Lockheed Aircraft Corporation

ADVANCED DEVELOPMENT PROJECTS

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MODEL D-21B

TITLE MANUFACTURER'S MODEL SPECIFICATION

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REVISIONS

DATE	PAGES AFFECTED

TABLE OF CONTENTS

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

D-21B COMPLETE WITH BOOSTER.

DIMENSIONS

OVERALL LENGTH	46.27 FEET (555.21 INS)
OVERALL HEIGHT (BOOSTER FIN FOLDED)	10.05 FEET (120.60 INS)
OVERALL HEIGHT (BOOSTER FIN EXTENDED)	12.55 FEET (150.60 INS)
OVERALL WIDTH	19.08 FEET (228.90 INS)

WEIGHT

GROSS WEIGHT AT LAUNCH	24,100 LBS
WEIGHT AT BOOSTER BURN-OUT	14,200 LBS.

D-21B ONLY.

WING

AREA (ACTUAL)	388.5 SQ FT
AREA (AERODYNAMIC REFERENCE)	280.0 SQ FT.
ASPECT RATIO	.937
ROOT CHORD (PROJECTED)	40.00 FEET. (480.00 INS)
TIP CHORD	0
SPAN (ACTUAL)	19.08 FEET. (228.90 INS)
SPAN (AERODYNAMIC REFERENCE)	15.50 FEET (186.00 INS)
DIHEDRAL (NEGATIVE)	7°
INCIDENCE	0°
AIRFOIL - MODIFIED BI-CONVEX	2.3% (MAX THICKNESS @ .63C
SWEEP @ .250C	70°-16'-33"
M.A.C. (AERODYNAMIC REFERENCE)	20.54 FEET (246.50 INS)

ELEVON

AREA (EACH)	12.90 SQ. FT.
TRAVEL	UP 17°, DOWN 18°

VERTICAL TAIL

AREA (ABOVE W.L. 100)	48.08 SQ FT
AREA (EXPOSED)	29.80 SQ. FT
ASPECT RATIO	.648
ROOT CHORD	13.50 FEET. (162.00 INS)
TIP CHORD	3.72 FEET. (44.66 INS)
SPAN	5.58 FEET. (67.00 INS)
AIRFOIL - MODIFIED BI-CONVEX	2½% @ W.L. 170; 4% @ W.L. 125 (MAX. THICK @ .70 C)
SWEEP @ .250 C	46°-48'-05"
M.A.C. @ W.L. 127.16	9.54 FEET (114.43 INS)

RUDDER

AREA	3.77 SQ FT
TRAVEL	±10°

FUSELAGE

DIAMETER	3.00 FEET (36.00 INS)
OVERALL LENGTH	42.85 FEET (514.21 INS)

WEIGHT

GROSS WEIGHT	11,200 LBS
ZERO FUEL WEIGHT	5,300 LBS.
FUEL WEIGHT	5,900 LBS.
PAYLOAD WEIGHT - RECOVERABLE	950 LBS.

BOOSTER ONLY.

DIMENSIONS

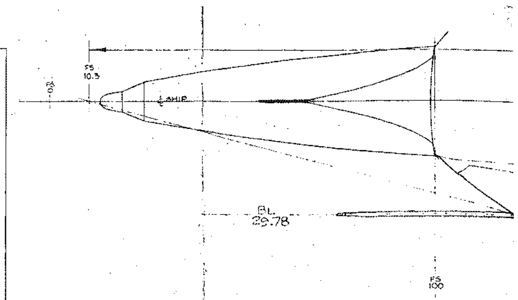
OVERALL LENGTH	44.25 FEET (531.00 INS)
DIAMETER - CASE	2.51 FEET (30.16 INS)
DIAMETER - MAX.	2.72 FEET (32.60 INS)

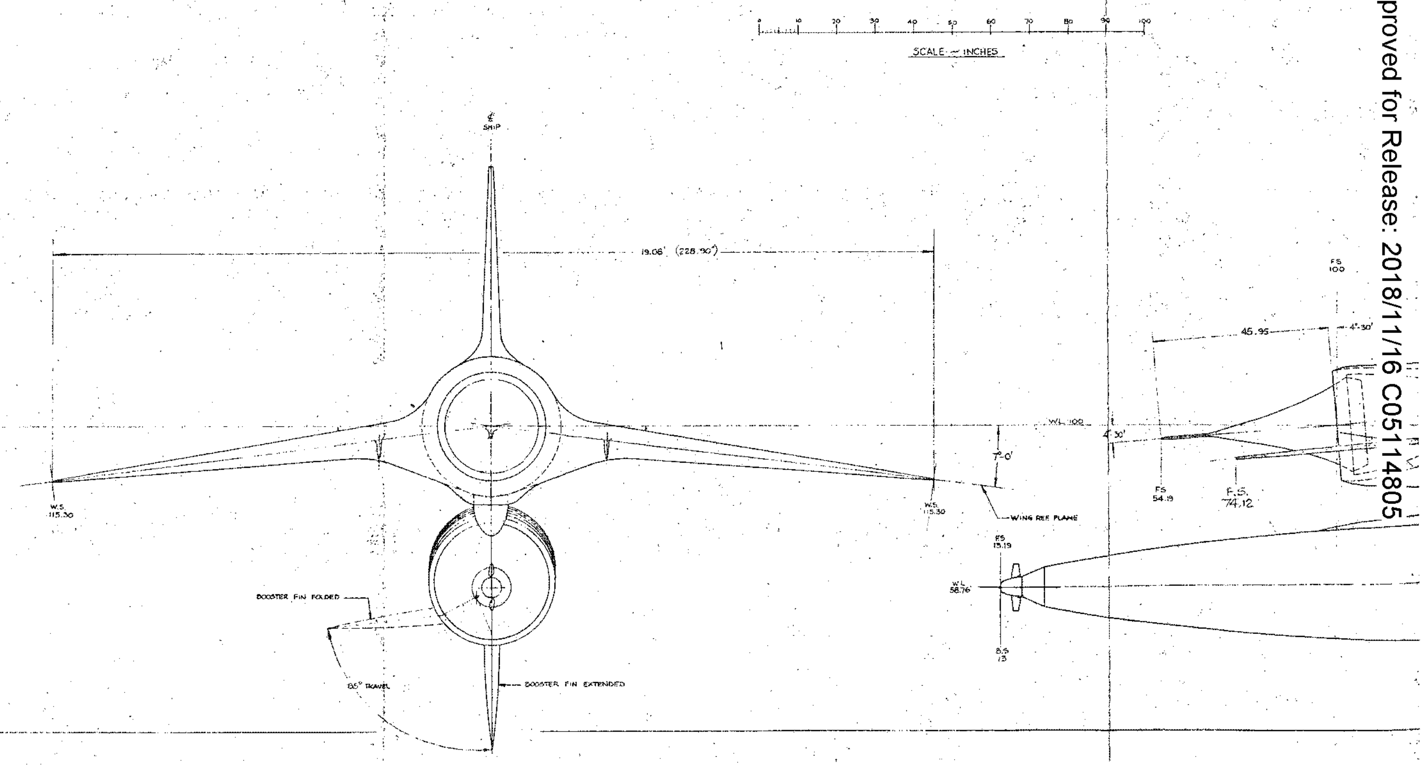
VENTRAL FIN - FOLDING.

