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INSPECTION, REPAIRS AND MODIFICATIONS, AND FLIGHT TEST OF THE FLEXIBLE-WING MANNED TEST VEHICLE XV-8A

By

J. F. IRVINE

JUNE 1968

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

CONTRACT DA 44-~~117~~ 177-AMC-402(T)

RYAN AERONAUTICAL COMPANY
SAN DIEGO, CALIFORNIA

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IN REPLY REFER TO:

This report was prepared by the Ryan Aeronautical Corporation under the terms of Contract DA 44-177-AMC-402(T). It presents information on (1) the inspection of the XV-8A aircraft, serial numbers 63-13003 and 63-13004; (2) repairs and modifications recommended under Contract DA 44-177-AMC-359(T) (these repairs and modifications were accomplished under Contract DA 44-177-AMC-395(T); and (3) instrumentation and flight tests.

The instrumentation and flight tests were carried out by the contractor at Edwards Air Force Base in conjunction with the U. S. Army Aviation Test Activity and the U. S. Army Aviation Materiel Laboratories.

The object of this contractual effort was to determine the ease of handling and flight characteristics of the XV-8A flexible-wing vehicle.

Test pilot evaluations indicated that the aircraft performed as expected and was as simple to fly as standard light aircraft.

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Contract DA 44-177-AMC-402(T)
USAAVLABS Technical Report 68-30
June 1968

INSPECTION, REPAIRS AND MODIFICATIONS, AND FLIGHT TEST OF THE FLEXIBLE-WING MANNED TEST VEHICLE XV-8A

Final Report

Ryan Report No. 16480-1A

By

J. F. Irvine

Prepared by

Ryan Aeronautical Company
San Diego, California

for

U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

This research was sponsored by the Advanced Research Projects Agency of the Department of Defense under ARPA No. 294, Amendments 13 and 19, and was monitored by the U. S. Army Aviation Materiel Laboratories under Contract DA 44-177-AMC-402(T).

SUMMARY

The task consisted of conducting critical inspection of aircraft serial numbers 63-13003 and 63-13004, providing a report of recommended repairs to make both vehicles airworthy, and recommending modifications for meeting flight test requirements and for improving handling.

The work under a prior contract consisted of accomplishing the recommended repairs to place the two aircraft in condition for flight testing, and incorporating the approved modifications.

Another prior contract required installing and checking out Government-furnished and Ryan instrumentation, performing flight tests, providing support of Government evaluation and flight research, and checking out five Government pilots in the aircraft to obtain a cross-section evaluation of flying qualities.

Extensive dismantling of both aircraft produced findings and suggestions that were provided in report form, and justified the accomplishment of repairs and modifications. Following these repairs and modifications, flight testing of an aircraft at Edwards Air Force Base, California, was performed. Flight tests were cut short when the instrumented vehicle was damaged by a taxi accident on 6 July 1966. This accident occurred during test pilot familiarization and before significant new testing could be performed or before precise test data could be acquired.

FOREWORD

This report presents technical information derived from inspecting, modifying and flight testing two flexible-wing manned test vehicles, under three separate but contiguous U. S. Army Aviation Materiel Laboratories contracts, by Ryan Aeronautical Company, San Diego, California. The three contracts were DA 44-177-AMC-359(T) (Recommended Aircraft Modifications and Repairs), DA 44-177-AMC-395(T) (Installation of Recommended Aircraft Modifications and Repairs), and DA 44-177-AMC-402(T) (Flight Research).

The Ryan Aeronautical Company gratefully acknowledges the efforts and cooperation put forth by all the personnel and agencies associated with this project.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF SYMBOLS

C_L	Lift coefficient
C_M	Mass coefficient
FTO	Flight test operation
i_W	Wing incidence
L/D	Lift to drag ratio
LH	Left hand
LOF	Lift off
MAP	Manifold absolute pressure, inches HG
OAT	Outside air temperature, degrees F
q	Dynamic pressure/ $lb/in.^2$
RH	Right hand
V	Velocity, knots
V_c	Climb speed, knots
YAPS	Combination of angles and pressure: β, α, pitot-static
α	Wing angle of attack, degrees
β	Angle of sideslip, degrees
δ	Control surface deflection, degrees
μ	Stress

INTRODUCTION

GENERAL

Two XV-8A aircraft were built under a previous contract. The first vehicle, S/N 63-13003, was utilized in three previous test programs, accumulating 55 hours of operational time, including 36 hours of flight, since June 1963. The second vehicle, S/N 63-13004, was never flown.

Following flight testing at Yuma Proving ground, aircraft number 63-13003 was returned to the Ryan Aeronautical Company plant in San Diego, California. The aircraft was extensively dismantled and carefully inspected to determine its material condition. The findings on aircraft 63-13003 were then used as a basis for determining the depth of inspection necessary to establish the material condition of aircraft number 63-13004. The findings were the basis of recommended repairs. In addition, minor modifications were recommended, based upon refinements which had suggested themselves as a result of earlier flight testing experience.

In brief, no evidence of corrosion was found. With one exception, structural discrepancies noted were those attributable to normal wear and use, and no equipment malfunctions were evident. The one structural problem encountered was a deterioration of the coating on the wing fabric, which reduced the strength of the fabric joints to an unacceptable level. New membranes were required before further flight.

Modifications included items for flight and ground handling improvement and features required for flight test operations at US Army Aviation Test Activity (USAAVNTA), Edwards AFB.

Upon completion of repairs and modifications, aircraft number 63-13004 departed by truck for Edwards AFB on 7 June 1966. It was returned to San Diego the same day, damaged from striking a highway overhead bridge.

Instrumented vehicle 63-13003 was shipped and off-loaded at Edwards AFB, California, on 14 June 1966. The aircraft was assembled and rigged, and the test instrumentation was calibrated prior to the first flight test operation.

Testing by Ryan subsequent to repair, modification, and instrumentation was started on 27 June 1966. Five flight test operations were completed for:

Taxi and lift-off	- 1 flight
Pilot familiarization	- 2 flights

Initial data accumulation and
airborne instrumentation
checkout - 2 flights

During a post-flight taxi operation for pilot familiarization with ground handling qualities by the USAAVNTA pilot, a gust of wind tipped the vehicle over as it was being returned to the flight line. The pilot was unhurt, but the aircraft was damaged beyond feasible field repair.

On 7 July 1966, the damaged vehicle 63-13003 was returned to San Diego by truck and the flight test program at Edwards AFB was terminated.

DESCRIPTION OF VEHICLE

The flexible-wing aerial utility vehicle is a self-propelled flying cargo platform supported from a Rogallo-type flexible wing. (See Figures 1 and 2.)

The vehicle contains controls and instrumentation necessary for manned self-powered flight. Control surfaces are operated by control cables and mechanical linkage manually actuated by controls in the cockpit. Pitch is controlled by forward and aft movement of the pilot's control column which moves ruddervator control cables. Pitch trim of the flexible wing is adjusted by a pitch trim handwheel adjacent to the pilot's seat. Roll is controlled by right or left rotation of a roll control wheel in the pilot's control column. Pitch control movement adjusts the ruddervators simultaneously in the same direction. Roll control movement adjusts hinged flaps on either side of the flexible wing to change the aerodynamic pattern of the wing, allowing air pressure to roll the wing, and also gives differential ruddervator displacement required for rudder control in a coordinated turn. By changing control and cable routing, and various linkages and bellcranks beneath the cockpit floor, the control system changes to a conventional three-control mode. Rudder control is then by direct connection to rudder pedals.

Instrumentation (consisting of a combined oil pressure, oil temperature, and fuel pressure gauge; an engine tachometer; an engine cylinder head temperature gauge; a magnetic compass; an airspeed indicator; and an altimeter) is mounted on the instrument panel. A fuel quantity gauge is mounted adjacent to the fueling connection.

The instrumented test vehicle was modified with an electric engine starter, an air-to-ground UHF radio, and an alternator for electrical power. These modifications were incorporated solely to facilitate testing at Edwards AFB and would not normally be required or provided in the simple operational environment for which the XV-8A was intended.

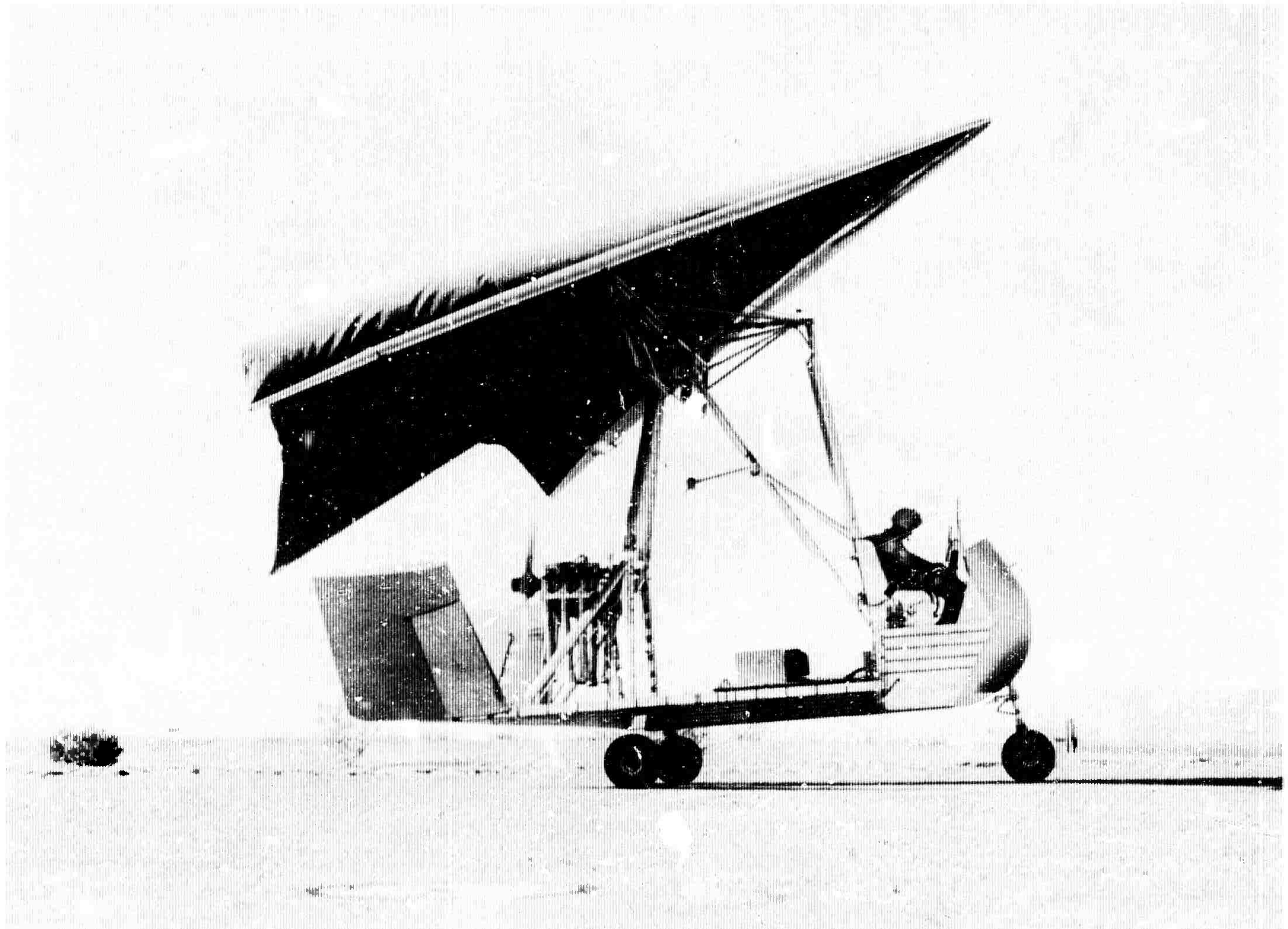


Figure 1. Flexible-Wing Aerial Utility Vehicle, Front View

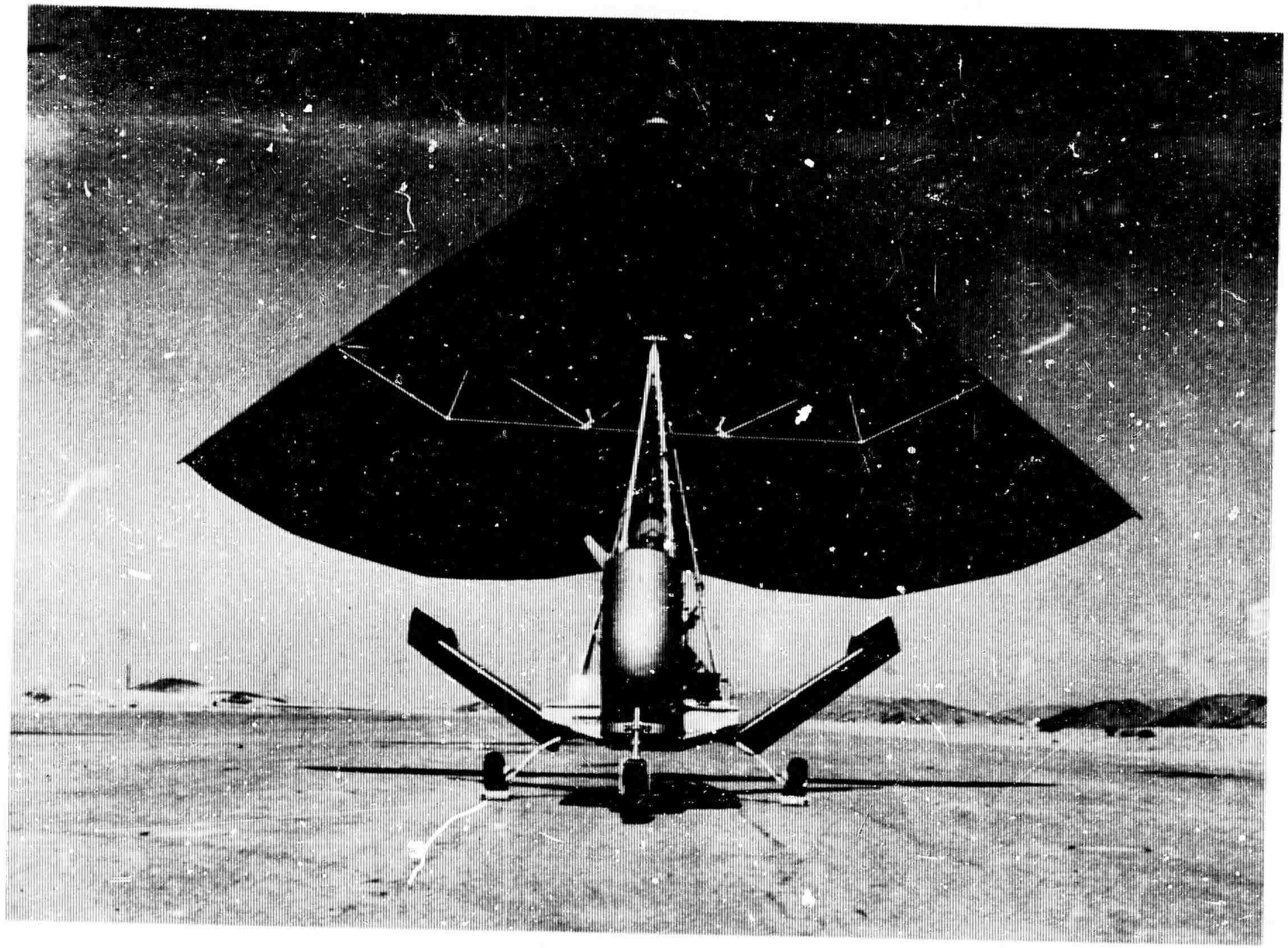


Figure 2. Flexible-Wing Aerial Utility Vehicle, Side View

The nose wheel of the tricycle landing gear is mounted on a shock strut, and the main wheels are mounted on cantilevered fiber glass springs. Main wheel hydraulic brakes are actuated independently by a brake cylinder mounted on each rudder pedal to give differential braking. The right and left foot pedals in the cockpit are mechanically connected to the nose wheel for steering while taxiing.

TEARDOWN INSPECTION RESULTS

INSPECTION PROCEDURE

The general mechanical inspection procedure was to dismantle each assembly to the extent necessary to verify the condition of all basic material, weld joints, end fittings, bolt holes, bushings, hinges, pulleys, turnbuckles, bearings, bellcranks, etc. Fasteners were inspected for thread condition, shear or bending deformation, wear, and cocked rivet or bolt heads. Cables were inspected for wire wear, fraying, kinks, and corrosion. Tail control surface fabric was tested by the Type III Seyboth fabric test. Dimensions were checked against new material dimensions where appropriate, and all components were inspected for any evidence of corrosion. Weld joints were stripped of paint and inspected for cracks by the dye penetrant method, assisted by a magnifying glass where appropriate.

Wing fabric specimens were destructively tested in the Materials Laboratory and compared with data on file from new material samples tested when the wings were made. Tensile strength tests were conducted to establish the basic Dacron fabric strength in the warp and fill directions. Lap shear strength tests were conducted to establish the integrity of the adhesive bonded and stitched seams in the wing. These tests were conducted with both bonding and stitching in the seam sample as a measure of total seam strength, and with the stitching removed as a measure of pure bonding strength. Peel strength tests were conducted as a further check on the adhesive bonding condition. Testing methods used are defined in Table I.

