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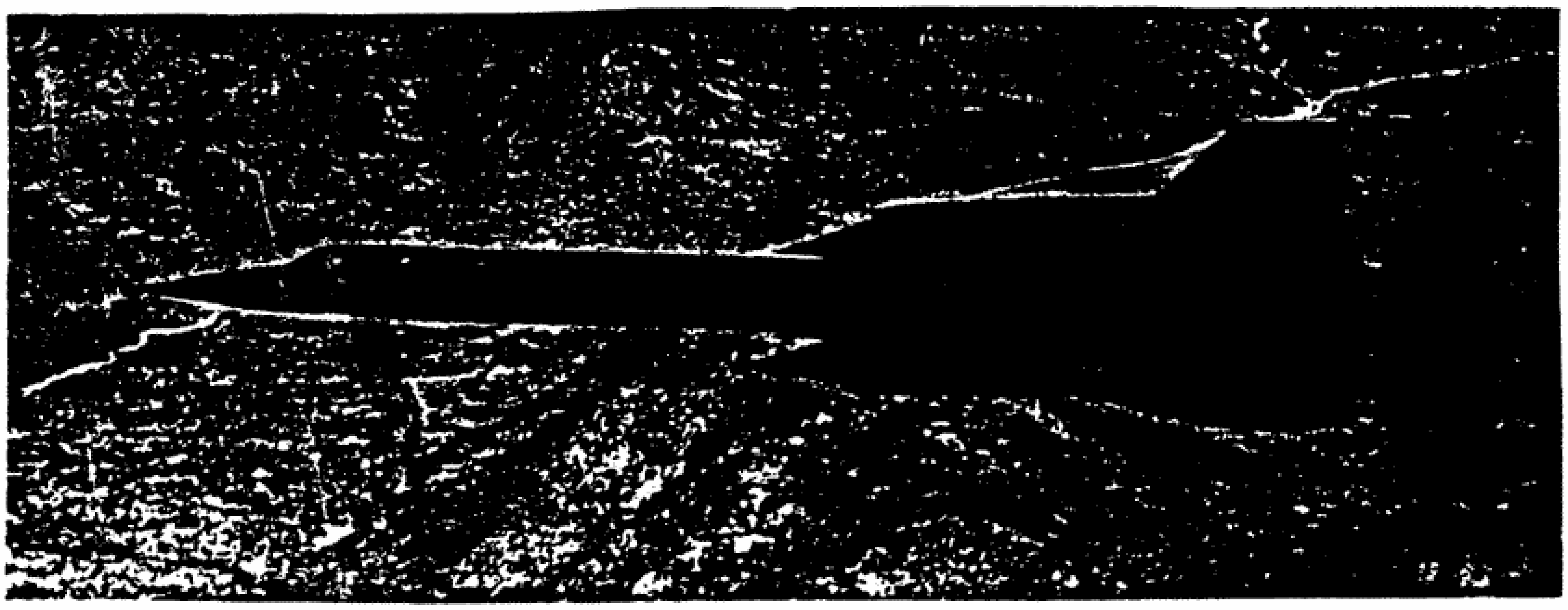
SR-71A FLIGHT MANUAL (U)



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Classified by: [illegible]own Program
Security Class[illegible] Guide,
25 May 198[illegible]
Declassify [illegible]OADR

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ISSUE E: 31 OCTOBER 1986
Change 2: 31 July 1989

[redacted]

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Dates of issue for original and changed pages are:

Original .... 31 October 1986
Change 1 .... 16 January 1989
Change 2 .... 31 July 1989

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SR-71A FLIGHT MANUAL

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FOREWORD

SCOPE. This manual contains the information necessary for safe and efficient operation of the SR-71A and the SR-71B aircraft. These instructions provide you with a general knowledge of the aircraft, its characteristics and specific normal and emergency operation procedures. Your prerequisite flying experience is recognized, and it is not considered necessary to discuss basic flight principles.

SOUND JUDGMENT. Instructions in this manual provide the best operating instructions under most circumstances, but they are not a substitute for sound judgment. Multiple emergencies, adverse weather, terrain, etc. may require modification of the procedures.

ARRANGEMENT. The manual is divided into eight nearly independent sections to simplify using it as a reference manual. Sections II, III and V must be thoroughly understood before attempting to fly the aircraft. Section I is subdivided into two parts. The first section provides information which is applicable to the basic SR-71A aircraft. Section IA provides special descriptive information for the SR-71B trainer aircraft. The remaining sections provide important information for safe and efficient mission accomplishment.

CHANGES. This manual will be revised by numbered changes to reflect information gained from tests and operational experience and to augment the data provided. Operational or safety of flight supplements indicated as -1S or -1SS respectively, will be issued when necessary and incorporated in the succeeding numbered change.

CHECKLISTS. The Flight Manual contains only amplified checklists. Abbreviated checklists are issued separately. Line items in the Flight Manual and checklists are identical with respect to arrangement and item number.

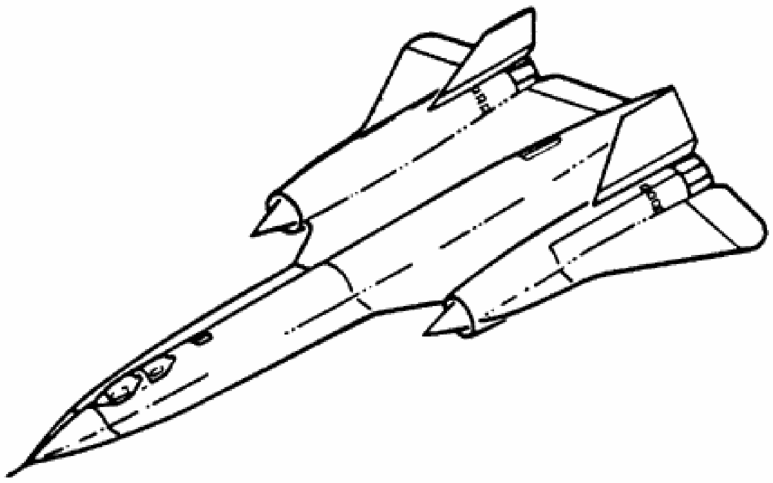
WARNINGS, CAUTIONS, AND NOTES. The following definitions apply to "Warnings", "Cautions", and "Notes" found throughout the manual.

WARNING — Operating procedures, practices, etc., which may result in personal injury or loss of life if not correctly followed.

CAUTION — Operating procedures, practices, etc., which if not strictly observed may result in damage to or destruction of equipment.

NOTE — An operating procedure, condition, etc., which it is essential to highlight.

YOUR RESPONSIBILITY - TO LET US KNOW. Comments, corrections, and questions regarding this manual are welcome. Air Force change recommendations will be submitted to 2762 LS Det 6/FT IAW SR-71 Logistics Support Manual - 400 for approval with simultaneous coordination copy furnished to Lockheed and other Air Force agencies using established channels and contact points. Contractor recommendations may be forwarded through the manufacturer's senior representative present or directly to manuals engineers in the flight test organization.



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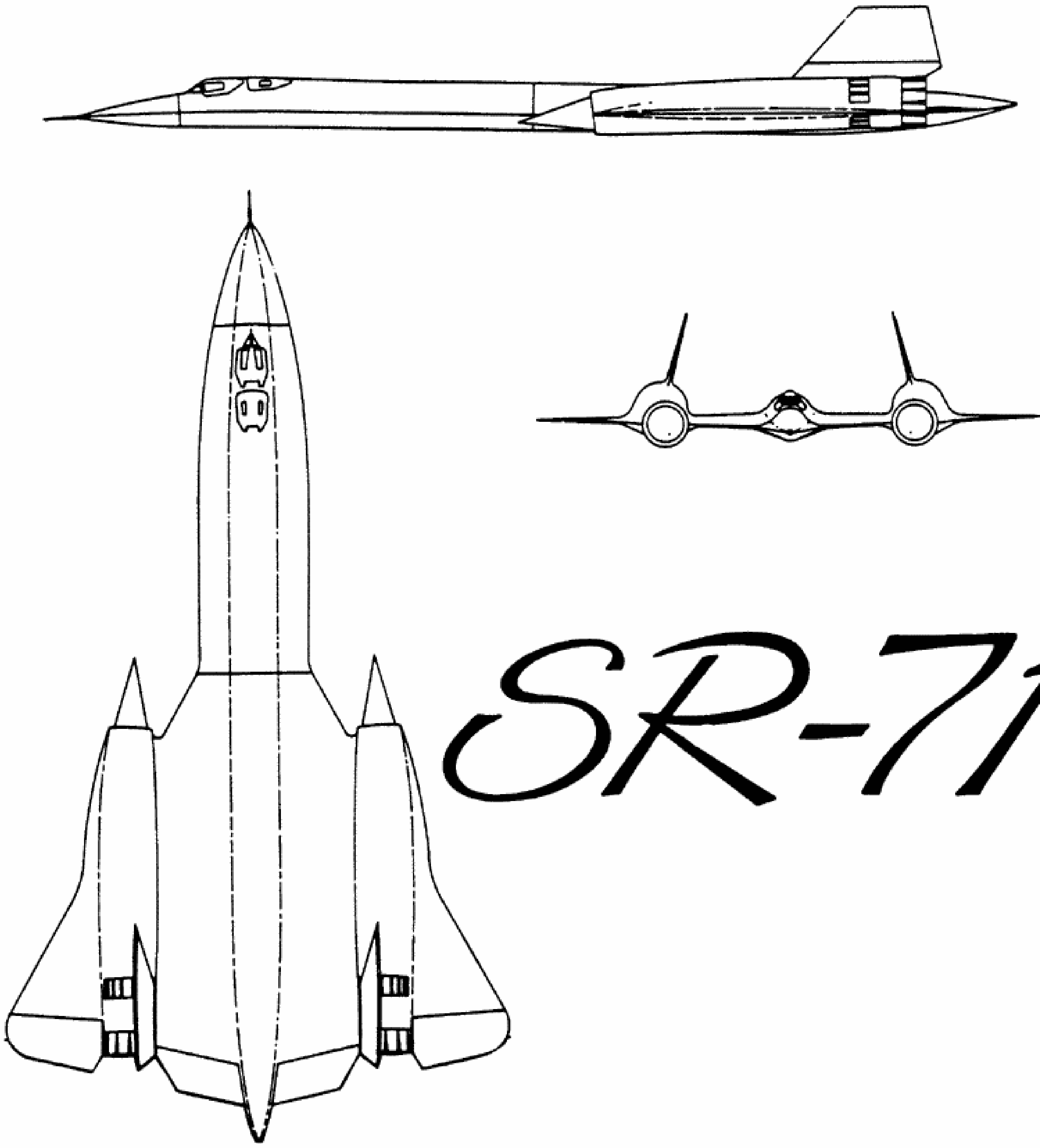
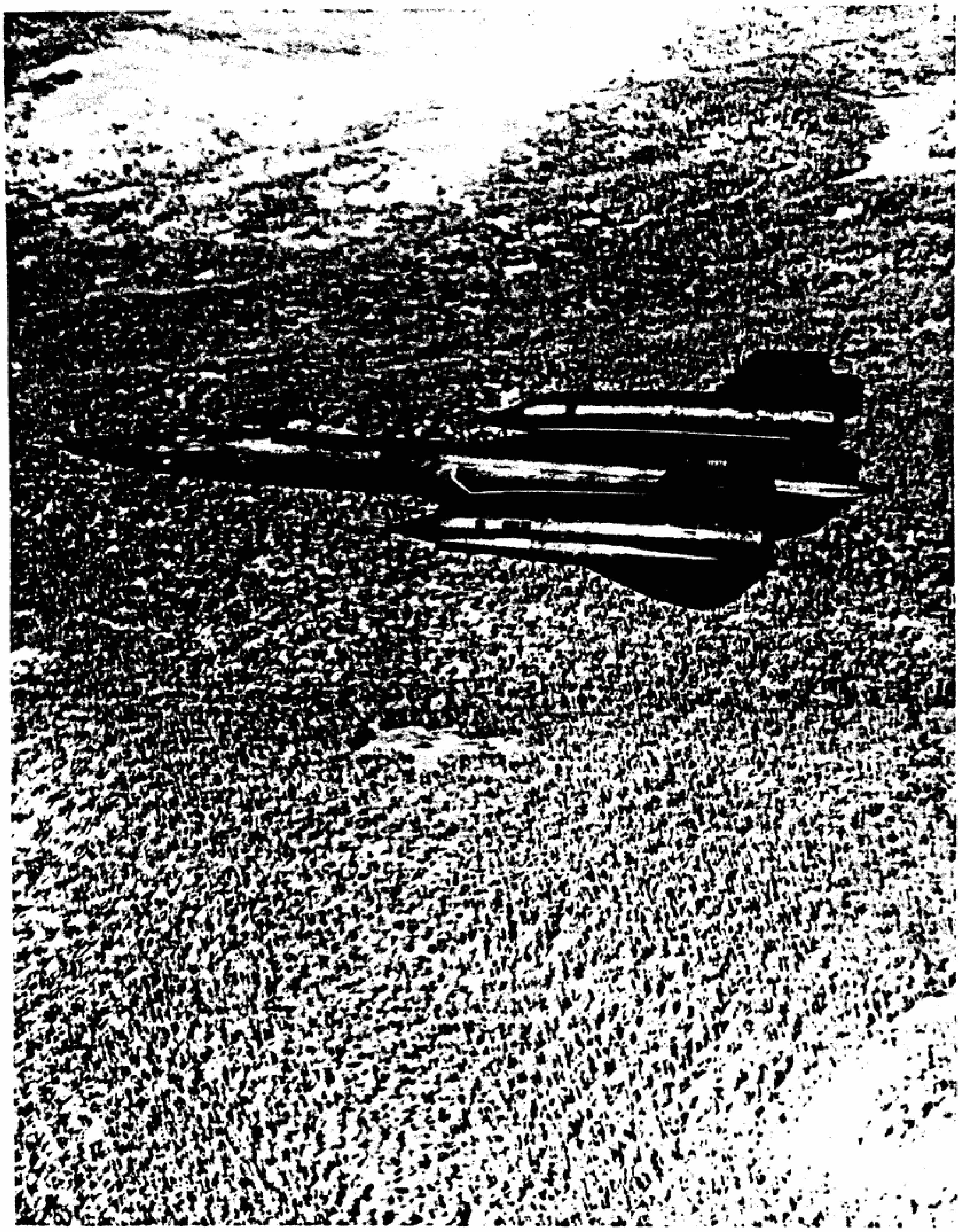


SR-71



SR-71A

INTRODUCTION

This section describes SR-71A reconnaissance aircraft. Subsection 1A describes the SR-71B.

THE AIRCRAFT

The SR-71 is a delta-wing, two-place aircraft powered by two axial-flow turbojet engines. The aircraft, built by the Lockheed California Company, features titanium construction and is designed to operate at high altitudes and high supersonic speeds. The aircraft has very thin wings, twin canted rudders mounted on top of the engine nacelles, and a pronounced fuselage "chine" extending from the nose to the leading edge of the wing. The propulsion system uses movable spikes to vary air inlet geometry. Surface controls are elevons and rudders, operated by irreversible hydraulic actuators with artificial pilot control feel. The aircraft can be refueled either in-flight or on the ground through separate receptacles that feed into a common refueling line. A drag chute is provided to augment the six-mainwheel brakes. The aircraft is painted black to reduce internal temperatures when at high speed.

Dimensions

Length (overall)	107.4	ft.
Height (to top of rudders)	18.5	ft.
Wing span	55.6	ft.
Wing area (reference)	1605 sq.	ft.
Tread (MLG middle wheel centerlines)	16.67	ft.

Gross Weight

The loaded gross weight of the aircraft varies from approximately 135,000 to over 140,000 pounds. Zero fuel weight varies from 56,500 to more than 60,000 pounds.

NOTE

Use SR-71 manual of weight and balance data applicable to specific aircraft to compute aircraft performance.

FUEL

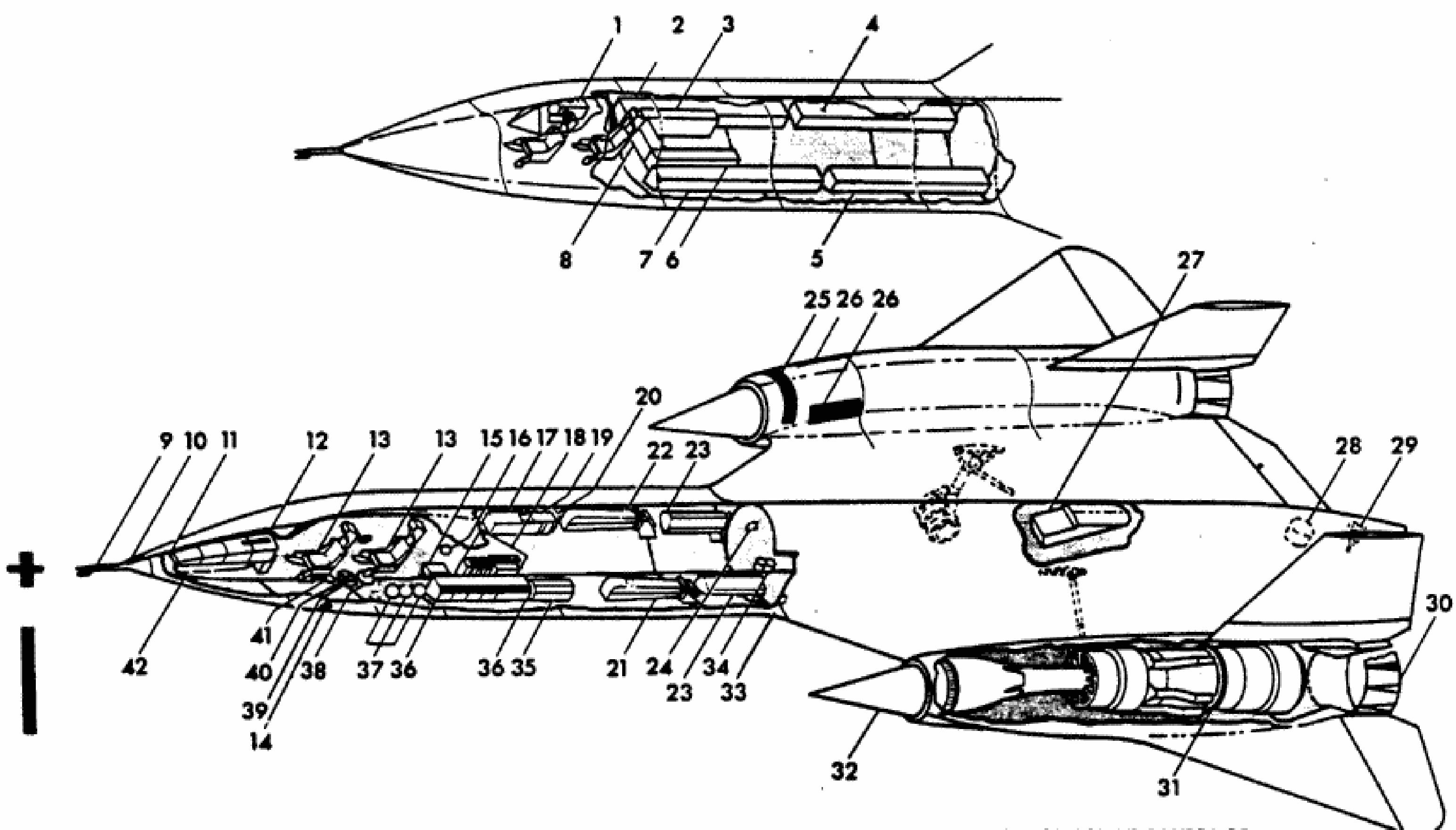
The operating envelope of the JT11D-20 engine requires special fuel. The fuel is not only the source of energy but is also used in the engine hydraulic system. During high Mach flight, the fuel is also a heat sink for the various aircraft and engine accessories which would otherwise overheat at the high temperatures encountered. This requires a fuel having high thermal stability so that it will not break down and deposit coke and varnishes in the fuel system passages. A high luminometer number (brightness of flame index) is required to minimize transfer of heat to the burner parts. Other items are also significant, such as the amount of sulfur impurities tolerated. Advanced fuels, JP-7 (PWA 535) and PWA 523E, were developed to meet the above requirements.

JP-7 and PWA 523E contain one gallon of PWA 536 lubricity additive per 5200 gallons of fuel to insure adequate lubrication of fuel hydraulic pumps.

ENGINE AND AFTERBURNER

Thrust is supplied by two Pratt & Whitney JT11D-20 bleed bypass turbojet engines with afterburners. (See Figure 1-2.) The engines are designed for continuous operation at compressor inlet temperatures above 400°C, which are associated with high Mach flight. The engine has a single-rotor, nine-stage, 8.8:1 pressure ratio compressor utilizing a compressor bleed bypass at high Mach. When opened, bypass valves bleed air from the fourth stage of the compressor, and six ducts route it around the rear stages of

GENERAL ARRANGEMENT AND BAY LOCATOR DIAGRAM



1 RIGHT CHINE BAY - COMPT D (DEF A, C AND M)
2 RIGHT FORWARD MISSION BAY - COMPT L AND N
3 RADIO EQUIPMENT BAY - COMPT R
4 RIGHT AFT MISSION BAY - COMPT Q AND T
5 LEFT AFT MISSION BAY - COMPT P AND S
6 ELECTRONICS BAY - COMPT E
7 LEFT FORWARD MISSION BAY - COMPT K AND M
8 CAMERA BAY - COMPT C
9 PITOT MAST
10 HF ANTENNA
11 LOCALIZER ANTENNA
12 RADAR OR OBC EQUIPMENT - COMPT A
13 EJECTION SEAT
14 FORWARD UHF ANTENNA (LEFT SIDE)
15 ANS PLATFORM AND COMPUTER
16 IFF ANTENNA
17 RADAR RECORDER
18 ELECTRICAL LOAD CENTER
19 AIR REFUELING RECEPTACLE
20 MISSION RECORDERS
21 TECHNICAL OBJECTIVE CAMERA
22 TECHNICAL OBJECTIVE CAMERA OR RADAR RECORDER
23 EIP
24 AFT UHF ANTENNA (RIGHT SIDE)
25 FORWARD BYPASS DOORS
26 POROUS BLEED AIR OUTLETS
27 DRAG CHUTE RECEPTACLE
28 ROLL AND PITCH MIXER
29 CW RECEIVE ANTENNA (DEF H)
30 EJECTOR FLAPS
31 J-58 ENGINE
32 MOVABLE SPIKE
33 VHF ANTENNA (LEFT SIDE)
34 SAS GYROS
35 DIGITAL AND AR1700 RECORDERS (EIP)
36 DEF H
37 LIQUID OXYGEN CONTAINERS
38 TACAN ANTENNA
39 DEF H CENTERLINE RECEIVE ANTENNA
40 UHF-ADF ANTENNA
41 GLIDE SLOPE ANTENNA
42 SLR ANTENNA

SEE SECTION IV FOR COMPLETE LIST OF BAY DESIGNATIONS AND EQUIPMENT LOCATIONS

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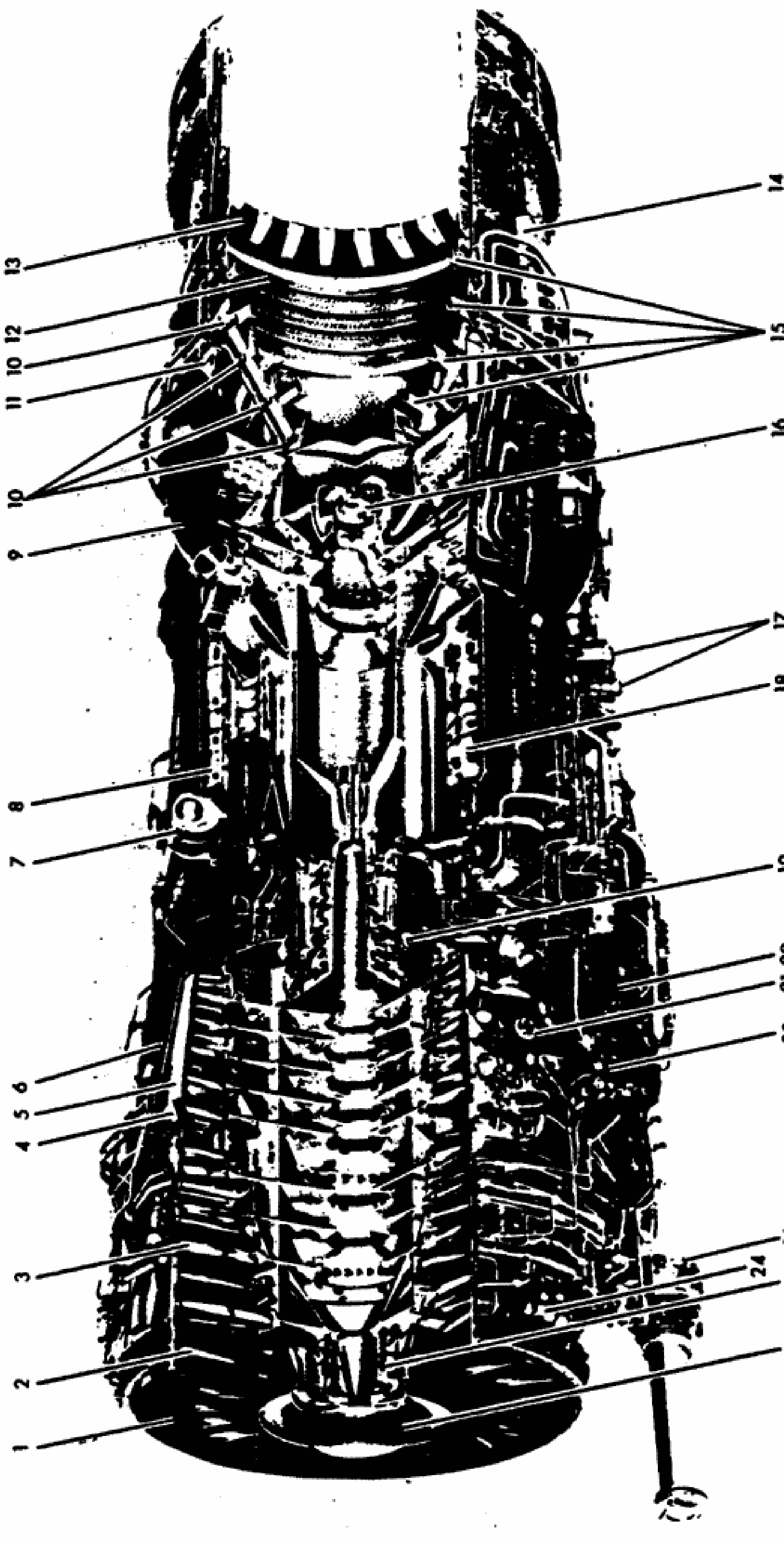
Figure 1-1

JT11D -20 ENGINE



1 Inlet Case
2 Variable IGV
3 Forward Compressor Section (4 stages)
4 Internal Bleeds (24)
5 Bypass Chamber
6 External Bleeds (12)
7 Chemical Ignition Tank (TEB)
8 Main Burner Injector Probe
9 Bleed Bypass Tubes (6)
10 Afterburner Spray Bar Rings (4)
11 Aft Engine Mount Ring
12 Afterburner Liner
13 Variable Area Exhaust Nozzle
14 Exhaust Nozzle Actuators (4)
15 Flame Holders (4)
16 Turbine Section and Bearing
17 Hydraulic Filters (2)
18 Burner Can (8)
19 Aft Compressor Bearing
20 Main Gearbox
21 Main Fuel Control
22 Main Fuel Pump
23 Reduction Gear Box
24 IGV Actuators (2)
25 Front Compressor Bearing
26 Inlet Case Island Cover

F203-3(c)

Figure 1-2

the compressor, the combustion section, and the turbine. The bleed air re-enters the turbine exhaust around the front of the afterburner where it is used for increased thrust and cooling. The transition to bypass operation is scheduled by the main fuel control as a function of compressor inlet temperature and engine speed. The transition normally occurs in a CIT range of 85° to 115°C, corresponding to a Mach range of 1.8 to 2.0.

When on the ground, or at low Mach numbers, engine speed varies with throttle movement when the throttle is between IDLE and slightly below the Military stop. At higher settings, up to maximum afterburner, the main fuel control schedules engine speed as a function of CIT and modulates the variable area exhaust nozzle to maintain approximately constant rpm. Throttle movement in the afterburning range only changes the afterburner fuel flow, nozzle position, and thrust. At high Mach number and constant inlet conditions, engine speed is essentially constant for all throttle positions down to and including IDLE. At a fixed throttle position, engine speed will vary according to main fuel control schedule when CIT (Mach) changes.

The engine contains a two-stage turbine. Turbine discharge temperatures are monitored by exhaust gas temperature indication. A chemical ignition system is used to ignite the low vapor pressure fuel. A separate engine-driven hydraulic system, using fuel as hydraulic fluid, operates the exhaust nozzle, chemical ignition system dump, compressor bypass, starting bleed systems, and Inlet Guide Vanes (IGV). The main fuel pump, engine hydraulic pump and tachometer are driven by the main engine gearbox. The afterburner fuel pump is powered by an air turbine, driven by compressor discharge air.

Maximum Rated Thrust

Maximum rated thrust is obtained in afterburning by placing the throttle against the quadrant forward stop. The maximum afterburning uninstalled thrust of each engine at sea level, static condition, and standard day is 34,000 pounds. Takeoff thrust in maximum afterburner is illustrated in Figure 1-3 at sea level pressure altitude. It shows the variation in thrust with ambient temperature and the effect of airspeed during the takeoff acceleration.

Partial Afterburning Thrust

Afterburning fuel flow and thrust are modulated by moving the throttle between the Military detent and the quadrant forward stop. Minimum afterburning thrust is obtained with the throttle just forward of Military and is approximately 85% of maximum afterburning thrust at sea level and

TAKEOFF THRUST

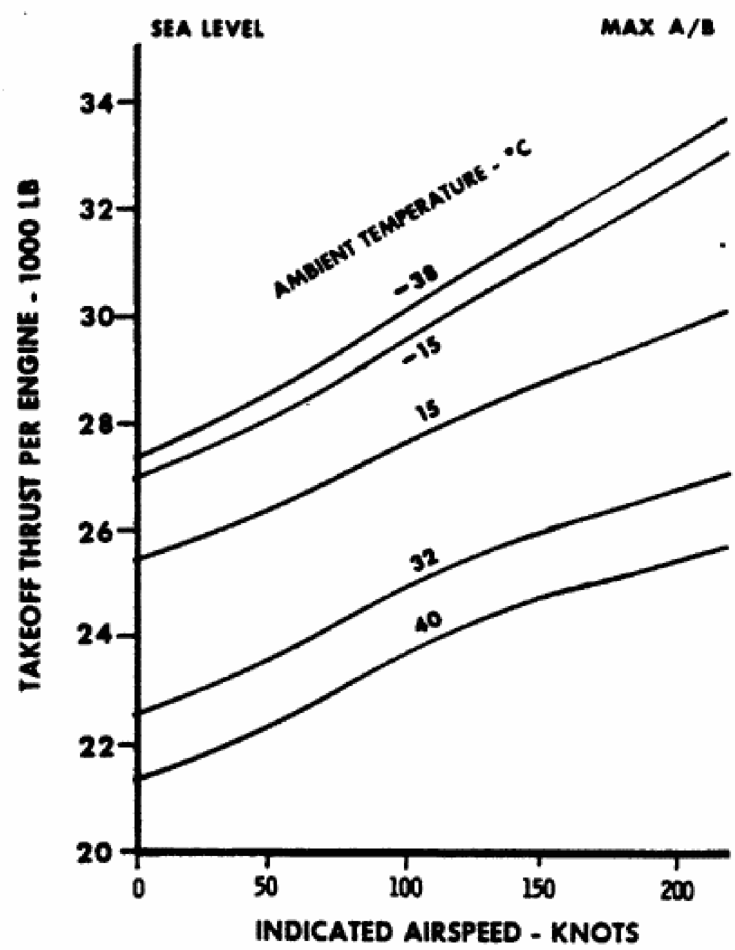


Figure 1-3

approximately 55% at high altitude. Afterburner ignition is automatically actuated when the throttle is advanced past the detent. The time required to obtain afterburner ignition after moving the throttle past the detent is a function of afterburner fuel manifold fill time. The fill time can be up to three seconds at sea level and up to seven seconds at altitude. Afterburner fuel flow is terminated when the throttle is retarded below the detent. The basic engine operates at Military rated thrust during all afterburning operation.

MILITARY THRUST

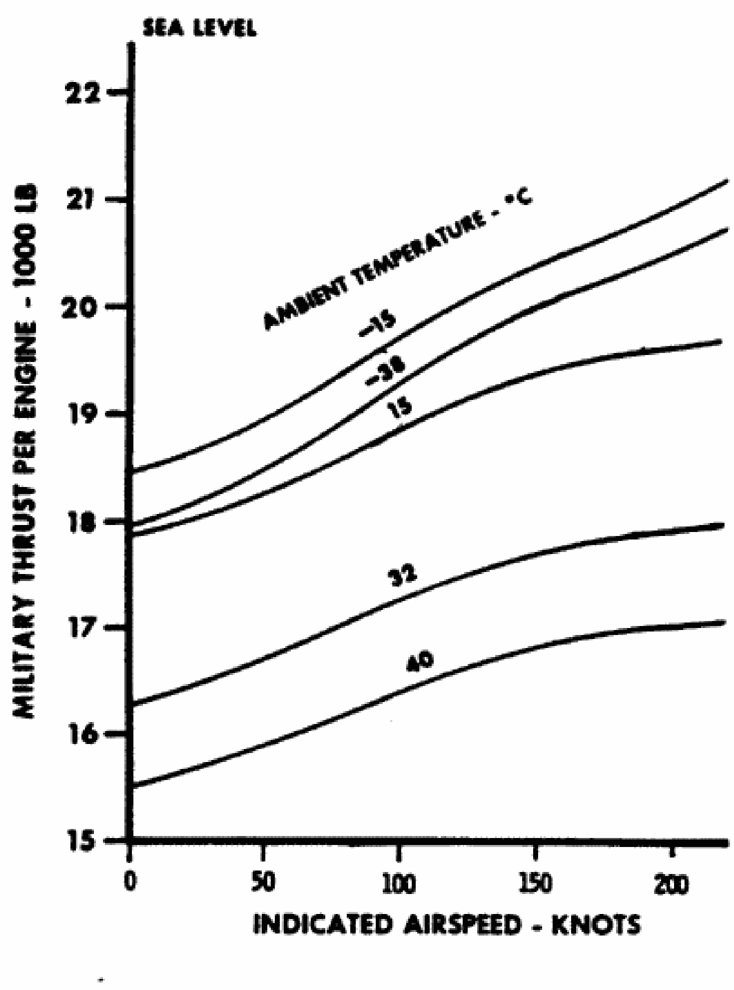


Figure 1-4

Military Thrust

Military thrust is the maximum non-afterburning thrust and is obtained by placing the throttle against the aft side of the Military detent. At sea level static conditions, military thrust is approximately 70% of maximum thrust. At high altitude, military thrust is approximately 28% of the maximum thrust available. Figure 1-4 illustrates the variation in military thrust with ambient temperature and airspeed at sea level pressure altitude.

Idle Thrust

Idle thrust is the minimum non-afterburning thrust level. With the throttle in IDLE, the engine operates at approximately 3975 rpm up to 60°C (140°F). At higher ambient temperatures, rpm increases approximately 50 rpm per 1°C. Idle thrust is illustrated in Figure 1-5, at sea level pressure altitude, for airspeeds typical of a landing and deceleration.

IDLE THRUST

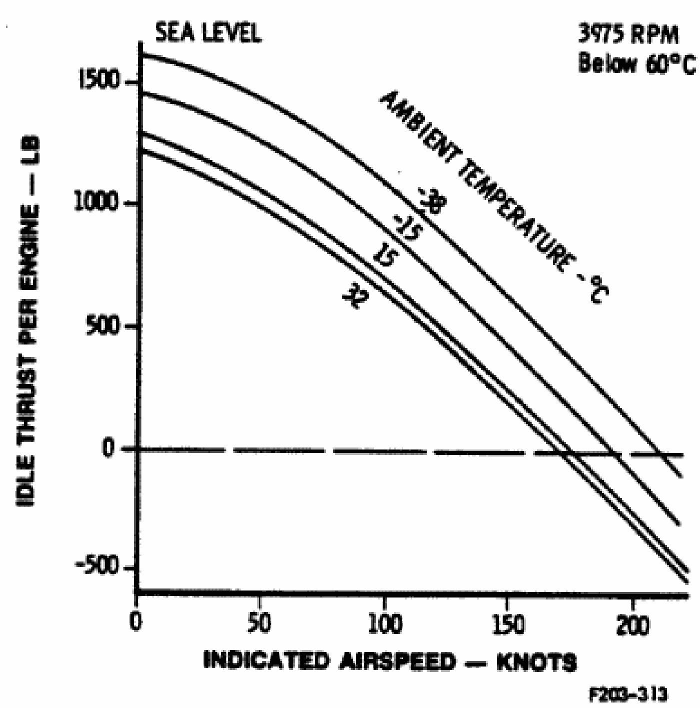


Figure 1-5

THROTTLES AND THROTTLE SETTINGS

Two throttle levers are located in a quadrant on the pilot's left forward console. The right throttle is mechanically linked to the right engine main fuel control. The left throttle is linked to the left engine afterburner fuel control. The afterburner and the main fuel controls are interconnected by a closed loop cable. The throttle quadrant has three labeled positions, OFF, IDLE, and AFTERBURNER, and an unlabeled Military power stop. See Figure 1-6. The non-afterburning operating range of the engine is between IDLE and Military.

A spring-loaded pushbutton switch is located on the right throttle knob. When depressed, the pilot's microphone is connected to the selected radio transmitter.

A throttle air inlet restart switch is located on the inboard side of the right throttle. The switch is used for restarting both air inlets simultaneously.

Off

In the OFF position, the windmill bypass valve cuts off fuel from the burner cans and routes it back to the aircraft system. This provides cooling for engine oil, fuel pump, and fuel hydraulic pump when an engine is windmilling.

Idle

When a throttle is moved forward from OFF to IDLE, a roller drops over a hidden ledge at the IDLE position. This ledge prevents the engine from being inadvertently cut off when the throttles are retarded to IDLE. The throttles must be lifted to be moved from IDLE to OFF.

Afterburner

The throttle must be slightly raised and pushed forward to clear the Military stop before additional forward movement of the throttle can initiate afterburner ignition. The AFTERBURNER range extends from the Military stop to the quadrant forward stop.

Start

There is no distinct throttle position for starting. Starting is accomplished by moving the throttle from OFF to IDLE as the engine is accelerated by the starter. As the proper engine speed is reached, fuel is directed to the engine burners by actuation of the windmill bypass valve and the chemical ignition system is actuated by fuel pressure.

Throttle Friction Lever

Throttle friction is controlled by a lever located on the inboard side of the throttle quadrant. Moving the lever forward, as the INCREASE FRICTION label indicates, progressively increases friction.

TEB Remaining Counters

Mechanical digital counters, aft of each throttle,indicate the number of TEB shots remaining for each engine. The counters are spring wound and set to 16 prior to engine start. Each time a throttle is moved forward from OFF to IDLE, or from Military to AFTERBURNER, the corresponding counter indication decreases by 1.

Tachometers

Tachometers for each engine are mounted on the right side of the pilot's instrument panel. They indicate engine speed in revolutions per minute by means of a main pointer and dial calibrated to 10,000 rpm, and a smaller dial and subpointer which make one complete revolution for each 1000 rpm. The tachometers are self-energized and operate independently of the aircraft electrical system.

ENGINE FUEL SYSTEM

Engine fuel system components include the engine-driven fuel pump, main fuel control,

THROTTLE QUADRANT

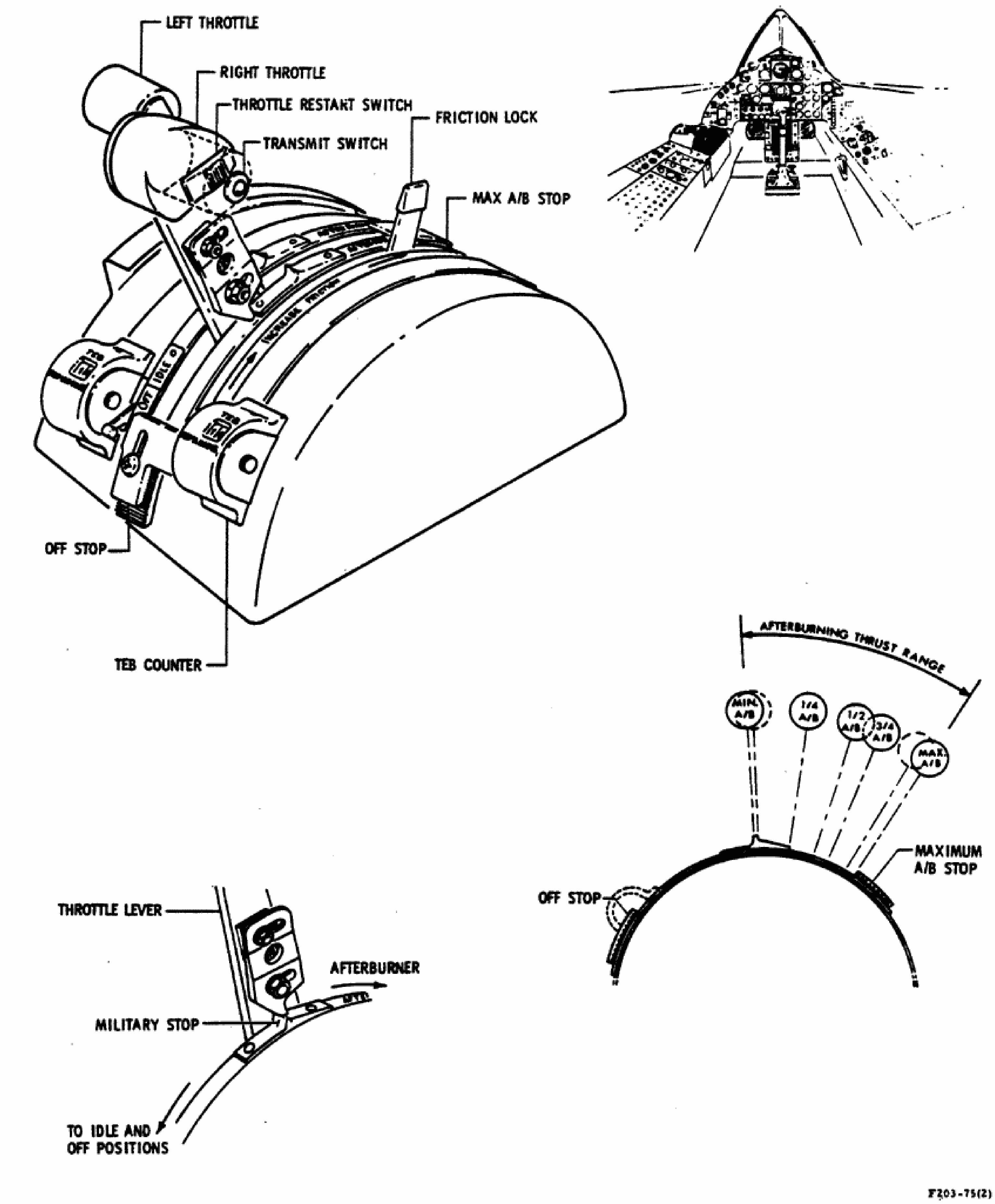


Figure 1-6

windmill bypass valve and variable area fuel nozzles in the main burner section. (See Figure 1-7.)

Main Fuel Pump

The engine-driven main fuel pump is a two-stage unit. The first stage, a single centrifugal pump, acts as a boost stage. The second stage consists of two parallel gear-type pumps with discharge check valves. The parallel pump and check valve arrangement permits continued operation if either pump fails.

Main Fuel Control

The main fuel control meters main burner fuel flow, controls the bleed bypass, start bleed valves, IGV, and exhaust nozzle modulation. It regulates main engine thrust as a function of throttle position, compressor inlet air temperature, main burner pressure, and engine speed. The bypass, start-bleed valve positions and IGV are controlled as a function of engine speed, biased by CIT. Afterburner operation is always at Military-rated engine speed and EGT. The control has a remote trimmer for EGT regulation. There is no emergency fuel control system.

Windmill Bypass and Dump Valve

The windmill bypass and dump valve directs fuel to the engine burners for normal operation or bypasses fuel to the recirculation system for accessory, engine component, and engine oil cooling during windmilling operation. The valve responds to signals from the main fuel control. The valve opens to drain the engine fuel manifold when the engine is shut down.

Fuel Nozzles

The engine has an eight-unit can-annular combustion section with 48 variable-area, dual-orifice fuel nozzles. The nozzles are arranged in clusters of six nozzles per burner. Each nozzle has a fixed area primary metering orifice and a variable area secondary metering orifice, discharging through a common opening. The secondary orifice opens as a function of primary pressure drop.

Combustion Chamber Drain Valve

The main engine ignition system plumbing is equipped with a fuel purge or "Dribble Tee". This allows fuel from the main fuel pump interstage to flush residual ignition fluid (TEB) from the ignition probe. It prevents "coking" from occurring which would restrict the ignition probe and prevent engine ignition. Hence, fuel in small quantity should drain from the main burner case overboard drain fitting anytime there is fuel pressure to the engine pump inlet, due to fuel boost pump operation or tank pressure developed by the LN_2 fuel tank pressurization system. If fuel does not drain normally, either the chemical ignition system probe is plugged or the burner drain has malfunctioned. The normal leakage from the main burner case overboard drain should be confirmed before start. If the overboard drain is restricted, it will increase the "wetted" fuel area in the burner and could result in severe torching during engine start.

Fuel Flow Indicators

Fuel flow indicators for each engine, mounted on the right side of the pilot's instrument panel, display total fuel flow (engine and afterburner) plus tank return flow, if any. Dial calibrations are provided in 5000 pound per hour increments to 95,000 pph. Five center digit windows show fuel flow to the nearest 100 pph. Power for the indicators is supplied from the essential ac bus through the L and R FLOW circuit breakers on the pilot's right console.

ENGINE AND AFTERBURNER FUEL SYSTEM

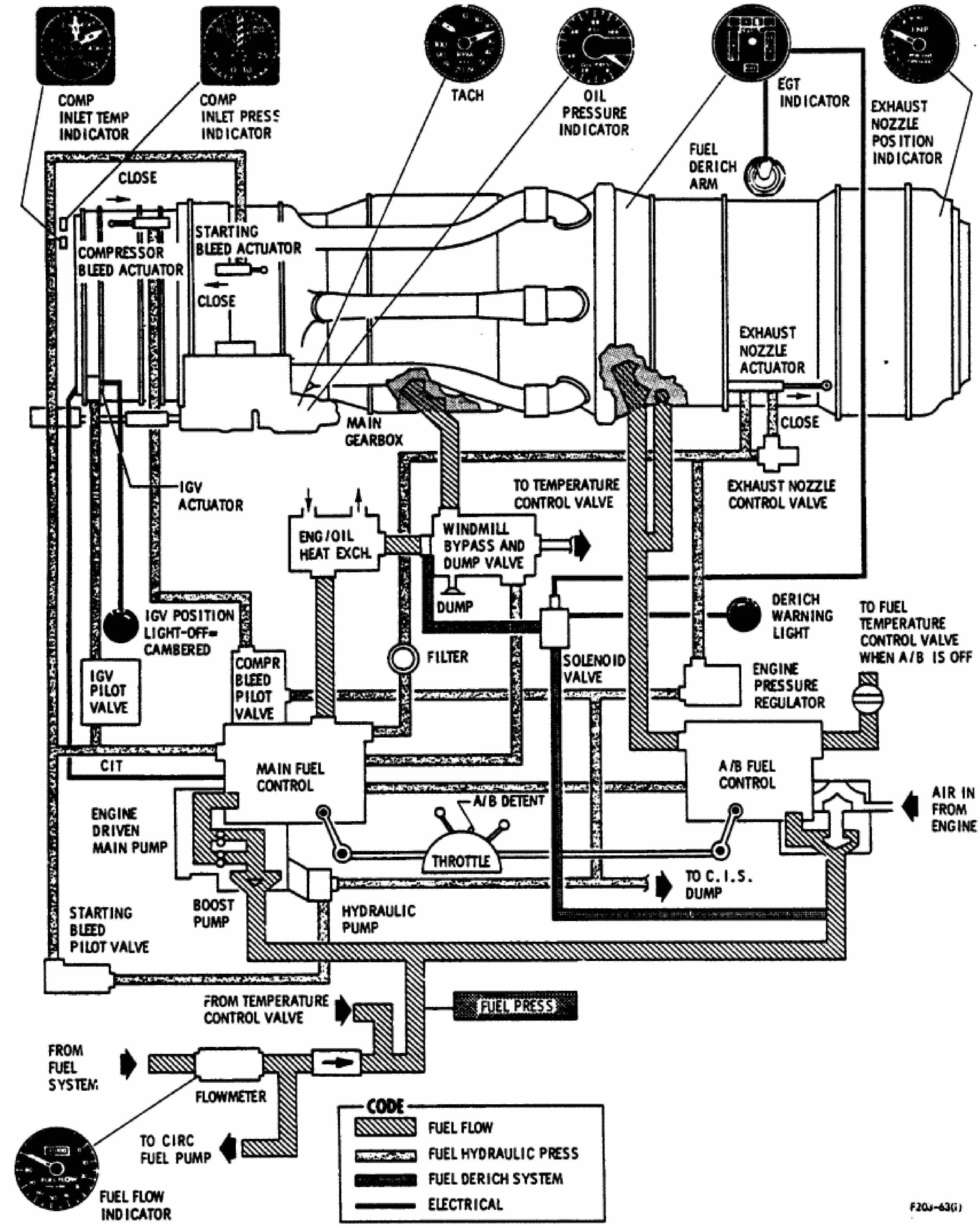


Figure 1-7

NOTE

Tank return flow forms an appreciable portion of the indication when at or below Military.

AFTERBURNER FUEL SYSTEM

Afterburner Fuel Pump

The afterburner fuel pump is a high speed, single stage centrifugal pump. The pump is driven by an air turbine, operated by engine compressor discharge air. The compressor discharge air supply is regulated by a butterfly valve in response to the demand of the afterburner fuel control.

Afterburner Fuel Control

The hydromechanical afterburner fuel control schedules fuel flow as a function of throttle position, main burner pressure, and compressor inlet temperature. Fuel flow is metered to discharge fuel from the four concentric afterburner spraybar rings.

FUEL DERICH SYSTEM

A derichment system on each engine protects against severe turbine overtemperature. If the respective EGT indicator reaches 860°C while the system is armed, the fuel/air ratio in the engine burner cans is automatically reduced (deriched). A signal from the EGT gage actuates a solenoid-operated valve which bypasses metered engine fuel from the fuel/oil cooler to the afterburner fuel pump inlet. See Figures 1-7 and 1-8. Once actuated, the solenoid valve is held open until the system is turned off or rearmed. A red, flashing FUEL DERICH warning light illuminates when the valve for the respective engine is open.

Derichment at sea level decreases thrust approximately 5% in maximum afterburner; 7% at Military. Derichment during supersonic cruise decreases engine thrust approximately 45% in maximum afterburner (overall engine/inlet thrust loss is about 10% for the deriched engine since derichment has no effect on CIP) and may cause the afterburner to blow out. Continuous operation with the engine deriched does not harm the engine (provided derichment can reduce EGT to normal limits).

After an unstart, do not move the fuel derich switch from ARM unless inlet roughness has cleared and the inlet has restarted (CIP recovered); otherwise, severe overtemperature can result. Do not attempt to relight the afterburner while deriched. Lighting the afterburner while deriched can result in engine speed suppression of up to 750 rpm.

Fuel Derich Arming Switch

A three-position FUEL DERICH arming toggle switch is located on the pilot's left instrument side panel. In the ARM (center) position, the derich circuit is armed and the derich solenoid valve will open and remain open if the respective EGT indication reaches 860°C. In the OFF (down) position, the derich solenoid valve is closed and the system cannot provide derichment. The REARM (up) position is spring-loaded and allows the pilot to rearm the fuel derich system without moving the switch to OFF. Power for the switch is furnished by the essential dc bus through the L and R FUEL DERICH circuit breakers on the pilot's left console.

Fuel Derich System Test Switch

A three-position toggle switch, labeled FUEL DERICH SYSTEM, is located on the pilot's left console. The switch is labeled L (left), R (right) and is spring-loaded to the center (off) position. When the switch is moved to the L or R position, the digital indication on the respective EGT gage slews toward 1198°C. When the EGT gage indication exceeds 860°C, the red jewel light in the gage illuminates; and, if the FUEL DERICH switch is in ARM, the respective fuel derich warning light flashes and the derich solenoid valve opens.

Fuel Derich Warning Light

Two red, flashing fuel derich warning lights are located on the right side of the pilot's instrument panel. A light flashes when the fuel derich system for the respective engine is activated (derich solenoid valve open) and continues flashing until the fuel derich system is rearmed or off.

EXHAUST GAS TEMPERATURE (EGT) TRIM SYSTEM

EGT Gages

Two EGT gages, one for each engine, are located on the right side of the pilot's instrument panel. Each gage has a digital indicator that shows turbine discharge temperature from 0° to 1198°C, a HOT (red) and COLD (yellow) condition flag, a red "jewel" overtemperature warning light that illuminates when the EGT digital indication reaches 860°C, and a power OFF warning flag. Each indicator receives power from the essential ac bus through its respective L or R EGT IND circuit breaker on the pilot's right console.

EGT Trim Switches

Two four-position EGT trim switches, one for each engine, are located on the pilot's left console. The positions are labeled AUTO (left), INCR (up), DECR (down) and HOLD (center). When a switch is held in INCR, a small electric motor on the engine fuel control increases the ratio of main burner fuel flow to main burner combustion pressure and thus increases the turbine discharge temperature (EGT). Holding a switch in DECR runs the motor in the opposite direction and decreases EGT. The switches have no effect on rpm as long as the nozzles are modulating to provide the scheduled engine speed. However, engine speed will increase (or decrease) with increasing (or decreasing) EGT when nozzle position is limited full closed (or open).

An EGT "permission" circuit prevents automatic trimming in either direction and manual uptrim when the respective throttle is positioned below Military or the engine is deriched. Manual EGT downtrim remains available even when the permission circuit is on (throttle below Military or engine deriched). Power for the trim motors is furnished by the essential ac bus through the L and R EGT TRIM circuit breakers on the pilot's right console. Power for the permission circuit is furnished by the essential dc bus through the L and R EGT circuit breakers on the pilot's left console.

Automatic EGT Trim

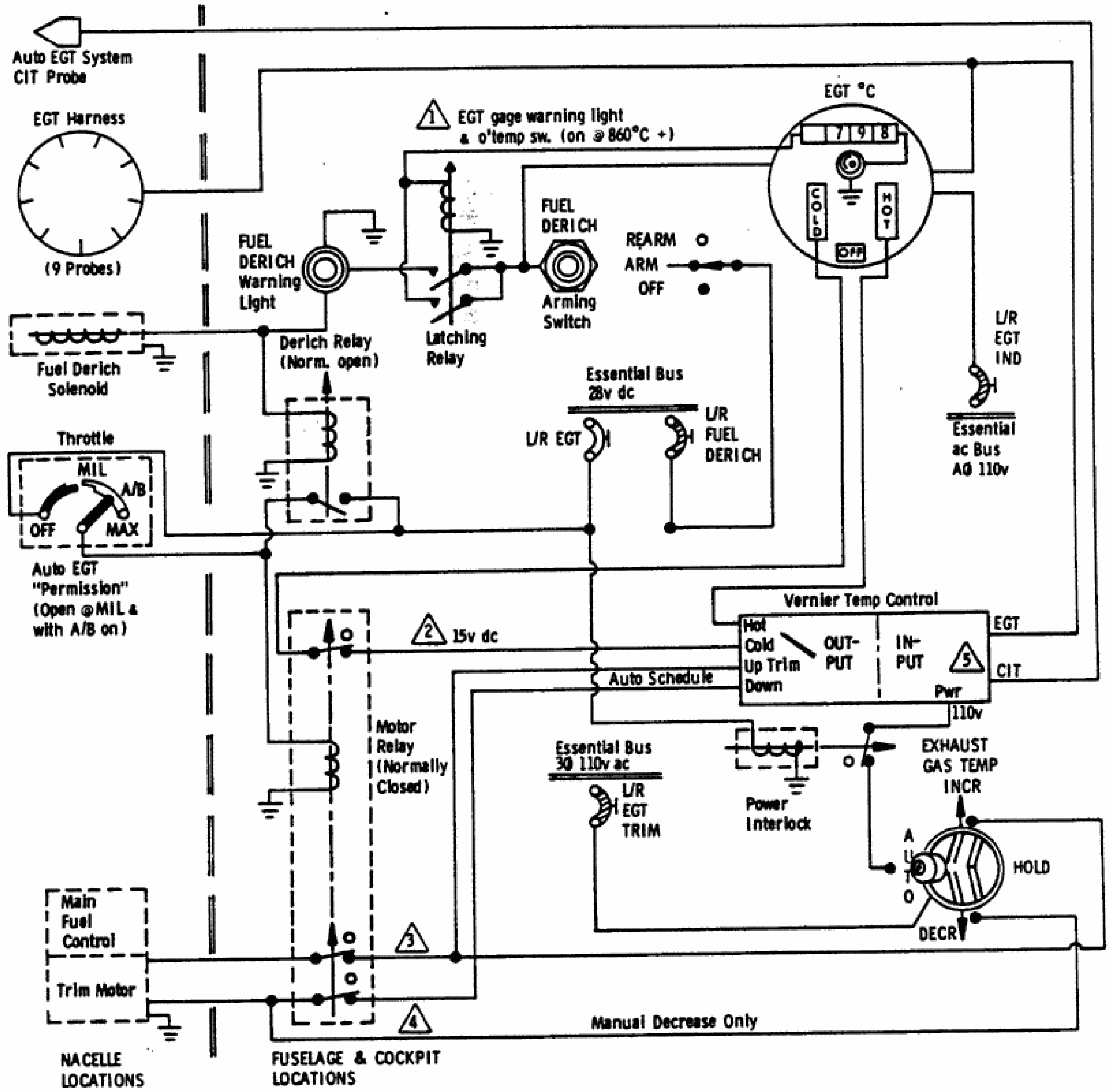
When an EGT trim switch is in AUTO, the respective throttle is positioned at or above Military, and that engine is not deriched, the permission circuit is opened (off) to allow automatic EGT trim. The electric trim motor for the respective engine regulates its main fuel control and automatically provides EGT within a 10°C nominal deadband. See Figure 1-9.

If the EGT for an engine is either above or below the deadband, the system trims EGT toward its deadband. The rate of trimming depends on temperature deviation from the deadband. If EGT is more than 10°C above the deadband, the system downtrims at its maximum rate (approximately 8°C per second), and the HOT flag is displayed on the EGT gage. When the EGT is more than 10°C below the deadband, the system uptrims at 1°C per second and the COLD flag is displayed. When EGT is 10°C or less from its deadband, the system trims at only 1/3°C per second and the condition flags retract.

CAUTION

If EGT tends to hunt or has an abnormal tendency to uptrim or downtrim while AUTO is selected, the corresponding engine should be operated in manual trim and the condition reported following flight. An EGT overtemperature may occur if continued operation in AUTO is attempted.

EGT INDICATION AND CONTROL SYSTEM



NOTE

1. Switch closes and light illuminates as 860°C reached. Switch stays closed and light remains on above 860°C. When EGT then decreases below 860°C, jewel light is extinguished but "latching" relay maintains power to derich solenoid until derich arming switch is cycled.
2. COLD flag does not operate when below Military power or when deriched. HOT and COLD flag operating power (15v dc) is produced within the vernier temperature control.
3. Direction of trim is controlled by ac power phase-sequencing.
4. Auto trim and manual uptrim are inoperative when below Military power or when deriched. Manual downtrim is always available if three-phase power is supplied.
5. Auto EGT vernier temperature control is powered only when AUTO is selected.

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Figure 1-8

NOMINAL EGT SCHEDULE

ENGINE AUTOMATIC TRIM SYSTEM

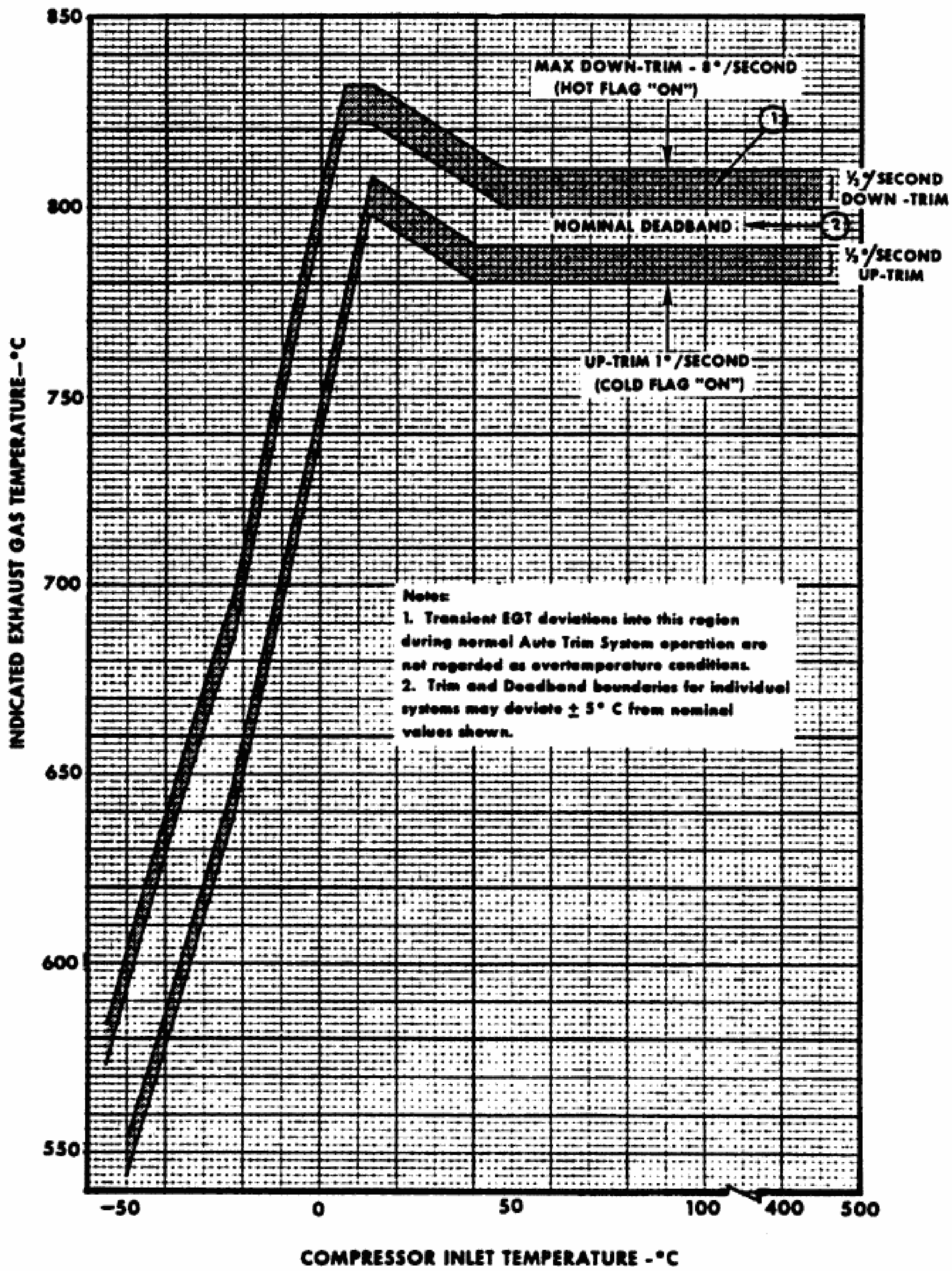


Figure 1-9

NOTE

- o The EGT condition flags do not operate when manual EGT trim is used.
- o With AUTO EGT selected, the COLD condition flag will not operate when the permission circuit is on (throttle below Military or deriched).
- o With AUTO EGT selected, the HOT condition flag will operate regardless of the condition of the permission circuit.

Auto EGT is normally used during the engine trim check; however, if the system is obviously uptrimmed above normal limits, reduce power and manually downtrim prior to resetting military power.

The hot flag overtemperature warning circuit is continually energized when in AUTO EGT. A hot flag may appear at throttle positions below the permission switch and should be corrected by manually downtrimming or retarding the throttle.

Repeated rapid throttle movements forward and back through the permission switch operating range can cause military EGT to increase sufficiently to produce derichment. This EGT ratcheting is caused by a lag in thermocouple response and can be avoided by selecting manual trim when repeated rapid throttle movements to and below Military are expected.

Selecting the spring-loaded HOLD (center) position deactivates automatic trimming and maintains the existing EGT trimmer setting.

NOTE

When AUTO EGT is selected, a brief spurious flag indication may occur in response to the EGT and CIT conditions that existed when AUTO EGT trim was last used. Valid flag indications and normal AUTO EGT trim operation should occur within five seconds.

INLET PARAMETER INDICATIONS

Compressor Inlet Pressure (CIP) Gage

The CIP gage, on the left of the pilot's instrument panel, has an L and R needle which indicate inlet static pressure at the face of each compressor, and a striped third needle that indicates expected normal CIP. The position of the striped pointer is governed by DAFICS using pressures sensed by the pitot-static system. The indication varies with Mach and KEAS so that the striped needle shows "normal" CIP for the flight condition. A substantial difference between the striped needle and actual CIP indicates improper inlet operation. Higher actual pressure at normal speeds and altitudes may produce unstarts. Lower pressure indicates poor pressure recovery due to improper spike and/or bypass door settings except at abnormal angles of attack or yaw conditions, where inlet operation is automatically biased to less than normal recovery. The spread between inlet CIP indications (L and R needles) should not exceed 1 psi. The needle can be used as a guide for bypass door settings during manual operation of one or both inlets; however, it is preferable to keep the L and R needles slightly below the "normal" indication to maintain a margin below unstart pressures. Automatic or manual inlet operation at pressures below the "normal" indication reduces aircraft range.

NOMINAL CIP RANGE

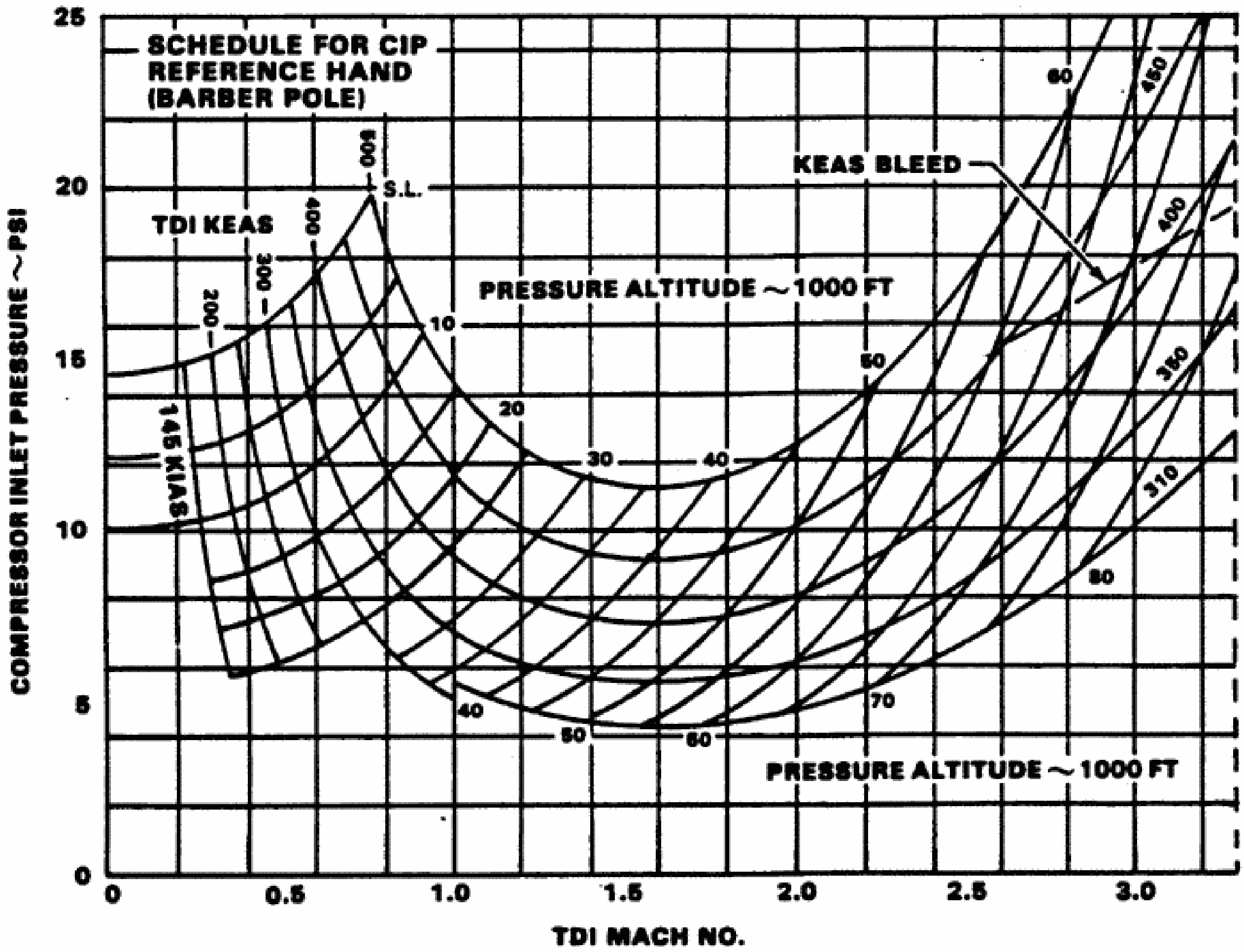


Figure 1-10

Power is supplied by the essential ac bus through the CIP circuit breaker on the pilot's right console.

__Compressor Inlet Temperature (CIT) Gage__

A dual indicating CIT gage is mounted on the left side of the pilot's instrument panel. L (left) and R (right) needles indicate the total (ram) air temperature forward of the first compressor stage in the corresponding engine inlet. Major calibrations are marked from 0°C to 500°C. The dial has 50° incremental markings below 300°C. Above 300°C, the gage has increased sensitivity and incremental marks are supplied for each 10°C. Slight differences between left and right CIT indications can be expected; however, differences of more than 15°C while at supersonic cruise speeds should be reported as a discrepancy. Power is furnished by the essential ac bus through the L and R CIT circuit breakers on the pilot's right console.

EXHAUST NOZZLE AND EJECTOR SYSTEM

The variable-area, iris-type, engine afterburner nozzle is comprised of segments operated by a cam and roller mechanism and four hydraulic actuators. The actuators are operated by fuel hydraulic system pressure. The engine afterburner nozzle is enclosed by a fixed-contour, convergent-divergent ejector nozzle to which free floating trailing edge flaps are attached. In flight, the inlet shock trap bleed and aft bypass doors (when open) supply secondary airflow between the engine and nacelle for cooling. During ground operation, suck-in doors in the aft nacelle area provide cooling air. Intake doors around the nacelle, just forward of the ejector, normally supply tertiary air to the ejector nozzle when subsonic. The tertiary doors and trailing edge flaps are free to open and close with varying internal nozzle pressure (a function of Mach and engine thrust).

Nozzle Actuation

The exhaust nozzle control and actuation system is composed of four actuators to position the exhaust nozzle, and an exhaust nozzle control which modulates pressure at the actuators in response to engine speed signals from the main fuel control. The exhaust nozzle control is mounted on the aft portion of the engine.

Exhaust Nozzle Position (ENP) Indicators

Two ENP indicators, one for each engine, are located on the right side of the pilot's instrument panel. They are marked from 0 to 10 as an index of nozzle position from closed to open. Each indicator responds to an electrical transducer located near its exhaust nozzle. The transducer is cooled by fuel and is operated by the afterburner nozzle feedback link. Power for the indicators is supplied from the essential ac bus through the L and R ENP circuit breakers on the pilot's right console.

ENGINE EXTERNAL AND INTERNAL BLEEDS

The internal bypass bleed control and actuation system consists of four two-position actuators to move the bleed valves and a pilot valve, within the main fuel control, to establish the pressure to the actuators. The pilot valve controls the bleed valve position in response to a mechanical signal from the main fuel control. Bleed valve position is scheduled within the main fuel control as a function of engine speed and CIT. The external bleed control and actuation system is similar to the internal bleed system, except that three actuators are used.

ENGINE INLET GUIDE VANES (IGV)

The engine compressor inlet case houses a two-position inlet guide vane (IGV) system. The guide vanes can be either in the cambered position, which is normal for cruise, or in the axial position which is normal for takeoff and acceleration to intermediate supersonic speed. The IGV axial position (parallel to the airflow) results in more thrust. Actuation to the cambered position occurs at a CIT of 85° to 115°C (about Mach 1.9) during acceleration. The cambered position is mandatory when operating continuously at CIT above 125°C (approximately Mach 2.0). Shifting is normally controlled by the main engine fuel control; however, the shift to the axial position from cambered is prevented if the IGV Lockout Switch is positioned to LOCKOUT. Refer to Figure 1-11 for IGV shift scheduling information.

IGV Lockout Switches

The shift schedules for the internal bypass bleeds and the inlet guide vanes are identical. There is a positive locking feature which prevents unscheduled IGV shift to axial after the cambered position has been reached. In addition, two-position IGV lockout switches (one for each engine) on the pilot's right console, can lock out IGV shift from cambered to axial. With a lift-loc switch in LOCKOUT, the respective IGV is maintained in the cambered position regardless of internal bleed position. The LOCKOUT position is ineffective until the guide vanes are in the cambered position. The switches cannot cause or prevent IGV shift from axial to cambered. With IGV NORM selected, IGV shift occurs with internal bleed shift. Power for the IGV lockout solenoid circuits is supplied from the essential dc bus through the L and R IGV circuit breakers on the pilot's left console.

Inlet Guide Vane Position Lights

Two rotate-to-dim, amber inlet guide vane (IGV) position lights are installed on the right side of the pilot's instrument panel. An indicator is provided for each engine, identified by L or R adjacent to the appropriate light. An IGV light illuminates when the inlet guide vanes of the respective engine shift to the axial position as scheduled by the main fuel control. The light extinguishes when the IGV reaches the cambered position. Inlet guide vane position is sensed by a switch on the engine compressor case which operates when the

COMPRESSOR BLEED AND IGV SHIFT SCHEDULE
IGV/Bypass Bleed Functions

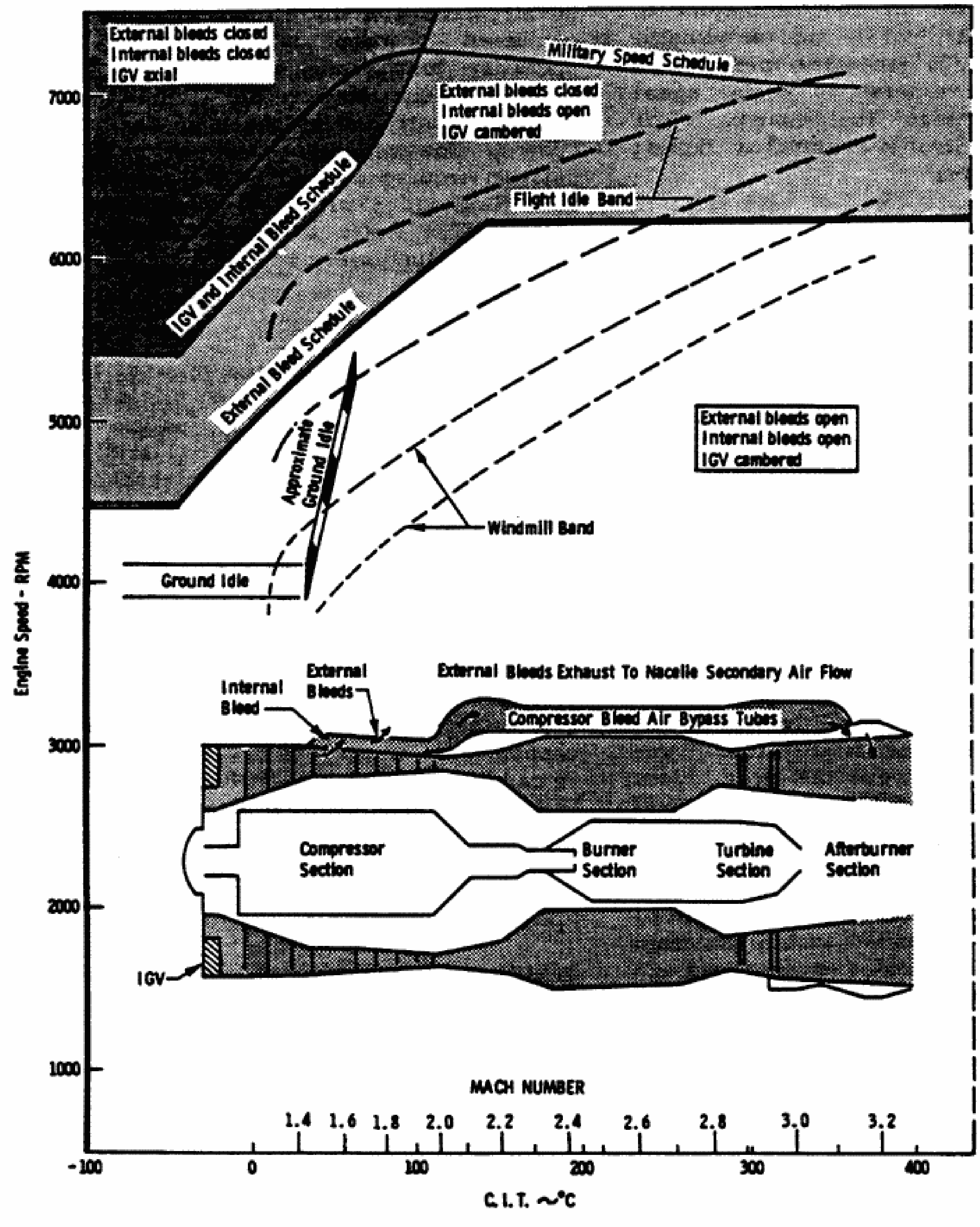


Figure 1-11

guide vanes reach or leave the cambered position. Power for the lights is furnished by the essential dc bus through the WARN 2 light circuit breaker on the pilot's left console.

a. The IGV lights must be off (IGV cambered) during start and at idle.

b. The IGV lights must be on (IGV axial) for takeoff.

c. The IGV lights must be off (IGV cambered) above 150°C (approximately Mach 2.2).

OIL SUPPLY SYSTEM

The engine and speed-reduction gearbox are lubricated by an engine-contained, "hot tank", closed system. The oil is cooled by circulation through an engine fuel-oil cooler. The oil tank is mounted on the lower right side of the engine compressor case. Tank volume is 6.7 US gallons. The oil tank is serviced to 5.15 US gallons. The oil is gravity-fed to the main oil pump which forces the oil through a filter and the fuel-oil cooler. The filter is equipped with a bypass in case of clogging. The oil is distributed to the engine bearings and gears from the fuel-oil cooler. Oil screens are installed at the lubricating jets for additional protection. Scavenge pumps return the oil to the tank where it is de-aerated. A pressure regulating valve keeps flow and pressure relatively constant during all flight conditions. Oil quantity warning lights are provided.

The approved oil is MIL-L-87100 (PWA 524). At low ambient temperatures, oil may be diluted with trichlorethylene, Federal Specification O-T-634, Type 1.

Main Fuel-Oil Cooler

Engine oil temperature is controlled by engine fuel which passes through the main fuel-oil heat exchanger. A bypass valve in the cooler passes additional fuel around the cooler when engine requirements are greater than the flow capacity of the cooler (approximately 12,000 pounds per hour).

Engine Oil Pressure Gages

An oil pressure gage for each engine is provided on the right side of the pilot's instrument panel. Each gage indicates output pressure of the respective engine oil pump in pounds per square inch, using electrical signals from a fuel-cooled transmitter. The dials are calibrated from 0 to 100 psi in 5-psi increments. Power for the gages is furnished by the essential ac bus 26 volt instrument transformer through the L and R OIL PRESS circuit breakers on the pilot's annunciator panel.

Engine Oil Temperature Lights

The L and R OIL TEMP annunciator lights are not functional. The OIL TEMP lights only illuminate when the IND & LT TEST push-button switch is depressed.

Low Oil Quantity Lights

L and R OIL QTY warning lights, on the pilot's annunciator panel, illuminate when oil quantity in the respective engine oil tank is less than 2-1/4 gallons.

ENGINE FUEL HYDRAULIC SYSTEM

Each engine is provided with a fuel hydraulic system for actuation of the afterburner exhaust nozzle, IGVs, and the start and bypass bleed valves. Fuel hydraulic pressure is also required to dump the chemical ignition system. An engine-driven pump maintains system pressures up to 1800 psi with a maximum flow of 50 gpm (approximately 19,700 pph) for transient requirements. Engine fuel is supplied to the pump from the main fuel pump boost stage. Some high-pressure fuel is diverted from the hydraulic system to cool the nonafterburning recirculation line and the windmill bypass valve discharge line. This fuel is returned to the aircraft fuel system. Low-pressure fuel from the hydraulic pump case is returned to the main fuel pump boost stage. Hydraulic system loop cooling is provided by the compensating fuel supplied by the main fuel pump.

ACCESSORY DRIVE SYSTEM (ADS)

An ADS is mounted forward of the engine in each nacelle. Its three major components include a constant speed drive, an accessory gearbox, and an all-attitude oil reservoir. Input power from the engine is transmitted to the ADS through a reduction gearbox on the engine and a flexible drive shaft. At the ADS, a constant speed drive unit converts the variable shaft speed to a constant rotational speed to power the ac generator. Two hydraulic pumps and a fuel circulating pump are also mounted on the ADS gearbox. The two hydraulic pumps supply power for the (A and L) or (B and R) hydraulic systems. The fuel circulating pump supplies fuel to the aircraft heat sink system. The speeds of these pumps vary directly with engine rpm.

The ADS is lubricated by an independent dry sump system with its own pump, using oil from an all-attitude reservoir. The reservoir is pressurized with nitrogen gas from the aircraft LN_2 system and supplies oil to the accessory gearbox, the constant speed drive, and the ac generator regardless of flight attitude. (Loss of the LN_2 supply to the ADS does not affect ADS operation.) The oil is cooled by circulation through a fuel-oil heat exchanger which is part of the heat sink system. Reservoir capacity is approximately 8 quarts.

EXTERNAL STARTER SYSTEM

An external starting unit is required for ground starts. This may be a compressed air supply, a self-contained gas engine cart, or a multiple air-turbine cart. The output drive gear of either cart connects to a starter gear on the main gearbox at the bottom of the engine. There are no aircraft controls for this system. It is turned on and off by the ground crew in response to instructions from the pilot.

CHEMICAL IGNITION (TEB) SYSTEM

Triethylborane (TEB) is used for starting ignition of main burner and afterburner fuel. Catalytic igniters attached to the afterburner flame holders tend to maintain afterburner operation after initial ignition.

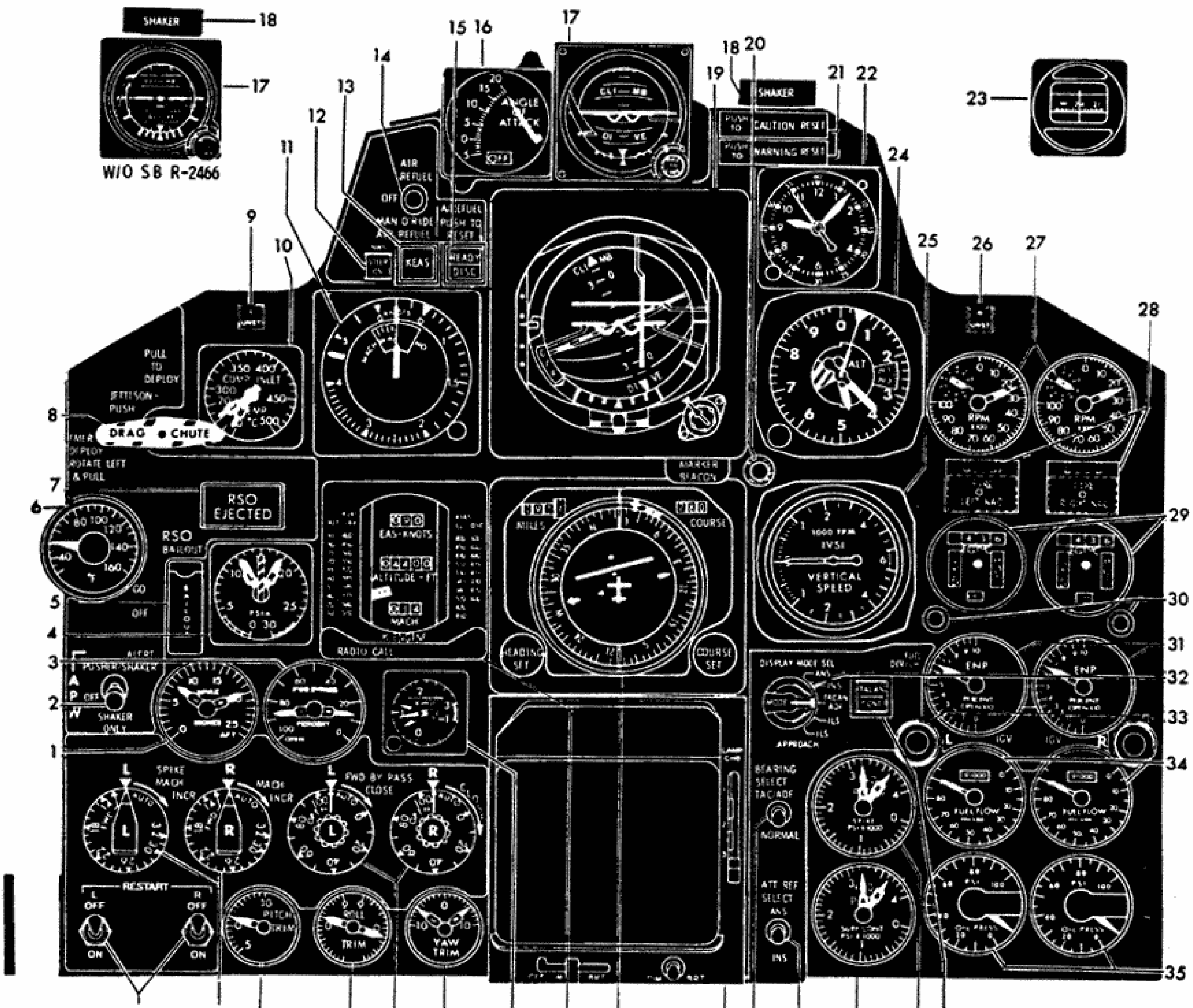
A 600 cc (1-1/4 pint) TEB storage tank is installed on each engine. The tanks are pressurized with nitrogen gas prior to flight to provide inerting and operating pressure. Special handling procedures are required for TEB as it will burn spontaneously with exposure to air above -5°C. The TEB tank is cooled by main burner fuel flow. A rupture disk is provided for each tank which will allow vaporized TEB and nitrogen gas to be discharged through the afterburner section if tank pressure exceeds a safe level. No indication of TEB tank discharge is provided to the flight crew.

At least 16 metered TEB injections can be made with one full tank of TEB. The system is controlled by engine fuel pressure signals while the engine is rotating. Throttle advancement from OFF to IDLE provides main burner ignition, and from Military into the AFTERBURNER range provides afterburner ignition. Main burner ignition occurs almost immediately during an airstart with the engine windmilling. The time required to obtain afterburner ignition is a function of the afterburner fuel manifold fill time, (up to three seconds at sea level and seven seconds at altitude).

Igniter Purge Switch

An IGNITER PURGE toggle switch is located on the pilot's right instrument side panel. When the switch is held in the up position, a solenoid-operated valve supplies fuel-hydraulic system pressure to the chemical ignition system dump valve if the engine is rotating. This allows the TEB to be dumped into the afterburner section. While dumping, engine speed should be above 5000 rpm to avoid afterburner liner damage. The purge switch must be actuated for at least 40 seconds to dump a full load of TEB. At the end of the dump period, the switch should be released and re-cycled to clean out the lines. Electrical power for purging is furnished from the essential dc bus through the IGN PURGE circuit breaker on the pilot's left console.

CENTER INSTRUMENT PANEL - Forward Cockpit

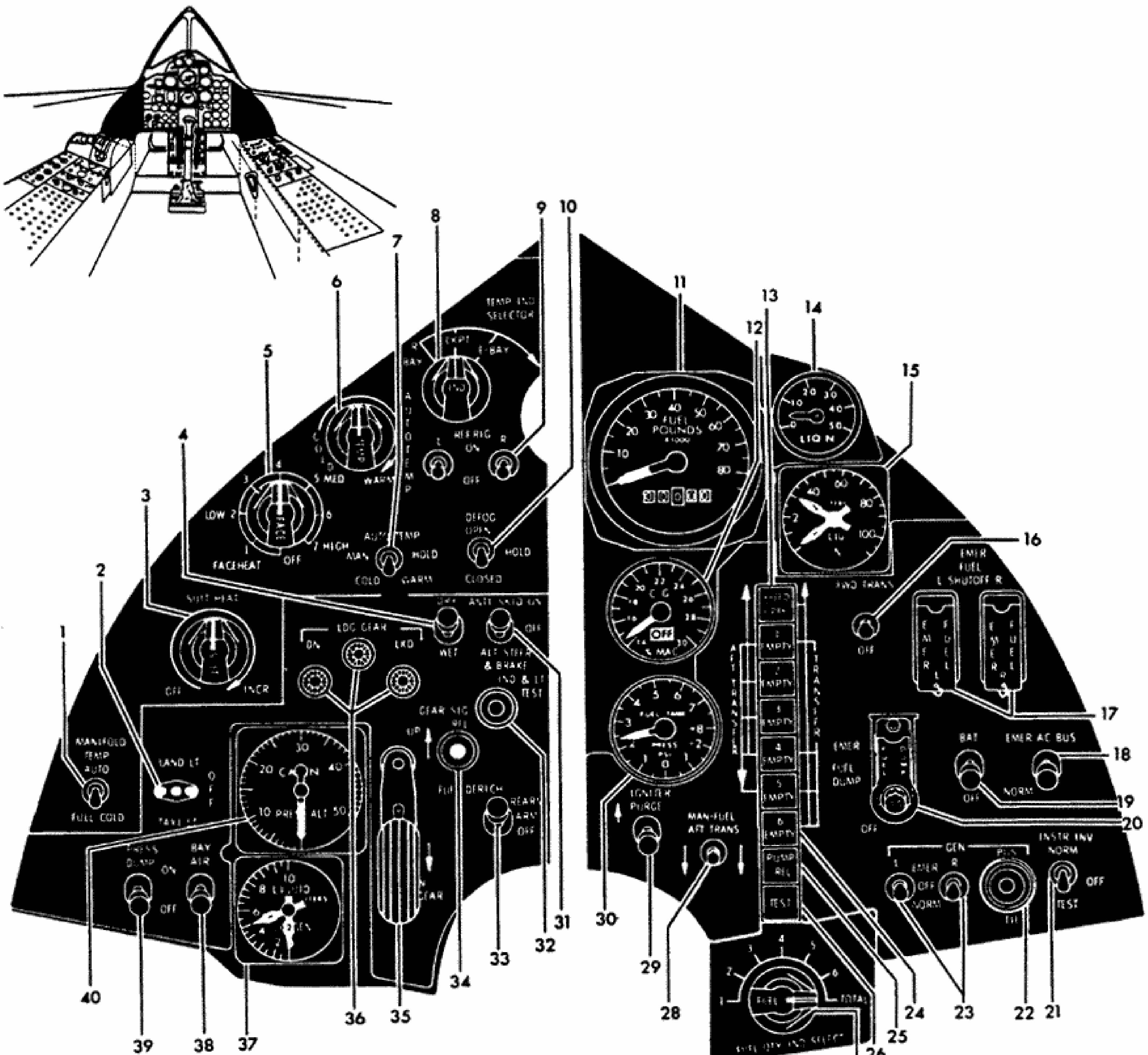


1 Spike Position Indicator
2 Pusher/Shaker Switch
3 Forward Bypass Position Indicator
4 Compressor Inlet Pressure Gage
5 RSO Bailout Switch
6 Temperature Indicator
7 RSO Ejected Indicator Light
8 Drag Chute Handle
9 Left Inlet Unstart Light
10 Compressor Inlet Temperature Gage
11 Airspeed - Mach Meter
12 Nosewheel Steering Engaged Light
13 KEAS Warning Light
14 Air Refuel Switch
15 Air Refuel Ready - Disc Pushbutton and Light
16 Angle of Attack Indicator
17 Standby Attitude Indicator
18 Shaker Indicator Light
19 Attitude Director Indicator
20 MarkerBeacon Light
21 Master Caution and Warning Lights
22 Elapsed Time Clock
23 Standby Compass (In Canopy)
24 Altimeter
25 Inertial - lead Vertical Speed Ind.
26 Right Inlet Unstart Light
27 Tachometers
28 Fire Warning Lights
29 Exhaust Gas Temperature Inds.
30 Fuel Derich Lights
31 Exhaust Nozzle Position Indicators
32 Display Mode Select Switch
33 IGV Lights
34 Fuel Flow Indicators
35 Oil Pressure Indicators
36 Tacan Control Transfer Switch
37 L and R Hydraulic Systems Pressure Gage
38 A and B Hydraulic Systems Pressure Gage
39 Attitude Reference Select Switch
40 Bearing Select Switch
41 Nav Map Display
42 Horizontal Situation Indicator
43 Triple Display Indicator
44 Accelerometer
45 Yaw Trim Indicator
46 Forward Bypass Switches
47 Roll Trim Indicator
48 Pitch Trim Indicator
49 Spike Switches
50 Inlet Restart Switches

F203-77(2)(p)

Figure 1-12

INSTRUMENT SIDE PANELS - Forward Cockpit

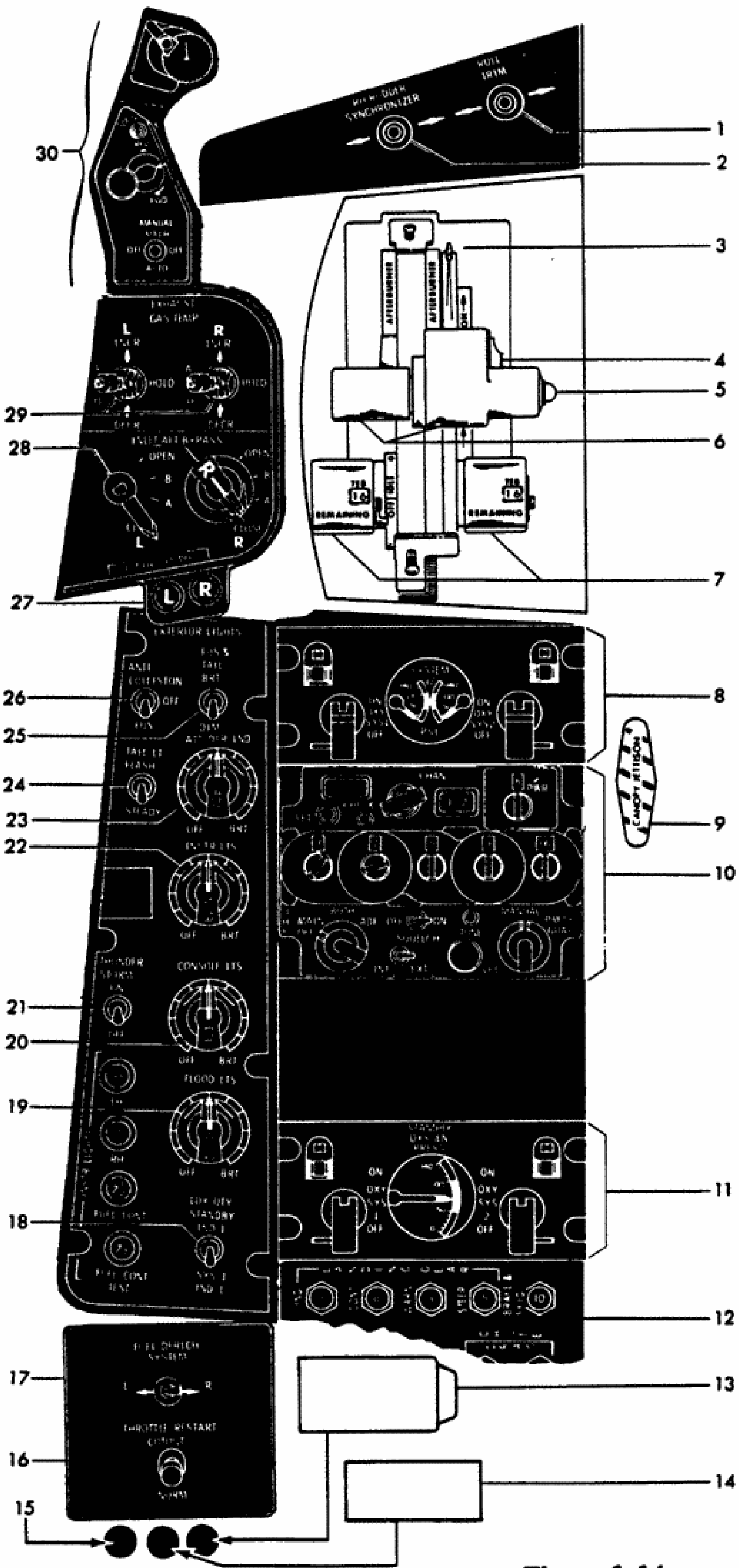


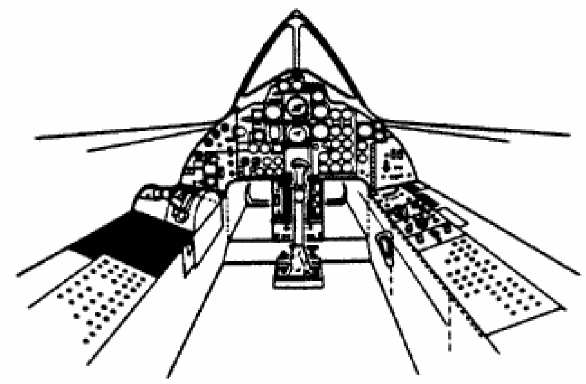
1 Manifold Temperature Switch
2 Landing and Taxi Light Switch
3 Suit Heat Rheostat
4 Wet-Dry Switch
5 Face Heat Rheostat
6 Cockpit Temperature Control
7 Cockpit Temperature Control and O-Ride
8 Temperature Indicator Selector Switch
9 L and R Refrigeration Switches
10 Defog Switch
11 Fuel Quantity Indicator
12 Center Of Gravity Indicator
13 Fuel Crossfeed Switch
14 System 3 Nitrogen Quantity Indicator
15 Liquid Nitrogen Quantity Indicator
16 Fuel Forward Transfer Switch
17 Emergency Fuel Shutoff Switches
18 Emergency AC Bus Switch
19 Battery Switch
20 Fuel Dump Switch
21 Instrument Inverter Switch
22 Generator Bus Tie Switch
23 L and R Generator Switches
24 Fuel Boost Pump Switches
25 Pump Release Switch
26 Fuel Boost Pump Light Test Switch
27 Fuel Quantity Indicator Selector Switch
28 Manual Fuel Aft Transfer Switch
29 Igniter Purge Switch
30 Fuel Tank Pressure Indicator
31 Brake Switch
32 Indicators and Light Test Switch
33 Fuel Derichment Switch
34 Gear Signal Release Switch
35 Landing Gear Lever
36 Landing Gear Indicator Lights
37 Liquid Oxygen Quantity Indicator
38 Bay Air Switch
39 Cockpit Pressure Dump Switch
40 Cabin Altitude Indicator

F203-314(o)

Figure 1-13

LEFT CONSOLE - Forward Cockpit



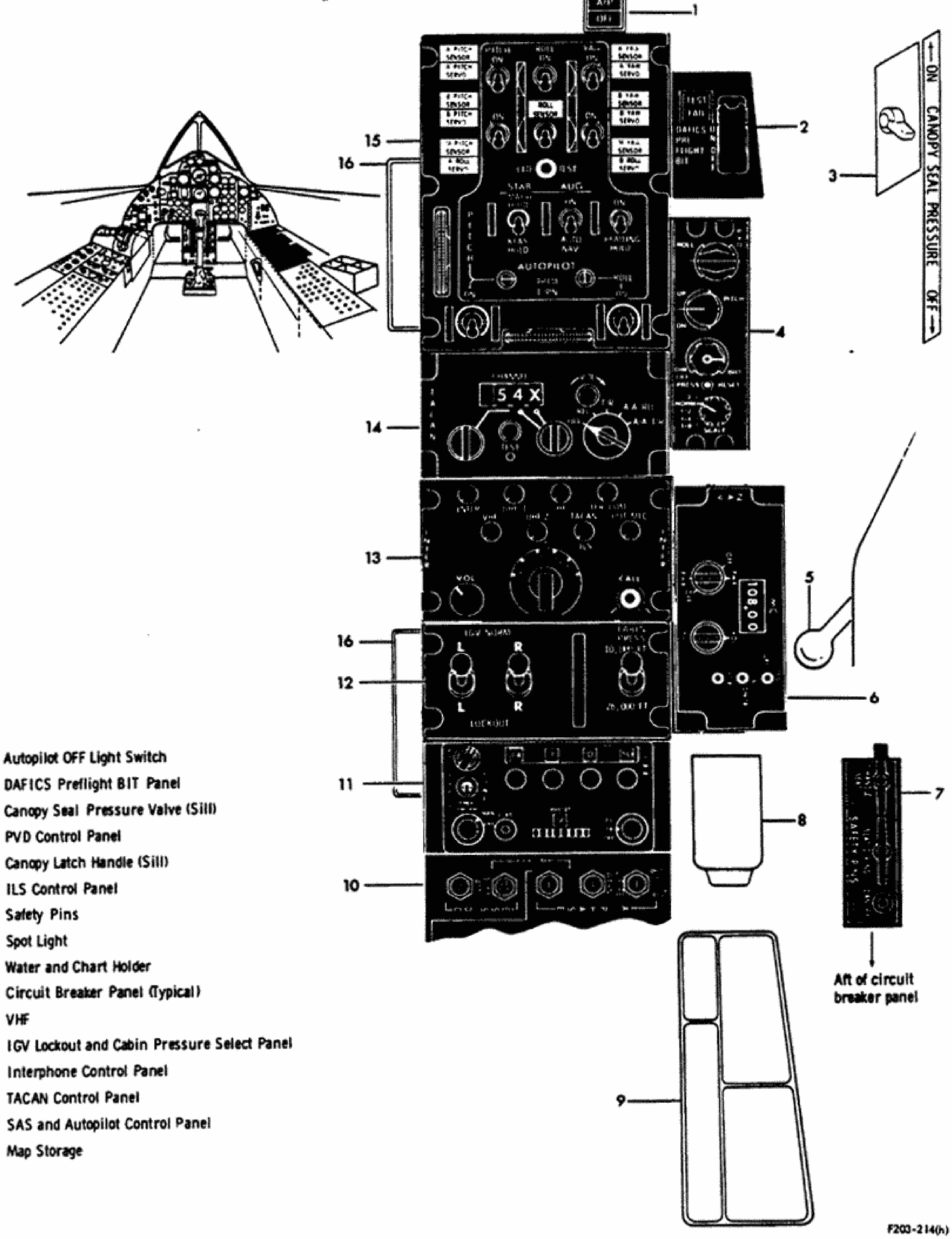


1 Roll Trim Switch
2 Right Hand Rudder Synchronizer Switch
3 Throttle Friction Lever
4 Throttle Inlet Control Restart Switch
5 Microphone Switch
6 Throttles
7 TEB Counters
8 Oxygen Systems Control Panel
9 Canopy Jettison Handle
10 UHF-1 Radio Control Panel
11 Standby Oxygen System Control Panel
12 Circuit Breaker Panel
13 Spotlight
14 Relief Pack Box
15 Storage
16 Throttle Restart Cutout Switch
17 Fuel Derich Test Switch
18 Liquid Oxygen System Quantity Switch
19 Floodlights Rheostat
20 Console Lights Rheostat
21 Thunderstorm Lights Switch
22 Instrument Lights Rheostat
23 Attitude Director Indicator Light Rheostat
24 Tail Lights Switch
25 Fuselage-Tail Lights Intensity Switch
26 Anti-Collision-Fuselage Lights Switch
27 Inlet Aft Bypass Position Lights
28 Inlet Aft Bypass Position Switches
29 Exhaust Gas Temperature Trim Switches
30 Map Projector Control Panel

F203-246(o)

Figure 1-14

RIGHT CONSOLE - Forward Cockpit



1 Autopilot OFF Light Switch
2 DAFICS Preflight BIT Panel
3 Canopy Seal Pressure Valve (Sill)
4 PVD Control Panel
5 Canopy Latch Handle (Sill)
6 ILS Control Panel
7 Safety Pins
8 Spot Light
9 Water and Chart Holder
10 Circuit Breaker Panel (Typical)
11 VHF
12 IGV Lockout and Cabin Pressure Select Panel
13 Interphone Control Panel
14 TACAN Control Panel
15 SAS and Autopilot Control Panel
16 Map Storage

Figure 1-15

ANNUNCIATOR PANEL - Forward Cockpit

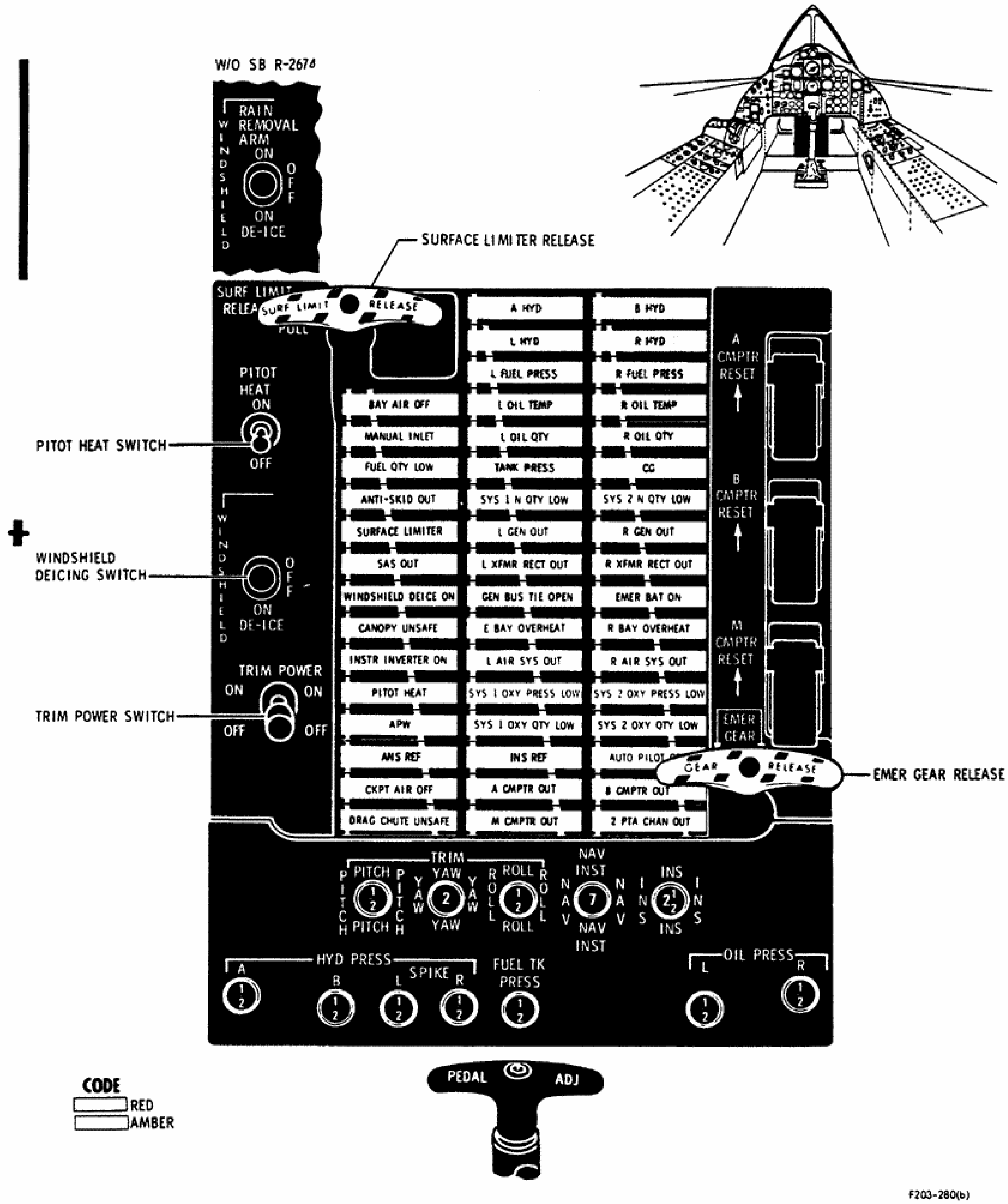
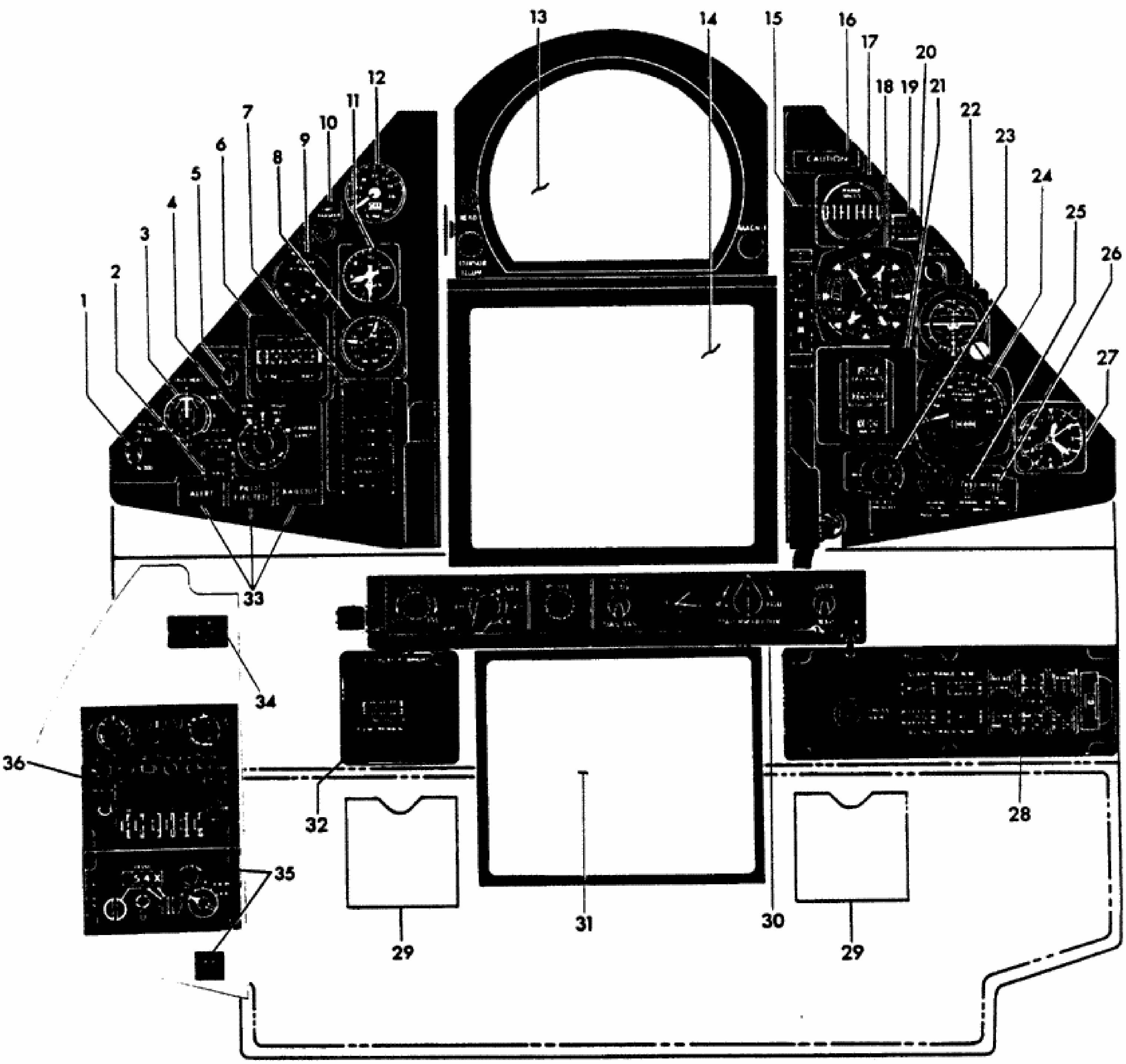


Figure 1-16

INSTRUMENT PANEL - Aft Cockpit



1 Cabin Pressure Switch
2 UHF Control Transfer Button
3 Face Heat Rheostat
4 Camera Exposure - Sun Angle Selector
5 Attitude Reference Select Switch
6 UHF Frequency Indicator
7 Annunciator Panel
8 V/H Indicator
9 Camera Point Angle Indicator
10 Forward Transfer Light (With S/B R-2691)
11 Liquid Oxygen Indicator
12 Center of Gravity Indicator
13 Viewsight
14 Radar Display
15 DEF Warning Light
16 RSO Master Caution Light
17 UHF Distance Indicator
18 Bearing Distance Heading Indicator
19 Pilot's Caution Light
20 IFF Caution Light
21 Triple Display Indicator
22 Attitude Indicator
23 Fuel Quantity Indicator Selector Switch
24 Fuel Quantity Indicator
25 BDHI Heading Select Switch
26 BDHI No. 1 Needle Select Switch
27 Elapsed Time Clock
28 RCD Control Panel
29 Map, Pencil Box
30 Viewsight Control Panel
31 Map / Data Projector
32 RCD Film Remaining Panel
33 Egress Lights
34 G Band Beacon Control Panel
35 TACAN Control Panel and Transfer Switch
36 IFF Control Panel

F203-281(b)

Figure 1-17

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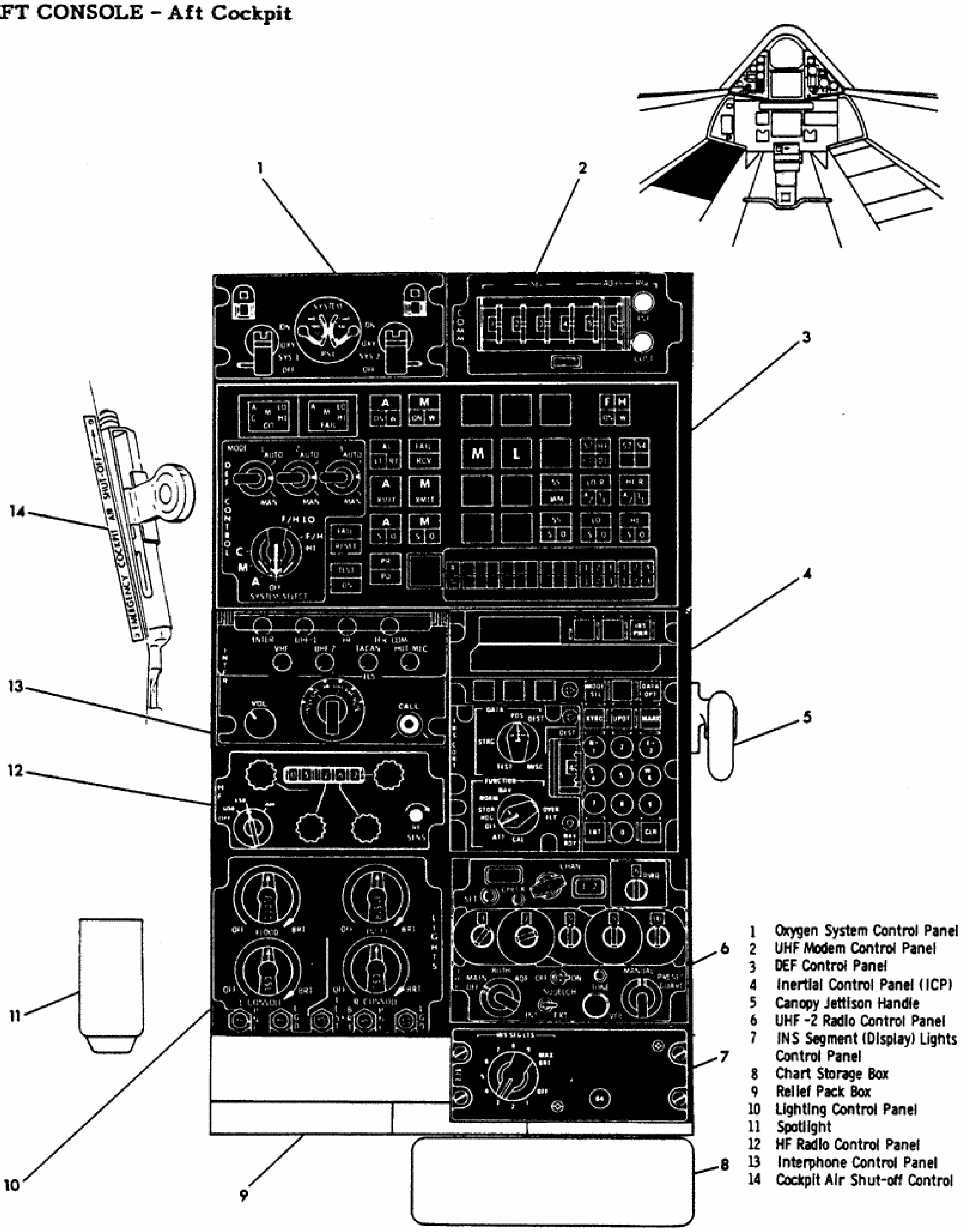
LEFT CONSOLE - Aft Cockpit

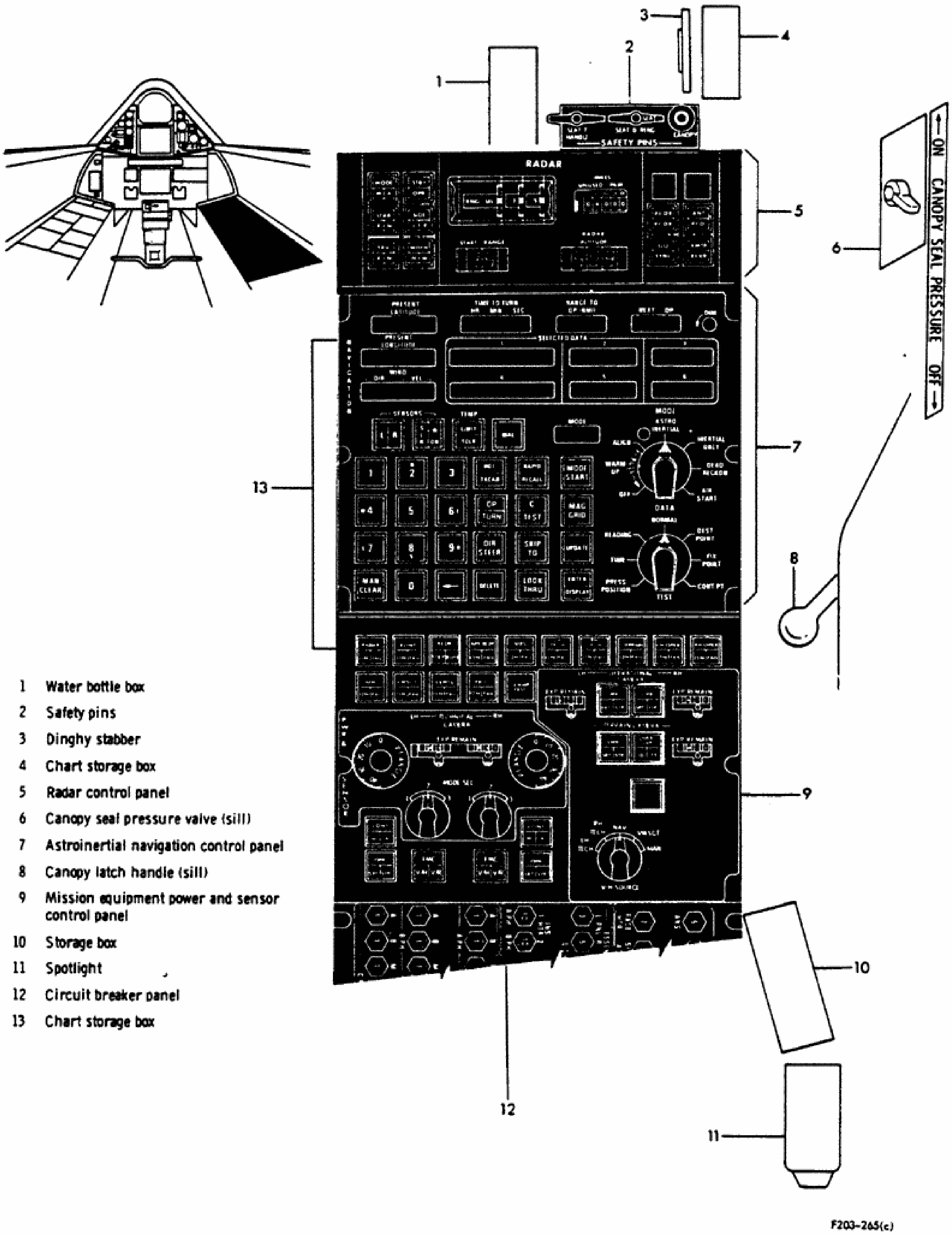


1 Oxygen System Control Panel
2 UHF Modem Control Panel
3 DEF Control Panel
4 Inertial Control Panel (ICP)
5 Canopy Jettison Handle
6 UHF -2 Radio Control Panel
7 INS Segment (Display) Lights Control Panel
8 Chart Storage Box
9 Relief Pack Box
10 Lighting Control Panel
11 Spotlight
12 HF Radio Control Panel
13 Interphone Control Panel
14 Cockpit Air Shut-off Control

F203-295(b)

Figure 1-18

RIGHT CONSOLE - Aft Cockpit



1 Water bottle box
2 Safety pins
3 Dinghy stabber
4 Chart storage box
5 Radar control panel
6 Canopy seal pressure valve (sill)
7 Astroinertial navigation control panel
8 Canopy latch handle (sill)
9 Mission equipment power and sensor control panel
10 Storage box
11 Spotlight
12 Circuit breaker panel
13 Chart storage box

Figure 1-19

AIR INLET SYSTEM

The air inlet system in each nacelle includes the cowl structure, a moving spike to provide optimum internal airflow characteristics, variable forward and aft bypass openings, a spike porous centerbody bleed, and an internal shock trap bleed for internal shock wave positioning and boundary layer flow control. Each inlet is canted inboard and downward to align with the local airflow pattern. (See Figures 1-20 and 1-21.)

The forward and aft bypass openings control airflow characteristics within the inlet and mass flow to the engine. Normally, the spike and forward bypass are operated automatically by DAFICS and the aft bypass is scheduled manually. Overriding manual controls are provided for the spike and forward bypass. The forward bypass can be operated manually when the spike is in automatic operation; however, when the spike is controlled manually, the forward bypass is also in manual control. Manual operation of the spike alone while the forward bypass control is in the AUTO position will cause the forward bypass to open 100%.

INLET SPIKES

The spikes are automatically locked in the forward postion for ground operation and for flight below 30,000 feet. They are unlocked above this altitude, but remain in their forward positions until Mach 1.6. During automatic operation above Mach 1.6, the spikes retract approximately 1-5/8 inch per 0.1 Mach number. Total spike motion is approximately 26 inches. This increases the captured stream tube area 112%, from 8.7 square feet to 18.5 square feet. The throat closes down to 4.16 square feet, 54% of the area at Mach 1.6.

During automatic operation, DAFICS schedules spike position as a function of Mach number with biasing for vertical acceleration, angle of attack, and angle of sideslip. See Figures 1-23, 1-25 and 1-27. DAFICS air data (sensed at the nose-mounted pitot mast and measured by the PTAs) are used to compute Mach, angle of attack, and angle of sideslip for automatic spike control.

Spike position can also be set manually by cockpit controls.

The spike centerbody is equipped with small slots which remove spike boundary layer air and prevent flow separation. The air is ducted overboard through the nacelle louvers after passing through the spike and its supporting struts.

INLET FORWARD BYPASS

The forward bypass openings in each inlet provide overboard exhausts for inlet air which is not required by the engine. The openings are a rotating band of ports located a short distance aft of the inlet throat. The air exits overboard through louvers located forward of the louvers for the spike centerbody bleed. Bypass position is automatically modulated by DAFICS to control inlet pressure aft of the normal shock (major internal shock wave) to position this shock properly near the throat.

In automatic operation, the forward bypass remains closed until above Mach 1.4; then it is released to modulate in accordance with DAFICS schedules. In automatic operation, the forward bypass returns to closed when below Mach 1.3. The inlet usually "starts" between Mach 1.6 and Mach 1.8; that is, the normal shock moves from in front of the inlet to a position near the shock trap bleed in the

AIR INLET SYSTEM - Spike Forward

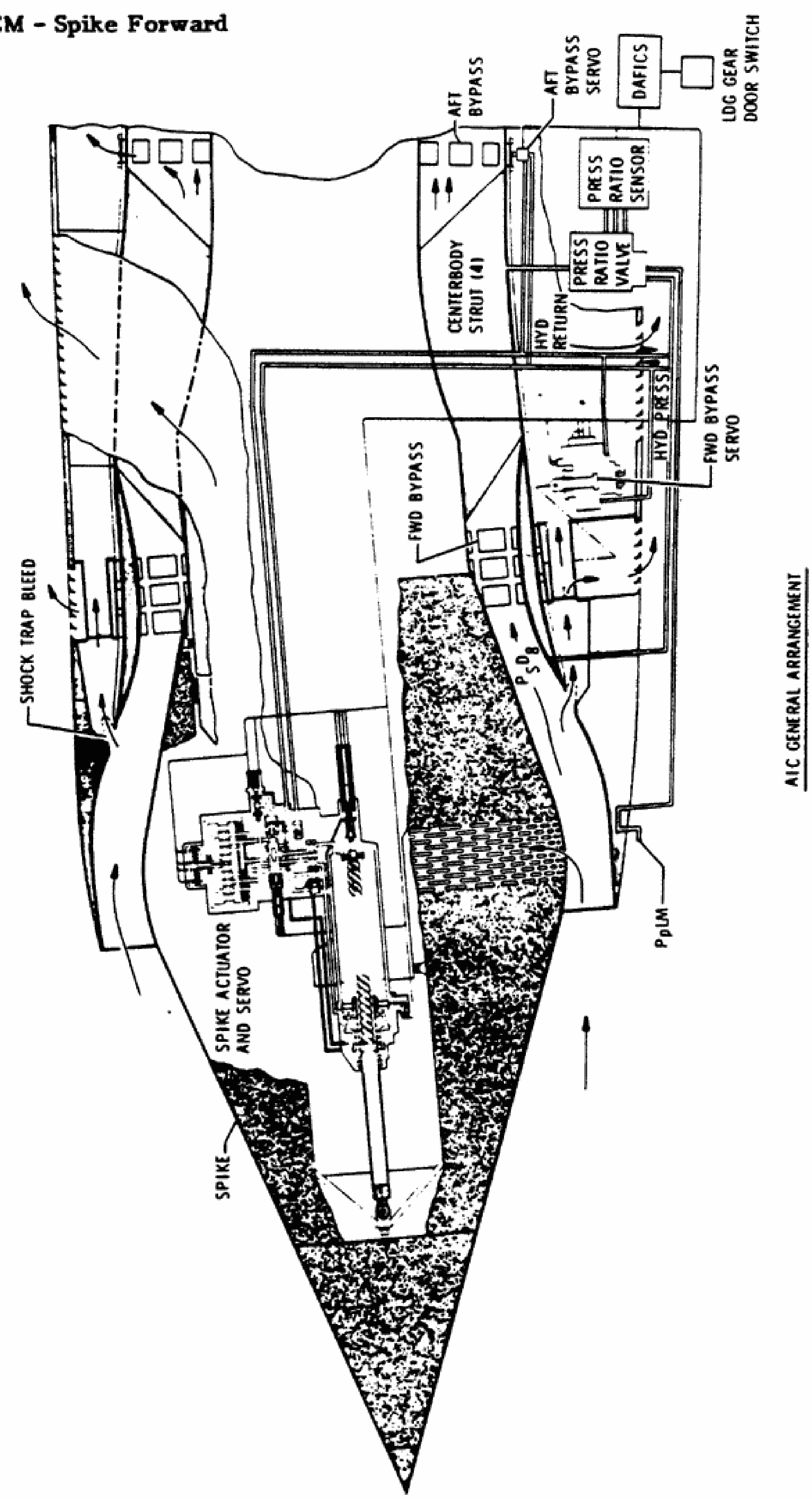


Figure 1-20

AIRFLOW PATTERNS

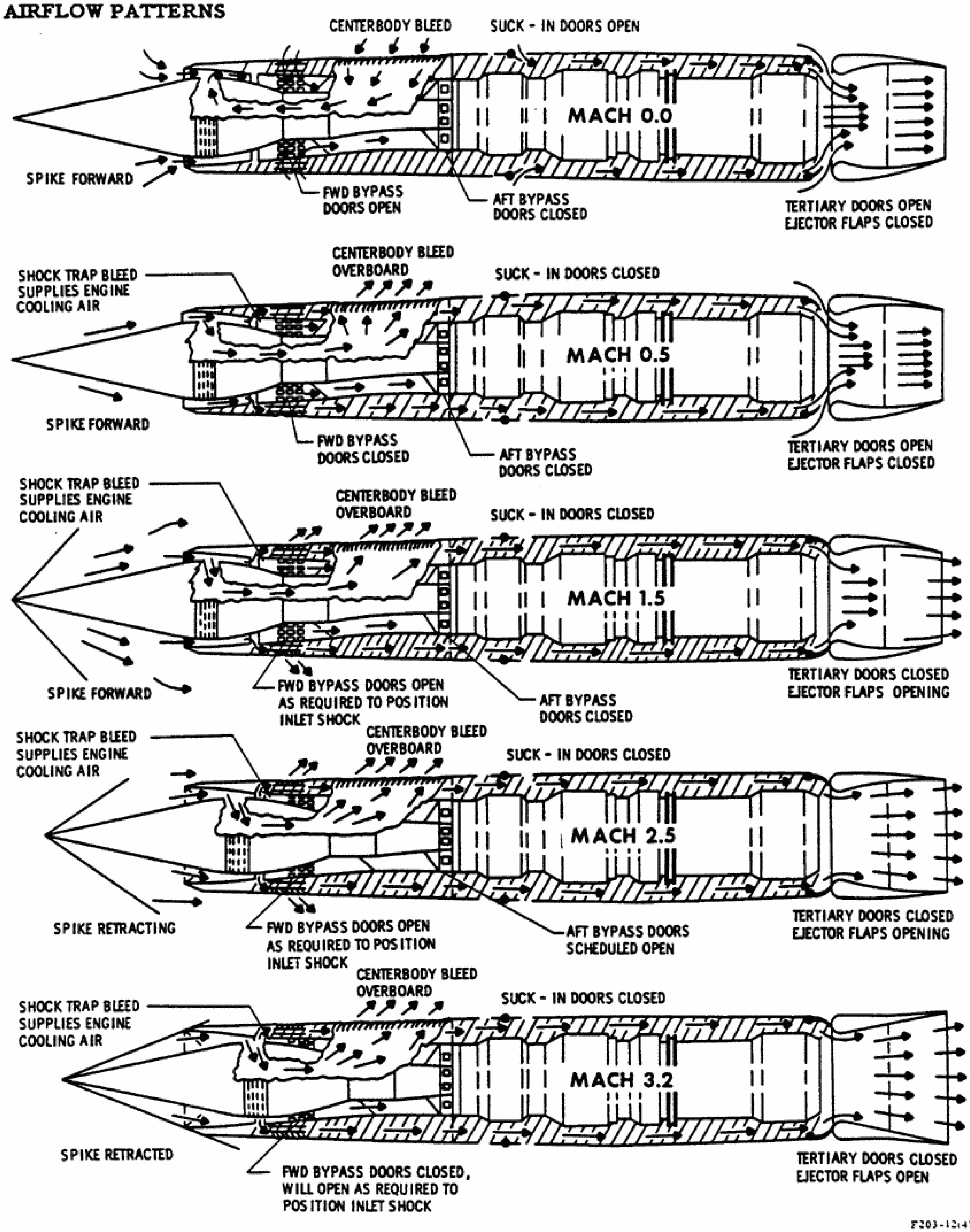


Figure 1-21

BARBER POLE C.I.P.

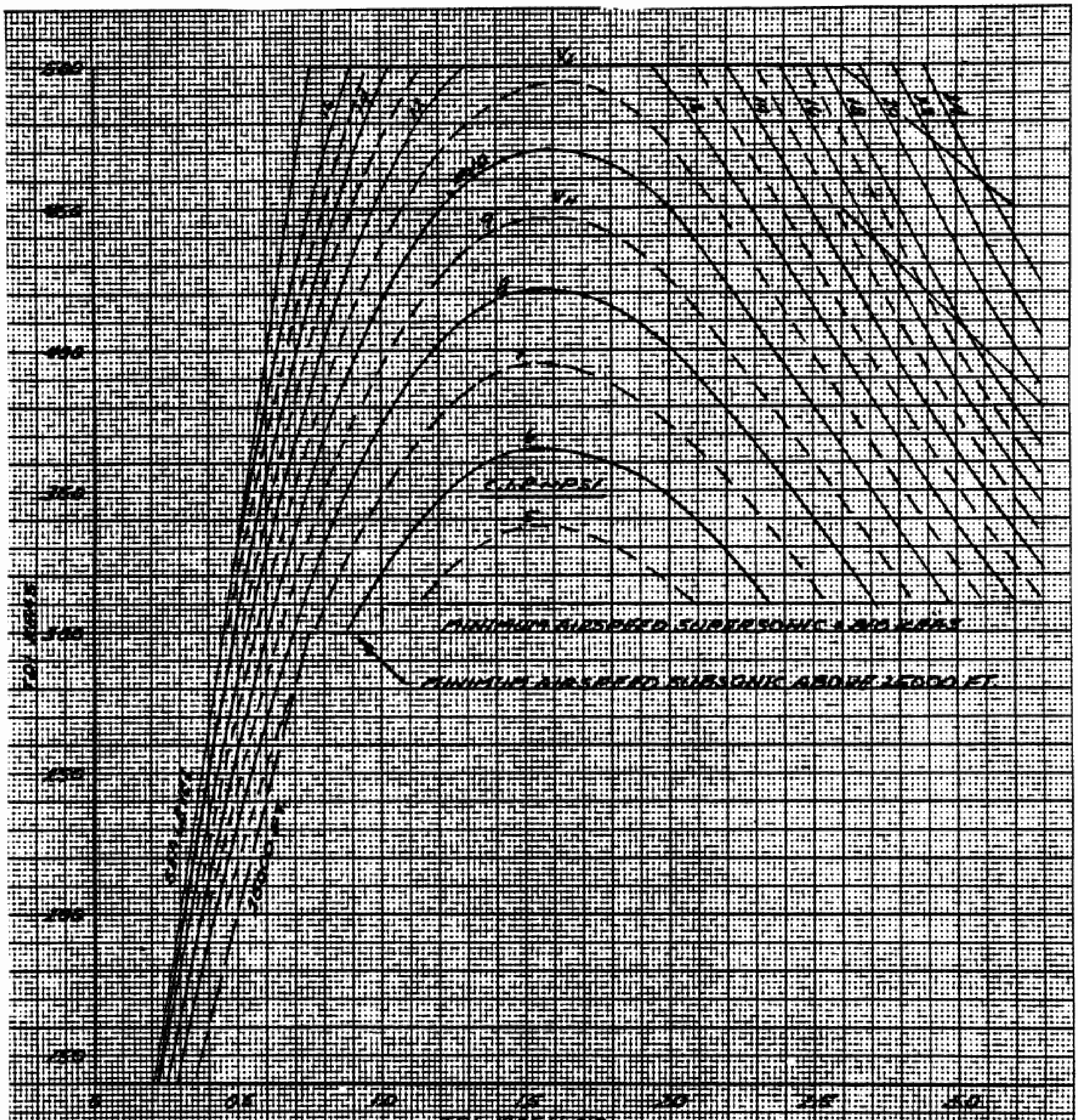


Figure 1-22 (Sheet 1 of 5)

AIR INLET SPIKE SCHEDULE

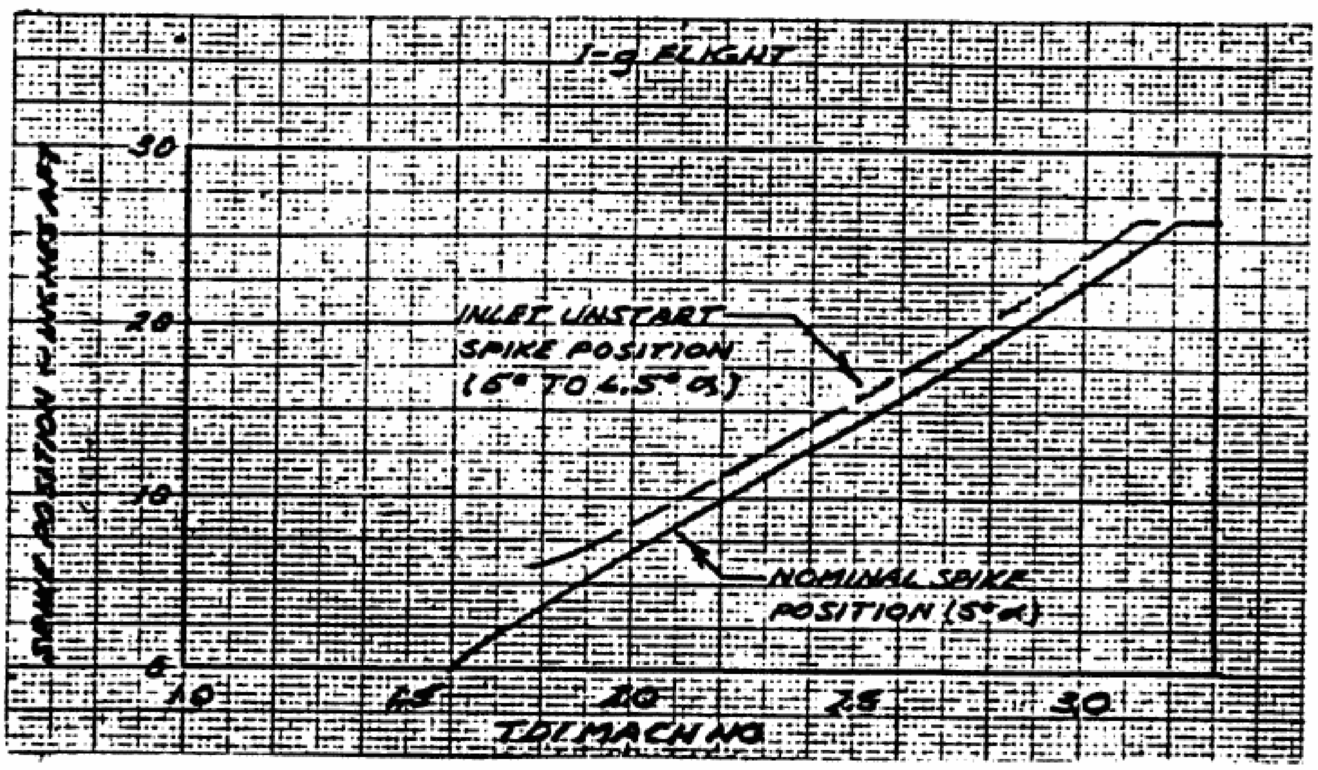


Figure 1-22 (Sheet 2 of 5)

throat. As Mach increases, the forward bypass position must modulate automatically, or by manual control, to keep the normal shock near the throat. When in manual control, the opening can be set in accordance with a Mach schedule or by referring to the position of the opposite inlet (if it is operating automatically). See Figure 3-5.

In automatic control, DAFICS positions the forward bypass to maintain a duct pressure ratio (DPR) schedule as a function of Mach number, with biasing for vertical acceleration, angle of attack, and angle of sideslip. (DPR = P_{sD8}/P_{pLM}, inlet duct static pressure immediately aft of the primary shock wave divided by total free stream pressure or pitot pressure outside the cowl.) (See Figure 1-20.) Four inlet duct static pressure taps measure P_{sD8}. These are located circumferentially on the inlet duct wall, aft of the shock trap bleed. The total free stream pressure, P_{pLM}, is sensed by two pitot probes located on the outside of each nacelle.

When the landing gear is down, the forward bypass is held 100% open by an override signal from a main gear door switch. Control of the forward bypass reverts to the mode selected by the pilot when the gear has retracted.

INLET AFT BYPASS

The inlet aft bypass consists of a rotating band of ports located just forward of the engine face. When rotated to an open position, inlet air is allowed to bypass the engine and join the flow from the shock trap bleed. The combined flow passes through the space between the engine case and the nacelle structure, cools these spaces, then augments the exhaust gas flow in the ejector area. See Figure 1-21.

