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INTRODUCTION

THE NEED . . .

REDUCE RUNWAY LENGTH

ELIMINATE RUNWAYS

ACHIEVE DISPERSED BASE OPERATION

THE MEANS . . .

LENGTH REDUCTION

WATER INJECT - AFTERBURNING

DRAG CHUTE - THRUST REVERSAL

ELIMINATION

HELICOPTER - CONVERTIPLANE

TURBOPROP

TURBOJET

ROCKET

PROJECT 1794

THE PROBLEM . . .

VTOL &

MILITARY PERFORMANCE

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GOOD SUPERSONIC L/D

GOOD INTAKE RECOVERY

HIGH THRUST LEVEL

INTEGRATION OF POWER PLANT & AIRFRAME, HIGH VOLUMETRIC EFFICIENCY.

AIRCRAFT WEIGHT EMPTY  
AIR MASS FLOW

AVRO A/C	$\frac{13,000 \text{ LB}}{1,000 \text{ LB/SEC}}$	= 13
F-104A	$\frac{11,269}{162}$	= 70
B-58	$\frac{47,827}{648}$	= 74

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PRESENTATION ON  
USAF PROJECT 1794

TITLE: AVRO VERTICAL TAKE-OFF AIRCRAFT

CONTRACTOR: AVRO AIRCRAFT LIMITED  
MALTON, ONTARIO, CANADA

PROJECT  
OFFICE: NEW DEVELOPMENT OFFICE (RDZSBA)  
BOMBARDMENT AIRCRAFT DIVISION  
DIRECTORATE OF SYSTEMS MANAGEMENT  
HQ ARDC, WRIGHT-PATTERSON AFB, OHIO

FOR: AIRCRAFT PANEL, USAF SCIENTIFIC ADVISORY BOARD

DATE: 20 AUGUST 1956

PLACE: LOS ANGELES, CALIF.

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PERSONNEL

HQ ARDC, WRIGHT-PATTERSON AFB, OHIO

COL. J.C. MAXWELL  
CHIEF, BOMB A/C DIV., DIR SYSTEMS MGT.

MAJ. W.R. STEPHENS  
ACTG CHIEF, NEW DEV., BOMB A/C DIV

WADC, WRIGHT-PATTERSON AFB, OHIO

MAJ. R.Z. NELSEN  
WIND TUNNEL BR., ACFT LAB

LT, B.H. PAIEWONSKY  
FLIGHT CONTROLS LAB

MIT

MR. E.E. COVERT  
NAVAL SUPERSONIC LAB

AVRO AIRCRAFT LIMITED, CANADA

MR. J.R. DOUGLAS - CONTRACTS ADMINISTRATOR

MR. J.C.M. FROST - CHIEF DESIGN ENGINEER, SPEC PROJ

MR. T.D. EARL - CHIEF AERODYNAMIST, SPEC PROJ

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PRESENTATION OUTLINE

BACKGROUND	MAJ. STEPHENS
CURRENT STATUS	MAJ. STEPHENS
DESIGN CONCEPT	MR. FROST
PERFORMANCE	MR. FROST
TESTING	MR. EARL
STUDY RESULTS	MR. EARL
ARDC EVALUATION	MAJ. STEPHENS
FUTURE PROSPECTS	MAJ. STEPHENS

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BACKGROUND

COMPANY ORIGINATED PROGRAM 1952  
TCO EXTENSIVE FOR RCAF 1954

USAF EVALUATION

ATTRACTIVE POSSIBILITIES

NO NATURAL LAWS VIOLATED, BUT FACTUAL DATA LACKING TO  
DETERMINE TECH FEASIBILITY TO ESTABLISH MILITARY  
POTENTIAL.

CONTRACTUAL

CONTRACT NO. AF33(600)-30161

MAY 1955 - JULY 1956

\$785,000 FIXED PRICE, NON-PROFIT

ANALYSES AND TESTS TO DETERMINE PRACTICABILITY OF DEVELOPING A  
FLAT VTOL, SUPERSONIC AIRCRAFT.

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BACKGROUND (CONT'D)

PRACTICABILITY INVESTIGATION  
MINIMUM EFFORT INVEST OF MAJOR PROBLEMS

DEFINED BY:

ARDC EVALUATION	JUN 54
SAB REPORT	NOV 54
NACA REVIEW	JUL 55

PROBLEM AREAS:

GROUND CUSHION EFFECT  
STABILITY & CONTROL  
INTAKE & EXHAUST SYSTEMS  
AIRCRAFT PERFORMANCE  
PROPULSION SYSTEM

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BACKGROUND (CONT'D)

VISITS TO AVRO

29 FEB - U.S. NAVY  
BUREAU OF AERO & CNO

23 MAY

OFFICE SECRETARY OF DEFENSE

OFFICE SECRETARY OF AIR FORCE

HQ NACAM HQ USAF, RCAF

13 JULY

GEN'S BAKER & MITCHELL, HQ AMC

20 JULY

MR. HORNER & MR. HURLEY, O. ASST SECY AF

PRESENTATIONS

HQ ARDC, HQ USAF 22 JUN, 28 AUG

COORD COMM DEPT OF DEF 25 JUN

SAB PANELS, EGLIN AFB 12 APR

CONTACTS BY

DEFENSE RESEARCH BOARD, CANADA

RCAF

BRITISH MINISTRY OF SUPPLY

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EVALUATION OF RESULTS INDICATES PRACTICABILITY OF DESIGN CONCEPT,  
TENDS TO SUPPORT CONTRACTOR'S ESTIMATES, POINTS OUT PROBLEMS TO  
SOLVED.