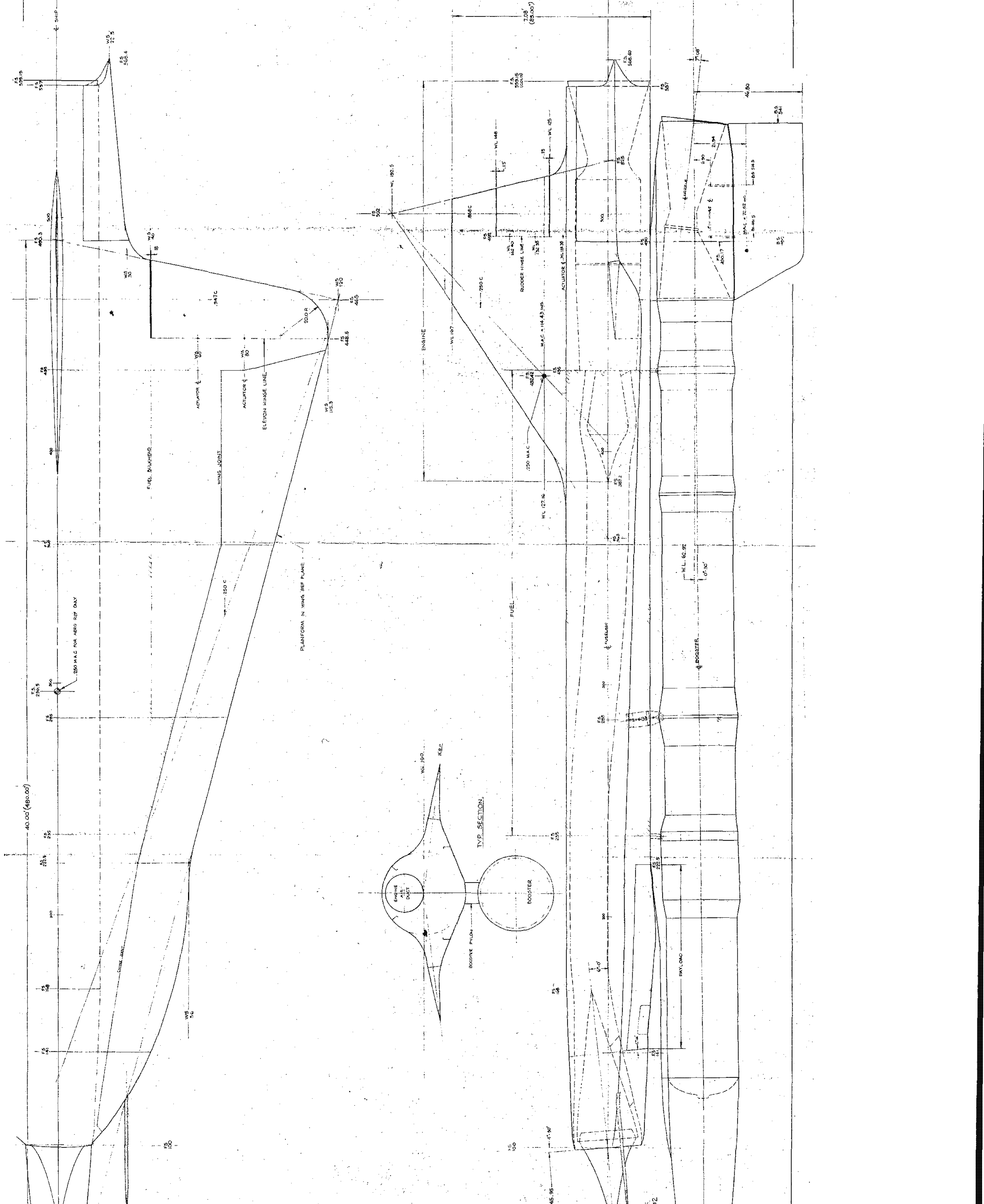
AREA (BELOW ℄ BOOSTER)	23.38 SQ FT
AREA (EXPOSED)	14.24 SQ. FT.
ASPECT RATIO.	.650
AIRFOIL - FLAT-SIDED BI-CONVEX.	MAX. THICKNESS - 4.00 INS.
ROOT CHORD.	7.12 FEET (85.49 INS)
TIP CHORD.	4.87 FEET (58.47 INS)
SPAN.	3.90 FEET (46.80 INS.)
M.A.C. (21.94 BELOW ℄ BOOSTER)	6.07 FEET. (72.82 INS)
TRAVEL (FOLDING)	85°

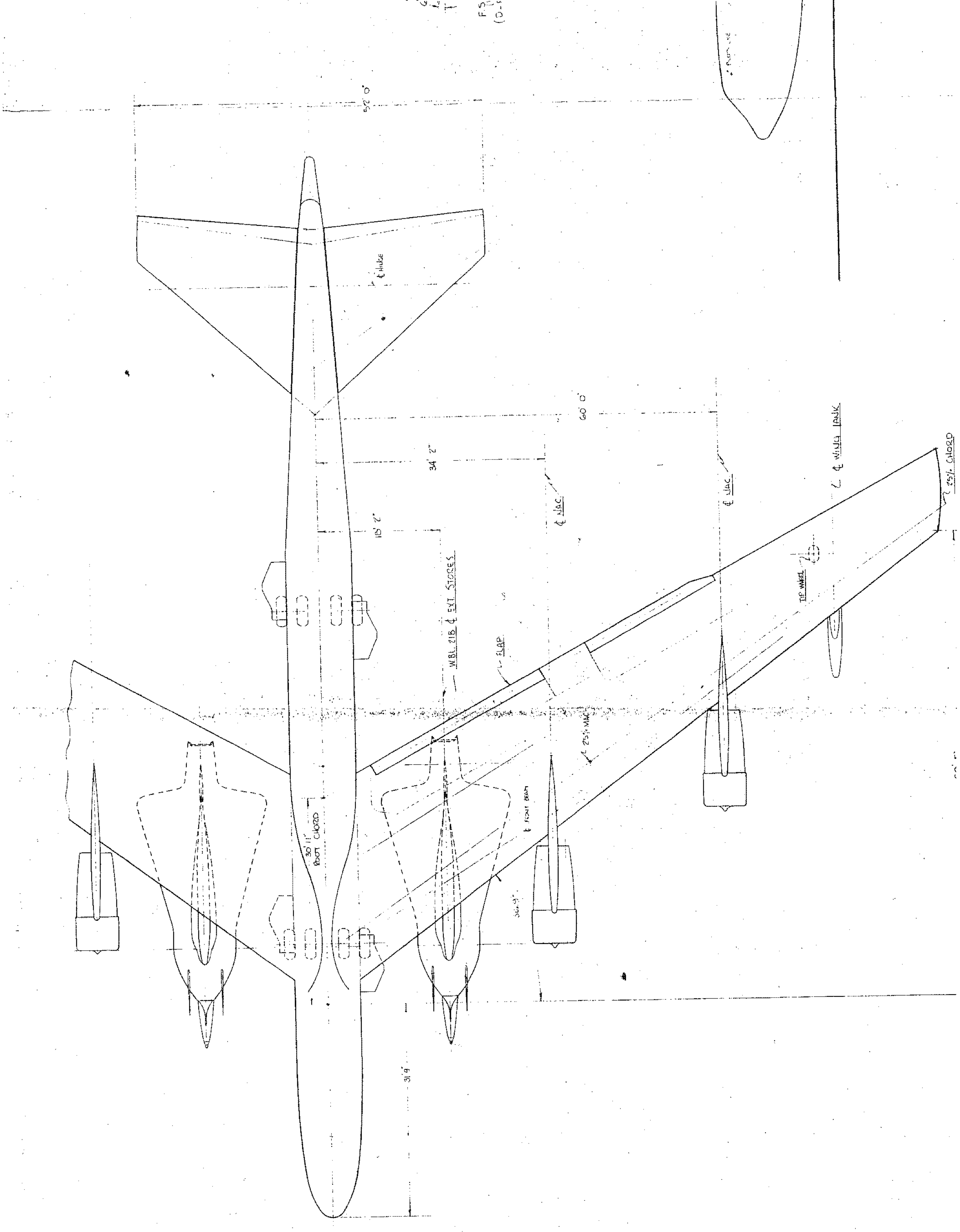
WEIGHT.