FORWARD BYPASS POSITION - Mach 2.20 to 2.80

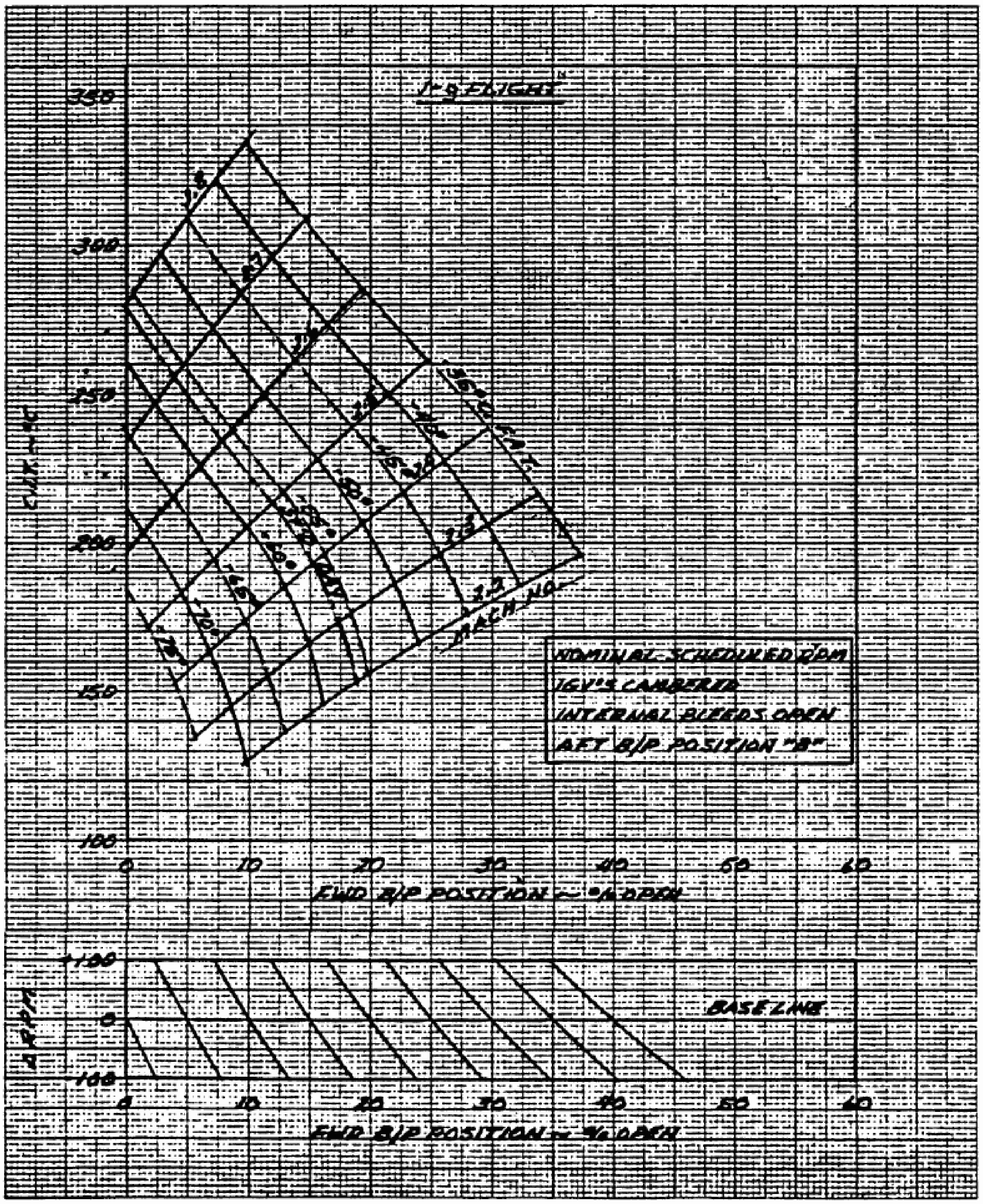


Figure 1-22 (Sheet 3 of 5)

FORWARD BYPASS POSITION - Mach 2.20 to 3.20

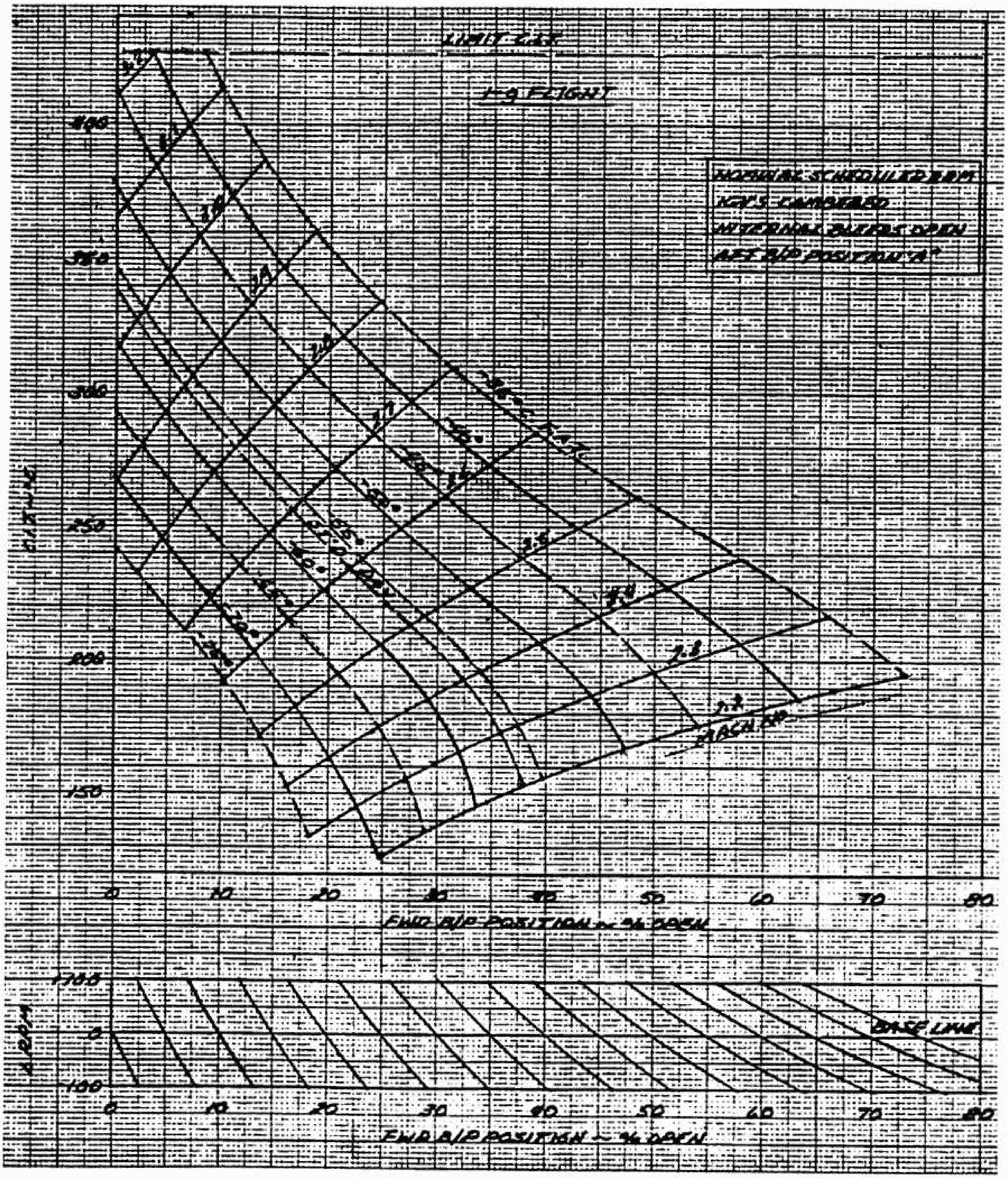


Figure 1-22 (Sheet 4 of 5)

FORWARD BYPASS POSITION - Mach 2.90 to 3.20

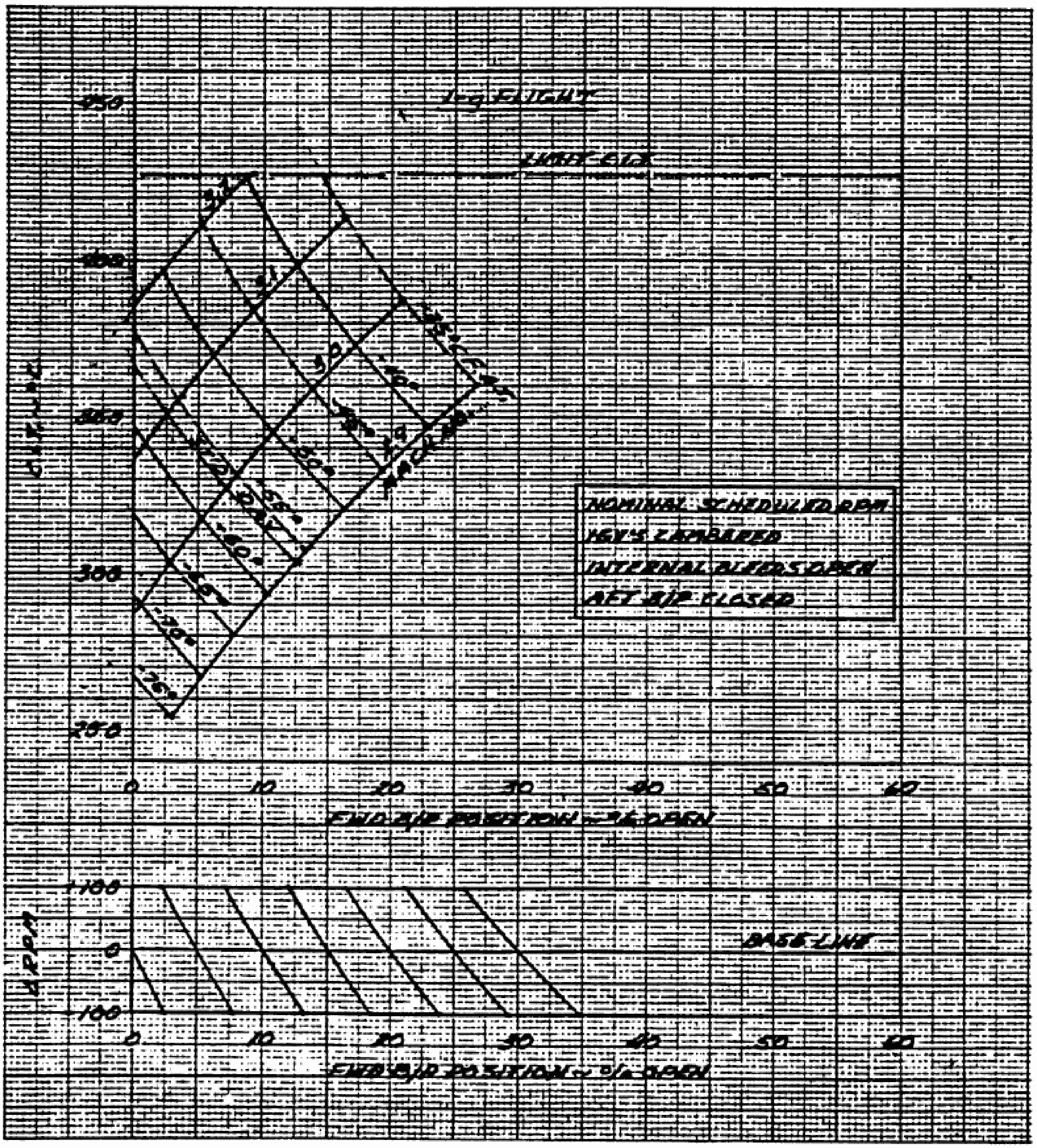


Figure 1-22 (Sheet 5 of 5)

The position of the aft bypass in each inlet is controlled by rotary selector switches in the pilot's cockpit. When the gear is extended, the aft bypass ports are held closed by an override signal from the nose gear downlock switch.

INLET CONTROL PARAMETERS

When the aircraft is supersonic, inlet airflow is controlled by positioning the spike and forward bypass so that the locations of shock waves ahead of the inlet and at the inlet throat produce maximum practical pressure recovery at the engine face, and supply the proper amount of air to the engine. Refer to spike position vs Mach number and forward bypass position vs Mach number and CIT, Figure 1-22. Manual operation of the aft bypass provides for those conditions where additional bypass area is required or when a reduction in forward bypass flow is desired. The forward and aft bypass openings and the spikes for the left and right inlets are operated by the L and R hydraulic systems, respectively. The inlet control also includes a shock expulsion sensor and restart system.

In automatic control, DAFICS schedules the spike and forward bypass positions as a function of Mach, with biasing for load factor, angle of attack, and angle of sideslip. Bias does not override a manually operated spike or forward bypass.

Load Factor Bias

The g-bias function in DAFICS schedules the spike forward and the forward bypass more open when load factor is greater than 1.5 g or less than 0.7 g during automatic inlet operation. The biasing noticeably decreases CIP and reduces the possiblity of unstarts. Figures 1-23 and 1-24 illustrate spike and door biasing, respectively.

SPIKE POSITION BIAS
DUE TO LOAD FACTOR

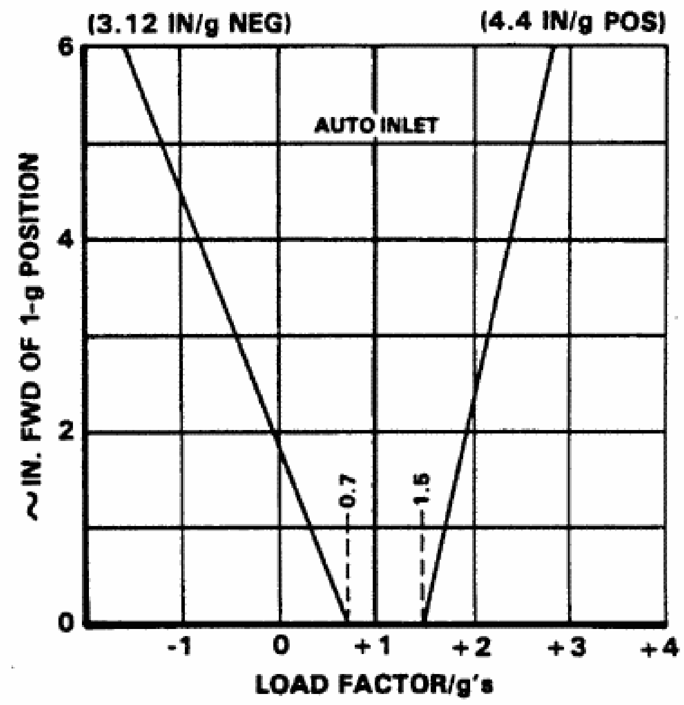


Figure 1-23

FWD BYPASS POSITION BIAS
DUE TO LOAD FACTOR AND DPR

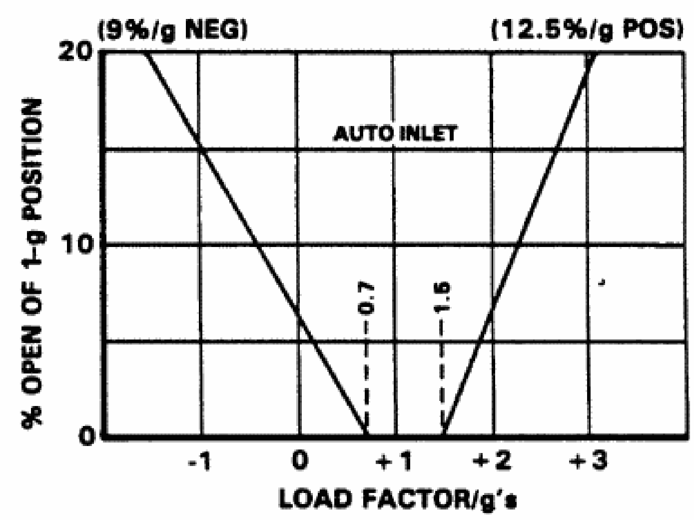


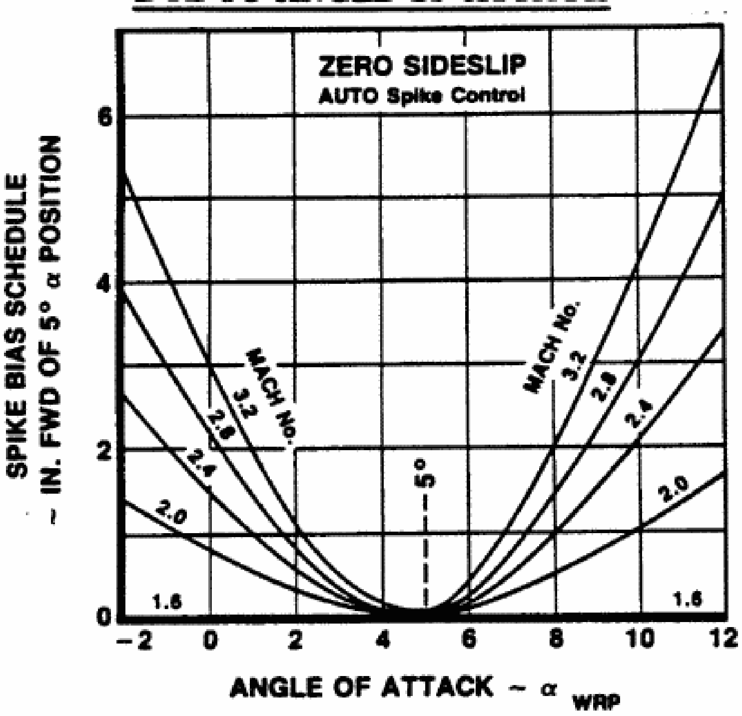
Figure 1-24

Angle of Attack Bias

During automatic inlet operation above Mach 1.6, spikes are biased forward when angle of attack deviates from five degrees (Figure 1-25). Add the angle of attack bias and load factor bias to obtain total bias in a turn or pull-up.

Figure 1-26 illustrates the effect of angle of attack bias on forward bypass position.

SPIKE POSITION BIAS DUE TO ANGLE OF ATTACK



F203-324

Figure 1-25

Angle of Sideslip Bias

During automatic inlet operation, spike position is also biased forward due to sideslip (yaw) angle. Figure 1-27 shows the bias for the left inlet. Because of the nacelle inlet cant, the chart is not applicable to the right inlet unless read with a reverse sign for sideslip angle, i.e., enter the chart with $-\beta$ for a nose-left condition.

EFFECT OF ANGLE OF ATTACK ON FORWARD BYPASS POSITION

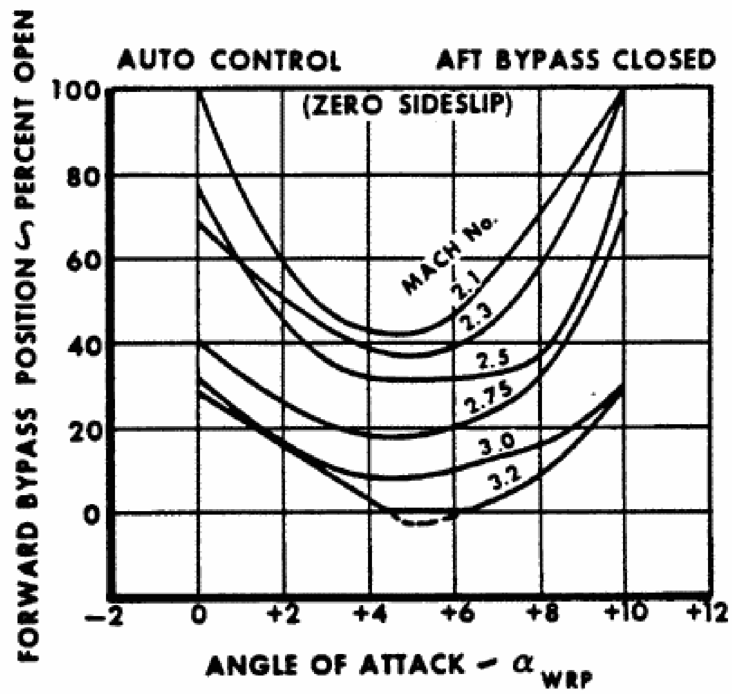


Figure 1-26

Sideslip angles of up to one degree are common. The result can be a "split" spike position indication. Because the spike control positioning tolerance is ± 0.2 inches, this could result in a split indication of up to 0.9 inches with a sideslip angle of 1° (with no indicator instrument error).

In automatic operation, the duct pressure ratio (DPR) is also biased lower due to sideslip angle. Figure 1-28 shows forward bypass position changes that result from spike and DPR biasing when flying with a sideslip at typical cruise speeds. Note that a 1° sideslip can result in a 3% difference between the two inlets. An additional 3% difference is possible due to the tolerance in DPR scheduling.

SPIKE POSITION BIAS DUE TO SIDESLIP (YAW)

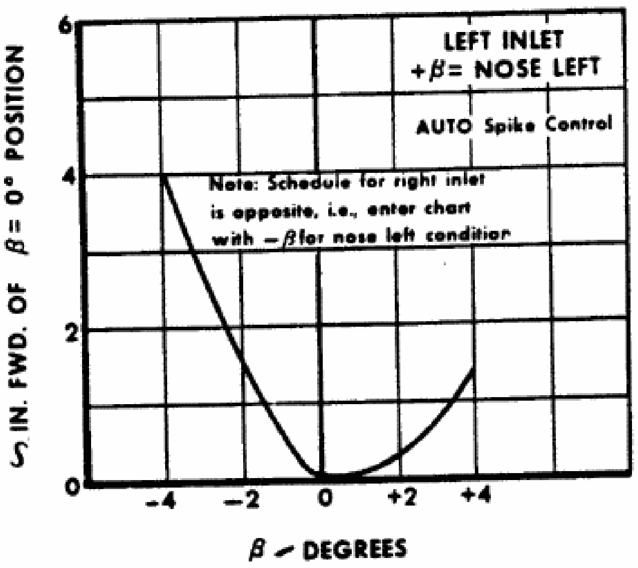


Figure 1-27

EFFECT OF SIDESLIP (YAW) ON FORWARD BYPASS POSITION

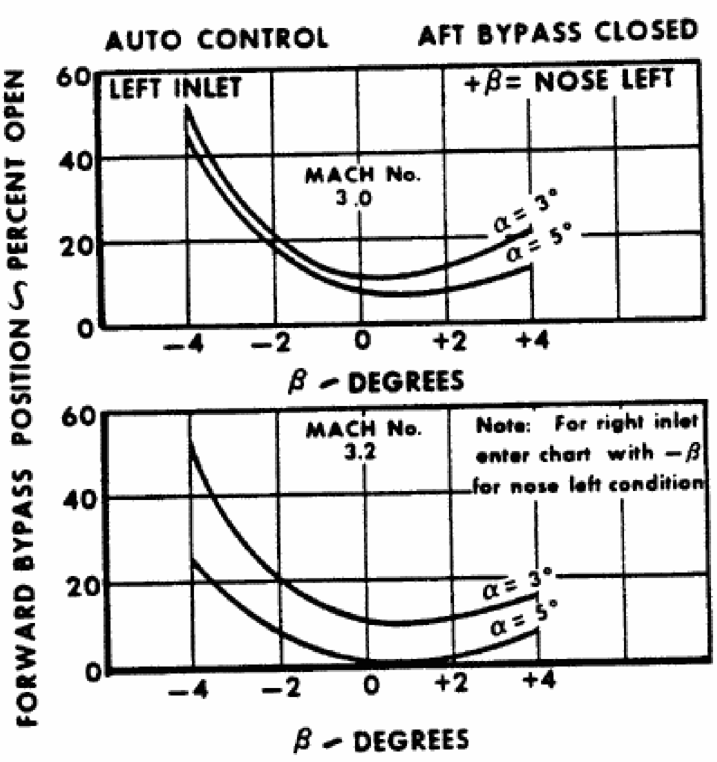


Figure 1-28

Effect of RPM on Forward Bypass Position

Engine speed also affects bypass position, as rpm directly affects engine airflow requirements. This amounts to approximately 4% increase in bypass opening per 100 rpm decrease in engine speed when at typical cruise conditions and with the bypass nearly closed. The influence of rpm change increases significantly as the forward bypass condition approaches 50% open, where a 10% difference in forward bypass indication per 100 rpm change is not unusual.

Malfunction Biases

During automatic inlet operation, the forward bypass door duct pressure ratio (DPR) schedule is biased slightly lower for: loss of DAFICS computer(s), loss of reliable M PTA air data for sideslip computations, or unstart(s).

The DPR schedules of both inlets are biased 40 mpr (milli-pressure ratios) lower if a DAFICS A, B, or M computer fails (appropriate A, B, or M CMPTR OUT caution light on the pilot's annunciator panel illuminated).

If DAFICS is not receiving sideslip angle data from the M PTA, or the sideslip angle data from the M PTA is unreasonably high (as determined by comparison with the yaw SAS lateral accelerometers), the angle of sideslip used for automatic inlet operation computations is zero and the DPR schedules for both inlets are biased 20 mpr lower.

Each time the shock expulsion sensor (SES) detects an unstart (as indicated by illumination of the L or R UNST light), the DPR schedule for the inlet that unstarted is reduced 10 mpr. The DPR schedule for the other inlet is not changed.

The total reduction in DPR schedule on each inlet will not exceed 40 mpr regardless of how many malfunctions occur. For comparison, a 40 mpr differential is the range of adjustment provided to maintenance for scheduling inlet DPR.

AIR INLET SYSTEM CONTROLS

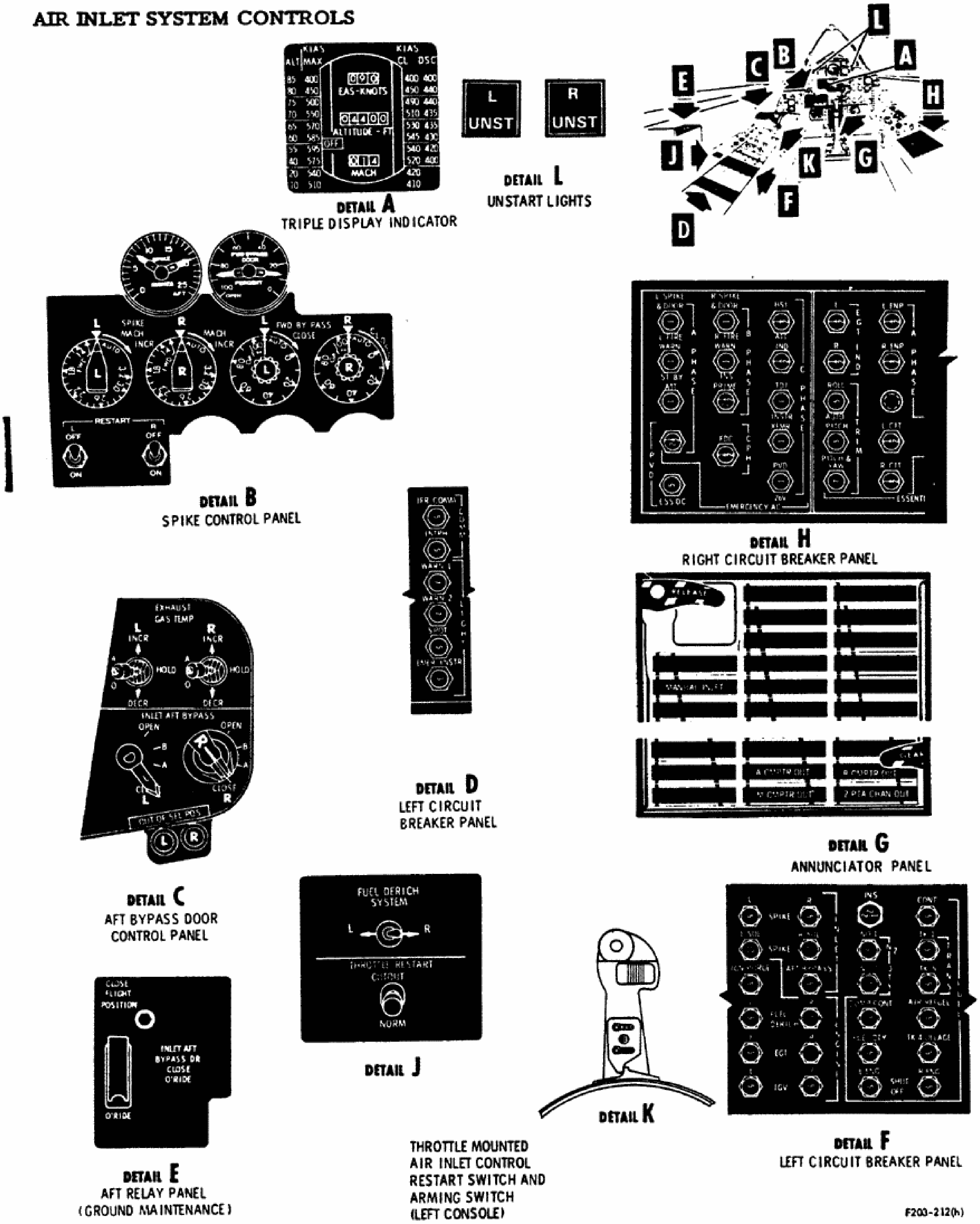


Figure 1-29

AUTOMATIC RESTART

The inlet control includes a shock expulsion sensor (SES) and an auto restart feature which operate automatically above Mach 1.6 (normally, SES is effective above Mach 2.0). If the inlet normal shock wave is expelled, the SES overrides the auto spike and forward bypass schedule (for both inlets above Mach 2.3). This "cross tie" feature keeps the other inlet from unstarting, reduces asymmetric thrust, and minimizes undesirable sideslip angles. During the automatic restart cycle, the forward bypasses open fully and the spikes move forward as much as 15 inches. Spike retraction starts 3.75 seconds after the expulsion is sensed. After the spikes return to their scheduled position, the forward bypasses return to automatic operation. In automatic operation, the forward bypass door duct pressure ratio schedule of the inlet that unstarted is biased slightly lower after each unstart, for up to 4 unstarts. The "cross tie" function is locked out below Mach 2.3 so that only the inlet which has unstarted will perform the automatic restart cycle.

Compressor inlet pressure (CIP) is the SES reference. The SES system actuates when a momentary CIP decrease of more than 23% occurs. Rapid CIP decrease is characteristic of an unstart; however, the SES can also be actuated by compressor stalls if CIP decreases rapidly more than 23%. Successive unstarts or compressor stalls may cause the SES reference pressure (CIP) to decay. The SES cannot operate if the momentary pressure drop is less than 23% of the existing reference pressure. In this event, manual restart will be necessary.

If an inlet remains unstarted (i.e, the shock is not recaptured) after automatic restart, the SES will not actuate since CIP will be low

and will not change. In this event, manual restart will be necessary.

The automatic restart and cross tie features do not override any manually positioned inlet control. If an unstart occurs on the inlet in manual spike operation, neither that inlet nor the opposite inlet will respond. With only one forward bypass door in manual control, an unstart on either inlet will result in automatic actuation of both spikes and the door in automatic control. If the manually controlled door is not opened manually, an unstart and possible engine stall can be expected on that inlet, even if the opposite inlet unstarts. Manual operation of the air inlet restart switch overrides the SES automatic restart cycle and manual position settings of that inlet.

INLET CONTROLS, INSTRUMENTS AND INDICATOR LIGHTS

Spike Switches

Individual rotary control knobs for each spike are on the left side of the pilot's instrument panel. Each switch has two detent positions, AUTO and FWD, indexed to the instrument panel lubber line engraved at the 12 o'clock position. The knobs are graduated counterclockwise in Mach from 1.4 through 3.2 to represent the manual override range of control. With the knob in the AUTO detent, the corresponding spike is positioned automatically. The FWD setting moves the spike to its forward stop, bypassing the automatic circuitry. The manual override settings schedule the spike to any desired position from full forward at the Mach 1.4 - 1.6 setting to full aft (26-inch position), at the Mach 3.2 setting. There is no automatic bias for load factor or angles of attack and sideslip during manual control.

NOTE

Inlet restart switches override all other inlet controls (the forward bypass door opens and the spike is driven forward).

The emergency ac bus provides power for manual and automatic control of the spikes and forward bypass doors through the L and R SPIKE AND DOOR circuit breakers on the pilot's right console. Power for the automatic control circuit relays is furnished from the essential dc bus through the L and R SPIKE circuit breakers on the pilot's left console. Power for spike unlock above 30,000 feet and Mach 1.4 is furnished from the essential dc bus through the L and R SPIKE SOL circuit breakers on the pilot's left console.

Spike Position Indicator

A dual position indicator for the left and right spikes is located on the left side of the pilot's instrument panel. This instrument is marked in one inch increments from 0 (forward) through 26 (full aft). Instrument power is provided from the essential dc bus through the R SPIKE circuit breaker on the pilot's left console.

Inlet Forward Bypass Switches

Two rotary control switches, one for each forward bypass system, are provided on the pilot's instrument panel. Each switch has two detent positions, AUTO and OPEN, indexed to the instrument panel lubber line engraved at the 12 o'clock position. The knobs may be rotated clockwise from the OPEN position to schedule the bypass between full open and full closed. The 100% OPEN detent positions the bypass full open. The manual settings allow the pilot to schedule forward bypass position, overriding the automatic system. Power for the circuit is furnished by the essential dc bus through the L and R SPIKE circuit breakers on the pilot's left console. Power for inlet forward bypass unlock above Mach 1.4 is furnished from the essential dc bus through the L and R SPIKE SOL circuit breakers on the pilot's left console.

MANUAL INLET FORWARD BYPASS BIAS VS. SPIKE KNOB MACH NUMBER

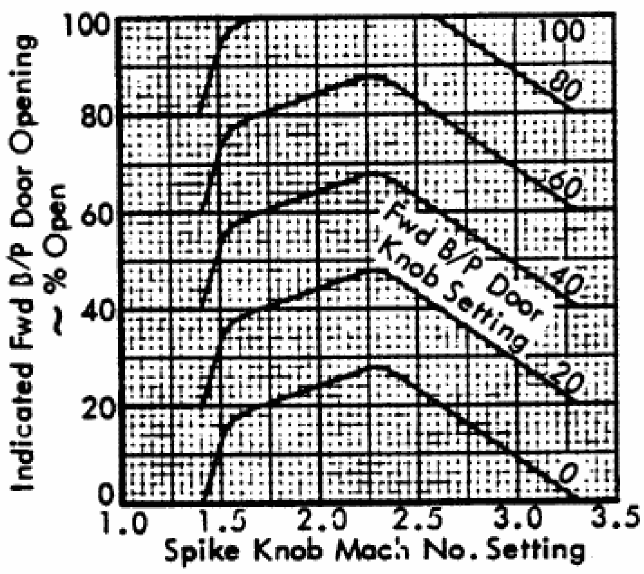


Figure 1-30

Forward Bypass Position Indicator

A dual position indicator for the left and right forward bypass is located on the left side of the pilot's instrument panel. The indicator shows the positions of the forward bypass from 0% (fully closed) to 100% (full open). The dial is marked in 20% increments, with additional marks at each 10% position. Instrument power is provided from the essential dc bus through the L SPIKE circuit breaker on the pilot's left console.

Forward Bypass Bias for Manual Spike Operation

A manual forward bypass bias schedule is applied to the forward bypass whenever the spike <u>and</u> the forward bypass are operated manually. This schedule prevents inadvertent closure of the forward bypass into a range where unstarts are likely. The indicator will show the forward bypass as being more open than the setting selected by the forward bypass switch. With the spike in manual:

a. With the forward bypass switch in AUTO or 100% position - The forward bypass will open fully.

b. With the forward bypass switch in any manual position, other than 100%, the forward bypass will close as far as the bias schedule will permit.

Inlet Aft Bypass Switches and Indicators

Two rotary INLET AFT BYPASS switches, one for each aft bypass system, are located left of the throttle quadrant. The switch positions are: CLOSE, A (15% open), B (50% open), and OPEN (100%). Two rotate-to-dim,amber lights, labeled L and R, are located below the switches. The lights illuminate when an aft bypass position and switch setting do not correspond and extinguish when the aft bypass reaches the setting selected by the aft bypass switches. Approximately 5 seconds is required for the aft bypass ring to move from full closed to full open. The aft bypass actuator control circuits and indicator lights are powered by the essential dc bus through the AFT BYPASS circuit breaker on the pilot's left console.

NOTE

> Occasional momentary illumination of either or both aft bypass out-of-position lights may occur with any switch position selected. This is caused by door actuator drift away from the commanded position limit switch. The door is then commanded back to the selected position and the door out-of-position light extinguishes. Such uncommanded movement of the aft bypass doors are generally too small to be detected by changes in auto inlet position indications, and will not affect aircraft performance.

A ground maintenance switch, labeled INLET AFT BYPASS DR CLOSE O'RIDE, is located on the left console relay panel in the forward cockpit. It overrides the aft bypass close signal when the landing gear is extended.

Inlet Restart Switches

Two inlet restart switches are installed on the lower left edge of the pilot's instrument panel. The two positions are off (center), and RESTART ON (down). When the switch is moved to RESTART ON, the respective inlet spike is moved forward and the forward bypass is positioned full open. Selection of RESTART ON overrides all other spike and forward bypass control settings for that inlet. Power for the respective inlet restart switches is furnished by the essential dc bus through the L and R SPIKE SOL circuit breakers on the pilot's left console.

NOTE

The forward bypass door linear voltage differential transformer (LVDT) is not temperature compensated. With RESTART ON, the forward bypass is 100% open but the gauge may indicate as low as 80% open.

Throttle Restart Switch

A throttle restart switch, located on the inboard side of the right throttle, restarts both inlets simultaneously. The three-position slide switch can be moved fore and aft by the pilot's left thumb. In the forward (off) position, the inlet spikes and forward bypass are controlled by settings of the inlet spike and forward bypass control switches, or by the individual inlet restart switches. The center position opens the forward bypass of both inlets but does not affect the position of the spikes. The aft position causes the forward bypass to open and the spikes to move full forward in both inlets. This switch is operative only when the throttle restart cutout switch is in NORM. Power for throttle restart switch control of the respective spike and forward bypass positions is from the essential dc bus through the L and R SPIKE SOL circuit breakers on the pilot's left console.

NOTE

The forward bypass door linear voltage differential transformer (LVDT) is not temperature compensated. With the throttle restart switch in the center or aft position, the forward bypass is 100% open but the gauge may indicate as low as 80% open.

Throttle Restart Cutout Switch

The THROTTLE RESTART CUTOUT switch is on the pilot's left console. It arms the circuit to the throttle restart switch. In the NORM position, the throttle restart switch is operable. If the throttle restart switch malfunctions, the throttle restart cutout switch should be placed in CUTOUT.

Inlet Unstart Lights

The inlet unstart lights, labeled L UNST and R UNST, are located on the pilot's instrument panel. The L UNST or R UNST light illuminates when the shock expulsion sensor (SES) detects an unstart in the corresponding inlet and extinguishes after 3.75 seconds when the SES resets. Power for the lights is furnished by the essential dc bus through the L and R SPIKE circuit breakers on the pilot's left console.

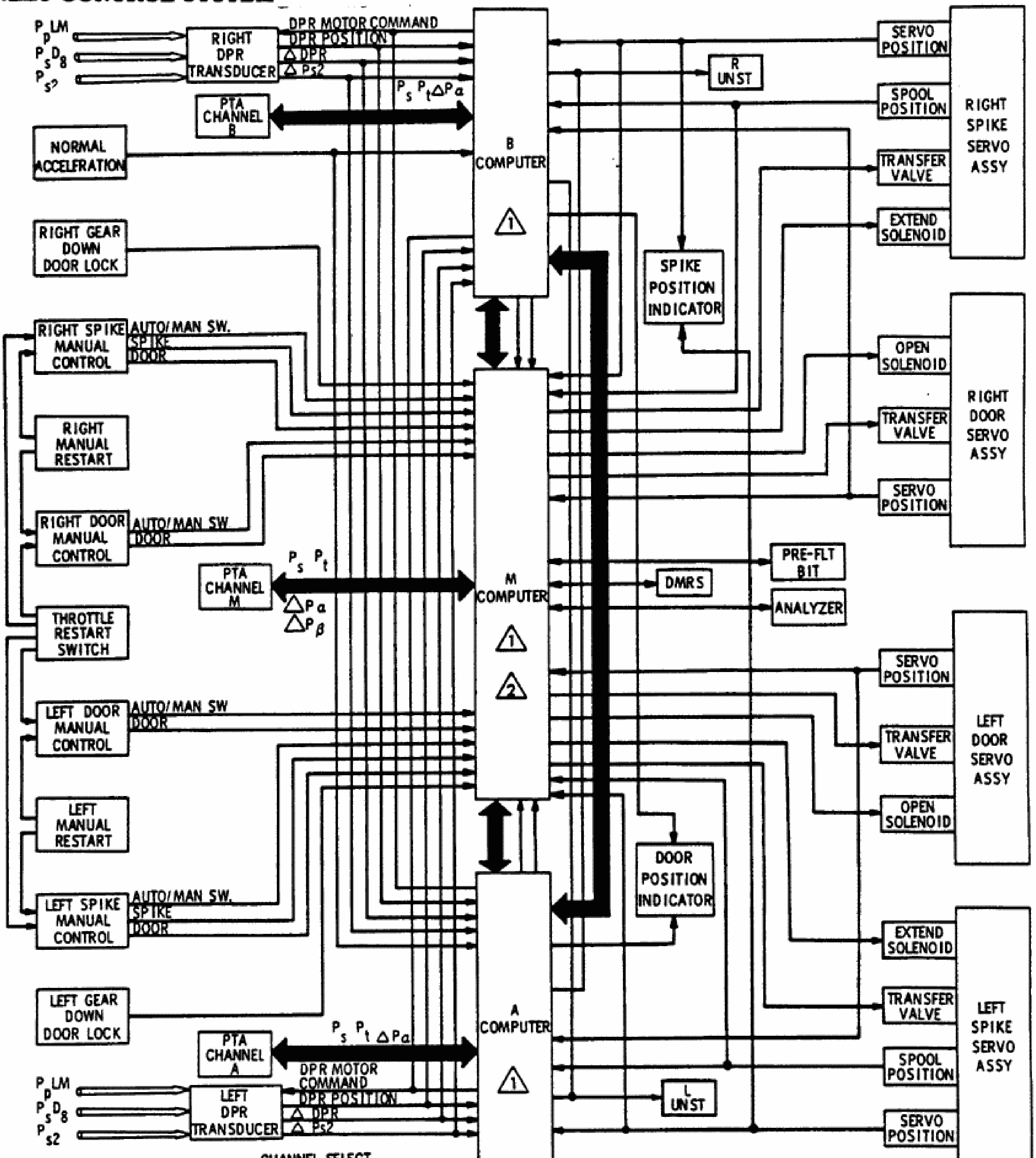
WARNING

Near design Mach, the inlet may remain unstarted after the L or R UNST light extinguishes.

NOTE

For multiple unstarts or an inlet which has not restarted, the unstart light(s) will not illuminate unless the subsequent unstart(s) is sensed by the SES.

INLET CONTROL SYSTEM



CHANNEL SELECT

COMPUTER CONDITION	CHANNEL DRIVING SERVOS ⚠1				COMMENTS
	LEFT SPIKE	RIGHT SPIKE	LEFT DOOR	RIGHT DOOR	
NORMAL	A	B	A	B	⚠2
FAIL A	B	B	B	B	⚠2
FAIL B	A	A	A	A	⚠2
FAIL A, B	M	M	M	M	MANUAL CONTROL ONLY

⚠1 Automatic spike and door control commands originate in "A" and "B" channels, but are output by the "M" channel computer.

⚠2 Manual control of individual servos through the "M" channel may be selected.

◄━━► Digital Interface

═══▷ Pneumatic Pressure

F203-274(a)

Figure 1-31

Manual Inlet Indicator Light

The MANUAL INLET caution light on the pilot's annunciator panel illuminates when one or more of the four rotary spike and/or forward bypass control knobs is not in AUTO, or an inlet restart switch is not in off.

INLET CONTROL SYSTEM

When in AUTO, the left and right spikes and forward bypass doors are controlled by the A and B computers, respectively, output through the M computer to the appropriate servo assemblies. Each computer (A and B) receives nonredundant inputs from its own duct pressure ratio (DPR) transducer assembly, but they share a common normal acceleration signal. Left and right DPR signals are crossfed, so that either A or B computer can control both inlets if the other computer fails. Left inlet auto control requires at least one phase of emergency ac power to the A computer through the COMPUTER circuit breakers in the aft cockpit. Right inlet auto control requires at least one phase of emergency ac power to the B computer through the COMPUTER circuit breakers in the aft cockpit.

Control of inlet unstart lights is direct from each computer (A and B), with cross control if either computer fails.

Manual spike and door control (both inlets) requires M computer A and C phase or B and C phase emergency ac power through the COMPUTER circuit breakers in the aft cockpit.

Left and right spike and door position signals are supplied to forward cockpit indicators. DMRS, PREFLIGHT BIT, and DAFICS Analyzer interfaces are via the M computer. Refer to Figure 1-31 for channel select table.

FUEL SYSTEM

There are five individual fuselage tanks, tanks 1A, 1, 2, 4, and 5, and two wing-fuselage tank groups, tanks 3 and 6. (See Figure 1-32.) Tank 6 is further divided into 6A and 6B. Interconnecting plumbing and electrically driven boost pumps are utilized for fuel feed, transfer, and dumping. Other components of the system include pump controls, nitrogen inerting, scavenging, pressurization and venting, single-point refueling receptacles, and a fuel quantity indicating system. The fuel heat sink system cools cockpit air, engine oil, accessory drive system oil, and hydraulic fluid.

The fuel system moves the aircraft center of gravity by:

a) automatic tank sequencing to the engine feed manifolds to control the fuel level in the various tanks;

b) early depletion of tank 1 fuel to a pre-selected shut-off level, which is dependent upon the zero fuel weight and C.G. position, and whether the flight is subsonic or supersonic;

c) automatic aft fuel transfer into tank 5 when tank 5 pumps are energized and tank 2 contains fuel. In addition, the manual aft transfer system is automatically energized if tank 1 has less than 1500 pounds of fuel, the tank 2 boost pumps are off, and the boost pumps in tanks 3 and 5 are on;

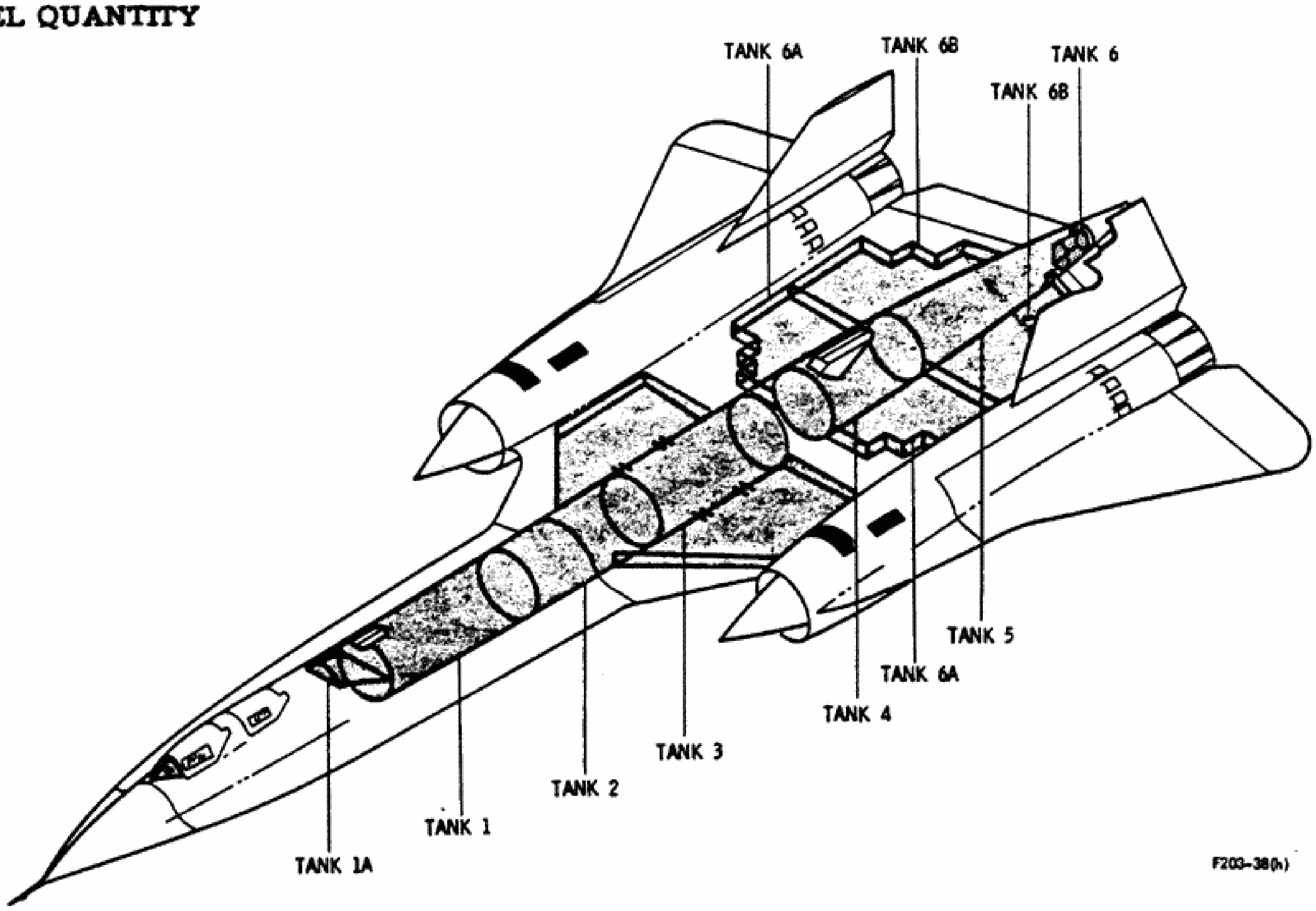
d) manual aft transfer into tank 5 when it is less than full;

e) manual forward transfer to tank 1. See Section 5, Use of Forward Transfer.

For automatic center of gravity scheduling to be effective, the fuel loading distribution given in T.M. SR-71-5 Weight and Balance Manual must be followed.

The automatic fuel feed system is designed to maintain the c.g. within the band depicted in Figure 1-33.

FUEL QUANTITY



FUEL TANK CAPACITIES
Normal Flight Attitude

Tank	Fuel/Gal	Fuel (JP-7)
1A	251.1	1650 lb.
1	2095.9	13770 lb.
2	1974.1	12970 lb.
3	2459.7	16160 lb.
4	1453.6	9550 lb.
5	1758.0	11550 lb.
6A (forward)	1158.3	7610 lb.
6B (Aft)	1068.5	7020 lb.
Total	12219.2	80280 lb. *

* At average fuel density of 6.57 lb./gal.
(46.2° API, Fuel temperature = 78°F)

Figure 1-32

[redacted]

C.G. VS. GROSS WEIGHT
OFF TANKER WITH FULL FUEL LOAD - SUPERSONIC CRUISE - AUTOMATIC FUEL SEQUENCING

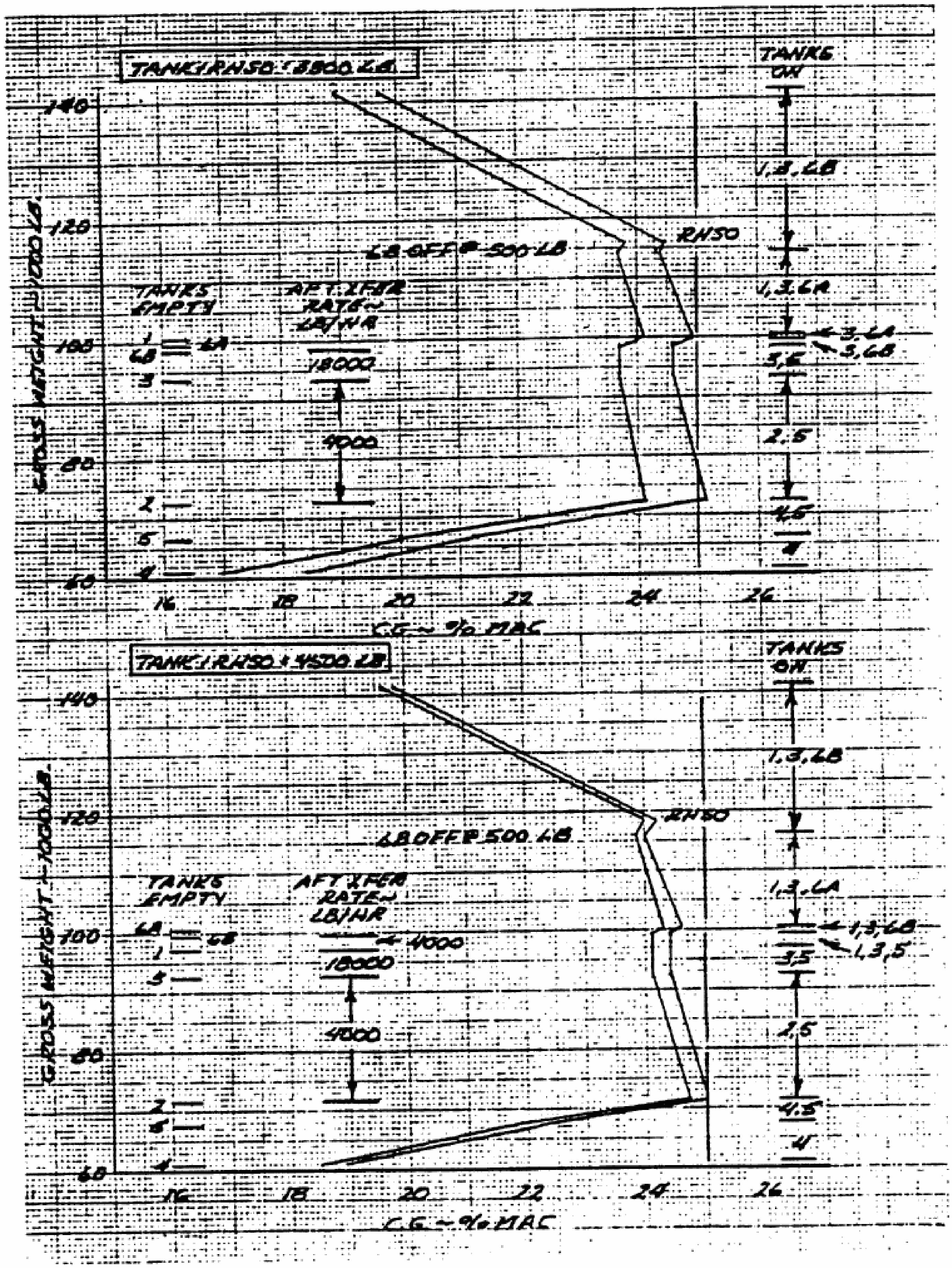


Figure 1-33

ZERO FUEL WEIGHT C.G. BANDWIDTH SUPERSONIC FLIGHT	
RHSO SETTING TANK 1 -LB	ZERO FUEL WEIGHT C. G. RANGE -% MAC
3300	17.0 to 18.4
4500	18.5 to 18.9
5000	19.0 to 19.5
5500	19.6 to 20.1
6000	20.2 to 20.8
6800	20.9 to 21.6
7500	21.7 to 22.3

Figure 1-34

FUEL TANKS

Tanks 1, 1A, 2, 4, and 5 are entirely contained in the fuselage. Tank 1A is a small tank located immediately forward of and feeding into tank 1. Tanks 3 and 6 consist of three and five tank groups, respectively. The No. 3 tank group is comprised of the forward section of each wing and a fuselage tank. The No. 6 tank group is located in the wings on either side of tanks 4 and 5 and includes a small sump tank (approximately 12 gallons) at the extreme aft end of the fuselage which contains the boost pumps for the group. All fuselage tanks are interconnected by a single vent line. Each wing tank is vented to its nearest fuselage tank. Submerged boost pumps are contained in the fuselage tanks. The pumps supply fuel through the left and right manifolds and transfer fuel for center of gravity control. The manifolds can be connected by opening a crossfeed valve. A fuel dump valve is installed in each manifold.

FUEL FEEDING AND SEQUENCING

The left engine is supplied from the left fuel manifold which is normally fed from tanks 1, 2, 3, and 4. The right engine is supplied from the right fuel manifold which is normally fed from tanks 1, 4, 5, and 6. Although crossfeed can be used to feed either engine from any tank, the normal automatic fuel sequencing schedule is:

Left engine supply tanks	Right engine supply tanks	Until
1, 3, 4*	1**, 6, 4*	6 empty
1, 3	1**, 5	1 empty
3	5	3 empty
2	5	2 or 5
2 or 4***	5 or 4***	empty
4	4	See note.

* If tank 4 is full initially, pumps 4-1 and 4-2 operate briefly to provide approximately 850 pounds ullage space. Tank 4 indicator light will not illuminate.

** Termination of tank 1 supply to the right engine depends on the right-hand shutoff float switch selection.

*** Depending on the right-hand shutoff float switch selection for tank 1, tank 2 may or may not shut off before tank 5 is depleted.

NOTE

Forward transfer is necessary during subsonic operation to maintain c.g. ahead of the aft limit.

Tank sequence is controlled automatically by float switches, see Figure 1-35. These switches optimize the center of gravity for supersonic cruise.

FUEL BOOST PUMP AND FLOAT ARRANGEMENT

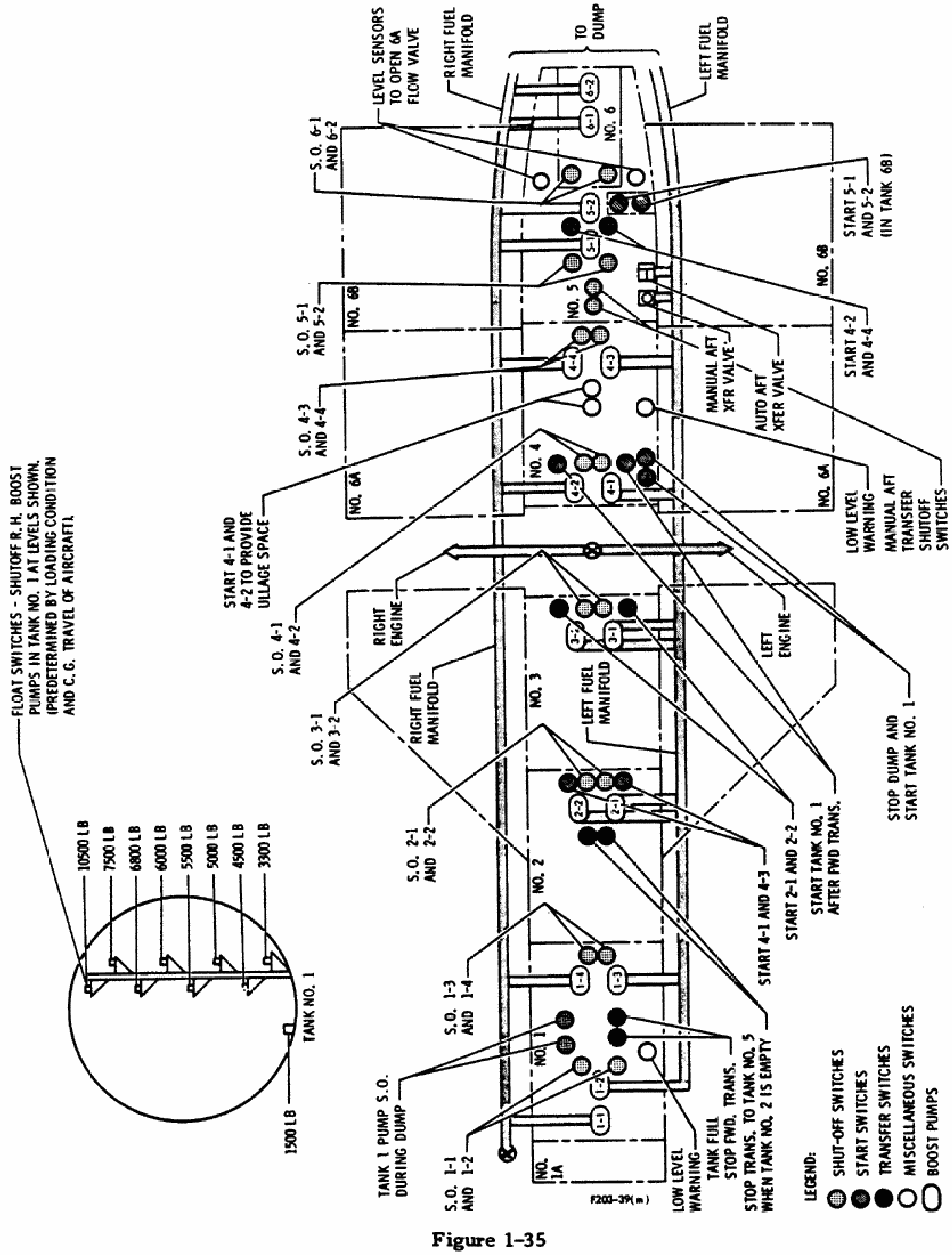


Figure 1-35

ATTITUDE EFFECTS ON FUEL TANK FLOAT SWITCH ACTUATION

TANK NO.	SWITCH	ANGLE OF ATTACK DEG	
		0	+6.2
		Tank Fuel Remaining - Lb (6.7 lb/gal.)	
1	STOP FORWARD TRANSFER TANK 1 PUMP SHUTOFF DURING DUMP LOW LEVEL WARNING SHUTOFF 1-1 AND 1-2 SHUTOFF 1-3 AND 1-4	13300 4550 4200 1650 400	13700 4850 5400 2850 65
2	STOP TRANSFER TO TANK 5 WHEN TANK 2 IS LOW START 4-1 AND 4-3 SHUTOFF 2-1 AND 2-2	600 500 300	400 100 65
3	START 2-1 AND 2-2 SHUTOFF 3-1 and 3-2	500 250	175 75
4	START 4-1 AND 4-2 TO PROVIDE ULLAGE SPACE LOW LEVEL WARNING STOP NORMAL DUMP AND START TANK NO. 1 START TANK NO. 1 WITH FORWARD TRANSFER ON SHUTOFF 4-3 AND 4-4 SHUTOFF 4-1 AND 4-2	9550 3750 3500 400 300 250	9400 4050 3950 1250 75 1100
5	MANUAL AFT TRANSFER SHUTOFF START 4-4 START 4-2 SHUTOFF 5-1 AND 5-2	10950 1700 1600 1400	10950 350 300 200
6	6A TO 6B FLOW CONTROL VALVES BEGIN SCHEDULING START 5-1 (SWITCH IN TANK 6B) START 5-2 (SWITCH IN TANK 6B) SHUTOFF 6-1 AND 6-2 (SWITCH IN TANK 6 SUMP TANK)	10900 6475 5200 10	8100 300 150 20

Figure 1-36

FUEL FEED SYSTEM

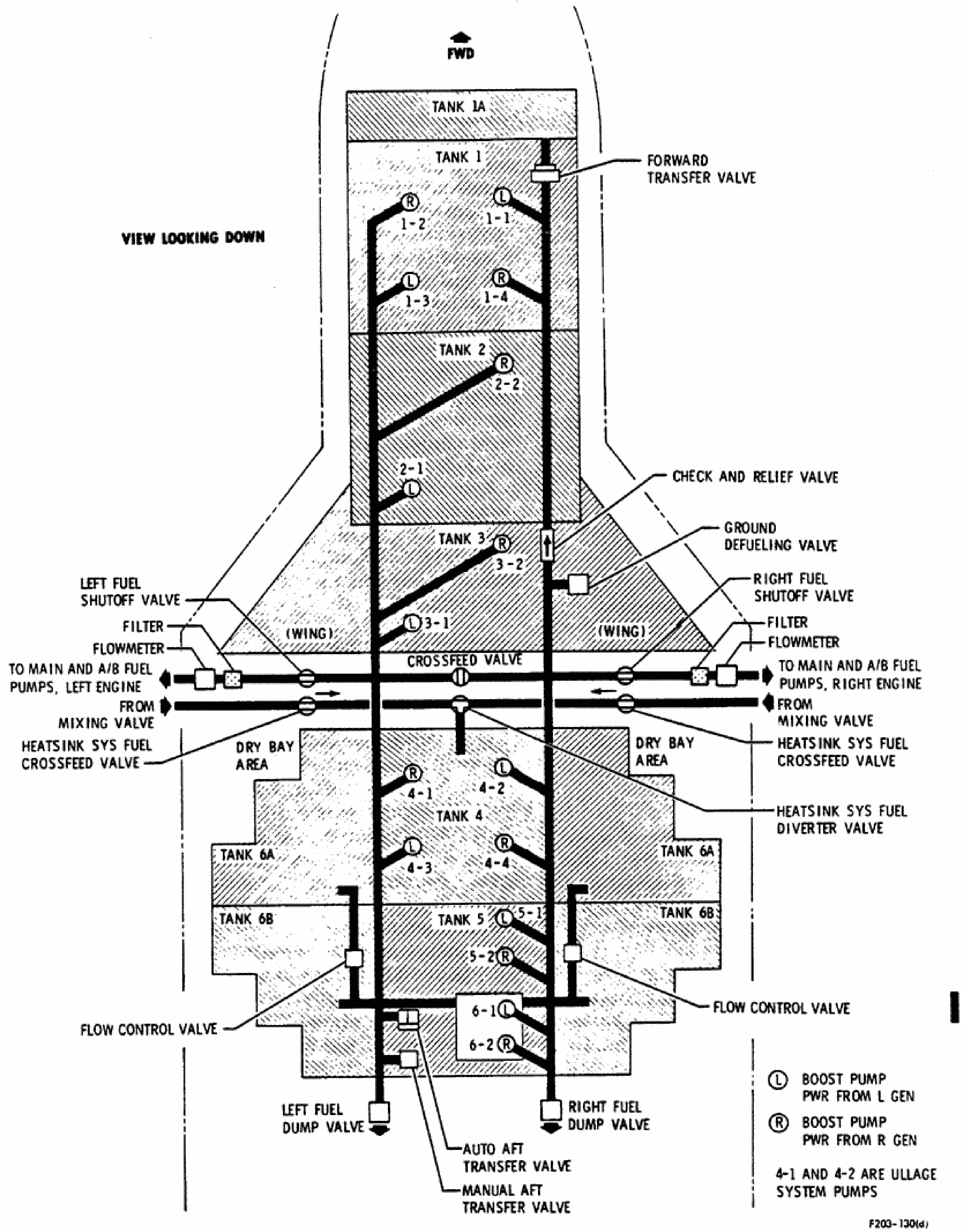


Figure 1-37

A stack of float switches, called right-hand shutoff switches, is installed in tank 1. These switches allow the automatic c.g. control system to compensate for variations in aircraft weight and c.g. due to sensor loading. The selection of a float switch determines the level of fuel remaining in Tank 1 at which boost pumps 1-1 and 1-4 (which supply the right fuel manifold) are shut off. Since boost pumps 1-2 and 1-3 continue to supply the left fuel manifold, the rate of fuel flow from tank 1 is reduced approximately 50% when shutoff occurs. This stops the rapid aft shift of c.g. experienced when tank 1 is supplying both fuel manifolds. Setting of the right-hand shutoff switches is accomplished by maintenance personnel prior to flight. Float switch selection is based on aircraft zero fuel weight and c.g. position as scheduled in the SR-71-5 Handbook of Weight and Balance Data.

NOTE

> Recommended weight and/or c.g. limits can be exceeded by seemingly normal loading arrangements. Check loading documents carefully.

Eight settings are provided between 3300 pounds and 10,500 pounds of fuel remaining in tank 1. Proper selection results in a schedule for c.g. in a band that closely approaches the aft limit during cruise.

+

The preselected float switch setting is overridden if tank 4 contains less than 3600 ±1200 lb of fuel. In this case, tank 1 supplies fuel to both manifolds until the tank 1 fuel low level switches shut off the boost pumps.

The tank 6 boost pump sump tank is fed by tank 6B. Two flow control valves are located between tanks 6A and 6B. When the valves are open, fuel in tank 6A can flow into tank 6B. The tank 6 flow control valves are held open by fuel pressure provided by the tank 6 boost pumps or by pump 5-1. Fuel pressure from the tank 6 boost pumps is provided to the valves only when the quantity of fuel in tank 6B is below approximately 500 pounds at cruise attitude. If pump 5-1 is not on, the valves function to maintain approximately 500 pounds of fuel in tank 6B until tank 6A is empty. If pump 5-1 is on, the valves are open regardless of the fuel quantity in tank 6B.

Because of the aft position of the tank 6 outlets, tank 6 may stop feeding if a nose down flight attitude is established while fuel remains in tank 6 wing tanks. A nose-down attitude and/or a deceleration shifts fuel forward in tanks 6A and/or 6B and uncovers the tank outlets. (Normally, the tank 6 group empties during climb and level cruise). With the wing tank outlets uncovered, fuel does not flow to the sump tank which contains the tank 6 boost pumps. As a result, tank 5 is sequenced on by the low level float switch in the aft portion of tank 6B. The tank 6 pumps are shut off when the sump tank empties, even though a substantial amount of fuel may remain in the wing tanks. An unusual c.g. condition can result if the incorrect sequencing persists. The c.g. may also move out of the desired range if a substantial mismatch of fuel flow to the engines exists (see Figure 2-8). Refer to Fuel Management in Section II.

FUEL BOOST PUMPS

Sixteen single-stage, centrifugal, ac-powered boost pumps supply the fuel manifolds. (See Figures 1-35 and 1-37). Tanks 1 and 4, which normally feed both engines, are equipped with four pumps each and tanks 2, 3, 5, and 6 have two pumps each. Either pump of a pair is capable of supplying sufficient pressure to permit engine operation at reduced afterburning thrust if the other pump fails. Two pumps are required for maximum afterburning fuel flow at lower altitudes. The pumps may be manually operated by use of individual tank boost pump control switches, located on the pilot's right instrument side panel. Manual control of the tank pumps supplements but does not terminate automatic tank sequencing. Manual selection of any tank pumps will change the programmed c.g. schedule and may cause a serious c.g. condition to develop. The boost pumps are cooled and lubricated by the fuel; therefore, manual activation of pumps should be terminated (by pressing the pump release switch) when the tank is empty.

In automatic operation, each pump is protected by a float switch that deactivates the pump when the tank is empty. Individual circuit breakers for each pump are loacted in the E-bay and are not accessible in flight. Three-phase ac power for the pumps is furnished by the generator buses. Odd-numbered pumps (except 4-1) are powered by the left generator ac bus and even numbered pumps (except 4-2) are powered by the right generator ac bus.

NOTE

- In tank 4, pump 4-2 and 4-3 are powered by the left generator bus and pump 4-1 and 4-4 are powered by the right generator bus. This precludes flameout due to fuel starvation if a single generator fails while the bus tie is split.
- If the left engine generator fails and the bus tie is split, fuel in tank 6A may become trapped due to insufficient tank 6 pump pressure and the unavailability of pump 5-1. Pump 5-1 pressure is ported directly to the level control and flow valves controlling tank 6A fuel feed.

FUEL TRANSFER SYSTEM

Fuel transfer systems control aircraft c.g. A manual forward transfer system and an automatic and a manual aft transfer system are provided.

Forward Transfer

Fuel may be transferred forward through the right fuel feed manifold from tanks 4, 5, and 6 into tank 1 at a maximum rate of approximately 950 lb/min. Fuel may be transferred from the left fuel feed manifold (tanks 2 and 3) by opening the crossfeed valve. Fuel transfer is initiated by the forward transfer valve in the forward end of the right fuel feed manifold opening into tank 1. This valve is controlled by the FWD TRANS fuel transfer switch. With RHSO settings of 6000 lbs or higher, forward transfer may be required more often.

Automatic Aft Transfer

Fuel can be transferred from the left fuel feed manifold into tank 5 either by automatic or manual operation. The automatic aft transfer system is started when the tank 5 boost pumps are energized if tank 2 contains fuel above the level of its low fuel quantity float switch. The automatic aft transfer stops when the tank 5 boost pumps are de-energized or when tank 2 fuel level reaches the low fuel quantity float switch. The rate of fuel transfer is determined by throttle position. The fuel automatic aft transfer rates are: 65 lb/min (4000 lb/hr) when both throttles are in afterburner, 23 lb/min (1400 lb/hr) otherwise. In addition, the 233 lb/min (14,000 lb/hr) manual aft transfer rate is automatically added when:

1. Tank 1 contains less than 1500 lbs, and
2. Tank 2 contains fuel, but it's boost pumps are not on, and
3. Tank 3 and 5 boost pumps are on.

Manual Aft Transfer

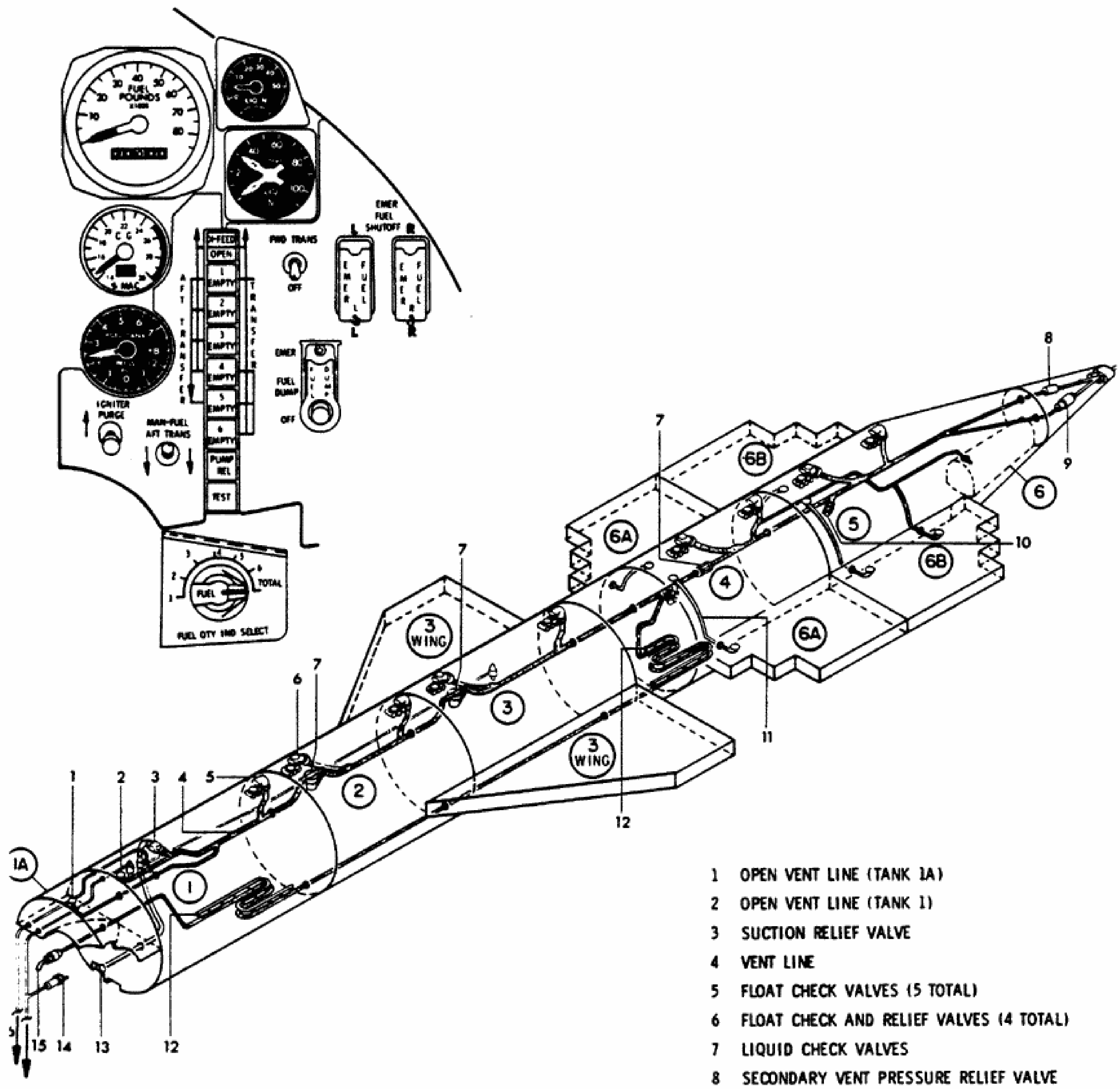
The manual aft transfer system permits the pilot to transfer fuel into tank 5 from any tank(s) whose pumps are supplying the left fuel manifold.

The manual aft transfer rate is approximately 233 lb/min (14,000 lb/hr).

NOTE

Forward transfer operates at a rate of approximately 950 lb/min, a rate more than sufficient to overcome the effects of automatic and manual aft transfer.

FUEL SYSTEM - Pressurization



1 OPEN VENT LINE (TANK 1A)
2 OPEN VENT LINE (TANK 1)
3 SUCTION RELIEF VALVE
4 VENT LINE
5 FLOAT CHECK VALVES (5 TOTAL)
6 FLOAT CHECK AND RELIEF VALVES (4 TOTAL)
7 LIQUID CHECK VALVES
8 SECONDARY VENT PRESSURE RELIEF VALVE
9 PRIMARY VENT PRESSURE RELIEF VALVE
10 VENT DRAIN VALVE
11 VENT LINE, WING TANK TO TOP OF FUSELAGE TANK (4 TOTAL)
12 FUEL LINE FROM FUEL PUMP OUTLETS
13 SUCTION RELIEF ORIFICE (NOSE WHEEL WELL)
14 TANK PRESSURE TRANSMITTER
15 LN_2 FLOW FROM DEWAR TANKS
16 TO NITROGEN TANK PRESSURE SENSORS

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Figure 1-38

FUEL HEAT SINK SYSTEM

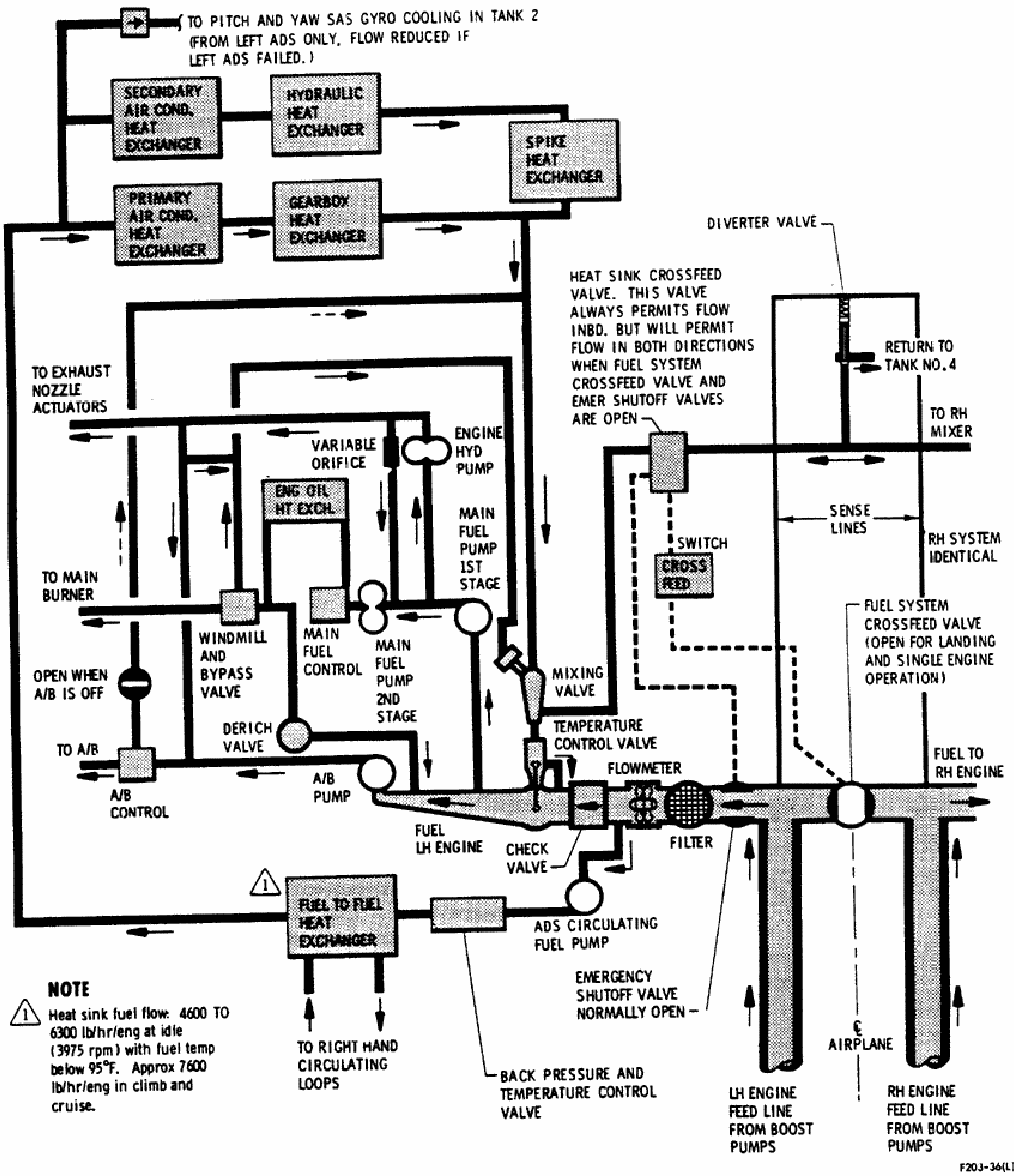

Figure 1-39

Manual aft transfer is controlled by the MAN-FUEL AFT TRANS switch on the pilot's right instrument side panel. Two ullage float switches automatically terminate manual aft transfer if the switch is held on while tank 5 is full; however, automatic aft transfer is not stopped.

FUEL TANK PRESSURIZATION SYSTEM

The fuel tank pressurization system (Figure 1-38) consists of indicators, three Dewar flasks and associated valves and plumbing to the fuel tanks. Two Dewar flasks, each containing 106 liters of liquid nitrogen, are located in the nosewheel well. The third Dewar flask, containing 50 liters of liquid nitrogen, is installed in the left forward chine (B bay). The nitrogen flasks are equipped with automatic ac-powered heaters to change the liquid nitrogen to gas. The nitrogen from the flasks is routed through heat exchangers (in tanks 1 and 4) to ensure that the nitrogen has become gaseous. The nitrogen gas is then ported to a common vent line and to the top of all tanks. The nitrogen gas pressurizes each fuel tank to 1.5 (±0.25) psi above ambient pressure and inerts the ullage space above the heated fuel to prevent autogenous ignition.

The fuel tank pressurization system provides 1.5 (±0.25) to 3.25 (±0.25) psi differential pressure to fuel tanks for a more positive fuel supply to the engines. Fuel tank positive pressure is prevented from exceeding 4.15 psi by a secondary pressure relief valve in the tail cone vent line.

Positive tank pressure is maintained in three ways:

1. The inerting system allows nitrogen flow into the tanks whenever fuel tank pressure differential drops below 1.5 (±0.25) psi.

2. Fuel vapor pressure tends to maintain 1.5 (±0.25) to 3.25 (±0.25) differential during supersonic cruise when fuel warms up.

3. Ascent into less dense atmosphere causes the pressure differential in the tanks to increase to the setting of the pressure relief valve of 3.25 (±0.25) psi at which time the tank will continue venting until level-off.

A small quantity of nitrogen is required for taxi, runup, and takeoff. After takeoff, little or no nitrogen is required until descent for refueling or landing. As the aircraft descends, atmospheric pressure increases causing a demand on the nitrogen pressurization system to keep the internal pressure of the tank higher than the increasing external pressure. For reliability, the nitrogen system is separated into two independent systems, each of which is capable of supplying the required flow for a normal descent. Two liquid nitrogen quantity indicators on the pilot's right instrument side panel indicate the quantity remaining in each flask. The system 3 liquid nitrogen quantity indicator, marked LIQ N, is above the quantity indicator for systems 1 and 2. Fluctuations of the system 3 gage are normal.

NOTE

The nitrogen systems may deplete at an uneven rate; consequently, the quantity gages may show different amounts remaining.

FUEL HEAT SINK SYSTEM

Fuel is used to cool the air-conditioning systems, the aircraft hydraulic fluid, and engine and accessory drive system oil. (See Figure 1-39.) Circulated fuel also cools the TEB tank and the control lines which actuate the afterburner nozzle. Engine oil is cooled by main engine fuel flow through an oil cooler, located between the main fuel control and the windmill bypass valve. This fuel is then directed to the main burner section. The other cooling is accomplished by fuel circulation through several cooling loops. If within engine consumption requirements, the

FUEL SYSTEM - Refueling

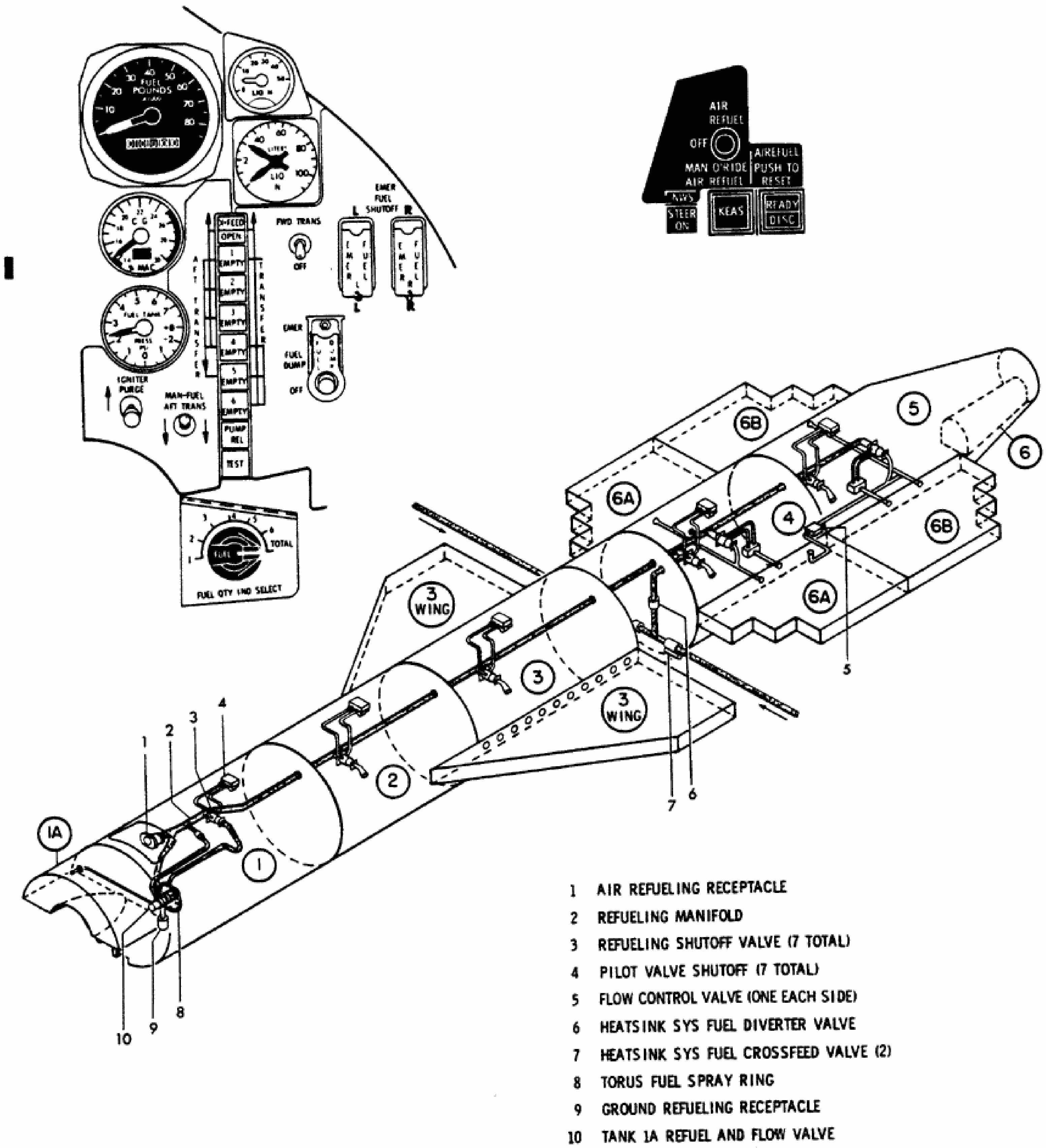

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Figure 1-40

hot fuel returning from the accessory drive system heat exchanger, the primary and secondary air-conditioning heat exchangers, the hydraulic fluid heat exchanger, the spike heat exchanger, and the exhaust nozzle actuators is circulated through a mixing valve and temperature limiting valve and returned to the main engine and afterburner fuel manifold. The quantity in excess of engine requirements is diverted to tank 4.

NOTE

> When cooling loop fuel temperature is less than 96°F, flow through the loop should be between 4600 and 6300 pph at idle rpm. Loop flow increases to approximately 7600 pph at military rpm. The cooling loop flow automatically increases approximately 3600 pph as a result of temperature control valve operation when loop fuel temperature is above 96°F. Loop flow and cockpit fuel flow indication are equal until engine consumption becomes greater than flow through the loop. Excess flow is returned to the fuel tanks when engine consumption is less than cooling loop flow.

If the temperature of the mixed cooling loop and incoming engine fuel exceeds 290°F, the temperature control valve starts to close and some of the cooling loop fuel is prevented from mixing with the incoming engine fuel. A pressure-operated valve routes the hot fuel to tank 4. The temperature control valve is completely closed at 300°F and all cooling loop fuel is returned to tank 4. If tank 4 is full, the return fuel will be diverted to the next tank that has space for it. During single engine operation with the inoperative engine throttle in OFF, actuation of the fuel crossfeed valve allows the hot recirculated fuel from the windmilling engine to cross over and mix with the cooling loop and incoming fuel for the operating engine. If within engine consumption requirements and if the mixed fuel temperature is below 290°F, all of the hot fuel will be burned by the operating engine and afterburner. If the mixed fuel temperature is above 300°F, all hot fuel from both engines is returned to tank 4 or to the next tank with space available. Placing the emergency fuel shutoff switch to the shutoff (up) position terminates heat sink fuel to the windmilling engine. When either of the fuel shutoff valves is closed, the corresponding heat sink crossfeed valve is deenergized to prevent fuel circulation through the inoperative engine.

AIR REFUELING SYSTEM

The air-refueling system can receive fuel at approximately 6000 pounds per minute from KC-10 or KC-135 boom-equipped tanker aircraft. Calibrated orifices for each tank allows all tanks to be filled simultaneously in 12 to 15 minutes with a refueling pressure of 65-70 psi. A shutoff pilot valve in each tank terminates refueling flow when the tank or tank group is full. The air refueling system consists of a boom receptacle, receptacle doors, hydraulic valves, hydraulic actuators, a signal amplifier, control switches, and panel indicator lights. The refueling doors are held closed by hydraulic pressure; if hydraulic pressure is lost, as when the engines are shut down on the ground, the doors open by spring action. This enables air refueling if both the L and R hydraulic systems fail. The system normally requires hydraulic actuating power from the L hydraulic system to operate the doors and boom receptacle. If L hydraulic pressure is below 2200 psi, the refueling doors and receptacle can be operated by R system pressure if the brake switch is in ALT STEER & BRAKE. Electrical power is required from the essential dc bus for operation of the controls and indicators.

Unless the SR-71 receiver is using the manual boom latching procedure for refueling (air refueling switch in MAN O'RIDE) the boom will automatically disconnect if fuel pressure exceeds 70 psi. Pressure disconnect is normal when tanks reach full if refueling with a KC-135 tanker. Because the KC-10 refueling system automatically reduces flow to maintain normal refueling pressure, pressure disconnect does not normally occur if refueling with a KC-10 tanker.

FUEL SYSTEM CONTROLS AND INDICATORS

Crossfeed Switch

The push-button crossfeed switch is mounted above the column of fuel boost pump switches. When depressed, a motor operated valve between the left and right fuel manifolds opens to join the two fuel manifolds, so either or both manifolds can feed either or both engines. The fuel heat sink systems are also interconnected. The crossfeed switch must be depressed a second time to terminate crossfeed operation. The legend XFEED illuminates as the valve starts to open and an OPEN legend illuminates when the valve is fully opened. The OPEN legend extinguishes when the valve starts to close, but the XFEED legend remains on until the valve is fully closed. Circuit control power is furnished by the essential dc bus through the fuel CONT circuit breaker on the pilot's left console. Three phase power for the crossfeed valve is furnished by the essential ac bus through circuit breakers in the E bay.

Fuel Boost Pump Switches and Indicator Lights

Six self-illuminated, square plastic fuel boost pump pushbutton switches are installed in a vertical line on the pilot's right instrument side panel. The switches control manual operation of the fuel boost pumps. The switches have an electrical hold and bail arrangement that allows manual selection of only one tank of tank group 1, 2, 3 and one tank of tank group 4, 5, 6 at the same time.

NOTE

> Manual operation supplements, but does not terminate, automatic fuel tank sequencing.

When a set of boost pump relays are actuated, either automatically or manually, a clear numeral on an illuminated green background in the upper half of the pushbutton illuminates. When a tank is empty, an amber EMPTY light in the lower half of the push button illuminates and that pump group stops, unless manually selected.

NOTE

> If all the fuel is used from a manually selected tank, its EMPTY light will not illuminate until the tank which normally turns on that tank is also empty.

Automatic operation of the ullage system pumps 4-1 and 4-2 does not affect the Tank 4 indicator light. The Tank 4 indicator light only illuminates if pump 4-3 or 4-4 (or both) is on. In automatic operation, pumps 4-3 and 4-1 are turned on by individual float switches in Tank 2; and pumps 4-4 and 4-2 are turned on by individual float switches in Tank 5.

When manually depressed, the boost pump switch will hold down electrically and the pumps continue to operate until the pump release switch is pressed. Power for the boost pump switch circuits is furnished by the essential dc bus through the fuel CONT circuit breaker on the pilot's left console. Power for the indicator lights is furnished by the ac hot bus through the INSTR light circuit breaker on the pilot's right console and the FUEL CONT circuit breaker on the light control panel on the pilot's left console.

NOTE

> Pulling the TK 5 TRANS circuit breaker will disable tank 2, 3, and 5 fuel boost pump indicator lights. The fuel boost pumps are not disabled.

Pump Release Switch

A push-button PUMP REL switch is located below the fuel boost pump switches. When the PUMP REL switch is depressed, any boost pump switch that has been manually actuated is released. Power for the circuit is furnished by the essential dc bus through the fuel CONT circuit breaker on the pilot's left console.

CAUTION

A manually selected boost pump should be released when the tank indicates EMPTY.

Tank Lights Test Switch

A push-button tank lights TEST switch, is below the pump release switch. When the switch is depressed, the fuel boost pump lights, crossfeed, pump release, and test lights illuminate. Power is furnished by the ac hot bus through the INSTR light circuit breaker on the pilot's right console and the FUEL CONT TEST circuit breaker on the pilot's light control panel.

Fuel Forward Transfer Switch

The two-position forward transfer switch, labeled FWD TRANS (up) and OFF (down), is located on the pilot's right instrument side panel. If tank 1 is not full, moving the switch to FWD TRANS shuts off all tank 1 boost pumps and opens the forward transfer valve, allowing fuel to transfer into tank 1. Forward transfer is stopped automatically, when tank 1 is full, by the tank 1 "full" float switches; however, tank 1 boost pumps will not resume operation until the forward transfer switch is OFF or tank 4 is almost empty. Power for the circuit is furnished by the essential dc bus through the TK 1 TRANS circuit breaker on the pilot's left console.

Fuel Forward Transfer Light

With S/B R-2691, a FWD TRANSFER light on the RSO's instrument panel illuminates when the fuel forward transfer switch in the forward cockpit is in FWD TRANS. Power for the light is from the TRANS TK1 circuit breaker on the pilot's left circuit breaker panel.

Fuel Aft Transfer Switch

The fuel aft transfer switch, located on the pilot's right instrument side panel, is spring-loaded to the off (up) position. Holding the switch in the down position operates a solenoid controlled valve in the left fuel manifold, if tank 5 is not full, and allows fuel to enter tank 5. If tank 5 is full, the two float switches prevent the solenoid valve from operating. Control power for the manual aft transfer valve solenoid is from the essential dc bus through the TK 5 TRANS circuit breaker on the pilot's left console.

NOTE

Pulling the TK 5 TRANS circuit breaker will disable tank 2, 3, and 5 fuel boost pump indicator lights. The fuel boost pumps are not disabled.

Fuel Dump Switch

A guarded, three-position, lift-lock FUEL DUMP switch is installed on the pilot's right instrument side panel. The switch positions are: EMER (up), FUEL DUMP (center), and a guarded OFF (down) position. The switch must be pulled out and up to move to the EMER position. In the FUEL DUMP position, dual solenoid dump valves in each fuel manifold open to commence dumping. All fuel tanks continue to feed in automatic sequence until tank 1 reaches approximately 4700 pounds, depending on aircraft attitude (see Figure 1-36), then tank 1 boost pumps stop. Fuel pumps in all other tanks continue to operate in automatic sequence until tank 4 reaches approximately 3700 pounds (again, a function of aircraft attitude). At 3700 pounds, fuel dump ceases and, if there is any fuel in tank 1, tank 1 boost pumps will start. With the switch in the EMER position, dumping is identical except that at the 3700 pound level in tank 4, fuel dump does not cease and dumping will continue to empty tanks.

WARNING

Emergency fuel dumping must be terminated by positioning the dump switch to OFF (or FUEL DUMP) or all tanks will empty.

The nominal dump rate is 2500 pounds per minute for both FUEL DUMP and EMER switch positions, but the rate varies with the amount of fuel remaining and the number of boost pumps operating. (Refer to Section II, Fuel Dumping). Power for the circuit is furnished by the essential dc bus through the fuel DUMP CONT circuit breaker on the pilot's left console.

Emergency Fuel Shutoff Switches

Independent emergency fuel shutoff switches for each engine are located on the pilot's right instrument side panel. The switches operate dc powered relays which control ac motor driven gate valves in the engine fuel lines. (See Figure 1-37). When the switches are in the guarded (fuel on) down position, the relays are deenergized and the gate valves are open and held open by the gate valve motors. When a shutoff switch is moved to the up (fuel off) position, its relay is energized and the corresponding gate valve motor closes the valve. Allow three to five seconds for the valve to close and shut off the fuel supply to that engine. This also isolates the fuel cooling loop for that side. (See Figure 1-39.) The valve remains closed as long as the relay is energized. The valve opens if the dc relay is deenergized and ac power is available.

Control power for the emergency fuel shutoff switch relays is provided from the essential dc bus through the L and R ENG SHUT OFF circuit breakers on the pilot's left console. Operating power for the shutoff valve motors is supplied from the essential ac bus through circuit breakers in the E-Bay.

Fuel Quantity Selector Switch

A fuel quantity selector switch is installed on the pilot's right instrument side panel and on the right side of the RSO's instrument panel. The switch has seven positions: TOTAL and six individual tank positions. The position selected determines the indication presented by the quantity gage. Operation of each fuel quantity selector switch and its respective quantity indicator is independent of the other cockpit.

Fuel Quantity Indicator

A fuel quantity indicator is located on the pilot's right instrument side panel and on the RSO's instrument panel. The indicator has a circular scale and a pointer that displays fuel quantity from 0 to 85,000 pounds. A five-digit window indicates fuel quantity to the nearest 100 pounds.

Power for both indicators is furnished by the ac hot bus through individual FUEL QTY circuit breakers in each cockpit.

Fuel Quantity Indicator Characteristics

When the aircraft is on the ground or in stabilized flight and the fuel quantity indicator selector switch is in TOTAL, the indicator should read within 780 lb of the sum of the individual tank readings. When the selector switch is rotated to another position, the indicator may require 8 to 10 seconds to reach a new reading. The normal time required to stabilize for individual tank readings is 1 to 3 seconds.

During forward acceleration or deceleration, or climbs and descents at relatively steep angles, the quantity indicator readings become inaccurate. This becomes apparent when either the forward or aft averaging probe in any tank becomes completely submerged in fuel and cannot compensate for response of the opposite probe. Because no sideslip compensation is provided, uncoordinated turns cause a lower quantity reading. Most malfunctions that affect an individual fuel tank quantity indication also affect total indication, even when the individual tank is empty, but do not influence the readings of the other individual tanks.

NOTE

> Fluctuations of the fuel quantity indications of about 5-percent of full scale can be expected with keying or modulation of the HF transmitter.

Center of Gravity (CG) Indicator

A cg indicator is located on the pilot's right instrument side panel and on the left side of the RSO's instrument panel. The pilot's indicator is connected to the tank fuel quantity sensors and displays aircraft center of gravity location in percent of reference chord (although indicator is marked % MAC). The indicator dial face has 1% scale divisions from 14% to 30% and labels in 2% increments. The RSO's indicator is a repeater.

FUEL QUANTITY AND C.G. INDICATION SYSTEMS

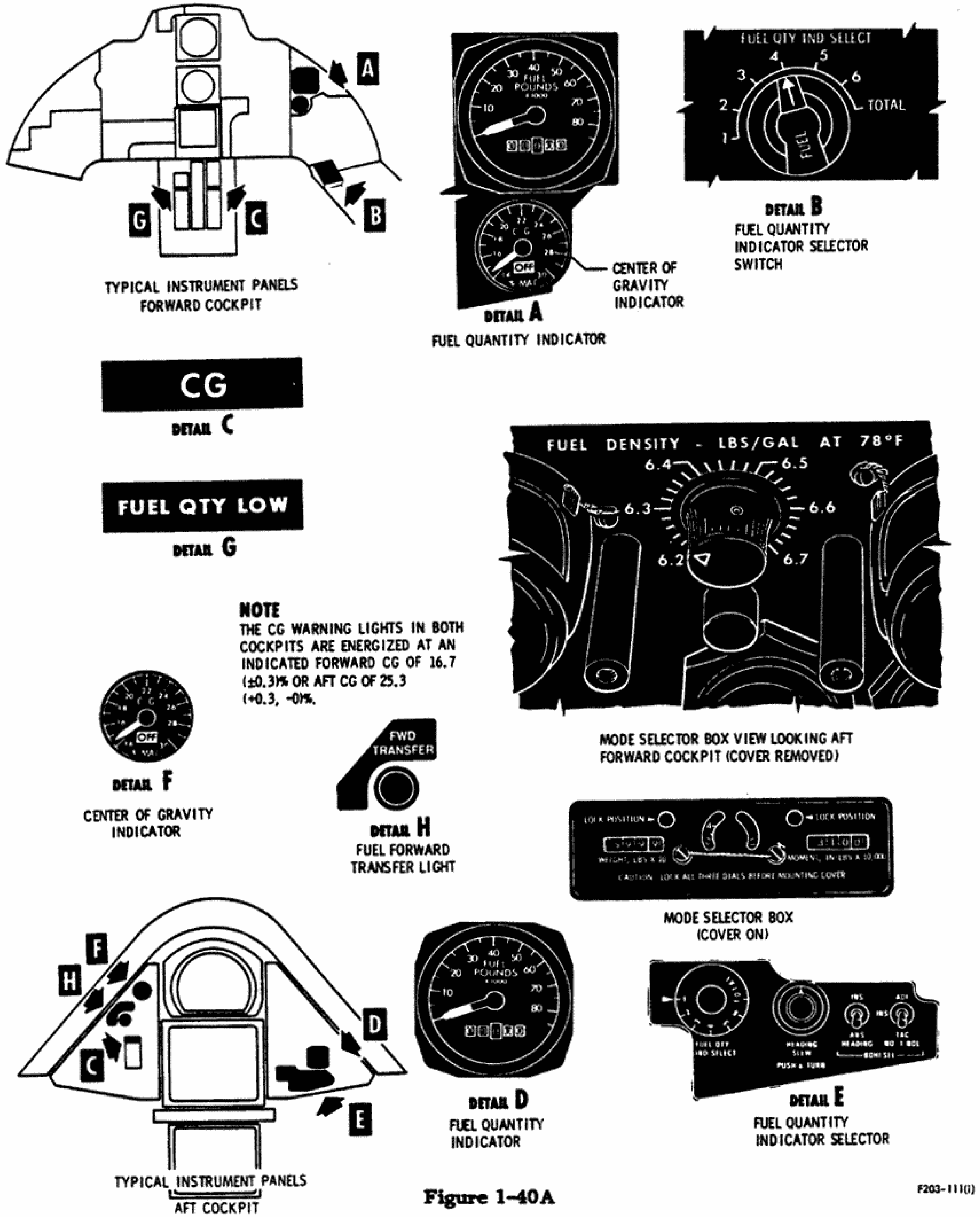


Figure 1-40A

A switch in the forward cockpit indicator causes the CG annunciator warning light in both cockpits to illuminate when cg reaches 25.3% to 25.6% aft cg or 16.4% to 17.0% forward cg. Power is furnished to the indicators by the ac hot bus through a FUEL QTY circuit breaker in each cockpit. An OFF warning flag is displayed only on the affected indicator if power is interrupted. If power to the forward cockpit indicator is lost, cg indication on both indicators will remain at the cg shown at the time of power interruption, but the aft cockpit indicator will not display an OFF warning flag.

NOTE

- An erroneous cg indication can be expected during steady sideslip, as during single-engine operation, when fuel remains in tank 6.
- Fluctuations of the cg indications of about 5 percent can be expected with keying or modulation of the HF transmitter.

CG Indicator Mode Selector

A mode selector for the cg indicator is located on a bulkhead aft and left of the seat in the forward cockpit. Values representing reference fuel density, aircraft weight without fuel, and the corresponding moment value must be set with the mode selector knobs. The mode selector control settings can be viewed by the pilot when entering the aircaft, but re not accessible in flight.

NOTE

The correct cg indicator mode selector settings must be set on the ground to obtain a proper cg indication in-flight. If the correct settings are not made, the cg indicator will appear to operate properly, but will be erroneous, and manual cg computations will be necessary.

Fuel Low Pressure Lights

Warning lights for each engine, labled L and R FUEL PRESS, are located on the pilot's annunciator panel. The light illuminates when fuel pressure in the respective main fuel manifold decreases to less than 7 (± 1/2) psi. The light extinguishes when fuel pressure rises above 10 psi.

NOTE

The L and/or R FUEL PRESS warning light(s) may illuminate sporadically during fuel dumping. The light for the left manifold may illuminate during manual aft transfer when tank sequencing occurs. The light for the right side may illuminate during forward transfer.

Fuel Quantity Low Light

A FUEL QTY LOW caution light on the pilot's annunciator panel is illuminated by the closing of low-level float switches in tanks 1 and 4. The switches are connected in series and both must close to illuminate the caution light. The switch in tank 1 closes when the fuel level has dropped below 4200 pounds at 0 degrees pitch angle and below 5400 pounds at +6.2 degrees pitch angle. The tank 4 switch closes when the fuel level has dropped below 3750 pounds at 0 degrees pitch angle and below 4050 pounds at +6.2 degrees pitch angle. Therefore, the light may illuminate at any condition of tanks 1 and 4 between 3750 pounds (0-degree pitch angle, fuel in tank 4 only) and 9450 pounds (+6.2 degree pitch angle and fuel in both tanks). This light will stay on after initial sensing and may be reset by moving the refuel switch to AIR REFUEL, then to OFF.

Fuel Tank Pressure Indicator

A fuel tank pressure indicator is installed on the pilot's right instrument side panel. The gage senses tank 3 pressure, which is common to all tanks, and is marked from -2 to +8 in increments of 1 psi. Power is supplied by the essential ac bus 26 volt instrument transformer through the FUEL TK PRESS circuit breaker on the pilot's annunciator panel.

Fuel Tank Low Pressure Light

A TANK PRESS warning light is located on the pilot's annunciator panel. The light illuminates when tank pressure is less than +0.25 psi.

Liquid Nitrogen Quantity Indicators

Two liquid nitrogen quantity indicators are installed on the pilot's right instrument side panel.

The dual needle lower indicator displays the quantity of liquid nitrogen remaining in the system 1 and system 2 Dewar flasks. The indicator is marked in 5-liter increments from 0 to 110 liters. When the indicators and warning lights test button (IND & LT TEST) is depressed, the quantity indicator needles move toward zero. Power for the indicator is furnished by the essential dc and ac busses through four circuit breakers. Two, labeled N2 QUAN NO 1 and NO 2, are located on the pilot's left console, and two labeled N QTY NO 1 and NO 2 are located on the pilot's right console.

NOTE

The Dewar flasks may deplete at an unequal rate.

A second liquid nitrogen quantity gage is installed above the dual needle indicator. The gage is marked LIQ N and displays the quantity of liquid nitrogen remaining in the system 3 Dewar flask. The dial is marked in 10 liter increments from 0 to 50 liters. Fluctuations of the gage are normal. The instrument indication is not affected by operation of the indicators and warning lights test button. Power is furnished from the essential dc bus through a circuit breaker in the C-Bay.

Nitrogen Quantity Low Indicator Lights

Two nitrogen quantity low caution lights, one for each system, are located on the pilot's annunciator panel. The lights are labeled SYS 1 N QTY LOW and SYS 2 N QTY LOW. When illuminated, the respective nitrogen quantity is less than 3 liters. Operation of the lights can be checked by depressing the indicators and warning lights test button until the quantity gauge indicates below 3 liters. When the test button is released, the nitrogen quantity low lights will remain illuminated momentarily.

NOTE

- If necessary, loiter in accordance with emergency procedures to cool the fuel tanks if LN_2 has been depleted. Cooling is not required if speed has not exceeded Mach 2.6.
- There is no caution light to indicate depletion of the system 3 liquid nitrogen supply.

Air Refuel Switch

An air refuel switch, located at the top of the pilot's instrument panel, has three positions: AIR REFUEL (up), OFF (center), and MAN O'RIDE (down). When the switch is placed in the AIR REFUEL or MAN O'RIDE position, the refueling door opens, the receptacle lights illuminate, and the READY light in the air refuel reset switch illuminates. In AIR REFUEL, the boom latches are automatically armed. In MAN O'RIDE, opening and closing of the boom latches must be controlled manually by the air refuel disconnect trigger switch.

CAUTION

Before opening or closing the refueling door, ensure that the probe is clear.

Air Refuel Reset Switch and Indicator Light

A dual-indicating, self-illuminating push-button switch, labeled PUSH TO RESET, is located on the top of the pilot's instrument panel. The upper half of the push-button switch illuminates green and displays the word READY when the air refuel ready switch is in either AIR REFUEL or MAN O'RIDE and the refueling system signal amplifier is on. The READY light extinguishes when the boom is seated and latched. If the boom disconnects from the refueling receptacle, the lower half of the push-button switch illuminates amber and displays DISC. The push-button switch must then be depressed (or the air refuel switch recycled) to illuminate READY before the boom can be reengaged. The READY light illuminates and the DISC light does not illuminate when a disconnect occurs while refueling in MAN O'RIDE.

Air Refuel Disconnect Trigger Switch

The trigger switch on the forward side of the control stick grip can be used to disconnect the refueling boom.

When refueling with the air refuel switch in MAN O'RIDE, the trigger switch is used to open and close the boom latches. Depressing the trigger switch opens the boom latches and holding it depressed keeps the boom latches open. When the boom is seated, the READY light extinguishes and the switch can be released to close the boom latches, locking the boom in the receptacle.

ELECTRICAL SYSTEM

Electrical power is normally supplied by two ac generators, rated at 60 KVA each. The generators are mechanically driven by their respective engines through constant speed drive (CSD) units and operate in parallel. They provide 115/200 volt, 4C0-cycle, three-phase power to five ac buses and to two, two-hundred ampere transformer-rectifiers (T-Rs). Three 28-volt dc buses are normally energized by these T-Rs. Either generator is capable of supplying the normal ac and dc power requirements of the aircraft. Figure 1-44 shows the ac and dc power supplies, control circuits, and power distribution system.

The electrical system operates automatically and the protective features and the emergency dc system are automatically available after the generators have been set and the batteries switched on. An emergency ac generating system is provided which may be available after some types of electrical system failures. It must be selected manually, using the generator control switches.

Electrical system back-up controls provided in the forward cockpit for emergency conditions include the generator bus tie, instrument inverter, and emergency ac bus switches. Seven caution lights indicate: generator(s) out, generator bus tie open, transformer-rectifier(s) out, instrument inverter on, and emergency battery on.

BATTERIES

Two 25 ampere-hour batteries are provided for emergency service. If both generators are off or inoperative, or both transformer-rectifiers fail, each battery individually supplies one of the two essential dc buses. The battery relays will not engage unless sufficient charge remains in the No. 1 battery.

The No. 1 battery energizes the No. 1 essential dc bus, which supplies the SAS pilot valves. It also energizes the emergency ac bus through an instrument inverter, rated at 1 KVA. See Emergency DC Power Supply, Figure 1-46.

The No. 2 battery energizes the No.2 essential dc bus which supplies SAS control power, DAFICS computers, and all other essential dc system loads. The No. 2 battery is always connected to the BAILOUT and PILOT EJECTED warning lights, regardless of the battery switch position.

The maximum duration of the dual-battery power system is approximately 40 minutes if unnecessary equipment is turned off. Figure 1-43 lists power requirements of equipment energized from the essential dc buses.

EMERGENCY AC POWER SYSTEM

Each main generator has an emergency operating mode which may be available if neither generator will function normally. To be usable, the generator(s) selected must still be rotating with intact windings. Then, setting the system to the emergency mode may generate usable, but unregulated, ac power. There is no control of voltage or frequency in the emergency mode since generator speed is not governed and the No. 2 battery provides direct excitation of the generator field. If either generator is operating in EMER, the bus tie will open. Emergency ac power is applied directly to the ac hot bus and to the generator bus associated with that engine. See Figure 1-45.

CAUTION

In-flight, do not operate either generator in EMER unless both generators have failed.

Primarily, the emergency ac system will supply power for the fuel boost pumps and will power the ac hot bus to provide fuel transfer, cross-feed, and pitch axis trim capability. It also supplies power to the corresponding T-R unit and, if sufficient voltage is generated, the dc buses will be powered by the T-R. With neither generator operating in NORM, the emergency ac bus is energized by the No. 1 essential dc bus through the instrument inverter and the essential ac bus is dead; the monitored dc bus is also dead.

If sufficient ac generator voltage is not available to the T-Rs, the essential dc buses and the instrument inverter will be powered by the batteries.

WARNING

During emergency ac operation, the normal automatic fuel sequencing system is disabled and the pilot must manually select tanks. The automatic aft transfer and ullage systems are inoperative. Normal generator fault protection is not provided.

EXTERNAL POWER

An external power receptacle in the nosewheel well accepts a six-wire type cable connection from an MD-3 or MD-4 (or equivalent) ground support unit. The supply must provide 115-120/200-208 volt, 400-cycle, three-phase ac power with A-B-C phase rotation, and 28 volt dc power. (The 28 volt dc supply only energizes the aircraft external power relay. Aircraft dc power is obtained from the external ac supply through the ship's T-R units.)

Transfer to Internal Power

The aircraft generator switches are ineffective when the engines are stopped. Normally, the generator switches are set to NORM after the engines start. The generators remain disengaged until the right engine CSD reaches a speed which allows its generator to synchronize with the frequency and phasing of the external supply. However, if the generator switches are set to NORM before the engines are started, the resulting paralleling transient may cause the ANS to trip off. The external power contactor is automatically opened when the right engine reaches a parallel condition with the external supply and the generator line contactor closes. The external power connector can be removed after this occurs, but its removal is normally delayed until both generators are on-line and the system operating normally - a condition indicated by all seven electrical system caution lights being off.

CIRCUIT BREAKER PANELS - Fwd Cockpit

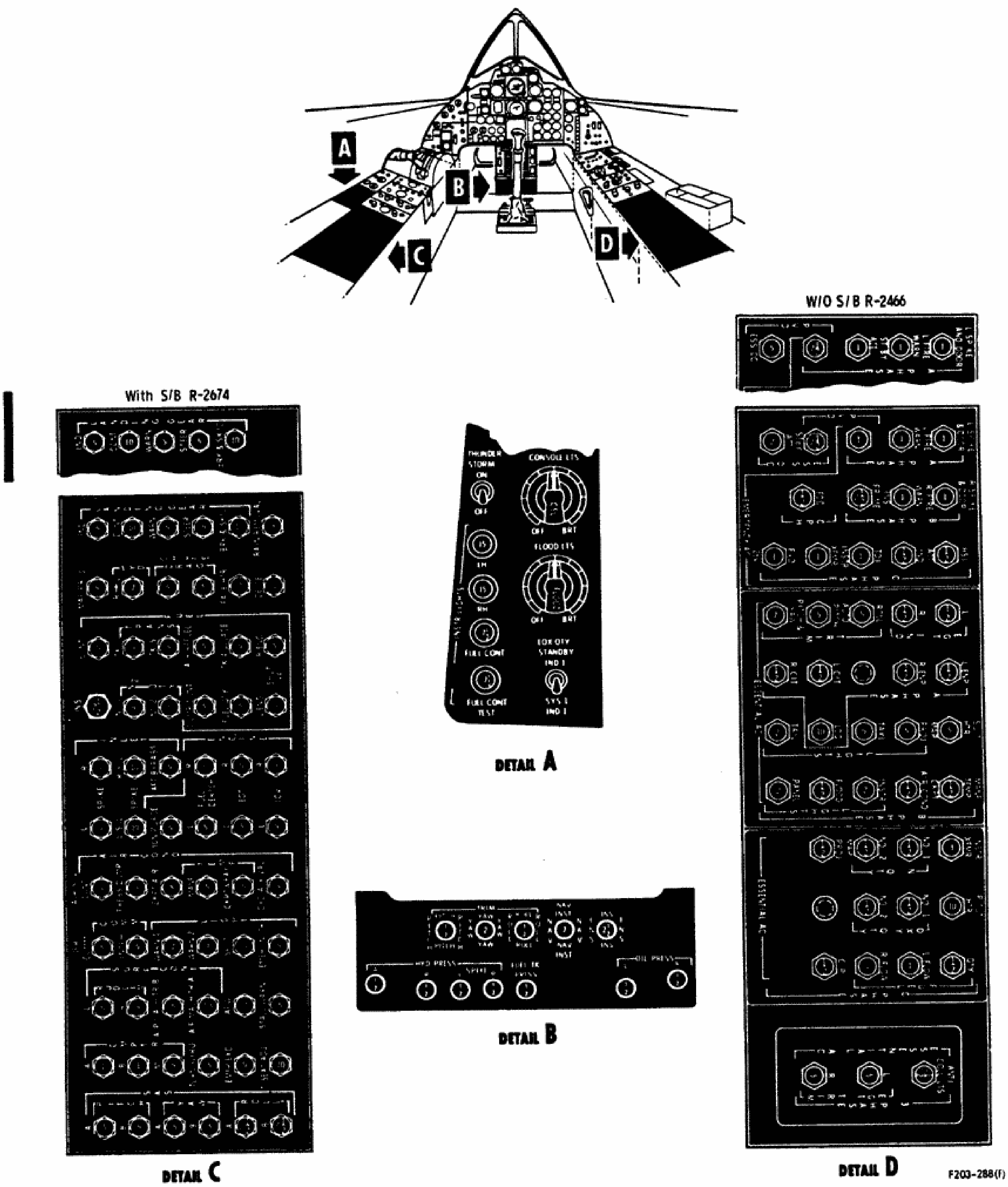
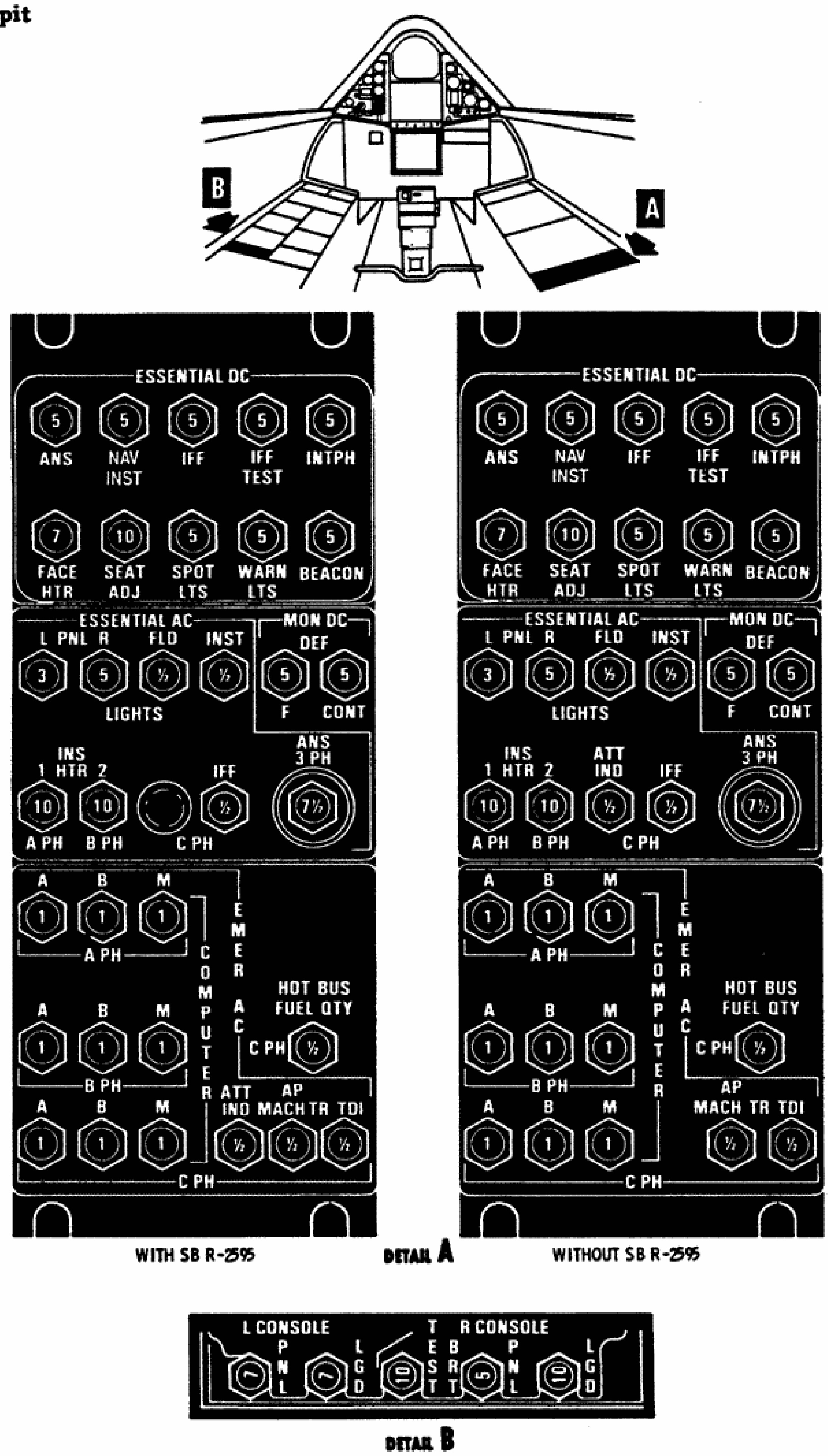


Figure 1-41

CIRCUIT BREAKER PANEL
Aft Cockpit



DETAIL B

F203-292(c)

Figure 1-42

The left engine generator automatically synchronizes its output with the right generator, then its contactor closes and the generators operate in parallel. If the right generator is not on line, the left generator can be set in NORM, but it may not parallel the external power supply and it will not come on line until external power is disconnected or shut off. A momentary power surge can result if the phasing is not synchoronized. The L GEN OUT caution light will remain on until power is transferred.

Engine starting without external electrical power is possible, but not recommended. Instrument indications, including EGT, require essential ac bus power and would not be available until the generators are turned on.

CIRCUIT BREAKERS

Circuit breaker panels, located in the forward and aft cockpits, contain pullout/push-to-reset breakers for certain ac and dc circuits. See Figures 1-41 and 1-42. Services interrupted by opening these circuit breakers are listed by Figure 1-47. Other circuit breaker panels which are not accessible during flight are located in the C and E bays.

Differential Protection Relays

A differential protection relay (DPR) is a part of each generator system. The DPRs provide automatic protection by disconnecting the associated generator for a significant fault within the generator, in the generator feeder lines (to the buses), and/or in the generator line contactors.

ELECTRICAL SYSTEM CONTROLS AND INDICATOR LIGHTS

Generator Switches

A 3-position lift-loc control switch for each generator is located on the pilot's right instrument side panel. The switch positions are NORM (down), OFF (center), and EMER (up). Placing either switch in NORM will return the respective generator to normal operation if it has been removed from the bus for any reason other than generator or system failure. The NORM position is locked to prevent accidental actuation to OFF or EMER. In OFF, the corresponding generator is removed from service.

NOTE

> If its protective circuits trip a generator and it does not reset automatically, the generator switch must be moved to OFF and then back to NORM to attempt a manual reset.

In EMER (used when both generators have failed), a 28 volt dc excitation current from the essential dc bus is applied to the respective generator exciter fields through a single 5 amp EMER EXC circuit breaker. If the generator is rotating and the windings are operative, an unregulated voltage and frequency ac current is developed which will power the hot bus and corresponding generator bus. The essential ac bus will be dead. Extinction of the corresponding L and/or R GEN OUT light(s), after selecting EMER, indicates successful emergency system operation. The corresponding L and/or R XFMR RECT OUT light may extinguish; if this occurs, the EMER BAT ON light will extinguish if either the battery voltage is exceeded by the transformer-rectifier output, or the battery output is less than 10 amperes.

Bus Tie Switch

A push-button bus tie switch is located on the pilot's right instrument side panel. If the GEN BUS TIE OPEN light illuminates simultaneously with indication of generator failure, depressing the switch should retie the L and R generator buses and extinguish the light, if the failure was in the generator or its control system.

ELECTRICAL LOAD ANALYSIS WHEN NO AC GENERATOR AVAILABLE

DC ESSENTIAL BUS ITEM	POSSIBLE LOAD IN AMPERES	CAN BE USED OR TURNED OFF BY SWITCH	CAN BE USED OR TURNED OFF BY CB	CANNOT BE USED-TURNED OFF BY SWITCH	CANNOT BE USED-TURNED OFF BY CB
AIR REFUEL	1.20	X			
AIR SHUTOFF CONTROL	2.80	X			
APW	2.50	X			
AUTOPILOT/MACH TRIM A	0.30		X		
AUTOPILOT/MACH TRIM B	0.30		X		
BRAKE AND SKID	1.60	X			
COCKPIT AIR	0.10		X		
COCKPIT AND BAY TEMP	0.30	X			
COMNAV-50	2.75			X	
COMPUTER A	0.20		X		
COMPUTER B	0.20		X		
COMPUTER M	0.20		X		
DRAG CHUTE	3.00	X			
EGT TRIM, L AND R	1.00		X		
EMER FUEL S/O, L AND R	0.40			X	
EMER GEN EXCITER	1.00	X			
FACE HEAT	0.88	X			
FUEL CONTROL	0.40				X
FUEL DERICH, L AND R	2.40		X		
FUEL DUMP	2.30				
FUEL FWD TRANSFER	1.50	X	X		
FUEL TANK 5 TRANSFER	2.40				X
GROUND AIR VALVES	0.70				X
IFF	0.18			X	
IFR INTERCOMM	0.07		X		
IGNITER PURGE, L AND R	2.00	X			
ILS	1.83	X			
INLET AFT BYPASS, L AND R	4.00		X		
INLET GUIDE VANES	0.08				
INS	2.00	X	X		
INSTRUMENT INVERTER	28.50	X			
INTERPHONE	0.32		X		
LANDING GEAR CONTROL			X		
LANDING GEAR INDICATORS			X		
LANDING GEAR WARNING			X		
LN_2 QUANTITY, NO. 1 AND NO. 2	2.00				X
MANIFOLD TEMP	1.30		X		
NAVIGATION INSTRUMENTS	0.86		X		
NAVIGATION SYSTEM					X
NOSE STEERING	2.15				X
PILOT VALVES	0.00				

Figure 1-43 (Sheet 1 of 2)

ELECTRICAL LOAD ANALYSIS WHEN NO AC GENERATOR AVAILABLE (CONT.)

DC ESSENTIAL BUS ITEM	POSSIBLE LOAD IN AMPERES	CAN BE USED OR TURNED OFF BY SWITCH	CAN BE USED OR TURNED OFF BY CB	CANNOT BE USED-TURNED OFF BY SWITCH	CANNOT BE USED-TURNED OFF BY CB
PITOT HEAT	0.00			X	
PRESSURE DUMP	0.40	X			
RAIN REMOVAL (W/O S/B 2674)	1.50	X			
RUDDER LIMITER, L AND R	3.30	HANDLE			
SAS A	8.80	X	X		
SAS B	8.80	X	X		
SEAT ADJUST	5.00	X			
SPIKE AND DOOR POS. IND.	0.80		X		
SPIKE CONTROL L	1.00		X		
SPIKE CONTROL R	1.00		X		
SPIKE SOL L	3.50		X		
SPIKE SOL R	3.50		X		
SPOT LIGHTS	0.36	X			
STALL WARNING	0.15		X		
STANDBY ATT. IND., 3-INCH	2.00		X		
TACAN (ARN-118)	2.00			X	
TANK 4 ULLAGE	0.15				X
T-STORM LIGHTS	1.43	X			
TURN AND SLIP INDICATOR	0.25		X		
UHF ANTENNA ACTUATOR	3.50	X			
VHF (ARC-186)	2.96	X			
WARNING LIGHTS	1.41		X		
WINDSHIELD DEICE	0.70	X			

EMERGENCY AC BUS ITEM	POSSIBLE LOAD IN VA	CAN BE USED OR TURNED OFF BY SWITCH	CAN BE USED OR TURNED OFF BY CB	CANNOT BE USED-TURNED OFF BY SWITCH	CANNOT BE USED-TURNED OFF BY CB
ANGLE OF ATTACK IND.	5.00				
ATTITUDE DIRECTOR IND.	20.00		X		
ATTITUDE IND-RSO (S/B 2595)	20.00		X		
AUTOPILOT/MACH TRIM	30.00		X		
COMPUTER A	124.00		X		
COMPUTER B	124.00		X		
COMPUTER M	124.00		X		
EMER INSTR TRANSFORMER	18.20		X		
FIRE WARNING, L AND R	2.20		X		
HSI	50.00		X		
INLET, L	20.00		X		
INLET, R	20.00		X		
INS	220.00	X			
PITCH INDICATOR	0.21		X		
STANDBY ATT. IND., 2-INCH	13.20		X		
TDI	39.00		X		

Figure 1-43 (Sheet 2 of 2)

ELECTRICAL POWER DISTRIBUTION

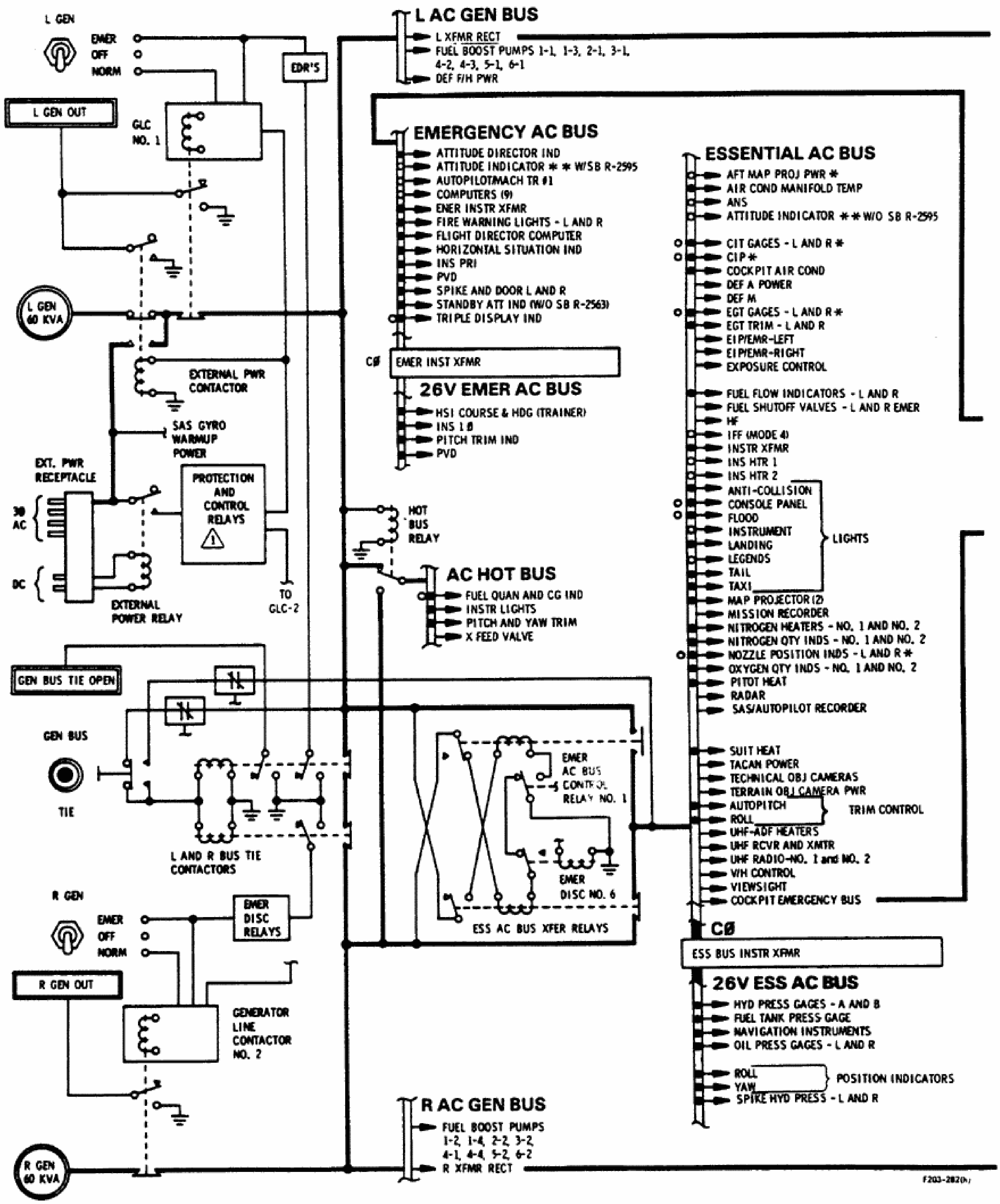


Figure 1-44 (Sheet 1 of 2)

ELECTRICAL POWER DISTRIBUTION

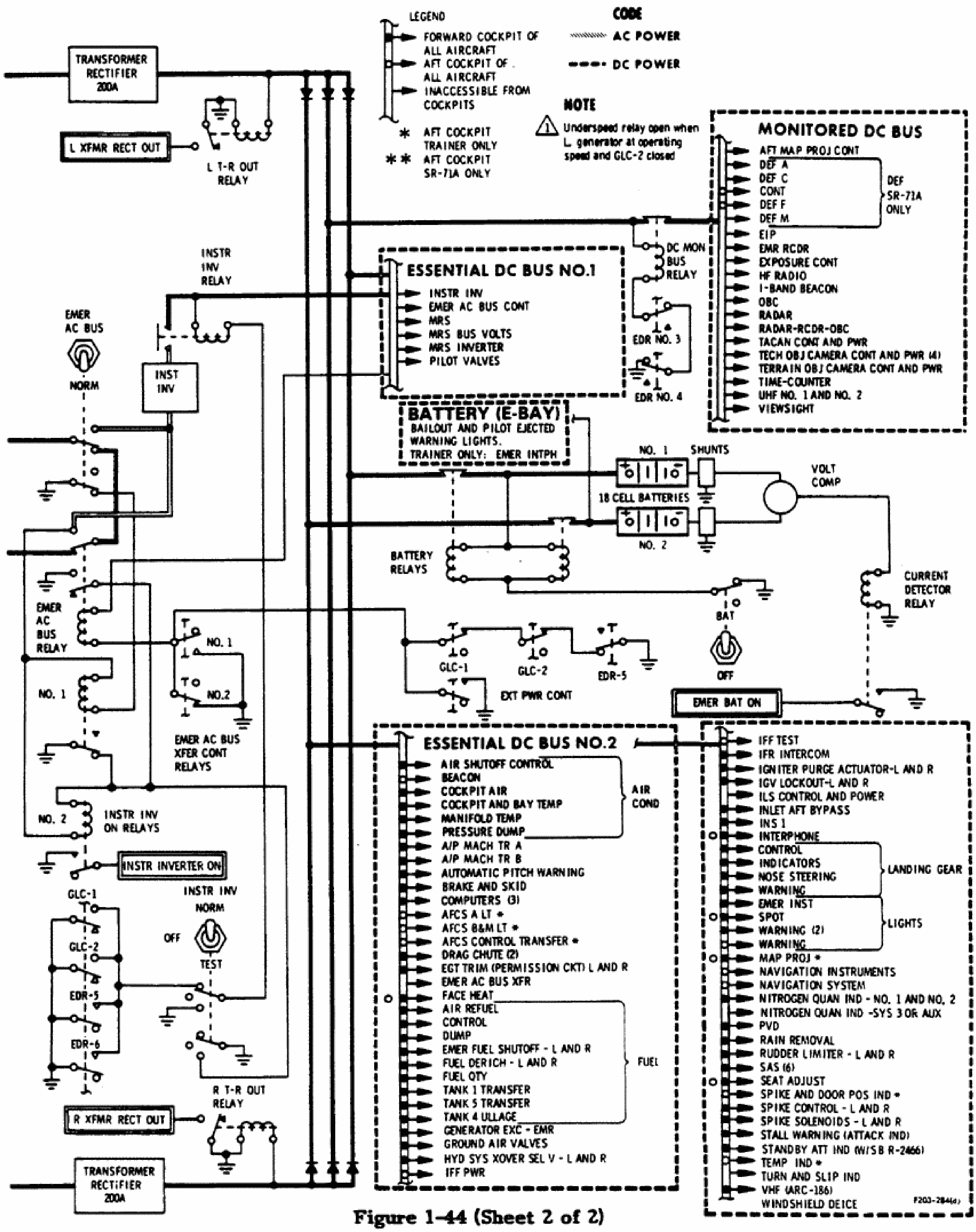


Figure 1-44 (Sheet 2 of 2)

SECTION I

EMERGENCY AC POWER SUPPLY

LEGEND
- FORWARD COCKPIT
- AFT COCKPIT
- INACCESSIBLE FROM COCKPIT

NOTE

Powered circuits are shown energized. Inoperative buses are not shown.