AVRO FUNDED PROGRAM

DESIGN & FABRICATE ONE RESEARCH AIRCRAFT  
INITIATED JAN 56 - FIRST FLIGHT 1958

TO

REDUCE DEVELOPMENT TIME  
ESTAB RIGHTS TO DESIGN CONCEPT  
DEMONSTRATE CC. FAITH IN PROJECT

NO COST CONTRACT EXTENSION

MAINTAINS ADMINISTRATIVE ARRANGEMENTS  
PROVIDES USAF ACCESS TO COMPANY PROGRAM

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TEST PROGRAM

PURPOSE:

TO PROVIDE FACTUAL DATA AS BASIS FOR DETERMINING PRACTICABILITY  
OF DEVELOPING A WEAPON SYSTEM,

LIMITATIONS:

FUNDING CUT TO MIN EFFORT LEVEL; ONE YEAR PROGRAM PRESCRIBED;  
NACA SUPPORT DENIED.

INCLUDED:

HOVER & LOW SPEED TESTS AT WADC

460 HRS, 20 FT TUNNEL

580 HRS, STATIC CAL & TEST

MACH RANGE 0.0 TO 0.4

MODEL: 5 FT DIA REFLECTION PLANE

HIGH SPEED TESTS AT MIT

90 HRS, NSL TUNNEL

MACH RANGE 1.5 TO 3.0

MODELS: STING, INTAKE, 18" REFLECT PLANE

TEST RIGS AT AVRO

GROUND EFFECTS MODEL

CONTROL SHUTTER

EXHAUST SYSTEM SECTOR

ANALYSES

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AIR CUSHION EFFECT (Dwg)

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PROJECT 1794 INTAKE PRESSURE RECOVERY (Dwg)

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PROJECT L794 VARIATION OF MAX L/D RATIO WITH MACH NR (Dwg)

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CURRENT STATUS

PRACTICABILITY INVEST COMPLETED & EVALUATED

CONTRACT EXTENDED ON NO COST BASIS

MAINTAINS ADMINISTRATIVE ARRANGEMENTS

PROVIDES USAF ACCESS TO COMPANY PROGRAM

PROVIDES MUTUAL AGREEMENT TEST PROGRAM

AVRO RESEARCH ACFT PROGRAM

DESIGN & FABRICATE ONE AIRCRAFT

INITIALLY SUBSONIC - MOD TO SUPERSONIC

INITIATED JAN 1956

FIRST FLIGHT EARLY 1958

PURPOSE

REDUCE DEVELOPMENT TIME

ESTAB RIGHTS TO DESIGN CONCEPT

DEMONSTRATE CO FAITH IN PROJECT

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FUTURE PROGRAMS

RESEARCH AIRCRAFT DEVELOPMENT

PURPOSE:

CORRELATE TEST DATA & VERIFY THEORY BY FULL SCALE FLIGHT TEST

INVESTIAGE AERO & THERMO PROBS TO INCLUDE:

VTOL & STOL

ARTIFICIAL STABILITY SYSTEMS

CONTROL BY JET REACTION

JET FLAP EFFECT

HIGH SPEED, HIGH ALT FLT

FLIGHT TEST EQUIP & SUBSYSTEMS

ESTABLISH BASIC DESIGN CRITERIA FOR DEV OF OPERATIONAL  
WEAPON SYSTEMS

1st SERVE AS GROUND TEST BED

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AVRO PROJECT PV 704

DESIGN & MANUFACTURE ONE RESEARCH A/C

35.3 FT DIAMETER

13,750 LB BASIC WEIGHT

20,000 LB NORMAL GROSS WT

27,322 LB MAX GROSS WT

PERFORMANCE: (CONTRACTOR'S EST)

MAX SPEED

INITIAL DRY  
M=0.48

AS MODIFIED  
A/B (1700°F)  
M=1.74

CEILING

24,000 FT

85,000 FT

RANGE

400 N.M.

700 N.M.

CRUISE

M=0.45 a 20,000FT M=1.70 a 80,000 FT

INCLUDES:

COMPONENT & SUBSYSTEM DEV

PROPULSION SYST TEST & QUALIFICATION

TOOLING (EXCEPT CHANGES)

FACILITIES (EXCEPT WIND TUNNELS)

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USAF PROGRAM

ADDITIONAL TEST & ANALYSIS TO:

FILL GAPS IN MINIMUM EFFORT PROGRAM, SUPPORT PV 704, USAF  
RESEARCH A/C PRESENTATION

INCLUDE:

SUPER, TRANS & SUBSONIC WIND TUNNEL TESTS  
COMBUSTION SYSTEM DEV FOR SUPERSONIC A/C  
SPARE ENGINE PURCHASE  
STABILITY & CONTROL ANALYSIS  
PROPULSION SYSTEM "OFF DESIGN" ANALYSIS  
APPLICATION STUDIES

DESIGN & FABRICATE TWO RESEARCH A/C

35.3 FT DIAMETER

15,750 LB BASIC WEIGHT

20,000 LB NORMAL GROSS WT

32,800 LB MAX GROSS WT

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USAF PROGRAM (Cont'd)

PERFORMANCE: (Contractor'S EST.)