Both engines were test run and inspected, and a thorough visual inspection was made of the engine mounts and propellers. Engine inspection was equivalent to a 100-hour periodic inspection with the exception of valve rocker cover removal. (Neither engine had reached 100 hours.) Engine serial No. 10007 installed in aircraft 63-13003 was test run and inspected under the supervision of Continental Motors Corporation. Rocker cover removal was considered to be unnecessary, and the engines were determined to be completely airworthy.

A spectrographic oil analysis was conducted on oil samples from each engine. Detailed results are shown in Table II. Although trend data over a period of time are more significant than a single test result, the spectrographic results are considered to be well within normal limits.

All cockpit instruments were recommended for overhaul and calibration before further flight.

TABLE 1. WING MEMBRANE DESTRUCTIVE TEST RESULTS

	Tensile Strength[1] (lb/in. of specimen width)		Lap Shear Strength[2] (lb/sq. in. of lap jointed area)		
Specimen	Warp	Fill	Adhesive bond only	Adhesive plus stitching	Peel Strength[3] (lb/in. width of bonded joint)
New Polyester-Coated Dacron Fabric	207.0	119.0	342.0	not done	5.2
XV-8A Aircraft 63-13003	214.6	135.3	39.5	32.0	2.0
XV-8A Aircraft 63-13004	197.5	117.5	20.9	25.3	1.5

1. Tensile fabric test in accordance with Federal Specification, Textile Test Methods No. CCC-T-191, Method 5104, and ASTM D 1682-59T.

2. Lap shear strength test procedure shown in sketch below.

3. Peel test in accordance with Federal Specification, Textile Test Methods No. CCO-T-191, Method 5960.

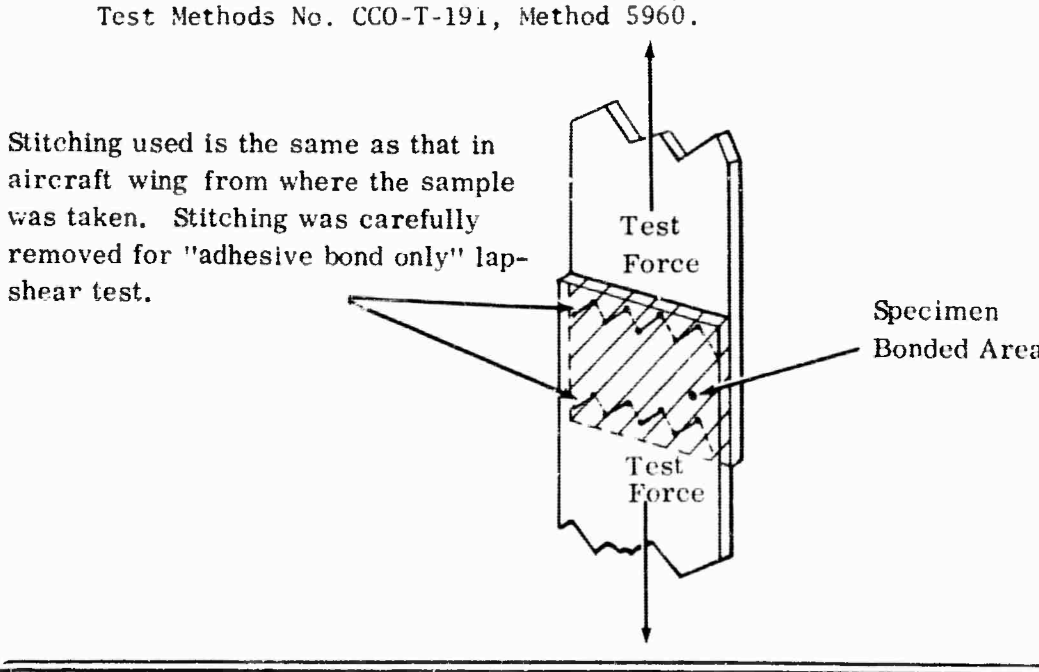


TABLE II. ENGINE OIL TEST RESULTS

	Engine Serial No. 10007 (XV-8A 63-13003)	Engine Serial No. 10013 (XV-8A 63-13004)
Spectrographic Analysis		
Parts per million		
Aluminum	3	3
Iron	23	3
Silicon	8	5
Copper	8	3
Chromium	2	2
Nickel	7	7
Lead	-	-
Tin	1	1
Silver	0.1	0.1
Fuel Dilution (percent)	1.0	1.0
Contamination Index (percent micro particles suspended in oil. Maximum allowable is usually 11 to 16%)	0.4	0.4
Sludge Index (percent, maximum to change oil 4%)	0.3	0.3
Viscosity (Faber viscosity in seconds. 481 to 600 normal for SAE-50 oil)	520	488

Instrumentation oscillograph recorders, signal conditioners, accelerometers, and potentiometers were inspected and found to be in good condition. Strain gauge bonding epoxies were overage and unusable. Wiring from measuring instruments to recording equipment was unserviceable because of field dismantling and subsequent complete disassembly for inspection.

INSPECTION FINDINGS

A detailed list of discrepancies is shown in Appendix I. None of the discrepancies are considered to be significant from a flight safety point of view, and all were easily repairable. No evidence of corrosion was found in either aircraft. The structural condition of both aircraft was excellent.

In view of the good material condition found on aircraft number 63-13003, number 63-13004 was inspected using localized disassembly as required for access to insure an equivalent condition. The second aircraft remained essentially intact.

Fabric specimens were taken from both aircraft in an area about two-thirds of the distance from the keel to the leading edge. This area was selected because wind tunnel tests have shown that this is the area of greatest wing loading. Specimens were cut from both right- and left-hand wing panels.

Inspection of both aircraft showed that the wings' polyester coating had become tacky and soft. The coating was sticky to the touch and adhered to itself when pressed together. However, no evidence of separation of the coating occurred when surfaces pressed together were pulled apart.

The results of the materials laboratory testing are shown in Table I. The strength of the basic Dacron fabric on both aircraft was unchanged with age. The warp and fill tensile strengths ranged from higher than new material test results for aircraft number 63-13003 fabric to very slightly under new material strength for aircraft number 63-13004 fabric.

The bonded joint strength, however, was alarmingly deteriorated on both aircraft. Test results showed that the adhesive bond had only 12 percent or less of the original strength in lap shear. Tests of seam strength with the stitching remaining in the sample were inconclusive but not reassuring. One sample with stitching showed reduced strength below adhesive-only conditions, and one showed a slight increase in strength. The peel strength results confirmed the inadequacy of the adhesive bonding, having only 38 percent or less of original strength.

The reason for this bonded joint strength reduction became apparent on inspection of the failed area. Failure occurred when one coated surface separated from its base Dacron fabric. The Dacron-to-coating-to-adhesive-to-coating bond remained sound on one-half of the failed specimen, while the other half consisted of Dacron with coating on one side only. It was concluded that this condition relates directly to the polyester tackiness previously mentioned. Consultation with the fabric vendor confirmed that this tendency to become tacky with age had been discovered and the manufacturing process had changed after the XV-8A fabric had been made.

Therefore, it was concluded that wing membranes of both aircraft were unsafe for flight and should be replaced with new fabric. A polyester-coated Dacron fabric of the same specification which does not become tacky was used. This helped to preserve wing performance characteristics and the effects upon airplane performance, stability, and control that had been established in earlier flight testing.

INSPECTION CONCLUSIONS

1. Generally, the material of both XV-8A aircraft was found to be in excellent condition.

2. The DD-7 polyester coating on the Dacron wing membranes deteriorates with age, becomes tacky, loses bonding strength to the basic fabric, and is unsuitable for use (see Appendix 1).

3. Structural components in the wing, wing spreader bar, empennage, platform, cockpit area, landing gear, engine mounts, and control system in both XV-8A aircraft were sound and ready for safe flight after minor repair, reassembly, rigging, and checkout.

4. The engines in both aircraft were in good condition for further flight operations.

REPAIRS AND MODIFICATIONS

DESCRIPTION OF REPAIRS PERFORMED

Table III presents a tabulation of repairs accomplished on each of the vehicles.

TABLE III. REPAIRS ACCOMPLISHED

Assembly	Repair	Accomplished on Serial Number 63-13003	63-13004
Wing and Spreader Bar	Remove and replace wing membrane.	X	X
	Repair loose balsa plug in RH aileron.	-	X
	Rig bolt ropes to correct length; secure at outboard end.	-	X
	Install aft cables to keep membrane out of propellor.	-	X
	Cover all brace cables with vinyl tubing.	-	X
	Repair elongated holes in outboard spreader bar fittings (P/N 164W014 - 1 and 2).	X	-
	Reinstall fairings on inboard spreader bar tubes and braces.	X	-
	Make and install missing balsa plugs in fairings.	X	-
	Make and install an incidence "down" stop block on top of roll structure.	-	X
Superstructure	Repair center tripod assembly.	X	-
	Refinish areas stripped for inspection.	X	X

TABLE III - CONTINUED

Assembly	Repair	Accomplished on Serial Number 63-13003	Accomplished on Serial Number 63-13004
Superstructure (Cont.)	Reinstall fairings removed for inspection.	X	X
	Trim fairings on forward A-frame and side braces to eliminate chafing.	-	X
	Make and install balsa plugs in fairings and tubes.	X	X
Platform, Seat Back, and Flight Deck	Repair bent channels in main landing gear spring socket area.	X	X
	Clear chafing elevator cables in LH and RH sides of platform.	X	-
	Enlarge holes in seat back as necessary to clear aileron cables. Install reinforcing plates.	-	X
Empennage	Replace loose rivets in scuff loops on auxiliary tail surfaces.	X	-
	Fabricate scuff loops and install on auxiliary tail surfaces.	-	X
Landing Gear	Replace cracked LH main wheel bearings.	X	-
	Replace all bearing seals.	X	-
	Pack main wheel bearings and adjust to eliminate rotation of seals. Install wheels and brake assemblies.	X	X

TABLE III - CONTINUED			
		Accomplished on Serial Number	
Assembly	Repair	63-13003	63-13004
Landing Gear (Cont.)	Rework front axle and shim installation to provide correct adjustment of nose wheel bearings.	X	X
	Replace rubber sleeves 164L005-11 at LH and RH trunnions.	X	X
Flight Control System	Make and install new RH aileron bellcrank 164W049-2 and 164C036-9.	-	X
	Install rudder pedal control provisions.	-	X
	Obtain and install pulleys for aileron cables at outer ends of spreader bar.	-	X
	Modify support arm assembly 164C038 to prevent interference between pulley brackets and supports.	X	X
	Install pitch trim indicator.	X	X
	Lengthen control column on 63-13003 to same length as on 63-13004. Lengthen chain to compensate.	X	-
Fuel System	Make fuel quantity gauge operable; design, bench test, fabricate and install.	NOT DONE	
	Install sump drain cock.	-	X
	Obtain and install fuel strainer.	-	X

TABLE III - CONTINUED

Assembly	Repair	Accomplished on Serial Number 63-13003	Accomplished on Serial Number 63-13004
Power Plant and Controls	Reinforce mixture control lever. Narrow lever to obtain full travel at injector pump.	-	X
	Make and install seals where spark plug leads enter cooling shroud.	-	X
	Clamp all loose fuel lines and control wires.	-	X
Instruments	Remove instruments for overhaul and calibration; reinstall.	X	X
	Modify panel for installation of vertical speed gauge.	-	X
	Mount compass.	X	X
	Mark operating ranges on instruments.	X	X
	Install plumbing for manifold pressure gauge.	-	X
	Replace manifold pressure gauge plumbing.	X	-
	Install pitot system.	-	X

DESCRIPTION OF MODIFICATIONS

GENERAL

Certain modifications were suggested based upon the contractor's XV-8A operating experience. These modifications were recommended to enhance flight test operations and to improve aircraft handling and reliability. They are listed in detail below, along with a brief description and justification.

CONTRACTOR-RECOMMENDED MODIFICATIONS

Improved Fuel Quantity System. The fuel quantity system design did not function as desired. Excess friction along the actuating rod from tank float to the quantity indicator was the cause. A recommendation to redesign and modify was sent to USAAVLABS. It was decided to restrict flight time of each operation so that adequate fuel would always remain.

Three-Control System. The controls of the XV-8A aircraft number 63-13003 had been converted from a two-control system to an optional three-control system (i.e., addition of directional control by rudder pedal coupling to ruddervators). In order to have the two aircraft identical in control and handling characteristics, the control system of number 63-13004 had to be modified. This modification was approved and was incorporated so that both aircraft could be easily converted to either the three-control or the two-control mode as desired.

Aileron Damping System. Prior flight testing showed that an aileron oscillation of 2 to 3 cycles per second occurs at speeds of 61 to 62 miles per hour, the maximum velocity. Further flight testing would have explored an extension of this velocity limit. Concurrently, it was desirable to investigate the effect of damping this aileron oscillation and relieving its disconcerting effect on the pilot. A modification of aileron mounting brackets and viscous dampers was recommended to explore these effects. It was the decision of the USAAVLABS not to incorporate this modification because of the expense that would have been incurred.

Vibration Analysis. Although not actually a modification, this analysis is closely related to the aileron damping system discussed above. Flight tests have shown that the aileron oscillation is induced by a traveling wave in the wing fabric, which occurs at high airspeeds. If the speed at which onset of this phenomenon occurs could be raised, or if the dynamics of the ripple could be altered, it might be possible to eliminate or favorably change the characteristics of the aileron oscillation. Therefore, an engineering analysis of this problem was recommended in an attempt to determine mass damping, aerodynamic damping, or other methods to reduce or control the fabric ripple.

This recommendation was accepted, and the analysis was conducted under Contract DA 44-177-AMC-395(T). The results appear herein as Appendix II.

GOVERNMENT-RECOMMENDED MODIFICATIONS

The modifications which follow were made at the request of the government.

Electrical System with Engine Starter and Voice Radio Communications. This modification was envisioned solely as an aid to flight test operations. It is not to be considered as a functional part of the basic XV-8A aircraft concept of a primitive, low-cost, low-maintenance, limited-performance, useful aerial vehicle.

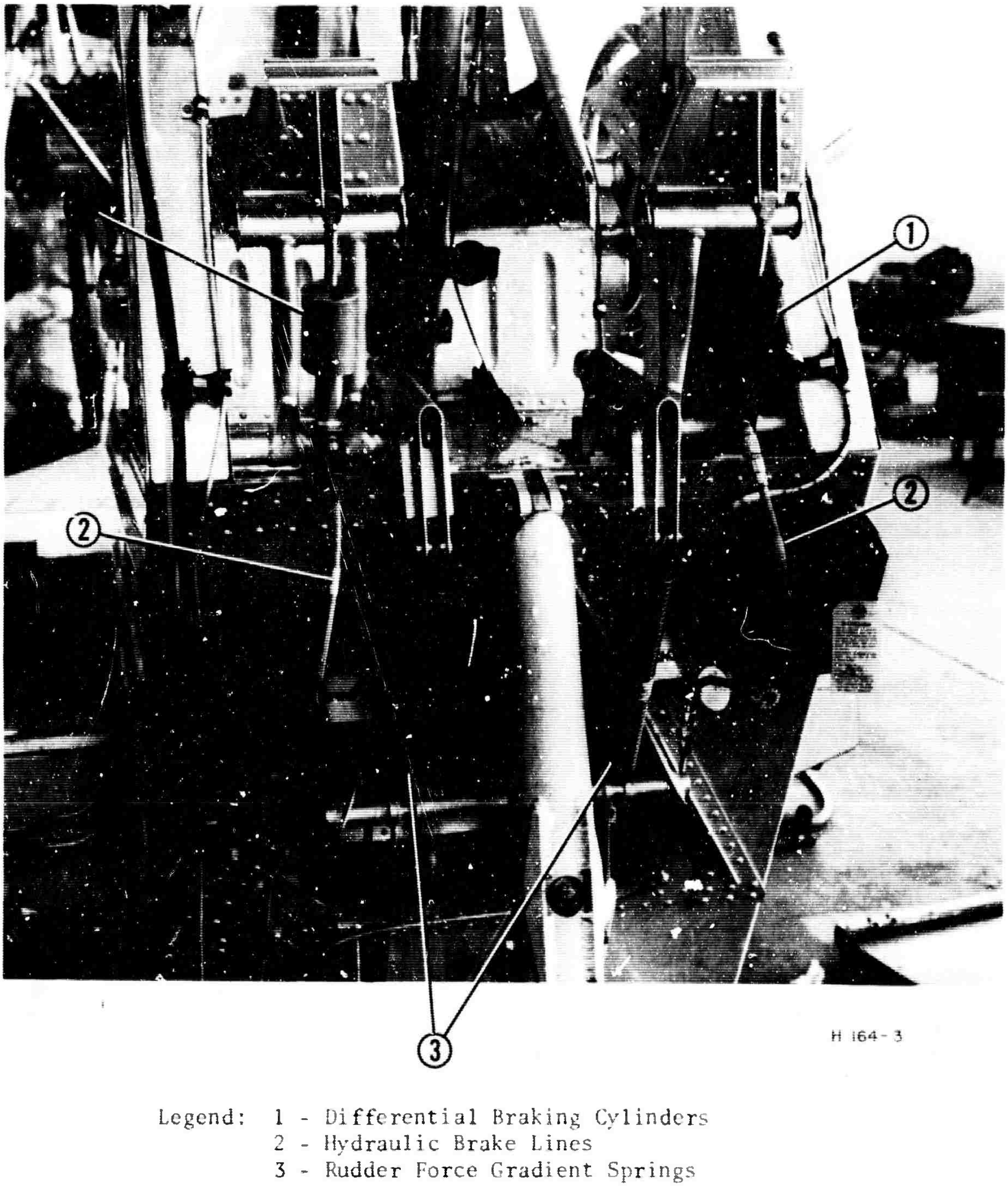
A two-way UHF voice radio communication set, AN/ARC 55, was needed to enhance test operations around high-density airports and test facilities. The electrical system alternator would provide communications power as well as test instrumentation power. The starter primarily would be a safety device to insure engine restarts at low dynamic pressures following engine shutdown at altitude, when exploring power-off landing characteristics. The starter, alternator, and UHF radio were installed in vehicle 63-13003; the AN/ARC 55 radio, in vehicle 63-13004.

