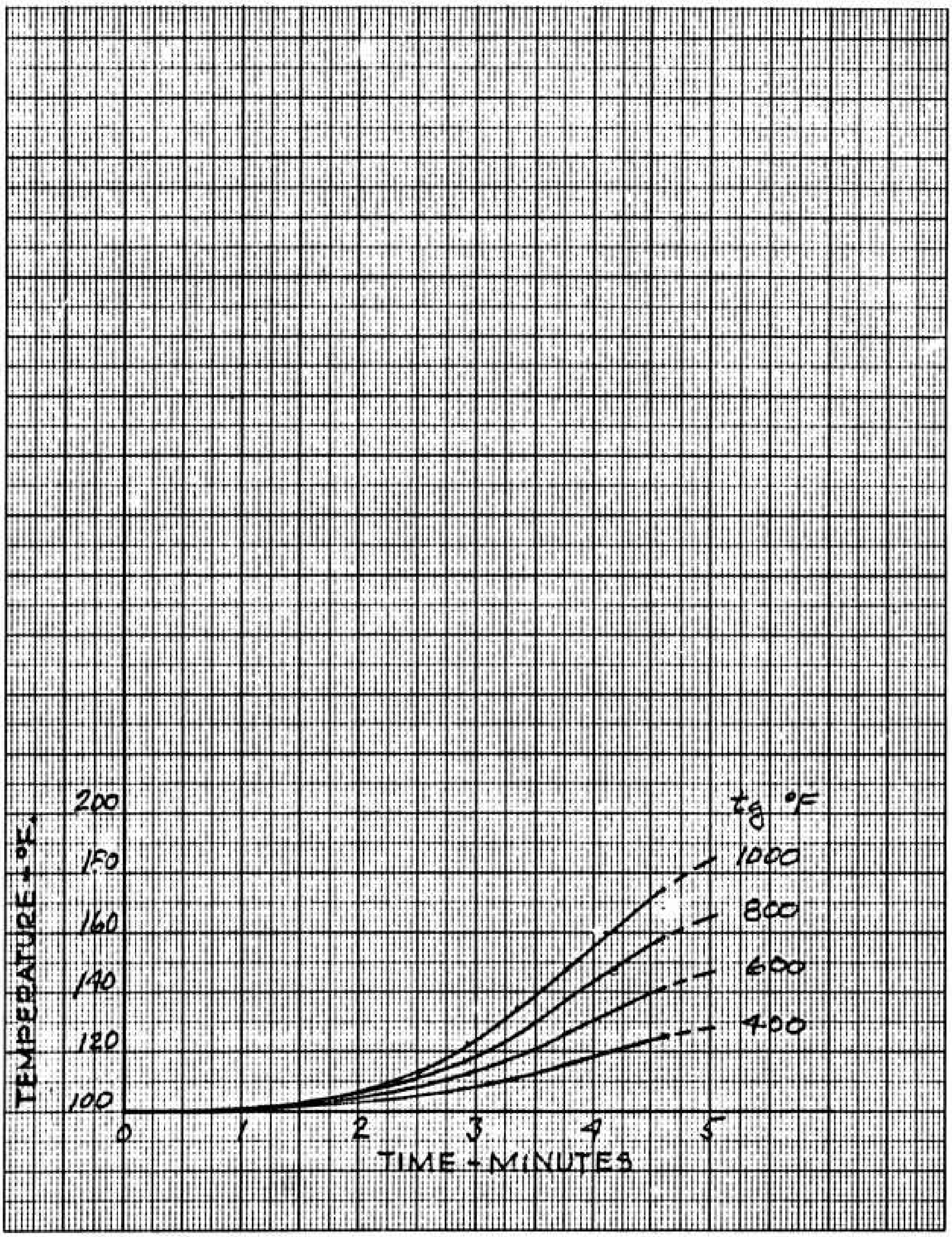

Figure 9.121 Skin Temperature-Time Profiles Vs Gas Temperatures
0.50" Min K Insulation on .025" Titanium

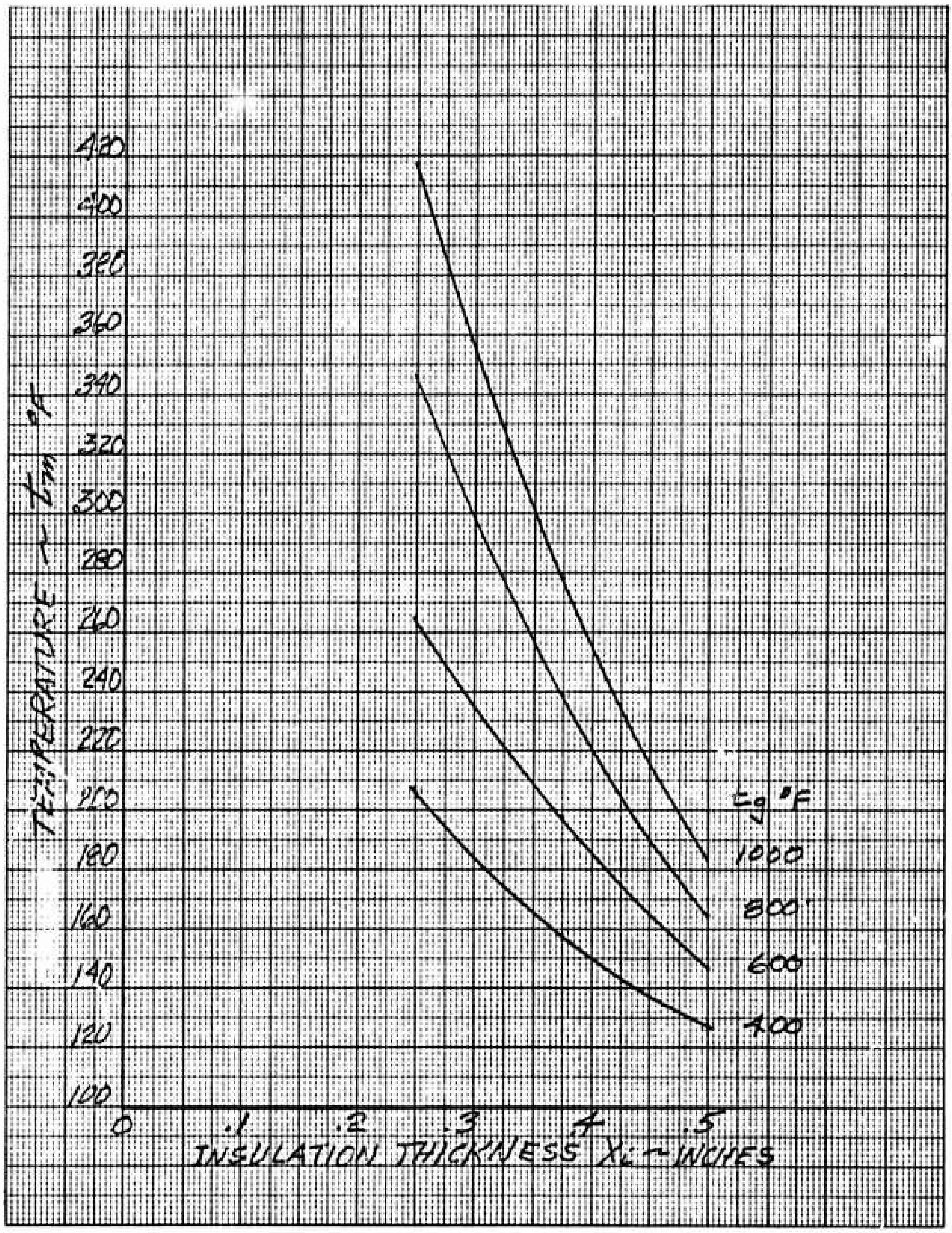

Figure 9.122 Skin Temperature Vs Insulation Thickness and Gas Temperature After 5 Minutes Exposure

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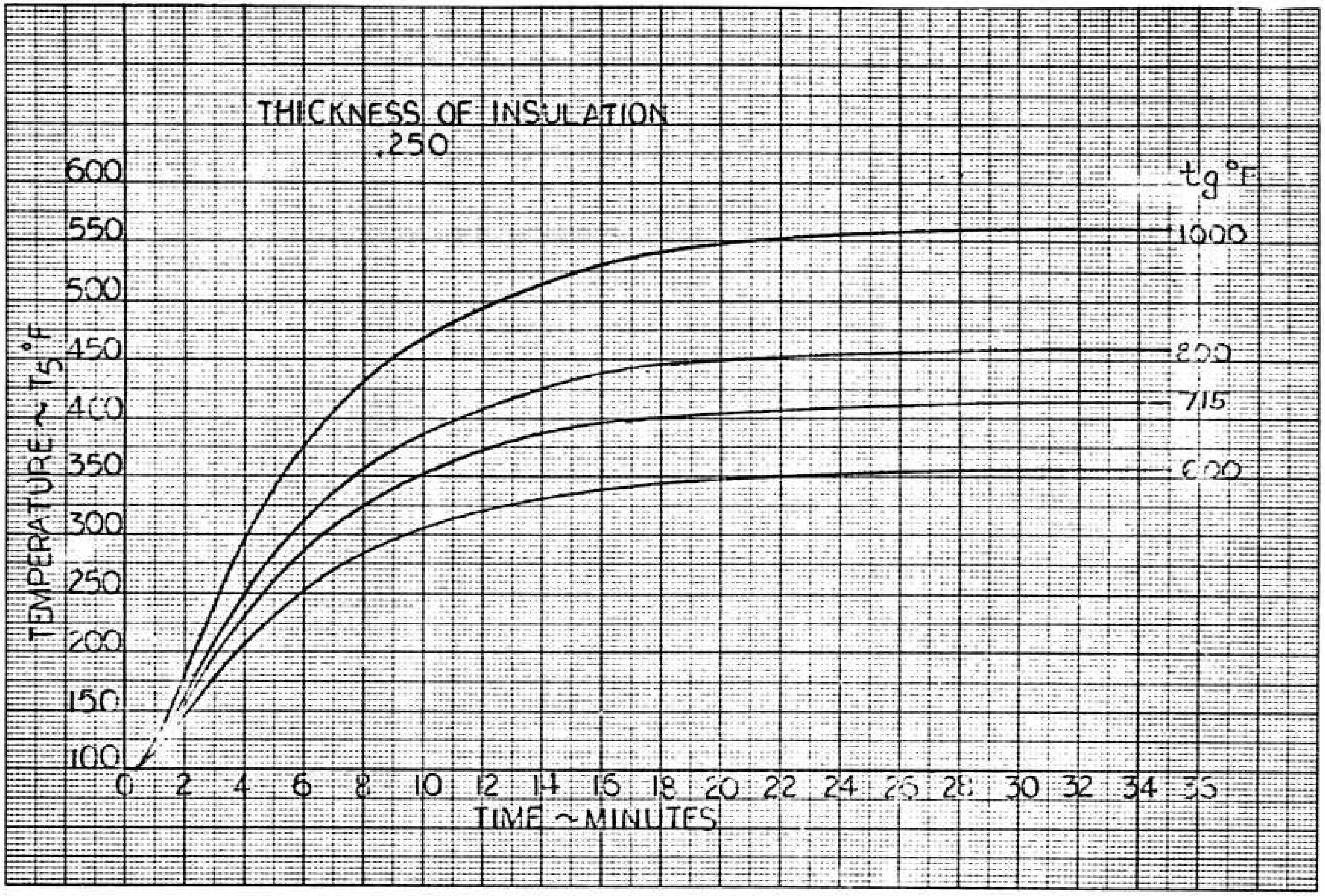

Figure 9.123 Skin Temperature-Time Profiles Vs Gas Temperature
0.25" Min K Insulation on .040" Aluminum

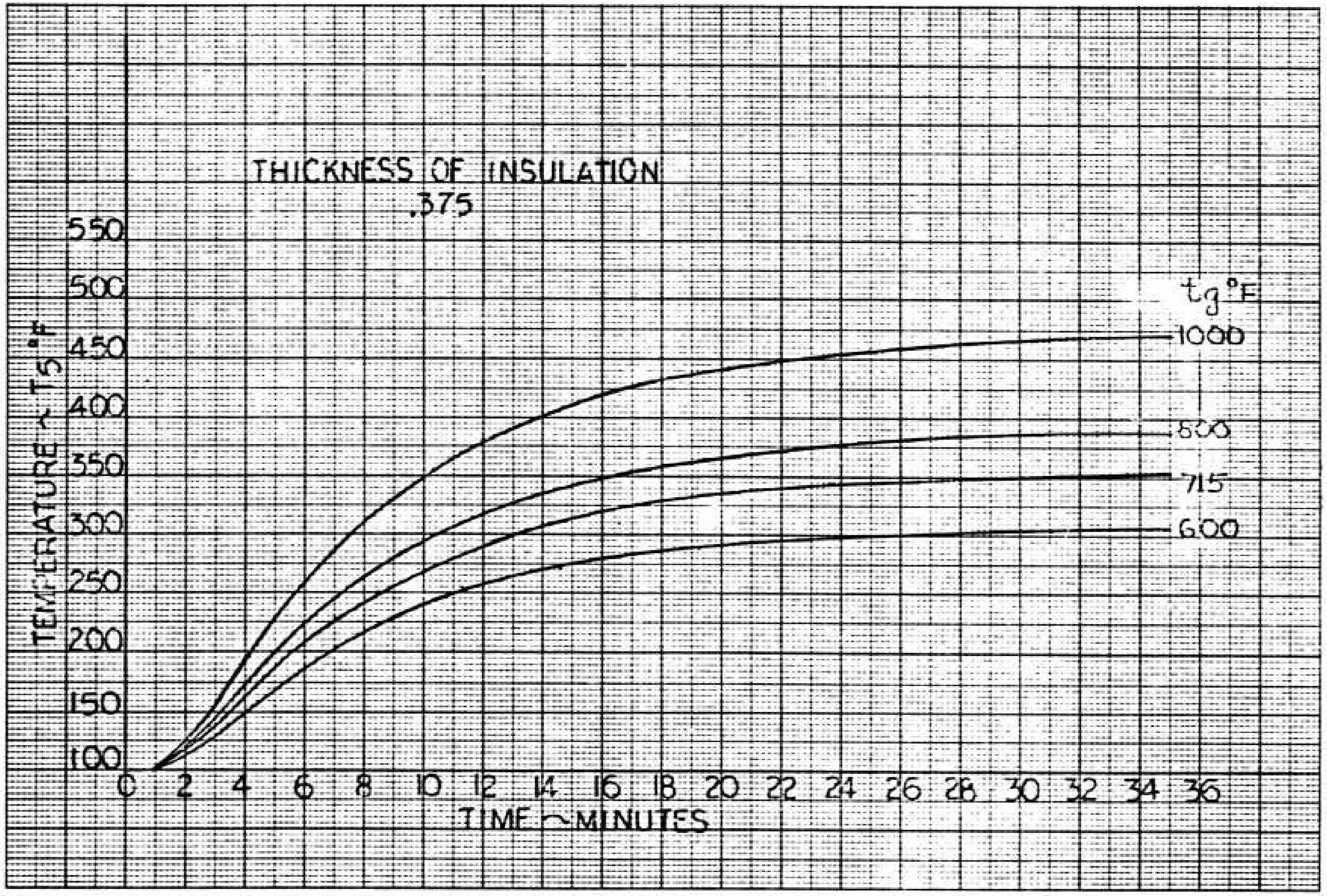

Figure 9.124 Skin Temperature-Time Profiles Vs Gas Temperature
0.375" Min K Insulation on .040" Aluminum

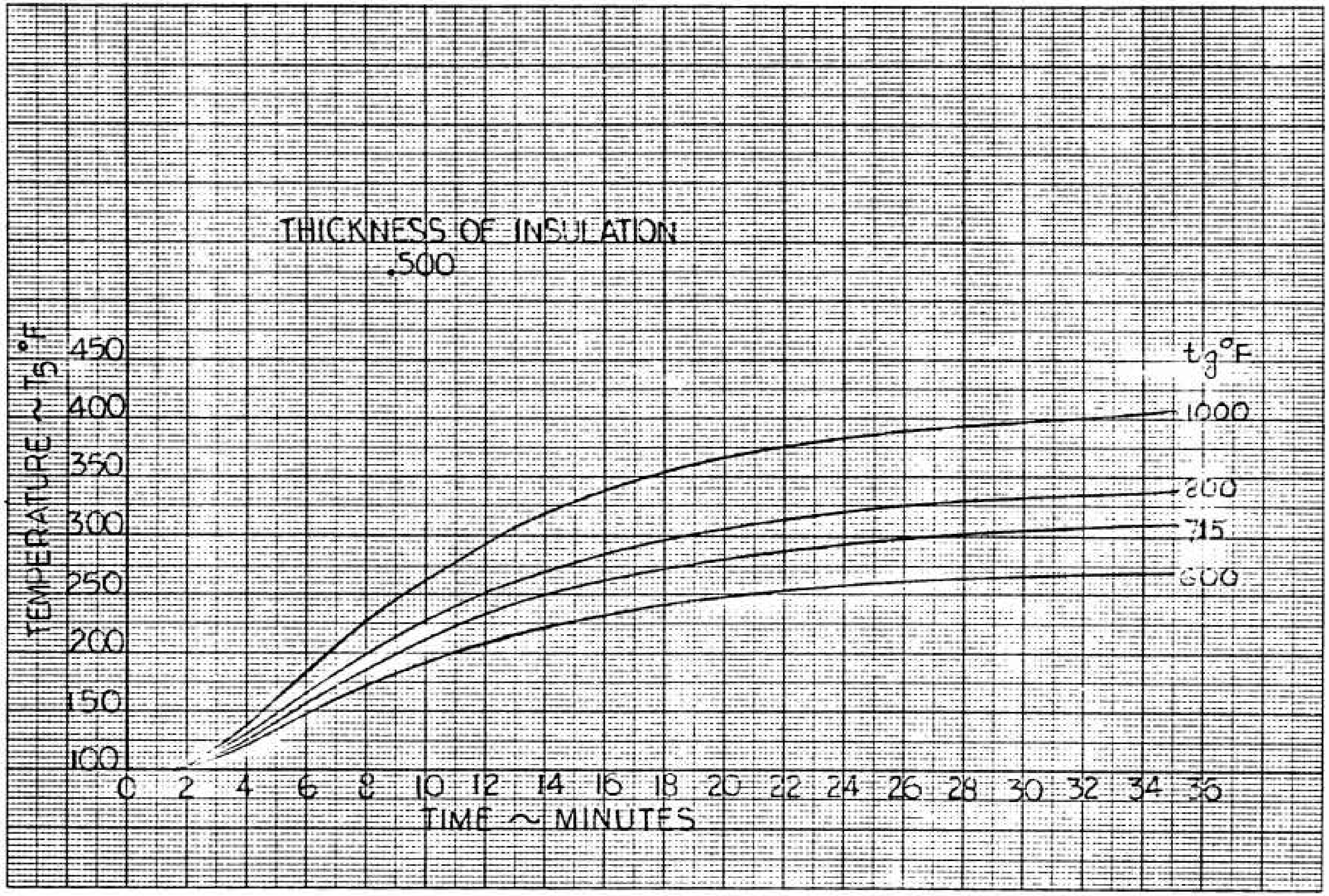

Figure 9.125 Skin Temperature-Time Profiles Vs Gas Temperature
0.500" Min K Insulation on .040" Aluminum

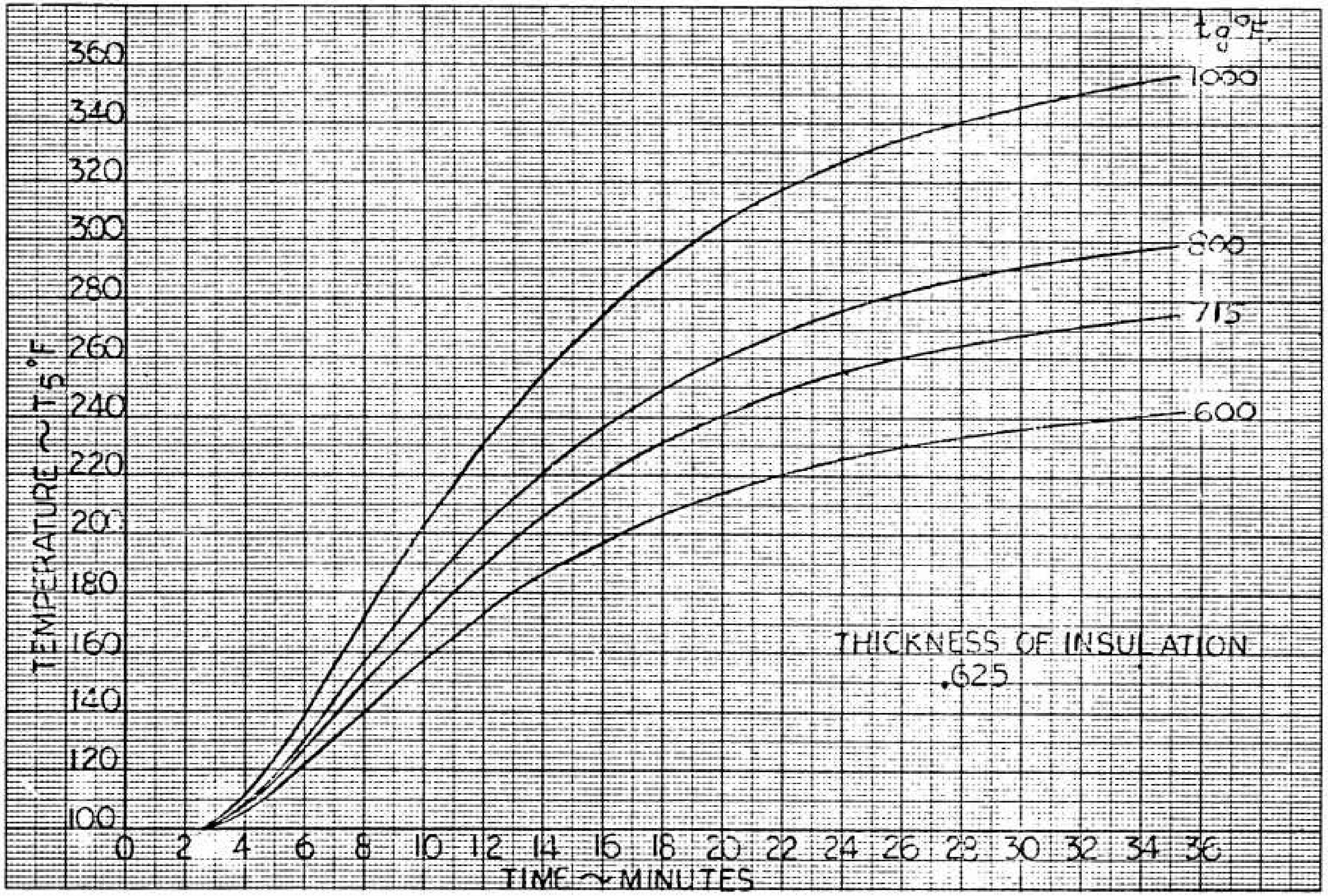

Figure 9.126 Skin Temperature-Time Profiles Vs Gas Temperature 0.625" Min K Insulation on .040" Aluminum

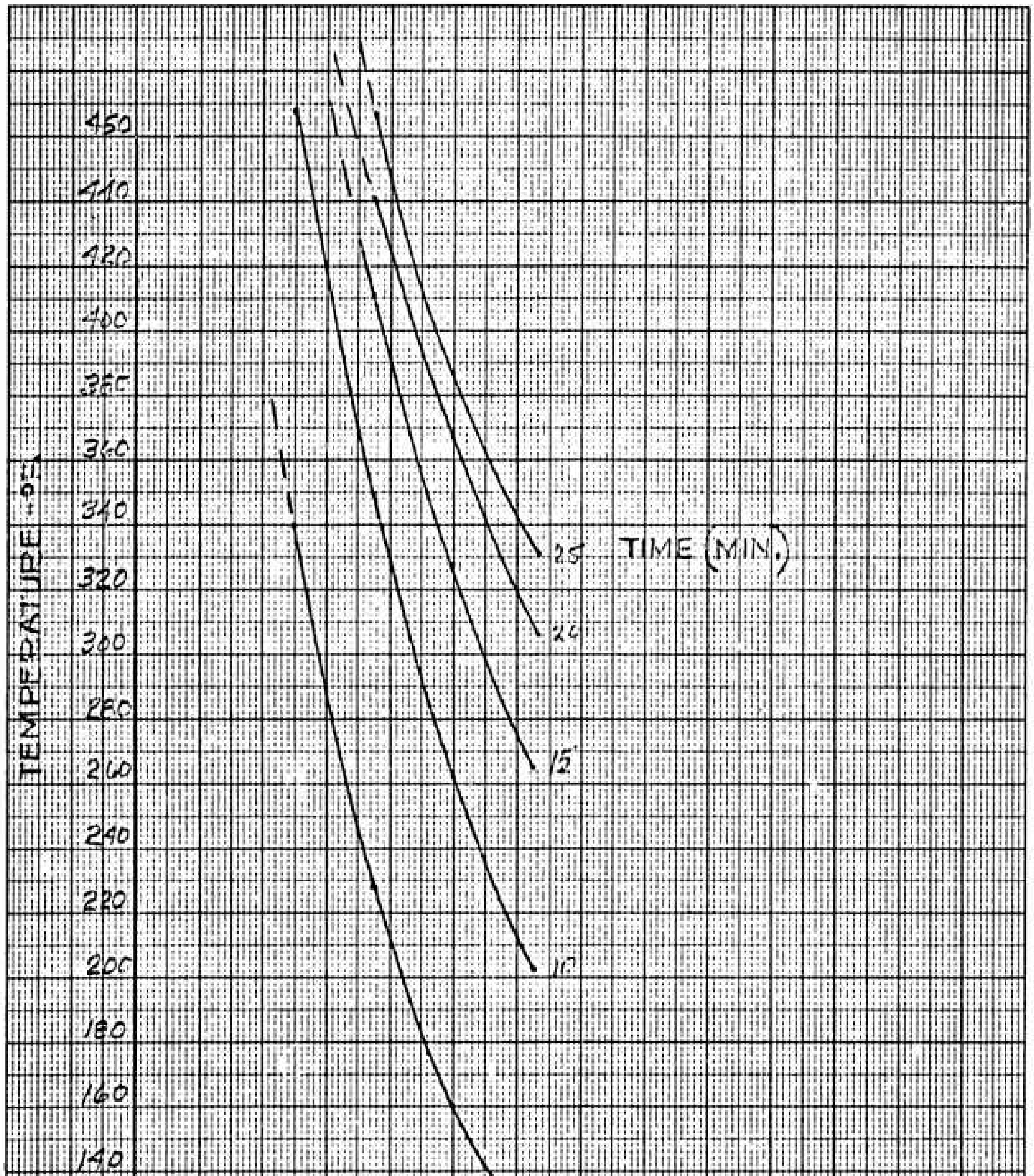

Figure 9.127 Skin Temperature Vs Insulation Thickness and Exposure Time; Gas Temperature 1000°F, and Aluminum Skin

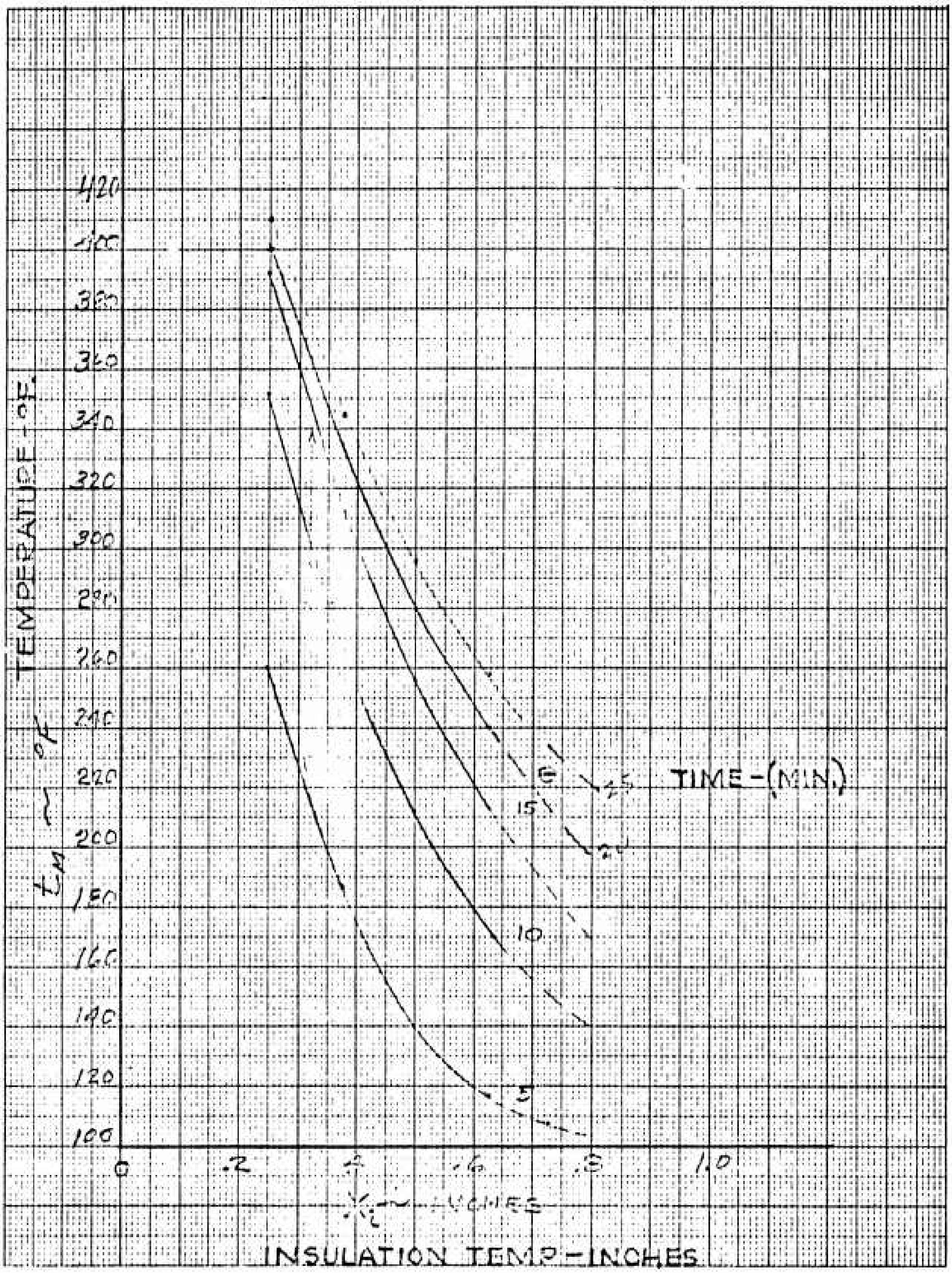

Figure 9.128 Skin Temperature Vs Insulation Thickness and Exposure Time; Gas Temperature 715° F, Aluminum Skin

ease. The validity of this method of transient analysis was established by comparison of predicted and experimentally determined temperature-time profiles as shown in Figures 9.117 and 9.118.

As an aid to selection of insulation thickness, temperature-time profiles were calculated for the series of 28 cases summarized in Table 9.11. These data and convenient cross-plots are presented in Figures 9.119 to 9.128.

9.6 NASA-AMES DATA FOR FULL SCALE XV-5A MODEL TEST 177

This section presents available data obtained from full scale XV-5A Model tests during NASA-Ames Test 177 conducted between 6 December 1962 and 18 January 1963. Test 177 was conducted primarily to obtain the aerodynamic characteristics of a full scale XV-5A model which are presented in Reference 19. Therodynamic considerations, particularly structural and evnironmental temperatures, were of secondary concern; however, approximately 24 temperature recording channels were available for gathering the test data summarized in Sections 9.6.5 through 9.6.7. A few unidentified installation photographs are presented in Section 9.6.1. Various other interpretive and supporting data are also presented. In all cases data is fragmentary, however, it represents the best data available at the time critical aircraft design decisions were being made. Mostly, the temperature data was used as recorded, but in a few instances corrections were required as outlined. Conversion of data from one set of operating conditions to another was accomplished by the correlating method of Section 5.3.5.2. The Test 177 data are presented in the following sections without further discussions.

9.6.1 Run Schedule NASA-Ames Test 177

This briefly indicates the test conditions established for the runs of Test 177. Rune 1 - 53 were conducted in the 40' x 80' Wind Tunnel at the NASA-Ames Research Center, Moffett Field, California. Runs 54 - 56 were outside ramp tests conducted at the same facility.