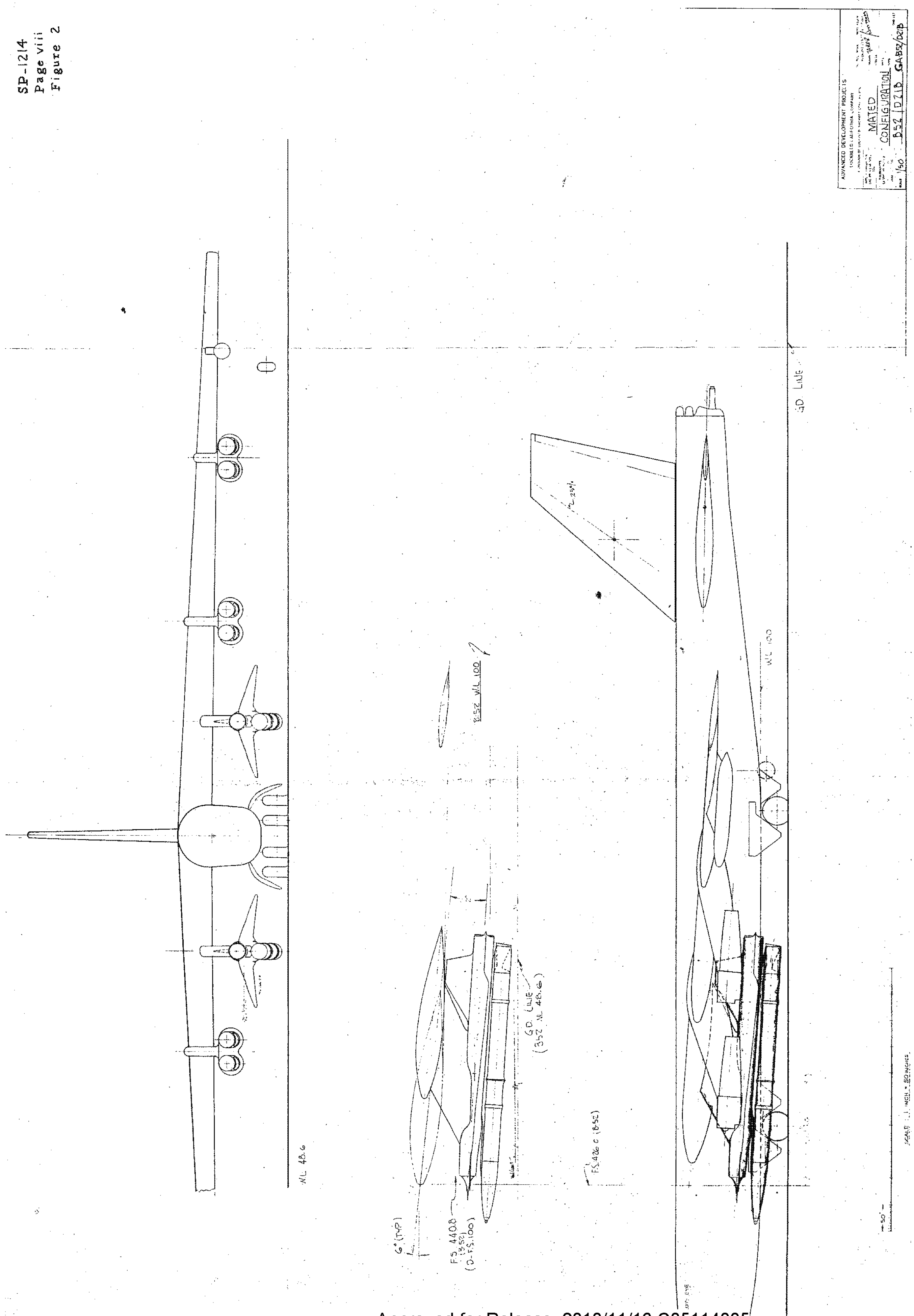
GROSS WEIGHT. (INCL. PYLON & FAIRINGS)	12,900 LBS.
PROPELLANT WEIGHT	9,280 LBS.






TYP. SECTION
ENGINE AIR DUCT
BOOSTER
BOOSTER PYLON
ENGINE
FUEL
PAYLOAD
FUEL BULKHEAD
WING JOINT
ELEVON HINGE LINE
RUDDER HINGE LINE
PLANFORM IN WING REF PLANE
40.00' (480.00")
7.08' (85.00")


52' 0"
60' 0"
34' 2"
18' 2"
W.BL. 218 ℄ EXT. STORES
FLAP
℄ MAC
℄ WING TANK
25% CHORD
TIP WHEEL
30' 11" ROOT CHORD
31' 9"


ADVANCED DEVELOPMENT PROJECTS
MATED
CONFIGURATION
B52/D21B
1/50
GD LINE
WL 100
B52 WL 100
WL 48.6
GD LINE
(B52 WL 48.6)
F.S. 426.0 (B52)
F.S. 440.8
(B52)
(D-F.S.100)
6° (TYP)

AIRCRAFT - RAMJET - HIGH ALTITUDE - RECONNAISSANCE

1.0 SCOPE AND CLASSIFICATION

1.1 This specification covers the following aircraft:

Service Model Designation	- Reconnaissance
Designers Name	- Lockheed Aircraft Corporation
Model Designation	- D-21B
Number and Places for Crew	- None
Number and Kind of Engines	- One; RJ-43 Ramjet Model MA20S-4 (Modification of MA-11)
Ramjet Applicable Spec	- MIL-E-8219
Booster	- One; Solid Propellant Rocket Motor LPC Model A92

2.0 APPLICABLE SPECIFICATIONS, OTHER PUBLICATIONS, AND DRAWINGS

2.1 The following publications, with dates as listed below, form a part of the Specification.

2.1.1 Specifications*

"Airplane Strength and Rigidity", MIL-A-8860

2.1.2 Other Publications*

"Handbook of Instructions for Airplane Designers" - HIAD Tenth Edition

3.0 REQUIREMENTS

3.1 Characteristics

3.1.1 Configuration - (See General Arrangement drawing)

3.1.2 Performance -

3.1.2.1 Guaranteed Performance -

Performance data are guaranteed for the design mission.

*These documents are made part of this Specification and are complied with to the extent permitted by the radical nature of this vehicle and its intended mission.

3.1.2.2 Performance Curves - (To be furnished)

3.1.2.3 The performance specified herein is based on the following atmospheric, fuel, and engine characteristics.

Atmosphere:	ARDC Model Atmosphere defined in AFCRC TR-59-267
Fuel:	PWA 523C Hydrocarbon Fuel Heating Value 18,900 BTU/Lb. Weight at $50^{o}F$ 6.6 Lbs./Gal.
Engine:	Engine Manufacturer's Specification ASD R-63-1 forms a part of this specification. Maximum thrust at 85,000 feet altitude at Mach 3.3 at 76% inlet recovery = 1,706 lbs. Specific fuel consumption at 85,000 feet altitude at Mach 3.3 at 76% inlet recovery = 2.08 lb./Hr./lb. thrust.
Booster:	Lockheed Report DP-1 "Avanti Booster Specification" forms a part of this specification.

3.1.3 Mission Requirement

Launch: The D-21B is launched from a B-52H carrier aircraft.