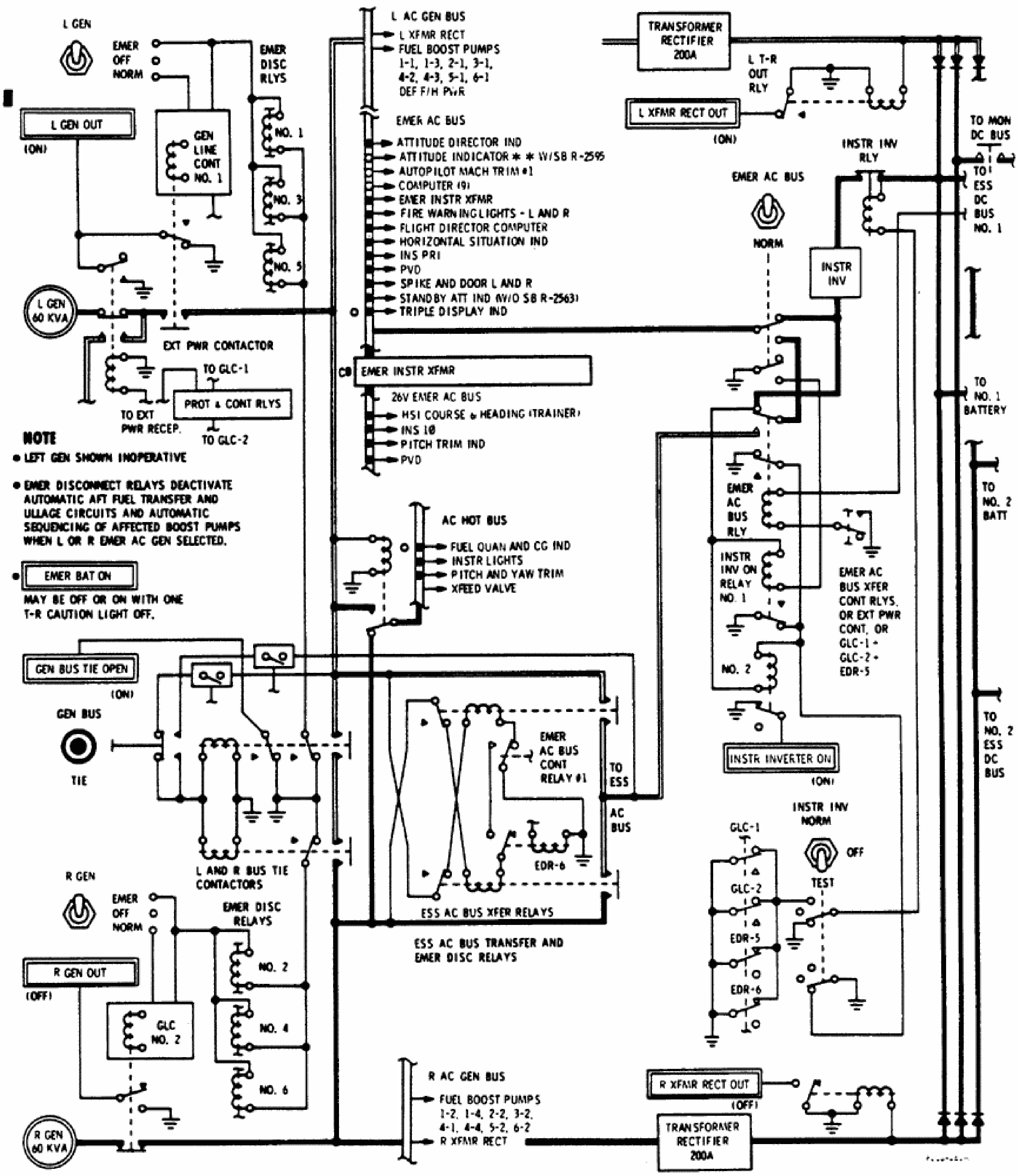


Figure 1-45

EMERGENCY DC POWER SUPPLY

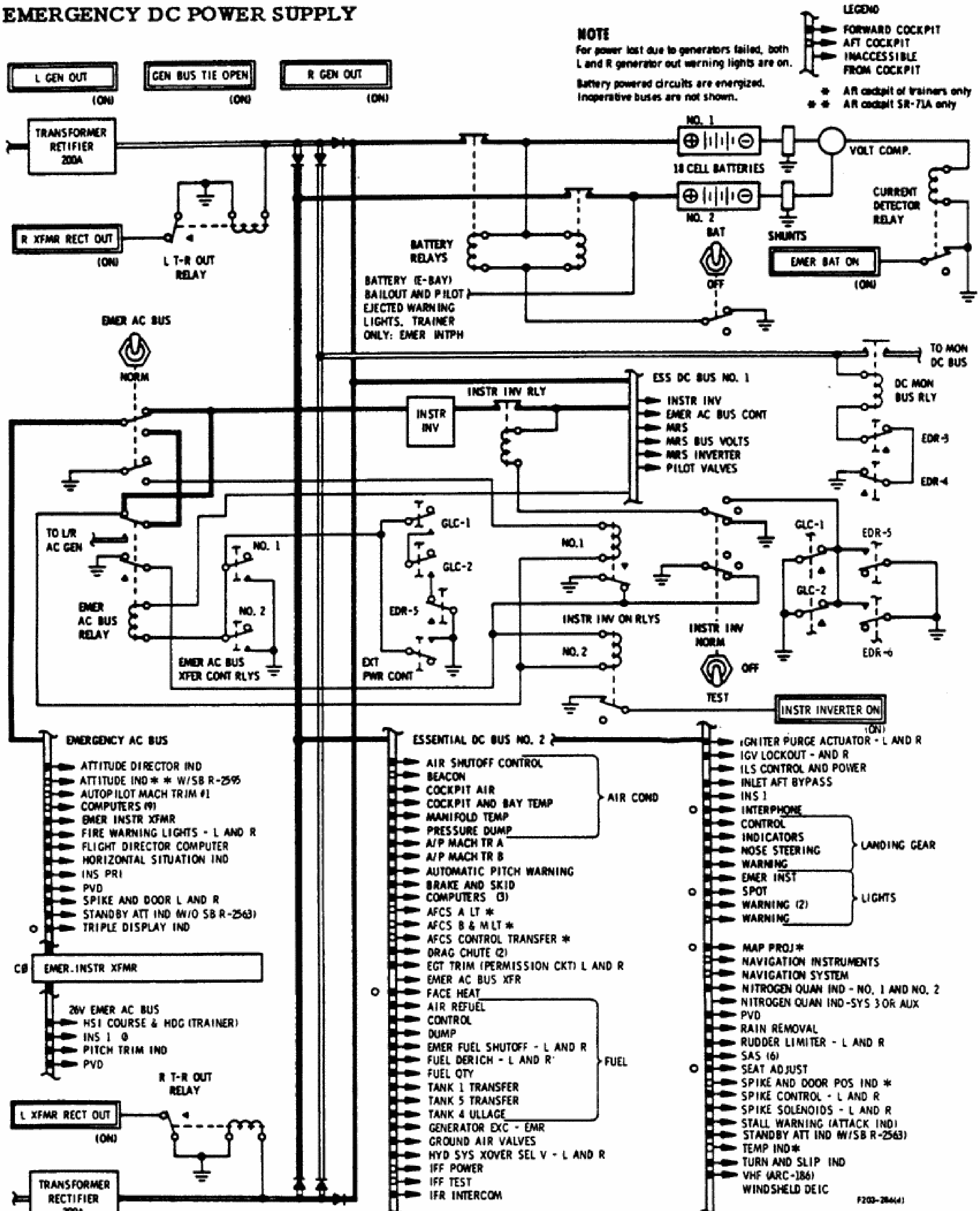


Figure 1-46

NOTE

If the bus tie switch is depressed during normal electrical system operation, or if the GEN BUS TIE OPEN light illuminates during normal generator operation, the bus tie contactors will open and cannot be retied in-flight. The generators will still supply power, but will no longer be operating in parallel.

Battery Switch

A two-position battery switch is located on the pilot's right instrument side panel. In BAT (up), the batteries will supply power to the essential dc busses (and the instrument inverter) if both generators or both transformer-rectifiers fail.

Instrument Inverter Switch

The instrument inverter switch is located on the pilot's right instrument side panel. The switch has three positions: NORM (up), OFF (center), and TEST (down).

In NORM, the instrument inverter is in a standby status during normal flight. The failure of either generator or placing either generator switch to OFF or EMER (or placing the instrument inverter switch to TEST) energizes the instrument inverter by closing the instrument inverter relay to the essential dc bus; however, the instrument inverter will not supply power to the emergency ac bus until the emergency ac bus relay operates. This occurs if both generators are inoperative (or OFF) or if all ac power is supplied by generator(s) in EMER.

In TEST, the instrument inverter is energized as indicated by illumination of the INSTR INVERTER ON light.

In OFF, the instrument inverter is not energized automatically. However, the inverter is energized if the emergency ac bus switch is in EMER AC BUS.

Emergency AC Bus Switch

A two-position lift-loc emergency ac bus switch is located on the pilot's right instrument side panel. In NORM (down), the emergency ac bus is automatically energized by the instrument inverter if both generators are failed (or OFF), or if all ac power is suppplied by generator(s) in EMER.

In EMER AC BUS (up), the instrument inverter is energized (by closing the instrument inverter relay to the essential dc bus) and the instrument inverter output is connected directly to (and energizing) the emergency ac bus (bypassing the emergency ac bus relay). The switch should be placed in EMER AC BUS to energize the inverter and supply power to the emergency ac bus if the INSTR INVERTER ON caution light does not illuminate with dual generator failure or if the emergency ac bus is not receiving power.

Transformer-Rectifier Out Caution Lights

L or R XFMR RECT OUT caution lights on the pilot's annunciator panel illuminate when the respective transformer-rectifier is not furnishing dc power.

Generator Bus Tie Open Caution Light

A GEN BUS TIE OPEN caution light on the pilot's annunciator panel illuminates when the bus tie contactors connecting the L and R ac generator buses have opened and the generators are no longer operating in parallel.

Instrument Inverter On Caution Light

An INSTR INVERTER ON caution light on the pilot's annunciator panel illuminates when the instrument inverter is energized by placing the instrument inverter switch to TEST, or when the emergency ac bus is powered by the instrument inverter.

Emergency Battery On Caution Light

An EMER BAT ON caution light on the pilot's annunciator panel illuminates when the

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	EFFECT OF POWER INTERRUPTION
	ESSENTIAL DC BUS (Forward Cockpit)
LANDING GEAR	
IND	Disabled: Landing gear indicator lights. Depress gear solenoid release button to move gear handle from DOWN to UP. Landing and tail lights will illuminate, if selected, while nose gear is up.
CONT	Disabled: Landing gear retraction, normal gear extension, normal nosewheel steering system.
WARN	Disabled: Lights in gear handle, pulse tone from gear warning horn.
STEER	Disabled: Nosewheel steering control switch (CSC/NWS) on control stick, and normal and alternate steering systems.
BRK & SKD	Disabled: High α system stick shaker, anti-skid brakes, alternate brake system, alternate nose wheel steering system.
RAIN REMOVAL	Disabled: Windshield rain removal system. Valve closes, if open.
MAP PROJ	Disabled: Pilot's map projector.
HYD R→L	Disabled: Hydraulic system crossover for gear retraction, alternate nosewheel steering system, aerial refueling with power from R hydraulic system.
DRAG CHUTE (2)	Disabled: Drag chute system if <u>both</u> breakers open.
FACE HTR	Disabled: Helmet face heat, forward cockpit.
DEICE	Disabled: Windshield deice system.
FUEL	
CONT	Disabled: Manual boost pump selection. Fuel crossfeed valve will close, if open. Fuel system reverts to automatic sequencing.
TRANS	
TK 1	Disabled: Forward fuel transfer. Transfer valve will close, if open.
TK 5	Disabled: Aft fuel transfer, manual and automatic. Also tank 2, 3, and 5 boost pump indicator lights.
AIR REFUEL	Refuel door opens, as energized circuit required to close door.
TK 4 ULLAGE	System will not sense fuel high level condition in tank 4 to start ullage pumps in that tank.
DUMP CONT	Disabled: Fuel dump valves. Valve will close, if open.
FUEL QTY	Disabled: Forward and aft cockpit fuel quantity and c.g. indicators.
SHUTOFF - L ENG	Disabled: Left engine fuel shutoff. AC power will open the valve, if closed. Left heat sink crossfeed will open, if closed.
SHUTOFF - R ENG	Disabled: Right engine fuel shutoff. AC power will open the valve, if closed. Right heat sink crossfeed valve will open, if closed.
INS	Disabled: Holding power for warning flag at top of ADI, flag comes in view but displayed information is still valid.
N2 QTY	
NO 1	Disabled: SYS 1 N QTY LOW light, LN_2 crossfeed valve, No. 1 LN_2 Dewar heater.
NO 2	Disabled: SYS 2 N QTY LOW light, No. 2 LN_2 aft regulator solenoid (will not sense low tank pressure), No. 2 LN_2 Dewar heater.
INLET	
SPIKE - L	Disabled: Left and right inlet forward bypass position indications, left inlet automatic control and left inlet unstart light.
SPIKE - R	Disabled: Left and right inlet spike position indications, right inlet automatic control and right inlet unstart light.

Figure 1-47 (Sheet 1 of 7)

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	EFFECT OF POWER INTERRUPTION
	ESSENTIAL DC BUS (Forward Cockpit - Cont.)
INLET (cont.)	
SPIKE - L SOL	Disabled: Left spike and door override solenoids. Open fwd bypass manually when landing.
SPIKE - R SOL	Disabled: Right spike and door override solenoids. Open fwd bypass manually when landing.
	Note: For the respective inlet, if the SPIKE SOL circuit breaker is open: the spike only moves 15 inches forward of auto schedule when restart ON is selected or the throttle restart switch is set to the aft position; the center position of the throttle restart switch is inoperative; if manual spike is selected, all normal manual restart capability is lost; 30,000 foot and Mach 1.4 switch for spike and Mach 1.4 switch for forward bypass door are inoperative. Forward bypass remains closed when gear is extended.
AFT BYPASS	Disabled: Left and right inlet aft bypass position control. Doors remain as set.
ENGINE	
IGN PURGE	Disabled: Chemical ignition system (TEB) tank dump.
FUEL DERICH - L	Disabled: Left engine fuel derich system.
FUEL DERICH - R	Disabled: Right engine fuel derich system.
EGT - L	Disabled: Left engine automatic EGT trim system permission circuit, and EGT autotrim.
EGT - R	Disabled: Right engine automatic EGT trim system permission circuit, and EGT autotrim.
IGV - L	Disabled: Left engine IGV lockout solenoid. Goes to unlocked condition.
IGV - R	Disabled: Right engine IGV lockout solenoid. Goes to unlocked condition.
AIR COND	
AIR SOV CONT	Disabled: Shutoff controls for L and R air conditioning systems, left and right mission bays, and nose section. Valves remain in set positions. Air conditioning continues if refrigeration switches are on when c/b opens.
PRESS DUMP	Disabled: Cockpit pressure dump valve. Valve closes, if open.
CKPT AIR	Disabled: Cockpit automatic and manual temperature controls and defog control.
TEMP	
MANF	Disabled: Manifold temperature control valve, full cold selection, hot air bypass system, ANS flow limiting valve.
CKPT & BAY	Disabled: Temperature indication for cockpit, R-Bay and E-Bay.
GRD AIR VAL	Disabled: L and R forward mission bay ground air shutoff valves.
COMM	
IFR COMM	Disabled: Air refueling system boom communication amplifier.
INTPH	Disabled: All audio to forward cockpit headset (except trainer EMERG ICS).
LIGHT	
WARN 1	Disabled: All forward cockpit warning and caution lights except nacelle fire, inlet unstart, and landing gear warning lights and lights on WARN 2 circuit breaker.
WARN 2	Disabled: KEAS warning, RSO ejected, both IGV, both Derich and A/P off lights.
SPOT	Disabled: Forward cockpit spot lights and flex point lights, thunderstorm lights, altimeter vibrator.
EMER INSTR	Disabled: Instrument panel emergency lighting circuit.
RUD LIM	
L	Disabled: Full deflection of left rudder. 10° available.
R	Disabled: Full deflection of right rudder. 10° available.

Figure 1-47 (Sheet 2 of 7)

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	EFFECT OF POWER INTERRUPTION
	ESSENTIAL DC BUS (Forward Cockpit – Cont.)
A/P MACH TR A	Autopilot redundancy is lost and Mach Trim redundancy is reduced.
A/P MACH TR B	Autopilot redundancy is lost and Mach Trim redundancy is reduced. NOTE • To disable the Autopilot, both A/P MACH TR A & B circuit breakers must be opened. • To disable Mach Trim, both A/P MACH TR A & B circuit breakers and the CMPTR M circuit breaker must be opened.
APW	Disabled: APW pusher and shaker. High α system shaker not affected.
STALL WARN	Disabled: High α warning system.
CMPTR	
A	Disabled: A computer.
B	Disabled: B computer.
M	Disabled: M computer, Mach trim redundancy is reduced.
TURN GYRO	Disabled: ADI turn rate indication.
EMER EXC	Disabled: Emergency generator DC exciter system.
SEAT ADJ	Disabled: Forward cockpit seat adjustment. Seat remains as set.
SAS	
PITCH	
A	Disabled: SAS Pitch A servos (left and right engage solenoids).
B	Disabled: SAS Pitch B servos (left and right engage solenoids).
YAW	
A	Disabled: SAS Yaw A servos (left and right engage solenoids).
B	Disabled: SAS Yaw B servos (left and right engage solenoids).
ROLL	
A	Disabled: SAS Roll A servo (left engage solenoid).
B	Disabled: SAS Roll B servo (right engage solenoid).
PVD (on RH Console)	Disabled: PVD.
STBY ATT (on RH Console)	Disabled: 3-inch standby attitude indicator gyro.
	EMERGENCY AC BUS (Forward Cockpit)
L SPIKE AND DOOR (AØ)	Disabled: Left inlet spike and forward bypass controls and position indications. Mechanical bias within servos programs spike full forward and forward bypass door full open. Indications freeze.
L FIRE WARN (AØ)	Disabled: Left nacelle fire warning system.
STBY ATT (AØ)	Disabled: 2-inch standby attitude indicator gyro.
PVD (AØ)	Disabled: PVD.

Figure 1-47 (Sheet 3 of 7)

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	Phase	EFFECT OF POWER INTERRUPTION
		EMERGENCY AC BUS (Forward Cockpit - Cont.)
R SPIKE AND DOOR	BØ	Disabled: Right inlet spike and forward bypass controls and position indications. Mechanical bias within servos programs spike full forward and forward bypass door full open. Indications freeze.
R FIRE WARN	BØ	Disabled: Right nacelle fire warning system.
INS PRIME	BØ	Disabled: Primary INS operate power and INS segment (display) lights. INS operates until INU battery reaches 18 volts, then shuts down.
FDC	CØ	Disabled: Flight director computer.
HSI	CØ	Disabled: HSI instrument except for localizer signal during ILS approach.
ATT IND	CØ	Disabled: ADI instrument except for glide slope signal and off flag during ILS approach.
TDI	CØ	Disabled: Forward cockpit TDI.
INSTR XFMR	CØ	Disabled: 26 v Emergency AC Bus (All functions of 26 v Emergency AC bus circuit breakers.)
		26 VOLT EMERGENCY AC BUS (Forward Cockpit)*
TRIM		
└ PITCH	CØ	Disabled: Pitch trim indication.
INS	CØ	Disabled: INS synchro power. INS attitude and heading indications are invalid (INS platform is not affected).
PVD (on RH Console)	CØ	Disabled: PVD
		*NOTE: Emergency AC Bus INSTR XFMR circuit breaker must be in for power to 26 V Emergency AC Bus.
		AC HOT BUS (Forward Cockpit - C/Bs located on ESS AC Bus C/B panel)
TRIM		
└ PITCH AND YAW		Disabled: Manual pitch and yaw trim.
LIGHTS		
└ INSTR		Disabled: All left console INSTR LIGHTS C/B functions. (LH, RH, FUEL CONT and FUEL CONT TEST C/Bs)
FUEL		
└ QTY		Disabled: Fuel quantity indication, forward cockpit, & c.g. indications, both cockpits.
INSTR LIGHTS		Left Console Lighting Panel
LH		Disabled: Left instrument panel lights.
RH		Disabled: Right instrument panel lights.
FUEL CONT		Disabled: Fuel system control panel lights, including cross-feed light.
└ FUEL CONT TEST		Disabled: Fuel system control panel lights test function, and pilot's ADI light.

Figure 1-47 (Sheet 4 of 7)

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	PHASE	EFFECT OF POWER INTERRUPTION
		ESSENTIAL AC BUS (Forward Cockpit)
EGT IND	AØ	
L	AØ	Disabled: Left engine EGT digital indication and EGT digital input to fuel derich system. EGT HOT and COLD flags are not affected.
R	AØ	Disabled: Right engine EGT digital indication and EGT digital input to fuel derich system EGT HOT and COLD flags are not affected.
TRIM	AØ	
ROLL	AØ	Disabled: Roll trim actuator.
AUTO PITCH	AØ	Disabled: Mach trim and Automatic (low speed) pitch trim.
PITCH AND YAW	AØ	See AC HOT BUS
L ENP	AØ	Disabled: Left engine nozzle position indication.
R ENP	AØ	Disabled: Right engine nozzle position indication.
L CIT	AØ	Disabled: Left inlet compressor inlet temperature indication.
R CIT	AØ	Disabled: Right inlet compressor inlet temperature indication.
LIGHTS	AØ	
LDG	AØ	Disabled: Landing light.
SUIT HTR	BØ	Disabled: Forward and aft cockpit suit air heater.
LIGHTS	BØ	
MAP PROJ	BØ	Disabled: Forward cockpit map projector light.
TAXI	BØ	Disabled: Taxi light.
TAIL	BØ	Disabled: Tail lights.
INSTR	BØ	See AC HOT BUS
FLOOD	BØ	Disabled: Forward cockpit flood lights.
PANEL	BØ	Disabled: Forward cockpit console panel lights, warning and caution lights brightness control.
MANF TEMP	BØ	Disabled: Cold air manifold automatic temperature control.
CKPT AIR COND	BØ	Disabled: Cockpit automatic temperature control.
INSTR XFMR	CØ	Disabled: 26 V Essential AC Bus (All functions of 26 V Essential AC circuit breakers).
N QTY	CØ	
NO. 1	CØ	Disabled: No. 1 LN_2 system quantity indication.
NO. 2	CØ	Disabled: No. 2 LN_2 system quantity indication.
MAP PROJ	CØ	Disabled: Forward cockpit map projector speed control.
PITOT HTR	CØ	Disabled: Pitot heater. PITOT HEAT light illuminates if flight altitude would normally require heat.
OXY QUAN	CØ	
NO. 1	CØ	Disabled: No. 1 oxygen system quantity indication.
NO. 2	CØ	Disabled: No. 2 oxygen system quantity indication.
FUEL	CØ	
QTY	CØ	See AC HOT BUS
L FLOW	CØ	Disabled: Left engine fuel flow indication.
R FLOW	CØ	Disabled: Right engine fuel flow indication.
CIP	CØ	Disabled: Left and right inlet compressor inlet pressure indications. Barber pole continues to function.

Figure 1-47 (Sheet 5 of 7)

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	EFFECT OF POWER INTERRUPTION
	ESSENTIAL AC BUS (Forward Cockpit - Cont.)
ANTI COLL LTS (3Ø)	Disabled: Anti-collision/fuselage lights.
EGT TRIM (3Ø)	
L	Disabled: Left engine EGT trim motor.
R	Disabled: Right engine EGT trim motor.
	26 VOLT AC ESSENTIAL BUS (Forward Cockpit/Center Pedestal)*
HYD PRESS	
A	Disabled: A-System hydraulic pressure indication.
B	Disabled: B-System hydraulic pressure indication.
SPIKE L	Disabled: L-System hydraulic pressure indication.
SPIKE R	Disabled: R-System hydraulic pressure indication.
FUEL TK PRESS	Disabled: Fuel system tank pressure indication.
OIL PRESS	
L	Disabled: Left engine oil pressure indication.
R	Disabled: Right engine oil pressure indication.
TRIM	
PITCH	See 26 V Emergency AC BUS
YAW	Disabled: Yaw trim condition indication.
ROLL	Disabled: Roll trim condition indication.
NAV INST	Disabled: ANS attitude signal to ADI and AI. ANS heading signal to HSI and BDHI.
INS	See 26 V Emergency AC BUS
	*NOTE: Essential AC Bus INSTR XFMR circuit breaker must be in for power to 26 V Essential AC BUS.
	ESSENTIAL DC BUS (Aft Cockpit)
ANS	Disabled: ANS
BEACON	Disabled: G-band beacon when S/B 1763K installed:
FACE HTR	Disabled: Helmet face heat, aft cockpit.
IFF	Disabled: All IFF modes.
IFF TEST	Disabled: IFF transponder self test capability, Modes 1, 2, 3A, and C.
INTPH	Disabled: All audio to aft cockpit headset (except trainer EMERG ICS).
NAV INST	Disabled: Navigation display relays. Attitude reference reverts to: Pilot-INS RSO-ANS. Autopilot will not engage with Pilot's ATT REF switch in ANS, HSI displays mag hdg and TACAN DME. BDHI displays true hdg and TACAN DME.
SEAT ADJ	Disabled: Aft cockpit seat adjustment. Seat remains as set.
SPOT LTS	Disabled: Aft cockpit spot lights and flex point lights.
WARN LTS	Disabled: All aft cockpit caution lights.
	MONITORED DC BUS (Aft Cockpit)
DEF F	Disabled: DEF H
DEF CONT	Disabled: ALL DEF control systems.

Figure 1-47 (Sheet 6 of 7)

CIRCUIT BREAKER FUNCTION TABLE

CIRCUIT BREAKER	EFFECT OF POWER INTERRUPTION
	EMERGENCY AC BUS (Aft Cockpit)
COMPUTER — AØ: A, B, M; BØ: A, B, M; CØ: A, B, M	NOTE: • With one circuit breaker opened to each computer, no capability is lost. • With two circuit breakers opened to a computer, that computer is likely to shut down. The corresponding pitch, yaw and/or roll sensors and servos are disabled if the following pairs of circuit breakers are opened: A Computer: A & B or A & C phase; B Computer: A & B or B & C phase; M Computer: A & C or B & C phase. • With all three A computer circuit breakers open, left auto inlet is disabled (inlet goes to restart). Manual control of left spike and door required. • With all three B computer circuit breakers open, right auto inlet is disabled (inlet goes to restart). Manual control of right spike and door required. • Manual inlet control is disabled if the M computer A and C phase or B and C phase circuit breakers are opened.
ATT IND (W/SB R-2595) (CØ)	Disabled: Aft cockpit attitude indicator.
AP MACH TR (CØ)	Disabled: Autopilot and Mach Trim systems, Analytical Redundancy, AOA, TDI OFF flags in view (indications remain valid), Bank Command steering bar remains centered.
TDI (CØ)	Disabled: Aft cockpit TDI. TAS to Pilot's & RSO's Map Projector - Automatic Map Rate.
	AC HOT BUS (Aft Cockpit)
FUEL QTY	Disabled: Fuel quantity and c.g. indications, aft cockpit.
	ESSENTIAL AC BUS (Aft Cockpit)
INS HTR 1 (AØ)	Disabled: No. 1 INS heater. INS performance will degrade.
LIGHTS (AØ)	
PNL L	Disabled: All functions of L CONSOLE PNL and L CONSOLE LGD circuit breakers on left console c/b panel.
PNL R	Disabled: All functions of R CONSOLE PNL, R CONSOLE LGD AND TEST & BRT circuit breakers on left console c/b panel.
FLD	Disabled: Aft cockpit flood lights.
INST	Disabled: Aft cockpit instrument panel lights.
INST LIGHTS (AØ)	<u>Left Console, aft cockpit</u>
L CONSOLE	
PNL	Disabled: Left console panel lights.
LGD	Disabled: Left console legend lights.
TEST & BRT	Disabled: Legend test function and, if right console rheostat switch is off, legend and panel lights associated with the right console rheostat.
R CONSOLE	
PNL	Disabled: Right console panel lights.
LGD	Disabled: Right console legend lights.
INS HTR 2 (BØ)	Disabled: No. 2 INS heater. INS performance will degrade.
ATT IND (W/O SB R-2595) (CØ)	Disabled: Aft cockpit attitude indicator.
IFF (CØ)	Disabled: IFF Mode 4 capability.
ANS 3 PH (3Ø)	Disabled: ANS

Figure 1-47 (Sheet 7 of 7)

batteries are furnishing at least 10 amperes to the essential dc buses. The services in Figure 1-43 can be powered by the batteries and instrument inverter.

If dc power from the T-Rs is interrupted, a time delay of ten seconds occurs before the EMER BAT ON light illuminates. The EMER BAT ON light will not illuminate if T-R dc power is restored within ten seconds.

NOTE

Occasional flickering of the EMER BAT ON caution light can be disregarded if not accompanied by other indications of abnormal electrical system operation.

Generator Out Caution Lights

The L or R GEN OUT caution light on the pilot's annunciator panel illuminates when the corresponding generator is disconnected automatically or the respective generator control switch is OFF.

HYDRAULIC SYSTEMS

Four separate hydraulic systems are provided, each with its own pressurized reservoir and engine-driven pump. (See Figure 1-48). Normally, all the systems are independent. The pumps for the A and L system are driven from the left engine accessory drive system (ADS) and the B and R pumps from the right engine ADS. The A, B, and L system reservoirs are serviced to 2.8 gallons of hydraulic fluid. The R system reservoir is serviced to 4.5 gallons of hydraulic fluid. Hydraulic fluid is cooled by fuel-oil heat exchangers, using the aircraft fuel supply for cooling.

The A and B hydraulic systems power the flight controls. An accumulator is provided in each of these two systems. The A hydraulic system also powers the APW system stick pusher.

The L hydraulic system powers the left engine air inlet system and normally powers the landing gear (including uplocks and door cylinders), brakes, air refueling door and receptacle, and nosewheel steering. The R hydraulic system powers the right engine air inlet system. In addition, if L system pressure is less than 2200 psi, the R system will automatically power the landing gear retraction cycle, and the pilot may select the R system to power nosewheel steering and the air refueling system (by setting the brake switch to ALT STEER & BRAKE). Regardless of L system pressure, the pilot may always select the R system to power the brakes. Antiskid braking is available with either L or R hydraulic system.

Hydraulic System Pressure Gages

Two dual-indicating hydraulic gages are installed on the pilot's instrument panel. The bottom (SURF CONT) gage indicates A and B system hydraulic pressures, and the top (SPIKE) gage indicates L and R system hydraulic pressures. The gages are calibrated in 100-psi increments from 0 to 4000 psi. Pressure indication is sent from remote transmitters in the individual systems.

Power for the gages is furnished by the essential ac bus 26 volt instrument transformer through the A, B, L SPIKE and R SPIKE circuit breakers on the pilot's annunciator panel.

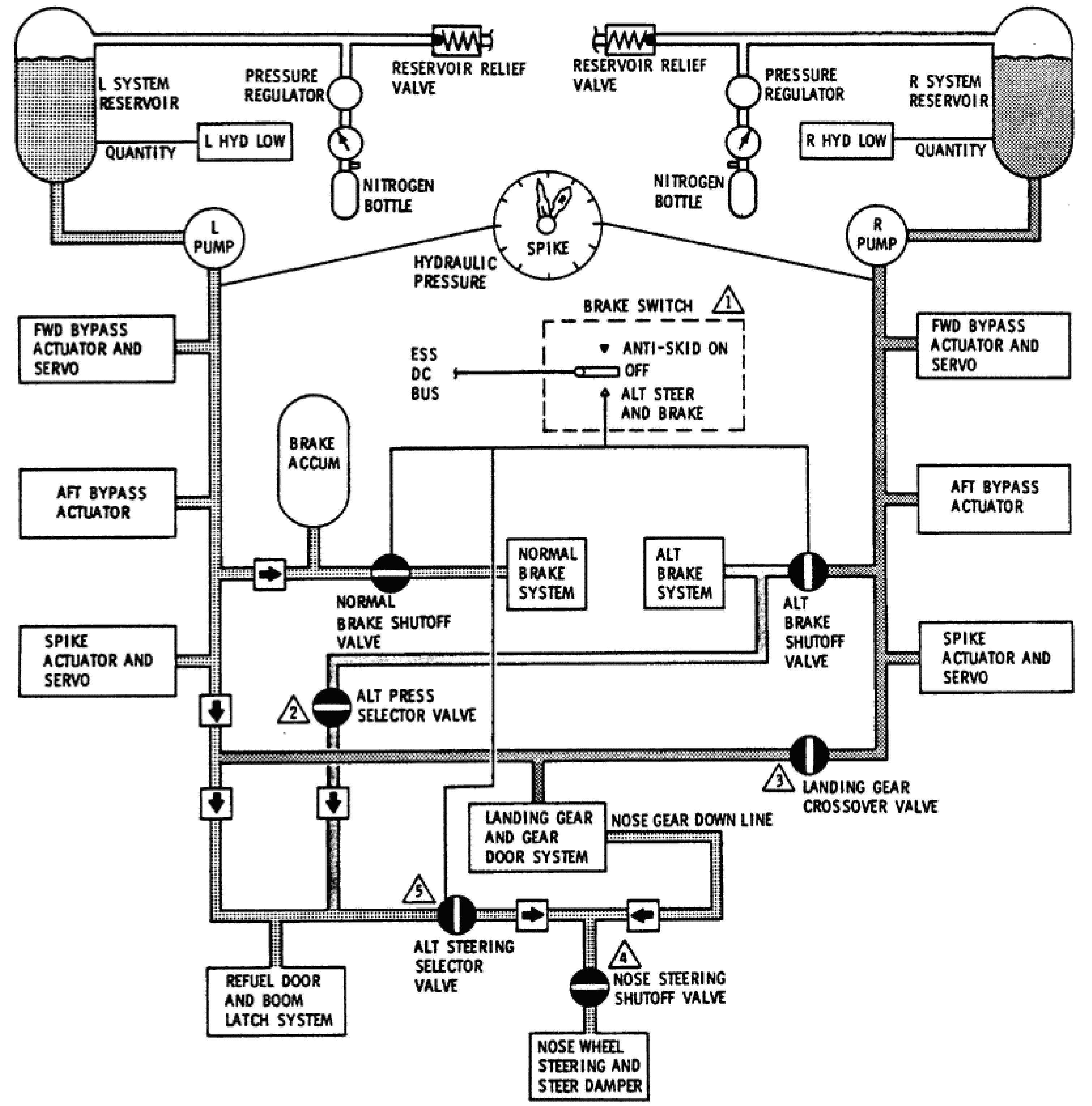
L and R Hydraulic Quantity Low Warning Lights

The L or R HYD warning light on the pilot's annunciator panel illuminates when hydraulic quantity in the respective reservoir decreases below 1.2 gallons.

A and B Hydraulic Quantity/Pressure Low Warning Lights

The A or B HYD warning light on the pilot's annunciator panel illuminates when hydraulic quantity in the respective reservoir decreases below approximately 1.2 gallons and/or the respective hydraulic pressure decreases below 2200 (±150) psi.

L AND R HYDRAULIC SYSTEMS



NOTE

1. OFF: "L" system powers brakes, no anti-skid protection.

   ANTI-SKID ON: Provides anti-skid protection on "Normal" brake system.

   ALT STEER AND BRAKE: Closes "Normal" and opens "Alt" brake shutoff valves, arms alternate system selector valves, and energizes "Alt. Anti-skid" system

2. With brake switch in "Alt Steer and Brake" position, valve is opened if "L" system pressure decreases below 2200 psi.

3. Crossover valve opens automatically if "L" system pressure decreases below 2200 psi, but only for gear retraction.

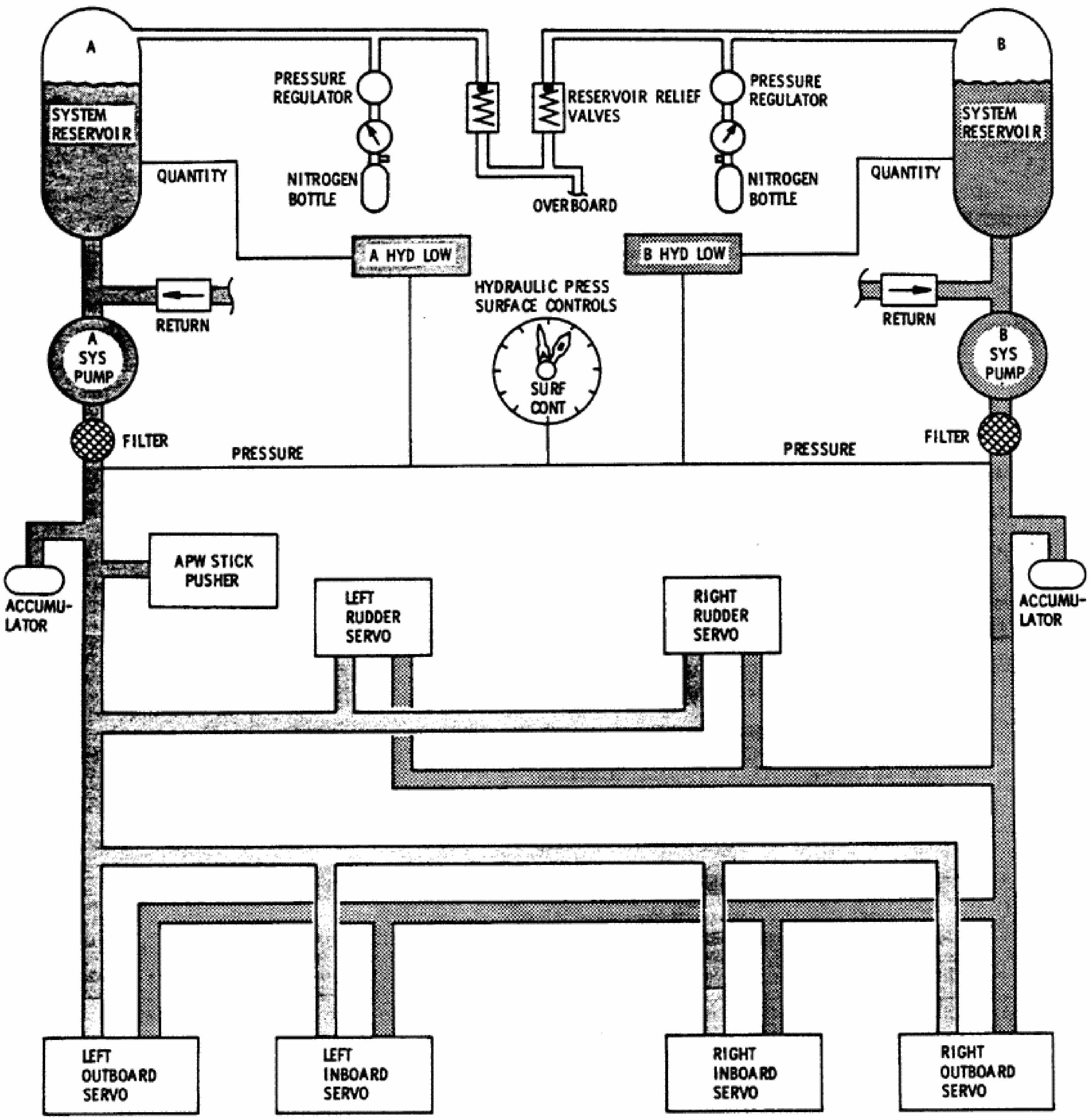
4. Steering controlled by CSC/NWS switch on control stick to provide nose steering on normal or alternate system pressure.

5. Valve opens when alternate steering and braking selected regardless of pressure in the L system

F203-16(h)

Figure 1-48 (Sheet 1 of 2)

A AND B HYDRAULIC SYSTEMS



NOTE

Each hydraulic system provides actuation power to half the actuating cylinders at each servo assembly.

HYD LOW lights are illuminated by decreasing quantity with 1.2 gallons remaining in the respective reservoir, and/or by decreasing pressure at approximately 2200 psi.

F203-15(I)

Figure 1-48 (Sheet 2 of 2)

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of the A and/or B HYD warning light(s). The light(s) should extinguish when flow demands diminish and normal pressure is restored.

LANDING GEAR SYSTEM

The tricycle landing gear and the main wheel well inboard doors are electrically controlled and hydraulically actuated. The main gear outboard doors and the nose gear doors are linked directly to the respective gear struts. Each three-wheeled main gear retracts inboard into the fuselage and the dual-wheel nose gear retracts forward into the fuselage. The main gear is locked up by the inboard doors and the nose gear by an uplock which engages the strut. There is no hydraulic pressure on the gear when it is up and locked. Downlocks inside the actuating cylinders hold the gear in place in the extended position. Normal gear operation is by L hydraulic pressure. L system hydraulic pressure is also on the gear when in the extended position. Normal gear retraction and extension time is 12 to 16 seconds. Should L hydraulic pressure drop to 2200 psi during retraction, the power source automatically changes to the R hydraulic system. If the L system fails, R system pressure cannot be used to extend the gear and the manual gear release must be used.

A landing gear strut damper system controls gear "walking," a fore-and-aft oscillation of the main landing gear strut associated with brake application. The system is sensitive to less than 1-g change in fore-and-aft acceleration. The damping is controlled through a g-monitoring valve which automatically increases or decreases the brake pressure as required. Hydraulic pressure for the damper system is provided by the L system. The damper does not function with the brake switch in ALT STEER & BRAKE. A strut damper shutoff valve removes L system pressure from the damper valve when the landing gear is retracted.

Landing and taxi lights are on the nose gear strut. Refer to Lighting Equipment, this section.

Landing Gear Handle

A wheel-shaped landing gear handle, on the pilot's left instrument side panel, has two positions: UP and DOWN. An up-lock latch prevents the gear handle from being inadvertently placed in DOWN. An up-lock release lever which extends from the top of the gear handle, must be pushed forward to release the up-lock latch. A safety-lock solenoid prevents the gear handle from being inadvertently placed UP while the aircraft is on the ground. A manual solenoid release button is located just above the gear handle. Depressing the release button overrides the safety-lock soleoid and allows the gear handle to be moved to UP. In UP, the gear will retract if hydraulic pressure is available except that the landing gear control circuit is interlocked with the gear scissor switches to prevent retraction of the gear on the ground.

A red warning light is located in the transparent gear handle. Power for the circuit is furnished by the essential dc bus through the landing gear CONT circuit breaker on the pilot's left console.

Manual Landing Gear Release Handle

A manual GEAR RELEASE T-handle is located on the pilot's annunciator panel. If the L hydraulic system fails, the landing gear handle should be placed DOWN and the CONT circuit breaker should be pulled before pulling the GEAR RELEASE handle. If the landing gear handle cannot be placed DOWN and the landing gear CONT circuit breaker is not pulled, the landing gear will retract if there is pressure in the R hydraulic system. When the GEAR RELEASE handle is pulled, the gear extends by gravity within 90 seconds. Up to 65 pounds of force and approximately 9-1/3 inches extension of the handle is required to release the gear. The uplocks are released in the following sequence as the cable extends: nosewheel, right main gear door aft latch, right main door forward latch, left main gear door aft latch, and left main door forward latch. Gear retraction can be accomplished after emergency extension if L or R hydraulic system pressure is available.

CAUTION

> The landing gear must not be retracted while the manual release handle is pulled, as damage to the system can result. Stow the handle before retracting the gear.

Landing Gear Position Lights

Three green lights on the pilot's left instrument side panel illuminate when each respective landing gear is down-and-locked. The location of each light corresponds to the gear it monitors. The lights also illuminate when the IND & LT TEST button is depressed. Power is furnished by the essential dc bus through the landing gear IND circuit breaker on the pilot's left console.

Landing Gear Warning Light and Audible Warning

The red warning light in the landing gear lever handle illuminates when:

1. Gear is cycling.
2. Gear system is not locked in the position (UP or DOWN), programmed by the landing gear handle.
3. Gear is UP and throttles are within approximately 1 inch of the IDLE stop, while below 10,000 $\pm$ 500 feet.

A pulsed-tone warning signal is produced in the pilot's and RSO's earphones when the throttles are retarded below minimum subsonic cruise setting, the landing gear is not in the down and locked position and aircraft altitude is below 10,000 ($\pm$ 500) feet. The pulsed tone circuit is isolated from the gear handle light circuit so that if an emergency gear extension is necessary with the gear handle up, the tone will not occur if the gear is locked down and the throttles are retarded. The tone sounds if the IND & LT TEST button is depressed while below 10,000 $\pm$500 feet. Power for the light and audible warning is furnished by the essential dc bus through the landing gear WARN circuit breaker on the pilot's left console.

Landing Gear Warning Cutout Button

The aural gear warning may be silenced by depressing the GEAR SIG REL button on the pilot's left instrument side panel. The circuit is reactivated when the throttles are advanced above the minimum cruise setting. Power is furnished by the essential dc bus through the landing gear WARN circuit breaker on the pilot's left console.

Landing Gear Ground Safety Pins

Removable ground safety pins are installed in the landing gear assemblies to prevent inadvertent gear retraction. Warning streamers direct attention to their removal before flight. Extra pins are provided in a container on the pilot's aft bulkhead left of the ejection seat.

NOSEWHEEL STEERING SYSTEM

The nosewheel steering system provides power steering while on the ground. It can be engaged when aircraft weight is on any gear by aligning rudder pedal position with nosewheel angle and depressing the CSC/NWS button on the control stick. A holding relay circuit keeps steering engaged when the button is released. The button must be depressed and released again to disengage steering.

A nosewheel steering engaged light is provided on the top left of the pilot's instrument panel. Illumination of the green STEER ON legend indicates nosewheel steering engagement. The light extinguishes if steering is disengaged. Steering disengages automatically when weight is not on any gear. With weight on a gear, steering disengages with loss of hydraulic pressure or when manually disengaged by the pilot.

The steering angle obtained is directly proportional to rudder pedal deflection. The nosewheel is steerable 45° either side of center. Minimum steering radius is approximately fifty-five feet. See Figure 2-3 for clearance requirements while turning.

WARNING

The landing gear side load strength is critical. Side loads during takeoff, landing, and ground operation must be kept to a minimum.

CAUTION

Do not engage nosewheel steering before nosewheel touchdown; otherwise, excessive strut and fuselage forebody loads could result from steering angles developed before nosewheel contact.

A hydraulically actuated clutch is located within the steering damper unit. The clutch engages and disengages nosewheel steering when the CSC-NWS switch is actuated.

Rudder control in-flight with the gear down is severely restricted if the clutch jams and nosewheel steering does not disengage.

WARNING

Retract the landing gear immediately to relieve restriction of rudder movement if jamming of the nosewheel steering clutch is suspected while in-flight.

NOTE

Approximately 6° of rudder would be available, through cable stretch, by applying 180 pounds of force at the rudder pedals. Rudder restriction would not be noted with the gear up.

A mechanically operated centering cam automatically centers the nosewheel when the gear retracts.

Rudder pedal movement controls a hydraulically operated nosewheel steering and shimmy damper unit by means of a cable system when steering is engaged. While on the ground with the brake switch in the ANTI-SKID ON or OFF position, hydraulic power for steering is obtained from the L system through the nose landing gear down line and the nose steering shutoff valve. If L system pressure decreases below 2200 psi, selection of the brake switch ALT STEER & BRAKE position makes R system hydraulic power available for steering. Then hydraulic power is supplied to the nose steering shutoff valve through the alternate brake shutoff valve, alternate pressure selector valve, and the alternate steering selector valve. See sheet 1 of Figure 1-48.

NOTE

With ALT STEER & BRAKE selected, the R hydraulic system cannot supply hydraulic pressure for nosewheel steering until L system pressure decreases below 2200 psi. The L system continues to supply hydraulic power while above 2200 psi.

NOTE

After the landing gear CONT circuit breaker has been opened, ALT STEER & BRAKE must be selected to open the alternate steering selector valve and obtain hydraulic power for nosewheel steering.

Electrical power for control of the nosewheel steering system is obtained from the essential dc bus through the STEER, BRK & SKID, and CONT circuit breakers. See sheet 1 of Figure 1-47 for functions lost when any of these circuit breakers is open.

WHEEL BRAKE SYSTEM

The aircraft is equipped with hydraulic operated power brakes, controlled through toe-action of the rudder pedals, and provided with artificial feel. Two interrelated brake systems are provided: a normal system using

L system hydraulic power, and an alternate system using R system hydraulic power. Selection of normal or alternate brake system is controlled by the brake switch on the pilot's left instrument side panel. Both systems use a hydraulically operated relay system to control metering of hydraulic pressure to the multiple-disc brake assemblies on each main gear wheel. Braking follows toe pressure command within one-half second.

The normal brake system has a small accumulator and a strut damper system. The accumulator is charged by L system pressure and may provide up to three brake applications if L system fails. The brake accumulator is not required to hold a charge. The probability that the accumulator will provide braking decreases as time from the loss of L hydraulic system pressure increases. Accumulator braking is not available with the brake switch in ALT STEER & BRAKE. The strut damper system dampens fore and aft oscillations of the main gear struts (associated with brake applications). Strut oscillation ("strut walk") occurs at approximately 10 cps. Strut damping is operational only on the normal brake system.

Antiskid protection is available to both the normal and alternate brake systems. The antiskid system senses wheel skid as a function of wheel rpm. Wheel rpm decreasing too rapidly causes the antiskid system to relieve brake pressure to the affected main gear. Pressure is relieved until rpm increases sufficiently to permit further brake application without skidding. If wheel rpm does not increase within 2.7 seconds after antiskid relieves brake pressure: the antiskid fail-safe circuit deactivates antiskid and illuminates the ANTI-SKID OUT annunciator caution light, and braking without antiskid protection becomes available.

The antiskid system is operational above 12 miles per hour. The brake system permits near full system pressure at the brake assemblies under extreme braking. With very heavy braking, locked wheels may occur at speeds of less than 25 knots. Momentary lockup and unlocking does not affect overall braking performance. A touchdown safety feature in the antiskid system prevents landing with the brakes applied when the brake switch is in ANTI SKID ON or ALT STEER & BRAKE.

A DRY-WET switch (on left instrument side panel) permits selection of antiskid sensitivity. The WET position increases the sensitivity of the antiskid system to wheel spindown and improves antiskid operation on wet or icy runways. The sensitivity of the antiskid system to wheel spindown in the WET mode is such that the deceleration from normal drag chute action above 90 knots will relieve brake pressure to both main gears.

BRAKE CONTROL SWITCHES AND INDICATORS

Brake Switch

The three-position brake switch is on the pilot's left instrument side panel. In OFF (center), L hydraulic pressure is available for braking without antiskid protection. In ANTI SKID ON (up), L hydraulic pressure is available for braking with antiskid protection unless (after S/B R-2695) the trigger switch is depressed. In ALT STEER & BRAKE (down), R-hydraulic pressure is available for braking immediately with antiskid unless (after S/B R-2595) the trigger switch is depressed, and nosewheel steering from R system is available when L system pressure drops below 2200 psi.

CAUTION

> If L hydraulic pressure is not available, R hydraulic system will not be available for braking or steering unless the brake switch is in ALT STEER & BRAKE.

Power is supplied to the brake switch from the essential dc bus through the BRK & SKID circuit breaker on the pilot's left console.

Antiskid Disconnect Trigger Switch

With S/B R-2695, antiskid system operation is interrupted while the trigger switch is held depressed. The hydraulic power source for brakes remains as selected by the brake switch.

WET-DRY Switch

The two-position wet-dry switch is on the pilot's left instrument side panel. In DRY (up), antiskid braking is compatible with wheel spindown characterisitics on a dry runway. The WET (down) position increases brake antiskid sensitivity to optimize braking on a wet or icy runway and reduces the probability of a blown tire and subsequent loss of antiskid braking. Electrical power is from the essential dc bus through the BRK & SKID circuit breaker.

ANTI-SKID OUT Light

The ANTI-SKID OUT caution light on the pilot's annunciator panel illuminates when the brake switch is OFF if the landing gear is down and there is weight on a gear, or if the antiskid system fail-safe circuit detects a fault.

After S/B R-2695, the ANTI-SKID OUT light also illuminates while the trigger switch is depressed if the landing gear is down and there is weight on a gear.

DRAG CHUTE SYSTEM

The drag chute system reduces landing roll and aborted takeoff rollout distance. The drag chute is stowed in an aft fuselage compartment above fuel tank 4. The drag chute attachment rides free in the compartment until locked to the aircraft during the initial stage of deployment. The drag chute and extraction system are packed in a deployment bag which contains a 42-inch vane-type pilot chute, a 10-foot extraction chute which produces aerodynamic lift, and a 40-foot ribbon-type drag chute. Normal chute deployment and jettisoning is accomplished electrically. Emergency deployment is accomplished mechanically. The drag chute handle operates both modes.

Drag Chute Handle

The T-shaped DRAG CHUTE handle is located on the upper left of the instrument panel. In the stowed (or jettison) position, the handle is horizontal, fully forward, and a red band on the shaft is not visible. Normal deployment is accomplished by pulling straight aft on the handle to the limit of its travel (approximately 1 inch). After chute deployment, jettisoning is accomplished by pushing the handle full forward. These handle positions operate switches which control the chute deploy and jettison actuator motors. Power for normal drag chute operation is provided by the essential dc bus through two DRAG CHUTE circuit breakers on the pilot's left console.

If normal deployment fails, emergency deployment is possible by rotating the handle 90 degrees counterclockwise from the normal deploy position and pulling to its aft travel limit (approximately 8 inches). The maximum pull force required is 60 pounds. When the handle is released, it is returned to the receptacle by the tension of a slack takeup spring. The drag chute cannot be jettisoned after emergency deployment because the actuator motor switches are disconnected during the manual deploy sequence.

CAUTION

If the DRAG CHUTE handle is pulled to the emergency deploy position and released immediately, damage could result to cockpit items as the handle snaps back to the receptacle.

NOTE

To avoid inadvertent emergency deployment, do not rotate the DRAG CHUTE handle during normal deployment.

Drag Chute Unsafe Light

The DRAG CHUTE UNSAFE caution light on the pilot's annunciator panel illuminates when: (1) the drag chute mechanism has been actuated to some degree either mechanically or electrically and is in an unsafe condition, or (2) power to both linear actuator dc motors is lost.

PRIMARY FLIGHT CONTROLS

The full-power irreversible flight control system consists of cockpit controls (stick and rudder pedals), four elevons, and two full-moving rudders. Two elevons are hinge-mounted to the upper trailing edge of each wing, one inboard and one outboard of the respective engine nacelle. A tetrahedral-shaped rudder is mounted to a fixed stub fin on the upper aft portion of each engine nacelle. Each rudder assembly is canted inward 15 degrees.

A servo assembly at each control surface meters dual system (A and B) hydraulic power for positioning the control surfaces. The control stick and rudder pedals are connected to the servos by cable and mechanical input systems. Feel springs in each axis provide the pilot with control feel proportional to the degree of control deflection. Artificial feel is provided since air loads are not felt by the pilot. Pilot inputs are limited to the force necessary to move the metering valve in the servos.

Control Stick

A conventional control stick operates the elevons. See Figure 1-49. Movement of the stick is approximately 9° forward and 16° aft of its neutral position and (with the control surface deflection limiters engaged) approximately 5 1/2° laterally. With the limiters disengaged, the stick can be positioned laterally approximately 8° from center at any point, and approximately 9° when not near its extreme forward or aft position. Similarly, full forward and aft stick positioning capability is reduced somewhat at the extreme "corners" of the deflection "box" when the limiters are disengaged. (This results because the elevon deflection angles are additive for combined pitch and roll commands. If surface deflection limits are reached, maximum stick pitch and roll command angles are also reached.) Full lateral movement requires approximately 10 pounds force. Approximately 25 pounds push force and 45 pounds pull force are required to reach the full forward and aft stick positions, respectively.

Three switches are located on the top and one switch on the right side of the grip. On the top left, a three-position communications switch labeled TRANS (up) and INPH (down) is springloaded to an unmarked off (center) position. The pilot's microphone is connected to the interphone system or to a selected radio transmitter when INPH or TRANS is selected, respectively. The microphone is disconnected when the center position is used unless the throttle-mounted microphone switch is pressed for radio communication or the interphone HOT MIC knob is pulled out. See Communications and Avionic Equipment, this section. A four-way (center-off) pitch and yaw axis TRIM switch operates as described under Manual Trim System, this section. A dual purpose CSC/NWS push-button switch, located to the right of the trim switch, either activates the autopilot Control Stick Command feature (if the autopilot is on) or engages/releases nosewheel steering while on the ground. Before S/B R-2674, pressing a rain removal system switch on the right side of the grip causes a quantity of rain removal fluid to be applied to the forward windshield panels if the windshield deicing switch on the left side of the pilot's annunciator panel has been set to RAIN REMOVAL ARM ON (up). After S/B R-2674, rain removal is deactivated.

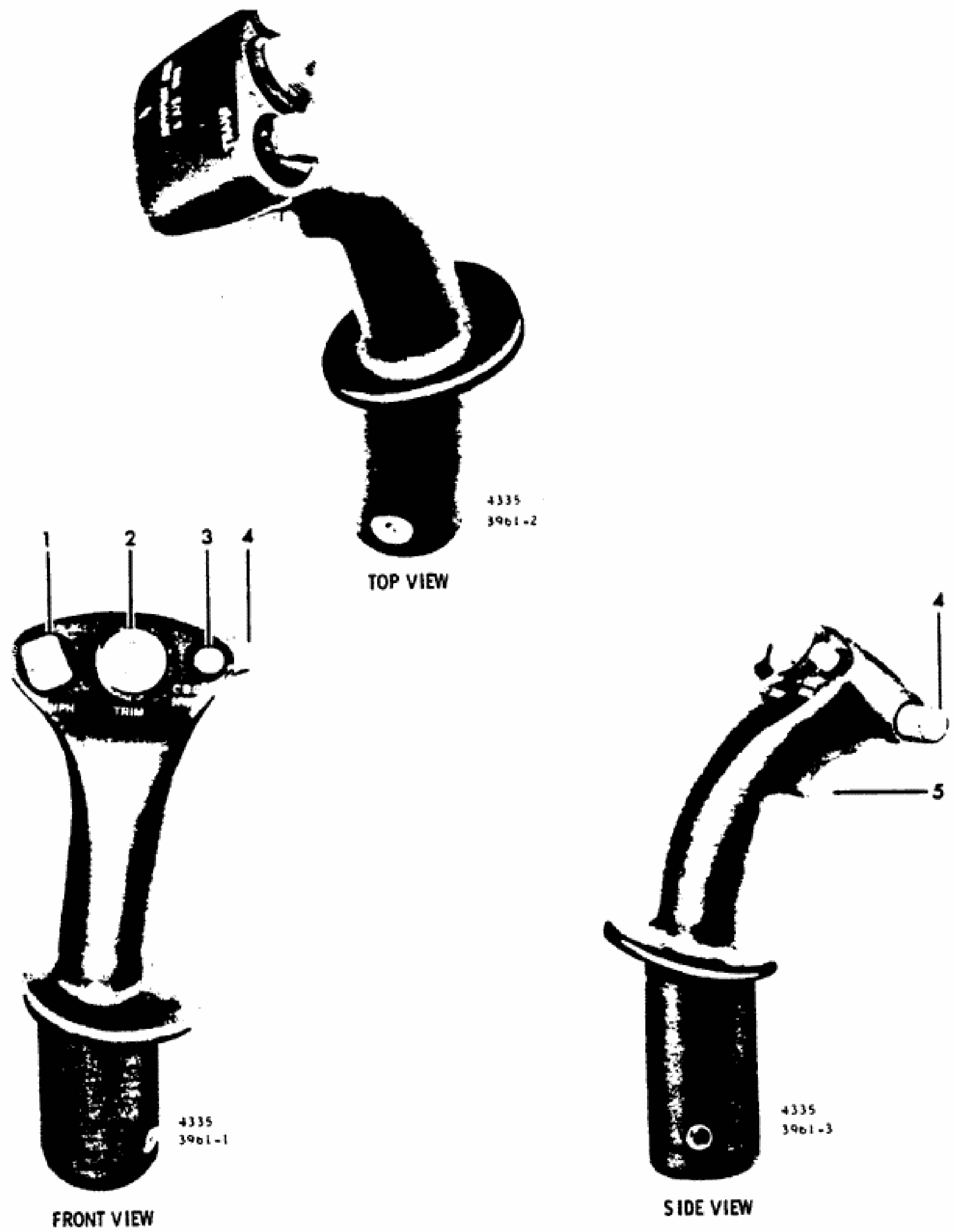
NOTE

> Do not operate the rain removal system unless the windshield is wet. The white fluid will stick to the glass and permanently obscure visibility if applied while the windshield is dry.

A multipurpose trigger switch is on the forward side of the grip. Operation of this switch disconnects air refueling, disengages autopilot, interrupts ac power to the pitch and yaw manual trim actuator motors (disabling the control stick trim switch and the RH RUDDER SYNCHRONIZER switch), interrupts the APW system stick pusher, and with S/B R-2695 interrupts antiskid system operation.

A stick-shaker motor is installed below the grip. It warns of a potentially high angle of

CONTROL STICK GRIP



NOTE

1 Transmitter-interphone microphone selector switch

2 Pitch and yaw trim switch

3 Control stick command-nosewheel steering button

4 Rain removal switch (Deactivated with S/B R-2674)

5 Trigger switch - disconnects air refueling and autopilot; interrupts pitch and yaw trim, APW stick pusher, and antiskid (with S/B R-2695).

F203-65(e)

Figure 1-49

attack and/or pitch rate. Operation of the shaker is controlled by the APW and High Alpha Warning systems. A red SHAKER warning light, located near the apex of the pilot's glareshield, illuminates when the shaker is on. A stick-pusher mechanism is also part of the APW system. The pusher displaces the stick forward to initiate corrective action in the pitch axis. (Refer to APW and High Alpha Warning Systems, this section.) Hydraulic pressure from the A system is required for pusher operation.

ELEVON CONTROL SYSTEM

The delta wing configuration uses elevons for pitch and roll control. The elevons respond to control inputs from the control stick, pitch and roll trim systems, SAS, and the autopilot. All control inputs are applied to the inboard elevon servo assemblies, which control actuation power for elevon positioning. The outboard elevons are mechanically slaved to their respective inboard elevon.

Elevon Control Cables

The control stick is connected by mechanical linkage to pitch and roll tension regulators in the cockpit. Dual control cables run from each tension regulator to respective cable quadrants above the mixer assembly in the tail cone.

Elevon Mixer Assembly

The mixer assembly provides the mechanical geometry necessary to sum the pitch and roll inputs from their respective control cable systems. The combined inputs are then applied as a single control input to the inboard elevon servo assemblies. The pitch and roll trim actuators are an integral part of the mixer assembly and are summed along with control stick inputs. All pitch and roll trim (Mach trim and auto trim included) is applied through the mixer assembly. The pitch and roll feel springs are in the mixer. Since the trim actuators are mounted downstream of the feel springs, the control stick is not displaced by elevon trim (pitch and roll) actuations.

Inboard Elevon Servos

All pitch and roll control inputs (stick, trim, SAS, and autopilot) are applied to the inboard elevon servos. In response to these inputs, the servos meter A and B hydraulic pressures to the actuating cylinders, which position the inboard elevon surface. Each hydraulic system provides power to three actuating cylinders at each inboard servo assembly.

Input Mechanism and Spring Cartridge

The outboard elevons are slaved to their respective inboard elevon by a mechanical input which connects the inboard surface to the outboard elevon servo. Thus, any movement of the inboard surface moves the outboard servo, which positions the outboard elevon.

A spring-loaded cartridge pushrod "shotgun" is installed in the inner wing portion of the input mechanism. Cartridge spring loads maintain four rollers in a detent during normal surface control operation, permitting the cartridge to act as a solid pushrod. If excessive backloads (approximately 900 pounds) are imposed on input mechanism movement by binding or seizure outboard of the cartridge, the rollers "jump their detent" to permit operation of the inboard elevon independent of the affected outboard elevon. Without this feature, failure at the outboard servo assembly or within the input mechanism could result in structural damage and/or loss of control in pitch and roll.

When operating the controls on only one hydraulic system, half of the actuating cylinders are inoperative and sufficient back pressure may be imposed on the input mechanism to cause the spring cartridge rollers to jump the detent at lower system pressures (approximately 1500 psi).

CAUTION

When starting engines, do not move the control stick until at least 1500 psi can be maintained on the A or B hydraulic system.

SURFACE CONTROL DEFLECTION LIMITS AND RATES

MODE OF OPERATION	SURFACE AUTHORITY LIMITS △1			SURFACE MAXIMUM RATES		
	PITCH	ROLL △2	YAW	PITCH	ROLL △2	YAW
MANUAL	10° DOWN △3 TO 24° UP △4	24°	20° LEFT TO 20° RIGHT	32.5°/SEC	65°/SEC	37°/SEC
LIMITED MANUAL		14°	10° LEFT TO 10° RIGHT			
APW PUSHER EXTENDED △6	10° DOWN △3 TO 10° UP △5					
SAS	6.5° UP TO 2.5° DOWN	4°	8° LEFT TO 8° RIGHT	15°/SEC	30°/SEC	28°/SEC
AUTOPILOT	2.3° DOWN TO 2.3° UP △7					
AUTO-TRIM MACH TRIM	5.0° DOWN TO 8.5° UP			NOMINAL 0.113° SEC		
MANUAL TRIM		9°	10° LEFT TO 10° RIGHT	NOMINAL 1.13°/SEC	NOMINAL .96°/SEC	NOMINAL .90°/SEC

NOTE

△1 Combined pitch and roll application is limited by actuating cylinder stroke extremes at 20° down to 35° up.

△2 Roll figures reflect differential roll applied.

△3 10° down if pitch trim indicator is at or below zero. Trim above zero indication decreases down elevon authority.

△4 24° up if pitch trim indicator is at or above zero. Trim below zero indication decreases up elevon authority.

△5 Assumes pitch trim indicator at zero. Trim above zero indication increases up elevon authority. Trim below zero indication decreases up elevon authority.

△6 Pusher deflects elevons 1.7° down from trimmed position. Up elevon movement above trimmed position requires additional force to overcome pusher.

△7 Autopilot authority limits are 2.3° above FL500, and 1.6° below FL500.

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Figure 1-50

FLIGHT CONTROL SYSTEMS

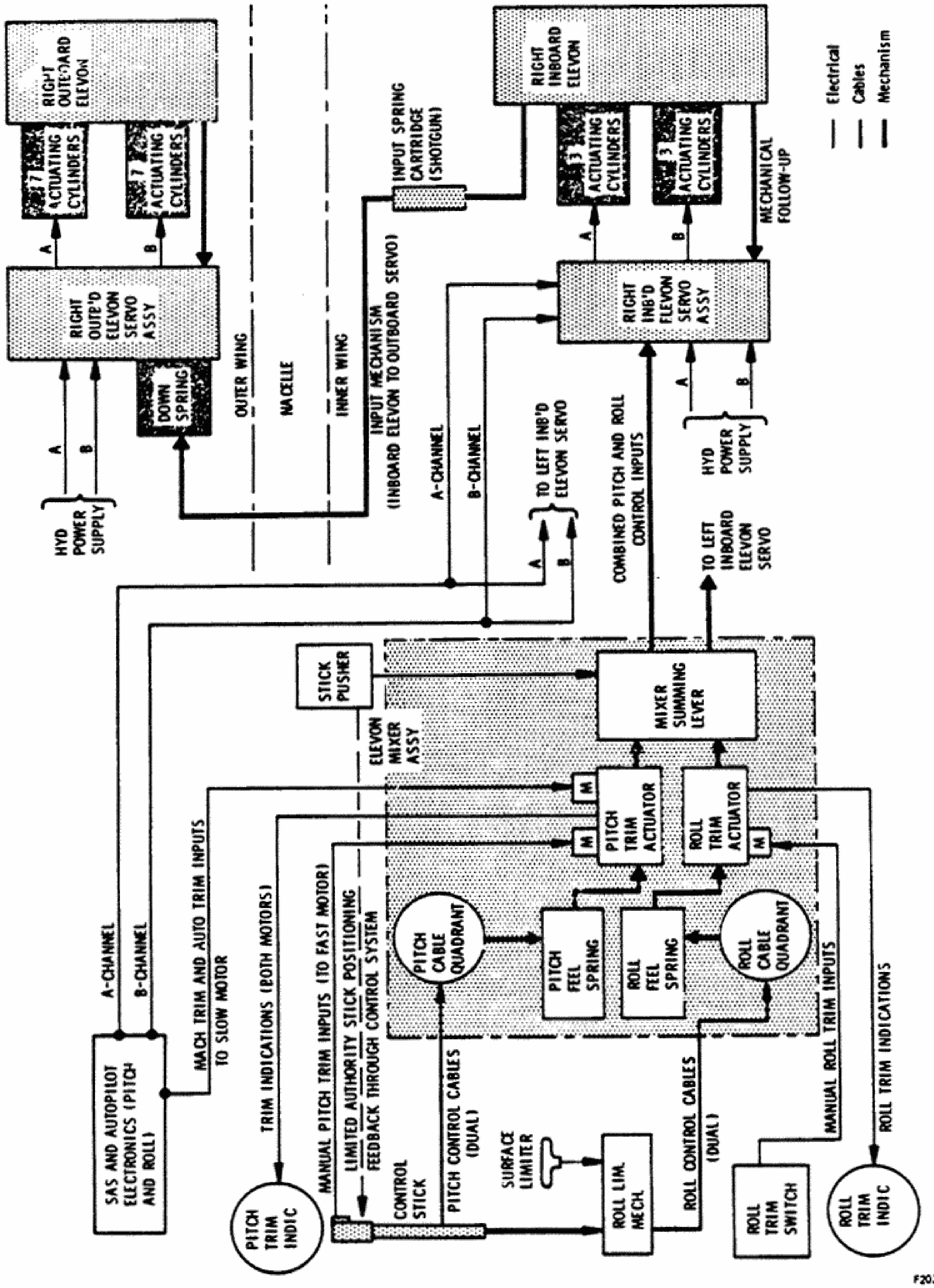

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Figure 1-51

RUDDER CONTROL SYSTEM

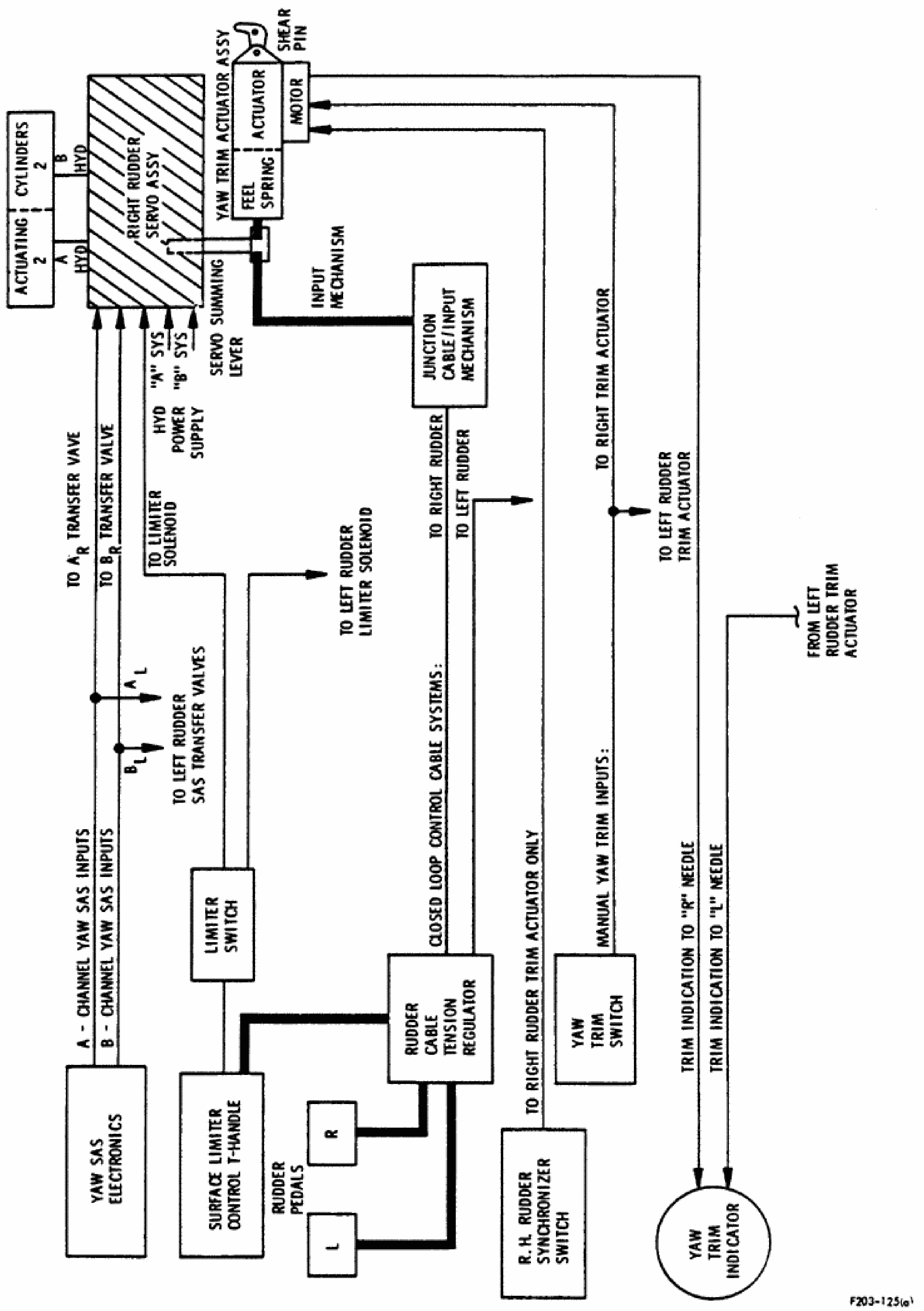

Figure 1-52

Outboard Servo and Limiter Spring

Inboard elevon movement is transmitted through the input mechanism to the outboard servo, which meters A and B hydraulic pressures to 14 actuating cylinders at each outboard elevon. Half of the cylinders are powered by each hydraulic system.

A limiter spring at the outboard servo input lever ensures that the outboard elevon does not travel full down if the input mechanism fails. Limiter spring force, in conjunction with servo bias spring loads, will position and maintain the outboard elevon at a three-degree-down position if disconnected. (Normal function of the servo bias spring is to apply a down-elevon load on the input mechanism to eliminate hysteresis.)

RUDDER CONTROL SYSTEM

The two full-moving rudders, which provide yaw (directional) control and stability, are positioned by control inputs from the rudder pedals, manual yaw trim system, and yaw SAS. Individual servo assemblies, which include a trim actuator and yaw feel spring, are installed in the fixed stub fin section of each rudder assembly.

Rudder Pedals and Input Mechanism

The rudder pedals connect to the yaw tension regulator by push-pull rods and bellcranks. A single closed-loop cable system to each rudder originates at the tension regulator and terminates at an input mechanism at the inboard side of each engine nacelle. The input mechanism transmits cable movement to the input lever at each rudder servo.

The rudder pedals are also used for main wheel braking (toe action) and nosewheel steering.

Pedal position is adjusted by the PEDAL ADJ T-handle, located at the bottom of the annunciator panel. To adjust rudder pedals, hold pedals and pull the PEDAL ADJ T-handle; the pedals are free to move fore-and-aft. Push or release the pedals to the desired position and release the T-handle to lock the pedals in place.

Rudder Servo Assembly

All yaw control inputs (pedals, manual trim, and SAS) are applied through the rudder servo which meters A and B hydraulic pressures to four actuating cylinders for positioning the rudder. (Two actuating cylinders at each servo powered by each hydraulic system.) A yaw trim actuator, incorporating a yaw feel spring, is installed at each servo. Yaw (rudder) trim is reflected in proportional rudder pedal movement.

MANUAL TRIM SYSTEM

All aircraft trim is achieved by positioning the main control surfaces. The pitch and roll trim actuators are an integral part of the elevon mixer assembly and a yaw trim actuator is installed at each rudder servo assembly.

Power for the manual pitch and yaw actuator motors is furnished by the ac hot bus through the PITCH & YAW circuit breaker on the pilot's right console. Power for the roll actuator motor is furnished by the essential ac bus through the ROLL circuit breaker on the pilot's right console.

Trim Power Switch

A TRIM POWER switch is located on the left side of the pilot's annunciator panel. In OFF, all trim (manual and auto) is inoperative. In ON, the trim system is operable.

Pitch, Roll, and Yaw Trim Indicators

Separate pitch, roll, and yaw trim indicators are on the pilot's instrument panel. The pitch trim indicator displays the sum of manual and Auto/Mach trim. SAS inputs are not shown. The roll trim indicator displays differential roll trim from 0 to 9 degrees. The yaw trim indicator displays the position of the left and right actuators individually on L and R needles. These needles are aligned (superimposed) when equal trim is applied at both rudders.

Power for the roll and yaw trim indicators is furnished by the essential ac bus 26 volt instrument transformer through the YAW and ROLL circuit breakers on the pilot's annunciator panel. Power for the pitch trim indicator is furnished by the emergency ac bus 26 volt instrument transformer through the PITCH circuit breaker on the pilot's annunciator panel.

Pitch Trim System

The pitch trim actuator may be operated by manual control, using a fast motor, or automatic control (including Mach Trim), using a slow motor. The manual (fast) trim motor trims ten times faster than the Auto/Mach (slow) trim motor. Pitch trim indication signals are provided by two position transmitters on the actuator. The slow motor transmitter also provides feedback signals to the autotrim system.

Pitch and Yaw Trim Switch

The manual pitch trim control switch is combined with the yaw trim switch on the control stick grip. Moving the switch up and down (from the spring-loaded center off position) applies nose-down and nose-up trim, respectively. Pitch trim application is limited to 5° ($-1/2^{\circ}$ $+1^{\circ}$) down and 8.5° (-1°, $+1/2^{\circ}$) up by actuator stroke limitations.

Moving the switch left and right applies left yaw and right yaw trim, respectively, to both rudders.

Manual pitch and yaw trim can be disconnected by pressing the trigger switch on the control stick grip. Mach trim is not affected.

CAUTION

To avoid runaway trim due to a sticking trim switch, assure positive switch movement to neutral after each actuation.

Roll Trim Switch

A three-position roll trim switch, located forward of the throttle quadrant, provides manual control of the roll trim actuator in the elevon mixer assembly. The self-centering switch may be toggled left and right to apply left roll and right roll trim, respectively. Roll trim application is limited (by actuator stroke length) to $\pm$ 4.5 degrees, for a maximum of 9 degrees differential roll trim.

Yaw Trim System

Yaw trim is applied by two trim actuators, one at each rudder servo assembly. The yaw function of the pitch and yaw trim switch on the control stick grip energizes both rudder trim actuators simultaneously. A right hand rudder synchronizer switch, located forward of the throttle quadrant, energizes the right rudder trim actuator only. Yaw trim is limited to approximately 10 degrees left and right by actuator stroke limits.

A shear pin is in the attach fittings of each actuator so rudder pedal inputs cannot be blocked by failure of a yaw feel spring in the trim actuator. If a seizure does occur, pedal inputs can break the shear pin and free the actuator attach point. When an actuator shear pin is broken, some yaw feel is lost and little or no yaw trim is available at the affected rudder.

NOTE

The trim actuator remains operative and the trim indicator needles will indicate normal trim operation, even though trim is applied at only one rudder. Rudder centering will be poor.

Right Hand Rudder Synchronizer Switch

Due to variations in rudder actuator motor speeds, yaw trim may not be applied equally to both rudders. A split in rudder position and yaw trim needle indications may result. A three-position, self-centering, RH RUDDER SYNCHRONIZER switch (located left of the roll trim switch) should be used to equalize left and right rudder trim positions. The switch may be toggled left and right to move the trailing edge of the right rudder left and right, respectively.

SURFACE LIMITER SYSTEM

Lateral (roll) control stick travel and rudder displacement are restricted by the surface limiter system. The system should be released (full travel mode) at speeds below Mach 0.5, and engaged (limited mode) at higher speeds. The surface limiter system is controlled by the SURF LIMIT RELEASE T-handle on the left side of the pilot's annunciator panel.

The T-handle is spring-loaded in the full forward (limited) position, and must be pulled aft to disengage the limiters and rotated 90 degrees clockwise to lock the handle aft. The T-handle is released (to engage the limiters) by rotating the handle 90 degrees counterclockwise.

A SURFACE LIMITER caution light on the pilot's annunciator panel illuminates if the limiters are in the wrong mode for the existing aircraft speed. The light is controlled by T-handle switch contacts and Mach inputs from DAFICS. With the limiters released, the light illuminates above Mach 0.5, and goes out when limiting is engaged. With limiters engaged, the light illuminates below Mach 0.5, and goes out when the full travel mode is selected.

Roll Travel Limiter System

With limiters engaged, a pin is inserted into a cam at the base of the control stick, physically limiting elevon travel to 14 degrees roll differential. Unlimited, the maximum roll differential is 24 degrees.

Rudder Travel Limiter System

Rudder travel is reduced from 20 degrees to 10 degrees left and right when the limiters are engaged. Rudder travel is limited by two different methods to ensure that no combination of rudder pedal, yaw trim, or yaw SAS can position the rudders beyond the limits. One method (mechanical), limits rudder pedal inputs by insertion of a pin between two stops on the rudder tension regulator in the forward cockpit. The second method (electro-hydraulic) limits travel of the rudder servo input lever at each servo by hydraulically extending solenoid limiter stops to restrict input lever movement.

The limiter control solenoids, located at each rudder servo, control hydraulic pressure for extension or retraction of the solenoid limiter stops. The control solenoids must be energized to permit hydraulic retraction of the stops when the limters are released. Power for solenoid control is furnished by the essential dc bus through individual RUD LIM circuit breakers on the pilot's left console. If limiter control power is lost, the solenoid stops extend to the limited position.

If power to one of the solenoid limiters is lost (loss of dc control power, relay failure, control circuit breaker trip, etc), rudder travel on the affected rudder will be limited to 10 degrees and the SURFACE LIMITER light will remain illuminated when full travel is selected. With one rudder limited and full travel selected, the non-limited rudder can be positioned well beyond the 10 degree limit by applying abnormal pressure on the rudder pedals.

DIGITAL AUTOMATIC FLIGHT AND INLET CONTROL SYSTEM (DAFICS)

The Digital Automatic Flight and Inlet Control System (DAFICS) comprises five major subsystems: stability augmentation system, autopilot/Mach trim system, automatic pitch warning and high angle of attack system, automatic/manual inlet control system, and air data system. The autopilot utilizes inputs from the ANS or the INS.

Air pressures measured independently by the A, B, and M channels of the pressure transducer assembly (PTA) are transmitted to the respective (A, B, and M) DAFICS computers, then shared between computers to determine best available measurements. DAFICS computes air data for schedules in DAFICS subsystems and cockpit displays (including the TDI).

The stability augmentation system provides automatic stability augmentation in the pitch, roll and yaw axis. The autopilot provides automatic flight control in the pitch and roll axes, and the Mach trim system provides speed stability augmentation in the pitch axis. The automatic pitch warning system provides a control stick shaker and stick pusher when approaching flight limits in the pitch axis. The inlet control system provides automatic and manual control of inlet air flow. (Refer to Figures 1-53 and 1-54.)

<u>Computer Reset Switches</u>

Individual A, B, and M CMPTR RESET switches on the pilot's annunciator panel allow manual restart of a computer. Holding a reset switch in the up position stops the respective DAFICS computer. Releasing the reset switch to the spring-loaded down position initiates restart. Deliberate computer(s) shutdown inflight is not authorized. The switches are powered by their respective A, B, and M CMPTR dc circuit breakers on the pilot's left console.

COMPUTER BUILT IN TEST

Computer inflight BIT performs a series of tests throughout flight to insure A, B, and M computer health and if any test fails, the computer will automatically shut itself down and turn on the appropriate CMPTR OUT light on the pilot's annunciator panel.

DAFICS PREFLIGHT BUILT IN TEST

The DAFICS preflight built in test (BIT) is normally accomplished before and after flight. The DAFICS PREFLIGHT BIT switch is located on the pilot's right console.

If the following requirements are not satisfied, the DAFICS PREFLIGHT BIT switch will not engage.

1. Hydraulic pressure - A system.
2. CMPTR OUT lights (3) not illuminated.
3. CSC/NWS switch - Released.
4. APW switch - PUSHER/SHAKER.
5. SPIKES & FWD BYPASS doors -AUTO.
6. RESTART switches - Off.
7. Throttle Restart switch - Off.
8. SAS channel engage switches - ON.
9. AUTOPILOT PITCH & ROLL switches - ON.
10. KEAS HOLD switch - ON.
11. HEADING HOLD switch - ON.

If B, L, or R hydraulic pressure is not available, the DAFICS PREFLIGHT BIT will fail.

During the DAFICS PREFLIGHT BIT, the APW pusher operates momentarily, the SHAKER warning light flashes momentarily, the A, B and M CMPTR OUT annunciator lights flash several times, the SAS SENSOR and SERVO lights flash momentarily, control surfaces move slightly, and the spikes move. The test cycle can be terminated manually by stopping any DAFICS computer. The BIT TEST light illuminates steady green while the test is running.

The test takes about one minute to complete. If the test is successful, the BIT TEST light flashes green at completion of the test. If any malfunctions are detected, the test continues, but at completion of the test the BIT TEST light extinguishes and the BIT FAIL light illuminates steady red.

When the DAFICS preflight BIT check is finished, indications are:

1. BIT FAIL light - Extinguished.
2. BIT TEST light - Flashing green.

or

1. BIT FAIL light - Steady red.
2. BIT TEST LIGHT - Extinguished.

3. MASTER CAUTION light - On.
4. SAS OUT annunciator panel light - Flashing.
5. Autopilot pitch and roll switches - Off.
6. HEADING HOLD switch - Off.
7. KEAS HOLD switch - Off.
8. AUTOPILOT OFF light - On.
9. OFF flags on both TDI's.
10. CIP barber pole at zero.
11. Spikes full forward.
12. DAFICS PRELIGHT BIT switch - OFF, automatically.

When the BIT terminates, if a steady red BIT TEST light, any SENSOR light, any SERVO light, or any CMPTR OUT light illuminates, notify maintenance.

The DAFICS remains in the test mode. Pressing one of the six SENSOR/SERVO recycle switches resets DAFICS to the flight mode. When DAFICS is reset to the flight mode, indications are:

1. A, B, and M CMPTR OUT lights - Flash, momentarily.

2. BIT TEST light - Off.

3. CIP Barber pole - Normal position.

4. Both TDI's will initiate resynchronization and run up to 55,000 ft, Mach 2.0, and 300 KEAS. AOA will indicate 10°. AOA will return to 0° in approximately 1 minute and 15 seconds and TDI indications will return to normal in approximately 2 minutes and 15 seconds after resetting DAFICS to the flight mode.

WARNING

- Failure to recycle a SENSOR/SERVO recycle switch will cause the DAFICS system to remain in the ground test mode. The SAS is non-functional while in the ground test mode. DAFICS will not operate normally until the system is reset.

- Do not attempt to activate the DAFICS PREFLIGHT BIT switch during flight. The DAFICS PREFLIGHT BIT check is inhibited unless there is weight on wheels, Mach number is less than 0.09, or KEAS is less than 101.

NOTE

Once DAFICS is reset to the flight mode, a flashing red BIT FAIL light indicates loss of SAS analytical redundancy.

STABILITY AUGMENTATION SYSTEM (SAS)

The stability augmentation system (SAS), a combination of electronic and hydraulic equipment, is an integral part of the basic aircraft control system. The system is normally engaged in all flight conditions, although it can be disengaged manually. Each axis of SAS (pitch, roll and yaw) is provided with two SAS channels. The SAS detects aircraft attitude changes and initiates control surface deflections to counteract the changes. Normally, the DAFICS A computer runs the A channel in pitch and yaw and the DAFICS B computer runs the B channel in pitch and yaw. The DAFICS M computer can take over for A computer or B computer or both in the pitch and yaw axis should A and/or B computer fail. The M computer drives through servo amplifiers in the A and B computer to provide surface control. The roll SAS is configured so that either A or B computer is capable of driving both roll servo channels. Sensor and servo monitors provide detection and automatic disengaging capability for faults.

During normal flight conditions, the aircraft experiences many small changes in attitude due to air loads or control inputs. These attitude changes are sensed by pitch, yaw, and roll sensors in each axis (three rate gyros in the pitch axis, three rate gyros plus three lateral accelerometers in the yaw axis, and two rate gyros in the roll axis). Analytical redundancy derived by the DAFICS computers from attitude displacements provides added redundancy for pitch, yaw and roll rate gyros, but not for the lateral accelerometers. The attitude changes detected by the sensors are sent to the DAFICS computers which electrically command the transfer valve positions of the SAS servos. The transfer valve converts the electrical signal into a proportional hydraulic flow into the SAS servo actuators. The SAS

COMPUTER INPUTS

COMPUTER INPUTS	DAFICS									
	SAS			AUTOPILOT & MACH TRIM	AIR DATA	APW & HIGH α WARNING	AIR INLET SYSTEM	COMPUTERS		
	PITCH	YAW	ROLL					A	B	M
A CMPTR RESET Switch								x		
B CMPTR RESET Switch									x	
M CMPTR RESET Switch										x
P_s	x	x	x	x	x	x	x	x	x	x
P_T	x	x	x	x	x	x	x	x	x	x
ΔP_α						x	x	x	x	x
ΔP_β							x			x
Duct Pressure Ratio Transducers (Left and Right)							x	x	x	
INLETS: AUTO SPIKE Switch Positions							x	x	x	x
AUTO FWD BYPASS Switch Positions							x	x	x	x
Manual Spikes							x			x
Manual Forward Bypass Doors							x			x
Manual BIAS Schedule Controls							x			x
G-BIAS (N_Z)							x	x	x	-
Total Temperature (From Left Inlet) ①								x	x	x
ELEVON SERVOS (2 Left and 2 Right)	x		x					x	x	x
RUDDER SERVOS (2 Left and 2 Right)		x						x	x	x
SURFACE RELEASE T-handle Position					x			x	x	
SAS: A Pitch Rate Sensor	x			x		x		x	x	
B Pitch Rate Sensor	x			x		x			x	x
M Pitch Rate Sensor	x			x		x		x		x
A Yaw Rate Sensor		x						x	x	
B Yaw Rate Sensor		x							x	x
M Yaw Rate Sensor		x						x		x
A Roll Rate Sensor			x	x				x	x	
B Roll Rate Sensor			x	x				x	x	
A Lateral Accelerometer Sensor		x						x	x	
B Lateral Accelerometer Sensor		x							x	x
M Lateral Accelerometer Sensor		x						x		x
A & B Pitch Channel Switches	x							x	x	x
A & B Yaw Channel Switches		x						x	x	x
A & B Roll Channel Switches			x					x	x	
A PITCH SENSOR Switch/Light	x							x	x	
B PITCH SENSOR Switch/Light	x								x	x
M PITCH SENSOR Switch/Light	x							x		x
A YAW SENSOR Switch/Light		x						x	x	
B YAW SENSOR Switch/Light		x							x	x
M YAW SENSOR Switch/Light		x						x		x
A PITCH SERVO Switch/Light								x		x
B PITCH SERVO Switch/Light									x	x
A YAW SERVO Switch/Light								x		x
B YAW SERVO Switch/Light									x	x
A ROLL SERVO Switch/Light								x	x	
B ROLL SERVO Switch/Light								x	x	
DAFICS PREFLIGHT BIT Switch	x	x	x	x	x	x	x	x	x	x
AUTOPILOT: All AUTOPILOT Panel Switches & Trim Wheels				x				x	x	
CSC Switch				x				x	x	
Trigger Switch (A/P Pusher Disconnect Switch)				x		x		x	x	
ATT REF SELECT Switch	x		x	x		x		x	x	x
INS: Pitch	x	x	x	x				x	x	x
Roll	x	x	x	x				x	x	x
Heading	x	x	x	x				x	x	x
Attitude Ready				x				x	x	
Heading Valid				x				x	x	
ANS: Pitch	x		x	x		x		x	x	x
Roll	x		x	x		x		x	x	x
Heading	x		x	x		x		x	x	x
Steering Commands				x				x	x	
NAV READY				x				x	x	
Hydro Pressure	x	x	x	x		x	x	x	x	x
Weight-On-Wheels (WOW)				x		x		x	x	x
Gear Up Locks						x		x	x	x
Door Down Locks							x			x

① Used in ANS and Map Projector

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Figure 1-53

COMPUTER OUTPUTS

	COMPUTER		
	A	B	M
TDI & TDI OFF FLAG (Pilot's and RSO's)	X	X	
INLETS:			
AUTO Spikes	X	X	
AUTO Forward Bypass Doors	X	X	
L & R UNST Lights	X	X	
ELEVON SERVOS (2 Left and 2 Right)	X	X	X
RUDDER SERVOS (2 Left and 2 Right)	X	X	X
SURFACE LIMITER Annunciator Panel Light	X	X	
SAS:			
A PITCH SENSOR Caution Light	X	X	
B PITCH SENSOR Caution Light		X	X
M PITCH SENSOR Caution Light	X		X
A YAW SENSOR Caution Light	X	X	
B YAW SENSOR Caution Light		X	X
M YAW SENSOR Caution Light	X		X
A or B or BOTH ROLL SENSOR Caution Light	X	X	
A PITCH SERVO Caution Light	X		X
B PITCH SERVO Caution Light		X	X
A YAW SERVO Caution Light	X		X
B YAW SERVO Caution Light		X	X
A ROLL SERVO Caution Light	X	X	
B ROLL SERVO Caution Light	X	X	
SAS OUT Annunciator Panel Light	X	X	X
DAFICS PREFLIGHT BIT Switch	X	X	X
BIT TEST/FAIL Lights	X	X	X
MACH TRIM	X	X	X
DAFICS:			
A CMPTR OUT Annunciator Panel Light	X		
B CMPTR OUT Annunciator Panel Light		X	
M CMPTR OUT Annunciator Panel Light			X
2 PTA CHANNELS OUT Annunciator Light	X	X	X
AUTOPILOT:			
Auto Trim	X	X	
Flight Director Steering Indicator	X	X	
Pitch Trim Indice	X	X	
Roll Trim Indice	X	X	
APW & HIGH α WARNING:			
Pusher	X	X	
Shaker	X	X	
SHAKER Warning Light	X	X	
APW Annunciator Panel Light	X	X	
ANGLE OF ATTACK Indicator	X	X	
ADI (APW Boundary Only)	X	X	

Figure 1-54 (Sheet 1 of 2)

COMPUTER OUTPUTS

	COMPUTER		
	A	B	M
KEAS Warning:	X	X	
KEAS Warning Light	X	X	
Low KEAS Aural Warning			X
DMRS (DAFICS related portions)			X
CIP (Barber Pole Only)			X
Altitude Reporting (IFF Mode C)			X
Altitude and TAS to ANS:			X
Altitude from ANS to V/H System - NAV Switch Position			
Altitude from ANS to CAPRE SLR for RADAR ALTITUDE			
TAS from ANS to Navigation Control & Display Panel			
TAS to Pilot's & RSO's Map Projector - Automatic Map Rate			X
Heading to PVD			X

Figure 1-54 (Sheet 2 of 2)

servos position the flight control surfaces to compensate for the original sensed rate of attitude change. The three pitch and the three yaw gyros are mounted in the No. 2 fuel tank; the two roll gyros are in the R bay; the lateral accelerometers are in the nose wheel well.

SAS Control

SAS engagement is controlled by an engage solenoid on each transfer valve. The solenoids must be energized to permit hydraulic flow into the transfer valve and engage the SAS. With the solenoid deenergized, hydraulic flow is shut off and the SAS is disengaged as SAS electronic inputs cannot position control surfaces when hydraulic flow to the transfer valves is shut off. The SAS is normally engaged (solenoids energized) by operating the SAS control switches to ON. The SAS may be disengaged manually by moving the control switches to OFF, or automatically by DAFICS.

SAS Redundancy

Basic SAS system redundancy is provided by the presence of two channels in each axis. Either channel alone is capable of providing satisfactory damping in the respective axis. SAS reliability is further assured by the fact that a single electrical or hydraulic failure cannot result in loss of both channels in any axis.

Separate sources of hydraulic power are provided for each channel; A hydraulic system for A channel SAS, and B hydraulic system for B channel SAS. Complete loss of either hydraulic system will not adversely affect operation of the remaining SAS channel, providing the pitch, roll and yaw engage switches of the failed SAS channel are OFF.

Similar protection through redundancy is provided in the SAS electrical supply and distribution systems. The AC and DC power supplies are from the two highest priority buses in the aircraft, the emergency AC and the essential DC buses. Both of these buses may be energized by aircraft battery power in the event of multiple failures within the electrical systems.

DC control power into the computers is through the A, B, and M CMPTR circuit breakers on the pilot's left console. Loss of A or B computer power does not eliminate roll SAS. Loss of power to any two computers does not eliminate pitch and yaw SAS. AC power distribution to the DAFICS and hence SAS is from the emergency AC bus, through nine circuit breakers on the right console in the aft cockpit (A COMPUTER AØ, BØ, CØ, B COMPUTER AØ, BØ, CØ, M CMPTR AØ, BØ, CØ). Each computer has isolated power. Each computer can have a single ac circuit breaker fail and continue to operate normally.

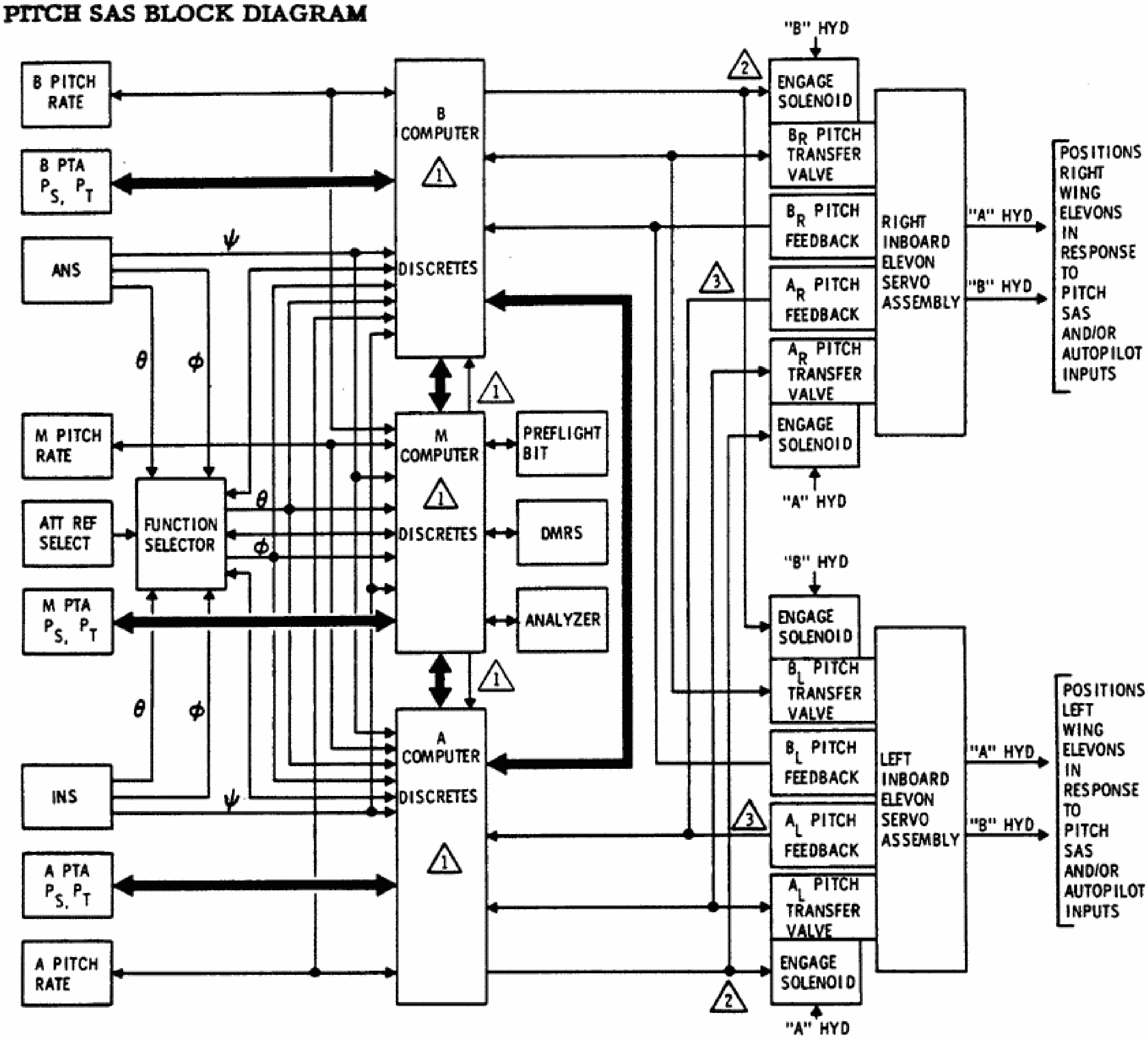
SAS servo engage power is separated from computer dc power to improve redundancy. Six circuit breakers on the pilot's left console (PITCH A, B; ROLL A, B; YAW A, B) provide independent engage power for each servo.

Pitch SAS

The SAS pitch axis control system consists of three pitch sensors (A, B, and M), the three DAFICS computers (A, B, and M) and two servo channels (A and B). Normally, the A computer drives the A servo channel the B computer drives the B servo channel. In case of A and/or B computer failures, the M computer can drive the A servo channel or the B servo channel or both. To obtain triple redundancy for pitch rate sensors, the DAFICS computers employ an analytical pitch rate derived from the pitch, roll and heading displacements of the platform (ANS or INS) selected on the pilot's ATT REF SELECT switch. This analytical redundancy pitch rate is used to isolate gyro faults after a second pitch rate gyro has failed, so that the remaining good gyro can be selected. The sensor selection process is shown on Figure 1-55.

The computers generate control inputs to the pitch SAS transfer valves in response to vehicle pitch rates. The transfer valves convert electronic metering signals into hydraulic flow to the SAS servos which are positioned to cause elevon deflections to counteract gyro-sensed attitude changes.

PITCH SAS BLOCK DIAGRAM



SENSOR (RATE) SELECT

SENSOR CONDITION	SENSOR USED COMPUTER A	COMPUTER B	COMPUTER M	SENSOR OUTPUT SELECTED
Normal	A	B	M	Median of A, B, M
Fail A	M	B	M	Average of B, M
Fail B	A	A	M	Average of A, M
Fail M	A	B	B	Average of A, B
WITH ANALYTICAL REDUNDANCY				
Fail A, B	M	-	M	M
Fail B, M	A	A	-	A
Fail A, M	-	B	B	B
WITHOUT ANALYTICAL REDUNDANCY				
Fail A, B	-	-	-	None
Fail B, M	-	-	-	None
Fail A, M	-	-	-	None

COMPUTER SELECT

COMPUTER CONDITION	COMPUTER DRIVING SERVOS A_L	A_R	B_L	B_R	BACKUP
Normal	A	A	B	B	M for A, B
Fail A	M	M	B	B	M for B
Fail B	A	A	M	M	M for A
Fail M	A	A	B	B	None
Fail A, B	M	M	M	M	None
Fail A, M	-	-	B	B	None
Fail B, M	A	A	-	-	None

NOTE

△1 Pitch SAS Control

△2 Controls engagement of SAS channel by controlling hydraulic flow through the transfer valve. With switch OFF or logic tripped, hydraulic flow is blocked and SAS / Autopilot signals cannot position elevons. Switch A controls A_L and A_R solenoids. Switch B controls B_L and B_R solenoids.

△3 Inputs indicate direction and degree of elevon deflection applied by SAS servos. An imbalance equal to 0.86 degrees elevon position will generate a logic 'trip' signal.

CODE

⟷ DIGITAL INTERFACE

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Figure 1-55

Pitch SAS authority is limited to 6.5 degrees trailing edge up and 2.5 degrees trailing edge down elevon deflections.

Each channel controls metering in two transfer valves. Outputs of A or M computer commands left (A_L) and right (A_R) transfer valve, one located on each inboard elevon servo assembly. B or M computer commands the other two pitch transfer valves (B_L and B_R). Each pitch engage switch controls the engage solenoids in two transfer valves, one on the left and one on the right inboard elevon servo assembly. (See Figure 1-55 for Pitch SAS block diagram.)

An increased pitch rate gain (7 degrees $\delta e/^{o}q$) with slowed ("lagged") response is used above 50,000 feet. The lagged pitch rate gain is blended into the pitch SAS control loop over an altitude range of 49,400 to 50,600 feet to prevent vehicle transients if maneuvering.

In addition, a lagged yaw rate correction is used during turns above 50,000 feet provided the roll autopilot channel is engaged. The LYR correction is blended into the pitch SAS servo loop over an altitude range of 49,400 to 50,600 feet to prevent vehicle transients in turns. The lagged yaw rate signal, which is derived from bank angle and the sustained yaw rate sensed by the SAS in a turn, is applied as an up elevon correction to oppose the down elevon command resulting from the sustained pitch rate sensed by the pitch SAS in a turn. Lagged yaw rate reduces the amount of up-trimming which would otherwise be required in a turn. The maximum authority of the LYR trim signal is 2.3 degrees δ e. A $\pm$10 degrees deadband in bank angle prevents nuisance corrections. No LYR up elevon correction will result until bank angle exceeds $\pm$10 degrees. The LYR feature is switched out of the control system when the roll autopilot is disengaged. No abrupt trim change requirement occurs during the transition. If disabled while turning, the LYR term fades out gradually to zero in approximately 15 seconds.

Yaw SAS

The SAS yaw axis control system is similar to the pitch SAS system, with three yaw rate gyro sensors, three lateral accelerometer sensors, the three DAFICS computers, and two servo channels. Yaw attitude changes are sensed by three yaw rate gyros and three lateral accelerometers, and their combined inputs are used to compute servo commands. The lateral accelerometers provide long term damping and apply corrective inputs to the control system to minimize aircraft sideslips. Analytical redundancy is available for yaw rate sensors but not for lateral accelerometers. Therefore, yaw SAS is operative with dual yaw rate gyro failures, but not for dual lateral accelerometer failures.

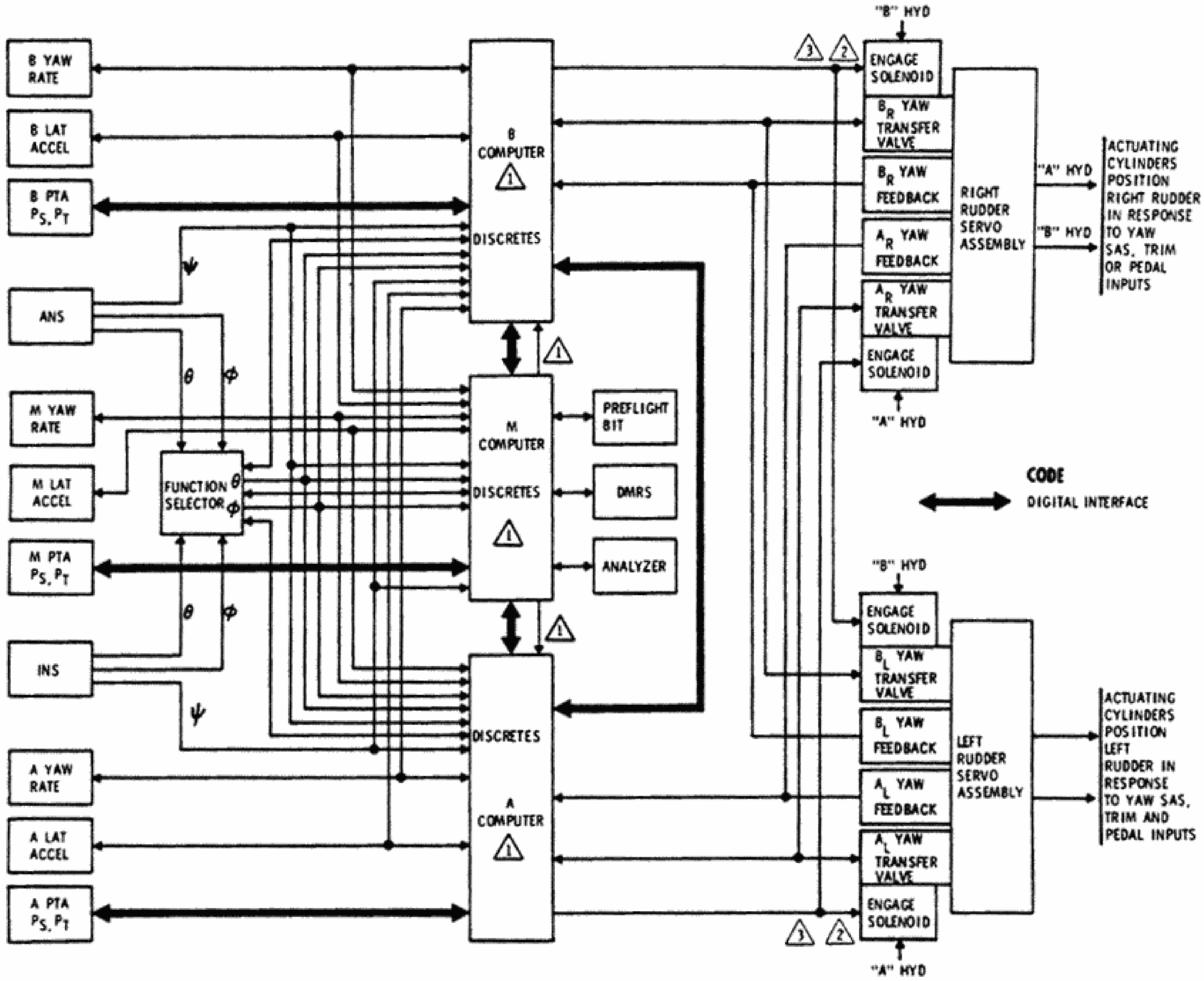
Two yaw transfer valves are mounted on each rudder servo in such an arrangement that each SAS channel provides half the SAS input. During single-channel operation, the gain is doubled into the operative channel to provide effective single-channel SAS operation. Each yaw SAS engage switch controls the engage solenoids in two transfer valves, one on each rudder servo. Yaw SAS authority is limited to approximately 8 degrees left and 8 degrees right. (See Figure 1-56 for Yaw SAS block diagram.)

Roll SAS

The SAS roll axis control system consists of two roll sensors (A and B), two DAFICS computers (A and B), and two servo channels (A and B). Either A or B computer is capable of driving both A and B independent servo channels in case of an A or B computer failure. Channel A controls the left elevons and channel B the right elevons through a single roll SAS transfer valve mounted on each inboard elevon servo assembly. The A roll engage switch controls the left roll SAS engage solenoid, and the B roll engage switch controls the right engage solenoid. With both servos operating, roll SAS is limited to approximately 4 degrees differential elevon.

When only one roll channel is engaged, automatic logic protection is unavailable. Since only one elevon is moving in response to roll

YAW SAS BLOCK DIAGRAM



SENSOR (RATE) SELECT

SENSOR CONDITION	SENSOR USED A	SENSOR USED B	SENSOR USED M	SENSOR OUTPUT SELECTED
Normal	A	B	M	Median of A, B, M
Fail A	M	B	M	Average of B, M
Fail B	A	A	M	Average of A, M
Fail M	A	B	B	Average of A, B
RATE GYRO WITH ANALYTICAL REDUNDANCY				
Fail A, B	M	-	M	M
Fail B, M	A	A	-	A
Fail A, M	-	B	B	B
RATE GYROS WITHOUT ANALYTICAL REDUNDANCY OR LATERAL ACCELEROMETER				
Fail A, B	-	-	-	None
Fail B, M	-	-	-	None
Fail A, M	-	-	-	None

COMPUTER SELECT

COMPUTER CONDITION	COMPUTER DRIVING SERVOS A_L	A_R	B_L	B_R	BACKUP
NORMAL	A	A	B	B	M for A, B
FAIL A	M	M	B	B	M for B
FAIL B	A	A	M	M	M for A
FAIL M	A	A	B	B	None
FAIL A, B	M	M	M	M	None
FAIL A, M	-	-	B	B	None
FAIL B, M	A	A	-	-	None

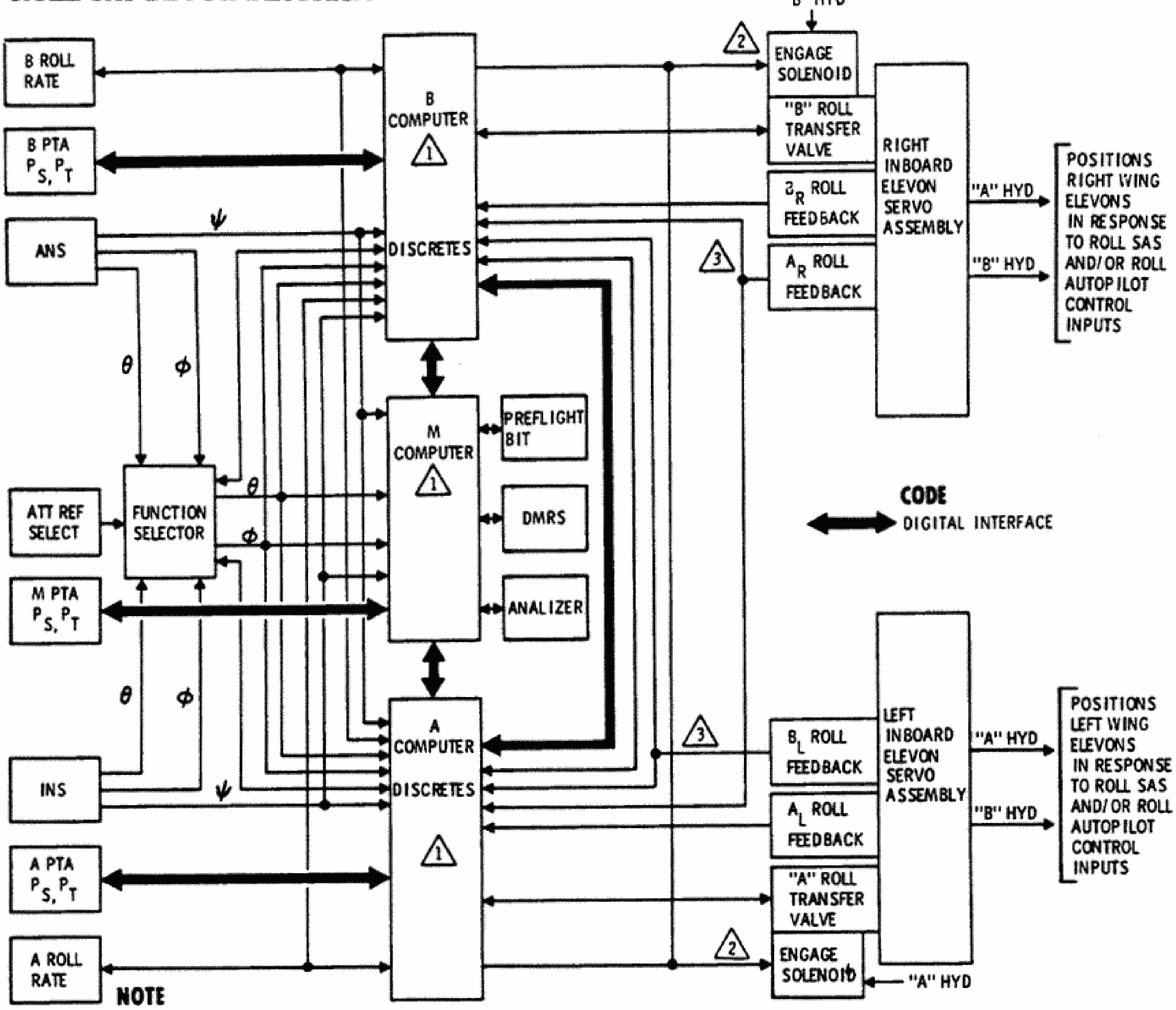
NOTE

1. YAW SAS Control
2. Logic outputs are generated by a "difference" between compared inputs, which disengage the faulty channel and energize SAS lamps to indicate whether fault was in SAS sensors or SAS servo. Gain is doubled in the remaining active channel to maintain effective Yaw SAS.
3. Controls engagement of SAS channel by controlling hydraulic flow through the transfer valve. With switch OFF or logic tripped, hydraulic flow is blocked and SAS signals cannot position rudders. Switch A controls A_L and A_R solenoids. Switch B controls B_L and B_R solenoids.

F203-272(a)

Fig[redacted]

ROLL SAS BLOCK DIAGRAM



NOTE

Roll SAS Control

a. Both switches OFF to ON engages both SAS channels and "ARMS" roll logic.

b. Sensor Failures
- First sensor failure - Normal roll SAS capability.
- Second sensor failure - No roll SAS capability.

c. Servo Failures
- Servo logic "trip" disengages both channels.
- For a hard failure, single channel operation can be selected by disengaging both A and B engage switches and re-engaging channel opposite from failed servo light.
- Single channel operation overrides all servo logic protection.
- For momentary failure, recycle either engage switch to resume normal operation.

⚠1 SENSOR (RATE) SELECT

SENSOR CONDITION	SENSOR USED COMPUTER A	COMPUTER B	SENSOR OUTPUT SELECTED
NORMAL	A	B	AVERAGE OF A, B
WITH ANALYTICAL REDUNDANCY			
Fail A	B	B	B
Fail B	A	A	A
Fail A, B	-	-	None
WITHOUT ANALYTICAL REDUNDANCY			
Fail A	-	-	None
Fail B	-	-	None

COMPUTER SELECT

COMPUTER CONDITION	COMPUTER DRIVING SERVOS LEFT	RIGHT	BACKUP
Normal	A	B	Other Computer
Fail A	B	B	None
Fail B	A	A	None

⚠2 Controls engagement of SAS channel by controlling hydraulic flow through transfer valve. With switch OFF or logic "TRIPPED", hydraulic flow is blocked and SAS/Autopilot control signals cannot position elevons.

⚠3 Inputs indicate direction and degree of elevon deflection applied by SAS servos. An imbalance equal to 0.6 degrees elevon position will generate a logic "TRIP" signal.

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Figure 1-57

SAS, differential elevon available is reduced from 4 to 2 degrees with some coupling into the pitch and yaw axes.

Analytical redundancy in the DAFICS computers derives a third roll rate to use for voting after a single rate gyro has failed. This capability provides dual sensor redundancy. (See Figure 1-57 for Roll SAS block diagram.)

SAS Controls and Indicators

Manual engage, disengage, and recycle control of SAS is provided by controls on the function selector panel on the pilot's right console. Indicator lights (recycle light/-switches) on the function selector panel display status of the system sensors and servos. When not in the ground test mode, the red BIT FAIL light flashes if analytical redundancy is not available. The SAS OUT light on the annunciator panel and the master CAUTION light illuminate for SAS failures but not for analytical redundancy failure. Refer to Figure 1-58, SAS Controls and Indications Table, for details of switch functions.

SAS LOGIC

DAFICS logic monitors voltages within all three axes of SAS so that malfunctions within the SAS can be detected at an early stage. The system is extremely sensitive and voltage tolerances are small, so even minor errors are detected to provide maximum protection. The logic system will disengage the affected servo when a difference in voltage is detected which is equivalent to approximately 2 degrees surface deflection error in pitch and yaw, and 0.6 degree in roll.

Pitch SAS

Sensors

Computer sensor select capability selects median between A, B and M gyro outputs and uses that signal for A, B or M computer SAS control. If tracking requirements are exceeded (first failure) the gyro that is out of tolerance is voted out and the appropriate PITCH SENSOR light on the function selector and the SAS OUT light on the annunciator panel are turned ON. The remaining two gyro outputs are now averaged and that signal is used for A, B or M computer SAS control. If the remaining two gyros exceed the tracking requirement (second failure) both gyros are compared with analytical redundancy derived pitch rate to pick out the failed gyro (appropriate PITCH SENSOR light on function selector and SAS OUT light on annunciator panel are turned ON). The remaining good gyro is now used for A, B or M computer SAS control. If the remaining gyro now exceeds tracking limit (third failure) all pitch SAS channels are disengaged (A, B and M PITCH SENSOR lights on function selector and SAS OUT light on annunciator panel are turned on).

If analytical redundancy is not available (flashing BIT FAIL light), when second gyro failure occurs, both pitch SAS channels are disengaged (A, B, and M PITCH SENSOR lights on function selector and SAS OUT lights on annunciator panel are turned on).

Servos

Computer servo monitoring compares left servo LVDT's with right servo LVDT's. If tracking requirement is exceeded, both LVDT's are compared with a servo model to isolate failure (appropriate PITCH SERVO light on function selector and SAS OUT light on annunciator panel are turned on) and that servo channel is disengaged.

Pitch servo LVDT primary and secondary monitors determine if impedence is within acceptable limits. If limits are exceeded, appropriate PITCH SERVO light on function selector and SAS OUT light on annunciator panel are turned on and the failed servo channel is disengaged.

Yaw SAS Logic

Sensors

Yaw sensor failure can be either a rate gyro or lateral accelerometer. Yaw rate gyro failures are indicated by a steady A, B, or M YAW SENSOR light. Lateral accelerometer failures are indicated by a flashing A, B, or M YAW SENSOR light. If the same yaw rate gyro and lateral accelerometer fail (A, B or M sensor), that YAW SENSOR light will be on steady. Computer sensor select capability for yaw rate gyros is the same as for pitch rate gyros, therefore, yaw SAS is available for single or dual gyro failures (if analytical redundancy is operative). Analytical redundancy is not provided for lateral accelerometers. Computer sensor select capability for lateral accelerometers is the same as for pitch rate gyros when analytical redundancy is not available, therefore, yaw SAS is not operative with dual lateral accelerometer failures.

Servos

Computer servo monitoring is the same as pitch SAS.

Yaw servo LVDT primary and secondary monitors are the same as for pitch SAS.

Roll SAS Logic

Sensors

Computer sensor select capability averages the A and B gyro outputs and uses that signal for A and B computer SAS control. If A and B gyro outputs exceed tracking requirement (first failure) both gyros are compared with the analytical redundancy derived roll rate signal. The remaining gyro that is within tolerance is selected and used for A and B computer SAS control (the ROLL SENSOR light on function selector and SAS OUT light on annunciator panel are turned on).

If analytical redundancy is not available (flashing BIT FAIL light), when first gyro failure occurs both roll SAS channels are disengaged (roll sensor light on function selector and SAS OUT light on annunciator panel are turned on). With analytical redundancy a second failure disengages roll SAS (ROLL SENSOR light on function selector and SAS OUT light on annunciator panel remain ON).

Servos

Computer servo monitoring compares left servo LVDT's with right servo LVDT's. If tracking requirement is exceeded both LVDT's are compared with a servo model to isolate failure and appropriate ROLL SERVO light on the function selector and SAS OUT light on annunciator panel are turned on and Roll SAS disengages. To select single channel Roll SAS engage the channel opposite from failed ROLL SERVO light on function selector.

Roll servo LVDT primary and secondary monitors determine if resistance is within acceptable limits. If limits are exceeded appropriate ROLL SERVO light on function selector and SAS OUT light on annunciator panel are turned on and Roll SAS disengages.

A subsequent servo failure in the reengaged good channel will neither disengage the servo nor illuminate the SERVO light in that channel.

AUTOPILOT

DAFICS A and B computers control the pitch and roll autopilot. Both the pitch and roll channels can be engaged, or either one may be operated independently. The autopilot pitch channel may be operated in the basic attitude hold mode, or with one of two other special features (Mach hold or KEAS hold). An automatic pitch trim system is energized when the pitch channel of the autopilot is engaged. A Mach trim system, not part of the autopilot, is enabled when the pitch channel of the autopilot is off. The roll channel may be operated in the basic attitude hold mode, or with one of two other features (heading hold or automatic navigation).

The autopilot pitch channel cannot be engaged unless at least one pitch SAS channel is engaged, and the autopilot roll channel cannot be engaged unless at least one roll SAS channel and one yaw SAS channel is engaged. Elevon control responses due to SAS and/or autopilot inputs are not reflected in control stick movement as they are applied

SAS CONTROLS AND INDICATIONS

CONTROL OR INDICATOR	POSITION OR INDICATION	FUNCTION
CHANNEL ENGAGE SWITCHES. One ON-OFF toggle switch for channel (A & B) of each axis. (On function selector.)	ON (A or B)	Energizes A or B channel of respective axis by energizing the engage solenoids of associated transfer valves.
	Off (A or B)	Disengages respective channel by de-energizing associated transfer valve engage solenoid. SERVO legend(s) corresponding to disengaged channel(s) illuminate.
SENSOR/SERVO Light-Switches, SENSOR half. One SENSOR light for each sensor (A, B & M) of Pitch SAS and Yaw SAS. (On function selector.)	All SENSOR lights Off.	Indicates normal pitch and yaw SAS conditions with all sensor inputs tracking within required limits.
	A, B or M SENSOR light On steady.	In pitch SAS, indicates failure and exclusion of sensor input. SAS remains engaged and operative. In yaw SAS, indicates exclusion of sensor input due to rate gyro failure. SAS remains engaged and operative.
	Push-button Recycling	Pushing any of the three push-buttons for that SAS axis recycles SAS logic to re-input the excluded sensor. SEE NOTE.
	A, B or M YAW SENSOR light Flashing. (1)	Indicates exclusion of yaw sensor input due to lateral accelerometer failure. SAS remains engaged and operative.
	Push-button Recycling	Pushing any of the three push-buttons for the yaw axis recycles SAS logic to re-input the excluded sensor. SEE NOTE.
	A & M or B & M or A & B SENSOR lights On steady. (2)	In pitch SAS, indicates failure and exclusion of two sensor inputs (analytical redundancy operating). SAS remains engaged and operative. In yaw SAS, indicates exclusion of two sensor inputs due to rate gyro failures (analytical redundancy operating). SAS remains engaged and operative.
	Push-button Recycling	Pushing any of the three push-buttons for that SAS axis recycles SAS logic to re-input one sensor. Pulse aircraft both directions in that axis, then press any of the three push-buttons again to re-input the other sensor. SEE NOTE.

(1) If both the yaw rate gyro and the lateral accelerometer fail in the same yaw sensor, that YAW SENSOR light will be On steady.

(2) Assumes at least two DAFICS computers operating.

Figure 1-58 (Sheet 1 of 4)

SAS CONTROLS AND INDICATIONS (Cont.)

CONTROL OR INDICATOR	POSITION OR INDICATION	FUNCTION
SENSOR/SERVO (Cont.)	A, B & M SENSOR lights On steady.	In Pitch SAS, indicates failure of all three sensors, or of two sensors and analytical redundancy. Both pitch servos disengage. In yaw SAS, indicates failure of all three sensors due to rate gyro malfunctions or of two rate gyros and analytical redundancy. Both yaw servos disengage.
	Push-button Recycling	Pushing any of the three push-buttons for that SAS axis recycles SAS logic to re-input one sensor. Pulse aircraft both directions in that axis, then press any of the three push-buttons again to re-input the next sensor. Repeat for last sensor. SEE NOTE.
	A, B & M YAW SENSOR lights Flashing	Indicates failure of at least two yaw sensors due to lateral accelerometer malfunctions. Both servos disengage.
	Push-button Recycling	Recycling has no effect.
Roll SENSOR Light. (On function selector between ROLL engage switches.)	Light Off	Indicates normal roll SAS condition with both sensor inputs tracking within required limits.
	Light On	Indicates failure and exclusion of one sensor, both sensors, or one sensor and analytical redundancy. Two failures cause both roll servos to disengage. With failure and exclusion of one sensor, roll SAS remains engaged and operative.
	Engage Switch Recycling	Recycling either SAS ROLL engage switch recycles SAS logic to re-input one sensor. If light remains on, roll aircraft both left and right, then recycle either engage switch to re-input the other sensor. SEE NOTE.

Figure 1-58 (Sheet 2 of 4)

SAS CONTROLS AND INDICATIONS (Cont.)

CONTROL OR INDICATOR	POSITION OR INDICATION	FUNCTION
SENSOR/SERVO Light-Switches, SERVO half. One SERVO light for each servo (A & B) of each SAS axis. (On function selector.)	All SERVO lights Off.	Normal condition with SAS engaged. (Engage switches ON and logic recycled.)
	A or B SERVO light ON. Pitch or Yaw SAS. △3	Indicates channel disengagement due to engage switch Off or servo logic trip in that channel (failure in transfer valve/servo portion of channel). SAS is still operational but servo redundancy is lost.
	Push-button Recycling	For pitch or yaw SAS servo logic trip, pressing any of the three push-buttons for that SAS axis recycles logic and re-engages the tripped channel. SEE NOTE.
	A or B SERVO light On. Roll SAS.	Indicates channel engage switch Off or servo logic trip in that channel. Both roll servos disengage.
	Engage Switch Recycling	Recycling either ROLL engage switch recycles logic and re-engages the tripped channel. SEE NOTE. To override if failure remains, disengage both switches and re-engage good servo only (to provide proper control gain). Subsequent failure in good servo will not disengage that channel or illuminate that servo light.
	A & B SERVO Lights On. Pitch or Yaw SAS.	Indicates both channel engage switches Off or servo logic trip in both channels. Both servos in that axis disengage.
	Push-button Recycling	For pitch or yaw SAS logic trip, pressing any one of the three push-buttons for that SAS axis will re-engage one servo. Press any of the three push-buttons again to re-engage the other servo. SEE NOTE.
	A & B SERVO Lights On. Roll SAS.	Indicates both channel engage switches Off or servo logic trip in both channels in infrequent occasions when system comparison of servos against model does not yield a positive identification of the servo which has failed. Both roll servos disengage.
	Engage Switch Recycling.	Recycling either ROLL engage switch re-engages both channels. SEE NOTE. To override if failure remains, disengage both switches and re-engage good servo only (to provide proper control gain). Subsequent failure in good servo will not disengage that channel or illuminate that servo light.

△3 Unless (A & M) or (B & M) computers failed.

Figure 1-58 (Sheet 3 of 4)

SAS CONTROLS AND INDICATIONS (Cont.)

CONTROL OR INDICATOR	POSITION OR INDICATION	FUNCTION
DAFICS Preflight BIT FAIL light (red).	Flashing	Indicates analytical redundancy is not available.
SAS LITE TEST switch. Press-to-test switch on function selector panel.	PRESS	Energizes all lights (13) on function selector panel and DAFICS PREFLIGHT BIT TEST/FAIL lights.
SAS OUT light on annunciator panel.	OFF	Normal condition with all SAS channels engaged.
	ON	Indicates failures and/or disengagement of a SAS sensor(s) or servo(s) or DAFICS in PREFLIGHT BIT mode.

NOTE: SAS logic trips may be due to transient, passive, or active failures.

A transient trip is usually due to temporary and excessive fluctuations of electrical or hydraulic supplies into SAS, and the tripped channel will re-engage and remain engaged when recycled (unless fluctuations continue or recur).

A passive trip is usually caused by a failure such as loss of ac or dc electrical power, electrical shorts/opens, or hydro/mechanical malfunction of the SAS transfer valves or servos. A channel with a passive failure will usually not engage upon recycling.

An active trip occurs when signals of some magnitude are generated within the affected channel. When recycled, the channel will re-engage and remain engaged until aircraft attitude changes initiate signals in the affected axis. Exercising the flight controls in that axis so as to generate strong signals in the suspect channel will permit an active check of channel integrity. (If channel remains engaged, the trip may be considered a transient type.)

Figure 1-58 (Sheet 4 of 4)

through series servos, common to both. However, pitch autotrim applications from the autopilot or Mach trim are displayed on the pitch trim indicator, as autotrim is applied through the pitch trim actuator in the mixer assembly.

Essential dc power is provided through the A/P MACH TR A and A/P MACH TR B circuit breakers on the pilot's left console. Emergency ac power is provided through the RSO's AP MACH TR circuit breaker.

NOTE

Autopilot redundancy is lost when one of the two A/P MACH TR dc circuit breakers is opened. To disable the autopilot, both A/P MACH TR A & B circuit breakers must be opened or the AP MACH TR ac circuit breaker in the aft cockpit must be opened.

Autopilot Reference Signals

The autopilot receives attitude, heading, and navigational inputs from the Astroinertial Navigation System. The Inertial Navigation

System, provides only attitude and heading inputs. The autopilot uses the attitude reference (ANS or INS) selected by the pilot's ATT REF SELECT switch. If the rate of change of pitch angle of the selected attitude reference is excessive compared to SAS pitch rate, the pitch autopilot disengages and the AUTOPILOT OFF light on the pilot's annunciator panel illuminates. DAFICS schedules autopilot signal strength (gain) relative to altitude and airspeed, and provides Mach and KEAS references.

Pre-engage Synchronize Mode

When not engaged, the autopilot operates in the pre-engage synchronize mode, which aligns autopilot signals with the existing aircraft attitude to minimize control transients when the autopilot is engaged.

Autopilot Alignment (Trim) Indicators

When the autopilot is engaged, the alignment indicators reflect the direction and magnitude of autopilot control inputs. Needles will normally be close to center, and a continuous deflection in the same direction indicates an out-of-trim condition.

NOTE

> The pilot should be prepared for control transients when engaging or disengaging the autopilot regardless of alignment indications, as out-of-synchronization conditions may exist which are not registered on the alignment indicators.

Attitude Hold Mode

Each autopilot channel is initially engaged in the attitude-hold mode. After initial engagement, secondary modes may be engaged as desired: KEAS hold or Mach hold in pitch channel, and heading hold or Auto-Nav in roll channel.

In attitude hold, the autopilot controls elevon deflections to maintain attitude, using change in attitude as an error signal. Manual control inputs from stick or trim will cause only momentary departures from the engaged attitude, as the autopilot will counteract such inputs to regain the reference attitude.

The reference attitude may be changed by use of the respective channel trim wheel or the CSC switch without disengaging the autopilot. The pitch and roll trim wheels permit vernier adjustments by inserting corrections at approximately 1 degree per 15 degrees wheel rotation in pitch and 1 degree per 8° wheel rotation in roll. Depressing the CSC push-button disengages the autopilot secondary modes and permits control stick changes to aircraft attitude without override or disengagement of the autopilot. The attitude existing when the CSC pushbutton is released becomes the new autopilot reference attitude.

Mach Hold and KEAS Hold

Mach hold or KEAS hold may be engaged after the pitch autopilot is engaged in attitude hold. When either secondary mode is engaged, the attitude-hold mode is rendered inoperative, and the autopilot controls pitch attitude to maintain the Mach or KEAS existing when the respective mode was engaged.

The DAFICS computers provide Mach and KEAS signals to both the autopilot and the triple display indicator, so if TDI indications are in error, do not engage Mach hold or KEAS hold. With the pitch autopilot engaged, stabilize the aircraft for a few seconds at the desired Mach or KEAS before engaging either mode. When switching between Mach hold and KEAS hold, a slight time delay is provided to permit autopilot synchronization to the new reference, and the pilot should monitor respective indications to ensure that the autopilot has engaged in the desired mode.

NOTE

> Manual control inputs from stick or trim will cause attitude transients while the autopilot is engaged in Mach hold or KEAS hold. If autopilot authority is exceeded while in Mach hold or KEAS hold, the autopilot will not maintain the engaged value. Use of CSC will disengage all autopilot secondary modes. If Mach hold or KEAS hold is engaged, autopilot pitch trim wheel inputs will disengage the autopilot pitch channel.

KEAS Bleed

The KEAS hold and Mach hold modes automatically control the autopilot pitch channel so that a speed schedule from 500 KEAS and 2.1 Mach to 380 KEAS and 3.3 Mach will not be exceeded. The bleed line is a linear function of 10 knots per 0.1 Mach number. (See Figure 1-59.)

When KEAS hold is engaged during climb, pitch attitude is controlled to maintain engage equivalent airspeed until the KEAS bleed schedule is intercepted. When KEAS hold is used for a normal 450 KEAS climb, bleed begins when the bleed line is intercepted at 2.6 Mach, and will continue to 380 KEAS and Mach 3.3. If a 430 KEAS climb speed was selected, bleed-off would begin at Mach 2.8.

If KEAS hold is disengaged after climb and reengaged at a speed below bleed line, the engage KEAS will be held constant for subsequent cruise or descent. However, if KEAS hold is not disengaged after climb, and Mach is reduced, the autopilot will follow the bleed line until the initial engage KEAS is reached, and then maintain that KEAS. If KEAS hold is engaged while airspeed is above the bleed line, the autopilot will slow the aircraft to the bleed-line schedule by nose-up attitude changes, and will follow the bleed schedule during subsequent cruise, climb, and descent.

If Mach hold is engaged, pitch attitude is controlled to maintain engage Mach unless the KEAS bleed line is intercepted. During climb at constant Mach, KEAS decrease. During descent at constant Mach, KEAS increase; however if the KEAS bleed line is intercepted the autopilot follows the KEAS bleed line. If Mach hold is engaged at Mach 3 and power is reduced, the autopilot holds Mach 3 by descending until equivalent airspeed reaches 410 KEAS and then descends following the KEAS bleed schedule (KEAS increase as Mach decreases). If power is then added, the autopilot follows the KEAS bleed schedule back to Mach 3, and then increases pitch to maintain Mach 3.

KEAS Warning Light and Aural Warning

A red KEAS warning light is installed on the upper left side of the pilot's instrument panel. Illumination of the KEAS light warns the pilot that an abnormally high or low airspeed condition has been reached and that appropriate corrective action must be taken.

At high airspeed, the light flashes if 470 KEAS is exceeded when below Mach 2.6. Above Mach 2.6, the light flashes 20 KEAS above the KEAS bleed schedule.

The light will also flash when airspeed is below 300 KEAS and above Mach 1.3.

The light will also flash and a steady tone will sound when airspeed is below approximately 250 KEAS. The low airspeed warning is deactivated below 0.5 Mach to prevent nuisance warnings during takeoff and landing. The pilot should increase airspeed immediately when the low airspeed KEAS warning is activated. If airspeed decreases after a low airspeed warning, the airplane could enter a flight region where recovery from a gust or high nose-up attitude might not be possible.

A small hysteresis band can be expected when passing through 250 KEAS or 0.5 Mach number, as follows:

a. Decreasing airspeed - Light on at 245 to 255 KEAS while above 0.5 Mach number.

b. Increasing airspeed - Light off at 250 to 260 KEAS.

c. Decreasing Mach number - Light off at 0.50 to 0.55 Mach number.

Refer to Figure 1-59, Autopilot KEAS Hold and KEAS Warning Light Schedules. Operation of the light is controlled by the DAFICS computers as shown by Figures 1-62, and 1-64.

Intensity of the light will be full bright if the console lights rheostat is OFF, and it will be dim in all other rheostat positions. Operation of the light can be tested by depressing the IND & LT TEST switch. Power for the light is supplied from the essential dc bus through the WARN 2 circuit breaker on the pilot's left console.

AUTOPILOT KEAS BLEED AND KEAS WARNING LIGHT SCHEDULES

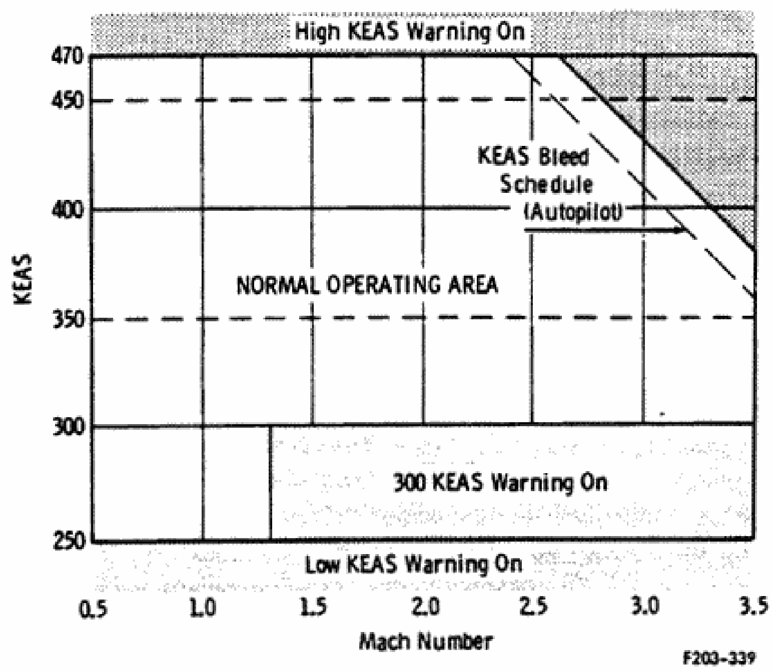


Figure 1-59

Heading Hold and Automatic Navigation

Heading hold or automatic navigation (AUTO NAV) may be engaged after the roll autopilot is engaged in attitude hold. When either secondary mode is engaged, roll attitude hold is overridden and the autopilot roll trim wheel is inoperative. These secondary modes cannot be engaged together. Use of CSC will disengage either secondary mode.

HEADING HOLD may be engaged at bank angles up to 50 degrees. The aircraft heading at engagement becomes the reference heading and the autopilot will roll the aircraft to capture and maintain the reference heading. The reference heading cannot be changed while heading hold is engaged.

AUTO NAV may be engaged only when the forward cockpit ATT REF SELECT switch is in ANS and the ANS-ready signal exists. With AUTO NAV engaged, the roll autopilot responds to bank inputs from the ANS. Bank angles in the auto-nav mode are limited to 45° by the ANS system.

Autopilot Controls and Indicators

Except for the control stick command (CSC) button and autopilot disengage trigger switch on the control stick grip, all autopilot controls are on the function selector panel. See Figure 1-60.

A/P OFF Light and Switch

A square A/P OFF switch/light is installed on the pilot's right console. The switch operates in conjunction with the AUTO PILOT OFF light on the annunciator panel: when an autopilot pitch and/or roll channel is disengaged, the AUTO PILOT OFF annunciator light illuminates; pressing the A/P OFF switch will cause the OFF portion of the switch to glow amber and also will extinguish the AUTO PILOT OFF annunciator light. The A/P OFF light remains on either until both channels of the autopilot have been engaged or until a pitch or roll channel is subsequently disengaged. Cycling of the A/P OFF switch has no effect after it illuminates. If one autopilot axis (pitch or roll) is still engaged, subsequent disengagement of that channel causes the AUTO PILOT OFF annunciator light to illuminate again.

Autopilot Operational Restrictions

Pitch and Roll Channels

Autopilot authority is so limited that malfunctions within the autopilot cannot cause damaging or uncontrollable aircraft attitude changes.

1. Roll channel authority is limited by roll SAS authority limitations (4 degrees roll differential with both roll SAS channels engaged, and 2 degrees differential with one roll SAS channel engaged).
2. Pitch channel authority is limited to 1.6 degrees up and down elevon below 50,000 feet pressure altitude, and 2.3 degrees at high altitudes.

The autopilot will disengage if bank angle exceeds 50 degrees.

Do not use the pitch autopilot with bank angles exceeding 45°.

The autopilot will disengage when changing attitude reference using the pilot's ATT REF SELECT switch.

The autopilot will disengage if the ready signal from the selected attitude reference source (ANS or INS) is interrupted.

A rate frequency monitor disengages the respective channel if a failure occurs. A condition of high turbulence could cause the frequency monitor to disengage a normally functioning autopilot, but repeated disengagements indicate failure within the autopilot.

NOTE

If the APW system stick warning switch is in PUSHER/SHAKER, the autopilot pitch channel will disengage when the pusher boundary is reached.

Pitch Channel

Do not engage Mach hold or KEAS hold if TDI indications are in error.

WARNING

Monitor flight instruments during autopilot operation. Assure that speed does not exceed the normal operating envelope.