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TEST 177 RUN SCHEDULE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	RUN NO.	VARIABLE	β	α	h/D	RPM_{LRF}	RPM_{RWF}	RPM_{RF}	V_{KTS}	δ_F	i_T	THRUST REVERSER	PLOTS	
1	1	RPM_{LRF}	0	0	1.7		~	0	0	45	0	SCALED	RPM vs LIFT	
2	2	RPM_{RWF}	0	0	2.2	0	~	0	0	45			RPM vs LIFT	
3		RPM_{LWF}	"	"	"	~	0	"	"	"				
4		RPM BOTH	"	"	"	~	~	"	"	"				
5	3	RPM_{RWF}	0	0	1.7	0	~	0	0	45				
6		RPM BOTH	"	"		~	~	"	"	"				
7	4	V	0	0	1.0	1700	1700	0	~	45				
8		RPM_{RWF}	"	"	"	0	~	"	0	"				
9		RPM_{LWF}	"	"	"	~	0	"	"	"				
10		RPM BOTH	"	"	"	~	~	"	"	"				
11	5	β	~	0	1.0	1700	1700	0	20	45				μ vs C_L Column
12		α	0	0.4	"	"	"	"	40	"			V=20 (MC 1)	
13		α	0	0	"	"	"	"	60	"				
14	6	α	0	-4.0	1.0	1700	1700	0	80	45			~(MCs 1 & 2)	μ vs C_L Column
15	7	β,V	~	0	1.0	1700	1700	0	80,60,40,30	45				μ vs C_L Column
16		α	0	~	"	"	"	"	80	"			~(MC 1 & 2)	
17		α	0	~	"	"	"	"	60	"			~(MC 1 & 2)	
18		α	0	~	"	"	"	"	40	"			~(MC 1 & 2)	
19		α	0	~	"	"	"	"	30	"			~(MC 1 & 2)	
20	8	β,V	~	0	1.0	1700	1700	0	30,40,60,80	45				μ vs C_L Column
21		α	20	~	1.0	1700	1700	"	30	"			~(MC 1 & 2)	(β = 20)
22		α	20,35	~	"	"	"	"	40	"			~(MC 1 & 2)	(BOTH β)
23		α	20,35	~	"	"	"	"	60	"			~(MC 1 & 2)	(BOTH β)
24		α	35	~	"	"	"	"	80	"			~(MC 1 & 2)	(β = 35)
25	9	α	0	~	1.7	1700	1700	0	30	45			~(MC 1 & 2)	
26		α	0	~	"	"	"	"	40	"				
27		α	0	~	"	"	"	"	60	"				
28		α	0	~	"	"	"	"	80	"				
29														μ vs C_L Column
30														

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Test 177 Run Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Run No.	Var.	β	α	H/D	RPM LF	RPM RF	RPM DF	V_{KTS}	δ_F	i_T	Thrust Reverser						Plots	
1	10	–	20°	0	1.7	1700	1700	0	20	45	0	[illegible]						μ vs C_L C_m	
2		α	20	~	"	"	"	"	30									~ (MC 1 & 2)	
3		α	20	~	"	"	"	"	40										
4		α	20	~	"	"	"	"	60										
5		–	20	0	"	"	"	"	20									μ vs C_L C_m	
6	11	α & β	~@α=0	~@β=35	1.7	1700	1700	0	40									~ (MC 1 & 2)	
7		α & β	~@α=0	~@β=35	"	"	"	"	80										
8		α & β	~@α=0	~@β=35	"	"	"	"	60										
9		β	~	0	"	"	"	"	30									μ vs C_L C_m	
10																			
11		α		~					20										
12	12	β	~	0	1.7	1700	1700	0	20									μ vs C_L C_m	
13	13	β	~	0	2.2	1700	1700	0	20									μ vs C_L C_m	
14		α	0	~	"	"	"	"	30									~ (MC 2)	
15		β	~	0	"	"	"	"	"									μ vs C_L C_m	
16		α	20	~	"	"	"	"	"										
17		α	0	~	"	"	"	"	60									~ (MC 1 & 2)	
18		β	~	0	"	"	"	"	60									μ vs C_L C_m	
19		α	20	~	"	"	"	"	60									~ (MC 1 & 2)	
20	14	α	0	~	2.2	1700	1700	0	40									~ (MC 1 & 2)	
21		β	~	0	"	"	"	"	40									μ vs C_L C_m	
22		α	20	~	"	"	"	"	40									~ (MC 1 & 2)	
23		α	0	~	"	"	"	"	80									~ (MC 1 & 2)	
24		β	~	0	"	"	"	"	80									μ vs C_L C_m	
25		α	35	~	"	"	"	"	80									~ (MC 1 & 2)	
26		α	35	~	"	"	"	"	40									~ (MC 1 & 2)	
27		α	35	~	"	"	"	"	60									~ (MC 1 & 2)	
28	15	T/R	0	0	2.2	0	0	2000	0			~						P.F. Thrust	
29		T/R						2600				~						vs. Reverser	
30																		Position	

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Test 177 Run Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	RUN NO.	VARIABLE	β	α	h/D	RPM L.F	RPM R.F	RPM P.F.	V_{KTS}	δF	i_T	THRUST REVERSER	PLOTS	
1	(16)	T/R	0	0	2.2	1700	1700	2400	30	45	0	~		μ vs CL Cm
2		α	"	~		1700	1700	2400	30			45		~(MC 1)
3		T/R	"	0		1400	1400	1700	40			~		μ vs CL CD Cm
4		T/R	"	~		1200	1200	1600	40			~		
5		α	"	~		1200	1200	1600	40			60		~(MC 1)
6		T/R	"	0		"	"	"	60			~		μ vs CL CD Cm
7		α	"	~		"	"	"	60			60		~(MC 1)
8		T/R	"	0		"	"	"	30			~		μ vs CL CD Cm
9		α	"	~		"	"	"	30			60		~(MC 1)
10	(17)	CORVUS OIL RUN BALANCE HOUSE DATA ONLY									h/D=2.2			
11	(18)	–	0	0	1.0	1700	1700	2400	30	45	0	0		
12		T/R	20	0	"	"	"	"	30			~		μ vs CL Cm
13		α	"	~	"	"	"	"	30			60		~(MC 1)
14		T/R	"	0	"	"	"	"	40			~		μ vs CL CD Cm
15		α	"	~	"	"	"	"	40			60		~(MC 1)
16		T/R	"	0	"	"	"	"	60			~		μ vs CL CD Cm
17		α	"	~	"	"	"	"	60			60		~(MC 1)
18		–	"	0	"	"	"	"	20			0		
19	(19)	α	20	~	1.7	1400	1400	1600	30	45	12	45	POLARS (~,MC 1)	
20		α	32	~	"	1200	1200	1600	40		12	60	THROUGH (~(MC 1))	
21		α	45	~	"	1200	1200	1600	50		16	60	TRIM (~(MC 1))	
22	(20)				1.7	PITCH FAN AND LEFT FAN ACCELERATION RUNS								
23	(21)	α	15	~	2.2	1700	1700	2400	30	45	16	60		(MC 1)
24		α	22	~	"	1700	1700	2400	40	"	16	60	POLARS	(MC 1)
25		α	35	~	"	1700	1700	0	60	"	17	0	THROUGH TRIM	(MC 1)
26		α	45	~	"	1700	1700	0	70?	"	17	0		(MC 1)
27														
28														
29														
30														

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177 Run Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Run No.	Variable	β	α	h/D	RPM LF	RPM RF	RPM PF	V KTS	δF	iT	Thrust Reverser		
1	22	β	~	0	2.2	1700	1700	0	30	45	0	Sealed	U vs CL CD Cm	
2		α & β	~@α:0	~@β:0	"	"	"	"	40	"	"		SPLIT	(MC 1)
3		α & β	~@α:0	~@β:0	"	"	"	"	60	"	"		AILERON	(MC 1)
4		α & β	~@α:0	~@β:0	"	"	"	"	80	"	"		ON δα ±30°	(RC1)
5		α	-12	~	"	"	"	"	60	"	"			(MC 1)
6		α	-12	~	"	"	"	"	40	"	"			(MC 1)
7	23	β	~	0	1.0	1700	1700	0	30	45	0	Sealed		U vs CL CD Cm
8		α	20	~	"	"	"	"	30	"	"			(MC 1)
9		β	~	0	"	"	"	"	40	"	"			U vs CL CD Cm
10		α	20	~	"	"	"	"	40	"	"			(MC 1)
11		α	20	~	"	"	"	"	60	"	"			(MC 1)
12	24	β	~	0	1.0	1700	1700	0	20	45	0	Sealed		U vs CL CD Cm
13		1 POINT	30	0	"	"	"	"	40	"	"			
14		β	~	0	"	"	"	"	60	"	"			U vs CL CD Cm
15		β	~	0	"	"	"	"	80	"	"			U vs CL CD Cm
16	25				1.7			"	~	45	0	"	SMOKE	RUN.
17	26	α & β	~@α:0,10	~@β:0	1.7	1700	1700	0	30	45	0	"	U vs CL CD Cm	(MC 1)
18		α & β	~@α:0	~@β:0	"			"	40	"	"	"	U vs CL CD Cm	(MC 1)
19		α & β	~@α:0	~@β:0	"			"	60	"	"	"	U vs CL CD Cm	(MC 1)
20		α & β	~@α:0	~@β:0	"			"	80	"	"	"	U vs CL CD Cm	(MC 1)
21		β	~	0	"			"	20	"	"	"	U vs CL CD Cm	
22	27	α	0	~	2.2	1700	1700	0	30	45	0	Sealed		(MC 1)
23		β	~	0	"	"	"	"	30	"	"	"	U vs CL CD Cm	
24		α	0	~	"	"	"	"	40	"	"	"		(MC 1)
25		β	~	0	"	"	"	"	40	"	"	"	U vs CL CD Cm	
26	28	α & β	~@α:0	~@β:0	2.2	1700	1700	0	30	45	OFF	Sealed	U vs CL CD Cm	(MC 1)
27		α & β	~@α:0	~@β:0,20	"	"	"	"	60	"	"	"	U vs CL CD Cm	(MC 1)
28		α & β	~@α:0	~@β:20	"	"	"	"	80	"	"	"	U vs CL CD Cm	(MC 1)
29		α & β	~@α:0	~@β:0,20	"	"	"	"	40	"	"	"	U vs CL CD Cm	(MC 1)
30		α	20	~	"	"	"	"	30	"	"	"		(MC 1)
ARC 711(b)		β	~	0	"	"	"	"	20	"	"	"	U vs CL CD Cm	

Test 177 Run Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Run No.	Variable	β	α	h/D	RPM L.F	RPM R.F	RPM P.F	V_{KTS}	SF	i_T	Thrust Reverser		
1	29	V	15	0	1.0	1700	1700	0	~	45	OFF	Sealed	Cowls	Oil RV
2	30	β&α	~α=0	~β=20	1.7	1700	1700	Sealed	30	45	OFF	Sealed	UVSGGG	(MCI)
3		β&α	~α=0	~β=0	"	"	"	"	40	"	"	"	UVSGGG	(MCI)
4		β&α	~α=0	~β=20	"	"	"	"	60	"	"	"	UVSGGG	(MCI)
5		α	20	~β=20	"	"	"	"	80	"	"	"		(MCI)
6		α	0	~β=0	"	"	"	"	60	"	"	"		(MCI)
7		α	20	~β=20	"	"	"	"	40	"	"	"		(MCI)
8		α	0	~β=0	"	"	"	"	30	"	"	"		(MCI)
9		β	~	0	"	"	"	"	20	"	"	"	UVSGGG	
10	31	α	30	~	1.0	OFF	OFF	"	60	"	"	"	Power	OFF (MCI)
11		α	30	~	"	"	"	"	80	"	"	"	Inlet Doors	OFF
12	32	V	30	0	1.0	1700	1700	"	~	45	"	"	Cowls	Oil
13	33	β	~	0	1.0	1700	1700	"	30	"	"	"	UVSGGG	
14		β	~	0	"	"	"	"	40	"	"	"	UVSGGG	
15		β	~	0	"	"	"	"	60	"	"	"	UVSGGG	
16		β	~	0	"	"	"	"	80	"	"	"	UVSGGG	
17		β	~	0	"	"	"	"	20	"	"	"	UVSGGG	
18	34	β	~	0	2.2	1700	1700	"	30	45	"	"	UVSGGG	
19		β	~	0	"	"	"	"	40	"	"	"	UVSGGG	
20		β	~	0	"	"	"	"	60	"	"	"	UVSGGG	
21		β	~	0	"	"	"	"	80	"	"	"	UVSGGG	
22	35	α&β	β@α=0	α@β=0	2.2	1700	1700	2400	30	45	OFF	0	UVSGGG	(MCI)
23		α&β	β@α=0	α@β=0	2.2	"	"	"	40	"	"	"	UVSGGG	(MCI)
24		α&β	β@α=0	α@β=0	"	"	"	"	60	"	"	"	UVSGGG	(MCI)
25		α&β	β@α=0	α@β=0	"	"	"	"	80	"	"	"	UVSGGG	(MCI)
26		β	~	0	"	"	"	"	20	"	"	"	UVSGGG	
27														
28														
29														
30														

ARC 711(b)

TEST 172 RUN SCHEDULE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	RUN NO.	VARIABLE	β	α	h/D	RPM LF	RPM RF	RPM PF	V KTS	δF	i_T	THRUST REVERSER	PLOTS	
1	36	α	0	~	1.0	1700	1700	2400	30	45	OFF	45	TUNNEL OPEN	
2		α & β	~ β α=0	~ β β=0	"	"	"	"	"	"	"	"	TUNNEL CLOSED	
3		β	~	0	"	"	"	"	"	"	"	0	UVsCLCD	
4		β	~	0	"	"	"	"	40	"	"	0 & 60	UVsCLCD	
5		β	~	0	"	"	"	"	60	"	"	60	UVsCLCD	
6		α	0	~	"	"	"	"	60	"	"	0		MC #1
7		α	20	~	"	"	"	"	40	"	"	30 & 45		MC #1
8	37		20	0	1.0	SMOKE STUDY			12 #/FT² TO	0		45		
9	38	α	20	~	2.2	1700	1700	2400	40	45	OFF	30,45,60	0	MC #1
10		α	20	~	"	1700	1700	1700	40	"	"	0		MC #1
11		α	20	~	"	1700	1700	2100	40	"	"	0		MC #1
12		α	20	~	"	1700	1700	1700	60	"	"	0		MC #1
13		α	20	~	"	1700	1700	1700	30	"	"	0		MC #1
14		α	20	~	"	1700	1700	1700	30	"	"	0		MC #1
15	39	β	~	0	1.0	1700	1700	2400	40	0	OFF	60	UVsCLCD	
16		β	~	"	"	"	"	"	60	"	"	"	UVsCLCD	
17		β	~	"	"	"	"	"	80	"	"	"	UVsCLCD	
18		β	~	"	"	"	"	"	20	"	"	"	UVsCLCD	
19	40	β	~	0	2.2	1700	1700	2400	60	0	OFF	60	UVsCLCD	
20		β	~	"	"	1500	1500	2000	70	"	"	"	UVsCLCD	
21		β	~	"	"	1700	1700	2400	40	"	"	"	UVsCLCD	
22		β	~	"	"	1700	1700	2400	30	"	"	"	UVsCLCD	
23		β	~	"	"	1700	1700	2400	20	"	"	"	UVsCLCD	
24	41	β	~	0	1.0	1700	1700	2400	40	45	OFF	60	UVsCLCD	
25		-	15	0	"	2400	2400	2400	40	45	"	"	1 DATA POINT	
26		β	~	"	"	1700	1700	2400	60	"	"	"	UVsCLCD	
27		β	~	"	"	1700	1700	2400	80	"	"	"	UVsCLCD	
28		β	~	"	"	1700	1700	2400	30	"	"	"	UVsCLCD	
29		β	~	"	"	1700	1700	2400	20	"	"	"	UVsCLCD	
30														

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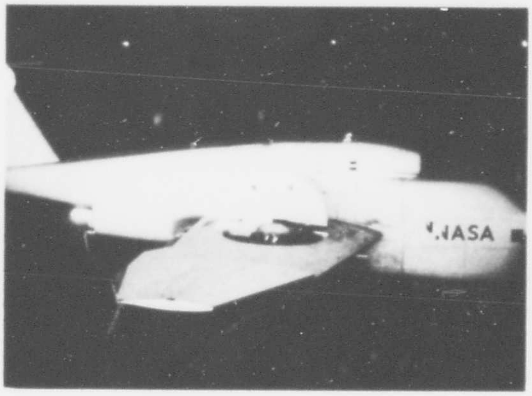
TEST 177 RUN SCHEDULE

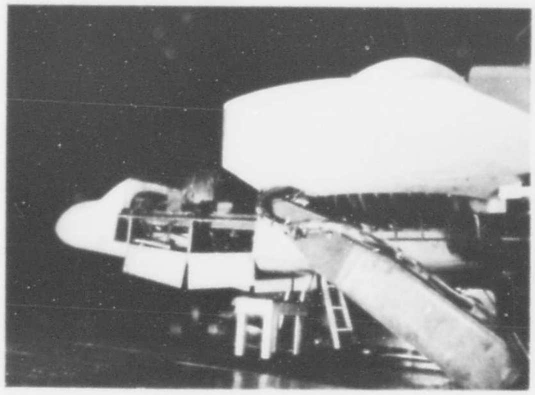
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	RUN NO.	VARIABLE	β	α	H/D	RPM L.M.F.	RPM R.M.F.	RPM P.F.	V_{KTS}	δ_f	i_T	THRUST REVERSER	PLOTS	
1	42	–	15	0	1.0	SMOKE	STUDY	12#/FT² TO		0	—	0		
2	43	REVERSER	—	0	2.2	– SEALED –		2400	30	45	OFF	~	H vs C.G.	
3		α	—	~	"	"	"	2400	30	"	"	60		(MC #1)
4		REVERSER	—	0	"	"		2400	40	"	"	~	H vs C.G.	
5		α	—	~	"	"	"	2400	40	"	"	60		(MC #1)
6		REVERSER	—	0	"	"	"	2400	50	"	"	~	H vs C.G.	
7		α	—	~	"	"	"	2400	60	"	"	60		(MC #1)
8		REVERSER	—	0	"	"	"	2400	80	"	"	~	H vs C.G.	
9		α	—	~	"	"	"	2400	80	"	"	60		(MC #1)
10		REVERSER	—	0	"	"		2400	20	"	"	~	H vs C.G.	
11		α	—	~	"			2400	20	"	"	60		(MC #1)
12	44	ENGINE RPM	—	0	2.2	– SEALED –		SEALED	0	45	OFF	SEALED	STATICS	ON
13	45	α	—	~	2.2	RYAN THRUST		DIVERTER	80	45	OFF	ENGINE RPM @ 95%		
14														
15			POWER OFF RUNS											
16														
17	46	α	—	~	2.2	—	—	—	20	45	OFF	—		(MC #1)
18		"	—	"	"	—	—	—	40	"	"	—		(MC #1)
19		"	—	"	"	—	—	—	60	"	"	—		(MC #1)
20		"	—	"	"	—	—	—	80	"	"	—		(MC #1)
21	47	α	—	~	1.7	—	—	—	80	45	OFF	—		(MC 1)
22	48	α	—	~	1.0	—	—	—	80	45	OFF	—		(MC 1)
23	49	α	—	~	2.2	—	—	—	80	0	OFF	—		(MC 1)
24	50	α	—	~	2.2	—	—	—	80	45	0	—		(MC 1)
25	51	α	—	~	1.7	—	—	—	80	45	0	—		(MC 1)
26	52	α	—	~	1.0	—	—	—	80	45	0			(MC 1)
27	53	α	—	~	2.2	—	—	—	80	45	0	AILERONS ON		(MC 1)
28	54	RPM	0	0	1.0	} RAMP TESTS								
29	55	RPM	0	0	1.0				—	45	0	—		
30	56	RPM	0	0	1.0				—	45		—		

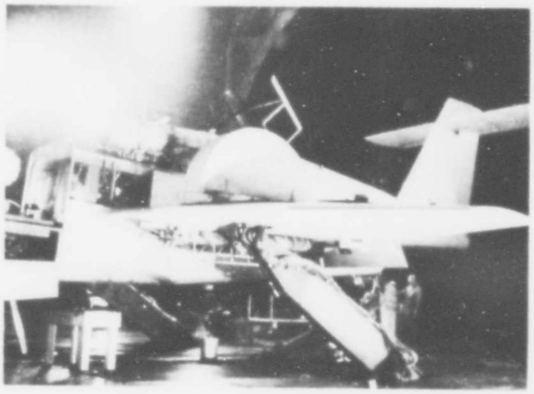
ARC 711(b)

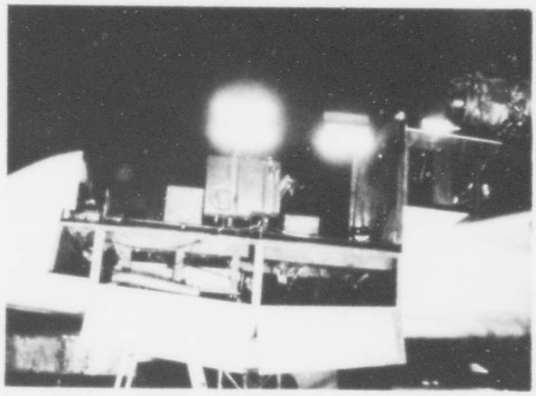
9.6.2 Installation and Model Photographs

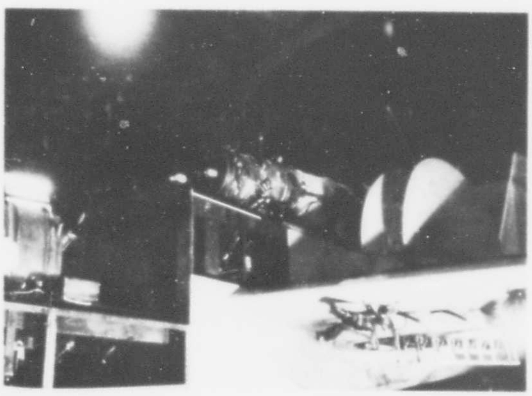
The installation and model photographs presented in this section, included primarily for documentation purposes, show various aspects of the full scale XV-5A Model including the two J85 gas generators for driving the wing fans, the T58 gas generator for driving the nose fan, method of model support, wing fan butterfly doors, louvers, and actuators, flap, tailpipes, thrust spoilers, landing gear environment thermocouple lattice and operators' console.

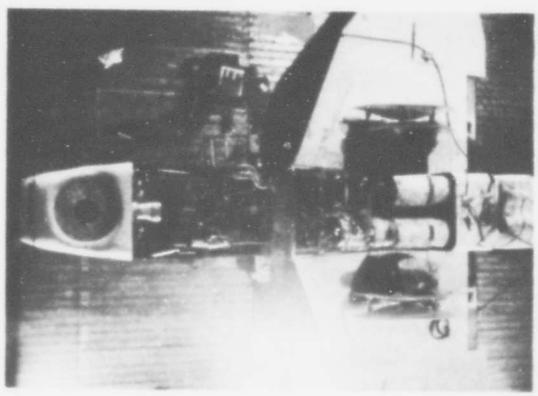

NASA

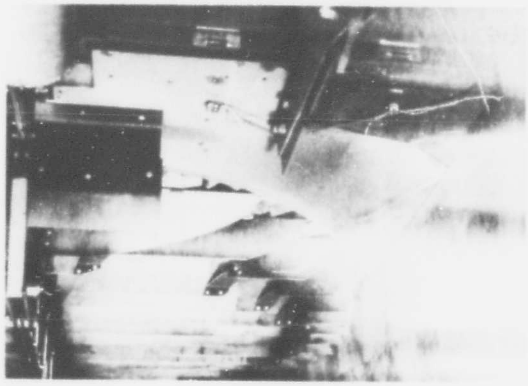


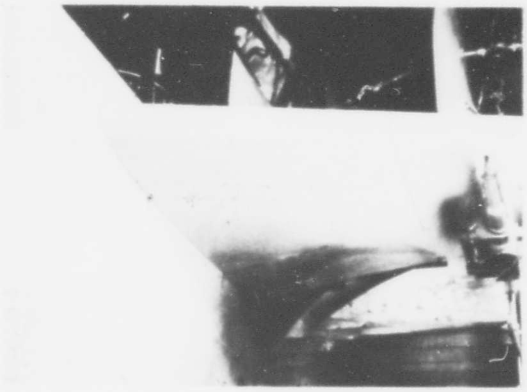


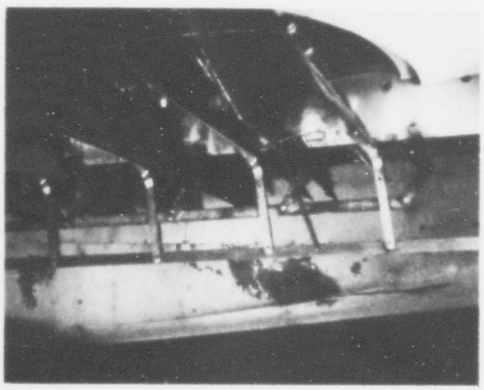


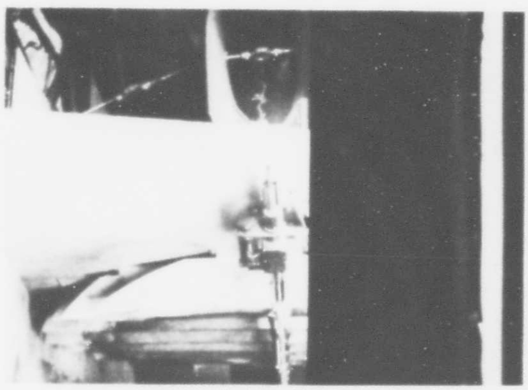


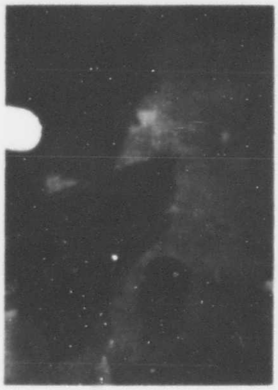
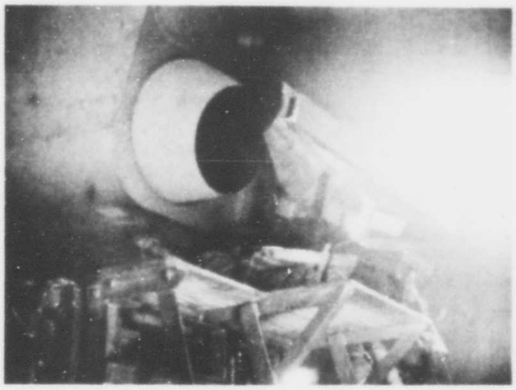
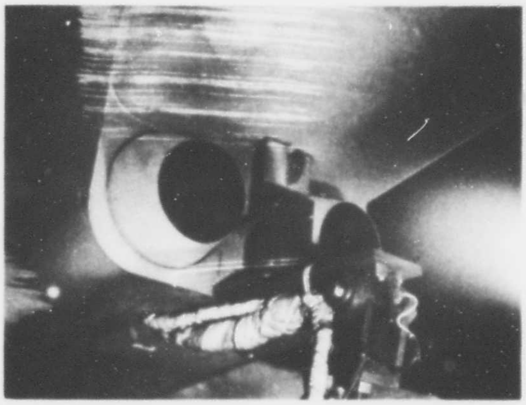
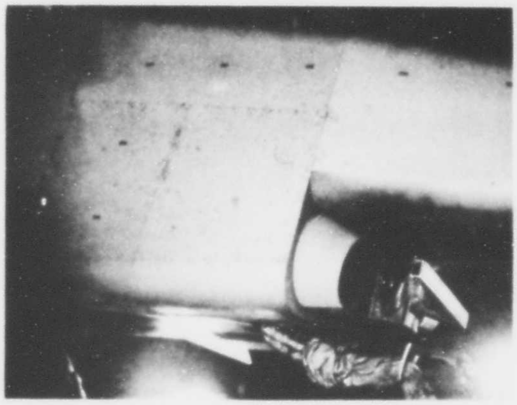
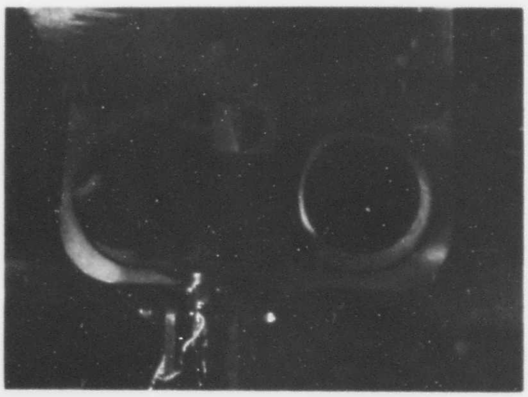


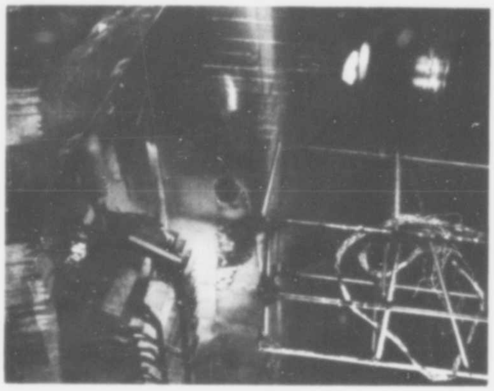
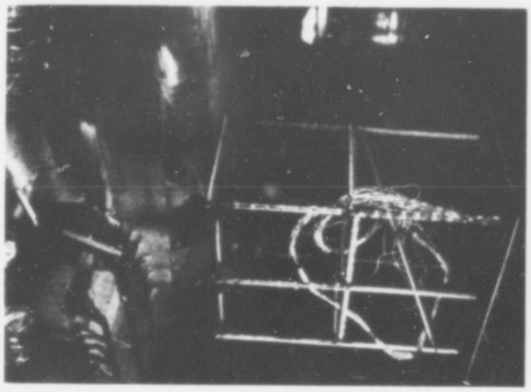
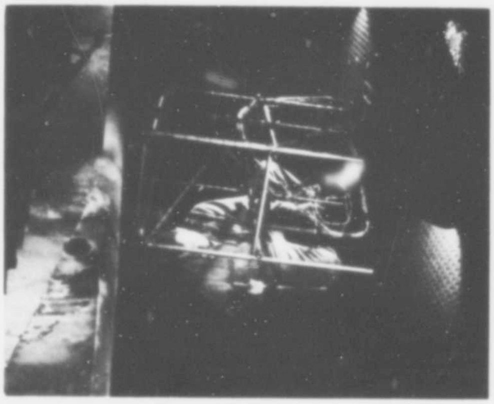
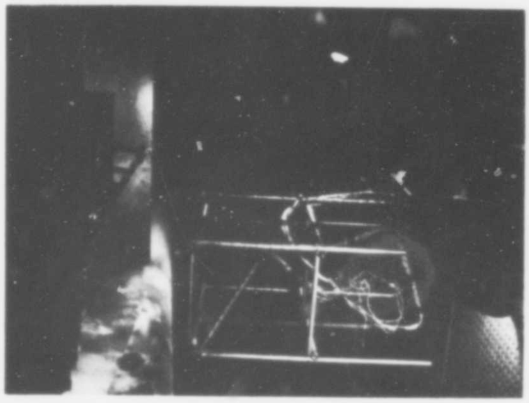
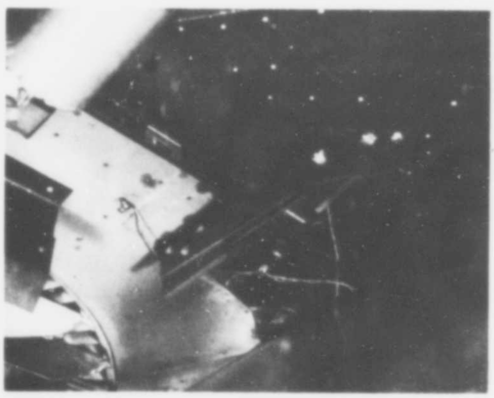
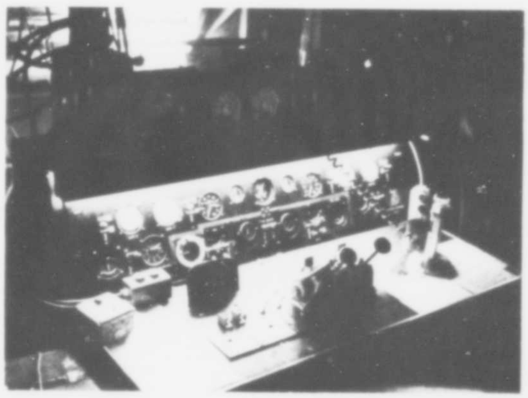








9.6.3 Engine Data

Operators' console data are presented in this section for the J85 and T58 gas generators used to drive the wing and nose fans, respectively. Where no data are presented, it generally means the particular engine(s) was (were) not operating. This may be verified by checking the Run Summary of Section 9.6.1.

RYAN 64B017

ENGINE DATA

30.19 BAR
71 Temp

	Left Eng								Right Eng										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Run	Date	RPM	EGT [illegible]	Disc Press	Temp Temp	[illegible]	Fuel	RPM	EGT	Disc Press	Temp Temp	[illegible]	Fuel	[illegible]				
1	1&2	12/6/[illegible]	49	570	32.[illegible]	57	18/20	140											
2			70	560	36.8	-	[illegible]/32	150											
3			71	560	40.3		[illegible]	150											
4			76	580	44	58	-												
5			[illegible]	610	[illegible]		[illegible]												
6			49						[illegible]										
7			71	[illegible]	36.[illegible]				73		[illegible]								
8			72		40				[illegible]		41.[illegible]								
9			[illegible]		43				[illegible]		45								
10																			
11	3	12/6							[illegible]	580	[illegible]	60				[illegible]			
12									73	[illegible]	[illegible]					72 [illegible]			
13									82	-	[illegible]		[illegible]						
14									[illegible]	-	[illegible]		[illegible]						
15			[illegible]	620	[illegible]	60			49	[illegible]	[illegible]								
16			70	550	36.1				70	[illegible]	[illegible]								
17			82		40.2				[illegible]	-	40.[illegible]								
18			[illegible]		42.[illegible]				[illegible]	-	[illegible]								
19																			
20	4	12/6	[illegible]	580	43	62	[illegible]	[illegible]	54.5	580	44		[illegible]	720	1700				
21			74		40.[illegible]	66			75		[illegible]			-	-				
22			87		41.6	[illegible]			87.5		42.[illegible]				-				
23			87.5						78.5		[illegible]				-				
24									50		32.[illegible]				795				
25						65			70	500	36.6				[illegible]				
26						[illegible]			[illegible]						15[illegible]				
27	[illegible]								87						1770				
28	[illegible]		52	550		67									750				
29			70	550											1170				
30			80	550											1500				

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(2)

	LEFT ENG								RIGHT ENG										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Run	Date	RPM	EGT	Disc. Press	Turbine Temp	oil	fuel	RPM	EGT	Disch Press	α	oil	fuel	[illegible] RPM	[illegible]	[illegible]	[illegible]	[illegible]
1	4	8/6	80	550	40	67													
2			86	"	43														
3			49	580	34				47.5	680	32				700				
4			70	500	36.5				72	500	37				1200				
5			76	"	39.5				78.5	"	41				1500				
6			81	"	43.2				81	"	45				1750				
7																			
8	5	8/10	72	500	43.6	57	✓	–	77	500	44.5		–	–	1750				
9			76	"	43.4	58	30/50	210	"	↓	43.7		40/60	220	1750				
10			24	"	"	60	30/45		85		44.1		30/55			15	15	15	15
11			82	520	43	63	30/32		85	↓	43.6					20	30	30	20
12			88.5	600	42.3	71			88.5	580	43.3		31/60			40	40	40	40
13			77	620	43	72			88	532	43.1		✓			0	0	0	0
14			83.7	561	41.5		35/60		86	520	43.0		33/60						
15																			
16	6	Data d[illegible]																	
17																			
18	7	12/10	84	500			40/30	200	85	500				225		+15	+15	+15	+15
19			84	510		67	40/26		85.5					235		+30	+30	+30	+30
20			84	510			40/25		85.5					225		+40	+40	+40	+40
21			83	510		69			85.5							+50	+50	+50	+50
22			84.5	520		70	40/25		86			+4		235		0	0	0	0
23			84.1	520		72	"		86			+6		"					
24			83	520			35/22		86			+4		"					
25			84.5	520			40/25		87			-4		225		↓	↓	↓	↓
26			84.5	520			"		87			0		225					
27			84.5	520		77	"		86.5	↓						-12	-12	-12	-12
28			85	530			38/22		86	480						+15	+15	+15	+15
29			84.5	530			35/30		85.5	490						+30	+30	+30	+30
30			84	530			45/25		86	490				↓		+40			

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	LEFT ENG								RIGHT ENG										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Run	Date	RPM	EGT	Disc. Pres	Trans Temp	Oil	Fuel	RPM	EGT	Disc Pres	α	Oil	Fuel	Fu Pres	B1	B2	B3	B4
1	7		82	540					84	500				225		+5			
2			85						86	5[illegible]		+4				0	0	0	0
3			85	7					8[illegible]	530		+2							
4			[illegible]	5[illegible]	42				[illegible]	570	43[illegible]	−4							
5			[illegible]		41.5	80			[illegible]		[illegible]	2							
6			85	6[illegible]	42		52/[illegible]		[illegible]	570	4[illegible]	0							
7			"	6[illegible]		81	52/30	200	[illegible]	"		−2							
8			77		42[illegible]	52	"		[illegible]	550	[illegible]	−4							
9			77.5		4[illegible]	7[illegible]	55/49		"	"	[illegible]	0							
10			"		4[illegible]	7[illegible]	[illegible]		"	"	"	−4							
11			"	7	4[illegible]	[illegible]	"	↓	"	"	4[illegible]	"				[illegible]	7	7	7
12																			
13	8	12/10	87	530	4[illegible]	64	[illegible]		[illegible]	530	4[illegible]		[illegible]			−12	−12	−12	−12
14			86.5	↓	4[illegible]	65		200	[illegible]		[illegible]			225		0	0		
15			85	7	"	[illegible]			"	7	[illegible]					−15	+15	[illegible]	[illegible]
16			85	510	4[illegible]	[illegible]	[illegible]		85	[illegible]	[illegible]		[illegible]			+20	→	→	→
17			83		42.5	75			8[illegible]		[illegible]					+4[illegible]	→	→	→
18			82		41.6	71			84		[illegible]					[illegible]	→	→	→
19			84.5		43	7[illegible]	54/[illegible]		87	7	[illegible]		[illegible]			20	→	→	→
20			85.5		[illegible]	74			90	530	[illegible]								
21			"		42[illegible]	75			[illegible]		[illegible]		[illegible]						
22			85		4[illegible]				87	7	4[illegible]								
23			85	500	4[illegible]	77			86.5	510	4[illegible]					↓	↓	↓	↓
24			"		42.7	"			[illegible]		[illegible]					7	7	7	7
25			85		"	7[illegible]			[illegible]		4[illegible]					3[illegible]	→	→	→
26			82.5		42	7[illegible]			85		43					4[illegible]	→	→	→
27			82		4[illegible]	"			84.5		[illegible]					5[illegible]	→	→	→
28		[illegible]	84.5	7	42	"			87	7	[illegible]					1[illegible]	→	→	→
29		[illegible]	85.5	530	4[illegible]	76			5[illegible]	550	[illegible]					0	→	→	→
30		"	59	"	4[illegible]	[illegible]			95	"	4[illegible]					−12	→	→	→