Differential Wheel Braking. Braking had been accomplished by applying equal braking to both wheels when the right brake pedal was depressed. Independent braking of the wheels by separate rudder pedal brake controls was needed to improve directional control on the ground, particularly in crosswinds. The modification was accomplished by simple brake pedal modification and the addition of a brake cylinder and hydraulic fluid tubing in both vehicles. See Figure 3.

Rudder Force Gradient. The aircraft inherently had very low forces that tended to return the rudder pedals to neutral in flight. Not only were dynamic pressures low, but the control surfaces were aerodynamically balanced. With the adoption of a three-control system, some "feel" was needed for the pilot through his rudder pedals in flight. The modification was accomplished by connecting springs to airframe brackets and to the rudder pedals as shown in Figure 3. To permit pilot selection, springs with three levels of gradient were used.

Tachometers. Engine tachometers on the instrument panel had been the automotive type, measuring engine revolutions by sensing magneto sparking. It was desired to replace these for flight test with aircraft-quality gauges and aircraft-type electric tachometer generators. The modification was made to vehicle 63-13003 only.

Shorten Control Column. The control column in aircraft 63-13003 had been shortened approximately 2 inches to better accommodate a specific test pilot. To maintain identical handling qualities with the two aircraft, it was proposed to perform a similar modification of aircraft 63-13004. During the course of other modifications, however, the Ryan and USAAVNTA pilots assigned to the project agreed that they would prefer to have both vehicles with the longer version of the column. In the final outcome, vehicle 63-13003's column was lengthened 2 inches.



Legend: 1 - Differential Braking Cylinders
2 - Hydraulic Brake Lines
3 - Rudder Force Gradient Springs

Figure 3. Brake and Rudder Force Gradient Modifications

STRUCTURAL FLIGHT TEST INSTRUMENTATION

The Government requested that the simplest structural instrumentation consistent with flight safety be defined for the XV-8A aircraft. The first purpose of any structural instrumentation is to monitor actual loads encountered in flight test while buildups are being conducted, to expand and define the operating envelope. The comparison of these actual structural loads with allowable values established by static test determines the flight envelope limit as a function of structural strength. The second purpose of structural instrumentation is to aid failure analysis in the event that unplanned events permit failure to occur independent of conditions predicted by flight test planning. Such instrumentation should therefore remain in use until all aircraft modifications which might affect structural loading are accomplished, and until the flight envelope is quite well fixed.

Flight testing conducted in the past had recorded dynamic loads in the principal structural members of the wing, wing support assemblies, and pitch and roll cables. At no time had the observed loads reached the allowable load limits established by the static structural tests. The only structure which experienced loads closely approaching the allowable values was the wing spreader bar assembly. It might then be concluded that continued monitoring of only these loads would be sufficient for flight safety, but only within the configuration and operating limits already established.

Instrumentation for continued use would be consistent with future flight test goals. These goals included investigations of aileron damping, extension of maximum airspeed limit, damping of fabric ripple, and accomplishment of full power-off landings. Army test pilots would again want to subject the aircraft to all the previously established limits. It was therefore concluded that the XV-8A aircraft should fly the next phase of flight testing with all structural instrumentation previously used. Any reduction of instrumentation as an effort toward simplification was not recommended at that stage of flight test development. A drawing index and arrangement of the flight test instrumentation are provided as Appendix III. The structural measurements given in Table IV were recommended (all to be oscillograph recorded).

A general arrangement of the installed instrumentation is shown in Figure 4. The power distribution instrumentation schematic is shown in Figure 5.

The pilot's instrument panel on aircraft 63-13003 was completely revised prior to this program, and the addition of an electrical system included installation of new pilot-operated switches and circuit breakers. The major test instrumentation was embodied in a 50-channel recording oscillograph and a 15-instrument photopanel, both on the platform of the vehicle. Measurements included all types of parameters; e.g., attitude and structural stresses. Arrangement of instruments on the special pallet is shown in Figure 6. General arrangement and schematics are shown in Appendix III.

A photopanel layout and a layout of the pilot's panel are provided as Figures 7 and 9. Table V shows oscillograph assignments.

The instrumentation system presented in Figure 8 proved to be outstanding in its brief period of usage. With a solid basic design and installation, good records were obtained on the first as well as succeeding test operations.

TABLE IV. STRUCTURAL MEASUREMENTS

Member	Location	Measurement
Spreader bar	Horizontal	Compression and Tension
Spreader bar	Diagonal	Compression and Tension
Wing keel	Pivot	Bending
Wing keel	Aft pivot	Shear
Wing keel	Apex	Vertical bending
Wing keel	Fwd. pivot	Shear
Leading edge	Pivot	Bending
Leading edge	Pivot	Compression and Tension
Center strut	-	Compression and Tension
Forward V strut	Right & left	Compression and Tension
Aft V strut	Right & left	Compression and Tension
Pitch cable	-	Tension
Roll cable	Right & left	Tension

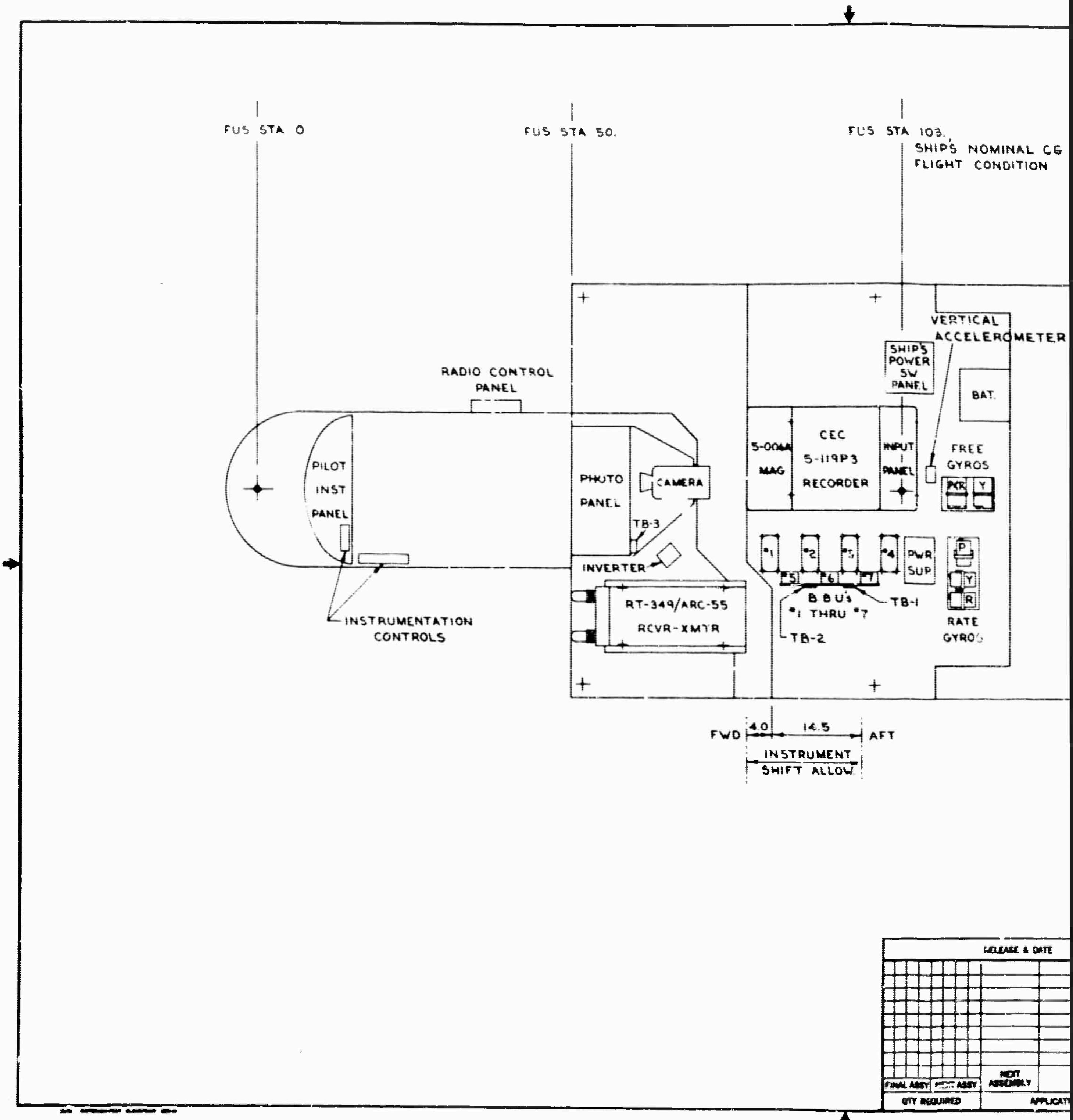
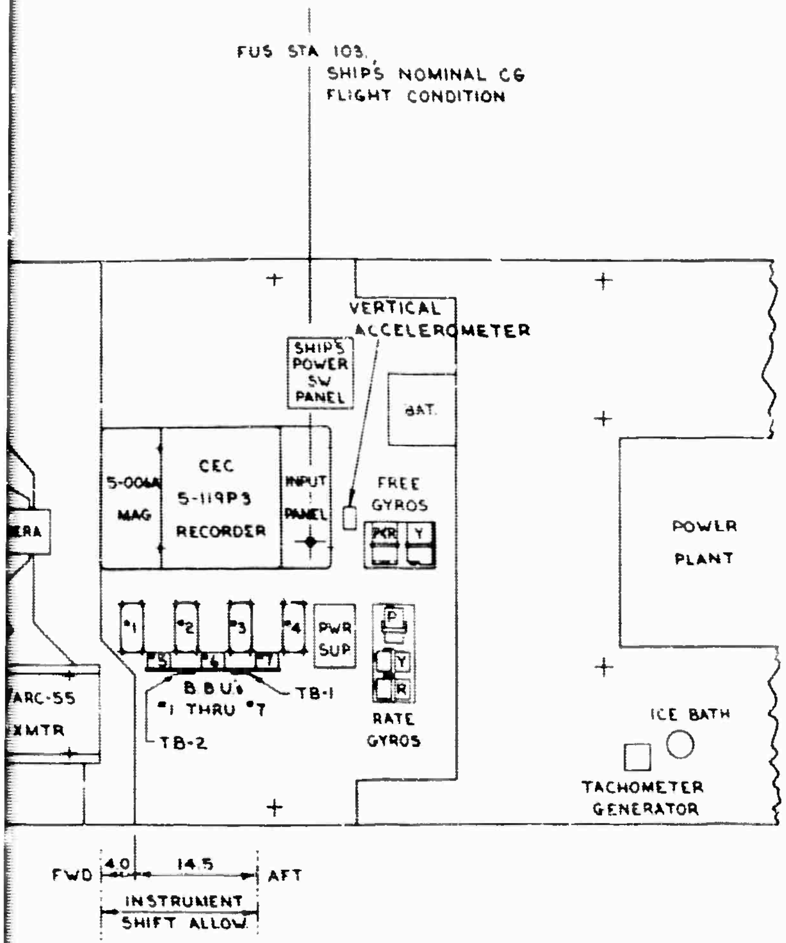


Figure 4. General Arrangement XV-8A Instrumentation



REVISIONS

LTR	EFF ON	DESCRIPTION	DATE	APPROVED

LIST OF MATERIAL

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEM APPLIED OR PLATED FINISHES

CONTRACT NUMBER DA44-177-AMC-395(T)

RYAN AERONAUTICAL COMPANY, SAN DIEGO, CALIFORNIA 92112

GENERAL ARRANGEMENT
XV8A INSTRUMENTATION

SIZE D | CODE IDENT NO. 78022 | NUMBER 164D001

SCALE 1/8

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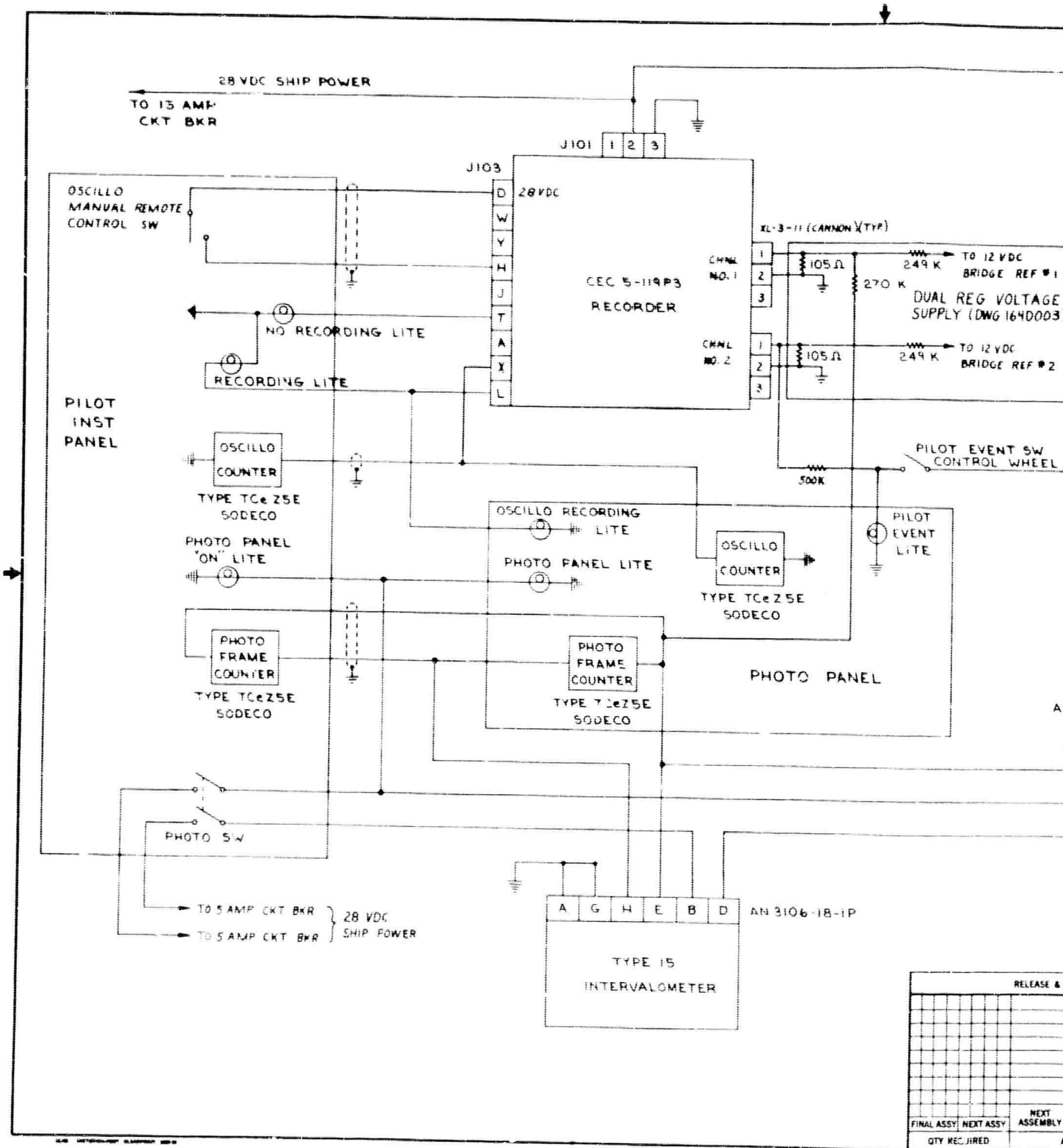
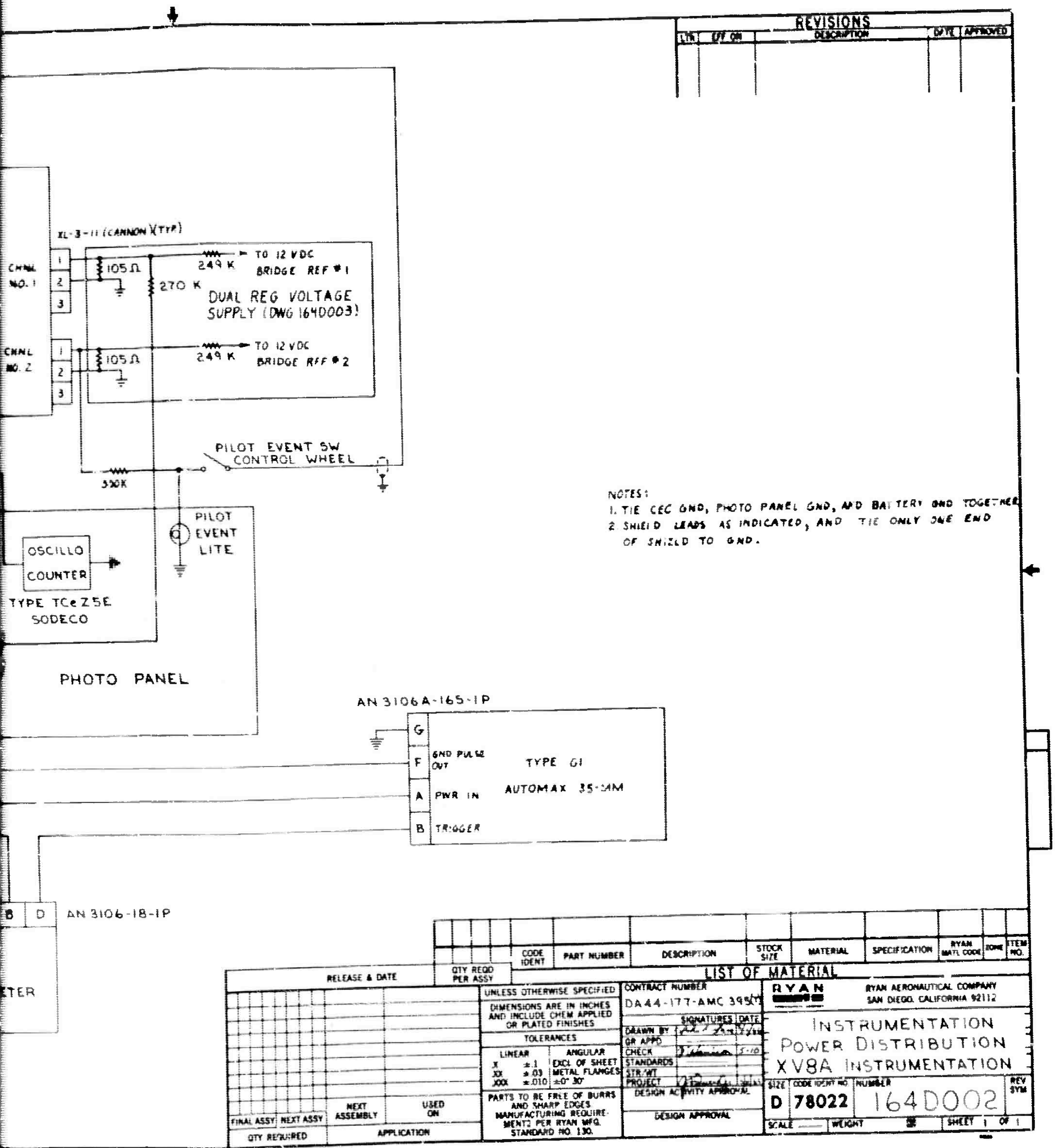