AUTOPILOT CONTROLS AND INDICATIONS

CONTROL OR INDICATOR	POSITION OR INDICATION	FUNCTION OF CONTROL OR INDICATOR
ALIGNMENT INDICATORS One floating-indices type indicator for each autopilot channel on function selector panel.	Respective channel not engaged.	Indicator needle centers.
	Channel engaged	Needle fluctuates with autopilot control inputs but should remain near center. Continuous deflections in same direction may indicate out-of-trim condition.
A/P ENGAGE SWITCHES One ON-OFF switch for each channel on function selector panel, solenoid held ON.	OFF	Respective autopilot channel is disengaged. Secondary modes cannot be engaged (Mach Hold, KEAS Hold, Auto-Nav, Heading Hold).
	ON	Respective channel is engaged in Attitude Hold mode. Secondary modes may be engaged.
TRIM WHEELS One serrated trim wheel for each channel on function selector panel. Top third of wheel is visible.	Channel not engaged	Trim wheels are inoperative.
	Channel engaged in Attitude Hold	Trim wheel permits vernier changes to reference attitude without disengaging autopilot. Roll trim wheel is inoperative in Heading Hold and Auto-Nav modes. If Mach hold or KEAS hold is engaged, pitch trim wheel inputs will disengage the autopilot pitch channel and illuminate the AUTOPILOT OFF annunciator light.
MACH HOLD/KEAS HOLD SWITCH A 3-position switch on function selector panel. Solenoid held in MACH HOLD or KEAS HOLD, springloaded OFF.	OFF	Mach Hold and Keas Hold disengaged.
	MACH HOLD	Pitch A/P channel is engaged in Mach Hold mode if the pitch channel engage switch is ON. A/P controls pitch attitude to maintain engage Mach or follow KEAS-bleed line. Switch will trip OFF if CSC is used.
	KEAS HOLD	Pitch A/P channel is engaged in KEAS Hold mode if pitch channel engage switch is ON. A/P controls pitch attitude to maintain engage KEAS or follow KEAS-bleed line. Switch will trip OFF if CSC is used.
HEADING HOLD SWITCH ON-OFF switch on function selector panel, solenoid held ON.	OFF	Heading Hold mode is disengaged.
	ON	Roll A/P channel is engaged in Heading Hold if roll channel engage switch is ON. If engaged in a turn, A/P will roll aircraft to capture the heading existing at time of engagement. Switch will trip OFF if Auto-Nav is selected or CSC is used.

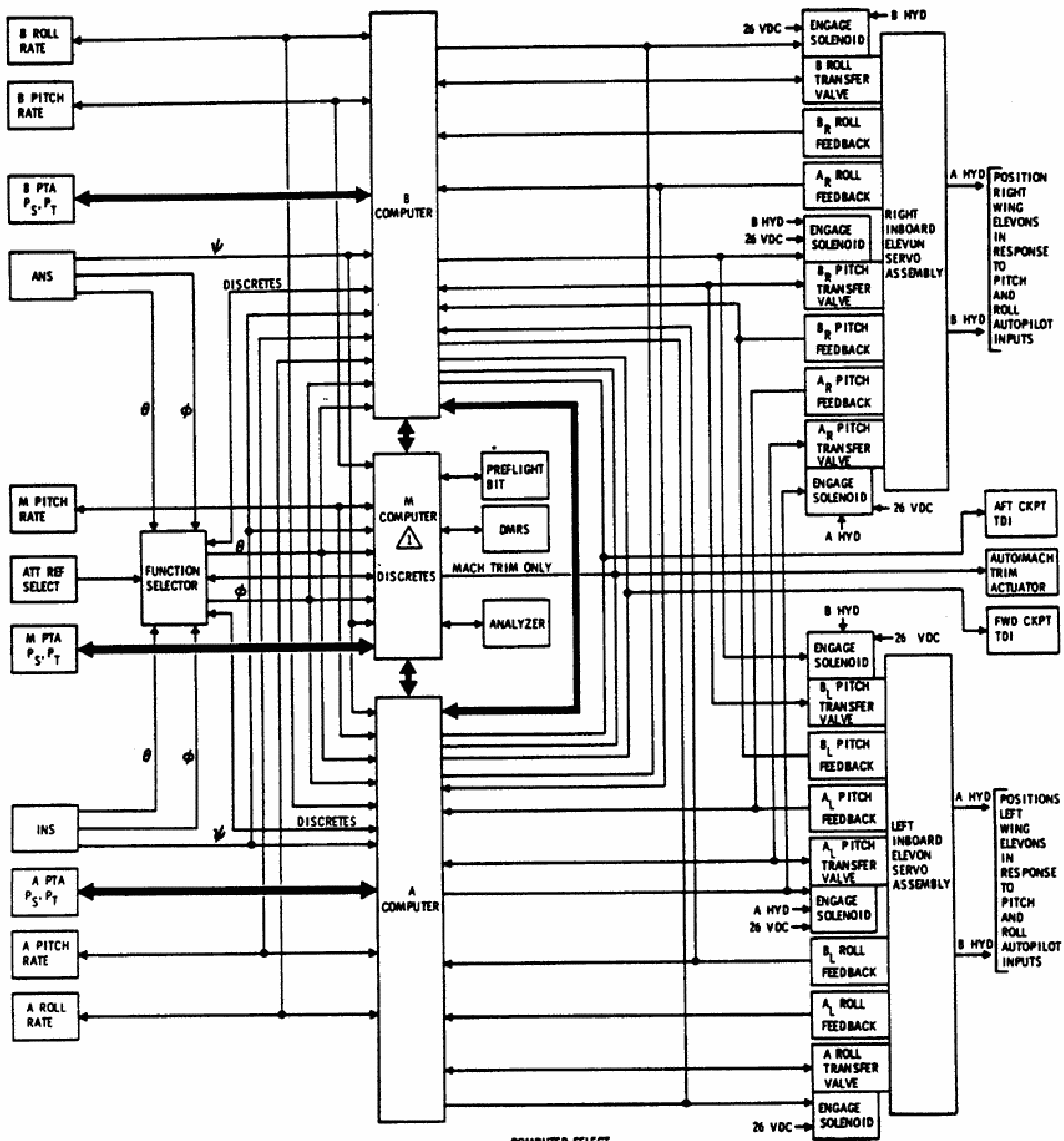
Figure 1-60 (Sheet 1 of 2)

AUTOPILOT CONTROLS AND INDICATIONS

CONTROL OR INDICATOR	POSITION OR INDICATION	FUNCTION OF CONTROL OR INDICATOR
AUTO NAV SWITCH	OFF	Auto-Nav mode is disengaged.
ON-OFF switch on function selector panel, solenoid held ON.	ON	Roll A/P channel is engaged in auto-nav mode if roll channel engage switch is ON and attitude reference selector is in ANS position. Switch will trip OFF if heading hold is selected or CSC is used.
ATTITUDE REF. SELECT SWITCH.	ANS	Permits autopilot use of attitude, heading, and navigational inputs from the ANS.
A 2-position (ANS-INS) switch on pilot's instrument panel.	INS	Permits autopilot use of attitude and heading inputs from the INS. Auto-nav mode is inoperative and cannot be engaged with INS selected.
	ANS to INS INS to ANS	Both Pitch and Roll A/P channels are disengaged, and must be manually re-engaged.
CSC SWITCH	Released	No affect.
Pushbutton switch on control stick grip.	Depressed	Disengages all secondary modes of Pitch and Roll A/P (Mach hold, KEAS hold, Auto-Nav and Heading hold switches trip OFF). Permits aircraft attitude changes without override or disengagement of A/P Attitude hold modes. Pitch and Roll channels of A/P accept attitude existing when CSC is released as the new reference attitude for Attitude-Hold modes. (Secondary modes must be manually re-engaged.)
A/P DISCONNECT SWITCH	Released	No affect.
Multi-function trigger switch on control stick grip.	Pressed	Disengages entire autopilot immediately. All modes must be manually reengaged. Also disconnects air refueling system and disables pitch and yaw trim switch and APW system stick pusher while depressed.
AUTOPILOT OFF Annunciator Panel light	Illuminated	Illuminated when pitch and/or roll autopilot disengages.
A/P OFF Rt instr side panel	Illuminated	When depressed, extinguishes the AUTO-PILOT OFF lite on annunciator panel.
AUTO NAV OUT RSO Annunciator Panel	Illuminated	Illuminates when auto-nav is not being used.

Figure 1-60 (Sheet 2 of 2)

AUTOPILOT AND MACH TRIM BLOCK DIAGRAM



COMPUTER SELECT

COMPUTER CONDITION	COMPUTER DRIVING SERVOS A_L	A_R	B_L	B_R	BACKUP
Normal	A	A	B	B	A for B, B for A
FAIL A	B	B	B	B	NONE
FAIL B	A	A	A	A	NONE

CODE

⟷ DIGITAL INTERFACE

NOTE

△1 Mach Trim is triple redundant and can also be commanded from the M computer.

F203-308

Figure 1-61

Pitch autopilot rate capability may be exceeded when elevon deflection requirements exceed autopilot authority plus autotrim rates. For example, this condition could appear as a loss of pitch trim wheel effectiveness during high pitch rate transonic acceleration maneuvers and supersonic turning decelerations.

Roll Channel

AUTO NAV commands a maximum bank angle of 45°.

The auto-nav mode can be disengaged by using either the AUTO NAV switch, the HEADING HOLD switch, or the CSC button. There should not be any transient roll attitude changes unless the alignment indices show an out-of-synchronization condition.

AUTO NAV will not engage unless the ATT REF SELECT switch is in ANS.

HEADING HOLD cannot be engaged if INS is the selected attitude reference and the INS is operating in the ATTITUDE mode.

Autopilot Operation

To engage autopilot in attitude hold:

1. Engage SAS
2. Manually trim the aircraft.
3. Pitch and/or roll engage switches - ON.

For minor changes to attitude, use pitch or roll trim wheels.

For major changes to engaged attitude:

4. CSC button - Hold depressed until aircraft is stabilized in new attitude.
5. CSC button - Release.

   Autopilot will reengage in existing pitch and roll attitude.

To engage Mach hold or KEAS hold:

6. With the pitch autopilot engaged, stabilize the aircraft for a few seconds at the desired Mach or KEAS before engaging either mode.
7. Mach hold/KEAS hold switch - As desired.

To engage Heading hold:

8. Heading hold switch - ON.

To engage Auto-Nav:

9. Attitude reference select switch - ANS.

   If the switch is in INS, the autopilot will disengage when the switch is moved to ANS.

10. Auto-nav switch - ON.

    Turns should be anticipated while in AUTO NAV and manual control stick inputs applied, if necessary, to avoid excessive roll or bank angles.

To disengage autopilot:

11. Alignment indicators - Monitor.

    Continuous deflections of indicator needle in same direction indicates that a transient will probably occur on disengagement.

To disengage all but attitude-hold modes:

12. Depress CSC button.

To disengage entire autopilot:

13. Depress control stick trigger switch.

To disengage respective channels:

14. Move corresponding pitch and/or roll axis engage switches to OFF.

To extinguish the annunciator panel AUTO PILOT OFF light:

15. Depress A/P OFF light.

MACH TRIM SYSTEM

Speed stability augmentation is provided by the Mach trim system while accelerating or decelerating in the 0.2 to 1.5 Mach range. Mach trim is scheduled by the DAFICS computers to restore conventional stick forces and trim requirements by applications of pitch trim through the slow-speed motor of the pitch trim actuator. No control switch is provided, although Mach trim is enabled with pitch autopilot OFF, and is disabled with pitch autopilot ON. All manual and auto trim (including Mach trim) can be disabled by moving the TRIM POWER switch on the annunciator panel to OFF.

Power is supplied to the Mach trim system by the essential dc bus through the A/P MACH TR A, A/P MACH TR B, and CMPTR M circuit breakers on the pilot's left console and the emergency ac bus through the A/P MACH TR circuit breaker in the aft cockpit.

NOTE

> Mach trim redundancy is reduced when one of the two A/P MACH TR dc circuit breakers is opened and redundancy is lost when both A/P MACH TR circuit breakers are opened. To disable the Mach trim system, both A and B channel circuit breakers and CMPTR M circuit breaker must be opened or the AP MACH TR ac circuit breaker in the aft cockpit must be opened.

AUTOMATIC PITCH WARNING AND HIGH ANGLE OF ATTACK WARNING SYSTEMS

An Automatic Pitch Warning (APW) system provides control stick pusher and stick shaker features. APW stick shaker operation warns that a potentially unsafe condition of angle of attack plus pitch rate has been reached. For those situations where both warnings are provided, the boundary for stick pusher operation is slightly more extreme than the boundary for the stick shaker. In addition to the APW System, a separate High Angle of Attack (High Alpha) warning system can also operate the stick shaker, but not the pusher.

The stick shaker can operate throughout the flight regime without restriction due to Mach number or stick or gear position. APW system inputs to the stick shaker can be disabled by setting the APW switch to OFF. The High Alpha shaker warning system starts the shaker anytime its Mach number vs angle of attack schedule is exceeded regardless of the APW switch position. Proximity to the APW stick shaker boundary is displayed by the glide slope indicator needle on the Attitude Director Indicator when the DISPLAY MODE SEL switch is not in ILS or ILS APPROACH. This display is independent of APW switch position. The SHAKER warning light near the pilot's glareshield illuminates when the stick shaker operates. An APW caution light on the pilot's annunciator panel illuminates if the APW switch is turned off, if the APW fails self check, or if the 2 PTA CHAN OUT light illuminates (the 2 PTA CHAN OUT light remains on until reset by maintenance, but the APW light may subsequently extinguish).

The stick pusher can only operate while subsonic with two of the three landing gear doors locked in the up position. Two of the three DAFICS computers must be operating. The pusher warning can be disabled manually by the APW switch, by depressing the control stick trigger switch, or by positioning the control stick more than 2.5 degrees (1.5 inches) forward of neutral.

The APW and High Alpha Warning systems are required because there is no buffet or other natural warning of approach to unstable angle of attack conditions. The pitch boundary indication on the ADI can provide the pilot with a display of angle of attack plus pitch rate relative to the APW stick shaker boundary. If the boundary is broached, activation of the stick shaker warns the pilot that he has reached a potentially dangerous angle of attack or that pitch rate is such that a potentially dangerous condition will be reached unless immediate action is taken. Refer to Figure 1-63 for the shaker boundary schedules. The shaker warning is a 30 cps vibration of the control stick.

The stick pusher starts control stick correction in pitch. An abrupt push force of approximately 30 pounds is applied when the pusher boundary has been reached until the stick is 2.5° (1.5") forward of neutral. The push force can be overcome by the pilot, if desired. The pusher function can be disabled by the control stick trigger switch or by moving the APW switch to OFF or SHAKER ONLY.

The boundaries for operation of the APW stick shaker and pusher warnings are functions of angle of attack and pitch rate summation vs Mach number. The warning schedule reflects the changing susceptibility to pitch-up at subsonic and supersonic speeds. The boundary for operation of the High Alpha system shaker warning is fixed at angles of attack of 14° for low speed and 8° for high speed operation, with the switchover at Mach 1.4 or 1.55 (decelerating or accelerating, respectively). Observance of the APW and High Alpha system warning boundaries provides adequate margin to avoid pitch-up at all speeds.

WARNING

Avoidance of the stick shaker or pusher/shaker warning boundaries does not, by itself, assure that load factor or angle of attack limits will be observed.

Reduce angle of attack and adjust attitude nose-down if a high angle of attack warning occurs or if an alpha limit is approached.

WARNING

When subsonic, if an APW system or high angle of attack warning occurs, or if angle of attack and airspeed are not within limits, make angle of attack and speed corrections before adjusting the throttles. These actions alone may clear engine stall conditions, and are mandatory to avoid pitch-up, if at high angle of attack and/or low airspeed.

Essential dc power for the stick shaker is obtained either through the APW or STALL WARN circuit breaker on the pilot's left console. The power routing depends on which system activates the shaker. This APW circuit breaker also supplies power for the stick pusher solenoid which controls operating power from the "A" hydraulic system. The A and/or B computer must be operative for either the APW or High Alpha Warning system to operate. The High Alpha Warning system also requires essential dc power from the BRK & SKID circuit breaker on the pilot's left console. This power causes the main gear scissors switches and relays to close when aircraft weight is removed from the main gear. With the right main gear relay open, no alpha signals are received by the High Alpha Warning system.

APW AND HIGH ALPHA WARNING SYSTEM CONTROLS AND INDICATORS

There is no single control of all APW and High Alpha Warning system functions. The ADI pitch boundary indication is controlled by the Display Mode Select switch. APW control stick warning is controlled by the APW PUSHER/SHAKER switch. The APW stick shaker boundary changes and the stick pusher is cut out when two of the three landing gear doors are not locked in the up position. Each gear-up signal is routed to one DAFICS computer so if two DAFICS computers are inoperative the APW reverts to gear-not-up logic. The angle of attack input to the APW is inhibited with weight on the left main gear. The High Alpha Warning System shaker is inhibited with weight on the right main gear. The stick pusher can be cut out manually by the APW switch, the control stick trigger switch and by stick positioning. APW system status is indicated by the ADI glide slope needle, SHAKER warning light, stick shaker and pusher, APW caution light, and DAFICS A and B CMPTR OUT caution lights. No controls are provided for the High Alpha Warning system. The High Alpha Warning system control stick shaker function is always operative while in flight.

APW Pusher/Shaker Switch

A three-position APW pusher/shaker switch is provided on the left side of the pilot's instrument panel. The APW system stick shaker and stick pusher are inoperative when OFF (center) is selected; however, the High Alpha Warning system remains operative and the pitch boundary indication to the ADI continues to operate. See Figure 1-66.

The APW stick shaker is operative when the SHAKER ONLY (down) position is selected. The APW stick shaker and stick pusher are operative when the PUSHER/SHAKER (up) position is set. The APW caution light illuminates when the APW switch is OFF. APW angle of attack and pitch rate schedules are shown by Figure 1-63, Sheet 1 and 2.

With a normally operating APW system, do not position the APW pusher/shaker switch to OFF.

Shaker Warning Light

A red SHAKER warning light is located near the apex of the glareshield in the pilot's cockpit. It illuminates whenever dc power is supplied to operate the stick shaker motor by either the High Alpha Warning or APW system. The light can be tested by pressing the pilot's IND & LT TEST push-button switch. Essential dc power for the light is obtained through the APW or STALL WARN circuit breaker, whichever system is controlling the stick shaker motor.

APW Caution Light

An amber APW caution light on the pilot's annunciator panel illuminates when the APW system stick warning switch is OFF. With PUSHER/SHAKER or SHAKER ONLY selected, the light illuminates when both A and B computers are operative and the APW outputs from the A computer do not match the B computer. The APW caution light also illuminates (although it may subsequently extinguish) when the 2 PTA CHAN OUT annunciator light illuminates. If both A and B CMPTR OUT annunciator lights illuminate, both the APW system and the High Alpha Warning System are inoperative, but the APW caution light will not illuminate.

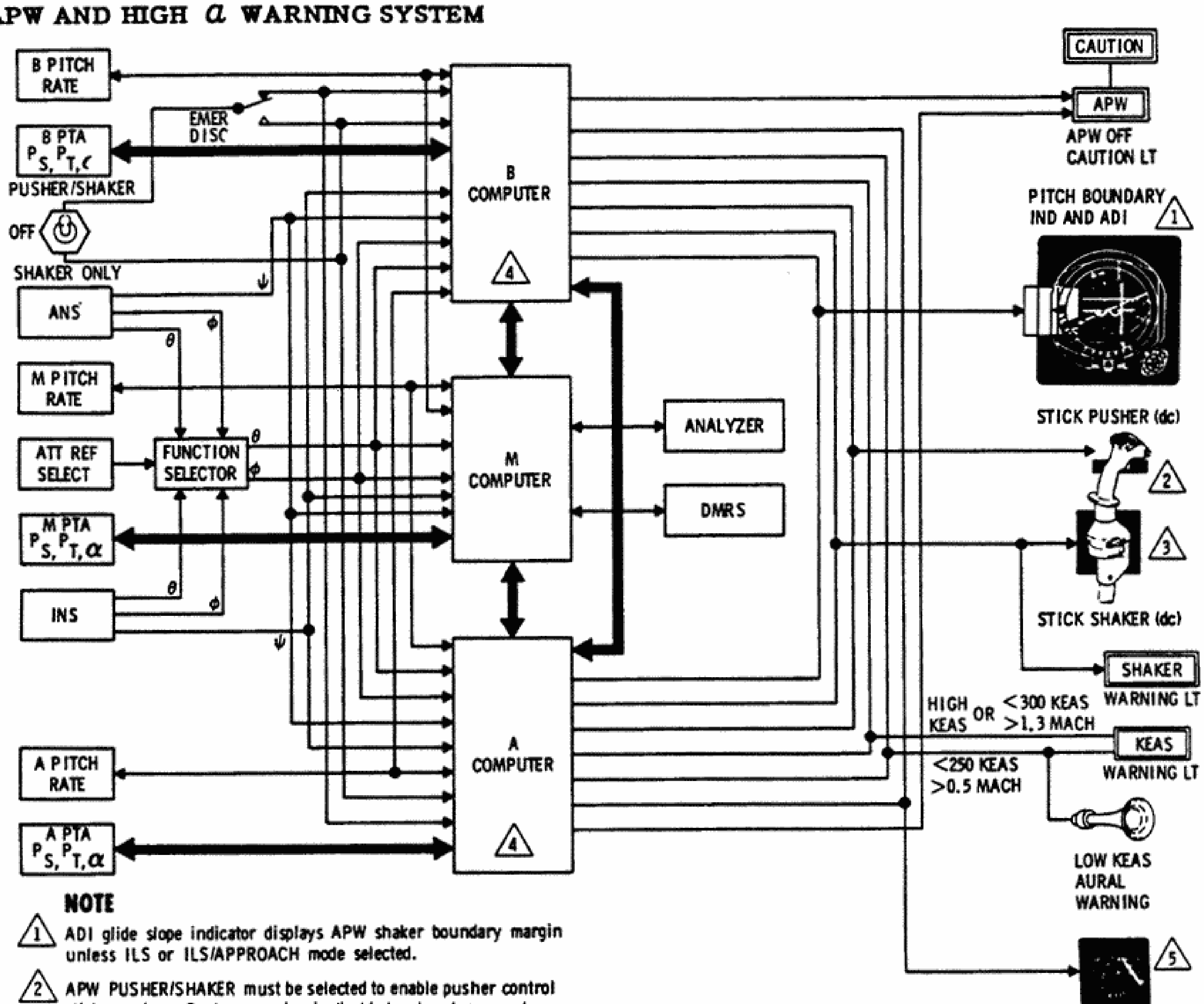
NOTE

The APW stick shaker and pusher are disabled when the APW annunciator light is on.

APW AND HIGH ALPHA WARNING SYSTEM OPERATION

APW computations are performed by the A and B DAFICS computers. Both computers use the same triple redundant digital input values for angle of attack and pitch rate as shown by Figures 1-62, and 1-64. If both the A and B computers are operating, both computers activate the shaker and pusher when the appropriate boundaries for the existing Mach number are exceeded. Pusher warning can not occur unless the APW shaker warning is also on. If the digital APW outputs from the A computer do not exactly match the digital APW outputs from the B computer, the APW annunciator light illuminates and both the pusher and shaker are deactivated. If either the A or B CMPTR OUT light illuminates, the remaining computer continues all APW functions including pusher, shaker, and ADI pitch boundary indication, but redundancy is lost.

APW AND HIGH α WARNING SYSTEM



NOTE

1. ADI glide slope indicator displays APW shaker boundary margin unless ILS or ILS/APPROACH mode selected.
2. APW PUSHER/SHAKER must be selected to enable pusher control stick warning. Pusher warning is disabled unless two gear doors are locked up, if speed is above Mach 1.0, or if the stick is more than 2.5° (1.5") forward of neutral. Also, stick pusher is inoperative if APW light is illuminated or any two computers have failed. Stick trigger disables pusher. Operation of pusher or stick trigger disengages autopilot.
3. Stick shaker operates if α exceeds either 8° or 14° (depending on status of Mach switch). Unless APW OFF selected, shaker operates if (α + q) APW shaker boundary is exceeded. With PUSHER/SHAKER selected, pusher operates when (α + q) APW pusher boundary is exceeded (unless pusher is disabled or its operation inhibited).
4. Mach switch is closed above Mach 1.55 with speed increasing and is open below Mach 1.4 with speed decreasing.
5. With DAFICS power on, alpha indicator reads 0 degrees below 101 KEAS and actual $\Delta P \alpha$ above 101 KEAS
6. Automatic pitch warning and stall warning is available if A or B or both computers are up and ready. M computer provides redundancy for air data and sensor select.
7. APW PUSHER/SHAKER operation is inhibited with weight on the left main gear. High α SHAKER operation is inhibited with weight on the right main gear.

SENSOR (RATE) SELECT

SENSOR CONDITION	SENSOR USED COMPUTER A	COMPUTER B	COMPUTER M	SENSOR OUTPUT SELECTED
Normal	A	B	M	Median of A, B, M
Fail A	M	B	M	Average of B, M"
Fail B	A	A	M	Average of A, M
Fail M	A	B	B	Average of A, B
WITH ANALYTICAL REDUNDANCY				
Fail A, B	M	-	M	M
Fail B, M	A	A	-	A
Fail A, M	-	B	B	B
WITHOUT ANALYTICAL REDUNDANCY				
Fail A, B	-	-	-	None
Fail B, M	-	-	-	None
Fail A, M	-	-	-	None

CODE

⟷ DIGITAL INTERFACE

F203-337

Figure 1-62

If both (A and M) CMPTR OUT or (B and M) CMPTR OUT annunciator caution lights illuminate, the APW pusher function is deactivated and the shaker boundary changes to gear down values.

If the A and B CMPTR OUT annunciator caution lights illuminate, both the APW system and High Alpha Warning system are inoperative, but the APW annunciator caution light will not illuminate.

The DAFICS A and B computers operate the high angle of attack warning system stick shaker function independently from the APW System. When activated by the right main gear scissors switch and relay, DAFICS angle of attack and Mach number inputs to the A and B computers are used to determine when the High Alpha system stick shaker is reached. The High Alpha Warning system shaker is inoperative with weight on the right main gear.

<u>APW Pitch Boundary Indication (PBI)</u>

While in flight, the pitch boundary indication (PBI) on the Attitude Director Indicator shows proximity to the APW stick shaker boundary (unless ILS or ILS APPROACH Display Mode is selected). A three-quarters scale deflection of the glide slope displacement indicator (second dot from the top of the scale) indicates that the APW shaker boundary has been reached. Refer to Figures 1-62, 1-64, and 1-66. The PBI pitch rate signal is obtained as shown on the Sensor (rate) Select chart of Figure 1-63 whether the pitch SAS is engaged or not. The PBI displays the angle of attack plus pitch rate continuously, regardless of APW switch positioning.

A slightly-below-center indication corresponds to optimum supersonic cruise (5° to 6° angle of attack with zero pitch rate). Three-quarters scale deflection will be approached at supersonic maximum cruise altitude and during intermediate altitude turns.

At cruise speeds near Mach 0.9 three-quarters scale deflection represents 11° to 12° angle of attack (with zero pitch rate). At the angle of attack for optimum cruise the PBI is slightly below center scale.

NOTE

> Since alpha + pitch rate is the function displayed, the PBI does not reflect angle of attack unless pitch rate is zero.

It is possible to cause the APW stick shaker to operate momentarily while taxiing. When on the ground, the PBI is normally deflected to the position of the lowest dot marking if the ANS, INS, or TAC/ADF display mode is selected. No angle of attack signal is received by the APW system while the left main gear scissors switch is open, and there would be no pitch rate while in a static condition. However, needle fluctuations will occur if pitch rate gyros sense fuselage motion in the pitch axis. It is possible, but unlikely, that while taxiing, pitch rates exceeding 14.6 degrees per second could be experienced which would cause the APW stick shaker to operate momentarily. The high angle of attack shaker warning can not occur, as the right main gear scissors switch relay opens this warning circuit while on the ground.

NOTE

> Positioning of the PBI at the bottom index while in one "g" flight could indicate no angle of attack input to the APW system. This could result from failure of the left main gear scissors switch.

<u>High Alpha Stick Shaker Boundaries</u>

In flight, the High Alpha Warning system powers the stick shaker when its angle of attack boundary is reached —<u>regardless of pitch rate and the pitch boundary indication.</u> The angle of attack settings for this system are 14° when below Mach 1.4 (or when below Mach 1.55 if accelerating) and 8° when above

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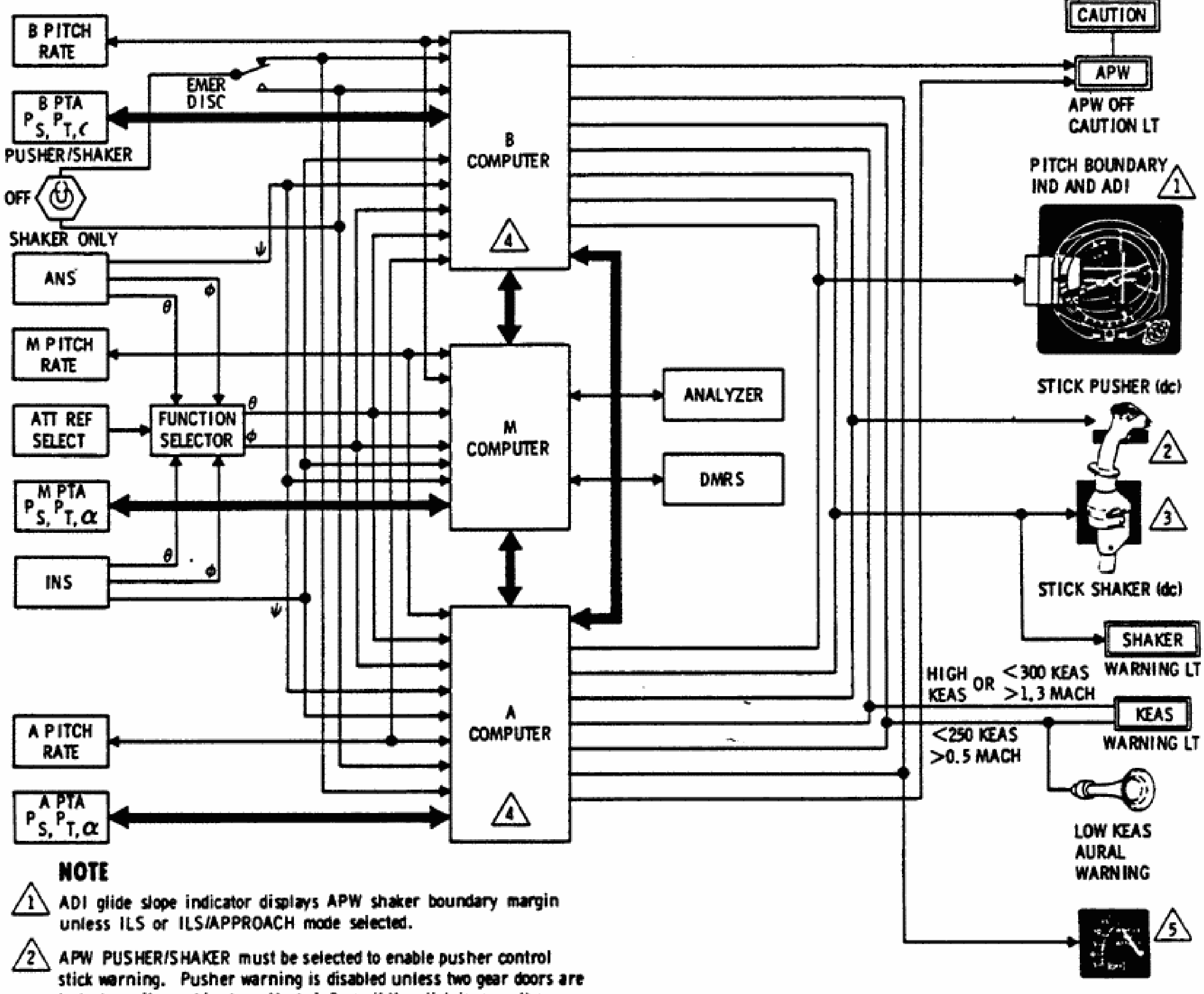
APW AND HIGH α WARNING SYSTEM (With S/B R-2559)



NOTE

1. ADI glide slope indicator displays APW shaker boundary margin unless ILS or ILS/APPROACH mode selected.
2. APW PUSHER/SHAKER must be selected to enable pusher control stick warning. Pusher warning is disabled unless two gear doors are locked up, if speed is above Mach 1.0, or if the stick is more than 2.5° (1.5") forward of neutral. Also, stick pusher is inoperative if APW light is illuminated or any two computers have failed. Stick trigger disables pusher. Operation of pusher or stick trigger disengages autopilot.
3. Stick shaker operates if α exceeds either 8° or 14° (depending on status of Mach switch). Unless APW OFF selected, shaker operates if (α + q) APW shaker boundary is exceeded. With PUSHER/SHAKER selected, pusher operates when (α + q) APW pusher boundary is exceeded (unless pusher is disabled or its operation inhibited).
4. Mach switch is closed above Mach 1.55 with speed increasing and is open below Mach 1.4 with speed decreasing.
5. With DAFICS power on, alpha indicator reads 0 degrees below 101 KEAS and actual $\Delta P \alpha$ above 101 KEAS
6. Automatic pitch warning and stall warning is available if A or B or both computers are up and ready. M computer provides redundancy for air data and sensor select.
7. APW PUSHER/SHAKER operation is inhibited with weight on the left main gear. High α SHAKER operation is inhibited with weight on the right main gear.

SENSOR (RATE) SELECT

SENSOR CONDITION	SENSOR USED COMPUTER A	COMPUTER B	COMPUTER M	SENSOR OUTPUT SELECTED
Normal	A	B	M	Median of A, B, M
Fail A	M	B	M	Average of B, M"
Fail B	A	A	M	Average of A, M
Fail M	A	B	B	Average of A, B
WITH ANALYTICAL REDUNDANCY				
Fail A, B	M	-	M	M
Fail B, M	A	A	-	A
Fail A, M	-	B	B	B
WITHOUT ANALYTICAL REDUNDANCY				
Fail A, B	-	-	-	None
Fail B, M	-	-	-	None
Fail A, M	-	-	-	None

CODE

DIGITAL INTERFACE

F203-337

Figure 1-62A

STICK WARNING SCHEDULES

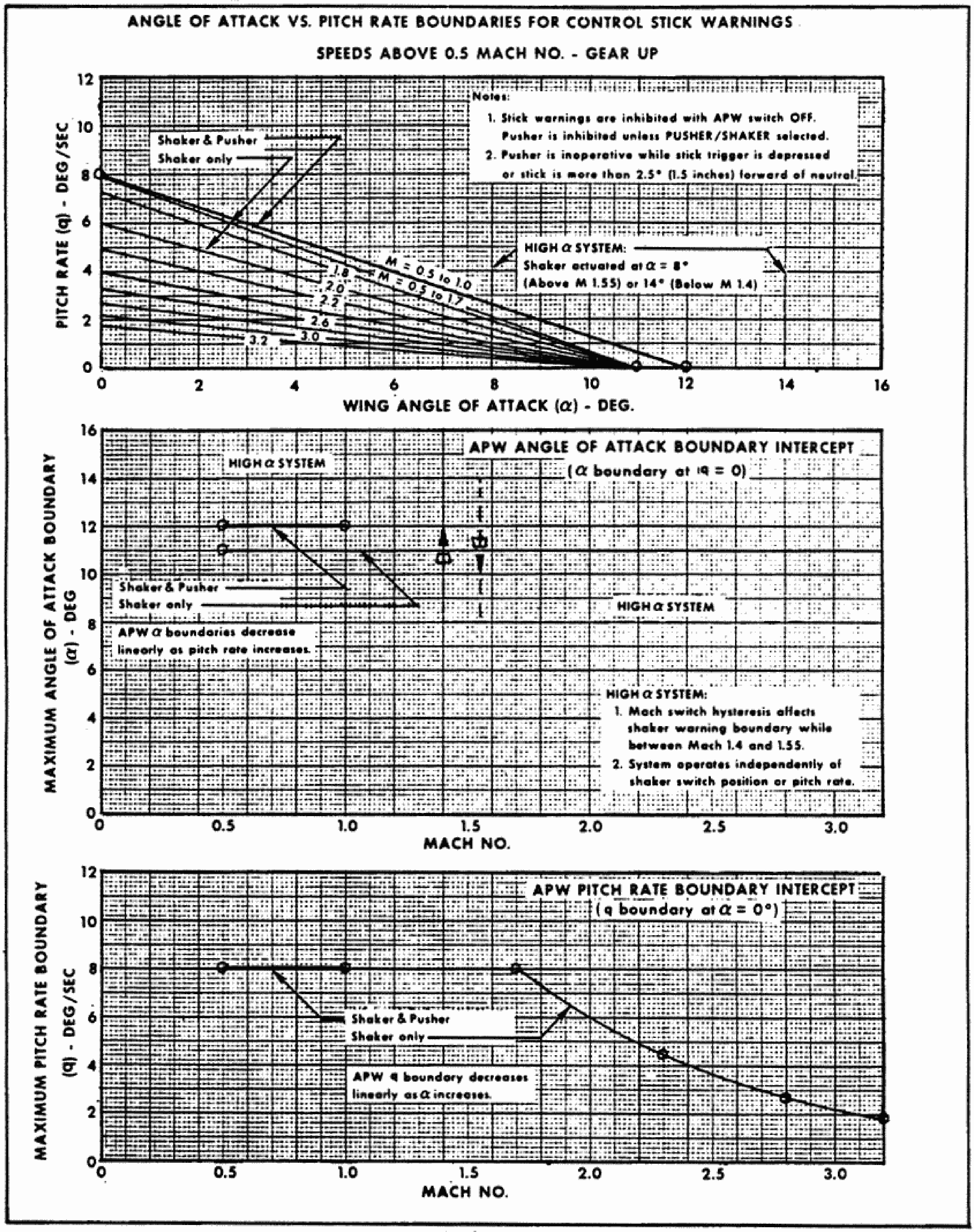


Figure 1-63 (Sheet 1 of 2)

STICK WARNING SCHEDULES

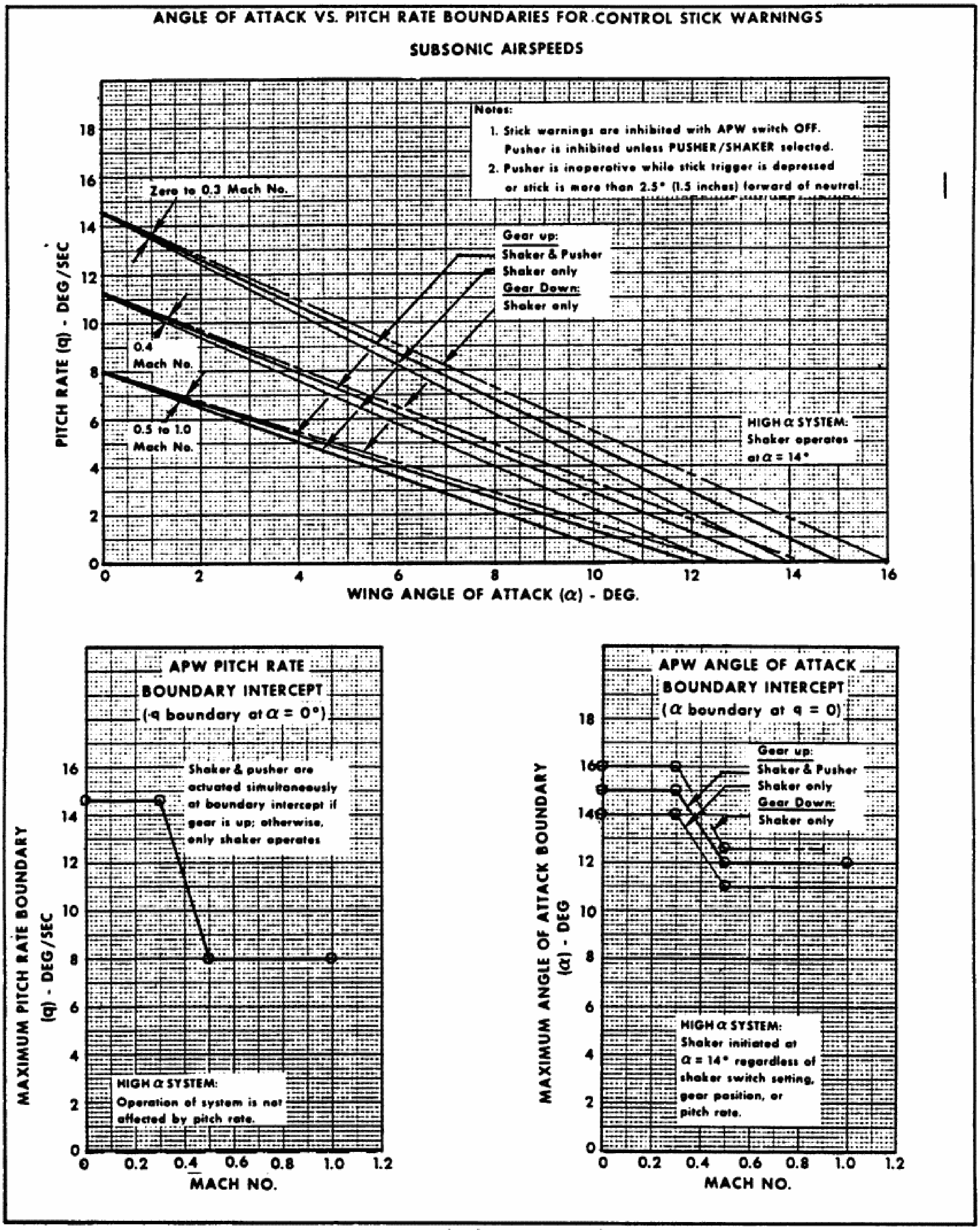


Figure 1-63 (Sheet 2 of 2)

Mach 1.55 (or when above Mach 1.4 when decelerating). See Figure 1-63.

APW Control Stick Warning Schedules

Refer to Figure 1-63, Sheet 1 and 2. Note that Sheet 1 only shows control stick warning schedules for gear up operation at speeds above Mach 0.5. These schedules apply to the major portion of flight. Schedules are included for lower speeds, typical for conditions before landing or after takeoff.

Notice that the APW alpha + pitch rate (q) boundary schedules, shown for the stick shaker and stick pusher, represent 100% of the APW boundary condition when the opposite factor (pitch rate or angle of attack) equals zero. For example: at Mach 3.2, an APW system angle of attack signal of 11° or a pitch rate signal of 1.8 degrees per second will cause the stick shaker to operate when the opposite pitch rate or alpha factor is zero. (See Note). Similarly, a 5.5° angle of attack obtained simultaneously with a 0.8 degree per second pitch rate will cause the shaker to operate. This is illustrated by the Mach 3.2 line on the angle of attack vs pitch rate boundary chart. Each of the 5.5° and 0.8°/sec angle of attack and pitch rate factors is 50% of its boundary intercept for Mach 3.2 speed. Any similar combination for the same speed would start the stick shaker.

NOTE

> Since the high angle of attack warning system setting is 8° in the high speed region, any angle of attack of 8° or more would start the stick shaker.

The stick pusher boundary intercept for gear up operation is 1° above the shaker boundary at zero pitch rate, as shown by Figure 1-63, Sheet 2 of 2. The difference decreases to zero at the pitch rate boundary intercept (alpha = 0°). The pusher is inhibited unless two gear are up, to eliminate pusher activation close to the ground immediately after takeoff or before landing. The shaker warning boundary is automatically shifted to a higher alpha schedule when two gear are not up, to minimize nuisance operation.

PITOT-STATIC SYSTEMS

A dual pitot-static and alpha/beta system supplies the total and static pressure necessary to operate the basic flight instruments and DAFICS. The pitot-static and alpha/beta probe is mounted on the nose of the aircraft. Pressure entering the tip of the probe is divided internally to produce two separate total pressure sources. Eight static ports on the probe furnish two separate static sources. One pitot and one static source are referred to as system 1 and the other two sources are referred to as system 2. System 1 supplies pressure to the pilot's altimeter, vertical speed indicator, and Mach-airspeed indicator. System 2 supplies pressure to the 3 channels of the pressure transducer assembly (PTA) which supplies digitized pressure information to the DAFICS computers. An alpha/beta probe provides angle of attack and sideslip pressure signals to the PTA. (See Figure 1-64.)

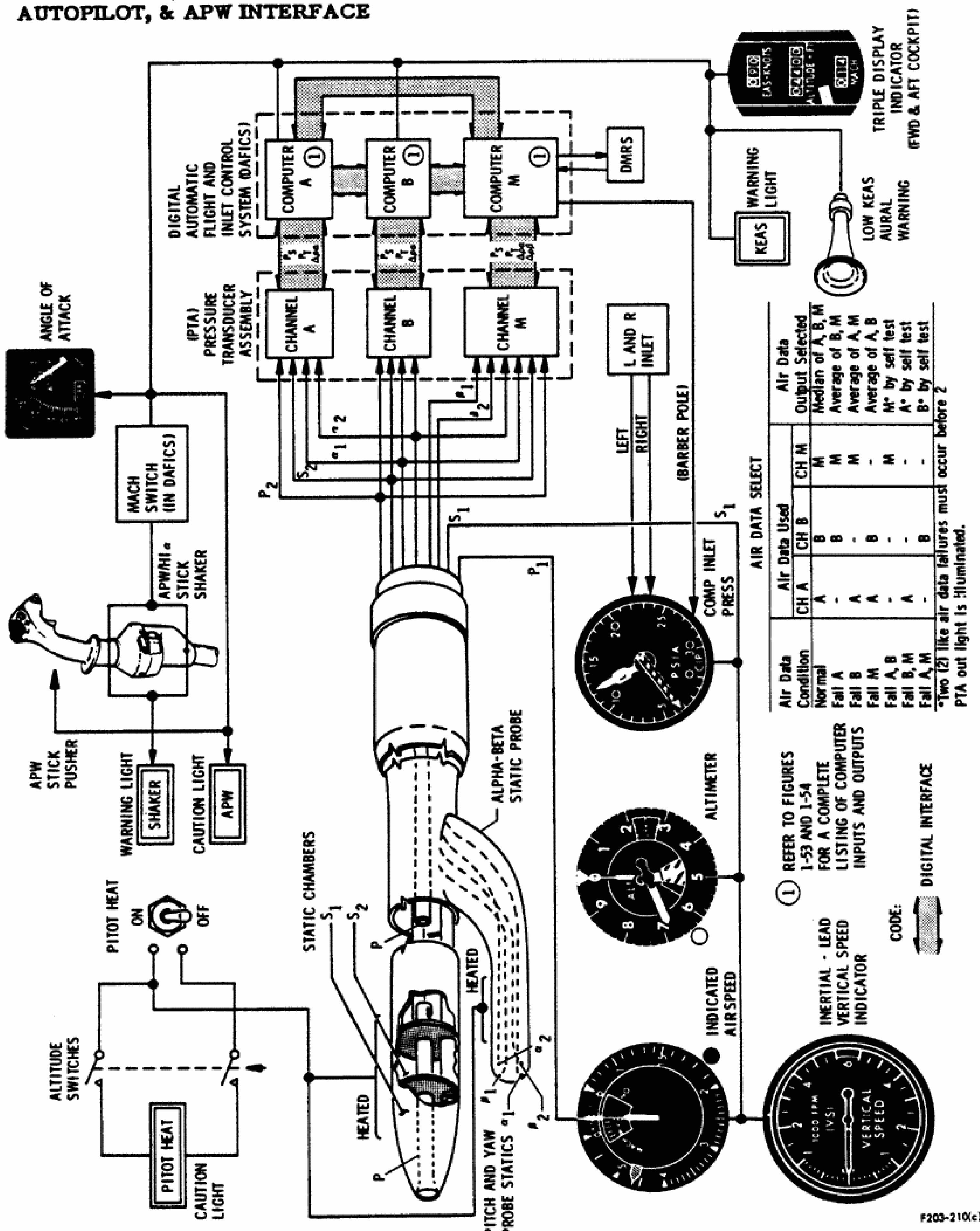
Heating elements for the probes are controlled by the pitot heat switch. Although there is no time limit for operation of the heater system while on the ground, the life span of the pitot heater element is lowered if pitot heat is left on unnecessarily.

Pitot Heat Switch and Indicator Light

A two-position PITOT HEAT switch is located on the pilot's annunciator panel. In ON, the essential ac bus powers heating elements of the pitot-static and alpha-beta probes through the PITOT HTR circuit breaker on the pilot's right console.

The circuit also incorporates a PITOT HEAT annunciator caution light, and two altitude pressure switches. The light illuminates when the pitot heat switch is not in the correct position for the aircraft altitude. With the pitot heat switch ON, the light is on when above 63,000 ± 4000 feet. With the pitot heat switch OFF, the light illuminates below 40,000 ± 2000 feet, and during climb extinguishes between 40,000 and 50,000 feet.

PITOT-STATIC, PTA, INLET, SAS, AUTOPILOT, & APW INTERFACE



AIR DATA SELECT

Air Data Condition	Air Data Used CH A	CH B	CH M	Air Data Output Selected
Normal	A	B	M	Median of A, B, M
Fail A	-	B	M	Average of B, M
Fail B	A	-	M	Average of A, M
Fail M	A	B	-	Average of A, B
Fail A, B	-	-	M	M* by self test
Fail B, M	A	-	-	A* by self test
Fail A, M	-	B	-	B* by self test

*Two (2) like air data failures must occur before 2 PTA out light is illuminated.

Figure 1-64

PRESSURE TRANSDUCER ASSEMBLY (PTA)

The PTA changes pressures (P_s, P_T, $\Delta P\alpha$, $\Delta P\beta$) to electrical signals for DAFICS. The PTA has three electrically independent channels (A, B, M) which produce digitized P_s, P_T, and $\Delta P\alpha$ data. In addition the M channel transduces $\Delta P\beta$ data. The PTA is located in the left forward chine bay, aft of the nose bulkhead and is cooled by cockpit exit air.

CAUTION

> Loss of cockpit pressurization or cockpit air off at supersonic cruise will cause overheat and subsequent failure of the PTAs if a descent is not begun within 15 minutes.

Each PTA Channel (A, B, and M) only sends data to its corresponding (A, B, and M) DAFICS computer. The DAFICS computers share PTA data and select the best air data for DAFICS computations. (See Air Data Select chart, Figure 1-64) All operating DAFICS computers use the same selected PTA data. If a DAFICS computer is inoperative, the corresponding PTA channel is also inoperative.

The A, B, and M channels of the PTA are powered by the emergency ac bus through the three A, B, and M COMPUTER circuit breakers for the respective computer located in the aft cockpit. With two circuit breakers opened to a computer, the corresponding PTA channel is disabled.

FLIGHT AND NAVIGATION INSTRUMENTS

TRIPLE DISPLAY INDICATOR (TDI)

A TDI on the instrument panel in each cockpit provides digital displays of airspeed (KEAS), pressure altitude, and Mach number as computed by DAFICS.

The altitude indication range of each TDI is 0 to 99,950 feet. At 100,000 feet, the first digit is dropped, indicating 09,950 feet at 109,950 feet (the maximum limit of the DAFICS signal to the instruments).

The TDI Mach number indication range is 0 to 3.99. The minimum indication at static conditions normally varies from 0.11 to 0.2 Mach number and the maximum limit of the DAFICS signal to the instruments is Mach 3.5.

The TDI knots equivalent airspeed (KEAS) indication range is 0 to 599 KEAS. The minimum indication normally varies from 25 to 110 KEAS. The maximum limit of the DAFICS signal to the instruments is 560 KEAS.

OFF flags appear on the faces of the TDI instruments and TDI values are unusable if the DAFICS A and B computers fail. OFF flags appear on both TDI instruments if the emergency ac bus AP MACH TR circuit breaker in the aft cockpit is open, but indications remain valid. The OFF flags will not necessarily appear in conjunction with a 2 PTA CHAN OUT annunciator caution light.

If the OFF flags should appear with the 2 PTA CHAN OUT caution, it indicates that none of the available PTA channels is passing self check. Refer to 2 PTA Channels Out Procedures, Section III.

Power for both instruments is from the emergency ac bus through the TDI circuit breakers. The forward cockpit TDI circuit breaker provides power to the forward cockpit TDI; the aft cockpit TDI circuit breaker provides power to the aft cockpit TDI, which in turn provides TAS signals to the Pilot's & RSO's Map Projector - Automatic Map Rate.

AIRSPEED - MACH METER

A combination airspeed and Mach meter, operating directly from pitot-static pressure, is installed on the pilot's instrument panel. Airspeed and Mach values shown are indicated values as opposed to equivalent airspeed and true Mach displayed on the TDI. A limit airspeed needle varies with altitude to show the KIAS limit corresponding to a preset KEAS vs altitude schedule. See Airspeed - Mach Meter, Section V.

NOTE

At low altitudes and airspeeds the high end of the Mach scale will show in the window.

ALTIMETER

A pressure altimeter is installed on the pilot's instrument panel. The instrument has 1000-foot and 100-foot pointers, and a 10,000 foot pointer (with a triangular marker at its extremity) which extends to the edge of the dial. The center of the instrument has a cutout through which yellow and black warning stripes appear when aircraft altitude is less than 16,000 feet. The barometric pressure scale appears in a cutout at the right side and barometric pressure is set by a knob located at the lower left side of the instrument.

NOTE

The static altimeter and the IVSI exhibit appreciably more lag while supersonic than subsonic.

Altimeter Correction Card

An altimeter altitude correction card, located on the pilot's right sunshade, shows the indicated corresponding pressure altitudes to fly for a corresponding true pressure altitude. The difference between the columns is altimeter instrument error only.

INERTIAL-LEAD VERTICAL SPEED INDICATOR (IVSI)

An IVSI, installed on the pilot's instrument panel, shows the rate of change of altitude in feet per minute up to 6000 feet per minute. See Figure 1-64. It is operated by static pressure changes sensed by the system 1 static ports. It operates like conventional vertical velocity instruments except that an internal mechanism, sensitive to load factors between 0.7 and 1.4 g's, momentarily alters static pressure within the IVSI under changing load factors. The pressure change causes a corresponding change in rate-of-climb or rate-of-descent indication when the load factor is increasing or decreasing, respectively. The indication change will usually precede aircraft altitude changes. Changing static pressure conditions, such as during climb or descent, cause the vertical speed indications to continue registering in the appropriate direction as the effect of the load factor pulse diminishes. The instrument appears to be "lag free" when subsonic. At high altitudes, reduced air density decreases instrument response and accuracy. Indications may be less than 1/3 of actual conditions. Response to acceleration is retained, but to a lesser degree.

Below approximately 40,000 feet, IVSI indications respond quickly to pitch control. In a level turn the IVSI will show a small rate of climb during roll-in and rate of descent during roll-out due to load factor changes. Expect a change of approximately 50 fpm at cruise.

ANGLE OF ATTACK (AOA) INDICATOR

An angle of attack indicator is mounted on the pilot's instrument panel. The dial displays positive and negative angles of attack in one-degree increments through a range from -5° to $+22^{\circ}$.

The instrument responds to synchro signals from DAFICS which uses differential pressures sensed by the alpha ports of the alpha/beta probe ($\Delta P\alpha$) related to total pressure (P_T). See Figure 1-64. A and/or B computer must be operating to provide angle of attack.

An OFF flag is displayed on the face of the indicator if power to the instrument is interrupted.

The AOA indicator reads 0° on the ground and reads aircraft actual AOA at 100 KEAS or higher. In level flight, pitch angle is 1.2° greater than the wing angle of attack because of the negative angle of incidence of the wing. See Angle of Attack, Section VI.

ATTITUDE-DIRECTOR INDICATOR (ADI)

An ADI, located on the pilot's instrument panel, combines an attitude indicator, turn-and-slip indicator, and a flight director with ILS glide slope presentation. Pitch and roll signals from the ANS or INS systems are routed to the instrument through the ATT REF SELECT switch. The attitude sphere allows presentation of pitch and roll through 360 degrees. The sphere moves behind a small aircraft symbol fixed at the center of the instrument face. A trim knob allows manual positioning of the sphere in pitch.

The sphere is marked with a horizon line, small dots for 5-degree increments, short lines for 10-degree increments, and numeral markers for each 30-degree increment; large dots indicate the poles. Indices are provided for bank angles of 10, 20, 30, 45, 60 and 90 degrees.

The turn-and-slip indicator is mounted at the bottom of the ADI. A deflection of one-needle-width indicates a 4-minute, 360-degree, standard rate turn. The rate-of-turn transmitter receives power from the essential dc bus through the TURN GYRO circuit breaker on the pilot's left console.

Bank and pitch steering command bars are superimposed on the ADI. The bank steering bar shows bank required to position the aircraft on a desired heading or course and will center when (1) on course with wings level, (2) flight attitude is correct for return to course, or (3) bank is correct for rollout on-course. When in AUTO NAV, the maximum bank angle command is 45°. The maximum bank command is 35° in INS, TACAN ADF and ILS modes. The maximum bank and pitch commands are 15° and 10°, respectively, in ILS APPROACH mode.

The pitch steering bar indicates pitch attitude change required to intercept the ILS glide slope. The bar centers when (1) on glide slope with proper pitch angle, (2) pitch angle is correct for return to glide slope, or (3) pitch angle is correct for leveling-out on glide slope.

The steering bars indicate corrective action required and not direction or displacement from a desired course or glide slope. The vertical (bank) and horizontal (pitch) steering bars will be centered when power is off. The pitch steering bar is stowed at the bottom of the instrument when the DISPLAY MODE SEL switch is in INS, or TACAN ADF. The bank steering bar receives command signals in all display modes.

The pitch steering bar indicates rate of climb or descent when the DISPLAY MODE SEL switch is in ANS. See Figure 1-66. The bar indicates zero vertical velocity when it is aligned with the small airplane symbol. Full scale deflection of the bar to the top or bottom dot on the glide slope displacement scale represents a vertical velocity of 3484 fpm or more. This provides a scale sensitivity of approximately 1000 fpm for each quarter-inch displacement. The minimum vertical speed which can be sensed by the ANS and displayed is approximately 55 fpm. The displacement of the steering bar is opposite in direction to the vertical velocity indicator, to indicate the direction of pitch attitude change required to offset the climb or descent. The pitch steering bar vertical velocity indication can be used to maintain precise control of altitude at high Mach.

A warning flag comes into view at the top of the ADI if the instrument receives unreliable steering information. If INS attitude reference is selected and the INS is in the attitude mode, the flag indicates that heading and INS steering information are not reliable. If ANS attitude reference is selected and the DISPLAY MODE SEL switch is in ANS, the flag indicates the ANS is not ready and attitude, true heading, and steering information are not reliable. The glide slope pointer at the left center of the instrument shows aircraft position above or below the ILS glide slope when ILS or ILS APPROACH display mode is selected and valid ILS signals are received. The glide slope warning flag appears if there is insufficient ILS signal strength. The glide slope pointer also is the pitch boundary indicator when ILS or ILS APPROACH display mode is not selected. Refer to Figure 1-66 and to the APW and High Angle of Attack

Warning Systems description, this section. A power failure warning flag appears in the lower left of the instrument when ac power is interrupted, ATT REF SELECT switch is in INS and the INS ready signal is not present, or the ATT REF SELECT switch is in ANS and the nav-ready signal is not present.

Display Mode Select Switch

The DISPLAY MODE SEL switch on the pilot's instrument panel has five positions: ANS, INS, TACAN ADF, ILS, and ILS APPROACH. The switch controls display inputs to components of the HSI and ADI. See Figure 1-66.

Attitude Reference Select Switch

The ATT REF SELECT switch on the pilot's instrument panel has two positions: ANS (up) and INS (down). It selects which system supplies pitch and roll signals to the attitude director indicator, and pitch, roll, and heading signals to the autopilot. Autopilot AUTO NAV is only operative when the ATT REF SELECT switch is in ANS. Changing the ATT REF SELECT switch disengages the autopilot. Autopilot HEADING HOLD will not engage if INS attitude reference is selected and the INS is in attitude mode.

WARNING

INS reference should be selected in both cockpits if ANS nav-not-ready warnings (pilot's ANS REF and RSO's ANS FAIL caution lights) appear. Otherwise, unreliable attitude information may be displayed.

PERIPHERAL VISION DISPLAY (PVD)

The PVD is a twilight and night attitude orientation device that projects on the pilot's instrument panel, a laser-generated, thinly focused red line parallel to the horizon. A mask in the PVD projector prevents display of the line on the ADI. Like an attitude indicator, the PVD line remains fixed in inertial space. The PVD is not intended to be consciously included in the pilot's instrument crosscheck. Instead, the laser line is perceived indirectly through peripheral vision and subconsiously supports spatial orientation just as a visible outside horizon supports orientation.

The PVD derives pitch and roll attitude from the attitude source (ANS or INS) selected by the pilot's ATT REF SELECT switch. Roll movement of the line corresponds with changes in roll attitude and has no limit. Pitch movement of the line corresponds with changes in pitch attitude. Pitch movement of the line stops when a display boundary at the edge of the instrument panel is reached. The pitch angle at which the line will reach a boundary depends on the position of the pitch adjust switch and the pitch scale switch. The line flashes at 4 Hz to warn of a potentially hazardous flight condition if pitch angle exceeds 35 degrees nose up or 15 degrees nose down.

Twelve regularly spaced variations in line intensity create subtle segments in the line that remain fixed in heading relative to inertial space. Movement of the segments across the instrument panel allows a sense of heading change during turns. Because rate of turn decreases at high speed, the effect is most noticable at low speed. DAFICS M computer provides rate of turn inputs to the PVD processor.

The PVD processor, located in the R bay, continually performs built-in-test. If an internal processing fault is detected, the laser line will not be generated. If DAFICS rate of turn input is lost or a rate of turn fault is detected, the line segments will not move (zero turn rate), but pitch and roll will still be displayed. To inhibit the PVD when inputs from the selected attitude reference are unreliable, the laser line is not generated if a DAFICS analytical redundancy (ANR) failure occurs (flashing DAFICS Preflight BIT FAIL light).

Power for the PVD is provided through three PVD circuit breakers on the pilot's right console: 115 volt emergency ac, 26 volt emergency ac and 28 volt essential dc. The laser line will not be displayed if any circuit breaker is open.

PVD Projector

The PVD projector is located on the lower right side of the forward canopy.

Laser Safety

The location of the PVD projector makes it difficult for a pilot in a pressure suit to inadvertently expose an eye to direct laser energy. Laser beam reflections are not hazardous. The PVD should be OFF when the canopy is open to prevent ground support personnel from inadvertently looking directly into the laser beam.

WARNING

Do not look directly into the laser beam.

PVD Control Panel

The PVD control panel is located on the pilot's right console. See Figure 1-65.

Roll Adjust Switch

The ROLL adjust switch allows ±5 degrees of display adjustment in roll. Normally the switch should be aligned with the horizontal index.

Pitch Adjust Switch

The PITCH adjust switch allows vertical adjustment of the reference point on the instrument panel for level flight. When the switch is aligned with the index mark, the laser line will be between the ADI and the HSI when the aircraft is in the nominal attitude for supersonic cruise (6 degrees pitch angle).

Intensity Switch

The OFF detent, at the counterclockwise position of the intensity switch, deenergizes the PVD. Intensity of the laser line increases with clockwise rotation of the switch. The full clockwise position is labeled BRT. The PVD may be manually reset by rotating the switch to OFF and back on or by depressing the white pushbutton projecting above the center of the switch.

Pitch Scale Switch

The pitch SCALE switch allows the pilot to select the ratio of laser line movement in pitch compared to movement of the real horizon. In the normal (NORM) position, the angular movement of the laser line, when observed by the pilot, is the same as the angular movement of the outside horizon. In the 2, 1/2, 1/4 and 1/8 positions, the line moves 2 times, 1/2, 1/4 and 1/8 as much as the angular movement of the outside horizon, respectively.

The position of the laser line changes when the SCALE switch is moved, unless the aircraft is in the nominal attitude for supersonic cruise.

PVD CONTROL PANEL

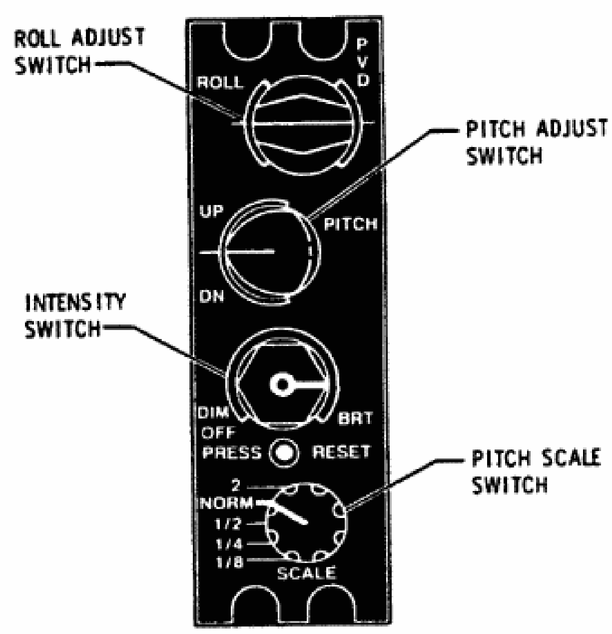


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Figure 1-65

2-INCH STANDBY ATTITUDE INDICATOR (Without S/B R-2466)

A self-contained standby attitude indicator is located at the top of the pilot's instrument panel. A cylinder rotates to indicate angles through 80° climb, 90° dive, and 360° roll. The cylinder is inscribed with a horizon and 5° graduations for pitch angle. Bank angle is marked on the instrument case in 10° increments up to 30° and then 30° increments up to 90°. See Figure 1-12.

A cutout disables the self-erection feature when pitch or roll angle exceeds 12 ± 1/2° to prevent the indicator from erecting to a false vertical. This puts the indicator into a free drift mode when above this angle.

The indicator has a built-in 7° pitch bias. With this bias, the gyro horizon will center relative to the case index marks when the pitch attitude is 7° nose-up (5.8° angle of attack). When the aircraft is at a 0° pitch attitude on the ground, the gyro will erect to a 7° nose-down indication.

A combination pitch trim and caging knob is provided on the lower right corner of the indicator. The knob can be turned to position the miniature airplane from 5° up to 5° down. The knob is also used to cage the gyro by pulling the knob out to its fully extended position. The OFF flag appears when the caging knob is pulled. Releasing the knob allows the gyro to erect to 7° nose down and 0° roll within five minutes if the aircraft is level. Pulling the knob out and turning it clockwise locks the cylinder in the caged position. The cylinder should be unlocked during normal use. The nominal erection rate is 2.5° per minute to the apparent vertical.

The indicator receives emergency ac power through the STBY ATT circuit breaker on the pilot's right console. An OFF flag appears if power is interrupted. The indicator displays useful pitch and roll information for at least nine minutes after power loss.

Standby Attitude Indicator Characteristics

The standby attitude indicator has a maximum free drift rate of 0.9 degrees per minute. In level flight, any tendency to drift is continuously corrected to the apparent vertical at a rate of two to three degrees per minute. An acceleration sensor disables the erection system at bank angles greater than twelve degrees to prevent bank errors during turns. In this free gyro mode, a random combination of errors due to gyro drift, earth's rate and earth's profile can accumulate at a maximum of 1.6 degrees per minute.

In wings-level flight, the normal aircraft acceleration and deceleration does not disable the erection system and the indicator will erect to the apparent vertical. During climbout and descent, pitch errors up to approximately four and eight degrees, respectively, can be expected. If a turn is initiated immediately after climbout or descent, the free gyro errors may add to the acceleration induced error. For example, the indicator error could reach four degrees in roll after a normal supersonic descent and a 90° subsonic turn (with bank angle greater than 12°).

If the bank or pitch error does not exceed approximately twelve degrees, the indicator will automatically correct the above errors at the normal erection rate when the aircraft is in level flight and at constant velocity. However, the indicator can be aligned more rapidly by pulling the caging knob. This control should be limited to level flight conditions, as the gyro is erected to the case reference.

NOTE

> If a bank or pitch error of more than twelve degrees is accumulated, the cut-out feature prevents automatic correction when level. Manual caging will be necessary.

3-INCH STANDBY ATTITUDE INDICATOR (With S/B R-2466)

A self-contained standby attitude indicator is located at the top of the pilot's instrument panel. A cylinder rotates to indicate angles of 85° climb and dive, and 360° roll. The cylinder is inscribed with an artificial horizon and 5° graduations for pitch angle. Bank angle is marked on the instrument case in 10° increments up to 30° and then 30° increments up to 90°. See Figure 1-12.

The indicator has a built-in 7° pitch bias. With this bias, the gyro horizon will center relative to the case index marks when the pitch attitude is 7° nose-up (5.8° angle of attack). When the aircraft is at a 0° pitch attitude on the ground, the gyro will erect to a 7° nose-down indication.

A combination pitch trim and caging knob is provided on the lower right corner of the indicator. The knob can be turned to position the miniature airplane from 5° up to 10° down. When the caging knob is pulled to the fully extended position, the OFF flag appears and the gyro horizon is caged to the case level-flight index. Pulling the knob out and turning it clockwise locks the cylinder in the caged position. The cylinder should be unlocked during normal use. The nominal erection rate is 2.5° per minute to the local vertical.

The indicator receives essential dc power through the STBY ATT circuit breaker on the pilot's right console. An OFF flag appears if power is interrupted. The indicator displays pitch and roll information accurate to within ±5° for at least nine minutes after power loss.

__Attitude Indicator Operating Characteristics__

The attitude indicator is maintained erect to the apparent vertical at a rate of two to three degrees per minute when the gyro spin axis displacement is less than 7° in pitch and roll (level flight). The gyro erects to gravity at a reduced rate of 0.75°/minute during turns and fore and aft velocity changes that exceed the 7° erection criteria.

The indicator will erect to the apparent vertical. During climbout and descent, pitch errors of approximately four and eight degrees, respectively, can be expected.

HORIZONTAL SITUATION INDICATOR (HSI)

The HSI, located on the pilot's instrument panel, integrates information from the TACAN, ANS, INS, and the ILS receiver. See Figure 1-66. Power for the HSI is furnished by the essential ac bus.

__Range Indicator__

The range indicator on the upper left side of the HSI displays distance in nautical miles. A shutter covers the numerals when a distance signal is not present. The maximum range readout is 1999 nautical miles. A "K" shutter covers the first digit of the range readout window when range is less than 1000 miles. When the shutter opens (over 999 NM range) a fixed numeral 1 is displayed. The shutter remains closed unless the DISPLAY MODE SEL switch is in ANS and the BEARING SELECT switch is in NORMAL.

With the DISPLAY MODE SEL switch in ANS and the BEARING SELECT switch in NORMAL, the range readout is to the ANS destination point (DP) or to the ANS-computed turn point, depending on the mode (DP or TURN, respectively) selected on the ANS control panel. Refer to Navigation Control and Display Panel DP/TURN switch, Section IV. With the DISPLAY MODE SEL switch in INS and the BEARING SELECT switch in NORMAL, the range readout is to the INS DP. With the BEARING SELECT switch in TAC/ADF, the range readout is to the selected TACAN station. With the DISPLAY MODE SEL switch __not__ in ANS or INS, range readout is to the selected TACAN station regardless of BEARING SELECT switch position.

Course Selector Window

The COURSE window displays ANS command course when the DISPLAY MODE SEL switch is in ANS. In all other modes, it displays the course that is manually selected with the COURSE SET knob.

Bearing Select Switch

A BEARING SELECT switch, located below the DISPLAY MODE SEL switch on the pilot's instrument panel, has two positions, NORMAL (down) and TAC/ADF (up). This switch is operated with the DISPLAY MODE SEL switch to select inputs to the HSI bearing pointer and HSI range indicator. See Figure 1-66.

Rotary Compass Card

The rotating azimuth ring is read at a stationary lubber line at the 12 o'clock position.

The card displays ANS true heading with the DISPLAY MODE SEL switch in ANS; in any other position, the display is INS computed magnetic heading. The RSO can provide true heading by manually selecting "0" mag var on the INS control panel. When the INS is operating in ATT mode (either by RSO selection or INS computer failure), the heading is set by the RSO using the heading slew knob.

Heading Marker

The heading marker is a rectangular marker located just outside of the rotating compass card. The marker is manually set by the HEADING SET knob except when the DISPLAY MODE SEL switch is in ANS, then, the heading marker displays INS heading.

Bearing Pointer

The bearing pointer is a heavy arrowhead located outside of the rotating compass card. Operation of the bearing pointer is affected by three switches: DISPLAY MODE SEL, BEARING SELECT and the UHF radio function selector.

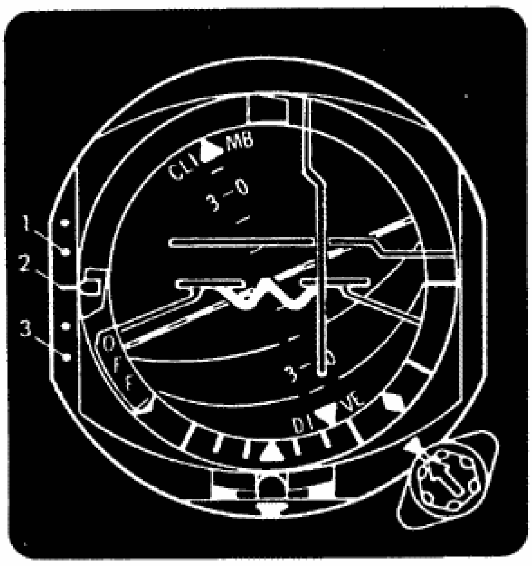
With the DISPLAY MODE SEL switch in ANS, the bearing pointer provides true bearing to a selected TACAN station or UHF transmitter regardless of the BEARING SELECT switch position. With the DISPLAY MODE SEL switch in INS, the bearing pointer is referenced to INS heading and with the BEARING SELECT switch in NORMAL, the bearing pointer displays bearing to the INS DP; with the BEARING SELECT switch in TAC/ADF, it displays bearing to a selected TACAN station or UHF transmitter. With the DISPLAY MODE SEL switch in TACAN ADF, the bearing is INS magnetic to a selected TACAN station or UHF transmitter, regardless of the BEARING SELECT switch position. With the DISPLAY MODE SEL switch in ILS or ILS APPROACH, the bearing pointer is servoed to the lubber line if the BEARING SELECT switch is in NORMAL; if in TAC/ADF, it will display INS magnetic bearing to a selected TACAN station or UHF transmitter.

Selecting the ADF position of the function selector switch on the UHF radio overrides TACAN information and provides UHF/ADF bearing.

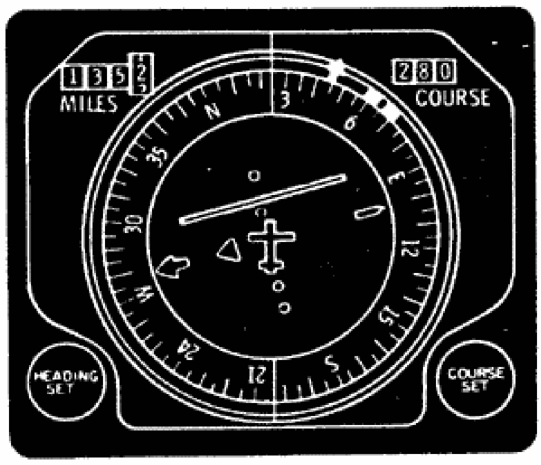
Course Arrow and Course Deviation Bar

The course arrow and course deviation bar are on the face of the rotating compass card. The course arrow displays a commanded or selected course and the course deviation bar displays displacement from the commanded or selected course. When the DISPLAY MODE SEL switch is in ANS, the course arrow and course window display desired ground track as computed by the ANS. The course deviation bar indicates left or right location of the desired course. Full deflection of the course deviation bar is proportional to 1 nm off-course. With the DISPLAY MODE SEL switch in INS, the course arrow is manually set to the desired INS course and the course deviation bar indicates deviation from the INS course. With the DISPLAY MODE SEL switch in TACAN ADF, the course may be selected manually with the COURSE SET knob and course deviation bar signals are received from the TACAN. With the DISPLAY MODE

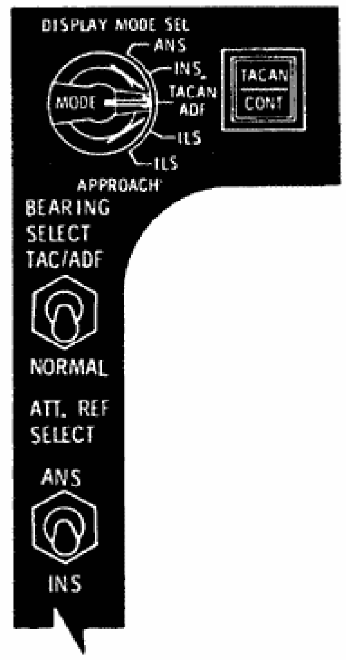
NAVIGATION INSTRUMENTS - Forward Cockpit



ATTITUDE DIRECTOR INDICATOR



HORIZONTAL SITUATION INDICATOR



* With ANS, INS, or TACAN/ADF display mode selected:

1. Indicator position if APW shaker boundary reached.
2. Pitch boundary or glide slope status indicator.
3. Indicator position for Angle of Attack and pitch rate - 0.

♦ 45° Index marks provided on ADI.

NOTE

▲ When UHF/ADF is operating it has priority on bearing pointer

The attitude reference select switch determines which system, ANS or INS, supplies pitch and roll to the attitude director indicator, pitch, roll, and heading to the autopilot. (The autopilot receives steering signals only in the ANS position).

⚠1 If the INS is operating in the attitude mode and the DISPLAY MODE SEL switch is in any position other than ANS, the course warning flag comes into view.

		DISPLAY MODE SELECTOR SWITCH									
		ANS		INS		TACAN/ADF		ILS		ILS/APCH	
		BEARING SEL. SW.		BEARING SEL. SW.		BEARING SEL. SW.		BEARING SEL. SW		BEARING SEL. SW.	
INDICATOR	INDICATOR FUNCTION	NORMAL	TAC/ADF	NORMAL	TAC/ADF	NORMAL	TAC/ADF	NORMAL	TAC/ADF	NORMAL	TAC/ADF
HORIZONTAL SITUATION INDICATOR	HEADING MARKER	INS Heading		Manually Set							
	BEARING POINTER	To Selected TACAN or ADF ▲		INS DP Bearing	TO SELECT TACAN OR ADF ▲	To Selected TACAN or ADF ▲		SERVOED TO LUBBER LINE	TO SELECT TACAN OR ADF ▲	SERVOED TO LUBBER LINE	TO SELECT TACAN OR ADF ▲
	COURSE ARROW	Command Course		Manually Set INS Course		Manually Set TACAN Course		Manually Set Inbound Localizer Course			
	COURSE DEVIATION	Left or Right of Command Course		Deviation from INS Course		Deviation From TACAN Course		Deviation From Localizer Course			
	TO-FROM INDICATOR ▲	Out of View		To Selected INS DP		To Selected Tacan Station		Out of View			
	RANGE INDICATOR	Dist. to DP/TURN	Dist to TACAN Station	Distance to INS DP	Distance to TACAN Station						
	K SHUTTER	Dist. to DP/TURN	Masked								
	AIRCRAFT HEADING	True		INS Heading (Magnetic or Alternate Mode Selected Heading)							
ATTITUDE DIRECTOR INDICATOR	BANK STEERING BAR	Command Course		INS Selected course		TACAN Course		Localizer Course			
	PITCH STEERING BAR	Vertical Velocity		Out of View						Pitch Direction for Glide Slope Beam	
	PITCH BOUNDARY OR G/S INDICATOR	Out of View / Angle of Attack and Pitch Rate Status Relative to APW Boundary						Position Relative to Glide Slope Beam			
⚠1	COURSE WARNING FLAG	← Out of View → ANS Valid		INS Heading Valid		TACAN Valid		Localizer Valid			
	GLIDE SLOPE WARNING FLAG	← Out of View →						Glide Slope Valid			
	POWER WARNING FLAG	Out of View - Attitude Reference Valid									

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Figure 1-66

SEL switch in ILS or ILS APPROACH, the course arrow should be manually set to the localizer course with the COURSE SET knob; course deviation bar signals are from the ILS.

To-From Indicator

The to-from arrow is located radially between one end of the course arrow and the miniature aircraft at the center of the instrument.

With the DISPLAY MODE SEL switch in INS, to-from information is relative to an INS DP. With the DISPLAY MODE SEL switch in TACAN ADF, to-from information is relative to the selected TACAN station. The to-from arrow is hidden from view in all other display modes.

BEARING, DISTANCE, HEADING INDICATOR

The bearing, distance, heading indicator (BDHI) on the RSO's instrument panel contains a rotating compass card, range window, and two pointers.

The compass card displays ANS or INS heading, depending on the position of the BDHI SEL-HEADING switch. The No. 1 pointer displays ADF, INS DP, or TACAN bearing, depending on the position of the BDHI SEL-NO. 1 NDL switch. The No. 2 pointer always displays ANS command course.

Range Readout Window

The range readout window behind the shutter is a three-digit counter which displays slant range to a TACAN station in nautical miles. The maximum range readout is 999 nautical miles. When TACAN information is unreliable, a shutter covers the range readout.

BDHI Heading Select Switch

The two-position BDHI heading select switch on the RSO's instrument panel is labeled HEADING. With the switch in INS (up), the compass card displays INS heading. With the switch in ANS (down), the compass card displays ANS heading.

Heading Slew Control

The HEADING SLEW control, on the RSO's instrument panel, is used to set the INS heading when the INS is in the ATT (attitude) mode.

BDHI SEL NO. 1 Pointer Select Switch

The BDHI SEL NO. 1 pointer select switch on the RSO's instrument panel has three positions: ADF (up), INS (center) and TACAN (down). The No. 1 pointer displays an ADF, INS DP, or TACAN bearing, as selected.

ATTITUDE INDICATOR-RSO

An attitude indicator on the RSO's instrument panel receives pitch and roll signals from either the ANS or INS. Power for the indicator is furnished by the emergency ac bus through the ATT IND circuit breaker on the RSO's right console.

Attitude Indicator Selector Switch

The ATT IND switch on the RSO's instrument panel has two positions: INS (up) and ANS (down). The switch selects the attitude reference source for the attitude indicator and for ready signals to the power-off flag.

ACCELEROMETER

A mechanical accelerometer on the pilot's instrument panel has one indicating pointer and two recording pointers (one each for loads greater or less than 1-G). The recording pointers remain at the maximum travel positions reached by the indicating pointer, thus providing a record of maximum positive and negative G-loads encountered. To return the recording pointers to the 1-G position, press the button on the lower left corner of the instrument.

MAGNETIC COMPASS

A magnetic compass is located on the forward part of the pilot's canopy. An on-off toggle light switch is located below and to the left of the compass.

COMMUNICATIONS AND AVIONIC EQUIPMENT

The communications and avionic equipment includes:

AN/AIC-18	Interphone system.
COMNAV-50	UHF communication and navigation system (UHF-1 and UHF-2).
AN/ARA-48	Automatic direction finder equipment, used with COMNAV-50.
AN/ARC-186(V)	VHF communication system.
618-T	HF radio.
ARC-190	HF radio.
51RV-1	Instrument landing system.
Wilcox 914X-2	IFF transponder.
G-Band Beacon	For radar tracking during special tests.
I-Band Beacon	For radar tracking during special tests.
AN/ARN-118(V)	TACAN system.

Refer to Section IV for descriptions of the Inertial and Astro-inertial Navigation systems, the sensor equipment, and the defensive systems. Some instruments used to display avionic systems navigation information are described under Flight and Navigation Instruments, this section.

Pilot's Microphone Switches

The pilot's microphone is connected to the radio transmitter selected on the interphone control panel when the pilot either depresses the microphone switch on the right throttle knob or selects the TRANS position of the microphone switch on the control stick grip. A transmission side tone is heard while the transmitter is keyed. The button and switch are spring loaded to the off position. When not transmitting, the pilot can receive communication signals selected on the interphone control panel. When the switch on the control stick is moved to INPH, the pilot's microphone is only connected to the interphone circuit. The Mission Recorder System records voice signals when either TRANS or INPH is selected or the interphone panel HOT MIC switch is on.

RSO's Microphone Switches

The RSO's radio transmit switch is located in the left footrest and the interphone switch is located in the right footrest. A quiet/listen (muting) switch is provided on the right side of the cockpit floor to inhibit all audio input to the RSO's headset except pilot's CALL signals. The quiet/listen switch operates only when the RSO's interphone selector knob is in the MUTE or INTER position. The Mission Recorder System records the RSO's voice signals whenever the aft cockpit radio transmit or interphone switch is depressed or the interphone panel HOT MIC switch is on.

INTERPHONE SYSTEM, AN/AIC-18

The interphone system provides crew intercommunication plus crewmember-to-ground-crew interphone and crewmember radio communication. Each crewmember's microphone and headset are connected to the communication equipment selected by the selector knob on individual interphone control panels. The system provides:

1. Either press-to-talk or HOT MIC interphone communication between cockpits.
2. HF, UHF-1, UHF-2, and VHF radio transmission and reception for the pilot and RSO.
3. A CALL button in each cockpit for emergency communication between cockpits.
4. Interphone communication with the ground crew by means of an external receptacle in the nosewheel well.

5. Landing gear system unsafe audio warning (pulsed tone) and low KEAS aural warning (steady tone) to pilot and RSO.

6. Monitoring of navigation radio audio signals.

7. Interphone communication with tanker during aerial refueling.

8. Recording of interphone system signals on the Mission Recorder System (MRS) whenever the pilot's or RSO's transmit or interphone switches are keyed, or when HOT MIC is selected.

Interphone Control Panel

An interphone system control panel is located on the pilot's right console and on the RSO's left console. Power is supplied by the essential dc bus through individual INTPH circuit breakers in each cockpit. Each panel contains a volume control, seven monitoring knobs, a HOT MIC knob, a six-position rotary selector, and a CALL button. See Figure 1-67.

Monitoring Switches

The seven combination volume-control and push-pull switches at the top of the interphone panel are labeled: INTER, UHF-1, HF, IFR COM, VHF, UHF-2, and TACAN/ILS. Pulling out a switch connects the output of the labeled equipment to the headset of the crewmember. Rotating a monitor switch knob varies the volume of the signal. The VOL (volume control) knob establishes the maximum strength of all seven monitor switches. The in-flight refueling communications (IFR COMM) monitor switch is used to monitor the tanker interphone system after refueling contact.

The TACAN and ILS systems share a single monitor button. TACAN signals are available except when the DISPLAY MODE SEL switch is in ILS or ILS APPROACH (when ILS signals become available).

Selector Knob

The rotary selector knob, labeled INTER, UHF-1, HF, UHF-2, VHF, and MUTE, connects the microphone and headset of the crewmember in that cockpit to the communication systems as follows:

INTER - Provides normal voice communication with the opposite cockpit and with the ground crew (if connected).

UHF-1 - For transmission and reception using the UHF radio in the forward cockpit.

HF - For transmission and reception using the HF radio.

UHF-2 - For transmission and reception using the UHF radio in the aft cockpit.

VHF - For transmission and reception using the VHF radio.

MUTE - Provides the RSO with a quiet/listen (muting) capability. When this position is selected and the quiet/listen switch on the aft cockpit floor is depressed, all interphone signals are muted except those from the pilot's CALL. This position is not normally used unless isolation from communication system distractions is required.

Hot Microphone Switch

The push-pull HOT MIC switch permits continuous interphone conversation between crewmembers without depressing a microphone button. Two-way hot microphone operation results if each crewmember pulls out the HOT MIC knob and sets the rotary selector switch to any position except INTER. (HOT MIC transmissions are not possible when the rotary selector in that cockpit is set to INTER.) In one-way operation, the HOT MIC signals are not received unless the other crewmember has the interphone monitor switch pulled up and/or the rotary selector switch set to INTER.

INTERPHONE CONTROL PANEL

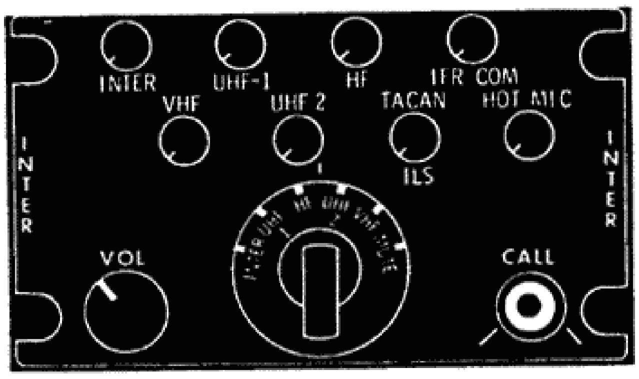

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Figure 1-67

Volume Control

The volume (VOL) control knob adjusts the maximum audio level for all monitored signals.

Call Button

Depressing the spring-loaded CALL button permits interphone conversation to override any signals being received by the other crewmember. The calling volume is preset at a higher level and cannot be adjusted. A microphone switch does not have to be depressed to use CALL.

INTERPHONE SYSTEM NORMAL OPERATION

Normal communication between cockpits is accomplished by depressing the INPH switch (Pilot's Control Stick Grip and RSO's right side communication button on aft cockpit footrest). The crewmember in the opposite cockpit can hear if the interphone (INTER) monitor switch is pulled out and set to normal volume.

COMNAV-50 UHF RADIO

The COMNAV-50 UHF radio provides voice transmission and reception on any of 7000 channels in the P-Band frequency range. A direction-finding capability is also supplied. The radio is conventional except for a capability to operate in either an "Internal" mode (compatible with conventional UHF radio equipment), and an "External" mode (not compatible with other types of UHF radios). In the external mode, coded communication is only possible with other COMNAV-50 (or equivalent) radios. This mode has high resistance to jamming, allows message privacy, and has a range measuring capability.

Two independent UHF radios are provided, designated UHF-1 (front cockpit) and UHF-2 (aft cockpit). They can be used independently, within limits, for internal mode communication. A modulator/demodulator (Modem) control (COMM) panel in the aft cockpit controls coding of external mode signals and discrete selection of the ranging partner. The Modem controls can be switched by the RSO to become a part of either UHF system and give either UHF-1 or UHF-2 an external mode operating capability. Internal mode voice communication capability (without ADF function) is maintained by the opposite system; however, external mode transmissions can interfere with reception by the system operating in the internal mode if proper frequency separation is not maintained. (See Figure 1-68).

Transmitter Power Output

Transmitter power output in the internal mode is adjustable in five steps from 8.0 microwatts to 30 watts in the frequency range from 225 to 399.975 MHz. Power positions 5 and 6 have the same transmitter power output in the internal mode.

WARNING

ILS reception can be affected by UHF transmission at high power settings.

NOTE

When making an ILS approach, set power 4 or lower.

The transmitter power output in the external mode is adjustable in six steps from 8.0 microwatts to 100 watts in the frequency range from 230 to 394.975 MHz. Transmitter power should be kept as low as practical to reduce the possibility of detection. The following tables list recommended transmitter power levels for air-to-air communication in the external mode.

For Voice Communication and Ranging

Power Level	Estimated Distance Capability
6	300 plus nm
5	100 to 300 nm
4	10 to 100 nm
3	1 to 10 nm
2	less than 1 nm
1	less than 0.1 nm

For Direction Finding

Power Level Of Other Transmitter	Distance To Other Transmitter
6	100 to 200 nm
5	30 to 100 nm
4	3 to 30 nm
3	0.3 to 3 nm

External Mode Signal Characteristics

In the external mode, the transmitted signal is encoded to appear as noise to all receivers except those equipped with a compatible decoding device. The "mission code" feature prevents intelligible reception by stations which possess the necessary equipment but do not have the code. Ranging can occur only between two stations with the address code. Automatic direction finding (ADF) can also be accomplished with an addressed station in the external mode concurrently with ranging. Voice/ranging communication and ADF operation have distinct range differences for the same power level. Range measurements can be accomplished only in the external mode.

UHF Radio Equipment Location and Power Supplies

The UHF radio units, modulator/demodulator (Modem coding unit), and the ARA-48 automatic direction finding (ADF) equipment are located in the radio bay and cooled by the environmental control system. Power is furnished by the essential ac bus and the monitored dc bus.

CAUTION

If either canopy is open, the aft canopy latch handle must be in the aft position or the cockpit air handle must be in the forward (off) position for adequate equipment cooling. Otherwise, most of the cooling air would exit through the cockpit openings instead of the bays.

UHF Control Transfer Switch

The push-on/push-off control transfer switch, labeled UHF TRANS, is located on the left side of the RSO's instrument panel. The switch determines which UHF radio has ADF and EXT mode capabilities. When the UHF TRANS switch is on (illuminated), UHF-2 is connected to the ADF antenna, the UHF Modem, and the forward UHF blade antenna; and UHF-1 is connected to the aft UHF blade antenna (INT mode voice communication capability only). Depressing the UHF TRANS switch when it is illuminated extinguishes the light and reverses UHF-1/UHF-2 capabilities. ADF and EXT mode communication/ranging can only be accomplished by the UHF radio connected to the ADF antenna, UHF Modem, and the forward antenna by the UHF TRANS switch. INT mode voice communication is always possible on either UHF radio. Refer to Figure 1-69.

NOTE

- Either crewmember can monitor or transmit on either the UHF-1 or UHF-2 system.
- The RSO always controls the Modem panel.

COMNAV-50 UHF COMMAND RADIO CONTROL PANELS AND INDICATORS

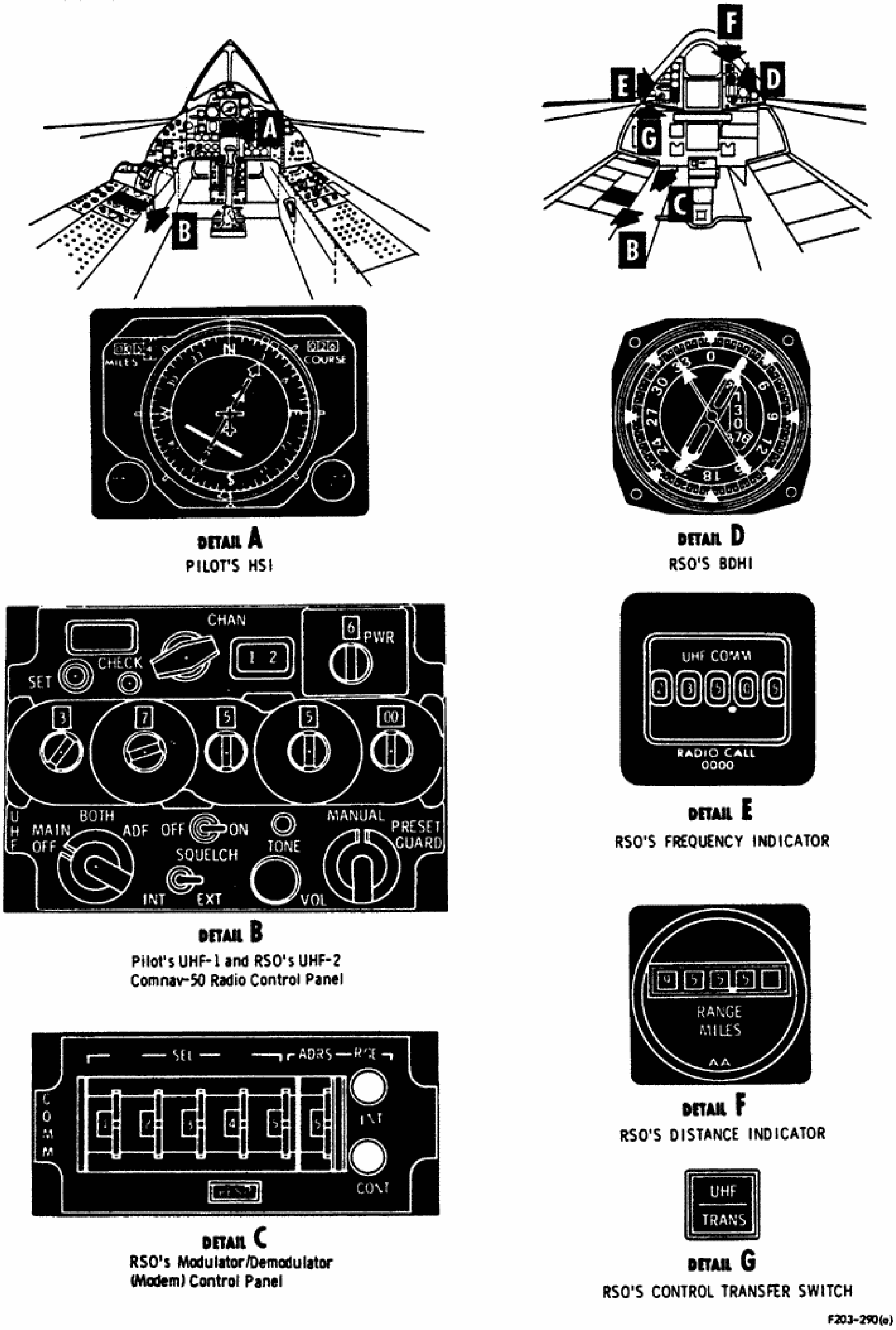


Figure 1-68

UHF RADIO CONTROL PANELS

A UHF radio control panel, labeled UHF, is located in each cockpit. Each crewmember can independently control operation of a UHF transmitter and its guard channel receiver. The ADF function on a radio is only operative when the RSO has selected control of the ARA-48 direction finding equipment (and the forward UHF antenna) for that radio, using the UHF TRANS switch.

Function Selector Switch

A four-position rotary function selector switch turns the radio on and OFF and selects MAIN, BOTH or ADF. ADF is operable with UHF-1 if the UHF TRANS switch light is off, and with UHF-2 if the UHF TRANS switch light is on.

The UHF radio is not energized when the function selector switch is OFF. In MAIN, only the transmitter and main receiver operate. In BOTH, the transmitter, and main and guard receivers operate. The Modem unit (used for external operation) is in standby when the selector is not OFF. In ADF, the ARA-48 is energized, and the main receiver and transmitter operate. Directional signals from the ARA-48 can be displayed on the forward cockpit HSI bearing pointer and the aft cockpit BDHI No. 1 needle.

NOTE

The guard receiver is inoperative in the ADF position.

Manual-Preset-Guard Selector

The MANUAL-PRESET-GUARD switch controls frequency selection. In MANUAL, the manual frequency selector switches are functional. In PRESET, the preset channel selector switch is functional. In GUARD, guard channel frequency (243.0 MHz) is set on the main receiver and transmitter.

Preset Channel Selector Switch

The preset channel selector switch, labeled CHAN, selects one of twenty preset frequencies when the MANUAL-PRESET-GUARD selector is in PRESET. The channel number appears to the right of the selector.

Manual Frequency Selector Switches

Five rotary switches located across the middle of the UHF radio panel selects any one of 7000 frequencies when the MANUAL-PRESET-GUARD selector knob is in MANUAL. The frequency is displayed above the switches.

INT-EXT Mode Switch

The two-position transmitting mode selector switch is labeled INT-EXT. In INT, the UHF radio transmits and receives narrow-band AM signals. This position is used for conventional UHF transmitting and receiving. In EXT, the radio and modulator/demodulator (Modem) are used together to receive and transmit the wide-band pseudonoise encoded signal. Range information in EXT is displayed on the distance indicator in the aft cockpit. Direction-finding using the ARA-48 ADF can be done with the switch in INT or EXT. The UHF radio which is not controlling external mode operation has only internal mode communication capability and no ADF function.

Power Selector Switch and Indicator

A rotary PWR switch controls transmitter output power in the internal and external modes. A digit above the knob indicates the relative power output, from "1" through "6". Power output can be set from a maximum of 30 watts (position 6 and 5) to a low of 8.0 microwatts (position 1) in the INT, or narrow band mode. In the EXT, or wide band mode, power is set from a maximum of 100 watts (position 6) to approximately 8.0 microwatts (position 1).

Volume Control

Clockwise rotation of the VOL knob increases receiver volume. The normal setting is nearly full clockwise so that the interphone controls can be set to make UHF volume compatible with other signals.

Tone Button

The TONE push-button generates a 1020-cycle tone for audio checking or homing. The tone can be generated in either the internal or external mode; however, the tone is inoperative in the external mode when the CONT switch light is illuminated.

Squelch Switch

The two-position SQUELCH switch provides ON and OFF positions for the control of receiver background noise. OFF position allows reception of weak signals and noise.

Frequency Set Switch

Pressing the SET button changes the frequency of that preset channel to the frequency set by the manual frequency selector switches.

Check Switch

Pressing the CHECK button displays the manual frequency corresponding to the selected preset channel in the display window above the switch.

REMOTE FREQUENCY INDICATOR

A UHF remote frequency indicator on the RSO's instrument panel shows the setting selected in the forward cockpit UHF. When the MANUAL-PRESET-GUARD switch on the UHF-1 radio control is in MANUAL, the selected frequency is displayed numerically on the indicator. The selected preset channel number is displayed when in PRESET. The indicator displays "G" when in GUARD.

MODULATOR/DEMODULATOR (MODEM) CONTROL PANEL

The modulator/demodulator (Modem) coding equipment provides the UHF radio with the following capabilities:

1. Communications with discreetly selected partners.
2. Message privacy.
3. Ranging (semi-automatic or automatic).
4. Combined direction finding and ranging.

The Modem control (COMM) panel is located on the forward portion of the RSO's left console. The Modem controls only function in the EXT mode of the UHF radio (UHF-1 or UHF-2) that is using the forward UHF antenna (as selected by the RSO's UHF TRANS switch).

Code Selector Switches

Five rotary selector switches, labeled SEL, have positions from 0 through 7. These switches establish the signal code in the external mode. A code of all zeros cannot be used. Stations must have identical code settings to communicate in the external mode.

Range Address Switch

The right rotary selector switch, labeled ADRS, provides selective ranging. It has eight settings: 0 through 5 plus "A" and "T". The "0" position is an off position which prevents another terminal from ranging, although discrete voice communication capability is retained. Positions 1 through 5 provide range addresses. The "A" position allows a range measurement on any terminal which can respond (having the same synchronization code setting), regardless of its range address code. This is considered an emergency code. "T" is a test position for checking indicator lights on the Modem control panel.

Interrogate Switch and Indicator Light

Depressing the interrogate (INT) push-button switch initiates range and bearing interrogations in the external mode. The INT switch illuminates while the range (or direction and range) is obtained. The switch light extinguishes after three seconds. If the UHF radio function switch is in MAIN, BOTH, or ADF the one-time range measurement in nautical miles and tenths of miles is displayed on the RSO's Distance Indicator. If the UHF radio function switch is in ADF, a one-time bearing is provided to the pilot's HSI and RSO's BDHI. The INT switch is also used with the continuous ranging (CONT) switch to establish automatic ranging and direction finding.

Continuous Ranging Switch

A continuous ranging (CONT) switch and indicator light at the right of the Modem panel initiates continuous ranging. Illumination of the CONT switch light shows that the Modem is in continuous ranging or in continuous ranging and direction finding. The mode depends on setting the UHF radio function selector switch to MAIN, BOTH, or ADF, as discussed above. The CONT switch illuminates at both stations while in continuous ranging or continuous ranging and direction finding; however, the station addressed must have activated its continuous ranging switch to maintain the sequence. The RSO's Distance Indicator is updated each five seconds in the continuous mode. The automatic cycle terminates if the CONT switch is depressed, if a microphone switch at either terminal is depressed for at least three seconds after tone terminates, or the INT/EXT mode switch is placed to INT. The distance indicator at the transmitting station will then reset to zero and the indicator at the receiving station will retain the last distance value. After the cycle is broken by depressing a microphone switch, the operator of either station can reestablish the mode by depressing the INT pushbutton.

Response Light

A respond (RESP) indicator light at the bottom of the Modem control panel illuminates while the other UHF system operating in the external mode is performing a range measurement.

DISTANCE INDICATOR

A distance indicator, on the RSO's instrument panel, displays the distance in nautical miles and tenths of miles between two COMNAV-50 (or equivalent) radio systems ranging in the external mode. The maximum indication is 999.9 miles. A negative contact indicates 000.0.

UHF ANTENNAS

Two fixed UHF blade antennas and a flush-mounted direction finding (ADF) antenna are provided. The forward (No. 1) blade antenna is under the left chine, abeam the cockpit. The aft (No. 2) antenna is under the right chine by the wing leading edge. The ADF antenna is on the centerline of the fuselage, below the aft cockpit.

The RSO's UHF TRANS switch controls access to the forward UHF blade and ADF antennas. See UHF Control Transfer Switch under COMNAV-50 UHF Radio, this section.

UHF RADIO OPERATION

The pilot controls UHF-1. The RSO controls UHF-2, the UHF TRANS switch and the Modem (COMM) panel. When the UHF TRANS switch is on (illuminated), only UHF-2 can use the direction finding and/or external communication modes. To use ADF and/-or EXT mode functions on UHF-1, the RSO must select UHF TRANS off (not illuminated). The RSO controls the Modem for EXT operation with either radio. See Figure 1-69.

Operations in Internal Mode

Normal Operation:

UHF radio panel:

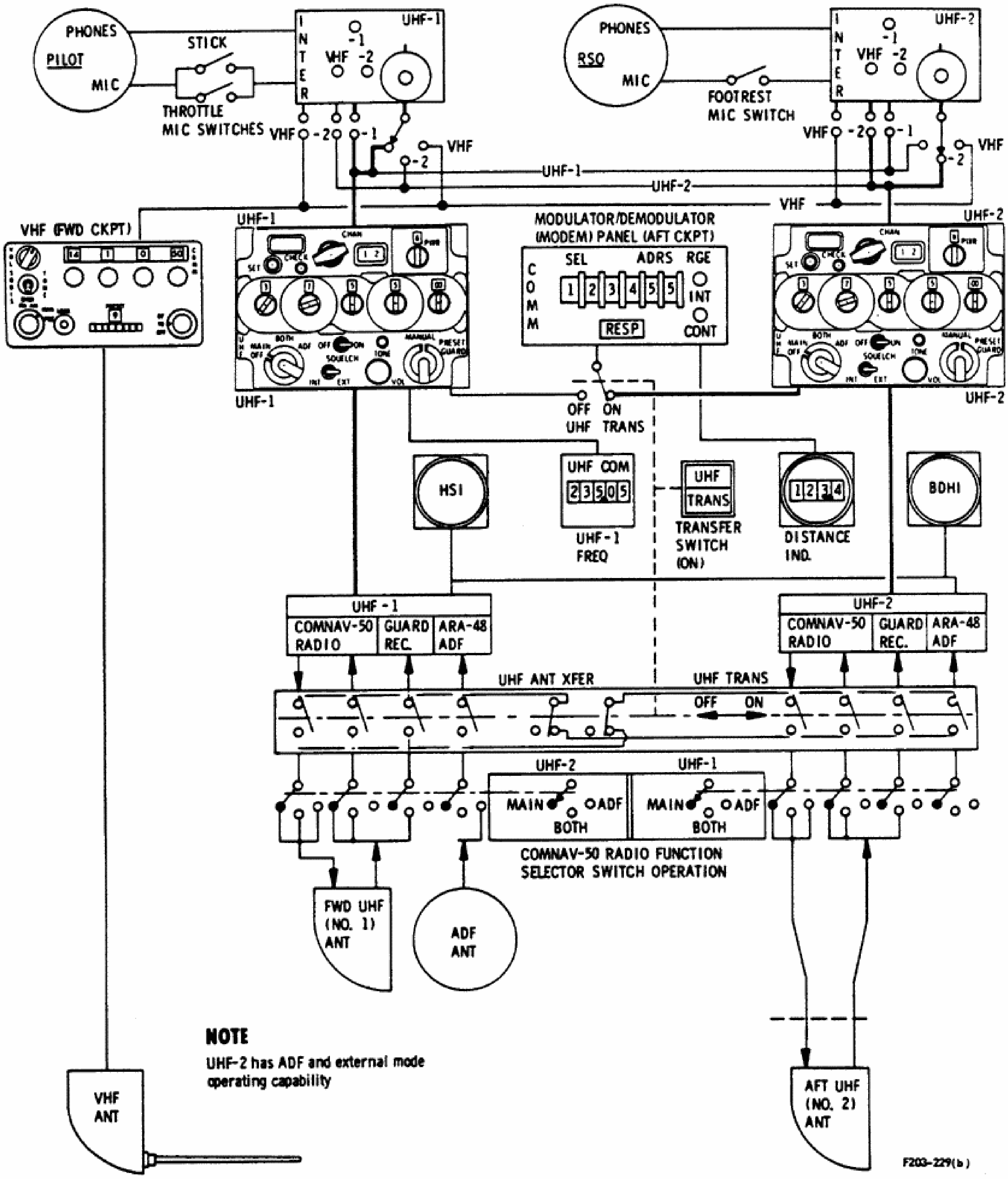
1. Mode switch - INT.

2. Volume control - Nearly full clockwise.

   Use the interphone panel controls for volume adjustments. If necessary, decrease the UHF volume control level to maintain compatibility with the range of adjustments available in the interphone panel.

COMNAV-50 UHF AND ARC-186(V) VHF RADIO CONTROL AND SIGNAL CHANNELS

UHF TRANS on, RSO on UHF-2, Pilot on UHF-1, VHF off.



NOTE

UHF-2 has ADF and external mode operating capability

Figure 1-69 (Sheet 1 of 3)

COMNAV-50 UHF AND ARC-186(V) VHF RADIO CONTROL AND SIGNAL CHANNELS

UHF TRANS off, RSO on UHF-2, Pilot on UHF-1, VHF off.

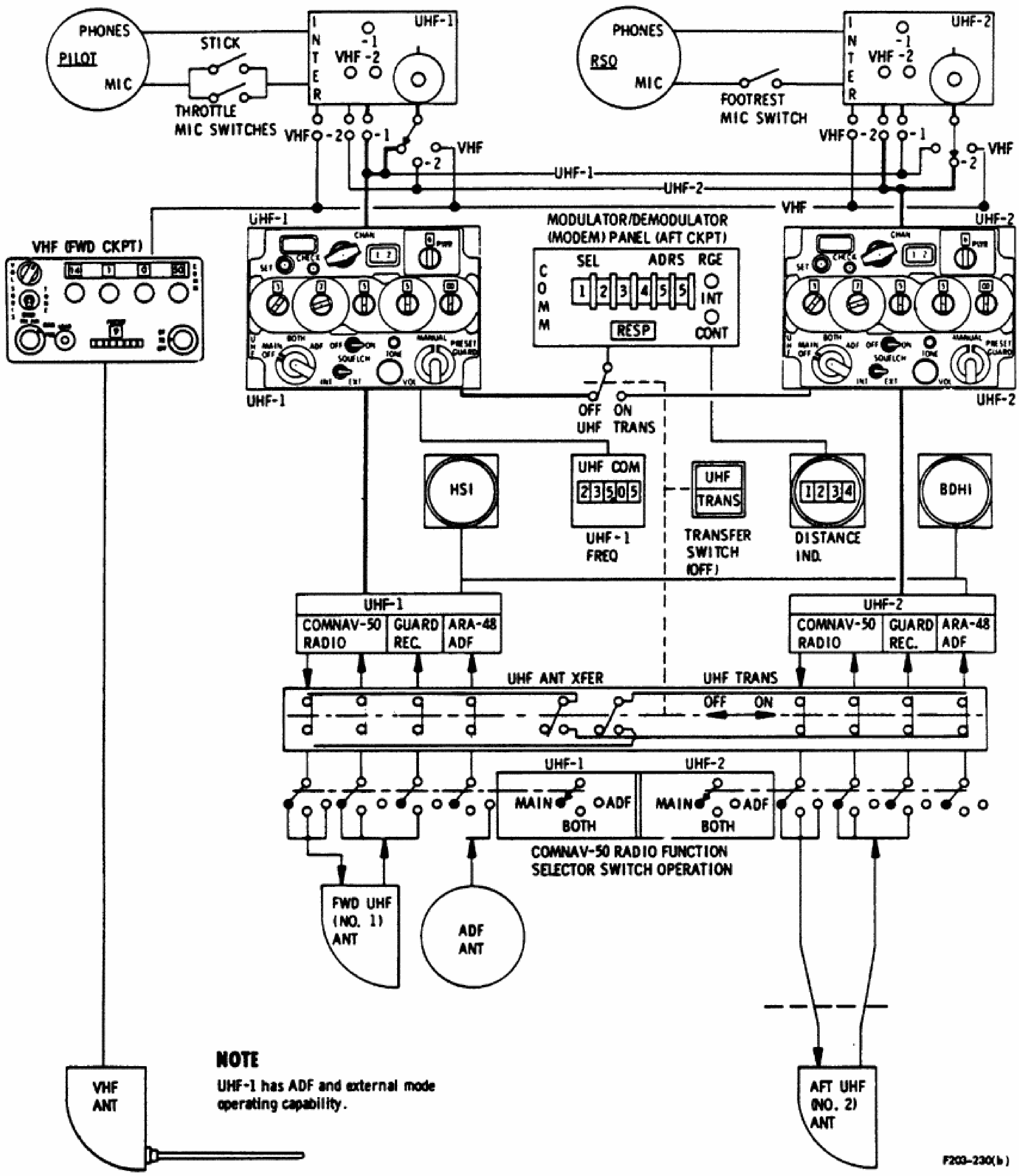


Figure 1-69 (Sheet 2 of 3)

COMNAV-50 UHF AND ARC-186(V) VHF RADIO CONTROL AND SIGNAL CHANNELS

Pilot on VHF, RSO on UHF-1, UHF-2 off, UHF TRANS off.

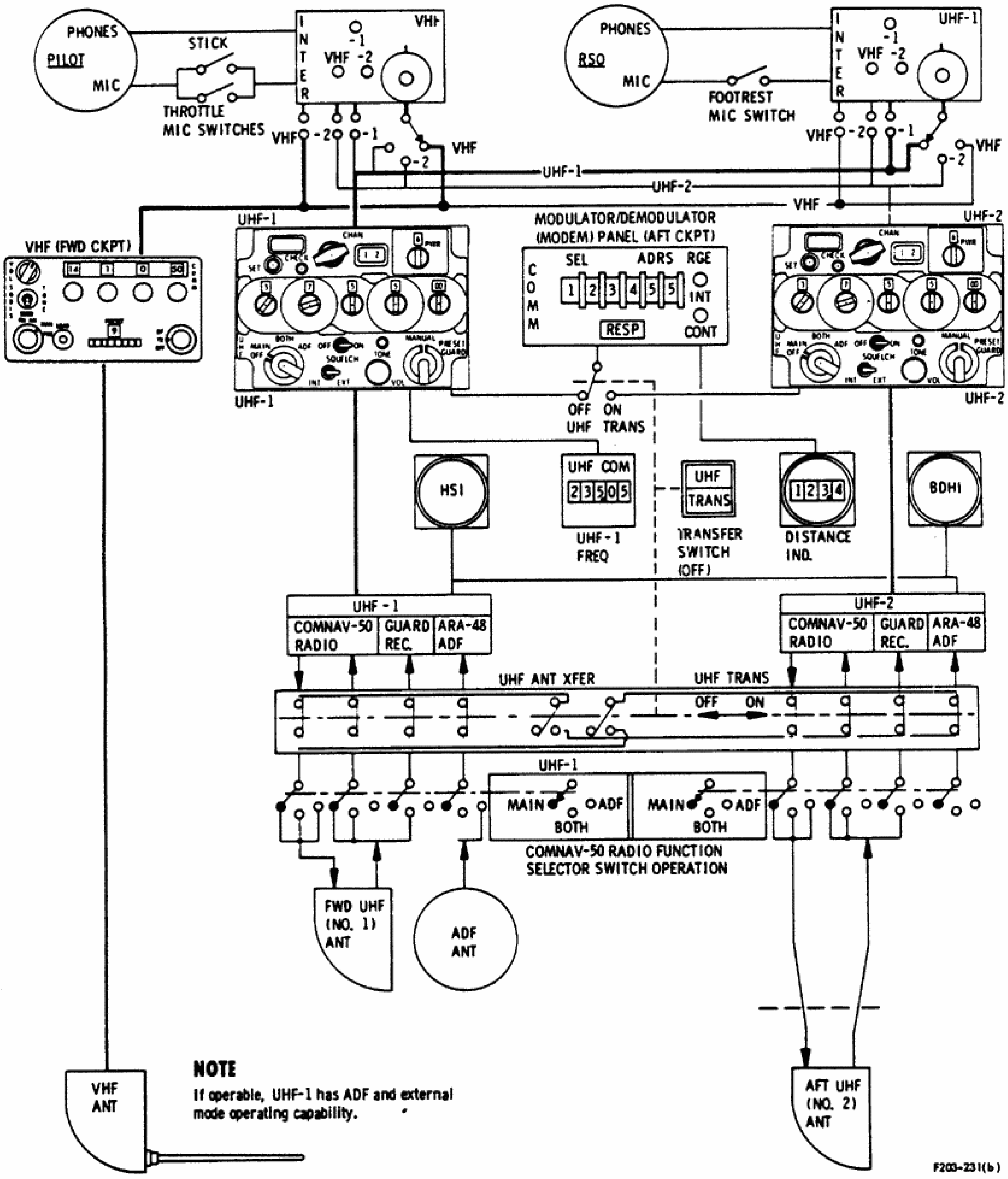


Figure 1-69 (Sheet 3 of 3)

3. Power switch - Set.

   Position 6 is normally used.

   WARNING

   ILS reception can be affected by UHF tranmission at high power settings.

   NOTE

   When making an ILS approach, set power 4 or lower.

4. Frequency - Set PRESET, MANUAL, or GUARD.

   Set the channel number with the CHAN knob if in PRESET.

   Use the five manual frequency selector switches if in MANUAL.

   Frequency is 243.0 if in GUARD.

5. Function selector switch - MAIN or BOTH.

   Set BOTH if guard channel monitoring is desired.

   Approximately ten minutes is required for warmup of the external mode equipment.

For voice communications:

6. Interphone controls - Set.

   Select UHF-1 or UHF-2 with the interphone panel rotary selector knob and pull appropriate monitor button. Adjust volume by interphone volume control and the monitor button.

To transmit:

7. Radio transmit switch - Hold depressed.

For internal mode direction-finding:

Accomplish steps (1), (2), (3), and (4) as for normal operation. Then:

1. Obtain ADF antenna control.

   For UHF-1, pilot coordinate UHF TRANS switch off with RSO. For UHF-2, RSO press UHF TRANS on (illuminated).

2. Bearing select switch - TACAN ADF.

   Required only if the DISPLAY MODE SEL switch is in INS, ILS or ILS APPROACH.

3. No. 1 pointer select switch - ADF.

4. Function selector switch - ADF.

5. Request continuous transmission or tone from communication station.

   A 100 Hz chopping noise will be present until the ADF antenna seeks a null.

6. Observe HSI or BDHI bearing.

   NOTE

   - The HSI bearing pointer and BDHI No. 1 pointer rapidly oscillate 5 to 10 degrees when a signal is received. The indicators are stationary or drift slowly when no signal is present.
   - COMNAV-50 range and bearing information may be lost when below the tanker if the tanker has not switched to lower antenna.

<u>**Operations in the External Mode**</u>

Normal Operation:

1. Obtain UHF TRANS control.

The RSO can operate the UHF-2 system independently when the UHF TRANS switch is on (illuminated). If UHF-1 is to be operated in the external mode, the UHF TRANS switch must be off and the RSO must operate the Modem panel. When operating one UHF in the external mode, the other UHF can only be operated in the internal mode. External mode transmissions by one radio can interfere with reception by the other radio.

UHF radio panel:

2. Mode switch - EXT.

NOTE

Communication in the external mode is possible only with another station having the same capability.

3. Volume control - Nearly full clockwise.

Use the interphone panel controls for volume adjustments. If necessary, decrease the UHF volume control level to maintain compatability with the range of adjustments available in the interphone panel.

4. Power switch - Set.

Position 6 is normal; however, position 5 is normally the maximum within the U.S.

5. Frequency - Set PRESET or MANUAL.

Set the channel number with the CHAN knob if in PRESET.

Use the manual frequency selector switches if in MANUAL.

With GUARD selected the main receiver and transmitter are switched to the internal mode. GUARD has priority over the external mode. ADF is functional.

6. Function selector switch - MAIN or BOTH.

Set BOTH if guard channel monitoring is desired. Guard channel monitoring is not functional in ADF mode.

Approximately ten minutes is required for warm-up of the external mode equipment.

Modem (COMM) panel:

(T7) Code selector switches - Set as briefed.

Set 0 to 7 on each of the five code selector switches.

(T8) Range address switch - Set 0, or as briefed.

The zero setting prevents ranging (unless the other station's ADRS switch is in A) but does not restrict voice communication capability.

For voice communication:

9. Interphone controls - Set.

Select UHF-1 or UHF-2 with the interphone panel rotary selector knob and pull appropriate monitor button. Adjust volume by interphone volume control and the monitor button.

To transmit:

10. Radio transmit switch - Hold depressed.

A one-second tone will be heard. Begin transmission after tone.

For semiautomatic (one-time) ranging or range and bearing:

Accomplish steps (1) through (8) above, then:

For bearing display:

1. Bearing select switch - TAC/ADF

Required only if the DISPLAY MODE SEL switch is in INS, ILS or ILS APPROACH.

(2.) No. 1 pointer select switch - ADF

3. Function selector switch - ADF

Guard channel monitoring is not available in ADF.

To initiate ranging:

(T4.) Interrogate (INT) push-button - Depress momentarily.

The light in the INT switch illuminates for approximately three seconds. A range indication appears on the RSO's distance indicator when the light goes out and bearing will be indicated on the HSI and BDHI if in ADF mode.

To update range or range-and-bearing indications:

(T5.) INT push-button - Depress momentarily.

To communicate with range partner:

6. Microphone switch - Press.

Wait for tone to mute.

For automatic (continuous) ranging or range and bearing:

Accomplish steps (1) through (8) as for Operations in the External Mode. Then:

For bearing display:

1. Bearing select switch - TAC/ADF.

Required only if the DISPLAY MODE SEL switch is in INS, ILS, or ILS APPROACH.

(2.) No. 1 pointer select switch - ADF.

3. Function selector switch - ADF.

Guard channel monitoring is not available in ADF.

To initiate automatic ranging cycle:

(T4.) CONT push-button - Depress.

(T5.) INT push-button - Depress.

NOTE

If ranging stops or can not be initiated, but voice communication is satisfactory, it may be due to marginal signals or to a temporary condition. Attempt to resume ranging by pressing the INT switch. If ranging does not resume, increase power at one or both stations.

(T6.) CONT light - Check illuminated.

(T7.) INT and RESP lights - Check alternating illumination.

Both stations will update readings: each 5 seconds if ranging only; each 8 seconds if ranging with one way ADF; or each 12 seconds if ranging with two way ADF.

NOTE

- The equipment will automatically reinterrogate once if a ranging interrogation cycle is not completed after continuous ranging has been established. The digital range indication will be held for approximately 10 seconds and then reset to zero, if ranging is not reestablished.

- An erroneous range may occasionally appear, but the proper value will be updated during the next interrogate cycle.

To terminate cycling:

8a. Microphone switch - Press.

Wait for tone to mute. A tone will be heard: from 0 to 5 seconds (ranging only), 0 to 8 seconds (one way ADF), or 0 to 12 seconds (two way ADF), depending on progress of the cycle.

NOTE

If ranging only, and a transmission is begun within 1.5 seconds after muting, that transmission will be to the ranging partner only. Subsequent transmissions will be heard by all stations having identical code selections.

OR

b. INT/EXT mode switch - INT.

OR

(T c) CONT push-button - Depress

Check that CONT light goes out.

As an alternate method of receiving ADF bearing during air refueling rendezvous, the UHF radio may be used to provide instantaneous direction finding (without ranging) in the external mode. This procedure is advantageous at close range.

The RSO should request the tanker to discontinue continuous ranging and transmit a tone in the external mode for five seconds every 15 seconds. The SR-71 UHF radio should be in the external mode with ADF selected. When the tone is transmitted, the ADF bearing will lock on steady and not tend to oscillate. Ranging with the tanker can be reestablished intermittently by requesting the tanker to reengage continuous ranging at one minute intervals.

AN/ARA-48 AUTOMATIC DIRECTION FINDER (ADF)

The AN/ARA-48 ADF antenna is used with the UHF system. When the UHF internal (INT) mode is used, the direction finder will point to emissions from any standard UHF radio transmitting on the same frequency. When the UHF external (EXT) mode is used, the ADF function is only compatible with other COMNAV-50 (or equivalent) equipment.

The ADF antenna is located under the RSO on the aircraft centerline. ADF is selected by the UHF radio function selector switch. Directional information can be displayed by the bearing pointer of the pilot's HSI and by the No. 1 pointer of the RSO's BDHI. Power is obtained from the essential ac and monitored dc buses. (See UHF Radio System Operation, this section).

AN/ARC-186(V) VHF RADIO

The ARC-186(V) VHF radio provides AM transmission and reception from 108.000 to 151.975 MHz. Frequency spacing is 25 KHz and 20 channels can be preset in addition to the preset guard frequency (121.5 MHz). Either narrowband or wideband operation is available, but must be preset by maintenance personnel. The FM capability of this radio is not operative.

The receiver/transmitter is located in the right forward chine bay. The antenna is located on the lower left fuselage, opposite the UHF-2 antenna. The radio control panel (Figure 1-70) is on the pilot's right console. Electrical power is provided by essential dc bus number 2.

Mode Select Switch

The rotary mode select switch has three positions:

OFF - Removes power.
TR - Applies power.
DF - Inoperative.

Frequency-Control/Emergency-Select Switch

The rotary frequency-control/emergency-select switch has four positions:

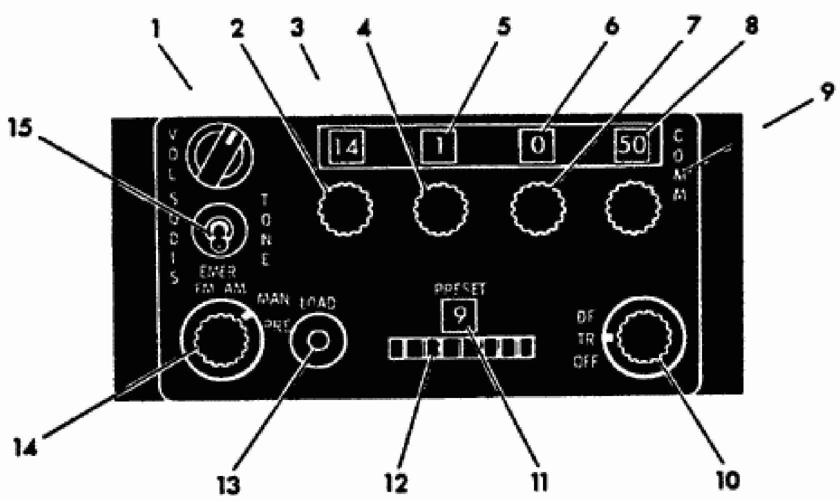
EMER FM - Inoperative.

EMER AM - Selects guard frequency (121.5 MHz).

MAN - Enables manual frequency selection.

PRE - Enables preset channel selection.

VHF CONTROL PANEL



1 VOLUME CONTROL
2 10.0 MHz SELECTOR
3 10.0 MHz INDICATOR
4 1.0 MHz SELECTOR
5 1.0 MHz INDICATOR
6 0.1 MHz INDICATOR
7 0.1 MHz SELECTOR
8 0.025 MHz INDICATOR
9 0.025 MHz SELECTOR
10 MODE SELECT SWITCH
11 PRESET CHANNEL INDICATOR
12 PRESET CHANNEL SELECTOR
13 LOAD SWITCH
14 FREQUENCY CONTROL/EMERGENCY SELECT SWITCH
15 SQUELCH DISABLE TONE SELECT SWITCH

F203-225

Figure 1-70

Squelch-Disable/Tone-Select Switch

The squelch-disable and tone-select toggle switch has three positions:

Center Position	-	Enables squelch.
SQ DIS	-	Disables squelch.
TONE	-	A spring-loaded-to-center position that transmits a tone at 1000 Hz for audio checking or homing.

Volume Control

Clockwise rotation of the volume control knob, labeled VOL, increases volume. The normal setting is nearly full clockwise so that the interphone controls can be set to make VHF volume compatible with other signals.

Manual Frequency Selector Switches

Four rotary switches are used to manually select a frequency when the frequency-control/emergency-select switch is in MAN. The windows above each switch display the selected frequency.

Preset Channel Selector

A rotary preset channel selector switch is used to select one of 20 preset frequencies when the frequency-control/emergency-select switch is in PRE. The selected channel number is displayed above the switch.

Load Switch

Pressing the recessed LOAD push-button switch changes the preset channel to the frequency set by the manual frequency selector switches.

VHF OPERATION

The VHF radio control panel is in the forward cockpit.

1. Mode select switch - TR.

2. Frequency-control/emergency-select switch - PRE or MAN.

   Set the channel number with the preset channel selector if in PRE.

   Use the manual frequency selector switches if in MAN.

3. Volume control - Nearly full clockwise.

4. Interphone controls - Set.

   Select VHF with the interphone panel rotary selector switch and pull VHF monitor button. Adjust volume by interphone volume control and the monitor button.

5. Squelch-disable/Tone-select switch - Center position.

To transmit:

6. Transmit switch - Hold depressed.

HF RADIO SYSTEM, 618-T

The 618-T HF radio is a long-range voice communications transceiver. The modes of transmission are single sideband (SSB) and amplitude modulation (AM). The frequency range is 2 to 30 MHz, tunable in 1-KHz steps. Because of the nature of the antenna (comprising the pitot boom and the insulated forward portion of the aircraft nose) it is not advisable to transmit at frequencies below 4 MHz. The equipment includes a transceiver and semiautomatic antenna coupler/coupler control, mounted in the radio bay in the right chine. The HF radio control panel is on the RSO's left console (Figure 1-71). Electrical power is supplied by the essential ac and essential dc buses.

Long-range HF communication is highly sensitive to hourly and seasonal variations in propagation conditions. For best results, frequency assignment planning should be based on HF propagation predictions.

Function Switch

The four-position function selector switch, labeled OFF, USB, LSB, and AM, energizes the equipment and selects the desired operating mode. In USB (upper sideband), only the upper sideband signal is transmitted or received. This is the sum of the voice signal and the radio frequency (rf) signal. In the LSB (lower sideband) position, only the lower sideband signal is transmitted or received. This signal is the difference of the voice signal and the rf signal. In the AM position, the signal is amplitude modulated and both sidebands and the original rf signal are transmitted and received.

Frequency Selector Knobs

Four rotary switches manually select a frequency. The windows in the middle of the panel display the frequency selected.

RF Sensitivity Knob

The RF sensitivity knob, labeled RF SENS, adjusts the receiver sensitivity level to control the signal-to-noise ratio.

Normal Operation:

1. Interphone controls - Set.

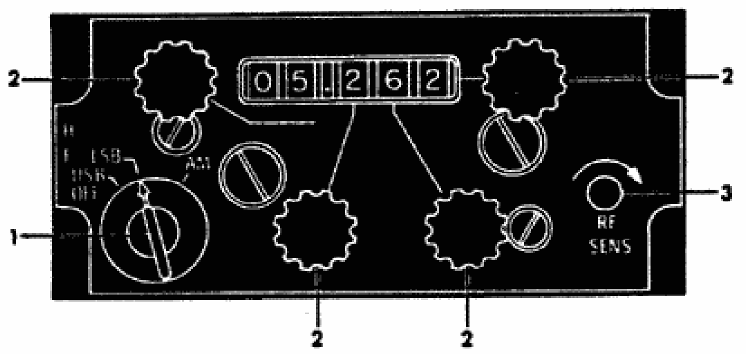
   Select HF with the interphone panel rotary selector switch and pull HF monitor button. Adjust volume by interphone volume control and the monitor button.

2. Function switch - USB, LSB, or AM.

3. Frequency selector knobs - Set.

   The muting of sound in the headset indicates the receiver is tuning to the new frequency.

HF CONTROL PANEL - 618T



1 FUNCTION SWITCH
2 FREQUENCY SELECTOR SWITCHES
3 RF SENSITIVITY SWITCH

F200-42(b)

Figure 1-71

When background sound is again heard:

4. RF sensitivity knob - Adjust.

   Turn the RF SENS knob clockwise until a distinct crackling background noise is heard. At this setting, the receiver is at maximum sensitivity and further rotation of the knob will not improve signal reception. Adjusting the RF SENS knob until there is no distinct background noise lowers receiver sensitivity and incoming signals may not be received. The background noise level varies with locality and propagation conditions, and small adjustments may be necessary to maintain the optimum sensitivity setting.

5. Transmit switch - Depress. Wait for the equipment to tune.

   A 1000 Hz tone will be heard until tuning is complete. Tuning may require 38 seconds.

   When the tone ceases, the transmitter is tuned. Adjust the interphone HF monitor switch volume.

   NOTE

   The HF radio should be retuned after takeoff to match the antenna inflight impedance condition.

   WARNING

   Rf energy from the HF radio during tuning or transmission has caused erroneous light and instrument indications.

Emergency Operation

If an overload exists in the power supply output, a protective circuit turns off the HF equipment. Attempt to restore normal operation as follows:

1. Function switch - OFF, then back to desired operating mode.

If the antenna coupler makes several consecutive tuning cycles, a thermal relay de-energizes the equipment. To restore operation:

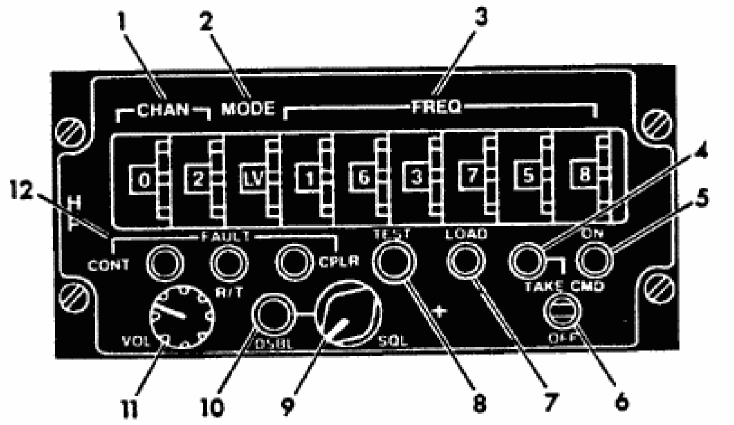
1. Function switch - OFF. After 2 minutes the thermal relay will cool.

2. Function switch - Set to desired operating mode.

HF RADIO SYSTEM, AN/ARC-190 (V)

The ARC-190 receives and transmits on 280,000 frequencies in a band from 2 to 29.9999 MHz spaced at 100 Hz. Frequencies below 4 MHz should not be used due to the nature of the antenna (comprising the pitot boom and the insulated forward portion of the aircraft nose). Modes of operation are upper and lower sideband, amplitude modulation and continuous wave. System components are: a receiver-transmitter (R/T) and antenna coupler located in the R bay;

HF CONTROL PANEL - ARC 190



1 CHANNEL SELECT THUMBWHEELS
2 MODE SELECT THUMBWHEEL
3 FREQUENCY SELECT THUMBWHEELS
4 TAKE COMMAND LIGHT
5 ON LIGHT
6 TAKE COMMAND/OFF SWITCH
7 LOAD PUSHBUTTON
8 TEST PUSHBUTTON
9 SQUELCH SWITCH
10 SQUELCH ENABLE/DISENABLE PUSHBUTTON
11 VOLUME SWITCH
12 FAULT INDICATOR LIGHTS

F203-312

Figure 1-72

antenna and antenna loading coil in the nose; and the HF control panel on the RSO's left console (Figure 1-72). Essential ac power is supplied through a circuit breaker in the C bay.

Automatic tuning occurs in both receive and transmit. Receive tuning requires less than 10 milliseconds. Transmit tuning requires 35 milliseconds on any of the 30 preset channels and 1 second on a manually selected frequency. The first transmission on a new frequency, even a momentary transmission, initiates the transmit tune cycle. A 1000-Hz audio tone is heard until tuning is complete.

Long-range voice HF communication is highly sensitive to hourly and seasonal variations in propagation conditions. For best results, frequency assignment planning should be based on HF propagation predictions.

Channel (CHAN) Switches

Two thumbwheel switches used to select 30 preset channels 00 through 29.

Mode Switch

An 8-position thumbwheel switch used to select modes of operation: LV, lower sideband voice; UV, upper sideband voice (must be set when selecting manual frequencies); LD, lower sideband data (not used); UD, upper sideband data (not used); CW, continuous wave; AM, amplitude modulation; P, preset (must be set when using the 30 preset channels); A, undefined (CONT FAULT will illuminate with A selected).

Frequency (FREQ) Switches

Six thumbwheel switches used to manually select frequencies.

ON Light

Illuminates when radio is on.

TAKE CMD/OFF Switch

Three position switch, spring-loaded to center position used to turn the radio on and off. Momentary TAKE CMD (forward) position turns the radio on. Momentary OFF (aft) position turns the radio off.

LOAD Switch

Pushbutton used to load preset channels in memory.

TEST Switch

Pushbutton used to initiate self-test. When pressed, a receive self-test cycle is initiated and all FAULT lights (3) illuminate. When released, all FAULT lights extinguish unless a component fault is present where indicated. A transmit self-test is initiated by depressing the transmit microphone switch (pilot or RSO with HF selected on interphone panel). A fault is indicated by illumination of the fault light(s).

NOTE

The transmit self-test can only be initiated after completion of a receive self-test.

FAULT Lights

CPLR - Indicates a coupler malfunction.

R/T - Indicates a receiver-transmitter malfunction or illuminates when an unloaded preset channel is selected with P selected in the MODE switch.

CONT - Indicates a control panel malfunction, FREQ switches set below 02.0000 MHz, or the MODE switch is set to A.

Squelch (SQL) Switch

Rotary switch that provides squelch threshold in 3 preset levels. Squelch is disabled in the fully counterclockwise position.

Disable (DSBL) Switch

Pushbutton that alternately enables and disenables the squelch (SQL) switch.

Volume (VOL) Switch

8-position rotary switch sets transmit-receive audio and transmit audio sidetone at 7 preset levels.

Normal Operation

1. Interphone rotary selector knob - HF.

2. Interphone HF monitor switch - Pull and rotate to approximately 12 o'clock position.

3. TAKE CMD/OFF switch -TAKE CMD.

   Momentarily position the switch to TAKE CMD to turn the radio on. The ON and TAKE CMD lights will illuminate.

4. MODE switch - Set.

   Set P for preset channel.

   Set UV for manually selected frequency.

5. CHAN or FREQ - Set.

   To use a preset channel, select the desired channel on the CHAN thumbwheels. If an unloaded preset channel is selected, the R/T FAULT light illuminates.

   To manually select a frequency, set the desired frequency on the FREQ thumbwheels. Do not use frequencies below 04.0000. If a frequency below 02.0000 is set, the CONT fault light illuminates.

6. VOL switch - Nearly full clockwise.

   Use the interphone panel controls for volume adjustments. If necessary, decrease the HF volume to maintain compatibility with the range of adjustments available in the interphone panel. The VOL switch also controls the transmit audio sidetone.

7. SQL and DSBL switches - Set.

   Rotate the squelch switch fully clockwise. If background noise is audible in the full clockwise position, depress the DSBL pushbutton to enable squelch. Rotate the SQL counterclockwise until background noise is audible. This position allows reception of any audible signal but with some continuous background noise. For normal operation rotate the switch one position more clockwise to set the threshold of reception just above the background noise.

8. TEST switch - Press.

   Check all three fault lights illuminate. When the switch is released, check no fault lights remain illuminated.

To transmit:

9. Microphone switch - Depress.

A 1000-Hz tone is heard during transmit tuning on the first transmission on a new frequency. Tuning is complete within one second.

WARNING

Rf energy from the HF radio during tuning or transmission has caused erroneous light and instrument indications.

To program a preset channel:

1. Mode switch - UV.
2. FREQ. - Set.
3. CHAN - Set.
4. LOAD pushbutton - Depress.

   The select channel will be programmed to the selected mode and frequency.

   Repeat as required for other channels.

To turn system off:

1. TAKE CMD/OFF switch - OFF.

   Momentarily position the switch to OFF. The ON and TAKE CMD lights will extinguish.

Emergency Operation

If the R/T FAULT light illuminates while receiving or transmitting:

1. Cycle a FREQ thumbwheel (if in UV mode) or a CHAN thumbwheel (if in P mode) at least three times.

Illumination of the R/T FAULT light when an unloaded preset channel is selected is normal.

If the R/T FAULT light remains on:

2. Attempt a short transmission.

CAUTION

If the ARC-190 HF transmits normally with the R/T FAULT light illuminated, use short transmissions sparingly to prevent overheat.

If transmission and/or reception is inoperative:

3. TAKE CMD/OFF switch - OFF.

   Attempt to restore normal operation by cooling the system at least two minutes. Reattempt normal operation as desired.

INSTRUMENT LANDING SYSTEM (ILS), 51RV-1

An ILS receiver supplies signals to the bank and pitch steering bars and glide slope indicator on the ADI, and to the course deviation indicator (CDI) on the HSI. Refer to Attitude-Director Indicator, Horizontal Situation Indicator, this section, and to Figure 1-66.

An invalid localizer or glide slope signal is indicated by a red warning flag appearing behind the bank steering bar or glide slope indicator, respectively.

WARNING

ILS reception can be affected by UHF transmission at high power settings.

The receiver operates on 20 frequencies. Localizer frequencies range from 108.1 to 111.9 MHz, and glide slope frequencies range from 329.3 to 335.0 MHz. The proper glide slope frequency is automatically tuned when the localizer frequency is selected.