Boost Phase:	Launch Altitude	-	40,000 Ft.
	Launch Mach No.	-	.80
	Final Boost Altitude	-	80.000 Ft. (Nom.)
	Final Boost Speed	-	370 KEAS (Nom.)
	Final Boost Mach No.	-	3.4 (Nom.)
Free Flight:	Initial Cruise Altitude	-	80,000 Ft.
	Final Cruise Altitude	-	95,000 Ft.
	Speed (Constant)	-	Mach 3.3
	Range	-	3,000 N.M.

Recovery: The payload is jettisonable, and is recovered by a modification of an existing "parachute and snatch" system. A JC-130B is used as the recovery aircraft. The payload parachute is installed in a suitable compartment adjacent to the payload.

3.1.4 Life - The original design life of twenty-five hours at elevated temperatues was governed by electrical and hydraulic components. In order to preserve these components during mated flight an auxiliary power unit (RAT) is installed in the nose of the booster and this unit provides electrical and hydraulic power to the D-21B during the extended carry out flights. Thus the high speed (M = 3.3) life of the D-21B is still twenty-five hours. The D-21B airframe fatigue life for mated flights is at least ten times this figure.

3.1.5 Weights - (See following tabulations)

3.1.5.1	Gross Weight	- 11,200 Lbs.
3.1.5.2	Zero Fuel Weight	- 5,300 Lbs.
3.1.5.3	Booster Gross Weight	13,150 Lbs.
3.1.5.4	Total Launch Weight	24,350 Lbs.

3.1.6 Center of Gravity Location -

3.1.6.1	With Booster	
	Forward Limit	- F.S. 290
	Aft Limit	- F.S. 294
3.1.6.2	At Booster Burnout	- F.S. 319.1
3.1.6.3	D-21B Alone	
	Forward Limit	- F.S. 300
	Aft Limit	- F.S. 320

3.1.7 Areas -

Wing area including elevons	- 388.5 sq. ft.
Elevon area each	- 12.9 sq. ft.
Vertical tail area including rudder at W.L. 100	- 48.08 sq. ft.
Rudder Area	- 3.77 sq. ft.
Flap Area	- None
Dive flap area	- None

3.1.8 Dimensions and General Data -

Wing

Span	-	19.08 ft. (228.90")
Aspect Ratio	-	0.937
Chord		
Theoretical Root (Centerline aircraft)	-	40.0 ft. (480")
Reference MAC	-	20.54 ft. (246.50")
Location of 25% MAC	-	F.S. 296.5
Airfoil Section	-	Modified Bi-convex
Airfoil Thickness (constant)	-	2.3% (Max. thickness at .63C)
Sweepback at 25% Chord	-	70° 16' 33"
Negative Dihedral	-	7°
Incidence	-	0°

Elevons

Span	-	6.26 ft. (75.1")
Chord		
Root (WS 40)	-	2 77 ft. (33.3")
Actual Tip (WS 115.30)	-	0
Average	-	2.076 ft. (24.912")
Hinge Line	-	F.S. 448.5

Vertical Tail

Span (From WL 100)	-	5.58 ft. (67.0")
Aspect Ratio	-	0.648

3.1.8 Dimensions and General Data - (Contd)

Chord		
Root (WL 100)	-	13.5 ft. (162")
Tip	-	3.72 ft. (44.66")
MAC (WL 127.16)	-	9.54 ft. (114.43")
Airfoil Section	-	Modified Bi-convex
Airfoil Thickness	-	2-1/2% at WL 170 (Theoretical) 4% at WL 125 (Max. thickness at .70C)
Sweepback at 25% Chord	-	46° 48' 05"
Rudder		
Span	-	1.89 ft. (22.7")
Chord		
Root	-	2.225 ft. (26.7")
Tip	-	1.758 ft. (21.1")
Average	-	1.992 ft. (23.9")
Hinge Line	-	F.S. 492
Booster		
Over-all Length (Including Fairings)	-	44.25 ft. (531")
Case Dia.	-	2.51 ft. (30.16")
Max. Dia.	-	2.72 ft. (32.60")
Ventral Fin Span (From Booster Centerline)	-	3.90 ft. (46.8")
Fin Root Chord (At Booster Centerline)	-	7.12 ft. (85.49")
Fin Tip Chord	-	4.87 ft. (58.47")

3.1.8 Dimensions and General Data (Contd)

Aspect Ratio	-	.650
Fin Area	-	23.38 sq. ft.
Fin Travel	-	85°

General

(Not including Booster)

Over-all Height (FRL Horizontal)	-	7.08 ft. (85")
Over-all Length	-	42.85 ft. (514.21")
Launch Angle (angle between wing reference planes of the D-21B and the B-52H)	-	-2°

WEIGHT STATEMENT

	Lbs.
Wing	634
Tail	104
Fuselage	1,708
Surface Controls	163
Propulsion	1,329
Auxiliary Power Unit	90
Hydraulics	121
Electrical	204
Electronics	268
Air Conditioning	80
Recovery System	138
Furnishings (Interior Insulation)	84
Payload	318
Unusable Fuel	59
Zero Fuel Weight	5,300
Fuel	5,900
D-21 Weight	11,200
Booster Weight	13,150
Launch Weight	24,350

3.2 General

The aircraft is a midwing monoplane type, of metal and plastic construction. Design is as simple as possible consistent with the necessary operational, maintenance, and checkout characteristics. The basic aircraft with its power unit is expendable.

3.2.1 General Interior Arrangement - The interior arrangement is essentially divided into four sections located in a fore to aft relationship. The first section is the circular engine air inlet with appropriate fixed spike and bypass installations to control air flow and boundary layer removal.

The second section is the equipment installation bay, which houses the payload, recovery parachute, and major electronic gear. This compartment is suitably cooled.

The third section extending for 200 inches comprises three fuel tanks, suitably interconnected to provide the entire fuel supply for the engine.

The fourth section is devoted to the installation of the engine with its integral tail pipe and nozzle.

3.2.2 Materials - The main structural material is titanium alloy, except for those areas where temperature requirements dictate the use of stainless steel and/or other high temperature alloys. Non-metallic materials are used in areas found to be suitable or as required for mission accomplishment.

The design procedures, material properties, and material processes conform to the standards established in Contractor's Reports, LAD-105, LAD-108, SP-153D, SP-156B, SP-154C, and SP-377. Standard parts and usage are as described in Report LAD-109.

3.2.3 Workmanship - Construction of the aircraft, including such operations as detail fabrication, assembly, and equipment installation is accomplished in a thorough and workmanlike manner consistent with high-grade aircraft manufacturing practices.

3.2.4 Production, Maintenance and Repair - The first considerations in the design and construction of the aircraft are performance and reliability. Secondary considerations are ease of access, maintenance and repair. All factors leading to rapid producibility are given careful consideration, but are not incorporated at the expense of performance, reliability or ease of maintenance. The design, while utilizing high strength titanium alloys and high temperature plastic materials, employs conventional fabrication and assembly techniques to the maximum degree possible. Precautions are observed in the handling, processing, and installation of titanium alloys to inhibit corrosion and fatigue. Such design practices and production procedures as defined in the documents outline in Paragraph 3.2.2.

The design policy affecting the flight control system; and hydraulic, fuel, and electrical systems, is to eliminate insofar as possible, any incorrect installation or re-installation of components or assemblies. Fluid lines, linkages and wire, etc., are so designed that incorrect installation is not possible by inadvertent action, where such error would involve damage, malfunction, or safety of flight.

The design of the vehicle permits effective inspection, maintenance, and repair procedures to be utilized in production and service. Accessibility is provided to permit scheduled maintenance and preflight check-outs as required for mission accomplishment. Emphasis is placed on ease of replacement of major units such as engine, subsystem components, electronic equipment, and payload.