Figure 5. Instrumentation Power Distribution XV-8A Instrumentation



trumentation

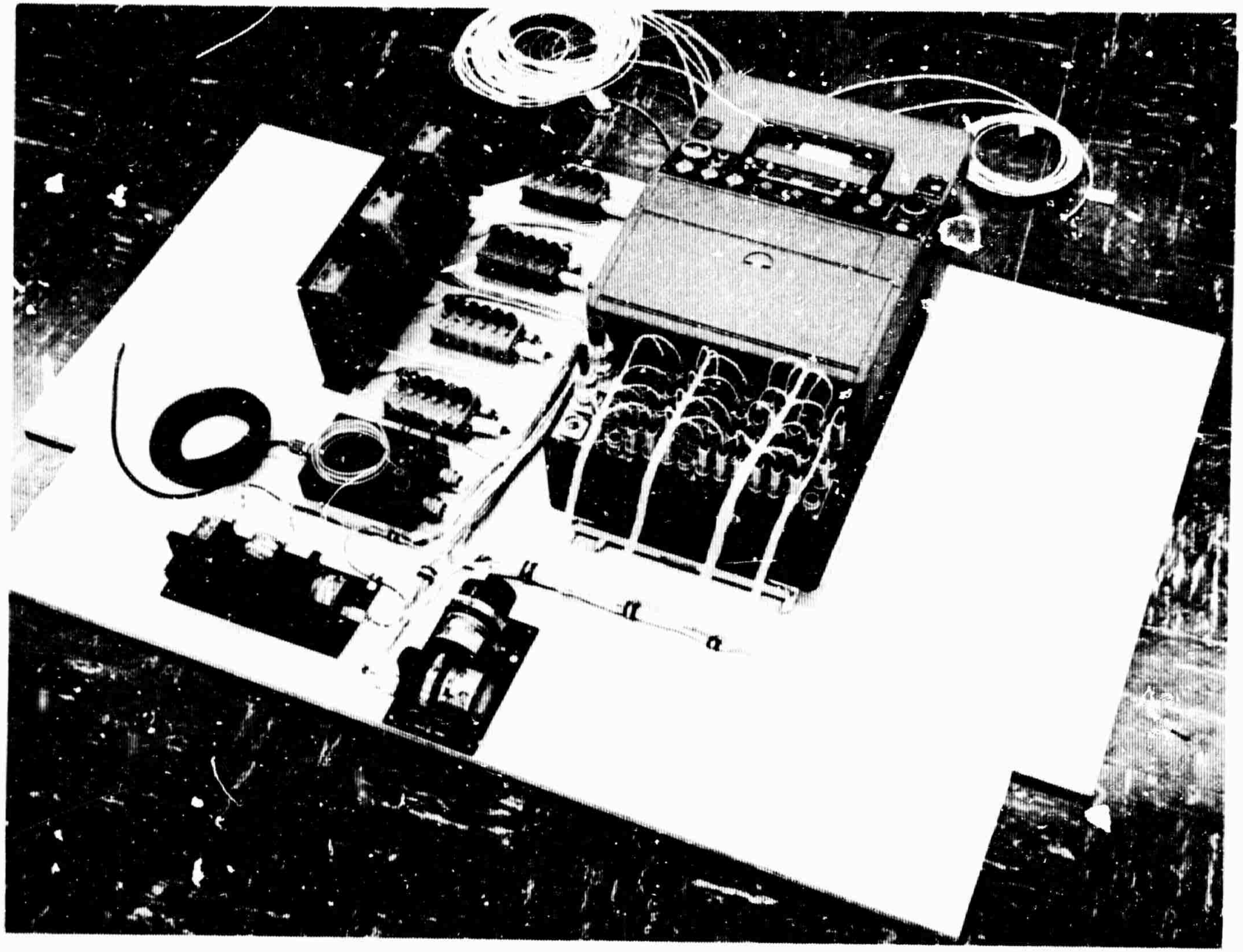
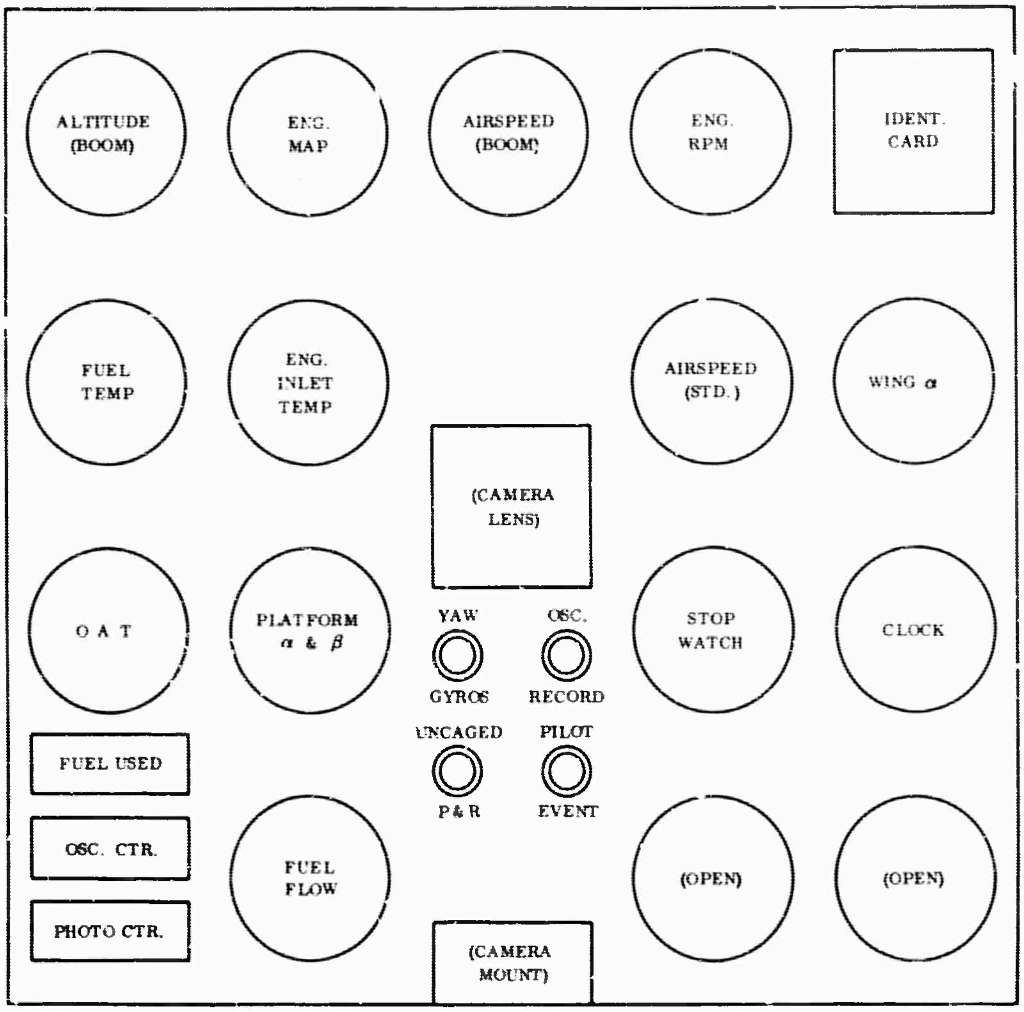


Figure 6. Palletized Instrumentation, Before Installation in Vehicle



NOTE:

INSTRUMENT LOCATIONS FROM BACK SIDE OF PANEL LOOKING FWD.