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Run	Date	RPM	EGT	Disc Press	Temp Temp	oil	Fuel	RPM	EGT	Disc Press	α	oil	Fuel	Fan RPM	β_1	β_2	β_1	β_2
1	[illegible]	[illegible]	[illegible]	500	42.2	80			[illegible]	500	[illegible]					[illegible]			
2			[illegible]		[illegible]	"			[illegible]		[illegible]					[illegible]			
3			[illegible]		42	81			[illegible]		[illegible]					25			
4			[illegible]		"	82	[illegible]	[illegible]	[illegible]		[illegible]								
5			"		"	"			"		[illegible]								
6			"			[illegible]					"								
7			[illegible]	[illegible]	42.2	[illegible]			[illegible]	[illegible]	44.3					20			
8			"			"			[illegible]		42.7								
9						"			"		[illegible]								
10			"			[illegible]			"		"								
11			[illegible]			[illegible]			86.5		[illegible]					25			
12			"	[illegible]	[illegible]	"			"	500	"					"	"	"	"
13			84.5	[illegible]	42.1	[illegible]	[illegible]	[illegible]	86.5	[illegible]	43.6		[illegible]	[illegible]		"	"	"	"
14			[illegible]		[illegible]	87					.5					"	"		
15			"		"	"										"	"	"	"
16			"		"			260	86		[illegible]			[illegible]		"	"	"	"
17			"		41.9	[illegible]		"	[illegible]		42.7			"		"	"	"	"
18		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]											
19	9	12/10	[illegible]	[illegible]	[illegible]	56	27/45	200	87	500	44.2	-4	[illegible]	225		0			
20			"		.3	57			"		"	0							
21			86		.5	59	[illegible]		86.5		"	+4							
22			[illegible]		.0	60			"		"	+6							
23			85		43.2	61					43.5	"							
24			86		.6	[illegible]					[illegible]	0							
25			85	[illegible]	[illegible]	67	[illegible]				[illegible]	-4	43/70	[illegible]					
26			84.5		.2	65			84.7		.2	[illegible]							
27			"		.2	[illegible]					[illegible]	[illegible]							
28			84.5		.1	69					[illegible]	[illegible]							
29			"		.0	69					43.6	[illegible]							
30			"		.0	70					.5	[illegible]							

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(5)

	LEFT ENG								RIGHT ENG										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Run	Date	RPM	EGT	Osc Press.	Tunnel Temp	oil	fuel	RPM	EGT	Osc Press	α	oil	fuel	Fan RPM	β_1	β_2	β_1	β_2
1	9		84.5	520	43	72		200	[illegible]	550	44.3	-4	[illegible]	225		0			
2			84		42.7	"					[illegible]	0							
3			[illegible]		.7	"					[illegible]	-2							
4			"		.9	73					.2	6	40/70						
5			84		.9	"						8							
6			84.5		.6	"						10							
7			"		"	74						-2							
8			84.5		.6	75						0							
9			"			76						+4							
10			"			"						[illegible]							
11			"			77						[illegible]							
12			84.5			77						12	▽						
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

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Run # 10 Tow 302

11 Dec '62

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	LEFT				RIGHT														
	RPM	EGT			RPM	EGT			α	β_0	β_2	β_1	β_2	Tunnel Temp	Q Knots				
1	86	540			87	510			0	20	→	→	→		20				
2	85				86	500			-4					53	30				
3	85				86	510			0					59					
4	85				86.5	500			+4					60					
5	85				86.5				6					62					
6	85				87				8					64					
7	85				86.5				10					65					
8	85								12					66					
9									14					68					
10									-4					69	40				
11									0					70					
12									-1					71					
13									+4					72					
14									6					73					
15									8					•					
16									10					74					
17									12					74					
18									14					75					
19					87				-4					76	60				
20									0					77					
21									+4					"					
22									6					"					
23									8					78					
24									10					"					
25									12					"					
26									14					79					
27									0					"	90				
28		[illegible]																	
29		[illegible]																	
30																			

M.F.-711(a)

ENGINE DATA

RUN 11 TEST START 10:31

DATE 13 DEC J O R-1306-T STOP 11:15

	LEFT ENGINE						RIGHT ENGINE						T-58			L		R		
	RPM	EGT	DISC PRES	TRANS TEMP	F.P.	OIL	RPM	EGT	DISC PRES	TRANS TEMP °F	FUEL	OIL	RPM	EGT	Q	β_1	β_2	β_1	β_2	α
1	84	520	43.2		200	40/35	85.5	520	45.5	64	225	30/30			40	+35				-4
2						58/28			"	66		30/28								0
3						"			45.4	67		"								+4
4			43.1			60/30			45.3	68		40/35								6
5			43.0						45.1	70		40/30								8
6									"	71		"								10
7									44.9	72		40/35								12
8			42.8						"	73		"								14
9			"					540	44.7	74		40/35				+40				0
10	82		42.4						"	75						+50				
11	85		42.8			65/35	87		45.8	76						+30				
12	"		"				"			77						+15				
13	86		43.7				89	560		78						+0				
14	87	580	43.0				89.5	590		80						-12				
15	85	560	42.8				87	560	45.5	81					80	+35				-4
16							86.5		45.1	82										0
17									"	"										+4
18									45.0	83										6
19	84	500	42.3			60/30	86	540	44.8	77		40/35								8
20									"	78										10
21									44.7	79										12
22	79		40.0						44.6	80										14
23	85		42.0			65/35			"	82		40/35				+40				0
24	84		42.1						44.5	83						50				
25	85		"				87		45.2	84	—					30				
26	85.5	[illegible]	42.5				87.5		45.5	"	235					15				
27	86	[illegible]	42.8				"		"	85						0				
28	85.5	[illegible]	"			60/30	87		45.0	88		35/30			60	35				-4
29	85		42.3						"	89		"								0
30	84.5		42.3						"	90		40/35								+4

RY . . N [redacted] 64B017

ENGINE DATA

RUN " TEST START

DATE 12-13-62 J O R-1306-T STOP

SHEET #2

	LEFT ENGINE						RIGHT ENGINE						T-58			L		R		
	E%	EGT	DISC P		F.B.	OIL	E%	EGT	DISC P	T/F	F.P.	OIL	RPM	EGT	Q	β_1	β_2	β_1	β_2	α
31	84	500	420		200	55/30	87	540	45	91	235	40/35			60	35				+6
32	84								"	"										+8
33	84.5								44.9	92										+10
34									44.8											+12
35									"											+14
36									44.7	93						40				0
37	83.5															50				
38	85.5	510	42.3			60/35	88	550	45.4							30				
39	86								45.5	94						15				
40									"	"						0				
41			42.4						45.6	95						-12				
42	89.5	600	"				91	610	44.3	96					30	-12				
43	88	"	42.5				90	"	44.7	97						0				
44	87	580	43.2				88.5	580	45.1	98						15				
45	86		42.3				88	560	44.9	99						30				
46	85.5		42.5				"		44.7	"						40				
47	82.5		41.7				87		44.3	100						50				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
26																				
27																				
28																				
29																				
30																				

ENGINE DATA

RUN 12 TEST 171 START

DATE 12-13-62 J.O. R1306 T STOP

	LEFT ENGINE						RIGHT ENGINE						T-58			L		R	
	RPM	EGT	DISC P	TURB TEMP	OIL	F	RPM	EGT	DISC P	TURB TEMP	OIL	F.P.	RPM	EGT	TURB TEMP	β_1	β_2	β_1	β_2
1	87.5	550	43	75	25/50	200	87.5	550	44.3		30	225				-.12	-.12		
2	89	|	43.8	78	|	|	89	|	45.1		"	|			0	0		
3	88	|	42	79	|	|	88.5	|	45.2		32/36	|			.15			
4	85.5	530	43	81	35/50	|	87	520	45		32/35	|			30			
5	83	|	42.2	83	|	—	86	|	41.5		"	|			90			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

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ENGINE DATA

RUN 13 **TEST** 177 **START**

DATE 12-13-62 **J.O.** R 1306-T **STOP**

	LEFT ENGINE RPM	LEFT ENGINE EGT	LEFT ENGINE DISC PRESS	LEFT ENGINE TORQUE TEMP	OIL	FUEL	RIGHT ENGINE RPM	RIGHT ENGINE EGT	RIGHT ENGINE DISC PRESS	RIGHT ENGINE α	OIL	FUEL	T-58 RPM	T-58 EGT	T-58 TORQUE TEMP	L β₁	L β₂	R β₁	R β₂
1	86	500	43.1	67	27/50	200	87	510	44.6	0	33/36	225				-12			
2	87		42.8	69			88		44.8							0			
3	87		43.4	70			"		44.8							15			
4	84.5		43	72			86		44.6							30			
5	"		43	74			"		43.8							40			
6	87.5	550	42.8	77			87.5	550	44.3							0			
7	87		42.5	80			88			4									
8	86.5		42.6	80	32/60					6	36/40								
9	"		42.7	81				560		8									
10	"			"						10									
11	"			82						12									
12	87			"				550	44.7	14									
13	"		42.8	83			88.5		45.1	0						-12			
14	86		43.1	85			87.5		45.2							+15			
15				"					45.1							20			
16				"				540	45.0	4									
17		540		86						6									
18			43.0	"						8									
19				87					44.9	10									
20				"					44.6	12									
21			42.9	"			87		44.7	14						20			
22	85.7		"	88			87.5		44.0	0						30			
23	84		42.5	89			86.5	550	43.1							40			
24	81	550	41.3	"	30/58		85		44.9		34/35					50			
25	85.5		42.1	91			87.5		45.2							0			
26			42.2	"			87.7		45.0	4									
27				"			"		"	6									
28				"			"		44.7	8									
29			42.1	"			87.3		-	10									
30			"	92			87.5		45.0	12									

ENGINE DATA

RUN 13 TEST 177 START

DATE 12-13-62 J O R1306-T STOP

	LEFT ENGINE						RIGHT ENGINE						T-58			L		R	
	RPM	EGT	DISC PRES	TUNNEL TEMP			RPM	EGT	DISC PRES	[illegible] α			RPM	EGT	TORQ	β_1	β_2	β_1	β_2
31	85.5	550	42.2	92			87.5	550	44.8	14	28/39	230				0			
32				93	32/60	200			45.0	0						-12			
33																+15			
34																20			
35		540						540		4									
36									44.9	6									
37				94						5									
38										10									
39							87.3		44.8	12									
40										14									
41			42.1	95						0						30			
42	84.5		42.1				87.0		44.6							40			
43	82.5		41.7				86.5		44.0							50			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

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ENGINE DATA

RUN 14 TEST 177 START

DATE 12-13-62 J.O. R-306-T STOP

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRESS	TRANS TEMP	OIL	FUEL	RPM	EGT	DISC. PRESS	TRANS TEMP	OIL	FUEL	RPM	EGT	TRANS TEMP	L			R
1	55.5	510	43.7	74	28/40	200	56	500	45.0	0	32/3?	225				10			
2	55		43.4	76			56.5		45.2	4									
3			43.5	77			56		44.8	6									
4			"	78			56.5		45	8									
5			43.2	"	32/60			510		10									
6			"	79						12									
7	54.7		42.7	"					44.5	14	30/32								
8	56		42.8	81			57		45.1	0						-12			
9	55.5		42.6	82					45.2	0						+15			
10				83	28/58					0						20			
11				84						+4	37/40	230							
12										6									
13									45.1	8									
14			42.4	85					45.0	10									
15			"						"	12									
16			42.5						44.9	14									
17			"	87	32/60				44.7	0	30/35					30			
18	54		42.2	88			55.5		44.3							40			
19	51.5		41.5	"			56		43.9							50			
20	55.5		42	89			57.5		45.0							0			
21				90						+4									
22										6									
23	56		42.5				57.3			8									
24	55		42.1							10									
25	56.5			91						12									
26	55.5		42.3						44.9	0						15			
27	55		42.1						"							30			
28	54.5		42				57		44.6							35			
29			41.9	92					44.4	+4									
30			"	"					"	6									

ENGINE DATA

RUN 14 **TEST** 111 START

DATE 12-13-62 **J.O.** R 1306-T STOP

	LEFT ENGINE						RIGHT ENGINE						T-58			L		R	
	RPM	EGT	DISC. PRESS	TUNNEL TEMP	OIL	F	RPM	EGT	DISC. PRESS	TUNNEL TEMP	OIL	F	RPM	EGT	TUNNEL TEMP	β1	β2	β1	β2
31	84.5	510	41.9	92	32/60	200	87	510	44.6		35/38	230				35			
32																			
33																			
34							86.5		44.2							40			
35	82.5		41.7	93			"		"							50			
36	84.5		41.9	96			87		44.5							35			
37	85																		
38																			
39																			
40																			
41				93			87.3												
42																			
43									44.4										
44																			
45																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
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ENGINE DATA

RUN 15 **TEST** 177 *START* ____

DATE 12-14-62 **J.O.** R1306-T *STOP* ____

	LEFT ENGINE						RIGHT ENGINE						T-58					PITCH EXIT DOORS	
	RPM	EGT	DISC. PRESS	TRANS TEMP			RPM	EGT	DISC. PRESS	TRANS TEMP			RPM	EGT	TRANS TEMP	OIL	FUEL	L	R
1													84.2	410	68	30	225	0	0
2													84.7				''	+15	+15
3													84.8				220	30	
4													85					45	
5																		60	
6																27	215	70	
7													95.5	420		35	240	0	
8														''				15	
9														440				30	
10													95.5				235	45	
11													95.7					60	
12													96					70	
13													100	500				0	
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

ENGINE DATA

RUN 16 TEST 177 START

DATE 12-14-62 J.O. R 1306-T STOP

	LEFT ENGINE				OIL	F	RIGHT ENGINE				FUEL OIL		T-58				F	O	
	RPM	EGT	DISC. PRESS	TRAILER TEMP			RPM	EGT	DISC. PRESS	TURB. TEMP			RPM	EGT	TURB. TEMP				
1	85	500	43.7	64	35/60	200	86	500	45.2		220		94	500			[illegible]	30	
2	"		"	65			"		"							15			
3	84.5		43.3	66			85.5		44.8							30			
4	85		43.2	67			86		45							45			
5	85.5		"	69			86.5									60			
6	86.5		42.4	70			88		44.8										
7	86		43	72			87		44.3				95.5	49.0		60			
8	"	510	43.4	74			87	510	45				96	"		45			
9	85.5		42.8	76			86.5		44.3					500		"			
10	86		42.6	77			"		"							"			
11	"		"				87		44.4								255	30	
12	77		39				80		40.6				82.5	410					
13			"	83			"		40.4										
14			"	84			79		40										
15			38.8				80.5		40.2										
16			"				"		"										
17	71		37				74		37.7				80				200	27	
18							75												
19							74							400					
20				85			"						80.5						
21																		27	
22	70.5						74										190	"	
23		500							37.[illegible]									26	
24																			
25																			
26																			
27				86										410					
28							74.5							"					
29							73		37.3					415					
30							72		37					"					

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ENGINE DATA

RUN 16 TEST START

DATE 12-14-62 J.O. STOP

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRESS	TURB. TEMP			RPM	EGT	DISC. PRESS	TURB. TEMP			RPM	EGT	TURB. TEMP	O	F		
31	70.5	500	37	87			71	500	36.8				80.5	410		24	190		
32	"						"		"				82						
33	71						74		37.3										
34							74.5		37.5										
35							75		37.7				81						
36													"						
37													79						
38	71.5						73.5		37.5				80						
39							74		37.4				81						
40							"		"										
41	71.0						73.7												
42	68.5			36.5			73.5												
43	65			35.8			69		37.3										
44	71			36.9			74		"				82	410		-5	200		
45									37.5										
46																			
47																			
48							73.5		37.4										
49				36.8					37.2										
50																			
51							74												
52							73.7												
53							"												
54							73.5												
55																			
56	70			36.6															
57	"			36.7	SMOKE		73	500	37.2				81	400					
28																			
29																			
30																			

ENGINE DATA

RUN 18 TEST 177 START

DATE 12-17-62 J O 12 1306-T STOP

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRESS	TUNNEL TEMP	OIL	FUEL	RPM	EGT	DISC PRESS	TUNNEL TEMP	OIL	FUEL	RPM	EGT	TUNNEL TEMP	OIL	FUEL		
1	85	500	43.8	61	35/60	200	55	500	44		35/40	225	95	510		35	200	0	20
2			..	64			56		44.7				94.5	500				0	
3			43	65					44.8				96	470				30	
4	84.5		42.6	67									95	475				45	
5	86		42.5	69			56.5						96.5	550				70	
6	85			70			57		44.3				97	510		32	225	60	
7				72					44				97						
8			42.3	73	30/60	200			..				97.5						
9	86		42.4	..					44.6				95.5	480				0	
10				75									..	..				30	
11				78									96	490				45	
12	85.5			79			56.5		43.5				97	510					
13	86		42.3	79			57		..				98						
14				80					43.8										
15				..					43.5										
16	85		42	81					43.8				99	520					
17	85.3		..	82					44				95.5	470		30			
18	85		41.6	83					43.9				..						
19			41.8	84					43.9				96						
20									44					450					
21									44.1					..					
22				85										490					
23													96.5	495					
24	84		41.3						44				96.5	..					
25	86	510	41.7				59		..				98	510					
26																			
27																			
28																			
29																			
30																			

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ENGINE DATA

RUN 19 **TEST** 177 *START* 9:52

DATE 17 DEC **J O** R 1306 T *STOP* 11:05

	LEFT ENGINE						RIGHT ENGINE						T-58			L		R		
	RPM	EGT	DISC PRESS	TURB TEMP			RPM	EGT	DISC PRESS	TURB TEMP			RPM	EGT	TURB TEMP	β	β	β	β	α
1	78.5	500	39.0	65			80	500	40.6				81.5	400		20	→			-4
2	78			66			"		"											-2
3	"			"			79		40.3											0
4	77.5			67			"													+2
5	77			68			80.5													4
6	79		38.7	69					40.4											6
7				"									80.5							8
8		510		70									80	410						10
9		"		72					40.1				"	"						12
10	71	500		74			73		"				78.5	400		32	→			-4
11	70.5		36.8	76			72.5		37.3											-2
12	70						72		"											0
13	70.5			77			71.5		37				79							+4
14							72													6
15							73													8
16																				10
17			36.5	78					37.2											12
18	69		"	"			71.5		"				78			45	→			-6
19			36.4	79					36.8				"							-4
20													78.5							0
21													"							+4
22							71						78.0	410						+6
23													77.5	"						+8
24													76	420						+10
25																				
26																				
27																				
28																				
29																				
30																				

ENGINE DATA

RUN 20 **TEST** 177 **START** 11:07

DATE 18 DEC 62 **J O** **STOP**

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC PRESS	TURB TEMP			RPM	EGT	DISC PRESS	TURB TEMP			RPM	EGT	TURB TEMP	OIL	FUEL	β	
1				58									58	460				0	
2				"									57	450					
3				59									101	500					
4													"	490				30	
5													"	495				60	
6													"	500				70	
7				60									58	440				30	
8				"														60	
9				61														70	
10													101	500				60	
11													"	490					
12													101.3						
13				62									101.4						
14													58	430					
15																			
16																			
17				63															
18				64									101.1	490				0	
19													101					30	
20																		60	
21				65										510				70	
22													58	430				30	
23													[illegible]	"				60	
24													59	"				70	
25				66									101	490				60	
26				"															
27				67															
28														500					
29													58	430					
30														420					

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ENGINE DATA

RUN 21 TEST 177 START 2:51

DATE 12-18-62 J OR-1306-T STOP 4:02

	LEFT ENGINE						RIGHT ENGINE						T-58				
	RPM	EGT	DISC. PRESS	TURB TEMP	OIL	FUEL	RPM	EGT	DISC PRES	TURB TEMP	OIL	FUEL	RPM	EGT	TURB TEMP	OIL	FUEL
1	86	500		76	35/60	200	87	500			38/40	225	91	500		30	400
2	86	"		77			"	"									
3	85.5	"		78	34/61	"	87.5	500			38/40	"	91	495		"	"
4	85.5	"		79			"	"			"	"	91.5	510		"	"
5	86	"		79			87.5	"			"	"	92	"			
6	"			81			"						92.5	510		"	"
7	"			81	35/61	200	"				37/40	225	"	510		"	"
8	"			82	"	"	"				"	"	"	"		"	"
9	85.7	500		87	"	"	87.1				"	"	91.7	480		87	"
10	"	"		87			87.5	500			"	"	92	"		"	"
11	86	"		87	"	"	88	"			"	"	92	"		"	"
12	86	"		88	"	"	88	"			"	"	92	"		"	"
13	85.9	"		88			88				"	"	92	"		"	"
14	"			89	"	"	88	"					92.4	"		"	"
15	85.8			89			88						92.8	490		"	"
16	85.3			91			86.5							[illegible]			
17	"		41.8	91	35/62	200	87				38/41	225					
18	85.2		41.8	92	"	"	87		43.8		"	"					
19	"		"	"	"	"	87	"	"								
20	"	500	"	"	"	"	87.2	500	"		"	"					
21				92													
22	85.2	"	41.8	93	"	"	86.8	"	43.7		"	"					
23	"	"	"	"	"	"	86.5	"	"		"	"					
24	84	"	41.7	95	"	"	"	"	43.4		"	"					
25	"	"	"	"	"	"	87	"	43.5		"	"					
26	"	500	"	"	"	"	"	510	43.6		"	"					
27	"	"	"	"	"	"	"	"	"		"	"					
28	"	"	"	96	"	"	"	"	"								
29																	
30																	

ENGINE DATA

RUN 22 TEST 177 START 9:42

DATE 12-18-62 J.O. R-1306-T STOP 11:17

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRESS	TUNNEL TEMP	Q_L	F_U	RPM	EGT	DISC. PRESS	TUNNEL TEMP	Q_R	F_U	RPM	EGT	TUNNEL TEMP	B_1	B_2	B_1	B_2
1	86.5	520		59			87	520								0			→
2	86.5	"	43.5				"	"	44.8							15			→
3	85		43.5		60/30	200	86		45.2							30			→
4	84.5	"		66			86	500			40/38	235				40			→
5	85.5	530		71			87	520			"	"				0			→
6	85	"	43	72	"	"	87	"	45		"	"				"			→
7	85.5	"	"	73	"	"	87	"	45.2		"	"				"			→
8	"	"	"				"	"	44.8							"			→
9	"	"	"	74			"	"	44.5		"	"				"			→
10	"	"	"	75			"	"	44.3		"	"				"			→
11	85.5	520	42.8	76			87.5	520	45.6		"	"				15			→
12	"	"	42.6	77	65/35	"	87	"	45.3		"	"				30			→
13	"	"	"	78			86.5	"	44.9							40			→
14	"	"	"	79	"	"	87.0	"			"	"				0			→
15	"	"	"	"	"	"	"	"	45.1		"	"				"			→
16	"	530	"	80	"	"	"	"	44.9		"	"				"			→
17	"	"	"	"	"	"	"	"	44.8		"	"				"			→
18	"	"	"	"	"	"	"	"	"		"	"				"			
19	"	"	"	"	"	"	"	"	"		"	"				"			→
20	86	520	42.9	81	"	"	87.5	520	45.2		"	"				15			→
21	85	"	42.6	"	"	"	87.5	"	45.3		"	"				30			→
22	"	"	"	82	"	"	87	"	44.5		"	"				40			→
23	86	"	42.8	83	"	"	87	"	44.9		"	"				0			→
24	86	"	"	84	"	"	87.5	"	45.0		"	"				0			→
25	"	"	"	"	"	"	"	"	"		"	"				"			→
26	"	"	42.9	85	"	"	85	"	45.3		"	"				"			→
27	"	"	"	"	"	"	87.5	"	"		"	"				"			→
28	83.5	"	41.2	"	"	"	81	"	41.1		"	"				"			→
29	86	"	42.7	"	"	"	82.5	"	45.0		"	"				15			→
30	[illegible]	"	42.5	"	"	"	?7	"	44.9		"	"				30			→

RYAN [redacted] 64B017

ENGINE DATA

RUN 22 TEST 177 START

DATE 12-18/62 J.O. R-306-T STOP

	LEFT ENGINE						RIGHT ENGINE						T-58			LEFT		RIGHT	
	RPM	EGT	DISC. PRESS	TUNNEL TEMP	OIL	FUEL	RPM	EGT	DISC. PRESS	TUNNEL TEMP	OIL	FUEL	RPM	EGT	TUNNEL TEMP	B_1	B_2	B_1	B_2
31	85	520	42.3	86	65/35	200	87	520	44.9		40/38	235				40	→	→	→
32	86	530	42.5	87	"	"	87.5	530	45.1		"	"				-12	→	→	→
33	"	"	"	"	"	"	"	"	"		"	"				"	→	→	→
34	"	520	42.4	88	"	"	87	530	44.8		"	"				"	→	→	→
35	"	"	"	"	"	"	88	"	44.9		"	"				"	→	→	→
36	"	"	"	"	"	"	"	"	45.1		"	"				"	→	→	→
37	"	"	"	"	"	"	87	"	44.7		"	"				"	→	→	→
38	87.5	550	43	89	"	"	89	550	45.1		"	"				"	→	→	→
39	87	"	"	"	"	"	"	"	"		"	"				"	→	→	→
40	"	"	42.5		"	"	"	"	44.6		"	"				"	→	→	→
41	"	"	42.3	90	"	"	"	"	44.5		"	"				"	→	→	→
42	"	"	"	"	"	"	"	"	44.2		"	"				"	→	→	→
43	"	"	"	91	"	"	"	"	"		"	"				"			
44																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

ENGINE DATA

RUN 35 TEST START

DATE 12-26-62 J O STOP

	LEFT ENGINE				RIGHT ENGINE				T-58			
	RPM	EGT	DISC. PRESS	TURB. TEMP	RPM	EGT	DISC. PRESS	TURB. TEMP	RPM	EGT	TURB. TEMP	SUM δ_1
1	85	520	43.7	61	86.5	520	45.7		73	500		-12
2	85.5		43.9	64	"		45.4		74			0
3			43.8	65	86.0		45.3		75			
4				67	86		45.0		"			
5				"					75.5			
6				69					75.5			
7			43.6	70	87		45.1		"			
8				71			45.2		75.8			
9				73	88	510	46.1		74.5	475		+15
10	86.5		43.2	"	87		45.5		74.5	490		+30
11	85		42.8	77	"	520	45.2		75.5			-12
12	86		43	78	87.5		"		75			0
13			42.9	79			45.0		75.5			
14	85.5		42.8			510			76			
15			42.7									
16				80								
17				"								
18			42.8	81	88		45.2		75.5			+15
19	86.5			"	87.5		"			415		+30
20	86.0		43.1	83			45.0		75	455		-12
21	85.5		42.9				45.2			450		0
22			"				44.9		75.5	460		
23			42.7	84	88		45.1			480		
24			42.[illegible]		87.5		45.2					
25	85		42.1		"		45.1					
26	86.5		42.9		88		"		76	490		
27	85		42.5				45.2		75	460		+15
28			42.4				45.3		75.5	450		+30
29	85.5	540	42.9	77	86.5	540	45.0		74	430		0
30			42.7	79	"	"	"		74.5	450		

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ENGINE DATA

RUN 35 TEST ______ START ______

DATE 12-26 J.O ______ STOP ______

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRES	TURB TEMP			RPM	EGT	DISC PRES	TURB TEMP			RPM	EGT	TURB TEMP	P			
31	85	510	47.2	80			87	540	44.9				96.5	450		0			
32	84.5		47.0	81			"		"				95	475		"			
33	85		42.2	"			87.5		45.3				96.5	450		+15			
34	"		41.5	82					45.5				"	430		+30			
35	86.5		43.0						44.6				95	445		-12			
36	"		43.4	—					44.9				95.5	500		0			
37	86		43.2	84									94.5	"		+15			
38	85.5	—	"	85			—	—	—				"	490		+30			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

ENGINE DATA

RUN 36 TEST J O START
DATE 12-26-62 STOP

	LEFT ENGINE				RIGHT ENGINE				T-58			
	RPM	EGT	DISC PRESS	TRANS TEMP	RPM	EGT	DISC PRESS	TRANS TEMP	RPM	EGT	TRANS TEMP	β
1	85	540	44.3	54	85	510	44.8		95	500	45°	0
2		530	44.2				44.6		"			
3			44.1	57			44.2		95.5			
4			43.8	58	86.5		43.9		"			
5	86	510	44.0	61	86	500	44.8		"			
6				62			"		"			
7			43.9	63			44.7		96			
8			43.7	64			44.3					[illegible]
9	86.5		43.8	65	86.5		43.5					-12
10	85.5	520	"	67	87.5	520	45.8		95.5	510		+15
11	84		42.9	68	86.5		45.6		96	490		30
12	85.5		"	70	"		45.6		95.0	510	0	0
13	86.5		43.1	"	87	500	45.0		96.5	520		-12
14	86		43.9	72			"		97.0	490		+15
15	86.5		43.3	73			45.2		95.5	475		+30
16	86.5		43.7	"	86		43.9		"	520		-12
17	86		43.1	75	87.5		44.8		97.0	"		0
18	85		42.9	"	87	490	45.2		97.0	480		+15
19	84.5		42.8	76	"	500	45.1		96.0	450		+30
20	90	560	44.1	"	87	540	43.6		95.5	530	60	12
21	86.5				87	520			98	540		0
22	85	520	43.2	68	86	530	44.7		96.5	500		+15
23	84		43.3	69	"	"	45.1		96	480		30
24		500	43.2	72	86.5	500	44.6		98.5	530		0
25			42.5	73			44.7		97	490		+15
26	84.5		42.7	"			45.1					+30
27	85		"	74	87		45.0				0	0
28			42.5	76			45.0					
29			"				44.9		97.5			
30			42.3				44.8		"	500		

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ENGINE DATA

RUN 36 TEST ______ START ______

DATE 2-26-62 J O ______ STOP ______

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. P	TURB. TEMP			RPM	EGT	DISC P	TURB TEMP			RPM	EGT	TURB. TEMP R	β			
31	85	500	42.8	69			86	500	45.2				94	450	30	+20			
32	84.5			"				520	45.1				94.5						
33	84.5			70					44.8				95						
34	84.5			71					44.7				"	470					
35	85.0			72			[illegible]		45.2					"	45				
36				73					45.2					480					
37									45.0				95.5	490					
38			42.6						42.9				96	"					
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

ENGINE DATA

RUN 38 TEST 177 START

DATE 12-27-62 J.O. STOP

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRESS	TUNNEL TEMP			RPM	EGT	DISC PRESS	TUNNEL TEMP			RPM	EGT	TUNNEL TEMP	P_1	P_2		
1	83.3	490	43.3	51			85.5	500	45.7				93	480		30	20		
2	83.5		″	53			85.6		45.5				92.7	470					
3			43.2	55			86						93	460					
4		500		56					45.4				93.5	470					
5				57			86.3						93.7						
6	84			58			86.1		45.3					480					
7							86		45				94						
8			43.1	60			86.5		45.5				94.2			45			
9	83.5		43	62			86.7						94.7						
10	84.2						87						94.8						
11				63									95						
12			42.8	64					45.4								20		
13	84		42.7	65			87.2	520	45.5										
14		510	43.1	62			86.5		45.3				93.8	470		65			
15	84.2		42.9	64									94						
16			42.8	66			86.7												
17	84.5						87		45.2				94.1						
18	84.7	520		67			87.2						94.2						
19	84.6			68										480					
20	84.4			70			86.8						94.1			0	20		
21	84.8			71			86.9		45.1				94.2						
22				72			87		45				94.3						
23	84.7			73			87.2						94.4						
24	84.5		42.7				87.3						94.5						
25	84		42.5				87		44.4				95	490					
26	84.8	510	43.4	70			86.5		45.3				82.3	390					
27	85		43.3	71			86.7		45.2				82.5	400					
28	84.5		43	72			87												
29	84.5			74					45.3				83.5						
30	84.5			75					45				83.8						

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ENGINE DATA

RUN 38 TEST 177 START

DATE 12-27-62 J.O STOP

	LEFT ENGINE						RIGHT ENGINE					T-58						
	RPM	EGT	DISC. PRESS	TUNNEL TEMP			RPM	EGT	DISC. PRESS	TUNNEL TEMP		RPM	EGT	TUNNEL TEMP				
31	84.3	510	42.8	75			87	520	44.8			83.8	410		0	20		
32	85			76			87.3		45			91						
33				78			"					90.2						
34			42.7	79			87.2					90.8						
35	84.5			80			87.2		44.9			91	420					
36	85						87.5		44.8			"	440					
37		520					87.7		44.9			91.2	460					
38			42.5	82			"		45.1			83	380					
39							87.4		45				390					
40							87.7		45.1									
41	84.5		42.4				87.5		44.9									
42				83			88		45.1			84	400					
43							"		"									
44	85.8		43	84			87.5		45			83.5						
45				85					44.9			83.6						
46									44.8			83.8	405					
47									"			83.8						
48			42.9						44.7			84	410					
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		

ENGINE DATA

RUN 39 TEST 177 START

DATE 12-27-62 J O STOP

	LEFT ENGINE						RIGHT ENGINE						T-58 Bar 30.26 @ 70°						
	RPM	EGT	DISC. PRESS	TURB. TEMP			RPM	EGT	DISC. PRESS	TURB. TEMP			RPM	EGT	TURB. TEMP R	β_1	β_2		
1	88	570	42.9	66			87.5	560	43.6				92	510		[illegible]			
2	86	560		68			86	540	43.8				94						
3	85		[illegible]	69				520	44.1				93						
4	83.5		42.8	70					44.6				94						
5	88			66			88	560					93.5		60	-12	→		
6	86	540					86	510	44.0				98	540		0			
7	85	"	43	70					44.5				96.5	500		+15			
8	84	530	42.1	72					44.9				96	490		+30			
9	86	"	43.3	75					43.0				99.5	550		-2			
10	84.5	500	42.2	76			87.5	490	44.8				98.5	530		0			
11	84.5	"	42.3	77					45.1				97	480		+15			
12	83.5	510	42.2	78			86.5	500	44.6				97	450		+30			
13	85.	520	42.0	80			87						95	460		0			
14	85		"	81					44.7					470		+15			
15	85		42.3						44.9					450		+30			
16	90	600					91	580	43.7				96.5	570		0			
17	[illegible]		[illegible]																
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

ENGINE DATA

RUN 40 TEST 177 START

DATE 12-27-62 J O STOP

	LEFT ENGINE				RIGHT ENGINE				T-58			
	RPM	EGT	DISC. PRESS	TUNNEL TEMP	RPM	EGT	DISC. PRESS	TUNNEL TEMP	RPM	EGT	TUNNEL TEMP R	Sym β
1	84.5	500	43.1	62	86	510	45.5		93.5	470	60	-12
2	84	⊥	43.0	63	86		⊥		93			0
3	⊥	⊥	42.7	65	86		45.4		93			+15
4	⊥	510	⊥	⊥	—		⊥		94	460		30
5	81	500	40.8	69	83		42.1		88	400		0
6	80	510	40.5	⊥	83.5		42.3		⊥			+15
7	79	⊥	40.3	70	83		⊥		⊥			30
8	85	500	42.6	71	88		45.6		95	480		-12
9	85.5	⊥	43.2	73	⊥		45.4		94.5	⊥		0
10	⊥	510	⊥	74	87.5		45.3		94.0			+15
11	84.5	⊥	42.9	⊥	87	⊥	⊥		94.5	470		30
12	88.5	540	44.3	75	88	530	44.7		96	500		-12
13	86.5		43.6	⊥	87.5		44.8		95.5	⊥		0
14	85.5		43.3	77	88	⊥	45.6		95	490		+15
15	84.5	—	42.8	78	87	⊥	45.0		⊥	⊥		+30
16	81	550	44.0	79	89.5	540	45.2		96	510		-12
17	⊥	560	43.9		90	550	45.5		96.5	⊥		0
18	85.5		43.2		88		45.1		95	500		+15
19	⊥	⊥	42.9	—	87.5	⊥	44.6		⊥	490	⊥	+30
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

ENGINE DATA

RUN 41 **TEST** 177 **START**

DATE 12-27-62 **J.O** **STOP**

	LEFT ENGINE				RIGHT ENGINE				T-58			
	RPM	EGT	DISC. PRESS	TRANS TEMP	RPM	EGT	DISC PRESS	TRANS TEMP	RPM	EGT	R	SYM β
1	88.5	550	44.6		87	530	46.3		74	520	60	-12
2	85.5	540	43.4	56	85.5	500	44.8		95.5	—		0
3	85	"	43.7	58	85.5	—	45.0		94.5	500		+15
4	96	610	67.5	59	96.5	560	68.9		97.5	520		+15
5	83	550	43.1	62	86	500	45.0		94.5	470		+30
6	85.5	540	43.7	64	85.5	—	42.9		97	540		-12
7	84	500	42.6	"	87	490	45.0		96.5	530		0
8	83		42.4	65	86.5	—	45.2		96	480		+15
9	84		42.8	66	86	—	"		95.5	450		+30
10	84.5		42.7	67	86.5	520	44.9		96	460		0
11	85		42.8	"	87	—	45.3		95	440		+15
12	84	—	"	68	86.5	—	45.5		95.5	450		+30
13	89	560	43	70	87.5	510	44.1		97	570		-12
14	87.5		43.3	71	87	—	44.2		—	—		0
15	86			72	87.5	520	45.1		—	510		+15
16	84.5			73	"	—	45.8		96	490		+30
17	88.5	—		"	87.5	520	45.2		96.5	510		-12
18	87	550		74	87	580	—		97	530		0
19	86.5	560	—	—	88	540	—		—	570		+15
20	85	"	43.1	—	87.5	530	45.5		96	410	—	+30
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

RYAN 64B017

ENGINE DATA

RUN 43 TEST 177 START 8:43

DATE 12-28-58 J.O. STOP 10:03

	LEFT ENGINE						RIGHT ENGINE					T-58						
	RPM	EGT	DISC. PRES.	TURB. TEMP			RPM	EGT	DISC. PRES.	TURB. TEMP		RPM	EGT	TURB. TEMP	R	Q KNOTS		
1												89	420	47	0	30		
2															15			
3															30			
4												89.5			45			
5															60			
6															75			
7															60			
8														48				
9																		
10																		
11												90	410					
12															0	60		
13															15			
14															30			
15															45			
16														49	60			
17															75			
18															60			
19																		
20																		
21																		
22																		
23												10.5			0	60		
24													400		15			
25															30			
26															45			
27															60			
28															75			
29														50	60			
30																		

ENGINE DATA

RUN 43 TEST ______ START ______

DATE 12-28-67 J O ______ STOP ______

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC PRESS	TURB TEMP			RPM	EGT	DISC PRESS	TURB TEMP			RPM	EGT	TURB TEMP	R	Q KNOTS		
1													90.5	400	50	60	60		
2																			
3													91			0	80		
4															51	15			
5																30			
6													105			45			
7																60			
8																75			
9																60			
10															52				
11																			
12													91						
13													90.5			0	20		
14													90			15			
15																30			
16																45			
17																60			
18																75			
19																60			
20																			
21																			
22														410					
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

ENGINE DATA

RUN 44 **TEST** 177 START

DATE 12-31-62 **J.O.** STOP

	LEFT ENGINE						RIGHT ENGINE						T-58					
	RPM	EGT	DISC PRES	TURB TEMP			RPM	EGT	DISC PRES	TURB TEMP			RPM	EGT	TURB TEMP			
1	69	500	36.4															
2	80	510	37.5															
3	85	..	42.3															
4	90	530	46.8															
5	95	560	53.7															
6							70	400	35.7									
7							80		38.8									
8							85		41.6									
9							90		45.7									
10							95		51.8									
11	70	500	36.3				70		35.1									
12	80		39.2				80		38.8									
13	85		41.5				85		41.2									
14	90		46.5				90		45.3									
15	95						95											
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		

ENGINE DATA

RUN 45 TEST 177 START

DATE 12-31-62 J O STOP

	LEFT ENGINE						RIGHT ENGINE						T-58						
	RPM	EGT	DISC. PRES	TURB. TEMP			RPM	EGT	DISC. PRES	TURB TEMP			RPM	EGT	TURB TEMP				
1	15	530	53.4	53			95	400	51.2										
2			〃	56					51.9										
3			53.2	57					51.7										
4	94.5	-	52.6	58			94.5		51.5										
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			

AMES RAMP RUNS - ENGINE DATA

Date	Run #		Left Engine		Right Engine		T-58		T/R	β_s	β_v
			RPM	EGT	RPM	EGT	RPM	EGT			
1-14-63	54		79	530	83	480	81	490	40	0	0
			80	500	81	480	31	480			
			86	500	86.5	430	87	490			
1-15-63	55		93	560	95	470	96	620	40	0	0
	56						100	630	0		
1-15-63			94.5	580	95.5	490	93	590	40	0	0
			95	620	97.5	580				0	0
			95	620	97.5	560				10	
			95	620	97.5	560				20	
			95	620	98	560				24	
			95	620	98	600				0	
			95	620	97.5	600				10	
			94.5	620	95	560				0	0
			86	560	86.5	500					
			79	530	41.5	510					
			-	-	79	450					
			-	-	87	450					
			-	-	95	520					
			-	-	96.5	500					
			80	490	-						
			87	500	-						
			93.5	580	-						
			94.5	600	-						
1-16-63	57		78	550	81	460					
			87.5	560	88	475					
			95	610	95.5	500					
			96	620	97	510					
1-16-63	58		77	480							
			83.5	500							
			92.5	580							
			93	580							
			79	480	80	460					
			84	490	85	960					
			93	600	94	480					
			93.5	620	95.5	550					
					78.5	440					
					85	450					
					94	530					
					95	570					
1-16-63	59	1	80	520							
		2	87	520							
		3	96	630							
		4	97	640							
		5			81	440					
		6			86	440					

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AMES RAMP RUNS - ENGINE DATA (Cont.)