3.2.5 Interchangeability and Replaceability - The following components are interchangeable substantially in accordance with MIL-I-8500.

Rudder
Equipment Bay Hatch and Installed Components
Elevons
Booster
Booster Nose Cone
Booster Tail Cone (incl. fin)

The following components are considered to be replaceable with minor trim and hole transfer.

Miscellaneous Doors
Vertical Fin
Wing Leading Edge
Inlet Spike

3.2.6 Finish - The standards used for the finish of the vehicle, both interior and exterior surfaces, are defined in the documents listed in Paragraph 3.2.2 of this specification.

3.2.7 Identification and Marking - No exterior markings other than the Manufacturer's serial number and access cover identification are applied to the aircraft.

3.2.8 Extreme Temperature Operation - The aircraft as a whole, with its equipment and accessories, is designed to meet the requirement for satisfactory function throughout the extreme environmental operation ambient flight temperature range of -90°F to +110°F. The ARDC temperature variation with altitude (Ref. AFCRC TR-59-267, #115, dated August 1959) is assumed for performance determination.

3.2.9 Ground Climatic Requirements - A ground ambient temperature range of -65°F to +160°F is assumed for the basic design of the aircraft. Special deviations to this temperature range must be given for the type of fuel, hydraulic oil and over-all cooling systems used. It is assumed that ground shelter will be provided so that normal ground environment is +35°F to +100°F.

3.2.10 Lubrication - Provisions made for lubricating the aircraft and its equipment and accessories are generally in accordance with the requirements of Specification MIL-L-6880B. However, due to unusual environmental conditions, some lubricants are selected as a result of Contractor's tests and are not necessarily in compliance with this Specification.

3.2.11 Standard Parts - Standard parts are as listed in the Lockheed Engineering Standards Manual, selection to be made in accordance with the requirements of MIL-STD-143.

3.2.12 Crew - Not Applicable.

3.2.13 Equipment Installation - The aircraft incorporates major items of equipment, or provisions therefore, as noted, listed in the following sub-paragraphs.

3.2.13.1 Armament - Not Applicable.

3.2.13.2 Inertial Navigation System

A Honeywell MH-390(d) Inertial Navigation System is installed on the equipment bay hatch. Output signals from the INS will be used as steering signals in the autopilot, and information signals in the payload.

3.2.13.2 Inertial Navigation System (Contd)

The system will provide point to point steering signals for up to 32 pre-determined destinations. The D-21B position error may be updated to the accuracy of the B-52H immediately prior to launch. Maximum position error at launch, employing the stellar tracker installed in the B-52H will be $\pm$1.7 nautical miles. During free flight the maximum rate of error build-up will be $\pm$ 2 nautical miles/hour.

The computer section is also used in conjunction with the In-flight Check-out System.

3.2.13.3 Instruments - Not Applicable.

3.2.13.4 Pyrotechnic Devices

3.2.13.4.1 Destruct System - A destructor system capable of destroying the aircraft and its payload is provided. The system conforms to the intent of USAF Spec X-28663. The destruct system is armed by time/command after launch, and is actuated by: (1) altitude during free flight phase, or by (2) altitude command during the terminal phase after payload ejection. There is no provision for destroying the payload and electronic equipment after hatch ejection.

3.2.13.4.2 Payload Pyrotechnic devices, (Gas Generator, Initiator, and Thrusters), are utilized to release and eject the payload (including beacon) from the vehicle at the termination of the flight. Payload recovery is accomplished by a drogue gun deployed stabilization and recovery parachute system having cartridge actuated release pins.

3.2.13.4.3 Launch System - The D-21B launch is accomplished by electrically activating three explosive bolts at the three pylon attach points.

3.2.13.4.4 Booster Jettison - After booster burnout the empty case is jettisoned by electrically activating two explosive bolts and a gas generator which pressurizes a cavity and drives a piston attached to the booster.

3.2.13.4.4 (Contd)

This action applies a separating force to the booster and insures a clean jettison. The booster may be jettisoned during mated flight also, however for aerodynamic reasons this will preclude any subsequent D-21B jettison.

3.2.13.5 In-Flight Check-out (IFCO) -

In order to insure a safe launch and successful mission completion, an in-flight check-out system is monitored in the B-52H. The following D-21B systems are tested prior to launch from the B-52H (Launch Control Officer Station):

1. Automatic Flight Control System
2. Inertial Navigation System
3. Payload
4. Electric Power System
5. Command Receiver System
6. Hydraulic System

3.2.13.6 In-Flight Monitor (IFM) -

The following systems of the D-21B are monitored continuously at the LCO station:

1. Destruct System Temperature
2. Altitude Switches
3. Command System
4. Hydraulic System
5. Fuel System
6. APU Speed
7. Battery
8. APU Overspeed Lockout
9. Launch Sensing System
10. INS Position Error
11. D-21B Mach No., Altitude and Heading

3.2.13.7 In-Flight Subsystem Control -

During mated flight the following D-21B Systems are controlled from the LCO station:

1. Fuel System
2. Hydraulic System (Pressure only)
3. Electric Power System
4. INS Position Update
5. Telemetry Transmitter

3.2.13.8 Launch Control -

The following launch functions are controlled from the LCO station:

1. Positioning of Booster Ventral Fin
2. Engine Fuel
3. Engine Ignition (Backup)
4. APU Air Transfer

Note: Functional Systems transfer from mated to free flight occurs automatically on electrical umbilical separation.

3.2.13.9 Payload Hatch -

The payload hatch is located between Stations 141 and 222.5, on the underside of the fuselage.

The following equipment is mounted on the hatch and is ejected with the hatch:

1. Payload
2. Payload Electronics
3. AFCS Air Data Computer
4. AFCS Electronic Components Assembly
5. INS Power Supply
6. INS Computer
7. INS Gimbal Control Electronics (GCE)
8. INS Inertial Electronics Unit (IEU)
9. INS Platform
10. Recovery Beacons (2)
11. Beacon Antenna Transfer Relays
12. Beacon Antennas
13. Generator Control Box
14. Command Receiver
15. Electrical Breakaway Couplings
16. Air System Breakaway Couplings
17. Telemetry System (excepting Transmitter)

All of the above components are enclosed by a housing comprised of the hatch and hatch cover so as to provide a water tight and bouyant unit.

In addition, the aerodynamic decelerator and recovery system is mounted on the hatch, but not within the water tight housing.

3.3 Aerodynamics

3.3.1 General - The external configuration of the aircraft is based on a modified delta wing planform. The body incorporates the circular air inlet with its spike in the extreme forward nose.

3.3.1 General (Contd)

The forebody incorporates chines which act as a canard-like surface. The engine is in the afterbody, and because of its completely internal installation, results in a smooth streamlined appearance for the entire aircraft. In general, all external surfaces are flush, utilizing butt joints and flush attachments.

3.3.2 Stability and Control - The aircraft is aerodynamically stable. The low aerodynamic damping at high altitudes requires artificial stability augmentation. Special effort is made to obtain the most stable platform at high altitude that the state of the art allows.

3.3.3 Jettison - The D-21B may be jettisoned, with no engine power, and with no "on board" electrical or normal hydraulic power available. The D-21B contains an emergency hydraulic system which energizes the control system in the event of a jettison. The booster may also be jettisoned during mated flight, but it is to be noted that for aerodynamic reasons the D-21B cannot be jettisoned alone.

3.4 Structural Design Criteria

3.4.1 General - The structural design criteria is based on the intent of the requirements of Specification MIL-A-8860 (ASG), dated 18 May 1960.