MAX SPEED	M=2.94
CEILING	94,000 ft
CRUISE	M=2.2 a 90,000 ft
RANGE	988 N.M
TURN ACCEL a 60,000 FT	5.2 g

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COMBINES VTOL OR STOL WITH HIGH ALTITUDE, HIGH SPEED PERFORMANCE  
TO OFFER A WEAPON SYSTEM POTENTIAL NO OTHER KNOWN AIRCRAFT POSSESSES.

SUCCESS NOT ASSURED - MANY DIFFICULT PROBLEMS TO BE SOLVED

ARTIFICIAL STABILITY & CONTROL

PROPULSION SYSTEM

INTERNAL FLOW

HEATED STRUCTURE

NOISE & VIBRATION

INCREASED USAF SUPPORT IS WARRANTED

NEXT STEP - RESEARCH AIRCRAFT PROGRAM

DATA INSUFFICIENT TO INITIATE W/S DEV

STUDY & MODEL TEST ALONE INCONCLUSIVE &  
TIME CONSUMING

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FUTURE OUTLOOK

APPLICATIONS OF A NEW CONCEPT

FLEXIBILITY OF VTOL & STOL WITH OUTSTANDING PERFORMANCE

UNIQUE:

HELICOPTER TYPE MISSIONS  
SHIP BASED AIRCRAFT  
ARMY AERIAL FIGHTING VEHICLE

CONVENTIONAL:

SPECIAL RECON W/S  
INTERCEPTOR  
FIGHTER-BOOMB OR TACTICAL BOMBER

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CONCLUSION

COMBINE VTOL OR STOL WITH HIGH ALTITUDE, HIGH SPEED PERFORMANCE  
TO OFFER AN UNIQUE WEAPON SYSTEM POTENTIAL.

SUCCESS NOT ASSURED - MANY DIFFICULT PROBLEMS TO BE SOLVED

ARTIFICIAL STABILITY & CONTROL

PROPULSION

INTERNAL FLOW

HEATED STRUCTURE

NOISE & VIBRATION

USAF PROGRAM JAN 57 - OCT 58

AID PROGRESS OF AVRO FUNDED PROGRAM;

PROVIDE DATA & INFO FOR USAF DECISION;

ACCOMPLISH INITIAL STEPS FOR USAF RESEARCH A/C PROG;

STUDY APPLICATION TO WEAPON SYSTEMS

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PROJECT 1794 DRAG & THRUST VS MACH NR 35,000 FT (DUG)

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JUNE 1956

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# AVRO VERTICAL TAKE-OFF AIRCRAFT

## USAF PROJECT 1794

*CONTRACTOR:* AVRO AIRCRAFT LIMITED  
MALTON, ONTARIO, CANADA

*PROJECT OFFICER:* MAJ: W. R. STEPHENS  
HQ ARDC (RDZSBA)  
WRIGHT-PATTERSON AFB, OHIO

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# BACKGROUND

COMPANY ORIGINATED PROGRAM 1952

TOO EXTENSIVE FOR RCAF 1954

## USAF EVALUATION

ATTRACTIVE POSSIBILITIES & NO  
NATURAL LAWS VIOLATED BUT  
FACTUAL DATA REQ'D TO DETERMINE  
PRACTICABILITY & MILITARY POTENTIAL  
LACKING.

## CONTRACTUAL

- CONTRACT NO. AF 33(600)-30161 MAY  
1955 - JULY 1956 - \$ 785,000

- ANALYSES & TESTS TO DETERMINE  
PRACTICABILITY OF DEVELOPING A  
FLAT-VTOL SUPERSONIC A/C.

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# CURRENT STATUS

PRACTICABILITY STUDIES & TESTS COMPLETED

COVERING:

AIR CUSHION EFFECT

STABILITY & CONTROL

INTAKE & EXHAUST SYSTEMS

A/C PERFORMANCE

PROPULSION SYSTEM

INCLUDING:

SUPERSONIC TESTS AT MIT

HOVER & LOW SPEED TESTS AT WADC

EVALUATION OF RESULTS

NO COST, ADMIN. CONTRACT EXTENSION

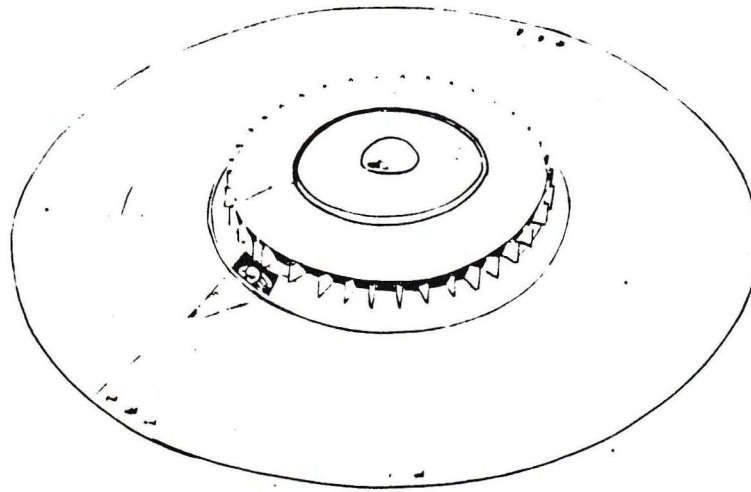
AVRO FUNDED FLT. TEST A/C PROGRAM

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# CHARACTERISTICS



## DESIGN . . .

FLYING POWER PLANT  
CIRCULAR PLANFORM - GROUND CUSHION  
EFFECT FOR VTOL  
DUCTED FAN-RAMJET PROPULSION SYSTEM  
CONTROL BY DIRECTION OF EXHAUST GASES  
STABILITY BY ARTIFICIAL MEANS  
USE OF JET FLAP EFFECT  
27,000 LB WT; 35 FT. DIAMETER