H 104-5

Figure 7. Photopanel Layout

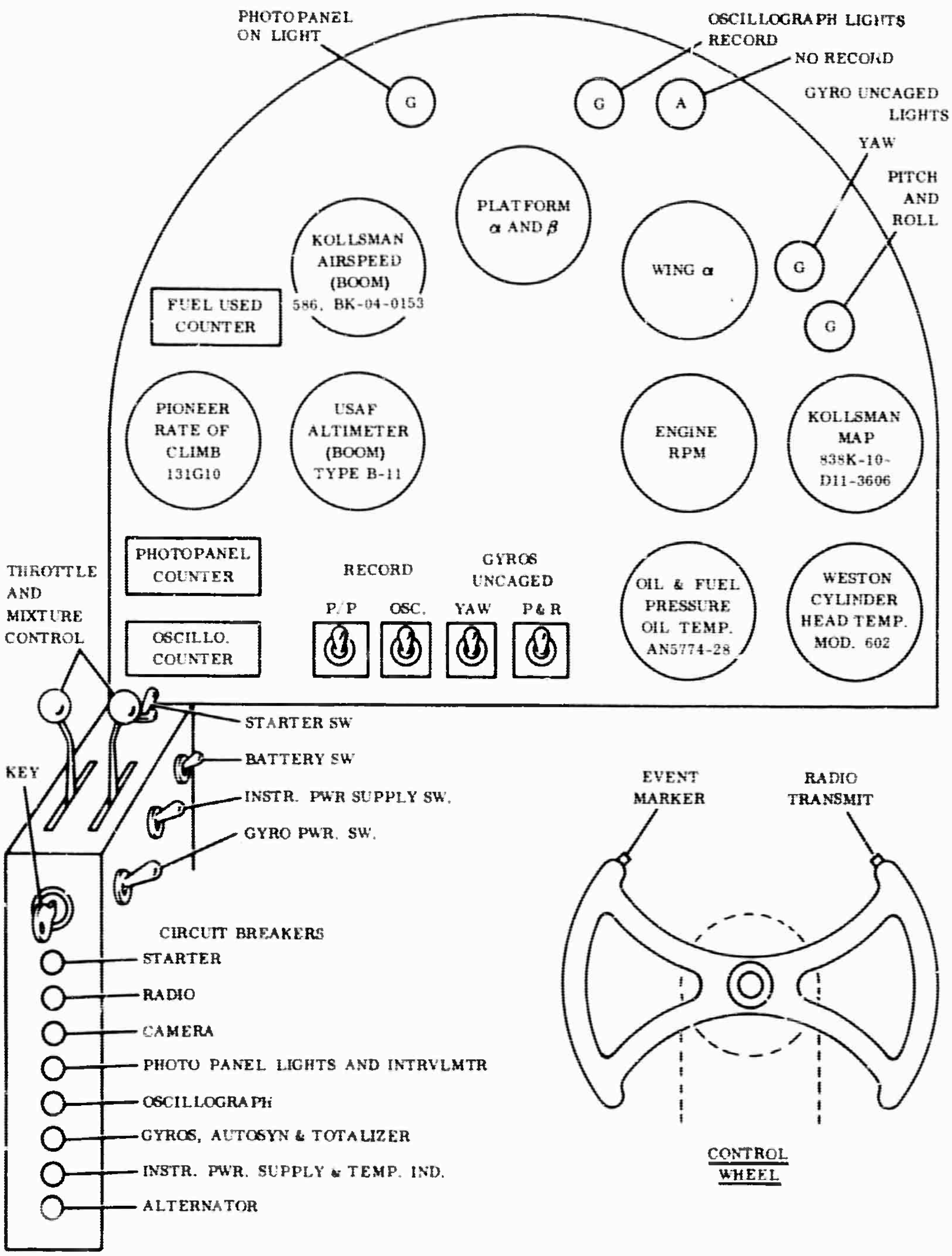


Figure 8. Pilot's Panel Arrangement

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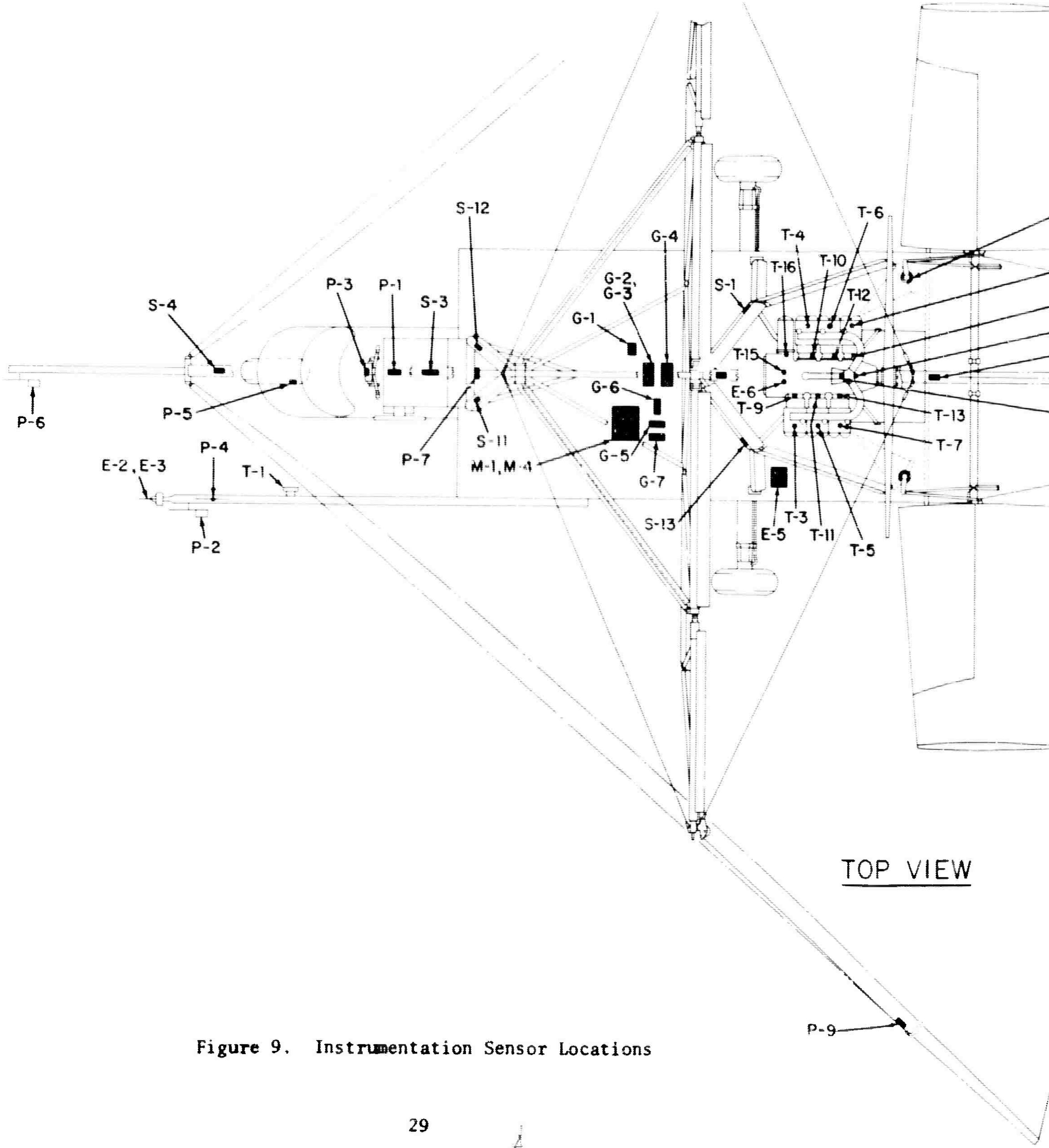
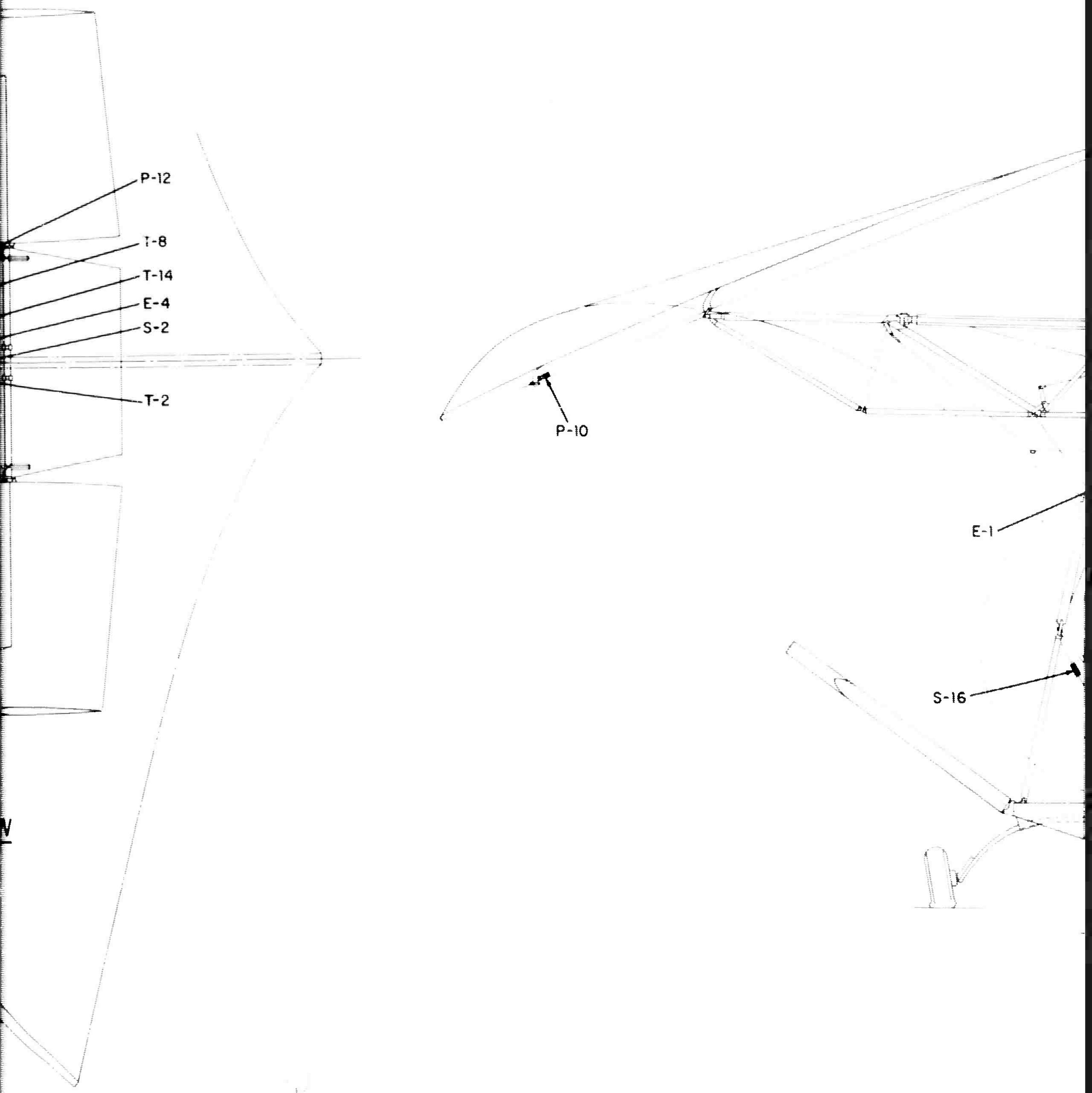
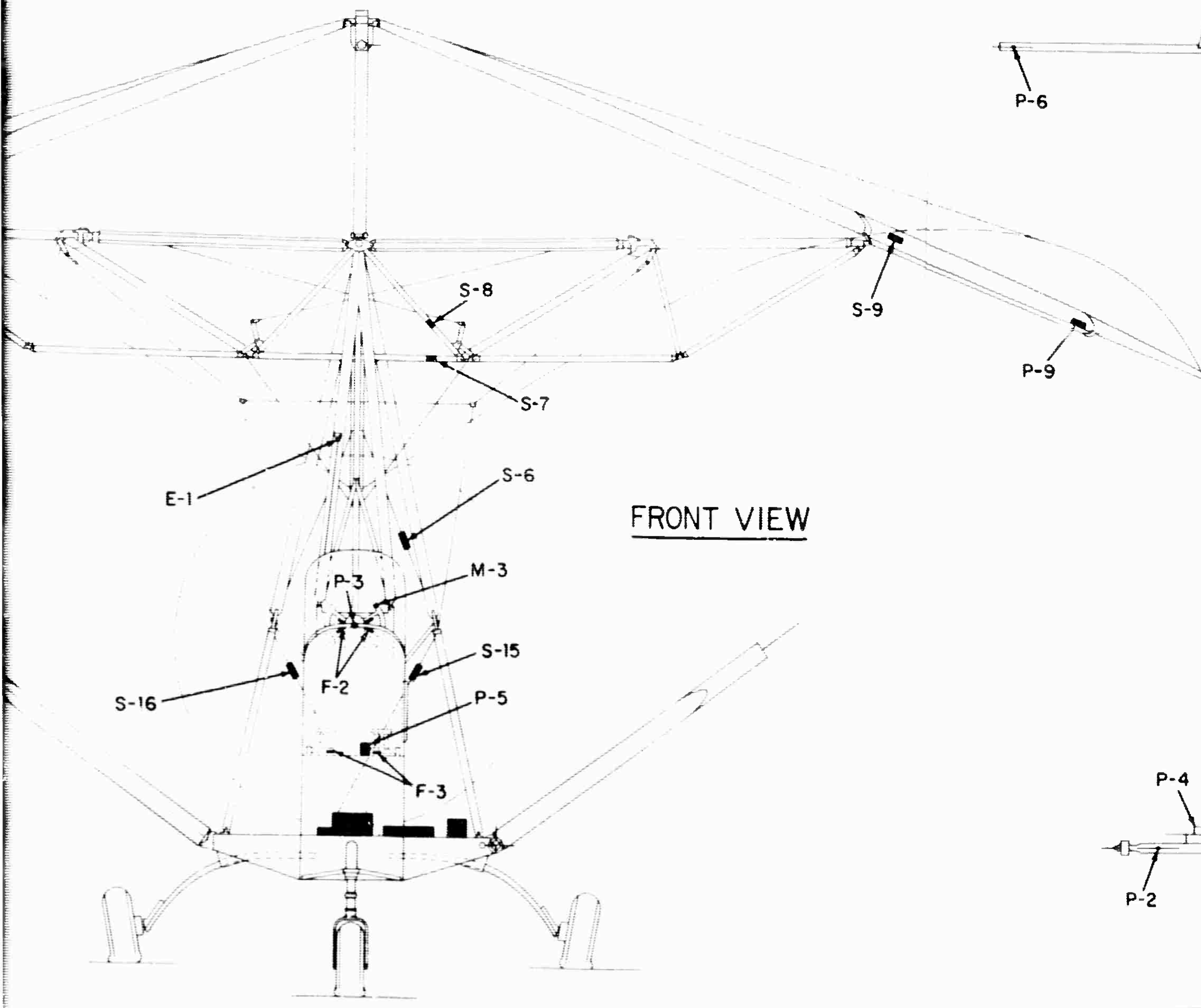
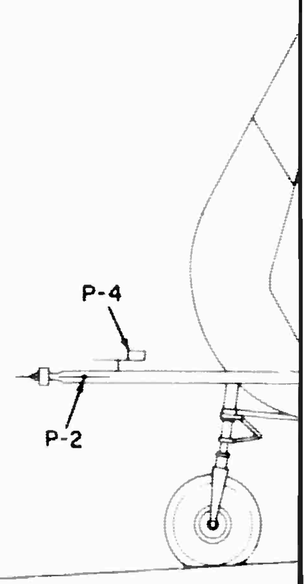


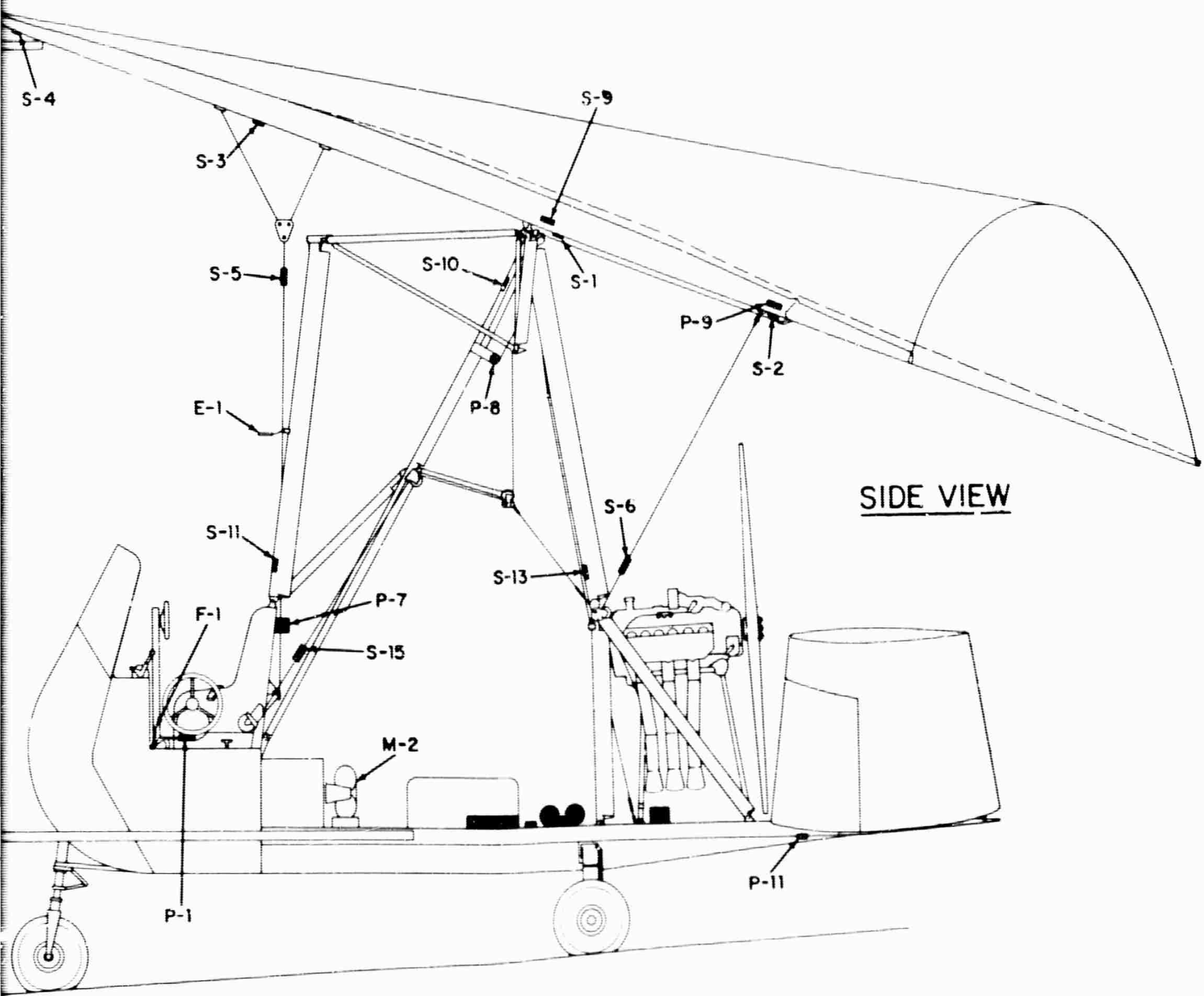
Figure 9. Instrumentation Sensor Locations


P-12
T-8
T-14
E-4
S-2
T-2
P-10
E-1
S-16



FRONT VIEW





SIDE VIEW

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TABLE V. XV-8A OSCILLOGRAPH ASSIGNMENTS

Galvo	Parameter	
0	CEC Oscillograph Paper Reference	
1	Voltage Reference No. 1 and Photopanel Correlation	(M-1) (M-2)
2	Event Marker and Voltage Reference No. 2	(M-3) (M-4)
3	Wing Keel Vertical Bend Pivot	(S-1)
4	Longitudinal Stick Position	(P-1)
5	Angle of Attack (Alpha)	(P-2)
6	Wing Keel Vertical Bend Aft	(S-2)
7	Longitudinal Stick Force	(F-1)
8	Lateral Control Wheel Force	(F-2)
9	Wing Keel Vertical Bend Forward	(S-3)
10	Control Wheel Position	(P-3)
11	Angle of Sideslip (Beta)	(P-4)
12	Wing Keel Axial Load	(S-4)
13	Left Rudder Position	(P-5)
14	Rudder Pedal Force	(F-3)
15	Foward Pitch Cable Tension	(S-5)
16	Wing Boom Vane Angle	(P-6)
17	Wing-Platform Pitch Angle	(P-7)
18	Aft Pitch Cable Tension	(S-6)
19	Wing-Platform Roll Angle	(P-8)
20	Vertical Acceleration	(G-1)

TABLE V - CONTINUED		
Galvo	Parameter	
21	Pitch Attenuator Gyro	(G-2)
22	Roll Attenuator Gyro	(G-3)
23	Yaw Attenuator Gyro	(G-4)
24	(not used)	
25	(not used)	
26	Yaw Rate Gyro	(G-7)
27	Cylinder Head No. 1 Temperature	(T-3)
28	Pitch Rate Gyro	(G-6)
29	Roll Rate Gyro	(G-6)
30	Spreader (Horizontal) Axial	(S-7)
31	Left Wing-Tip Angle	(P-9)
32	Right Wing-Tip Angle	(P-10)
33	Spreader (Diagonal) Axial	(S-8)
34	Cylinder Base No. 5 Temperature	(T-13)
35	Cylinder Base No. 6 Temperature	(T-14)
36	Left Foward-Aft Bend Pivot	(S-9)
37	Left Roll Cable Tension	(S-15)
38	Right Roll Cable Tension	(S-16)
39	Center Strut Axial Load Oil Temperature	(S-10) (T-16)
40	Left Ruddervator Angle	(P-11)
41	Right Ruddervator Angle	(P-12)

TABLE V - CONTINUED

Galvo	Parameter	
42	Left-Forward V-strut Axial Cylinder Head No. 2 Temperature	(S-11) (T-4)
43	Cylinder Head No. 6 Temperature	(T-8)
44	Right-Forward V-strut Axial Cylinder Head No. 3 Temperature	(S-12) (T-5)
45	Cylinder Base No. 1 Temperature	(T-9)
46	Left-Aft V-strut Axial Cylinder Head No. 4 Temperature	(S-13) (T-6)
47	Cylinder Base No. 2 Temperature	(T-10)
48	Right-Aft V-strut Axial Cylinder Head No. 5 Temperature	(S-14) (T-7)
49	Cylinder Base No. 3 Temperature	(T-11)
50	Cylinder Base No. 4 Temperature	(T-12)
51	CEC Oscillograph Paper Reference	

LATERAL CONTROLS OSCILLATION ANALYSIS

Appendix II presents an engineering study of a low-frequency aileron oscillation experienced at speeds of 61 to 62 miles per hour and reported in USATRECOM Technical Report 64-55. (See Reference 1.)

This oscillation is induced by a travelling wave in the wing fabric. The wave originates near the wing spreader bar and moves aft. As each wave reaches the trailing edge of the wing, the flapping action is transmitted to the ailerons, which in turn feed through the control system to the pilot's control wheel. This characteristic is present only at high speed when the wave frequency approaches 2 to 3 cycles per second. This phenomenon starts as a random pulse at the control wheel; as speed is increased, it builds up to a steady beat. In all cases, it has been readily discernible by the pilot. This characteristic does not present a serious operational limit to the aircraft. Trim speeds or normal operating speeds are well below V_{max}. Consequently, this oscillation will not be experienced unless a deliberate attempt is made to reach these speeds.