Date	Run #		Left Engine		Right Engine		T-58		T/P	β_s	β_v
			RPM	EGT	RPM	EGT	RPM	EGT			
		7			94.5	480					
		8			96.5	500					
		9	78	500	82	450					
		10	86.5	550	86.5	460					
1-17-63	60	1	80	520	80	500	77.5	480	40	0	0
		2	85.5	520	86		84.5				
		3	94		95						
		4	81	530	81	500					
		5	88.5	550	88.5	520					
		7	77	520							
		8	85.5	530							
		9	94	600							
		10	94.5	620							
		11			79	440					
		12			85.5	430					
		13			94.5	480					
		14			96.5	500					
1-18-63	61										
T_{amb} = 46°		1	78	520	78.5	460	78	430			
		2	85	520	85	460	89.5	500			
		3	94	600	94	480	99	640			
		4	94	600	97	500	89.5	640			
		5	94	600	98	500	101	630			
		6	94	600	98.5	500	101	630			
		7	78		78		101	630			
		8	86	560	86	500					
		9	94	600	96.5	580					
		10	78	460	80	440					
		11	85	500	85.5	450					
		12	93.5	600	95	460					
		13	94	620	96	480					
1-18-63	62										
T_{amb} = 50°		1	78	500	80	440					
		2	85	500	86	470					
		3	93	570	94.5	540					
		4	94	600	96.5	600					
		5	76	510							
		6	84.7	520							
		7	93.5	580							
		8	94	600							
		9			78.5	440					
		10			86	440					
		11			94.5	490					
		12			95.5	520					

TIME AFTER RUN #62 1-18-62

Left Engine	37:19
Left Fan	33:31
Right Engine	36:42
Right Fan	33:00
T-58 Pitch Fan	17:34

T-58 PITCH FAN DATA

Run#	N T-58	EGT	N_{PF}	T_2	
54	70	480	1550	50	
1-14-63	75	460	1680		Bleeds cut off
	80	480	2000		
	81	490	2050		
	87	495	2400		Shut down for fuselage panel repair
55	74	400	1820		
56	95	630	3350		
57	96	630	3400		
	95	620	3350		
	96	620	3400		
	99	620	3750		Pitch fan by itself with no ingestion

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9.6.4 Test 177 Summary - Thermocouple Locations and Identification

The information included herein is applicable to the reduced temperature data of Section 9.6.5.

Test 177 consisted of approximately 62 runs, some of which involved simultaneous operation of lift and pitch fans. Only one data point (point 4 of run #41) was made at wing lift fan speeds above 1750 rpm - for this point the speeds were both 2410 rpm.

Data have been reduced for runs 18, 19, and 21, (16 and 41 partially). At the present, two rolls of temperature records are in the San Diego plant, but these are Ames property and will be returned soon. These records represent the temperatures of runs 25 and on.

The data available from these records are: gas temperatures in wing voids around both fans, internal fuselage gas temperatures, gas temperatures on the under side of the wing and flap (L/H), J85 engine inlet temperatures, wing fan inlet temperatures and on the last run in which the thrust deflector was installed, seven gas temperatures from the aft fuselage.

Thermocouple Locations for Ames Test 177

Run 11

Description		STA. L.	W. L.	B. L.
Gas temperatures below L/H wing surface with 45° flap	16	296(296)*	96(96)*	32
	17	296(296)	96(96)	46
	18	310(302)	98(97)	32
	19	310(302)	98(97)	46
	20	319(312)	91(99)	32
	21	319(312)	91(99)	46

* Values in parentheses are STA. L. and B. L. for thermocouples if the flap was retracted.

Gas temperatures	1	271	+13	31
Landing	2	286	+13	31

Gear	3	301	+13	31
Rake	4	271	-7	31
	5	286	-7	31
($h/_D = 1.7$)	6	301	-7	31
	7	271	+13	51
	8	286	+13	51
	9	301	+13	51
	10	271	-7	51
	11	286	-7	51
	12	301	-7	51

Run 18

Description		STA. L.	W. L.	B. L.
Gas temperatures below L/H wing surface with 45° flap	identical to Run 11 data			
Gas temperatures	1	271	63	31
Landing Gear	2	286	63	31
Rake	3	301	63	31
	4	271	43	31
($h/_D = 1.0$)	5	286	43	31
	6	301	43	31
	7	271	63	51
	8	286	63	51
	9	301	63	51
	10	271	43	51
	11	286	43	51
	12	301	43	51
	13	301	23	51

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Run 19

		STA.L.	W.L.	B.L.
Engine Inlet Duct	16	182	156	15R
	17	182	147	0.0
	18	182	156	15L
	19	182	147	15L
	20	182	156	0.0
	21	182	147	15R
Fuselage Temperatures	12	208	134	0
	13	218	147	0
	14	257	110	0
	15	269	126	0
Wing and flap lower surface surface gas temperatures	identical to Run 11 data			

Run 21

		STA.L.	W.L.	B.L.
Landing Gear h/d =2.2 Rake	1	271	-23	31
	2	286	-23	31
	3	301	-23	31
L/H wing Gas (Internal)	6	216	100	61
	7	236	100	41
	8	278	100	41
	9	294	100	61
Fuselage Temperatures	identical to Run 19			
Engine Inlet Temperatures	identical to Run 19			

Run 41

Engine Inlet Temperatures	identical to Run 19
L/H Wing Gas Temperatures	identical to Run 21
Wing and flap lower surface Gas temperatures	identical to Run 11

Run 45

		STA.L.	W.L.	B.L.
Aft fuselage gas temperatures (about 1/2" clearance from skin)	6	430	100	T.P.℄
	16	394	94	22
	17	430	110	19
	18	394	110	22
	19	376	110	23
	20	406	110	21
	21	376	94	23

Run 56

L/H Flap-Ext.	6	324(324)	87(100)	25
	16	315(207)	92(99)	43
	17	324(324)	87(100)	61
	18	308(303)	98(98)	43
	19	308(303)	102(103)	43
	20	324(324)	87(100)	61
	21	315(207)	92(99)	43
L/H Wing - Fwd.	3	214	106	61
	16	214	94	43
	17	214	107	43
	18	214	106	25
	19	214	106	43

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L/H Wing Int. -	identical to Run				
Fuselage - Internal		10	132	89	0
		11	230	114	0
		12-15	identical to Run		

Addenda to Thermocouple Location

Run 11 Landing gear thermocouples - the beads were separated from the frame by 1/4" to 1/2". Two comments - 1) possible error due to radiation, 2) high gas velocity brought about rapid temperature changes and rapid attainment of equilibrium

Wing gas temperatures - 16 and 17 were separated from skin by 1/4", 16 under wooden skin and 17 under steel skin. 18-21 were separated from steel skin by 1/16 asbestos paper, but heat-sinked by brass mounting screw to skin. 18-21 were washer-type thermocouples

Fan Inlet temperstures - G.E. had 8 thermocouples installed on each fan, 2 on the upper side of each strut. These fan inlet temperatures should be considered suspect for two or three reasons. First, they were mounted inside a shield intended to give them the stagnation temperature, however, the shield assumed the same temperature as the hot strut causing a radiation error. Note that the temperatures rise steadily. Second, instrumentation technicians did not keep ice in the reference bath, so the data are also in error due to reference drift. Third, the technicians did not always recognize individually each of the eight thermocouples. Much later (for the ramp test) these thermocouples were replaced by true gas temperature couples, but this data is available only from G.E., because the data were recorded on an oscillograph to be reduced at Evandale.

Engine Inlet - Six inlet thermocouples were recorded, but detailed interest was expressed after these data had been reduced. Where a max, or min, is listed, it refers to the six temperatures.

Fuselage Maximum and Wing Maximum - The same can be said for these measurements as was said for engine inlet.

Run 18 No change

Run 19 The engine inlet duct temperatures are recorded separately. The beads extended into the throat of the inlet about 2" (from the side) at a point about 10" aft of the inlet mouth.

Fuselage Temperatures - Bare thermocouple beads supported by ceramic separators and held 1.5" to 3" away from metal structure. All couples (10-15) are on the ship centerline inside the fuselage.

Wing and flap temperatures - same as Run 11.

Run 21 Landing gear rake - Same as Run 11.

L/H wing gas - listed separately for the first time. These couples were bare beads mounted midway between upper and lower surfaces and about 2" to 6" from the fan.

Fuselage temperatures - Same as paragraph above.

Engine inlet - Same as Run 18.

Run 41 Engine inlet - Same as Run 18.

L/H fan - Same as paragraph above.

Wing and flap - Same as Run 11.

Run 45 Aft fuselage temperatures - 7 couples were bare beads mounted 1/4" to 1/2" from skin.

Run 55 and 56 L. Flap Ext. - No. 6, 16, 17, 18, and 19 were bare bead 1/4" from steel skin. No. 20 and 21 were beads that were clamped between steel skin and the aluminum clip that held the associated air temperature couple. Although these beads were heat-sinked to the skin and were probably closer to skin temperature than air temperature, they were not as accurate as a washer with a large contact surface would have been.

9.6.5 Reduced Temperature Data

The reduced temperature data presented in this section are identified in Section 9.6.4 and are augmented by the data in the following Section 9.6.6.

DATA SUMMARY - AMES 40×80 WIND TUNNEL - 6 DEC 1962

T_{i_L} = L WING FAN INLET TEMP
T_{i_R} = R/H (ETC)
$T_{i_{ENG}}$ = ENG. INLET TEMP.

RUN NO.	DATA POINT NO.	L/H FAN RPM	R/H FAN RPM	PITCH FAN RPM	W.T. VEL. KNOTS	α	β	h/D	T_{AMB} (W.T.) °F	T_{i_L} °F	T_{i_R} °F	$T_{i_{ENG}}$ °F	
2	1	0	560	0	0	0	0	2.2	56		64	SEE NOTE 1	
	2		1200						56		70		
	3		1510						56		74		
	4		1720						57		81		
	5	660	0						57	68			
	6	1190							57	65			
	7	1500							58	67			
	8	1740							58	68			
	9	2300							58	69			
	10	660	800						58	89	91	122	SEE NOTE 3
	11	1170	1170						58	89	91	108	
	12	1500	1530						58	82	90	105	
	13	1700	1750						59	86	100	112	
3	1	0	750	0	0	0	0	[illegible].7	60		SEE NOTE 2	61	SEE NOTE 4
	2		1190									60	
	3		1500									66	
	4		1760									71	
	5	650	810							75	83	64	
	6	1140	1140							88	86	81	
	7	1540	1510							89	92	82	
	8	1700	1780							80	97	114	
4	1	1695	1695	0	80	0	0	[illegible].0	62	61	78	65	
	2	1700	1690		60				66	61	76	76	
	3	1680	1680		40				68	107	143	121	
	4	1670	1670		30				68	89	159	/	SEE NOTE 5
	5	0	700		0				69		100	80	
	6		1160						69		101	80	
	7		1560						68		106	106	
	8		1710						68		109	114	
	9	730	0						65	61		70	
	10	1170							67	58		76	
	11	1520								65		96	
	12	1720								60	56	128	
	13	710	760							68	108	80	
	14	1200	1200							75	117	90	
	15	1480	1480							71	113	108	
	16	1750	1760							—		104	

NOTES:

1. DATA POINTS WERE NOT ANNOTATED. ENGINE INLET TEMP APPROX. 25°F ABOVE T_{AMB}.
2. IN ABSENCE OF RECORDED DATA, MUST ASSUME T_{AMB}.
4. $T_{i_{ENG}}$ REPRESENTS THE AVERAGE OF 5 (OCCASIONALLY 6) INLET DUCT TEMPS, CORRECTED FOR TEMP DIFF. BETWEEN COPPER COLD JUNCTION ON MODEL AND RECORDER IN TUNNEL CONTROL ROOM. ESTIMATED ACCURACY ~ 1% TO 5%
3. DATA WITH WHICH TO CORRECT THESE FIGURES NOT AVAILABLE. ESTIMATED ACCURACY ~10% TO 30%. (APPLIES TO $T_{i_{ENG}}$ ONLY.)
5. COPPER COLD JUNCTION SUBJECTED TO WARM GAS ATMOSPHERE. EVEN WITH CORRECTION FACTOR, ACCURACY ESTIMATED ~10% (APPLIES TO $T_{i_{ENG}}$ ONLY.)

COMMENTS: INTUITION TELLS ME THAT THIS SOMETIMES SELF-CONTRADICTORY DATA SHOULD NOT BE ACCEPTED AT FACE VALUE. HOWEVER, IT DOES GIVE EVIDENCE THAT EXHAUST INGESTION MAY OCCUR CONSISTENTLY UP H/D ≥ 2.2.

[signature] 7 DEC 1962
MOFFETT FIELD, CALIF.

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AMES TEST 177 RUN 11 13 DEC 62 h/D=1.7, 45° FLAPS, SYMMETRICAL β, ZERO STAGGER, FAN$_D$ INOPERATIVE

DATA POINT	TIME	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	TUN. VEL. (KTS)	TUN. TEMP (°F)	α	β	FAN INLET R	FAN INLET L	ENG INLET MAX	ENG INLET MIN	GAS TEMPS LANDING GEAR RAKE 1	2	3	4	5	6	7	8	9	10	11	12	13	GAS TEMPS BELOW L/H WING SURFACE 16	17	18	19	20	21	WING GAS MAX	FUS GAS MAX
1	1041	1700	1700	0	40	64	-4°	35°	113	86	67	62	64	70	212	64	64	64	170	186	264	64	64	64	-	175	93	161	93	115	107	367	261
2	1042½	1710	1700			66	0		121	86	70	64	66	150	244	84	84	92	196	260	122	76	74	112	-	169	105	165	102	156	106	392	286
3	1044	1710	1630			67	+4		130	99	72	65	108	264	232	108	122	202	206	228	68	94	106	208	-	234	114	172	110	122	116	494	293
4	1045	1710	1630			68	6		136	104	75	66	182	274	220	152	192	242	262	140	80	138	190	184	-	254	138	182	126	142	154	412	296
5	1046½	1700	1675			70	8		143	106	76	65	232	254	154	174	258	238	234	80	82	170	310	312	-	318	180	195	162	194	192	508	302
6	1047½	1700	1675			71	10		147	108	76	69	350	304	178	226	310	230	238	82	82	230	228	82	-	324	236	210	216	244	246	434	304
7	1049	1700	1680			72	12		152	106	78	71	344	290	230	256	312	230	185	82	82	246	166	84	-	351	265	220	255	281	283	491	303
8	1050	1700	1630			73	14		160	113	79	72	296	194	304	338	318	172	190	86	84	280	116	86	-	353	305	225	283	305	307	438	303
9	1052½	1720	1690			74	0	40	167	113	82	75	90	80	140	82	80	76	186	78	190	74	74	74	-	261	215	235	155	160	135	401	321
10	1055	1720	1740			75		50	186	117	83	75	76	74	80	74	72	72	178	74	80	72	72	72		600+	331	309	163	413	139	391	333
11	1051	1710	1710			76		30	182	119	83	76	210	272	230	140	178	228	238	170	86	140	183	184		207	141	229	159	185	161	507	325
12	1057	1700	1700			77		15	183	117	85	77	332	282	338	244	222	176	156	92	92	104	96	92	-	335	304	224	260	254	260	472	322
13	1100½	1750	1750			78		0	230	147	85	73	262	334	358	176	258	234	118	110	232	100	102	198	-	286	254	226	262	254	254	444	293
14	1103	1700	1720			80		-12	243	147	100	73	356	334	294	302	352	272	134	232	242	142	242	230	-	279	271	221	245	206	235	447	275
15	1107½	1730	1705		80	81	-4	35	203	104	84	80	80	80	80	80	80	80	80	80	80	80	80	80		378	244	294	242	244	212	422	342
16	1110	1720	1700			82	0		208	108	83	82	80	80	82	80	80	80	80	80	80	80	80	80	-	404	244	288	284	296	240	422	350
17	1110½	1720	1700			83	+4		216	117	83	80	82	80	142	80	80	80	80	80	100	80	80	80	-	446	236	292	286	336	256	412	354
18	1112½	1725	1700			83	6		216	139	85	81	82	87	145	81	80	80	84	82	130	81	81	81	-	482	239	294	286	370	265	386	359
19	1245	1700	1700			78	8		156	104	81	78	76	117	146	76	76	76	76	78	140	76	76	76	-	513	237	237	300	369	273	349	321
20	1246	1690	1700			79	10		162	104	82	79	93	172	115	77	76	78	80	114	146	77	78	76	-	568	265	243	349	419	315	317	327
21	1247	1710	1700			80	12		169	106	84	80	155	182	100	76	81	114	112	176	172	78	80	103	-	600+	331	246	352	453	351	327	323
22	1249	1730	1710			82	14		132	110	84	79	80	80	122	78	78	78	80	80	80	79	78	78	-	576	276	274	182	444	195	343	323
23	1252	1720	1700			82	0	40	134	113	84	81	80	80	80	80	80	80	80	80	80	80	80	80	-	432	257	280	254	300	199	397	345
24	1253½	1750	1730			84		50	199	121	86	82	82	81	81	102	81	81	81	81	81	81	105	81	-	600+	359	307	403	569	416	419	353

MOUNTAIN VIEW, CALIF. 16 DEC 62 DON FISHER

RUN 11 $H/D_f = 1.7$

Rdg.	α	β	V_p	N_f	N_{Pf}
42	0	-12	30	1700	0
43		0			
44		15			
45		30			
46		40			
47		50			
14		-12	40		
13		0			
12		15			
11		30			
9		40			
10		50			
41		-12	60		
40		0			
39		15			
38		30			
36		40			
37		50			
27		0	80		
26		15			
25		30			
23		40			
24		50			

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RUN 11

β_V	Temp. Corr.	Rdg.	16		17		18		19		20		21	
12	-65°	42	292	227	282	217	244	179	250	185	232	167	238	173
0	-62	43	306	244	276	214	240	178	252	190	230	168	236	174
15	-46	44	408	362	304	258	244	198	264	218	250	204	252	206
30	-45	45	260	215	242	197	242	197	220	175	208	163	192	147
40	-57	46	140	83	130	73	242	185	130	73	98	41	96/	39
50	-54	47	600+	546+	328	274	374	320	112	58	276	222	86	32
-12	-50	14	258	208	250	200	200	150	224	174	206	156	212	162
0	-63	13	272	209	270	207	212	149	248	185	240	177	240	177
15	-75	12	386	311	302	225	222	147	258	183	252	177	258	183
30	-70	11	204	134	138	68	226	156	156	86	182	112	158	88
40	-75	9	256	181	210	135	230	155	150	75	144	69	130	55
50	-90	10	600+	510+	328	238	306	216	160	70	410	320	136	46
-12	-95	41	262	167	266	171	256	161	252	157	246	151	248	153
0	-95	40	272	177	272	177	250	185	256	161	244	149	250	155
15	-75	39	256	181	144	69	246	171	200	125	156/	81	178	103
30	-85	38	396	311	170	85	282	197	274	189	226/	141	240	155
40	-90	36	474	384	222	132	274	184	270	180	270	180	208/	118
50	-106	37	600+	494+	344	238	362	256	376	270	574	468	430/	324
0	-41	27	252		172/	133	268	227	208	167	144	103	174/	133
15	-44	26	292	248	178/	134	288	244	256	212	190	146	214/	170
30	-52	25	398	346	230	78	302	250	342	290	326	274	296	244
40	-50	23	428	378	254	204	280	230	250/	200	296/	246	196	146
50	-75	24	600+	525+	356	281	304	229	400	375	566	491	412/	335

RUN 11

	δ	$t_{CORR.}$	16	17	18	19	20	21	α
	1	-35	153	81	139	81	93	85	-4
	2	-48	124	70	130	66	120	70	0
$40V_K$	3	-59	187	67	125	63	75	70	+4
$\alpha =$	4	-61	235	89	133	77	93	105	6
$\beta_V = 35°$	5	-69	259	121	139	103	125	133	8
	6	-80	252	164	138	144	172	174	10
	7	-75	279	193	145	183	209	211	12
	8	-70	280	232	152	210	232	235	14
	15	-21	325	191	241	189	191	159	-4
	16	-18	358	198	252	238	250	194	0
$V_K = 80$	17	-28	392	182	238	232	282	202	+4
$\alpha =$	18	-37	419	175	231	223	307	205	6
$\beta_V = 35°$	19	-51	461	185	185	247	337	223	8
	20	-53	511	209	187	293	363	259	10
	21	-53	547	275	189	325	397	295	12
	22	-64	510	210	208	118	380	126	14

Run 13 — H/D_p = 2.2

	α	β	V_p	N_1	N_{pf}
Rdg. 1	0	-12	20	1700	0
2	↓	0	↓	↓	↓
3		15			
4		30			
5		40			
6		0	30		
13		-12	↓		
14		15			
15		20			
32		-12	60		
33		15	↓		
34	↓	20		↓	↓

Temp. Corr.	Rdg	#16	17	18	19	20	21	β	V_p
(+22)	1	(238) 260	(230) 252	(186) 208	(186) 208	(194) 216	(190) 212	-12	20
(+29)	2	(150) 179	(146) 175	(164) 193	(142) 171	(148) 177	(138) 167	0	↓
(+38)	3	(60) 98	(66) 104	(126) 164	(80) 118	(62) 100	(64) 102	15	
(+40)	4	(42) 82	(54) 94	(120) 160	(62) 102	(46) 86	(50) 90	30	
(+47)	5	(206) 253	(198) 245	(164) 211	(144) 191	(164) 211	(160) 207	40	
(+53)	6	(195) 247	(190) 243	(166) 219	(150) 204	(158) 211	(150) 203	0	30
(+92)	13	(160) 252	(150) 242	(130) 222	(120) 212	(110) 202	(110) 202	-12	
(+94)	14	(76) 170	(76) 170	(110) 204	(66) 160	(52) 146	(46) 140	15	
(+91)	15	(110) 201	(116) 207	(124) 215	(64) 155	(102) 193	(96) 187	20	
(+34)	32	(210) 244	(124) 158	(214) 248	(126) 160	(136) 170	(130) 164	-12	60
(+29)	33	(212) 241	(130) 159	(208) 237	(120) 149	(164) 193	(126) 155	15	
(+28)	34	(216) 244	(122) 150	(212) 240	(122) 150	(152) 180	(140) 168	20	

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Run # 14   h/D = 2.2

Rdg.	α	β	V_p	N_f	N_{pf}
8	0	-12	40	1700	0
1	0	0	40	1700	0
9	0	+15			
10	↓	+20	↓	↓	↓
17	↓	30	↓	↓	↓
18	↓	40	↓	↓	↓
19	↓	50	↓	↓	↓
26	↓	15	80	↓	↓
27	↓	30	↓	↓	↓
28	↓	35	↓	↓	↓
34	↓	40	↓	↓	↓
35	↓	50	↓	↓	↓

Rdg.	16		17		18		19		20		21	
-12 (+54) 8	(136)	190	(76)	130	(156)	210	(108)	162	(82)	136	(90)	144
0 (+17) 1	(220)	237	(220)	237	(194)	211	(192)	209	(196)	213	(190)	207
15 (+51) 9	(130)	181	(66)	117	(142)	193	(74)	125	(70)	121	(70)	121
20 (+48) 10	(122)	170	(60)	108	(138)	186	(70)	118	(60)	108	(68)	116
30 (+39) 17	(170)	209	(78)	117	(170)	209	(88)	127	(78)	117	(80)	119
40 (+38) 18	(210)	248	(152)	192	(116)	214	(84)	122	(96)	134	(72)	110
50 (+35) 19	(590)	625	(306)	341	(258)	293	(96)	135	(190)	225	(84)	119
15 (+20) 26	(270)	290	(154)	174	(242)	262	(202)	222	(156)	176	(180)	200
30 (+20) 27	(324)	344	(232)	252	(282)	302	(234)	254	(220)	240	(220)	240
35 (+20) 28	(372)	392	(250)	270	(282)	302	(244)	264	(264)	284	(222)	242
40 (+19) 34	(440)	459	(308)	327	(290)	309	(232)	251	(244)	263	(172)	191
50 (+19) 35	(600+)	619+	(360)	379	(354)	373	(414)	433	(580)	599	(450)	469

RESULTS OF TEMP-PLATE SURVEY [illegible] FLIGHT [illegible] (ALL TEMPS IN °F)

1. UNDER FUSELAGE — STA. [illegible] — TEMP. ([illegible])

[illegible]

2. LEFT SIDE OF FUSELAGE [illegible]

[illegible]

3. WING LEADING EDGE [illegible]

	5" FROM [illegible]	[illegible]	[illegible]
LEADING EDGE	(ABSENT)	(ABSENT)	450°
5" [illegible]	450°	450°	400°
[illegible]	LESS THAN 400°	LESS THAN 400°	LESS THAN 400°

4. UPPER SURFACE OF FLAP ([illegible] FLAP [illegible])

	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	400°	400°	400°	400°
MIDDLE	[illegible]	LESS THAN 400°	(ABSENT)	(ABSENT)
TRAILING EDGE	[illegible]	400°	400°	400°

5. LOWER FLAP SURFACE

([illegible])

	[illegible]	[illegible]	[illegible]	[illegible]
TEMPERATURE	[illegible]	[illegible]	[illegible]	400°

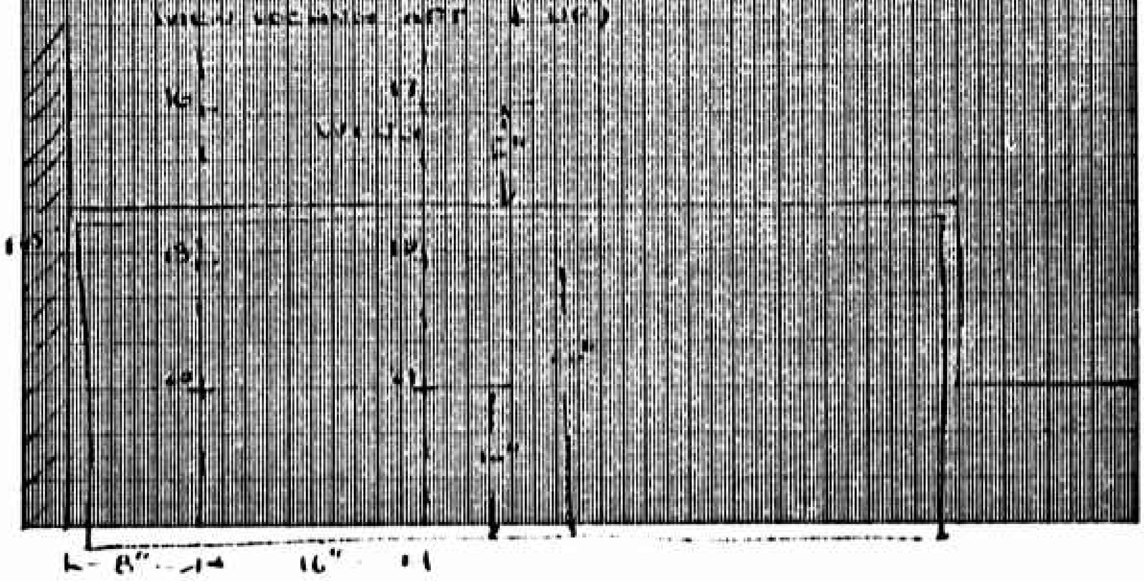
6. AFT SIDE OF AFT [illegible]

[illegible]

* INDICATES [illegible] TEMP-PLATES

LOCATION OF [illegible] FLAP

(VIEW LOOKING AFT & UP)



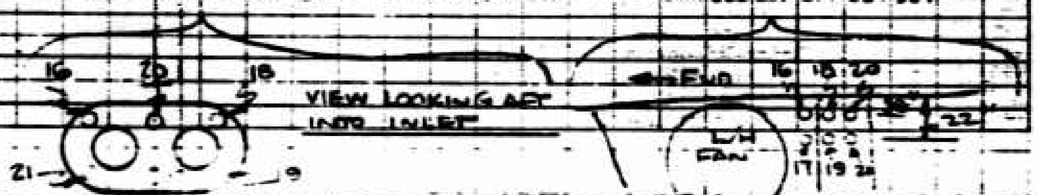
RYAN 64B017

AMES TEST 177 RUN NO 18 DATE 17 DEC 62 h/D = 1.0 δF = 45° [illegible] COMPILED BY

DATA POINT NO.	TIME	LEFT FAN RPM	RIGHT FAN RPM	TAIL FAN RPM	δe	β	R	TUN VEL (KTS)	T AMB °F	T L FAN	T R FAN	T TAIL FAN	1	2	3	4	5	6	7	8	9	10	11	12	13	16	17	18	19	20	21	[illegible]	[illegible]
1	1509	1710	1690	2400	0	0	0	30	61	—	75	72	98	400	392	90	130	394	91	105	181	84	85	168	91	343	261	180	252	250	257	379	211
2	1512	1700	1710			20	—		68	130	156	68	103	376	474	200	141	200	90	85	330	86	90	84	88	339	300	250	322	342	304	337	232
3	1513	1650	1710				30		65		165	73	100	406	438	155	116	214	85	80	334	84	86	82	94	445	286	275	302	307	279	371	250
4	1515	1680	1700				45		67	143	166	82	117	366	284	167	140	196	100	88	325	103	101	91	108	573	291	264	321	335	302	355	247
5	1516	1700	1690	2423			70		69	165	221	93	142	386	536	209	164	219	112	107	373	111	111	107	124	556	354	387	358	380	341	364	254
6	1518	1690	1700	2375			60		70	—	225	91	125	358	536	232	144	216	109	91	354	74	112	102	118	561	314	390	346	366	329	382	257
7	1520	1700		2375	2				72	173	231	97	132	436	446	147	135	270	117	96	326	125	115	106	120	583	319	386	343	368	335	375	250
8	1521	1690		2400	4				73	162	247	101	134	442	429	123	122	428	125	103	250	134	116	122	118	557	347	395	349	354	340	363	261
9	1525	1700	1690		0		0	40	76	156	195	91	132	443	520	173	160	232	122	100	364	92	90	91	92	550	349	384	336	354	318	364	255
10	1527	1700	1710				30		78		131	95	135	373	517	275	170	218	140	100	353	96	97	96	94	573	347	400	343	355	322	486	285
11	1528	1710	1700	2375			45		78	163	22[illegible]	87	133	366	526	222	164	230	120	102	340	107	105	99	106	564	336	336	348	358	330	464	293
12	1529	1630	1670	2400			70		79	165	243	111	162	423	542	247	213	262	98	118	338	107	106	105	127	597	368	425	373	383	380	449	294
13	1530½	1700	1680				60		79	178	231	105	140	433	536	193	96	245	112	112	352	112	108	106	114	571	375	419	367	381	352	454	233
14	1531½	1710	1700		2				80	182	236	110	139	442	479	162	150	283	115	116	348	120	112	111	126	591	349	437	376	387	368	445	286
15	1532½	1710	1670	2375	4				81	191		115	145	448	502	161	150	362	124	116	313	132	122	117	126	592	360	433	378	395	371	459	291
16	1534	1700	1700	2400	6				82	208	325	116	142	447	436	174	161	446	134	124	333	137	133	137	138	592	337	496	389	408	375	439	287
17	1537		1680		0		0	60	82	191	263	103	132	436	542	343	174	306	135	102	344	100	100	100	104	634	400	437	366	384	345	550	316
18	1538		1670				30		83	212	287	106	136	440	543	233	158	302	124	106	340	114	104	106	114	548	390	412	372	372	352	506	327
19	1539	1710	1680				45		84	208	260	105	130	456	582	217	198	270	124	118	357	130	116	115	134	628	428	452	382	400	363	478	325
20	1540	1700	1700				70			196	265	106	166	464	547	333	212	289	110	114	352	110	106	106	122	605	411	442	380	404	361	480	324
21	1541	1700	1690				60			191	260		178	484	538	341	240	293	120	119	352	116	112	113	126	596	412	442	378	398	369	378	324
22	1542½	1710	1700		2						263	108	184	484	498	265	226	385	118	121	335	120	116	120	127	589	414	438	383	404	365	495	324
23	1544	1720			4				85	199	287		198	500	443	216	213	473	121	122	300	122	120	135	127	584	395	417	384	413	370	488	326
24	1545	1680		2375	6						265		174	476	434	200	227	528	123	121	282	124	118	163	124	634	390	448	382	410	368	482	325
25	1549	1680	1730	2350	0		0	20		234	236	135	130	412	542	221	150	210	118	100	376	141	125	113	40	637	547	440	384	407	353	451	315

