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ISCAP Appeal No. 2011-093, document 1
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FINAL TECHNICAL REPORT

ON A

STUDY TO VALIDATE THE INTEGRATION OF ADVANCED ENERGY-MANEUVERABILITY THEORY WITH TRADEOFF ANALYSIS

(TITLE UNCLASSIFIED)

Contract F33615-71-C-1564 NEW

Project No. B101

D D C
JAN 26 1972

GENERAL DYNAMICS

Convair Aerospace Division

P. O. Box 748, Fort Worth, Texas 76101

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15 September 1971

FINAL TECHNICAL REPORT

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CONTRACT NO. F33615-71-C-1564
PROJECT NO. B101

JAN 26 1972

CONTROL
20157

Prepared for

Deputy for Development Planning
Aeronautical Systems Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

Control No. FW/71/77/64

GENERAL DYNAMICS
CONVAIR AEROSPACE DIVISION

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FOREWORD

This document is the final technical report on a four-month conceptual design and analysis study of several day-fighter aircraft configurations (F33615-71-C-1564, Project B101). The study was performed by the Convair Aerospace Division of General Dynamics and sponsored by the Deputy for Development Planning (ASD/XRL), Wright-Patterson Air Force Base, Ohio. The contract study covered the period 15 April to 15 August 1971. Mr. Howard K. Gerritzen (ASD/XRL) was the Program Manager. The General Dynamics Project Engineer was Mr. H. J. Hillaker; the Program Study Leader was Mr. D. Lobrecht.

The objectives of the four-month study were (1) to define day-fighter configurations that represent an optimum combination of air-to-air capability (performance and handling qualities) and weight, and (2) to generate data that will permit credible performance tradeoffs and cost analyses to be conducted by the Air Force.

Data presented in the Convair Mid-Term R&D Contract Status Report (FZM-5726, dated 25 June 1971) are included in this final report. The report is submitted in fulfillment of the requirements of Contract Item 0002 in accordance with Exhibit A (DD Form 1423) to the subject contract as specified by Sequence Number A002.

This report contains no classified information extracted from other classified documents, with the exception of F100-PW-100 engine data resulting from the P&WA F-14B/F1-5 engine contract (F33657-70-C-0600). These data are Confidential, Group 4, and carry the NOFORN classification.

UNCLASSIFIED ABSTRACT

A number of air-superiority day-fighter concepts are synthesized so that low unit cost and high transonic maneuverability are paramount. The basic approach used to maximize fighting qualities while minimizing size and cost was to employ only minimum or mission-essential equipment and to optimize only on those capabilities that contribute directly and demonstratably to the visual air-to-air combat environment. The primary configuration tradeoff issues addressed are (1) single-engine versus twin-engine concepts, (2) aircraft size versus performance, and (3) effects of recent technology advancements in aerodynamic design and structural materials. Study results show that visual air-to-air day fighters utilizing current technology can be developed to have superior maneuvering performance, with adequate range and combat fuel allowance, at gross weights less than one-half that of current air-superiority fighters. Single-engine concepts provide greater maneuverability and 5000-pound lower gross weights than twin-engine concepts, when using presently identified engines. The use of smaller engines in the single-engine concepts to further reduce aircraft size results in prohibitive reductions in maneuverability or insufficient mission range. Composite materials can be utilized to increase combat maneuverability significantly. As an example, if it is desired to utilize all of the benefits of composites to increase turning capability (within constraints of equal acceleration capability and equal mission radius), airplane sustained turn rates can be increased over an aluminum airplane by 12 percent with a composite wing and 36 percent with maximum composite usage. Supercritical airfoils used on fixed-wing supersonic aircraft can be utilized to improve transonic capability but at the expense of supersonic capability.

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SECTION 1

INTRODUCTION

(U) The purpose of this study is to define a number of baseline air-superiority day-fighter concepts that are synthesized so that low unit cost and high transonic maneuverability are paramount. Thus, the trend toward achieving high unit effectiveness through sophistication and attendant high unit cost that results in reductions in force levels will be reversed, and the basic need for larger numbers of aircraft with high unit effectiveness will be fulfilled. The basic approach used to maximize fighting qualities, while minimizing size and cost, was to use only minimum or mission-essential equipment and to optimize the design only for those capabilities that contribute directly and demonstratably to the visual air-to-air combat environment. The weight saving from this approach allows a tradeoff for more optimum wing loading and a significant increase in thrust/weight ratio. It is this use of design discipline and emphasis on simplicity that provide the greatest achievements in superior maneuvering performance, higher reliability, reduced maintenance, increased utilization rate, and lower procurement and operating costs.

(U) The principal issue addressed is whether a lightweight fighter can have superior maneuvering performance and still have adequate range and combat fuel allowance. If it can, at less than one-half the weight of current air superiority fighters, it must then be determined whether it can be built for one-half the cost or less. The primary configuration tradeoff issues studied to assess these issues are: (1) single-engine versus twin-engine concepts, (2) aircraft size versus performance capability, and (3) recent technology advancements in aerodynamic design and structural materials versus conventional technology and materials.

1.1 STUDY TASKS

(U) Three different aircraft concepts were designed around two different engines: Concept 1, a single-engine aircraft using the high-thrust F100-PW-100 engine (see Section 3); Concept 2, a single-engine aircraft using a smaller, J101-GE-100 engine (see Section 4); and Concept 3, a twin-engine aircraft using the J101-GE-100 engines (see Section 5).

~~(S)~~ [One aircraft version of the larger, single-engine concept (Concept 1) was designed with a specified wing geometry: wing loading of 60 psf, aspect ratio of 3.0, taper ratio of 0.4, thickness/chord ratio of 4 percent, fixed leading-edge sweep of 35 degrees, straight leading and trailing edges, and manually selectable single-hinge leading-edge high-lift devices (see Section 6). The selected wing used on the Concept 1, 2, and 3 designs is the same except that the taper ratio is .20 and the wing leading edge is faired inboard and rounded at the tips.]

(U) In addition, two new technology developments were evaluated on Concept 1 to identify the potential of application to this type of aircraft. The new developments are advanced transonic aerodynamics (supercritical wing design) and advanced composite materials, which can be utilized to provide a smaller aircraft or significantly enhance transonic maneuverability by allowing greater freedom in optimizing the aerodynamic design. The supercritical wing study is presented in Section 7 and the composite material study in Section 8.

(U) Also, an inlet trade study was accomplished to determine the impact and implications of other fixed- and variable-inlet types for comparison with the basic normal shock inlet (see Section 9).

(U) Other tradeoffs (wing geometry, tail hook, self-sealing fuel tanks, structural criteria, and mission rules) were also conducted during the course of the study. These are presented in Section 10.

1.2 AIRCRAFT DESIGN OBJECTIVES

(U) Certain specific aspects of an aircraft cannot be compromised if a truly superior fighter is to be achieved. The design ground rules, constraints, and performance objectives used in the study are identified below.

1.2.1 Performance

~~(S)~~ Two combat missions, short range and long range, were used for sizing the aircraft. On both missions, the outbound and return legs are optimum speed and altitude, with combat [at 30,000 feet consisting of one acceleration from Mach 0.9 to 1.5, two 360-degree turns at Mach 1.2, and

~~(S)~~ three 360-degree turns at Mach 0.8. (Specific mission rules are presented in Section 3.2.) For the Short-Range Air-Superiority Mission (SRASM), the desired radius of action is not less than 225 n.mi, using internal fuel only. For the Long-Range Air-Superiority Mission (LRASM) the desired radius of action is 750 n.mi, using external fuel for all fuel requirements prior to combat so that combat starts with full internal fuel. A non-refueled ferry range of 2600 n.mi is desired, using external fuel tanks (retained).

(U) Maneuvering performance (energy rate and turn rate) is the essential prerequisite for success in visual air-to-air engagements. Used in defense, it allows the aircraft to counter enemy missile and gun attacks. In offense, it is the means for achieving successful missile or gun-firing position. No predetermined maneuverability goals were specified for the study; however, the objective of the study was to determine the maximum maneuverability that the technology can provide within the constraints of the design problem.

~~(S)~~ No compromises are made for speeds outside the projected air combat arena (Mach 0.6 to 1.6). The placard speed is Mach 1.2 at sea level (no overspeed criteria). Maximum speed at altitude is the maximum attainable with fixed-geometry inlets and with no maneuvering, stability, and tracking qualities required of flight above Mach 1.6.

(U) Special attention has been given to configuration design features that will provide excellent handling qualities, i.e., controllability at all aircraft angles of attack and rotational rates, good tracking qualities, high response rates, no pitch-up characteristics, no post-stall departure, no adverse yaw up to stall, and controllability in stall.

1.2.2 Armament

~~(S)~~ One of the essential features that contributes to fighter excellence is credible, lethal ordnance. The armament consists of guns and usable, reliable, low-cost missiles. Although an improved gun is necessary, this study is based on two 20-mm M-39 guns with 500 rounds of ammunition for weight and space allocations. The aircraft are configured to carry up to four AIM-9X missiles. The design missions are quoted for two AIM-9X missiles onboard, which are considered expended at the end of combat.

~~(S)~~ In addition to the missile hardpoints, there are three hard points for bomb or fuel-tank carriage. The outboard cruise leg of the Long Range Air Superiority Mission requires two external fuel tanks (300 or 450 gallons depending on the design). For Ferry missions the configurations are capable of carrying two 600-gallon fuel tanks and one 150-gallon centerline tank. FRD [redacted]

1.2.3 Crew Station and Escape System

(U) One of the basic requirements of a superior fighter is outstanding visibility. Vision constraints for design are 15 degrees over the nose, 195 degrees vertical, full 360 degrees horizontal, and 40 degrees over the shoulder with minimum restrictions due to seats, ducts, bowframes, wing, etc.

The seat should be optimized for simplicity, low weight, and high visibility. The YANKEE 705 seat is used in this study. The HIAD cockpit does not apply, and the cockpit can be narrower than that described in HIAD. There are no requirements for pressure suits or powered canopy.

1.2.4 Propulsion

(U) Only presently identified engines that have undergone full-scale demonstration, or alternate derivatives utilizing the basic core engines, are considered. The basic single-engine concept is designed around the F100-PW-100 engine, and the twin-engine concept is designed around two smaller J101-GE-100 engines. The tradeoff of size versus performance is accomplished by designing a small single-engine concept around the J101-GE-100 engine for comparison to the larger single-engine concept.

(U) All aircraft designs have fixed, normal-shock inlets; however, trade studies are presented on the effect of other fixed- and variable-geometry inlets.

1.2.5 Structures and Materials

~~(S)~~ The aircraft are designed for a limit load factor of 6.5g at 80 percent internal fuel weight with two AIM-9X missiles and full ammunition (without external fuel tanks). The limit load factor with external tanks is 3.5g.

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~~Atomic Energy Act, 1954~~

(U) The aircraft and landing gear are designed to accept a maximum of 10 fps rate of sink at 40 percent internal fuel, no external stores, and gun empty. No requirement exists for nose wheel steering or special soft-field landing capability.

~~(S)~~ [The placard structural and flutter limit is Mach 1.2 at sea level (full maneuver capability). No overspeed criteria is required. No maneuvering capabilities are required for flight above Mach 1.6. Safe level flight is possible beyond Mach 1.6 up to the maximum-speed thrust limit.]

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1.4.(a)(g)

(U) Conventional aluminum construction is used on the basic designs. A trade study of composite material usage is presented.

(U) There are no requirements for foam or self-sealing fuel tanks in the wings. Fuselage fuel tanks are self-sealing. There are three hard points for external fuel tanks. Inflight refueling capability is provided.

1.2.6 Avionics

~~(S)~~ Only mission-essential avionic equipment needed for a visual day fighter is provided. Items that may be potentially attractive but that have substantial development risks are left for retrofit or growth versions. It is assumed that any functions pilots perform in combat today without strain need not be automated. The avionics equipment for the purposes of this study comprises (1) a fire control system consisting of a snap-shoot gunsight, range-only radar, simplified armament panel, 20-mm gun, and AIM-9X missile provisions; (2) a navigation system consisting of an inertial 3-mph system (lightweight, low-cost, LN-30 type system), TACAN, and ILS (no autopilot requirement); (3) a communication system consisting of a primary UHF radio with direction finding, a back-up UHF radio, and an air-to-ground IFF; and (4) an APR-36 radar warning system and an APX-72 identification system.

SECTION 2

SUMMARY

(U) The specific results of this study show that visual air-to-air day fighters at weights less than one-half of current air-superiority fighters can be developed to have superior maneuvering performance and adequate mission range and combat fuel allowance without the use of advanced technologies. It is the mission-essential/combat-relevant/design-discipline approach to the concept that provides the superior maneuverability necessary to win air battles against future threats. The nature of the concept -- small size and simplicity -- will ensure low procurement and operating costs. Each of the many requirements that could be added to the concept (e.g., sophisticated inlets for better high-Mach capability, higher structural load factor, self-sealing fuel tanks, tail hooks, speed brakes, autopilot, nose wheel steering, etc.) does not by itself add a significant penalty to the aircraft to perform the design mission or markedly reduce its maeuverability; however, taken collectively, they destroy the feasibility of providing a truly superior maneuvering fighter and increase the procurement and operating costs. The greatest achievements are attained by excluding each design criterion and specification that does not contribute directly to winning the air-to-air engagement through superior maneuverability in the primary air battle arena.

(U) A brief summary of each configuration concept and trade study is presented in the following subsections.

2.1 LARGE SINGLE-ENGINE CONCEPT
(401B/F100-PW-100)

~~(S)~~ The 401B aircraft (Concept 1) is a single-place, single-engine, fixed-wing design concept utilizing the F100-PW-100 engine and a blended lifting-body configuration (Figures 2.1-1 and 2.1-2). The primary distinguishing features of Configuration 401B are (1) wing/body blending for lift at high angles of attack, and cross-sectional area shaping; (2) mid-wing with thickened wing root; (3) forward engine location with aft fuselage extensions to obtain a balanced airplane with reasonable tail arms; (4) twin vertical tails; (5) bottom, aft normal-shock-inlet location; and (6) bubble canopy.

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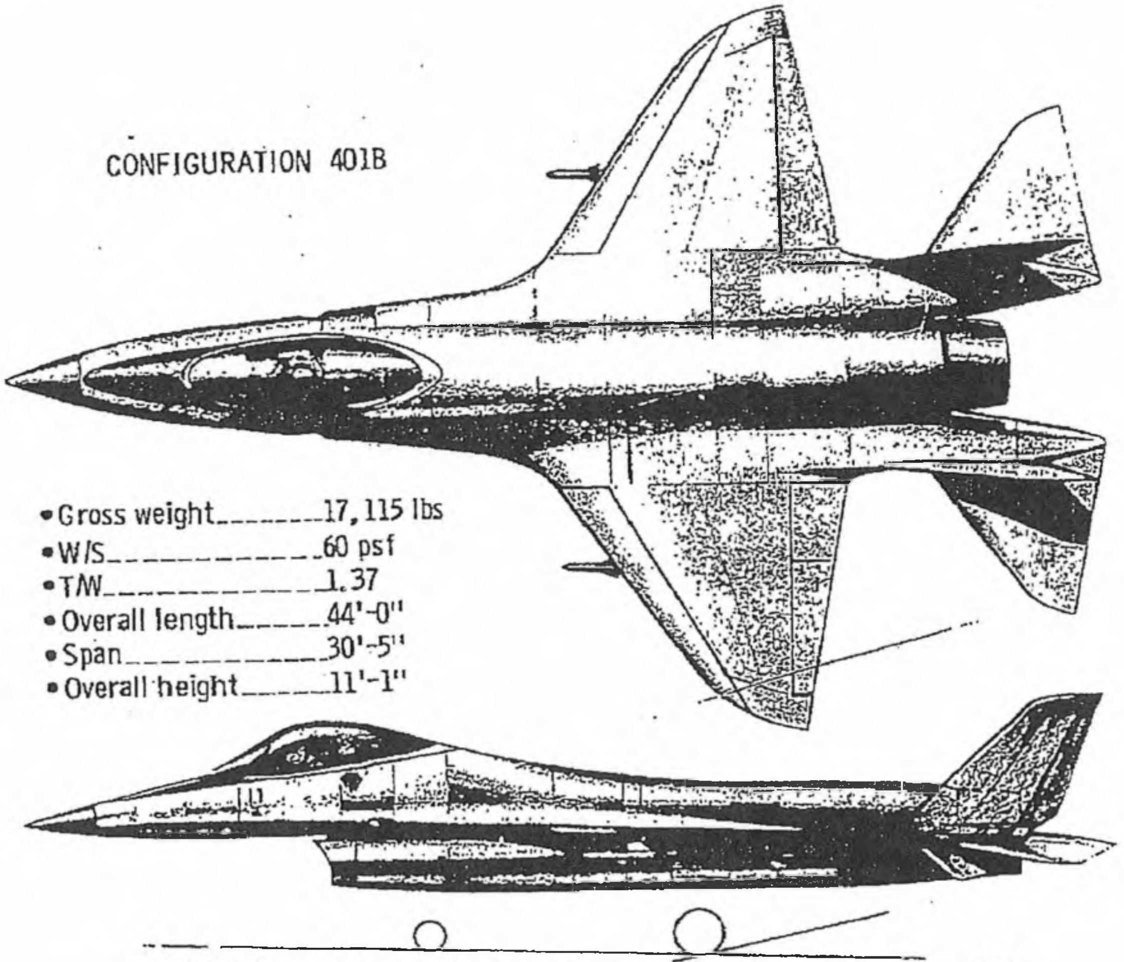

~~(S)~~ Figure 2.1-1 Single-Engine 401B, Top and Side Views (U)

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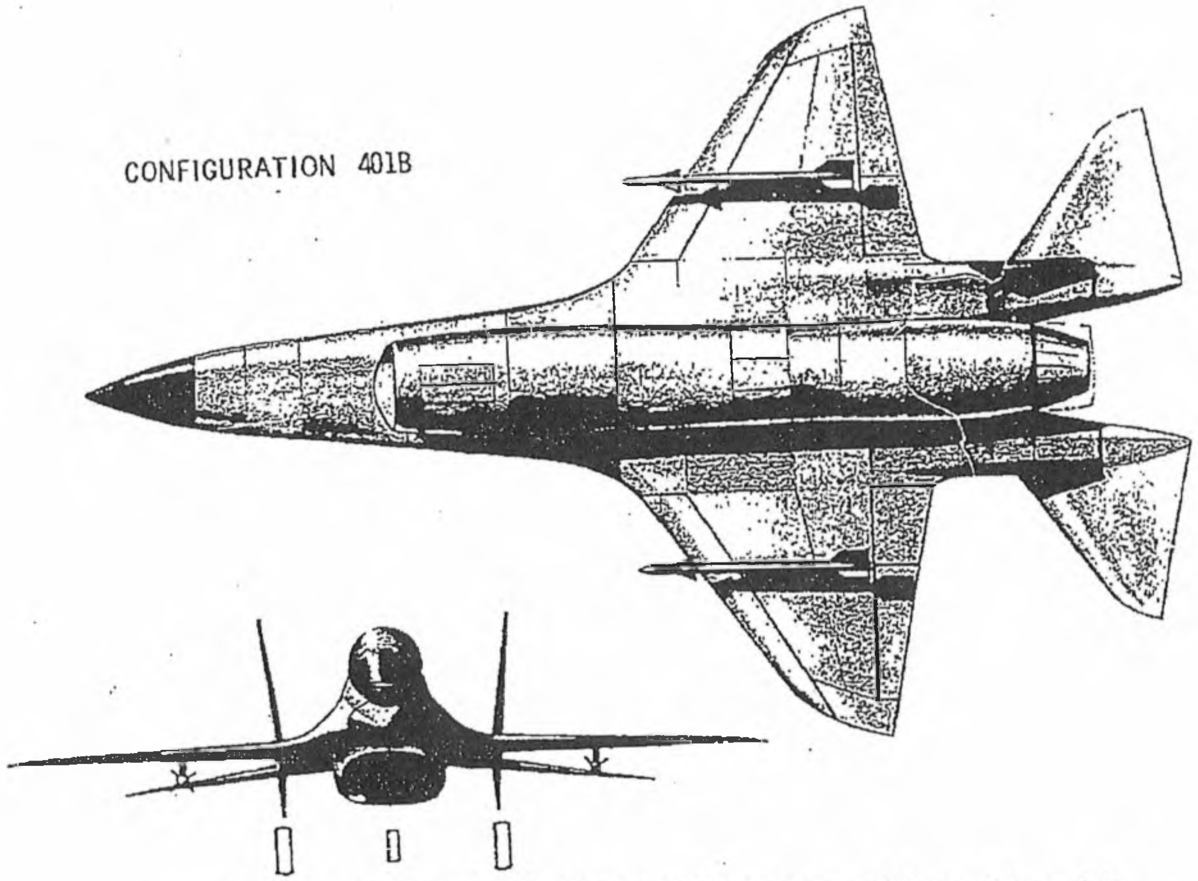

~~(S)~~ Figure 2.1-2 Single-Engine 401B, Bottom and Front Views (U)

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~~(S)~~ Gross weight (full-up internal fuel plus mission payload) of the initial design is 16,800 lb. Growth data for aircraft weights of 15,600 lb to 18,000 lb, holding constant wing loading and engine size, were obtained for final sizing of the aircraft. [The 23,470-lb rated thrust of the engine provides a thrust/weight ratio spread of 1.5 to 1.3 for the growth curve. The aircraft, when sized to perform the Long-Range Air-Superiority Mission (750 n.mi) and designed with sufficient overload capability to meet the ferry range (2600 n.mi), requires a gross weight of 17,115 lb, which results in a thrust/weight ratio of 1.37. The LRASM requires two 300-gal external fuel tanks for the outbound portion of the mission. The Short-Range Air-Superiority Mission capability, which is performed without external fuel tanks, has a radius of 239 n.mi. The ferry mission requires the use of two 600-gal. fuel tanks and one, 150-gal. tank to achieve the desired 2600-n.mi range with tanks retained.]

~~(S)~~ If the aircraft were sized [for the LRASM only, without the additional overload penalties associated with the ferry objective, the gross weight would be approximately 16,800 lb, with a corresponding thrust/weight ratio of 1.4. Summary mission capabilities of the 17,115-lb version are tabulated below. Detailed design data and rationale, and performance, aerodynamics, handling qualities, weight, and propulsion data are presented in Section 3.

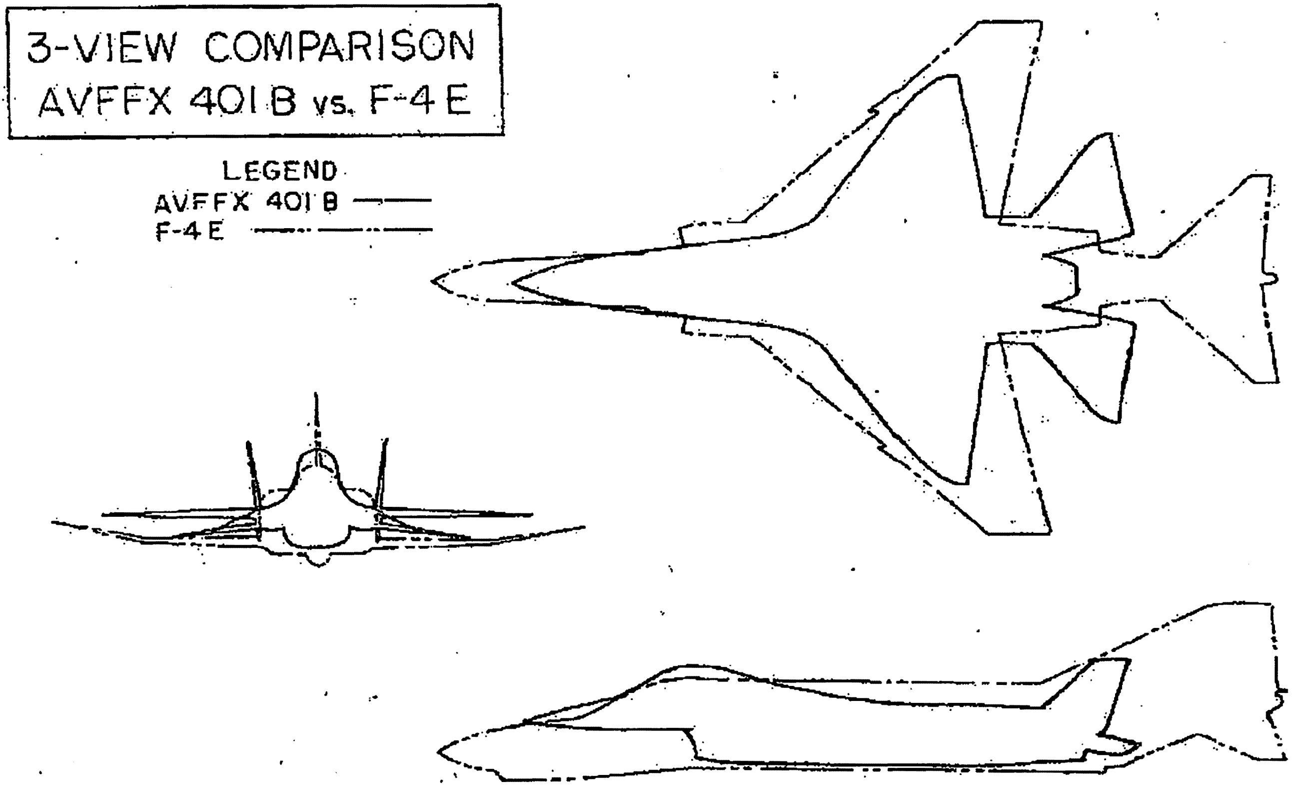
401B MISSION SUMMARY
(17,115-lb A/P)

Mission	Range (n.mi)	Radius (n.mi)	$\dot{\theta}_{M.8}$ (deg/sec)	$\dot{\theta}_{M1.2}$ (deg/sec)	Accel. Time (sec)
LRASM	-	750	9.8	8.1	35.5
SRASM	-	239	10.9	9.1	32.4
Ferry	2614	-	-	-	-

Silhouettes of the 17,115-lb version of 401B are superimposed on equal-scale outlines of the F-4 and MIG-21 aircraft in Figures 2.1-3 and 2.1-4 to show relative sizes.

2.2 SMALL SINGLE-ENGINE CONCEPT
(403/J101-GE-100)

~~(S)~~ The 403 aircraft (Concept 2) utilizes the same configuration concept as the 401B except that it is designed around



~~(S)~~ Figure 2.1-3 Relative Size Comparison, Single-Engine 401B vs F-4E (U)

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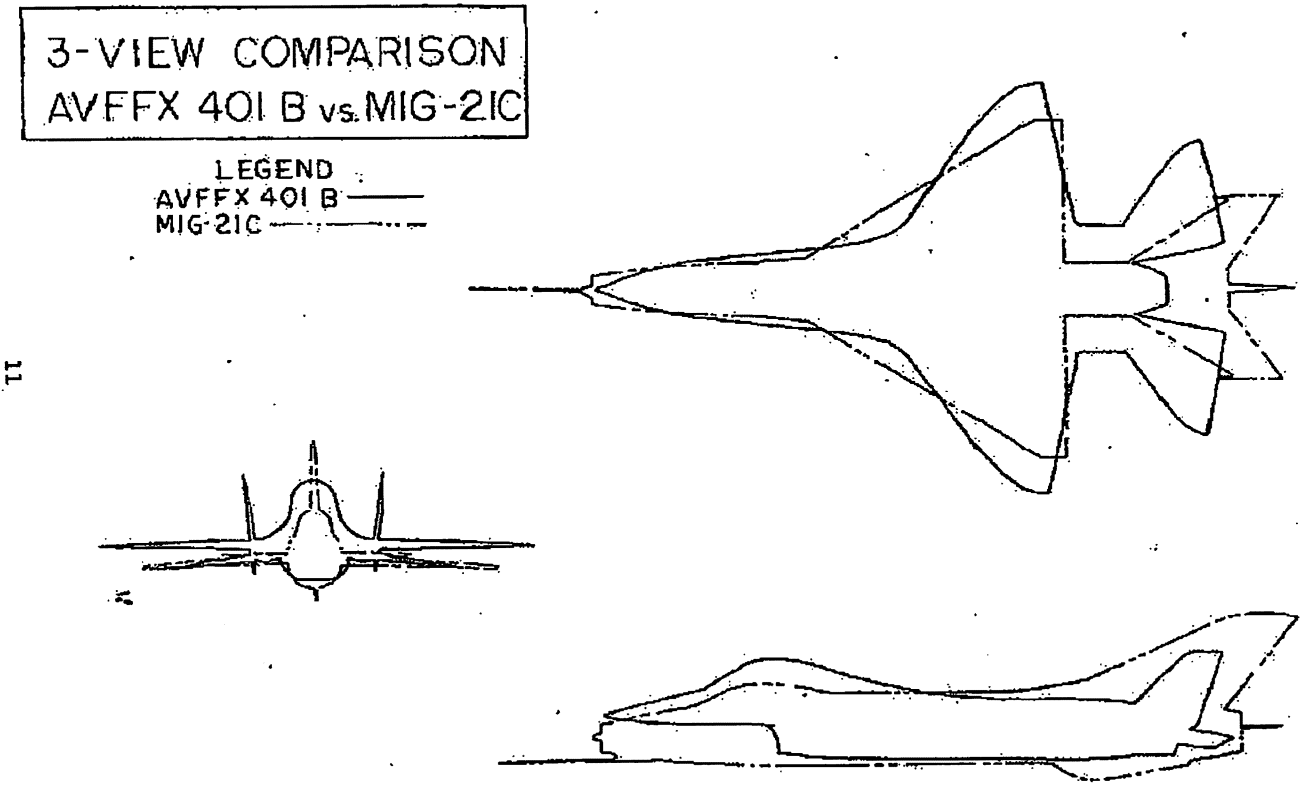


~~(S)~~ Figure 2.1-4 Relative Size Comparison, Single-Engine 401B vs MIG-21C (U)

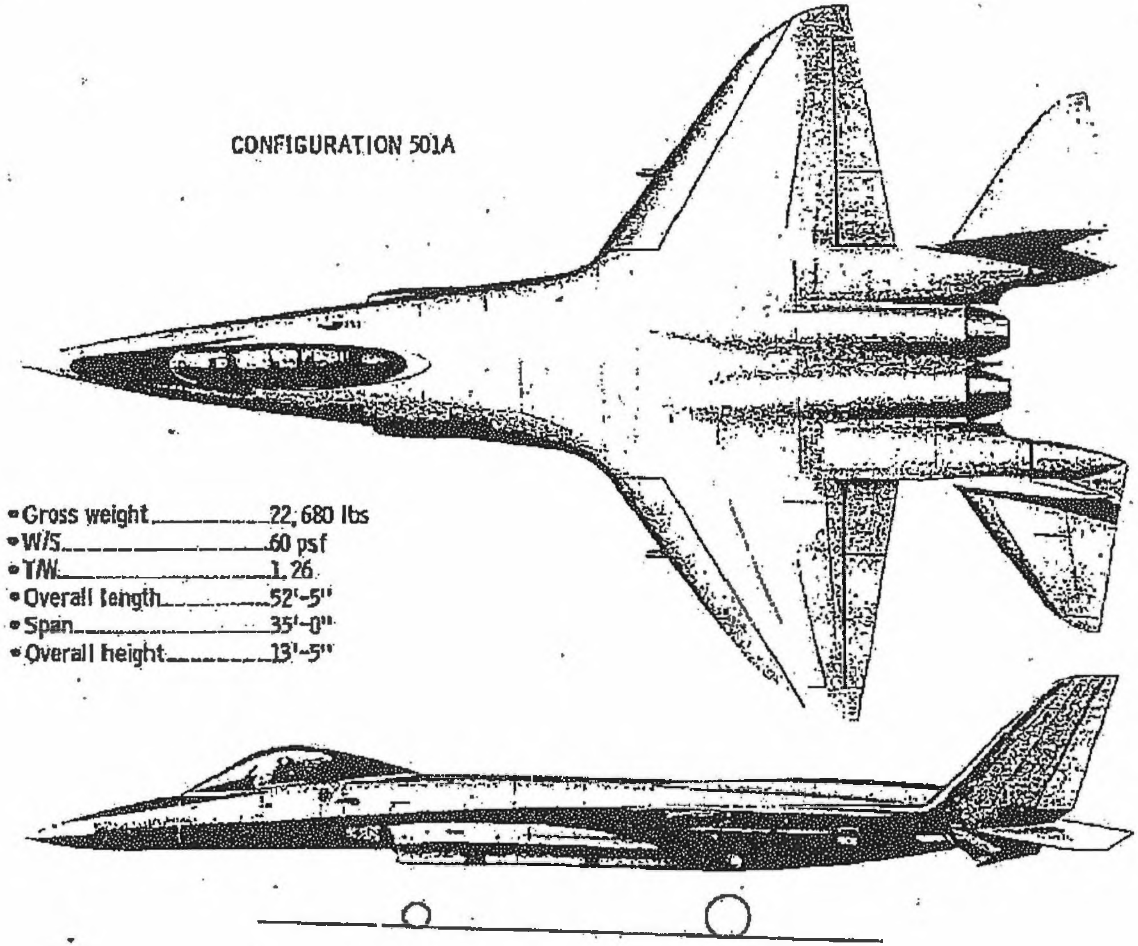
~~(S)~~ a single J101-GE-100 engine [(rated thrust of 14,295 lb). The basic point-design layout was made at a size of 13,000 lb, and design data were also generated for a 10,000-lb and a 16,800-lb version. This provided a T/W variation of 1.43, 1.10, and 0.85.]

(U) The results show that no airplane size within the constraints of the design objectives can be made to perform the design mission when using only one of these small engines. At the smaller sizes (10,000 and 13,000 lb) the basic problem is simply insufficient fuel. As the size is increased to achieve higher fuel fractions, the combat fuel allowance required increases disproportionately because of the reduced T/W. Finally, at about 18,500 lb there is insufficient thrust to perform the acceleration requirement of the mission. Technical data for this concept are presented in Section 4.

2.3 LARGE TWIN-ENGINE CONCEPT
(501A/J101-GE-100)

~~(S)~~ The 501A aircraft (Concept 3) is a single-place, twin-engine, fixed-wing design that utilizes J101-GE-100 engines and as many of the design features of the single-engine concepts as possible that are consistent with good twin-engine design (Figures 2.3-1 and 2.3-2). [The gross weight of the initial design is 19,000 lb. Growth data for final sizing are also established by use of design gross weights of 16,800, 22,000, and 24,000 lb, resulting in a T/W variation of 1.7 to 1.2 (rated thrust is 14,295 lb per engine).]

~~(S)~~ The aircraft, when sized to perform the [LRASM (750 n.mi), requires a gross weight of 22,680 lb, resulting in a T/W of 1.26. The LRASM requires two 450-gal] external fuel tanks for the outbound portion of the mission. The [SRASM capability (no external fuel tanks) has a radius of 244 n.mi. The ferry mission capability when carrying a reasonable upper limit of external fuel (two 600-gal and one 150-gal tanks) is only 2166 n.mi with tanks retained. Summary mission capabilities of the 22,680-lb twin-engine aircraft are tabulated below. Detailed design, performance, aerodynamics, handling qualities, weight, and propulsion data are presented in Section 5.]



CONFIGURATION 501A

Gross weight	22,680 lbs
W/S	60 psf
T/W	1.26
Overall length	52'-5"
Span	35'-0"
Overall height	13'-5"

~~(S)~~ Figure 2.3-1 Twin-Engine 501A, Top and Side Views (U)

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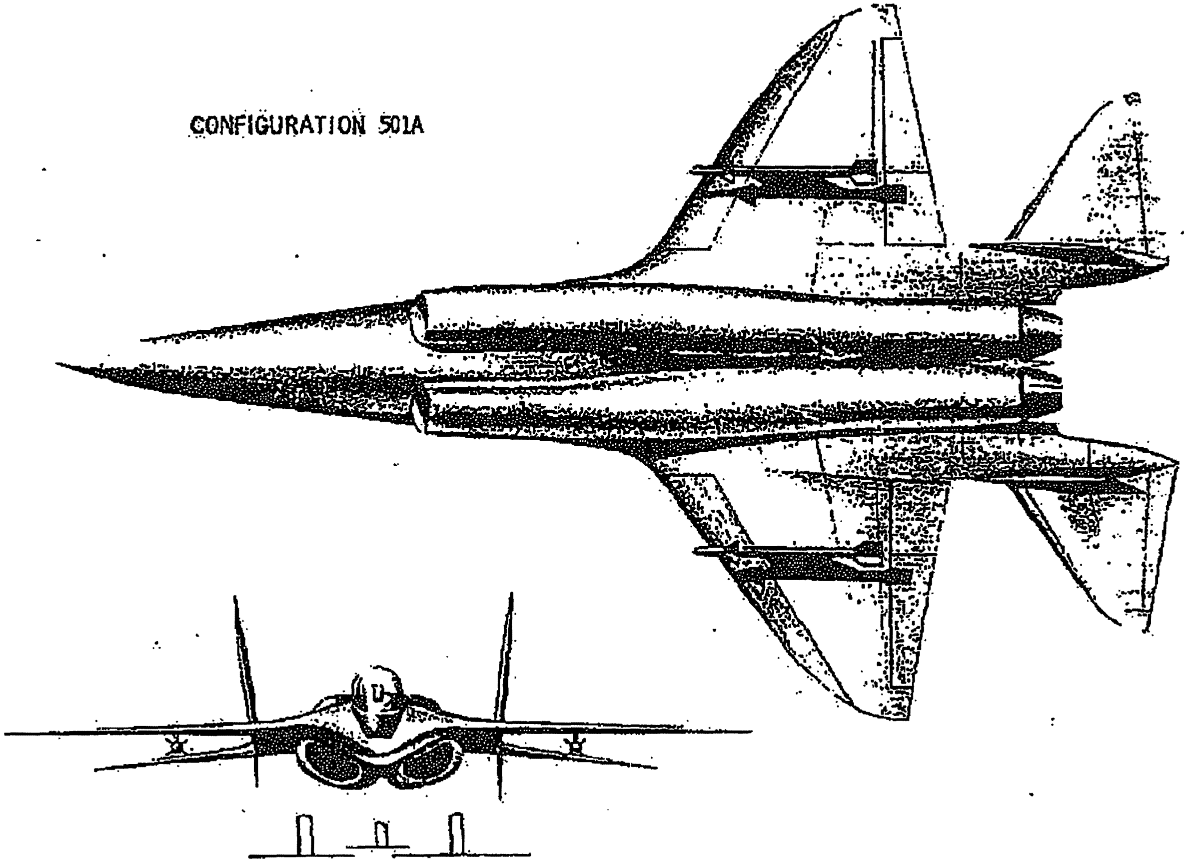
CONFIGURATION 501A



~~(S)~~ Figure 2.3-2 Twin-Engine 501A, Bottom and Front Views (U)

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501A MISSION SUMMARY
(22,680-lb A/P)

Mission	Range (n.mi)	Radius (n.mi)	$\dot{\theta}_{M.8}$ (deg/sec)	$\dot{\theta}_{M1.2}$ (deg/sec)	Accel. Time (sec)
LRASM	-	750	9.5	6.9	51.4
SRASM	-	244	10.5	7.6	46.1
Ferry	2166	-	-	-	-

Silhouettes of the 22,680-lb version of 501A are superimposed on equal-scale] outlines of the F-4 and MIG-21 aircraft in Figure 2.3-3 and 2.3-4 to show relative sizes.

2.4 0.4 TAPER RATIO WING ON 401B

~~(S)~~ The Concept 1 aircraft (the large single-engine 401B concept) was also designed with a [contract-specified wing geometry: wing loading of 60 psf, aspect ratio of 3.0, taper ratio of 0.4, thickness/chord ratio of 4 percent, fixed leading-edge sweep of 35 degrees, straight leading and trailing edges, and manually selectable single-hinge leading-edge high-lift devices. This wing differs from the selected wing used on the Concept 1, 2, and 3 designs in two respects: taper ratio of 0.4 versus 0.20, and squared rather than rounded wing tips.]

~~(S)~~ If the [wing t/c is a constant 4 percent, the configuration when sized for a 16,800-lb airplane has a dry-weight penalty of 270 lb as compared to the Concept 1 401B. This is primarily due to taper ratio. However, because of the higher taper ratio, a tapered t/c can be utilized to minimize the weight penalty; therefore, the wing was redefined to have a tip t/c of 2.5 percent and an inboard t/c (at beginning of thickened wing root) of 4.84 percent, which results in an exposed RMS t/c of 4.0 percent. This change reduces the dry-weight penalty from 270 lb to 119 lb.]

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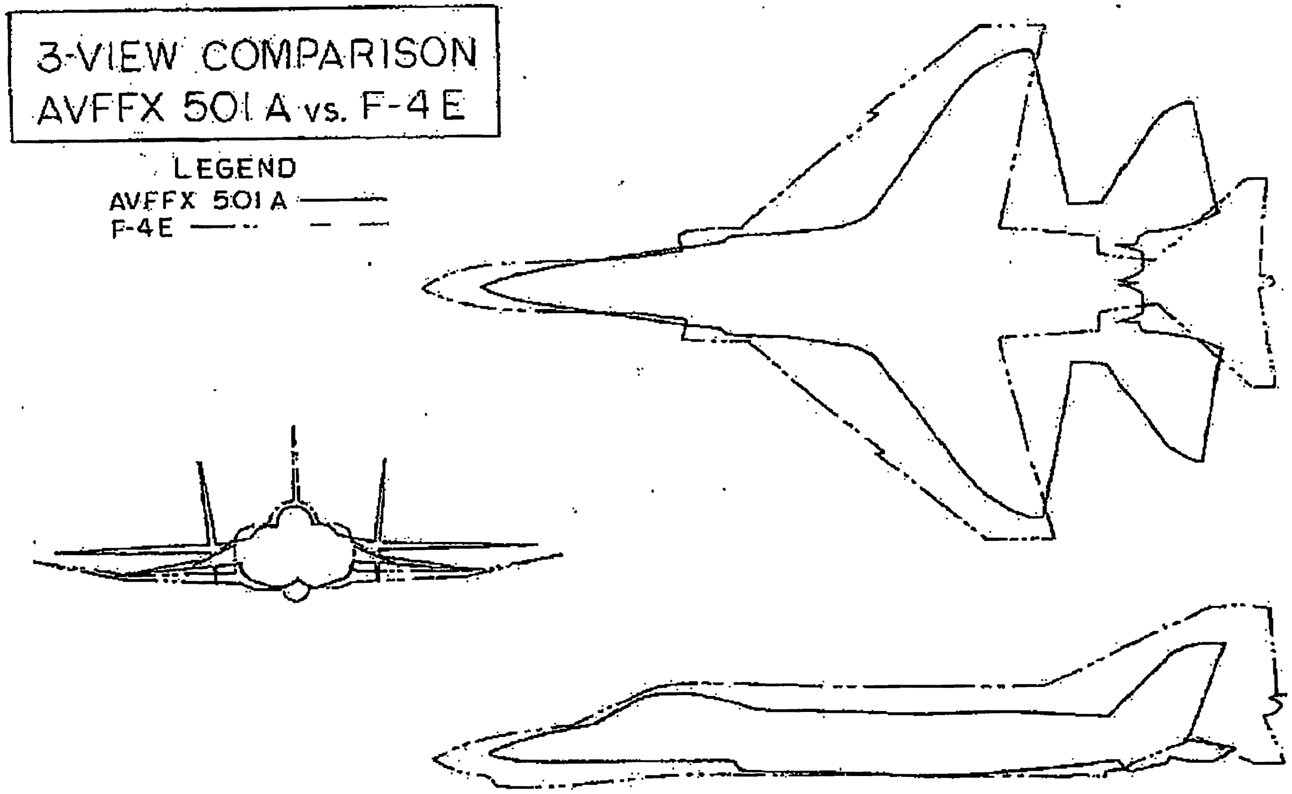
~~(S)~~ When sized to meet the [LRASM, this airplane has a gross weight of 17,735 lb.] Summary mission capabilities at this weight are tabulated below. Detailed technical data are presented in Section 6.



~~(S)~~ Figure 2.3-3 Relative Size Comparison, Twin-Engine 501A vs F-4E (U)

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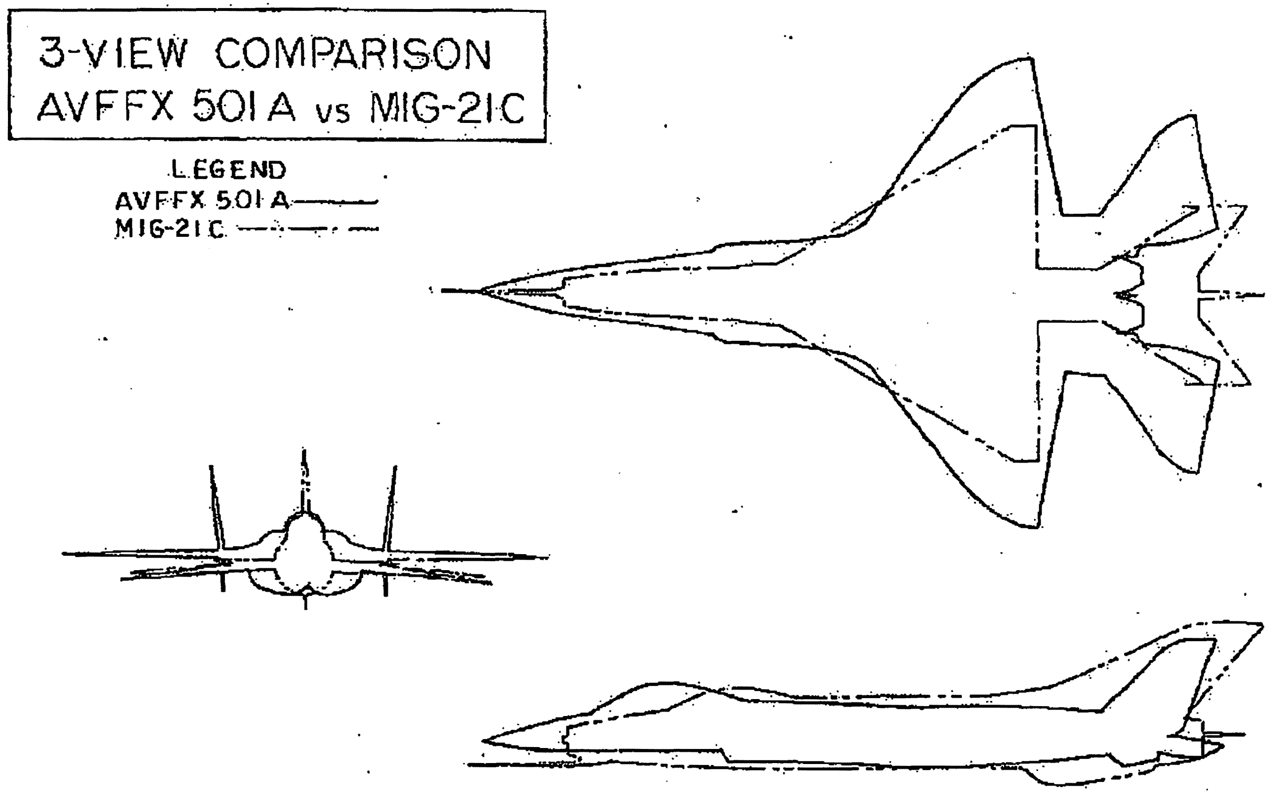

~~(S)~~ Figure 2.3-4 Relative Size Comparison, Twin-Engine 501A vs MIG-21C (U)

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[401B λ=.4 MISSION SUMMARY
(17,735-1b A/P)

Mission	Range (n.mi)	Radius (n.mi)	$\dot{\theta}_{M=.8}$ (deg/sec)	$\dot{\theta}_{M=1.2}$ (deg/sec)	Accel. Time (sec)
LRASM	-	750	9.2	8.0	38.6
SRASM	-	244	10.1	8.7	35.2
Ferry	2478	-	-	-	-

]

2.5 SUPERCRITICAL WING STUDY ON 401B

(U) Effective utilization of the supercritical airfoil is attained only through proper selection of the wing planform. Merely to replace the biconvex airfoil with a supercritical airfoil on the Concept 1 planform is not sufficient. For example, a blunt-nosed airfoil on the Concept 1 planform is expected to have high wave drag that can be considerably reduced by increasing the wing sweep. Also, since the payoff of a supercritical airfoil is proportional to t/c, a slightly higher thickness of 6 percent was choosen to provide a useful supercritical payoff.

(U) The planform selection was made non-arbitrary by performing an abbreviated parametric study. The planform parameters investigated were wing sweep, wing loading, and aspect ratio. The effects of weight as well as aerodynamics were considered. From a weight standpoint, the thicker wing along with the elimination of leading-edge flaps provides a weight savings that can be translated into higher sweep, higher aspect ratio, or lower wing loading. [The basis for comparison in the planform study was two representative maneuverability parameters: maximum sustained load factor between Mach 0.8 and 1.2 at 30,000 ft, and energy rate at Mach 0.9/10,000 ft/1g.]

~~(S)~~ The results of the parametric study reveal that no single planform will be best for all flight conditions, and the final selected planform must necessarily be a compromise. Two planforms were selected for detailed analysis and mission performance, one favoring sustained turn rates and one favoring acceleration capability. [Both have a leading-edge sweep of 45 degrees, wing loading of 60 psf, and thickness/chord ratio of 6 percent. The selected aspect ratios were 3.0 and 3.75, based on span of the average tip chord (or aspect ratios of 3.2 and 4.0 based on overall span where the tip is rounded in such a way as to hold constant wing area).]

~~(S)~~ The SRASM radius objective was more critical than that of the LRASM and was therefore chosen as the sizing criterion. [The higher-aspect-ratio wing requires a gross weight of 17,115 lb (coincidentally the same as the basic 401B). The lower-aspect-ratio wing requires a gross weight of 16,640 lb. Summary mission capabilities are tabulated below.

401 S/C AR 3.75 MISSION SUMMARY
(17,115-lb A/P)

Mission	Range (n.mi)	Radius (n.mi)	$\dot{\theta}_{M=.8}$ (deg/sec)	$\dot{\theta}_{M=1.2}$ (deg/sec)	Accel. Time (sec)
LRASM	-	794	11.0	7.6	62.6
SRASM	-	225	11.7	8.3	57.2
Ferry	3252	-	-	-	-

401 S/C AR 3.0 MISSION SUMMARY
(16,640-lb A/P)

Mission	Range (n.mi)	Radius (n.mi)	$\dot{\theta}_{M=.8}$ (deg/sec)	$\dot{\theta}_{M=1.2}$ (deg/sec)	Accel. Time (sec)
LRASM	-	767	10.6	7.5	55.8
SRASM	-	225	11.4	8.2	51.1
Ferry	3571	-	-	-	-

~~(S)~~ The general conclusions from these data are that supercritical airfoils, when used on fixed-wing supersonic airplanes, can be utilized to provide approximately 10-percent higher Mach 0.8 sustained turn rates but at the expense of reduced supersonic capability (10-percent lower Mach 1.2 sustained turn rate, and 70-percent or 25-second higher acceleration time from Mach 0.9 to 1.5). However, for speeds closer to the critical region, such as Mach 0.9, the sustained turn rate advantage becomes larger (13 percent over the Concept 1), and significant improvements in buffet limits are attained in the critical region. A side payoff of the supercritical wing designs is greatly improved ferry range. A side penalty of the supercritical wing designs is greatly reduced maximum speeds (from Mach 2.2 to 1.8). Detailed design data and performance, handling qualities, and weight data for the supercritical wing study are presented in Section 7.]

88th ABW/PA
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(6)
1.4 (a)(g)

(U) Through additional configuration shaping and development of thin-wing supercritical design, it is believed that the supersonic penalties can be reduced. Such studies were not possible within the scope of this study.

2.6 COMPOSITE MATERIAL STUDY ON 401B

~~(S)~~ A matrix of wing design variables were evaluated to determine whether the weight reductions attained through the use of composite materials should be used for increased aspect ratio, reduced wing loading, reduced aircraft size (higher T/W), or a combination of the three to maximize the maneuver capabilities. [The matrix of variables evaluated were: (1) aspect ratios of 3, 4, 5, and 6; (2) wing loadings of 45, 50, 55, and 60 psf; and (3) gross weights of 15,600, 16,800, and 18,000 lb, with corresponding thrust/weight ratios of 1.5, 1.4, and 1.3 when using the fixed-size F100-PW-100 engine. This matrix of variables was evaluated for four levels of composite usage: (1) none (all aluminum), (2) composite wing, (3) composite wing, tails, and duct, and (4) all composite.]

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(4)
1.4 (a)(g)

~~(S)~~ For each level of composite usage and for each combination of aspect ratio and wing loading, the aircraft was sized to perform the 750-n.mi-radius LRASM. Two types of energy-maneuverability were selected to show the payoff of composite usage: [(1) sustained turn rate at Mach 0.8 and 30,000 ft as being representative of a high-lift turning condition, and (2) acceleration time from Mach 0.9 to 1.5 at 30,000 ft as being representative of a low-lift accelerating capability or 1-g energy rate. The Mach 0.8 turn rate was then plotted versus acceleration time for the matrix of AR and W/S to establish the maximum capabilities for each level of composite usage.]

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)
(4)
1.4 (a)(g)

~~(S)~~ The composite trade study results along with backup data are presented in Section 8. As an example, if it is desired to utilize all of the benefits of composites to increase subsonic turning capability (within constraints of equal acceleration capability and equal mission radius), [airplane sustained turn rates at Mach 0.8 can be increased over an aluminum airplane by 12 percent with a composite wing or 36 percent with maximum composite usage. Energy-maneuverability plots, including maximum maneuver diagrams, for various selected combinations of variables are needed]

FOIA 13526
SEC 3.3 (b)(1)(4)
SEC 1.4 (a)(g)

to allow comparisons over the whole maneuvering flight spectrum before the optimum combinations of variables can be selected.

2.7 INLET TRADE STUDY ON 401B

~~(S)~~ Four inlet designs were evaluated during the study to assess the payoff and penalties associated with inlet sophistication. The inlet configurations selected and evaluated are:

Inlet	Design Mach	Capture Area, A_i (in.^{2})	Variable Geometry	Bypass
(1) Open-nose (401B basic)	1.6	740	No	No
(2) Half-axisymmetric, fixed-spike	2.0	1020	No	Yes
(3) Half-axisymmetric, variable-diameter	2.2	890	Yes	No
(4) Two-dimensional, variable-ramp	2.2	840	Yes	No

(U) The inlet designs were evaluated against Concept 1 as the basic vehicle. Each inlet was incorporated into the 401B airframe and lines were generated in sufficient detail to determine aircraft cross-sectional and wetted-area changes, structural and control system weights, inlet pressure recoveries, and drags.

~~(S)~~ A performance comparison in terms LRASM radius, aircraft gross weight required to achieve a 750-n.mi radius, mission maneuver capability, supersonic P_s, and Mach 2.2 ceiling was made between each inlet configuration. The variable-geometry inlets have significantly better performance above Mach 1.6, as expected, but with a significant degradation in mission radius, which requires increasing the aircraft size. For example, the 2-D variable-ramp-inlet airplane achieves 136 n.mi less mission radius, which requires resizing to 17,790 lb (from the basic 17,115-lb airplane). At speeds less than

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~(S)~~ Mach 1.2, the aircraft with the basic open-nose inlet has maneuver capabilities slightly better than aircraft with any of the alternate inlets. This is a result primarily of the 4-percent-higher T/W of the smaller airplane size.

(U) The fixed-spike inlet with bypass was not competitive with the variable-geometry inlets in terms of either energy maneuverability or mission radius.

(U) Configuration layouts, performance comparisons, and supporting data are presented in Section 9.

2.8 OTHER TRADES AND CONSIDERATIONS

~~(S)~~ The various tradeoff effects established during the course of the study are presented in Section 10. Some of the summary results are listed below in terms of aircraft size required to perform the 750-n.mi mission.

Trade	Gross Weight (lb)
Concept 1 (401B)	17,115
Addition of tail hook	17,320
Self sealing of 100% fuel rather than only fuselage fuel	17,277
Increasing design load factor from 6.5g to 8.0g at 80% fuel	17,693
Increasing design load factor from 6.5g to 8.0g at constant nw	17,191
Increasing landing R/S from 10 fps to 15 fps (fuselage structure only)	17,196
Applying 1.05 factor to fuel flows	17,520
Applying 1.05 factor to fuel flows and adding 5% fuel reserve	18,075

2.9 ENERGY MANEUVERABILITY PLOTS

~~(S)~~ One of the purposes of this study is to provide data for use in validating the integration of Col. J. R. Boyd's Advanced Energy-Maneuverability Theory with tradeoff analyses. The methods used with Col. Boyd's theory for displaying and comparing the capabilities of different design [concepts are described in Armament Memorandum Report 71-2.* Examples of the energy-maneuverability plots generated by Convair under this study are presented in Figure 2.9-1 through 2.9-3. These data are for Configuration 401B, the single-engine concept with the F100-PW-100 engine and having a mission weight of 17,115 lb.]

~~(S)~~ The combat arena plot (Figure 2.9-1) displays the region of the flight envelope for various types of maximum maneuver capabilities:

1. The top line is the basic 1-g ceiling.
2. The quickest/tightest turn line is the highest altitude for limit load factor (i.e., the "corner velocity" of v-n diagrams). To the left of this line, maximum turn rates are aerodynamically limited; to the right, structurally limited.
3. The top line of the Maximum Maneuver Corridor is the Best Energy Climb path (or the maximum 1-g energy rate (P_s) for each level of energy (E_s).
4. The bottom line of the Maximum Maneuver Corridor is the maximum energy rate for each level of energy while turning at structural limit load factor.
5. The Maximum Maneuver Corridor is the region of maximum turn rate for any energy rate, or the maximum energy rate for any turn rate.

88th ABW/IRI
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(4)
1.4 (a)(g)

(1)
EO 13526 Sec 3.3(b)(4)
Sec. 1.4(a)(g)
Sec. 1

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*Boyd, J. R., Col., USAF, Christie, T. P., and Drabant, R. E., Capt., USAF, Maximum Maneuver Concept, Armament Memorandum Report 71-2, August 1971.

6. The maximum sustained maneuver region is identified by the contour line of zero energy rate at limit load factor.

7. The zero-energy-rate ($P_s = 0$) line for maximum excess L/D bounds the transient maneuver region where the most efficient turns may be sustained. Maneuvering combat outside this region will most likely be hit-and-run attacks. These data show the configuration 401B to have efficient maneuvering capability up to the upper limits of the anticipated air-to-air combat region (Mach 1.6).

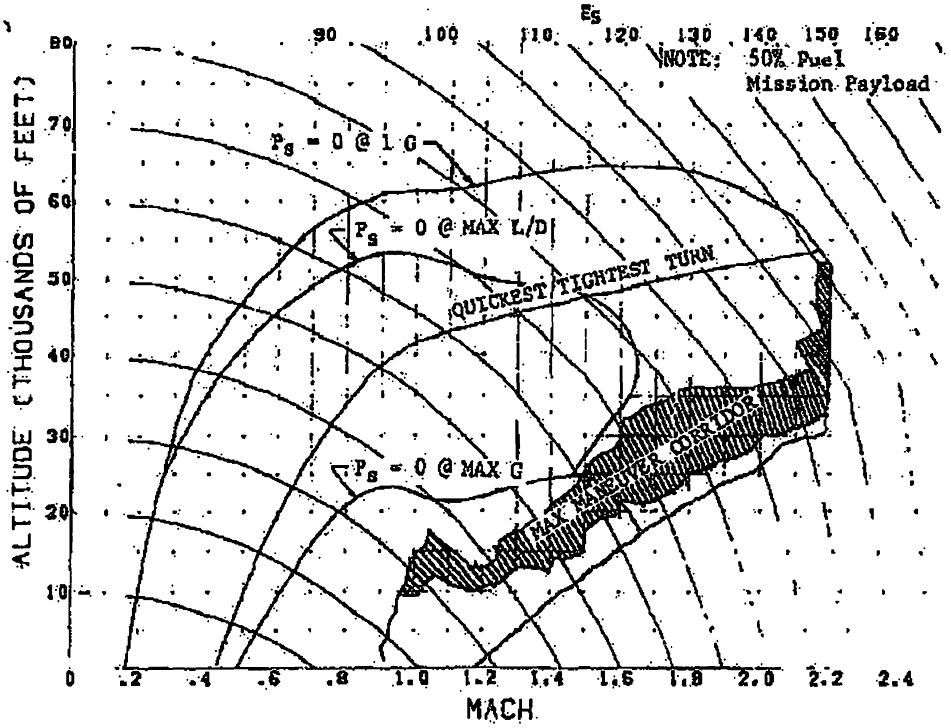
[redacted]

88th ABW/IPI
FOIA (b)(1)
E.O.13526, SEC 3.3(b)(4)
1.4(a)(g)

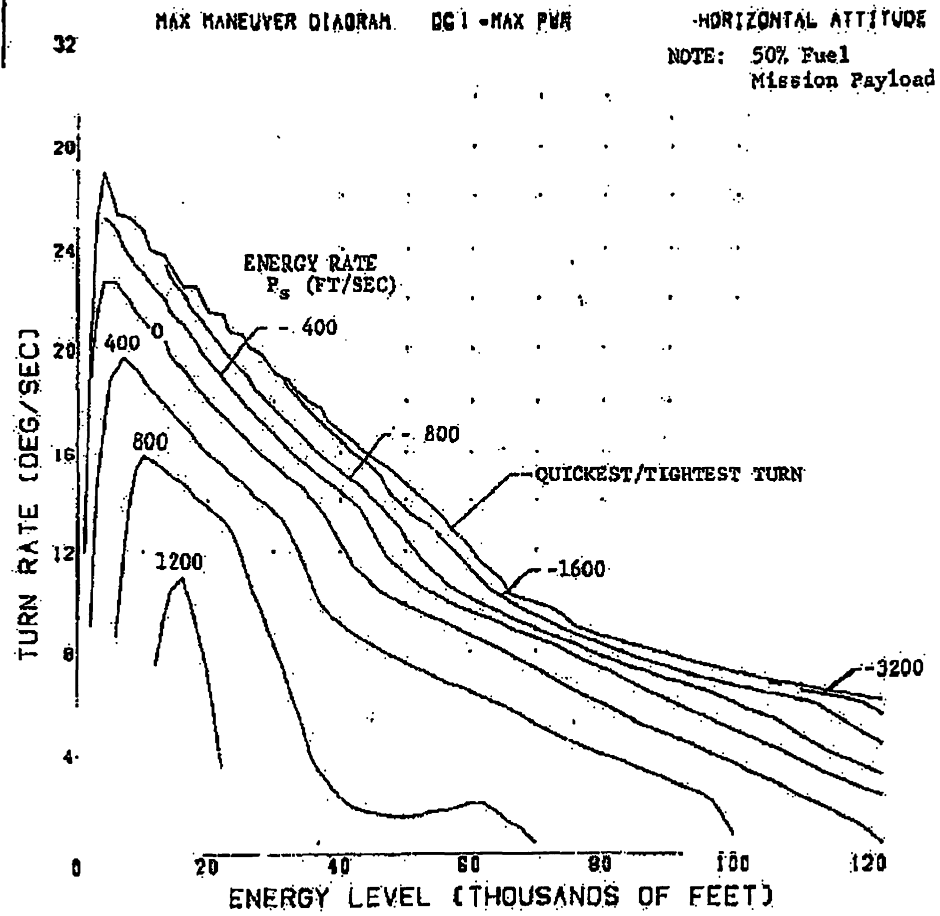
88 ABW FOIA (b)(1) EO 13526 SEC 3.3(b)(4) SEC 1.4(a)(g)

(U) The Maximum Maneuver Diagrams, Figures 2.9-2 and 2.9-3, for Configuration 401B display data of the same type - one displaying turn rate versus energy level (E_s) with energy-rate contours, the other displaying energy rate versus energy level with turn-rate contours. As shown in Figure 2.9-2, the quickest/tightest turn boundary is the top line. The Mach/altitude combination for this boundary at any energy level can be obtained from Figure 2.9-1. Energy rates associated with the Best Energy Climb are located on the longitudinal axis. The energy-rate (P_s) contours represent the maximum energy rate for any turn rate available for any energy-rate/energy-level combination.

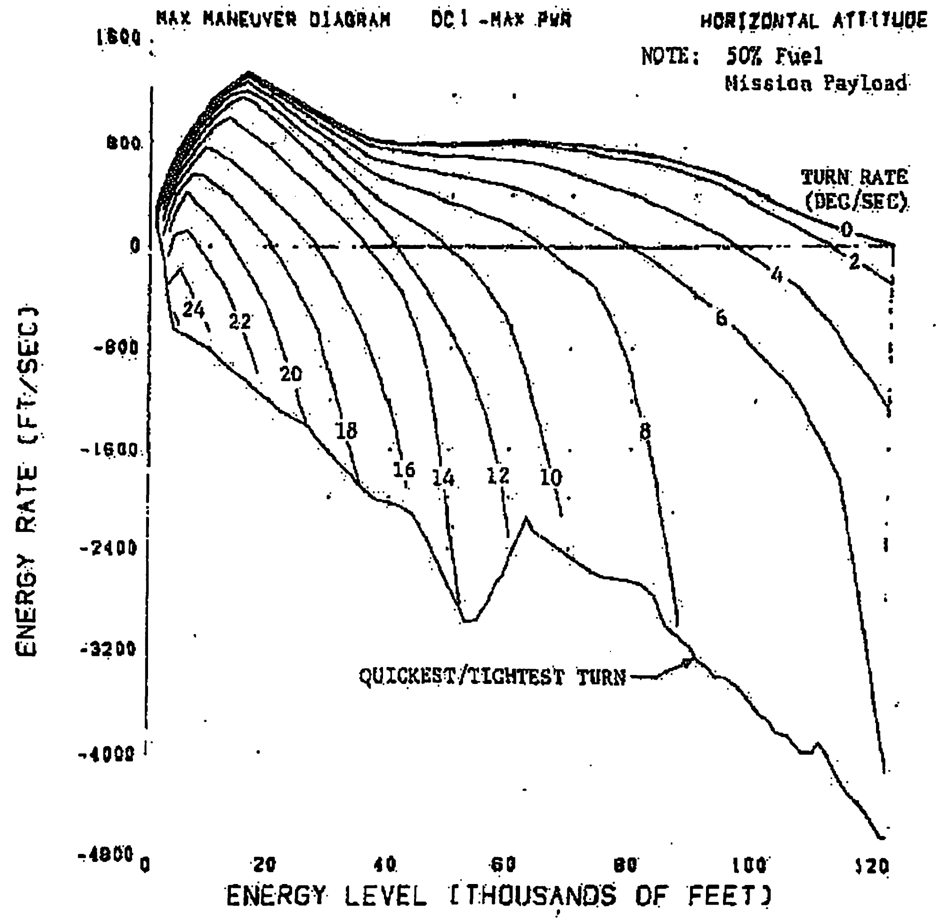
COMBAT ARENA   DC-1 -MAX PWR   HORIZONTAL ATTITUDE



~~(S)~~ Figure 2.9-1 Configuration 401B Combat Arena (U)



~~(S)~~ Figure 2.9-2 Configuration 401B Max Maneuver Diagram - Turn Rate vs Energy Level (U)



~~(S)~~ Figure 2.9-3 Configuration 401B Max Maneuver Diagram
- Energy Rate vs Energy Level (U)

SECTION 3

LARGE SINGLE-ENGINE CONCEPT
(401B/F100-PW-100)

3.1 VEHICLE DESIGN

(U) In this subsection, a description is presented of the large single-engine concept, a brief explanation is given of the overall configuration rationale, and the configuration growth data that were generated to provide the basis for structure, aerodynamic, and performance analyses required to size the vehicle are summarized.

3.1.1 Vehicle Description

~~(S)~~ The large single-engine fighter concept (Concept 1) has been designated Configuration 401B. The general arrangement of the point design aircraft, a vehicle with a 17,115-lb mission weight is presented in Figure 3.1-1. The basic lines, inboard profile, and general arrangement of the 401B-type vehicle at a mission weight of 16,800 lb are shown in Figures 3.1-2, -3, and -4, respectively. This vehicle size was initially developed and used as a data point in generating the growth data which formed the basis for sizing the final point-design aircraft. The data sheets on which the basic geometry characteristics, area distribution, etc., are defined for Configuration 401B (at 16,800 lb) are presented along with the growth data in Subsection 3.1.3.2.

~~(S)~~ Configuration 401B is a small high-performance fighter [with a wing loading of 60 psf and a thrust-to-weight ratio of 1.37 (uninstalled). The basic features of the configuration arrangement are summarized in Figure 3.1-5.]

(U) Four major elements comprise the 401B configuration: (1) the fuselage, (2) the wing, (3) the empennage, and (4) the landing gear. These components are described briefly in the following subsections along with a description of the external stores capability of the airplane.

(U) 3.1.1.1 Fuselage

The fuselage of 401B contains the cockpit, equipment bay, armament, fuel tanks, and propulsion system.

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19.2

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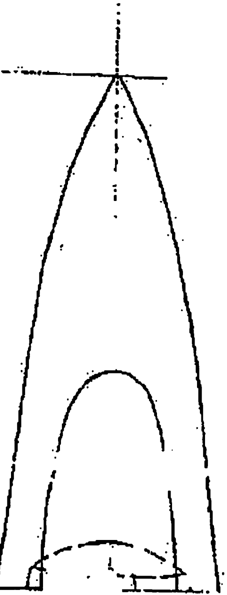

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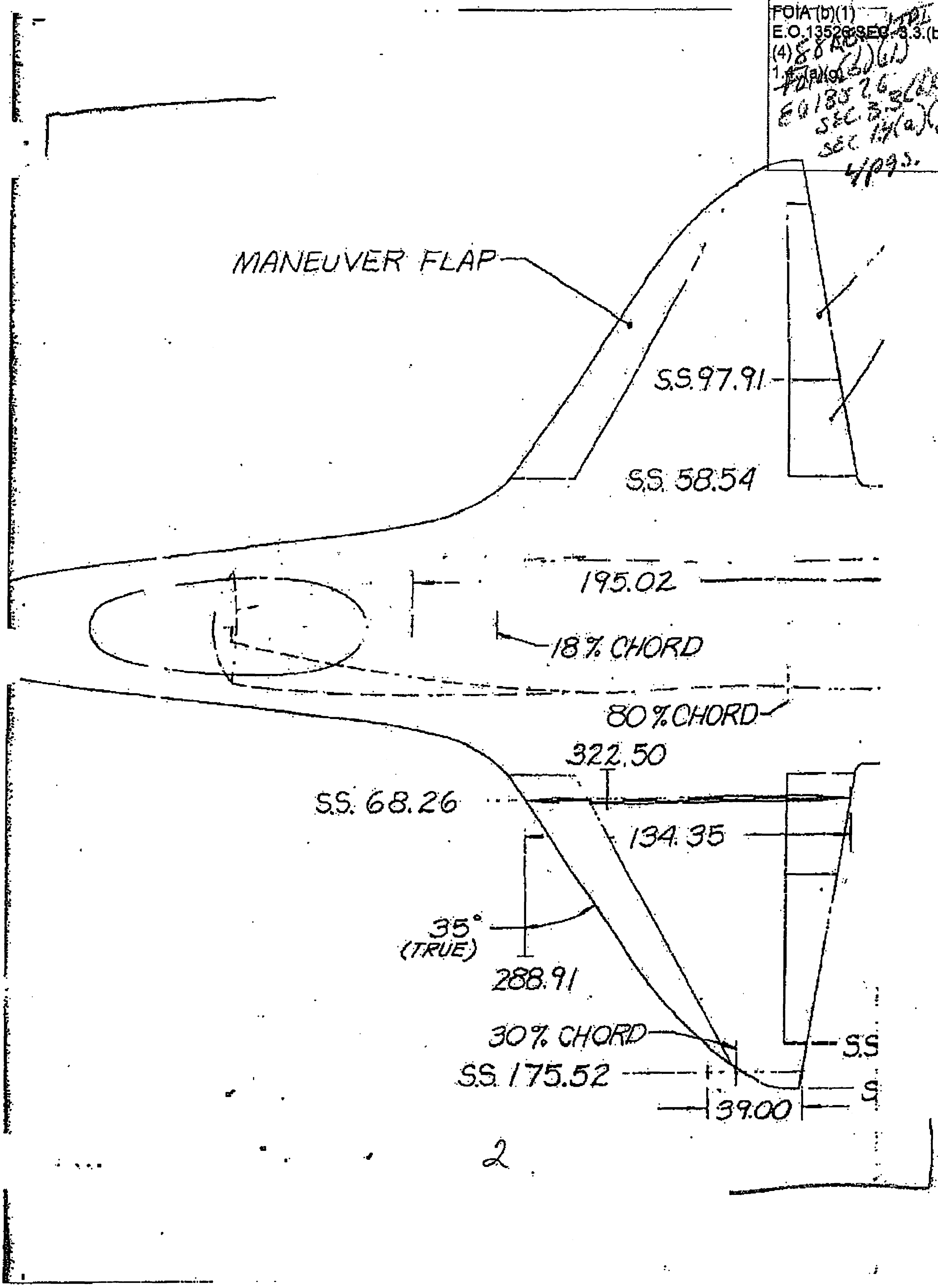
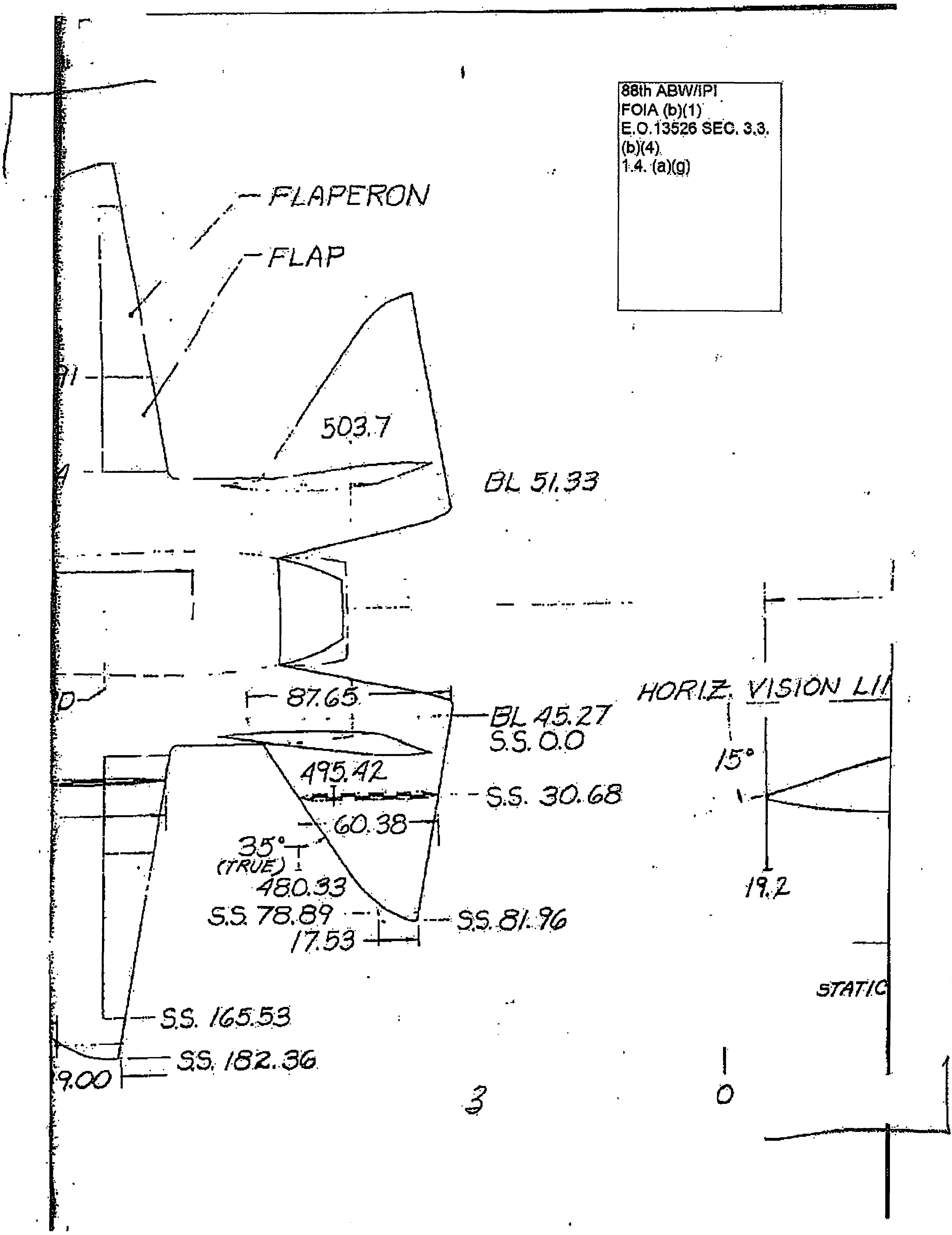
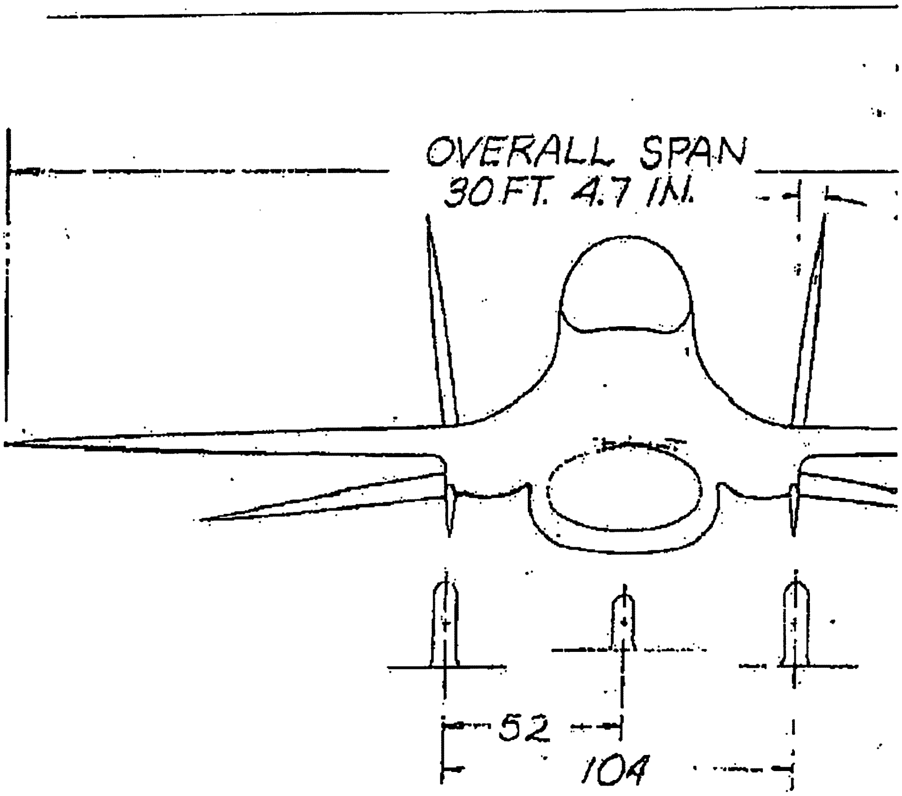
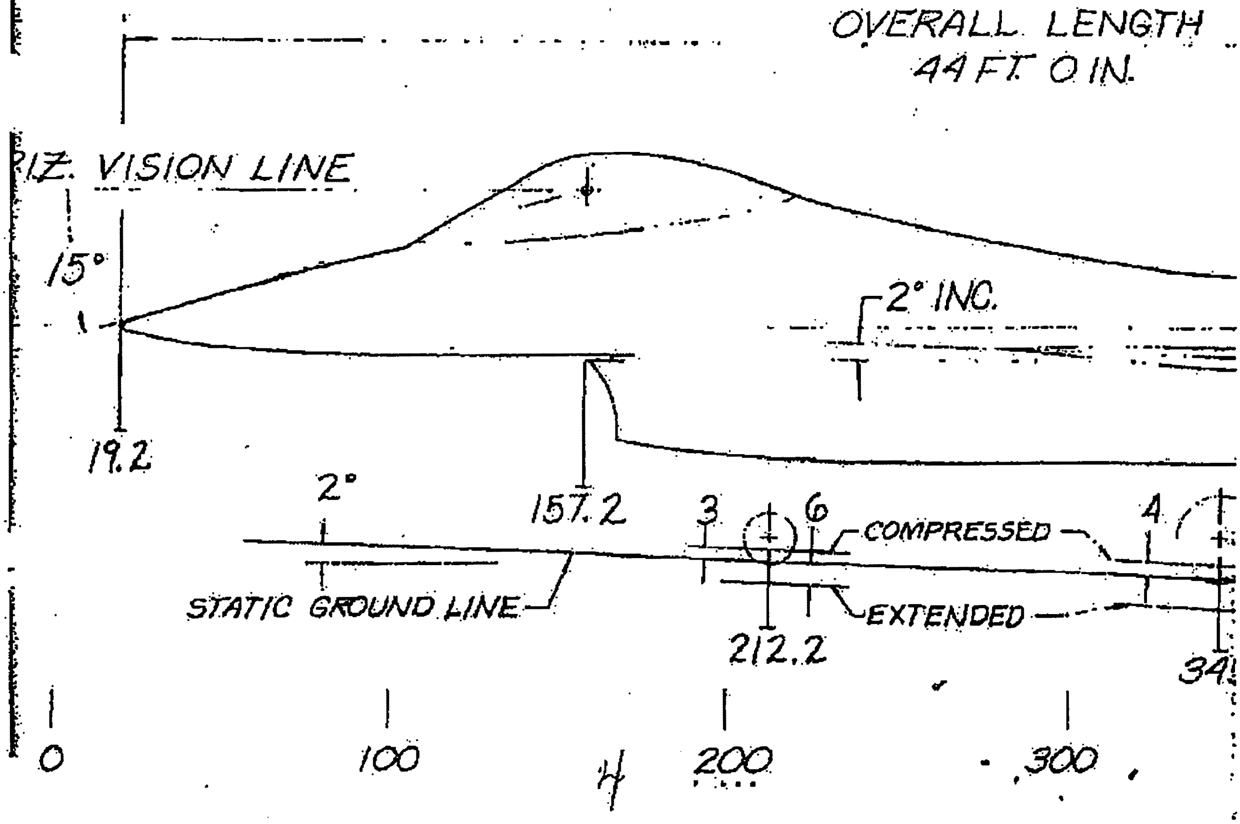

MANEUVER FLAP
S.S. 97.91
S.S. 58.54
195.02
18% CHORD
80% CHORD
322.50
S.S. 68.26
134.35
35°
(TRUE)
288.91
30% CHORD
S.S. 175.52
39.00
S.S

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)





88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

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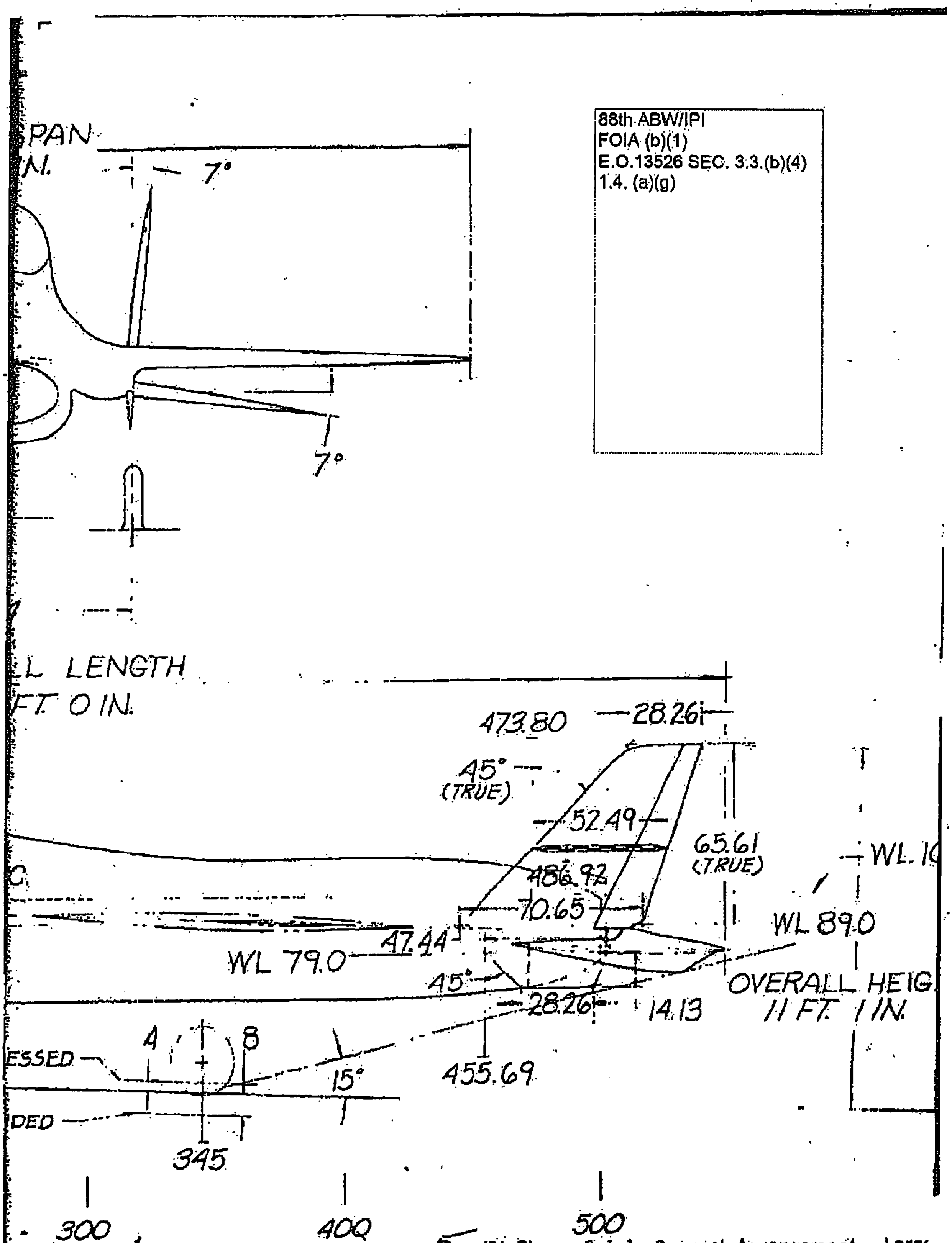
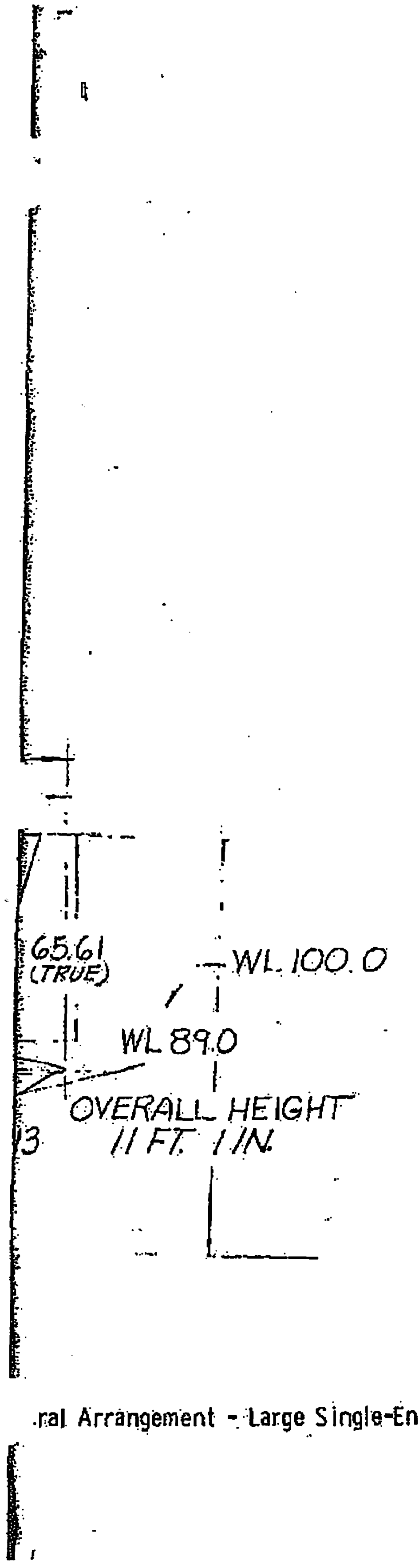


S ~~(S)~~ Figure 3.1-1 General Arrangement - Large



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WING (REFERENCE)	
AREA	[illegible] SQ FT
ASPECT RATIO	[illegible]
TAPER RATIO	[illegible]
SPAN	[illegible] FT
SWEEP-LEADING EDGE	[illegible]
ROOT CHORD	[illegible] IN
TIP CHORD	[illegible] IN
M.A.C.	[illegible] IN
AIRFOIL SECTION	[illegible]
INCIDENCE	[illegible]
DIHEDRAL	[illegible]
[illegible] FLAP	
TYPE	PLAIN
TOTAL AREA	[illegible] SQ FT
SPAN-PER SIDE	11' 6 IN
ROOT CHORD	[illegible] IN
TIP CHORD	11.7 IN
DEFLECTION	25°
HINGE LINE	
ROOT	10%
TIP	30%
FLAPS	
TYPE	PLAIN
TOTAL AREA - INCLUDING FLAPERON	[illegible] SQ FT
ROOT CHORD	28.8 IN
TIP CHORD	9.6 IN
FLAPERON	
TOTAL AREA	16.3 SQ FT
SPAN - PER SIDE	[illegible] IN
ROOT CHORD	21.6 IN
TIP CHORD	9.6 IN
DEFLECTION	-20°, +30°
FLAP DEFLECTION - MAX	30°
FLAP [illegible]	80%
VERTICAL TAIL	
AREA-TOTAL	[illegible] SQ FT
ASPECT RATIO	[illegible]
TAPER RATIO	[illegible]
SPAN	[illegible] IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	[illegible] IN
TIP CHORD	[illegible] IN
AIRFOIL SECTION	[illegible] ROOT, [illegible] TIP BICONVEX
RUDDER	
AREA - TOTAL	[illegible] SQ FT
SPAN	65.01 IN
ROOT CHORD	[illegible] IN
TIP CHORD	[illegible] IN
DEFLECTION	±30°
VENTRAL FIN	
AREA - TOTAL	[illegible] SQ FT
ASPECT RATIO	[illegible]
TAPER RATIO	[illegible]
SPAN	[illegible] IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	[illegible] IN
TIP CHORD	[illegible] IN
AIRFOIL SECTION	6% BICONVEX
HORIZONTAL TAIL [illegible]	
AREA	[illegible] SQ FT
ASPECT RATIO	[illegible]
TAPER RATIO	[illegible]
SPAN - EXPOSED	[illegible] IN
SWEEP - LEADING EDGE	[illegible]
ROOT CHORD	[illegible] IN
TIP CHORD	[illegible] IN
M.A.C.	[illegible] IN
INCIDENCE	[illegible]
AIRFOIL SECTION	[illegible] TIP - BICONVEX
DIHEDRAL	[illegible]
DEFLECTION	[illegible] UP 15°, DWN 10°
POWERPLANT	
P&W [illegible] TURBOFAN ENGINE	
LANDING GEAR	
MAIN GEAR TIRE	[illegible]
NOSE GEAR TIRE	[illegible]
TAIL LENGTHS	
C/4 WING TO C/4 VERTICAL TAIL	13 FT. 5.6 IN
C/4 WING TO C/4 HORIZONTAL TAIL	[illegible] FT [illegible] IN

Aircraft Mission Weight -- 17,115 lb

PRELIMINARY DESIGN DRAWING

GENERAL ARRANGEMENT -
LARGE SINGLE ENGINE CONCEPT
POINT DESIGN, [illegible]

[illegible]	APPROVED	SCALE [illegible]	DATE [illegible]
GENERAL DYNAMICS *Convair Aerospace Division* Fort Worth Operation		[illegible]	
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29/30 ~~SECRET~~

ral Arrangement - Large Single-Engine Concept Point Design Configuration 401B (U)

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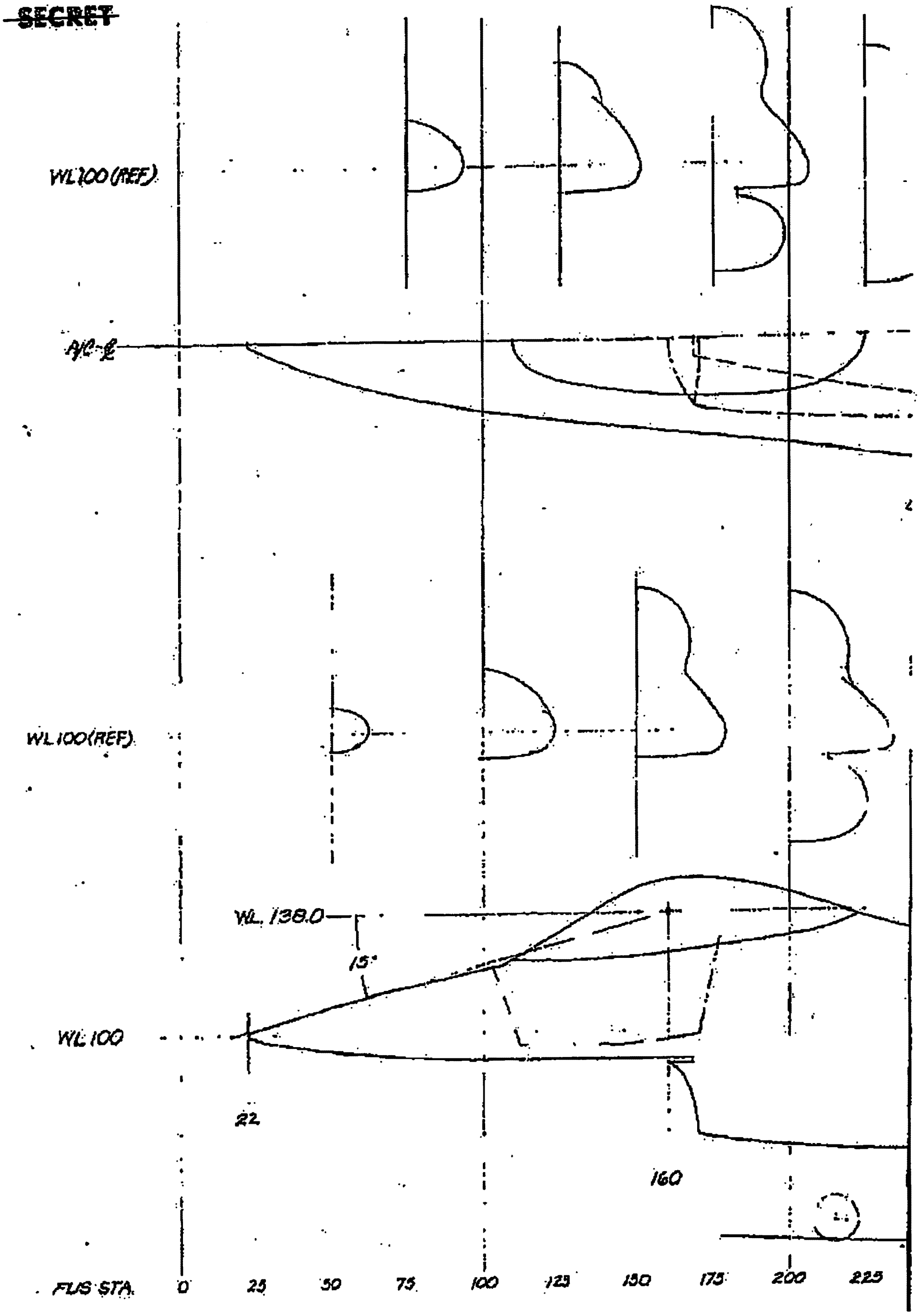

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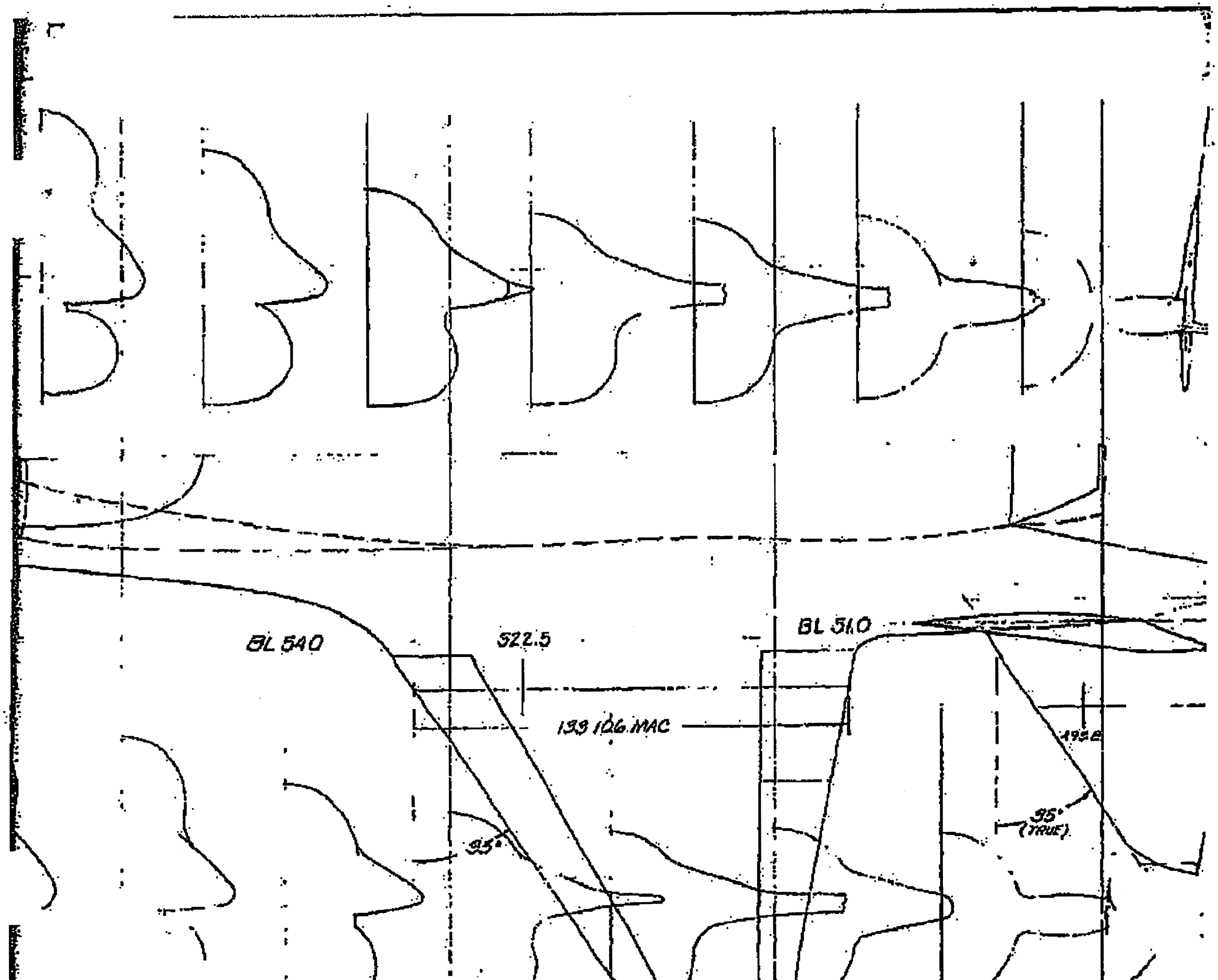
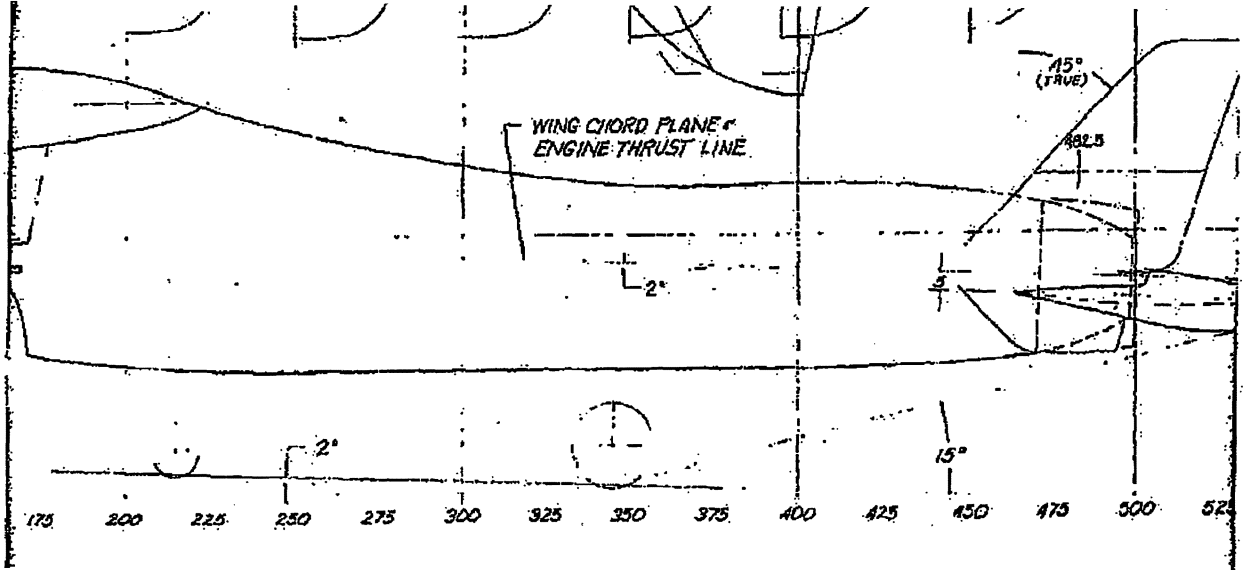


BL 54.0
522.5
139 106.MAC
BL 51.0
195.8
35°
35°
(TRUE)



2 ~~(S)~~ Figure 3.1-2 Lines – Large Sing

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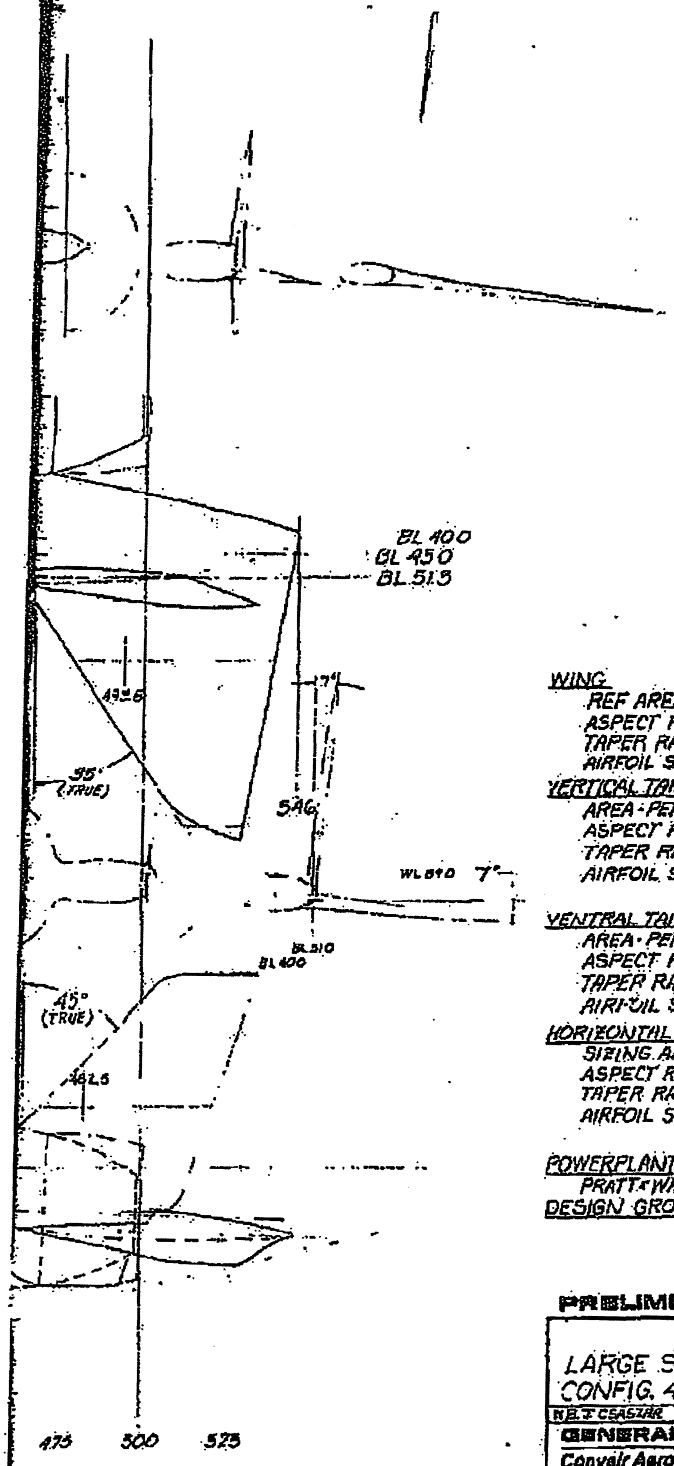

BASIC DATA

WING		
REF AREA		280 SQ.FT
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION		4% BI-CONVEX
VERTICAL TAIL		
AREA - PER TAIL		22.12 SQ.FT
ASPECT RATIO		1.3265
TAPER RATIO		0.4
AIRFOIL SECTION	ROOT	6% BI-CONVEX
	TIP	4% BI-CONVEX
VENTRAL TAIL		
AREA - PER FIN		3.646 SQ.FT
ASPECT RATIO		0.3733
TAPER RATIO		0.5957
AIRFOIL SECTION		6% BI-CONVEX
HORIZONTAL TAIL		
SIZING AREA		56.56 SQ.FT
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION	TIP	4% BI-CONVEX
	BL 51.5	6% BI-CONVEX
POWERPLANT		
PRATT & WHITNEY F-100-PW-100 ENGINE		
DESIGN GROSS WEIGHT		16,800 LBS

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PRELIMINARY DESIGN DRAWING

— LAYOUT —
LARGE SINGLE ENGINE CONCEPT
CONFIG. 401B ; AVFFX PROGRAM

N.B.T. CSASZAR | SCALE 1/20 | DATE 6-16-71

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

FW7104066

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es – Large Single-Engine Concept Configuration 401B Type (U) 31/32

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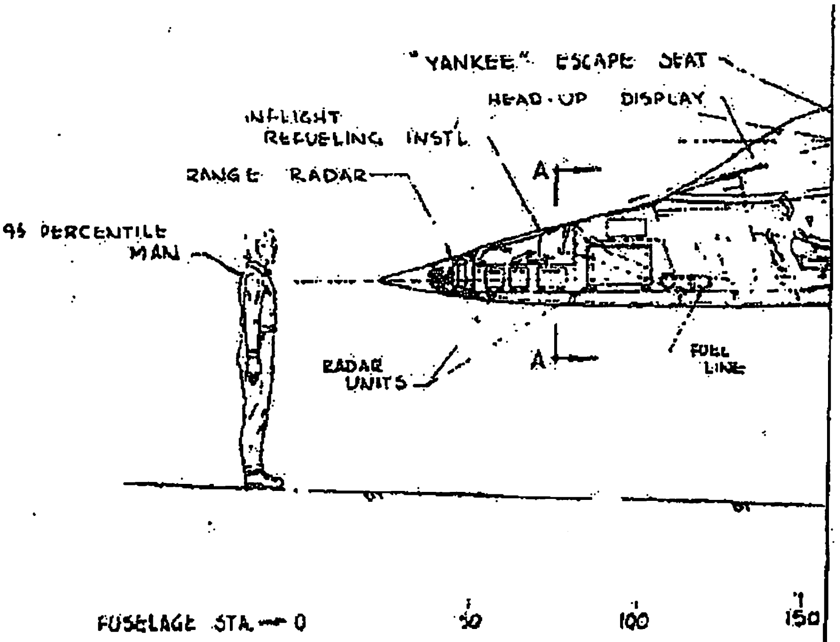
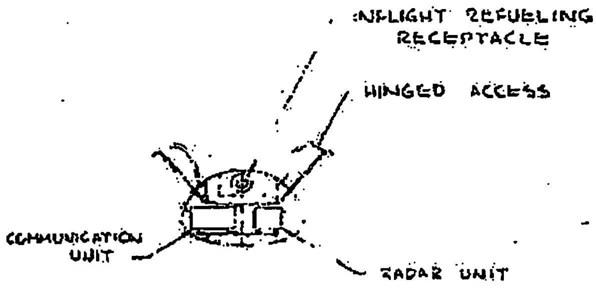
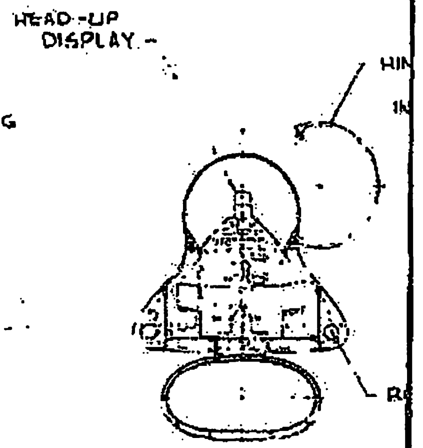




SECTION A A



SECTION B-B

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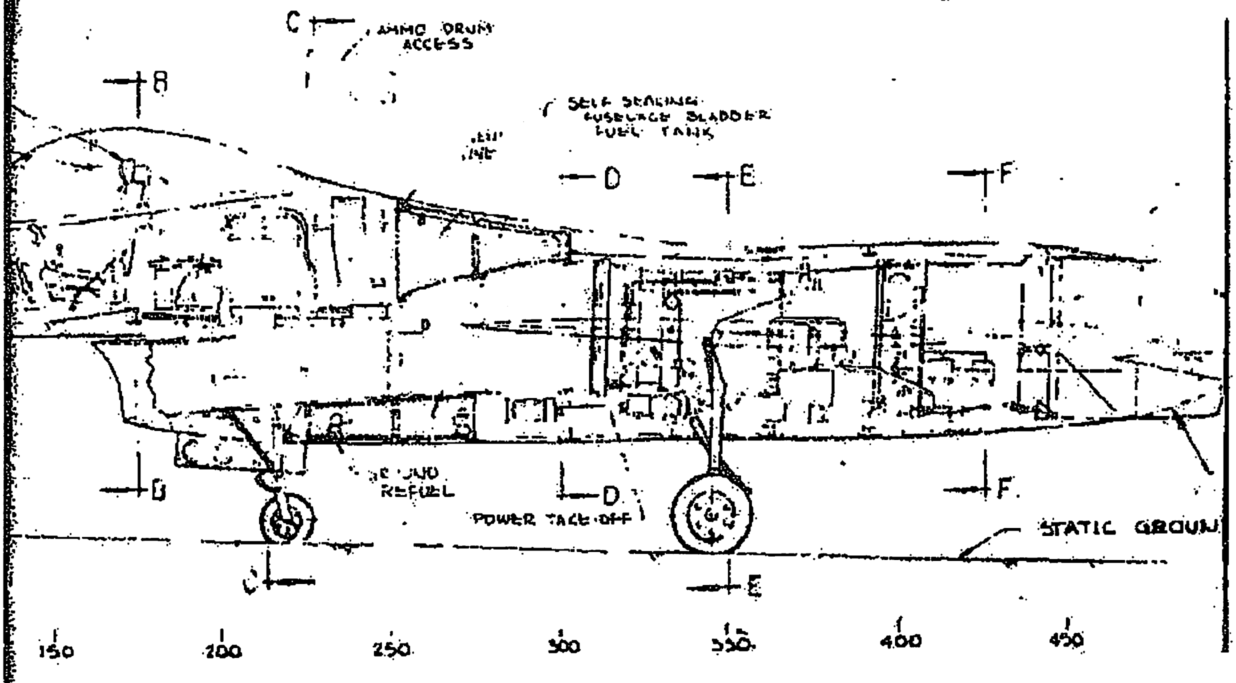
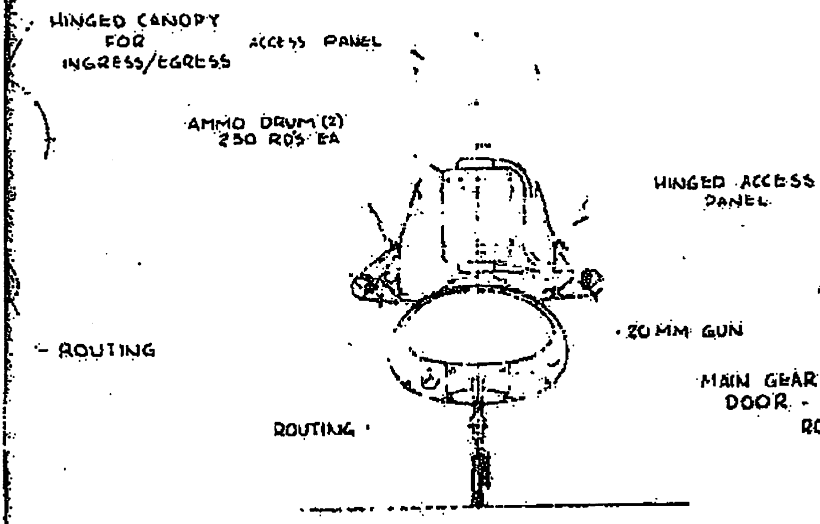
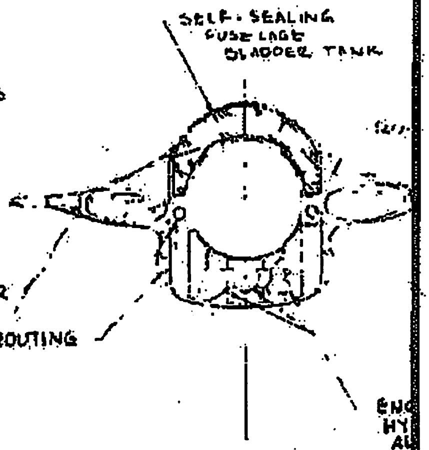
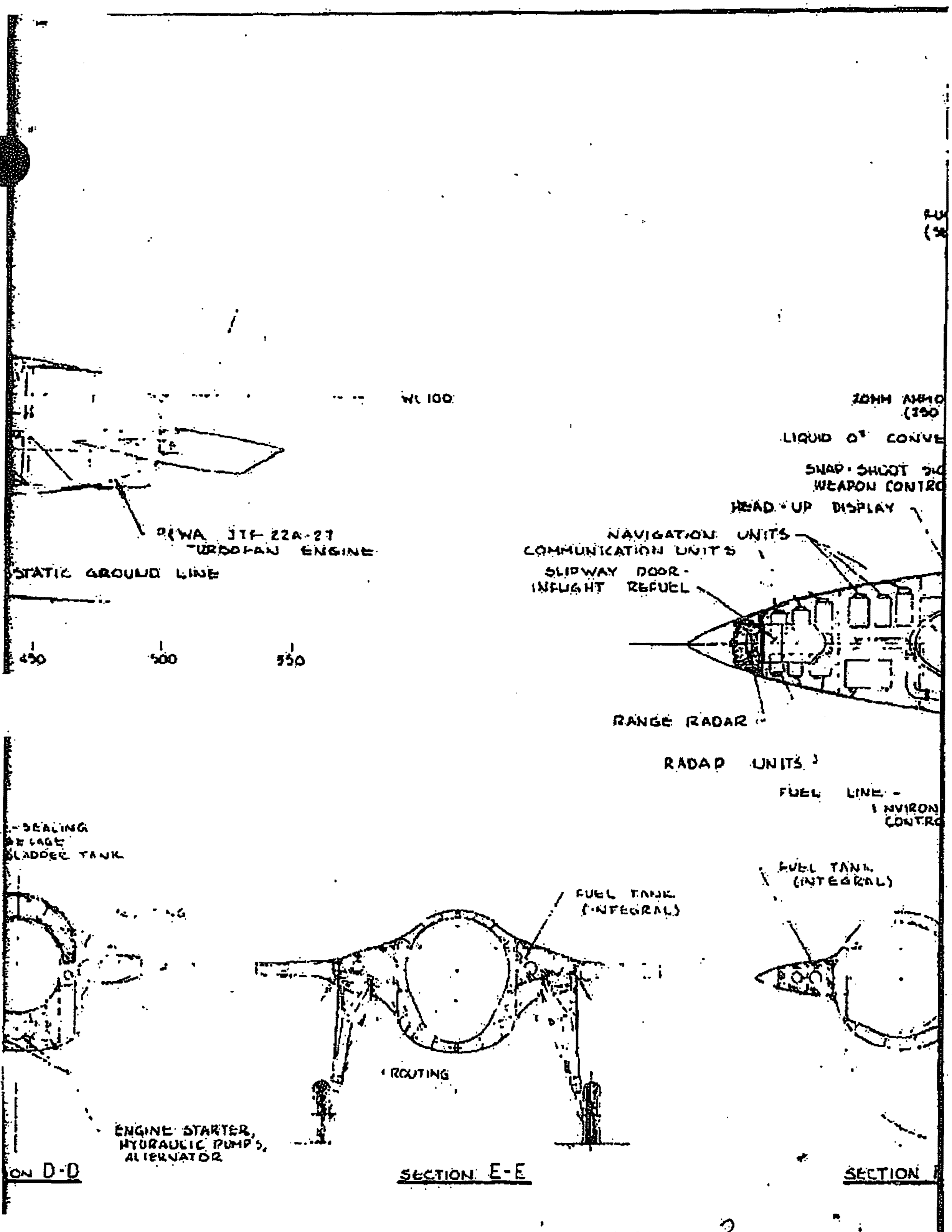


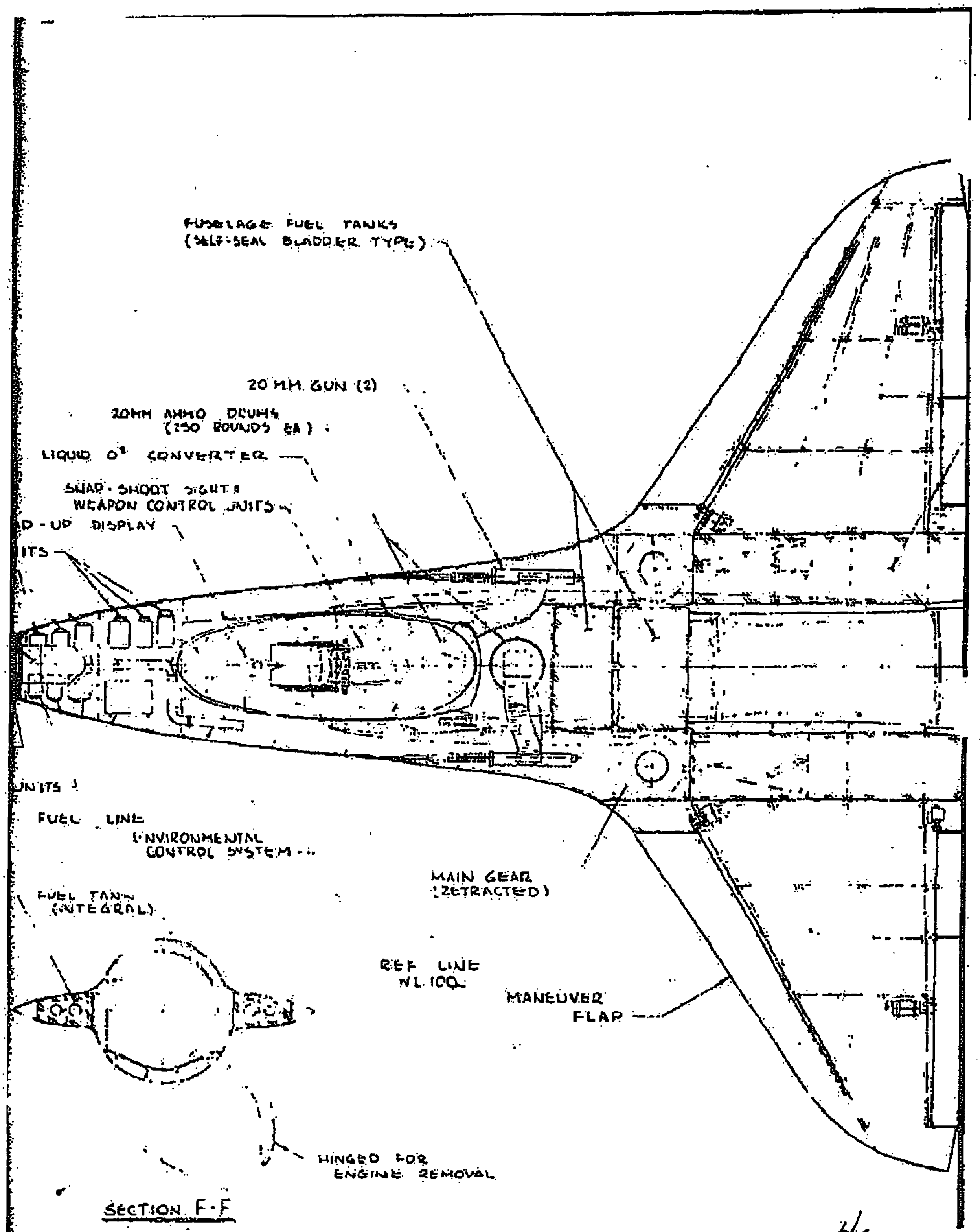


SECTION C-C



SECTION D-D


WL 100
PRWA JTF 22A-27 TURBOFAN ENGINE
STATIC GROUND LINE
450
500
550
20MM AMMO (350
LIQUID O² CONVE
SNAP-SHOOT SIG WEAPON CONTRO
HEAD-UP DISPLAY
NAVIGATION UNITS
COMMUNICATION UNITS
SLIPWAY DOOR-INFLIGHT REFUEL
RANGE RADAR
RADAR UNITS
FUEL LINE
ENVIRON CONTRO
SEALING ELAGE BLADDER TANK
FUEL TANK (INTEGRAL)
FUEL TANK (INTEGRAL)
ROUTING
ENGINE STARTER, HYDRAULIC PUMPS, ALTERNATOR
ON D-D
SECTION E-E
SECTION



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~~(S)~~ Figure 3.1-3 Inboard Pro

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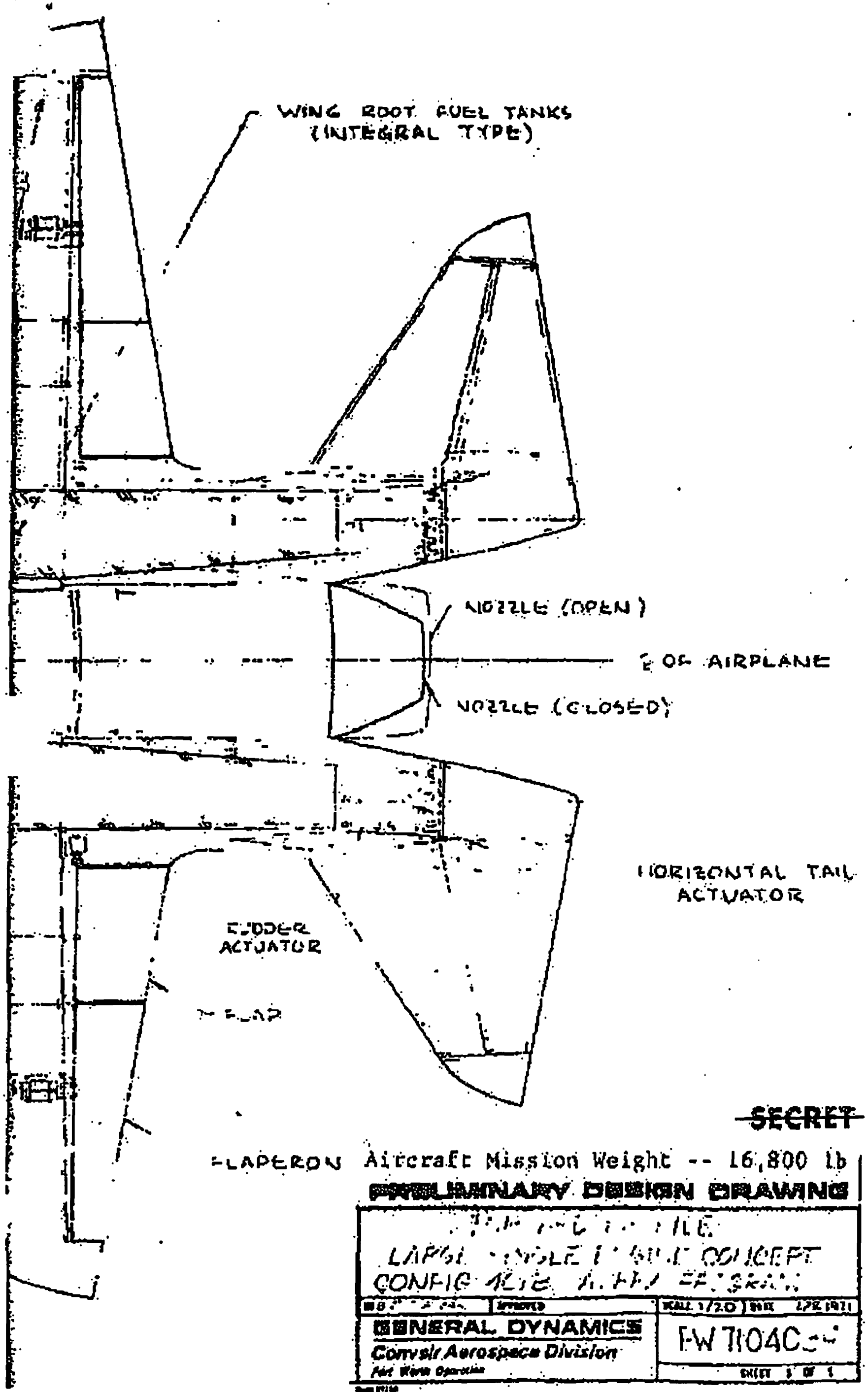

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Aircraft Mission Weight -- 16,800 lb

PRELIMINARY DESIGN DRAWING

LARGE SINGLE ENGINE CONCEPT
CONFIG 401B

SCALE 1/20

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

FW 7104C

SHEET 1 OF 1

5

Profile - Large Single-Engine Concept Configuration 401B Type (U)

WING [illegible]
AREA — 280 SQ FT
ASPECT RATIO — [illegible]
TAPER RATIO — 020
SPAN — [illegible]
SWEEP - LEADING EDGE — 35
ROOT CHORD — [illegible] IN
TIP CHORD — 38.64 IN
MAC — [illegible]
AIRFOIL SECTION — [illegible] BICONVEX
INCIDENCE — [illegible]
DIHEDRAL — 0

[illegible] FLAP
TYPE — [illegible]
TOTAL AREA — [illegible]
SPAN, PER SIDE — [illegible]
ROOT CHORD — [illegible]
TIP CHORD — [illegible]
DEFLECTION — [illegible]
HINGE LINE — [illegible]
ROOT — [illegible]
TIP — [illegible]

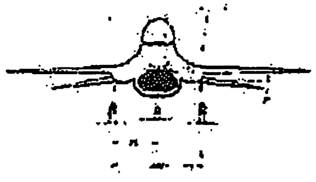
[illegible]
TOTAL AREA INCLUDING [illegible] — [illegible]
[illegible]
[illegible]
[illegible] AREA — [illegible]
SPAN PER SIDE — [illegible]
ROOT [illegible] — [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
ASPECT RATIO — [illegible]
TAPER RATIO — [illegible]
SPAN — [illegible]
SWEEP LEADING EDGE — [illegible]
[illegible]
AIRFOIL SECTION — [illegible] BICONVEX
[illegible]
AREA TOTAL — [illegible]
[illegible]

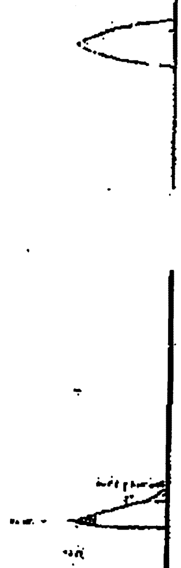
HORIZONTAL TAIL (ALL MOVABLE)
AREA — 56.6
ASPECT RATIO —
TAPER RATIO —
SPAN EXPOSED — 156
SWEEP - LEADING EDGE —
ROOT CHORD —
TIP CHORD —
M A C —
INCIDENCE
AIRFOIL SECTION — [illegible] BICO
DIHEDRAL
DEFLECTION — [illegible]

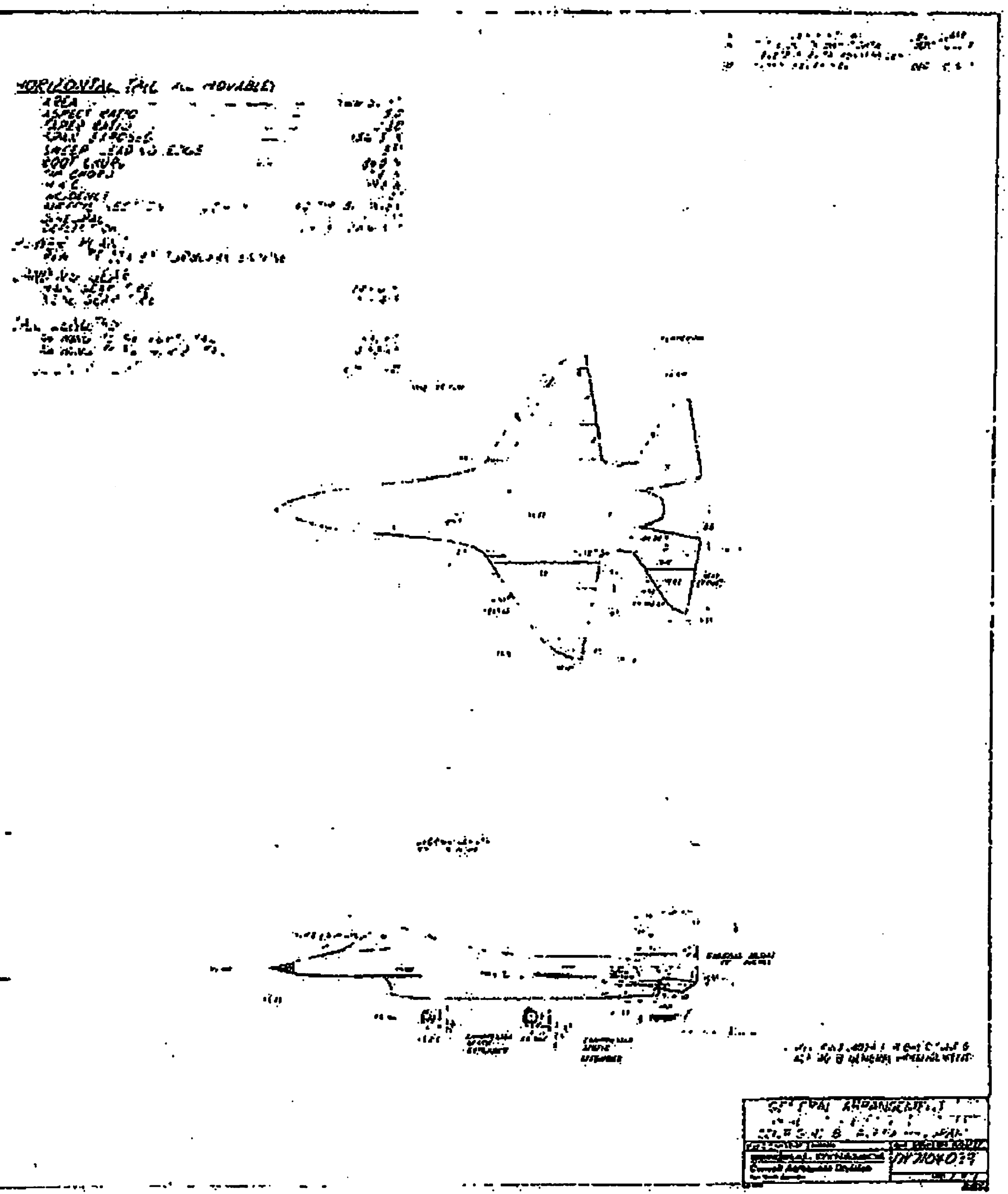
POWER PLANT
[illegible] TURBOFAN ENGINE

LANDING GEAR
MAIN GEAR TIRE — [illegible]
NOSE GEAR TIRE — [illegible]

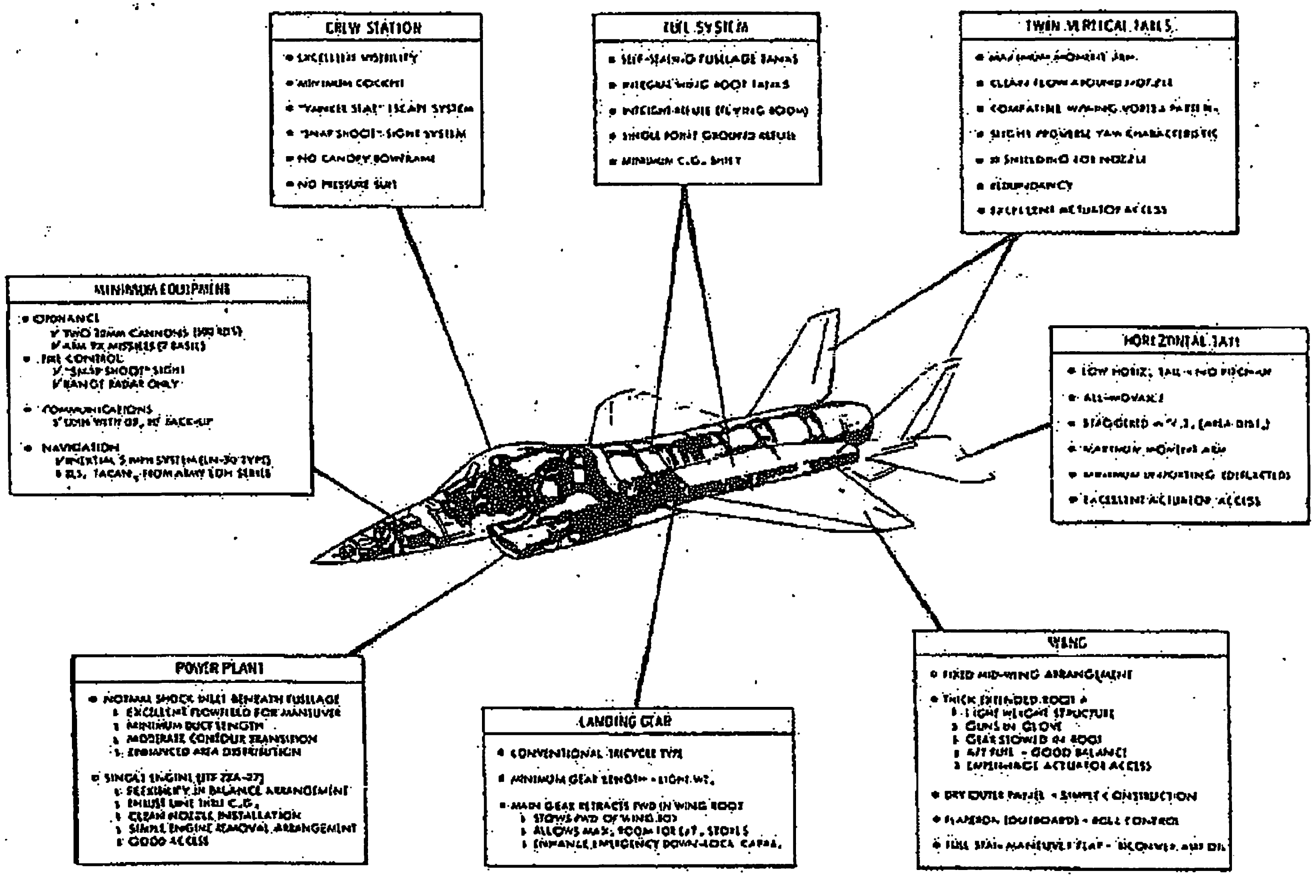
TAIL LENGTHS
[illegible] WING [illegible] VERT TAIL — [illegible]
[illegible] WING [illegible] TAIL — [illegible]
[illegible]







~~(S)~~ Figure 3.1-4 General Arrangement
Large Single-Engine Concept
Configuration 401B Type (U)



~~(S)~~ Figure 3.1-5 Configuration 401B Arrangement Features (U)

(U) The cockpit is arranged to provide excellent visibility, with special consideration given to the avoidance, where practical, of features which tend to restrict vision such as seats, inlet ducts, wing, etc. The following basic vision limits apply on 401B:

1. 15° down vision over the nose (0° azimuth)

2. 40° down vision over the side (90° azimuth)

3. 0° down vision aft (180° azimuth).

(U) The canopy consists of a one-piece transparent bubble with full-vision capability (no bowframe vision obstruction). The canopy is hinged about the right-hand side and is manually operated for normal ingress and egress. Canopy jettison for pilot ejection is accomplished by a thruster, which rotates the canopy and frame about a hinge at the aft end as in most conventional fighter aircraft. A head-up display utilizes a thick transparent shield that provides blast protection for the pilot upon canopy ejection. A "snapshoot" sight is integrated with the head-up display. Configuration 401B employs the "Yankee 705" seat, which provides a simple, lightweight escape system. The cockpit dimensions are held to a minimum to provide a crew station envelope which is adequate without compromising cockpit visibility. The cockpit is pressurized, and no provision is made for a pressure suit.

(U) Equipment compartments are located forward and aft of the crew station. The forward (nose) bay contains the range radar, navigation, and communications equipment in compartments which are accessible through hinged panels located at eye level for ease of maintenance. The upper portion of the nose compartment contains the inflight refueling receptacle which is compatible with the USAF "Flying Boom" tanker refueling system. The aft equipment bay is divided into two sections. The forward section provides space for the environmental control system, the sight and weapon control units, and miscellaneous equipment. The aft section houses the ammunition drums for two 20mm cannons.

~~(S)~~ The basic armament consists of two 20mm cannons and two AIM-9X missiles. A single-barrel 20mm cannon is located on either side of the forward fuselage in the glove section of the body. The guns are situated aft and above the

~~(S)~~ engine inlet to preclude any adverse effect from the muzzle blast. Access to the guns for loading and maintenance is provided through hinged fuselage panels at shoulder level, within easy reach by ground personnel.

(U) Fuel is contained in three tanks: a forward fuselage tank and wing root tanks located on either side of the engine in the thickened root section where the wing blends into the fuselage. The forward tank is located above and below the inlet duct between the aft equipment bay and the engine firewall bulkhead.

(U) The fuselage tank is of the self-sealing bladder type and is so arranged that the engine fuel supply is taken from the lower section. Check valves are provided in the interconnect lines to ensure a full tank for all flight conditions. This portion of the tank also contains the single-point ground refuel receptacle, which is within easy reach of ground personnel.

~~(C)~~ The power plant for Configuration 401B is a single Pratt & Whitney Aircraft JTF22A-27 engine [(USAF Designation F100-PW-100) with a rated thrust of 23,470 pounds on maximum power. Engine accessories are mounted on the engine, and engine-driven aircraft accessories are airframe-mounted in the lower fuselage forward of the firewall bulkhead. A power take-off from the engine drives these accessories and is disconnected for engine removal. The engine is removed by sliding the unit aft along rails. The lower fuselage in the region aft of the rear spar bulkhead is hinged to allow for engine installation and removal. Primary air for the engine is supplied through a duct from an elliptically shaped, fixed, normal-shock inlet which is located beneath the crew station region of the forward fuselage. The inlet is positioned slightly away from the fuselage by a diverter that allows boundary layer air to be plowed off. A portion of this air is taken onboard by an inlet in the diverter leading edge to supply air for the environmental control system. The inlet lip is also shaped in profile in a manner designed to provide proper control of the inlet shock system throughout the operational envelope.]

~~(S)~~ 3.1.1.2 Wing

Configuration 401B is a fixed, mid-wing airplane [with a wing loading of 60 psf, an aspect ratio of 3.00, a taper

~~(S)~~ ratio of 0.20, and a leading-edge sweep of 35.0 degrees. The wing tip is rounded in a manner that maintains constant wing area (280 sq. ft. for the 16,800-lb design) and results in an aspect ratio of 3.2. The wing employs a 4-percent biconvex airfoil with leading- and trailing-edge flaps. The full-span leading-edge flap is utilized both during landing and in maneuvering flight to provide the particular lift-drag characteristics required of these two portions of the operating envelope. For maneuvering flight, the leading-edge flap is a manually operated, three position, flap. A maximum setting of 25 degrees (leading edge down) is provided for the landing configuration. The outboard trailing-edge control surface is a flaperon, which provides for both the roll control and landing flap functions. A simple flap is also provided on the inboard section to provide lift augmentation for landing operations.

(U) Four hardpoints are provided on the wing for external stores. The external stores capability is described in Subsection 3.1.1.5.

(U) As described in the previous subsection, the wing employs a thickened root section that blends into the fuselage centerbody. For the most part this root section contains the aft fuel tanks. These wing-root tanks are of the integral type and are located outboard of the engine compartment so that a double-wall section is provided to separate the fuel and engine compartments.

(U) Wing structural loads are distributed into the fuselage through four major spar bulkheads that are continuous around the fuselage.

(U) 3.1.1.3 Empennage

Configuration 401B utilizes twin vertical tails and ventral fins along with an all-movable horizontal tail arrangement. The horizontal and vertical tails are staggered longitudinally with respect to each other to provide a favorable area distribution effect and to gain maximum permissible tail moment arms.

(U) The vertical tail surface planform has a leading-edge sweep of 45 degrees, an aspect ratio of 1.33, and a taper ratio of 0.40. Each tail has a planform area of 22.12 ft^2 for a total of 44.24 ft^2 per airplane. The rudder comprises the aft 25 percent tail chord on each

(U) surface. The vertical surfaces are canted 7 degrees outboard to provide separation between them and to allow a proper relationship with the vortex which emanates from the wing-fuselage intersection at the wing leading edge. The vertical tails are located at the outer extremity of the aft outer-body extension.

(U) Ventral fins, located immediately beneath the upper vertical tails, also have a leading-edge sweep of 45 degrees. The exposed ventral fin aspect ratio is 0.37 and the taper ratio is 0.60.

(U) The horizontal tail is an all-movable control surface which provides trim and pitch control for the airplane. For tail sizing purposes, the surface is defined with a leading-edge sweep of 35 degrees, an aspect ratio of 3.00, and a taper ratio of 0.20. The portion of the horizontal tail outboard of the vertical tail has a negative dihedral angle of 7 degrees to allow maximum vertical separation distance between the wing and horizontal surface chord planes. This separation is important in the design of an airplane to provide linear pitch characteristics. The aft portion of the fuselage outer-body extension forms the inboard section of the horizontal tail. This feature allows for a maximum effective moment arm and, thus, a minimum surface-area requirement. The forward portion of the horizontal tail pivots about Fuselage Station 502 and fits flush alongside the outer surface of the vertical tail and ventral so that clean lines are maintained as the tail rotates through its deflection envelope, thus insuring good airflow over the surfaces under these conditions.

(U) 3.1.1.4 Landing Gear

Configuration 401B utilizes a conventional tricycle landing gear arrangement. The main gear employs a single-tire configuration which retracts up and forward into the wing root section just ahead of the front spar bulkhead. The wheels rotate approximately 90 degrees during the retraction sequence to fit flush within the wheel well. When the gear is in the retracted position, the struts are housed in the lower root fairing beneath the primary wing structure. The nose gear retracts up and forward into the lower fuselage section just aft of the engine inlet. The strut is compressed and the nose wheel is also rotated 90 degrees upon retraction to allow the nose gear to be stowed in the nose wheel well.

~~(S)~~ 3.1.1.5 External Stores

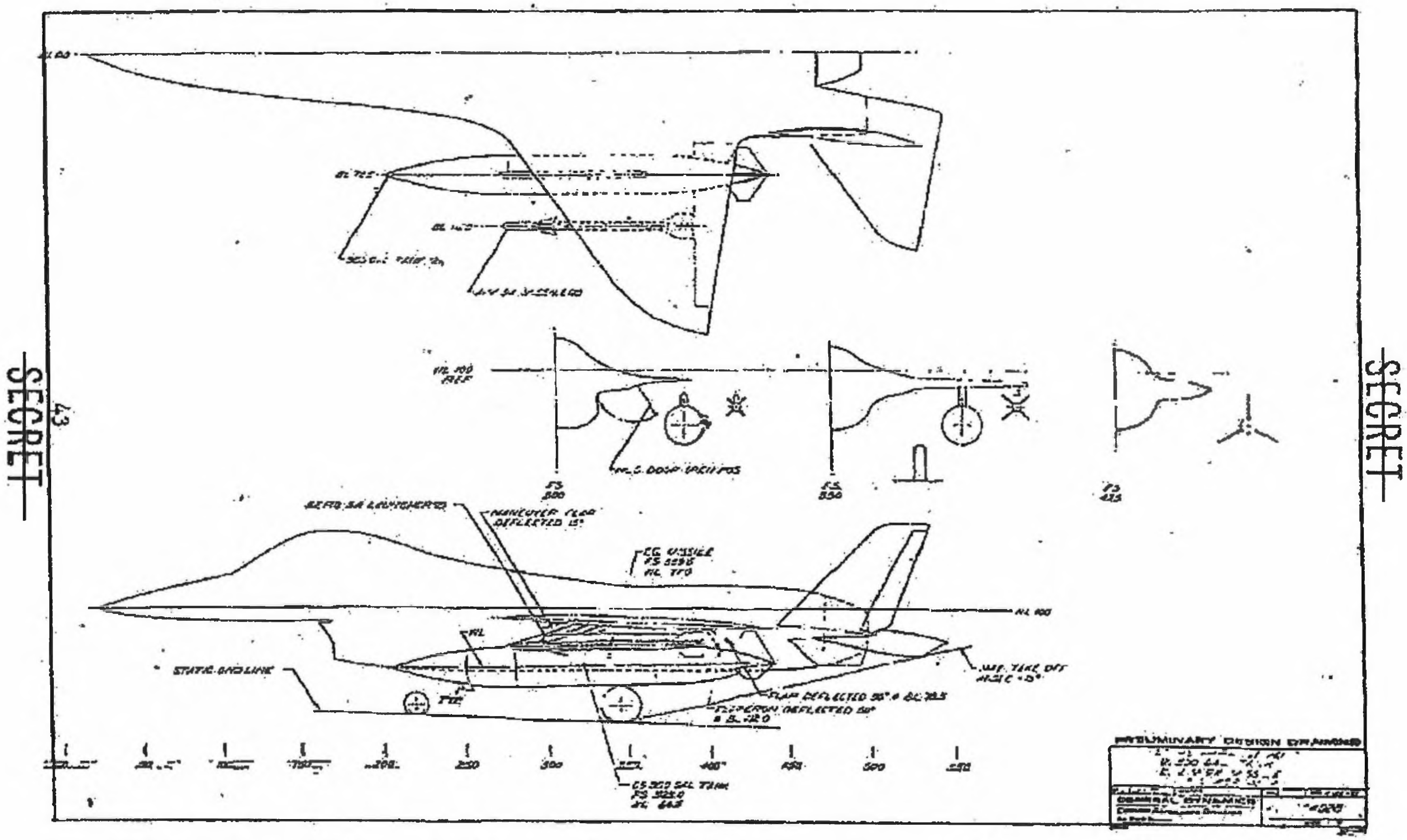
Capability is provided at the wing inboard hardpoints for pylons to accommodate two external fuel tanks up to a maximum of 600 gallons each (ferry mission). Capability at these hardpoints is also provided to carry two nuclear weapons as an alternate. The wing outboard hardpoints are designed to accommodate the basic missile complement of two AIM-9X weapons. Each outboard hardpoint is also capable of accommodating two AIM-9X weapons for a maximum of four missiles per airplane. Selected arrangements of the external stores capabilities are shown in Figures 3.1-6, -7, and -8. An alternate approach for carrying four AIM-9X missiles along with the two basic 300-gallon wing-mounted fuel tanks is shown in Figure 3.1-9.

3.1.2 Overall Design Rationale

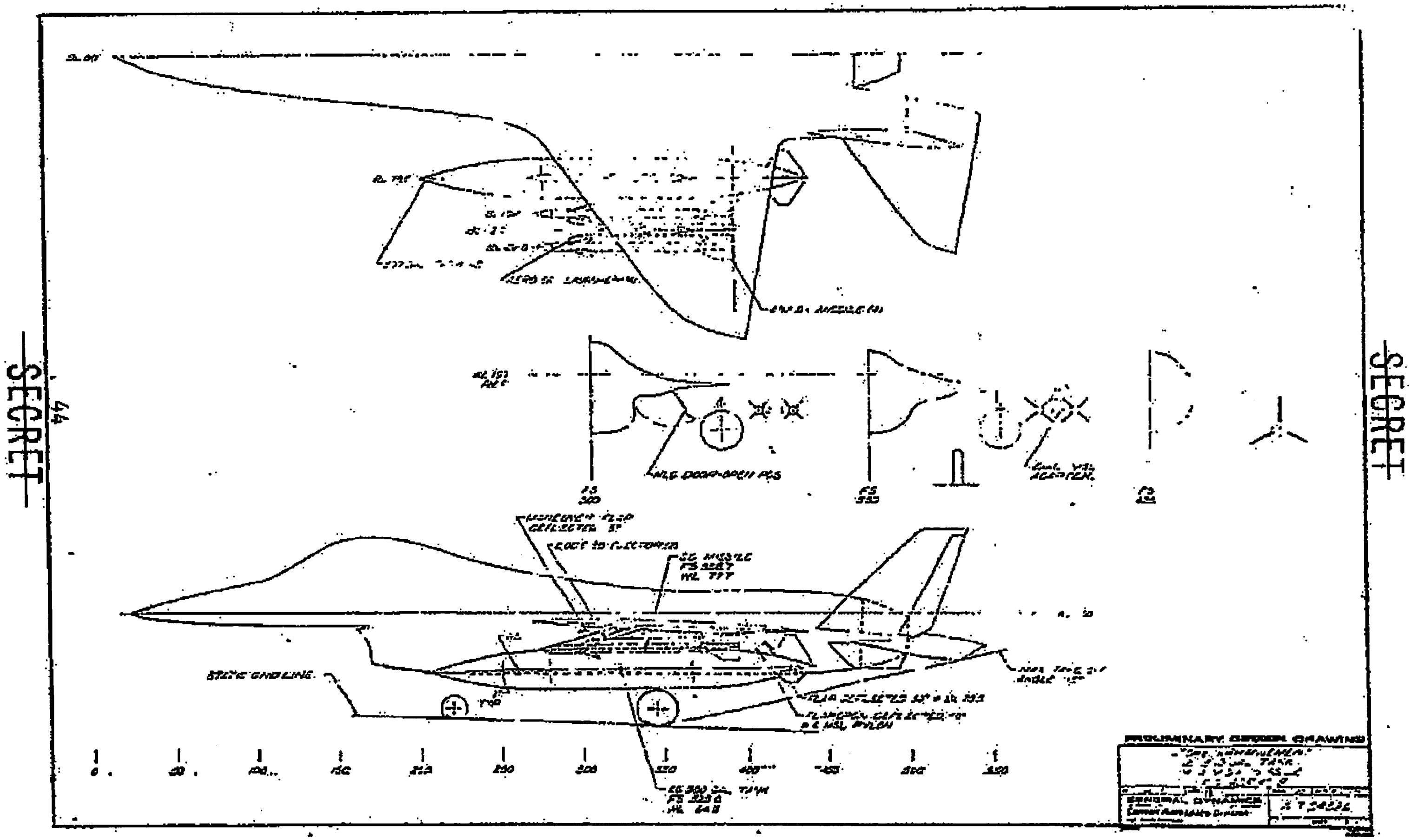
(U) The overall design rationale for configuration 401B is described in the following paragraphs. Details of the rationale for selected specific features such as wing, inlet, etc., are covered in the subsequent sections of this report. The distinguishing features of Configuration 401B, as outlined in Figure 3.1-10, are

1. Forward engine location
2. Mid-wing
3. Outer blended body
4. Twin vertical tails
5. Under-fuselage inlet location
6. Bubble canopy.

(U) Results of design studies conducted prior to the contractural period indicated that for all configurations it was necessary to place the engine as far forward with respect to the wing as possible in order to provide appropriate balance characteristics and still maintain a reasonable tail moment arm. This situation results primarily from the nature of the dry-weight distribution inherent in this particular type of airplane (i.e., the dry weight forward consists primarily of crew station and armament since



~~(S)~~ Figure 3.1-6 External Store Arrangement - Basic Long-Range Air-Superiority Mission (U)



~~(S)~~ Figure 3.1-7 External Store Arrangement - Full Missile Load Capability (U)

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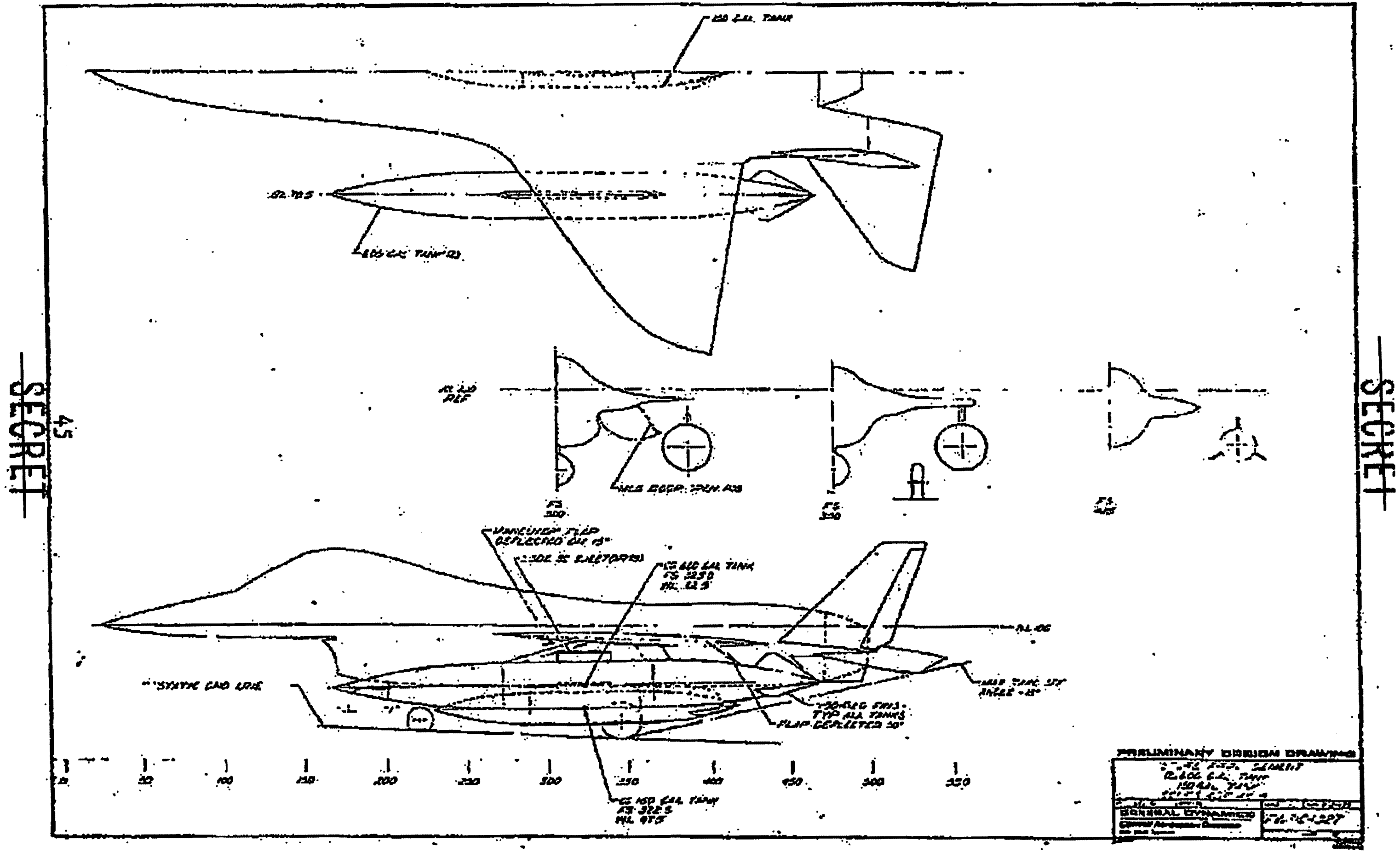

~~(S)~~ Figure 3.1-8 External Store Arrangement - Ferry Mission (U)

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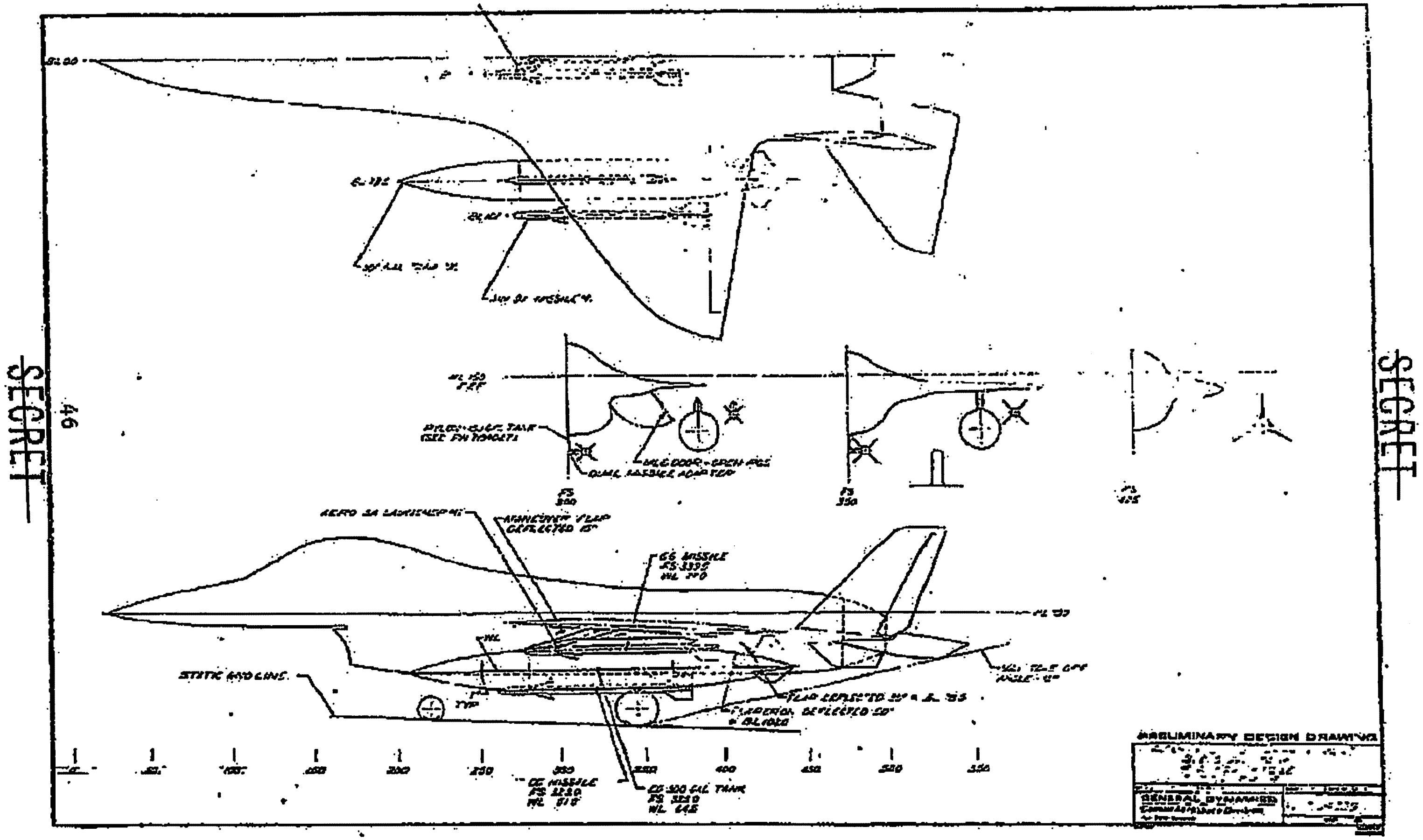

~~(S)~~ Figure 3.1-9 Alternate External Store Arrangement - Full Missile Load Capability (U)

~~SECRET~~

FORWARD ENGINE LOCATION
- Balance
- Tail Arm
- Mass Dyn.

TWIN TAILS
- Handling Qual.
  - ✓ STABILITY AT α
  - ✓ CONTROL AT α
- Clean Nozzle

BUBBLE CANOPY
- Excellent Visibility

MID WING
- Thick Root
- Dynamics
- Wing/Tail Separation

INLET LOCATION
- Flowfield (α & β)
- Duct Length

OUTER BODIES
- Blended Forward Fuselage
- Thickened Wing Root
- Aft Fuselage Extension

~~(S)~~ Figure 3.1-10 Distinguishing Features - Configuration 401B (U)

(U) virtually no avionics systems are required). The combination of this lack of weight in the nose and the resultant engine/wing relationship leads to the conclusion that some kind of overhang beyond the engine nozzle is necessary so as to achieve a satisfactory balance arrangement.

(U) The three basic approaches that can be employed to provide such an overhang arrangement are

1. Single fuselage extension above the nozzle
2. Single fuselage extension below the nozzle
3. Twin fuselage extensions on either side of the nozzle.

(U) Approach 1 lends itself best to single vertical tail designs. The over-the-nozzle body extension also can incorporate cross-section shape variations anywhere from circular or elliptical to a wide-shelf arrangement and, thus, can also be adapted for twin vertical tail arrangements. Approach 2 has the potential for allowing increased horizontal arms; however, the vertical tail arm would still be limited by the nozzle, and it would require a single vertical tail concept. In this case, the horizontal tail ground clearance envelope at takeoff and landing would impose a constraint having considerable effect on gear length (i.e., weight). In addition, the lower-shelf structure would tend to make engine removal provisions complex or vice versa. Approach 3 allows the cleanest aft-end design in terms of providing a favorable flow field around the engine nozzle. This arrangement also has the capability to allow vertical separation between the wing and horizontal tail. Such a relationship has been shown by test and experience to be necessary to achieve the best handling qualities. Of the three approaches considered concerning fuselage overhang extension, the third approach offers the best arrangement.

(U) The selection of such an overhang concept with the horizontal tails mounted on side fuselage extensions requires that these extension elements be faired forward, making a mid-wing concept most logical. To make a mid-wing concept feasible (since loads must be carried around the engine and duct through bulkheads), there must be significant root thickening to allow a favorable structural load distribution from the wing to the fuselage. A thickened wing root thus affords a natural situation for fairing

(U) the contour aft into the outer body to which the horizontal tail is attached. Likewise, the thickened root, if incorporated, must be faired forward, either in the form of a thick glove or a wide, blended fuselage.

(U) The incorporation of the outer-body concept with its attendant wing root thickening, forward blended fuselage (or glove), and aft fuselage extensions thus provides many advantages from the standpoint of equipment arrangement. For example, the mid-wing concept allows a reasonably short landing gear that can be retracted into the thickened wing root region just forward of the front spar bulkhead. The retraction envelope traced by this arrangement allows the lower fuselage and a considerable portion of the wing to be free for the accommodation of external stores. The forward blended body (or glove) contributes a cross-sectional area fill at a region which enhances the transonic aerodynamic characteristics of the configuration. It also provides an ideal location for the two 20mm guns. The gun muzzles are thus positioned aft and above the inlet to preclude inlet ingestion problems. Accessibility to the gun compartments is at shoulder level, which affords an excellent arrangement for loading and maintanance operations. The aft portion of the outer body provides space for aft-located fuel to balance that of the forward fuselage tanks. This distribution arrangement is necessary to minimize c.g. shift during fuel burn; thus, proper c.g. control can be maintained with a minimum of trim. At the same time, this arrangement eliminates the need for the incorporation of self-sealing provisions in this portion of the fuel tankage. The aft portion of the outer body provides an ideal space for tail actuators (rudder and stabilizer) in that it affords sufficient volume and excellent accessibility.

(U) A configuration with after-body extensions on either side of the fuselage also lends itself quite readily to the twin-vertical tail concept. The adaptation of this tail arrangement geometry on Configuration 401B provides several primary advantages. First, it allows a reasonable tail moment arm and acts in concert with the after bodies to allow a clean flow field around the engine nozzle. The outboard placement enhances tail affectiveness at high angles of attack since the tails are essentially not blanked out by the fuselage forebody as a centerline tail would be. The outboard location also provides a relationship with the aileron which enhances neutral aileron yaw

(U) characteristic for the airplane, a highly desirable feature for an aircraft requiring good handling qualities. The outward cant of the vertical tails on 401B provides maximum separation between the two surfaces and positions them properly in relation to the wing/fuselage vortex flow. Redundance and inherent I.R. shielding capability are also features which accrue from the twin vertical tail and matching ventrals.

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(4)
1.4 (a)(g)

~~(S)~~ The inlet location, below the forward fuselage, was selected to provide the most favorable flow field for the engine air supply. This placement provides the best inlet performance at high angles of attack and yaw, which is of paramount importance for a highly maneuverable fighter. A fixed-geometry inlet is employed to give the best performance in the combat arena (Mach 0.6 to 1.6) for the utmost in simplicity, reliability, and light weight. The aft location minimizes duct length (i.e., weight) and allows a fuselage forebody shape that enhances the directional stability of the configuration.

(U) A one-piece transparent bubble canopy with full-vision capability (no bow-frame vision obstruction) is utilized on Configuration 401B. This feature allows excellent pilot vision, which is so absolutely necessary for a highly maneuverable air-superiority fighter.

3.1.3 Configuration Growth Data

(U) Configuration 401B was developed and sized originally on the basis of preliminary growth studies conducted some time prior to the initiation of the contractual effort. A number of minor modifications to various elements of the configuration were made during the time between the development of the growth study data and the final completion of the configuration. In order to ensure that the selected single-engine concept sizing was still valid, a new growth curve was generated around 401B.

(U) The approach utilized to develop the configuration size variations is outlined below. Also, the basic parametric configuration design data generated to support the structure, aerodynamic, and performance analyses are summarized.

~~(S)~~ 3.1.3.1 Aircraft Sizing Approach

Mission weight of the 401B configuration was established at 16,800 pounds during the beginning of the contractual effort. The verification study was conducted by examining a gross-weight range extending 1200 pounds on either side of the baseline 16,800-pound value. Configuration data were developed by varying the airplane's basic component geometry as outlined in Figures 3.1-11 and 3.1-12.

~~(S)~~ Wing loading was held constant at 60 psf, and a family of configurations was developed in which the wing and tail sizing criteria shown in Figure 3.1-11 were utilized. Basic planform geometry for all surfaces was held constant, as shown, and surfaces were scaled according to the ground rules noted. In addition to these basic ground rules and constants, information on basic wing and tail dimensional constants and key ratios are also shown in the diagram of Figure 3.1-11. All dimensional relationships used in the development of the data are referenced to the quarter-chord point of the wing mean-aerodynamic-chord.

88th ABW/JPI
FOIA (b)(1)
EO 13526 SEC
3.3(b)(4)
1.4(a)(g)

(U) The scaling process utilized for the fuselage involved basically a variation in length since the engine size was fixed and 401B constituted a minimum attainable fuselage cross section. In Figure 3.1-12, the basic elements of the fuselage are outlined and the key constants and variables are shown. Crew station and equipment compartments remained fixed in size, as did the engine, accessories, and landing gear. Inlet location was held at a constant distance from the nose to retain the same geometric relationship between the nose, canopy, inlet, and nose gear. The basic fuselage variation then consisted of a length change in the center fuselage, which adjusted fuel tank volume and air inlet duct length. As shown in Figure 3.1-12, the variations were referenced to the quarter-chord position of the wing mean-aerodynamic-chord. The nose was lengthened and the engine was moved aft to provide appropriate balance characteristics, with the total linear increase sized to be proportional to the square root of the gross-weight ratio. In addition, the portion of the wing root that blends into the fuselage was increased in width in order to maintain a constant percent of wing span for this boundary. This relationship provided a change in wing-root fuel-tank volume, which balances that added in the fuselage fuel-tank length increase and, thereby, maintains the appropriate full-up balance characteristics.

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(6)
1.4(a)(g)

SEC 3.3(b)(4)
SEC 1.4(a)(g)
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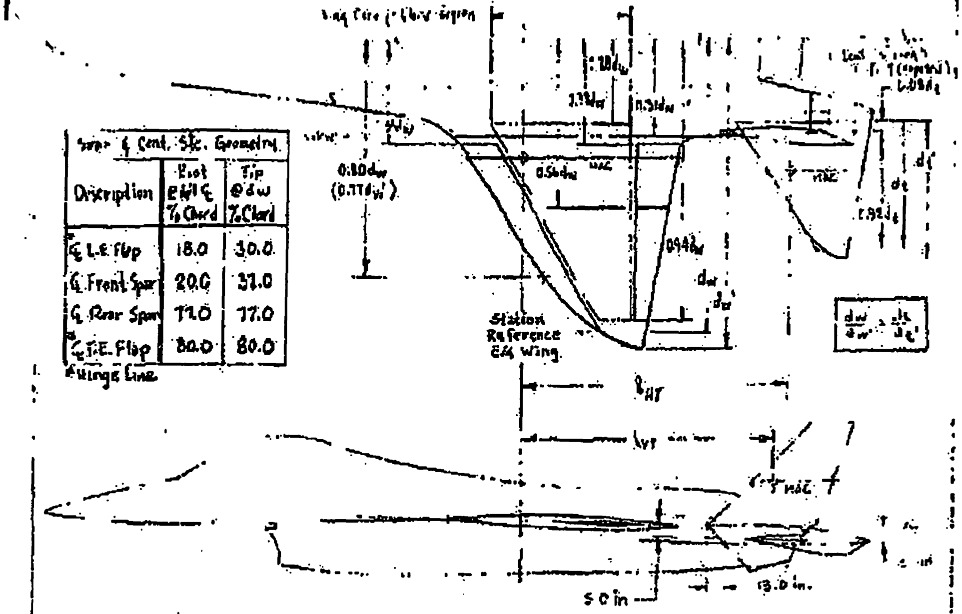


Spar & Cont. Sfc. Geometry		
Description	Root @ W/I ℄ % Chord	Tip @ d_w % Chord
℄ L.E. Flap	18.0	30.0
℄ Front Spar	20.0	31.0
℄ Rear Spar	71.0	77.0
℄ T.E. Flap	80.0	80.0

Hinge Line

SCALING GUIDING RULES

- Planform area of wing and horizontal tail scaled as a function of takeoff Gross Weight. $[S_2 = (G.W._2/G.W._1)(S_1)]$
- Glove planform area is proportional to matching wing area.
- Vertical tail moment arm (ℓ_{VT}) scaled as function of T.O. G.W. ($\ell_{VT_2} = \ell_{VT_1}\sqrt{GW_2/GW_1}$)
- Exposed ventral fin area proportional to vertical tail area. ($S_{VF}/S_{VT} = 0.115$)

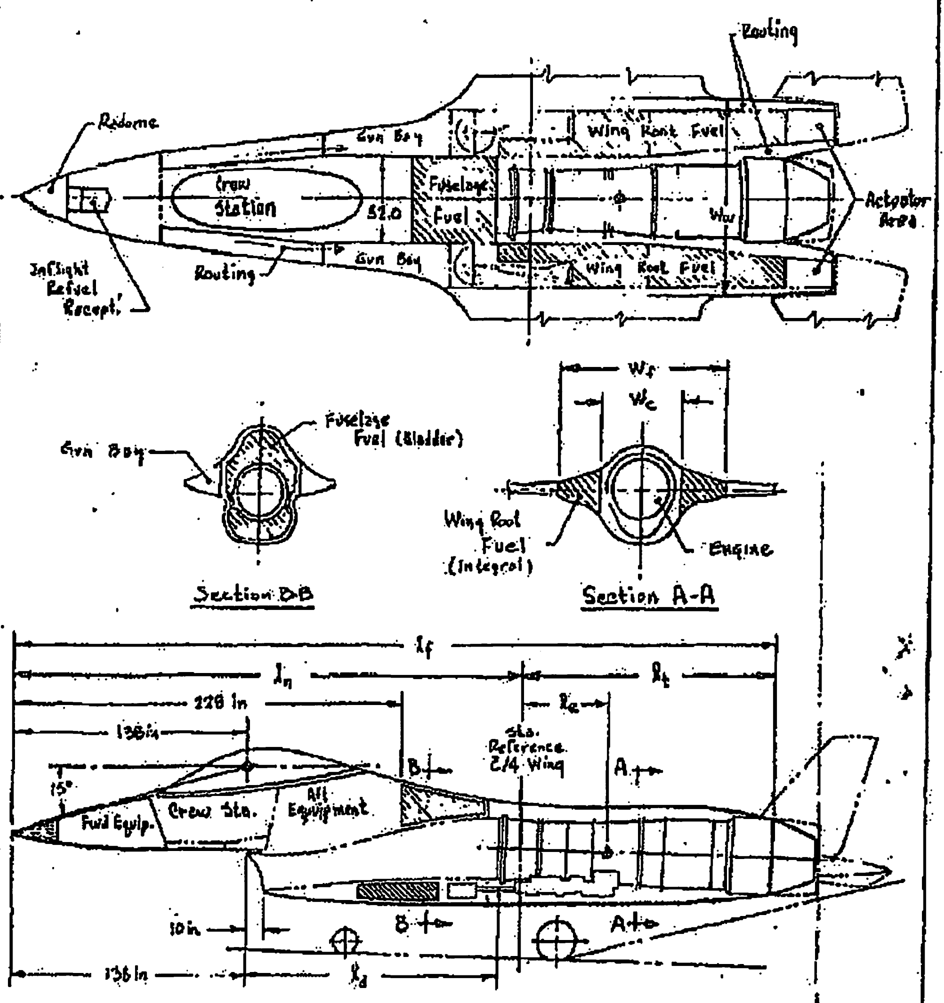
BASIC CONSTANTS

Description	Wing	Horiz. Tail	Vert. Tail	Ventral Fin
Wing Loading, lbs/ft²	60.00	—	—	—
Aspect Ratio	3.00	3.00	1.33	0.37
Taper Ratio	0.20	0.20	0.40	0.60
Tail Vol. Coefficient	—	0.26	* 0.037	—
L.E. Sweep Angle, deg.	35.0	35.0	45.0	45.0
Airfoil @ root	4% Biconvex	6% Bicon. (exp. root)	6% Biconvex	6% Biconvex
Airfoil @ tip	4% Biconvex	4% Biconvex	4% Biconvex	6% Biconvex

* Tail volume coefficient tabulated is value per side (Coeff. = 0.074 per airplane)

~~(S)~~ Figure 3.1-11 Parametric Configuration Scaling - Wing and Tail Criteria (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



BASIC SCALING GROUND RULES

- Fuselage centerbody length is scaled as G.W. function. ($l_{f_2} = l_{f_1}\sqrt{GW_2/GW_1}$).
- Fuselage outerbody length is a function of Horiz. Tail Location.
- W_f is constant percentage of Reference Wing span (W_f = 28% Span)
- W_w is constant percentage of Reference Wing span (W_w = 31% Span)
- W_c is constant dimension (function of engine size)

~~(S)~~ Figure 3.1-12 Parametric Configuration Scaling - Fuselage Criteria (U)

(U) 3.1.3.2 Growth Data

The configuration design data that were generated in the growth study to support the structure, aerodynamic, and performance analyses are summarized in Figures 3.1-13 through 3.1-24. The variation of airplane wetted area with airplane size (mission weight) and a definition of the major airplane components contributing to the wetted-area total are shown in Figure 3.1-13. The breakout of wetted area versus mission weight for the various major components is shown in Figure 3.1-14. The manner in which selected key characteristic fuselage dimensions vary with airplane size in the growth airplane family are plotted in Figure 3.1-15. Similar variations of selected key characteristic surface dimensions for the growth family are plotted in Figure 3.1-16. In Figures 3.1-17 through 3.1-22, general airplane geometric data are summarized for the data points at the three gross weights used to establish the growth family. A normal area distribution curve and fuel distribution plot are presented for the basic 401B configuration (16,800-lb mission weight) in Figures 3.1-23 and 3.1-24, respectively.

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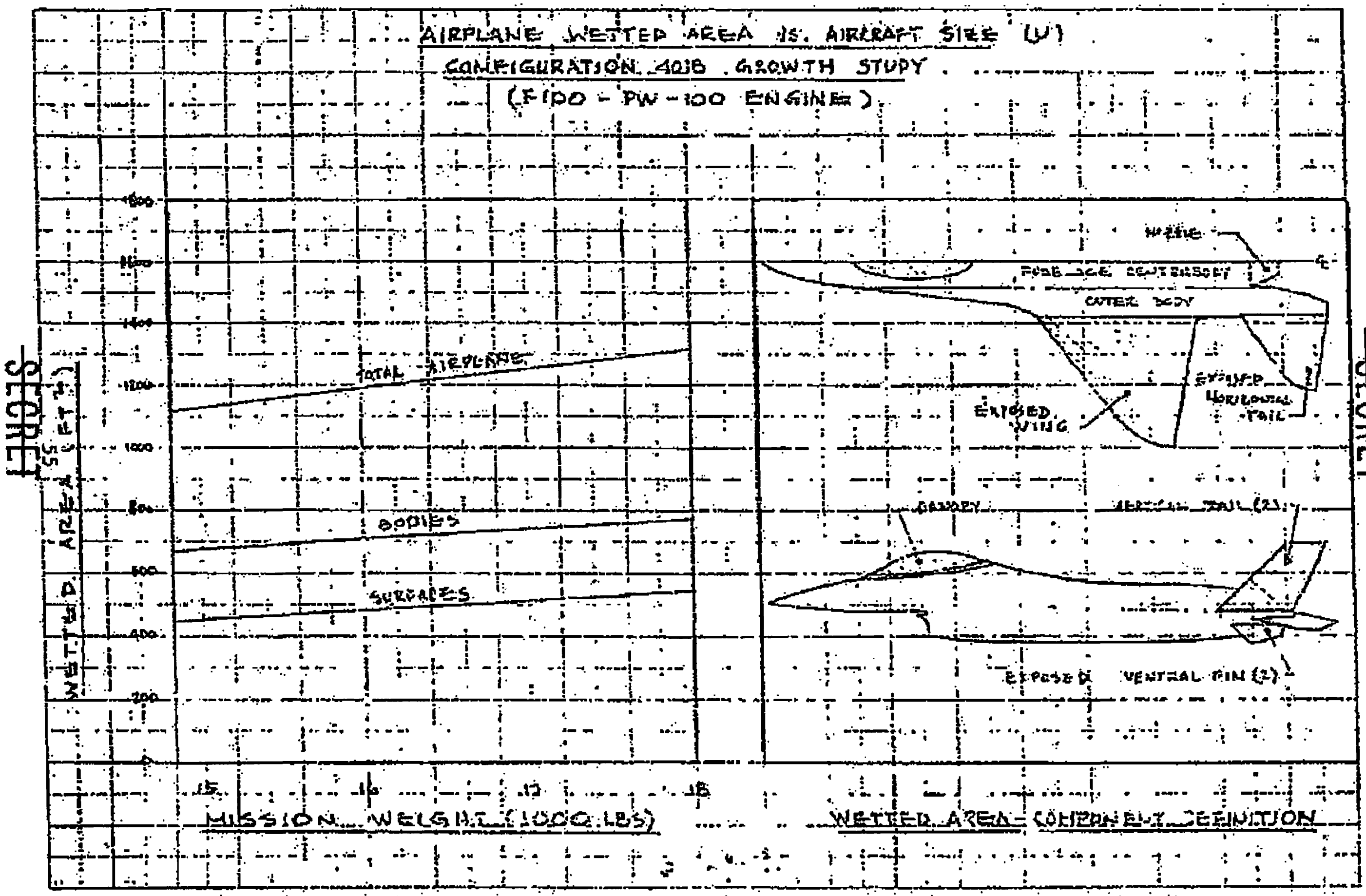
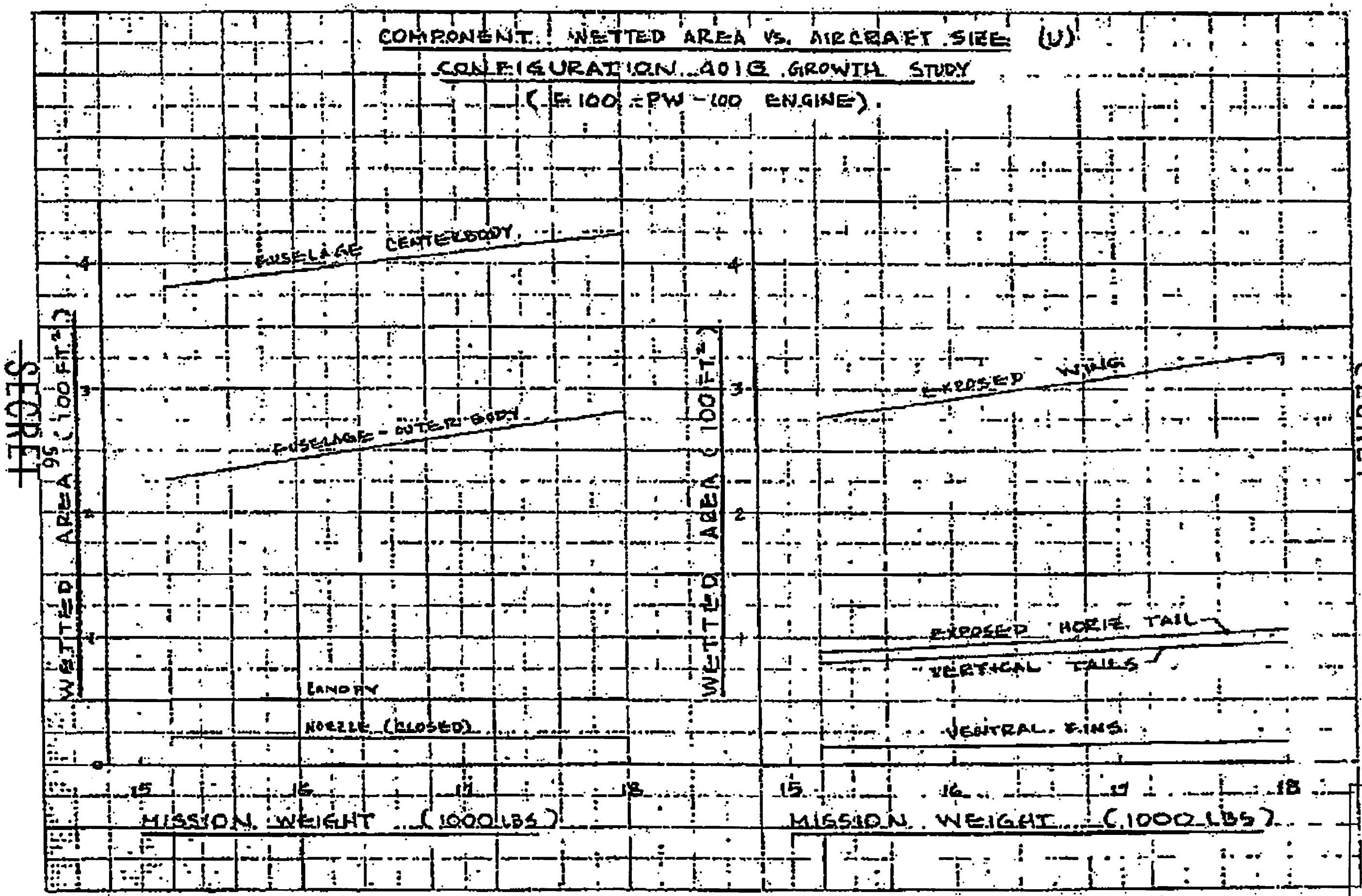


SECRET

~~(S)~~ Figure 3.1-13 Total Aircraft Wetted Area vs. Aircraft Mission Weight (U)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3
(b)(4)
1.4(a)(b)

SECRET

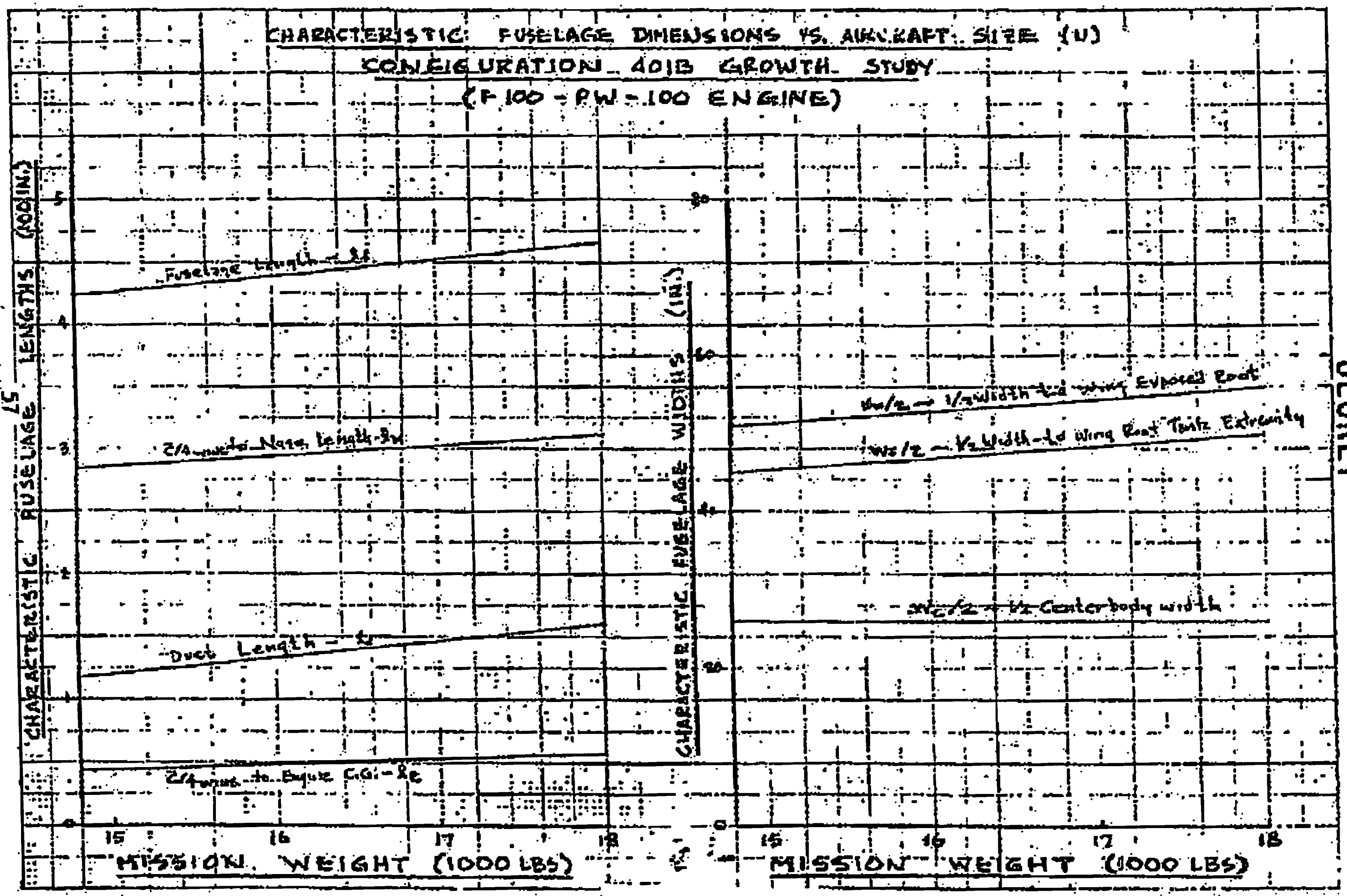


~~(S)~~ Figure 3.1-14 Aircraft Component Wetted Areas vs. Aircraft Mission Weight (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

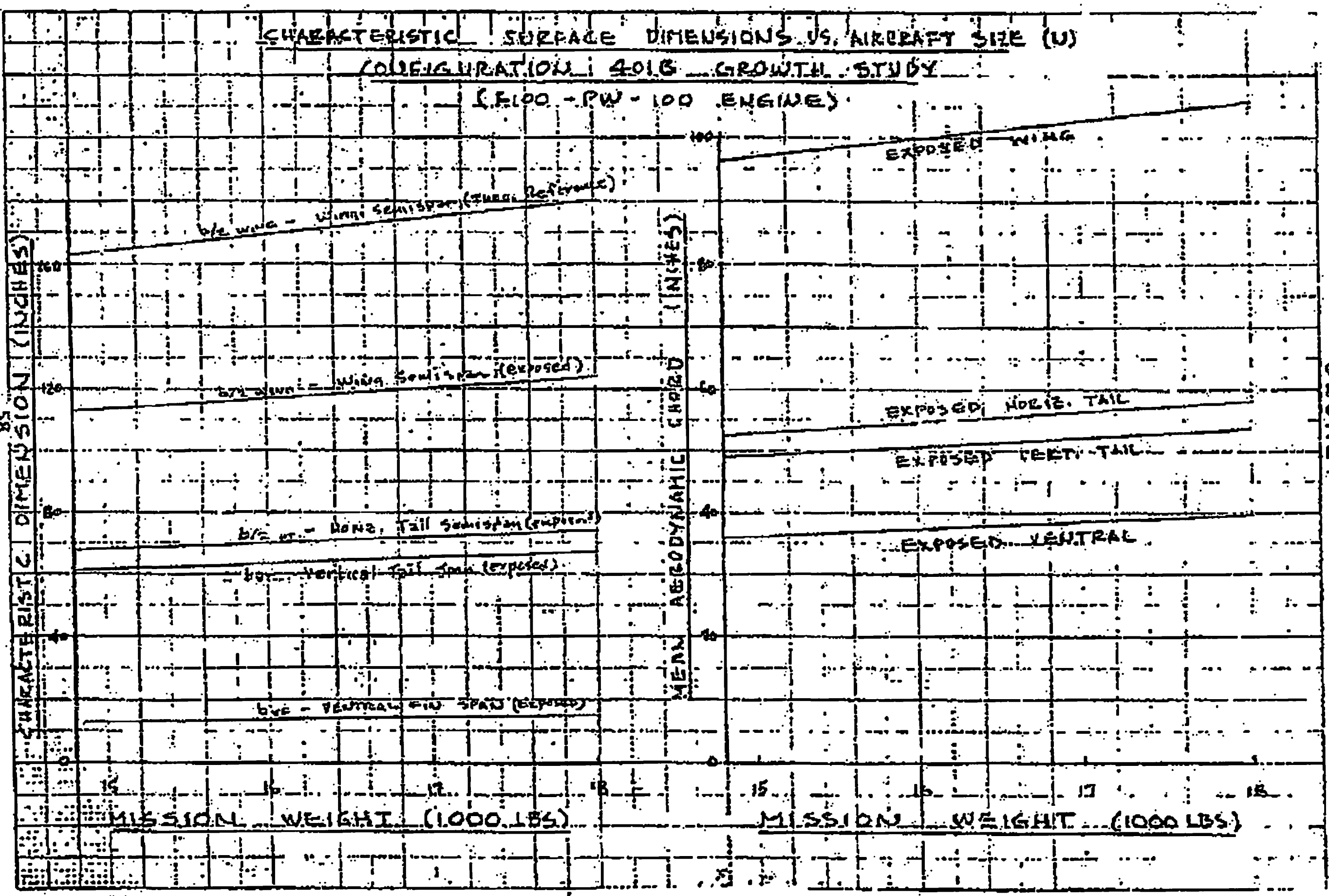
SECRET



~~(S)~~ Figure 3.1-15 Characteristic Fuselage Dimensions vs. Aircraft Mission Weight (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.1-16 Characteristic Surface Dimensions vs. Aircraft Mission Weight (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

BASIC DESCRIPTIONS

GW = 15,600 lbs.
W/S = 60 lbs/ft²
T/W = 1.504 (UNINSTALLED)
ENGINE – P&W JTF22A-27
(AF Designation F100-PW-100)

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE w/o CANOPY CENTERBODY	* 462.2	0	0	0
FUSELAGE OUTERBODY	404.0	102.0	±39	0
CANOPY	143.0	95.0	0	+35.0

* INCLUDES NOZZLE LENGTH ([illegible])

WING REF. AREA (IN²)
37,440

SURFACES

		2° INCIDENCE WING [illegible]	2° INCIDENCE DOWN, HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT²)		260.00	116.25	20.54	3.35
AR – ASPECT RATIO		3.00	3.423	1.33	0.3733
λ – TAPER RATIO		0.20	0.1359	0.40	0.59574
	E1	+55°	+55°	+45°	+45°
	E2	+10°41'	+10°41'	−19°22'	+19°22'
a – CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R – ROOT CHORD (IN.)		196.19	123.13	67.37	45.32
C_T – TIP CHORD (IN.)		37.24	16.74	26.95	27.00
b – SPAN (IN.)		335.14	239.38	62.72	13.50
AIRFOIL		4% BICONVEX	6% @ exp root 4% @ tip BICONVEX [illegible]	6% @ root 4% @ tip BICONVEX	6% BICONVEX
d (IN.)		52.00	50.627	0	0
x (IN.)		249.00	425.0	429.57	442.57
y (IN.)		0	0	±53.53	±50.25
z (IN.)		0	−13.30	0	−13.00

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (−) from fuselage ref. line WL 92 to body or surface ref line.

~~(S)~~ Figure 3.1-17 Basic Description Data Sheet - Configuration 401B Type at 15,600-lb Mission Weight (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

BASIC DESCRIPTIONS

GW = 16,800 lbs.
W/S = 60 lbs/ft²
T/W = 1.397 (UNINSTALLED)
ENGINE - P&W JTF 22A-27
(AF Designation - F100 PW-100)

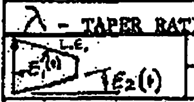
BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY w/o canopy	* 478.6	0	0	0
FUSELAGE OUTERBODY	421.0	102.0	±40.0	0
CANOPY	143.0	85.0	0	+39.0

* INCLUDES NOZZLE LENGTH (OMU)

WING REF. AREA (IN²)
40,320

SURFACES

		2° INCIDENCE WING ANNULAR	7° INCIDENCE-[illegible] HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT²)		280.00	123.14	22.12	3.65
AR - ASPECT RATIO		3.00	3.415	1.33	0.3733
λ - TAPER RATIO		0.20	0.137	0.40	0.59574
 L.E. $E_1(+)$ $E_2(+)$	E_1	+55°	+55°	+45°	+45°
	E_2	+10°41'	+10°41'	−19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_1}{\tan(90-E_2)}$					
C_R - ROOT CHORD (IN.)		193.22	126.74	69.91	47.03
C_T - TIP CHORD (IN.)		38.64	17.37	27.96	28.02
b - SPAN (IN.)		347.79	246.09	65.09	14.01
AIRFOIL		4% BICONVEX	6% @ exposed root 4% @ tip BICONVEX [illegible] B.L. 51.50	1% @ root 4% @ tip BICONVEX	6% BICONVEX
d (IN.)		54.00	51.89	0	0
x (IN.)		357.50	440.0	422.52	435.52
y (IN.)		0	0	±54.9	± 51.50
z (IN.)		0	−13.90	0	−13.00
		0° DIHEDRAL	7° NEG. DIHEDRAL	7° INWD CANT ∡	0° CANT ∡

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (−) from fuselage ref. line WL 92 to body or surface ref line.

~~(S)~~ Figure 3.1-18 Basic Description Data Sheet - Configuration 401B Type at 16,800-lb Mission Weight (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

BASIC DESCRIPTIONS

GW = 18000 lbs
W/S = 60 lbs/ft²
T/W = 1.304 (UNINSTALLED)
ENGINE - P&W JTF 22A-27
(AF Designation - F100-PW-100)

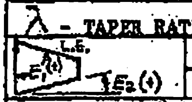
BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE ~~CENTERBODY~~ w/o CANOPY	# 494.4	0	0	0
FUSELAGE OUTERBODY	441.0	102.0	± 41.0	0
CANOPY	143.0	85.0	0	+29.0

INCLUDES NOZZLE LENGTH (OPEN)

WING REF. AREA (IN²)
43200

SURFACES

		2° INCIDENCE WING (NOMINAL)	2° INCIDENCE (NOM) HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT²)		300.00	131.91	23.70	3.51
$\mathcal{R}$ - ASPECT RATIO		3.00	3.415	1.33	0.3733
λ - TAPER RATIO		0.20	0.1371	0.40	0.59574
	E_1	+ 55°	+55°	+45°	+45°
	E_2	+ 10°41'	+10°41'	-19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		200.00	131.13	72.37	48.68
C_T - TIP CHORD (IN.)		40.00	17.98	28.95	29.00
b - SPAN (IN.)		360.00	254.51	67.37	14.50
AIRFOIL		4% BICONVEX	6% @ [illegible] 4% @ TIP BICONVEX [illegible]	6% @ ROOT 4% @ TIP BICONVEX	6% BICONVEX
d (IN.)		55.90	53.106	0	0
x (IN.)		268.50	456.5	416.80	479.80
y (IN.)		0	0	± 56.23	± 52.71
z (IN.)		0	- 14.1	0	- 13.00
		0° DIHEDRAL	[illegible] NEG. DIHEDRAL	7° INBD. CANT	0° CANT

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL92.0 to body or surface ref line.

~~(S)~~ Figure 3.1-19 Basic Description Data Sheet - Configuration 401B Type at 18,000-lb Mission Weight (U)

88th ABW/IP
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

FRICTION DRAG DATA

GW = 15,600 lbs.
W/S = 60 lbs/ft²
T/W = 1.500 (UNINSTALLED)
ENGINE – P&WA JTF22A-27

BODIES (AF Designation – F100-PW-100)

BODY	WETTED AREA (FT^2)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
FUSELAGE CENTERBODY		388.9	* 460.8	52.0	71.0
FUSELAGE OUTERBODY		234.7	404.0	26.0	18.0
CANOPY (incl Fairing)		50.7	143.0	40.00	27.0
Nozzle – Closed		20.8	27.2	43.5 DIA.	43.3 DIA.
Nozzle – Open	26.7		28.6	43.5 DIA.	43.5 DIA.
BODY TOTAL		695.1			

*Length includes nozzle (Awet shown separately above)

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		284.4	98.53	14°30′	4% BICONVEX
HORIZ. TAIL		91.0	54.05	14°30′	[illegible] 4% BICONVEX @ tip
VERT. TAIL (2)		82.2	50.05	34°15′	[illegible]
VENTRAL FIN (2)		13.6	36.94	17°45′	6% BICONVEX
SURFACE TOTAL		471.2			
AIRPLANE TOTAL		1166.3			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE – BASIC REF WING	TRAPEZOID SHAPE FOR CURVED TIP WING
AREA (FT^2)	260.00	263.114
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

~~(S)~~ Figure 3.1-20 Friction Drag Data Sheet - Configuration 401B Type at 15,600-lb Mission Weight (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)

~~SECRET~~

FRICTION DRAG DATA
GW = 16,800 LBS
W/S = 60 lbs/ft²
T/W = 1.397 (uninstalled)
ENGINE - P&W JTF 22A-27

BODIES

BODY	WETTED AREA (FT^2)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
FUSELAGE CENTERBODY		405.5	* 476.2	52.0	71.0
FUSELAGE OUTERBODY		259.0	421.0	28.00	18.0
CANOPY (INCL. FAIRING)		50.7	143.0	40.00	27.0
NOZZLE (Closed)		20.8	27.2	43.5 DIA.	43.5 DIA.
NOZZLE (OPEN)	26.7		28.6	43.5 DIA.	43.5 DIA.
BODY TOTAL		736.0			

* Length [illegible]

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX.THICKNESS SWEEP (DEG.)	AIRFOIL
WING		306.2	102.23	14°30'	4% BICONVEX
HORIZ. TAIL		98.0	56.09	14°30'	6% Bicon - root 4% Bicon - tip
VERT. TAIL (2)		88.5	51.53	34°15'	6% Biconv - root 4% Biconv - tip
VENTRAL FIN (2)		14.6	38.33	17°45'	6% BICONVEX
SURFACE TOTAL		507.3			
AIRPLANE TOTAL		1243.3			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE - BASIC REF. WING	TRAPEZOID SHAPE FOR CURVED TIP WING
AREA (FT^2)	280.00	283.353
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

~~(S)~~ Figure 3.1-21 Friction Drag Data Sheet - Configuration 401B Type at 16,800-lb Mission Weight (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

FRICTION DRAG DATA

GW = 18,000 lbs
W/S = 60 lbs/Ft²
T/W = 1.304 (UNINSTALLED)
ENGINE — P&W JTF 22A-27

BODIES (AF Designation - F100-PW-100)

BODY	WETTED AREA (FT^2)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
Fuselage Center Body		423.6	* 493.0	52.0	71.0
Fuselage Outer Body	-	280.5	441.0	30.0	18.0
Canopy (incl. fairing)		50.7	143.0	40.0	27.0
Nozzle - Closed		20.8	27.2	43.5 DIA.	43.5 DIA.
Nozzle - Open	26.7		28.6	43.5 DIA.	43.5 DIA.
BODY TOTAL		775.6			

*Length includes nozzle (but shown separately also)

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		328.0	105.81	14° 30'	4% BICONVEX
HORIZ. TAIL		105.0	58.06	14° 30'	6% Biconvex @ root 4% Biconvex tip
VERT. TAIL (2)		94.8	53.76	34° 15'	6% @ root 4% @ tip
VENTRAL FIN (2)		15.6	39.67	17° 45'	6% BICONVEX
SURFACE TOTAL		543.4			
AIRPLANE TOTAL		1319.0			

BASIC WING GEOMETRY:

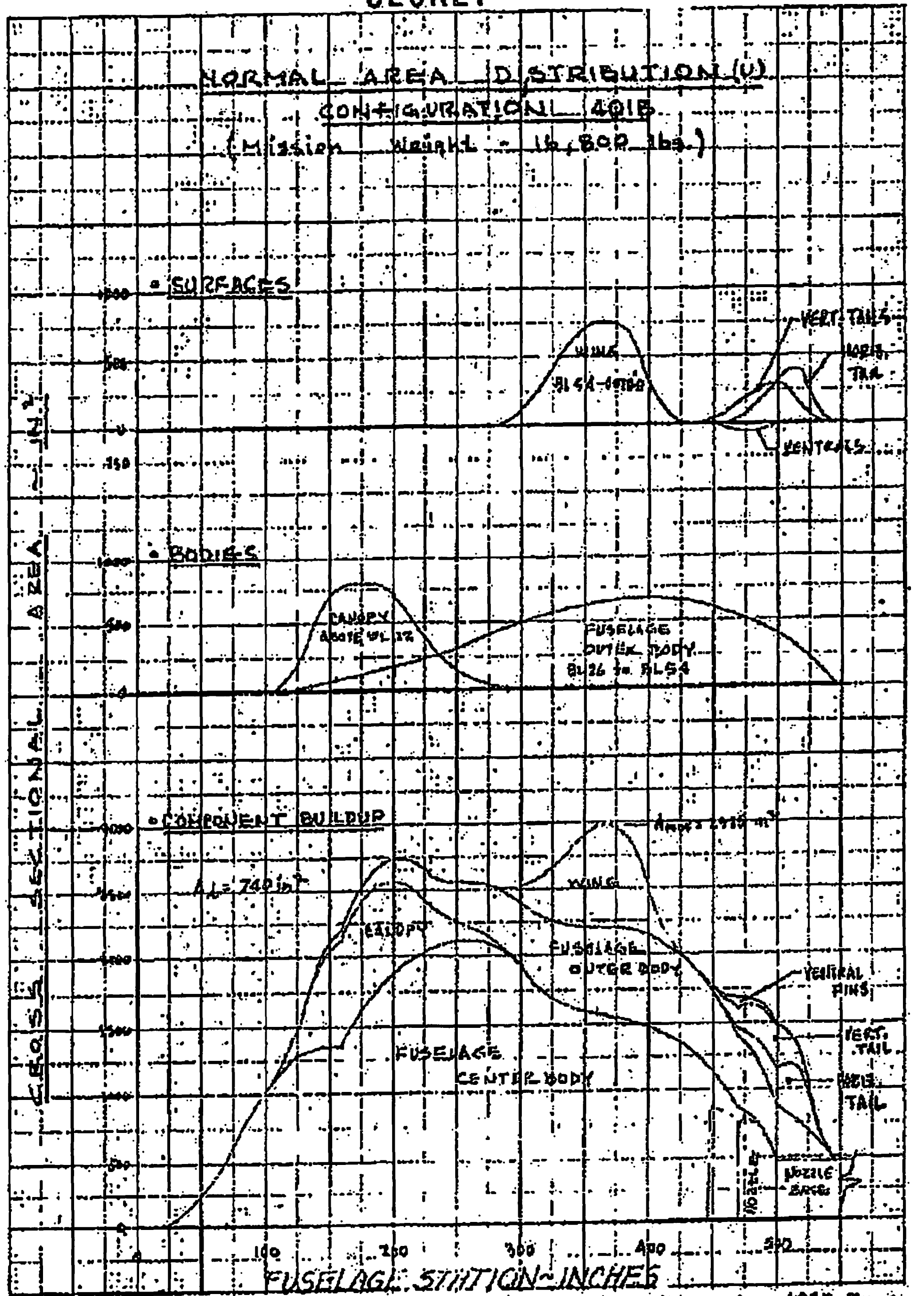
	TRAPEZOID SHAPE BASIC REF WING	TRAPEZOID SHAPE FOR [illegible] WING
AREA (FT^2)	300.00	303.593
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

~~(S)~~ Figure 3.1-22 Friction Drag Data Sheet - Configuration 401B Type at 18,000-lb Mission Weight (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

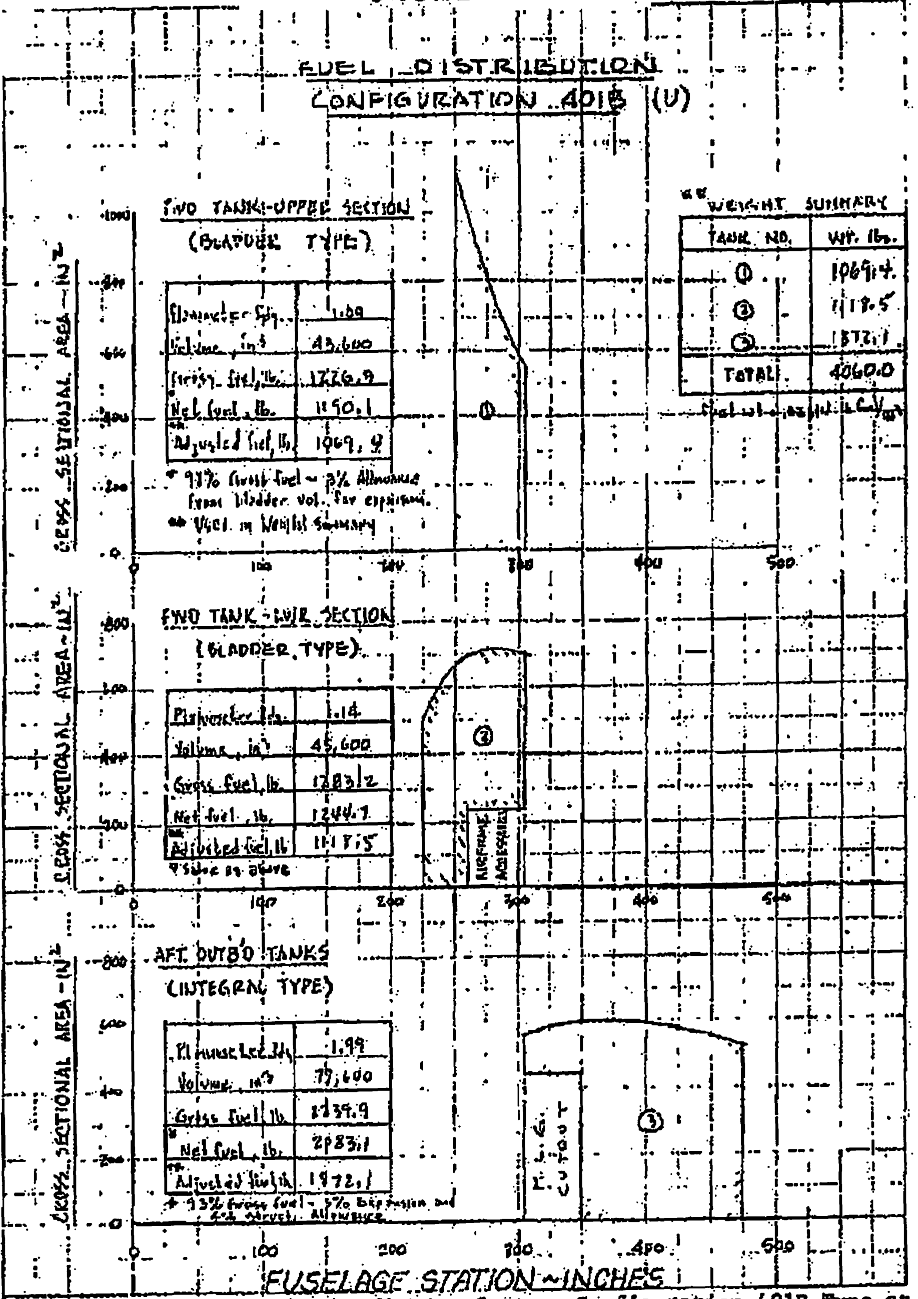
~~SECRET~~



~~(S)~~ Figure 3.1-23 Area Distribution Curve - Configuration 401B Type at 16,800-lb Mission Weight (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



Planimeter Sq.	1.09
Volume, in³	43,600
Gross fuel, lb.	1236.9
* Net fuel, lb.	1150.1
** Adjusted fuel, lb.	1069.4

* 93% Gross fuel – 3% Allowance from bladder vol. for expansion.
** Used in Weight Summary

Planimeter Sq.	1.14
Volume, in³	45,600
Gross fuel, lb.	1283.2
* Net fuel, lb.	1244.7
** Adjusted fuel, lb.	1118.5

* Same as above

Planimeter Sq.	1.99
Volume, in³	79,600
Gross fuel, lb.	2239.9
* Net fuel, lb.	2083.1
** Adjusted fuel, lb.	1872.1

* 93% Gross fuel – 5% Expansion and 2% Struct. Allowance

** WEIGHT SUMMARY

TANK NO.	WT. lbs.
①	1069.4
②	1118.5
③	1872.1
TOTAL	4060.0

Fuel wt. based [illegible]

~~(S)~~ Figure 3.1-24 Fuel Distribution Curve - Configuration 401B Type at 16,800-lb Mission Weight (U)

3.2 PERFORMANCE

(U) Both basic performance and sensitivity data are presented in this section for the large single-engine concept (Configuration 401B). Performance data are presented in the form of maneuver data (i.e., energy rate vs turn rate, persistence plots, and thrust required) for the aircraft with 50 percent fuel and in the form of mission data for the three missions specified in the Statement of Work and described below.