ILS CONTROL PANEL

An ILS control panel (Figure 1-73), labeled NAV, is located on the pilot's right console. The panel contains concentric power (outer ring) and frequency (inner knob) switches. The power switch has two positions: OFF and PWR. The panel also has concentric volume control (outer ring) and frequency (inner knob) switches. Turning the VOL (outer ring) clockwise increases localizer identification volume. The TACAN/ILS interphone switch must be pulled and the DISPLAY MODE SEL switch must be in ILS or ILS APPROACH to hear the ILS identifier and/or marker beacon. A window, labeled MC, displays the localizer frequency (selected by rotating the inner knobs of the concentric switches). The ILS TEST buttons, labeled UP/L and DN/R, test the ILS system (excluding the antenna). The VOR button is not operable.

MARKER BEACON

A conventional 75 MHz ILS marker beacon receiver illuminates the amber MARKER BEACON light on the pilot's instrument panel and generates an audio signal when the aircraft is over an ILS marker. Power for the receiver is furnished by the essential dc bus.

NOTE

> The marker beacon antenna is located inside the right nosewheel door and is operational only when the nosewheel is down.

ILS Operation

1. Interphone ILS monitor switch - Pull and set volume.
2. DISPLAY MODE SEL switch - ILS or ILS APPROACH.
3. Power switch - ON.

   Allow 90 seconds for warmup.

4. Volume - Nearly full clockwise.

To self-test the ILS:

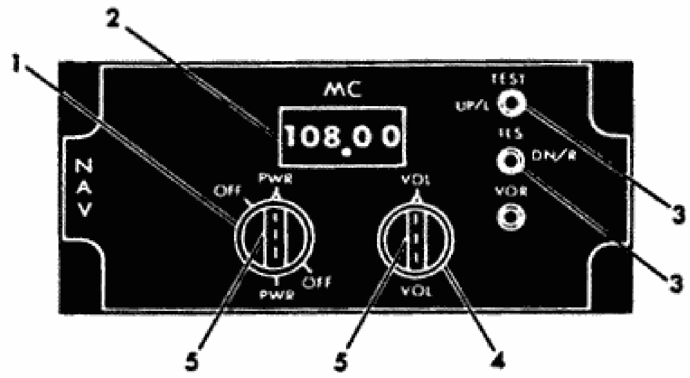
1. Select any localizer frequency.
2. Align the HSI course arrow with the lubberline.
3. DISPLAY MODE SEL switch - ILS APPROACH.
4. Press UP/L.

   The localizer and glide slope warning flags disappear, (the INS must be in NAV for the localizer warning flag to disappear), the glide slope indicator moves 1-dot up, the localizer moves 1-dot left, and the pitch and bank steering bars move half-scale up and left, respectively.

5. Press DN/R.

   The same actions occur as in step 4, but the directions are down and right.

ILS CONTROL PANEL



1. POWER SWITCH
2. FREQUENCY WINDOW
3. TEST BUTTON
4. VOLUME CONTROL
5. FREQUENCY SELECTOR

F203-53(d)

Figure 1-73

AN/APX-108(V) IFF (W/SB R-2668) WILCOX 914X-2 IFF (W/O SB R-2668)

The IFF transponder responds to radar interrogation. The system includes altitude reporting, selective identification, and emergency reporting features. The Mode 4 function provides an encrypted IFF capability.

IFF CONTROL PANEL

The IFF control panel is located on the RSO's instrument panel. The controls for Mode 4 are on the left side of the IFF control panel, and the controls for Modes 1, 2, 3A and C are on the right side. See Figure 1-74.

Master Selector Switch

The rotary master selector switch has five positions:

OFF - Removes power. The switch must be pulled out before it can be rotated to OFF.

STBY - Standby. Applies power, but transmission is inhibited.

LOW - Only responds to strong (local) interrogations. Used at the request of a controller.

NORM - Normal operation. All modes selected have full sensitivity.

EMER - Emergency. Responds to interrogations in Modes 1, 2 and 3A. Mode 3A responds with code 7700. Mode C and 4 operate normally if selected. The switch must be pulled out before it can be rotated to EMER.

Mode 1, 2, 3A and C Controls

Mode 1, 2, 3A and C Control Switches

Four three-position toggle switches select Modes 1, 2, 3A and C. The ON (center) position places the corresponding mode in operation and the OUT (down) position disables the corresponding mode. The momentary TEST (up) position is used to test each mode. Continuous illumination of the TEST indicator light, while a mode control switch is held in TEST and the master selector switch is in NORM, indicates successful self-test of that mode.

Mode C responds with altitude information pulses in addition to the framing pulses (for tracking) sent in Mode 3A.

RAD-OUT-MON Switch

The three-position RAD-OUT-MON switch is provided for testing and monitoring the IFF system. The spring-loaded momentary RAD position is used with ground equipment for maintenance test. In the MON (monitoring) position, the TEST light will illuminate intermittently when responding to radar interrogations in the mode(s) selected. In the OUT position, the TEST light will only respond to self-test inputs using the mode control switches and will not indicate response to radar interrogation.

Mode 1 and 3A Code Selector Switches

Six thumb-wheel switches select the codes for Mode 1 and Mode 3A. The two switches on the left select Mode 1 codes and the other four switches select Mode 3A codes. The left Mode 1 switch is numbered 0 through 7, the other is numbered 0 through 3 on each half of the drum. The Mode 3A switches are numbered 0 through 7.

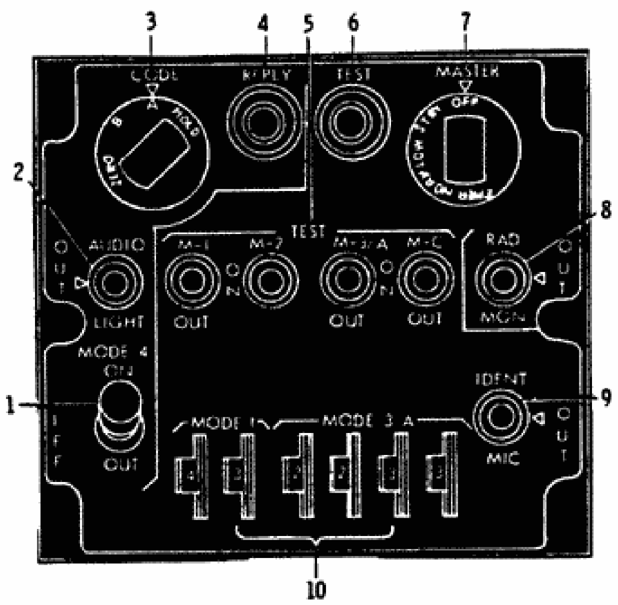
Identification-of-Position Switch

The three position identification-of-position (I/P) switch controls transmission of I/P pulse groups. The I/P timer is energized for thirty seconds when the switch is momentarily held in spring-loaded IDENT,and I/P replies will be made if a Mode 1, 2, or 3A interrogation is recognized within thirty seconds. The I/P pulse group is not transmitted when the I/P switch is in OUT. The MIC position is inactive.

Test Indicator Light

A rotate-to-dim, press-to-test, green TEST light indicates satisfactory operation of the transponder. With the master selector switch

IFF CONTROL PANEL



1 Mode 4 On-Out Switch
2 Mode 4 Indication Switch
3 Mode 4 Code Select Switch
4 Mode 4 Reply Light
5 Mode Control Switches
6 Test Indicator Light
7 Master Selector Switch
8 Rad-Out-Mon Switch
9 Identification-of-Position Switch
10 Code Selector Switches

F203-173(-)

Figure 1-74

Mode C Altitude Reporting and Identification Capability Schedule

Mode Selector Switch Settings		Response	
Mode 3A	Mode C	Mode 3A	Mode C
ON	ON	Normal	Normal (Altitude Code)
ON	OUT	Normal	*Framing Pulses Only
OUT	ON	None	Normal (Altitude Code)
OUT	OUT	None	None

*Response indicates aircraft with Mode C altitude reporting capability to interrogating station.

Notes:

Mode 3A selector switch enables Mode 3A and Mode C decoder.

Mode C selector switch enables Mode C decoder and information pulses.

Mode C altitude reporting information is enabled by the DAFICS M computer. If the M computer fails, Mode C will continue to report the altitude at the time the computer failure occurred.

Figure 1-75

in NORM, the light illuminates when a mode switch (1, 2, 3A, or C) is placed in TEST if the self-test is satisfactory. When the system is operating (master selector switch in LOW or NORM), and the RAD-OUT-MON switch is in MON, the light blinks when the IFF responds to interrogation in the mode(s) selected.

Mode 4 Controls

Mode 4 is also controlled by the master selector switch.

Mode 4 Code Select Switch

The Mode 4 code select switch is labeled ZERO, B, A, and HOLD. Placing the switch in ZERO cancels (zeroizes) both the code settings. The switch must be pulled out before it can be rotated to ZERO. When the switch is in A or B, the transponder will respond to Mode 4 interrogation sources using the same code. The spring-loaded HOLD position is used (before power is removed from the transponder) to retain codes when the aircraft is on the ground.

NOTE

> Weight must be on the nosegear before the HOLD position is functional.

To retain code settings, the switch must be held in HOLD for at least 5 seconds and transponder power must be left on for an additional 15 seconds. Otherwise, the code settings may not be mechanically latched and will zeroize when the master selector switch is turned off or power is disconnected.

Mode 4 Reply Light

A rotate-to-dim, press-to-test, green REPLY light illuminates when the Mode 4 indication switch is in either AUDIO or LIGHT, if transponder Mode 4 replies are satisfactory. Press-to-test is only operative in the AUDIO or LIGHT position.

Mode 4 Indication Switch

A three-position AUDIO-OUT-LIGHT toggle switch controls Mode 4 indications.

W/O SB R-2668, with the indication switch in AUDIO (up), an audio tone is heard in the aft cockpit only if a proper Mode 4 interrogation is received, and the REPLY light illuminates when Mode 4 generates a reply.

With SB R-2668, with the indication switch in AUDIO (up) an audio tone is heard in the aft cockpit if Mode 4 does not respond to a proper interrogation and the REPLY light will not illuminate.

NOTE

> The RSO's IFR COM knob controls the volume of the Mode 4 audio.

In LIGHT (down), the REPLY light illuminates without audio when Mode 4 replies are transmitted. In OUT (center), both light and audio indications are inoperative.

Mode 4 On-Out Switch

A two-position toggle switch controls Mode 4 operation. A Mode 4 response cannot be transmitted unless: ON (up) is selected; the Master Selector Switch is in LOW, NORM, or EMER; and the Mode 4 code has not been zeroized. The switch must be pulled out to be moved to OUT (down).

Mode 4 IFF Caution Light

A rotate-to-dim, amber IFF CAUTION light, is located on the RSO instrument panel. The light illuminates each time the transponder fails to reply to a proper interrogation. If the Mode 4 codes are zeroized, or if self-test detects a system fault, the light will be on steady. Pressing the LAMP TEST switch checks the light .

IFF NORMAL OPERATION

Modes 1, 2, 3A and C

1. Master Selector Switch - STBY.

   Three minutes are required for warm-up.

2. Master Selector Switch - NORM.

   LOW should only be used at the request of a controller.

3. Mode 1 and 3A Code Selector Switches - Set.

NOTE

The Mode 2 Code is preset on the ground.

4. Mode Switch(es) - As required.

To test operation of individual Modes:

1. RAD-OUT-MON switch -OUT.

If the switch is in MON, the TEST light will illuminate for both self-test and monitor functions.

2. Individual mode switch - TEST.

Illumination of the TEST light indicates the corresponding Mode is operational. Repeat for each mode.

NOTE

Test modes individually.

3. Mode switches - As required.

To monitor operation of individual Modes:

1. RAD-OUT-MON switch - MON.

2. Individual Mode switch - ON.

The TEST light will blink to indicate responses to interrogation. Repeat for other modes.

To transmit identification of position:

1. Identification switch - IDENT.

Mode 4

1. Mode 4 ON-OUT switch - ON.

2. Code select switch - A or B, as required.

Code A is the code for a prescribed 24-hour period; Code B is for the next 24-hour period.

3. Audio/Light indicator switch - As desired.

To zeroize the codes:

1. Mode 4 code select switch - ZERO.

The codes can also be zeroized by turning the master selector switch OFF, if the HOLD function has not been used.

NOTE

Once zeroized, Mode 4 is inoperative until the codes are reinserted on the ground.

To retain the codes after landing:

1. Mode 4 code select switch - HOLD.

Place the switch in the HOLD position for 5 seconds, then wait another 15 seconds before turning equipment OFF.

To turn IFF off:

1. Master selector switch - OFF.

IFF EMERGENCY OPERATION

Modes 1, 2, and 3A

1. Master selector switch - EMER.

NOTE

In EMER, Mode 4 and Mode C replies are normal.

Mode 4

Illumination of the IFF CAUTION light indicates the transponder will not respond to Mode 4 interrogations.

With IFF CAUTION light illuminated:

1. Master selector switch - Check NORM.

2. Mode 4 ON-OUT switch - Check ON.

3. Mode 4 code select switch - Check.

   Check A or B.

G-BAND BEACON

The G-band (formerly C-band) beacon is a radio frequency transponder used to aid radar tracking of aircraft during special tests. The beacon responds to interrogation in the 5400 to 5900 MHz range. The transmitter radiates with at least 400 watts peak power at 500 pps. Receive and transmit frequencies are displaced at least 50 MHz for protection of the beacon receiver. Transmitter operation can not be adjusted while in-flight.

The beacon is controlled by two two-condition push-button switches located left of the viewsight controls on the RSO's instrument panel. Power is controlled by the BEACON switch. Actuating the switch illuminates an ON legend in the lower half of the switch. A warm-up period of at least three minutes is desired. A 15-minute warm-up period results in maximum signal stability. Another switch actuation turns the beacon off and extinguishes the ON legend. Two antennas are provided. Actuating the ANT (antenna) switch illuminates either a B (bottom antenna) or T (top antenna) legend in the lower quarters of the switch when the beacon is on.

Power for the beacon is from the Essential DC Bus through the BEACON circuit breaker on the RSO's right console.

I-BAND BEACON

The I-band beacon is provided when Mission Kit 4AT1030 is installed. The antenna can be installed in the left EIP door, right EIP door, left TECH door, or right TECH door.

The I-band beacon is a radio frequency transponder used to aid radar tracking of aircraft during special tests. The beacon responds to interrogation in the 8500 to 9600 MHz range. Receive and transmit frequencies are displaced at least 50 MHz for protection of the beacon receiver. Transmitter operation can not be adjusted while in flight.

The beacon is controlled by the OOC LH OPER power switch if the antenna is installed on the left EIP door or the left TECH door or by the OOC RH OPER power switch if the antenna is installed on the right EIP door or the right TECH door. Actuating the switch illuminates the ON legend in the lower half of the switch. System warm-up is from 20 seconds to two minutes. Another switch actuation turns the beacon off and extinguishes the ON legend. (The FAIL light is not functional and will not illuminate.)

Power for operation of the beacon is provided from the Monitored DC Bus through the left or right OOC CONT AND PWR circuit breaker in the C-bay.

TACAN SYSTEM AN/ARN 118(V)

The Tactical Air Navigation (TACAN) system operates with ground stations and cooperating aircraft. Continuous slant range and bearing information is obtained from ground stations. Range and bearing are also obtained through mutual transponding with cooperating aircraft; however, bearing information can not be transmitted by the SR-71 to the other aircraft. Operational range can be over 300 nautical miles at high altitudes.

126 X-mode and 126 Y-mode channels are available.

Transmitter interrogation frequencies range from 1025 to 1150 MHz with 1-MHz separation. Receiver frequencies range from 962 to 1024 MHz and 1151 to 1213 MHz when operating in the air-to-ground (T/R) mode.

NOTE

> TACAN reception can be affected by UHF transmissions at high power settings in external mode.

In the air-to-air mode, receiver frequencies used are the same as for transmitter interrogation; however, a pair of channels with 63 MHz separation is required. Since the air-to-air modes can operate at or near the IFF system frequencies (1090 and 1030 MHz for transmit and receive), IFF interference can cause unreliable TACAN operation on channels 1-11, 58-74, and 121-126.

The IFF receiver is suppressed during TACAN transmission and the TACAN receiver is suppressed during IFF transmissions, to protect the receivers. If no signal is received when a strong TACAN or IFF signal is expected, a malfunction of the suppression circuits can be identified by momentarily turning off one of the systems.

When TACAN channels are changed, acquisition time for the new channel is less than one second. No more than three seconds are required for bearing lock-on.

If the received TACAN distance signal is invalid, the distance displays on the HSI and BDHI are covered. If the DISPLAY MODE SEL switch is in TACAN, the steering bar warning flag appears if TACAN bearing is not valid. The identifier of the interfering station is purposely garbled if co-channel interference occurs in T/R. If signal loss occurs, velocity memories keep the bearing and range indications tracking for up to 3 and 15 seconds, respectively, or until the signal is reacquired. An automatic self-test is performed after each signal loss and the TEST light illuminates if the test fails.

Power for TACAN operation is provided by the essential ac bus and by the monitored dc bus through circuit breakers in the C-bay.

The TACAN antenna is a high temperature annular slot type (identical to the IFF antenna) located on the bottom centerline of the fuselage forward of the nosewheel well.

TACAN CONTROL PANEL

A TACAN control panel and a TACAN control transfer switch are provided in each cockpit (Figure 1-76).

Channel Selectors

Two channel selector knobs and an X-Y mode selector, control TACAN frequency. The channel number (01 through 126), selected by rotating the tens and units channel selector knobs, is displayed on the panel. Rotating the ring which surrounds the base of the units channel selector knob selects X or Y mode.

Mode Selector Switch

The rotary mode selector switch has five positions:

OFF - Removes power.

REC - Bearing to selected ground station. Range is not available.

NOTE

- After tuning a new station, the bearing pointer may slew to a bearing 90° greater than the actual bearing and remain there for about two seconds. This is normal.
- After signal loss and re-acquisition, the bearing pointer will slew to 270° and remain there for about seven seconds during the automatic self-test. After self-test, the bearing pointer may slew to a bearing 90° greater than the actual bearing and remain there for about two seconds.

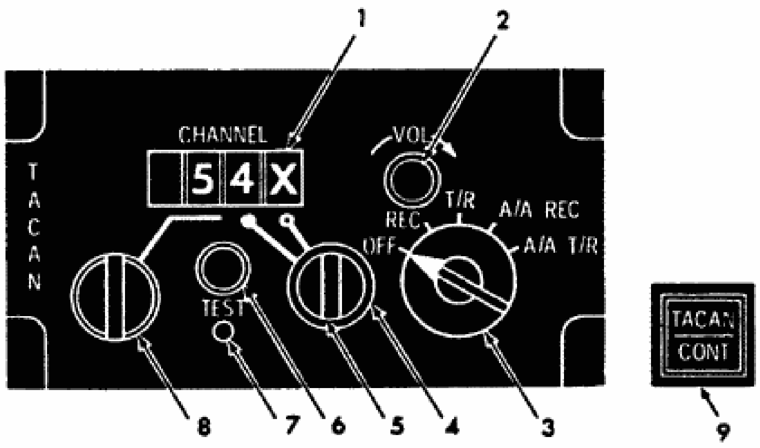
T/R - Bearing and slant range to a selected ground station.

A/A REC - Bearing to a suitably equipped cooperating aircraft (also in A/A with 63 channel separation). Range is not available.

A/A T/R - Bearing and slant range to a cooperating aircraft.

AN/ARN-118(V) TACAN CONTROLS

TACAN CONTROL PANEL
PILOT RIGHT CONSOLE
RSO LEFT INSTRUMENT PANEL



1 CHANNEL DIGITAL DISPLAY
2 STATION IDENTIFICATION VOLUME CONTROL
3 MODE SELECTOR CONTROL
4 X-Y CHANNEL SELECTOR CONTROL
5 UNITS CHANNEL SELECTOR CONTROL
6 R/T STATUS INDICATOR LIGHT
7 TEST SWITCH
8 TENS CHANNEL SELECTOR CONTROL
9 TACAN CONTROL TRANSFER SWITCH - PILOT'S AND RSO'S INSTR PANELS

F203-201(b)

Figure 1-76

NOTE

Some aircraft, including the SR-71, cannot transmit bearing. Range is available to both aircraft.

Volume Control Knob

Rotating the volume (VOL) control clockwise increases the TACAN identification signal audio level. The TACAN/ILS interphone switch must be pulled and the DISPLAY MODE SEL switch must be in ANS, INS, or TACAN ADF to hear the TACAN identifier.

Self-Test Push-button

A self-test of the TACAN equipment and its interface with the HSI and BDHI is initiated by actuating the TEST push-button. The adjacent indicator light flashes momentarily when the TEST switch is pressed.

NOTE

If the TEST light illuminates other than at the start of self-test, a TACAN fault exists.

A self-test can be terminated immediately by rotating a channel selector or the mode selector switch to another position.

NOTE

- o Bearing and/or distance indications may still be present when the TEST light is on. Such indications may be accurate, but are unreliable.
- o Be prepared for failure of TACAN equipment if the TEST light illuminates.

Small recesses on the outside of each side of the canopies provide lifting points so the canopies can be opened from outside. A latch on top of the nitrogen counterbalance cylinder engages when the canopy is fully open and holds the canopy in that position until the latch is released by pressing the latch release lever. The two canopies are independent in operation, except for the external jettison feature.

CAUTION

- o Canopies shall be opened or closed only when the aircraft is stopped. To prevent wind forces from shearing the canopy hinge pins, hold canopy securely when opening.
- o Maximum taxi speed with the canopy open is 40 knots. Gusts should be included as part of the 40 knot limit.

Canopy Latching Mechanism

Each canopy is latched closed by four hooks (two in each canopy sill). The canopy is latched and unlatched by a handle at the forward right side of each cockpit. Moving the handle rotates a transverse torque tube behind the seat to simultaneously position all four hooks. With the canopy closed, forward movement of the handle latches and locks the canopy, while aft movement releases the hooks and unlocks the canopy. The ejection or canopy jettisoning sequence unlatches the canopy by gas pressure from the canopy unlatch thruster behind the seat.

The aft canopy latching torque tube is mechanically connected to a cockpit air shutoff valve in the air-conditioning system. To conserve cooling air for electronic equipment, this valve shuts off air flow to both cockpits when the canopy latch handle is in the aft position. This valve is also operated by the RSO's Cockpit Air handle. The forward (off) position of the RSO's Cockpit Air handle will shut off air to both cockpits even if the aft canopy latch handle is forward. Refer to Environmental Control System Controls, Cockpit Air Valve, this section.

CAUTION

If either canopy is open, the aft canopy latch handle must be in the aft position or the cockpit air handle must be in the forward (off) position for adequate equipment cooling. Otherwise, most of the cooling air would exit through the cockpit openings instead of the bays.

Canopy Counterbalance System

Normal opening and closing of the canopy is assisted by gaseous nitrogen pressure from the canopy counterbalance cylinder at the left rear of the seat. Without counterbalance assistance, the canopy is difficult to raise (requiring approximately 112 pounds of force), and can drop with sufficient force to injure personnel. A counterbalance system pressure gage is located above the nitrogen cylinder and the pointer should indicate in the green if system pressure is normal.

WARNING

To avoid injury, verify that counterbalance pressure indication is normal before pushing the canopy latch release.

CAUTION

Do not rotate the canopy upward beyond its normal full-open position or canopy shear pins may be severed.

Canopy Seal System

An inflatable seal is installed along the edge of each canopy frame. The seal is inflated by engine bleed pressure to provide an airtight seal between the canopy and the canopy sills and windshield. A pressure regulator and control valve is provided in each cockpit. The seal selector lever is located in the right forward corner of each cockpit and is used to inflate or deflate the seals. Seal pressure is regulated to no more than 23 psi.

CANOPIES, CANOPY CONTROLS and INDICATOR

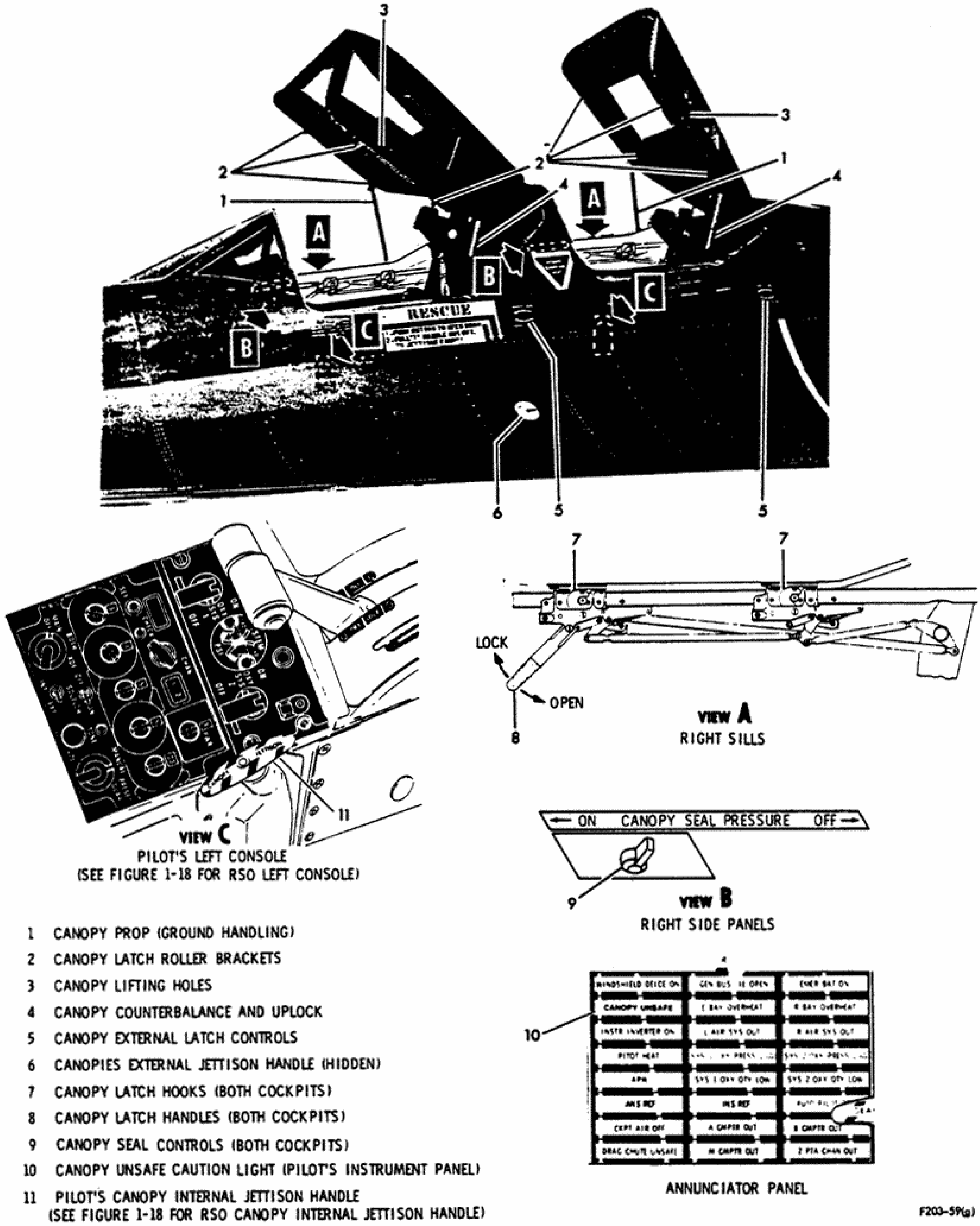


Figure 1-77

REAR VIEW PERISCOPE

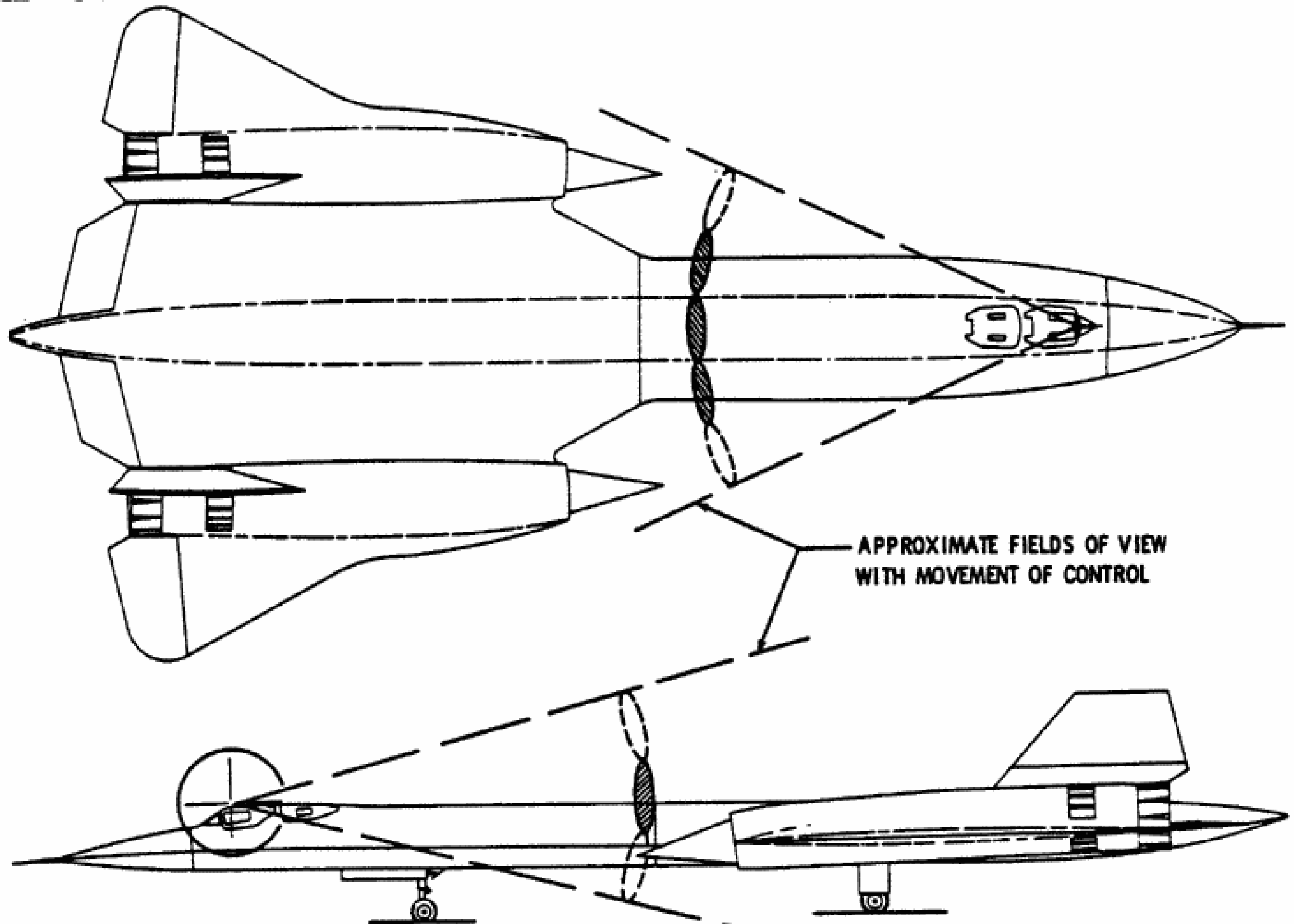


Figure 1-78

F203-112(b)

CAUTION

- Do not inflate seals unless the canopy is latched closed, or damage to seals may occur.
- The OBC must be off unless both canopies are closed and the canopy seals are on.

Canopy Unsafe Warning Light

Illumination of the CANOPY UNSAFE annunciator caution light indicates that one or both canopies is not latched down and/or properly sealed.

Canopy Jettsion System

The canopy is jettisoned by gas pressure from a canopy unlatch thruster on the aft bulkhead of the respective cockpit. The unlatch thruster may be fired by pulling the ejection seat D-ring, or the CANOPY JETTISON T-handle located outboard of the left forward corner of each ejection seat.

When the unlatch thruster fires, it rotates the canopy hooks to the unlatch position and releases the canopy. The thruster charge is then ported to the canopy-removal thruster and seal-hose cutter. The seal-hose cutter severs the canopy seal hose, and the canopy-removal thruster forces the canopy up and aft, shearing the hinge attach points and thrusting the canopy clear of the aircraft.

The canopy can also be removed in-flight by manually unlatching it and pushing it up into the airstream. If the cockpit is pressurized when the canopy latches are released, the canopy will be blown upward into the airstream by cockpit pressure.

WARNING

Do not enter or leave the cockpit unless ground safety pins are installed in the seat ejection D-ring, the seat ejection T-handle, and the canopy jettison T-handle.

Canopy External Latch Controls

Individual external latch release fittings are flush-mounted on left side of the fuselage, just below the canopy hinge points. Fittings accept a 1/2-inch-square bar extension to open the canopies from outside the aircraft. The canopy must be raised manually after releasing the latch hooks externally.

Canopy External Jettison System

Both canopies may be jettisoned on the ground by the external jettison system. An external jettison handle is located under an access panel on top of the left chine, at the aft end of the forward cockpit. When the external jettison handle is pulled, both canopies jettison in sequence, the forward canopy first, the aft canopy 1 second later. A long jettison cable allows the person pulling the handle to be well clear of the fuselage during jettison.

Cockpit Sunshades (Bat Wings)

Two 12.5" x 8" sunshades (bat wings) in the front cockpit are used to block the intense sunlight prevalent at high altitude, and to reduce cockpit light reflections at night. A sunshade is located on each canopy side-frame, below the side windows, and is attached to a rod mounted 5" aft of the forward end of the canopy. Each sunshade is individually adjustable: the sunshade can be extended along the rod, the rod elevated, and the sunshade rotated. They may be joined together to form an extension of the glare shield (refer to Night Flying, Interior Light Reflections, Section VII). A lever to adjust rotational friction is located on the top, inboard portion of the left bat wing; similar levers at both rod attachment points adjust elevation friction and allows the bat wings to be joined together. The right bat wing may be folded lengthwise and stowed above the PVD projector. Both bat wings have extension panels, located on the lower side, which increase the area by 50% when pulled out. The altimeter correction card is attached to the outboard side of the right bat wing.

REAR-VIEW PERISCOPE

A manually extended rear-view periscope is mounted in the top of the pilot's canopy. It is moved by using a white nylon handle mounted on the aft side of the viewing tube. Pushing the handle left unlocks the tube, allowing the periscope to be extended. Pushing the tube upward to a spring-detented position makes the rear view available. Cockpit pressure assists extension and resists retraction. The cone of view is approximately 10 degrees across; however, head movement extends the viewing cone to approximately 30 degrees total angle. (See Figure 1-78.) When extended, the periscope can be rotated horizontally to move the center of the viewing arc up to 10 degrees from the aft centerline. The lens provides a 2 to 1 reduction ratio.

MAP PROJECTORS

A strip-film projector is installed in each cockpit to provide a strip map of the route to be flown with mission data and emergency information. (See Figure 1-79.) Film strips are provided for each mission. The pilot and RSO projectors are of different design and are independently controlled.

PILOT'S MAP PROJECTOR

The pilot's map projector is located in the bottom center of the instrument panel. Projector controls are located on the panel borders of the 4-1/4 by 4-1/4 inch display and on the map projector control panel on the left console, forward of the throttle quadrant. The projector can display up to 25 feet of 35 mm film.

Illumination Control

The illumination control slide switch at the bottom edge of the navigation map display is a combination power on-off switch and illumination rheostat. When the control is in the left-hand detent, the projector is deenergized; moving the control down and sliding it to the right energizes the projector lamp, blower, and film-drive motors. Moving the

MAP PROJECTORS

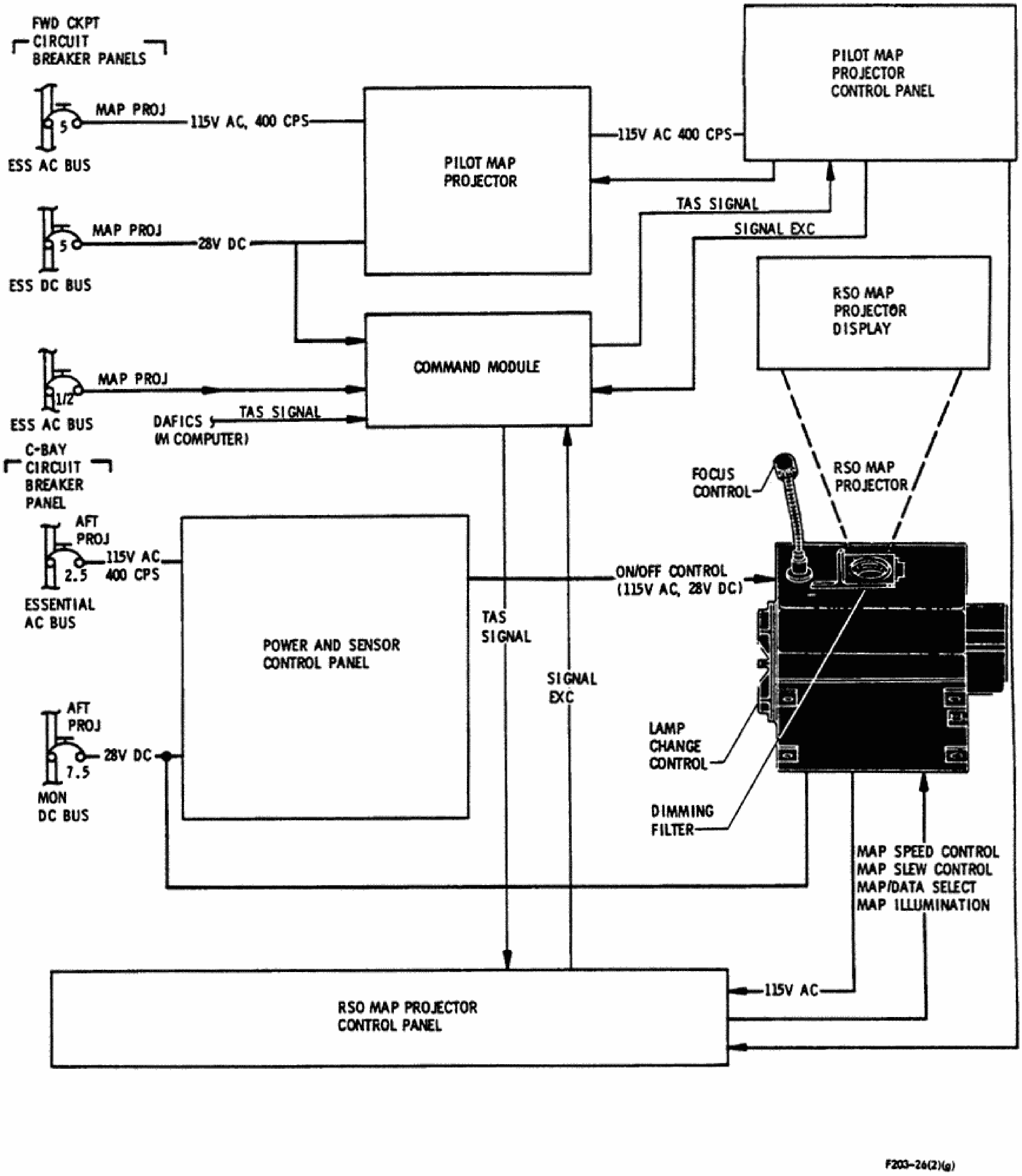


Figure 1-79

control from DIM towards BRT increases the display brightness.

Projector Lamp DIM-BRT Switch

A three-position projector lamp dimming toggle switch is provided on the bottom edge of the navigation map display, to the right of the illumination control. In DIM, low voltage is applied to the navigation map projector lamp and the range of image brightness is reduced. In BRT the maximum range of image brightness is available. The unmarked middle position provides medium brightness.

Lamp Change Control

The lamp change control on the right border of the nav map display is labeled LAMP CHG. The lever switch has detent positions (labeled 1, 2, and 3) to provide a choice of three bulbs. If a bulb burns out, another may be selected by moving the lever to the right, out of detent, and repositioning it to one of the other two marked positions.

Slew Control Switch

The rotary slew control switch on the map projector control panel, is spring-loaded to the center (off) position. Counterclockwise rotation of the switch causes reverse slew and clockwise rotation causes forward slew of the film strip. The rate of film movement is variable in both directions. Increased rotation of the switch increases the slew speed.

NOTE

> To return to a specific position, reverse slew, then slew forward and stop on the point of interest. This eliminates any delay in automatic film drive advance.

Drive Switch

The drive switch on the map projector control panel, selects either manual rate control (MANUAL MACH), automatic map rate synchronized to true airspeed (AUTO), or OFF (film stop).

Map Rate Control and Indicator

The map rate control on the map projector control panel, is a single-turn potentiometer calibrated in Mach. This control permits manual synchronization between map film speed and aircraft groundspeed when the drive switch is in the MANUAL MACH position. The control has a dial face with seven major outer divisions, representing Mach, and a single pointer. The inner O marking with + and - arrows provides a means of biasing the map rate when the drive switch is in AUTO. For normal operation the pointer should be in the O position to provide zero bias. Counterclockwise rotation from the O position decreases map film speed; clockwise rotation increases map film speed. The control has no effect when the drive switch is in OFF. The projector is intended for use with map films scaled at 365 nautical miles per inch.

CAUTION

> Attempting to turn the control clockwise past 35 or counterclockwise past zero will damage internal stops and cause a loss in dial reference.

PILOT'S MAP PROJECTOR OPERATION

1. Illumination control - Slide right to turn on and obtain desired brillance.
2. Map DRIVE switch - AUTO or MANUAL MACH, as desired.
3. RATE control - O position for AUTO or as required for MANUAL MACH.

   Adjust + or -, as necessary.
4. SLEW control - REV or FWD, as required.

RSO's MAP PROJECTOR

The RSO's map projector system includes the projector, projector controls, and a 9 by 9-inch display screen. Some map projector controls are located on the viewsight control panel (Figure 4-33 without S/B R-2538, Figure 4-33A with S/B R-2538). When the RCD is installed, the map projector is mounted on the floor and projects onto a hinged viewing screen below the RCD. When the RCD is not installed, the projector is mounted horizonally at a higher position on the bottom of the instrument panel, and projection is then onto the display screen mounted in place of the RCD.

NOTE

> The map film continues to move when data film is selected for viewing, even though the film is not projected. The rate of movement always corresponds to 250 nautical miles per inch.

Projector Power Switch

The projector power switch is located on the PWR & SENSOR control panel. A white illuminated legend PROJ appears in the top half of the switch. A green ON legend, that illuminates alternately when the pushbutton is depressed, and a red non-functional FAIL legend occupy the lower quarters of the switch.

Lamp Change Control

A rotary lamp change control is located on the side of the projector case. The control has three detented positions for different bulb selections. When the RCD is installed, the control is located on the right side of the projector case and may be operated by the RSO's foot when a bulb burns out. When the RCD is not installed, the control is located on the left side of the projector case and can be reached by hand.

Projector Focus Control

Map projector focus is adjustable by turning the focus control knob flexible stem on top of the map projector assembly.

Map Drive Switch

A map drive switch on the viewsight control panel provides selection of either manual map rate control (MAN-TAS), or automatic map rate (AUTO) synchronized to true airspeed.

Map Rate Control and Indicator

The map rate control on the viewsight control panel is a two-turn potentiometer, calibrated to true airspeed, which permits synchronization between map film speed and aircraft groundspeed when the map DRIVE switch is in MAN - TAS. The control has a dial face with 10 peripheral divisions labeled 1 through 0 (10), a long and a short pointer, and a movable knurled bezel to move the pointers. The short pointer indicates thousands of knots and the long pointer indicates hundreds of knots. The inner O marking with + and - arrows provides a reference to bias the map rate when the DRIVE switch is in AUTO. For normal automatic operation both the short and long pointers should be on the O inner scale position (1 on outer scale) to provide zero bias. Counterclockwise rotation decrases map film speed; clockwise rotation increases map film speed.

Slew Control Switch

A rotary control switch, labeled SLEW, is located on the viewsight control panel. It controls the direction and speed of the film strip that has been selected by the film-select switch. Counterclockwise rotation of the switch toward REV (REW with video viewsight) causes reverse slew and clockwise rotation toward FWD causes forward slew. Increasing switch rotation causes an increasing rate of film movement in the indicated direction up to 0.6 ips for map film and 0.9 ips for data film. At the end of switch travel an electrical contact is made to cause rapid slewing of 3.5 ips for map film and 6 ips for data film. (Image speed across projector screen is nine times the film speeds.)

NOTE

> To return to a specific position, reverse slew, then slew forward and stop on the point of interest. This eliminates any delay in automatic film drive advance.

Film Select Switch

A two-position film-select toggle switch, labeled SELECT, is located on the viewsight control panel. The DATA and MAP positions select the type of film to be projected.

Illumination Control Switch

A three-position illumination control switch, labeled ILLUM, is located underneath the right end of the optical viewsight control panel and on the front of the video viewsight panel. The switch is springloaded to the center off position. A motor closes or opens an iris in the projector to change the degree of illumination; when held in the forward (DIM) position or the aft (BRT) position on the optical viewsight panel, or in the down (DIM) position or up (BRT) position on the video viewsight panel.

Dimming Filter

A manually positioned dimming filter can be placed over the projector lens to reduce brightness during night operation.

RSO MAP PROJECTOR OPERATION

1. PROJ power switch on PWR & SENSOR panel - Press to illuminate ON.
2. ILLUM switch - BRT or DIM, as desired.
3. SELECT switch - DATA or MAP, as desired.
4. DRIVE switch - AUTO or MAN-TAS as desired.
5. MAP rate knob - as desired.

If no display:

1. ILLUM switch - BRT as required.
2. Lens dimming filter - Check open.
3. Projector slew control - Slew to assure dark leader is not blocking light.
4. Lamp change control - Rotate to new position.

If image is out of focus:

1. Focus adjustment - Set.

LIGHTING EQUIPMENT

EXTERIOR LIGHTING

Landing/Taxi lights and Switch

A 1000 watt landing light and a 450 watt taxi light are mounted on the nose gear strut. The lights are controlled by a luminous three-position landing and taxi lights switch on the pilot's left instrument side panel. The switch positions are LAND LT (up), TAXI LT (down), and OFF (center). The switch is ineffective when the nose gear is retracted, as the uplock switch prevents power being applied to the lights. Power for the lights is obtained from the essential ac bus through the LDG LT and TAXI LT circuit breakers on the pilot's right console.

CAUTION

Use the taxi light if lighting is required during ground operation or after landing. The landing light burns out without airstream cooling.

Anti-Collision/Fuselage Lights and Switch

Two combination retractable anti-collision and fuselage lights are located at the top and bottom of the fuselage, near the middle. The lights are controlled by a three-position toggle switch on the pilot's lighting panel. The switch positions are: ANTI COLLISION (forward), FUS (aft), and OFF (center). In ANTI COLLISION, the lights extend, illuminate red, and rotate at 45 rpm (which produces 90 flashes per minute). In FUS (fuselage), the lights are retracted and illuminate white. The lights are retracted and off when the switch is in OFF. Three-phase essential ac powers the lights through the ANTI COLL LTS circuit breaker on the pilot's right console.

Tail Lights and Switch

A white tail light is located on the top and bottom of the tail cone. The lights are controlled by a three-position toggle switch, labeled TAIL LT, on the pilot's lighting panel. In STEADY (aft), the lights illuminate continuously. In FLASH (forward), the lights flash 85 times per minute. The center position is off. Power is furnished by the essential ac bus through the TAIL light circuit breaker on the pilot's right console.

Fuselage and Tail Lights Intensity Switch

A FUS & TAIL lights intensity switch is located on the pilot's lighting panel. The positions are BRT (forward) and DIM (aft). The switch controls the light intensity of the tail lights and also the anti-collision lights when they are operated as fuselage lights.

FORWARD COCKPIT LIGHTING

Integral and edge lighting for the instruments and consoles is controlled by the lighting panel on the left console. The four instrument lights circuit breakers on the lighting panel (LH, RH, FUEL CONT, and FUEL CONT TEST) are only operative if the ac hot bus INSTR light circuit breaker on the right console is closed. Front cockpit interior lighting also includes: one floodlight located above each side console, and one floodlight located above the circuit breaker panel on each side; a thunderstorm light located on the canopy on each side; a movable spotlight secured on the console on each side; flex point lights mounted on the canopy sill on each side; two emergency instrument lights located on the instrument panel glareshield; and one combination floodlight/emergency instrument light, above the right console, which illuminates the right instrument side panel.

ADI Light Rheostat

The ATT DIR IND rheostat on the lighting panel, controls light intensity of the attitude director indicator only. Power is from the ac hot bus through the FUEL CONT TEST instrument lights circuit breaker.

Instrument Lights Rheostat

The INSTR LTS rheostat on the lighting panel, controls instrument panel light intensity. Power is from the ac hot bus through the LH and RH instrument lights circuit breakers.

Console Lights Rheostat

The CONSOLE LTS rheostat on the lighting panel, controls light intensity of the right and left consoles. When the rheostat is not OFF, all caution and warning lights (including annunciator panel lights) are dimmed, except the nacelle fire warning lights and the landing gear handle warning light. Power is from the essential ac bus through the PANEL lights circuit breaker on the right console.

Floodlights Rheostat

The FLOOD LTS rheostat on the lighting panel, controls light intensity of the floodlights. Power is from the essential ac bus through the FLOOD lights circuit breaker on the right console.

Thunderstorm Lights Switch

The THUNDERSTORM lights switch on the lighting panel has two positions: ON (forward) and OFF (aft). Power is from the essential dc bus through the SPOT light circuit breaker on the left console.

Spotlights

The spotlights (utility lights) incorporate a rheostat on the aft end to control light intensity. A push-button switch bypasses the rheostat to provide maximum intensity. Power is from the essential dc bus through the SPOT light circuit breaker on the left console.

Flex Point Lights

The bodies of the two flex point lights are fixed to the left and right canopy sills. A flexible shaft, attached to each light body, contains a hood used to vary the size of the light beam. The hood is covered with velcro pile for stowing the flexible shaft under the canopy sill when not in use. A rheostat at the aft end controls light intensity. A push-button switch bypasses the rheostat to provide maximum intensity. Power is from the essential dc bus through the SPOT light circuit breaker on the left console.

Emergency Instrument Lights

The emergency instrument lights are automatically energized if ac hot bus power is lost or the ac hot bus INSTR light circuit breaker is open. Power is from the essential dc bus through the EMER INSTR light circuit breaker on the left console.

AFT COCKPIT LIGHTING

Integral and edge lighting for the instruments and consoles are controlled from the lighting panel on the left console. The left console PNL and LGD lighting circuit breakers on the lighting panel are only operative if the essential ac PNL L circuit breaker on the right console is closed. The right console TEST & BRT, PNL, and LGD lighting circuit breakers on the lighting panel are only operative if the essential ac PNL R circuit breaker on the right console is closed. Aft cockpit interior lighting also includes: one floodlight located above the left console; two floodlights above the right console; two floodlights above the circuit breaker panel on the right side; a floodlight on the canopy on each side; a spotlight secured on the left console; a spotlight secured on the right console; and flex point lights mounted on the canopy sill on each side.

Instrument Lights Rheostat

The INSTR rheostat on the lighting panel controls instrument panel light intensity. Power is from the essential ac bus through the INST lights circuit breaker on the right console.

L and R Console Lights Rheostats

The L CONSOLE and R CONSOLE rheostats on the lighting panel control legend light intensity for the left and right consoles, respectively. Power is from the essential ac bus through the respective PNL and LGD circuit breakers.

Floodlights Rheostat

The FLOOD rheostat on the lighting panel controls light intensity of the floodlights. Power is from the essential ac bus through the FLD lights circuit breaker on the right console.

Spotlights

The spotlights (utility lights) are identical to the spotlights in the forward cockpit. Power is from the essential dc bus through the SPOT LTS circuit breaker on the right console.

Flex Point Lights

The flex point lights are identical to the flex point lights in the forward cockpit. Power is from the essential dc bus through the SPOT LTS circuit breaker on the right console.

ENVIRONMENTAL CONTROL SYSTEM

These aircraft operate in an extremely adverse speed and altitude environment. Ram air temperatures may exceed 400°C at design airspeed, and ambient static air pressure can be less than 1/3 psi near the limit altitude. The external skin surfaces are painted black to radiate heat. Special insulating materials are used extensively to minimize temperature build-up within the aircraft. Pressurized and conditioned air must be supplied to the crew and equipment to provide a suitable environment. Both crewmembers wear full pressure suits for protection against cockpit depressurization or bailout at high altitude.

Air-conditioning includes two identical and parallel air-cycle compressor turbine refrigeration systems. Each is supplied by ninth-stage bleed air from one engine. The bleed air is regulated to no more than 26 psi, and is cooled by air-to-air and air-to-fuel heat exchangers before it is ducted to the air-cycle units. A temperature of about 200°F is maintained while below 44,000 feet. At higher altitudes, the air receives the maximum possible cooling. The bleed air supply is shut off if pressure can not be maintained above 5 psi. Cold air manifolds from the refrigeration turbines supply the chine and mission bays and the electrical, radio, and navigation bays. Conditioned air, which is temperature-controlled by the pilot, is used to pressurize and ventilate the cockpits and pressure suits. Cockpit exhaust air cools the nose and radar equipment and supplements cooling of the chine and equipment bays. Regulated bleed air supplies windshield deicing and, when mixed with conditioned air, windshield defogging. Regulated bleed air is also used to pressurize the canopy seals, some of the nose radar equipment, and the windshield rain removal system reservoir. The inlet control pressure ratio transducers and the inlet forward bypass actuator LVDT's, which are located in high temperature environments in the nacelles, are also cooled by regulated bleed air. Engine inlet ram air and engine fuel are used as heat sinks for the air-conditioning system. The ram air is exhausted within the nacelles after passing through the air-to-air heat exchangers. Heat sink fuel is either returned to the engine fuel supply system or diverted to tank 4 after use in the air-to-fuel heat exchangers. Refer to Figure 1-80, Environmental Control System, and Figure 1-39, Fuel Heat Sink System, for schematic diagrams.

Either of the two refrigeration systems can maintain a suitable cockpit environment and cool the ANS and essential radio and flight equipment in the E and R Bays. However, if one of the refrigeration systems fails at high supersonic speeds, cooling air for the nose, chine, and mission bays must be turned off and use of most of the equipment in these spaces should be discontinued.

The air pressure available at the chine and bay equipment boxes is substantially the same as that provided in the cockpits; however, pressure is reduced by orifices in individual equipment supply or bay vent manifolds to regulate flow to individual equipment. Normally, the cooling air temperature is automatically controlled to -30°F when at supersonic flight altitudes. Selecting FULL COLD on the manifold temperature switch can result in much lower supply temperatures in some cases. With the manifold temperature switch in AUTO, equipment cooling air temperature is approximately +37°F when below 41,000 to 44,000 feet, to prevent ice formation in the cold air manifold.

Water separators are provided in the supply manifolds to the ANS and bay areas. Although they have sufficient capacity for normal flight operations, they may not be adequate for sustained periods of ground operation when high humidity conditions exist. Suitable ground support equipment can be connected when prolonged ground operation is anticipated. The cockpit air supply is not dehumidified.

COCKPIT PRESSURIZATION SCHEDULES AND TEMPERATURE SELECTION

The crewmembers operate within a sealed and specially insulated compartment which contains the two cockpits. The compartment can be pressurized at either a 10,000 FT (foot) or 26,000 FT schedule. Each of the schedules can be used without restriction; however, the 26,000 FT schedule is usually preferred since it allows more airflow through the cockpits and enhances cockpit and bay cooling. An automatic control restricts the maximum rate of pressure change to approximately 5000 fpm when the selection is altered. Refer to Environmental Control Systems Controls, Cabin Pressure Switch, this section.

The cockpits remain essentially unpressurized while below 26,000 to 28,000 feet pressure altitude with the 26,000 FT schedule. Cockpit pressure is then maintained at 26,000 feet at all higher flight altitudes. With the 10,000 FT schedule selected, the cockpits remain substantially unpressurized while below 10,000 feet. They maintain approximately 10,000 feet until aircraft altitude exceeds

28,000 feet, then a pressure 5 psi greater than ambient at higher altitudes. Refer to Figure 1-81. Note that at 25,000 feet aircraft altitude, for example, cockpit pressure altitude would be only slightly less than the flight altitude with the 26,000 FT pressure schedule, and would equal 10,000 feet with the 10,000 FT schedule. The 10,000 FT schedule can be used at subsonic flight altitudes if a crewmember wishes to open the helmet faceplate temporarily.

Cooling capability of the air-conditioning system will be reduced somewhat during descents from supersonic cruise if the 10,000 FT schedule is used. This is due to increased back pressure at the cooling turbines and the resultant decrease in cooling capability. To minimize the effect of reduced cooling, the cockpit AUTOTEMP control should be turned toward COLD before descending from high supersonic cruise.

NOTE

> Use of the 26,000 FT schedule is recommended if air-conditioning system difficulties result in high cockpit temperatures.

A safety relief valve opens automatically to maintain 5.4 psi differential pressure if the normal pressure regulator valve malfunctions. The safety valve can also be fully opened by the PRESS DUMP switch, on the pilot's left instrument side panel. Operation of this solenoid dumps cockpit pressure to ambient static pressure very rapidly.

The pilot controls cockpit air temperature by adjustment of his automatic controls or by manually selecting the proportion of regulated hot air that is mixed with the cockpit cold air supply. Suit ventilation air temperature is also controlled by the pilot, but suit vent flow is controlled individually. Individual controls are provided for helmet faceplate heat settings and for oxygen system selection. The pilot controls the refrigeration system shutoff valves and the cockpit pressure dump valve. The RSO controls the cockpit air shutoff valve.

ENVIRONMENTAL CONTROL SYSTEM CONTROLS

Refer to the following discussions in this section: Windshield, for a description of the Windshield Hot Air De-Icing/Rain Removal System; Canopy, for the canopy latching system and the canopy seal; and Life Support Systems, for the suit and helmet protective systems (including suit and faceplate heat control).

<u>Refrigeration Switches</u>

The two-position REFRIG switches, on the pilot's left instrument side panel, control the engine bleed air supply valves for each refrigeration system. The valves are located downstream from the air-to-air and air-to-fuel heat exchangers in the "heat sink packages" in each wing, inboard of the nacelles. See Figure 1-80.

The ON (up) position of either the L (left) or R (right) refrigeration switch deenergizes the respective control circuit and allows the corresponding system shutoff valve and pressure regulator to open.

Each valve is spring-loaded closed and when its control circuit is deenergized, the valve opens fully if at least 5 psi bleed air pressure is available from its engine. The OFF (down) position of either switch energizes a solenoid in the corresponding shutoff valve and closes the valve, stopping all of the air supplied for that pressurization and air conditioning system. The solenoid is also energized automatically by action of either of two thermal switches if temperatures exceed 365 $\pm 15^{\circ}$F at the compressor inlet or intercooler outlet positions of the systems air cycle refrigeration machine. The shutoff valve reopens automatically when lower temperatures are sensed. An L or R AIR SYST OUT caution light on the annunciator panel illuminates when the corresponding shutoff valve is closed.

The shutoff valve solenoids are powered by the essential dc bus through the AIR SOV CONT circuit breaker on the pilot's left console.

ENVIRONMENTAL CONTROL SYSTEM

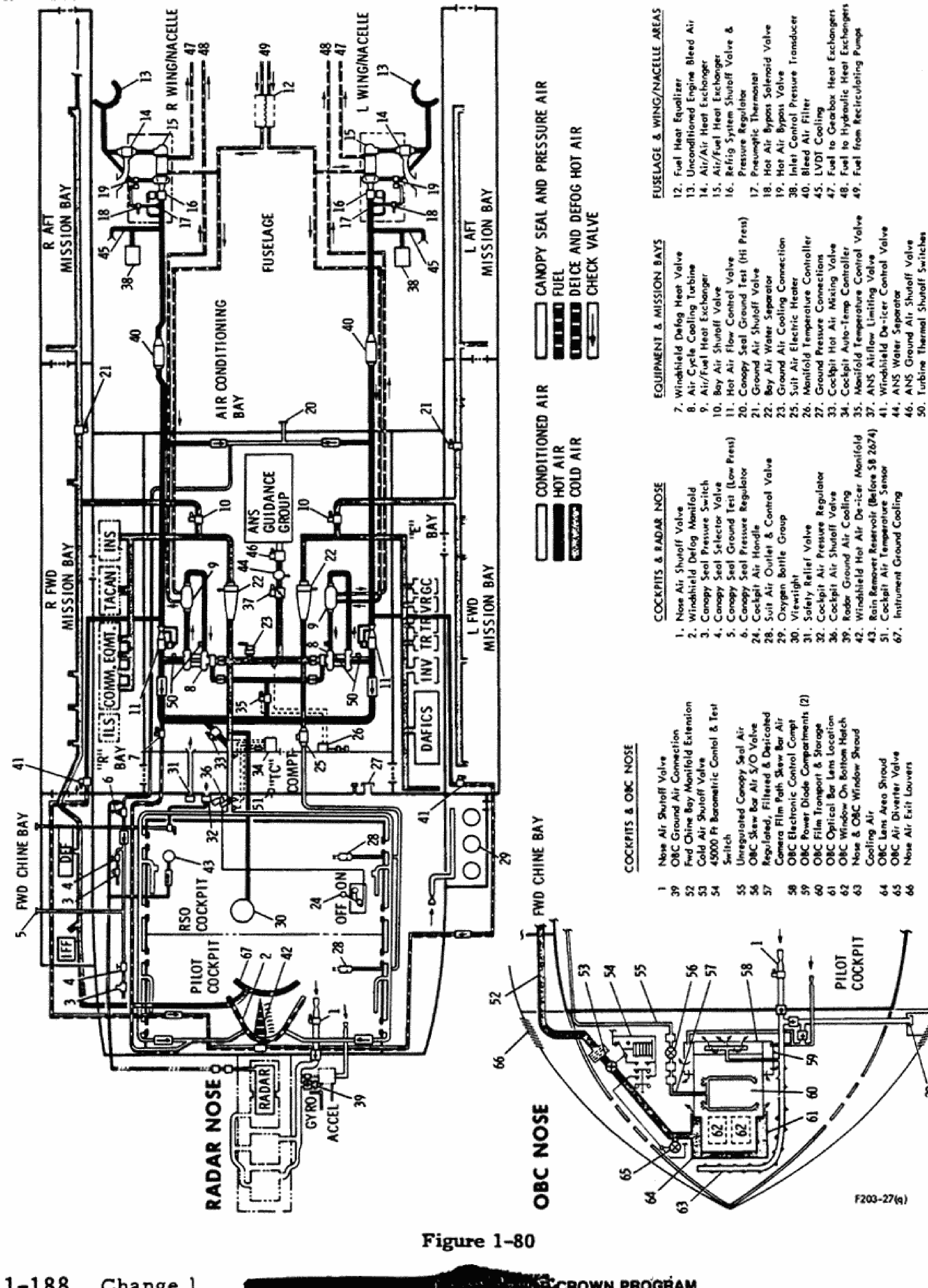
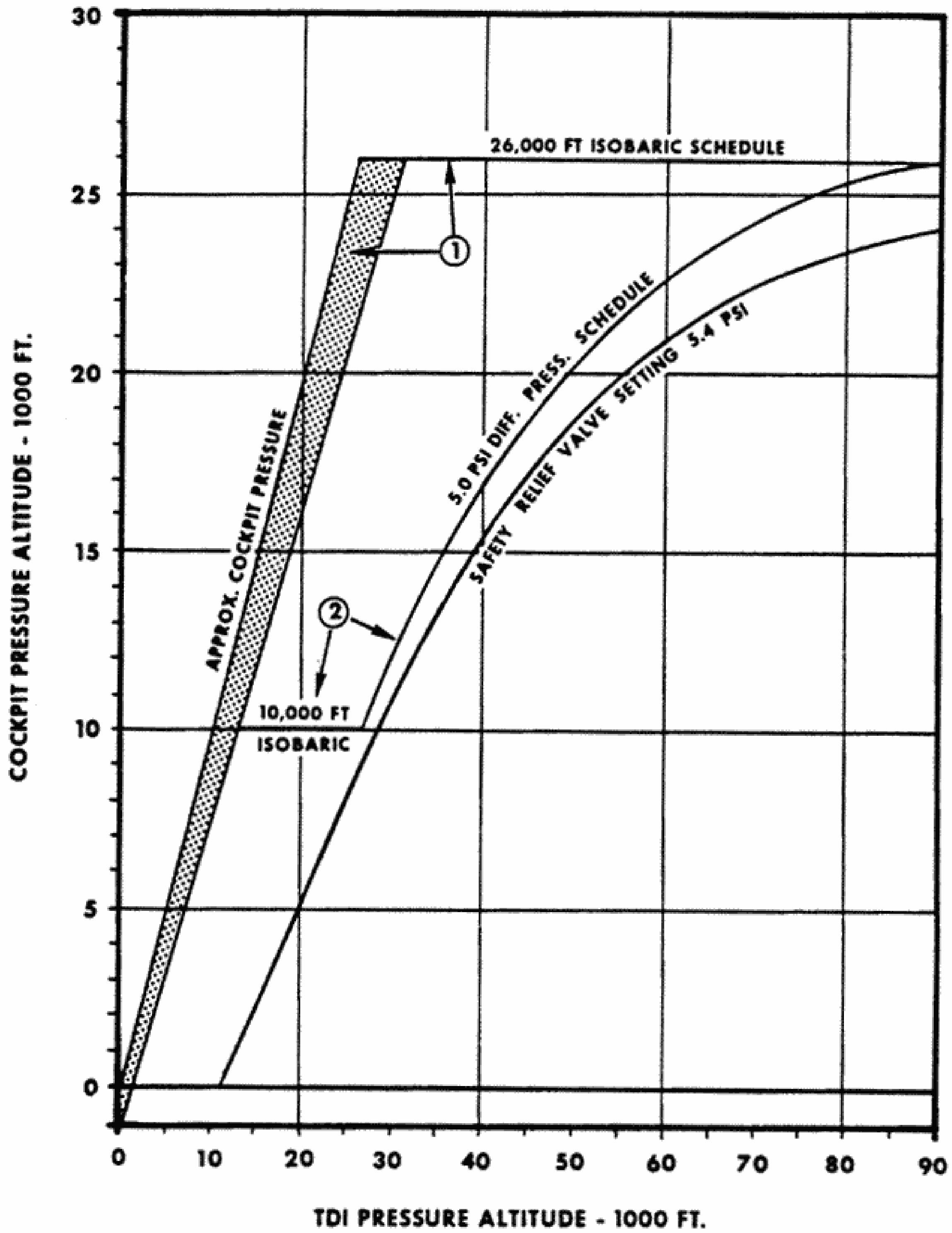


Figure 1-80

COCKPIT PRESSURIZATION SCHEDULE



(1) 26,000 FT PRESSURE SCHEDULE

(2) 10,000 FT PRESSURE SCHEDULE

Figure 1-81

CAUTION

Both refrigeration switches must be OFF during ground operation until just before the ground air supply is disconnected. This minimizes the possibility of trapping moisture in the air-conditioning system cold air supply manifold and sustaining water damage to the ANS.

NOTE

One refrigeration system should be turned OFF when the cockpit air valve and the bay air shutoff valves are both closed. This prevents an increase in the cold air manifold temperature due to increased back pressure at the refrigeration turbines. The right system is normally turned off.

Cockpit Temperature Control Switch

An AUTO TEMP cockpit temperature control rheostat is located on the pilot's left instrument side panel. An arrow inscribed in the panel indicates clockwise rotation from COLD to WARM temperature settings. The control is ineffective unless the Cockpit Temperature Control and Override switch is in AUTO TEMP.

The setting of a hot air control valve in the cockpit air supply manifold is modulated with AUTO TEMP selected. Positioning of the control rheostat regulates cockpit (outflow) air temperature between 40° and 100°F. The variation of temperature with control position is nearly linear. The AUTO TEMP function automatically compensates for changes in hot and cold air manifold temperatures.

A duct high temperature limit sensor operates with AUTO TEMP selected to limit cockpit air to a maximum of 126° ± 12°F. A high limit switch is also provided which limits cockpit air to a maximum of 155° ± 5°F in auto or manual control. Both limit controls reduce temperature by reducing flow from the regulated hot air duct.

Because a ratcheting technique is used to position the hot air control valve and modulate mixed air temperature, the automatic temperature control is much slower in accomplishing temperature changes than manual control, using the override switch. Electrical power for the cockpit temperature control circuit is furnished by the essential dc bus and the essential ac bus through a CKPT AIR COND circuit breaker located on each console in the forward cockpit.

Cockpit Air Temperature Control and Override Switch

A cockpit air temperature control and override switch is located on the pilot's left instrument side panel. The switch has four positions: AUTO TEMP (up), COLD (down left), WARM (down right) and MAN HOLD (center). The switch is spring loaded to MAN HOLD from the COLD and WARM positions. The switch is normally in AUTO TEMP. The pilot can override automatic control by moving the switch to either the momentary COLD or WARM position. The cockpit temperature control valve, which supplies air from the hot manifold, requires up to 10 seconds to close or open when COLD or HOT, respectively, is selected; however, cockpit temperature indication may require several minutes to change. Manual control of temperature is required when on battery power.

Temperature Selector Switch and Indicator

A three-position TEMP IND SELECTOR switch is located on the pilot's left instrument side panel, adjacent to a temperature indicator. Selection of the R-BAY, CKPT, or E-BAY position displays the air temperature in the corresponding compartment on the temperature indicator. Sensors for the E-BAY and R-BAY temperatures are located at the aft outboard walls of these bays. The sensor for the cockpit temperature indication is located near the cockpit pressure regulator and outflow valve, aft of the RSO's seat. The

Indicator displays temperature in 5°F increments from 30°F to 160°F. Temperature indications below 30°F are normal for E-Bay or R-Bay while above 44,000 feet. Power for the indicator and thermoresistor elements is from the essential dc bus through the CKPT AND BAY TEMP circuit breaker on the pilot's left console.

NOTE

> The pressure suits may keep the crewmembers relatively comfortable in a cockpit environment that is too warm. The temperature gage allows anticipation of conditions that might eventually become too hot.

Manifold Temperature Control Switch

A two-position MANIFOLD TEMP switch, on the pilot's left instrument side panel, selects either a full cold or an automatic refrigeration system operation. The AUTO (up) position is normally selected. In AUTO, the cold air manifold temperature is regulated to +37°F when below 44,000 feet and to a minimum of -30°F at higher altitudes. During descents from above 44,000 feet, cold air manifold temperature regulation to +37°F begins at 41,000 feet.

In FULL COLD (down), air entering the cold air manifold receives the maximum cooling from the air cycle refrigeration machines and their intercoolers. As a result, cold air manifold temperature varies with bleed air temperature, fuel temperature in the intercoolers and heat exchangers, altitude, and system back pressure. Temperatures can be considerably lower than -30°F in some cases. Therefore, FULL COLD is not recommended unless automatic air-conditioning regulation is not satisfactory.

Power for the automatic manifold temperature control is from the essential ac bus. Power for the manifold temperature control valves and hot air bypass control systems is from the essential dc bus. Circuit breakers for both circuits are labeled MANF TEMP and are located in the forward cockpit.

At altitudes where +37°F is provided in the cold air manifold, air in the hot air supply lines is mixed with unconditioned (hot) engine bleed air and heated to about 200°F after it has passed through the nacelle air-to-air and air-to-fuel heat exchangers. This regulation and mixing is accomplished by a pneumatic thermostat and hot air bypass valve in each of the hot air supply lines. Bypass valve positions are controlled by barometric switching similar to that used for control of temperature level selection in the cold air manifold. They are not affected directly by manifold temperature control switch settings; however, both bypass valves close and hot air supply line temperatures are minimized if dc power from the MANF TEMP circuit breaker is interrupted after FULL COLD manifold temperature is selected.

Bay Air Switch

A two-position BAY AIR switch is provided on the pilot's left instrument side panel. In the ON (up) position, pressurized air from the cold air manifold is directed to the chine bays and chine bay equipment boxes. It also allows conditioned air from the cockpits to exhaust through a sonic venturi to the nose and nose radar compartments. The switch must be pulled out before it can be moved OFF (down). In OFF, shutoff valves in the chine bay distribution manifolds terminate direct flow from the cold air manifold. The spring-loaded-closed nose air shutoff valve actuator is deenergized and air flow to the nose from the cockpits is stopped. Air continues to flow to the cockpits, pressure suits, ANS equipment, and E-Bay and R-Bay equipment. It is exhausted through the chine bays for secondary cooling.

The BAY AIR switch should be on during normal flight and ground operations.

CAUTION

> The BAY AIR switch should always be positioned OFF if one refrigeration system is turned off, manually or automatically, while at high speeds (high CIT).

Bay air may be off or on, to suit requirements for cockpit cooling, if one refrigeration system is off while CIT is low (subsonic). Bay air should not be turned off when cockpit air is shut off unless one REFRIG switch is also turned off, as cold air manifold temperatures could increase due to back pressure at the refrigeration turbines, and all of the cooling flow would then be directed toward and exceed the supply requirements for the ANS and E-Bay and R-Bay equipment boxes.

Power for the bay air shutoff valves and for opening the nose air shutoff valve is from the essential dc bus through the AIR SOV CONT circuit breaker on the pilot's left console.

CAUTION

With the Bay Air switch off, the chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

<u>**Cabin Pressure Switch**</u>

A two-position lift-lock CABIN PRESS switch is on the pilot's right console and on the RSO's instrument panel. The 26,000 FT position is normally preferred on flights involving high altitudes and air refueling as cockpit pressure remains relatively constant and cockpit and bay cooling is more effective. The switches in both cockpits must be in the 26,000 FT position to select the 26,000 FT pressure schedule. If either crewmember selects the 10,000 FT position, the 10,000 FT pressure schedule is selected. Figure 1-101 depicts the pressure schedules.

NOTE

- At low power settings, cockpit altitude may exceed 10,000 feet while below 28,000 feet altitude with the 10,000 FT schedule selected due to reduced bleed air supply pressure.
- Suit and cockpit cooling may be reduced due to increased back pressure with the 10,000 FT schedule selected.

<u>**Cockpit Air Valve**</u>

A cockpit air shutoff valve is located in the duct which supplies conditioned air to the cockpits. It is operated manually, either by the cockpit air handle under the RSO's left canopy sill, or by the RSO's canopy latch handle. The valve is open and air is furnished to the cockpits when the cockpit air handle is aft <u>and</u> the canopy latch handle is forward (locked). The valve is closed and conditioned air flow to the cockpits is shut off when the cockpit air handle is positioned forward to its OFF detent <u>or</u> when the canopy latch handle is aft (unlatched). Cockpit air is normally shut off for landing to prevent fog entering the cockpits from the air-conditioning system. The pilot's CKPT AIR OFF annunciator panel caution light illuminates when the cockpit air valve is closed.

WARNING

In high humidity conditions, do not resume use of cockpit air while at low altitude or after landing until certain that onset of fog will not endanger the aircraft.

When the cockpit air valve (36, Figure 1-80) is closed, the hot air mixing valve (33, Figure 1-80) is also closed automatically and the cockpit air supply temperature becomes full cold. If the cockpit temperature control switch is in AUTO TEMP, the hot air mixing valve reopens when the flow of cockpit air is resumed, and modulation at the selected automatic temperature level continues after a short delay. If the air temperature control is in MAN HOLD, the air supply temperature remains full cold when flow of cockpit air is resumed. The pilot must reset the temperature if a warmer temperature is desired.

Movement of the RSO's cockpit air handle has no effect when the canopy latch handle is in the aft (unlatched) position. Movement of the RSO's canopy latch handle has no effect on the cockpit air valve when the RSO's cockpit air handle is in the forward (off) position. In both cases, the cockpit air valve remains closed.

CAUTION

If either canopy is open, the aft canopy latch handle must be in the aft position or the cockpit air handle must be in the forward (off) position for adequate equipment cooling. Otherwise, most of the cooling air would exit through the cockpit openings instead of the bays.

Unless operating with a ground air supply connected, closing the cockpit air valve may increase the cold air manifold temperature slightly due to an increase in back pressure at the refrigeration turbines.

CAUTION

Do not operate with the cockpit air and bay air shutoff valves closed while above 10,000 feet unless one refrigeration system is also shut off. The increase in back pressure can result in decreased refrigeration turbine efficiency, higher than normal cold air manifold temperatures, and ANS equipment overheating.

The cockpit air temperature controls are not effective with cockpit air shut off, but hot air from the windshield defog system may be used to raise cockpit air temperature.

Cockpit Pressure Dump Switch

A two-position PRESS DUMP switch is on the pilot's left instrument side panel. It allows the pilot to dump cockpit pressure to ambient. In OFF (down), the cockpit pressure safety relief valve is closed and the cockpits are pressurized. The switch must be pulled out before it can be moved to ON (up). With ON selected, a solenoid in the safety relief valve fully opens the valve and the cockpit compartment depressurizes rapidly to air conditioning bay pressure (approximately ambient). The pressure suits inflate if cabin altitude exceeds 35,000 feet. As pressure in the cold air manifold is not affected substantially by the loss of cockpit pressure, airflow to equipment boxes in the bays and chines is not materially reduced by depressurizing the cockpits. Hot air remains available for defogging and windshield deicing. Power for the dump valve solenoid is from the essential dc bus through the PRESS DUMP circuit breaker on the pilot's left console.

WARNING

Cockpit pressure dump and/or repressurization occurs very rapidly.

Cabin Altimeter

A single-revolution cabin altimeter is located on the pilot's left instrument side panel. It is vented to cockpit static pressure and indicates cockpit altitude in increments of 1,000 feet from sea level to 50,000 feet.

Air System Caution Lights

The following caution lights on the annunciator panels are associated with the environmental control system.

Forward cockpit:
- L AIR SYS OUT
- R AIR SYS OUT
- E BAY OVERHEAT
- R BAY OVERHEAT
- CKPT AIR OFF
- WINDSHIELD DEICE ON
- CANOPY UNSAFE
- ANS REF
- BAY AIR OFF

Aft cockpit:
- ANS FAIL

The L or R AIR SYS OUT light illuminates when its corresponding refrigeration system shutoff valve is closed, either manually (using the refrigeration switches) or automatically because of high air temperature at the refrigerator compressor inlet or intercooler outlet.

The E or R BAY OVERHEAT light illuminates when air temperature exceeds 150°F at the aft outboard wall of the corresponding compartment.

The CKPT AIR OFF light illuminates when the cockpit air valve is closed either by aft (unlocked) positioning of the RSO's canopy latch handle or by setting the RSO's cockpit air handle to OFF (forward).

The WINDSHIELD DEICE ON light illuminates when the windshield deicing switch is in ON DE-ICE. The need for hot air deicing should be monitored, as the quantity of air available to the air contitioning and pressurization systems is reduced by deicing. Temperature of the air supply is approximately 200°F when below 44,000 feet.

The CANOPY UNSAFE light illuminates if either canopy is not closed properly on its sill, if either canopy latch handle is not full forward (latched), or if the canopy seals in either cockpit are not fully inflated.

The forward cockpit ANS REF and aft cockpit ANS FAIL lights illuminate if cooling air flow to the ANS is inadequate (less than 2.5 pounds per minute), if ANS component temperatures are too high or too low, or if the ANS is not operating normally. The RSO's ANS MAL and TEMP LIMIT/TEMP TOLR lights indicate abnormal air temperature and /or quantity. (Refer to Astroinertial Navigation System, Section IV.)

The BAY AIR OFF light illuminates if the BAY AIR switch is OFF or fails, or if the cap for the ground air receptacle is improperly installed, or if the microswitch in the cap for the ground air receptacle fails.

LIFE SUPPORT SYSTEMS

AIRCRAFT OXYGEN SYSTEM

One standby and two normal oxygen systems are provided. The normal system has two 10-liter liquid-oxygen-converter containers, and the standby system has one. Each of the three containers, located in the left chine opposite the aft cockpit, have a buildup circuit which maintains pressure at 65-100 psi until the oxygen supply is virtually depleted. Pressure above 120 psi opens a relief valve and vents overboard. The liquid oxygen from each converter is warmed and converted into a gas by passing through the supply line tubing (See Figure 1-82.)

Oxygen Control Panels

Control panels for both the normal and standby systems are located on the pilot's left console. A control panel for the normal system only is located on the RSO's left console. Two ON-OFF levers, labeled SYS 1 (system 1) and SYS 2 (system 2), located on each panel, manually control oxygen shutoff valves. When a lever is ON (full forward) a mechanical latch prevents moving the lever to OFF (aft). The normal control panels have a dual-reading pressure gage (0 to 140 psi) and the standby control panel has a single pointer pressure gage (0 to 140 psi). The normal oxygen gages indicate pressure only when the individual levers are ON, while the standby system pressure gage indicates pressure regardless of the position of the levers on the standby panel. Moving any lever to

ON opens a valve and permits oxygen to flow to the respective pressure suit helmet or oxygen mask of the crewmember. Check valves are provided at the seat disconnect for each of the supply lines, to prevent free flow of oxygen if a system valve is turned ON while the suit connections are disengaged.

NOTE

> If standby system pressure is higher than the normal system pressure, standby system oxygen pressure is displayed on the normal oxygen control panel gage(s) when the system(s) (1 and/or 2) levers are ON for both the normal and standby control panels.

Liquid Oxygen Quantity Gage

A LIQUID OXYGEN quantity gage is on the pilot's left instrument side panel and the RSO's instrument panel. The gages have dual pointers that indicate the volume in liters of the normal system or standby system, depending on the position of the liquid oxygen system quantity switch. The gages are calibrated in 1/2-liter increments from 0 to 10 liters.

Liquid Oxygen System Quantity Switch

A two-position switch, labeled LOX QTY, is on the pilot's left console. In SYS 1 IND 1 (aft), the liquid oxygen quantity indicators in both cockpits display the volume of liquid oxygen in systems 1 and 2. In STANDBY IND 1 (forward), needle 1 of both cockpit liquid oxygen quantity indicators display the volume of liquid oxygen in the standby system.

NOTE

> The volume of liquid oxygen in system 2 is always displayed by pointer 2 regardless of the position of the switch.

Oxygen System Caution Lights

Four oxygen system caution lights are installed on the annunciator panel in each cockpit. The SYS 1 OXY QTY LOW and SYS 2 OXY QTY LOW lights illuminate when the quantity of the respective system is less than 1 liter. If the No. 1 pointer is selected to indicate the standby system quantity, the SYS 1 OXY QTY LOW light indicates that the standby system quantity is less than 1 liter. The SYS 1 OXY PRESS LOW and SYS 2 OXY PRESS LOW lights illuminate when the pressure in the supply lines of the respective system is less than 50 ($\pm$ 3) psi.

EMERGENCY OXYGEN SYSTEM

Each crewmember has two independent emergency oxygen bottles in the ejection seat survival kit. Each 45 cubic-inch capacity cylinder is pressurized to 2000 psi. Both emergency oxygen bottles are supplied automatically to the helmet upon ejection. Both oxygen systems can be activated manually by pulling the "green apple". Once the emergency oxygen system is actuated, it cannot be shut off. The emergency oxygen system should be actuated if the aircraft is not delivering the desired amount of oxygen from the ship systems, or hypoxia or noxious fumes are suspected. When actuated, check-valves prevent oxygen flow into the aircraft system. To prevent emergency oxygen flowing if aircraft system pressure is available, emergency oxygen system regulated pressure is slightly lower than the aircraft system pressure. Because emergency oxygen system regulated pressure is lower than the aircraft system pressure, turn the normal oxygen system supply levers to OFF after actuating emergency oxygen if contamination of the aircraft system is suspected. Pressure in the emergency system containers is indicated by gages on the forward left side of the survival kit (Figure 1-84) container.

Oxygen Consumption

The rate of oxygen consumption varies inversely with cockpit altitude. For a normal mission profile with the cockpit pressure switch in 26,000 FT, the average rate of oxygen consumption for two persons is 1 liquid liter per hour; with the switch in 10,000 FT, this average rate increases to 1.3

OXYGEN SYSTEM

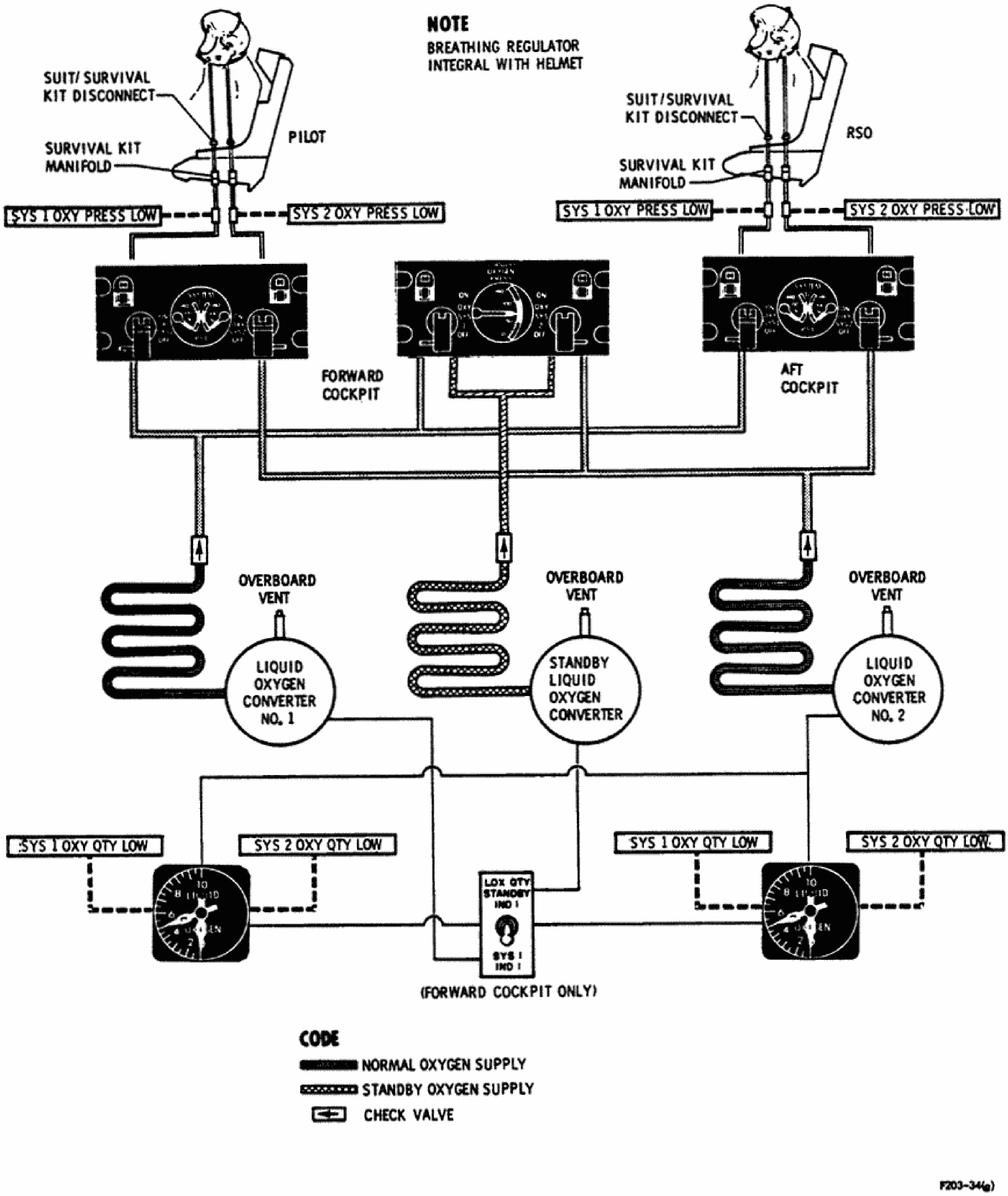


Figure 1-82

liquid liters per hour. The rate of consumption for individual crewmembers may vary between 50% and 150% of average consumption rates. Emergency oxygen duration is approximately 15 minutes.

FULL-PRESSURE SUIT

The model 1030 full-pressure suit provides the crewmember a safe environment, regardless of cockpit pressure. The suit has six layers: internal comfort liner, vent duct, bladder, exposure garment, link net restraint, and exterior cover. The ventilation layer allows vent air to circulate between the crewmember's cotton underwear and the bladder layer. The airtight bladder holds pressurized air. The link net is a mesh used to shape the suit to the crewmember's body. The outer garmet provides some protection from high temperatures and wind. A vertical entry zipper is locate in the back.

Thermal Protective Garment

The double-walled, dual-function gas container/exposure garment contains the pressurized gas. The double-wall provides an interspace which can be orally inflated by a tube stored behind the left thigh pocket, to create an air-space, thermal-barrier for exposure protection. This double-walled bladder extends over most of the torso, arms, and legs (except for the hands and feet).

Pressure Suit Vent Air

Air for suit ventilation comes directly from the air conditioning cold air manifold. In cruise, the temperature of this air may be as low as -30°F with suit heat OFF and the MANIFOLD TEMP switch in AUTO. The air temperature can be substantially lower with FULL COLD selected. The air can be warmed by positioning the suit heat rheostat. Vent air and exhaled breathing air exhausts through the suit controller valve which controls suit pressure and vent flow rate.

Suit Heat Rheostat

A suit heat rheostat, on the pilot's left instrument side panel, controls an electric heater for the air supply to the pilot's and RSO's pressure suits. Individual comfort adjustment is accomplished by varying suit airflow through the ventilated air valve on each suit.

Suit Controller Valve

Air pressure in the suit is regulated by dual suit controller valves on the front of the suit just above the waist. Each controller valve meters airflow to keep internal suit pressure at 3.5 psi if the cockpit depressurizes. A press-to-test button on each controller valve bypasses the suit controller by closing the outflow valve, allowing the suit to inflate. A knurled knob may be rotated to check suit inflation or to partially inflate the suit for comfort.

Helmet

The helmet head area is divided into two sections by a rubber face seal. The front area receives oxygen from either the aircraft or emergency oxygen system through two independent regulators built into the helmet. Inhalation causes oxygen to flow across the visor and accomplishes some visor defogging before it is inhaled. The rear area receives ventilating air. The face seal may not be positive; however, oxygen pressure in the face area is slightly higher than in the rear area and prevents air from leaking forward. If the oxygen supply is interrupted or exhausted, an antisuffocation valve in the helmet senses the drop in pressure and allows ambient air to enter the helmet to prevent suffocation.

A transverse "Baylor" bar encircles half of the helmet. It pivots at each side attachment point. When raised, it lifts the visor and closes the helmet oxygen regulator valves. When lowered, it opens the helmet oxygen regulator valves and closes the visor. A latch below the face opening must be engaged by the bar and a lever on the bar rotated 90 degrees to lock and hold the visor sealed.

A microphone adjustment knob, below the helmet face opening, adjusts the fore-and-aft position of the helmet microphone.

CAUTION

Do not force the microphone adjustment knob after the microphone has reached full travel; otherwise, the helmet shell may be damaged.

The visor is raised and lowered by the Baylor bar. With the bar raised, the visor is held up by a spring, uplock plunger, and cam on each side of the helmet. A transparent dark sunshade also pivots at each side connection. A friction clutch holds the sunshade in any position from fully open to closed. An external knob at the rear of the helmet adjusts the face seal. External helmet connections include two oxygen supply hoses and an electrical lead which provides power for visor heat, microphone, and earphone connections.

Face Heat Switches

A FACE HEAT rheostat switch is on the pilot's left instrument side panel and the RSO's instrument panel. The discrete switch positions are numbered 1 thru 7 with additional labels: OFF, LOW, MED and HIGH. Both oxygen flow and face heat defog the visor. Power for the switches is from the essential dc bus through individual FACE HTR circuit breakers in each cockpit.

CAUTION

- Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH heat position may delaminate the visor.
- The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

Boots

A boot bladder is fastened to the suit by a zipper near the calf. The boot bladder will retain pressure. Flying boots are worn over the pressure suit boot bladder.

Gloves

Gloves fasten onto the suit at the wrist rings. The inner bladder of the glove is similar to the suit inner bladder and will retain pressure. The outer glove palm is leather.

TORSO HARNESS

The parachute harness is part of a torso harness worn over the pressure suit. The torso harness contains a built-in, dual-cell flotation vest with inflators to provide bouyancy in water after ejection. The two flotation sections are contained within removable velcro patches.

Each of the two cells is inflated by a water sensitive inflator which actuates within 0.5 second after immersion. Each automatic immersion inflator is a battery powered, electrically fired explosive squib which pierces the CO_2 bottle and inflates the vest. Each cell may also be manually actuated by a lanyard. Each cell may be inflated (or deflated) by an oral inflation tube.

The torso harness is also used for "shirt-sleeve" flights (flights below 50,000 ft. without a pressure suit). For shirt-sleeve flight, extra attachments are fastened on the harness to restrain the oxygen regulator. The left attachment (located where suit vent would be if a pressure suit were worn) has a pocket to hold the oxygen regulator. The right attachment (where the suit controller valve would be if a pressure suit were worn) restrains the oxygen line.

OXYGEN MASK AND REGULATOR

An oxygen mask assembly is used for "shirt-sleeve" flights below 50,000 ft. The mask assembly consists of a standard oxygen mask, a special oxygen regulator, an antisuffocation valve, and oxygen personal leads with connectors for both aircraft and emergency oxygen systems. If the regulator malfunctions or the oxygen supply is exhausted, the antisuffocation valve between the regulator and the mask senses a drop in pressure and permits ambient air to enter the mask to prevent suffocation.

EMERGENCY ESCAPE SYSTEM

The emergency escape system is comprised of an SR-1 stabilized ejection seat, canopy jettison system, and the operating controls and indicators in both cockpits. (See Figure 1-83.)

EJECTION SEAT

The SR-1 seat is usable from zero speed and altitude to the extremities of the flight envelope. The ejection seat is a rocket-propelled, upward-ejecting unit, which uses a drogue chute to stabilize seat descent until man-seat separation occurs automatically at approximately 15,000 feet. The personnel (main) chute is deployed automatically immediately after separation from the seat.

In the normal ejection sequence using the D-ring, the canopy is automatically jettisoned prior to seat ejection. If using the secondary ejection method (initiated by pulling the seat T-handle), the canopy must be jettisoned by separate action prior to pulling the T-handle.

WARNING

Do not pull the secondary ejection T-handle with the canopy still in place.

The survival kit, with emergency oxygen supply, and parachute are installed in the seat before the crewmember enters the cockpit. Hookup to the crewmember is by means of five quick-disconnect attachments.

Seat Vertical Adjustment

An electric motor, controlled by a 3-position switch on the right side of each seat bucket, moves the seat up or down. Seat movement is in the same direction as switch movement. The spring-loaded center position de-energizes the motor. Maximum vertical seat travel is 9 inches for the pilot's seat, and 6.75 inches for the RSO's seat. Power is from the essential dc bus through a SEAT ADJ circuit breaker in each cockpit.

Emergency Face Heat

A battery on the left side of the seat automatically provides face heat after ejection. The battery is hose-connected to the D-ring ballistic line, and a power cable is connected (by pull-to-release plug) to the helmet. During ejection, a squib in the battery fires to rupture diaphragms at both ends of the battery and forces electrolyte into the battery cells, providing a charged battery for visor heat. The battery cable plug is pulled loose from the helmet or seat during man-seat separation.

Inertia Reel

An inertia reel in the seat headrest maintains constant pressure on the shoulder harness straps to keep them taut and permit unrestricted movement of the crewmember. Placing the inertia reel control knob (on the left side of each seat) in the LOCK (forward) position manually locks the shoulder straps. When the inertia reel control knob is in the normal (UNLOCK) position, the reel will automatically lock with an instantaneous forward load of 2 to 3 g, and remains locked until released by moving the control knob to LOCK then back to UNLOCK.

Early in the ejection sequence, an initiator fires to roll up and lock the shoulder straps. Later in the ejection sequence, the shoulder straps are automatically severed when strap cutters fire. If the straps are not cut, they pull free of the inertia reel during man-seat separation. The strap cutters are fired manually by pulling the manual release (scramble) handle on the right side of the seat.

D-Ring Assembly

A D-ring, located on the forward part of the seat, is pulled to initiate ejection and also is a handhold for protection of the arms during ejection. A compression spring within the D-ring assembly acts as a shock absorber. During man-seat separation, the D-ring cable is automatically severed to release the D-ring. The D-ring cable cutter may be fired manually by pulling the scramble handle. A safety pin is inserted in a hole at the base of the D-ring (when on the ground) to prevent accidental firing of the ejection system.

T-Handle Assembly

A T-handle backup ejection control, is used if the D-ring initiator does not fire. The T-handle is located on the left side of the seat, under a cover shield which must be pushed away to gain access to the handle. A safety pin is inserted in a hole in the cover shield to prevent accidental firing of the ejection system when on the ground. Pulling the T-handle initiates only seat ejection; the canopy must be jettisoned by separate action prior to pulling the T-handle. The D-ring must be pulled before the T-handle can be actuated, since pulling the D-ring arms the T-handle system (secondary ejection sequence).

Scramble Handle

The manual release (scramble) handle on the right side of each seat is a quick release from the seat for bailout with the ejection seat inoperative, or for ground emergency egress. When a button at the forward end of the handle is depressed and the handle is pulled, the handle mechanically rotates the seat torque tube to release the lap belt and the parachute arming cable (the lap belt and cable remain attached to the parachute) and fires a no-delay initiator to release the crewmember from the seat through the following actions:

1. Foot retraction cables are cut.
2. Shoulder harness straps are severed.
3. Inertia reel is released (so shoulder straps pull free of reel if cutters fail).
4. D-ring cable is cut.
5. Main (personnel) chute lanyard is released from the seat.

NOTE

When pulling the scramble handle, expect a loud report from the initiator firing.

After a manual bailout using the scramble handle, the parachute must be manually deployed, using the shoulder D-ring.

Foot Retention System

The crewmember connects shoe spurs to foot retention fittings at the rear of the footrest. The fittings are cable-connected to reel assemblies which maintain the cables under slight spring tension to permit unrestricted foot movement. When ejection is initiated, the foot spur cables automatically retract to hold the crewmember's feet in the footrests. The spur cables are severed automatically during man-seat separation, or may be severed by pulling the scramble handle.

The spur is normally released from the cable by moving the foot aft (against the seat footrest) and raising the heel.

Parachute Beacon

A battery powered radio beacon is installed in the parachute. The beacon has a minimum operating life of 15 hours, and transmits an automatic signal on a frequency of 243.0 megacycles. During chute deployment, the beacon automatically turns on when a lanyard, attached to a chute riser, pulls a plastic plug from between the beacon control switch contacts. The beacon has a 22-inch telescoping antenna and a flexible removable antenna. Pulling a push-pull control knob, attached to the chute harness at the right front shoulder, disables the automatic beacon activation feature.

Seat Catapult

During ejection, the catapult gas charge is pressure-fired to initiate seat ejection. The catapult gas charge has a duration of 0.15 seconds, sufficient to raise the seat above the canopy sills, at which point the seat rocket motor automatically ignites. The seat rocket motor provides sufficient thrust and duration (0.5 second) to provide a seat elevation (relative to the aircraft) of approximately 300 feet.

When ejection is initiated by the D-ring, the seat catapult fires through a 0.3-second-delay initiator to provide time for canopy jettison prior to seat ejection. When the T-handle is used, the seat catapult fires immediately and no canopy ballistics are fired. The canopy must be jettisoned by separate action prior to pulling the T-handle.

Ejection Seat Drogue Parachute

A 6.5-foot-diameter drogue chute (stowed in the headrest) is deployed by a ballistic drogue gun, which fires 0.2 second after the seat catapult fires. The drogue (stabilizing) chute is connected to the seat at four points by a bridle and 10 feet of webbing. Ten seconds after drogue chute deployment (to permit seat deceleration), the lower two bridle lines are automatically severed to stabilize the seat, and the seat continues its descent upright. The drogue chute controls rate of descent and attitude until man-seat separation at approximately 15,000 feet.

Man-Seat Separation

Dual aneroid-actuated initiators located on the upper left and right sides of the seat, delay man-seat separation until 15,000 feet if ejection occurs at a higher altitude. Each unit contains a small dial, colored red and green. The dial is a leak indicator for the aneroid bellows and will indicate in the red band if the bellows leaks. When man-seat separation is initiated:

a. Foot retention cables are severed.

b. Drogue chute upper risers are severed 0.3 seconds after seat separation (to release drogue chute).

c. Lap belt is released.

d. Shoulder harness is severed and inertia reel is unlocked.

e. D-ring cable is severed.

f. Rotary actuator (butt-snapper) is fired.

When the rotary actuator is fired, the crewmember is forcibly separated from the seat as seat webbing is rapidly retracted by reel rotation. The seat webbing is secured to the front of the seat and passes under the seat pack, up to the rotary actuator in the headrest. Rapid tightening (retraction) of the seat webbing as the actuator fires, snaps the crewmember from the seat with a sling-shot action. The main chute is automatically deployed by a lanyard after man-seat separation.

Main Parachute

A 35-foot diameter main parachute in a backpack is deployed automatically after man-seat separation. The chute can also be deployed manually, after separation from the seat.

Automatic deployment is initiated by a drogue gun in the upper left corner of the pack. A lanyard connected to the seat fires the drogue gun as the man and seat separate. Accidental deployment is prevented by a lanyard housing which disconnects from the seat at separation.

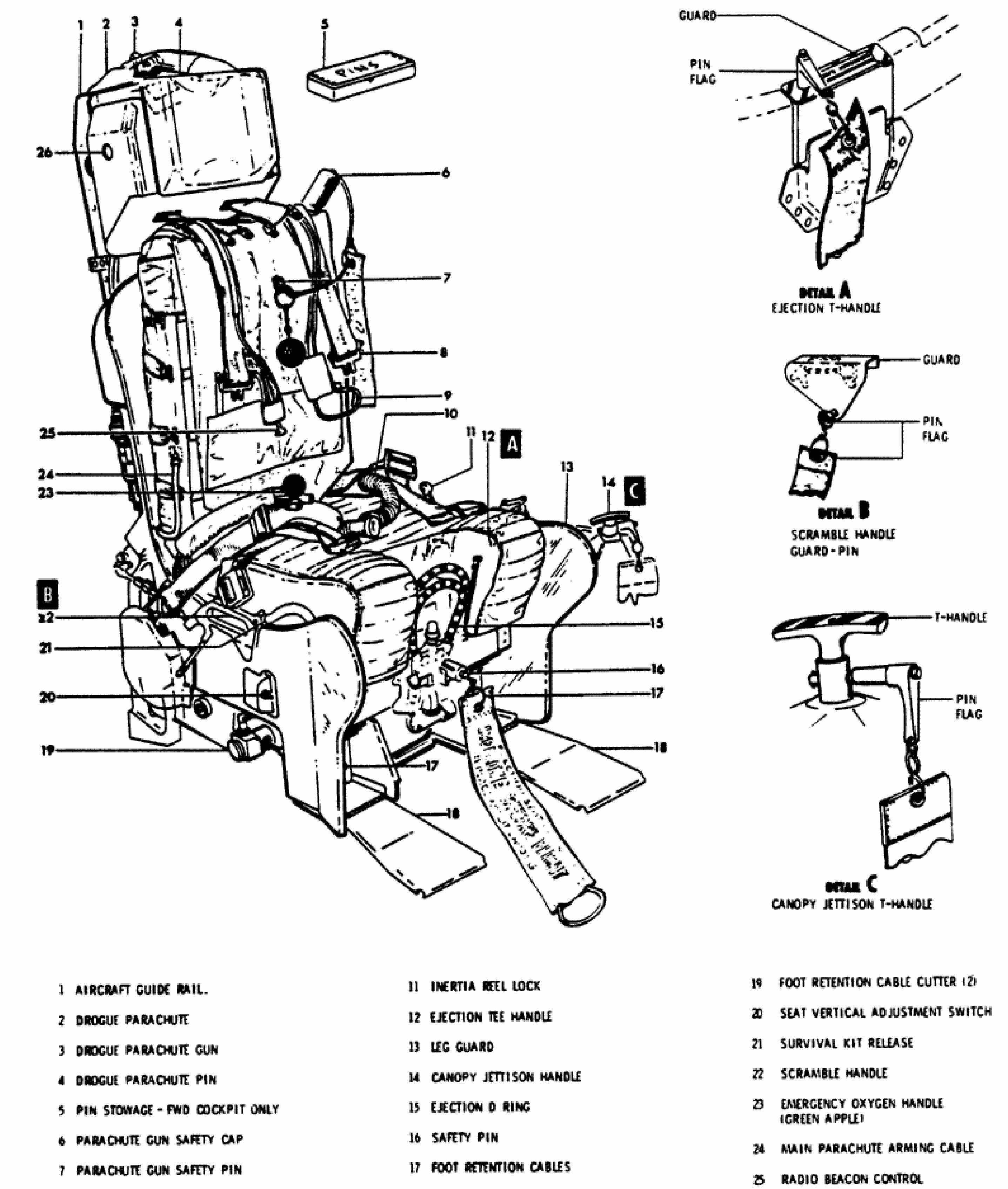
The chute can be manually deployed by pulling the D-ring which is held in place by a Velcro patch on the suit, near the left shoulder harness. See Figure 1-83. The drogue gun is not fired when the chute is manually deployed.

NOTE

> The main chute must be deployed manually if the crewmember has used the scramble handle for manual bailout, as the main chute lanyard is released from the seat when the scramble handle is pulled.

The chute has a lanyard with a 7-inch loop tacked with breakaway thread on each rear riser strap. After deployment, if the parachute is not damaged, each loop should be pulled downward with a sharp tug approximately 1-1/2 feet. This releases three pairs of suspension lines on each side (24 pairs

EJECTION SEAT



1 AIRCRAFT GUIDE RAIL.
2 DROGUE PARACHUTE
3 DROGUE PARACHUTE GUN
4 DROGUE PARACHUTE PIN
5 PIN STOWAGE - FWD COCKPIT ONLY
6 PARACHUTE GUN SAFETY CAP
7 PARACHUTE GUN SAFETY PIN
8 SHOULDER HARNESS
9 MANUAL PARACHUTE DEPLOY RING
10 SUIT VENT AIR HOSE
11 INERTIA REEL LOCK
12 EJECTION TEE HANDLE
13 LEG GUARD
14 CANOPY JETTISON HANDLE
15 EJECTION D RING
16 SAFETY PIN
17 FOOT RETENTION CABLES
18 FOOT RAMPS
19 FOOT RETENTION CABLE CUTTER (2)
20 SEAT VERTICAL ADJUSTMENT SWITCH
21 SURVIVAL KIT RELEASE
22 SCRAMBLE HANDLE
23 EMERGENCY OXYGEN HANDLE (GREEN APPLE)
24 MAIN PARACHUTE ARMING CABLE
25 RADIO BEACON CONTROL
26 LEAK DETECTOR ANEROID ACTUATED INITIATOR

F203-19(2)(1)

Figure 1-83

remain), provides steering capability, and imparts a three to four ft/second forward speed to the chute.

WARNING

Do not pull either loop if the chute has sustained damage.

NOTE

Pull both loops. The chute will revolve continuously if only one set of lines is released.

For maximum effectiveness, start steering soon after chute deployment. A 180° turn requires 20 to 30 seconds.

The parachute may be equipped with a back cushion and/or a lowering device for descending from a tree. The lowering device consists of a let-down hook assembly, riser line section (colored blue), and 150 feet of nylon lead line packed in a special container in the parachute backpad. The last 25 feet of the lead line is colored differently (yellow, red, black, or white). See Figure 3-3.

__Survival Kit__

The survival kit is a hard-shell seat pack containing an emergency oxygen supply and survival equipment. Emergency oxygen quick disconnects are on the aft right corner of the kit, and two small oxygen quantity gages are at the forward left corner. (See Figure 1-84.) During ejection, emergency oxygen is turned on by a lanyard attached to the seat rail, or may be manually turned on by pulling the green apple. The kit may be released from the crewmember harness by pulling the kit release handle at the right side of the kit. The kit release handle should be pulled while descending in the main parachute, except when a tree landing is anticipated. When the release handle is pulled, the kit falls to the end of a 25-foot lanyard. The lanyard is disconnected from the harness if the release handle is pulled while seated.

WARNING

Pulling the kit release handle while seated disconnects both normal and emergency oxygen supplies.

PRIMARY EJECTION SEQUENCE

The D-ring is pulled to initiate the primary ejection sequence, which includes automatic canopy jettison. Pulling the D-ring fires an initiator on the front apron of the seat. Gas pressure from the D-ring initiator is ported directly to the foot retractor, the shoulder harness reel, and the canopy unlatch thruster. Pulling the D-ring also arms the secondary ejection sequence.

When the canopy unlatch thruster reaches full throw, gas pressure is ported to the canopy seal cutter and canopy removal thruster. Another initiator (pin-fired as the canopy is raised) ports pressure through the jettison valve to a 0.3-second delay initiator, which allows time for complete canopy jettison prior to firing the seat catapult initiator.

Gas pressure from the delay initiator provides pressure to fire the catapult initiator and arm the 0.2 and 1.4-second delay initiators in the drogue chute. The seat rocket motor ignites as the catapult raises the seat above the canopy sills.

The 0.2-second-delay initiator fires the drogue gun to deploy the drogue chute. The 1.4-second-delay initiator fires to arm the drogue chute lower riser cutters and the dual aneroid actuators. The lower riser cutters are armed through a 10-second delay, which provides time for seat deceleration before severing the lower riser lines. When the lower risers are severed, the seat is stabilized upright by the drogue chute. The dual aneroid actuators delay man-seat separation until 15,000 feet altitude if ejection occurs at a higher altitude. At completion of man-seat separation, the main chute is automatically deployed. See Figure 1-85.

SURVIVAL KIT

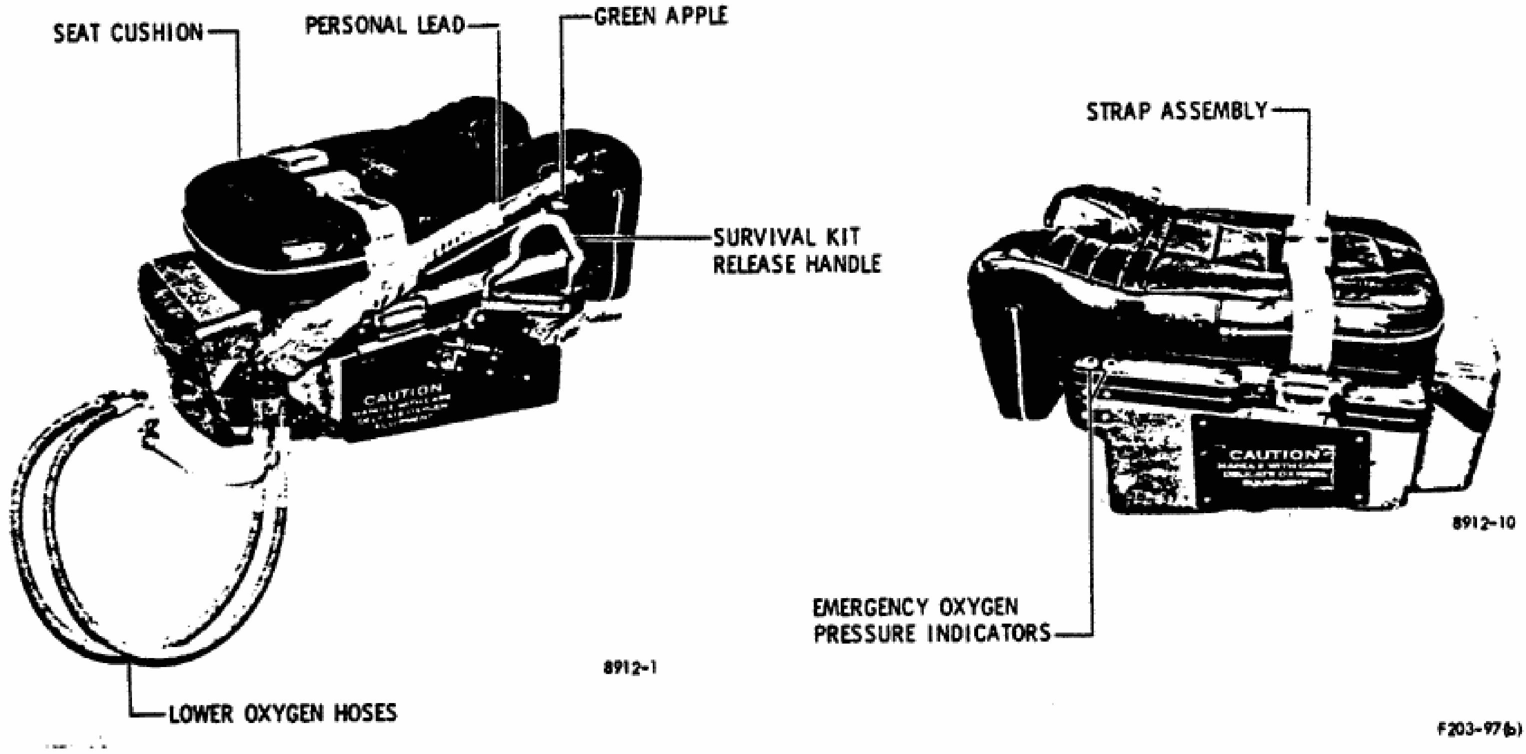


Figure 1-84

SECONDARY EJECTION SEQUENCE

If the primary ejection sequence malfunctions, the canopy must be jettisoned and then the ejection seat T-handle is pulled to initiate the secondary ejection sequence. The secondary sequence does not automatically jettison the canopy.

WARNING

Do not pull the secondary ejection T-handle with the canopy still in place.

NOTE

Secondary ejection sequence can not be initiated before the D-ring is pulled.

When the T-handle is pulled, the catapult initiator fires immediately and gas is ported to the two delay initiators in the drogue chute. Action downstream of the 1.4-second-delay initiator in the drogue chute is identical to the primary ejection sequence.

EGRESS COORDINATION SYSTEM

An egress coordination system supplements interphone communication. With this system, the pilot can issue and check compliance with an electrical bailout signal.

Egress Lights and Switches

A guarded RSO BAILOUT switch on the pilot's instrument panel has three positions: ALERT (down), OFF (center), and GO (up). Above this switch is a red RSO EJECTED warning light. The RSO instrument panel has an ALERT caution light, and PILOT EJECTED and BAILOUT warning lights. When the pilot actuates the RSO BAILOUT switch to ALERT or BAILOUT position, the corresponding light on the RSO panel illuminates. The ALERT light is a flashing amber light and the BAILOUT light is a steady red light. The forward cockpit RSO EJECTED light is operated by a switch on the aft cockpit ejection seat track. The aft cockpit PILOT EJECTED light is operated by a switch on the forward cockpit ejection seat

EJECTION TRAJECTORIES

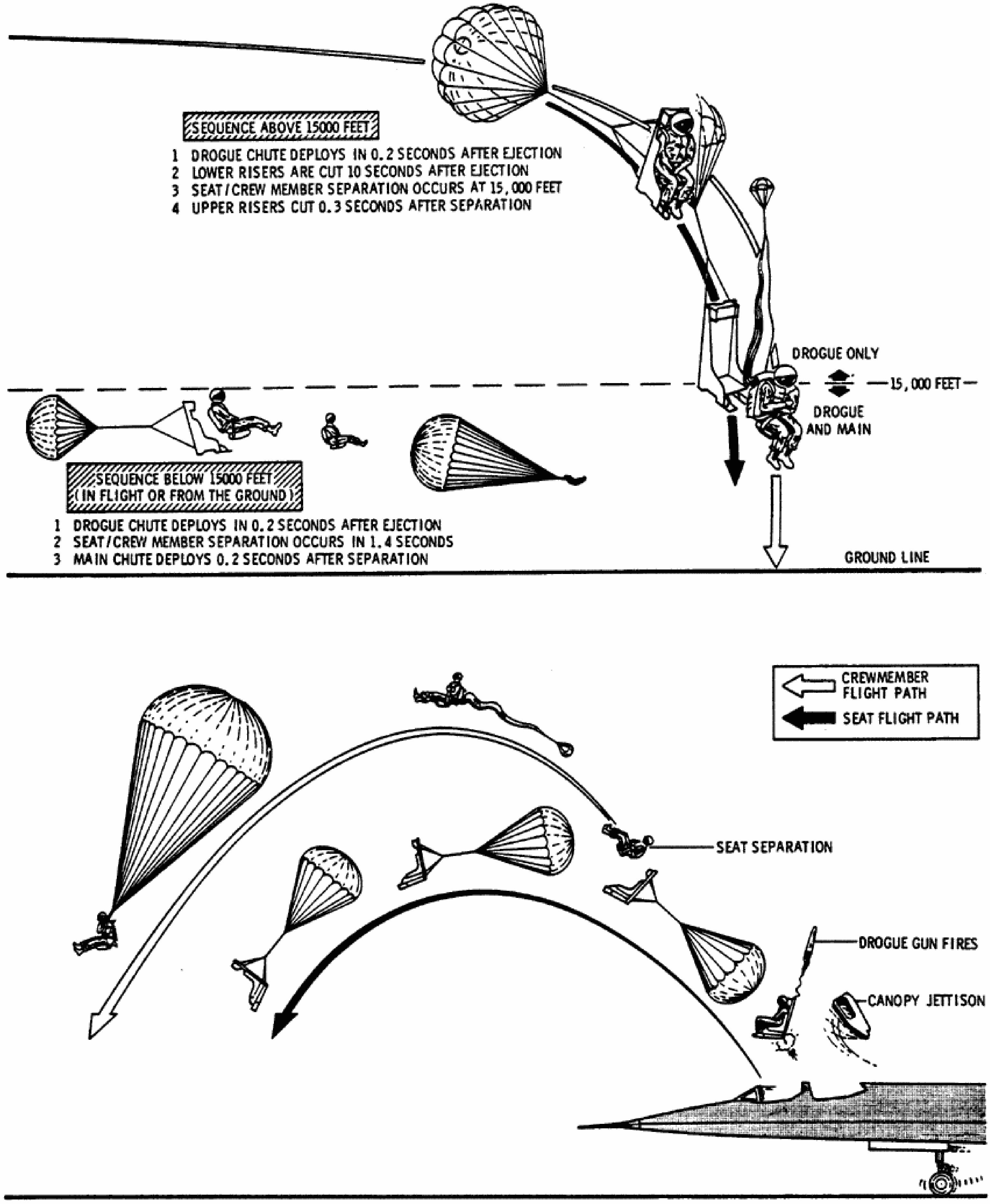


Figure 1-85

track. When a seat ejects, the respective light illuminates in the opposite cockpit. The aft cockpit BAILOUT light illuminates automatically when the PILOT EJECTED light illuminates. Power for the lights is provided directly from the battery through a BAILOUT LT circuit breaker in the E-bay.

EMERGENCY WARNING EQUIPMENT

MASTER WARNING SYSTEM

Forward Cockpit

An annunciator panel, located below the instrument panel, contains amber caution and red warning lights, with engraved legends, to indicate abnormalities of certain systems.

An amber master CAUTION light and a red master WARNING light are located at the top of the instrument panel. Annunciator lights flash when initially activated. A flashing amber or red annunciator light will cause the corresponding master CAUTION or master WARNING light to illuminate steady. Depressing the master light (amber or red) extinguishes the master light and causes the associated annunciator light to illuminate steady. Any subsequent annunciator light that illuminates will flash until the associated master light is pressed.

The annunciator lights do not give an indication of multiple failures such as could occur in the A or B HYD system. For example: The loss of A system hydraulic fluid illuminates the A HYD light and the master CAUTION light. The A HYD light will flash until the master CAUTION Light is reset, then will remain on steady. If the A HYD pressure subsequently fails, the A HYD light will remain on steady and the master CAUTION will remain off.

The master caution and warning lights do not illuminate with fire, inlet unstart, or landing gear unsafe warning lights.

All caution and warning lights, except the nacelle fire warning lights and landing gear handle warning light, are dimmed when the CONSOLE LTS switch is not OFF. Power for the KEAS warning, RSO ejected, A/P OFF, both IGV, and both derich lights is furnished by the essential dc bus through the WARN 2 circuit breaker on the pilot's left console. Power for all annunciator caution and warning lights and all other caution and warning lights except the nacelle fire warning lights, the inlet unstart lights, the landing gear handle warning light and lights on the WARN 2 circuit breaker is furnished by the essential dc bus through the WARN 1 circuit breaker on the pilot's left console.

NOTE

The L and R OIL TEMP annunciator lights are not functional. The OIL TEMP lights only illuminate when the IND & LT TEST switch is pressed.

Aft Cockpit

An annunciator panel and an amber master CAUTION light are located on the instrument panel. The annunciator lights and CAUTION light function the same as those in the forward cockpit except that the annunciator lights illuminate steady instead of flashing. The annunciator lights and master CAUTION light cannot be dimmed. There are no red annunciator lights or master warning light in the aft cockpit.

An amber PILOTS CAUTION light illuminates when the pilot's master WARNING and/or master CAUTION light illuminates. The PILOTS CAUTION light remains illuminated until the master light(s) in the forward cockpit are pressed off. This permits the RSO to alert the pilot if the forward lights are not immediately noticed by the pilot. Power for aft cockpit caution lights is furnished by the essential dc bus through the WARN LTS circuit breaker on the RSO's right console.

Indicators and Warning Lights Test Button

Forward Cockpit

A push-button indicator and warning lights test switch, labeled IND & LT TEST, is located on the left instrument side panel. When the IND & LT TEST switch is depressed:

The following indicators move to their full counter-clockwise positions:

- Liquid nitrogen quantity
- Liquid oxygen quantity
- Fuel quantity
- CIP
- CG (forward and aft cockpit)
- Spike and forward bypass

The following lights illuminate:

- Annunciator panel caution and warning
- Master CAUTION and master WARNING
- L & R UNST
- Air refueling READY and DISC
- Fuel derich
- IGV
- KEAS
- SHAKER
- Landing gear indication (3 green lights)
- Nacelle fire warning. Illumination of each fire warning light indicates that the respective fire warning loop is functioning.
- Landing gear handle warning. (landing gear warning tone also heard in both headsets if one or both throttles are in idle or OFF).

All annunciator lights illuminate steady 1-1/2 seconds after the IND & LT TEST switch is depressed. Depressing the switch also illuminates the following aft cockpit lights: CG, master CAUTION, and PILOTS CAUTION.

Aft Cockpit

An indicator and warning light push-button test switch, labeled LAMP TEST, is located on the PWR & SENSOR control panel. Power for the switch is furnished by the essential dc bus. When the LAMP TEST switch is depressed:

Oxygen quantity indicator needle moves toward zero.

Fuel quantity needle moves toward zero.

The following lights illuminate:

- Annunciator panel
- UHF TRANS
- Master CAUTION
- ANS control panel
- PWR & SENSOR control
- Radar control, test and display panel
- DEF control and DEF warning panel

NACELLE FIRE WARNING SYSTEM

A fire warning system indicates the presence of a fire or hot spot in the engine nacelles. A high temperature, anywhere along the length of the detection circuits, illuminates the warning light for the corresponding nacelle.

There are two pairs of fire warning loops in each nacelle. One forward and aft pair is on the outboard side of the nacelle and the other forward and aft pair is on the inboard side. Both wires of a pair must sense a hot condition before a warning is given. Pressing the pilot's IND & LT TEST switch illuminates the FIRE LEFT NAC and FIRE RIGHT NAC warning lights if the fire warning loops are intact.

Nacelle Fire Warning Lights

FIRE LEFT NAC and FIRE RIGHT NAC warning lights, on the pilot's instrument panel, illuminate when nacelle temperature near the turbine or afterburner exceeds 1200° ($\pm$ 50°) F. Covers are provided for reducing the brightness of the lights at night. Power for the lights is furnished by the emergency ac bus through the L and R FIRE WARN circuit breakers on the pilot's right console.

Fire Warning Loop Test Switches

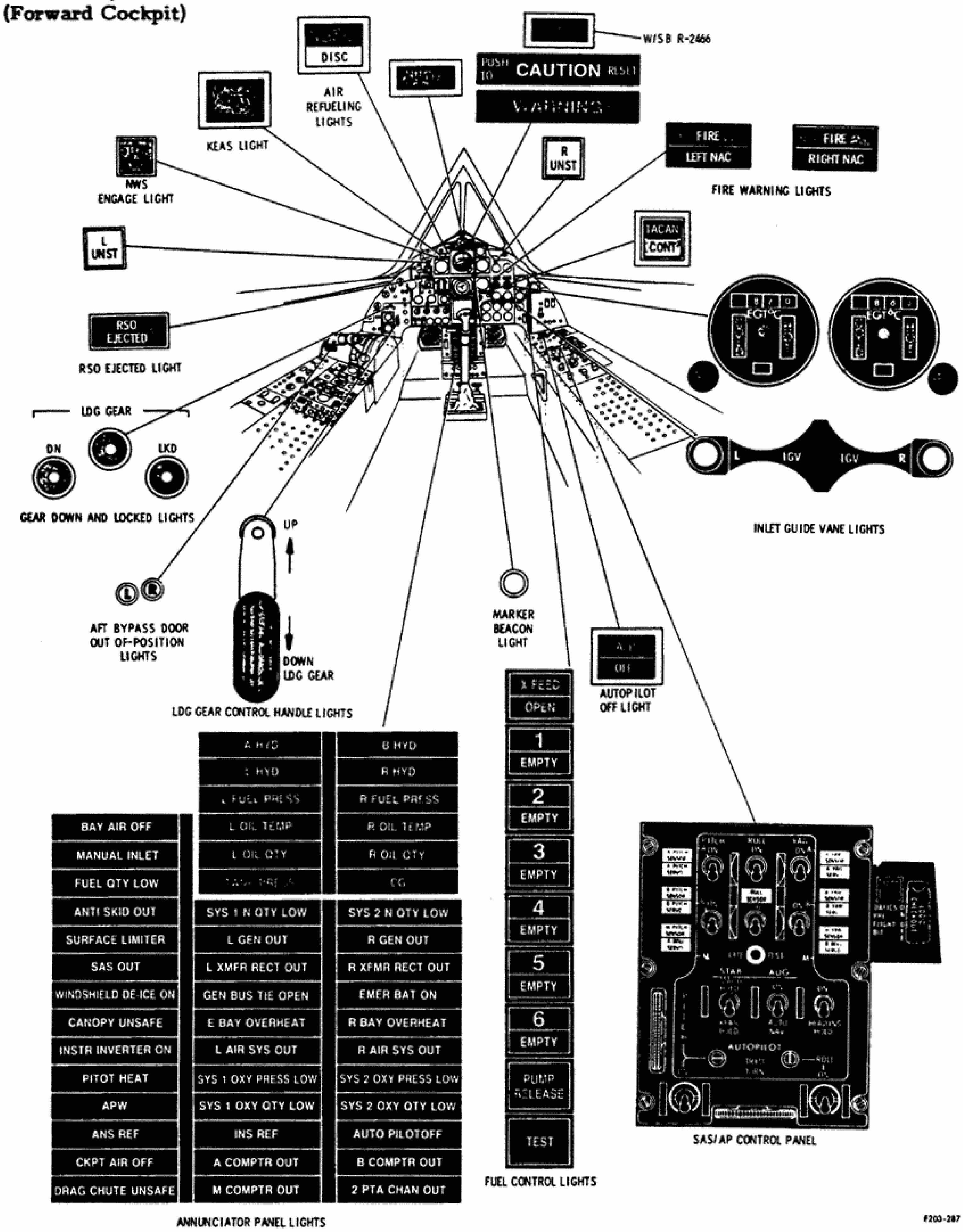
Two switches, one for each engine, are installed above and aft of the left console in the forward cockpit. The switches, labeled L LOOP SEL SW and R LOOP SEL SW, are used by maintenance personnel to checkout the fire warning system.

MISCELLANEOUS EQUIPMENT

Dinghy Stabber

A dinghy stabber, on the pilot's glareshield and on the RSO's right console, is provided to deflate the dinghy if it accidentally inflates in the cockpit.

WARNING, CAUTION AND CONDITION LIGHTS (Forward Cockpit)



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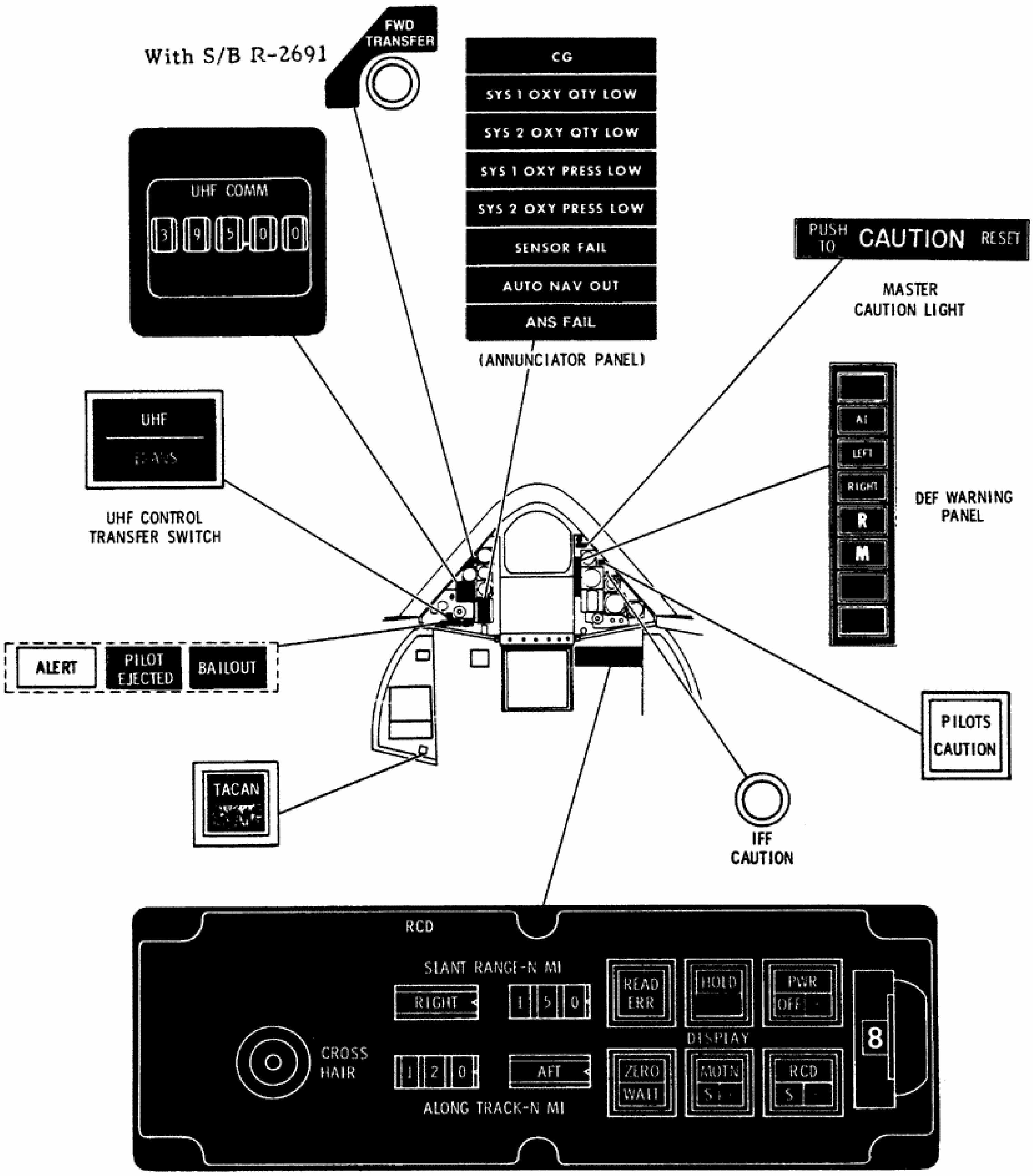
WARNING, CAUTION AND CONDITION LIGHTS
(Aft Cockpit Instrument Panel)



F203-167(c)

Figure 1-87

WARNING, CAUTION AND CONDITION LIGHTS
(Aft Cockpit Consoles)

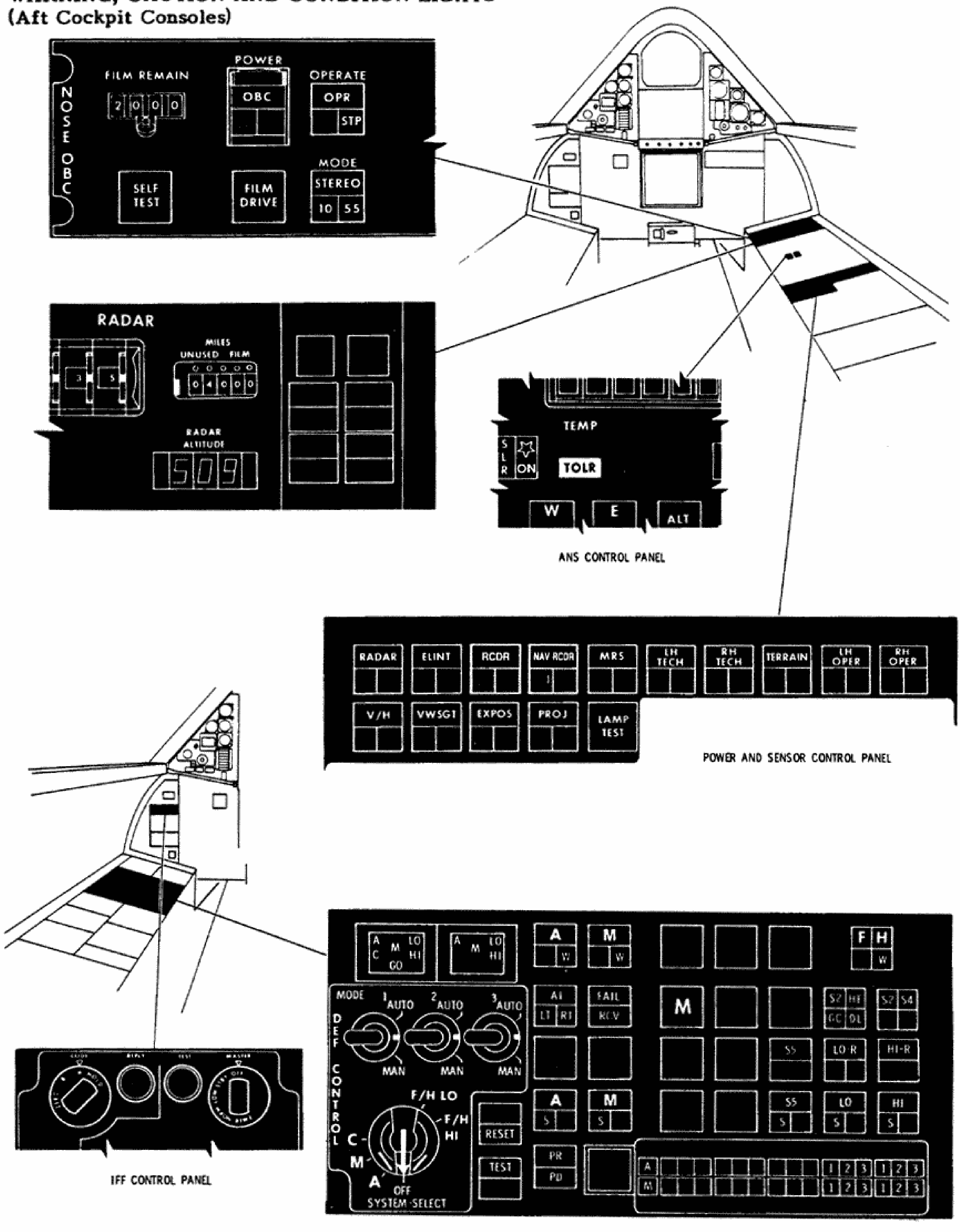


Figure 1-88

F203-185(c)

SR-71 TRAINER

INTRODUCTION

This subsection of Section I describes the SR-71B trainer aircraft. The normal and emergency operating procedures, limitations, and performance data for this aircraft are included in the appropriate sections of the SR-71A-1 Flight Manual. The aircraft systems and controls are identical with the like systems and controls in the SR-71A aircraft except as indicated in the following paragraphs. The controls and indicators in the aft cockpit are identical with the like controls in the forward cockpit except as indicated.

THE SR-71B AIRCRAFT

The SR-71B is a trainer aircraft with a full set of engine and flight controls in the aft cockpit. For pilot training purposes, the student pilot (S/P) occupies the forward cockpit and the instructor pilot (I/P) occupies the aft cockpit. For other than training flights the pilot will normally occupy the forward cockpit.

The forward cockpit of the SR-71B appears identical to the forward cockpit of an SR-71A except for the addition of a control transfer panel, an emergency intercom system switch, a panel to indicate autopilot modes selected by the other cockpit, ALERT AND BAILOUT warning lights, and the lack of a TACAN CONT switch and a system 3 liquid nitrogen gage. The aft cockpit duplicates most of the functions in the forward cockpit and retains basic navigational capabilities. The trainer does not have camera equipment, viewsight, radar, or electromagnetic radiation gear. The trainer external configuration is distinguished by a stabilizing fin extending downward along the bottom centerline of each engine nacelle, and the aft cockpit canopy is higher than the forward cockpit canopy.

AIRCRAFT GROSS WEIGHT

The gross weight of the SR-71B trainer aircraft with two pilots and full fuel load is approximately 139,200 pounds. Zero fuel weight is approximately 59,000 pounds. Refer to weight and balance handbook.

ENGINE AND AFTERBURNER

Two throttles are installed in each cockpit. The throttles are interconnected by a cable system which provides each cockpit with the capability of controlling engines from idle cutoff to maximum afterburner.

TEB Remaining Counters

The TEB counters are installed only on the throttle quadrant in the forward cockpit.

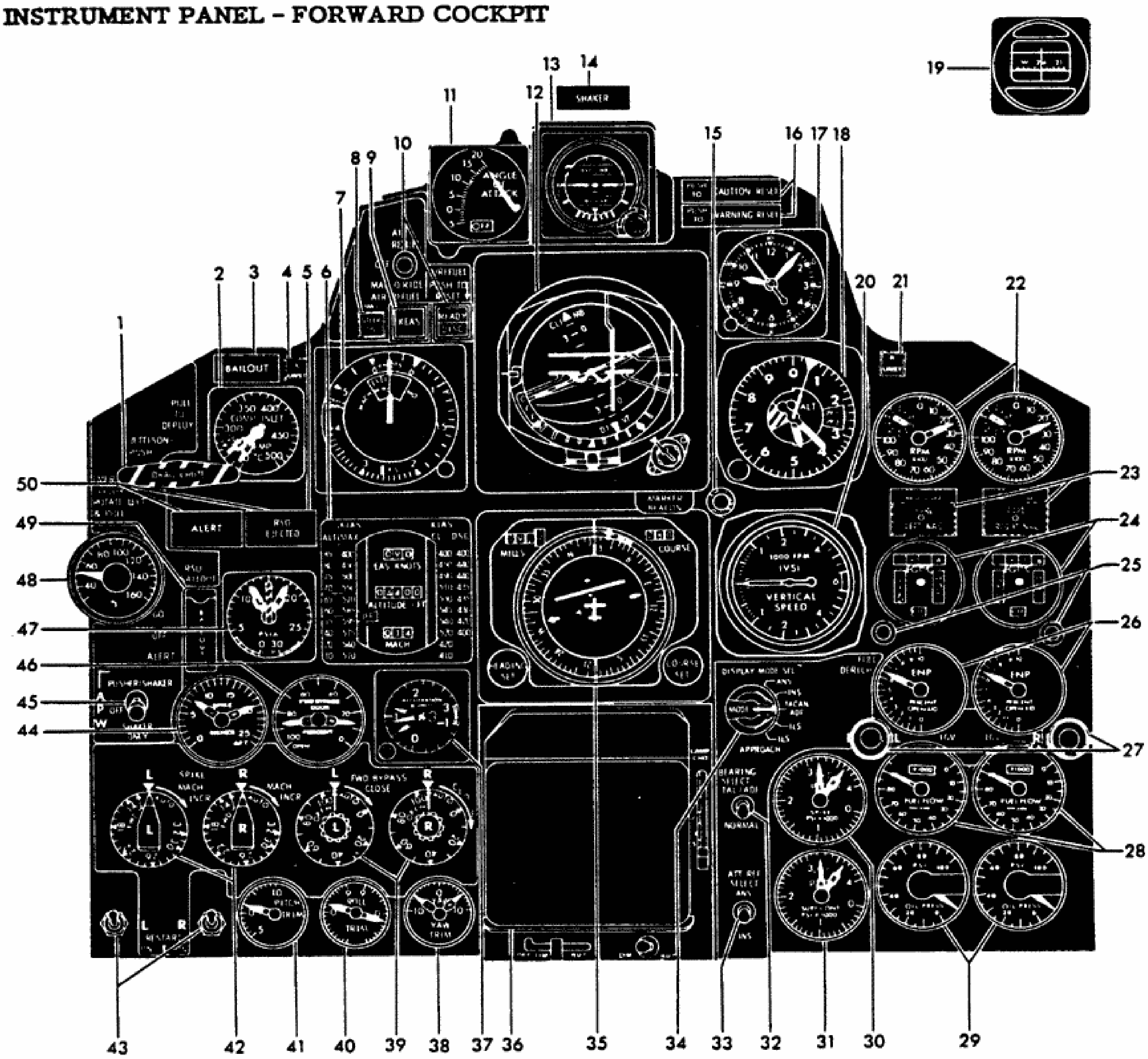
EGT Gages

There are two EGT gages, one for each engine, in each cockpit. The two gages in the aft cockpit repeat the forward cockpit temperature indications but do not affect the operation of the fuel derich system. The fuel derich system is actuated only by the forward cockpit gage indications. Because of gage tolerances, the rear cockpit gages can indicate as much as 16°C different from the forward cockpit gages. HOT and COLD flag indicators in each cockpit independently display signals from the automatic EGT control system. The overtemperature warning light in each gage operates independently.