AMES TEST 77 RUN NO 19 DATE 17 DEC 62 $\eta = 1.7$ δF = 45° ADD. DATA $i_T = 12°$ (DATA PT 1-17), $i_T = 16°$ (D.P. 19 on) COMPILED BY D. FISHER 26 DEC 62

DATA POINT NO.	TIME	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	α	β	R	TUN VEL (KTS)	TUN TEMP °F	T_1 L FAN	T_2 R FAN	T_3 GAS MAX	1 (ENGINE INLET DUCT 16)	2 (17)	3 (18)	4 (19)	5 (20)	6 (21)	7	8 (FUS TEMPS 12)	9 (13)	10 (14)	11 (15)	12	13	16 (WING & F. LEADING SURFACE GAS TEMPS)	17	18	19	20	21	[illegible] GAS MAX	[illegible]
1																																	
2	2206½	1400	1390	1800	-2	20	45	30	66	82	130		72	87	76	76	72	70		201	205	234	251			304	295	226	252	264	258		
3	2208	1400	1390	1775	0	″	″	″	″	84	134		78	87	82	82	75	74		204	227	266	273			306	297	228	254	266	260		
4	2209	1390	1390	1750	+2	″	″	″	67	108	139		77	90	89	89	76	77		208	230	266	284			295	281	236	257	254	254		
5	2210	1350	1360	1750	+4	″	″	″	68	108	143		79	92	93	93	77	77		212	233	266	289			281	275	239	252	242	247		
6																																	
7																																	
8																																	
9																																	
10																																	
11	2223	1200	1200	1600	-2	32	60	40	76	108	134		82	85	86	85	84	83		237	241	285	301			160	108	212	116	103	106		
12	2225	1190	1150	1600	0	″	″	″	″	104	134		82	83	86	84	84	83		236	241	284	299			135	111	213	109	99	101		
13	2226½	1210	1175	1600	+4	″	″	″	77	85	130		79	84	93	91	92	91		232	242	285	296			164	111	217	105	107	103		
14																																	
15																																	
16																																	
17																																	
18																																	
19																																	
20	2243	1200	1200	1600	0	45	60	-50	79	95	143		77	78	78	74	79	77		245	245	313	315			616	317	318	254	330	237		
21	2244½	1200	1200	1600	4	″	″	″	″	90	148		79	79	78	76	81	80		230	251	313	315			644	358	361	314	524	324		
22																																	
23																																	
24																																	
25																																	



AMES TEST 77 RUN NO. 21 DATE 17 DEC 63 δ = 2.2 δf = 45° ... COMPILED BY D. ... 21 DEC 63

DATA POINT NO.	TIME	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	α	β	R	TIP TURB.	T AMB °F	T L FAN	T R FAN	T ENG GAS	LANDING GEAR 1	2	3	GEAR CAVE TEMP L/H WING GAS 64	79	58	97	FUS. TEMPS 9	28	30	48	58	WING INLET 16	WING GAS TEMPS 6	17	8	19	20	21	WING GAS	FUS GAS
1	1504½	1700	1690	2400	0	15	60	30	76				328	384	340	157	222	135	353				271	293		94	100	96	87	84	84		
2	1505½	1700	1670		2				77				346	314	286	164	229	202	352				272	234		101	102	101	90	86	88		
3	1507	1630	1690		4				78				324	286	292	174	236	213	342				268	294		105	104	105	94	91	90		
4	1508	1630		2390	6				79				292	246	276	180	245	221	336				268	296		110	109	103	97	94	94		
5	1509	1700		2375	8				80				272	266	270	189	244	219	351				265	295		118	109	115	98	98	98		
6	1510½	1630	1680	2390	10				81				266	286	256	186	247	226	305				265	293		120	113	110	100	104	100		
7	1511½	1670	1660	2380	12				81				264	302	234	188	254	236	306				270	298		126	117	134	107	110	110		
8	1513	1670	1670	2370	14				82				272	296	240	193	260	244	302				270	298		127	117	131	103	108	121		
9	1518	1630	1680	2400	-2	22		40	86				128	124	204	186	247	244	423				342	323		99	115	104	100	102	101		
10	1519				0				87				132	132	234	186	244	232	426				306	322		103	116	105	97	101	10[illegible]		
11	1521				2				87				136	254	316	185	239	234	425				304	318		113	114	108	93	98	10[illegible]		
12	1522½	1700	1700		6				88				230	276	292	186	243	243	430				306	318		107	110	109	91	97	97		
13	1524	1700	1700		8				88				256	294	262	187	234	231	405				307	321		115	112	109	90	97	100		
14	1524½	1690	1690	2390	10				89				256	304	250	191	233	233	385				311	323		115	113	110	89	97	100		
15	1526½	1680	1680	2390	14				89				350	286	316	134	271	270	356				323	326		120	114	113	87	100	104		
16	1535	1700	1670	0	-4	0	0	60	91				85	86	88	226	135	263	440				346	332		79	83	80	77	82	82		
17	1537		1700		0				91				88	88	88	237	135	264	437				347	333		82	86	82	79	83	82		
18	1538½		1690		4				92							206	86	234	434				348	336		83	88	83	81	84	83		
19	1539½		1680		6											204	177	234	437				349	339		83	88	83	81	83	82		
20	1540½		1700		8											203	175	232	434				350	340		83	83	84	82	84	82		
21	1542		1700		10				93						90	204	166	232	436				348	340		85	91	85	84	85	83		
22	1543	1710	1710		12				93						104	203	164	230	435				345	342		85	92	86	85	85	84		
23	1544	1710	1680		14				95							204	177	231	435				339	343		86	92	86	85	85	84		
24	1552½	1700	1680		-6			-70°					92	92	92	196	182	303	432				345	348		89	90	90	85	86	84		
25	1554	1700	1700		-4			70°								197	178	301	432				355	344		89	92	90	85	87	84		

NOT AVAILABLE THIS RUN

SEE ENG INLET GAS TEMPS 10-13

SEE L/H WING GAS TEMPS 9-10

SEE FUS TEMPS 11-15

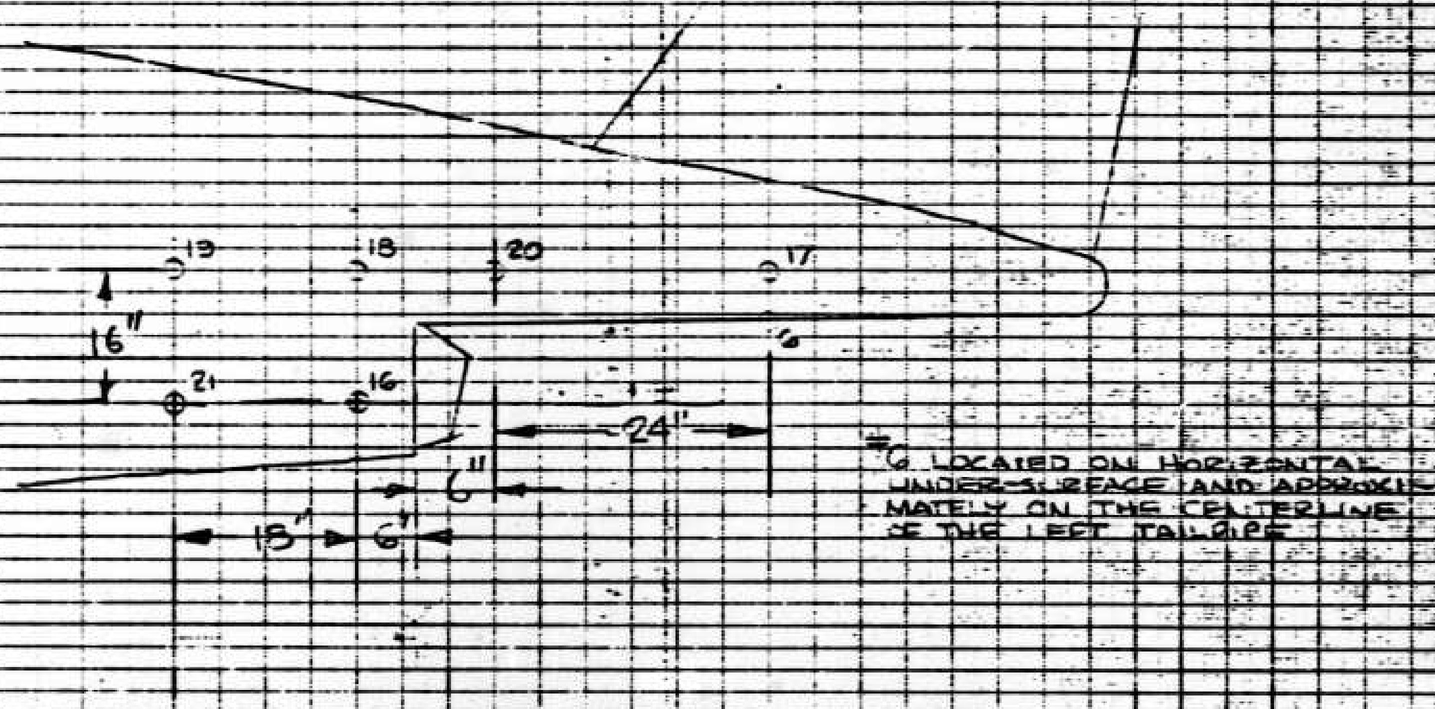
RYAN [redacted] 64B017

AMES TEST 77 RUN NO 41 DATE 27 DEC 62 $V_{/D}$ = 1.0 δF = 45° ALT. DATA δA = 30°, EMPENNAGE OFF COMPILED BY DEISHER 9 JAN 63

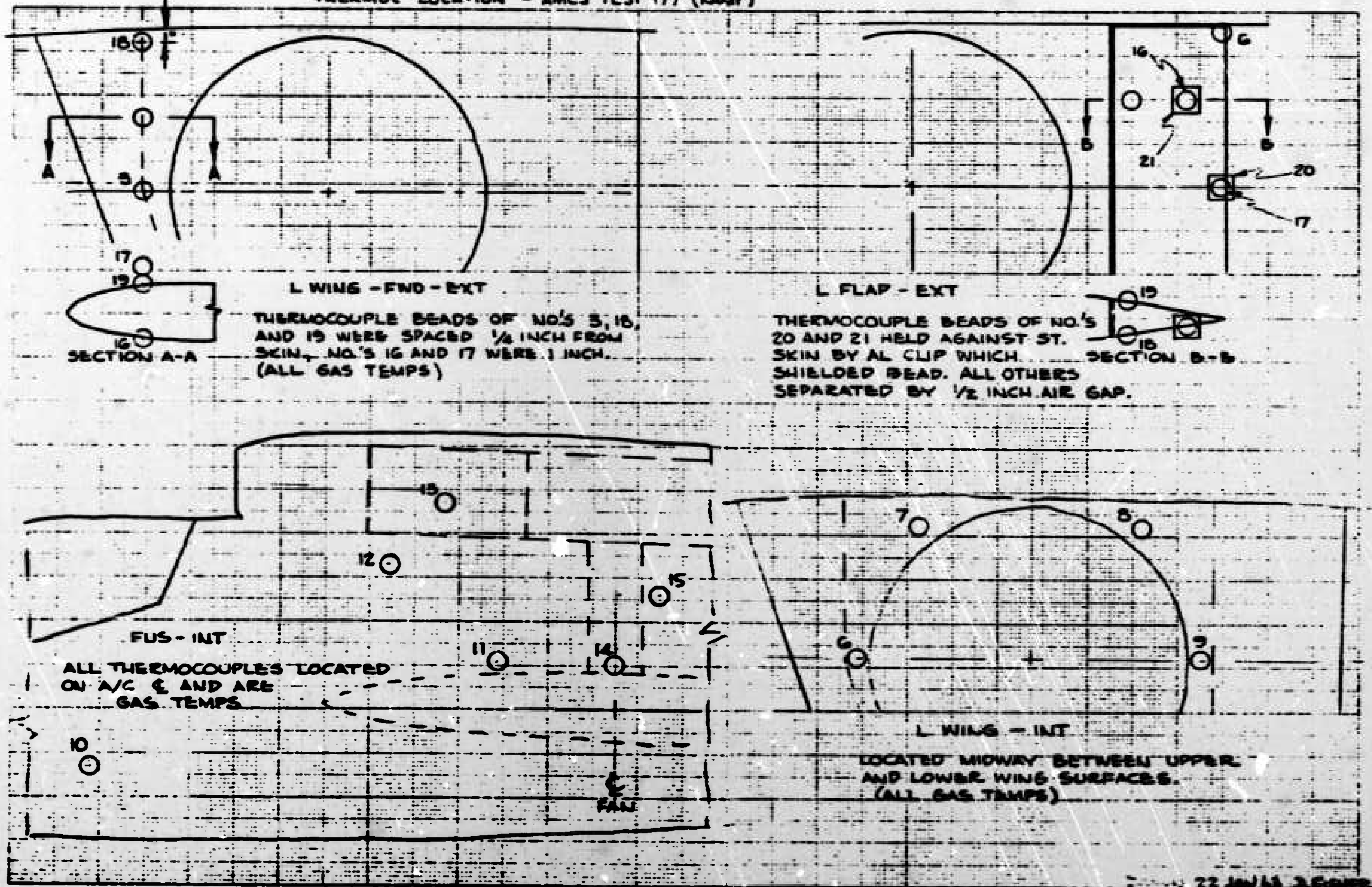
DATA POINT NO.	TIME	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	α	β	R	TUN. VEL. (KN)	TUN. TEMP (°F)	T_1 L. FAN	T_2 R. FAN	T_3 ENG. ...	ENGINE 1	2	3	INLET TEMP 4	5	6	7	L.A. FAN 8	9	10		12	13	WING & FLAP LOWER SURFACE GAS TEMPS. 16	17	18	19	20	21	WING GAS ...	EXIT GAS ...
1	2249				0	-12		40	56				85	23	39	114	83	103		173	97	93				194	204	214	238	240	298		
2	2250½					0			56				74	79	93	69	73	68		217	103	04				204	222	238	278	290	306		
3	2252					-5			58				65	75	77	53	63	58		255	129	59				314	284	356	302	482	566		
4	2254	240	2410	2400		5			59				83	76	87	73	71	65		300	90	78				240	282	300	574	536	562		
5	2256					30		—	62				58	81	71	53	57	56		258	76	65				295	357	478	627	627	627		
6	2258					-12		60	64				117	25	73	44	63	81		240	117	116				290	283	288	315	360	447		
7	2300					0			64				78	67	65	40	58	60		254	128	90				250	296	300	332	364	510		
8	2304½					5			65				62	68	54	38	57	56		138	71	68				366	346	362	476	436	534		
9	2303					30		—	66																								
10	2306					0		80	67																								
11	2312					5			67																								
12	2313½					30		—	68																								
13	2316					-12		80	70																								
14	2319					0			71																								
15	2320½					15			72																								
16	2322					30		—	73																								
17	2324					-12		20	73																								
18	2324½					0			74																								
19	2326					5																											
20	2327				—	30		—	—																								
21																																	
22																																	
23																																	
24																																	

AMES TEST ... RUN NO 45 DATE 12/31/52 ... COMPILED BY ______

DATA POINT NO.	TIME	LEFT ENG RPM	RIGHT ENG RPM	LH EGT	EST	MPS	MPS	TEMP	THERMOCOUPLE 6	16	17	18	19	20	21
1	1113	—	—	—	—	—	—	—	81	[illegible]	[illegible]	95	[illegible]	[illegible]	78
2	1119	95	95	530	400	534	512	53	600°	76	332	190	[illegible]	236	92
3	1121	95	95	530	400	534	519	56	600°	92	379	200	109	268	[illegible]
4	1122	95	95	530	400	522	519	57	600°	[illegible]	400	[illegible]	[illegible]	278	[illegible]
5	1128	94.5	94.5	530	400	526	515	58	600°	92	[illegible]	[illegible]	[illegible]	278	[illegible]



THERMOC LOCATION - AMES TEST 177 (RAMP)



RUN	TIME	EVENT	ENG-L	ENG-R	ENG-F	L FLAP - EXT 6	16	17	18	19	20	21
56	1256	T58 START			IDLE	60	72	60	70	101	59	81
	1327	J-85 ST/DIV	IDLE	IDLE		73	73	71	73	80	68	78
	1336	DATA PT. 1	2340	2085	?	213	254	232	260	78	119	215
	1337	DIVERT/TP	2400	2400	4000	254	212	154	220	104	158	238
	1343	DIVERT/FAN				104	134	94	139	143	196	169
	1344	DATA PT. 2				264	274	253	313	194	178	251
	1345	3				267	275	242	323	208	192	268
	1346	4				235	302	270	346	198	209	256
	1347	5				303	313	283	352	180	218	301
	1351	7				238	278	256	304	192	228	292
	1354	8	2300	2300	2800	295	292	270	292	220	218	289
	1356	9	1700	1625	0	286	293	271	331	192	226	288
	1357	10	1450	1400		265	229	176	260	153	237	279
	1401	11	0	1360		157	173	133	180	152	226	214
	1402	12		1730		150	168	138	174	146	216	204
	1403	13		2300		152	162	138	166	142	208	198
	1404	14		2400		130	138	121	143	125	186	168
	1410	L J85 ST/DIV				103	124	100	128	143	170	143
	1411	DATA PT. 15	1420			77	96	75	102	110	218	114
	1413	16	1700			70	71	57	92	66	131	89
	1414	17	2280			54	52	43	65	45	115	71
	1415	DIVERT/TP				59	57	48	68	49	117	74
	1416	ENG OFF				64	70	60	82	77	168	77
55		ZERO				45	45	45	45	43	41	45
	1007	J85 START				69	63	67	65	67	49	55
	1009	DIV/FAN				71	67	71	67	55	66	60
	1013	DATA PT. 1	2190	2290	3515	213	246	226	276	95	119	224
	1017	DIV/TP				239	261	238	292	122	165	245
	1020	ENG OFF				97	140	93	151	91	157	173
	1021	END ZERO										

TIME	L WING - FWD - EXT 3	16	17	18	19	L WING - INT 6	7	8	9	FUSELAGE - INT 10	11	12	13	14	15
1256	58	58	53	55	54	57	57	66	56	65	66	68	92	71	73
1327	58	61	54	55	53	60	58	69	64	91	65	65	67	64	68
1336	65	128	64	62	60	116	124	86	114	135	101	107	180	110	140
1337	70	293	62	62	58	145	152	150	168	157	157	157	215	113	154
1343	72	68	58	64	62	120	208	209	172	154	235	252	206	344	354
1344	67	280	83	97	91	148	184	178	180	141	141	146	231	166	200
1345	91	299	94	93	82	165	209	211	201	143	142	142	268	156	210
1346	73	301	74	80	77	183	219	169	224	149	138	133	269	171	234
1347	83	258	73	83	74	187	236	214	239	157	145	149	—	173	234
1351	82	320	104	113	88	199	233	168	252	139	160	158	288	178	240
1354	108	251	98	100	92	196	242	166	268	161	169	163	290	232	310
1356	93	295	101	109	99	207	248	206	277	164	197	197	266	298	346
1357	110	296	106	114	101	207	248	212	282	168	198	198	266	344	374
1401	81	95	64	68	68	181	239	219	257	146	198	198	245	306	344
1402	79	95	67	71	71	179	231	216	260	142	156	157	241	258	323
1403	72	87	67	70	70	176	227	208	261	144	168	170	266	236	300
1404	73	75	58	61	61	160	200	179	242	131	156	157	251	206	256
1410	71	59	54	58	58	132	184	178	195	124	124	124	217	218	237
1411	57	68	51	58	49	157	167	160	167	115	156	156	215	297	292
1413	40	58	44	52	42	140	158	79	158	122	136	136	212	166	178
1414	32	32	26	30	24	136	154	114	146	108	119	119	191	121	173
1415	36	32	26	31	24	—	182	117	146	110	111	112	201	120	178
1416	45	36	29	35	30	134	196	172	146	104	160	150	201	238	264
ZERO	43	46	45	45	42	42	43	45	41	42	43	43	43	43	45
1007	51	68	58	58	52	46	49	51	47	54	56	57	57	76	79
1009	51	76	61	57	55	46	67	67	50	62	116	117	136	160	[illegible]
1013	63	177	—	57	57	100	106	108	107	115	145	147	165	78	98
1017	56	155	52	53	52	140	135	135	141	129	130	130	216	86	109
1020	72	182	—	67	72	105	195	196	137	114	164	114	200	295	305
1021	69	107	80	70	61	106	[illegible]	[illegible]		115	114	114	201		

ACCURACY OF DATA IN DASHED LINES UNKNOWN BECAUSE OF SHORTED COMPENSATION REFERENCE THERMOCOUPLE

9.6.6 Aircraft Temperature During XV-5A Model Tests

This section reproduces unpublished data NASA-Ames Test 177 temperature presented in an Evaluation Memorandum prepared by General Electric Company.

RYAN 64B017

EVALUATION MEMORANDUM

T&E - E.M. #110

SUBJECT: AIRCRAFT TEMPERATURES DURING XV-5A MODEL TESTS

DATE: FEBRUARY 13, 1963

AUTHOR: G.C. Alford
G. C. ALFORD

cc: AP Adamson
ED Alderson
DE Clark & Staff
RT Haenel
LC Jensen
WR Morgan & Staff
RH Goldsmith & Staff
JT Kutney
WB Campbell

Aircraft temperature data gathered during the XV-5A model tests at Ames are presented here.

The data from Runs 11, 16, 18, 19, 21, 41, 45, 55 and 56 were collected and reduced by Don Fisher of Ryan. Additional data are included from Runs 59 through 62.

The following statements explain the tabulation of data. (see Figure 1)

Run 11: Fan Inlet - Obtained from G.E. fan inlet thermocouples.

Engine Inlet - Maximum & minimum temperature from six inlet thermocouples (#16-21) are presented.

Landing Gear Rake - Numbering is as follows: (see Figure 2) on the inboard side, the upper deck is numbered from forward to aft 1, 2, 3 and the lower deck 4, 5 and 6; on the outboard side, the upper deck is numbered from forward to aft 7, 8, 9 and the lower deck 10, 11 and 12. Note that at a model height of 1.7, this rake is not in a true landing gear position.

Left Hand Wing - Six thermocouples were placed on the wing and flap as shown in the diagram on the data sheet for Run 19. Numbers 16 and 17 were free air temperatures, but the remaining four on the flap were slightly sinked to the flap sink by their mounting screws.

Wing Gas, Maximum - Maximum of the nine internal wing gas temperatures (#1-9). The number recorded was usually 5 or 9.

Fuselage Gas, Maximum - Maximum of six internal fuselage gas temperatures (#10-15). The number recorded was usually 14 or 15.

Run 16: Temperature-Plate survey as diagramed on data sheet.

Run 18: T_{1L} and T_{1R} - Taken from analog sheet $T_{1\ Eng}$ - average of engine inlets 16-21. (see data sheet for Run 19)

Landing Gear Rake - Same as for Run 11 with the addition of 13 which is the temperature at the outboard-aft-floor corner of the rake. At H/D = 1.0, these data represent true landing gear temperatures

Wing Surface; Wing Gas, Maximum: Fuselage Gas, Maximum - Same as Run 11.

Run 19: Selected data points as shown. Inlet duct and fuselage gas temperatures are recorded individually as noted.

Run 21: Includes: Three landing gear rake temperatures - Four L/H wing gas gemperatures. Two fuselage temperatures. Six engine inlet temperatures.

Run 41: Data presented must be completed from the Ames run sheets.

Run 45: Primarily aft fuselage temperature data.

Run 55: Ramp Test. Figure 3 shows location of the following types of thermocouples.

5 - Type A - Gas temperature forward, L/H fan;

5	-	Type A	-	Gas temperature forward, L/H fan; exterior of wing.
4	-	Type B	-	Gas temperature interior left wing.
6	-	Type C	-	Gas temperature interior fuselage.
5	-	Type D	-	Gas temperature exterior, L/H flap and trailing edge.
2	-	Type E	-	Flap skin temperature.
4	-	Type F	-	Gas temperature interior right wing.

Run 56: Same as Run 55.

Run 59: through Run 62: The following table explains the data.

5	-	Type A	-	Gas temperature forward, L/H fan; exterior of wing.
4	-	Type B	-	Gas temperature interior left wing.
6	-	Type C	-	Gas temperature interior fuselage.
5	-	Type D	-	Gas temperature exterior, L/H flap and trailing edge.
2	-	Type E	-	Flap skin temperature.
4	-	Type F	-	Gas temperature interior right wing.

NOTE: There are only (3) copies available of the following:

Figures 1 and 3
Data sheets for Runs 11, 16, 18, 19, 21, 41, 45, 55 and 56

If you would like to see these tabulations, please see G.C. Alford, J.D. Corbett or R. H. Goldsmith

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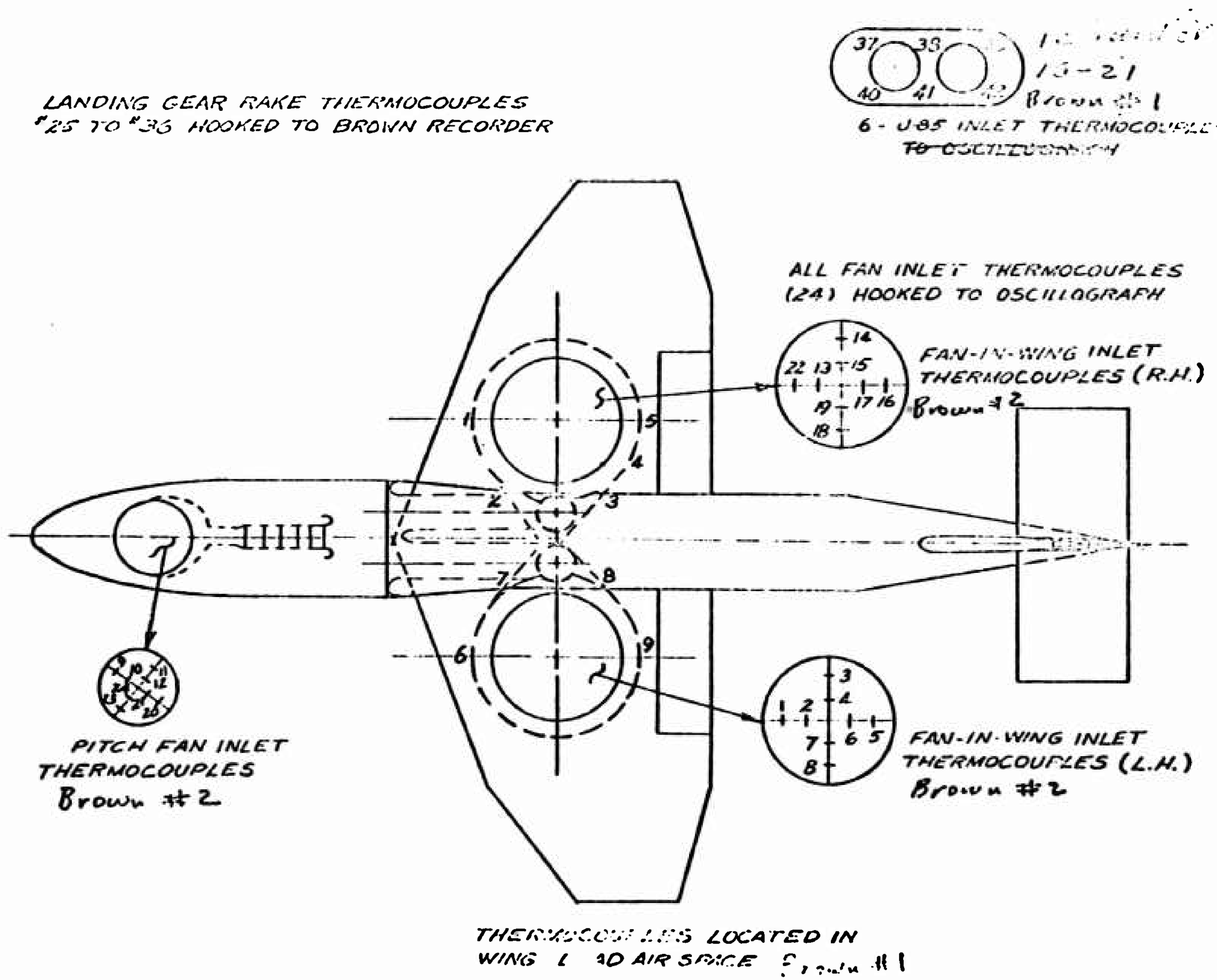
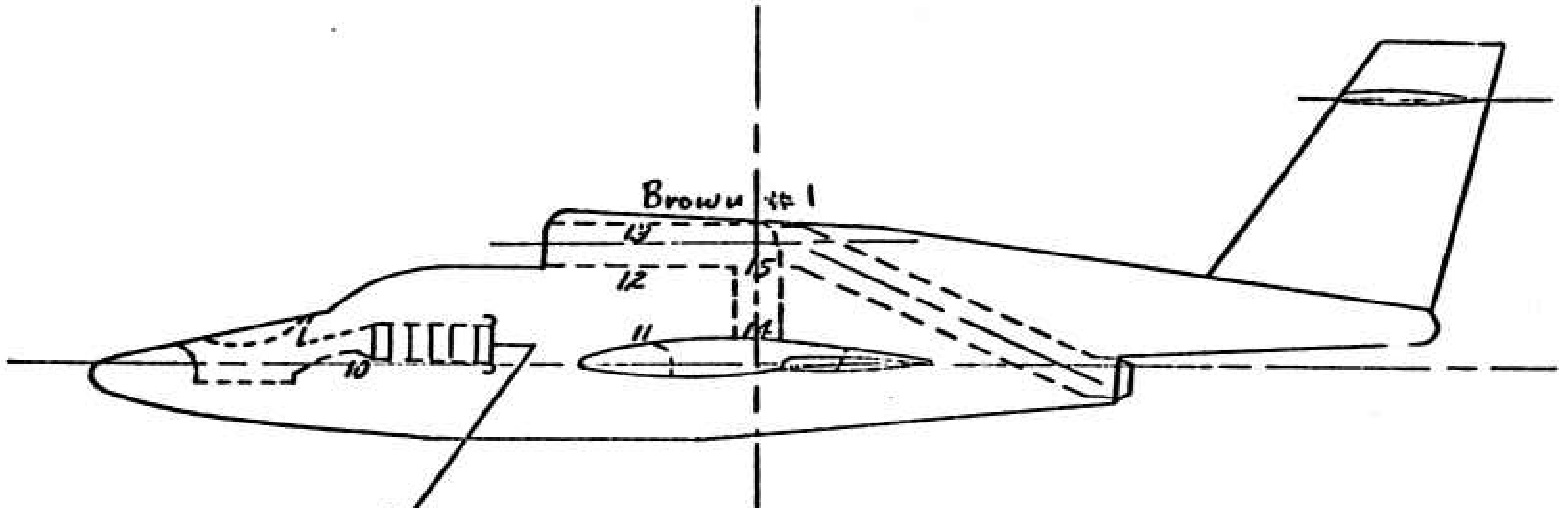
RYAN 64B017

THERMOCOUPLE #	BROWN #1 (0-300°F)	BROWN #3 (0-600°F)
1	F	-
2	F	-
3	A	-
4	-	F
5	-	F
6	63 ext. wing	6 D } Flap
7	-	7 B } int. wing
8	-	8 B } int. wing
9	-	9 B } int. wing
10	C } int. fus.	-
11	C } int. fus.	-
12	C } int. fus.	-
13	C } int. fus.	-
14	Recorder Temperature Compensator	14 C } int. fus
15	Model Terminal Strip Temperature	15 C } int. fus
16	A } ext. wing	16 D } Flap
17	A } ext. wing	17 D } Flap
18	A } ext. wing	18 D } Flap
19	A } ext. wing	19 D } Flap
20	-	20 E } Flap
21	-	21 E } Flap
22	T-58 Inlet Temperature	-
23	T-58 Inlet Temperature	-
24	T-58 Inlet Temperature	-

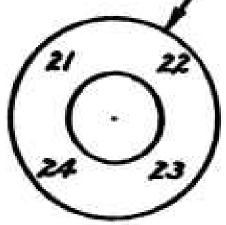
Note 1: All temperatures read on Brown #1 should be corrected by adding ΔT, where; $\Delta T = 15_{(1)} - 14_{(1)}$.

Note 2: Temperatures on Brown #3 should be doubled, then corrected by ΔT added as above.