## PERFORMANCE (*contractor's estimated*)

FLAT: VTOL  
SPEED: MACH 3 to 4  
CEILING: 90,000 to 100,000 FT.  
CRUISE: M = 2 @ 85,000 FT.  
RANGE: 1,000 N. MI. @ W<sub>G</sub> = 27,000 LB.  
CLIMB: 3 MIN. to 75,000 FT.

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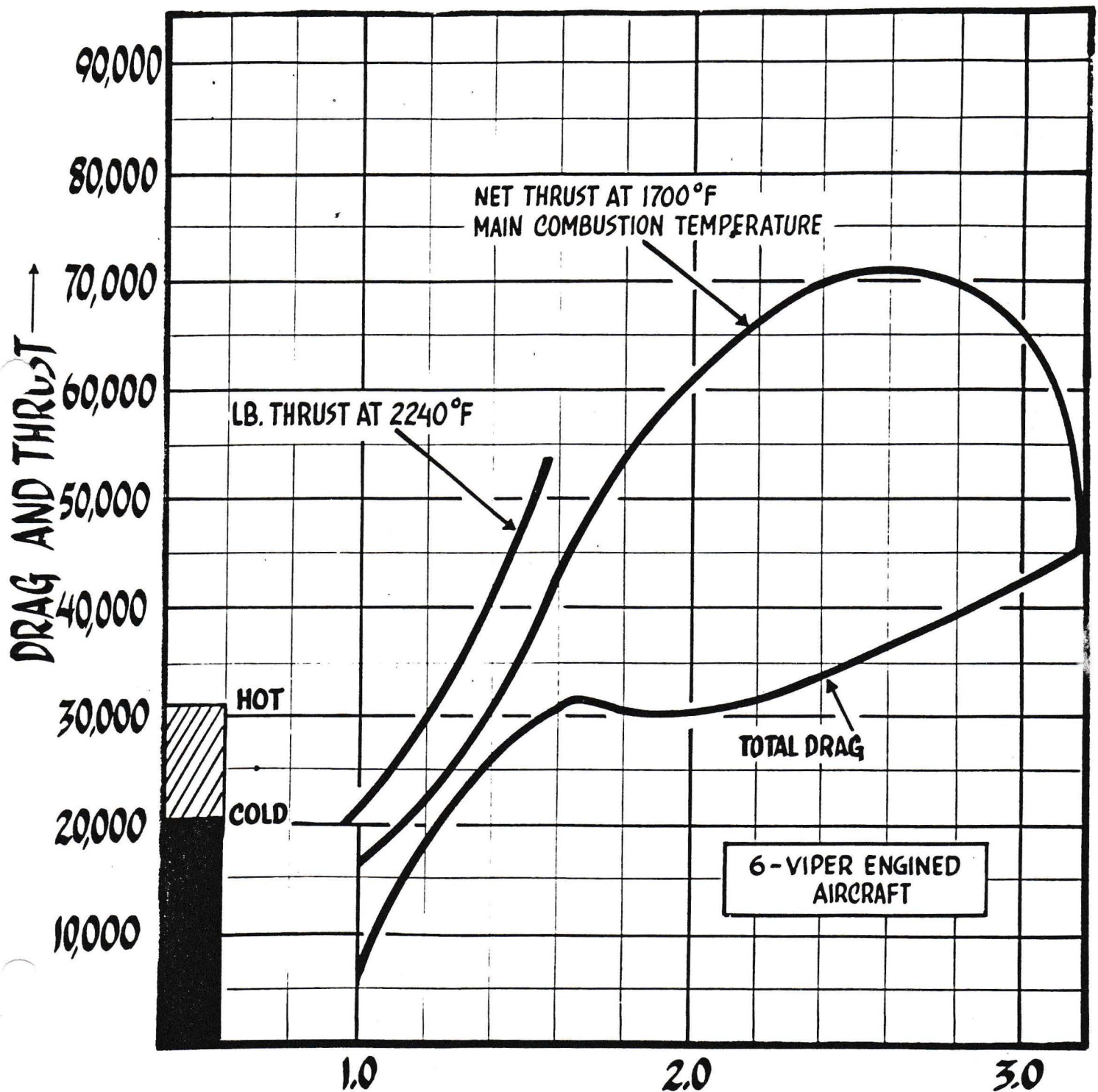
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# PROJECT 1794 DRAG & THRUST vs MACH NO. 35,000 FT.