3.2.1 Mission Definitions

~~(S)~~ Three representative air-superiority fighter missions were used for aircraft performance evaluations. These are short- and long-range air-superiority missions and a ferry mission. (The ferry mission is important for deployment considerations.)

1. Short-Range Air-Superiority Mission (SRASM) - This is a radius mission without external tanks. The minimum desired radius is 225 n.mi. The payload is two AIM-9X missiles and 500 rounds of ammunition. The missiles and one half of the ammunition are expended at the end of combat. The mission rules are as follows:

   a. Ground Operation:

      Six minutes at power setting of $T/W = 0.2$

   b. Takeoff and Acceleration:

$$\text{Fuel} = \frac{W_1 V_1}{g(T-D)_1} \quad \frac{\dot{W}_0 + \dot{W}_1}{2}$$

0 = Sea-Level Static

1 = Climb Speed ($M = 0.5$)

W = Takeoff Gross Weight, lb

$\dot{W}$ = Maximum-Power Fuel Flow, lb/sec

~~(S)~~ T = Thrust, lb

D = Drag, lb

V = Velocity, fps

c. Climb is calculated from sea level at best climb speed to best cruise speed and altitude. Range accumulated is credited to radius.

d. Outbound and return legs are optimum speed and altitude (no dash).

e. Combat fuel allowance is that required to achieve the following maximum power maneuvers at the 30,000-ft altitude at the average combat weight (average combat weight equals weight at start of combat - ½ combat fuel).

(1) Constant altitude acceleration from Mach 0.9 to 1.5.

(2) Three ($P_s = 0$) turns at Mach 0.8

(3) Two ($P_s = 0$) turns at Mach 1.2.

(Missiles and one half of ammunition are expended at the end of combat).

f. Descent: No fuel used; no range gained.

g. Landing: 20-minute sea-level endurance.

2. Long-Range Air-Superiority Mission (LRASM) - This is a radius mission in which all fuel required prior to combat is external fuel so that combat starts with full internal fuel. Tanks are dropped at start of combat. All other mission rules are the same as specified for the SRASM. The desired radius is 750 n.mi.

3. Ferry Mission - A non-refueled ferry range of 2600 n.mi is desired. External fuel

~~(S)~~ tanks are used and retained and full ammunition (500 rounds) but no missiles are carried. Fuel allowances for takeoff and landing are the same as for the SRASM plus a fuel reserve of 5 percent initial fuel (initial fuel includes external tankage).

3.2.2 Thrust-Drag Bookkeeping System

(U) In the system of thrust-drag bookkeeping employed, all components of drag that do not vary with power setting are included in the aerodynamic drag data presented in Section 3.3. The aerodynamic data of Section 3.3 are for a capture ratio of 1.0, a reference exhaust nozzle position (40-inch diameter at the exit plane) and a reference nozzle pressure ratio which is defined in Section 3.6. Any effects due to changes in power setting are included in the propulsion data presented in Section 3.6.

3.2.3 Basic Performance Data

~~(S)~~ Configuration 401B performance data are presented for the aircraft sized to meet the LRASM required radius of 750 n.mi. The size aircraft required has a mission weight of 17,115 lb (i.e., full-up weight with mission payload and without external tanks which is the SRASM takeoff gross weight as well as the LRASM initial combat weight). This is an increase of 315 lb over the aircraft size (16,800 lb) used for the initial layout and evaluation. This increase is caused primarily by the ferry-range requirement.

~~(S)~~ The variation of ferry range with external fuel for a 16,800-pound aircraft (Figure 3.2-1) shows that a takeoff gross weight of nearly 27,000 lb is required to obtain the 2600-n.mi desired ferry range with external tanks retained. This is a 60-percent overload above the basic mission weight without tanks (16,800 lb). The initial structural weight evaluation considered an overload capability of 40 percent above the full-up clean airplane weight, which approximately corresponds to the takeoff gross weight for the LRASM (i.e., the maximum overload condition specified in the Statement of Work). The additional 20-percent overload capability for the ferry mission resulted in a 101-lb increase in the dry weight of the 16,800-lb aircraft for larger tires and structural beefup. This 101-lb increase due to increased overload

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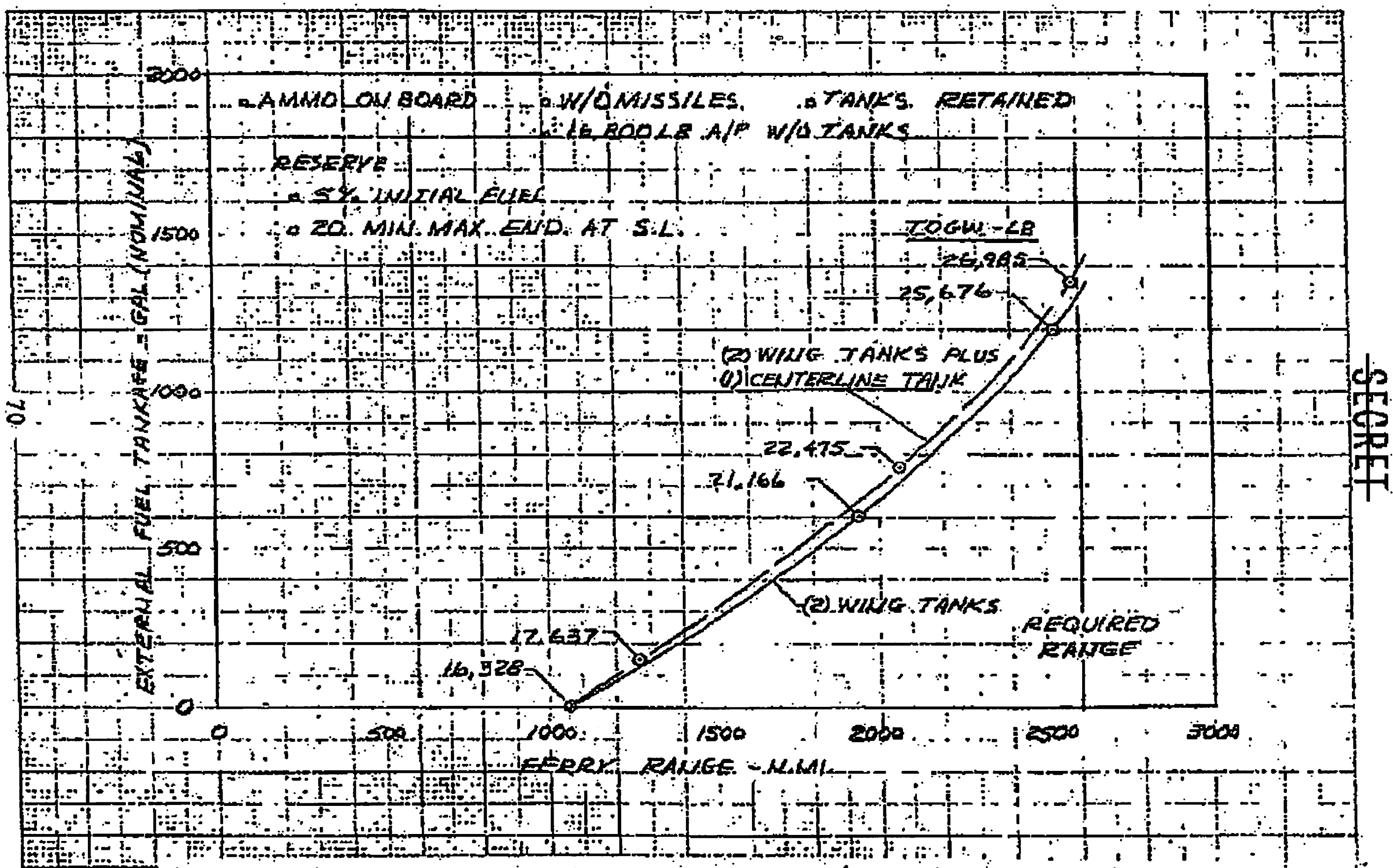

~~(S)~~ Figure 3.2-1 Effect of External Fuel on Ferry Range, Configuration 401B (U)

SECRET

~~(S)~~ capability together with a 36-lb increase due to revised weight estimates resulted in a 61-n.mi reduction in the LRASM radius. An increase in size to 17,115 lb was required to regain the lost radius. Thus, while the aircraft was primarily sized for the LRASM, the sizing was also influenced by the ferry-mission requirements.

88th ABW/PA
FOIA (b)(1)
E.O. 13526 SEC 3.3.
(b)(4)
1.4(a)(g)

EO 13526 SEC 3.3(b)(4)
SEC 1.4(a)(g)

(U) The performance data presented in this section are for standard-day conditions and are based on the following basic data:

1. Aerodynamic data presented in Section 3.3.
2. Stability and Control data presented in Section 3.4.
3. Weight data presented in Section 3.5.
4. Propulsion data presented in Section 3.6.

(U) The following corrections, obtained from the growth data presented in Subsection 3.3.1.3, were added to the basic aerodynamic data of Section 3.3 to account for increased aircraft size and wing area change. The reference wing area increased from 280 sq ft to 285.2 sq ft to maintain a constant wing loading of 60 psf.

Mach No.	ΔC_D
0.6	-0.00013
0.8	-0.00013
0.9	-0.00015
1.2	-0.00059
1.5	-0.00045

(U) The weight data presented in Section 3.5 were corrected for the change in aircraft size. The growth data presented in Section 3.5 were used to make the corrections. A summary of the corrected weight data is presented in Table 3.2-1.

(U) The engine size was maintained fixed at a scale of 100%, and the propulsion data from Section 3.6 were used without modification.

(U) The summary of the resized Configuration 401B's mission capabilities is presented in Figure 3.2-2. Tabulations of the pertinent data for each segment of the three missions are presented in Tables 3.2-2 through 3.2-4.

(U) General performance data are presented in support of the tabulated data. These include:

1. Takeoff Performance (Figure 3.2-3)
2. Landing Performance (Figure 3.2-4)
3. Initial-Climb Performance (Figure 3.2-5)
4. Climb After Combat (Figure 3.2-6)
5. Cruise Performance (Figure 3.2-7)
6. Combat Fuel Allowance (Figure 3.2-8)
7. Sea-Level Loiter Performance (Figure 3.2-9)

(U) Maneuver performance data in the form of energy rate versus turn rate, persistence plot, and thrust required are presented in Figures 3.2-10 through 3.2-12, respectively.

(U) Sensitivity to weight-empty variations is shown in Figure 3.2-13. Sensitivity is shown for two methods of aircraft growth. One is for the case where engine size, wing area, and fuselage size are fixed. The mission weight (i.e., full-up weight with mission payload and without external tanks) changes by the amount of weight-empty change and the amount of internal fuel change required to maintain the LRASM radius. In the other method, a constant wing loading is maintained while the engine size is held fixed. Mission weight changes by the amount of weight-empty change and the amount of internal fuel and structural weight change associated with the change in aircraft size. The relationship of internal fuel and structural weight change with the change in aircraft size (maintaining constant wing loading) is discussed in Section 3.5.

(U) Performance sensitivities for the case where the engine size is fixed and the wing loading is maintained at 60 psf are shown in Figures 3.2-14 through 3.2-20. The size variations of the fuselage, tails, etc. for this case are as discussed in Section 3.1.

~~(S)~~ Table 3.2-1 CONFIGURATION 401B WEIGHT SUMMARY

(17,115-Lb Airplane Without Tanks)

Item	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	12,225
Ammunition (500 rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,257
SRASM Takeoff Gross Weight	17,115
Two Full 300-Gallon Tanks & Pylons	4,838
LRASM Takeoff Gross Weight	21,953
Basic Operating Weight	12,225
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	447
SRASM and LRASM Landing Weight	12,814
2. FERRY MISSION	
Basic Operating Weight	12,225
Missile Pylon (Removed)	- 124
Ammunition (500 Rounds)	285
Zero Fuel Weight	12,386
Internal Fuel	4,257
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	27,300
Zero Fuel Weight	12,386
Two Empty 600-Gallon Tanks & Pylons	1,506
One Empty 150-Gallon Tank & Pylon	308
Five-Percent Initial Fuel	655
Twenty-Minute Sea-Level Loiter	554
Landing Weight	15,409

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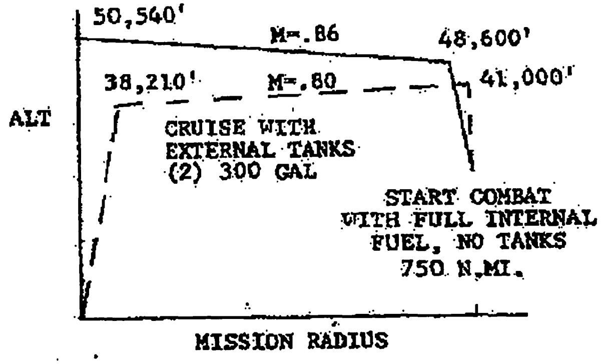
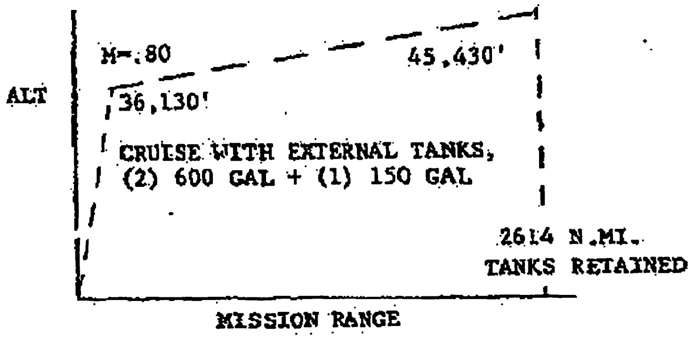
(17,115 LB A/P W/O TANKS)

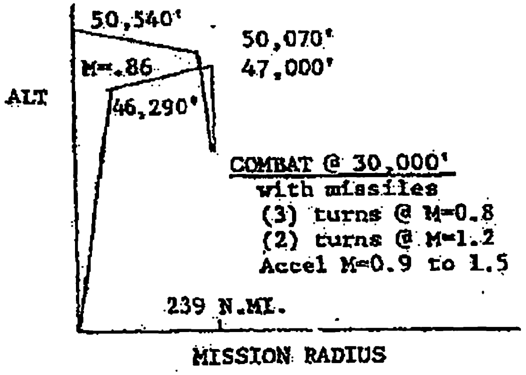
LONG RANGE AIR SUPERIORITY MISSION



FERRY MISSION



SHORT RANGE AIR SUPERIORITY MISSION



LONG RANGE AIR SUPERIORITY MISSION

Takeoff Gross Weight	21,953 lb
Takeoff Distance over 50 ft	1,970 ft
Landing Distance over 50 ft	3,330 ft
Accel Time, M=0.9 to 1.5	35.5 sec
Turn Rate @ M=0.8	9.8 deg/sec
Turn Rate @ M=1.2	8.1 deg/sec

SHORT RANGE AIR SUPERIORITY MISSION

Takeoff Gross Weight	17,115 lb
Takeoff Distance over 50 ft	1,330 ft
Landing Distance over 50 ft	3,330 ft
Accel Time, M=0.9 to 1.5	32.4 sec
Turn Rate @ M=20.8	10.9 deg/sec
Turn Rate @ M=1.2	9.1 deg/sec

~~(S)~~ Figure 3.2-2 Configuration 401B Mission Performance Summary (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3(b)(4)
1.4. (a)(g)

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~~(S)~~ Table 3.2-2 CONFIGURATION 401B LRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat g's
Initial Weight	0	0	21953								
Ground Operation				327	0	0					
	0	0	21626								
Accel to Climb Speed				249	0	.11					
	.500	0	21377				2718	.875	7.10		
Climb to Cruise Alt.				506	38	.08					
	.80	38212	20871				2250	.827	9.35		
Outbound Cruise				2711	712	1.54					
	.80	41000	18160								
Drop Tanks				1045	0	0					
(847#Tank+198#Fuel)	.80	4100	17115								
Combat				(1887)		(.066)					
Accel M0.9-M1.5	0.9-1.5	30000		340	0	.010					
(2)M1.2 Turns	1.2	30000		831	0	.025				.490	5.48
(2)M0.8 Turns	0.8	30000		716	0	.031				.880	4.37
	0.86	30000	15228								
Drop Payload				348	0	0					
	0.86	30000	14880								
Drop ½ Ammo				143	0	0					
	0.86	30000	14737				2208	.875	6.40		
Climb to Cruise Alt.				149	26	.054					
	0.86	48605	14588				1490	.863	9.89		
Return Cruise				1774	724	1.46					
	0.86	50539	12814								
Descend				0	0	0					
	0.27	0	12814				1190	1.140	10.79		
Landing Reserves (20-Min. Loiter S.L.)				447	0	.33					
Zero-Fuel Weight			12367								

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~~(S)~~ Table 3.2-3 CONFIGURATION 401B SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat g's
Initial Weight	0	0	17115								
Ground Operation				238	0	0					
	0	0	16877								
Accel to Climb Speed				190	0	.10					
	.50	0	16687				2254	.875	6.18		
Climb to Cruise Alt.				450	42	.10					
	0.86	46291	16237				1690	.855	9.73		
Outbound Cruise				563	197	.39					
	0.86	47001	15674								
Combat				(1722)		(.06)					
Accel M0.9-M1.5	.9-1.5	30000		309	0	.01					
(2)M1.2 Turns	1.2	30000		754	0	.02				.490	5.98
(3)M0.8 Turns	0.8	30000		659	0	.03				.880	4.77
	0.86	30000	13952								
Drop Payload				348	0	0					
	0.86	30000	13604								
Drop ½ Ammo				143	0	0					
	0.86	30000	13461				2189	.875	5.86		
Climb to Cruise Alt.				145	26	.06					
	0.86	50069	13316				1358	.870	9.85		
Return Cruise				502	213	.43					
	0.86	50539	12814								
Descend				0	0	0					
	.27	0	12814				1190	1.14	10.79		
Landing Reserves (20 Min. Loiter S.L.)				447	0	.33					
Zero-Fuel Weight			12367								

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~(S)~~ Table 3.2-4 CONFIGURATION 401B FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (Ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat C_L	Combat [illegible]
Initial Weight	0	0	27300								
Ground Operation				394	0	0					
	0	0	26906								
Accel to Climb Speed				316	0	.11					
	.50	0	26590				3063	0.875	8.11		
Climb to Cruise Alt.				663	48	.11					
	.80	36125	25927				2882	0.820	9.020		
Cruise w/(2)Ext.Tanks				10522	2566	5.59					
	.80	45433	15405								
Descend				0	0	0					
	.28	0	15405				1650	1.015	9.37		
Landing Reserves				(1205)							
(20Min. Loiter S.L.)		0		550		.34					
(5% Initial Fuel)				655							
Zero-Fuel Weight			14200								

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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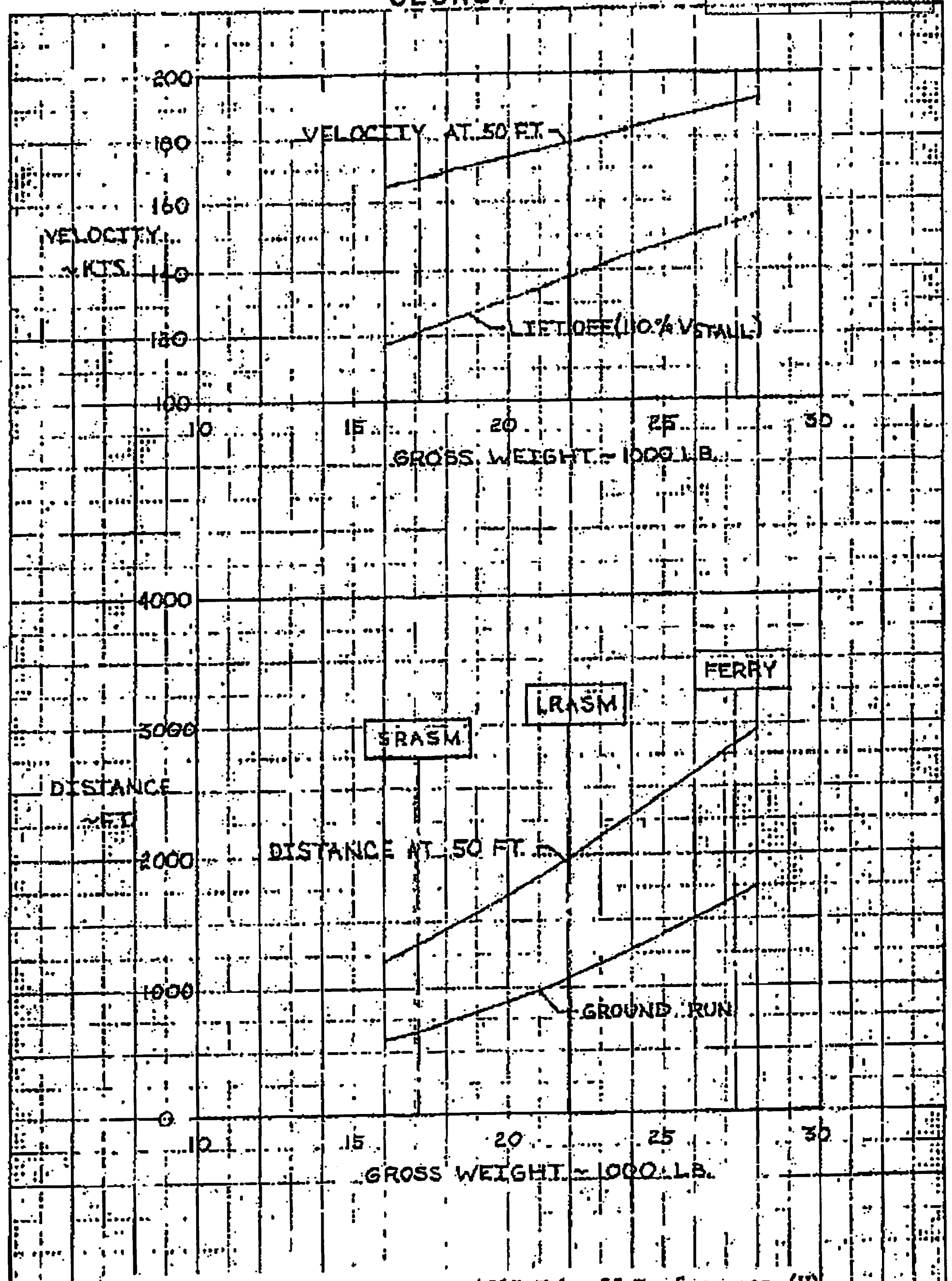

~~(S)~~ Figure 3.2-3 Configuration 401B Takeoff Performance (U)

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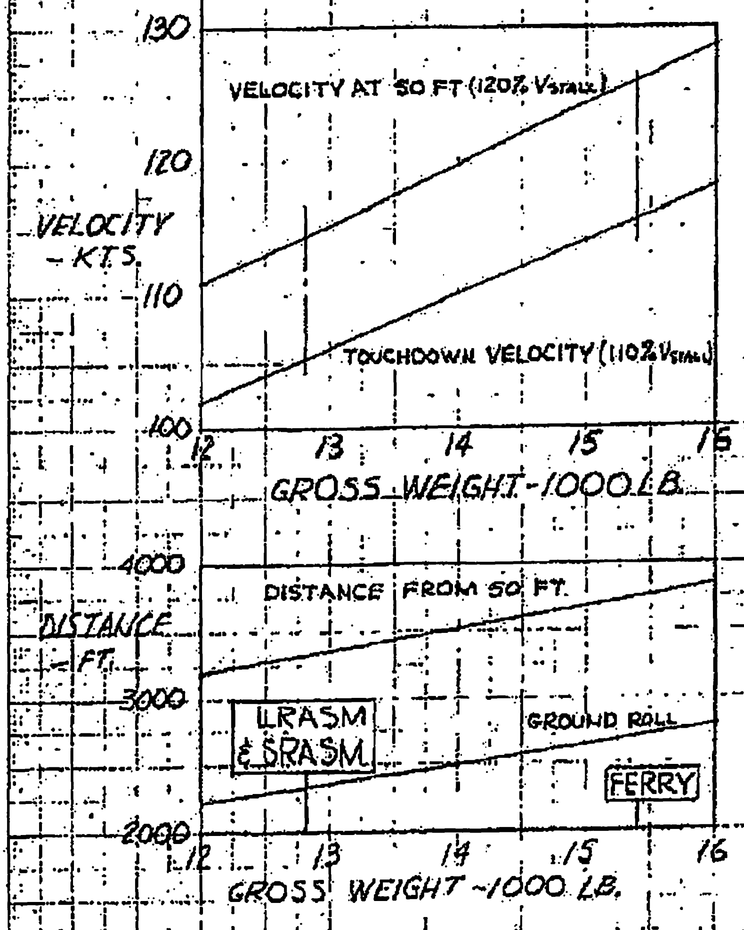
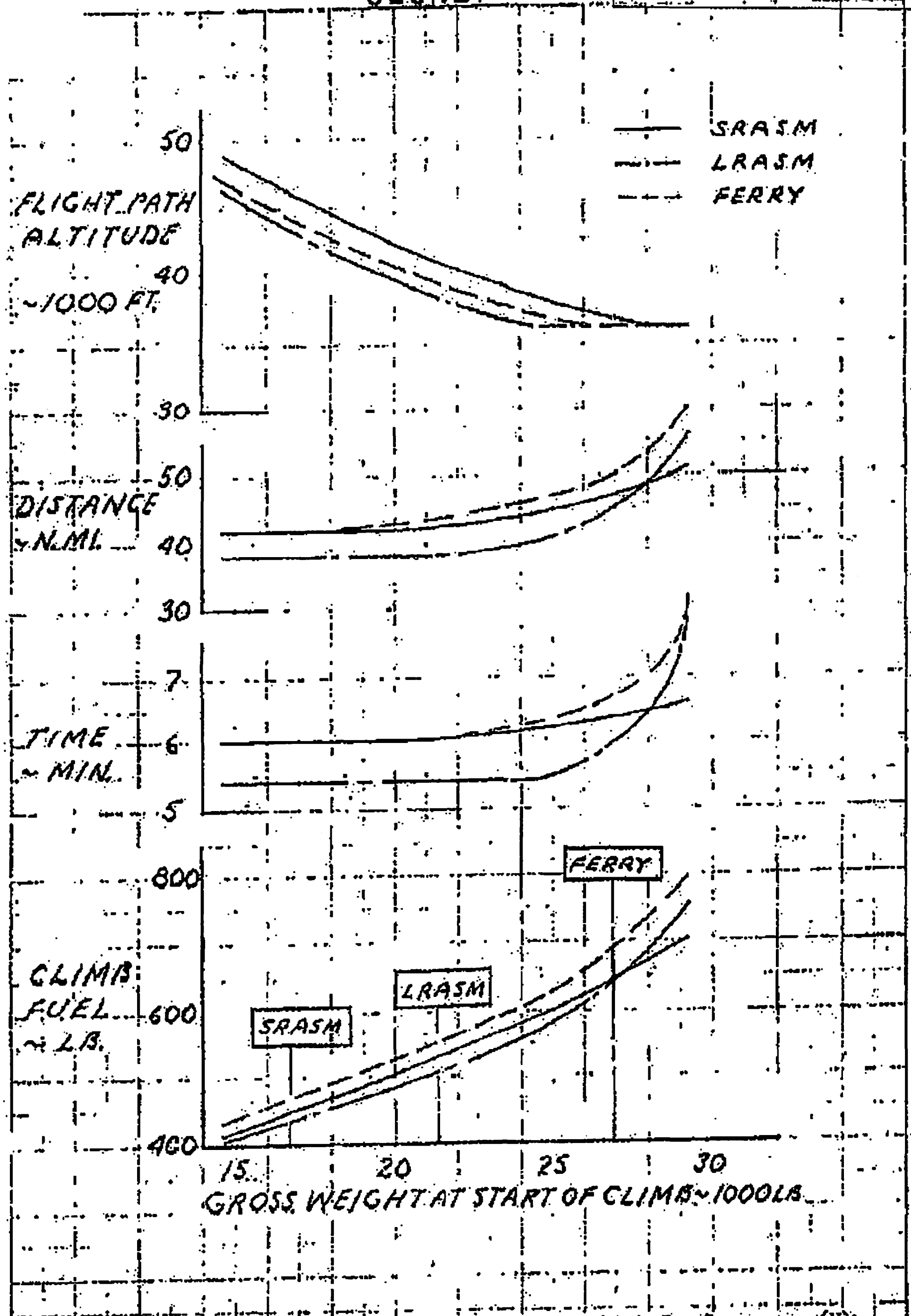
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

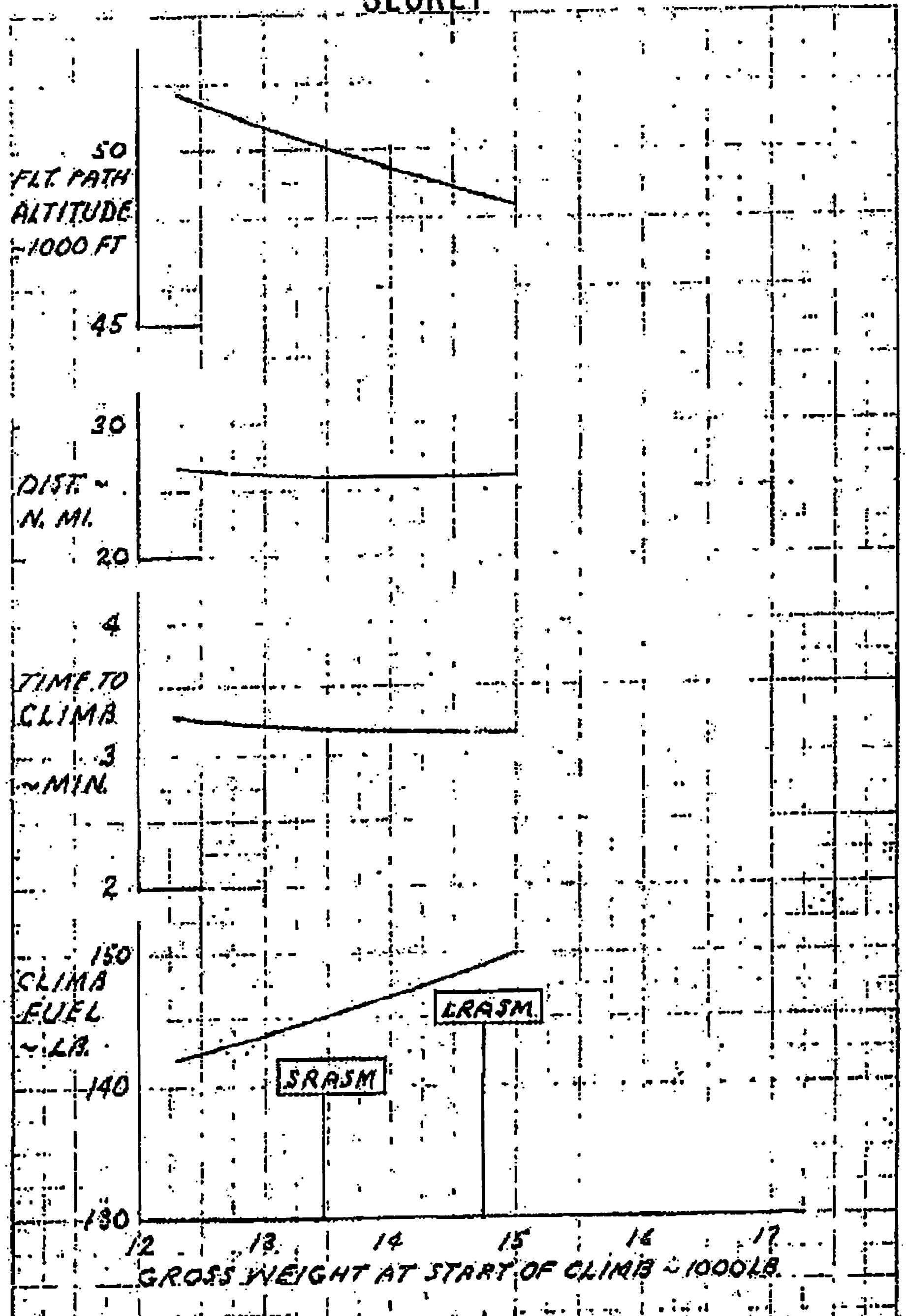


~~(S)~~ Figure 3.2-4 Configuration 401B Landing Performance (U)



~~(S)~~ Figure 3.2-5 Configuration 401B Initial Climb Performance (U)

88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC. 3.3.~~
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.2-6 Configuration 401B Climb After Combat (U)

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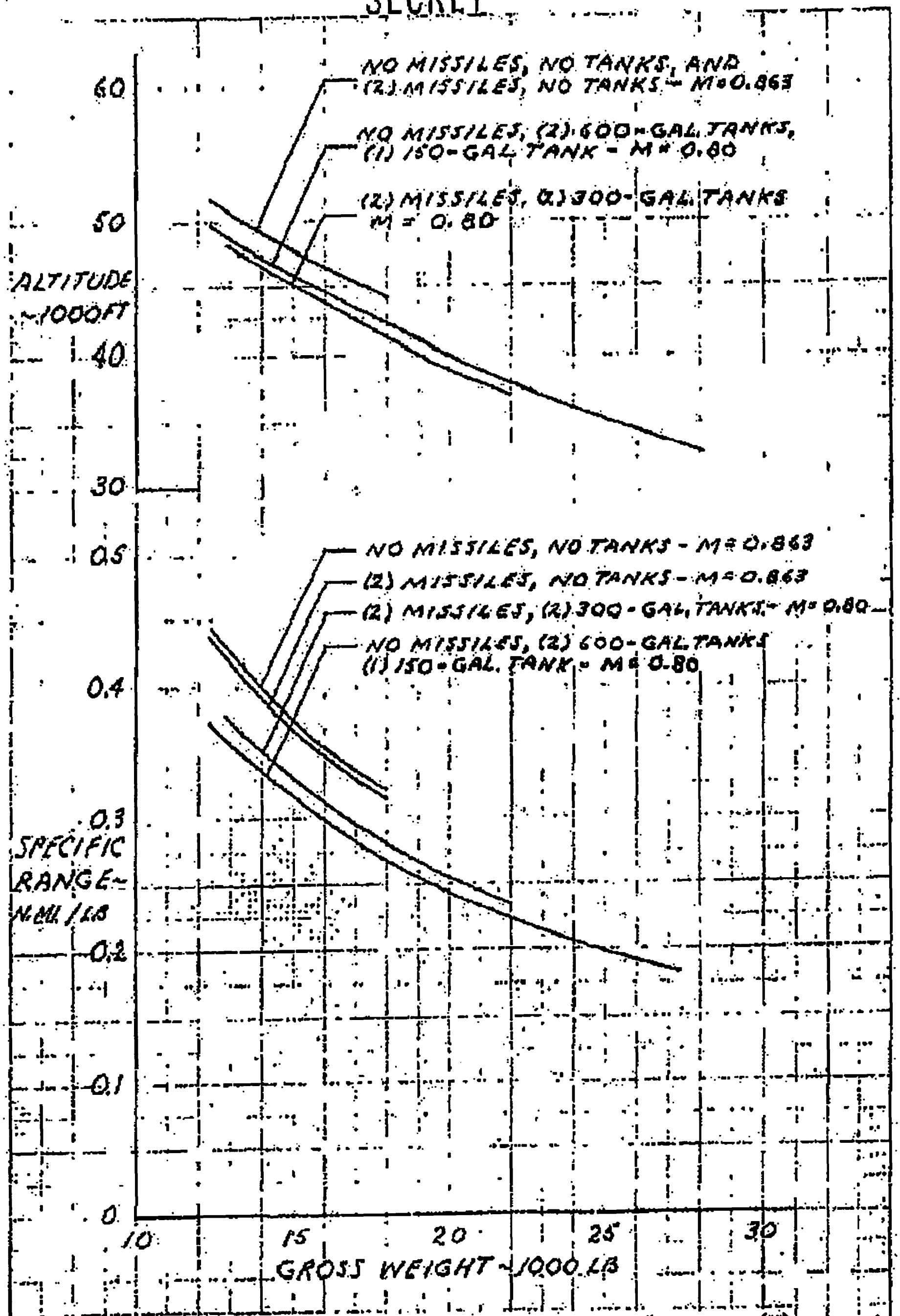

~~(S)~~ Figure 3.2-7 Configuration 401B Cruise Performance (U)

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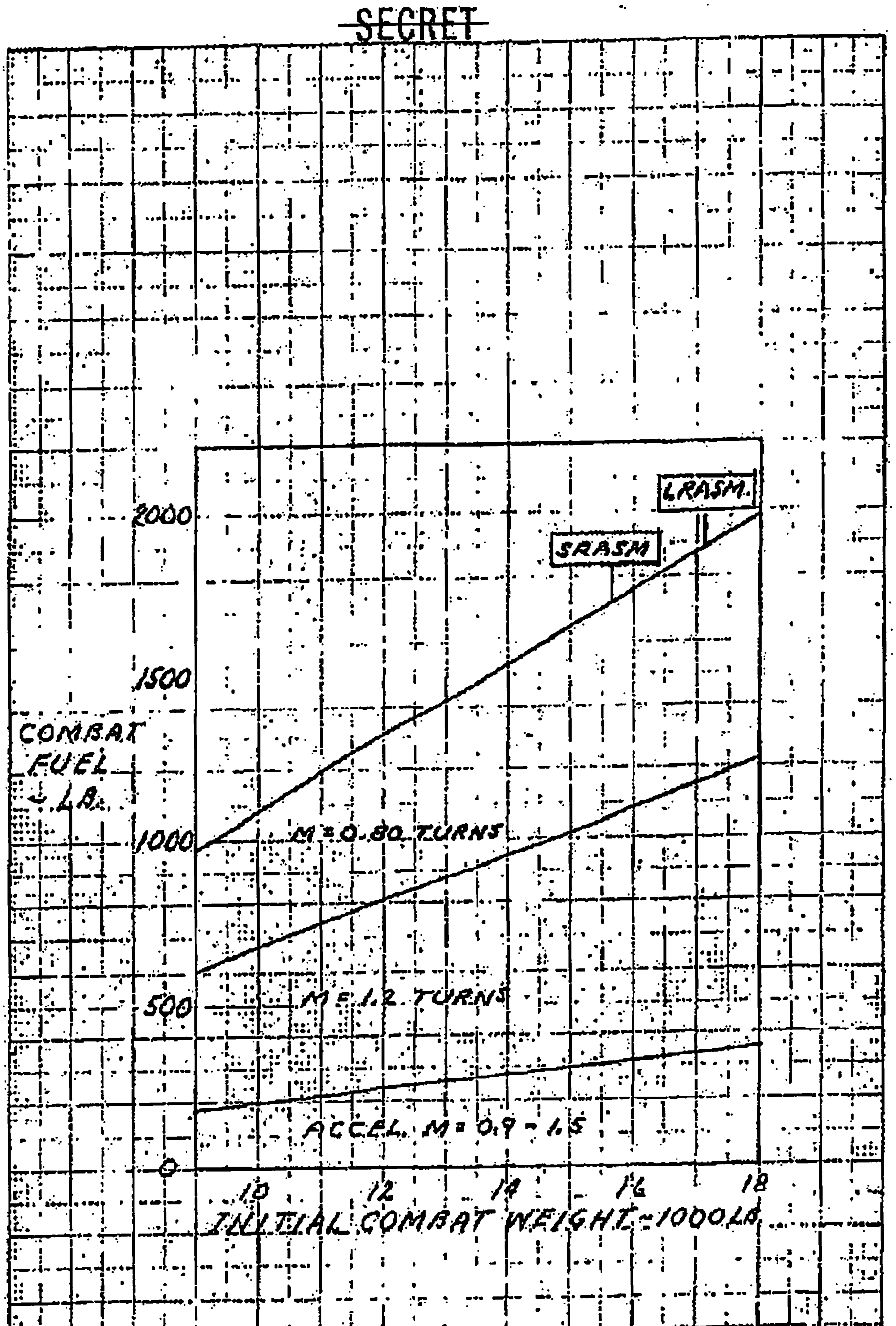
88th
ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)
(4)
1.4. (a)(g)



~~(S)~~ Figure 3.2-8 Configuration 401B Combat Fuel Allowance (U)

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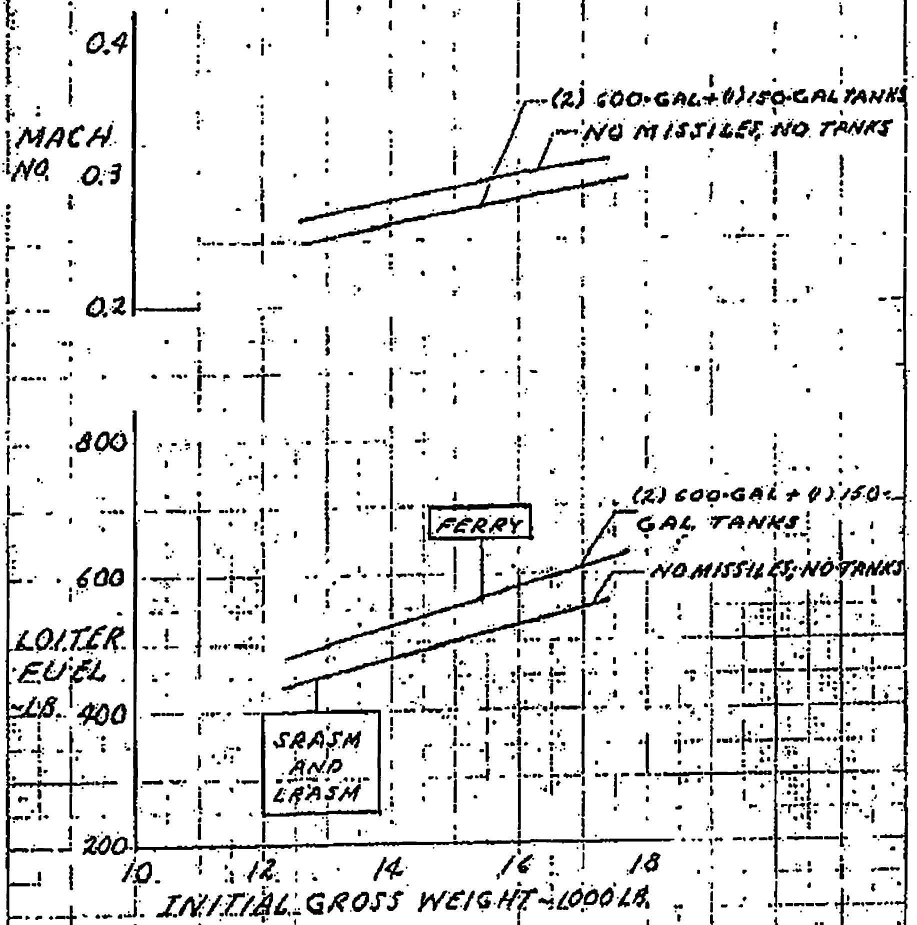
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.2-9 Configuration 401B Sea-Level Loiter Performance (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

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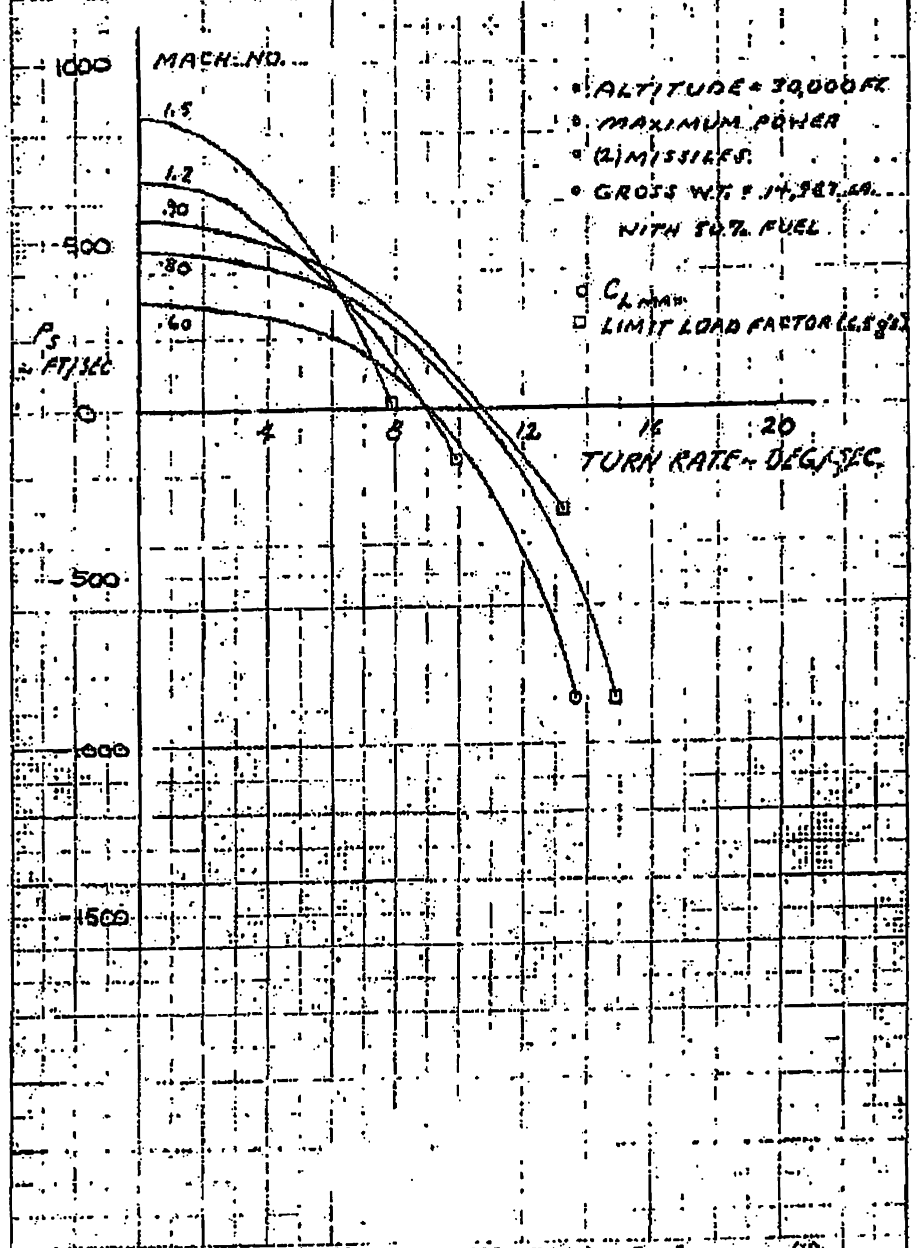

~~(S)~~ Figure 3.2-10 Configuration 401B Turning Performance (U)

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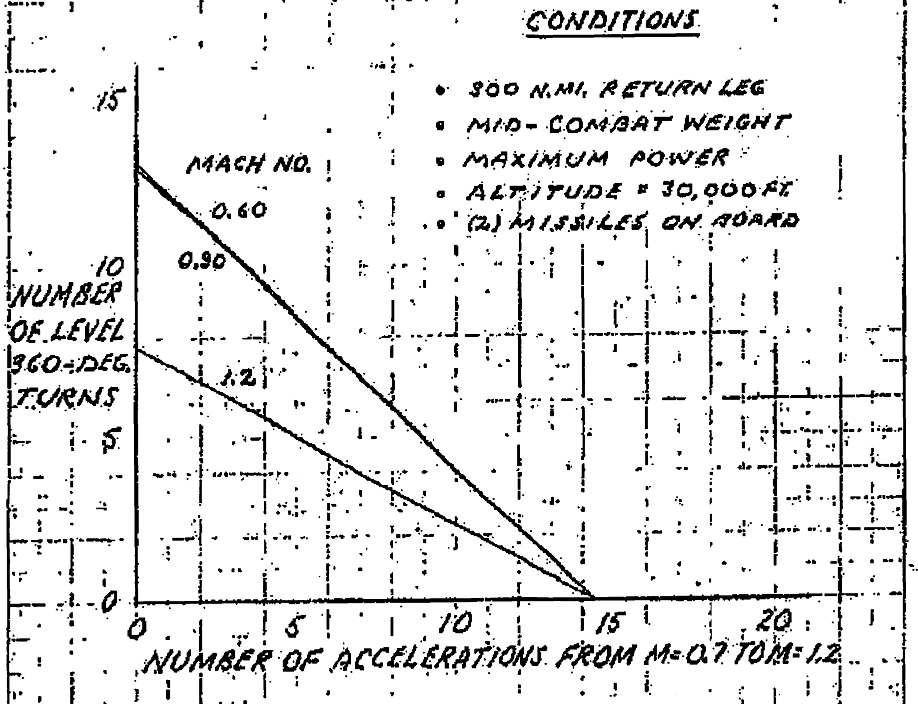
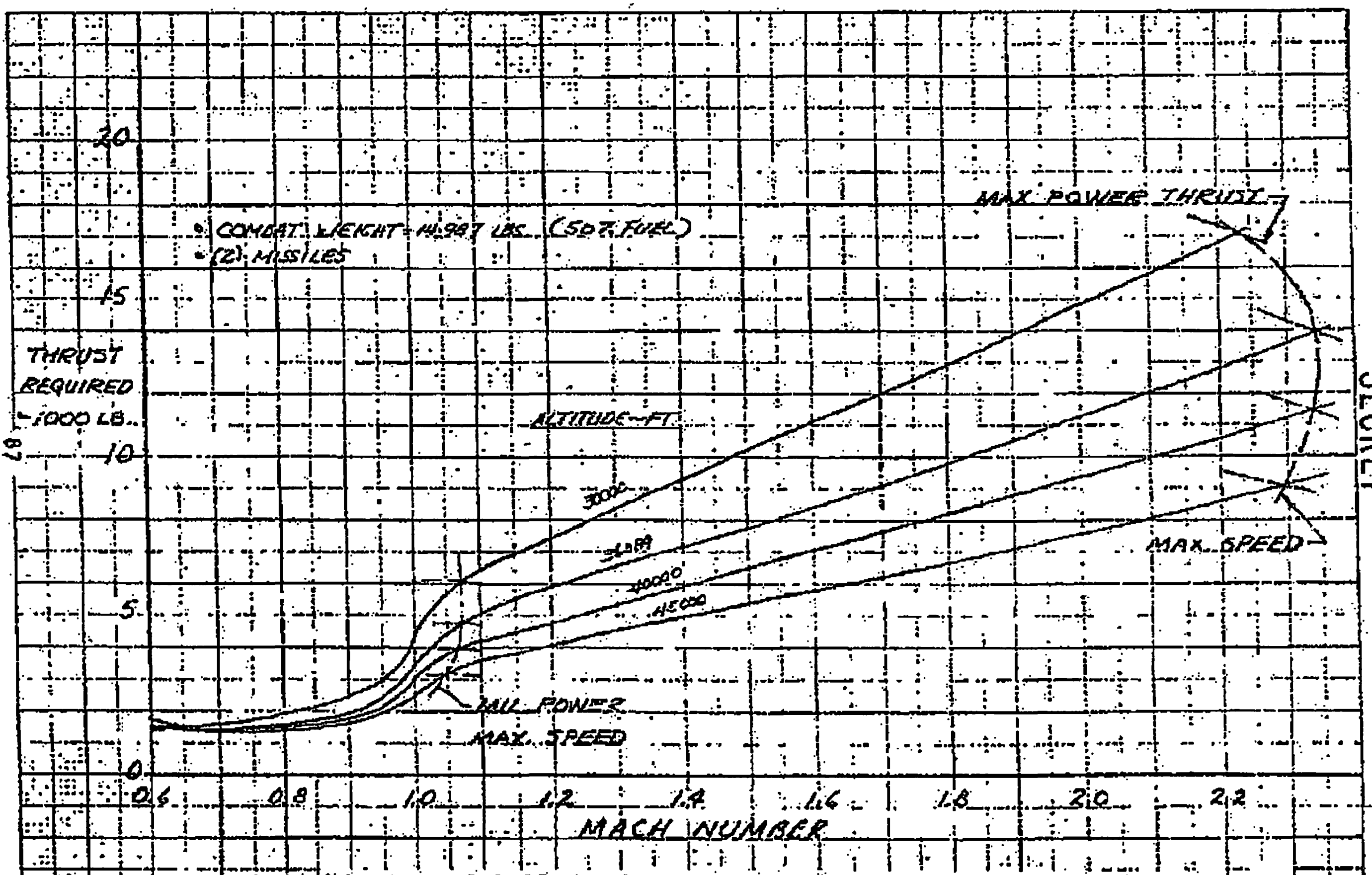
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

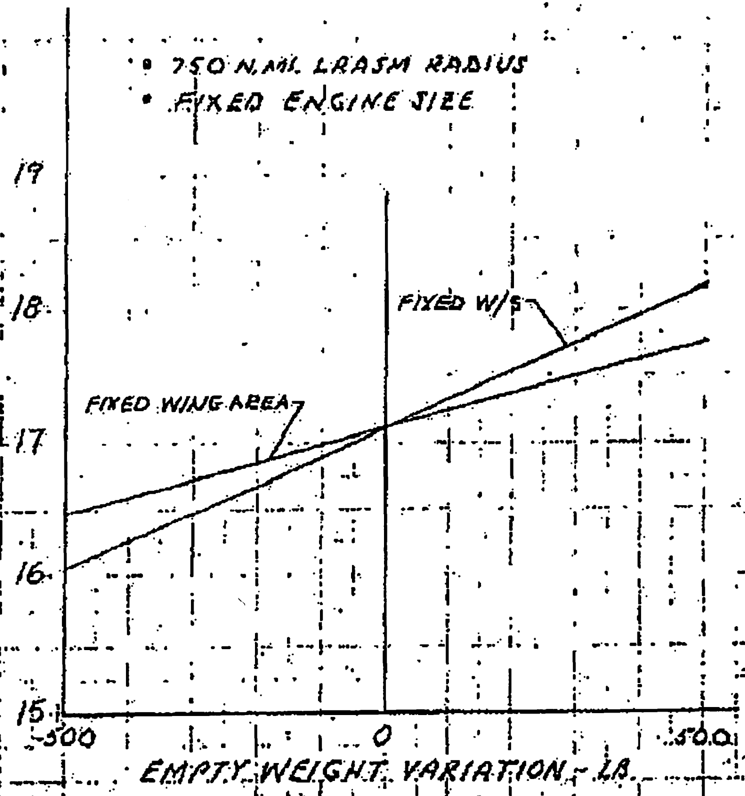


~~(S)~~ Figure 3.2-11 Configuration 401B Persistence Plot (U)

88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.2-12 Configuration 401B Thrust Required (U)



~~(S)~~ Figure 3.2-13 Configuration 401B Sensitivity to Weight-Empty Variation (U)

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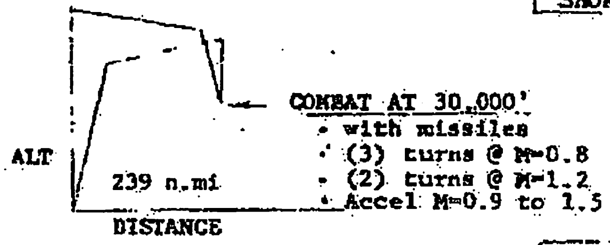
• 17,115 lb A/P W/O TANKS

SHORT RANGE AIR SUPERIORITY MISSION

DRAG SENSITIVITY: 1.1 n.mi/ct

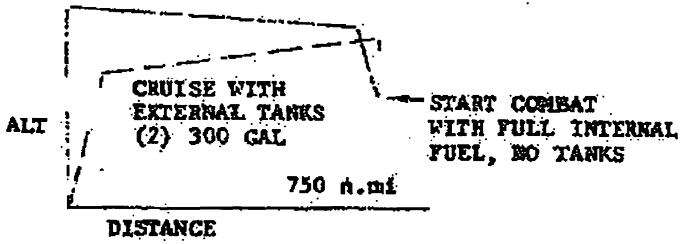
WEIGHT SENSITIVITY: 0.21 n.mi/lb



LONG RANGE AIR SUPERIORITY MISSION

DRAG SENSITIVITY: 2.6 n.mi/cc

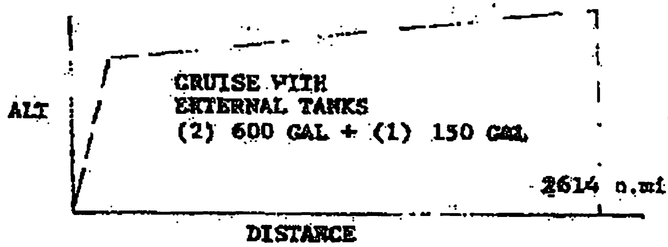
WEIGHT SENSITIVITY: 0.43 n.mi/lb



FERRY MISSION

DRAG SENSITIVITY: 5.5 n.mi/ct

WEIGHT SENSITIVITY: 0.31 n.mi/lb

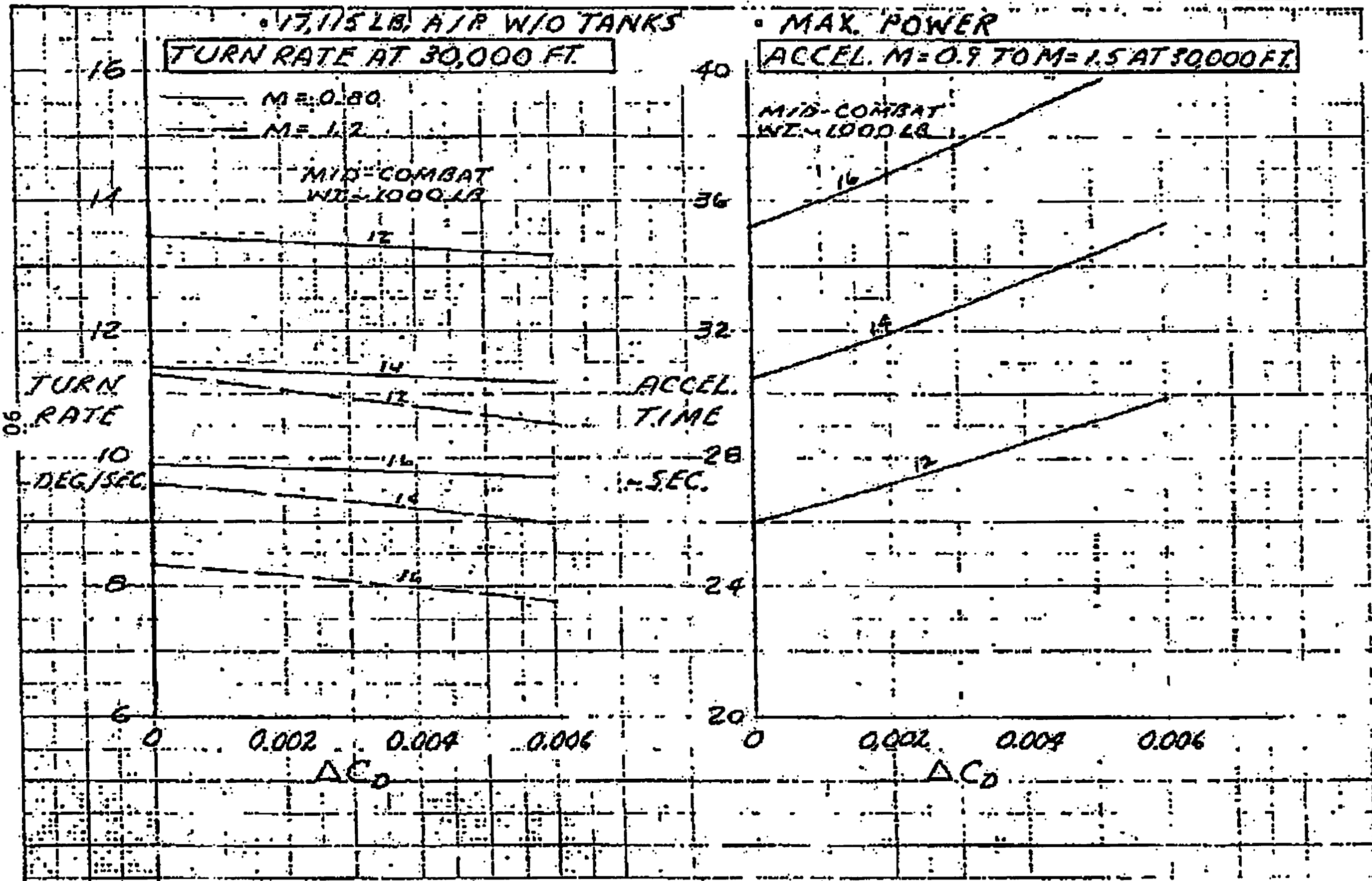


~~(S)~~ Figure 3.2-14 Configuration 401B Range Sensitivity (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)
(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 3.2-15 Configuration 401B Maneuver Sensitivity to Drag (U)

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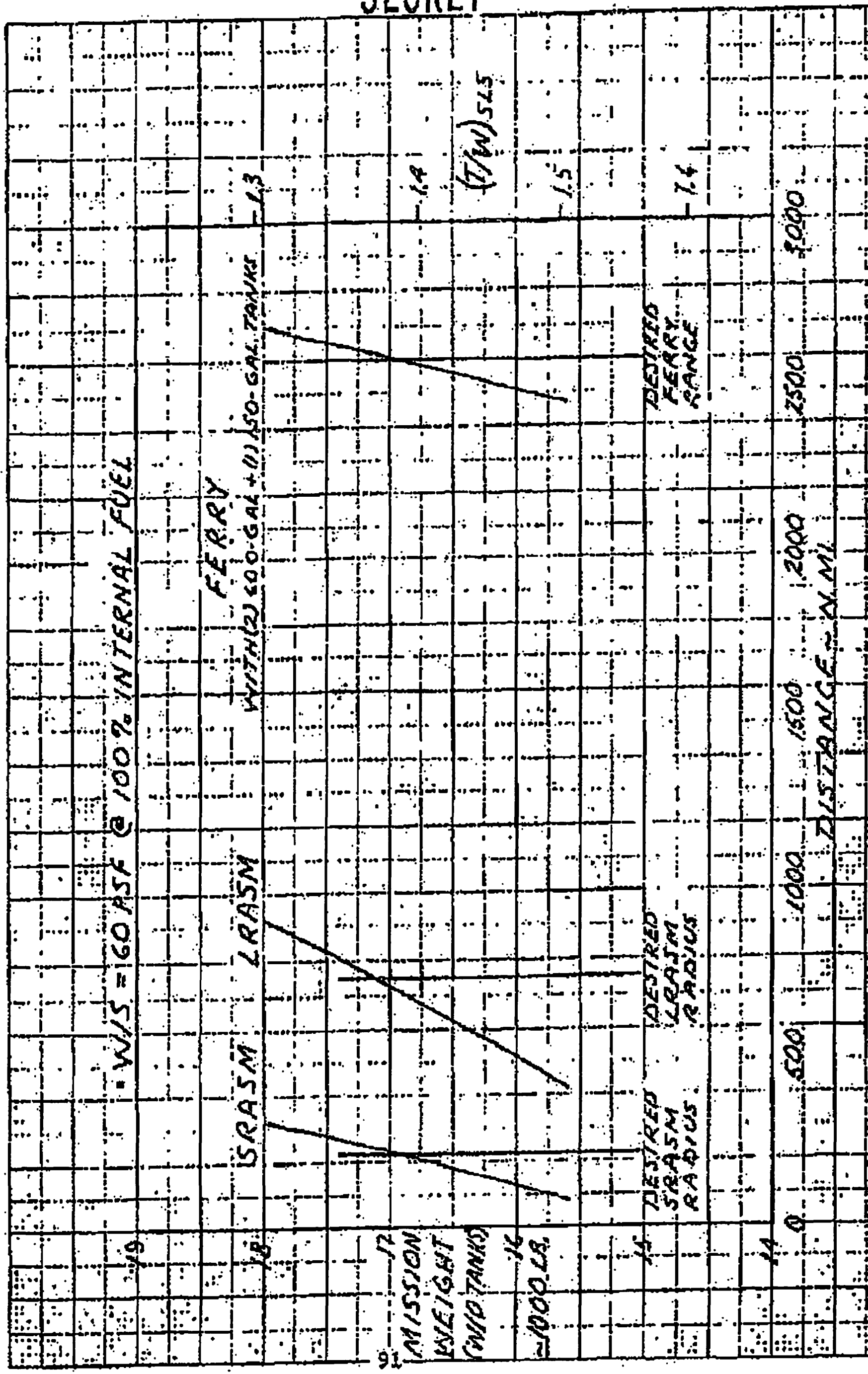
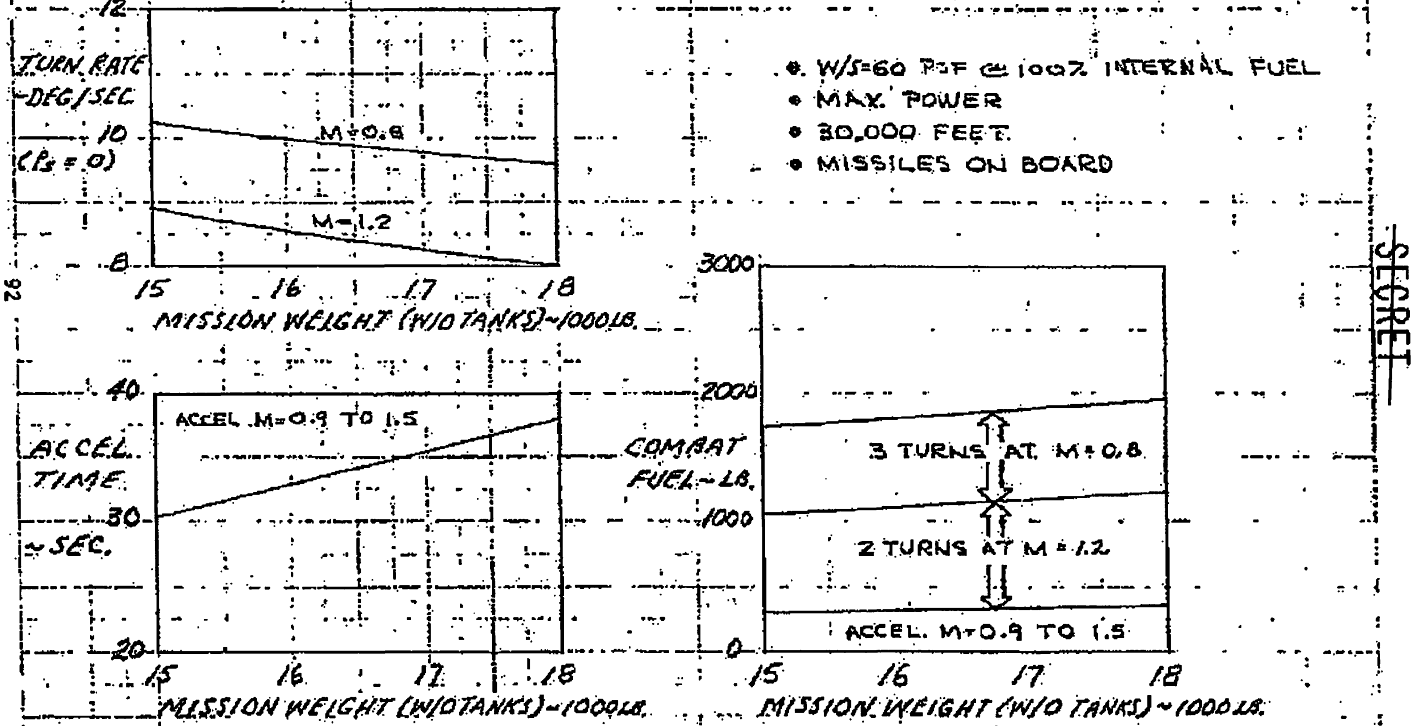
88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC: 3.3.(b)
(4)
1.4. (a)(g)



~~(S)~~ Figure 3.2-16 Configuration 401B Growth Curve (U)



~~(S)~~ Figure 3.2-17 Configuration 401B LRASM Maneuver Sensitivity to Aircraft Size (U)

88th ABW/IP
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

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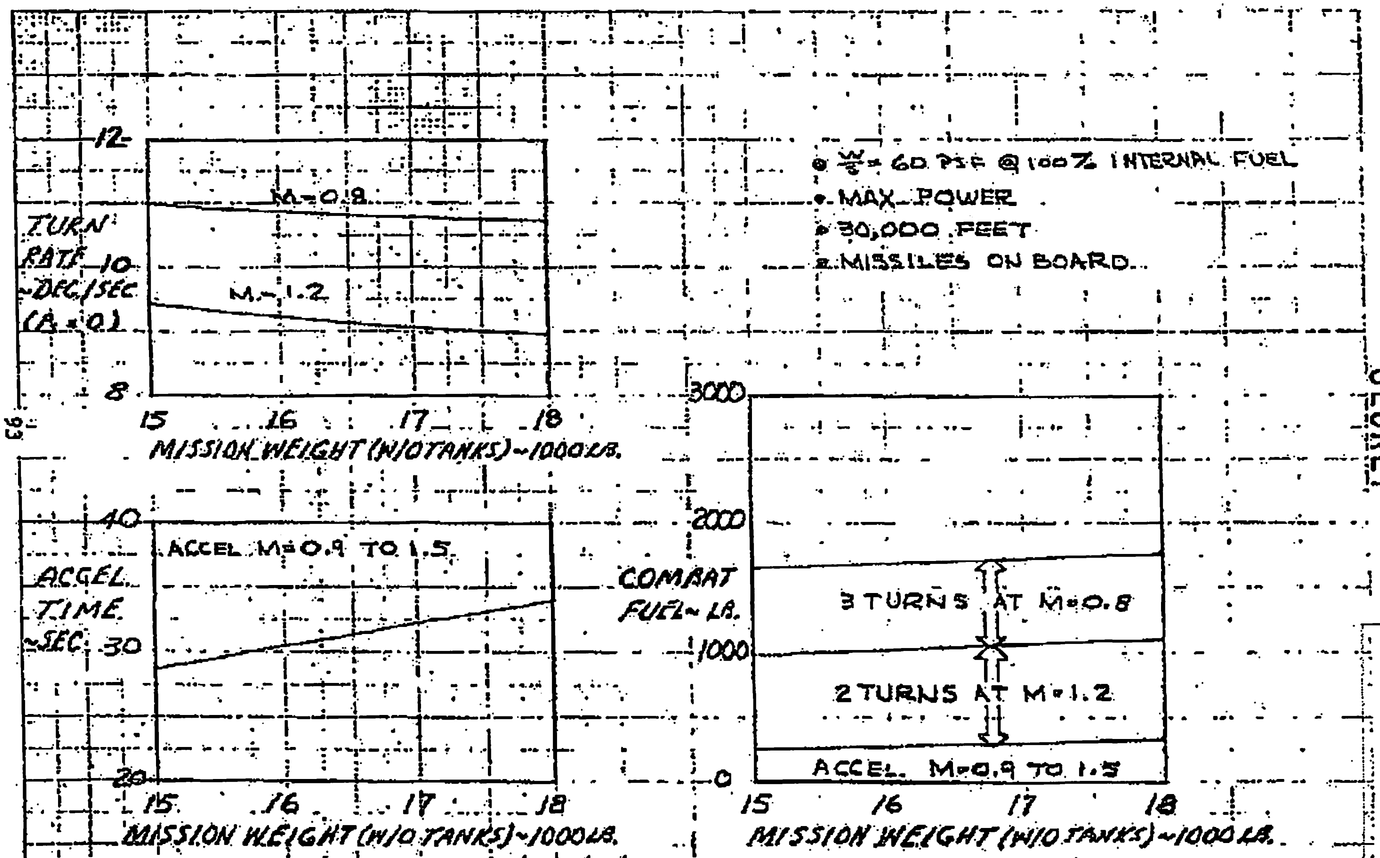

~~(S)~~ Figure 3.2-18 Configuration 401B SRASM Maneuver Sensitivity to Aircraft Size (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526,SEC. 3.3(b)(4)
1.4. (a)(g)

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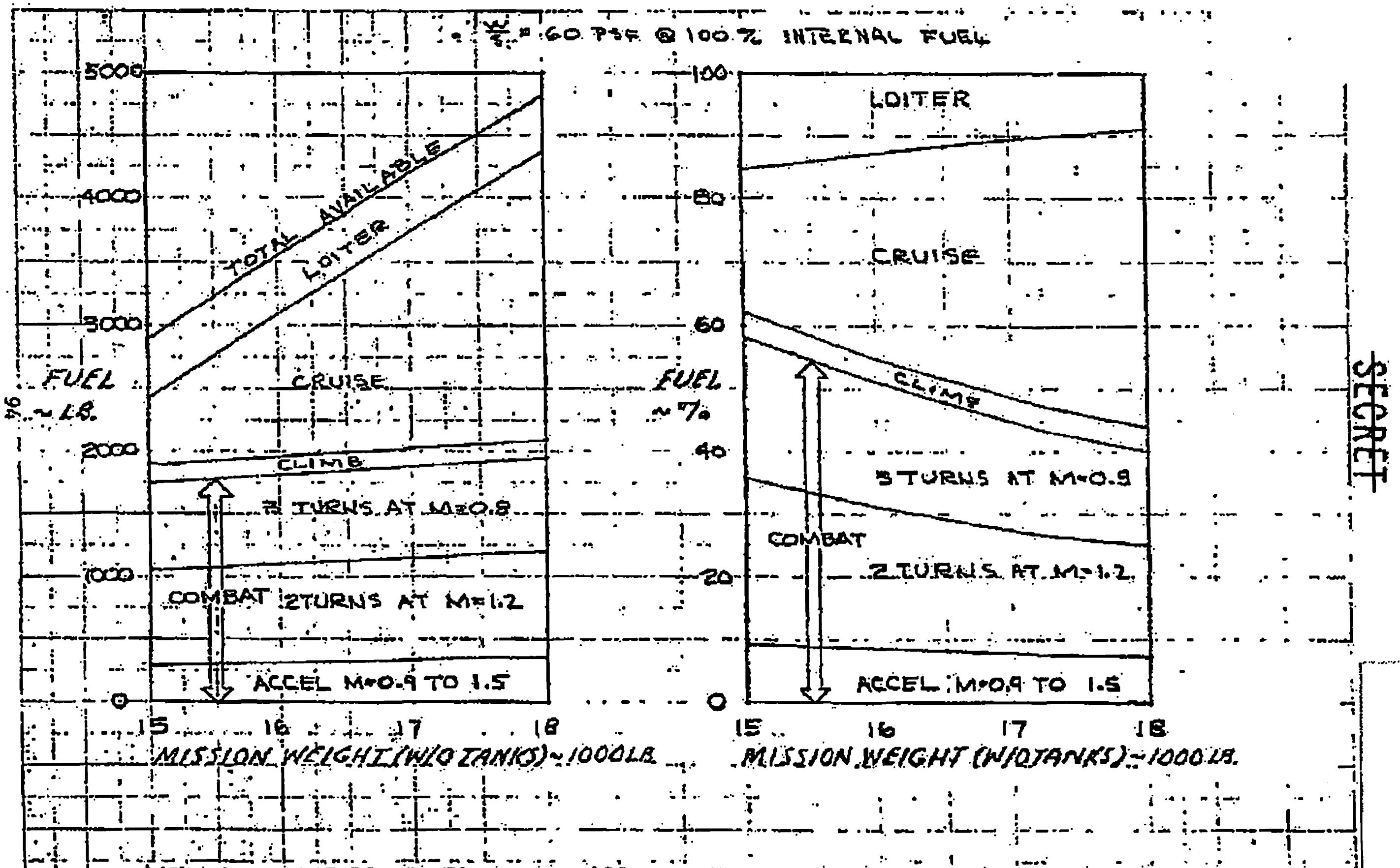

~~(S)~~ Figure 3.2-19 Configuration 401B LRASM Total Fuel Usage vs Aircraft Size (U)

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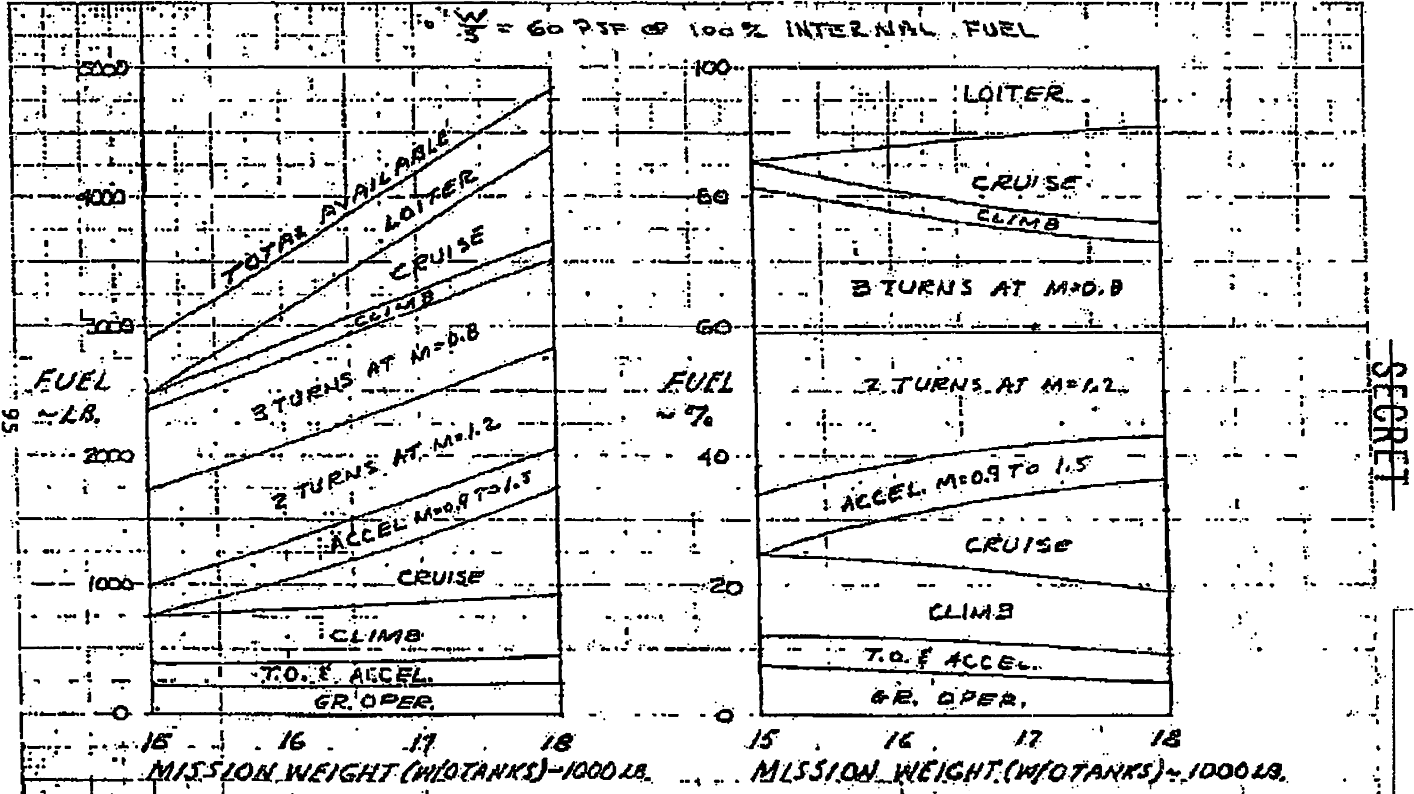
88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

SECRET



(S) Figure 3.2-20 Configuration 401B SRASM Total Fuel Usage vs Aircraft Size (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3,
(b)(4)
1.4. (a)(g)

3.3 AERODYNAMICS

(U) The aerodynamic characteristics of the baseline airplane, Configuration 401B, are presented in this section. The data are derived from theoretical and empirical methods and from wind tunnel data for a similar configuration developed during Convair's FX proposal effort (FX-132).

(U) The total drag of the airplane is defined by

$$C_{D_{total}} = C_{D_{min}} + \Delta C_{D_{stores}} + C_{D_L} + (\Delta C_{D_{min}})_{\delta_{LEF}} + \Delta C_{D_{trim}}$$

Each of the above terms is discussed in the following subsections.

3.3.1 Minimum Drag

3.3.1.1 Basic Minimum Drag

(U) The minimum drag at subsonic speeds is defined by

$$C_{D_{min}} = C_{D_{friction}} + C_{D_{form}} + \Delta C_{D_{canopy}} + \Delta C_{D_{nozzle}}$$

$$+ \Delta C_{D_{diverter}} + \Delta C_{D_{cowl}} + \Delta C_{D_{\substack{secondary\\systems}}} + \Delta C_{D_{\substack{missile\\pylons}}}$$

$$+ \Delta C_{D_{protuberances}}$$

The equation is the same for supersonic speeds except that $C_{D_{form}}$ is replaced by $C_{D_{wave}}$.

(U) Configuration 401B total minimum drag (or drag at zero-lift) is plotted in Figure 3.3-1 for various altitudes. The method used to determine the minimum-drag buildup is consistent with Convair's experience in correlating analytical methodology with wind tunnel and flight test data. Use of this method assures that the drag levels are realistic.

(U) The friction and subsonic form drag are computed by the methods documented in Reference 1, and the zero-lift wave drag is obtained from the Convair Aerospace supersonic area-rule method (digital computer procedure K35). The predicted effect of curved wing tips on minimum drag is based

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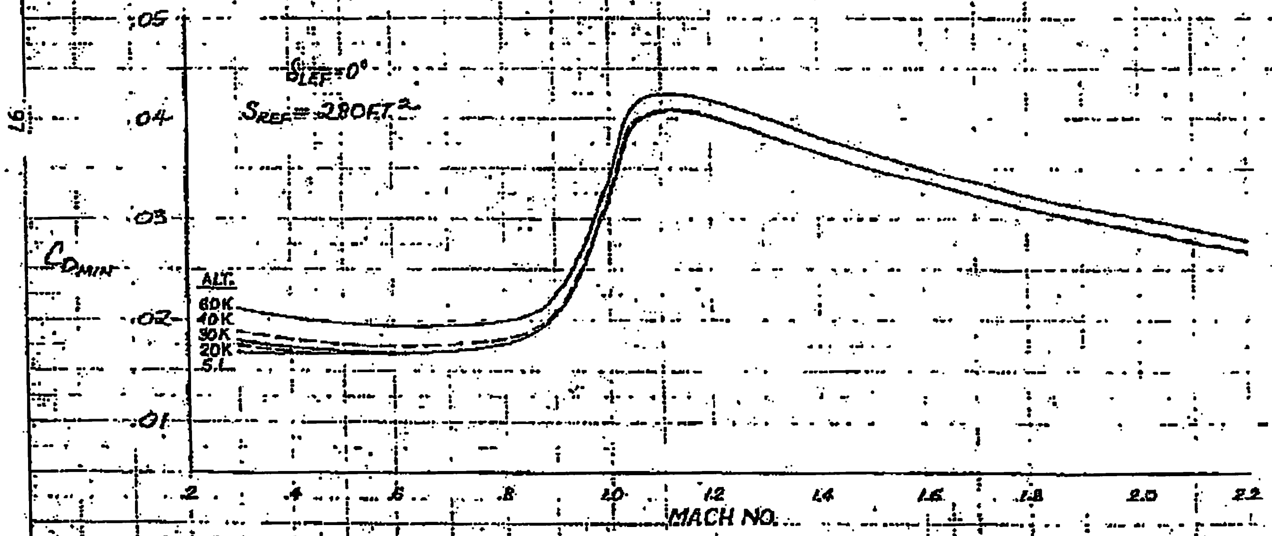

~~(S)~~ Figure 3.3-1 Minimum Drag vs Mach Number, Configuration 401B(U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

on an empirical correlation of wing tunnel data on the effects of tip shape (Reference 2). It is estimated that the tip curvature of 401B reduces the minimum drag coefficient by .0005 at subsonic speeds and by .0015 at supersonic speeds. These are the increments applied to the form and wave drag components, respectively, in the minimum drag buildup.

(U) The remaining increments in the above equation require special treatment and are discussed in the following paragraphs. The incremental minimum drag variations with Mach number for the effects of canopy, nozzle, diverter, cowl, secondary systems, missile pylons, and protuberances are plotted in Figures 3.3-2.

(U) Canopy. The canopy drag is derived from Convair FX wind tunnel test C.A.L. 316-133. The test canopy is similar to the canopy on Configuration 401B. As a result, the 401B canopy D/q is obtained from the test data by ratioing the canopy frontal areas and then basing the drag coefficient on the 401B wing reference area.

(U) Nozzle. The reference nozzle drag is the boattail pressure drag on the installed nozzle. An average maximum-power nozzle position (40-inch exit diameter) was used as the reference nozzle position for all (both subsonic and supersonic) calculations of the reference nozzle drag. Variations in nozzle drag due to engine power setting are included in the thrust. Reference nozzle drag is estimated by use of the "Revised McDonald-Hughes Method," as described in Reference 3. Additional discussion of the nozzle drag is given in Section 3.6.

(U) Diverter. This drag increment is the pressure drag on the inlet boundary-layer diverter. It is determined from a computation of the average wedge pressure coefficient accounting for the total pressure loss through the boundary layer, when significant.

(U) Cowl. This drag increment accounts for the compression due to the locally high slopes in the first 30 inches of the inlet cowl when operating at a A_0/A_i of 1.0 (the basic drag equation applies at $A_0/A_i = 1.0$ only). A second-order shock-expansion method applicable to bodies of revolution (Reference 4) was used to predict this increment. Cowl drag variation with reduced A_0/A_i are included in the propulsion data (Section 3.6).

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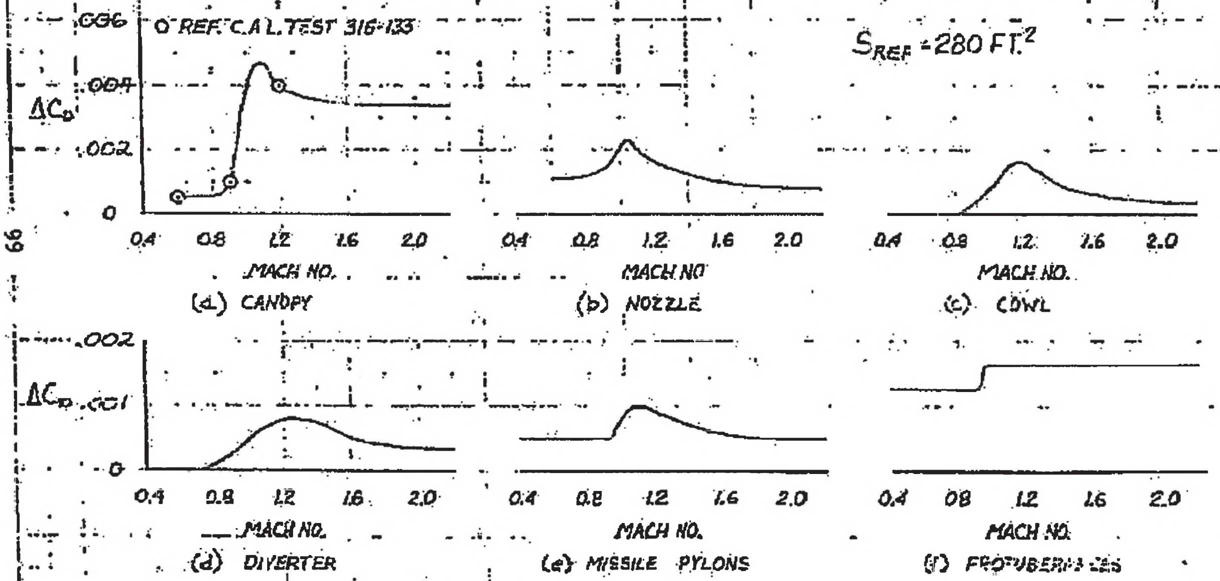


~~(S)~~ Figure 3.3-2 Components Used in Minimum Drag Buildup, Configuration 401B (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

(U) Secondary Systems. This drag increment accounts for momentun losses due to the aircraft auxiliary air systems. These systems encompass all functions, other than the engine, requiring external air. Included are the ECS ram-air system, the gun-compartment purging system, the oil-cooler air system, and the engine-compartment air system. The drag coefficient increment applied for these systems on 401B is .0002 at both subsonic and supersonic speeds. A momentun-loss analysis for the secondary-air system is the basis for this estimate. Additional discussion is provided in Section 3.6.

(U) Missile Pylons. This drag increment accounts for the two AIM-9X missile pylons. It is based on test data reported in References 5 and 6 adjusted for pylon size differences.

(U) Protuberances. This is an estimate of the drag due to antennae, air-data probes, ram-air scoops, navigation lights, and static dischargers. This drag term is based on data provided in Reference 7.

3.3.1.2 External Store Drag

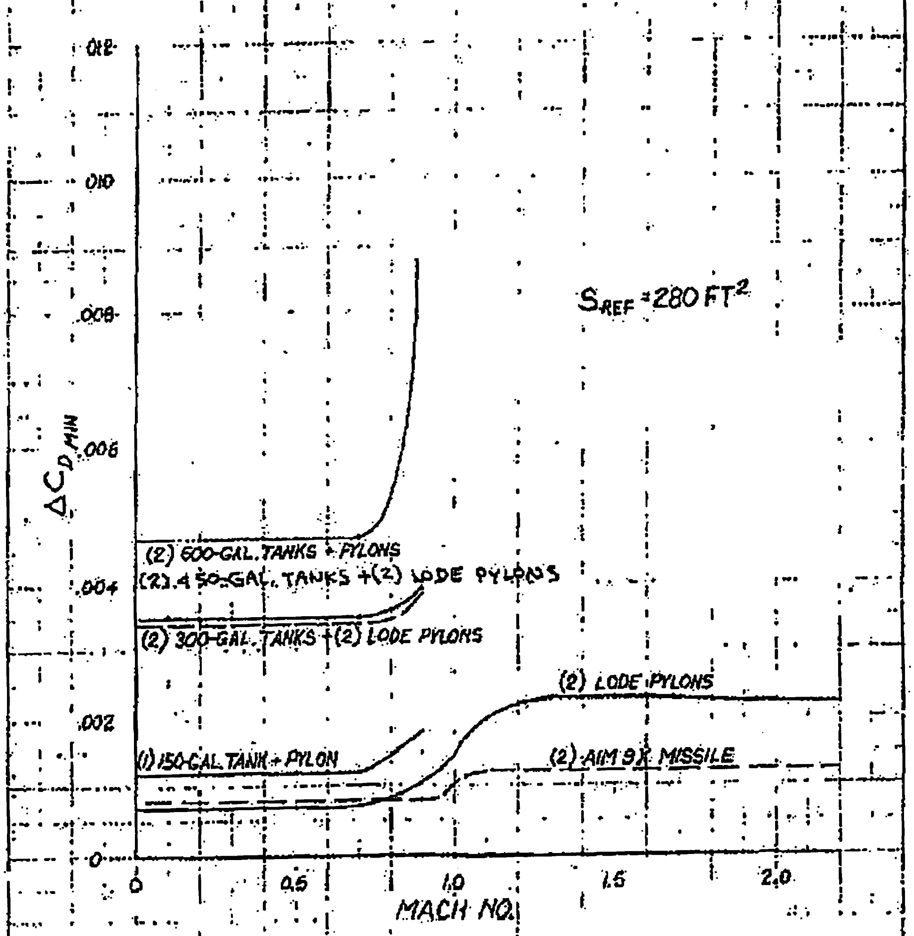
(U) The external store drags used in mission performance calculations are shown in Figure 3.3-3. The increments are derived from F-111 test data documented in References 5 and 6.

3.3.1.3 Airplane Growth Effects

(U) The variation of minimum drag drag coefficient with aircraft size (gross weight) at constant wing loading is presented in Figure 3.3-4. The basic form and friction drag were computed for two other gross-weight airplanes, 15,600 and 18,000 lb. Canopy, nozzle, cowl, diverter, secondary systems, missile pylons and protuberances are assumed to have constant D/q, (i.e., are constant size and independent of airplane size). Also, it is assumed that the ratio of tail and ventral area to wing area is approximately independent of airplane size, and, therefore, the wave drag coefficient of the wing, tails, and ventrals is constant. The fuselage wave drag coefficient (based on frontal area) is considered to be inversely proportional to the square of the fineness ratio; therefore,

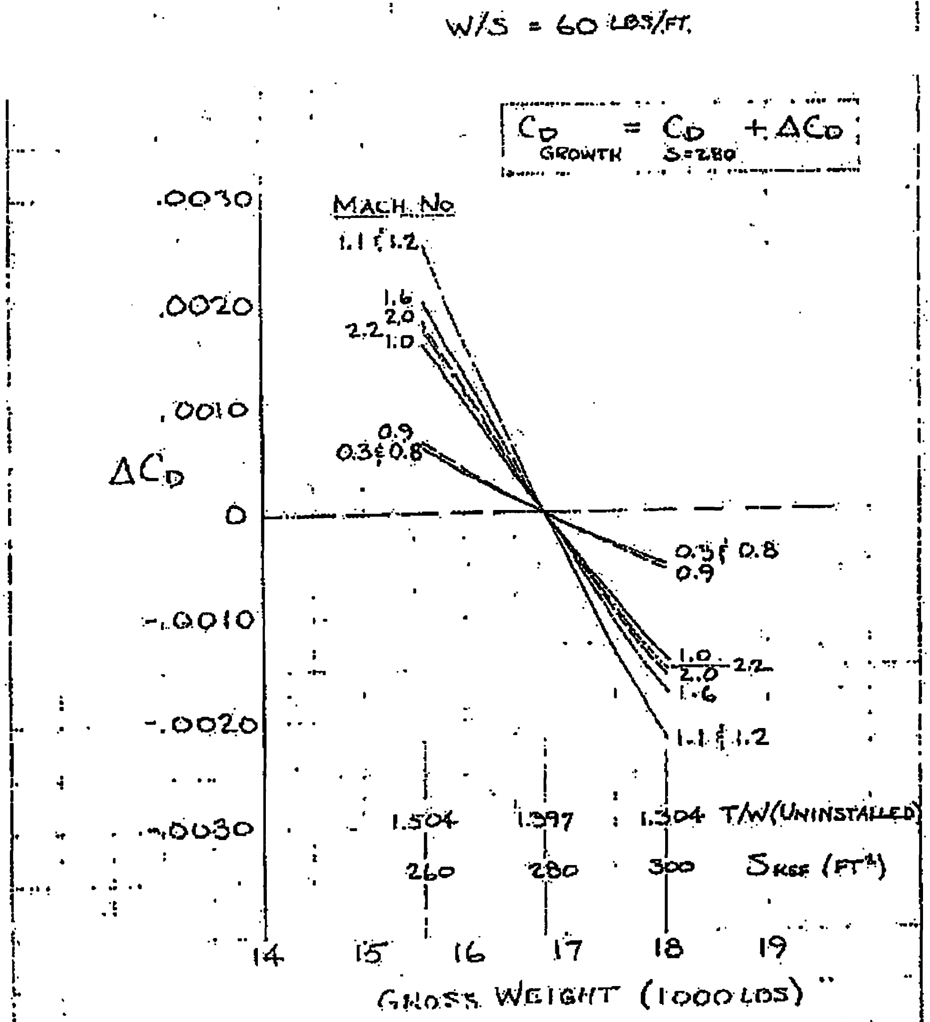
$$(C_{D_{wave}})_{fuselage} \propto \frac{1}{FR^2} \left(\frac{A_{frontal}}{S_{ref}}\right)$$

~~88th ABW/IPK~~
FOIA (b)(1)
E.O. 13526 SEC. 3.3(b)(4);
1.4(a)(g)
Sec 3.3 Sec 1.4(a)(g)
2035



~~(S)~~ Figure 3.3-3 External Store Drags (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.3-4 Effect of Aircraft Size on Minimum Drag Coefficient, Configuration 401B (U)

(U) If an estimate of the length and frontal area variation with aircraft size is given, the variation of fuselage wave drag can be computed.

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC.
3.3 (b)(4)
1.4 (a)(g)
FOIA (b)(1)
EO 13526
SEC 3.3 (b)(4)
SEC 1.4 (a)(4)

~~(S)~~ The minimum drag presented above in Subsection 3.3.1.1 is for the initial design gross weight of 16,800 lb. The final gross weight required for mission performance is slightly higher, 17,115 lb, and the minimum drag can be adjusted accordingly from the data of Figure 3.3-4.

3.3.2 Drag Due to Lift

(U) The drag polar shape, including the effects of leading-edge flaps, are based on Convair Aerospace FX wind tunnel tests at the Cornell Aeronautical Laboratory (C.A.L. Test 316-113 and C.A.L. Test G52-423). The validity of this data for application to Configuration 401B is readily seen in Figure 3.3-5, where the planforms of the FX-132 wind tunnel model and Configuration 401B are compared.

(U) The leading-edge-flap design on the wind tunnel model has

$$C_f/C = 18\% \text{ at the root}$$

and

$$C_f/C = 30\% \text{ at the tip}$$

This is identical to the leading-edge maneuver flap designed for Configuration 401B.

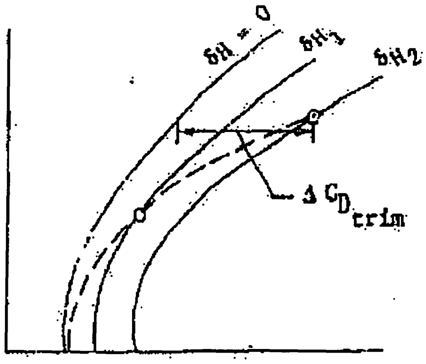
The only adjustments made to the test data are

1. An aspect ratio correction of 3.0 to 3.2.
2. A t/c correction of .035 to .040.

(U) The drag-due-to-lift polars are presented for specific Mach numbers at the pertinent leading edge flap settings in in Figures 3.3-6 through 3.3-10. The minimum-drag increment due to leading-edge flap deflection is defined in Figure 3.3-11.

3.3.3 Trim Drag

(U) Trim drag is defined to be the drag increment at constant C_L between the $\delta_H = 0$ polar and the $\delta_H = \delta_{H_{trim}}$ polar as shown by the sketch below.



(U) The longitudinal stability characteristics and horizontal tail deflections required to trim are discussed in Section 3.4. These required deflections at various pertinent flight conditions are plotted in Figure 3.3-12.

(U) The estimated drag due to these deflections, shown in Figure 3.3-13, is based on wind tunnel data (from C.A.L. Test G52-423) for an FX-132 configuration with an aspect ratio 3.0 planform, differing only slightly ($\Lambda = 31.5^\circ$ instead of 35°, $\lambda = 0.3$ instead of 0.2) from the one shown in Figure 3.3-5. The airfoil (.035 biconvex) and leading-edge flap are identical.

(U) As indicated in Figures 3.3-12 and -13 all performance calculations are made for a center of gravity of 27% MAC, which was selected to provide a minimum of 3% static margin within the combat envelope.

3.3.4 Trimmed Drag Polars

(U) The trimmed drag polars used in the performance calculations are shown in Figures 3.3-14 through 3.3-19. The high C_L drag polars used for the energy-maneuverability plots are given in Figure 3.3-18. The trimmed drag polars used in takeoff and landing calculations are given in 3.3-19. In Figures 3.3-20 through 3.3-24, the same data are plotted on the basis of $C_L/(W/S)$ versus $C_D/(W/S)$.

(U) Trimmed $(L/D)_{max}$ versus Mach number is presented in Figure 3.3-25 for various leading-edge flap deflections. It is seen that the leading-edge flap design of Configuration 401B is a very effective cambering device. A deflection of 10 degrees increases the $(L/D)_{max}$ by 20 percent, to 10.8. This is only about 12 percent less than the $(L/D)_{max}$ expected for a blunt-nosed cambered airfoil, and the variable flap eliminates the off-design penalties associated with fixed camber.

3.3.5 Lift and Buffet Characteristics

(U) Trimmed and untrimmed C_L-vs-α curves for Configuration 401B are shown in Figures 3.3-26 through 3.3-29. The trimmed C_L-vs-α curves for takeoff and landing are shown in Figure 3.3-30. These lift predictions are based on C_L-vs-α and C_L-vs-δ_H from C.A.L. Test G52-423 mentioned earlier.

(U) The method used for predicting buffet characteristics is based on an analysis of the C_L-vs-α curves in the nonlinear region. This method has been checked through comparison with available flight data, and reasonable agreement has been obtained. Derivation and documentation of the method is contained in Reference 8.

(U) The following boundaries are defined in terms of predicted flight buffet acceleration:

buffet onset: $\Delta n_B = \pm .05g$

moderate buffet: $\Delta n_B = \pm .25g$

heavy buffet: $\Delta n_B = \pm .50g$

(U) These buffet boundaries are shown in Figure 3.3-31 as a function of Mach number. It is readily seen that the leading-edge flap design for Configuration 401B raises the buffet boundaries to a highly desirable level for buffet-free sustained turns at Mach 0.8/30,000-ft altitude.

(U) Configuration planforms of the 401B and FX-132 type generate large amounts of vortex lift after the main wing has stalled, and the maximum C_L is limited only by tail power. The control limit C_L for Configuration 401B is shown as the upper boundary in Figure 3.3-31 (also see Section 3.4).

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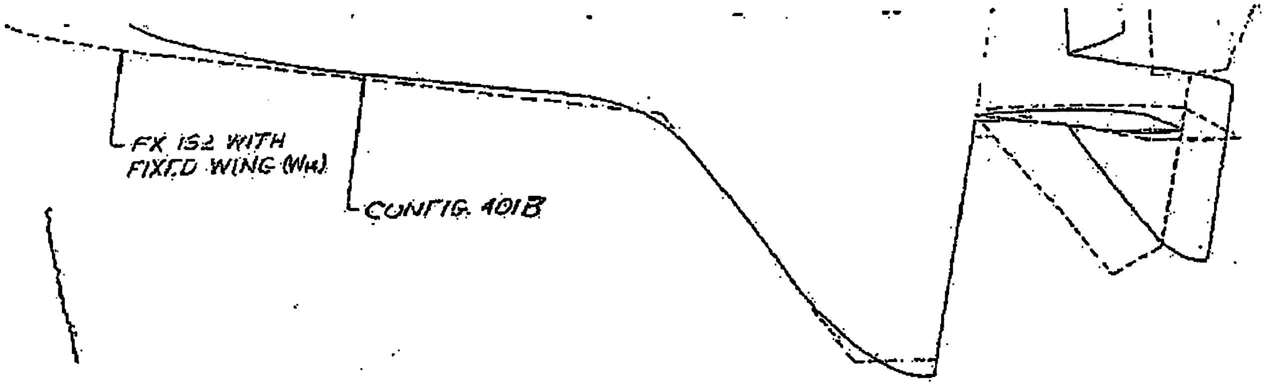
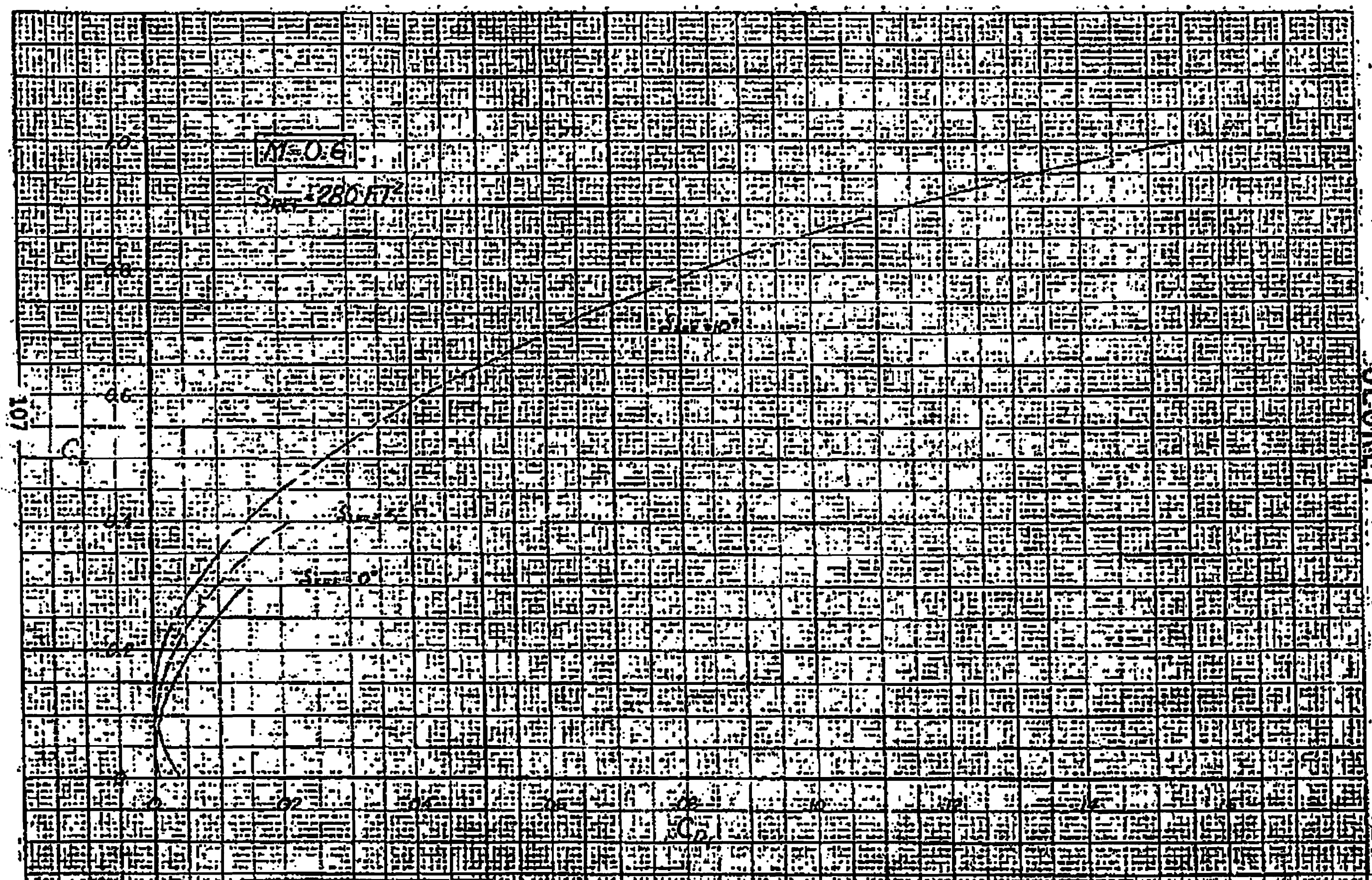


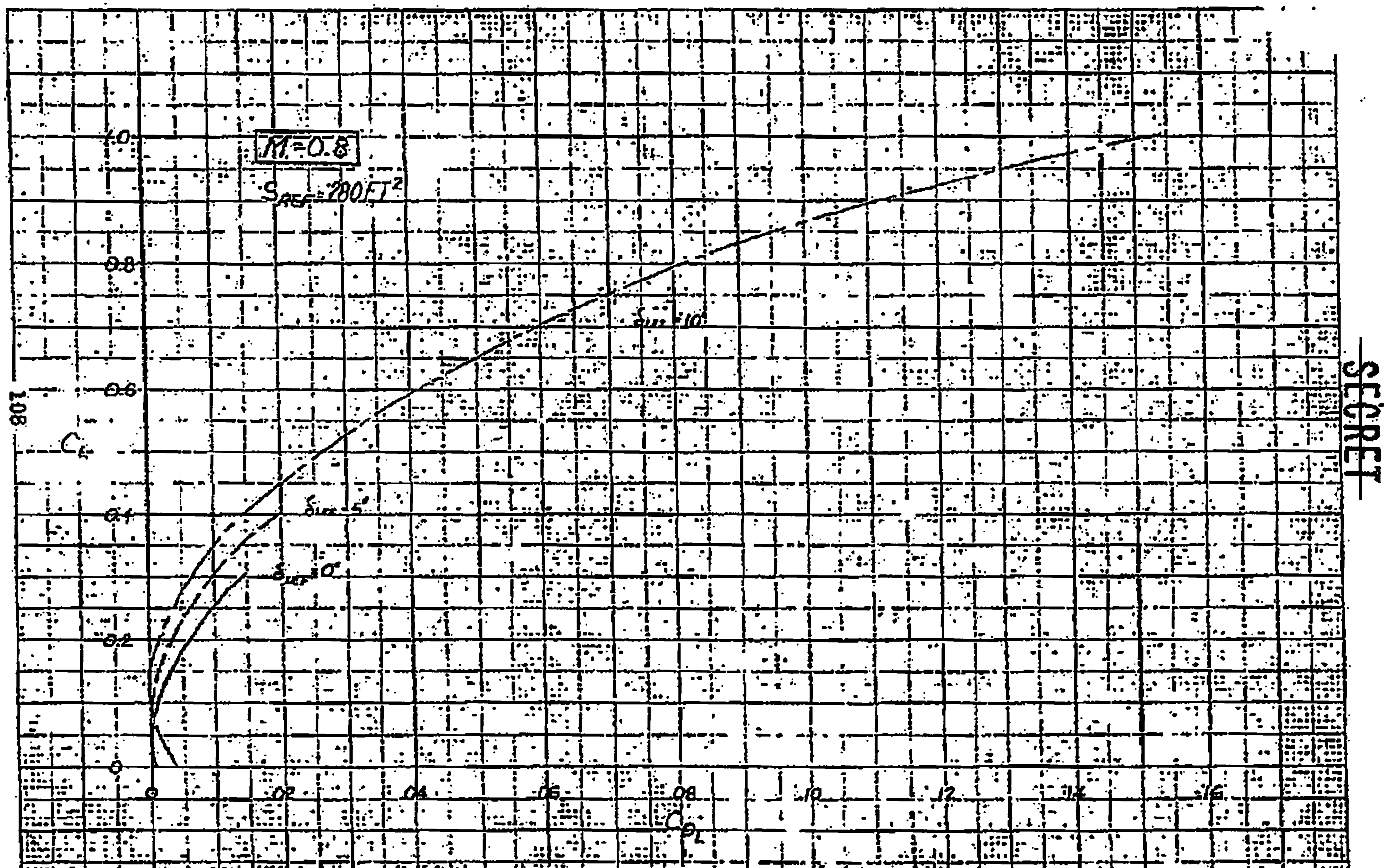
~~(S)~~ Figure 3.3-5 Planforms of Configuration 401B and the FX-132 Wind Tunnel Model (U)

~~SECRET~~

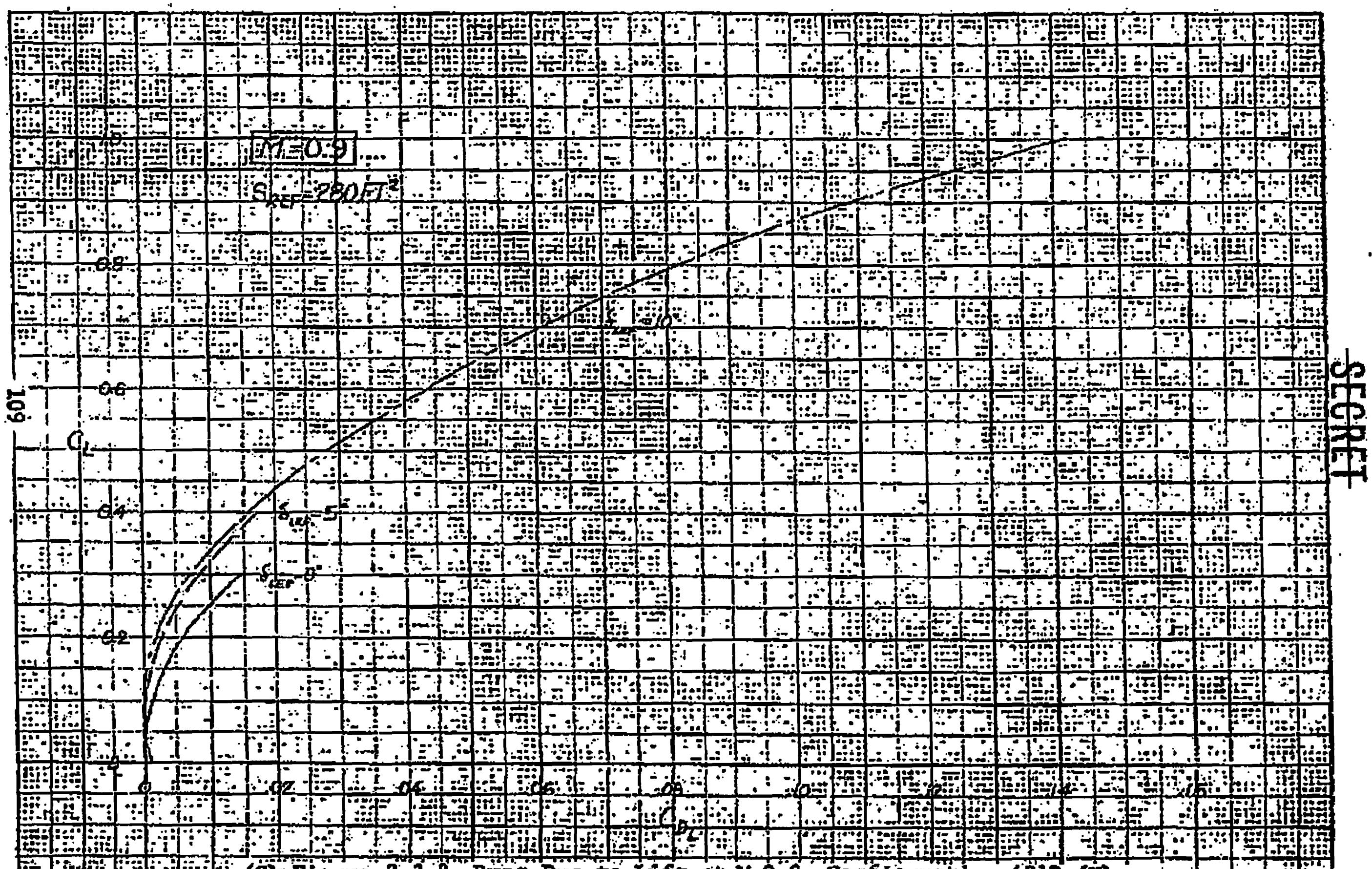


~~(S)~~ Figure 3.3-6 Drag Due to Lift at M=0.6, Configuration 401B (U)

88th ABW/PI
FOIA (b)(1)
E.O 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.3-7 Drag Due to Lift at M=0.8, Configuration 401B (U)

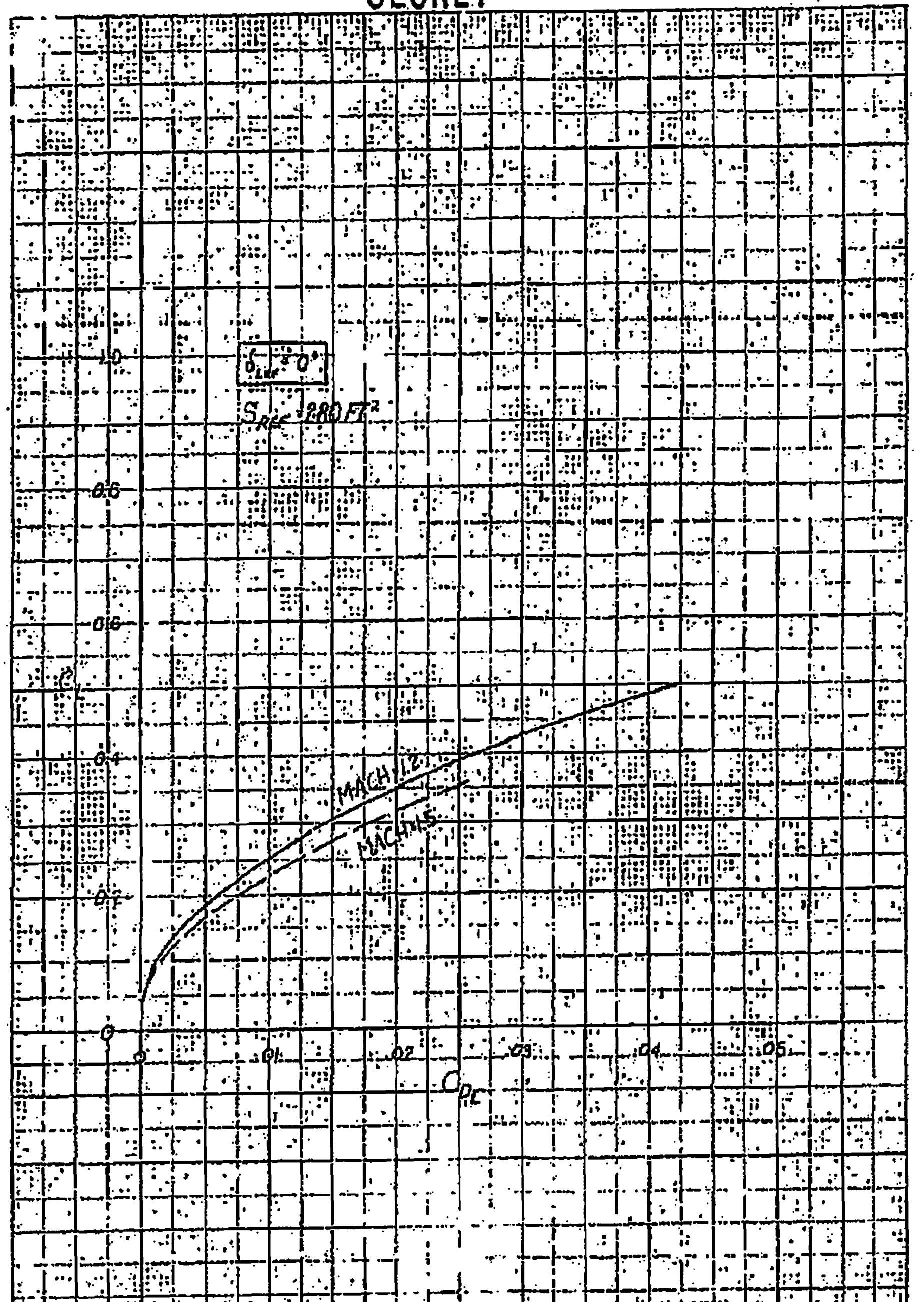


~~(S)~~ Figure 3.3-8 Drag Due to Lift at M=0.9, Configuration 401B (U)

88th
ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)
(4)
1.4. (a)(g)

~~SECRET~~

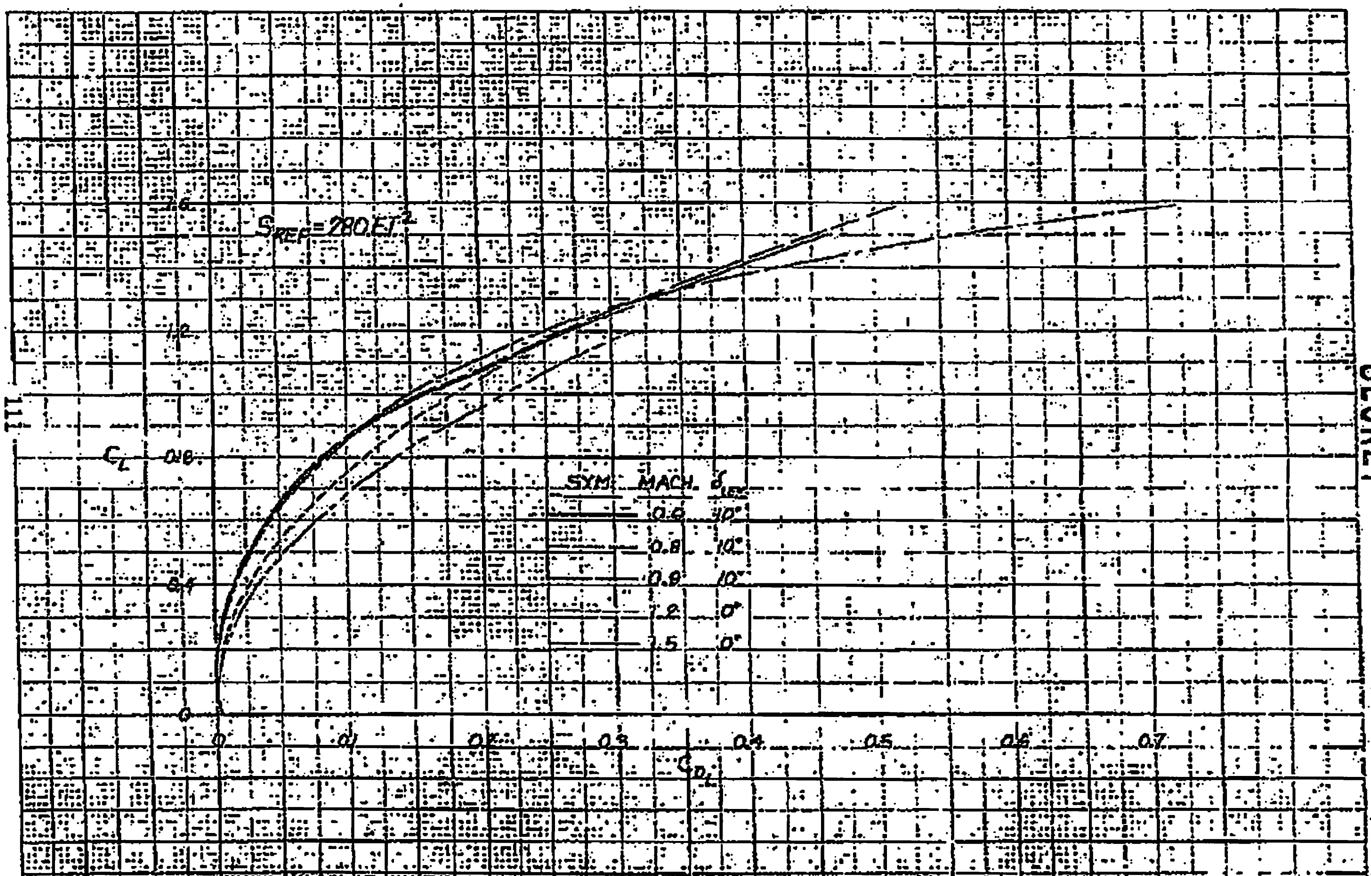
88th
ABW/IPI
FOIA (b)(3)
E.O.13526
SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.3-9 Drag Due to Lift at M=1.2 and M=1.5, Configuration 401B (U)

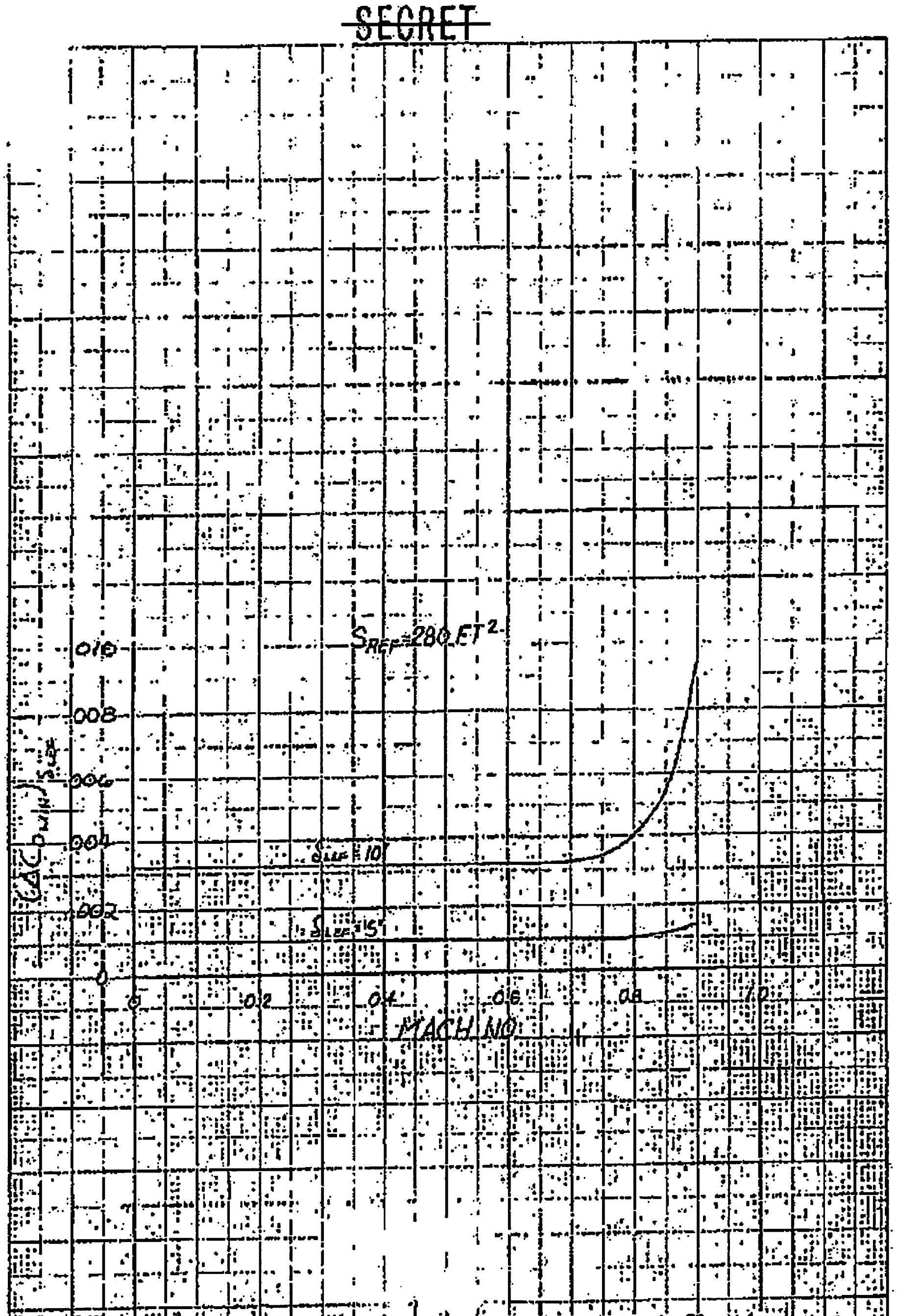
~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 3.3-10 Drag Due to Lift at High C_L's, Configuration 401B (U)

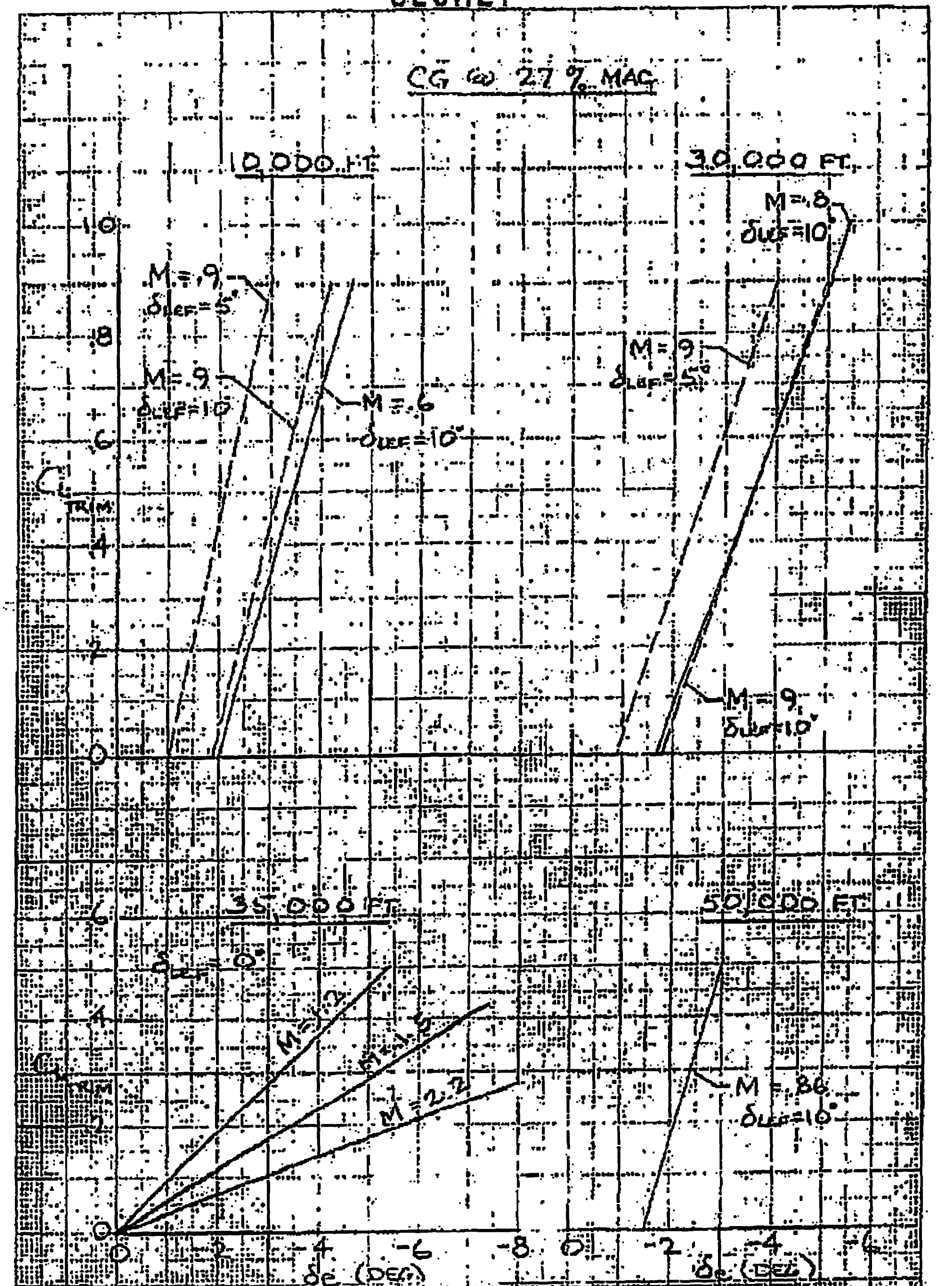
88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)



(S) Figure 3.3-11 Minimum Drag Increment Due to Deflection of Leading-Edge Flap (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 3.3-12 Estimated Trim Horizontal Fail Deflections, Configuration 401B (U)

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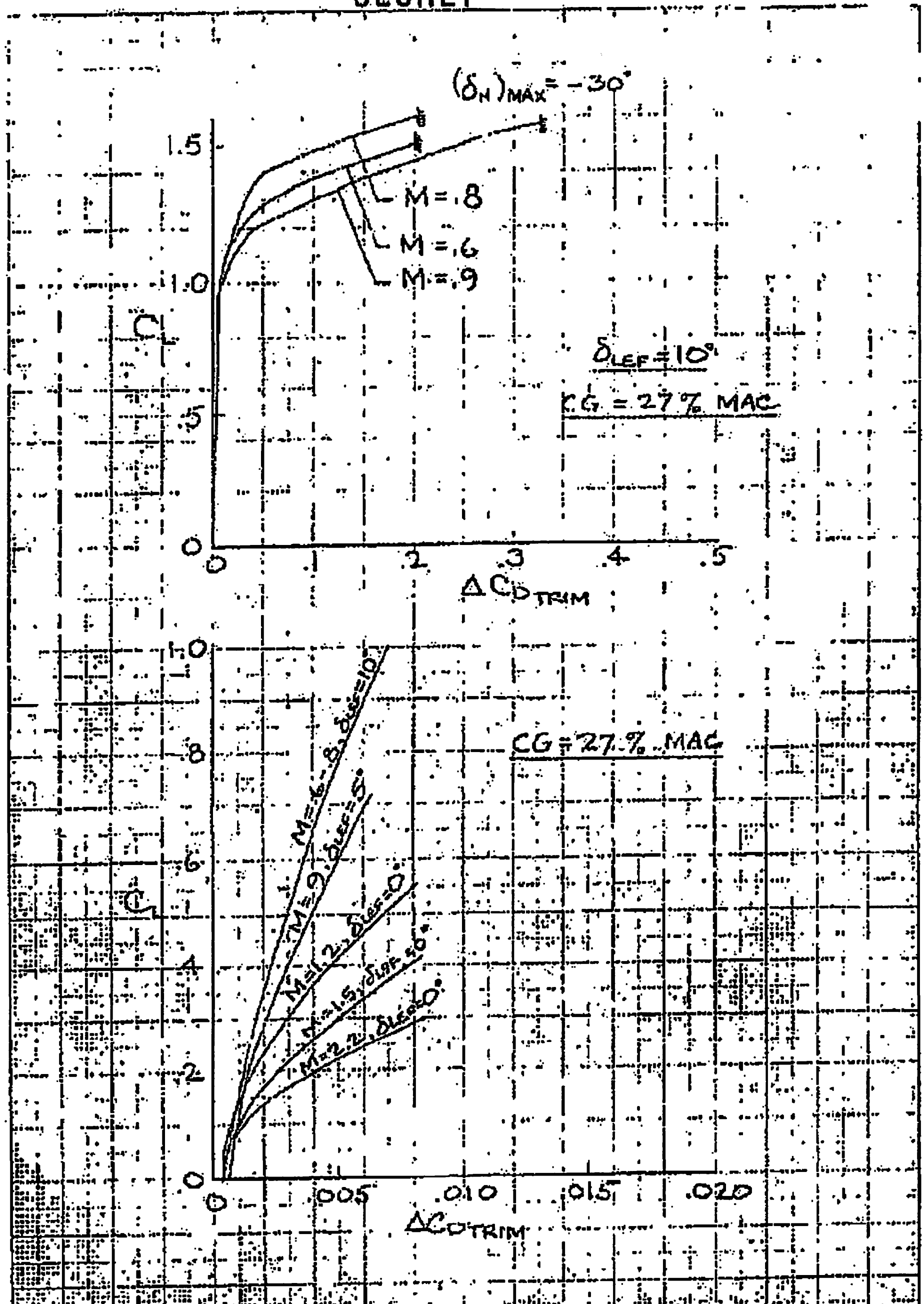
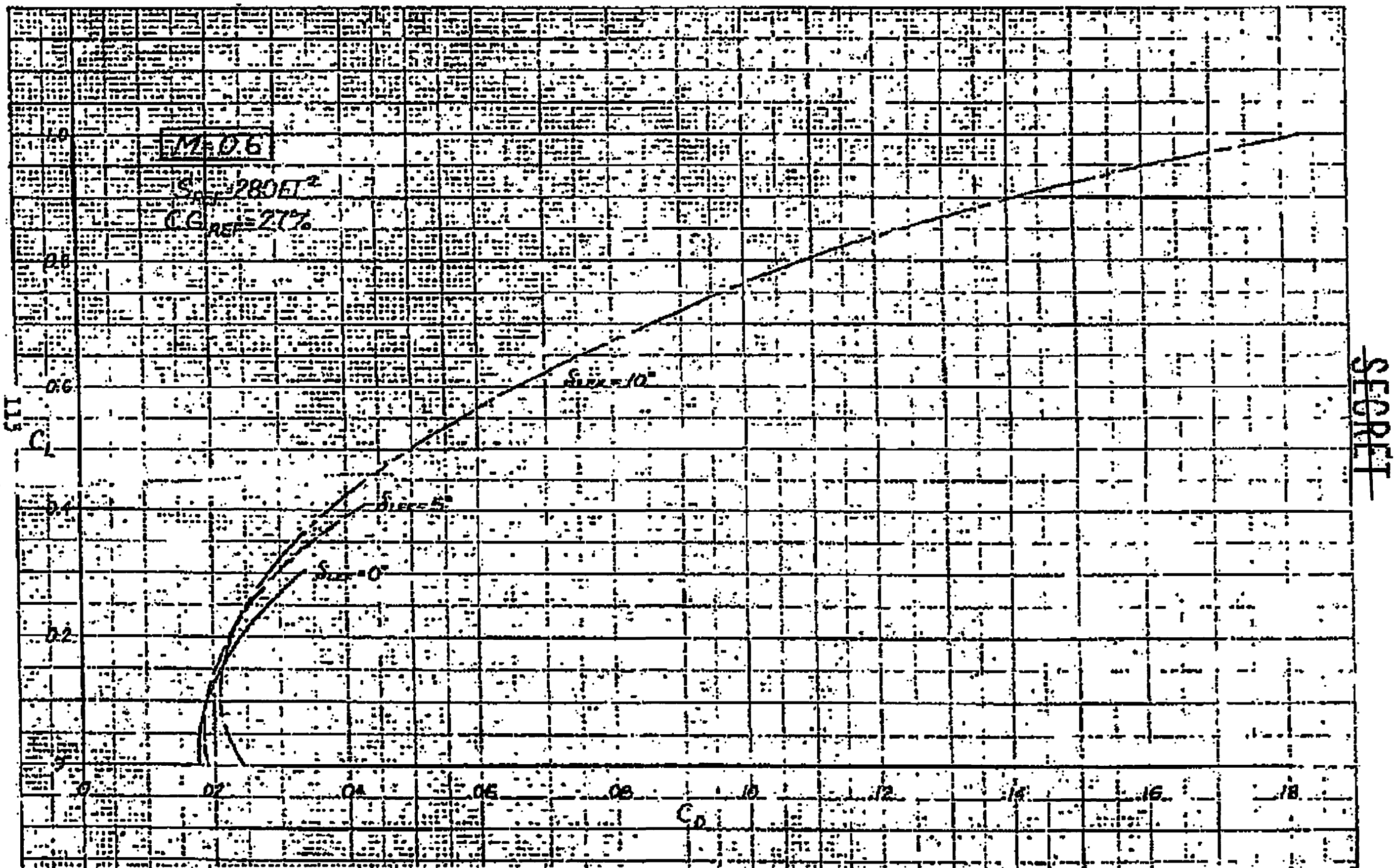


~~(S)~~ Figure 3.3-13 Trim Drag, Configuration 401B (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 3.3-14 Trimmed Drag Polars at M=0.6, Configuration 401B (U)

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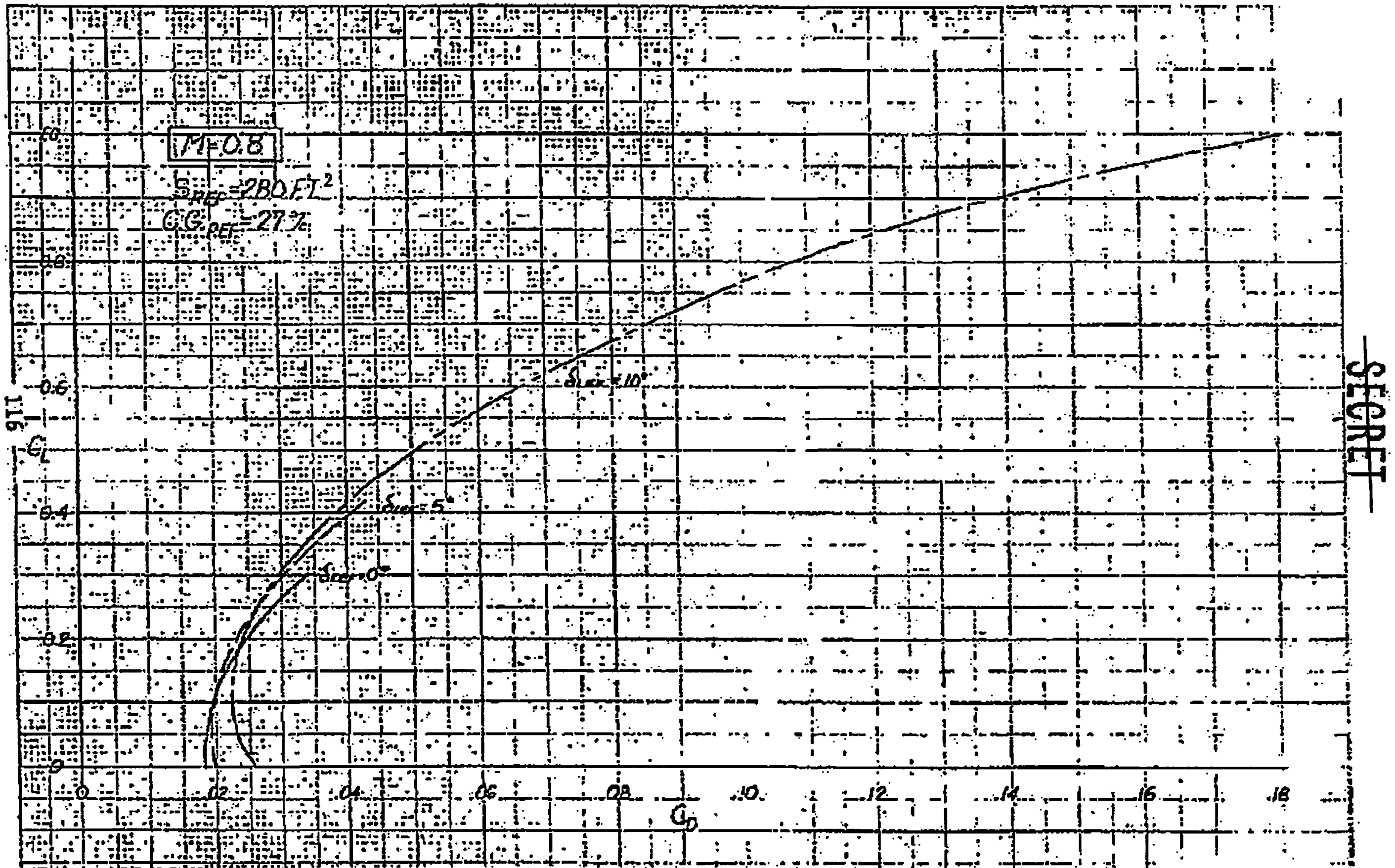
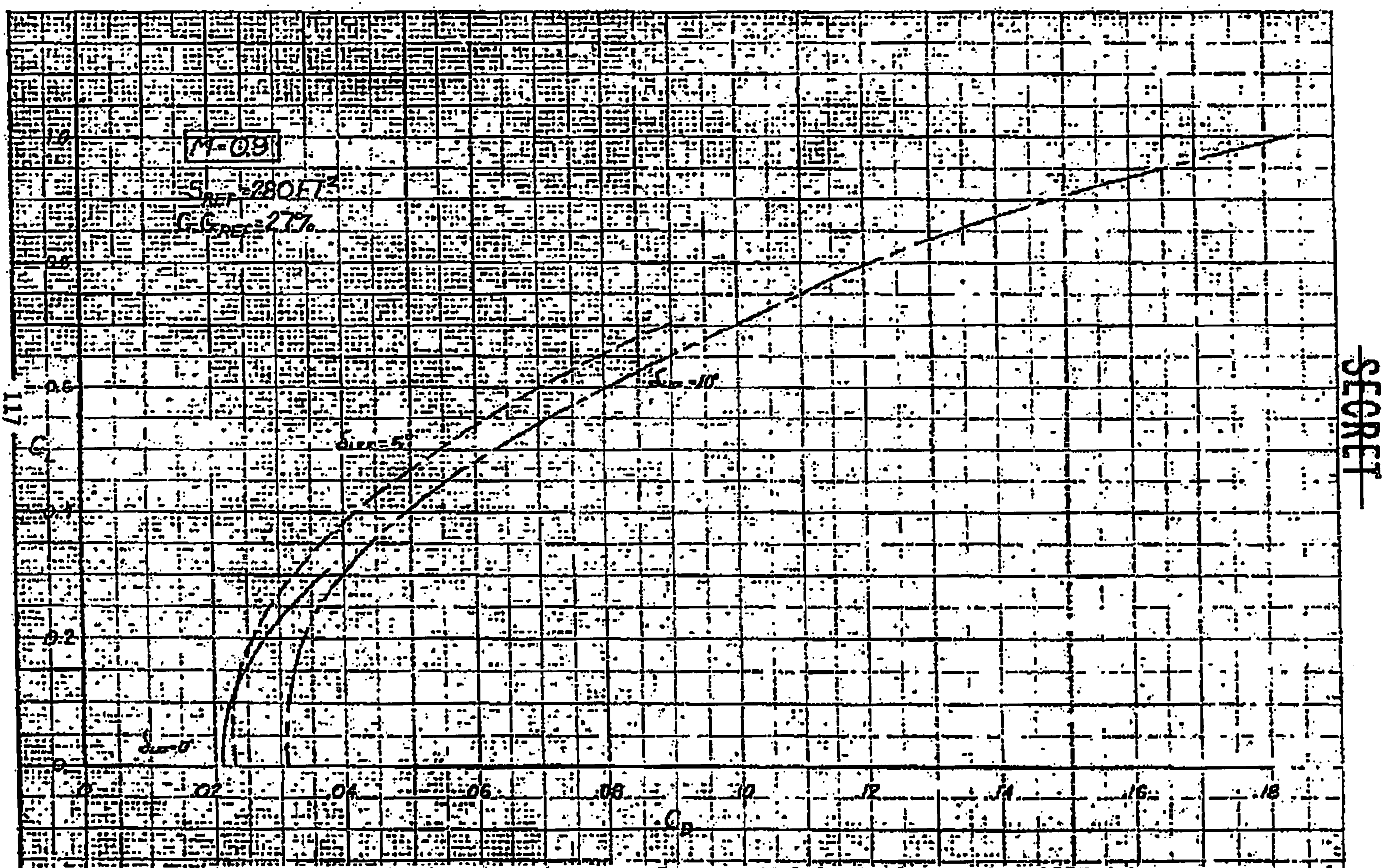
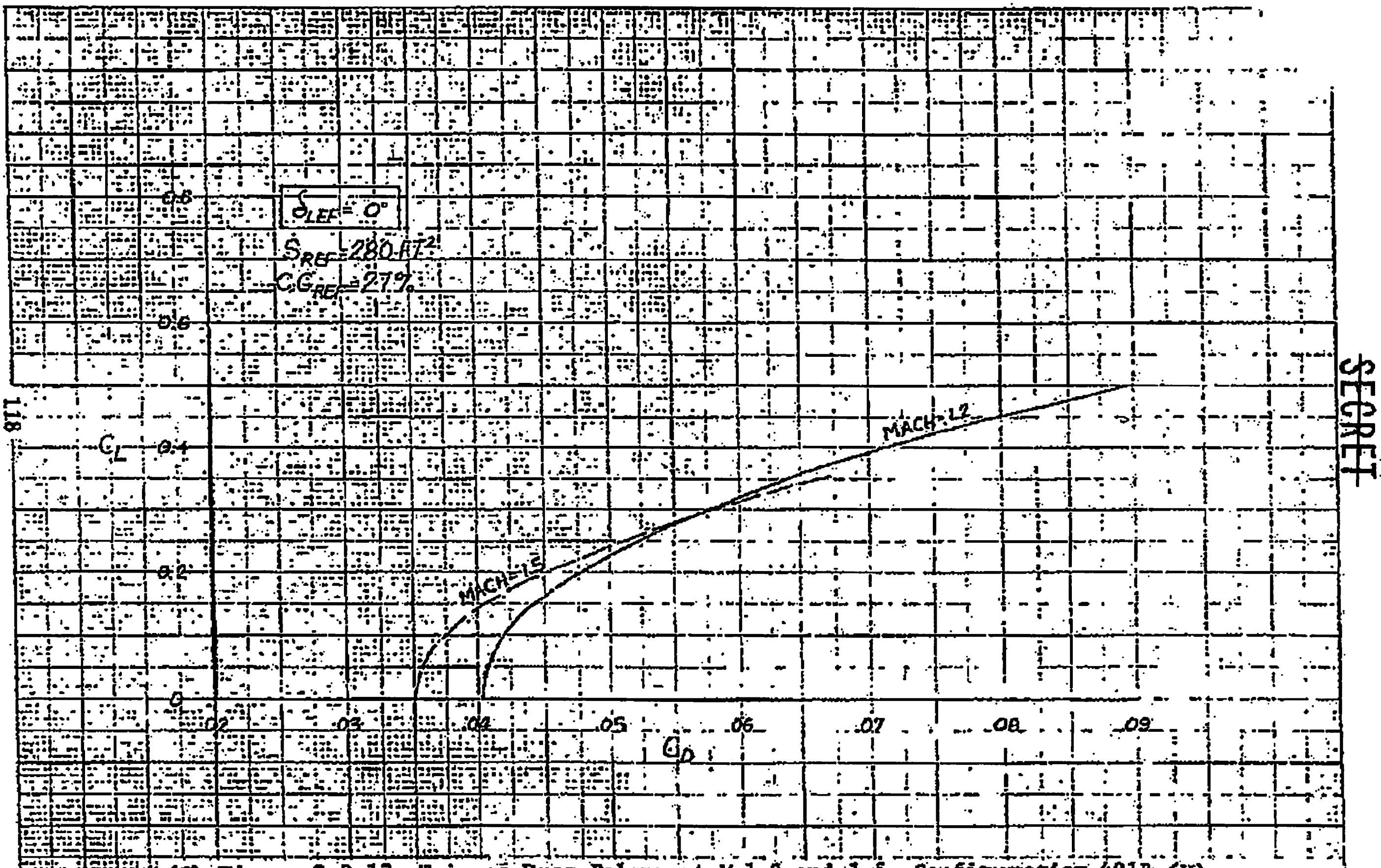


~~(S)~~ Figure 3.3-15 Trimmed Drag Polars at M=0.8, Configuration 401B (U)

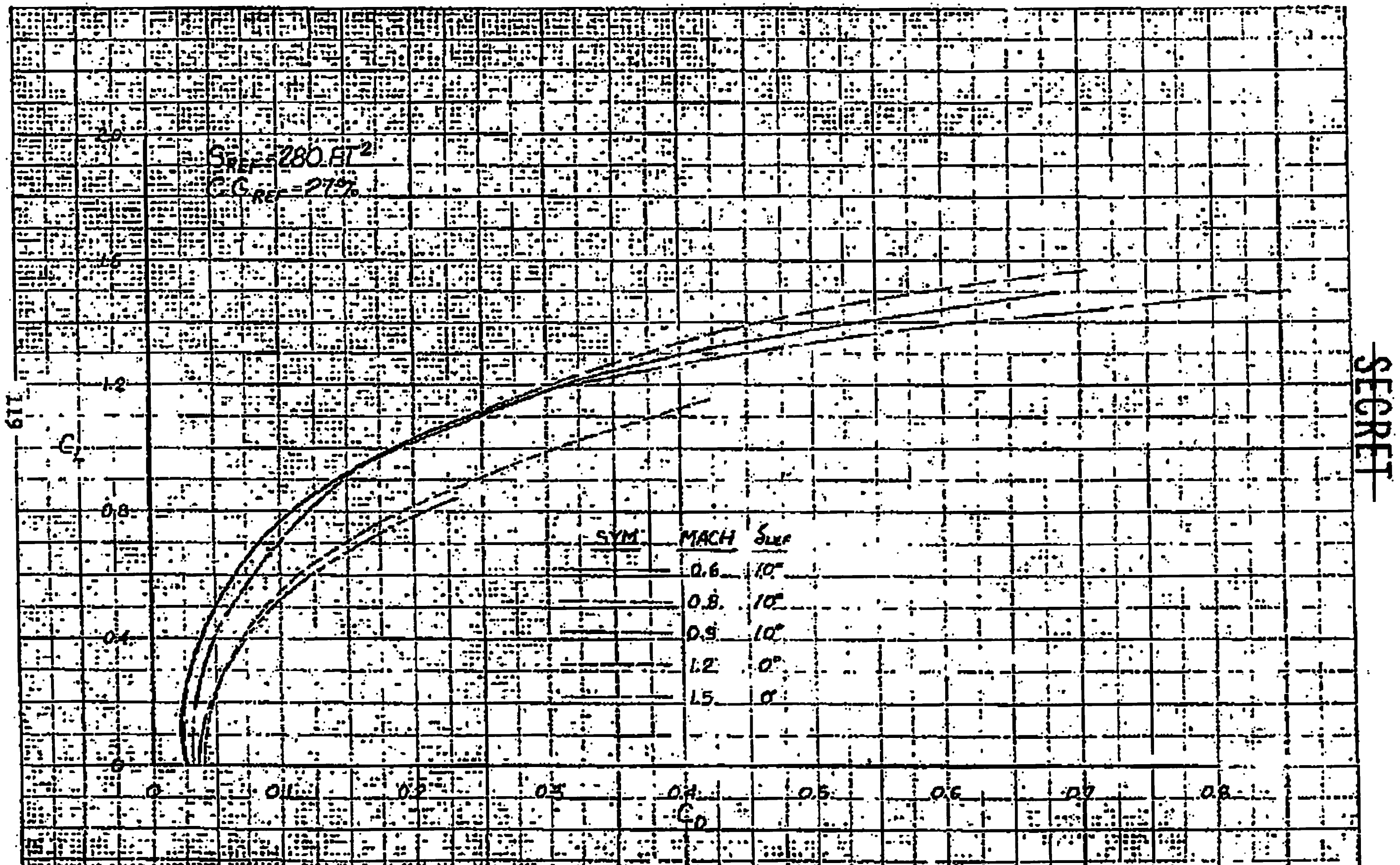


~~(S)~~ Figure 3.3-16 Trimmed Drag Polars at M=0.9, Configuration 401B (U)



~~(S)~~ Figure 3.3-17 Trimmed Drag Polars at M=1.2 and 1.5, Configuration 401B (U)

88th ABW/IPI FOIA (b)(1) E.O.13526 SEC. 3.3.(b)(4) 1.4. (a)(g)



(S) Figure 3.3-18 Trimmed Drag Polars at High C_L's, Configuration 401B (U)

88th ABW/IPI FOIA (b)(1) E.O.13526 SEC. 3.3.(b)(4) 1.4. (a)(g)

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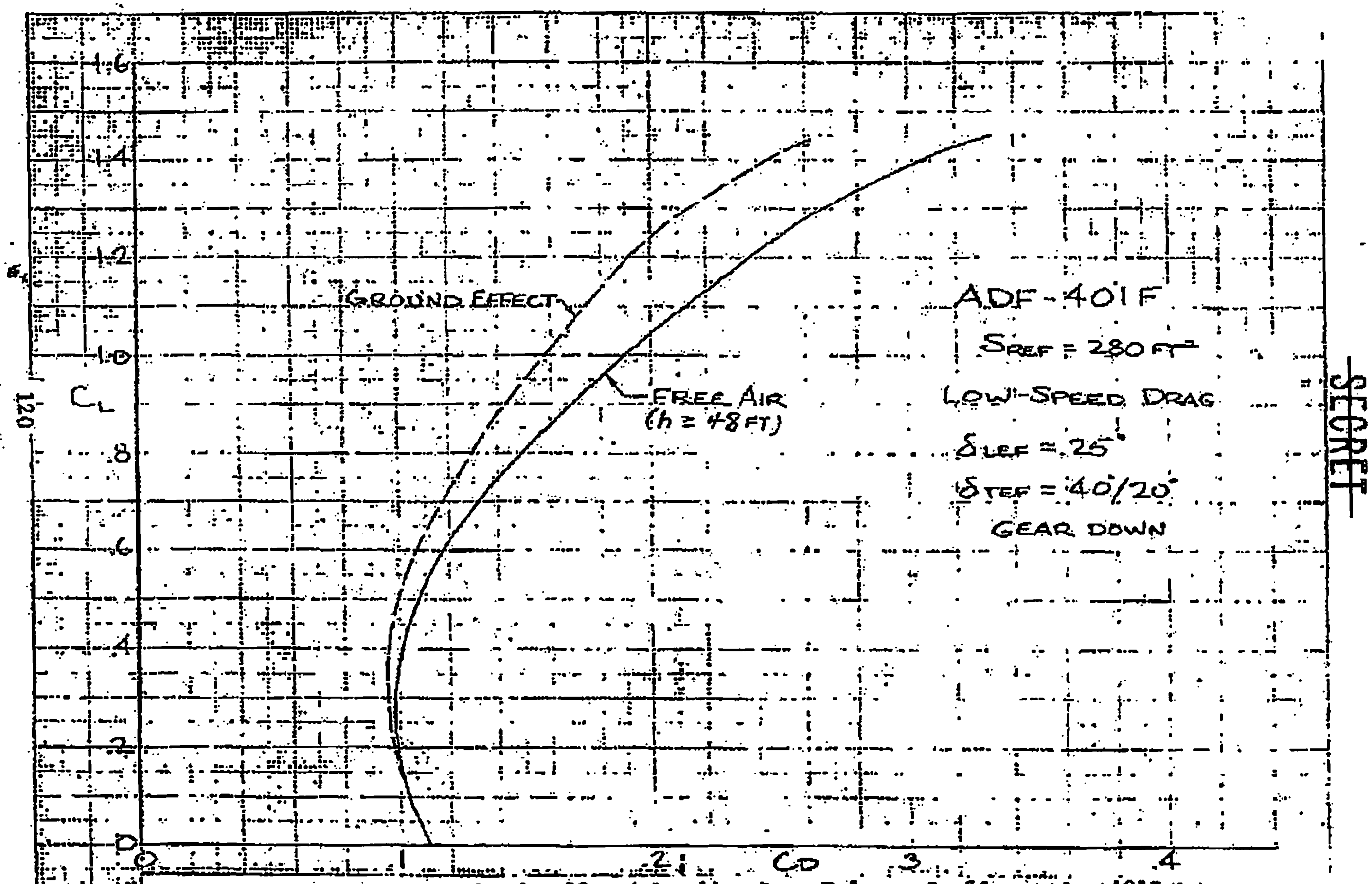
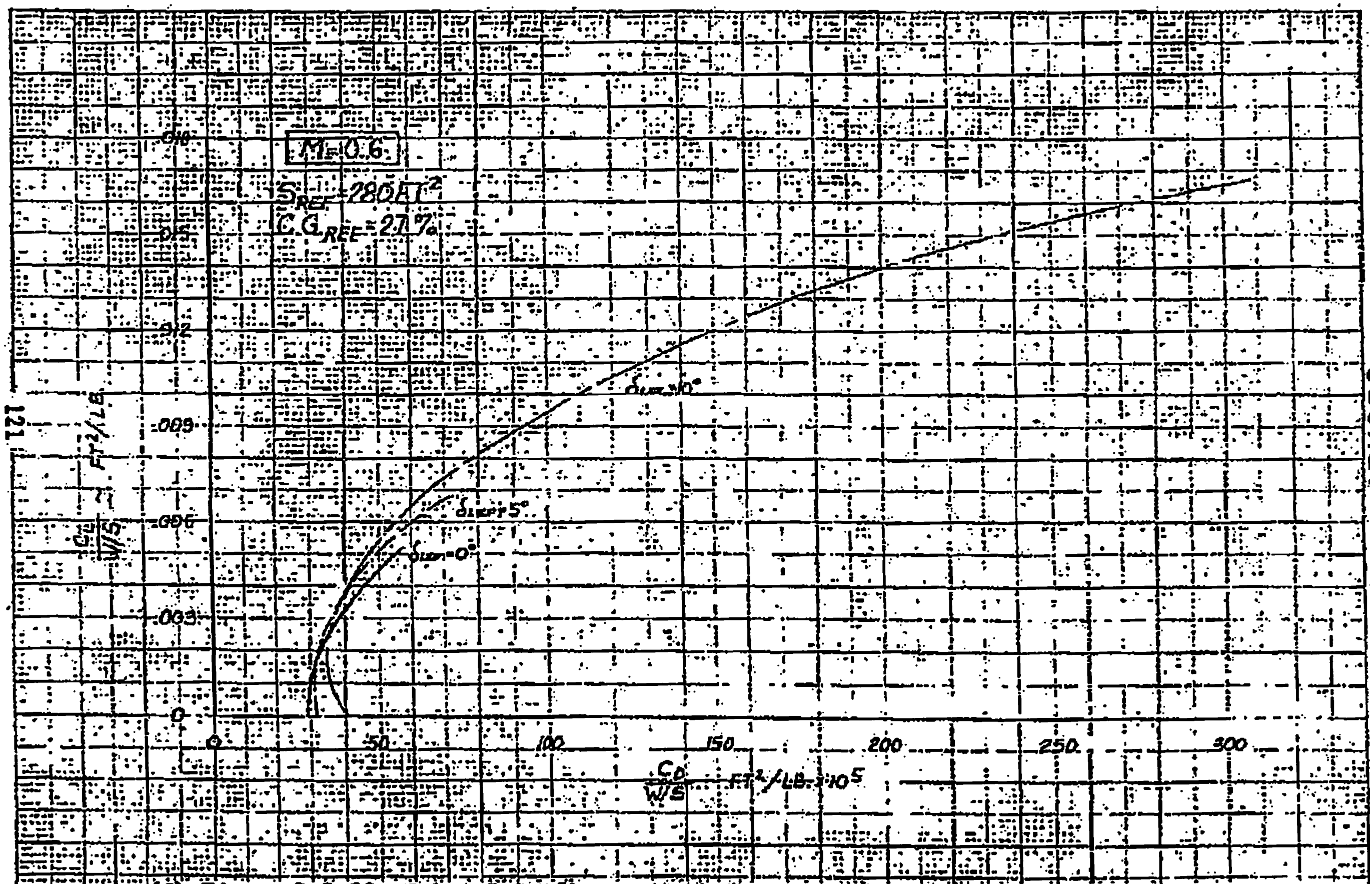


~~(S)~~ Figure 3.3-19 Trimmed Takeoff and Landing Drag Polars, Configuration 401B (U)

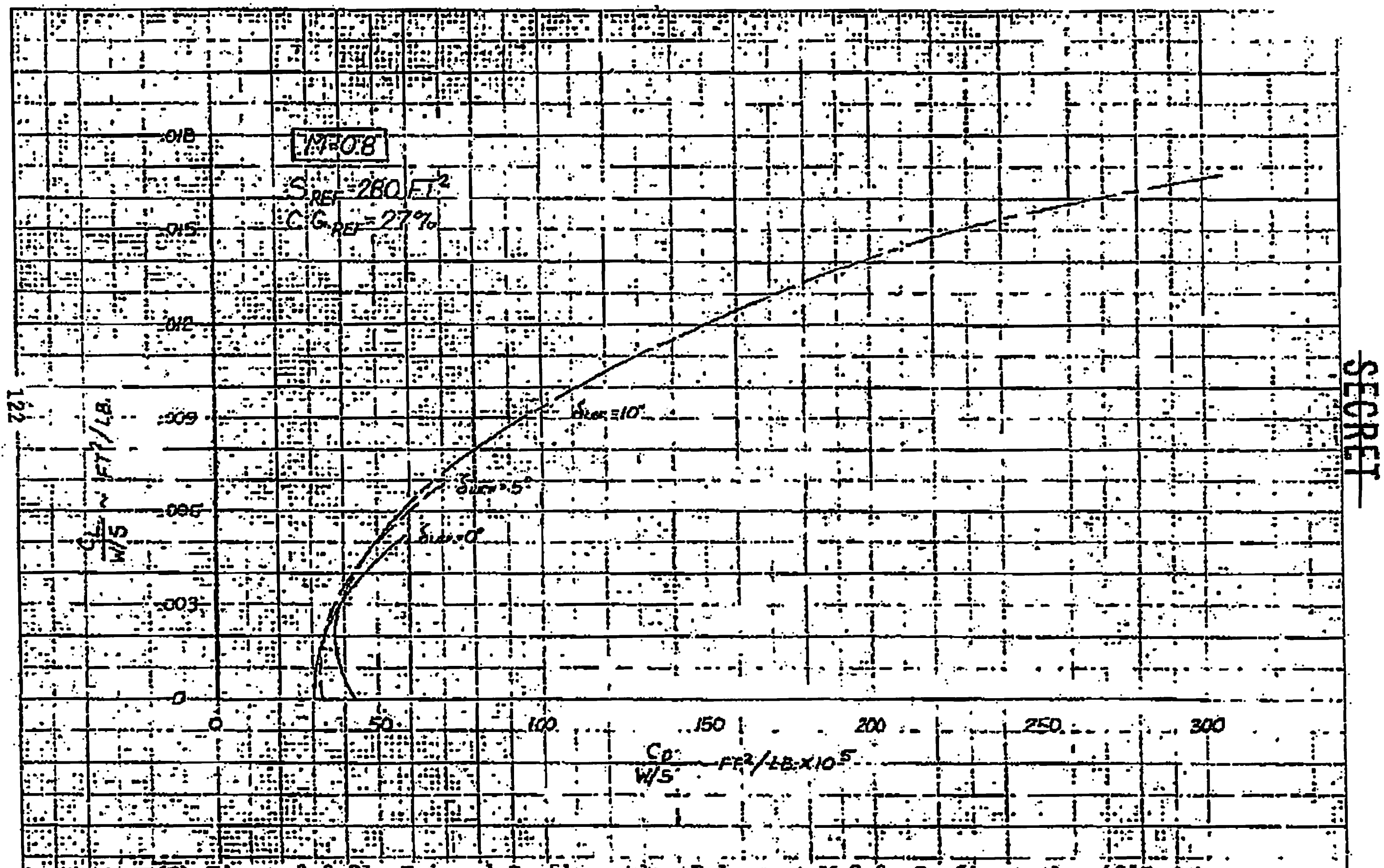
SECRET

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.
(b)(4)
1.4. (a)(g)



(S) Figure 3.3-20 Trimmed Configuration Polars at M=0.6, Configuration 401B (U)

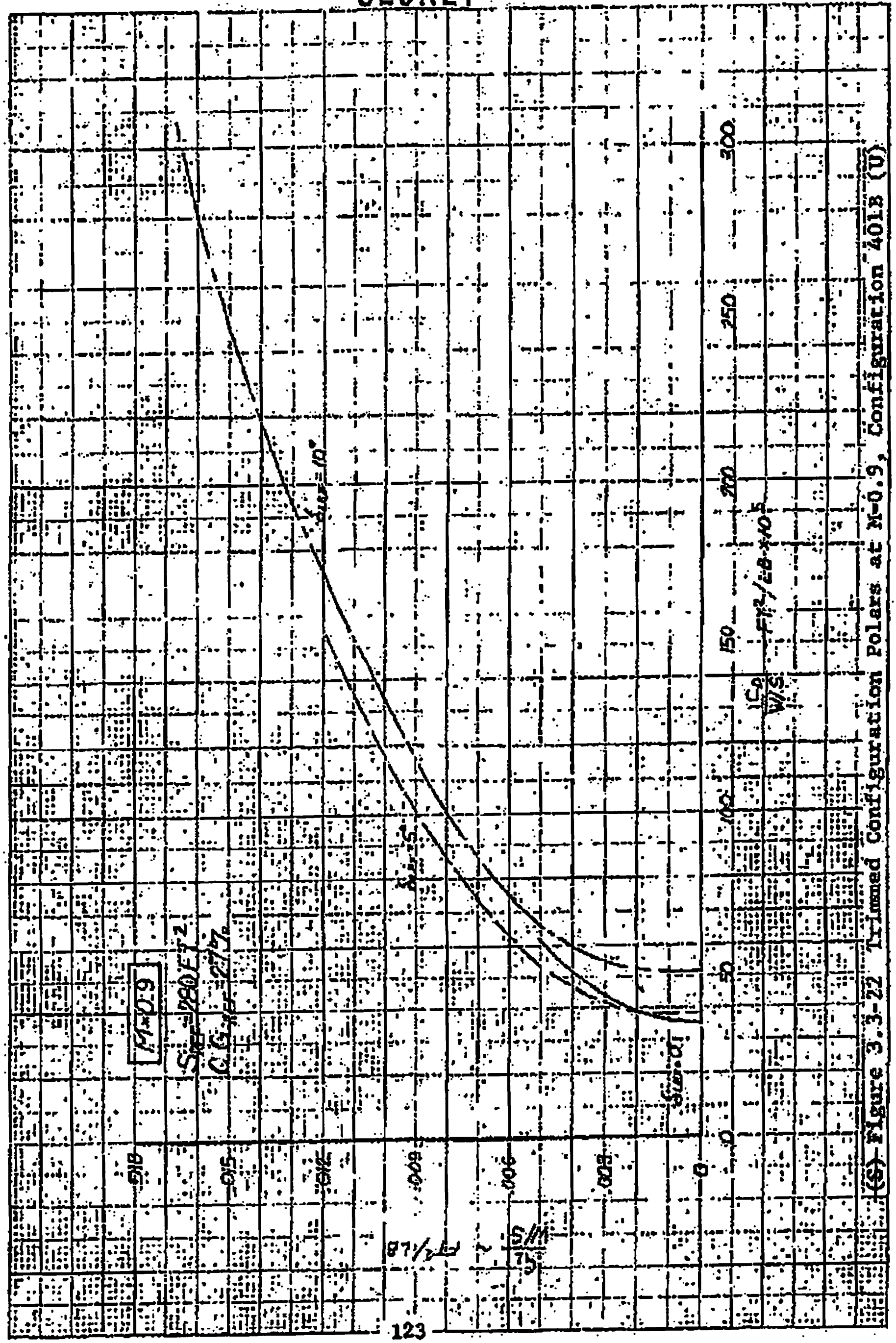
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



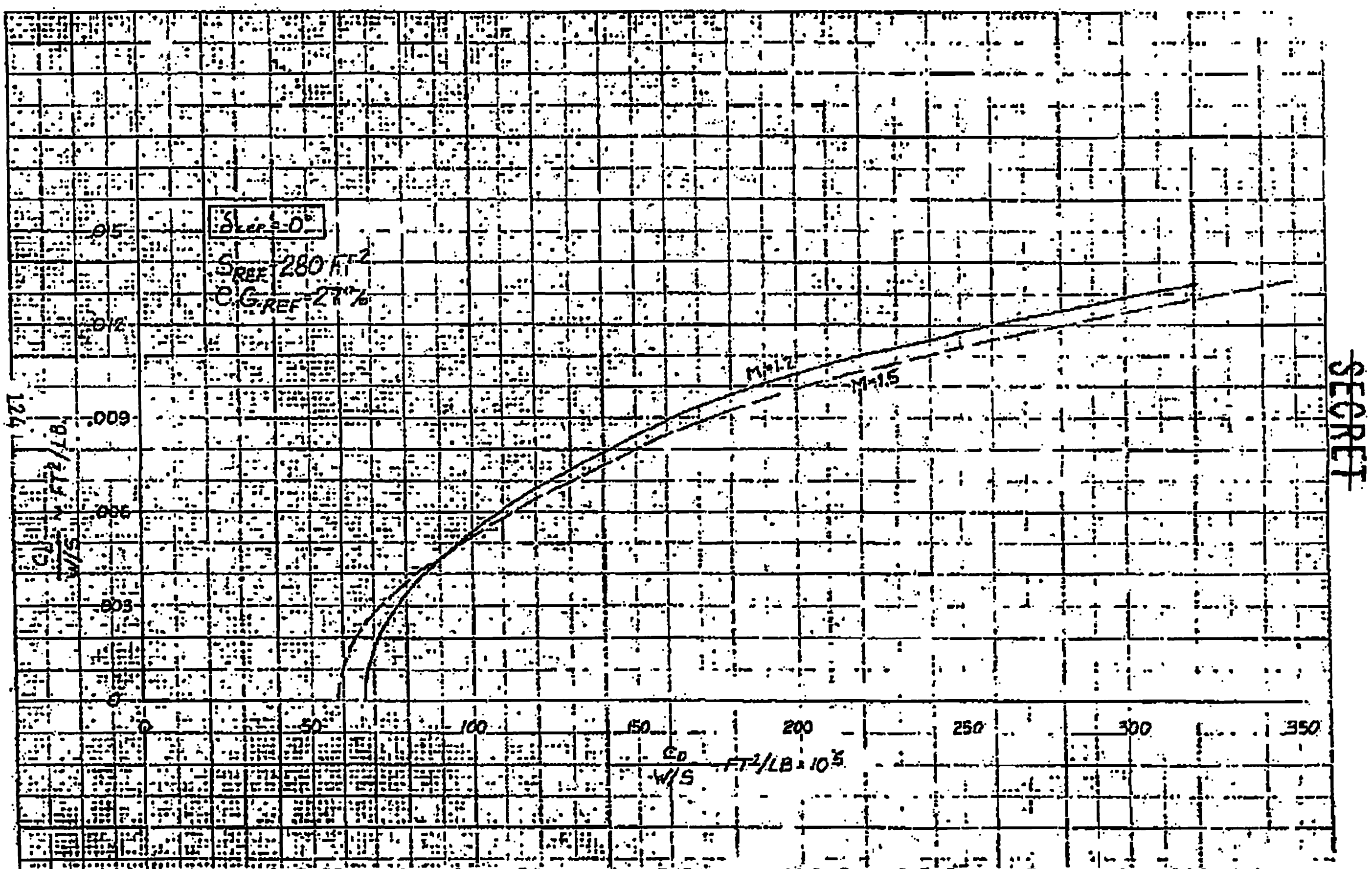
(S) Figure 3.3-21 Trimmed Configuration Polars at M=0.8, Configuration 401B (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g).

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)



(S) Figure 3.3-22 Trimmed Configuration Polars at M=0.9, Configuration 401B (U)



(S) Figure 3.3-23 Trimmed Configuration Polars at M=1.2 and 1.5, Configuration 401B (U)

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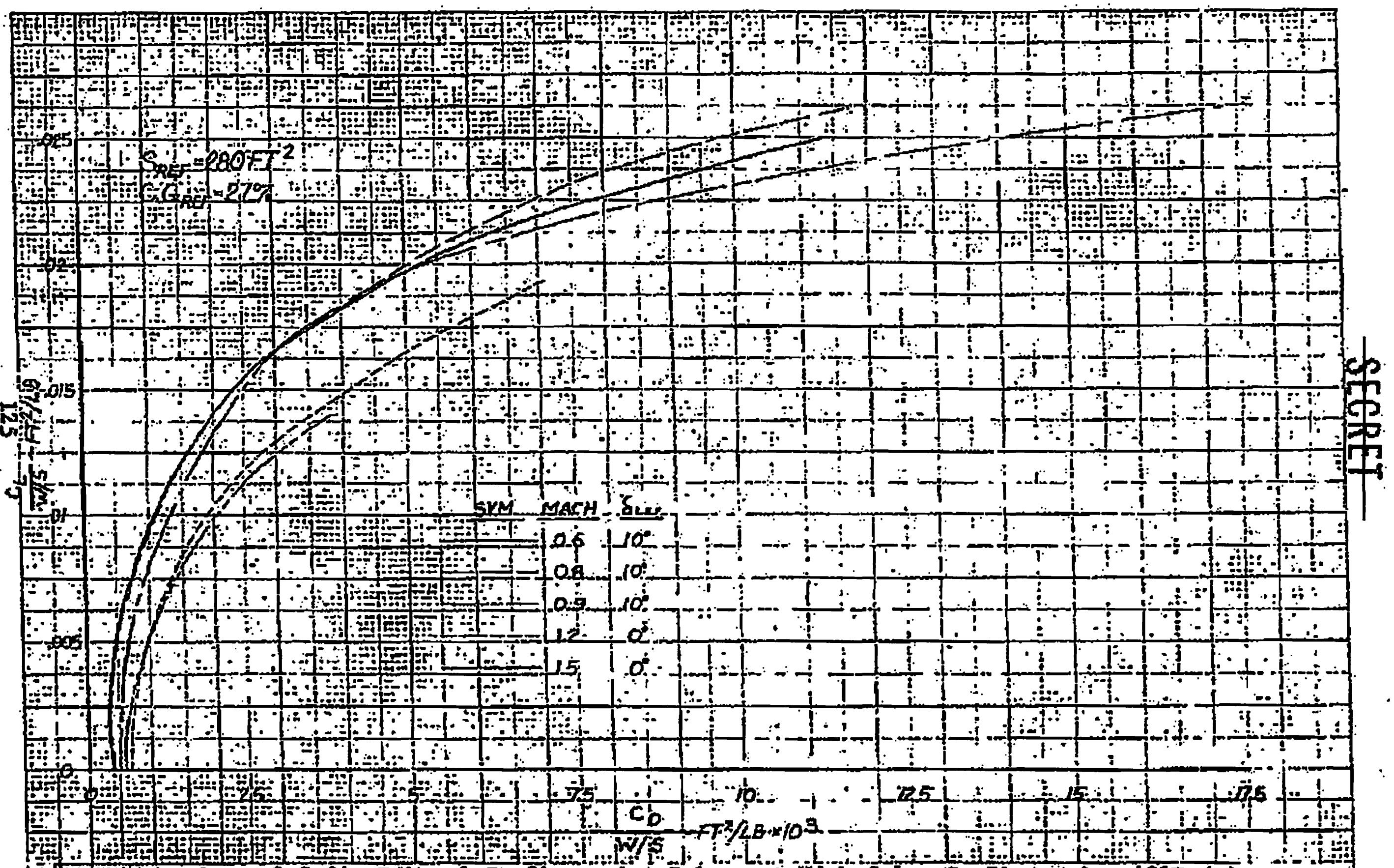
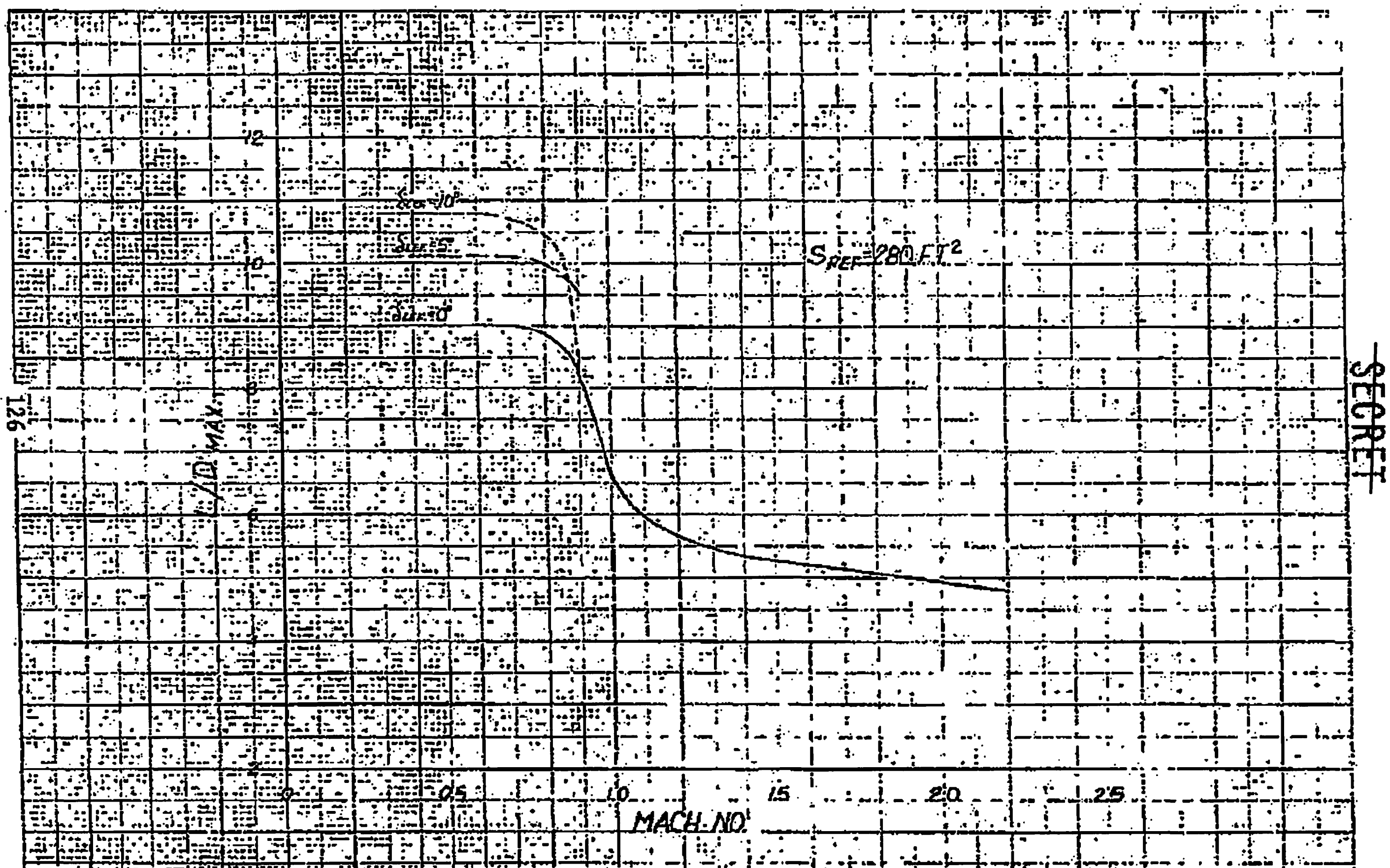


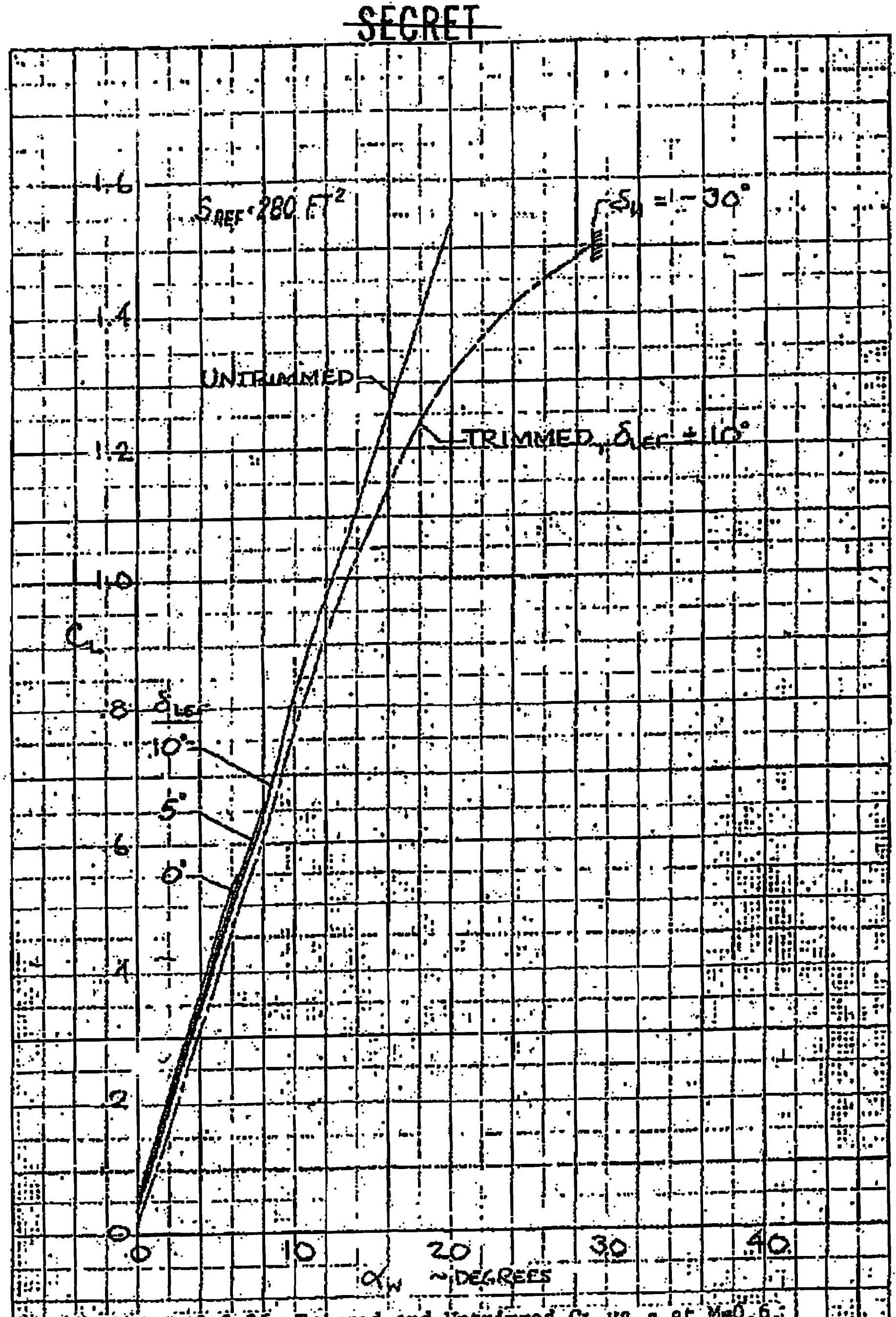
(S) Figure 3.3-24 Trimmed Configuration Polars at High C_L's, Configuration 401B (U)

SECRET

88th
ABW/IPI
FOIA (b)(1)
E.O. 3526
SEC 3.3.(b)
(4)
1.4. (a)(g)

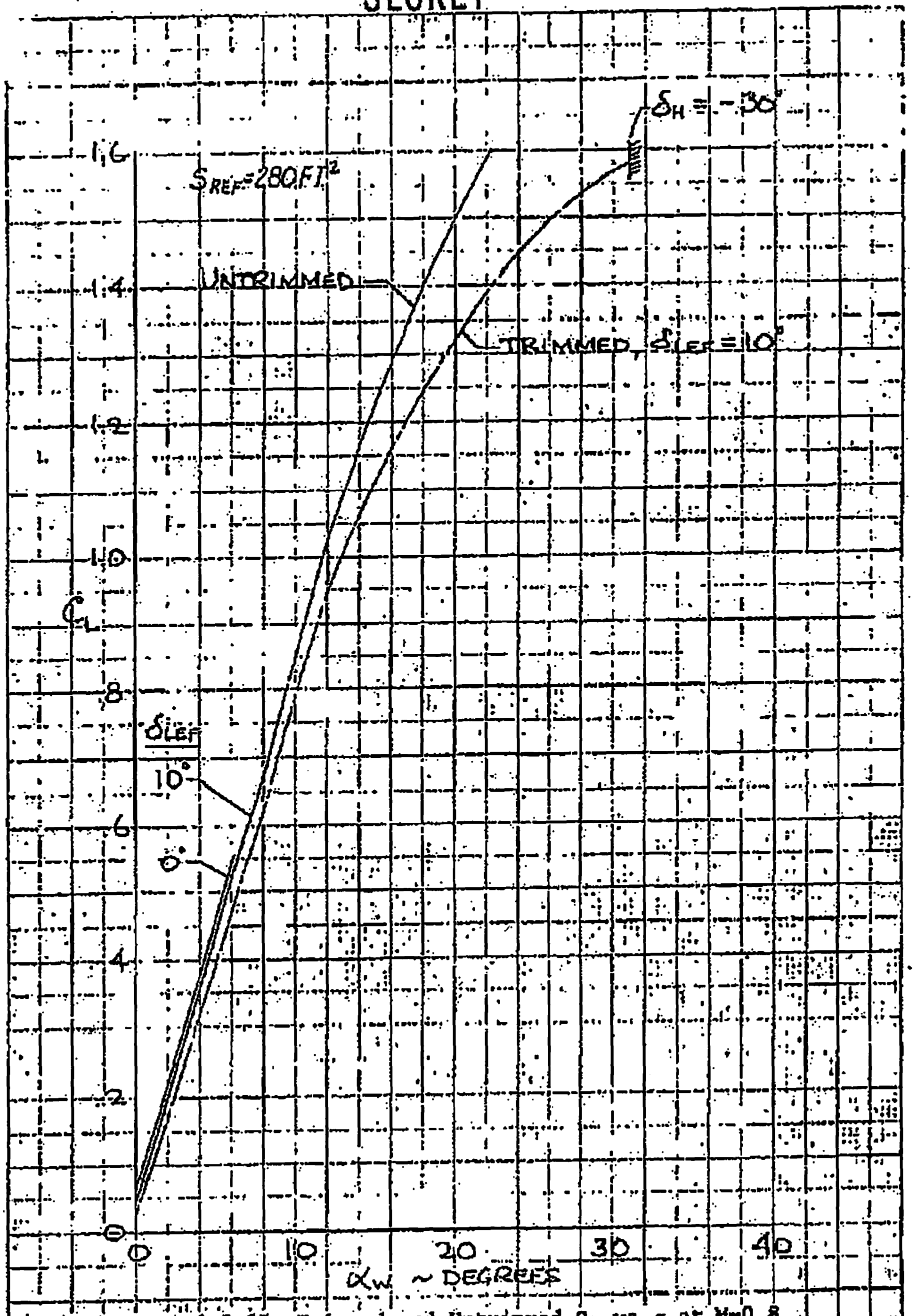


~~(S)~~ Figure 3.3-25 Trimmed (L/D) Max vs Mach Number, Configuration 401B (U)



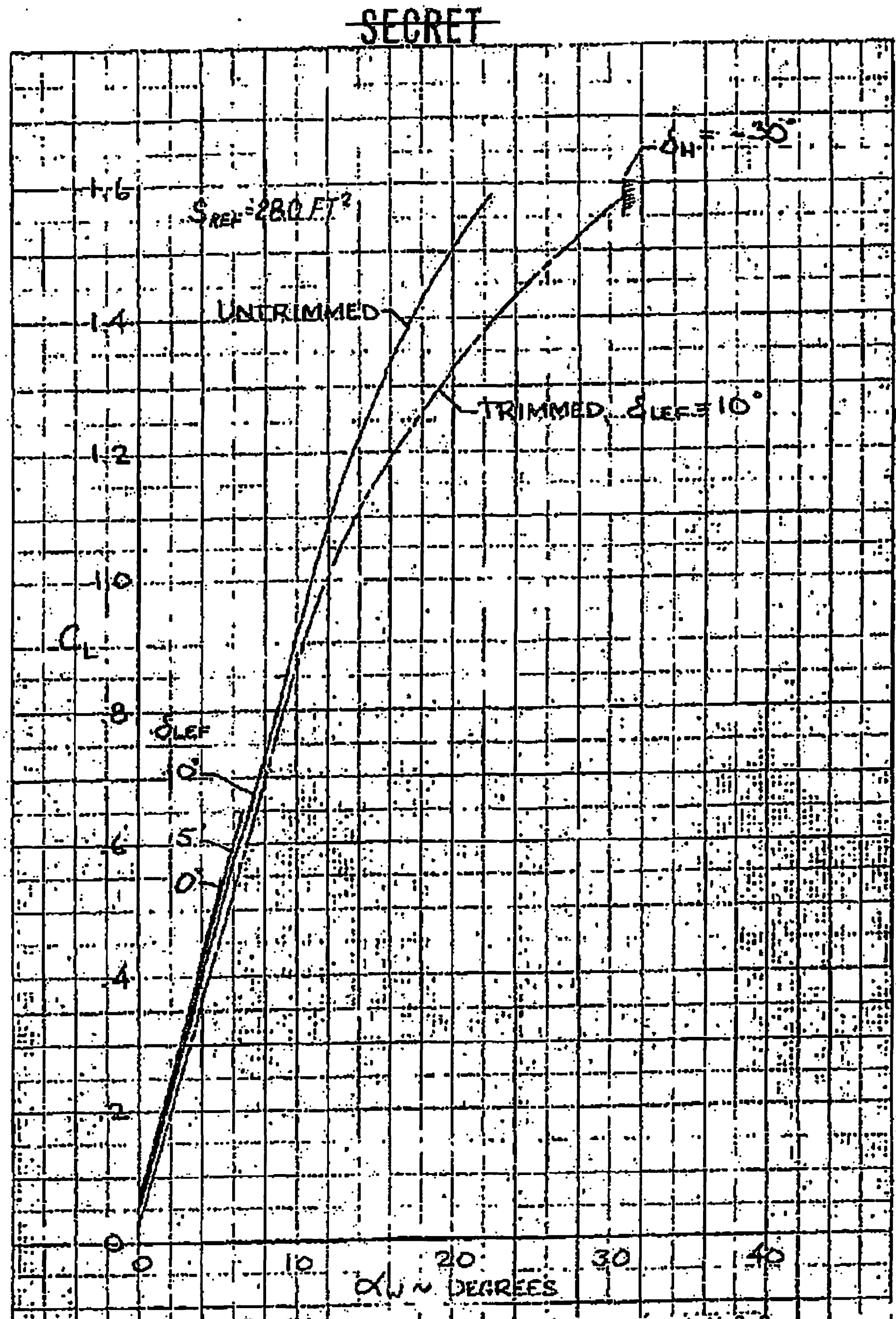
~~(S)~~ Figure 3.3-26 Trimmed and Untrimmed C_L vs α at M=0.6, Configuration 401B (U)

88th ABW/PI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

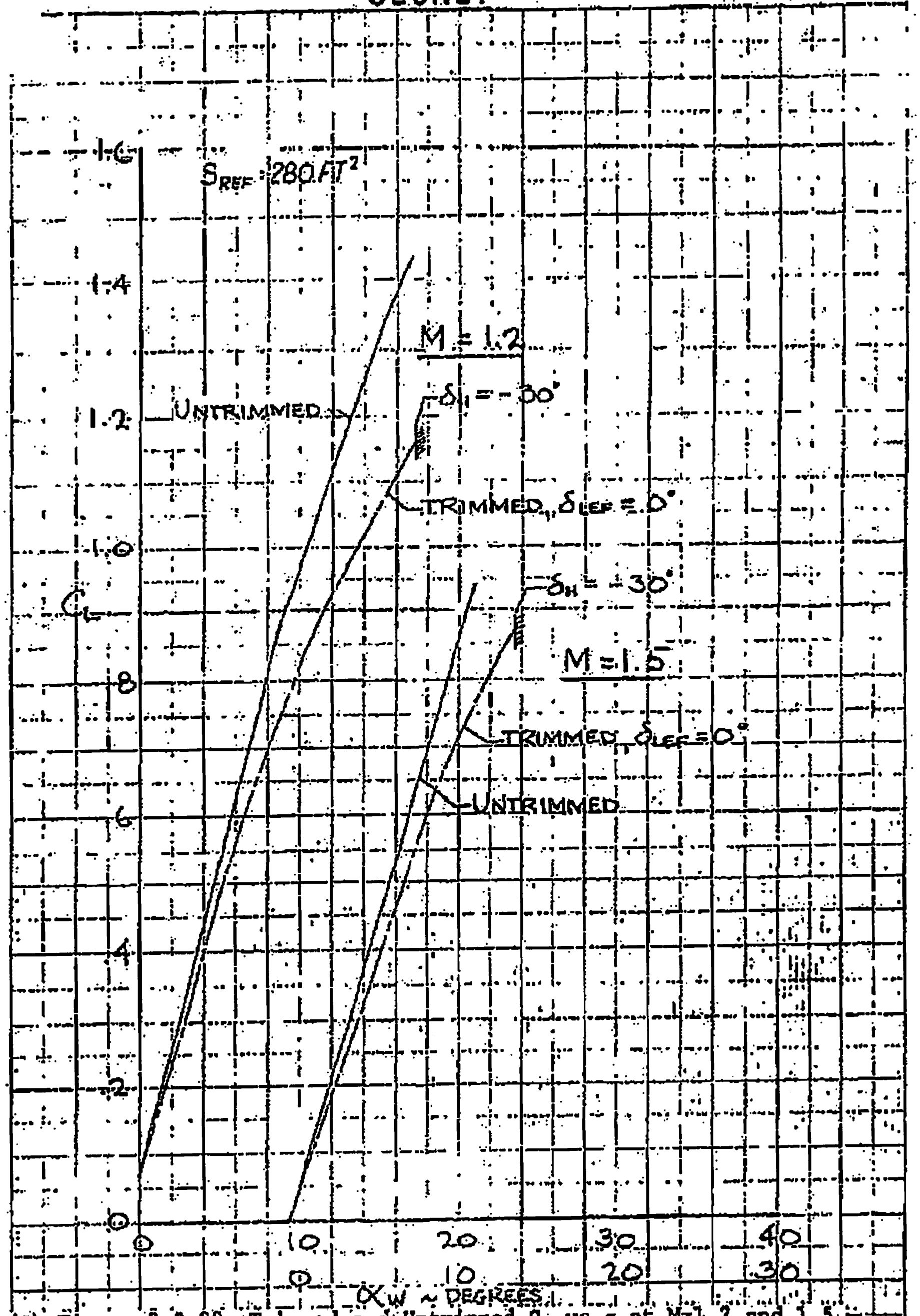


~~(S)~~ Figure 3.3-27 Trimmed and Untrimmed C_L vs α at M=0.8, Configuration 401B (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

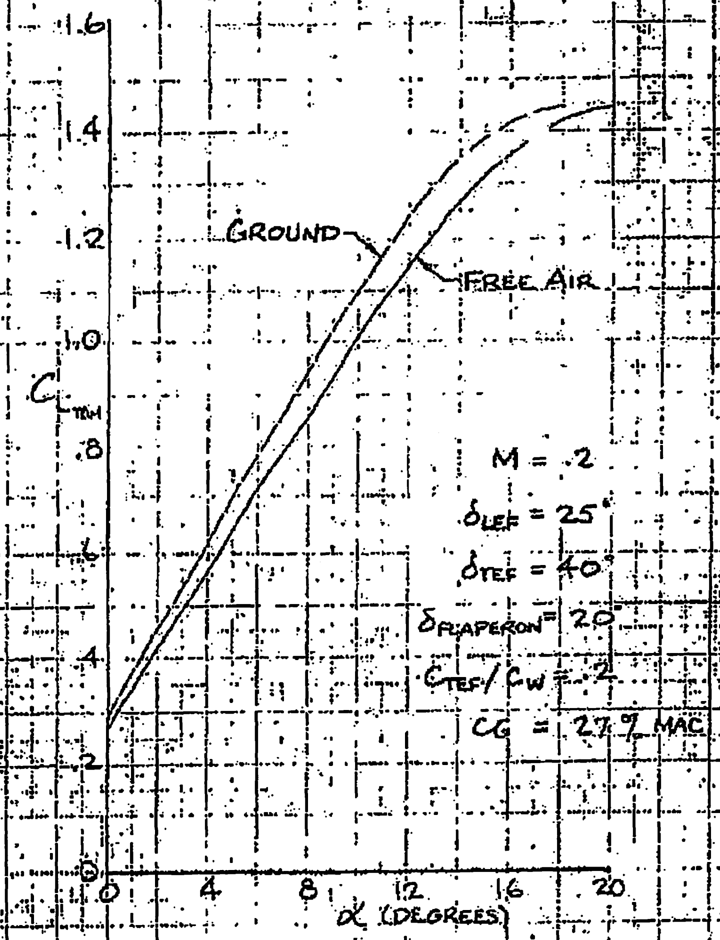


~~(S)~~ Figure 3.3-28 Trimmed and Untrimmed C_L vs α at M=0.9, Configuration 401B (U)

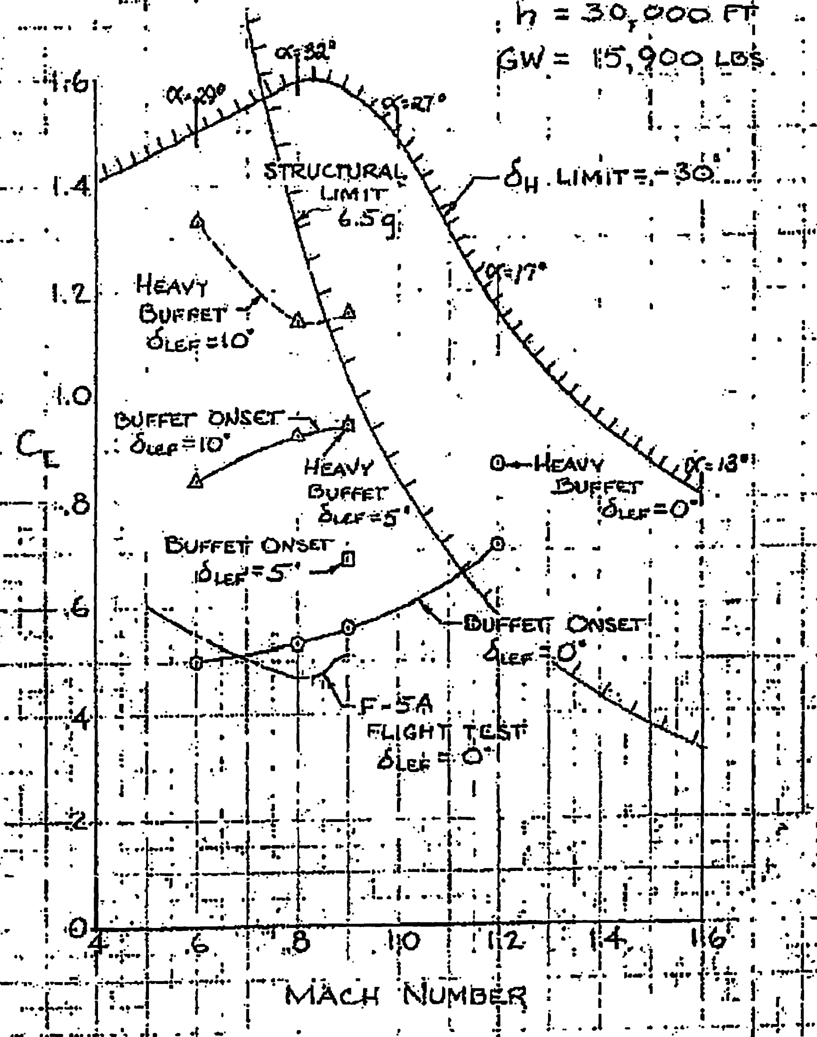


~~(S)~~ Figure 3.3-29 Trimmed and Untrimmed C_L vs α at M=1.2 and 1.5, Configuration 401B (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



(S) Figure 3.3-30 Trimmed Takeoff and Landing C_L vs α, Configuration 401B (U)



~~(S)~~ Figure 3.3-31 Buffet Boundaries and Control Limit C_L vs Mach Number, Configuration 401B (U)

3.4 STABILITY, CONTROL, AND HANDLING QUALITIES

(U) Handling qualities/stability and control studies have been primarily directed toward identifying design features necessary to provide excellent handling qualities. This very demanding goal is basically achievable through proper aerodynamic configuration tailoring to ensure superior inherent longitudinal and lateral-directional stability and control. Pertinent results of the stability and control design techniques and the approach followed in support of this demanding goal of excellent fighter handling qualities are presented and discussed in this section.

3.4.1 Handling Qualities Design Rationale

(U) Specific stability and control design objectives that were followed in the development of Configuration 401B for excellent handling qualities in the combat region are listed in Table 3.4-1. The key factors in configuration design development are listed in the table for each of the objectives. Major benefits to be derived for each objective are also noted.

(U) In addition to the objectives listed in the table, low inertias are desirable for improved maneuver response with minimum-sized control and stabilizing surfaces.