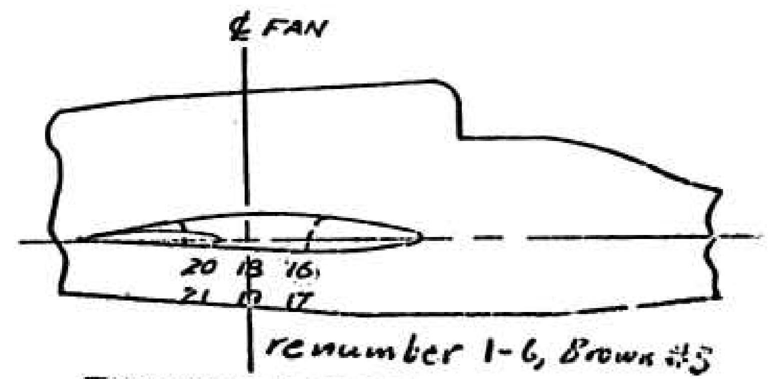

LANDING GEAR RAKE THERMOCOUPLES
#25 TO #36 HOOKED TO BROWN RECORDER
13-21
Brown #1
6 - J85 INLET THERMOCOUPLES
TO OSCILLOGRAPH
ALL FAN INLET THERMOCOUPLES
(24) HOOKED TO OSCILLOGRAPH
FAN-IN-WING INLET
THERMOCOUPLES (R.H.)
Brown #2
FAN-IN-WING INLET
THERMOCOUPLES (L.H.)
Brown #2
PITCH FAN INLET
THERMOCOUPLES
Brown #2
LOCATED IN
WING
AIR SPACE



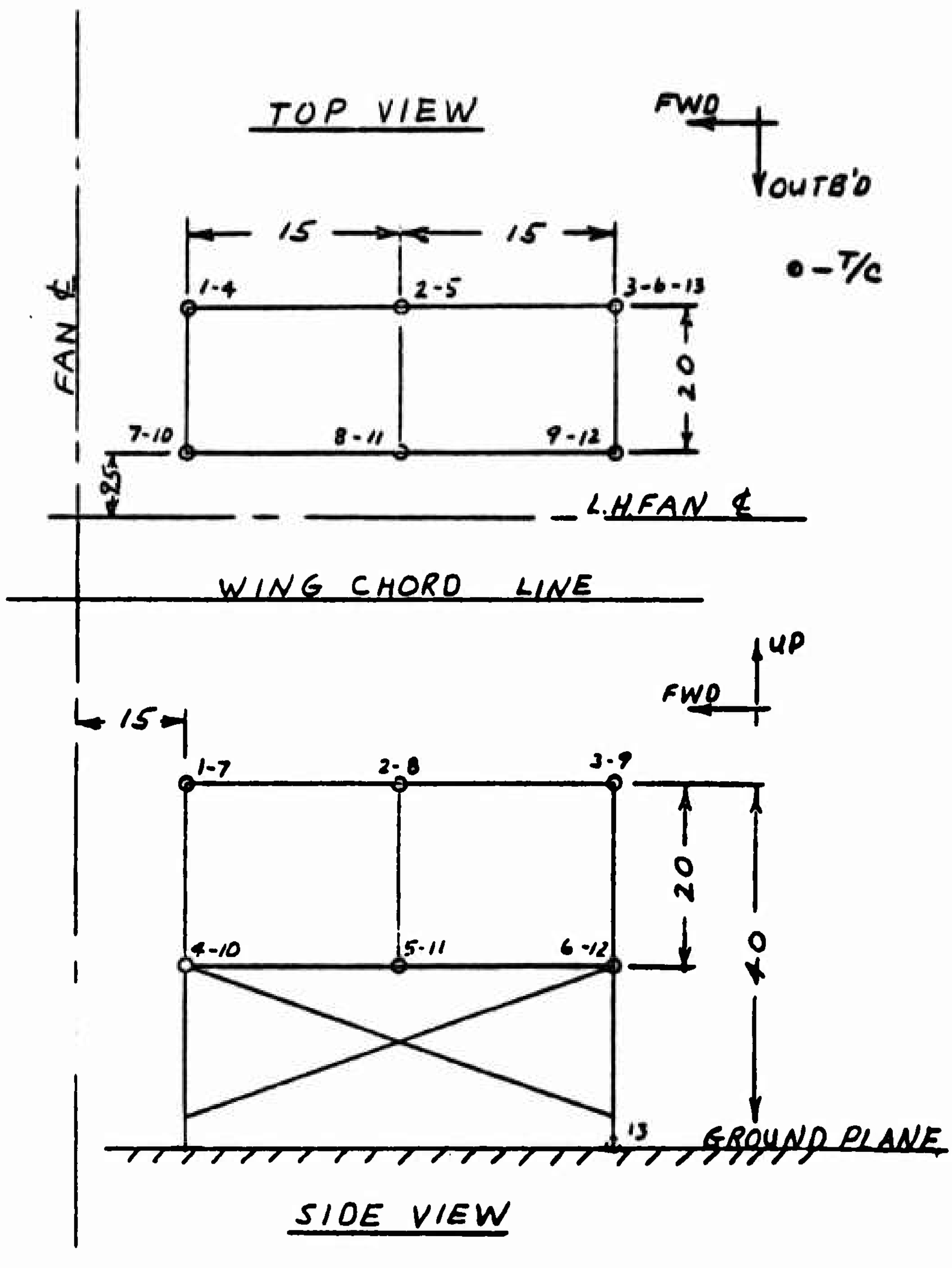
THERMOCOUPLES LOCATED ON FUSELAGE ℄



T-58 INLET THERMOCOUPLES
Brown #1



THERMOCOUPLES LOCATED ON FUSELAGE SKIN UNDER FAN (RT. SIDE ONLY)



LANDING GEAR TEMP. SURVEY - XV-5A MODEL
AMES WTT

FIG 2

RYAN 64B017

FAN SPEEDS RUNS 59 THRU 62

[illegible] NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
RUN 59 (1.22)																				
L.H.	N_{LF}	1400	1700	2300	2370	0	0	0	0	1380	1700									
R.H.	N_{LF}	0	0	0	0	1425	1700	2300	2420	1420	1700									
	N_{PF}	0	0	0	0	0	0	0	0	0	0									
RUN 60 (1.22)																				
L.H.	N_{LF}	1450	1680	2300	1400	1750	[illegible]	1350	1700	2300	2370	0	0	0	0					
R.H.	N_{LF}	1420	1700	2300	1380	1780	[illegible]	0	0	0	0	1390	1690	2300	2420					
	N_{PF}	2000	2450	3400	0	0	0	0	0	0	0	0	0	0	0					
RUN 61 (1.00)																				
L.H.	N_{LF}	1430	1700	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1400	1700	2300	1400	[illegible]	[illegible]	[illegible]	0	0	0	0
R.H.	N_{LF}	1400	1680	[illegible]	[illegible]	[illegible]	[illegible]	2470	[illegible]	1400	1700	2300	0	0	0	0	1400	1700	2525	2920
	N_{PF}	2020	2470	3670	3670	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0
	T/R°	40	40	40	40	0	15	30	45	0	0	0	0	0	0	0	0	0	0	0
RUN 62 (1.00)																				
L.H.	N_{LF}	1350	1150	2210	2370	1380	1750	2280	2380	0	0	0	0							
R.H.	N_{LF}	1400	1740	2300	2385	0	0	0	0	1380	1700	2370	2400							
	N_{PF}	0	0	0	0	0	0	0	0	0	0	0	0							

RYAN 64B017

GROUND #1

RUN # 59		h = 76" ; INLET DOORS OFF ; 1-16-63									
POINT #	0	1	2	3	4	5	6	7	8	9	10
1	81	97	113	120	125	133	147	130	134	152	179
2	85	91	89	94	92	94	84	82	85	115	108
3	"	"	89	94	"	"	"	"	"	"	111
4	"	"	90	"	"	"	"	"	"	"	113
5	"	"	90	"	"	"	"	"	"	"	113
6	"	98	117	127	133	134	130	124	123	126	153
7	"	"	"	"	"	"	"	"	"	"	"
8	"	"	"	"	"	"	"	"	"	"	"
9	"	"	"	"	"	"	"	"	"	"	"
10	"	90	98	106	110	102	98	95	93	98	105
11	"	115	129	128	126	136	139	132	136	158	167
12	"	123	161	169	158	158	169	165	163	205	213
13	"	115	161	168	200	213	208	249	243	229	259
14	79	79	79	79	79	54	80	?	?	98	?
15	54	54	56	"	"	80	"	80	92	—	—
16	54	54	56	"	"	80	"	"	71	—	—
17	85	94	95	100	97	84	"	"	79	120	104
18	91	107	107	103	105	89	85	83	82	129	"
19	87	92	93	97	77	88	85	82	81	118	"
20	81	103	105	99	98	102	99	90	86	233	221
21	81	104	105	99	100	101	99	"	"	240	217
22	83	85	90	98	"	90	91	"	"	120	99
23	83	85	90	77	"	90	91	"	"	93	99
24	83	85	87	89	90	89	89	87	"	90	94
L.H. N_{LE}	~~1430~~	~~1790~~	~~2530~~	~~2376~~					1580	1700	
R.H. N_{LE}					~~1725~~	~~1730~~	~~2500~~	~~2435~~	1420	1700	
N_{OF}											

BROWN #1

RUN # [illegible] 60 h = 26" ; INLET DOOR [illegible] 1-17-[illegible]

POINT #	0	1	2	3	4	5	6	7	8	9	10
1	74	142	151	150	185	178	170	200	196	182	158
2	81	106	108	85	100	102	99	75	67	65	66
3	81	106	113	"	105	108	98	70	"	"	"
4	89	105	"	"	108	105	"	"	"	"	"
5	89	105	"	"	108	105	"	"	"	"	"
6 (L.Gear, points 1–12)	79	125	143	148	165	168	175	177	172	163	152
7	77	"	"	"	"	160	"	"	"	145	146
8	77	"	"	"	"	"	"	"	"	"	"
9	77	"	"	"	"	"	"	"	"	"	"
10	88	123	129	157	156	146	145	131	126	123	119
11	91	128	120	119	158	140	151	197	196	176	157
12	97	190	203	212	231	230	231	222	212	206	194
13	115	203	232	225	243	253	252	256	245	237	234
14 (8)	72	74	?	95	?	?	?	?	?	?	?
15	75	"	75	75	75	81	73	74	75	75	72
16	75	"	75	75	75	81	73	74	75	75	72
17	77	179	118	93	155	135	78	66	62	60	61
18	78	152	133	99	167	153	90	79	66	65	70
19 (JJS Ta, points 16–21)	77	125	116	91	148	125	85	69	67	64	64
20	76	260	245	213	280	258	142	77	70	67	66
21	76	300	282	211	300+	292	137	77	70	67	66
22	93	190	160	163	175	185	135	139	146	146	145
23	93	145	151	163	145	138	135	139	146	146	145
24	95	127	131	170	145	133	125	120	115	112	110

BROWN #1

h = 64"; INLET DUCKS ON [illegible]

RUN #	60				61						
POINT # →	11	12	13	14	0	1	2	3	4	5	6
T/C # ↓											
1	158	160	135	132	65	114	133	138	156	153	159
2	73	69	69	68	55	71	75	63	80	73	69
3	"	"	"	"	"	"	"	68	81	67	"
4	"	"	"	"	"	"	"	"	83	66	"
5	"	"	"	"	"	"	"	"	83	66	"
6	140	136	132	128	"	98	118	125	144	148	158
7	132	125	136	"	"	"	"	"	"	"	"
8	"	"	"	"	"	"	"	"	"	"	"
9	"	"	"	"	"	"	"	"	"	"	"
10	117	119	117	117	62	97	112	120	132	139	143
11	140	130	121	114	62	97	107	102	115	102	136
12	183	187	179	173	77	155	168	168	186	183	184
13	201	215	242	250	96	174	204	185	212	196	201
14	74	72	72	70	52	52	?	56	80	?	?
15	"	"	"	"	52	"	53	53	53	53	53
16	"	"	"	"	53	"	53	53	53	53	53
17	61	59	58	58	58	66	67	56	58	55	55
18	66	65	63	62	58	"	67	"	59	59	60
19	69	67	67	66	57	"	66	"	59	60	53
20	90	87	78	75	87	197	200	195	195	195	190
21	91	87	78	75	87	248	280	284	300+	300+	300+
22	125	124	132	133	74	126	157	165	?	190	190
23	125	124	132	133	73	116	132	141	145	157	161
24	107	106	105	104	76	114	135	147	145	174	176

BROWN #1

RUN # / POINT #	61 / 7	8	9	10	11	12	13	14	15	16	17
1	157	170	181	164	155	160	144	130	125	115	105
2	65	65	81	68	50	42	42	39	39	50	44
3	62	65	76	"	"	"	"	"	"	"	"
4	"	64	"	"	"	"	"	"	"	"	"
5	"	64	"	"	"	"	"	"	"	"	"
6	170	169	175	161	160	161	158	147	147	106	88
7	"	"	"	"	"	"	"	"	"	"	"
8	"	"	"	"	"	"	"	"	"	"	"
9	"	"	"	"	"	"	"	"	"	"	"
10	145	146	148	140	142	113	108	103	98	88	77
11	145	146	148	140	142	113	108	114	101	89	78
12	190	195	199	194	198	171	176	171	160	133	141
13	207	211	227	232	264	217	203	193	199	179	169
14	?	?	?	?	?	?	?	?	?	56	5?
15	53	53	53	53	61	54	54	55	55	56	"
16	"	53	53	53	61	54	54	55	55	56	"
17	"	50	113	60	44	32	27	28	26	39	35
18	"	54	124	69	50	36	31	40	30	40	37
19	"	49	107	64	45	34	28	27	26	49	40
20	190	185	240	190	180	57	41	40	40	45	39
21	300+	300+	300+	296	300+	57	41	40	40	44	38
22	190	190	190	185	190	133	138	136	130	103	108
23	159	152	134	131	134	133	138	136	131	103	108
24	167	167	135	127	123	106	102	98	95	80	77

BROWN #1

h = 64" ; INLET DECKS OFF [illegible] 78 [illegible]

RUN #	61		62								
POINT #	18	19	0	1	2	3	4	5	6	7	8
1	100	104	56	155	147	140	145	152	146	135	127
2	40	38	60	82	73	61	51	54	49	47	48
3	"	"	"	80	7[illegible]	"	"	"	"	"	"
4	"	"	"	79	"	"	"	"	"	"	"
5	"	"	"	79	"	"	"	"	"	"	"
6	91	92	62	143	143	140	148	160	153	135	130
7	"	"	"	"	"	"	"	"	"	"	"
8	"	"	"	"	"	"	"	"	"	"	"
9	"	"	"	"	"	"	"	"	"	"	"
10	73	71	"	87	91	92	97	87	83	80	78
11	73	71	"	162	139	92	115	178	165	130	113
12	132	129	69	178	180	184	194	172	178	173	164
13	189	207	91	202	223	261	187	225	217	212	216
14	60	?	63	?	?	?	65	?	?	?	?
15	"	58	68	65	65	66	"	65	64	65	65
16	"	58	70	65	65	66	"	65	64	65	65
17	32	30	60	61	70	58	46	47	42	40	43
18	33	31	61	68	69	62	51	52	44	44	46
19	39	35	66	69	68	61	48	48	43	42	44
20	37	"	72	204	206	195	87	62	52	48	50
21	36	"	72	300*	235	292	85	62	52	48	50
22	94	94	67	190	106	170	88	91	92	91	91
23	94	94	67	111	85	93	88	91	92	91	91
24	72	70	63	79	81	84	85	81	79	77	76

BROWN # 1

POINT #	62 9	10	11	12
1	134	126	120	117
2	63	61	61	60
3	"	"	"	"
4	"	"	"	"
5	"	"	"	"
6	125	119	116	113
7	"	"	"	"
8	"	"	"	"
9	"	"	"	"
10	80	79	78	78
11	108	80	78	78
12	150	169	157	152
13	220	204	219	214
14	?	?	?	?
15	65	66	66	65
16	65	66	66	65
17	50	51	49	49
18	56	55	54	55
19	69	63	60	60
20	68	61	57	59
21	67	61	57	54
22	88	87	87	85
23	88	87	87	85
24	75	75	75	75

RYAN 64B017

DROWN #3

RUN #	59										
POINT #	0	1	2	3	4	5	6	7	8	9	10
1	45									83	109
2	45									83	109
3	42	62	61	58	51	65	70	68	73	89	103
4	"	55	55	53	50	63	67	66	72	81	96
5	"									112	117
6	"									111	118
7	"	68	75	74	58	75	70	67	67	84	94
8	"	68	76	61	61	72	66	62	63	82	70
9	"						58	57	62	69	74
10	"						"	"	"	"	"
11	"						"	"	"	"	"
12	"						"	"	"	"	"
13	"						"	"	"	"	"
14 (int. fus.)	"				78	97	70	80	95	129	~~115~~ 23[illegible]
15 (int. fus.)	"	69	72	68	79	110	113	98	99	134	122 244
16 (flap)	"									~~118~~ 236	~~128~~ 256
17 (flap)	"									~~120~~ 240	~~126~~ 252
18 (flap)	44									~~125~~ 250	~~131~~ 262
19 (flap)	51									~~95~~ 190	~~46~~ 92
20 (flap)	42									"	71
21 (flap)	45									"	112
22	46									"	"
23	"									"	"
24	"									"	"

Multiply all readings by 2

NO ENTRY IS MADE FOR CONTINUOUS AMBIENT READINGS

BROWN #3

RUN # 60 / POINT # →		0	1	2	3	4	5	6	7	8	9	10
1		38	87	100	104							
2		"	87	100	104							
3		"	68	62	72	88	85	62	107	115	93	65
4		"	67	66	78	87	80	68	96	102	93	75
5		46	110	113	112	118	119	113	50	47	44	40
6		46	110	114	111	116	120	114	50	47	44	40
7		38	67	66	69	85	75	96	93	89	95	92
8		"	52	53	55	66	58	96	93	89	95	92
9		"	"	63	74	80	82	85	88	89	87	85
10		"	"	"	"							
11		"	"	"	"							
12		"	"	"	"							
13		"	"	"	"							
14	int. fus.	56	91	73	89	127	100	77	129	119	95	85
15	int. fus.	56	94	88	107	130	111	105	138	124	112	103
16	flap	45	115	119	118	125	120	124	61	53	47	44
17	flap	"	113	116	114	119	115	122	42	38	38	35
18	flap	"	125	123	119	133	126	127	60	53	50	48
19	flap	50	67	55	40	77	58	44	43	40	40	35
20	flap	39	62	68	75	84	80	80	89	85	75	88
21	flap	46	101	110	115	116	117	119	88	76	69	62
22		39	90	102								
23		"	"	"								
24		"	"	"								

Multiply all readings by 2

RYAN 64B017

BROWN #3

RUN #	60				61						
POINT # →	11	12	13	14	0	1	2	3	4	5	6
T/C #											
1											
3	75	70	67	69	26	56	57	54	65	55	60
4	70	68	65	66	26	54	58	56	68	61	67
5	42	40	39	39	36	115	124	131	121	140	140
6 - Flap	42	40	39	39	36	114	124	131	124	138	140
7	79	72	70	67	26	56	58	61	60	65	70
8	78	72	70	67	26	44	45	50	50	54	70
9	75	75	75	74	26	41	53	62	75	80	93
14 } int. fus.	123	88	76	71	30	68	53	45	60	47	46
15 }	137	122	103	99	30	78	67	55	87	62	56
16 }	48	44	41	40	35	123	134	148	133	~~181~~ 232	~~198~~ 296
17 } Flap	40	38	36	37	38	107	112	125	109	~~122~~ 244	~~117~~ 234
18 }	50	47	44	43	35	147	164	179	187	~~203~~ 406	~~197~~ 394
19 }	44	40	39	38	30	28	31	30	50	~~47~~ 94	~~62~~ 124
20 }	60	59	57	55	26	54	60	65	72	72	77
21 }	55	52	49	47	29	106	118	129	127	141	141

Multiply all readings by 2

BROWN #3

RUN #	61												
POINT #	7	8	9	10	11	12	13	14	15	16	17	18	19
3	62	65	83	86	66	107	97	57	45	44	57	50	59
4	74	75	79	65	72	87	89	65	55	47	56	54	60
5	136	133	133	129	135	34	32	29	29	35	34	35	30
6	137	128	130	124	134	34	32	30	29	36	34	36	31
7	71	69	84	77	81	77	72	92	92	55	48	52	[illegible]
8	73	51	74	60	68	67	61	50	50	53	45	44	[illegible]
9	89	91	95	94	96	85	83	77	72	59	54	56	[illegible]
14 } int. fus.	49	64	116	74	54	110	101	62	55	82	65	59	58
15 }	59	104	124	102	89	114	110	92	88	105	106	83	76
16 } flap	145	137	140	130	146	44	40	34	33	37	30	33	29
17 }	120	107	109	107	118	26	25	24	24	34	27	29	26
18 }	200	187	194	160	196	57	51	47	44	35	28	32	30
19 }	73	57	60	26	48	24	24	24	22	25	22	21	20
20 }	79	81	94	85	79	72	69	65	61	46	43	45	45
21 }	143	136	132	128	137	70	63	55	51	37	32	32	31

Multiply all readings by 2

RYAN 64B017

BROWN #3

RUN # / POINT #	62 / 0	1	2	3	4	5	6	7	8	9	10	11.	12
3	34	89	84	66	75	102	100	61	51	55	53	55	62
4	28	79	80	69	78	96	98	70	61	55	54	57	61
5	28	107	115	125	103	45	40	38	37	37	35	33	34
6	28	105	111	123	100	45	40	38	38	37	35	34	34
7	32	82	80	80	80	83	79	87	92	69	63	65	64
8	36	67	55	58	59	77	64	53	49	59	54	52	46
9	30	68	72	77	83	85	83	78	74	66	66	65	64
14 } int. fus.	28	125	80	62	119	126	108	75	84	114	71	67	73
15 }	28	120	101	80	122	126	116	99	105	128	88	87	104
16 } flap	28	118	119	130	91	65	53	48	46	43	40	38	37
17	32	105	105	117	64	37	33	31	29	33	32	30	31
18	36	138	130	149	98	75	58	55	50	47	43	40	39
19	30	106	49	90	34	30	27	28	27	35	34	32	33
20	30	83	76	80	82	83	73	65	60	54	53	52	50
21	30	106	112	123	112	90	77	69	65	55	51	49	46

Multiply all readings by 2

9.6.7 40' x 80' Wind Tunnel and Aircraft Operational Control Data

Test Control data are presented in this section together with occasional summaries of temperature data. Temperature data are identified from Section 9.6.6.

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 171 RUN 11 DATE 13 DEC 62

CONFIGURATION BROWN

δ	(1) LEFT FAN RPM	(2) RIGHT FAN RPM	(3) PITCH FAN RPM	(4) V FPS	(5) i_t	(6) α_u	(7) β	(8)	(9)	(10)	(11) L_u	(12) D_u	M_u	REMARKS
a	74	75	75	75	75	75	74	74	74	74	75	76		1030 ENG START
b	74	74	145	75	75	75	111	115	75	75	91	107		1032 DIVERT
1	203	178	266	136	75	177	212	205	79	70	137	193		1081
2	202	195	274	143	76	182	207	209	81	69	148	203		1042½
3	201	204	280	151	78	171	206	214	85	69	167	214		1043½
4	203	210	289	159	83	174	214	224	96	61	150	223		1045
5	200	220	293	166	86	181	224	228	101	69	135	227		1046½
6	199	227	293	166	85	179	228	227	119	68	123	227		1047½
7	197	230	293	164	86	200	234	234	106	66	118	228		1049
8	195	231	293	159	83	199	233	234	106	63	121	226		1050
9	192	243	300	182	99	176	215	238	112	60	103	230		1052½
10	166	281	300+	184	101	211	300+	256	128	61	95	221		1059
11	193	242	300+	182	94	210	232	250	124	61	151	243		1051
12	195	238	277	180	78	175	266	267	110	64	176	245		1057
13	185	266	300+	181	79	193	245	248	122	57	192	232		1100½
14	169	265	294	165	86	184	234	242	115	46	150	220		1103
15	141	234	280	151	79	179	143	236	107	38	107	162		1107½
16	131	245	283	154	81	185	132	247	120	46	101	166		1110
17	123	265	286	156	82	160	124	246	125	46	97	171		1110½
18	112	236	273	163	86	140	130	255	131	48	91	167		1112½
c	111	236	296	172	73	150	147	251	132	49	91	167		1114 DIVERT
d	74	126	146	78	76	107	131	153	77	87	79	167		1123 ENG OFF
e	74	76	106	82	33	85	87	109	81	75	93	83		1237 ENG START
f	75	79	161	82	33/	84	120	184	81	75	118	97		1237½ DIVERT
19	118	243	300+	181	33/	143	265	247	120	77	106	164		1245
20	114	239	300+	150	34	145	264	251	124	77	106	165		1246
21	112	236	300+	153	34	146	271	255	128	75	107	159		1247
22	118	241	300+	182	34	142	262	300+	189	73	109	188		1249
23	140	263	300+	155	33/	162	219	217	152	75	115	177		1252
24	116	242	300+	183	33/	167	271	258	164	75	113	200		1253½
25	165	251	300+	184	33/	162	210	285	153	76	118	181		1255
26	170	233	300+	182	34	137	184	272	146	75	122	167		1256½
27	167	211	300+	150	34	125	151	265	139	75	117	159		1258
28	201	288	300+	182	34	167	111	211	151	75	134	208		1303½
29	171	247	300+	182	33/	167	172	213	157	75	121	216		1304

J-85 ENG INLET — T-58 INLET

δ	(13) q	(14) C_L	(15) C_D	(16) C_m	(17) T_c	(18) ρ	(19)	(20)	(21) V_o RPM	(22) V_o RPM	(23) V_o RPM	(24) 4 ET	4 LOT	4 RE	RPM ET	RPM LOT	RPM RE	TUN TEMP
a	75	74	85	76	76	76	75	75	[illegible]	75	75	76		76				
b	133	75	74	75	79	77	75	76	[illegible]	74	74	75		76				
1	141	108	73	75	80	77	76	78	62	72	72	72		77		-13	1	65°
2	250	116	65	76	82	79	79	79	65	72	72	72		78		-12	2	66°
3	258	126	67	77	84	80	80	80	69	71	72	73		79		-12	3	67°
4	265	132	71	78	85	82	81	81	72	70	72	72		80		-12	4	68°
5	266	134	65	78	86	81	81	82	81	70	71	71		80		-10	5	70
6	269	137	57	77	84	50	78	80	74	69	71	70		79		-8	6	71°
7	266	133	58	74	81	76	75	76	71	66	68	67		75		-3	7	72°
8	261	127	57	69	76	71	69	71	67	63	63	63		70		+3	8	73°
9	265	132	60	70	77	72	71	72	70	62	63	61		70		+5	9	75
10	273	142	56	72	80	75	74	74	72	63	63	63		73		+3	10	76
11	266	133	57	73	80	75	75	75	73	63	64	63		74		+3	11	77
12	267	134	55	75	83	78	77	77	75	64	64	64		76		+2	12	78
13	258	123	57	74	69	60	57	56	89	59	58	51		65		+14	13	79
14	245	112	56	52	67	52	65	51	79	58	53	37		59		+21	14	80°
15	191	77	56	42	44	44	41	42	40	43	44	39		41		+40	15	81°
16	211	79	61	50	51	52	49	51	35	47	47	45		50		+32	16	82°
17	219	85	57	54	55	55	52	54	37	49	50	46		54		+28	17	82°
18	225	91	54	57	59	59	55	57	44	51	51	48		57		+26	18	83°
c	235	97	51	57	60	60	58	59	46	52	52	49		59				
d	70	71	51	64	63	64	69	61	72	55	55	50		63				
e	83	82	56	72	72	73	70	71	86	76	76	76		71				
f	130	82	53	72	71	73	71	73	72	76	76	76		72		+6		78
19	239	104	53	78	80	80	77	79	[illegible]	77	77	77		78		+1	19	79
20	240	105	52	78	81	81	78	80	[illegible]	76	76	76		79		+1	20	80
21	234	105	52	77	81	80	78	79	[illegible]	75	75	75		78		+3	21	81
22	252	117	53	76	81	80	78	79	92	74	74	74		78		+3	22	8[illegible]
23	236	102	51	80	82	82	79	81	[illegible]	74	75	75		80		+2	23	[illegible]
24	257	125	50	80	82	83	80	83	79	75	75	75		80		+3	24	[illegible]
25	240	105	50	80	83	83	80	82	[illegible]	75	75	75		81		+3	25	84°
26	228	74	49	81	83	84	80	83	[illegible]	75	75	75		81		+3	26	84
27	227	92	49	80	83	83	80	83	82	75	75	75		82		+3	27	85°
28	264	130	50	83	88	85	83	84	83	75	75	75		83		+5	28	88
29	269	134	51	83	87	86	86	85	84	75	75	75		84		+5	29	87°

Run 11 (Sheet 1 of 6)

BLANK PAGE

RYAN 64B017

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 11 DATE 13 DEC

CONFIGURATION BROWN #1

	δ	(1) Left Fan RPM	(2) Right Fan RPM	(3) Pitch Fan RPM	(5) V FPS	(9) i_t	(6) α_u	(7) β				(11) L_u	(12) D_u	M_u	Time / Remarks	(13) q	(14) C_L	(15) C_D	(10) C_M	(17) T°C	ρ	2q/ρ	√(2q/ρ)	V_0/RPM	V_0/RPM	V_0/RPM	u_{RE}	u_{LFT}	u_{RE}	RPM EL	RPM LFT	RPM RE	
	30	175	252	300+	182	34	167	175	282	157	75	116	217		1305½	271	137	51	83	87	86	85	85	84	75	75	75		84		+6		90
	31	171	251	300+	182	33/	165	190	275	154	75	115	272		1307	275	142	48	83	88	86	85	85	85	75	76	74		85		+6		91
	32	182	255	300+	183	33/	167	210	276	152	75	116	222		1308	275	142	50	83	89	86	86	85	86	75	75	74		85		+6		91
	33	177	254	300+	183	34	167	222	273	148	74	112	220		1309½	276	142	50	83	90	86	86	85	87	74	75	74	.	85		+7		92
	34	167	273	300+	183	33/	168	230	274	149	74	115	227		1310½	250	145	48	83	90	85	85	84	77	73	75	73		84		+8		92
	35	163	286	300+	183	33/	166	233	272	145	70	121	226		1312	280	148	47	80	87	83	82	83	81	70	72	71		82		+10		92
	36	189	300+	300+	184	34	167	235	290	165	67	110	217		1314	273	140	47	79	85	82	80	82	80	70	70	69		80		+13		73
1241	37	130	252	300+	186	33/	166	300+	300+	167	69	110	237		1316	292	161	53	[illegible]	70	84	83	82	78	70	71	70		81		12		93
	38	196	286	300+	183	34	167	226	282	158	69	114	213		1317½	269	135	45	80	86	84	82	83	82	70	71	70		82		11		93
	39	200	227	300+	152	33/	156	199	272	145	70	114	207		1319	267	134	47	81	81	84	82	82	82	72	72	70		82		12		94
	40	200	234	300+	154	34	164	235	271	147	71	118	228		1320½	275	143	46	80	81	84	83	82	82	71	72	71		82		12		94
	41	197	282	300+	183	34	165	248	228	164	68	201	241		1322	275	143	46	77	83	80	87	80	82	67	68	67		80		15		95
	42	190	295	300+	—	34/	167	264	278	152	91	223	239		1325½	260	—	49	71	101	83	93	79	42	101	65	60	.	82		16		96
	43	174	292	300+	-	34	167	260	272	146	51	186	220		1327	245	110	45	57	65	70	85	45	60	69	63	40		68		29		97
	44	159	274	300	-	34	166	253	248	122	32	168	209		1329	223	81	45	22	33	23	24	18	18	48	45	26		20		78		98
	45	155	256	296	-	34	166	247	243	118	26	161	209		1330	226	-	45	21	32	23	20	18	16	43	40	23		19		80		99
	46	150	262	299	-	34	166	252	247	121	22	126	207		1331½	235	-	45	23	34	27	25	26	20	37	35	23		23		76		99
	47	156	270	300+	-	34	166	238	264	139	25	113	216		1333	237	-	44	30	42	33	30	30	26	37	35	28		29		91		100°
	g	162	276	299	-	33/	166	247	247	12?	31	172	212		1338½ ENG OFF	221	-	44	16	26	16	15	11	3	64	50	32		14		86		100
END	Run	#	11																										TEMP				
START	Run	#	12																										CORE				
	a	70	93	135	83	34	87	99	126	82	76	111	108		1612 EVE START	101	82	95	56	57	59	57	56	55	79	79	77		13	56			.
	1	202	236	250	-	34/	163	218	216	84	97	225	193		1615½	222	82	109	60	78	61	86	70	74	99	91	71		27	70	+6	.	76
	2	194	241	257	.	34/	165	233	211	54	55	218	195		11 1/2	230	"	122	63	77	56	71	55	51	100	66	64		40	57	+21		78
	3	188	254	260	-	35	165	227	224	16	62	196	203		1619	221	.	130	51	46	61	86	28	32	75	69	53		48	39	+41		80
	4	170	221	256	-	34/	165	211	179	81	37	174	182		1622½	—	81	146	6	4	4	33	3	1	45	42	38		65	3	+78		81
	5	166	242	278	-	31/	167	223	176	81	34	165	190		1624	214	—	147	9	8	8	5	1	2	42	39	35		66	4	+78		82
															162 ENG OFF																		
END	Run	#12																															
																			69	70	72	70	69	68									
																			87	105	88	113	97	101									
																			103	117	96	111	95	91									78
																			99	94	109	134	76	80									
																			71	69	69	98	68	66									81
																			75	74	74	71	67	68									

Run 11 (Sheet 2 of 6)

(ALL READINGS x 2)

CHECK BROWN'S FACTOR — FOR CORRECTION

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 11 DATE 13 DEC

CONFIGURATION BROWN

δ	(1) LEFT FAN RPM	(2) RIGHT FAN RPM	(3) PITCH FAN RPM	(4) V ETS	(5) i_t	(6) α_u	(7) β	(8)	(9)	(10)	(11) L_u	(12) D_u	M_u	TIME REMARKS
a	27	27	27	27	27	27	27	27	38/	27	27	27		1030 ENG START
b	28	28	28	56/	60	25	25	28	53	28	28	28		1032 DIVERT
1	32	35	106	130	161	31	31	32	194	85	93	132		1041
2	33	75	122	133	155	42	42	46	202	98	130	66		1042½
3	54	132	116	131	168	59	61	101	253	103	114	34		1044
4	91	137	110	142	175	76	16	121	212	131	70	40		1045
5	146	127	77	146	182	87	129	119	259	147	45	41		1046½
6	175	152	89	150	194	113	155	115	251	119	41	41		1047½
7	172	145	115	155	198	128	156	115	247	94	41	41		1049
8	148	77	152	155	194	169	159	56	243	95	43	42	35	1050
9	45	40	70	155	198	41	40	38	175	93	39	95	40	1052½
10	38	37	40	160	193	37	36	36	194	89	37	40	50	1059
11	105	136	165	150	175	70	84	114	252	129	55	43	30	1051
12	166	141	169	147	159	122	111	88	235	79	46	46	95	1057
13	131	192	179	140	129	88	129	167	215	59	55	126	6	1100½
14	193	197	147	144	139	151	176	136	213	67	141	121		1103
15	40	40	40	138	144	40	40	40	175	40	40	40		1107½
16	40	40	41	140	147	40	40	40	178	40	40	40		1110
17	41	40	71	144	151	40	40	40	193	41	40	50		1110½
18	41	43/	71/	145	157	40/	40	40	180	42	41	65		1112½
c	41	44	71	150	158	41	41	41	176	41	42/	75		1114 DIVERT
d	39	39	39	88	80	39	39	37	62	71	39	39		1123 ENG OFF
e	34	34	34	56/	52/	34	34	34	47	34	34	34		1237 ENG START
f	34	34	34	77	67	34/	34/	34/	62	34/	34/	34/		1239½ DIVERT
19	38	58/	73	147	152/	35	[illegible]	[illegible]	174	37	39	70		1245
20	46/	86	57/	152	157	35/	35	34	155	40	57	73		1246
21	77/	91	50	158	162	35	40/	57	149	56	55	86		1247
22	40	40	61	163	170/	31	37	39	151	40	40	40		1249
23	40	40	40	113	176/	40	40	40	197	50	40	40		1252
24	41	40/	40/	172	208	51	40/	40/	197	83	40/	40/		1253½
25	41	41	73/	162	171	40/	40/	40/	176/	41	41	60		1255
26	73/	67	48	146/	148	41	43	58/	171	78	54/	47		1256½
27	65	84	211	144	146	75	57	126	207	48	47/	78		1258
28	43	43	43	154	160/	42	41/	41/	177	94	42/	53		1303
29	40	40	63	158	164	41	41/	41/	197	94	44	83/		1304

δ	(13) q	(14) C_L	(15) C_D	(16) C_M	(17) T_c	(18) ρ	(19) $2q/\rho$	(20) $\sqrt{2q/\rho}$	(21) V_o RFL	(22) V_o RFR	(23) V_o RFP	(24) 4 ET	4 LOT	4 RE	RPM ET	RPM LOT	RPM RE
a	27	39	37	39	39	39	39	39	39	27	27	40					
b	25	11	92	43	40	66	37	41/	40	28	28	40					
1	32	147	143	94	58	87	58	64	60	31	32	40		-13			
2	35	149	146	86	59	89	57	84	59	37	56	40		-12			
3	47	151	151	123	63	92	61	67	64	53	104	40		-12			
4	65	153	154	145	75	97	69	77	83	95	92	40		-12			
5	85	155	158	164	95	104	86	97	101	125	52	40		-10			
6	115	154	156	166	122	109	112	126	127	114	41	40		-8			
7	123	150	153	177	134	110	129	142	143	83	42	40		-3			
8	140	146	154	175	151	111	140	151	152	58	43	40		+3			
9	37	154	158	128	105	115	75	77	65	37	37	40		+5			
10	36	162	165	300+	164	153	80	205	68	36	36	41		+3			
11	70	160	161	102	69	113	78	91	79	94	92	41		+3			
12	52	158	160	193	151	111	129	126	129	48	46	41		+2			
13	50	137	141	136	135	106	124	120	120	51	99	41		+14			
14	71	123	126	129	125	100	112	103	106	121	115	41		+21			
15	40	155	145	173	106	131	105	106	90	40	40	41		+32	15		
16	40	161	152	188	105	135	128	134	106	40	40	41		+28	16		
17	40	164	154	210	105	133	130	155	115	40	40	41		+26	19		
18	40/	166	156	228	106/	134	130	172	121	40/	40/	41/			18		
c	40/	166	158	276/	124	126	148	175	125	40/	40/	41/					
d	39	105	140	137	134	57/	45/	37/	45	39	39	42					
e	34	52	51/	42/	39	46	38	37	38	34	34	43/		+6			
f	34/	65	77	47/	40	53/	39	41	39	34/	34	43/		+1			
19	38	160	148	256	118	118	147/	194	137	38	38	43		+1	19		
20	38/	162	150	282/	138	120	173	208	156	39	39	43		+3	20		
21	37	160	150/	300+	164	121/	151	225	174	40	51/	43		+3			
22	37/	160	153	257	137	136	91	222	95/	39	39	43		+2			
23	40	171/	162/	214	127	140	125/	148	98	40	40	43		+3			
24	40/	178	169/	300+	175	152	200	283	206/	54	40	43		+3			
25	41	177/	168/	177	115	151	171/	163	148	41	41	43		+3	25		
26	41	175	163	146	87/	144/	128	95	107/	49/	58	43		+3			
27	52/	175/	161/	126	56/	134	104/	77	87/	46	51	43		+3			
28	41	175	165	173	53/	120	112	112/	101	41	41	42/		+5			
29	42	176	172	177	117	123	126	130	115/	41	41	42/		+5	29		

Run 11 (Sheet 3 of 6)

RYAN 64B017

(ALL READINGS ×2)