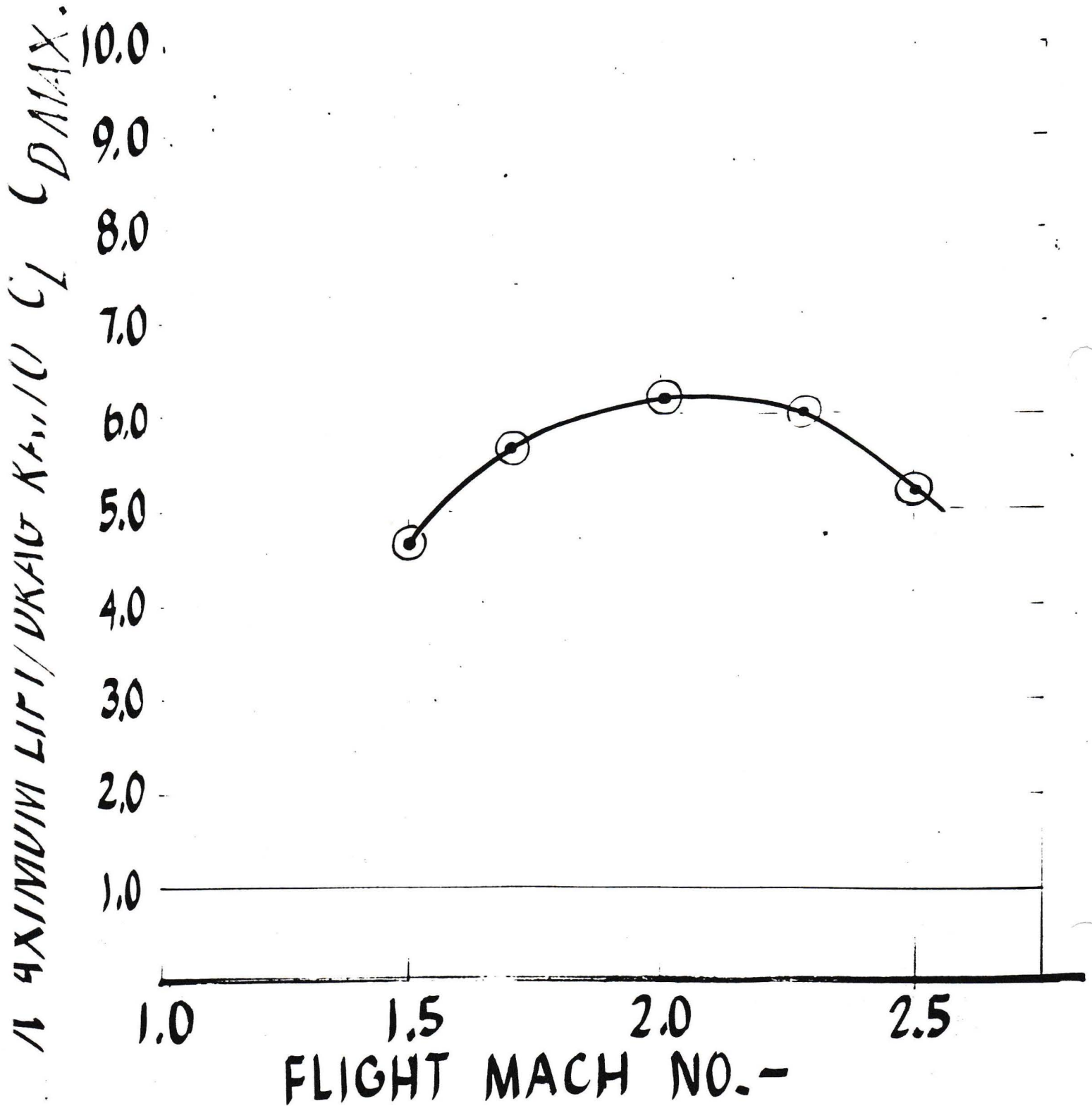


FLIGHT MACH NO. UNCLASSIFIED

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# PROJECT 1794 VARIATION of MAXIMUM LIFT/DRAG RATIO WITH MACH NUMBER