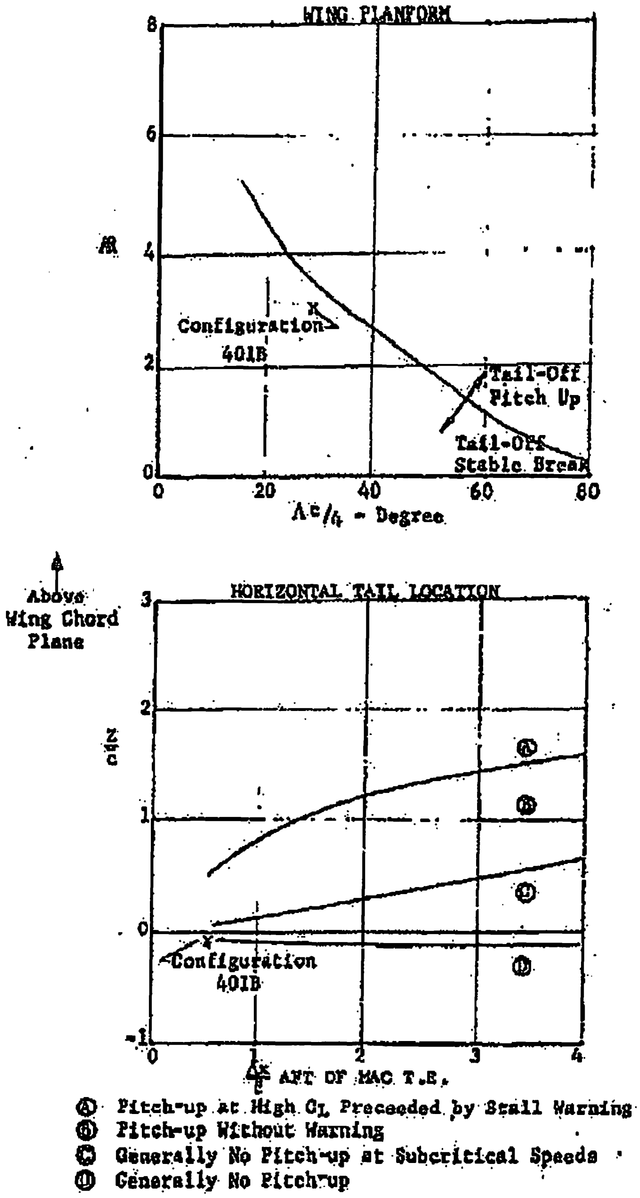
3.4.2 Stability and Control Design Techniques

(U) General design guides to provide superior inherent stability and control characteristics were established. These design guides are related to pitchup, pitch control, directional stability, and aileron yaw and are discussed below in relation to wing planform, horizontal tail location, fuselage nose shape, vertical stabilizing surfaces, and aileron design.

(U) Wing Planform - Pitchup criteria from Reference 10 are presented in Figure 3.4-1. The wing planform pitchup boundary is given as a function of the wing aspect ratio and quarter chord sweep in the upper plot of Figure 3.4-1. Configuration 401B falls near the boundary in the satisfactory region. Proximity to the boundary in the satisfactory region is desirable in lieu of large displacement below the boundary. In general, the severity of the stable

(U) Table 3.4-1 HANDLING-QUALITIES DESIGN RATIONALE

OBJECTIVE	CONFIG. DESIGN APPROACH	BENEFITS DERIVED
NO PITCHUP	• WING GEOMETRY (AR vs. Λ RELATIONSHIP) • TAIL LOCATION (LOW)	• INCREASED COMBAT AGILITY • FULL MANEUVERING POTENTIAL AND PENETRATION INTO HEAVY BUFFET WITH NO PILOT FEAR OF NOSE UP TENDENCIES
NO AILERON YAW	• AILERON LOCATION (AIL./V.T. RELATIONSHIP FOR $C_{n_{\delta_a}} = 0$) • VERTICAL STABILIZING SURFACES (Hi V.T. Vol.)	• RAPID COORDINATED ROLL • PRECISE TRACKING • ANTI SPIN
NO WING ROCK	• WING PANEL GEOMETRY (CAMBER, TWIST, L.E. DEVICE) • WING PLANFORM (Hi $C_{L_{\alpha_W}}$ FOR INHERENT ROLL DAMPING)	• POSITIVE EFFECTIVE DIHEDRAL • STALLING OF LEADING WING PANEL DURING SIDESLIP AT HIGH ANGLES OF ATTACK ELIMINATED
NO DIRECTIONAL DIVERGENCE	• VERTICAL TAIL GEOMETRY AND LOCATION (Hi V.T. Vol., AR_{VT}, V.T./WING/BODY SIDEWASH RELATIONSHIP) • FUSELAGE FOREBODY CROSS SECTION • VENTRAL	• INCREASED COMBAT AGILITY AND MANEUVERABILITY • ANTI SPIN • POSITIVE DYNAMIC DIRECTIONAL STABILITY • NOSE SLICE ELIMINATED
CONTROL IN STALL	• TAIL LOCATION (BELOW WING CHORD PLANE IN LOW DOWNWASH REGION AND BELOW WING WAKE) • AILERON LOCATION (MID SPAN/OUTBOARD)	• POSITIVE CONTROL IN STALL • INCREASED COMBAT AGILITY • AIL./H.T. ROLL INTERFERENCE MINIMIZED • SPIN SUSCEPTIBILITY MINIMIZED
INHERENT DAMPING (FREE AIRFRAME)	• AERODYNAMIC STABILIZING SUR. (HI TAIL Vol.) • WING PLANFORM (Hi $C_{L_{\alpha_W}}$)	• FAST SETTLING TIME • STABLE GUNNERY PLATFORM • PRECISE TRACKING CONTROL



Reference: TM X-26

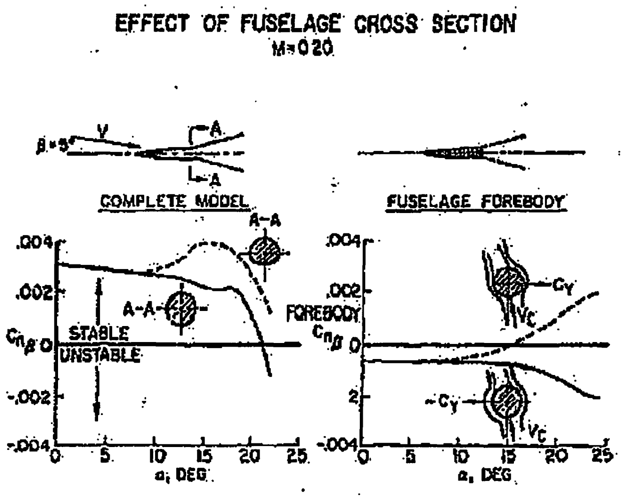
(U) Figure 3.4-1 NASA Pitch-up Criteria

break in the wing/body pitching moment is proportional to the displacement variation below the boundary. Severe stabilizing breaks have a detrimental effect in reducing the maneuvering control power, especially for a low horizontal tail location.

(U) Low Horizontal Tail - Horizontal tail placement of the 401B configuration falls in the low-tail region "D" in the lower plot of Figure 3.4-1. This low tail position, in combination with the good wing planform pitchup characteristics, assures near linear pitching moment characteristics at subsonic and transonic speeds. The horizontal tail below the wing chord plane is in the low downwash region to provide the desirable aft aerodynamic-center position at low subsonic speeds. The low tail remains in the low downwash region as the airplane rotates to high angles of attack and, thus, precludes its passing alternately from high to low downwash regions as it passes through the wing wake. The result is a desirable near linear pitching moment curve to high angles of attack. The horizontal tails mounted low and aft on the fuselage extensions also provide high trimming effectiveness. Another important aspect of the low tail is that it minimizes the transonic aft aerodynamic-center travel. The low horizontal tail is a key feature in configuration layout of an air superiority fighter.

(U) Fuselage Nose Ellipticity - Static directional stability is the most significant aerodynamic derivative affecting lateral-directional handling qualities. Maintaining a positive level of directional stability at very high angles of attack is a matter of major design importance. A contributing factor to the directional stability level is the instability of the fuselage. Proper tailoring of the fuselage nose forebody section can have a pronounced effect in reducing fuselage instability at high angles of attack (References 11 and 12). Fuselage forebody ellipticity with the major axis in the horizontal plane can greatly influence the overall improvement in fighter directional stability at high angles of attack, as represented in Figure 3.4-2. Forebody-shape ellipticity has been integrated into the 401B design.

(U) Model test data on the F-5 (Reference 13) and F-100 (Reference 14) airplanes substantiate the influence of an elliptical cross section shape on the fuselage nose toward improving the directional stability at high angles of attack. Tail-off directional stability derived from the F-5 is presented as a function of angle of attack in the upper plot of



(U) Figure 3.4-2 Effect of Fuselage Forebody on Directional Stability

Figure 3.4.3. Above an angle of attack of about 16 degrees there is a decided improvement in stability with increasing angle of attack. This improvement is attributed to the F-5 nose ellipticity.

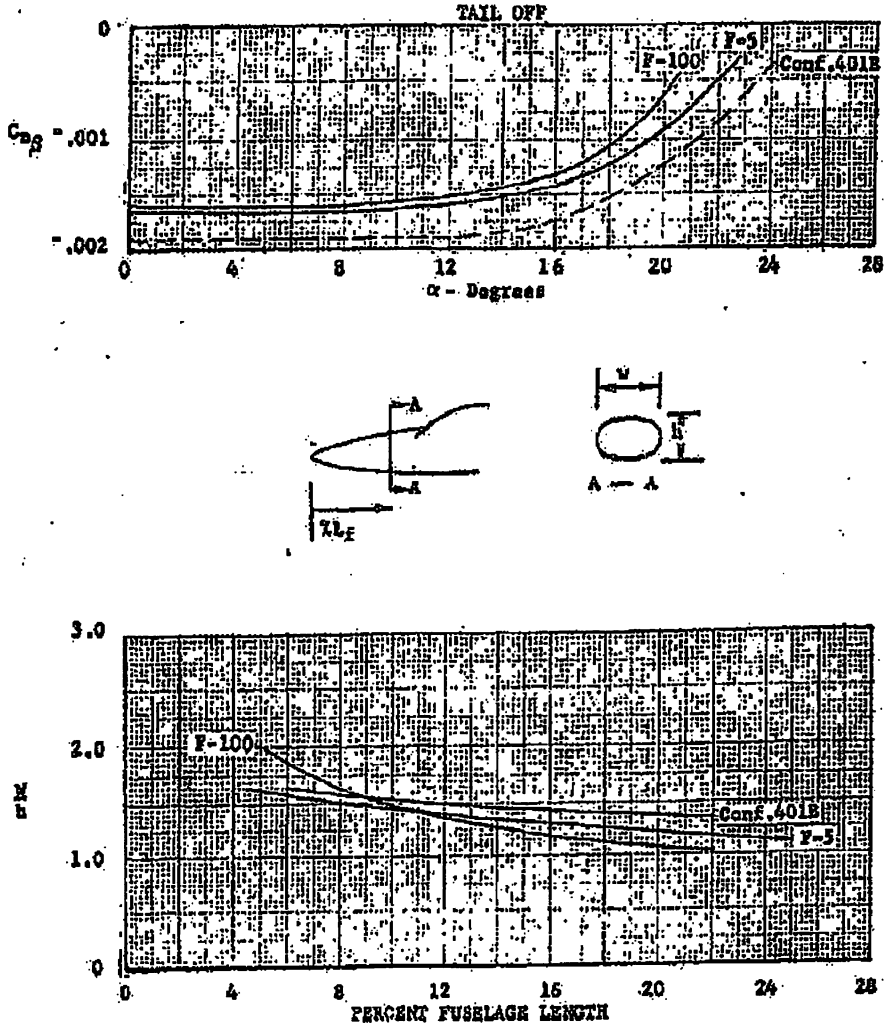
(U) Supersonic directional stability data at Mach 1.6 for the F-100 with the vertical tail off is also shown in this plot. At an angle of attack of approximately 16 degrees, there is a definite stabilizing trend in the high-angle-of attack range. Such improvement in stability level for the F-100 is also attributed to the fuselage nose ellipticity.

(U) Also in Figure 3.4-3 (lower plot), a comparison is given of the nose ellipticity of the 401B configuration with that of the F-5 and F-100. The nose ellipticity is shown as a function of percent fuselage length, and it is evident that all three have essentially the same level of ellipticity. Consequently, it is projected into the upper plot (dashed line) that Configuration 401B will possess the same favorable improvement in directional stability at high angles of attack.

(U) Twin Fins and Ventrals - Another important design aspect followed in providing good directional stability to high angles of attack is the location of the vertical stabilizing surfaces. The most important single parameter in defining tail effectiveness at high angles of attack is the amount of vertical surface area above and clear of destabilizing vortices generated by the fuselage nose, the canopy, and the wing/body intersection. On the basis of these considerations, outboard twin fins on aft fuselage extensions with ventrals projecting directly below and in the plane of upper fins have been selected to serve as effective stabilizing surfaces to very high angles of attack.

(U) Mid-Outboard Ailerons - Configuration factors which influence aileron yaw have been investigated for preliminary design guidelines. It has been found that aileron deflection produces yawing moment primarily by two effects, namely, side forces induced on the vertical tail/aft fuselage and differences in drag increments for the up-going and down-going controls. For the case of an air superiority fighter, major factors in order of importance are:

1. Vertical tail location with respect to ailerons
2. Wing height on the fuselage



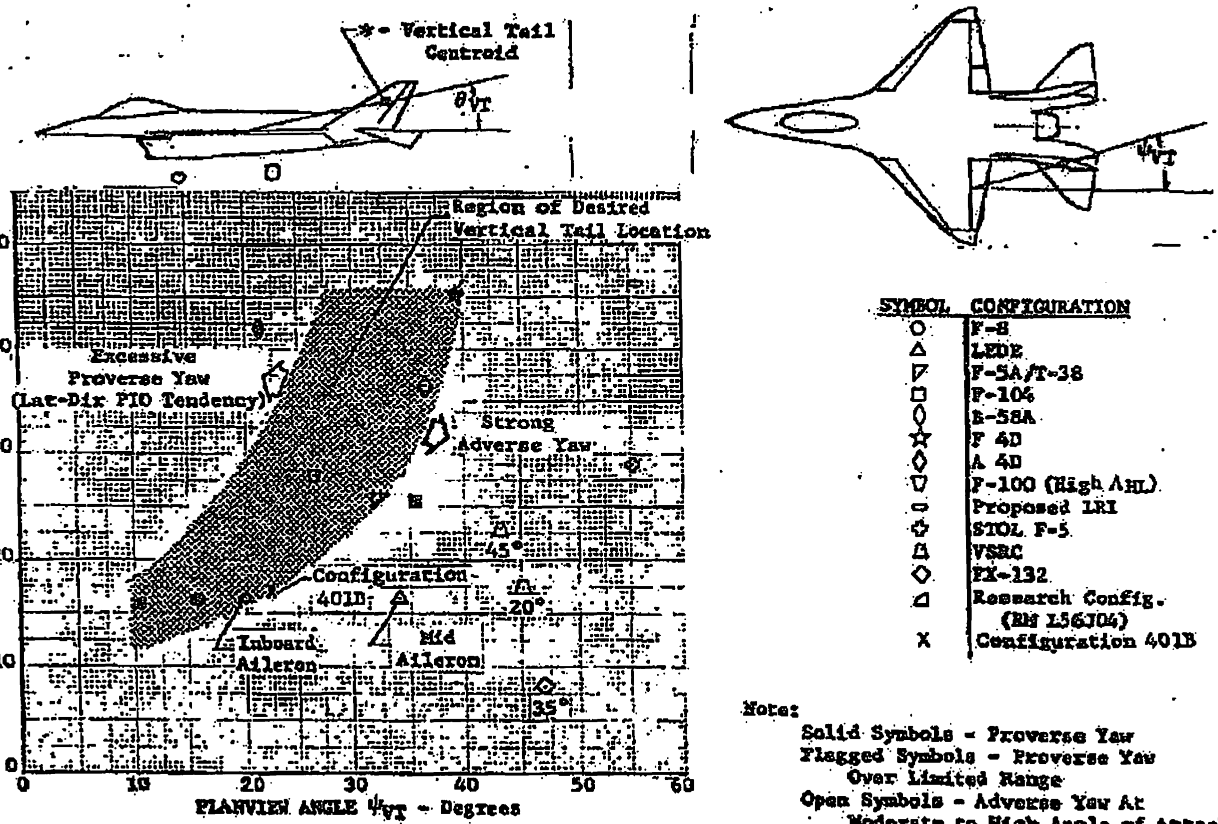
(U) Figure 3.4-3 Fuselage Nose Ellipticity

3. Drag differential of the up-going versus the down-going controls.

Factors 1 and 2 are basically related to the increased pressure field induced above the up-deflected surface, and are particularly potent at transonic and supersonic speeds because of the presence of strong shock waves. Generally, vertical tail location determines the level of yawing moment due to aileron. Drag variations with control deflection are the chief source of adverse yaw. Factor 3 would be dominant only for high-aspect-ratio wings with outboard ailerons. In fact, each of the factors is influenced by wing planform and section geometry, with sweep angle being of particular importance to Factors 1 and 2.

(U) On the basis of the aileron yaw investigation results, a configuration design guideline providing desirable vertical tail locations based on aileron yaw characteristics has been developed and is presented in Figure 3.4-4. Vertical tail location relative to the aileron is specified in terms of profile angle in the vertical plane and planview angle in the horizontal plane. The desirable region of vertical tail location indicated in Figure 3.4-4 is based upon transonic aileron-control yawing-moment data for the number of specific configurations listed. Configurations with large planview angles tend to have strong adverse yaw and thus would be susceptible to aileron-induced spins. Configurations with extremely low planview angles should also be avoided, since excessive proverse yaw is a prime contributor to lateral-directional pilot-induced oscillations. In general, the latter configurations would normally have inboard ailerons in close proximity to the horizontal tail. Such an arrangement may have large roll-control power losses due to horizontal tail interference effects. It is seen that the Configuration 401B aileron/vertical tail arrangement is in the acceptable region.

(U) A low wing height position on the fuselage also contributes to proverse aileron yaw due to induced aileron sidewash on the aft body. The opposite effect, or adverse yaw occurs with a high wing on the body. For a mid-wing on the body such as configuration 401B, a neutral effect from the body contribution due to aileron sidewash is experienced.



SYMBOL	CONFIGURATION
○	F-8
△	LEDE
▽	F-5A/T-38
□	F-104
◊	B-58A
☆	F 4D
◇	A 4D
▽	F-100 (High Λ_{HL})
▭	Proposed LRI
✩	STOL F-5
△	VSRC
◇	FX-132
◁	Research Config. (RM L56J04)
X	Configuration 401B

Note:
Solid Symbols - Proverse Yaw
Flagged Symbols - Proverse Yaw Over Limited Range
Open Symbols - Adverse Yaw At Moderate to High Angle of Attack

(U) Figure 3.4-4 Desirable Vertical Tail Locations Based on Aileron Yaw Characteristics

88th ABW/IP [illegible]
FOIA (b)(1)
E.O. 13526 SEC 3.3(b)(5)
(b)(4) 3.3(b)(4)
1.4(a) 3.3(b)(4)
SEC 1.4(a)(4)

3.4.3 Stability and Control Basic Data

(U) Stability and control characteristics are the fundamental contribution to handling qualities. In this subsection, the predicted basic stability and control derivatives used in developing the predicted handling qualities of the 401B configuration are presented. In general, standard NASA symbols and definitions are employed, with the forces referred to the wind axes and the moments referred to the stability axes except in the cases for the dynamic directional stability and lateral control spin parameters, which are referred to the body axes system.

3.4.3.1 Longitudinal Stability and Control

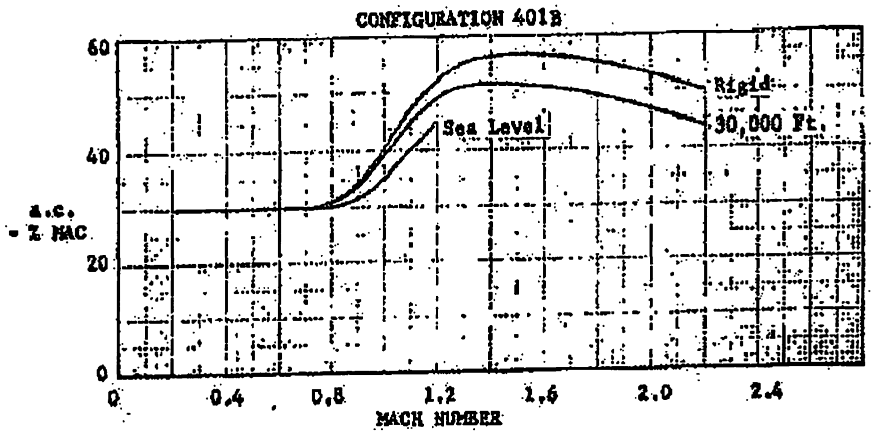
(U) The two prime basic stability characteristics, namely, aerodynamic center and elevator control effectiveness are presented as functions of Mach number in Figures 3.4-5 and 3.4-6. Straight-forward analytical techniques, successfully used and proven reliable in the past for similar wing planform configurations and tails, have been employed to develop these characteristics. The effects of aeroelasticity, based on fixed-wing FX estimates, have been included.

(U) Weight and balance characteristics of Configuration 401B are listed in Table 3.4-2.

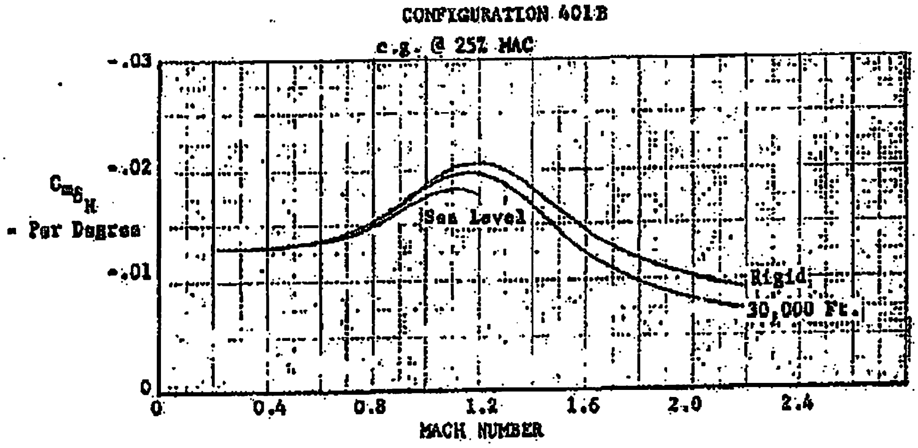
~~(S)~~ Table 3.4-2 WEIGHT & BALANCE CHARACTERISTICS

Gross Weight (lb)	C.G. (% MAC)
16,800 (full up)	24.9
12,614 (zero fuel)	21.2
11,981 (basic operating weight)	22.4
11,582 (weight empty)	24.7

With a low-speed aerodynamic center of 30% MAC, adequate static margin is provided for the takeoff and landing conditions. Similarly, positive static margins are available throughout the flight envelope. A detail summary of weight and balance is presented in Section 3.5.



(U) Figure 3.4-5 Aerodynamic Center vs Mach Number



(U) Figure 3.4-6 Elevator Control Effectiveness vs Mach Number

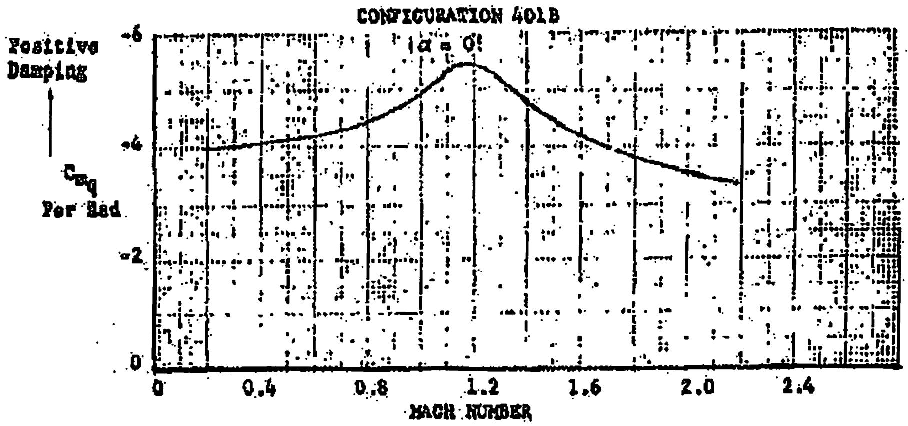
(U) Estimated pitch damping is presented as a function of Mach number in Figure 3.4-7 and a function of angle of attack in Figure 3.4-8. Pitch dynamic-model test data (see Paper 4 of Reference 11) substantiates that the blended wing/body of Configuration 401B will maintain a good positive level of pitch damping at high angles of attack near the stall.

3.4.3.2 Lateral-Directional Stability and Control

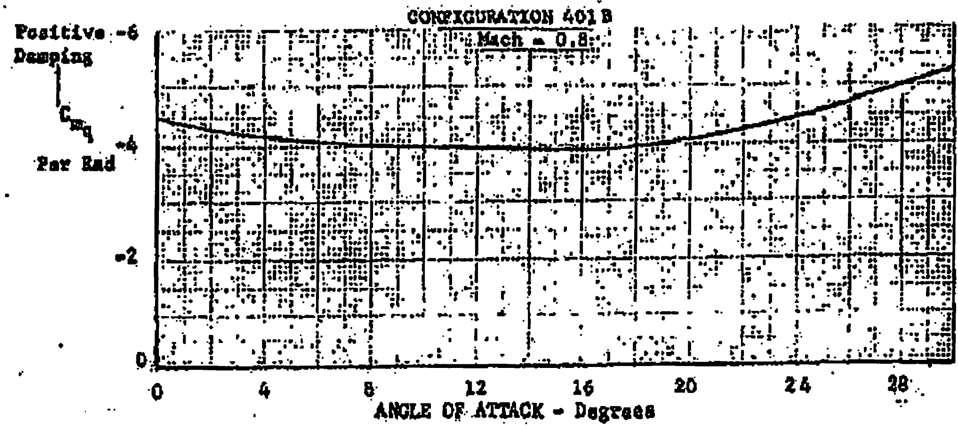
(U) Static directional stability is the most significant stability derivative that affects lateral-directional handling qualities. Predicted directional stability of the twin-fin/ventral arrangement is shown for zero angle of attack as a function of Mach number in Figure 3.4-9 and for a Mach number of 0.8 as a function of angle of attack in Figure 3.4-10. Standard prediction techniques for vertical tail effectiveness were employed. The variation in vertical tail stabilizing effectiveness with angle of attack has been patterned after the FX twin-fin model data. Vertical tail aeroelastic effects shown are based upon FX estimates. The effectiveness of the ventrals in providing directional stability was derived through proper ventral volume coefficient corrections applied to FX model ventral test data. Body instability at low angles of attack was estimated according to Multhopp's method.

(U) The high levels of directional stability indicate good lateral-directional handling qualities to angles of attack well above limit buffet and well past maneuver limit, as shown in Figure 3.4-10. The improvement in directional stability at the very high angles of attack in Figure 3.4-10 is attributed to the forebody nose ellipticity, as described in Subsection 3.4.2. This favorable forebody contribution to improve body instability at high angles of attack is based on F-5 and F-100 body directional stability data as shown in Figure 3.4-3.

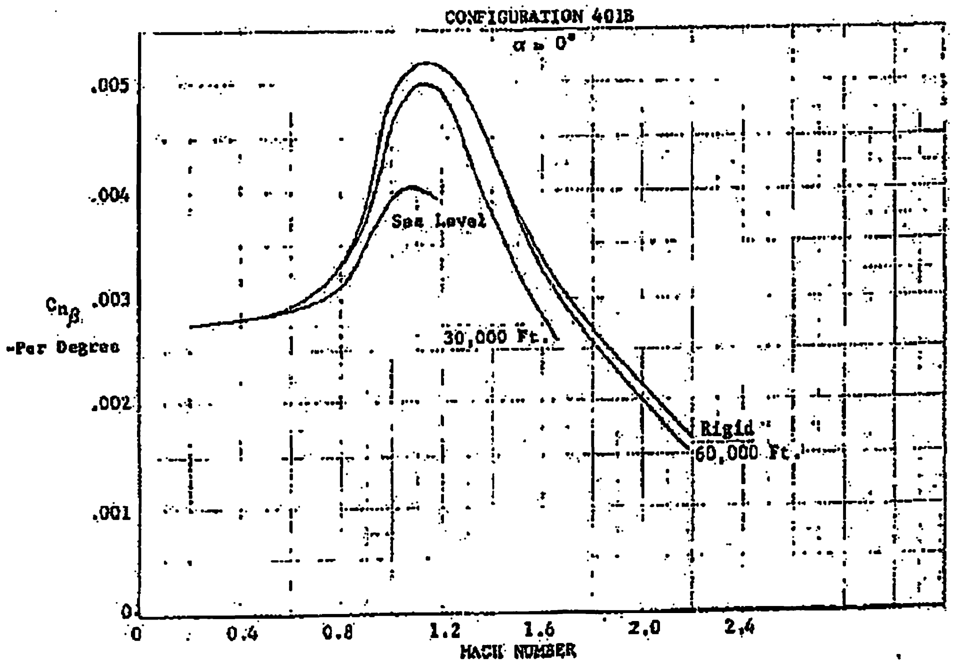
(U) Static lateral stability in terms of effective dihedral is presented as a function of Mach number in Figure 3.4-11 and as a function of angle of attack in Figure 3.4-12. The predicted variations are patterned after similar data for the F-5 airplane. Positive dihedral effect is apparent even to high angles of attack. The positive level of effective dihedral shown at high angles of attack precludes the presence of wing rock.



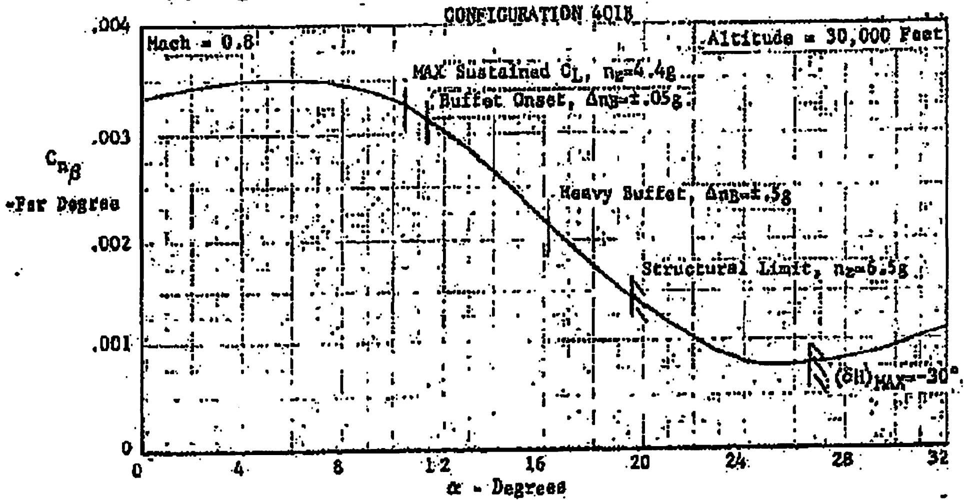
(U) Figure 3.4-7 Pitch-Rate Damping vs Mach



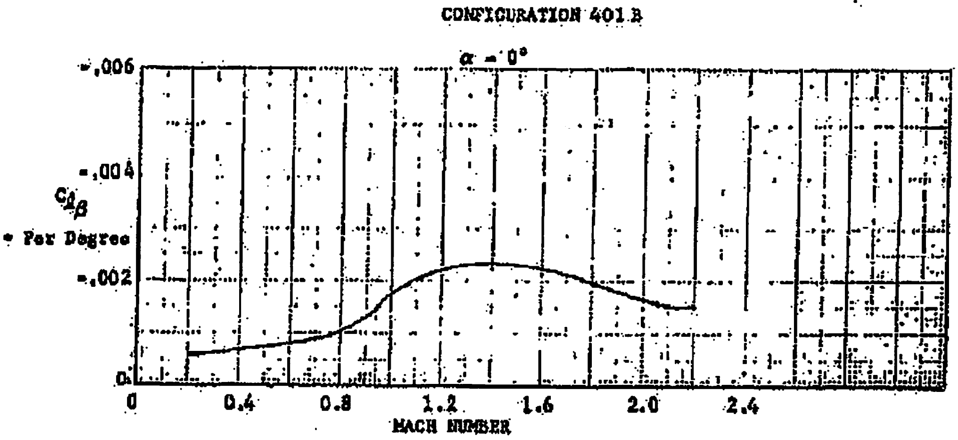
(U) Figure 3.4-8 Pitch-Rate Damping vs Angle of Attack



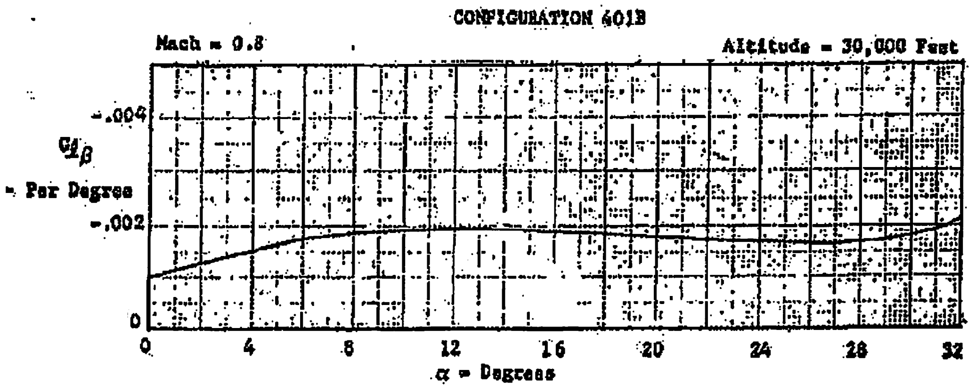
(U) Figure 3.4-9 Directional Stability vs Mach Number



(U) Figure 3.4-10 Directional Stability vs Angle of Attack



(U) Figure 3.4-11 Effective Dihedral vs Mach Number



(U) Figure 3.4-12 Effective Dihedral vs Angle of Attack

(U) The variations of aileron control effectiveness with Mach number and angle of attack are shown in Figures 3.4-13 and 3.4-14, respectively. These data are based directly upon transonic roll research model tests (Reference 15). Adequate aileron control effectiveness is provided to high angles of attack. Estimated aeroelastic effects on aileron control are included and show that adequate aileron roll-control effectiveness is maintained throughout the flight envelope. The mid-wing design concept allows a highly efficient, thick, wing root structure, which, in conjunction with the low structural aspect ratio of the wing, provides a highly rigid wing airframe to preclude aeroelastic aileron roll reversal.

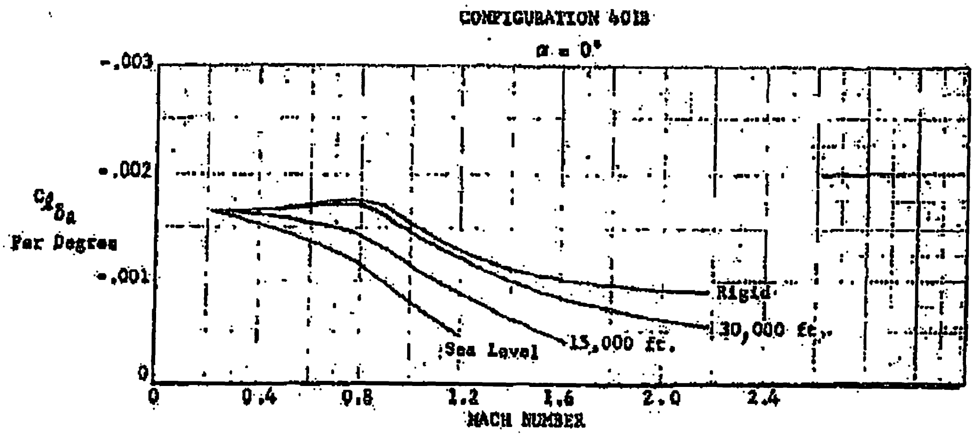
(U) The predicted yaw due to aileron deflection, compatible with the roll effectiveness predictions, is presented as a function of Mach number in Figure 3.4-15 and as a function of angle of attack in Figure 3.4-16. These predicted parameters are based on the results of analyses of available test data for similar configurations. The primary configuration effects were isolated and the values were estimated for the 401B arrangement. Note, particularly, that $C_{n_{\delta_a}}$ demonstrates a relatively small variation with angle of attack and does not assume very large adverse or proverse levels even at very high flight attitudes.

(U) Rudder effectiveness is presented as a function of Mach number in Figure 3.4-17. Aeroelastic effects on rudder effectiveness are based on FX estimates. Adequate directional control is available throughout the Mach-altitude flight envelope.

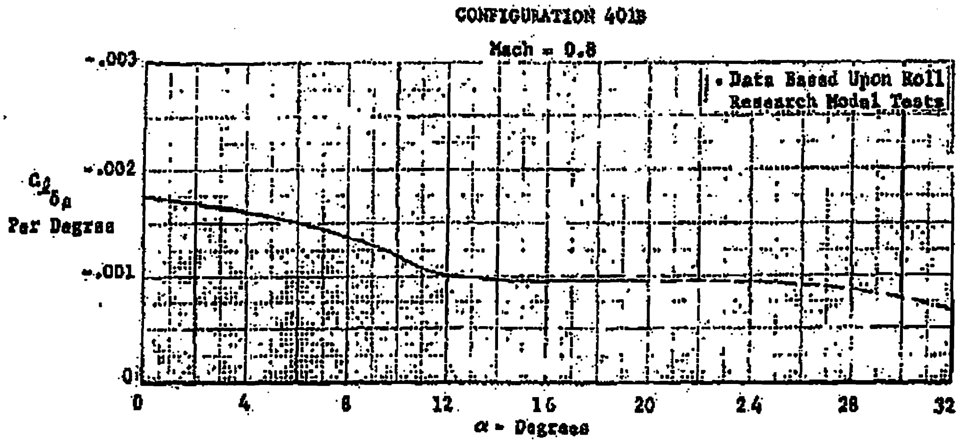
(U) Estimates of yaw- and roll-rate damping parameters are presented as a function of Mach number in Figures 3.4-18 and 3.4-19, respectively. These parameters are used in establishing the lateral-directional free-airplane dynamics.

3.4.4 Handling Qualities

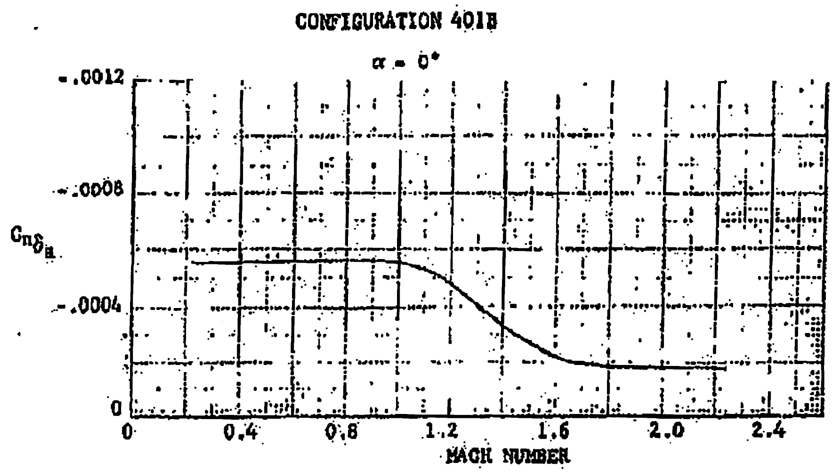
(U) A limited analysis of the free airplane handling qualities of configuration 401B fighter has been conducted. In some cases, appropriate MIL-F-8785B specifications are indicated for comparative purposes.



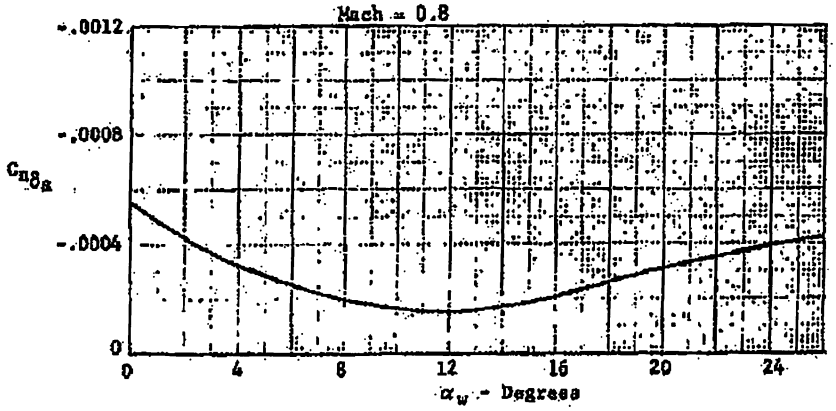
(U) Figure 3.4-13 Aileron Control Effectiveness vs Mach Number



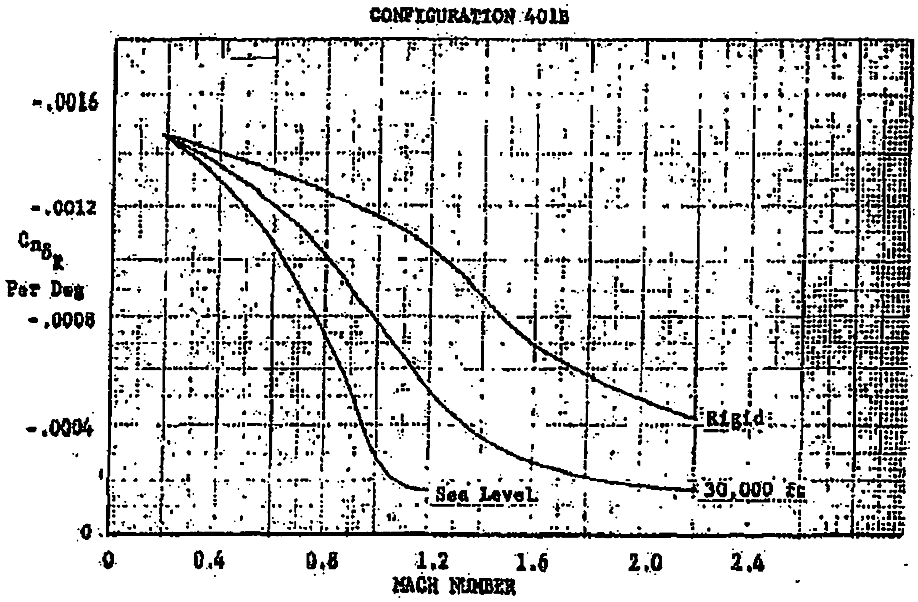
(U) Figure 3.4-14 Aileron Control Effectiveness vs Angle of Attack



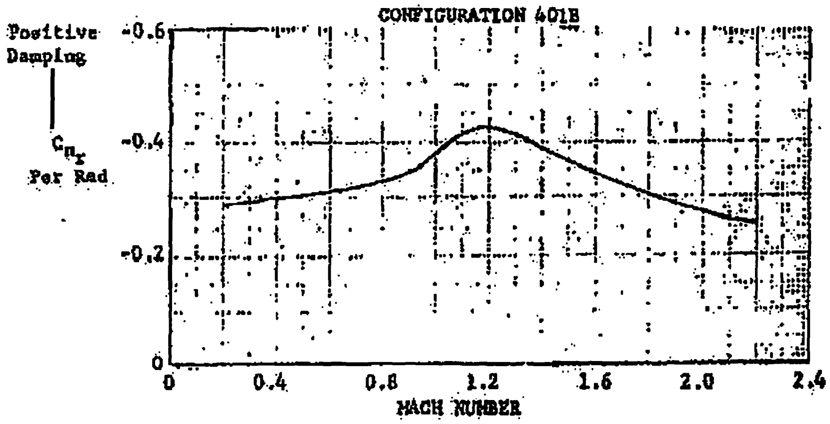
(U) Figure 3.4-15 Yaw Moment Due to Aileron Deflection vs Mach Number



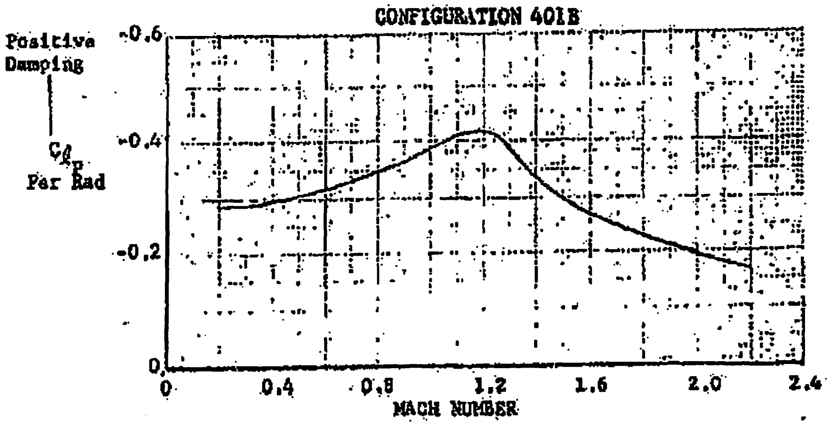
(U) Figure 3.4-16 Yaw Moment Due to Aileron Deflection vs Angle of Attack



(U) Figure 3.4-17 Rudder Effectiveness vs Mach Number



(U) Figure 3.4-18 Yaw-Rate Damping vs Mach Number



(U) Figure 3.4-19 Roll-Rate Damping vs Mach Number

(U) Pertinent handling qualities for the primary operating conditions in the combat region, shown in Figure 3.4-20, have been investigated to establish the predicted combat flight characteristics of the free airplane. These characteristics will be enhanced by a simple stability and command augmentation system.

(U) In general, the handling qualities characteristics have been investigated at the more demanding maximum sustained load factors in turning flight rather than for trim level flight. Handling qualities investigations included free-airplane longitudinal and lateral-directional dynamics, maximum trim lift, maneuver-gradients roll response, and spin-resistance factors. These analyses assumed maximum internal fuel and minimum static margin. Specific airplane parameters used are listed in Table 3.4-3. The moments of inertia are about the principal axes and the inclination of the principal axis with the wing root reference chord is 1 degree down.

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC. 3.3(b)
(4)&(6)
1.4(a)(g)

DOE (b)(1) (b)(3) 6 (b)(4)
EO SEC 3.3
SEC 1.4(a)(g)

~~(S)~~ Table 3.4-3 PHYSICAL PARAMETERS (U)

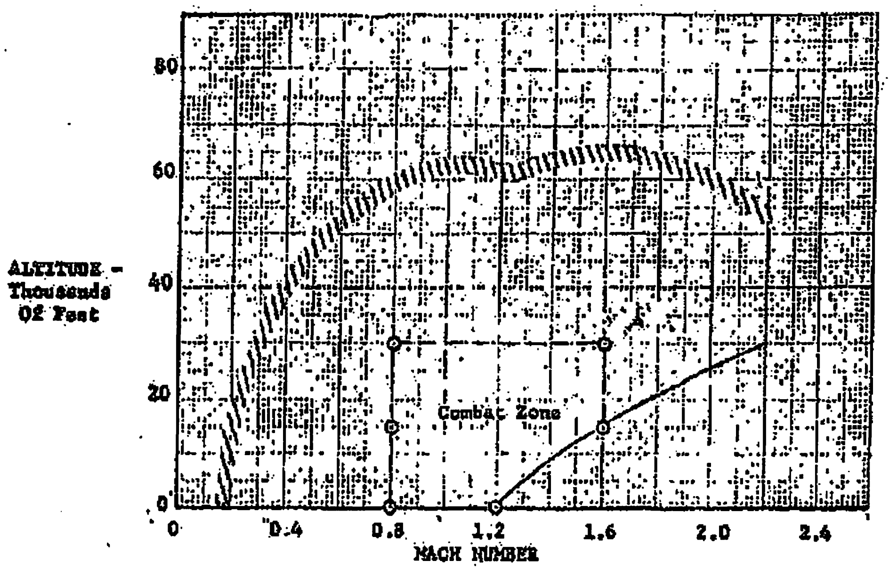
Gross Weight	16,800 lb
Center of Gravity	25 - 27% MAC
Pitch Inertia	31,886 slug-ft^2
Yaw Inertia	36,228 slug-ft^2
Roll Inertia	6,727 slug-ft^2
Wing Ref. Area	280 ft^2
MAC	133 in.
Wing Ref. Span	29 ft

3.4.4.1 Dynamics

(U) Longitudinal short-period frequency characteristics are presented in Figure 3.4-21 for the free airplane. Requirements of MIL-F-8785B are indicated for comparative purposes only to show that all of the combat flight conditions investigated fall in the satisfactory Level 1 region. Unaugmented short-period pitch-damping ratios for the corresponding flight conditions are tabulated in the legend in Figure 3.4-21. Good free-airplane damping ratios are evident; however, the augmentation system will further enhance these characteristics. These data are indicative of the excellent longitudinal short-period dynamic characteristics inherently designed into the 401B fighter.

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC 3.6
(b)(4)
1.4. (a)(g)

SEC. 3.3(b)(4)
SEC. 1.4(a)(g)

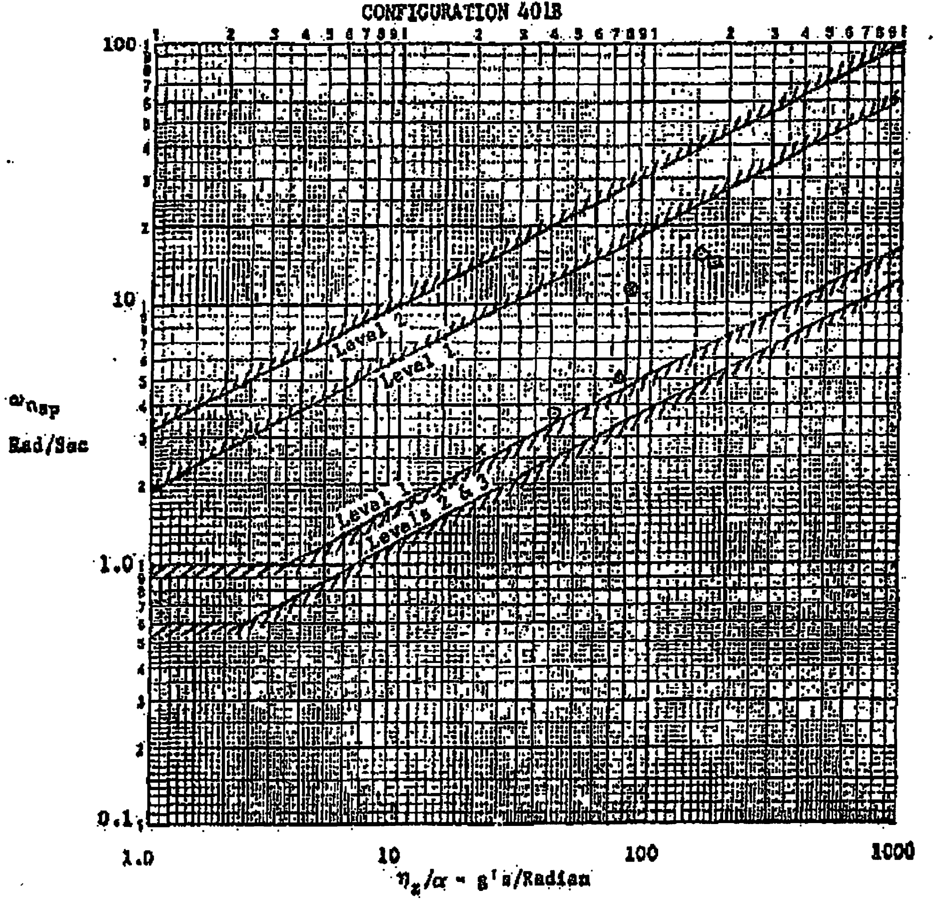


(U) Figure 3.4-20 Combat Flight Conditions

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC 3.3(b)(4)
1.4(a)(g)

88 ABW/IPI
FOIA (b)(1)
E.O.13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)

Symbol	Mach	Altitude	ζ_{sp}
×	0.8	30,000 ft	.31
⊗	1.6	30,000 ft	.15
○	0.8	15,000 ft	.41
△	0.8	Sea Level	.51
□	1.2	Sea Level	.31
◇	1.6	15,000 ft	.19

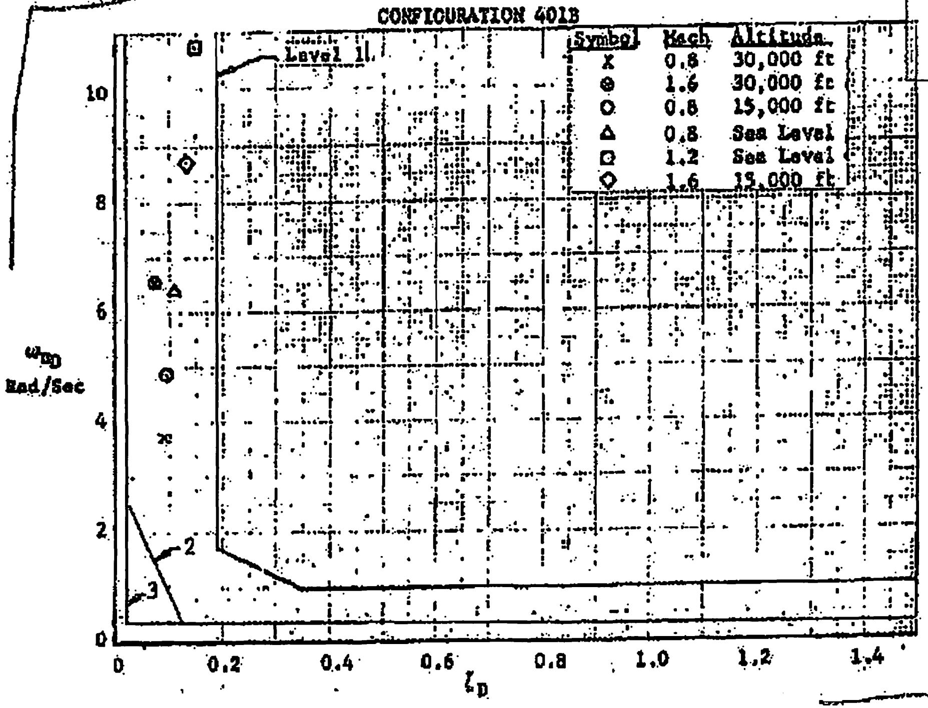


(U) Figure 3.4-21 Free-Airframe Longitudinal Dynamics

88th ABW/IP
FOIA (b)(1)
E.O.12958 SEC. 3.3(b)
(4)(5)
1.4.(a)(g)

EO 13526
SEC. 3.3(b)(2)(9)
SEC 1.4(a)(g)

2 p45



(U) Figure 3.4-22 Free-Airframe Dutch-Roll Characteristics

(U) Free airplane Dutch roll frequency as a function of damping ratio is presented in Figure 3.4-22. MIL-F-8785B requirements for Category A (combat) flight phase are superimposed for reference purposes. The analyzed flight conditions fall in the Level 2 requirements region. Level 2 represents handling qualities adequate to accomplish the mission but with some increase in work load. Consequently, achievement of Level 2 lateral-directional dynamics with the free airplane demonstrates the results of the same careful design that produced the good longitudinal dynamics. In both longitudinal and lateral-directional modes, the final augmented handling qualities of Configuration 401B will be further enhanced by the stability and command augmentation system.

3.4.4.2 Trim Control Power

(U) An all-movable horizontal tail surface is used to maximize control effectiveness at supersonic speed. Based upon an inflight aft c.g. of 27% MAC, adequate longitudinal maneuvering-response control power is available as demonstrated by the trim capability summarized in Table 3.4-4. Trim deflections have also been estimated to establish trim drag polars for the performance analysis in Subsection 3.4.

Table 3.4-4 TRIM ELEVATOR FOR LIMIT LOAD FACTOR

Alt. (Ft)	Mach	$(C_L)_{n_L}$	$\delta_{H_{n_L}}$ (deg)
30,000	.8	1.3	-6.5
30,000	1.6	.326	-6.8

The trim deflections noted above have been estimated for a typical combat wing loading.

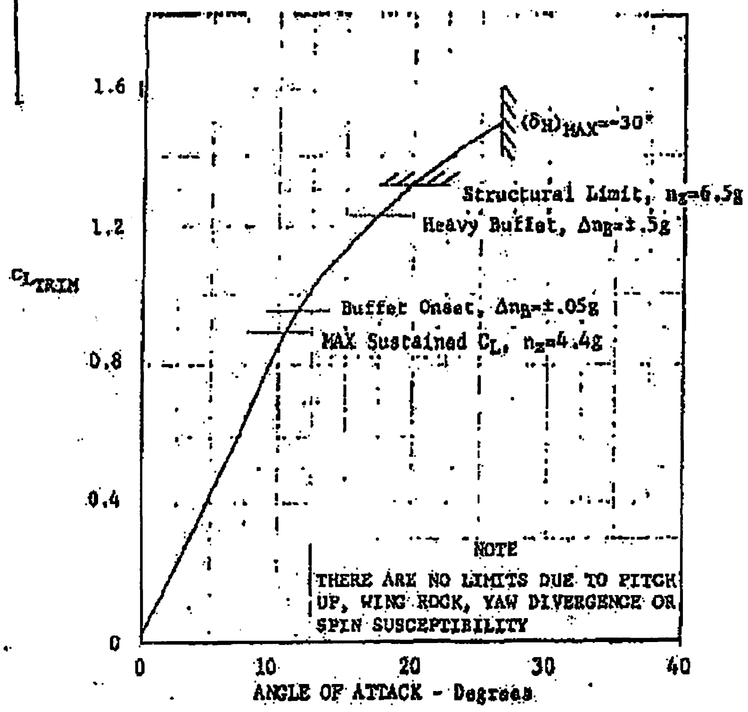
(U) Combat maneuver criteria dictate good handling qualities up to the maximum wing angle of attack as determined by aerodynamic stall or airframe structural limits. Trim lift characteristics at the Mach 0.8, 30,000-foot condition are presented in Figure 3.4-23. The pitch control power is sufficient to develop angles of attack corresponding to the maximum lift capability of the airplane within the operational envelope. Reference to Figure 3.4-10 shows that a

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4),
1.4. (a)(g)

FOIA (b)(1)
E.O 13526
3.3.(b)(4)
1.4.(A)(G)

CONFIGURATION 401B

Mach = 0.8
Altitude = 30,000 Feet
Gross Weight = 15,870 lbs.
Center of Gravity = 27% MAC
δ_{LEF} = 15 Degrees



~~(S)~~ Figure 3.4-23 Trimmed Lift Curve (U) good level of static directional stability is maintained throughout this angle-of-attack range. Further, as discussed below in Subsection 3.4.4.5, in the dynamic directional stability and the lateral control spin parameter demonstrate high positive levels at the high angles of attack that can be developed. These positive values preclude yaw divergence and indicate the presence of high spin resistance.

3.4.4.3 Maneuver Gradients

(U) Elevator maneuver gradients (δ_H/g) have been estimated for the combat flight conditions and are listed in Table 3.4-5.

Table 3.4-5 ELEVATOR MANEUVER GRADIENTS

GW = 16,800 lb CG @ 25% MAC

Mach	Altitude (ft)	δ_H/g (deg/g)
.8	SL	-.26
.8	15,000	-.49
.8	30,000	-.90
1.2	SL	-.34
1.6	15,000	-.58
1.6	30,000	-1.11

During flight on the deck, the maneuver gradients are relatively low. Design of a command augmentation system will mask the effects of low δ_H/g values from the pilot and provide near constant stick force per g characteristics. Also, the stick force gradient (F_H/g) supplied by the pitch command augmentation below 6 g will be designed for 3 to 5 lb/g with a nearly constant relationship. In addition, the stick force gradient will be increased above 6 g to three times the normal value.

3.4.4.4 Roll Response

(U) The 401B fighter is highly responsive to pilot roll command as evidenced in Table 3.4-6 by the bank angles achieved in 1 second for full stick throw at the combat flight conditions. The roll response quoted in Table 3.4-6 is representative of the unaugmented flexible airplane and indicates ample roll-control power availability. A roll-control command augmentation system can be incorporated to moderate the exceedingly high roll rates above 200 degrees per second and will tend to hold constant response with varying dynamic pressures.

(U) As mentioned previously, the mid-wing placement in conjunction with the low structural-wing aspect ratio affords a relatively rigid structural wing frame. This allows ailerons to be used throughout the flight envelope without encountering aeroelastic roll reversal.

Table 3.4-6 FREE-AIRPLANE ROLL RESPONSE

GW = 16,800 lb CG @ 25% MAC

Mach	Altitude (ft)	Bank Angle in 1 Second (deg)
.8	SL	168
.8	15,000	199
.8	30,000	196
1.2	SL	101
1.2	15,000	269
1.2	30,000	161

3.4.4.5 Spin Resistance

(U) Two important parameters that are prime indicators of spin susceptibility (or degree of spin resistance) are the dynamic-directional-stability parameter and the lateral-control spin parameter (LCSP). Each has been evaluated at the Mach 0.8, 20,000-foot condition and are presented as a function of angle of attack in Figure 3.4-24. Increasing positive values of these two parameters are representative of increasing spin resistance. The curves of Figure 3.4-24 indicate that positive levels are maintained to very high angles of attack. Such levels indicate that there will be a high spin resistance and that there will be no post-stall yaw departure. Thus, the fighter pilot can maneuver the 401B configuration to its maximum potential with full confidence that it has no pitch up or yaw divergence and is highly spin resistant.

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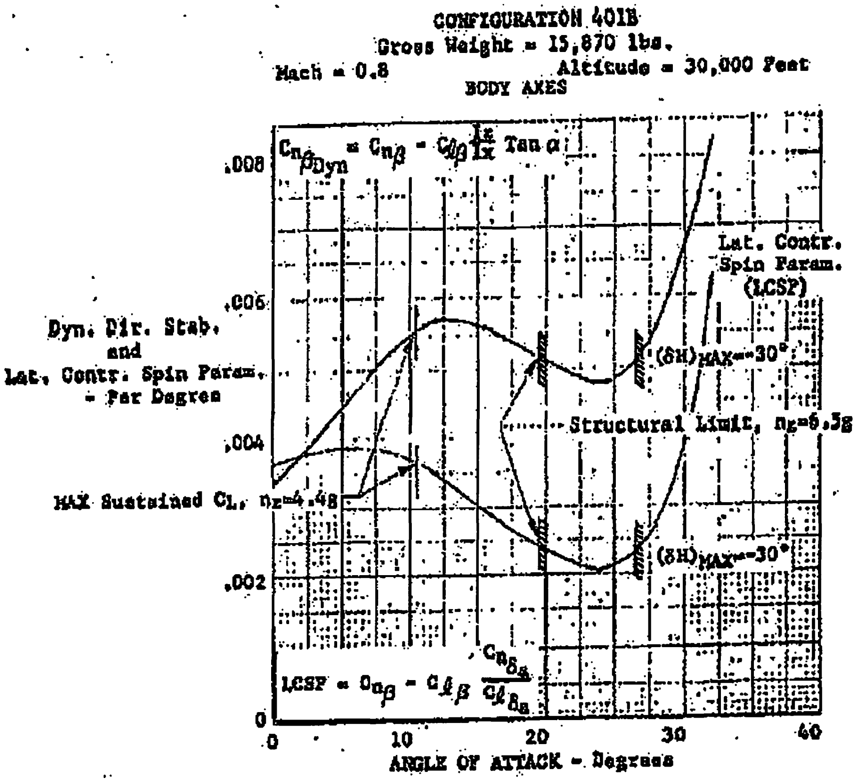

~~(S)~~ Figure 3.4-24 Dynamic Directional Stability and Lateral Control Spin Parameter (U)

3.5 STRUCTURES AND WEIGHTS

3.5.1 Structural Design Rationale

(U) Considerable emphasis has been given to the structural design during the development of the study configuration. One of the key features of the configuration is an expanded wing-root section, which provides the following effects: (1) a reduction of axial forces due to bending as a result of the deeper section; (2) the elimination of potential aileron reversal and other dynamic problems because of the stiffer wing; (3) a reduction of structural weight, and (4) an increase in fuel capacity.

(U) Other structural design features include the following:

1. Relatively deep fuselage rings that provide load paths for the wing carry-through moment and permit control system routing through the frames. Spar caps are attached directly to these frames for continuity of the basic wing load paths.
2. Main landing gear stowage forward of the basic wing box that permits minimum interruption of the basic wing load paths.
3. A relatively deep mid-fuselage that provides for minimum longeron area requirements.
4. A twin-vertical-tail/aft-fuselage-extension configuration that minimizes engine heating and acoustical problems.
5. A relatively low-aspect-ratio wing that results in a reduced wing bending moment because of the shorter span.
6. A relatively low-taper-ratio wing that results in a long root chord which distributes the wing root forces to several ring bulkheads to provide a multi-load path structure.
7. Engine removal from the aft end of the airplane that permits a fixed structure, thereby maintaining continuity of load paths.

8. A 6-percent thickness-to-chord ratio at the roots of the vertical and horizontal tails and a 4-percent ratio at the tips that provide better stiffness characteristics than a constant thickness-to-chord ratio.

(U) These features have evolved through many trade studies and illustrate to some extent the impact of structural design and analysis on the study configurations.

3.5.2 Weight and Balance

(U) The weights for Configuration 401B were calculated through the use of analytical-statistical methods developed over several years under corporate-sponsored Independent Research and Development (IRAD) programs. These methods are documented in Convair Aerospace Division reports ERR-FW-242, "Aircraft Structural Weight Estimating Methods" (Reference 16), and ERR-FW-613, "Aircraft Propulsion and Fixed Equipment Weight Estimating Methods" (Reference 17). These reports are on file at ASD for reference purposes. The detailed weight analyses are not presented as a part of this technical report because the detailed weight calculations as defined in the ERR-FW-242 and ERR-FW-613 reports are quite voluminous in nature. However, these calculations are available for review.

~~(S)~~ Three gross weights were selected for the growth study on Configuration 401B. The points selected for study and the various gross-weight conditions (in pounds) for each point are as follows:

SRASM TOGW	(80% Fuel) Struct DGW	LRASM Overload GW	Ferry Mission Overload GW
15600	14920	20438	25800
16800	15960	21638	27000
18000	17000	23838	28200

~~(S)~~ Input data for the weight equations were derived from the scaling data presented in Section 3.1 together with layouts as required to develop specific area and dimensional data. Considerable emphasis was given to the definition of weighing parameters to assure the validity of the resulting growth curve. A weight summary for the three selected airplanes is presented in Table 3.5-1. It should be noted

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SEC 1.4 (a)(g)
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~~(S)~~ Table 3.5-1 WEIGHT SUMMARY: CONFIGURATION 401B GROWTH STUDY (pounds) (U)

Item	Airplane Size (Gross Weight)		
	15,600	16,800	18,000
Structure	(5133)	(5426)	(5744)
Wing	1443	1576	1716
Fuselage	2485	2572	2666
Horizontal Tail	318	346	382
Vertical Tail	292	316	344
Landing Gear	595	616	636
Propulsion System	(3459)	(3530)	(3603)
Engine (F100-PW-100)	2737	2737	2737
Air Induction	296	322	349
Fuel System	377	421	467
Engine Controls	21	22	22
Starting System	28	28	28
Systems and Equipment	(2699)	(2751)	(2804)
Surface Controls	566	593	621
Landing Gear Controls	112	115	118
Instruments	94	94	94
Hydraulics and Pneumatics	271	286	302
Electrical	363	370	376
Avionics	460	460	460
Furnishings	238	238	238
Air Conditioning	142	142	142
Armament	453	453	453
Weight Empty	11,291	11,707	12,151
Useful Load	(395)	(400)	(405)
Crew	200	200	200
Unusable Fuel	18	23	28
Engine Oil	17	17	17
Missile Racks and Pylons	124	124	124
Miscellaneous	36	36	36
Basic Operating Weight	11,686	12,107	12,556
Payload	(633)	(633)	(633)
Ammo (500 rounds)	285	285	285
Missiles (2)	348	348	348
Zero Fuel Weight	12,319	12,740	13,189
Fuel	3281	4060	4811
Gross Weight	15,600	16,800	18,000

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that the fixed-inlet structure has been coded as air-induction weight under Propulsion System. Since this structure is an integral part of the fuselage, it performs the dual function of resisting inlet pressure loads together with resisting the basic body loads. A plot of weight variation versus mission design weight is shown in Figure 3.5-1. The center-of-gravity and inertia properties are summarized below for the 16,800-pound-gross-weight SRASM configuration.

Properties	Basic Operating Weight	Zero Fuel Weight	Gross Weight
Weight (lb)	12,107	12,740	16,800
Horiz. CG (% MAC)	23.9	23.2	20.5
I_{xx}	4932	5702	6727
I_{yy}	30,130	30,515	31,886
I_{zz}	32,988	34,058	36,228

~~(S)~~ The maximum overload condition is defined by the ferry mission requirements. A weight summary for the LRASM and the ferry mission for the 16,800-pound-design-gross-weight configuration is shown in Table 3.5-2. A center of gravity summary for these conditions is as follows:

Item	LRASM		Ferry Mission	
	Weight (lb)	C.G. (% MAC)	Weight (lb)	C.G. (% MAC)
Basic Operating Weight	12,955	21.5	13,797	21.5
Zero Fuel Weight	13,588	20.9	14,082	20.5
Gross Weight	21,638	19.9	27,000	20.7

When sized to meet LRASM requirements, the design gross weight of Configuration 401B is 17,115 pounds. There is no significant center-of-gravity difference between the 16,800-pound configuration and the 17,115-pound configuration. A weight summary for this configuration is given in Table 3.5-3.

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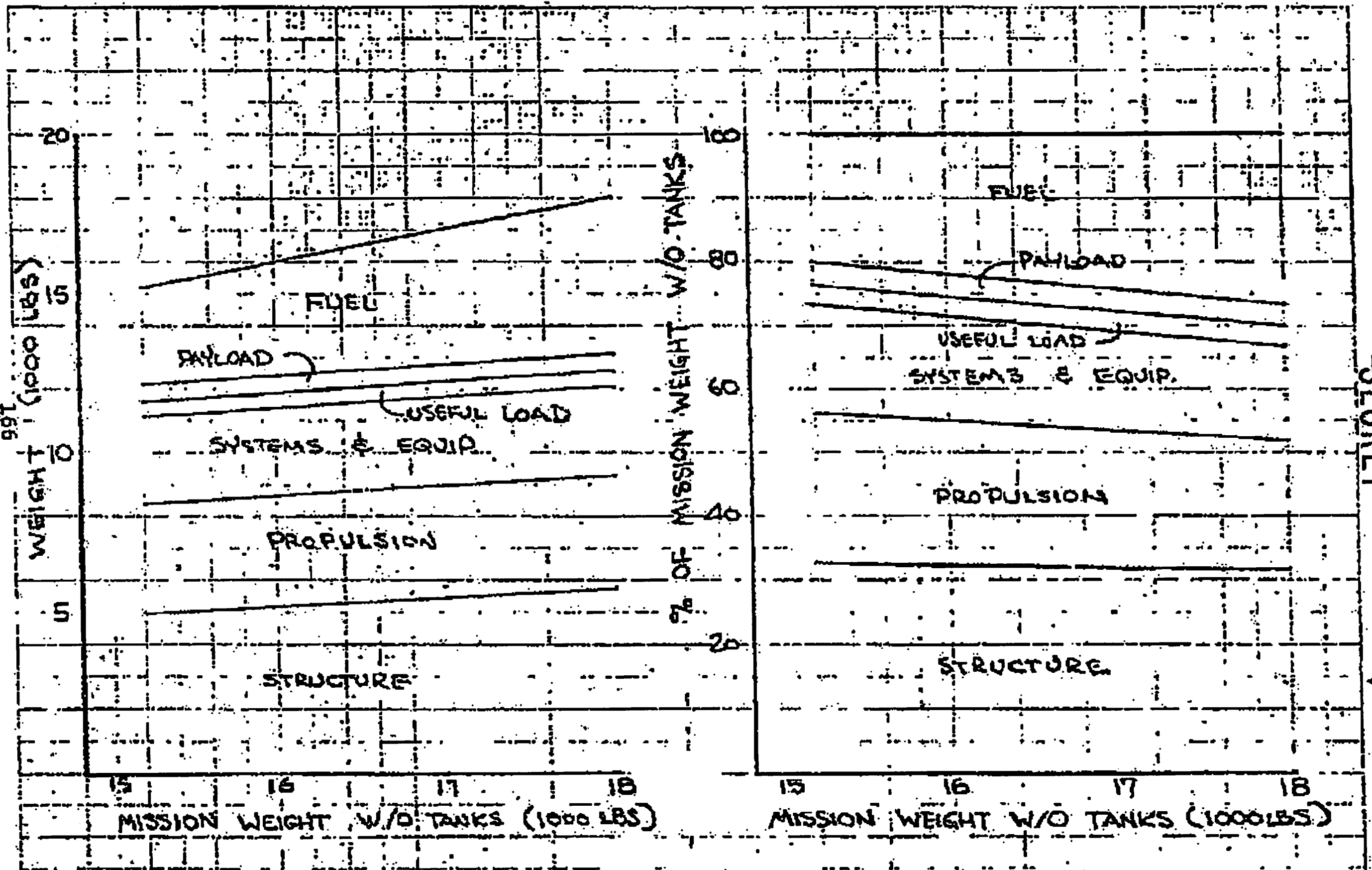

~~(S)~~ Figure 3.5-1 Weight Variation with Aircraft Size: Configuration 401B (U)

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~~(S)~~ Table 3.5-2 WEIGHT SUMMARY:
CONFIGURATION 401B LRASM AND FERRY MISSION (U)
(pounds)

16,800-lb. AIRPLANE

Item	LRASM Weight	Ferry Mission Weight
Weight Empty	11,707	11,707
Useful Load	(1,248)	(2,090)
Crew	200	200
Unusable Fuel-Internal	23	23
Engine Oil	17	17
Missile Racks & Pylons	124	-
Miscellaneous	36	36
(2) 300-Gal. Tanks	848	-
(1) 150-Gal. Tank	-	308
(2) 600-Gal. Tanks	-	1,506
Basic Operating Weight	12,955	13,797
Payload	(633)	(285)
Ammo (500 rounds)	285	285
(2) AIM 9-X	348	-
Zero Fuel Weight	13,588	14,082
Fuel	(8,050)	(12,918)
Internal	4,060	4,060
External		
(2) 300-Gal. Tanks	3,990	-
(1) 150-Gal. Tank	-	1,016
(2) 600-Gal. Tanks	-	7,842
Gross Weight	21,638	27,000

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~~(S)~~ Table 3.5-3 WEIGHT SUMMARY: CONFIGURATION 401B SIZED TO MEET LRASM REQUIREMENTS (U)
(pounds)

Item	Weight
Structure	(5510)
Wing	1612
Fuselage	2600
Horizontal Tail	355
Vertical Tail	322
Landing Gear	621
Propulsion System	(3548)
Engine (F-100-PW-100)	2737
Air Induction	328
Fuel System	433
Engine Controls	22
Starting System	28
Systems and Equipment	(2766)
Surface Controls	601
Landing Gear Controls	116
Instruments	94
Hydraulics and Pneumatics	290
Electrical	372
Avionics	460
Furnishings	238
Air Conditioning System	142
Armament	453
Weight Empty	11,824
Useful Load	(401)
Crew	200
Unuseable Fuel	24
Engine Oil	17
Missile Racks and Pylons	124
Miscellaneous	36
Basic Operating Weight	12,225
Payload	(633)
Ammo (500 rounds)	285
Missiles (2)	348
Zero Fuel Weight	12,858
Fuel	4,257
Gross Weight	17,115

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3.6 PROPULSION (401B/F100-PW-100)

(U) The engine installed in Configuration 401B is essentially the F100-PW-100. Certain accessories and attachments unique to the F-15 airplane installation are deleted. The Pratt & Whitney Aircraft designation for this study derivative engine is JTF22A-27 (Reference 18). In this report the engine will be referred to as the F100-PW-100. Engine performance data are furnished by P&WA in their customer computer deck CCD 1025 (Reference 19). A more recent deck was received on 1 April 1971 from P&WA. However, time did not permit revision of the installed-propulsion-system performance data package. The fuel control schedule selected for the engine performance data presented in this report is that which provides near-optimum engine thrust during afterburning (Reference 20), but exhibits an undesirable airflow schedule at some flight conditions. A brief investigation showed that propulsion performance data from the new deck for the F100-PW-100 design airflow are different from those contained in this report only at altitudes above 50,000 feet (maximum thrust reduction of 25% occurs at low supersonic Mach numbers). Performance below intermediate power is not affected.

(U) The engine is located in the aircraft aft fuselage, with primary air flow supplied by a single open-nose inlet located under the forward fuselage. A full description of the inlet is given in Subsection 3.6.2.

(U) The exhaust nozzle is the F100 engine balanced-beam nozzle (BBN), which is exposed aft of the customer connect. The nozzle exhaust area varies slightly during non-afterburning operation and is fully modulating from minimum to maximum afterburning. At Mach number below about 1.1 the nozzle area ratio is approximately 1.3. At about Mach 1.1, the nozzle exit area is shifted open to give an increase area ratio (approximately 1.6) at higher Mach numbers. This increased area ratio is referred to as "high gear". A more detailed description of, and data for, the nozzle is given in Subsection 3.6.3.

(U) A small amount of ventilation air flows through the nacelle. The drag for nacelle ventilation is not included in the engine performance data but is accounted for in the airplane drag (see Subsection 3.6.4)

(U) High-pressure air is bled from the high-pressure-compressor discharge port provided on the engine for operation of the environmental control system. Shaft power is extracted from the high-pressure-compressor rotor to generate electrical and hydraulic power for the airplane.

3.6.1 Propulsion System Performance

(U) The installed thrust specific fuel consumption (TSFCS) and propulsion net thrust (F_{NS}) of the F100-PW-100 are plotted in Figures 3.6-1 through 3.6-14. The data shown comprise a complete package needed for airplane energy-maneuverability analysis. The installed net thrust presented, F_{NS}, accounts for all drag changes that occur with power setting changes. The installed net thrust is defined as follows:

$$F_{NS} = F_N - F_{sp} - F_{noz}$$

where:

F_{NS}	is the installed net thrust of the propulsion system for aircraft performance analysis.
F_N	is the CCD 1025-1.1 computer program net thrust which accounts for (1) inlet pressure recovery (see Subsection 3.6.2), (2) shaft-power extraction and high-pressure-compressor airbleed (see Subsection 3.6.5), and (3) exhaust nozzle internal performance (contained in P&WA CCD 1025-0.1).
F_{sp}	is the inlet spillage drag, which accounts for the inlet drag when capture area ratios are other than 1.0 (see Subsection 3.6.2).
F_{noz}	accounts for drag changes associated with power setting when the nozzle is at other than the maximum open position (see Subsection 3.6.3).

Therefore, airplane drag levels used in conjunction with the installed thrust, F_{NS}, are for the inlet operating at a capture area ratio of 1.0 and the engine exhaust nozzle in the maximum open ("high gear") position.

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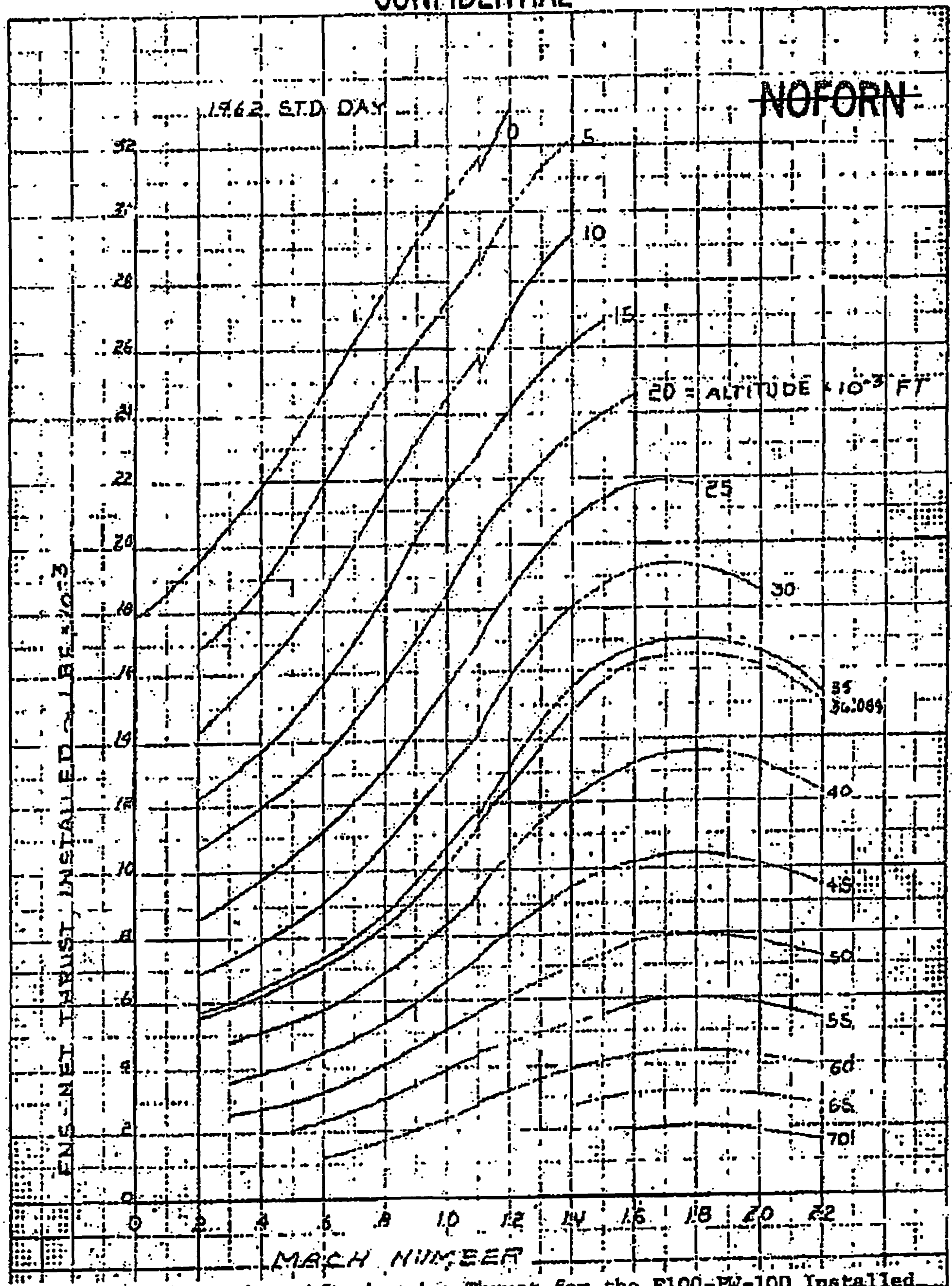

~~(C)~~ Figure 3.6-1 Maximum Afterburning Thrust for the F100-PW-100 Installed in Configuration 401B (U)

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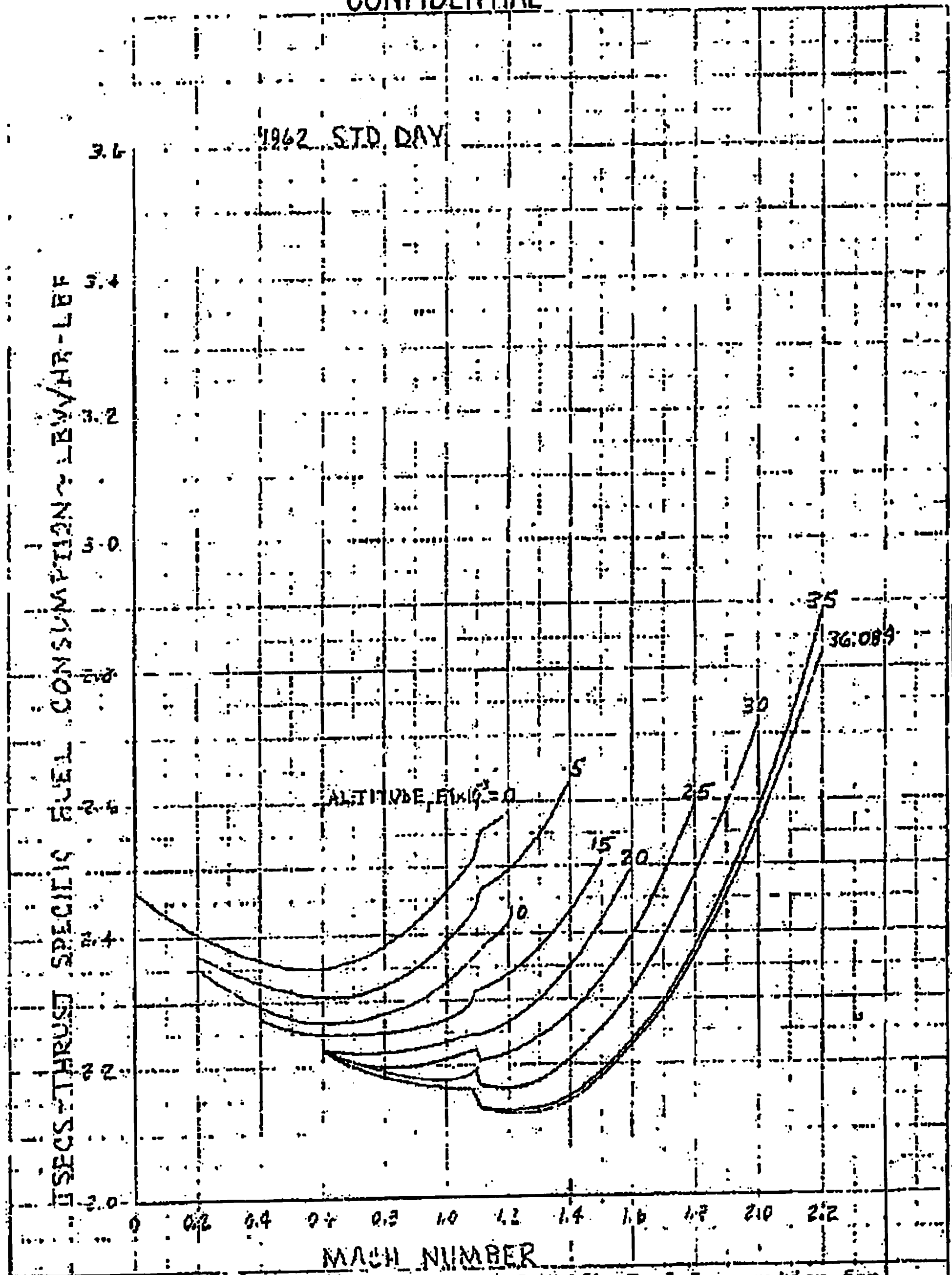

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~~(C)~~ Figure 3.6-2 Maximum Afterburning Specific Fuel Consumption for the F100-PW-100 Installed in Configuration 401B, Sea Level to 36,089 feet (U)

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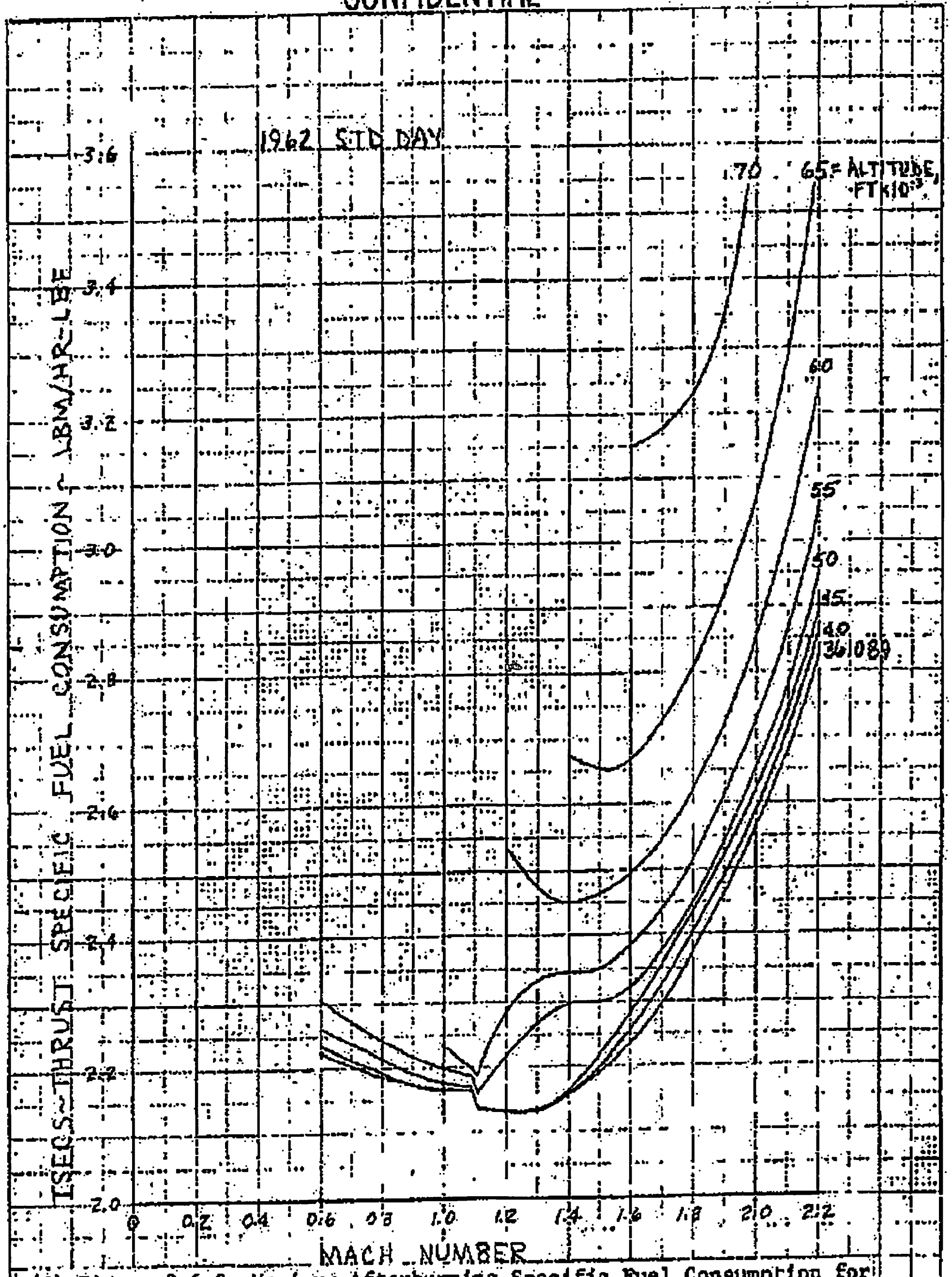

~~(C)~~ Figure 3.6-3 Maximum Afterburning Specific Fuel Consumption for the F100-PW-100 Installed in Configuration 401B, 36,089 to 70,000 feet (U)

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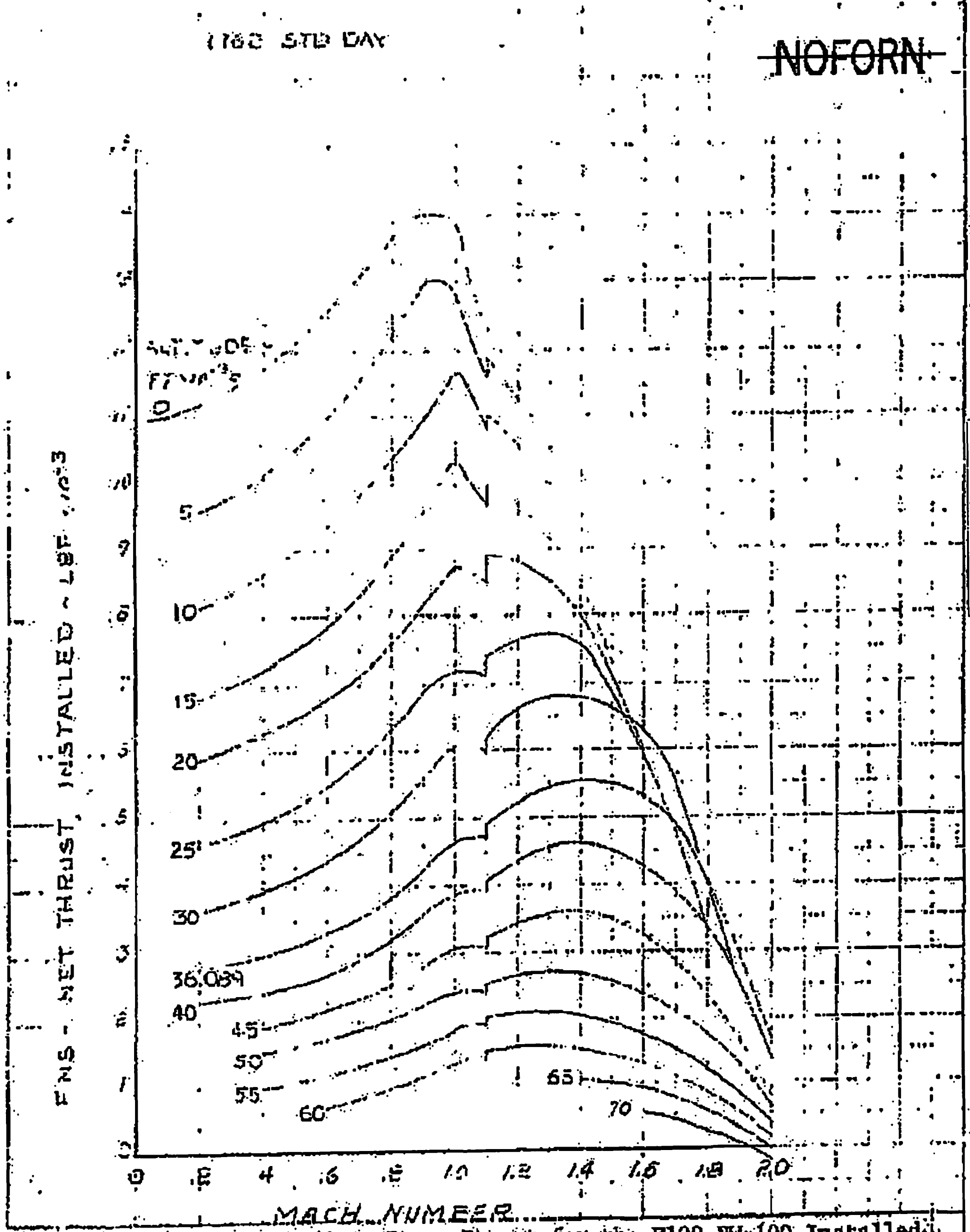

~~(C)~~ Figure 3.6-4 Intermediate Power Thrust for the F100-PW-100 Installed in Configuration 401B (U)

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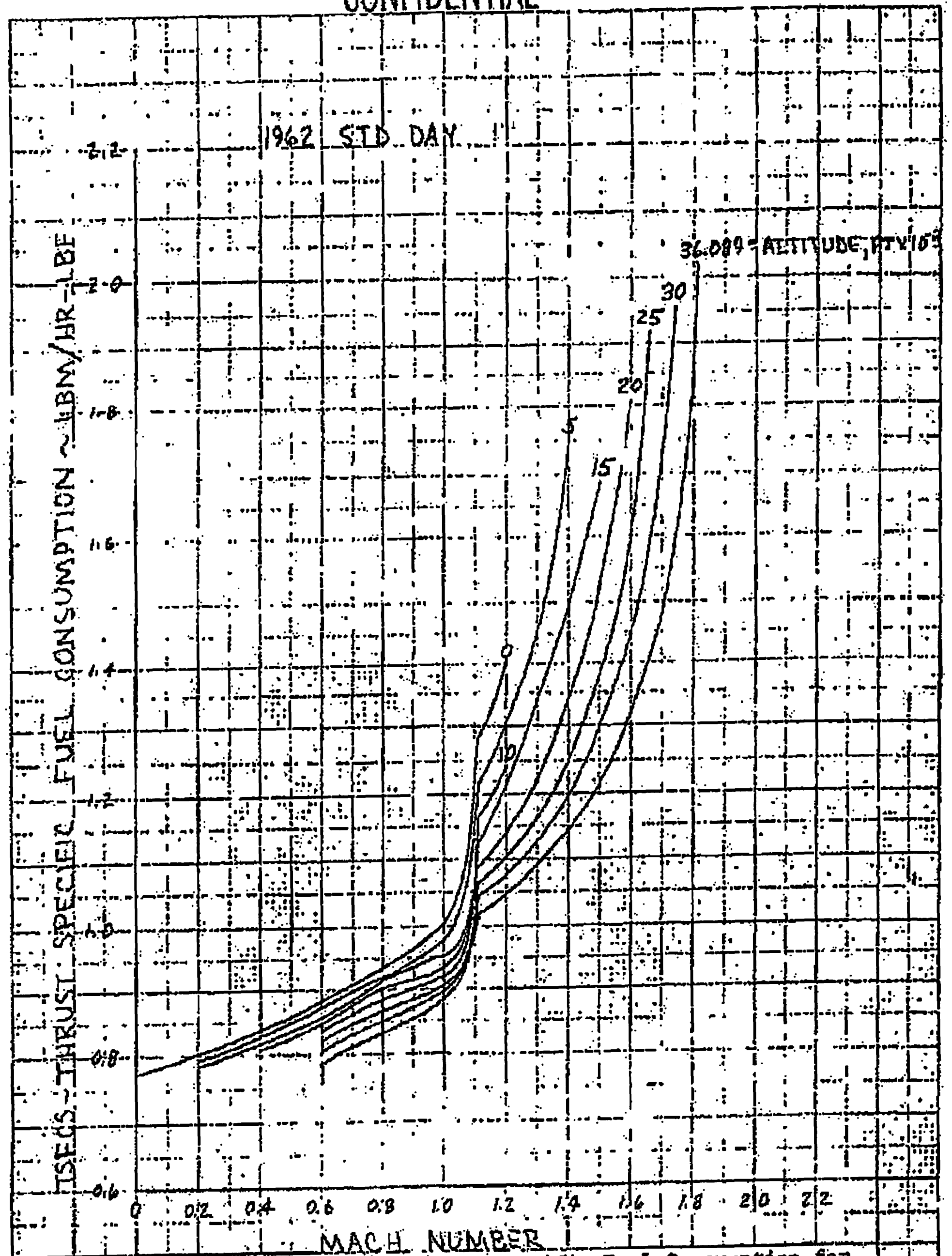

~~(C)~~ Figure 3.6-5 Intermediate Power Specific Fuel Consumption for the F100-PW-100 Installed in Configuration 401B, Sea Level to 36,089 feet (U)

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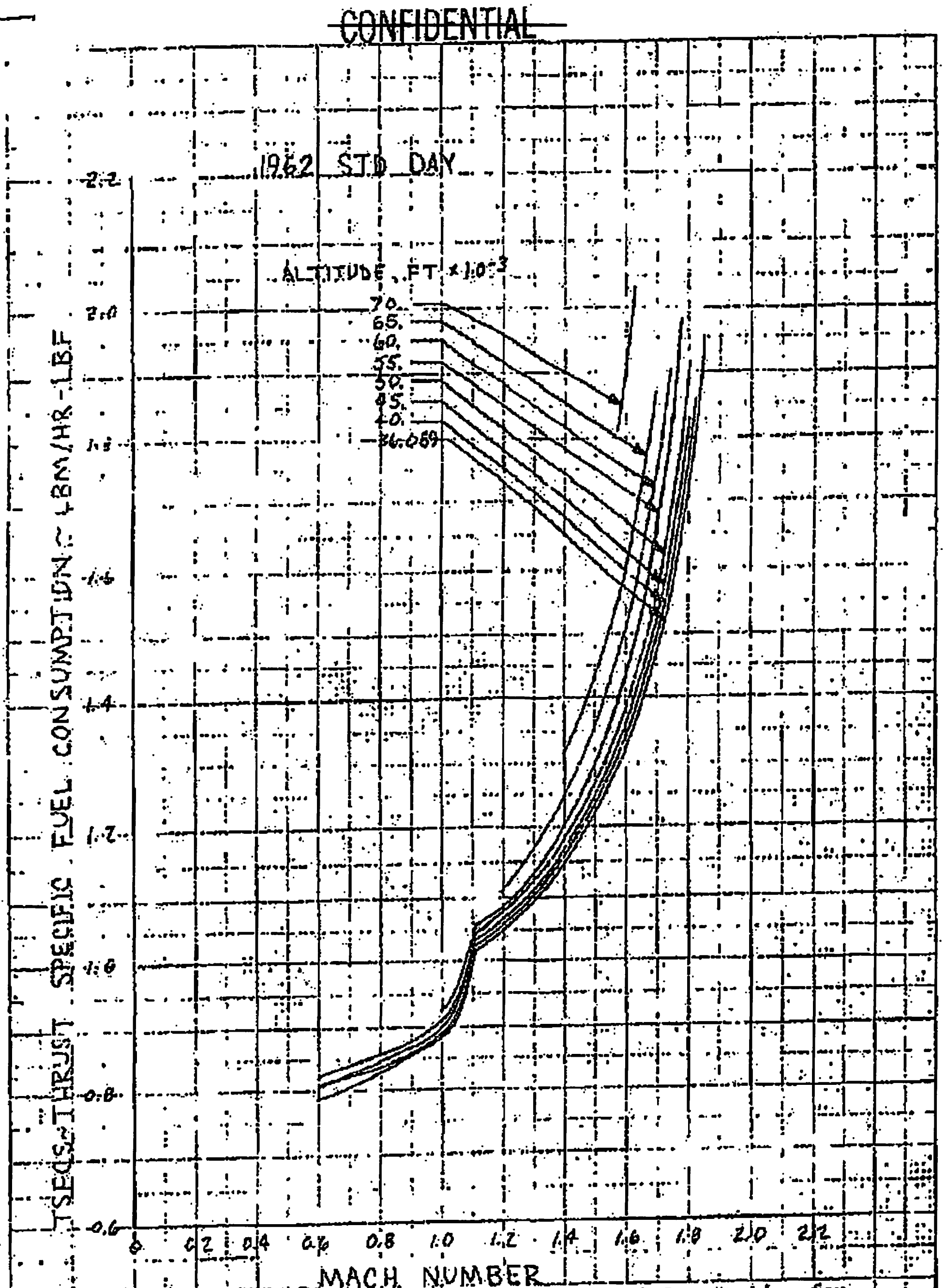

~~(C)~~ Figure 3.6-6 Intermediate Power Specific Fuel Consumption for the F100-PW-100 Installed in Configuration 401B, 36,089 to 70,000 feet (U)

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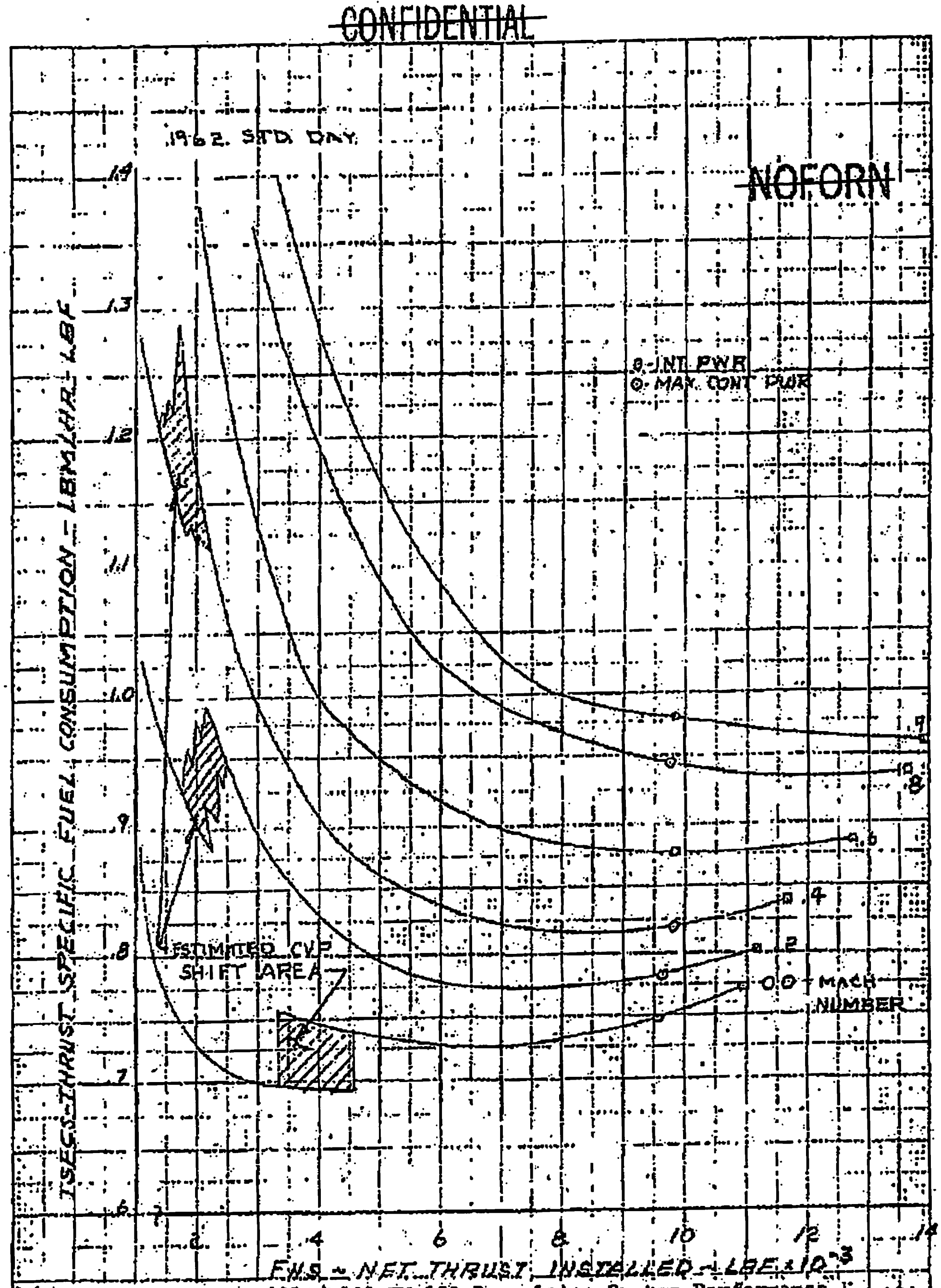

~~(C)~~ Figure 3.6-7 401B/F100-PW-100 Propulsion System Performance, Intermediate and Reduced Power, Sea Level (U)

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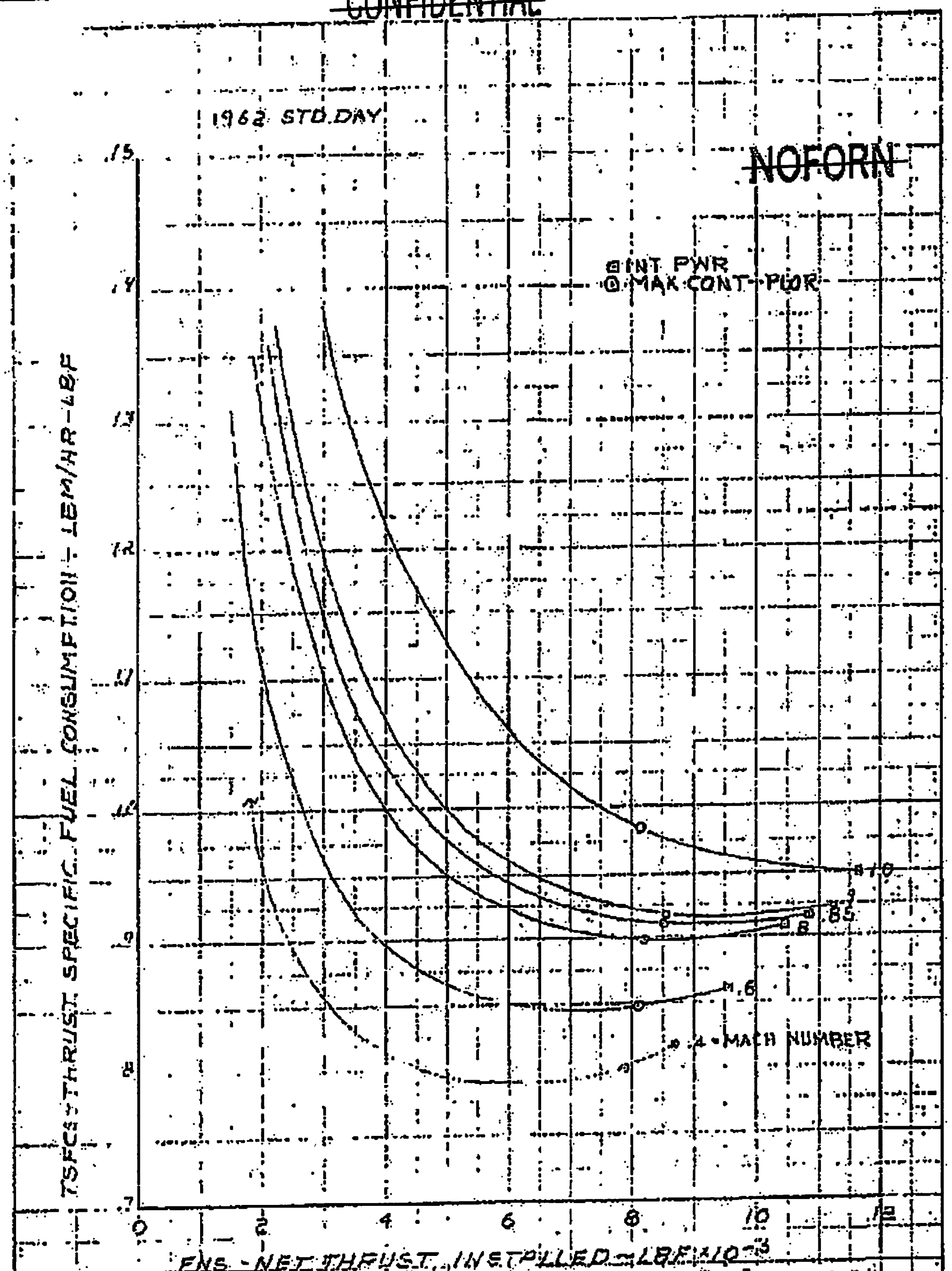

~~(C)~~ Figure 3.6-8 401B/F100-PW-100 Propulsion System Performance, Intermediate and Reduced Power, 10,000 feet (U)

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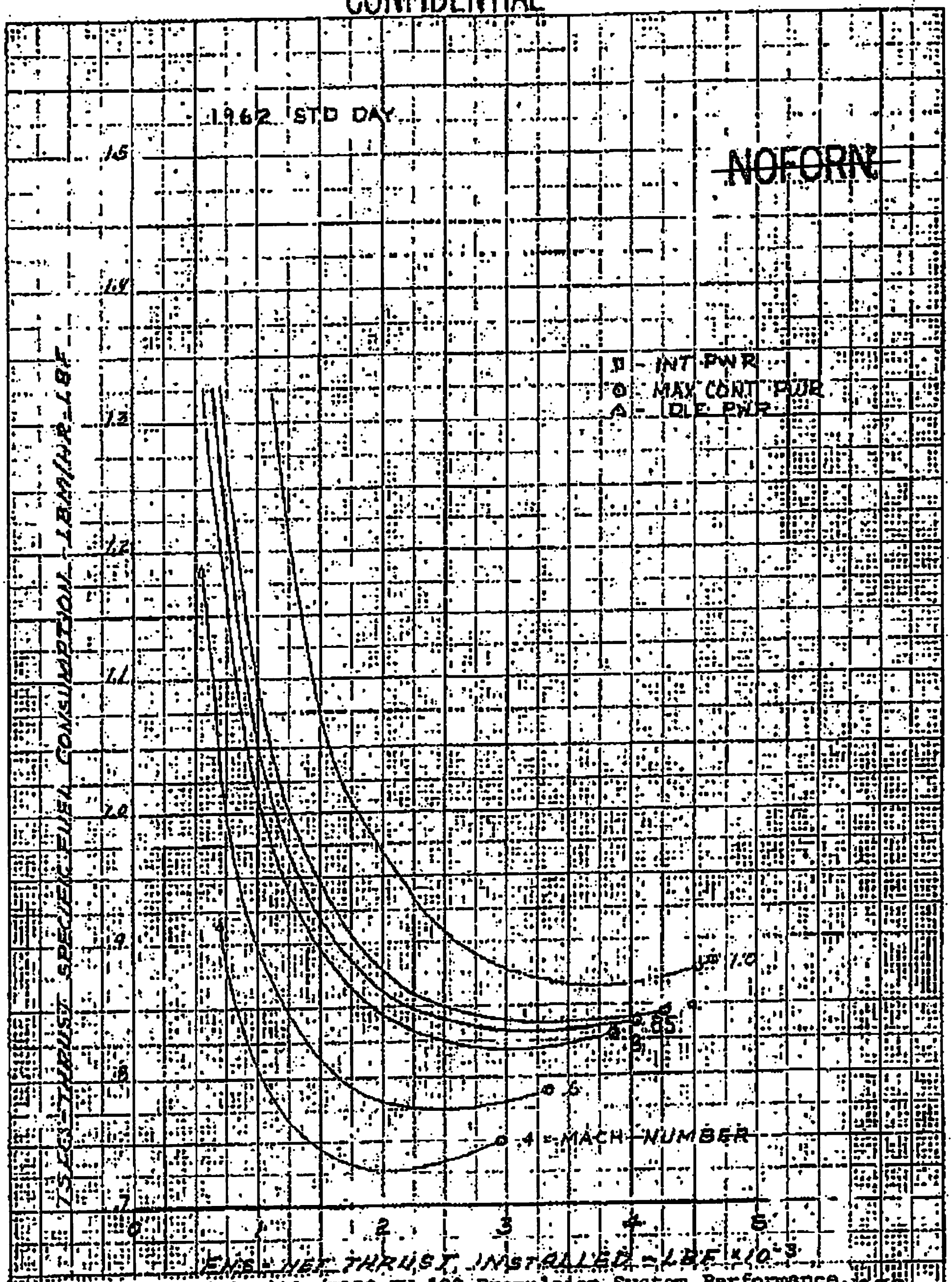

~~(C)~~ Figure 3.6-9 401B/F100-PW-100 Propulsion System Performance, Intermediate and Reduced Power, 36,089 feet (U)

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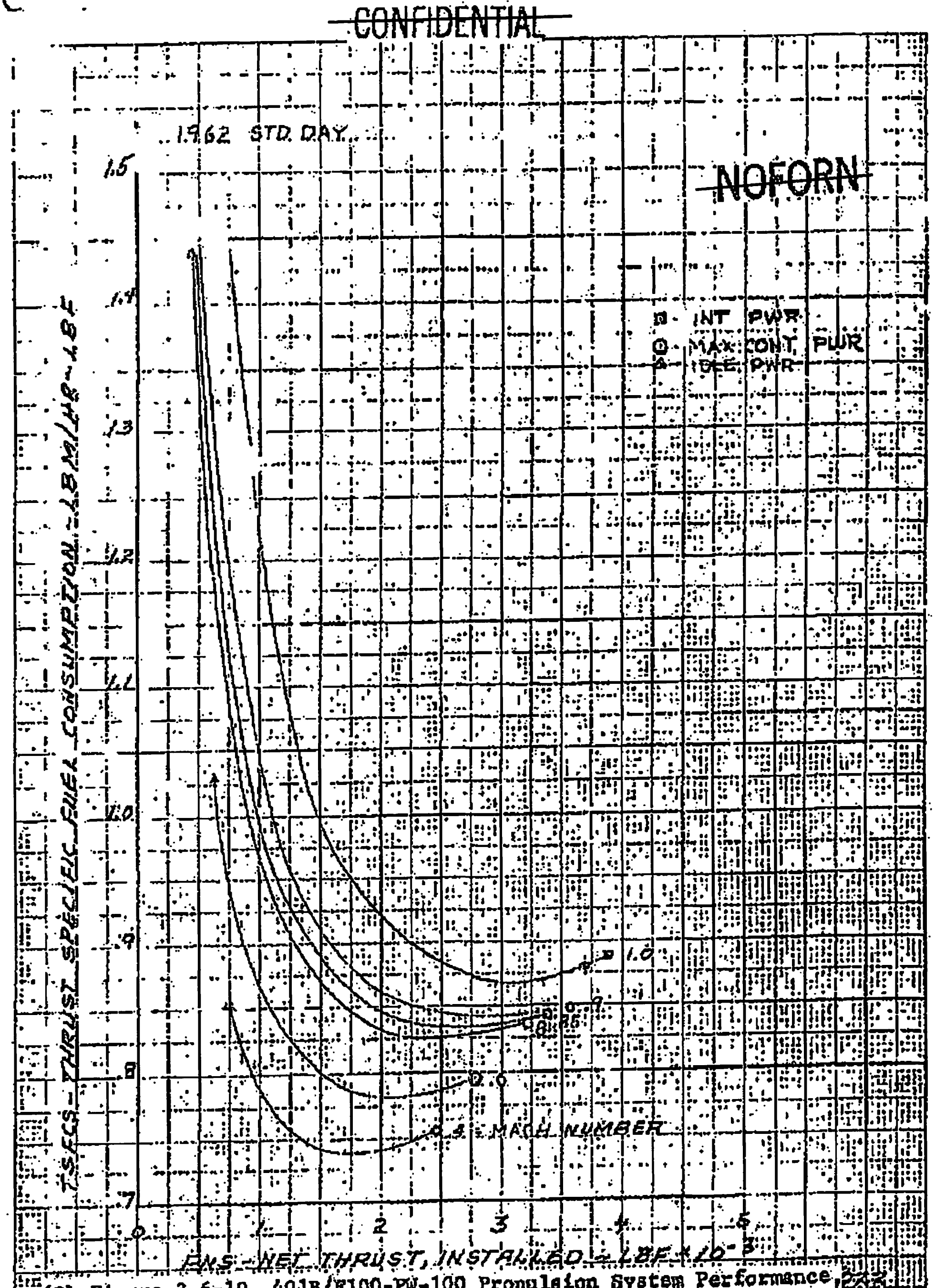

~~(C)~~ Figure 3.6-10 401B/F100-PW-100 Propulsion System Performance, ~~???~~ Intermediate and Reduced Power, 40,000 feet (U)

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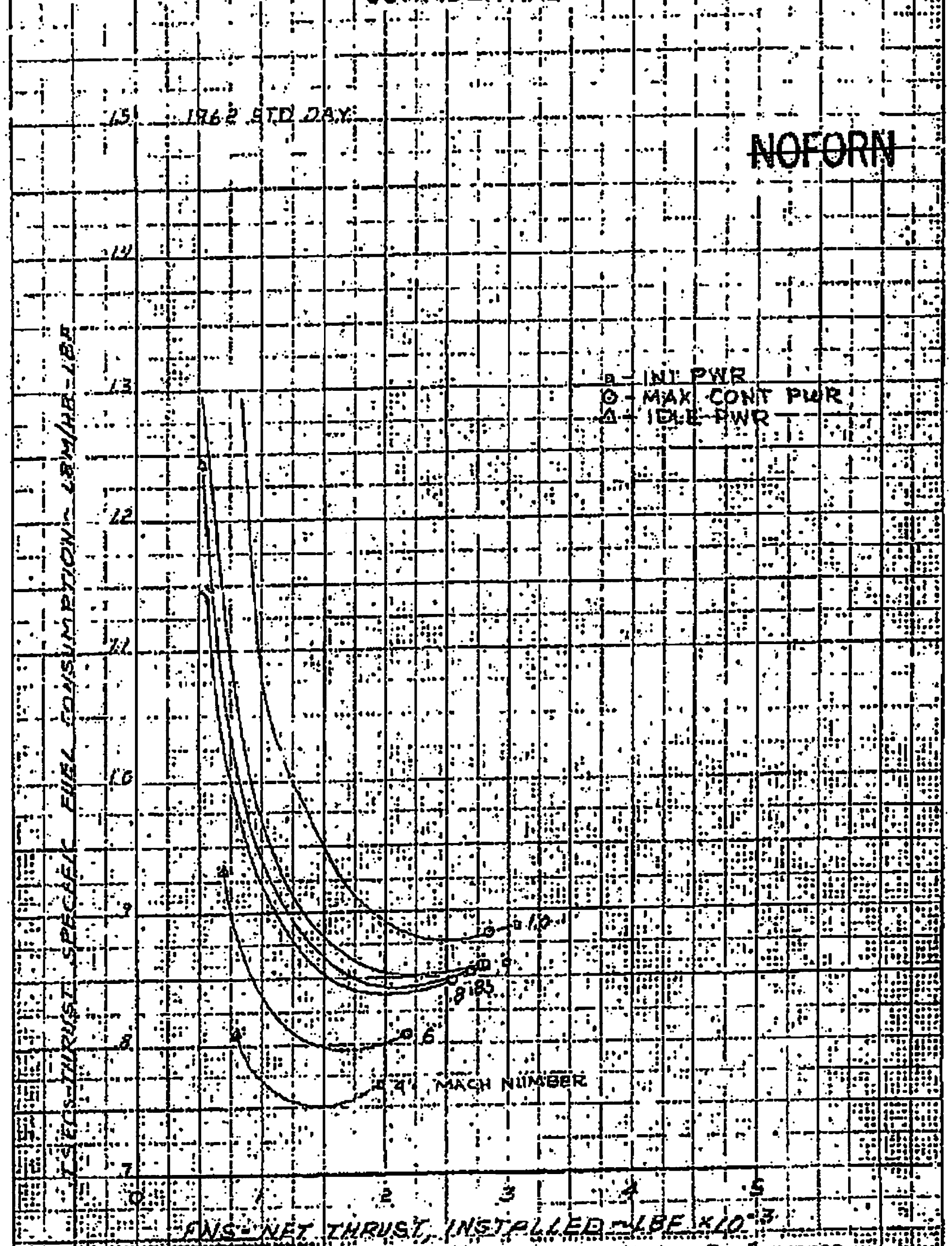

~~(C)~~ Figure 3.6-11 401B/F100-PW-100 Propulsion System Performance, ~~C~~ Intermediate and Reduced Power, 45,000 feet (U)

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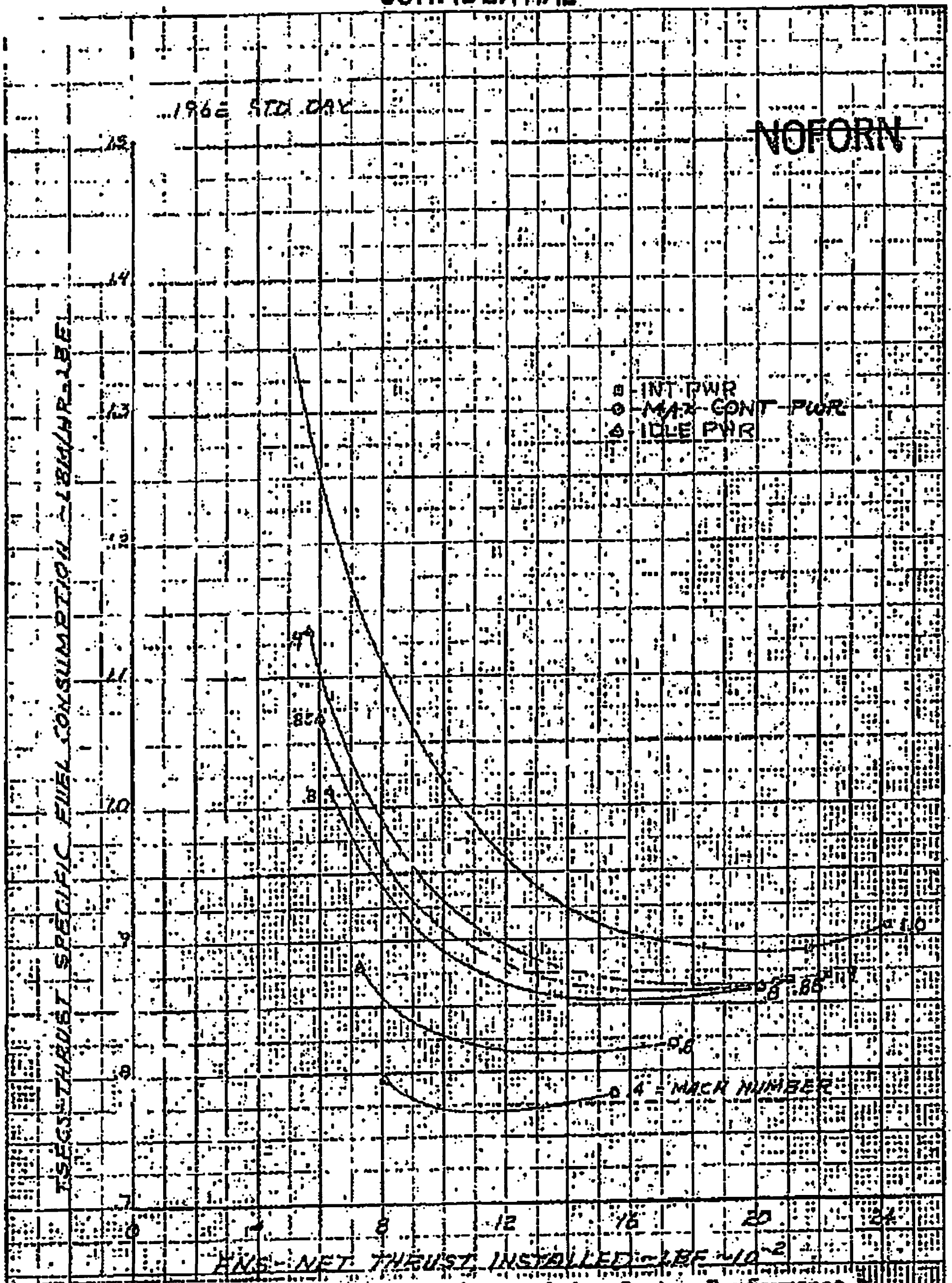

~~(C)~~ Figure 3.6-12 401B/F100-PW-100 Propulsion System Performance, Intermediate and Reduced Power, 50,000 feet (U)

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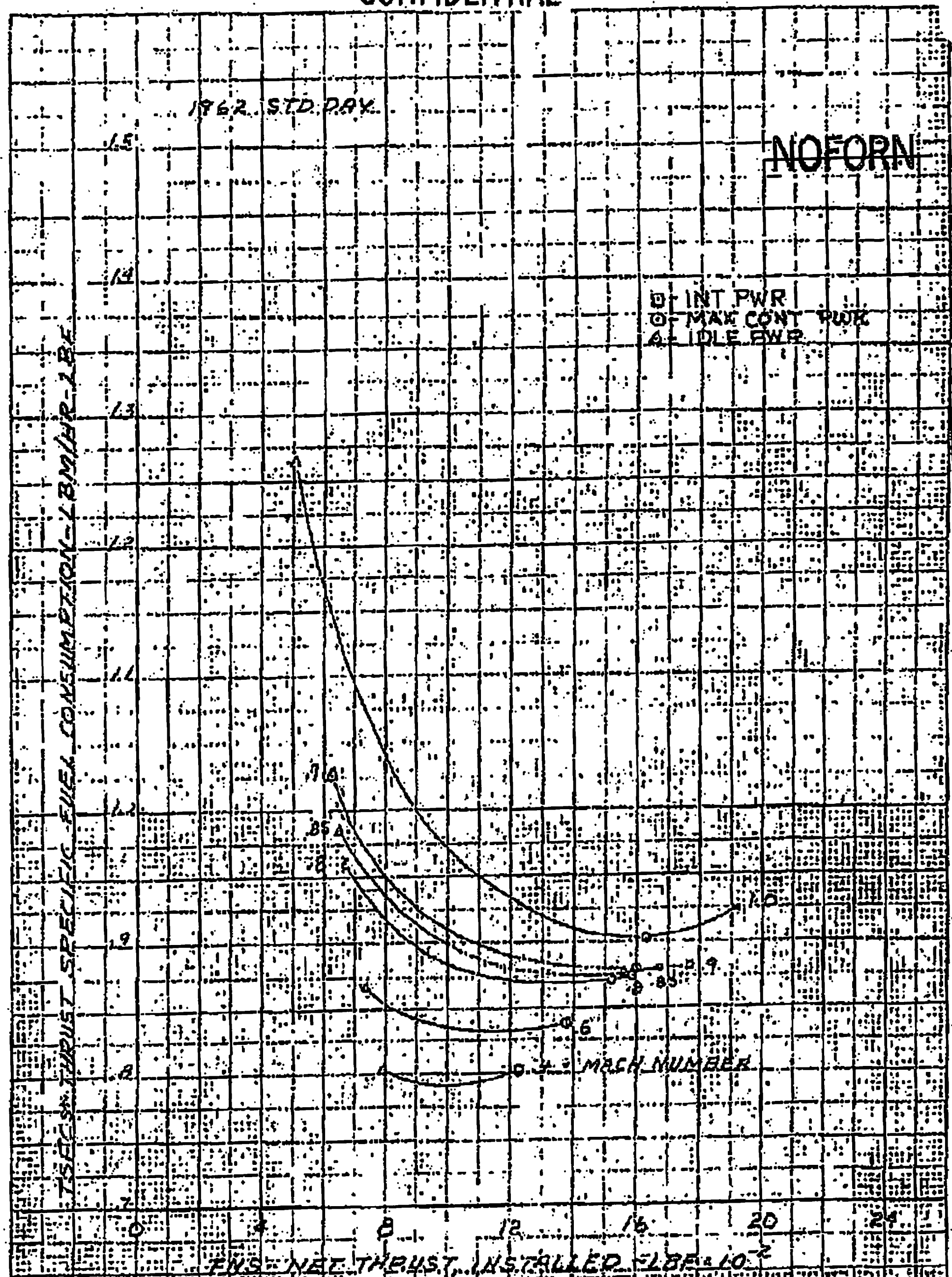

~~(C)~~ Figure 3.6-13 401B/F100-PW-100 Propulsion System Performance, Intermediate and Reduced Power, 55,000 Feet (U)

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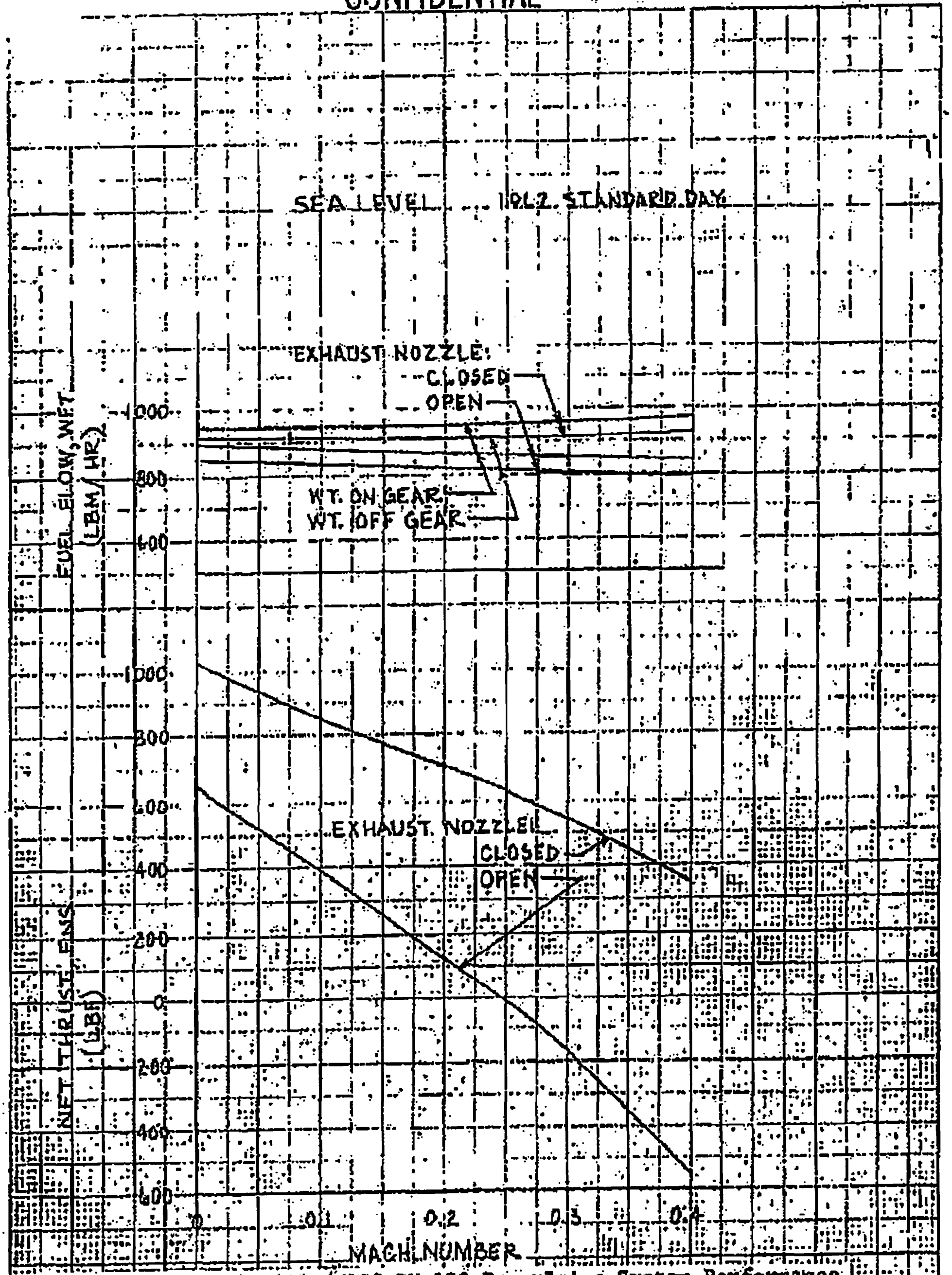

~~(C)~~ Figure 3.6-14 401B/F100-PW-100 Propulsion System Performance, Idle Power, Sea Level (U)

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(U) The thrust specific fuel consumption, TSFCS, is the ratio of the installed total fuel flow and installed propulsion system net thrust, F_{NS}.

(U) At Mach 1.1 the performance exhibits a slight discontinuity. This effect is from the shift in the exhaust nozzle operating mode, described earlier, from the low- to the high-area-ratio mode of operation (low gear to high gear) above Mach 1.1.

(U) In the data curves of Figure 3.6-7, note the shaded areas defined as "Estimated CVP Shift Area". This variation in performance at the low exhaust-nozzle pressure ratios is obtained from the engine computer deck; the affected parameter is CVP (exhaust nozzle internal gross-thrust coefficient). The change in CVP is caused by flow separation in the nozzle divergent section when the nozzle is operating at low pressure ratios.

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EO SEC 3.3 (b)(4)
SEC 1.4(a)

3.6.2 Inlet

~~(C)~~ The baseline inlet configuration is of the fixed-geometry open-nose type, initially elliptical in cross section, connected to the engine face by a subsonic duct about 4.05 compressor-face diameters in length. The inlet and engine face centerlines are offset approximately 14.0 inches or 0.10 times the duct length. The minimum separation between the inlet and lower fuselage surface is 1.9 inches so that low-energy fuselage boundary-layer air will not be ingested by the inlet. The inlet upper-lip leading edge is extended 10.0 inches ahead of the lower-lip leading edge to isolate the inlet normal shock from the fuselage boundary layer. The inlet upper-lip leading edge is relatively sharp to preclude shock detachment ahead of the lip. The lower lip is moderately blunt to provide good lip suction characteristics and to reduce internal lip flow separation at low speeds and during high-angle-of-attack operation. The lip bluntness used gives an internal area contraction of 4.0 percent.

~~(C)~~ A minimum amount of upper cowl-lip extension is used to isolate the inlet shock from the fuselage boundary layer; this minimizes boundary-layer buildup on the inlet side of the upper cowl lip. At high supersonic speeds (Mach 1.9 to 2.2), moderate boundary-layer control in the form of vortex generators and/or bleed may be required in the inlet throat

~~(C)~~ to reduce the shock/boundary-layer-induced separation (turbulence) to an acceptable level for engine/inlet compatibility.

~~(C)~~ The inlet is sized to accept maximum engine-corrected airflow (227 lbm/sec) at a throat Mach number of 0.70 based on geometric throat area. The resulting inlet capture area is 740 sq in., with a throat area of 710 sq in.

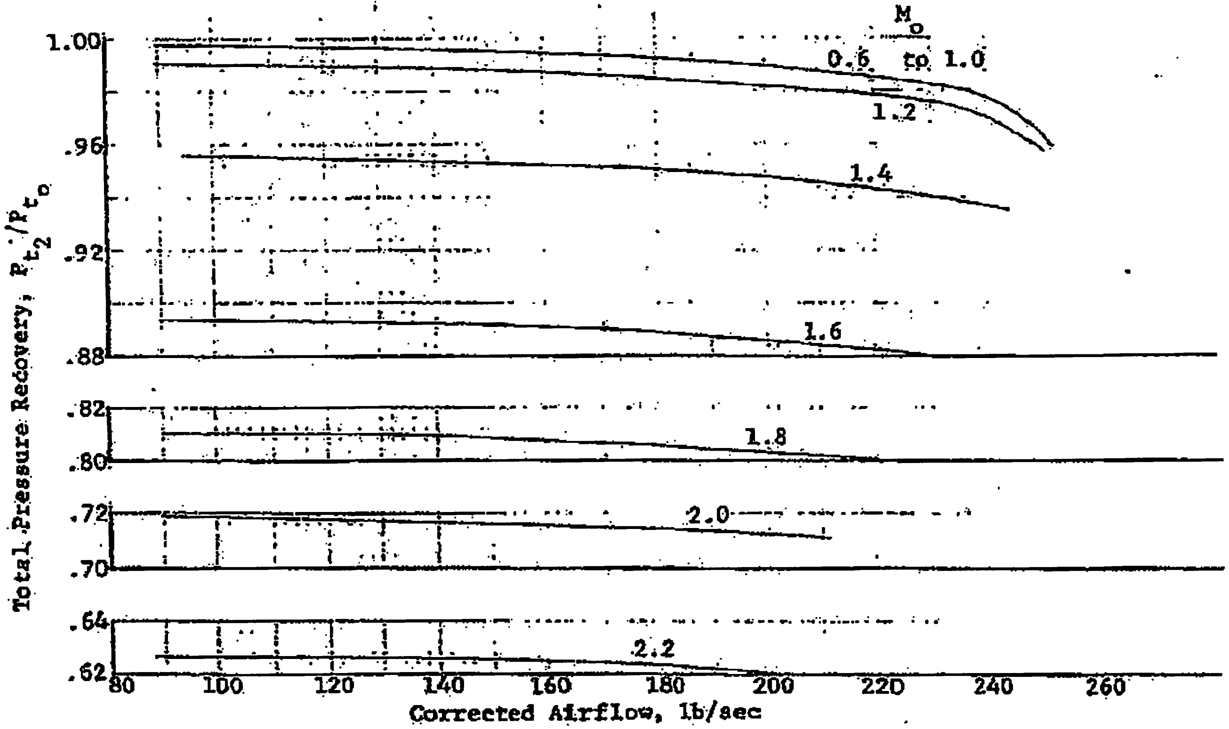
(U) Inlet total pressure recovery for Configuration 401B/F100-PW-100 is presented in Figure 3.6-15. These data are based on normal-shock total pressure recovery and subsonic duct losses correlated as a function of initial boundary-layer displacement thickness, throat Mach number, expansion angle, area ratio (inlet-to-exit), and engine-to-inlet offset. The method of analysis is documented in SEG-TR-67-1 (Reference 21). A revised duct-offset loss factor is used that is based on experimental data reported in AFFDL-TR-69-21 (Reference 22) and recent Convair Aerospace tests (Project Tailor-Mate, Reference 23).

(U) The takeoff and low-speed inlet total pressure recovery is presented in Figure 3.6-16. The method of analysis is from SEG-TR-67-1 in which takeoff and low-speed pressure recovery are correlated in terms of a lip-bluntness parameter and mass flow ratio. No auxiliary inlets are assumed.

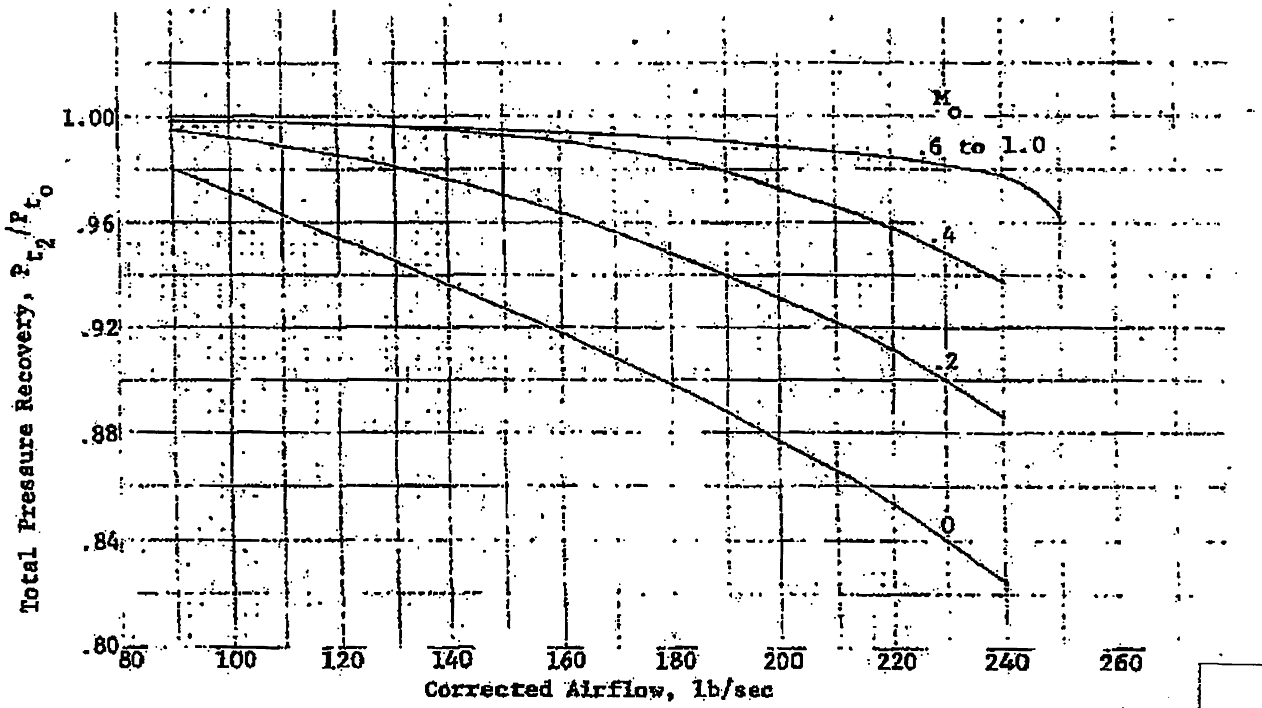
(U) Predicted inlet spillage drag data are plotted in Figure 3.6-17. These data are based on open-nose inlet additive drag and the lip suction characteristics plotted in Figure 3.6-18. The technique for predicting lip suction, reported in Reference 24 uses isolated inlet-cowl model test data as a basis and presents cowl efficiency in terms of cowl leading-edge radius, initial cowl slope, external camber, Mach number, and level of additive drag. Factors are included to account for non-axisymmetric geometries.

3.6.3 Nozzle

(U) The selected nozzle is the 1.61/1.1 balance-beam configuration, which is the primary option offered for this engine by P&WA. This is a non-ejector, convergent/divergent nozzle, having modes of operation as shown in the Figure 3.6-19 sketch. The "1.61" refers to the internal expansion-area ratio when the nozzle is in the wide-open position and the "1.1" corresponds to this area-ratio with the nozzle in the minimum-area position.

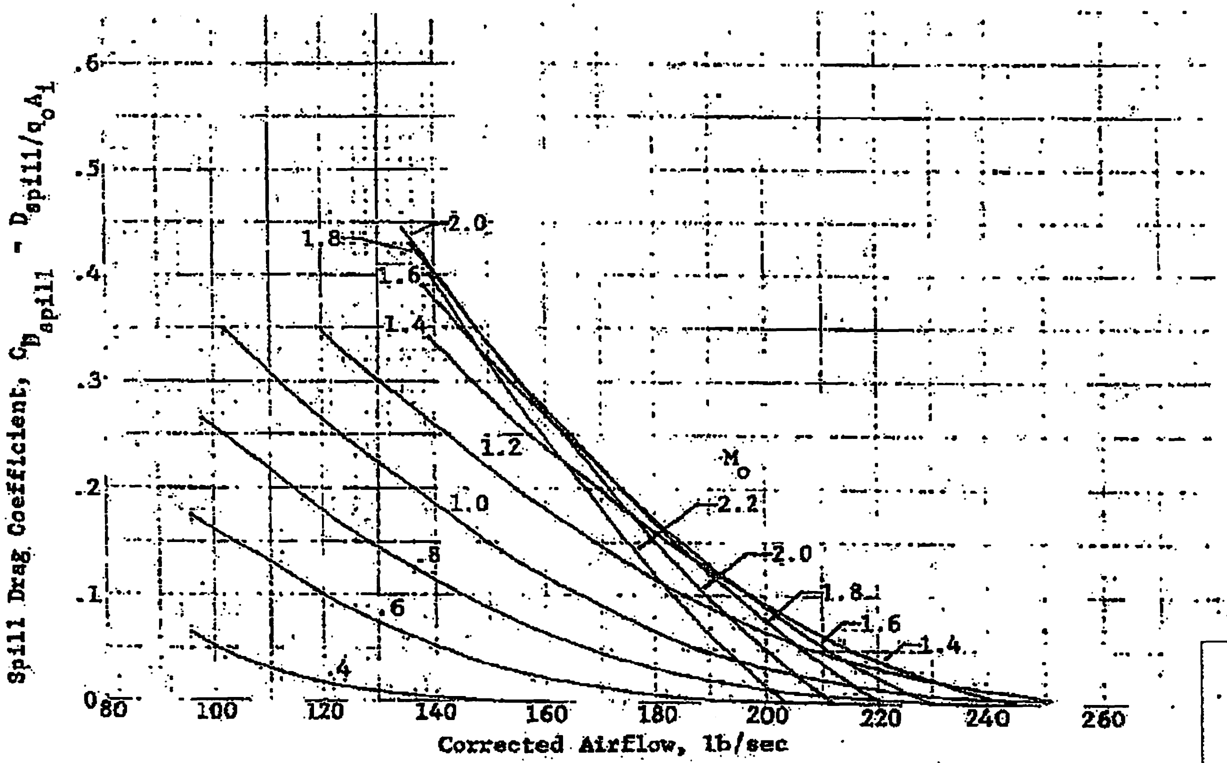


~~(C)~~ Figure 3.6-15 Open-nose-inlet Total Pressure Recovery, Mach 0.6 to 2.2



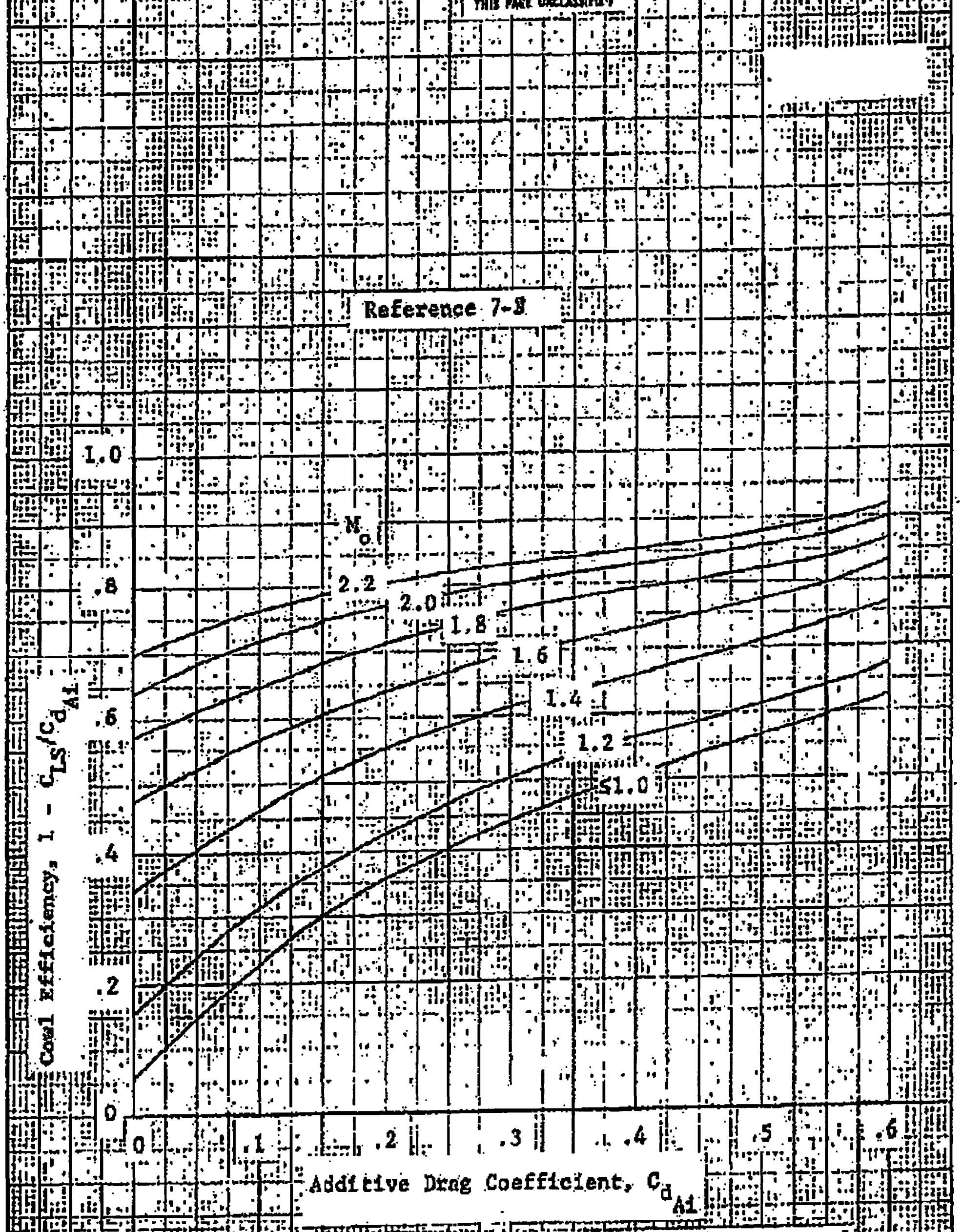
~~(C)~~ Figure 3.6-16 Open-nose-inlet Total Pressure Recovery, Mach 0 to 0.6

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

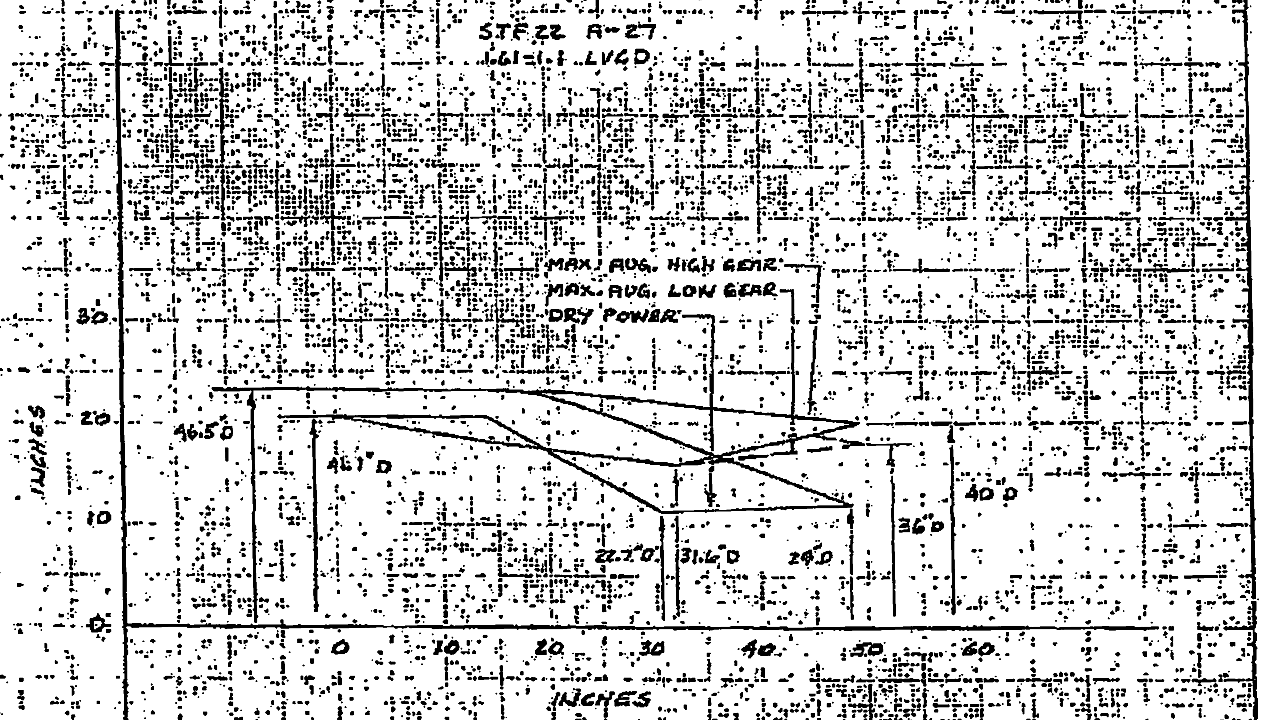


~~(C)~~ Figure 3.6-17 Open-nose-inlet Spillage Drag

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



(U) Figure 3.6-18 Open-nose-Inlet Cowl Efficiency (Lip Suction)



(U) Figure 3.6-19 Sketch of the F100-PW-100 Balanced-Beam Nozzle Configuration

(U) A pressure drag analysis was made of the nozzle for each mode of operation; the estimated drags are shown in Figures 3.6-20 through 3.6-23. The nominal values of exit diameter for maximum augmentation and for dry power are shown in Figure 3.6-19. These values are used for estimating the nozzle drag. Also shown in Figure 3.6-19 is the baseline nozzle diameter used to derive the baseline nozzle drag shown in Figure 3.6-20. The baseline configuration is the same as the maximum augmented power configuration at Mach 1.1 and above (referred to as "high gear"). The baseline nozzle pressure ratio is shown in Figure 3.6-24.

(U) The baseline nozzle drag is included in the airplane drag data, and any increment in nozzle drag caused by changing engine power setting, from the baseline, appears in the propulsion data. The maximum augmentation nozzle drags shown in Figure 3.6-21 are included in the propulsion data and are actually the increment in drag between baseline and the true operating conditions (nozzle pressure ratio and nozzle geometry). This increment is zero at Mach 1.1 and above since the baseline reflects the true operating geometry and also is not influenced by changing nozzle pressure ratio.

(U) The dry-power nozzle drags included in the propulsion data are presented in Figures 3.6-22 and -23. These data are increments from the baseline as described above.

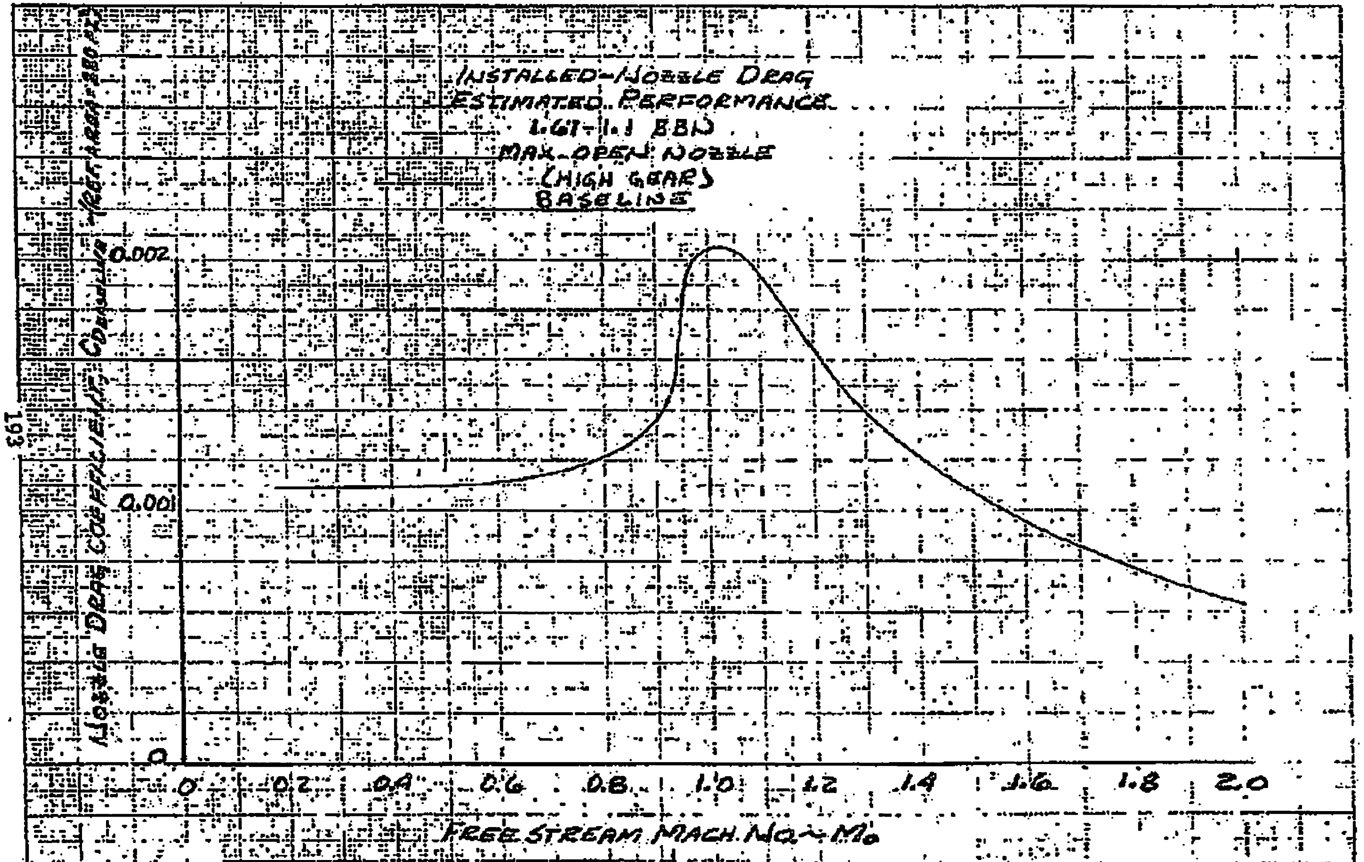
(U) These data, reflecting the specific installation, were used for the vehicle performance analysis rather than the uninstalled-nozzle drag data provided in the engine performance data deck, CCD 1025.

3.6.4 Auxiliary Air

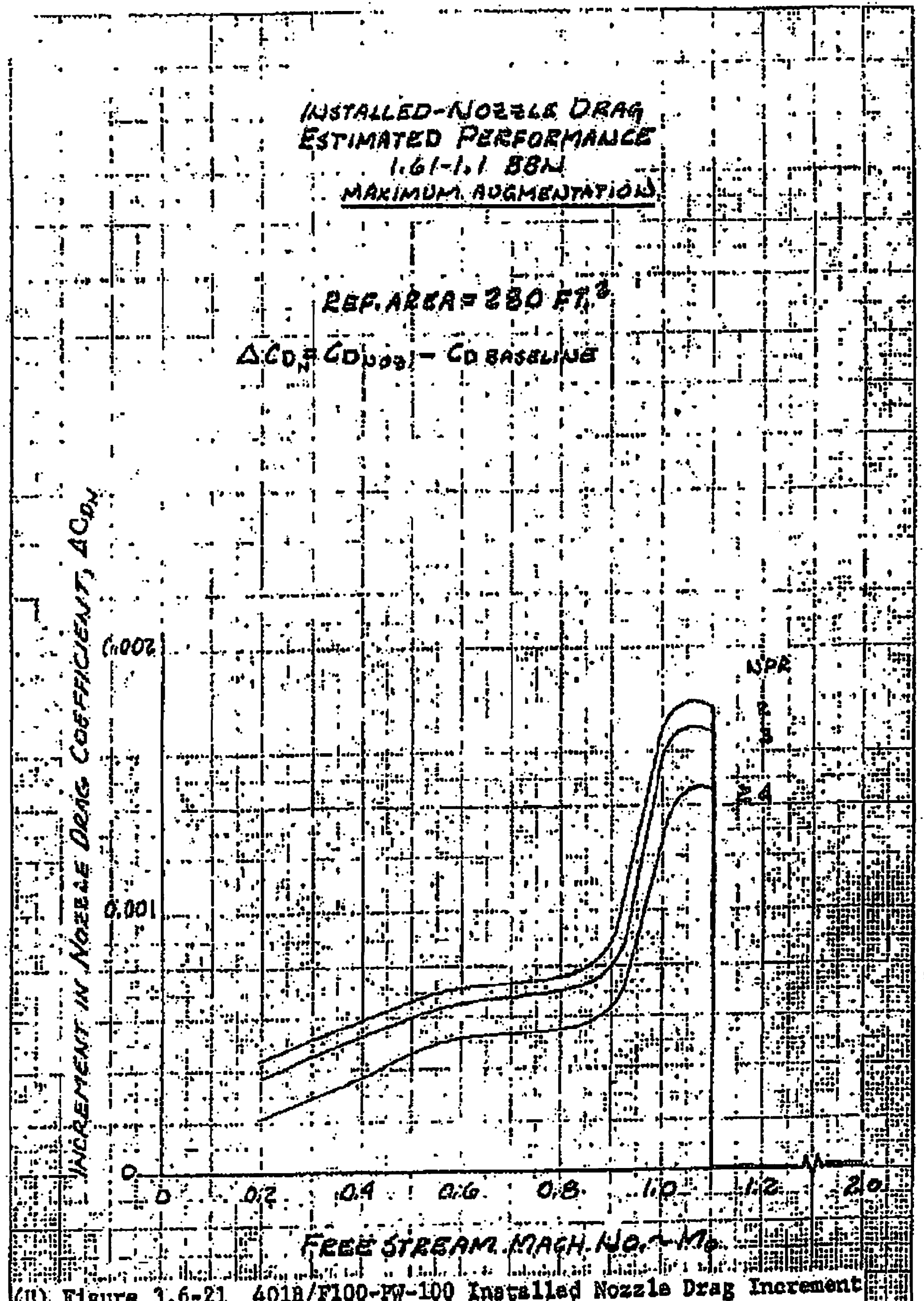
(U) The auxiliary air system serves only to ventilate the nacelle and prevent the accumulation of flammable fluids and vapors. The system consists of a forward-mounted flush inlet (near the engine front-frame) and aft-mounted flush exits (near the nozzle customer-connect). Only a small quantity of air is required to fulfill the system function and the drag penalty is estimated to be 2.5 counts (280-sq ft reference area).

3.6.5 Shaft Power and Compressor Bleed Extraction

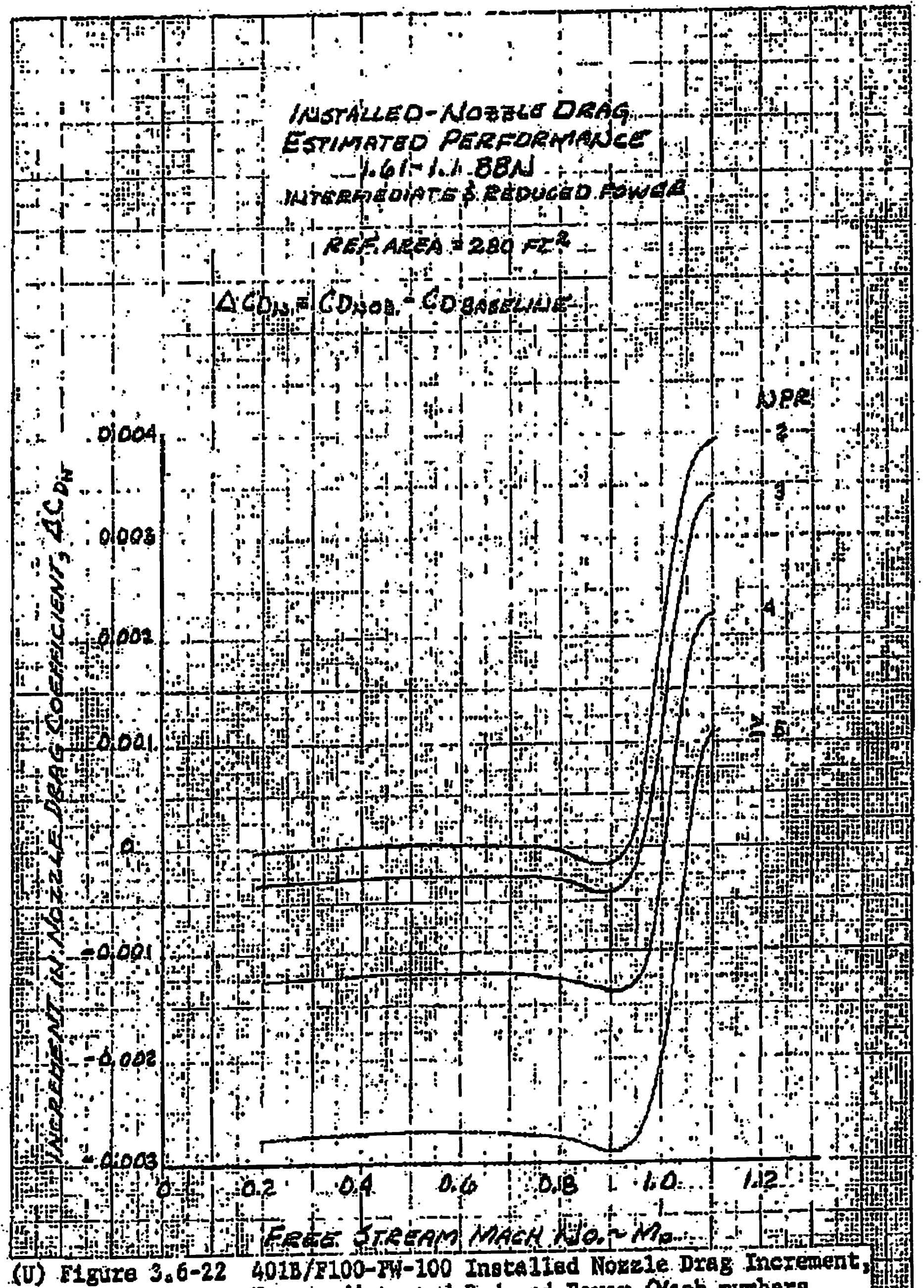
(U) Power is extracted through the engine gear-box power-take-off shaft to drive the airplane electric generator and



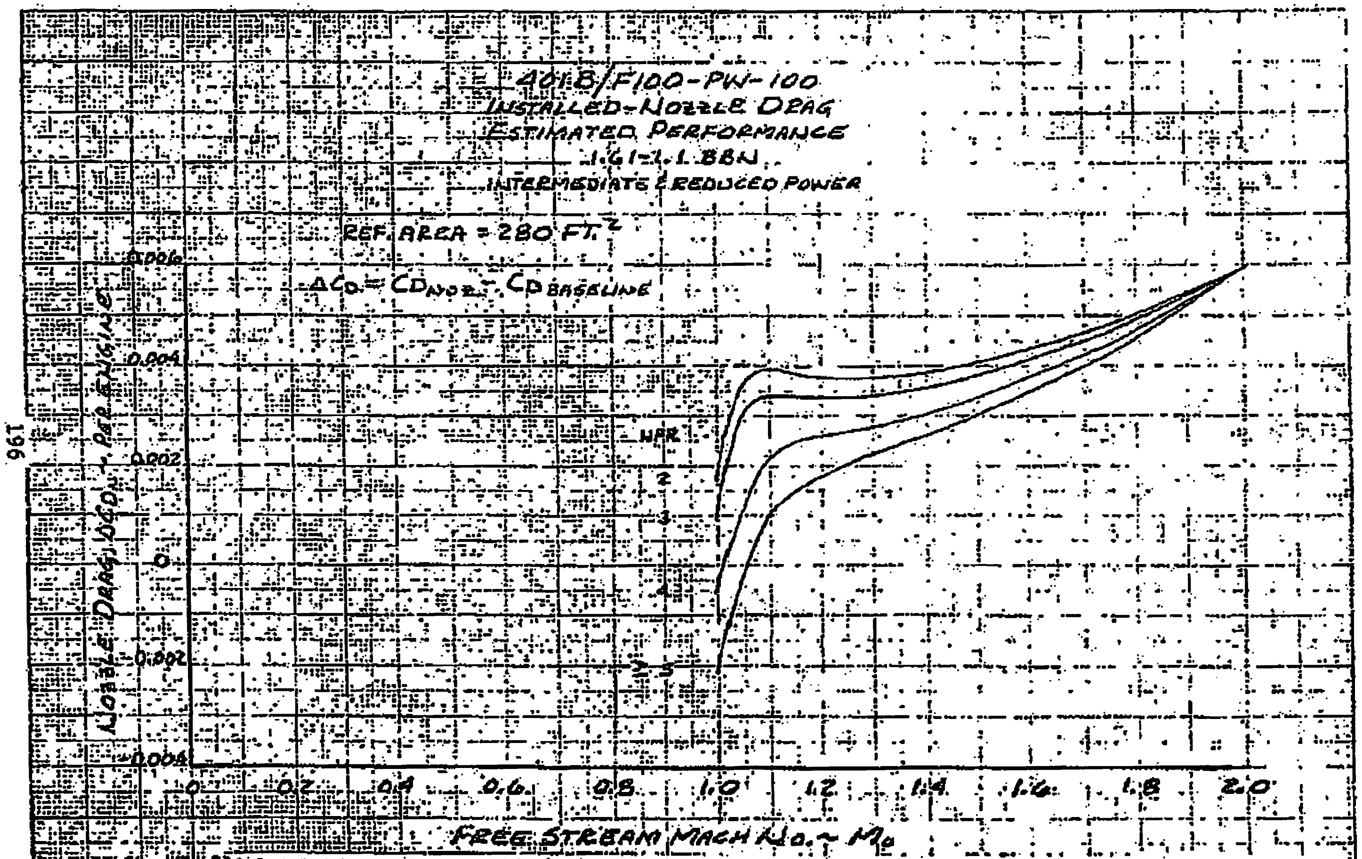
(U) Figure 3.6-20 401B/F100-PW-100 Installed Nozzle Drag, Maximum Open Nozzle (High-Gear Position)



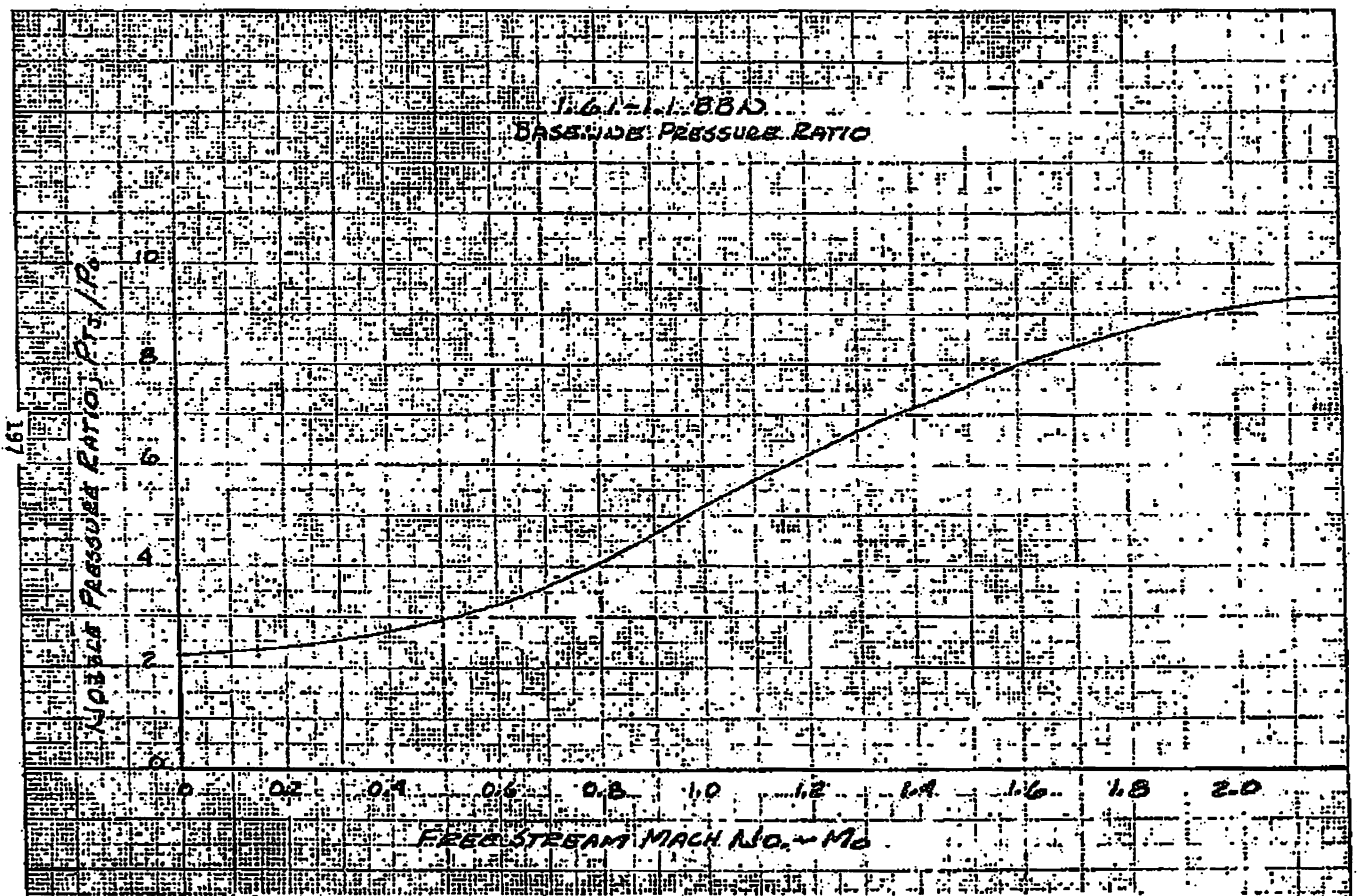
(U) Figure 3.6-21 401B/F100-PW-100 Installed Nozzle Drag Increment during Maximum Afterburning



(U) Figure 3.6-22 401B/F100-PW-100 Installed Nozzle Drag Increment, Intermediate and Reduced Power (Mach numbers less than 1.1)



(U) Figure 3.6-23 401B/F100-PW-100 Installed Nozzle Drag Increment, Intermediate and Reduced Powers (Mach numbers greater than 1.0)



(U) Figure 3.6-24 401B/F100-PW-100 Baseline Nozzle Pressure Ratio hydraulic pumps. An estimated value of the total power extraction is 70 hp. The installed propulsion system performance data accounts for 70 hp at all flight conditions and power settings.

(U) High-pressure bleed air is extracted from the compressor discharge for operating the environmental control system. In flight, the bleed air-flow rate is approximately 0.4 lbm/sec. The installed propulsion system performance data accounts for 0.4 lbm/sec at all flight conditions and power settings.

(U) During ground operation (airplane weight resting on the landing gear), a switch on the landing gear provides signals to valves that direct the flow of high-pressure bleed air to additional systems such as nacelle-ventilation and oil-cooler ejectors. The total airflow for weight-on-gear operation is estimated to be about 1.20 lbm/sec for the airplane. The installed takeoff thrust and fuel flow are corrected for this weight-on-gear bleed flow rate.

SECTION 4

SMALL SINGLE-ENGINE CONCEPT

(403/J101-GE-100)

4.1 VEHICLE DESIGN

(U) In this subsection a description is presented of the small single-engine concept, a brief explanation is given of the overall configuration rationale, and the configuration growth data that were generated for aircraft sizing purposes are summarized.

4.1.1 Vehicle Description

~~(S)~~ The small single-engine fighter concept (Concept 2), designated Configuration 403, is presented in Figures 4.1-1 and 4.1-2, which show the general arrangement and basic lines arrangement respectively. This design was developed as one of a family of three configurations generated to establish growth data for the airplane powered by the small GE15-1/J1A5 engine (USAF designation J101-GE-100).

~~(S)~~ Configuration 403 is essentially the same as the Configuration 401B concept (see Subsection 3.1.1) except for its scaled-down size and changes in some internal relationships which result from the variation in engine-to-airplane proportions brought about by the engine differences. The 403 design shown in Figures 4.1-1 and 4.1-2 has a gross weight of 13,000 pounds [a wing loading of 60 psf, and a thrust-to-weight ratio of 1.01 (uninstalled).]

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3
(b)(4)

~~(S)~~ Since an aircraft could not be properly sized for the design mission in this case, an example 403 type at the 13,000-lb mission weight is presented. Further explanation concerning aircraft sizing is given in the performance discussion of Subsection 4.2.

4.1.2 Design Rationale

(U) The rationale for Configuration 403 is the same as that of the 401B concept (see Subsection 3.1.2).

4.1.3 Growth Data

(U) The aircraft sizing approach is outlined and the design data developed for the growth study are summarized in the following paragraphs.

Three data points were investigated to supply the necessary design information to develop the growth curves. A complete layout was made of the 403 configuration (13,000-lb mission weight), which served as a focal point of the growth family. A small 10,000-pound configuration layout was also developed along with a 16,800-pound design that was defined by modification of the original 401B configuration to a small-engine version. A family of airplane data was thus generated in which the data from the two layouts and the modified 401B information were utilized to provide growth data curves for the gross-weight range from 10,000 pounds to 16,800 pounds. Weight and balance considerations and internal fuel requirements for this wider range of gross weight combined to alter the fuselage scaling factors from those utilized in the original 401B growth study. However, virtually all other scaling parameters such as surface area ratios, tail volume coefficients, aspect ratios, taper ratios, etc., remained intact. The basic landing gear dimensions and tire sizes were varied for the main gear but remained the same for the nose gear.

(U) The variation of airplane wetted area with airplane size (mission weight) is shown in Figure 4.1-3. A breakout of wetted area versus mission weight for the various major airplane components is given in Figure 4.1-4. The variation of several key configuration characteristic dimensions is plotted as a function of mission weight in Figures 4.1-5 and 4.1-6 for the fuselage and surfaces, respectively. In Figures 4.1-7 through 4.1-12, data sheets are presented on which friction drag design data and basic geometric descriptions are tabulated for airplanes at each of the three selected gross-weight data points. A normal-area distribution curve and fuel distribution plot are presented for the 403 configuration (13,000-lb mission weight) in Figures 4.1-13 and 4.1-14, respectively.

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC 3.3(b)
(4)
1.4 (a)(g)

2PPS

~~SECRET~~

WING (REFERENCE)

AREA	216.67 SQ FT
ASPECT RATIO	3.0
TAPER RATIO	0.2
SPAN	25 FT 5.94 IN
SWEEP-LEADING EDGE	35°
ROOT CHORD	169.37 IN
TIP CHORD	33.99 IN
MAC	117.01 IN
AIRFOIL SECTION	4% BICONVEX
INCIDENCE	2°
DIHEDRAL	0°

MANEUVER FLAP

TYPE	PLAIN
TOTAL AREA	19.73 SQ FT
SPAN-PER SIDE	82.69 IN
ROOT CHORD	23.15 IN
TIP CHORD	11.44 IN
DEFLECTION	35°
HINGE LINE	
ROOT	18%
TIP	30%

FLAPS

TYPE	PLAIN
TOTAL AREA-INCLUDING FLAPERON	21.82 SQ FT
ROOT CHORD	24.63 IN
TIP CHORD	8.8 IN
FLAPERON	
TOTAL AREA	11.61 IN
SPAN-PER SIDE	58.14 IN
ROOT CHORD	19.35 IN
TIP CHORD	8.8 IN
DEFLECTION	-20°+30°
FLAP DEFLECTION-MAX	30°
FLAP HINGE	80%

VERTICAL TAIL

AREA-TOTAL	55.2 SQ FT
ASPECT RATIO	1.33
TAPER RATIO	.34
SPAN	38.06 IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	62.96 IN
TIP CHORD	21.14 IN
AIRFOIL SECTION	6% ROOT, 4% TIP BICONVEX

RUDDER

AREA TOTAL	8.8 SQ FT
SPAN	39.06 IN
ROOT CHORD	15.33 IN
TIP CHORD	6.24 IN
DEFLECTION	±30°

VENTRAL FINS

AREA TOTAL	3.8 SQ FT
ASPECT RATIO	0.3733
TAPER RATIO	0.5957
SPAN	12.49 IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	46.92 IN
TIP CHORD	24.17 IN
AIRFOIL SECTION	6% BICONVEX

HORIZONTAL TAIL (ALL MOVABLE)

AREA	43.77 SQ FT
ASPECT RATIO	3.0
TAPER RATIO	0.2
SPAN-EXPOSED	137.31 IN
SWEEP LEADING EDGE	35°
ROOT CHORD	76.91 IN
TIP CHORD	15.38 IN
MAC	52.63 IN
INCIDENCE	2°
AIRFOIL SECTION	6% AT BL 44.2, 4% TIP BICONVEX
DIHEDRAL	[illegible]
DEFLECTION	LE UP 15°, DWN 30°

POWERPLANT

GENERAL ELECTRIC GE 15-1/J7A5 ENGINE

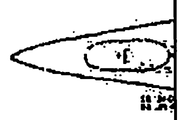
LANDING GEAR

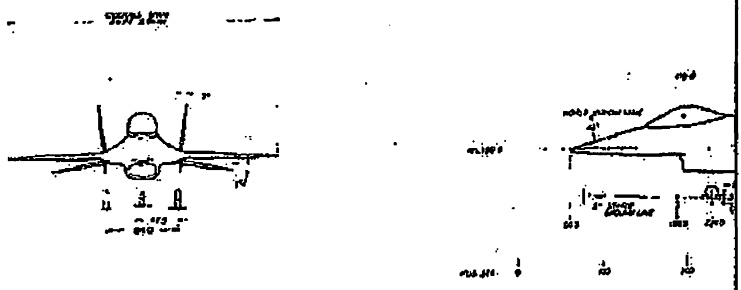
MAIN GEAR TIRE	22×5.5
NOSE GEAR TIRE	15×4.5

TAIL LENGTHS

C/4 WING TO C/4 VERT TAIL	11.61 FT
C/4 WING TO C/4 HORIZ TAIL	12.56 FT

MISSION WEIGHT	15000 LB





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~~(S)~~ Fi

88th ABW/IPI
~~FOIA (b)(1)~~
E.O. 13526 SEC 3.3(b)(4)
1.4 (a)(g)
EO 13526
3.3(b)(4)
1.4(A)(G)

~~SECRET~~

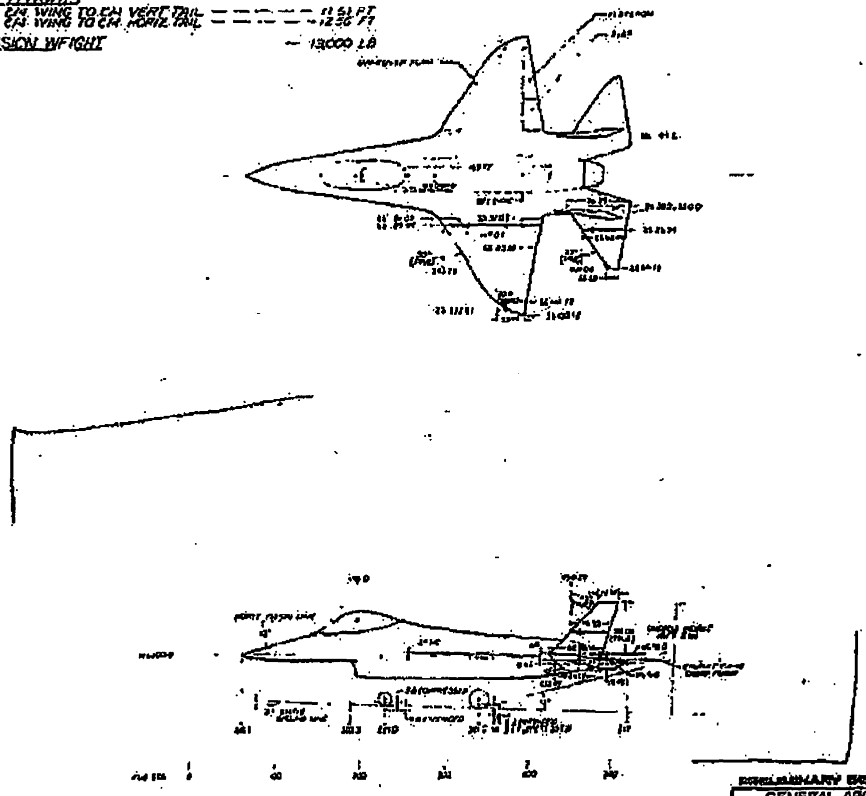
HORIZONTAL TAIL (ALL MOVABLE)
AREA — 43.77 SQ FT
ASPECT RATIO — 3.0
TAPER RATIO — 0.2
SPAN-EXPOSED — 137.31 IN
SWEEP LEADING EDGE — 35°
ROOT CHORD — 76.39 IN.
TIP CHORD — 15.28 IN
MAC — 52.63 IN
INCIDENCE — 2°
AIRFOIL SECTION — 6% AT B.L. 44.2, 4% TIP BI CONVEX
DIHEDRAL — 15°
DEFLECTION — L.E. UP 15°, DWN 30°

POWERPLANT
GENERAL ELECTRIC SE 15-1/JTA3 ENGINE

LANDING GEAR
MAIN GEAR TIRE — 22×5.5
NOSE GEAR TIRE — 15×4.5

TAIL LENGTHS
C/4 WING TO C/4 VERT TAIL — 11.51 FT
C/4 WING TO C/4 HORIZ TAIL — 12.56 FT

MISSION WEIGHT — 13000 LB

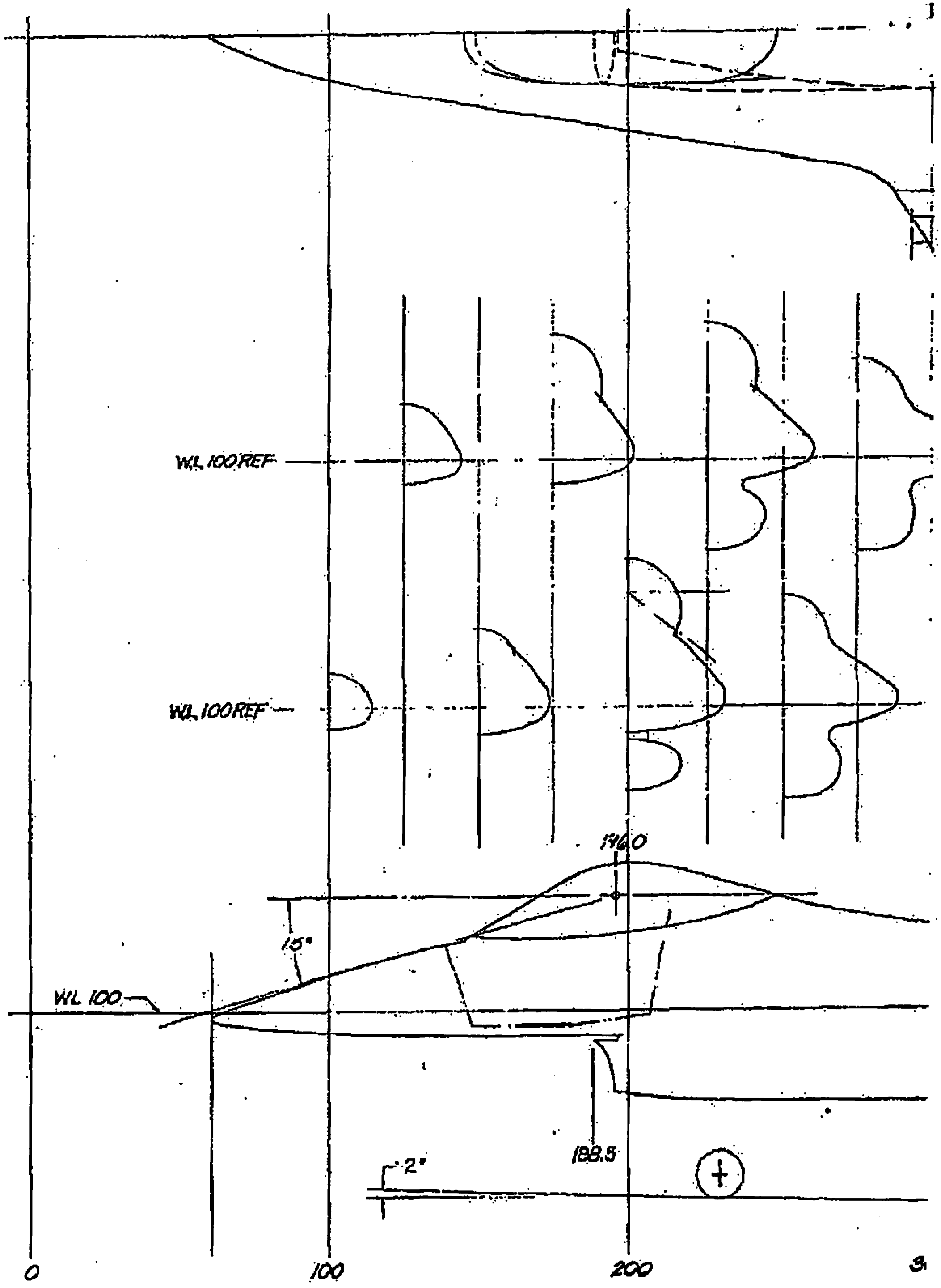


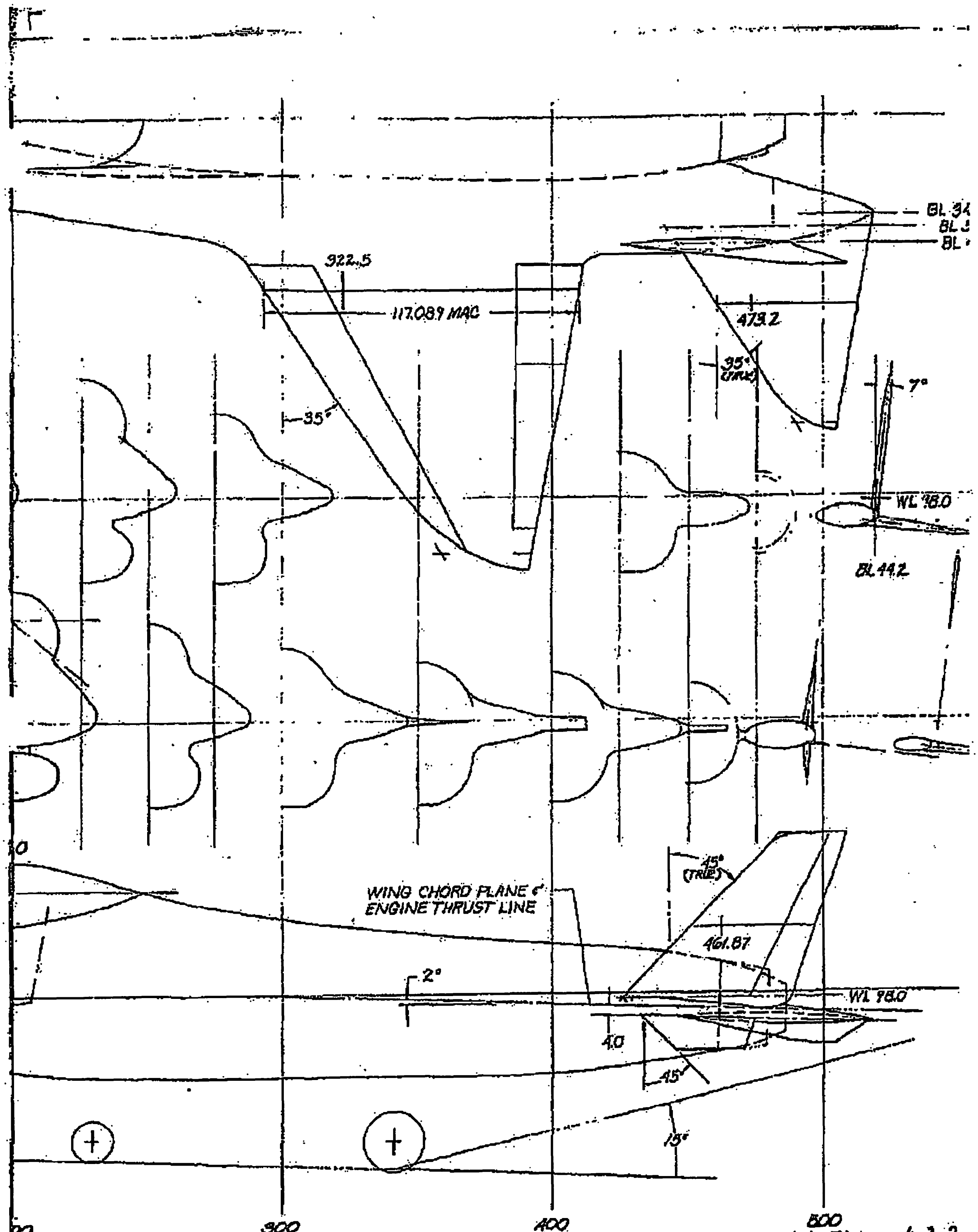
~~SECRET~~

PRELIMINARY DESIGN DRAWING
GENERAL ARRANGEMENT
SMALL SINGLE ENGINE CONCEPT
CONFIG 403 AVFFX PROGRAM
GENERAL DYNAMICS
FW7I04073

~~(S)~~ Figure 4.1-1 General Arrangement Small Single-Engine Concept configuration 403 (U)

2


W.L. 100 REF
W.L. 100 REF
196.0
15°
W.L. 100
188.5
2"
0
100
200
3



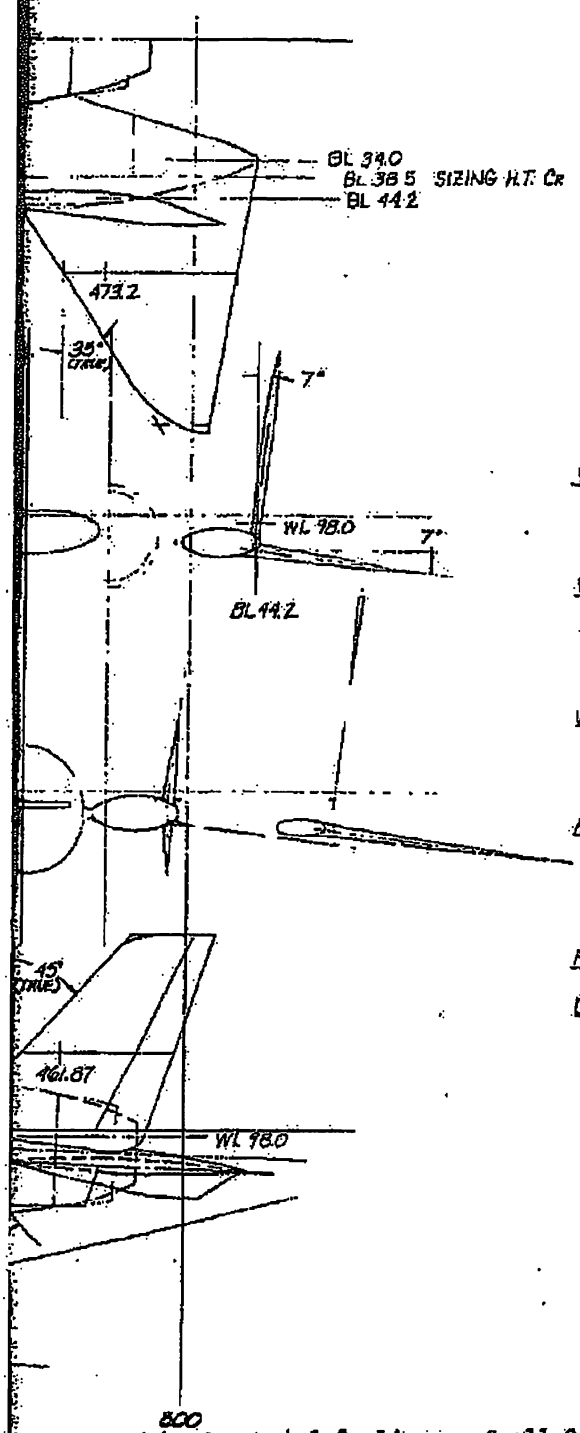
~~(S)~~ Figure 4.1-2

2

88th ABW/IR
FOIA (b)(1)
E.O.13526 SEC. 3.3(b)
(4)
1.4 (a)(g)

pgs 203-208

~~SECRET~~



BASIC DATA

WING		
REF. AREA		216.67 SQ.FT.
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION		4% BI-CONVEX
VERTICAL TAIL		
AREA (PER TAIL)		17.6 SQ.FT.
ASPECT RATIO		1.33
TAPER RATIO		0.4
AIRFOIL SECTION	ROOT	6% BI-CONVEX
	TIP	4% BI-CONVEX
VENTRAL FIN		
AREA (PER FIN)		2.9 SQ.FT.
ASPECT RATIO		0.3735
TAPER RATIO		0.59574
AIRFOIL SECTION		6% BI-CONVEX
HORIZONTAL TAIL		
SIZING AREA		43.77 SQ.FT.
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION	TIP	4% BI-CONVEX
	BL 44.2	6% BI-CONVEX
POWERPLANT		
GENERAL ELECTRIC GE 15-1/J1A5 ENGINE		
DESIGN GROSS WEIGHT		19,000 LBS

~~SECRET~~

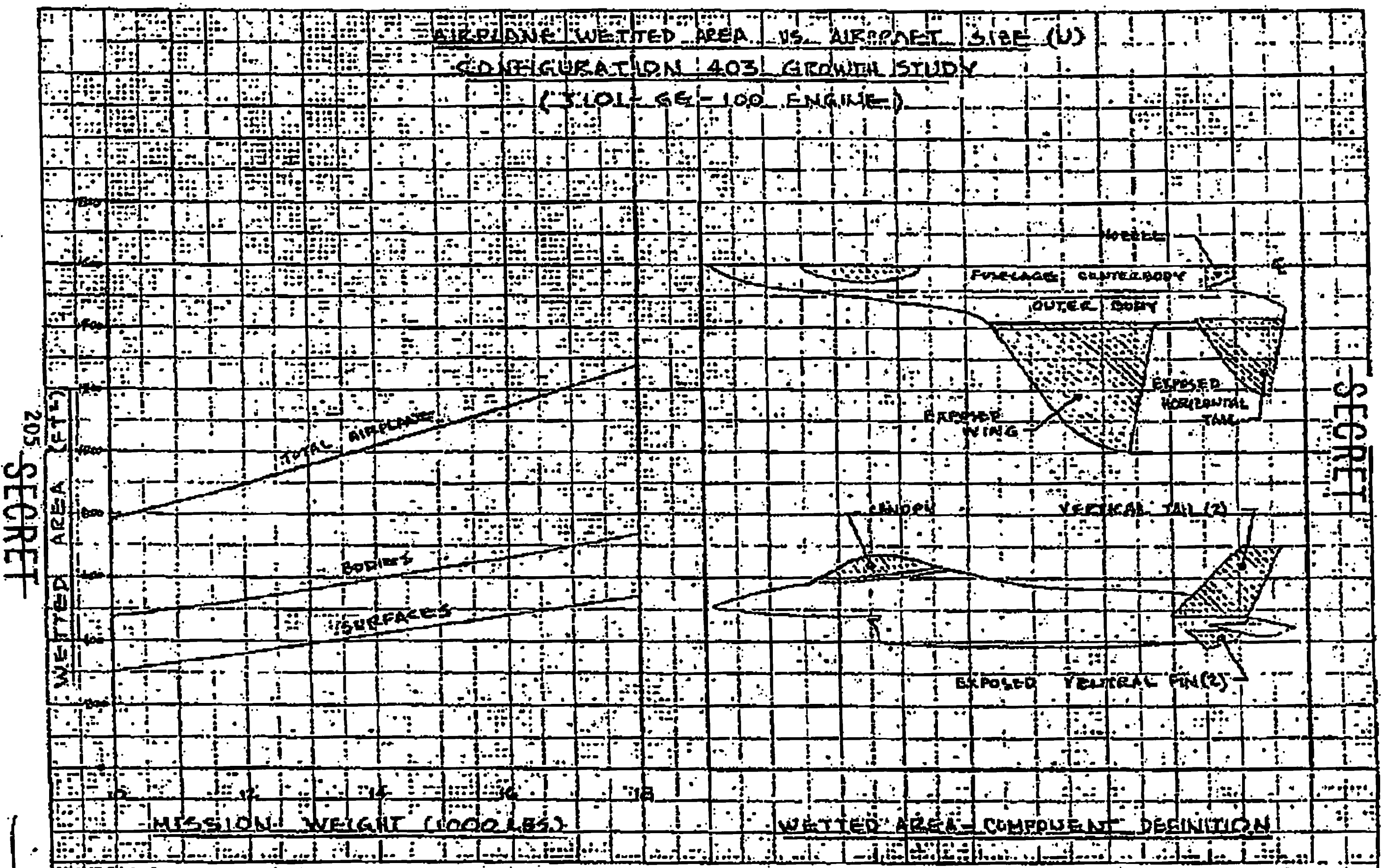
PRELIMINARY DESIGN DRAWING

— LINES LAYOUT —
SMALL SINGLE ENGINE CONCEPT
CONFIG. 403, AVFFX PROGRAM

R.G.J. CSASERR. APPROVED
SCALE 1/20 DATE 6-18-71
GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation
FW7104067
SHEET

~~(S)~~ Figure 4.1-2 Lines - Small Single-Engine Concept Configuration 403 (U)

SECRET

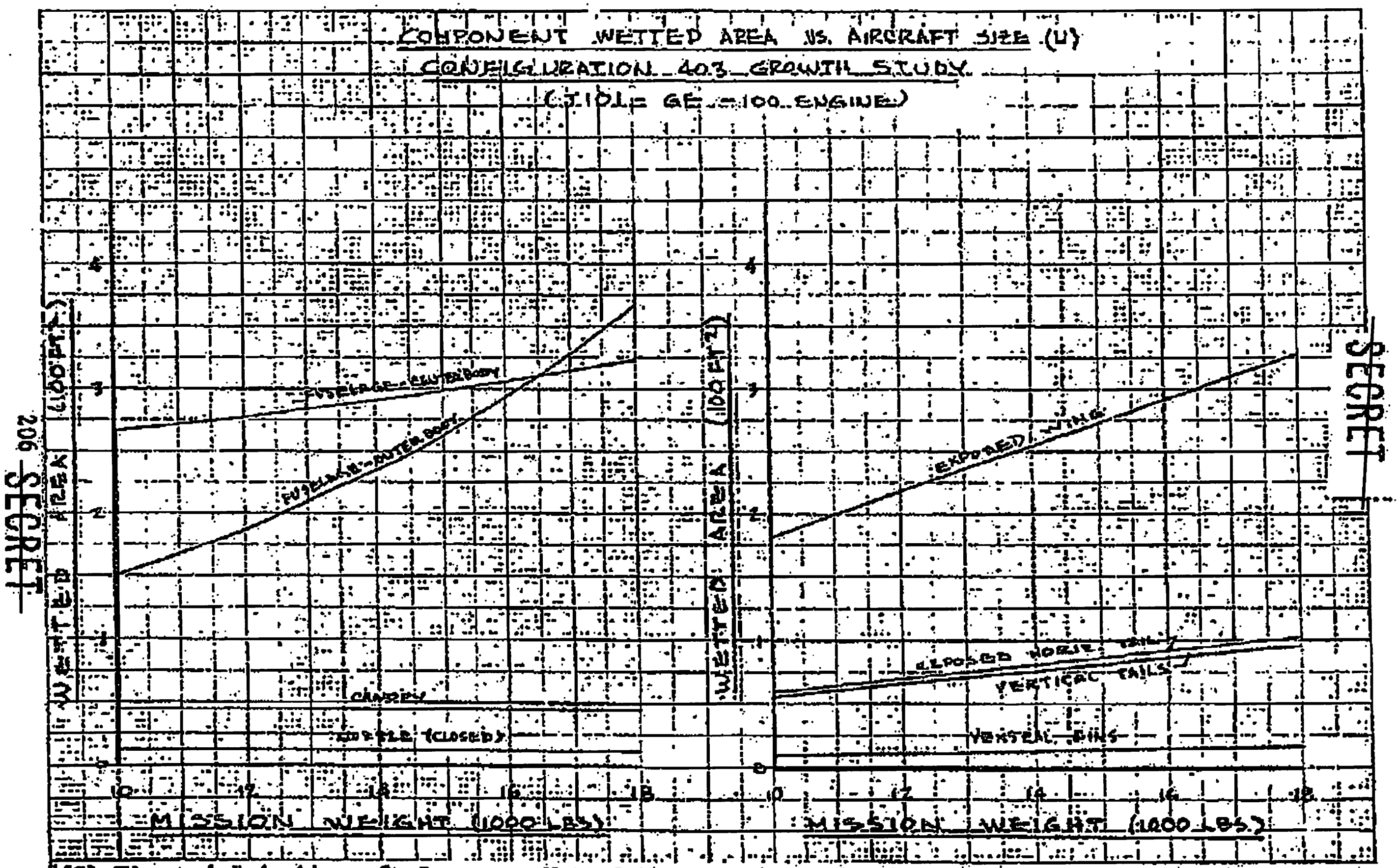


~~(S)~~ Figure 4.1-3 Aircraft Wetted Area vs. Aircraft Size - Small Single-Engine Concept (U)

SECRET

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC. 3.3(b)
(4) E.O. 13526
1.4 (a)(b)(4)
1.4 (a)(g)

SECRET

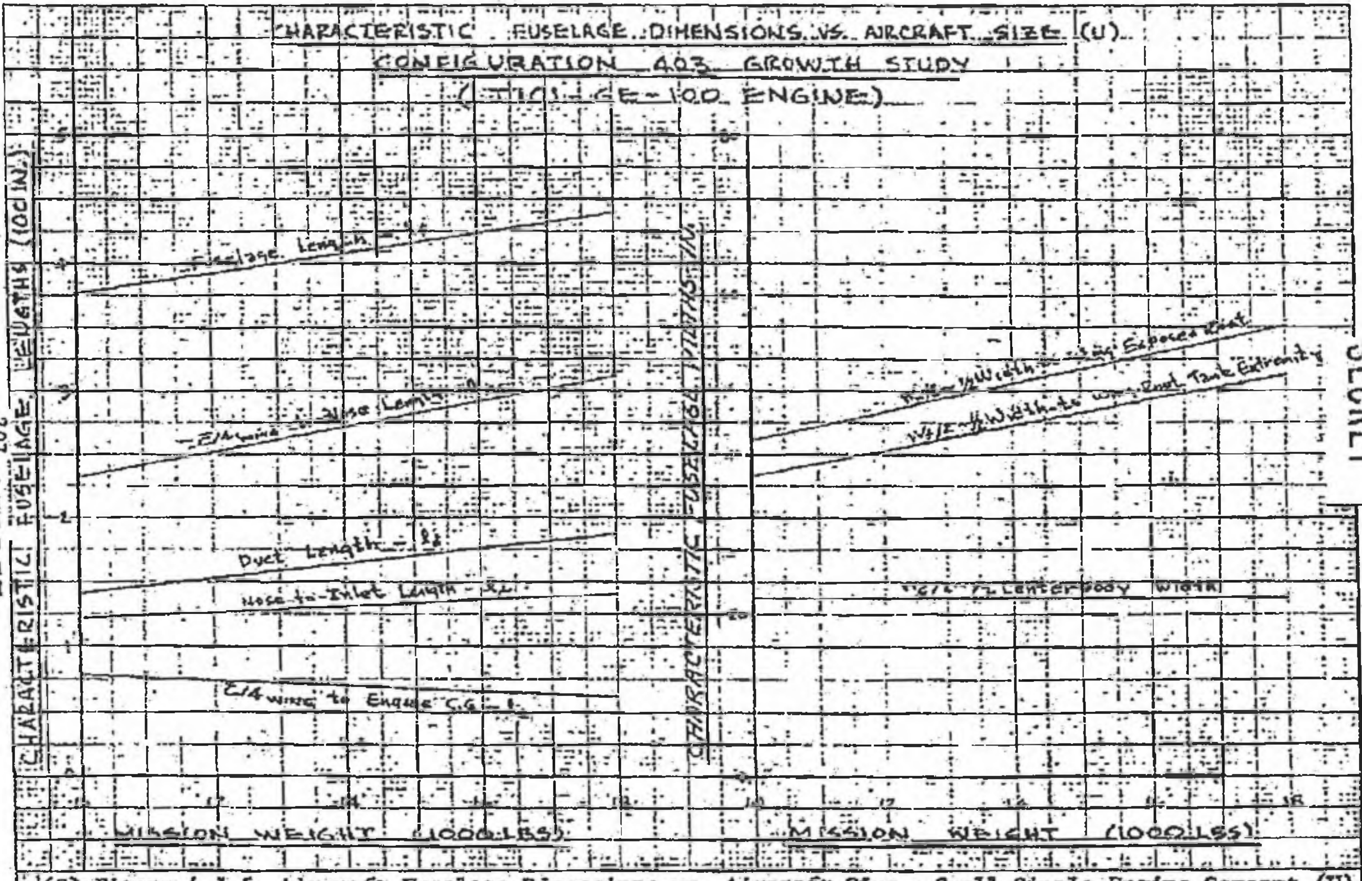


~~(S)~~ Figure 4.1-4 Aircraft Component Wetted Area vs. Aircraft Size - Small Single-Engine Concept (U)

SECRET

88th ABW/IPI
FOIA (b)(1)(a)
E.O. 13526 SEC
3.3(b)(5) 2,6
1.4 3(a)(g)(4)
1.4(A)(5)

SECRET

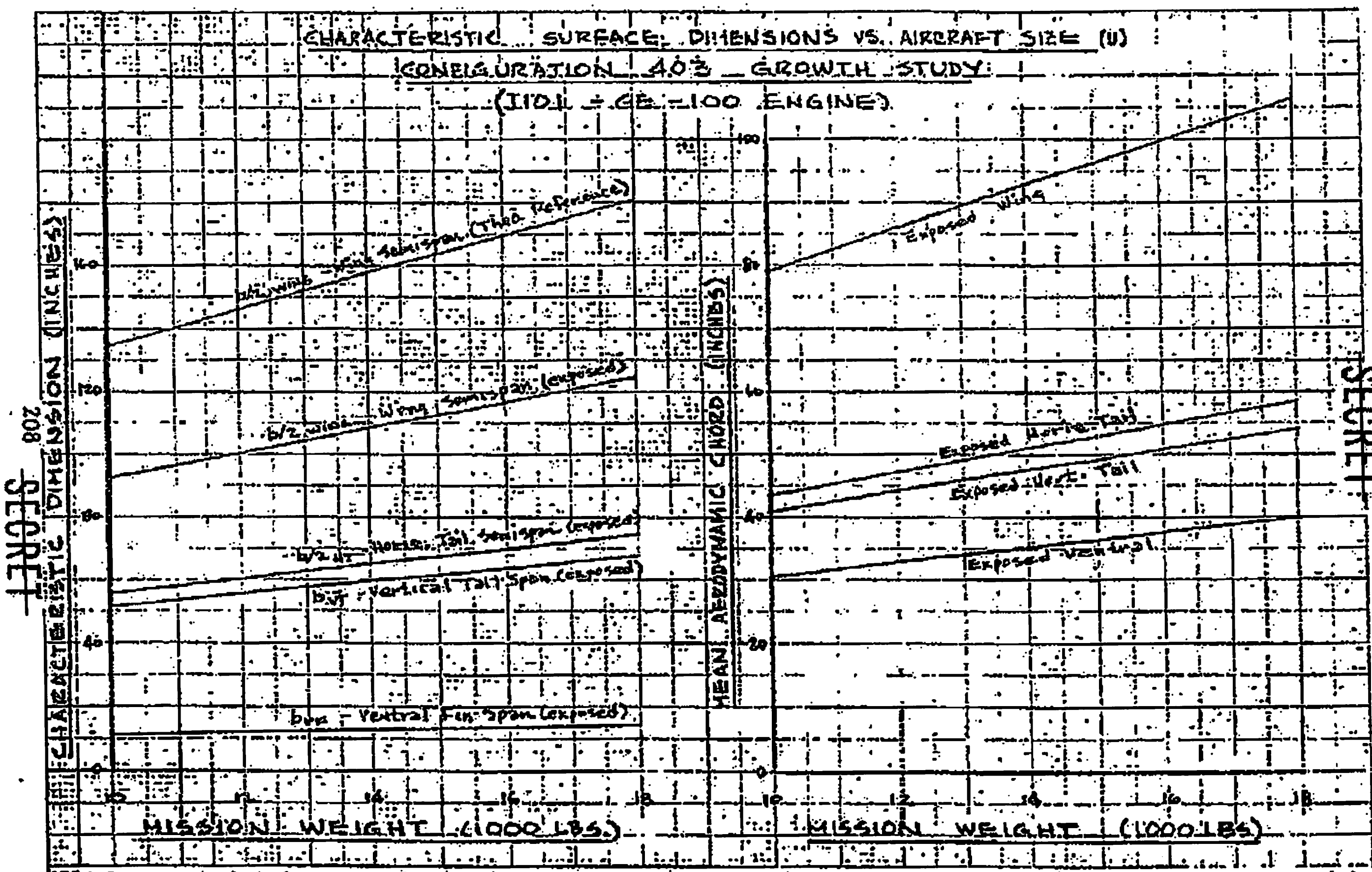


~~(S)~~ Figure 4.1-5 Aircraft Fuselage Dimensions vs. Aircraft Size - Small Single-Engine Concept (U).