3.4.2 Maximum flight Design Gross Weight - The maximum flight design gross weight is 24,350 pounds for captive flight, launch, and boosted flight. Free flight maximum gross weight is 11,200 pounds.

3.4.3 Landing Design Gross Weight - Not Applicable.

3.4.4 Limit Flight Load Factors - Limit flight load factors are positive 1.6g and 0.5g for captive flight. Free flight maneuver load factors are positive 5.0g and negative 2.0g.

The maximum free flight gust load factor is based on an empty weight and a gust velocity of 27.5 ft./sec. (rough air). Critical altitude and speed are 60,000 ft. and 400 KEAS respectively:

$$\Delta\ n_z\ (\text{gust}) = 2.00g$$

$$\therefore n_z\ (\text{total}) = 3.00g$$

Maximum captive flight gust load factor is based on a B-52H/D-21B gross weight of 210,000 pounds, a gust velocity of 50.0 ft./sec., an altitude of 20,000 ft. and V_H=250 KEAS.

$$\Delta\ n_z\ (\text{gust}) = 1.38g$$

$$\therefore n_z\ (\text{total}) = 2.38g$$

3.4.5 Limit Landing Load Factor - Not Applicable

3.4.6 Limit Speed

3.4.6.1 Captive Flight -

Limit speed in captive flight is 250 KEAS or M = .80.

3.4.6.2 Boosted Flight -

Limit speed in boosted flight is 500 KEAS or M = 3.6.

3.4.6.3 Free Flight -

Limit speed in free flight is 450 KEAS or M = 3.3.

3.4.7 Limit Taxi and Ground Handling Load Factors

3.4.7.1 Taxi Loads -

Taxi of the B-52H or the towable transporter cart does not generate load factors within the aircraft, greater than those listed for ground handling conditions.

3.4.7.2 Ground Handling Loads -

For the 11,200 pounds gross weight condition the ground handling load factors are:

Vertical:	$\pm$ 2.0g
Lateral:	$\pm$0.5g
Fore & Aft:	$\pm$ 0.5g

3.4.7.3 Air Transport Loads -

For the 5,300 pounds gross weight condition (no fuel) the following combinations are applied:

Vertical:	$\pm$ 2.0g
Lateral:	$\pm$ 2.0g
Fore & Aft:	$\pm$ 0.5g

3.4.7.4 Jacking Loads -

Structural strength is provided for hoisting the vehicle at appropriate points and for transporting the vehicle on a towable cart.

3.4.7.5 Crash Loads -

For a crash condition wherein the D-21B is mated to the B-52H, strength is provided to withstand a forward load factor of 3.0g (ult.) combined with a downward load factor of 2.0g (ult.) at a D-21B gross weight of 11,200 pounds.

3.5 Wing Group

3.5.1

3.5.2

3.5.3

Elevon travel is 17° up and 18° down.

There are no provisions for balance weights or trim tabs.

3.6 Tail Group

3.6.1 Description and Components - The tail group consists of a vertical stabilizer mounted on the centerline of the upper aft fuselage, containing a hinged rudder. Rudder travel is 10° each side of neutral. There is also a ventral fin located on the booster.

3.6.2 Construction - The vertical stabilizer, rudder and ventral fin are titanium throughout and are of conventional skin and rib construction.

3.6.3 Rudder - The rudder is operated by a torque tube mounted in the stub fin. The rudder servo unit is connected to the torque tube, and is mounted on the upper surface of the fuselage within the stub fin.

3.6.4 Ventral Fin - The ventral fin is a conventional airfoil section which can be rotated 85° about the booster so as to provide ground clearance. The rotation mechanism which is driven by an electrical actuator, is activated when airborne, causing the ventral fin to swing down to a bottom centerline position.

3.7 Body

3.7.1 Fuselage -

3.7.1.1 Essentially, the fuselage is a cylindrical shape extending from the engine air inlet to the engine tail pipe. The general configuration contains the major elements necessary for the aircraft mission. The smooth streamlined form is the result of aerodynamic and functional considerations.

3.7.1.2 Construction -

The prime fuselage structure is a titanium alloy, semi-monocoque construction, employing smooth skin attached to formed frames.

Two major openings are provided in the fuselage:

One, in the forward lower body between Stations 141 and 222.5, and approximately 40 inches wide. This opening accommodates the equipment compartment hatch which is ejectable.

3.7.1.2 Construction (Contd)

The second opening is on the top centerline of the mid-fuselage over the fuel tank area; approximately 22 inches wide, it extends from Station 235 to Station 385. This opening provides access for servicing and inspecting the fuel tanks.

Suitable insulation is applied to the outside of the fuselage in the vicinity of the fuel tanks.

3.7.1.3 Equipment Compartment -

The equipment compartment is constructed in the forward section of the fuselage between Station 141 and Station 235. Titanium structure is designed to provide the necessary space and mounting provisions for the auxiliary power unit and other subsystem equipment.

The major electronic equipment, the payload, and the recovery parachutes are all mounted on the compartment hatch in the opening provided in the fuselage. The hatch is ejectable to serve as a platform for the payload and electronic gear in their recovery descent.

3.7.1.4 Dive Flaps - None

3.8 Alighting Gear

None

3.9 Surface Control System

3.9.1 Primary Flight Control - The basic flight control system consists of an autopilot, servo control valves, hydraulic actuating cylinders and the surfaces. The prime motivation will be the signals derived in the autopilot and stability augmentation system. These signals will in turn control the positioning of the servo valves, thus establishing the flow of oil to the hydraulic cylinders located at the surfaces. Two sets of two cylinders actuate the elevon and one cylinder actuates the rudder. Automatic spring-loaded locks are provided to prevent flutter in the event of complete loss of hydraulic system during mated flight. Emergency jettison control valves actuated and powered by the emergency jettison hydraulic system meter oil directly to the primary cylinders to position the surfaces for jettison. The major components of the flight control system are designed as subassemblies where practicable to facilitate bench assembly and check-out. The autopilot is located in the equipment compartment hatch and the servos and cylinders in the tail group. Accessibility is provided for inspection, removal and replacement.

3.9.2 Secondary Flight Controls - None

3.9.3 Lift and Drag Increasing Devices - None

3.9.4 Trim Control System - None

3.9.5 Automatic Flight Control System - The automatic flight control system consists of the air data computer, the stability augmentation system and the autopilot. The air data computer provides a source of data for the stability augmentation system, the guidance system, and the payload. The stability augmentation system incorporates logic circuitry to insure maximum reliability. Stability augmentation is provided on three axes. The autopilot modes are launch, cruise or Mach hold, and recovery mode.

3.10 Engine Section

3.10.1 Description and Components - The engine is contained in the aft portion of the fuselage.

3.10.2 Construction - The fuselage structure in this area is all metal, semi-monocoque structure utilizing titanium alloy as the prime material.

3.10.3 Engine Mounts - The engine is mounted by means of spherical ball fittings located in two fuselage planes. At Station 435.93 a single ball fitting attaches to the bulkhead on the top centerline. This fitting is designed to take full engine thrust loads. At Station 468.13 the mounting consists of three spherical ball fittings located at 120 degree intervals around the engine. These fittings are attached to the fuselage frame at this station through suitable linkages designed to take engine radial loads.

3.10.4 Vibration Isolators - Nylon vibration isolators are provided at all metal to metal contacting locations between the D-21B and the rocket booster. These are to isolate high frequency vibration generated in the rocket motor.

3.10.5 Firewall - Fuselage Station 435 bulkhead serves as an aft tank bulkhead as well as a firewall.

3.10.6 Cowling and Cowl Flaps - Not Applicable.

3.10.7 Access for Inspection and Maintenance - Access to the engine is by removal of the aft fuselage structural shell.

3.11 Propulsion

3.11.1 General Description and Components - One Marquardt RJ-43, Model MA-20S-4 Ramjet engine constitutes the free flight propulsion system for the aircraft.