FLIGHT TEST ANALYSIS

ANALYSIS DATA REQUIREMENTS

The following analyses were required by the contract:

1. Airspeed Calibration - Plot airspeed position error and altimeter position error as a function of indicated airspeed.

2. Engine Cooling Tests - Make time history plots of observed outside air temperature, cylinder head, cylinder base, and oil temperature for level flight and climb. Present a similar plot for the effect of cargo loading. Correct peak temperatures for hottest cylinder head, base, and oil temperatures to indicate peak temperatures on a hot day of 100°F and show in time histories.

3. Lateral-Directional Static Stability - Make plots of rudder, elevator and lateral (including lateral wing displacement) angles and forces, rudder and lateral control positions, and angle of bank against angle of sideslip.

4. Lateral-Directional Dynamic Stability - Make plots of time histories of ruddervator and lateral control deflections, normal acceleration, angle of sideslip, angle of bank, yawing, and rolling velocities versus time.

5. Descent Performance - For the emergency condition, plot rat of descent as a function of velocity (assuming propeller stopped). Plot longitudinal trim (i_W), longitudinal control position, velocity, and rate of descent versus engine rpm (0 to 1800). Data from previous tests may be applied here if applicable. Present qualitative evaluation of landing characteristics with engine shut down (simulated emergency landing).

6. Stalls - Present data in the form of time histories of control forces, positions, deflections, attitudes, accelerations, indicated airspeed, and altitude. Compare two-control and three-control stall characteristics. Compare stall characteristics with and without cargo loading.

7. Maneuvering Stability - Plot stick force and control deflection versus normal acceleration.

8. Longitudinal Characteristics - The level-flight speed envelope shown in Figure 22 of USATRECOM Technical Report 64-55 (Ryan Report No. 64B082A) should be used to present the data obtained during this test. Present investigation of the lateral control oscillation frequency as a function of spee

9. Flight Loads - Present demonstrated maneuvering Flight Envelope showing maximum load factors obtained; superimpose the data on the design V-n diagram.

10. Checkout No. 2 Aircraft (63-130[illegible]) - Plot airspeed position error as a function of indicated airspeed for the aircraft's standard pitot-static system. Plot the Level Flight Speed Envelope (i_w vs. V_C) against that obtained for aircraft 63-13003. Summarize the flight characteristics, particularly any difference between the two prototypes.

FLIGHT TEST RESULTS

Because of the accident damage to aircraft 63-13004 in transit, and the officially termed "incident" damage to aircraft 63-13003, only five test operations were completed. The only qualitative data obtained was that obtained during pilot qualifications. Structural stress data obtained on FTO 164-03-4 are presented in Table VI, substantiating XV-8A structural integrity.

The pilot's comments are probably the best source of information on this abbreviated program and are provided as available. Listed below are some other remarks in specific test areas.

Airspeed Calibration. A speed course method airspeed calibration was scheduled daily; it was cancelled on days when surface winds exceeded 3 to 4 knots. The boom airspeed system contained a GFE-YAPS head pitot-static source. The standard pitot-static source on a strut aft and above the pilot's cockpit was also installed. Reference to the flight envelope data plotted on Figure 10 indicates a boom system position error based on pilot readouts to be in the area of 6 knots additive correction. The pilot's indicator had zero instrument error over the range used. The standard system was recorded on the photopanel.

Flight Envelope. Data were obtained on the mid c.g., design gross weight flight envelope in FTO 164-03-4. Figure 10 shows the pilot-observed points in comparison with the trim and limit speed lines obtained in the previous test program. The airspeed scales were adjusted as indicated on the plot. Minimum speeds were obtained with near-full-aft stick (not on aft stop) and above a speed with any roll-off tendency. Control forces were noted to be heavy in the aft stick position. Maximum speeds were limited by full forward stick under the aileron oscillation limit. On one previous flight, an aileron oscillation had been triggered at 52 to 52.5 KIAS by a wind gust.

Engine Cooling. One preliminary cooling check climb was made on FTO 164-03-5. The highest pilot-observed CHT was 200°C; the limit temperature is 238°C. Maximum observed engine oil temperature was 79°C; recommended operating temperature is 77°C, and maximum allowable is 107°C. The vernatherm valve was not blocked for maximum cooling on this climb, and the oscillograph records were not analyzed and corrected to obtain the hottest temperatures.

Descents. Several descents were made on FTO 164-03-5, using 18[illegible]0 to 1000 rpm. An increase in rate of descent was obtained with a decrease in rpm, similar to that obtained in the previous test program. Several methods were tried to check the descents after the rate had stabilized; power application was found to be the only positive method. Elevator inputs from nea[illegible] full-forward to near-full-aft stick resulted in an airspeed decrease and a nose-up platform rotation but not much decrease in the rate of descent, especially in atmospheric turbulence.

Structural Stress Data. The XV-8A was flown five times in the two-week period (27 June to 6 July 1966) before the damage occurred. By the last flight, however, enough data were obtained to show that the aircraft was structurally well within its design limits. For this reason, all but four of the structural items were deleted from the oscillograph prior to FTO 164-03-5.

A brief summary of the peak loads is presented in Table VI for critical time periods in the last two flights. Since the peak values were desired, the readings were not made at exactly the same time, as the peak load values in the different structured members usually occurred at different times.

In FTO 164-03-3, the peak forward and aft cable tensions reached magnitudes of 400 pounds and 800 pounds, respectively. These occurred during periods of brief, high-frequency, 11-cps wing oscillations.

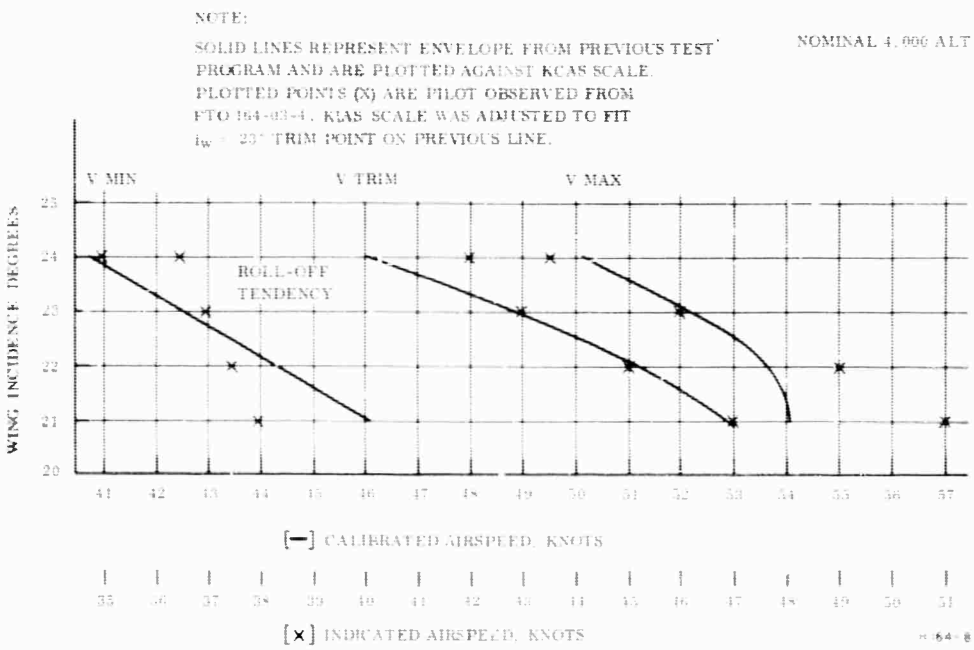

Figure 10. Flight Envelope for 2300 Pounds Gross Weight and Mid-C.G.

TABLE VI. PEAK STRUCTURAL LOADS
(μ in./in. except as noted)

		Start Taxi	Lift-off	Straight and Level	Turns and Oscillations
FTO 164-03-4					
S-1	Wing keel vertical bending at pivot	-310	1760	1910	2070
S-2	Wing keel vertical bending at aft cable	390	3550	3750	4090
S-3	Wing keel vertical bending at forward cable	-1210	530	270	750
S-4	Wing keel axial load near apex	200	115	115	115
S-5	Forward pitch cable tension (lb)	65	95	25	125
S-6	Aft pitch cable tension (lb)	0	100	100	110
S-7	Spreader horizontal tube axial load	-290	-1460	-1430	-1620
S-8	Spreader inboard diagonal tube axial load	-230	-210	-205	-220
S-9	Leading edge forward-aft bending at pivot	1260	3190	3400	3600
S-10	Center strut axial load	-440	-1440	570	650
S-11	Left forward V-strut axial load	120	155	100	-270
S-12	Right forward V-strut axial load	105	50	70	400
S-13	Left aft V-strut axial load	-20	-590	190	340
S-14	Right aft V-strut axial load	20	-50	-190	-390

TABLE VI - CONTINUED					
		Start Taxi	Lift-off	Straight and Level	Turns and Oscillations
FTO 164-03-4 - (Cont.)					
S-15	Left roll cable tension (lb)	0	0	10	25
S-16	Right roll cable tension (lb)	0	0	5	15
F-1	Longitudinal stick force (lb)	8	16	2	12
F-2	Lateral control wheel force (lb)	10	0	0	30
F-3	Rudder pedal force (lb)	30	15	0	0
FTO 164-03-5					
S-1		-5[illegible]0	1800	1840	1260
S-8		-180	-970	-970	-1005
S-9		1220	3590	3440	3920
S-10		670	670	650	480

PILOT EVALUATIONS

EVALUATION OF AIRCRAFT MODIFICATIONS

The major vehicle modifications accomplished prior to the test program were not fully evaluated during the short-duration flight program, as indicated below.

Electrical System. Operation was satisfactory; no problems were encountered. The starter was utilized for all ground starts, but air starts were not attempted.

Wing Fabric. The aircraft appeared to have approximately the same characteristics with the new wing fabric installed. The high-speed aileron oscillation appears to occur at a higher speed than obtained previously. This higher speed may be attributed to the new fabric installation or wing/aileron rigging.

UHF Radio Installation. The RT-346/ARC-55 receiver transmitter presented no problem. Some blanking out of ground communications was evidenced because of antenna location (underneath the platform) coupled with varying relative positions of the aircraft to the radio communications vehicle. All airborne communications were satisfactory.

Rudder Force Gradient Spring. Three-control operations were not conducted prior to test shutdown.

Two additional modifications are recommended by the test pilot prior to performing any further tests:

1. Install a good wing incidence indicator for the pilot. This is a critical trim parameter; the current indication system was built in the field during a previous program and has a 0.8-degree (1/4-inch) looseness in the mechanism. This is over 15% error in the total travel used. In addition, it is sensed in the wrong direction; i.e., aircraft nose down, decreasing wing incidence is correctly obtained by forward motion of the trim wheel, but the indicator ball moved aft for a decreasing value.

2. Provide reliable means for the pilot to determine the quantity of fuel used or remaining. The present aircraft system is inoperative.

PILOT'S FLIGHT TEST REPORTS

The following reports, FTO 164-03-2 through FTO 164-03-5, represent informal recording of events and impressions by the pilot. Table VII summarizes the pertinent information.

TABLE VII. XV-8A

Date	FTO	Surface Temp.	Wing Dir./Vel.	Flt./Assum.	Pilot	Gross Weigh
6-27-66	164-03-1	-	--	:00/:00	Schaeffer	2120
6-28-66	164-03-2	70°F	Calm	:25/:25	Schaeffer	2300
6-29-66	164-03-3	72°F	240°/7K	1:10/1:35	Schaeffer	2300
6-30-66	-	-	-	-	-	-
7-1-66	164-03-4	70°F	230-240°/8-10K	1:15/2:50	Schaeffer	2300
7-4-66						
7-5-66						
7-6-66	164-03-5	71-83°F	220°/5-10K	1:05/3:55	Schaeffer	2300
					Watts	2190

A

TABLE VII. XV-8A FLIGHT-TEST CALENDAR

ssum.	Pilot	Gross Weight	Center of Gravity	Pertinent Configuration	Purpose	Remarks
00	Schaeffer	2120	102.6	Modified A/C	Pilot familiarization	12 taxi runs, including lift-offs on lake bed. Fly off 39 KIAS with 20° wing and 35 KIAS with 23° wing.
25	Schaeffer	2300	103.2	Added 180-pound ballast	Pilot familiarization	4 taxi runs 3 LOF - 500- ft altitude feel-out with 23° wing. Set static idle at 1000 rpm.
:35	Schaeffer	2300	103.2	-	Pilot familiarization	Flight from lake bed to +1500 feet. Included 9 T&G with surface winds to 10K. Flt. env. 20-24° wing-trim, min. and max. speeds. Some qualification descent arrest checks.
	-	-	-	-	-	Cancelled FTO because of wind condition (8-12 K, gust 14-16 K).
2:50	Schaeffer	2300	103.2	-	Flt. Env. definition, mid-c.g.	4K flt. env. 21-24° wing trim, min. and max. speeds - completed. Pilot got some lower altitude and surface/wind/gust experience
						Holiday.
						No flight schedule.
3:55	Schaeffer	2300	103.2	Reset idle to 610-630 rpm	Eng. cooling check climb, descents	Cooling climb OK, 5 descents 1800-1000 rpm, and pilot qualification checks of lateral control power.
	Watts	2190	103.5	Post-flight check taxi operation	Pilot familiarization	Completed 2 taxi runs, 25-29 KIAS. Taxi back to line. Tip-over from wind gust.

1. FTO 164-03-2

SUMMARY

"The aircraft was flown for the first time on a familiarization flight by the writer. After three lift offs and touch downs, a prolonged 20 minute flight at altitudes of five to six hundred feet above the lake bed was performed. No difficulty was encountered and the pilot feels that the aircraft is quite easily handled, and compares favorably to that of a Piper J-3.

PURPOSE

"The purpose of this flight was to familiarize the pilot with the existing flight envelope.

PROCEDURE

"The aircraft was taken aloft from Edwards Air Force lake bed. The prolonged flight of 20 minutes was preceded by three low altitude lift offs. During each of the airborne trips, the pilot evaluated on a familiarization basis various flight characteristics. Small inputs were followed by ever-increasing flight control inputs.

RESULTS

"A slow taxi build up in speed to a value of 39 knots was punctuated with various longitudinal and lateral impulses. The longitudinal inputs up to flying speed resulted in no response. Lateral response was noted at a speed of roughly 36 knots. The aircraft became airborne at 39-1/2 knots and began to climb steadily.

"The actual lift off is very, very hard to distinguish. It is felt that if the pilot's eyes were closed, he would not know the exact moment that he became airborne. The only telltale sense was the aerodynamic lateral control required at lift off.

"The first three lift offs and touch downs showed that the aircraft was very responsive to power for altitude control. They also showed that very little longitudinal control is available at speeds of 39 to 41 knots with power to maintain level flight.

"The aircraft was landed in each case very simply by reducing power and setting up a slow sink rate. Lateral control was good. It was found that lateral responses to increased control pressure was ever diminishing i.e., more pressure on the lateral yoke did not produce its proportionate amount of roll.

"The prolonged flight was initiated after a landing confidence was planted in the pilot. This lift off was followed by a climb to approximately 500 feet above the lake bed. The aircraft was maneuvered in ever increasing amounts. Lateral control was checked up to fairly respectable bank angles at speeds between 40 and 47 knots. It was found that maximum speed was limited by forward longitudinal control. At a speed of 47 knots with full forward stick, the aircraft would with increased power just continue climb. Lateral control was very good throughout this flight.

"It was found that the aircraft flew hands off at speeds of between 42-1/2 and 43-1/2 knots. In this speed range, all that was necessary was to use power for control of this altitude and lateral control to steer the vehicle in whichever direction desired. If power was not decreased too low, the aircraft speed stability was great enough to give very, very precise altitude, i.e., climb and descent control. With healthy increments of reduced power, the effect was to reduce the airspeed markedly before stability took over to regain airspeed. The aircraft was not allowed to fly slower than 39-1/2 knots during this flight.

"Longitudinal control was considered barely adequate around the trim speed envelope. The aircraft could be pushed over to a speed of 50 knots but would very quickly return to 47 knots with full forward stick application. Low speed full aft stick flight was not investigated. The only wing incident angle during this flight was 23°. The landing approach was performed with power alone at the trim hands off speed. The aircraft was touched down on the lake bed at approximately 42 knots.

IMPRESSIONS

"It is felt that the aircraft is very simple to operate and to fly at speeds very near the trim speed for the wing incidence. From the comparison of the FLEEP and the Piper J-3 type aircraft, it is felt that if the FLEEP is flown at trim speeds, it is easier to fly. It is also felt that a very inexperienced aviator would have little trouble in handling the aircraft if he were properly instructed to fly only at trim speeds. He need only to realize that outside forces were not to be responded to and that the airplane itself in its extreme inherent stability would react to these forces. He only need to be made aware that the aircraft does not respond immediately to control inputs."

/s/ V. H. Schaeffer

2. FTO 164-03-3

PURPOSE

"The purpose of this flight was pilot familiarization, with special emphasis on dynamic response at various flight conditions such as slow and fast flight for angles of incidence 21 through 24 .