SECRET

88th ABW/IPL
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4 (a)(g)

SECRET



~~(S)~~ Figure 4.1-6 Aircraft Surface Dimensions vs. Aircraft Size - Small Single-Engine Concept (U)

SECRET

88th ABW/IP
FOIA (b)(1)
E.O.13526 SEC. 3.3(b)(4)
1.4(a)(g)

FOIA (b)(1)
EO 13526 (b)(4)
Sec 3.3
Sec 1.4(a)(g)
pgs 209-216

BASIC DESCRIPTION ~~SECRET~~

G.W. = 10,000 LBS.
W/S = 60 LBS./FT²
T/W = 1.4295 (UNINSTALLED)
ENGINE ~ GE J1A5
~ A.F. Designation J101-GE-100)

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE Centerbody	396.0	0	0	0
Fuselage Outerbody	342.0	63.0	±30	0
Canopy	130.0	85.0	0	+39.0

WING REF. AREA (IN²)
24000.48

SURFACES

	2° incidence WING (nominal)	3° incidence HORIZ. TAIL	(Per side) VERT. TAIL	(Per side) VENTRAL
AREA (FT²)	166.67	72.84	13.69	2.26
Æ - ASPECT RATIO	3.00	3.411	1.33	0.3733
λ - TAPER RATIO	0.20	0.137	0.40	0.5957
 E_1	+ 55°	+55°	+ 45°	+ 45°
E_2	+10°41'	+10°41'	−19°22'	−19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$				
C_R - ROOT CHORD (IN.)	149.071	97.493	55.00	37.01
C_T - TIP CHORD (IN.)	29.814	13.400	22.00	22.05
b - SPAN (IN.)	268.328	189.184	51.20	11.02
AIRFOIL	4% BICONVEX	6% @ root (exp) 4% @ tip BICONVEX	6% @ root 4% @ tip BICONVEX	6% BICONVEX
d (IN.)	41.70	36.29	0	0
x (IN.)	199.00	339.0	322.0	328.5
y (IN.)	0	0	±41.68	±39.0
z (IN.)	−4.50	−15.14	−9.00	−16.00
	2° DIHEDRAL	15 DEG. ANHEDRAL	[illegible]	5° CANT

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (−) from fuselage ref. line WL100 to body or surface ref line.

8061-14

~~(S)~~ Figure 4.1-7 Basic Description Data Sheet - Configuration 403 Type at 10,000-lb Mission Weight (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

BASIC DESCRIPTION ~~SECRET~~

G.W. = 13,000 LBS.
W/S = 60 LBS/FT²
T/W = 1.0996 (uninstalled)
Engine = Gen. Elec. J1A5
AF Designation J101-GE-100

BODIES

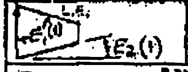
	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY w/o CANOPY	* 418.5	0	0	0
Fuselage Outer body	316.5	82.0	± 34	0
Canopy	130.0	85.0	0	+39.0

(* length includes nozzle in open position)

WING REF. AREA (IN²)
31,200.48

Note: Dimensions shown in chord plane of surface.

SURFACES

		2° incidence WING (nominal)	2° incidence HORIZ. TAIL (nom)	(Per Side) Vert Tail	(Per Side) VENTRAL FIN
AREA (FT²)		216.67	94.26	17.60	2.90
AR - ASPECT RATIO		3.00	3.41	1.33	0.3733
λ - TAPER RATIO		0.20	0.1378	0.40	0.59574
 L.E. E₁(+) E₂(+)	E₁	+ 55°	+55°	+45°	+ 45°
	E₂	+10°41'	+10°41'	-19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		169.967	110.907	62.361	41.920
C_T - TIP CHORD (IN.)		33.993	15.279	24.944	24.973
b - SPAN (IN.)		305.941	215.152	58.058	12.486
AIRFOIL		4% Biconvex	6% @ exposed root 4% @ tip Biconvex	6% @ root 4% @ tip Biconvex	6% Biconvex
d (IN.)		47.5	44.53	0	0
x (IN.)		224.5	385.0	364.9	371.9
y (IN.)		0	0	± 47.23	± 44.2
z (IN.)		0	-11.0	0	-7.0
		0° DIHEDRAL	1° NEG. DIHEDRAL	7° OUTBD CANT	0° CANT

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line to body or surface ref line.

(W.L. 99.0 Reference line)

8061-31

~~(S)~~ Figure 4.1-8 Basic Description Data Sheet - Configuration 403 Type at 13,000-lb Mission Weight (U)

~~SECRET~~

G.W. = 16,800 LBS
W/S = 60 LBS/FT²
T/W = 0.85089
Engine ~ GE J1A5
(AF Designation J101-GE-100

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE W/O CANOPY CENTERBODY	452.0	0	0	0
FUSELAGE OUTER BODY	449.0	74.0	±40.0	0
CANOPY	130.0	85.0	0	+39.0

WING REF. AREA (IN²)
40,320

SURFACES

		3° INCIDENCE WING [illegible]	6° INCIDENCE (LDH) HORIZ. TAIL	(Per Side) VERT. TAIL	(Per Side) VENTRAL
AREA (FT²)		280.00	123.14	22.12	3.646
Æ - ASPECT RATIO		3.00	3.415	1.33	0.3733
λ - TAPER RATIO		0.20	0.137	0.40	0.59574
 L.E. E₁(+) E₂(+)	E₁	+55°	+55°	+45°	+45°
	E₂	+10°41′	+10°41′	−19°22′	+19°22′
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		193.218	126.74	70	47.03
C_T - TIP CHORD (IN.)		38.644	17.37	28	28.02
b - SPAN (IN.)		347.793	246.09	65	14.01
AIRFOIL		4% BICONVEX	6% Biconv. @ exposed root 4% Biconv. @ tip exposed @ BL 51.5	6% Biconv. @ root 4% Biconv. @ tip root @ WL 92.0	6% BICONVEX
d (IN.)		54.00	51.89	0	0
x (IN.)		237.50	440.00	419.50	429.50
y (IN.)		0	0	±54.40	51.00
z (IN.)		0	−13.90	−2.00	−13.00
		0° DIHEDRAL	7° NEG DIHEDRAL	7° OUTBD CANT	0° CANT ∡

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (−) from fuselage ref. line (WL 92.0) to body or surface ref line.

8061-34

~~(S)~~ Figure 4.1-9 Basic Description Data Sheet - Configuration 403 Type at 16,800-lb Mission Weight (U)

~~SECRET~~

FRICTION DRAG DATA
G.W. = 10,000 LBS.
W/S = 60 LBS/FT²
T/W = 1.4295 (UNINSTALLED)
ENGINE – GE J1A5 (AF Desig. J101-GE-100)

BODIES

BODY	WETTED AREA (FT²)		LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)
Fuselage Centerbody		266.0	* 402.0	44.0	63.0
Fuselage Outerbody		152.1	346.0	22.0	22.0
Canopy (incl fairing)		44.4	130.0	34.0	16.0
Nozzle – Closed		12.6	25.05	32.4 DIA.	32.4 DIA.
Nozzle – Open	12.0		19.50	32.4 DIA.	32.4 DIA.
BODY TOTAL		475.1			

* Length includes nozzle closed (Awet for nozzle shown separately)

SURFACES

SURFACE	WETTED AREA (FT²)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		182.1	78.85	14° 30'	4% BICONVEX
HORIZ. TAIL		58.3	43.28	14° 30'	[illegible] BICONVEX
VERT. TAIL (2)		54.8	40.86	34° 15'	[illegible]
VENTRAL FIN (2)		9.0	30.16	17° 45'	6% BICONVEX
SURFACE TOTAL		304.2			
AIRPLANE TOTAL		779.3			

BASIC WING GEOMETRY:

	TRAPEZOIDAL SHAPE BASIC REFERENCE WING	TRAPEZOID SHAPE FOR RAKED TIP WING
AREA (FT²)	166.67	168.666
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1695
LEADING EDGE SWEEP (DEG.)	35.0	35.0

ΔAwet = 4 ft²

~~SECRET~~

8061-13

~~(S)~~ Figure 4.1-10 Friction Drag Data Sheet – Configuration 403 Type at 10,000-lb Mission Weight (U)

~~SECRET~~

~~SECRET~~

FRICTION DRAG DATA
G.W. = 13,000 LBS
W/S = 60.0 LBS/FT²
T/W = 1.0996 (UNINSTALLED)
ENGINE - GE, J1A5 Engine
(AF Designation J-101-GE-100)

BODIES

BODY	WETTED AREA (FT²)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
(BL 72 inbd) Fuselage Centerbody		284.0	* 425.0	44.0	63.0
(BL 72-[illegible]) Fuselage Outerbody		218.0	376.5	25.5	21.5
Canopy (incl fairing)		44.4	130.0	34.0	16.0
Nozzle - Closed		12.6	25.05	32.4 DIA	32.4 DIA
Nozzle - Open	12.0	—	19.50	32.4 DIA	32.4 DIA
BODY TOTAL		559.0			

*length includes nozzle closed (Awet for nozzle shown separately)

SURFACES

SURFACE	WETTED AREA (FT²)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		236.9	89.93	14°30'	4% BICONVEX
HORIZ. TAIL		75.8	49.34	14°30'	6% Biconv. @ root 4% Biconv. @ tip
VERT. TAIL (2)		70.4	46.33	34°15'	6% Biconv. @ root 4% Biconv. @ tip
VENTRAL FIN (2)		11.6	34.16	17°45'	6% BICONVEX
SURFACE TOTAL		394.7			
AIRPLANE TOTAL		953.7			

exp.

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC
3.3 (b)(4)
1.4 (a)(g)

3.3(b)(4)
1.4(A)(G)

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE BASIC REFERENCE WING	TRAPEZOID SHAPE FOR CURVED TIP WING
AREA (FT²)	216.67	219.265
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1685
LEADING EDGE SWEEP (DEG.)	35.0	35.0

← ΔAwet = 5.2 ft²

8061-13

~~(S)~~ Figure 4.1-11 Friction Drag Data Sheet - Configuration 403 Type at 13,000-lb Mission Weight (U)

~~SECRET~~

~~SECRET~~

FRICTION DRAG DATA
GW = 16,900 LBS
W/S = 60 LBS / FT²
T/W = 0.85039

ENGINE ~ GE 31AS (AF Designation J-101-GE-100)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526
SEC 3.3(b)(4) 3.3(b)(4)
1.4(a)(g) 1(a)(g)

BODIES

BODY	WETTED AREA (FT²)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
Fuselage Centerbody		312.5	* 457.0	44.0	63.0
Fuselage Outerbody		323.6	449.0	32.0	18.0
Canopy (incl Fairing)		44.4	130.0	34.0	16.0
Nozzle-Closed		12.6	25.05	32.4 DIA	32.4 DIA
Nozzle-Open	12.0	—	19.50	32.4 DIA	32.4 DIA
BODY TOTAL		693.1			

* Length includes nozzle closed (Awet for nozzle shown separately)

SURFACES

SURFACE	WETTED AREA (FT²)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		306.2	102.2	14° 30'	4% BICONVEX
HORIZ. TAIL		98.0	56.1	14° 30'	6% Bicon - root 4% Bicon - tip } exp.
VERT. TAIL (2)		88.5	52.0	34° 15'	6% Bicon - root 4% Bicon - tip
VENTRAL FIN (2)		14.6	38.3	17° 45'	6% BICONVEX
SURFACE TOTAL		507.3			
AIRPLANE TOTAL		1200.4			

BASIC WING GEOMETRY:

	Trapezoidal Shape Basic Reference Wing	Trapezoidal Shape for Curved Tip Wing
AREA (FT²)	280	293.353
ASPECT RATIO	3.0	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

$\Delta A_{wet} = + 6.7 ft^2$

~~SECRET~~

8061-13

~~(S)~~ Figure 4.1-12 Friction Drag Data Sheet - Configuration 403 Type at 16,800-lb Mission Weight (U)

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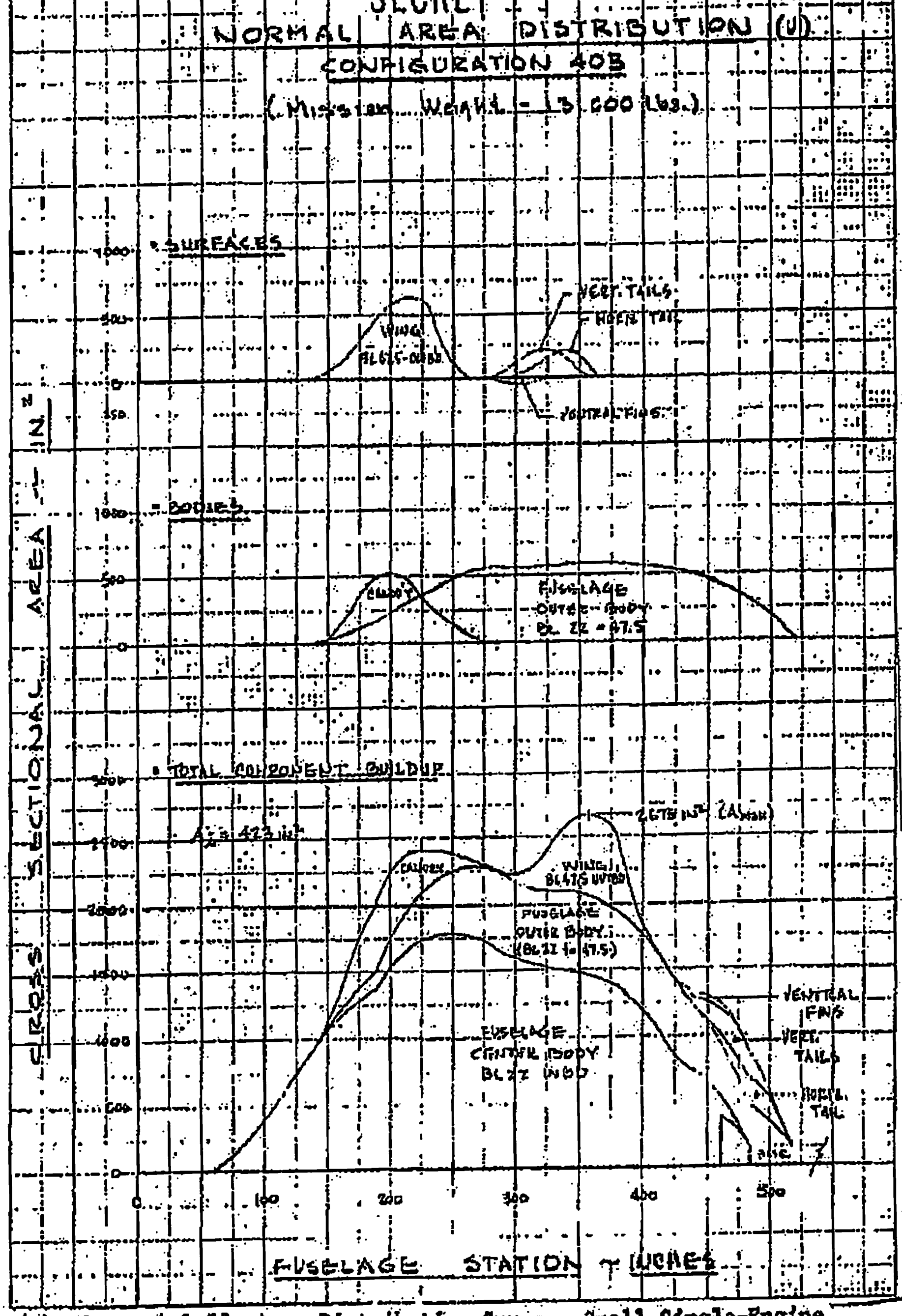
~~SECRET~~



88th ABW(PI)
FOIA (b)(1)
E.O. 13526
SEC 3.3(b)(4)
1.4(a)(g)

~~(S)~~ Figure 4.1-13 Area Distribution Curve - Small Single-Engine Concept Configuration 403 (U)

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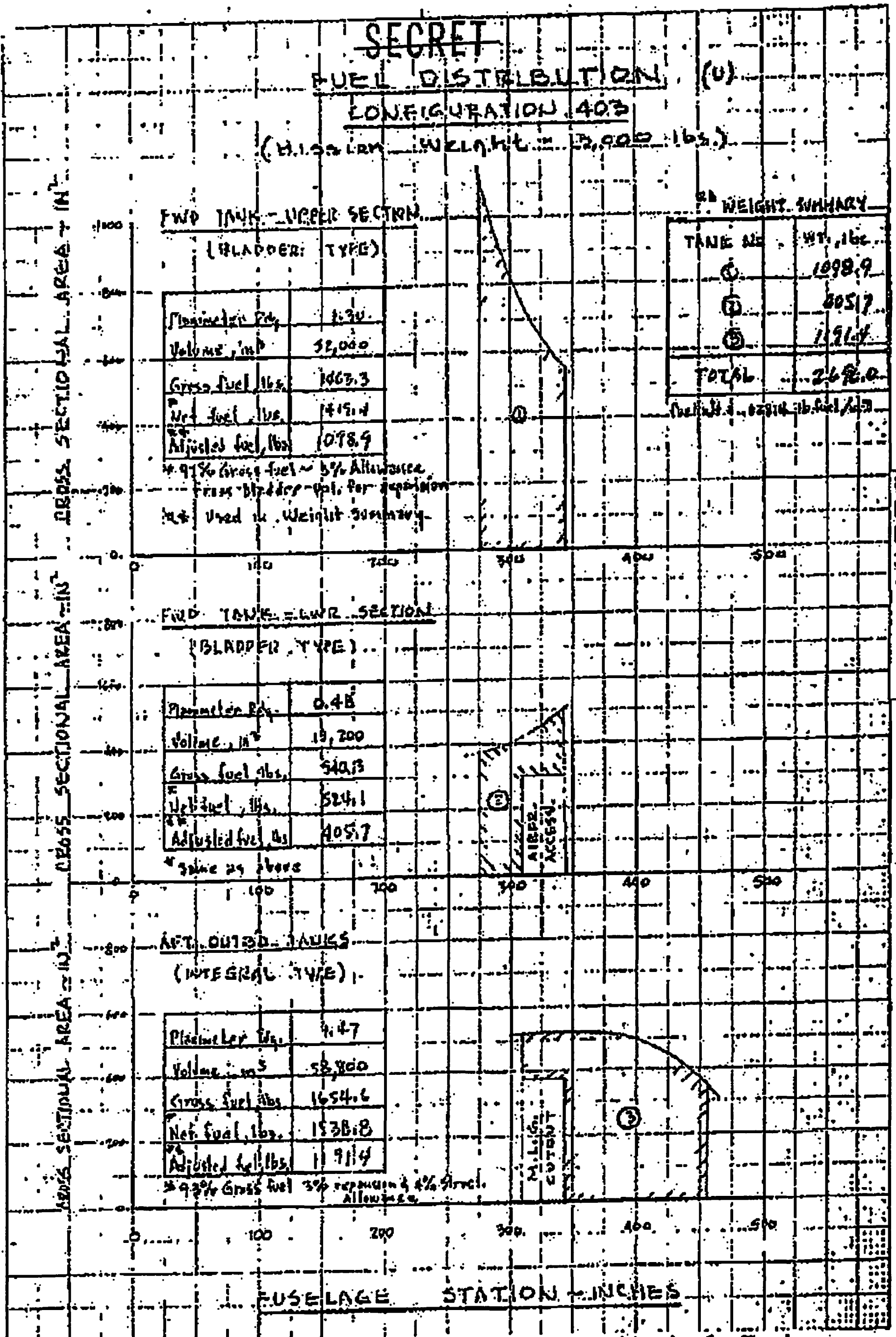
~~SECRET~~



FUEL DISTRIBUTION (U)

CONFIGURATION 403

(Mission Weight = 3,000 lbs.)

FWD TANK – UPPER SECTION
(BLADDER TYPE)

Planimeter Rdg.	1.30
Volume, in³	52,000
Gross fuel lbs.	1463.3
* Net fuel, lbs.	1415.4
** Adjusted fuel, lbs.	1098.9

* 97% Gross fuel ~ 3% Allowance from bladder vol. for expansion

** Used in Weight Summary

FWD TANK – LWR SECTION
(BLADDER TYPE)

Planimeter Rdg.	0.48
Volume, in³	19,200
Gross fuel lbs.	540.3
* Net fuel, lbs.	524.1
** Adjusted fuel, lbs.	405.7

* Same as above

AFT OUTBD. TANKS
(INTEGRAL TYPE)

Planimeter Rdg.	1.47
Volume, in³	58,800
Gross fuel lbs.	1654.6
* Net fuel, lbs.	1538.8
** Adjusted fuel, lbs.	1191.4

* 93% Gross fuel 3% expansion & 4% struct. Allowance.

** WEIGHT SUMMARY

TANK No.	WT., lbs.
①	1098.9
②	405.7
③	1191.4
TOTAL	2696.0

(Density = .02814 lb.fuel/in³)

~~(S)~~ Figure 4.1-14 Fuel Distribution Curve - Small Single-Engine Concept Configuration 403 (U)

88th ABW/IPI
FOIA (b)(1) (b)(4)
E.O. 13526 SEC.
3.3(b)(4)(5)&(6)
1.4 (a)(g), (b)(4)
1.4(A)(G)

~~SECRET~~

4.2 PERFORMANCE

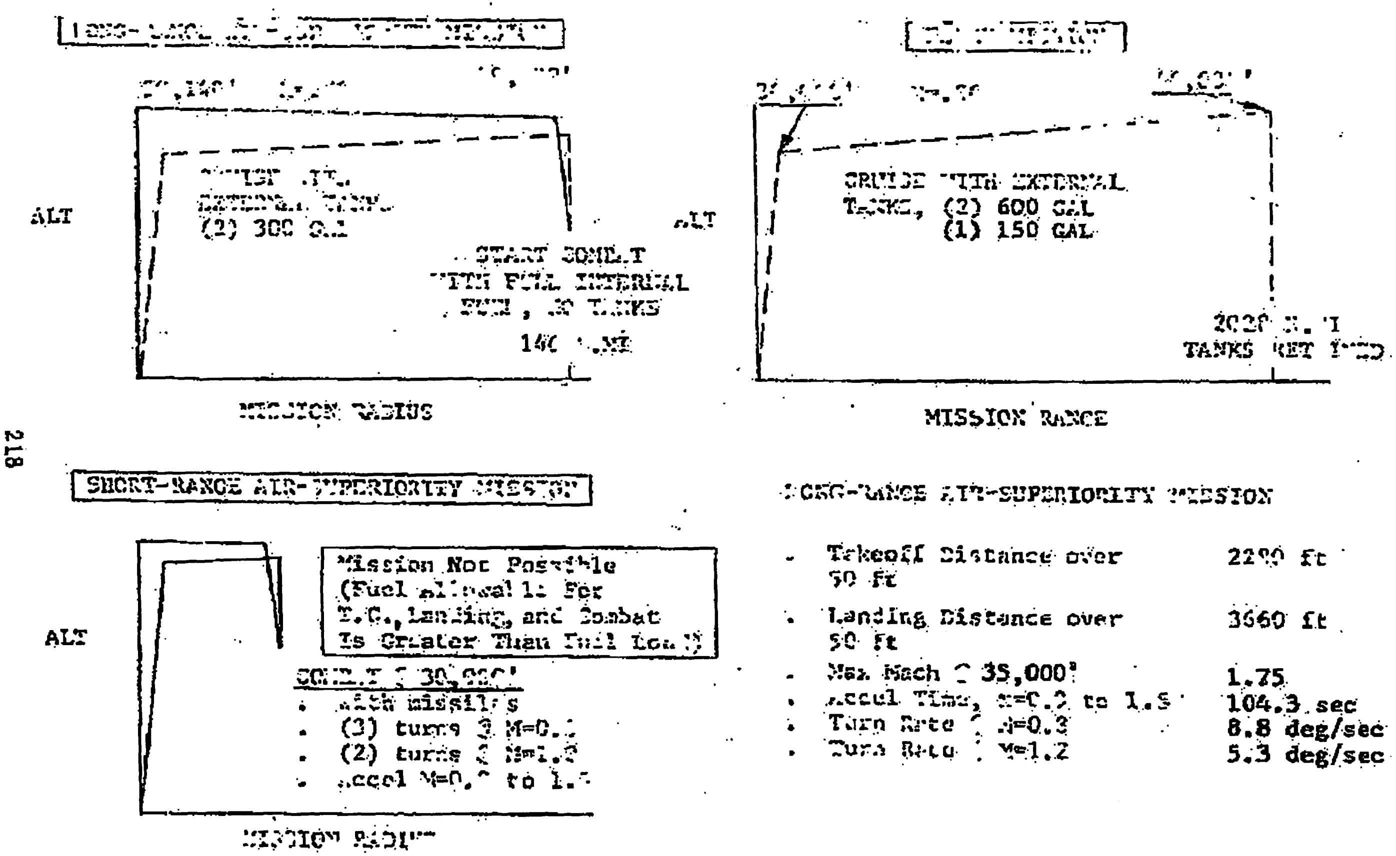
~~(S)~~ Basic performance data computed for the small single-engine concept, Configuration 403, are based on the same mission definitions and performance rules as presented in Section 3.2 for Configuration 401B. Calculations were made on aircraft of three sizes. These were a 13,000-lb size used for the design layout and two growth versions discussed in Section 4.1. The basic data used in the performance calculations are presented in Sections 4.3 through 4.6.

~~(S)~~ The mission performance capabilities of Configuration 403 at 13,000 lb are summarized in Figure 4.2-1. The performance of Configuration 403 at 13,000 lb is far from satisfactory. The LRASM radius is only 146 n.mi., and the SRASM is not possible under the existing ground rules because the fuel allowances for takeoff, climb, combat, and landing exceed the fuel capacity. Even growing the aircraft, as shown in Figure 4.2-2, will not accomplish the desired mission radius for either the LRASM or the SRASM. The problem with the larger-sized aircraft is the small thrust excess during acceleration. Growing the airplane in size (without increasing engine size) results in lower acceleration capabilities, which require more time and fuel for the acceleration portion of the combat allowance. When the aircraft is grown to approximately 18,500 lb it is incapable of accelerating to Mach 1.5 and cannot perform the mission.

88th ABW/PI
FOIA (b)(1)
E.O. 13526 SEC
3.3(b)(4)
1.4(a)(g)

(U) The small single-engine concept was dropped from further consideration.

(13,000-LB. A/P W/O TANKS)

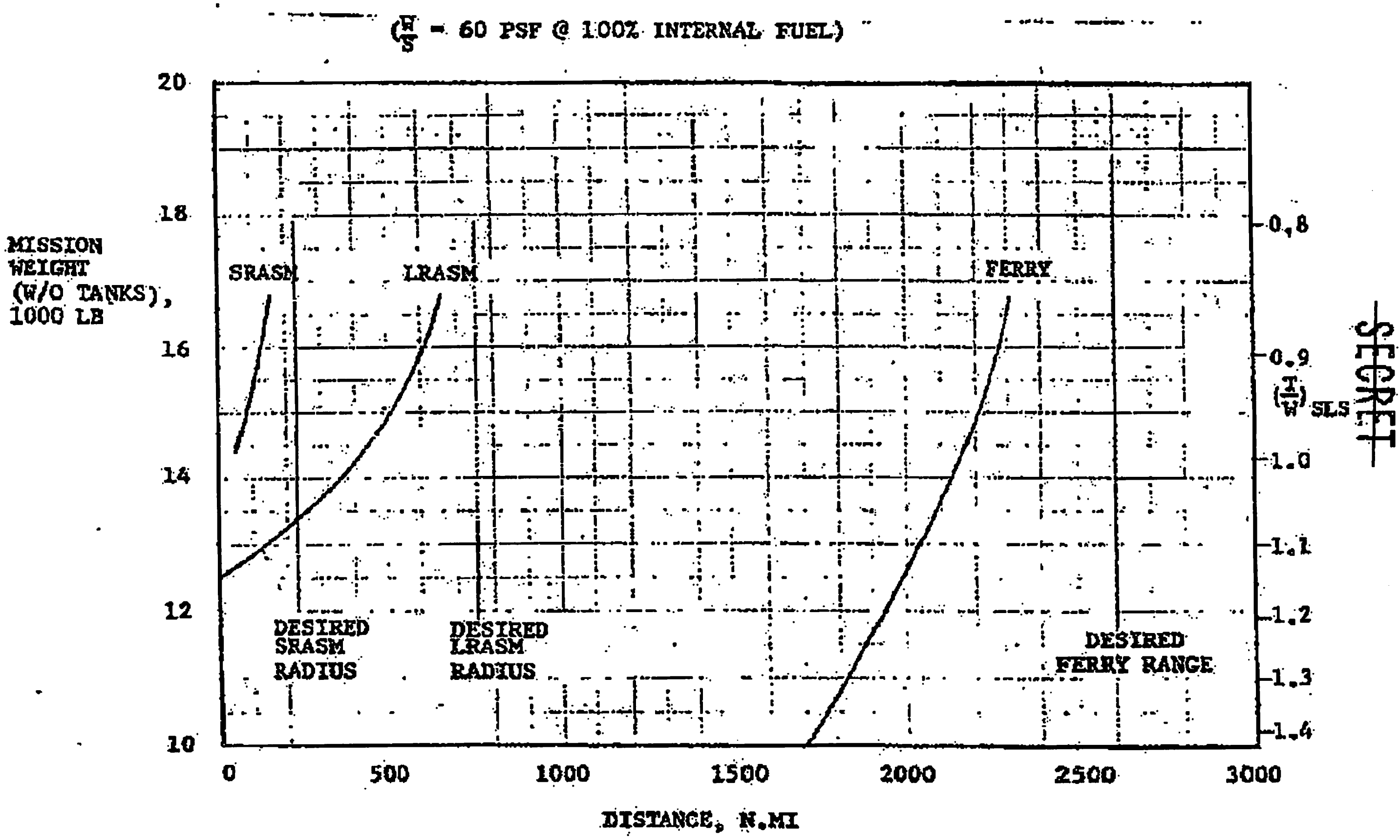


LONG-RANGE AIR-SUPERIORITY MISSION

Takeoff Distance over 50 ft	2290 ft
Landing Distance over 50 ft	3660 ft
Max Mach @ 35,000'	1.75
Accel Time, M=0.9 to 1.5	104.3 sec
Turn Rate @ M=0.3	8.8 deg/sec
Turn Rate @ M=1.2	5.3 deg/sec

~~(S)~~ Figure 4.2-1 Configuration 403 Mission Performance Summary (U)

~~SECRET~~



~~(S)~~ Figure 4.2-2 Configuration 403 Growth Curve (U)

~~SECRET~~

4.3 AERODYNAMICS

(U) For the small single-engine airplane (Configuration 403), the overall configuration planform, as well as the wing itself, it geometrically similar to the large single-engine airplane (401B) of Section 3. Furthermore, the wing airfoil section, t/c = .04 biconvex, and leading-edge-flap geometry are identical to that for the large single-engine airplane. It is therefore assumed that the aerodynamic characteristics of the two are also identical, except for the minimum drag.

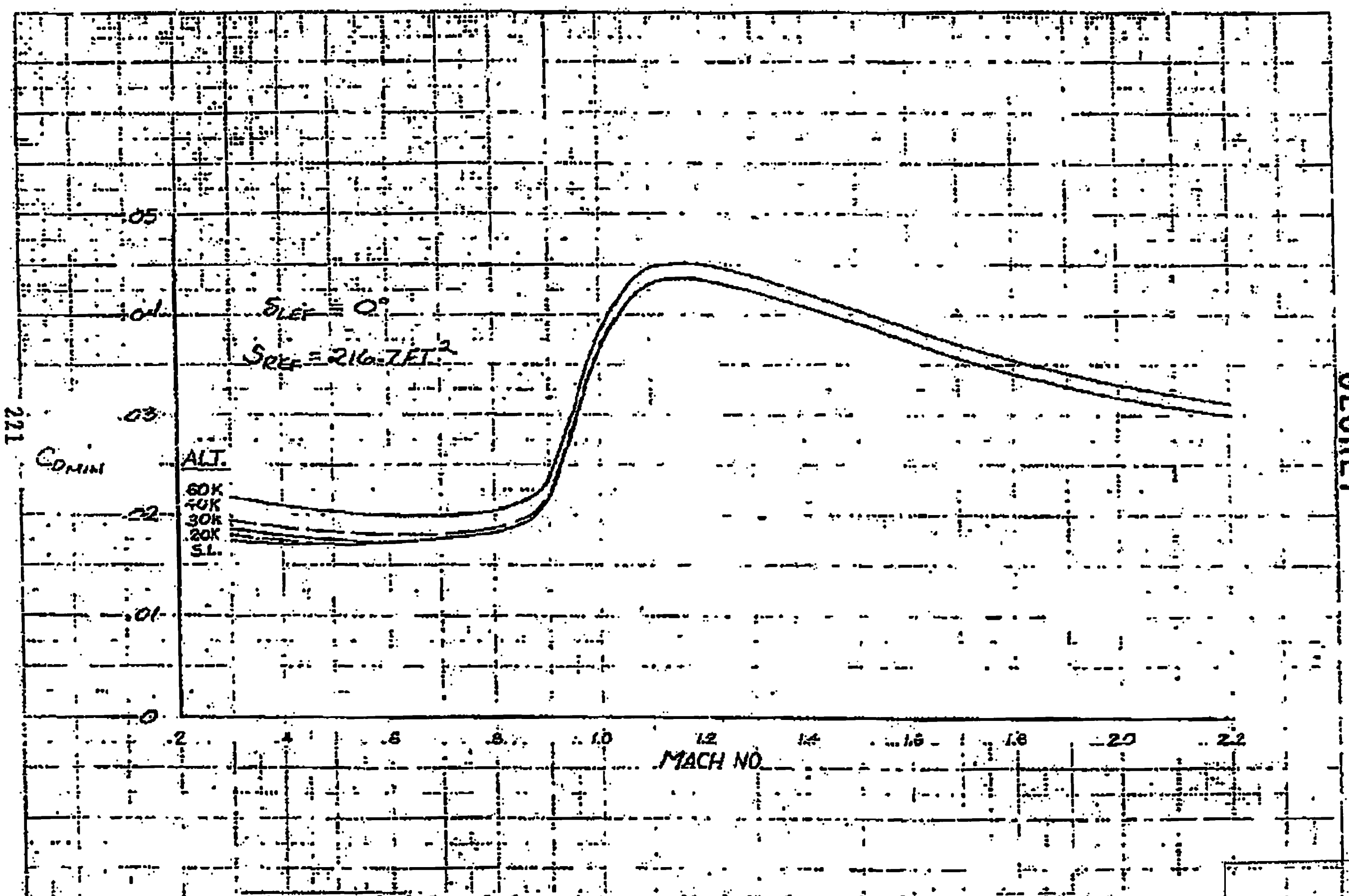
(U) The minimum drag for Configuration 403 is predicted by use of the same methodology as was used on Configuration 401B (Section 3.3).

(U) The total minimum drag is presented in Figure 4.3-1 for various altitudes. The D/q's for the canopy, missile pylons, and protuberances are the same as those for 401B. However, there are small differences in the nozzle, cowl, and diverter drags. These drag components are shown in Figure 4.3-2. The effect of airplane size on minimum drag is shown in Figure 4.3-3 for this concept.

(U) The trimmed drag polars and trimmed configuration polars are presented in Figures 4.3-4 through 4.3-9. The drag due to lift, leading-edge-flap drag, and trim drag are the same as those for the 403 Configuration, given in Figures 3.3-6 through 3.3-13 of Section 3.3

(U) The trimmed (L/D) data for this configuration are plotted in Figure 4.3-10. A comparison of these max data with those of Figure 3.3-25 shows that the 403 configuration has 5 percent less (L/D) max than the 401B configuration.

(U) Since the planform and wing loading are the same as for the 401B configuration, the lift curves, buffet boundaries, and control-limit C_L's shown in Figure 3.3-26 through 3.3-31 of Section 3.3 also apply to the 403 configuration.



(S)Figure 4.3-1 Minimum Drag vs Mach Number, Configuration 403(U)

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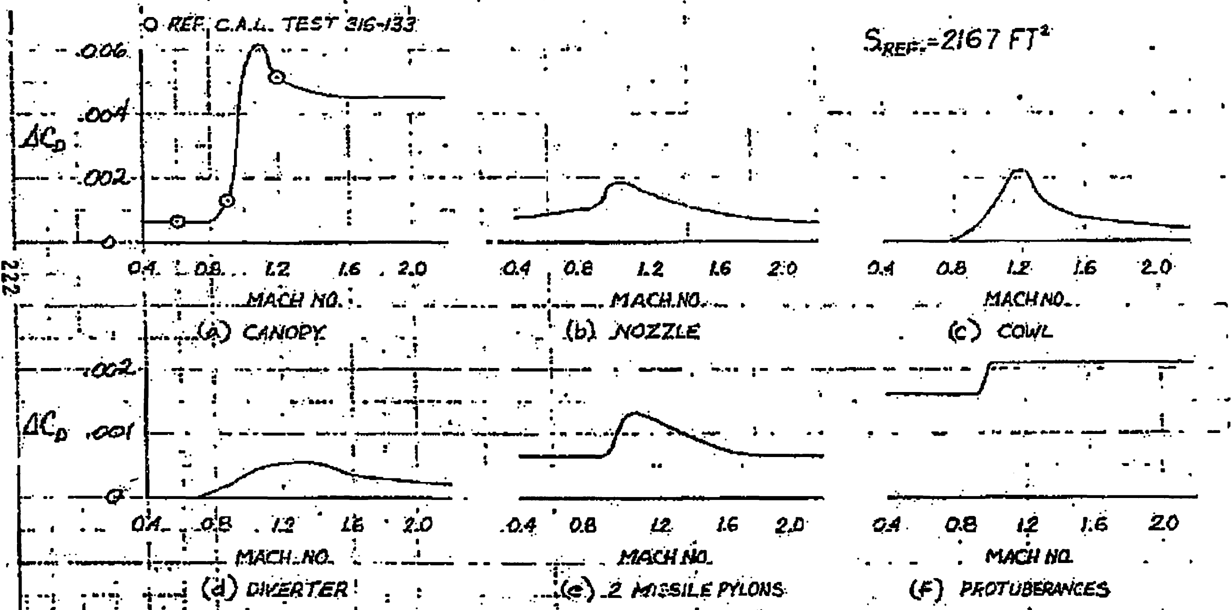

Figure 4.3-2 Components Used in Minimum Drag Buildup, Configuration 403

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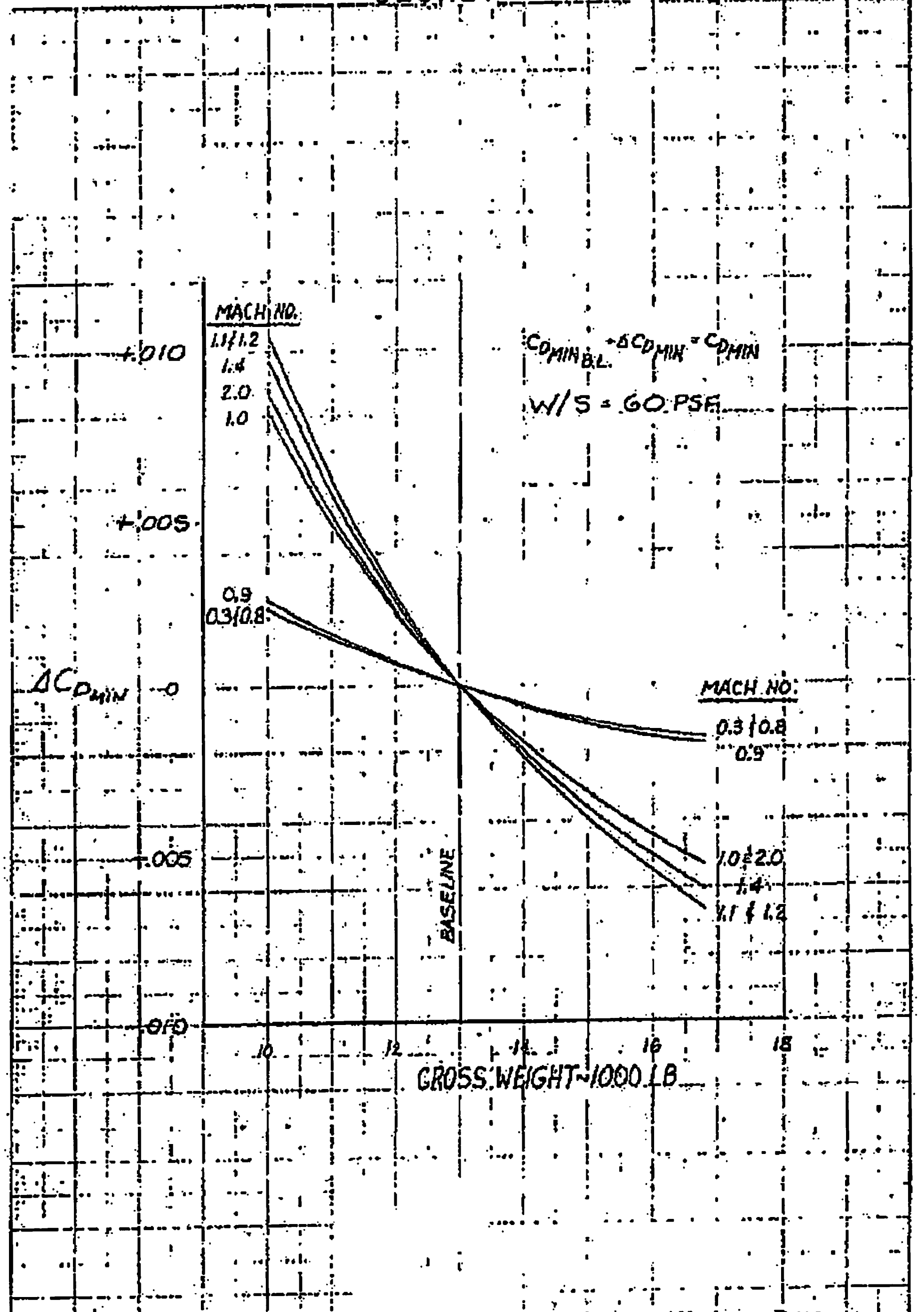
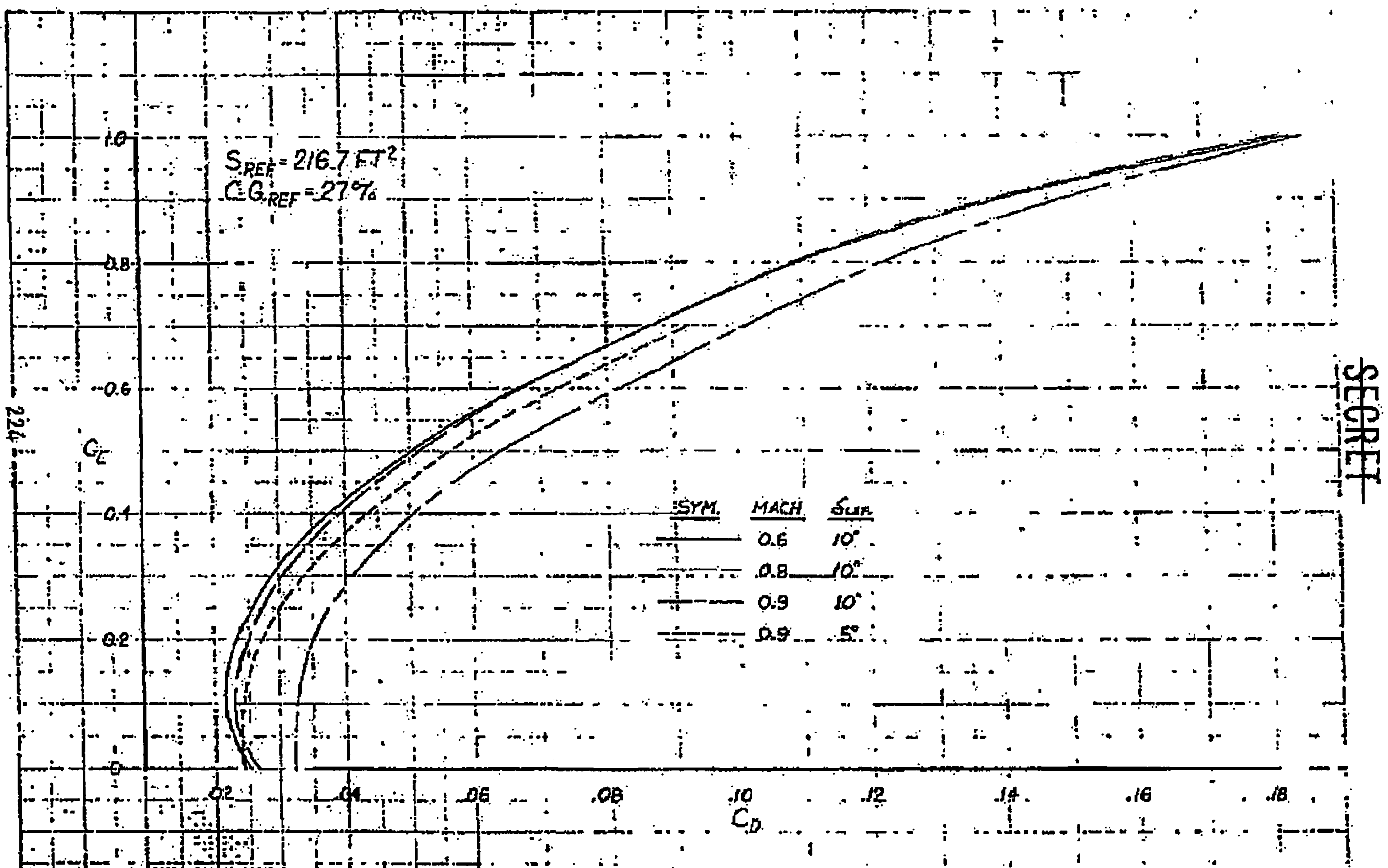


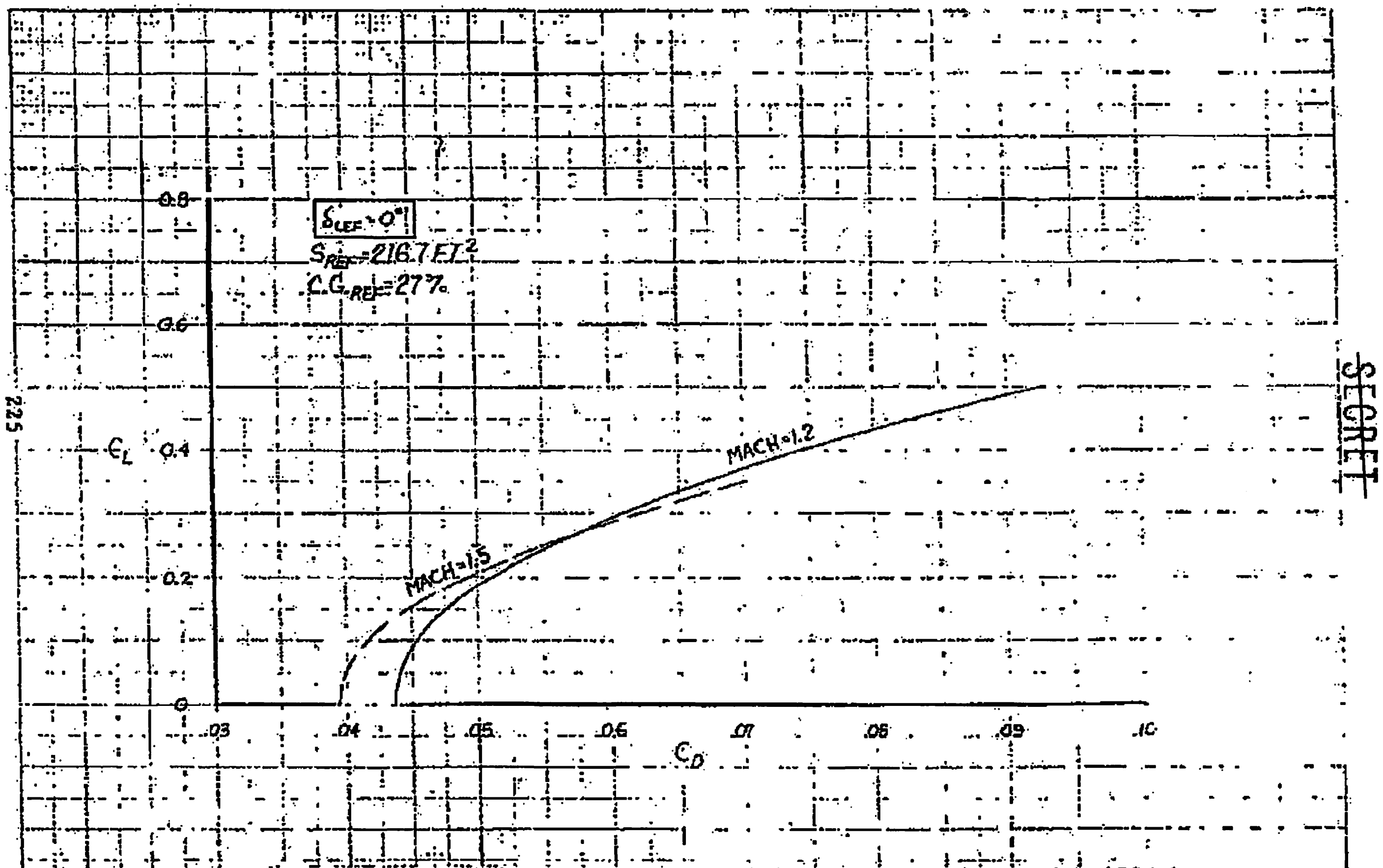
~~(S)~~ Figure 4.3-3 Effect of Aircraft Size on Minimum Drag Coefficient, Configuration 403 (U)



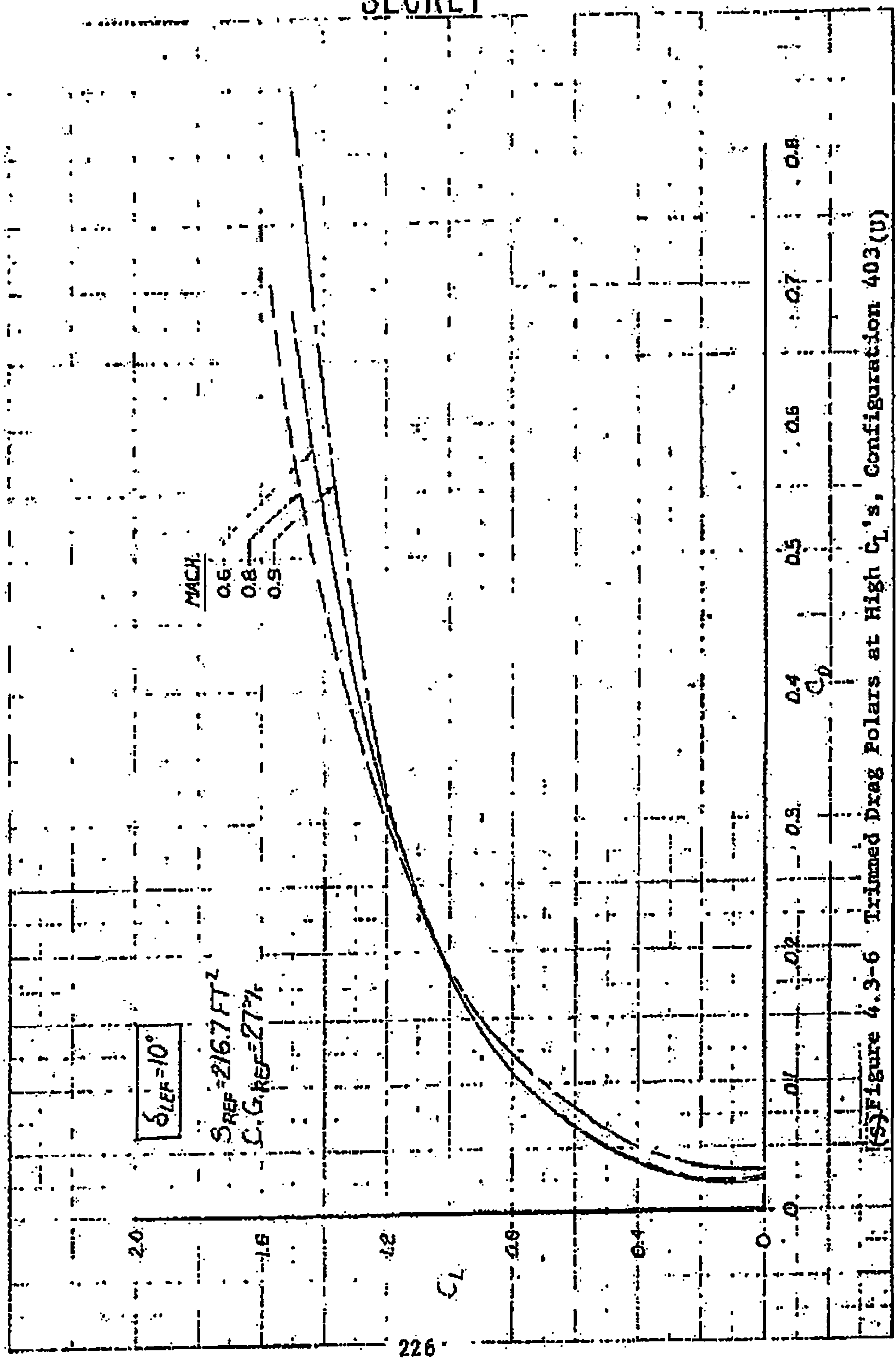
(S) Figure 4.3-4 Trimmed Drag Polars at M=0.6, 0.8, and 0.9, Configuration 403 (U)

[redacted]

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 4.3-5 Trimmed Drag Polars at M=1.2 and 1.5, Configuration 403(U)



(S) Figure 4.3-6 Trimmed Drag Polars at High C_L's, Configuration 403(U)

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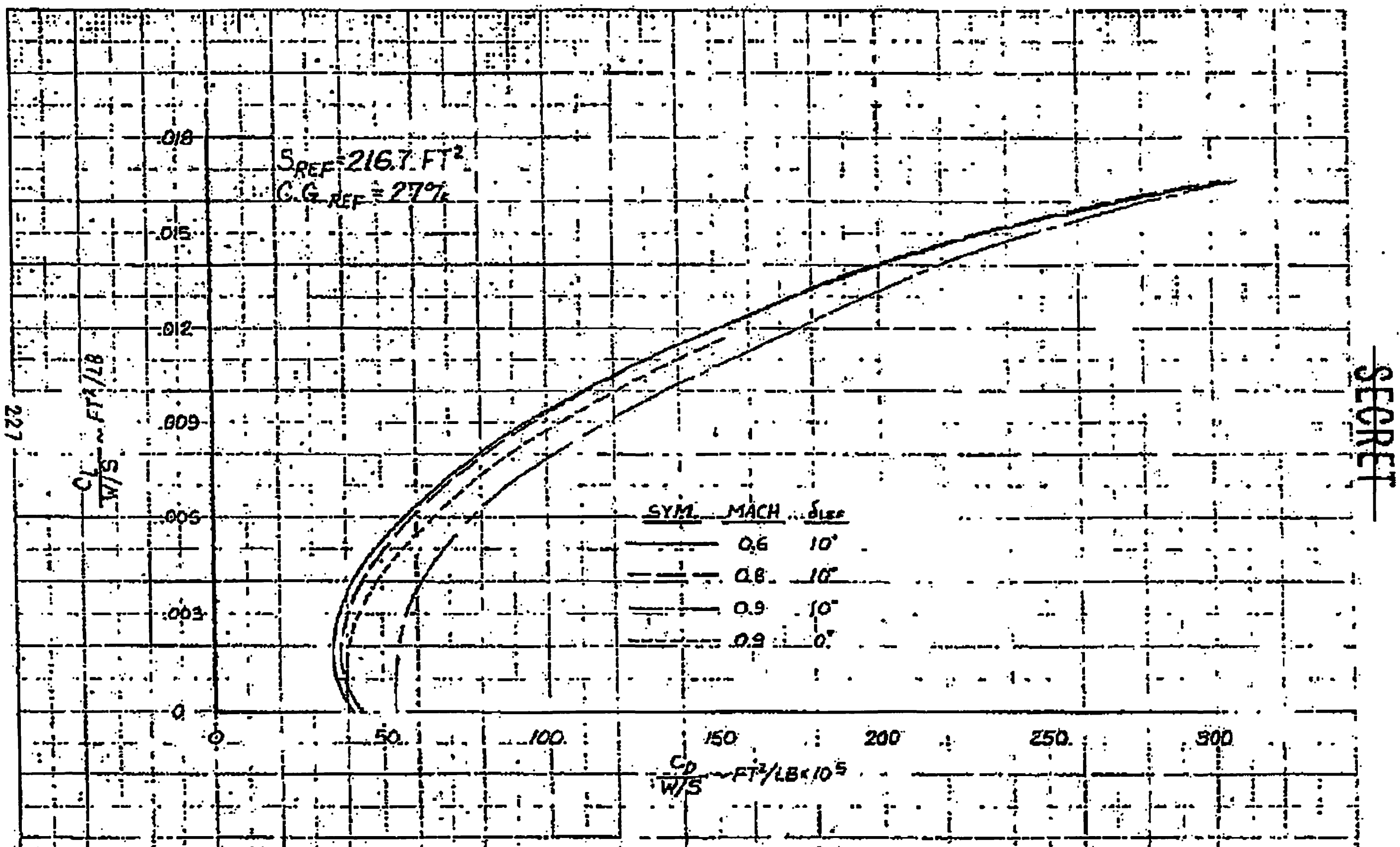
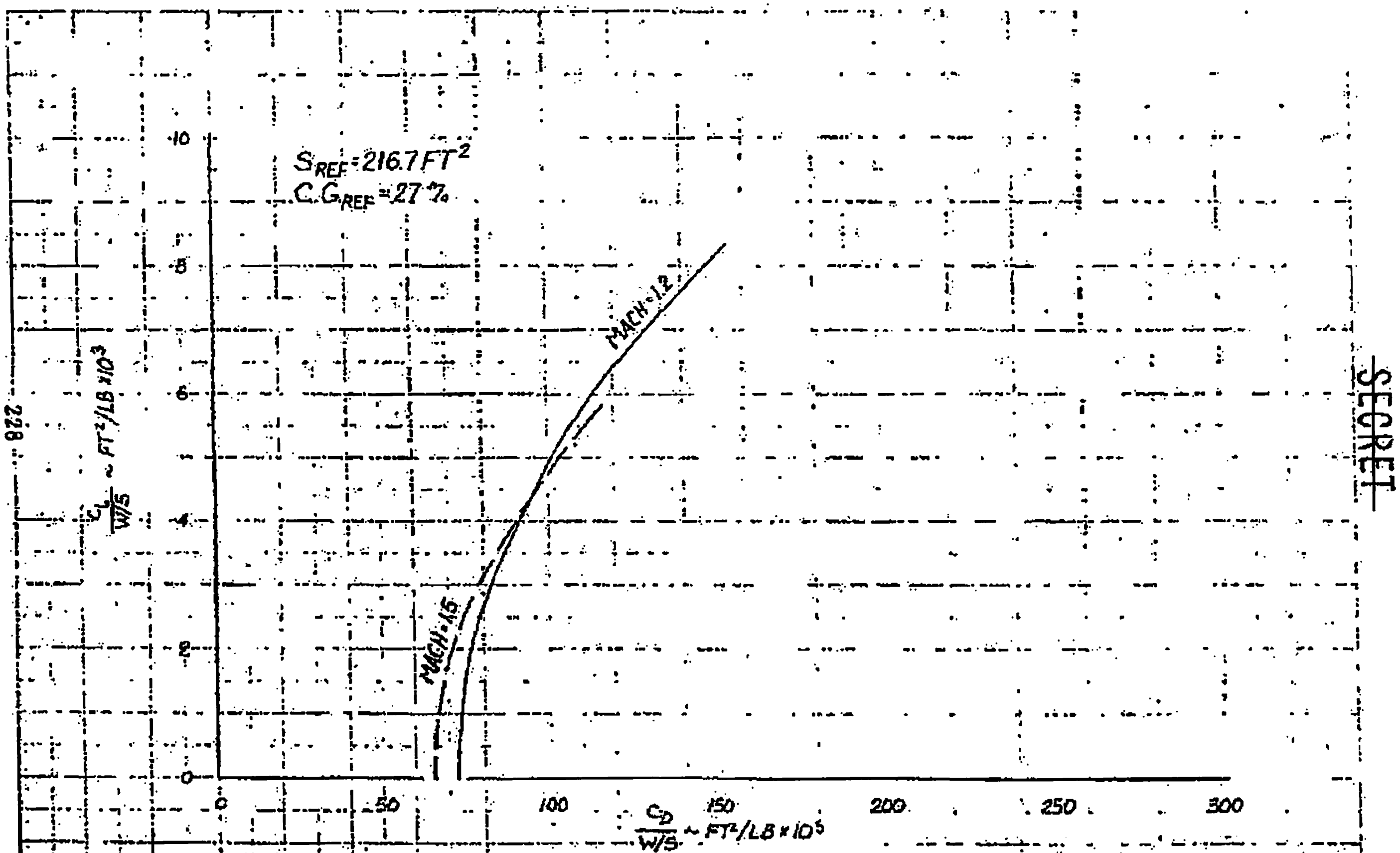


~~(S)~~ Figure 4.3-7 Trimmed Configuration Polars at M=0.6, 0.8, and 0.9, Configuration 403(U)

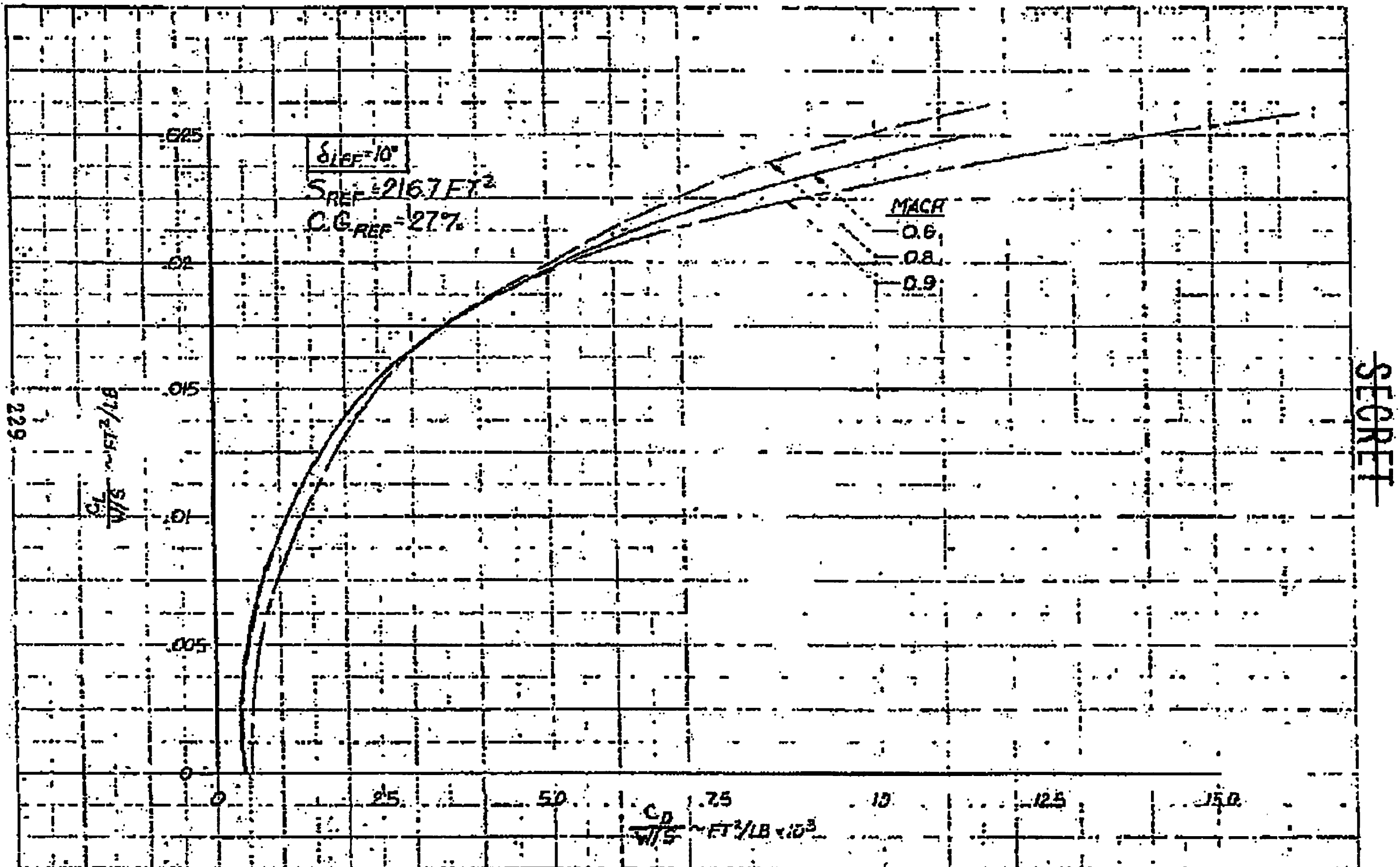
~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 4.3-8 Trimmed Configuration Polars at M=1.2 and 1.5, Configuration 403 (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

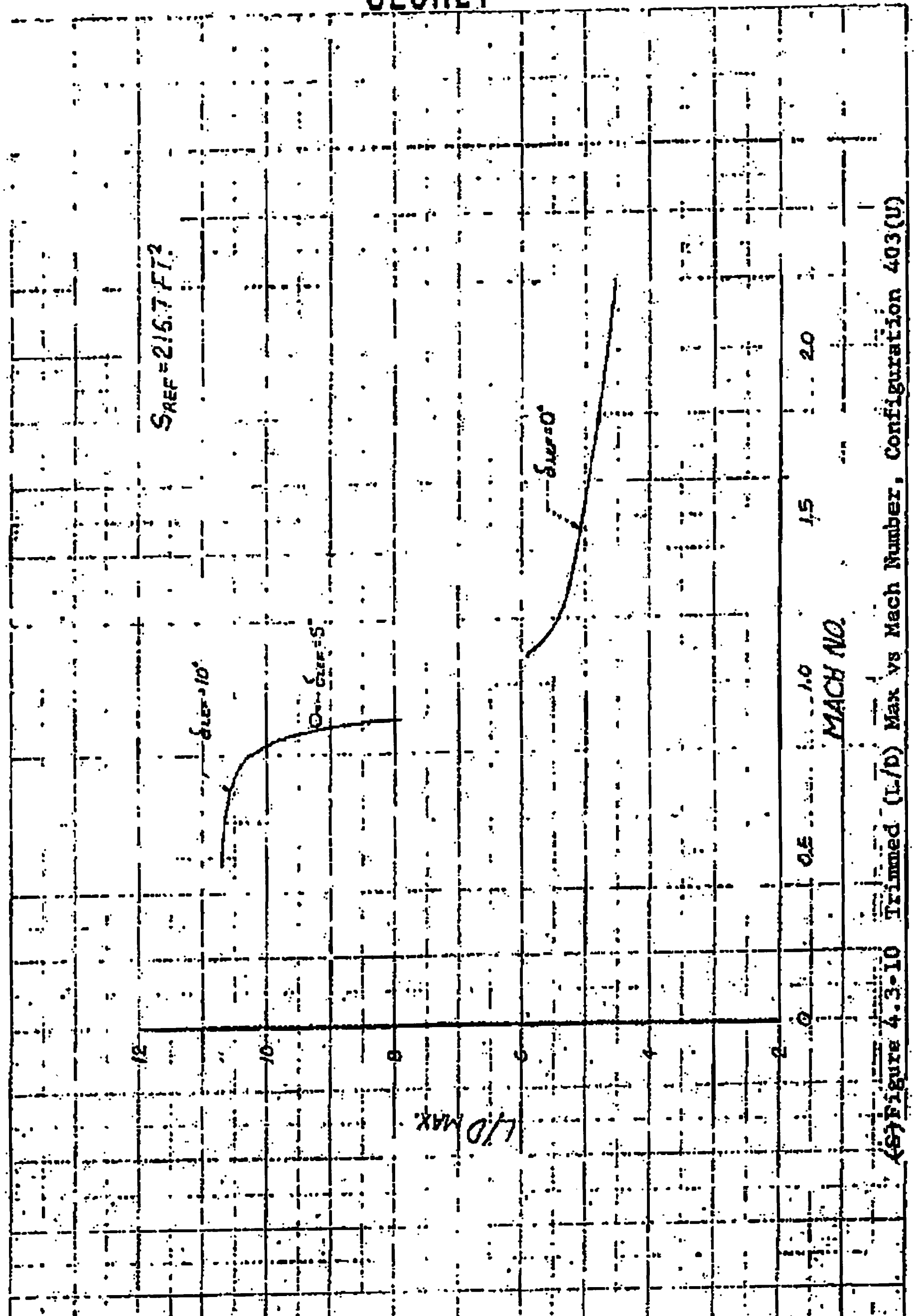


~~(S)~~Figure 4.3-9 Trimmed Configuration Polars at High C_L's, Configuration 403(U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 4.3-10 Trimmed (L/D) Max vs Mach Number, Configuration 403(U)

~~SECRET~~

4.4 STABILITY, CONTROL, AND HANDLING QUALITIES

(U) In the case of the small single-engine design concept (Configuration 403), the same basis for handling qualities design aspects as previously presented in Section 3.4 for the 401B configuration has been followed. The overall configurations of the 401B and the 403 concepts are very similar. In these design studies, the respective volume coefficients of the horizontal and vertical tails have been maintained equal for the configuration layouts. Consequently, the stability and control characteristics of the small design will be basically the same as those presented in Subsection 3.4.3. A small difference may exist in the handling qualities of the two designs with the advantage in favor of the smaller design because of its correspondingly lower moments of inertia.

4.5 STRUCTURES AND WEIGHTS

~~(S)~~ Weight analysis for the Configuration 403 growth curve was performed in the same manner as for the Configuration 401B growth curve. Three airplanes were selected for analysis at design gross weights (in pounds) as shown below.

TOGW	(80% Fuel) Struct DGW	Ferry Mission Overload GW
10,000	9,460	20,200
13,000	12,300	23,200
16,800	15,800	27,000

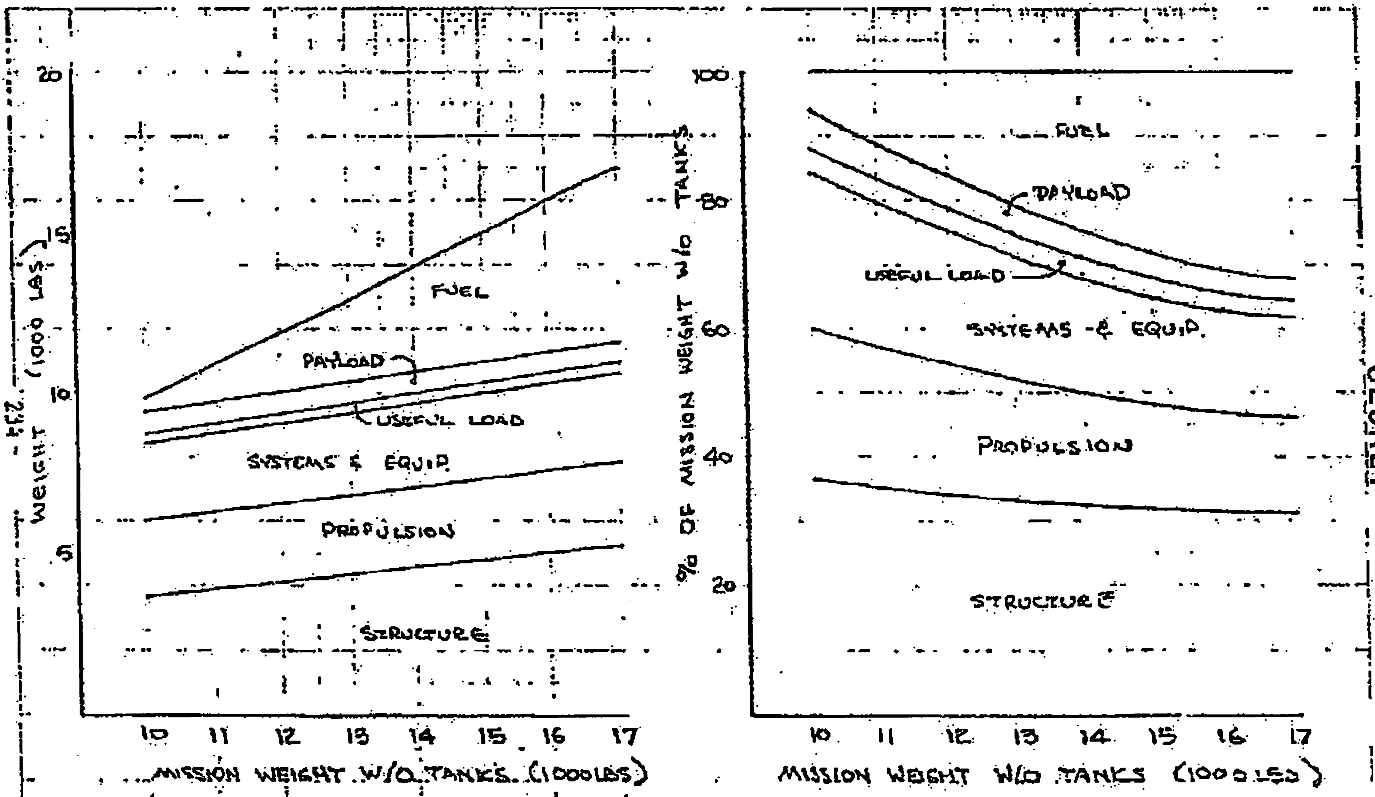
(U) Input data for weight equations were derived from the scaling data presented in Section 4.1 together with layouts as required to develop specific area and dimensional data.

~~(S)~~ A weight summary for each of the three selected airplanes is presented in Table 4.5-1. A plot of weight variation versus gross weight is shown in Figure 4.5-1. A summary of the center-of-gravity conditions for the 13,000-pound-gross-weight configuration is shown below.

Item	Weight (lb)	C.G. (% MAC)
Basic Operating Weight	9,671	25.5
Zero Fuel Weight	10,304	25.3
Gross Weight	13,000	25.1

~~(S)~~ Table 4.5-1 WEIGHT SUMMARY: CONFIGURATION 403 GROWTH STUDY (Pounds) (U)

Item	Airplane Size (Gross Weight)		
	10,000	13,000	16,800
Structure	(3662)	(4332)	(5263)
Wing	886	1193	1595
Fuselage	2006	2145	2376
Horizontal Tail	176	250	362
Vertical Tail	186	242	316
Landing Gear	408	502	614
Propulsion System	(2333)	(2422)	(2522)
Engine (G.E. 15-1/J1A5)	1790	1790	1790
Air Induction	223	231	244
Fuel System	283	364	449
Engine Controls	17	17	19
Starting System	20	20	20
Systems and Equipment	(2412)	(2536)	(2703)
Surface Controls	412	475	563
Landing Gear Controls	81	97	115
Instruments	94	94	94
Hydraulics and Pneumatics	185	218	267
Electrical	347	359	371
Avionics	460	460	460
Furnishings	238	238	238
Air Conditioning	142	142	142
Armament	453	453	453
Weight Empty	8407	9290	10,488
Useful Load	(375)	(381)	(387)
Crew	200	200	200
Unusable Fuel	11	17	23
Engine Oil	10	10	10
Missile Racks and Pylon	124	124	124
Starter Cartridge (2)	20	20	20
Miscellaneous	10	10	10
Basic Operating Weight	8782	9671	10,875
Payload	(633)	(633)	(633)
Ammo (500 rounds)	285	285	285
Missiles (2)	348	348	348
Zero Fuel Weight	9415	10,304	11,508
Fuel	585	2696	5292
Gross Weight	10,000	13,000	16,800



~~(S)~~ Figure 4.5-1 Weight Variation with Aircraft Size: Configuration 403 (U)

4.6 PROPULSION (403/J101-GE-100)

(U) A single General Electric continuous-bleed turbojet, J101-GE-100, is installed in the Configuration 403 airplane. The General Electric designation for this engine is GE15/J1A5 (Reference 25). In this report the engine will be referred to as the J101-GE-100. Performance data were furnished by General Electric (Reference 26) accounting for Convair estimates of inlet pressure recovery, engine bleed and shaft power extraction.

(U) In this section, the J101-GE-100 propulsion system performance data are presented for the engine installed in a manner similar to that of the Configuration 401B engine installation described in Section 3.6. The same amounts of high-pressure air bleed and shaft power are extracted.

(U) The exhaust nozzle is a contoured translating-flap convergent-divergent (TFCD) configuration. The nozzle exhaust area is fully modulated during afterburning operation and varies to a lesser extent when the engine is operating in non-afterburning power settings.

4.6.1 Propulsion System Performance

(U) The installed thrust specific fuel consumption, TSFCS, and propulsion system net thrust, F_{NS}, of the J101-GE-100 are presented in Table 4.6-1 and Figure 4.6-1 through 4.6-7. The data shown comprise a minimum package needed for the Configuration 403 airplane design and mission analysis.

(U) The definition of the installed propulsion system net thrust, F_{NS}, is similar to that given in Subsection 3.6.1

(U) It should be noted that some differences exist between the propulsion system performance data contained in this section of the report and those shown in Subsection 5.6.1 for the twin-engine airplane. Subsection 5.6.1 contains later engine data from General Electric. The data contained in this section are the same as those reported in the Convair interim report (FZM-5726). A change in the propulsion system performance data to the later set of data will not affect the conclusions made on the single-engine airplane. Therefore no effort was made to update the single-engine propulsion performance.

(U) Table 4.6-1 403/J101-GE-100 MAXIMUM AFTERBURNING AND INTERMEDIATE POWER PROPULSION SYSTEM PERFORMANCE DATA (U)

Altitude (ft)	Mach Number	F_{NS} (lbf)	TSFCS (lbm/hr/lbf)
Power Setting - Maximum Afterburning			
0	0	11295.	2.047
0	.5	13254.	2.202
10000.	.6	11130.	2.088
10000.	.9	12611.	2.229
30000.	.8	6442.	2.053
	.9	7018.	2.051
	1.0	7688.	2.053
	1.1	8315.	2.063
	1.2	8813.	2.093
	1.3	9212.	2.147
	1.4	9509.	2.219
	1.5	9953.	2.273
35000.	1.6	8787.	2.275
	1.8	8447.	2.467
	2.0	7440.	2.821
40000.	1.6	7013.	2.275
	1.8	6776.	2.457
	2.0	6060.	2.791
Power Setting - Intermediate Power			
0	0	7669.	.893
0	.5	8093.	1.021
10000.	.6	6651.	1.036
10000.	.9	7037.	1.090
20000.	.713	5258.	1.032
25000.	.783	4538.	1.035

4.6.2 Inlet

~~(C)~~ The inlet system for configuration 403/J101-GE-100 is essentially the same as that described in Subsection 3.6.2, but scaled to match the airflow requirements of the J101-GE-100 engine. The resulting inlet capture area, 423 sq in. is based on a maximum engine corrected airflow of 129.8 lbm/sec. The inlet performance data presented in Subsection 3.6.2 is made applicable to the J101-GE-100 engine by multiplying the engine corrected airflow scale by the ratio of maximum standard-day engine corrected airflows:

$$\frac{129.8}{227} = 0.572$$

4.6.3 Nozzle

(U) The nozzle employed for this engine is a translating-flap-type convergent/divergent, non-ejector nozzle as depicted in the Figure 4.6-8 sketch. A pressure-drag analysis was made, and the data are shown in Figures 4.6-9 and 4.6-10.

(U) The drag bookkeeping system employed is the same as that defined in Subsection 3.6.1. The maximum augmentation drag given in Figure 4.6-9 is the baseline, and the dry-power drag given in Figure 4.6-10 is the increment included in the propulsion data. Also, nozzle/aft-fuselage flow-field interactions are accounted for as defined in Subsection 3.6.3. The baseline nozzle pressure ratio is shown in Figure 4.6-11.

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)
(4)
1.4(a)(g)

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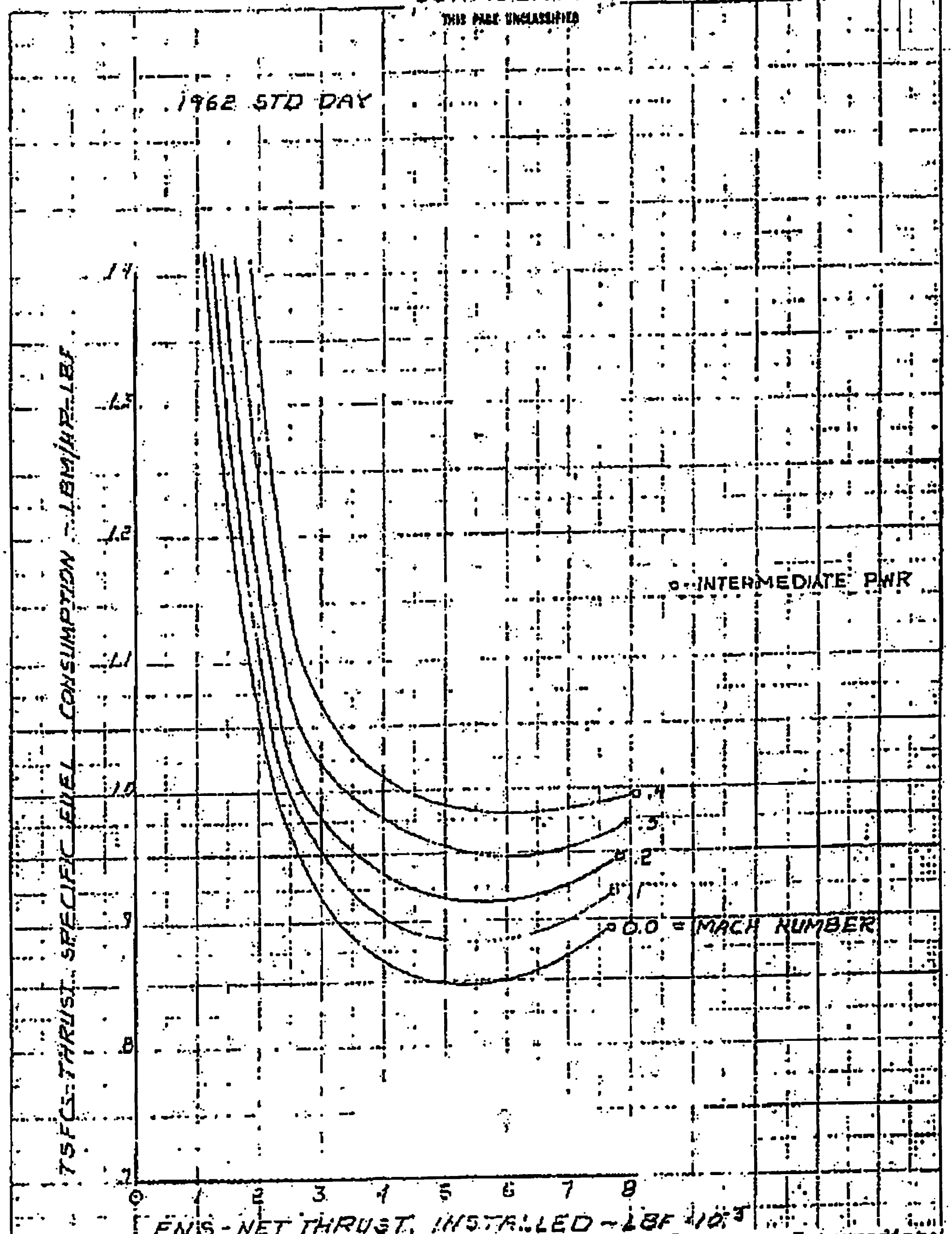

(U) Figure 4.6-1 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, Sea Level

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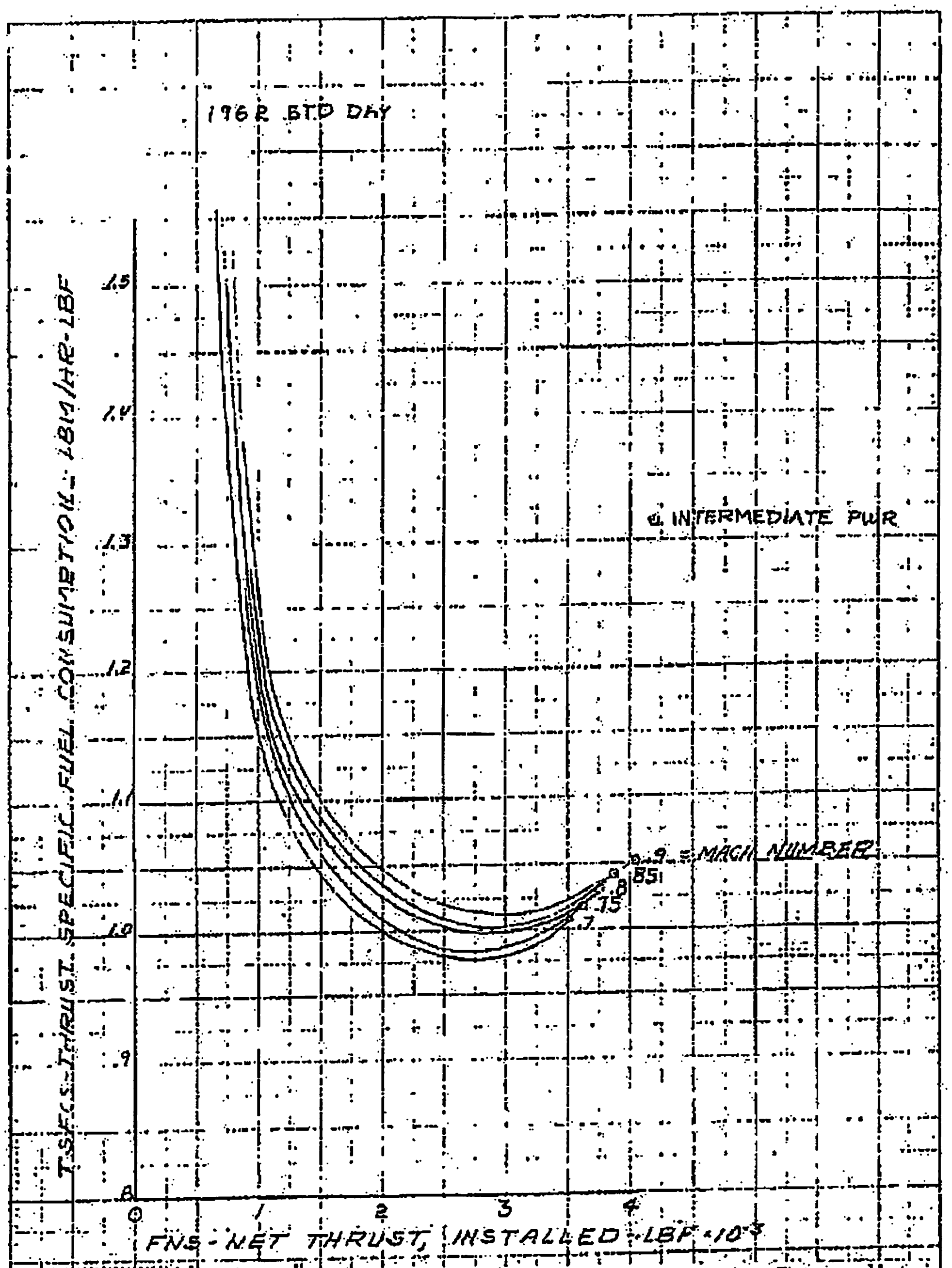
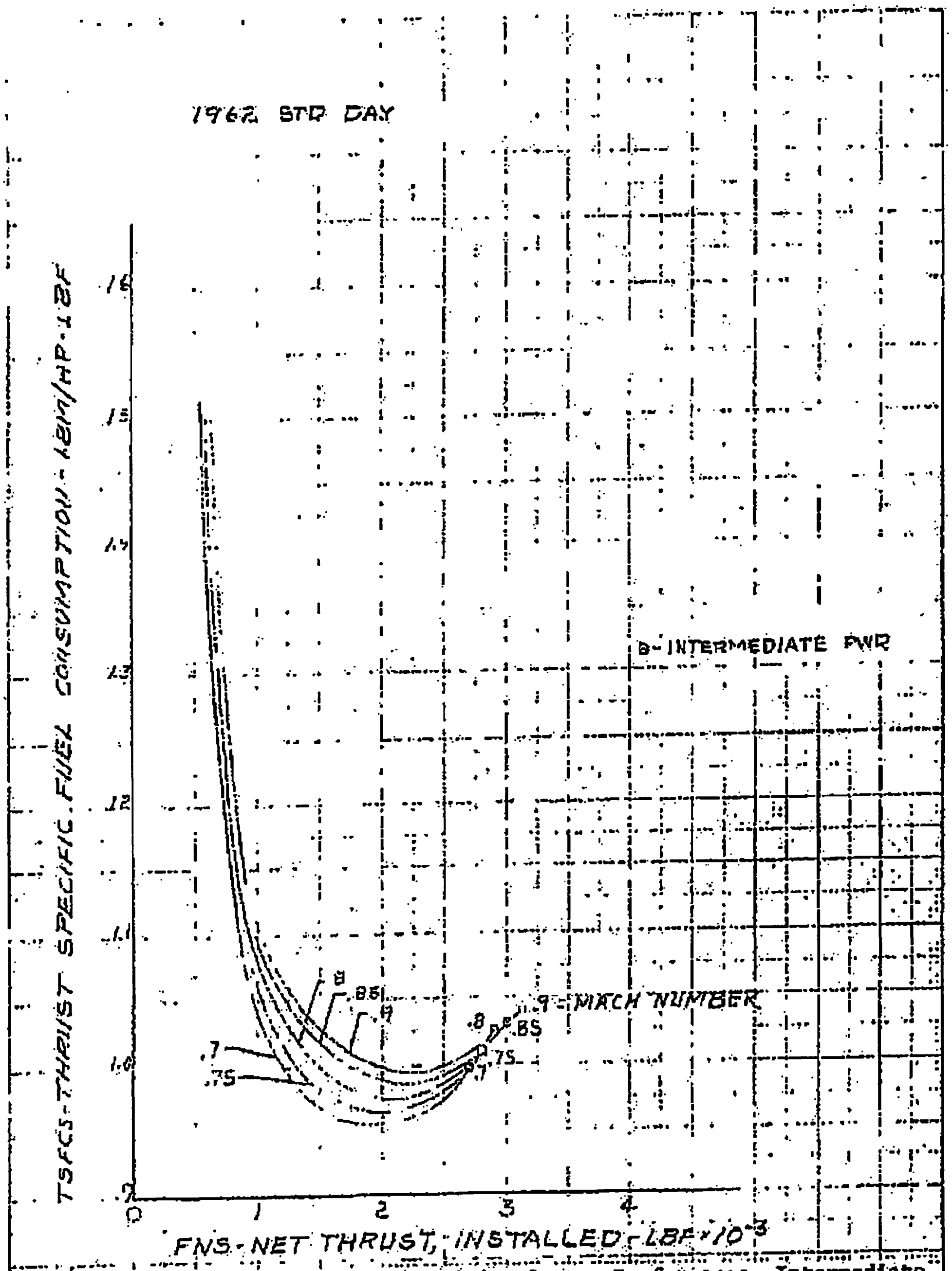


(U) Figure 4.6-2 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 30,000 Feet



(U) Figure 4.6-3 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 36,089 Feet

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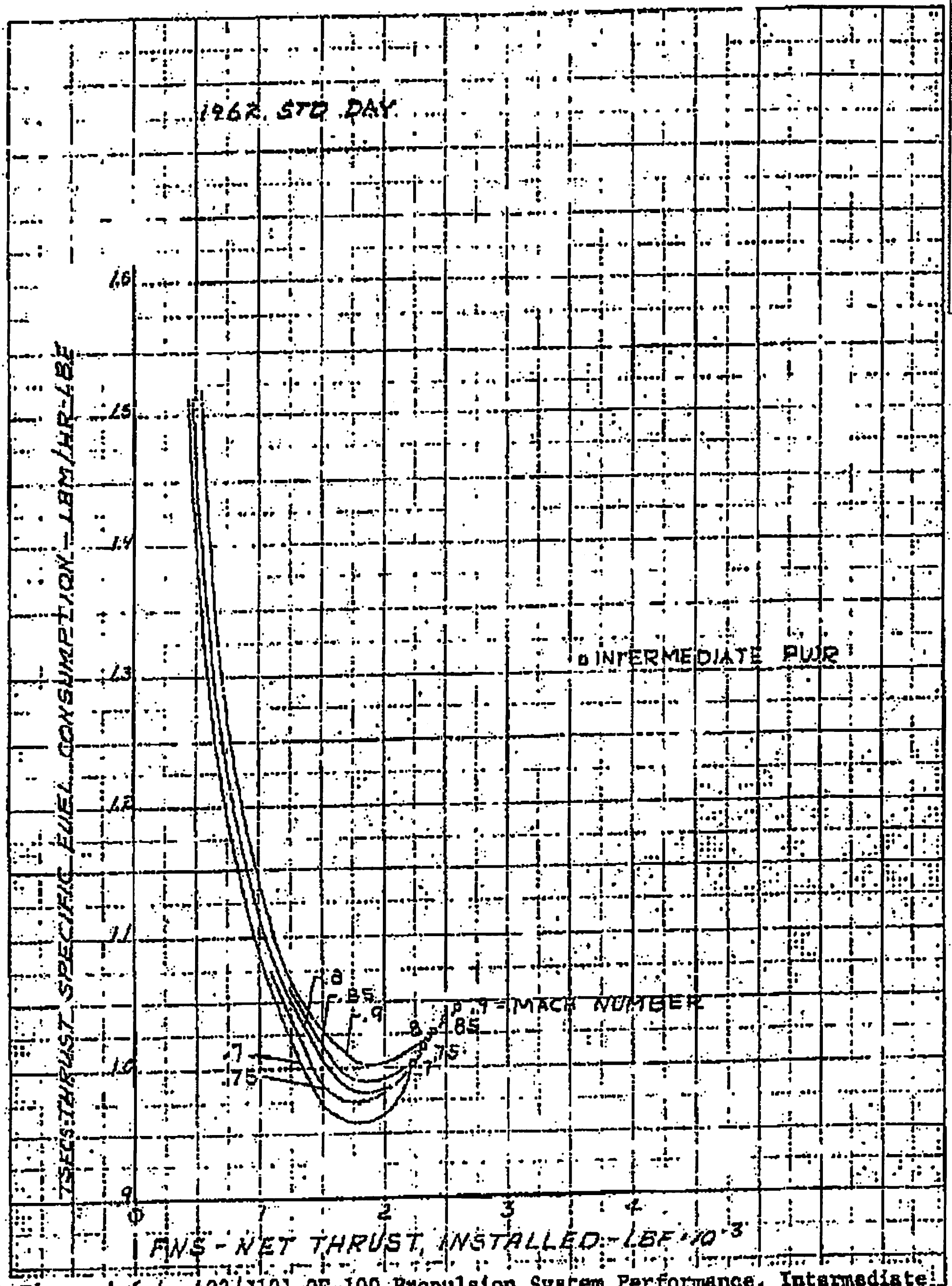
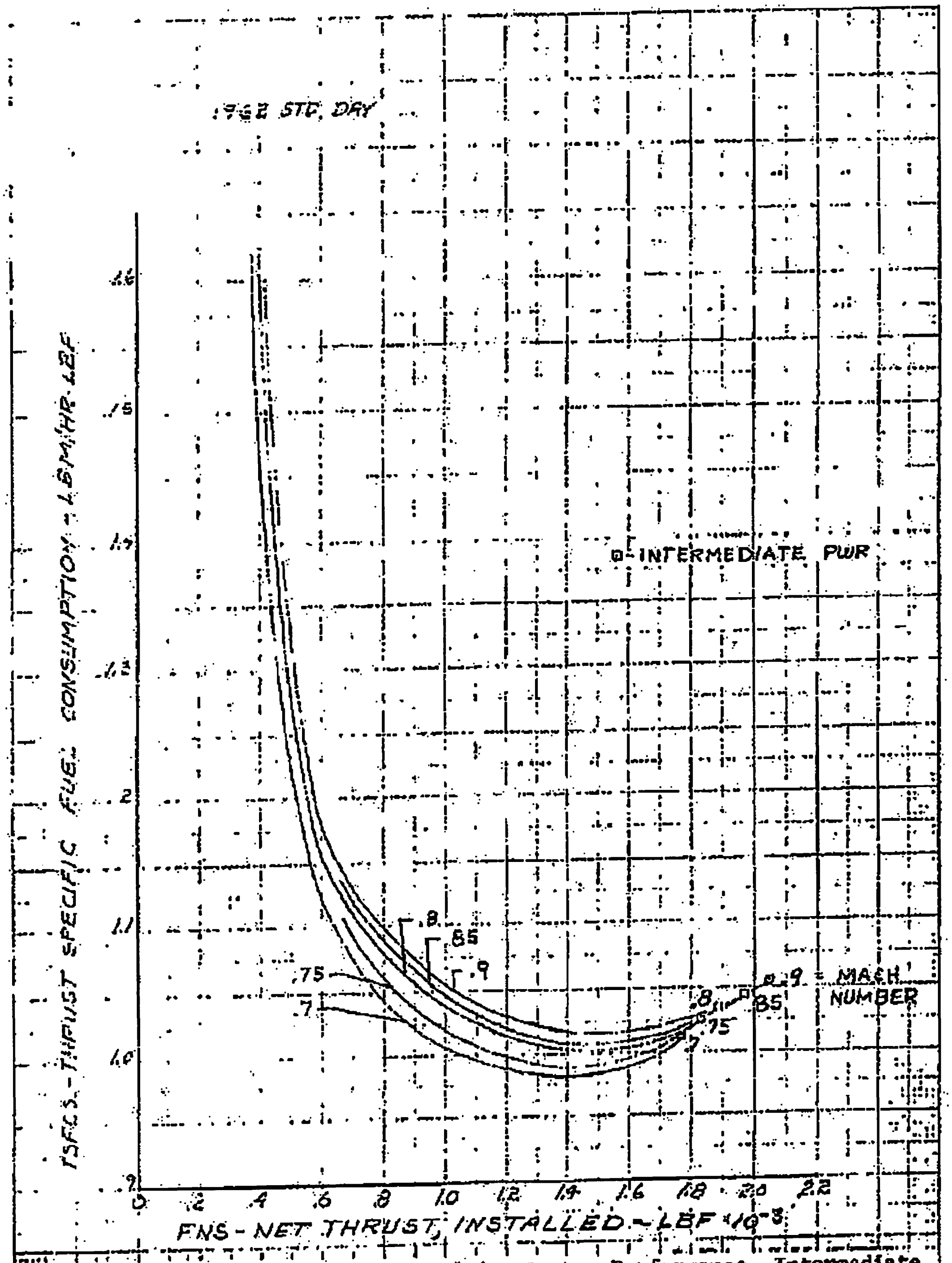
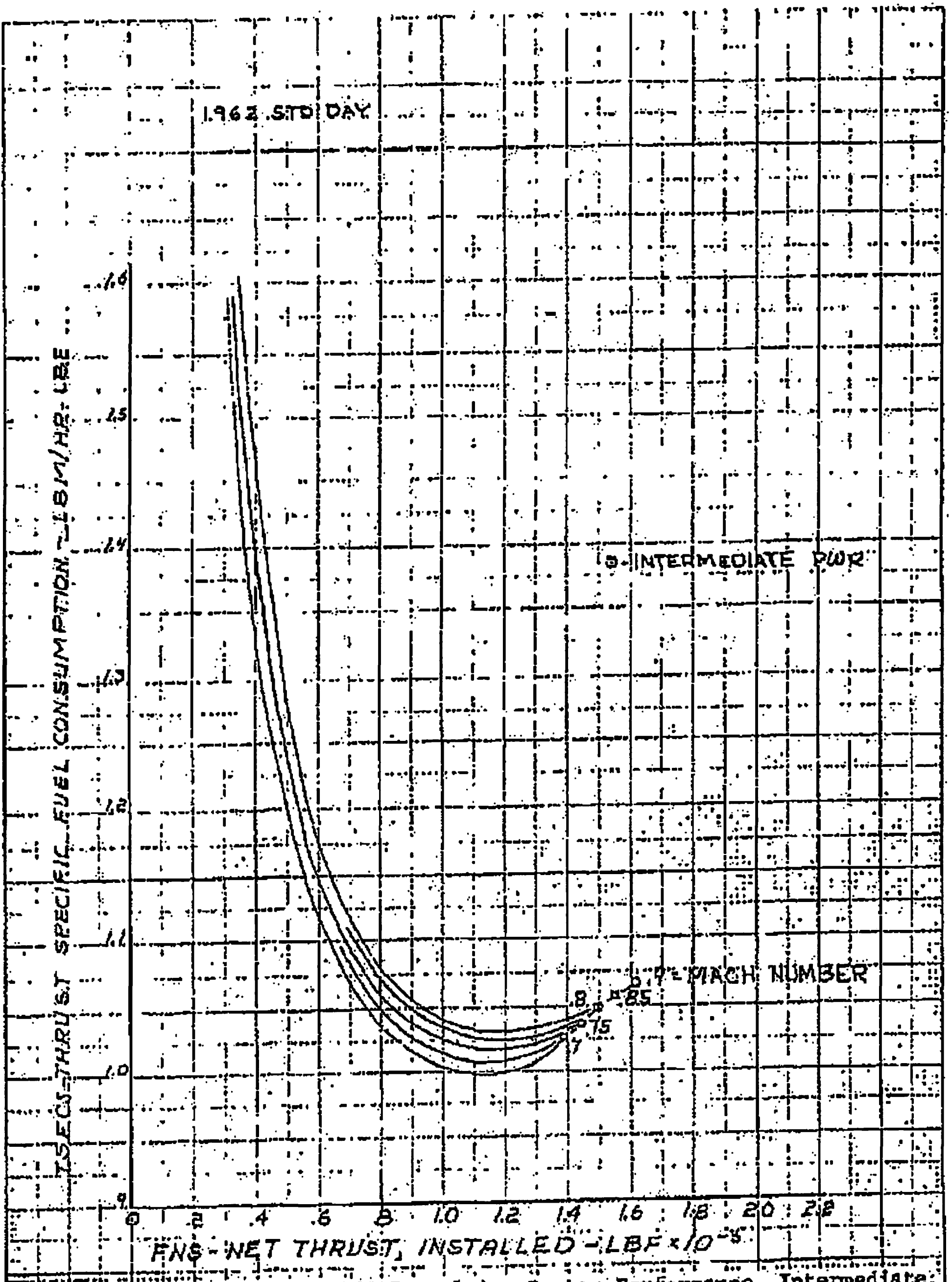


(U) Figure 4.6-4 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 40,000 Feet

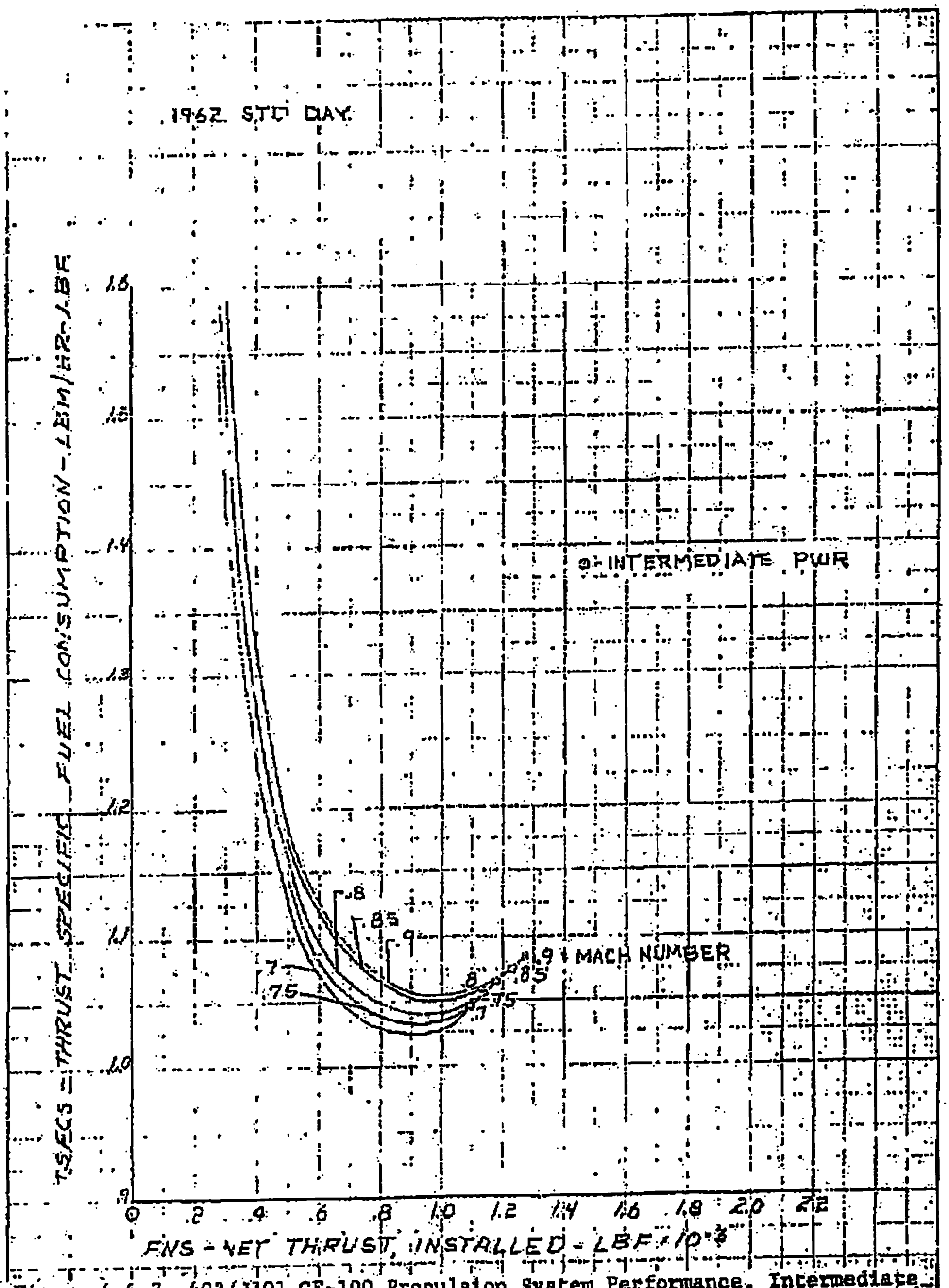


(U) Figure 4.6-5 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 45,000 Feet

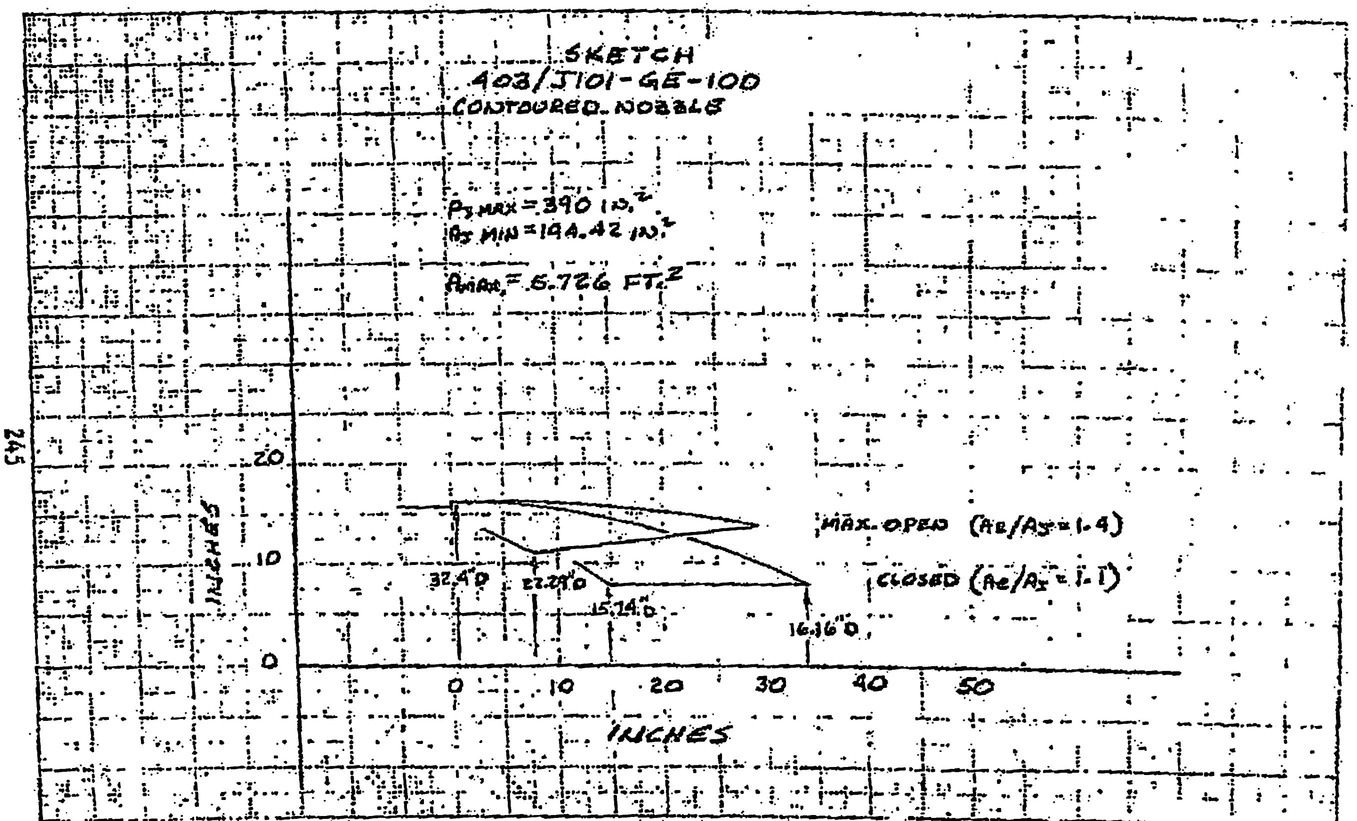
RSEC AV-71-004



(U) Figure 4.6-6 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 50,000 Feet



(U) Figure 4.6-7 403/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 55,000 Feet



(U) Figure 4.6-8 Sketch of the J101-GE-100 Contoured Nozzle Configuration

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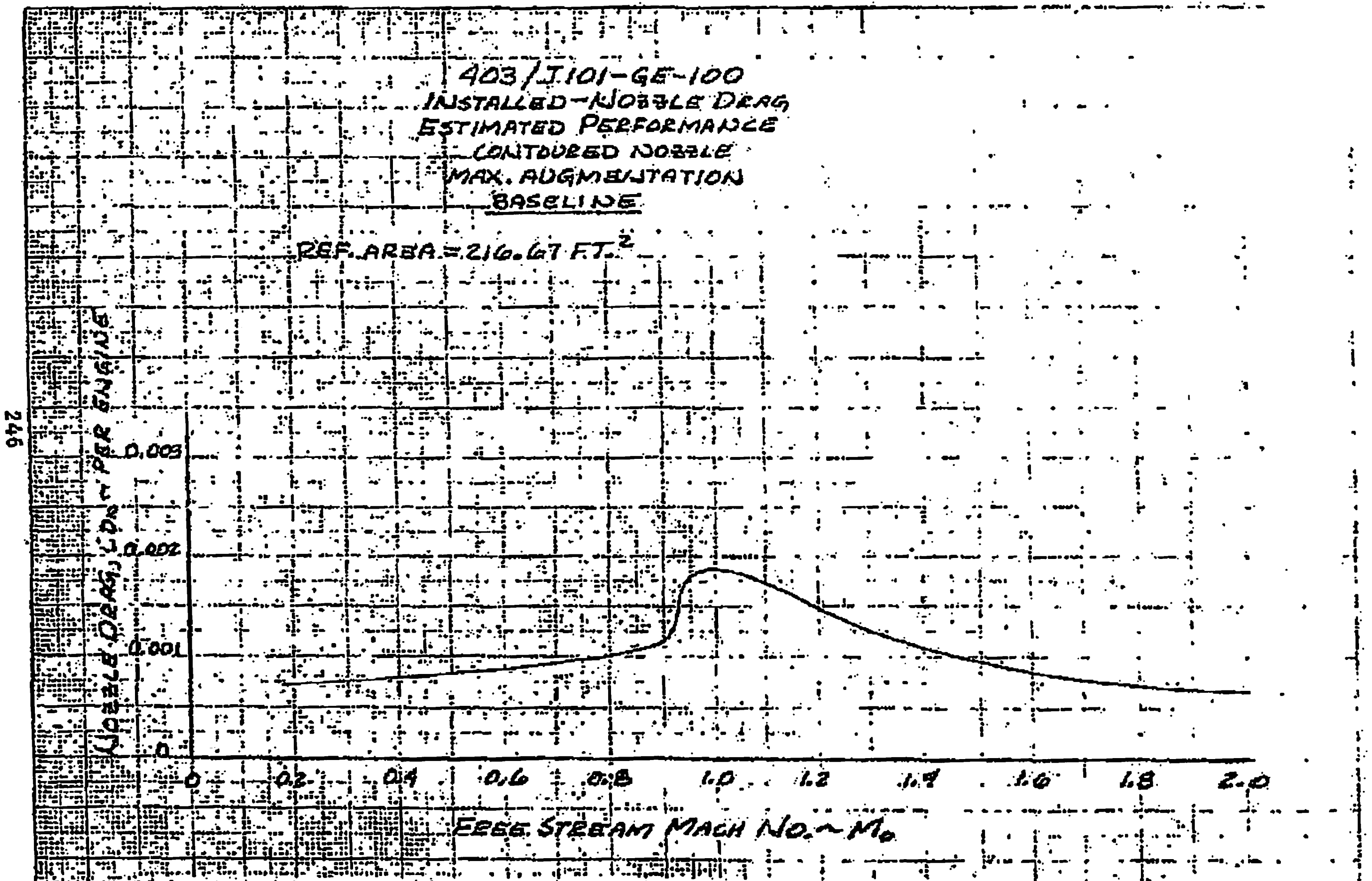
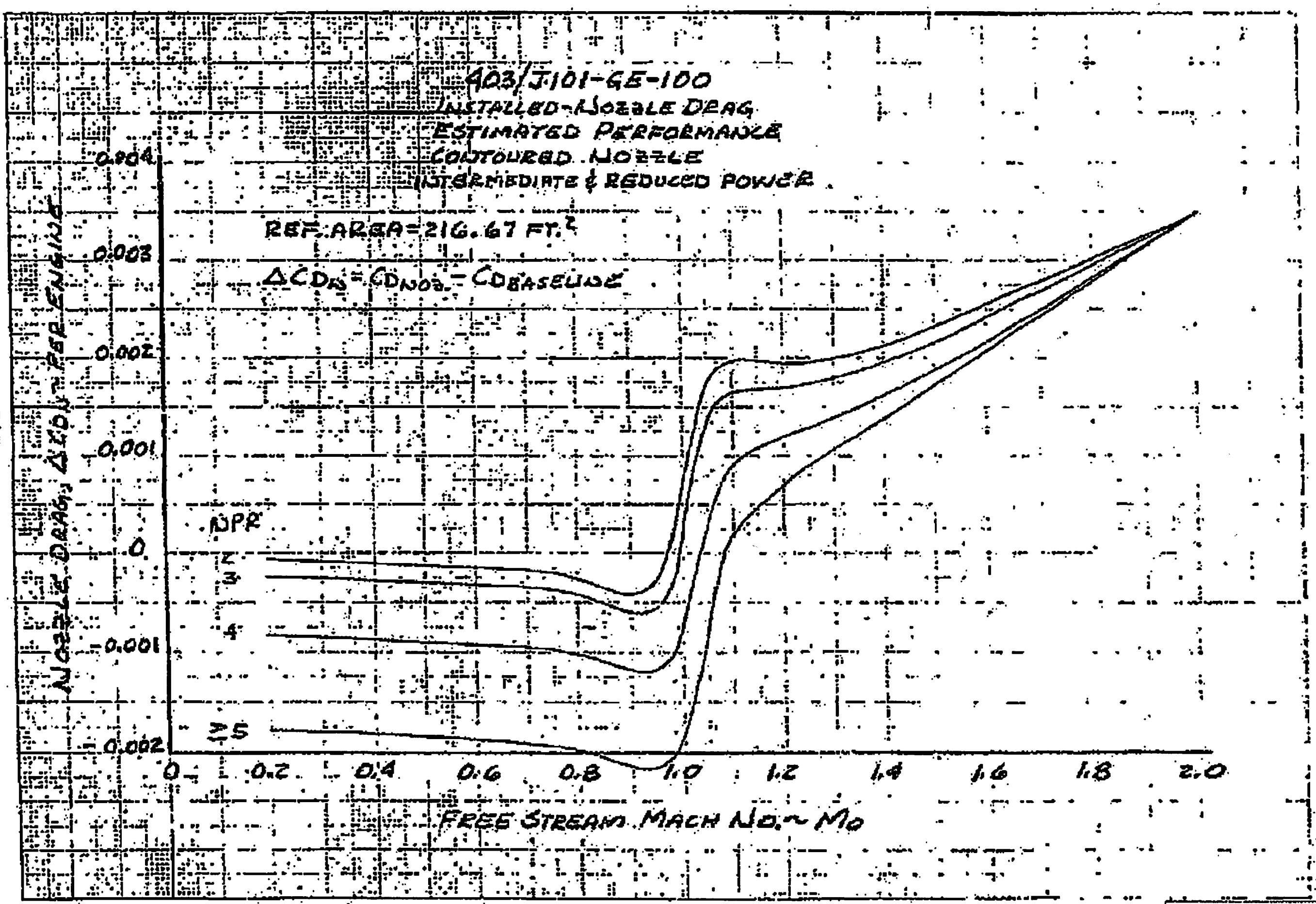


(U) Figure 4.6-9 403/J101-GE-100 Installed Nozzle Drag, Maximum Afterburning



(U) Figure 4.6-10 403/J101-GE-100 Installed Nozzle Drag, Intermediate and Reduced Powers

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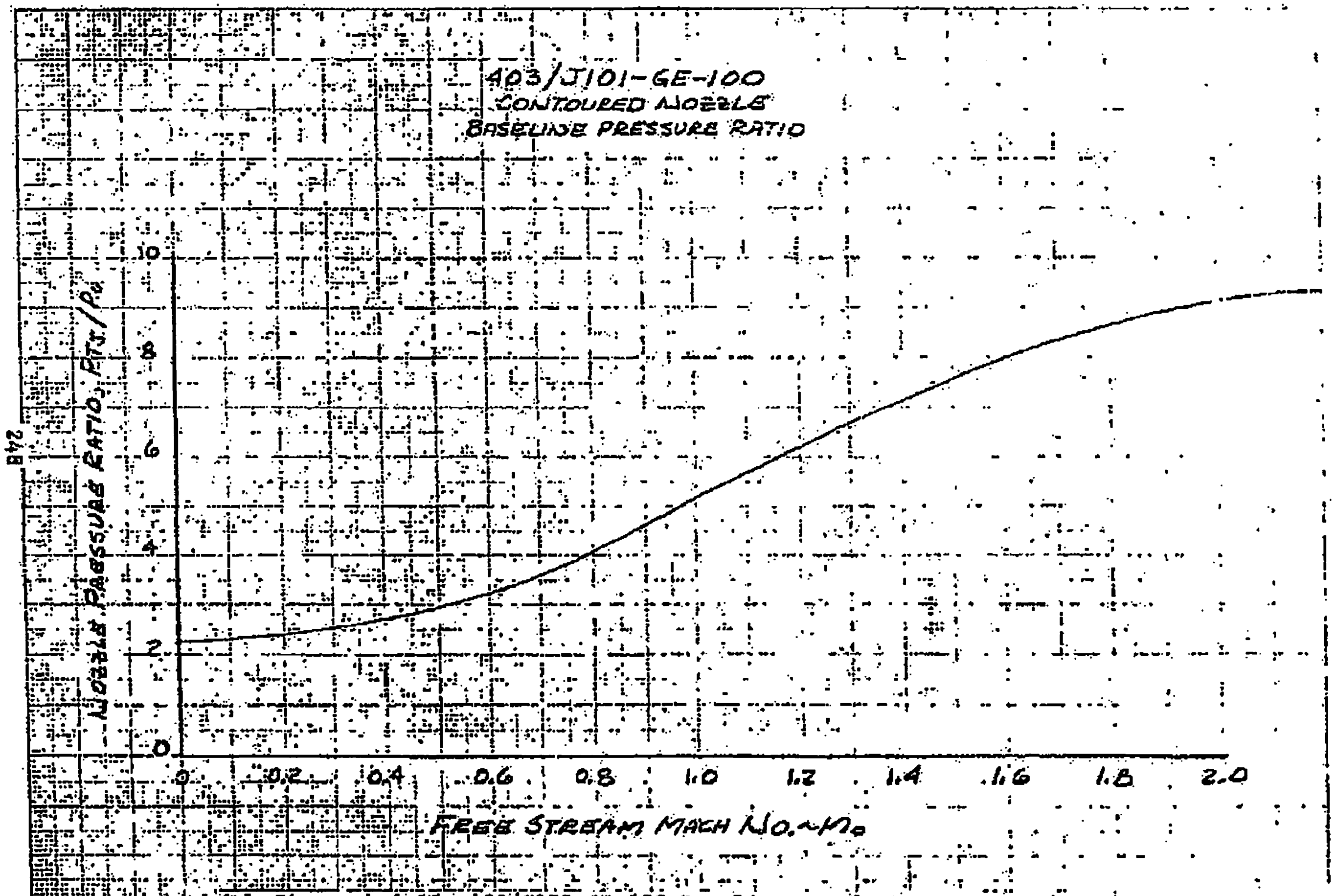
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



(U) Figure 4.6-11 403/J101-GE-100 Baseline Nozzle Pressure Ratio

88th ABW/IP
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E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

SECTION 5

LARGE TWIN - ENGINE CONCEPT

(501A/J101-GE-100)

5.1 VEHICLE DESIGN

(U) In this subsection a description is presented of the large twin-engine concept, a brief explanation is given of the configuration rationale, and the configuration growth data that were generated for sizing the point-design vehicle are summarized.

5.1.1 Vehicle Description

~~(S)~~ The large twin-engine fighter concept (Concept 3) designated Configuration 501A, is presented in Figure 5.1-1, which shows the general arrangement of the point-design airplane (22,680-lb mission weight). An inboard profile and basic lines arrangement of a 501A-type airplane are shown in Figures 5.1-2 and 5.1-3 at a mission weight of 19,000 pounds. The airplane depicted in these two figures was designed for a gross weight of 19,000 pounds and was used as a basis for development of the growth data generated to determine the sized airplane of Figure 5.1-1.

~~(S)~~ Configuration 501A is a high-performance fighter with a gross weight of 22,680 pounds, a wing loading of 60 psf and a thrust-to-weight ratio of 1.26 (uninstalled).

88th ABW/PI
FOIA (b)(4)
E.O. 13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

(U) Configuration 501A is basically very similar to Configurations 401B and 403. Overall characteristics such as wing and control surface planform and arrangement geometry, crew station, fuel tankage, and equipment arrangement are essentially the same. The major differences occur in the engine/inlet system, the landing gear, and the gun installation. These differences are described briefly in the following subsections.

5.1.1.1 Engine/Inlet

(U) In Configuration 501A, the two J101-GE-100 engines are clustered closely together in the aft fuselage section of the airplane. Primary air is supplied to each engine by a separate duct which incorporates a semi-D-shaped, fixed, normal-shock inlet. The inlets are located just forward of the nose gear on either side of the fuselage centerline and spaced approximately one engine diameter apart. The fuselage is contoured forward of the inlets in a manner designed to provide an integrated forebody/inlet geometry that will allow good air inlet characteristics throughout the maneuver envelope.

5.1.1.2 Landing Gear

(U) A conventional tricycle landing gear arrangement is employed on Configuration 501A. The main gear is located in the fuselage in the region just ahead of the engine compartment and retracts forward into a bay on either side beneath the engine inlet ducts. The nose gear is a semi-articulated design with a free-castering, single-wheel arrangement. It is located just aft and between the engine inlets and retracts forward into a bay in the lower center fuselage.

5.1.1.3 Gun Installation

~~(S)~~ The gun installation of configuration 501A is similar to that of Configuration 401B except that the ammunition cannisters are located in a more favorable area for easy access as a result of the twin inlet arrangement. A 20mm gun is located on either side of the airplane in the glove region provided by the forward extension of the thickened wing root as in the 401B concept. The gun compartment is thus situated above the inlet duct on either side and is accessible through hinged panels in the upper fuselage skin. A separate ammunition cannister is provided for each gun in a center-fuselage bay between the gun compartments and just forward of the fuselage fuel tank. The ammunition cannisters are easily removable through access panels in the lower fuselage.

5.1.2 Design Rationale

(U) Most of the overall design rationale that applies to the single-engine concept (401B) also applies to the 501A concept. In order to provide the fairest comparison between the twin-engine and single-engine concepts, the primary features of the 401B concept were adopted insofar as possible. Of the six major distinguishing features of the 401B concept,

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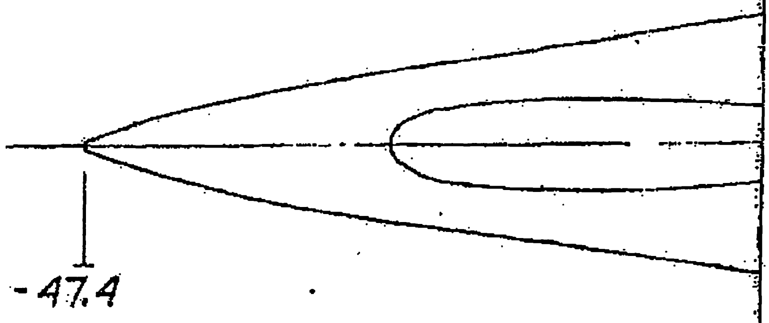

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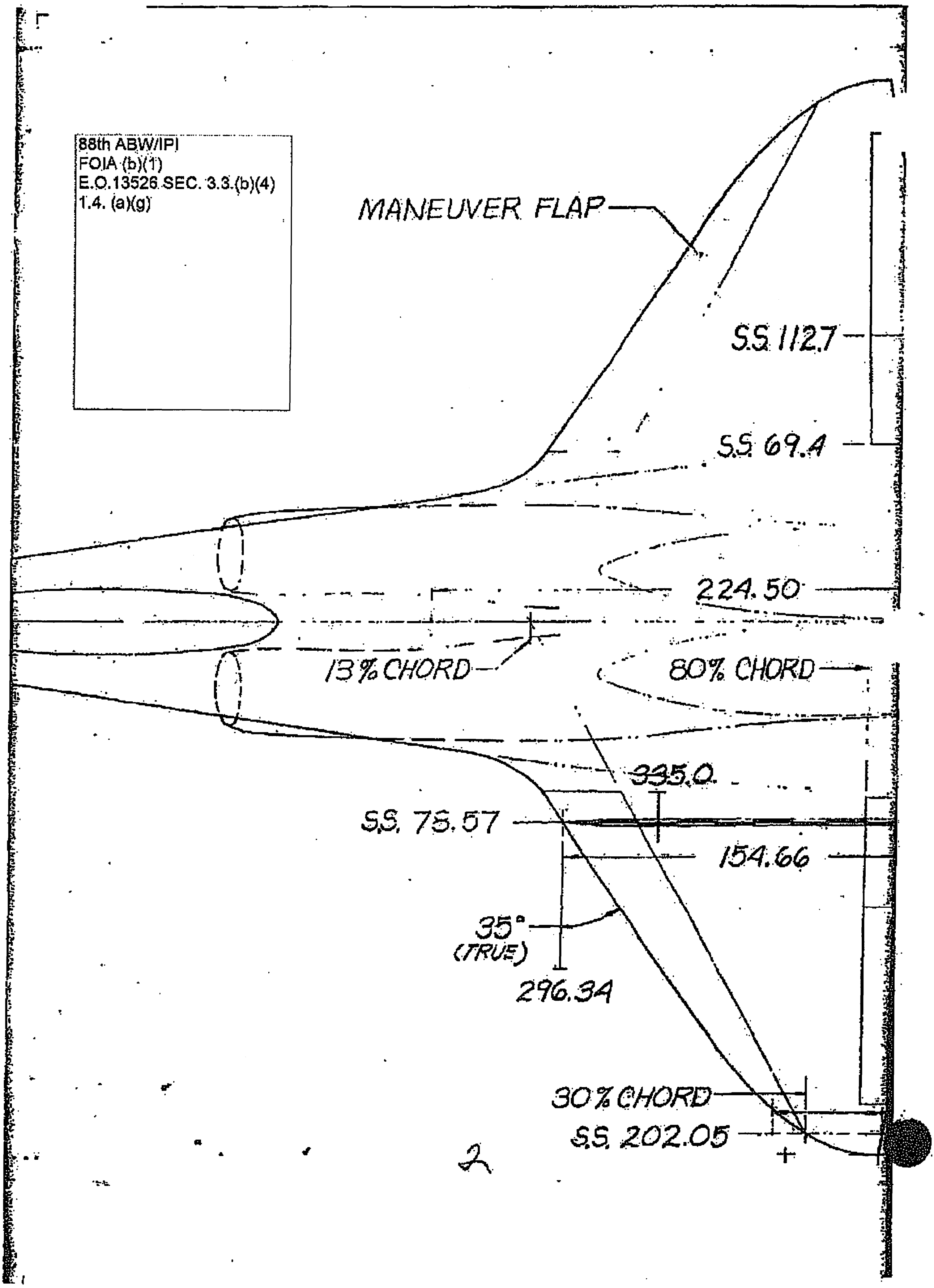

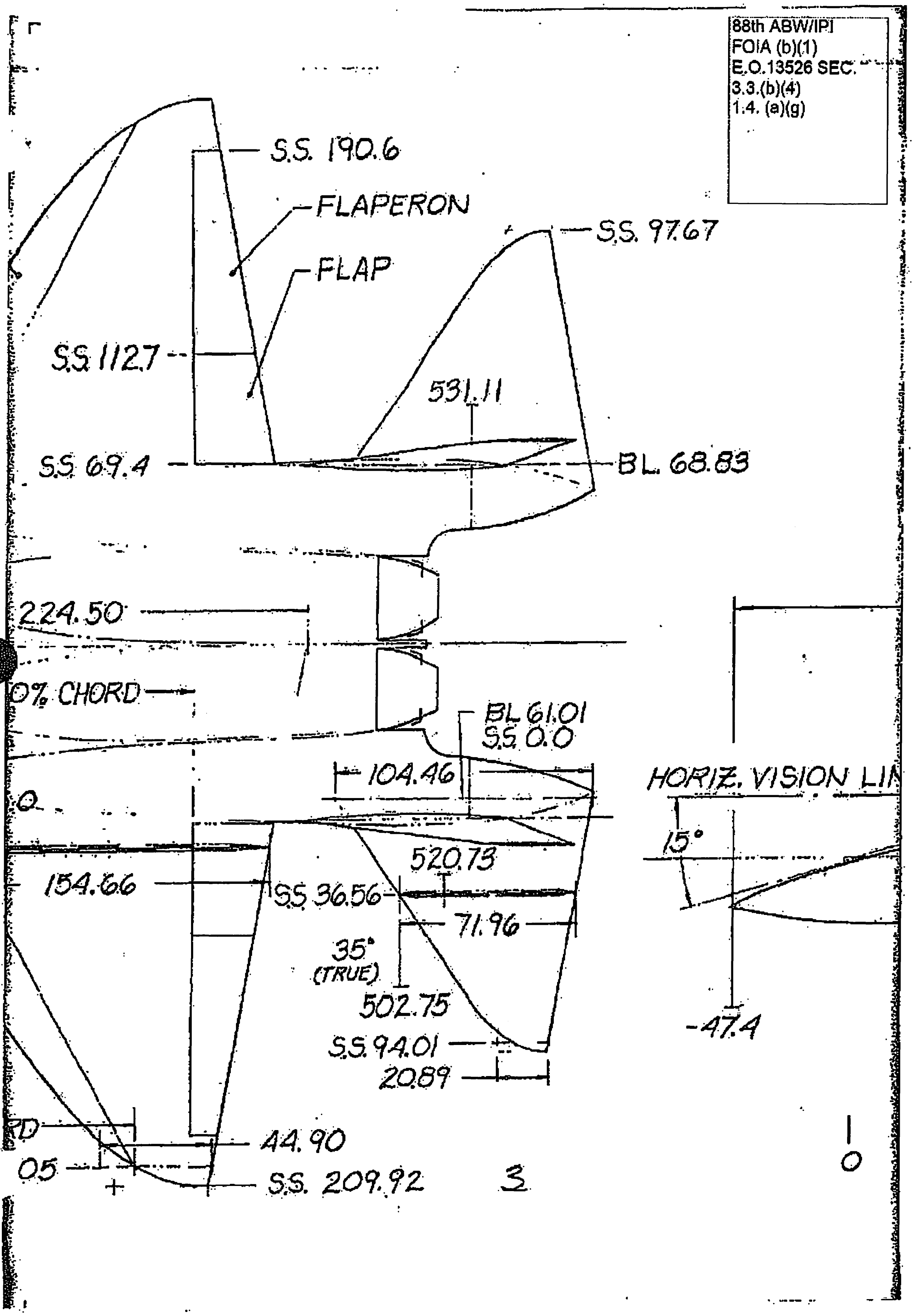
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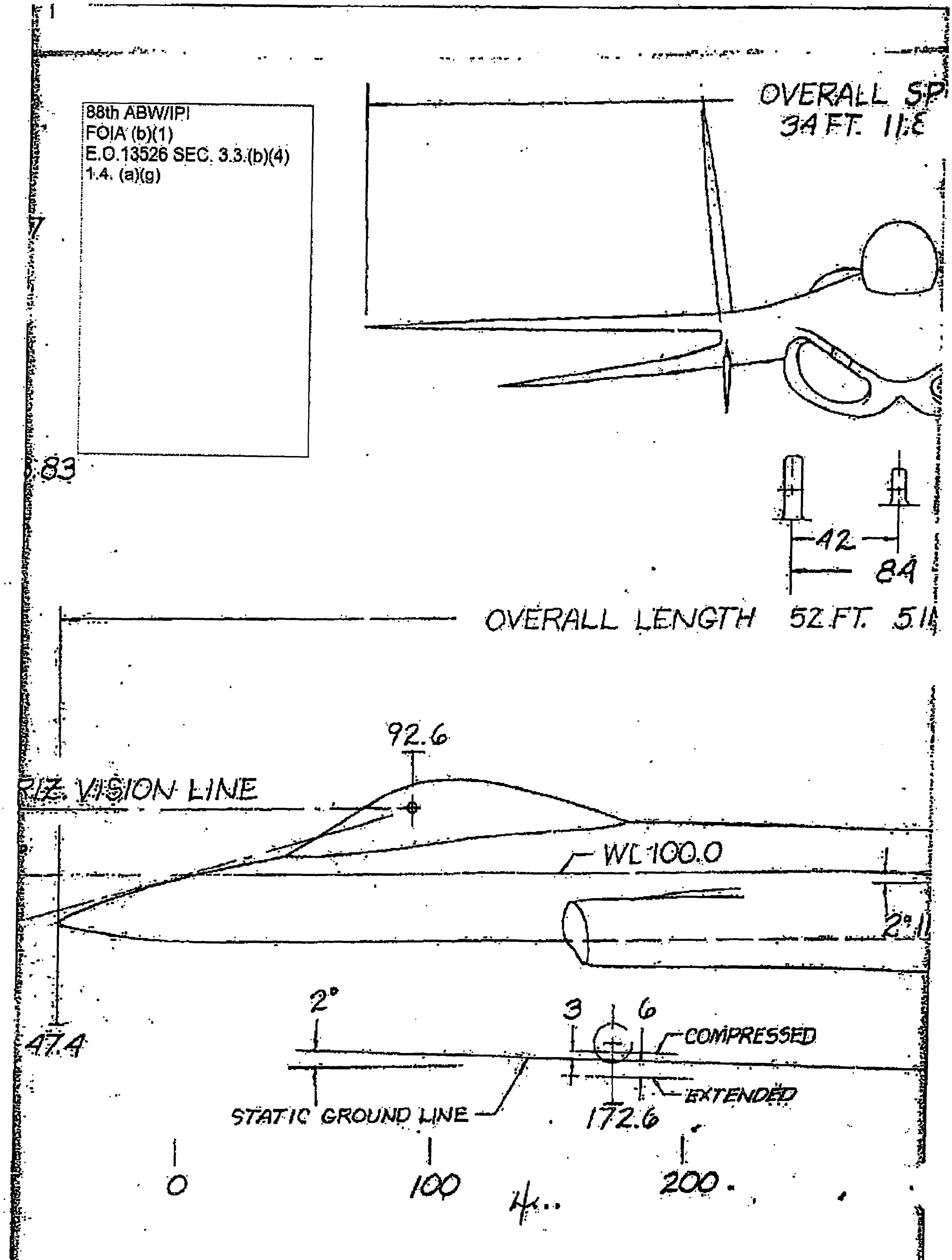
FLAPERON
FLAP
S.S. 97.67
S.S. 112.7
531.11
S.S. 69.4
BL. 68.83
224.50
0% CHORD
BL 61.01
S.S. 0.0
104.46
HORIZ. VISION LI
0
15°
520.73
154.66
S.S. 36.56
71.96
35°
(TRUE)
502.75
-47.4
S.S. 94.01
20.89
RD
44.90
05
S.S. 209.92
3
1
0



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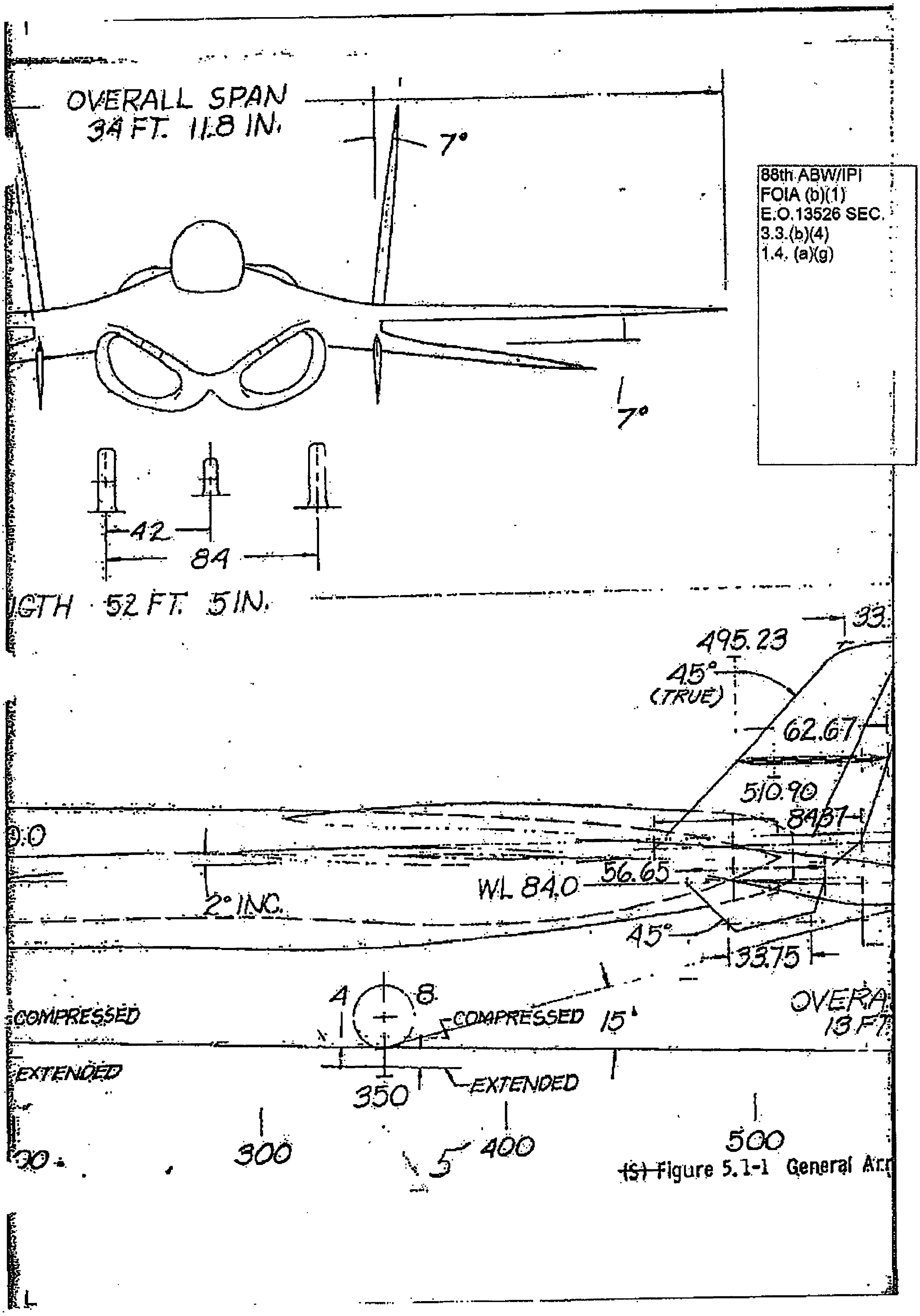

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~~(S)~~ Figure 5.1-1 General Arr

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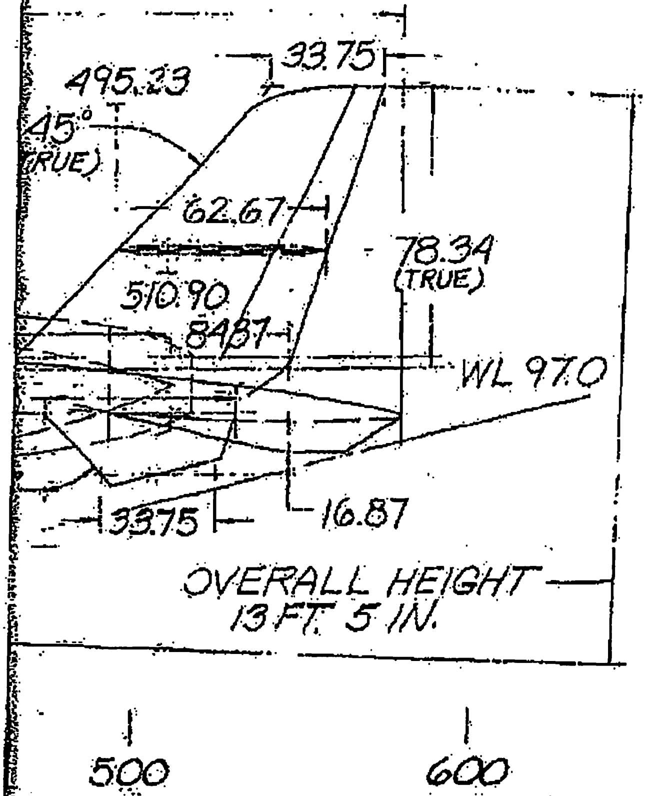
Aircraft Mission Weight -- 22,680 lb

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

WING (REFERENCE)	
AREA	338.00 SQ. FT
ASPECT RATIO	3.5
TAPER RATIO	0.2
SPAN	33.67 FT
SWEEP-LEADING EDGE	35°
ROOT CHORD	276.30 IN
TIP CHORD	46.90 IN
M.A.C.	184.00 IN
AIRFOIL SECTION	4% BICONVEX
INCIDENCE	1°
DIHEDRAL	0°
MANEUVER FLAP	
TYPE	PLAIN
TOTAL AREA	39.8 SQ. FT
SPAN-PER SIDE	135.6 IN
ROOT CHORD	31.8 IN
TIP CHORD	13.5 IN
DEFLECTION	25°
HINGE LINE	
ROOT	70%
TIP	30%
FLAPS	
TYPE	PLAIN
TOTAL AREA-INCLUDING FLAPERON	36.0 SQ. FT
ROOT CHORD	37.5 IN
TIP CHORD	24.0 IN
FLAPERON	
TOTAL AREA	17.3 SQ. FT
SPAN-PER SIDE	77.9 IN
ROOT CHORD	26.9 IN
TIP CHORD	11.0 IN
DEFLECTION	-20°, +30°
FLAP DEFLECTION-MAX	30°
FLAP HINGE	80%
VERTICAL TAIL	
AREA-TOTAL	66.78 SQ. FT
ASPECT RATIO	1.3263
TAPER RATIO	0.4
SPAN	78.34 IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	84.37 IN
TIP CHORD	33.75 IN
AIRFOIL SECTION	6% ROOT, 4% TIP BICONVEX
RUDDER	
AREA-TOTAL	10.07 SQ. FT
SPAN	58.36 IN
ROOT CHORD	31.01 IN
TIP CHORD	8.44 IN
DEFLECTION	±30°
VENTRAL FIN	
AREA-TOTAL	10.39 SQ. FT
ASPECT RATIO	0.1733
TAPER RATIO	0.5937
SPAN	16.87 IN
SWEEP-LEADING EDGE	65°
ROOT CHORD	56.65 IN
TIP CHORD	33.75 IN
AIRFOIL SECTION	6% BICONVEX
HORIZONTAL TAIL (ALL MOVABLE)	
AREA	81.61 SQ. FT
ASPECT RATIO	3.0
TAPER RATIO	0.2
SPAN EXPOSED	180.08 IN
SWEEP-LEADING EDGE	35°
ROOT CHORD	106.36 IN
TIP CHORD	20.89 IN
M.A.C.	71.96 IN
INCIDENCE	0°
AIRFOIL SECTION	- 6% AT BL 48.43, 4% TIP - BICONVEX
DIHEDRAL	-7°
DEFLECTION	- L.E. UP 15°, DN 30°
POWERPLANT	
P&W JTF 22A-77 TURBO FAN ENGINE	2 REQ'D
LANDING GEAR	
MAIN GEAR TIRE	24 x 6.5
NOSE GEAR TIRE	15 x 4.5
TAIL LENGTHS	
C/4 WING TO C/4 VERTICAL TAIL	16 FT, 3.4 IN
C/4 WING TO C/4 HORIZONTAL TAIL	15 FT, 5.7 IN



PRELIMINARY DESIGN DRAWING

GENERAL ARRANGEMENT
LARGE TWIN ENGINE CONCEPT
POINT DESIGN, AVFFX PROGRAM

BY BJ CSASZAR | APPROVED | SCALE 1/40 | DATE 28 AUG 72

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

FW7104139

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gure 5.1-1 General Arrangement - Large Twin-Engine Concept Point Design Configuration (U)

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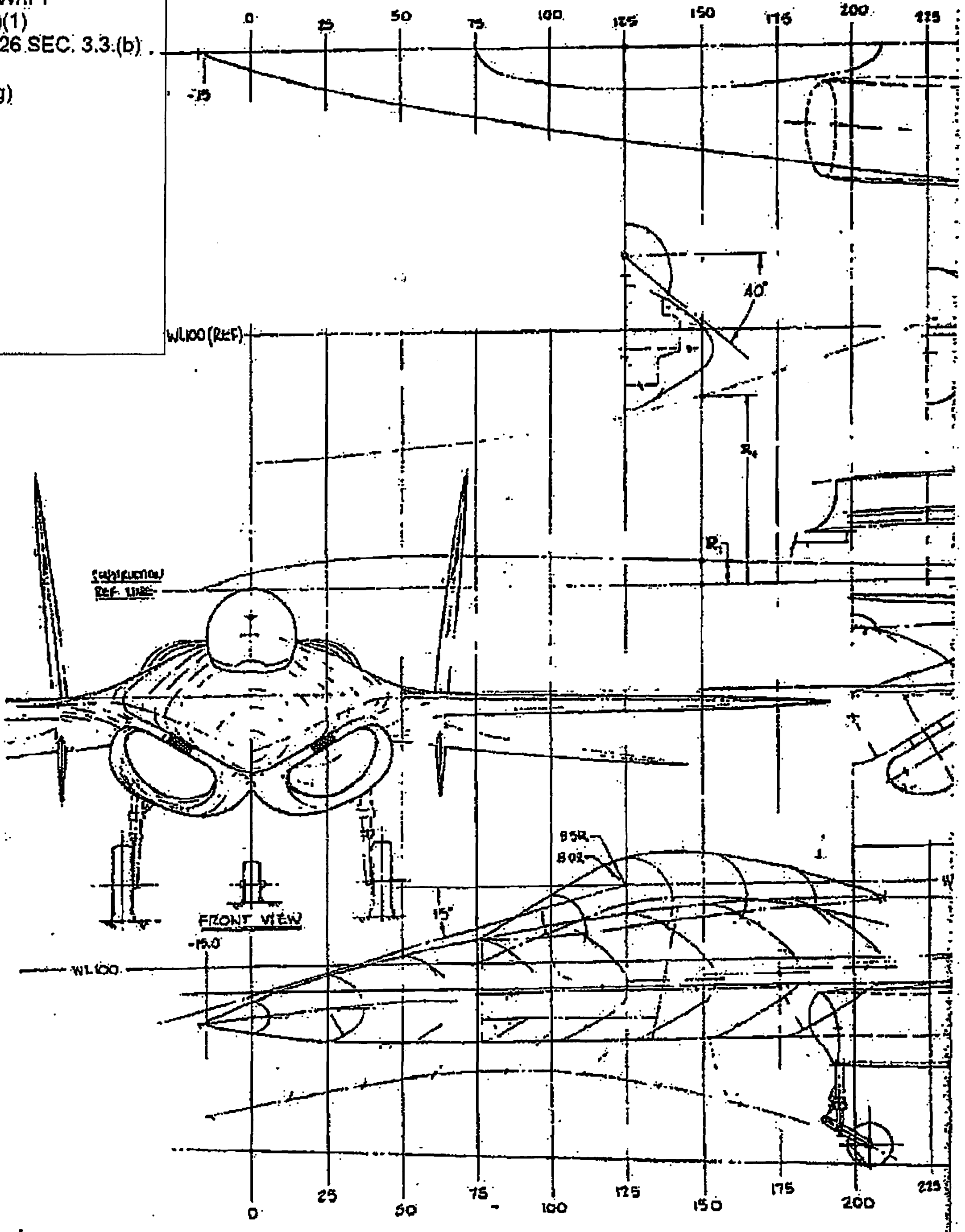
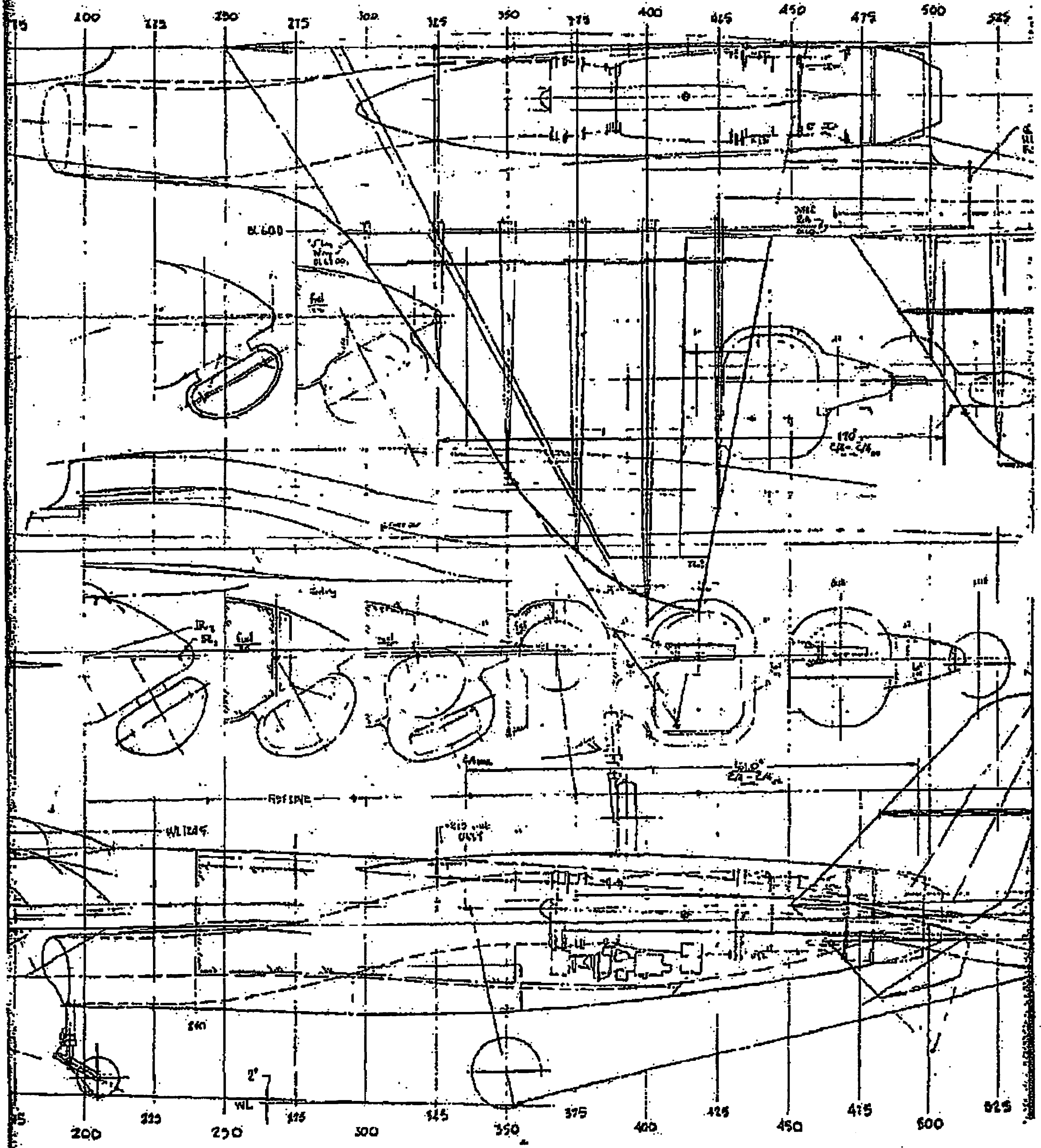
1.4. (a)(g)





2 ~~(S)~~ Figure 5.1-2 Lines - Large Twin-Engine Co

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SEC 3.3 (b)(4)
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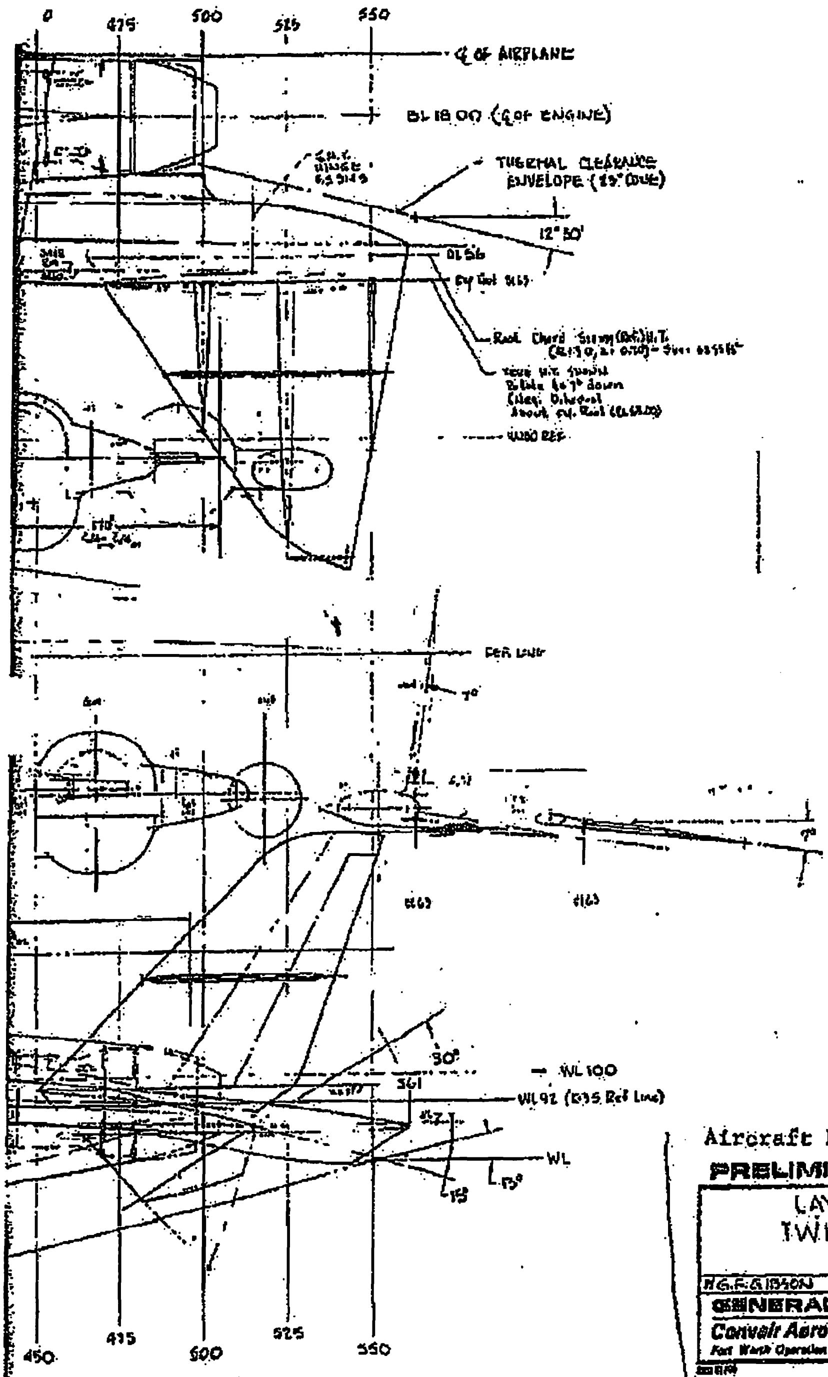

Large Twin-Engine Concept Configuration 501A (U)

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Aircraft Mission Weight -- 19,000 lb

PRELIMINARY DESIGN DRAWING

LAYOUT - CONFIG. 501A TWIN-ENGINE CONCEPT AVFFX PROGRAM	
H.G.F. GIBSON	APPROVED
SCALE 1/20	DATE 7-26-71
GENERAL DYNAMICS *Convair Aerospace Division* Fort Worth Operation	FW7104104
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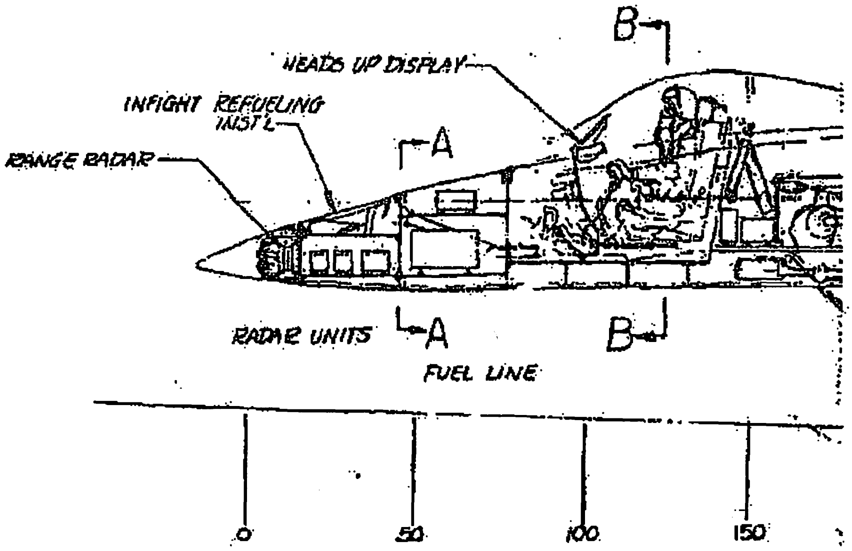
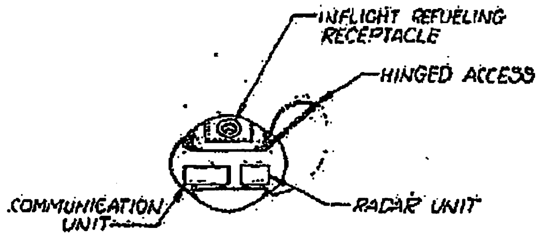
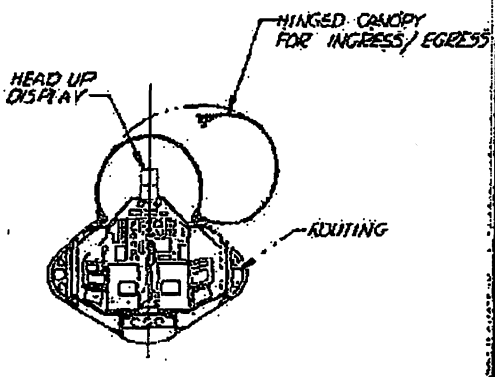




SECTION A-A



SECTION B-B

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88th ABW/IPI
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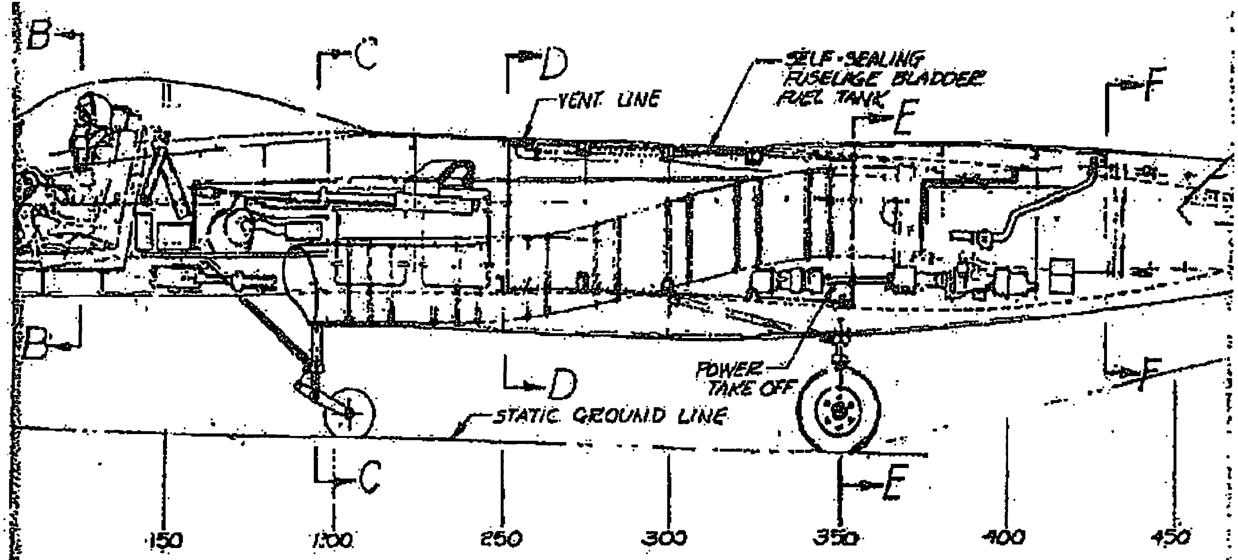
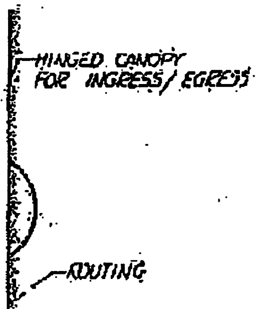
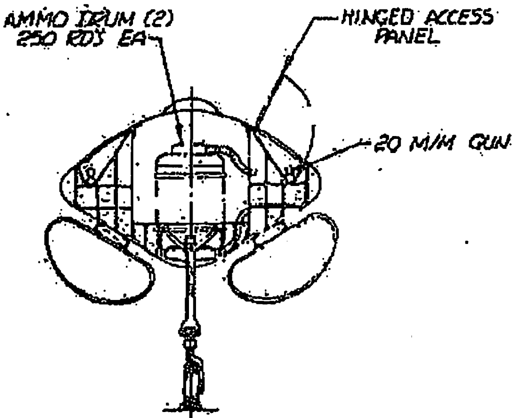
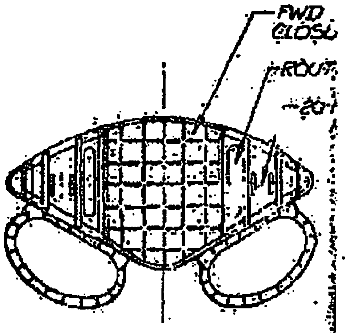






SECTION C-C



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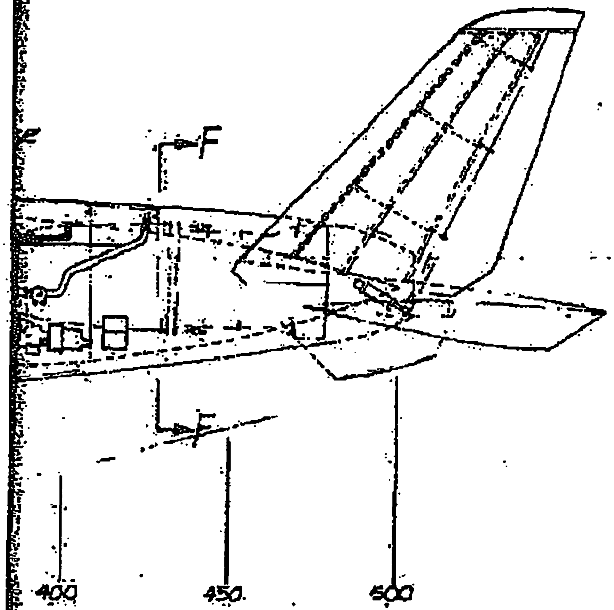
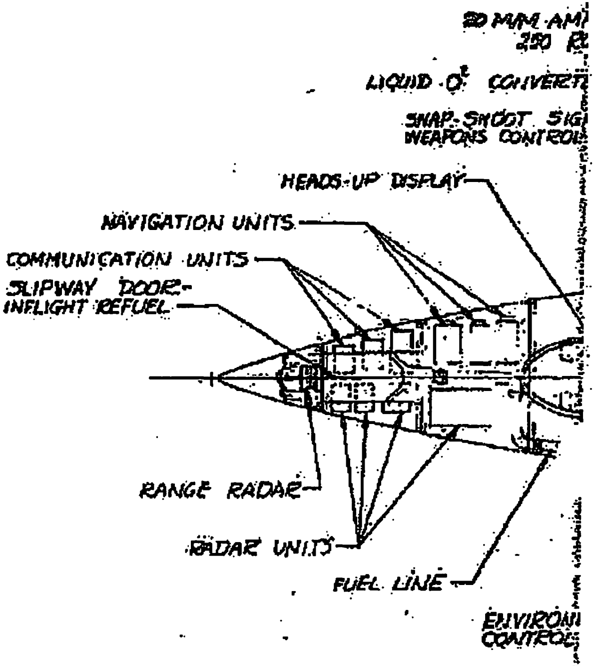
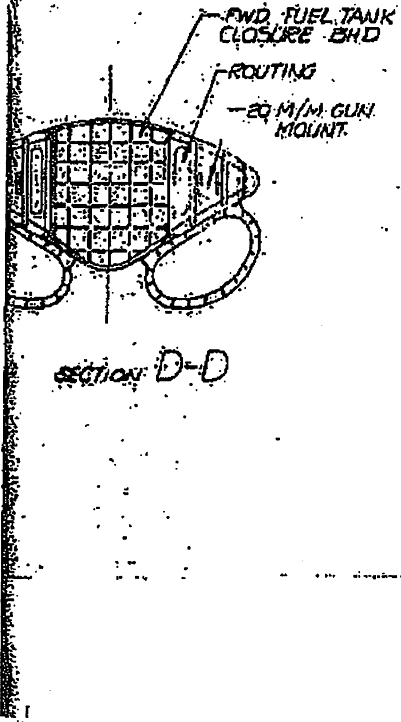
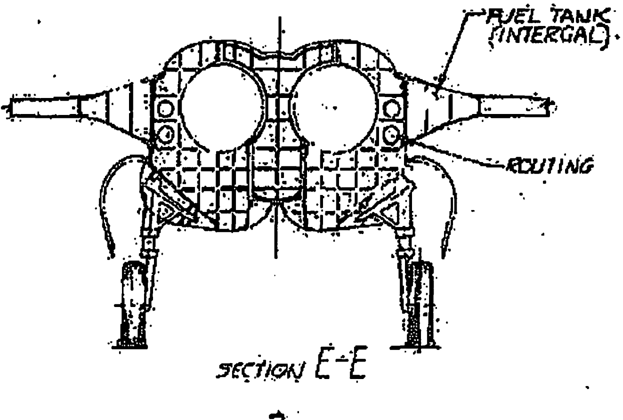
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)





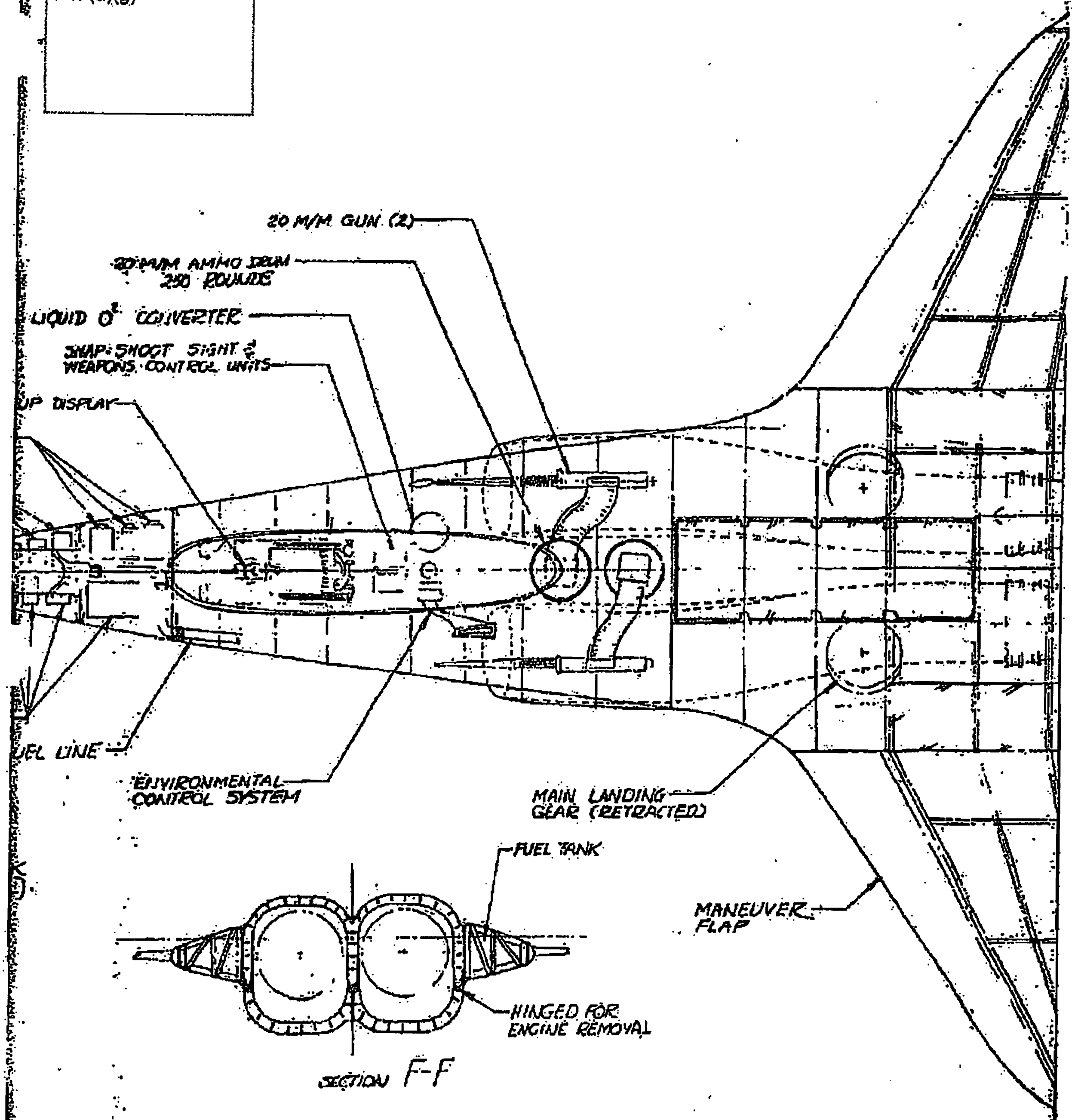


SECTION D-D



SECTION E-E

88th ABW/IPI
FOIA (b)(1)
~~E.O.13526~~ SEC. 3.3.
(b)(4)
1.4. (a)(g)



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~~(S)~~ Figure 5.1-3 Inboard Profile - Large Twin-Engine Concept,

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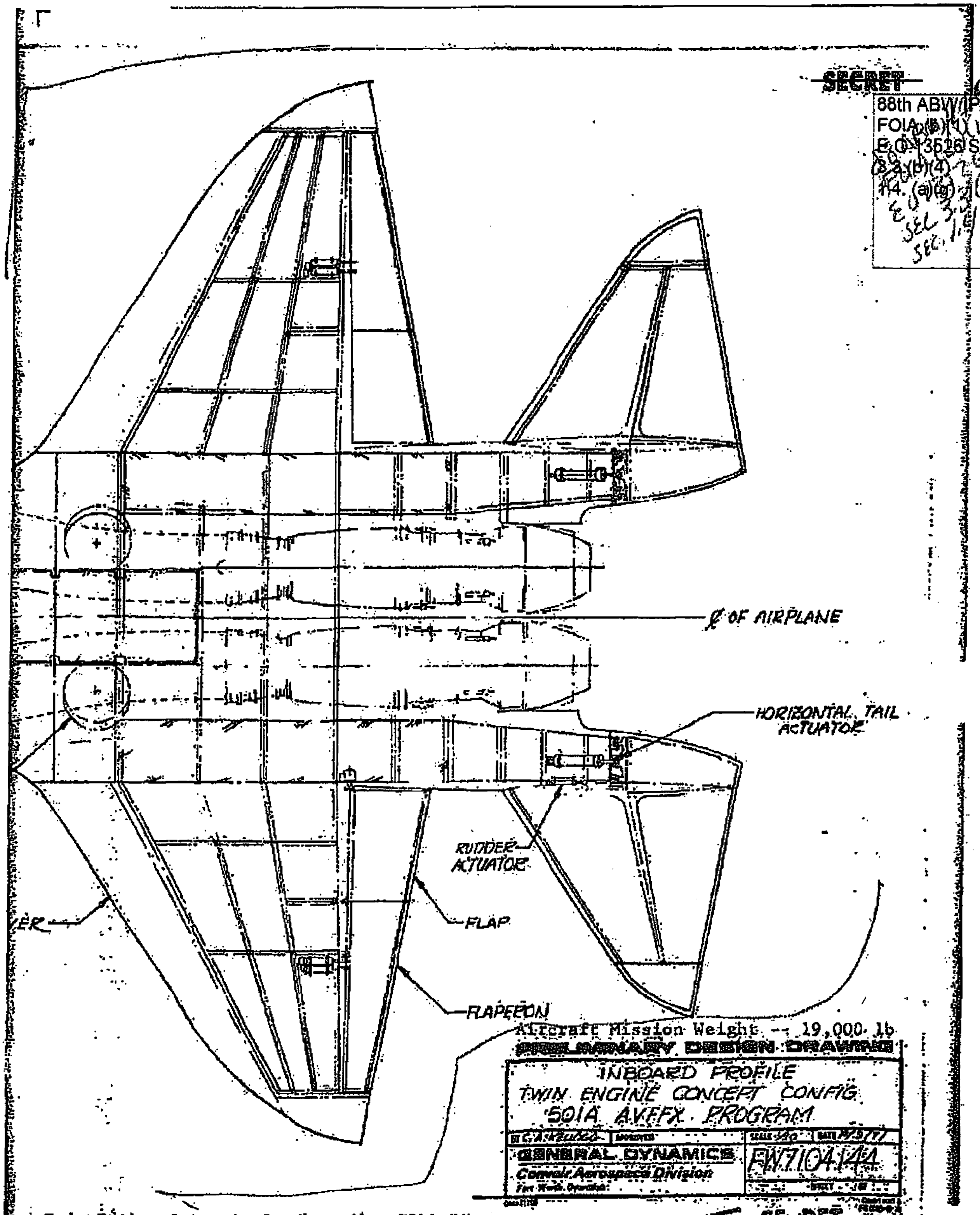
88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC
3.3(b)(4)
1.4. (a)(g)



ge Twin-Engine Concept, Configuration 501A (U)

5 ~~SECRET~~

all but one were retained. The lone exception involved the inlet location, and even this feature did not depart radically from that of the former design concept.

(U) To reiterate, the distinguishing features of Configuration 501A are essentially the same as those of 401B (described in Section 3). They are as follows:

1. Forward engine location
2. Mid-wing
3. Outer faired body
4. Twin vertical tails
5. Under-fuselage inlet location
6. Bubble canopy.

(U) A brief discussion of these features, as they relate to the 501A concept and differ with the 401B concept, is presented in the following paragraphs.

(U) The forward engine relationship required in the 401B concept to provide appropriate balance characteristics consistent with reasonable tail moment arms is also a basic characteristic necessary in the 501A arrangement. In fact, this effect is even more pronounced in the twin-engine design because the combined weight of the two small engines is more than that of the single large engine and the distance from the nozzle to the engine c.g. of the small engine is shorter. These two factors combine to increase the tail overhang tendency on the 501A arrangement. In the development of the 501A concept, adjustments were made in forward fuselage length, tail overhang, and engine location to provide a reasonable compromise in airplane geometry and still retain the balance characteristics required.

(U) The mid-wing and wing-body blending features are essentially the same in both the single-engine and twin-engine concepts. The fore and aft extension of the wing-body shaping arrangement serve the same basic functions on 501A as on 401B. The major differences of 501A lie in the fact that the center body section must ring two engines instead of one and that the 501A arrangement also lends itself better to a fuselage-mounted main gear design. In the latter case the volume provided by fairing the inlet duct into the aft fuselage is adequate for stowing the retracted gear and also allows a reasonably short gear length (i.e., reduced weight).

(U) The twin vertical tail feature of 401B was retained on the 501A concept, and the same rationale applies here. A slight increase in the width of the aft root extension was required to allow a reasonable structural cross section for this element alongside the proportionally wider twin-engine installation. This results in a slightly higher proportional relationship between the horizontal tail and wing span on 501A than that of the single-engine concept.

~~(S)~~ The major deviation in the two concepts lies in the inlet/engine arrangement. The inlet/forebody concept of 501A is based largely on experience derived from past test work conducted by General Dynamics on various inlet/airframe integration concepts for highly maneuverable aircraft. The inlet arrangement incorporated on the 501A concept is intended to provide for good flow characteristics at both high angle of attack and yaw conditions. Essentially, the same normal-shock, fixed-geometry inlet features of the 401B concept are also employed to give the best performance in the combat arena (Mach 0.6 to 1.6) with a simple, reliable, light-weight system.

(U) The transparent bubble canopy with the full-vision capability remains unchanged from that of Configuration 401B.

5.1.3 Configuration Growth Data

(U) In this subsection, the approach utilized to develop the configuration size variations in the growth study is outlined, and the basic parametric configuration design data that was generated to support the structure, aerodynamic, and performance analyses are summarized.

5.1.3.1 Aircraft Sizing Approach

~~(S)~~ Layouts were developed for the 501A concept at a gross weight of 19,000 pounds. This configuration formed the basis for the growth study. Airplane geometry was scaled from the basic 19,000-pound version by use of essentially the same scaling relationships developed for the 401B concept. In general, surface areas were scaled as a function of gross-weight ratio and characteristic lengths were scaled as a function of the square root of the gross-weight ratio. These scaling relationships were used to develop additional data points for gross weights of 16,800, 22,000, and 24,000 pounds in order to provide growth curves for aircraft sizing. For all cases, wing loading was held constant at 60 psf and the family of aircraft configurations was developed through use of the wing and tail sizing criteria discussed previously in Section 3.

5.1.3.2 Growth Data

(U) Presented in this subsection is a summary of the configuration design data that were generated in the growth study to support the structure, aerodynamic, and performance analyses. The variation of airplane wetted area with airplane size (mission weight) and a definition of the major airplane components contributing to the wetted-area total are shown in Figure 5.1-4. The major component breakdown of wetted area versus mission weight is shown in Figure 5.1-5. The manner in which selected key characteristic fuselage dimensions vary with airplane size in the growth airplane family are plotted in Figure 5.1-6. Similar variations of selected key characteristic surface dimensions for the growth family are plotted in Figure 5.1-7. In Figures 5.1-8 through 5.1-15, general airplane geometric data are summarized for the data points at the four gross weights used to establish the growth family. A normal area distribution curve and fuel distribution plot are presented for the basic 501A configuration (19,000-lb mission weight) in Figures 5.1-16 and 5.1-17, respectively.

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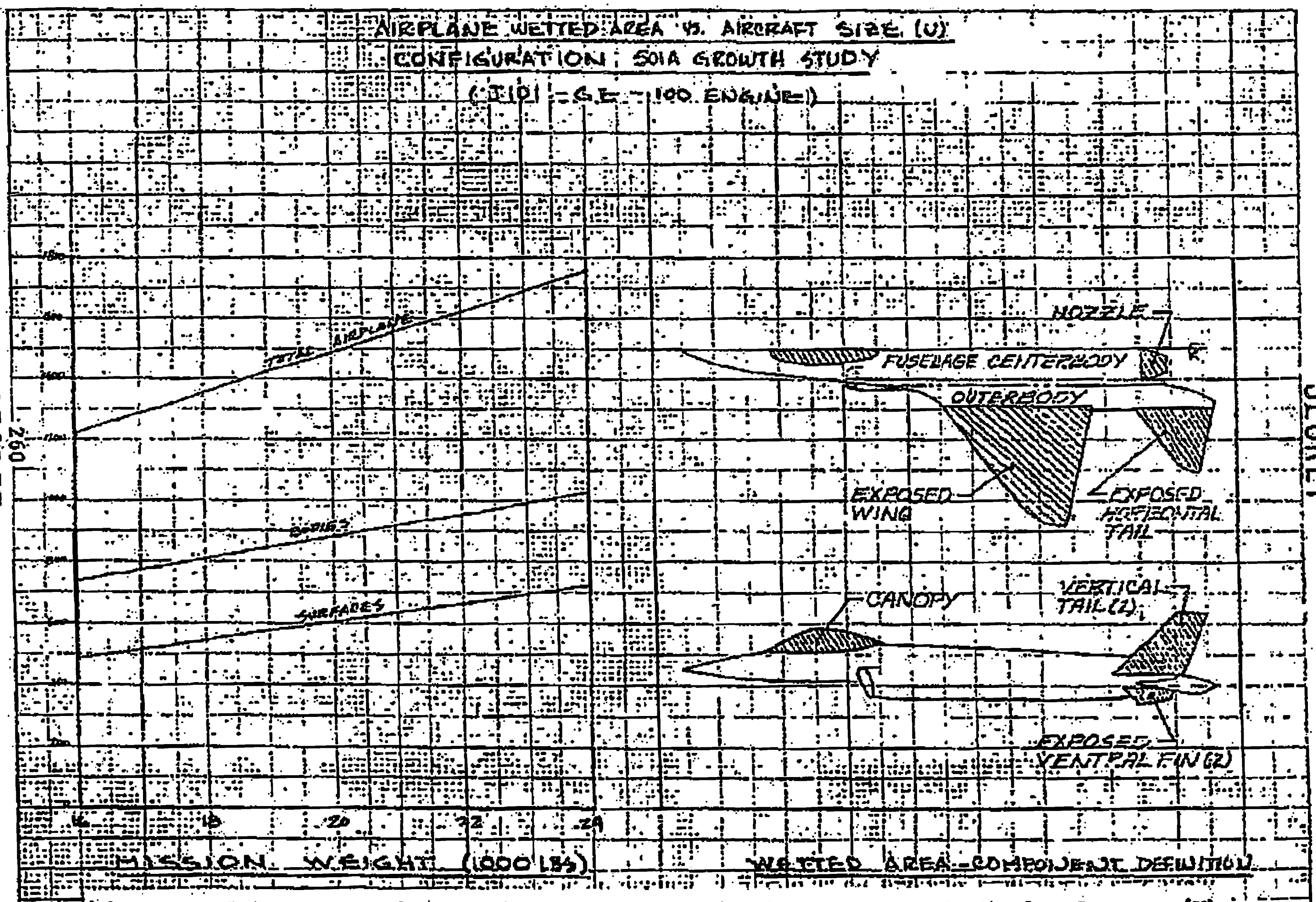

~~(S)~~ Figure 5.1-4 Aircraft Wetted Area vs. Aircraft Size - Large Twin-Engine Concept (U)

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88th ABW/IP
FOIA (b)(4)
E.O. 13526 SEC. 3.3

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7 of 15

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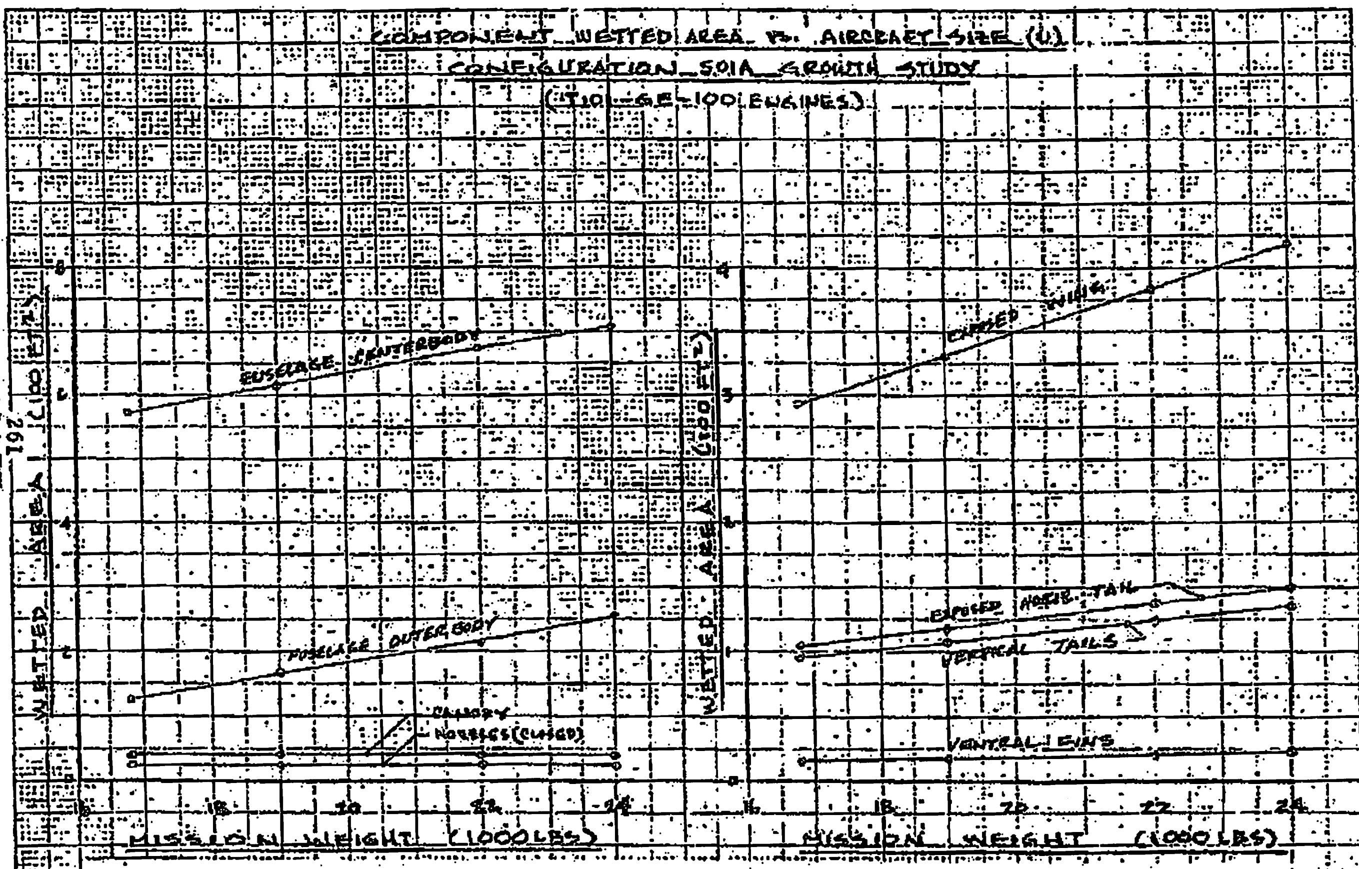
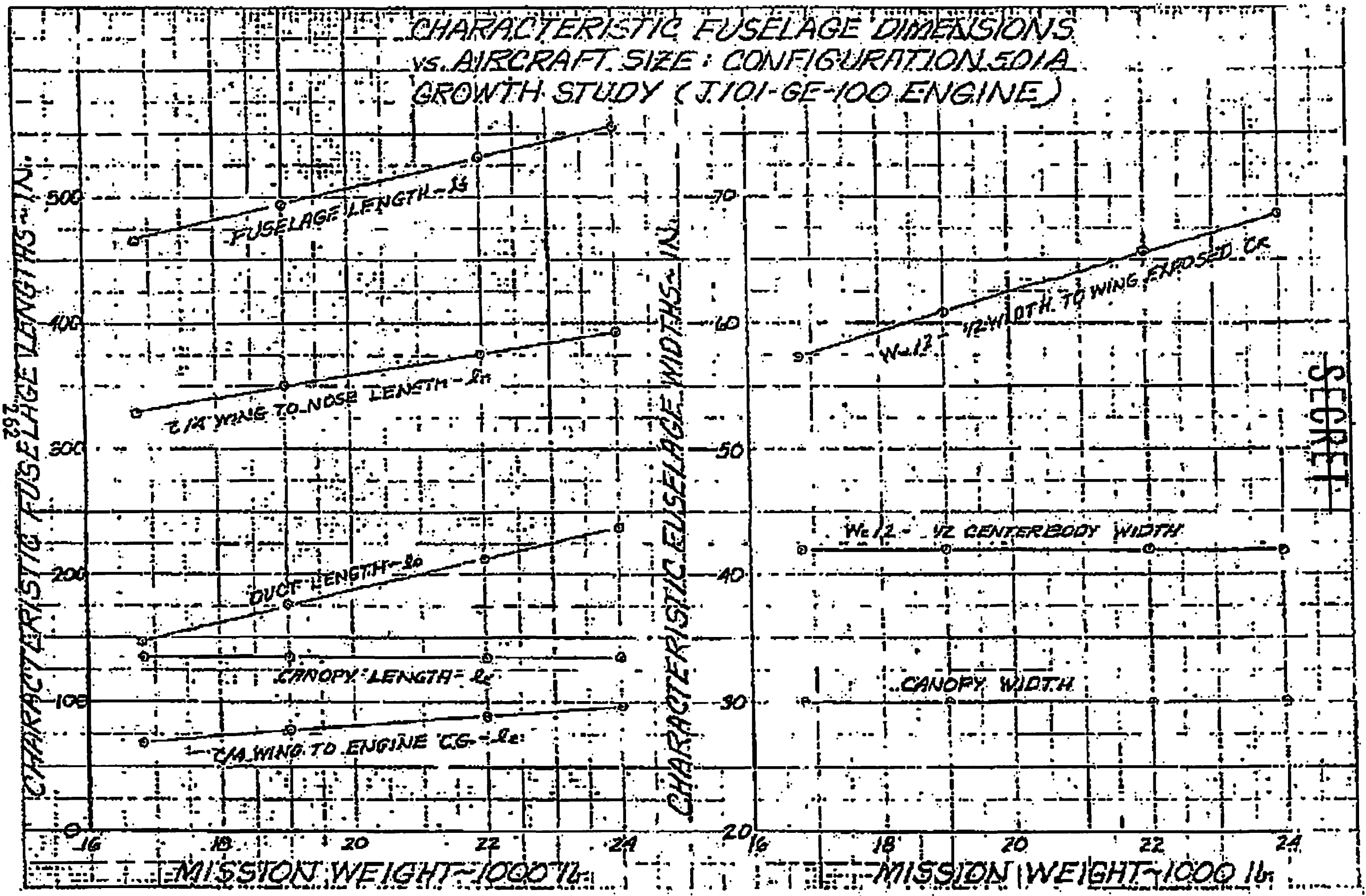


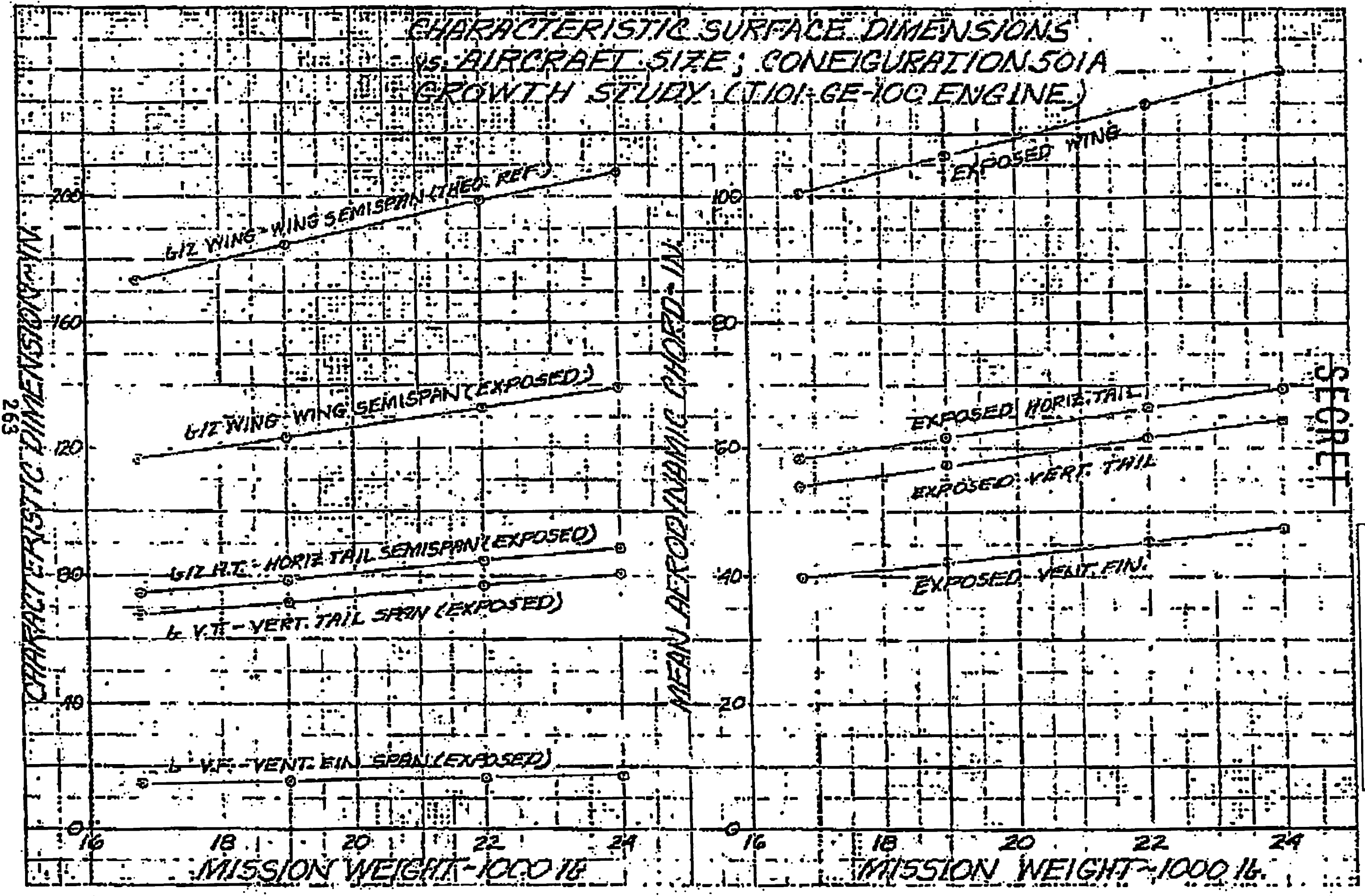
(S) Figure 5.1-5 Component Wetted Area vs. Aircraft Size - Large Twin-Engine Concept (U)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.1-6 Characteristic Fuselage Dimensions vs. Aircraft Size - Large Twin-Engine Concept (U)



~~(S)~~ Figure 5.1-7 Characteristic Surface Dimensions vs. Aircraft Size - Large Twin-Engine Concept (U)

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88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC.~~
3.3.(b)(4)
1.4. (a)(g)

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BASIC DESCRIPTIONS

G.W. = 16,800 lbs
W/S = 60 PSF
T/W = 1.702
PROPULSION - (2) J101-GE-100 ENGINES

PROJECT: AVFEX PROGRAM

CONFIGURATION: 501A-GROWTH STUDY
501A - 16800

DATE: 28 JULY 1971

Nose at F.S. +5.9

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE W/O CANOPY CENTERBODY	* 495.8	0	0	0
FUSELAGE OUTERBODY	307.1	234.5	± 49.8	+2.0
CANOPY	135.0	90.0	0	+32.5

* Length includes nozzle (open position)

WING REF. AREA (IN^2)

SURFACES

		[illegible] WING-NOMINAL	3° ANHEDRAL [illegible] HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL
AREA (FT^2)		280.00	143.21	23.80	7.92
AR - ASPECT RATIO		3.00	3.453	1.83	0.373
λ - TAPER RATIO		0.20	0.132	0.40	0.596
 L.E. E_1(+) E_2(+)	E_1	+55°	+55°	+45°	+45°
	E_2	+10°41'	+10°41'	-19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(E_2-E_1)}$					
C_R - ROOT CHORD (IN.)		193.218	136.579	72.613	48.754
C_T - TIP CHORD (IN.)		38.644	17.980	29.045	29.045
b - SPAN (IN.)		347.793	266.847	67.426	14.523
AIRFOIL		4% BICONVEX	6% BICON - exposed root 4% BICON - tip [illegible]	6% BICON - ROOT 4% BICON - TIP [illegible]	6% BICONVEX
d (IN.)		57.36	59.24	0	0
x (IN.)		288.6	455.6	418.10	431.1
Y (IN.)		0	0	± 62.76	± 59.24
Z (IN.)		+5.0	-9.55	+5.0	-8.0
		0° DIHEDRAL	3° NEG. DIHEDRAL	7° OUTBD CANT	0° CANT

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd. from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL 92.0 to body or surface ref line.