3.11.2 Auxiliary Propulsion Units - One Lockheed Propulsion Company solid propellant rocket booster. LPC Model A92, "Avanti".

3.11.3 Engine-Driven Accessories - None

3.11.4 Air Induction System - The air induction system consists of a circular inlet located in the extreme forward portion of the fuselage. A duct, circular in cross section, connects the air inlet to the engine. An inlet fixed spike and bypass vent installations are provided to control inlet shock position and boundary layer removal.

3.11.5 Exhaust System - The exhaust system is supplied with the engine and consists of a tailpipe and a nozzle.

3.11.6 Engine Compartment Cooling - The engine compartment is cooled by bleed air taken from the main air inlet duct through a fixed annulus ring located at fuselage Station 435. The gap in the engine tailpipe is calibrated to provide a cooling air flow around the engine.

3.11.7 Lubrication System - The lubrication system is integral with the engine.

3.11.8 Fuel System -

3.11.8.1 Description and Components -

The fuel is contained in three integral tanks, with the center tank as the sump tank feeding the engine. The fuel transfer system consists of an AC electrically driven fuel pump, one each in the forward and aft tanks, pumping to the center sump feed tank for C.G. control. The center feed tank has an AC electrically driven booster pump to maintain adequate pressure and flow to the engine.

A nitrogen inerting system is installed to pressurize the fuel tanks to 1.5 ± 0.5 psi. The nitrogen is carried in liquid in a Dewar flask. The quantity of nitrogen is sufficient for the maximum mission duration, or for a return to base in case of an abort at the launch point.

3.11.8.2 Fuel System Management -

The fuel in the D-21B is used as the heat sink for the environmental control system during free flight.

The normal fuel load of 915 gallons is loaded on the ground before T.O. There are no in-flight fueling provisions. Fuel is loaded to give the maximum forward C.G., i.e., tanks #1 and #2 are filled to shut-off levels and the remainder goes into tank #3.

During carry-out portion of the mission the fuel system is shut-down until approximately one hour before launch at which time the number 3 tank transfer pump is turned on to transfer to tanks 1 and 2 any fuel that might have leaked aft, and thus ensure a forward C.G. for launch.

3.11.8.3 Pumps -

All pumps are the submerged centrifugal type, three phase, 200 volts, 400 cps AC, induction wet motors, which are able to operate at 230/520 Hz.

3.11.8.4 Tanks -

The fuel is contained in three tanks integral with fuselage and inner wing structure. Total usable fuel is 5,900 pounds at 6.6 pounds per gallon. A 3% air space is utilized for fuel expansion.

3.11.8.5 Vent System -

Tanks #1 and #2 vent into a common manifold line into #3 tank and relieve through a pressure relief valve set at a normal 3 psi $^{+.25}_{-0}$, and vacuum relief set at 2 to 4 inches of water.

3.11.8.6 Piping and Fittings -

Aluminum alloy piping and fittings are utilized for fuel, the nitrogen, and vent systems.

3.11.8.7 Valves -

Electrically operated solenoid shut-off valves are installed on the engine fuel feedline. Dual float-operated shut-off valves are installed on the fueling lines in each tank. Pressure fueling is utilized for ground fueling. Self-sealing breakaway fittings are utilized. Suitable check valves are used as required.

3.11.8.8 Strainers and Filters -

A 200 mesh fuel filter is installed in the engine feedline.

3.11.8.9 Quantity Gages -

No quantity gages are installed.

3.11.8.10 Fuel Vapor Inerting -

The quantity of nitrogen aboard is sufficient for the carry out and free flight portions of the mission. The quantity of nitrogen aboard is determined by overfilling the system.

3.11.8.11 Drainage Provisions -

Each fuel tank has adequate provisions for draining sediments and water at low tank points.

3.11.8.12 Fuel Evaporation Control -

Fuel evaporation is controlled by use of low vapor pressure fuel and by tank pressurization in excess of the fuel vapor pressure.

3.11.8.13 Fueling Provisions -

The vehicle has a pressure fueling fitting in the bottom of the fuselage. This connects to a trunk line leading to all tanks. Dual shut-off valves in each tank are controlled by dual pilot valves which are located at a point which gives approximately 3% air space when the D-21B aircraft is fueled.

3.11.8.14 Defueling Provisions -

The vehicle is defueled through a breakaway fitting in the bottom of the fuselage. The AC booster pump in Tank No. 2 is used for defueling.

3.11.9 Ignition System - A triethylborane ignition/re-ignition system is provided, and is an integral part of the engine.

3.12 Auxiliary Power Unit

3.12.1 Description and Components - An auxiliary power unit is provided to drive the hydraulic pump, the AC/DC generator, and to furnish cooling air for the electronic units and the payload. This unit consists of a variable area nozzle air turbine, gear box and power pads, lubricating system, speed control system, and an outlet air temperature control system. Turbine exhaust temperature is sensed by thermistors connected through the temperature control system to the fuel flow by-pass valve which meters heat exchanger inlet fuel as required to regulate cooling air within set limits. Up to 20,000 ft. altitude, because of the possibility of freezing, exhaust air is controlled to a minimum temperature of 40°F. Above this altitude a control temperature of 0°F is maintained to provide greater cooling capacity where moisture is not a problem.

3.12.2 Ram Air Turbine - A turbine assembly consisting of a two bladed, self governing ram air turbine directly driving an integral generator and a hydraulic pump is provided to supply electrical and hydraulic power for the carry out and boost phase of the mission. (See the electrical and hydraulic sections for descriptions of the electrical and hydraulic systems driven by the RAT.)

3.13 Electric System

3.13.1 Description - Power Sources - The prime power source for the electric system is a combination brushless AC/DC generator, driven at 12,000 rpm ± 5% by the auxiliary power unit. The generator has a capacity of 4 kva, 120/208 volts, 400 Hz AC plus 100 amps 28 volts DC.

Auxiliary electric power for electric system operation during the boost phase is supplied by a permanent magnet AC generator, installed on the nose cone of the booster rocket and driven by a ram air turbine. This generator has a rating of 4.5 kva, 120/200 volts, 400 Hz AC. Part of the AC output is supplied to a transformer rectifier which supplies 60 amps 28 volts DC.

3.13.1 Description-Power Sources (Contd)

AC and DC power is supplied to utilization equipments via simple distribution systems.

A 600 VA solid state inverter is supplied to provide 400 Hz $\pm$ 1%, 115/200 volts AC power to the Inertial Navigation system and the Autopilot.

3.13.1.1 General Conformance -

The electrical system conforms to the intent of MIL-E-25366.

3.13.2 Batteries -

3.13.2.1 Aircraft -

A 28V, 25 ampere hour silver-zinc battery is provided to supply power for the inverter, command receiver, the destruct system, and the recovery system after engine shut-down and prior to package separation.

The battery is connected to the remainder of the direct current system via a blocking diode which allows the battery to receive power, but prevents the battery from discharging into any other than the above specified loads. A suitable heater is also provided for this battery.

3.13.2.2 Package -

A 28V, 7 ampere hour nickel-cadmium battery is provided to supply power for the operation of the Telemetry System during the recovery phase.

A separate battery is provided for the recovery system beacon and is installed inside the beacon package.

3.13.3 Receptacles - Umbilical receptacles are located on the top and bottom centerline of the vehicle and mate with their counter parts installed in the pylon of the B-52H and the booster rocket. Wiring connected to these receptacles is used for control and check-out of the vehicle during the ground test and mated flight phases as well as to supply power during the ground test, mated and boosted flight phases of the vehicle mission.