CAUTION

The fuel derich system is activated only by the forward cockpit gage indications. Failure of a forward cockpit EGT gage results in loss of derich protection for the respective engine.

INSTRUMENT PANEL - FORWARD COCKPIT

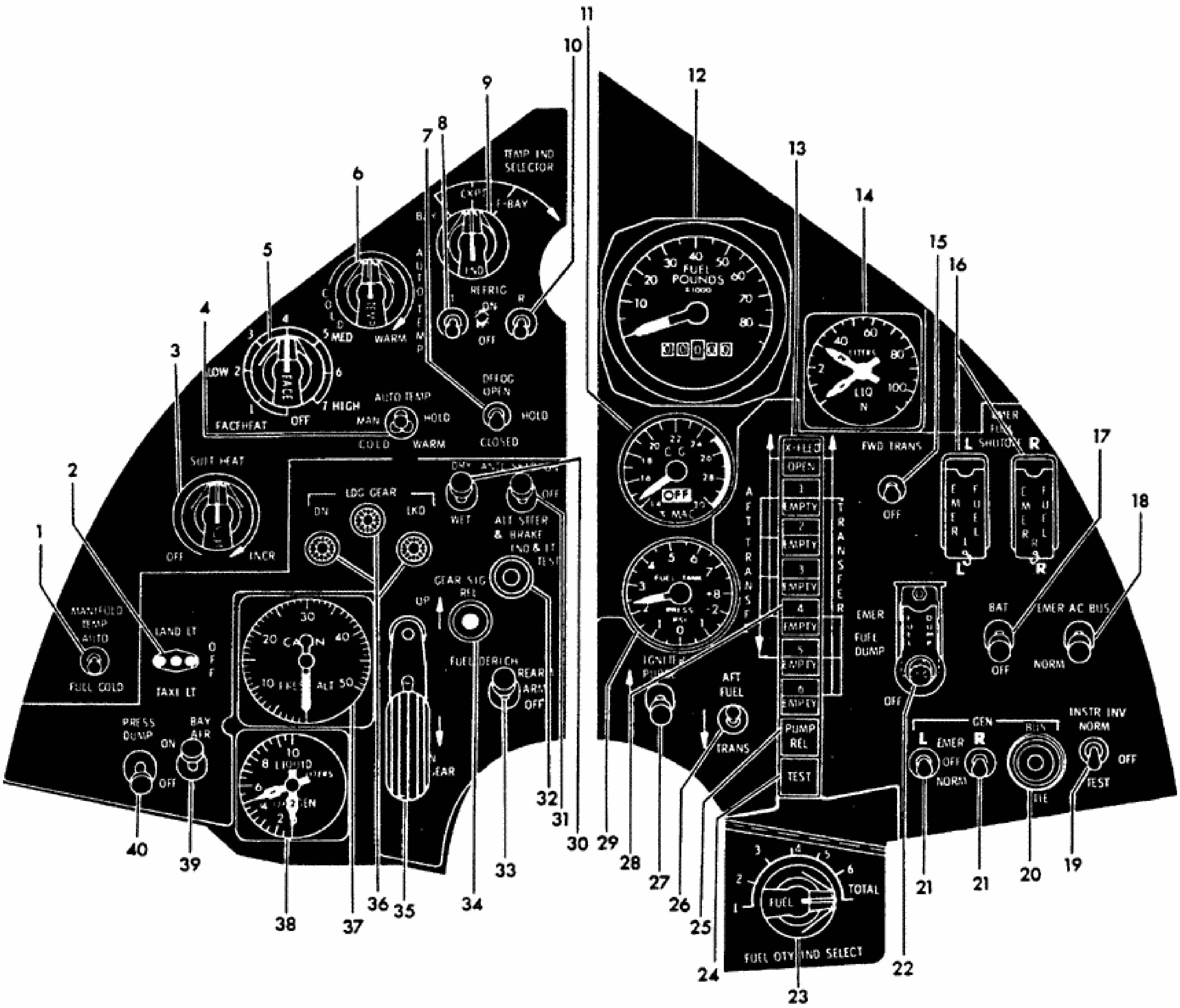


1 Drag Chute Handle
2 Compressor Inlet Temp Gage
3 Egress Light
4 Left Unstart Indicator Light
5 RSO Ejected Light
6 Triple Display Indicator
7 Airspeed-Machmeter
8 Nosewheel Steering Engaged Light
9 KEAS Warning Light
10 Air Refuel Switches
11 Angle of Attack Indicator
12 Attitude Director Indicator
13 Standby Attitude Indicator
14 Shaker Indicator Light
15 Marker Beacon Light
16 Master Caution and Warning Light
17 Elapsed Time Clock
18 Altimeter
19 Standby Compass (In Canopy)
20 Inertial-Lead Vertical Speed Indicator
21 Right Unstart Indicator Light
22 Tachometer
23 Fire Warning Lights
24 Exhaust Gas Temperature Indicators
25 Fuel Derich Lights
26 Exhaust Nozzle Position Indicators
27 IGV Lights
28 Fuel Flow Indicators
29 Oil Pressure Indicators
30 L and R Hydraulic Systems Pressure Gage
31 A and B Hydraulic Systems Pressure Gage
32 Bearing Select Switch
33 Attitude Reference Selector Switch
34 Display Mode Selector Switch
35 Horizontal Situation Indicator
36 Navigation Map Projector
37 Accelerometer
38 Yaw Trim Indicator
39 Forward Bypass Control Knobs
40 Roll Trim Indicator
41 Pitch Trim Indicator
42 Spike Control Knobs
43 Inlet Restart Switches
44 Spike Position Indicator
45 APW Switch
46 Forward Bypass Position Indicator
47 Compressor Inlet Pressure Gage
48 Temperature Indicator
49 RSO Bailout Switch
50 Egress Lights

F203-141(h)

Figure 1A-1

INSTRUMENT SIDE PANELS - FORWARD COCKPIT

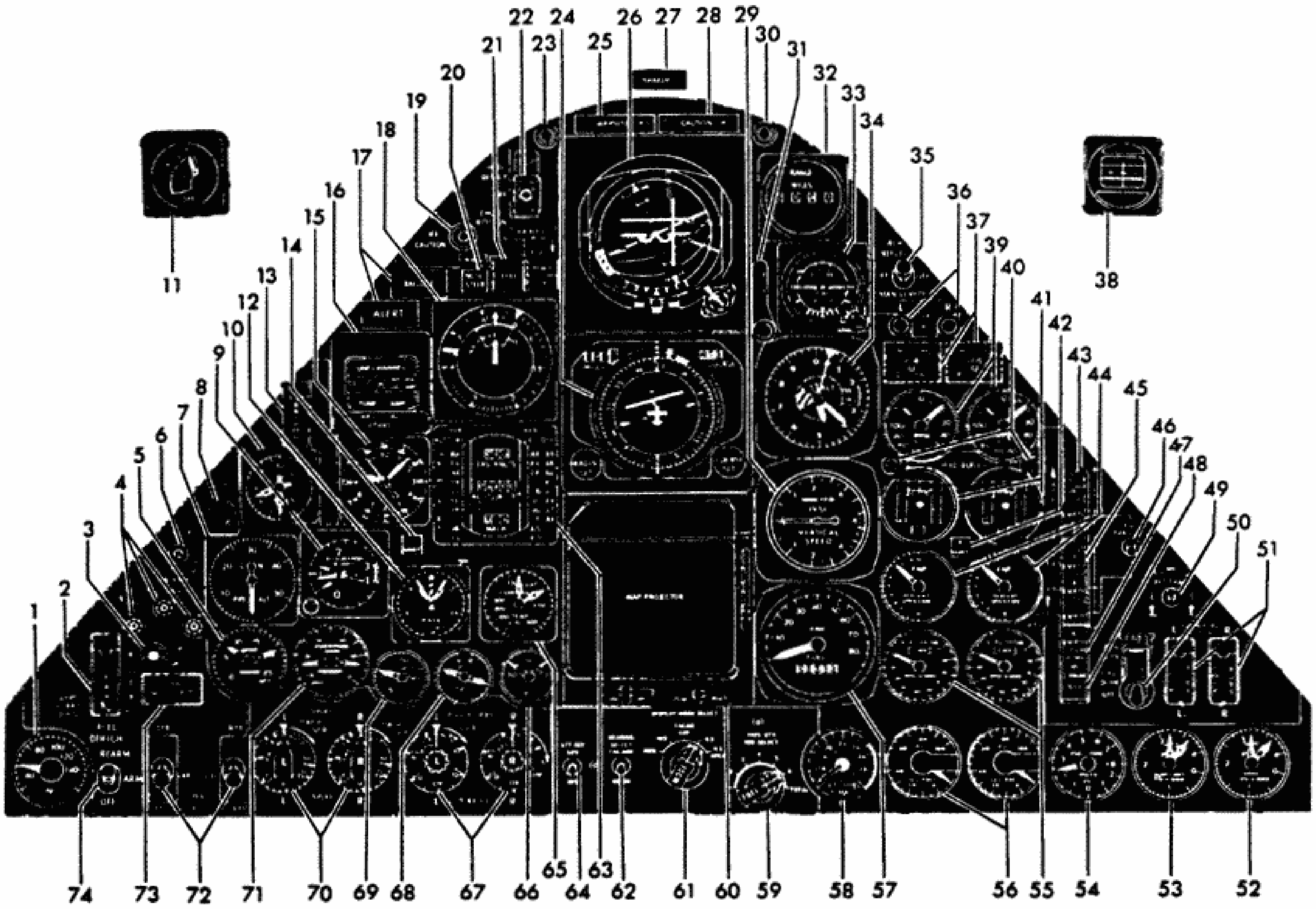


1 Manifold Temperature Switch
2 Landing and Taxi Light Switch
3 Suit Heat Rheostat
4 Cockpit Temperature Control and O'Ride
5 Face Heat Rheostat
6 Cockpit Temperature Control
7 Defog Switch
8 L Refrigeration Switch
9 Temperature Indicator Selector Switch
10 R Refrigeration Switch
11 Center of Gravity Indicator
12 Fuel Quantity Indicator
13 Fuel Crossfeed Switch
14 Liquid Nitrogen Quantity Indicator
15 Forward Transfer Switch
16 Emergency Fuel Shutoff Switches
17 Battery Switch
18 Emergency AC Bus Switch
19 Instrument Inverter Switch
20 Generator Bus Tie Switch
21 L and R Generator Switches
22 Fuel Dump Switch
23 Fuel Quantity Indicator Selector Switch
24 Fuel Boost Pump Light Test Switch
25 Pump Release Switch
26 Manual Aft Transfer Switch
27 Igniter-Purge Switch
28 Fuel Boost Pump Switches
29 Fuel Tank Pressure Indicator
30 Wet-Dry Switch
31 Brake Switch
32 Indicators and Light Test Switch
33 Fuel Derich Switch
34 Gear Signal Release Switch
35 Landing Gear Lever
36 Landing Gear Indicator Lights
37 Cabin Altimeter
38 Liquid Oxygen Quantity Indicator
39 Bay Air Switch
40 Cockpit Pressure Dump Switch

F203-142(f)

Figure 1A-2

INSTRUMENT PANEL - AFT COCKPIT



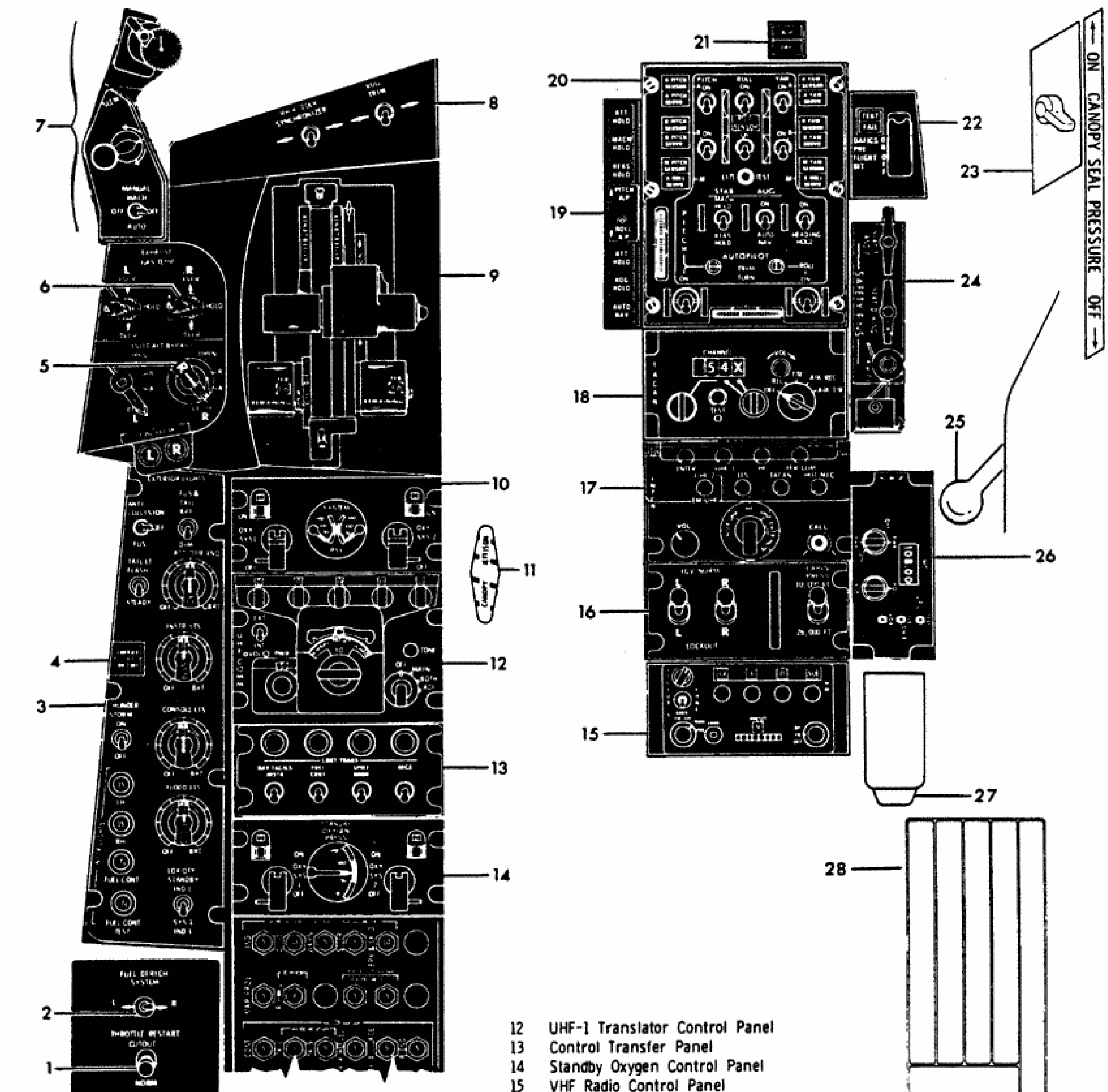
1 Temperature Indicator
2 Landing Gear Switch
3 Gear Signal Release Switch
4 Landing Gear Indicator Lights
5 Spike Position Indicator
6 Brake Switch
7 Cabin Altimeter
8 Indicators and Light Test Switch
9 Accelerometer
10 Liquid Oxygen Quantity Indicator
11 Angle of Attack Indicator (Mounted in Glare Shield)
12 Compressor Inlet Pressure Gage
13 S/P Bailout Switch
14 Left Unstart Indicator Light
15 Elapsed Time Clock
16 UHF Frequency Indicator
17 Egress Lights
18 Airspeed - Mach Meter
19 IFF Caution Light
20 Nose Wheel Steering Engaged Light
21 KEAS Warning Light
22 Drag Chute Switch
23 Supplementary Master Warning Light
24 Horizontal Situation Indicator
25 Master Warning Light
26 Attitude Director Indicator
27 Shaker Indicator Light
28 Master Caution Light
29 Inertial-lead Vertical Speed Ind.
30 Supplementary Master Caution Light
31 Marker Beacon Light
32 Distance Indicator
33 Standby Attitude Indicator
34 Altimeter
35 Air Refuel Switch
36 Inlet Guide Vane Lights
37 Engine Fire Warning Lights
38 Standby Compass (Mounted in Canopy)
39 Tachmometer
40 Fuel Derich Lights
41 Exhaust Gas Temperature Indicators
42 Right Unstart Indicator Light
43 Fuel Crossfeed Switch
44 Exhaust Nozzle Position Indicators
45 Fuel Boost Pump Switches
46 Fuel Forward Transfer Switch
47 Pump Release Switch
48 Fuel Boost Pump Lights Test Switch
49 Manual Aft Transfer Switch
50 Fuel Dump Switch
51 Emergency Fuel Shutoff Switches
52 Hydraulic Pressure-Spike Dual Indicator
53 Hydraulic Pressure-Surface Control Dual Indicator
54 Fuel Tank Pressure Indicator
55 Fuel Flow Indicators
56 Engine Oil Pressure Indicators
57 Fuel Quantity Indicator
58 Center of Gravity Indicator
59 Fuel Quantity Indicator Select Switch
60 Navigation Map Projector
61 Display Mode Selector Switch
62 Bearing Select Switch
63 Triple Display Indicator
64 Attitude Reference Selector Switch
65 Compressor Inlet Temperature Indicator
66 Yaw Trim Indicator
67 Forward Bypass Switches
68 Roll Trim Indicator
69 Pitch Trim Indicator
70 Spike Switches
71 Forward Bypass Position Indicator
72 Restart Switches
73 Gear Unsafe Warning Light
74 Fuel Derich Switch

F203-144(f)

Figure 1A-3

[redacted]

LEFT AND RIGHT CONSOLES - FORWARD COCKPIT



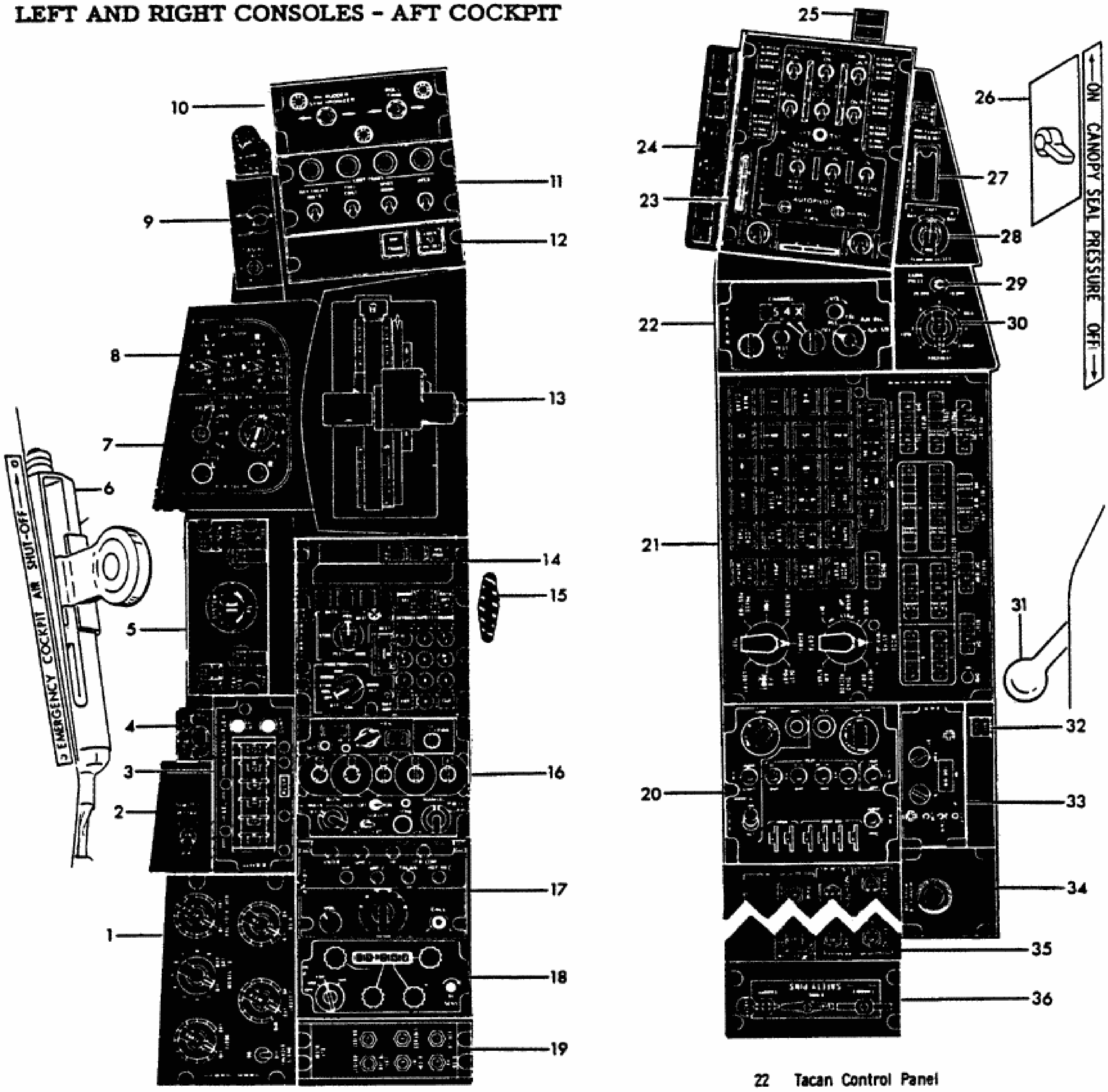
1 Throttle Restart Arming Switch
2 Fuel Derich Test Switch
3 Light Control Panel
4 Emergency ICS Switch
5 Inlet Aft Bypass Switches and Ind. Lights
6 EGT Trim Switches
7 Map Projector Control Panel
8 Manual Trim Control (Roll and Rudder Synchronizer)
9 Throttle Quadrant
10 Oxygen Control Panel
11 Canopy Jettison Handle
12 UHF-1 Translator Control Panel
13 Control Transfer Panel
14 Standby Oxygen Control Panel
15 VHF Radio Control Panel
16 IGV and Cabin Pressure Panel
17 Interphone Control Panel
18 TACAN Control Panel
19 Autopilot Indicator Panel
20 SAS/Autopilot Control Panel
21 Autopilot Off Light Switch
22 DAFICS Preflt BIT Switch and TEST/FAIL Light
23 Canopy Seal Pressure Valve (Sill)
24 Safety Pins
25 Canopy Latch Handle (Sill)
26 ILS Control Panel
27 Spotlight
28 Chart Holder

F203-143(h)

Figure 1A-4

[redacted]

LEFT AND RIGHT CONSOLES - AFT COCKPIT



1 Light Control Panel
2 Throttle Restart Arming Switch
3 UHF Modem Control Panel
4 Spotlight Receptacle
5 Oxygen Control Panel
6 Cockpit Air Shutoff Control
7 Inlet Aft Bypass Switches and Indicator Lights
8 EGT Trim Switches
9 Map Projector Control Panel
10 Manual Trim Control (Roll and Rudder Synchronizer)
11 Control Transfer Panel
12 Emergency ICS Switch and UHF Transfer Control Switch
13 Throttle Quadrant
14 INS Control Panel
15 Emergency Canopy Jettison Handle
16 UHF-2 Radio Control Panel
17 Interphone Control Panel
18 HF Radio Control Panel
19 Circuit Breaker Panel
20 IFF Control Panel
21 Navigation Control and Display Panel
22 Tacan Control Panel
23 SAS/Autopilot Control Panel
24 Autopilot Indicator Panel
25 Autopilot OFF Light Switch
26 Canopy Seal Pressure Valve
27 DAFICS Preflt BIT Switch and TEST/FAIL Light
28 Temperature Indicator Selector Switch
29 Cabin Pressure Switch
30 Face Heat Switch
31 Canopy Latch Handle
32 MRS Power Switch
33 ILS Control Panel
34 INS Heading Slew Control
35 Circuit Breaker Panel
36 Seat and Canopy Safety Pins

F203-145(k)

Figure 1A-5

ANNUNCIATOR PANEL - FORWARD COCKPIT

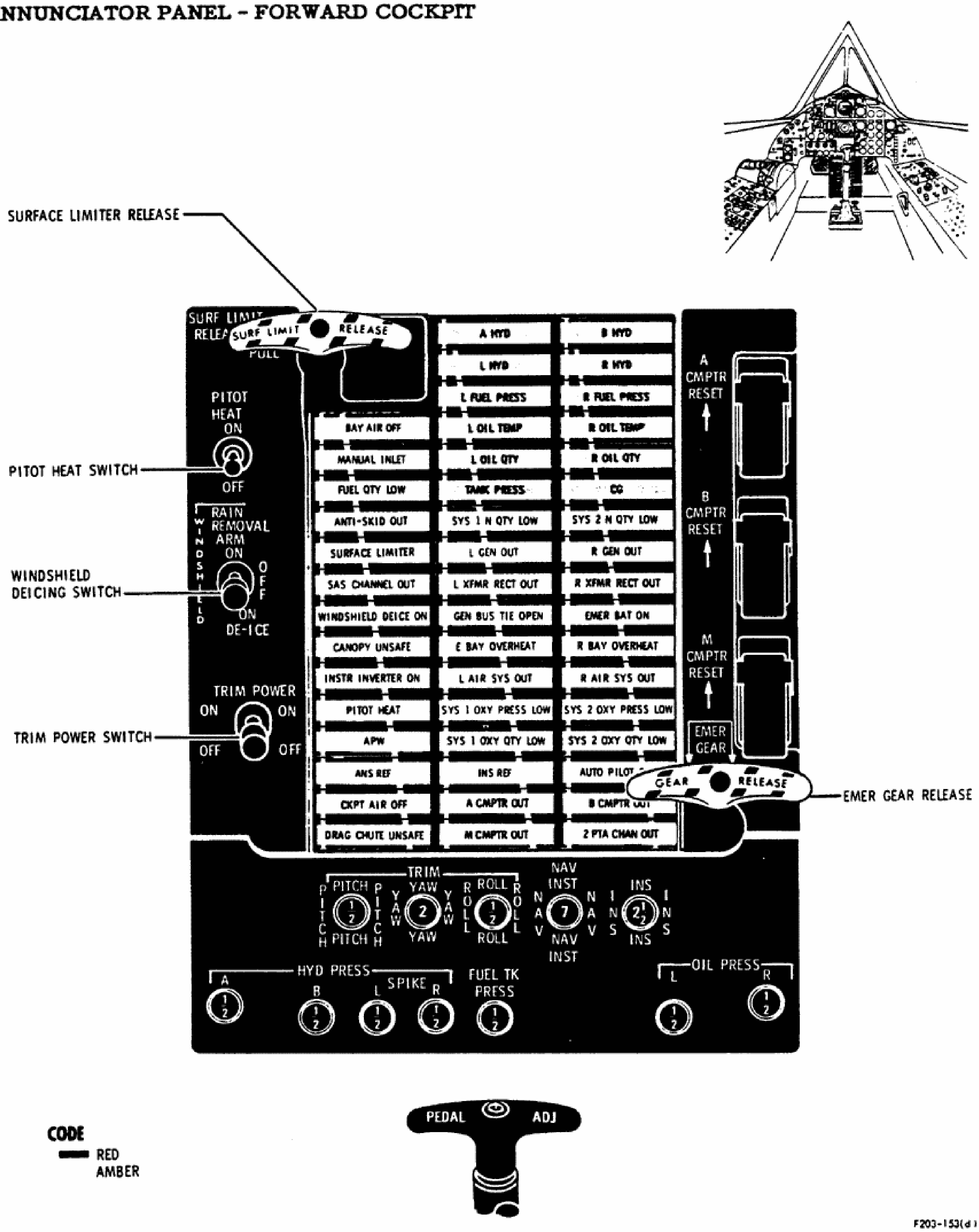
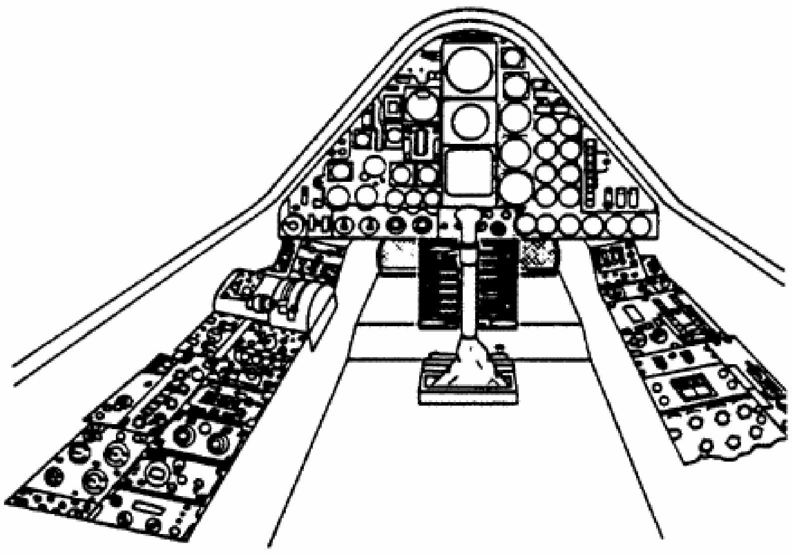


Figure 1A-6

ANNUNCIATOR PANEL - AFT COCKPIT



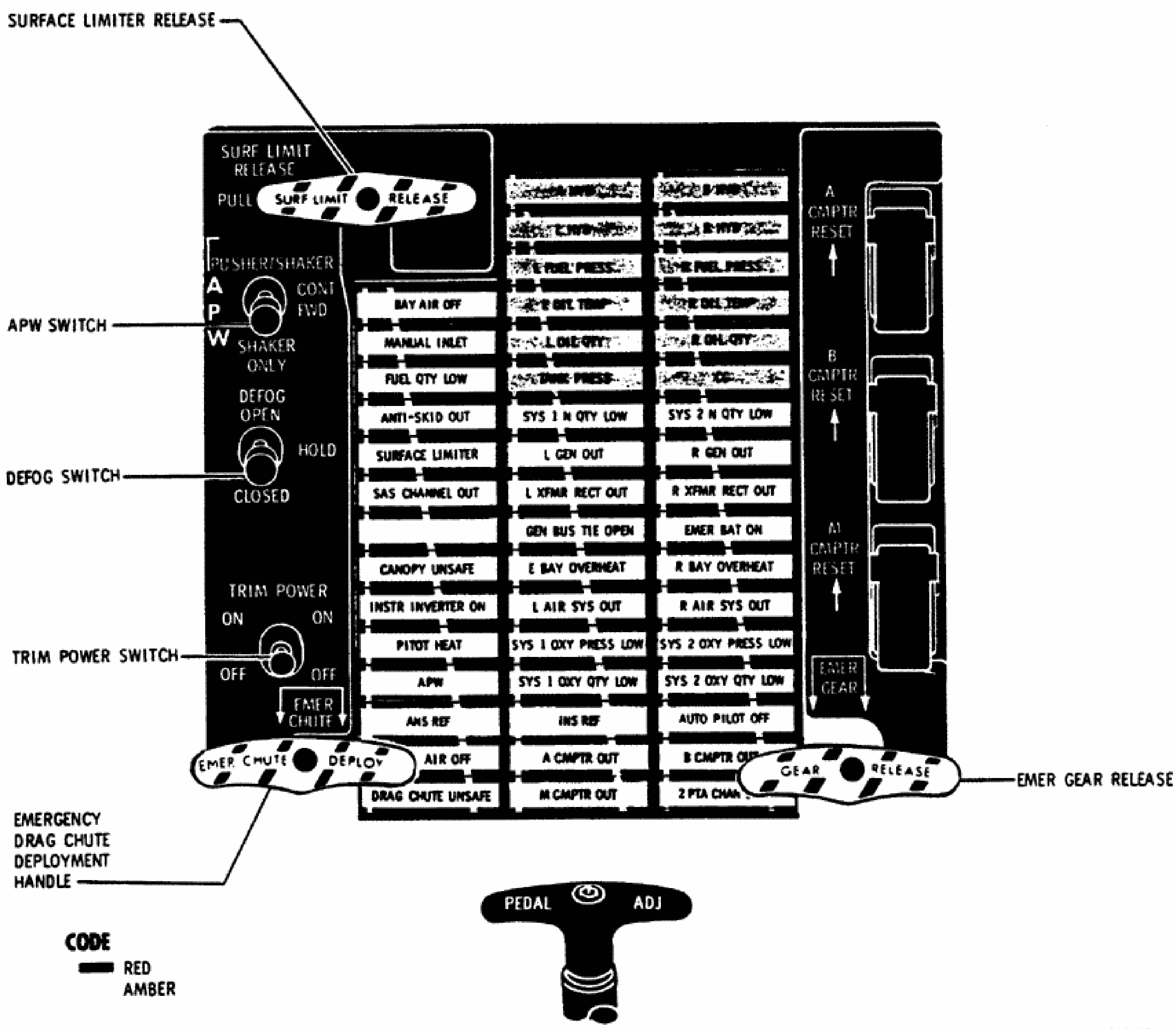


Figure 1A-7

EGT Trim Switches

EGT trim switches are installed in both cockpits. Operation of the aft cockpit switches out of the center position (marked HOLD & FWD CONT) overrides the switch positions in the forward cockpit.

Fuel Derich Arming Switch

A fuel derich arming switch is installed in each cockpit. Only the switch in the cockpit with the FUEL CONT transfer light illuminated on the control transfer panel is functional.

Fuel Derich System Test Switch

A fuel derich test switch is installed in the forward cockpit only. During the derich system test the aft cockpit EGT gages indicate only 200°C above the nominal EGT indication.

Fuel Derich Warning Light

Two fuel derich warning lights, one for each engine, are installed in each cockpit. The aft cockpit lights repeat the forward cockpit lights and are not affected by aft cockpit EGT indications.

IGV Lockout Switches

IGV lockout switches are installed in the forward cockpit only. IGV postion lights are installed in each cockpit.

Igniter Purge Switch

The igniter purge switch is installed in the forward cockpit only.

AIR INLET SYSTEM

Inlet Aft Bypass Switches and Indicators

The aft bypass control switches and indicator lights are installed in both cockpits. The aft cockpit switches have an extra position, labeled FWD CONTROL, which allows the forward cockpit to control the aft bypass doors. Operation of the switches in the aft cockpit out of the FWD CONTROL position overrides the switch positions in the forward cockpit.

Spike and Forward Bypass Control Knobs

The four rotary knobs for spike and forward bypass control are only functional in the cockpit with the SPIKE DOOR transfer light illuminated on the control transfer panel.

Inlet Restart Swtiches

The forward cockpit restart switches are only functional when the forward cockpit has the SPIKE DOOR transfer light illuminated on the control transfer panel. The RESTART ON position of either aft cockpit restart switch: puts the corresponding inlet in restart; overrides the SPIKE DOOR transfer switches to put the aft cockpit in control of the spikes and forward bypass doors of both inlets, regardless of which cockpit previously had SPIKE DOOR control; and illuminates the MANUAL INLET caution lights in both cockpits and the SPIKE DOOR transfer light on the aft cockpit control transfer panel. When both aft cockpit restart switches are returned to the OFF position, spike and forward bypass control as well as SPIKE DOOR transfer light illumination reverts to the cockpit selected on the control transfer panel.

Throttle Restart Switch

The forward cockpit throttle restart switch is only functional when the forward cockpit has SPIKE DOOR control. The aft cockpit throttle restart switch, when armed, is always functional. In addition, positioning the aft cockpit throttle restart switch out of the OFF position overrides the SPIKE DOOR transfer switches to put the aft cockpit in control of the spikes as well as the forward bypass doors of both inlets regardless of which cockpit previously had SPIKE DOOR control, and illuminates the MANUAL INLET caution lights in both cockpits and the SPIKE

DOOR transfer light on the aft cockpit control transfer panel. When the aft cockpit throttle restart switch is returned to the OFF position, spike and forward bypass control as well as SPIKE DOOR transfer light illumination reverts to the cockpit selected on the control transfer panel.

Throttle Restart Arming Switch

A throttle restart arming switch is installed in each cockpit. Each restart arming switch operates independently from the other.

Manual Inlet Indicator Light

The MANUAL INLET lights on the annunciator panels in both cockpits illuminate simultaneously when: the crewmember with SPIKE DOOR control moves one or more of the four rotary spike and/or forward bypass control switches out of the AUTO position; the crewmember with SPIKE DOOR control moves any inlet restart switch out of the OFF position regardless of which cockpit previously had SPIKE DOOR control.

FUEL SUPPLY SYSTEM

FUEL SYSTEM CONTROLS, INSTRUMENTS AND INDICATOR LIGHTS

Crossfeed Switch

The cockpits have independent operation of the crossfeed switch, but actual control of the crossfeed valves (and the X-FEED and OPEN light indications in both cockpits) is retained by the cockpit that has the FUEL CONT transfer light illuminated on the control transfer panel. When control of the fuel system is transferred, the crossfeed valve assumes the position commanded in the cockpit taking control.

Fuel Boost Pump Switches and Indicator Lights

Identical square fuel boost pump switches are installed in each cockpit. Manual boost pump control and the pump release switch are only functional in the cockpit that has the FUEL CONT transfer light illuminated on the control transfer panel. Numerals showing boost pump relays actuated and tank EMPTY lights appear simultaneously in both cockpits, thus providing monitoring of fuel sequencing to both cockpits. When control of the fuel system is transferred, fuel sequencing reverts to automatic, even though it may have been manually supplemented previously. If manual sequencing is desired by the cockpit taking control, boost pump switches must again be manually depressed.

Tank Lights Test Switch

The square pushbutton tank lights TEST switch below the pump release switch in each cockpit tests only the lights in that cockpit. The switch works regardless of which cockpit has the FUEL CONT transfer light illuminated on the control transfer panel.

Forward Fuel Transfer Switch

A two-position forward transfer switch, is installed in each cockpit.

NOTE

> Either cockpit can initiate forward fuel transfer regardless of which cockpit has the FUEL CONT light illuminated on the transfer control panel. Both switches must be off to terminate transfer.

Aft Transfer Swtich

An aft transfer switch is installed in each cockpit. Both switches must be off to terminate transfer.

Fuel Dump Swtich

A fuel dump switch is installed in each cockpit.

NOTE

Operating either fuel dump switch to the FUEL DUMP position will open the fuel dump valves regardless of which cockpit has the FUEL CONT Light illuminated on the transfer control panel. Operating either switch to the EMER DUMP position will dump all remaining fuel. Both switches must be off to terminate dumping.

Emergency Fuel Shutoff Switch

Emergency Fuel Shutoff switches are installed in each cockpit. Operating either switch to off (up) shuts off the fuel to the respective engine.

Fuel Quantity Selector Switch

A fuel quantity selector switch is installed on the right console in the forward cockpit and on the lower portion of the instrument panel in the aft cockpit. Operation of a fuel quantity selector switch and its respective quantity indicator is independent of the selector switch and indicator in the other cockpit.

Liquid Nitrogen Quantity Indicator

A liquid nitorgen quantity indicator is installed in the forward cockpit only. System 3 liquid nitrogen system and indicator are not installed.

Air Refuel Ready Switch

An air refuel ready switch is installed in each cockpit. Positioning this aft cockpit air refuel switch out of the OFF position overrides the forward cockpit switch positions.

Air Refuel Reset Switch and Indicator Light

A square, air refuel mechanism resetting pushbutton, is located on each instrument panel. The switches operate in parallel, so that depressing either switch will reset the signal amplifier and recycle the refueling receptacle locking mechanism.

Disconnect Trigger Switch

A disconnect trigger switch, is installed on each control stick grip. Depressing either trigger switch will initiate a refueling disconnect. Depressing either trigger opens the receptacle latches during air refueling using manual override.

ELECTRICAL SYSTEM

The electrical supply system of the SR-71B aircraft is basically identical with the system in the SR-71A aircraft except for some of the circuit breakers, (see Figure 1A-8). Other than circuit breakers, there are no electrical system contols in the aft cockpit.

NOTE

The following controls are only provided in the forward cockpit.

L and R generator switches
Generator bus tie switch
Battery switch
Instrument inverter switch
Emergency ac bus switch

LANDING GEAR SYSTEM

The landing gear is controlled from the forward cockpit by a landing gear lever, and from the aft cockpit by a switch.

Landing Gear Lever

A landing gear lever is located in the forward cockpit only.

Landing Gear Switch

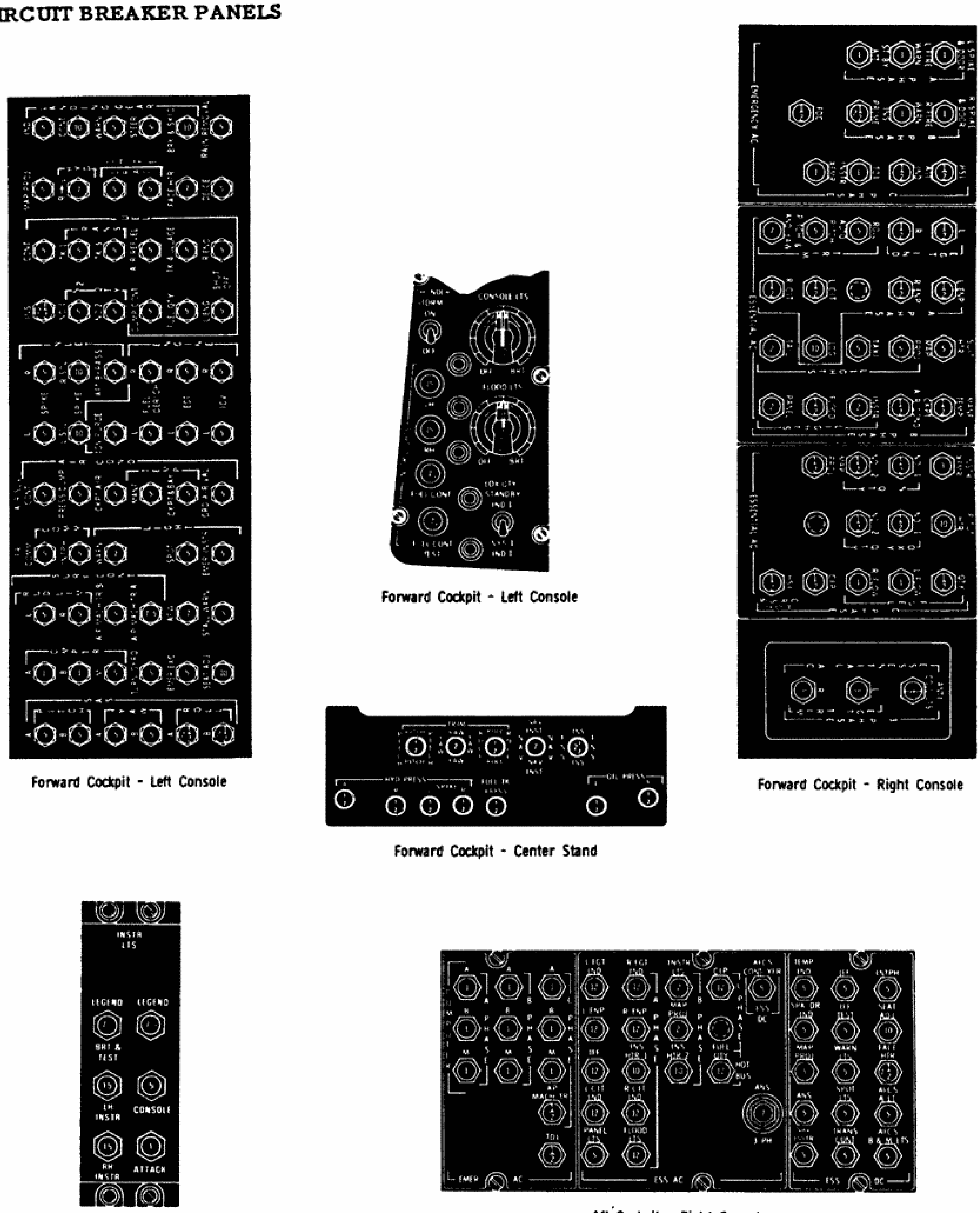
A guarded, lock-wired, three-position toggle switch for operating the landing gear is located on the lower left side of the instrument panel in the aft cockpit. The UP (up) and DOWN (down) positions of the switch override the position of the landing gear lever in the forward cockpit. After use, if the switch is returned to OFF (center) and the landing gear lever in the forward cockpit is not in agreement with the actual position of the landing gear, the gear position does not change but hydraulic pressure and

CIRCUIT BREAKER FUNCTION TABLE - TRAINER

CIRCUIT BREAKER	EFFECT OF POWER INTERRUPTION
	Essential DC BUS (Forward Cockpit)
WARN	Disabled: All forward cockpit warning and caution lights except nacelle fire and landing gear warning lights, and 2 PTA CHAN OUT, SAS OUT, and A, B & M COMPTR OUT caution lights.
	Essential DC BUS (Aft Cockpit)
AFCS CONT XFR	Disabled: AFCS transfer control and light. AFCS control reverts to forward cockpit.
TEMP IND	Disabled: Aft cockpit temperature indication for cockpit, R-Bay and E-Bay.
SPK-DR IND	Disabled: Aft cockpit left and right spike and door position indicators.
MAP PROJ	Disabled: Aft cockpit map projector.
WARN LTS	Disabled: All aft cockpit warning and caution lights except nacelle fire and landing gear warning lights, and 2 PTA CHAN OUT, SAS OUT, and A, B & M CMPTR OUT caution lights.
TRANS CONT	Disabled: NAV/TAC/ILS INSTR, FUEL CONT, and SPIKE DOOR transfer control and lights. NAV/TAC/ILS INSTR, FUEL CONT, and SPIKE DOOR control reverts to the forward cockpit.
AFCS A LT	Disabled: A PITCH and A YAW SENSOR/SERVO, A ROLL SERVO, ROLL SENSOR, A CMPTR OUT, 2 PTA CHAN OUT, SAS OUT and BIT TEST lights. (Both cockpits)
AFCS B&M LTS	Disabled: B PITCH and B YAW SENSOR/SERVO, M PITCH and M YAW SENSOR, B ROLL SERVO, B CMPTR OUT, M CMPTR OUT, and BIT FAIL lights. (Both cockpits)
	Essential AC BUS (Aft Cockpit)
L EGT IND	Disabled: Aft cockpit left EGT indicator.
R EGT IND	Disabled: Aft cockpit right EGT indicator.
L ENP	Disabled: Aft cockpit left nozzle position indicator.
R ENP	Disabled: Aft cockpit right nozzle position indicator.
L CIT IND AØ	Disabled: Aft cockpit left compressor inlet temperature indication.
R CIT IND	Disabled: Aft cockpit right compressor inlet temperature indication.
PANEL LTS	Disabled: LEGEND, LEGEND BRT & TEST and CONSOLE circuit breakers on left console.
MAP PROJ BØ	Disabled: Aft cockpit map projector speed control.
INSTR LTS	Disabled: LH INSTR, RH INSTR and ATTACK circuit breakers on left console.
CIP CØ	Disabled: Aft cockpit left and right compressor inlet pressure indicators. Barber pole continues to function.
LEGEND	Disabled: Aft cockpit switch legends when in the dimming range.
LEGEND BRT & TEST AØ	Disabled: Aft cockpit switch legends when in bright and in Warning lights test.
CONSOLE (Left Console)	Disabled: Aft cockpit console lights
LH INSTR	Disabled: Aft cockpit ADI, HSI and left hand instrument panel lighting.
RH INSTR BØ	Disabled: Aft cockpit right hand instrument panel lighting.
ATTACK	Disabled: Aft cockpit angle of attack indicator light.
	26 VOLT EMERGENCY AC BUS (Forward Cockpit)
HSI CRS & HDG	Disabled: Manual course and heading inputs to HSI in cockpit with NAV/TAC/ILS INSTR control are not repeated in the other cockpit.

Figure 1A-8

CIRCUIT BREAKER PANELS



Forward Cockpit - Left Console

Forward Cockpit - Left Console

Forward Cockpit - Right Console

Forward Cockpit - Center Stand

Aft Cockpit - Left Console

Aft Cockpit - Right Console

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Figure 1A-9

electrical command of gear position is removed from the landing gear system. If the switch is returned to OFF and the landing gear lever in the forward cockpit is in the position of the landing gear or is moved to the position of the landing gear, the landing gear lever and system again become operative. The switch is normally lock-wired in the OFF position and must be in that position for normal gear operation from the forward cockpit. Location of the switch in its center position can be verified by noting the appearance of a yellow dot in the end of the switch which should be visible through an aperture in the guard when it is lowered.

Manual Landing Gear Release Handle

A manual landing gear release handle is installed in each cockpit; the two handles are interconnected mechanically and pulling either handle will release the landing gear latches.

Landing Gear Warning Cutout Button

A landing gear warning cutout pushbutton is installed in each cockpit. Depressing the button in either cockpit will disable the warning circuit in both cockpits.

Gear Unsafe Warning Light

The gear unsafe warning light, labeled GEAR NOT LOCKED, is located on the lower left portion of the instrument panel in the aft cockpit only. The light functions similarly to the light in the gear handle in the forward cockpit, lighting red whenever the gear is not in the position called for by the gear handle position or the aft cockpit landing gear switch.

NOSEWHEEL STEERING SYSTEM

Nosewheel Steering Button

A nosewheel steering pushbutton is provided on the control stick grip in each cockpit. Either pushbutton may be depressed to engage or release nosewheel steering. A nosewheel steering engaged light is installed in each cockpit.

WHEEL BRAKE SYSTEM

Brake Switch

A brake switch is located in both cockpits. Positioning the switch in the aft cockpit out of the OFF position overrides the forward cockpit switch positions. To control the wheel brake system from the forward cockpit, the aft cockpit brake switch must be in the OFF (center) position.

Antiskid Disconnect Trigger Switch

With S/B R-2695, antiskid system operation is interrupted while either trigger switch is held depressed.

DRY-WET Switch

The dry-wet switch for braking selection is installed in the forward cockpit only.

DRAG CHUTE SYSTEM

Normal and emergency deployment of the drag chute can be initiated from either cockpit.

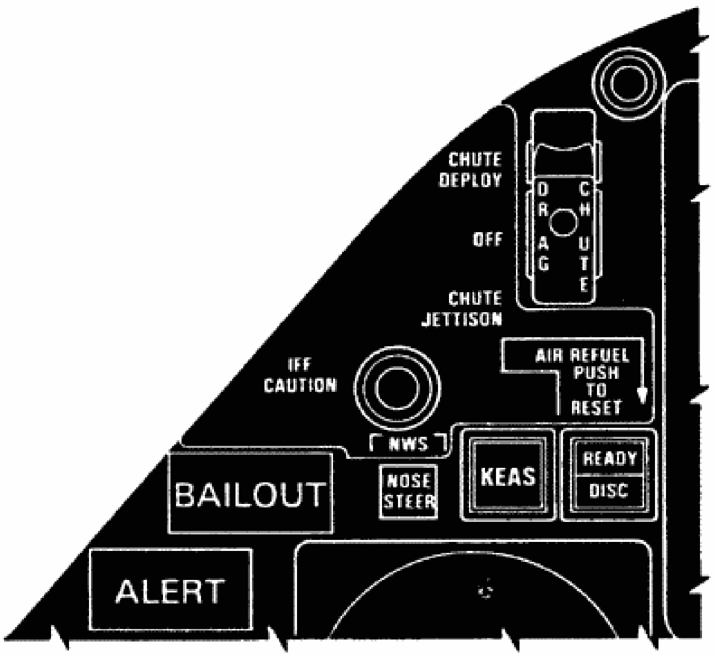
Drag Chute Switch

A guarded three-position DRAG CHUTE switch is provided in the upper left side of the instrument panel in the aft cockpit. (See Figure 1A-10.) Its guarded OFF (center) position corresponds to the stowed position of the drag chute handle in the forward cockpit. The guard must be raised to move the switch to the CHUTE DEPLOY (up) position, or to the CHUTE JETTISON (down) position. The switch is automatically reset to the OFF position when the guard is lowered. Location of the switch in its center position can be verified by noting the appearance of a yellow dot in the end of the switch which should be visible through an aperture in the guard when it is lowered. The control in the aft cockpit can always be used to operate the drag chute mechanism. The aft cockpit switch must be placed in its guarded OFF position to transfer control of the drag chute mechanism to the forward cockpit crewmember for normal deployment or jettisoning.

NOTE

If the aft cockpit deploys the drag chute and the forward cockpit handle remains stowed, returning the aft cockpit drag chute switch to OFF will jettison the drag chute.

INSTRUMENT PANEL - Aft Cockpit SR-71B



F203-300

Figure 1A-10

Drag Chute Emergency Deployment

In the aft cockpit, an EMER CHUTE DEPLOY Tee-handle is provided at the lower left edge of the annunciator panel. This handle is attached to the same cable and mechanism which is used to deploy the chute manually from the forward cockpit, and approximately the same pull force and handle motion are required.

FLIGHT CONTROL SYSTEM

The forward cockpit and aft cockpit flight controls are connected in tandem and work together.

Surface Limiter Control Handle

A surface limiter control handle is installed in each cockpit. The two handles are interconnected so that they move together; consequently, either pilot may operate the surface limiter system.

MANUAL TRIM SYSTEM

Trim Power Switch

A trim power switch is installed in each cockpit. The switches operate in series so that both must be ON to apply power to the trim motors. Operating either cockpit switch to OFF will turn off trim power.

Pitch and Yaw Trim Switch

A pitch and yaw trim switch is located on the control stick grip in each cockpit. The aft cockpit switch overrides the forward cockpit switch if they are operated simultaneously. Operation of either control stick trigger switch disables the control stick trim switch in both cockpits.

Roll Trim Switch

A roll trim switch is installed in each cockpit. Operating the aft cockpit roll trim switch overrides the forward cockpit switch if they are operated simultaneously.

Right Hand Rudder Synchronization Switch

A right hand rudder synchronization switch is installed in each cockpit. The switches are in parallel so that operating either switch will actuate the trim motor. Both must be in center (off) position to stop the trim motor.

DIGITAL AUTOMATIC FLIGHT AND INLET CONTROL SYSTEM (DAFICS)

DAFICS PRELIGHT BUILT IN TEST (BIT)

The DAFICS Preflight BIT switch only operates in the cockpit with the AFCS control transfer light illuminated on the control transfer panel. DAFICS Preflight BIT TEST/FAIL light indications (including ANR failure) appear simultaneously in both cockpits. The DAFICS Preflight BIT tests for switch input faults only in: SAS and autopilot switch inputs from the cockpit with AFCS control; inlet control switch inputs from the cockpit with SPIKE DOOR control; and one APW switch input (aft cockpit unless the aft cockpit APW switch is in CONT FWD).

Computer Reset Switches

Individual computer reset switches are installed in both cockpits. The computers can be restarted manually at any time with the computer RESET switches in either cockpit.

SAS/AUTOPILOT FUNCTION SELECTOR

Identical DAFICS function selector panels are installed in both cockpits. The cockpit with the AFCS transfer light illuminated on the control transfer panel has control of the SAS and autopilot.

SAS CONTROLS AND INDICATORS

SAS will not disengage when AFCS control is transferred provided the channel engage switches are on in the cockpit assuming control. The SAS channel engage switches and the ROLL SENSOR/SERVO recycle functions only operate in the cockpit with AFCS control. PITCH and YAW pushbutton SENSOR/SERVO recycle functions operate in either cockpit regardless of which cockpit has AFCS control. Identical SENSOR/SERVO light indications appear simultaneously in both cockpits. The SAS LITE TEST switch on each SAS control panel operates independently but illuminates the Preflight Bit TEST/FAIL lights in both cockpits.

WARNING

Only the positions of the SAS channel engage switches in the cockpit that has AFCS control effect the SENSOR/SERVO and SAS OUT caution lights. No warning is displayed if the SAS channel engage switches are not ON in the cockpit that does not have AFCS control. If the SAS engage switch(es) are OFF in the cockpit that does not have AFCS control, transferring AFCS control to that cockpit results in loss of SAS until the switch(es) are engaged.

AUTOPILOT SYSTEM

The cockpit with the AFCS transfer indicator light illuminated on the control transfer panel has control of the SAS and autopilot. The autopilot will disconnect if AFCS control is transferred to the opposite cockpit. Autopilot mode engage switches, trim wheels, and alignment indices only function on the SAS control panel in the cockpit with AFCS control.

Autopilot Indicator Panel

An autopilot indicator panel is located to the left of the SAS control panel in each cockpit. Autopilot mode lights only illuminate in the cockpit not in control of the AFCS to allow monitoring of the autopilot modes selected in the other cockpit.

Control Stick Command Switch

A control stick command (CSC) switch is installed in each cockpit. The switch is only functional in the cockpit with AFCS control.

Autopilot Disconnect Switch

An autopilot trigger disconnect switch is installed in each cockpit. Depressing either switch disengages the autopilot regardless of which cockpit has AFCS control.

A/P OFF Light

An A/P OFF light is installed in each cockpit. Depressing the light in either cockpit extinguishes the AUTOPILOT OFF annunciator light in both cockpits.

APW AND HIGH ANGLE OF ATTACK WARNING SYSTEMS

APW System Stick Warning Switch

A three-position APW system stick warning control switch is provided on the left side of the annunciator panel in the rear cockpit. The functions of the PUSHER/SHAKER (up) and SHAKER ONLY (down) positions are the same as for the APW control switch in the forward cockpit. Selection of either switch position overrides the position of the forward cockpit switch. Selection of the CONT FWD (center) position transfers control of the APW stick warning system to the forward cockpit.

PITOT-STATIC SYSTEMS

Pitot Heat Switch

The pitot heat switch is installed in the forward cockpit only.

FLIGHT INSTRUMENTS

The front cockpit flight instruments are duplicated in the aft cockpit except as indicated. (See Figures 1A-1 and 1A-3.)

Attitude Reference Selector Switch

Each cockpit can independently select the attitude reference source for the ADI in that cockpit. DAFICS autopilot and analytical redundancy inputs are determined by the position of the attitude reference switch in the cockpit with the AFCS transfer light illuminated on the control transfer panel.

HORIZONTAL SITUATION INDICATOR

The HSI displays and the corresponding ADI steering indications selected by the cockpit with the NAV/TAC/ILS INSTR transfer light illuminated on the control transfer panel are repeated in the other cockpit.

COMMUNICATION & AVIONIC EQUIPMENT

Microphone Switches

The forward cockpit microphone switches are identical with the like switches in the SR-71A aircraft forward cockpit. The aft cockpit has four microphone switches, one on the control stick, one on the inboard throttle, and one on each side of the floorboard near the scuff plates. The floor-mounted switch on the right side is only for operation of the interphone.

EMERGENCY INTERCOMMUNICATIONS SYSTEM

A separate, press to talk emergency system is provided for communicating between the two cockpits when ac power is lost. There is no hot microphone capability when the emergency ICS is activated. The system is controlled by identical square, self-illuminated pushbutton switches located on the light control panel in the forward cockpit and on a separate panel on the left console in the aft cockpit. The top half of the pushbuttons are labeled EMERG ICS. The EMERG ICS is put into operation by depressing either or both control pushbutton(s), which (1) illuminates a green ON legend on the pushbutton face in both cockpits, (2) connects the intercom directly to the battery bus and (3) isolates all other sources of audio from the headsets of the pilots.

Depressing the same pushbutton switch again deselects the EMERG ICS. If neither cockpit has EMERG ICS selected the amber OFF light in both cockpit pushbutton switches illuminates and the isolated audio sources are reconnected.

Power is furnished to the emergency ICS by the 28v dc battery through the EMER INTPH circuit breaker located in the E bay.

UHF COMMUNICATIONS AND NAVIGATION SYSTEM

UHF Control Transfer Switch

The UHF control transfer switch is located on the left console in the aft cockpit.

UHF Remote Frequency Indicator

The UHF remote frequency indicator is located on the aft cockpit instrument panel.

UHF Modulator/Demodulator Control Panel

The UHF modulator/demodulator (MODEM) control panel is located on the left console in the aft cockpit.

UHF Distance Indicator

The UHF distance indicator is located on the upper right of the instrument panel in the aft cockpit.

HF RADIO

The HF radio is located on the left console in the aft cockpit.

INSTRUMENT LANDING SYSTEM

An ILS control panel is installed on the right console in both cockpits. Only the ILS control panel in the cockpit with the NAV/TAC/ILS INSTR transfer light illuminated on the control transfer panel is operative. A marker beacon indicator is installed in each cockpit.

IFF

The IFF control panel is located on the right console in the aft cockpit.

TACAN

A TACAN control panel is installed on the right console in each cockpit.

WINDSHIELD

The aft cockpit windshield is similar to the forward cockpit but does not have hot-air deicing provisions or the liquid rain-removal system.

Defog Switch

Defog air is controlled independently in each cockpit. The defog switch in the aft cockpit is located on the left side of the annunciator panel.

Windshield Deice On Caution Light

The forward cockpit WINDSHIELD DEICE ON caution light is the only annunciator caution light installed on only one annunciator panel. Only the master caution light in the forward cockpit illuminates when the WINDSHIELD DEICE ON light illuminates.

CANOPIES

Canopy Unsafe Warning Light

The CANOPY UNSAFE warning light in both cockpits illuminates when either one or both of the canopies is not latched down and/or properly sealed.

REAR VIEW PERISCOPE

A rear view periscope is installed on each canopy. The field of view of the front periscope is partially blocked by the aft cockpit.

LIGHTING EQUIPMENT

EXTERIOR LIGHTS

All exterior lights including the landing, taxi, anti-collision, fuselage, and the tail light are controlled by switches located in the front cockpit only.

AFT COCKPIT INTERIOR LIGHTING

The instrument panel lights, console panel lights and floodlights are controlled by rheostat switches located on the lighting panel on the left console. A two position thunderstorm light switch is located on the lighting panel. Separate rheostat switches are provided on the aft cockpit lighting panel for the segment (alpha-numeric) lights on the INS control panel and the angle of attack gage.

The green landing gear indicator lights, the GEAR NOT LOCKED, NOSE STEER, KEAS, air refuel READY/DISC, SHAKER, IGV and DERICH lights in the aft cockpit are dimmed when the forward cockpit console lights switch is out of the OFF position. The remaining aft cockpit warning and caution lights are dimmed when the aft cockpit console lights switch is out of the OFF position.

ENVIRONMENTAL CONTROL SYSTEM

The following controls are only provided in the forward cockpit:

- Refrigeration switches
- Cockpit temperature control switch
- Cockpit air temperature control and override switch
- Manifold temperature control switch
- Bay air switch
- Cockpit pressure dump switch

A cabin pressure selector switch, cabin altimeter, temperature indicator, and temperature indicator selector switch are installed in each cockpit. The cockpit air handle is in the aft cockpit.

Temperature Indicator and Selector Switch

In the aft cockpit, the temperature indicator is located on the lower left side of the instrument panel and the temperature selector switch is on the right console. The temperature indicator and temperature selector switch for each cockpit operates independently.

LIFE SUPPORT SYSTEMS

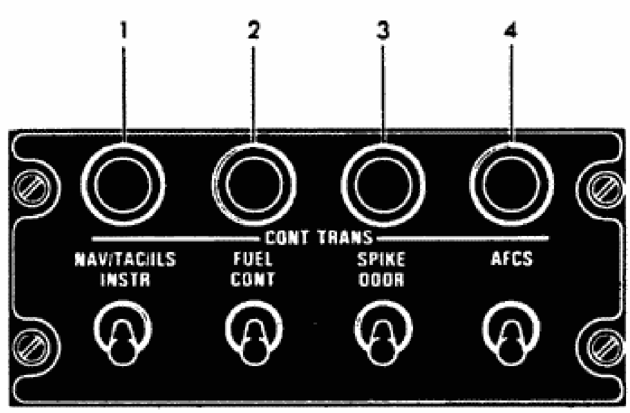
Suit Heat Rheostat

The pressure suit heat control is installed only in the forward cockpit.

Visor Heat Rheostat

Visor heat is controlled independently in each cockpit. The visor heat rheostat in the aft cockpit is located on the right console.

CONTROL TRANSFER PANEL - SR-71B



1 NAV/TAC/ILS control transfer switch and indicator light
2 FUEL CONT control transfer switch and indicator light
3 SPIKE DOOR control transfer switch and indicator light
4 AFCS control transfer switch and indicator light

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Figure 1A-11

CONTROL TRANSFER PANELS

A control transfer panel is located on the left console in both cockpits. Each panel contains four two-position toggle switches and four associated control transfer indicator lights. The switches allow either crewmember to give or take control of the aircraft system(s) associated with each switch. (See Figure 1A-11.) Changing the position of a control transfer switch once (fore or aft) on either control transfer panel transfers control from whichever cockpit previously had control to the other cockpit. Control of a system is indicated in the cockpit with control by illumination of the associated transfer indicator light. Control transfer and transfer indicator lights are powered by the Essential DC bus through the TRANS CONT and AFCS CONT XFR 28v dc circuit breakers.

NOTE

In the event of control transfer relay malfunction or loss of power in one of the four transfer circuits, control of the associated system reverts to the forward cockpit.

NAV/TAC/ILS INSTR Control

The cockpit with the NAV/TAC/ILS INSTR transfer light illuminated has control of the Display Mode Select switch, Bearing Select switch, HSI Course and Heading Set knobs, and the TACAN and ILS control panels. The ADI steering commands and HSI displays selected by the controlling cockpit are repeated in the other cockpit.

Fuel System Control

The cockpit with the FUEL CONT transfer light illuminated has control of those components within the fuel system that are operated manually: derich, crossfeed, boost pumps and pump release.

NOTE

When control of the fuel system is transferred, fuel sequencing reverts to automatic, even though it may have been manually supplemented previously. If manual sequencing is desired by the cockpit taking control, boost pump switches must again be manually depressed.

The crossfeed valve assumes the position commanded in the cockpit taking control.

Inlet Spike and Forward Bypass Control

The cockpit with the SPIKE DOOR transfer light illuminated has control of the inlet spike and forward bypass door control knobs. The forward cockpit restart switches and throttle restart switch are only functional when the forward cockpit has SPIKE DOOR control.

NOTE

When out of the OFF position, either aft cockpit restart switch or the aft cockpit throttle restart switch overrides the SPIKE DOOR transfer switch to put the aft cockpit in control of the spikes and forward bypass doors of both inlets and illuminates the MANUAL INLET caution lights in both cockpits and the SPIKE DOOR transfer light on the aft cockpit control transfer panel. When all aft restart switches are returned to the OFF position, SPIKE DOOR control as well as SPIKE DOOR transfer light illumination reverts to the cockpit selected on the control transfer panel.

Automatic Flight Control System Control

The cockpit with the AFCS transfer light illuminated has control of the stability augmentation system, autopilot controls, and the DAFICS Preflight BIT switch.

INTERTIAL NAVIGATION SYSTEM (INS)

Inertial Control Panel

The INS control panel is located on the left console in the aft cockpit.

Heading Slew Knob

The heading slew knob is located on the outboard aft portion of the right console in the aft cockpit.

INS Segment Lights Control

The INS segment (alpha-numeric) lights on the inertial control panel are controlled by the INS SEG LTS rheostat on the lighting control panel.

ASTROINERTIAL NAVIGATION SYSTEM

The Astroinertial Navigation System (ANS) control panel is located on the right console in the aft cockpit. Navigational accuracy may be degraded to the extent that position accuracy cannot be updated by reference to viewsight and radar system data.

Star tracking may be degraded because the field of view of the astrotracker is reduced by the position of the astrotracker window behind the aft canopy.

SENSOR EQUIPMENT

There is no sensor equipment installed in the trainer aircraft.

MISSION RECORDER

The mission recorder is controlled by a square, self-illuminated, pushbutton switch labeled MRS on the top half of the pushbutton and located on the right console in the aft cockpit. Depressing the pushbutton turns on the mission recorder, illuminating the lower left quarter of the pushbutton ON in green: depressing a lighted pushbutton turns off the recorder. In case a failure occurs in the 28-VDC or 400-cycle power supply to the recorder, the bottom right quarter of the pushbutton face lights FAIL in red. If power is subsequently restored the recorder will resume operation; however, the FAIL light will not go out, having to be reset on the ground.

EGRESS COORDINATION SYSTEM

The bailout switch located on the left side of the instrument panel in the forward cockpit is labeled RSO (rear seat occupant) BAILOUT; the bailout switch in the corresponding location in the aft cockpit is labeled S/P (student pilot) BAILOUT. Each switch is covered by a red guard and has three positions, OFF (center), ALERT (down), and GO (up). An ALERT and BAILOUT light are located on the left side of the instrument panel in both cockpits. Operating either bailout switch to the GO position causes the BAILOUT light in the other cockpit to illuminate. Operating either switch to the ALERT position illuminates the ALERT light in the other cockpit. The bailout switch is normally in the OFF position, with the guard down. When the aft cockpit seat ejects, RSO EJECTED illuminates in the forward cockpit, signifying that the forward cockpit pilot may eject safely; if the forward cockpit seat ejects first, the rear seat occupant must rely on sound and vision to determine when the forward seat is gone.

EMERGENCY WARNING EQUIPMENT

MASTER WARNING SYSTEM

The annunciator panel lights in the aft cockpit duplicate all the warnings and cautions displayed on the forward cockpit annunciator panel except one. The WINDSHIELD DEICE ON annunciator caution light is only installed in the forward cockpit.

<u>Master Warning and Master Caution Lights</u>

Depressing the master warning or master caution light extinguishes the master caution or warning light and causes the associated annunciator light to illuminate steady in that cockpit only.

A supplementary post-type warning and master caution light is located at the top of the instrument panel in the aft cockpit. These lights are fitted with a plastic lighttube so that they are visible when the canopy is down and the seat is in an elevated position.

<u>Indicators and Warning Lights Test Button</u>

The indicator and warning lights test button, labeled IND & LT TEST, is installed in each cockpit. Depressing the button in either cockpit will test the indicators and lights in both cockpits.

MISCELLANEOUS EQUIPMENT

<u>Dinghy Stabber</u>

A dinghy stabber is located on the glareshield in the forward cockpit and on the right side of the canopy in the aft cockpit.

INTRODUCTION

The following procedures provide an amplified listing which applies to the SR-71A/B aircraft.

Symbol Coding

1. Steps without special notations apply to the forward cockpit of all aircraft.

(2.) Steps with an enclosed number apply to the aft cockpit of the SR-71A.

▲3. Steps preceded by the ▲ symbol apply to both cockpits of all aircraft.

T 4. Steps preceded by a T apply to the forward cockpit of all aircraft as well as the aft cockpit of the SR-71B.

(T5.) Steps with an enclosed T and step number apply to the aft cockpit of SR-71A/B.

(T) 6. Steps preceded by an enclosed T apply only to the aft cockpit of the SR-71B.

The same system is used for abbreviated checklists which are provided separately for the Pilot and RSO. Interior Preflight checklists are provided for each crew position. From Starting Engines on, checklists are common.

CREW COORDINATION

Crew coordination is paramount to mission success and safety of flight. Communication between crewmembers should be continuous when accomplishing checklists. Verbal coordination between crewmembers is required prior to:

a. Going off interphone.

b. Going off aircraft oxygen system or opening faceplate.

c. Changing the programmed mission or steering reference points, changing the pilot's ANS distance display mode (DP/TURN), or changing navigational system mode.

d. Changing the attitude reference.

e. The pilot pressing the indicator and warning lights test button.

f. Autopilot engagement or disengagement (including KEAS HOLD, MACH HOLD, and AUTO NAV).

g. Change of fuel panel settings or fuel crossfeed or transfer operation.

The RSO must monitor aircraft attitude, altitude, and airspeed and advise the pilot if a potentially dangerous situation exists. This is particularly important during critical phases of flight involving substantial changes in aircraft attitude, altitude, and speed.

It may be advantageous to use the interphone system HOT MIC feature for crew communication during some flight phases.

PREPARATION FOR FLIGHT

FLIGHT RESTRICTIONS

Refer to Section V for operating restrictions and limitations.

FLIGHT PLANNING

Refer to Appendix I.

TAKEOFF AND LANDING DATA

Refer to Appendix I.

WEIGHT AND BALANCE

For detailed loading information, refer to Handbook of Weight and Balance data.

PERSONAL EQUIPMENT HOOKUP - Pressure Suit

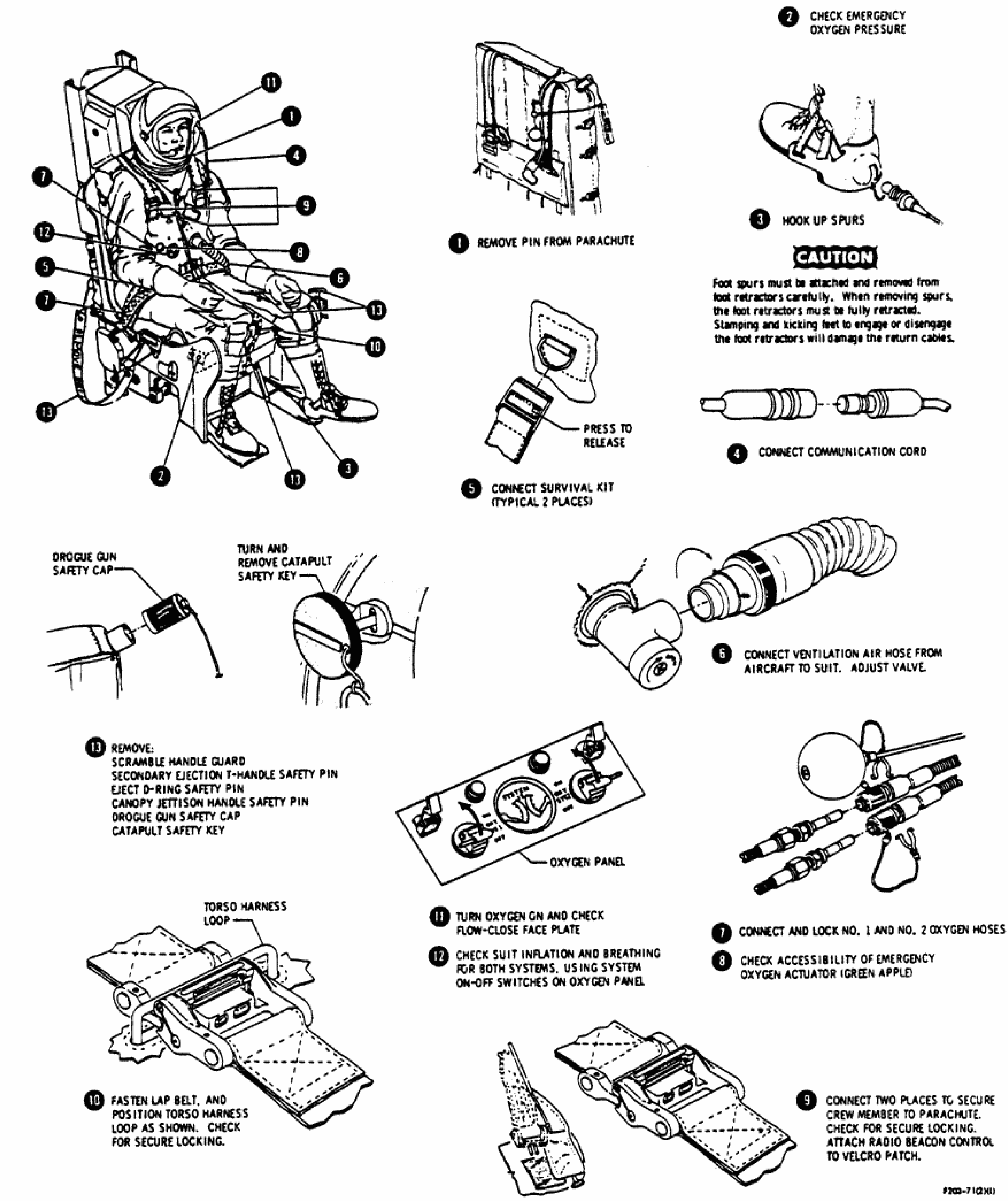


Figure 2-1 (Sheet 1 of 2)

PERSONAL EQUIPMENT HOOKUP - Shirt Sleeve Flight

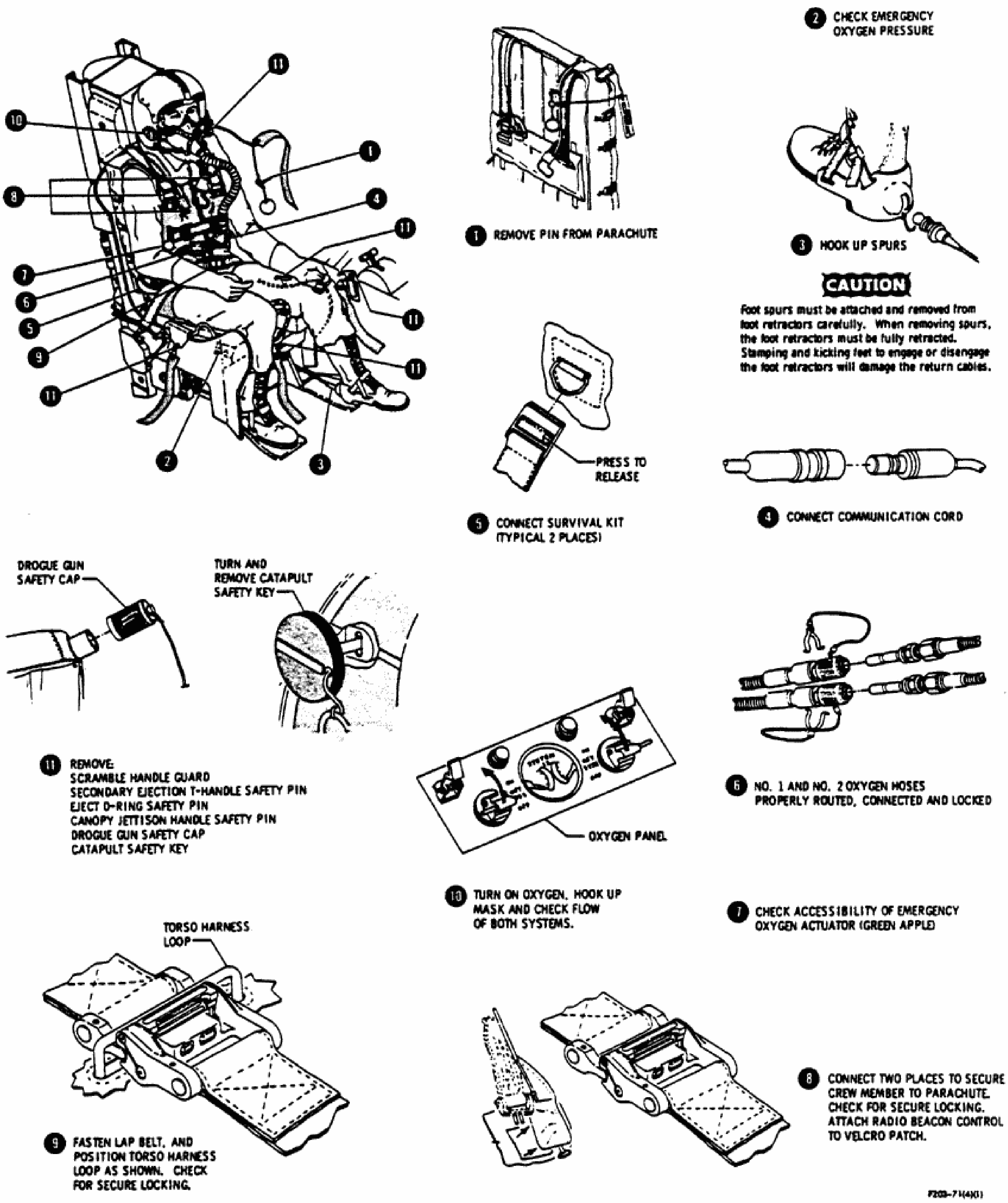


Figure 2-1 (Sheet 2 of 2)

Before each flight, check takeoff and anticipated landing gross weights and weight-and-balance clearance (Form 365F or local substitute). Note weight and moment values programmed for CG mode selector box.

NOTE

> Recommended weight and/or c.g. limits can be exceeded by seemingly normal loading arrangements. Check loading documents carefully.

AIRCRAFT STATUS

Refer to AF Form 781 for engineering, servicing, and equipment status.

PREFLIGHT CHECK - SR-71A/B

EXTERIOR INSPECTION

Because it is not practical for the flight crew to perform an exterior inspection while wearing pressure suits, the exterior inspection should be accomplished by other qualified personnel.

BEFORE ENTERING COCKPIT - SR-71A/B

▲1. Ejection seat and canopy pins -Installed

▲2. Circuit breakers - Checked in (set).

If any DAFICS computer circuit breakers are open, those in the aft cockpit should be reset approximately one minute prior to resetting those in the front cockpit.

▲3. Canopy handles - Checked.

Fwd cockpit - Locked forward.
Aft cockpit - Aft position.

4. Mode selector reference moment setting - Checked.

▲5. Publications - Checked.

FRONT COCKPIT INTERIOR CHECK - SR-71A/B

Check personal equipment hookup. (See Figure 2-1). Hookup will be performed by personal equipment personnel.

Left Console - Pilot

1. Throttle restart arming switch - NORM.
2. Liquid oxygen quantity indicators -Check SYS 1, SYS 2, and STANDBY.
   a. LOX QTY selector switch - SYS 1, IND 1.
   b. LOX quantity gage - Check both full.
   c. LOX QTY selector switch - STANDBY, IND. 1.
   d. LOX quantity gage - Check No. 1 full.
   e. LOX QTY selector switch - SYS 1, IND 1.
3. Light rheostat switches - Checked.
4. Thunderstorm lights switch - As desired.

   At night, use of these lights can facilitate the P.E. Hookup.
5. Emergency ICS switch - OFF. (Trainer only)
6. Standby oxygen system switches -OFF.
7. Control transfer panel lights - All on. (Trainer only)

Cycle control transfer switches if needed to obtain control in the forward cockpit and illuminate all four transfer lights.

8. UHF radio - ON and set.

   a. Mode - INT.

   b. VOL - Nearly full clockwise.

   c. PWR - Set.

   d. Frequency - Set.

   e. Function select - Set.

9. Oxygen control panel - Set.

10. Aft bypass position lights - Checked.

    Press to test.

11. L and R aft bypass switches -CLOSE.

12. EGT trim switches - AUTO.

13. Map projector controls - Set.

14. Throttles - OFF.

15. Throttle friction lever - Set.

16. Throttle restart switch - Cycle to OFF.

    Slide the switch to the forward bypass open and then to the restart position. Check that the MANUAL INLET and CAUTION lights illuminate. Return the switch to OFF.

17. TEB counters - 16.

Instrument Panel - Pilot

1. Cockpit pressure dump switch - OFF.

2. Bay Air switch - ON.

3. Manifold temperature switch - AUTO.

4. Landing/Taxi light switch - OFF.

5. Suit heat rheostat - OFF.

6. Face heat rheostat - Set.

   Use face heat at all times. Adjust for comfort.

   CAUTION

   o Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH position may delaminate the visor.

   o The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

7. Cockpit temperature control rheostat - 12 o'clock position.

   Cockpit temperature control may have to be adjusted for varying ambient conditions.

8. Temperature indicator selector switch - R BAY.

9. L and R refrigeration switches - OFF.

10. Cockpit temperature mode selector and override switch - AUTO.

11. Defog switch - CLOSED.

12. Brake switches - Set.

    a. Set ANTI-SKID ON, or ALT STEER & BRAKES, respectively, depending on whether the left or right engine is to be started first.

    b. Set WET/DRY switch DRY.

13. Indicators and warning lights test button - Press.

    a. Spike and forward bypass position indicators full counterclockwise, (0 inches and 100% open).

b. LN_2 and LOX quantity indicators decrease to zero.

c. All cockpit caution and warning lights illuminate.

d. Gear warning tone sounds in headset.

e. All CIP indicator needles decrease to zero.

f. Fuel quantity indicator needle moves to zero. The c.g. indicator indicates 14%.

g. The annunciator panel C.G. warning light remains illuminated until c.g. indicator needle is above 17%.

14. Fuel derich switch - ARM.

15. Landing gear lever - DOWN.

16. Cabin altimeter - Field elevation.

17. Standby attitude indicator - Erecting.

If required, pull the cage knob to erect the instrument, then release the knob. The instrument will erect and then seek 7° nose-down and 0° roll (if the aircraft is level).

NOTE

A jitter of $\pm 1/2^{\circ}$ in the pitch axis is acceptable and may occur at any pitch angle.

18. Angle of attack indicator - Checked.

Check OFF flag out of view and AOA indicates zero.

19. Drag chute control - Checked in, light off.

Verify that the drag chute handle is in the full forward detent JETTISON position and that the DRAG CHUTE UNSAFE annunciator light is not illuminated.

WARNING

The red marking on the drag chute handle shaft must not be visible.

20. Compressor inlet temperature (CIT) gage - Checked.

Check needles together and ambient temperature indicated.

21. Airspeed/Mach Meter - Checked.

a. Limit hand setting - 460 KIAS.

b. Airspeed indication - 60 knots or less.

c. Mach number indication - Right half of window blanked. Disregard Mach reading in left half of window.

22. RSO EJECTED light - Press to test.

23. Compressor inlet pressure (CIP) gage - Checked.

L and R needles and reference pointer together and indicating barometric pressure.

24. APW switch - PUSHER/SHAKER.

With ANS, INS, or TACAN selected on the Display Mode Selector switch, the ADI glide slope pointer should deflect to the lowest dot on the glide slope displacement scale. The pointer may fluctuate if there is fuselage motion in the pitch axis.

25. Spike and forward bypass position indicators - Checked.

    a. Spikes - 0 in. aft.

    b. Forward bypass - Open 100%.

26. Accelerometer - Reset.

27. L and R spike and forward bypass controls - Cycle, then AUTO.

    Check knobs for security. Check that the MANUAL INLET and CAUTION lights are on when not in AUTO.

28. L and R restart switches - Cycle to RESTART ON, then off, individually.

    Check operation of the MANUAL INLET light when in RESTART ON.

29. Projector - Checked.

    a. Verify proper loading.

    b. Check controls and lights.

    c. Illumination as desired.

30. Surface limiter release handle - Pulled, and SURFACE LIMITER caution light off.

31. Pitot heat switch - OFF.

    Check that the PITOT HEAT caution light is on.

32. Windshield rain removal and de-ice switch - OFF.

33. Trim power switch - ON.

34. A, B and M CMPTR RESET switches - Normal (Guard down).

35. Clock - Set.

36. Altimeter - Set.

NOTE

It is possible to rotate the barometric set knob through full travel so that the 10,000-foot pointer is 10,000 feet in error. Check that the 10,000-foot pointer is reading correctly.

37. Vertical velocity indicator - Checked.

    Check for zero indication.

38. TACAN control transfer switch - CONT illuminated (SR-71A).

    Press to obtain control in the forward cockpit.

39. Engine instruments - Checked.

40. Igniter purge switch - Off.

41. Liquid nitrogen quantity gages -Checked.

42. Forward transfer switch - OFF.

43. Emergency fuel shutoff switches - Fuel on (guards safety wired down).

44. Fuel dump switch - OFF (guard down).

45. Battery - BAT.

46. Emergency ac bus switch - NORM.

47. Generators - OFF.

48. Instrument inverter switch - NORM.

    Place switch to TEST and check that INST INVERTER ON light illuminates, then set to NORM.

<u>**Right Console - Pilot**</u>

1. PVD - OFF.

2. ILS power switch - ON.

3. SAS - OFF.

4. SAS lights - Test.

   All SAS panel warning lights should illuminate when the test switch is depressed including the DAFICS BIT TEST and FAIL lights.

5. Autopilot - OFF.

   Press the right console A/P OFF switch and check that the A/P OFF light is on.

6. TACAN mode selector - T/R.

7. Interphone control panel - Set.

8. IGV Lockout switches - NORM.

9. Cockpit pressure selector switch - Set.

   Select either the 10,000 or 26,000 foot setting. The 26,000 foot setting is normally desired.

10. VHF radio - TR and set.

    a. Mode select switch - As desired.

    b. Frequency control/Emergency select switch - PRE or MAN.

    c. Frequency - Set.

    d. Volume control - Nearly full clockwise.

11. Canopy seal - OFF.

TRAINER AFT COCKPIT INTERIOR CHECK

<u>Left Console - Instructor Pilot</u>

1. Thunderstorm lights switch - As desired.

   At night, use of these lights can facilitate the P.E. Hookup.

2. Light rheostat switches - Checked.

3. Throttle restart arming switch - NORM.

4. UHF modulator/demodulator (Modem) control - Set.

   a. Code selector switches - Set.

   b. Range address switch - Set.

5. Oxygen control panel - Set.

6. HF radio - OFF and set.

7. Interphone control panel - Set.

8. UHF radio - ON and set.

9. INS - Check aligning.

   a. Check present position.

   b. Function switch - NORM or STOR HDG.

   NOTE

   INS must be in NAV to obtain a valid mag heading.

   c. Check/enter desired DP's.

   d. Adjust INS segment lights as desired.

10. Aft bypass position lights - Checked.

    Press to test.

11. L and R aft bypass switches - FWD CONT.

12. EGT trim switches - HOLD & FWD CONT.

13. Map projector controls - Set.

14. Throttles - OFF.

15. Throttle friction lever - Set.

16. Throttle restart switch - Cycle to OFF.

    Check that the MANUAL INLET and CAUTION lights are on and the SPIKE DOOR transfer light on the control transfer panel is on when the throttle restart switch is not in the OFF position.

17. Emergency ICS switch - OFF.

18. UHF TRANS switch - Set.

19. Control transfer panel - Cycle to forward control.

    Verify lights illuminate when aft cockpit has control and then transfer to forward control.

20. Cockpit air handle - Off (forward).

<u>Instrument Panel - Instructor Pilot</u>

1. Indicators and warning lights test button - Press.

    a. Spike and forward bypass position indicators full counterclockwise (0 inches and 100% open).

    b. LOX quantity indicators decrease to zero.

    c. All cockpit caution and warning lights illuminate.

    d. Gear warning tone sounds in both headsets.

    e. All CIP indicator needles decrease to zero.

    f. Fuel quantity indicator needle moves to zero. The c.g. indicator indicates 14%.

2. Brake switch - OFF.

3. Landing gear switch - OFF.

4. Fuel derich switch - ARM.

5. Drag chute switch - OFF, light off.

    Check that the yellow dot in the end of the switch is visible with the guard down and the DRAG CHUTE UNSAFE annunciator light is not illuminated.

6. Airspeed/Mach Meter - Checked.

    a. Limit hand setting - 460 KIAS.

    b. Airspeed indication - 60 knots or less.

    c. Mach number indication - Right half of window blanked. Disregard Mach reading in left half of window.

7. Liquid oxygen quantity indicators -Check SYS 1, SYS 2 and STANDBY.

    Coordinate with forward cockpit to check System 1 and Standby system.

8. Clock - Set.

9. Cabin altimeter - Field elevation.

10. Accelerometer - Reset.

11. Compressor inlet pressure (CIP) gage - Checked.

    L and R needles and reference pointer together and indicating barometric pressure.

12. Compressor inlet temperature (CIT) gage - Checked.

    Check needles together and ambient temperature indicated.

13. Spike and forward bypass position indicators - Checked.

    a. Spikes - 0 in. aft.

b. Forward bypass - Open 100%.

14. L and R spike and forward bypass controls - Cycle, then AUTO.

    Check knobs for security. MANUAL INLET and CAUTION lights will not illuminate when knobs are not in AUTO unless aft cockpit has SPIKE DOOR transfer light illuminated on control transfer panel.

15. L and R restart switches, - Cycle to RESTART ON, then off, individually.

    Check that the MANUAL INLET and CAUTION lights are on and the SPIKE DOOR transfer light on the control transfer panel is on when in RESTART ON.

16. Projector - Checked.

    a. Verify proper loading.

    b. Check controls and lights.

    c. Illumination as desired.

17. Surface limiter release handle - Pulled, and SURFACE LIMITER caution light off.

18. APW switch - CONT FWD.

19. Defog switch - CLOSED.

20. Trim power switch - ON.

21. Drag chute emergency deploy switch - Stowed and safetied.

22. A, B, and M CMPTR RESET switches - Normal (Guard down).

23. Standby attitude indicator - Erecting.

    If required, pull the cage knob to erect the instrument, then release the knob. The instrument will erect and then seek 7° nose down and 0° roll (if the aircraft is level).

NOTE

A jitter of $\pm 1/2^{\circ}$ in the pitch axis is acceptable and may occur at any pitch angle.

24. Air refuel switch - OFF.

25. Altimeter - Set.

NOTE

It is possible to rotate the barometric set knob through full travel so that the 10,000-foot pointer is 10,000 feet in error. Check that the 10,000-foot pointer is reading correctly.

26. Vertical velocity indicator - Checked.

    Check for zero indication.

27. Engine instruments - Checked.

28. Forward transfer switch - OFF.

29. Fuel dump switch - OFF (guard down).

30. Emergency fuel shutoff switches - Fuel on (guards safety wired down).

Right Console - Instructor Pilot

1. SAS - OFF.

2. SAS lights - Test.

   All SAS panel warning lights should illuminate when the test switch is depressed including the DAFICS BIT TEST and FAIL lights.

3. Autopilot - OFF.

   Press the right console A/P OFF switch and check that the A/P OFF light is on.

4. TACAN mode selector - T/R.

5. Temperature indicator selector switch - R BAY.

6. Cockpit pressure selector switch - Set.

   Select either the 10,000 or 26,000 foot setting. The 26,000 foot setting is normally desired.

7. Face heat rheostat - Set.

   Use face heat at all times. Adjust for comfort.

   CAUTION

   - Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH position may delaminate the visor.
   - The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

8. ANS - Checked, MAG set.

   a. DATA Switch - TEST

      Press DISPLAY push-button switch to display data.

   b. Check mission tape number and Star Catalog number.

   c. DATA Switch - As required.

      Check Control and Display Panel readouts. Check mission modifications as required.

   d. MAG/GRID push-button switch - MAG.

9. ANS DATA Switch - NORMAL

   Press DISPLAY push-button switch to display selected data.

10. IFF - Set.

11. ILS power switch - ON.

12. MRS power switch - ON.

    Check green ON illuminated, red FAIL not illuminated.

13. Canopy seal - OFF.

AFT COCKPIT INTERIOR CHECK - SR-71A

Left Console - Aft Cockpit

1. Cockpit air handle - Off (forward).

2. Light rheostat switches - Set.

3. HF radio - OFF and set.

4. UHF radio - On and set.

   a. Mode - INT.

   b. Vol - Nearly full clockwise.

   c. PWR - Set.

   d. Frequency - Set.

   e. Function select - Set.

   f. UHF TRANS switch - Set.

5. Interphone control panel - Set.

6. INS - Check aligning.

   a. Check present position.

   b. Function switch - NORM or STOR HDG.

   NOTE

   INS must be in NAV to obtain a valid mag heading on BDHI and HSI.

   c. Check/enter desired DP's.

d. Adjust INS segment lights as desired.

7. DEF systems - Off.

System A: System A power ON legend not illuminated.
System H: Warmup and standby lights extinguished and the mode switch MAN and AUTO legends off.

WARNING

Assure that the System H Mode Indicator lights for the H LO and H HI bands are extinguished. System H transmitter radiation while on the ground is hazardous to personnel if antenna hoods are not installed.

System M: System M power ON legend not illuminated.

8. UHF modulator/demodulator (Modem) control - Set.

    a. Code selector switches - Set.

    b. Range address switch - Set.

9. Oxygen control panel - Set.

10. DEF gating generator switch - Guard down.

This switch is nonfunctional.

Instrument Panel - Aft Cockpit

1. TACAN CONT transfer switch light -Off

2. TACAN mode selector - T/R.

3. IFF - Set.

4. G-Band Beacon switch - OFF.

5. RCD display brightness control - Full clockwise.

6. Egress lights - Press to test.

Press to test the ALERT, PILOT EJECTED and BAILOUT lights.

7. Cockpit pressure selector switch - Set.

Select either the 10,000 or 26,000-foot position. The 26,000-foot position is normally set.

8. Face heat rheostat - Set.

Use face heat at all times. Adjust for comfort.

CAUTION

- Do not use the HIGH face heat position when equipped with the PPG (glass) visor except for emergency heating. Continuous use of the HIGH position may delaminate the visor.

- The face heat switch should not be set above 5 with the visor raised, or the faceplate may be damaged.

9. Camera exposure control - Checked and set.

    a. Rotate the exposure dial full clockwise to align the 90° index with the first high reflectivity dot.

    b. Set the briefed sun angle value.

NOTE

If the 90° index does not align with the first high reflectivity dot in the full clockwise position, the dial is not correctly installed. The corresponding electrical value on the sun dial will be incorrect.

10. Attitude indicator - Checked and set.

    a. Check indicator movement and set zero pitch angle.

    b. Attitude Reference Selector - ANS.

11. V/H indicator M pointer - Set.
12. Liquid oxygen quantity indicators - Check.
13. Clock - Set.
14. BDHI No. 1 needle select switch - ADF.
15. BDHI heading select switch - INS.

NOTE

INS must be in NAV to obtain a valid mag heading on BDHI and HSI.

Viewsight Control Panel - Aft Cockpit

1. V/H select switch - BUS.
2. Map drive switch - Set.
3. Map rate control - Set.
4. MAP/DATA film select switch -Set.

Right Console - Aft Cockpit

1. Canopy seal - OFF.
2. OBC Power switch - Off.
3. ANS - Checked, MAG set.
   a. Check mission tape number.
   b. Normal Display - Check C&D panel readouts.
   c. Mission modifications - Check as required.
   d. MAG/GRID push-button switch - MAG.
4. Sensor power switches - STP then OFF (ON extinguished).
   a. RADAR
   b. ELINT
   c. RCDR
   d. LH and RH TECH
   e. TERRAIN
5. NAV RCDR power switch - ON.
6. MRS power switch - ON.
7. V/H power switch - ON.
8. VWSGT power switch - ON.
9. EXPOS power switch - ON.
10. Map projector - Checked.
    a. Verify proper loading.
    b. Check controls and lights.
    c. Illumination as desired.
11. LAMP TEST - Press to test.

    Check all instrument panel and console lights.
12. Left and right technical camera CONT switches - A (Auto).
13. FMC switches - V/R.
14. V/H SOURCE - NAV.

AFT COCKPIT CHECK (SOLO FLIGHT) - SR-71A/B

NOTE

Abbreviated checklists are not supplied for this procedure.

Before flight, check the following items in the rear cockpit. The trainer aircraft shall be flown solo only from the front cockpit.

1. Lap belt, shoulder harness and all personal leads - Secured.
2. All circuit breakers - In.

WARNING

For the SR-71B:

- The following controls in the aft cockpit can override the forward cockpit:

  Aft bypass switches
  EGT Trim switches
  Throttle restart switch
  Brake switch
  Landing gear switch
  Drag chute switch
  Restart switches
  APW switch
  Air refuel switch
  Trim switches

- Trim power must be ON in both cockpits to enable the trim system.

- Fuel forward transfer switches, fuel dump switches, and emergency fuel shutoff switches must be off in both cockpits to turn the respective systems off.

Left Console - SR-71A/B (Solo)

1. Cockpit air handle - On (aft).
2. Panel, instrument, and thunderstorm light switches - OFF.

(T) 3. Throttle restart arming switch - CUT-OUT.

4. UHF modulator/demodulator (Modem) control - Set.
5. Oxygen control panel - Sys 1 and 2 ON.
6. HF radio control panel - Set.
7. Interphone control panel - Set.
8. UHF radio - BOTH, frequency set.
9. INS - Checked, set to NAV.

   a. Check present position.

   b. Check alignment complete (NAV RDY light flashing).

   c. Check/enter desired DP.

   d. Set FUNCTION switch to NAV.

NOTE

INS must be in NAV to obtain a valid mag heading.

SR-71A:

10. DEF systems - Off.

(T) 11. L and R aft bypass switches - FWD CONTROL.

(T) 12. EGT trim switches - HOLD & FWD CONT.

(T) 13. Throttle friction - OFF.

(T) 14. Emergency ICS panel - OFF.

(T) 15. UHF TRANS switch - OFF.

Check UHF TRANS switch off to provide UHF-1 with ADF and external mode operating capability.

(T) 16. Control transfer panel - Set (lights OFF).

Instrument Panel - SR-71A (Solo)

1. TACAN - T/R, frequency set.
2. IFF - NORMAL, modes and codes set.
3. Cockpit pressure switch - 26,000 FT.
4. Face heat switch - OFF.
5. UHF TRANS switch - OFF.

   Check UHF TRANS switch off to provide UHF-1 with ADF and external mode operating capability.

<u>Instrument Panel - SR-71B (Solo)</u>

1. Brake switch - OFF.
2. Landing gear switch - OFF; guard safety wired.
3. Drag chute switch - OFF.
4. S/P BAILOUT switch - OFF.
5. L and R spike and forward bypass controls - AUTO.
6. L and R restart switches - OFF.
7. APW shaker - CONT FWD.
8. Defog switch - CLOSED.
9. Trim power switch - ON.
10. Emergency chute deployment handle - Stowed and safetied.
11. A, B, and M CMPTR RESET switches - Normal (Guard down).
12. Bearing select switch - TAC/ADF.
13. Display mode select switch - ILS APCH.
14. Air refuel switch - OFF.
15. Forward transfer switch - OFF.
16. Fuel dump switch - OFF (guard down).
17. Emergency fuel shutoff switches - Fuel on (guards safety wired down).

<u>Right Console - SR-71A/B (Solo)</u>

(T) 1. SAS - ON.

(T) 2. Autopilot - OFF.

(T) 3. TACAN - T/R, frequency set.

(T) 4. Cockpit pressure switch - 26,000 FT.

(T) 5. Face heat switch - OFF.

6. ANS - Checked and set.

SR-71A:

7. Sensor power - OFF.

(T) 8. IFF - NORMAL, modes and codes set.

(T) 9. ILS panel - ON, frequency set.

10. MRS power switch - ON.

    Check green ON illuminated, red FAIL not illuminated.

11. Canopy seal - ON.

    After the engines are started, the canopy seal will inflate and remain inflated until engine shutdown.

    Close rear cockpit canopy and lock externally immediately prior to engine start.

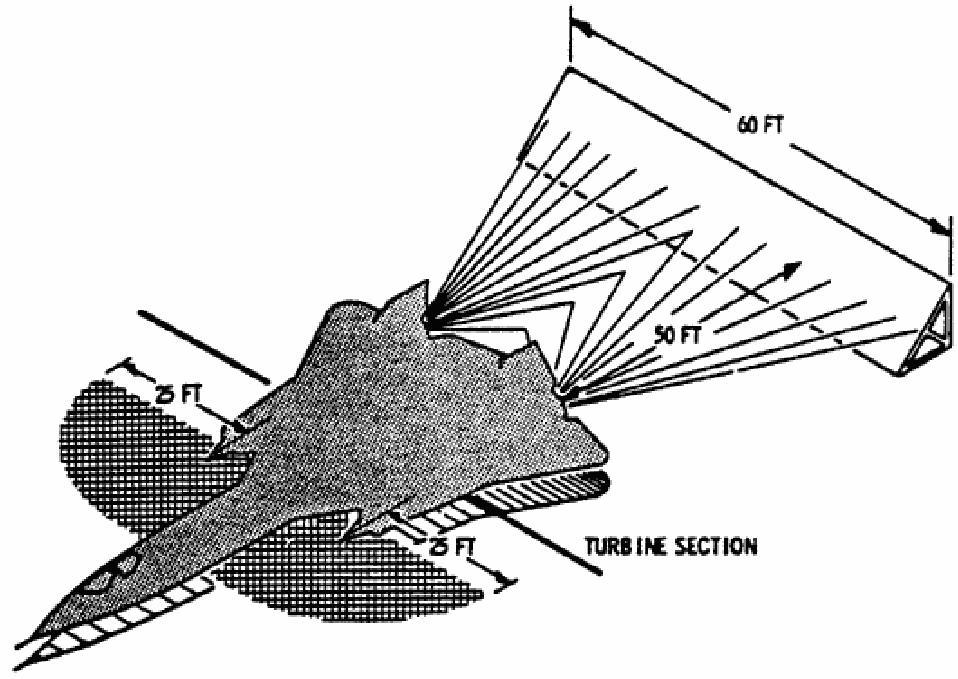
CAUTION

Leave the rear cockpit canopy open until just before engine start to maintain adequate cooling in the equipment bays. Close the front cockpit canopy followed by the rear cockpit canopy immediately prior to engine start.

DANGER AREAS - Engine Operation

WARNING

THE ENGINE TURBINE SECTION AND NACELLE INTAKE AND EXHAUST AREAS CAN BE DANGEROUS. KEEP CLEAR.
ENGINE NOISE CAN DAMAGE HEARING PERMANENTLY. DURING ENGINE RUNUP, USE EAR PLUGS AND MUFFS WITHIN 400 FEET DURING AFTERBURNER OPERATION AND WITHIN 200 FEET DURING MILITARY POWER OPERATION.



ESTIMATED JET WAKE DIAGRAMS

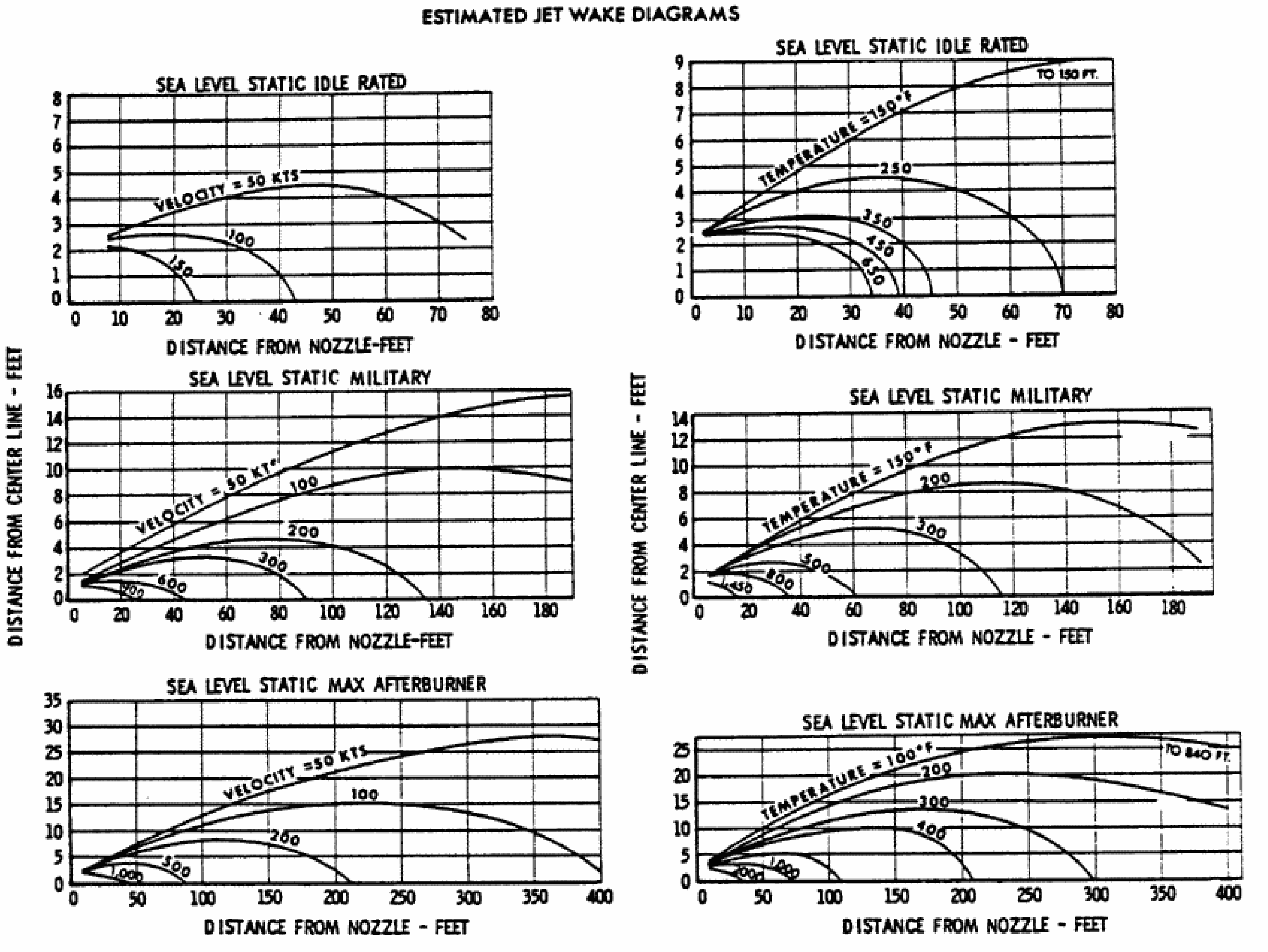
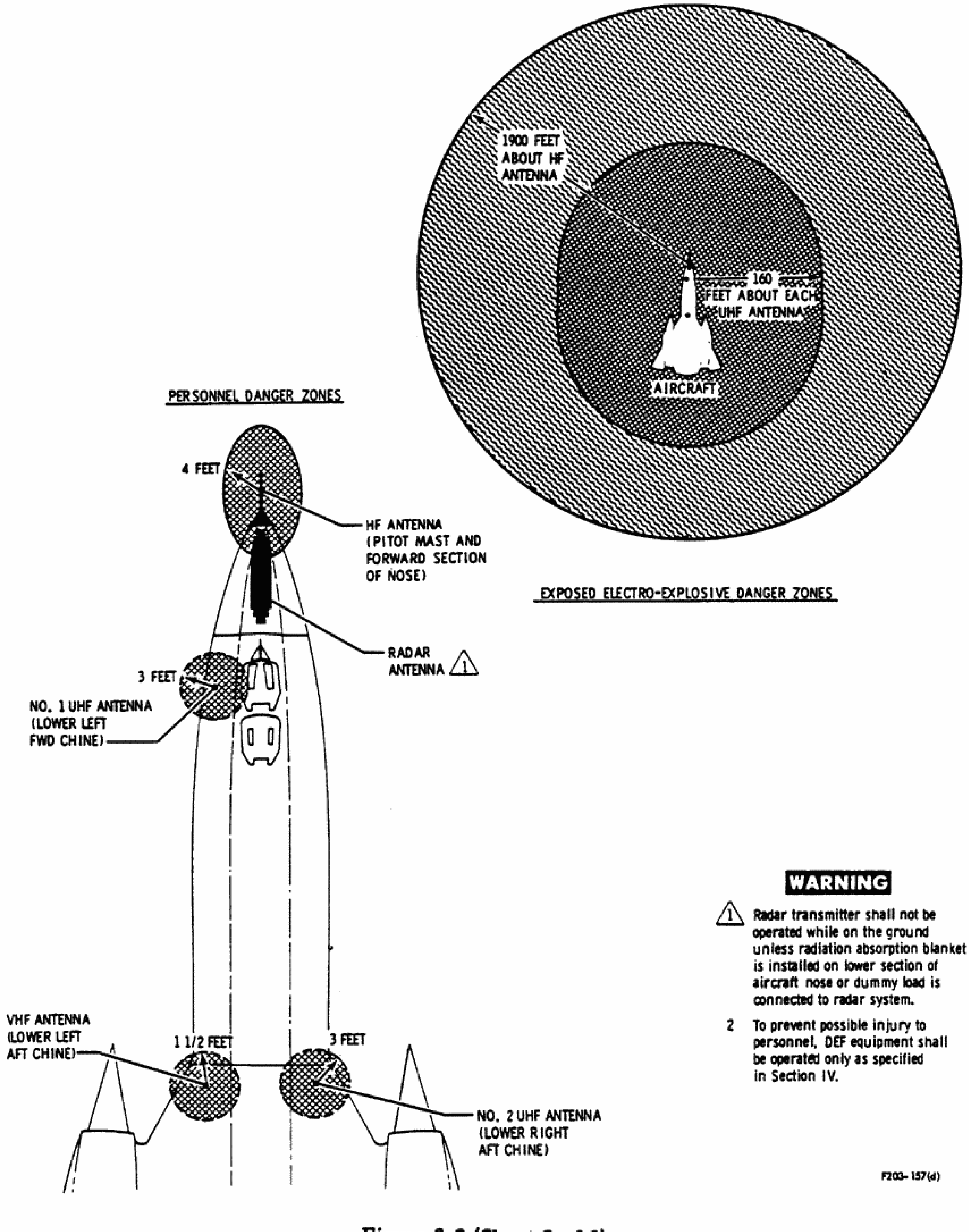


Figure 2-2 (Sheet 1 of 2)

DANGER AREAS - EMF Radiation



WARNING

1. Radar transmitter shall not be operated while on the ground unless radiation absorption blanket is installed on lower section of aircraft nose or dummy load is connected to radar system.
2. To prevent possible injury to personnel, DEF equipment shall be operated only as specified in Section IV.

F203-157(d)

Figure 2-2 (Sheet 2 of 2)

All subsequent checklists apply to both cockpits of the SR-71 A/B.

NOTE

Pilot and RSO (or IP) coordination is required. RSO (or IP) reads -Pilot responds. Alphabetized items need not be read.

STARTING ENGINES

▲1. Interphone - Checked.

Check CALL, HOT MIC, and normal functions (and emergency ICS in SR-71B).

▲2. BAILOUT light - Checked.

Coordinate ALERT and BAILOUT light illumination with switch position. Return switch to OFF (guard down).

▲3. Triple display indicator - Check.

a. Altitude - Within ±200 feet of pressure altimeter indication when altimeter is set at 29.92 inches Hg. Maximum difference between TDI's, fwd and aft cockpits, 100 feet.

b. Airspeed - 75 to 110 KEAS.

c. Mach - 0.11 to 0.2 normal.

▲4. Fuel quantity indicating system - Checked.

a. Individual tank quantities - Check. (within 550 lb between cockpits)

b. Sum of individual tank quantities - Check. (within 780 lb of TOTAL)

c. TOTAL fuel quantity - Check. (within 850 lb between cockpits)

▲5. Indicated and corrected computed c.g. - Within 0.5% MAC.

Check indicated c.g. reading between cockpits and compute c.g. with manual computer.

NOTE

While on the ground, c.g. computed using the manual c.g. computer should be corrected as follows to allow for the effect of level rather than flight attitude (with normal fuel distribution per T.O. 1-1B-40).

Total Fuel	Correction to MAC for computed c.g.*
Full tanks	-0.3%
70,000	-0.4%
65,000	-0.55%
60,000	-0.7%
55,000	-0.85%
55,000 (tank 6 empty)	-0.5%
50,000	-1.0%
45,000	-1.2%
45,000 (tank 6 empty)	-0.8%
40,000	-1.4%
35,000	-1.2%
30,000 (tank 6 empty)	-1.0%
25,000 (tank 6 empty)	-1.0%
20,000 (tank 6 empty)	-1.0%

*In level attitude, computed c.g. is aft of actual c.g. (The c.g. gage should read actual c.g.).

NOTE

When tank 6 is not full, use tank 6A and 6B scale. Fuel distribution must be obtained from mission loading form.

One minute before starting engines:

▲6. No. 1 and No. 2 oxygen systems - ON and checked.

Sys 1 and Sys 2 oxygen supply levers both latched ON and pressure checked.

▲7. Baylor bar - Latched and locked.

8. Exterior light switches - ON.

   a. FUS & TAIL switch - BRT.

   b. TAIL LT switch - STEADY.

   c. ANTI - COLLISION switch - ANTI-COLLISION.

9. Brake switch - Setting checked.

   Set ALT STEER & BRAKES if the right engine is to be started first.

10. First engine - Start.

   Although either engine can be started first, it is recommended that the left engine be started first (and shut down first) for odd numbered flights. Start the right engine first for even numbered flights. This enables a flight control system check to be made on alternate single-hydraulic systems immediately after starting.

   Ground personnel using interphone equipment will observe exhaust nozzle and nacelle inspection panels during start.

   WARNING

   Determine intake and exhaust areas are clear of personnel and ground equipment. Check fire guard(s) standing by.

   CAUTION

   o Before starting an engine, assure wheels are chocked. There is no parking brake.

   o Do not move control stick until at least 1500 psi can be maintained on the A or B hydraulic system.

NOTE

The crewchief will call the pilot when the starting unit is connected, and the pilot will instruct the crewchief to turn the unit on after verbally confirming that the engine combustion chamber drain valves are open and fuel is draining from each engine.

   a. Pilot - Signal for engine rotation.

   b. Throttle - IDLE at first indication of rpm increase.

      When necessary, an alternate technique of advancing the throttle at 1000 rpm may be used.

   c. Fuel flow - Checked for increase.

   d. IGV lights - Off.

NOTE

With pressurization of the engine fuel hydraulic system during start, the IGV position light must be extinguished (IGV cambered); if not, discontinue the start and determine the cause.

   e. Ignition - Verify within 15 seconds when using gas engine cart or within 20 seconds when using 3AG1100 air turbine starter. If no ignition indicated by an rpm increase and a rise in EGT within the allowable time, move throttle to off and continue cranking engine for 30 seconds at 1000 rpm.

CAUTION

- o In case of a false start, use Clearing Engine procedure, this section.
- o When using the 3AG1100 air turbine starter, do not exceed 5 seconds steady-state cranking operation between 1370 and 1470 rpm. Resonant frequency of the air turbine is in this range. No problems are encountered accelerating through this range, providing the transition period is less than 5 seconds.

f. Ground starting unit - Signal for disconnect at 3200 rpm.

g. If 565°C is exceeded, move throttle to OFF. If 649°C is exceeded, do not attempt to restart the engine.

NOTE

If the engine does not accelerate smoothly to idle rpm, but appears to "hang" in the 2600 to 2800 rpm range, retard the throttle to OFF and then quickly return it to IDLE. This "double clutching" procedure momentarily leans the fuel/air mixture and positions the flame front correctly in the burner cans so the engine can accelerate normally to idle rpm.

h. Idle rpm - Checked.

Engine idle speed is 3975 $\pm$ 50 rpm below 60C (140°F).

CAUTION

- o When using the MA-1A carts (or equivalent) abort start if Idle rpm is not obtained after 90 seconds.
- o When using the shelter airstart system, abort start if Idle rpm is not obtained after 120 seconds.

i. Engine and hydraulic instruments - Check normal indications.

(1) EGT - 350° to 565°C (start limit).

(2) Fuel flow - 4600 to 6300 lb/hr. A lower indication is evidence of heat sink system malfunction. If this occurs, shutdown and request investigation of circulating systems.

(3) Oil pressure - 35 psi minimum.

CAUTION

Discontinue start if oil pressure rise is not observed by the time IDLE rpm is obtained.

(4) Hydraulic system pressures - Checked.

(5) CIP should decrease to slightly below ambient.

Two minutes after engine start:

11. Flight controls - Steady neutral position.

Confirm with maintenance that the control surfaces arrive at a steady neutral position.

WARNING

Abort flight if maintenance detects surface movement without stick or rudder inputs.

12. Flight control system - Checked.

With nosewheel steering disengaged, individually check each axis for full deflection and freedom of travel in both directions. Confirm correct deflection and normal response by ground crew observation using the sequence: nose up, nose down, left roll, right roll, nose left, nose right.

If the right engine was started first and the elevon up travel is restricted, the pusher piston may be extended. Inform maintenance of the restriction, wait until the mixer access panel is removed, and then overpower the restriction. Check the flight control system after the left engine start.

If a restriction to rudder travel is felt and a force of approximately 10 pounds overpowers the restriction, the cause may be an extended rudder servo limiter piston due to the nonoperating engine. The rudders must be checked after the second engine is started to insure that the rudders are not restricted.

If nosewheel steering will not disengage, rudder control will be severely restricted in-flight with the gear down.

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of an A or B HYD warning light. The light should extinguish when flow demands diminish and normal pressure is restored.

13. Second engine - Start.

    Use the same sequence as for items a thru i of step 11.

    If the right engine was started first and the elevon up travel was restricted, check the flight control system after left engine start.

    If a restriction to rudder travel occurred after the first engine start and a force of approximately 10 pounds overpowered the restriction, check the rudders again to insure that the rudders are not restricted. If a restriction to rudder travel occurs again, a flight control system problem exists.

14. TEB counters - Checked.

15. Generators - On (NORM), and lights off.

    Check R and L GEN OUT lights extinguish.

    NOTE

    With transfer of electrical power while on the ground, the DAFICS will undergo ground re-initialization indicated by momentary illumination of the A, B, and M CMPTR OUT caution lights, OFF flags in both TDIs, and TDI resynchronization to 55,000 ft., Mach 2.0, and 300 KEAS. If DAFICS indications are abnormal, notify maintenance.

16. Generator Bus Tie light - Off.

17. External power -Disconnected.

    Signal ground crew to disconnect.

T 18. Fuel system - Checked.

   a. Check all pump, tank empty, crossfeed and pump release lights are on when TEST is pressed.
   b. Press the crossfeed switch to obtain OPEN.

      Illumination of the OPEN portion of the switch confirms crossfeed is on.
   c. Press pump switches 1 through 6 ON in sequence.
   d. Press ON an additional tank containing fuel.
   e. Press pump release switch and check that the manually selected tank is released.
   f. Press crossfeed switch OFF.
   g. Tanks 1, 3, & 6 (or 5) boost pump lights on.

19. Left and right forward bypass - Both confirmed open.

    Ground crew confirms doors open.

T 20. Spike and forward bypass position indicators - Check.

    a. Spikes - 0 in. aft.
    b. Forward bypass - 100% open.

T 21. Brakes - Normal & alternate systems checked, set ANTI SKID ON.

    Pump brakes and check normal feel while crew chief visually confirms brake actuation on both trucks. Normal feel does not necessarily indicate braking action. Perform the check both in ANTI SKID ON and ALT STEER & BRAKE. While applying moderate brake pressure, cycle the brake switch and check for a slight pedal movement (thump) and small position change when shifting between hydraulic systems. The absence of the thump indicates only one braking system available.

    Pause slightly while passing through the ANTI SKID OFF position and observe the ANTI-SKID OUT light illuminated. If the light does not illuminate, there may be an electrical/switch failure and only one braking system may be available.

    With S/B R-2695, check the antiskid disconnect feature of the trigger switch. With the brake switch in ANTI SKID ON and/or ALT STEER & BRAKE, check the ANTI-SKID OUT annunciator caution light illuminates while the trigger is depressed and extinguishes when the trigger is released.

    Set ANTI SKID ON at the conclusion of the check.

NOTE

If both engines must be shut down temporarily after start and it is necessary to retain ANS alignment, insure that ground air and power are connected and on, and turn generators off before shutting down the second engine.

CLEARING ENGINE

Cool the engine and remove trapped fuel and vapor as follows:

1. Throttle - OFF.

CAUTION

Allow a <u>minimum</u> of 1 minute for fuel drainage and coast down before motoring engine.

2. Starter - Engage and motor engine for at least 30 seconds and until EGT is below 150°C.

   Signal ground crew to motor engine at 1000 rpm. Crew chief will advise pilot when engine is clear and ready for start.

CAUTION

Do not motor the engine with the fuel shut off switch in the fuel off position except in an emergency. Damage to the engine may result with the engine fuel-hydraulic system off.

NOTE

If an electrical power interruption has occurred, cycle the MRS power switch off (light extinguished) then ON to assure reestablishment of MRS operation. Fuel boost pump circuit breakers should also be checked after electrical power interruption.

AFT TOWING - ENGINE OPERATING

Aft towing of the aircraft with engines running is permitted with:

a. Engines at idle.

b. 120,000 pounds gross weight or less.

c. Interphone communications maintained between the pilot and tow operation observer.

d. All braking accomplished by the tow tractor.

WARNING

The pilot shall not use aircraft braking except in an emergency.

e. Aircraft steering accomplished by a ground crewmember, using a nose wheel tow bar.

WARNING

Do not move the rudder pedals during hookup of the nose steering linkage at completion of towing.

BEFORE TAXIING

(T1) IFF - STBY.

(T2) HF - On.

Refer to Danger Areas, Figure 2-2, for extent of danger to personnel and exposed electro-explosive devices.

WARNING

Do not transmit on ground until safe to do so.

(T3) INS - Checked, set to NAV

Check alignment complete (NAV RDY light flashing)

NOTE

INS must be in NAV to obtain a valid mag heading on BDHI and HSI.

T 4. DAFICS Preflight BIT - Check.

a. SAS channel engage switches - ON.

b. SENSOR/SERVO lights - Checked off.

c. Cycle controls in pitch, roll and yaw and check for abnormal control surface oscillation or vibration.

d. Autopilot pitch and roll engage switches - ON.

e. Control stick trigger switch - Depress.

Check autopilot disengagement.

(T) f. Aft cockpit SAS channel engage switches - ON.

(T) g. AFCS control - Transfer to aft cockpit.

Check AFCS transfer light illuminated in aft cockpit.

(T) h. SAS Lights - Off.

Check SENSOR/SERVO lights remain off.

(T) i. Cycle aft cockpit controls in pitch, roll and yaw and check for abnormal control surface oscillation or vibration.

(T) j. Aft cockpit autopilot pitch and roll engage switches -ON.

(Note: Page 2-24A/(2-24B Blank) deleted)

Check autopilot disengagement.

(T) l. AFCS control - Transfer to forward cockpit.

m. Autopilot pitch and roll engage switches - ON.

(T) k. Aft cockpit control stick trigger switch - Depress.

Check autopilot disengagement.

(T) l. AFCS control - Transfer to forward cockpit.

m. Autopilot pitch and roll engage switches - ON.

n. Forward cockpit switch positions for DAFICS PREFLIGHT BIT - Set.

- ATT REF SELECT switch - INS
- KEAS HOLD switch - ON
- HEADING HOLD switch - ON

o. DAFICS PREFLIGHT BIT switch - ON.

The BIT TEST light illuminates steady green while the test is running. The BIT TEST light also illuminates when the function selector on the maintenance analyzer panel is not in the OFF position.

The PREFLIGHT BIT check can be terminated manually (once it is initiated) by stopping any DAFICS computer.

Pressure from A hydraulic system is required to engage the DAFICS PREFLIGHT BIT. Low pressure or flow from A, B, L or R hydraulic system will cause the DAFICS preflight BIT to fail.

If the DAFICS PREFLIGHT BIT switch will not engage, recheck:

1) CSC/NWS switch - Released.
2) ATT REF SELECT switch - INS
3) APW switch - PUSHER/SHAKER
4) SPIKES & FWD BYPASS doors - AUTO
5) RESTART switches - Off
6) Throttle Restart switch -Off
7) SAS channel engage switches - ON
8) AUTOPILOT PITCH & ROLL engage switches - ON
9) KEAS HOLD switch - ON
10) HEADING HOLD switch -ON

NOTE

If at BIT completion the FAIL light, any SENSOR light, any SERVO light, or any CMPTR OUT light illuminates, notify maintenance.

After one minute:

p. Check BIT TEST light flashing green, sensor and servo lights extinguished, BIT FAIL light extinguished, and OFF Flags in both TDI's. The CIP barber pole reads zero.

q. Check autopilot pitch and roll engage switches, KEAS HOLD switch, and HEADING HOLD switch-Off. AUTOPILOT OFF and SAS OUT lights illuminated.

The flashing BIT TEST light and SAS OUT light indicates that the SAS is still in the ground test mode.

r. Check DAFICS PREFLIGHT BIT switch - OFF (guard down).

s. SENSOR/SERVO recycle switches - Press one of the six.

Pressing one of the six SENSOR/SERVO recycle switches resets the DAFICS system to the flight mode. Check SENSOR/SERVO lights, BIT TEST light, and SAS OUT lights are out. Check both spikes have returned to the full forward position and the CIP barber pole has returned to normal. Both TDI's will initiate resynchronization and run up to 55,000 ft, Mach 2.0, and 300 KEAS. AOA will indicate 10°. AOA will return to 0° in approximately 1 min 15 sec and TDI indications will return to normal in approximately 2 min 15 sec after the DAFICS system has been reset to the flight mode. The A, B, and M CMPTR OUT annunciator panel lights will flash momentarily when the DAFICS system is reset.

WARNING

The SAS is non-functional while in the ground test mode. DAFICS will not operate normally until the system is reset. Failure to press a SENSOR/SERVO recycle switch after the DAFICS Preflight BIT is complete will cause the DAFICS to remain in the ground test mode.

T 5. Flight instruments and navigation equipment - Checked.

a. Turn display mode selector switch to:

(1) INS - Check that bearing pointer and DME display TACAN/ADF data with Bearing Select switch set to TAC/ADF. Check that bearing pointer and DME display INS data with Bearing Select switch in NORMAL. Adjust Course Set knob to check for proper CDI indications.

(2) TACAN/ADF - Tune and identify TACAN station. Check for bearing pointer and DME indication. Adjust Course Set knob to check proper CDI and To-From indications.

(3) ILS - Tune and identify ILS station. Set Course Set knob to final approach course and check CDI and glide slope indications in relation to present position.

(4) ILS/APPROACH - Adjust Course Set knob to align the course arrow with the top index. Depress ILS test buttons on ILS control panel and check for proper indications on steering bars, glide slope, and CDI.

(T6) UHF-1 and UHF-2 radios - Checked.

Check external and internal operation. For external operation, using power level 4 or less, depress CONT and INT lights to confirm normal operation. The interrogate light should remain on for three to four seconds.

7. VHF radio - Checked.

T 8. SAS channel engage switches - OFF.

T 9. Trim - Checked.

Check pitch (full travel), roll, and yaw trim and set to zero. Confirm that direction of movement corresponds with indication in the sequence: nose up, nose down, left roll, right roll, nose left and nose right. Check RH rudder synchronizer.

T 10. Flight control system - Checked.

With nosewheel steering disengaged, check each axis for full deflection and freedom of travel in both directions, and confirm correct deflection of control surfaces in the sequence: nose up, nose down, left roll, right roll, nose left and nose right.

If nosewheel steering will not disengage, rudder control will be severely restricted in flight with the gear down.

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of an A and/or B HYD warning light. The light should extinguish when flow demands diminish and normal pressure is restored.

11. Shotgun cartridge - Checked.

Confirm left and right cartridges engaged.

12. Fuel derich system - Both checked and rearmed.

a. Set both engines 400 rpm above idle speed.

b. Actuate the derich test switch until 860°C EGT is exceeded with LEFT and then RIGHT selected.

When the EGT indications exceed 860°C:

c. Verify that the EGT gage warning lights are on and that the Fuel Derich lights are on.

d. Note that engine speeds decrease between 50 and 400 rpm.

e. Cycle the fuel derich switch to REARM then ARM.

Verify that each engine returns to 400 rpm above idle, and EGT indications are normal.

f. Reset the throttles to IDLE.

13. Air refueling system and drag chute doors - Checked.

a. Air refuel switch - AIR REFUEL.

Check READY light on. Confirm doors open and light on, toggles unlatched.

b. Air refuel switch - MAN O'RIDE. Confirm door open, and light on, toggles latched.

c. Actuate stick trigger, confirm toggles retract.

d. Air refuel switch - OFF. Confirm light off, door closed.

e. Confirm with ground crew that drag chute doors are locked. A paddle indicator on the drag chute door should be flush with the fuselage contour when viewed from alongside the cockpit at the level of the crew station.

(T14.) ANS mode - Set.

The ANS is normally placed in the INERTIAL ONLY mode.

▲15. ANS - Checked.

a. Pilot set display mode select switch to ANS. Check true heading under HSI lubber line and programmed true course in HSI course window.

b. RSO check ANS heading against INS heading. Check for proper DP code and coordinates, and crosscheck command course and distance to DP with pilot.

c. Pilot check bearing select switch in both positions for normal operation of bearing pointer and DME.

d. Pilot and RSO check for normal attitude indications in both attitude reference select switch positions.

e. Pilot check standby attitude indicator.

▲16. INS - Checked.

a. Pilot set display mode select switch to INS, bearing select switch to NORMAL.

b. RSO set BDHI SEL HEADING and NO. 1 NDL switches to INS. Display distance to DP on Inertial Control Panel (Data switch set to STRG, distance is in left display).

c. Confirm INS DP bearing and distance are the same in both cockpits.

▲17. Ejection seat and canopy pins -Removed.

▲18. Canopy - Closed and locked.

Visually check engagement of canopy hooks.

CAUTION

To prevent overheating the ANS, the RSO canopy must not be closed and locked prior to the pilot's canopy unless the cockpit air handle is off (forward).

NOTE

Severe cockpit fogging may occur if cold cockpit temperature control settings are selected unless the RSO's cockpit air handle is off.

▲19. Canopy seal switch - ON.

(T20.) Cockpit air handle - On (aft).

21. L and R refrigeration switches - ON.

Minimize the time between locking the aft canopy and activation of a ship air-conditioning system. A delay increases the possibility of overheating equipment.

T 22. CANOPY UNSAFE, L and R AIR SYS OUT and CKPT AIR OFF caution lights - Off.

The RSO should recycle the cockpit air shutoff lever if the CKPT AIR OFF caution light is illuminated.

23. Ground air - Disconnect.

Signal ground crew for disconnect. Confirm the BAY AIR OFF light extinguishes.

(24.) OBC Power switch - ON.

25. PVD - On and set.

Up to 25 seconds may be required before laser line is visible.

a. Set ROLL to index.

b. Set PITCH to index or as desired.

c. Set intensity as desired.

d. Set SCALE to NORM or as desired.

WARNING

Do not look directly into the laser beam.

(T) 26. Angle of Attack indicator -Checked.

Check OFF flag out of view and AOA indicates zero.

T 27. Periscope - Checked.

T 28. Nosewheel steering - Engaged and checked.

Nose should swing as rudder pedals are moved slightly. Nosewheel STEER ON light should illuminate.

29. Panels and gear pins - Secured and removed.

Crewchief confirms all panels and doors secured. Crewchief disconnects interphone and displays landing gear downlock pins.

(30.) OBC self test - Completed, OPR/STP light on.

CAUTION

If installed, the Optical Bar Camera must always be operated in the standby or operate modes while in flight; if shut down, the optical bar may be damaged.

TAXIING

Observe crewchief for signal.

CAUTION

Taxi and turn at low speed to minimize side loads on the landing gear. Fast taxiing should also be avoided to prevent excessive brake and tire heating and wear.

T 1. Braking and nosewheel steering - Checked.

When clear of obstacles disengage nosewheel steering and check individual brake operation on L and R systems, and for dragging brakes. Release pedal pressure before changing hydraulic systems. Engage NWS and check steering operation.

NOTE

Rudder pedal feedback, due to nosewheel castering, indicates that nosewheel steering has not disengaged. The STEER ON light also remains on.

T 2. Turn-and-slip indicator - Checked.

Check turn needle deflection in the direction of turn and ball free in race.

T 3. SAS lights - Checked.

Check SAS control panel for PITCH, ROLL, or YAW SENSOR lights during turns or braking. Attempt to reset SENSOR lights. All SENSOR lights should be out prior to takeoff.

(T4.) ANS - As desired.

If the ANS is in the INERTIAL ONLY mode and NAVIGATE/ASTRO INERTIAL mode is desired for takeoff, place the ANS in NAVIGATE/ASTRO INERTIAL.

BEFORE TAKEOFF

▲1. Pilot's ANS distance display mode - DP/TURN.

(Ta.) ANS DATA switch - TEST.

Press DISPLAY push-button switch to display data.

(Tb.) DP/TURN push-button switch - As desired.

RSO will coordinate the pilot's desired ANS distance display mode.

2. Flight instruments - Set for takeoff.

a. Display Mode Select switch - Set.

b. Attitude Reference Select switch - INS.

c. For instrument departure, tune and identify TACAN station.

d. HSI Course Select knob - Set.

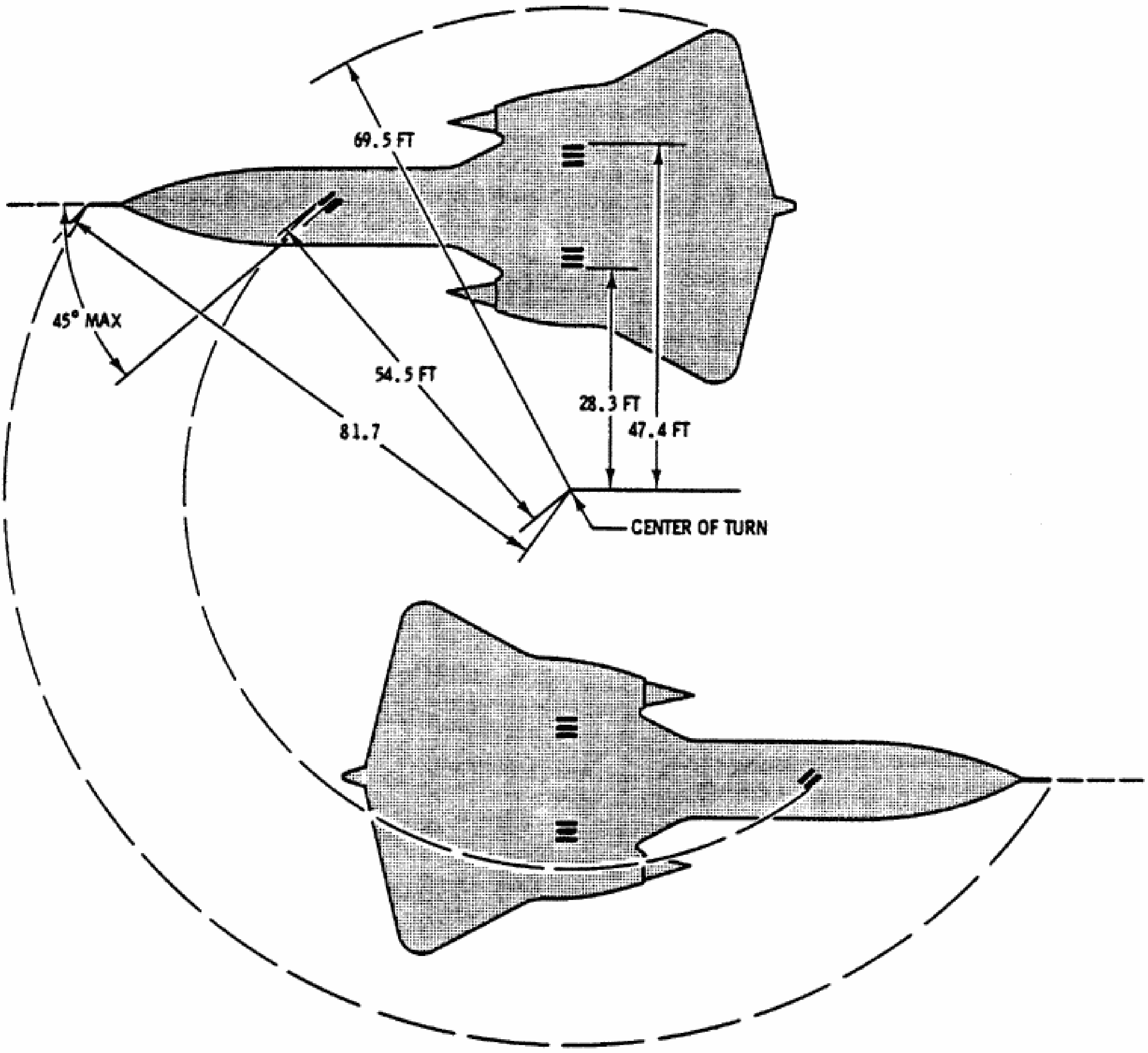
3. Engine run - Lockout and EGT trim checked.

a. Wheels - Chocked.

b. Brakes - Apply.

c. IGV switches - LOCKOUT.

MINIMUM TURNING RADIUS



NOTE

101.9 MINIMUM RUNWAY WIDTH REQUIRED FOR 180-DEGREE TURN (MAIN GEAR WHEELS ON EDGE OF RUNWAY AT START OF TURN).

F203-5d(a)

Figure 2-3

One engine at a time, with AUTO EGT selected:

d. Throttle - Military.

Move the throttle smoothly to the Military stop, observing ENP and EGT. EGT should increase and ENP indication should move toward zero. An EGT gage COLD flag will appear when the throttle reaches the Military position if EGT is below the nominal trim band.

NOTE

Automatic trimming does not occur until the throttle is positioned at or above the Military position.

e. Throttle - Retard approximately one-half inch aft of the Military position and return to Military rapidly. This removes hysteresis from the fuel control linkage. Hold the military power throttle setting for at least 30 seconds to allow MRS recording of engine parameters.

Note EGT gage COLD/HOT flag operation. If the throttle is retarded before EGT reaches the nominal trim band, disappearance of the COLD flag while the throttle is retarded confirms normal operation of the automatic EGT trim system permission circuit.

f. IGV light - Off.

The IGV position light should remain off.

g. IGV switch - NORM (as EGT approaches the nominal trim band).

h. IGV light - On.

The IGV position light should illuminate immediately when IGV NORM is selected, indicating an IGV shift to the axial position. The nozzle should open slightly at IGV shift.

