SECRET

Research and Development System

Abbreviated Development Plan

(U) AVRO VTOL High Performance Research System

System No. 453L

30 August 1956

[redacted]

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OPERATIONAL DATE
(Research System)

3rd Quarter - FY 1959

Combat Ready Date
Not Applicable

INTRODUCTION:

This research system development plan presents the preliminary planning for continued USAF support of the AVRO vertical take-off supersonic aircraft design. Analytical investigations, design studies, and substantiating tests have been completed on a minimum basis in accordance with the Project 1794 Development Plan, dated 15 September 1954, Hq USAF letter, subject: Remuneration (Secret), dated 29 December 1954, and the USAF Technical Program Directive No. 2, dated 9 February 1955. The results of this investigation indicate that continued USAF support is warranted. (Secret)

In order to meet proposed schedule; funds, facilities, decisions or approvals are required as shown. (Unclassified)

R&D PROJECT CARD SECRET	TYPE OF REPORT Proposed Research & Development System	REPORT CONTROL SYMBOL

1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NO.
(U) AVRO VTOL High Performance Research System	SECRET	System 453L
	4. INDEX NUMBER	5. REPORT DATE: 30 August 1956

6. BASIC FIELD OR SUBJECT	7. SUB FIELD OR SUBJECT SUB GROUP	7A. TECH. OBJ.
Supporting System (Research)	(01)	SR-1f, g

8. COGNIZANT AGENCY	12. CONTRACTOR AND/OR LABORATORY	CONTRACT/W. O. NO.
ARDC	AVRO Aircraft Limited Melton, Ontario Canada	
9. DIRECTING AGENCY: RDZPR, Ext 79, 97		
10. REQUESTING AGENCY: HQ ARDC		

11. PARTICIPATION AND/OR COORDINATION	13. RELATED PROJECTS	17. EST. COMPLETION DATES
NACA (P) Canadian Defense Research Bd (C) AMC (C) US NAVY (X) US ARMY (X)	Project 1794, 1227, & 1228	RES. Continuing DEV. February 59 TEST Feb 60 (est) OP. EVAL.

14. DATE APPROVED	15. PRIORITY	16. MAJOR CATEGORY
Proposed	1A(requested)	A

18. FY	FISCAL ESTIMATES
57	$2000M
58	$4000M
59	$2800M
60	$500M
	$9300M

19. REPLACED PROJECT CARD AND PROJECT STATUS
This report replaces Form 613, titled as above, dated 11 April 1956.

20. REQUIREMENT AND/OR JUSTIFICATION

TPR No. 2, dated 9 February 1955, established the requirement to obtain sufficient data on the AVRO vertical take-off supersonic design to provide for its earliest utilization in operational systems if the concept proved promising. The limited investigation that has been completed under Project 1794 indicates the feasibility of the AVRO design and the potential of successfully accomplishing the ultimate objectives. However, additional investigations, including full scale research flight articles, are required before undertaking a weapon system development. (Confidential)

21. BRIEF OF PROJECT AND OBJECTIVE

The proposed program will accomplish the following:

a. Provide additional wind tunnel and analytic data in substantiation of performance particularly in regard to flow distribution within the air intakes, internal flow, transonic drag, and thrust nozzle losses.

b. Provide for correlation of wind tunnel and other test data, and verification of theoretical predications by full scale flight testing.

c. Investigate the aerodynamic and thermodynamic problems in full scale flight. Special areas of investigation will include VTOL, artificial stability

22. OASD (R&D)	SN.	CN.	C.	X.	I.	C.

DD FORM 1 APR 55 613
REPLACES DD FORM 613, 1 JAN 52, WHICH MAY BE USED.

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System 453L

21. Brief of Project and Objective (Continued)

systems, control by propulsive jet and jet flap effect, radial flow propulsion system, effect of integration of airframe and propulsion system, and high-altitude high-speed flight.

d. Establish basic design criteria for development of operational weapon systems with the combined vertical take-off and tactical high altitude supersonic capability.