~~(S)~~ Figure 5.1-8 Basic Description Data Sheet - Configuration 501A Growth Study at 16,800-lb Mission Weight (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

BASIC DESCRIPTIONS

G.W. = 19,000 Lbs.
W/S = 60PSF
T/W = 1.505
PROPULSION - (2) J101-GE-100 ENGINES

PROJECT: AVFFX PROGRAM

CONFIGURATION: 501A-GROWTH STUDY
501A-19000

DATE: 29 JULY 1971

Nose at F.S. -15.0

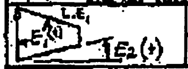
BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY W/O CANOPY	* 513.5	0	0	0
FUSELAGE OUTERBODY	341.5	234.5	± 53.0	+ 2.0
CANOPY	135.0	90.0	0	+ 32.5

* Length includes nozzle (open position)

WING REF. AREA (IN^2)

SURFACES

	2° INCIDENCE WING [illegible]	1° INCIDENCE (AD) HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL
AREA (FT^2)	316.67	161.96	26.92	4.44
AR - ASPECT RATIO	3.00	3.453	1.33	0.373
λ - TAPER RATIO	0.20	0.132	0.40	0.596
 L.E. $E_1(+)$ $E_2(+)$ — E_1	+55°	+55°	+45°	+45°
E_2	+10°41'	+10°41'	-19°22'	+19°22'
α - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$				
C_R - ROOT CHORD (IN.)	205.480	145.247	77.221	51.848
C_T - TIP CHORD (IN.)	41.096	19.122	30.888	30.888
b - SPAN (IN.)	369.865	283.781	71.705	15.444
AIRFOIL	4% BICONVEX	6% biconv-exp root 4% biconv-tip exp. root @ BL	6% biconv-@ root 4% biconv @ tip root @ WL 97	6% BICONVEX
d (IN.)	61.00	63.00	0	0
x (IN.)	306.5	485.0	465.93	478.93
Y (IN.)	0	0	± 66.75	± 63.00
Z (IN.)	+5.0	-9.77	+5.0	-8.0
	4° DIHEDRAL	7° NEG. DIHEDRAL	7° OUTBD CANT ∠	0° CANT ∠

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL 92.0 to body or surface ref line.

~~(S)~~ Figure 5.1-9 Basic Description Data Sheet - Configuration 501A Growth Study at 19,000-lb Mission Weight (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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G.W.= 22,000 lbs
W/S= 60PSF
T/W = 1.2995
PROPULSION – (2) J101-GE-100
Engines

PROJECT: AVFFX PROGRAM

CONFIGURATION: 501A-GROWTH STUDY
501A-22000

DATE: 28 JULY 1971

Nose at F.S. -416

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE ~~centerbody~~ w/o canopy	* 551.1	0	0	0
Fuselage outerbody	385.6	234.5	±57.0	+2.0
Canopy	135.0	90.0	0	+32.5

* Length includes nozzle (open position)

WING REF. AREA (IN²)

SURFACES

		2° WASHOUT WING [illegible]	1° INCID. ([illegible]) HORIZ. TAIL	Per Side VERT. TAIL	Per Side VENTRAL
AREA (FT²)		366.67	187.53	31.17	5.14
Æ - ASPECT RATIO		3.00	3.453	1.33	0.373
λ - TAPER RATIO		0.20	0.132	0.40	0.596
 L.E. E₁(+) E₂(+)	E_1	+55°	+55°	+45°	+45°
	E_2	+10°41'	+10°41'	-19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		221.108	156.293	83.094	55.792
C_T - TIP CHORD (IN.)		44.222	20.576	33.238	33.238
b - SPAN (IN.)		397.995	305.364	77.159	16.619
AIRFOIL		4% BICONVEX	6% BICON. - eq. root 4% BICON. - tip [illegible] root @ BL	6% BICON. - @ root 4% BICON. @ tip root @ BL 97	6% BICONVEX
d (IN.)		65.64	67.79	0	0
x (IN.)		330.1	522.1	501.35	514.35
Y (IN.)		0	0	± 71.82	± 67.79
Z (IN.)		+5.0	-10.06	+5.0	-8.0
		0° DIHEDRAL	7° NEG. DIHEDRAL	7° OUTBD CANT ∠	0° CANT ∠

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL92.0 to body or surface ref line.

~~(S)~~ Figure 5.1-10 Basic Description Data Sheet - Configuration 501A Growth Study at 22,000-lb Mission Weight (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

BASIC DESCRIPTIONS

GW = 24,000 lbs
W/S = 60 PSF
T/W = 1.191
PROPULSION – (2) J101-GE-100 Engines

PROJECT: AVFFX PROGRAM
CONFIGURATION: 501A-GROWTH STUDY 501A-24000
DATE: 28 JULY 71

Nose at F.S. -584

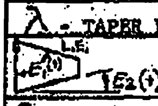
BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY W/O CANOPY	* 574.7	0	0	0
FUSELAGE OUTERBODY	413.5	334.5	± 59.6	± 2.0
CANOPY	135.0	90.0	0	+ 32.5

*Length includes nozzle (open position)

WING REF. AREA (IN²)

SURFACES

		2° INCIDENCE WING NORMAL	3° INCIDENCE [illegible] HORIZ TAIL	PER SIDE VERT TAIL	PER SIDE VENTRAL
AREA (FT²)		400.00	204.58	34.00	5.60
Æ - ASPECT RATIO		3.00	3.453	1.33	0.373
λ - TAPER RATIO		0.20	0.132	0.40	0.596
 L.E. E1(+) E2(+)	E1	+55°	+55°	+45°	+45°
	E2	+10°41'	+10°41'	-19°22'	+19°22'
α - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		230.940	163.243	86.789	58.273
C_T - TIP CHORD (IN.)		46.188	21.491	34.716	34.716
b - SPAN (IN.)		415.692	318.943	80.590	17.358
AIRFOIL		4% BICONVEX	6% BICONVEX-ROOT 4% BICONVEX-TIP [illegible]	6% BICONVEX-ROOT 4% BICONVEX-TIP [illegible] WL 57	6% BICONVEX
d (IN.)		68.56	70.81	0	0
x (IN.)		344.9	545.4	523.69	536.69
y (IN.)		0	0	± 75.02	± 70.81
z (IN.)		+5.0	-10.24	+5.0	-8.0
		0° DIHEDRAL	7° NEG. DIHEDRAL	7° OUTBD CANT ⊥	0° CANT ⊥

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL 92.0 to body or surface ref line.

~~(S)~~ Figure 5.1-11 Basic Description Data Sheet - Configuration 501A Growth Study at 24,000-lb Mission Weight (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

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FRICTION DRAG DATA

PROJECT AVEFX PROGRAM
CONFIGURATION 501A GROWTH STUDY
501A-16800
DATE 28 JULY 1971

G.W. = 16,800 lbs
W/S = 60 PSF
T/W = 1.702
PROPULSION - (2) J101-GE-100 ENGINES

[Scaled down from 501A
DWG FW7104104]

BODIES

BODY	WETTED AREA (FT^2)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
FUSELAGE CENTERBODY		571.5	* 501.35	84.0	54.5
FUSELAGE OUTERBODY		124.3	307.1	19.0	19.8
CANOPY (INCL. FAIRING)		41.0	135.0	30.0	19.0
NOZZLE (CLOSED)		25.2	15.05	32.4 DIA.	32.4 DIA.
NOZZLE (OPEN)	24.0	—	19.50	32.4 DIA.	32.4 DIA.
BODY TOTAL		762.0			

* Length measured from nose to nozzle end in closed position (Awet for nozzle broken out separately)

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		292.8	100.33	14°30'	4% BICONVEX
HORIZ. TAIL		105.0	58.06	14°30'	6% Bicon-exp root 4% Bicon - tip
VERT TAIL (2)		96.0	53.94	34°15'	6% Bicon - root 4% Bicon - tip
VENTRAL FIN (2)		15.7	39.73	17°45'	6% BICONVEX
SURFACE TOTAL		509.5			
AIRPLANE TOTAL		1271.5			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE – BASIC REF WING	TRAPEZOID SHAPE – CURVED TIP WING
AREA (FT^2)	280.0	283.353
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

~~(S)~~ Figure 5.1-12 Friction Drag Data Sheet - Configuration 501A Growth Study at 16,800-lb Mission Weight (U)

~~SECRET~~

88th ABW/IPI
~~FOIA (b)(1)~~
E.O. 13526 SEC.
3.3.(b)(4)

~~SECRET~~

FRICTION DRAG DATA
G.W. = 19,000 lbs.
W/S = 60 PSF
T/W = 1.505
PROPULSION – (2) J101 – GE – 100 Engines

PROJECT AVFFX PROGRAM
CONFIGURATION 501A GROWTH STUDY
501A – 19000
DATE 28 JULY 1971
[Reference Config 501A
DWG FW 7104104]

BODIES

BODY	WETTED AREA (FT^2)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
FUSELAGE CENTERBODY		615.9	* 519.05	84.0	54.5
FUSELAGE OUTERBODY		166.7	341.5	22.5	21.0
CANOPY (INCL. FAIRING)		41.0	135.0	30.0	19.0
NOZZLE (CLOSED)		25.2	25.05	32.4 DIA.	32.4 DIA.
NOZZLE (OPEN)	24.0	—	19.50	32.4 DIA.	32.4 DIA.
BODY TOTAL		848.8			

* Length measured from nose to nozzle end in closed position (exept for nozzle broken out separately)

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		331.1	106.69	14° 30'	4% BICONVEX
HORIZ. TAIL		118.7	61.75	14° 30'	6% BICONV - root 4% BICONV - tip
VERT. TAIL (2)		107.7	57.36	34° 15'	6% BICONV - root 4% BICONV - tip
VENTRAL FIN (2)		17.8	42.25	17° 45'	6% BICONVEX
SURFACE TOTAL		575.3			
AIRPLANE TOTAL		1424.1			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE – BASIC REF. WING	TRAPEZOID SHAPE – CURVED TIP WING
AREA (FT^2)	316.67	320.462
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

~~(S)~~ Figure 5.1-13 Friction Drag Data Sheet – Configuration 501A Growth Study at 19,000-lb Mission Weight (U)

~~SECRET~~

FRICTION DRAG DATA ~~SECRET~~ PROJECT AVFFX PROGRAM

G.W. = 22,000 lbs.
W/S = 60 PSF
T/W = 1.2995
PROPULSION – (2) J101-GE-100 ENGINES

CONFIGURATION 501A GROWTH STUDY
501A-22000
DATE 28 JULY 1971
[Scaled up from 501A
DWG FWT104104]

BODIES

BODY	WETTED AREA (FT^2)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
FUSELAGE CENTERBODY		673.6	* 556.65	74.0	54.5
FUSELAGE OUTERBODY		214.6	385.6	26.0	21.0
CANOPY (INCL. FAIRING)		41.0	135.0	30.0	22.6
NOZZLE (CLOSED) (2)		25.2	25.05	32.4 DIA.	32.4 DIA.
NOZZLE (OPEN) (2)	24.0	—	19.50	32.4 DIA.	32.4 DIA.
BODY TOTAL		954.4			

* Length measured from nose to nozzle end in closed position (Area for nozzle broken out separately)

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		383.4	114.81	14° 30'	4% BICONVEX
HORIZ. TAIL		137.5	66.44	14° 30'	6% BICON.-ROOT 4% BICON.-TIP
VERT. TAIL (2)		124.7	61.73	34° 15'	6% BICON.-ROOT 4% BICON.-TIP
VENTRAL FIN (2)		20.6	45.47	17° 45'	6% BICONVEX
SURFACE TOTAL		666.2			
AIRPLANE TOTAL		1620.6			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE — BASIC REF. WING	TRAPEZOID SHAPE — CURVED TIP WING
AREA (FT^2)	366.67	371.61 [illegible]
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.0	35.0

~~(S)~~ Figure 5.1-14 Friction Drag Data Sheet - Configuration 501A Growth Study at 22,000-lb Mission Weight (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

FRICTION DRAG DATA
G.W. = 24,000 lbs.
W/S = 60 lbs / ft²
T/W = 1.191
PROPULSION - (2) J101-GE-100 Engines

PROJECT AVEEX PROGRAM
CONFIGURATION 501A - GROWTH STUDY
501A - 24000
DATE 28 JULY 1971

[Scaled up from 501A Dwg #w7104104]

BODIES

BODY	WETTED AREA (FT²)		LENGTH (IN)	MAX. WIDTH (IN)	MAX. HEIGHT (IN)
FUSELAGE CENTERBODY		707.6	* 580.25	84.0	54.5
FUSELAGE OUTERBODY		257.6	413.5	30.0	19.8
CANOPY (INCL. FAIRING)		41.0	135.0	30.0	23.6
NOZZLE (CLOSED)(2)		25.2	25.05	32.4 DIA.	32.4 DIA.
NOZZLE (OPEN) (2)	24.0	—	19.50	32.4 DIA.	32.4 DIA.

BODY TOTAL 1031.4

* Length measured from nose to nozzle end in closed position (Areas for nozzle broken out separately)

SURFACES

SURFACE	WETTED AREA (FT²)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		418.2	119.91	14°30'	4% BICONVEX
HORIZ. TAIL		150.0	69.40	14°30'	6% BICONV.-ROOT 4% BICONV.-TIP
VERT. TAIL (2)		136.0	64.47	34°15'	6% BICONV.-ROOT 4% BICONV.-TIP
VENTRAL FIN (2)		22.4	47.49	17°45'	6% BICONVEX

SURFACE TOTAL 726.6

AIRPLANE TOTAL 1758.0

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE — BASIC REF WING	TRAPEZOID SHAPE — CURVED TIP WING
AREA (FT²)	400.00	404.790
ASPECT RATIO	3.00	3.20
TAPER RATIO	0.20	0.1689
LEADING EDGE SWEEP (DEG.)	35.00	35.00

~~(S)~~ Figure 5.1-15 Friction Drag Data Sheet - Configuration 501A Growth Study at 24,000-lb Mission Weight (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)

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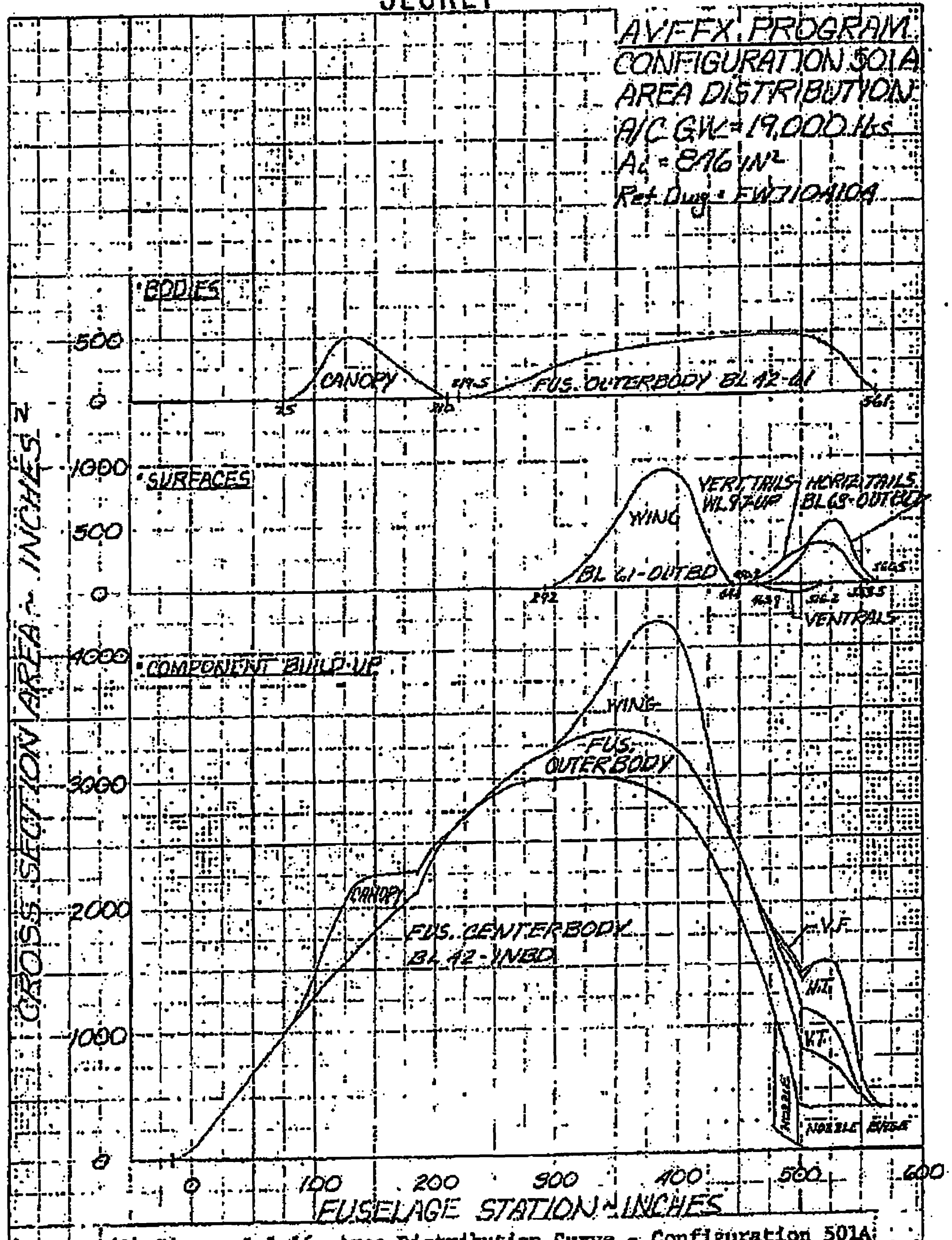

~~(S)~~ Figure 5.1-16 Area Distribution Curve - Configuration 501A at 19,000-lb Gross Weight (U)

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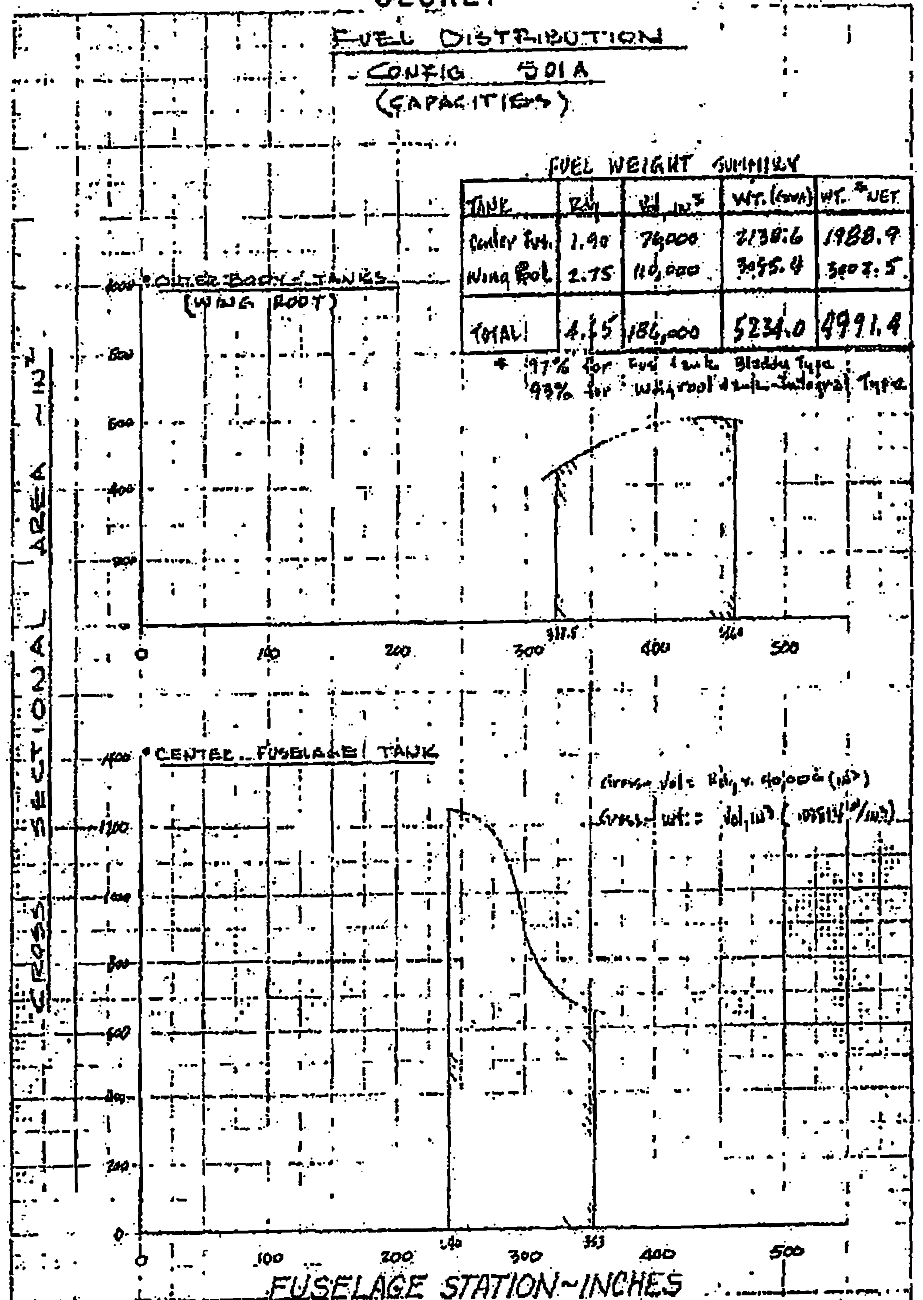
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



FUEL WEIGHT SUMMARY

TANK	ft³	Vol in³	WT. (Gross)	WT. * NET
Center Fus.	1.90	76,000	2138.6	1988.9
Wing Root	2.75	110,000	3095.4	3002.5
TOTAL	4.65	186,000	5234.0	4991.4

* 97% for Fus tank Bladder Type
93% for wingroot tank-Integral Type

~~(S)~~ Figure 5.1-17 Fuel Distribution Curve - Configuration 501A at 19,000-lb Gross Weight (U)

5.2 PERFORMANCE

~~(S)~~ The mission performance capabilities of Configuration 501A were evaluated at the 19,000-lb-size aircraft used for the design layout and at a smaller and a larger size. The mission definitions and performance rules of Section 3.2 (Configuration 401B) were used. The results of the evaluation are presented in Figure 5.2-1. [The performance data presented in this section are for Configuration 501A sized to meet the desired 750-n.mi LRASM radius. The resulting mission weight for this distance is 22,680 lb. This configuration can be compared to 401B as follows:

	501A	401B	% Change
Wing Loading, lb/sq ft	60	60	None
Thrust Loading	1.26	1.37	-8.0
Takeoff Gross Weight, lb	22680	17115	+32.2
Basic Operating Weight, lb	15712	12367	+26.4
SRASM Radius, n.mi	240	239	Negl.
LRASM Radius, n.mi	750	750	None
Ferry Range, n.mi	2166	2614	-17.1
Turn Rate - LRASM, sec	9.45	9.9	-4.6
Accel. Time - LRASM, sec	51.0	35.5	+43.6

~~(S)~~ The major cause for the large size of the 501A twin-engine aircraft compared to the 401B single-engine aircraft is the difference in engine cycle. The TSFC's for GE engines used in the twin-engine aircraft are approximately 20-percent higher than those of the P&W engine used in the single-engine aircraft. Also, when compared at the same uninstalled thrust loading (1.37), the twin-engine aircraft weight-empty is 2575 lb greater than the single-engine aircraft. This means that it has 2575 lb less fuel for a constant mission weight.]

(U) The performance data presented in this section are for standard-day conditions and are based on

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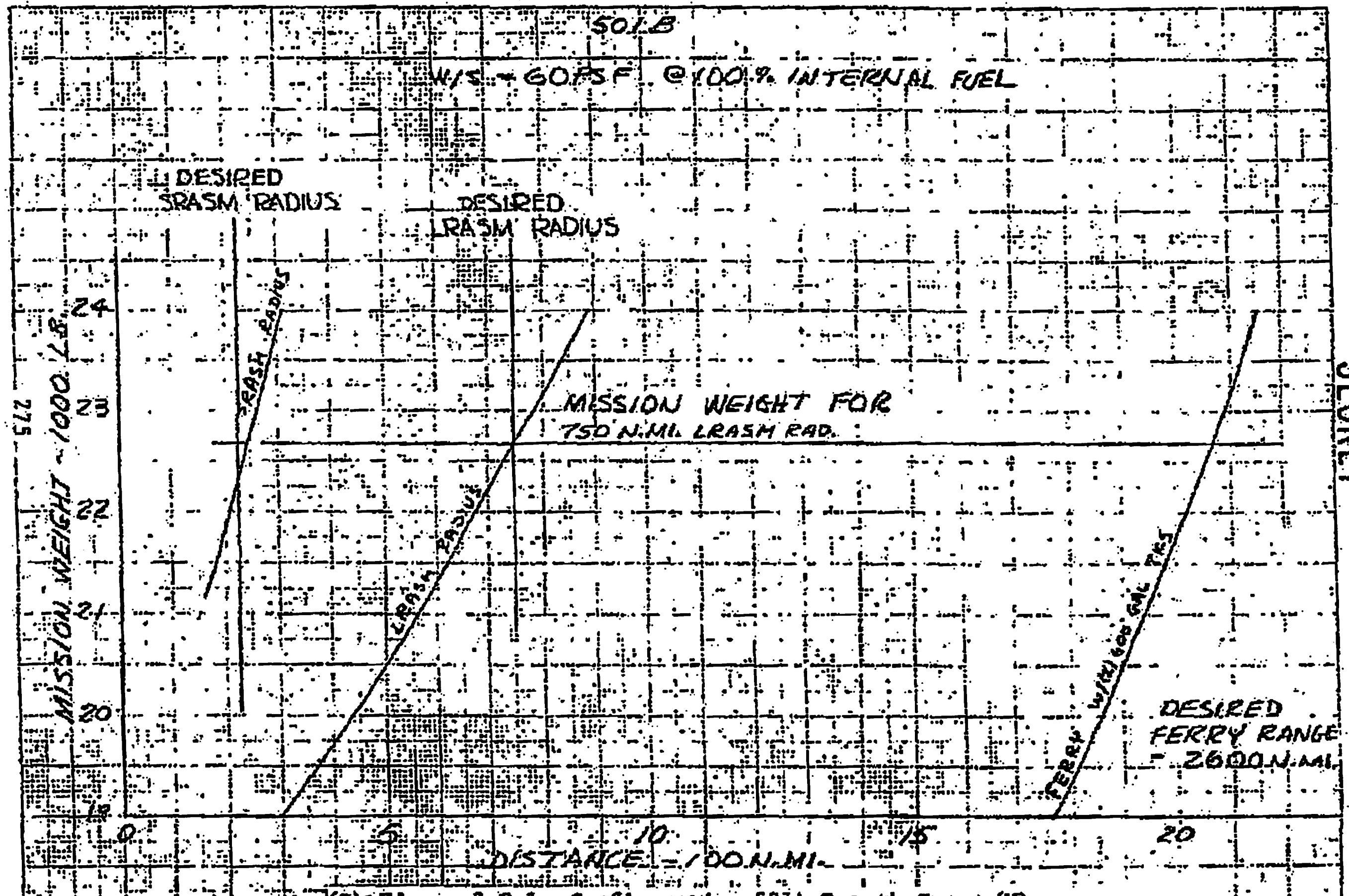

~~(S)~~ Figure 5.2-1 Configuration 501A Growth Curve (U)

SECRET

1. Aerodynamic data presented in Section 5.3.
2. Stability and Control data presented in Section 5.4.
3. Weight data presented in Section 5.5.
4. Propulsion data presented in Section 5.6.

~~(S)~~ The following corrections, obtained from the growth data presented in Section 5.3, were added to the basic aerodynamic data of Section 3.3, together with the increment for differences between Configuration 501A and 401B from Section 5.3, to account for the configuration differences in aircraft and the increased aircraft size and wing area. (The reference wing area of Configuration 501A changed from 316.7 sq ft at 19,000 lb to 378.0 sq ft at 22,680 lb to maintain a constant wing loading of 60 psf.)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3.
(b)(4)
1.4 (a)(g)
SEC 3.3(b)(4)
SEC 1.4(a)(g)

Mach No.	$\Delta C_{D_{401B \text{ to } 501A}}$	$\Delta C_{D_{Size}}$	$\Delta C_{D_{Total}}$
0.6	-0.00005	-0.00112	-0.00117
0.8	0.00010	-0.00112	-0.00102
0.9	0.00035	-0.00125	-0.00095
1.2	0.00535	-0.00600	-0.00065
1.5	0.00365	-0.00580	-0.00215

~~(S)~~ The weight data for the 22,680-lb aircraft were determined from the growth data presented in Section 5.5. A summary of the weight data used in the performance calculations is presented in Table 5.2-1.

(U) The engine size was maintained fixed, and the propulsion data from Section 5.6 were used without modification.

~~(S)~~ The basic mission performance of Configuration 501A sized to 22,680 lb is summarized in Figure 5.2-2. Mission tabulated data are presented in Tables 5.2-2 through 5.2-4. General performance data are shown in Figures 5.2-3 through 5.2-12.

(U) The sensitivity of aircraft size to weight-empty variation is shown in Figure 5.2-13.

~~(S)~~ Table 5.2-1 CONFIGURATION 501A WEIGHT SUMMARY
(22,680-Lb Airplane Without Tanks)

Item	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	15,557
Ammunition (500 rounds)	285
Two AIM9-X Missiles	348
Fuel	6,490
SRASM Takeoff Gross Weight	22,680
Two Full 450-Gallon Tanks and Pylons	7,004
LRASM Takeoff Gross Weight	29,684
Basic Operating Weight	15,557
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	1,038
SRASM and LRASM Landing Weight	16,737
2. FERRY MISSION	
Basic Operating Weight	15,557
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	15,718
Internal Fuel	6,490
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	32,865
Zero Fuel Weight	15,718
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five percent Initial Fuel	767
Twenty-Minute Sea-Level Loiter	1,128
Landing Weight	19,427

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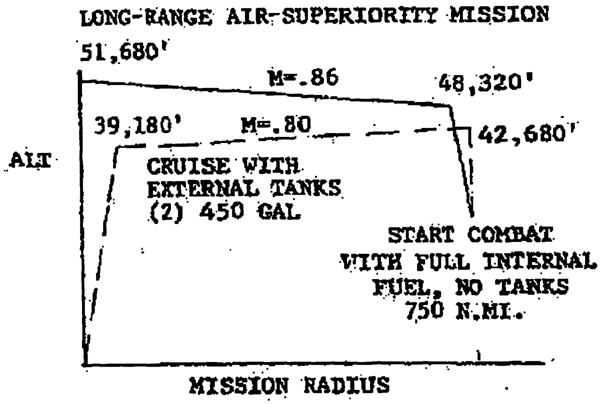
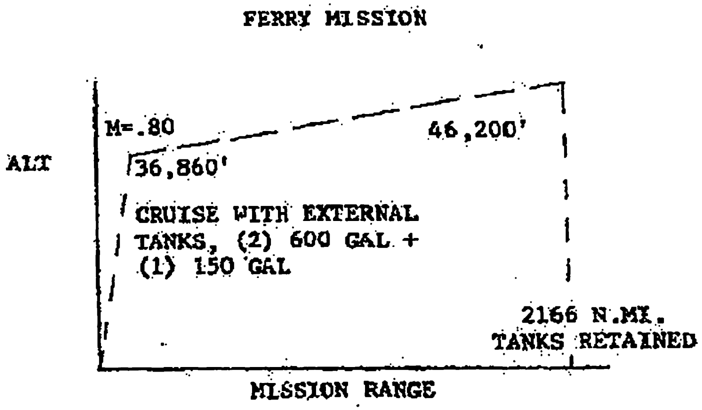
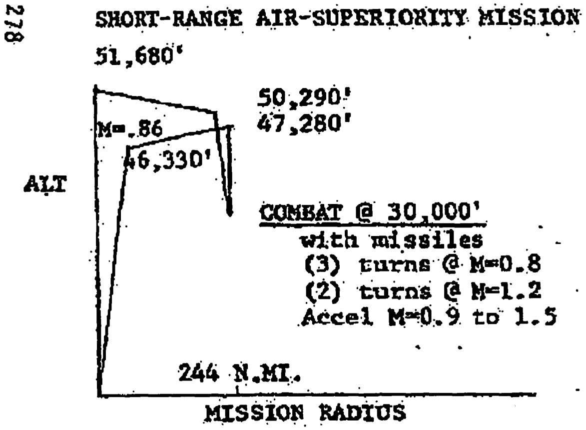
(22,680-LB A/P W/O TANKS)







LONG-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	29,684 lb
Takeoff Distance over 50 ft	2,150 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	51.4 sec
Turn Rate @ M=0.8	9.5 deg/sec
Turn Rate @ M=1.2	6.9 deg/sec

SHORT RANGE AIR SUPERIORITY MISSION

Takeoff Gross Weight	22,680 lb
Takeoff Distance over 50 ft	1,400 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M = 0.9 to 1.5	46.1 sec
Turn Rate @ M= 0.8	10.5 deg/sec
Turn Rate @ M=1.2	7.6 deg/sec

SECRET

~~(S)~~ Figure 5.2-2 Configuration 501A Mission Performance Summary (U)

88th ABW/IPI
FOIA (b)(1)
EO 13526 SEC 3.3(b)(4)
1.4(a)(g)
EO 13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)
Pgs 278-307

~~(S)~~ Table 5.2-2 CONFIGURATION 501A LRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat C_L	Combat g's
Initial Weight	0	0	29684								
Ground Operation				523	0	0					
	0	0	29161								
Accel to Climb Speed				332	0	.11					
	0.50	0	28829				3398	1.015	7.65		
Climb to Cruise Alt.				764	33	.08					
	0.80	39183	28065				2942	.977	9.64		
Outbound Cruise				4163	717	1.56					
	0.80	42678	23902								
Drop Tanks				1222	0	0					
(1076#Tank+146#Fuel)	0.80	42678	22680								
Combat				(2444)		(.08)					
Accel M0.9-M1.5	0.9-1.5	30000		535	0	.02					
(2)M1.2 Turns	1.2	30000		1065	0	.03				.411	4.57
(2)M0.8 Turns	0.8	30000		844	0	.03				.852	4.20
	0.86	30000	20236								
Drop Payload				348	0	0					
	0.86	30000	19888								
Drop ½ Ammo				143	0	0					
	0.86	30000	19745				2885	1.036	6.49		
Climb to Cruise Alt.				209	20	.04					
	0.86	48318	19536				1980	1.025	9.98		
Return Cruise				2799	730	1.47					
	0.86	51684	16737								
Descend				0	0	0					
	0.21	0	16737				2000	1.57	8.37		
Landing Reserves				1038	0	.33					
(20-Min.Loiter S.L.)											
Zero-Fuel Weight			15699								

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~SECRET~~

~~(S)~~ Table 5.2-3 CONFIGURATION 501A SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Fn	Initial TSFC	Initial L/D	Combat C_L	Combat g's
Initial Weight	0	0	22680								
Ground Operation				412	0	0					
	0	0	22268								
Accel to Climb Speed				247	0	.11					
	0.50	0	22021				2890	1.015	6.30		
Climb to Cruise Alt.				653	34	.07					
	0.86	46327	21368				2190	1.015	9.84		
Outbound Cruise				923	210	.43					
	0.86	47278	20445								
Combat				(2192)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		535	0	.01					
(2)M1.2 Turns	1.2	30000		965	0	.03				.406	5.02
(3)M0.8 Turns	0.8	30000		692	0	.03				.841	4.63
	0.86	30000	18253								
Drop Payload				348	0	0					
	0.86	30000	17905								
Drop ½ Ammo				143	0	0					
	0.86	30000	17762				2858	1.036	5.63		
Climb to Cruise Alt.				207	21	.05					
	0.86	50286	17555				1780	1.040	9.93		
Return Cruise				818	223	.45					
	0.86	51684	16737								
Descend				0	0	0					
	0.21	0	16737				2000	1.570	8.40		
Landing Reserves (20 Min. Loiter S.L.)				1038	0	.33					
Zero-Fuel Weight			15699								

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~(S)~~ Table 5.2-4 CONFIGURATION 501A FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Treq	Initial TSFC	Initial L/D	Combat C_L	Combat g's
Initial Weight	0	0	32865								
Ground Operation				565	0	0					
	0	0	32300								
Accel to Climb Speed				373	0	.11					
	0.50	0	31927				3657	1.015	8.15		
Climb to Cruise Alt.				840	35	.08					
	0.80	36361	31087				3350	.968	9.47		
Cruise w/(2)Ext.Tanks				21660	2131	4.65					
	0.80	46200	19427								
Descend				0	0	0					
	0.22	0	19427				2450	1.40	8.00		
Landing Reserves				(1895)							
(20Min.Loiter S.L.)				1128	0	.36					
(5% Initial Fuel)				767							
			17532								
Zero-Fuel Weight											

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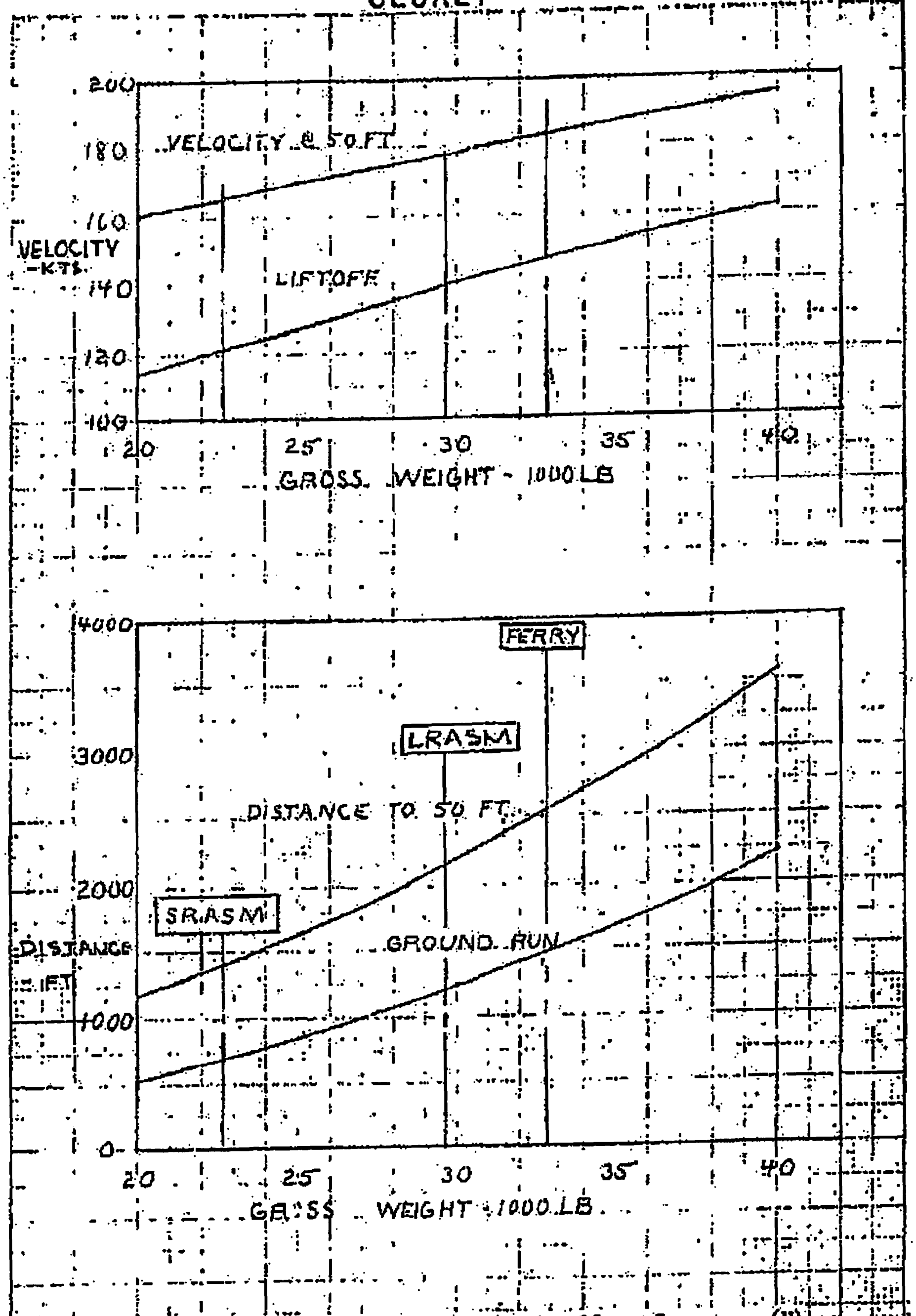
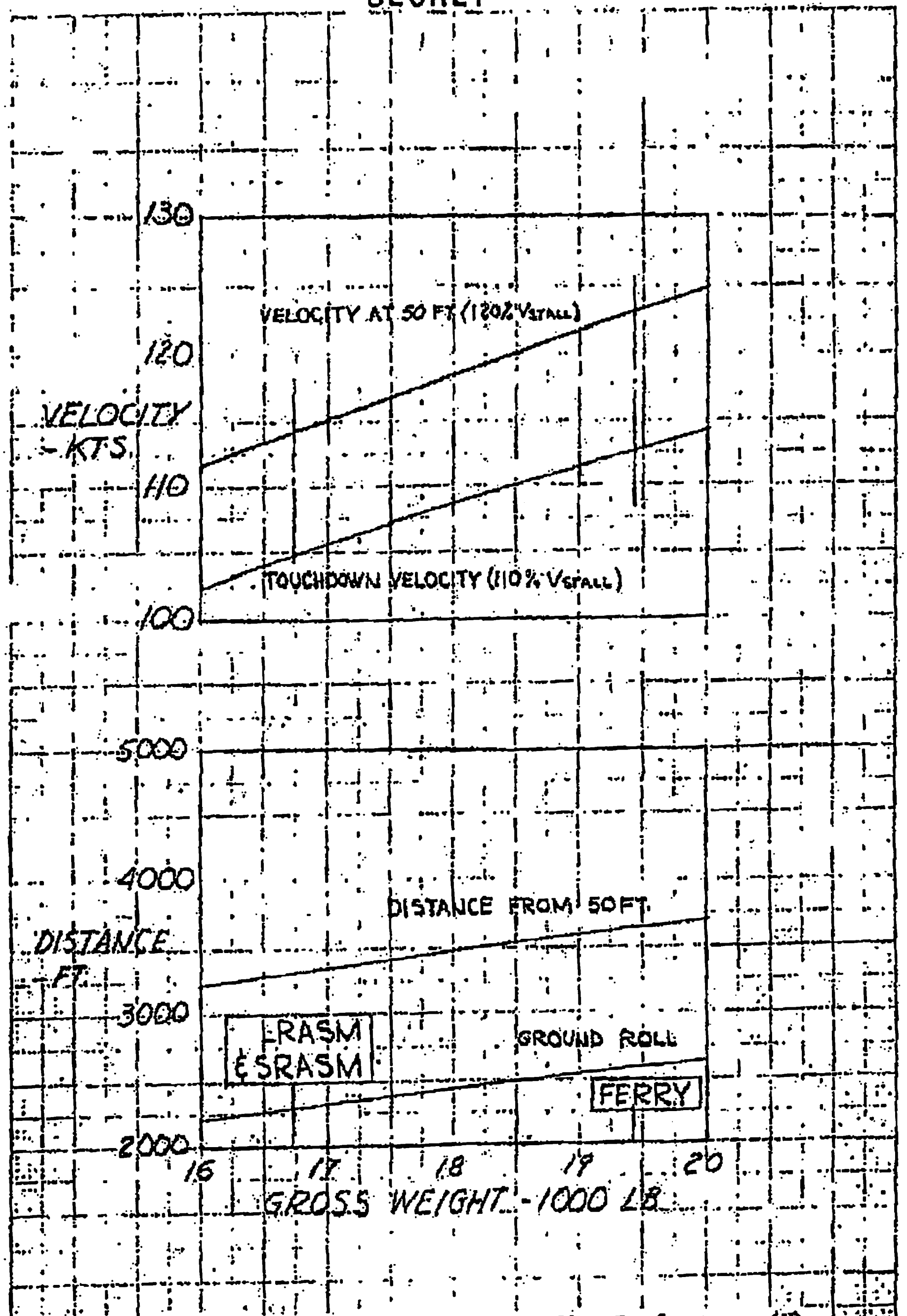
88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4.(a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.2-3 Configuration 501A Takeoff Performance (U)

88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.2-4 Configuration 501A Landing Performance (U)

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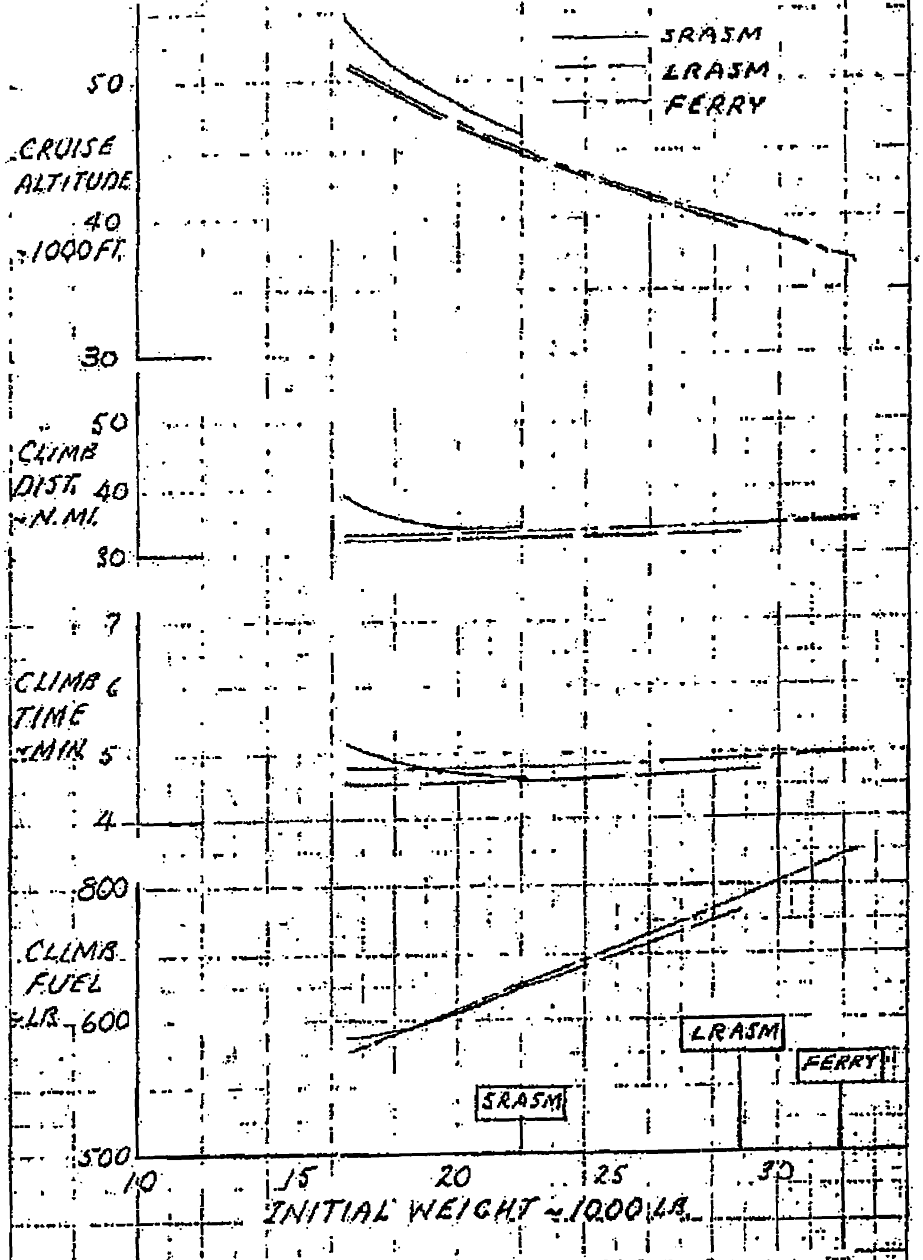

~~(S)~~ Figure 5.2-5 Configuration 501A Initial Climb Performance (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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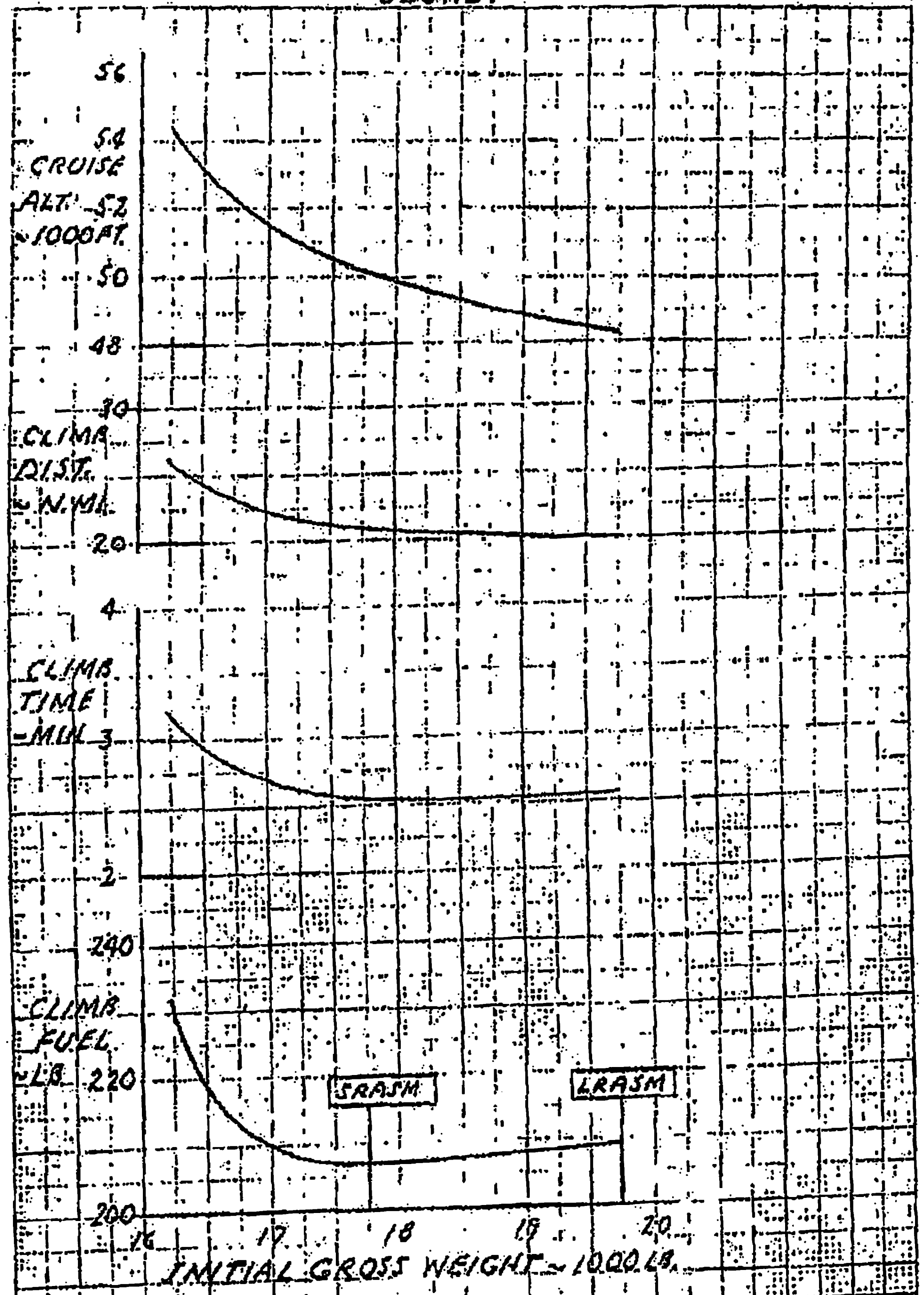

~~(S)~~ Figure 5.2-6 Configuration 501A Climb After Combat (U)

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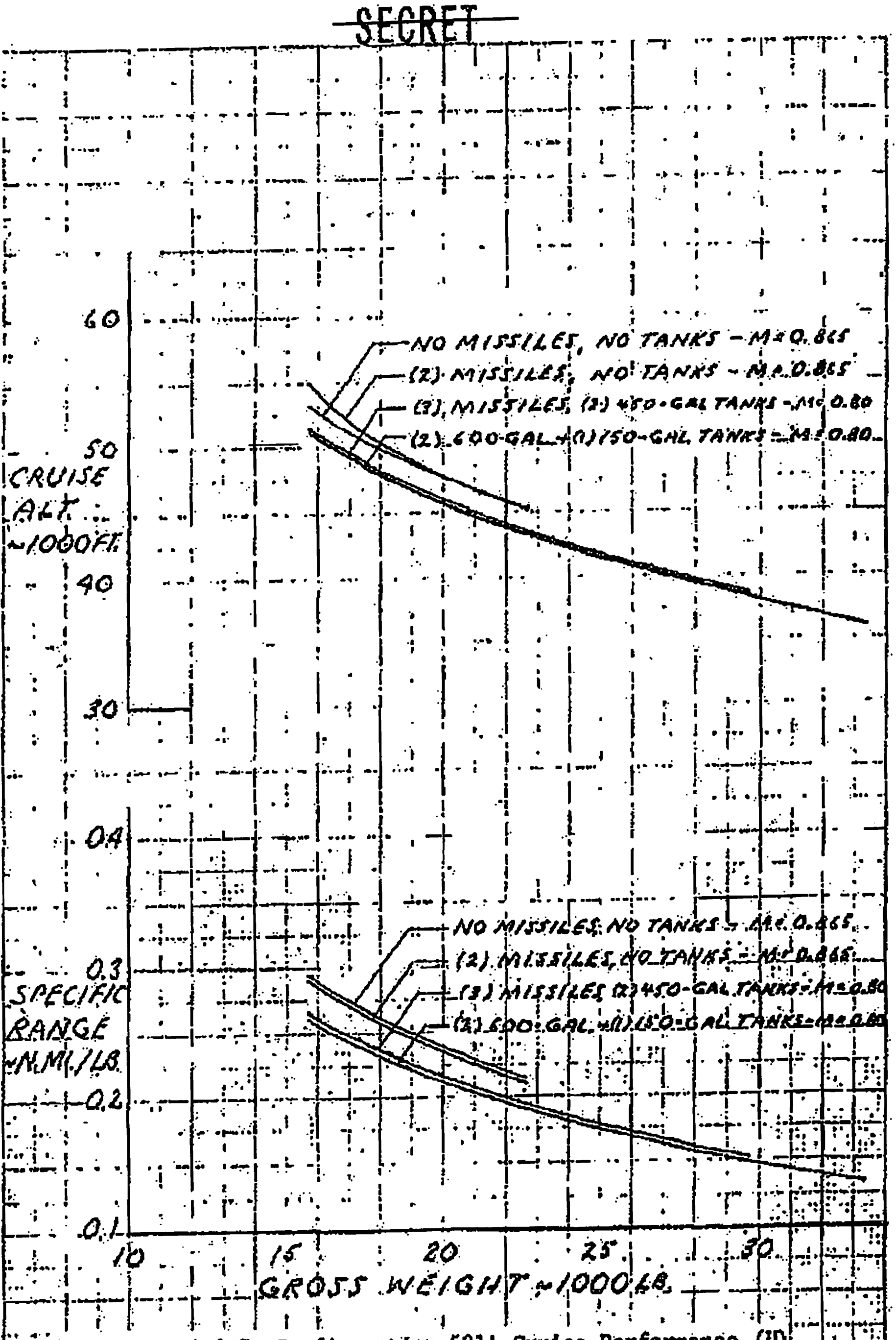
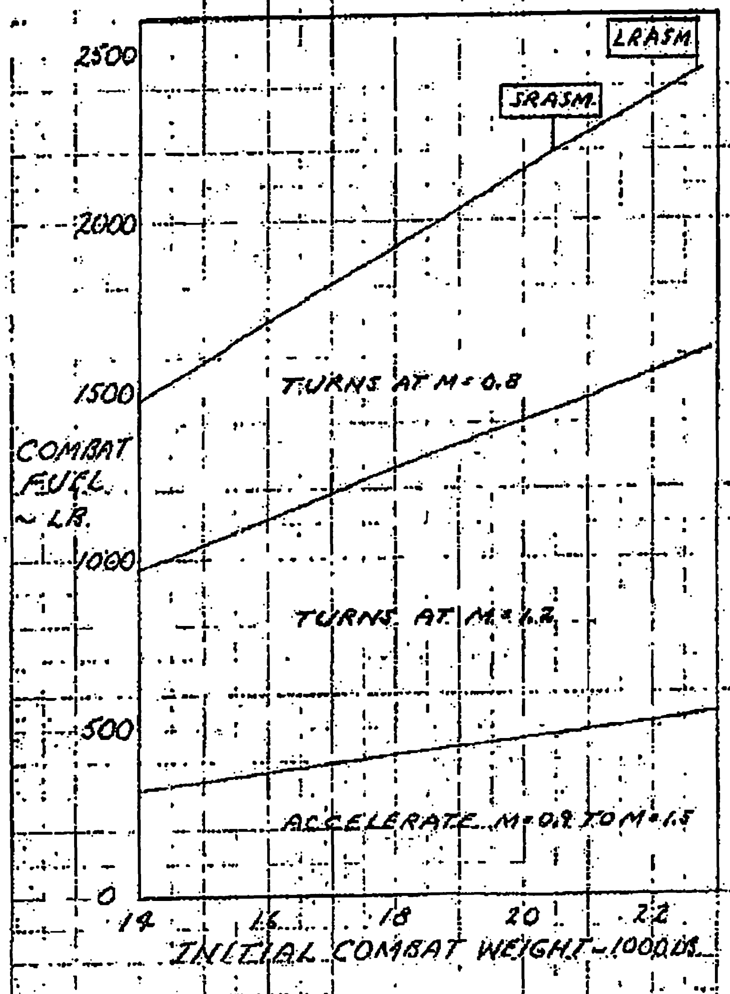
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.2-7 Configuration 501A Cruise Performance (U)



~~(S)~~ Figure 5.2-8 Configuration 501A Combat Fuel Allowance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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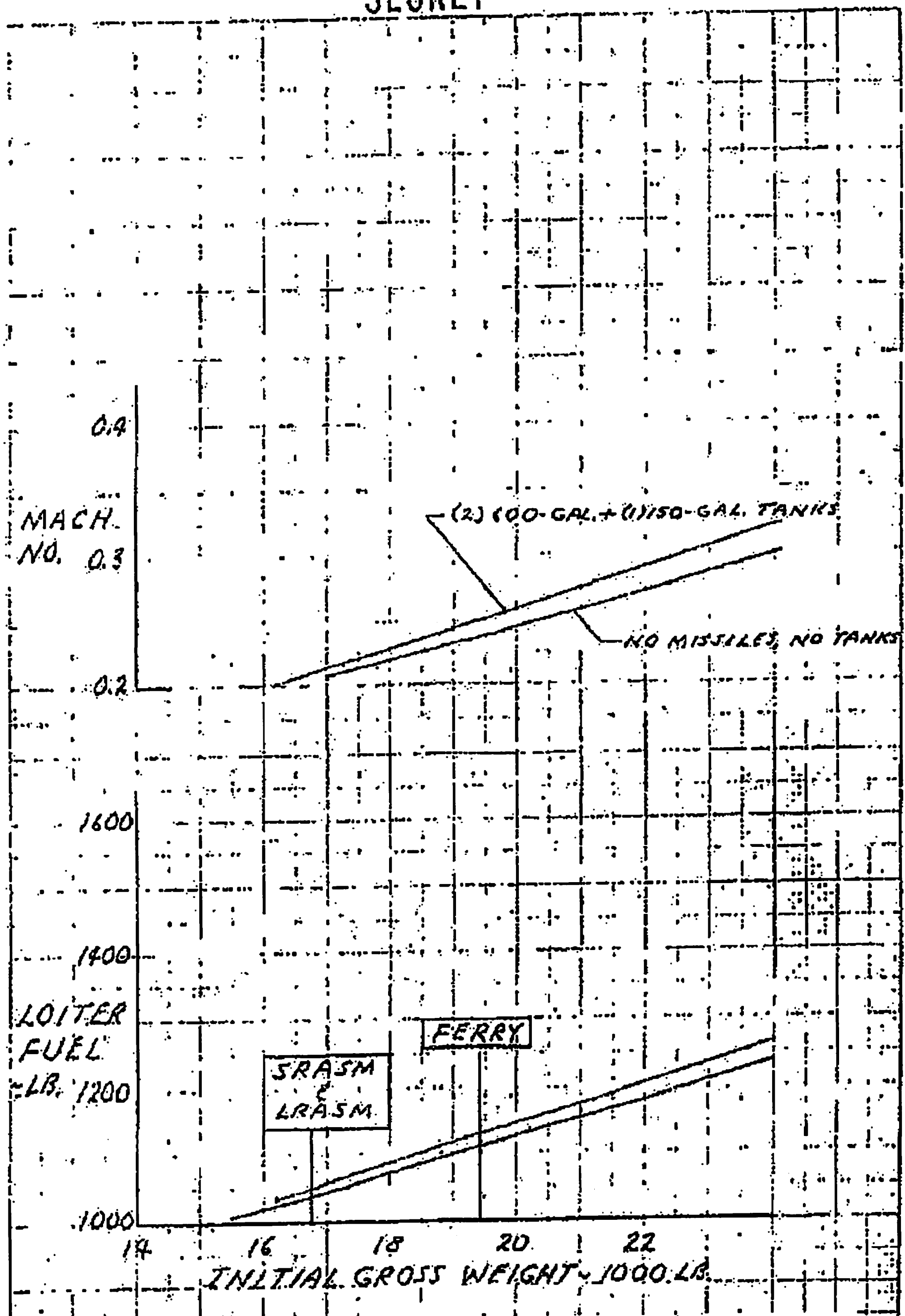

~~(S)~~ Figure 5.2-9 Configuration 501A Sea-Level Loiter Performance (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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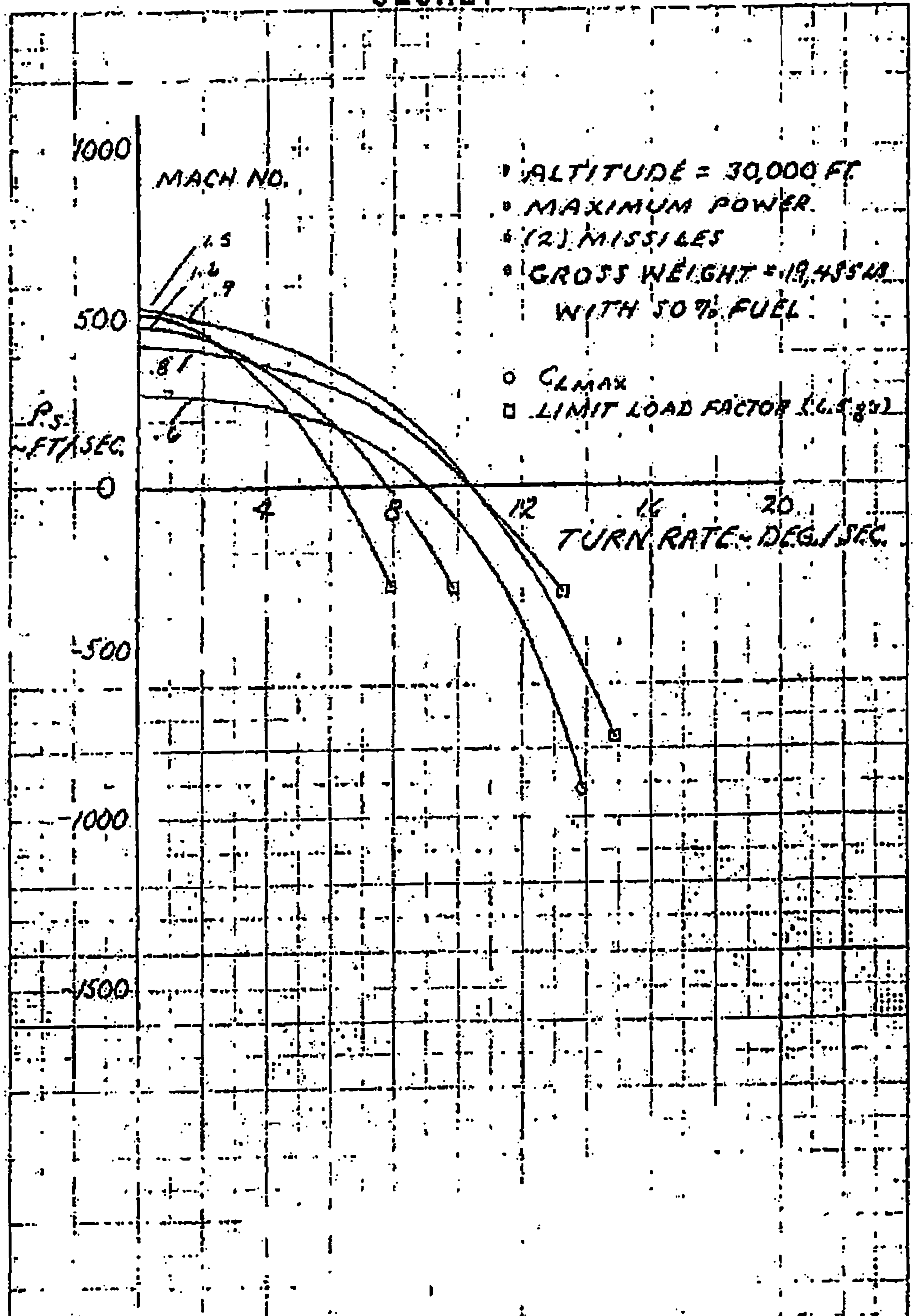
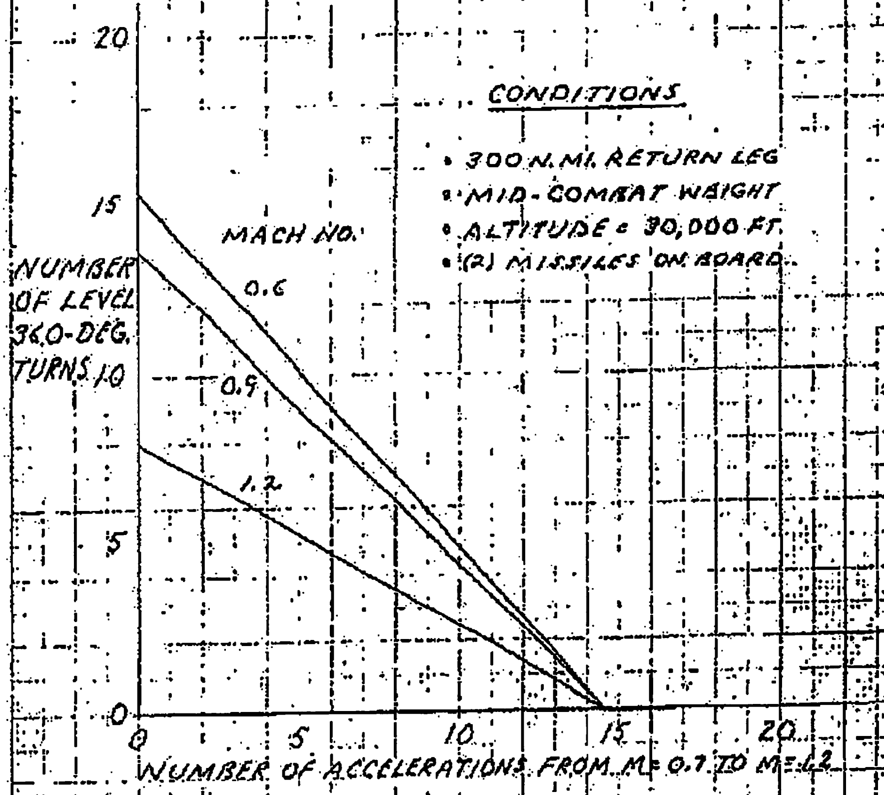


~~(S)~~ Figure 5.2-10 Configuration 501A Turning Performance (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

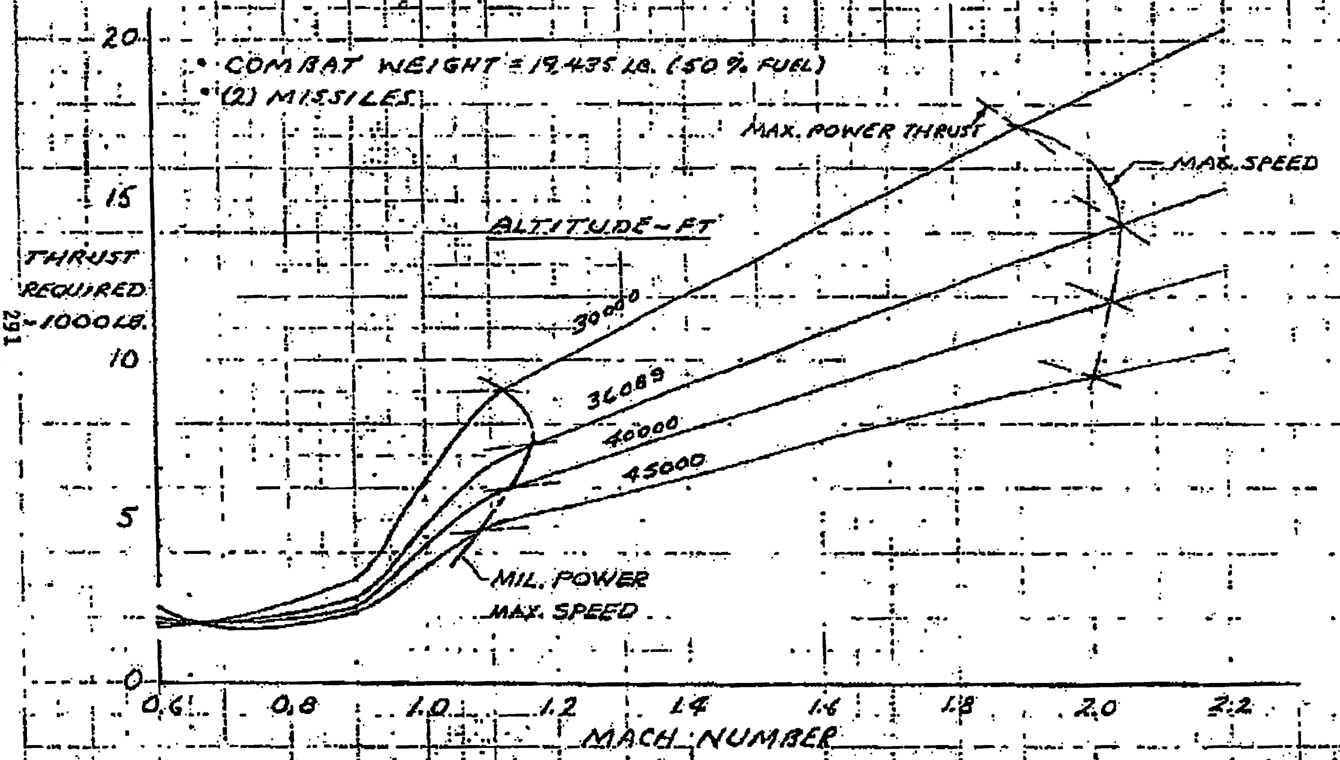


~~(S)~~ Figure 5.2-11 Configuration 501A Persistence Plot (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

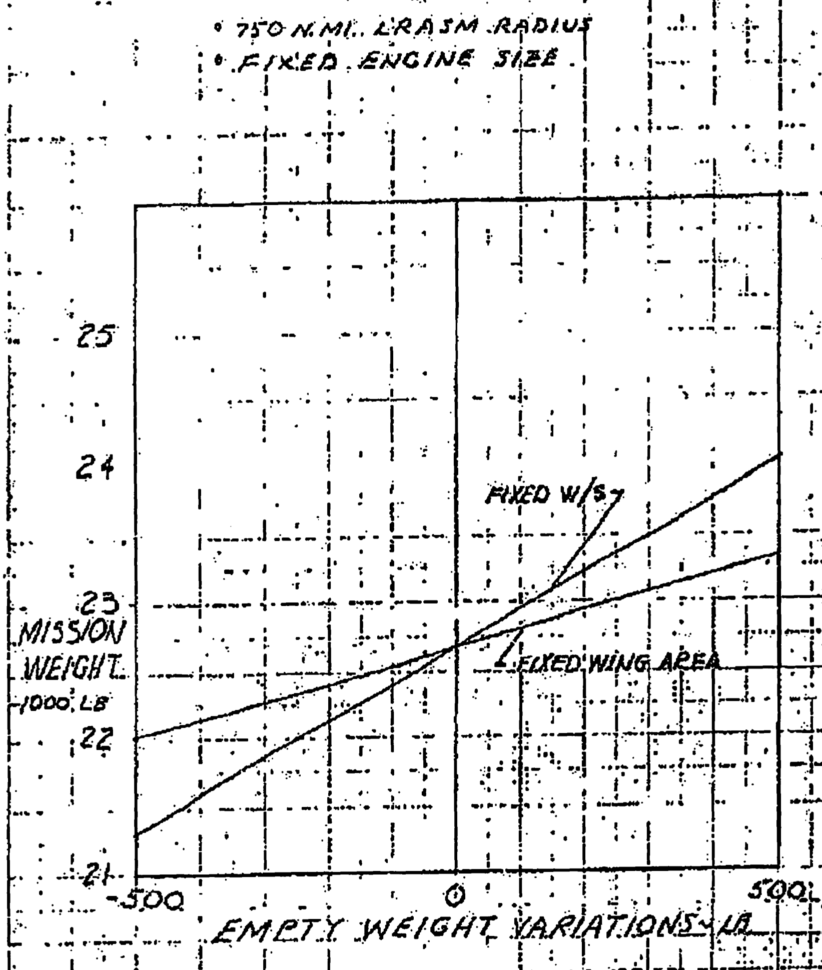


~~(S)~~ Figure 5.2-12 Configuration 501A Thrust Required (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 5.2-13 Configuration 501A Sensitivity to Weight Variation (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

5.3 AERODYNAMICS

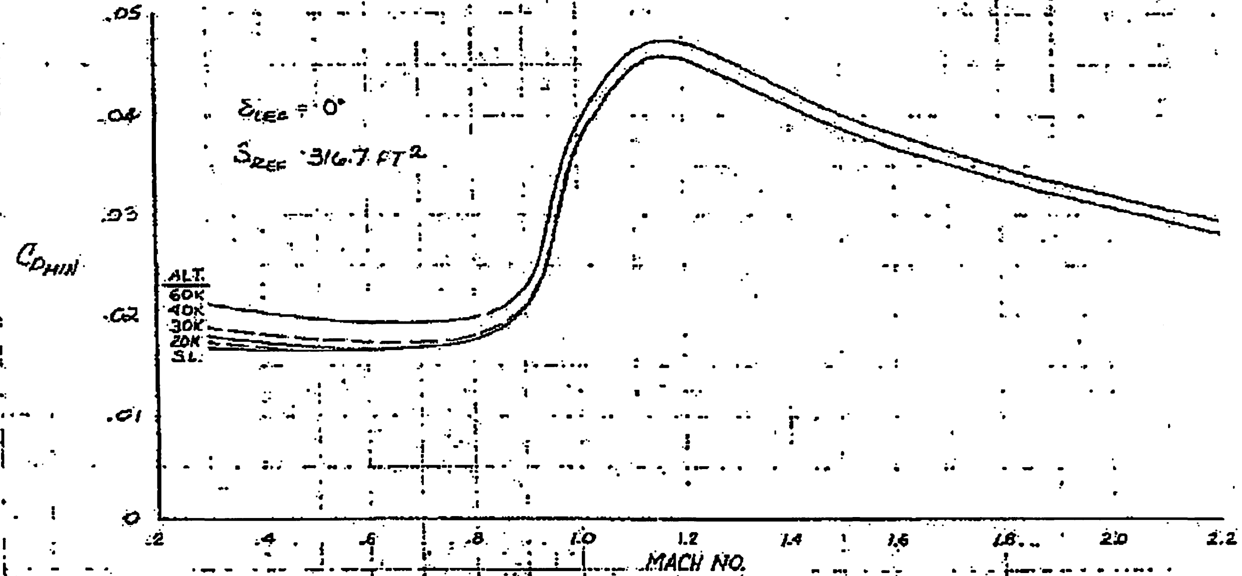
(U) Like Configuration 403, the twin-engine airplane (501A) is geometrically similar to Configuration 401B, and, therefore, the only aerodynamic differences are in the minimum drag.

(U) Again, the methodology and assumptions outlined in Section 3.3 were applied consistently to this configuration. Figures 5.3-1, -2, and -3 summarized the minimum drag data. The most significant difference between Configurations 501A and 401B is in the wave drag - 501A has a coefficient .0054 higher at $M = 1.2$ and .0034 higher at $M = 1.6$. This is due to the increased frontal area and steeper aft slopes, as is seen by comparing the normal area distribution curves shown in Figures 3.1-23 and 5.1-16.

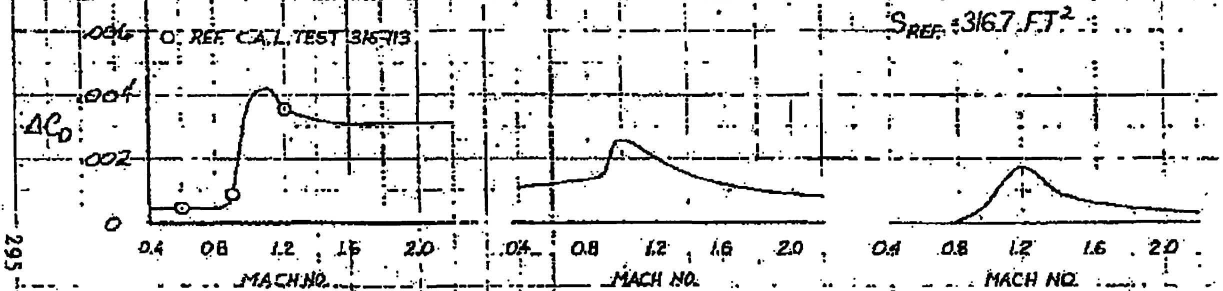
(U) The trimmed drag polars and trimmed configuration polars for Configuration 501A are presented in Figures 5.3-4 through 5.3-13. The $(L/D)_{max}$ data are plotted in Figure 5.3-14. A comparison of these data with those of Figure 3.3-25 shows that at subsonic speeds Configurations 501A and 401B are equivalent, but, at Mach 1.2, Configuration 501A has a 6-percent lower $(L/D)_{max}$.

(U) Since the planform and wing loading are the same as for the 401B configuration, the lift curves, buffet boundaries, and control-limit C_L's shown in Figures 3.3-26 through 3.3-31 of Section 3.3 also apply to the 501A configuration.

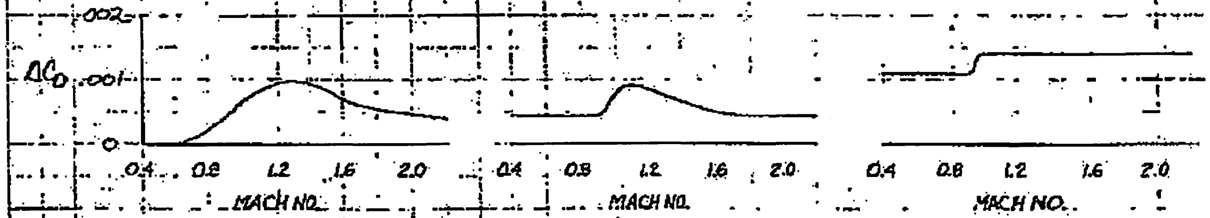
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.3-1 Minimum Drag vs Mach Number, Configuration 501A



(a) CANOPY (b) NOZZLE (c) COWL

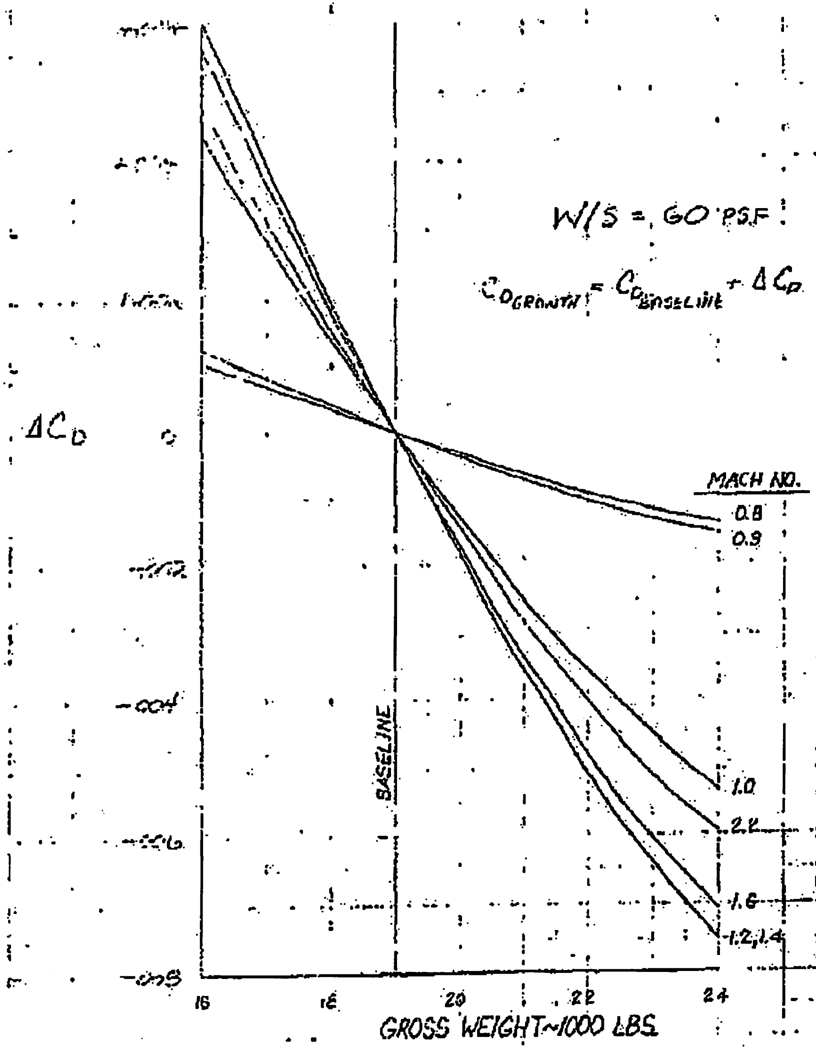


(d) DIVERTER (e). 2 MISSILE PYLONS (f) PROTUBERANCES

~~(S)~~ Figure 5.3-2 Components Used in Minimum Drag Buildup, Configuration 501A

88th ABW/IPI
FOIA (b)(1)
E.O. 13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 5.3-3 Effect of Aircraft Size on Minimum Drag Coefficient, Configuration 501A (U)

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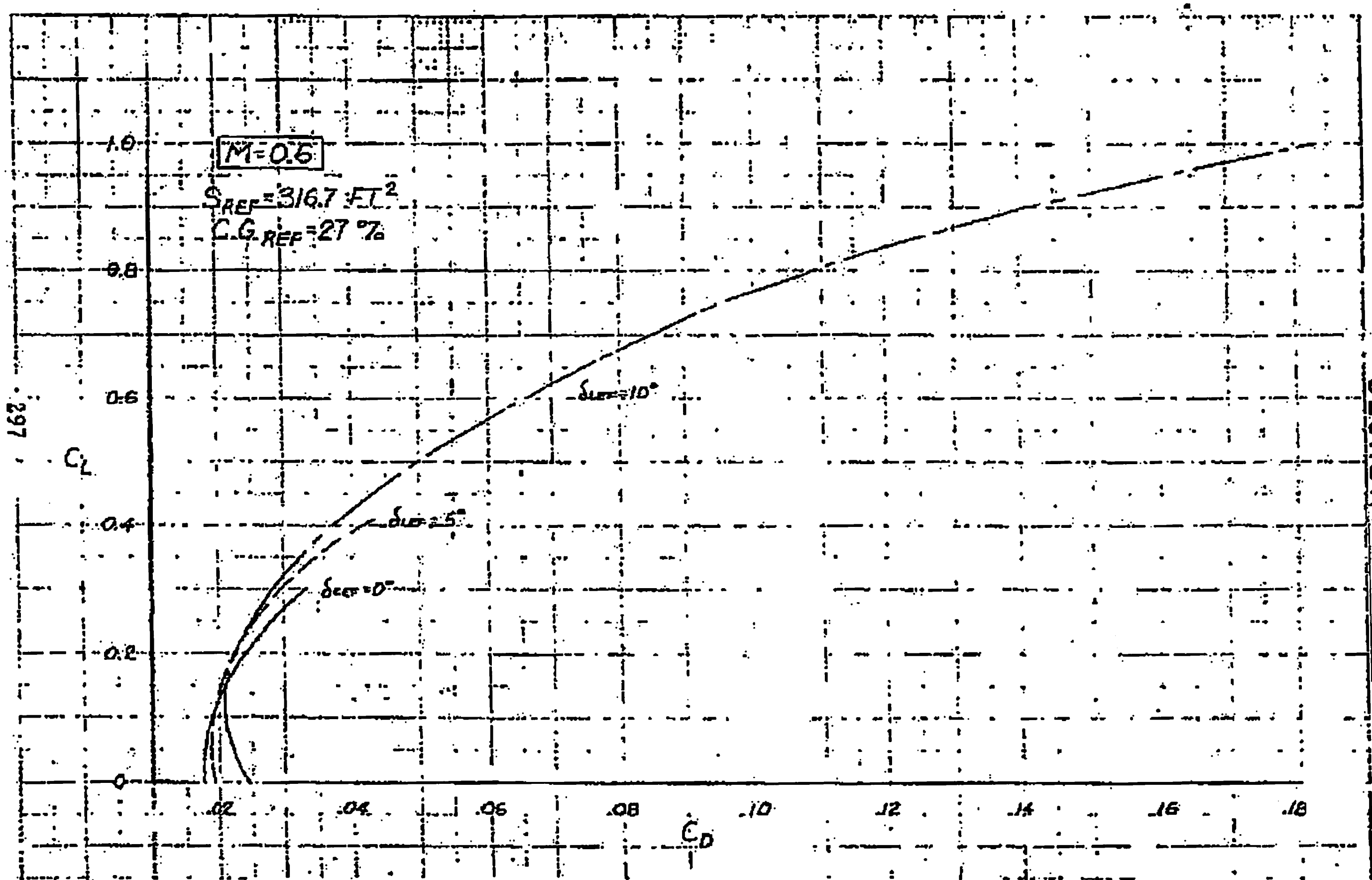
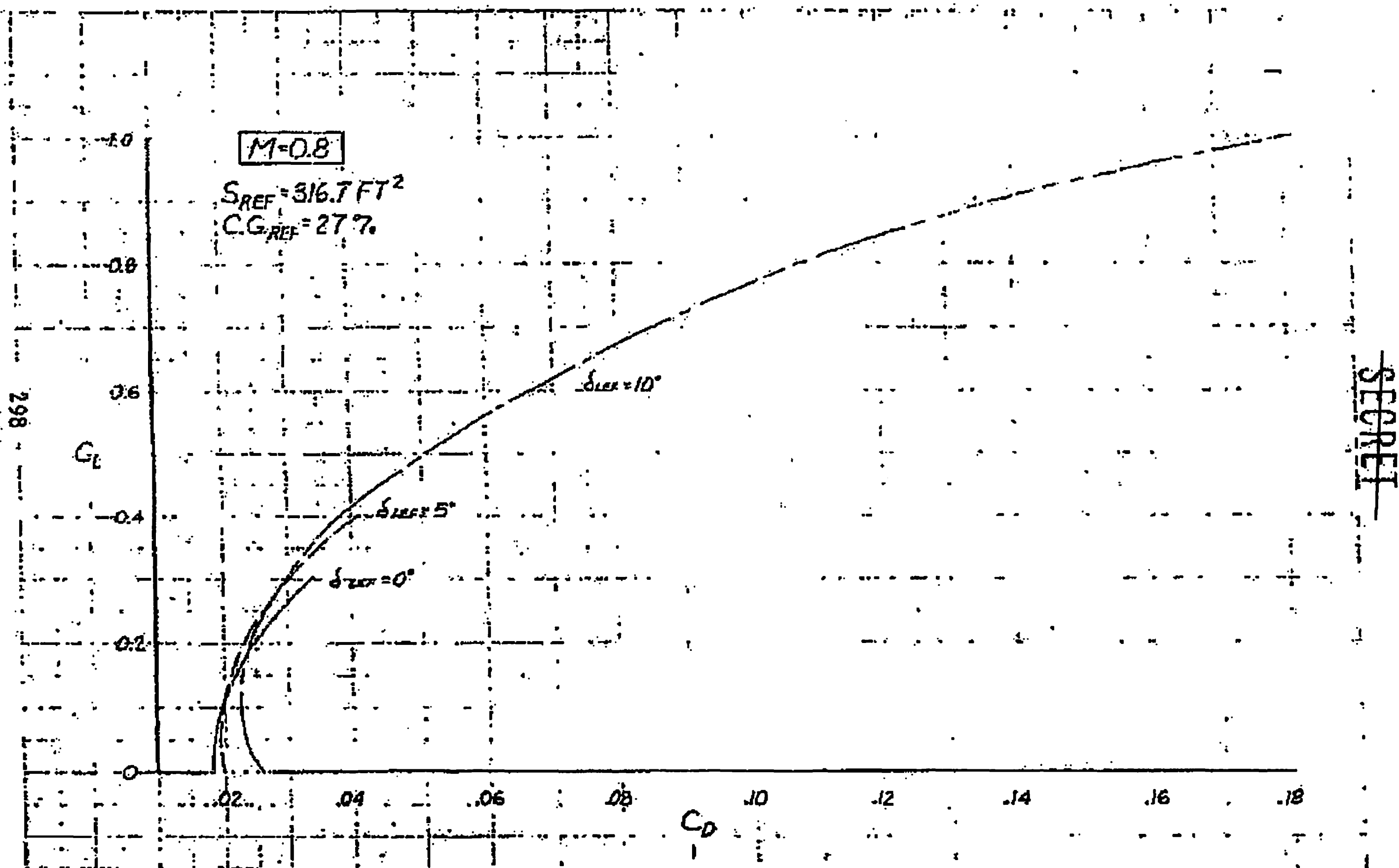
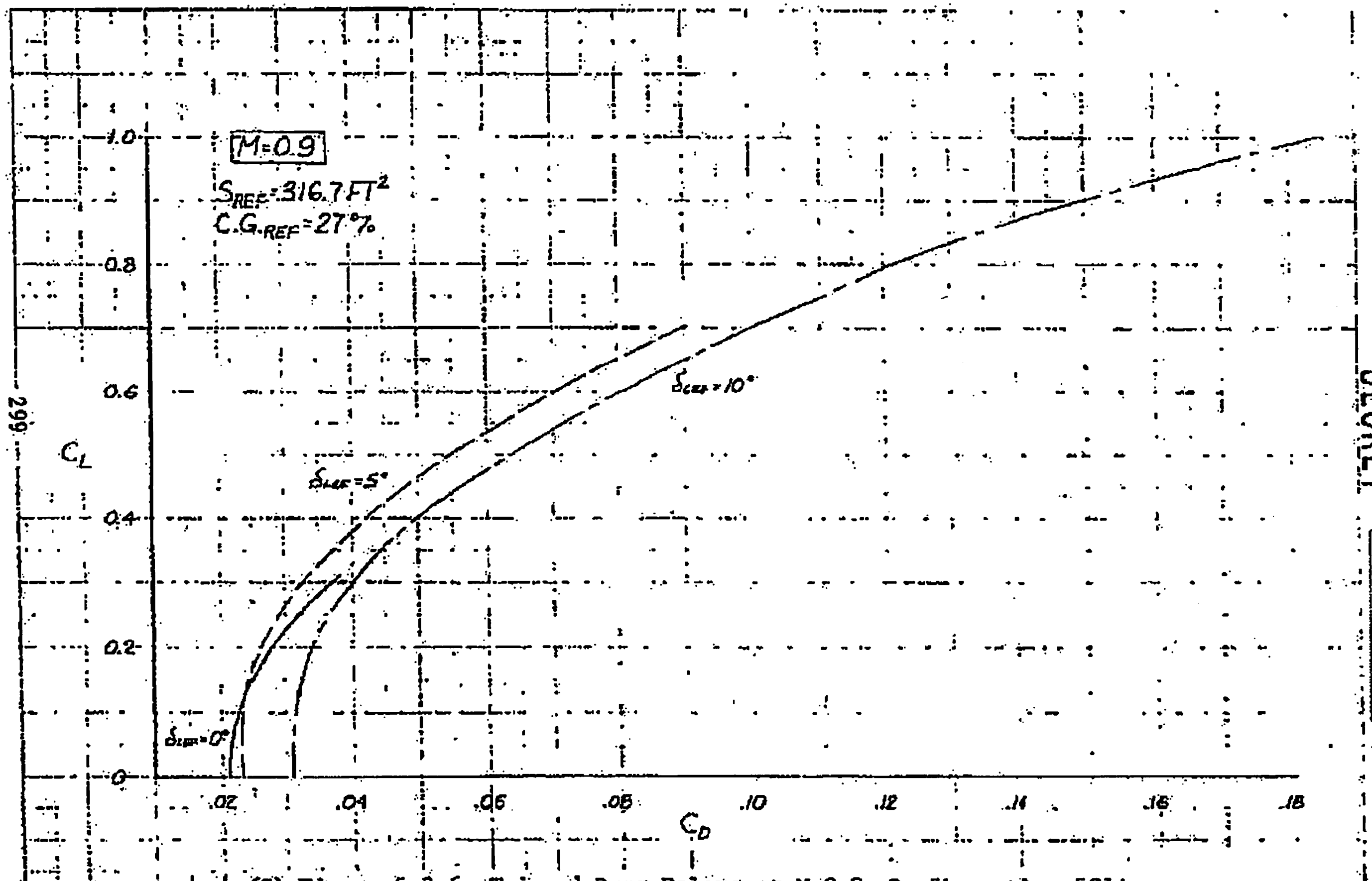


~~(S)~~ Figure 5.3-4 Trimmed Drag Polars at M=0.6, Configuration 501A



~~(S)~~ Figure 5.3-5 Trimmed Drag Polars at M=0.8, Configuration 501A

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.3-6 Trimmed Drag Polars at M=0.9, Configuration 501A

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

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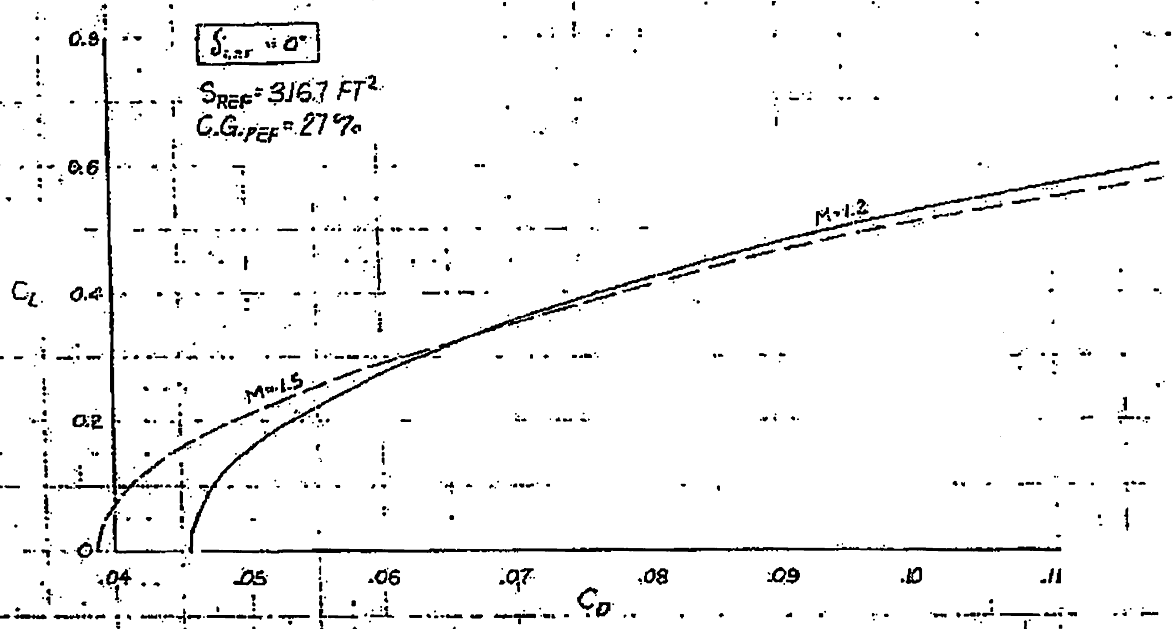

~~(S)~~ Figure 5.3-7 Trimmed Drag Polars at M=1.2 and 1.5, Configuration 501A

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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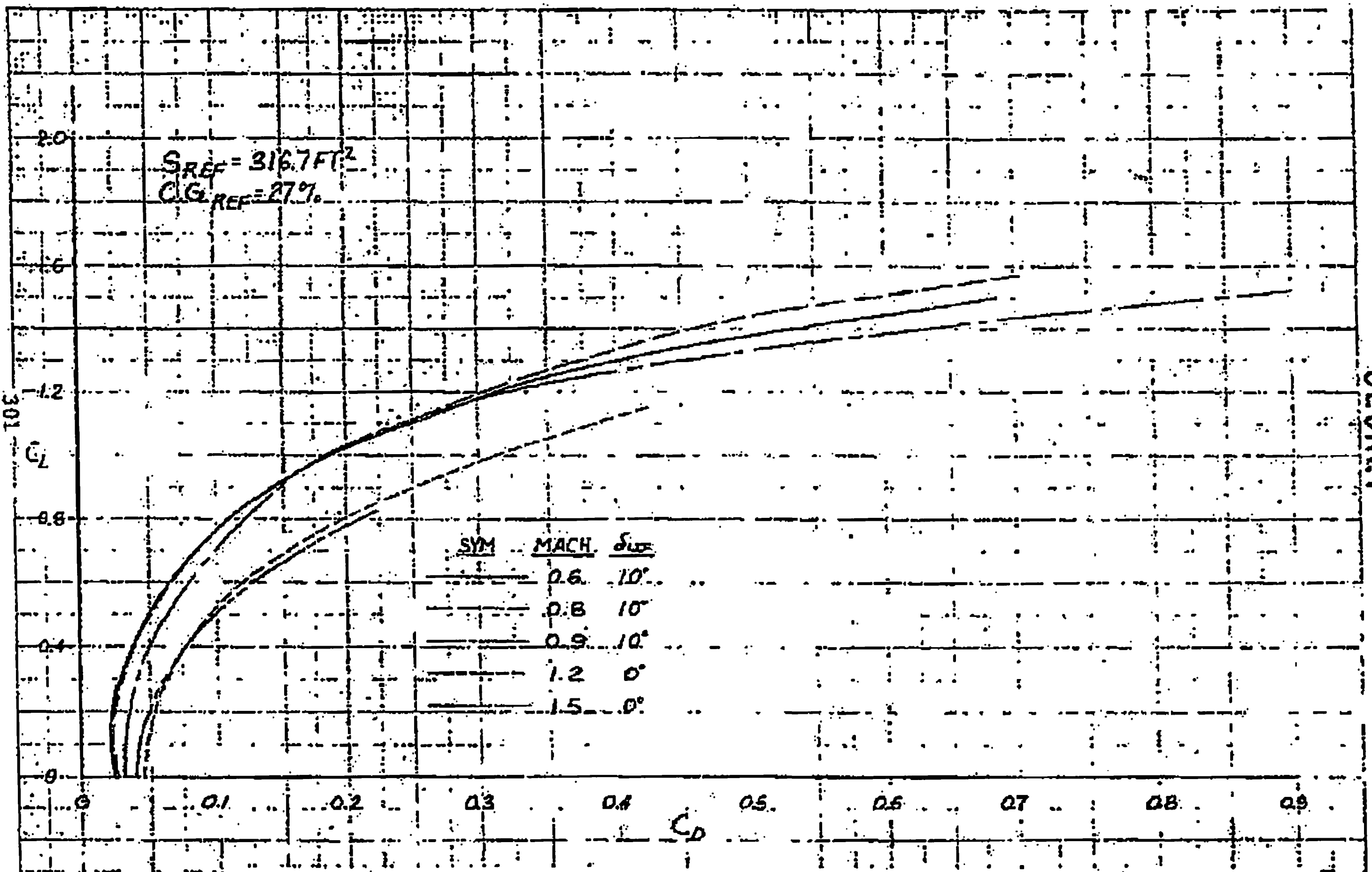

~~(S)~~ Figure 5.3-8 Trimmed Drag Polars at High C_L's, Configuration 501A

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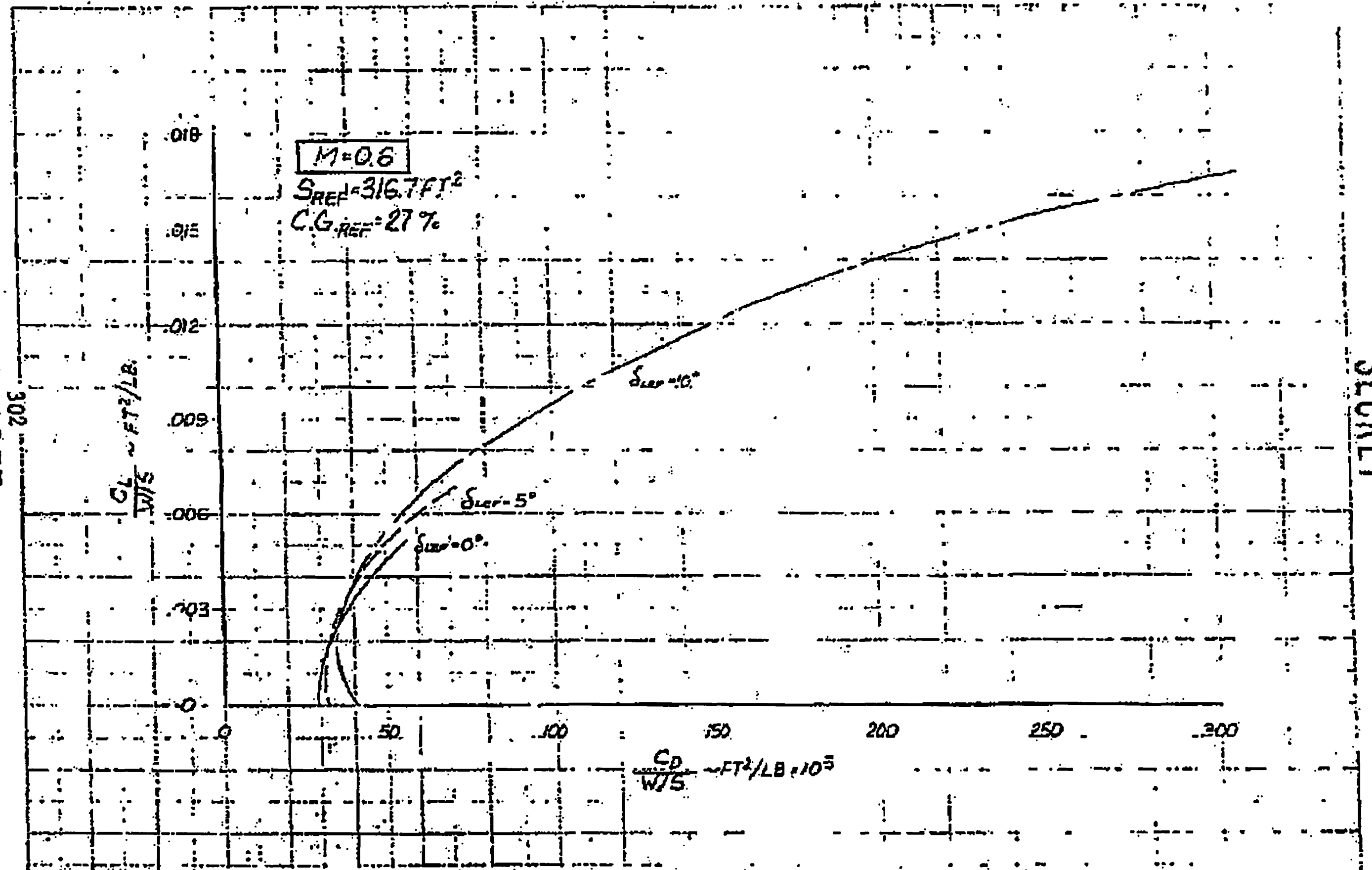

(S) Figure 5.3-9 Trimmed Configuration Polars at M=0.6, Configuration 501A

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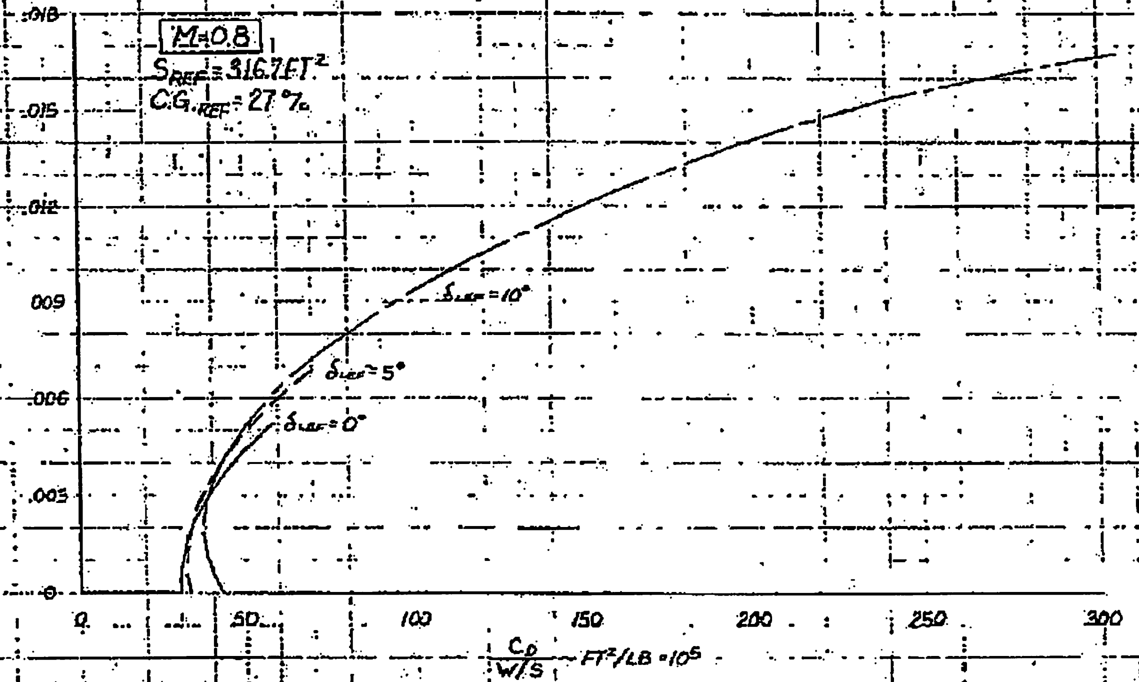
88th ABW/IPI
~~FOIA (b)(4)~~
E.O. 13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

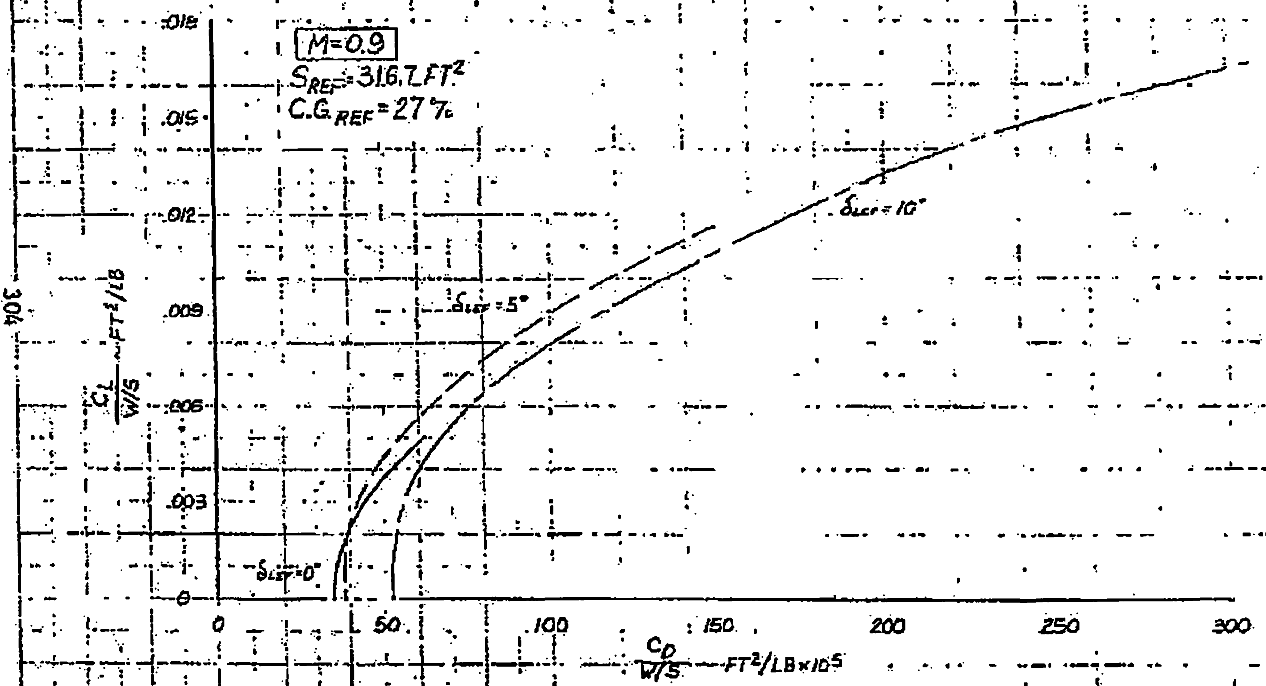
SECRET



(S) Figure 5.3-10 Trimmed Configuration Polars at M=0.8, Configuration 501A

SECRET

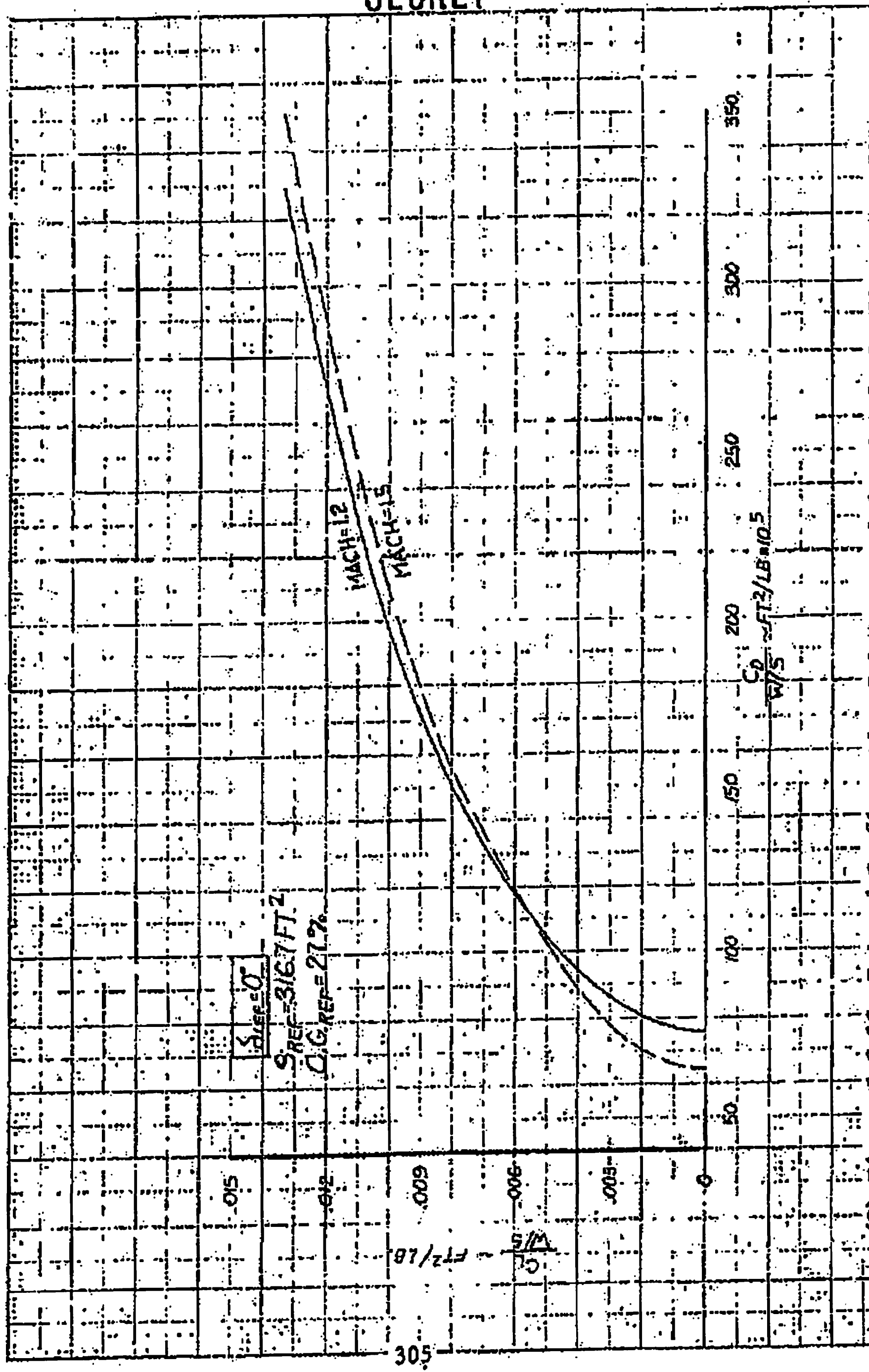
88th ABW/IP)
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 5.3-11 Trimmed Configuration Polars at M=0.9, Configuration 501A

88th
ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b

~~SECRET~~



~~(S)~~ Figure 5.3-12 Trimmed Configuration Polars at M=1.2 and 1.5, Configuration 501A

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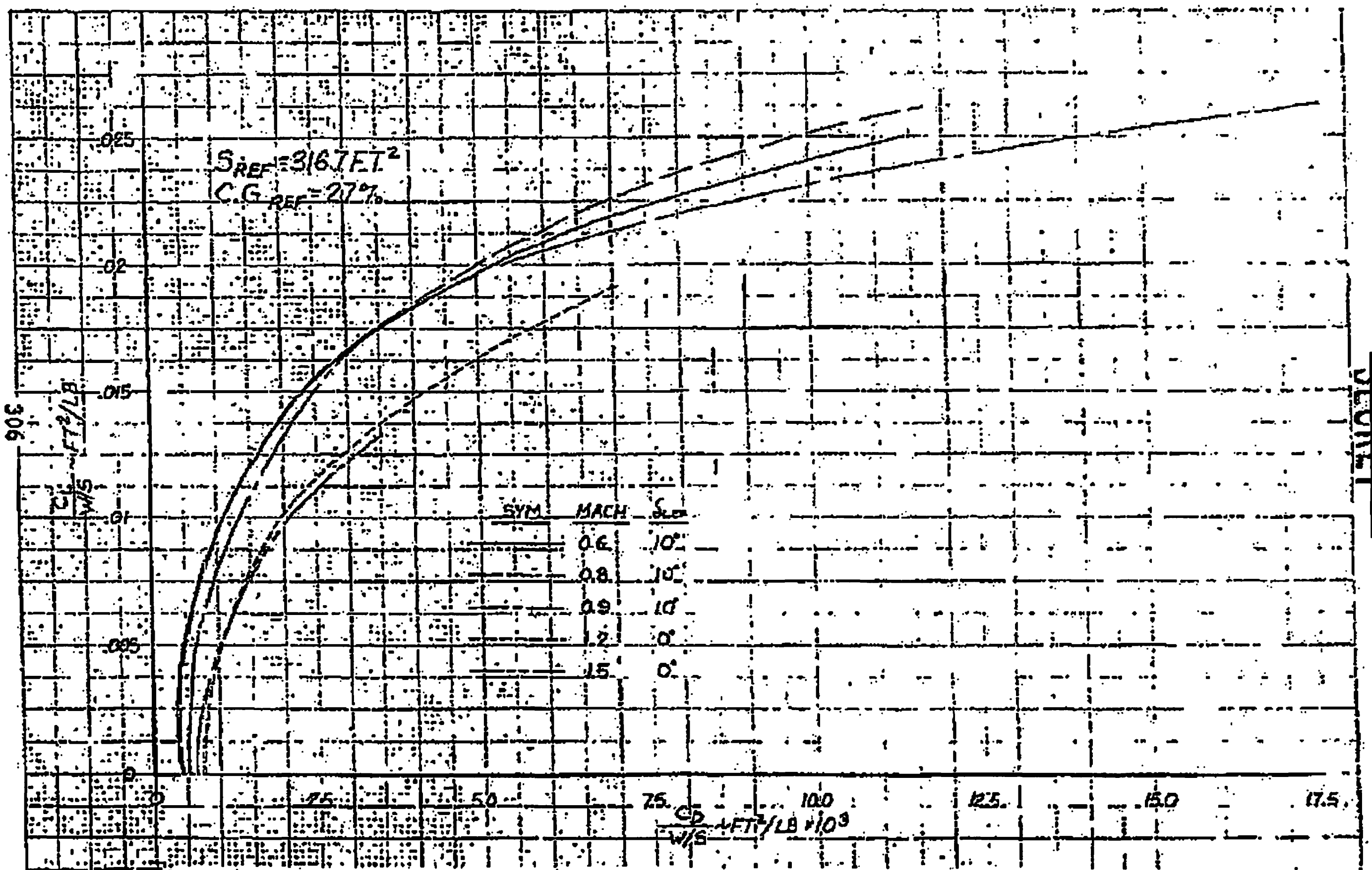


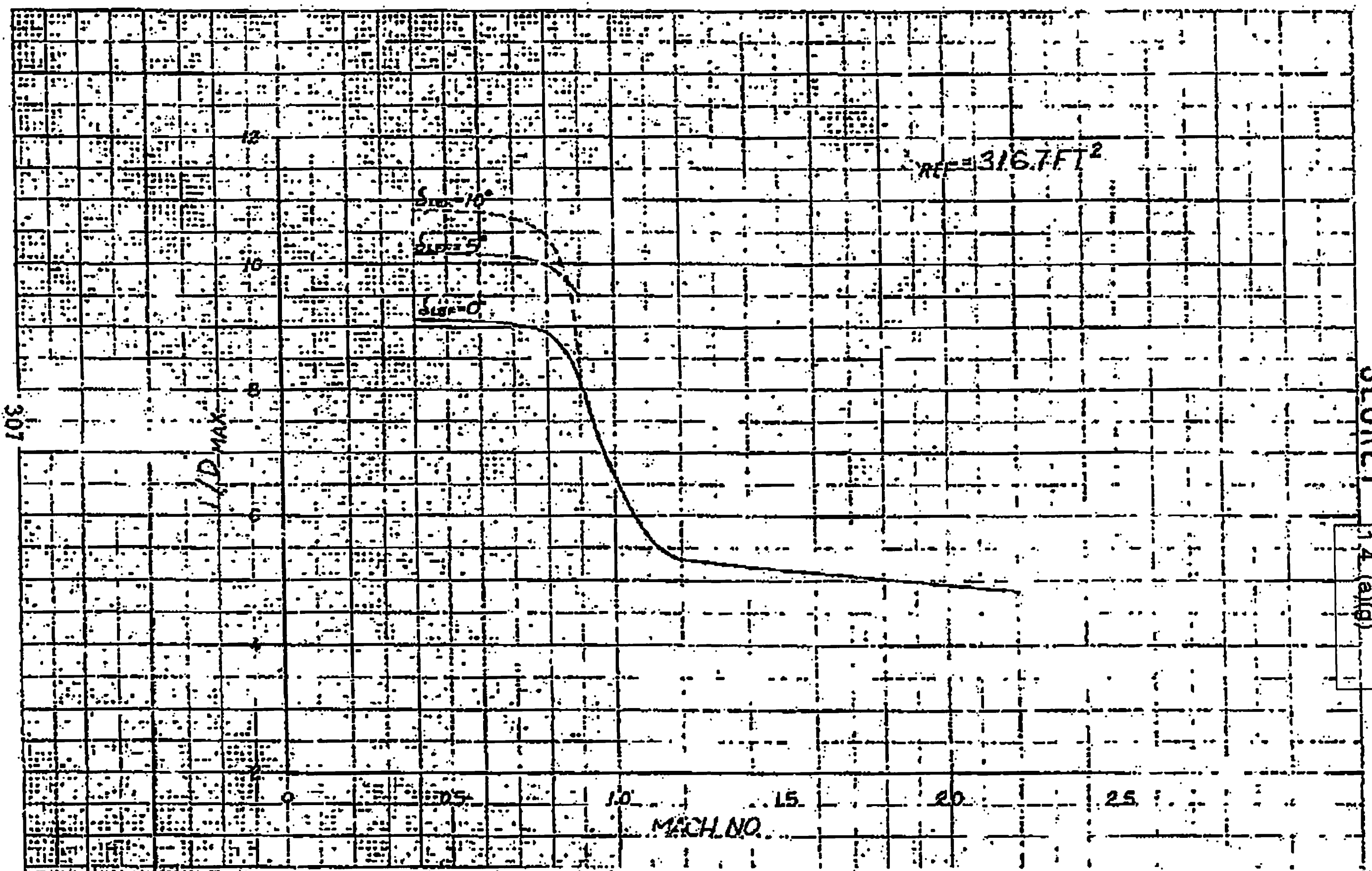
(S) Figure 5.3-13 Trimmed Configuration Polars at High C_L's, Configuration 501A

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526
SEC. 3.3.(b)
(4)
1.4 (a)(g)

~~SECRET~~

88th ABW/IPL
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)
(4)
1.4. (a)(g)



(S) Figure 5.3-14 Trimmed $(L/D)_{max}$ vs Mach Number, Configuration 501A

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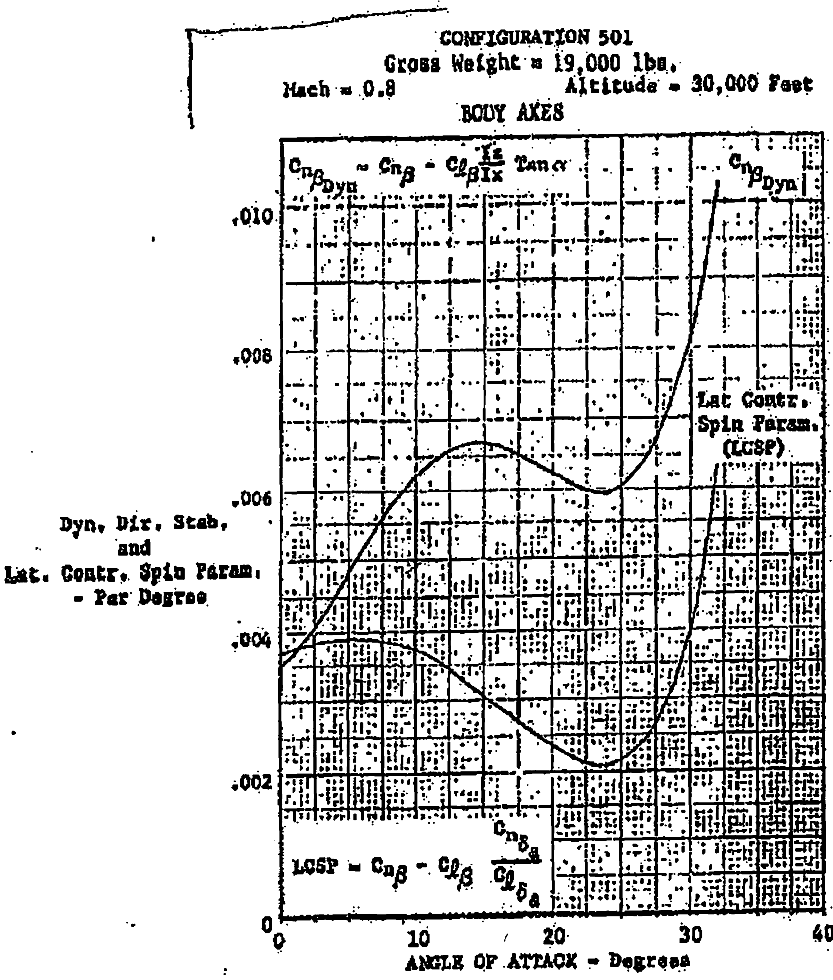
5.4 STABILITY, CONTROL, AND HANDLING QUALITIES

(U) The same basic stability and control and handling qualities design philosophy previously reported for the single-engine 401B configuration has been followed in development of the large twin-engine concept 501A configuration. Overall, the basic configurations are similar since the respective tail volume coefficients have been kept equivalent for the 401B single-engine and the 501A two engine design. The stability and control characteristics of the 501A will be basically the same as those presented for the 401B in Subsection 3.4.3. In general, no major difference can be expected in the handling qualities between the two designs as a result of the higher moment of inertias of the larger two-engine configuration. The dynamic directional stability parameter for Configuration 501A is plotted in Figure 5.4-1 along with the lateral-control spin parameter. When compared with similar curves for the 401B configuration (Figure 3.4-24), the 501A exhibits higher dynamic directional stability and, hence, higher spin resistance than the 401B. The higher spin resistance of configuration 501A is attributed to the higher ratio of yawing moment of inertia to rolling moment of inertia.

88th ABW/IRI
FOIA (b)(1)
E.O. 13526 SEC.
3.3 (b)(4)
1.4 (a)(g)

EO 13526 SEC 3.3 (b)(4) SEC 1.4 (a)(g)



~~(S)~~ Figure 5.4-1 Dynamic Directional Stability and Lateral Control Spin Parameter (U)

5.5 STRUCTURES AND WEIGHTS

~~(S)~~ Weight analysis for the Configuration 501A growth curve was performed in the same manner as for the Configuration 401B growth curve. Four airplanes were selected for analysis at design gross weights (in pounds) as shown below.

SRASM TOGW	(80% Fuel) Struct DGW	Ferry Mission Overload GW
16,800	15,940	27,000
19,000	18,100	29,200
22,000	21,040	32,200
24,000	23,000	34,200

(U) Input data for weight equations were derived from scaling data presented in Section 5.1 together with layouts as required to develop specific area and dimensional data.

~~(S)~~ A weight summary for each of the four selected airplanes is presented in Table 5.5-1. A plot of weight variation versus gross weight is shown in Figure 5.5-1. The center-of-gravity and inertia properties are summarized below for the 19,000-pound-gross-weight SRASM configuration.

Properties	Basic Operating Weight	Zero Fuel Weight	Gross Weight
Weight (lb)	14,107	14,740	19,000
Horiz. C.G. (% MAC)	22.7	21.2	20.6
I_{xx} (slug ft^2)	7543	8044	9104
I_{yy} (slug ft^2)	49,021	50,317	53,953
I_{zz} (slug ft^2)	53,676	55,444	59,952

~~(S)~~ A summary of the center-of-gravity conditions for the LRASM and ferry mission for the 19,000-pound-gross-weight configuration is as follows:

~~(S)~~

Item	LRASM Weight (lb)	LRASM C.G. (% MAC)	Ferry Mission Weight (lb)	Ferry Mission C.G. (% MAC)
Basic Operating Weight	14,955	22.3	15,797	21.8
Zero Fuel Weight	15,588	20.9	16,082	20.0
Gross Weight	23,838	19.8	29,200	18.8

Based on mission requirements, the airplane has been sized at a SRASM gross weight of 22,680 pounds. A weight summary for this configuration is presented in Table 5.5-2. The center-of-gravity conditions for this weight level are not included since they will not differ significantly from the center-of-gravity conditions shown above.

88th ABW/PI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.
(b)(4)
1.4.(a)(g)

(b)(1)
SEC 1.4
(a)(g)

~~(S)~~ Table 5.5-1 WEIGHT SUMMARY: CONFIGURATION 501A GROWTH STUDY (U) (pounds)

Item	Airplane Sizes 16,800GW	 19,000GW	 22,000GW	 24,000GW
Structure	(5,404)	(6,075)	(6,992)	(7,657)
Wing	1,474	1,725	2,058	2,303
Fuselage	2,604	2,832	3,152	3,381
Horizontal Tail	372	438	538	606
Vertical Tail	334	380	448	496
Landing Gear	620	700	796	871
Propulsion System	(4,458)	(4,617)	(4,792)	(4,881)
Engines (2) (J101-GE-100)	3,580	3,580	3,580	3,580
Air Induction	438	501	580	625
Fuel System	364	458	552	595
Engine Controls	36	38	40	41
Starting System	40	40	40	40
Systems and Equipment	(2,820)	(2,933)	(3,072)	(3,158)
Surface Controls	613	661	724	762
Landing Gear Controls	116	128	143	154
Instruments	109	109	109	109
Hydraulics & Pneumatics	296	327	368	395
Electrical	386	408	428	438
Avionics	460	460	460	460
Furnishings	245	245	245	245
Air Conditioning	142	142	142	142
Armament	453	453	453	453
Weight Empty	12,682	13,625	14,856	15,696
Useful Load	(389)	(396)	(406)	(410)
Crew	200	200	200	200
Unusable Fuel	15	22	32	36
Engine Oil	20	20	20	20
Missile Racks and Pylons	124	124	124	124
Miscellaneous	30	30	30	30
Basic Operating Weight	13,071	14,021	15,262	16,106
Payload	(633)	(633)	(633)	(633)
Ammo (500 rounds)	285	285	285	285
Missiles (2)	348	348	348	348
Zero Fuel Weight	13,704	14,654	15,895	16,739
Fuel	3,096	4,346	6,105	7,261
Gross Weight	16,800	19,000	22,000	24,000

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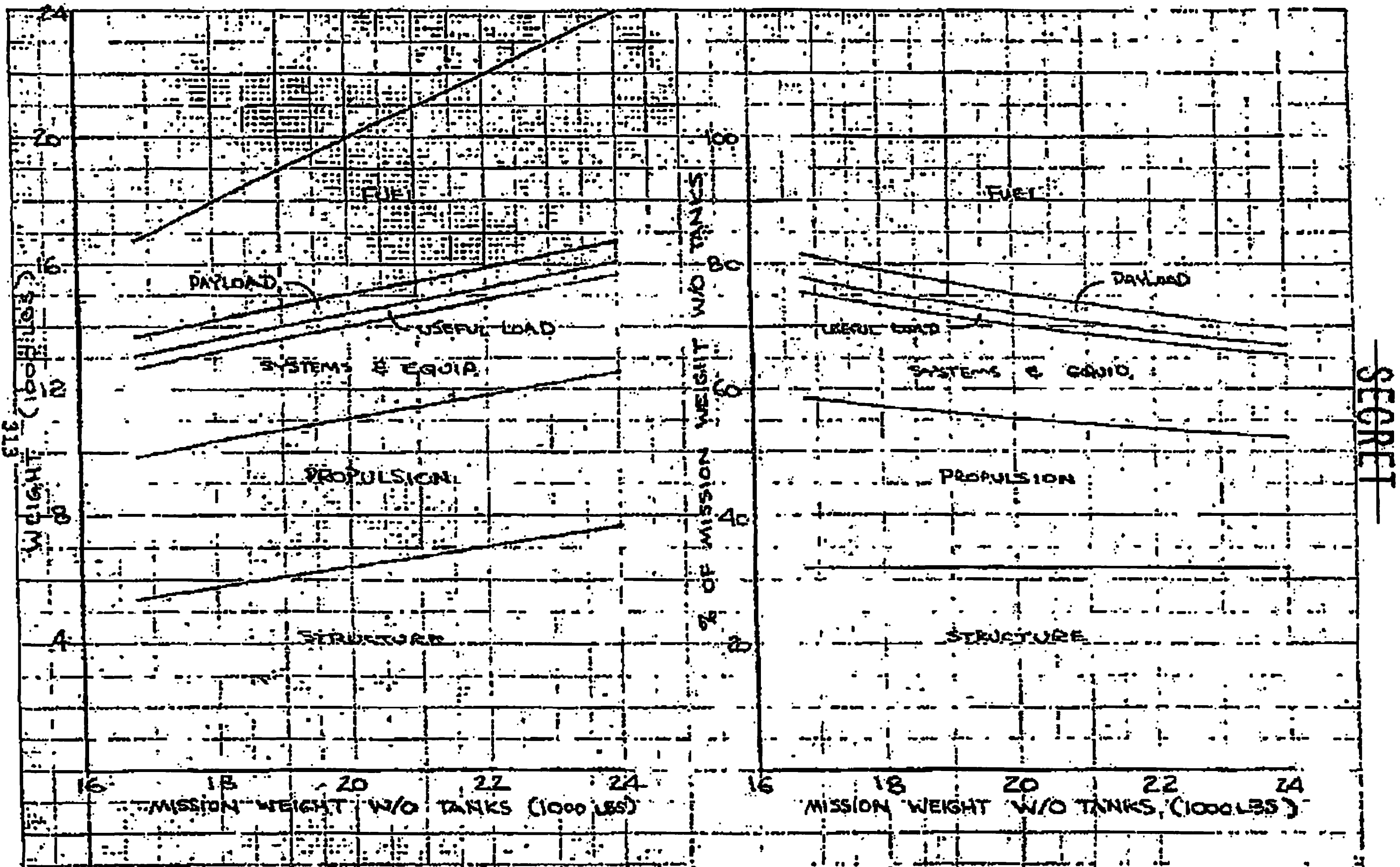

~~(S)~~ Figure 5.5-1 Weight Variation with Aircraft Size: Configuration 501A (U)

SECRET

~~(S)~~ Table 5.5-2 WEIGHT SUMMARY: CONFIGURATION 501A SIZED TO MEET LRASM REQUIREMENTS (pounds) (U)

Item	Weight
Structure	(7209)
Wing	2145
Fuselage	3233
Horizontal Tail	545
Vertical Tail	463
Landing Gear	823
Propulsion System	(4822)
Engine (2) (J101-GE-100)	3580
Air Induction	595
Fuel System	567
Engine Controls	40
Starting System	40
Systems and Equipment	(3112)
Surface Controls	740
Landing Gear Controls	145
Instruments	109
Hydraulics and Pneumatics	380
Electrical	438
Avionics	460
Furnishings	245
Air Conditioning System	142
Armament	453
Weight Empty	15,143
Useful Load	(406)
Crew	200
Unusable	32
Engine Oil	20
Missile Racks and Pylons	124
Miscellaneous	30
Basic Operating Weight	15,549
Payload	(633)
Ammo (500 rounds)	285
Missiles (2)	348
Zero Fuel Weight	16,182
Fuel	6498
Gross Weight	22,680

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4 (a)(g)

EO 13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)

5.6 PROPULSION (501A/J101-GE-100)

(U) Two General Electric continuous-bleed turbojets, J101-GE-100, are installed in the Configuration 501 airplane. This is geometrically the same engine, including the exhaust nozzle, that is installed in the Configuration 403 airplane (see Section 4.6). However, the engine performance data furnished by General Electric are more recent than those used in the analysis of Configuration 403.

(U) In this section, the J101-GE-100 propulsion system performance data are presented for the engines installed in the airplane. The effects of installation are accounted for in the data explained below.

(U) Subsequent to the analysis of the J101-GE-100, General Electric described a lower-weight J101 having a revised cycle (referred to as the 7/23 cycle). The thrust is increased and the specific fuel consumption is reduced. The new weight is 4.8% lower, and the sea-level-static rated thrust is 4.3% higher. Cruise TSFC is about 4% lower. Since this information only became known at the end of the reporting period, time did not permit evaluation of the 7/23 cycle.

(U) The engines are located side by side in the aircraft aft fuselage, with primary airflow delivered to each engine by an open-nose inlet. The airplane has two independent inlets and ducts, one for each engine.

(U) A small amount of ventilation air flows into and out of the nacelles in a manner similar to that of the single-engine configuration. The drag for this airflow is assumed to be the same as that for the single-engine configuration and is accounted for in the airplane drag.

5.6.1 Propulsion System Performance

(U) The installed thrust specific fuel consumption, TSFCS, and propulsion system net thrust, F_{NS}, are presented in Figures 5.6-1 through 5.6-13 for each engine of the Configuration 501 airplane. The data shown comprise a complete package needed for airplane energy-maneuverability analysis.

(U) The definition of F_{NS} is the same as that given in Subsection 3.6.1, except for the sources of the data employed.

(U) The installed net-thrust values, F_N, are taken from data supplied by GE in References 27 and 28. The GE data takes into account the inlet pressure recovery, compressor bleed for ECS, and power extraction specified by Convair. The exhaust nozzle drag, per engine, is assumed to be the same as that for the Configuration 403 airplane. (see Subsection 4.6.3)

5.6.2 Inlet

(U) The Configuration 501 inlet system consists of two separate inlets located on either side of the fuselage with separate ducts to each engine. The inlet sizing criteria and performance data are the same as described in Subsection 4.6.2 for Configuration 403/J101-GE-100. The inlet design rationale is essentially the same as for Configuration 401B/F100-PW-100 (Subsection 3.6.2). D-shaped inlets were chosen for Configuration 501 (as opposed to elliptical) to minimize the boundary-layer diverter.

5.6.3 Shaft Power and Compressor Bleed Extraction

(U) Power is extracted through the engine gear-box power-take-off shaft to drive the airplane electric generator and hydraulic pumps. The estimated value of total power extraction is 70 hp for the airplane, or 35 hp from each engine. The installed propulsion system performance data (each engine) accounts for 35 hp at all flight conditions and power settings.

(U) High-pressure bleed air is extracted from the compressors for operating the environmental control system. The bleed air-flow rate is estimated to be 0.4 lbm/sec for the airplane, or 0.2 lbm/sec from each engine. The installed propulsion system performance data (each engine) accounts for 0.2 lbm/sec at all flight conditions and power settings.

(U) During ground operation the bleed flow is estimated to be 1.2 lbm/sec for the airplane. The installed propulsion system performance data during takeoff accounts for 0.6 lbm/sec from each engine.

88th ABW/IPI
~~FOIA (b)(1)~~
E.O. 13526, SEC 3.3(b)(4)
1.4 (a)(g)(b)(1)
EO 13526 SEC 3.3(b)(4)
SEC 1.4 (a)(g)

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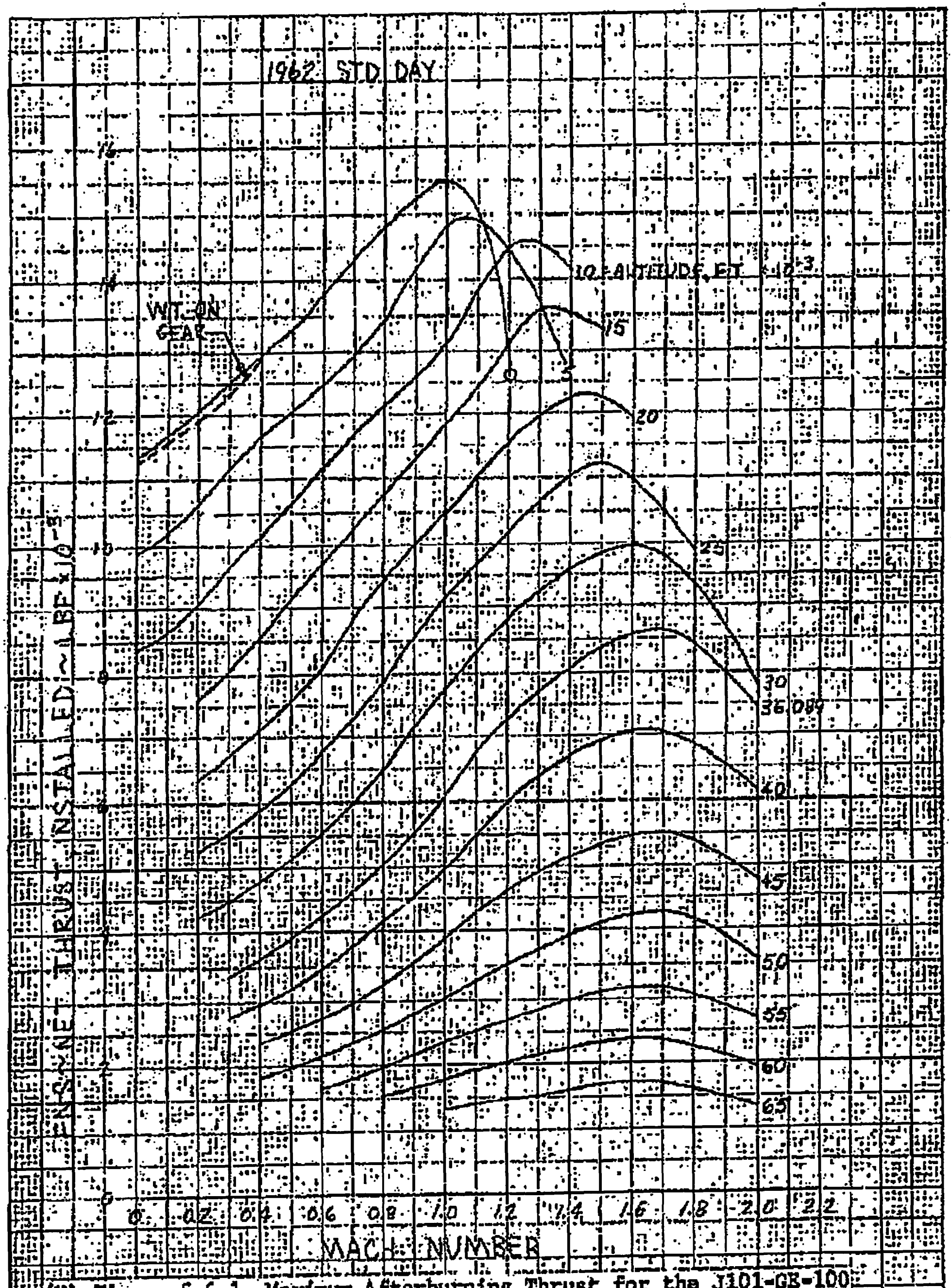
TCRA-23 83-0060 8-3-71



(U) Figure 5.6-1 Maximum Afterburning Thrust for the J101-GE-100 Installed in Configuration 501

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3(b)(4)
1.4. (a)(g) (b)(1)
EO 13526 SEC. 3.3(b)(4)
SEC 1.4 (a)(g)

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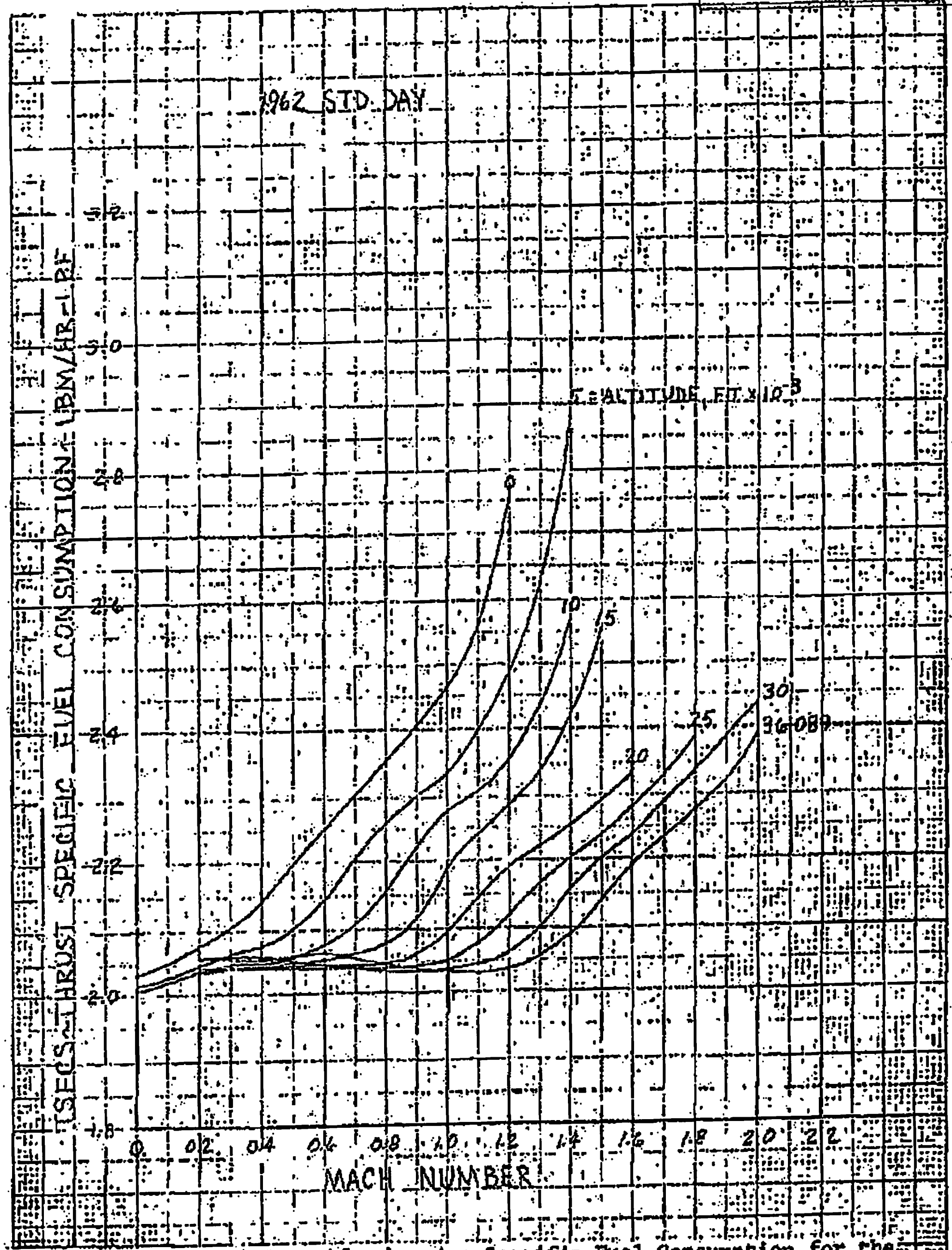
318-329

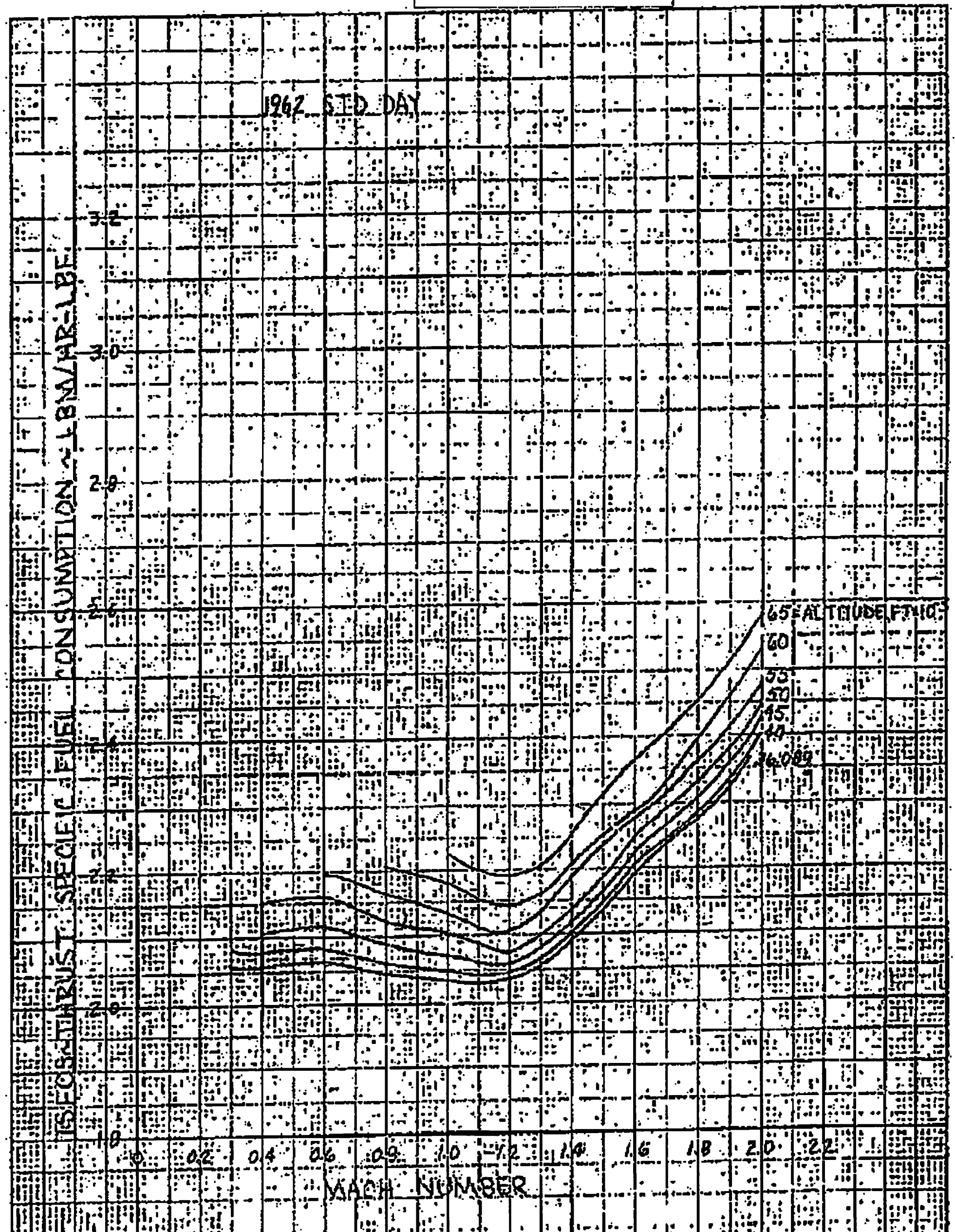


(U) Figure 5.6-2 Maximum Afterburning Specific Fuel Consumption for the J101-GE-100 Installed in Configuration 501, Sea Level to 36,089 feet

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)

PSCC AV-71-005

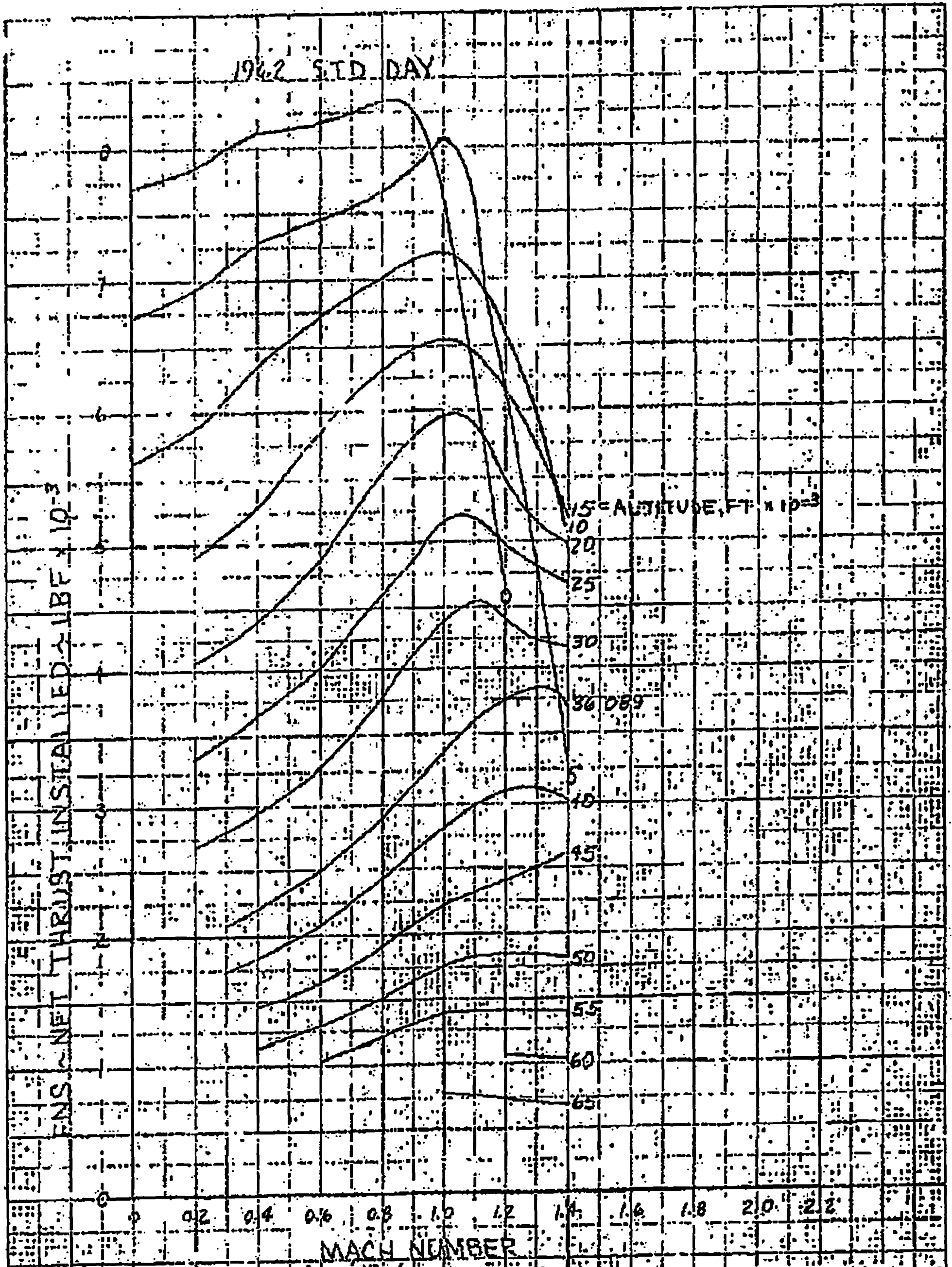
71PA-2383-010 9-3-71



(U) Figure 5.6-3 Maximum Afterburning Specific Fuel Consumption for the J101-GE-100 Installed in Configuration 501, 36,089 to 65,000 feet

PSCC AV-71-005

71PA-2583-011 9-3-71

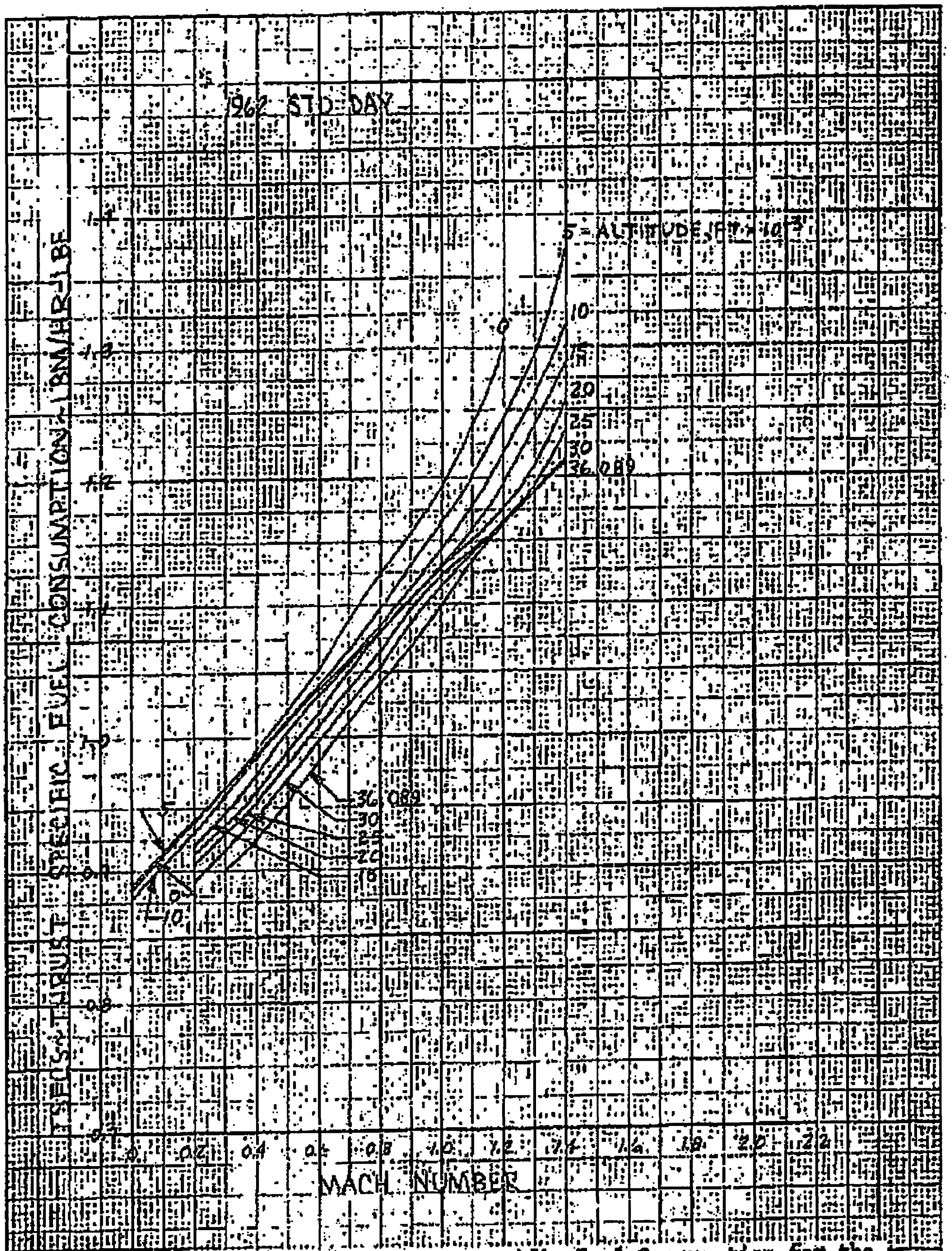


(U) Figure 5.6-4 Intermediate Power Thrust for the J101-GE-100 Installed in Configuration 501

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

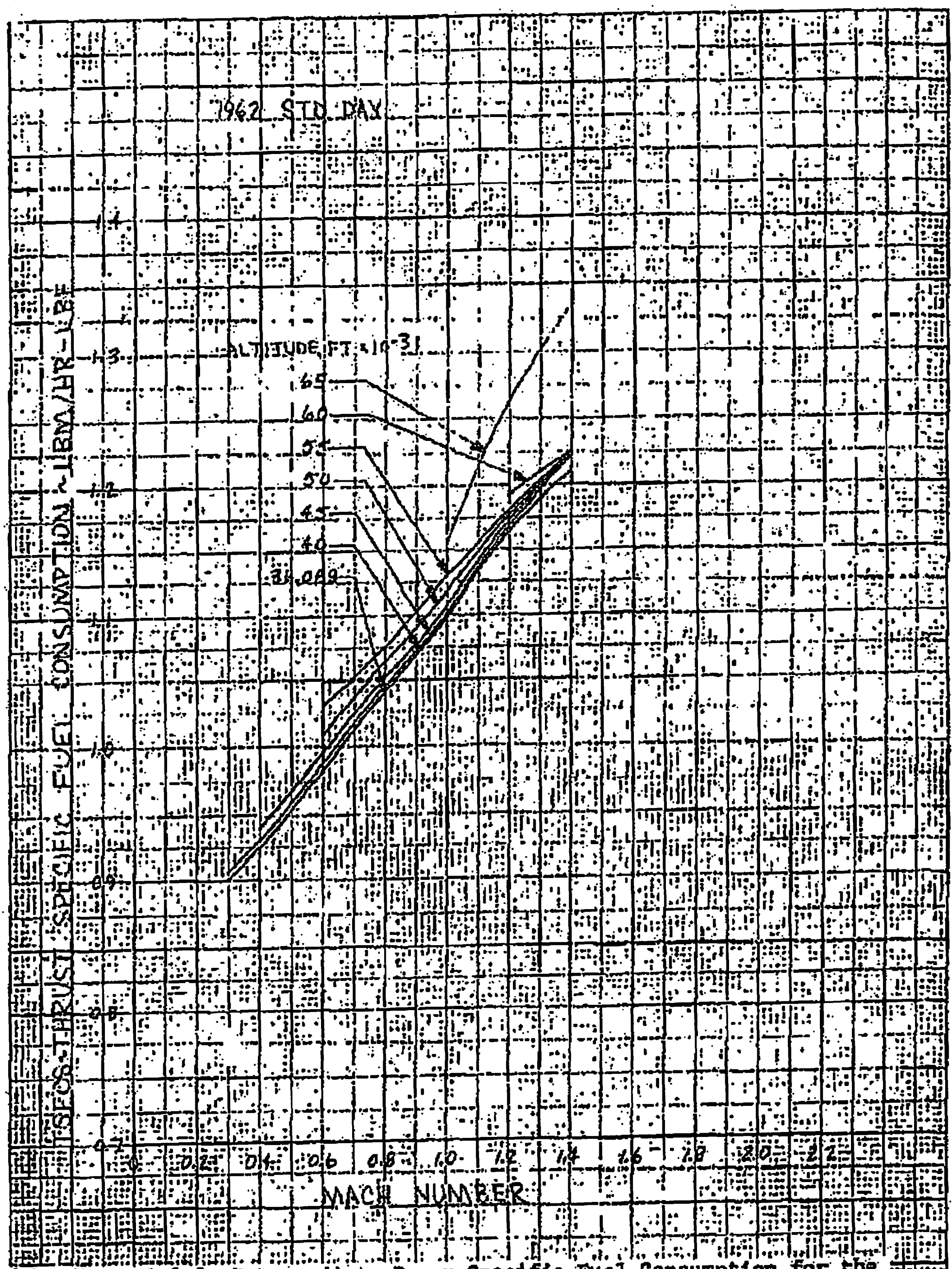
Tsec AY-71-005

71PA-2383-012 9-8-71



(U) Figure 5.6-5 Intermediate Power Specific Fuel Consumption for the J101-GE-100 Installed in Configuration 501, Sea Level to 36,089 feet

88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC.~~
3.3.(b)(4)
1.4. (a)(g)

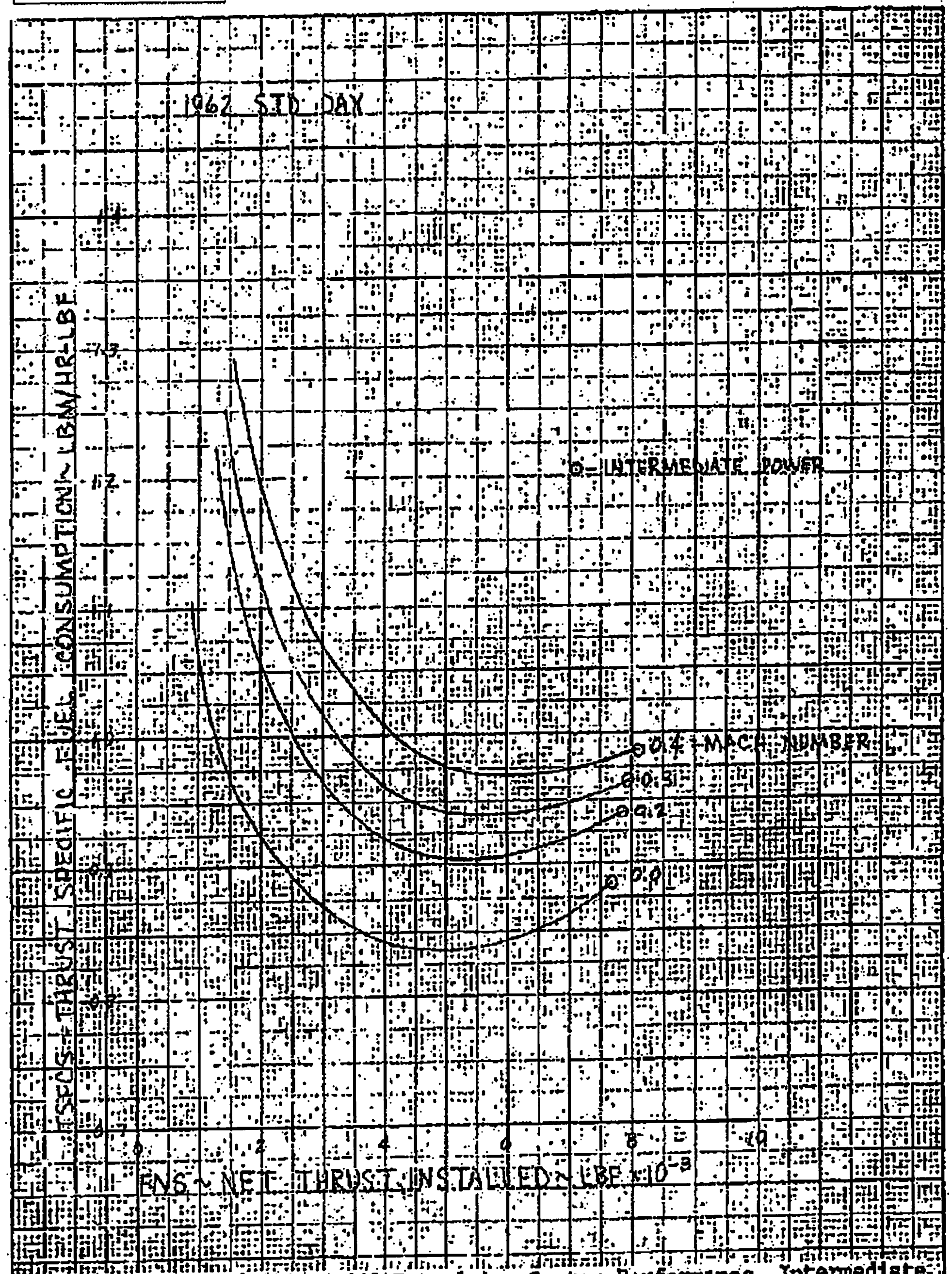


(U) Figure 5.6-6 Intermediate Power Specific Fuel Consumption for the J101-GE-100 Installed in Configuration 501, 36,089 to 65,000 feet

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

PSCC AV-71-005

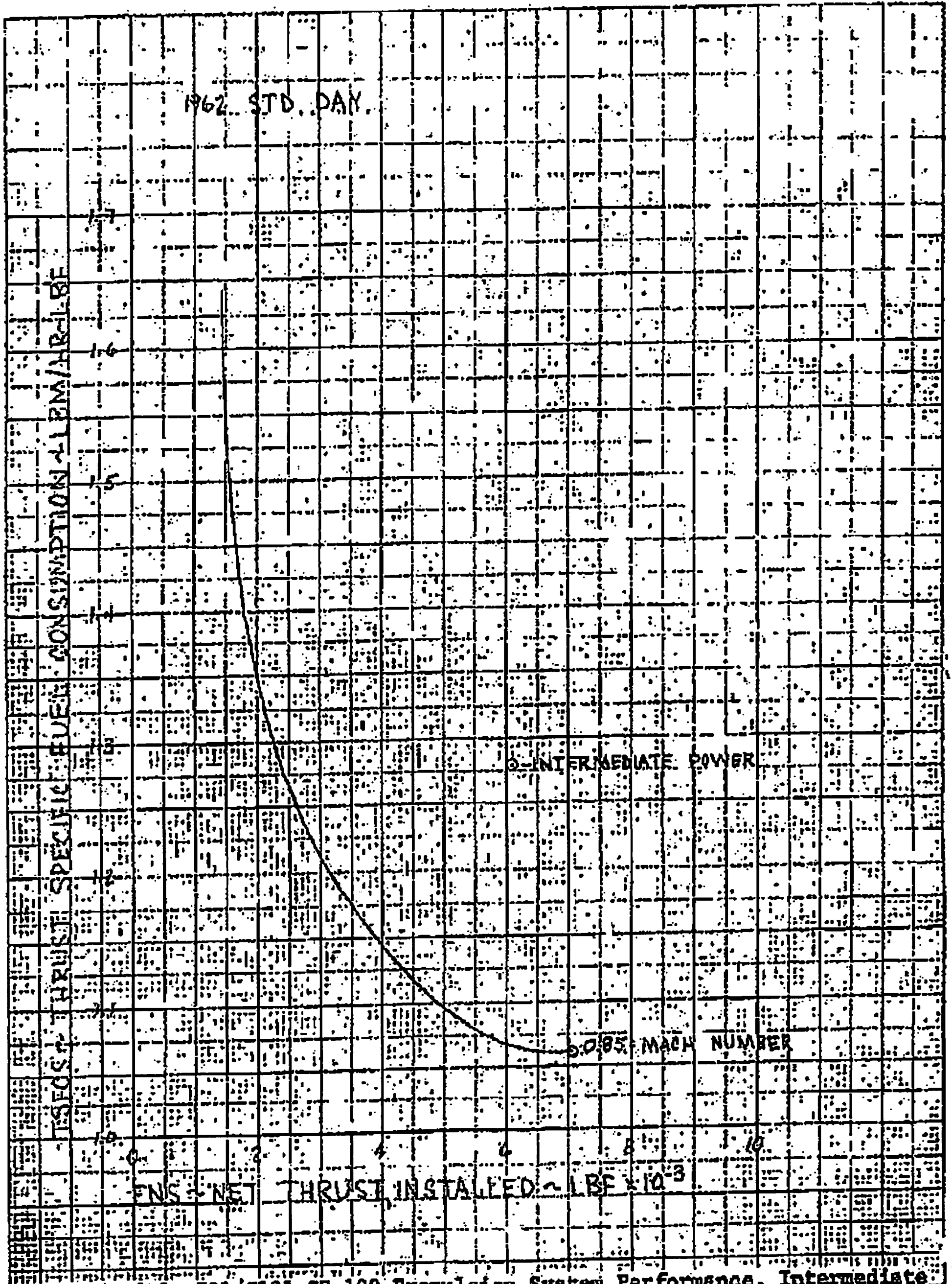
71PA-2383-014 9-5-71



(U) Figure 5.6-7 501/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Power, Sea Level

PSCC AV-71-005

71PA-2383-015 4-9-71

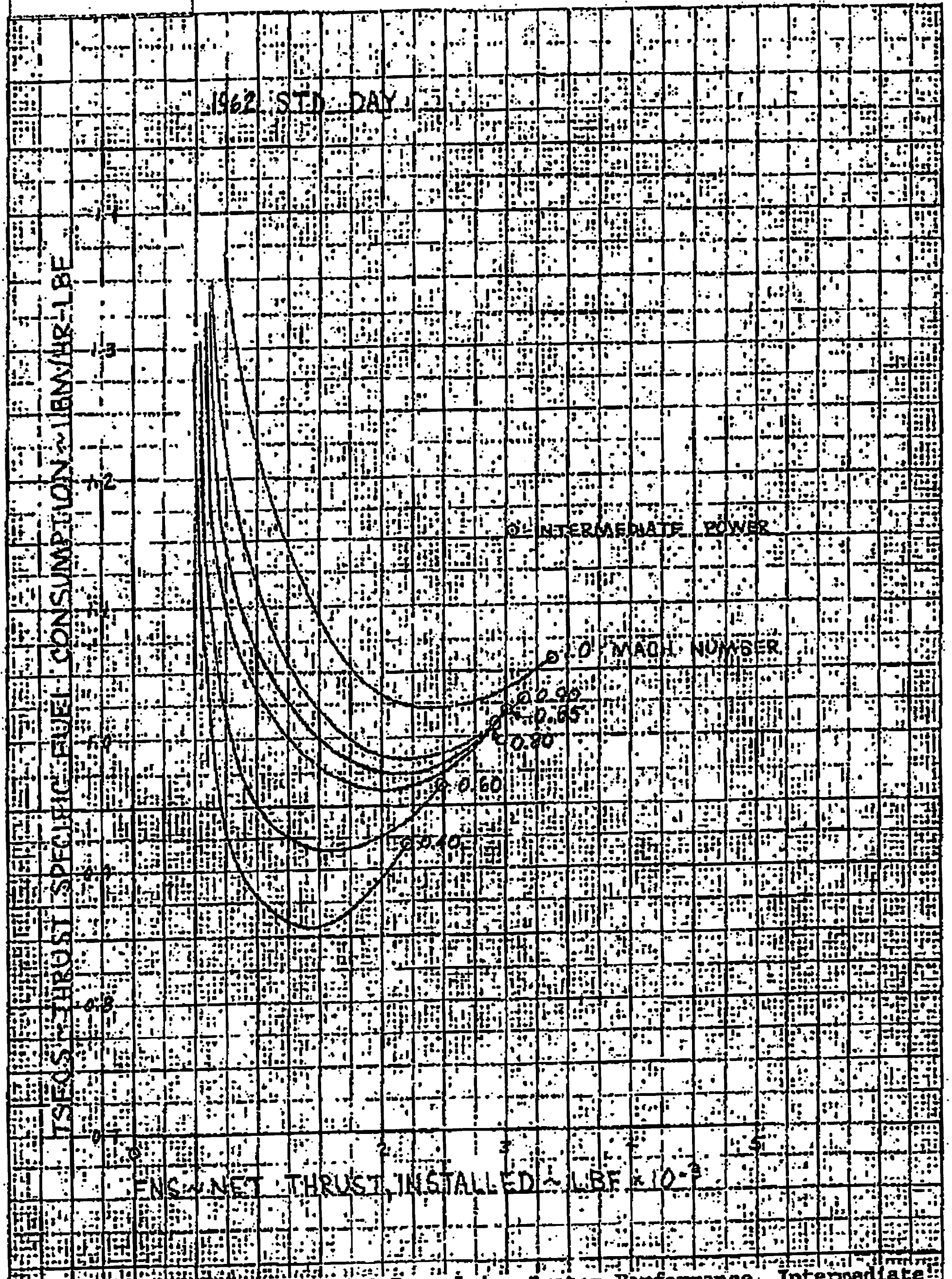


(U) Figure 5.6-8 501/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 10,000 feet

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

PSCC-AV-71-005

71 PA-2383-016 9-3-71



(U) Figure 5.6-9 501/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 36,089 feet

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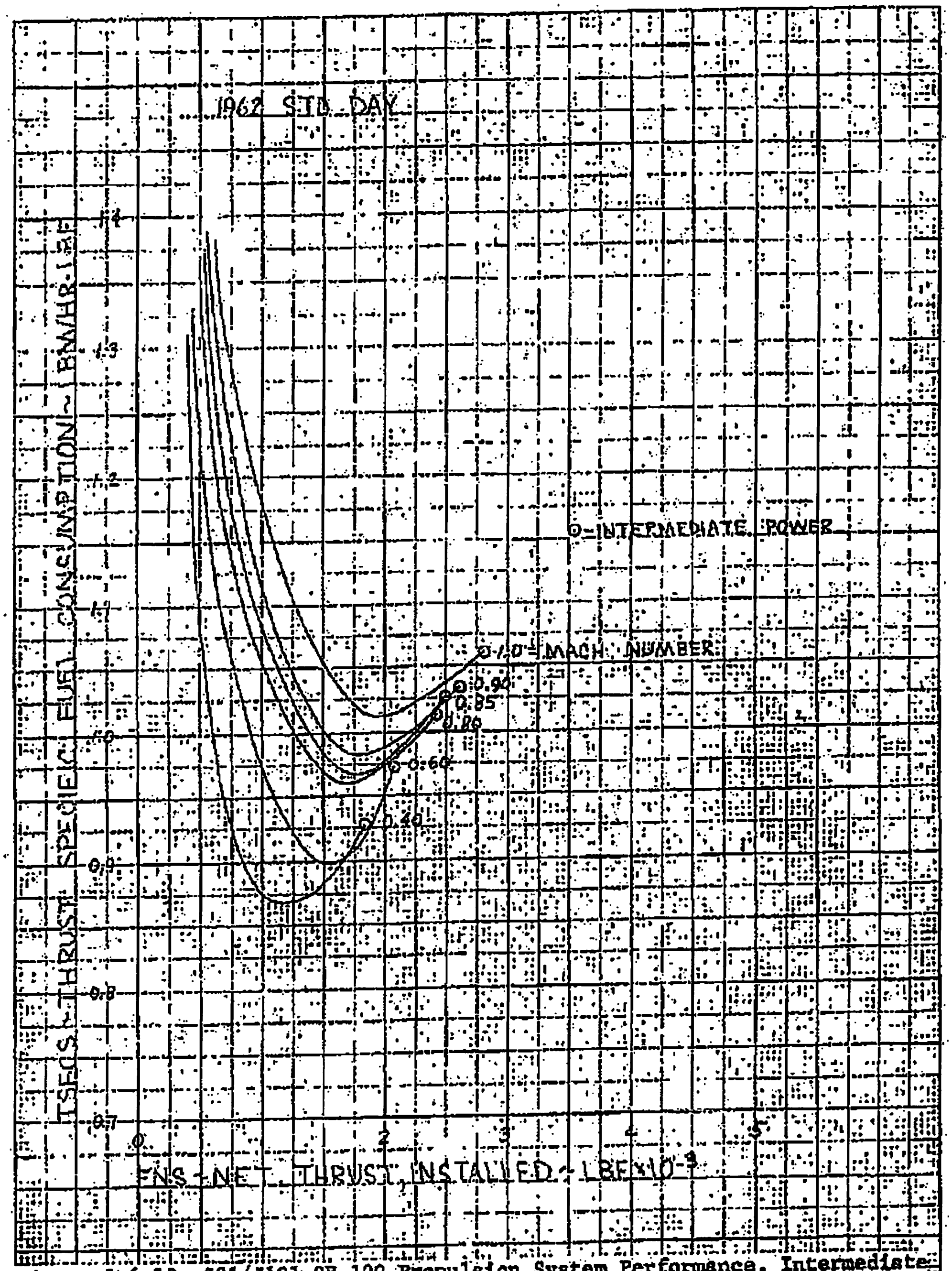
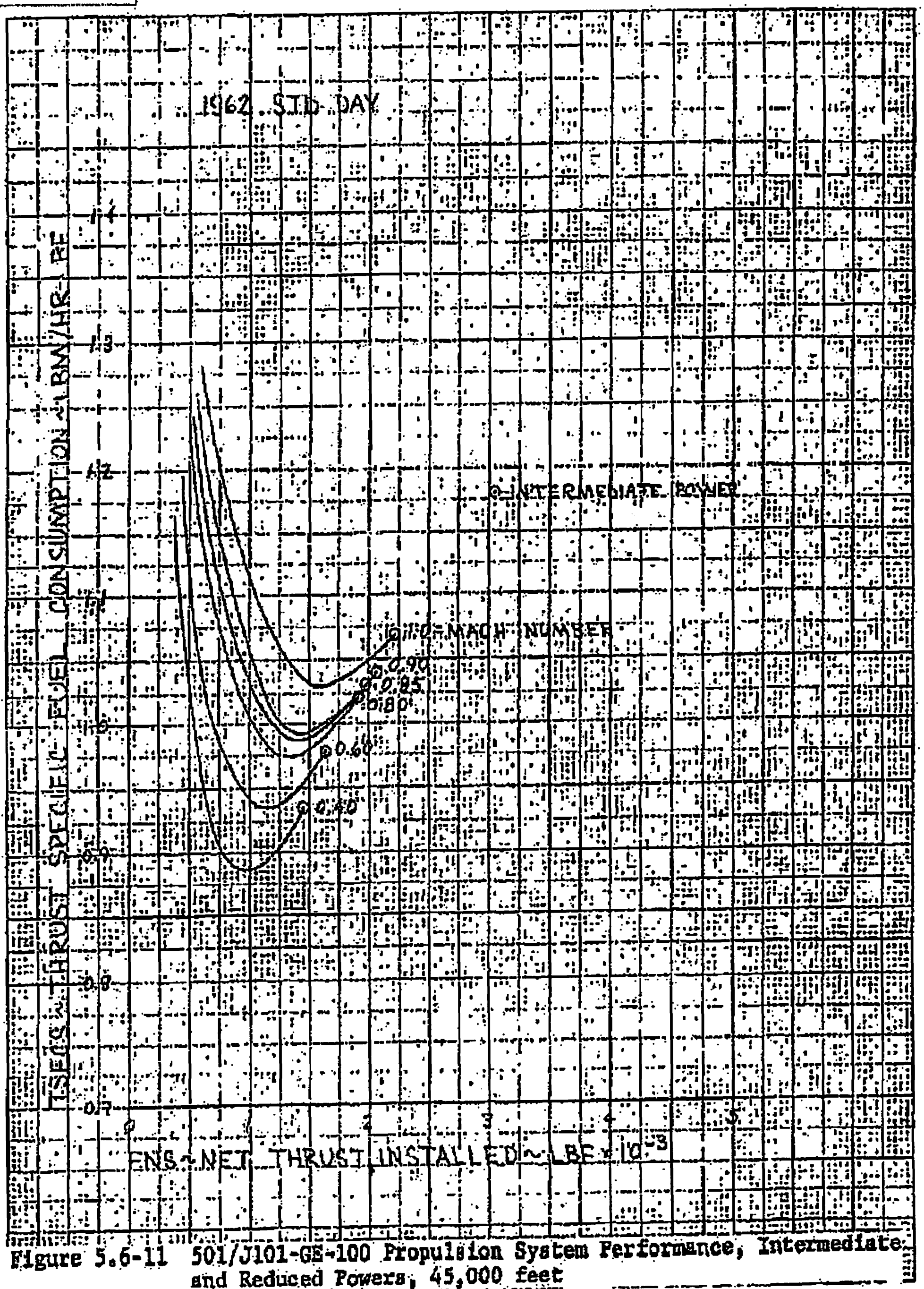
PSCC AV-71-005



(U) Figure 5.6-10 501/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 40,000 feet

71PA-2383-018 9-3-71

TSCC AV-71-005

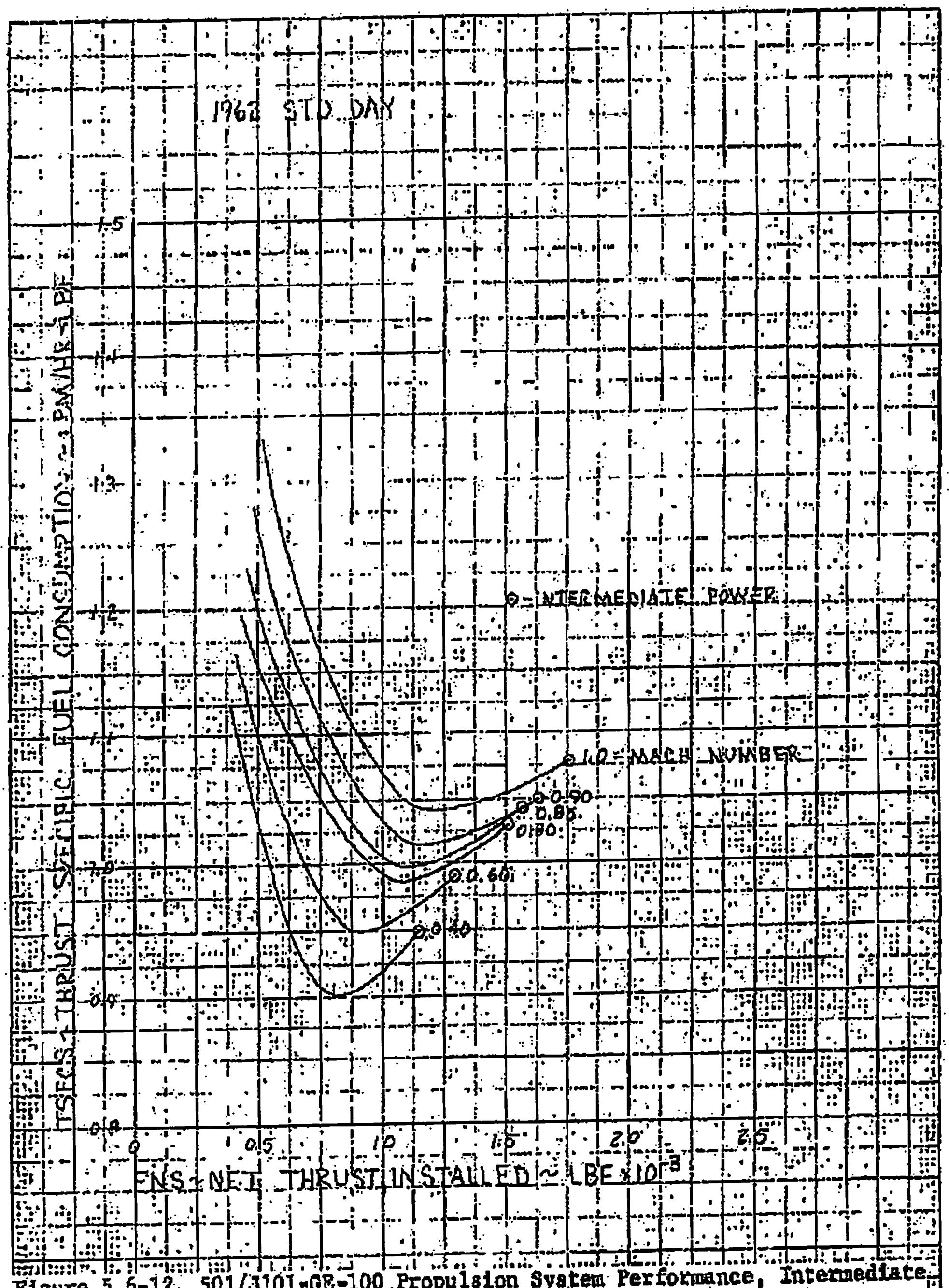


(U) Figure 5.6-11 501/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 45,000 feet

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

PSCC AY-71-005

71PA-2381-019 9-3-71



(U) Figure 5.6-12 501/J101-GE-100 Propulsion System Performance, Intermediate and Reduced Powers, 50,000 feet

SECTION 6

0.4 TAPER RATIO WING

ON 401B

6.1 VEHICLE DESIGN

~~(S)~~ The Concept 1 aircraft (the large single-engine 401B concept) was also designed with a contract-specified wing geometry: [wing loading of 60 psf, aspect ratio of 3.0, taper ratio of 0.4, thickness/chord ratio of 4 percent, fixed leading-edge sweep of 35 degrees, straight leading and trailing edges, and manually selectable single-hinge leading-edge high-lift devices. This wing differs from the selected wing used on the Concept 1, 2, and 3 designs in two respects: taper ratio of 0.4 versus 0.20, and squared rather than rounded wing tips.]

88th ABW/IPI
FOIA (b)(1) /IPI
E.O. 13526 SEC. 3.3.(b)(4)
1.4(a)(g)
EO 13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)

~~(S)~~ A version of the large single-engine airplane concept (401B) with the Statement of Work (S.O.W) wing planform is presented in the general arrangement drawing of Figure 6.1-1. In the drawing, an example aircraft is shown at a mission weight of 16,800 pounds, which was one of the data points used in generating the growth curves. The point-design mission weight of the airplane with the S.O.W. [wing was determined by the performance analysis to be 17,735 pounds. The final point-design arrangement is not presented since the changes in dimensions are very small and can be determined by applying the appropriate scale factors described in Section 3.]

88th ABW/IPI
FOIA (b)(1) /IPI
E.O. 13526 SEC. 3.3.(b)(4)
1.4.(a)(g)
SEC 3.3(b)(4)
SEC 1.4(a)(g)

(U) This configuration is the same as 401B externally except for the wing planform, wing thickness distribution, and horizontal tail size. Internal structure is slightly rearranged to accommodate the change in wing box structural geometry, but the subsystem arrangement remains essentially unchanged.

6.1.1 Design Rationale

~~(S)~~ The rationale for the S.O.W. wing installation is essentially identical to that of the basic 401B concept. [Primary differences involve design of the wing and horizontal tail. The wing is located longitudinally at the same

88th ABW/IPI
FOIA (b)(1) /IPI
E.O. 13526 SEC. 3.3.(b)(4)
1.4.(a)(g)
EO 13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O 13526 SEC 3.3(b)
(4)
1.4. (a)(g)

FOIA (b)(1)
13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)

~~SECRET~~

WING

AREA	280 SQ FT
ASPECT RATIO	3.0
TAPER RATIO	0.4
SPAN	28 FT 11.8 IN
SWEEP - LEADING EDGE	35°
ROOT CHORD	165.616 IN
TIP CHORD	66.246 IN
M.A.C.	123.039 IN
AIRFOIL SECTION	5% AT BICONVEX
INCIDENCE	[illegible]
DIHEDRAL	0°

MANEUVER FLAP

TYPE	PLAIN
TOTAL AREA	17.3 SQ FT
SPAN - PER SIDE	115.9 IN
ROOT CHORD	26.5 IN
TIP CHORD	19.9 IN
DEFLECTION	20°
HINGE LINE	
ROOT	18%
TIP	30%

FLAPS

TYPE	PLAIN
TOTAL AREA - INCLUDING FLAPERON	30.28 SQ FT
ROOT CHORD	26.5 IN
TIP CHORD	22.04 IN
FLAPERON	
TOTAL AREA	12.18 FT
SPAN - PER SIDE	68.0 IN
ROOT CHORD	22.04 IN
TIP CHORD	14.27 IN
DEFLECTION	-20°; -30°
FLAP DEFLECTION - MAX	30°
FLAP HINGE	60%

VERTICAL TAIL

AREA - TOTAL	44.26 SQ FT
ASPECT RATIO	1.3765
TAPER RATIO	0.4
SPAN	93.0 IN
SWEEP - LEADING EDGE	45°
ROOT CHORD	70.0 IN
TIP CHORD	28.0 IN
AIRFOIL SECTION	6% ROOT, 4% TIP - BICONVEX

RUDDER

AREA - TOTAL	10.53 SQ FT
SPAN	51.0 IN
ROOT CHORD	17.9 IN
TIP CHORD	7.64 IN
DEFLECTION	±30°

VENTRAL FINS

AREA - TOTAL	2.79 SQ FT
ASPECT RATIO	0.3733
TAPER RATIO	0.3951
SPAN	14.0 IN
SWEEP - LEADING EDGE	65°
ROOT CHORD	47.0 IN
TIP CHORD	28.0 IN
AIRFOIL SECTION	6% ROOT, 4% TIP - BICONVEX

HORIZONTAL TAIL (ALL MOVABLE)

AREA	
ASPECT RATIO	
TAPER RATIO	
SPAN - EXPOSED	
SWEEP - LEADING EDGE	
ROOT CHORD	
TIP CHORD	
M.A.C.	
INCIDENCE - NOMINAL	
AIRFOIL SECTION	6% AT BL 54.5,
DIHEDRAL	
DEFLECTION	NOSE

POWER PLANT

P&W JTF 22A-27 TURBOFAN ENGINE

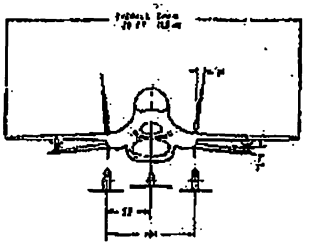
LANDING GEAR

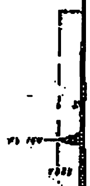
MAIN GEAR TIRE	
NOSE GEAR TIRE	

TAIL LENGTHS

¼ WING TO ¼ VERT TAIL	
¼ WING TO ¼ HORIZ TAIL	

MISSION WEIGHT	





~~SECRET~~

~~88th ABW/PI~~
FOIA (b)(1)(3) / IDL
E.O. 13526 SEC 3.3 (b)(4)
1.4. (a)(g)
EO 13526 SEC 3.3 (b)(4)
SEC 1.4(a)(g)

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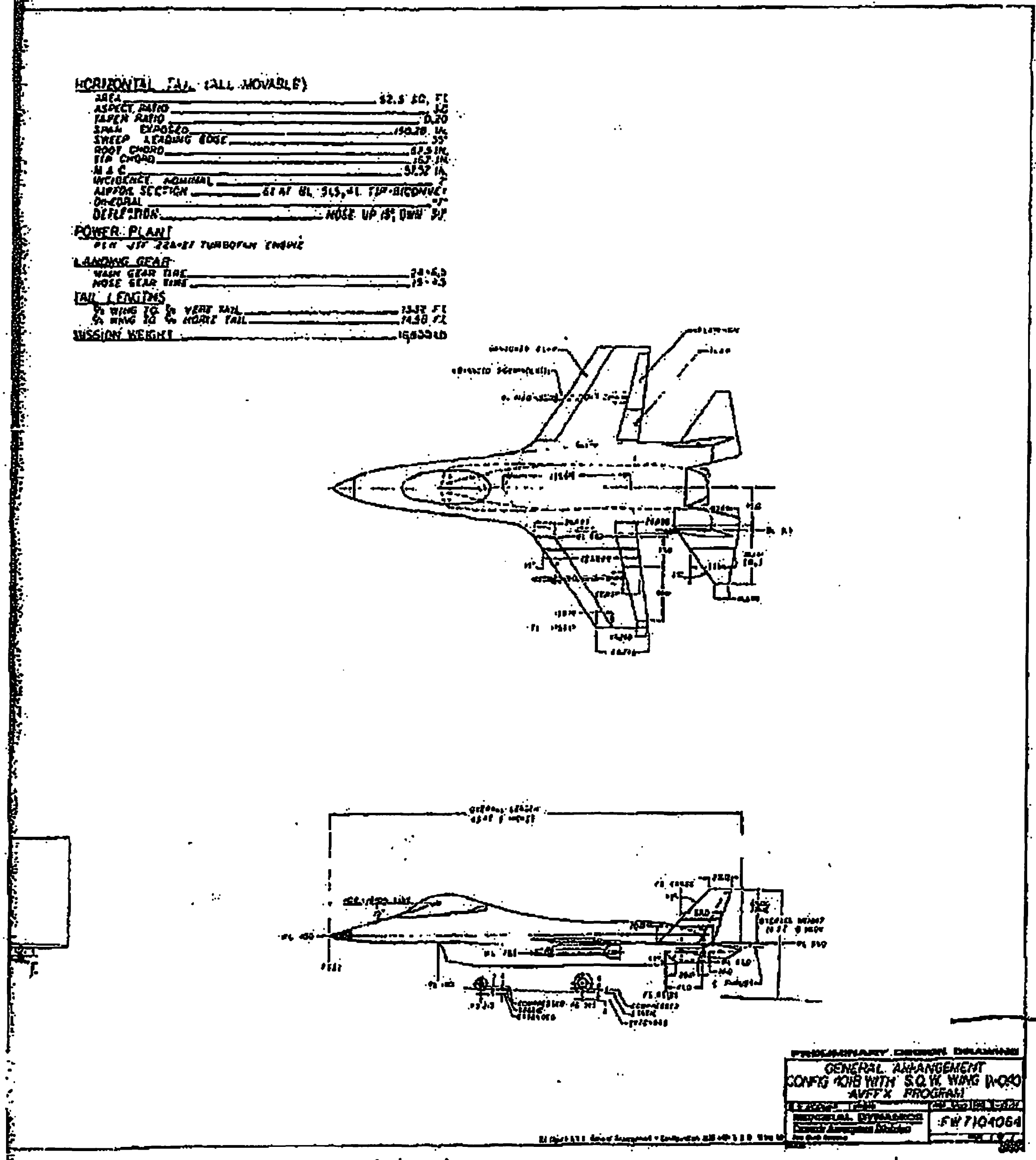

HORIZONTAL TAIL (ALL MOVABLE)
AREA — 52.5 SQ. FT
ASPECT RATIO — 3.0
TAPER RATIO — 0.20
SPAN EXPOSED — 150.28 IN.
SWEEP LEADING EDGE — 35°
ROOT CHORD — 67.5 IN.
TIP CHORD — 16.7 IN.
M A C — 51.52 IN.
INCIDENCE NOMINAL — 2°
AIRFOIL SECTION — 6% AT BL 315, 4% TIP BICONVEX
DIHEDRAL — -5°
DEFLECTION — NOSE UP 15°, DWN 9.5°

POWER PLANT
P&W JTF 22A-27 TURBOFAN ENGINE

LANDING GEAR
MAIN GEAR TIRE — 24×6.5
NOSE GEAR TIRE — 15×4.5

TAIL LENGTHS
25% WING TO 25% VERT TAIL — 15.32 FT
25% WING TO 25% HORIZ TAIL — 14.38 FT

MISSION WEIGHT — 16833 LB

PRELIMINARY DESIGN DRAWING
GENERAL ARRANGEMENT
CONFIG 401B WITH S.O.W. WING (t/c=0.040)
AVFFX PROGRAM
GENERAL DYNAMICS
FW 7104064

~~(S)~~ Figure 6.1-1 General Arrangement Configuration 401B with S.O.W. Wing (U)

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9 of 5

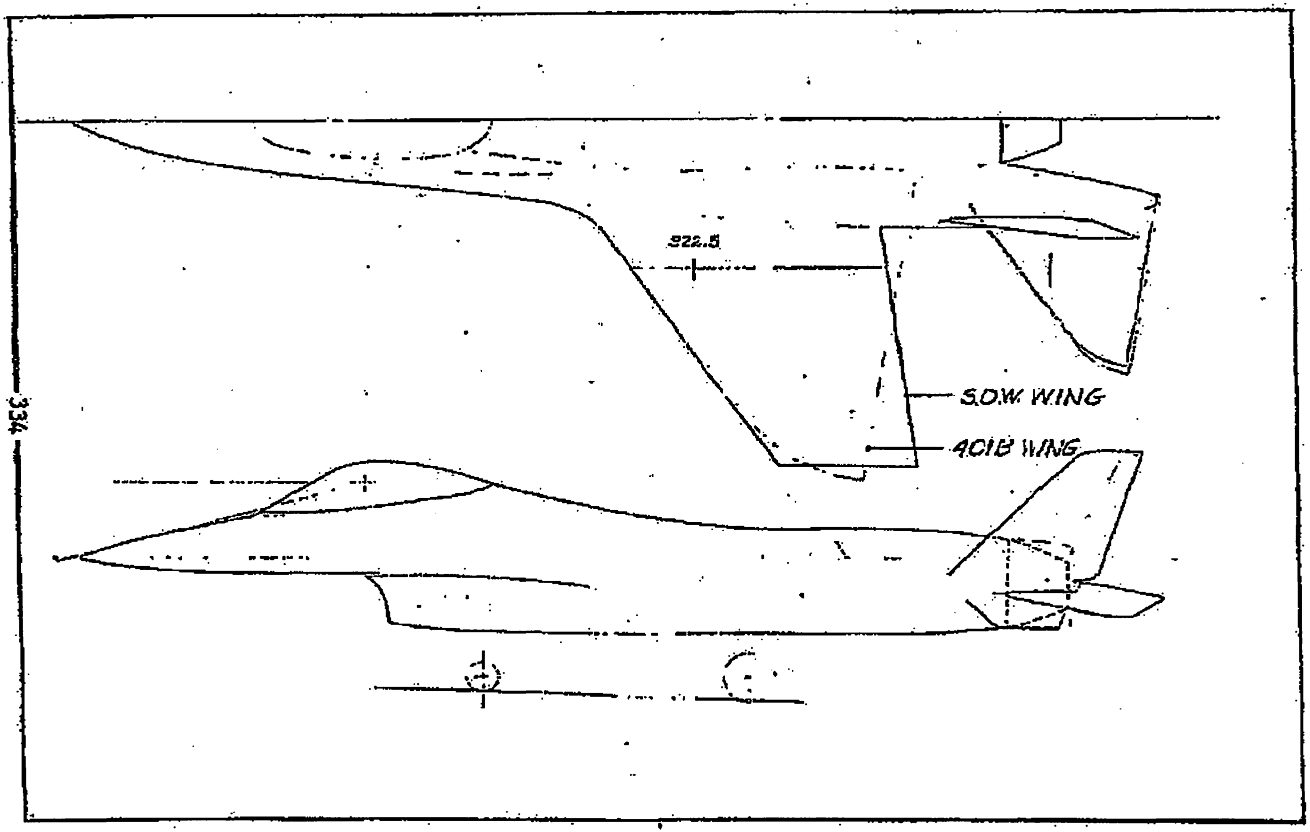
~~(S)~~ quarter-chord location on the mean aerodynamic chord as the 401B wing planform. Wing thickness ratio was also modified on the S.O.W. wing to provide an offsetting effect to the weight penalty imposed by the difference in taper ratio between the S.O.W. wing (0.40) and the 401B wing (0.20). A biconvex wing with a t/c of .04 RMS (based on exposed planform) was used instead of a constant t/c = .04 to allow the structural weight reduction necessary for minimizing the weight difference between the two wings. This rationale is explained in more detail in subsection 6.5.

EO 13526 3.3(b)(4)
SEC 1.4(a)(g)

~~(S)~~ The new horizontal tail, which was sized to the same tail volume coefficient as 401B (0.26), is so located that the tail moment arm remains the same as that of the basic 401B horizontal tail. This wing and tail relationship was established to maintain the original balance characteristics of 401B as nearly as possible on the modified configuration. The planform of the original horizontal tail is also retained. A comparison of the two wing planforms superimposed on the airplane is presented in Figure 6.1-2 for a gross weight of 16,800 pounds.

6.1.2 Design Data

(U) A summary of basic configuration data for the S.O.W. aircraft at a mission weight of 16,800 pounds is presented in Figures 6.1-3, -4, and -5. Basic geometric description data are given in Figure 6.1-3. Friction drag design data for the airplane are given in Figure 6.1-4 The normal area distribution for the airplane with the S.O.W. wing is presented in Figure 6.1-5.



~~(C)~~ Figure 6.1-2 Planform Comparison - Configuration 401B Wing vs. S.O.W. Wing at 16,800-lb Mission Weight (U)

BASIC DESCRIPTION

G.W. = 16,800 lbs
W/S = 60 lbs/ft.²
T/W = 1.397 (UNINSTALLED)
Engine P&W JTF 22A-27
(AF Designation F100-PW-100)

PROJECT: ADV. DAY FIGHTER
CONFIGURATION: ADF-401B/SOWWING
DATE: 23 JUNE 71

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE W/O CANOPY CENTERBODY	* 478.6	0	0	0
FUSELAGE OUTERBODY	421.0	102.0	±40.0	0
CANOPY	143.0	85.0	0	+39.0

* INCLUDES NOZZLE LENGTH (OPEN)

WING REF. AREA (IN²)
40320

SURFACES

		2° INCIDENCE WING (NOMINAL)	2° INCIDENCE-UPN. HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT²)		280.00	117.63	22.12	3.65
AR - ASPECT RATIO		3.00	3.03	1.33	0.3733
λ - TAPER RATIO		0.40	0.135	0.40	0.59574
 L.E. E₁(+) E₂(+)	E₁	+55°	+55	+45°	+45°
	E₂	-7.34°	+10°41'	-19°22'	+19°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		165.62	123.83	69.91	47.03
C_T - TIP CHORD (IN.)		66.25	16.70	27.96	28.02
b - SPAN (IN.)		347.79	241.06	65.09	14.01
AIRFOIL		4% BMS Biconvex Tip-2.5% Biconvex BL 54 - 1.89% Biconvex	Tip - 4% Biconvex BS 51.5 & 6% Biconvex	6% @ root 4% @ tip BICONVEX	6% BICONVEX
d (IN.)		54.00	51.887	0	0
x (IN.)		255.50	441.0	422.52	435.52
y (IN.)		0	0	±54.9	± 51.50
z (IN.)		0	-13.80	0	-13.00
		0° DIHEDRAL	1° NEG. DIHEDRAL	1° OUTBD CANT	0° CANT X

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL92 to body or surface ref line.

8061-14

~~(S)~~ Figure 6.1-3 Basic Description Data Sheet - Configuration 401B with S.O.W. Wing (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1) / IPT
E.O. 13526 SEC. 3.3
(b)(4) (b)(4)
1.4(a)(g) 25
SEC 3.3 (b)(4)
SEC 1.4 (a)(g)

FRICTION DRAG DATA

G.W. = 16,800 lbs
W/S = 60 lbs/ft²
T/W = 1.397 (UNINSTALLED)
ENGINE - P&W JTF 22A-27

PROJECT ADV DAY FIGHTER
CONFIGURATION ADF-401B / S.O.W. WING
DATE 22 JUNE 71

BODIES

BODY	WETTED AREA (FT²)		LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)
FUSELAGE CENTERBODY		405.5	* 476.2	52.0	71.0
FUSELAGE OUTERBODY		259.0	421.0	28.0	18.0
CANOPY (INCL FAIRING)		50.7	147.0	40.0	27.0
NOZZLE (CLOSED)		20.8	27.2	43.5 DIA	43.5 DIA
NOZZLE (OPEN)	26.7		28.6	43.5 DIA	43.5 DIA
BODY TOTAL		736.0			

* Length includes nozzle (closed)
Area for nozzle shown separately

SURFACES

SURFACE	WETTED AREA (FT²)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
WING		334.7	104.35	14°30'	4% BICONVEX RMS
HORIZ. TAIL		90.0	53.78	14°30'	6% BICONV - ROOT 4% BICONV - TIP
VERT TAIL (2)		88.5	51.93	34°15'	6% BICONV - ROOT 4% BICONV - TIP
VENTRAL FIN (2)		14.6	37.33	17°45'	6% BICONVEX
SURFACE TOTAL		527.8			
AIRPLANE TOTAL		1263.8			

BASIC WING GEOMETRY:	TRAPEZOID SHAPE BASIC REF. WING
AREA (FT²)	280.00
ASPECT RATIO	3.0
TAPER RATIO	0.4
LEADING EDGE SWEEP (DEG.)	35.