PROCEDURE

"The vehicle was flown off the lake bed at an angle of incidence of 23° using trim speed of 43 knots. The vehicle was climbed to 3,000 feet. Level flight wing incidences of 22°, 21° and 24° were investigated at high and low airspeeds. High speed was accomplished by maximum power and full forward stick. Slow speed for each angle of incidence was determined when the airplane exerted a roll-off characteristic. Dynamic inputs were employed in both flight axes, i.e., roll and pitch. Small inputs were followed by ever increasing displacements. After descending to the lake bed numerous landings were made to build up pilot confidence and to develop techniques for precision landing. Various techniques such as steep approach angles and flat approach angles were evaluated.

RESULTS

"Results of the above procedure built much confidence in the controllability of the XV-8A. Top speed was obtained with maximum power and 21° of wing incidence. Top speed was 52 to 53 knots steady with gusts to 54 or 55 knots during encounters of turbulence. On two occasions when turbulence was encountered, the wing tip began to flutter and it required slowing down to rid the flapping in the wing. The pulses came at 2 to 3 per second. It was found that with full forward stick and maximum power the airplane still climbed at 100 feet per minute. Maximum speed holding level altitude was 51 knots and required a reduction in power.

"Slow flight for each wing incidence was terminated when the vehicle showed a tendency to roll to the right. In each case, the roll off was to the right. Roll-off to the left was only encountered from a left bank at slow speeds. It was found that under each condition roll-off was experienced at 34 to 34-1/2 knots. At a wing incidence of 21° minimum speed with full aft stick was 36 knots. No roll-off was experienced. At angles of incidence 22°, 23° and 24° roll-off occurred prior to full aft stick. During dynamic response evaluation it was found in every case that the inputs created a dead-beat oscillation. During the entire flight no real excitement was encountered. It was found that the aircraft very decidedly had a trim speed for each wing incidence at which it wanted to fly. All attempts to fly at other airspeeds were strongly resisted. It was found that the aircraft would fly nicely at the trim speeds even in turbulent air and if the pilot would train himself not to be bothered by platform oscillation due to turbulence, he would have no problem in driving the vehicle around.

"The various above techniques of landing resulted in the most accurate being a low flat approach to the point of touch down using the wing incidence trim speed. The aircraft could be controlled to a spot landing and very quickly stopped. Using any other technique such as high, slow, or fast sink rates made accurate touch downs almost impossible. Many, many landings were made and confidence in the ability to land the vehicle became high. Roll out during each landing was very short even though no brakes were used.

IMPRESSIONS

"From the previous and above flights, it is felt that the XV-8A can be easily transitioned, and too, that the less experienced aviator will be little bothered by the usual flight characteristics It is felt that first flights in the XV-8A would be less exciting than first flights in a Piper Cub. It is recommended that during the upcoming pilot check out phase, a Piper Cub be made available to the pilot just prior to flying the FLEEP. This would have the advantage of comparative evaluation to the checkout pilots."

/s/ V. H. Schaeffer

3. FTO 164-03-4

PURPOSE

"This flight was planned to acquire data of maximum, minimum, and trim speeds for wing angles of incidence 21 through 24 degrees.

PROCEDURE

"Takeoff was performed at a wing incidence of 23° and was followed by a climb to 4,000 feet. At an altitude of 4,000 feet, data was taken of level flight trim speeds for various wing incidence angles. Stabilized trim speed was with no stick longitudinal deflection (hands off). Power was varied until an absolute no-rate-of-climb condition existed. This was carried for one to two minutes prior to initiating 10 seconds of data acquisition (oscillograph and photo-panel). Maximum stabilized airspeed for each angle of wing incidence was obtained with full forward stick and power to maintain level altitude. Minimum speed was maintained at 1 knot above roll-off with power for level altitude and with aft stick forces. Again after one or two minutes of stabilized flight, records were obtained. All runs were made either into or away from the wind.

RESULTS

"The results of the above tests show that the aircraft is very speed stable. During all operations, the trim speed for no longitudinal control is the speed at which the airplane wants to fly and strongly resists all efforts to fly at any other speed. Data of actual speeds obtained during each of the above stability points can be obtained from Flight Test Engineering records.

"Following the actual data tests, the aircraft was flown at low power in descents for familiarization. It was found that the aircraft at low power settings is very sensitive to pitch control. RPM's of 1800, 1600 and 1400 were investigated and simulated roll-outs were performed at an altitude of around 3,500 to 3,000 feet (800 tape line). In each case, the sink rate recovery was disappointing. A roundout to 35 knots only reduced the sink rate 100 to 200 feet.

"A number of landings were performed using the lake bed compass rose for direction into or slightly out of the wind. It was found during these landings that the best approach to a precise landing was that of a simulated carrier power where low level flight was maintained and at the desired touch down point, the aircraft was lowered to touch down with power. A very high degree of accuracy is available. It was found that high angle sink rates were very hard to control due to the aircraft's tendency to return to its hands off trim speed. Descent angles to a desired touch down point under these conditions were difficult. It was also found that power recovery of the descent rate was slow but positive. Round-out, of course, did not seem to arrest the sink rate. High sink rate approaches will result in the various hard landings while low level approaches will result in precision, easy touch downs.

"The final touch down was made on the Douglas ramp with 50 to 100 feet roll out. It was found during this approach that any gusts that tend to carry the vehicle either in roll or sideward can very decidedly be recovered from by muscling to desired flight with positive lateral wing tilt.

IMPRESSIONS

"Gusting winds which were experienced during the above described landings, while tending to excite the pilot, can positively be controlled. It is felt that if he ignored the short period oscillations and over-powered with lateral control any long term tendencies the aircraft could be controlled significantly. It is felt that the use of two hands on the wheel during landing is very desirable. It is felt that if a foot throttle were installed so that the pilot could control power with one foot and steer with both hands, the vehicle would in fact fly like a pickup truck is driven. A driver who was mentally adjusted to the pendulum effect from gusting air on the wing and who did not attempt to maneuver the airplane in any other than his trim speed would find the XV-8A simple to handle. It is felt that a pilot with more experience will find himself more excited by the flight characteristics of the FLEEP than an inexperienced aviator.

"Landing into winds between 8 and 12 knots with gusts, using level flight approach, was no problem. Slight off-wind landings were performed and found to be relatively simple."

/s/ V. H. Schaeffer

4. FTO 164-03-5

PURPOSE

"The purpose of this flight was to obtain climb data at 23° of wing incidence after five minutes of level flight with trim speed at 300 feet. It was also planned to obtain descent data at various engine RPM's down to idle.

PROCEDURE

"Idle RPM was set prior to takeoff at 630. After a 23° wing incidence takeoff and climb to 3,000 feet, five minutes of loiter was performed. Records were obtained every 30 to 45 seconds. Following this period, a climb of 4,500 feet was made using full power at vehicle trim speed. Again records were obtained roughly every 300 feet of climb.

"Descents were then performed at 1800, 1600, 1400, and 1200 RPM. Descents were performed from 5,000 to 3,500 feet. Records were obtained prior to and turned off after recovery. One descent was made for each RPM setting.

RESULTS

"During level flight at 3,000 feet engine oil cylinder head temperatures remained in the 75° and 195° to 200° temperature ranges, respectively. During maximum performance climb the cylinder head temperature climbed to 200° and remained steady until the final portion of the climb where it eased off to 195°. Oil temperature during the climb reached no higher than 78°.

"Between the climb and the descents, many minutes were spent flying in a rough air layer around 4,000 feet. It was found that the XV-8A could very easily be muscled from almost any gust which tended to tip the airplane severely. It was found that a fair degree of lateral control power is present. Much confidence in the lateral controllability of the FLEEP was obtained.

"During the above descents, the aircraft was found to arrest its sink rate very poorly with pitch. This was also the case experienced on the previous flight. It was interesting to note on two occasions when 35 knots was overshot to 34, there was no tendency to roll off. It was also found that the additional one knot of slower speed seemed to begin a very marked arresting rate. It is strongly felt that roll-off at slow speeds is due to engine power driving the wing against a high degree of resistance. Like all kites in high wind, it takes the easiest course of low resistance, which is a roll-off. It is felt that at low power, much lower speeds can be obtained by the flex wing. This lower speed will also arrest a higher percentage of sink rate. A low power stall investigation is of primary importance before low power sink rate landings are demonstrated. It is felt that with its very sensitive pitch control at low power settings a relatively low airspeed can be obtained before the vehicle falls nose down from lack of pitch power.

"Forcing the vehicle to higher speeds with low power was found to be more uncomfortable and is not desirable during high sink rates. The aircraft wants desperately to get back to its trim speed and continually fights this high speed stick position. Further investigation here is mandatory.

"The landing in very gusty conditions was of no consequence. However, the desire for a foot pedal for power control was experienced.

"It was also discovered what has caused the pitch up tendency experienced on landings during the previous program. A decided nose up pitch is the result of quick power reductions, even as small as 200 RPM. Reductions greater than 200 RPM rapidly employed will excite the pilot to use forward stick as a check. A sharp reduction coupled with a sharp aft stick deflection as on landings will definitely feel awful."

/s/ V. M. Schaeffer

QUALITATIVE EVALUATION BY GOVERNMENT PILOTS

A requirement of the contracts that Ryan provide support, indoctrination, and 10 hours of training for Government pilots was not met because of the damages suffered by both aircraft. In the absence of such training, qualitative evaluation data cannot be procured from pilots.

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4. Ryan Aeronautical Co., REPORT OF AN INVESTIGATION INTO THE CIRCUMSTANCES SURROUNDING A TAXI INCIDENT WITH XV-8A, SERIAL NO. 63-13003, ON 6 JULY 1966, 13 July 1966.

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6. Ryar Aeronautical Co., XV-8A FLIGHT TEST INSTRUMENTATION CIRCUIT DIAGRAMS, June 1966.

7. STATEMENT OF WORK, APPENDIX I, XV-8A DETAILS OF TEST, Contract No. DA 44-177-AMC-402(T), 22 April 1966.

APPENDIX I
DETAILED INSPECTION FINDINGS AND NECESSARY REPAIRS

XV-8A AIRCRAFT NO. 63-13003

A. WING MEMBRANE

The DD-7 polyester-coated Dacron fabric specimens were tested to new material specifications with the following results:

DISCREPANCIES	NECESSARY REPAIRS
1. Tensile test of basic fabric exceeded the new material tensile specification of 207 lb/in. by 119 lb/in.	None
2. Lap shear test of adhesive bonding of the membrane lapped joints showed approximately an 88% loss of original strength (average 39.5 lb/in.^{2} compared to 342 lb/in.^{2}).	Repair not considered feasible. New membrane required.
3. Lap shear test of adhesive bonded and stitched lapped joints showed average strength of 32 lb/in.^{2}	Repair not considered feasible. New membrane required.
4. Peel test of adhesive joint showed 2.0 lb/in. compared with 5.2 lb/in. new material data.	Repair not considered feasible. New membrane required.
5. The DD-7 coating on the Dacron fabric was found to be generally tacky and soft. The manner of failure noted in the three joint tests was separation of the coating from the fabric. The coating-to-adhesive-to-coating bond remained sound. It was therefore concluded that no coating treatment was practical that would correct the tackiness and restore joint strength to an acceptable safety-of-flight condition.	Repair not considered feasible. New membrane required.

B. WING, STRUCTURAL

DISCREPANCIES	NECESSARY REPAIRS
1. Two fairings 164W037-5 have field change cut-outs to provide turnbuckle and cable access. Effectiveness and integrity of fairings not affected.	Drawing change only to show required cut-outs for maintenance and inspection
2. Left-side spreader bar outboard arm assembly 164W014-1, left fitting 164W010-1 taper pin hole (0.379-0.380 in. dia.) elongated to 0.391 in. for one-third of hole depth. Caused by repeated taper pin insertion during wing spreading operations. Satisfactory as is.	None
3. Right-side spreader bar outboard arm assembly 164W010-7 fitting in 164W014-2 arm assembly, 0.378-0.380 in. diameter hole elongated to 0.382-0.389 in. diameter for one-third of hole depth. Satisfactory as is.	None

C. WING SUPPORT STRUCTURE

DISCREPANCIES	NECESSARY REPAIRS
1. Balsa wood plug broken in RH and LH aft tripod fairing 164F008-15.	Make and install new plugs.
2. Balsa wood plugs broken in RH and LH center tripod side brace fairing 164F014-11.	Make and install new plugs.
3. Two cracks at edge of weld on each side of -39 center fitting on wing support center tripod 164F006-1 (one 1-1/4 inches long, one 1/4 inch long).	Grind out and reweld.
4. Two indications of porosity at root of weld where -9 lug joins -3 tube on forward A-frame strut assembly, 164F007-1.	Grind out at depths of 1/16 inch and 1/32 inch, respectively. Satisfactory without rewelding.

D. PLATFORM ASSEMBLY

DISCREPANCIES	NECESSARY REPAIRS
1. 0.190-inch-diameter attach holes for pilot seat 164F017-35 elongated 0.215 to 0.250 in. Condition exists in 20 to 32 holes. Security of seat to seat assembly not seriously affected.	None

DISCREPANCIES	NECESSARY REPAIRS
2. Elevator control cables on right and left sides, running through platform assembly, rubbing against bulkhead sections.	Clear bulkhead sections and fit plastic tubing chafing strip over cables as required.
3. 164F001-1 platform assembly. Both RH and LH inboard main landing gear spring supports (station 129.00) slightly deformed at 164L011-5 lower aluminum hat section. Top of hat section area (4.00 x 1.50 inches) compressed approximately 3/32 inch with slight bowing of sides.	Reinforce hat section by bolting in tight fitting micarta blocks to strengthen hat section.

E. FIN AND RUDDERVATOR

DISCREPANCIES	NECESSARY REPAIRS
1. 164T005-1 and -2 left and right auxiliary tail surfaces. Scuff loops on underside scratched and have loose rivets.	Replace as required.
2. 164T005-1 and -2 LH and RH auxiliary tail surfaces. One blind rivet broken off by scuff loops.	Replace.
3. 164T003-1 and -2 left and right ruddervator. Ceconite 101 fabric has 1/8-inch puncture from Seyboth penetrator resulting from fabric test.	Patch.

F. LANDING GEAR

DISCREPANCIES	NECESSARY REPAIRS
1. Left-hand wheel assembly. Inner and outer bearing assembly 13889 bearing retainers cracked. Condition appears to have existed since new.	Replace.
2. RH and LH wheel bearing dust covers 9524218 excessively worn at contact with bearing inner race.	Replace.
3. Nose wheel inner bearing races Brinelled by bearing impact over approximately 90° of race arc.	Replace.
4. Nose wheel bearing dust covers 9524218 excessively worn at contact with inner race.	Replace.

DISCREPANCIES	NECESSARY REPAIRS
5. Nose wheel axle shim 164[illegible]12-13 worn.	Replace.
6. RH and LH brake lining 9511269, Taper wear 0.023 in.	None. Replace in service when required.
7. RH main landing gear spring 164L003-1. Paint chipped.	Repaint.
8. RH and LH main landing gear spring attach assembly. Rubber tubes 164L005-11 worn.	Replace.

G. FLIGHT CONTROL SYSTEM

Aileron pulley support assembly 164C038-1. The -17 bracket swivel action causes the -19 support to contact the -9 and -10 brackets.	Modify swivel action to eliminate contact, and file out nicks where contact has occurred.

H. ENGINE AND ENGINE CONTROL SYSTEM

No discrepancies.

I. COCKPIT INSTRUMENTS

1. In accordance with the Contracting Officer Representative's request, overhaul, calibrate, and mark operating limits on all cockpit instruments: airspeed indicator, cylinder head temperature gauge, multigage, manifold pressure gauge, altimeter, and rate-of-climb indicator.	Overhaul, recalibrate, and mark operating limits.
2. Manifold pressure gauge tubing bent and kinked.	Replace.

J. INSTRUMENTATION

1. Overage and deteriorated bonding to structural members at all strain gauge installations require replacement.	None at this time. Future total instrumentation requirements must first be defined and then treated as an integrated package.

DISCREPANCIES	NECESSARY REPAIRS
2. Wiring from measuring instruments to recording equipment in the wing and wing support structure area necessarily cut and damaged during complete disassembly for structural inspection.	None at this time. Future total instrumentation requirements must first be defined and then treated as an integrated package.

XV-8A AIRCRAFT NO. 63-13004

DISCREPANCIES	NECESSARY REPAIRS
A. WING MEMBRANE	
The DD-7 polyester-coated Dacron fabric specimens were tested to new material specifications with the following results:	
1. Tensile test of basic fabric exceeded the new material tensile specification of 207 lb/in. by 119 lb/in.	None
2. Lap shear test of adhesive bonding of the membrane lapped joints showed approximately a 94% loss of original strength (average 20.9 lb/in.^{2} compared to 342 lb/in.^{2}).	Repair not considered feasible. New membrane required.
3. Lap shear test of adhesive bonded and stitched lapped joints showed average strength of 25.3 lb/in.^{2}.	Repair not considered feasible. New membrane required.
4. Peel test of adhesive joint showed 1.5 lb/in. compared with 5.2 lb/in. new material data.	Repair not considered feasible. New membrane required.
5. The DD-7 coating on the Dacron fabric was found to be generally tacky and soft. The manner of failure noted in the three joint tests was separation of the coating from the fabric. The coating-to-adhesive-to-coating bond remained sound. It was therefore concluded that no coating treatment was practical that would correct the tackiness and restore joint strength to an acceptable safety-of-flight condition.	Repair not considered feasible. New membrane required.
B. WING, STRUCTURAL	
1. Fairings 164W037-5 do not permit access to turnbuckle and cable for inspection and rigging.	Cut out fairings similar to aircraft 63-13003.
2. Balsa plugs 164W019-89, -91 loose in RH aileron.	Secure in place.