21a. Brief and Military Characteristics -

The research system will provide technical data and design criteria for use in further evaluation of the AVRO concept and will accommodate the use of this concept in future optimized weapon systems. It is estimated that the AF research systems will have the capability of VTOL and supersonic speed up to approximately M = 2.94, at 94,000 ft altitude, (based on contractors data and Air Force evaluation to date). The contractor will construct at his own expense an initial subsonic vehicle of this configuration with the VTOL capability and with provisions for modification to obtain supersonic performance at a later date.

The design is a jet propelled all wing aircraft of circular planform. A centrally located upper and lower intake system directs air through counter-rotating impellers driven by six Armstrong-Siddeley Viper turbo jet engines mounted radially within the wing and exhausting inward through a turbine which is directly connected to the impellers. After the intake air passes through the impellers, approximately 80% is routed radially out through the wing between the Viper engines to controllable shutters and provides stability and control as well as the propulsive force. Approximately 20% of the impeller output is directed back to feed the Viper engines which in turn drive the impellers. For maximum performance, the larger quantity of high pressure intake air is diffused within the wing to combustion chambers positioned at the periphery where fuel may be added to augment the basic thrust. The gases are then exhausted through the pneumatically controlled shutters to provide a larger propulsive force. The air cushion effect near the ground increases the lift on the aircraft at take-off to permit VTOL at thrust to weight ratios of less than one.

21b. Approach -

The first research vehicle is being funded by AVRO Aircraft Limited. Engineering design has already been initiated. This aircraft will have the simplest possible equipment and is intended primarily as a subsonic research vehicle not originally incorporating the periphery combustion system. Completion of this aircraft is scheduled in June 1958. The second and third vehicles will be funded by the USAF and will be initially designed to include the periphery combustion system. This will extend the performance of the aircraft to the desired supersonic high altitude

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21b. Approach - (Continued)

capability and into the flight region where aerodynamic heating will be experienced. Consequently, these two vehicles will be constructed of steel while the initial vehicle will be constructed primarily of aluminum alloy. As much as possible of the continuing technical investigation and evaluation (analytical, wind tunnel, design, etc.) will be conducted prior to the actual commitment for fabrication or the Air Force vehicles but still insuring compatibility, continuity and adequate time phasing of the entire program. Tooling cost will be held to a minimum in view of the limited quantity of aircraft planned in the research vehicle size and configuration. Construction of the two AF aircraft will follow the initial aircraft by approximately 8 and 14 months respectively.

The contractor funded portion of the program will be primarily aimed toward development of the basic aircraft and components for the subsonic flight regime with Air Force facility support. The additional Air Force support will be primarily aimed toward the high altitude, high speed flight regime, development of the perimeter combustion system, and design study including theoretical analysis directed toward weapon system potential and maximum capability.

21c. All subsystems are the responsibility of AVRO Aircraft Limited and could be subdivided as follows:

(1) Airframe sub-system

(2) Basic propulsion sub-system

(3) Perifery combustion sub-system

(4) Stability and control sub-system

21d. Other Information

(1) General:

(a) Support of the NACA is urgently required especially in accomplishing additional wind tunnel testing.

(b) Appropriate arrangements by Hq USAF with the Canadian Defense Research Board and the Royal Canadian Air Force will be required.

(c) The Department of the Navy and Department of the Army have indicated considerable interest in this program.

(2) Survey of Simular Existing Standardized Equipment or Techniques - none.

(3) Survey of Simular Equipment in Process of R&D - none.

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21d. Other Information (Continued)

(4) Statment of Effect - Complete substantiation and demonstration of this design concept could result in certain future AF aircraft having capabilities which would eliminate the requirement for runways in accomplishing their intended missions.

21e. Background History

(1) The original concept of the contractor was to increase the aircraft thrust-frontal area ratio far in excess of that obtainable with conventional jet turbine engines by re-arrangement of the power plant for radial flow. Such increases in aircraft thrust-frontal area ratio were desired in order to improve supersonic flight performance. Development of this idea as Project Y and Y2 by AVRO Aircraft Ltd., under RCAF cognizance, was extended to include application to a vertical take-off aircraft when it was determined that thrust/weight ratios were sufficiently high and that the use of the radial flow engines with jet exhaust at the periphery produced a ground cushion effect. Preliminary ingenious small scale model testing by AVRO demonstrated this phenomenon.