~~(S)~~ Figure 6.1-4 Friction Drag Data Sheet - Configuration 401B with S.O.W. Wing (U) 8061-13

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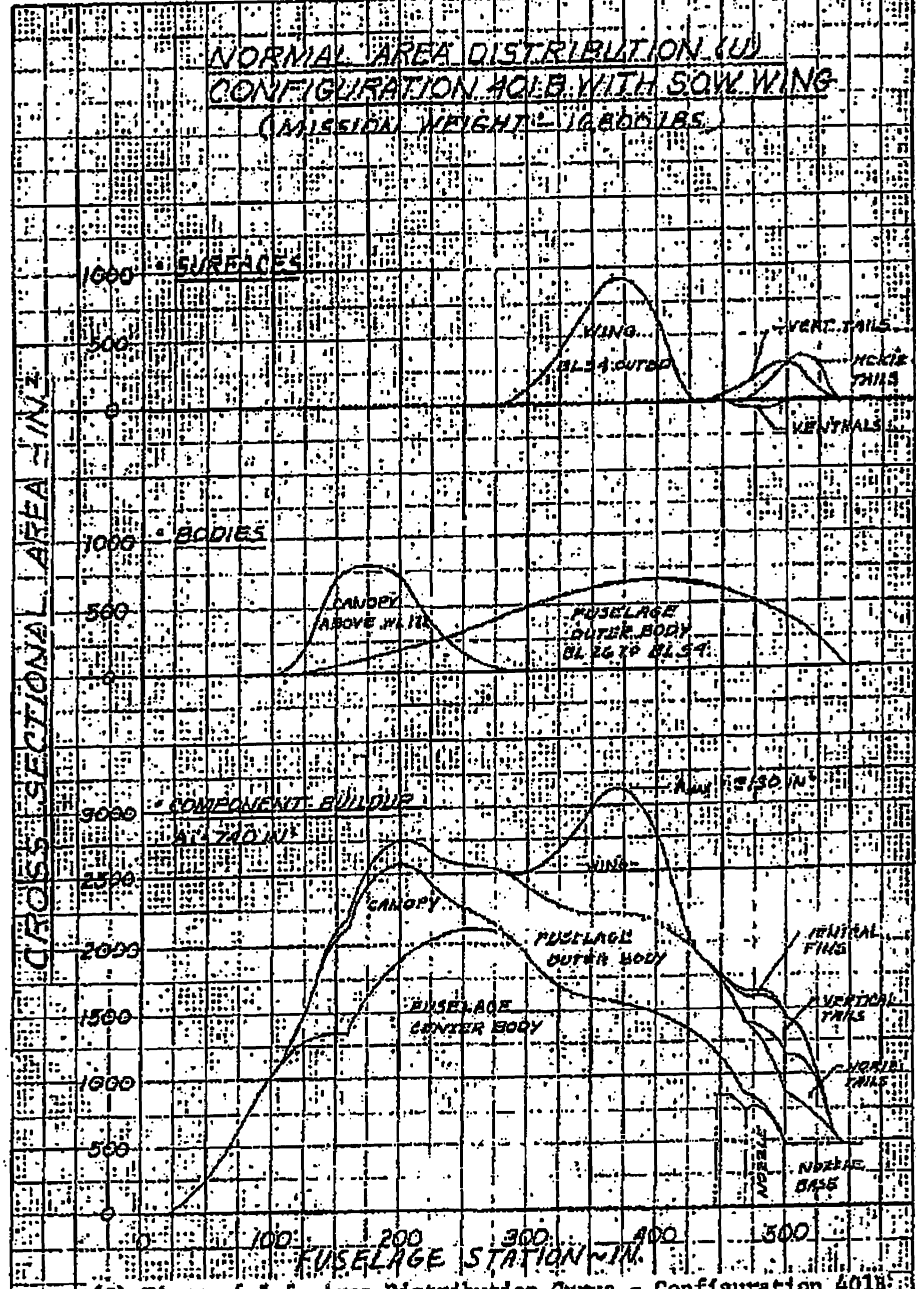
88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC
3.3(b)(1)
1.4 (a)(g)
sec 3.3(b)(
sec 1.4(a)(g)



~~(S)~~ Figure 6.1-5 Area Distribution Curve - Configuration 401B with S.O.W. Wing (U)

6.2 PERFORMANCE

(U) The performance characteristics of Configuration 401B with the 0.4 taper-ratio wing are based on the same mission definitions and performance rules as presented in Section 3.2 for Configuration 401B with the 0.2 taper-ratio wing.

~~(S)~~ The LRASM performance capabilities of Configuration 401B with the 0.4 taper-ratio wing are compared with the basic 401B Configuration in Figure 6.2-1. The comparison is for the 16,800-lb size used for the design layout described in Section 6.1. The mission radius with the 0.4 taper-ratio is 115 n.mi less than that with the basic wing, which has a 0.2 taper-ratio for the theoretical trapezoidal wing (i.e., without curved tips). Approximately one half of the radius loss is due to the 119-lb heavier weight of the 0.4 taper-ratio design. This is a resulting 119-lb loss of fuel when the analysis is made at a constant mission weight, as is the case in this analysis. The remainder of the radius loss is due to the lower L/D of the 0.4 taper-ratio wing.

88th ABW/IP
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4.(a)(g)

~~[illegible]~~ When the 0.4 taper-ratio wing design is sized to meet the 750-n.mi LRASM radius, it is 620-lb heavier than the basic design. (This is the reason for having chosen the baseline design.) The sizing of Configuration 401B with a 0.4 taper-ratio wing to meet the LRASM radius requirements was done by use of corrections obtained from the growth data presented in Sections 3.3 and 3.5.

~~(S)~~ The following corrections, obtained from the Section 3.3 growth data, were added to the basic aerodynamic data of Section 6.3 to account for increased aircraft size and wing area change:

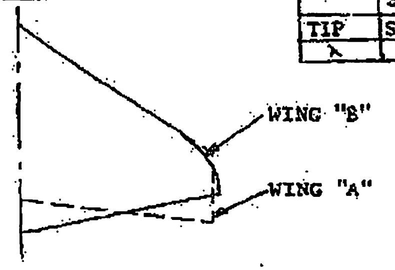
Mach No.	ΔC_D
0.6	-0.00013
0.8	-0.00013
0.9	-0.00015
1.2	-0.00017
1.5	-0.00045

16,800-lb A/P W/O Tanks

Δ WEIGHT: WING "A" − WING "B"

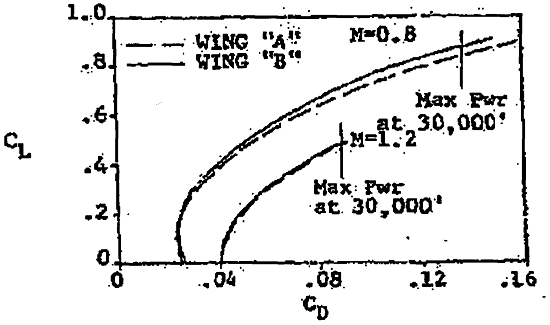
Structure	
- Wing	111 lb
- Fuselage	16
- Horizontal Tail	−24
	103 lb
Controls	
- Surface Controls	19 lb
- Hyd & Pneu	−3
	16
Total	119 lb

GEOMETRY



WING	A S.O.W.	B 401B
TIP	SQUARE	CURVED
λ	0.4	0.2

AERODYNAMIC COMPARISON



PERFORMANCE COMPARISON FOR LRASM

	WING "A"	WING "B"	EQUIVALENT RAD, N.MI
Combat Fuel	1924	1866	−23
- Accel Time, sec	36.1	34.8	
- Turn Rate @ M=0.8	9.3	9.8	
- Turn Rate @ M=1.2	8.2	8.3	
Climb Dist/Fuel	25/144	25/144	0
Cruise Range Constant	5281	5563	−30
- L/D	9.226	9.823	
- M	.870	.863	
- TSFC	.872	.870	
Reserve Fuel	473	446	−11
Weight	119	0	−51
			−115

~~(S)~~ Figure 6.2-1 Comparison of 0.4 Taper-Ratio Wing and Basic 401B Wing LRASM Performance (U)

88th ABW/IPI
~~FOIA (b)(4)~~
~~E.O. 13526 SEC 3.3(b)(4)~~
~~1.4(a)(g)~~
FOIA (b)(1)
EO 13526 Sec 3.3 (b)(4)
Sec 1.4 (a)(g)

~~88th ABW/IPI~~
FOIA (b)(1)
~~E.O. 13526 SEC 3.3(b)(4)~~
~~1.4 (a)(g)~~ (b)(1)
EO 13526 SEC 3.3(b)(4)
SEC 1.4(a)(g)

~~(S)~~ The reference wing area was changed from 280 sq. ft. to 295.6 sq. ft. to maintain a constant wing loading of 60 psf.

(U) The weight data presented in Section 6.3 were corrected for change in aircraft size. The corrections were made by use of the growth data presented in Section 3.5. A summary of the corrected weight data is presented in Table 6.2-1.

(U) The engine size was maintained fixed, and the propulsion data from Section 3.6 were used without modification.

(U) A summary of the mission capabilities of the resized Configuration 401B with a 0.4 taper-ratio wing is presented in Figure 6.2-2. Tabulations of the pertinent data for each segment of the three missions are presented in Tables 6.2-2 through 6.2-4. General performance data are presented in Figures 6.2-3 through 6.2-12. Sensitivity to weight-empty variation is presented in Figure 6.2-13.

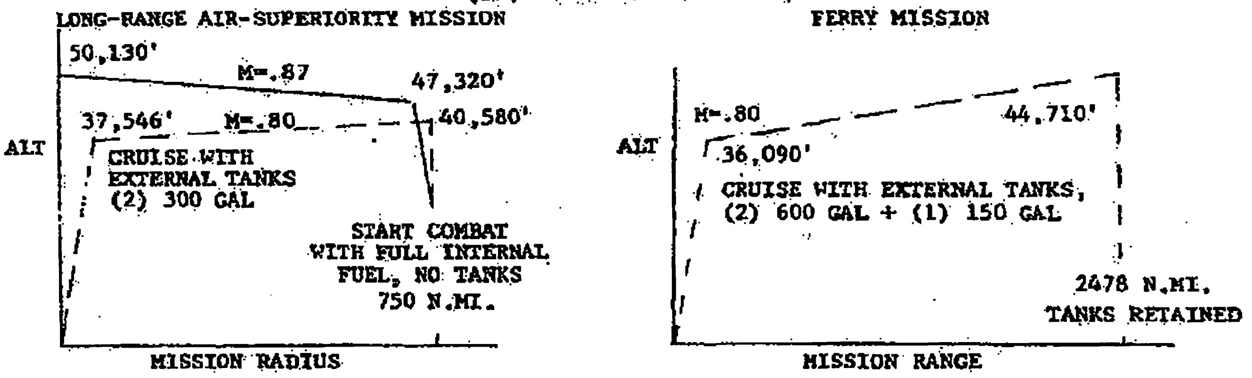
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)
88 ABW
FOIA (b)(1)
EO 13526
SEC 3.3 (b)(4)
SEC 1.4 (a)(g)
PPS
341-356

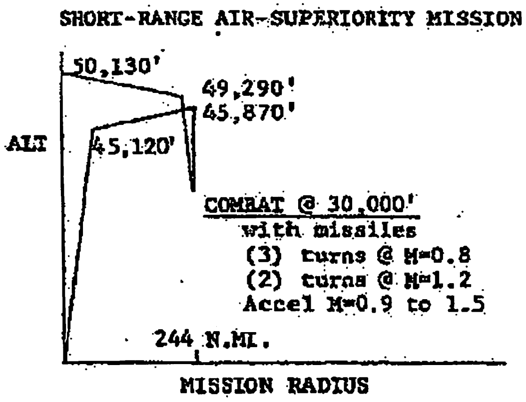
~~(S)~~ Table 6.2-1 CONFIGURATION 401B WITH 0.4 TAPER RATIO WING WEIGHT SUMMARY

(17,735-Lb Airplane Without Tanks)

Items	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	12,566
Ammunition (500 rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,536
SRASM Takeoff Gross Weight	17,735
Two Full 300-Gallon Tanks and Pylons	4,838
LRASM Takeoff Gross Weight	22,573
Basic Operating Weight	12,566
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	476
SRASM and LRASM Landing Weight	13,184
2. FERRY MISSION	
Basic Operating Weight	12,566
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	12,727
Internal Fuel	4,536
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	27,920
Zero Fuel Weight	12,727
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five Percent Initial Fuel	669
Twenty-Minute Sea-Level Loiter	584
Landing Weight	15,794

(17,735-lb A/P V/O Tanks)





LONG-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	22,573 lb
Takeoff Distance over 50 ft	2,060 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	38.6 sec
Turn Rate @ M=0.8	9.2 deg/sec
Turn Rate @ M=1.2	8.0 deg/sec

SHORT-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	17,735 lb
Takeoff Distance over 50 ft	1,370 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	35.2 sec
Turn Rate @ M=20.8	10.1 deg/sec
Turn Rate @ M=1.2	8.7 deg/sec

~~(S)~~ Figure 6.2-2 Configuration 401B with 0.4 Taper-Ratio Wing Mission Performance Summary (U)

SECRET

~~(S)~~ Table 6.2-2 CONFIGURATION 401B WITH 0.4 TAPER RATIO WING LRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Disc. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat g s
Initial Weight	0	0	22573								
Ground Operation				335	0	0					
	0	0	22238								
Accel to Climb Speed				258	0	.11					
	0.50	0	21980				2904	0.875	6.89		
Climb to Cruise Alt.				537	39	.09					
	0.80	37546	21443				2445	0.825	8.84		
Outbound Cruise				2923	711	1.55					
	0.80	40580	18520								
Drop Tanks				785*	0	0					
(847#Tank+ 62#Fuel)	0.80	40580	17735								
Combat				(1997)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		364	0	.01					
(2)M1.2 Turns	1.2	30000		863	0	.03				.470	5.19
(2)M0.8 Turns	0.8	30000		770	0	.03				.822	4.03
	0.87	30000	15738								
Drop Payload				348	0	0					
	0.87	30000	15390								
Drop ½ Ammo				143	0	0					
	0.87	30000	15247				2456	0.876	6.01		
Climb to Cruise Alt.				152	25	.05					
	0.87	47321	15095				1614	0.859	9.36		
Return Cruise				1911	725	1.45					
	0.87	50133	13184								
Descend				0	0	0					
	0.28	0	13184				1295	1.117	10.20		
Landing Reserves (20-Min.Loiter S.L.)				476	0	.33					
Zero-Fuel Weight			12708								

*62 Lb. Additional Fuel Needed

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526
SEC. 3.3.(b)
(4)
1.4. (a)(g)

~~(S)~~ Table 6.2-3 CONFIGURATION 401B WITH 0.4 TAPER RATIO WING SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Tr/Q	Initial TSFC	Initial L/D	Combat CL	Combat g's
Initial Weight	0	0	17735								
Ground Operation				246	0	0					
	0	0	17489								
Accel to Climb Speed				198	0	.10					
	0.50	0	17291				2411	0.875	6.09		
Climb to Cruise Alt.				477	44	.10					
	0.87	45117	16814				1838	0.853	9.21		
Outbound Cruise				619	200	.40					
	0.87	45869	16195								
Combat				(1817)		(.06)					
Accel M0.9-M1.5	0.9-1.5	30000		333	0	.01					
(2)M1.2 Turns	1.2	30000		783	0	.02				.466	5.63
(3)M0.8 Turns	0.8	30000		701	0	.03				.819	4.40
	0.87	30000	14378								
Drop Payload				348	0	0					
	0.87	30000	14030								
Drop ½ Ammo				143	0	0					
	0.87	30000	13887				2430	0.876	5.50		
Climb to Cruise Alt.				153	27	.06					
	0.87	49289	13734				1485	0.865	9.32		
Return Cruise				550	217	.43					
	0.87	50133	13184								
Descend				0	0	0					
	0.28	0	13184				1295	1.117	10.20		
Landing Reserves (20 Min. Loiter S.L.)				476	0	.33					
Zero-Fuel Weight			12708								

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

SECRET

~~(S)~~ Table 3.2-[illegible] CONFIGURATION [illegible] WITH 0.4 TAPER RATIO WING
FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt (Ft)	Flight Weight (lb)	Weight (lb)	Dist (n.mi)	Time (hr)	Initial [illegible]	Initial TSFC	Initial L/D	Coe[illegible]	Comments	
Initial Weight	0	0	27920									
Ground Operation				403	0	0						
	0	0	27517									
Accel to Climb Speed				326	0	.11						
	0.50	0	27191				3277	0.875	7.80			
Climb to Cruise Alt.				732	55	.12						
	0.80	36089	26459				3236	0.820	8.51			
Cruise w/(2)Ext.Tanks				10665	2423	5.28						
	0.80	44708	15794									
Descend				0	0	0						
	0.27	0	15794				1801	0.987	8.83			
Landing Reserves				(1253)								
(20Min.Loiter S.L.)				584	0	.33						
(5% Initial Fuel)				669								
Zero-Fuel Weight			14541									

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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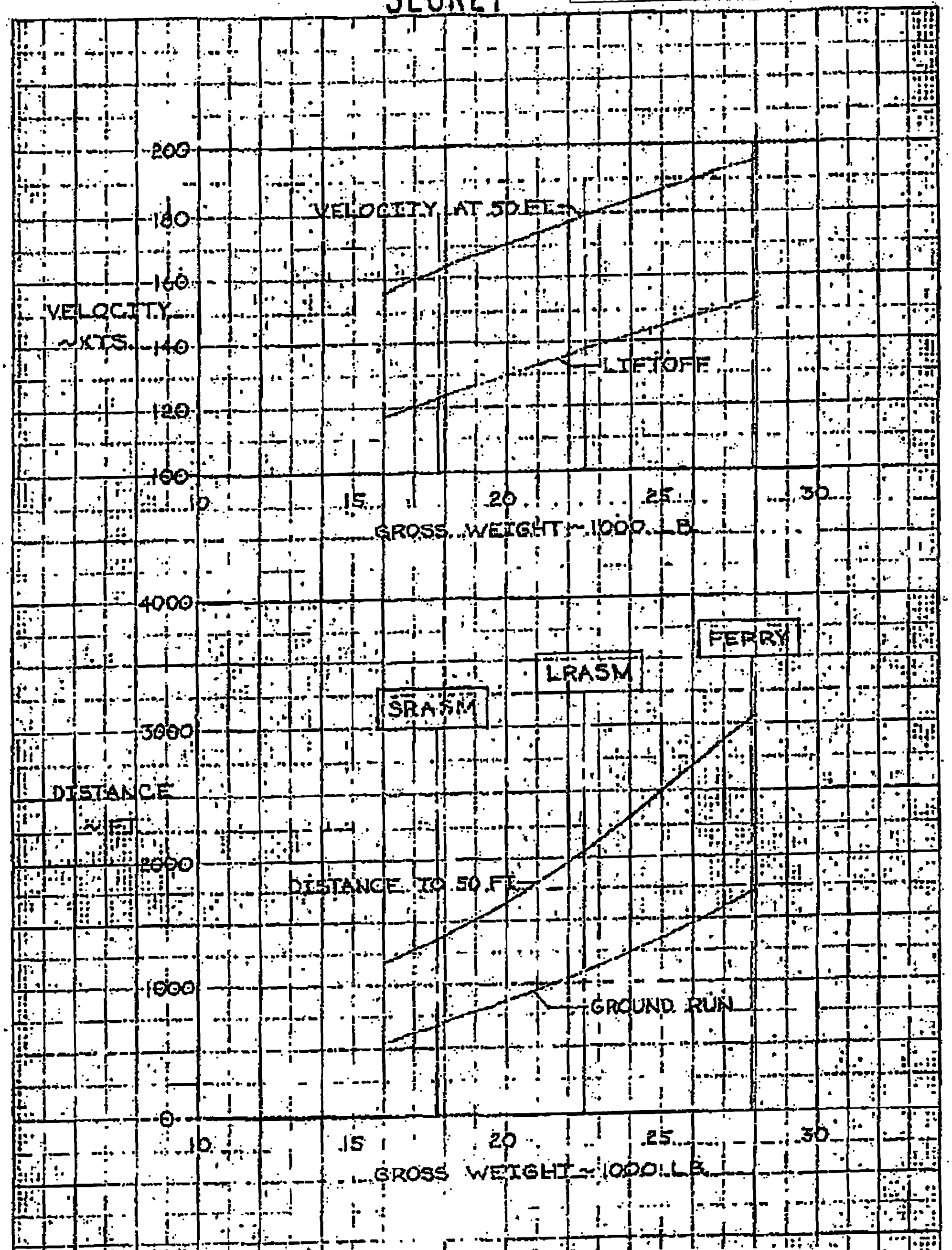

~~(S)~~ Figure 6.2-3 Configuration 401B with 0.4 Taper-Ratio Wing Takeoff Performance (U)

~~SECRET~~

88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

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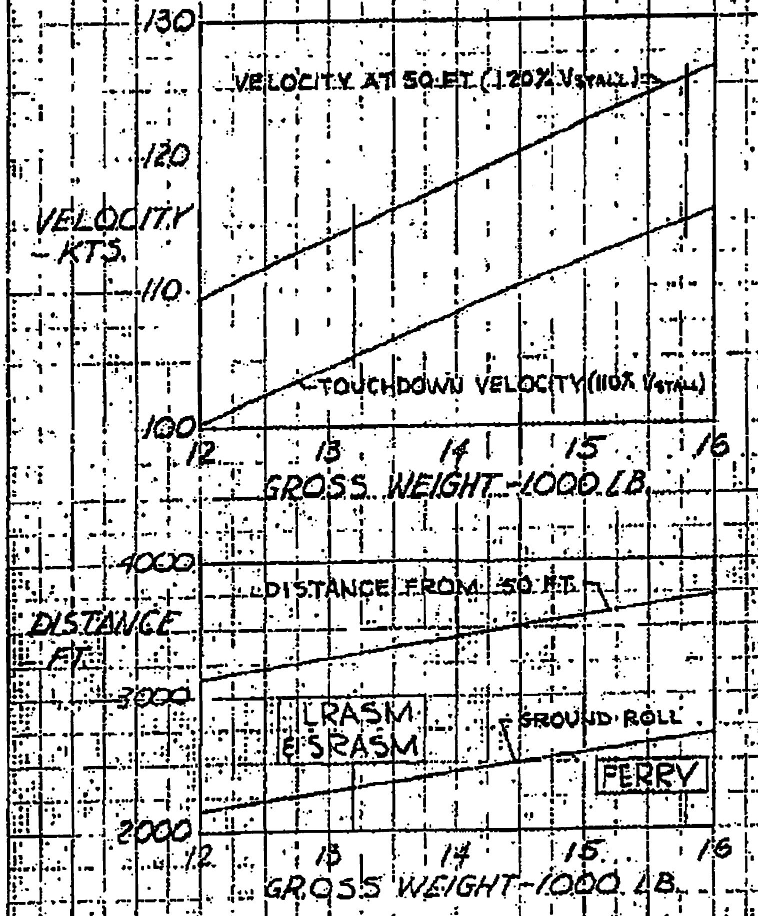

~~(C)~~ Figure 6.2-4 Configuration 401B with 0.4 Taper-Ratio Wing Landing Performance (U)

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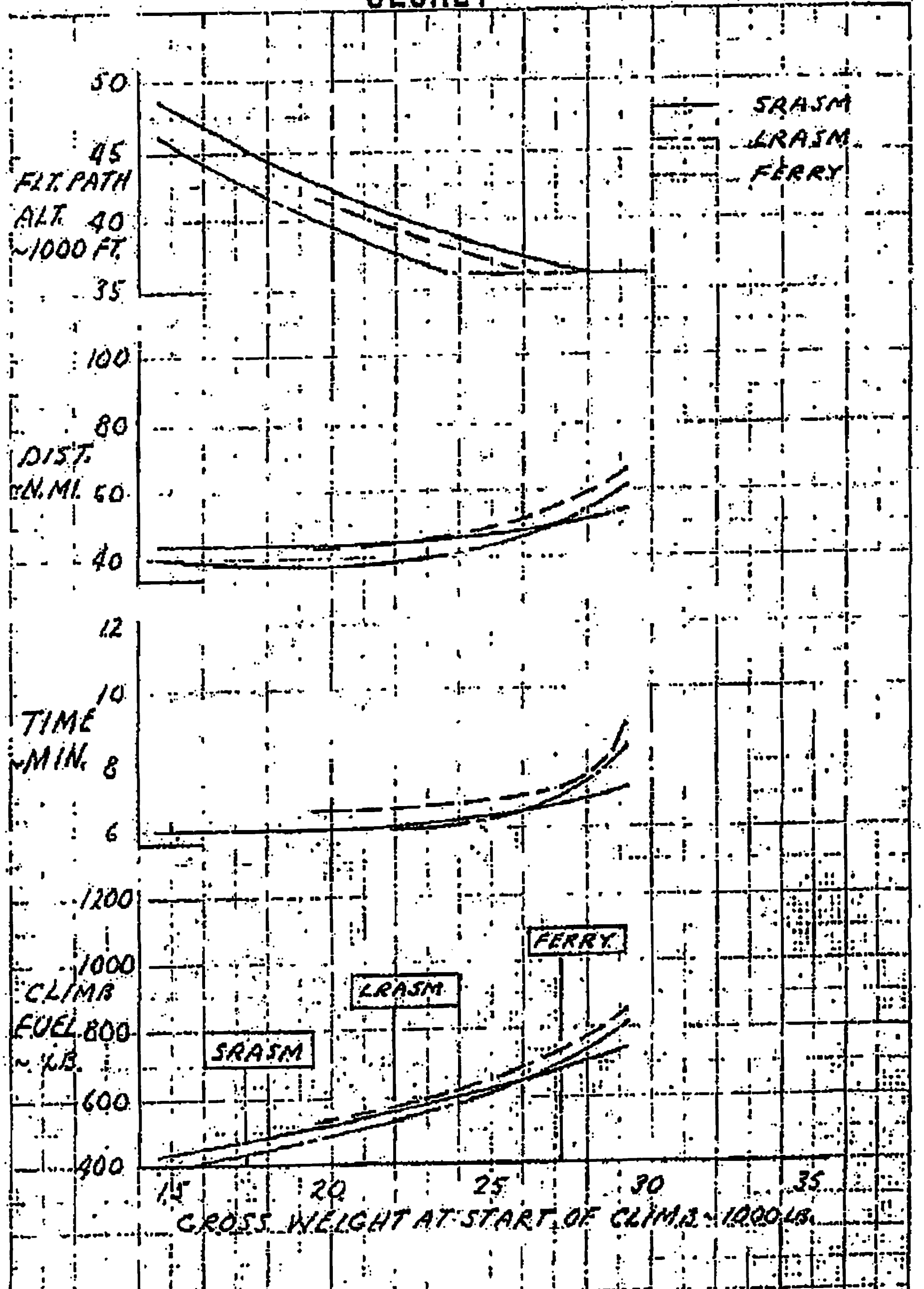
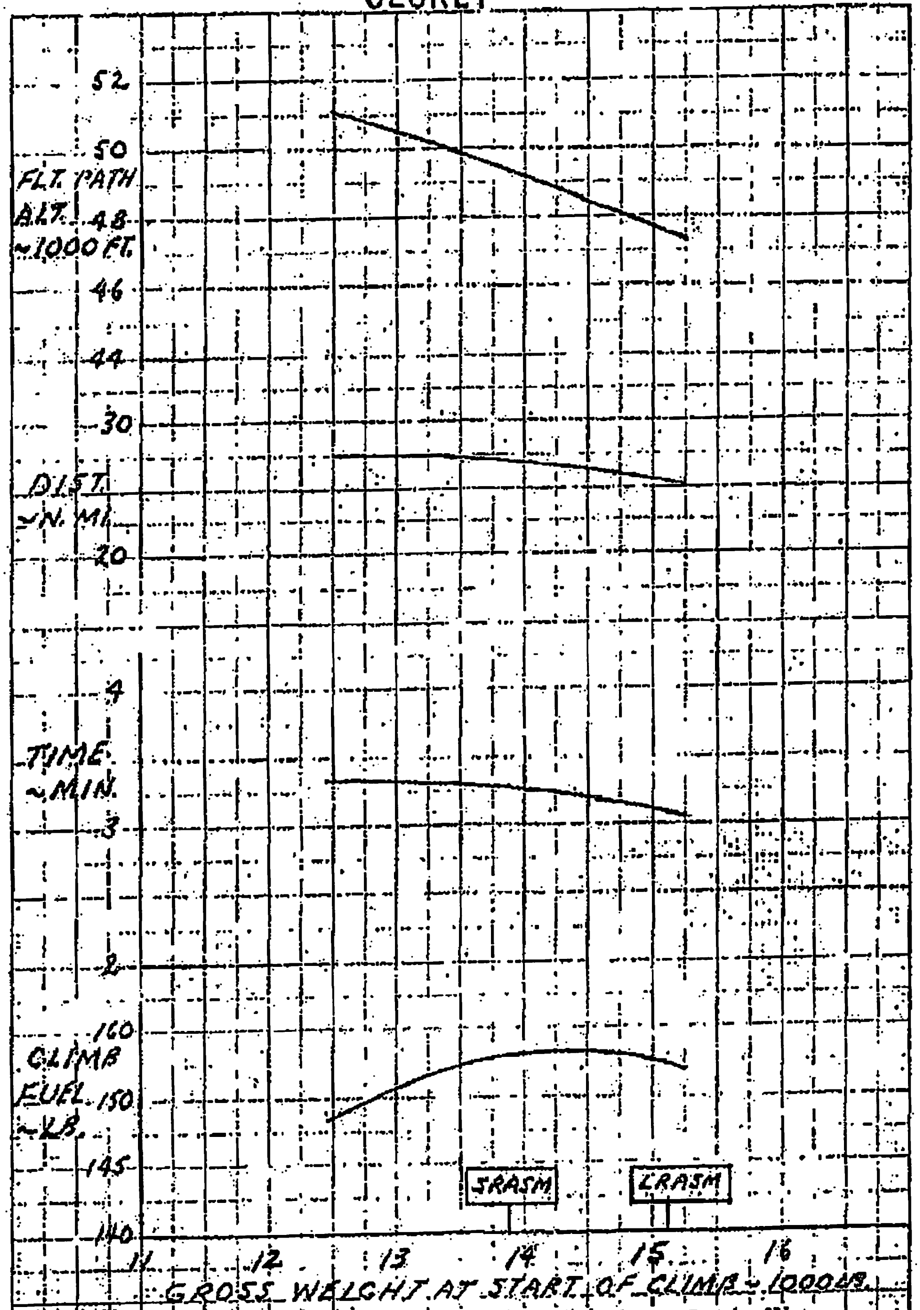
88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 6.2-5 Configuration 401B with 0.4 Taper-Ratio Wing Initial Climb Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

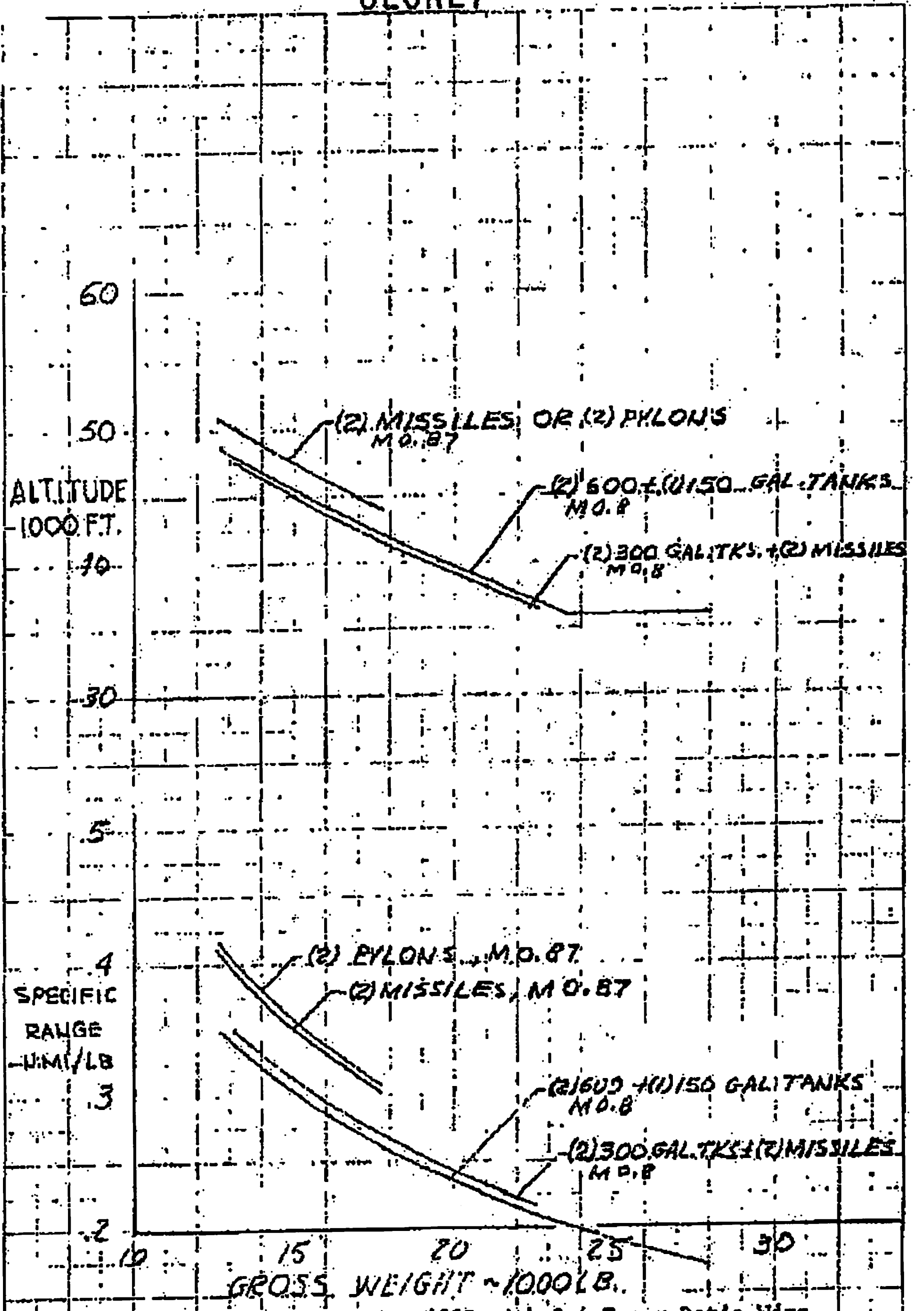
~~SECRET~~



~~(S)~~ Figure 6.2-6 Configuration 401B with 0.4 Taper-Ratio Wing Climb After Combat (U)

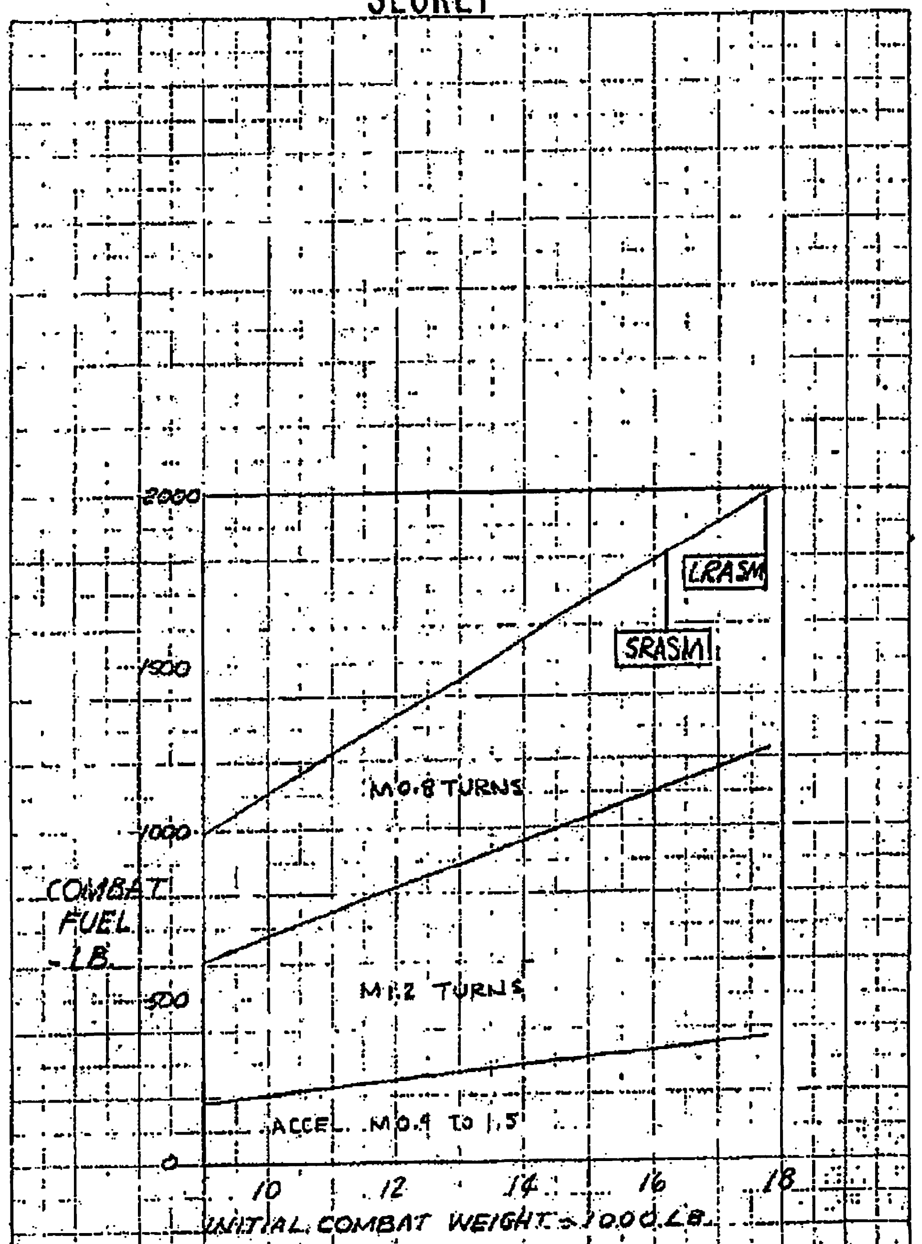
~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC. 3.3.(b)~~
(4)
1.4. (a)(g)

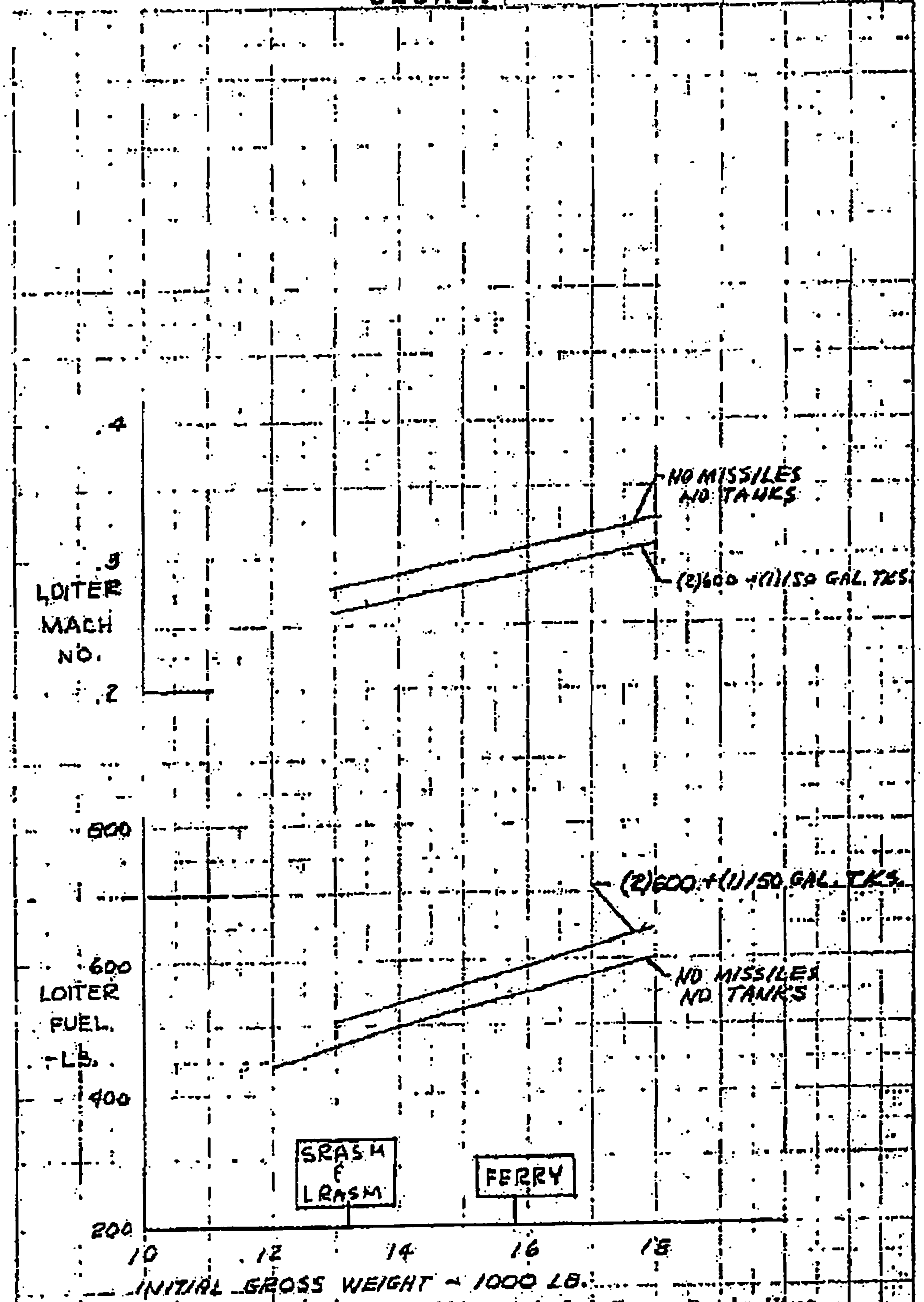


~~(S)~~ Figure 6.2-7 Configuration 401B with 0.4 Taper-Ratio Wing Cruise Performance (U)

88th ABW/IPI
~~FOIA (b)(4)~~
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 6.2-8 Configuration 401B with 0.4 Taper-Ratio Wing Combat Fuel Allowance (U)



~~(S)~~ Figure 6.2-9 Configuration 401B with 0.4 Taper-Ratio Wing Sea-Level Loiter Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

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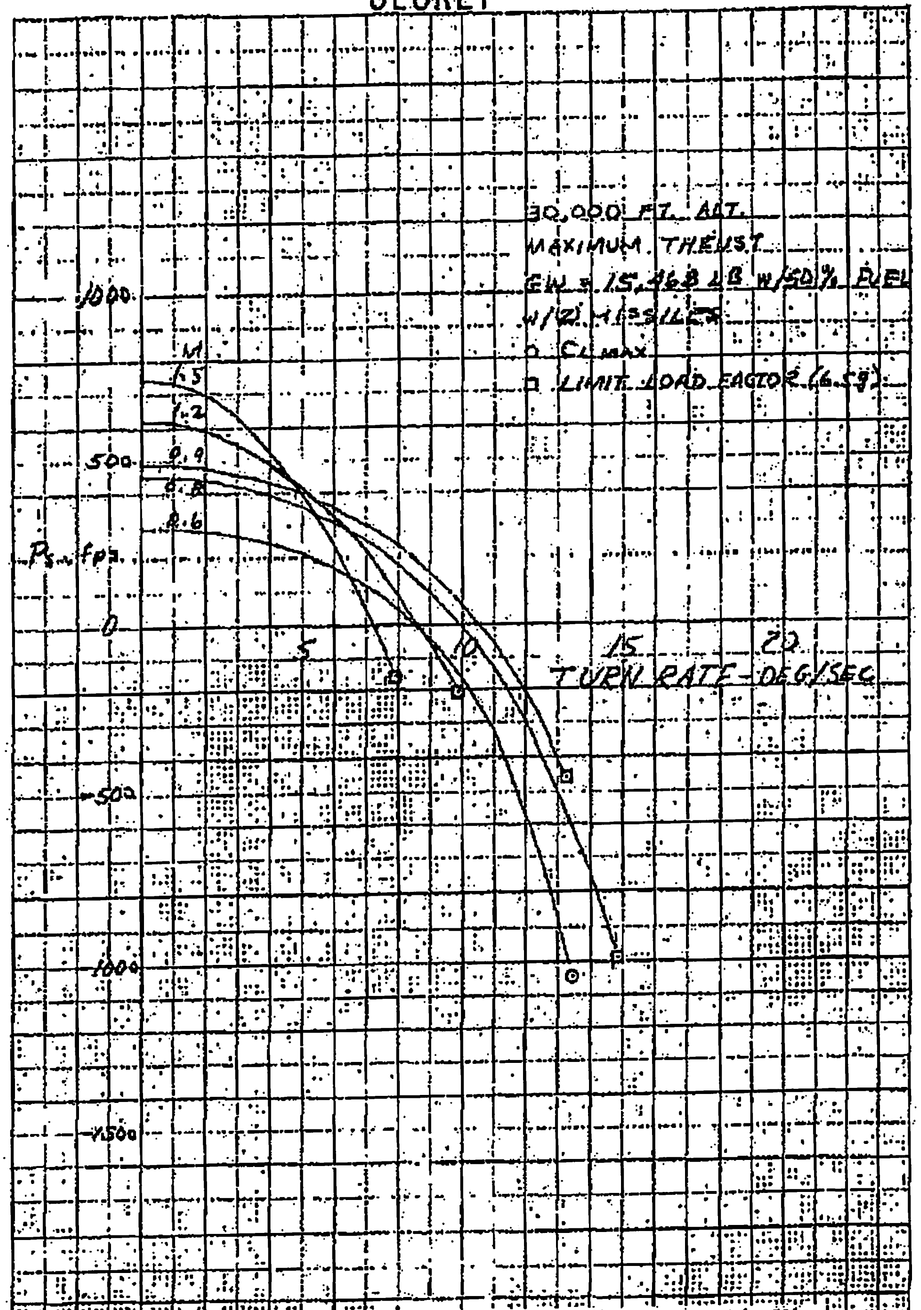

~~(S)~~ Figure 6.2-10 Configuration 401B with 0.4 Taper-Ratio Wing Turning Performance (U)

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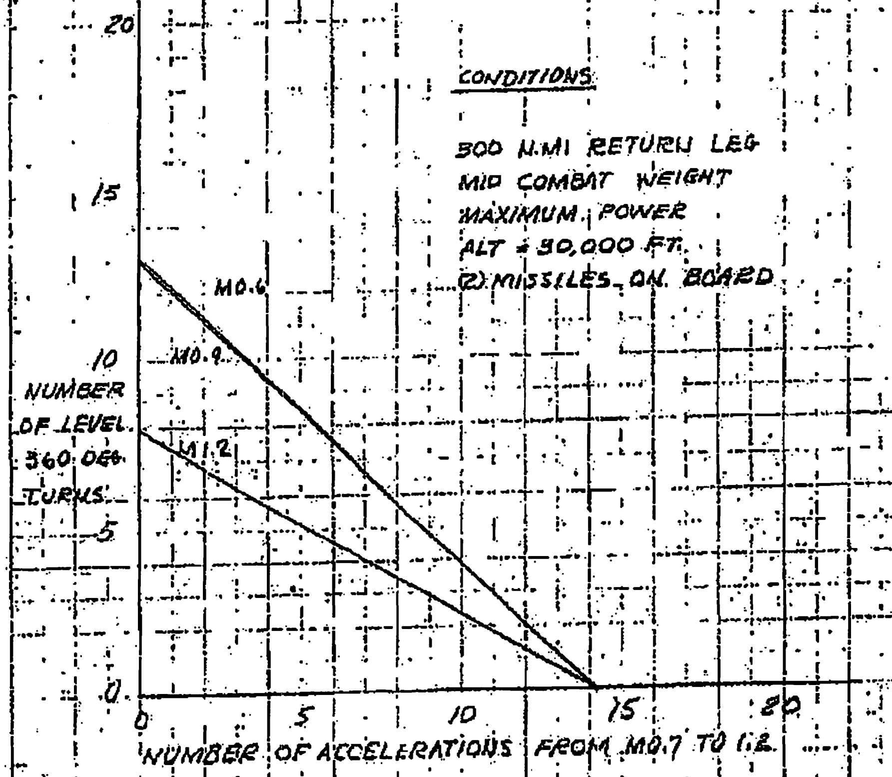

~~(S)~~ Figure 6.2-11 Configuration 401B with 0.4 Taper-Ratio Wing Persistence Plot (U)

88th ABW/IPI
~~FOIA (b)(1)~~
E.O. 13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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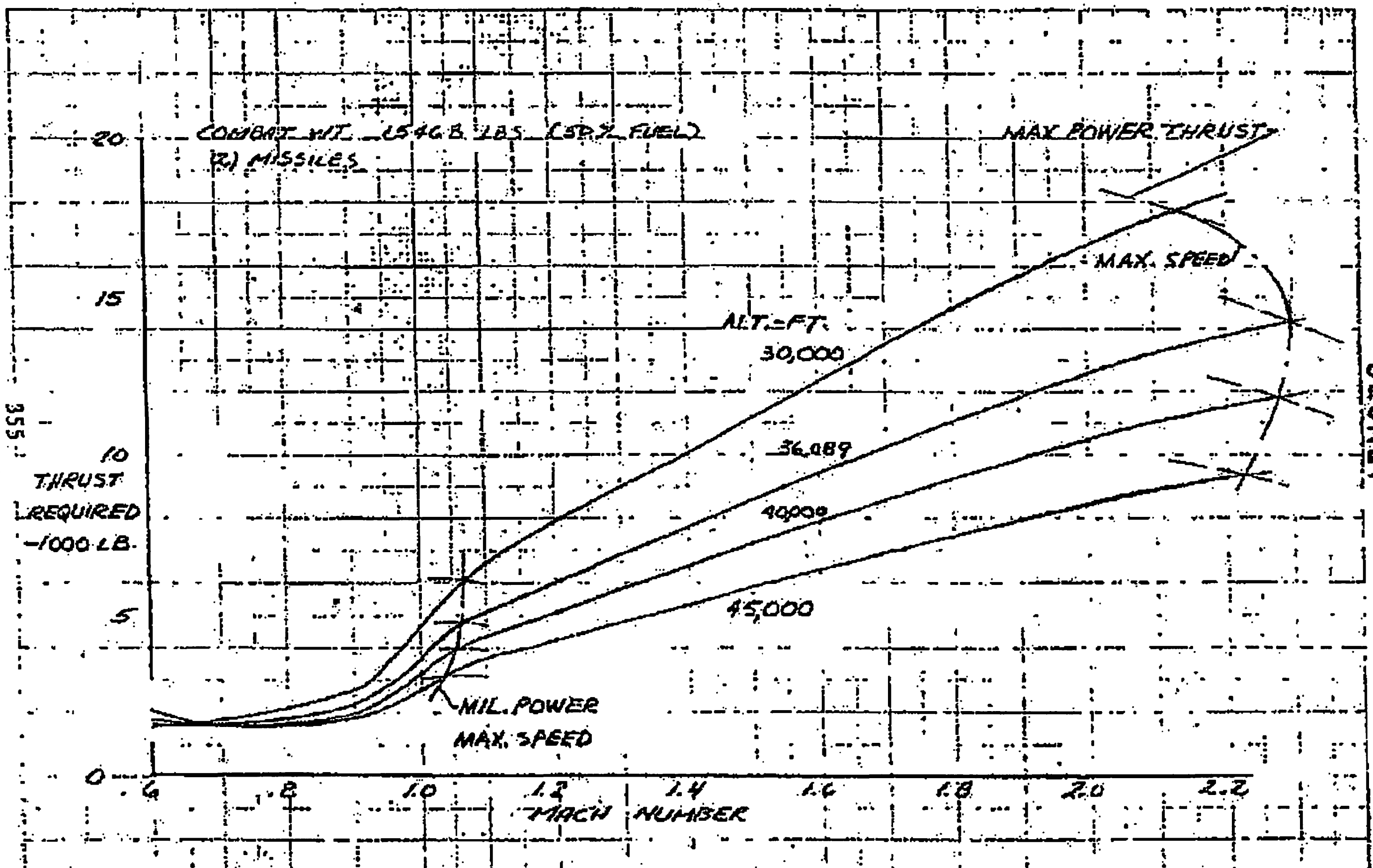

~~(S)~~ Figure 6.2-12 Configuration 401B with 0.4 Taper-Ratio Wing Thrust Required (U)

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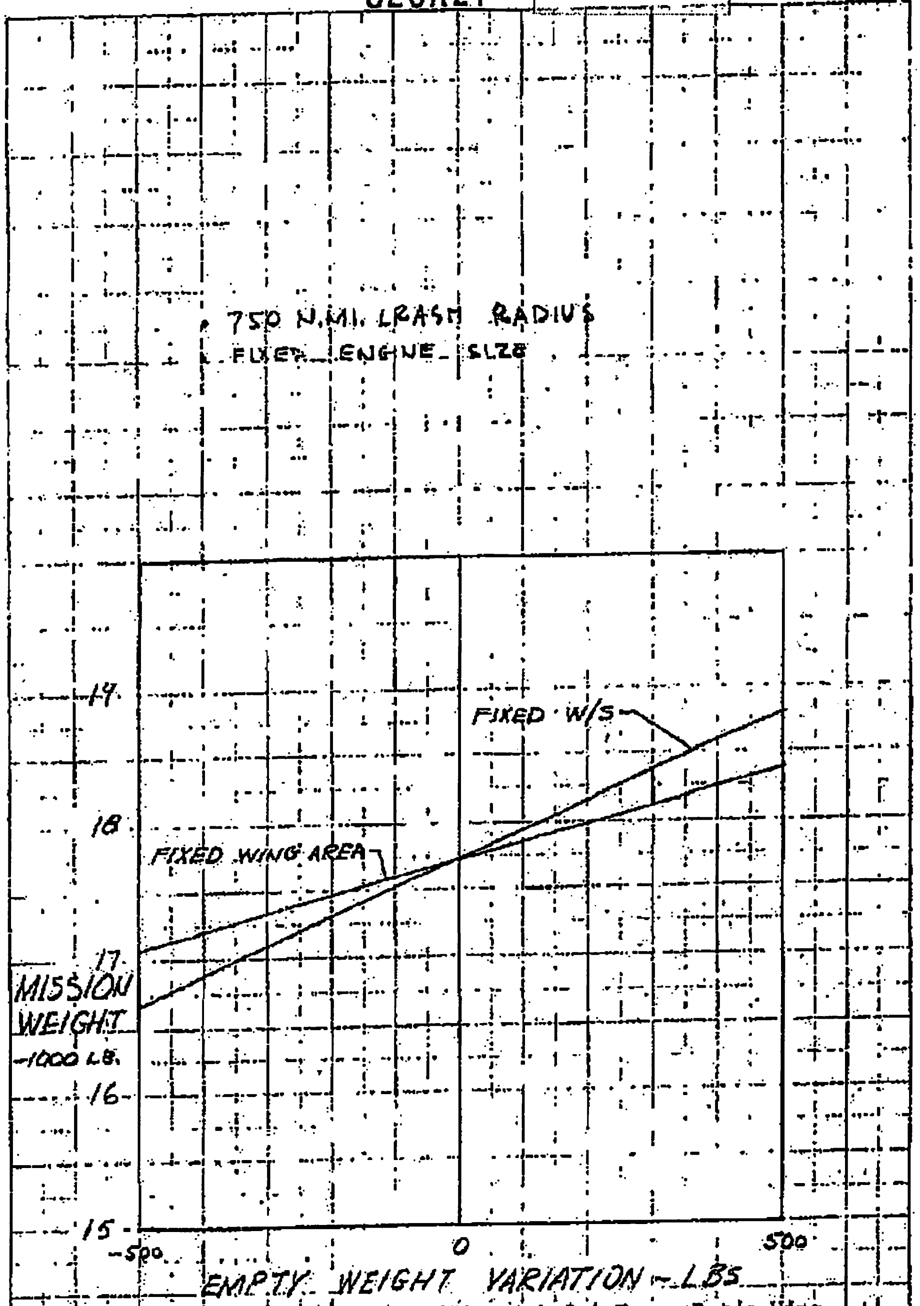

~~(S)~~ Figure 6.2-13 Configuration 401B with 0.4 Taper-Ratio Wing Sensitivity to Dry-Weight Variation (U)

6.3 AERODYNAMICS

(U) The aerodynamic characteristics for Configuration 401B with the 0.4 taper-ratio wing were generated through use of the same methods and wind tunnel data as were used for the basic 401B configuration of Section 3.

6.3.1 Minimum Drag

(U) The total minimum drag is plotted in Figure 6.3-1 for various altitudes. The minimum drag coefficient is higher at supersonic speeds because of a higher basic wave drag and no drag reduction due to curve tips, as discussed in Subsection 3.3.1. [The net wave drag coefficient is .0030 higher at Mach 1.2 and .0043 higher at Mach 1.6.]

88th ABW/IPI
FOIA (b)(1) DOE
E.O. 13526 SEC. 3.3.
(b)(4) E.O. 13526
1.4(a)(g) Sec 3.3(b)(4)
Sec 1.4(a)(g)

(U) The drag component and growth curves of Figures 3.3-2 and 3.3-4 are applicable to this configuration.

6.3.2 Drag Due to Lift

(U) The drag due to lift shown in Figures 6.3-2 through 6.3-6 also is derived from the FX wind tunnel tests discussed in Section 3.3. [The induced drag for the 0.4 taper-ratio wing is higher for the following reasons:

88th ABW/IPI DOE
FOIA (b)(1)
E.O. 13526 SEC. 3.3.
(b)(4) 13526
1.4(a)(g) 3.3(b)(4)
Sec 1.4(a)(g)

1. The increased wing cutout (i.e., increased trailing edge sweep) causes a reduction in $C_{L\alpha}$ and therefore a reduction in span efficiency since $1/e \propto 1/C_{L\alpha}$
2. The trapezoidal tips have less span than the curved tips; AR = 3.0 instead of 3.2.

The net result is that the 0.4 taper-ratio wing has about 10-percent higher induced drag at subsonic speeds and at Mach 1.2.]

(U) The associated leading-edge-flap drag is plotted in Figure 6.3-7. It is essentially the same as that for the basic 401B airplane.

6.3.3 Trim Drag

(U) The trim drag shown in Figure 3.3-13 for Configuration 401B also applies to the 0.4 taper-ratio wing.

88th ABW/IPI
FOIA (b)(7)
FOIA (b)(1)

6.3.4 Trimmed Drag Polars

(U) The trimmed drag polars and configuration polars for 401B with the 0.4 taper-ratio wing are given in Figure 6.3-8 through 6.3-17. The $(L/D)_{max}$ data plotted in Figure 6.3-18 are, as expected, lower than similar data for the basic 401B configuration (see Figure 3.3-25).

6.3.5 Lift and Buffet Data

(U) The C_L-vs-α curves, control limit C_L's, and buffet boundaries shown in Figures 6.3-19 through 6.3-23 are derived from the same wind tunnel data as was used for the basic 401B. However, an adjustment for the change in taper ratio was made. This correction is small, since $C_{L\alpha}$ is reduced only about 3-percent from that of the basic 401B.

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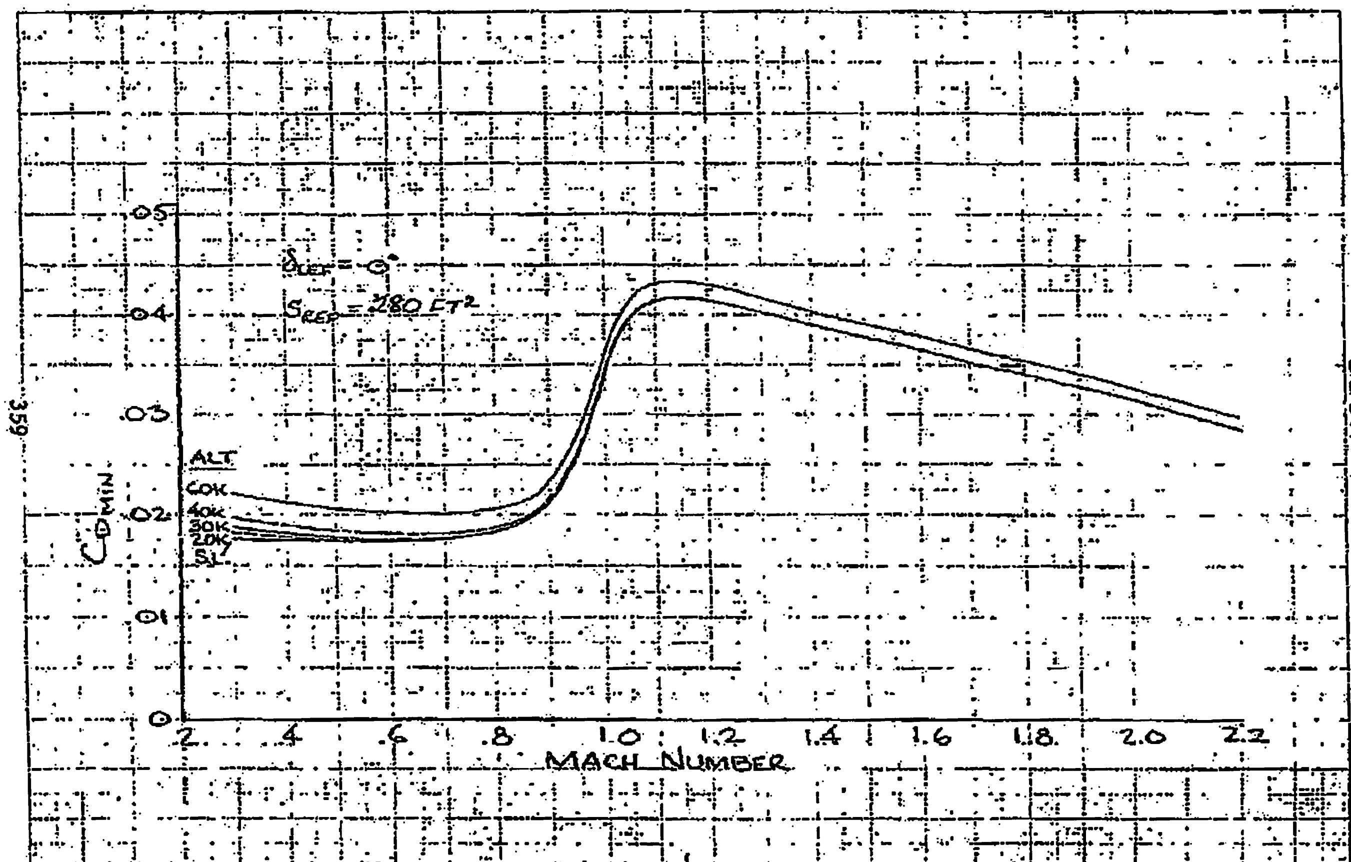


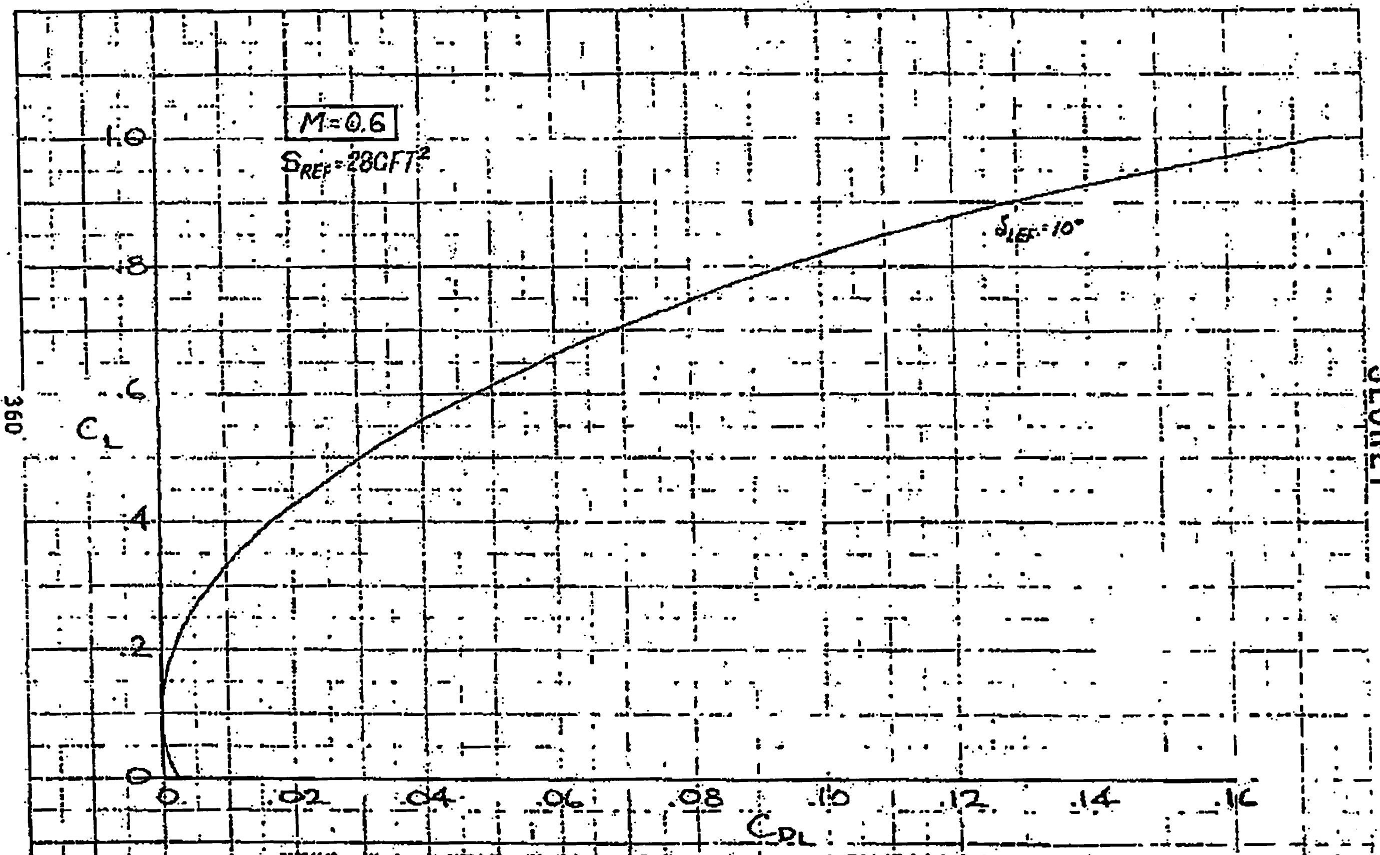
~~(S)~~ Figure 6.3-1 Minimum Drag vs Mach Number, Configuration 401B with 0.4 Taper-Ratio Wing (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
~~E.O. 13526 SEC 3.3(b)(4)~~
~~1.4(a)(g)~~
FOIA (b)(1)
E0 13526 SEC 3.3(b)(4)
SEC 1.4(a)(g)
pgs
357-381

88th ABW/IPI
~~FOIA (b)(4)~~
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 6.3-2 Drag Due to Lift at M=0.6, Configuration 401B with 0.4 Taper-Ratio Wing (U)

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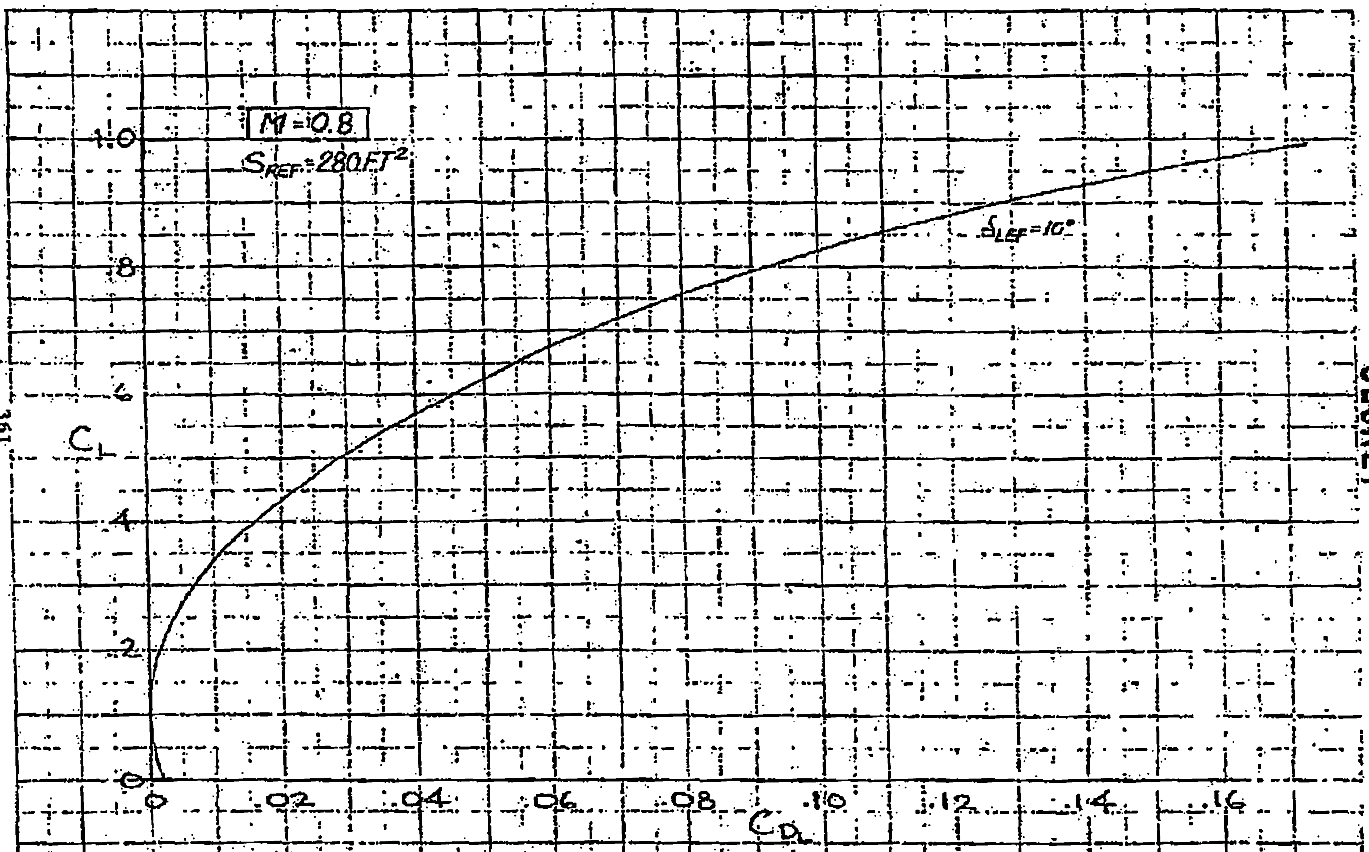
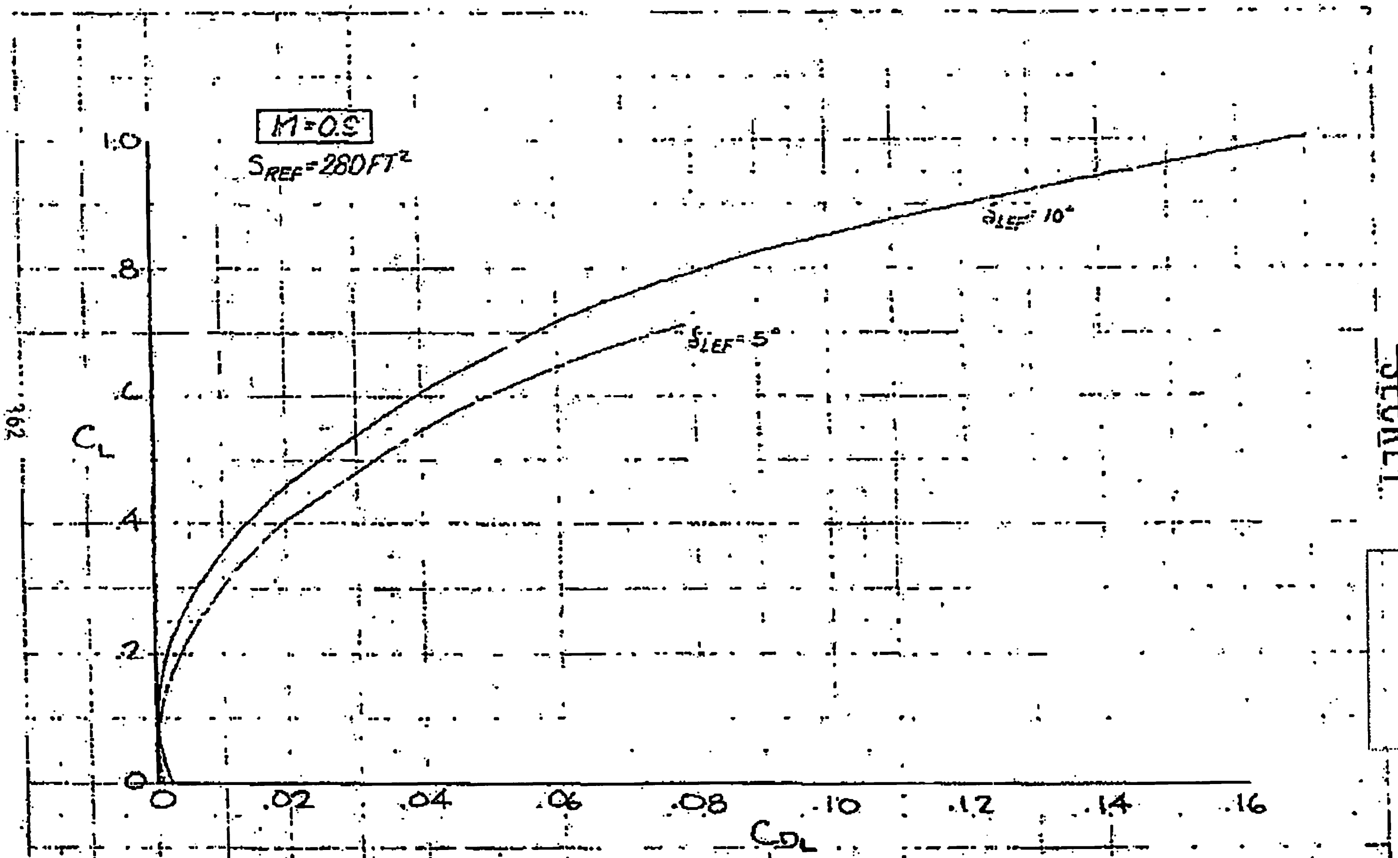


~~(S)~~ Figure 6.3-3 Drag Due to Lift at M=0.8, Configuration 401B with 0.4 Taper-Ratio Wing (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 6.3-4 Drag Due to Lift at M=0.9, Configuration 401B with 0.4 Taper-Ratio Wing (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
~~E.O. 13526 SEC.~~
3.3.(b)(4)
1.4 (a)(g)

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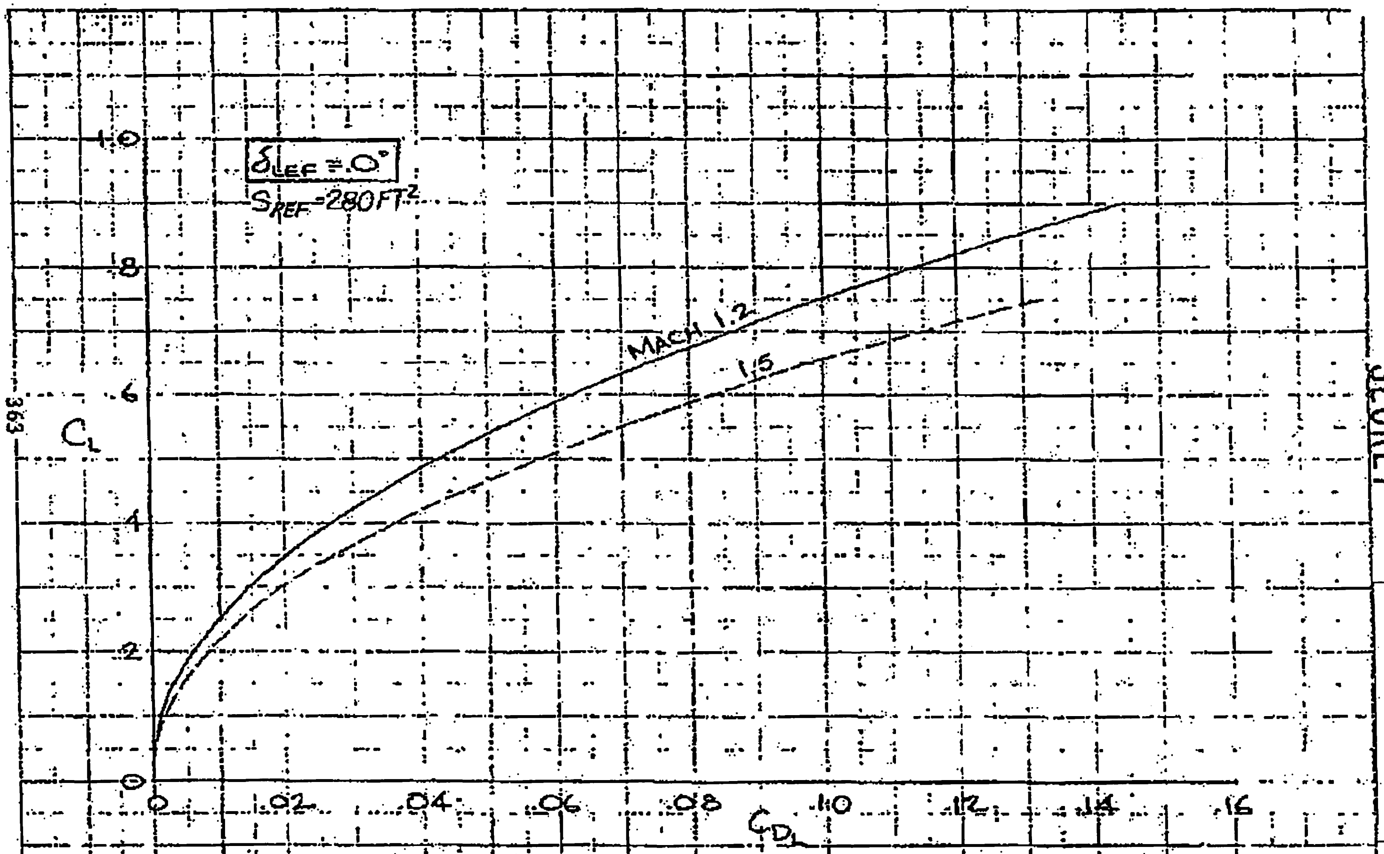
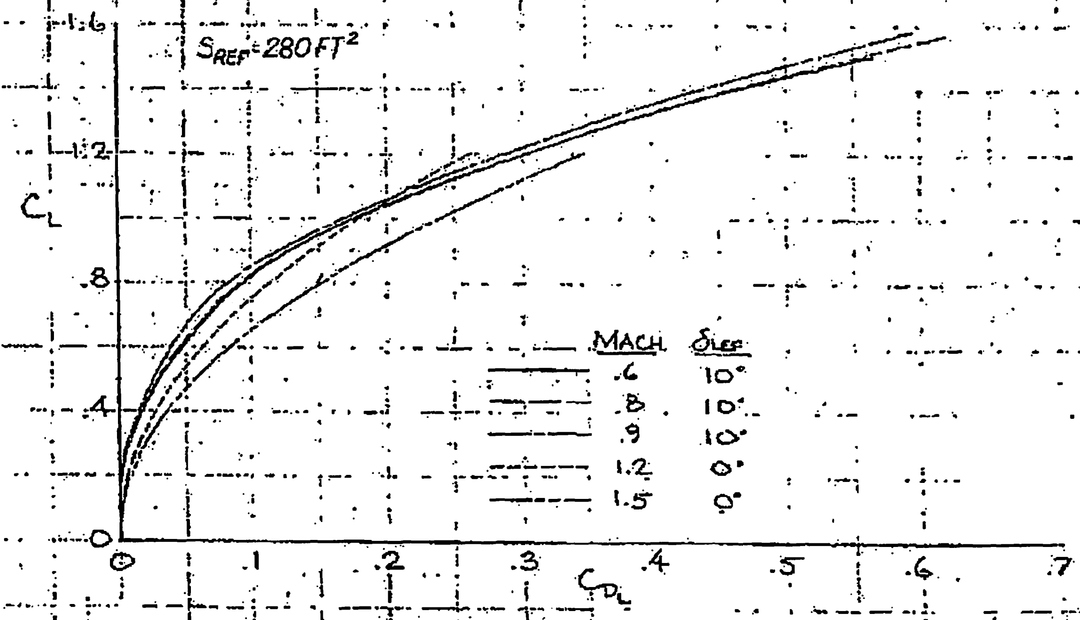


~~(S)~~ Figure 6.3-5 Drag Due to Lift at M=1.2 and 1.5, Configuration 401B with 0.4 Taper-Ratio Wing (U)

~~SECRET~~

88th ABW/IPI
~~FOIA (b)(4)~~
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~SECRET~~

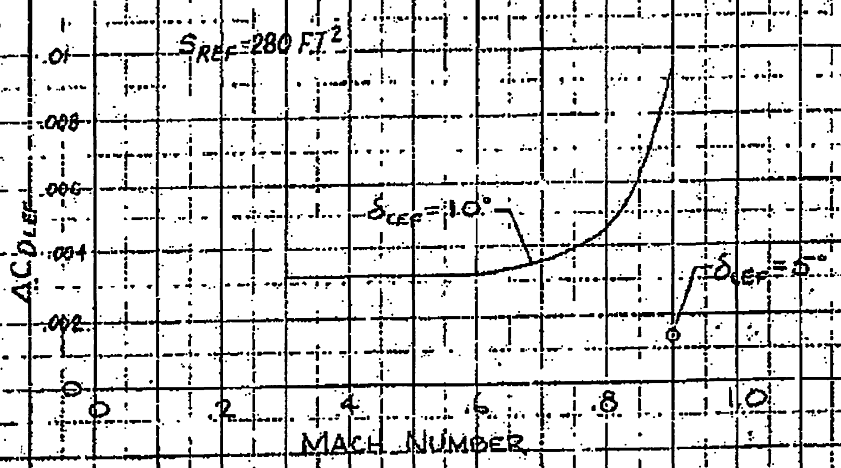


~~(S)~~ Figure 6.3-6 Drag Due to Lift at High C_L's, Configuration 401B with 0.4 Taper-Ratio Wing (U)

~~SECRET~~

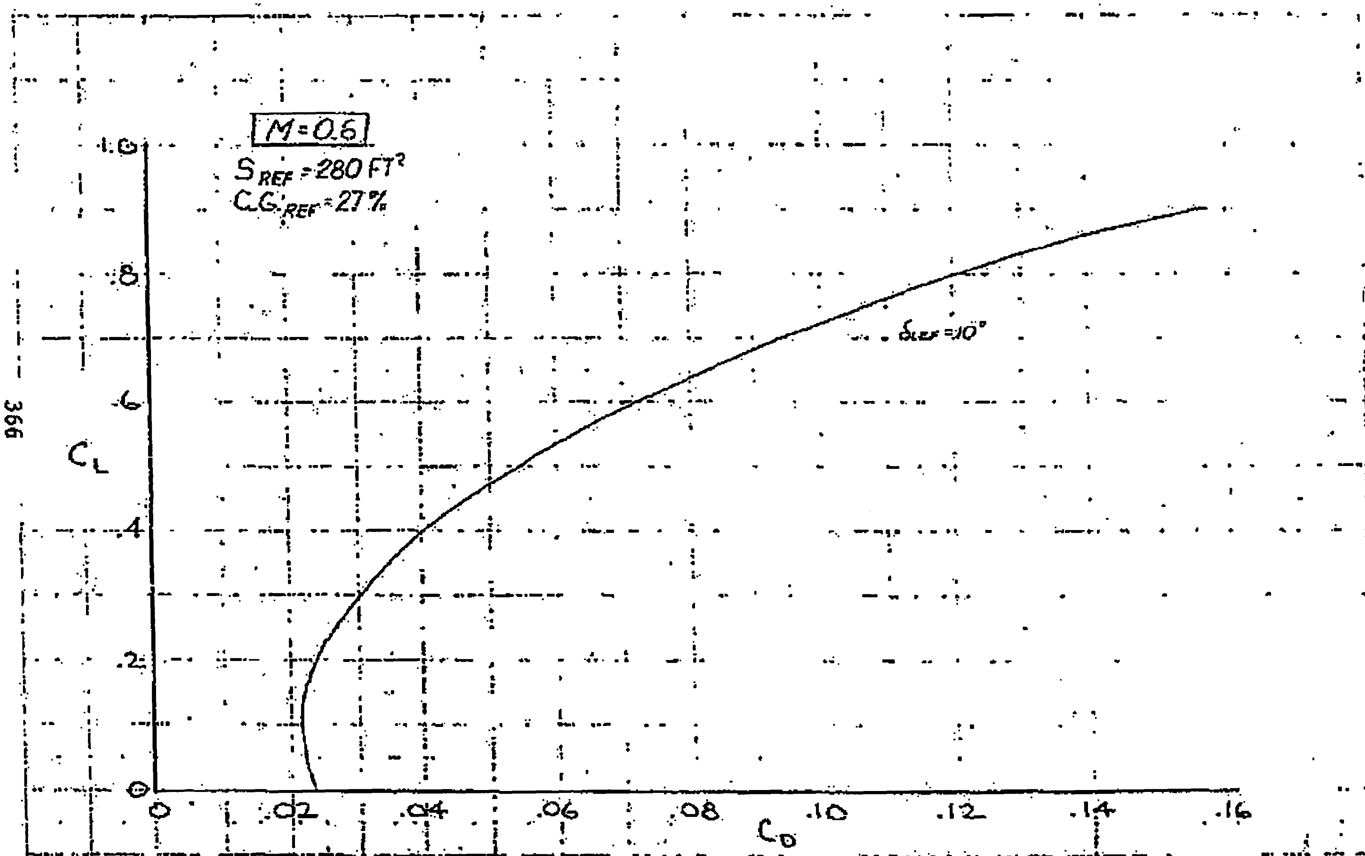
88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 6.3-7 Minimum Drag Increment Due to Deflection of Leading-Edge Flap, Configuration 401B with 0.4 Taper-Ratio Wing (U)

~~SECRET~~

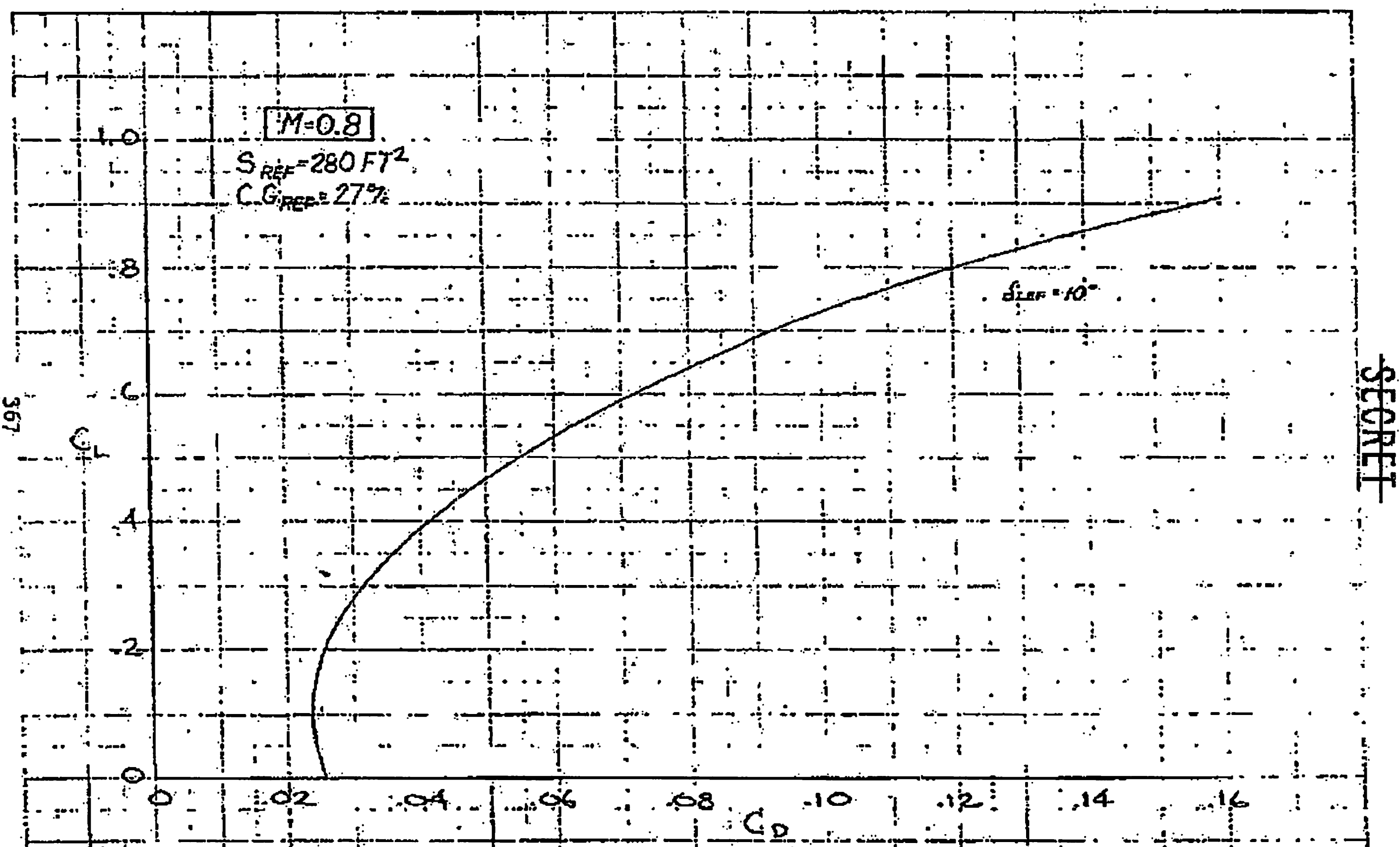


~~(S)~~ Figure 6.3-8 Trimmed Drag Polar at M=0.6, Configuration 401B with 0.4 Taper-Ratio Wing (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)
(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 6.3-9 Trimmed Drag Polar at M=0.8, Configuration 401B with 0.4 Taper-Ratio Wing (U)

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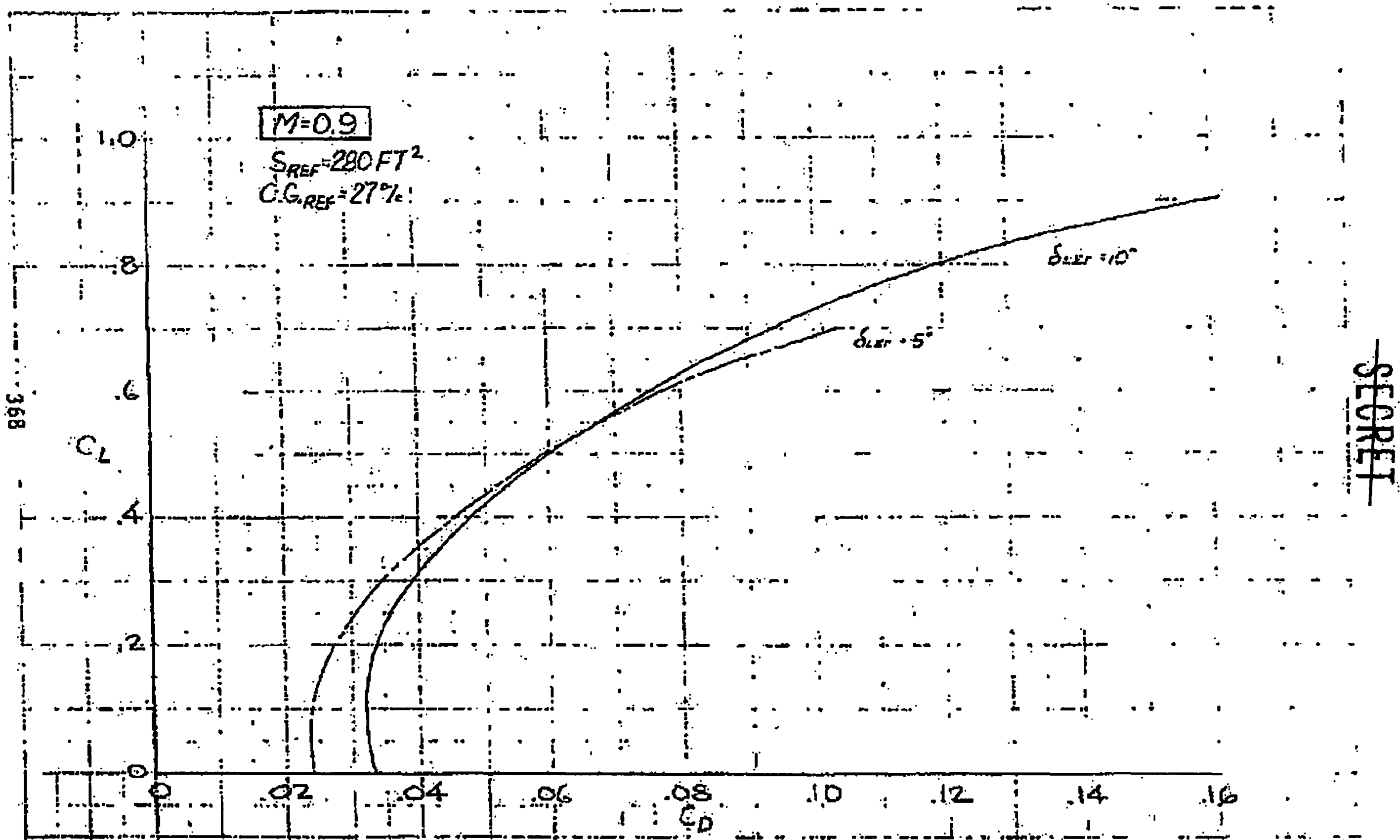
~~SECRET~~



~~(S)~~ Figure 6.3-10 Trimmed Drag Polar at M=0.9, Configuration 401B with 0.4 Taper-Ratio Wing (U)

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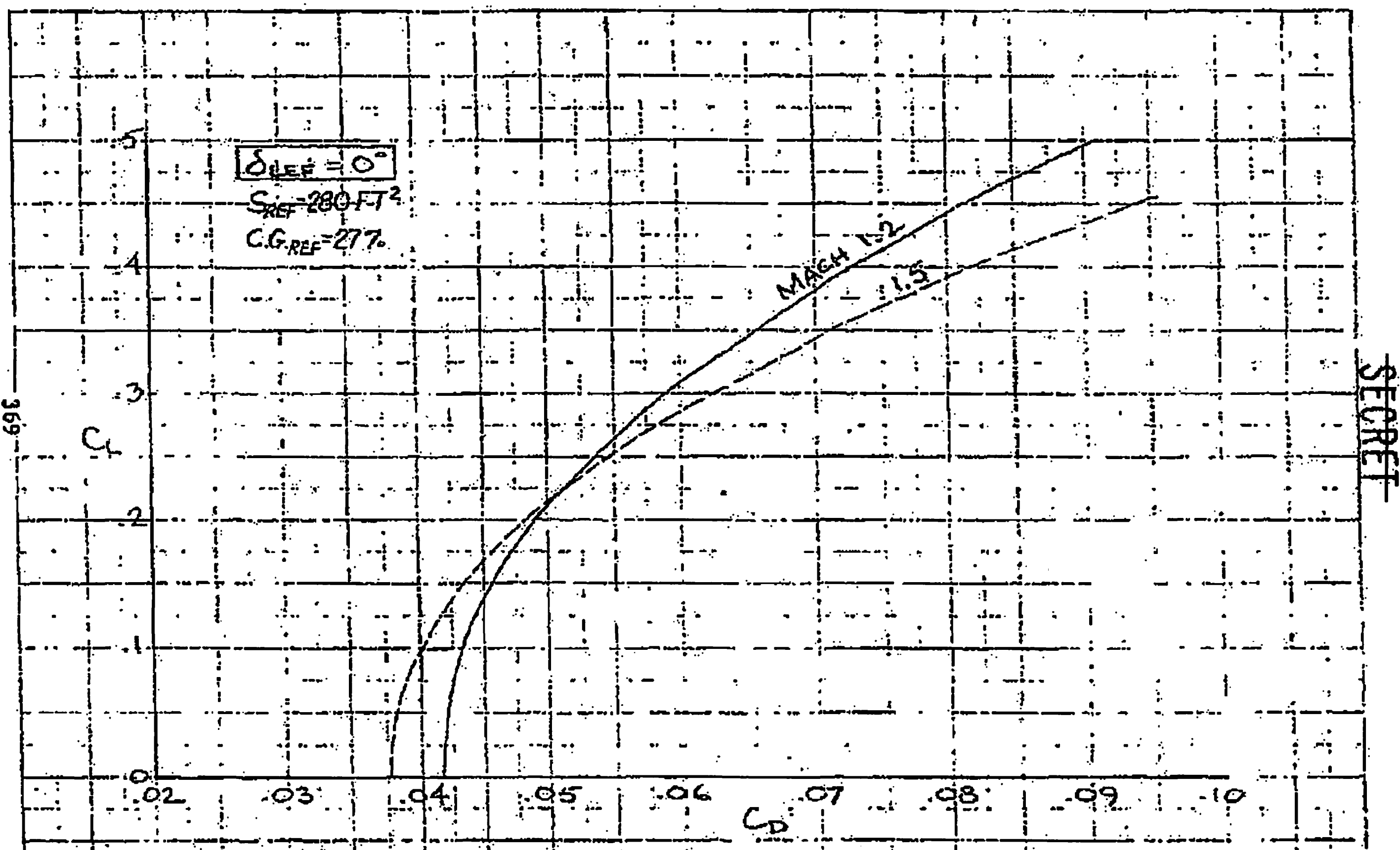
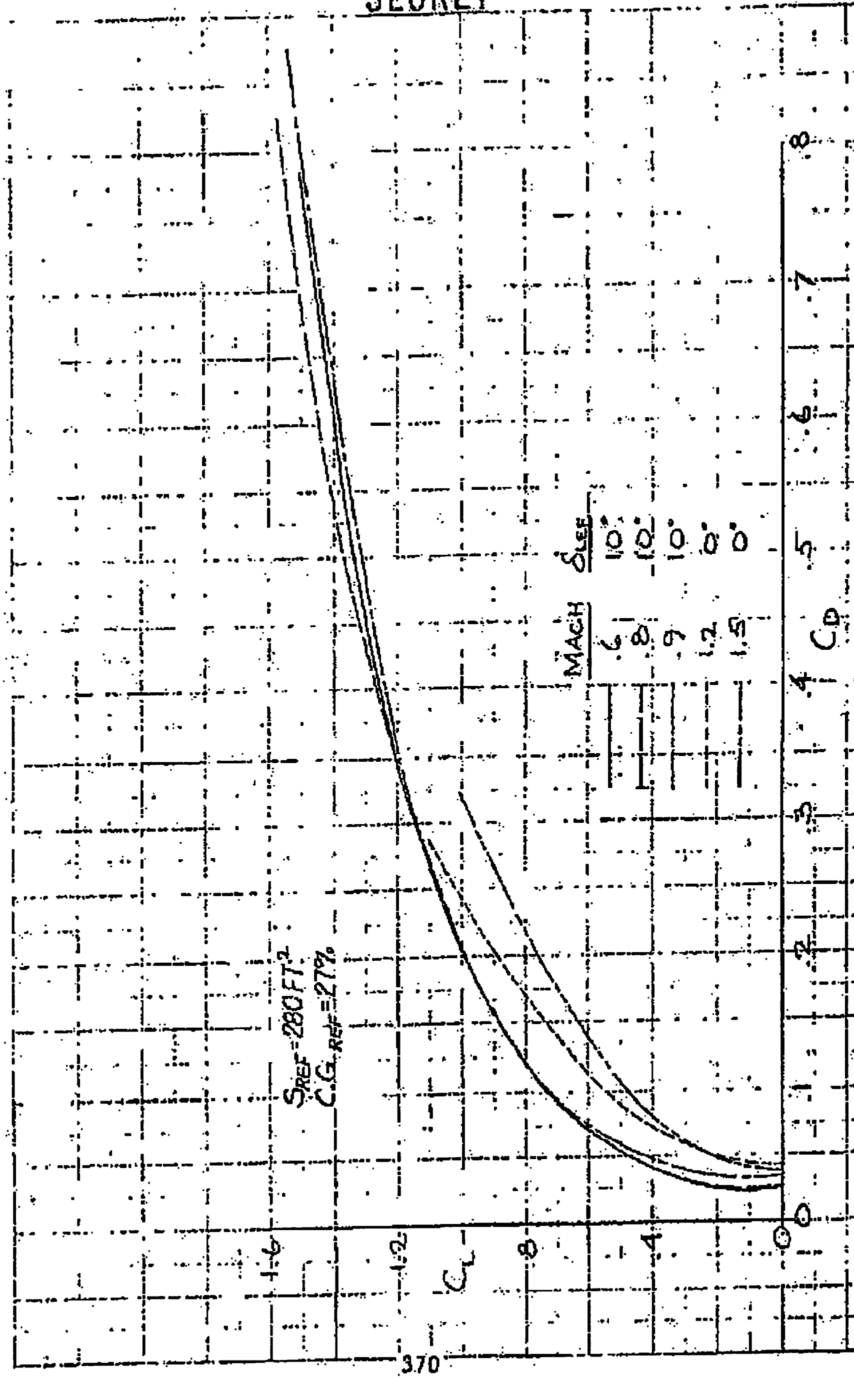


~~(S)~~ Figure 6.3-11 Trimmed Drag Polar at M=1.2 and 1.5, Configuration 401B with 0.4 Taper-Ratio Wing (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 6.3-12 Trimmed Drag Polar at High C_L's, Configuration 401B with 0.4 Taper-Ratio Wing (U)

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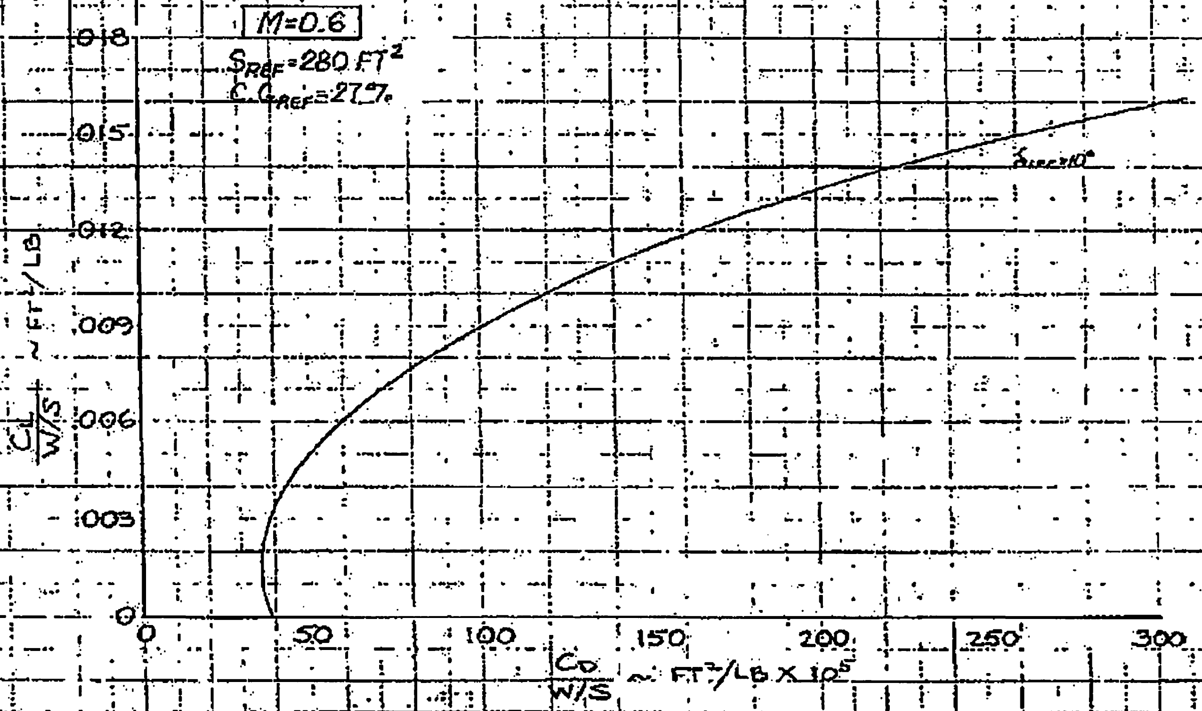
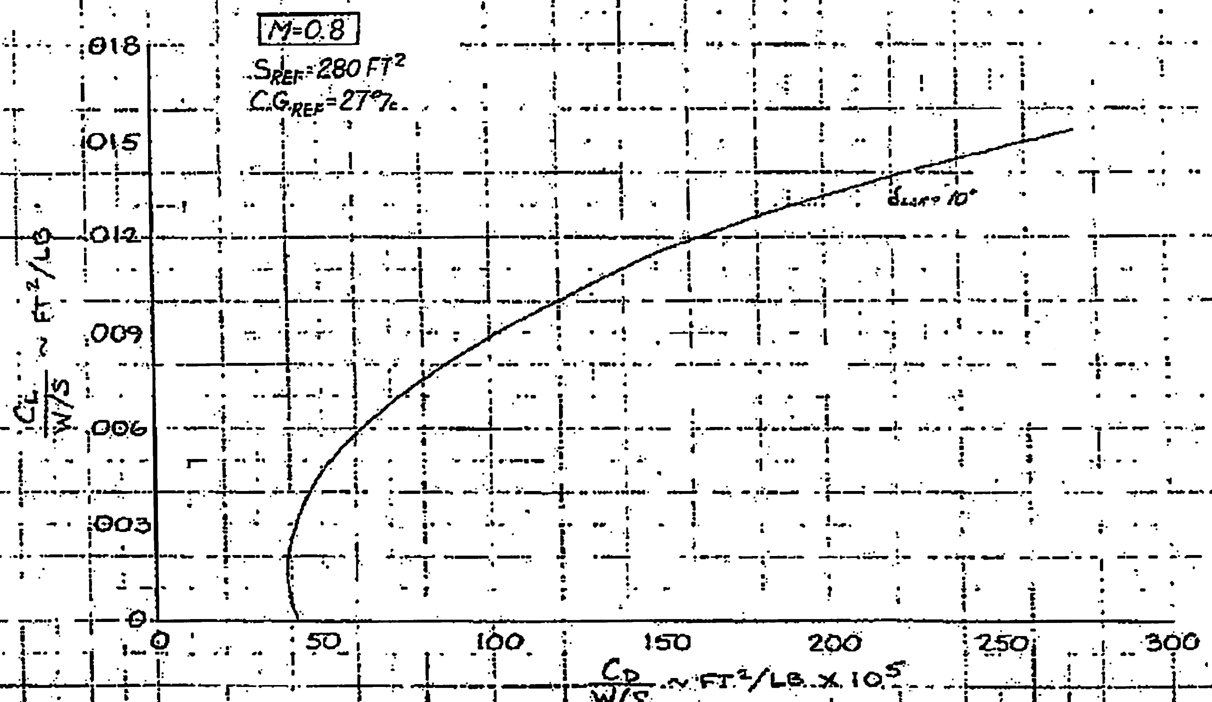


~~(S)~~ Figure 6.3-13 Trimmed Configuration Polars at M=0.6, Configuration 401B with 0.4 Taper-Ratio Wing (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 6.3-14 Trimmed Configuration Polars at M=0.8, Configuration 401B with Taper-Ratio Wing (U)

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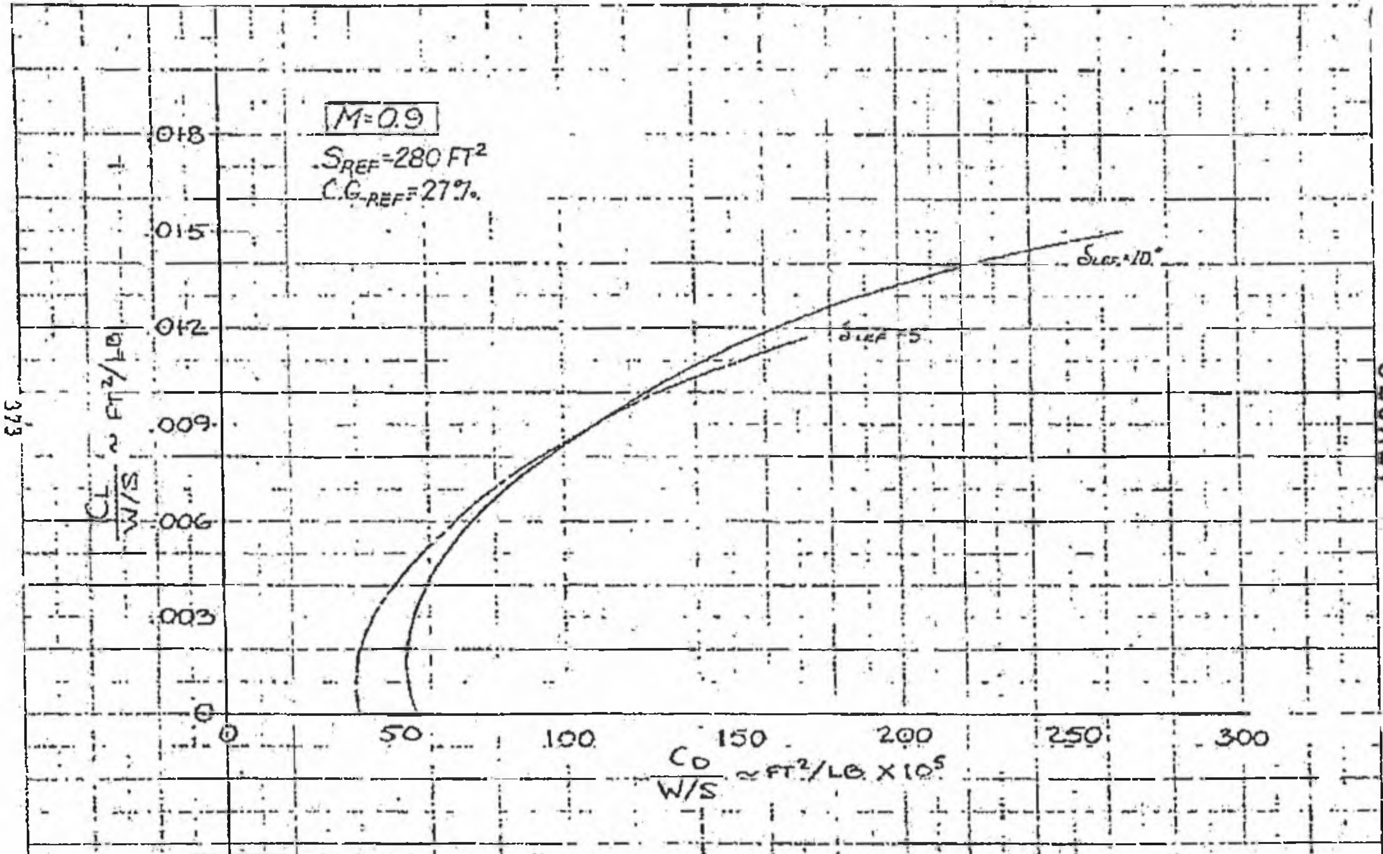
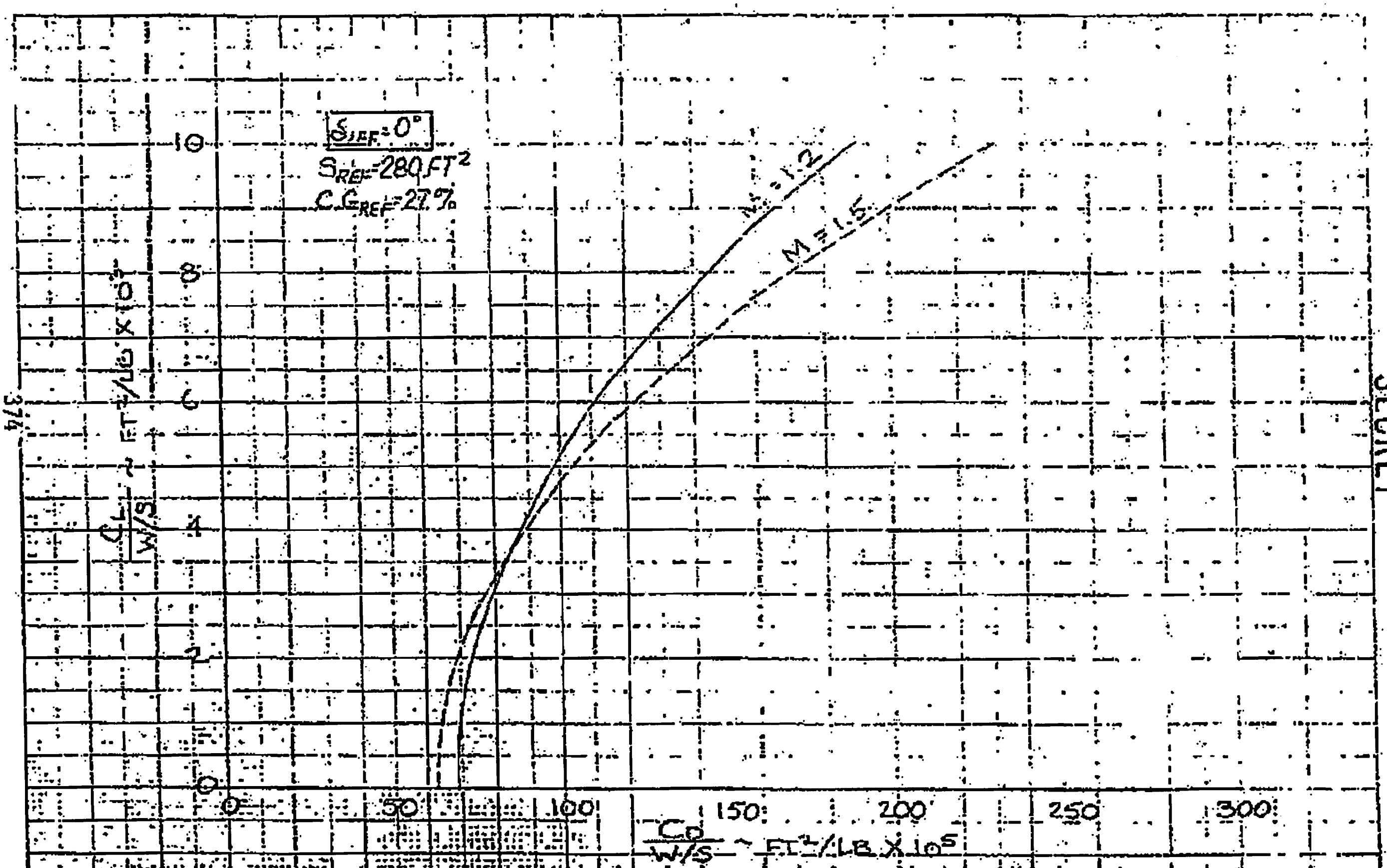


~~(S)~~ Figure 6.3-15 Trimmed Configuration Polars at M=0.9, Configuration 401B with 0.4 Taper-Ratio Wing (U)

SECRET

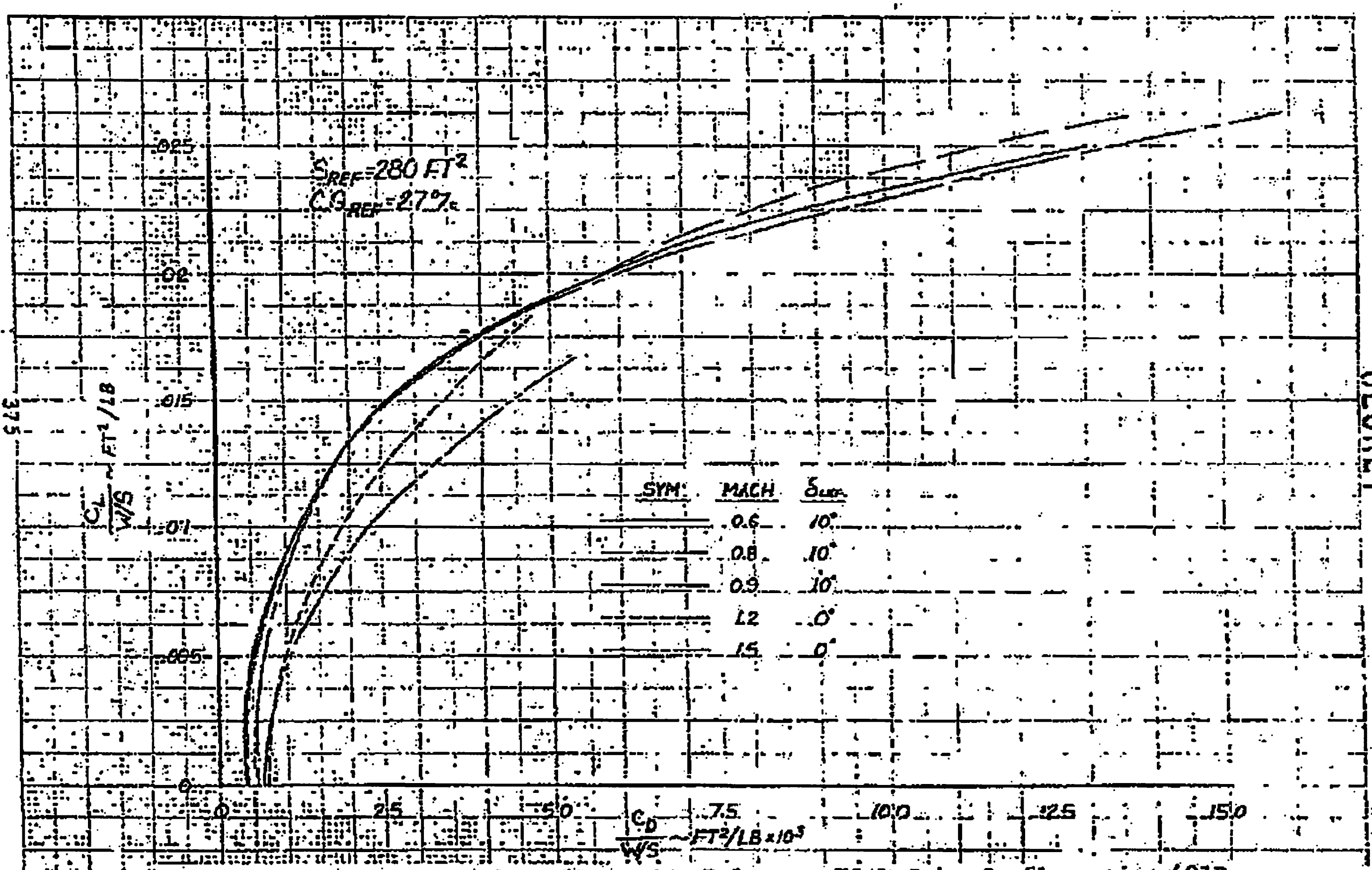
88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



(S) Figure 6.3-16 Trimmed Configuration Polars at M=1.2 and 1.5, Configuration 401B with 0.4 Taper-Ratio Wing (U)

SECRET



~~(S)~~ Figure 6.3-17 Trimmed Configuration Polars at High C_L's, Configuration 401B with Taper-Ratio Wing (U)

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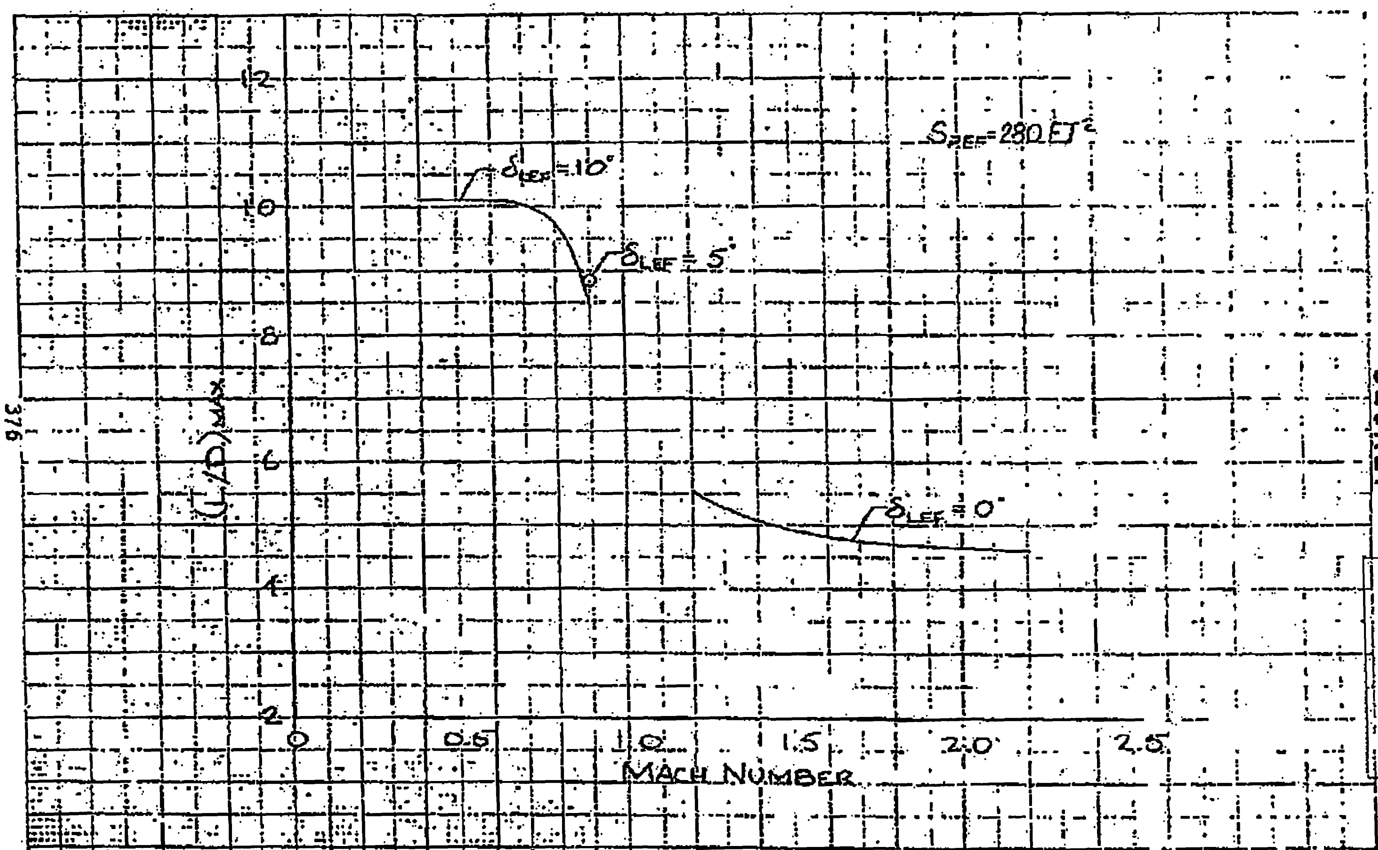
SECRET

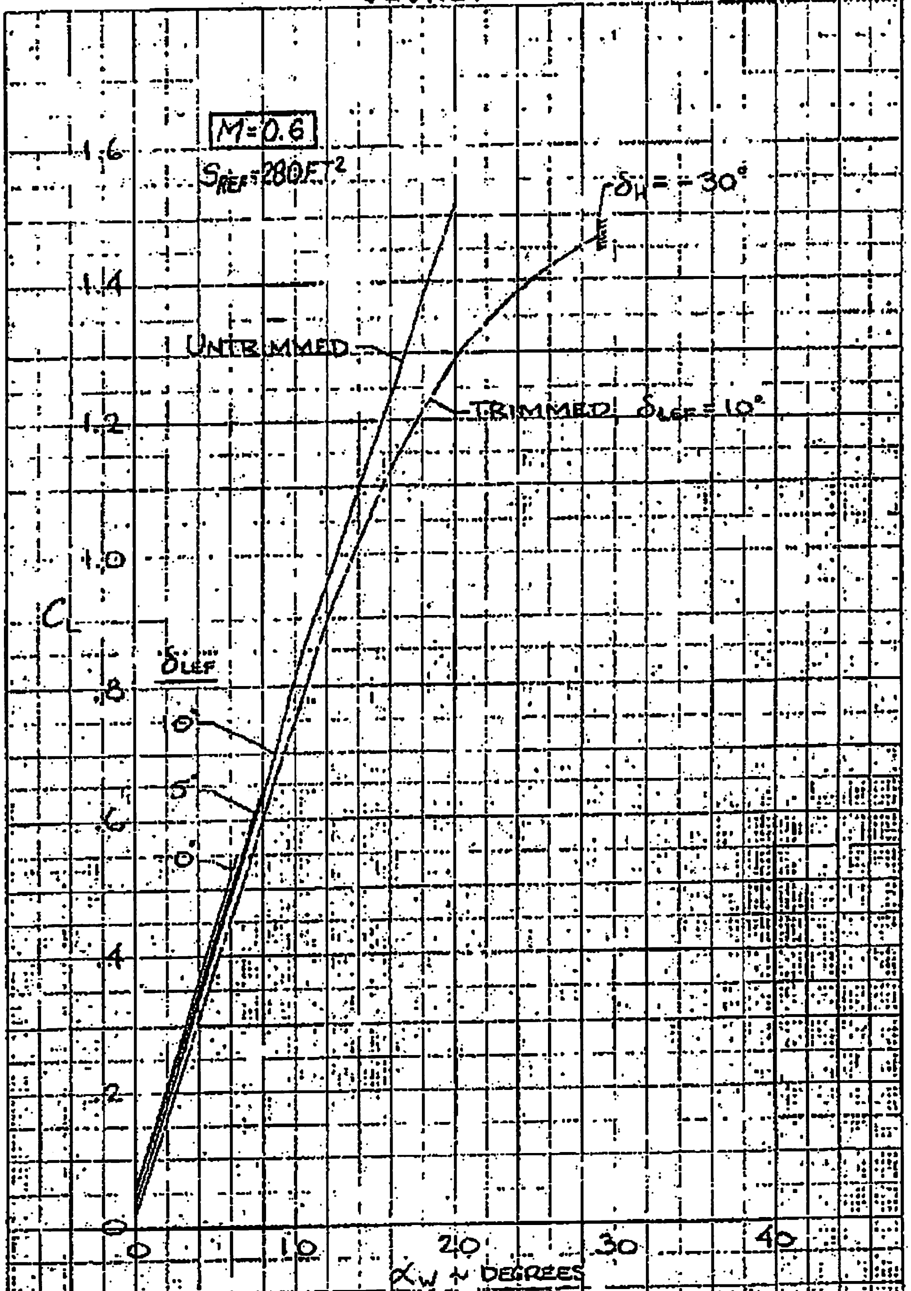


(S) Figure 6.3-18 Trimmed (L/D) max vs Mach Number, Configuration 401B with 0.4 Taper-Ratio Wing (U)

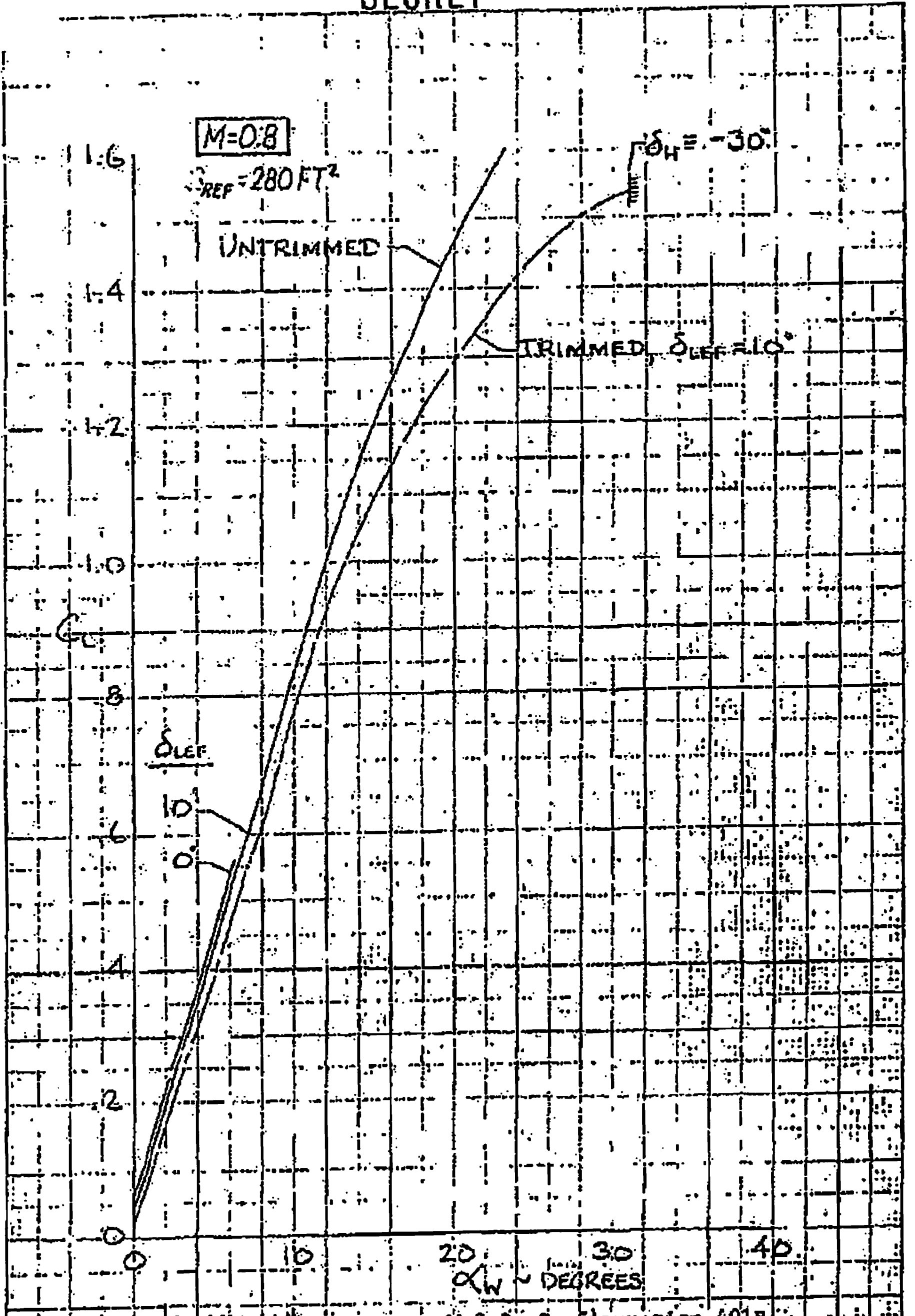
SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

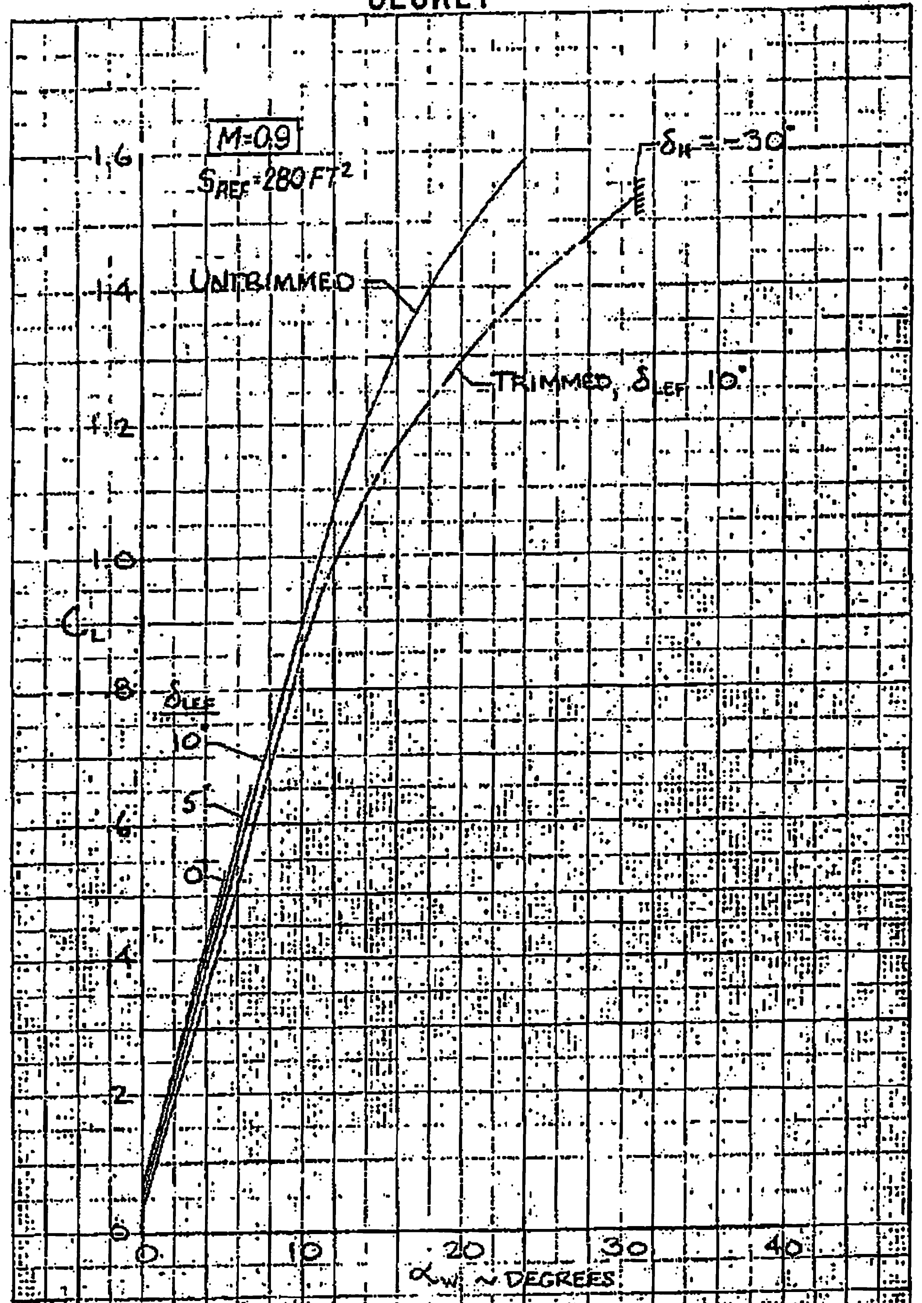


(S) Figure 6.3-19 C_L vs α at M=0.6, Configuration 401B with 0.4 Taper-Ratio Wing (U)

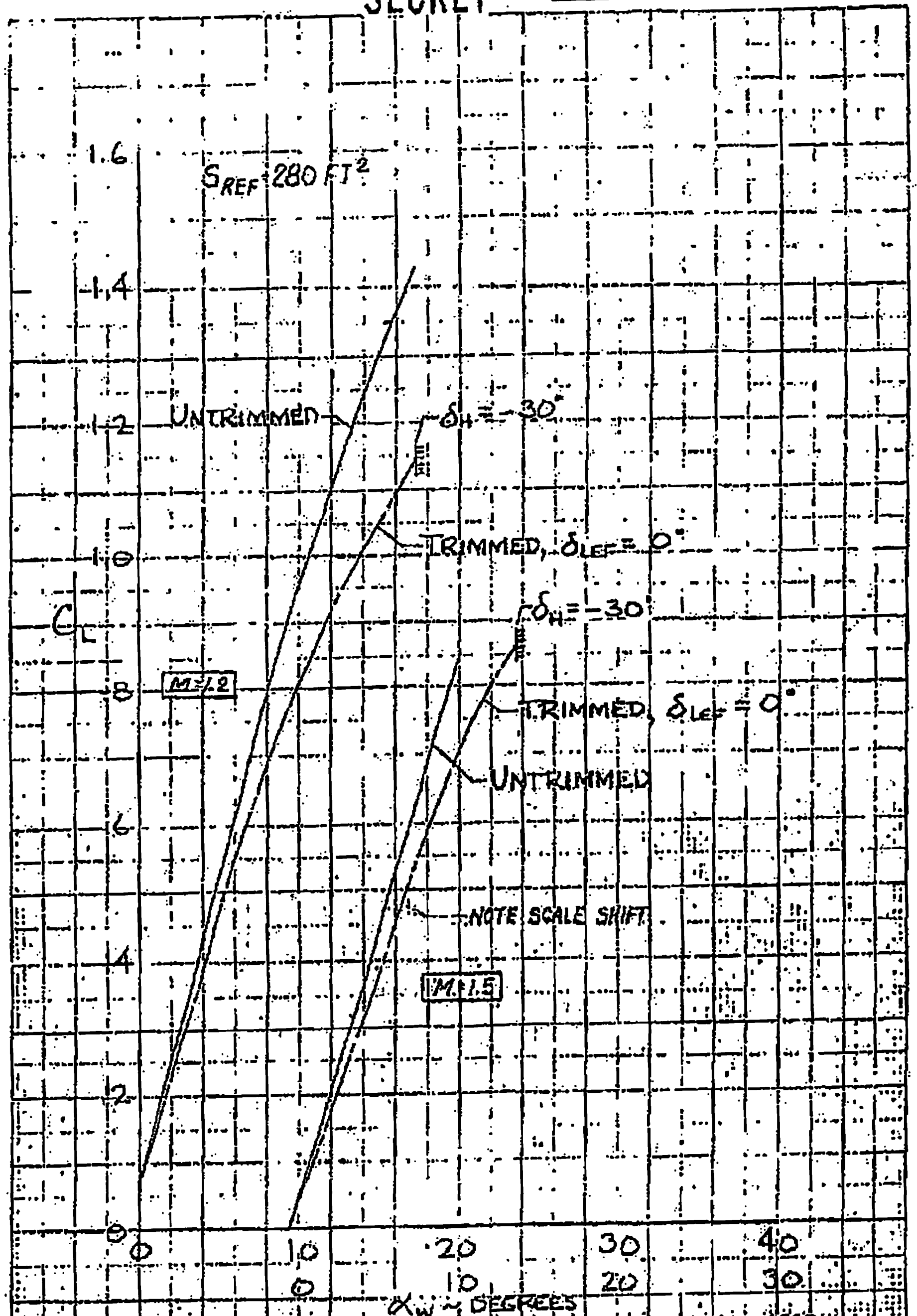


~~(S)~~ Figure 6.3-20 C_L vs α at M=0.8, Configuration 401B with 0.4 Taper-Ratio Wing (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

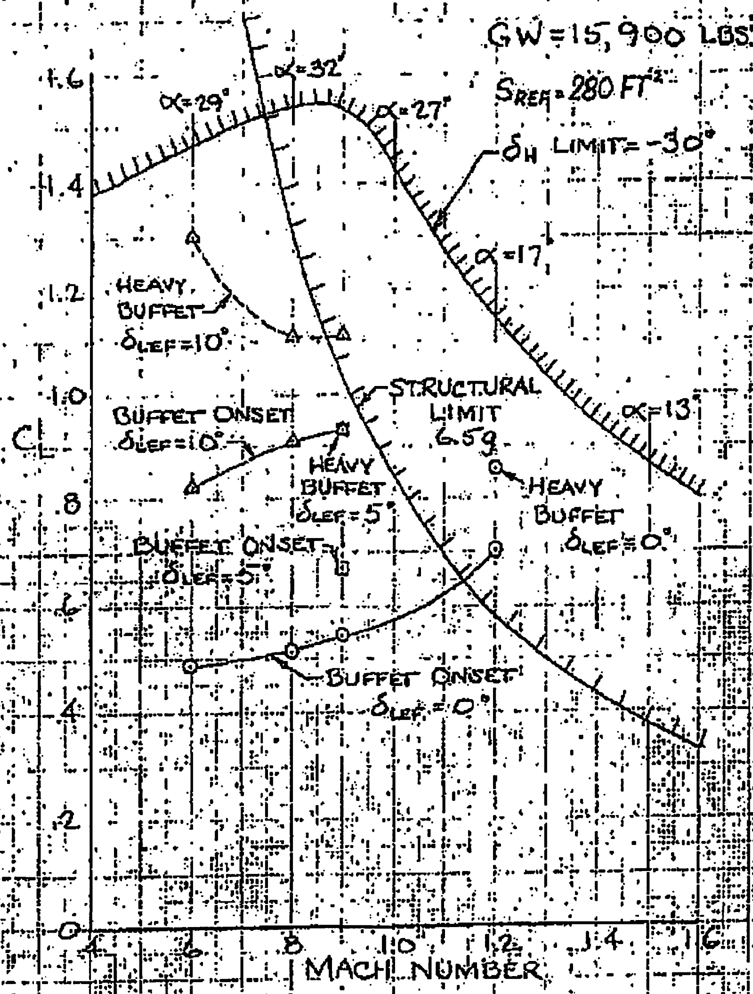


~~(S)~~ Figure 6.3-21 C_L vs α at M=0.9, Configuration 401B with 0.4 Taper-Ratio Wing (U)



~~(S)~~ Figure 6.3-22 C_L vs α at M=1.2 and 1.5, Configuration 401B with 0.4 Taper-Ratio Wing (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 6.3-23 Buffet Boundaries and Control Limit C_L's vs Mach Number, Configuration 401B with 0.4 Taper-Ratio Wing (U)

88th ABW/IPI
FOIA (b)(1)
88 ABW/IPI
FOIA (b)(1)

6.4 STABILITY, CONTROL, AND HANDLING QUALITIES

(U) The basic stability and handling qualities of Configuration 401B were not significantly altered by the change in wing taper ratio from 0.2 to 0.4. Since the leading-edge sweep angle and aspect ratio were held constant, the increased taper ratio shifted the wing area aft. The net change in longitudinal stability was very small, however, because the trailing-edge sweep angle changed with taper ratio and the consequent change in cutout factor was compensatory. Similarly, since the configuration was essentially identical in other respects, there are no changes in lateral-directional stability attributable to the increased taper ratio. As a result, the stability and control characteristics and handling qualities reported in Section 3.4 for the basic 401B configuration are also directly applicable to the 0.4 taper-ratio fighter.

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3 (b)(4)
1.4. (a)(g)
SEC 3.3 (b)(X4)
SEC 1.4 (a)(g)
p 95 -
383-384

6.5 STRUCTURES AND WEIGHTS

~~(S)~~ Weight analysis for the 0.4 taper-ratio wing on Configuration 401B was performed in the same manner as the weight analyses described in previous sections (see Section 3.5). The 16,800-pound configuration was used to evaluate this wing with a structural design gross weight (80% fuel) of 15,960 pounds and a ferry mission overload gross weight of 27,000 pounds.

~~(S)~~ Input data for the weight equations were derived from the data presented in Section 6.1. The statement of work specifies a 4% thickness-to-chord ratio for this wing. In order to achieve a minimum weight, this 4% thickness was interpreted to be an RMS thickness of 4%, which results in a thickness-to-chord ratio of 2.5% at the tip and 4.84% at Buttock Line 54, the start of the expanded root section. This interpretation resulted in a wing structural weight decrement of 151 pounds.

~~(S)~~ A weight summary for this configuration is shown in Table 6.5-1. A summary of the center-of-gravity conditions for the various missions is shown below.

Condition	Basic Operating Weight	Zero Fuel Weight	Gross Weight
SRASM			
Weight (lb)	12,226	12,859	16,800
C.G. (% MAC)	23.9	23.1	20.0
LRASM			
Weight (lb)	13,074	13,707	21,638
C.G. (% MAC)	24.0	23.3	21.2
Ferry Mission			
Weight (lb)	13,916	14,201	27,000
C.G. (% MAC)	23.9	22.7	21.7

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4. (a)(g)

~~(S)~~ Table 6.5-1 WEIGHT SUMMARY: CONFIGURATION 401B WITH 0.4 TAPER RATIO WING (pounds) (U)

Item	Weight
Structure	(5529)
Wing	1687
Fuselage	2588
Horizontal Tail	322
Vertical Tail	316
Landing Gear	616
Propulsion	(3530)
Engine	2737
Air Induction	322
Fuel System	421
Engine Controls	22
Starting System	28
Systems and Equipment	(2767)
Surface Controls	612
Landing Gear Controls	115
Instruments	94
Hydraulics and Pneumatics	283
Electrical	370
Avionics	460
Furnishings	238
Air Conditioning System	142
Armament	453
Weight Empty	11,826
Useful Load	(400)
Crew	200
Unuseable fuel	23
Engine Oil	17
Missile Racks and Pylons	124
Miscellaneous	36
Basic Operating Weight	12,226
Payload	(633)
Ammo (500 Rounds)	285
Missiles (2)	348
Zero Fuel Weight	12,859
Fuel	3941
Gross Weight	16,800

SECTION 7

SUPERCRITICAL WING STUDY

(U) The supercritical wing, which is an outgrowth of recent advances in transonic aerodynamic technology, has been evaluated on Configuration 401B to determine its potential for improved transonic maneuverability. The supercritical wing study was conducted in two phases:

1. An abbreviated wing-planform parametric study was conducted to select the planforms having the most potential on a highly maneuverable fighter.
2. Detailed layouts of the select planforms were then made, and point-design structural weight, aerodynamic, and performance analyses were carried out.

7.1 WING PLANFORM PARAMETRIC STUDY

88th ABW/PI
FOIA (b)(1)
E.O. 13526 SEC.
3.3(b)(4)
1.4(a)(g)
SEC. 1.4
(a)(g)

~~(S)~~ In Phase 1 of the study, the wing-planform selection, wing loading, aspect ratio, and leading-edge sweep angle were varied. The matrix of wing sizes and leading edge sweep angles is defined as follows:

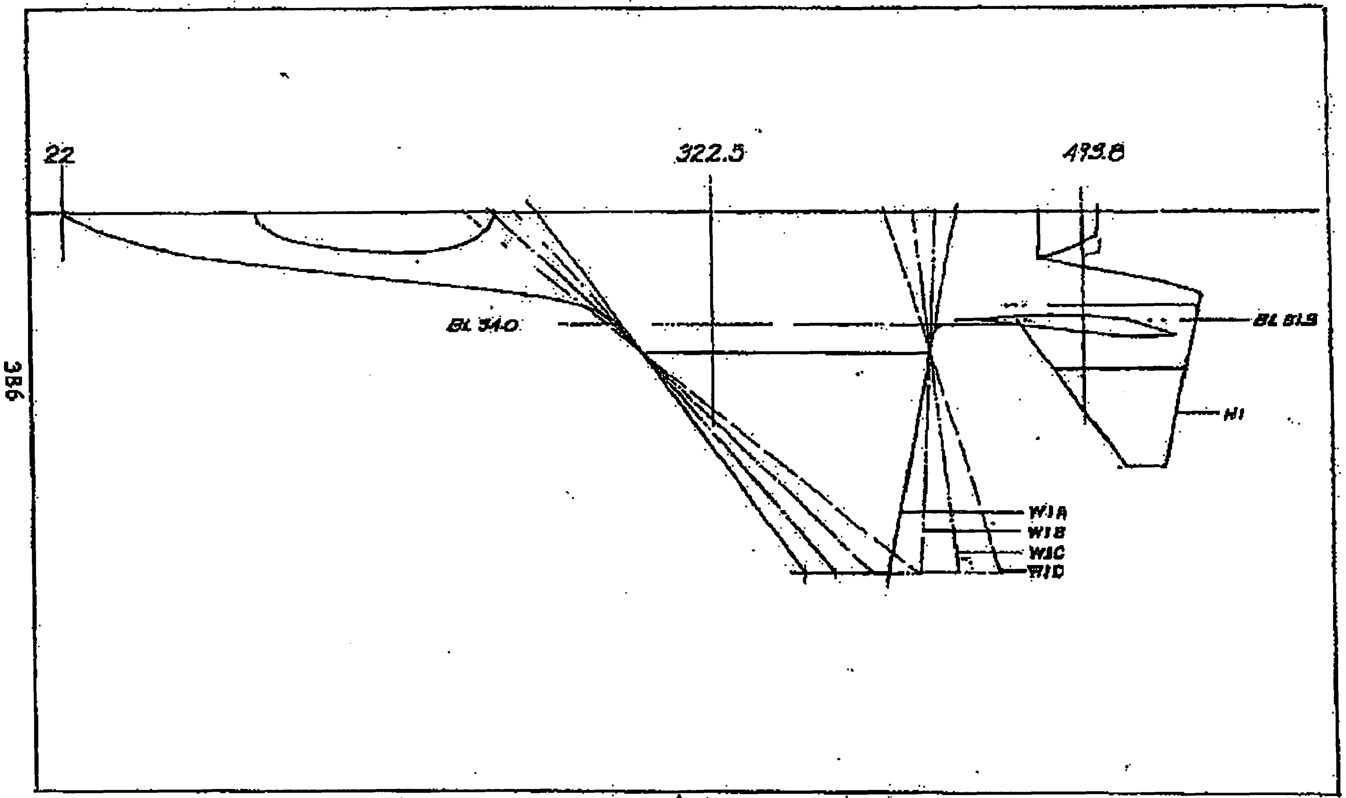
Wing 1 (W1): $AR = 3.0$; $W/S = 60$ psf; $\Lambda = 35^\circ, 40^\circ, 45^\circ, 50^\circ$

Wing 2 (W2): $AR = 3.5$; $W/S = 70$ psf; $\Lambda = 35^\circ, 40^\circ, 45^\circ, 50^\circ$

Wing 3 (W3): $AR = 4.0$; $W/S = 80$ psf; $\Lambda = 35^\circ, 40^\circ, 45^\circ, 50^\circ$

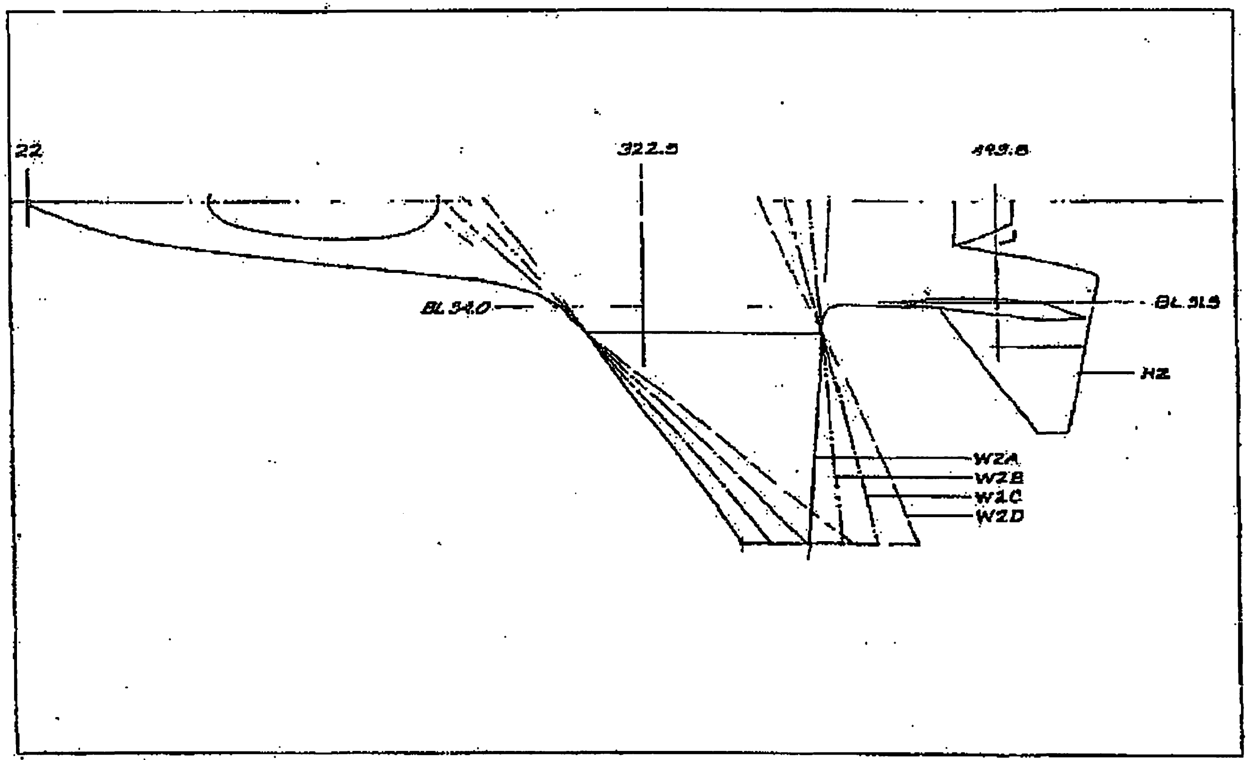
Wing 4 (W4): $AR = 4.5$; $W/S = 90$ psf; $\Lambda = 35^\circ, 40^\circ, 45^\circ, 50^\circ$

~~(S)~~ Airplane planform comparisons are shown in Figure 7.1-1 through 7.1-4 at the four wing sweep angles for Wings 1, 2, 3, and 4 of the matrix. (The letters A, B, C, D in the figures signify wing sweeps at 35, 40, 45, and 50 degrees, respectively.) A comparison is shown in Figure 7.1-5 for the 35-degree-wing-sweep case with the four different wings delineated above and the tail sizes associated with each. Similar data are shown in Figure 7.1-6 for the 45-degree-wing-sweep case at a constant 60-psf wing loading.



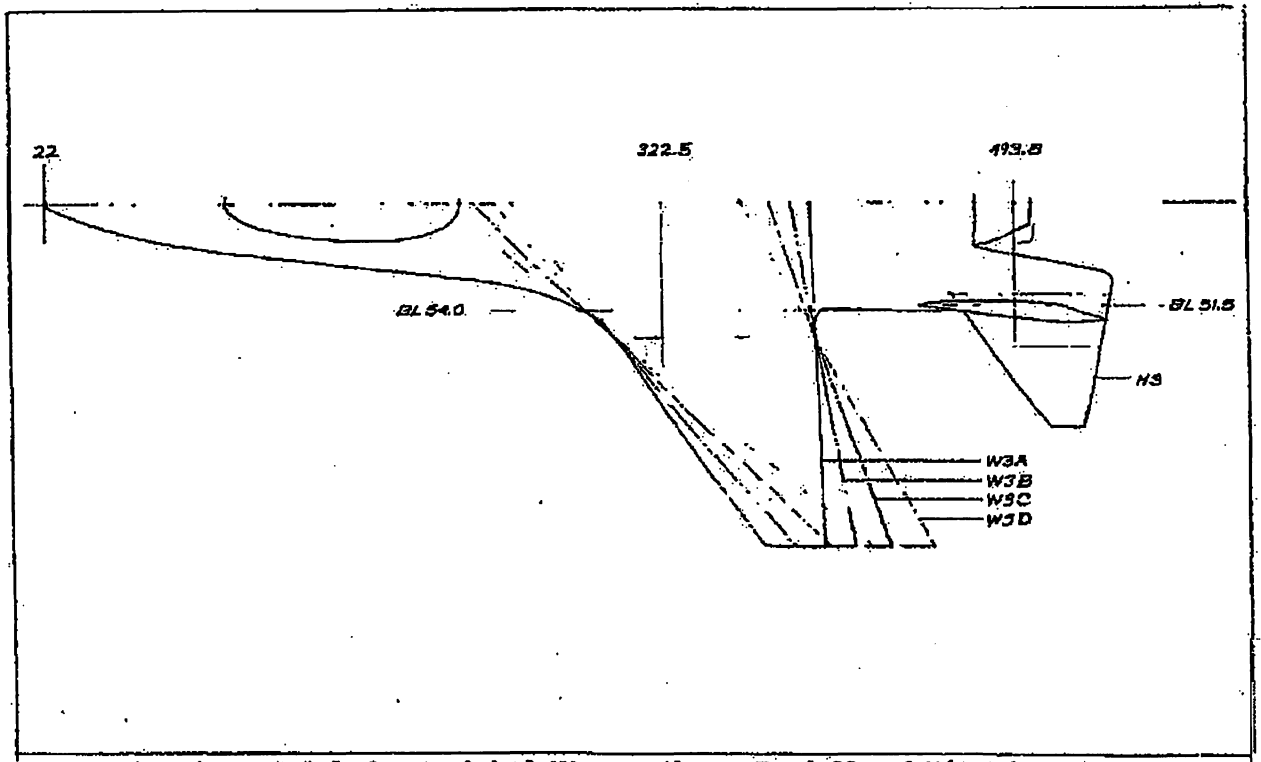
~~(C)~~ Figure 7.1-1 Supercritical Wing Family at AR = 3.00 and W/S = 60 psf (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

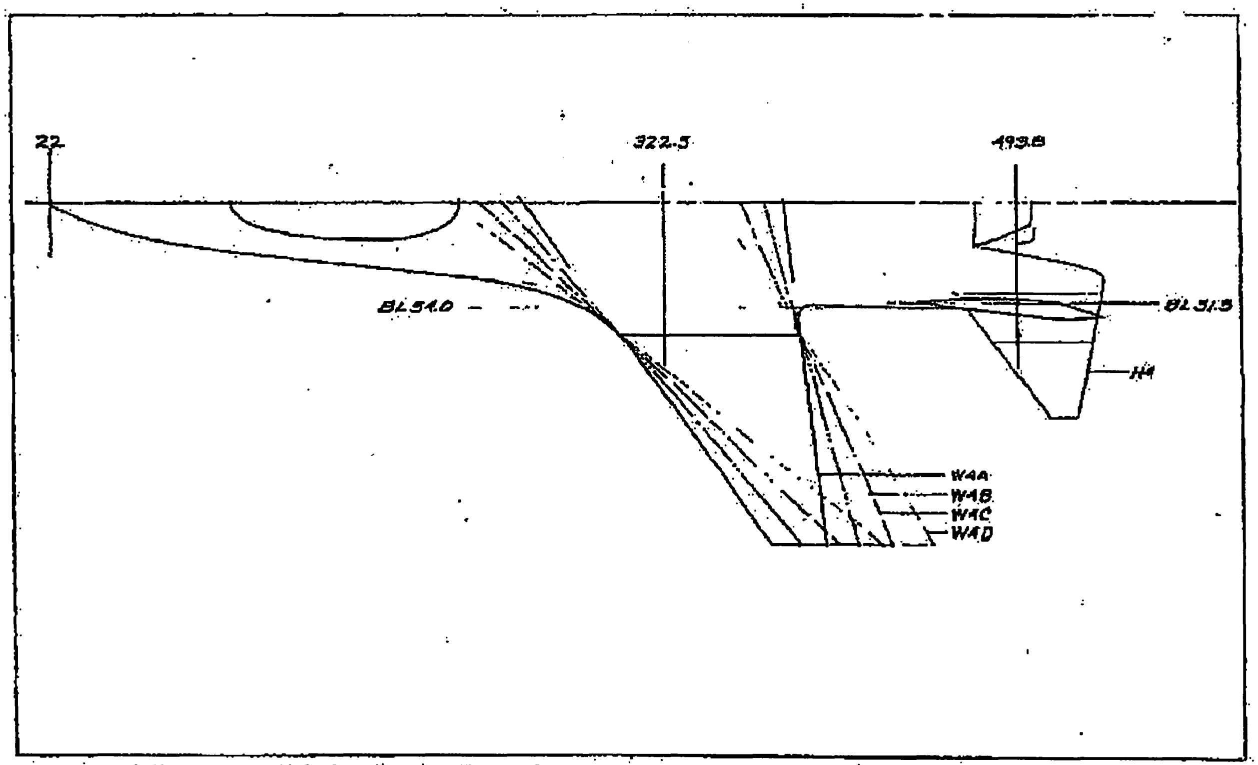


~~(C)~~ Figure 7.1-2 Supercritical Wing Family at $\mathcal{R}$ = 3.50 and W/S = 70 psf (U)

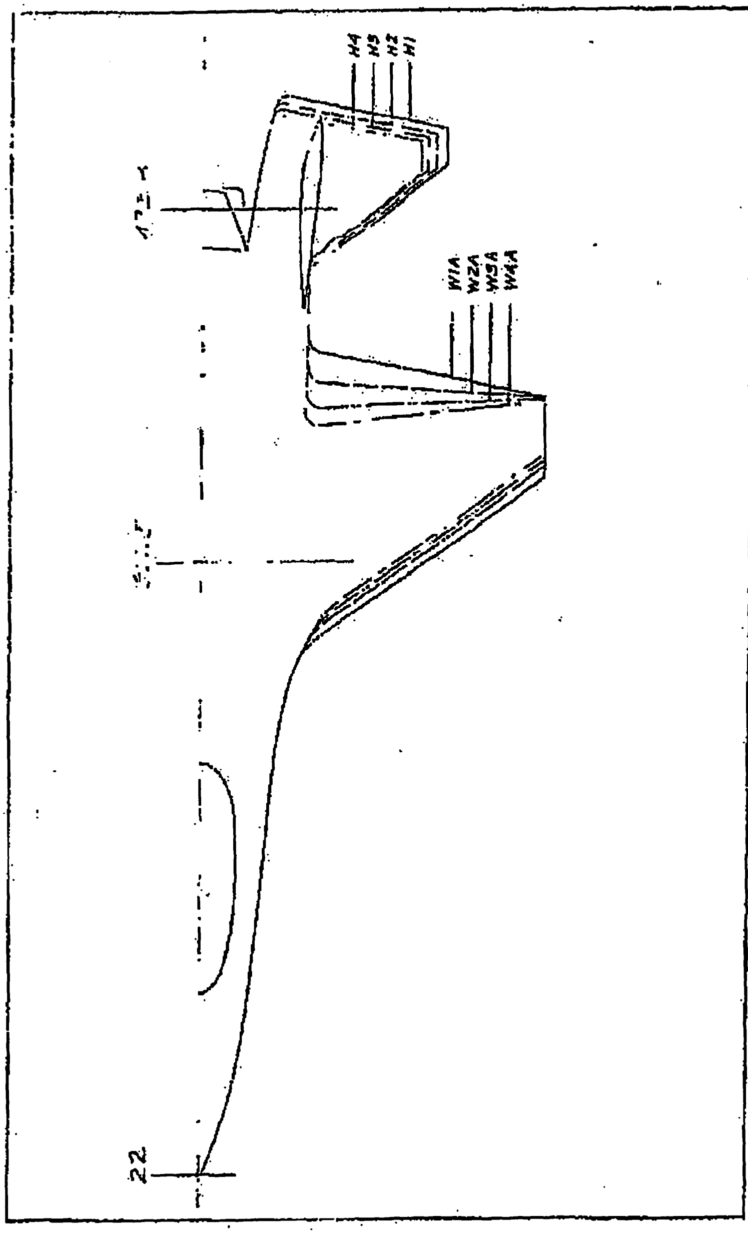
~~88th ABW/IPI~~
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(C)~~ Figure 7.1-3 Supercritical Wing Family at AR = 4.00 and W/S = 80 psf (U)

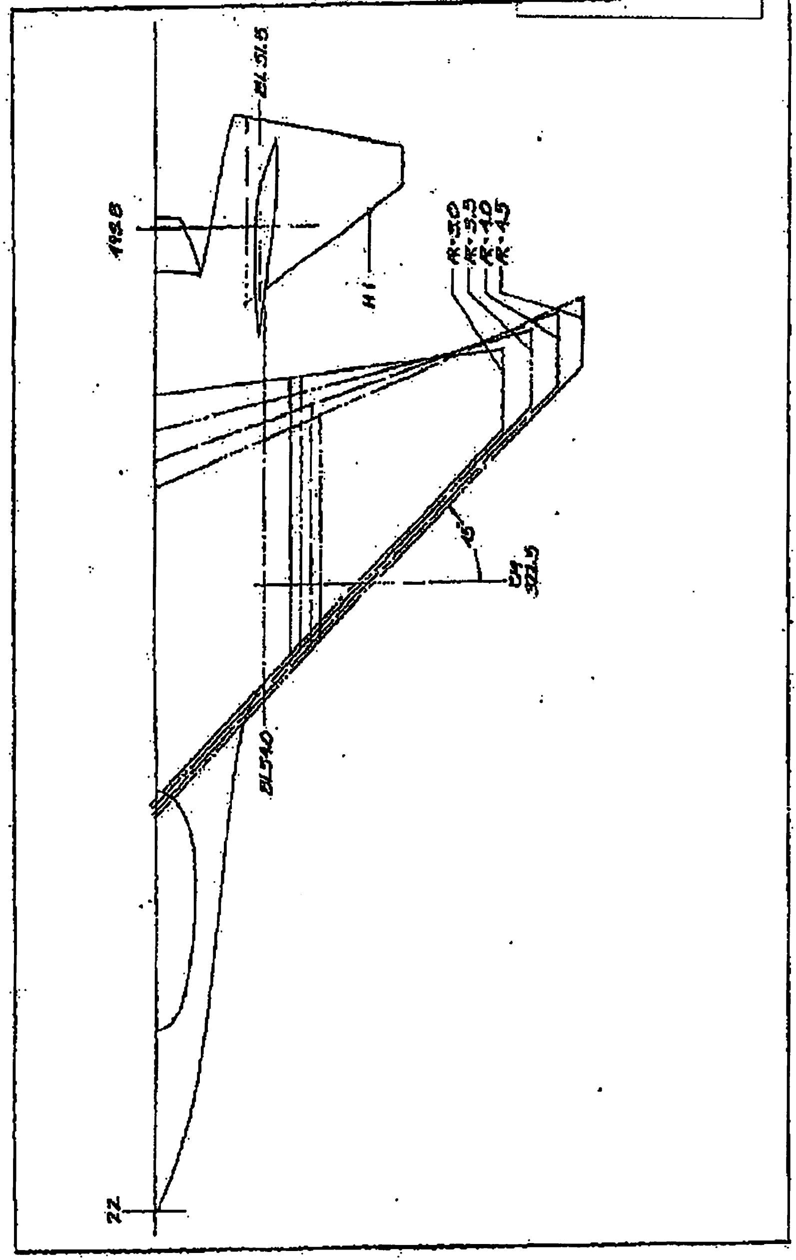


~~(C)~~ Figure 7.1-4 Supercritical Wing Family at AR= 4.50 and W/S = 90 psf (U)



~~(C)~~ Figure 7.1-5 Supercritical Wing Family of Wing-Loading/Aspect-Ratio's at L.E. Sweep = 35° (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(C)~~ Figure 7.1-6 Supercritical Wing Family of Aspect Ratios at L.E. Sweep = 45° and Wing Loading = 60 psf (U)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3 (b)(4)
1.4. (a)(g)
E.O 13526 SEC. 3.3 (b)(4)
SEC 1.4 (a)(g)
pgs 392-395

~~(S)~~ In the study, taper ratio, λ, was held constant at a value of 0.2. Wings with less taper (higher taper ratios) tend to be heavier, while wings with more taper are prone to flutter and pitchup because of early tip stall.

~~(S)~~ A wing thickness ratio of 0.06 was used for all planforms considered. Experience gained in the application of supercritical airfoils to wings of several types (including F-111, F-111 TACT, B-1, FX) indicates that the potential payoff reduces as wing t/c reduces. As a result of this experience and in consultation with Dr. R. T. Whitcomb of NASA Langley, it was decided to limit the t/c of this study to 0.06 or greater.

~~(S)~~ The following list summarizes the ground rules that were established in conjunction with the matrix of variables previously described for generating the required aircraft design data:

1. Aircraft gross weight remains constant (16,800 lb).
2. The $\bar{c}/4$ of all reference wings is located at a constant fuselage station.
3. The horizontal tail moment arm is held constant (171.3 in.).
4. The wing thickness and taper ratios are held constant ($t/c = 0.06$, $\lambda = 0.2$).
5. The vertical tail geometry and position is held constant ($S_{H.T.} = 22.12$ ft^2, $AR = 1.3265$, $\lambda = 0.4$, $\Lambda_{LE} = 45^\circ$).
6. The "d" distance to the exposed wing root chord is held constant (54 in., measured from airplane centerline).
7. The sizing horizontal tail geometry characteristics ($AR = 3.0$, $\lambda = 0.2$, and $\Lambda_{LE} = 35^\circ$) remain constant.
8. The "d" distance to the exposed horizontal tail root chord remains constant (51.5 in., measured from airplane centerline).

~~(S)~~ 9. The ratio of the exposed horizontal tail area to the sizing horizontal tail area remains constant (0.866).

10. An initial sizing horizontal tail is determined by a horizontal tail volume coefficient of 0.26 and by wing geometry defined by AR = 3.0, $\lambda = 0.2$, W/S = 60 psf. This establishes a horizontal-tail-area/wing-area ratio of 0.202. As the wing geometry changes because of variations in aspect ratio and wing loading, the sizing horizontal tail area is established by keeping the area ratio of 0.202 constant.

(U) Since the primary interest is in maneuverability, the parametric comparison plots were constructed on the basis of two maneuver parameters:

1. Maximum sustained load factor at Mach .8, .9, .95, and 1.2 at 30,000 ft.
2. Energy rate for 1-g flight at Mach 0.9 at 10,000 ft.

(U) The weight and aerodynamic data used and the performance results obtained are presented in the following subsections.

7.1.1 Structures and Weights

(U) The weight analysis for the parametric study was performed with the same techniques discussed in Section 3.5. The results of this study are shown in Figures 7.1-7 and -8. It is noted that the leading-edge maneuver flap has been replaced by a fixed leading edge and that the weights reflect this change.

7.1.2 Aerodynamics

(U) The minimum drag and drag due to lift are computed by the methodology documented in Reference 1. The primary impact of the supercritical airfoil is manifested in the increase in drag divergence Mach number, which is determined from the following equation:

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4: (a)(g)

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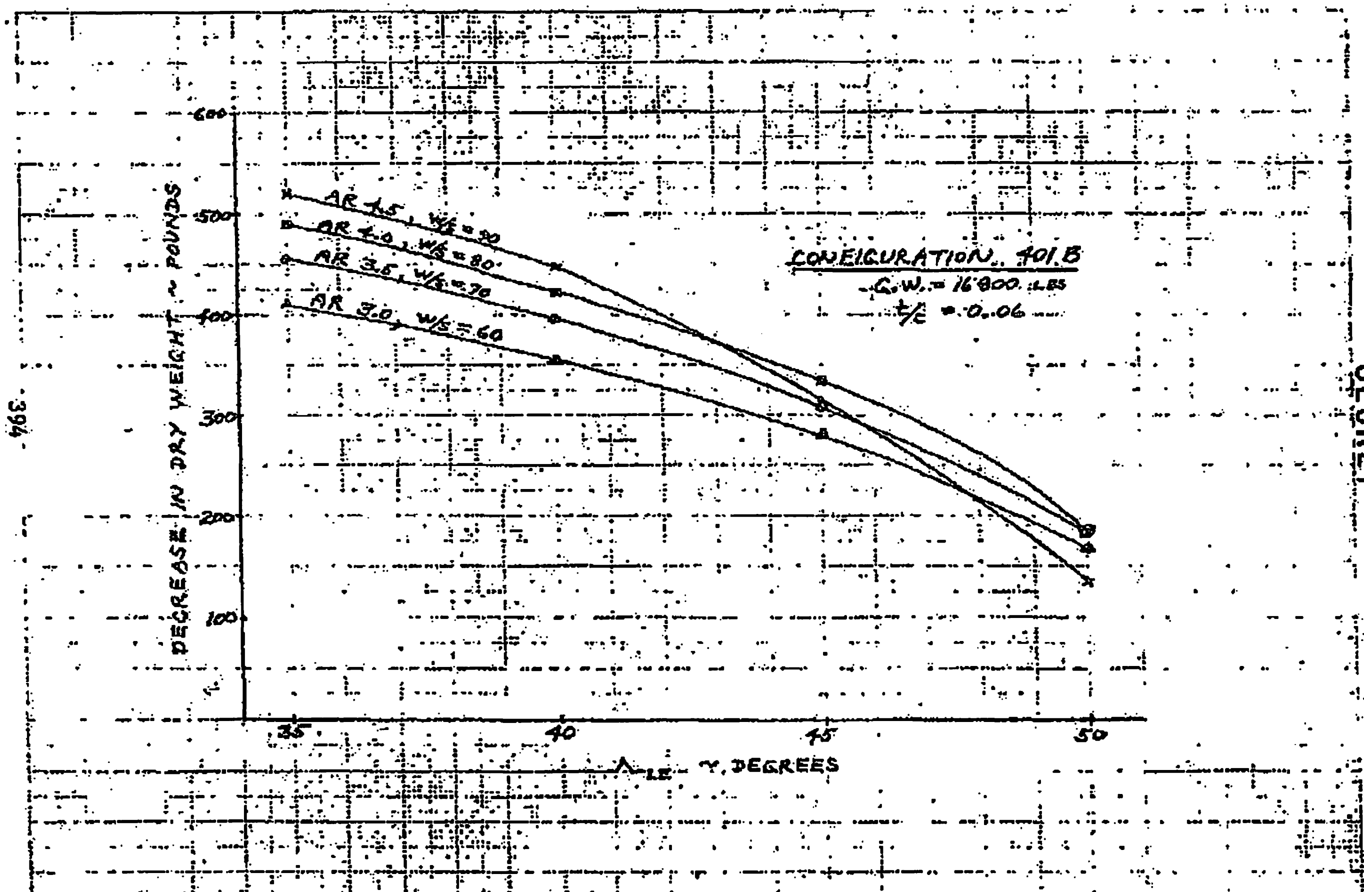

~~(S)~~ Figure 7.1-7 Supercritical Wing Study: Effect of Wing Sweep on Dry Weight (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

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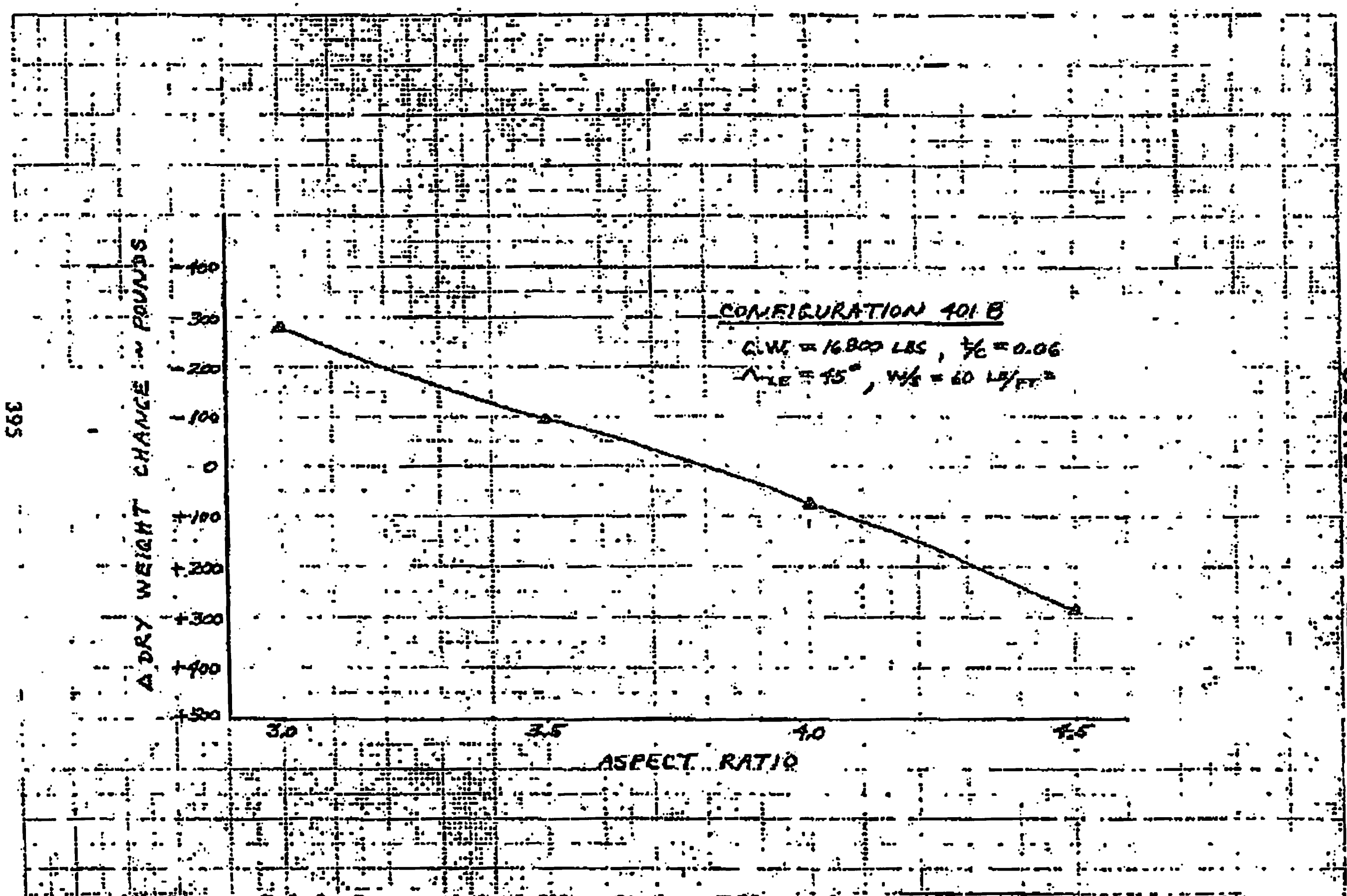

(U) Figure 7.1-8 Supercritical Wing Study: Effect of Aspect Ratio on Dry Weight (U)

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(U) $$\Delta M_{DD} = (\Delta M_{DD})_{Ref} + (t/c - 0.082)$$

The $(\Delta M_{DD})_{Ref}$, shown in Figure 7.1-9 is derived from Langley Research Center wind tunnel tests of the F-111/TACT model with supercritical airfoils. The second term of the equation corrects for difference in thickness ratio between the wings considered in this study and the wings that were tested.

(U) In addition to increasing the drag divergence Mach number, the supercritical airfoil also has the advantage of obtaining high L/D's without the use of a leading-edge flap because of the blunt leading edge. All supercritical wing configurations have a fixed leading edge and therefore offer an additional weight savings.

(U) With regard to trim drag, certain simplifying assumptions are made in the design and development of a fighter. Considerable effort is directed toward minimization of trim drag, and it is reasonable to assume that levels of trim drag comparable to those for the basic biconvex airfoil are attainable for the supercritical wing. The trim drag is computed by taking the ratio of trimmed to untrimmed drag due to lift from the Configuration 401B and applying this ratio to the untrimmed drag due to lift for the supercritical configurations.

7.1.3 Performance

(U) Realistic estimates of the maneuver performance parameters must include both aerodynamics and weights. That is

$$(n_Z)_{max} = \frac{\text{lift @ max thrust}}{\text{combat weight}}$$

and

$$P_S = \frac{\text{max thrust - drag}}{\text{combat weight}} \times \text{velocity for 1-g flight}$$

where

$$\text{combat wt.} = (\text{combat wt})_{\substack{401B \\ \text{Baseline}}} + \Delta\text{combat wt.}$$

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4.(a)(g)

88 ABW/IPI
FOIA (b)(1)
EO 13526 SEC. 3.3 (b)(4)
SEC. 1.4 (a)(g)

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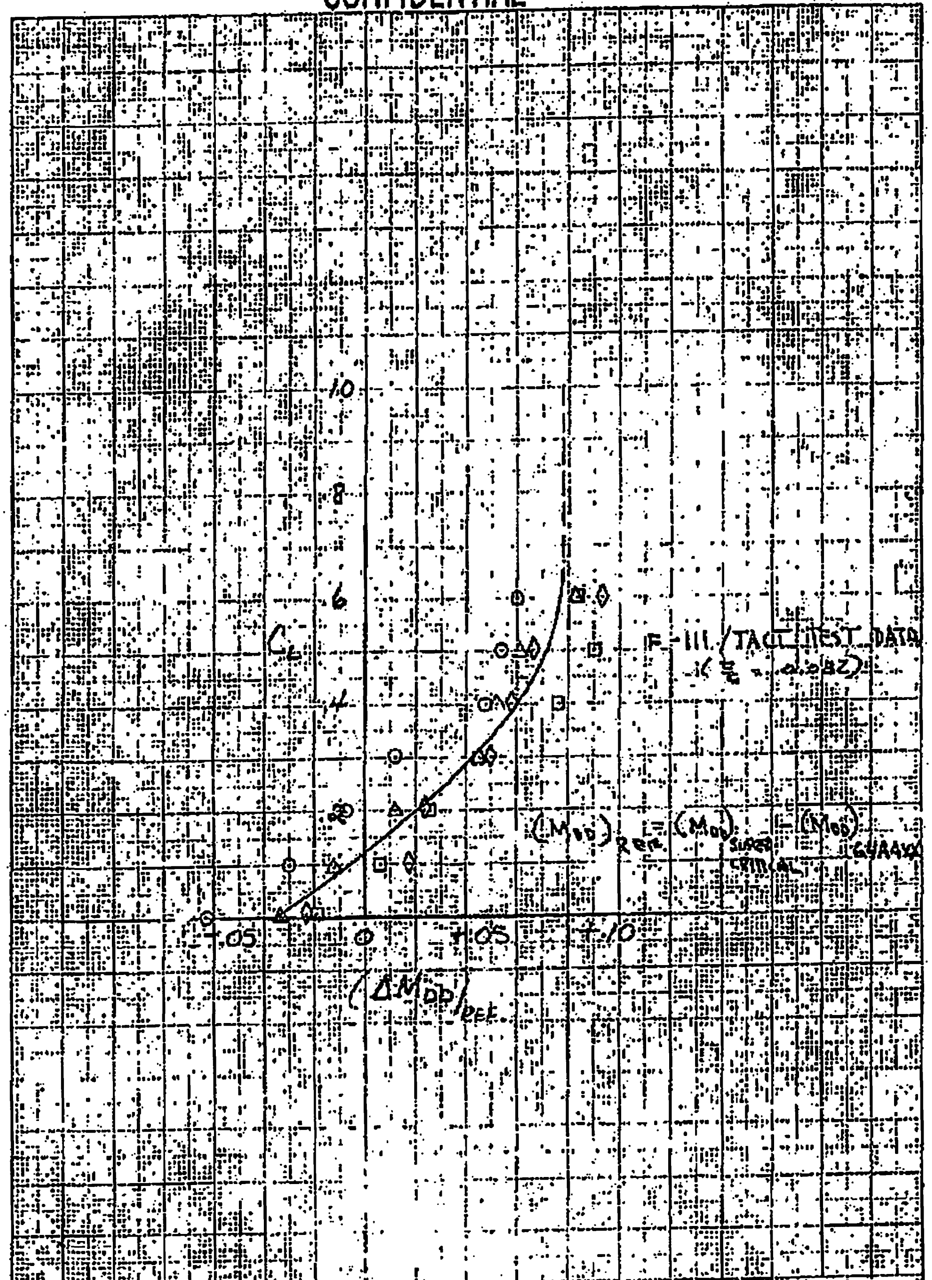


~~(C)~~ Figure 7.1-9 Drag Divergence Mach Number Increase Through Use of Supercritical Airfoil (U)

~~CONFIDENTIAL~~

Previous studies show that the change in combat weight may be approximated by the simple equation

$$\Delta\text{Combat wt} = 2.25 \times \Delta\text{structural wt.}$$

(U) The results of the parametric study are summarized in Figures 7.1-10 through 7.1-13 in the form of comparisons of the selected maneuver parameters.

(U) The effect of sweep at constant aspect ratio (3.0) is shown in Figure 7.1-10, where it is seen that increasing sweep generally improves both n_{max} and P_s up to about 45 degrees. This is a good example of the tradeoff between weight and aerodynamics. Performance data for Configuration 401B (with biconvex wing) are shown in the figure for reference. The supercritical wing provides larger load-factor values at subsonic speeds and slightly smaller values at Mach 1.2. The supercritical airfoil also has a lower energy rate (P_s) at the Mach 0.9 1-g condition at a wing leading edge sweep of 35 degrees. This is due to the higher minimum drag of the blunt supercritical wing as compared to the sharp biconvex wing. As wing leading-edge sweep is increased, the minimum drag is reduced so that the energy rate for the supercritical airfoil exceeds that for the biconvex wing at sweep angles above 40 degrees.

(U) The effects of varying wing loading at constant span, b, are shown in Figures 7.1-11 and -12. Obviously, changing wing loading with span held constant requires aspect ratio (b^2/S) to vary along with wing loading (W/S). The result is to keep induced drag (C_{D_i}) constant (for a given lift) so that the pure effect of wing size (S) can be observed, i.e., $C_{D_i} = C_L^2/\pi(b^2/S)\,e$. It is seen that increasing wing loading improves the sustained load-factor capability and degrades the 1-g energy rate. The increased turn rate (higher n_Z) for the $W/S = 60$ psf supercritical wing configurations ($\Lambda = 35°$ and $45°$) at subsonic speeds, relative to the basic 401B, indicates a greater lift per unit area for the supercritical wing section. The 45-degree-sweep supercritical wing configuration of Figure 7.1-12 also shows a higher energy rate (P_s) than the basic 401B wing configuration.

(U) The $\Lambda = 45°$, $W/S = 60$ psf ($AR = 3.0$) planform was selected as the best compromise for the aspect-ratio variation. This effect is summarized in Figure 7.1-13. At subsonic speeds it is seen that increasing AR improves n_Z but degrades the 1-g P_s at Mach 1.2, n_Z reaches an optimum at about $AR = 3.5$.

(U) It becomes readily apparent that no one planform is best for all conditions; therefore, the selected planforms will necessarily be a compromise. Two planforms were selected for detailed analysis.

(1) AR = 3.75 (AR = 4.0 with curved tips)

Λ = 45°

W/S = 60 psf

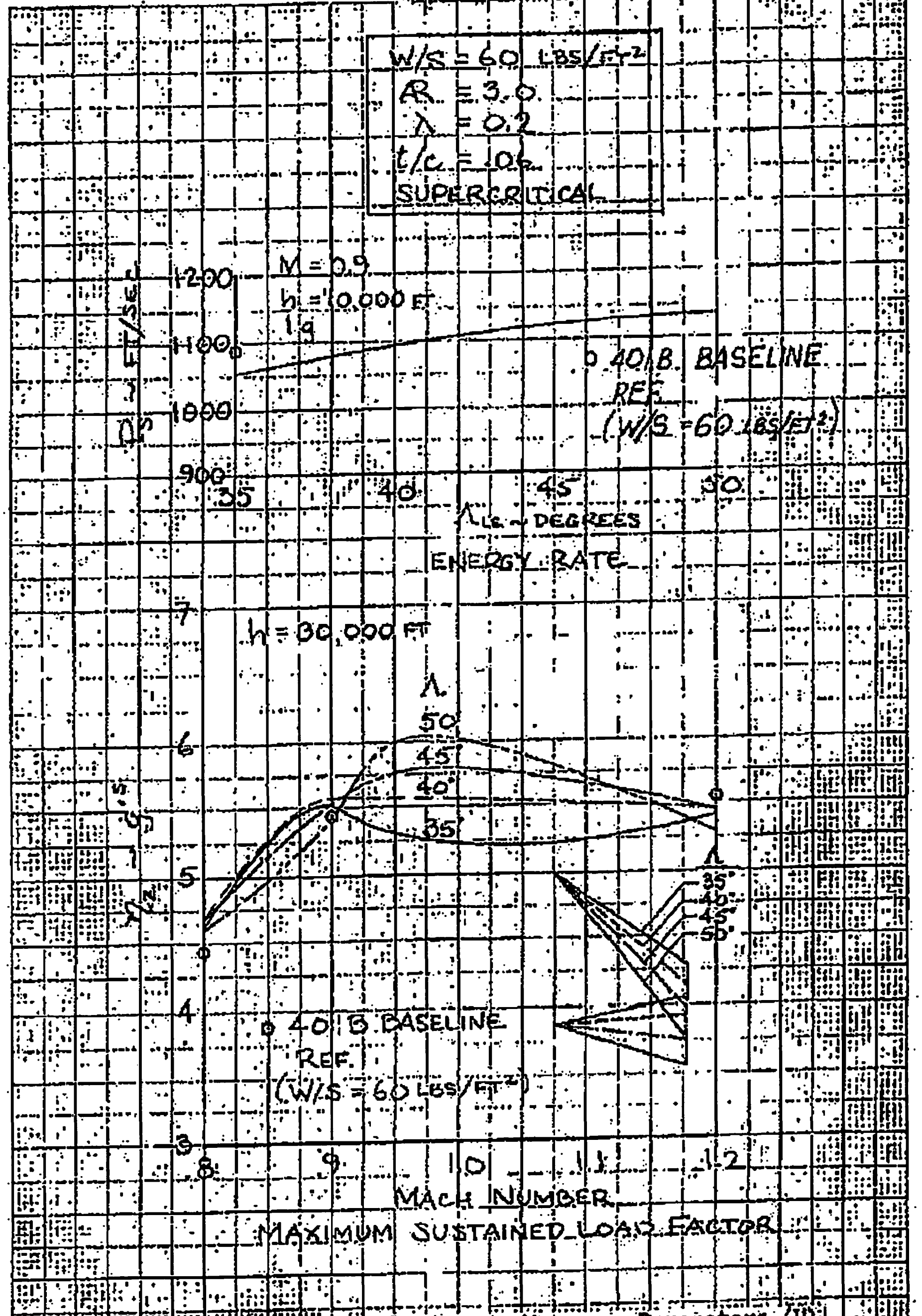
(2) AR = 3.0 (AR = 3.2 with curved tips)

Λ = 45°

W/S = 60 psf

2011-093 11 of 15

88th ABW/IP
FOIA (b)(1) 13/IPI
E.O. 13526 SEC. 3.3.(b)(4)
E.O. 4.3(a)(2) SEC. 3.3(b)(4)
SEC. 1.4(a)(g)



(S) Figure 7.1-10 Effect of Sweep on Maneuver Parameters (U)

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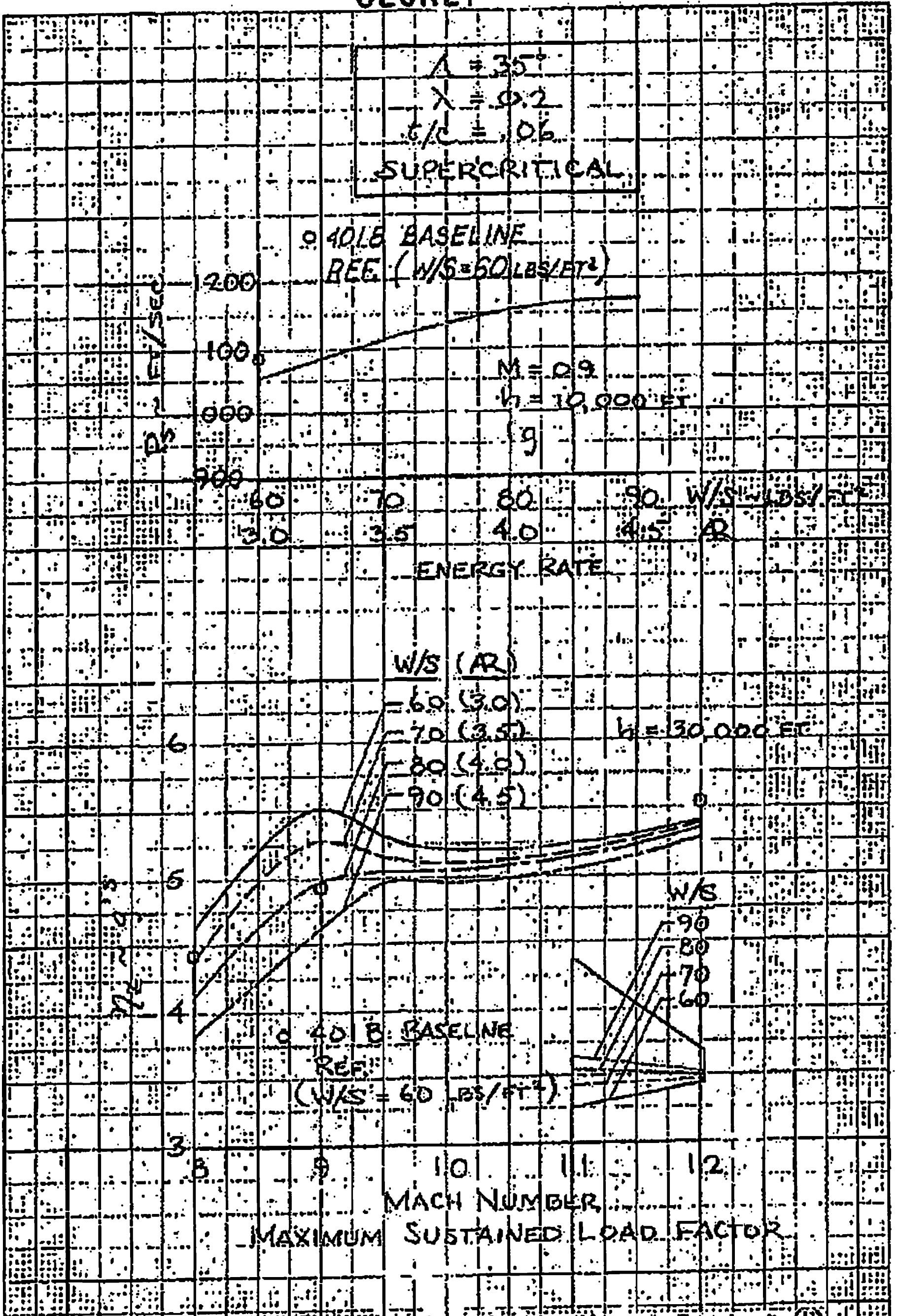
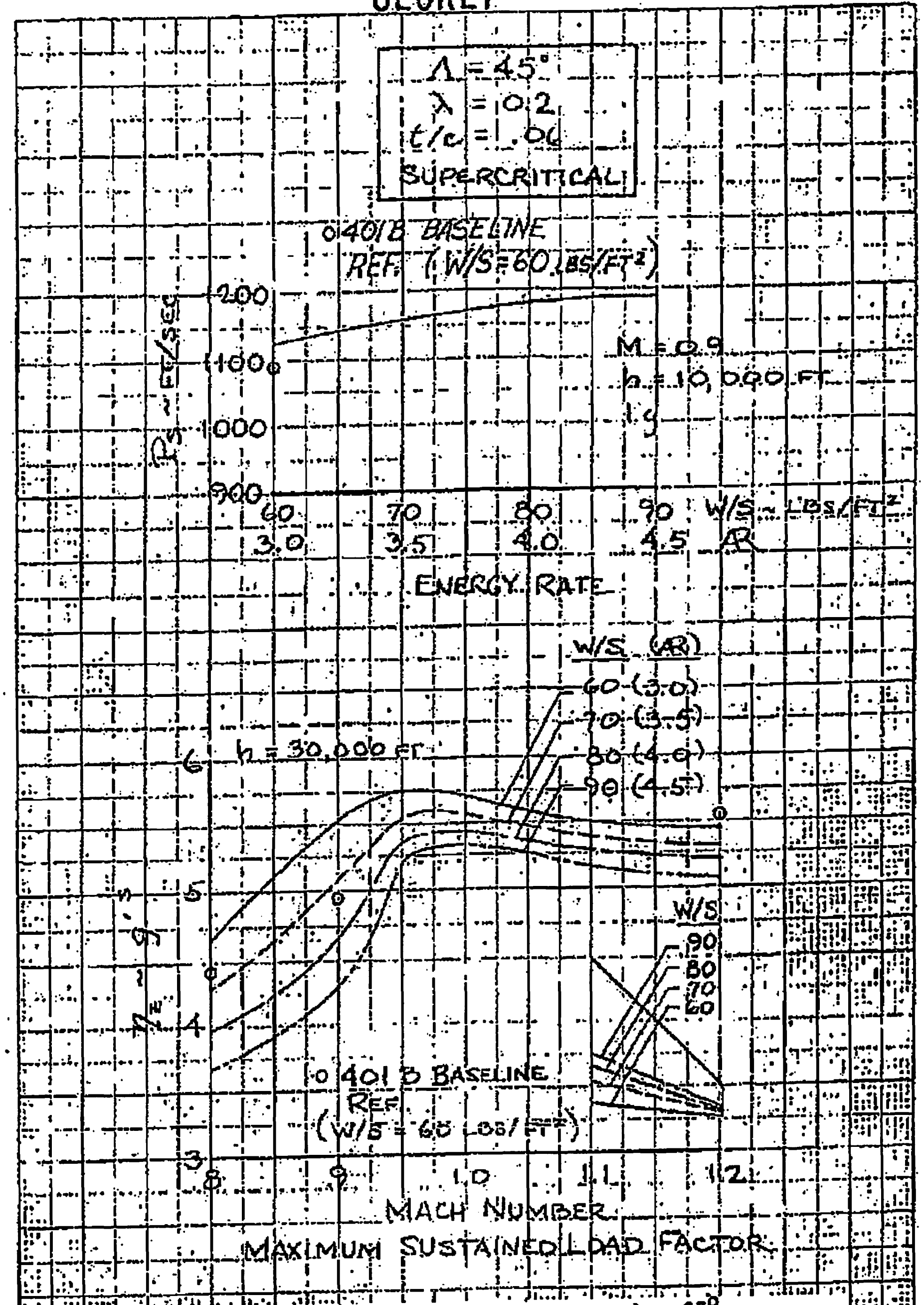
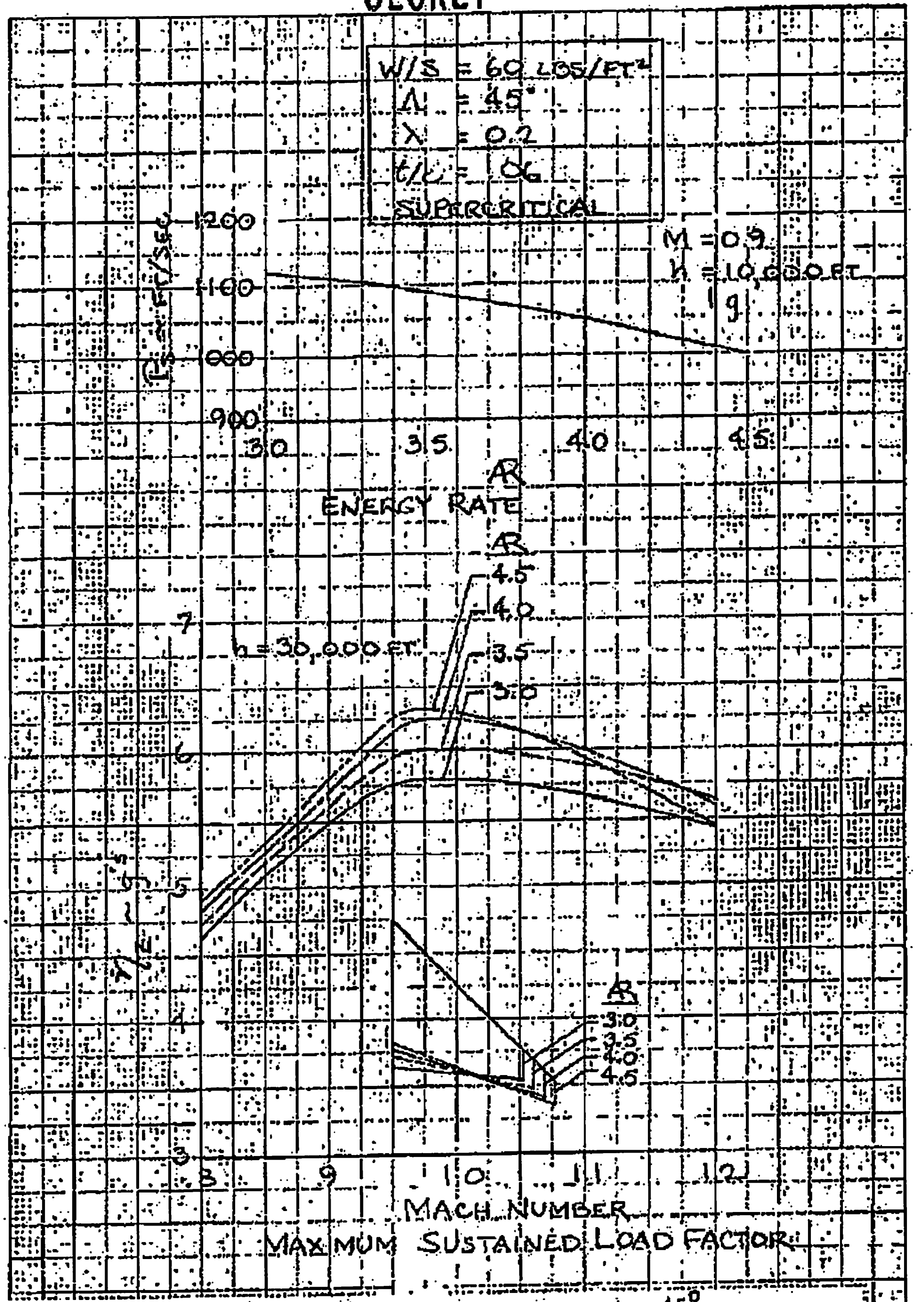
401-403



~~(S)~~ Figure 7.1-11 Effect of Varying Wing Loading at Constant (U)



~~(S)~~ Figure 7.1-12 Span on Maneuver Parameters, Λ = 35°
Effect of Varying Wing Loading at Constant (U)



~~(S)~~ Figure 7.1-13 Span on Maneuver Parameters, Λ = 45°
Effect of Aspect Ratio on Maneuver Parameters (U)

7.2 VEHICLE DESIGN

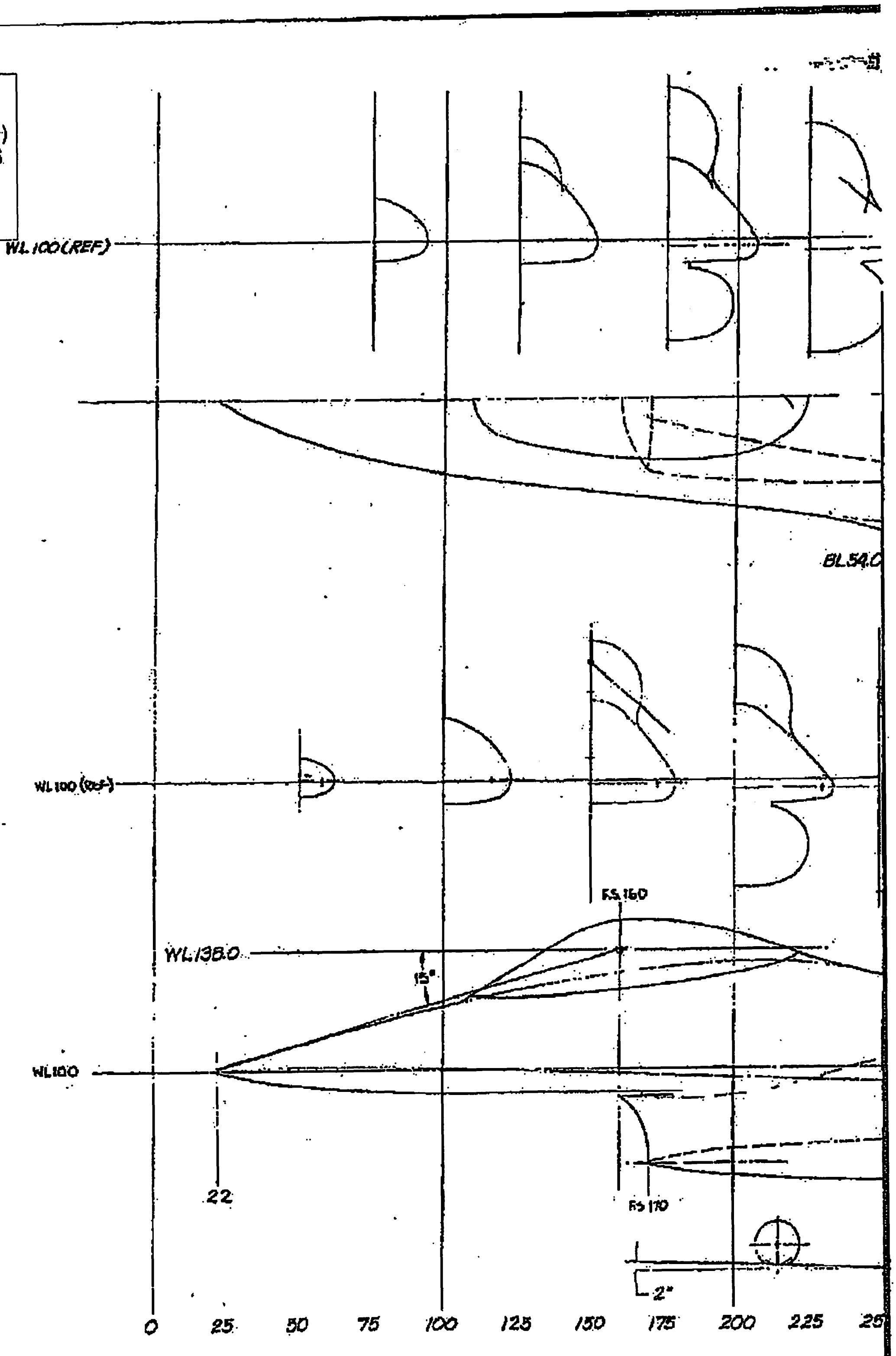
~~(S)~~ Layouts for the two selected supercritical wing configurations were developed for a detailed analysis. [The selected design points were for wing aspect ratios of 3.00 and 3.75 and an airplane mission weight of 16,800 lb. These aspect ratios are based on a theoretical trapezoidal planform. The true aspect ratios, based on wings with curved tips, are 3.2 and 4.0, respectively. Each configuration is essentially the same as the basic 401B arrangement except for the wing planform and the associated tail size changes. Each point design was reconfigured to provide appropriate balance characteristics, and both horizontal and vertical tail sizes were adjusted so that the tail volume remained the same.]

(U) The lines layout of the large single-engine airplane (401B) with a supercritical wing is presented in Figure 7.2-1 for an aspect ratio of 3.00. The basic description data and friction drag data are summarized in Figures 7.2-2 and -3, respectively, for the AR = 3.00 design. The normal area distribution for the AR = 3.00 arrangement is shown in Figure 7.2-4.

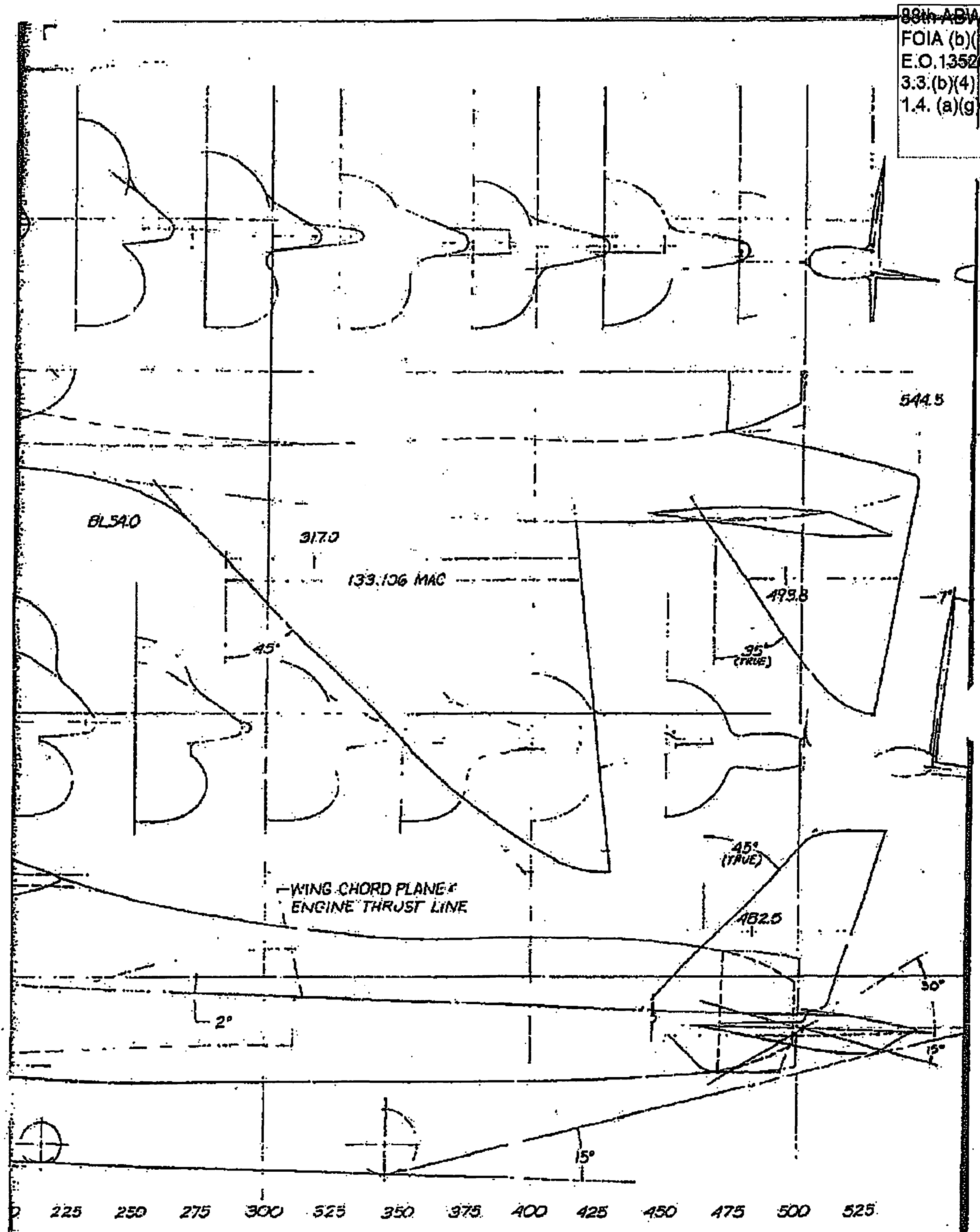
(U) The lines layout of the large single-engine aircraft [with a supercritical wing is presented in Figure 7.2-5 for an aspect ratio of 3.75. The basic description data and friction drag data are summarized in Figures 7.2-6 and -7, respectively, for the AR = 3.75 design. The normal area distribution for the AR = 3.75 arrangement is shown in Figure 7.2-8.]