NOTE

- Do not takeoff if the IGV position light fails to illuminate.
- An inoperative IGV lockout which is detected during the before takeoff trim check does not require aborting the flight.
- The engine IGV light should not illuminate on rpm increase with its IGV switch in the LOCKOUT position. With IGV NORM selected, the engine IGV light should illuminate during rpm increase (approximately 300 to 800 rpm below the Military rpm schedule) and extinguish when the guide vanes reach the cambered position as the throttle is retarded to idle.

i. EGT trim - As required.

Check automatic EGT trims to within the nominal band shown by Figure 2-4.

If a HOT flag appears and EGT approaches an overtemperature condition, retard the throttle, select manual EGT control, downtrim as required, then recheck trim at Military in AUTO EGT.

If no HOT or COLD flag is observed and EGT is normal at Military power, downtrim EGT momentarily in manual control, then select AUTO EGT. At Military, the COLD flag should appear temporarily, and the engine should retrim to the AUTO EGT deadband range.

If Auto EGT is unusable, trim manually as shown in Figure 2-4.

j. RPM - Check engine speed vs the schedule shown by Figure 2-4.

k. Engine and inlet instruments - Check.

EGT Auto Trim Check Schedule

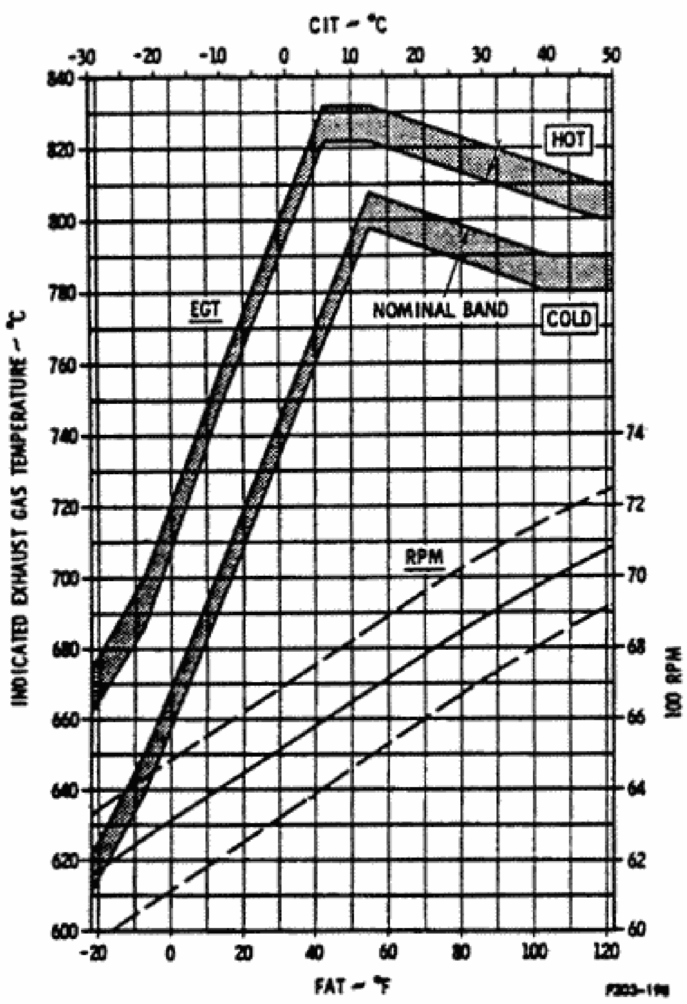


Figure 2-4

Check engine instruments for normal indications. Note ENP and fuel flow values (for engine comparison), and oil pressure values. Note L and R CIP; CIP indication should be less than at idle.

4. EGT trim switches - HOLD or AUTO

During cold temperature ground operations, engine surge (compressor stall) may occur at or above military power if EGT goes above the nominal trim band.

With EGT trim in AUTO, EGT uptrim starts when the throttle is advanced to the military position and continues until EGT increases into the deadband. Even if an engine was previously trimmed within the deadband, thermal lag results in a slight EGT overshoot when readvancing the throttle to military.

a. To avoid compressor stalls on takeoff when outside air temperature is below 15°C (59°F), position EGT trim to HOLD after stabilized in military power within the nominal EGT operating band. Select automatic trim, if desired, after takeoff.

Engine surge should not occur when ambient temperature is above 15°C (59°F).

If compressor stalls occur during engine run, retard throttle and downtrim EGT. Refer to Exhaust Gas Temperature Limits, Ground Operation, Section V.

b. Throttle - Retard smoothly to IDLE.

Check that ENP indication is normal during power reduction.

NOTE

After retarding from Military power to IDLE, do not readvance the throttle for at least ten seconds (for the engine to stablize at idle rpm). Otherwise, stall and dieout may occur. The stall may be inaudible, but dieout is indicated by decreasing rpm and, particularly, by increasing EGT. If dieout occurs, move the throttle to OFF to prevent overtemperature. The engine may be restarted as soon as a starter is available; accomplish Clearing Engine checklist. The stall and dieout occur only during ground static operation and is more likely when relatively high ambient temperatures exist.

c. IGV light - Off.

The IGV light should extinguish.

NOTE

If cockpit fog is encountered, increase cockpit temperature. Twelve-to-one o'clock auto-temperature control rheostat positions are normally sufficient.

T 5. Flight controls and trim settings -Check.

Cycle and check hydraulic pressure. Recheck trim settings zero.

▲6. Fuel sequencing - Checked.

a. Check tanks 1, 3, and 6 or 5 ON, depending on fuel load, and quantities decreasing. If less than full load, check tank 4 increasing.

NOTE

To check tank 3 pump operation, if no decrease in tank 3 fuel quantity has been noted, transfer fuel or increase left engine rpm.

▲7. CG - Checked.

Takeoff c.g. must be forward of 22%. (To check the c.g. which will occur in the flight attitude, increase the indicated c.g. value by the amount of the hand-held c.g. computer correction.) When the takeoff fuel load is above 70,000 pounds, the c.g. should be no further forward than 20%. With less than 70,000 pounds of fuel, c.g. should not be aft of 20% while level, to allow for the aft c.g. shift during takeoff.

NOTE

- A supersonic leg with less than a full fuel load may require manual control of the fuel system to achieve a desirable supersonic c.g.
- Press the Tank 5 or Tank 4 boost pumps on before transferring fuel forward. Otherwise, with crossfeed off, a reduction in fuel flow to approximately 3600 lb per hour will occur on the right side. This is less than the desired value for normal operation of the fuel heat sink system. Release the tank after completing fuel transfer.

T 8. Forward transfer - OFF.

T 9. Fuel Derich switch - ARM.

▲10. No. 1 and No. 2 oxygen systems - ON and pressure checked.

Verbally confirm oxygen latched ON with normal pressure.

▲11. Baylor bar - Latched and locked.

12. Brake switches - DRY or WET, and ANTI SKID ON.

Use the DRY position for a RCR of 21 or more. Wet runway conditions shall be assumed to exist and the WET position used if RCR is less than 21. If RCR is not available, assume a wet runway condition if moisture is visible on the runway, particularly as evidenced by glare or reflections.

▲13. Takeoff data - Review.

a. Acceleration Check.

b. Refusal speed.

c. Rotation speed.

d. Takeoff speed.

e. Single-engine speed.

NOTE

If a tire cooling period has been required, do not takeoff until ground crew signals that tire condition is satisfactory.

14. Pitot heat switch - ON and checked.

Ground crew confirms heat on.

15. Battery switch - Checked BAT.

16. Instrument inverter switch - Checked NORM.

(T17) INS altitude - Update.

Update the INS altitude to the sustained or mid-altitude expected after takeoff, i.e. enter A/R altitude, or if climbing immediately to cruise conditions enter 35,000 or 40,000 feet.

18. VHF radio antenna cover - Removed.

Ground crew displays cover to pilot.

TAKEOFF

(T1) IFF - NORMAL

Set proper mode and code.

2. SAS - Engaged, lights off.

   a. Channel engage switches - ON.

   b. SENSOR/SERVO lights - Check off.

   c. BIT TEST light - Check off.

WARNING

The SAS is non-functional while in the ground test mode. DAFICS will not operate normally until the system is reset. Failure to press a SENSOR/SERVO recycle switch after the DAFICS Preflight BIT is complete will cause the DAFICS to remain in the ground test mode.

(T) 3. Aft cockpit SAS - ON.

Channel engage switches all ON.

NOTE

For normal operations, all SAS channel engage switches should remain ON in both cockpits for entire flight regardless of which cockpit has AFCS control.

(T) 4. AFCS control - Transfer to other cockpit.

Check AFCS transfer light illuminated in cockpit not previously in control.

(T) 5. SAS Lights - Off.

Check SENSOR/SERVO lights remain off.

(T) 6. AFCS control - As desired.

WARNING

In the SR-71B, only the positions of the SAS channel engage switches in the cockpit that has the AFCS transfer light illuminated on the control transfer panel effect the SENSOR/SERVO and SAS OUT caution lights. No warning is displayed if the SAS channel engage switches are not ON in the cockpit that does not have AFCS control. If the SAS engage switch(es) are OFF in the cockpit that does not have AFCS control, transferring AFCS control to that cockpit results in loss of SAS until the SAS switch(es) are engaged.

▲7. Warning and caution lights - Checked.

Any amber caution lights (autopilot, cockpit air, etc.) which remain on must be justified by an intentional and acceptable operating situation. Do not start a takeoff if any red warning lights are on.

▲8. Circuit breakers - Checked.

9. Tank 4 boost pump switch - Press on.

▲10. Compass - Checked.

Check INS and standby compass against runway heading. Start ANS runway heading alignment when required.

11. Nosewheel steering -Engaged.

Confirm STEER ON light illuminated.

Refer to Figure 2-5 for illustration of the typical sequence of events during takeoff.

a. Brakes - Release when IGV lights illuminate (approximately 6000 rpm) as the throttles are advanced.

CAUTION

The tires may skid if the brakes are held at high thrust.

NOTE

Abort takeoff if IGV position lights fail to illuminate with Military rpm during engine acceleration.

b. At Military power - Check engine instruments for values at or approaching those observed during trim.

(1) Tachometer.
(2) EGT.
(3) Nozzle Position.
(4) Oil Pressure.

c. Throttles - Advance to mid afterburner range for A/B ignition, then smoothly advance to maximum afterburner.

CAUTION

- To prevent overspeed, afterburners must not be ignited before engines reach Military rpm.
- Abort the takeoff if an afterburner fails to ignite within 3 seconds.
- Advancing the throttle will result in momentary nozzle excursion, and engine transient speed oscillation may approach 250 rpm.

d. Maximum A/B - Check engine instruments.

Exact readout of these instruments is time consuming. The readouts should be anticipated and needle position checked against a clock position. If there is any indication of deficient engine performance during throttle advancement, abort the takeoff. If possible, any abort decision should be made before the aircraft has reached high speed. Refer to takeoff performance data in the Appendix. Directional control should be maintained with nosewheel steering up to nosewheel lift-off speed.

e. Acceleration - Check.

Check KIAS against computed acceleration check speed at selected acceleration check distance. Refer to takeoff performance data in the Appendix.

NOTE

Failure of the IGV lights to remain illuminated during takeoff results in inability to develop full rated thrust; unless a more serious malfunction is indicated, the takeoff may be continued if the acceleration check speed has been reached satisfactorily.

ROTATION TECHNIQUE

In general, the tires are more vulnerable to blowouts during takeoff than at landing because of the higher groundspeeds and gross weights involved. Wing lift quickly relieves the gear load as the nose is raised. Apply smooth, constant back pressure 15 to 25 knots below computed rotation speed. Lift the nosewheel off at rotation speed, using the rotation rate required to leave the ground at computed takeoff speed. Depending on gross weight, normal takeoff attitude is 8° to 10°

TAKEOFF - Typical

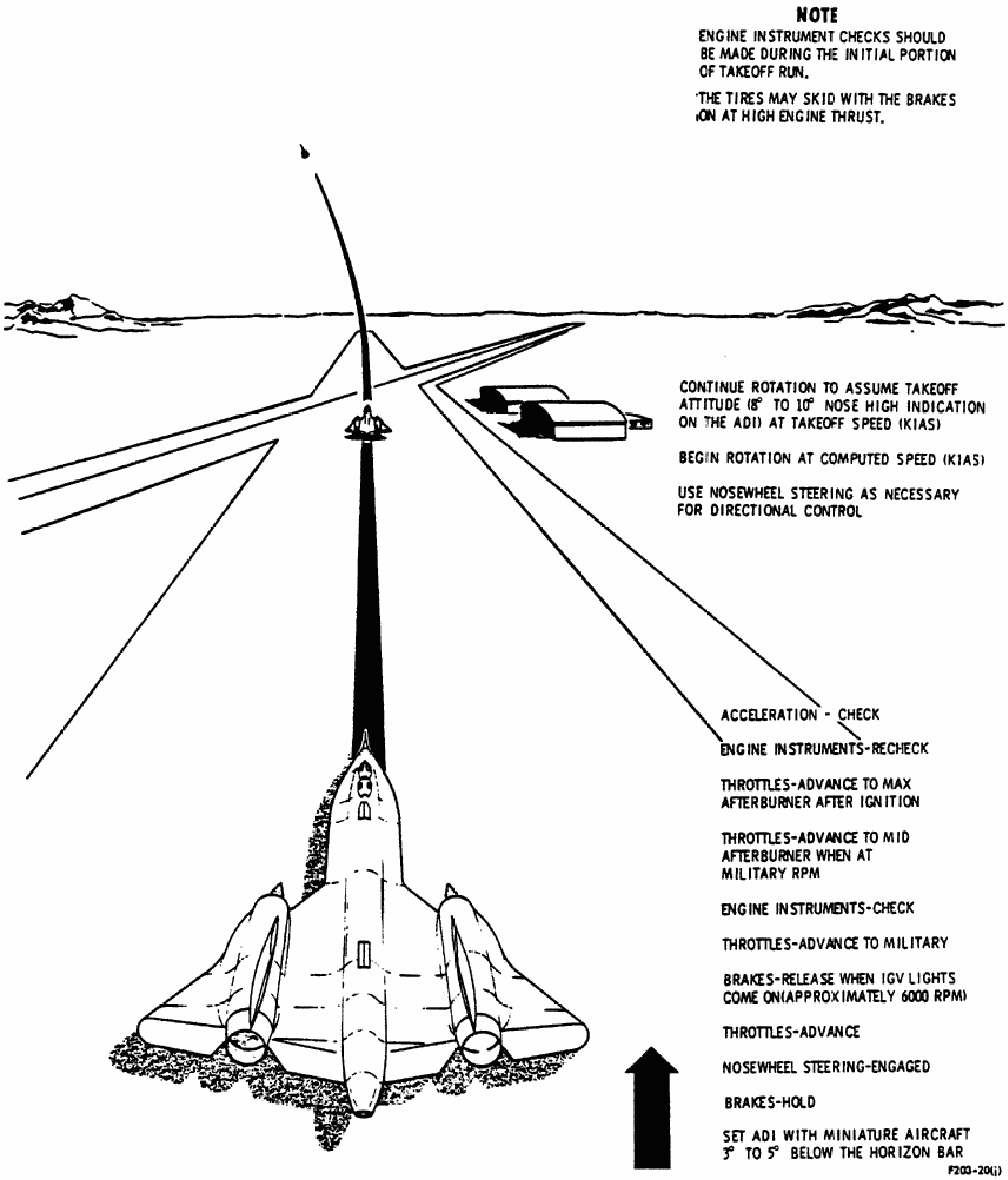


Figure 2-5

nose high indication on the ADI. The transition from start of rotation to takeoff requires approximately 5 seconds when using the normal takeoff technique. Refer to Takeoff Speed Schedule in Part II of the Appendix for rotation and takeoff speeds.

Premature nosewheel liftoff should be avoided because the unnecessary drag extends the ground run and may result in excessive tire loads.

NOTE

> AOA indicates zero at airspeeds less than 100 KEAS and actual AOA at higher airspeeds.

CROSSWIND TAKEOFF

The aircraft weathervanes into the wind during crosswind takeoffs when the nosewheel lifts off and nosewheel steering is no longer available. Rudder pressure must be held to counteract the crosswind. A definite correction must be made as the aircraft breaks ground. Apply lateral control as necessary for wings-level flight. Both the directional and lateral control applications are normal and no problems should be encountered when taking off during reasonable crosswind conditions.

AFTER TAKEOFF

When definitely airborne:

1. Landing gear lever - UP.

   Gear retraction requires 12 to 16 seconds.

WARNING

- Single engine operation is critical immediately after takeoff. Increasing airspeed and decreasing angle of attack have greater benefits than gaining altitude at a maximum rate. Single engine flight capability is presented in Part II of the Appendix. With gear down, the minimum safe speed out of ground effect is approximately 30 knots greater than in ground effect.
- Immediately depress the control stick trigger switch to deactivate APW System stick pusher operation if a false stick pusher warning occurs. If the stick pusher is not deactivated by the trigger, use a pull force of 30 to 35 pounds in addition to normal stick forces to overcome the stick pusher spring. Use pitch trim to relieve stick force.

After gear retraction is completed and single engine flying speed is obtained, establish climb power as desired. A military power climb conserves fuel.

2. Engine instruments - Check.

At Mach 0.5:

3. Surface limiter - Engaged, SURFACE LIMITER light off.

   Rotate handle counterclockwise and release to engage limiters.

4. Attitude Reference - ANS (pilot).

   The RSO will crosscheck attitude sources before the pilot selects the opposite reference. This is especially critical for night or instrument flight conditions.

   NOTE

   The RSO should vigilantly monitor attitude during takeoff/climb out and crosscheck his attitude indicator references by alternately selecting ANS/INS. He will notify the pilot immediately if any abnormal attitude is suspected.

5. EGT trim switches - AUTO

CLIMB

NOTE

If the cockpit air handle was positioned OFF for takeoff, wait until a safe altitude out of the moist air before positioning the handle to on. Approximately 5000 feet above ground level should be sufficient.

Normal climb is 400 KEAS until Mach 0.90 is intercepted, then hold Mach 0.90.

WARNING

If moderate turbulence is encountered, reduce airspeed to 300 - 350 KEAS while subsonic. Climb at 400 KEAS if supersonic, or decelerate to subsonic speeds at 350 KEAS if the climb cannot be continued. Refer to Section VII, Operation in Turbulence.

NOTE

The pilot must advise the RSO of autopilot engagement or disengagement and the mode(s) affected.

1. PUMP REL switch - Press, Tank 4 released, light out.

   During climb at maximum power when the right-hand shut-off float switches in tank 1 have been actuated because of tank depletion or flight attitude, illumination of the L and/or R FUEL PRESS warning light(s) (a fuel low pressure warning) may occur if tank 4 is released. At maximum power, do not release tank 4 at low altitude.

T 2. Altimeter - Set.

   Set 29.92 as required.

(3.) Sensor power - As briefed.

   All sensor power switches except DEF may be turned on at this time. The RCD or IPD power switch ON legend should illuminate when Radar power is applied. The OBC should be in STBY before takeoff.

   Sensor warmup times are:

RADAR	-	6 min.
RCD	-	1 to 3 min.
EIP/EMR	-	2 min.
TECH	-	20 to 40 sec.

   Ensure TECHs and radar in AUTO or MANUAL modes as required.

(T) 4. HF radio - Retune (618-T-only).

   Recycle HF tuning to in-flight antenna impedance by momentarily placing freq control knob off-frequency, then back to original position. Recycle antenna coupler by keying transmitter.

WARNING

Rf energy from the HF radio during tuning or transmission has caused erroneous light and instrument indications.

(5.) DEF system power - As briefed.

Depress DEF System A power switch to illuminate the ON legend. After two minutes warm-up, the S (standby) legend should illuminate.

Depress the DEF F/H power switch. The W (warm-up) legend illuminates immediately. In approximately five minutes, the W legend extinguishes and the S (standby) legend illuminates.

Depress the DEF M power switch to illuminate the W and ON legends. After three minutes warmup, the W legend extinguishes.

(6.) DEF systems - Checked.

Refer to the DEF System Procedures, Section IV.

CAUTION

To avoid DEF system damage due to overheating, do not exceed the transmission time periods scheduled for the checks while testing in the manual mode below FL 500.

NOTE

These tests can be finished after transonic acceleration if the system warm-up time requirement does not allow earlier completion.

(7.) G-band Beacon switch - As required.

Attitude Control

Each crew member must be aware of attitude reference operating characteristics and be alert for failures. The RSO should select INS attitude reference when the pilot has ANS selected, and vice versa. The pilot should crosscheck attitude with the standby attitude indicator. The RSO should periodically cross check attitude reference sources by alternately selecting INS and ANS.

If the ANS nav-ready signal is lost, the pilot's ANS REF annunciator caution light illuminates, and the RSO's ANS FAIL annunciator caution light illuminates. If the pilot's ATT REF select switch is in ANS: the autopilot disengages, the DAFICS ANR light flashes (flashing DAFICS Preflight BIT FAIL light), the PVD is inhibited, and the power OFF flag appears in the ADI. If the RSO's ATT IND switch is in ANS, the power OFF flag appears in the attitude indicator.

If the INS is operating in the attitude mode, the pilot's INS REF annunciator caution light illuminates. If the pilot's DISPLAY MODE SEL switch is in any position other than ANS, the course warning flag comes into view.

If the INS platform fails, the pilot's INS REF annunciator caution light illuminates. If the pilot's ATT REF SELECT switch is in INS: the autopilot disengages, the DAFICS ANR light flashes (flashing DAFICS Preflight BIT FAIL light), the PVD is inhibited, and the power OFF flag appears in the ADI. If the RSO's ATT IND switch is in INS, the power OFF flag appears in the attitude indicator.

ACCELERATION

The TDI is the primary speed and altitude reference for acceleration to, during, and for deceleration from supersonic flight. The pilot should crosscheck TDI indications with the pitot-static instruments. The RSO should monitor altitude, attitude, and speed. Cross-check navigation system ground speed against aircraft speed indications.

SUPERSONIC AIRSPEED SCHEDULES

The optimum supersonic airspeed is 450 KEAS while climbing between Mach 1.25 and

NORMAL EVENTS AFTER TAKEOFF OR REFUELING DURING TRANSITION TO SUPERSONIC CRUISE

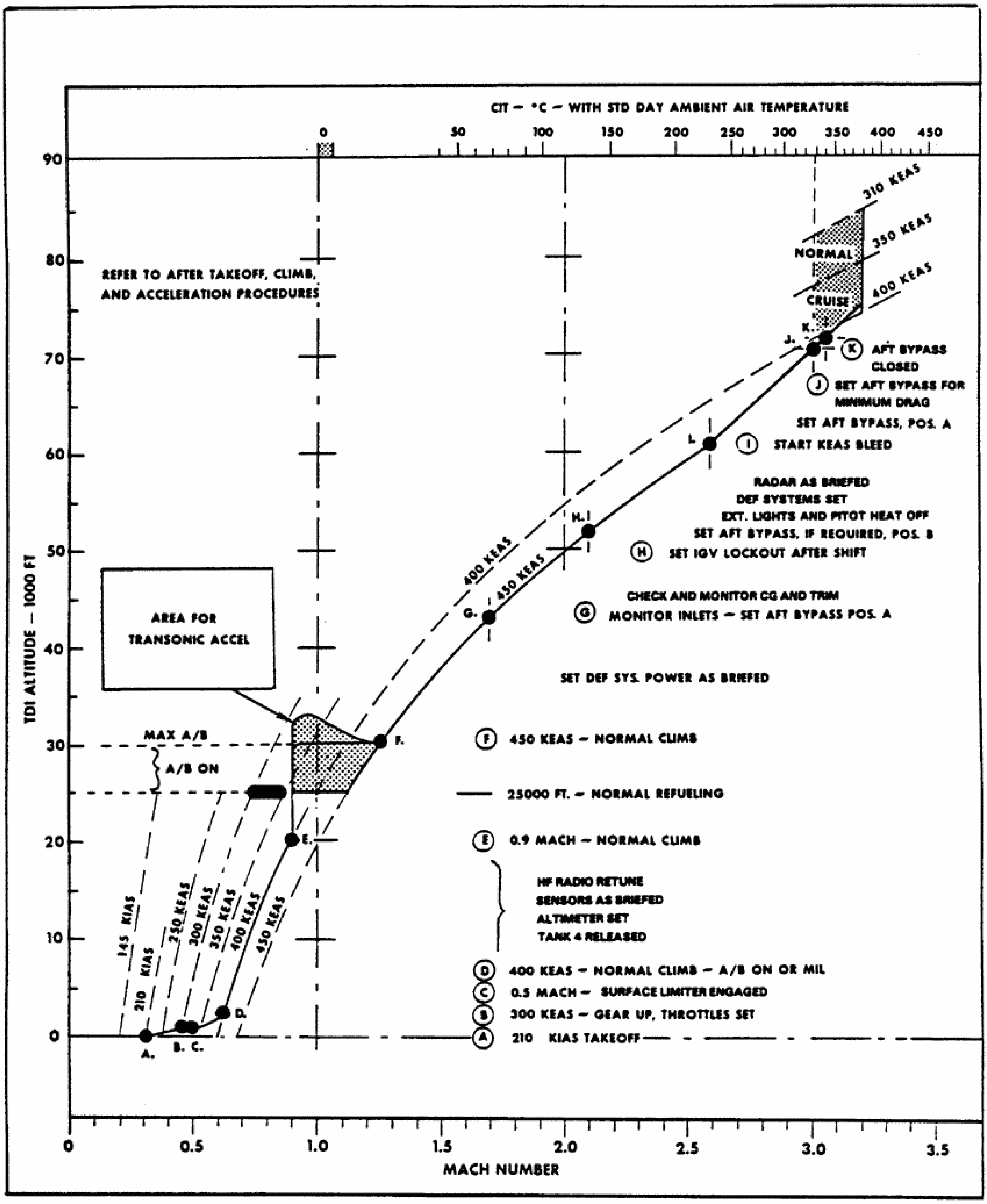


Figure 2-6

Mach 2.6. Lower airspeeds such as 400 or 375 KEAS may be used, as when turbulence is encountered, but performance is considerably degraded.

TRANSONIC ACCELERATION PROCEDURE

Transonic acceleration is accomplished at either a level altitude or during a climb-and-descent maneuver.

NOTE

> The climb-and-descent acceleration is recommended for best specific range (NM per pound of fuel used).

Level Acceleration

A level acceleration to intercept the supersonic climb speed schedule can be made at refueling altitude, normally 25,000 feet. When ambient temperatures are near or lower than standard, less time and distance are required to intercept the climb speed schedule than the climb-and-descent procedure. The total range penalty is small under these conditions.

Start the acceleration with minimum afterburner. Complete course changes while subsonic so that the additional power required for turning will not diminish the power available for transonic acceleration. Set maximum power at Mach 0.9. Gently increase pitch to climb attitude near 430 KEAS. A smooth technique is required, as 450 KEAS is only slightly more than Mach 1.1 at 25,000 feet and is still within the critical thrust/drag speed range which begins near Mach 1.05.

WARNING

> Airspeed may increase rapidly after Mach 1.1 is reached. Reduce power (below Military, if necessary) to avoid high airspeeds. Do not use excessive load factors to prevent exceeding 450 KEAS.

The procedure can be used at another altitude; however, when lower, the transition to 450 KEAS climb attitude must be made in the unfavorable speed range from Mach 1.05 to 1.10. At higher altitudes, the transition through this speed range can be completed before starting the climb, but less thrust is available. If ambient temperature increases, thrust decreases and the time, fuel and distance penalty for using the level acceleration procedure is greater.

Climb-And-Descent Acceleration

The climb-and-descent procedure requires less fuel to intercept the climb speed schedule than the level acceleration when ambient temperatures are warmer than standard.

NOTE

> The climb-and-descent procedure is recommended for best specific range (NM per pound of fuel used) at all temperatures.

WARNING

> Although angle of attack increases during the subsonic climb, pitch attitude must decrease to avoid dangerous flight conditions. Failure to monitor and control attitude, speed, and angle of attack can result in approach to pitch-up conditions.

Start the acceleration with minimum afterburner power. Intercept 0.9 Mach. Set maximum afterburner at 30,000 feet for the remainder of the acceleration, observing the 300 KEAS restriction. At 33,000 feet, increase speed to at least Mach 0.95. This speed is slightly above the start of the drag rise region. Make a smooth transition to establish a 2500 to 3000 fpm rate of descent.

NOTE

Engine stalls during the subsonic climb may indicate a potentially dangerous flight situation. Stalls can result from low CIP or high distortion in the inlet associated with aircraft operation beyond established flight limits. Refer to Subsonic Compressor Stalls, Section III.

After establishing the descent rate, maintain attitude until initiating climb. Avoid higher rates of descent since the usual result is altitude penetration below 29,000 feet and high fuel consumption.

When using the climb-and-descent procedure, it is important to exceed Mach 1.05 early in the descent, and to avoid turning until the climb is established. Begin the transition to climb near 435 KEAS so as to intercept 450 KEAS while climbing.

WARNING

- Airspeed may increase rapidly after Mach 1.1 is reached. Reduce power (below Military, if necessary) to avoid high airspeeds. Do not use excessive load factors to prevent exceeding 450 KEAS.
- In turbulence, reduce climb speed as specified in Section VII, Operation in Turbulence.

Transonic Acceleration Performance Comparison

Figure 2-7 is provided for convenience only. Refer to the appendix for detailed performance values.

TRANSONIC ACCELERATION PERFORMANCE COMPARISON
140,000 initial gross weight
Initial speed = Mach 0.75 at 25,000 feet

Temp difference from Std.		-10°C	Std	+10°C	+20°C	
Level Accel. at 25,000 Ft.	Fuel	4800	5500	6800	8800	lb
	Time	3.1	3.6	4.4	5.8	min
	Dist.	30	36	47	63	nmi
Level Accel. at 30,000 Ft.	Fuel	4900	5600	6600	8300	lb
	Time	4.0	4.6	5.4	6.7	min
	Dist.	38	44	54	69	nmi
Climb to 33,000 Ft.	Fuel	4900	5400	6100	7200	lb
	Time	4.3	4.7	5.3	6.2	min
	Dist.	39	44	51	62	nmi

Std. Temp. = -34.5°C @ 25,000 Ft., -44.4°C @ 30,000 Ft.
Min. A/B to Mach 0.9 and for subsonic climb to FL 300.
Max. A/B for level accel. above Mach 0.9 and above FL 300.

Figure 2-7

SUPERSONIC ACCELERATION PROCEDURE

1. Throttles - A/B

   Use minimum or maximum afterburner, as desired.

   Intercept Mach 0.90 and climb at that speed until starting the transition to the supersonic schedule.

   If the pitch autopilot is used during subsonic climb, the Mach Hold function must be engaged to climb at constant Mach.

   Refer to appendix Figure A1-4 for approximate differences between IAS and EAS indications. At Mach 0.9, correct airspeed indications at 30,000 feet are 324 KEAS and 347 KIAS. The TDI can be monitored by comparing TDI Mach with indicated Mach.

At start of transonic acceleration:

2. Throttles - Maximum A/B.

   Advance both throttles smoothly to maximum power and advise the RSO.

   Use either the level acceleration procedure or the climb-and-descent procedure.

   NOTE

   - The Auto-Nav feature of the autopilot is normally used if the roll autopilot is engaged.
   - If the autopilot KEAS hold mode is used, engage the pitch autopilot and stabilize KEAS for a few seconds before engaging KEAS hold.

After reaching speeds above Mach 1.25 when operating without the automatic EGT control engaged, trim as necessary to maintain nominal EGT as shown in Figure 2-4. EGT must not exceed 830°C below 40°C CIT and 805°C above 40°C CIT. Maintain EGT between 775 and 805°C after climb is established.

At Mach 1.7:

3. Inlet parameters - Monitor.

   Monitor spike and forward door positions and CIP.

4. Aft bypass controls - Set.

   Normally set Position A at Mach 1.7, but wait until the forward bypass doors move out of full closed to set the aft bypass.

5. C.G. and trim - Monitor.

   NOTE

   - Manual boost pump selection for the purpose of shifting c.g. is not normally necessary with a full fuel load. With reduced fuel loads, manual control of the fuel system may be required to achieve a desirable supersonic c.g. position. (See Cruise Fuel Management, this section.) The c.g. normally moves aft 1% per 5000 lb of fuel used until the right-hand shutoff switch in tank 1 operates.
   - While at maximum power with high fuel flows, press tank 5 (or tank 4) boost pumps on before using fuel forward transfer to prevent an R FUEL PRESS warning. Release the tank after completing fuel transfer.

At IGV shift (CIT limit is 150°C):

6. IGV switches - LOCKOUT.

CAUTION

Decelerate to 125°C CIT or less (approximately Mach 2.0) if the IGV lights are not extinguished upon reaching 150°C CIT (approximately Mach 2.2 with ambient temperature near standard).

The IGV lights should extinguish on completion of IGV shift at 85° to 115°C CIT (approximately Mach 1.7 to 2.3, depending on ambient temperature). The lights must be out at 150°C CIT. When the guide vanes shift, forward bypass opening will increase and fuel flow and thrust will decrease. The engines may not shift simultaneously due to tolerances in fuel control schedules.

NOTE

If the IGV lights extinguish (IGV shift to cambered) while below the normal shift range, land when practical.

7. Aft bypass controls - Position B, if required.

   a. Set Position B when the lights extinguish if forward bypass opening exceeds 20%. Drag increases noticeably if the forward bypass schedules in excess of 20% open.

   b. Monitor forward bypass door position. Shift the aft bypass from position B to A when the forward bypass approaches closed. Allowing the forward bypass doors to schedule less than 5% open with the aft bypass doors in position B reduces inlet stability and increases the probability of an unstart without appreciably increasing overall inlet efficiency.

8. Exterior lights - Off.

   a. Anticollision/fuselage lights switch - OFF.

   b. TAIL LT switch - Off (center position).

9. Pitot heat switch - OFF.

10. DEF systems - Set and checked.

NOTE

Set DEF system operating conditions as briefed when above FL 500.

11. Radar - As briefed.

At FL 600:

T12. IFF - Mode C OUT.

This prevents automatic altitude reporting.

At Mach 2.6:

13. Aft bypass controls - Set position A, when required.

Shift from the B to the A position when the forward bypass approaches closed.

Allowing the forward bypass doors to schedule less than 5% open with the aft bypass doors in position B reduces inlet stability and increases the probability of an unstart without appreciably increasing overall inlet efficiency.

14. KEAS bleed - Monitor.

For normal climb at 450 KEAS, decrease KEAS 10 knots per 0.1 Mach number increase above Mach 2.6.

NOTE

The minimum pitch trim indication to be expected at Mach 2.6 is +0.5°. At higher Mach, the minimum limit depends on KEAS, aircraft weight and c.g. Assure trim is at or above 0° except for the specific high Mach, high KEAS conditions at 25% c.g. depicted on Figure 6-7. Check the c.g. if less nose-up trim is indicated.

(T15) INS altitude - Update as required.

Update the INS altitude to the mid-leg altitude between level off and start of descent.

At Mach 3.0:

16. Aft bypass controls - Set.

Maintain position A or use the CLOSE setting for cruise near Mach 3.0. If the forward doors are not closed with position A selected, maintain position A for best performance.

The optimum setting for cruise near Mach 3.0 may be determined by setting the aft doors to CLOSE individually. If drag increase on the closed side is noted, cruise with aft bypass in position A.

At Mach 3.05:

17. Aft bypass controls - Set CLOSE.

Set CLOSE position for cruise above Mach 3.05.

CRUISE

Cross-check the TDI altitude, KEAS, and Mach displays with IAS, indicated Mach, and altimeter, periodically, to detect discrepancies in the TDI. If Mach number appears to be inaccurate, make appropriate adjustments so that flight limits will not be exceeded.

The checklist Mach-KEAS-Altitude Relationship chart and the Mach-Airspeed-Temperature Conversion chart can be used to check the TDI and ANS true airspeed. Indicated spike position vs. the TDI and indicated Mach provides another cross-check on Mach number, as spike position is based on DAFICS Mach output.

WARNING

In the SR-71B, no warning is displayed if the SAS channel engage switches are not ON in the cockpit that does not have AFCS control. If the SAS engage switch(es) are OFF in the cockpit that does not have AFCS control, transferring AFCS control to that cockpit results in loss of SAS until the SAS switch(es) are engaged. Verbally confirm the position of the SAS channel engage switches before transferring AFCS control.

Flight will not be extended into night or IFR conditions if the pilot's standby attitude indicator and either the ANS or INS reference for the ADI are inoperative or erroneous. Climb and penetration through overcast is permitted. If already operating in night or IFR conditions, land when practical.

Pitot Static Reference - Subsonic Operation

The pressure altimeter is the primary altitude reference for subsonic flight operation; to fly an assigned altitude, use the altimeter correction card.

IFF Mode C uses DAFICS (TDI) altitude for automatic altitude reporting.

Operation at Supersonic Speeds

Avoid sustained operation at speeds between Mach 2.5 and 2.7 when convenient. This area is normally more susceptible to inlet duct roughness than higher or lower speeds. Refer to Climb, Section VI.

Autopilot Operation, Cruise or Climb

Manual trim in the yaw and roll axes may be used while the roll autopilot is engaged in Heading Hold or Auto Nav modes to minimize track error (course hang-off). When only attitude-hold mode (pitch or roll autopilot) is engaged, use the trim wheel on the function selector panel to adjust attitude. (Manual trim inputs at this time will only cause control transients.) If Mach hold is desired, engage the pitch autopilot and stabilize the aircraft at the desired Mach before engaging the Mach hold mode.

Optimizing Trim

Trim should be optimized during cruise to minimize drag. With the autopilot on, match fuel flows then apply yaw trim as needed to center the turn-and-slip ball. The periscope may be used to visually confirm rudder trim symmetry. With the roll autopilot engaged, check for off-center displacement of the roll autopilot alignment needle. "Beep" roll trim in the direction of needle displacement until the needle is centered. It may be necessary to repeat the procedure if KEAS or Mach changes.

The max range loss factors for rudder, sideslip, or c.g. deviation (based on symmetrical power and supersonic cruise) are:

rudder: 1° - 3 nm 2° - 12 nm

sideslip: 1° - 12 nm 2° - 48 nm

c.g.: 50 nm/% c.g. fwd of 25% MAC

Turning, in Auto Nav Mode

While in the Auto Nav mode, anticipate turn entry. Use manual stick inputs, if necessary, to avoid excessive roll rates and bank angles. It is unlikely that the stick shaker warning will be encountered during the roll-in to a normal turn. If shaker warning occurs while rolling into a steep turn, manually reduce the roll rate.

Steep Turns

The pitch autopilot can be used for turns with bank angles up to 45°. Pitch and roll attitude must be monitored when making steep turns.

C.G. Crosscheck

Since center of gravity control is important for optimum cruise performance and safety, crosscheck the c.g. indication with pitch trim and, occasionally, by computation.

During climb, the c.g. normally moves aft approximately 1% per 5000 pounds of fuel used and can be expected to reach 24% to 25% when the fuel in tank 1 reaches the right-hand shutoff setting. This should occur near the level-off point in a supersonic flight profile after air refueling to full tanks. After right-hand shutoff, the automatic sequencing provides a center of gravity which will approach 25%. This minimizes elevon deflection and trim drag during supersonic operation. If c.g. should exceed 25%, transfer fuel forward (C.G. annunciator panel warning light illuminates when c.g. reaches 25.3 to 25.6%). During subsonic mission legs, successive forward transfers may be necessary to keep the c.g. forward of the subsonic aft limit (22%).

NOTE

> The optimum supersonic c.g. position may not be reached automatically with a partial fuel load. Manual fuel management may be required.

Fuel Management

Maintain c.g. forward of the center of gravity limit by using forward transfer. Forward transfer should also be used for an electrical system or SAS emergency.

Select fuel crossfeed OPEN any time tanks 5 and 6 are empty with both engines operating normally, and any time the FUEL QTY LOW caution light or an L or R FUEL PRESS warning light illuminates. Even though symmetrical thrust conditions exist, the use of crossfeed during afterburner operation can result in mismatched fuel flow indications of as much as 7000 lb per hour, due to fuel crossflow through the fuel heat sink system.

With crossfeed closed, should fuel flows to the engines be mismatched, c.g. may move out of the desired range. If the right fuel flow is higher, c.g. will not move aft as fast as the normal schedule and if the left fuel flow is higher, the converse is true. If fuel flows are mismatched, c.g. should be closely monitored as the full capabilities of the transfer system may be needed to obtain optimum c.g.

Manual aft transfer is provided to augment the automatic aft transfer system. Manual aft transfer is only effective if tank 5 is less than full.

The following three methods are designed to move the c.g. aft. Early manual fuel management is especially important with a less-than-full fuel load during supersonic acceleration. Manual aft transfer has a lower rate of c.g. movement than Method a only, being equal to 71% of Method a rate.

Method a

Press tank 1 on to override the RHSO until the fuel level in tank 1 reaches 3000 pounds.

CAUTION

Do not manually select tank 1 with less than 3000 pounds remaining in that tank. The forward pumps would be operating without fuel cooling and lubrication.

Method b

Pressing tank 2 on and opening the crossfeed valve is effective until tank 3 is empty. The rate of c.g. movement of this method will vary depending on the amounts of fuel remaining in tanks 1 and 2.

NOTE

Using this method eliminates automatic aft transfer. Increased aft c.g. movement can be obtained by depressing the manual aft transfer switch once tank 5 starts to operate.

Method c

Depressing the manual aft transfer switch is the primary means for moving the c.g. aft when tank 2 and 5 are supplying fuel during normal fuel sequencing.

NOTE

With the crossfeed valve open and only one forward tank supplying fuel, the c.g. may move forward.

Engine Operation

Exhaust gas temperature and engine speed limits vary with compressor inlet temperature. Refer to Engine Operating Limits, Section V. When encountered, slow fluctuations in EGT, fuel flow and rpm should be reported for maintenance evaluation; however, fluctuations of ±1% are expected and are not detrimental to engine operation. Random fluctuations of ±4% are expected in nozzle position indication and are not detrimental to engine operation.

EFFECT OF ASYMMETRIC ENGINE FUEL FLOW ON AUTOMATIC CG SCHEDULING

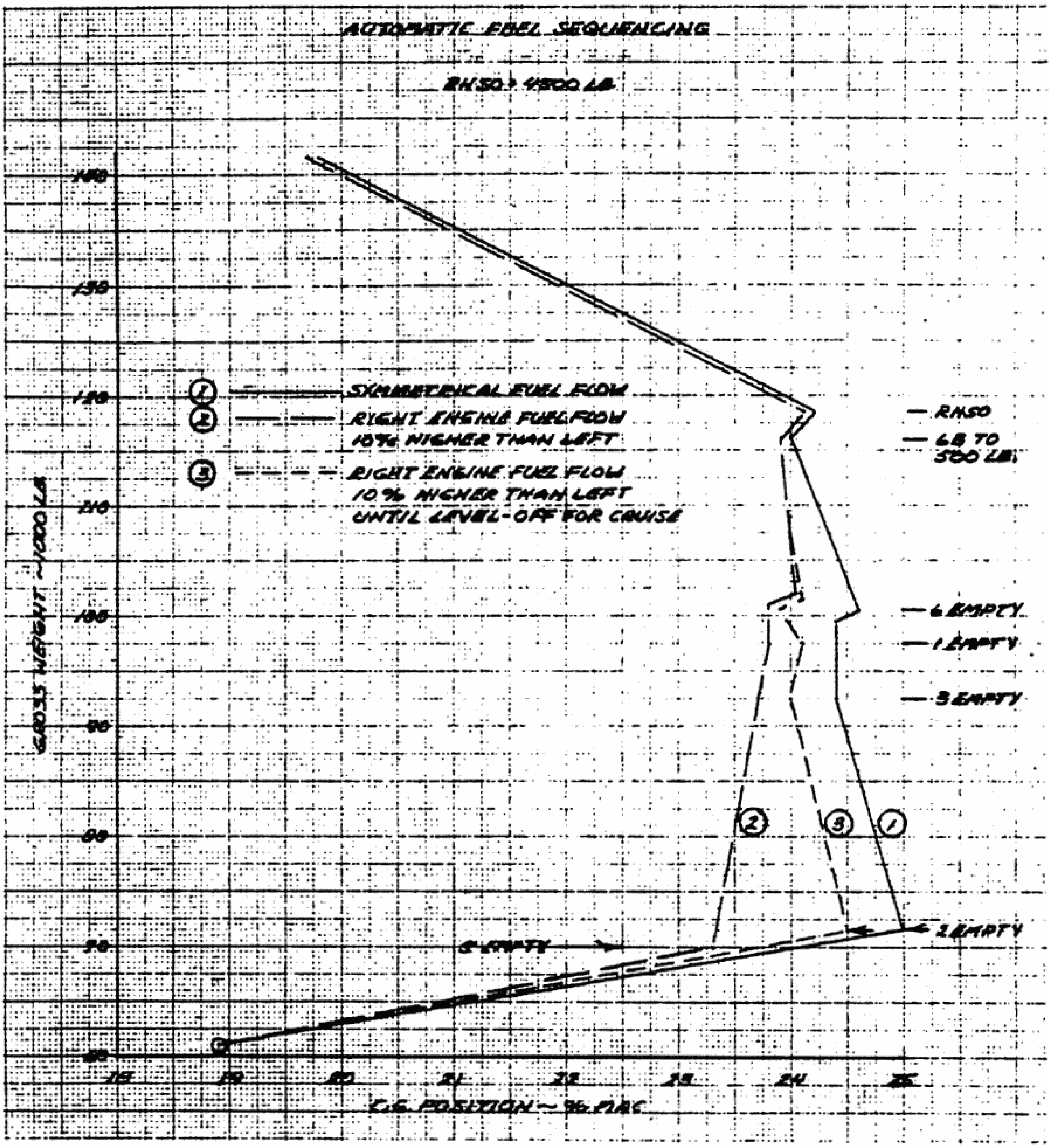


Figure 2-8

EFFECT OF AUTOMATIC AND MANUAL FUEL MANAGEMENT ON C.G. SHIFT RATE*

TANKS ON	PROCEDURE	Percent of Base C.G. Aft Shift Rate
1-3-6 to RHSO	HANDS OFF (NO ALTERNATE AVAILABLE)	+100%** (Base Rate)
HANDS OFF 1-3-6 after RHSO, >3000 lb in tank 1	 Press on tank 1 Press on tank 2, open crossfeed Open crossfeed Tank 5 on after tank 6 is empty	-19% +100% +67% +41% +35%
1-3-6 after RHSO <3000 lb in tank 1, before tank 5 on	HANDS OFF Press on tank 1 (See Note) Press on tank 2, open crossfeed Open crossfeed	+7% +100% +67% +41%
tank 5 on, before tank 2 on	HANDS OFF Press on tank 2, open crossfeed Open crossfeed Press on tank 2 Press on tank 2, manual aft transfer held on Press on tank 2, open crossfeed, manual aft transfer held on	+0.8% +11.3% -28.8% -28.8% +34.6% +49.7%
tank 2 on, before tank 4 on	HANDS OFF Open crossfeed Manual aft transfer held on Open crossfeed, manual aft transfer held on	+3.3% -14.1% +92.0% +29.7%

* Based on nominal, matched fuel flow consumption to each engine.

** This rate, which is 1% of C.G. movement for every 5000 lbs of fuel consumption, is used for comparison throughout all stages of tank sequencing. A (+) or (-) sign indicates that the C.G. is moving aft or fwd.

Note: Do not manually select tank 1 with less than 3000 lbs remaining in that tank. The forward pumps would be operating without fuel cooling and lubrication.

Figure 2-9

Effect of Engine Thrust Variation with EGT

For a given level of thrust, higher throttle settings and increased fuel flow are required as EGT is decreased, because combined burning efficiency of the engine and AB decreases with lowered EGT. Full throttle ceilings are therefore reduced. The degradation in thrust for all throttle settings, at Mach 3.2 and 80,000 feet, is approximately 1.3 percent per 10°C of EGT decrease. The trend is the same for other flight conditions.

Effect of RPM Suppression on Maximum Thrust

As EGT decreases, the engine nozzle opens to maintain scheduled rpm. At high Mach and maximum power, the nozzle may open fully and any EGT decrease will result in rpm suppression below schedule. When this occurs, engine speed will suppress approximately 50 rpm for each 10°C of EGT decrease. The airflow through the engine decreases due to the suppressed rpm, leading to a higher inlet bypass requirement and opening of the forward bypass doors. At Mach 3.2 this results in a thrust degradation and drag increase of approximately 3.5 percent per 10°C of EGT decrease for each engine. If Mach number decreases as a result of the change in thrust and drag, the spikes schedule more forward and the forward bypass doors open further. Performance will deteriorate rapidly under these cumulative effects. Cruise EGT should be maintained between 775°C and 805°C to avoid this situation.

Crew Comfort

Pressure suit ventilation air temperature tends to increase and flow decreases while approaching the end of long cruise periods at maximum speed. The increase in temperature is associated with increasing fuel manifold temperature as tank 3 empties and the quantity remaining is exposed to high skin temperatures. This results in less cooling of the engine bleed air as it passes through the fuel-air heat exhangers in the environmental control system. Comfortable suit vent temperatures are restored as soon as tank 2 is scheduled on.

If uncomfortably warm suit vent temperatures are encountered, insure that the suit heat rheostat in the forward cockpit is OFF. Each crewmember can open his air controller valve to increase flow through the suits. If this is not sufficient, the pilot can manually select the tank 2 boost pumps on if the condition can be associated with depletion of tank 3. The c.g. indication must be monitored and kept within limits. Premature use of tank 4 is not recommended as an alternate to using tank 2 fuel.

__PRIOR TO DESCENT__

▲1. Pilot's ANS distance display mode - DP/TURN.

   a. Display Mode Select Switch - ANS.

   b. Bearing Select switch - NORMAL.

   (Tc) ANS DATA switch - TEST.

   Press DISPLAY push-button switch to display data.

   (Td) DP/TURN push-button switch - As desired.

   RSO will coordinate the pilot's desired ANS distance display mode and will read the backset from DP or distance to turn, as applicable, over interphone.

2. IGV switches - LOCKOUT checked.

3. LN_2 quantity - Checked.

   Check total liquid nitrogen quantity. If not sufficient for normal descent, refer to Fuel Tank Pressurization emergency procedure, Section III.

4. Inlet Controls - AUTO & CLOSE.

   Inlet spike and forward bypass controls will be placed in AUTO and the aft bypass controls set at CLOSE unless manual inlet procedures are used. Refer to Section III, Figure 3-5 for manual inlet schedule.

(T5) INS altitude - Update as required.

Update to the after descent condition (air refueling, penetration or field elevation).

DESCENT

1. For inlet(s) in manual control, restart(s) - ON.

2. Throttles - 720°C EGT to Military.

Slowly retard both throttles to 720°C EGT to Military. 720°C EGT results in approximately 10 nm less descent distance than Military.

Expect a fuel vapor trail to occur while the afterburner fuel lines clear.

NOTE

- Pause at minimum A/B approximately 5 seconds if retarding from a high power setting.
- If 720°C EGT is selected, monitor EGT, RPM, and nozzle position. Expect EGT to decrease as Mach decreases. 700°C EGT should hold rpm at the Military schedule and maintain nozzle governing.

With IGV lockout inoperative:

a. Set Military.

For inlet(s) in restart:

b. Set 720°C EGT to Military.

For inlet(s) in restart with IGV lockout inoperative:

c. Set Military.

Refer to Schedule for Manual Inlet Control, Section III.

3. Airspeed - 365 KEAS (350 minimum).

Maintain cruise altitude while decelerating, or maintain cruise Mach number while descending, until approximately 365 KEAS. If KEAS hold is desired, engage the pitch autopilot and stabilize the aircraft at the desired KEAS for a few seconds before engaging KEAS hold. Maintain 350 KEAS <u>minimum</u> while decelerating to reduce the probability of unstart and minimize the possibility of engine stall or flameout.

4. Fuel tank pressure - Monitor.

Descend so that minimum tank pressure (-0.5) is not exceeded.

At Mach 2.5:

5. Throttles - Set 6900 rpm.

Retard throttles simultaneously. Some throttle misalignment may be required. An rpm decrease of 400-500 rpm can be expected from Mach 2.5 to 1.3. Maintain at least 6500 rpm while above Mach 2.0.

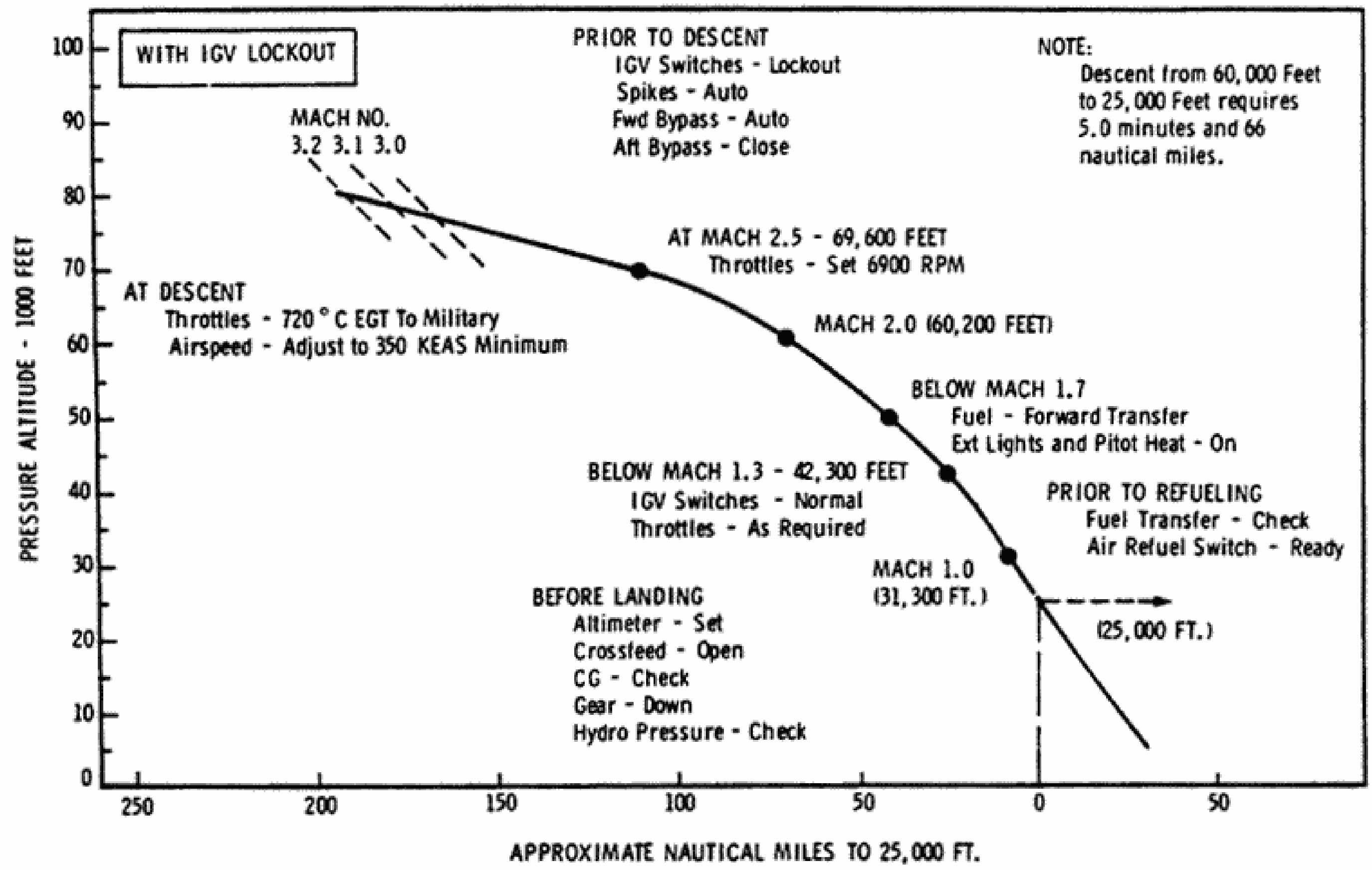
With IGV lockout inoperative:

a. Set 720°C EGT and maintain 700°C EGT minimum.

This procedure will increase descent distance approximately 25 - 30 nm. Maintain at least 700°C EGT while above Mach 1.3 to hold the military rpm schedule and maintain nozzle governing. ENP greater than 70% open will result in less than military rpm; in this event, advance the throttle as necessary to maintain military rpm. Maximum rpm occurs near 100°C CIT, as during climb. Mild compressor stalls may be encountered when near 85°C CIT (approximately Mach 1.8) as the IGV and internal bleeds shift.

For inlet(s) in restart:

DESCENT PROFILE



350 KEAS DESCENT

ALT	DISTANCE (NM) – CRUISE MACH 3.2	3.15	3.1	3.0	2.9	2.8	2.6	2.4	PROFILE CHECK – 350 KEAS DIST	IAS	ETE
84K	238	232	226								
82K	236	229	223	211							
80K	234	227	220	208	198	187			234	422	:15.5
78K	231	224	218	206	195	184					
76K	228	221	215	204	193	182	165		196	440	:14.0
74K	225	218	212	202	191	180	162				
72K			209	200	189	177	159	141			
70K				198	187	175	157	139	148	437	:12.0
68K					185	173	154	136			
66K						171	151	134			
64K						169	149	132	120	432	:11.0
62K							147	130			
60K								128	106	428	:10.0
55K									92	422	:09.5
50K									80	416	:08.5
45K	WITH LOCKOUT			W/O LOCKOUT					71	409	:08.0
40K	720° EGT ABOVE M2.5			MIL PWR ABOVE M2.5					63	401	:07.5
35K	6900 RPM AT M2.5			720° EGT BELOW M2.5 (700° MIN)					56	391	:06.5
30K									50	376	:06.0
25K									40	370	:05.0

NOTE

1. Distance and time includes 40 NM L/O prior to ARCP.
2. Add 35 NM for each IGV not locked out.
3. Subtract 25 NM for each restart on.
4. Subtract 30 NM for each inlet in restart w/o lockout.
5. Subtract 51 NM and :06 to FL 310 (IAF).
6. Subtract 40 NM and :05 to FL 250 (IAF).
7. Subtract 25 NM and :03 to FL 160.
8. Subtract 1 NM for each 10° of turn in descent.
9. 5500-6100 RPM below M 1.0.

F203-315(c)

Figure 2-10

b. Set 6500 rpm.

If the forward bypass doors are nearly full open (for any reason) and the engine internal bleeds shift <u>before</u> rpm is reduced, engine stall and flameout are possible.

Refer to Schedule for Manual Inlet Control, Section III.

For inlet(s) in restart with IGV lockout inoperative:

c. Set 6500 rpm. At Mach 2.0, set idle.

Refer to Schedule for Manual Inlet Control, Section III.

CAUTION

If protracted or non self-clearing stalls are encountered, follow procedures in Section III, Compressor Stall In Descent. Use restart and retard throttle to Idle on the affected engine only. Restarts on between Mach 2.5 and 1.3 near Military rpm may result in compressor stall. Check aft bypass doors closed.

At FL 600:

(T6) IFF Mode C - Set as briefed.

(7.) DEF systems - As required.

The DEF systems may be turned off if descending to land, or placed in standby. If the systems are turned off, check that all System H automatic and manual mode legends and the W and S legends are off. Avoid operating System H below FL 500. The other systems should be in standby before reaching FL 500.

NOTE

System H can be maintained in the standby mode below FL 500 if immediate availability of the system is desirable. In this event, perform an automatic self test each half hour with transmit modes selected. Shut down the system when immediate availability is not required.

Below Mach 1.7:

8. Fuel forward transfer switch -On.

Transfer fuel to obtain c.g. within subsonic limits. Check tank 1 fuel quantity increasing.

9. Pitot heat switch - ON.

10. Exterior lights - On.

 a. Anticollision/fuselage lights switch - ANTICOLLISION.

 b. TAIL LT switch - STEADY.

Below Mach 1.3:

11. Inlet controls - Checked.

Check spike and forward bypass controls AUTO and aft bypass controls at CLOSE unless manual inlet control procedures are required.

12. IGV switches - NORMAL.

De-energizing the IGV Lockout System restores the engine to maximum thrust capability. The IGV should shift to axial and IGV lights illuminate if RPM is above 5500-6000 rpm. (See Figure 1-11.)

13. Throttles - As required.

Adjust descent profile as required. Reduce rate of descent, if necessary, to avoid low fuel tank pressure below FL 400.

When the desired c.g. is obtained:

14. Fuel forward transfer switch -OFF.

15. Crossfeed switch - Set.

    Crossfeed OPEN should be selected if immediate penetration for landing is to be accomplished, if tanks 5 and 6 are empty, or if the FUEL QTY LOW light illuminates.

AIR REFUELING DATA CARD			
TKR TCS			
AREA			
ARCP			
DP #			
TRACK			
ARCT			
ALT BLOCK			
A/R ALT			
A/A TAC			
HF FREQ			
UHF Prim.			
UHF Backup			
EXT. CODE			
ON LOAD			
FULL TANK CG			
MISSED A/R ALT	DP CH	DP CH	DP CH
BINGO FUEL			
PLANNED RES			

Figure 2-11

AIR REFUELING

The pitot-static flight instruments will be used for tanker rendezvous and in-flight refueling procedures. Check that the altimeter is set at 29.92 in. Hg.

Air Refueling Data Card

Air refueling data is recorded on checklist cards similar to Figure 2-11.

Pilot Director Lights (On Tanker)

For the KC-135, refer to Figures 2-12 and 2-13. Receiver director lights are located on the bottom of the tanker fuselage between the nose gear and the main gear. They consist of two rows of lights, the left row for elevation and the right row for boom telescoping.

The elevation lights consist of five colored panels with green strips, green triangles, and red triangles to indicate relative position. Two illuminated letters, D and U for down and up movement, respectively, indicate elevation corrections. Background lights are located behind the panels. The elevation lights are controlled by boom elevation during contact.

KC-10 pilot director lights, Figure 2-14, are similar to the KC-135 director lights. The KC-10 elevation director lights consist of a green square, amber triangles, red triangles, and amber D and U letters. The lights are controlled by boom elevation plus boom elevation rate during contact.

The colored panels which indicate KC-135 boom telescoping are not illuminated by background lights. An illuminated white panel between each colored panel serves as a reference. The letters A for aft and F for forward are visible at the ends of the boom telescoping panel. Figure 2-13 shows the panel illumination at various boom nozzle positions within the boom envelope. When contact is made, the lights are controlled by boom extension. There are no lights to indicate azimuth; however, a yellow line on the tanker indicates the centerline.

KC-135 AIR REFUELING BOOM LIMITS

NOTE

Tanker automatic disconnect occurs at boundary of gray areas.

CAUTION

Tanker auto-disconnect limits do not apply when receiver using manual boom latching

Also see T.O. 1-1C-1

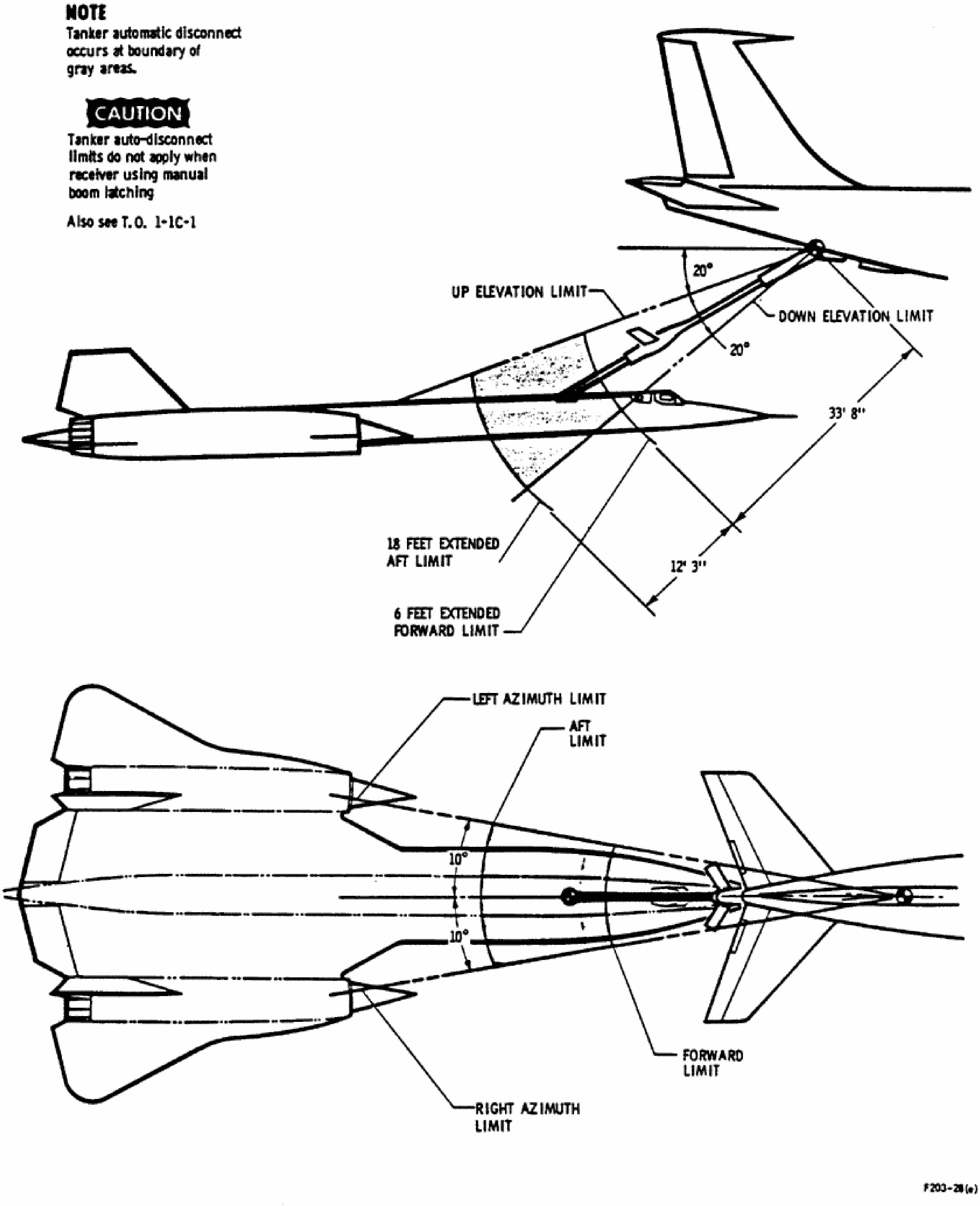


Figure 2-12

RECEIVER DIRECTOR LIGHTS AND ILLUMINATION PROFILE (KC-135)
(Also see T.O. 1-1C-1)

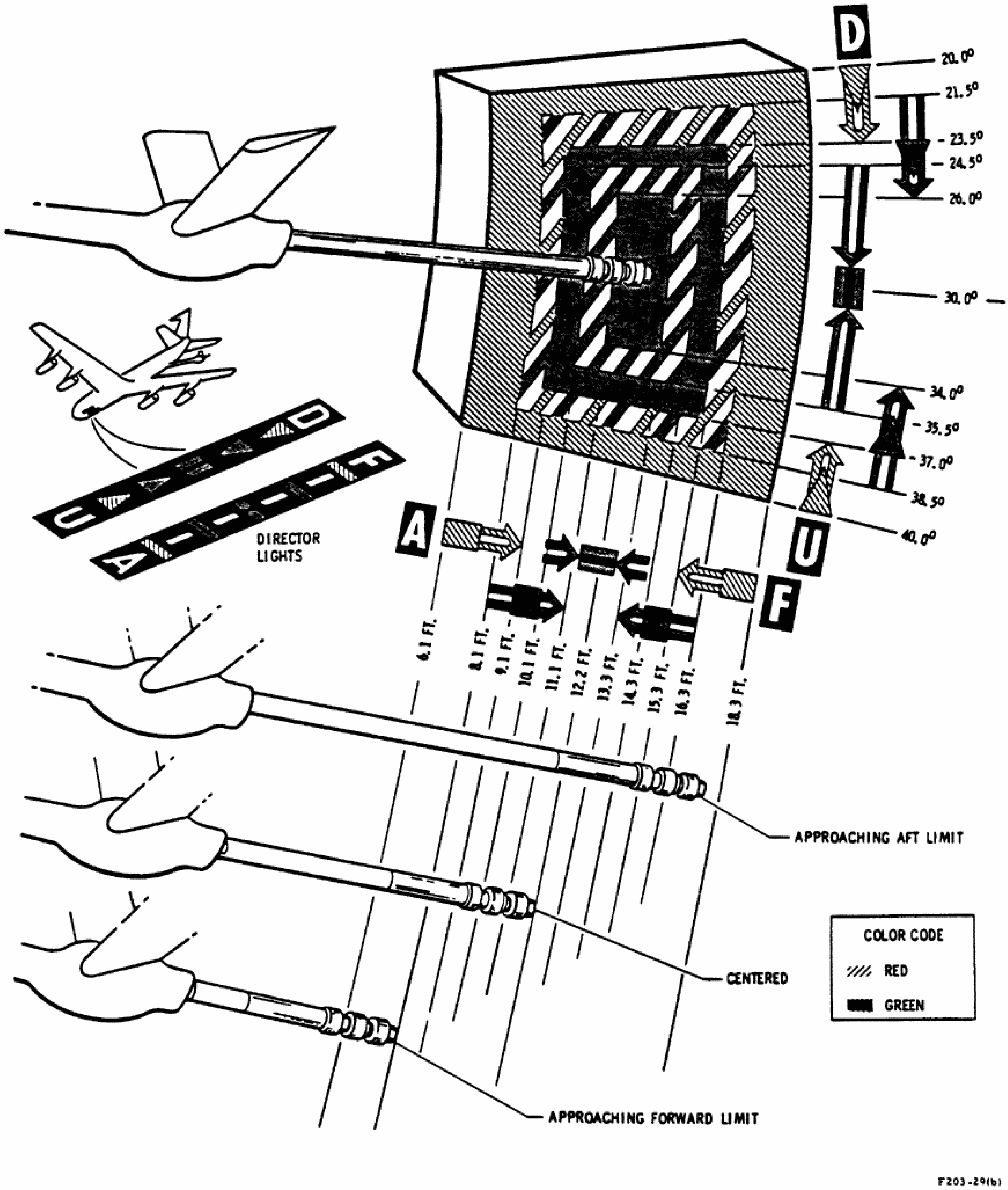


Figure 2-13

RECEIVER DIRECTOR LIGHTS AND ILLUMINATION PROFILE (KC-10)
(Also See T.O. 1-1C-1)

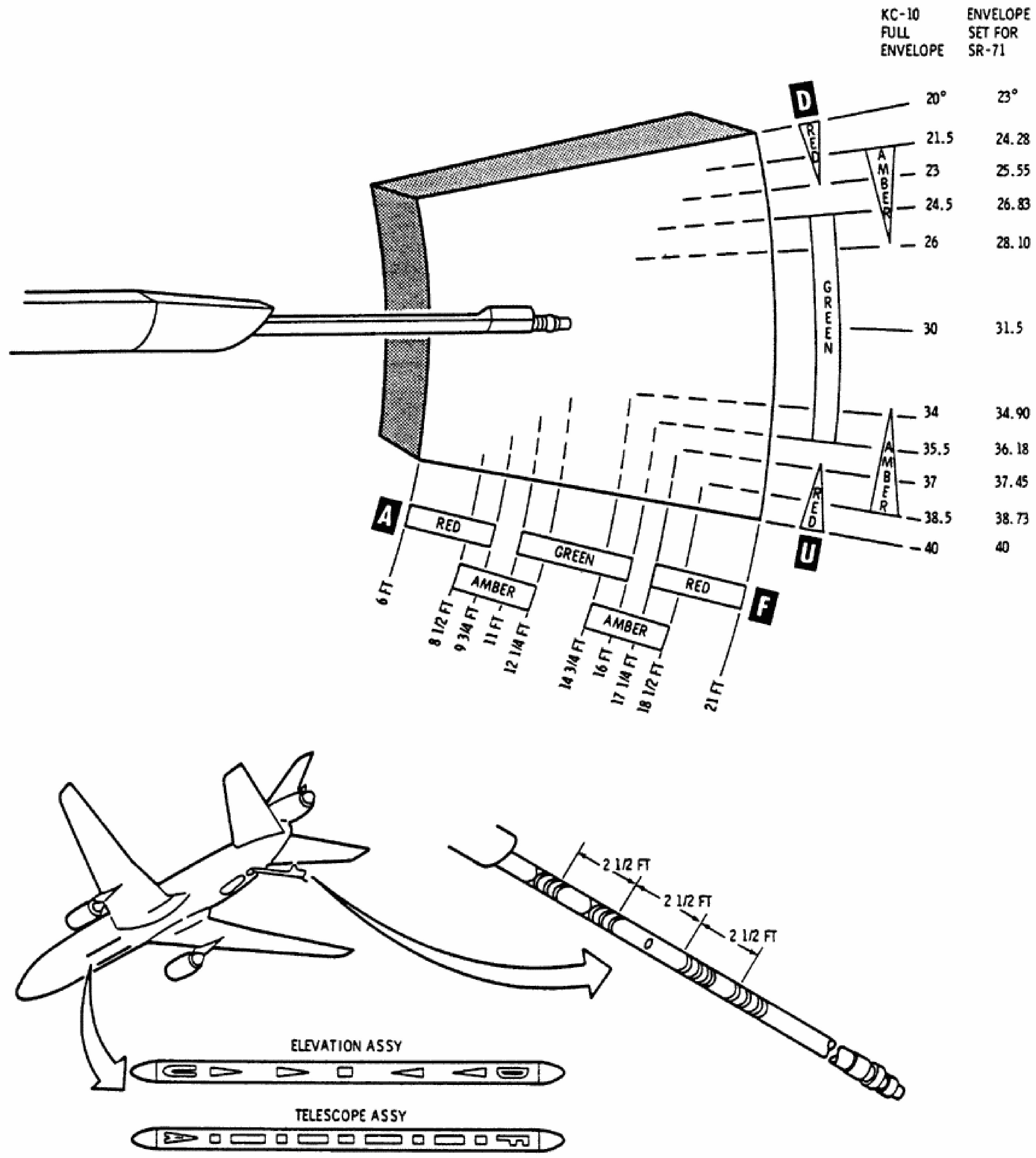
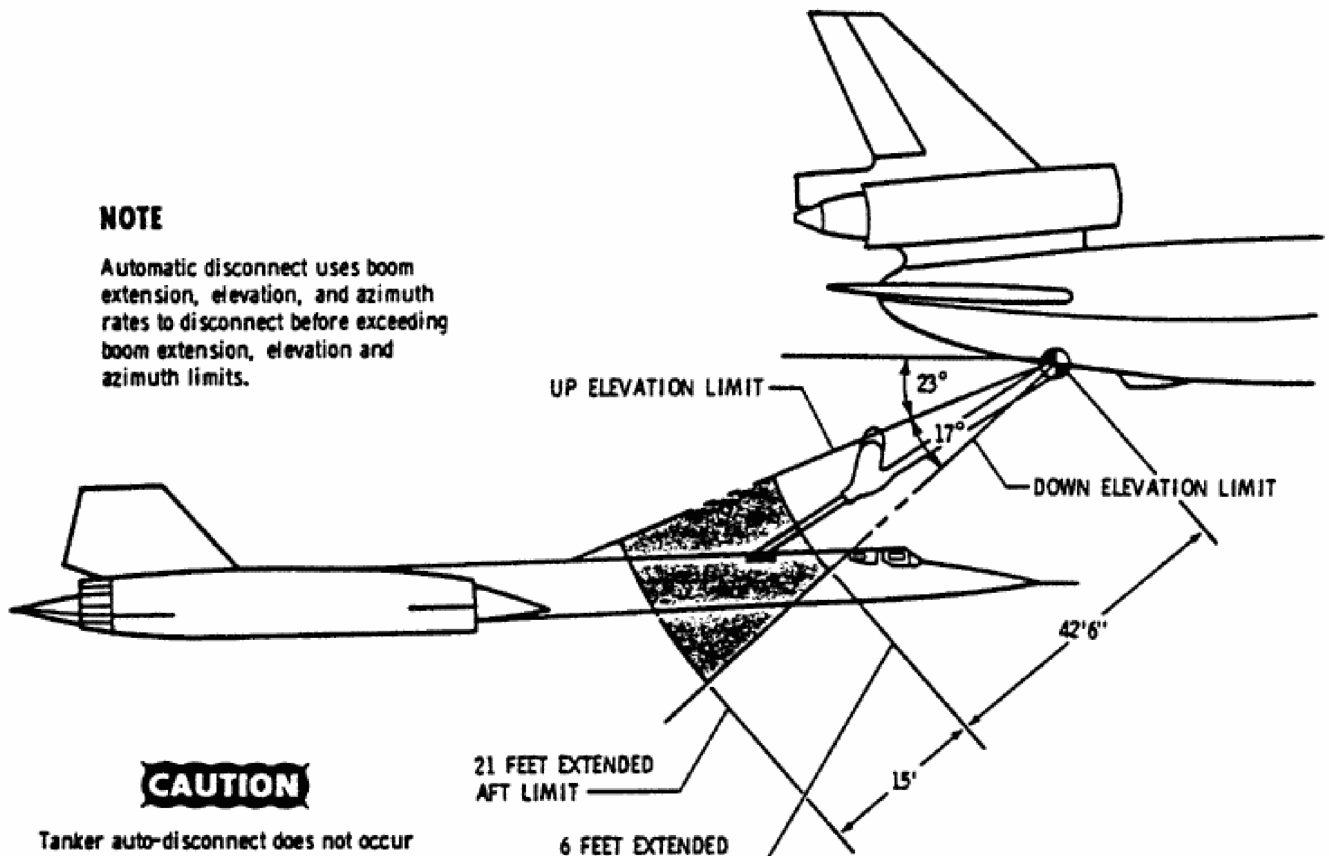


Figure 2-14

KC-10 AIR REFUELING BOOM LIMITS

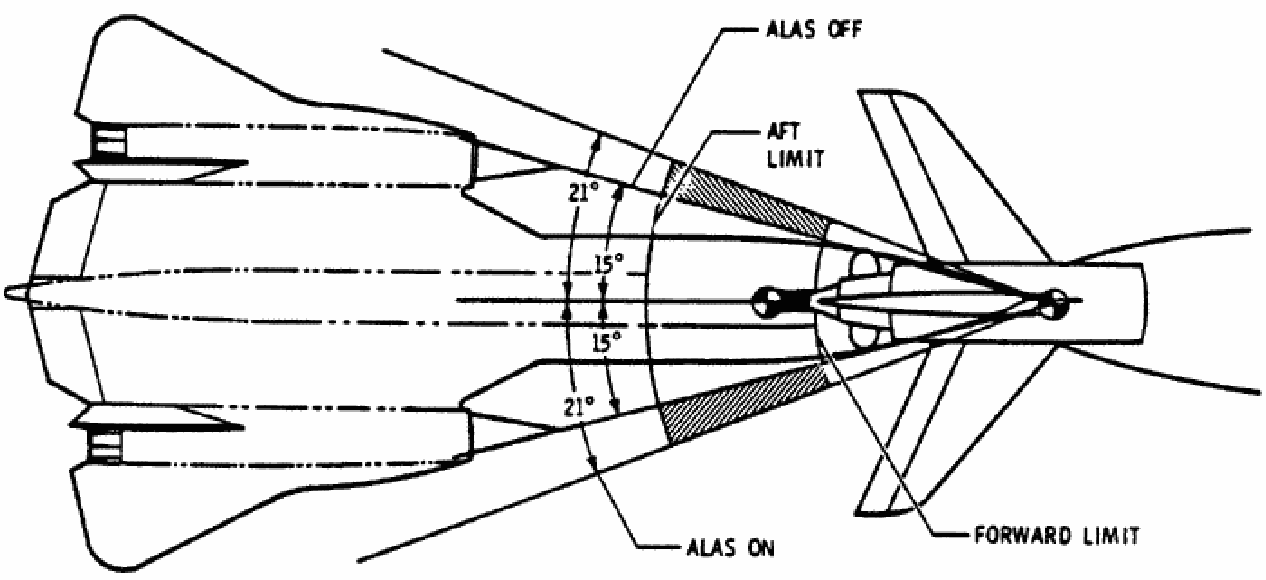
NOTE

Automatic disconnect uses boom extension, elevation, and azimuth rates to disconnect before exceeding boom extension, elevation and azimuth limits.



CAUTION

Tanker auto-disconnect does not occur when using receiver manual boom latching or in tanker manual operation (TMO).



NOTE

Automatic azimuth disconnect set at ±21 degrees with the boom ALAS operating or ±15 degrees with ALAS off.

F203-298

Figure 2-15

The KC-10 lights which indicate boom telescoping are shown in Figure 2-14. When contact is made, the panels are controlled by boom extension plus extension rate.

During radio silence, when in the ready condition, the boom operator actuates the red panels of the receiver director lights to direct the receiver pilot. Illumination of the triangular panels nearest the U and D letters directs the pilot to move up or down respectively. The rectangular panels nearest the F and A letters direct the pilot to move forward or aft respectively. A steady red light indicates that a relatively large correction is desired in the indicated direction. A flashing red light indicates that relatively small correction is necessary.

Fuel Management Prior to Refueling

Transfer fuel as necessary to maintain c.g. within the subsonic limits and manually energize the tank 4 fuel pumps. Reducing the quantity in tank 4 provides more space for cool fuel from the tanker to reduce the temperature of tank 4 fuel and prevents the ullage pumps from cycling due to fuel level fluctuations during refueling. Forward transfer provides a more desirable center of gravity for unaugmented pitch stability and also replenishes tank 1 so that its boost pumps will supply the left fuel manifold during refueling. Fuel is also supplied to the right manifold when tank 4 is below 3600 ± 1200 pounds, or tank 1 is pressed on manually, or the tank 1 fuel level is above the right hand shutoff level. Forward transfer should be repeated if there is any appreciable delay before initial refueling contact or between subsequent refueling contacts. Do not transfer excessive amounts to tank 1, however, as cg forward of 17% reduces load factor limits. Forward transfer should be shut off before making contact.

NOTE

Crossfeed should be used if the FUEL QTY LOW light illuminates or tanks 5 and 6 are empty.

Approach For Refueling

Make the approach from behind and below. Deicing is only provided on the left windshield panel. The seat should be lowered prior to reaching the observation position. Upon completion of the Before Refueling procedure, maneuver to the pre-contact position about 50 feet to the rear and 10 feet below the refueling position. Stabilize and trim the aircraft. Maneuver as indicated by director light signals or by verbal instructions of the boom operator.

NOTE

- o COMNAV 50 range and bearing information may be lost when below the tanker if the tanker has not switched to lower antenna.
- o The air-to-air mode of the TACAN provides both range and bearing with all KC-10 and some KC-135Q aircraft, but range only with other KC-135Qs. TACAN information may be lost within one mile due to antenna blanking. TACAN signals are not resistant to meaconing, interference, and jamming.

Refueling Hookup

A successful hookup is confirmed by steady illumination of the director light panel and extinguishing of the ready light. Hookup can be maintained between the aircraft and tanker during a turn or in a descent. No adverse flight characteristics result from tanker downwash. Clear away aft and down along the axis of the refueling boom after disconnect.

Boom Elevation Limits

The KC-135 boom upper elevation limit is 20 degrees and the lower elevation limit is 40 degrees. For the SR-71 receiver, refueling above 25 degrees (green triangle) is not recommended. Any illumination of the red "down" triangle is outside the recommended SR-71 receiver envelope.

The upper disconnect limit of the KC-10 boom can be varied. Although the KC-10 can refuel between 20 degrees and 40 degrees, the upper limit for the SR-71 has been set at 23 degrees. With the 23 degree upper limit set, the director lights will show the center of the envelope at 31.5 degrees (Figure 2-14). During refueling, the KC-10 director lights are higher in the pilot's field of view than the KC-135 director lights. Below 36 degrees elevation, the SR-71 pilot may not be able to see the KC-10 director lights even with the seat full down.

Boom Extension Limits

	KC-135	KC-10
Range of Travel	12.2 ft.	15.0 ft.
Inner Disconnect	6.1 ft.	6.0 ft.
Outer Disconnect	18.3 ft.	21.0 ft.
Mid Boom	12.2 ft.	13.5 ft.

Boom Azimuth Limits

The KC-135 azimuth limit is ± 10 degrees. No automatic disconnect is provided in azimuth.

The KC-10 ALAS (Automatic Load Alleviation System) positions the boom elevator and rudders to reduce boom loading after contact. For the SR-71, the automatic disconnect azimuth limit is set to ±21 degrees with ALAS operating and ±15 degrees with ALAS off.

EGT Trimming

Manual EGT trimming may be used in lieu of the automatic trim system, if desired. This will avoid the possibility of "ratcheting." Manual trimming to temperatures above the nominal deadband schedule depicted in Figure 2-4 is permitted. If the engine should stall, or if EGT exceeds 830°C, downtrim immediately.

Disconnect

A disconnect may be accomplished:

1. Automatically.

   a. If boom envelope limits are exceeded.

   b. When fuel pressure exceeds 70 psi.

Pressure disconnects do not usually occur with the KC-10 since the refueling system reduces flow to maintain normal refueling pressure.

2. Manually.

   a. By the boom operator.

   b. By depressing the A/R DISC trigger on the control stick grip.

   c. By the KC-10 boom operator activating the Independent Disconnect System (IDS). The IDS retracts the KC-10 boom latch surface inward and frees the boom even with the SR-71 boom latches still extended.

   d. When pull on the boom becomes excessive ("tension" or "brute force" disconnect).

NOTE

The latch toggle hydraulic system incorporates a pressure relief valve which will permit the boom to be pulled out when a pullout force of approximately 5400 pounds is applied. Therefore, if a malfunction occurs which prevents disconnecting the boom, place the air refuel switch in the MAN O'RIDE position, depress the A/R DISC trigger switch, and proceed with brute-force pullout.

CAUTION

Disconnect in an aft and downward direction, and avoid forward relative motion during disconnect. Disconnect maneuvers which tend to pry the boom out of the receptacle will damage the receptacle or airframe.

Boom Control Failure (KC-10)

The KC-10 boom control system is a dual channel fly-by-wire system. If the two control channels disagree, the boom fails passive with controls in their last position.

CAUTION

If KC-10 boom control failure occurs, the receiver pilot should follow the boom operator's instructions. The boom operator will direct the receiver to a position that will allow a safe disconnect with the boom loaded slightly away from the receiver.

NORMAL AIR REFUELING PROCEDURE

Refueling can be accomplished from either cockpit of the SR-71B.

1. Center of gravity - Checked.

   Transfer fuel to maintain subsonic c.g.; the c.g. will tend to travel aft slightly during the initial portion of the refueling. After c.g. adjustment, the pitch trim should indicate at least 0° to 1° nose up. CG forward of 17% reduces load factor limits.

2. Windshield Deice switch - Set.

   If icing conditions are anticipated, set the Windshield Deice switch ON (down) to start hot air flow across the outside of the left windshield panel. Check that the WINDSHIELD DEICE ON caution light illuminates if deicing is selected.

3. Air refuel switch - AIR REFUEL, READY light on.

4. Tank 4 boost pump switch - Press on.

(T5) IFF - As required.

6. Forward transfer - OFF.

▲7. Interphone - Set.

   a. Pull and set HOT MIC.
   b. Pull and set IFR COMM.

NOTE

If the tanker is not equipped with boom interphone, or if the tanker interphone is off, actuation of either cockpit INPH switch will result in disconnect.

▲8. TACAN Mode selector switch - T/R.

▲9. Radios - Set.

   Check UHF/VHF frequencies. Set UHF Mode switch to INT and power as required. Set interphone selector to radio with primary refueling frequency.

10. Anticollision lights switch - FUS.

11. (Night only) FUS & TAIL switch - DIM.

   For night refuelings, boom operators may request lights off.

CAUTION

While refueling, do not transmit on HF radio as the tanker HF transceiver may be damaged.

NOTE

After tanker hook-up the air refuel READY light should extinguish.

Total fuel quantity, pitch trim, and c.g. should be monitored.

CAUTION

Under normal conditions, if trimming is required, disconnect and retrim in the precontact position. If trimming on the boom, be alert for runaway trim. To avoid runaway trim due to a sticking trim switch, assure positive switch movement to neutral after each actuation.

Disconnect is indicated by illumination of the DISC light.

When refueling is complete:

12. Air refuel switch - OFF.

▲13. Speeds - Crosscheck and monitor.

Use the ANS ground speed to confirm speed is increasing and as a systems crosscheck.

WARNING

Monitor airspeed and angle of attack after refueling and adjust attitude as necessary to remain within limits. A minimum of 300 KEAS is required.

(T14.) Precomputed c.g. - Check.

Compare c.g. precomputed for the end of refueling with actual c.g. Cross-check tank quantity indications if c.g. is not as expected.

15. Pump release switch - Press and confirm normal tank lights on.

After releasing the tank 4 pumps, only tanks 1,3, and 6 fuel tank boost pump switches remain illuminated.

NOTE

The tank 4 boost pumps must be released after refueling or premature depletion of that tank will occur.

16. Crossfeed - Closed.

(T17.) IFF - Set.

18. EGT trim switches - As required.

19. Windshield Deice switch - OFF.

Check the WINDSHIELD DEICE ON caution light extinguished.

20. Anticollision lights - ANTI COLLISION.

21. (Night Only) FUS & TAIL switch -Bright.

▲22. Interphone control panel - Set.

▲23. Pilot's ANS distance display mode - DP/TURN.

(Ta) ANS DATA switch - TEST.

Press DISPLAY push-button to display data.

(Tb) DP/TURN push-button switch - As desired.

RSO will coordinate the desired pilot's ANS distance display mode.

POWER LIMITED REFUELING

Engine EGT may be manually uptrimmed. Uptrimming should be done prior to establishing tanker contact, but is permissible during contact. If CIT is below 5°C, the nominal EGT schedule in Figure 2-4 decreases rapidly and compressor surge (stall) is possible if the schedule is exceeded. Downtrim immediately if EGT exceeds 830°C or if the engine stalls.

If military power limit is reached prior to completion of fuel transfer, the receiver may request the tanker to initiate a "toboggan" maneuver, or may elect to use one afterburner. If afterburner is used, set one throttle in Minimum A/B. Left afterburner is recommended. A slightly downtrimmed EGT on the afterburning engine helps minimize power asymmetry. Use the opposite throttle to vary thrust. For actual and simulated single engine air refueling procedures, see Section III, Single Engine Air Refueling.

BREAKAWAY PROCEDURE

Any tanker or receiver crewmember, if an emergency arises, will transmit on the air refueling frequency the tanker aircraft call sign followed by "breakaway, breakaway, breakaway." The boom operator may signal breakaway by rapidly flashing the receiver director lights. The receiver pilot will actuate the A/R DISC trigger. Retard throttles and drop aft and down until the entire tanker is in sight.

WARNING

The pilot should use care not to overrun the tanker. If overrunning does occur, under no conditions should a turn be made until breakaway has been completed.

<u>Breakaway Signal</u>

To visually signal emergency breakaway, the tanker turns on the rotating beacon and rapidly flashes the director lights.

AIR REFUELING ALTERNATE PROCEDURE

If L hydraulic pressure is lost, R pressure may be utilized for refueling by moving the brake switch to ALT STEER & BRAKE.

Normal and manual boom latching air refueling procedures apply with ALT STEER & BRAKE selected.

CAUTION

Do not leave the brake switch in ALT STEER & BRAKE after refueling. R hydraulic pressure may be lost also if L system fluid loss is due to a malfunction of the steering or refueling system.

MANUAL BOOM LATCHING

A manual refueling procedure may be used if the signal amplifier fails. This procedure requires manual control of the refueling boom latches. The refueling boom latches are open with the air refuel switch in MAN O'RIDE and the A/R DISC trigger on the control stick grip depressed. The receiver pilot can usually feel the boom nozzle bottom in the receptacle. The READY light will extinguish when the boom nozzle is properly seated; then the pilot should latch the boom in the receptacle by releasing the trigger switch. When latching the boom manually:

1. Air refuel switch - MAN O'RIDE, READY light on.

2. Trigger switch - Press and hold.

After nozzle is seated in receptacle <u>and</u> READY light is <u>off</u>:

3. Trigger switch - Release.

When refueling is completed:

4. Trigger switch - Press and hold until boom is clear.

   READY light illuminates when boom is not seated. DISC light will not illuminate.

Subsequent procedures are the same as after normal refueling.

CAUTION

- If the A/R DISC trigger switch is released when the nozzle is not in the bottom of the receptacle (READY light is off), it is possible for the nozzle to damage or break the extended nozzle latches, preventing any further refueling.

- The boom limit switches are deactivated when using manual boom latching. The receiver pilot must initiate disconnect before exceeding the boom limits since the boom operator will be unable to release the nozzle latches. KC-10 boom operators can still use the Independent Disconnect System.

NOTE

There will not be a pressure disconnect when using manual boom latching, but the refuel manifold accepts tanker pressure with ample margin after tanks shut off automatically. The fuel vent manifold releases excess tank pressure if the tank shutoff valves malfunction.

RADIO SILENCE REFUELING PROCEDURE

Radio silence air refueling can be conducted if the following procedures are observed and both crews are experienced in normal air refueling procedures. The method, time, and place of rendezvous, and amount of fuel to be transferred, must be coordinated.

a. Air refueling checks will be completed before moving to the precontact position.

b. Before contact, maneuver as directed by tanker director lights. A steady red light indicates a large correction and a flashing red light indicates a small correction in the direction indicated by the red director lights. When contact is made, boom interphone may be used.

AIR REFUELING VISUAL SIGNALS

The following visual signals will be used for radio communication failure or radio silence.

Signals From Tanker

With boom in trail:

a. Ten foot extension of the probe means that the tanker is ready for contact.

When the ready signal is received, move from the observation position and stabilize in the precontact position, then move to the contact position.

b. Full extension of the probe means that the tanker is ready for contact but that he is in manual control, without disconnect control capability.

Close and open the Air Refueling door to acknowledge this signal.

NOTE

Boom interphone is inoperative when the tanker is in manual operation.

c. Full retraction of the boom indicates that offload has been completed.

Boom stowed:

a. Full retraction of the probe means that the tanker air refueling system is inoperative.

b. Five foot extension of the probe indicates that there is an air refueling system malfunction.

Check the air refueling system.

Director lights off:

A request to disconnect is signalled by turning the director lights off. Return to the precontact position after disconnecting.

Director lights flashing:

The BREAKAWAY command is signalled by turning the lower rotating beacon on and rapid flashing of the director lights.

Signal From Receiver

Cycle the Air Refueling Door:

Cycling the A/R door while in the precontact position indicates that the Manual Boom Latching procedure will be used. The tanker should signal acknowledgement by full extension of the refueling probe with the boom in trail, and then retract the probe to the ready position.

CAUTION

During manual boom latching, the receiver pilot must initiate all disconnects. KC-10 boom operators can still use the Independent Disconnect System.

Rock wings (daytime) and turn rotating beacon on/off at ten second intervals:

This signal indicates that the receiver must refuel. If not at a scheduled time or place for refueling (when the boom operator might not be in place) take a position where the signals are visible from the tanker cockpit.

FUEL DUMPING

Fuel dumping provides a means of reducing gross weight rapidly. The nominal dump rate is 2500 pounds per minute for both FUEL DUMP and EMER switch positions, but the rate varies with the amount of fuel remaining and the number of boost pumps operating.

Normally, fuel is dumped in the automatic fuel sequence. An additional tank can be selected in each tank group to increase the dump rate.

To dump fuel:

1. Fuel dump switch - FUEL DUMP.

   All tanks containing fuel will empty in the normal usage sequence except tank 1. Tank 1 will dump automatically with the other tanks until its fuel level reaches approximately 4700 pounds, depending on aircraft attitude (see Fig. 1-36), then it will stop. The other tanks will continue dumping until the fuel level in tank 4 reaches 3700 pounds (again depending on aircraft attitude), then normal dumping is terminated automatically regardless of the fuel quantities remaining in the other tanks.

2. C.G. - Monitor.

   Transfer fuel as necessary to maintain c.g. within limits. At heavy weight, with more than 40,000 pounds of fuel remaining, consider pressing tank 2 on manually to avoid any abnormal forward c.g. condition during dumping. Crossfeed can also be used and will tend to shift c.g. aft.

3. Fuel quantity - Monitor total and tank 4.

   a. Tank 1 dumping should terminate automatically when 4700 pounds remain in that tank.

   b. All dumping should terminate automatically when 3700 pounds remain in tank 4.

When the desired fuel quantity remains:

4. Fuel dump switch - OFF.

To dump fuel when tank 4 contains less than 4000 pounds, or if the FUEL DUMP switch position is inoperative:

5. Fuel dump switch - EMER.

   Selection of the fuel dump switch emergency position overrides the stop-dump feature of the normal dump system.

6. Fuel quantities - Monitor tanks 1 and 4.

WARNING

Emergency fuel dumping must be terminated by positioning the dump switch to OFF (or FUEL DUMP), or all tanks will empty.

When tank 1 is below 5000 pounds:

7. Fuel crossfeed switch - Press to OPEN.

When the desired fuel quantity remains:

8. Fuel dump switch - OFF.

BEFORE PENETRATION

The pitot-static flight instruments will be used when subsonic.

1. Display mode selector switch - Set.

T 2. Defog switch - Set.

T 3. Altimeter - Set.

(4) DEF systems power - Off.

(5) Sensor operate switches -STP.

(6) Sensor power switches -Off.

(7) V/H power switch - Off.

(8) Exposure power switch - Off.

(9) G-band Beacon switch - OFF.

NOTE

Do not shut down the MRS.

(T10) INS altitude - Update.

Update to the field elevation.

PENETRATION

1. Crossfeed switch - OPEN.

CAUTION

Leave crossfeed open to assure fuel supply to both engines during landing and possible go-around operations.

2. Brake switches - DRY or WET, and ANTI SKID ON.

Use the DRY position for a RCR of 21 or more. Wet runway conditions shall be assumed to exist and the WET position used if RCR is less than 21. If RCR is not available, assume a wet runway condition if moisture is visible on the runway, particularly as evidenced by glare or reflections.

(T) a. Brake switch - OFF.

Below Mach 0.5:

3. Surface limiter control handle - Pulled, SURFACE LIMITER light out.

Pull and rotate the surface limiter handle 90 degrees to disengage the surface limiters, lock the handle, and extinguish the SURFACE LIMITER caution light.

▲4. UHF power selector - Set.

Set power 4 or lower, if making an ILS approach.

WARNING

ILS reception can be affected by UHF transmission at high power settings.

T 5. Defog switch - Set.

To dissipate fog in the windshield area, hold the defog switch OPEN for several seconds to provide hot air to the windshield, then select HOLD.

NOTE

Fog usually occurs in the rear cockpit first.

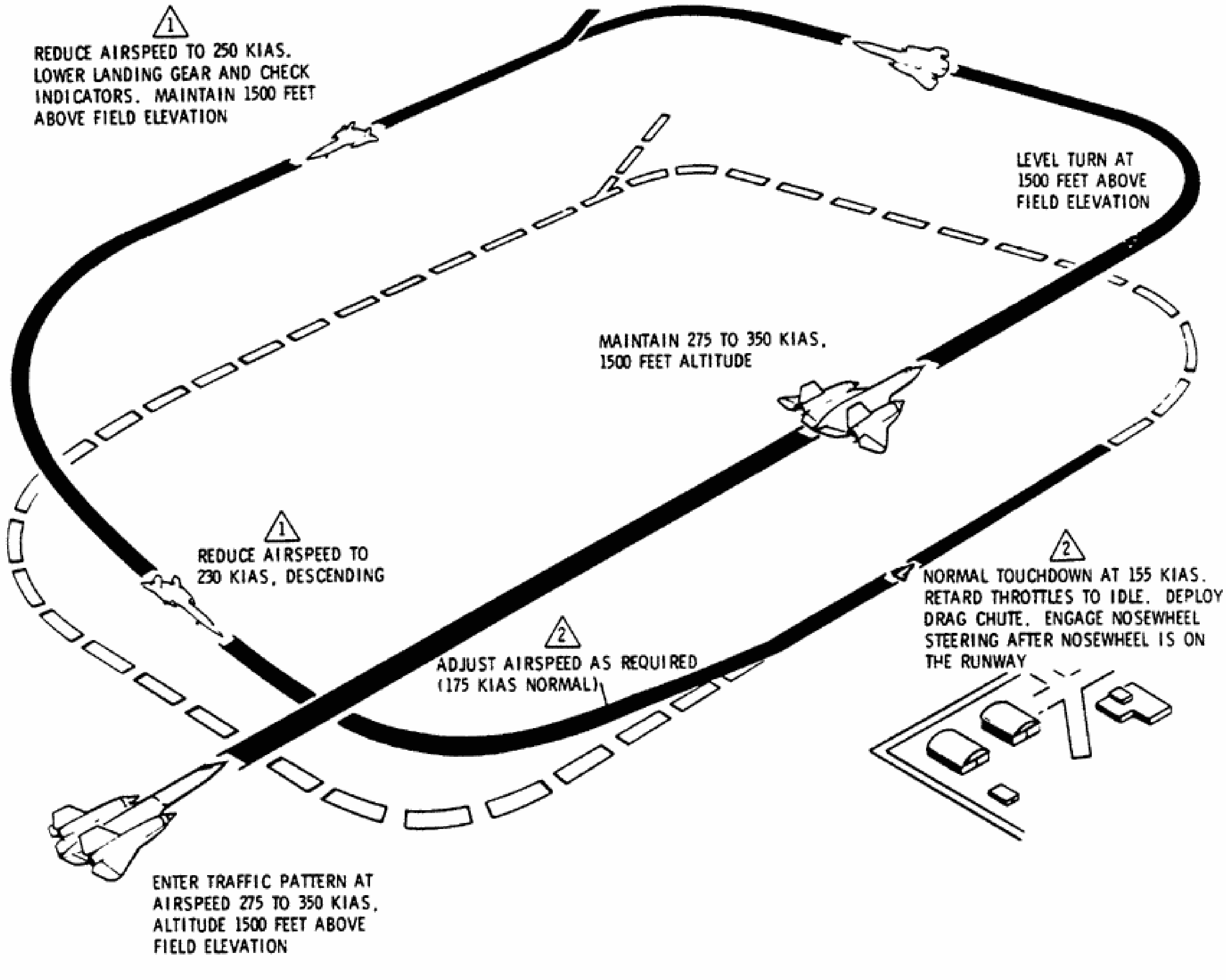
6. Landing light switch - On

BEFORE LANDING

Figure 2-16 depicts a typical landing pattern. At heavy weights, increase airspeed if necessary to maintain angle of attack less than 8 degrees for turns to base leg and 9 degrees for turns to final approach.

The design landing weight is 68,000 pounds with 10 fps sink rate. When landing at higher weights is required, the following speed and sink rate schedule applies.

LANDING PATTERN - Typical



NOTE

1. For aircraft over 100,000 lbs. (more than 40,000 lb. fuel remaining), maintain 275 KIAS on downwind leg and 250 KIAS on base leg; and use an angle of attack of approximately 10.5° for final approach and landing.

2. Increase normal speed for final approach (175 KIAS) and landing (155 KIAS) by 1 knot per 1000 lb of fuel over 10,000 lb remaining. For maximum performance, the minimum landing speed is 10 KIAS less than the speed determined by this rule. See Appendix figure A2-15. The minimum final approach speed is 20 KIAS above the intended landing speed.

Figure 2-16

NORMAL LANDING SPEED SCHEDULES

Approx Fuel Remaining	Final Approach KIAS	Landing Speed KIAS	Max Sink Rate Allowable
10,000 lb or less	175	155	10 fps (600 fpm)
20,000 lb	185	165	9 fps (540 fpm)
25,000 lb	190	170	8.7 fps (522 fpm)
30,000 lb	195	175	8.5 fps (510 fpm)
40,000 lb	205	185	7.75 fps (465 fpm)
With over 40,000 lb remaining, observe Section V landing sink rate limits.			

Figure 2-17

CAUTION

When feasible, routine full stop landings should be made with no more than 10,000 pounds of fuel.

For heavyweight landings: With over 40,000 lb of fuel remaining, use the normal final approach speed schedule and maximum performance landing speed (10 KIAS less than normal landing speed). See Figure 2-17. Use the maximum performance landing technique for stopping.

NOTE

Maximum performance landing speeds result in touchdown angles of attack 1/2 to 1 degree greater than for normal landing speeds.

▲1. Approach and landing speeds -Computed.

Final approach and landing speeds are based on weight. Angle of attack will be approximately 10 degrees for a normal final approach.

Use the maximum performance landing speed schedule when conditions such as wet runway or short field length require minimum roll after touch down.

▲2. Center of gravity - Checked.

Transfer fuel as necessary to maintain subsonic c.g. limits. CG forward of 17% reduces load factor limits. If cg is forward of 17%, insure that no more than half the fuel remaining is in tank 1.

3. Landing gear lever - DOWN and checked.

Check gear warning lights.

CAUTION

Do not extend the landing gear more than 10 times each flight.

NOTE

- Normal gear extension time is 12 to 16 seconds.
- When at heavy weights, gear extension may be delayed until after turn to final approach course, if desired.

4. Hydraulic pressure - Checked.

5. Right refrigeration switch - OFF.

The pilot's R AIR SYS OUT caution light illuminates. Monitor E and R Bay temperatures and suit vent flow for adequate flow from the operating refrigeration unit. Turn the right refrigeration system on and the left refrigeration system off if flow is inadequate.

(T6.) Cockpit air handle - OFF

Place the cockpit air handle in the forward (valve closed) position to prevent cockpit fogging. The pilot's CKPT AIR OFF caution light illuminates.

NOTE

Refrigeration system shutoff and cockpit air shutoff are not normally required for low approaches.

7. Annunciator panel - Checked.

NOTE

Lowering the vision splitter during night landings reduces glare from reflections off the inside of the windshield.

NORMAL LANDING

Touchdown is made with the throttles in IDLE, and at approximately 9.5 degrees angle of attack. (Due to ground effect, angle of attack is nearly the same as for final approach.) Pitch angle is approximately 10.5 degrees, with the nose almost on the horizon. A high rate of sink will develop if airspeed becomes excessively low on final approach, and result in a hard landing.

NOTE

- Throttle movement should follow the quadrant curvature so that the hidden ledge at the IDLE position can prevent inadvertent engine cutoff.
- With cockpit air on, sudden fogging can occur when the throttles are retarded during the landing flare. Use the Cockpit Fog emergency procedure in this event.

NOTE

- Angle of attack at touchdown must not exceed 14 degrees to avoid scraping the tail.

Use the maximum performance landing touchdown speed when wet or slippery runway conditions exist which degrade braking capability.

AFTER TOUCHDOWN

1. Drag chute - Deploy.

Deploy the chute when the main gear is on the runway and angle of attack is 10 degrees or less.

CAUTION

Deploying the drag chute at greater than 10 degrees angle of attack may result in the chute canopy contacting the runway and receiving scuff damage.

Pull the drag chute handle straight aft to the limit of its travel (approximately one inch).

WARNING

Avoid resting the hand on or near the drag chute handle after pulling it aft for normal deployment. Otherwise, the chute will be jettisoned if the handle is pushed forward inadvertently when the chute opens.

The initial forces caused by chute opening normally approximate one-half "g" deceleration. See Section VI, Figure 6-11.

If the chute does not deploy normally in approximately five seconds, turn the chute handle 90 degrees counterclockwise and pull aft, approximately six inches, to the limit of its travel.

NOTE

The drag chute switch in the aft cockpit of the SR-71B must be OFF to deploy from the forward cockpit; otherwise, the handle in the forward cockpit is inoperative.

Start the nose down at touchdown. Excessive nose gear loads may result on contact if a high angle of attack is maintained until airspeed is too low for positive control of attitude.

2. Nosewheel steering - Engage.

Engage nosewheel steering when the nosewheel is on the runway. Steering will not engage until the rudder pedals and nosewheel are aligned and aircraft weight is on any one gear.

Illumination of the nosewheel steering STEER ON light is a positive indication that steering has engaged.

It may be necessary to move the rudder pedals through a small range on each side of neutral to assure alignment with the nosewheel castering angle. In a crosswind, engagement will probably require momentarily moving the pedals in a direction opposite to that desired for steering.

Although the steering system includes a holding relay in the engagement circuit, the recommended method for positive engagement is to hold the nosewheel steering (CSC/NWS) button on the control stick depressed until steering is engaged. The button may be released after engagement.

Nosewheel steering is released by pressing and releasing the button a second time (whether actually engaged or not). If steering is inadvertently released, depress the button again and reengage steering as before.

3. Brakes - Checked.

Check for normal brake operation by light application prior to jettisoning the drag chute.

Anti-skid braking is available when aircraft weight is on at least one main gear; however, delay braking until the nosewheel is on the runway.

The normal performance procedure should be used on a dry runway or on a grooved runway with braking equivalent to a dry runway. (Refer to Wet/Slippery Runway Landings, this section, if landing on a runway where braking may be degraded). Apply brakes as required. Light braking is sufficient if the drag chute deploys normally. If the drag chute does not deploy, moderate braking force is necessary at normal landing weight.

4. Drag chute - Jettison.

Push the drag chute handle fully forward from the deploy position to jettison the chute.

The drag chute is normally jettisoned at or above 55 KIAS when on a dry runway or with equivalent braking action available; however, do not jettison the chute if the crosswind component exceeds 12 knots or if braking action is unsatisfactory.

(T) a. Drag chute switch - OFF.

WARNING

In the SR-71B, if the aft cockpit deploys the drag chute and the forward cockpit handle remains stowed, returning the aft cockpit drag chute switch to OFF will jettison the drag chute.

CAUTION

If the drag chute is not jettisoned, the elevons should not be moved during taxiing as the shroud lines may jam between the inboard elevons and fuselage and cause structural damage.

NOTE

The drag chute can not be jettisoned after using the emergency deployment system.

CROSSWIND LANDING

Refer to Landing Gear System, Crosswind Limits in Section V. Also refer to the Crosswind Component chart in the Appendix, Figure A2-1.

Runway alignment on final approach can be maintained by crabbing and/or dropping one wing. Remove any crab before touchdown, and use the wing-low technique to align the aircraft with the runway and prevent side drift.

Reduce sink rate to a minimum to accomplish a smooth touchdown. As crosswind components increase, sink rate must be minimized due to the increased side loads imposed on the landing gear.

CAUTION

It is essential to remove all crab before touchdown to minimize scuffing damage to the tires.

Crosswind Condition With Dry or Grooved Runway

Touchdown and try to remain on the upwind side of the runway. This provides more runway space on the downwind side, and puts the crosswind and runway "crown" effects in opposition. Deploy the drag chute early in the landing roll, as for a normal landing, but lower the nosewheel first and engage steering if the crosswind component is over 15 knots.

The chute's tendency to pull the aircraft off the runway in a crosswind decreases as speed is reduced, and the effect is easily controllable with nosewheel steering. Keep the stick forward to improve nosewheel steering effectiveness. Increasing rudder deflection and/or increasing elevon differential is required as speed decreases.

Do not shut down either engine when on a dry runway, or on a grooved runway which provides equivalent braking.

Crosswind Condition With Slippery Runway

For landing on a slippery runway with a crosswind, start the nose down immediately on landing and engage nosewheel steering before deploying the drag chute. After the nose is lowered, use lateral stick deflection and/or rudders to increase directional control. Use roll inputs in the same direction as rudder/nosewheel steering. This also increases braking on that side when combined with neutral or aft stick.

With a slippery runway, shutdown of one engine to assist in stopping is permissible if required due to drag chute failure. Shutdown the upwind engine when under 100 KIAS, and select ALT STEER & BRAKE if continuing on the right engine alone. Shutdown is not recommended if barrier engagement is available.

The nosewheel steering system provides adequate control in allowable crosswinds on slippery runways, even with damaged main gear tires. However, be careful not to overcontrol the aircraft and start a lateral skid. The nosewheel steering force can be very large and this force, combined with the reduced side reaction force capability of the main gear tires, may cause the main gear tires to "break away" and slide. The nosewheel steering force reaches a maximum at a 13-1/2 degree angle between the tires and the ground track. This corresponds to 6 degrees rudder deflection with the aircraft heading along the ground track.

WET/SLIPPERY RUNWAY LANDINGS

When landing on a runway where degraded braking is expected (i.e., on a wet runway without grooves), select the WET anti-skid braking mode. When crosswind is not a factor, use the maximum performance touchdown speed schedule and lower the nose while deploying the drag chute. Apply maximum braking as soon as the nosewheel is on the runway and engage nosewheel steering. Frequent anti-skid cycling may be felt. Retain the drag chute if stopping distance is critical. The chute can be jettisoned if a control problem or a lateral skid develops.

If the drag chute fails to deploy, use moderate up-elevon to increase drag and the load on the main gear. The WET anti-skid mode provides the best braking capability with or without the drag chute unless tire failure has occurred; in this event, it may be necessary to complete the stop with anti-skid OFF and the wheels locked. Refer to Flat Tire Landing emergency procedure, Section III. If the chute fails, shutdown of one engine is permissible when under 100 KIAS if required to assist in stopping, but shutdown is not recommended if barrier engagement is available.

Icy Runway Procedure

Use the same techniques as for the Wet/Slippery Runway landing.

MAXIMUM PERFORMANCE LANDING

Use the maximum performance schedule whenever minimum landing distance is desirable. Maximum performance touchdown speed is 10 KIAS less than normal touchdown speed. Start drag chute deployment as soon as the main gear is on the runway and angle of attack is 10 degrees or less.

WARNING

Do not deploy the chute in flight.

CAUTION

Deploying the drag chute at greater than 10 degrees angle of attack may result in the canopy contacting the runway and receiving scuff damage.

Lower the nose and apply maximum braking as soon as the nosewheel is on the runway. Engage nosewheel steering. Retain the drag chute. One engine may be shutdown after touchdown to reduce thrust and shorten the landing roll.

WARNING

Do not shutdown both engines, as it may result in the loss of brakes. Nosewheel steering will be lost when engine speed decays.

MINIMUM ROLL

Reduce fuel weight to 5000 pounds, if possible, and use the maximum performance landing procedure.

HEAVYWEIGHT LANDING

Landings with more than 40,000 pounds of fuel remaining should be avoided, but can be accomplished if necessary. Use normal final approach speeds, but do not exceed 11 degrees angle of attack. Use the maximum performance touchdown speed schedule and observe touchdown rate of sink limits from Section V. When touchdown speed is less than the chute deploy limit speed (210 KIAS), lower the nose and deploy the drag chute as soon as the main gear is on the runway. If touchdown speed is higher than 210 KIAS, hold the nose off until 210 KIAS is reached, then lower the nose and deploy the drag chute. To minimize the possibility of tire

GO AROUND - Typical

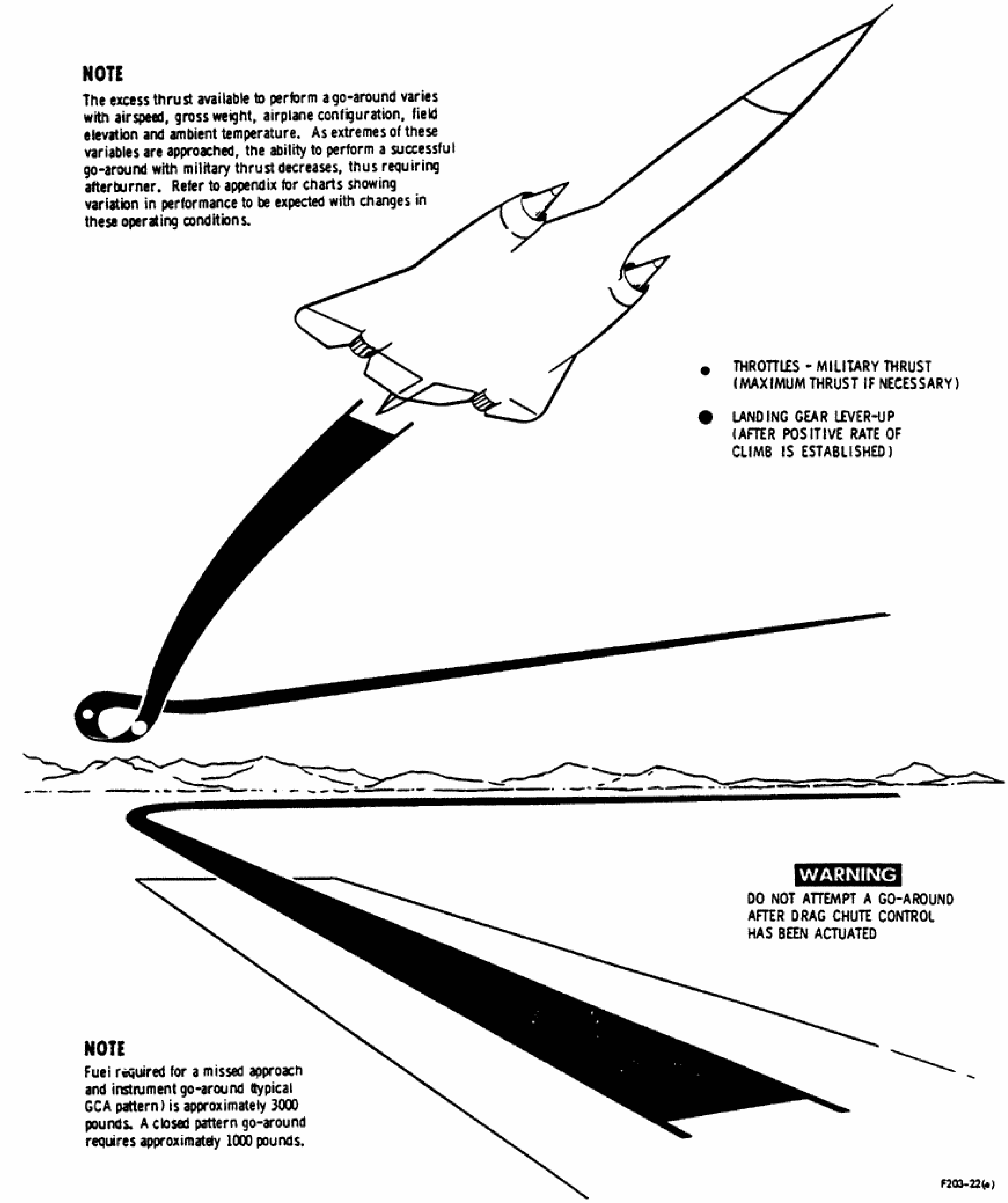


Figure 2-18

failure at heavy weight, the brakes should be applied early in the landing roll. This reduces the distance travelled at high speed. Retain the drag chute. Barrier engagement should be anticipated, since the brake energy rating may be exceeded. Refer to Figure 5-9, Section V.

GO-AROUND

A go-around may be initiated at any time during the approach or landing roll when sufficient runway remains for takeoff and no attempt to deploy the drag chute has been made. (See Figure 2-18.) For go-around after touchdown, reduce pitch attitude to approximately 5 degrees pitch angle (5 degrees above what the attitude would be with the nose on the ground) then adjust attitude to takeoff at 210 KIAS.

TOUCH-AND-GO LANDING

Normal Before Landing and After Takeoff procedures apply to touch-and-go operations. The maximum fuel load recommended is 25,000 pounds remaining and cg aft of 17%. The limit sink rate is 8.7 fps (522 fpm) with 25,000 pounds of fuel.

CAUTION

Do not extend the landing gear more than 10 times each flight.

At least ten complete retract and extend cycles of the gear can be made with normal hydraulic quantity and reservoir nitrogen pressure servicing. If reservoir nitrogen pressure is depleted, cycling the landing gear may cavitate the L hydraulic system pump and cause complete loss of L hydraulic system pressure.

NOTE

Manual EGT trim may be used when making successive low approaches or touch and go landings. This prevents auto EGT up-trim "ratcheting" which could occur because of power manipulation during approach, and which might result in EGT overtemperature while at or above Military power during go-around.

1. Throttles - IDLE.
2. Touchdown speed - As required.

   Base touchdown speed on fuel remaining.

After touchdown:

3. Pitch angle - Approximately $+5^{\circ}$

   Reduce pitch attitude to approximately 5 degrees pitch angle (5 degrees above what the attitude would be with the nose on the ground). The nosewheel should not touch the runway.

4. Throttles - Military
5. Pitch attitude - Adjust to fly off at 210 KIAS.

AFTER LANDING

T 1. SAS channel engage switches - Off.

2. Landing light - OFF.

   Select TAXI LT if lighting is required; otherwise, select OFF. The landing light should not be operated without airstream cooling or it will burn out prematurely.

3. Right refrigeration switch - ON.

(T4) Cockpit air shutoff handle - ON.

(T5) HF radio - OFF.

(T6) IFF - OFF.

When clear of the runway:

7. Pitot heat switch - OFF.

8. Crossfeed - Closed.

T 9. EGT trim switches - HOLD.

T 10. Periscope - Stowed.

(11) Viewsight power - Off.

ENGINE SHUTDOWN

1. Wheel chocks - Installed.

2. Nosewheel steering - Disengaged.

(3.) OBC Power Control switch - OFF.

4. C.G. - Forward of 17%.

Transfer fuel forward of 17% for easier downloading of sensor equipment.

NOTE

If Tank 4 is not on, press Tank 4 boost pumps on before transferring fuel forward. Otherwise, with cross-feed off, a reduction in fuel flow to approximately 3600 lb per hour will occur on the right side. This is less than the desired value for normal operation of the fuel heat sink system. Release the tank after completing fuel transfer.

In the SR-71B, use the DAFICS BIT check after landing to check aft cockpit switch inputs to DAFICS.

(T) 5. APW switch - PUSHER/SHAKER. APW switch position in the cockpit that does not have APW switch control does not affect the DAFICS BIT.

(T) 6. SPIKE DOOR control transfer - Take control. Check SPIKE DOOR transfer light illuminated on aft cockpit control transfer panel. Inlet switches in the cockpit that does not have SPIKE DOOR control are not functional and do not affect the DAFICS BIT.

(T) 7. AFCS control transfer - Take control.

T 8. DAFICS Preflight BIT - Check.

T a. SAS channel engage switches - ON.

T b. SENSOR/SERVO lights - Check off.

T c. Forward cockpit (aft cockpit in SR-71B) switch positions for DAFICS PREFLIGHT BIT - Set.
- Autopilot pitch and roll engage switches - ON.
- ATT REF SELECT switch - ANS
- KEAS HOLD switch - ON
- HEADING HOLD switch - ON

T d. DAFICS PREFLIGHT BIT switch - ON.

The BIT TEST light illuminates steady green while the test is running.

Pressure from A hydraulic system is required to engage the DAFICS PREFLIGHT BIT. Low pressure or flow from A, B, L or R hydraulic system will cause the DAFICS preflight BIT to fail.

If the DAFICS PREFLIGHT BIT switch will not engage, recheck:

1) CSC/NWS switch - Released.
2) ATT REF SELECT switch - ANS
3) APW switch - PUSHER/SHAKER
4) SPIKES & FWD BYPASS doors - AUTO
5) RESTART switches - Off
6) Throttle Restart switch - Off
7) SAS channel engage switches - ON.
8) AUTOPILOT PITCH & ROLL engage switches - ON
9) KEAS HOLD switch - ON
10) HEADING HOLD switch - ON

NOTE

If at BIT completion the FAIL light, any SENSOR light, any SERVO light, or any CMPTR OUT light illuminates, notify maintenance.

After one minute:

e. Check BIT TEST light flashing green, sensor and servo lights extinguished, BIT FAIL light extinguished, and OFF flags in both TDI's. The CIP barber pole reads zero.

f. Check autopilot pitch and roll engage switches, KEAS HOLD switch, and HEADING HOLD switch -Off. AUTOPILOT OFF and SAS OUT lights illuminated.

g. Check DAFICS PREFLIGHT BIT switch - OFF (guard down).

h. SENSOR/SERVO recycle switches - Press one of the six.

Pressing one of the six SENSOR/SERVO recycle switches resets the DAFICS system to the flight mode. Check SENSOR/SERVO lights, BIT TEST light, and SAS OUT lights are out. Check both spikes have returned to the full forward position and the CIP barber pole has returned to normal. Both TDI's will initiate resynchronization and run up to 55,000 ft., Mach 2.0, and 300 KEAS. AOA will indicate 10°. AOA will return to 0° in approximately 1 min 15 sec and TDI indications will return to normal in approximately 2 min 15 sec after the DAFICS system has been reset to the flight mode. The A, B, and M CMPTR OUT annunciator panel lights flash momentarily when the DAFICS system is reset.

9. Exterior lights - OFF.

▲10. TACAN and ILS - OFF.

11. PVD - OFF.

▲12. Loose items - Secured.

▲13. Canopy seal pressure lever - OFF.

▲14. Canopy - Open

CAUTION

The pilot should notify the RSO when he opens the canopy. If either canopy is open, the aft canopy latch handle must be in the aft position or the cockpit air handle must be in the forward (off) position for adequate equipment cooling. Otherwise, most of the cooling air would exit through the cockpit openings instead of the bays.

15. SENSOR/SERVO lights - Check off.

All pitch, yaw, and roll SAS channels should be engaged before checking the effects of generator switching.

(T16.) ANS MODE switch - OFF.

Prior to ANS shutdown, place system in DEAD RECKON MODE and record LAT/LONG from Present Position Display. Coordinates will be used for system evaluation.

17. Right generator switch - OFF.

NOTE

With transfer of electrical power while on the ground, the DAFICS may undergo ground reinitialization indicated by momentary illumination of the A, B, and M CMPTR OUT caution lights, OFF flags in both TDIs, and TDI resynchronization to 55,000 ft., Mach 2.0, and 300 KEAS.

18. Bus tie pushbutton - Press.

    Split the buses to obtain satisfactory MRS records.

    NOTE

    The tank 4 boost pump indicator light may extinguish.

    The tank 4 boost pump indicator light is associated with the power supply to pumps 4-3 and 4-4 only. If pumps 4-2 and 4-4 are on and pumps 4-1 and 4-3 are off (tank 5 empty, tank 2 feeding, tank 4 not manually selected), when the right generator is turned off and the buses are split, the tank 4 boost pump indicator light will extinguish as pump 4-4 is de-energized. In this condition, pumps 2-1 and 4-2 continue to supply the engines. The tank 4 boost pump indicator light should illuminate again when the right generator is returned to service.

19. Right generator switch - NORM.

    Check the GEN BUS TIE OPEN caution light on and the R GEN OUT caution light extinguished.

20. APW System switch - OFF.

    (T)a. Aft cockpit - CONT FWD.

21. Fuel derich system - Both checked, rearmed, and OFF.

    a. Set both engines 400 rpm above idle speed.

    b. Actuate the derich test switch until 860°C EGT is exceeded with LEFT and then RIGHT selected.

    When the EGT indications exceed 860°C:

    c. Verify that the EGT gage warning lights are on and that the Fuel Derich lights are on.

    d. Note that engine speeds decrease between 50 and 400 rpm.

    e. Cycle the fuel derich switch to REARM, and then OFF.

       Verify that each engine returns to 400 rpm above idle, and EGT indications are normal.

    f. Reset the throttles to IDLE.

22. Tanks No. 1 & 4 boost pump switches - Press on.

23. Left generator switch - OFF.

After fifteen seconds for MRS recording:

24. Left generator switch - NORM.

25. Right generator switch - OFF.

After fifteen seconds:

26. Left generator switch - OFF.

    Check that both GEN OUT caution lights are on. DAFICS computers should automatically reset after power transfer, and no SAS SENSOR or SERVO lights should illuminate.

    Check that the following lights are off:

    SAS OUT
    MRS power switch (RSO)

Check that the following lights are on:

INSTR INVERTER ON
GEN BUS TIE OPEN
L and R GEN OUT
L and R XFMR RECT OUT

CAUTION

This step should be completed and ac power restored to the fuel system boost pumps without delay. An engine fuel-hydraulic pump can be damaged by cavitation if operation is continued for any significant period with a low fuel pressure condition.

27. Left and right generator switches - EMER.

The following annunciator panel lights should not be illuminated:

L and R GEN OUT
L and R XFMR RECT OUT
EMER BAT ON

Fuel panel lights for empty tanks should illuminate EMPTY.

▲28. INS - Check normal operation.

INS continues to operate on aircraft battery and instrument inverter power with both generators OFF or in EMER.

a. INS REF annunciator light - Check not illuminated.

b. ADI - Check attitude indication is unchanged and no OFF flags in view.

(c.) RSO attitude indicator:

With S/B R-2595 check attitude is unchanged and no OFF flag.

Without S/B R-2595 attitude not valid and OFF flag is in view.

(Td.) INS FUNCTION switch - Set ATT and check heading slew.

Set the INS Function switch to ATT, INS REF annunciator light illuminates, flag at top of ADI comes in view (heading not valid), ADI attitude remains valid. Push and turn the heading slew knob and confirm HSI and BDHI compass card rotation.

(T29.) INS FUNCTION switch - OFF.

(T30.) INS PWR switch - Press (off).

31. One generator switch - NORM.

Resume normal operation with the generator corresponding to the engine which is to be shut down last.

32. Remaining generator switch - OFF.

Turn off generator corresponding to the engine which is to be shut down first (usually the engine that was started first). Check that the L and R FUEL PRESS warning lights are off to assure that normal pressure exists in the fuel supply manifolds.

T 33. SAS channel engage switches - Off.

34. Brake switch - Set.

Set ALT STEER & BRAKES if the left engine is to be shut down first.

35. First engine throttle - OFF.

Confirm with ground personnel that area under engine is clear before shutting down the engine.

36. Flight control system - Checked.

Check nosewheel disengaged. After flight control (A or B) hydraulic steady-state pressure from the first engine is below 1500 psi, individually check each axis for full deflection and freedom of travel in both directions. Confirm correct ground crew observation, using the following sequence: nose up, nose down, left roll, right roll, nose left and nose right.

NOTE

Rapid control surface deflection while near idle rpm may result in temporary illumination of an A or B HYD warning light. The light should extinguish when flow demands on the system diminish and normal pressure is restored.

37. Brakes and steering - Checked.

Check brakes and nosewheel steering operate with only one hydraulic system (L or R) operating. Pump brakes and check normal pressure while crew chief visually confirms brake actuation on both trucks. Nosewheel STEER ON light illuminates when nosewheel steering engaged. Nose should swing as rudder pedals are moved slightly.

+38. Second generator switch - OFF.

Confirm with ground personnel that area under engine is clear.

CAUTION

Do not delay engine shutdown after generator power to the boost pumps is removed.

39. Second engine throttle - OFF.

40. Instrument inverter - Checked and OFF.

Check that the following lights are on:

INSTR INVERTER ON
EMER BAT ON

NOTE

A relay delays EMER BAT ON light illumination for 10 seconds after loss of T-Rs (Step 38).

Press the Indicator and Lights Test switch to check AØ and BØ (bright illumination of the left and right FIRE lights, respectively) of the instrument inverter. TDI off flag (Pilot and RSO) remaining out of view with normal TDI indications (or TDI values increasing or decreasing in response to DAFICS resynchronization) is a check of CØ instrument inverter power.

▲41. Seat and canopy safety pins -Installed.

▲42. UHF and VHF radios - OFF

43. Battery switch - OFF.

NORMAL GROUND EGRESS - Pressure Suit

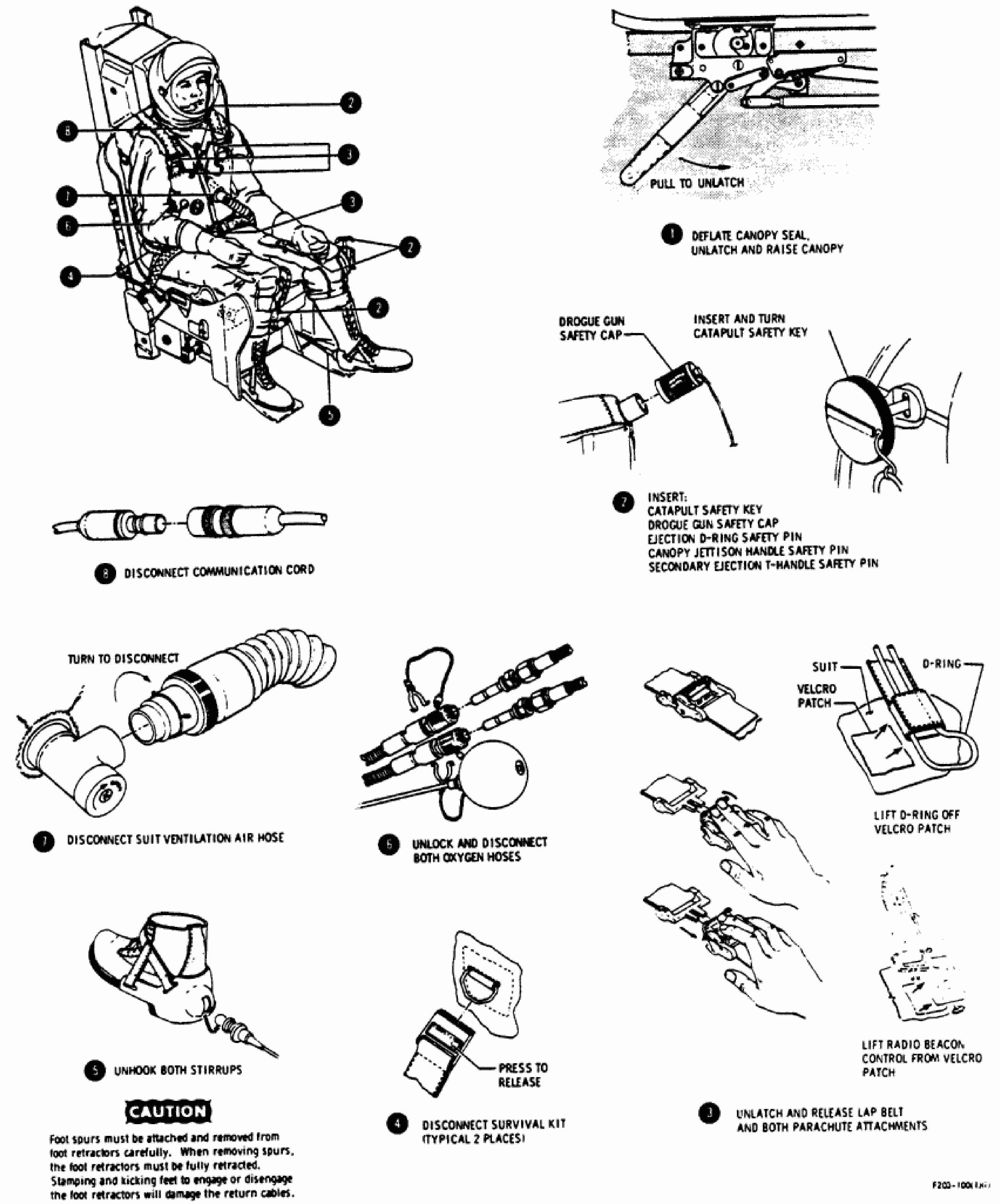


Figure 2-19

SURVIVAL QUICK LAUNCH

WARNING

Quick Launch procedures are not intended for normal operations. Quick Launch procedures will only be used when directed by the commander.

Takeoff using Survival Quick Launch procedures should be used only to avoid destruction of the aircraft.

QUICK LAUNCH SETUP

The Quick Launch Setup procedures require that <u>all</u> normal procedures <u>through</u> Before Taxiing (<u>or</u> Before Takeoff) have been completed before the Quick Launch Setup checklist is initiated.

QUICK LAUNCH SETUP PROCEDURE

After Before Taxiing (or Before Takeoff) checks complete:

(T1) HF Radio - OFF.

(T2) IFF mode 4 code select switch - HOLD.

Place the switch in the momentary HOLD position for 15 seconds, then wait another 15 seconds before turning equipment OFF.

After 15 seconds:

(T3) IFF - OFF.

(4.) Sensor and OBC power - Off.

5. Pitot heat switch - OFF.

6. EGT trim switches - Downtrim, if desired, then AUTO.

If engine run to check automatic EGT trim has not been completed, consider downtrimming EGT slightly. Return EGT trim switch to AUTO so that automatic EGT trimming will trim EGT into the nominal band during takeoff.

7. C. G. - 18%.

Transfer fuel to 18% so that c.g. will be at 18% to 20% for takeoff.

8. PVD - OFF.

▲9. Loose items - Secured.

(T10.) Cockpit air - Off (forward).

▲11. Canopy seal switch - OFF.

▲12. Canopy - Open.

(T13.) ANS MODE switch - OFF.

(T14.) INS FUNCTION switch - OFF.

(T15.) INS PWR switch - Press (Off).

16. Right generator switch - OFF.

17. Right throttle - OFF.

Confirm with ground personnel that area under engine is clear before shutting down the engine.

18. Left generator switch - OFF.

Confirm with ground personnel that area under engine is clear.

CAUTION

Do not delay engine shutdown after generator power to the boost pumps is removed.

19. Left throttle - OFF.

20. Instrument inverter - Checked and <u>NORM</u>.

21. Cabin pressure switch - 10,000 FT, if desired.

▲22. Seat and canopy pins - Installed.

23. Pilot's A, B, and M CMPTR circuit breakers (3 total) - Pull.

T24. RSO's A, B, and M COMPUTER circuit breakers (9 total) - Pull.

T25. INS FUNCTION switch - STOR HDG.

▲26. Oxygen - OFF.

27. Battery switch - OFF.

QUICK LAUNCH START

While subject to Quick Launch, ensure that nobody has access to the aircraft unless authorized by the aircrew.

If Quick Launch Setup procedures were not completed prior to start or if the aircraft is removed from Quick Launch status, use normal procedures for launch.

When routine aircraft servicing is required, cockpit access requires crew authorization and the crew should accompany maintenance personnel (to remain aware of aircraft status and confirm that cockpit setup is not changed).

Quick Launch Setup and Quick Launch Start procedures require ANS Ground Hot Start and INS Stored Heading procedures. If the aircraft is moved after the ANS and INS are shutdown, these alignments are invalidated and normal procedures for ANS and INS alignment should be used.

Survival Quick Launch procedures assume external power is available for start. If external power fails the engines can be started but engine instrument indications, except for rpm, will not be available until a generator is turned on. If the crew chief does not use a headset during start, the aircrew must coordinate the hand signals to be used prior to assuming Quick Launch status.

QUICK LAUNCH START PROCEDURES

After external power applied:

T1. INS PWR switch - Press (On).

2. Battery switch - BAT.

3. Right engine - Start.

T4. RSO's A, B, and M COMPUTER circuit breakers (9 total) - Push in.

These circuit breakers are pulled to keep the PTAs from being powered until cooling air is available. The circuit breakers may be reset as soon as the start procedures are in progress. Since the left and right refrigeration switches are still on (from Before Taxiing checks), cooling air to the PTAs will be available as soon as the right engine starts.

The DAFICS circuit breakers in the front cockpit are reset after the DAFICS circuit breakers in the aft cockpit to prevent the DAFICS computers from operating (sensing and storing power faults) until DAFICS has proper power. If the forward cockpit circuit breakers are reset first, DAFICS memory will indicate transient power faults, however DAFICS operation and reliability is not degraded.

After right engine is started:

5. Right generator - On (NORM), light off.

Check R GEN OUT light extinguishes

T6. ANS Mode switch - INERTIAL ONLY.

The ANS is not turned on until after the right engine is started so that the ANS has cooling and the LIMIT light will not flash.

The MAL light will flash until the HOT switch is pressed.

T7. ANS HOT switch - Press.

8. External power - Disconnected.

9. Left engine - Start.

10. Left generator - On (NORM), light off.

Check L GEN OUT light extinguishes.

11. Pilot's A, B, and M CMPTR circuit breakers (3) - Push In.

Setting the 3 dc CMPTR circuit breakers in the forward cockpit starts the DAFICS computers. Check the A, B, and M CMPTR OUT annunciator lights extinguish.

▲12. Ejection seat and canopy pins - Removed.

▲13. Canopy - Closed and locked.

▲14. Canopy seal switch - ON.

(T15.) Cockpit air - On (aft).

16. Nosewheel steering - Engaged.

With NAV RDY light flashing:

(T17.) INS FUNCTION switch - NAV.

With F/A in mode window:

(T18.) ANS MODE START switch - Press.

The chronometer may not be charged for Quick Launch procedures; if not, the ANS will not star track if Astro-Inertial mode is selected.

(T19.) MRS - ON.

QUICK LAUNCH TAXI

1. Brakes - DRY or WET and ANTI SKID ON.

▲2. Circuit breakers - Checked.

3. Flight controls and trim setting - Check.

4. Fuel - Check tanks 1, 3, and 5 (or 6) on.

▲5. CG - Checked.

▲6. Oxygen - ON and pressure checked.

7. Pitot heat switch - ON.

(T8.) IFF - NORMAL.

(T9.) HF radio - On.

QUICK LAUNCH TAKEOFF

T 1. SAS - Engaged, lights off.

▲2. Warning and caution lights - Checked.

3. Tank 4 - Press on.

The following summary of bold print steps is provided as a training aid. The amplified procedures should be reviewed to assure complete understanding of the meaning and intent of the bold print steps.