(2) During January 1954, AVRO Aircraft Ltd. and the Canadian Defense Research Board invited the USAF to visit the contractor and discuss preliminary aspects of a new flat riser concept. As a result of this visit, subsequent briefings by the contractor to the USAF, and receipt of an AVRO proposal, a requirement was issued to exploit the potential of this project under BPSM 1-1794.

(3) USAF Contract No. AF 33(600)-30161 with AVRO Aircraft Ltd. was essentially a feasibility study with design configuration effort confined to the minimum required for demonstration of the proposed principals to a practical application. The areas for test and analysis were defined as:

(a) Air Cushion effect.

(b) Stability and control.

(c) Air intake and gas exhaust system test.

(d) Aircraft performance.

(e) Radial flow engine feasibility.

(4) During the course of the contract period, the initial design was improved. In early 1956 the contractor decided to sponsor the construction of a research vehicle, initially subsonic, to further investigate and demonstrate this design concept. The final technical summary under Contract No. AF 33(600)-30161 was issued on 12 July 1956 and together with the AF evaluation indicated that further AF support was warranted to proceed to the research vehicle stage of development.

21g. References

(1) USAF Ltr dated 26 April 1954, subject: "Project Y (A. V. Roe, Canada Ltd.)" (

(2) USAF letter dated 3 July 1954, subject:"Project Ladybird". (S).

(3) Hq ARDC Technical Requirement #3 dated 13 August 1954 (S).

(4) A. V. Roe Canada Limited Development Proposal "Project Y2" (S).

(5) A. V. Roe Canada Limited Brochure Nr 1, "Project Y2 Flat Vertical Take-off Supersonic Gyroplane", dated June 1954 (S).

(6) Project 1794 Development Plan dated 15 September 1954.

(7) TPR Nr 2, subject: "Renumeration", dated 9 February 1955.

(8) TPD Nr 2, subject: "Renumeration", dated 9 February 1955.

(9) TR Nr 3, Hq ARDC, 13 August 1955 (S).

(10) PDD Nr 1794, Hq ARDC, 12 January 1955.

(11) Project 1794 Final Development Summary Report (S).

(12) Project 1794 Final Technical Report (S).

(13) System 453L Abbreviated Development Plan, 30 August 1956 (S).

(14) AVRO Report TR-161, "Design Study of a Proposed USAF Research Aircraft Similar to the AVROCAR" (S).

(15) PPR AVROCAR I dated 20 May 1958 (S).

(16) AVRO Program Planning Report Re-directed System 606A Program, 1 May 1958 (S).

(17) VTOL Supersonic Fighter/Bomber Pre-Phase I Development Program, 12 January 59 (S).

(18) Hq USAF letter dated 19 December 1958, subject: "(U) System 606A Program (Hq USAF Reprogramming 59-600-21).

(19) ARDC System Requirement 198, 26 January 1959.

(20) AF33(600)-30161

(21) AF33(600)-37496

SEE REVISED 4/5-1/5 NEXT PAGE

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21f. Future Plans

Successful completion of the proposed program outlined in this report will provide sufficient technical data and design criteria to utilize this concept in AF aircraft.

21g. Reference:

(1) USAF ltr, dtd 3 Jul 1954, subject: (Secret) Project Ladybird (Secret)

(2) Project 1794 Development Plan, dated 15 Sep 1954.

(3) TPR #2, subject: (Secret) Remuneration, dated 9 February 1955.

(4) TPD #2, subject: (Secret) Remuneration, dated 9 February 1955.

(5) AVRO Area Report No. 1, Air Cushion Effect - 1.D. No. 56-RDZ-13710.

(6) AVRO Area Report No. 2, Stability and Control - 1.D, No. 56-RDZ-13711.