~~(S)~~ The performance evaluation (Section 7.4) resulted in a mission [weight of 16,640 lb for the aspect-ratio 3.0 design and a mission weight of 17,115 lb for the aspect-ratio 3.75 design. A general arrangement drawing of the airplane with a wing aspect ratio of 3.75 at a mission weight of 17,115 lb is shown in Figure 7.2-9. The general arrangement of the airplane with a wing aspect ratio of 3.0 is basically the same as shown in Section 3.1 (Figure 3.1-4). The small difference in size (mission weight of 16,640 lb compared to 17,115 lb) does not warrant a new layout.]

88th
ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.
(b)(4)
1.4. (a)(g)



88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.2-1 Configuration 401B

2

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3(b)(4)
1.4 (a)(g)
FOIA (b)(1)
EO 13526 SEC. 3.3(b)(4)
SEC. 1.4 (a)(g)

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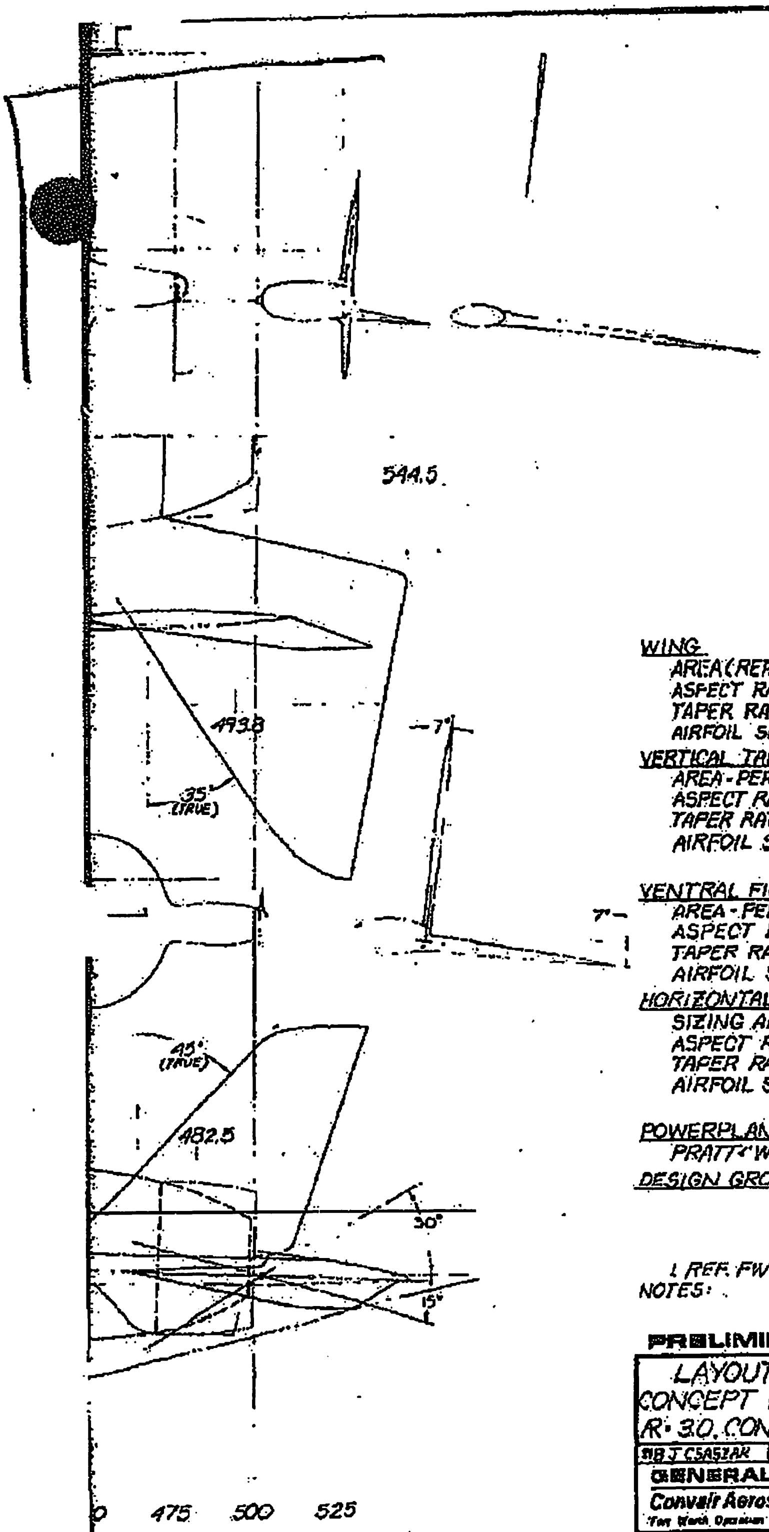

BASIC DATA

WING		
AREA (REF.)		280 SQ.FT.
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION		6 % SUPERCRITICAL
VERTICAL TAIL		
AREA - PER TAIL		21.383 SQ.FT.
ASPECT RATIO		1.3265
TAPER RATIO		0.4
AIRFOIL SECTION	ROOT	6 % BI-CONVEX
	TIP	4 % BI-CONVEX
VENTRAL FIN		
AREA - PER FIN		3.525 SQ.FT.
ASPECT RATIO		0.3733
TAPER RATIO		0.5957
AIRFOIL SECTION		6% BI-CONVEX
HORIZONTAL TAIL		
SIZING AREA		54.80 SQ.FT.
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION	ROOT	6% BI-CONVEX
	TIP	4% BI-CONVEX
POWERPLANT		
PRATT & WHITNEY F100-PW-100 ENGINE		
DESIGN GROSS WEIGHT		16,800 LBS

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1 REF. FW 7104066 FOR BASIC CONFIG. 401B LINES
NOTES:

PRELIMINARY DESIGN DRAWING

LAYOUT-LARGE SINGLE ENGINE
CONCEPT WITH SUPERCRITICAL WING
AR=3.0, CONFIG. 401B AVFFX PROGRAM

DR B J CSASZAR | APPROVED | SCALE 1/20 | DATE 19 AUG 71
GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation
FW 7104119
SHEET OF

e 7.2-1 Configuration 401B with Supercritical Wing of Aspect Ratio = 3.00 (U)

3

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

Fg1

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BASIC DESCRIPTIONS

PROJECT: AVFFX PROGRAM

G.W = 16,800 lbs.
W/S = 60 lbs./ft²
T/W = 1.397 (Uninstalled)
Eng = P&WA JTF 22A-27
(Mfr designation F100-PW-100)

CONFIGURATION: 401B WITH SUPERCRITICAL WING AR=3.0

DATE: 23 AUG 71

Ref. Dwg FW7104119

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY	* 478	0	0	0
FUSELAGE OUTERBODY	420.5	102	± 40.0	0
+ CANOPY	183.5	85	0	+38

* Includes Nozzle Length Open
\+ For K.55 Program Only

WING REF. AREA (IN²)

SURFACES

		2° INCIDENCE WING (NOMINAL)	-2° INCIDENCE NOM HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT²)		280	120.908	21.383	3.525
AR - ASPECT RATIO		3.0	3.4215	1.32653	0.37[illegible]
λ - TAPER RATIO		0.2	0.13615	0.4	0.59[illegible]
L.E. E₁(+) E₂(+)	E₁	+45°	55°	+45°	+45°
	E₂	-6.5°	+10°41'	-19°22'	+1[illegible]°22'
a - CUTOUT = [illegible]					
C_R - ROOT CHORD (IN.)		193.22	125.57	68.827	46.212
C_T - TIP CHORD (IN.)		38.64	17.096	27.531	27.531
b - SPAN (IN.)		347.79	244.067	63.911	13.765
AIRFOIL		6% Supercritical See Item 3, Cover Ltr	Exp Root - 6% Biconvex Tip 4% Biconvex Exp. Root @ BL 51.5	Root - 6% Biconvex Tip - 4% Biconvex	6% Biconvex
d (IN.)		54	51.5	0	0
x (IN.)		248	439	460	[illegible]
y (IN.)		0	0	±54.7 [illegible]	±51.5
z (IN.)		0	0 @ 1/4 MAC -14.1	-3	-13
		0° DIHEDRAL	7° NEG DIHEDRAL	7° OUTBD CANT ∠	0° CANT ∠

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line (WL 92.0) to body or surface ref line.

~~(S)~~ Figure 7.2-2 Basic Description Data Sheet - Configuration 401B with Supercritical Wing of Aspect Ratio = 3.00 (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

FRICTION DRAG DATA

G.W. = 16,800 LBS
W/S = 60 LBS/FT²
T/W = 1.397 (uninstalled)
Eng = P&WA JTF 22A-27

PROJECT AVFFX PROGRAM
CONFIGURATION 401B WITH SUPERCRITICAL WING, AR=3.0
DATE 20 Aug 71
Ref. Dwg. FW7104119

BODIES (AF Designation: F100-PW-100)

BODY	WETTED AREA (FT²)		LENGTH (IN)	MAX WIDTH (IN)	MAX HEIGHT (IN)
Fuselage (Inlet body)		405.5	*476.6	52.0	71.0
Fuselage (Outer body)		261.1	422.5	28.0	18.0
Canopy ([illegible])		50.7	143.0	40.0	27.0
Nozzle (Closed)		20.8	27.2	43.5	Dia
Nozzle (Open)	26.7		28.6	43.5	Dia
BODY TOTAL		738.1			

* Length Includes Nozzle Closed – A ref for Nozzle Shown Separately

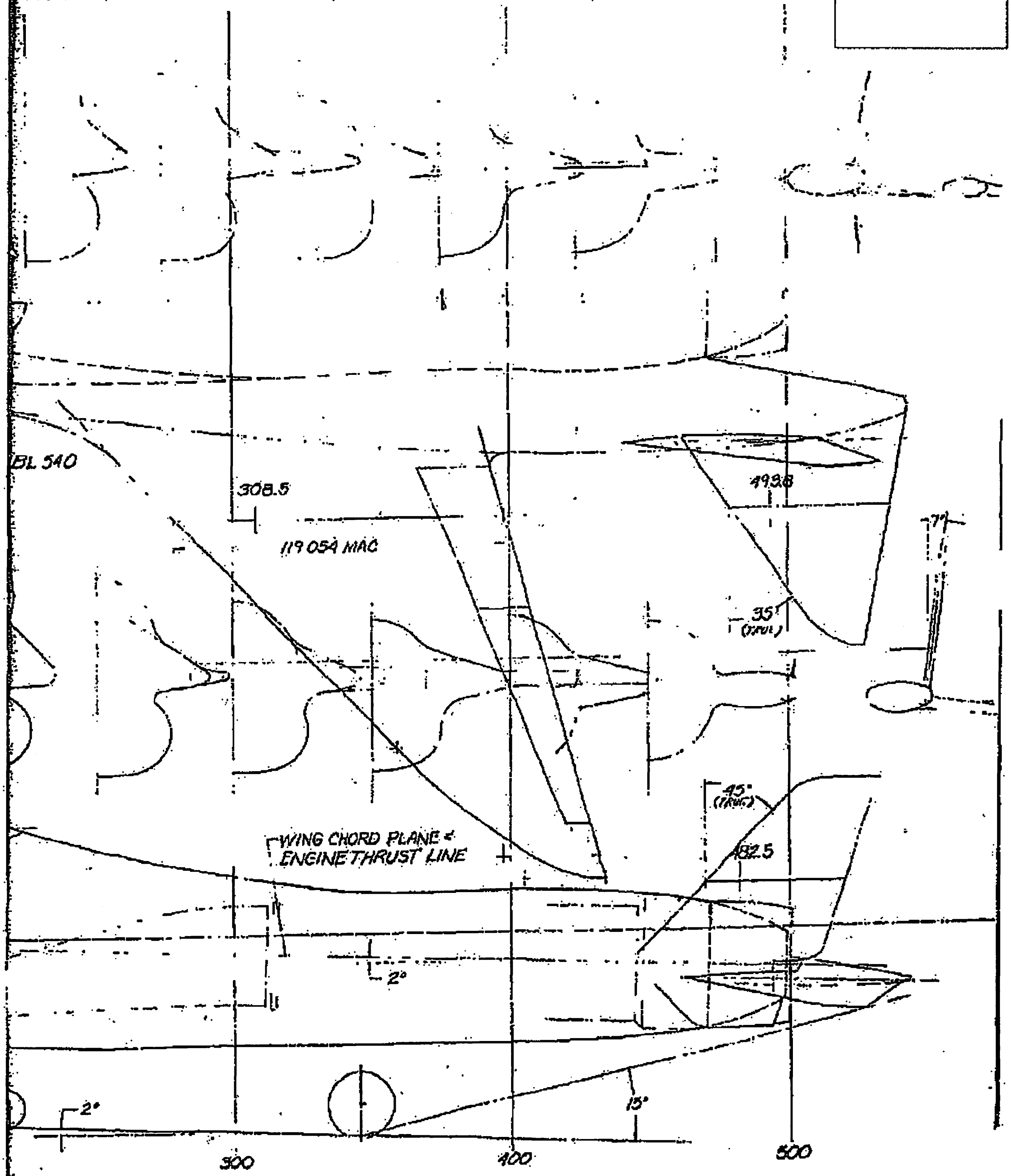
SURFACES

SURFACE	WETTED AREA (FT²)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
Wing		306.2	102.23	34.5	6% supercritical
Horiz Tail		98	56.09	14°30'	Exp Root 6% [illegible]
Vert. Tail (2)		88.5	52.20	54°15'	[illegible]
Ventral Fin (2)		14.6	[illegible]	17°15'	6% [illegible]
SURFACE TOTAL		507.3			
AIRPLANE TOTAL		1245.4			

BASIC WING GEOMETRY:

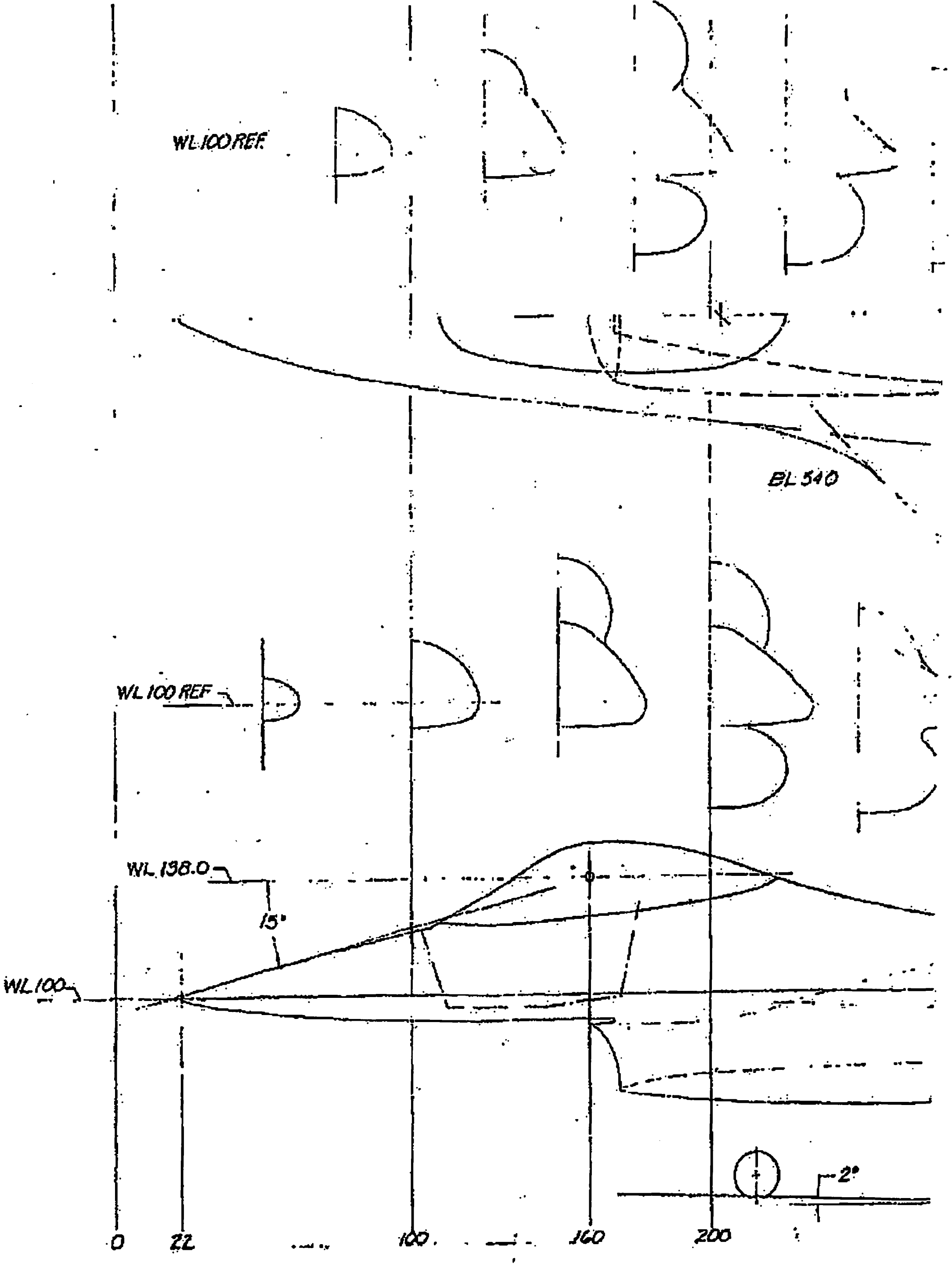
	TRAPEZOID SHAPE BASIC REF WING	TRAPEZOID SHAPE FOR CURVED TIP REF WING
AREA (FT²)	280	283.353
ASPECT RATIO	3.0	3.2
TAPER RATIO	0.2	0.16883
LEADING EDGE SWEEP (DEG.)	45°	45°

~~(S)~~ Figure 7.2-3 Friction Drag Data Sheet – Configuration 401B with Supercritical Wing of Aspect Ratio = 3.00 (U)

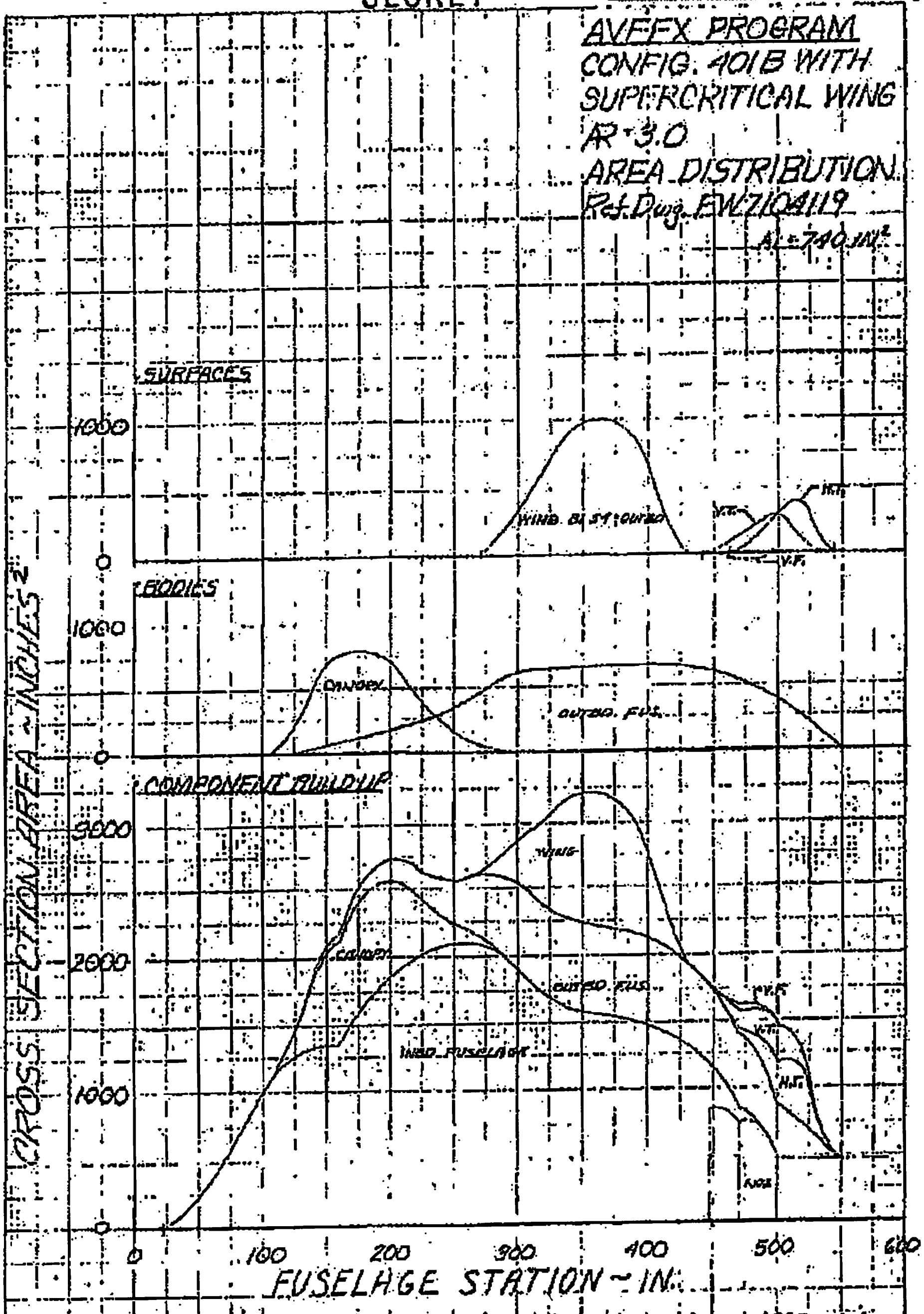


~~(S)~~ Figure 7.2-5 Configuration 401B wit

2


WL 100 REF
BL 540
WL 100 REF
WL 138.0
15°
WL 100
2°
0
22
100
160
200

~~SECRET~~



~~(S)~~ Figure 7.2-4 Area Distribution Curve - Configuration 401B with Supercritical Wing of Aspect Ratio = 3.00 (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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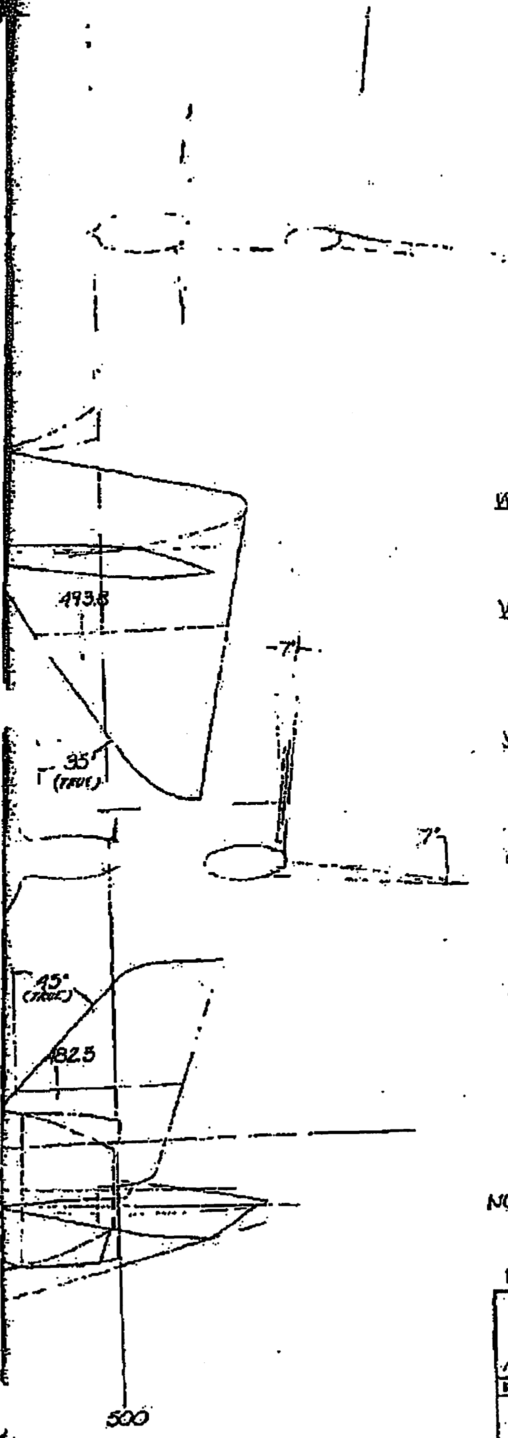

BASIC DATA

WING		
REF AREA		280 SQ.FT
ASPECT RATIO		3.75
TAPER RATIO		0.2
AIRFOIL SECTION		6% SUPERCRITICAL
VERTICAL TAIL		
AREA - PER TAIL		20.398 SQ.FT
ASPECT RATIO		1.3265
TAPER RATIO		0.4
AIRFOIL SECTION	ROOT	6% BICONVEX
	TIP	4% BICONVEX
VENTRAL FIN		
AREA - PER FIN		3.352 SQ.FT
ASPECT RATIO		0.3733
TAPER RATIO		0.5957
AIRFOIL SECTION		6% BICONVEX
HORIZONTAL TAIL		
SIZING AREA		52.287 SQ.FT
ASPECT RATIO		3.0
TAPER RATIO		0.2
AIRFOIL SECTION	BL 51.5	6% BICONVEX
	TIP	4% BI-CONVEX
POWERPLANT		
PRATT & WHITNEY F100-PW-100 ENGINE		
DESIGN GROSS WEIGHT		16,800 LBS

NOTES:
1. REF FW 7104066 FOR BASIC CONFIG 401B LINES

~~SECRET~~

PRELIMINARY DESIGN DRAWING

LAYOUT - LARGE SINGLE ENGINE CONCEPT WITH SUPERCRITICAL WING. AR-3.75, CONFIG 401B AVFTX PROGRAM

SCALE 1/20 DATE 12 AUG 71

GENERAL DYNAMICS
Convair Aerospace Division
Fort Worth Operation

FW7104103

2-5 Configuration 401B with Supercritical Wing of Aspect Ratio = 3.75 (U)

~~SECRET~~

BASIC DESCRIPTON

G.W. = 16,800 LBS
W/S = 60 lbs/ft²
T/W = 1.397 (uninstalled)
Eng = P&WA JTF 22A-27
(AF Designation F100-PW-100)

PROJECT: AVFFX PROGRAM

CONFIGURATION: 401E WITH SUPERCRITICAL WING

DATE: 30 July 71 K-3.15

Rev. Drg. FW 7104103

BODIES

	LENGTH (IN.)	X (IN.)	Y (IN.)	Z (IN.)
FUSELAGE CENTERBODY	* 478	0	0	0
FUSELAGE OUTERBODY	420	102	± 40	0
CANOPY +	183.5	85	0	+38

* Includes Nozzle Length (given)
\+ For K-35 Program Only

WING REF. AREA (IN²)

SURFACES

		2° INCIDENCE WING (NOMINAL)	2° INCIDENCE NOM HORIZ. TAIL	PER SIDE VERT. TAIL	PER SIDE VENTRAL FIN
AREA (FT²)		280	117.401	20.338	3.352
Æ - ASPECT RATIO		3.75	3.42967	1.92653	0.37333
λ = TAPER RATIO		0.2	0.13496	0.4	0.59514
	E_1	+ 45°	+ 55°	+ 45°	+ 15°
	E_2	-16°	+ 10°41'	-11°22'	+ 11°22'
a - CUTOUT = $\frac{\tan E_2}{\tan(90-E_1)}$					
C_R - ROOT CHORD (IN.)		172.820	129.718	67.125	45.070
C_T - TIP CHORD (IN.)		34.564	16.699	26.850	26.850
b - SPAN (IN.)		388.514	240.793	62.330	13.425
AIRFOIL		6% Supercritical (See Aero for Drawing)	Flw Root 6% Biconvex Tip 4% Biconvex	Root 6% Biconvex Tip 4% Biconvex	6% [illegible]
d (IN.)		54	51.5	0	0
x (IN.)		235	441	421.3	431.2
y (IN.)		0	0	±54.4 @ MAC	±1.0
z (IN.)		0	@ MAC 3/4 -14.1	-3	-13
		0° INCIDENCE	7° AVG. DIHEDRAL	7° OUTBD CANT X	0° CANT A

d = Average buried semi-span
x = Distance aft from fuselage nose to body nose or surface fuselage intersection point.
y = Distance outbd from fuselage ref. line to body ref. line or vertical surface chord line.
z = Distance up (+) or down (-) from fuselage ref. line WL 92.0 to body or surface ref line.

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3(b)(4)
1.4(a)(g)

~~(S)~~ Figure 7.2-6 Basic Description Data Sheet - Configuration 401B with Supercritical Wing of Aspect Ratio = 3.75 (U)

~~SECRET~~

~~SECRET~~

FRICTION DRAG DATA

G.W. = 16,800 LBS
W/S = 60 lbs/ft²
T/W = 1.397 (uninstalled)
Eng = PrWA JTF 22A-27

PROJECT AVFFX PROGRAM
CONFIGURATION 401B WITH SUPERCRITICAL WING
DATE 12 Aug 71 R-375
Ref. Dwg. FW7104103

88th ABW/IPI
FOIA (b)(1)
E.O 13526 SEC. 3,3.
4.4 (a)(g)
SEC 3.3(5)(4)
SEC 1.4(a)(9)

BODIES (AF Designation F100-PW-100)

BODY	WETTED AREA (FT^2)		MAX LENGTH (IN)	MAX WIDTH (IN)	MAX HEIGHT (IN)
Fuselage (Centerbody)		405.5	*476.6	52.0	71
Fuselage (Outerbody)		268.0	420	28.0	18.0
Canopy (Incl Fairing)		50.7	149.0	40.0	27.0
Nozzle (Closed)		20.8	27.2	43.5	Dia.
Nozzle (Open)	26.7		28.6	43.5	Dia.
BODY TOTAL		745.0			

* Length Includes Nozzle Closed - A wet for Nozzle Shown Separately

SURFACES

SURFACE	WETTED AREA (FT^2)		EXPOSED MAC LENGTH (IN)	MAX. THICKNESS SWEEP (DEG.)	AIRFOIL
Wing		329.6	94.38	37°	6% Supercritical
Horiz Tail		90.6	58.92	14°30'	Tip Root 6% Biconvex
Vert. Tail (2)		81.4	49.86	34°15'	Tip 4% Biconvex
Ventral Fin (2)		13.4	36.78	17°45'	6% Biconvex
SURFACE TOTAL		515.0			
AIRPLANE TOTAL		1260			

BASIC WING GEOMETRY:

	TRAPEZOID SHAPE BASIC REF WING	TRAPEZOID SHAPE FOR CURVED TIP REF WING
AREA (FT^2)	280	283.353
ASPECT RATIO	3.75	4.00
TAPER RATIO	0.2	0.1688
LEADING EDGE SWEEP (DEG.)	45°	45°

~~(S)~~ Figure 7.2-7 Friction Drag Data Sheet - Configuration 401B with Supercritical Wing of Aspect Ratio = 3.75 (U)

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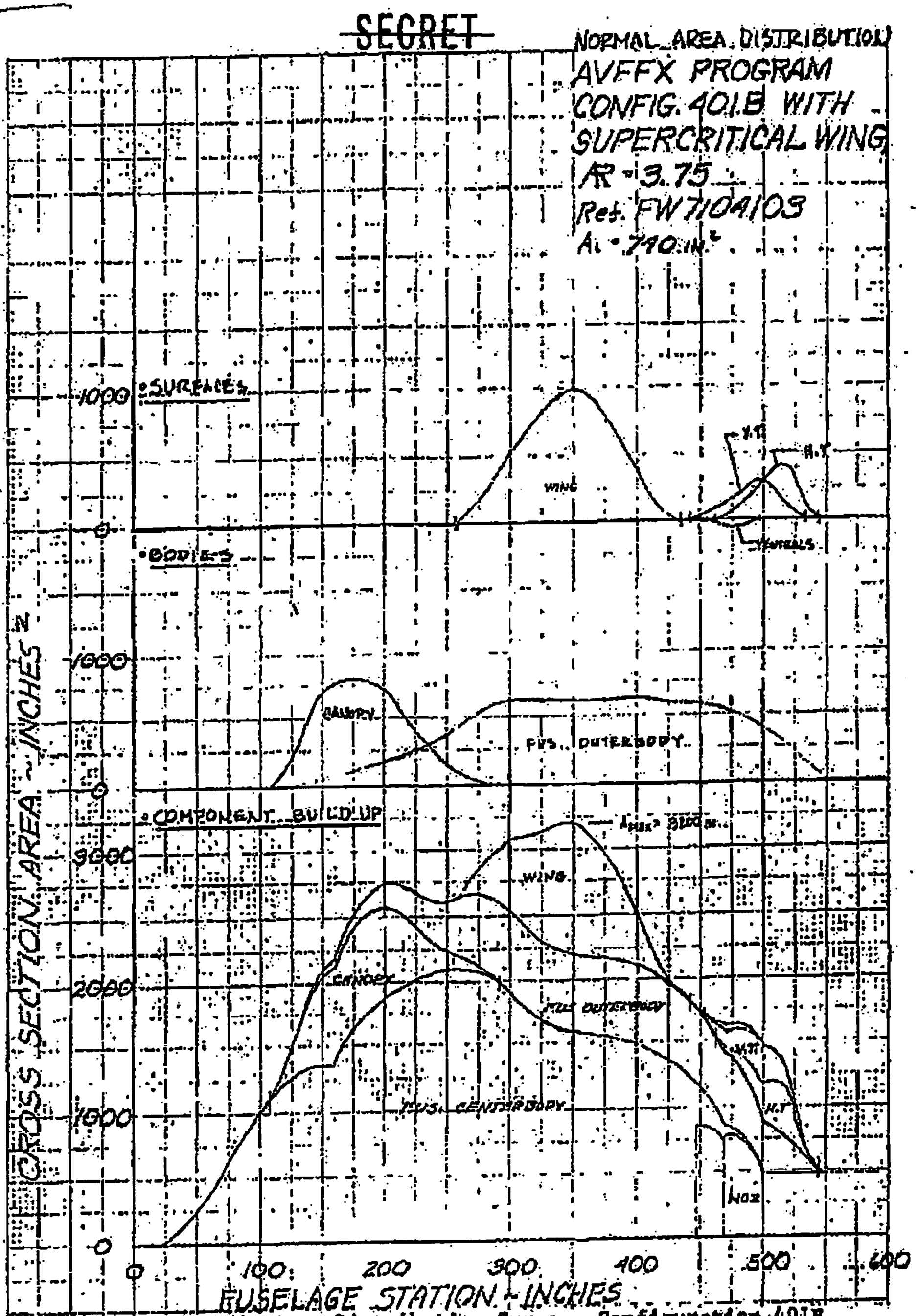

~~(S)~~ Figure 7.2-8 Area Distribution Curve - Configuration 401B with Supercritical Wing of Aspect Ratio = 3.75 (U)

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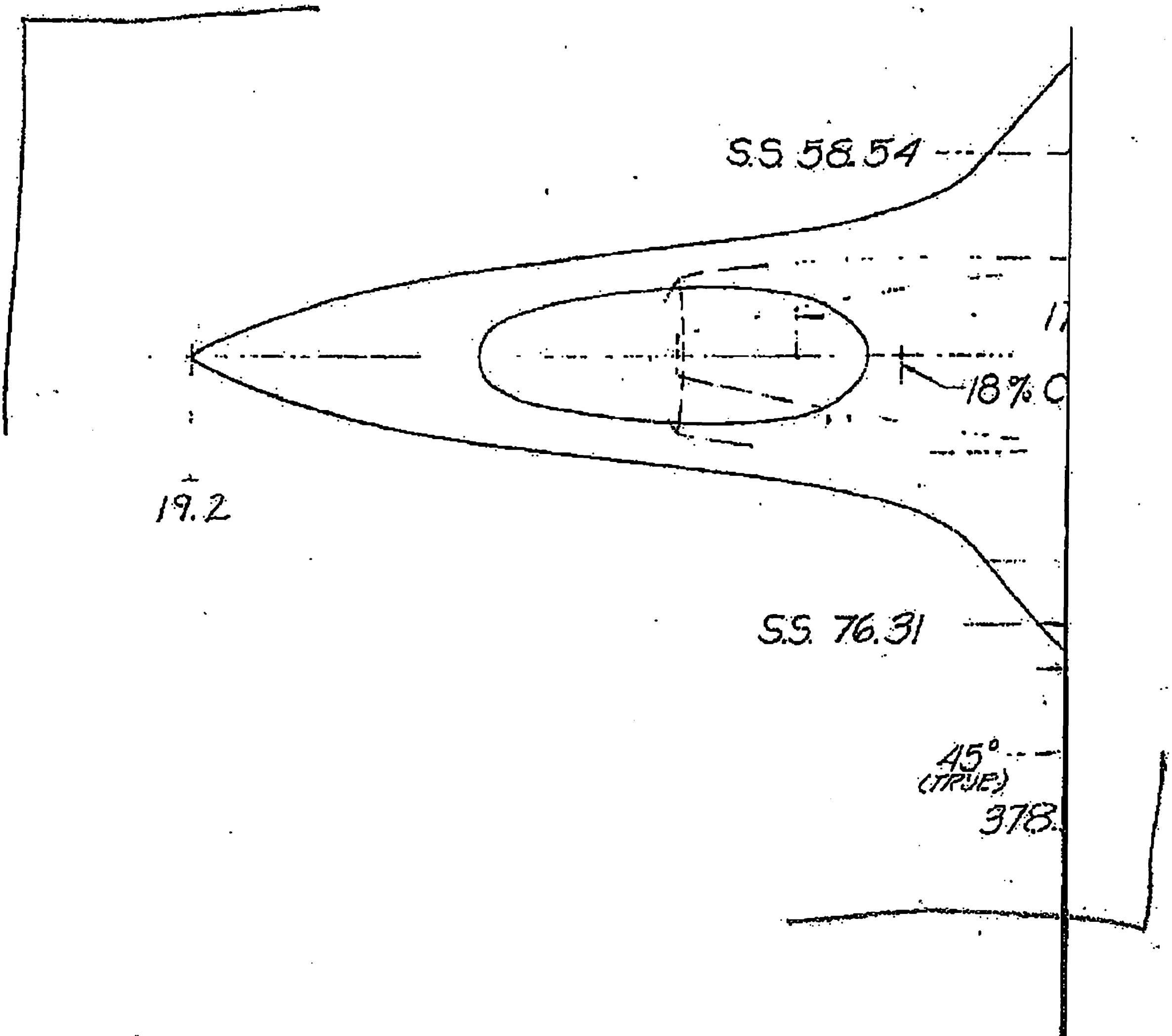
88th ABW/IPI
FOIA (b)(1)
88 ABW/IPI
FOIA (b)(1)

MANEUVER FLA



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88th ABW/IPJ
FOIA (b)(1)

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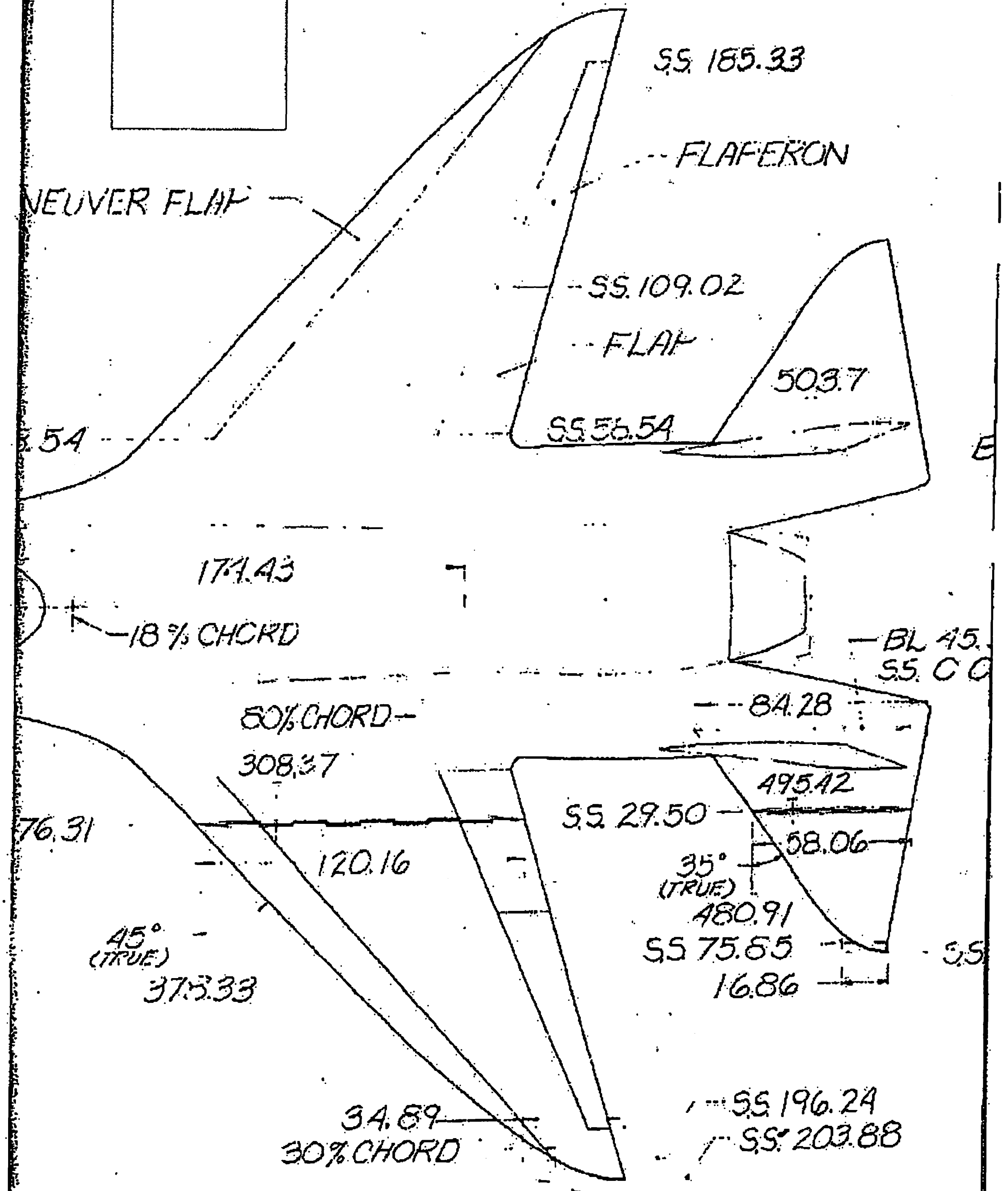

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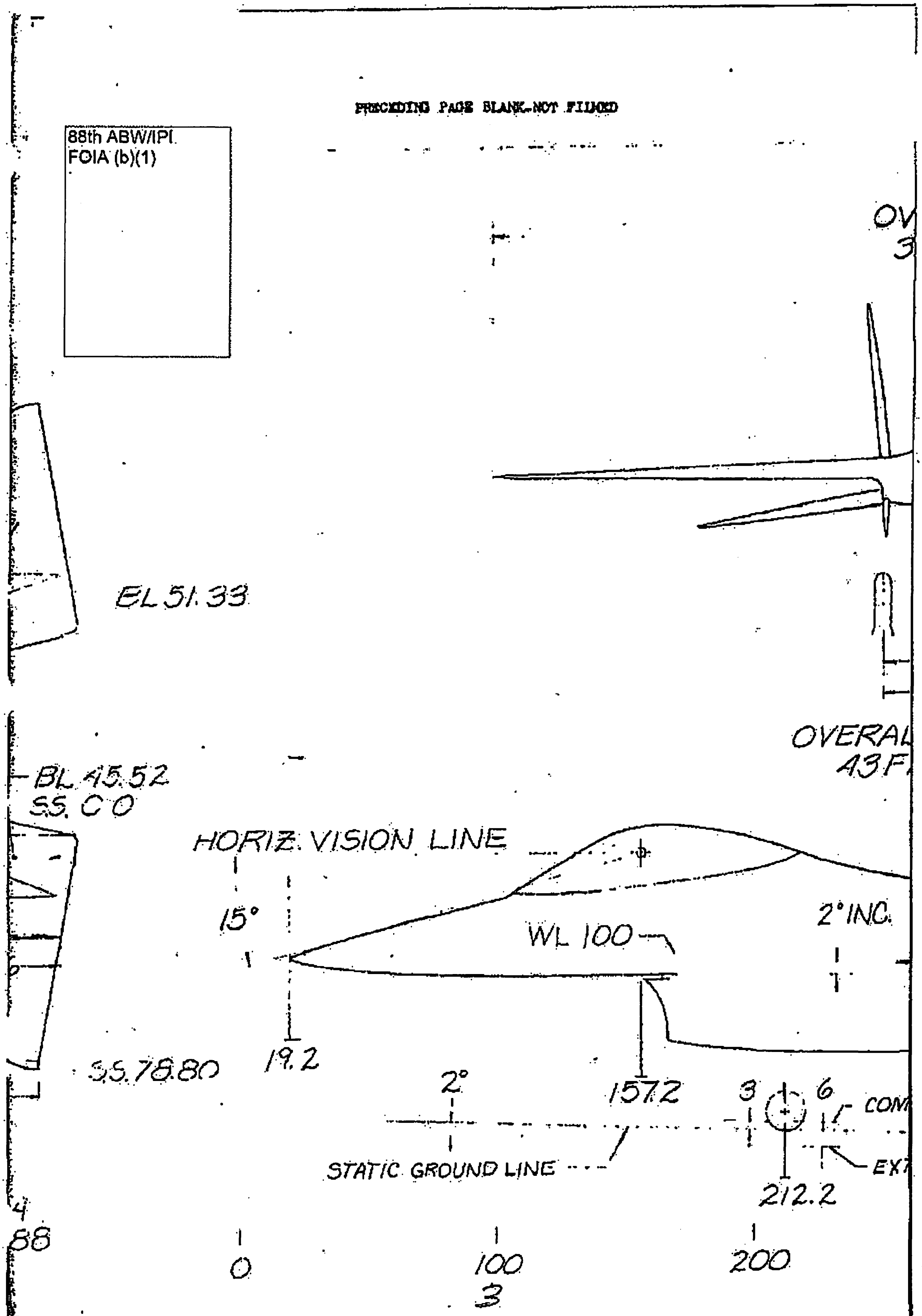
88th ABW/IPI
FOIA (b)(1)



88th ABW/IPI
FOIA (b)(1)

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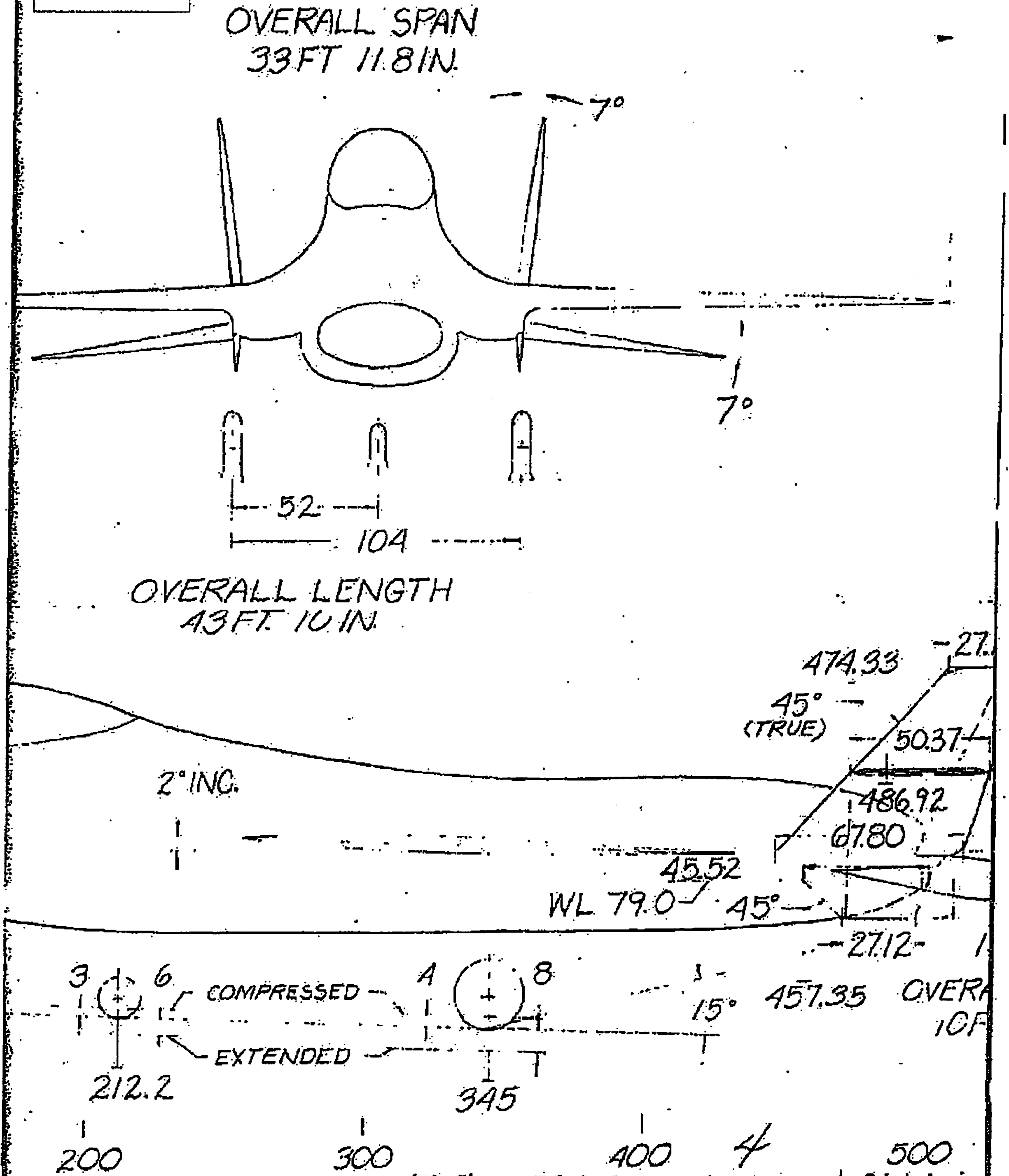

~~(S)~~ Figure 7.2-9. General Arrangement, Point Desig

88th ABW/IPI
FOIA (b)(1)/(b)(3) ~~(b)(1)~~
E.O. 13526 SEC 3.3.(b)(4) (6) (7)
1.4 (a)(g)
EO 13526 SEC 3.3 (b)(4)
SEC 1.4(a)(g)

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Aircraft Mission Weight -- 17,115 lb

WING (REFERENCE)	
AREA	285.31 SQ. FT
ASPECT RATIO	3.75
TAPER RATIO	0.2
SPAN	32.71 FT
SWEEP-LEADING EDGE	45°
ROOT CHORD	174.63 IN
TIP CHORD	34.93 IN
M.A.C.	120.16 IN
AIRFOIL SECTION	6% BICONVEX
INCIDENCE	2°
DIHEDRAL	0°

MANEUVER FLAP	
TYPE	PLAIN
TOTAL AREA	32.35 SQ. FT
SPAN-PER SIDE	137.3 IN
ROOT CHORD	25.8 IN
TIP CHORD	10.5 IN
DEFLECTION	25°
HINGE LINE	
ROOT	18%
TIP	30%

FLAPS	
TYPE	PLAIN
TOTAL AREA - INCLUDING FLAPERONS	30.92 SQ. FT
ROOT CHORD	26.0 IN
TIP CHORD	19.6 IN
FLAPERON	
TOTAL AREA	14.29 SQ. FT
SPAN-PER SIDE	76.31 IN
ROOT CHORD	19.6 IN
TIP CHORD	8.5 IN
DEFLECTION	-20°, +30°
FLAP DEFLECTION - MAX	30°
FLAP HINGE	80%

VERTICAL TAIL	
AREA - TOTAL	42.30 SQ. FT
ASPECT RATIO	1.3365
TAPER RATIO	0.4
SPAN	62.96 IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	67.80 IN
TIP CHORD	27.12 IN
AIRFOIL SECTION	6% ROOT, 4% TIP BICONVEX

RUDDER	
AREA-TOTAL	10.33 SQ. FT
SPAN	62.96 IN
ROOT CHORD	16.93 IN
TIP CHORD	6.78 IN
DEFLECTION	±30°

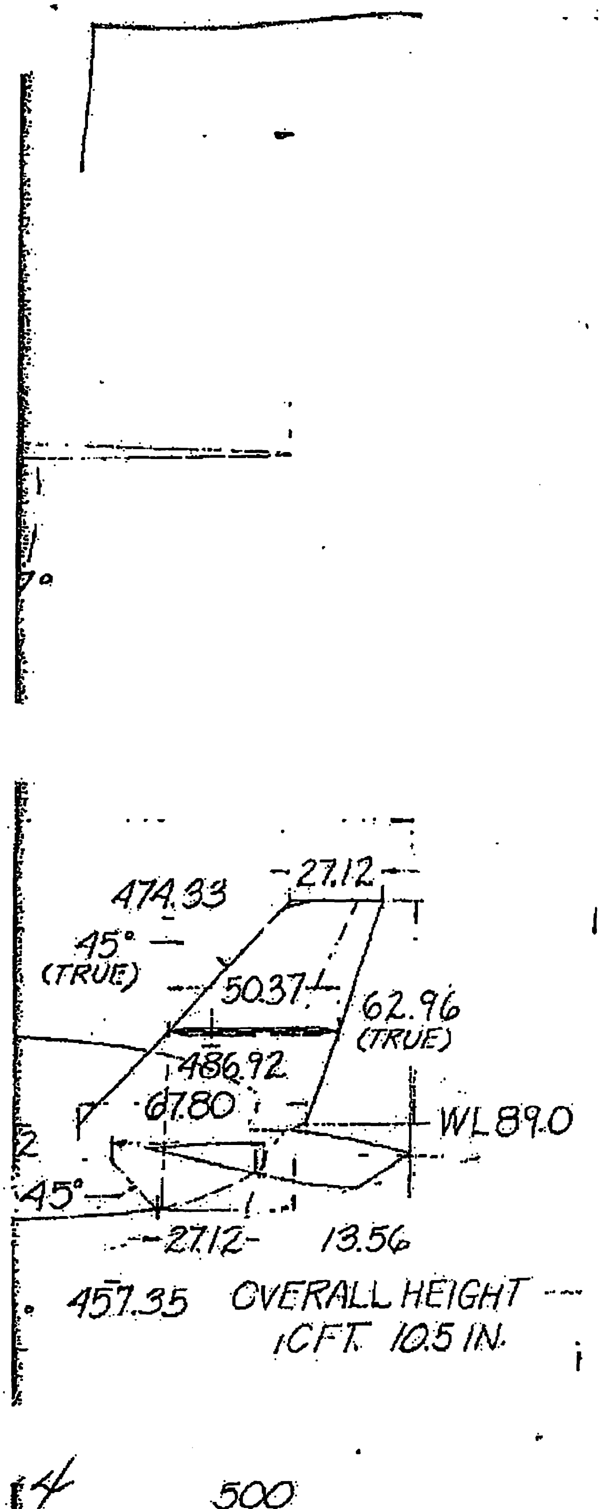
VENTRAL FIN	
AREA-TOTAL	5.86 SQ. FT
ASPECT RATIO	0.3333
TAPER RATIO	0.5957
SPAN	13.56 IN
SWEEP-LEADING EDGE	45°
ROOT CHORD	45.52 IN
TIP CHORD	27.12 IN
AIRFOIL SECTION	6% BICONVEX

HORIZONTAL TAIL (ALL MOVABLE)	
AREA	33.37 SQ FT
ASPECT RATIO	3.0
TAPER RATIO	0.3
SPAN EXPOSED	151.70 IN
SWEEP-LEADING EDGE	35°
ROOT CHORD	84.26 IN
TIP CHORD	18.66 IN
M.A.C.	58.06 IN
INCIDENCE	0°
AIRFOIL SECTION	6% AT BL 51.83, 4% TIP BICONVEX
DIHEDRAL	-7°
DEFLECTION	L.E. UP 15°, DWN 30°

POWERPLANT
PWA JTF22A-27 TURBOFAN ENGINE

LANDING GEAR	
MAIN GEAR SIZE	26 x 6.5
NOSE GEAR SIZE	15 x 4.5

TAIL LENGTHS	
C/4 WING TO C/4 VERTICAL TAIL	14 FT, 10.6 IN
C/4 WING TO C/4 HORIZONTAL TAIL	15 FT, 7.1 IN



PRELIMINARY DESIGN DRAWING

GENERAL ARRANGEMENT POINT DESIGN CONFIG 401B TYPE WITH SUPERCRITICAL WING AR 3.75, AVFFX PROGRAM	
BY B.J. CSISZAR · APPROVED	SCALE 1/40 · DATE 8 SEPT 71
GENERAL DYNAMICS Convair Aerospace Division Fort Worth Operation	FW7104146 SHEET

417/418 5

rangement, Point Design 401B Type with AR 3.75 Supercritical Wing (U) ~~SECRET~~

7.3 AERODYNAMICS

(U) The derivation of the aerodynamic characteristics in this section are based on the true aspect ratios of 3.2 and 4.0 for the two supercritical wings with curved wing tips. However, for consistincy with the preceeding sections, these will be referred to as 3.0 and 3.75, respectively, throughout this section.

7.3.1 Minimum Drag

(U) The minimum drags for the two supercritical wing aircraft are defined in Figures 7.3-1a and -1b. The drag buildup is the same as is defined in Section 3.3.1, and the additional drag components (canopy, diverter, etc.) are the same as shown in Figure 3.3-2.

(U) The supersonic wave drag was computed by the supersonic area-rule procedure (K35). This calculation does not include camber drag, which is included in the drag due to lift discussed in the following subsection.

7.3.2 Drag Due to Lift

(U) The drag due to lift is shown in Figures 7.3-2a through -4b. The camber drag is presented in Figure 7.3-5. At subsonic speeds, the increment was calculated by an analytical prediction; at supersonic speeds, the increment was derived from wind tunnel test of an AR = 3.0 supercritical wing.

7.3.3 Trim Drag

(U) As for the parametric study, it is presumed that design refinements to the supercritical wing configuration will remove the trim penalty associated with the airfoil, and the levels of trim drag will be comparable to the basic 401B configuration. For a consistent comparison, therefore, the trim drag increments used for the basic configuration were used for the supercritical wing configurations. (See Figure 3.3-13).

7.3.4 Trimmed-Drag Polars

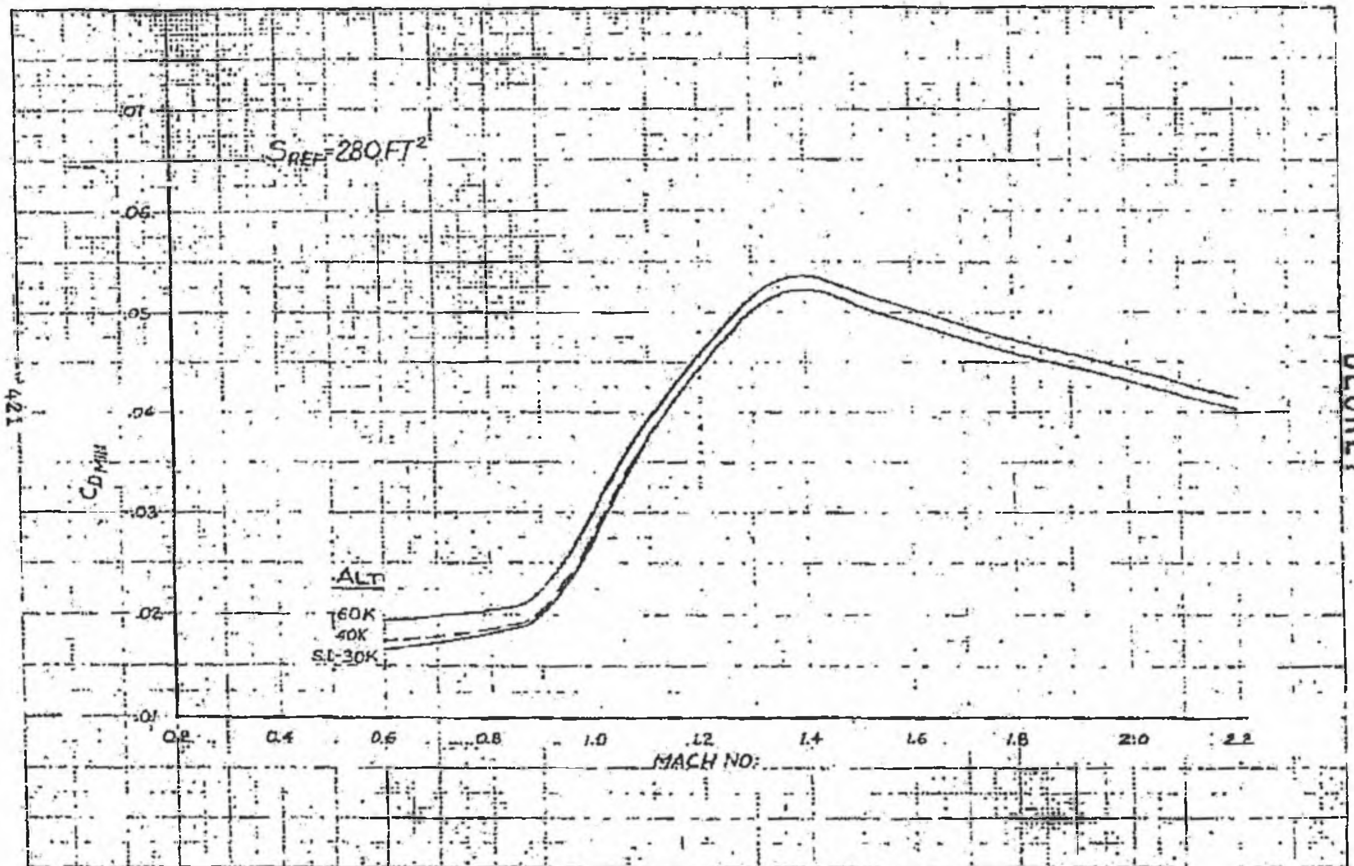
(U) The trimmed drag polars used in mission performance for the supercritical-wing aircraft are presented in Figures 7.3-6a through -8b. The trimmed configuration polars are presented in Figures 7.3-9a through -11b.

(U) Trimmed $(L/D)_{max}$ is shown in Figure 7.3-12 along with values for the 401B configuration. The aspect-ratio 3.0 and 3.75 supercritical wing configuration show higher $(L/D)_{max}$ levels at subsonic speeds as compared to the basic 401B configuration (biconvex wing with leading-edge flap), but the inverse is indicated at supersonic speeds, due primarily to supercritical airfoil thickness and camber drag effects.

7.3.5 Lift and Buffet Data

(U) The predicted untrimmed C_L-vs-α curves are shown in Figures 7.3-13a and -13b. Analytical estimates of the trimmed C_L-vs-α data were not made.

(U) The supercritical wing is expected to have superior buffet characteristics at transonic speeds. This is shown by the data of Figure 7.2-14 in which the buffet onset C_L's of the F-111A are compared with those of the F-111/TACT.

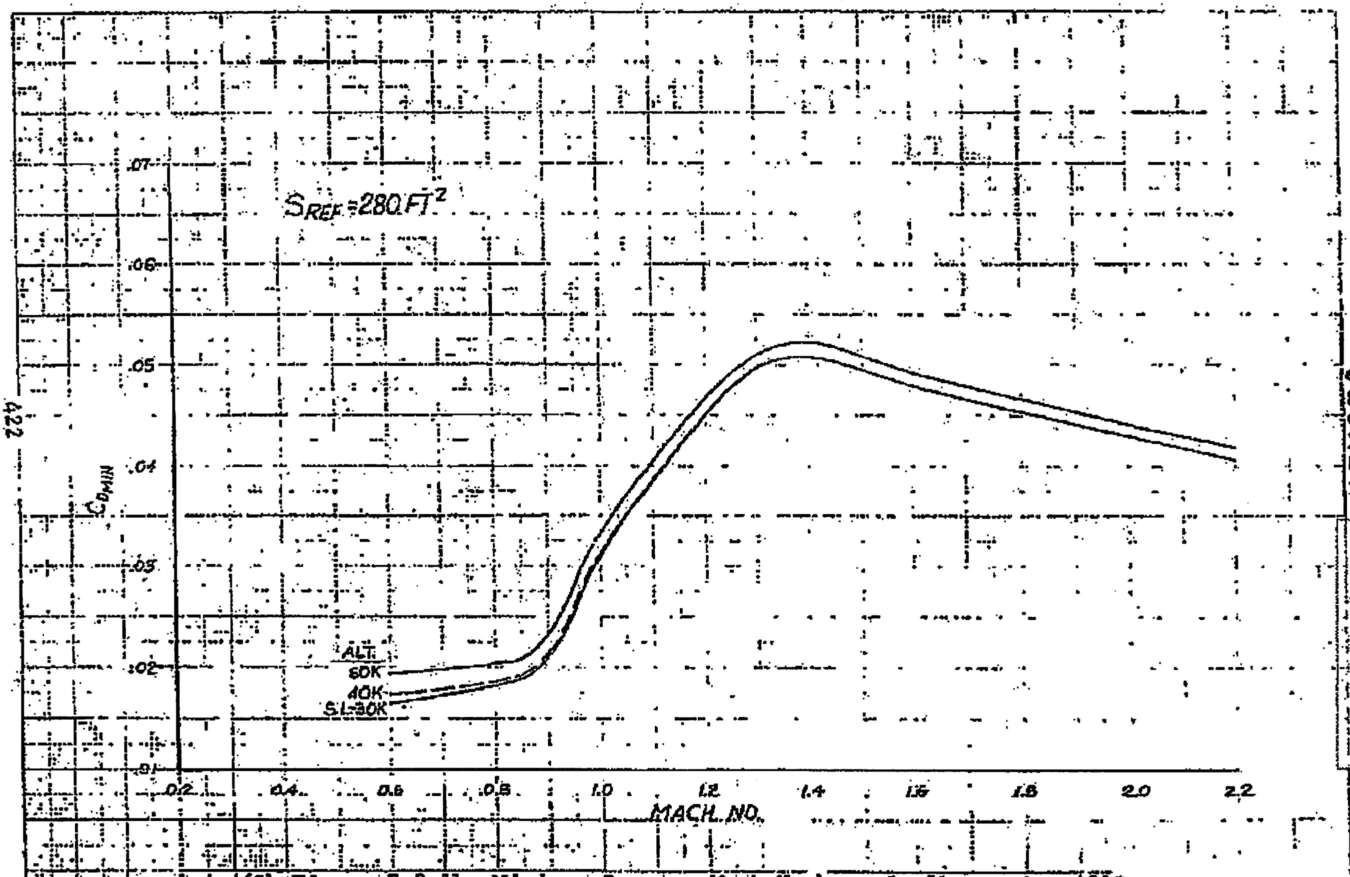


~~(S)~~ Figure 7.3-1a Minimum Drag vs Mach Number, Configuration 401B with AR= 3.75 Supercritical Wing (U)

P93
421-445

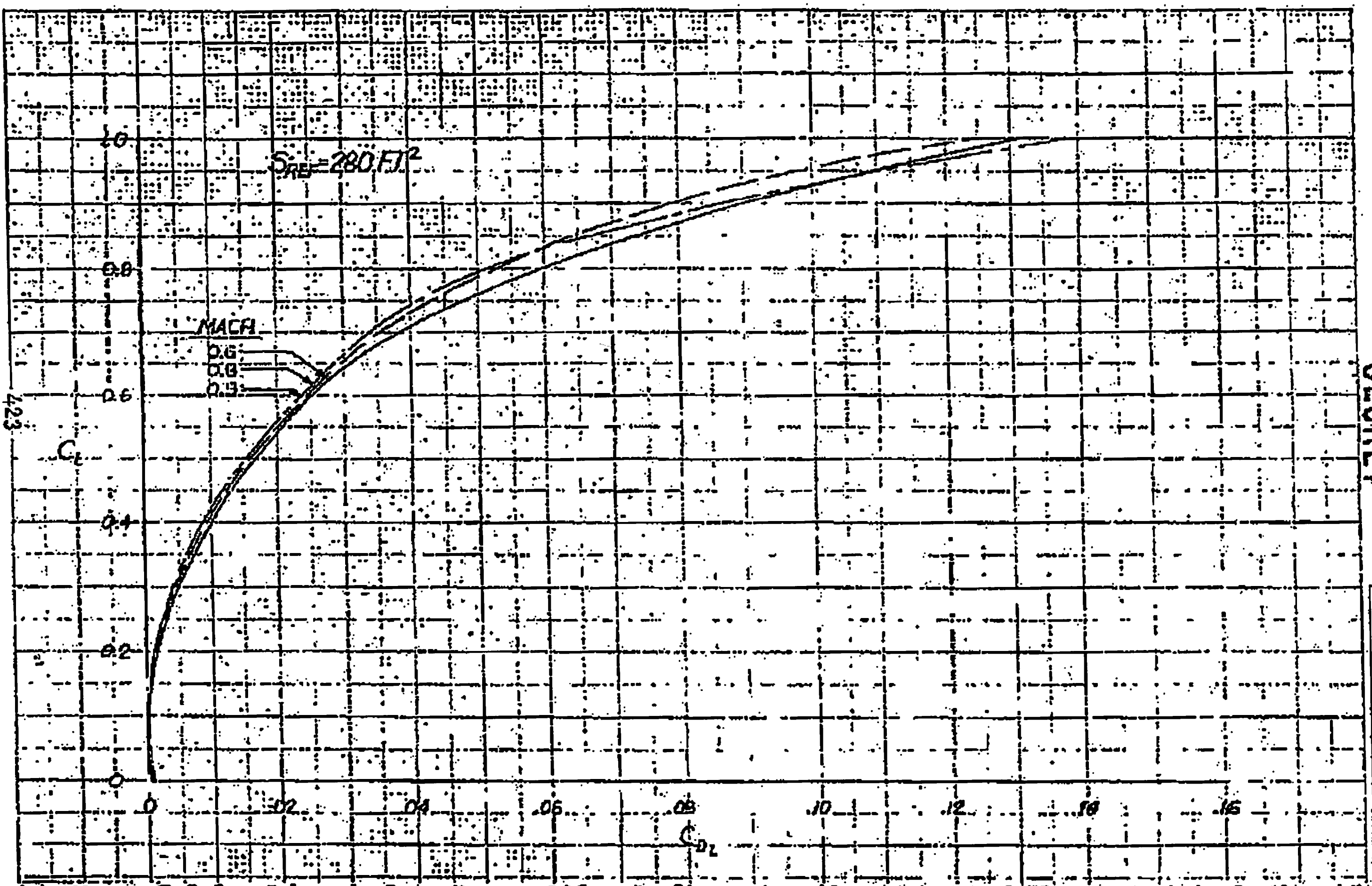
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~SECRET~~



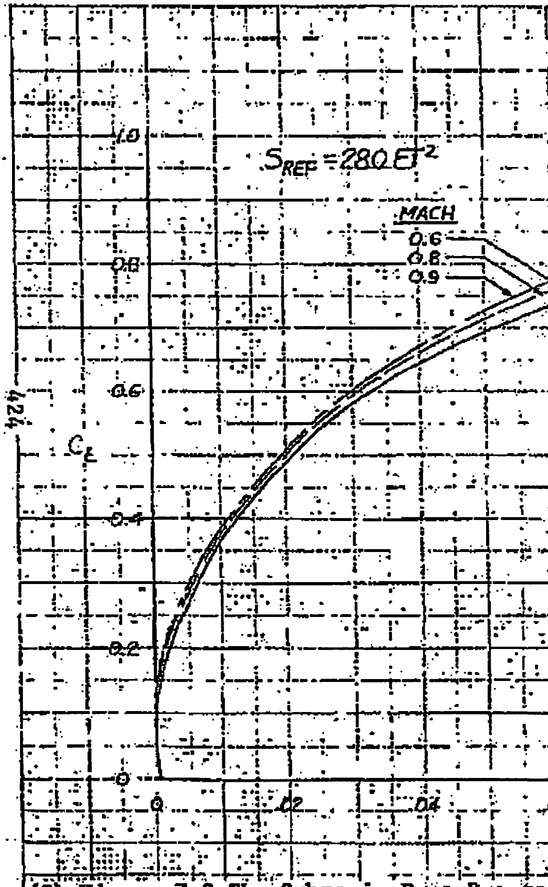
~~(S)~~ Figure 7.3-1b Minimum Drag vs Mach Number, Configuration 401B with AR = 3.0 Supercritical Wing (U)

~~SECRET~~

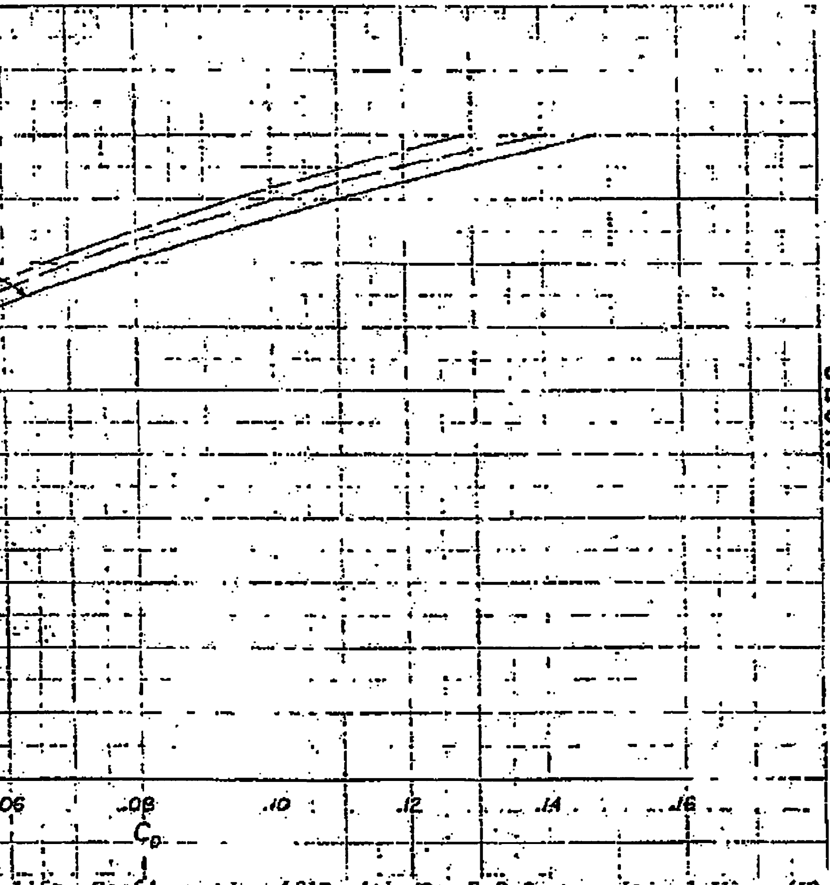


~~(S)~~ Figure 7.3-2a Subsonic Drag Due to Lift, Configuration 401B with AR= 3.75 Supercritical Wing (U)

SECRET



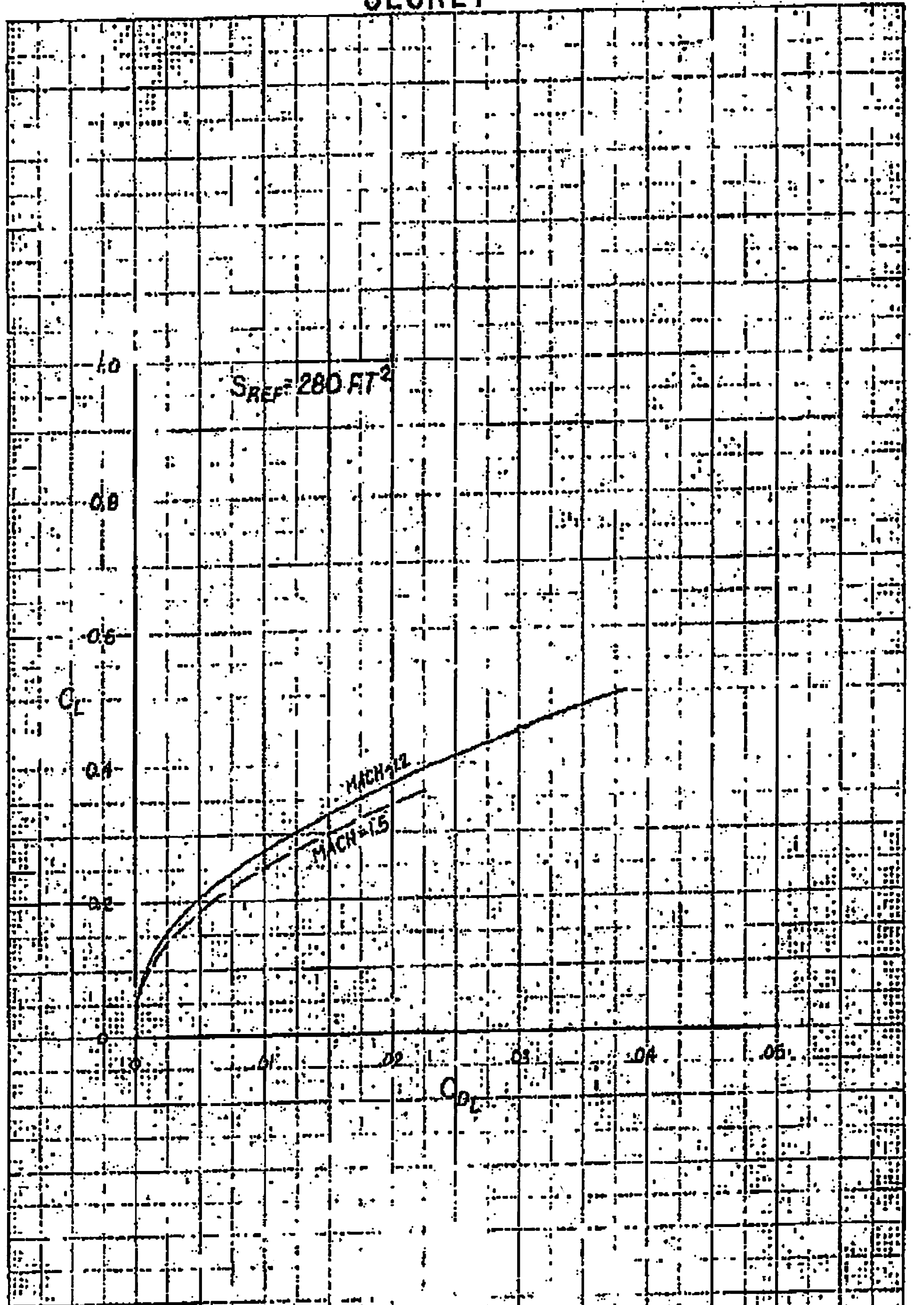
~~(S)~~ Figure 7.3-2b Subsonic Drag Due to



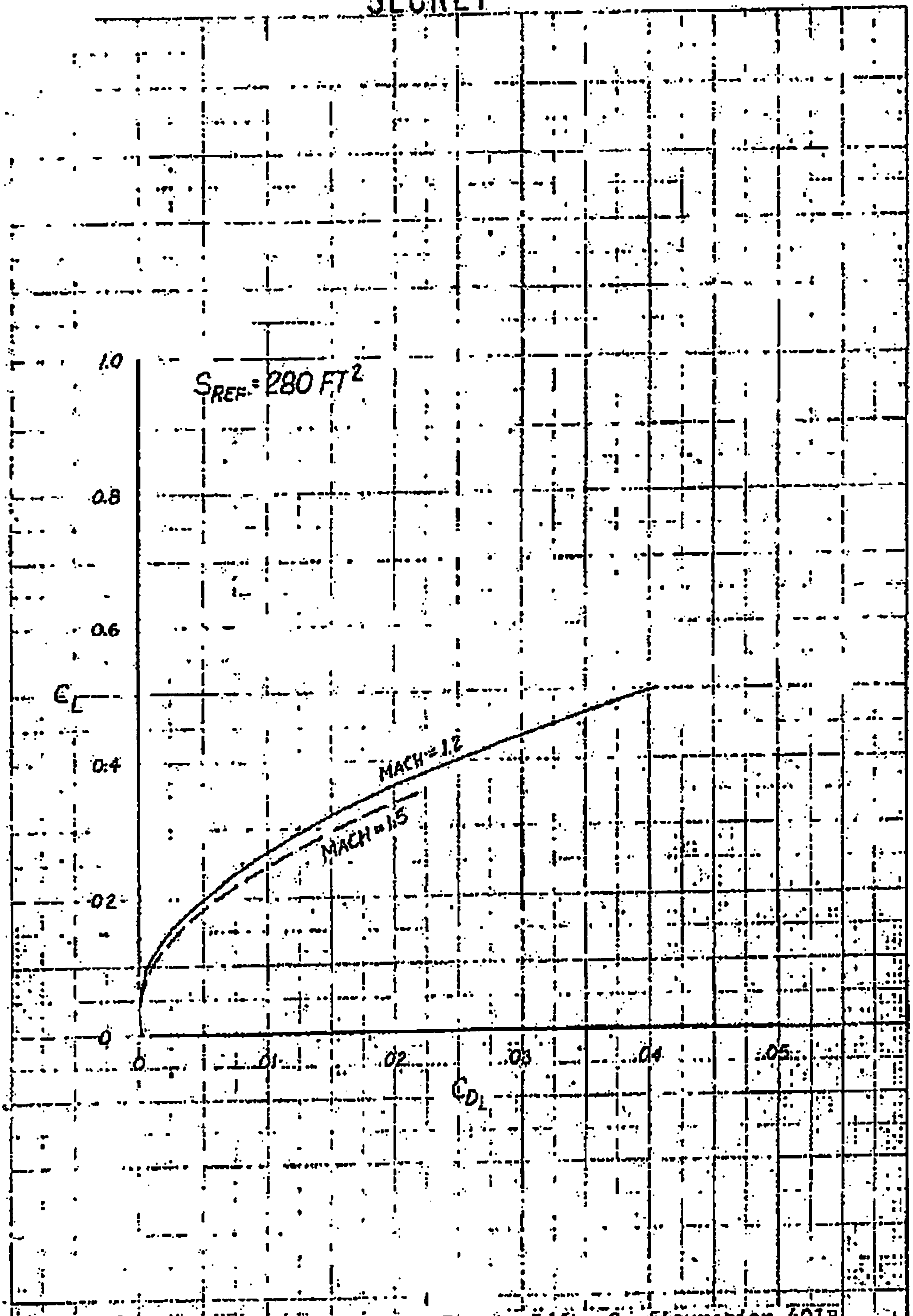
Lift, Configuration 401B with AR = 3.0 Supercritical Wing (U)

SECRET

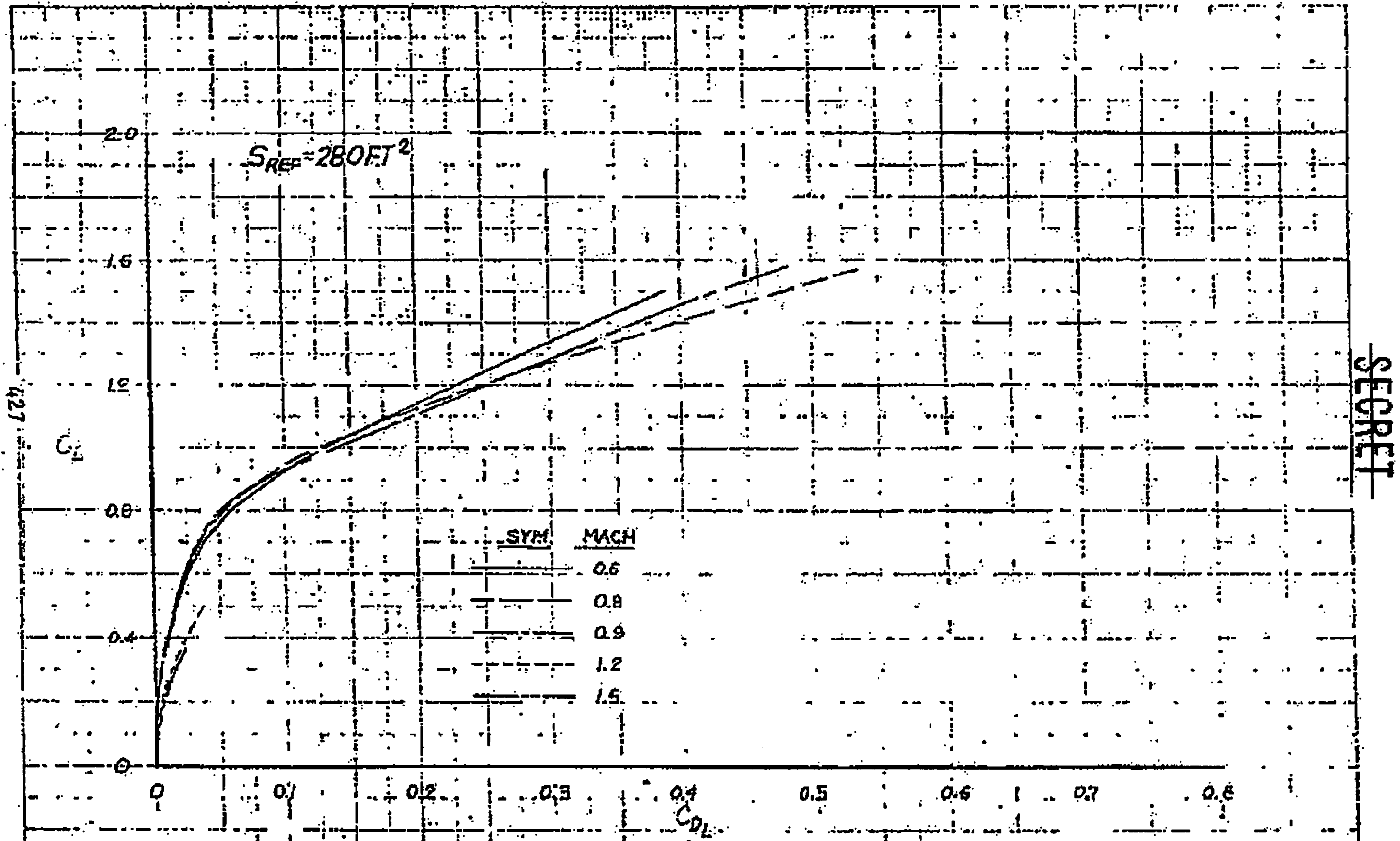
88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.3-3a Supersonic Drag Due to Lift, Configuration 401B with AR= 3.75 Supercritical Wing (U)

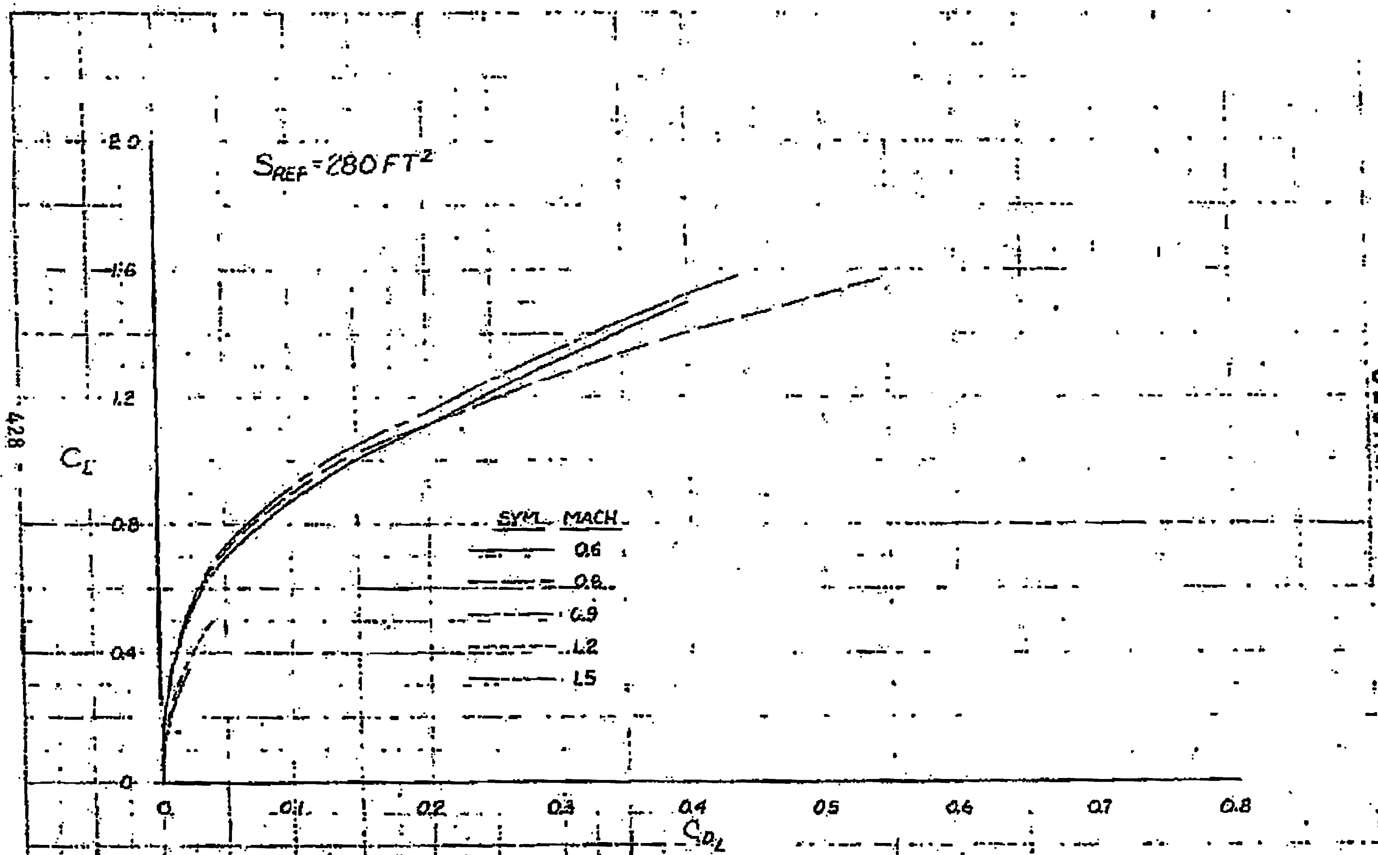


~~(S)~~ Figure 7.3-3b Supersonic Drag Due to Lift, Configuration 401B with AR= 3.0 Supercritical Wing (U)



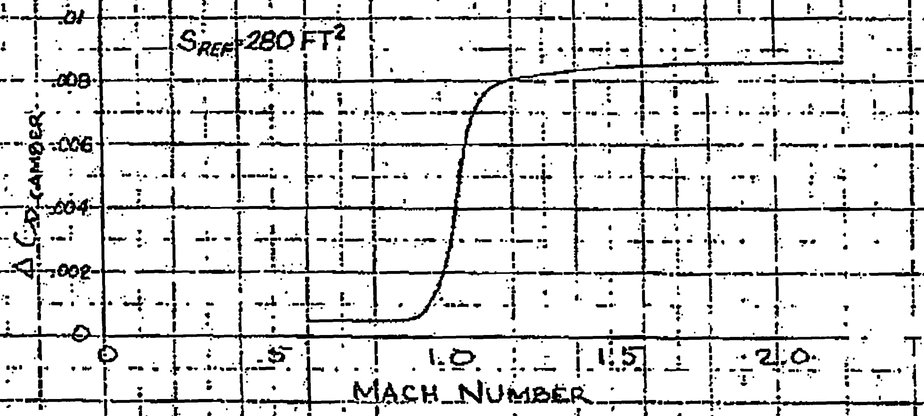
~~(S)~~ Figure 7.3-4a Drag Due to Lift at High C_L's, Configuration 401B with Æ = 3.75 Supercritical Wing (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.3-4b Drag Due to Lift at High C_L's, Configuration 401B with Æ= 3.0 Supercritical Wing (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.3-5 Camber Drag for Supercritical Wings (U)

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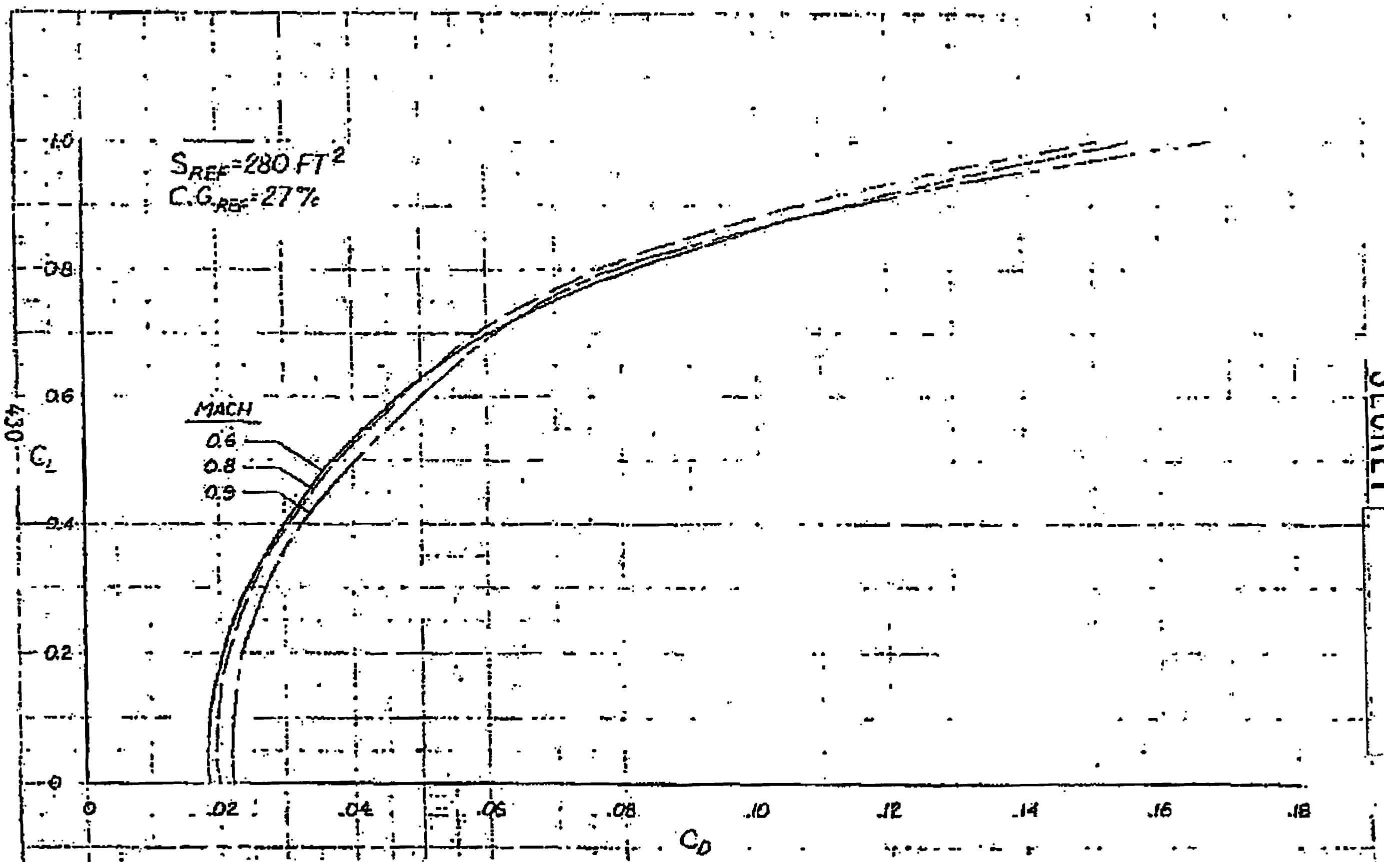

~~(S)~~ Figure 7.3-6a Trimmed Subsonic Drag Polars, Configuration 401B with AR= 3.75 Supercritical Wing (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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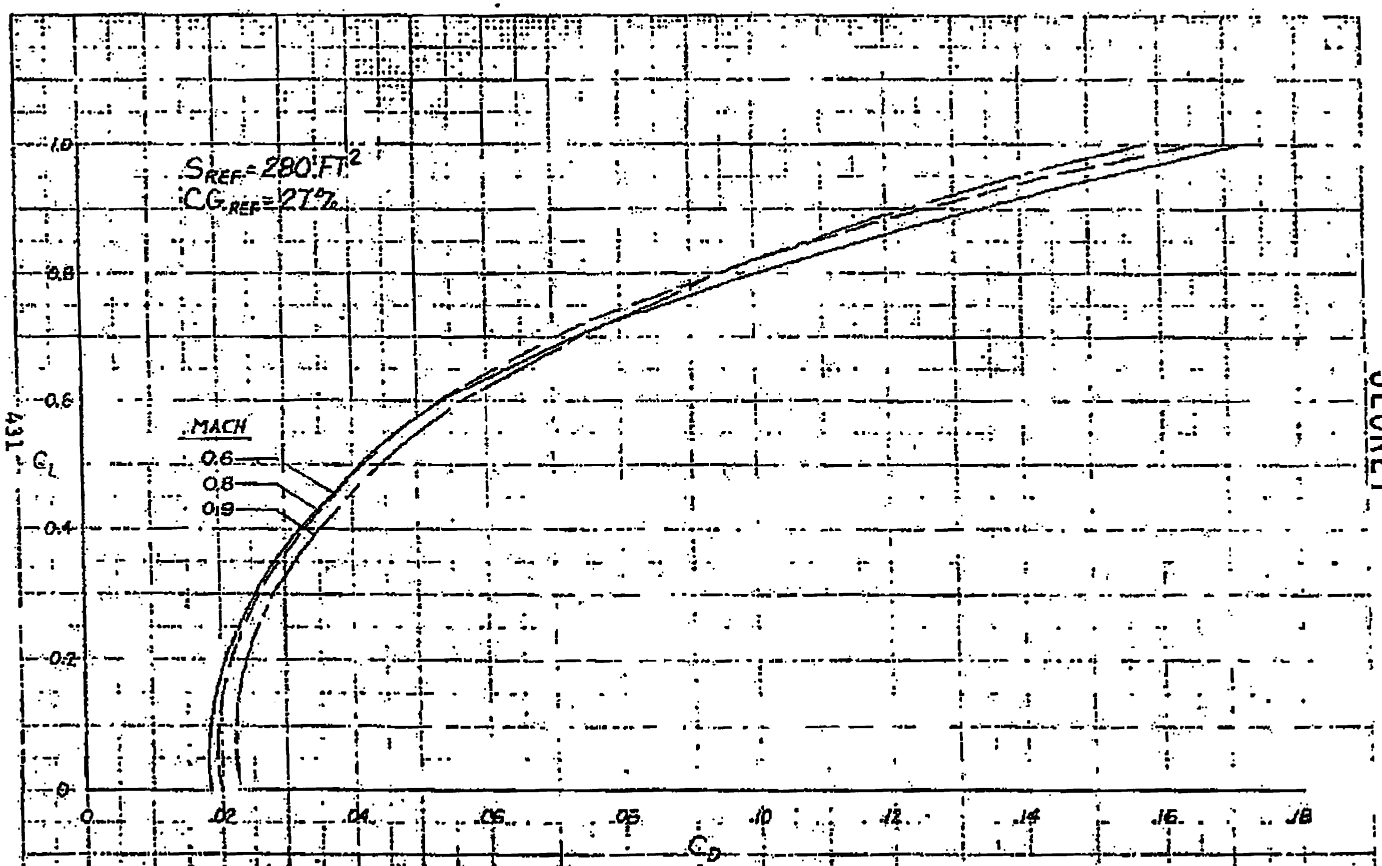

~~(S)~~ Figure 7.3-6b Trimmed Subsonic Drag Polars, Configuration 401B with AR= 3.0 Supercritical Wing (U)

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FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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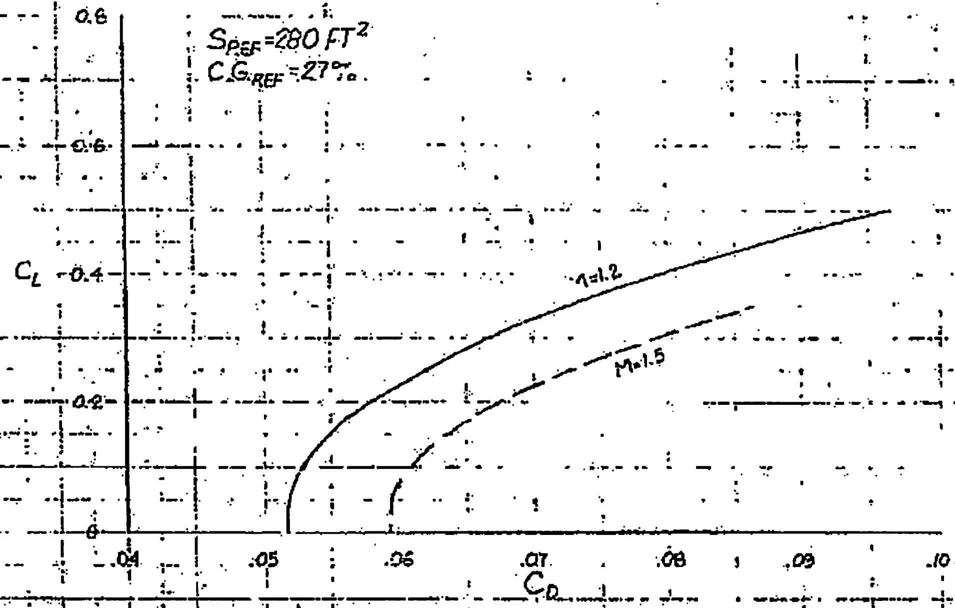

(S) Figure 7.3-7a Trimmed Supersonic Drag Polars, Configuration 401B with AR= 3.75 Supercritical Wing (U)

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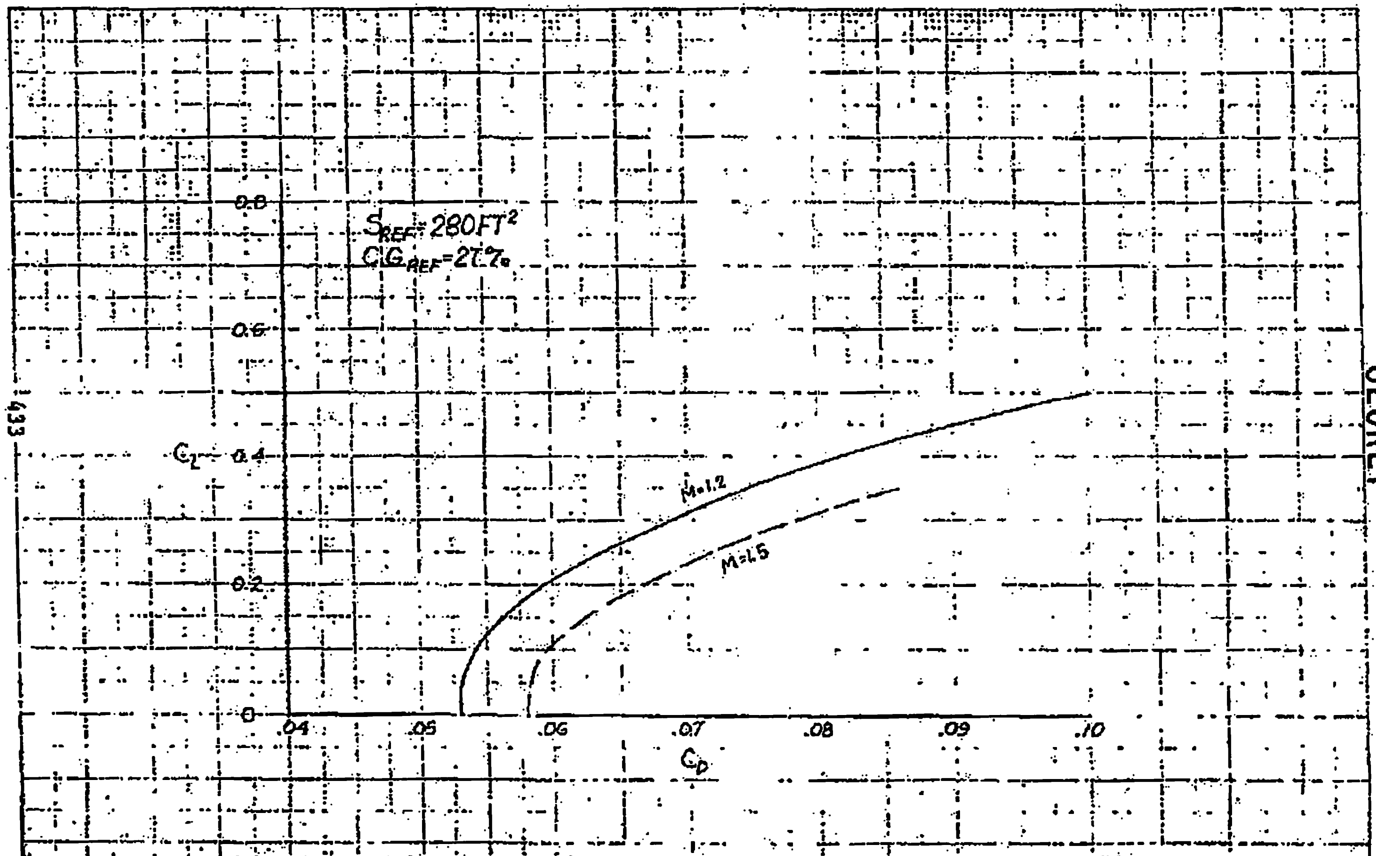

~~(S)~~ Figure 7.3-7b Trimmed Supersonic Drag Polars, Configuration 401B with AR= 3.0 Supercritical Wing (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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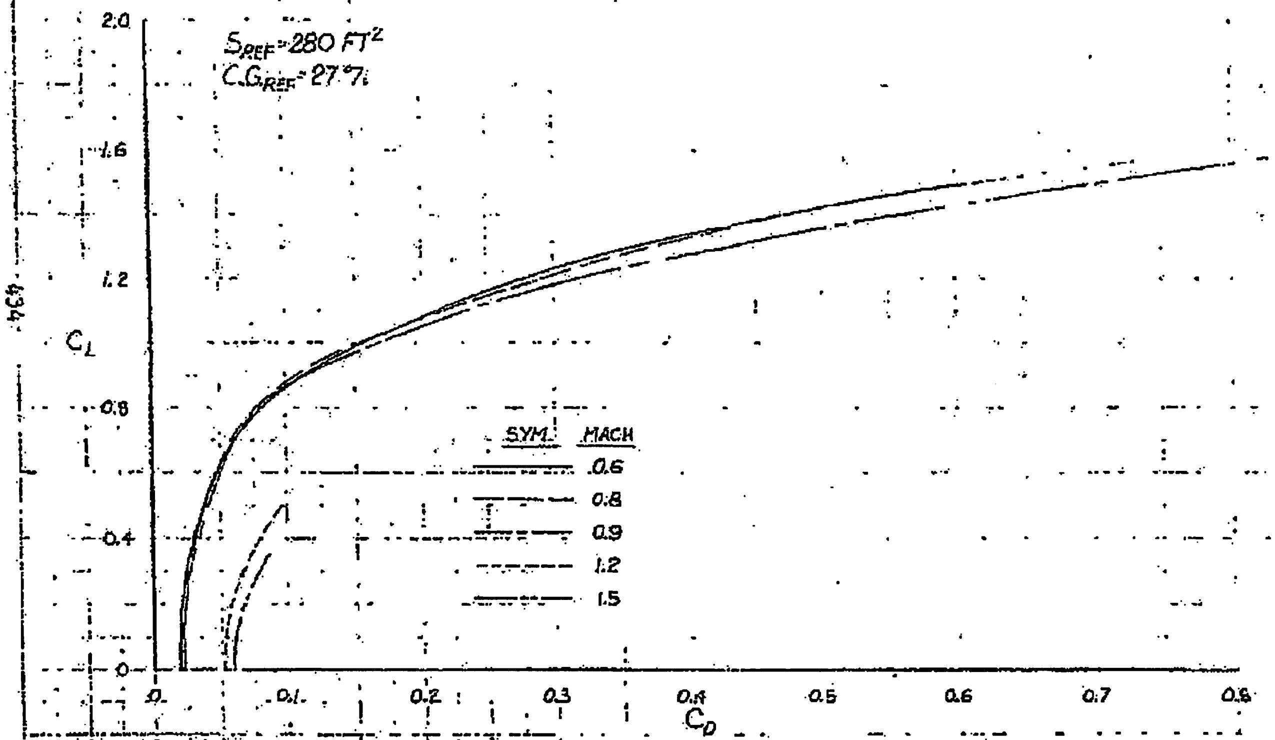

~~(S)~~ Figure 7.3-8a Trimmed Drag Polars at High C_L's, Configuration 401B with Æ= 3.75 Supercritical Wing (U)

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88th ABW/IPL
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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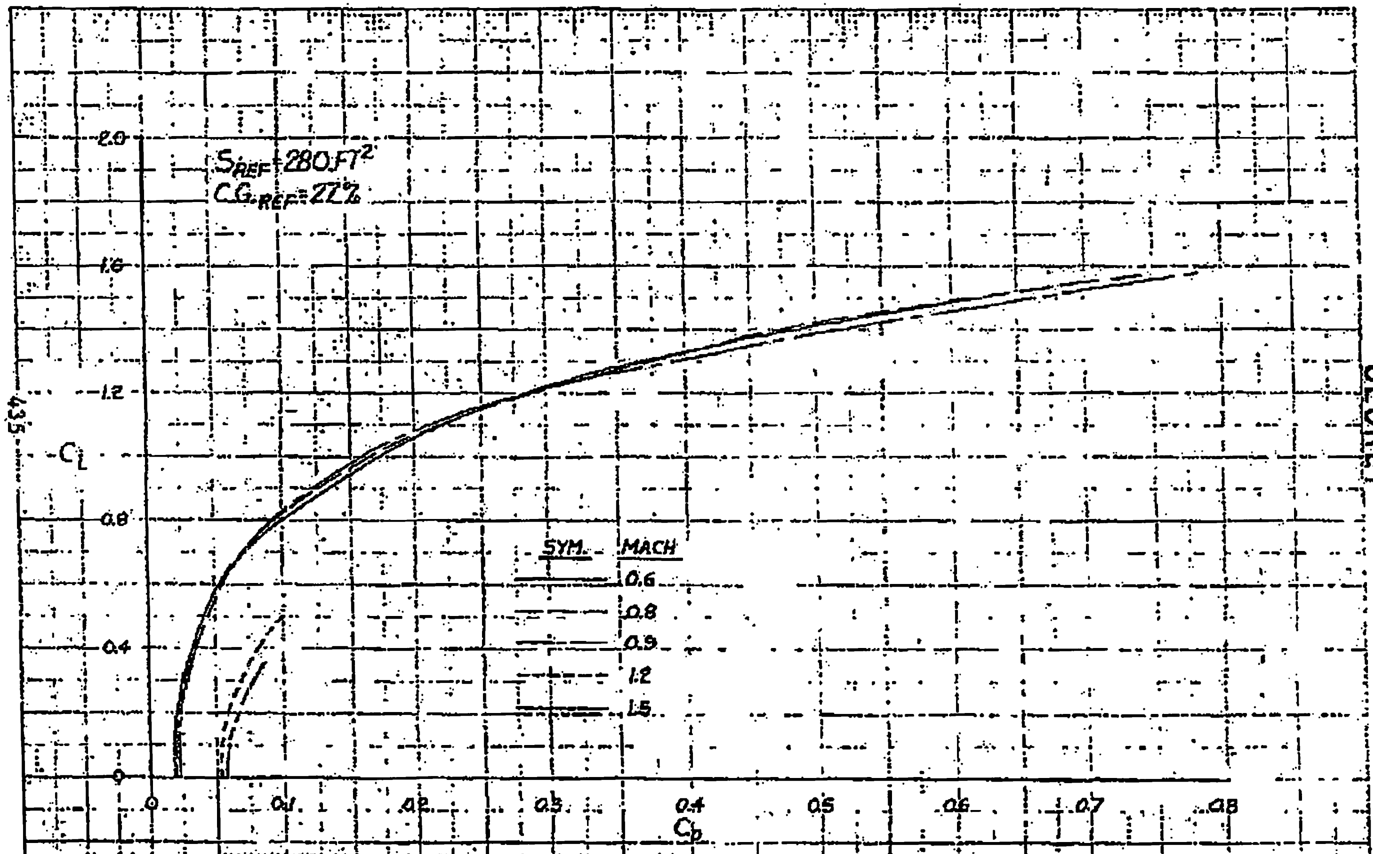

(S) Figure 7.3-8b Trimmed Drag Polars at High C_L's, Configuration 401B with Æ = 3.0 Supercritical Wing (U)

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526
SEC. 3.3.(b)
(4)
1.4. (a)(g).

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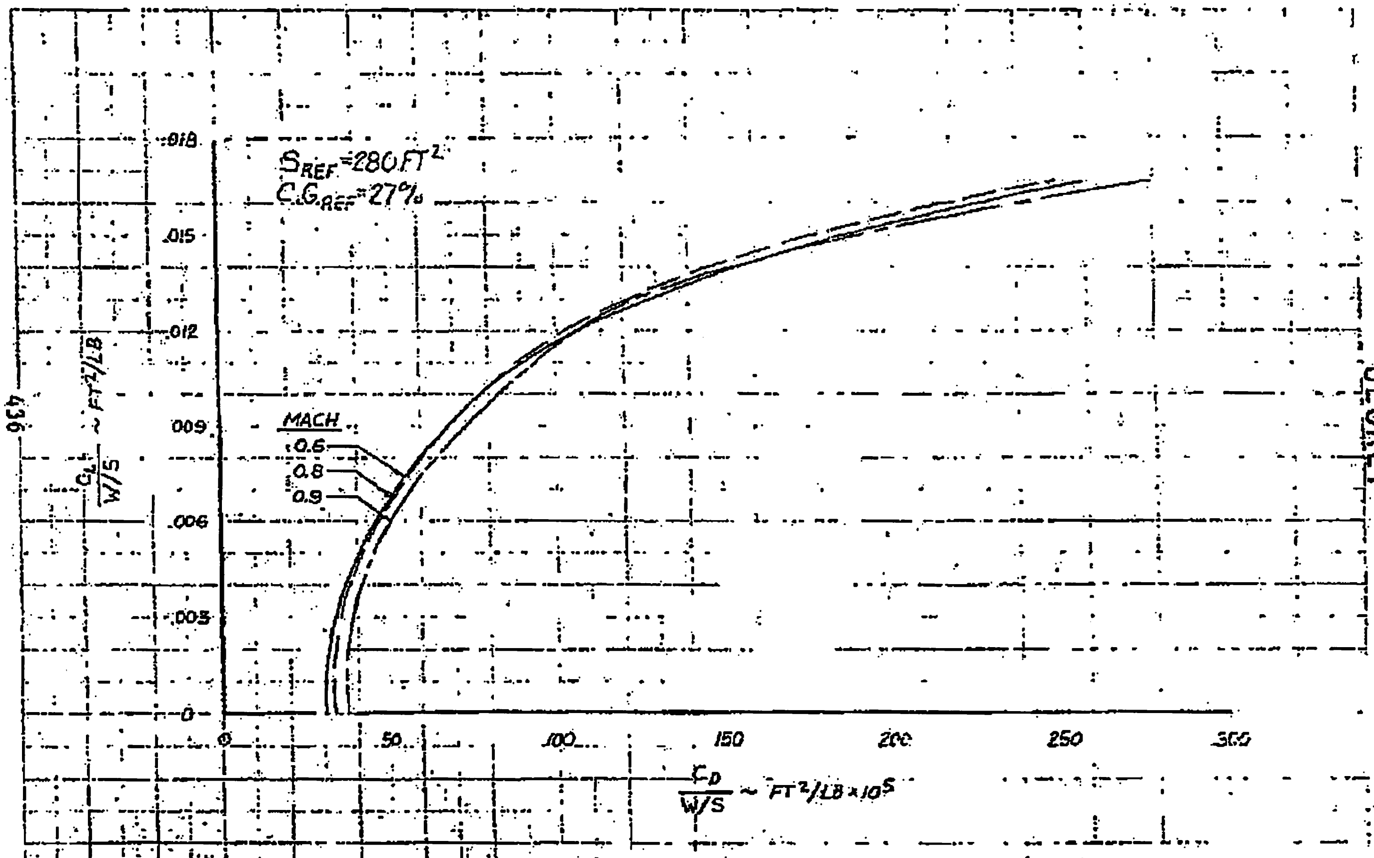

~~(S)~~ Figure 7.3-9a Trimmed Subsonic Configuration Polars, Configuration 401B with AR = 3.75 Supercritical Wing (U)

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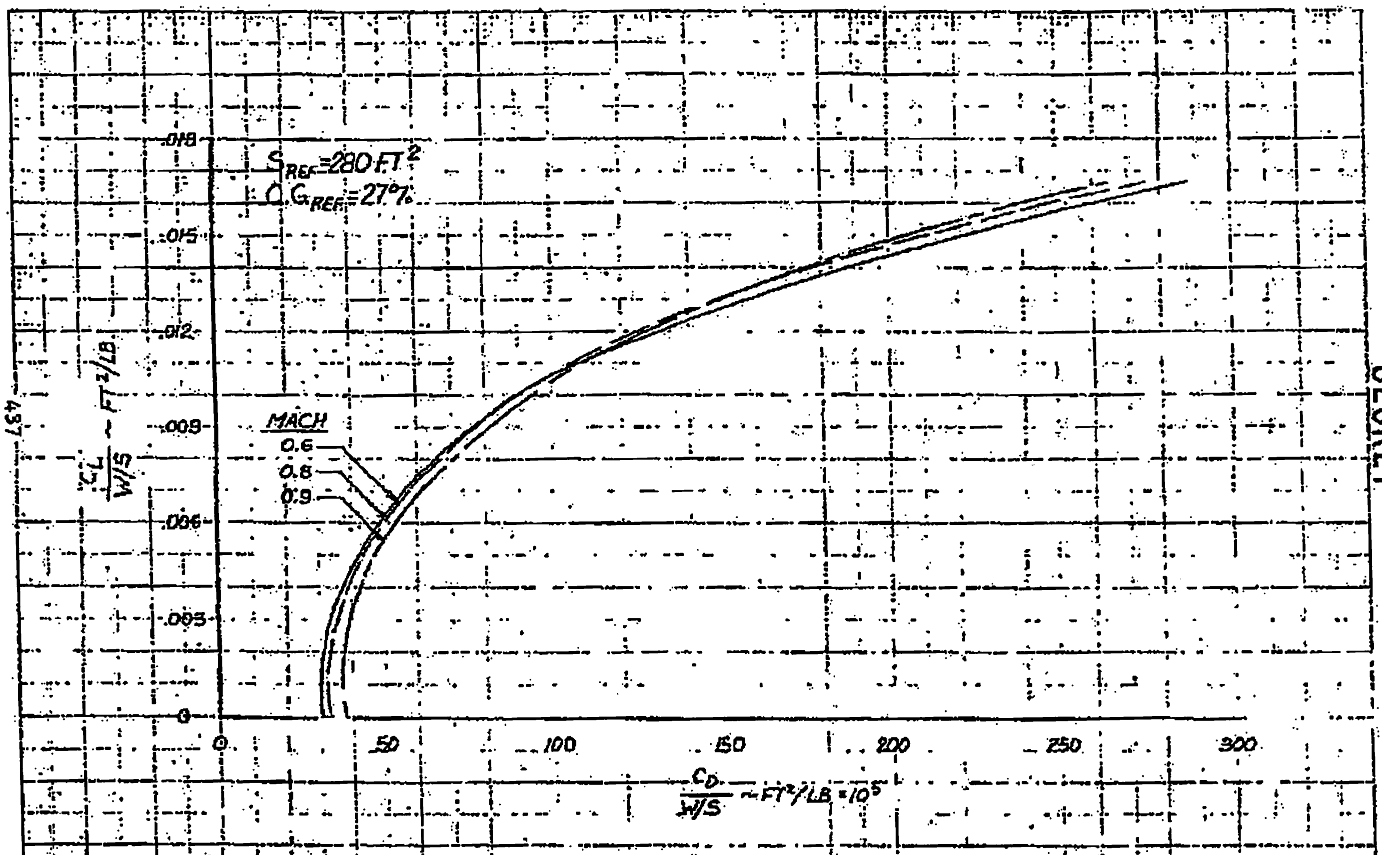

~~(S)~~ Figure 7.3-9b Trimmed Subsonic Configuration Polars, Configuration 401B with AR = 3.0 Supercritical Wing (U)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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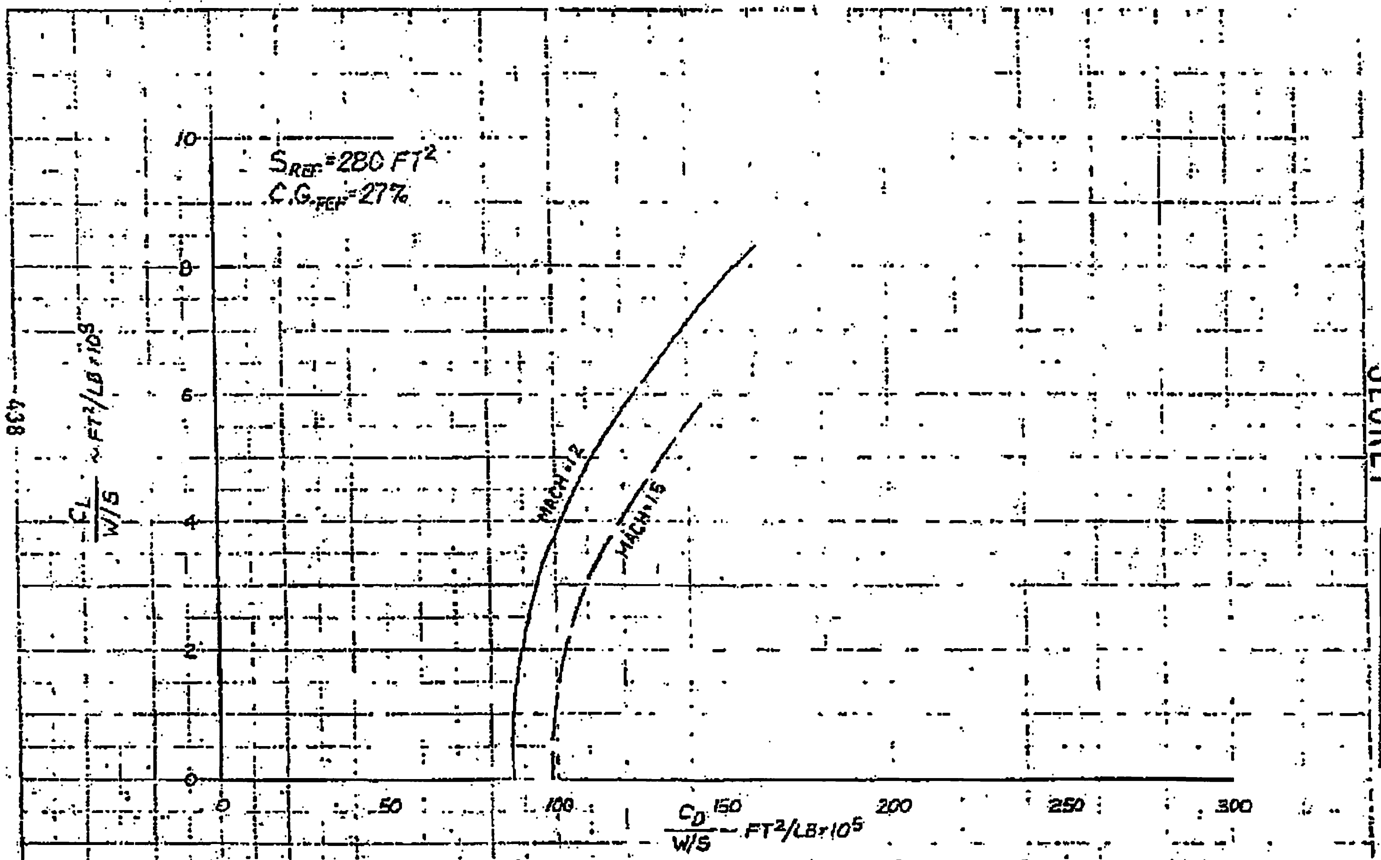

~~(S)~~ Figure 7.3-10a Trimmed Supersonic Configuration Polars, Configuration 401B with AR= 3.75 Supercritical Wing (U)

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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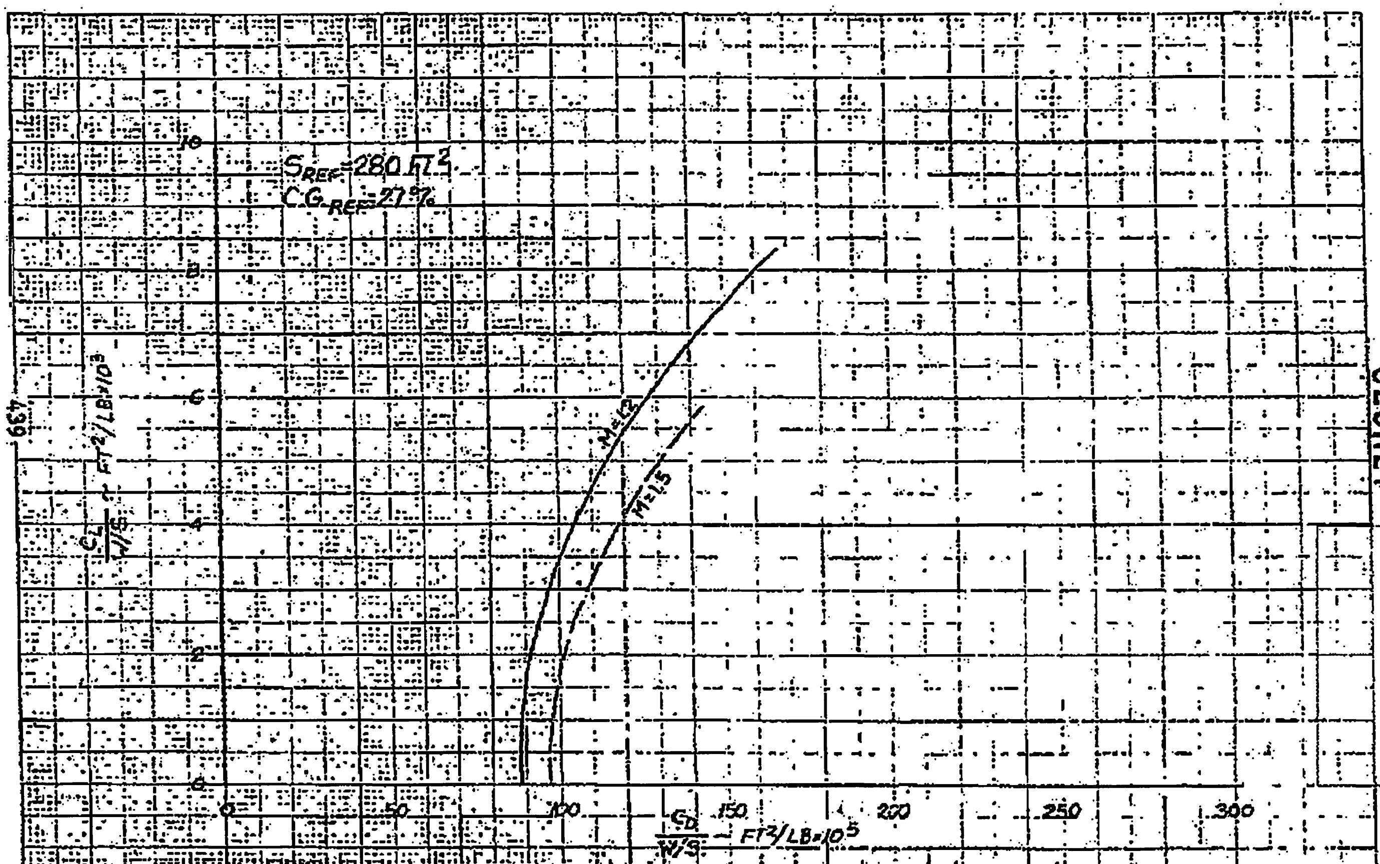

(S) Figure 7.3-10b Trimmed Supersonic Configuration Polars, Configuration 401B with Æ = 3.0 Supercritical Wing (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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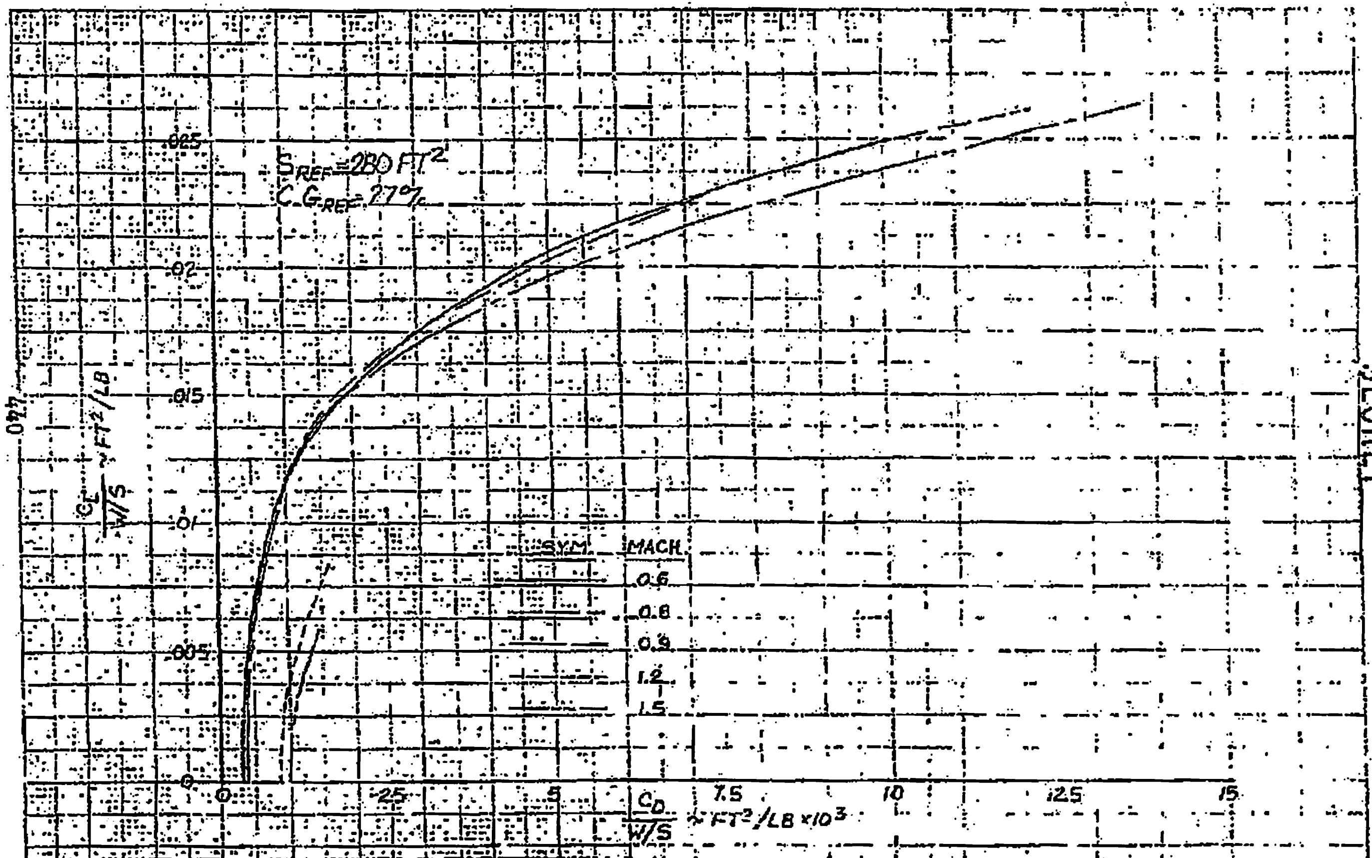

(S) Figure 7.3-11a Trimmed Configuration Polars at High C_L's, Configuration 401B with AR= 3.75 Supercritical Wing (U)

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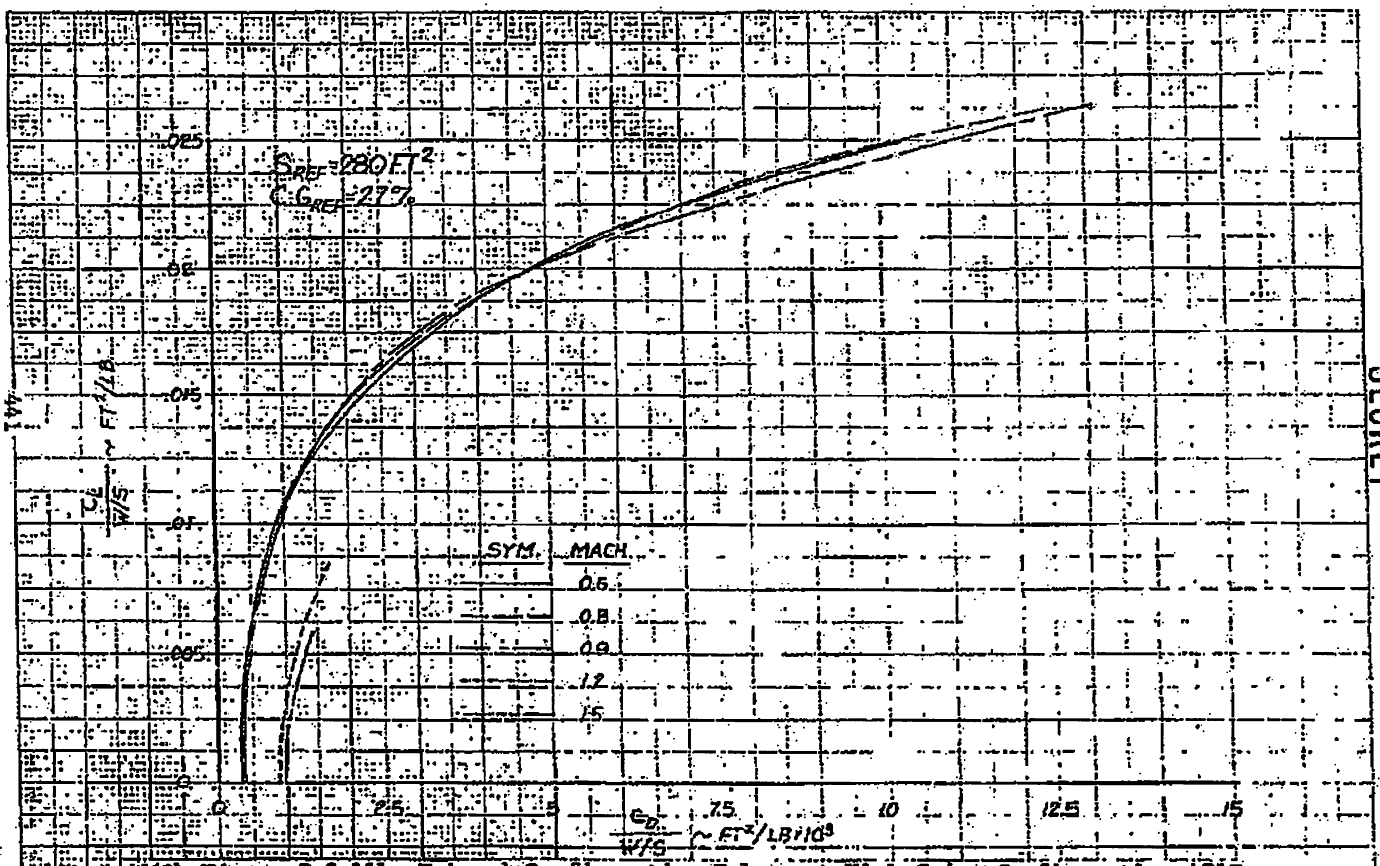

(S) Figure 7.3-11b Trimmed Configuration Polars at High C_L's, Configuration 401B with Æ= 3.0 Supercritical Wing (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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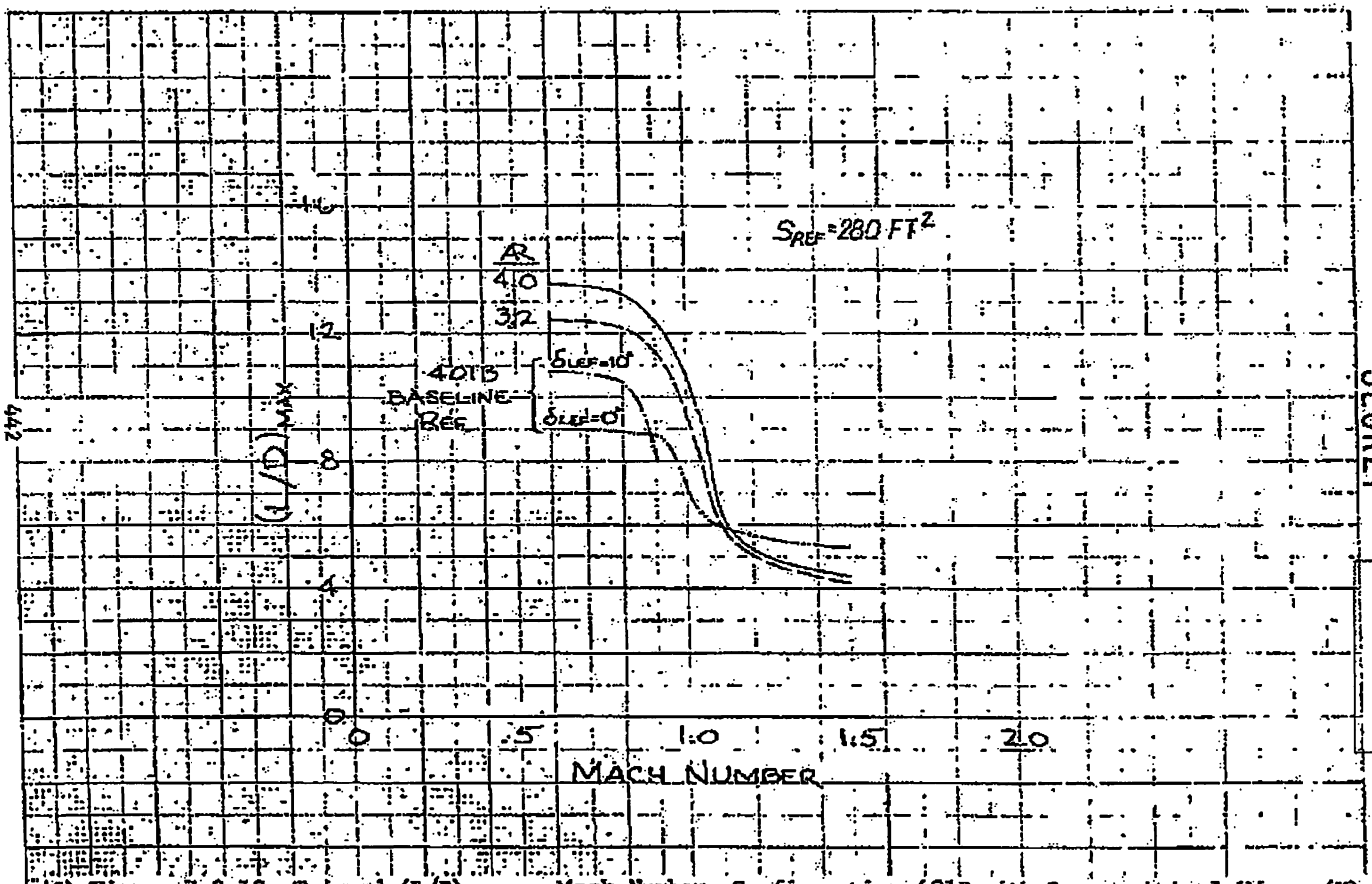

(S) Figure 7.3-12 Trimmed $(L/D)_{max}$ vs Mach Number, Configuration 401B with Supercritical Wings (U)

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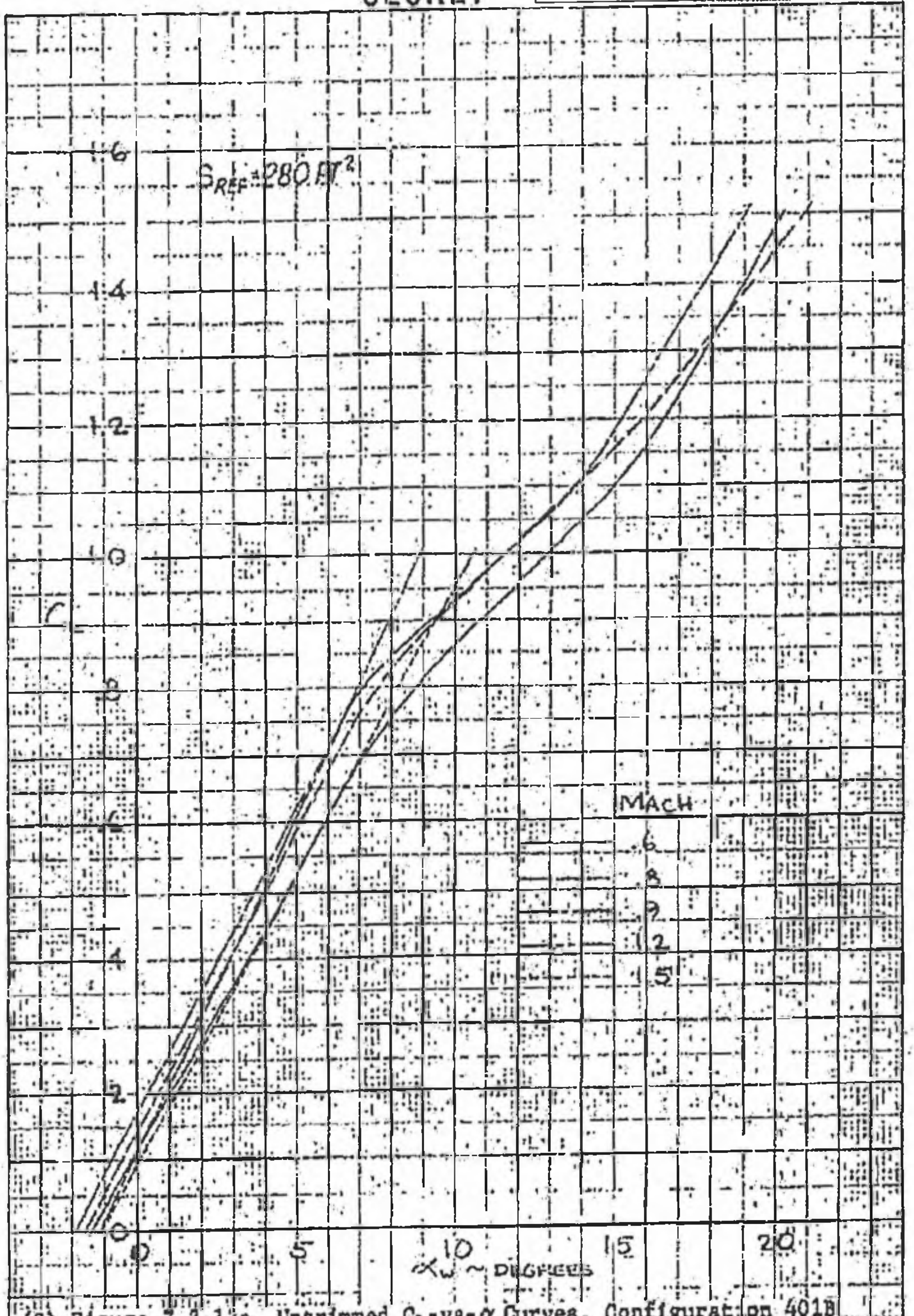
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



(S) Figure 7.3-13a Untrimmed C_L-vs-α Curves, Configuration 401B with Æ = 3.75 Supercritical Wing (U)

88th ABW/IPI
FOIA (b)(1)
~~E.O. 13526 SEC. 3.3.~~
(b)(4)
1.4. (a)(g)

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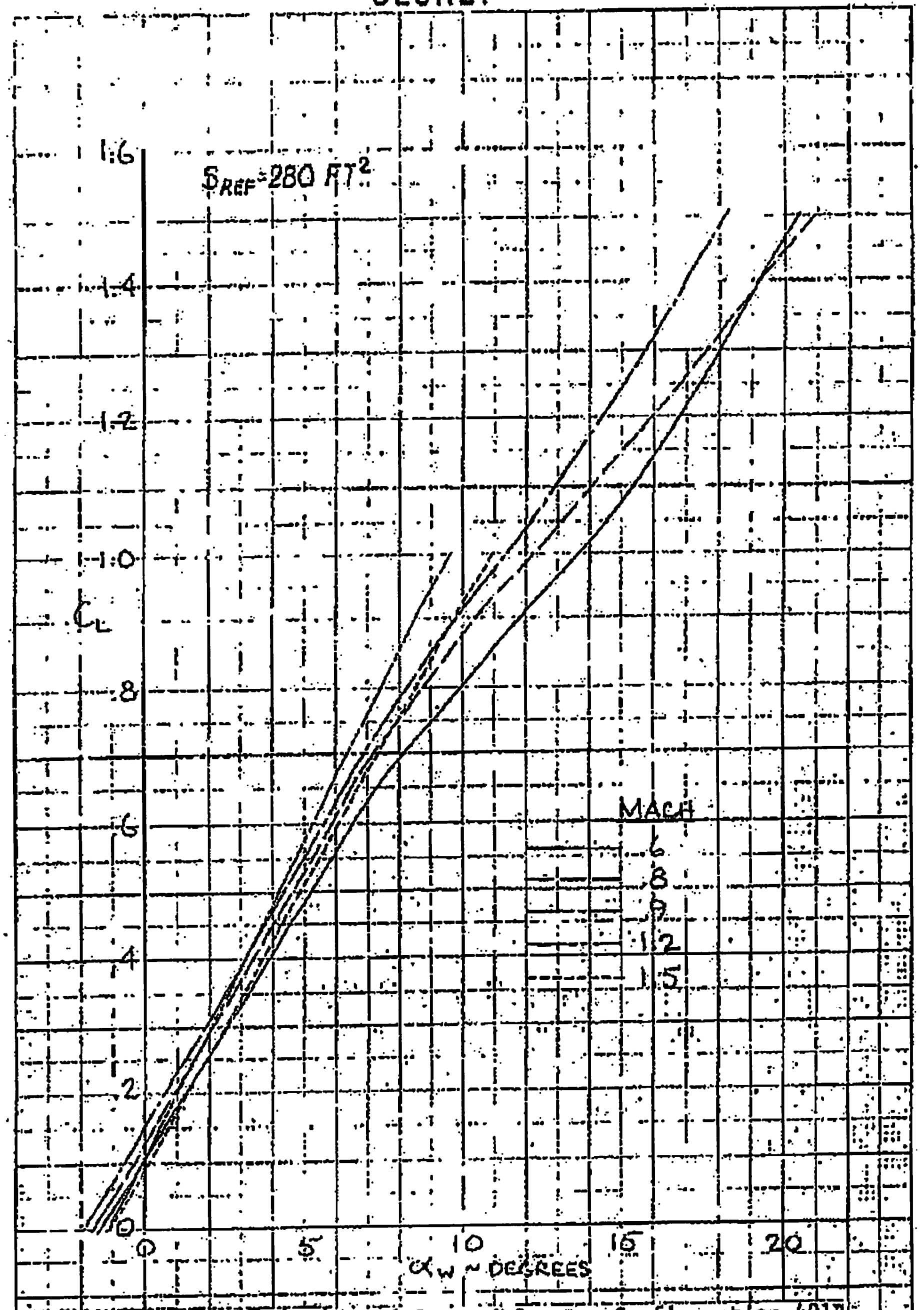

~~(S)~~ Figure 7.3-13b Untrimmed C_L-vs-α Curves, Configuration 401B with AR= 3.0 Supercritical Wing (U)

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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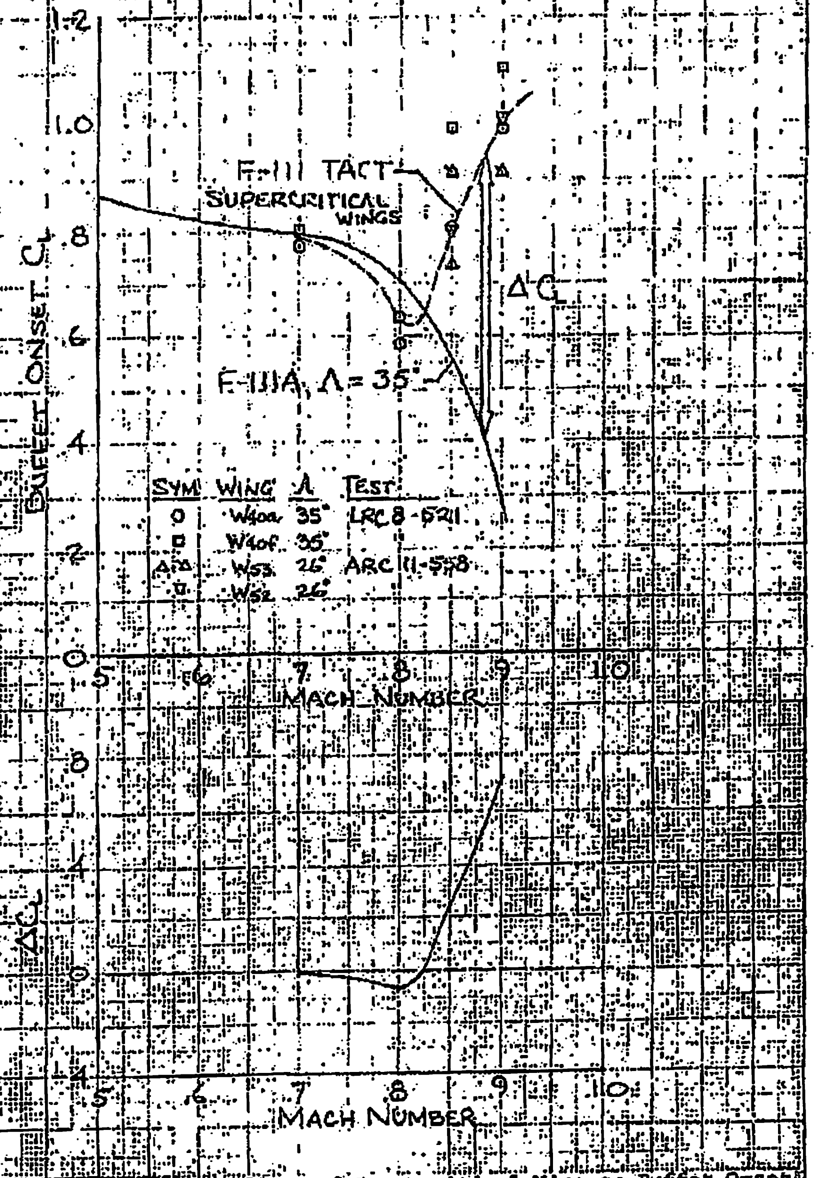

~~(C)~~ Figure 7.3-14 Effect of Supercritical Wing on Buffet Onset C_L for F-111 (U)

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7.4 PERFORMANCE

(U) The performance capabilities of Configuration 401B with the two supercritical airfoils (AR = 3.0 and 3.75) were evaluated for the same missions and ground rules as set forth in Section 3.2. Both wings have a wing loading of 60 psf and a leading-edge sweep of 45 degrees.

~~(S)~~ The LRASM and SRASM mission radius capabilities for the two design concepts are shown below for the 16,800-lb versions described in Section 7.2.

Aspect Ratio	Mission	Radius (n.mi)	$\dot{\theta}$ M0.8 (deg/sec)	$\dot{\theta}$ M1.2 (deg/sec)	Accel. Time (sec)
3.0	LRASM	802	10.65	7.42	56.9
	SRASM	244	11.50	8.10	52.1
3.75	LRASM	726	11.10	7.88	59.9
	SRASM	193	11.93	8.42	55.3

~~(S)~~ After the supercritical designs were evaluated at a fixed design weight of 16,800 lb, both designs were resized to meet the 225-n.mi SRASM radius requirement rather than the 750-n.mi LRASM radius requirement. This was done because of the poor supersonic performance of the supercritical airfoil design, which results in more fuel required for combat. The SRASM does not have enough cruise distance for the better cruise L/D offered by the supercritical wing to compensate for added combat fuel requirement, as is the case with the LRASM.

~~(S)~~ The reference areas of the supercritical wings changed from 280 sq ft to 277.3 sq ft for the aspect-ratio 3.0 wing and to 385.2 sq ft for the aspect ratio 3.75 wing. The following corrections, obtained from the growth data presented in Section 3.3, were added to the basic aerodynamic data of Section 7.3 to account for the change in aircraft size and wing area.

Mach No.	ΔC_D AR 3.0	ΔC_D AR 3.75
0.6	.00008	-.00015
0.8	.00008	-.00015
0.9	.00008	-.00017
1.2	.00034	-.00062
1.5	.00031	-.00056

(U) The weight data presented in Section 7.6 were corrected for change in aircraft size through use of the growth data presented in Section 3.5. A summary of the corrected weight data is presented in Table 7.4-1 for the aspect-ratio 3.0 wing and in Table 7.4-2 for the aspect-ratio 3.75 wing.

(U) The engine size was maintained fixed, and the propulsion data from Section 3.6 were used without modification.

~~(S)~~ Summaries of the mission capabilities of the resized aircraft are presented in Figures 7.4-1 and -2. A comparison with the basic 401B configuration is presented below:

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3. (b)(4)
1.4(a)(g)
SEC. 3.3 (b)(4)
SEC 1.4(a)(g)

Config.	Mission Weight (lb)	LRASM Radius (n.mi)	$\dot{\theta}$ M0.8 (deg/sec)	$\dot{\theta}$ M0.9 (deg/sec)	$\dot{\theta}$ M1.2 (deg/sec)
Basic 401B	17,115	750	9.8	10.2	8.1
AR 3.0	16,640	767	10.6	11.3	7.5
AR 3.75	17,115	794	11.0	11.8	7.7

Config.	Accel. Time (sec)	Max. Mach No.
Basic 401B	35.5	2.35
AR 3.0	55.8	1.79
AR 3.75	62.6	1.77

Mission weight listed above is full-up weight with mission payload and without tanks. This is the SRASM takeoff gross weith and the LRASM weight at start of combat.

(U) The supercritical airfoil design with an aspect ratio of 3.75 is the same-size aircraft as the basic 401B configuration and has a 1.2-deg/sec increase in subsonic turn rate (approximately 10 percent increase). The supersonic design with an aspect ratio of 3.0 is of slightly smaller size than the basic 401B and has an 0.8-deg/sec increase in subsonic turn rate. Both supercritical airfoil configurations perform worse at supersonic speeds than does the basic 401B configuration. This is caused by the increased wave drag associated with the thicker airfoil section and blunter leading edge.

(U) Tabulations of the pertinent data for each segment of the three missions are presented in Tables 7.4-3 through

(U) 7.4-8. General performance data are presented in Figures 7.4-3 through 7.4-22. Sensitivity of mission weight to weight-empty variations is presented in Figure 7.4-23 for the aspect-ratio 3.0 wing and in Figure 7.4-24 for the aspect ratio 3.75 wing.

~~(S)~~ Table 7.4-1 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL WING WEIGHT SUMMARY

(16,640-Lb Airplane Without Tanks)

Item	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	11,779
Ammunition (500 Rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,228
SRASM Takeoff Gross Weight	16,640
Two Full 300-Gallon Tanks and Pylons	4,838
LRASM Takeoff Gross Weight	21,478
Basic Operating Weight	11,779
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	397
SRASM and LRASM Landing Weight	12,318
2. FERRY MISSION	
Basic Operating Weight	11,779
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	11,940
Internal Fuel	4,228
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	26,825
Zero Fuel Weight	11,940
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five Percent Initial Fuel	654
Twenty-Minute Sea-Level Loiter	484
Landing Weight	14,892

~~(S)~~ Table 7.4-2 CONFIGURATION 401B WITH ASPECT RATIO 3.75 SUPERCRITICAL WING WEIGHT SUMMARY

(17,115-Lb Airplane Without Tanks)

Item	Weight (lb)
1. SRASM and LRASM	
Basic Operating Weight	12,249
Ammunition (500 Rounds)	285
Two AIM 9-X Missiles	348
Fuel	4,233
SRASM Takeoff Gross Weight	17,115
Two Full 300-Gallon Tanks and Pylons	4,838
LRASM Takeoff Gross Weight	21,953
Basic Operating Weight	12,249
One Half Ammunition	142
Fuel for 20-Minute Sea-Level Loiter	379
SRASM and LRASM Landing Weight	12,770
2. FERRY MISSION	
Basic Operating Weight	12,249
Missile Pylon (Removed)	-124
Ammunition (500 Rounds)	285
Zero Fuel Weight	12,410
Internal Fuel	4,233
Two Full 600-Gallon Tanks and Pylons	9,348
One Full 150-Gallon Tank and Pylon	1,309
Takeoff Gross Weight	27,300
Zero Fuel Weight	12,410
Two Empty 600-Gallon Tanks and Pylons	1,506
One Empty 150-Gallon Tank and Pylon	308
Five Percent Initial Fuel	654
Twenty-Minute Sea-Level Loiter	470
Landing Weight	15,348

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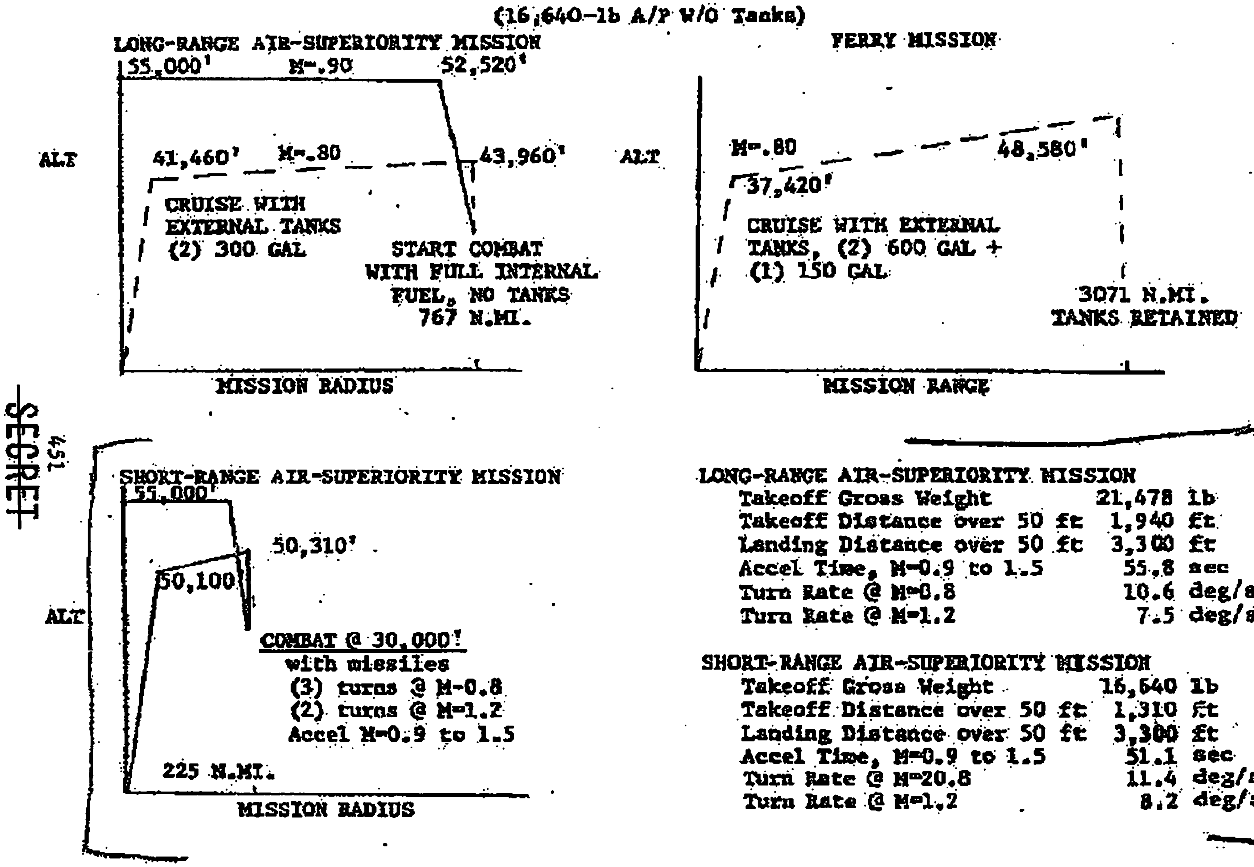

LONG-RANGE AIR-SUPERIORITY MISSION		
Takeoff Gross Weight	21,478	lb
Takeoff Distance over 50 ft	1,940	ft
Landing Distance over 50 ft	3,300	ft
Accel Time, M=0.9 to 1.5	55.8	sec
Turn Rate @ M=0.8	10.6	deg/sec
Turn Rate @ M=1.2	7.5	deg/sec
SHORT-RANGE AIR-SUPERIORITY MISSION		
Takeoff Gross Weight	16,640	lb
Takeoff Distance over 50 ft	1,310	ft
Landing Distance over 50 ft	3,300	ft
Accel Time, M=0.9 to 1.5	51.1	sec
Turn Rate @ M=20.8	11.4	deg/sec
Turn Rate @ M=1.2	8.2	deg/sec

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~~(S)~~ Figure 7.4-1 Configuration 401B with Aspect Ratio 3.0 Supercritical Wing Mission Performance Summary (U)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 Sec 3.3(b)(4)
1.4(a)(g) (b)(1)
E.O. 13526 Sec 3.3(b)(4)
Sec 1.4 (a)(g)

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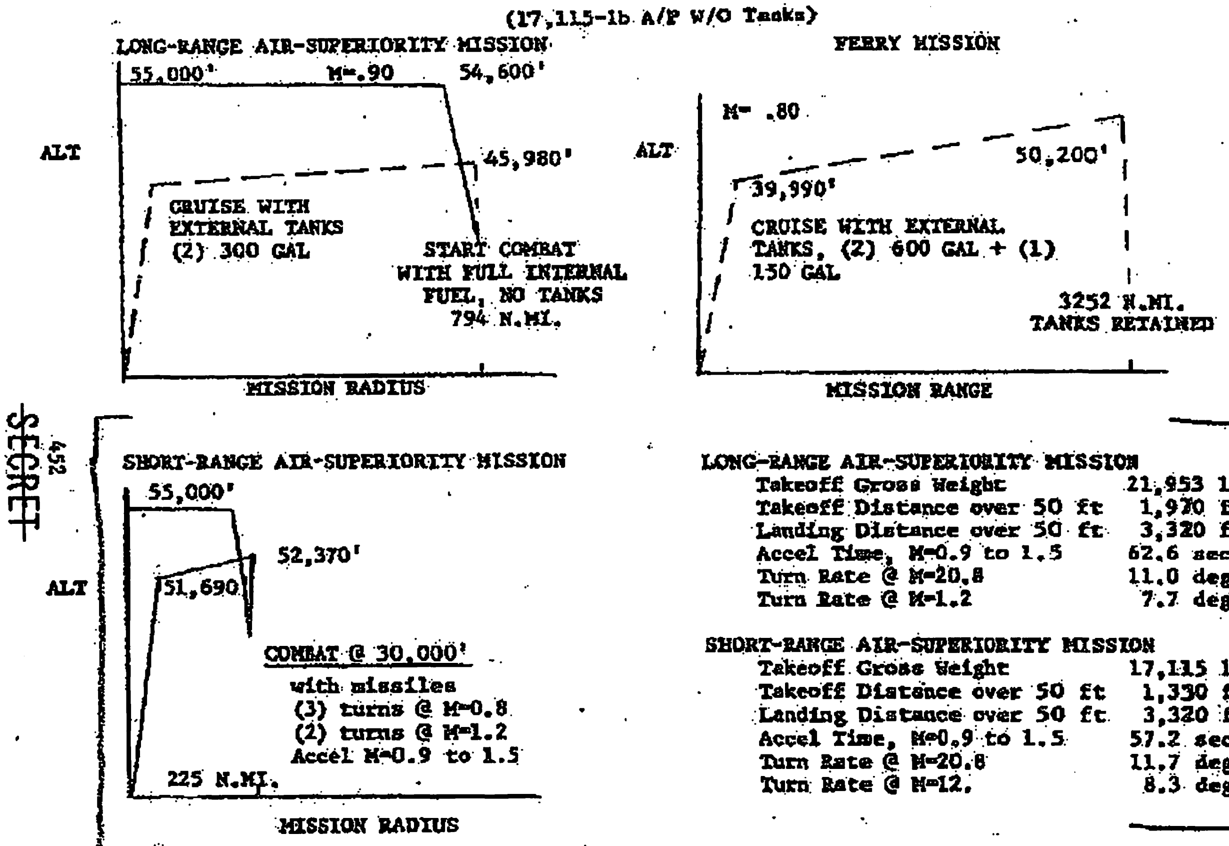

LONG-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	21,953 lb
Takeoff Distance over 50 ft	1,970 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	62.6 sec
Turn Rate @ M=20.8	11.0 deg/sec
Turn Rate @ M=1.2	7.7 deg/sec

SHORT-RANGE AIR-SUPERIORITY MISSION

Takeoff Gross Weight	17,115 lb
Takeoff Distance over 50 ft	1,330 ft
Landing Distance over 50 ft	3,320 ft
Accel Time, M=0.9 to 1.5	57.2 sec
Turn Rate @ M=20.8	11.7 deg/sec
Turn Rate @ M=12.	8.3 deg/sec

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~~(S)~~ Figure 7.4-2 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Mission Performance Summary (U)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3(b)(4)
1.4 (e)(g) SEC 3.3 (b)(4)
SEC 1.4(a)(g)

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3.(b)(4)
2 (a)(b)
EO 13526 SEC 3.3 (b)(4)
SEC 1.4(a)(2)
PGS 453-480

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~~(S)~~ Table 7.4-3 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL WING LRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial T_{REQ}	Initial TSFC	Initial L/D	Combat C_L	Combat g's
Initial Weight	0	0	21478								
Ground Operation				321	0	0					
	0	0	21157								
Accel to Climb Speed				241	0	.10					
	0.50	0	20916				2520	.875	7.42		
Climb to Cruise Alt.				511	42	.10					
	0.80	41463	20405				1923	.835	10.71		
Outbound Cruise				2397	723	1.59					
	0.80	43961	18008								
Drop Tanks				1368	0	0					
(847#Tank+521#Fuel)	0.80	43961	16640								
Combat				(2145)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		555	0	.02					
(2)M1.2 Turns	1.2	30000		910	0	.02				.432	4.88
(2)M0.8 Turns	0.8	30000		680	0	.03				.917	4.61
	0.90	30000	14495								
Drop Payload				348	0	0					
	0.90	30000	14147								
Drop ½ Ammo				143	0	0					
	0.90	30000	14004				2269	.887	5.89		
Climb to Cruise Alt.				166	32	.06					
	0.90	52517	13838				1275	.886	10.98		
Return Cruise				1520	735	1.42					
	0.90	55000	12318								
Descend				0	0	0					
	0.25	0	12318				1025	1.175	12.07		
Landing Reserves											
(20-Min.Loiter S.L.)				397	0	.33					
Zero-Fuel Weight			11921								

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88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3(b)(4)
1.4. (a)(g)

~~(S)~~ Table 7.4-4 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL WING SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (Ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat E s
Initial Weight	0	0	16640								
Ground Operation				232	0	0					
	0	0	16408								
Accel to Climb Speed				183	0	.10					
	0.50	0	16225				2039	.875	6.50		
Climb to Cruise Alt.				462	49	.11					
	0.90	50097	15763				1466	.872	10.81		
Outbound Cruise				432	176	.34					
	0.90	50312	15331								
Combat				(1970)		(.06)					
Accel M0.9-M1.5	0.9-1.5	30000		505	0	.01					
(2)M1.2 Turns	1.2	30000		845	0	.03				.431	5.28
(3)M0.8 Turns	0.8	30000		620	0	.02				.910	4.94
			13361								
Drop Payload				348	0	0					
	0.90	30000	13013								
Drop ½ Ammo				143	0	0					
	0.90	30000	12870				2253	.876	5.42		
Climb to Cruise Alt.				173	37	.07					
	0.90	55000	12697				1167	.885	10.93		
Return Cruise				379	188	.36					
	0.90	55000	12318								
Descend				0	0	0					
	0.25		12318				1025	1.175	12.07		
Landing Reserves (20 Min. Loiter S.L.)				379	0	.33					
Zero-Fuel Weight			11921								

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4 (a)(g)

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~~(S)~~ Table 7.4-5 CONFIGURATION 401B WITH ASPECT RATIO 3.0 SUPERCRITICAL WING FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Treq	Initial TSFC	Initial L/D	Combat C_L	Combat R S
Initial Weight	0	0	26825								
Ground Operation				387	0	0					
	0	0	26438								
Accel to Climb Speed				307	0	.11					
	0.50	0	26131				2845	.875	8.53		
Climb to Cruise Alt.				627	46	.11					
	0.80	37424	25504				2485	.825	10.37		
Cruise w/(2)Ext.Tanks				10612	3025	6.60					
	0.80	48576	14892								
Descend				0	0	0					
	0.20	0	14892				1315	.973	9.98		
Landing Reserves				(1138)							
(20Min.Loiter S.L.)				484							
(5% Initial Fuel)				654							
Zero-Fuel Weight			13754								

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88th ABW/IPI
FOIA (b)(1)
~~E.O. 13526 SEC. 3.3 (b)(4)~~
1.4. (a)(g)

SECRET

~~(S)~~ Table 7.4-6 CONFIGURATION 401B WITH ASPECT RATIO 3.75 SUPERCRITICAL WING LRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat CL	Combat g's
Initial Weight	0	0	21953								
Ground Operation				327	0	0					
	0	0	21626								
Accel to Climb Speed				247	0	.10					
	0.50	0	21379				2513	0.875	7.65		
Climb to Cruise Alt.				551	48	.11					
	0.80	43499	20828				1794	0.839	11.73		
Outbound Cruise				2315	746	1.44					
	0.80	45980	18513								
Drop Tanks				1398	0	0					
(847#Tank+521#Fuel)	0.80	45980	17115								
Combat				(2179)		(.08)					
Accel M0.9-M1.5	0.9-1.5	30000		635	0	.02					
(2)M1.2 Turns	1.2	30000		895	0	.03				.441	4.97
(2)M0.8 Turns	0.8	30000		649	0	.03				.949	4.75
	0.90	30000	14936								
Drop Payload				348	0	0					
	0.90	30000	14588								
Drop ½ Ammo				143	0	0					
	0.90	30000	14445				2305	0.887	6.00		
Climb to Cruise Alt.				193	40	.08					
	0.90	54606	14252				1198	0.892	11.99		
Return Cruise				1482	754	0					
	0.90	55000	12770								
Descend				0	0	0					
	0.24	0	12770				949	1.213	13.51		
Landing Reserves (20-Min. Loiter S.L.)				379	0	.33					
Zero-Fuel Weight			12391								

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SECRET

~~(S)~~ Table 7.4-7 CONFIGURATION 401B WITH ASPECT RATIO 3.75
SUPERCRITICAL WING SRASM MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial TREQ	Initial TSFC	Initial L/D	Combat C_L	Combat g's
Initial Weight	0	0	17115								
Ground Operation				238	0	0					
	0	0	16877								
Accel to Climb Speed				188	0	.10					
	0.50	0	16689				2054	0.875	6.72		
Climb to Cruise Alt.				493	55	.12					
	0.90	51687	16196				1387	0.878	11.81		
Outbound Cruise				396	170	.33					
	0.90	52372	15800								
Combat				(2004)		(.07)					
Accel M0.9-M1.5	0.9-1.5	30000		580	0	.02					
(2)M1.2 Turns	1.2	30000		825	0	.02				.440	5.38
(3)M0.8 Turns	0.8	30000		599	0	.03				.929	5.04
			13796								
Drop Payload				348	0	0					
	0.90	30000	13448								
Drop ½ Ammo				143	0	0					
	0.90	30000	13305				2296	0.887	5.53		
Climb to Cruise Alt.				175	37	.07					
	0.90	55000	13130				1107	0.899	11.90		
Return Cruise				360	188	.36					
	0.90	55000	12770				949	1.213	13.51		
Descend				0	0	0					
	0.24	0	12770								
Landing Reserves (20 Min. Loiter S.L.)				379	0	.33					
Zero-Fuel Weight			12391								

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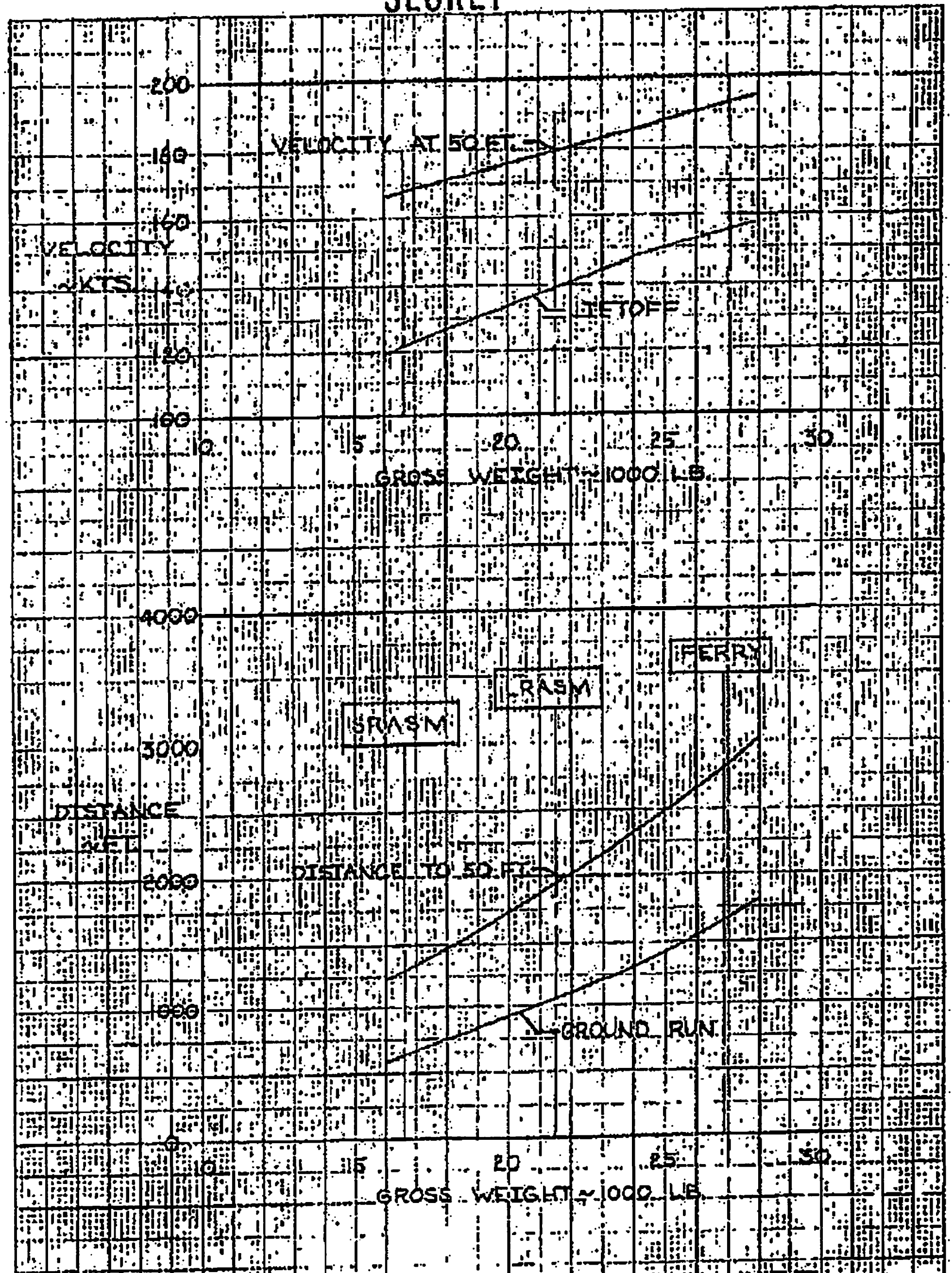
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

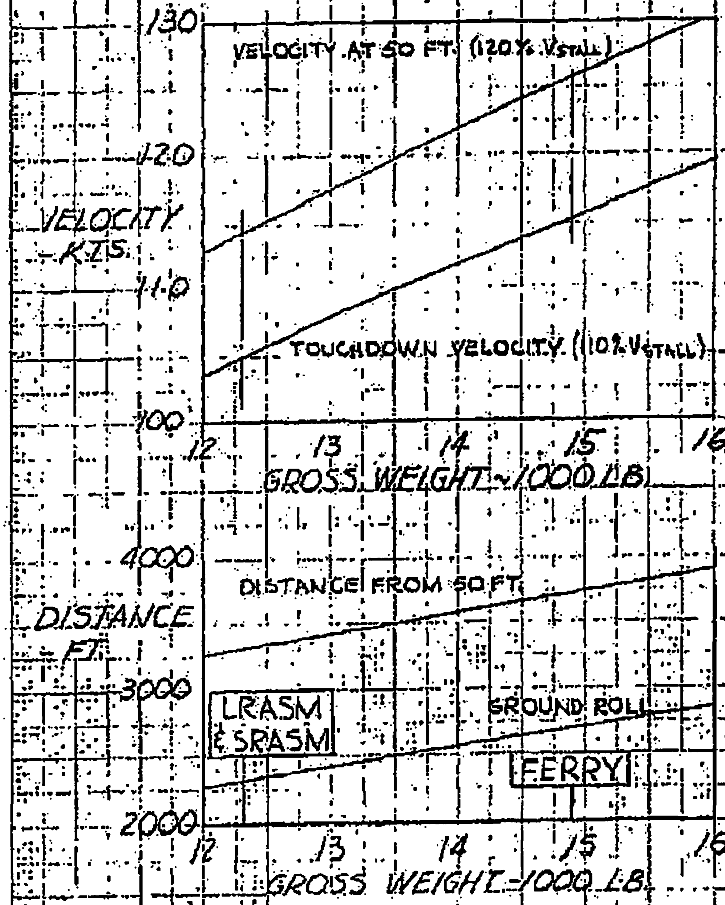
~~(S)~~ Table 7.4-8 CONFIGURATION 401B WITH ASPECT RATIO 3.75 SUPERCRITICAL WING FERRY MISSION TABULATION (U)

Mission Phase	Mach No.	Alt. (ft)	Weight (lb)	Weight (lb)	Dist. (n.mi)	Time (hr)	Initial Treq	Initial TSFC	Initial L/D	Combat C_L	Combat [illegible]
Initial Weight	0	0	27300								
Ground Operation				392	0	0					
	0	0	26908								
Accel to Climb Speed				312	0	.11					
	0.50	0	26596				2827	0.875	9.02		
Climb to Cruise Alt.				678	55	.13					
	0.80	39985	25918				2292	0.828	11.28		
Cruise w/(2)Ext.Tanks				10570	3197	6.97					
	0.80	50201	15348								
Descend				0	0	6					
	0.26	0	15348				1301	1.095	11.85		
Landing Reserves				(1124)							
(20Min.Loiter S.L.)				470							
(5% Initial Fuel)				654							
Zero-Fuel Weight			14224								

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

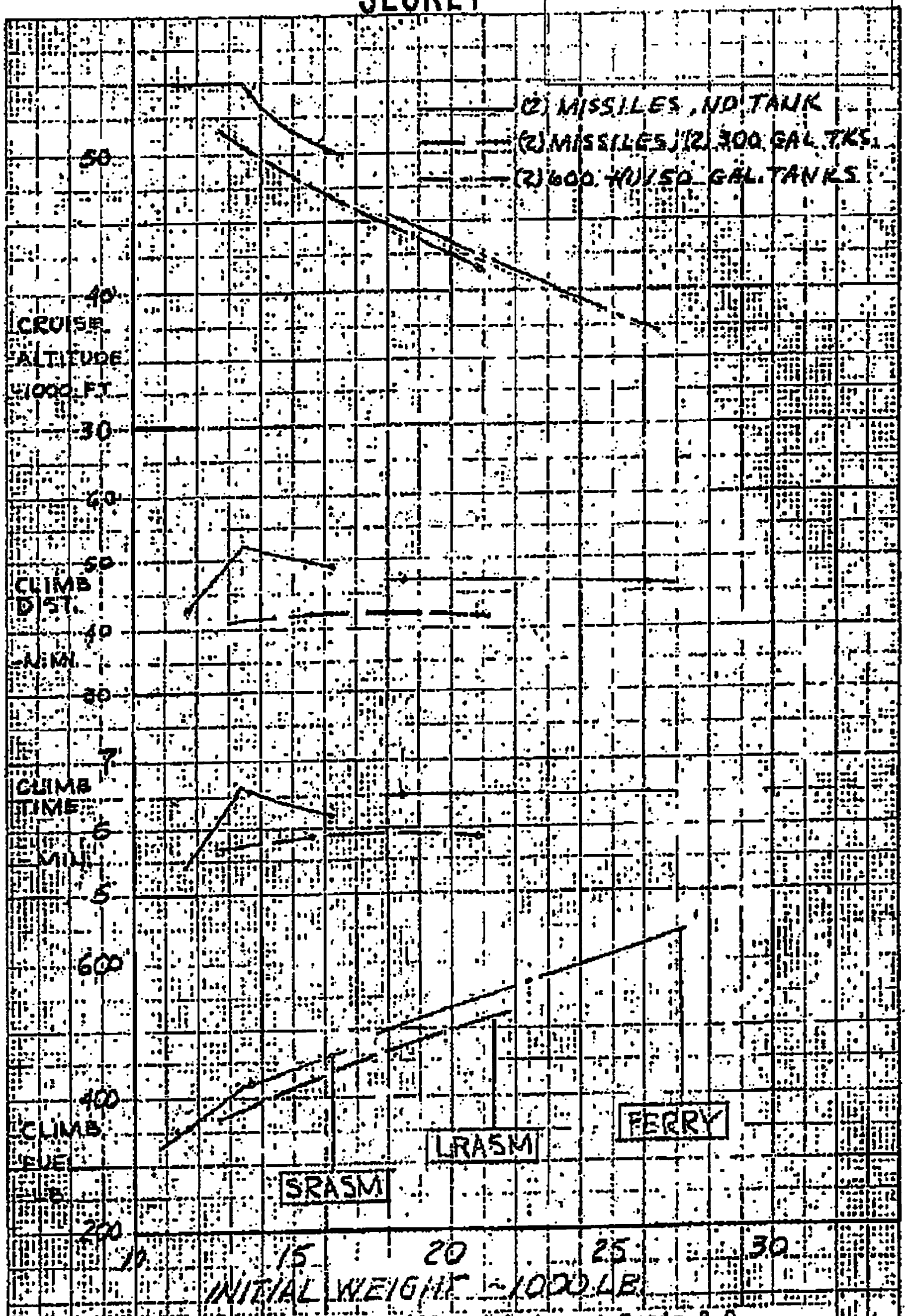


(S) Figure 7.4-3 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Takeoff Performance (U)



~~(S)~~ Figure 7.4-4 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Landing Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-5 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Initial Climb Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

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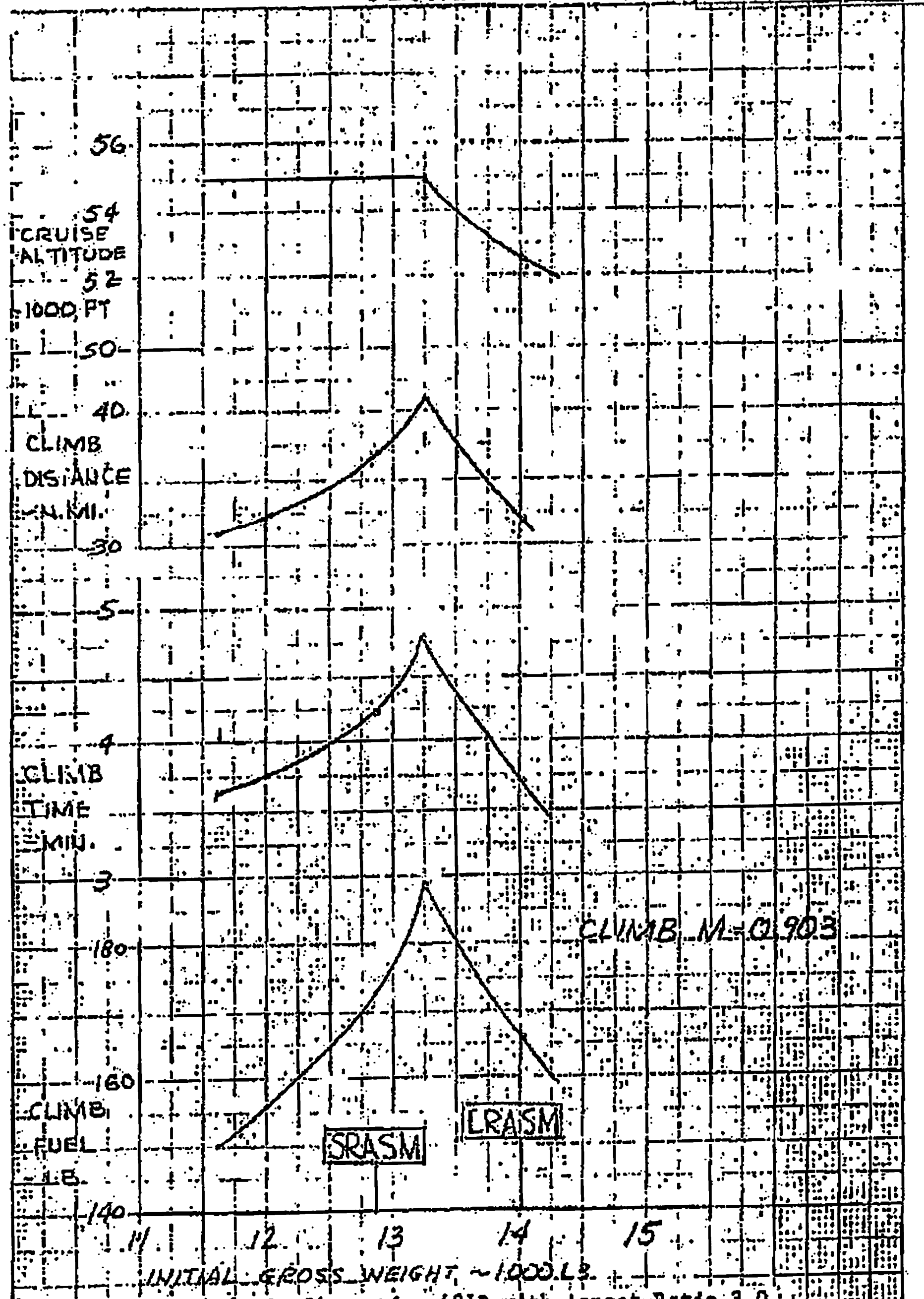

~~(S)~~ Figure 7.4-6 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Climb After Combat (U)

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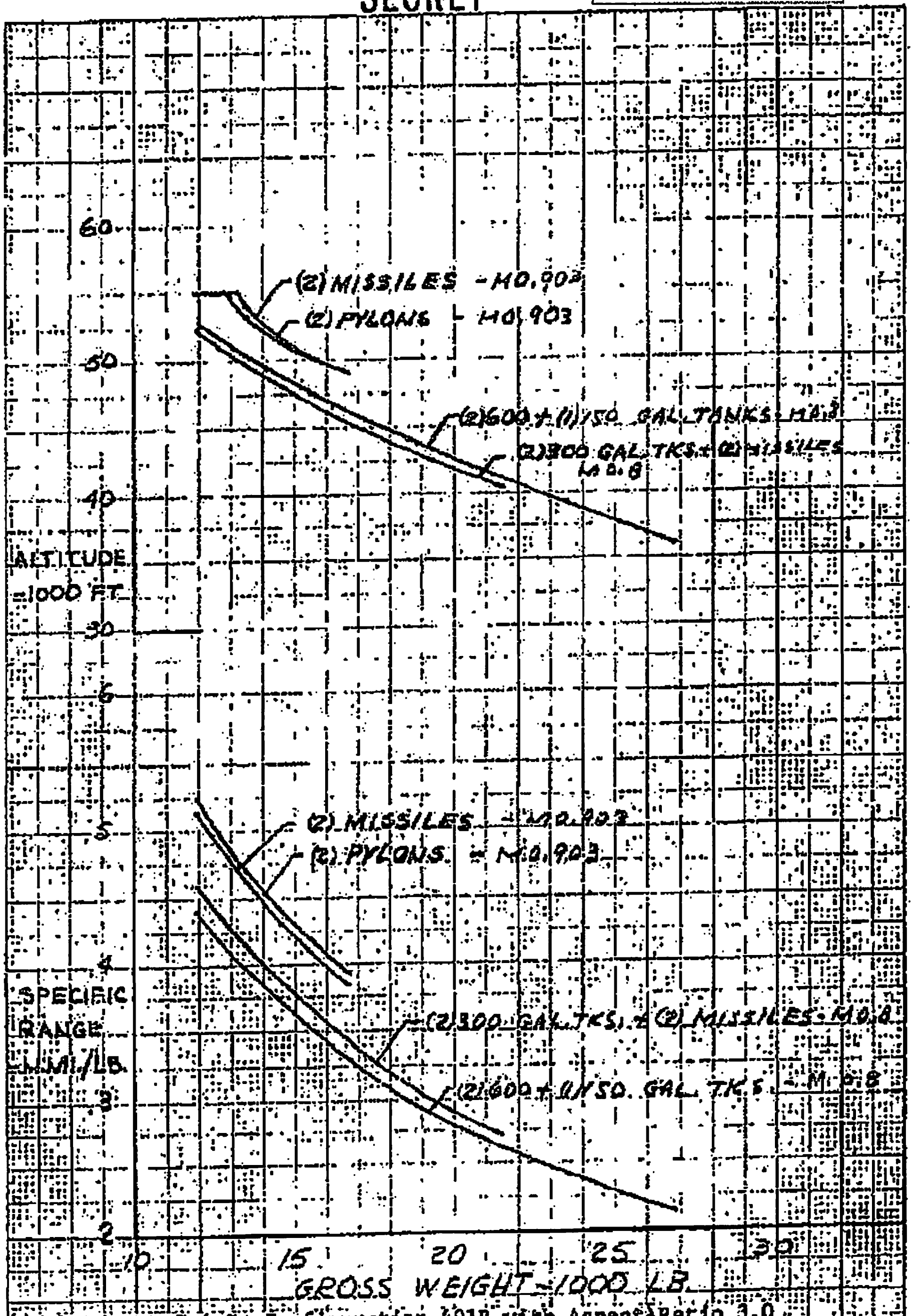
88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~SECRET~~

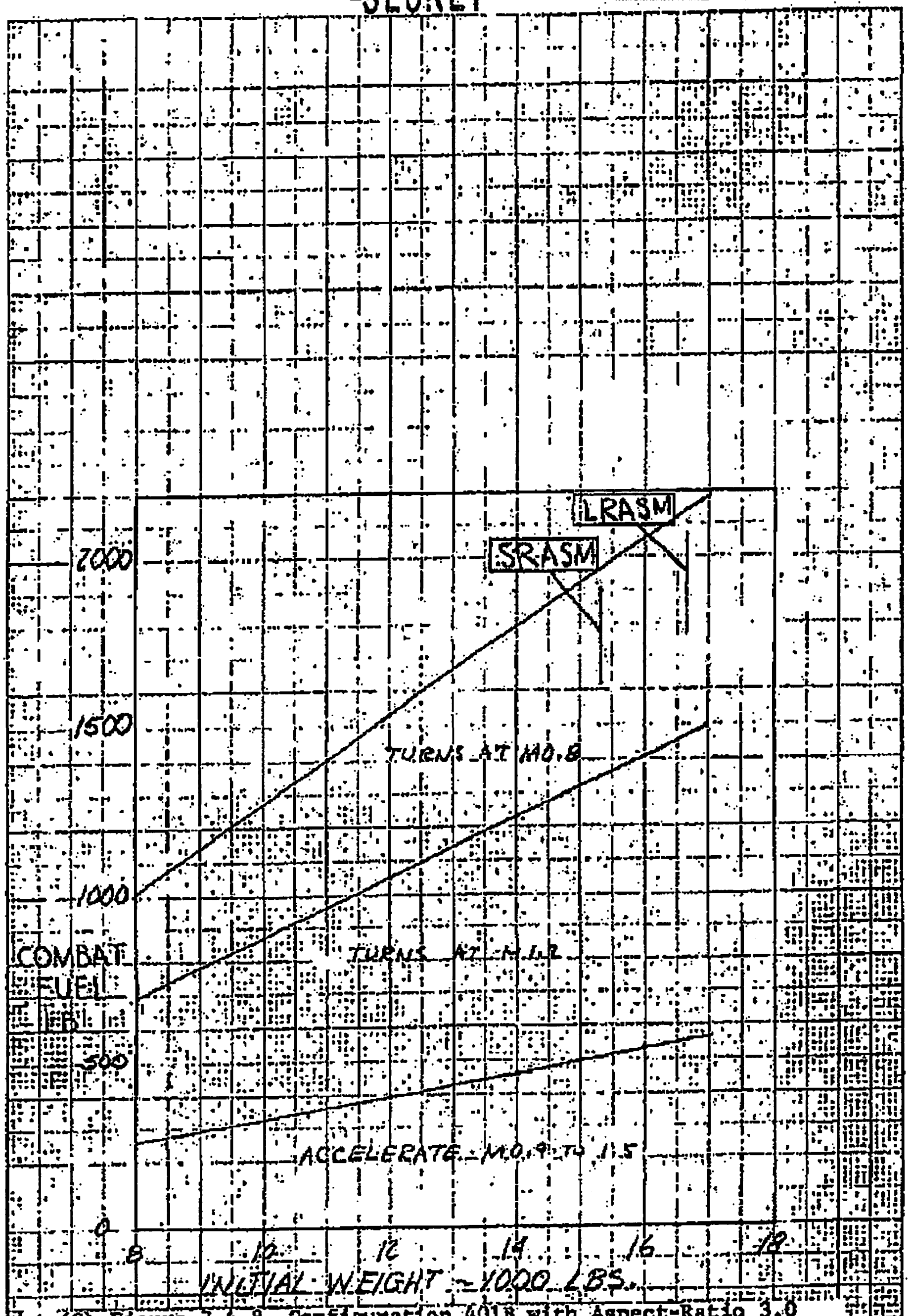


~~(S)~~ Figure 7.4-7 Configuration 401B with Aspect Ratio 3.0 Supercritical Wing Cruise Performance (U)

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 7.4-8 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Combat Fuel Allowance (U)

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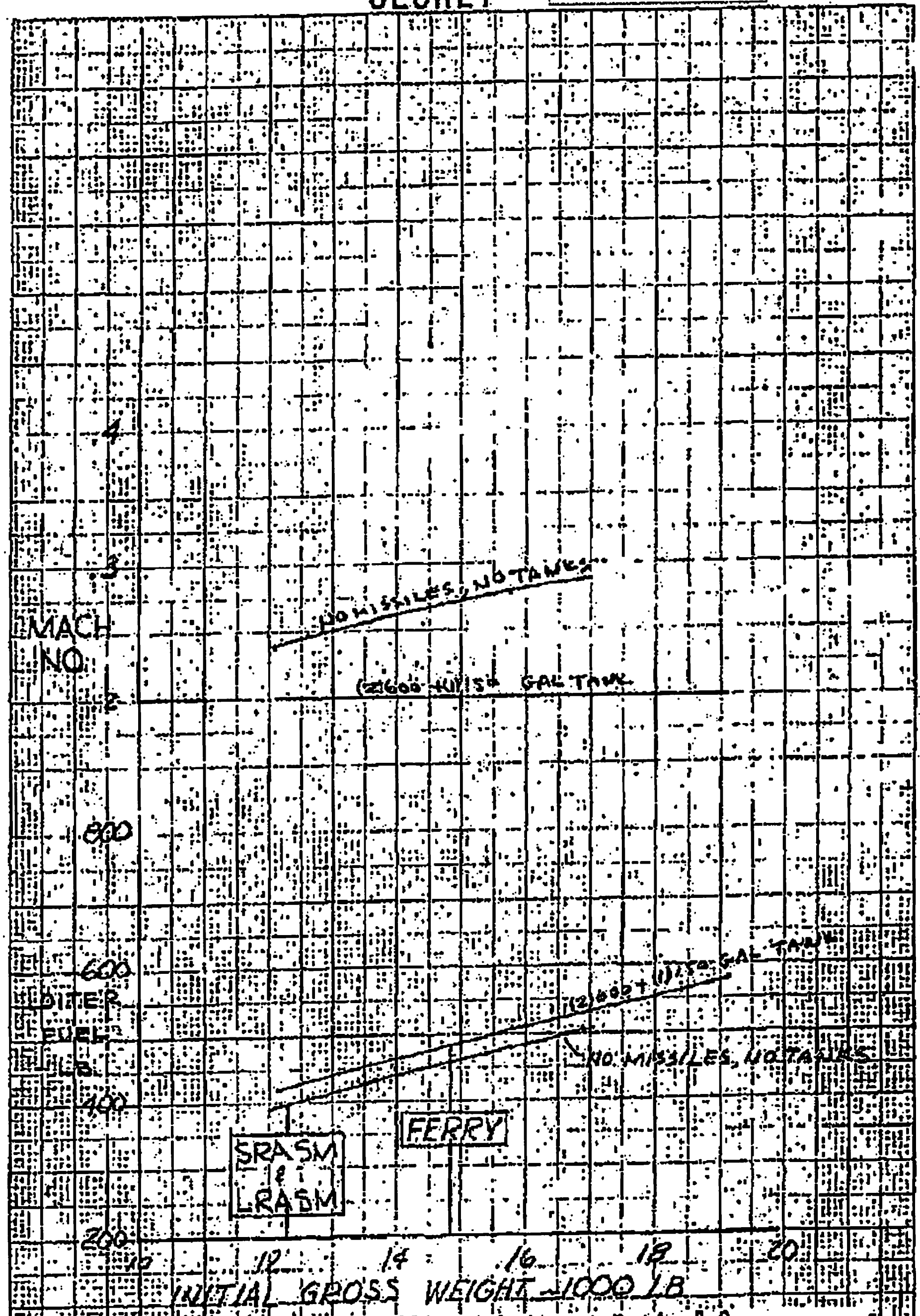
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 7.4-9 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Sea-Level Loiter Performance (U)

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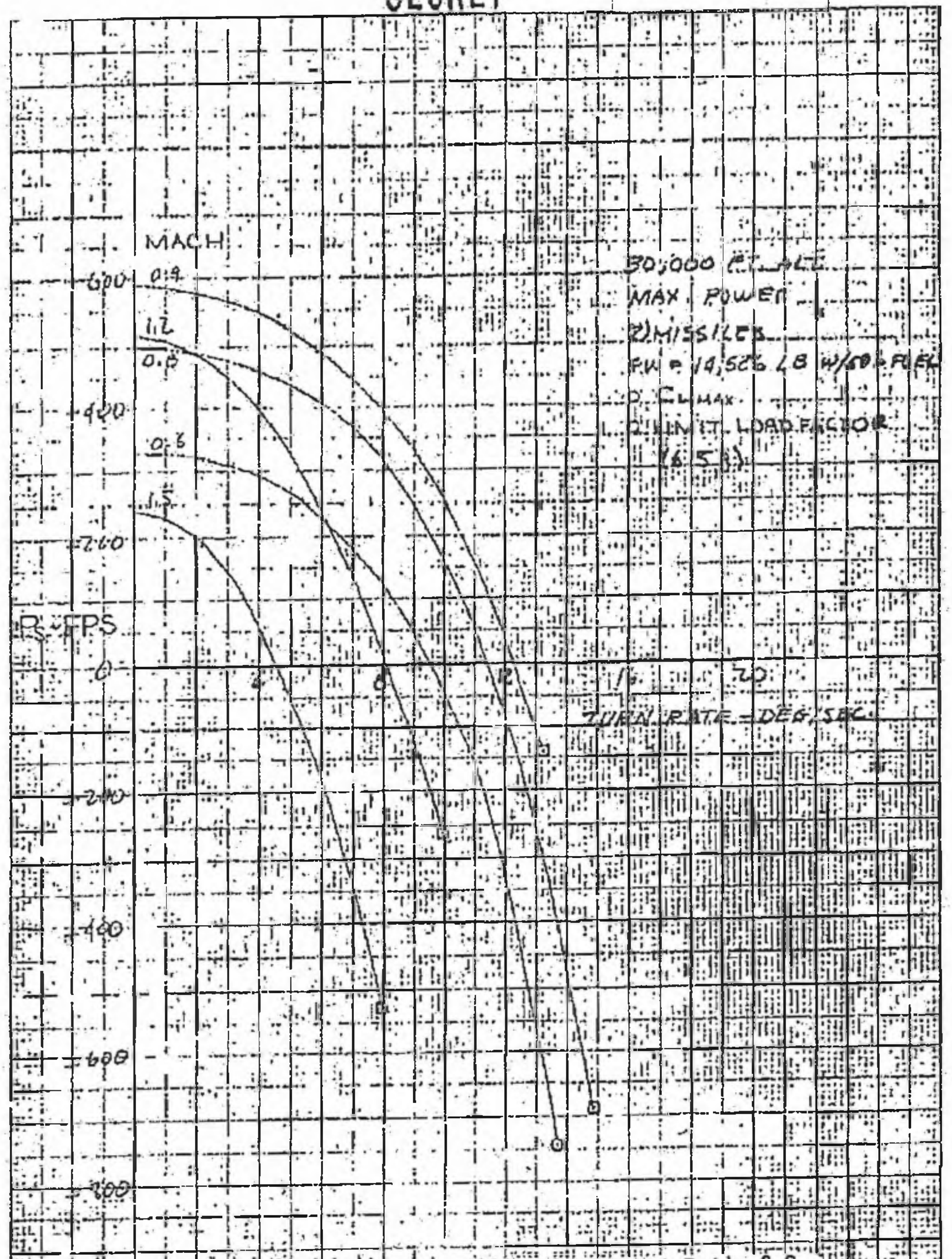
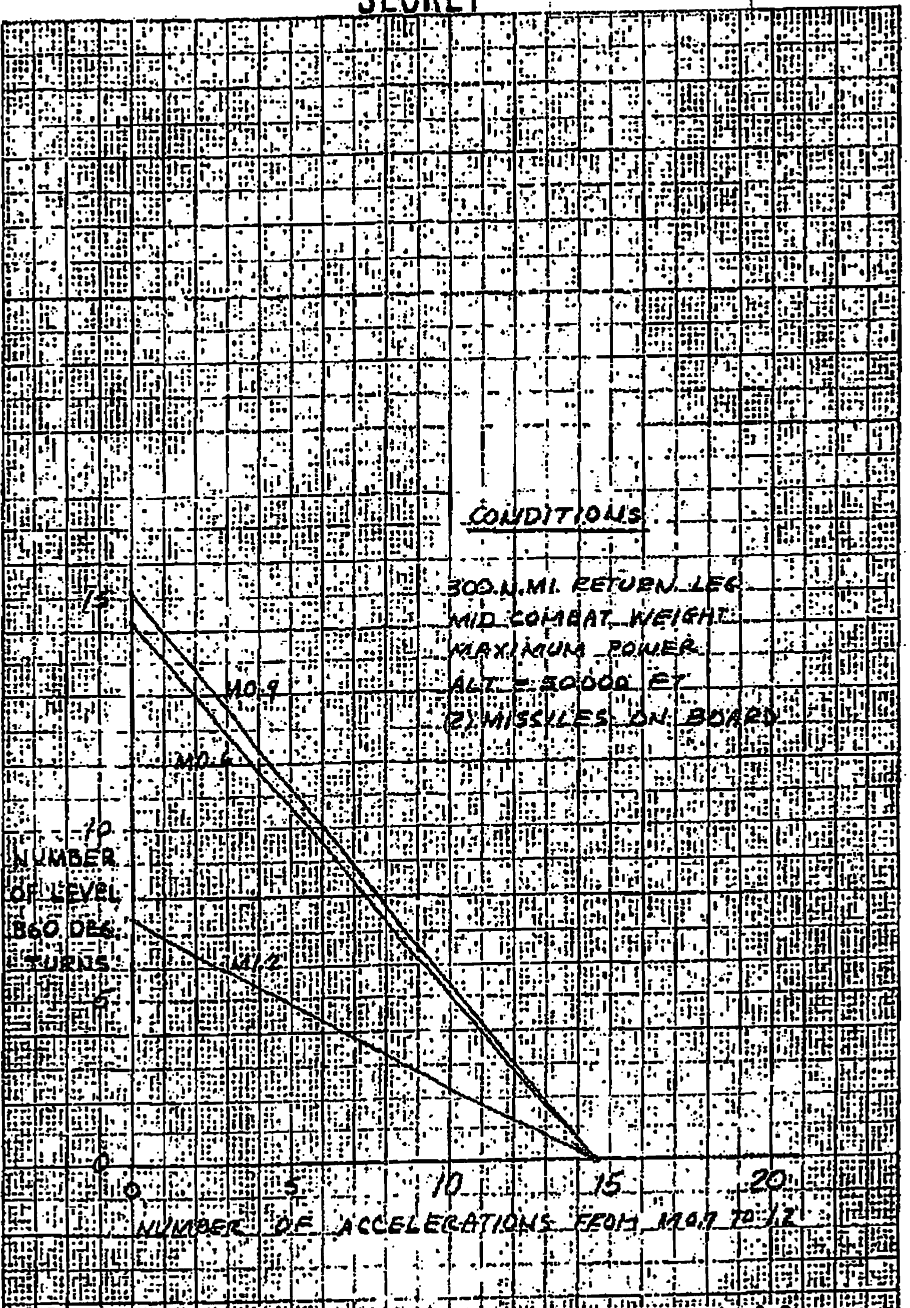