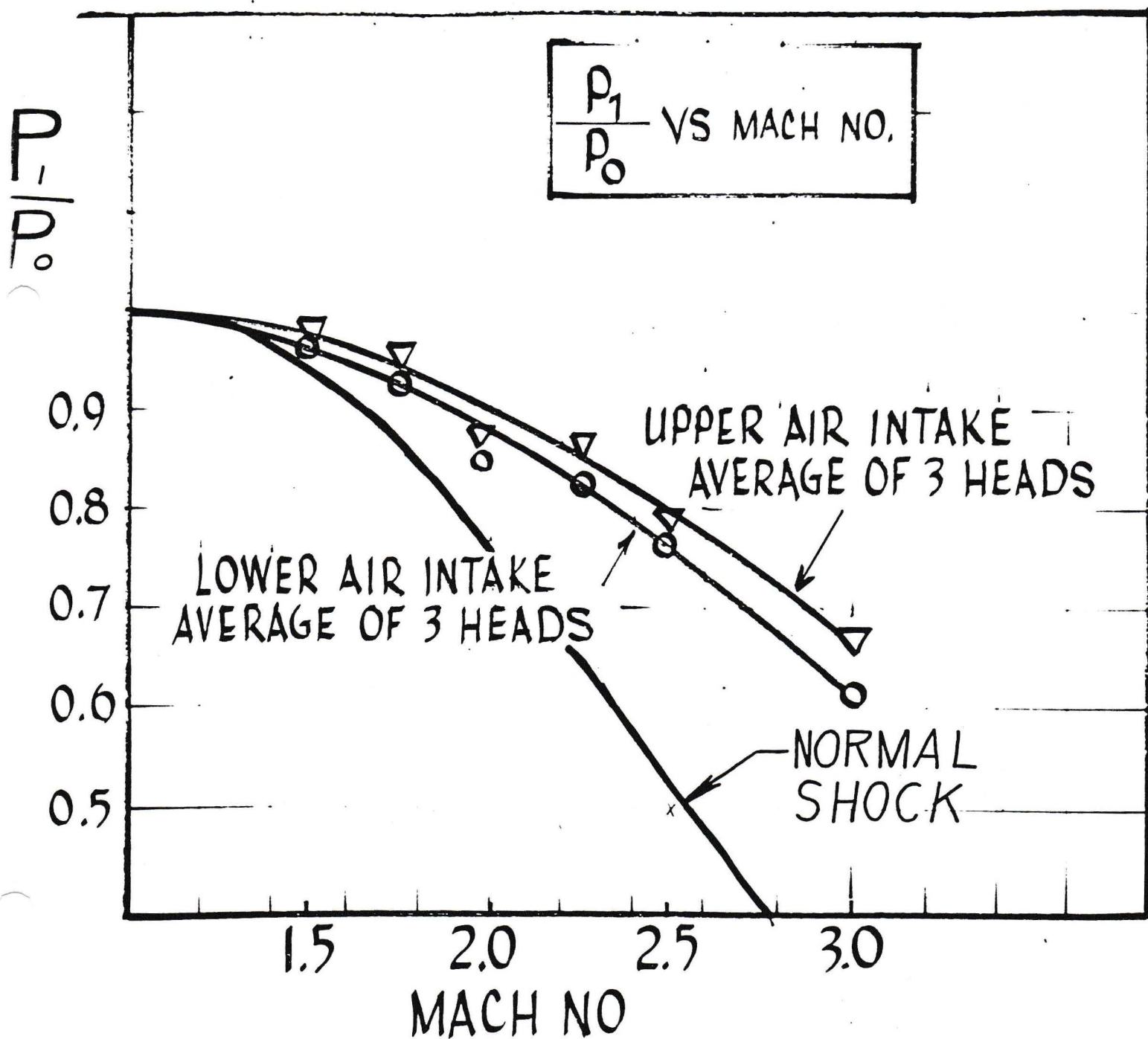


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# PROJECT 1794 INTAKE PRESSURE RECOVERY



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SLR-2080



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# WHY??

GOOD SUPERSONIC  $L/D$

GOOD INTAKE RECOVERY

✓ HIGH THRUST LEVEL

✓ INTEGRATION OF POWER PLANT &  
AIRFRAME, HIGH VOLUMETRIC  
EFFICIENCY.