(7) AVRO Area Report No. 3, Intake and Exhaust - 1.D. No. 56-RDZ-13712.

(8) AVRO Area Report No. 4, Performance - 1.D. No. 56-RDZ-13713.

(9) AVRO Area Report No. 5, Propulsion System - 1.D. No. 56-RDZ-13714.

(10) AVRO/SPG/Tr. 12 - 1.D. No. 56-RDZ-13715 - Presentation and Discussion of 1/16th Scale Model Subsonic Wind Tunnel Test Results.

(11) AVRO/SPG/Tr. 22-1.D. No. 56-RDZ-13716 - Results and Analysis of Supersonic Test on a 1/23rd Scale Half Plane Force Model.

(12) AVRO/SPG/Tr. 6 - 1.D. No. 56-RDZ-13717 - Results and Analysis of Supersonic Tests on a 1/40th Scale Sting Mounted Force Model.

(13) Project 1794 Final Development Summary Report - 1.D. No. 56-RDZ-19954.

(14) Project 1794 Final Technical Report - 1.D. No. 56-RDZ-13709.

(Secret)

TAB 1

General Design Specification

1. General

a. Statment of the Problem

Certain future operational aircraft will require a combined capability of VTOL, high altitude, high supersonic speed, and adequate range for their intended mission. Several research vehicle programs are presently underway to investigate various concepts of obtaining this desired result. TPR #2, dated 9 February 1955, established the requirement to obtain, on a minimum basis, sufficient data concerning the AVRO Aircraft Ltd. design concept to provide for its earliest utilization in operational aircraft, should the concept prove promising. During the investigation that has presently been completed under Project 1794, the AVRO design has been considerably improved. The results and AF evaluation of this investigation indicated the feasibility of the AVRO design and the likely potential of this concept to successfully accomplishing the ultimate objective of combining VTOL and tactical capability. However, additional investigation and flight test of a research vehicle utilizing this design concept are required prior to incorporating the development into a weapon system.

b. Approach

A review of the results of Project 1794 indicates that additional investigation is required for further substantiation of performance, particularly in regard to flow distribution within the air intakes, internal flow, transonic drag, and thrust nozzle loss. To a certain extent, the contractor is dependent upon the USAF to make available wind tunnel facilities for this continued investigation. In order to demonstrate their "faith" in the concept and to reduce development time to a minimum, the contractor is funding for an initial research vehicle intended primarily for expediting full scale investigation of the VTOL, hover, and subsonic range of flight. This effort was initiated during early CY 56, and is considered to be a fundamental step toward an Air Force supported research vehicle program to investigate the full potential of the design concept. This continued Air Force support is immediately required to provide for timely phasing of the overall program and to provide the ultimate objective as outlined in Hq USAF requirements documentation.

c. Solution

Immediate initiation of the proposed Air Force program will provide the information required to make proper decisions in regard to further development of the AVRO Aircraft Ltd. flat rising VTOL, high performance concept in operational weapon systems. In view of limited funding and the rapid pace of present technical advancements, the proposed approach is considered to be extremely attractive to provide for maximum returns from Air Force funds and at the same time

Tab 1
General Design Specification (Continued)

provide a timely solution in maintaining the required potential of the Air Force capability. An alternate solution regarding funding would be to permit other interested agencies to participate in the program. This would not materially change the results obtained except to add additional considerations, complexity and possibly time requirements.

d. Logistic Characteristics

The primary logistics considerations are the potential of the design concept to eliminate runway requirements in fulfilling certain AF missions, and the construction and maintenance of aircraft that have approximately 1/12 the number of different parts as a conventional design. (Secret)

2. Description

The AVRO VTOL High Performance Research System will be, in general, a jet propelled all-wing aircraft of circular planform, embodying a new arrangement of a turbojet engine and employing reaction control (Diagram 1). The research vehicle will have the following general basic characteristics:

Basic weight - 15,750# (Wt of AVRO vehicle 13,750# due to aluminum construction

Normal gross Wt - 20,000#

Maximum gross Wt - 32,802# (gross wt. limit of AVRO vehicle 27,322# due to the engine used)

Diameter - 35.3 feet

Ground Clearance - 2 feet

Maximum thickness - 7.7 feet

Impeller diameter - 8 feet

Six Armstrong Siddeley Viper turbo-jet engines are mounted radially within the wing, exhausting inward, to drive a pair of center-rotating compressors by means of a radial in-flow turbine (Diagram2).