3.13.4 Equipment Installation - All equipment, except those items required for the fuel system, engine control, and the auto-pilot gyros, are located in the equipment compartment, or are an integral part of the recovery package.

3.13.5 Wiring - The electrical wiring installation is in accordance with applicable requirements of specification MIL-W-8160 as interpreted by approved Lockheed Process Specification. MIL-W-16878C type wire (329°F ambient) is installed in the equipment compartment. Wire installed in uncooled areas is MIL-C-25038 nickel clad copper wire suitable for 650°F ambient temperatures. MIL-W-16878C, Type E teflon wire (329° F ambient) is installed in the fuel tanks. Spec LAC 1-140 wire is installed in the payload package.

3.13.6 Bonding - Bonding is accomplished in accordance with the requirements of specification MIL-B-5087.

3.13.7 Controls - (Refer to 3.2.13.7)

3.13.8 Lighting - Not applicable.

3.13.9 Ignition System - (See 3.11.9)

3.13.10 Indicators - Not applicable.

3.13.11 Electric Drives -

3.13.11.1 One linear actuator, driven by a 28V DC motor, conforming to MIL-M-8609 and equipped with a radio noise filter per MIL-I-6181 is installed in the aft section of the booster rocket.

The actuator is used to extend and retract a foldable ventral fin on the booster.

3.13.12 Relays - The utilization and installation of relays is based upon the requirements of the aircraft system. Relays conform to MIL-R-6106 or their applicable detail specifications and MS drawings.

3.13.13 Booster Coil - Not applicable.

3.13.14 Filters - Radio interference filters are installed as required in conformance with the requirements of MIL-I-6051.

3.14 Hydraulic System

3.14.1 Description and Components - Two hydraulic power systems are provided, the RAT and Main systems, both of which feed into the main control and distribution system which actuates the flight control surfaces only.

3.14.1 Description and Components (Contd)

The RAT system, driven by the ram air turbine in the nose cone of the booster provides hydraulic power for the carry out and boost phases of the mission.

The Main system is driven by the APU and provides hydraulic power for the free flight cruise phase of the mission.

The Main hydraulic system consists of a variable delivery pump, two reservoirs; a nitrogen gas pressurized reservoir and a piston (self pressurizing) reservoir, filters, valves, and related fittings and tubing.

Components of the Main system generally conform to MIL-H-8775 except where deviations are necessary to provide satisfactory operation throughout the unusual flight envelope.

The normal operating pressure of the Main Hydraulic System is 3300 psi at zero flow and 3200 psi at full flow.

To prevent structural damage in the event of a hard over elevon failure during mated flight, the hydraulic system pressure is reduced to 900 psi. Pressure control is effected by solenoid operation of a pressure reducing valve via a switch at the LCO station.

The hydraulic fluid used in the system is SP-302 (MIL-H-2760) a high temperature de-waxed mineral oil. An oil-to-fuel heat exchanger is provided to prevent fluid temperature at the pump from exceeding 500°F. The hydraulic system is designed to conform to the intent of MIL-H-25475, except where deviations are necessary to provide satisfactory operation throughout the intended ground and flight envelope.

The RAT system consists of a variable delivery pump driven by the ram air turbine, a heat sink reservoir, shut-off valve, filters and related fittings and tubing. Self sealing breakaway fittings are provided to seal the two systems at booster separation.

The basic operating pressure of the RAT system is 3100 psi at zero flow and 3000 psi at full flow which is normally lower than that of the Main system. This enables the Main system to lock out the RAT system at switchover during acceleration in the boost phase and assume the full flight load.

Both the Main and RAT hydraulic systems are serviced on the ground through disconnects provided in the lower surface of the fuselage and in the booster nose cone respectively.

When mated, the ground servicing for the complete system is through the disconnects in the booster nose cone.

3.14.2 Emergency Hydraulic System -

Emergency hydraulic power is supplied by a cold gas blow-down accumulator which directs reserve fluid through mechanical servo valves into the primary actuators to position the control surfaces for jettison.

3.15 Pneumatic System

3.15.1 Adequate cooling for the electronic equipment and payload installed in the equipment compartment is provided by the auxiliary power unit (See Paragraph 3.12.1). Cool air is ducted directly to electronic units to provide suitable air circulation within the units as specified by the manufacturer, and air is also supplied for externally cooling the payload and other equipment not internally cooled. Water is removed from the air by a water trapping device incorporated in the air system in the B-52 which provides cooling air during carry out.

3.15.2 Ground Cooling - For cooling when either one or two D-21Bs are mated to the B-52, a ground connection for each D-21B is provided in the B-52 forward wheel well. The ground connections are not intended for ground operation of the APU. They are structurally capable, but inlet air temperature must be held at 180° - 186°F.

3.15.3 Anti-Icing Provisions - A heated pitot tube is provided to preclude icing of the pitot ports.

3.16 Utilities and Equipment Subsystems

3.16.1 Instruments - None

3.16.2 Furnishings - None

3.16.3 Oxygen System - None

3.16.4 Emergency Rescue - None

3.17 Communications, Navigation and Guidance

The following equipment is installed, placed in normal operating condition, and tested in accordance with the intent of MIL-E-25336.

The equipment conforms to MIL-E-8189 where possible.

Inertial Guidance System
Autopilot with Stability Augmentation System
Command Receiver
Recovery Beacons
Telemetry Transmitting System

This equipment is located in a cooled compartment.

3.17 Communications, Navigation and Guidance (Contd)

3.17.1 Communication Equipment - A nine channel command receiver is provided, for remote control of recovery beacons, telemetry transmitter, fuel shut-off, package eject, destruct arm, destruct disable, engine ignition, booster separate, and manual destruct.

3.17.2 Navigation Equipment - A Honeywell H-390 (D) Inertial Navigation System is installed to provide steering information to the autopilot and present position for programming operating commands.

3.17.3 Autopilot - (See 3.9.1)

3.17.4 Telemetry - A Telemetering System is installed to provide transmission of vehicle performance characteristics for monitoring at remote locations.

3.17.5 Antenna Installations - Flush mounted antennas are provided for command receiver, recovery beacons, and telemetry transmitter as required to provide adequate space coverage.

These antenna installations will conform to MIL-A-7772 where possible.

3.18 Reconnaissance System

Provisions for installation of a GFAE camera (Hycon HR-335) and accessories, are made.

3.19 Fire Control System - None

3.20 Armament System - None

3.21 Ground Handling and Servicing Provisions

3.21.1 Towing Provisions - None

3.21.2 Jacking Provisions - None

3.21.3 Mooring Provisions - None

3.21.4 Hoisting Provisions - Hoisting fittings are provided at appropriate points for raising and lowering the vehicle off and on the towable transport cart, and the B-52H aircraft.

3.21.5 Measuring and Leveling Provisions - Are installed at Stations 222.5 and 444.5.

3.22 Aerial Refueling System - None

4.0 QUALITY ASSURANCE PROVISIONS

The method of inspection and tests are in accordance with Lockheed Aircraft Corporation, Advanced Development Projects Division standard procedure.

5.0 PREPARATION FOR DELIVERY

Vehicle will be prepared and delivered in accordance with the terms of the contract.

6.0 NOTES

6.1 Intended Use

This specification is intended to describe the vehicle configuration at time of delivery as complete, assembled and flyable unit produced by Lockheed Aircraft Corporation under terms of the contract.

6.2 Revisions

The Contractor will take suitable action to maintain this specification current by issuance of revised pages as necessary and appropriate, through delivery of the last vehicle described by this specification.