$$\frac{\text{AIRCRAFT WEIGHT (EMPTY)}}{\text{AIR MASS FLOW}}$$

$$\text{AVRO A/C} \quad \frac{13,000 \text{ lb.}}{1,000 \text{ lb/sec}} = 13$$

$$\text{F-104 A} \quad \frac{11,269}{162} = 70$$

$$\text{B-58} \quad \frac{47,827}{648} = 74$$

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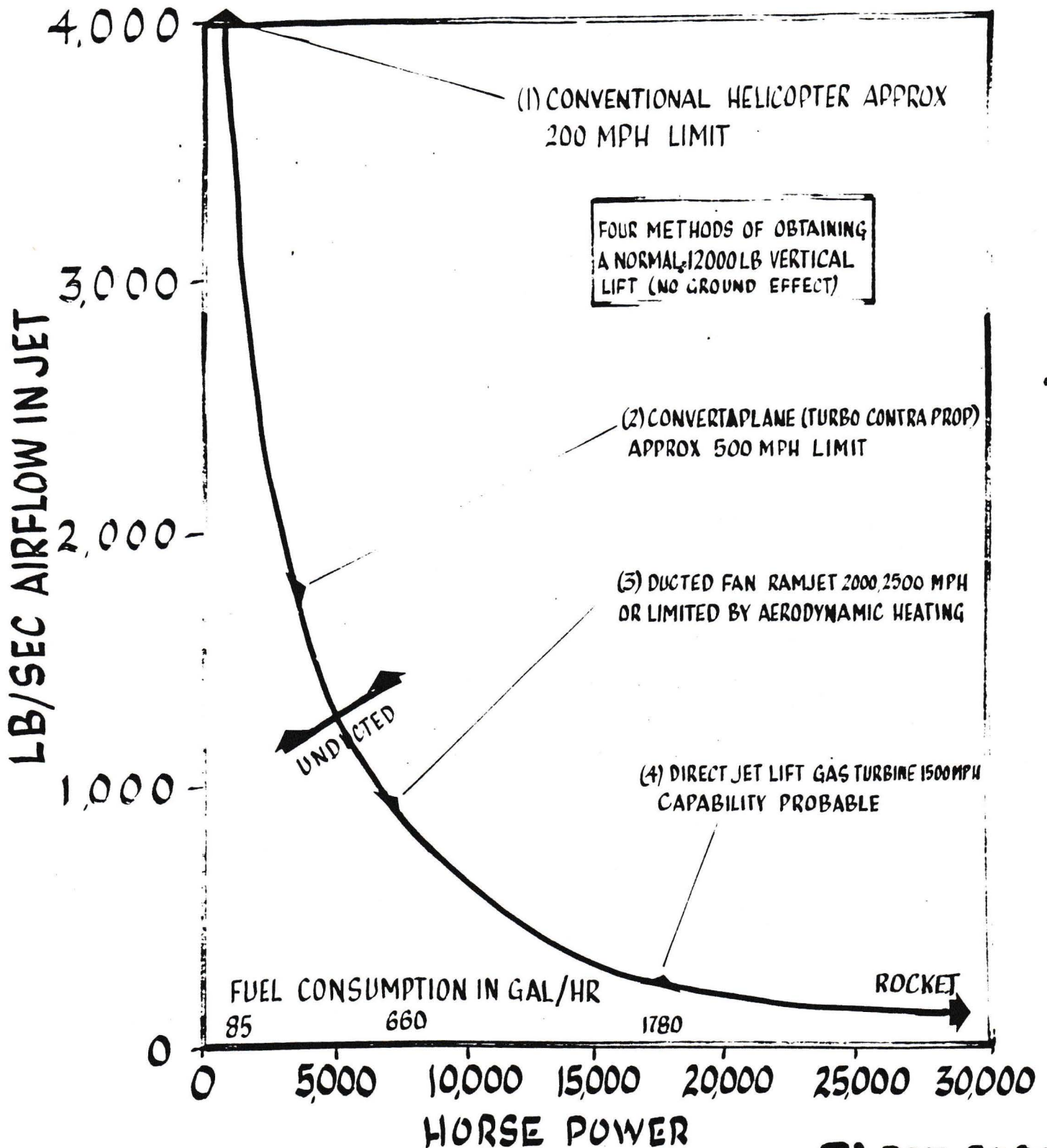
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COMPARATIVE

VELOCITY



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# FUTURE OUTLOOK

APPLICATIONS OF NEW CONCEPT GIVING ~  
\* FLEXIBILITY OF VTOL 4\* OUTSTANDING  
PERFORMANCE ~

CONVENTIONAL:

SPECIAL RECON. WEAPON SYSTEM  
INTERCEPTOR

FIGHTER BOMBER-TACTICAL BOMBER

UNIQUE:

HELICOPTER MISSIONS

SHIP BASED A/C

ARMY AERIAL FIGHTING VEHICLE

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# DEVELOPMENT PROGRAM

<u>PHASE</u>	<u>TIME PERIOD</u>	<u>R &amp; D FUNDS</u>	<u>PRO. FUNDS</u>
PRACTICABILITY INVEST.	MAY 55 JUN 56	\$785,000 38,000	FY54 —
NO COST EXTENSION	AUG 56 JUL 57	—	—
AVRO RESEARCH A/C (1)	MAY 56 JAN 58	AVRO FUNDED	
USAF RESEARCH A/C (2)	FY 57 FY 58	\$2,000,000 6,000,000	— —
WEA.SYST. PHASE I	FY 59		

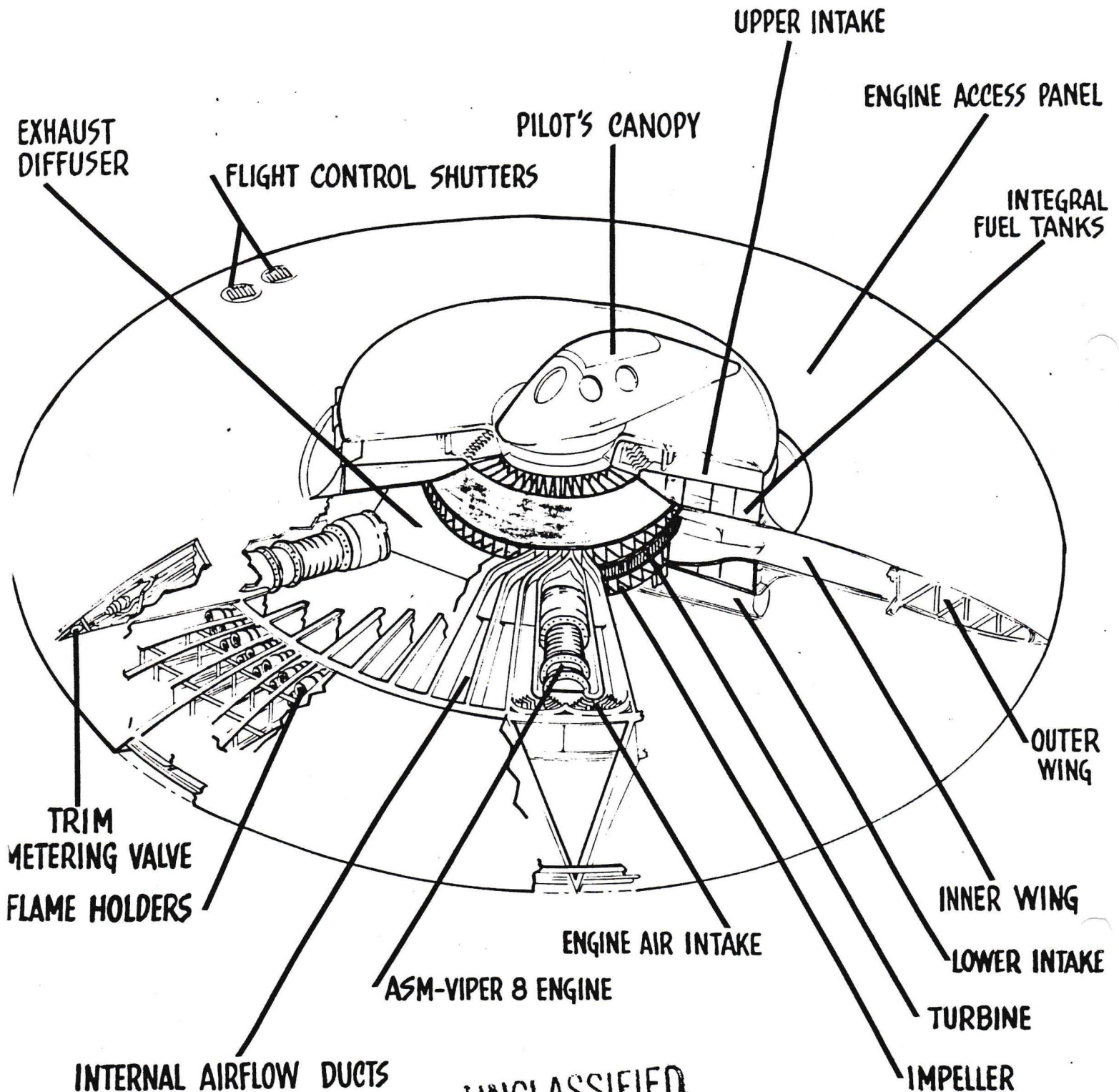
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# STRUCTURE CUTAWAY