The Viper (-8) engine, capable of developing, 1,900# thrust each, will be used in the AVRO funded vehicle. Since this engine is limited to Mach 1.74, consideration is being given to using Viper 10 or J85 engines in the AF funded vehicles consistent with a policy of no or minimum change to the basic airframe.

The eight foot diameter compressors (Diagram 3) rotates slowly in comparison with conventional turbo-jets (500-600 rpm top speed). This compressor draws air from the upper and lower intakes and forces it radially out through the wing

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Tab 1
General Design Specification (Continued)

between the viper engines with a small amount being directed back to feed the Viper engines (Diagram 4). The majority of the air is diffused within the wing to a high pressure at the flame holders where fuel may be added to augment the thrust, and is then exhausted through pneumatically controlled shutters (Diagram 5) which directs the thrust as it exhausts all around the aircraft periphery. This thrust either raises the aircraft vertically off the ground or propels it in forward flight. The control of the thrust direction provides control and stabilization of the aircraft in all flight conditions. For stabilization, a diaphragm is attached to the main rotors to sense aircraft pitch and make corrections through the thrust direction controls.

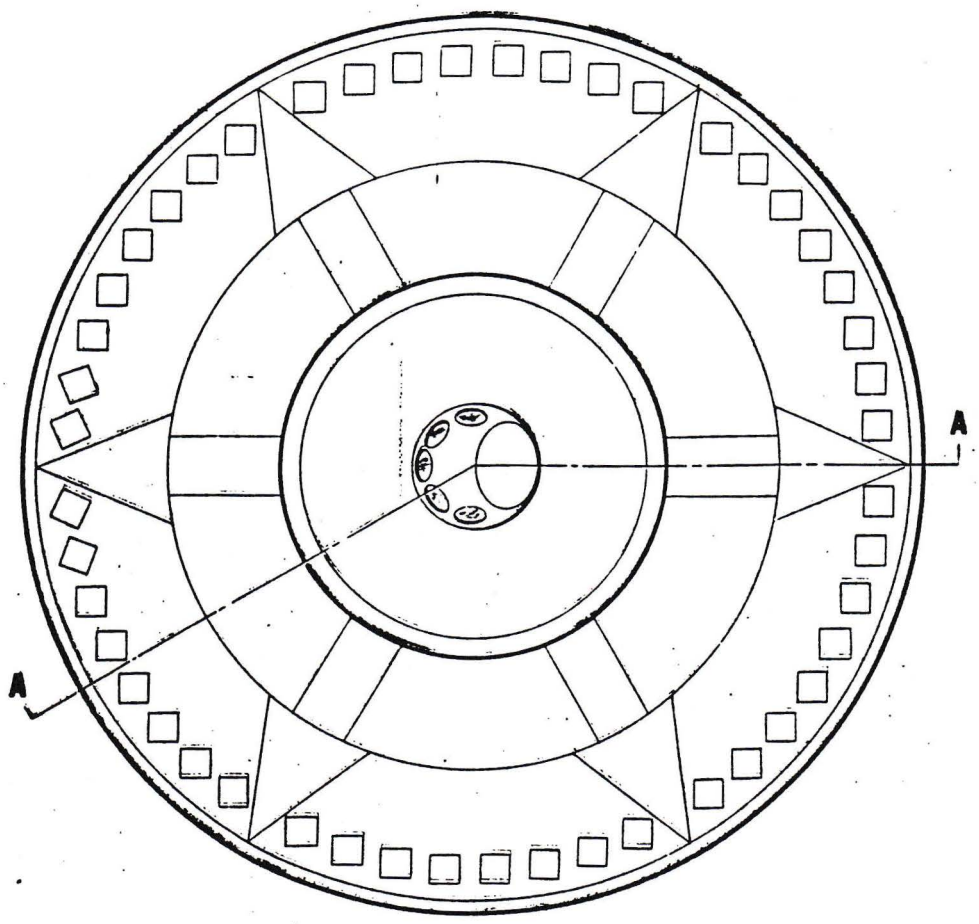
Normal operation for take-off is with all the exhaust shutters on the top of the wing closed and those on the bottom wide open and directed downward. Without adding fuel to augment the thrust, approximately 20,000 lbs. thrust is produced. However, this circular curtain of air produces a powerful take-off air cushion so that the lift on the aircraft increases to possibly 30,000# (Diagram 6). This air cushion effect rapidly falls off at an altitude of approximately 50% of the aircraft span; however, transition to forward flight could possibly be from the air cushion. For transition to forward flight, the thrust line of the perimeter jets will be gradually directed backward and the nose of the aircraft slightly raised. For hovering at altitudes outside of the air cushion effect, afterburning or reduction of gross weight will be required to increase the thrust wt ratio above a value of one. In forward flight ram air will increase the pressure at the flame tubes and provide for more efficient burning. Thrust augmentation by utilizing the periphery combustion chambers (approximately 1700°F) will be necessary for supersonic flight and, in combination with the large air mass flow, should provide adequate thrust for the estimated high speed and altitude performance. Descent will be made without thrust augmentation and transition to landing is the reverse of the take-off technique.