DISCREPANCIES	NECESSARY REPAIRS
3. Wing aileron system. Bellcrank assembly 164W049-2 missing (lost since aircraft was shipped to Detroit for SAE convention display).	Fabricate and install new bellcrank.
4. Pulleys missing from spreader bar outboard arm assembly 164W014-1, -2 RH and LH.	Replace pulleys.
5. Wing bolt ropes not rigged to same length as aircraft 63-13003.	Make correct length.
6. Wing brace cables not protectively covered with vinyl tubing as in aircraft 63-13003.	Cover cables with tubing.
7. Wing incidence "down" stop block not installed as in aircraft 63-13003.	Fabricate and install stop block.
8. Balsa wood tip 164W019-93 on wing leading edge assembly driven into -5 aileron assembly fairing.	Reposition and secure to retain smooth tip contour.

C. WING SUPPORT STRUCTURE

RH forward A-frame fairing 164F007-11 has interference fit with side brace assembly 164F014-1.	Trim fairing to clear.

D. PLATFORM ASSEMBLY

1. Platform access door 164F001-133. Two of 20 holes (0.193 dia.) elongated to 0.220-0.228 inch.	None
2. RH and LH inboard main landing gear spring support 164L011-5 unmodified. Aircraft 63-13003 has shown need for reinforced hat section due to slight deformation noted after landing loads.	Reinforce equivalent to aircraft 63-13003 with bolt securing tight-fitting micarta block inside hat section.

E. FIN AND RUDDERVATOR

1. 164T005-1, -2 LH and RH auxiliary tail surface scuff loops missing on underside of trailing edge (never installed on this aircraft).	Fabricate and install.

DISCREPANCIES	NECESSARY REPAIRS
2. 164T003-1, -2 LH and RH ruddervator Ceconite fabric has 1/8-inch puncture from Seyboth penetrator resulting from fabric test.	Patch.
3. 164T005-1, -2 RH and LH auxiliary tail surface trailing edge dented. Nut missing on -33 hinge assembly. Safety wire and cotter pins missing.	Straighten skin, replace, and safety-wire fasteners as required.
4. 164T004 fin attaching fitting, RH NAS1334C-6C7 quick-release pin and NAS1104-11 bolt which attach fin to fitting installed reverse of blueprint.	Remove and install correctly.
5. 164T004 LH and RH fin attaching fitting. All nuts missing where attached to 164T002 fin.	Replace nuts.
6. 164T003-1, -2 ruddervator bolt and nut installations not safety-wired at 164C027-5 control rod.	Safety-wire as required.

F. LANDING GEAR

DISCREPANCIES	NECESSARY REPAIRS
1. 164L005 LH and RH main landing gear nut AN320-6 loose and not safety-wired.	Tighten and install AN381-3-16 cotter pin as required.
2. Adjust all wheel bearings to prevent excessive wear of dust covers 9524218 as occurred in aircraft No. 63-13003.	Readjust all wheel bearings.

G. FLIGHT CONTROL SYSTEM

DISCREPANCIES	NECESSARY REPAIRS
1. Aileron pulley support arm assembly 164C038-1. The -17 bracket swivel action causes the -19 support to contact the -9 and -10 brackets.	Modify swivel action to eliminate contact.
2. 164C058-1 wing aileron system extension assembly RH which attaches to 164W049-2 bellcrank missing (lost since aircraft was shipped to Detroit for SAE convention display).	Fabricate and install.

DISCREPANCIES	NECESSARY REPAIRS
3. 164C036-11 wing aileron system cable assembly missing (lost since aircraft was shipped to Detroit for SAE convention display).	Fabricate and install.
4. Pilot's pitch trim indicator (field modification in aircraft No. 63-13003) never installed in this aircraft.	Install pitch trim indicator.
H. ENGINE and ENGINE CONTROL SYSTEM	
1. Fuel strainer 9199-25B missing.	Procure and install.
2. Full range of mixture control lever does not give full travel at engine injector pump.	Reinforce mixture control lever and make narrower to permit full travel.
3. Engine cooling shroud seals around spark plug leads never installed on this aircraft.	Fabricate and install.
I. COCKPIT INSTRUMENTS	
In accordance with the Contracting Officer Representative's request, overhaul, calibrate, and mark operating limits on all cockpit instruments (airspeed indicator, altimeter, rate-of-climb indicator, cylinder head temperature gauge, multigage, manifold pressure gauge).	Overhaul, calibrate, and mark operating limits.
J. GENERAL	
Paint stripped in multiple areas for dye penetrant inspection.	Repaint.

APPENDIX II
ENGINEERING STUDY OF MEMBRANE RIPPLE AT HIGH AIRSPEEDS

INTRODUCTION

An aileron oscillation with a frequency of 2 to 3 cycles per second, reported in reference 1, is experienced on the XV-8A at a speed of 62 miles per hour, corresponding to a dynamic pressure of 9.0, a keel angle of attack of 21°, and a C_L of 0.42. The oscillation is induced by a traveling wave in the wing fabric which apparently originates near the wing spreader bar and moves aft.

The purpose of this study is to investigate possible causes of the phenomenon and to recommend design changes which may eliminate it.

DISCUSSION OF PROBLEM

Reference 2 provides the only systematic experimental data on flutter, and it is obvious from the results that correlation is not possible until a satisfactory criterion for flutter is established. It appears that the flutter "boundaries" of this reference are based on first observations of membrane ripple, whereas better correlation would be possible if a criterion dependent on the frequency, amplitude, and area of wing affected by the oscillations were used.

The results of reference 2 are, however, more detailed than those of reference 1, and it is obvious that the onset of flutter is a function of α, q, and slackness ratio and that the flutter first occurs at the inboard trailing edge of the wing. With decreasing α or increasing q, the amplitude of the motion increases and the affected area spreads toward the nose and edge members.

References 3 and 4 cover most of the theory presently available on flex wings. These are based on thin airfoil theory and provide for the calculation of the parawing shape and loading under normal conditions only. No theory is presently available which accounts for the fabric motion or the conditions responsible for the onset of flutter. The theories of references 3 and 4 might, however, be used to correlate the theoretical pressures at the aft end of the parawing with test observations of the onset of flutter.

The flutter condition is obviously caused by a lack of tension in the fabric of the aft portion of the wing at low lift coefficients, and a solution is therefore dependent on the ability to increase tension in that area when flutter occurs. Some possible solutions to the problem have been tested by NASA, (references 5, 6 and 7) with various degrees of success. Most of the methods tested are based on the principle of increasing tension n the trailing edge, though in the case of battens an attempt is made to increase the rigidity of the fabric. Each method has been considered, and the results are summarized in the following paragraphs.

1. Addition of Trailing Edge Battens

References 1 and 5 show that the addition of battens merely alters the characteristics of the wave motion and moves the apparent source further forward on the wing without effecting a cure. In reference 5 it was also found that doubling the length of the original battens and rearranging them did not improve the wing characteristics appreciably.

2. Addition of Boltrope

This is an effective method of increasing tension at the trailing edge, and tests reported in reference 2 showed successful results for wings with slackness ratios less than 1.06. Slackness is defined as the ratio of the fabric length between the wing tips to the span of the wing. The XV-8A has a slackness ratio of 1.12; the tests of reference 5, at this higher ratio, show that boltrope tightening has no appreciable effect on flutter. This lack of success is probably due to "ballooning" of the fabric forward of the trailing edge at higher slackness ratios.

3. Scalloped Trailing Edge

Tests of both a scalloped trailing edge alone and in combination with a boltrope are reported in reference 5. Both were unsuccessful. This shows that attempts to rectify the flutter situation by the use of devices too far aft on the wing are futile.

As a result of these test, it is felt that it would be more profitable to concentrate on efforts to increase tension on the aft section of the wing by increasing the aerodynamic loading in this area. This is best done by adding camber to the aft section of the wing, and there are several ways of doing this:

1. Contoured Fabric

This could be done by removing gores from the fabric to reduce the spanwise curvature as the trailing edge is approached, thus increasing the camber at the aft end. The only testing of this type of configuration to date is that of reference 7, where the model had flexible leading edges. Unfortunately, flutter was not a problem in this case, so the efficiency of this type of system is still unknown. The system also has the disadvantage of being nonadjustable in flight and would represent a change in XV-8A configuration over the whole flight regime.

2. Wing Tip Deflection

To add camber at the rear of the wing, the tips could be deflected either down or out. This would also reduce the slack in the trailing edge region and decrease the washout, all of which would be beneficial. The choice between the two systems would depend on their relative powers as lateral controls. Reference 6 shows that differential deflection in the horizontal plane provides more roll power and that the accompanying yawing moment is small.

There is no evidence that such a system is an effective means of combatting flutter.

3. Addition of V-Tail

This system is described in reference 8, where it is proposed as an improvement to the existing XV-8A longitudinal control system. Downward deflection of the tail would increase the load over the inner aft section of the wing, but the increase would be very small, and the prevention of flutter by adding to the rigidity of the trailing edge is doubtful.

4. Keel Tip Deflection

In this type of system, a section of the aft end of the keel is hinged so that downward deflection adds camber to the aft portion of the fabric. The hinged keel may also be used as a longitudinal control. Tests of reference 5, on a configuration similar to the XV-8A, showed keel deflection to be a successful antiflutter device; references 5 and 6 both show that, if horizontal as well as vertical deflection is possible, good lateral control may be achieved.

CONCLUSIONS

Based on the results of NASA tests contained in the references, keel tip deflection gives the best practical solution to the flutter problem and contains desirable lateral control characteristics. It is therefore recommended that this system be tested on the XV-8A as an antiflutter device. With this in mind, the characteristics of such a system are discussed below. Also suggested are two alternate approaches which are as yet untried variations on the boltrope and the batten approaches. These approaches may be tested with only minor and temporary changes to the wing and, for this reason, should be pursued.

KEEL TIP DEFLECTION

The length of keel to be deflected should be the aft 25 percent. With downward deflection to control flutter, there will be an increment in C_L and in C_M with no changes in static margin or (L/D) max, which will occur at approximately the same α as the basic XV-8A.

The amount of keel deflection required to control flutter, and the corresponding pitching moment increments, will determine the necessity for design changes, as elevator power may limit the maximum speed of the vehicle to less than that available from thrust considerations. The characteristics may be determined from tests which result in a diagram similar to that shown in Figure 11. This shows the change in elevator deflection required to trim caused by deflection of the keel to control flutter. To test keel tip deflection as a flutter control, the existing aircraft could be modified to include a hinged keel section operated by a wheel control similar to that used at present for incidence adjustment. Various keel tip deflections could then be tested to determine the flutter boundary as a function of C_L, q, and keel deflection.

Following the successful testing of this method, it will be necessary to design a permanent installation. Further tests will then be necessary to provide an accurate basis for design. The minimum tests would provide:

1. α versus q flutter boundary for basic configuration covering operational range of XV-8A.

2. Effect of various keel deflections on boundary.

3. Pitching moment and hinge moment data at various keel deflections.

SPANWISE STIFFENING ROPES

These ropes will be attached to the fabric at several longitudinal positions, the first rope being located at the most forward point of observed flutter. This first rope would cause the main portion of the flutter to move aft on the wing, and this movement would determine the position of the second rope, et cetera. With such a system, there will be some flutter in the fabric between the ropes, but this probably will be negligible.

LONGITUDINAL BATTENS

The longitudinal battens placed at the most forward point of observed flutter will have the same effect as the forward ropes, and the addition of a single stiffening rope aft of the battens may be sufficient to damp the residual oscillations. However, concavity created in the fabric forward of the battens, as described in reference 5, may remain a problem.

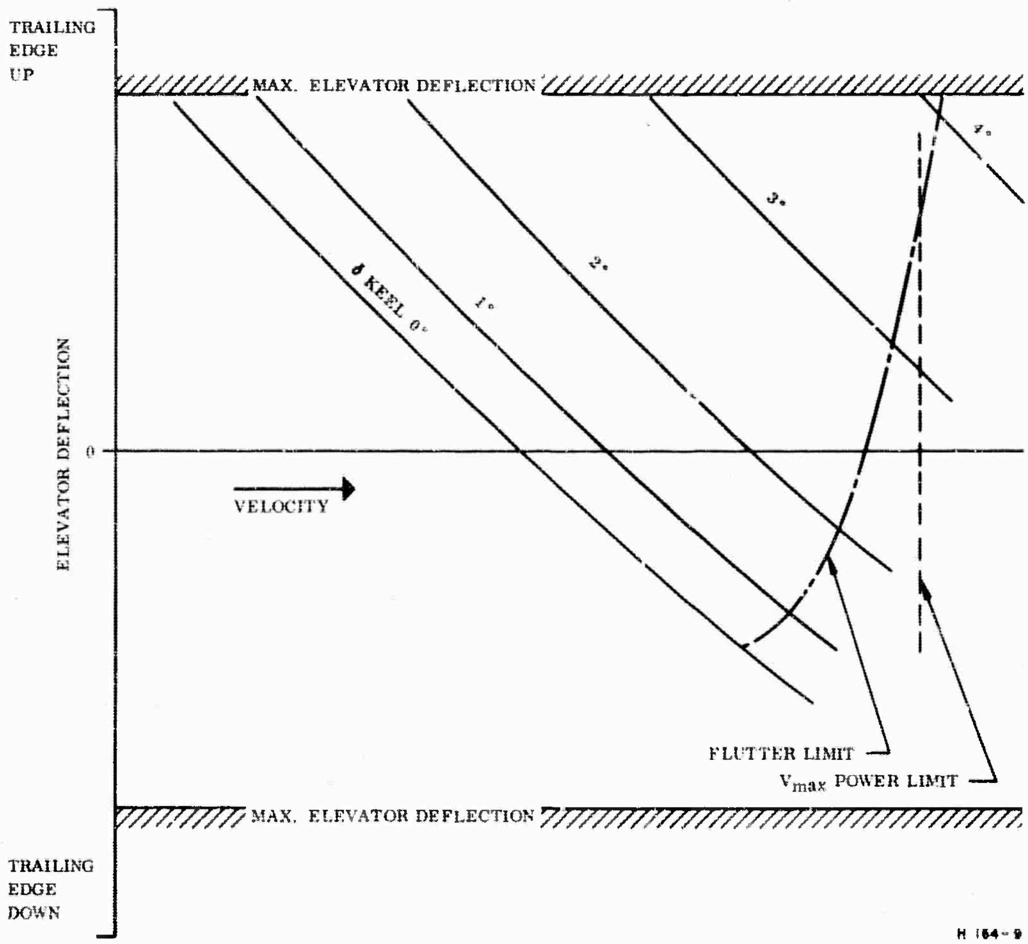

Figure 11. Change in Elevator Deflection Required for Trim When Keel Deflection is Used to Reduce Membrane Ripple

APPENDIX III
XV-8A INSTRUMENTATION DRAWING INDEX

DRAWING NO.	SUBJECT
	General
164D001	General Arrangement
002	Power Distribution
003	Bridge Circuit Regulated Voltage Supply
	Control Force Measurements ("F" Coded Circuits)
164D011	Control Stick Force, Longitudinal
012	Control Wheel Force, Lateral
013	Rudder Pedal Force
	Gyro & Acceleration Measurements ("G" Coded Circuits)
164D021	Vertical Acceleration
022	Pitch & Roll Attitude
024	Yaw Attitude
025	Rate Gyros
	Position Measurements ("P" Coded Circuits)
164D031	Stick Position Longitudinal
032	Platform Alpha and Beta Angles
033	Control Wheel Position, Lateral
035	Rudder Pedal Position
036	Wing Alpha Angle
037	Wing Incidence Position Angle
038	Wing Roll Position Angle
039	Left Aileron Position Angle
164D040	Right Aileron Position Angle
041	Left Ruddervator Position Angle
042	Right Ruddervator Position Angle
	Structural Measurements ("S" Coded Circuits)
164D051	Vertical Bending, Wing Keel
052	Vertical Bending, Wing Keel
053	Vertical Bending, Wing Keel
054	Axial Load, Wing Keel Apex
055	Tension, Forward Wing Pitch Cable
056	Tension, Aft Wing
057	Axial Load, Spreader Bar
058	Axial Load, Spreader Bar
059	Bending Load, Wing Leading Edge

DRAWING NO.	SUBJECT
164D060	Axial Load, Center Wing Support Strut
061	Axial Load, Left Forward "V" Strut
062	Axial Load, Right Forward "V" Strut
063	Axial Load, Left Aft "V" STrut
064	Axial Load, Right Aft "V" Strut
065	Tension, Left Roll Cable
066	Tension, Right Roll Cable
	Temperature Measurements ("T" Coded Circuits)
164D071	All Temperatures

Unclassified
Security Classification

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13. ABSTRACT
This report provides engineering data, including results of teardown inspection, flight tests, and evaluation of flight characteristics, for two manned flexible-wing aerial utility vehicles XV-8A.

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XV-8A FLEEP Aerial Utility Vehicle						