CHECK BROWN #1 FOIL CORRECTION FACTOR

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 11 DATE 13 DEC

CONFIGURATION BROWN #3

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β				L_u	D_u	M_u	TIME REMARKS	q	C_L	C_D	C_M	$T_C°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_o}{RF}$	$\frac{V_o}{RF}$	$\frac{V_o}{RF}$	4_{ET}	4_{LEFT}	4_{RE}	RPM ET	RPM LEFT	RPM RF
30	42	47	77	161	167	41	41	41	198	57	61	54		1305½	42	175	173	206	104	125	110	128	90	42	42	42					
31	42	74	88	162	167	42	42	42	177	69	61	55		1307	42	174	173	217	116	127	113	134	93	42	43	43					
32	60	120	106	164	172	42	43	54	237	64	110	54		1308	43	173	173	241	129	126	139	157	125	43	65	43					
33	95	120	91	166	176	43	45	82	221	75	96	47		1309½	43	172	172	273	125	126	164	175	148	48	91	43					
34	119	102	66	170	186	44	45	91	221	123	73	48		1310½	43	169	170	283	140	127	184	173	170	58	85	43					
35	135	117	65	172	170	44	43	74	221	127	55	45		1312	44	162	162	272	142	127	181	173	172	72	75	43					
36	47	45	45	181	199	43	43	44	200	86	45	45		1314	44	176	174	237	111	137	135	135	104	43	44	43					
37	44	44	44	150	214	56	43	43	201	51	45	45		1316	44	162	151	300+	172	151	161	287	215	61	44	42					
38	45	85	93	170	176	45	44	45	203	73	73	66		1317½	45	178	174	178	55	141	137	113	120	45	46	43					
39	119	126	121	157	160	55	54	94	232	78	51	51		1319	67	176	172	128	77	123	100	78	89	67	52	43					
40	99	175	153	158	161	82	101	169	244	89	57	124		1320½	55	172	173	138	138	125	128	122	125	54	90	43					
41	192	206	196	161	151	137	201	162	227	72	153	127		1322	60	160	161	131	133	128	126	123	124	137	145	43					
42	173	215	164	159	134	167	182	143	215	76	122	108		1325½	76	144	104	146	141	122	125	116	119	111	109	43					
44	190	159	174	156	153	151	126	106	224	67	57	56		1328	72	133	127	204	152	122	132	125	126	69	56	43					
45	178	207	252	150	167	152	182	112	233	177	42	52		1330	150	127	135	130	121	121	110	104	96	178	106	43					
46	77	64	125	164	176	56	63	61	216	75	70	138		1331½	52	141	140	70	65	125	65	49	48	53	57	42					
47	57	52	56	158	228	72	50	97	207	105	50	51		1333	49	150	154	300+	164	187	56	138	43	48	48	42					
9	164	183	153	153	132	114	143	167	203	75	14	115		1335½ [illegible]	67	142	132	13[illegible]	126	114	110	105	110	87	111	42					
END TURN #1																															
START RUN #12																															
0	33	33	33	67	50	33	32	33	48	33	33	33		1612 [illegible]	32	35	76	36	33	40	33	31	31	32	32	42					
1	172	175	139	112	74	147	163	130	193	66	115	136		1615½	67	122	115	139	125	102	109	104	104	100	95	42					
2	141	150	157	120	102	101	136	155	172	52	60	94		1617½	56	124	120	147	127	102	114	111	111	55	85	42					
3	174	156	166	127	112	151	131	151	161	[illegible]	58	52		1619	77	122	120	255	157	116	138	132	134	82	60	42					
4	175	244	172	116	125	230	248	224	201	[illegible]	126	52		1622½	212	120	116	75	62	82	60	64	56	208	129	42					
5	107	109	152	145	143	127	120	122	226	14	51	127		1624	102	124	121	28	47	82	42	28	31	101	96	42					
														162- [illegible]																	
END RUN #12																															

Run 11 (Sheet 4 of 6)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 11 DATE 13 DEC 62

CONFIGURATION W/D=1.7 δ_f = 45° PITCH FAN SEALED TAIL ON, i_t = 0

δ	Left Fan RPM	Right Fan RPM	Pitch Fan RPM	V FPS	i_t	α_u	β	L Vane	T_i R	T_r L	L_u	D_u	M_u	$\frac{1}{\sqrt{\sigma}}$ Remarks R?	L?	q	C_L	C_D	C_M	T°	ρ ×10⁶	$\frac{2q}{\rho}$	$V_0 \sqrt{\frac{2q}{\rho}}$	L V_0/RPM	R V_0/RPM	V_0/RPM	3.463 u L	u R	u	RPM ET	RPM EST	RPM RF	
1	1700	1700	X	40	0	-4	35°	14°	113	86				.975	.950	5.74				64	2363	.4958	69.7	.0410	.0410		.1504	.1504		1615	1658		
2	1710	1700				0		13	121	"				"	.945	5.82				66	2352		70.4	.0412	.0414		.1501	.1515		1607	1667		
3	"	1690				+4		15	130	99				.963	.938	6.00				67	2347		71.5	.0428	.0423		.1566	.1548		1585	1647		
4	1700	"				6		"	136	104				.958	.934	5.82				68	2342		70.5	.0412	.0417		.1508	.1526		1578	1638		
5		1675				8		"	143	106				.956	.928	5.82				70	2311		70.8	.0417	.0413		.1526	.1548		1554	1625		
6		"				10		17	147	108				.954	.926	5.83				71	2306		70.8	"	.0423		"	"		1551	1622		
7		1650				12		16	152	106				.956	.922	5.78				72	2321		71.9	.0423	.0428		.1508	.1566		1599	1625		
8	—	"				14		16	160	113				.956	.916	5.82				73	2316		70.9	.0417	.0422		.1526	.1505		1539	1615		
9	1720	1690				0	40	15	167	"				.950	.912	5.76				74	2311		71.9	.0418	.0425		.1530	.1552		1541	1634		
10	"	1780					50	16	186	117				.946	.896	5.82				75	2307		70.9	.0412	.0407		.1508	.1490		1559	1627		
11	1710	1710					30	17	182	119				.944	[illegible]	6.17				76	2302		73.4	.0429	.0429		.1570	.1570		1536	1614		
12	1700	1700					15	7	188	117				.946	.895	5.74				77	2296		70.7	.0416	.0416		.1523	.1523		1522	1605		
13	1750	1750					0	30	230	147				.952	.868	6.00				78	2293		72.4	.0413	.0413		.1512	.1512		1519	1619		
14	1700	1720					-12	31	243	"				.925	.860	5.88				80	2251		71.9	.0423	.0418		.1548	.1530		1479	1573		
15	1730	1705		80		-4	35	4	203	08				.955	.855	22.73				81	2276		140.6	.0809	.0821		.2961	.3005		1509	1657		
16	1720	1700				0		15	208	108				.958	.852	22.21				82	2272		139.9	.0814	.0823		.2979	.3012		1499	1641		
17	1720					+4		16	216	117				.946	.897	22.09				-	"		139.7	.0812	.0822		.2972	.3009		1491	1627		
18	1725					6		17	"	139				.932	-	22.13				83	2266		"	.0810	"		.2965	"		"	1608		
19	1700					8		18	156	104				.953	.919	23.13				77	2296		141.5	.0835	.0835		.3056	.3056		1562	1629		
20	1610					10		20	162	"				"	.915	21.96				78	2293		138.3	.0818	.0813		.2996	.2976		1556	1619		
21	1710					12		40	169	106				.956	.910	21.96				79	2287		138.3	.0808	"		.2957	"		1547	1635		
22	1730	1710				14		13	132	110				.953	.937	22.09				80	2251		139.3	.0805	.0814		.2946	.2979		1602	1649		
23	1720	1700				0	40	3	134	113				.950	.935	22.17				82	2272		137.6	.0815	.0821		.2976	.3005		1590	1636		
24	1750	1730					50	4	199	121				.945	[illegible]	22.09				"	"		139.6	.0798	.0807		.2921	.2954		1536	1654		
25	1700	1710					30		191	"				"	.923	22.11				84	2261		139.5	.0821	.0817		.3005	.2990		1527	1607		
26	"	"					15		199	117				.946	[illegible]	21.66				"	"		141.2	.0831	.0825		.3041	.3020		1516	1608		
27	1730	1700					0		201	110				.953	[illegible]	19.72				85	2255		132.1	.0765	.0778		.2800	.2847		1508	1649		
28	1750			60		-4	35	5	210	104				.955	[illegible]	13.07				88	2241		107.8	.0616	.0631		.2255	.2324		1498	1677		
29	1710					0		6	"	108				.954		12.96				89	2235		107.8	.0631	"		.2309	"		"	1631		
30	"	1710				4		5	205	"				"	[illegible]	13.07				90	2230		108.2	.0633	.0633		.2317	.2317		1508	"		
31	1690					6		1	216	110				.953	[illegible]	"				91	2225		108.2	.0641	"		.2346	"		1507	1611		
32	1675					8		6	210	"				"		"				"	"		108.2	.0646	"		.2364	"		"	1596		
33	1700					10		7	212	111				.952	[illegible]	12.96				92	2220		108.0	.0635	.0631		.2324	.2309		1505	1618		
34	1710	1730				12			"	108				.954	"	12.84				"	"		107.7	.0630	.0623		.2306	.2280		1572	1631		
35	"	1730				14			210	111				.952	[illegible]	12.96				"	"		108.2	.0633	.0619		"	.2266		1542	1628		

Run 11 (Sheet 5 of 6)

RYAN
64B017

40x80 Load Cell and Analog Computer Program

TEST 179 RUN 11 CONT DATE 13 DEC 62

CONFIGURATION h/D = 1.7, δF = 45°, PITCH FAN SEALED, TAIL ON $i_t = 0$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	i_t	α_u	β	I_V	T_i R	T_i L	L_u	D_u	M_u	$\frac{1}{\sqrt{\sigma}}$ REMARKS L	R	q	C_L	C_D	C_M	T_F°	ρ ×10⁶	$\frac{2q}{\rho}$	$V_0 \sqrt{\frac{2q}{\rho}}$	$\frac{V_0}{RPM}$ L	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	4 L	4 R	4 RE	RPM ET.	RPM LOFT	RPM P.F.	
36	1710	1720	0	60	0	0	60	6	212	110				.953	.880	3.07				93	2215		108.6	.0636	.0632		2328	2313		1514	1630		
37	1750	1753					50	9	234	126				.942	.865	13.09				94	"		"	.0621	.0621		2273	2273		"	1649		
38	1700	1760					30	5	223	113				.950	.873	12.90				"	"		108.6	.0635	.0621		2324	2273		1519	1615		
39	1710	1720					15	6	221	117				.946	.874	12.74				94	2209		108.3	.0633	.0629		2317	2302		1503	1618		
40	1730	1730					0	6	225	152				.922	.871	11.98				"	"		108.3	.0603	.0603		2207	2207		1507	1595		
41	1770	1730					-12	7	251	156				.919	.855	12.76				95	2205		108.6	.0631	.0628		2309	2298		1479	1581		
42	1700	1700		30			-12	21	280	165				.912	.868	3.40				96	2200		55.6	.0327	.0327		1197	1197		1476	1550		
43	"	"					0	41	"	137				.933	"	3.51				97	2195		55.5	.0328	.0328		1200	1200		"	1536		
44	1720	1710					15	10	268	117				.946	.852	3.42				98	2158		55.8	.0325			1196	1193		1508	1627		
45	1700	1700					30	12	139	86				.975	.932	3.67				99	2183		58.0	.0341			1248	1248		1584	1658		
46	1740	1730					40	10	121	56				"	.945	3.57				"	"		57.3	.0329	.0331		1204	1211		1635	1696		
47	1720	1750					50	11	77	57				1.003	.954	3.24				100	2176		54.6	.0315	.0312		1164	1142		1722	1725		

Run 11 (Sheet 6 of 6)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 12 DATE 13 DEC 62

CONFIGURATION $\delta_F = 45°$ TAIL ON T58 SEALED $h/D = 1.7$ $i_T = 0$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	ζ	T_i R	T_i L	L_u	D_u	M_u	REMARKS	q	C_L	$\frac{C_D}{R}$	C_m	T°F	$\rho \times 10^6$		$\frac{\sqrt{}}{\rho}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$				RPM ET	RPM LEFT	RPM RE	
1	1700	1680	0	70	6	0	-12	32							1.92		.956		75	2304	4667	40.5	.0240	.0243		.0859	.0818		1656	1676		
2	1750	1720					0	26							1.37		.983		78	2288		36.6	.0195	.0201		.0736	.0745		1691	1720		
3	1750	1730					+15	55							1.96		.962		79	2254		41.5	.0237	.0240		.0678	.0667		1699	1719		
4	1720	1700					30	31							1.50		.980		81	2273		39.8	.0231	.0234		.0656	.0645		1666	1656		
5	1700	1700					40	10							1.65		.978		83	2263		35.2	.0226	.0225		.0824	.0824		1663	1663		

Run 12 (Sheet 1 of 1)

RYAN 64B017

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 13 DATE 13 DEC 63

CONFIGURATION $\delta_f = 45°$ TAIL ON $i_t = 0$ TS8 STALLED L/D = 2.2

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FTS	i_t	α_u	β	[illegible]	T_i R	T_i L	L_u	D_u	M_u	$1/\sqrt{\theta}$ REMARKS R	L	q	C_L	C_D	C_M	$T_c°$	ρ $\times 10^5$	$2q/\rho$	$\sqrt{2q/\rho}$	V_o/RF L	V_o/RF R	V_o/RF	ψ_{ET}	ψ_{LEFT}	ψ_{RE}	RPM ET	RPM LEFT	RPM P.E.	
1	1700	1700	0	20	0	0	-12	21	171	90				.945	.772	1.67				67	2344		37.7	0222	0222			0813	0813	1607	1652		
2	1670	1680					0	24	141	104				.930	.957	1.24				69	2334		37.7	0196	0194			0717	0710	1562	1602		
3	1700	1700					15	27	160	113				.916	.955	1.72				70	2326		38.2	0226	0226			0827	0827	1557	1615		
4	1670						30	15	130	68				.939	.972	1.53				74	2307		37.6	0225	0221			0824	0809	1596	1651		
5	1720						40	11	134	90				.935	.971	1.63				74	"		37.6	0219	"			0832	"	1590	1672		
6	1680	1650		30			0	31	173	121				.908	.945	2.46				77	2293		46.3	0276	0276			1010	1010	1525	1588		
7	1670	1690				4		28	186	130				.897	.935	3.62				80	2275		56.4	0335	0333			1237	1219	1516	1566		
8	1680	1680				6		15	191	126				.893	.942	3.55				80	2278		55.4	0329	0329			1204	1204	1506	1593		
9	1700	1700				8		15	199	"				.898	.942	3.59				81	2273		58.6	0345	0345			1263	1263	1510	1601		
10	"					10		10		128					.946	3.48				"	"		55.4	0326	0326			1173	1193		1598		
11	1710					12		10		134					.936	3.57				82	2267		58.4	0342	0344			1252	1257		1601		
12	1700	1685				14			208	132				.882	.937	3.66				"	"		58.8	0334	0335			1222	1237	1482	1593		
13	"	1700				0	-12		210	134				.881	.936	3.29				83	2263		54.0	0318	0318			1164	1164	1498	1591		
14	"						+15		178	117				.902	.948	3.13				55	2257		52.8	0311	0311			1138	1138	1533	1612		
15							20	2	"	121				.902	.945	3.13							"	"	"			"	"	"	1609		
16						4			182	117				.877	.948	3.62							56.7	0334	0334			1222	1222	1528	1612		
17						6			"	126				"	.942	"				56	2248		"	"	"			"	"	"	1601		
18						8			186	130				.896	.935	3.55				"	"		55.8	0328	0328			1200	1200	1523	1595		
19						10			171	134				.893	.936	3.60				57	2242		56.7	0334	0334			1222	1222	1518	1591		
20						12			195	139				.891	.932	3.60							"	0334	"			"	1222	1515	1584		
21						14			212	141				.880	.926	3.48							55.8	0328	0328			1200	1200	1496	1579		
22							30		191	126				.893	.942	3.38				88	2238		55.0	0324	0324			1186	1186	1518	1601		
23		1650					40		191	134				"	.936	3.48				59	2232		55.7	0329	0329			1204	1204	1500	1591		
24	1690						50		195	130				.891	.935	3.40				"	"		55.2	0327	0328			1197	1200	1497	1555		
25	"			60			0	6	208	152				.882	.922	13.29				91	2222		109.5	0648	0652			2372	2386	1482	1558		
26	1700	1700				4		4	208	"				"	.922	13.56							110.4	0651	0651			2383	2383	1469	1564		
27	1690	1690				6		6	210	143				.881	.929	12.64							106.8	0632	0632			2313	2313	1459	1590		
28	1700	1700				8		7	208	"				.882	.929	12.64							"	0625	0625			2295	2298	1459	1579		
29		1690				10		9	208	156				"	.919	12.74							107.7	0630	0634			2306	2320	1491	1553		
30		1700				12		10		160				"	.916	12.62				92	2216		106.4	0627	0627			2295	2295	1469	1557		
31		1720				14		8		162				.884	.914	12.70				"	"		107.0	0630	0622			2306	2277	"	1572		
32		1700				0	-12	6	205	139				"	.932	12.58				93	2212		106.8	0628	0625			2298	2298	1503	1584		
33	1680	1690					+15	6		121				"	.945	13.15							109.2	0646	0646			2364	2364	1494	1597		
34							20	6		117				"	.948	12.72							107.2	0635	0635			2324	2324	1494	1602		
35						4	20	7		152				"	.922	12.48							106.2	0628	0625			2298	2298	1494	1558		

Run 13 (Sheet 1 of 2)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 13 DATE 13 DEC 62

CONFIGURATION $\delta_F = 45°$ TAIL ON $i_t = 0$ TSR SEALED h/D = 2.2

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	[illegible]	T_i R	T_i L	L_u	D_u	M_u	REMARKS $\sqrt{\theta}$ L	REMARKS $\sqrt{\theta}$ R	q	C_L	C_D	C_m	T_E°	ρ ×10⁶	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	u_{ET}	u_{LFT} SCT	u_{RT} SCT	EPM ET	EPM LFT	EPM RF	
36	1690	1690	0	60	0	6	+20	6	205	156				.884	.919	12.51				93	2212		106.3	.0629	.0629			.2302	.2302	.1496	.553		
37	│	│	│	│	│	8	│	6	208	"				.882	"	12.72				94	2206		107.3	.0635	.0635			.2324	.2306	.1491	"		
38	│	│	│	│	│	10	│	7	205	.158				.884	.917	12.5				│	│		106.7	.0631	.0631			.2309	.2309	.1446	.155		
39	1700	1704	│	│	│	12	│	8	│	162				"	.914	12.43				│	│		106.?	.0625	.0625			.2258	.2258	.1503	.155		
40	│	"	│	│	│	14	│	7	│	"				"	"	12.51				│	│		106.3	"	.0625			"	"	"	"		
41	│	1690	│	│	│	0	30	5	205	.167				.882	.926	12.19				95	2202		105.4	.0619	.0623			.2266	.2250	.1499	.1574		
42	│	1700	│	│	│	0	40	7	│	134				"	.936	12.35				│	│		106.1	.0625	.0625			.2288	.2257	.1503	.1591		
43	│	│	│	│	│	0	50	8	│	.134				"	"	12.49				│	│		105.3	.0620	.0620			.2269	.2264	.1503	"		

Run 13 (Sheet 2 of 2)

RYAN
64B017

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM
TEST 177   RUN 14   DATE 13 DEC 62
CONFIGURATION δF = 45° TAIL ON $i_t = 0$ TS8 SEALED $L/D = 2.2$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V ETS	i_t	α_u	β	L [illegible]	T_i R	T_i L	L_u	D_u	M_u	$\frac{1}{\sqrt{\theta}}$ REMARKS		q	C_L	C_D	C_m	T_t°	ρ	ρ (×10⁻⁶)	$V_0 \frac{\sqrt{\sigma}}{P}$	L $\frac{V_0}{RPM}$	R $\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	μ ET	μ LEFT	μ RE	RPM ET	RPM LEFT	RPM R.F.	
1	1700	1690	0	40	0	0	0	9	119	75				.986	.946	6.04				74		2305	72.3	0425	0428		1566	1556		1599	1676		
2		1700				4		11	121	86				.976	.945	5.84				76		2299	71.2	0419	0419		1534	1534		1607	1659		
3		1690				6		10	130	"				"	.938	5.69				77		2293	70.5	0414	0417		1526	1515		1587	1659		
4	—	1700				8		13	136	90				.972	.934	5.53				78		2288	71.8	0419	0419		1534	1534		1588	1652		
5	1710					10		12	143	97				.965	.928	6.00				"		"	72.4	0423	0426		1559	1548		1578	1650		
6	1700					12		16	167	99				.963	.926	6.06				79		2254	73.0	0429	0429		1510	1510		1574	1637		
7	1690					14	—	16	"	108				.958	"	5.74				"		"	72.1	0427	0424		1552	1563		"	1646		
8	1710					0	-12	16	162	"				"	.914	6.33				81		2273	76.7	0436	0439		1607	1596		1554	1635		
9	1700						+15	8	152	97				.965	.922	5.88				82		2269	72.0	0423	0423		1548	1548		1567	1641		
10	1690					—	20	9	156	99				.963	.917	6.16				83		2263	74.0	0435	0435		1592	1607		1562	1637		
11	1700					4		7	"	104				.958	"	6.04				84		2258	75.1	0430	0430		1514	1524		"	1629		
12						6		7	162	"				"	.914	6.04				"				0430	"		"	1574		1554	"		
13	—	—				8		8	165	108				.957	.912	6."				"		—		"	"		"	"		1550	1627		
14	1690	1690				10		7	162	110				.953	.914	6.04				85		2253		0433	0433		1555	1588		1565	1611		
15	"	"				12		10	165	"				.953	.912	"							—	"	"		1585	1585		1541	"		
16	1700	1700				14	—	11	167	113				.950	.911	6.04				—		—	73.3	0432	0432		1581	1581		1569	1615		
17		"				0	30	12	"	"				"	"	"				87		2242	73.6	"	"		"	"		"	"		
18	—	1690					60	10	169	117				.946	.910	5.9				88		2238	72.6	0427	0430		1514	1523		1538	1608		
19	1690	1700		—			50	10	171	119				.944	.905	5.6				"		2238	70.5	0416	0416		1526	1530		1564	1597		
20	1700			80		—	0	4	184	147				.926	.878	23.2				89		2232	144.3	0849	0849		3107	3107		1527	1574		
21	1690					4		3	193	139				.932	.892	23.6				90		2227	145.8	0852	0858		3140	3155		1516	1575		
22	"	—				6		3	"	143				.929	"	23.5							141.5	0837	0831		3061	3063		"	1570		
23	1710	1690				8		3	195					"	.891	23.4							145.2	0849	0859		3144	3107		1506	1589		
24	1690	"				10		3	199	—				"	.858	23.4				—		—	"	0857	"		"	3144		1501	1570		
25	1710	1710				12	—		197	152				.922	.890	23.1				91		2222	144.5	0845	0845		3093	3093		1522	1577		
26	1700	1690				0	15		195	143				.929	.891	23.0							144.3	0848	0853		3122	3104		1506	1519		
27	"	1700					30		195	130				.938	.871	23.0							144.2	0849	0849		3107	3107		1515	1595		
28	"					—	35		"	104				.958	"	23.1				—		—	144.6	0849	"		"	"		"	1629		
29	1690					4			"	147				.926	"	"				92		2216	144.6	0853	0849		"	3122		"	1565		
30	1700					6			199	152				.922	.858	23.6							146.4	0859	0859		3144	3144		1510	1587		
31						8				154				.920		23.5							145.8	0857	0857		3177	3177		"	1524		
32	1710					10				152				.922		23.3							145.2	0849	0854		3126	3107		"	1577		
33	1700					12	—			"				"		23.1				—		—	144.6	0850	0850		3111	3111			1567		
34		—				0	40			90				.972	—	23.7				93		2212	146.4	0855	0855		3129	3124		—	1571		
35	—	1710	—	—	—	—	50	—	204	99				.963	.855	23.3				—		"	145.6	0857	0853		3122	3137		1513	1505		

Run 14 (Sheet 1 of 2)

SHEET 2 OF 2

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 14 DATE 13 DEC 62

CONFIGURATION SC 45° TAIL ON $i_T = 0$ TSB STALLED $h/D = 2.2$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	i_t	α_u	β		T_i R	T_i L	L_u	D_u	M_u	$\frac{1}{\sqrt{\theta}}$ REMARKS L	R	q	C_L	C_D	C_m	T_C°	ρ $\times 10^6$	$\frac{2q}{\rho}$	$\frac{\sqrt{2q}}{\rho}$	$\frac{V_o}{RPM}$	$\frac{V_o}{RPM}$	$\frac{V_o}{RPM}$	U	U R	U L	RPM EL	RPM DST	RPM RF	
36	1690	1700	0	40	0	0	35	9°	208	134				.936	.852	6.41				96	2.06		76.4	.0452	.0443			.1643	.1654	.1499	.1582		
37	1700					4			205	132				.937	.884	6.12							76.6	.0439	.0439			.1607	.1607	.1508	.1593		
38						6			205	″				″	″	6.05							76.4	.0437	.0437			.1599	.1599	″	″		
39						8			205	134				.936	″	6.08							″	″	″			″	″	″	.1591		
40						10		10°						″	″	6.00							73.9	.0435	.0435			.1592	.1592		″		
41				60		0		6						.932	″	12.45				98	2.185		106.5	.0626	.0626			.2291	.2291		.1584		
42						4		″	203	139				.927	.886	13.15							109.8	.0644	.0644			.2364	.2364	.1506	.1576		
43						6		5	″	145				.926	″	13.05							109.4	.0643	.0643			.2354	.2353	″	.1574		
44						8		″	201	127				.932	.887	12.86							108.2	.0637	.0637			.2331	.2334	.1508	.1584		
45						10		6	″	139				″	″	12.62							107.9	.0632	.0632			.2313	.2318	″	.1584		

Run 14 (Sheet 2 of 2)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 15 DATE 14 DEC 62

CONFIGURATION [illegible]

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	ε	T_i °F		L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_M	T_E°	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_o}{RPM}$	$\frac{V_o}{RPM}$	$\frac{V_o}{RPM}$	μ_{ET}	μ_{LEFT}	μ_{RE}	RPM ET	RPM LEFT	RPM P.F.	$\sqrt{\theta}$
1	0	0	2000	0	0	0	0	0	76																						[illegible]	[illegible]
2								15																								
3								30																								
4								45																								
5								60																								
6			2050					70																							[illegible]	
7			2600					0																							[illegible]	
8								15																								
9								30																								
10			2550					45																							[illegible]	
11			2600					60	77																						[illegible]	954
12			2630					70																								
13			3003																													

Run 15 (Sheet 1 of 1)

$h/D = 2.2$

40x80 Load Cell and Analog Computer Program

Test 177 Run 16 Date 14 DEC 62

Configuration $\delta_F = 45°$ Tail On $i_t = 0$ Pitch Fan Open

δ	Left Fan RPM	Right Fan RPM	Pitch Fan RPM	V KTS	i_t	α_u	β	R	Inlet ST	Δ	L_u	D_u	M_u	$1/T_0$ Remarks L	$1/T_0$ Remarks R
1	1760	1710	2600	30	0	0	0	0	17	3.42				.958	.938
2	1740	1730						15	20	[illegible]				✓	.936
3	1660	1660						30	25	3.40				✓	.932
4	1700	1700	2340					45	24	3.54				.953	✓
5	1660	1720	2600					60	35	3.29				.938	.106
6	1670	1690	2340					70	40	3.44				[illegible]	[illegible]
7	1700	1680	2600					60	17	3.38				.943	.112
8	1710	1710				4		45	?	3.25				✓	.106
9	1690	1690				6				3.40				✓	.102
10	1690	1670				8				3.36				.938	.576
11	1700	1680				10				3.48				.936	.571
12	1390	1400	1700	40		0		0		5.59				.932	[illegible]
13	1390	1390						15		5.66					
14	1400	1360						30		5.54				.936	✓
15		1370						45		6.07				.932	✓
16		1400						60		6.21				.936	✓
17		1400						70		6.19				.936	.705
18	1190	1200	1600					0		5.74				.932	.701
19	1190	1210						15		6.11				.930	.577
20	1200	1220						30		5.62				.932	.575
21		1200	1575					45		6.09				✓	.577
22		1180	1600					60		5.97				.936	.817
23	1190	1190						70		5.79				.934	✓
24	"	1200						60		6.19				.936	✓
25	1200	"				4				6.32				.936	✓
26		1210				6				6.44				✓	✓
27		"				8				6.38				.932	✓
28		1220				10				6.38				✓	✓
29		1200				12				6.30				✓	✓
30	1190	1150	1590			.4				6.19				✓	.705
31	1200	1160	1650	60		0		0	8	12.62				.919	.882
32		1150						15		12.62				✓	✓
33		1200						30		12.58				✓	.878
34		1210						45	7	12.59				✓	.880
35	1150	1220						60	7	12.95				✓	.881

δ	T_D/q	T_L/q	T_{PF}/q	$1/T_0\ C_m$ PF	T_c	ρ	$\frac{ST}{\rho}$	$\sqrt{\ }/\rho$	L V_0/RPM	R V_0/RPM	P V_0/RPM	3.66 μ LE	3.66 μ LFT	6.36 μ RE	RPM LE	RPM LFT	RPM RF
1	130	104	68	.996		2349		51.0	.0315	.1157	.0226	.1157	.1168	.1431	1604	1629	2390
2	134	104	68	.996		2345		51.7	.0297	.1094	.0215	.1094	.1089	.1367	1619	1667	"
3	131	109	68	.992		2359		58.0	.0300	.1015	.0279	.1095	.1095	.1431	1566	1609	2381
4	131	108	78	.963		2335		55.1	.0324	.1156	.0231	.1156	.1156	.1469	1584	1620	2349
5						2324		53.3	.0317	.1135	.0272	.1135	.1160	.1412			
6	173	130	70	.992		2320		54.5	.0323	.1153	.0228	.1152	.1152	.1460	1531	1585	2323
7	165	121	65	.995		2309		54.2	.0316	.1152	.0226	.1152	.1164	.1427	1604	1603	2358
8	173		86	.996		2299		53.2	.0311	.1135	.0222	.1135	.1135	.1412	1531	1613	2342
9	178		56	✓		2289		54.5	.0323	.1152	.0227	.1152	.1152	.1444	1549	1594	"
10	156	130	56	✓		2284		50.4	.0322	.1193	.0226	.1113	.1179	.1437	1496	1585	"
11	175	134	56	✓		2284		55.3	.0325	.1204	.0230	.1204	.1190	.1463	1687	1591	"
12	152	134	56	✓		2257		72.2	.0519	.1559	.0425	.1589	.1900	.2703	1259	1215	1659
13						2250		71.2	.0507	.1574	.0419	.1574	.1574	.2665			
14	152	134	86	✓		2254		70.1	.0500	.1559	.0412	.1559	.1530	.2620	1240	1310	1659
15	182	138		✓		2249		73.5	.0525	.1765	.0433	.1465	.1723	.2754	1232	1305	
16	182	134		✓		2249		76.1	.0531	.1943	.0438	.1943	.1943	.2718	1259	1310	
17	175	134	79	.982		2249		76.2	.0534	.1940	.0436	.1940	.1940	.2773	1267	1310	
18	180	139	82	.979		2249		71.5	.0601	.2161	.0447	.2161	.2200	.2843	1081	1109	1669
19	182	141		✓		2249		73.8	.0620	.2233	.0461	.2233	.2269	.2932	1088	1109	
20	186	139		✓		2249		70.7	.0559	.2119	.0442	.2119	.2156	.2810	1093	1118	
21	184	139	56	.976		2263		73.7	.0614	.2247	.0468	.2247	.2247	.2676	1078	1118	1537
22	182	134	56	✓		2263		73.3	.0611	.2213	.0458	.2273	.2236	[illegible]	1061	1123	1562
23	182	136	79	.982		2263		73.3	.0615	.2251	.0458	.2251	.2251	.2913	1050	1101	1571
24	182	134	79	✓				74.4	.0625	.2267	.0465	.2269	.2256	.2957	1079	1114	"
25		134	57	.979				75.2	.0627	.2295	.0470	.2295	.2295	.2957	"	1123	1566
26		134	52	✓				75.9	.0632	.2295	.0475	.2295	.2313	.3021	1085	1123	1571
27		139	79	.982		2239		75.5	.0627	.2254	.0472	.2254	.2302	.3002	"	1118	"
28		139	86	.976				75.5	.0629	.2262	.0472	.2262	.2302	.3002	1097		1562
29		139		✓				75.1	.0626	.2291	.0469	.2291	.2291	.2953	1079		"
30	175	139						74.3	.0624	.2306	.0468	.2306	.2254	.2976	1079	1109	1552
31	208	156				2233		106.4	.0556	.3356	.0646	.3356	.3243	.4169	1023	1103	1610
32	208							106.4	.0556	.3356	.0646	.3356	.3243	.4109	1016		
33	214							106.3	.0556	.3243	.0646	.3243	.3243	.4109	1054		
34	212							107.4	.0583	.3250	.0650	.3250	.3276	.4134	1065		
35	210							107.8	.0563	.3232	.0653	.3232	.3343	.4153	1075	1054	

Run 16 (Sheet 1 of 4)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST ______ RUN ______ DATE ______

CONFIGURATION ______

δ	Left Fan RPM	Right Fan RPM	Pitch Fan RPM	V FPS	i_t	α_u	β	R	Ingest	η	L_u	D_u	M_u
36	1170	1220	1625	60	0	0	0	70	6	2.58			
37	1160	"	1560			2		60	6	2.42			
38	1200	1200	1600			4			5	2.89			
39	"					6			5	2.95			
40	1210					8			4	3.03			
41	1200					10				3.03			
42	"					12			3	2.93			
43	1150	1300	1575			14			12	3.22			
44	1200	1200	1600	30		0		0	?	3.40			
45	1190							15		3.27			
46	1200							30		3.11			
47	1190							45		3.36			
48	1200	1190						60		3.48			
49	1180	1180						70		3.38			
50	1200	1190						60		3.29			
51		1200				4				3.29			
52		[illegible]				6				3.21			
53						8				3.34			
54						10				3.19			
55	1170					12				3.29			
56	1180	1200				14				3.34			

δ	$1/\sqrt{\sigma}$ Remarks L	R	T_{iR}	T_{iL}	T_{iPF}	$1/\sqrt{\sigma}$ PF C_M	TC	ρ			L Vo/RPM	R Vo/RPM	PF Vo/RPM	3.66 J_{RT}	3.66 J_{LFT}	6.36 J_{PF}	RPM RT	RPM LFT	RPM P.F.
36	.919	.881	210	156	56	.476		2233	106.3		.0573	.0571	.0654	.3258	.3265	.4157	1015	1094	1556
37								"	105.5		.0574	.0565	.0677	.3166	.3277	.4306	1075	1054	1523
38								2228	107.4		"	.0564	.0671	.3270	"	.4246	1057	1103	1562
39									107.8		.0517	.0527	.0674	.3240	.3290	.4257	1057	1103	1562
40									108.2		.0595	.0703	.0677	.3301	.3276	.4306	1057	1112	
41									108.2		.0502	.0502	.0677	.3301	.3301	.4306	1057	1103	
42		.880	212						107.8		.0598	.0595	.0674	.3257	.3267	.4257	1056	"	
43		.877	216						108.1		.0596	.0537	.0671	.3053	.3462	.4285	1140	1057	1537
44	.922	.880	212	152					55.3		.0461	.0461	.0345	.1657	.1657	.2194	1056	1106	1562
45	.919	.877	216	156				2223	54.3		.0457	.0453	.0339	.1655	.1673	.2150	1052	1094	
46									53.7		.0441	.0441	.0331	.1614	.1614	.2106		1103	
47									55.1		.0463	.0451	.0345	.1650	.1695	.2166		1094	
48	.922	.881	210	152					56.1		.0468	.0471	.0351	.1724	.1713	.2233	1088	1106	
49		"	"	"					55.2		.0465	.0468	.0345	.1713	.1713	.2194	1040	1088	
50		.877	216	150				2218	54.5		.0455	.0452	.0341	.1676	.1665	.2169	1044	1106	
51	.912	.874	221	165					54.5		"	.0455	.0341	.1665	.1665	.2169	1049	1094	
52	.919	.871	225	156					53.7		.0449	.0453	.0337	.1658	.1643	.2143	1036	1103	
53		"	"					2213	55.0		.0458	.0462	.0344	.1661	.1676	.2168	"		
54		.867	230						53.7		.0446	.0451	.0336	.1651	.1640	.2137	1031		
55	.916	"	"	160					52.9		.0440	.0440	.0331	.1610	.1610	.2105	"	1090	
56	.911	.871	225	167					55.1		.0467	.0457	.0344	.1660	.1709	.2158	1045	1070	