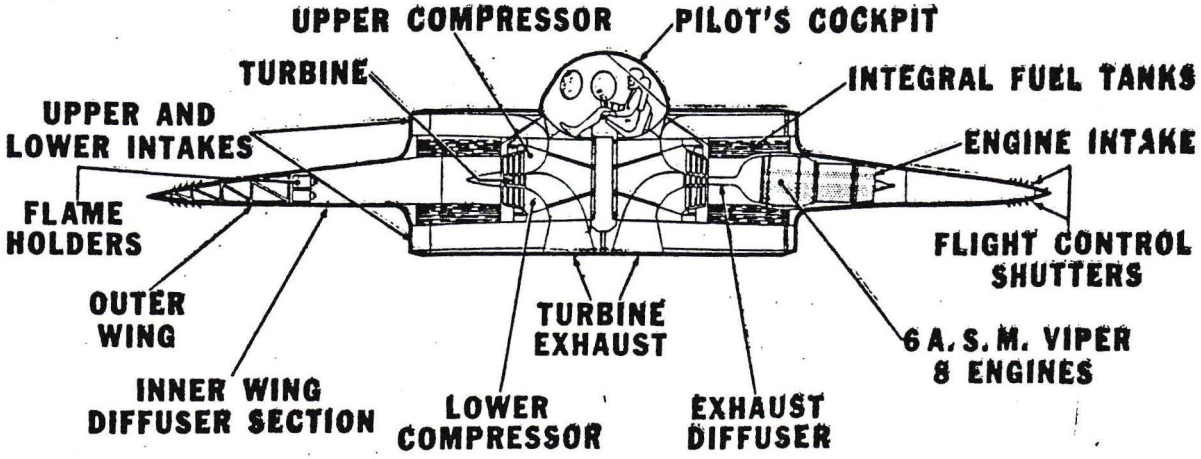
Construction of the main rotors and exhaust diffuser fantails will be of high grade nickle-alloy steel. The contractor's funded subsonic vehicle will utilize aluminum alloy for the center body section, air intake, fuel tanks and cockpit while the AF funded supersonic vehicles will probably be constructed primarily of steel (Diagram 7). The additional weight of the material used in the second and third vehicles will be off-set by the increased performance of the higher rated turbojet engines being considered. (Secret)

3. Estimated Performance

	Subsonic Acft	Supersonic Acft
Cruise speed (Mach No.)	0.45 (20,000)	2.2 (90,000')
Max. level speed (Mach No.)	0.48	2.94
Ceiling (ft)	25,000	94,000
Range (N.M.)	400	988