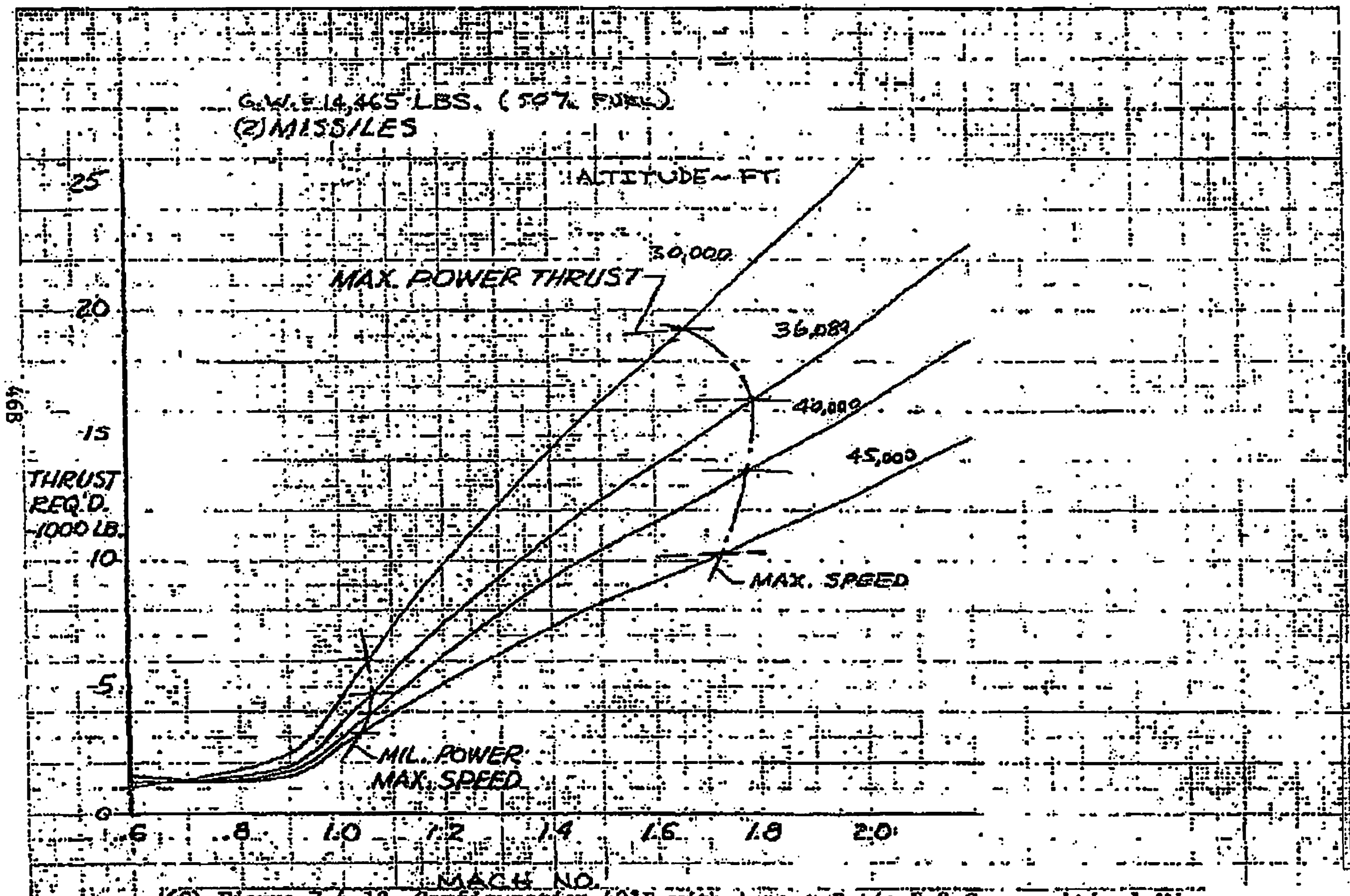
~~(S)~~ Figure 7.4-10 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Turning Performance (U)



(S) Figure 7.4-11 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Persistence Plot (U)

88th ABW/IP
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 7.4-12 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Thrust Required (U)

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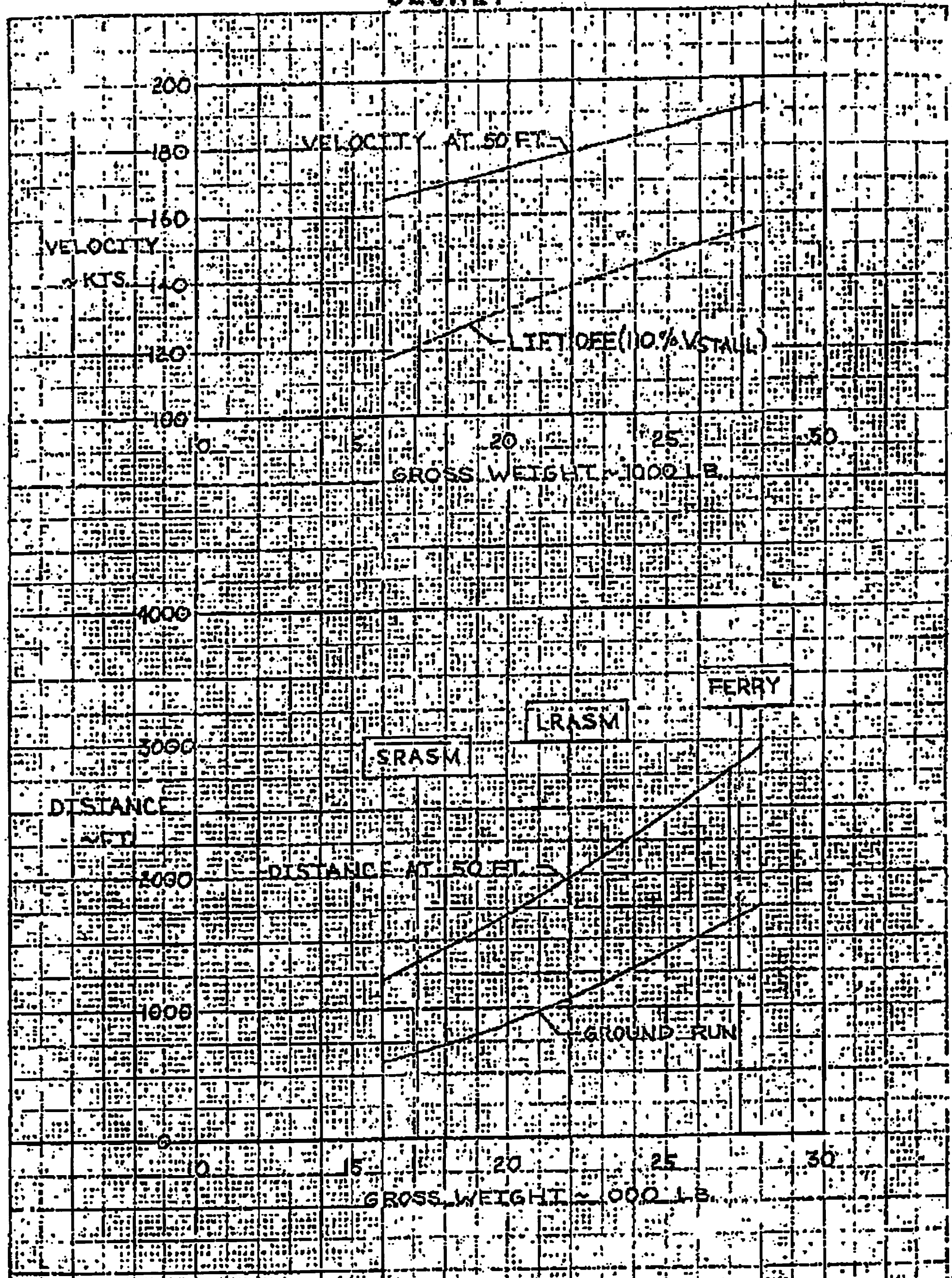
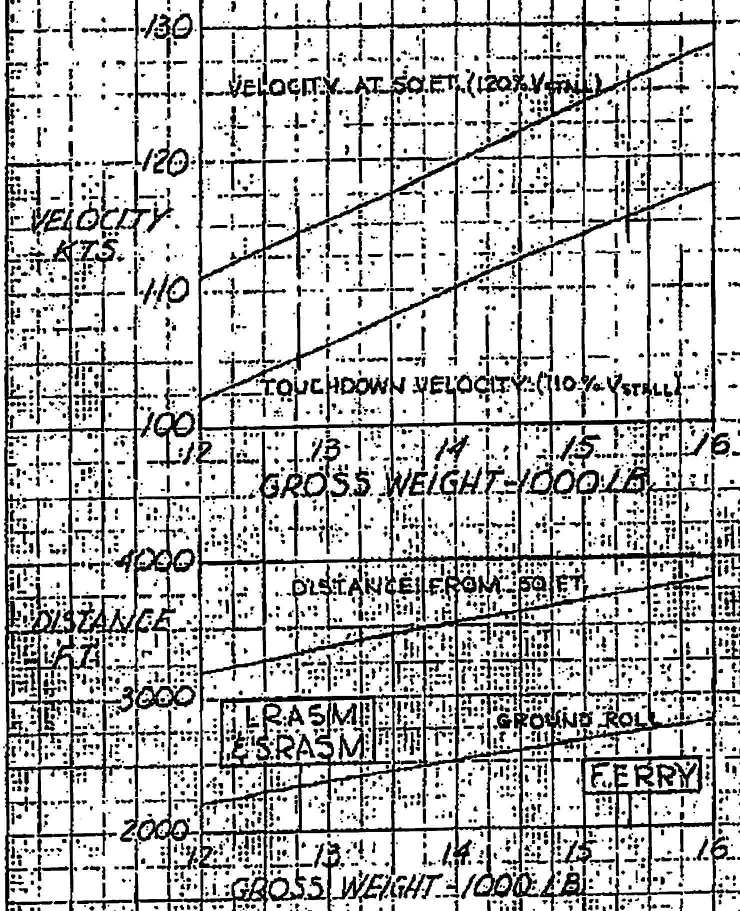
88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



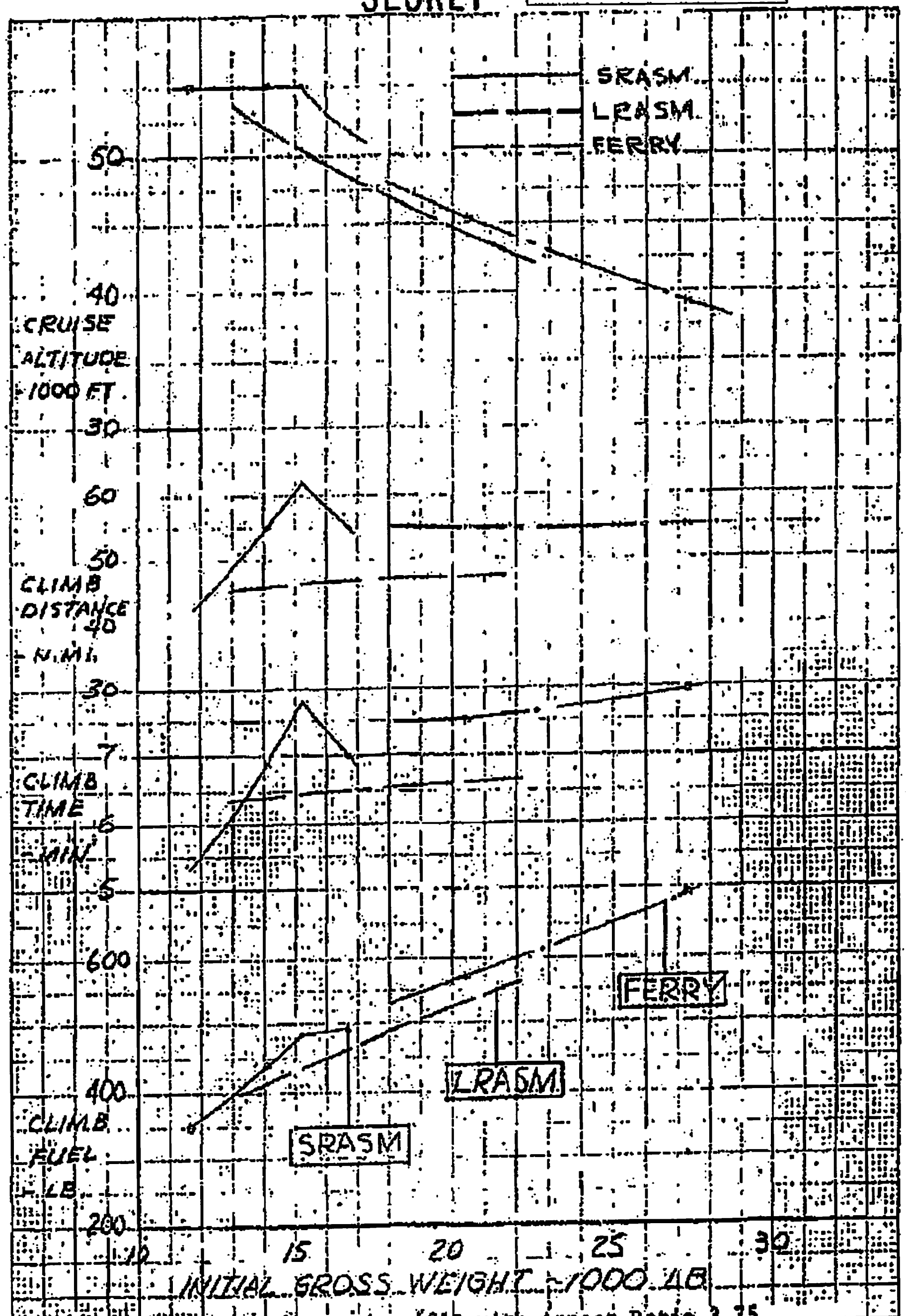
~~(S)~~ Figure 7.4-13 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Takeoff Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



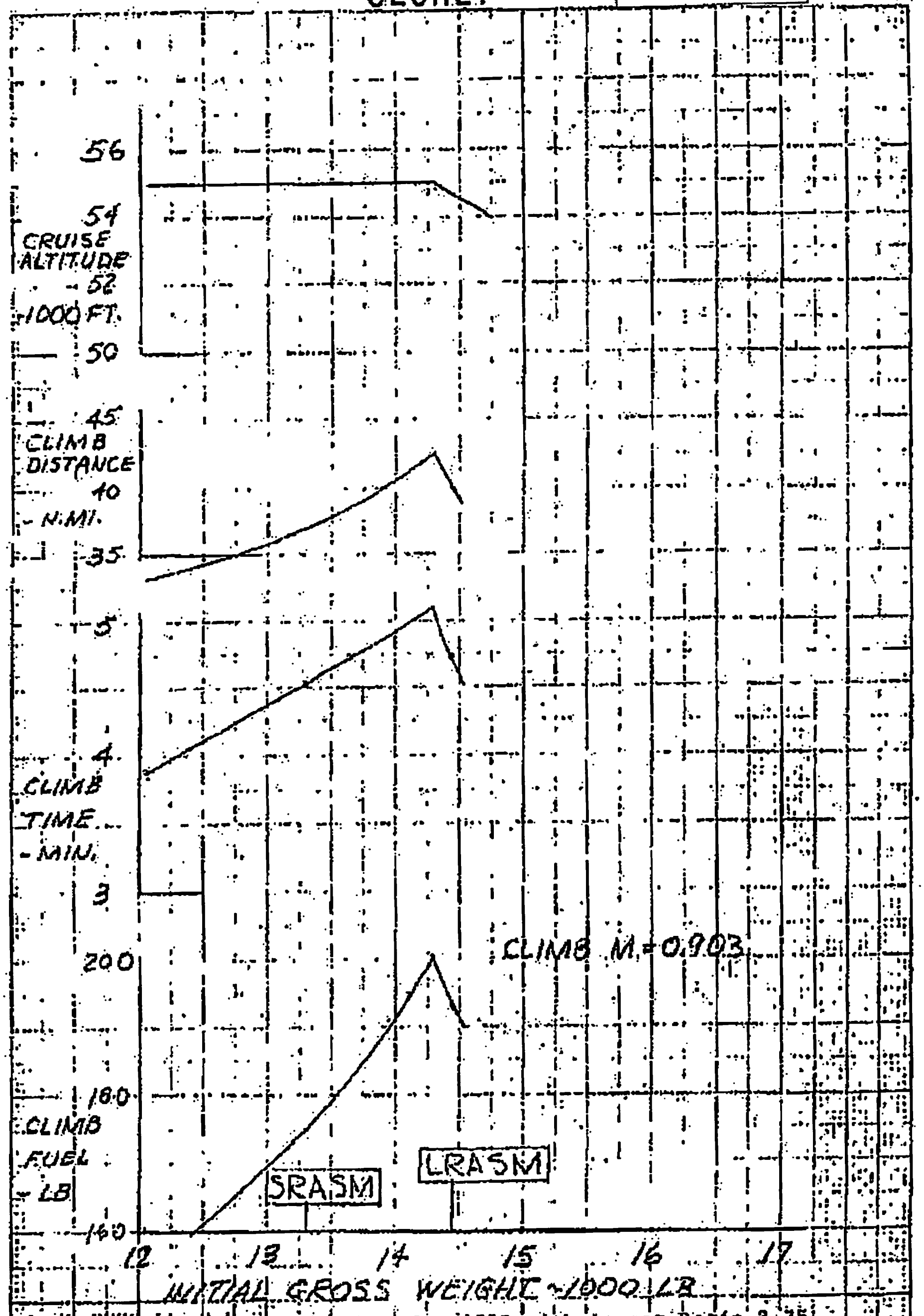
~~(S)~~ Figure 7.4-14 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Landing Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

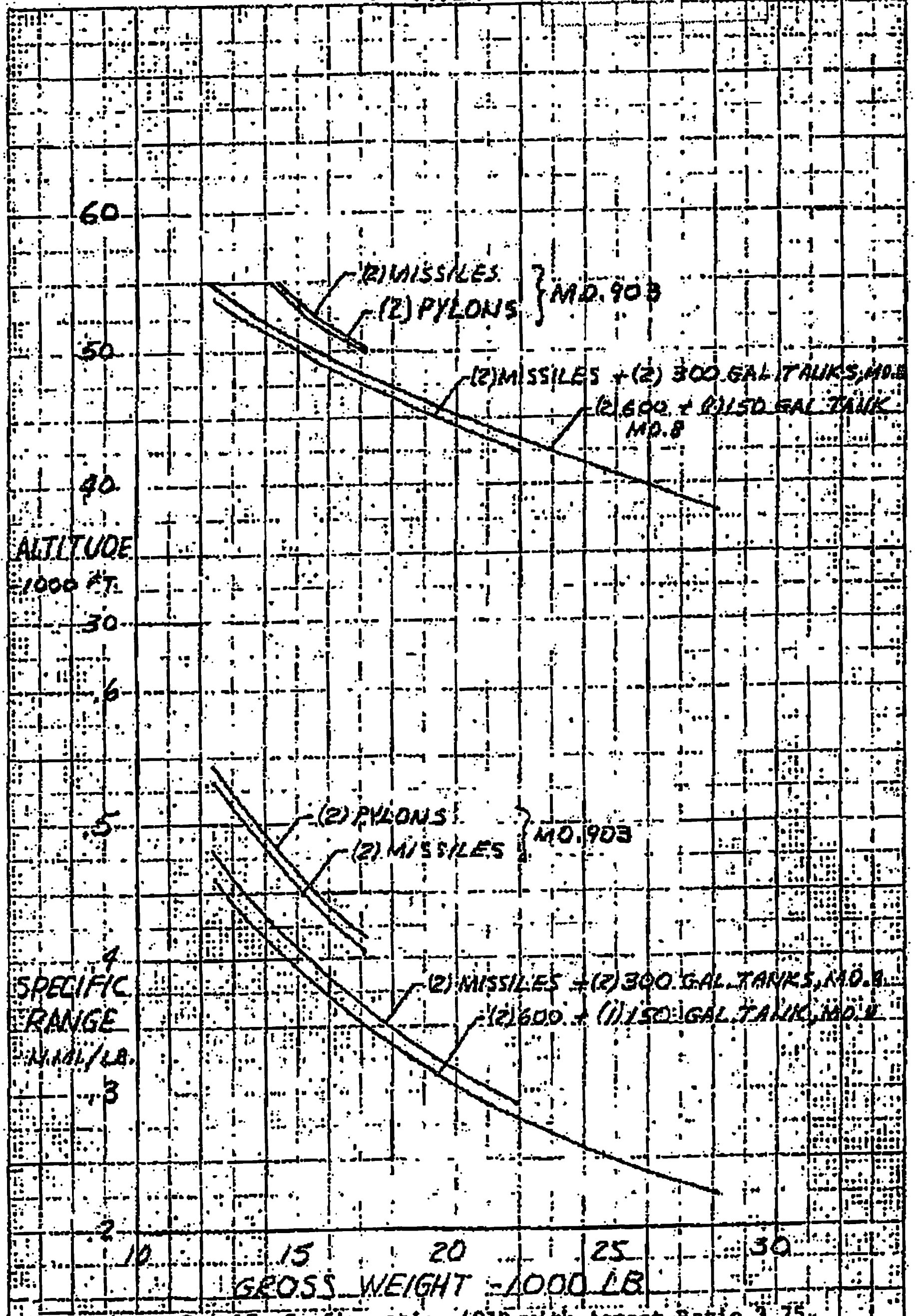


~~(S)~~ Figure 7.4-15 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Initial Climb Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

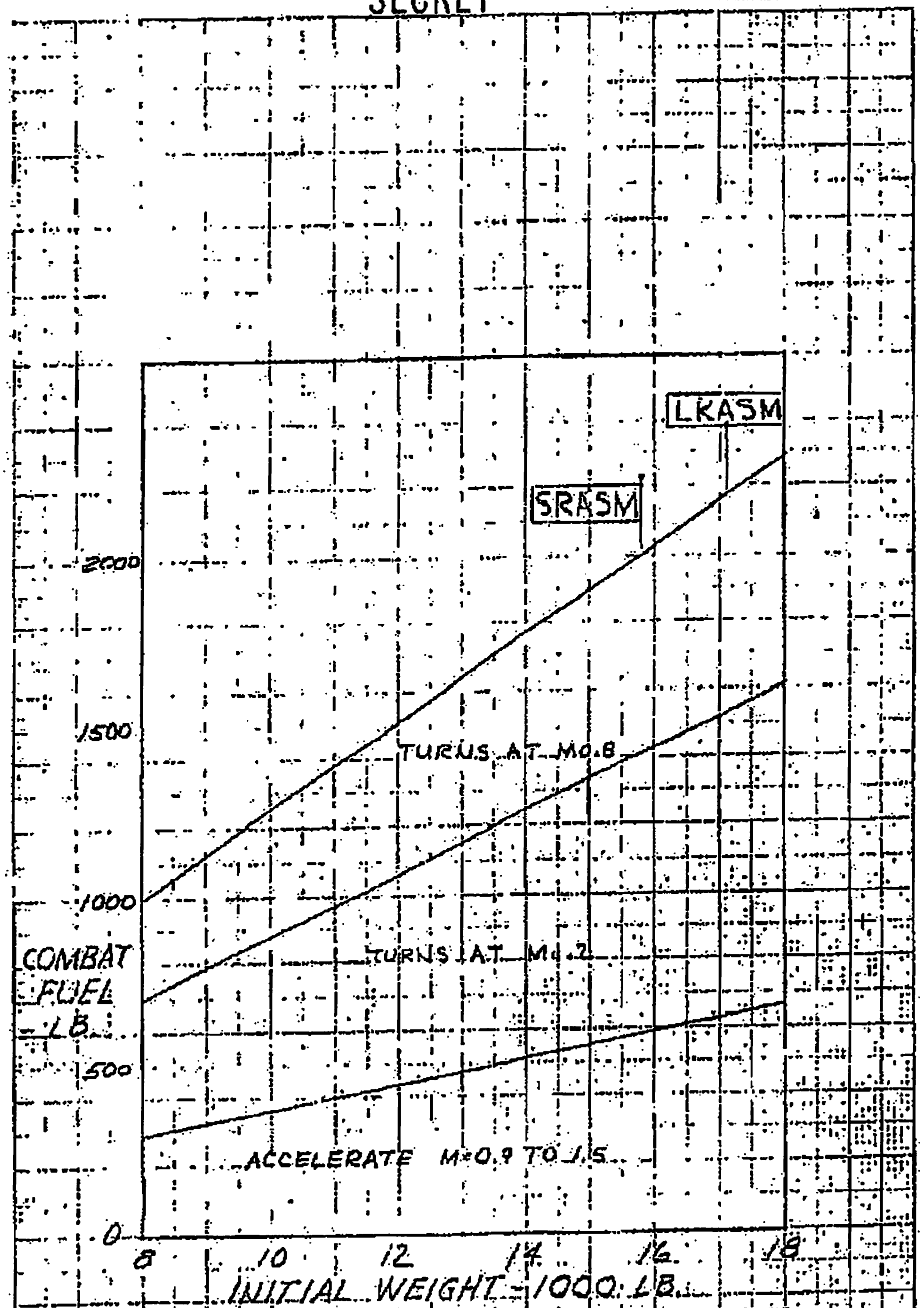


~~(S)~~ Figure 7.4-16 Configuration 4018 with Aspect-Ratio 3.75 Supercritical Wing Climb After Combat (U)



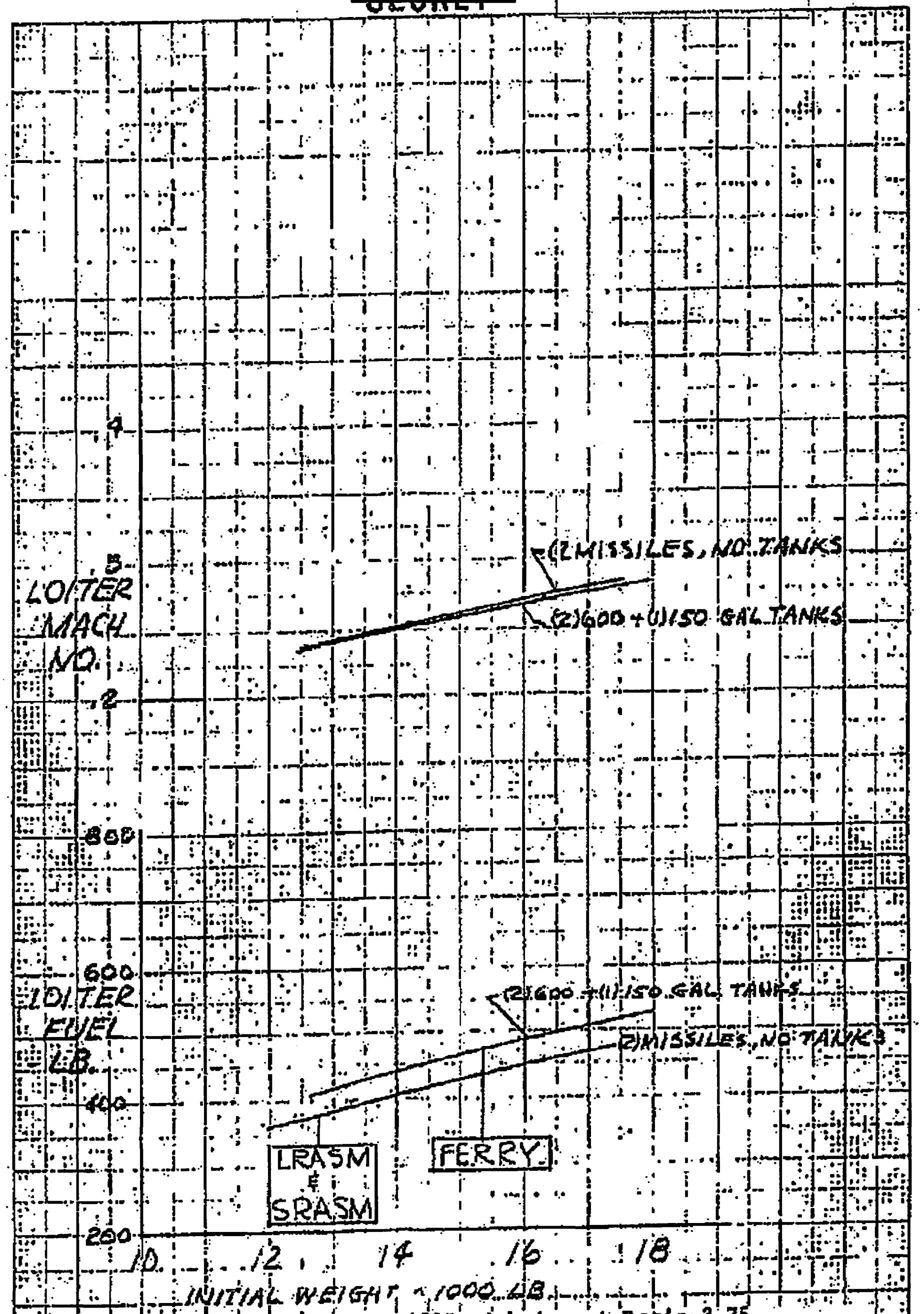
(S) Figure 7.4-17 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Cruise Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-18 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Combat Fuel Allowance (U)

88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC. 3.3.~~
(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-19 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Sea-Level Loiter Performance (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

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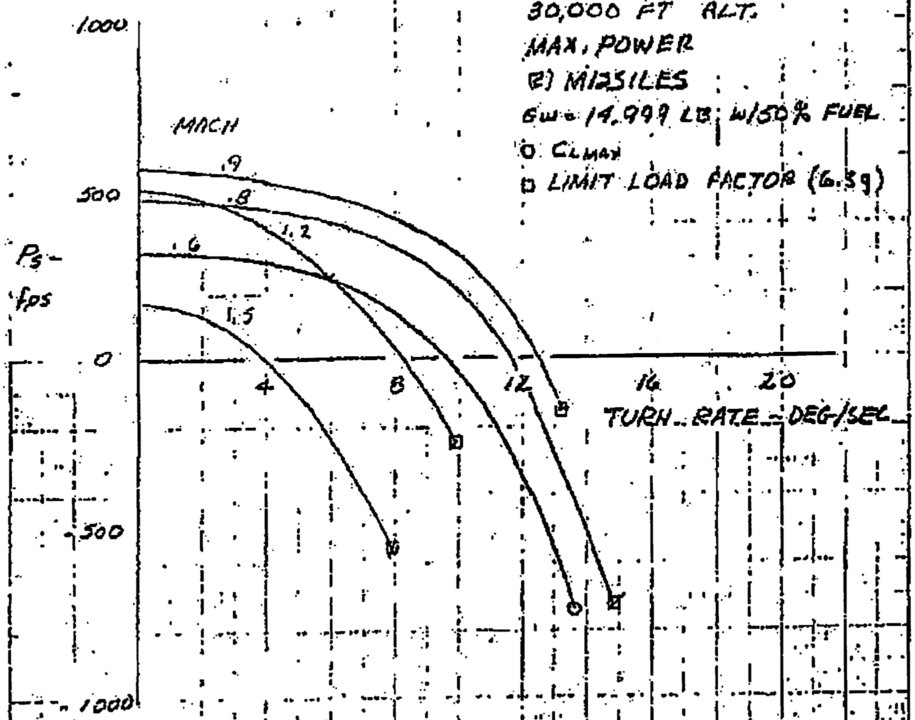
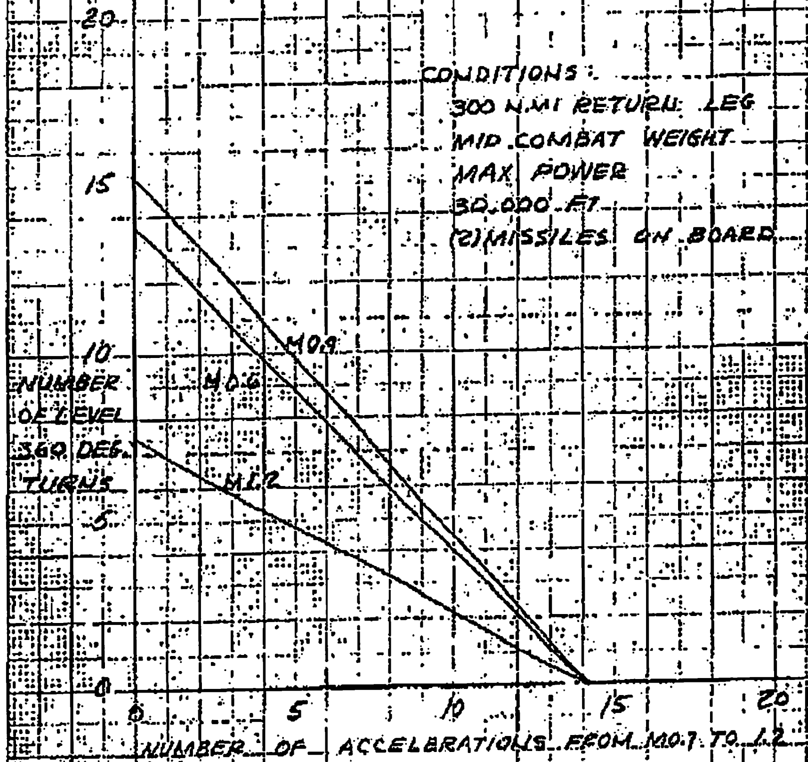


~~(S)~~ Figure 7.4-20 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Turning Performance (U)

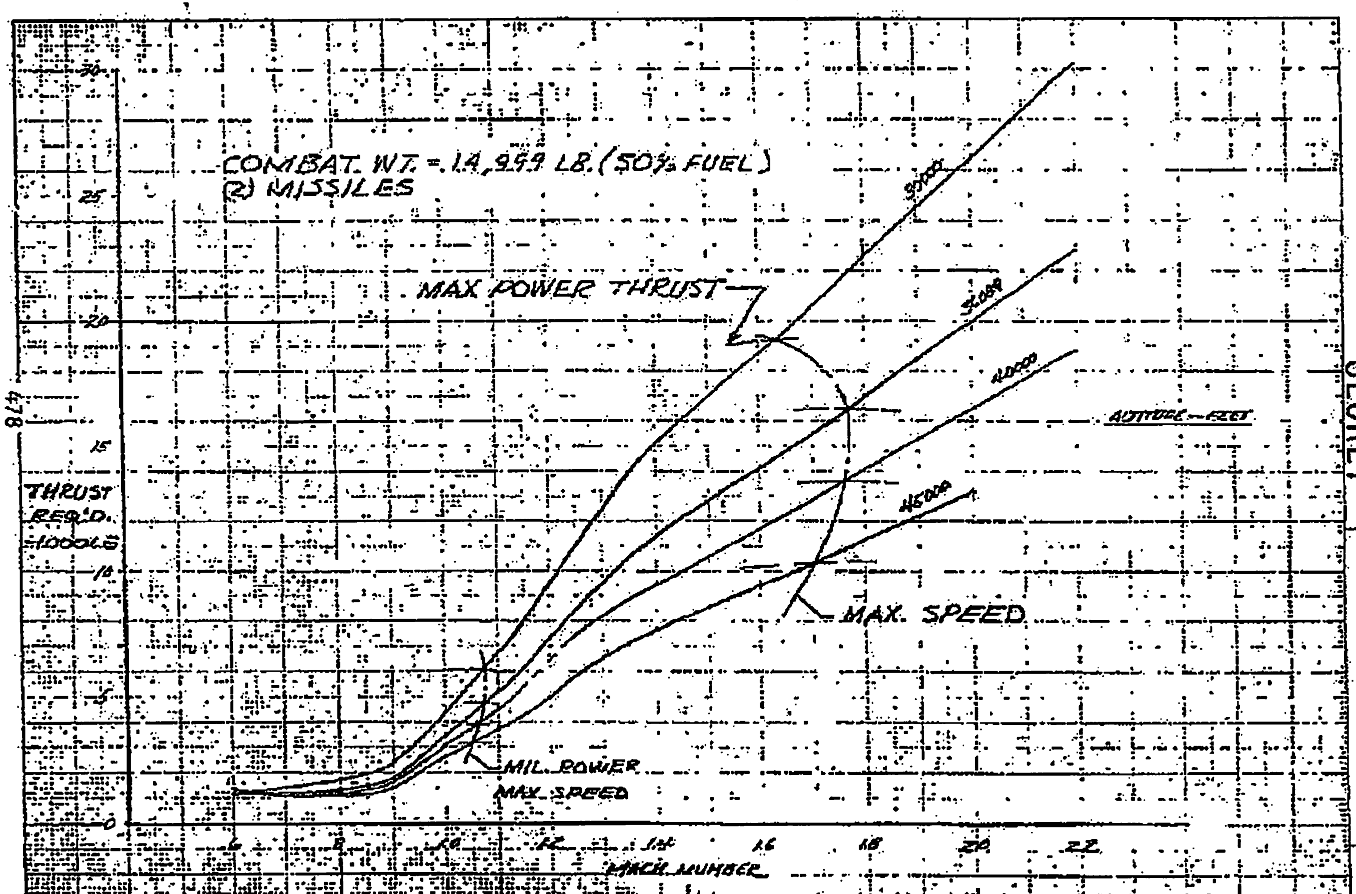
~~SECRET~~



~~(S)~~ Figure 7.4-21 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Persistence Plot (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

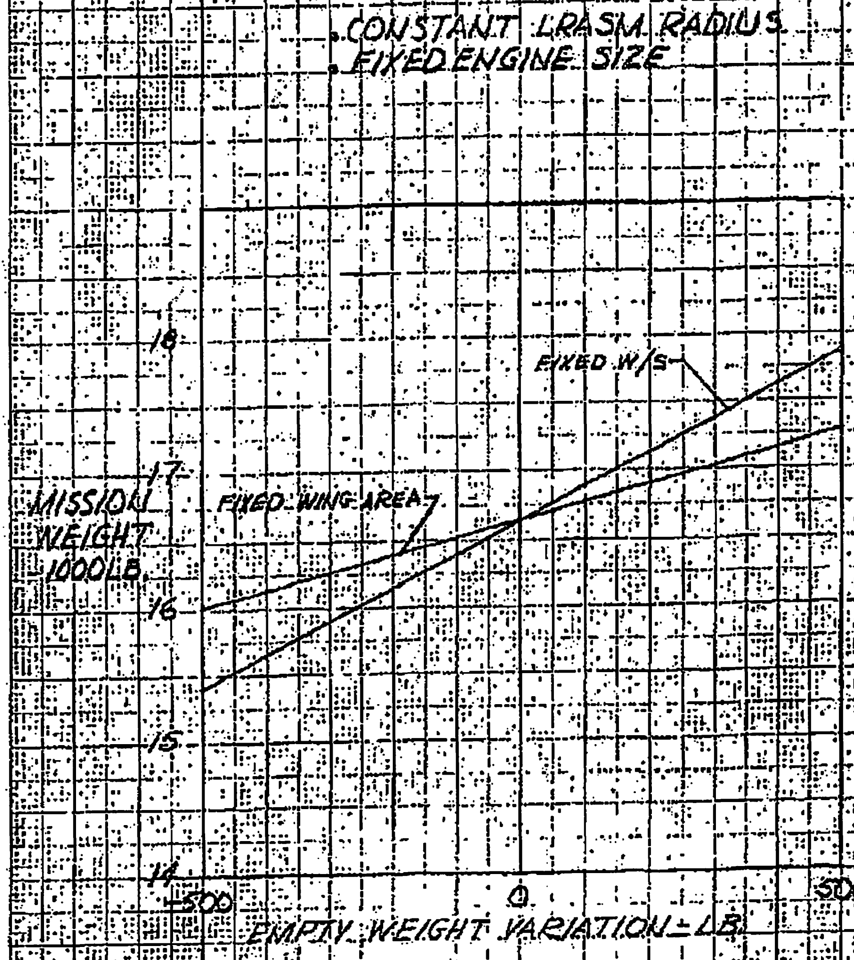
~~SECRET~~



~~(S)~~ Figure 7.4-22 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Thrust Required (U)

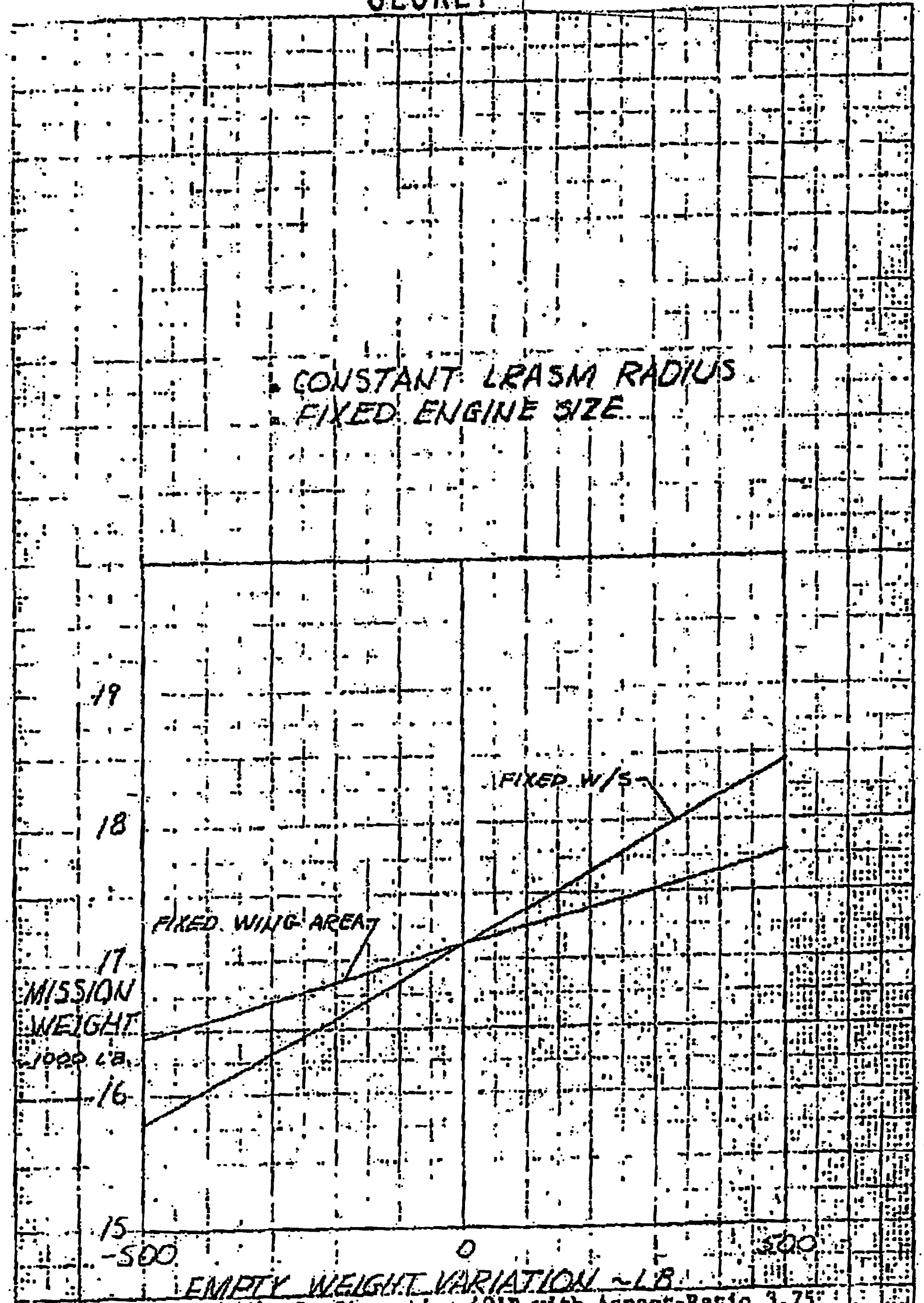
~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC 3.3 (b)(4)
1.4. (a)(g)



~~(S)~~ Figure 7.4-23 Configuration 401B with Aspect-Ratio 3.0 Supercritical Wing Sensitivity to Weight-Empty Variation (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

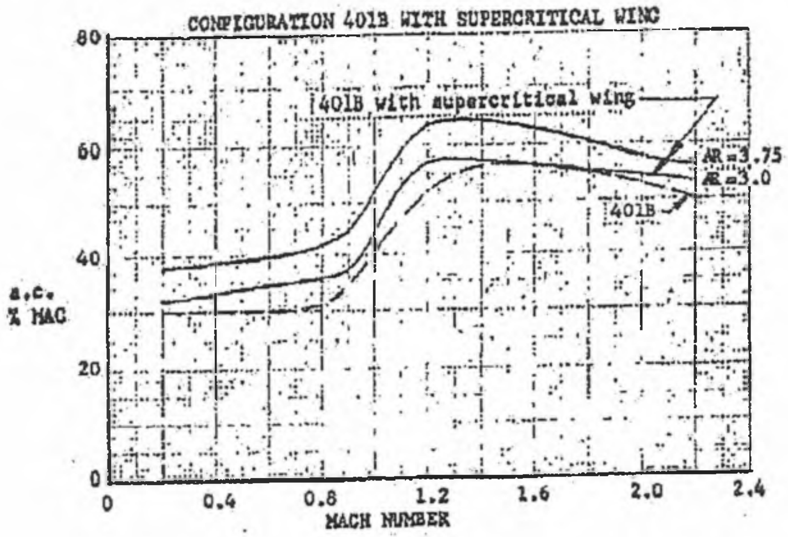


~~(S)~~ Figure 7.4-24 Configuration 401B with Aspect-Ratio 3.75 Supercritical Wing Sensitivity to Weight-Empty Variation (U)

7.5 STABILITY AND CONTROL

(U) Other than an evaluation of the aerodynamic-center location, since there had been an alteration of wing-sweep angle and aspect ratio, no attempt was made to establish specific stability and control characteristics for the supercritical wing study. The variation of aerodynamic-center location with Mach number is presented in Figure 7.5-1 for the point design airplanes. Also shown in this figure for comparative purposes is the predicted aerodynamic-center location for the basic 401B configuration.

(U) With the exception of the aerodynamic-center location noted above, the basic stability and control parameters for the selected supercritical wing point-design configurations are similar to those presented in Section 3.4 for the 401B configuration.



(U) Figure 7.5-1 Aerodynamic Center Location for Supercritical Point-Design Configurations

7.6 STRUCTURES AND WEIGHTS

~~(S)~~ The two airplanes selected from the parametric study were examined in detail by use of the same techniques discussed in Section 3.5. These airplanes have an aspect ratio of 3.0 and 3.75. Input data for weighing these airplanes were obtained from the design layouts shown in Section 7.2. The resulting weight breakdowns are shown in Table 7.6-1. A summary of the center-of-gravity conditions for the various mission loadings is as follows:

Condition	Basic Operating Weight	Zero Fuel Weight	Gross Weight
AR 3.0			
SRASM			
Weight (lb)	11,835	12,468	16,800
C.G. (% MAC)	26.6	25.8	23.1
LRASM			
Weight (lb)	12,683	13,316	21.638
C.G. (% MAC)	26.7	26.0	24.2
Ferry Mission			
Weight (lb)	13,525	13,810	27,000
C.G. (% MAC)	26.6	25.6	24.8
AR 3.75			
SRASM			
Weight (lb)	12,131	12,764	16,800
C.G. (% MAC)	31.9	31.1	28.9
LRASM			
Weight (lb)	12,979	13,612	21,638
C.G. (% MAC)	31.5	30.8	28.1
Ferry Mission			
Weight (lb)	13,821	14,106	27,000
C.G. (% MAC)	31.2	30.0	27.7

~~(S)~~ Table 7.6-1 WEIGHT SUMMARY: CONFIGURATION 401B WITH SUPERCRITICAL WING WITH 3.0 AND 3.75 ASPECT RATIO (pounds) ~~(S)~~

Item	Weight	
	AR=3.0	AR=3.75
Structure	(5302)	(5561)
Wing	1400	1671
Fuselage	2608	2636
Horizontal Tail	368	336
Vertical Tail	310	302
Landing Gear	616	616
Propulsion	(3530)	(3530)
Engines	2737	2737
Air Induction	322	322
Fuel System	421	421
Engine Controls	22	22
Starting System	28	28
System and Equipment	(2603)	(2641)
Surface Controls	468	481
Landing Gear Controls	115	115
Instruments	94	94
Hydraulics and Pneumatics	271	288
Electrical	362	370
Avionics	460	460
Furnishings	238	238
Air Conditioning	142	142
Armament	453	453
Weight Empty	11,435	11,732
Useful Load	(400)	(399)
Crew	200	200
Unusable Fuel	23	22
Engine Oil	17	17
Missile Racks and Pylons	124	124
Miscellaneous	36	36
Basic Operating Weight	11,835	12,131
Payload	(633)	(633)
Ammo (500 rounds)	285	285
Missiles (2)	348	348
Zero Fuel Weight	12,468	12,764
Fuel	4332	4036
Gross Weight	16,800	16,800

SECTION 8

COMPOSITE MATERIAL STUDY ON 401B

~~(S)~~ A design tradeoff study was conducted to determine how the potential weight reduction from the use of composite materials should be used to maximize the maneuver capabilities. The study yielded the following results:

1. The weight reduction should be used to change aspect ratio, wing loading, and aircraft size simultaneously rather than any one variable separately.

2. The degree of change of each variable is dependent upon the degree of composite material usage in the aircraft construction.

3. The best combination of variables is dependent upon the aspect of the maneuver capability that is to be maximized (i.e., increased subsonic turn rate requires increased wing aspect ratio and size, while increased acceleration capability requires the opposite.)

4. The following selection of variables is for the case where turn rate is maximized while acceleration time between Mach 0.9 and 1.5 is held constant. Both turn rate and acceleration are for maximum power and 30,000-ft altitude conditions.

Parameter	Aluminum	Composite Wing	Composite Wing, Tail, and Inlet	All Composite
Accel Time, sec	35.5	35.5	35.5	35.5
M.8 deg/sec	9.9	11.2	11.8	13.5
Mission Wt, lb	17,115	16,570	16,270	15,600
Aspect Ratio	3.0	3.3	3.4	3.8
W/S psf	60	54	47	45
T/W	1.37	1.42	1.45	1.50

8.1 STUDY PLAN AND DESIGN DATA

8.1.1 Study Plan

(U) The plan followed in the composite material study on Configuration 401B sought to determine the best way to use the weight reductions resulting from use of composite materials to maximize maneuver capabilities. The first step was the establishment of a matrix of variables to be considered. The second step was the selection of maneuver conditions to use for the evaluation.

8.1.1.1 Matrix of Variables

(U) A matrix of variables was selected to determine whether the weight reductions from the use of composite materials should be used for increased wing aspect ratio (AR), reduced wing loading (W/S), reduced aircraft size, or a combination of the three to maximize the maneuver capabilities. That is,

$$\text{Lower Weight} \longrightarrow \left\{\begin{array}{l}\text{Higher AR}\\ \text{Lower W/S}\\ \text{Smaller Size}\\ \text{(Higher T/W)}\end{array}\right\} \longrightarrow \begin{array}{l}\text{Maximum Turn Rate}\\ \text{Minimize Accel. Time}\end{array}$$

88th ABW/IPZ M.L.
FOIA (b)(1)(4)
E.O. 13526 SEC. 3.3.
(b)(4) 35 (6)(x4)
1.4(a)(g) (5)
SEC 1.4(a)(g)

~~(S)~~ The matrix of variables selected is:

Mission Weight (Aircraft Size), lb	15,600; 16,800; 18,000
Wing Loading, psf	45, 50, 55, 60
Aspect Ratio	3, 4, 5, 6
Composite Material Content	1. None (all aluminum), 2. Wing only, 3. Wing, tail and inlet duct, and 4. Maximum usable

~~(S)~~ The other configuration variables (i.e., wing leading-edge sweep angle, thickness ratio, and taper ratio) are held constant to keep the matrix of variables within a reasonable size; also, the present values are felt to be near optimum. Flying qualities and lift and drag considerations have shown the 35-degree leading-edge sweep to be desirable for an air superiority fighter. The requirement for supersonic operation restricts the wing thickness ratio to a low value. The thickness ratio of 0.04 and the taper ratio of 0.2 were held constant as practical values.

8.1.1.2 Maneuver Conditions

(U) Two conditions were selected for evaluating the maneuver capabilities of the various combination of variables. Both conditions are for maximum power operation at 30,000 feet. One condition is the maximum sustained turn rate at Mach 0.8, which is representative of the high-subsonic-speed turning portion of air-to-air combat. The second condition is a level acceleration from Mach 0.9 to 1.5, which gives an insight into the supersonic capabilities.

~~(S)~~ Maneuver capabilities attained with the various combinations were compared at the mid-combat weight for the Long-Range Air-Superiority Mission (LRASM) with a 750-n.mi radius. The results are presented as plots of turn rate versus acceleration time for each level of composite material usage.

8.1.2 Design Data

(U) In this subsection, the manner in which the design data were derived is described, the ground rules which governed the development of the data are defined, and the geometric data that formed the basis for the analytical studies are summarized.

~~(S)~~ The matrix of 48 airplanes described above in Subsection 8.1.1 was developed around the three growth data points derived in the 401B growth study (Subsection 3.1.1). The data from the three growth data points at mission weights of 15,600, 16,800, and 18,000 pounds were expanded to include the four aspect ratios and four wing loadings to develop the desired matrix for the parametric investigation. Variations in fuselage, wing, and tail surfaces were governed by the list of ground rules, which are summarized briefly as follows:

1. The values $t/c = .04$, $\Lambda_{LE} = 35^\circ$ and $\lambda = 0.2$ remain constant for all wings.

~~(S)~~

2. The $\bar{c}/4$ of all reference wings is located at a constant fuselage station.

3. The horizontal and vertical tail moment arm (distance from $\bar{c}/4$ wing to $\bar{c}/4$ of the tails) is constant at a given aircraft mission weight.

4. The sizing horizontal tail planform geometry remains constant (AR = 3.0, $\lambda = 0.2$, and $\Lambda_{LE} = 35^\circ$).

5. The vertical tail planform geometry remains constant (AR = 1.3265, $\lambda = 0.4$, and $\Lambda_{LE} = 45^\circ$).

6. The horizontal tail and vertical tail moment arms vary as aircraft mission weight varies (scaled according to the square root of the aircraft gross-weight ratio).

7. The "d" distances to the exposed wing root chord exposed horizontal tail chord (measured from airplane centerline) remain constant for a given aircraft mission weight. This "d" distance varies as a function of aircraft mission weight (scaled according to the square root of the gross-weight ratio).

8. The ratio of the exposed horizontal tail area to the sizing tail area remains constant at a value of 0.866.

9. The vertical tail size is constant for a given mission weight and is determined by a vertical tail coefficient of 0.037 (per tail) and a wing geometry defined by AR = 3.0 and W/S = 60 psf.

10. For a given aircraft mission weight, an initial sizing horizontal tail is determined by a horizontal tail volume coefficient of 0.26 and a wing geometry defined by AR = 3.0 and W/S = 60 psf. This establishes a horizontal tail area to wing area ratio of 0.202. As wing geometry changes because of corresponding variations in aspect ratio and wing loading, the sizing horizontal tail area is determined by keeping the area ratio of 0.202 constant.

11. Fuselage length is constant for a given aircraft design mission weight. As mission weight is varied, the fuselage length is scaled as a function of the square root of the gross-weight ratio.

(U) External airplane comparisons that indicate the effect of selected variations of the matrix on the airplane arrangement are presented in Figure 8.1-1, -2, and -3. These comparisons show the effect of varying aspect ratio at a constant wing loading and aircraft mission weight (Figure 8.1-1), the effect of varying wing loading at a constant wing aspect ratio and given mission weight (Figure 8.1-2), and effects of varying aircraft mission weight at a constant wing aspect ratio and wing loading (Figure 8.1-3).

(U) The geometry for each reference wing of the 48-airplane matrix is defined in Figures 8.1-4, -5, and -6. The geometry of each of the sizing horizontal tail planforms utilized in the study is defined in Figure 8.1-7. The geometry for each of the vertical tails and ventral fins of the matrix is defined in Figure 8.1-8.

~~(S)~~ The reference wing area variation is plotted as a function of wing loading for the three mission weights in Figure 8.1-9. The variation of total wetted area for the aircraft configuration is plotted as a function of wing aspect ratio and wing loading in Figures 8.1-10, -11, and -12 for airplane mission weights of 15,600, 16,800, and 18,000 pounds, respectively. Wetted-area variations for the various components in the matrix are shown plotted in Figures 8.1-13 through 8.1-18. Further explanation of the definition of these components as they relate to wetted-area buildup is presented in the growth study approach contained in Subsection 3.1.3.1.

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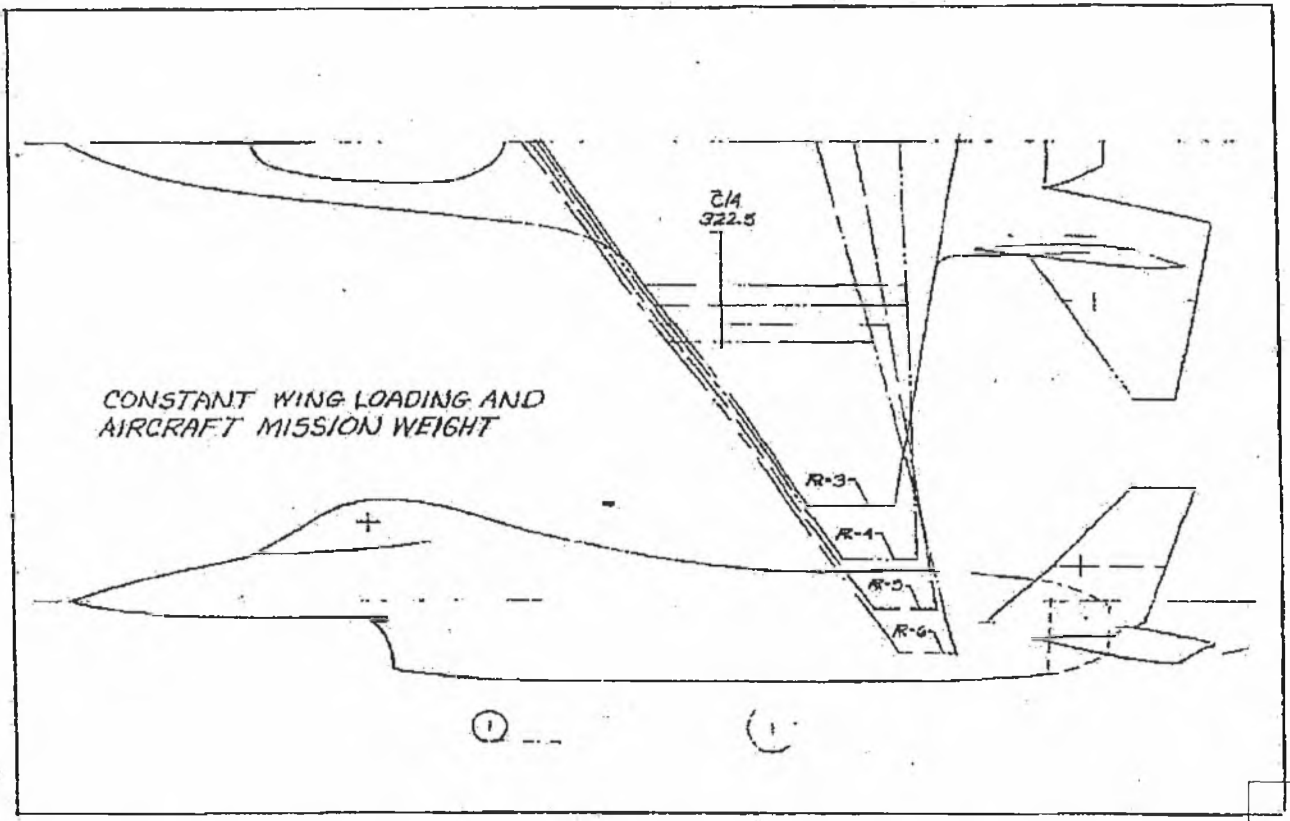

~~(S)~~ Figure 8.1-1 Configuration Comparison - Wing Aspect Ratio Variation (U)

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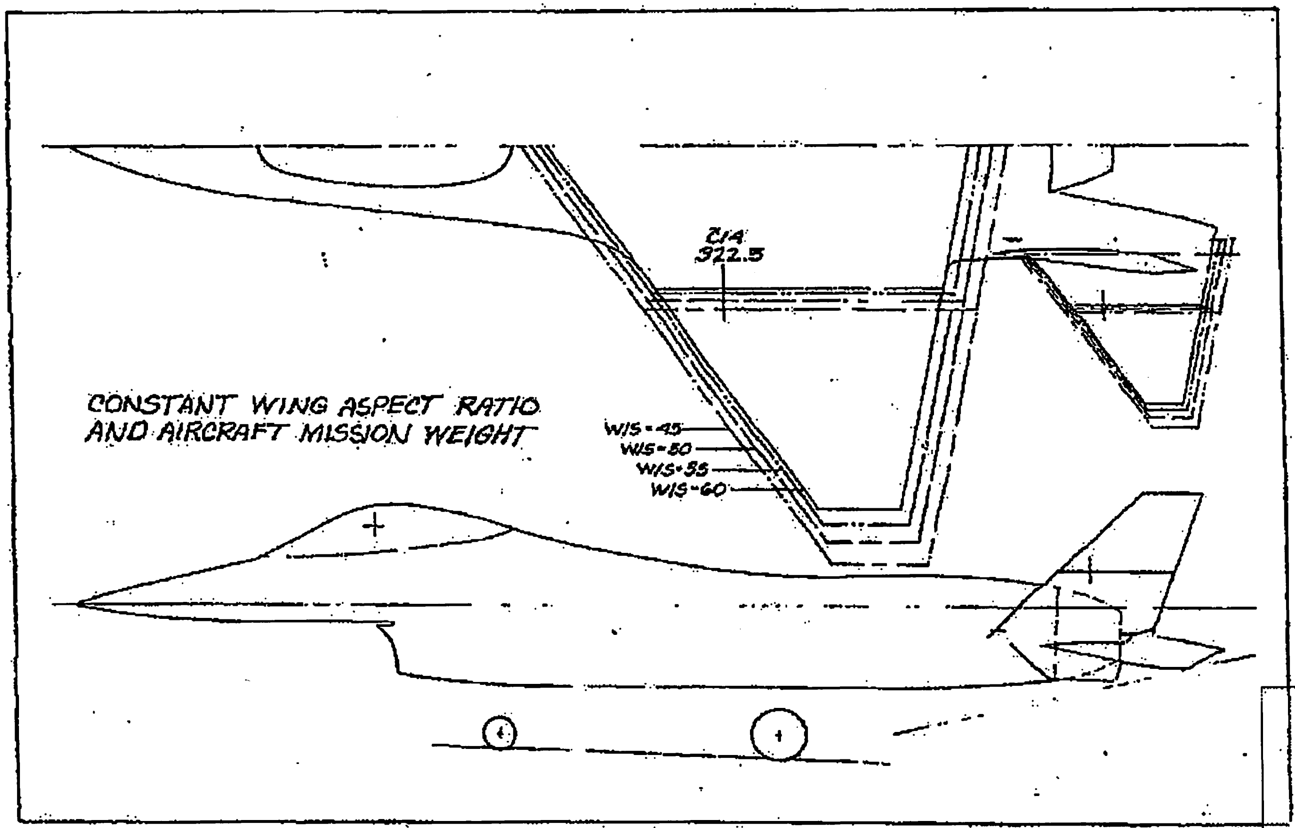
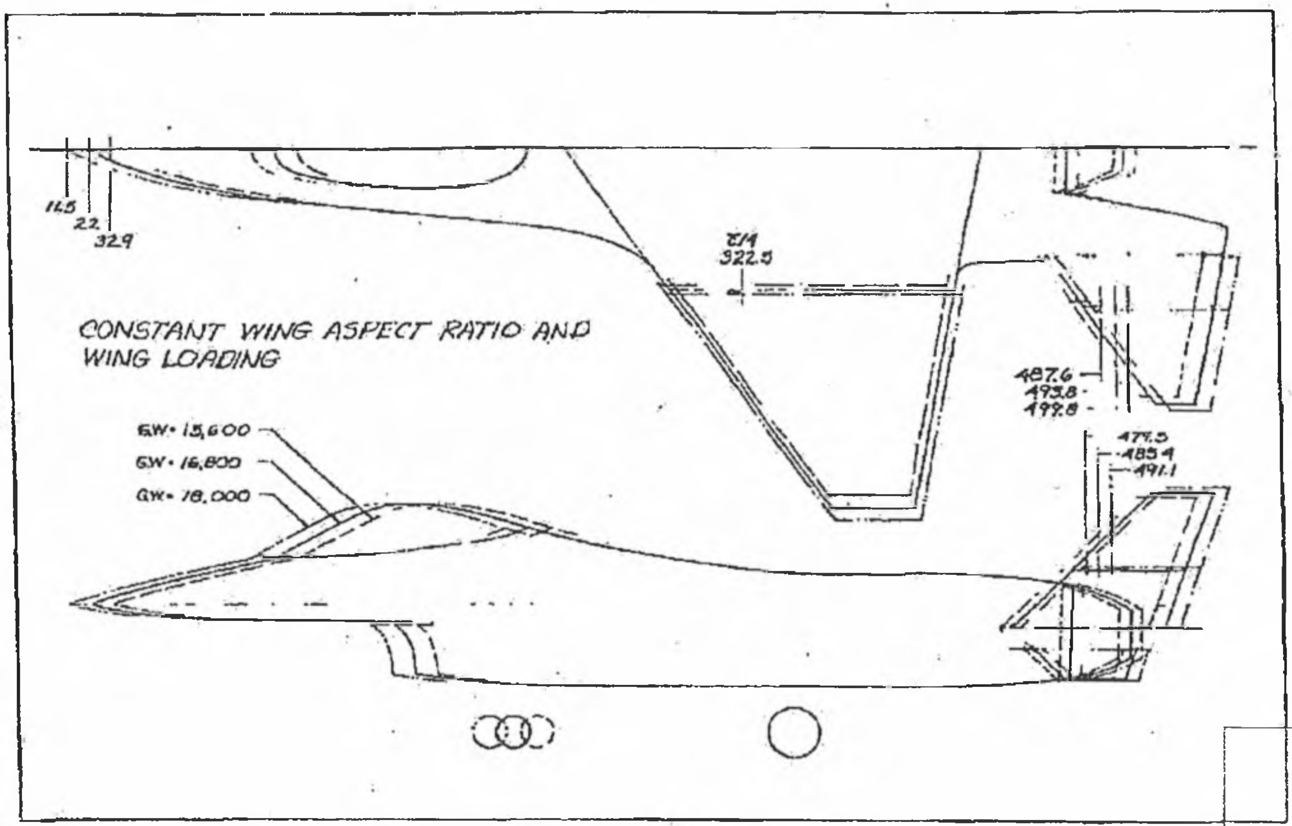
88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC. 3.3.(b)(4)
1.4(a)(g) (b)(1)
EO 13526 SEC 3.3(b)(6)(5-9)
SEC 1.4(a)(g)
PGS 490-492



~~(S)~~ Figure 8.1-2 Configuration Comparison - Wing Loading Variation (U)

[redacted]

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 8.1-3 Configuration Comparison - Mission Weight Variation (U)

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13 of 15

88th ABW/IPI
FOIA (b)(1)(3)
E.O. 13526 SEC 3.3 (b)(4)
1.4 (a)(g)
E.O. 13526 SEC 3.3 (b)(1)
SEC 1.4 (a)(g)

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WING GEOMETRY MATRIX - A/C G.W.=15600 lbs.

		AR=3	AR=4	AR=5	AR=6
W/S=45	G.W.	15600	15600	15600	15600
	W/S	45	45	45	45
	S	346.666666	346.666666	346.666666	346.666666
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	386.988360	446.855676	499.591028	547.284362
	b/2	193.494180	223.427838	249.795514	273.641656
	C_R	214.593536	186.185664	166.533276	152.623357
	C_T	42.998707	37.237977	33.366655	30.404678
	$\bar{c}$	148.106751	128.264209	114.722596	104.787891
	$\bar{c}/4$	37.026687	32.066057	28.680749	26.121327
	$\bar{y}$	75.247692	96.888544	87.144344	106.476706
W/S=50	G.W.	15600	15600	15600	15600
	W/S	50	50	50	50
	S	312.000000	312.000000	312.000000	312.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	367.129404	423.924814	473.962096	519.153320
	b/2	183.564702	211.962258	236.981048	259.576660
	C_R	203.560772	176.625212	157.987332	144.222648
	C_T	40.712154	35.325042	31.597466	28.844530
	$\bar{c}$	140.506355	121.682112	108.835786	99.353015
	$\bar{c}/4$	35.126609	30.420528	27.208946	24.838253
	$\bar{y}$	71.382924	82.429716	82.155226	100.957376
W/S=55	G.W.	15600	15600	15600	15600
	W/S	55	55	55	55
	S	283.636363	283.636363	283.636363	283.636363
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	350.044152	404.156168	451.561042	495.037116
	b/2	175.022076	202.078084	225.782724	247.515594
	C_R	194.428064	168.415068	150.623012	137.510375
	C_T	38.885795	33.683013	30.124602	27.502075
	$\bar{c}$	133.960593	116.015347	103.770584	94.773393
	$\bar{c}/4$	33.491858	29.003836	25.942713	23.693349
	$\bar{y}$	68.064096	78.583667	87.870377	96.617172
W/S=60	G.W.	15600	15600	15600	15600
	W/S	60	60	60	60
	S	260.000000	260.000000	260.000000	260.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	335.141760	386.988360	432.666344	473.962096
	b/2	167.570880	193.494180	216.333077	236.981048
	C_R	186.185364	161.245157	144.222048	131.656116
	C_T	37.237072	32.249030	28.844409	26.331223
	$\bar{c}$	128.264207	111.050063	99.753070	90.169452
	$\bar{c}/4$	32.066052	27.770015	24.938257	22.542123
	$\bar{y}$	65.176406	75.547657	84.129468	92.158226

~~(S)~~ Figure 8.1-4 Wing Geometry Matrix Data - 15,600-lb Aircraft (U)

~~SECRET~~

FOIA (b)(1)
EO 13526 SEC 3.3 (b)(4)
SEC 1.4 (a)(g)

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WING GEOMETRY MATRIX · A/C G.W. = 16,800 lbs.

		AR = 3	AR = 4	AR = 5	AR = 6
W/S = 45	GW	16800	16800	16800	16800
	W/S	45	45	45	45
	S	373.333333	373.333333	373.333333	373.333333
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	401.596817	463.724052	518.459244	567.943656
	b/2	200.798408	231.862026	259.229622	283.971828
	C_R	223.109340	193.218348	172.819788	157.762126
	C_T	44.621868	38.643669	34.563958	31.552425
	$\bar{c}$	153.697642	133.106057	119.053662	108.680576
	$\bar{c}/4$	38.424410	33.276514	29.763416	27.170144
	$\bar{y}$	78.088274	90.168564	100.811520	110.433489
W/S = 50	G.W.	16800	16800	16800	16800
	W/S	50	50	50	50
	S	336.000000	336.000000	336.000000	336.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	380.988180	439.927260	491.853636	538.798664
	b/2	190.494090	219.963630	245.926818	269.399332
	C_R	211.660124	183.303094	163.951217	149.666297
	C_T	42.332025	36.660619	32.790243	29.933259
	$\bar{c}$	145.810308	126.275416	112.944172	103.103448
	$\bar{c}/4$	36.452577	31.568854	28.236043	25.775862
	$\bar{y}$	74.081035	85.541412	95.638152	104.766407
W/S = 55	GW	16800	16800	16800	16800
	W/S	55	55	55	55
	S	305.454545	305.454545	305.454545	305.454545
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	363.257976	419.454160	468.964032	513.724368
	b/2	181.628988	209.727080	234.482016	256.862184
	C_R	201.809968	174.772572	156.321325	142.701214
	C_T	40.361997	34.954514	31.264265	28.540243
	$\bar{c}$	139.024746	120.398958	107.688016	98.305281
	$\bar{c}/4$	34.756186	30.099739	26.922004	24.576320
	$\bar{y}$	70.633495	81.560533	91.187451	99.890854
W/S = 60	G.W.	16800	16800	16800	16800
	W/S	60	60	60	60
	S	280.000000	280.000000	280.000000	280.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	347.793036	401.596817	448.998876	491.853636
	b/2	173.896518	200.798408	224.499438	245.926818
	C_R	193.218348	167.331995	149.666297	136.626010
	C_T	38.643669	33.466399	29.933259	27.325202
	$\bar{c}$	133.106057	115.273224	103.103449	94.120584
	$\bar{c}/4$	33.276514	28.818306	25.775862	23.530146
	$\bar{y}$	67.626424	78.088274	87.305892	95.638152

~~(S)~~ Figure 8.1-5 Wing Geometry Matrix Data - 16,800-lb Aircraft (U)

~~SECRET~~

88th ABW/IPI
~~FOIA (b)(1)~~ (b)(1)
E.O.13526 SEC 3.3(b)(4)
1.4 (a)(g)
E.O. 13526 SEC 3.3(b)(4)
SEC 1.4(a)(g)

WING GEOMETRY MATRIX - A/C G.W. = 18,000 lbs.

		AR=3	AR=4	AR=5	AR=6
W/S=45	G.W.	18000	18000	18000	18000
	W/S	45	45	45	45
	S	400.000000	400.000000	400.000000	400.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	415.692192	480.000000	536.656308	587.877556
	b/2	207.846096	240.000000	268.328154	293.938784
	C_R	230.940108	199.999992	178.885440	163.299319
	C_T	46.188021	39.999998	35.777088	32.659867
	$\bar{c}$	159.092175	137.777759	123.232270	112.495157
	$\bar{c}/4$	39.773043	34.444464	30.808067	28.123788
	$\bar{y}$	80.829088	93.333276	104.349766	114.309444
W/S=50	G.W.	18000	18000	18000	18000
	W/S	50	50	50	50
	S	360.000000	360.000000	360.000000	360.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	394.360236	455.367972	509.116872	557.709601
	b/2	197.180118	227.683986	254.558436	278.854800
	C_R	219.089016	189.736656	169.705620	154.919328
	C_T	43.817803	37.947331	33.941124	30.983866
	$\bar{c}$	150.928064	130.707556	116.908396	106.722270
	$\bar{c}/4$	37.732071	32.676889	29.227097	26.680567
	$\bar{y}$	76.681104	88.543716	98.994960	108.441460
W/S=55	G.W.	18000	18000	18000	18000
	W/S	55	55	55	55
	S	327.272727	327.272727	327.272727	327.272727
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	376.007736	434.176338	485.423558	531.755277
	b/2	188.003868	217.088166	242.711784	265.877618
	C_R	208.893160	180.906904	161.807964	147.709768
	C_T	41.778636	36.181360	32.361592	29.541957
	$\bar{c}$	143.904281	124.624866	111.467778	101.755456
	$\bar{c}/4$	35.976070	31.156151	27.866944	25.438874
	$\bar{y}$	73.112608	84.423120	94.387520	103.396762
W/S=60	G.W.	18000	18000	18000	18000
	W/S	60	60	60	60
	S	300.000000	300.000000	300.000000	300.000000
	AR	3.0	4.0	5.0	6.0
	λ	0.2	0.2	0.2	0.2
	b	360.000000	415.692192	464.757996	509.116877
	b/2	180.000000	207.846096	232.378998	254.558438
	C_R	199.999997	173.205072	154.919328	141.421356
	C_T	39.999998	34.641016	30.983866	28.284271
	$\bar{c}$	137.777759	119.319124	106.722270	97.423662
	$\bar{c}/4$	34.444464	29.829781	26.680567	24.355915
	$\bar{y}$	69.999960	80.829088	90.369557	98.994920

~~(S)~~ Figure 8.1-6 Wing Geometry Matrix Data - 18,000-lb Aircraft (U)

SIZING HORIZ. TAIL GEOMETRY MATRIX

		A/C GROSS WEIGHT - LBS		
		15,600	16,800	18,000
WING W/S = 45	$S_{H.T.}$	70·026667	75·413333	80·800000
	AR	3·0	3·0	3·0
	λ	0·2	0·2	0·2
	b	173·929632	180·495312	186·830400
	$b/2$	86·964816	90·247656	93·415200
	C_R	96·627576	100·275168	103·794660
	C_T	19·325415	20·055033	20·758932
	$\bar{c}$	66·565705	69·078492	71·503033
	$\bar{c}/4$	16·641426	17·269623	17·875758
	$\bar{y}$	33·819624	35·096280	36·328104
WING W/S = 50	$S_{H.T.}$	63·024000	67·872000	72·720000
	AR	3·0	3·0	3·0
	λ	0·2	0·2	0·2
	b	165·004140	171·232884	177·242880
	$b/2$	82·502070	85·616442	88·621440
	C_R	91·668972	95·129388	98·468268
	C_T	18·333794	19·025877	19·693653
	$\bar{c}$	63·149776	65·533620	67·833738
	$\bar{c}/4$	15·787444	16·383405	16·958434
	$\bar{y}$	32·084112	33·295260	34·463868
WING W/S = 55	$S_{H.T.}$	57·294545	61·701818	66·109091
	AR	3·0	3·0	3·0
	λ	0·2	0·2	0·2
	b	157·325268	163·264152	168·994452
	$b/2$	78·662634	81·632076	84·497226
	C_R	87·402936	90·702312	93·885804
	C_T	17·480587	18·140462	18·777160
	$\bar{c}$	60·210349	62·483854	64·676928
	$\bar{c}/4$	15·052737	15·620963	16·169232
	$\bar{y}$	30·591000	31·745784	32·860008
WING W/S = 60	$S_{H.T.}$	52·520000	56·560000	60·600000
	AR	3·0	3·0	3·0
	λ	0·2	0·2	0·2
	b	150·627480	156·313524	161·799876
	$b/2$	75·313740	78·156762	80·899938
	C_R	83·681940	86·840844	89·888820
	C_T	16·736388	17·368168	17·977764
	$\bar{c}$	57·647594	59·823730	61·923448
	$\bar{c}/4$	14·411898	14·955932	15·480862
	$\bar{y}$	29·288652	30·394272	31·461060

~~(S)~~ Figure 8.1-7 Sizing Horizontal Geometry Matrix Data (U)

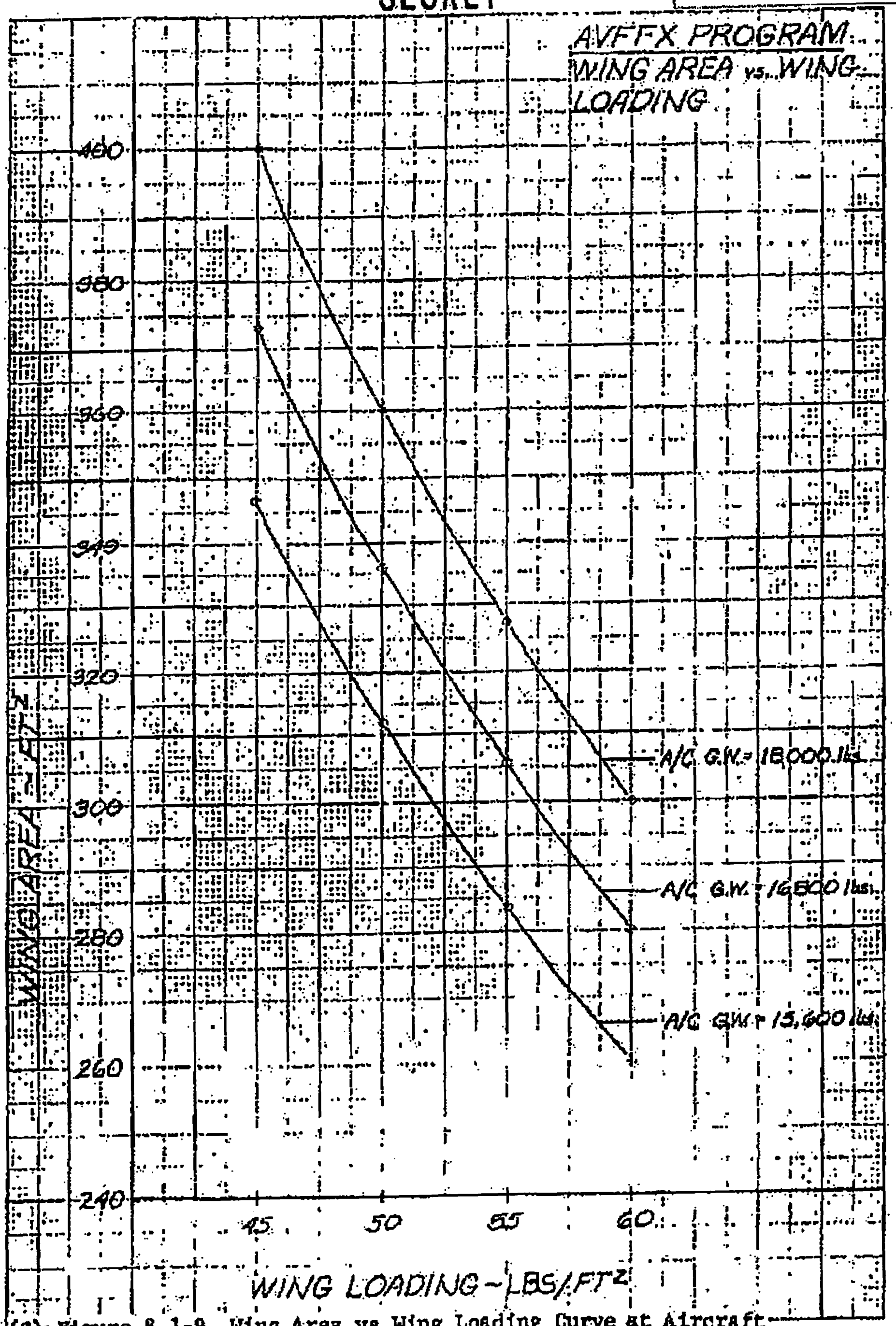
VERTICAL TAIL GEOMETRY MATRIX

	A/C GROSS WEIGHT-LBS.		
	15,600	16,800	18,000
$S_{V.T.}$	20.538131	22.118055	23.697922
AR	1.326530	1.326530	1.326530
λ	0.4	0.4	0.4
b	62.635452	64.999980	67.281372
$b/2$	31.317726	32.499990	33.640686
C_R	67.453596	70.000008	72.456932
C_T	26.981438	28.000003	28.982764
$\bar{c}$	50.108397	52.000018	53.825147
$\bar{c}/4$	12.527099	13.000004	13.456286
$\bar{y}/2$	13.421868	13.928556	14.417424
$\bar{y}$	26.843736	27.857112	28.834848

VENTRAL FIN GEOMETRY MATRIX

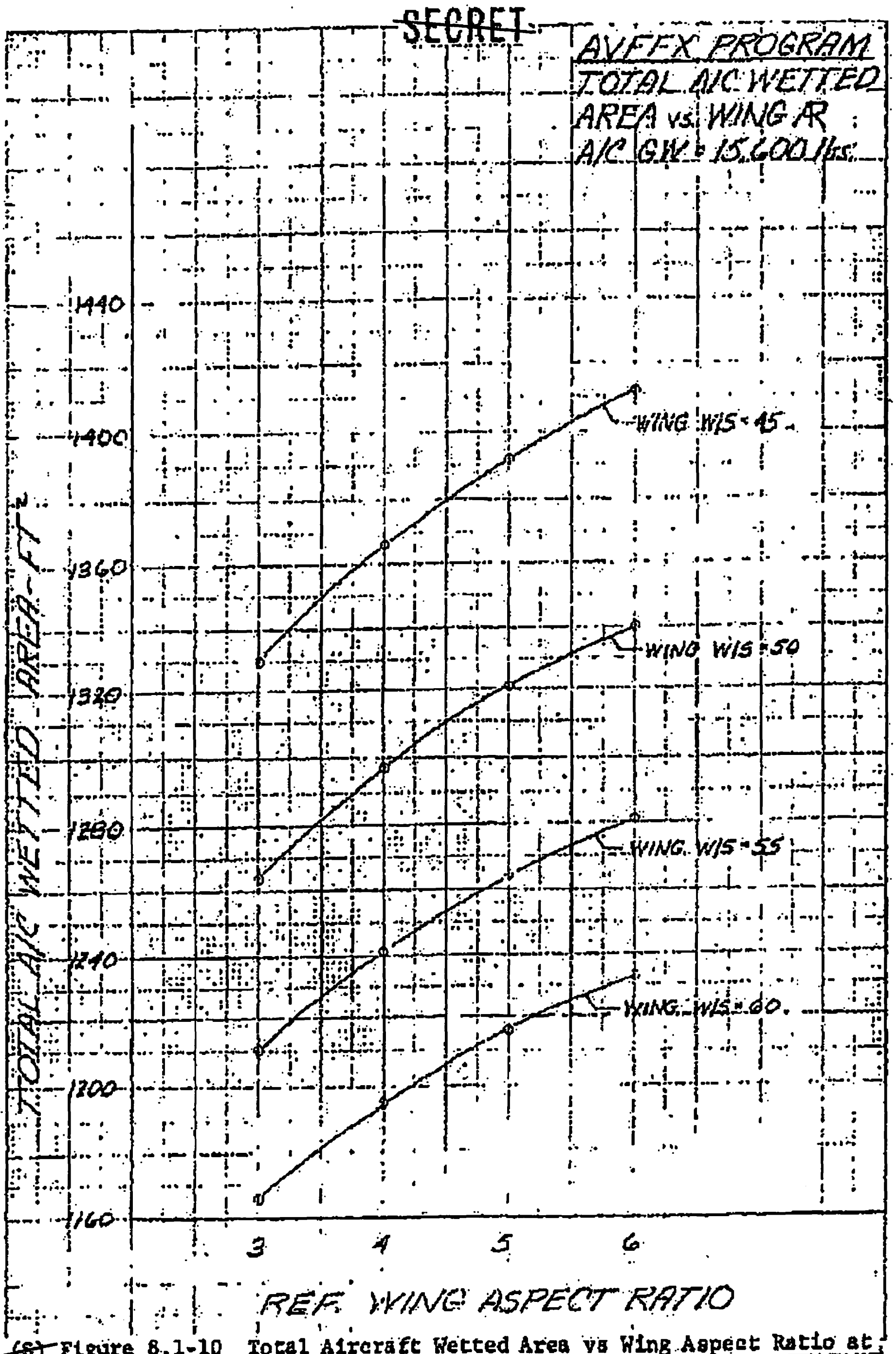
	A/C GROSS WEIGHT - LBS		
	15,600	16,800	18,000
S_{VF}	3.385406	3.645833	3.906251
AR	0.373333	0.373333	0.373333
λ	0.595744	0.595744	0.595744
b	13.490700	13.999980	14.491368
$b/2$	6.745350	6.999990	7.245684
C_R	45.290316	47.000064	48.649668
C_T	26.981434	28.000006	28.982743
$\bar{c}$	36.908919	38.302262	39.646592
$\bar{c}/4$	9.227229	9.575565	9.911648
$\bar{y}/2$	3.087864	3.204432	3.316908
$\bar{y}$	6.175728	6.408864	6.633816

~~(S)~~ Figure 8.1-8 Vertical Tail and Ventral Fin Geometry Matrix Data (U)

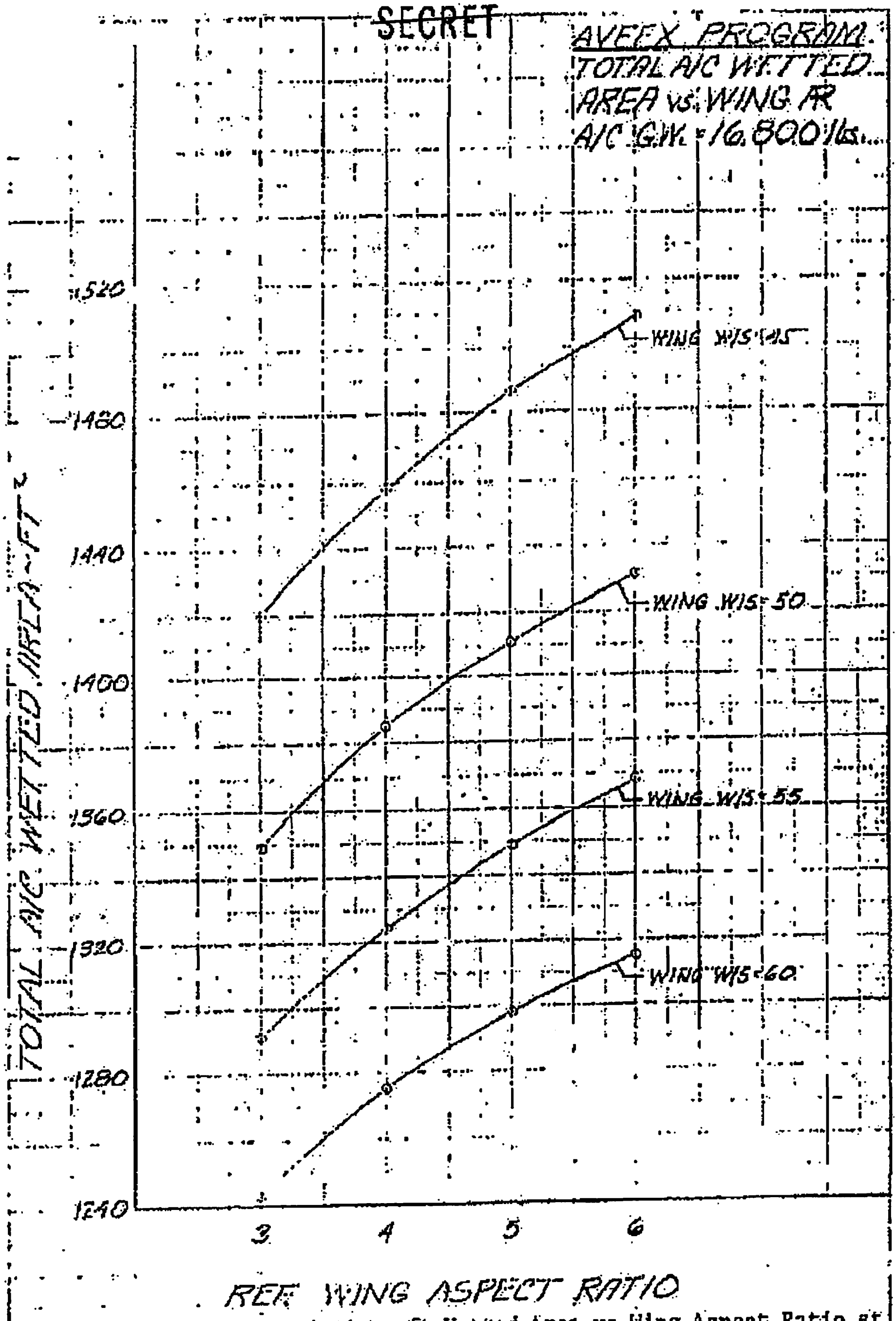


~~(S)~~ Figure 8.1-9 Wing Area vs Wing Loading Curve at Aircraft Mission Weights (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 8.1-10 Total Aircraft Wetted Area vs Wing Aspect Ratio at Variable Wing Loadings for a 15,600-lb Aircraft (U)



~~(S)~~ Figure 8.1-11 Total Aircraft Wetted Area vs Wing Aspect Ratio at Variable Wing Loadings for a 16,800-lb Aircraft (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
~~1.4. (a)(g)~~

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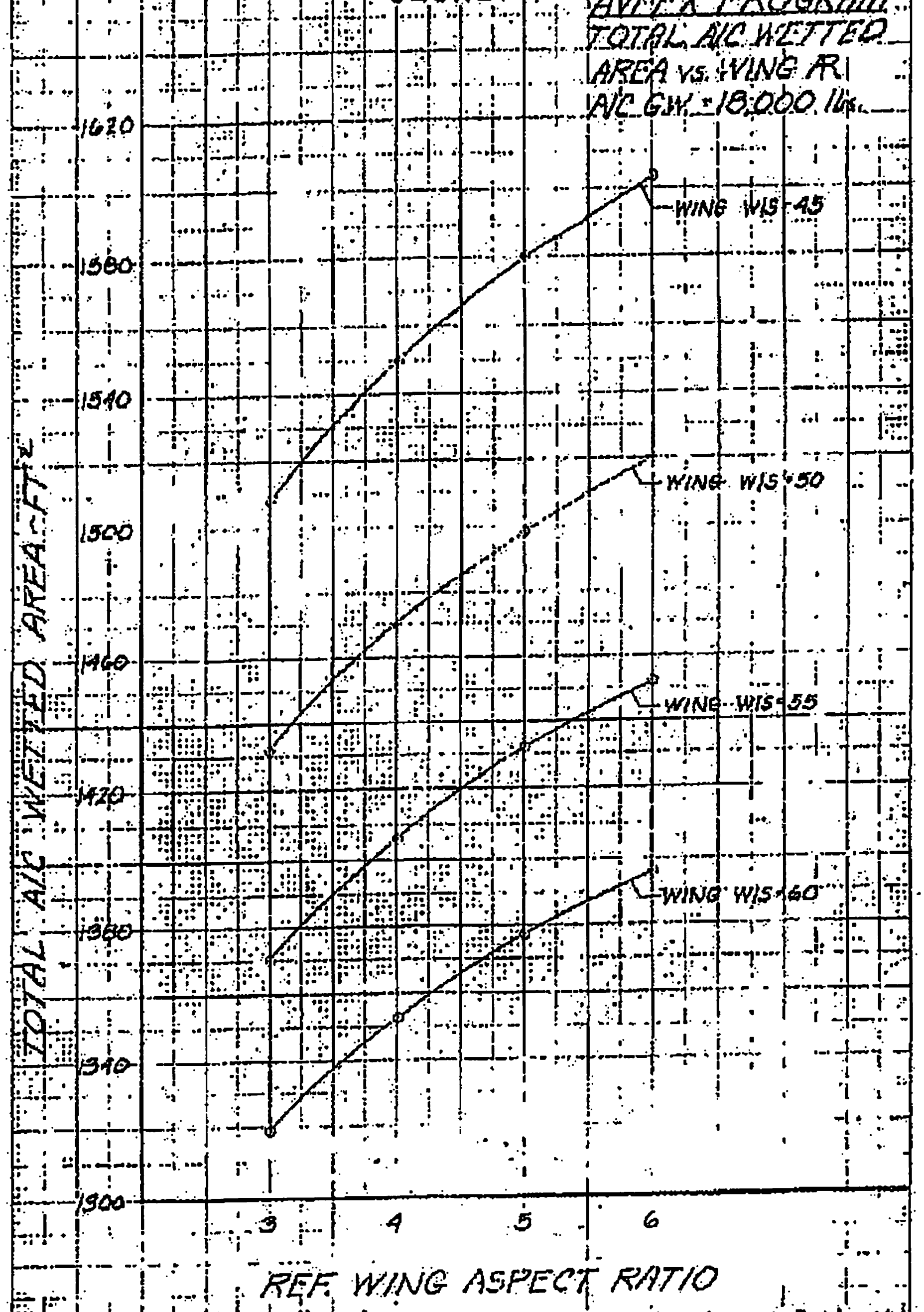

~~(S)~~ Figure 8.1-12 Total Aircraft Wetted Area vs Wing Aspect Ratio at Variable Wing Loadings for a 18,000-lb Aircraft (U)

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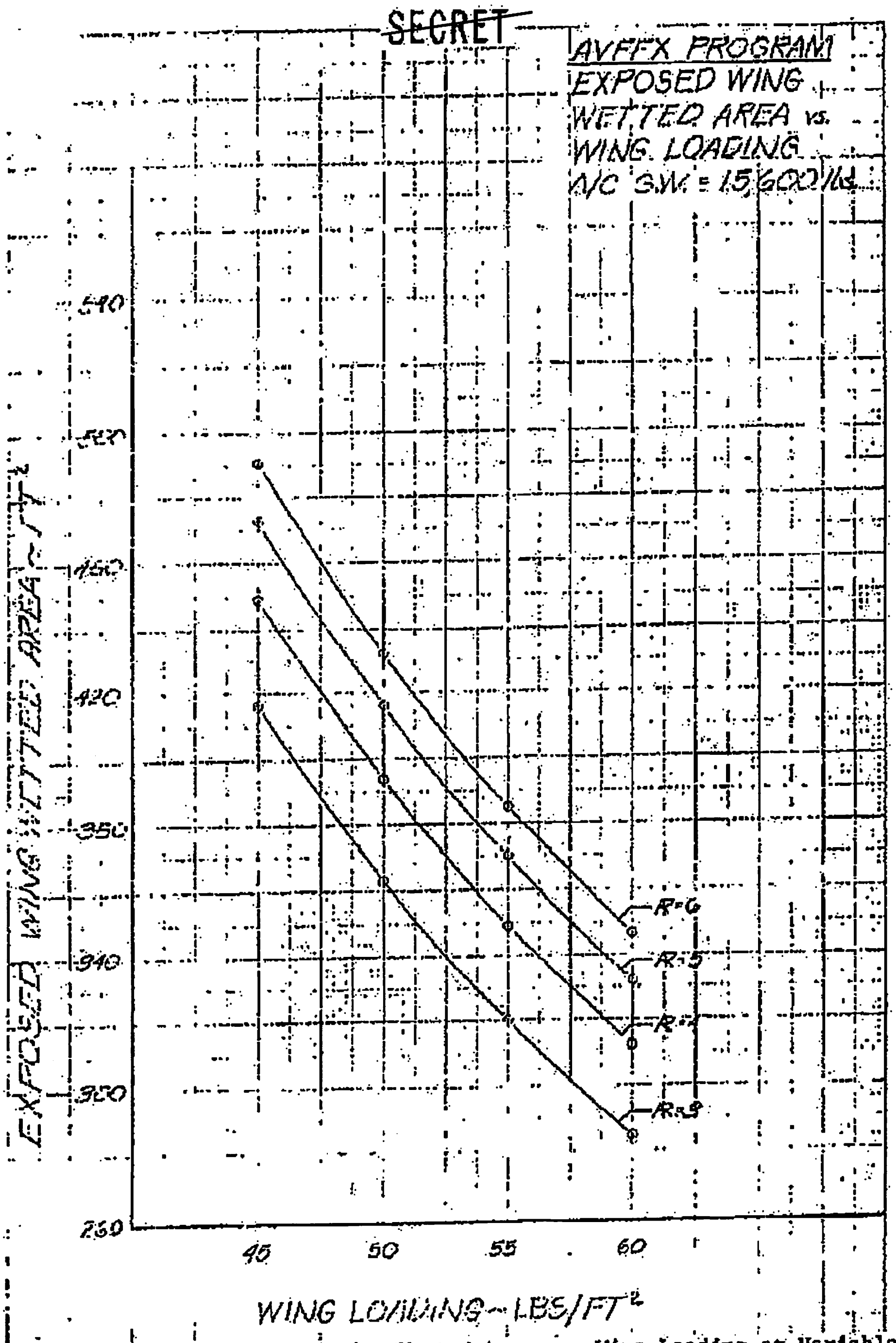
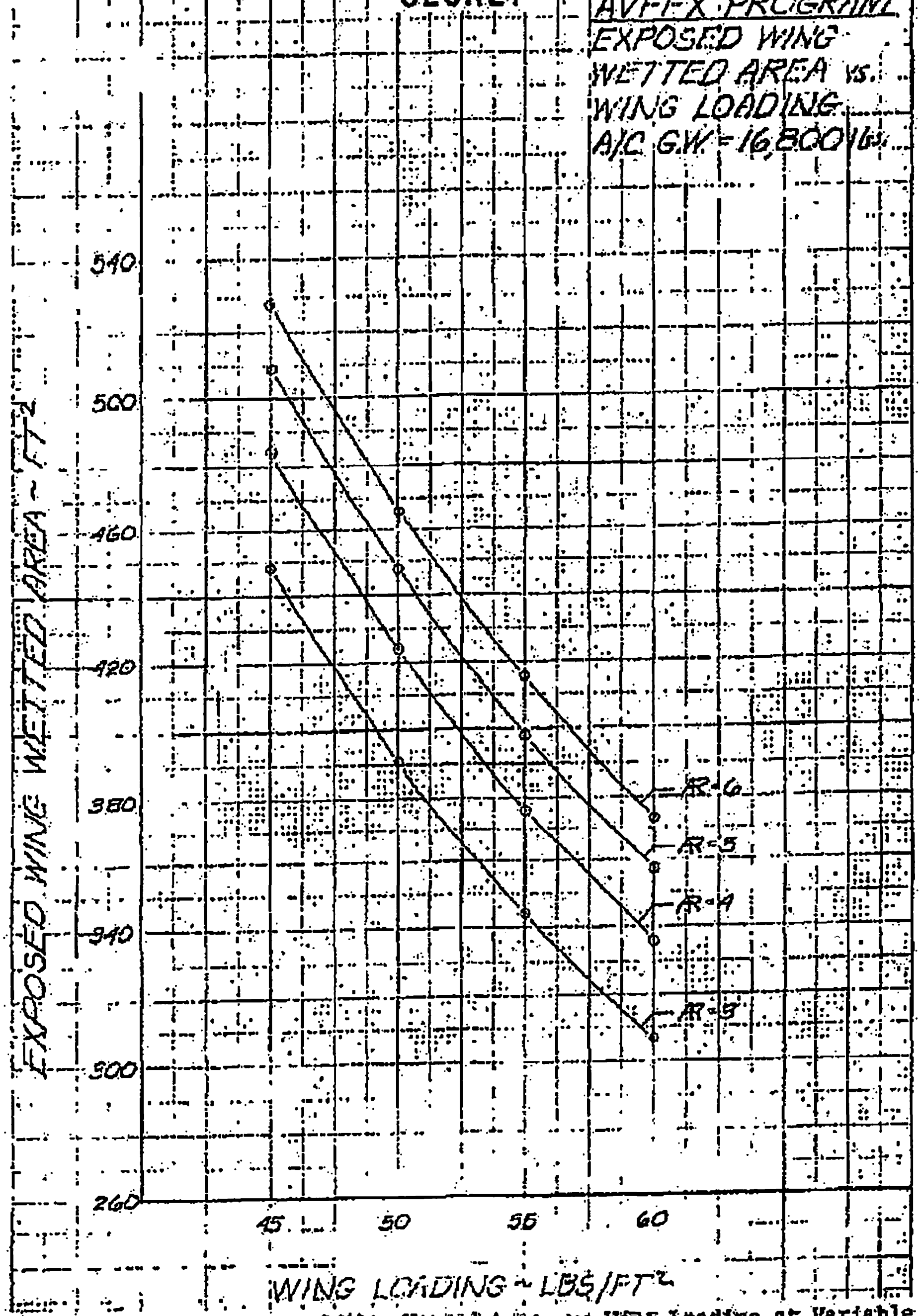
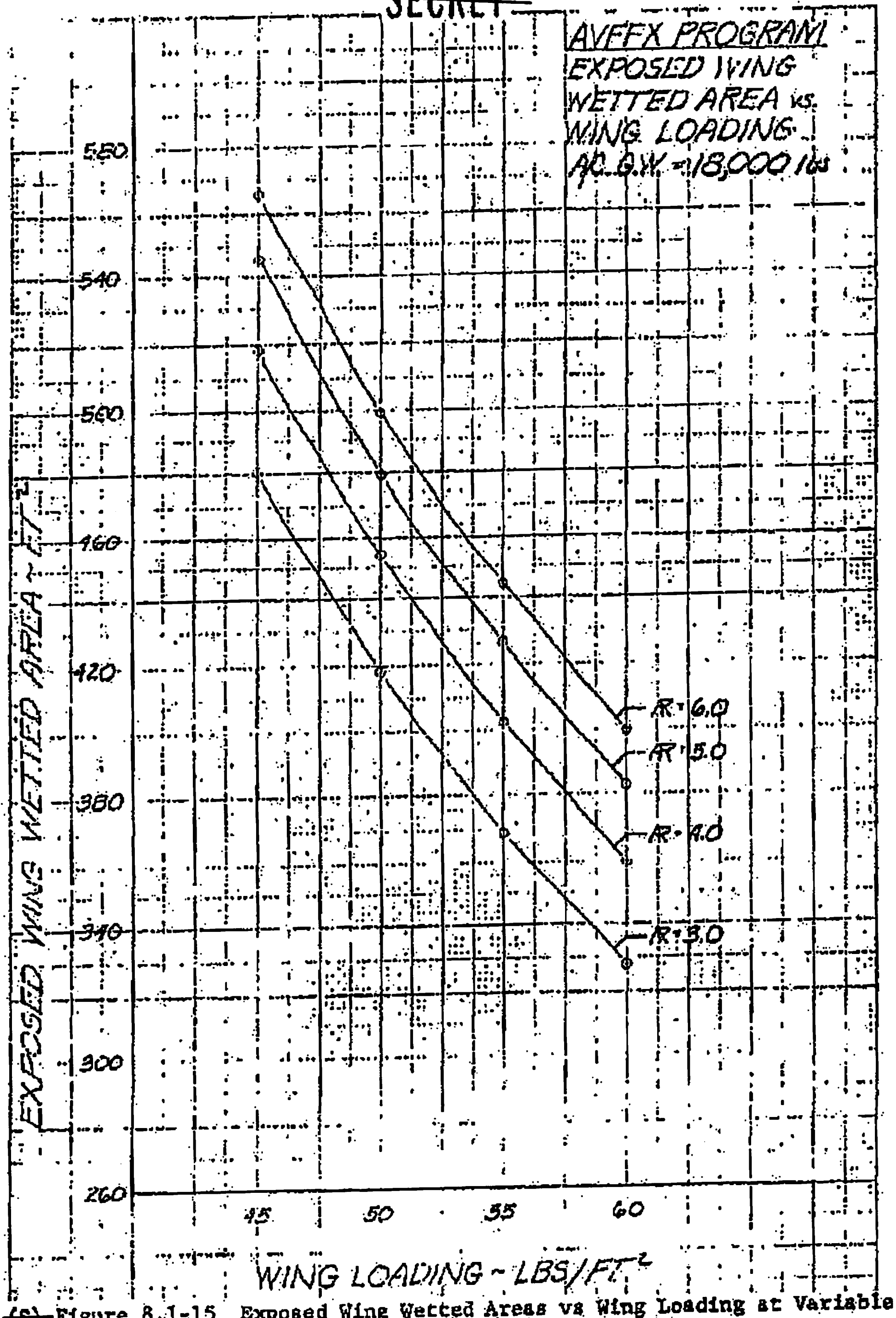


~~(S)~~ Figure 8.1-13 Exposed Wing Wetted Areas vs Wing Loading at Variable Aspect Ratios for a 15,600-lb Aircraft (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526
SEC. 3.3.(b)(4)
1.4.(a)(g)



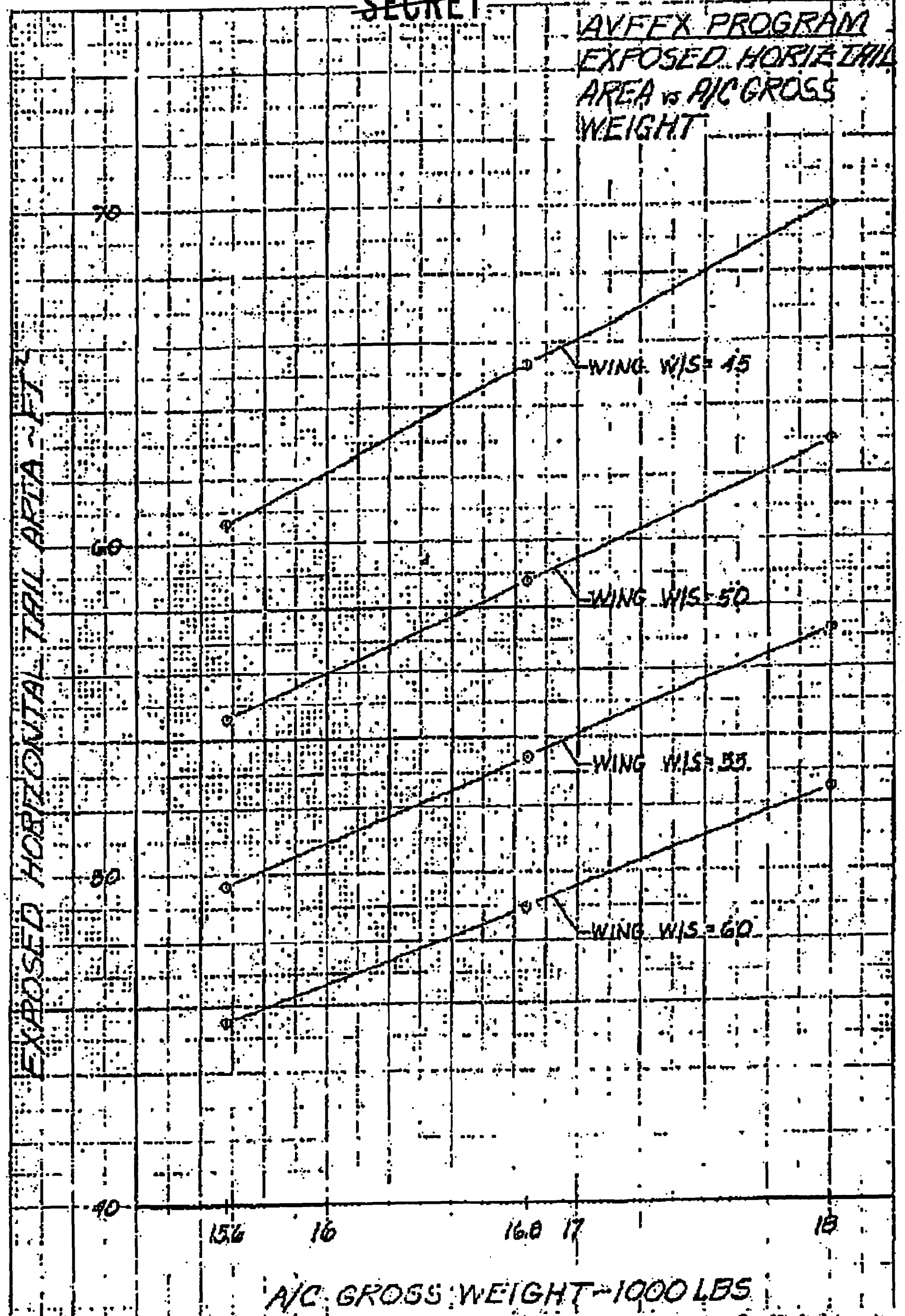
~~(S)~~ Figure 8.1-14 Exposed Wing Wetted Areas vs Wing Loading at Variable Aspect Ratios for a 16,800-lb Aircraft



88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

~~(S)~~ Figure 8.1-15 Exposed Wing Wetted Areas vs Wing Loading at Variable Aspect Ratios for a 18,000-lb Aircraft

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)



~~(S)~~ Figure 8.1-16 Exposed Horizontal Tail Area vs Aircraft Weight at Variable Wing Loadings

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88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

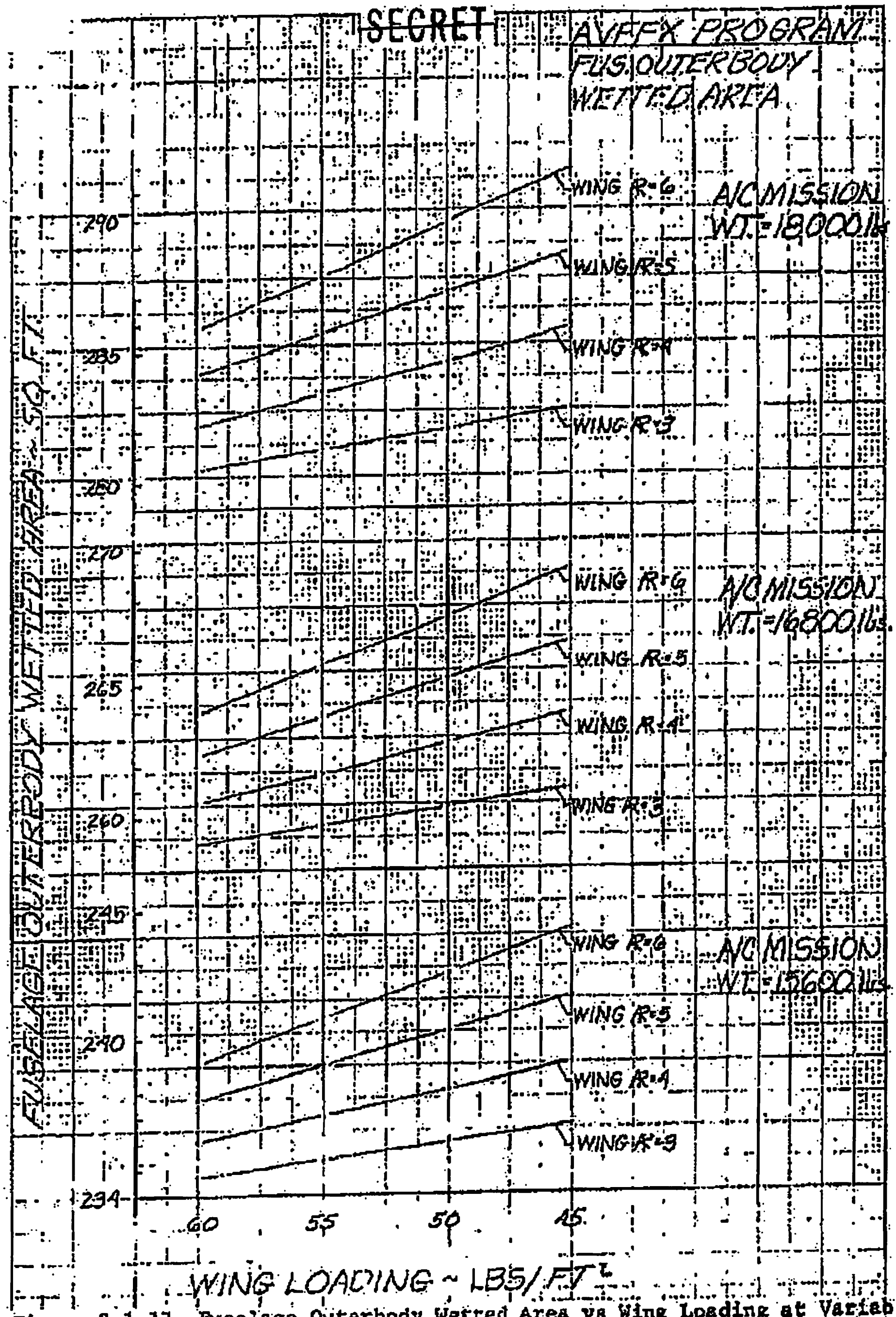
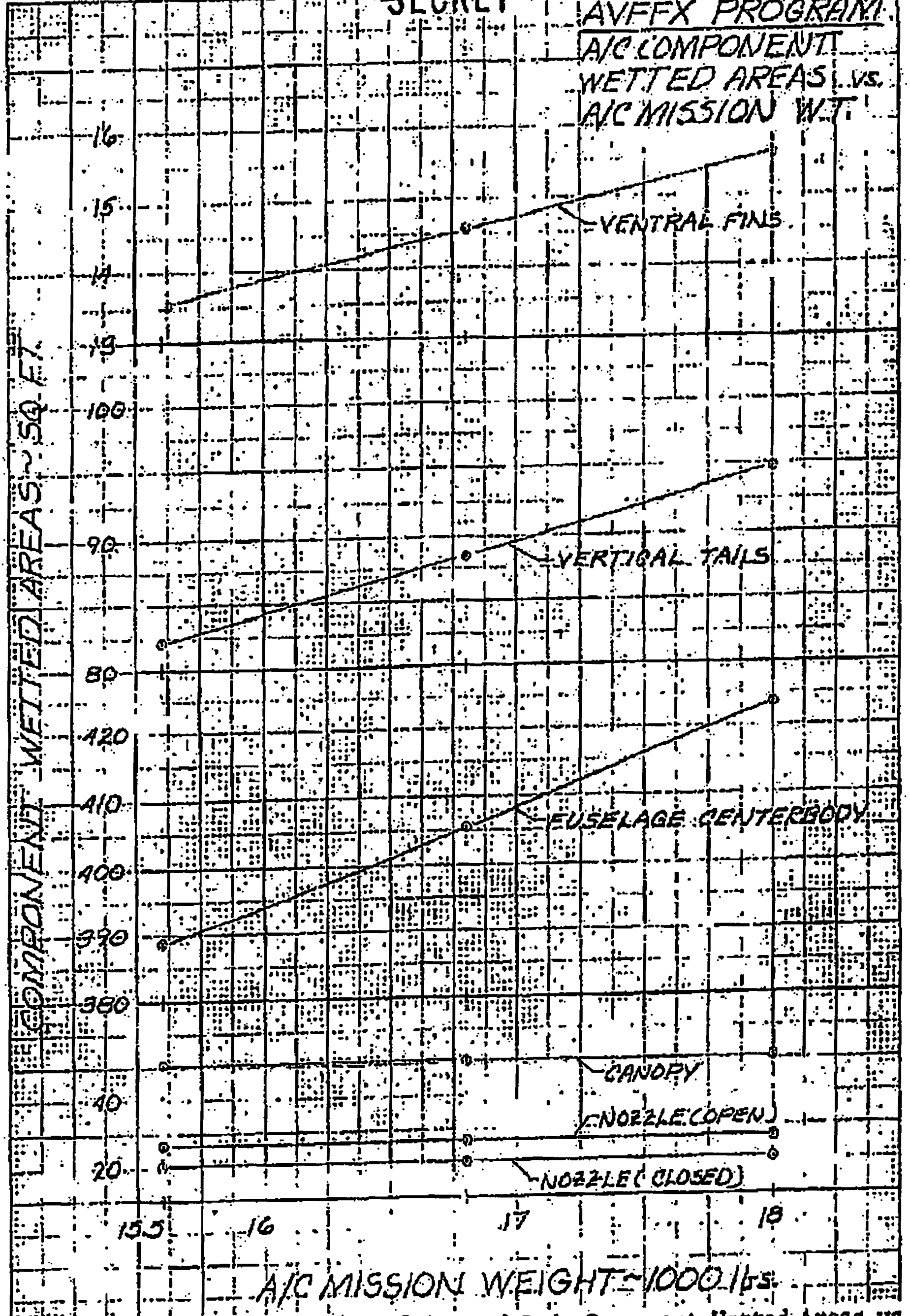


Figure 8.1-17 Fuselage Outerbody Wetted Area vs Wing Loading at Variable Wing Aspect Ratios for 15,600-, 16,800-, and 18,000-lb Aircraft (U)

~~SECRET~~



~~(S)~~ Figure 8.1-18 Aircraft Surfaces and Body Component Wetted Areas vs Aircraft Mission Weights (U)

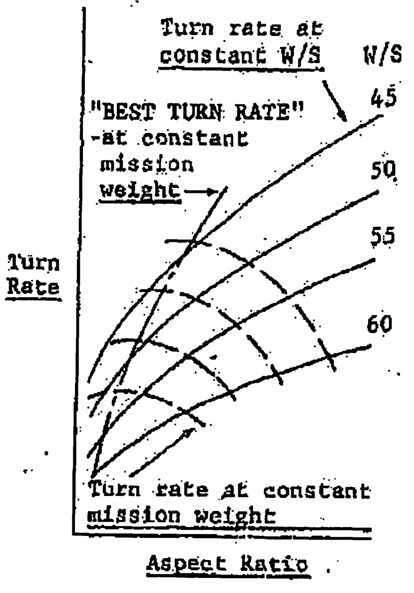
8.2 PERFORMANCE

~~(S)~~ Long-range air-superiority missions (LRASM) were computed for all the combinations of aspect ratio, wing loading, mission weights, and composite content - a total of 192 configurations. For each configuration, [a mission weight was determined to yield the desired 750-n.mi LRASM radius. For each composite content, the aspect-ratio/wing-loading combinations were optimized to give the maximum turn rate at Mach 0.8, 30,000 feet.]

~~(S)~~ In Figures 8.2-1 through 8.2-4, the variation of LRASM radius with mission weight is plotted for each wing-loading/composite-content combination for each aspect ratio. The mission weight for the 750-n.mi LRASM radius for each configuration was determined from these curves.

~~(S)~~ [In Figures 8.2-5 and 8.2-6, the turn rate at Mach 0.8, 30,000 feet and acceleration time from Mach 0.9 to 1.5 at 30,000 ft are presented. The mission weights for the 750-n.mi LRASM radius are marked for each configuration of apsect ratio, wing loading, and composite content.]

(U) The mission weights determined from Figures 8.2-1 through 8.2-4 and the turn rates and acceleration times determined from Figures 8.2-5 and 8.2-5 are presented in Figures 8.2-7 through 8.2-10 for each level of composite content. A combination of aspect radio, wing loading, and mission weight for best turn rate was determined by plotting lines of constant mission weight on the aspect-ratio-vs-turn-rate chart and picking the peak value of turn rate for each mission weight, as illustrated in the sketch on the right. The best combination is noted by a line labeled "BEST TURN RATE" on each of Figures 8.2-7 through 8.2-10.

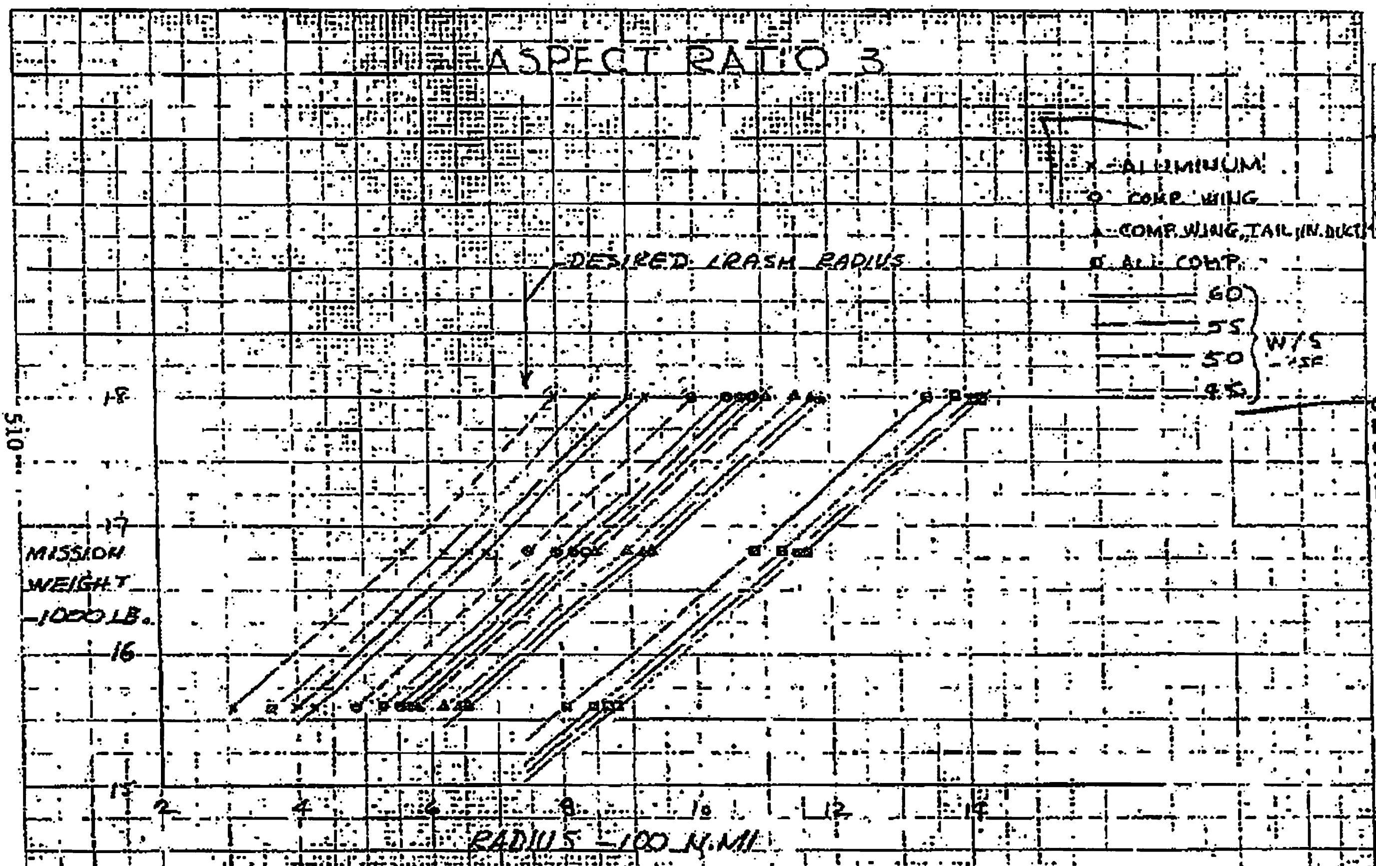


88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3 (b)(4)
1.4 (a)(g)

3.3 (b)(4)
SEC 1.4

~~(S)~~ [The configurations for best turn rate at each level of composite content are presented in Figure 8.2-11. This figure presents wing loading, aspect ratio, and mission weight for best turn rate versus the resulting acceleration times for each composite content series. The chart of turn rate versus acceleration time shows increasing time to accelerate for increase in turn rate for each composite content series. As turn rate is increased, the mission weight and aspect ratio increase and wing loading decreases. Comparing composite content series at a selected acceleration time shows an increasing turn rate, mission weight, and aspect ratio with decreasing wing loading. For example, at a 35.5-second acceleration time, a comparison of the all-aluminum and all-composite configurations is as follows:

	Aluminum	Composite	% Change
Turn Rate, deg/sec	9.9	13.5	+ 36.3
Mission Weight, lb	17,115	15,600	- 8.8
Aspect Ratio	3.0	3.8	+ 26.7
W/S, psf	60	45	- 25.0]



(S) Figure 8.2-1 LRASM Growth Curves for Configuration 401B with Aspect Ratio 3.0 Wing (U)

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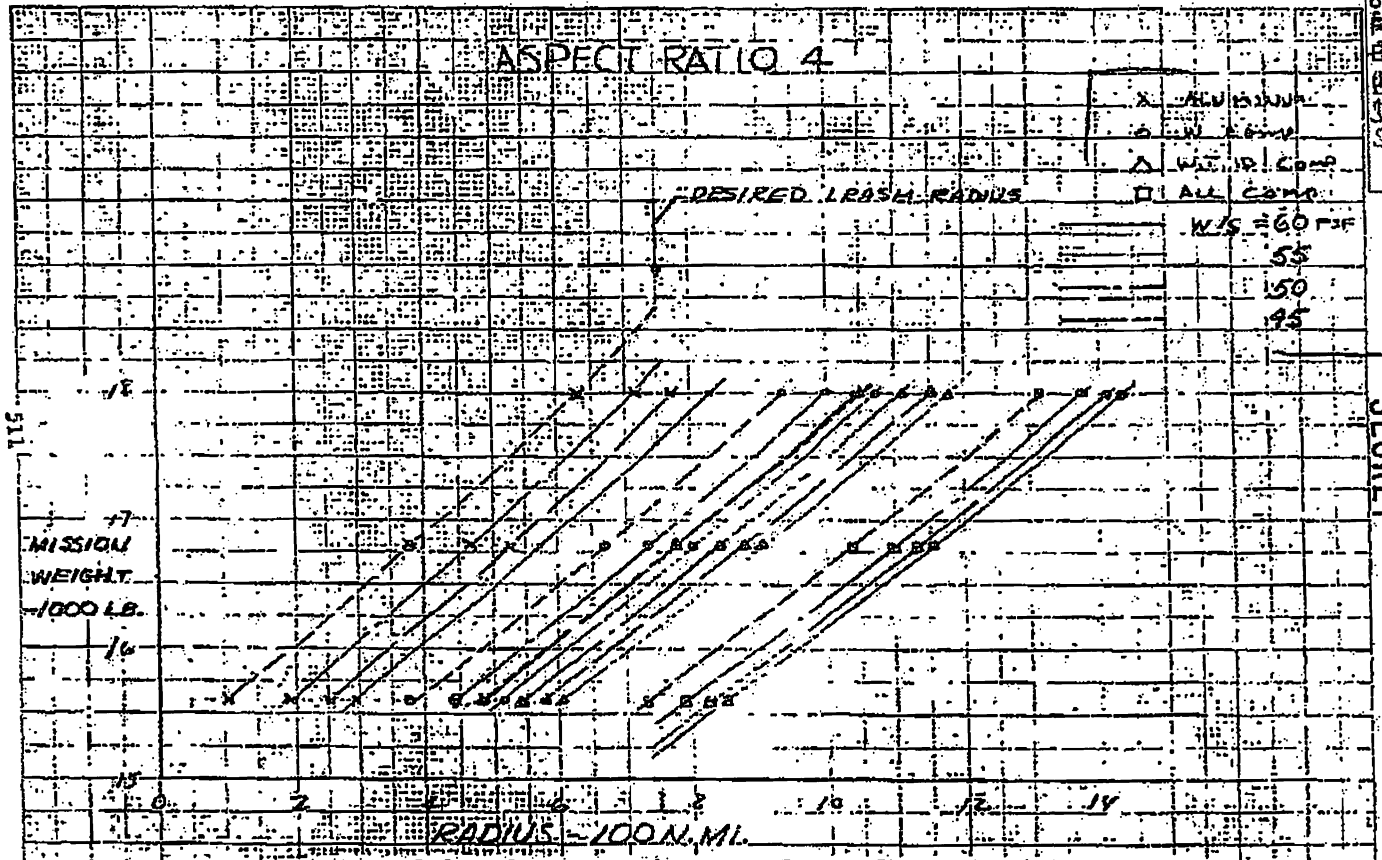


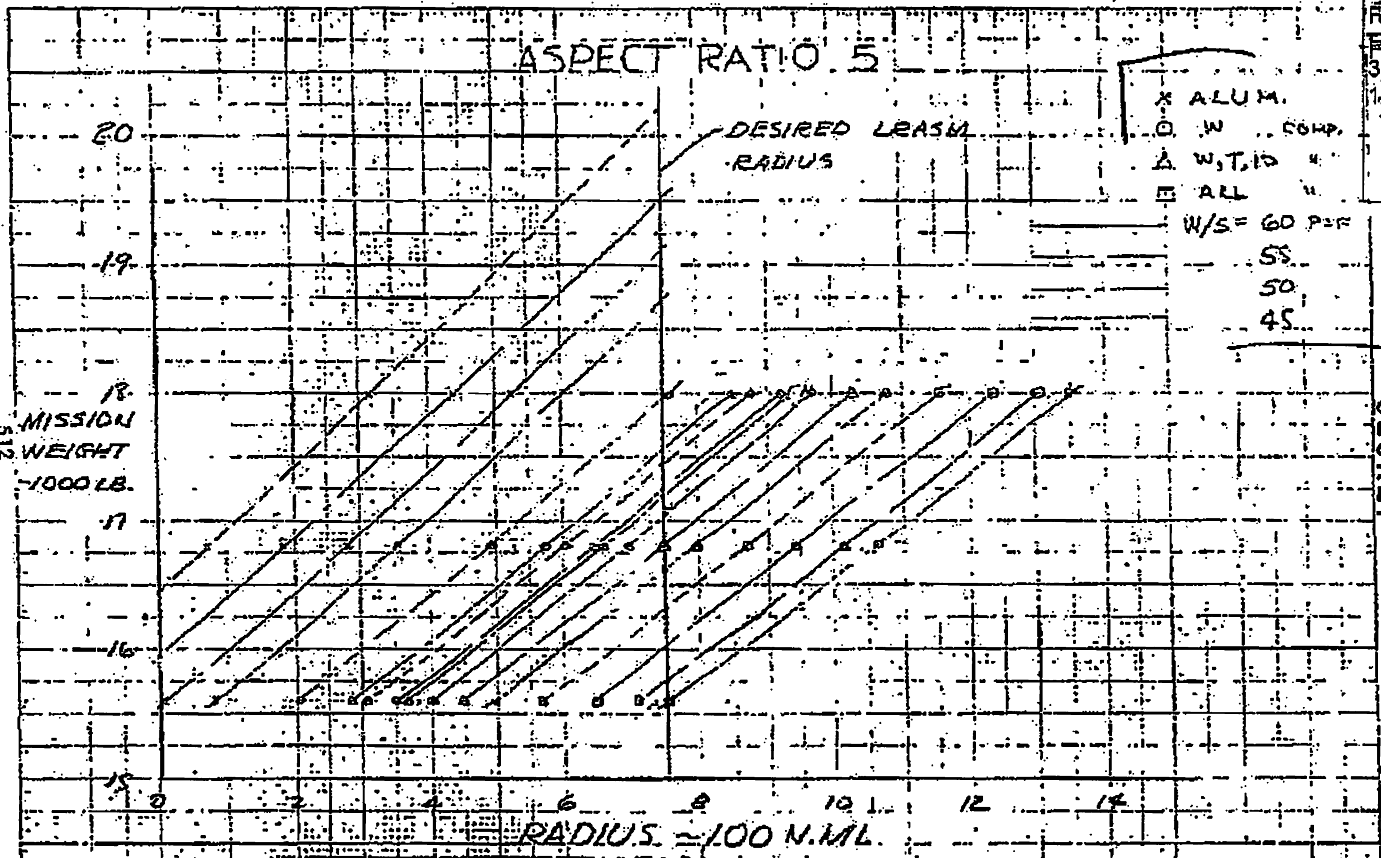
~~(S)~~ Figure 8.2-2 LRASM Growth Curves for Configuration 401B with Aspect Ratio 4.0 Wing (U)

88th ABW/IPL
FOIA (b)(1)
E.O. 13526 SEC. 3.3
(b)(4) 3526
1.4c (a)(g) (6)(4)
SEC. 1.4(a)(g)

SECRET

88th ABW/IP
FOIA (b)(1) (b)(1)
E.O. 13526 SEC
3.3(b)(4) 25
1.4(a)(g)
SEC 3.3(b)(
SEC 1.4(a)(

SECRET



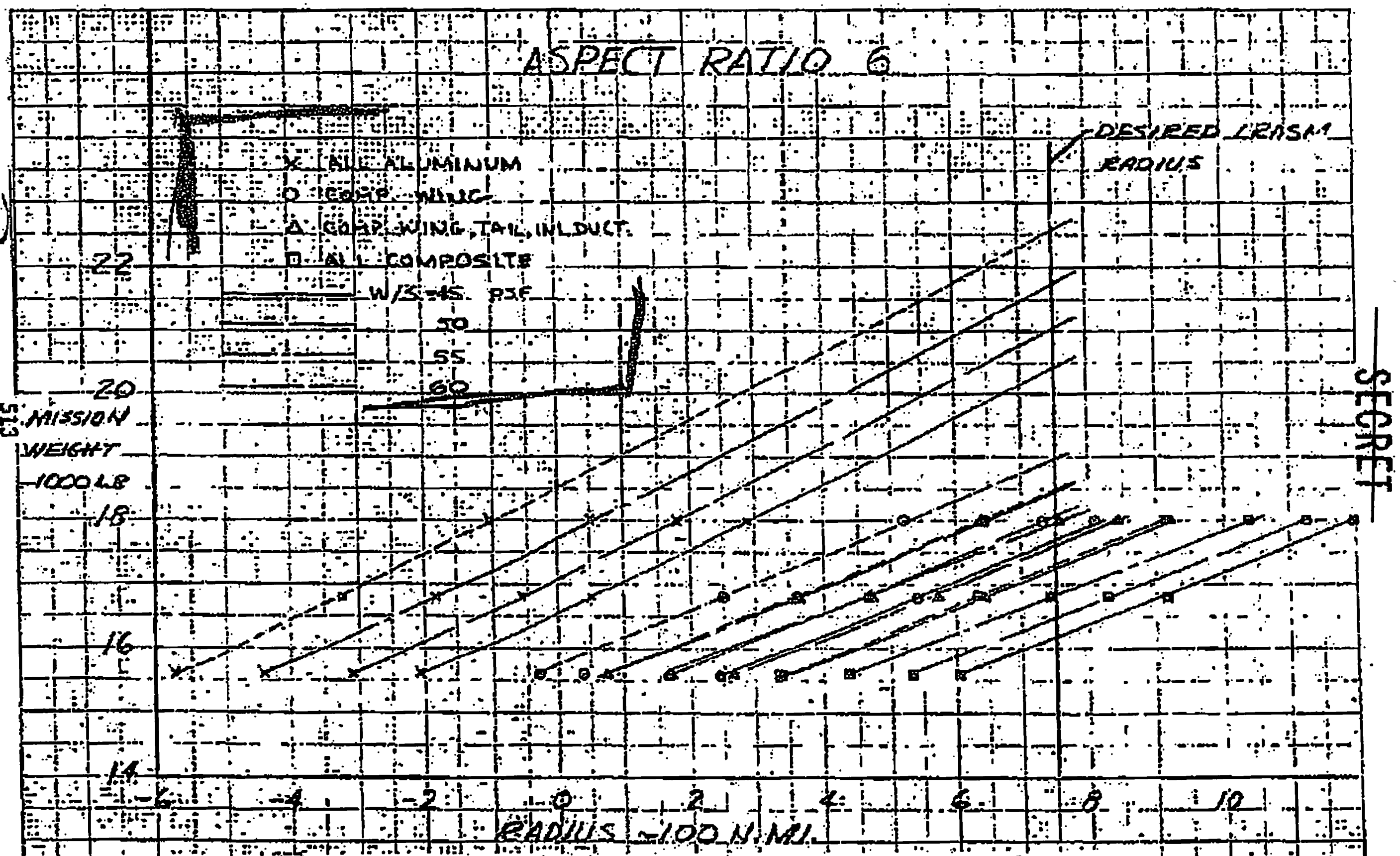
(S) Figure 8.2-3 LRASM Growth Curves for Configuration 401B with Aspect Ratio 5.0 Wing (U)

SECRET

88th ABW/IPI
FOIA (b)(1)
E.O. 13526 SEC 3.3 (b)(4)
1.4. (a)(g)

EO13526
SEC 3.3(b)(4)
SEC 1.4(a)(g)

SECRET



(S) Figure 8.2-4 LRASM Growth Curves for Configuration 4013 with Aspect Ratio 6.0 Wing (U)

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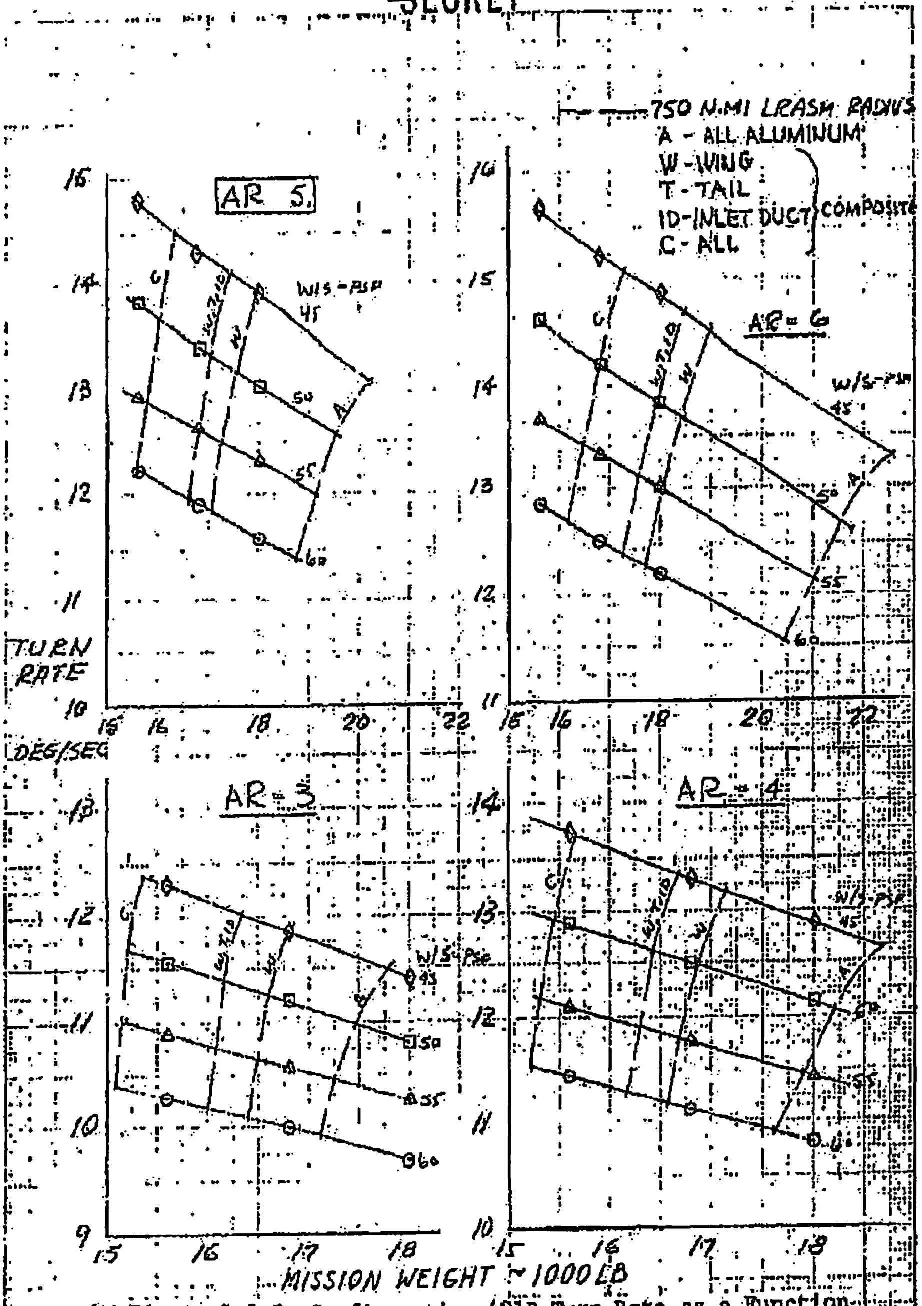
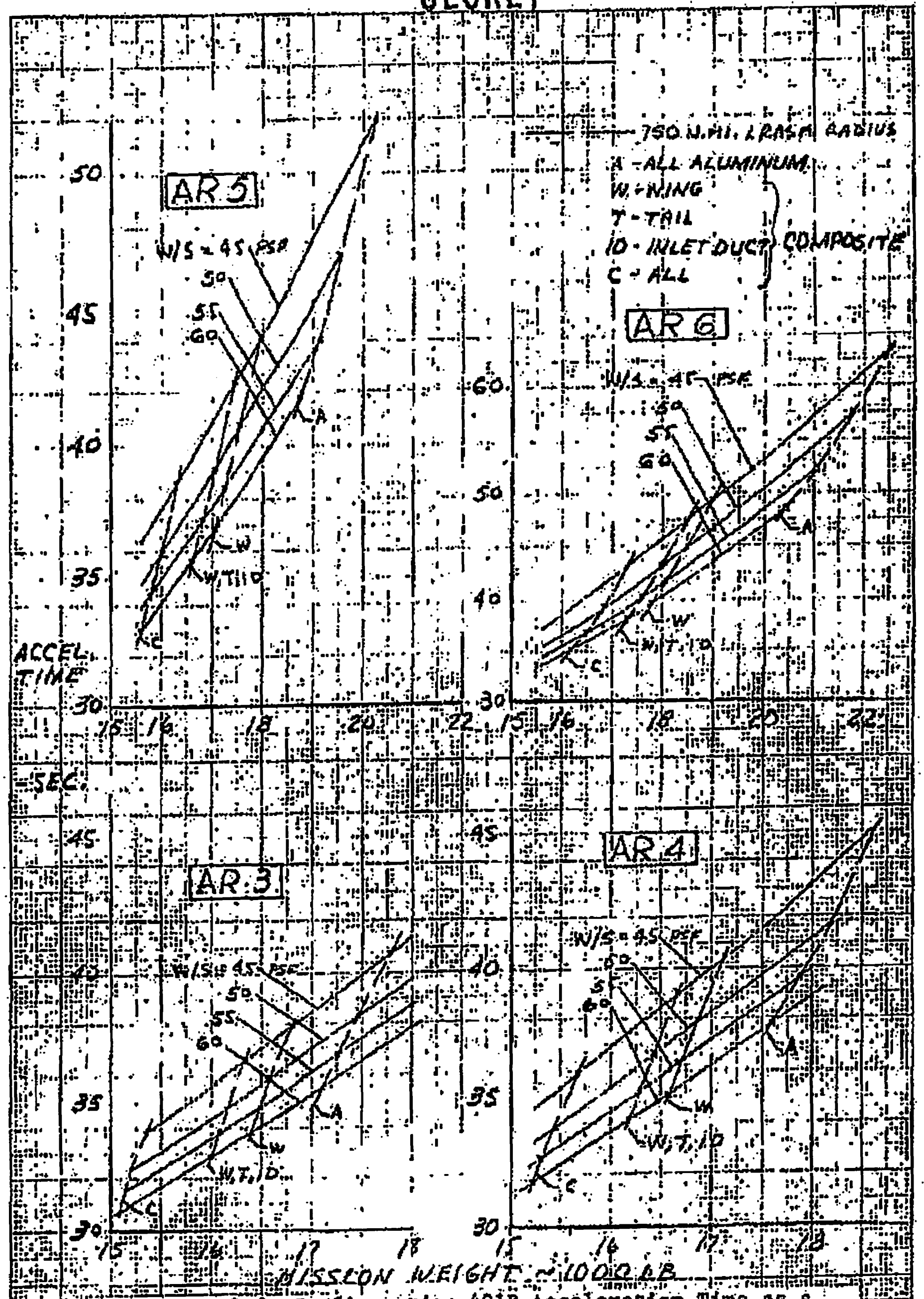


~~(S)~~ Figure 8.2-5 Configuration 401B Turn Rate as a Function of Aspect Ratio and Wing Loading ~~(U)~~

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 8.2-6 Configuration 401B Acceleration Time as a Function of Aspect Ratio and Wing Loading (U)

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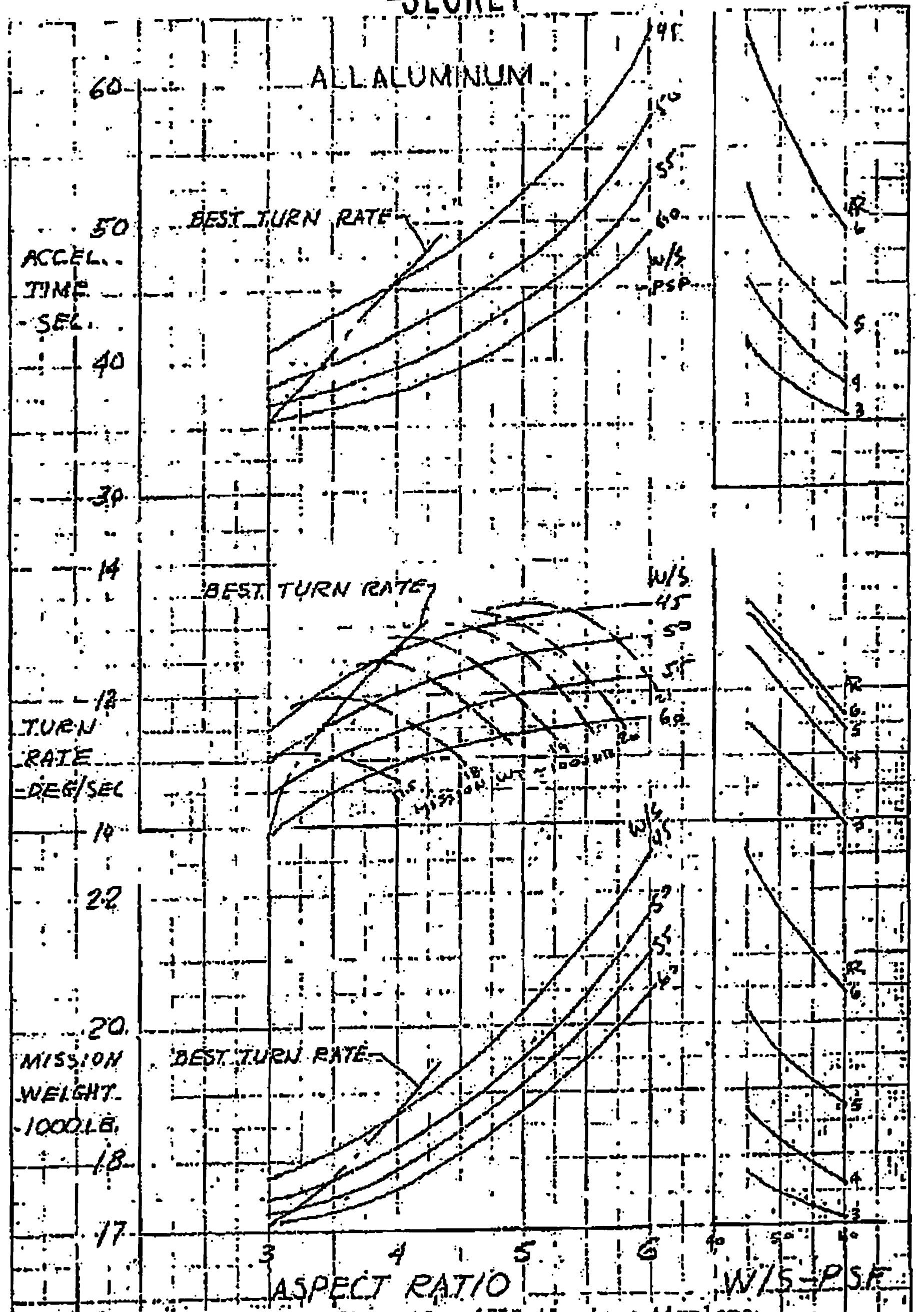

~~(S)~~ Figure 8.2-7 Configuration 4018 Aluminum Airplane LRASM Performance Trades (U)

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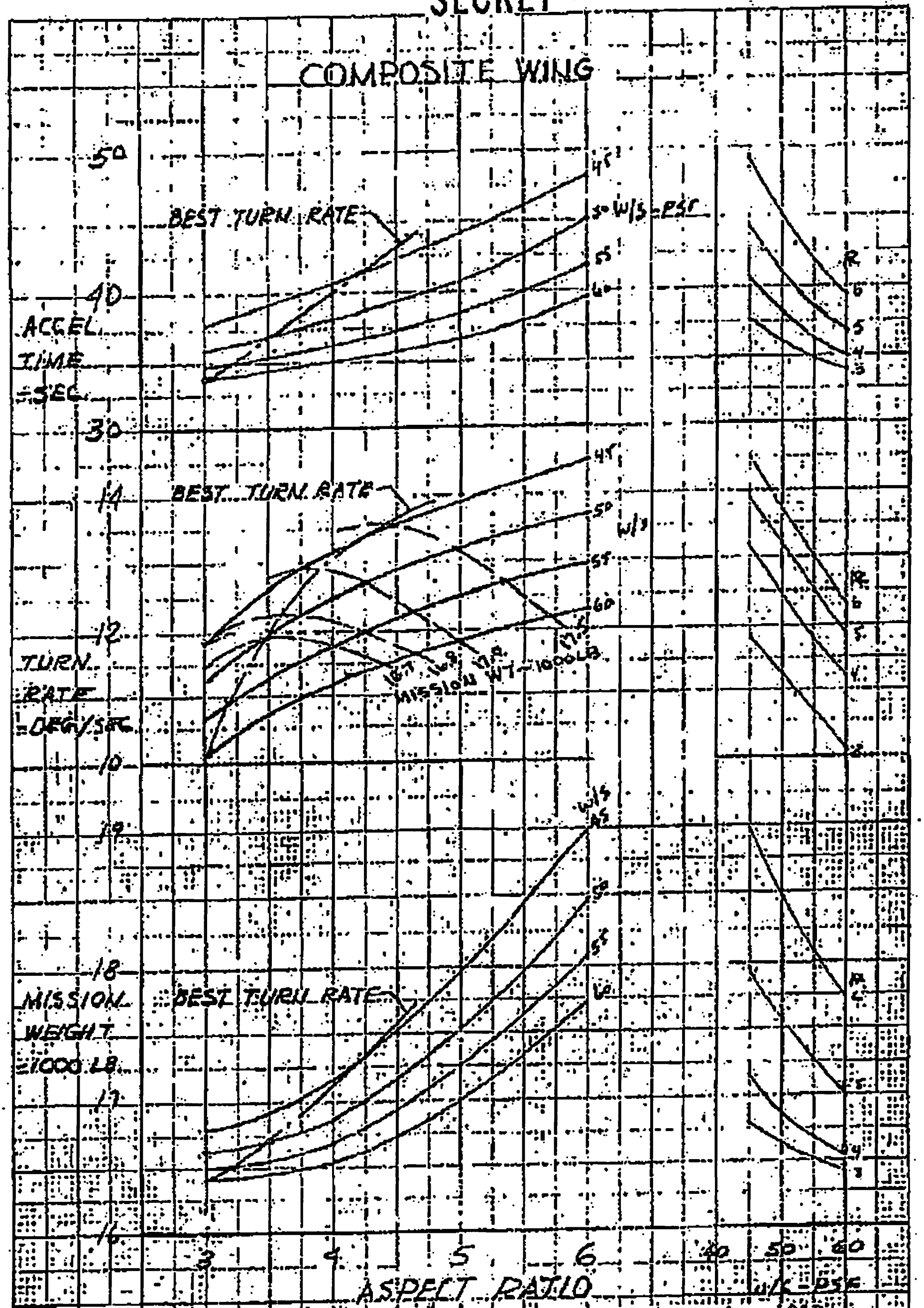
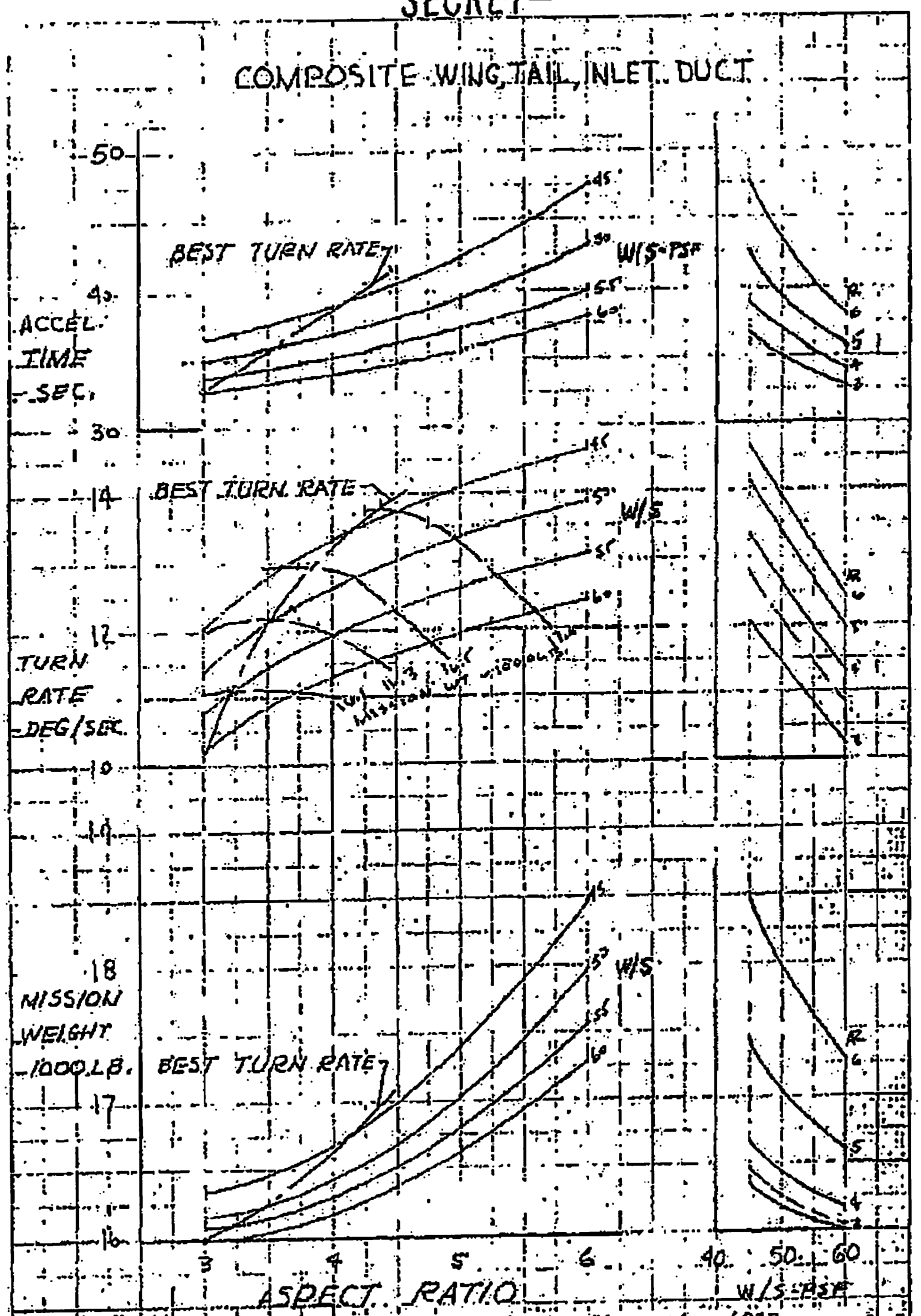


~~(S)~~ Figure 8.2-8 LRASM Performance Trades for Configuration 401B with Composite Material Wing (U)



~~(S)~~ Figure 8.2-9 LRASM Performance Trades for Configuration 401B with Composite Material Wing, Tail, and Inlet Duct (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC.
3.3.(b)(4)
1.4. (a)(g)

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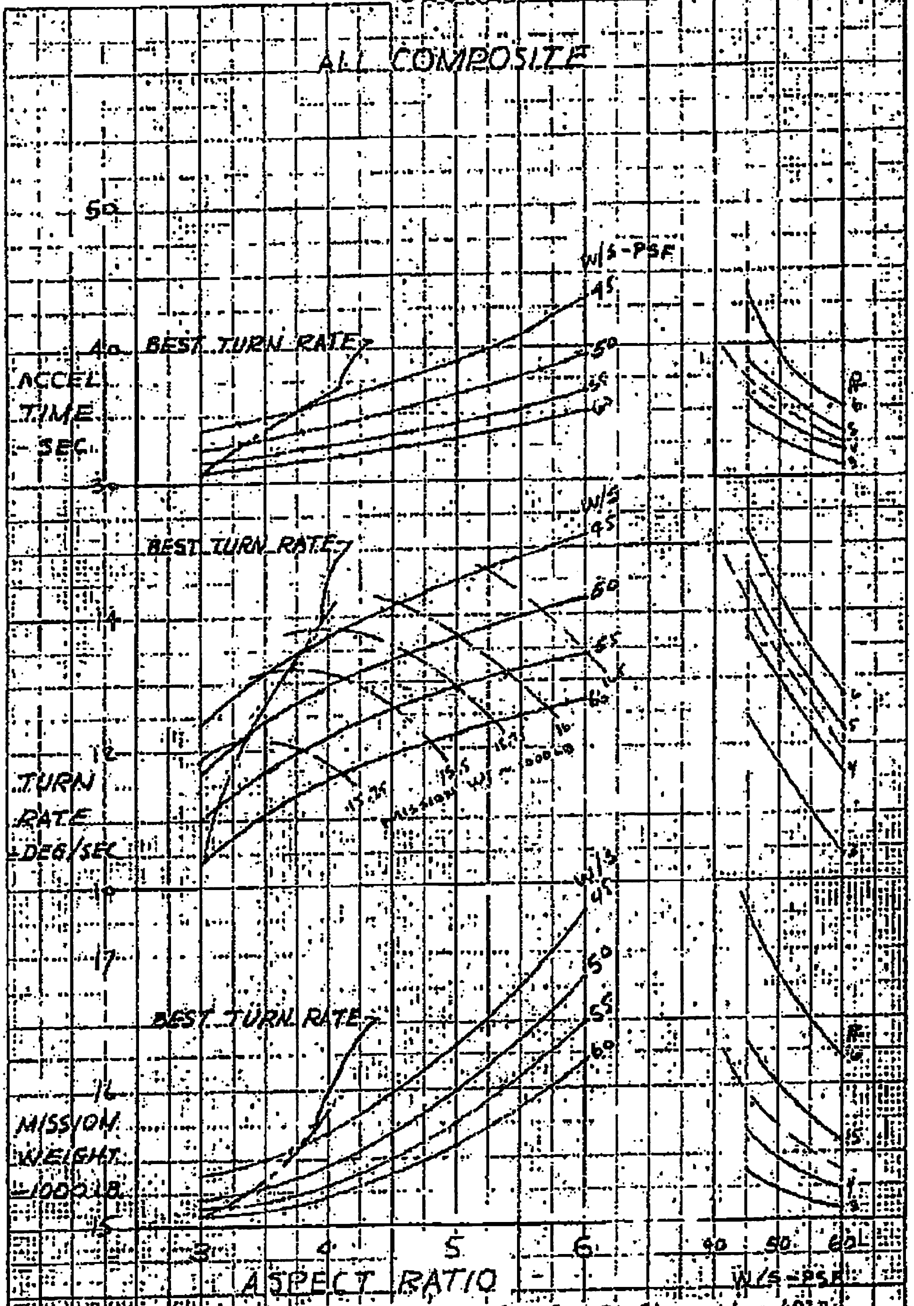
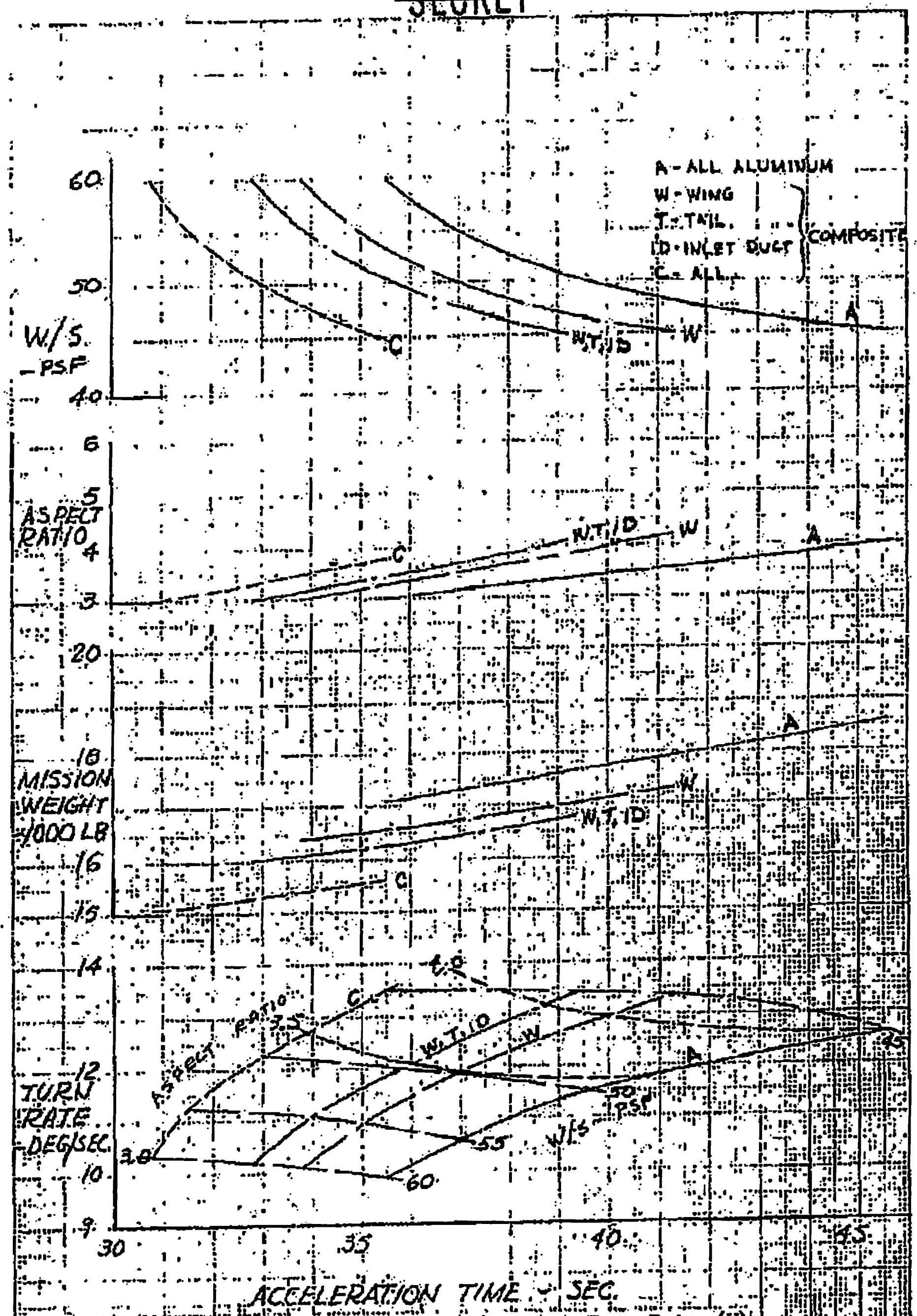


~~(S)~~ Figure 8.2-10 LRASM Performance Trades for Configuration 401B All-Composite Material Airplane (U)

~~SECRET~~



(S) Figure 8.2-11 Configurations for Best Turn Rate (U)

[redacted]

8.3 AERODYNAMICS

(U) With respect to aerodynamics there is a matrix of 48 aircraft configurations:

$AR = 3.0, 4.0, 5.0, 6.0$

$W/S = 45, 50, 55,$ and 60 psf

G.W. = 15,600, 16,800, and 18,000 lb

The approach is to generate complete aerodynamics data for each of the aspect ratios at a reference gross weight and wing loading. Variations in gross weight and wing loading from the reference are then given as increments in minimum drag. The fundamental assumption here is that, to a first-order analysis, changes in airplane size or wing loading do not affect the induced-drag coefficient.

(U) The reference gross weight and wing loading are 16,800 lb and 60 psf respectively. The reference AR = 3.0 data is that of the 401B Configuration discussed in Section 3. All planforms have curved tips similar to the 401B airplane; therefore, the true aspect ratios are 3.2, 4.27, 5.33, and 6.4.

8.3.1 Minimum Drag

(U) In Figure 8.3-1, $C_{D_{min}}$ versus Mach number is plotted for the reference configurations at sea level. The methods and procedures are the same as those described in Section 3.3. The area-rule procedure (K35) was used to compute wave drag for each of the configurations shown. The minimum-drag coefficient at other altitudes may be incremented by the amounts shown in Figure 3.3-1 of Section 3.3.

(U) The variation in minimum drag as a function of gross weight and wing loading is plotted in Figure 8.3-2. The increments shown are from the reference 60-psf wing loading and 16,800-lb gross weight and are applicable to all aspect ratios.

8.3.2 Drag Due to Lift

(U) The drag due to lift for the AR = 4.0, 5.0, and 6.0 wings was obtained by applying aspect-ratio corrections to the drag due to lift of the Configuration 401B airplane (AR = 3.0). At subsonic speeds, the correction is simply

$$C_{D_{L_{AR_1}}} = (C_{D_L})_{401B} \times \frac{3.0}{AR_1}$$

(U) At supersonic speeds, the induced drag factor, K (= C_{D_L}/C_L^2), is predicted by the method given in the USAF Stability and Control Datcom (Reference 9). This method is also given in Reference 1. The ratio of the induced-drag factor is applied to the 401B drag-due-to-lift data given in Section 3.3:

$$C_{D_{L_{AR_1}}} = C_{D_{L_{401B}}} \times \frac{K_{401B}}{K_{AR_1}}$$

8.3.3 Trim Drag

(U) Since trim drag is largely a function of tail load required to trim and wing-span efficiency, it is assumed that trim drag is proportional to induced drag. The same ratios applied to the induced drag are also applied to the baseline trim drag.

8.3.4 Trimmed Drag Polars

(U) The subsonic and supersonic drag polars for the aspect ratio 4.0, 5.0, and 6.0 wings at the reference gross weight and wing loading are presented in Figures 8.3-3 through 8.3-8.

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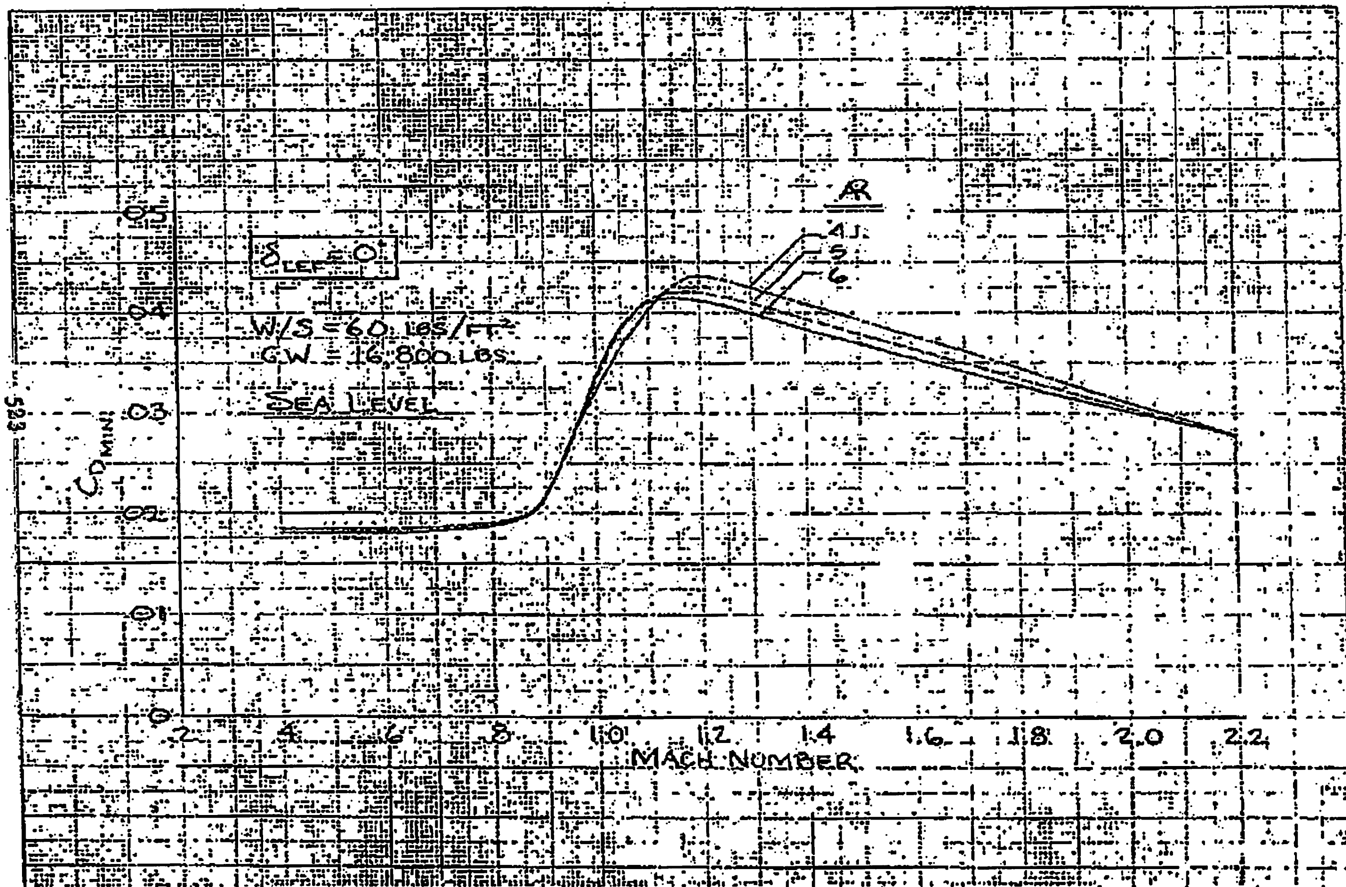

(S) Figure 8.3-1 Minimum Drag vs Mach Number, ĀR = 4, 5, and 6

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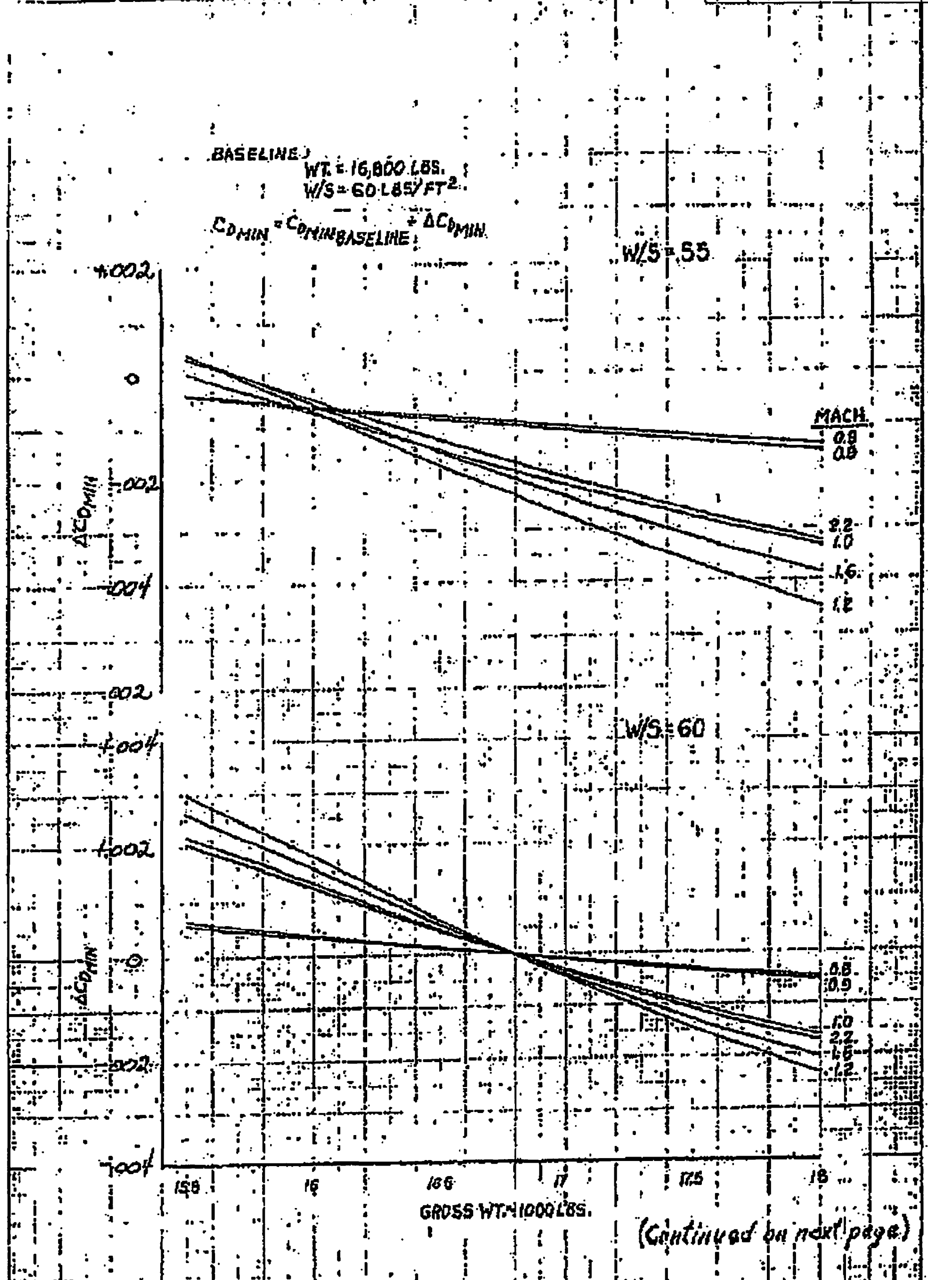
88th ABW/IPI
~~FOIA (b)(1)~~
~~E.O 13526 SEC 3.3(b)(4)~~
1.4 (a)(g)
FOIA (b)(1)
EO 13526 SEC 3.3(b)(4)
SEC 1.4 (a)(g)
pg 523-531

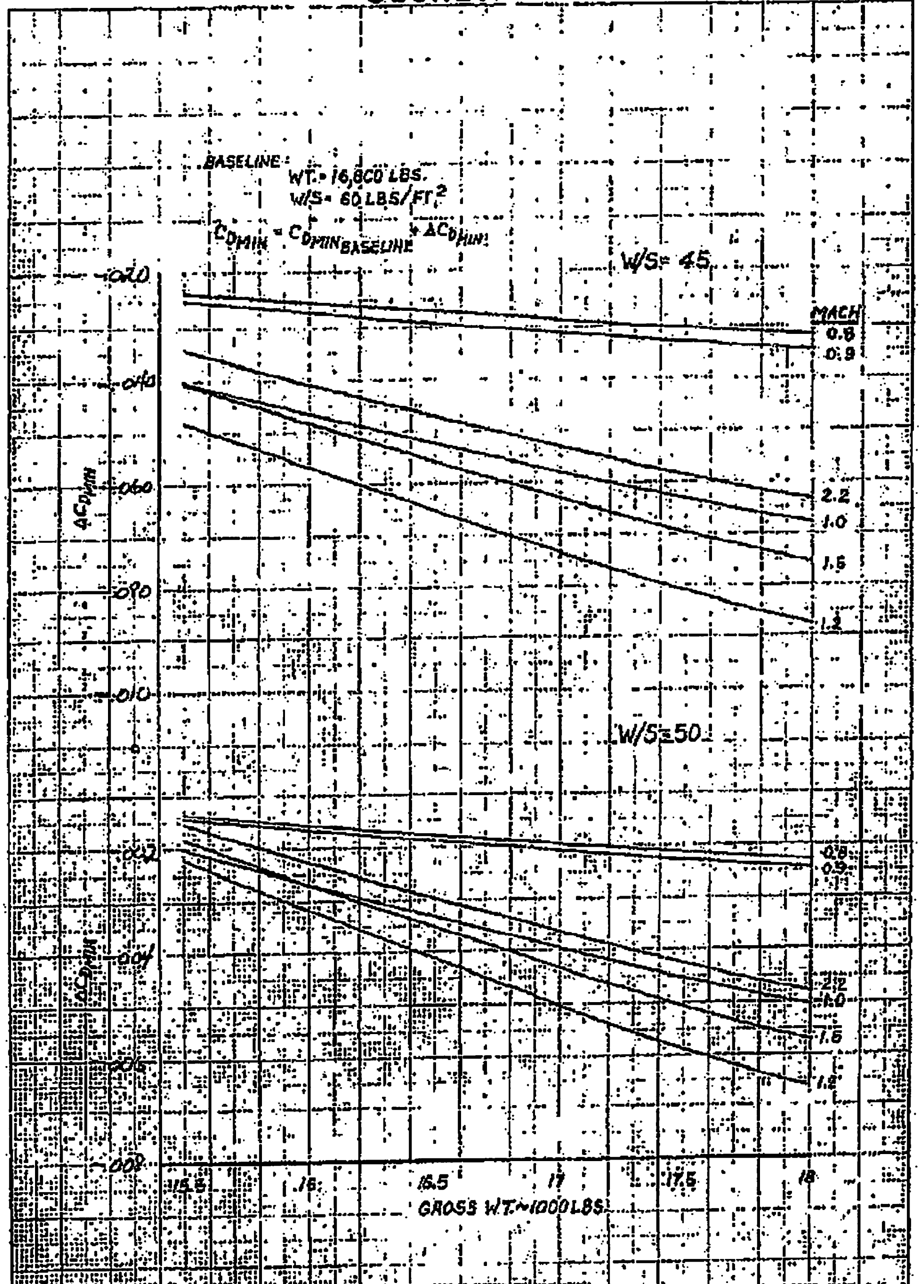
88th ABW/IPI
~~FOIA (b)(1)~~
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)



(Continued on next page)

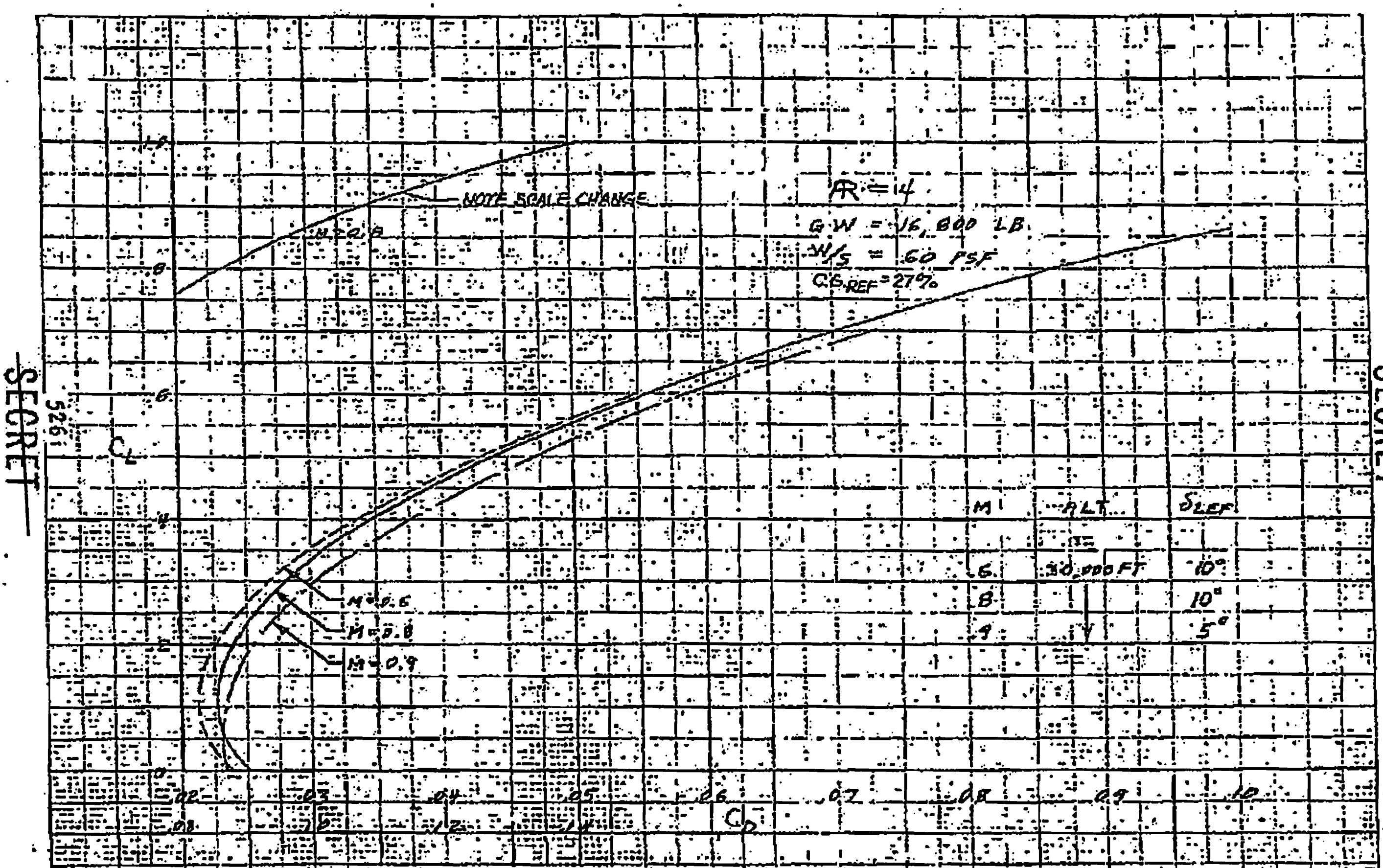
~~(S)~~ Figure 8.3-2 Aircraft Growth and Wing Loading Effect (U)

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)

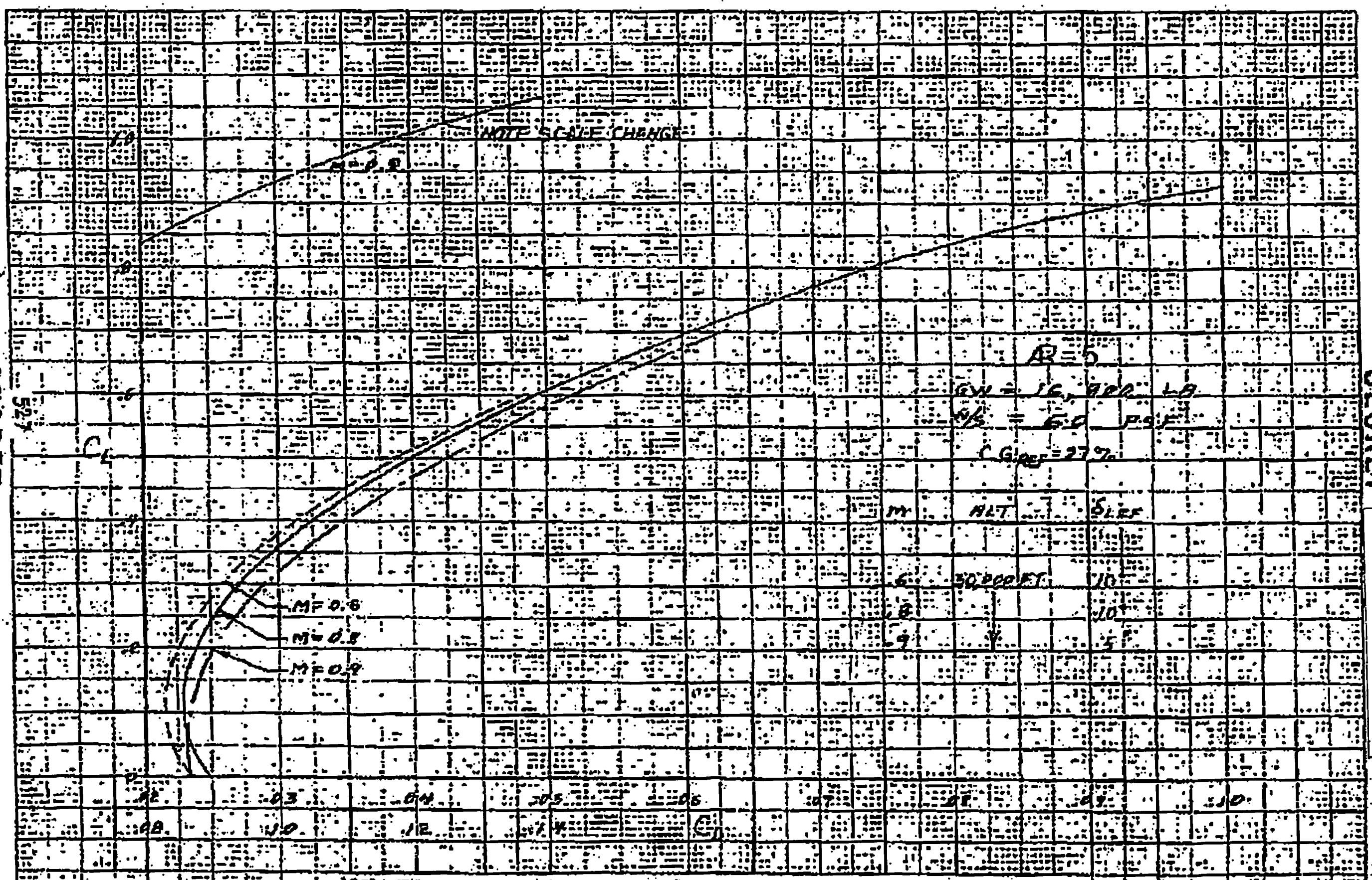


~~(S)~~ Figure 8.3-2 Continued

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.
(b)(4)
1.4. (a)(g)



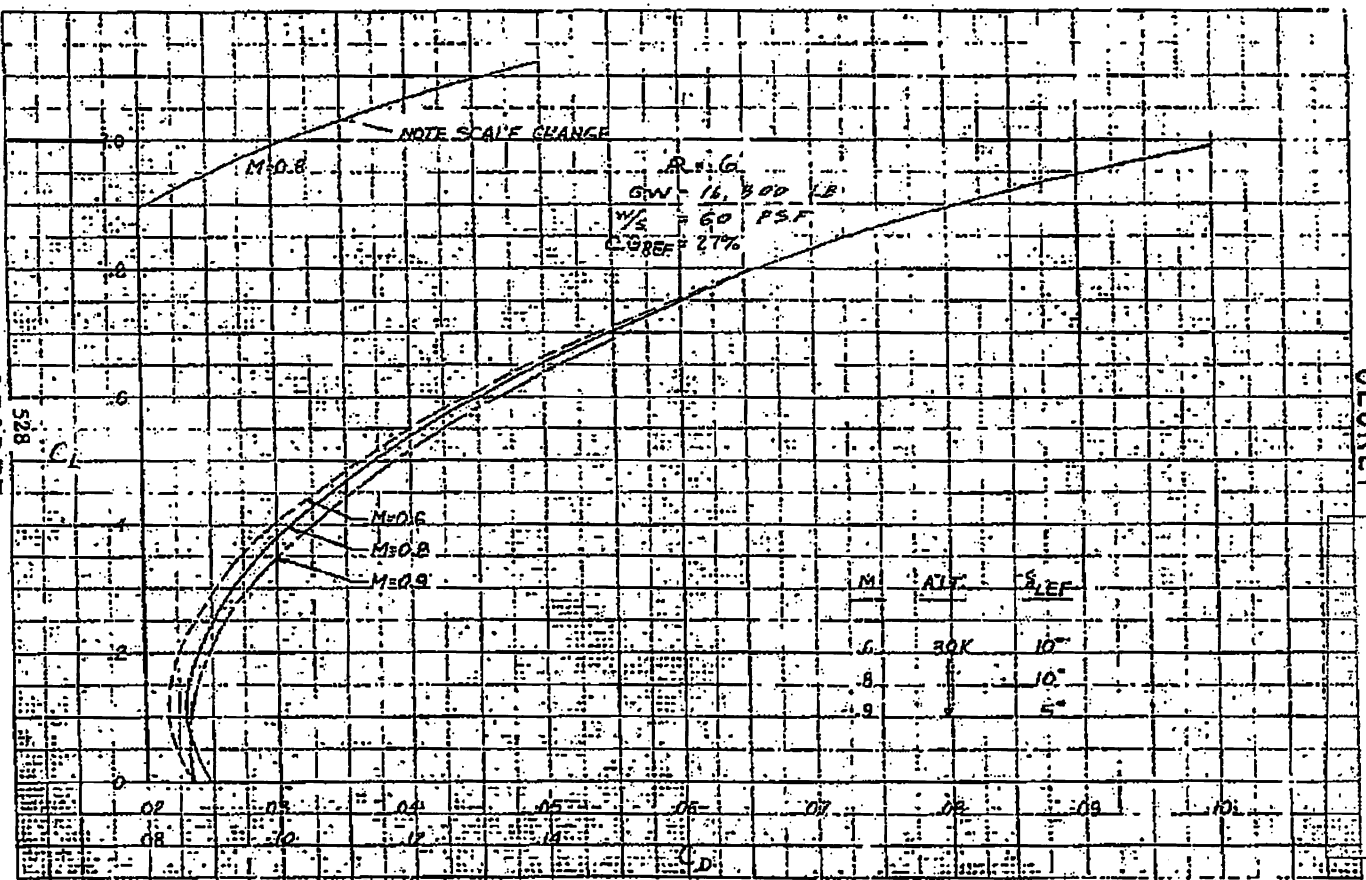
(S) Figure 8.3-3 Trimmed Subsonic Drag Polars, AR = 4



~~(S)~~ Figure 8.3-4 Trimmed Subsonic Drag Polars, AR= 5

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)(4)
1.4. (a)(g)

~~SECRET~~

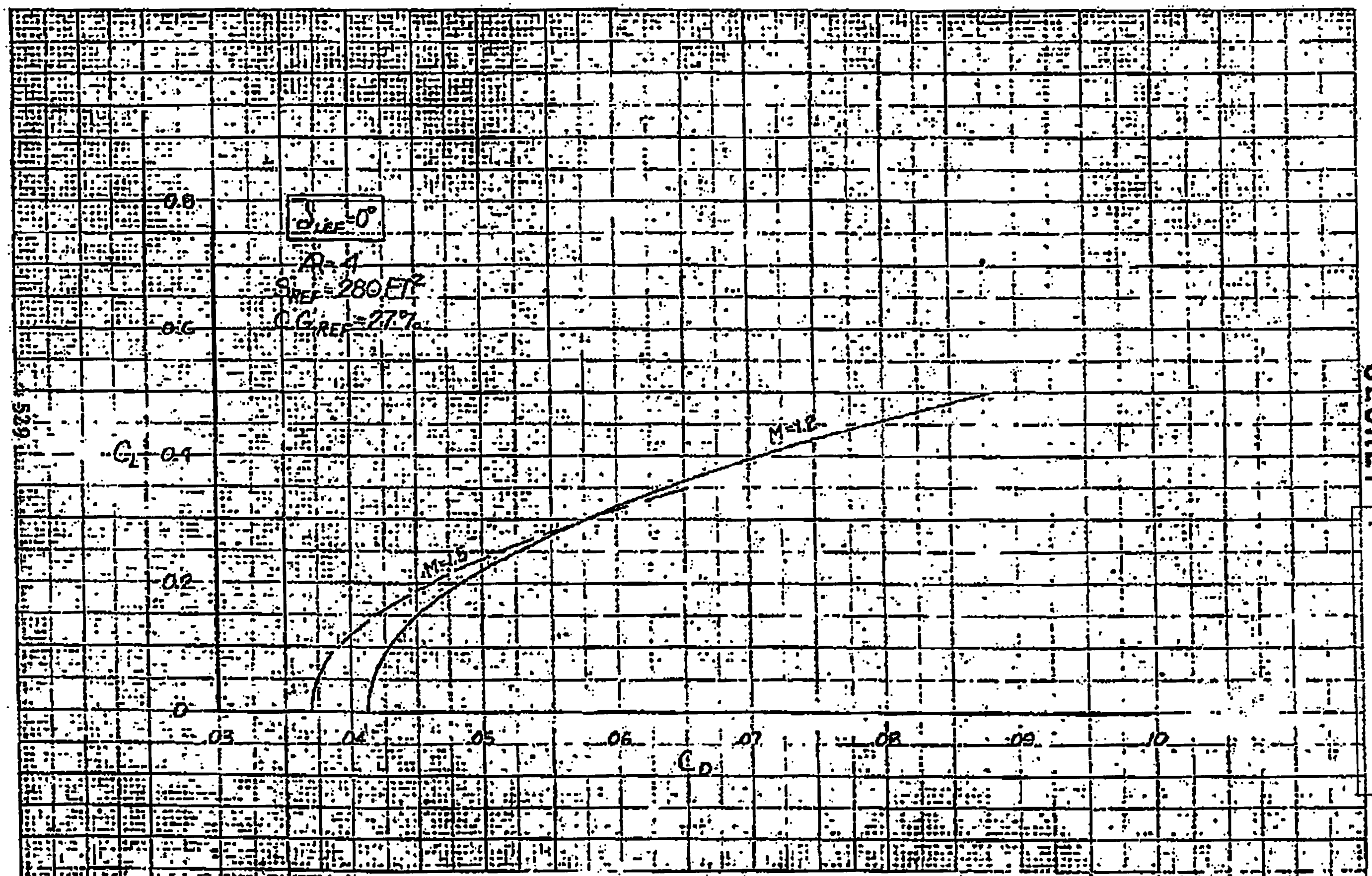


(S) Figure 8.3-5 Trimmed Subsonic Drag Polars, Æ = 6

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
E.O.13526 SEC. 3.3.(b)
(4)
1.4. (a)(g)

~~SECRET~~

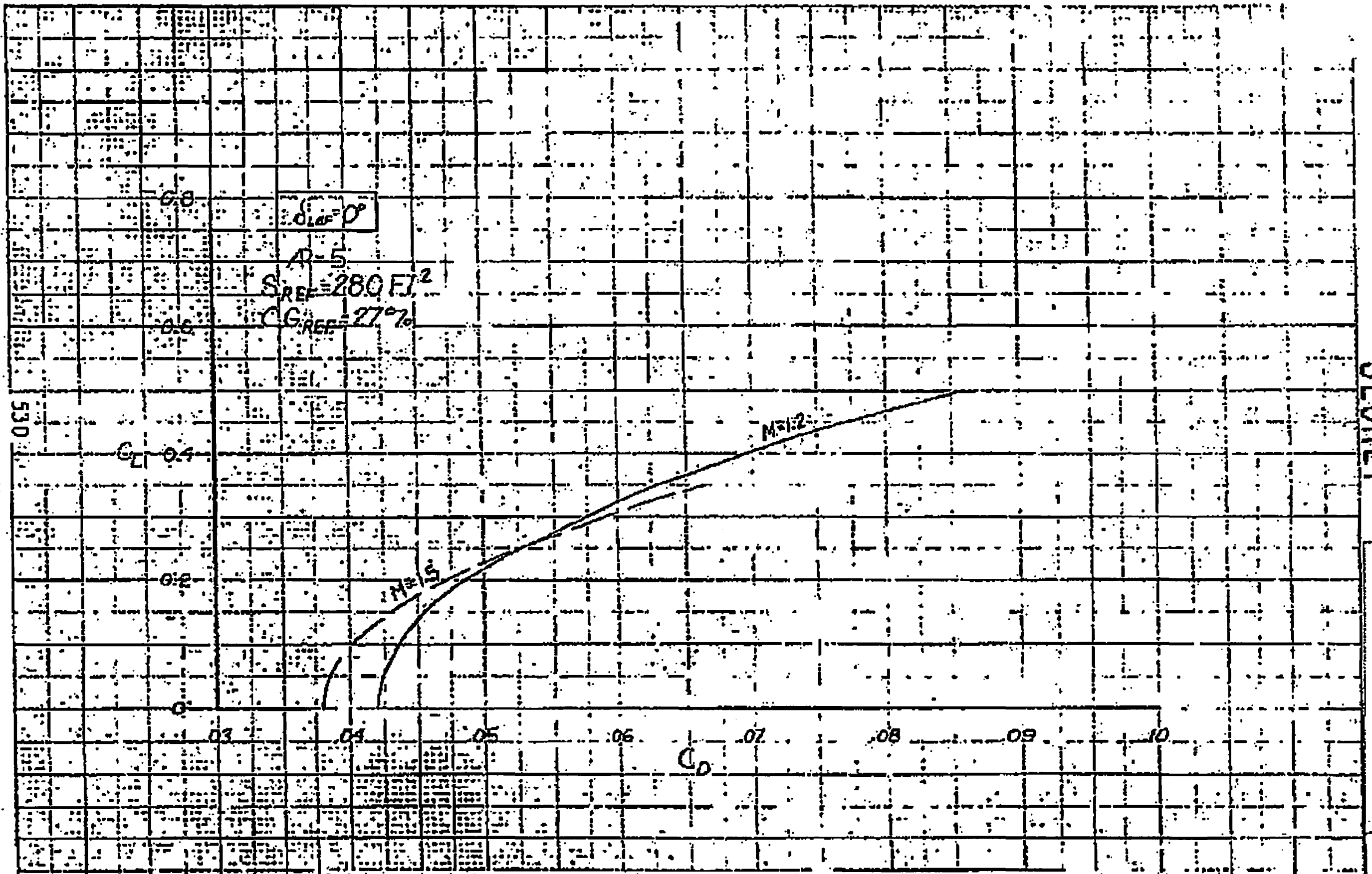


(S) Figure 8.3-6 Trimmed Supersonic Drag Polars, AR = 4

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
~~E.O. 13526 SEC. 3.3.(b)(4)~~
1.4. (a)(g)

~~SECRET~~

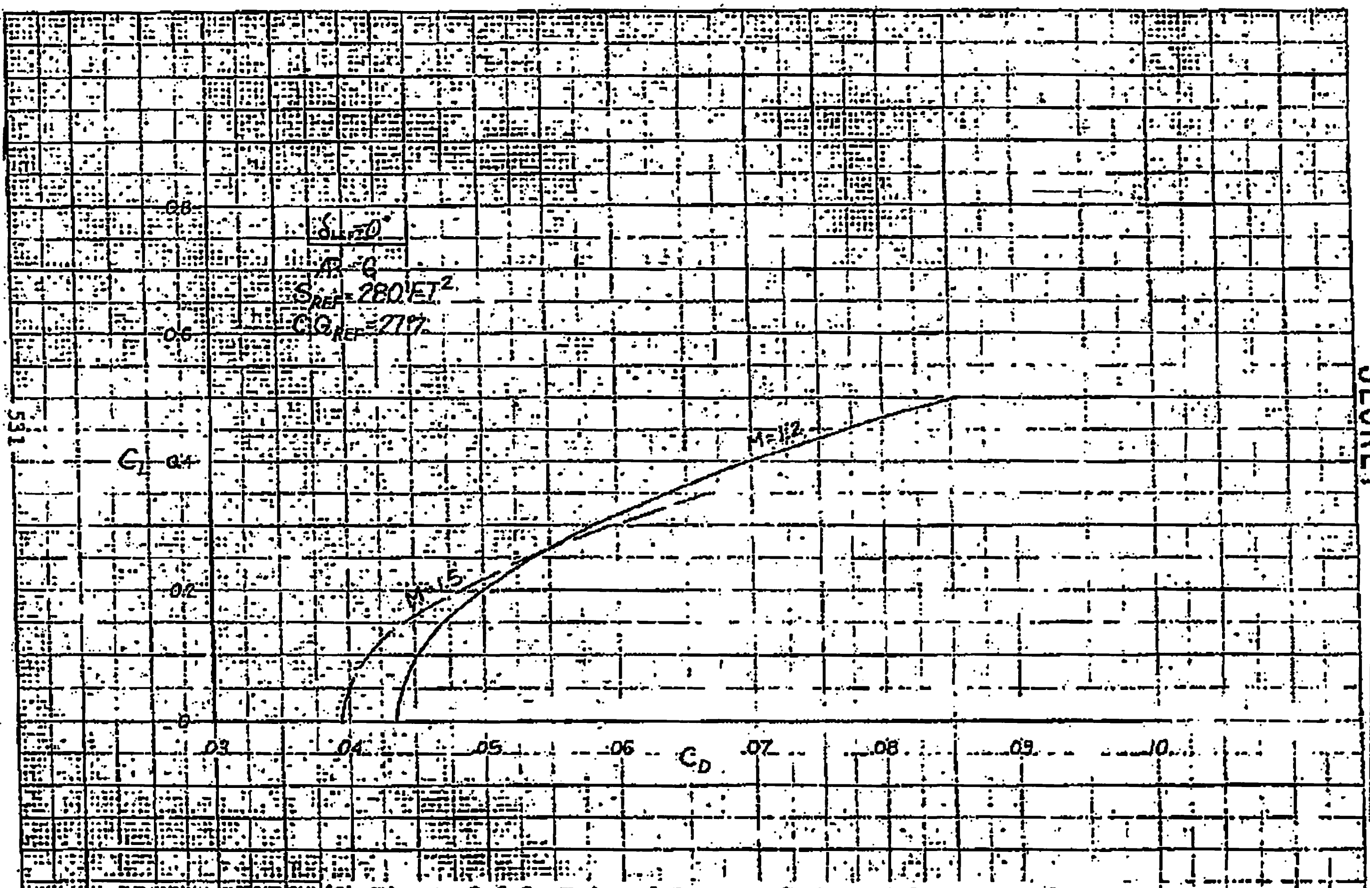


(S) Figure 8.3-7 Trimmed Supersonic Drag Polars, $AR = 5$

~~SECRET~~

88th ABW/IPI
FOIA (b)(1)
~~E.O.13526 SEC. 3.3.(b)(4)~~
1.4. (a)(g)

~~SECRET~~



~~(S)~~ Figure 8.3-8 Trimmed Supersonic Drag Polars, $AR = 6$

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8.4 STABILITY, CONTROL, AND HANDLING QUALITIES

(U) For the composite-material aircraft matrix study, similar general guidelines were given for realistic sizing of the horizontal and vertical stabilizing surfaces as was done for the supercritical wing parametric study (Section 7.5). Ground rules followed in sizing the tails are specified in Subsection 8.1.2. No specific stability and control parameters were generated for this study.

8.5 STRUCTURES AND WEIGHTS

~~(S)~~ For the composite materials study, a matrix of 48 airplanes was selected with the variables of gross weight, aspect ratio, and wing loading. The 3 x 4 x 4 matrix for the study is shown below:

GW	AR	W/S
15600	3	45
16800	4	50
18000	5	55
	6	60

(U) Weight analyses were performed for all airplanes, with aluminum serving as the basic structural material to provide a baseline. The aluminum weights were calculated by the analytical-statistical methods previously described (see Section 3.1). Weights were developed for three levels of composite usage:

1. All composite
2. Composite wing only
3. Composite wing, tails, and inlet duct.

(U) In the study, all of the structural material was not changed to composite in the individual components. In regions of high-load introduction and high-load interaction such as the wing-fuselage interaction, landing gear bulkheads, and gun support structure, there was no attempt to use composites.

(U) Conversion factors were developed from data generated during composite materials research conducted over the past decade. The boron-epoxy and graphite-epoxy systems have advanced from basic materials testing through flight test and limited production in certain applications. With the data from these studies, an assessment of realistic weight savings was made, and weight conversion factors were derived. The factors were then applied to the various structural items of the aluminum component weights to determine the composite weights.

~~(S)~~ The fuselage weight saving is based on the engineering analysis for the F-5 composite fuselage presently being fabricated by Convair Aerospace. The horizontal tail data were obtained from the F-111A composite production tail. Several previous studies were used as a basis for the vertical tail factors. Strength-density factors were applied to the theoretical skins of the wing structural box, and savings on secondary structure were based on existing hardware. No composite savings were attempted for the landing gear.

(U) Weight summaries for the various levels of composite usage and for the aluminum baseline are given in Tables 8.5-1 through 8.5-4. The resulting zero-fuel-weight-vs-aspect-ratio curves are shown in Figures 8.5-1 through 8.5-3.