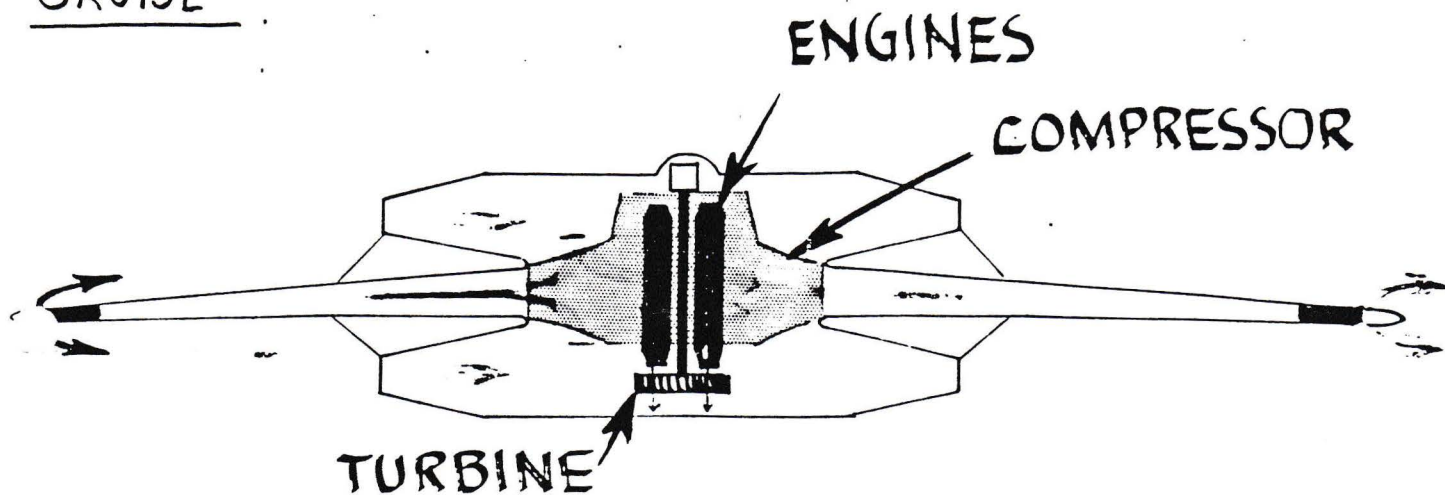
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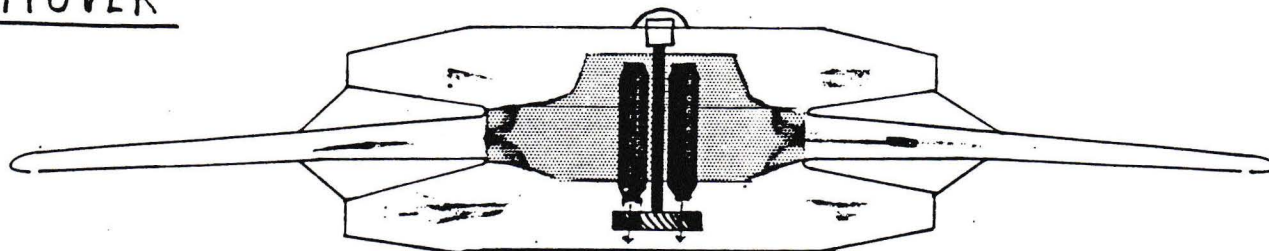
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GAS

CRUISE



HOVER



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