(Secret)





SECTION A-A

FIG. 1 PLAIN VIEW AND SECTION THROUGH AIRCRAFT

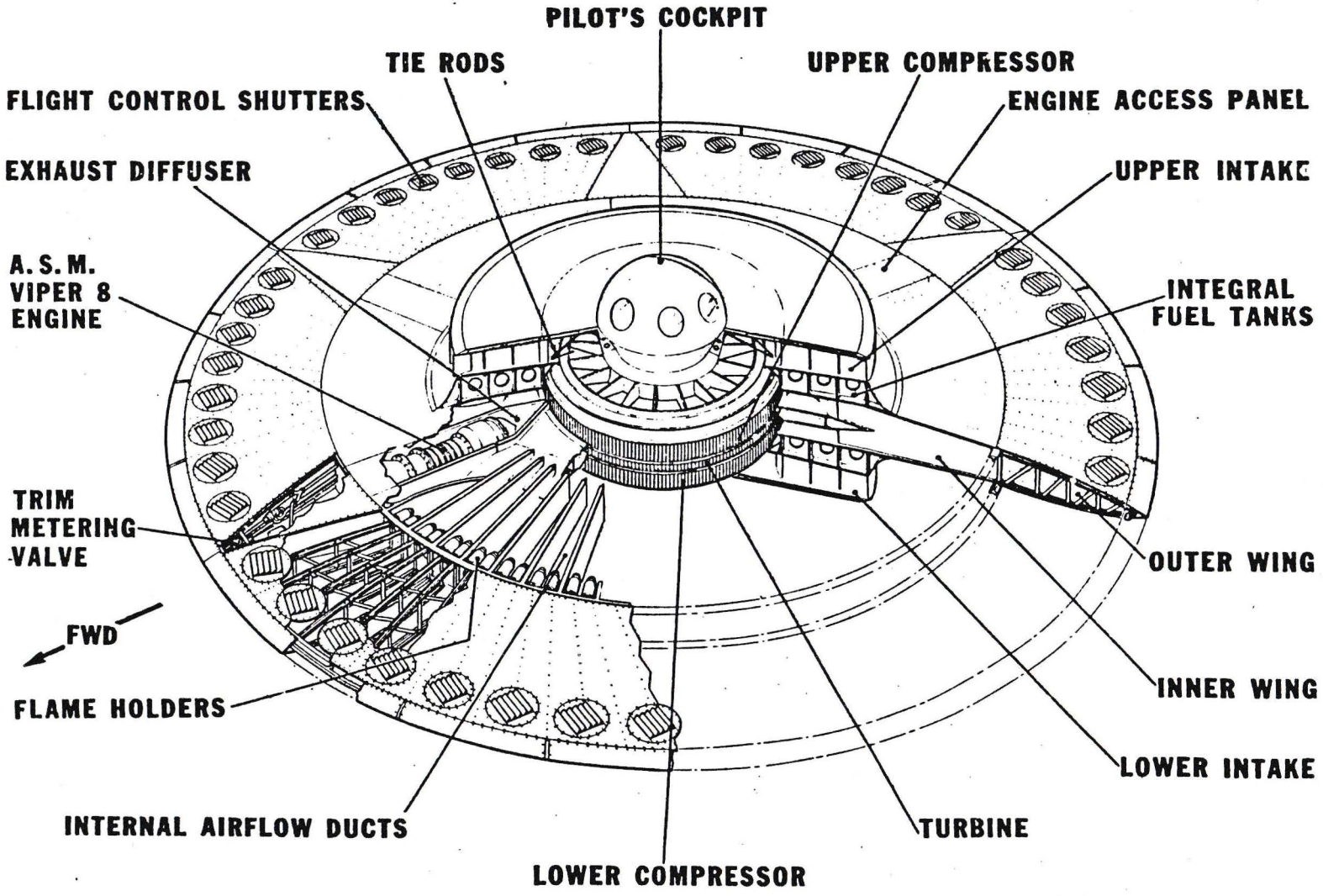