Run 16 (Sheet 2 of 4)

h/D = 2.2

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 16 DATE 12-14-62

CONFIGURATION PITCH FAN OPEN, TAIL ON, $i_t = 0$ $\xi_F = 45$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	R	IN		L_u	D_u	M_u	REMARKS	T_i q	T_i L C_L	T_i PF C_D	C_m	$T_c°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	V_0/RPM	V_0/RPM	V_0/RPM	μ LT	μ RT	μ PF	EPR LT	EPR RT	EPR PF	
1	1700	1710	2400	30	0	0	0	0	17°						130	104	64															
2	1740	1720	2400					15	20						134	104	64															
3	1680	1680	2400					30	25						139	104	68															
4	1700	1700	2370					45	24						137	108	78															
5	1660	1720	2400					60	38																							
6	1610	1690	2370					70	40					[illegible]	113	130	90															
7	1700	1680	2400					60	17						165	121	65															
8	1710	1710	2400			4		45	?						173	121	86															
9	1670	1670	2400			6									178	121	86															
10	1690	1670	2400			8									186	130	86															
11	1700	1680	2400			10									175	134	86															
12	1390	1400	1700	40		0		0							152	139	86															
13	1390	1390	1700					15																								
14	1400	1380	1700					30							182	124	86															
15	1400	1370	1700					45							182	139	86															
16	1400	1400	1700					60							182	134	86															
17	1400	1400	1700					70							175	134	79															
18	1190	1200	1600					0							180	139	82															
19	1190	1210	1600					15							182	141	82															
20	1200	1220	1600					30							186	139	82															
21	1200	1200	1575					45							184	139	86															
22	1200	1180	1600					60							182	134	86															
23	1190	1190	1600					70							182	136	79															
24	1190	1200	1600					60							182	134	79															
25	1200	1200	1600			4									182	134	82															
26	1200	1210	1600			6									182	134	82															
27	1200	1210	1600			8									182	139	79															
28	1200	1220	1600			10									182	139	86															
29	1200	1200	1600			12									182	139	86															
30	1190	1180	1590			14									175	139	86															
31	1200	1160	1650	60		0		0	8°						206	156	86															
32	1200	1150	1650					15	8						208	156	86															
33	1200	1200	1650					30	8						214	156	86															
34	1200	1210	1650					45	7						212	156	86															
35	1180	1220	1650					60	7						210	156	86															

Run 16 (Sheet 3 of 4)

RYAN 64B017

$h/D = 2.2$

R16 CONT

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 **RUN** 16 CONT **DATE** 12-14-62

CONFIGURATION $\delta_F = 45°$ TAIL ON $i_T = 0°$ PITCH FAN OPEN

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FTS	i_t	α_u	β	R	ζ		L_u	D_u	M_u	REMARKS	T_i R q	T_i L C_L	T_i RC C_D	C_m	$T_E°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	4 ET	4 LEFT	4 RE	RPM ET.	RPM LEFT	RPM R.F.	
36	1190	1220	1625	60	0	0	0	70	6°						210	156	86															
37	1180	1220	1560	″	″	″	″	60	6°						210	156	86															
38	1200	1200	1600	″	″	4	″	″	5°						210	156	86															
39	1200	1200	1600	″	″	6	″	″	5°						210	156	86															
40	1210	1200	1600	″	″	8	″	″	4°						210	156	86															
41	1200	1200	1600	″	″	10	″	″							210	158	86															
42	1200	1200	1600	″	″	12	″	″	3°						212	156	86															
43	1150	1300	1575	″	″	14	″	″	12°						216	156	86															
44	1200	1200	1600	30	″	0	″	0	7						212	152	86															
45	1190	1200	1600	″	″	″	″	15	″						216	152	86															
46	1200	1200	1600	″	″	″	″	30	″						216	156	86															
47	1190	1200	1600	″	″	″	″	45	″						216	156	86															
48	1200	1170	1600	″	″	″	″	60	″						210	152	86															
49	1180	1180	1600	″	″	″	″	70	″						210	152	86															
50	1200	1190	1600	″	″	″	″	60	″						216	156	86															
51	1200	1200	1600	″	″	4	″	″	″						221	165	86															
52	1200	1170	1600	″	″	6	″	″	″						225	156	86															
53	1200	1170	1600	″	″	5	″	″	″						225	156	86															
54	1200	1190	1600	″	″	10	″	″	″						230	158	86															
55	1190	1190	1600	″	″	12	″	″	″						230	160	86															
56	1180	1200	1600	″	″	14	″	″	″						225	167	86															

Run 16 (Sheet 4 of 4)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 171 RUN 18 DATE 17 DEC 62

CONFIGURATION δ = 45° TAIL ON i_T = 0 h/D = 1.0 (3.66 V... ″ ″)

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	i_t	α_u	β	R	R T_{iF}	L T_{iF}	L_u	D_u	M_u	ENG REMARKS INGEST	PITCH FAN T_i
1	1710	1690	2800	30	0	0	0	0	75	-				25	70
2	1700	1710					20		156	130				12	64
3	1650	1710						30	165	"				15	65
4	1680	1700	2400					45	182	163				12	68
5	1700	1690	2425					70	221	165				28	73
6	1690	1700	2375					60	225	"				16	73
7	1700	1700	"			2			251	173				26	73
8	1690	1700	2400			4			241	182				31	75
9	1700	1690		40		0		0	195	156				18	77
10	1700	1710						30	191	"				19	
11	1710	1700	2375					45	221	169				15	
12	1690	1670	2400					70	243	165				28	
13	1700	1680						60	251	178				19	
14	1710	1700				2			296	182				25	
15	1710	1670	2375			4			296	191				33	64
16	1700	1700	2400			6			305	208				37	
17	1700	1680		60		0		0	269	191				11	
18	1700	1670						30	281	212				9	
19	1710	1680						45	260	205				7	59
20	1700	1700						70	265	196				10	64
21	1700	1690						60	260	191				8	
22	1710	1700				2			269	"				9	
23	1700	1700				4			287	199				9	68
24	1680	1700	2375			6			265	199				10	"
25	1680	1730	2350	20		0		0	296	234				38	86

δ	q	C_L	C_D	C_M	T_E°	ρ	$2q/\rho$	$V_0 = \sqrt{2q/\rho}$	L V_0/RF	R V_0/RF	PF V_0/RF	4 ET	4 LFT	4 RF	RPM ET	RPM LFT	RPM RF
1	3.46	-	.756	.996	61	2349	2946	50.3	.0316	.0321	.0226	.1175	.1164	.1637	1666	-	2376
2	3.55	.938	.717	.996	64	2334	3033	55.1	.0324	.0324	.0230	.1179	.1160	.1464	1571	1595	2390
3	3.54	.935	.712	.992	65	2390	2962	56.4	.0324	.0318	.0227	.1164	.1165	.1462	1560	1576	2381
4	3.44	.936	.579	.992	67	2320	2966	56.5	.0324	.0321	.0234	.1174	.1188	.1415	1528	1559	2331
5	3.68	.912	.574	.966	69	2310	3186	56.4	.0318	.0334	.0235	.1221	.1214	.1405	1477	1550	2371
6	3.19	.912	.572	.966	70	2304	2769	52.6	.0311	.0309	.0217	.1174	.1180	.1379	1482	1541	2395
7	3.60	.906	.555	.966	72	2293	3140	56.0	.0329	.0329	.0236	.1206	.1206	.1500	1454	1540	2347
8	3.96	.900	.558	.996	73	2288	3462	58.8	.0346	.0346	.0248	.1266	.1273	.1515	1459	1521	2342
9	5.93	.916	.571	.954	"	2269	5226	72.3	.0415	.0428	.0301	.1566	.1556	.1916	1506	1561	2362
10	6.13	.916	.593	.964	78	2264	5415	73.6	.0434	.0430	.0307	.1575	.1585	.1960	1527	1561	2362
11	6.13	.910	.574	.964	78	2264	5415	73.6	.0430	.0433	.0307	.1585	.1575	.1950	1486	1556	2362
12	5.85	.912	.560	.954	79	2259	5149	72.0	.0425	.0431	.0303	.1578	.1559	.1928	1436	1541	2337
13	5.79	.903	.555	.954	"	2259	5303	72.8	.0425	.0433	.0303	.1592	.1567	.1929	1436	1533	2362
14	6.03	.900	.550	.954	80	2255	5346	73.1	.0427	.0430	.0305	.1574	.1564	.1937	1411	1539	2362
15	5.97	.893	.530	.996	"	2249	5309	72.9	.0426	.0427	.0304	.1546	.1560	.1932	1419	1527	2390
16	5.99	.882	.525	.996	81	2245	5327	73.0	.0427	.0429	.0307	.1572	.1572	.1955	1403	1499	2366
17	12.51	.893	.543	.996	82	2244	11150	105.6	.0621	.0629	.0440	.2301	.2274	.2718	1416	1518	2390
18	12.62	.880	.535	.996	83	2239	11273	106.2	.0625	.0636	.0448	.2323	.2356	.2814	1396	1496	2390
19	12.25	.882	.549	1.010	84	2234	10967	104.7	.0612	.0623	.0432	.2251	.2261	.2715	1426	1608	2424
20	12.47	.886	.846	.996		2234	11611	107.8	.0634	.0634	.0449	.2321	.2321	.2551	1438	1523	2390
21	12.47	.593	.549	.996		2234	11611	107.8	.0634	.0635	.0449	.2334	.2321	.2557	1435	1516	2390
22	12.49	.893	.843	.996	85	2225	11194	105.8	.0618	.0622	.0441	.2275	.2266	.2604	1433	1527	2390
23	12.47	.888	.535	.992			11194	105.8	.0615	.0622	.0441	.2278	.2251	.2604	1420	1527	2381
24	12.57	.888	.886	.992			11230	106.0	.0631	.0624	.0446	.2282	.2310	.2837	1438	1492	2356
25	12.56	.886	.830	.996			11275	106.2	.0632	.0614	.0452	.2247	.2314	.2874	1436	1455	2274

Run 18 (Sheet 1 of 1)

$h/D = 1.7$

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM
TEST 127 RUN 19 DATE 17 DEC 62
CONFIGURATION I-950

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	R	L T_i	R T_i	L_u	D_u	M_u	REMARKS W_G	q	C_L	C_D	C_m	T°	ρ	2q/ρ	√(2q/ρ)	Vo/RPM	Vo/RPM	Vo/RPM	4 LE	4 LFT	4 RE	DTL ET.	RPM LEFT	RPM R.F.
1	1410	1390	1800	30	12	-4	20	45	121	75				18																	
2	1400	1390	1800			-2			130	82				16																	
3	1400	1390	1775			0			134	86				15																	
4	1390	1390	1750			+2			139	108				15																	
5	1350	1360	1750			4			143	108				16																	
6	1400	1410	1750			6			143	113				16																	
7	1400	1410	1700			8			143	121				23																	
8	1400	1400	1700			10			143	121				26																	
9	1400	1400	1650			12			147	130				17																	
10	1225	1200	1600	40		-4	32	60	134	117				14																	
11	1200	1200	1600			-2			134	108				12																	
12	1180	1190	1600			0			134	104																					
13	1220	1175	1600			4			130	95				15																	
14	1210	1175	1600			6			130	99				20																	
15	1200	1200	1600			8			123	95				15																	
16	1200	1210	1600			10			123	90				14																	
17	1210	1225	1600	50		12			121	104				15																	
18	1200	1225	1600		+16	-6	45	60	121	90																					
19	1200	1200	1600			-4			134	82				5																	
20	1200	1200	1600			0			143	95				5																	
21	1200	1200	1600			4			143	90																					
22	1240	1200	1550			6			147	104				4																	
23	1180	1190	1550			8			147	130				7																	
24	1180	1180	1550			10			152	117				12																	
25	[illegible]	[illegible]	[illegible]																												

Run 19 (Sheet 1 of 1)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 20 DATE 13 DEC 62

CONFIGURATION SF = 45° h/D = 1.7 TP on i_T = 0

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	R			L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_M	T°F	ρ ×10⁶	$\frac{2q}{\rho}$	V_0 $\sqrt{\frac{2q}{\rho}}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	P.xx $\frac{V_0}{RPM}$	u_{RT}	u_{LFT}	L.36 u_{RE}	RPM RT	RPM LEFT	RPM RE	
1	0	0	2400	0	0	0	0	0						1.002					58	2373	0	0			0			0			2400	
2			2360	60										"	12.54				58	"	10515	102.8			.0435			.2766			2365	
3			3140											1.001	12.47				59	2369	10527	102.6			.0336			.2073			3143	
4			3140					30						"	12.27					"	10355	101.5			.0334			.2061			"	
5			3100					60						"	12.41					"	10476	102.4			.0330			.2049			3103	
6			3160					70						"	12.47					"	10527	102.6			.0326			.2013			3143	
7			2350					30						1.000	12.43				60	2364	10516	102.5			.0434			.2735			2350	
8			2330					60						"	12.05				"	"	10196	100.9			.0433			.2754			2334	
9			2370					70						.999	12.29				61	2359	10417	102.1			.0427			.2716			2351	
10			3100					60						.999	12.60						10716	103.5			.0333			.2118			[illegible]	
11			3110			4								"	12.70						10767	103.8			"			"			3107	
12			"			8								"	12.38						10462	102.7			.0328			.2086			3107	
13			3130			12								.998	12.56				62	2356	10671	103.3			.0330			.2099			3124	
14			2400			4								"	12.52						10637	103.1			.0429			.2725			2392	
15			2400			8								"	12.35						10492	102.4			.0426			.2709			2395	
16			2400			12								"	12.47						10594	102.9			.0428			.2723			"	
17			"	80		0								.997	23.26				63	2349	19820	140.8			.0586			.3717			2393	
18			3160											.996	23.77				64	2344	20307	142.3			.0453			.2881			3127	
19			3150					30						"	23.59						20127	141.9			.0450			.2862			3137	
20			3120					60						"	22.62						19300	138.9			.0445			.2834			3105	
21			3100					70						.995	23.48				65	2339	20076	141.7			.0457			.2907			3055	
22			2370					30						"	23.18						19820	140.8			.0589			.3746			2378	
23			2350					60						"	23.48						20076	141.7			.0602			.3829			2335	
24			2400					70						"	"						20076	141.7			.0590			.3152			"	
25			3075					60						.994	23.46				66	2334	20102	141.8			.0461			.2930			3057	
26			3100			4								"	22.72				"	"	19451	139.5			.0450			.2862			3061	
27						8								.993	23.22				67	2329	19939	141.2			.0455			.2344			3078	
28						12								"	23.48						20128	141.9			.0457			.2907			"	
29			2400			4								"	23.52						20197	142.2			.0592			.3765			2381	
30			2390			8								"	23.34						20049	141.6			.0592			.3765			2378	
31			"			12								"	23.57						20240	142.3			.0595			.3784			"	

Run 20 (Sheet 1 of 1)

40x80 Load Cell and Analog Computer Program

Test 177 Run 21 Date 12-18-62

Configuration SF=45° Trail ON h/D = 2.2 Trim Runs

δ	Left Fan RPM	Right Fan RPM	Pitch Fan RPM	V fps	i_t	α_u	β	R	T_{iR}	T_{iL}	L_u	D_u	M_u	Remarks	q	C_L	C_D	C_M	T°C	ρ ×10^6	2q/ρ	$V_o=\sqrt{2q/\rho}$	V_o/RPM	V_o/RPM	V_o/RPM	μ ET	μ LFT	μ RF	RPM ET	RPM LFT	RPM RF	
1	1700	1690	2400	30	16°	0	15°	60°							3.42				76	2253		54.7							1665	1675	2364	
2	"	1670				2													77	2275		54.8							1643	1673	2362	
3	1690	1690				4									—				78	2274		"							1661	1661	2359	
4	1680		2390			6									3.32				79	2265		54.1							1660	1650	2347	
5	1700		2375			8									3.29				80	2263		53.9							1658	1668	2330	
6	1690	1650	2390			10									3.27				81	2257		53.8							1646	1656	2342	
7	1670	1660	2380			12									3.35				"	"		54.7							1627	1637	2332	
8	"	1670	2370			14									3.34				82	2253		54.4							1635	1635	2320	
9	1690	1650	2400	40		-2	22°								5.72				86	2233		72.1							1640	1649	2342	
10						0									5.88				87	2227		72.7							1635	1648	2340	
11						+4									5.65				"	"		71.3							"	"	2334	
12	1700	1700				6									5.72				88	2221		72.9							1656	1658	2338	
13	"	"				8									5.50				"	"		72.2							"	1656	"	
14	1690	1690	2390			10									5.90				89	2217		72.9							1644	1644	2335	
15	1680	1650	2390			14									5.76				"	"		72.1							1635	1635	"	
16	1700	1670	0	60	17°	-4	35°	0							12.57				91	2207		106.7							1623	1652		
17		1700				0													"	"		"							1652	"		
18		1690				+4													92	2202		106.9							1639	1649		
19		1660				6																							1630	"		
20		1700				8																							1649	"		
21		"				10									12.47							106.4							"	"		
22	1710	1710				12									12.57				93	2197		106.7							1657	1657		
23	"	1690				14									12.43				"	"		106.6							1638	"		
24	1700	1680		70?		-6	45°								17.21				95	2186		125.5							1636	1646		
25		1700		70?		-4									17.21							"							1646	1646		
26						0									17.15							125.3							"			
27				71.6		4									"							"							"			
28						8									17.31				96	2182		126.0							1644	1644		

Run 21 (Sheet 1 of 2)

40x80 Load Cell and Analog Computer Program

TEST 127 RUN 21 DATE 12-18-62

CONFIGURATION

T_c 11 14 13

δ	Left Fan RPM	Center Fan RPM	Right Fan RPM	V EAS	i_t	α_u	β	16	17	18	L_u 19	D_u 20	M_u 21	Remarks Time	q	C_L	C_D (1)	C_m (2)	T (3)	ρ	3T/δ	√δ/θ	V_o/...	V_o/... (8)	V_o/EPR	4/... (4)	4/... (5)	4/...	EPR EL	EPR ...	EPR RE	
1	47		235	212	263			59	93	87	80	77	77	1504½	76		164	177	155		150	[illegible]	178	176		132	143					1
2	10		236	215	264			91	72	91	80	76	78	1505½	77		173	157	143		154	211	172	171		131	142					2
3	12		240	216	266			13	92	93	82	77	75	1507	76		162	143	144		162	224	[illegible]	165		128	141					3
4	16		240	216	267			94	93	13	81	78	78	1508	79		146	173	137		164	221	205	160		126	140					4
5	19		235	217	265			97	90	16	79	79	79	1509			136	133	135		110	225	[illegible]	156		123	138					5
6	21		234	218	265			99	72	18	79	83	79	1510½			134	143	125		165	226	205	142		122	136					6
7	24		234	218	265			102	73	110	83	86	86	1511½	81		132	[illegible]	127		164	230	212	141		123	137					7
8	28		233	218	265			97	89	103	75	81	93	1513	82		136	148	120		155	232	216	137		121	135					8
9	39		228	218	257			63	80	65	61	63	62	1518	86		64	62	102		147	[illegible]	205	145		136	142					9
10	40		225	217	256			63	76	65	57	61	61	1519	87		67	76	117		146	204	197	173		133	141					10
11	40		227	216	256			73	74	68	53	59	61	1521			78	128	152		165	179	176	144		132	139					11
12	40		231	216	252			67	70	69	51	57	57	1522½	88		115	[illegible]	[illegible]		143	[illegible]	[illegible]	115		132	131					12
13	41		225	217	257			74	71	68	49	56	57	1524			128	148	131		[illegible]	[illegible]	210	182		133	140					13
14	41		224	217	256			79	72	69	48	56	57	1524½	89		143	154	125		150	218	212	172		135	141					14
15	42		241	219	260			78	72	71	45	58	62	1526½	89		175	143	[illegible]		152	22[illegible]	[illegible]	157		133	142					15
16	42		127	130	199			37	41	38	35	40	40	1535	"		44	44	44		184	153	247	159		152	145					16
17	41		129	133	197			41	45	41	35	42	41	1537	"		44	44	44		166	154	245	15[illegible]		153	146					17
18	40		126	140	207			43	48	43	41	44	43	1538½	92		44	44	44		166	146	244	197		154	148					18
19	39		127	147	214			44	47	44	42	44	43	1539½	"		—	—	—		165	138	245	198		155	150					19
20	38		127	163	222			45	51	46	44	46	44	1540½	"		—	—	—		165	137	244	198		153	151					20
21	38		134	177	227			47	53	47	46	47	45	1542			—	—			166	128	244	199		155	151					21
22	38		137	182	233			47	54	48	47	47	46	1543	73		—	—	45		165	126	242	200		155	152					22
23	37		134	184	241			49	55	49	48	48	47	1544	"		—	—	52		167	140	244	179		151	153					23
24	30		117	122	189			59	60	60	55	56	54	1552½	95		46	46	46		166	152	273	201		157	159					24
25	30		116	122	194			57	60	60	55	57	54	1554	"		—		—		167	148	271	201		164	159					25
26	28		117	123	204			61	63	61	58	59	56	1556½	"		—	—	—		167	167	257	200		162	161					26
27	28		111	129	221			62	65	62	59	60	57	1558½			—	—			166	227	275	202		170	163					27
28	27		117	163	243			63	67	64	62	61	58	1600	96		—	—	—		166	175	279	"		171	164					28

Run 21 (Sheet 2 of 2)

RYAN
[redacted] 64B017

GP # 3

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM
TEST 177 RUN 22 DATE 12-18-62
CONFIGURATION δf = 45° [illegible] SPLIT PITCH FAN CLOSED OFF H/D = 2.2

δ	A LEFT FAN RPM	B RIGHT FAN RPM	C PITCH FAN RPM	V FPS	i_t	α_u	β	TRACTION?			L_u -310	D_u -6	M_u -275	REMARKS	q/δ	C_S	δ_D	δ_M	$V/\sqrt{TC}$	ρ	$2q/\rho$	$\sqrt{2q/\rho}$	LEFT V_o/RPM	RIGHT V_o/RPM	P.F. V_o/RPM	μ LEFT	μ RIGHT	μ PF	LEFT RPM	RIGHT RPM	PF RPM	
1	1700	1710	0	30	0	0	0	22°			270	480	-250	+1 WT. BLNG	3.47				1.001	.00234	2875	53.6	.0315	.0315		.1153	.1146		1702	1712		
2	1800	1700		↓		↓	15	7°			300	-140	-263	-1 WT. BLNG	3.11				1.000	73	2621	51.2	.0284	.0268		.1039	.1054		1800	1780		
3	1833	1700					30	6°	FEM	RPM.	148	309	-409		3.17				.997	56	2641	51.4	.0309	.0305		.1131	.1116		1875	1695		
4	1725	1700					40	5°			12	155	-415		3.40				.994	43	2902	53.9	.0312	.0317		.1142	.1160		1720	1690		
5	1700	1733		40	0	0	0	8°			320	-183	-96		5.77				.989	19	4981	70.6	.0416	.0415		.1521	.1519		1701	1681		
6	1690	1690				4		10°			318	-70	-88		5.80				.988	13	5045	71.0	.0420	.0413		.1537	.1548		1678	1660		
7	1700	1700				8		8°			370	165	-83		6.31				✓	17	5470	74.0	.0435	.0435		.1575	.1573		1660	1669		
8	1700	1675				10		11°			345	190	-78		5.75				.987	.00232	5157	71.8	.0422	.0429		.1575	.1570		1638	1663		
9	1710	1725				12		14°		CORRECT	333	315	-73		6.31				✓	✓	5482	74.0	.0433	.1432		.1535	.1518		1663	✓		
10	1770	1757				14	↓	14°	AMBIENT		335	390	-71		5.79				.986	.00228	5339	73.1	.0414	.1430		.1570	.1574		1676	1627		
11	1780	1720				0	15	8°			294	221	-233		6.51				.985	19	5676	75.4	.0414	.0438		.1535	.1603		1635	1644		
12	1700	1700					30	8°			182	-310	-265		5.47				.984	83	5133	71.6	.0416	.0421		.1525	.1511		1637	1673		
13	1753	1700		↓		↓	40	9°			71	412	-395		✓				.983	83	5147	71.7	.0414	.0422		.1515	.1595		1701	1671		
14	1700	1685		60			0	6°			428	268	-49		12.97				.982	38	11,359	106.7	.0629	.0635		.2295	.2324		1669	1650		
15	1700	1700				4		6°		TO	507	397	-43		✓				✓	✓	✓	✓	✓	.0628		✓	.2298		✓	1669		
16	[illegible]	1710				8		8°			570	500	-35		12.73				.981	37	11,206	105.9	.0623	.0623		.2269	.2280		1668	1669		
17	1700	1700				10		7°			-392	-375	-41	FE + UNIT W.	✓				✓	✓	✓	✓	✓	✓		✓	✓		✓	✓		
18	1700	[illegible]				12		7°	TUNNEL		-352	-310	-32		13.39				✓	✓	11,387	107.6	.0639	.0631		.2337	.2309		✓	1659		
19	[illegible]	[illegible]				14	↓	7°		SHEET	-315	-95	-27		13.35				✓	✓	11,752	105.9	.0634	.0630		.2330	.2306		1678	✓		
20	1700	1700				0	15	7°			+325	-252	-24	FE + UNIT W.	12.79				.980	68	11,379	106.2	.0625	.0625		.2288	.2288		1666	1666		
21	1700	1720					30	8			+284	+182	-221		12.75				✓	✓	11,343	106.0	.0624	.0616		.2289	.2355		✓	1656		
22	1740	1700					40	10			+177	+23	-233		13.12				.979	63	11,595	107.7	.0619	.0634		.2242	.2320		1703	1664		
23	1700	1680		80		0	0	7°			-1140	-125	-20		23.43				.978	57	20,762	144.1	[illegible]	.0858		.3104	.3148		1668	1643		
24	[illegible]	[illegible]				4		4	USE		-391	-72	-18		23.93				✓	52	21,357	145.9	.0853	.0856		.3132	✓		1672	1663		
25	1710	1690				6		5		RUN	-160	-23	-6		23.81				✓	✓	21,195	145.4	.0850	.0860		.3035	.3192		1660	1652		
26	1720	1730				10		5			-75	+243	+3		23.50				.977	46	20,926	144.7	.0841	.0836		.3078	.3060		1660	1690		
27	1725	1752				12		4			-15	+372	+5		23.66				✓	✓	21,065	145.0	.0838	.0834		.3065	.3039		1690	1700		
28	1700	1720				14		4			-310	-70	-50		24.17				✓	✓	21,533	146.7	.0853	.0863		.3098	.3157		1661	1661		
29	1720	1700	→			0	15	4			-477	+335	-47		23.64				✓	✓	[illegible]	[illegible]	[illegible]	[illegible]		.3099	.3082		1690	✓		
30		C	POI 17	#39		1st one	WICK DRAG SCALE 5 FR								24.11				✓	✓	21,469	146.5	—	—		—	—		—	—		
31	1720	1700				0	30	3			+440	-122	-57		23.69				.976	46	20,975	143.5	.0844	.0849		.3069	.3059		1659	1659		
32	1710	1725				0	40	4			+342	-388	-78		12.67				.975	36	11,268	106.2	.0621	.0624		.2283	.2297		1649	1669		
33	1720	1700	0	60	0	0	-12	5			+400	-10	+82		12.69				✓	✓	11,358	106.5	.0619	.0626		.2266	.2291		1639	1659		
34	1700	1700				4	-12	6			+425	-257	+90		[illegible]				.974	.00233	[illegible]	[illegible]	.0601	.0601		.2200	.2300		1654	1654		

Run 22 (Sheet 1 of 2)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 122 RUN 22 [illegible] DATE 12-18-62

CONFIGURATION

δ	LEFT FAN RPM	RIGHT FAN RPM	REAR FAN RPM	V FPS	i_t	α_u	β	[illegible]			L_u	D_u	M_u	REMARKS
36	1700	1710		60	0	10	-12	7			-625	+40	-40	
37	1710	1710				12	-12	6			-410	+232	-2	
38	1710	1692				14	-12	5			-455	+240	-8	
39	1725	1725		40		0	-12	17			+265	+260		
40	1725	1725				4	-12	21			+270	+432	-75	
41	[illegible]	[illegible]				6	-12	24			+270	+450	-77	
42	1700	1710				10	-12	18			+270	+560	-70	
43	1700	1700				12	-12	19			+280	-420	+53	
44	1710	1680				14	-12	27			+285	-310	+70	
45														

δ	g	C_L	C_D	C_M	T_c	ρ	[illegible]	[illegible]	[illegible] V_0	[illegible] V_0	PF V_0	μ [illegible]	μ [illegible]	μ [illegible]	EFF. [illegible]	EFF. [illegible]	EFF. RK	
36	13.59				.574	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.2357	.2152		1.456	1.462		
37	12.24				✓	✓	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		1.466	✓		
38	5.97				.975	26	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		
39	6.09				✓	✓	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		
40	6.01				.972	21	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		
41	6.13				✓	✓	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		
42	6.57				✓	✓	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		
43	6.51				✓	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		✓	[illegible]		
44	?							—	—	—		—	-		—	—		
45																		

Run 22 (Sheet 2 of 2)

RYAN 64B017

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST 177 RUN 23 DATE 14 DEC 67

CONFIGURATION $h/D = 1.0$ [illegible] $\delta_F = 45°$ $i_T = 0$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	INGEST.	FAN INLET TEMP Lt	FAN INLET TEMP Rt	L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_M	$T_C°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	L $\frac{V_0}{RPM}$	R $\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	4 ET	4 LEFT	4 RE	RPM ET	RPM LEFT	RPM RF	
1	1700	1720	0	30	0	0	0	20												[illegible]		52.2	.0307									
2	1690	1700					15	33	90	100										[illegible]		52.1	.0308									
3	1700	1710					20	8	75	55										[illegible]		53.2	.0312									
4		1700				2		22	105	75										[illegible]		52.1	.0306									
5		1700				4		45	70	115										[illegible]		53.3	.0313									
6		1690				6		49												[illegible]		53.6	.0315									
7	1710	1700				0	30	8	70	66										[illegible]			.0313									
8	1690	1690					-12	11	59	90										[illegible]		51.7	.0306									
9	1730	1660		80			-12	15	110	110										[illegible]		71.2	.0419									
10		1700					0	25	125	115										[illegible]			.0410									
11		1670					15	35	50	10										[illegible]		70.5	.0417									
12		1700					20	5	75	75										[illegible]		72.6	.0427									
13	1710	1700				2		5	75	75										[illegible]		71.9	.0419									
14	1770	1770				4		15	85	85										[illegible]			.0419									
15	1710	1700				6		30	90	90										[illegible]		71.9	.0420									
16	1720	1650		60		6		0	80	80										[illegible]		105.6	.0614									
17	1710	1650				2		0	30	30										[illegible]		105.2	.0615									
18	1720	1710				4		0	80	80												104.6	.0627									
19	1720	1710				6		0	50	30												104.3	.0626									

Run 23 (Sheet 1 of 1)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST ______ RUN 35 ______ DATE 12-26-55

CONFIGURATION $\delta_F = 35°$, TAIL OFF, RE SMALL, h/D = 2.2

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β	T_i L	T_i R	T_i °F	L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_m	T_E°	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	μ	μ	μ	RPM ET	RPM	RPM RF	
1				30	OFF	0	-12			68																						
2						2	0			70																						
3						2				77																						
4						4				75																						
5						6				77																						
6						8																										
7						10																										
8						12																										
9						0	15			79																						
10							30																									
11				40			-12																									
12							0			54																						
13						4																										
14						6																										
15						8																										
16						10																										
17						12				79																						
18						0	15																									
19							30																									
20				60			-12																									
21							0			84																						
22						4																										
23						6																										
24						8																										
25						10																										
26						12																										
27						0	15																									
28							30																									
29				80			0			77																						
30						4																										
31						6				79																						
32						8																										
33						0	15			82																						
34							30																									
35				20			-12			87																						

Run 35 (Sheet 1 of 2)

RYAN 64B017

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST ________ RUN ________ DATE ________

CONFIGURATION ________

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	i_t	α_u	β	T_i L	T_i R	T_i PF	L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_M	$T_c°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_o}{RF}$	$\frac{V_o}{PF}$	$\frac{V_o}{RF}$	4_{ET}	4_{LEFT}	4_{RE}	RPM ET	RPM LEFT	RPM P.F.	
36				20	5+F	0	0			79																						
37				|			15			|																						
38				⊥			30			—																							

Run 35 (Sheet 2 of 2)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST ______ RUN 36 DATE 12-26-62

CONFIGURATION $\delta_F = 45°$ | TAIL OFF RF OPEN LF DOORS ON $H/D = 1.0$

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	i_t	α_u	β			R	L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_m	T_c	ρ			V_0/RPM	V_0/RPM	V_0/RPM				RPM EC	RPM LEFT	RPM RF	
1				30	OFF	0	0			45																						
2						2																										
3						4																										
4						6																										
5						0																										
6						2																										
7						4																										
8						6	—																									
9						0	-15																									
10							15																									
11							30			—																						
12							0			0																						
13							-15																									
14				—			15																									
15							30																									
16				40			-15																									
17							0																									
18							15																									
19							30			—																						
20							-15			60																						
21							0																									
22				—			15																									
23				60			30																									
24							0																									
25							15																									
26							30			—																						
27							0			0																						
28						2																										
29						4																										
30				—		6	—			—																						
31				40		0	20			30																						
32						2																										
33						4																										
34						6				—																						
35				—	—	0				45																						

Run 36 (Sheet 1 of 2)

RYAN 64B017

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST ______ RUN 36 DATE 12-26-62

CONFIGURATION ______

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	i_t	α_u	β				L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_m	$T_E°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_o}{RPM}$	$\frac{V_o}{RPM}$	$\frac{V_o}{RPM}$	4_{RT}	4_{LEFT}	4_{RE}	RPM_c RT.	RPM_c LEFT	RPM_c P.F.	
36				40	OFF	2	20																									
37						4																										
28						6																										

Run 36 (Sheet 2 of 2)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST______ RUN 39 DATE 12-27-62

CONFIGURATION ______ δf = 0 TAIL OFF h/D = 1.0 INLET DOORS ON

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V KTS	T/e h/D	α_u	β				L_u	D_u	M_u	REMARKS
1				30	60	0	-12							
2							0							
3							15							
4							30							
5				40			-12							
6							0							
7							15							
8							30							
9				60			-12							
10							0							
11							15							
12							30							
13				80			0							
14							15							
15							30							
16				20			0							
17							-12							

δ	q	C_L	C_D	C_M	$T_C°$	ρ	$\frac{2q}{\rho}$	$\sqrt{\frac{2q}{\rho}}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	$\frac{V_0}{RPM}$	4 EC	4 LEFT	4 RE	RPM EC	RPM LEFT	RPM RE	
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		

Run 39 (Sheet 1 of 1)

40x80 LOAD CELL AND ANALOG COMPUTER PROGRAM

TEST ________ RUN 41 DATE 12-27-62

CONFIGURATION δ_F = 45° FAN 'FF' δ_A = 30° PF OPEN H/D = 1.0

δ	LEFT FAN RPM	RIGHT FAN RPM	PITCH FAN RPM	V FPS	i_t	α_u	β				L_u	D_u	M_u	REMARKS	q	C_L	C_D	C_M	$T_E°$	ρ	$\frac{2q}{\rho}$	$\frac{\sqrt{2q}}{\rho}$	$\frac{V_0}{RF}$	$\frac{V_0}{RF}$	$\frac{V_0}{RF}$	4 ET	4 LET	4 RE	RPM ET	RPM LET	RPM RF	
1				40	60	0	-12																									
2							0																									
3							15																									
4	2460	2410	2600				15																									
5							30																									
6				60			-12																									
7							0																									
8							15																									
9							30																									
10				20			0																									
11							15																									
12							30																									
13				30			-12																									
14							0																									
15							15																									
16							30																									
17				20			-12																									
18							0																									
19							15																									
20							30																									

Run 41 (Sheet 1 of 1)