FIG. 2 CUTAWAY OF AIRCRAFT STRUCTURE

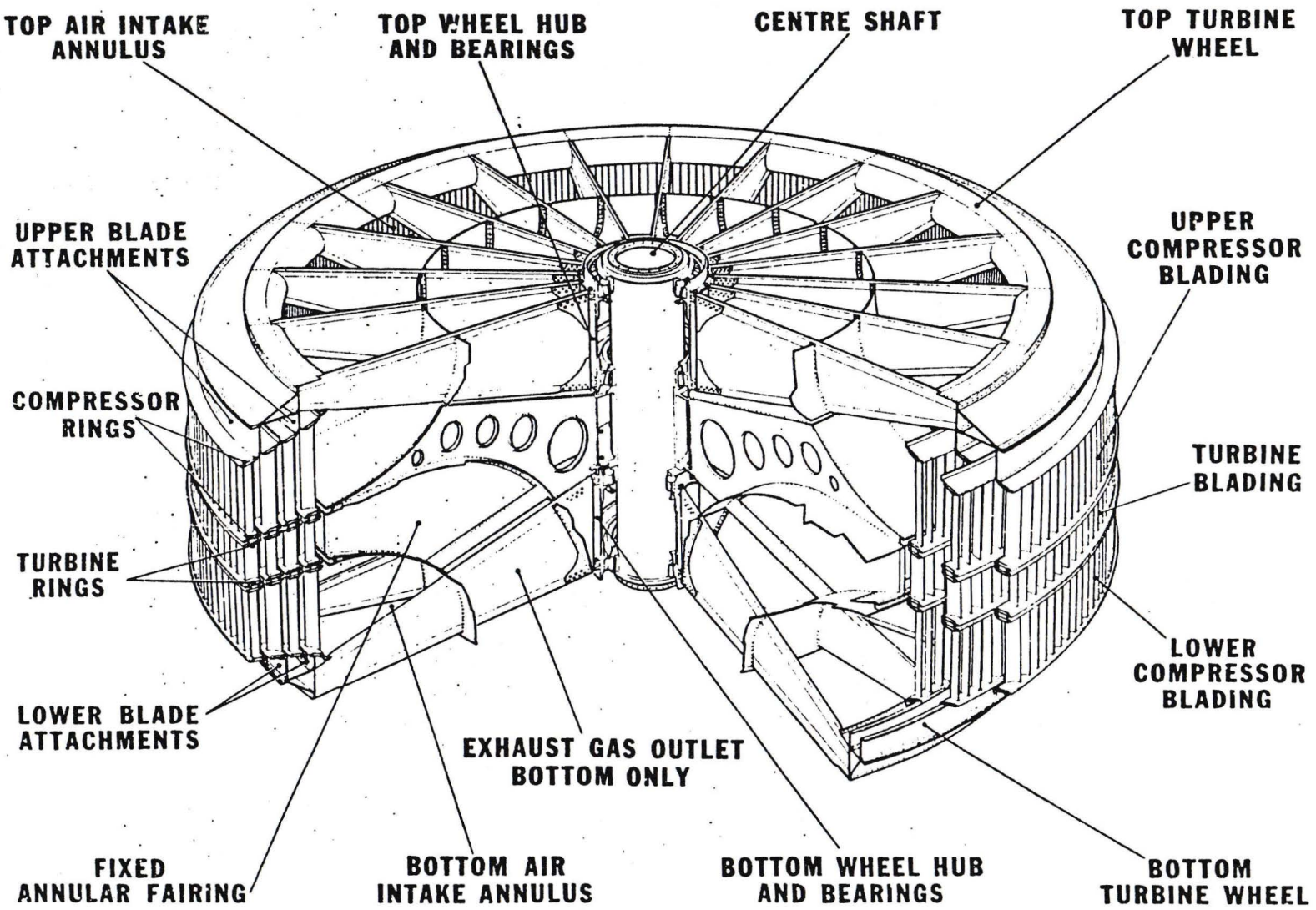


FIG. 3 TURBINE-COMPRESSOR ASSEMBLY