GROUND OPERATION

GROUND EMERGENCY EGRESS

▲ 1. **CANOPY OPEN OR JETTISON**
▲ 2. **SCRAMBLE HANDLE**
▲ 3. **KIT HANDLE**
▲ 4. **CHUTE RELEASE**

ENGINE FIRE

1. **THROTTLES OFF**
2. **FUEL OFF**

BRAKE OR STEERING FAILURE

If normal brakes/steering not effective or if L hydro out:
1. **ALT STEER & BRAKE**

If alternate brakes ineffective:
2. **ANTISKID OFF**

TAKEOFF EMERGENCIES

ENGINE FAILURE

If conditions permit and gear down:
1. **ABORT**

After takeoff,
If unable to hold altitude and accel:
▲ 1. **EJECT**

If able to hold altitude or accel:
1. **THROTTLES MAX**
2. **GEAR UP**

BARRIER ENGAGEMENT

1. **NOSE DOWN**
2. **BRAKES RELEASE**

ABORT

1. **THROTTLES IDLE**
2. **BRAKES**
3. **CHUTE DEPLOY**

If tire failure occurs and braking abnormal:
4. **ANTISKID OFF**

TIRE FAILURE

Before accel check speed:
1. **ABORT**

If takeoff continued:
1. **DON'T RETRACT GEAR**
2. **ANTISKID OFF**
3. **BRAKE WHEELS**

IN-FLIGHT EMERGENCIES

BAILOUT

1. **ALERT RSO**
▲ 2. **EJECTION D-RING**

If seat fails to eject:
▲ 3. **CANOPY JETTISON**
▲ 4. **EJECTION T-HANDLE**

EMERGENCY DESCENT

1. **RESTARTS ON**
2. **THROTTLES IDLE**

Propulsion System Emergencies

INLET UNSTART

For inlet A/D:
1. α WITHIN LIMIT

If either inlet in manual before A/D, or autorestart not effective (unstart recurs, inlet does not clear, or CIP does not recover):

2. RESTARTS ON
3. AFT BYPASS
4. CHECK EGT
5. 350 KEAS

SUBSONIC COMPRESSOR STALL

1. α WITHIN LIMIT

DOUBLE ENGINE FLAMEOUT

With both L & R GEN OUT lights on:

▲ 1. ATTITUDE REFERENCE INS
2. BOTH GENS EMER
3. PRESS TANK 4 ON

Engine(s):

4. AIRSTART

AIRSTART

Affected side:
1. RESTART ON
2. AFT BYPASS OPEN
☆ 3. DERICH
☆ 4. X-FEED OPEN
☆ 5. THROTTLE OFF, THEN 1/3 TO 1/2 MIL

After engine starts:

6. AFT BYPASS SET

If subsonic — only do ☆ items

ENGINE FIRE/SHUTDOWN

☆ 1. THROTTLE MIL/IDLE

To shut down engine:

2. RESTART ON
☆ 3. THROTTLE OFF
☆ 4. AFT BYPASS OPEN
☆ 5. FUEL OFF FOR FIRE

ACCESSORY DRIVE SYSTEM

☆ 1. THROTTLE RESTART ON

Other Aircraft System Emergencies

FUEL PRESSURE LOW

1. X-FEED OPEN
2. PRESS TANK 4 ON

L AND/OR R HYDRAULIC SYSTEM FAILURE

With low quantity, or pressure below 2200 psi:

☆ 1. RESTART ON

FLIGHT CONTROL SYSTEM TRIM FAILURE

1. TRIGGER HOLD

DOUBLE GENERATOR FAILURE

▲ 1. ATTITUDE REFERENCE INS
2. BOTH GENS EMER
3. PRESS TANK 4 ON

APW SYSTEM

For false stick pusher:

1. TRIGGER HOLD

LANDING EMERGENCIES

COCKPIT FOG

(T1.) COCKPIT AIR OFF

BLOWN TIRE AFTER LANDING

If main gear tire fails and braking abnormal:

1. ANTISKID OFF

INTRODUCTION

The emergency procedures recommended in this section should be followed unless circumstances such as weather, fuel, or other reasons dictate otherwise. The safest region for continued operation is subsonic unless altitude or aircraft range is a factor.

Checklists have been provided where specific corrective steps can be enumerated. A narrative format has been used where an analysis is necessary to determine the correct course of action. In some cases, where a decision-tree analysis is possible, the forms have been combined.

MULTIPLE EMERGENCIES

Procedures are based on the assumption that each crewmember understands normal systems operation. Procedures usually cover single emergencies. Crewmembers must recognize that single malfunctions often affect operation of other aircraft systems and may require actions beyond those contained in a specific emergency procedure.

ASSUMPTIONS

Three basic assumptions are made which are not reiterated in each individual procedure. These are: (1) Aircraft control is paramount. (2) Circuit breakers associated with a malfunctioning system must be checked. (3) The other crewmember must be advised of any emergency situation.

SYMBOL CODING

Symbols used to identify crew responsibility are the same as normal procedures. These are:

1. Steps without special notation apply to the forward cockpit of all aircraft.

(2.) Steps with an enclosed step number apply to the aft cockpit of the SR-71A.

▲3. Steps preceded by the ▲ symbol apply to both cockpits of all aircraft.

T 4. Steps preceded by a T apply to the forward cockpit of all aircraft as well as the aft cockpit of the SR-71B.

(T5) Steps with an enclosed T <u>and</u> step number apply to the aft cockpit of SR-71A/B.

(T) 6. Steps preceded by an enclosed T apply only to the aft cockpit of the SR-71B.

DEFINITIONS OF LANDING SITUATIONS

The terms "land when practical" and "land as soon as possible" are not interchangeable.

<u>Land when practical</u> means land at home base or other suitable alternate, with air refueling as necessary.

<u>Land as soon as possible</u> means land at the nearest suitable facility.

USE OF CHECKLISTS

Critical emergency checklist steps appear in capital bold print. The <u>actions</u> required must be committed to memory. In an emergency, the crewmember(s) must be able to accomplish these steps immediately without reference to the abbreviated checklist. This prevents any delay which might aggravate the emergency. Other checklist steps should be accomplished using the challenge and response method when time and circumstance permit. The most important consideration is to maintain aircraft control. Where an emergency situation requires more than one procedure, a reference to the other procedure(s) is included.

GROUND EMERGENCY EGRESS

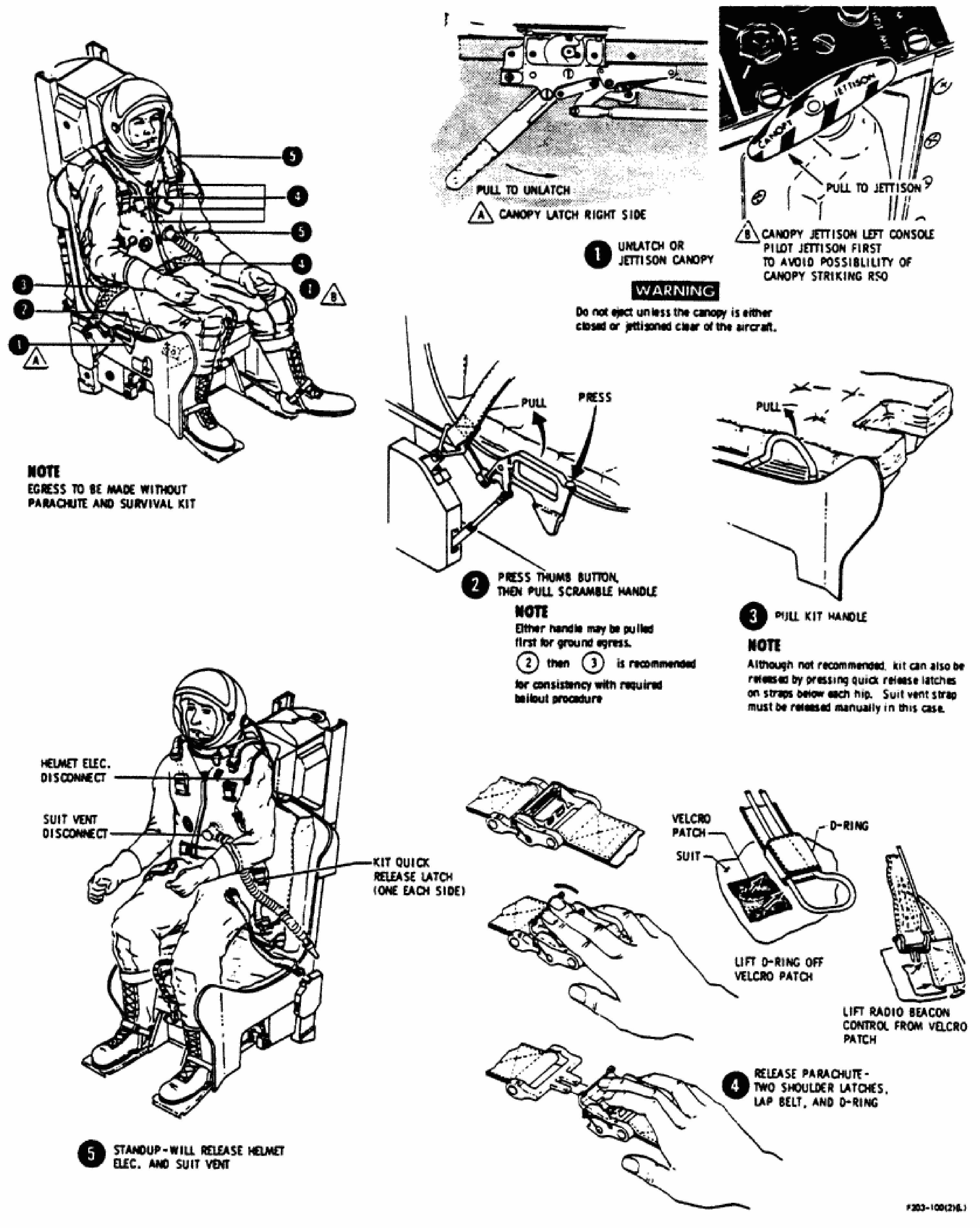


Figure 3-1

GROUND OPERATION

GROUND EMERGENCY EGRESS

In an emergency requiring ground abandonment, the primary concern is to leave the immediate area of the aircraft as soon as possible. The following procedure provides the fastest means of escape. The lap belt should not be released until the aircraft has stopped.

Aircraft On Fire

When the aircraft or the surrounding area is engulfed in flames, the crew may abandon the aircraft (relying on the faceplate, helmet, and suit for protection) or eject.

WARNING

Do not eject unless the canopy is either closed or jettisoned clear of the aircraft.

GROUND EMERGENCY EGRESS PROCEDURE

▲1. CANOPY OPEN OR JETTISON.

Open or jettison the canopies first unless fire danger exists. Retain the canopies until all preparations for evacuation are completed if there is danger of fire engulfing the cockpit area.

The recommended order for canopy jettison is pilot, then RSO, so that the pilot's canopy cannot fall upon an open RSO cockpit and strike the RSO.

▲2. SCRAMBLE HANDLE.

Pull the scramble handle after the aircraft has stopped. This releases:

(1) Lap belt. (The belt remains attached to the parachute.)
(2) Inertia reel shoulder harness.
(3) Foot retention cables.
(4) Parachute arming lanyard and housing.
(5) Cable on ejection D-ring.

NOTE

When pulling the scramble handle, expect a loud report from the initiator firing.

WARNING

If the scramble handle does not function normally, the ejection seat safety pin should be installed to prevent inadvertent ejection. Then the harness, spurs, and lap belt must be released manually as required.

▲3. KIT HANDLE.

Pull the survival kit handle. This releases the kit from the torso harness, disconnects personal leads to the normal and emergency oxygen supplies, and releases the parachute from the survival kit lid. It also detaches the kit lanyard from the torso harness if the kit is seated firmly.

The kit can also be released manually by pressing the quick release latches below each hip. The right latch also releases the kit lanyard.

WARNING

- The crewmember must remain seated until the survival kit handle is pulled.
- The crewmember is still attached to the survival kit by the oxygen hose when using the quick release latches instead of the kit handle to disconnect from the kit.

▲4. CHUTE RELEASE.

Open the parachute quick disconnects at the shoulder and lap, and lift the shoulder straps from the suit velcro patches.

Egress with the chute is possible if it cannot be released.

WARNING

Mobility with the chute is limited.

Standing up separates the helmet electrical connections and the suit vent hose.

ENGINE FIRE

If a fire is evident during start, or on notification:

1. **THROTTLES OFF.**

2. **FUEL OFF.**

   Set both guarded EMER FUEL SHUTOFF switches to the fuel off position (up). Ac and dc power are required. During engine start, the ground crew should continue turning the engine if the fire is contained in the tailpipe. If the starter unit has disengaged, it cannot be re-engaged until the engine has come to a complete stop.

3. Battery - OFF.

▲4. Abandon the aircraft.

CAUTION

Without ground power, simultaneous shutdown of both engines may result in generator cut-out and loss of AC power before the emergency fuel shutoff valves can completely shut off the engine fuel supply. Similarly, actuating the battery switch within 5 seconds of closing the emergency fuel shutoff switches may result in incomplete valve operation.

CAUTION

If ground power is not connected, as during taxiing or after landing, and if crew safety is not an immediate factor, shut down the affected engine first followed by the affected engine fuel shutoff switch. To assure complete fuel shut-off to that side, allow 5 seconds before shutting down the second engine and actuating the battery switch.

BRAKE OR STEERING FAILURE

Illumination of the ANTI-SKID OUT caution light may indicate brake failure.

BRAKE OR STEERING FAILURE PROCEDURE

If normal brakes and/or nosewheel steering are not effective, or if L hydraulic pressure is not available:

1. **ALT STEER & BRAKE**

   The green nosewheel steering engaged (STEER ON) light extinguishes if steering disengages due to loss of hydraulic pressure. Release brake pedal pressure, then move the brake switch to ALT STEER & BRAKE.

   In ALT STEER & BRAKE, the power source for braking is the R hydraulic system; nosewheel steering is powered by the L system until L system pressure decreases below 2200 psi, then steering shifts to the R hydraulic system automatically.

NOTE

If both engines are shutdown while the aircraft is moving, the brake switch should be set to OFF and steady pressure applied in one application until completely stopped; otherwise, antiskid cycling or pumping the brakes depletes the hydraulic system accumulator and results in loss of brakes. The L hydraulic system accumulator may provide up to 3 brake applications; however, the brake accumulator is not required to hold a charge.

If the antiskid system relieves brake pressure and wheel rpm does not increase within 2.7 seconds: the antiskid fail-safe circuit should deactivate antiskid and illuminate the ANTI SKID OUT annunciator caution light; and braking without antiskid protection should become available.

(T) a. Brake switch - OFF.

Selection of OFF electrically disengages the aft cockpit switch from the brake system. Selection of ANTI SKID ON or ALT STEER & BRAKE overrides the forward cockpit brake switch setting.

If alternate brakes are ineffective:

2. **ANTISKID OFF.**

If the brake switch is placed to OFF: the L hydraulic system powers braking and steering, antiskid is disabled, and the ANTI-SKID OUT annunciator caution light illuminates.

After S/B R-2695, holding the trigger switch depressed will disable antiskid and illuminate the ANTI-SKID OUT annunciator caution light. The hydraulic power source for brakes remains as selected by the brake switch. If R hydraulic pressure is not available, move the brake switch out of ALT STEER & BRAKE.

ANTISKID OUT

The ANTI-SKID OUT caution light illuminates while on the ground if: the brake switch is in OFF; the antiskid system is disabled or fails; or, after S/B R-2695, the trigger switch is held depressed.

With the ANTI-SKID OUT light on unaccountably:

1. Antiskid - Recycle.

Attempt to recycle the antiskid brake system by repositioning the brake switch if the situation permits and if there is no apparent reason for the system being disabled. After S/B R-2695 check that the trigger switch is not stuck in the depressed position.

If the ANTI-SKID OUT light persists:

2. Brake switch - OFF.

Without antiskid operating, extreme caution must be used while braking to prevent wheel skid. Skidding is hard to detect due to aircraft size and weight. Tires may fail before a skid can be recognized and corrected. A main landing gear tire blowout may be sensed as a thump or muffled explosive sound.

TIRE FAILURE

At takeoff weights, to decrease the probability of further tire failures, taxi distance should be minimized if one or two tires per main gear are flat. Taxiing is permitted to clear a runway with all tires failed on a main gear, as the massive tire bead protects the wheels for some distance. At normal landing weight, the aircraft can be taxied if one tire per main gear remains inflated.

SINGLE-ENGINE MINIMUM AERODYNAMIC CONTROL SPEED

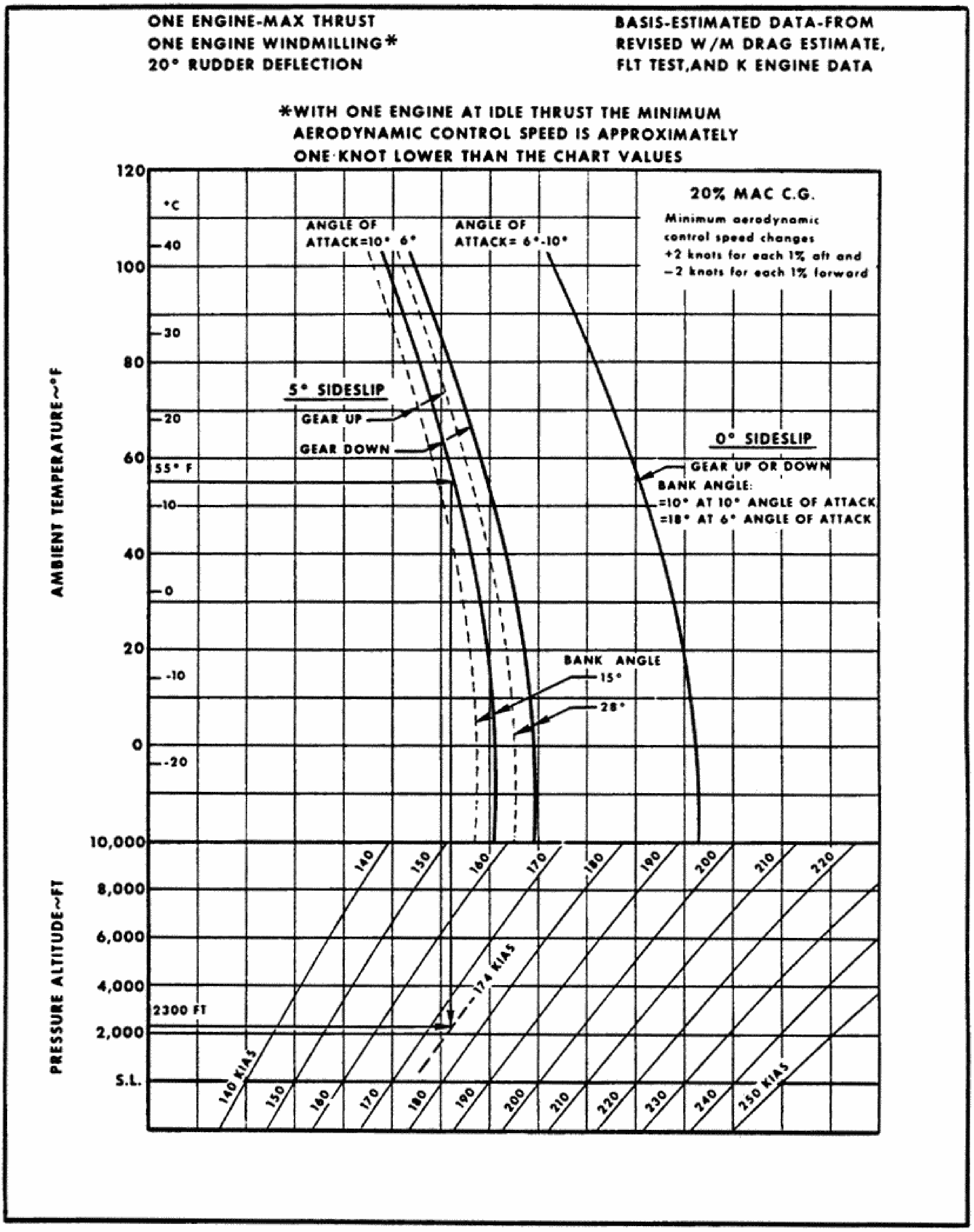


Figure 3-2

TAKEOFF EMERGENCIES

These procedures apply from the start of takeoff until the initial climb schedule is established.

PROPULSION SYSTEM

The propulsion system includes the main engines, afterburners, inlets, nozzles, tailpipes, fuel controls, and fuel-hydraulic, lubrication, and ignition systems. If abnormal operation of any of these components is indicated prior to reaching the acceleration check distance, the takeoff should be aborted. Refer to Abort procedure, this section.

ENGINE FAILURE

If conditions permit and gear retraction has not been initiated:

1. **ABORT.**

   Abort if abnormal operation of any of the propulsion system components is indicated before reaching the acceleration check distance.

   Abort if the acceleration check is unsatisfactory, or if a fire warning occurs before refusal speed.

   Abort if the thrust of either engine decays to the point that minimum single-engine flight speed cannot be attained, provided that conditions permit and landing gear retraction has not been initiated.

   WARNING

   Under most conditions below single-engine minimum aerodynamic control speed, directional control on the ground cannot be maintained with maximum thrust on one engine and the other engine decaying or failed.

   If both engines fail immediately after takeoff, decay of engine rpm results in rapid loss of A and B hydraulic system pressure and subsequent loss of aircraft control. Land straight ahead if the gear is down and sufficient runway is available.

After takeoff, if unable to hold altitude and accelerate:

▲1. **EJECT.**

   If gear retraction has been initiated, eject rather than attempt to land with the gear partially retracted or up.

If able to maintain altitude or accelerate:

1. **THROTTLES MAX.**

   If an engine fails immediately after takeoff and the decision is made to continue, maintain Maximum thrust on the operating engine. Lateral and directional control can be maintained when airspeed remains above the minimum single engine control speeds shown on Figure 3-2; however, ability to maintain altitude and accelerate or climb depends on weight, drag, altitude, airspeed, and temperature. Refer to performance data, Appendix I.

2. **GEAR UP.**

   Initiate gear retraction if not already accomplished.

3. Dump fuel as required.

   Fuel dumping in addition to consumption by the operating engine lightens the aircraft at an appreciable rate. When at heavy weight for the existing air temperature, dumping fuel may reduce weight sufficiently to remain airborne. If turning at a sufficient speed, the inoperative engine will also discharge fuel from its afterburner.

Monitor c.g. carefully if dumping with crossfeed open.

4. PUMP REL switch - Press to release Tank 4.

   Dumping fuel with Tank 4 selected manually will cause premature termination of normal fuel dumping when Tank 4 quantity reaches 3700 lbs.

5. Rudder trim - As necessary.

   Bank and sideslip toward the operating engine as necessary to maintain directional control and minimize drag. 7 to 9 degrees of rudder trim, with bank and sideslip to maintain course, yields minimum drag in the critical speed range from 220 to 250 KIAS.

Failed engine:

6. Complete Engine Shutdown or Airstart procedure, as appropriate.

   WARNING

   Positively identify the failed engine before retarding the throttle.

AFTERBURNER FAILURE DURING TAKEOFF

Abort if an afterburner fails prior to reaching the acceleration check speed. Refer to the Abort Procedure, this section.

If an afterburner fails after reaching the acceleration check speed, confirm that both throttles are at the maximum afterburner position and continue the takeoff. Check EGT and for derichment. When safely airborne, positively identify the affected engine and then retard that throttle below the afterburner range. Pause at Military if the nozzle position indication is near closed, then check nozzle operation by retarding the throttle until the nozzle starts to open. A relight may be attempted if engine instrument indications and observation of the nacelle with the periscope disclose normal conditions; however, a malfunction should be assumed. Land when practical.

AFTERBURNER NOZZLE FAILURE

Nozzle failure is indicated when nozzle position and engine rpm response to throttle positioning are not normal. Engine shutdown may be necessary.

If a nozzle fails open and takeoff is continued, keep the throttle in maximum afterburner until a reduction in thrust is possible. Anticipate engine overspeed when the throttle is retarded and be prepared to reduce throttle position below Military.

If a nozzle fails toward closed, expect EGT rise, rpm suppression, compressor stall, and possible engine flameout.

Use the Afterburner Nozzle Failure procedures under In-Flight Emergency Procedures, this section, and land as soon as possible.

FIRE

Abort if either fire warning light illuminates before refusal speed. Above refusal speed, use the Engine Fire/Engine Shutdown procedure, this section, and land as soon as possible.

ABORT

The abort procedure assumes that a decision to abort is made before rotation speed. Aborts from above rotation speed are not prohibited, but the risks associated with aborting from such a high initial speed at takeoff weight must be balanced against the risks of continuing a takeoff. In general, after rotation speed, the best course of action is to continue rather than abort, unless the aircraft cannot fly.

Engine Management

Both throttles should be retarded to IDLE and the brakes applied with the nose down as soon as the decision to abort is made. The planned rotation speed may be exceeded; however, the nosewheel should be kept on the runway to take advantage of nosewheel steering.

NOTE

> For chute failure, shutdown the right engine after both are idling, or complete the shutdown of a failed or flamed out engine. This reduction in thrust decreases stopping distance and reduces the possibility of tire failure.

WARNING

> Wait until rpm and EGT show that both engines are idling (or that one engine is failing) before selecting the engine to shutdown. Loss of both engines will result in loss of hydraulic pressure for steering, and braking may not be possible.

Aircraft Attitude, With Decision to Abort

Lower the nose and start braking at nosewheel contact. When rotation is well advanced, the aircraft may accelerate beyond takeoff speed and lift off before rotation can be checked. In this case, hold the aircraft off sufficiently to regain control and then touchdown without sideslip, near the center of the runway if possible.

Chute Deployment

The drag chute requires 4 to 5 seconds for deployment after drag chute control actuation. If above 210 KIAS, it is permissible to actuate the DRAG CHUTE T-handle while decelerating in anticipation of reaching the limit airspeed for chute deployment; however, deployment above 210 KIAS can destroy the chute. Actuation of the chute system to reach 210 KIAS simultaneously with loading of the chute is not recommended unless the risk is justified by very marginal stopping distance. Retain the drag chute.

Drag Chute Failure

If the drag chute does not deploy, shut down the failed engine (or shut down the right engine if there has been no engine failure) to reduce thrust and decrease stopping distance. Use moderate up elevon to provide as much drag as possible without lifting the nosewheel. The increased gear load may cause tire failure at heavy weight; however, tire failure may be acceptable since the tires will not necessarily disintegrate. Braking deceleration available is nearly the same for braked tire rolling and blown tire locked conditions with a smooth, wet surface. Locked wheel skids of 7000 feet on an ungrooved wet runway have left the wheels undamaged.

Braking On Wet Runways

Unless hydroplaning, good nosewheel and rudder steering characteristics can be expected. Well controlled stops have been demonstrated on wet runways with and without the drag chute, with all main gear tires blown and wheels locked, and with one engine shut down.

Hydroplaning is a limiting factor with wet runway conditions and, although nosewheel and rudder steering remain effective, wheel braking force is nil until the tires can make contact with the runway. The aircraft tends to follow a trajectory and drifts with a crosswind.

Except for the extended stopping distances, skids across or into dry runway areas are the chief hazard of wet runway stops. The wheels tend to lock-up and cause blown tires while sliding on a wet surface. Dry areas can destroy the tires due to increased friction or wheel spin-up. This allows the wheels to make runway contact and may ultimately destroy the wheels and brake assemblies.

Even so, the aircraft can probably survive on the landing gear struts if it remains on the runway or on a hard surface overrun (assuming a smooth transition from runway to overrun).

ABORT PROCEDURE

WARNING

- Do not release lap belt or shoulder harness, or pull scramble handle until the aircraft stops.
- The landing gear should be left extended.

1. **THROTTLES IDLE.**

Retard both throttles to IDLE. Do not shut down either engine immediately unless failure to do so would vitally endanger the aircraft, such as engine fire.

2. **BRAKES.**

Lower nose and -
For dry runway: Use moderate to heavy brake pressure until stop is assured. Do not use up elevon because risk of tire failure is increased.

For wet runway: Use light to moderate brake pressure. Up elevon for additional drag may be used if braking is marginal or if the drag chute fails.

NOTE

- Rated brake energy capacities and maximum braking speeds may be disregarded during an abort. It is better to use the brakes at high speed, as tire failure may occur if the roll is extended by delayed braking.
- On wet runways without grooves, deceleration is nearly the same with blown tires locked as with braked tires rolling.

CAUTION

Hard braking may result in brake seizure after stopping, increasing time to clear the runway. If possible, keep the aircraft moving at slow speed until clear of the runway. Taxiing at low speed to clear a runway is permitted with all tires failed on a main gear. The massive tire bead protects the wheels for a short distance at heavy weight.

3. **CHUTE DEPLOY.**

The maximum airspeed for drag chute deployment is 210 KIAS. Retain the drag chute.

If normal chute deployment does not occur in five seconds, rotate the DRAG CHUTE control handle 90 degrees counterclockwise and pull out 8 inches. A pull force of approximately 65 pounds is required.

If tire failure occurs and braking is abnormal:

4. **ANTISKID OFF.**

Set the brake switch OFF or, after S/B R-2695, depress and hold the trigger switch. Brake with steady pressure.

If tire failure occurs with either wet or dry conditions, increased brake pressure will be required on that side to maintain braking force on the remaining tires. Maintain moderate to heavy brake pressure to prevent spin-up of wheels with failed tires and wheel and/or tire disintegration at high rotational speeds.

For L hydraulic or left engine failure:

5. Brake switch - ALT STEER & BRAKE.

Set the brake switch to ALT STEER & BRAKE when the L hydraulic pressure is below normal, or with left engine failure. Extinguishing of the STEER ON light may indicate L hydraulic system failure.

CAUTION

Selecting ALT STEER & BRAKE changes the source of brake pressure from the L to the R hydraulic system. Decrease brake pressure momentarily to avoid skidding the tires.

For fire, drag chute failure, or if stopping distance is critical:

6. Throttle - OFF.

   a. Shutdown the engine that is failed or on fire.

   WARNING

   Positively identify the failed engine before retarding the throttle.

   b. Shutdown the right engine if both engines and L hydraulic pressure are normal at idle.

7. Fuel - OFF.

   The periscope may assist in determining if a major fire exists. For engine fire (if crew safety is not an immediate factor) shut down the affected engine and allow 5 seconds for operation of the engine fuel shutoff valve before shutting down the other engine.

   WARNING

   If the aircraft is on fire, shut down both engines after stop and abandon the aircraft.

Prepare to engage the barrier if a suitable barrier is available and it appears that a reasonably safe stop can be made. If a safe stop is obviously impossible, ejection prior to reaching an unprepared surface is recommended.

If ejecting, eject early enough to avoid descent into a fire area.

WARNING

- If the aircraft has a major fire, ejection prior to barrier engagement is recommended. Burning fuel can engulf and spread ahead of the aircraft as it stops in the restraining cable.
- If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

If possible, turn into the wind when stopping.

CAUTION

Brakes must be cooled to approximately ambient temperature before attempting another takeoff.

BARRIER ENGAGEMENT

The following applies only to BAK-11 cable engaging systems installed with modified dual BAK-12 arresting engines.

Barrier Operation

The barrier is controlled from the control tower, and is armed prior to all takeoffs and landings. The pilot may call for disarming of the barrier if it is apparent that a safe stop can be made without it.

When armed, the barrier is operated by the aircraft nosewheel and main gear as they roll over pressure-sensitive switchmats located in the runway ahead of the main cable. A row of switchmats located a short distance beyond the arresting cable prevents barrier actuation before the nosewheel has passed over the cable. The switches energize a timing computer which causes the arresting cable to be thrown up to engage the main gear struts. On engagement, the arresting cable is pulled out with a relatively constant restraining force to stop the aircraft within 2000 feet.

Operating Restrictions

The maximum recommended groundspeed for barrier engagement is 180 knots at all gross weights. The minimum groundspeed is 30 knots with the model 8200/BAK-11/12 installation (Beale AFB) and 15 knots with the model 8200-2/BAK-11/12 installation (Kadena AB). The barrier cable will not eject below these speeds.

Optimum barrier engagement is perpendicular between the runway side stripe markings. A successful engagement can be expected, however, if the aircraft centerline is no closer than approximately 40 feet from the edge of the runway at the barrier. The probability of a successful engagement when closer than 40 feet to the edge of the runway is marginal, especially at high speeds.

The nosewheel must be on the runway when crossing the switchmats. Steer to maintain runway heading and contact the barrier squarely.

BARRIER ENGAGEMENT PROCEDURE

1. **NOSE DOWN.**

   Barrier switchmats must be crossed in a three-point attitude.

2. **BRAKES RELEASE.**

   To prevent exceeding strut structural limits, release brakes before barrier engagement. Steer to approach the barrier squarely, and if possible, in the center. Do not jettison the drag chute.

   CAUTION

   Steer to engage perpendicular to the barrier and discontinue braking before engagement.

3. Fuel - Off.

   Allow 5 seconds for the fuel shutoff valves to close.

4. Throttles - OFF.

WARNING

- If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.
- Do not release lap belt or shoulder harness, or pull the scramble handle until the aircraft stops.

TIRE FAILURE

Long runs during taxi or takeoff at heavy weight can result in blown tires. Critical temperature in the tire bead is approximately 455°F. Failure of a main gear tire during takeoff overloads the remaining tires on that side when takeoff weight exceeds 92,500 pounds; however, the remaining tires should sustain a 50% overload for the remaining period required to takeoff at maximum weight or stop if required cooling procedures are completed before takeoff. (See Figures 5-7 and 5-8.) Because each main gear tire loss decreases the available brake energy capability by one-sixth, ability to stop from high speed is largely dependent on the drag chute.

Nosewheel Tire Failure

Failure of a nosewheel tire should not fail the other tire. It may not be possible to determine immediately whether a nose or main gear tire has failed. In either case, engine or structural damage may be sustained from tire fragments.

Tire Failure Procedure

Depending on airspeed and whether or not engine damage is indicated, takeoff may be preferable to aborting. The speed at which takeoff becomes preferable is close to acceleration check speed. Before refusal speed, attempt to determine if engine damage has been sustained.

If tire failure occurs before acceleration check speed:

1. **ABORT.**

If takeoff is continued:

1. **DON'T RETRACT GEAR.**

   Leave the gear extended to minimize damage to the wheel well.

2. **ANTISKID OFF.**

   Braking is disabled while the gear is down without weight on the gear if antiskid is enabled. The brake switch must be OFF or, after S/B R-2695, the trigger switch must be held depressed to stop the wheels rapidly after takeoff. The ANTI-SKID out annunciator caution light will not illuminate when antiskid is disabled while airborne.

3. **BRAKE WHEELS.**

   The blown tire(s) must be stopped to minimize damage to the aircraft.

4. Confirm tire and aircraft condition.

   The gear should not be retracted until visually checked from another aircraft or the ground.

EMERGENCY GEAR RETRACTION

If the gear lever cannot be moved UP after takeoff:

1. Gear override button - Press and hold.

   This overrides the solenoid which is normally actuated by the landing gear switch.

2. Landing gear lever - UP.

IN-FLIGHT EMERGENCIES

BAILOUT

Eject if loss of control is imminent, or if a safe landing or stop cannot be accomplished. Ejection expectations are:

a. At sea level, wind blast exerts minor forces on the body up to 525 KIAS; appreciable forces from 525 to 600 KIAS; and excessive forces above 600 KIAS. The aircraft limit airspeed is below the speeds for excessive forces; however, when flying without a pressure suit, delay ejection until below Mach 1.0 and 420 KEAS (slower when conditions permit.)

b. Successful chute deployment should result after ejection from zero speed and altitude.

c. Free fall from high altitude down to 15,000 feet with drogue chute stabilization is the quickest descent.

During any low altitude ejection, the chance for success is greatly increased by zooming the aircraft to exchange excess airspeed for altitude. Ejection should be accomplished while the aircraft is level or climbing. A climbing or level attitude results in a more nearly vertical trajectory for the seat and crew member, thus providing more altitude and time for seat separation and parachute deployment. The zero altitude capability of the ejection system should not be used as a basis for delaying ejection. Accident statistics emphatically show a progressive decrease in successful ejections as ejection altitude decreases below 2000 feet. Whenever possible, eject above 2000 feet.

Before Ejection

If time and conditions permit:

1. Alert RSO

   Advise the RSO by interphone and the ALERT position of the RSO BAILOUT switch. See Figure 3-3.

2. Altitude - Reduce so that the pressure suit is not essential to survival.

3. Airspeed - Reduce to subsonic and as slow as conditions permit.

4. Head aircraft toward unpopulated area.

5. Transmit location and intentions to nearest radio facility.

(T6) IFF - EMER.

▲7. Lower helmet visor.

▲8. Green apple - Pull.

To Bailout

Accomplish as many of the following steps as are necessary to clear the aircraft. Refer to Figure 3-3.

1. **ALERT RSO.**

   Call "bailout, bailout, bailout" or otherwise positively advise RSO on the interphone, and set the RSO BAILOUT switch to GO.

▲2. **EJECTION D-RING.**

   Sit erect with head against headrest and feet back firmly against the seat. To pull ejection D-ring, cross arms (if possible) to assist in keeping arms close to the body.

   The RSO should eject first. The pilot should wait for the RSO EJECTED light to illuminate before ejecting, if conditions permit.

If the seat fails to eject:

▲3. **CANOPY JETTISON**

Pull the canopy jettison handle. If the canopy still does not jettison, pull the canopy latching handle aft and push the canopy into the air stream.

▲4. **EJECTION T-HANDLE.**

WARNING

- Do not pull the secondary ejection T-handle with the canopy still in place.
- Keep elbows close to sides and feet firmly against seat while pulling the secondary ejection T-handle, since the foot retractors and shoulder harness powered retraction may not have actuated.

If an ejection seat is inoperative:

The following procedure should be used to separate from the aircraft if sufficient control remains. If the RSO's seat fails, the pilot should remain with the aircraft, assist the RSO to leave the aircraft, and then eject.

5. Airspeed - 250 to 300 KEAS.

▲6. Green apple - Pull.

▲7. Scramble handle - Pull.

WARNING

Do not pull the survival kit release (inboard) handle while in the seat, as this disconnects the emergency oxygen supply and releases the kit and kit lanyard.

▲8. Suit vent hose - Disconnect.

9. Trim full nose down.

▲10. Lean forward, push stick forward, and push against seat to separate.

After manual bailout, when clear of the aircraft and below 20,000 feet:

▲11. Pull parachute manual deploy ring.

WARNING

- The crewmember must deploy the main chute manually, using the chute D-ring, after separating from the seat manually.
- After manual bailout, the crewmember is not stabilized by the drogue chute and may spin or tumble until the main chute is deployed.
- A free fall to a reasonably safe altitude avoids serious chute damage due to high speed deployment.
- Visor heat will not be available.

After Ejection

After ejection, descent is normally made to approximately 15,000 feet while in the seat with drogue chute stabilization. (Refer to Figure 3-3.)

NOTE

The seat may spin and rotate while descending with the drogue chute deployed. It may be possible to arrest such motions by using the arms and hands in the air stream.

If the automatic man-seat separation sequence fails, or if the crewmember elects to separate from the seat before automatic separation at approximately 15,000 feet, the crewmember initiates separation manually by pulling the scramble handle.

WARNING

- Do not pull the survival kit release (inboard) handle while in the seat, as this disconnects the emergency oxygen supply and releases the kit and kit lanyard.

- The crewmember must deploy the main chute manually, using the chute D-ring, after separating from the seat manually.

- After manual seat separation, the crewmember is not stabilized by the drogue chute and may spin or tumble until the main chute is deployed.

- A free fall to a reasonably safe altitude avoids serious chute damage due to high speed deployment.

- Visor heat will not be available.

A lanyard with a 7-inch loop is provided on each rear riser, tacked to the strap with breakaway thread. If the parachute is not damaged, pull each loop downward approximately 1-1/2 feet with a sharp tug. This releases three pairs of suspension lines on each side -- 24 remain -- and imparts a three to four ft/sec forward speed to the chute for steering.

WARNING

Do not pull either loop if the chute has sustained damage.

NOTE

Pull both loops. The chute will revolve continuously if only one set of lines is released.

Before Landing

Unless a tree landing is anticipated, pull the yellow survival kit release handle after the main parachute has opened and when approximately 2000 feet above the landing point. The release handle should be pulled rapidly through its complete arc of travel for a clean release. Refer to Figure 3-3.

NOTE

Do not pull the kit release handle if a tree landing is anticipated. This avoids entanglement of the kit, lanyard, and gear.

Prior to water landing:

(a) Close the visor to prevent the helmet from filling with water.

(b) Inflate the flotation gear by pulling down firmly on a CO_2 inflation tab. If flotation gear fails to inflate, pull the other CO_2 inflation tab.

NOTE

The flotation gear cannot be inflated orally without actuating the CO_2 lanyards first.

(c) Remove spurs if possible.

CAUTION

If retained, the spurs or severed foot retraction cables may puncture the dinghy.

(d) Release both Koch parachute riser releases when in the water.

(e) Open visor after returning to the surface of the water.

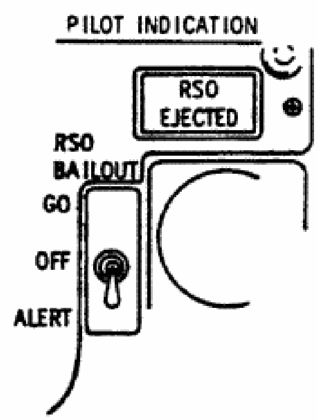
NOTE

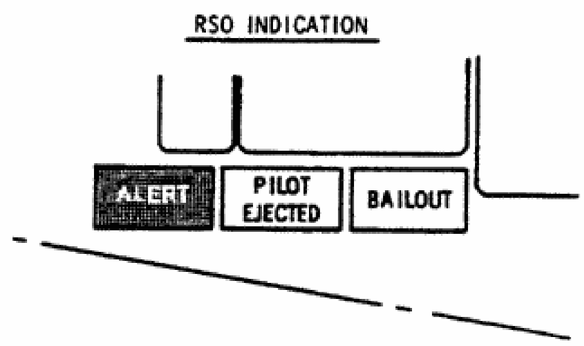
If latches fail to keep visor open, bend the microphone boom out to prevent the visor from closing.

(f) Release the chute bag by opening the lap belt Koch fastener if desired. Attempt to salvage the radio beacon.

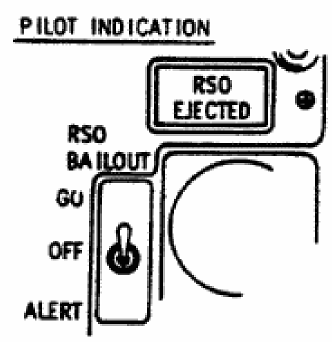
EJECTION

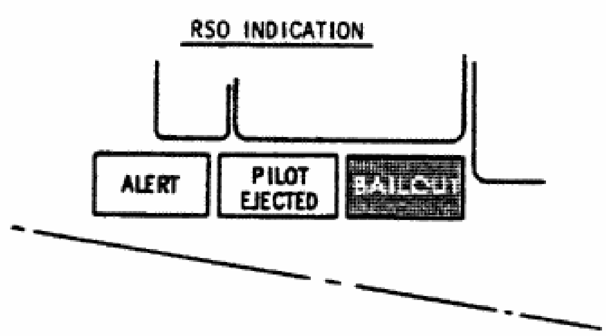
1 ALERT RSO
Pilot moves RSO BAILOUT switch to ALERT (down) position



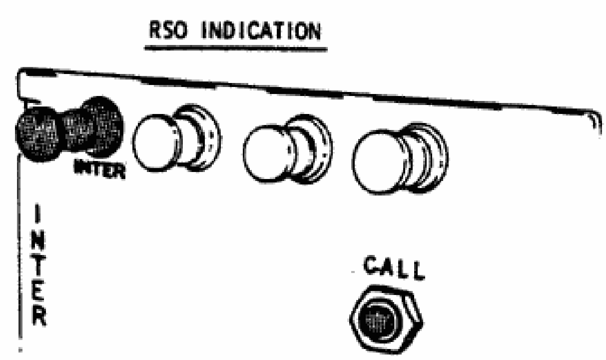


2 BAILOUT SIGNAL TO RSO
Pilot moves RSO BAILOUT switch to GO (up) position



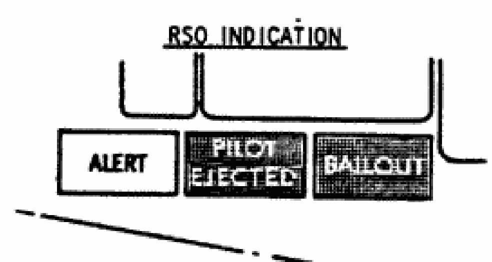


3 RSO INTERPHONE SETTING FOR BAILOUT
An emergency announcement accomplished by pressing the CALL button will always be heard.



4 PILOT INDICATION THAT RSO HAS EJECTED
The RSO seat ejection activates the RSO EJECTED light on the pilots instrument panel

5 RSO INDICATION SHOULD THE PILOT EJECT FIRST
The pilot seat ejection activates the PILOT EJECTED light on the RSO instrument panel



The PILOT EJECTED light and the BAILOUT light will be on

Figure 3-3 (Sheet 1 of 8)

F203-96(1)(c)

EJECTION

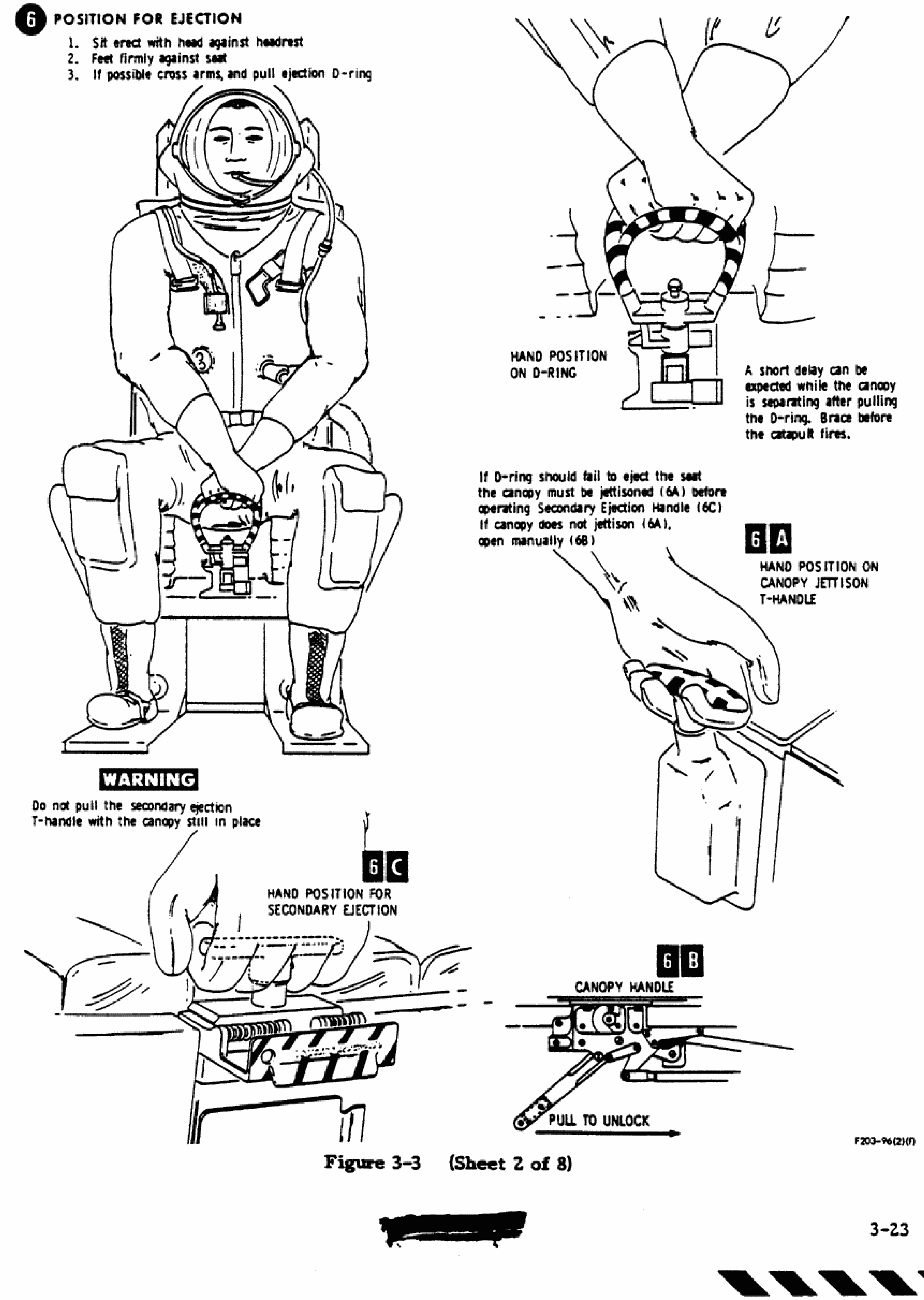
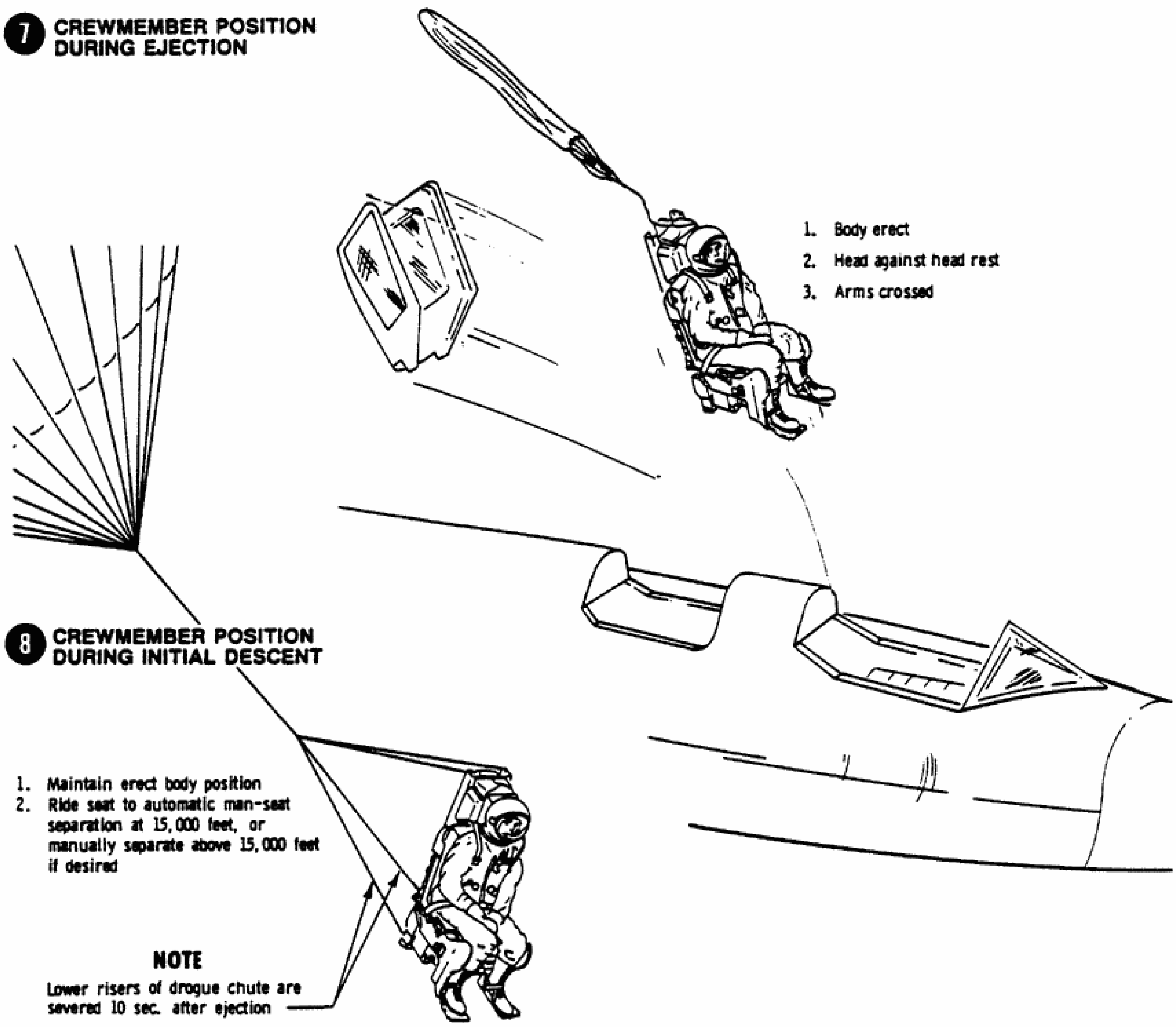
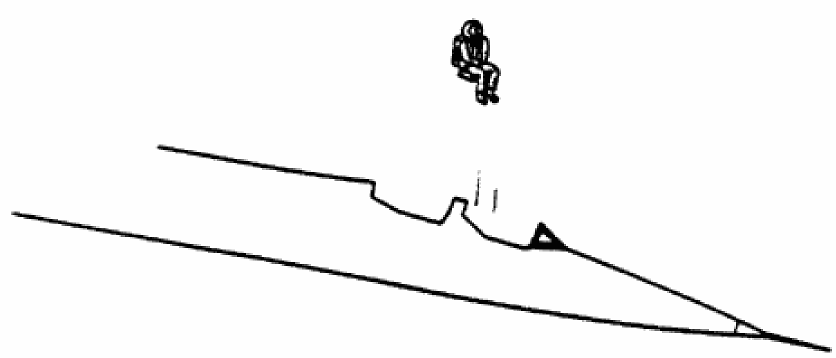


Figure 3-3 (Sheet 2 of 8)

EJECTION



BAILOUT WITH EJECTION SEAT INOPERATIVE



1. Airspeed - 250 to 300 KEAS
2. Canopy - Jettison or manually release
3. Green Apple - Pull
4. Scramble Handle - Pull
5. Trim full nose down.
6. Lean forward, push stick forward, and push sharply against seat to separate.
7. When clear of aircraft and below 20,000 feet pull parachute manual deploy ring.

Sequence continues at step 10

F203 96(3)(d)

Figure 3-3 (Sheet 3 of 8)

EJECTION

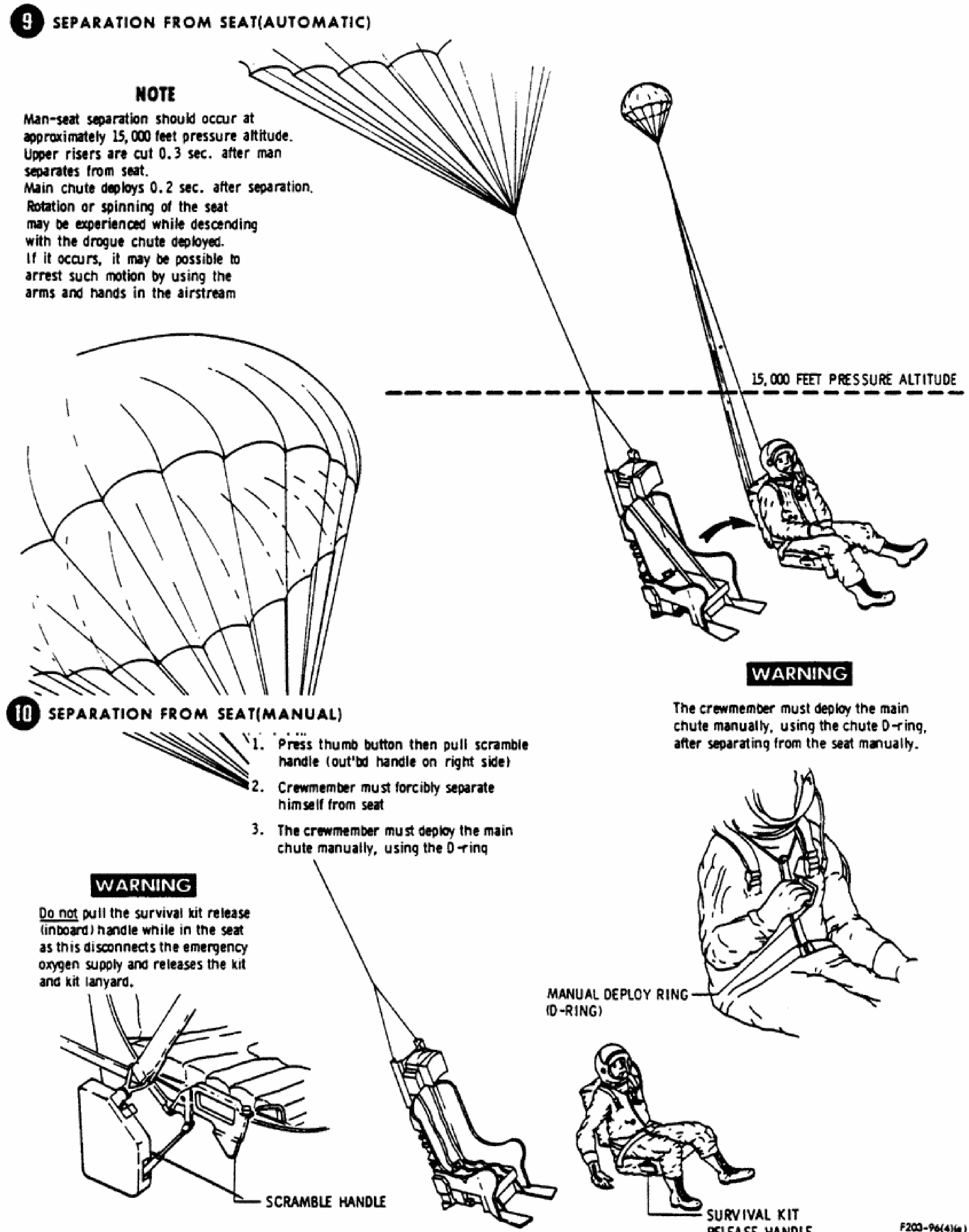


Figure 3-3 (Sheet 4 of 8)

EJECTION

⓫ PREPARATION FOR LANDING

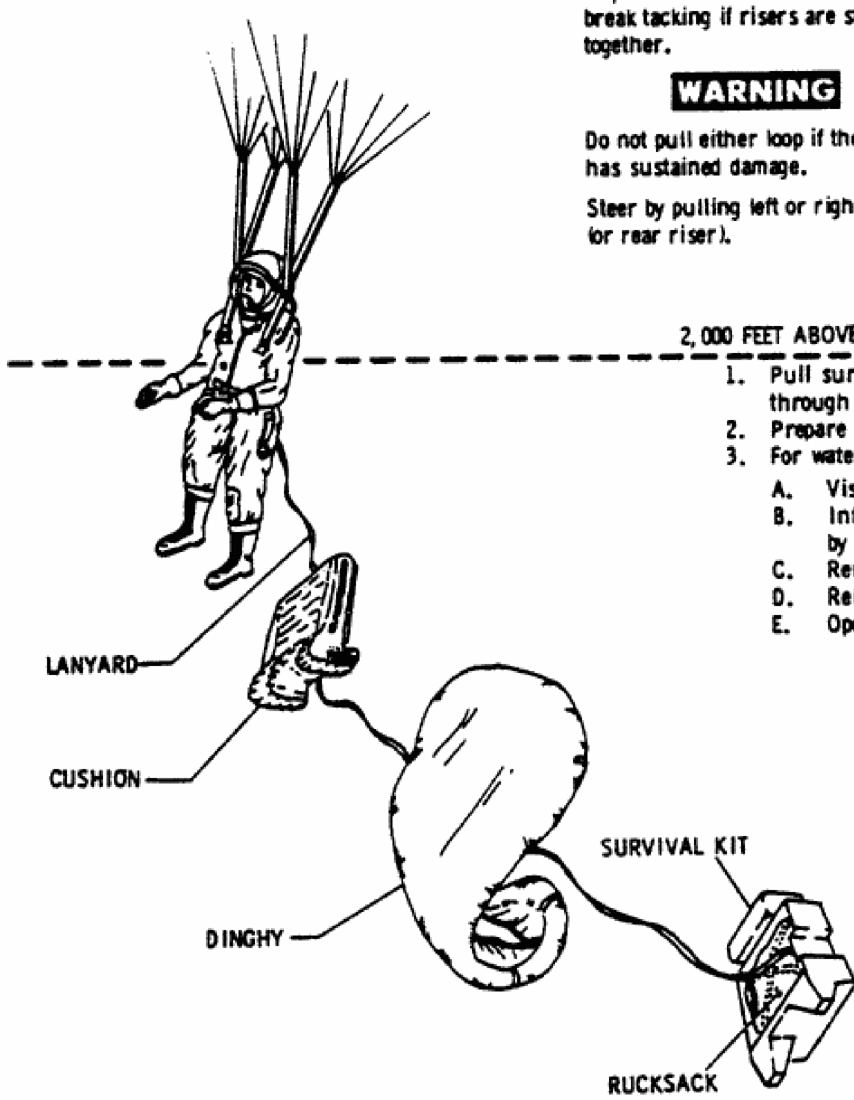
AFTER CHUTE DEPLOYMENT

Pull loops to release slip-knots of suspension lines from rear straps. Slip hand between riser straps and break tacking if risers are stuck together.

WARNING

Do not pull either loop if the chute has sustained damage.

Steer by pulling left or right loop (or rear riser).



2,000 FEET ABOVE LANDING SURFACE

1. Pull survival kit release handle rapidly through its complete arc of travel
2. Prepare for landing
3. For water landing:
   - A. Visor down
   - B. Inflate flotation vest before water entry by actuating lanyard.
   - C. Remove spurs.
   - D. Release chute when in water.
   - E. Open visor.

NOTE

If latches fail to keep visor open, bend the microphone boom out to prevent the visor from closing.

CAUTION

If retained, the foot spurs or severed foot retraction cables may puncture the dinghy.

NOTE

Kit touchdown relief can be felt prior to crewmember landing

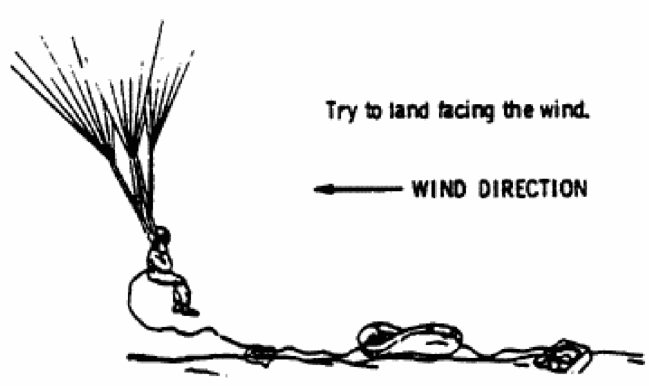
Retain helmet liner if possible, it can be used as a cap

If signal fire built, stand away from fire area to simplify helicopter rescue

Turn radio beacon off, after rescue is assured, to avoid interference with voice communications on the rescue frequency

⓬ SURFACE CONTACT POSITIONS

Try to land facing the wind.

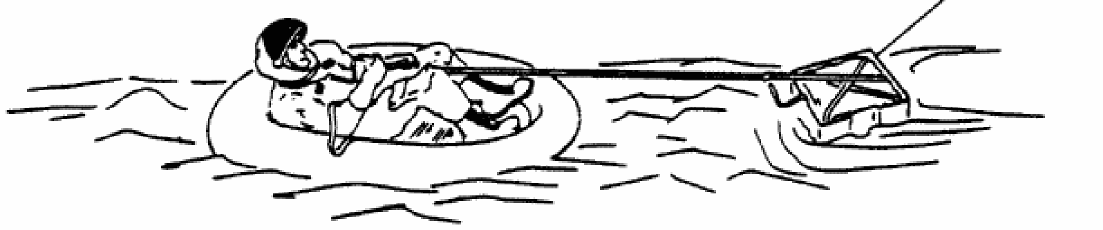


F203-96(5)(1)

Figure 3-3 (Sheet 5 of 8)

EJECTION

13 RETRIEVAL OF SURVIVAL GEAR (WATER LANDING)



14 SUMMARY OF SEQUENCE OF EVENTS

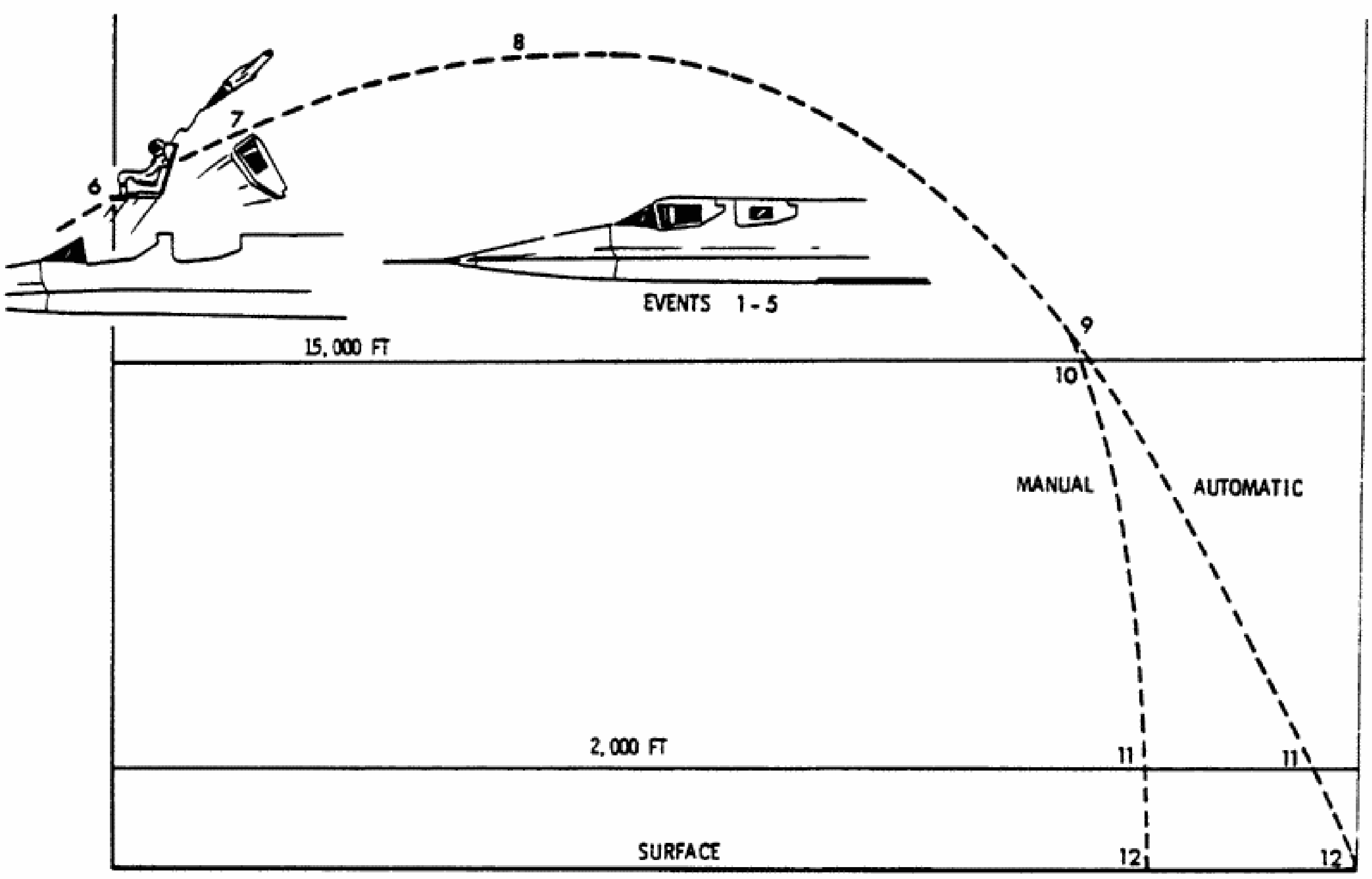


Figure 3-3 (Sheet 6 of 8)

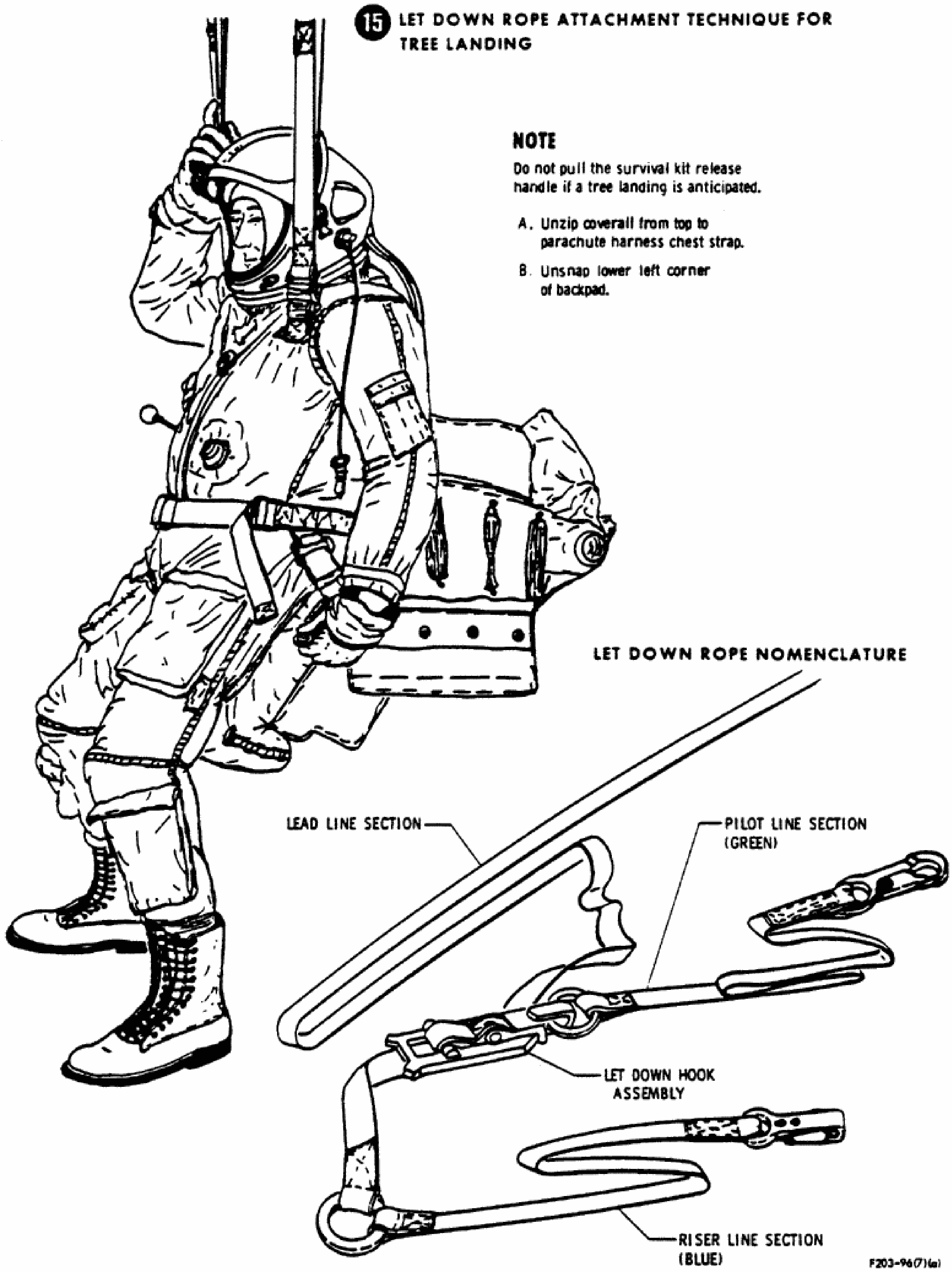


Figure 3-3 (Sheet 7 of 8)

EJECTION

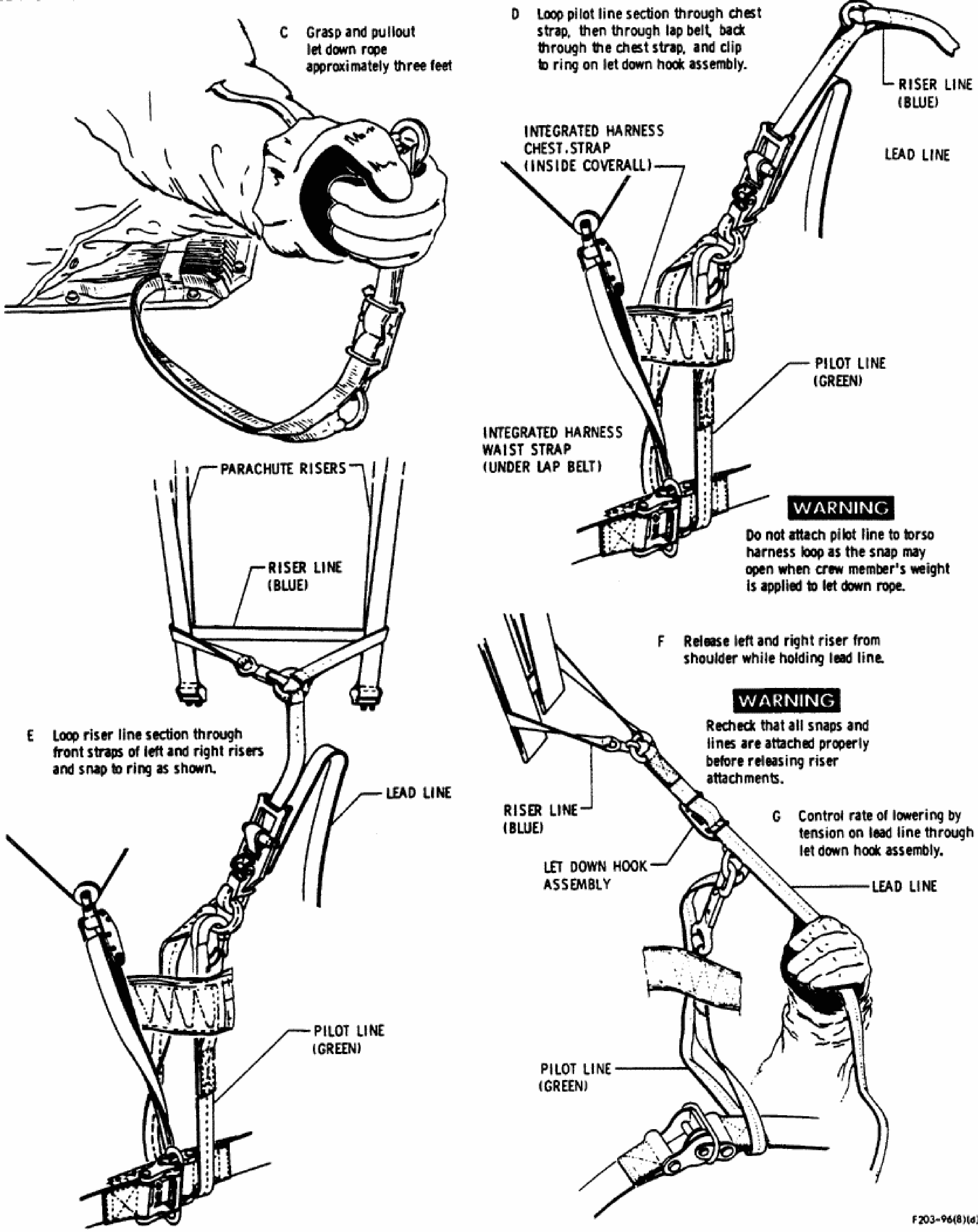


Figure 3-3 (Sheet 8 of 8)

FORCED LANDING OR DITCHING

Ditching, landing with both engines inoperative, or other forced landing should not be attempted. Ejection is the best course of action. If an ejection seat fails to fire, manual bailout is preferable to ditching or forced landing, since the aircraft will probably break up on touchdown.

SMOKE OR FUMES

The crew cannot detect cockpit fumes when wearing pressure suits. Each helmet oxygen system is independent of the cockpit and suit air supply. Smoke can be eliminated promptly by dumping cabin pressure unless smoke is entering the cockpit from the air conditioning system.

WARNING

When cabin pressure is dumped, cockpit depressurization occurs very rapidly.

The pressure suits inflate if altitude is above 35,000 feet.

AIR-CONDITIONING SYSTEM SMOKE

If smoke is entering the cockpit from the air conditioning system:

1. L and R refrigeration switches - Cycle individually.

   Attempt to isolate the source of smoke by operating either L or R refrigeration switch to OFF for a few seconds. If the smoke does not begin to clear, operate the switch back to ON and then set the other refrigeration switch to OFF.

With source isolated to one system:

2. Complete L or R Air System Out procedure.

With smoke from both systems:

3. L and R refrigeration switches - OFF.

   If smoke is entering from both systems, shutdown both systems. This shuts off all vehicle air.

WARNING

- Shutting off both systems will depressurize the cockpits rapidly.
- Continuing at supersonic speeds with both systems off will rapidly overheat the cockpit and equipment areas.

4. Begin emergency descent (if supersonic).

ELECTRICAL FIRE

The pilot and RSO depend on visual detection of electrical fire when wearing pressure suits since they cannot smell cockpit air.

▲1. Isolate the malfunction.

   Turn off electrical systems to isolate the malfunction(s). If necessary, deactivate suspected systems by pulling circuit breakers. The battery and one generator may be turned off without adverse effect on essential systems; however, both generators should not be off simultaneously unless absolutely necessary as this shuts down all fuel boost pumps.

▲2. Leave failed system off.

If required:

3. Cockpit pressure dump switch - ON.
4. Land as soon as possible.

EMERGENCY DESCENT

This procedure may be used when extreme circumstances exist or are expected to develop (such as crew emergency, impending loss of all fuel or control system hydrualic power, etc.) and minimum descent time is absolutely required.

Aircraft Control and Attitudes

A minimum use of flight controls is recommended for rapid descents during which aircraft control has become or may become critical (e.g., crew emergency, aft c.g. location with boost pumps inoperative). This may include nonturning flight until lower speeds are attained. If aircraft control is not critical (e.g., low oxygen quantity) a spiral descent is very effective in providing a rapid loss of altitude.

The nose will be between 10 and 30 degrees below the horizon while descending through the transonic speed region.

Power Setting and Inlet Configuration

The configuration of restarts on, idle power, and aft bypass closed provides high drag for rapid descent, the least probability of yaw asymmetry due to unstart, and the best means of avoiding compressor stall and flameout. Inlet unstarts may be encountered near Mach 2.0 if engine rpm is below nominal idle rpm. (See unstart boundary with spike forward and forward bypass open, Figure 3-4.)

CAUTION

> Some damage to the engines can occur during an emergency descent if initial CIT is high and rate of deceleration exceeds 1.0 Mach number in three minutes while above Mach 1.8; however, continued subsonic operation is permissible if engine operation appears normal.

Use Of Landing Gear For Drag

The landing gear may be extended at 400 KEAS when subsonic to maintain maximum rate of descent; however, the gear doors may be damaged if the gear is extended while above 300 KEAS or Mach 0.7. Gear extension at supersonic speeds is forbidden. Extending the landing gear above Mach 2.3 may cause heat damage to the tires and result in a hazardous landing condition. With gear extended, a large nose-up pitching moment occurs between Mach 1.6 and 0.9. Full nose-down elevon is insufficient to maintain 1-g flight at high KEAS and/or aft c.g. in this area.

EMERGENCY DESCENT PROCEDURE

If extreme conditions require a rapid descent:

1. **RESTARTS ON.**

   Move the throttle restart switch to its aft position, or position both inlet restart switches to ON simultaneously. Expect large yawing moments if the inlets do not respond together.

   WARNING

   If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected all normal restart capability for the respective inlet is lost.

2. **THROTTLES IDLE.**
3. Aft bypass switches - CLOSE.
4. KEAS - 350 to 400

   The autopilot KEAS hold mode may be engaged.

WARNING

- Do not exceed 400 KEAS or 1.5 g load factor.
- Increase rpm of one engine if high suit inflow temperatures are experienced. Engine stall might result, especially if IGV shift occurs.

5. Monitor fuel tank pressure.

WARNING

If necessary, reduce rate of descent to maintain fuel tank pressure above -.5 psi.

6. IGV switches - LOCKOUT checked.

▲7. Cockpit pressure selector switch - Set 10,000 FT.

NOTE

Select Bay Air OFF while descending if the pressure suit tends to inflate. This provides maximum airflow to the cockpits and closes the nose air shut-off valve. Return the Bay Air switch to ON when subsonic.

8. C.G. - Forward of 22%.

Transfer fuel to maintain c.g. within subsonic limits.

Below Mach 1.7:

9. Pitot heat - ON.

10. Exterior lights - On.

When subsonic:

11. Inlets - Normal.

Move the throttle restart switch to the normal (forward) position, or select the off (up) position of the inlet restart switches.

12. IGV switches - NORMAL.

NOTE

Continued subsonic operation is permissible if engine appears normal.

For continued descent:

13. Landing gear lever - DOWN.

WARNING

Gear extension at supersonic speeds is forbidden.

CAUTION

Gear door strength limits the airspeed with gear down to 300 KEAS or Mach 0.7, whichever is less, with a maximum permissible sideslip angle of 10°. Maximum permissible speeds are 300 KEAS or Mach 0.9, whichever is less, with gear down when sideslip angle does not exceed 5°.

PROPULSION SYSTEM EMERGENCIES

Propulsion system components are: inlet, engine, afterburner, nozzle, fuel control, lubrication, fuel-hydraulic, and ignition systems.

INLET UNSTART

Inlet unstarts can only occur when supersonic after an inlet has been "started"; that is, supersonic flow is established inside part of the inlet. Unstart (shock expulsion) may be caused by inlet pressure behind the shock wave becoming too great or spike position too far aft. Improper spike or door positions can result from inlet control error, loss of hydraulic power, or electrical or mechanical failure. Unstarts are usually associated with climb or cruise operations above Mach 2 when at normal engine speeds; however, they may be encountered during reduced rpm descents at speeds above Mach 1.3.

Between Mach 1.3 and 2.2, when near Military rpm, recovery procedures using restart ON may result in compressor stall.

Inlet unstart characteristics may be similar to compressor stall characteristics and, in fact, stalls and unstarts may be intermingled. The term "aerodynamic disturbance" or "A/D", as used in the Inlet Unstart procedure, refers to either condition - - regardless of whether it has or has not been identified as an unstart or compressor stall.

Flight Characteristics During Unstarts

Unstarts are generally recognizable by airframe roughness, loud "banging" noises, aircraft yawing and rolling, and decrease of compressor inlet pressure (CIP) toward 4 psi. Fuel flow decreases quickly and the afterburner may blow out. EGT usually rises, with the rate of increase being faster when operating near limit Mach number and ceiling. A distinct increase in drag and loss of thrust occurs because of increased air spillage around the inlet and reduced airflow through the engine.

The aircraft yaws toward an unstarted inlet. This yaw causes a roll in the same direction. A pitch-up tendency may occur due to yaw and roll rates developed during the inlet unstart. Pitch control problems can also occur during associated maneuvering and will be accentuated by low KEAS and/or high angles of attack, maximum altitude operation, aft c.g., high Mach, and any pitch rate which existed prior to inlet unstart. During the unstart, primary emphasis must be placed on maintaining pitch control to prevent nose-up pitch rates and angles of attack in excess of eight degrees. Reduce thrust asymmetry as soon as possible.

Above Mach 2.8, inlet unstart may require yaw axis stability augmentation to avoid excessive sideslip and bank angles which could cause the other inlet to unstart.

Aileron effectiveness is reduced at high altitudes and high angles of attack. Roll control may become critical if the unstart occurs on the down-wing inlet during a bank. At altitudes above 75,000 feet, aileron control may be ineffective in controlling roll during an unstart unless the angle of attack is immediately reduced. Aileron effectiveness increases rapidly as the angle of attack is reduced and only moderate aileron inputs will be required to control the roll. An excessive nose-down attitude may result in an overspeed (KEAS and Mach) if the inlets are restarted during a recovery maneuver. Therefore, maintain the restart configuration until speed and attitude are fully under control.

The roughness usually clears after the forward bypass doors open and the spikes are started forward (manually or automatically) however, five to eight seconds may be required to clear the roughness. Roughness may persist until the spikes are fully forward during manual restarts at design Mach when aft bypass open has been required.

Inlet pressure should be checked during recovery. Moderate CIP increases occur as the inlet "clears" (inlet in restart configuration with no roughness). If the inlet has restarted (captured the shock), moderate CIP increases occur when the spike retracts to restrict the inlet throat, and CIP then increases to normal pressure when the forward bypass door closes to the normal schedule.

Unstarts caused by improper automatic spike scheduling will recur if the aircraft accelerates again to the unstart Mach. Manual spike and forward bypass door scheduling is necessary to accelerate further.

If unstarts occur because automatic scheduling is closing the forward doors too much, check the aft bypass position and manually schedule the forward bypass door. In general, more bypass is required than for automatic operation and required bypass area decreases as Mach increases.

Each time the shock expulsion sensor (SES) detects an unstart, the DPR schedule for the forward bypass door of the inlet that unstarted, is reduced 10 mpr (milli-pressure ratios). The DPR schedule for the other inlet is not changed. The lower DPR schedule commands the forward bypass door slightly more open when the inlet returns to automatic control after autorestart. A 10 mpr change in DPR schedule is so small it may not be noticeable to the pilot. If unstart occurred because the DPR schedule was set too high, unstart should not recur after one autorestart. If unstart was caused by a mechanical malfunction (such as a leak in the PSD8 lines that measure inlet pressure), the reduction in DPR is unlikely to prevent repeated unstarts and the forward door must be manually scheduled. The total reduction in DPR schedule on each inlet will not exceed 40 mpr regardless of how many unstarts occur.

<u>**Unstart Boundary Charts**</u>

Figure 3-4 shows unstart boundaries (a function of Mach, engine speed, and spike and bypass door positions). With spike full forward, the smallest roughness area below the idle rpm range occurs with the forward and aft bypass doors open. A more extensive area occurs with the bypass doors open, but with the spike moving automatically. In both cases, the onset of inlet airflow instability occurs earlier (i.e., at higher engine speeds) with the bypass doors closed. At windmilling rpm, heavy roughness will occur above Mach 1.3 unless the spike is positioned fully aft.

INLET UNSTART PROCEDURE

Accomplish only those steps which are necessary to clear the inlet and return to normal operation.

For inlet A/D:

1. **α WITHIN LIMIT.**

   Apply pure pitch correction (stick forward) first to eliminate the nose-up pitch rate and to maintain angle of attack within the limit. Alpha and pitch rate must be kept, or reestablished, within the APW stick shaker boundary. Rudders may be used to assist in roll correction, if necessary. Delay roll correction (with the stick) until pitch angle is controlled.
   Disconnect autopilot (or press the CSC button) if it is necessary to hold the control stick forward; otherwise, the autopilot will trim the elevons up, thus reducing nose-down control authority.

WARNING

- Start pitch correction first. High angles of attack can develop if pitch rate is not controlled, and this can result in pitch-up. Maintain angle of attack and pitch rate below the APW stick shaker boundary. Decreasing angle of attack first assists roll control and makes recovery of attitude more positive.
- Nose-up pitch trim above zero indication reduces down-elevon authority. If full forward stick is not sufficient to control angle of attack and pitch rate, <u>trim nose down</u>.

Except for spike(s) and forward bypass door(s) in manual control, the automatic inlet restart system will automatically position the spike and forward bypass to clear the A/D. Above Mach 2.3, both inlets respond due to the inlet cross-tie feature.

Observe CIP changes, and spike and forward bypass position indications to confirm normal action of the autorestart system (forward doors open, spikes move 15 inches forward then back to normal, CIP recovers to normal as forward doors close to normal). At high Mach, autorestart may not recapture the shock. If CIP does not recover after autorestart, manual restart is necessary to move the spike full forward and capture the shock.

With only one forward bypass door in manual control, an unstart on either inlet results in automatic actuation of both spikes and the door in automatic control. If the manually controlled door remains in its position, an unstart and possible engine stall can be expected on

INLET UNSTART BOUNDARIES AFT BYPASS CLOSED*

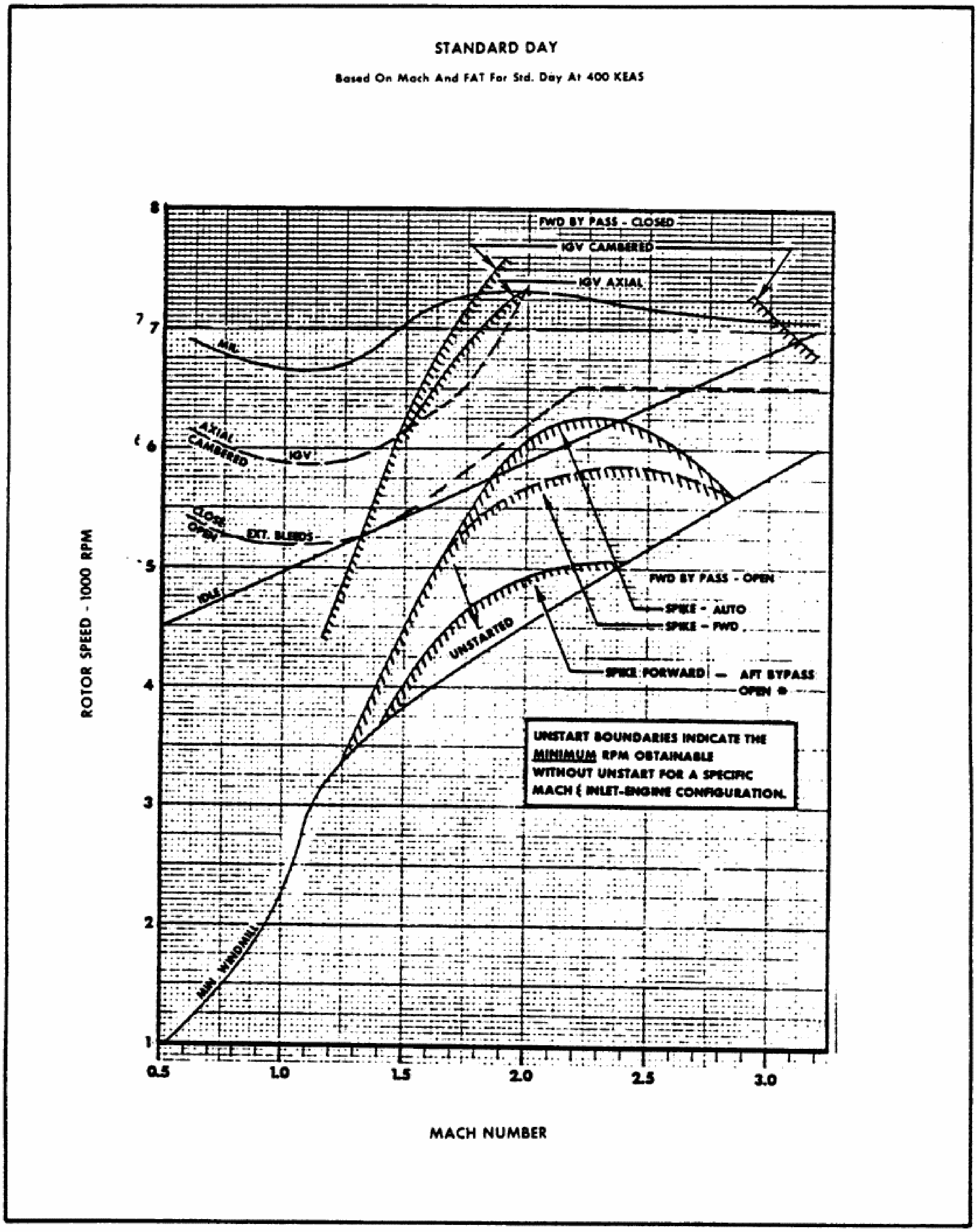


Figure 3-4

that inlet, even if unstart of the opposite inlet initiated automatic restart. The forward bypass must be set 100% open by the respective restart switch or forward bypass control knob. The intermediate position of the throttle restart switch may be used to control forward bypass positioning of both inlets during the autorestart cycle; otherwise, proceed as follows.

If either inlet is in manual control prior to the A/D, or if autorestart is not effective (unstart recurs, inlet does not clear, or CIP does not recover):

2. RESTARTS ON.

The inlet autorestart and cross-tie features do not override a manually positioned forward bypass, or spike and forward bypass combination, on either inlet. If using a manual inlet schedule or if autorestart is not effective in one cycle of the spike and bypass positioning, either use the throttle restart switch or set both inlet restart switches ON (down) to establish the restart configuration. In the restart position, the forward bypass is 100% open and the spike is full forward.

WARNING

- Initially put both inlets in the restart configuration to avoid confusing which inlet unstarted and to reduce control problems.

- If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

3. AFT BYPASS.

If roughness does not clear with the inlets in restart, cycle the aft bypass switches OPEN, then to CLOSE. Aft bypass cycling is not normally required below Mach 3.0, and definitely should not be used if roughness is associated with compressor stall.

CAUTION

- If roughness cannot be cleared, retard the throttles to minimum afterburner or Military, depending on the severity of the unstart.

- Check for engine failure or inlet system malfunction.

If deceleration is required with the inlets in restart, close the aft bypass of each inlet and set the affected engine throttle to 6500 rpm upon reaching Mach 2.5. Refer to the Inlet Malfunction procedure and to the manual inlet schedule, this section.

4. CHECK EGT.

Be prepared to shutdown the affected engine(s).

WARNING

Shutdown the affected engine for EGT:

- Above emergency EGT limit (845°C above 40°C CIT; 865°C below 40°C CIT) and below 900°C for 2 minutes.

- Between 900°C and 950°C for 15 seconds.

- Over 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

Since the main fuel control cannot reduce fuel flow below the minimum fixed schedule, manual or automatic EGT trimming and throttle reduction to IDLE have no effect during a severe overtemperature condition with the inlet(s) unstarted. See Abnormal EGT Indications, Engine Fire/Shutdown, Engine Flameout, Glide Distance, and Airstart, this section.

At high Mach and high altitude, inlet unstart can cause severe engine overtemperature if the derich system is not effective, or if the Fuel Derich switch is positioned to REARM or OFF before inlet restart (CIP recovery) is obtained.

CAUTION

Do not move the Fuel Derich switch from ARM until inlet restart (CIP recovery) is obtained; otherwise, severe overtemperature can result.

5. **350 KEAS.**

   Adjust airspeed toward 350 KEAS.

WARNING

If in a nose-down attitide, leave the inlets in the restart configuration until speed and attitude are under control.

Below Mach 3.0, continued heavy roughness with the inlets in the restart configuration indicates compressor stall, regardless of the cause of the initial disturbance. Maintain airspeed above 350 KEAS and employ the compressor stall recovery procedure immediately to preclude flameout.

For compressor stall below Mach 3, affected inlet:

6. Aft bypass switch - CLOSE.

   If the aft bypass doors are not closed, this is a high risk stall area with the inlet in restart. (See Figure 3-7.)

If the compressor stall does not clear, affected engine(s):

7. Throttle - Reduce rpm.

   Retard the throttle toward IDLE until the compressor stall clears.

   Remain in the restart configuration while retarding the throttle, regardless of Mach. Refer to Figures 3-4 and 3-7. Note that there is a chance of clearing the stall while still near military rpm by returning the spike to automatic scheduling. However, with substantial rpm reduction toward idle, there is a definite probability of encountering the idle rpm unstart region between Mach 1.8 and 2.4, unless the spike is kept forward.

When the unstart or compressor stall clears:

8. Inlets - Reset individually.

   If the throttle restart switch has been used, setting both restart switches ON before moving the throttle switch off (forward) will allow inlets to be reset individually. Then, unless in manual inlet control before the A/D, resume automatic operation by setting the restart switches off individually.

   If using the manual inlet schedule prior to the A/D, do not set the restart switches off before selecting 100% OPEN on the affected inlet forward bypass control. Return to the manual bypass schedule after the spike has been returned to automatic scheduling or to the desired manual position.

   Alternatively, <u>if</u> automatic spike operation appears normal, position the throttle restart switch in the middle position, allow the spikes to recover to the automatic schedule, and set the affected inlet forward bypass to 100% OPEN before moving the throttle restart switch off.

<u>After CIP recovers:</u>

9. Derich switch - Recycle to ARM as necessary.

   If a fuel derich light is on, move the fuel derich switch to REARM, then back to ARM.

   CAUTION

   Do not move the Fuel Derich switch from ARM until inlet restart (CIP recovery) is obtained; otherwise, severe overtemperature can result.

   After derichment (derich light on), rearm the fuel derich system only <u>after</u> CIP has recovered and <u>before</u> lighting the afterburner. Relighting the A/B while deriched can result in engine speed suppression of up to 750 rpm.

   Afterburner blowout due to low EGT and suppressed rpm, may occur during inlet recovery. The afterburner may relight automatically when EGT returns to normal (after the derich system is cycled) through operation of the catalytic igniters.

   Without derichment, the catalytic igniters may sustain the afterburners or cause relights as soon as the inlet recovers.

10. Throttles - Reset and check afterburners as desired.

    After CIP has recovered, reset the throttles, if necessary. Check that the nozzles are not abnornally closed if throttles are in afterburning range. Check that nozzle position responds to throttle position (by retarding throttle below Military) if afterburner blowout occurs. Relight the afterburner, if desired.

If an inlet unstarts after its restart switch is off, set the affected inlet restart switch ON and use the Manual Inlet Schedule or complete the Inlet Malfunction procedure, this section.

INLET MALFUNCTION

When at supersonic speeds, inlet system malfunction is indicated by successive unstarts, abnormally high or low CIP, or engine stalls. Malfunction of an inlet may be due to failure of the spike and/or forward bypass automatic controls, aft bypass control, actuators, or electrical or hydraulic control power. The engine and hydraulic instruments and inlet control circuit breakers should be checked before employing the inlet malfunction procedure, to determine that an inlet malfunction is not associated with some other abnormal condition. The respective inlet restart switch, or spike and door position controls, individually control the left or right inlet. The throttle restart switch affects both inlets simultaneously.

NOTE

- o Since nozzle failure will affect engine rpm, and rpm, in turn, affects automatic forward bypass door operation (supersonic), abnormal forward bypass door indications can result from nozzle failure.
- o Use spike and forward bypass position, turn-and-slip ball, CIP, ENP, fuel flow, and rpm indications for malfunction analysis.
- o In some cases when unstarts have occurred due to automatic spike control malfunction, automatic operation can be continued below the Mach at which the unstart occured. Continuing at lower Mach may be preferable to using the manual spike schedule.

<u>Failure To Schedule Normally</u>

A combination of asymmetric thrust and fuel flow, and low CIP on one side during acceleration indicates that a spike and/or forward bypass has failed to schedule properly. This may be caused by failure of the automatic control(s) or of the spike forward lock to disengage when above 30,000 feet, or by circuit breaker opening. Normal spike and forward bypass positions and CIPs are provided by Figure 1-22.

Inlet Spike Unstable

Spike instability is reflected by fluctuations of the respective L or R hydraulic (SPIKE) pressure gage and by the spike position indication. If large-amplitude spike oscillations occur, the gage fluctuations are several hundred psi and a "hammering" may be felt. If spike instability persists, attempt to restore normal operation by cycling the manual spike control to match flight Mach number, then return to automatic control. If the condition persists, use the schedule for manual inlet operation until a different Mach number is reached, then return to automatic control. If the condition still continues, use the manual schedule.

Aft Bypass Control Failure

Malfunction of an aft bypass control is indicated by failure of the corresponding position indication light to extinguish after the aft bypass control position setting is changed. It may be possible to correct a malfunction by cycling the control setting. Control failure can result in reduced performance, inlet roughness or unstart, or engine stall, depending on the existing or subsequent flight conditions. Refer to Stall and Unstart Boundary charts, this section, for conditions to expect with the aft bypass, spike, and forward bypass in various positions.

INLET MALFUNCTION PROCEDURE

This procedure should be followed when the pilot has identified a specific inlet that will not operate automatically, but has not identified the reason for the unstart(s). The procedure allows an orderly transition from a cleared inlet, in the restart configuration, to the appropriate manual inlet schedule.

CAUTION

Observe altitude, speed, and bank angle restrictions during manual inlet operation.

Affected inlet:

1. Restart switch - ON.
2. Forward bypass control - 100% OPEN.
3. Restart switch - Off.

If unstart does not repeat:

4. Forward bypass control - Manual schedule.

   Assume that spike operation is normal and if aft bypass operation is normal, that there is a malfunction in the automatic forward bypass control.

If unstart repeats:

5. Restart switch - ON.

   WARNING

   If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

6. Spike control - Manual schedule.
7. Restart switch - Off.

   Unstart should not repeat if malfunction is in the automatic spike control.

8. Forward and aft bypass controls - Manual schedule.

   The normal aft bypass and manual forward bypass schedules must be used when operating with manual spike control to obtain near-normal inlet performance.

After CIP recovers:

9. Derich switch - Recycle to ARM as necessary.

   If a fuel derich light is on, move the fuel derich switch to REARM, then back to ARM.

   CAUTION

   Do not move the Fuel Derich switch from ARM until inlet restart (CIP recovery) is obtained; otherwise, severe overtemperature can result.

   After derichment (derich light on), rearm the fuel derich system only after CIP has recovered and before lighting the afterburner. Relighting the A/B while deriched can result in engine speed suppression of up to 750 rpm.

   Afterburner blowout due to low EGT and suppressed rpm, may occur during inlet recovery. The afterburner may relight automatically when EGT returns to normal (after the derich system is cycled) through operation of the catalytic igniters.

   Without derichment, the catalytic igniters may sustain the afterburners or cause relights as soon as the inlet recovers.

10. Throttles - Reset and check afterburners as desired.

    After CIP has recovered, reset the throttles, if necessary. Check that the nozzles are not abnormally closed if throttles are in afterburning range. Check that nozzle position responds to throttle position (by retarding throttle below Military) if afterburner blowout occurs. Relight the afterburner, if desired.

MANUAL INLET OPERATION

The inlet spike and forward bypass may be positioned manually if an automatic inlet control malfunctions. Manual control is also desirable if engine shutdown is necessary while at high speed, as the spike aft position results in minimum inlet roughness during descent to subsonic speeds. Refer to Engine Shutdown procedure, this section.

CAUTION

Observe altitude, speed, and bank angle restrictions during manual inlet operation.

Manual Control of Forward Bypass

Manual operation of the forward bypass is permissible with AUTO spike selected, or in combination with manual spike scheduling. The normal aft bypass schedule should be used with the manual inlet schedule, (Figure 3-5). Figure 3-6 illustrates the forward bypass positioning for manual scheduling and for standard-day automatic operation.

NOTE

During cruise, if one inlet is controlled manually, set the forward bypass control to 1.0 psi less than the CIP of the normally operating inlet. If both inlets are controlled manually, set the forward bypass controls to 2.0 psi below the CIP "barber pole".

Manual Control of Spike

Manual operation of a spike is permissible; however, the effect on forward bypass positioning must be recognized. When an inlet forward bypass control is in AUTO and the spike control is in the manual range, the manual spike control overrides automatic bypass operation and causes the forward bypass

SCHEDULE FOR MANUAL INLET CONTROL FOR SPIKE AND/OR FORWARD BYPASS AUTOMATIC CONTROL MALFUNCTION

CLIMB & CRUISE SPEED	SPIKE SETTINGS		FWD DOOR SETTINGS		
	SPIKE **WITH** (1) IND	SPIKE W/O (2) IND	auto/man spike, DOOR **WITH** IND (1)	auto spike, DOOR W/O IND (2)	man spike, DOOR W/O IND
Below M 1.7	FWD	FWD	0%	0%	0%
Before IGV Shift	1" fwd of auto side	Lag TDI 0.1 Mach	Match auto side + 25%	40%	20%
After IGV Shift			Auto + 10%	30% (3)	10%
Cruise		Match Mach	CIP - 1 psi low (4)		

Use normal aft bypass schedule.
Adjust fwd door 20% more open before shifting aft door toward closed, or A/B light or cutoff.
Adjust spike 0.1 Mach no. forward before turns.

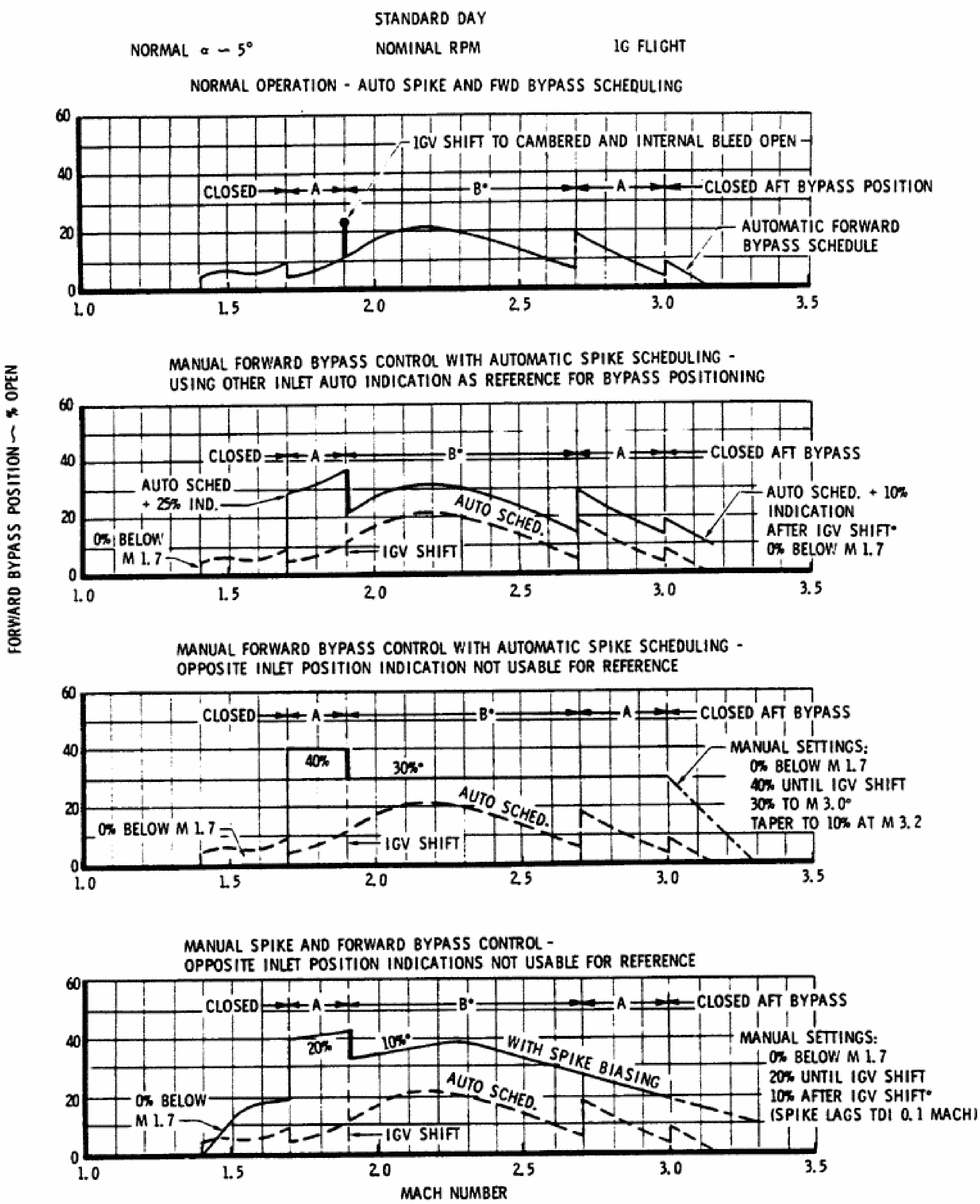
(1) Set indicator relative to opposite inlet auto indicator.
(2) Set marked knob setting if indicator inop, or if opposite inlet indicator is manual or inop.
(3) If IGV shifts below Mach 2.1, set aft bypass to B before closing fwd bypass.
(4) With dual manual inlet: 2 psi below barber pole.

MANUAL INLET RESTRICTIONS:
Max speed: Above FL 700; Mach 3.0, 400 KEAS.
Max altitude: FL 800.
Max bank: 20° above FL 750, 35° between FL 700 & FL 750.
Min airspeed: Above FL 700, KEAS for 6° α.

SUPERSONIC DESCENT	
SPEED	All manual inlet conditions
All	RESTART - ON
Above M2.5	720° EGT to Military
Below M2.5	Set 6500 rpm. Let rpm decrease. Retard throttle if compressor stalls.
With IGV Lockout Failure: At M2.0	Set idle
At M1.3	Spike forward, forward bypass closed, then restart OFF.

Figure 3-5

FORWARD BYPASS POSITIONING - AUTOMATIC & MANUAL SCHEDULING



*SET B POSITION AFTER IGV SHIFT (a) IF BELOW MACH 2.1 OR (b) IF AUTO FWD BYPASS OVER 20% OPEN. CHANGE FWD BYPASS AFTER SETTING AFT BYPASS TO B POSITION.

F203-194(a)

Figure 3-6

to open 100%. The forward bypass must be controlled manually to obtain positions less than 100% open during manual spike operation. When both are set in the manual control range, spike settings above Mach 1.4 bias the actual forward bypass position more open than the bypass control position settings. The maximum bias is approximately 25% when the spike setting is Mach 2.3, and at least 10% bias when spike control settings are between Mach 1.5 and Mach 2.8. Refer to Figures 1-30 and 3-6.

CAUTION

During supersonic climbs above Mach 1.7 but before IGV shift to cambered, expect the manual spike setting to bias the forward door about 20% more open (see Figure 1-30). Forward door indications of more than 40% open may cause stalls in this region of the climb. These stalls usually can be cleared by closing the forward door to the setting specified in Figure 3-5.

NOTE

Set spike position first when manual spike and forward bypass setting changes are scheduled. Allow the spike to reach its new position, then reset the forward bypass.

Manual Inlet Schedule

Use the schedule from Figure 3-5 if manual inlet operation is necessary or desired. (Checklist emergency procedures include an abbreviated form of this table.) During manual inlet descent below Mach 2.5, a combination of restart on and high rpm results in compressor stall. Set 6500 rpm at Mach 2.5 and let rpm drop under the stall boundary condition. If an IGV lockout failure is suspected on the affected manual inlet, set Idle at Mach 2.0. Unless rpm is reduced below the IGV/internal bleed shift line in Figure 3-7, stall may be encountered when the internal bleed and IGV shift with the forward door near 100% open.

WARNING

Risk of engine stall and flameout exists if the internal bleed and IGV shifts (to axial) during deceleration with an inlet forward bypass full open. Engine stalls have also been encountered during acceleration with the forward bypass failed open.

COMPRESSOR STALL

Compressor stall is usually indicated by thumping pulsations. Other characteristic indications are a loss of thrust, fluctuating CIP, RPM, ENP, or EGT at fixed throttle position, or failure of rpm to increase during throttle advance. Afterburner flameout with/without catalytic reignition can occur. At low airspeeds, compressor stall frequently results in engine flameout. Some of these stall characteristics are also descriptive of inlet unstarts, so accurate differentiation between stall and unstart is difficult. In addition, stalls and unstarts may be intermingled, making identification more difficult. A supersonic stall clearing procedure is incorporated in the Inlet Unstart procedure.

Compressor Stall Regions - Supersonic

Stall regions are shown in Figure 3-7. Maximum stall risk is at military rpm with IGV axial, aft bypass full open, and in restart. Minimum stall risk is near idle rpm with IGV cambered, engine internal bleeds open, with aft bypass closed. Stalls may be caused by transient airflow conditions resulting from compressor bleed or IGV shift, or by unstable or manual inlet operations. Other causes may be abrupt or erratic throttle movement, failure to momentarily delay throttle advancement during afterburner light, or improper scheduling of IGV or engine bleeds. Recovery from stall accompanying inlet unstart at high altitude is aided by reducing altitude. Below Mach 2.5, recovery is more consistently obtained by retarding the throttle.

ENGINE STALL REGIONS - SUPERSONIC

STANDARD DAY

Based On Mach And FAT
For Std. Day At 400 KEAS

STALL REGION / ENGINE CONFIG		STALL RISK ① IGV AXIAL	STALL RISK ② INT. BL. OPEN	STALL RISK ③ EXT. BL. OPEN
INLET CONFIG	AUTO - AFT CLSD	MODERATE	SLIGHT	SLIGHT
	AUTO - AFT OPEN	MODERATE	SLIGHT	MODERATE
	RESTART - AFT CLSD	EXTREME	MODERATE	SLIGHT
	RESTART - AFT OPEN	EXTREME	HIGH	HIGH

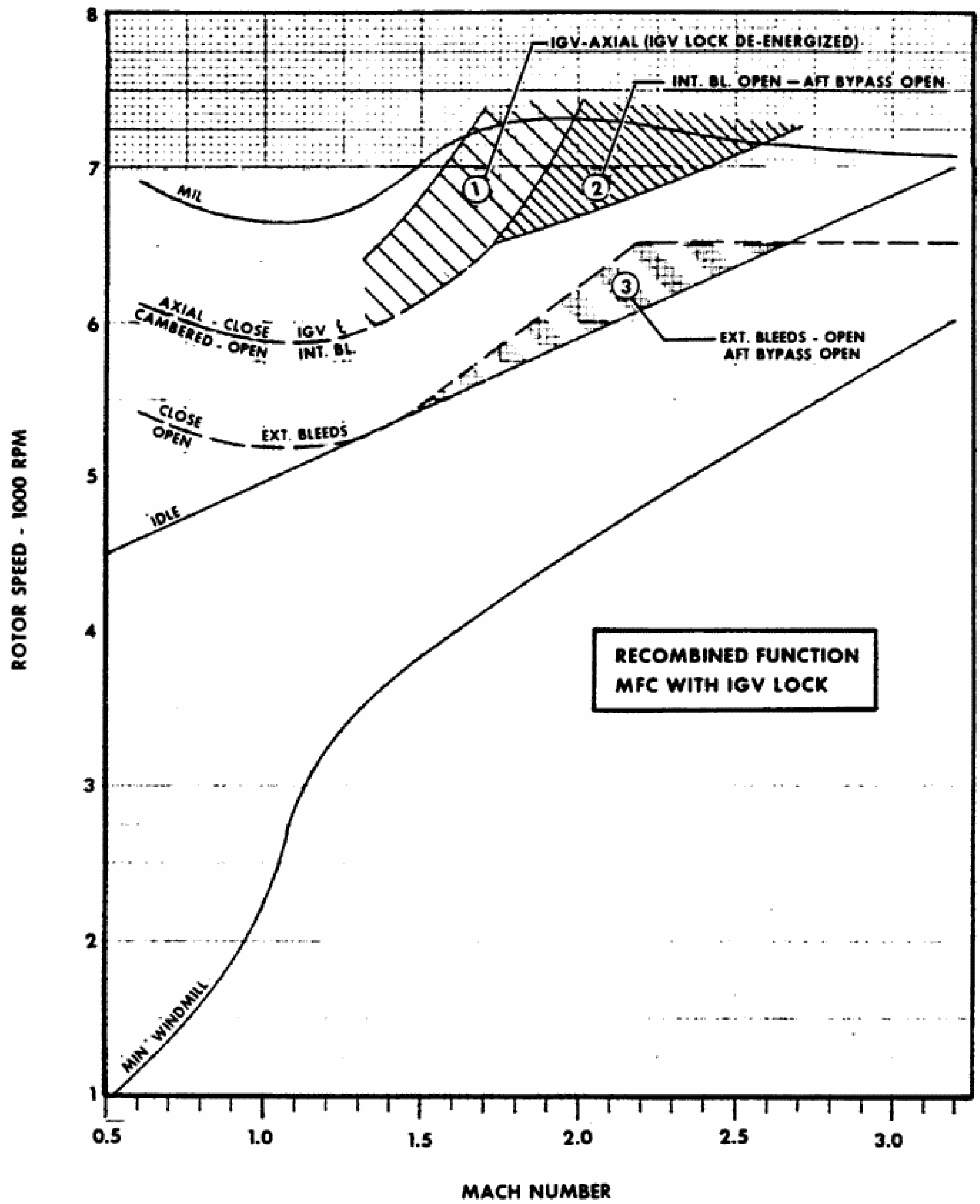


Figure 3-7

Effect of Open Aft Bypass on Stall - Supersonic

Unless the shock trap bleed flow is restricted by secondary airflow back pressure, open aft bypass positioning generally has slight effect on engine stall at supersonic speeds as long as the forward bypass continues scheduling. Stall risk, particularly below Mach 3.0, is significantly increased when excessive aft bypass opening results in a closed, non-scheduling forward bypass. While below Mach 2.5 with an inlet restart switch ON, appreciable stall risk exists while near Military rpm and in Idle with engine start (external) bleeds open. During airstart, the aft bypass should be closed as rpm increases.

Effect of Manual Inlet Operation - Supersonic

During manual inlet operation, stall risk is increased due to greater inlet distortion and reduced inlet efficiency. Full open forward bypass or restart results in extreme stall risk when the IGV light is on (indicating axial position), and should be avoided.

SUBSONIC COMPRESSOR STALLS

In addition to the more readily recognized abnormal rpm, EGT, nozzle position, and fuel flow conditions (for which emergency procedures are described in this section), engine stall parameters include angle of attack (α), compressor inlet pressure (CIP), turbulence, wind shear, and rapidly changing ambient air temperatures.

Engine stalls that occur during throttle advance are usually the result of excessive EGT uptrim. Engine stalls may also be caused by excessive EGT while at constant throttle settings, or malfunctioning nozzles, fuel controls, guide vanes, or engine bleeds. Engine stalls that occur when engine operating conditions are otherwise normal and when control parameters are not being changed may indicate an approach to dangerous flight situations. A low airspeed or high angle of attack condition, or both, may exist. Then, the stalls can be a result of low CIP (which is associated with low airspeed when at moderate to high subsonic operating altitudes) or result from high distortion in the inlet (which occurs at high angles of attack). Either can be dangerous when associated with operation beyond established flight limits.

When subsonic at angles of attack above 10°, engine compressor stalls may occur; however, stall-free operation has been obtained at angles of attack as high as 15° (Aircraft limit is 14°. See Figure 5-3).

Engine stalls are more probable when at Military rpm with CIT's below +10°C than at higher CIT's. This condition is in the rapidly changing portion of the EGT trim band. The probability of stall is increased at low CIP (high altitude, low airspeed), if there is a sudden decrease in air temperature, or if there is clear air turbulence, aircraft maneuvering, or open bypass door conditions. The effects can be additive.

High angles of attack do not affect CIP directly; rather, they cause nonuniform pressure distribution (inlet distortion) and disturbed airflow at the engine face. An engine can operate normally with large amounts of distortion if at relatively high CIP (low altitude or high KEAS). If there is very little distortion, operation may continue at CIP's as low as 2.5 psi. If at moderate to high altitudes and at low KEAS or CIP, a small amount of distortion can result in compressor stall.

Figure 6-2, which presents lift coefficient vs angle of attack, shows a generally linear slope for subsonic conditions away from ground effect. At angles of attack for normal subsonic flight (Mach 0.75 to 0.90), increasing load factor (or lift coefficient) results in an almost linear (equal factor) increase in angle of attack. Thus, if a gust changes load factor from one-g to two-g's, angle of attack will also double.

Sudden increases in angle of attack, such as from gusts, do not change CIP significantly; however, such sudden increases do increase inlet distortion. Therefore, gusts can contribute to engine stall probability.

SUBSONIC COMPRESSOR STALL PROCEDURE

1. **α WITHIN LIMIT.**

   Reduce angle of attack and then maintain angle of attack and airspeed within limits.

   WARNING

   When subsonic, if an APW system or high angle of attack warning occurs, or if angle of attack and airspeed are not within limits, make angle of attack and speed corrections before adjusting the throttles. These actions alone may clear engine stall conditions, and are mandatory to avoid pitch-up, if at high angle of attack and/or low airspeed.

After angle of attack and KEAS within limits:

2. Throttle - Retard toward 6100 rpm.

   Retard both throttles as necessary to clear the compressor stall, but do not reduce engine speed below 6100 rpm until nozzle response can be checked. Continuing stalls with EGT below the military schedule may indicate engine fuel-hydraulic system failure. In this event, maintain engine speed above 6100 rpm at whatever speed can be maintained without stalling. The engine will not operate at idle rpm with internal and external bleed valves closed or exhaust nozzles failed closed. Refer to Fuel-Hydraulic System Failure and Afterburner Nozzle Failure, this section.

If the compressor stall does not clear and nozzle response is normal, continue throttle reduction toward idle. Check IGV shift to cambered (IGV light off) as an indication of normal fuel-hydraulic system operation.

3. KEAS - Adjust toward 350 KEAS.

   Apply sufficient pitch correction to compensate for thrust loss. Airspeeds near 350 KEAS are favorable to normal engine operation.

When the engine stall clears:

4. EGT - Downtrim manually if necessary.

   Downtrim EGT if the compressor stalls occurred at military power or with the afterburner operating.

   Downtrim both EGT trim switches for <u>at least</u> three seconds if engine stalls are due to high EGT. With the throttles retarded, the response to trim will not be apparent in EGT indication as trim only affects EGT at or above Military power.

5. Derich switch - Recycle to ARM as necessary.

   If the fuel derich light is on and EGT is not high, move the fuel derich switch to REARM, then back to ARM.

6. EGT - Monitor.

   Retrim EGT manually to the normal operating range if necessary. If AUTO EGT trimming is resumed, monitor EGT and HOT/COLD flag indications to assure that no malfunction persists.

If stalls persist, affected engine:

7. Throttle - OFF.

8. Aft Bypass - Open.

9. Nozzle position - Verify full open.

10. IGV position - Check IGV light off (cambered position).

NOTE

> If IGV and/or nozzle position indications are abnormal, set the throttle to Military when starting if an airstart attempt is necessary. An airstart attempt may result in further engine damage. Engine stalls are likely following light-off, but it may be possible to accelerate and obtain stall-free operation at military power. Observe EGT limits, and follow nozzle failed <u>closed</u> procedures for the remainder of the flight.

11. Check for abnormally high fuel flow.

12. Check visually for streaming fuel.

    Check through the periscope for a fuel trail.

If high fuel flow or streaming fuel observed:

13. Emergency fuel shutoff - Fuel off.

If IGV, nozzle, and fuel flow normal:

14. Accomplish Airstart procedure, if desired.

If airstart not desired:

15. Complete the Engine Shutdown & Descent procedure.

COMPRESSOR STALL IN DESCENT

Compressor stalls may occur during descent at internal bleed and IGV shifts, especially if rpm droops below the military schedule. Often these stalls are self-clearing through re-opening bleeds or recambering IGV. After a few of these cycles of shift followed by stall, the bleed or IGV shift is completed and stalls then do not recur. IGV Lockout prevents IGV shift but does not prevent internal bleed shift. With forward bypass open or inlet in restart, compressor stalls are likely at any rpm while above Mach 1.4 when the internal bleeds shift to closed and if the IGV shifts to axial. Stall and unstart characteristics are very similar and accurate identification of which condition exists is difficult. Use of the wrong corrective procedure can result in continued stall or unstart with eventual flameout. The following procedure is designed to clear severe or protracted stalls, or similar inlet roughness conditions which cannot be positively identified.

For severe or protracted compressor stall in descent:

Affected engine:

1. Restart - ON.

   Do not use the throttle restart switch as both inlets would be affected.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

2. Throttle - IDLE immediately.

   Retard the throttle to idle immediately after setting the inlet restart switch ON.

NOTE

When near the internal bleed shift point (about Mach 1.8), setting the restart switch ON without throttle reduction can induce engine stall and flameout.

If stall persists:

3. Increase KEAS.

When subsonic:

4. Restart - OFF.

5. Throttles - As desired.

CAUTION

If an engine stall cannot be cleared, shut down that engine and accomplish airstart.

IGV Lockout Failure

The IGV light illuminates when the guide vanes leave the fully cambered position if the IGV lockout fails. The IGV and bypass bleed shift occurs at approximately 65^{o}C CIT or Mach 1.7 while decelerating with reduced rpm, and at approximately 85^{o}C CIT or Mach 1.8 when using the 720^{o} EGT descent procedure. Mild self-clearing compressor stalls may occur during the shift. If protracted or non-self-clearing stalls are encountered, accomplish the Compressor Stall in Descent procedure.

With a known IGV lockout failure prior to descent, set the throttle of the affected engine to Military above Mach 2.5 and 720^{o} EGT at Mach 2.5, rather than 6900 RPM. Maintain at least 700^{o}C EGT on that engine while above Mach 1.3. If the affected inlet was in manual operation, use the manual inlet descent procedure, but set Idle at Mach 2.0.

NOTE

> Monitor EGT, rpm, and nozzle position. 700^{o}C EGT minimum should hold rpm at the military schedule and maintain nozzle governing. ENP greater than 70% open will result in less than military rpm; in this event, advance the throttle as necessary to maintain military rpm. Maximum rpm occurs near 100^{o}C CIT, as during acceleration. Mild self-clearing stalls may occur near 85^{o}C CIT (at Military rpm) when the IGV/internal bleeds shift if EGT has dropped excessively.

ENGINE FLAMEOUT

Engine flameout characteristics are a loss of thrust, and a drop in EGT and rpm. If flameout occurs during supersonic descent, recognition will be especially difficult because of the similarity between normal engine instrument indications and those of an engine which has flamed out. The only positive indications of a failure in this regime may be low EGT and a lack of response to a change in throttle position. Fuel flow may or may not decrease, depending on the operating condition prior to flameout. Engine flameout can result from interruption of fuel supply, component malfunctions, or unstable inlet conditions with the compressor stalled.

If flameout occurs with afterburners on, the operating engine's throttle should be retarded to minimum afterburning to reduce thrust asymmetry.

For engine flameout, as confirmed by cross-checking EGT, fuel flow, rpm, and ENP, either accomplish the Engine Shutdown and Descent, or the Airstart procedure.

DOUBLE ENGINE FLAMEOUT

With both engines out, the hydraulic pumps provide sufficient flow for satisfactory control surface rates at engine windmilling speeds above 3000 rpm. Control capability is progressively reduced as speed decreases, becoming marginal at approximately 1500 rpm.

Generator(s) in NORM continue to supply ac electrical power at engine windmilling speeds down to 3500 rpm, below which the frequency will begin to drop and then the generator(s) trip off. If both generators drop off, the battery and inverter provide power for DAFICS and other equipment on the emergency ac and essential dc busses. Without generator power, the boost pumps are inoperative and the probability of engine start is reduced, particularly if one or more fuel tanks are empty.

Below 3500 rpm engine windmilling speed, when generator(s) in the EMER mode power the boost pumps, boost pump output decreases as engine windmilling speed decreases. See Figure 3-7 for a comparison of engine rpm with Mach. The essential ac bus is not powered by generator(s) operating in EMER mode.

DOUBLE ENGINE FLAMEOUT PROCEDURE

With both L and R GEN OUT lights:

Perform the Double Generator Failure boldface procedure to regain boost pump pressure. Refer to Double Generator Failure Procedures, this section.

▲1. **ATTITUDE REFERENCE INS**

Select the INS to maintain a primary attitude reference.

2. **BOTH GENS EMER**

With both generators inoperative, placing both generator switches in EMER should restore power to the boost pumps and the ac hot bus.

3. **PRESS TANK 4 ON**

If at least one generator operates in EMER, manually selecting Tank 4 should restore some fuel manifold pressure to both engines.

Engine(s):

4. **AIRSTART**

When altitude is critical or flight control is marginal:

▲5. Eject

WINDMILLING GLIDE DISTANCE

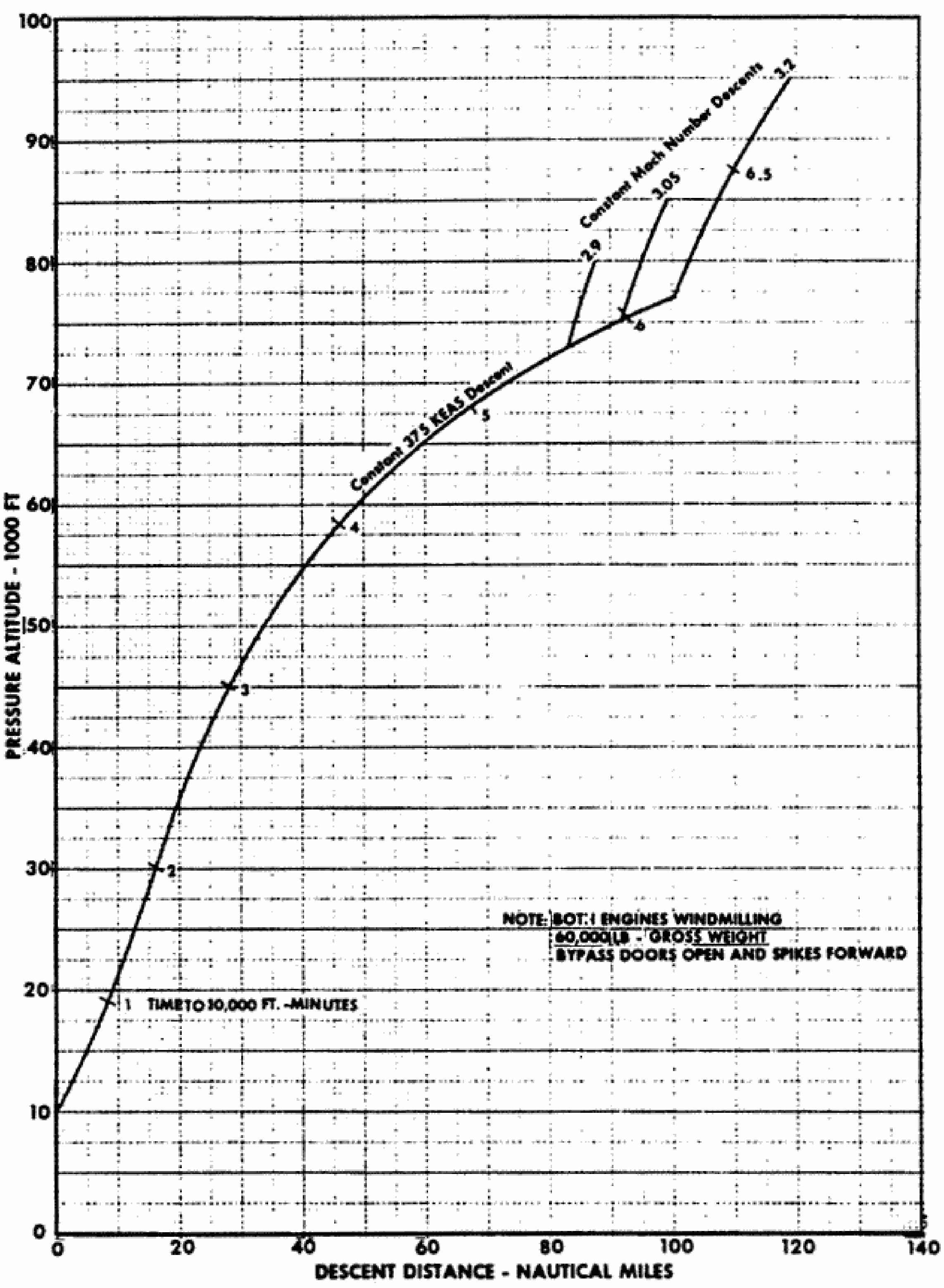


Figure 3-8

Glide Distance - Both Engines Inoperative

The glide distance chart, Figure 3-8, shows zero-wind glide distances with both engines windmilling. 375 KEAS glide speed is recommended for airstarts. Somewhat slower airspeeds provide greater range but reduced airstart capability. There is sufficient engine rpm for adequate hydraulic pressure to approximately 10,000 feet.

WARNING

Landing with both engines inoperative should not be attempted.

AIRSTART

If flameout is caused by temporary flow interruption, the throttle should be moved OFF immediately. Airstart procedures should be initiated after flameout; however, the reason for the flameout or shutdown must be considered before initiating restart.

Use of Crossfeed

If crossfeed is left open after an airstart is obtained, c.g. will move aft. Turn on an additional tank to the side where flow interruption is suspected before crossfeed is discontinued.

Airstart With Cold Oil

There are no special restrictions on airstarting and subsequent operation of the engines as long as oil pressure indications respond normally to rpm changes during the start. Operation above IDLE should be minimized after starting if oil pressure is not normal.

AIRSTART PROCEDURE

The best airstart conditions are 375 to 400 KEAS and at least 7 psi CIP.

NOTE

If subsonic, accomplish only * items.

On the affected side:

1. **RESTART ON.**

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

2. **AFT BYPASS OPEN**

Set the restart switch ON and open the aft bypass to avoid unstart and/or to attempt smoothing the inlet. (Figure 3-4 shows that unstart is probable below Mach 2.8 if the aft bypass is not open.) This procedure may not smooth the inlet, and roughness may become severe below Mach 2.8. Although airstarts have been obtained while in roughness (inlet unstarted), there is a higher probability of restarting the engine when smooth operation has been restored.

If the restart switch on the opposite inlet is also placed ON, reduce rpm on that side to avoid compressor stall and/or flameout. (See Figure 3-7).

* 3. **DERICH.**

Cycle the derich switch to REARM, then to ARM, if the fuel derichment system has been actuated by high EGT.

* 4. **X-FEED OPEN**

Selecting crossfeed OPEN is the fastest method of assuring a positive supply of fuel to the engine before attempting an airstart.

* 5. **THROTTLE OFF, THEN 1/3 TO 1/2 MIL.**

Cycle the throttle to OFF, pause several seconds to assure cycling of the TEB chemical ignition system, then set the throttle at the position for 1/3 to 1/2 of the non-A/B range.

While supersonic, allow 15 seconds for rpm to increase (indicating that an airstart is being accomplished), observing the cessation of streaming fuel by use of the periscope. Repeat procedure as necessary. Do not expend all TEB during airstart attempts while supersonic.

While subsonic, an airstart can usually be obtained in 15 to 30 seconds at almost any allowable flight condition; however, 375-400 KEAS and at least 7 psi CIP are recommended. Over 30 seconds may be required for starting. Repeated rapid airstart attempts are not as effective as leaving the throttle in OFF several seconds to assure complete cycling of the TEB system and then leaving the throttle in the 1/3 to 1/2 Military position several minutes until positive that no start was obtained.

CAUTION

If rotor speed is below 1200 rpm, airstart is unlikely. Severe roughness and EGT overtemperature should be anticipated if airstart is attempted.

After engine starts:

6. **AFT BYPASS SET.**

Set the inlet aft bypass closed as rpm increases. Between approximately Mach 1.3 and Mach 2.3, compressor stall may be encountered if the IGV shifts as engine speed increases. If compressor stall in this speed range results in flameout, repeat the procedure, and maintain rpm below 6000 rpm after start. After starting and with the aft bypass closed, set the throttles as required and reset the crossfeed switch and inlet controls.

If continued airstart attempts in the descent are desired:

7. Check operative inlet and engine conditions and complete steps 9 through 15 of the Engine Shutdown & Descent procedure.

If the engine will not start:

* 8. Complete the Engine Shutdown & Descent procedure.

ENGINE FIRE & ENGINE SHUTDOWN

Illumination of a FIRE warning light indicates a nacelle compartment temperature above 565°C.

Engine shutdown must be accomplished after complete engine failure, such as seizure, explosion, or fire. Shutdown should also be accomplished for mechanical failure within the engine or its accessories to avoid or delay complete engine failure. Mechanical failure situations include uncontrollable rpm or EGT, and unaccountably abnormal oil pressure, fuel flow, or vibration. Refer to emergency procedures related to the engine oil, EGT, fuel, and nozzle systems, and to information in this section relating to operation with one or both engines inoperative.

Windmill speeds below 3500 rpm result in generator lowspeed cutout and a 50% loss of fuel tank boost pump capability to the good engine if the bus tie splits. If below Mach 2.0 or decelerating through Mach 2.0, turn off the affected generator as soon as possible after engine failure to prevent bus tie split and assure full boost pump capability.

Complete engine failure probably will not permit normal windmilling operation, but if the engine continues to rotate, cooling fuel circulates through the engine and aircraft cooling loops even with the throttle off. If the engine is not windmilling, an airstart should not be attempted since doing so could result in fire or explosion. Normal windmilling speeds can be expected after shutdown for some mechanical failures. Fuel cooling will continue unless the emergency fuel shutoff switch is shutoff or drive shaft power to the fuel circulating pumps is lost.

Descent distance can be extended by decelerating with maximum afterburning on the good engine. Overall economy can be improved by decelerating with minimum afterburning or Military power on the operating side. Base the choice of A/B (on or off) on the power condition to be used for single-engine cruise. When no airstart is to be attempted, descend at 350 KEAS until subsonic cruise altitude is reached.

WARNING

> With the spike forward, roughness intensity increases during deceleration between Mach 2.5 and Mach 1.3. Very severe roughness should be anticipated in this speed range if the spike is not positioned aft. Maximum structural loads imposed are severe, but are well below design limits.

ENGINE FIRE/ENGINE SHUTDOWN & DESCENT PROCEDURE

NOTE

> If subsonic, accomplish only * items.

If a FIRE warning light illuminates, affected engine:

* 1. **THROTTLE MIL/IDLE.**

Positively identify the affected engine. Then retard its throttle to Military when operating at a higher power setting. Retard the throttle toward IDLE if the warning light remains on or if operating with afterburner off when the warning occurs. If supersonic, retarding the throttle of the affected engine to Military (or less) will result in deceleration to subsonic speeds.

The thrust required for level flight may govern the power reduction possible on the affected engine if at low airspeed and heavy weight, as for fire warning immediately after takeoff. During landing approach, minimum control speed considerations may govern the amount of power advancement which can be used on the unaffected engine.

Check for abnormal EGT, trailing smoke, or any other indicaton of fire. Use the rear view periscope and RSO mirrors. Request confirmation of fire from other personnel if available. In case of doubt, assume that a fire does exist.

If the FIRE light extinguishes while at reduced power, and if there is no confirmation of fire, the flight may be continued with power reduced on the affected engine until a landing can be made at the nearest suitable facility. Land as soon as possible.

If the FIRE light remains on with the throttle at IDLE, or if a fire is confirmed, shutdown that engine.

WARNING

> If the fire warning light extinguishes while shutting down the engine, do not attempt a restart. Fire or explosion could result.

If engine shutdown is necessary:

2. **RESTART ON.**

The spike-forward and forward-bypass-open configuration delays onset of roughness or unstart if the engine is shutdown near Mach 3. Use of the throttle restart switch affects both inlets and may not be desirable.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

* 3. **THROTTLE OFF.**

* 4. **AFT BYPASS OPEN.**

Initial onset of roughness can be expected near Mach 2.5 with the aft bypass open, inlet in restart.

* 5. **FUEL OFF FOR FIRE.**

Positively identify the emergency fuel shutoff switch for the affected engine and set it to the fuel off (up) position if shutdown is a result of fire.

WARNING

Shutting off fuel to a windmilling engine while at high Mach may cause additional emergencies due to loss of cooling fuel for the engine and aircraft systems. However, it is imperative to shut off fuel to the nacelle in the event of fire.

Fuel shutoff stops flow through one fuel cooling loop system. If speed is above approximately Mach 2.2, shutting off the fuel may cause engine oil to overheat and result in engine seizure. Shutting off the fuel may also cause additional emergencies due to loss of the associated aircraft cooling systems. Reduced Mach decreases cooling requirements.

6. Spike control - Mach 3.2 (full clockwise).

7. Airspeed - 350 KEAS (recommended).

Adjust speed toward 375 KEAS if airstart attempt is intended.

When roughness is encountered:

8. Restart switch - OFF.

Turn the restart switch OFF at onset of roughness (approximately Mach 2.5).

The full clockwise position of the spike control provides full aft spike and forward bypass open positioning (with the forward bypass control in the AUTO position) after the restart switch is off. Expect mild buffet as the spike moves aft and restricts inlet airflow.

CAUTION

Do not attempt airstart with the spike positioned aft.

At Mach 2.0:

* 9. Affected engine generator switch - OFF.

Check that the affected engine GEN OUT caution light illuminates.

Tripping the generator of the affected engine provides the most rapid load transfer to the unaffected engine generator. This minimizes switching delays which might otherwise occur when the windmilling engine generator automatically trips due to the underspeed cut-out. The remaining generator has sufficient capacity for all normal electrical loads.

CAUTION

Windmill speeds below 3500 rpm result in generator lowspeed cutout and a 50% loss of fuel tank boost pump capability to the good engine if the bus tie splits. If below Mach 2.0 or decelerating through Mach 2.0, shut off the affected generator as soon as possible after engine failure to prevent bus tie split and assure full boost pump capability.

NOTE

All flight control trim systems will be inoperative if the remaining generator fails, unless power is available from the EMER function of the generator(s) to power pitch and yaw trim through the ac hot bus.

Operative Inlet & Engine Conditions

1. Inlet controls - AUTO and CLOSE

   Position the spike and forward bypass controls to AUTO and set the aft bypass controls at CLOSE unless manual inlet control procedures are required.

2. IGV switch - LOCKOUT.

3. Throttle - Min A/B above Mach 2.0.

4. Throttle - Mil or Min A/B below Mach 2.0.

   A/B on is required while above Mach 2.0 to keep deceleration rates within limits. Minimum afterburner or Military power is recommended below Mach 2.0 until subsonic. Maximum afterburner results in greatest descent distance extension; however, maximum power should not be selected while above Mach 3.0 (to avoid unstarting the good inlet due to sideslip) and it is relatively uneconomical while below Mach 2.0.

* 10. Bay air switch - OFF.

This makes the maximum amount of cooling air available to the cockpits and closes the nose air shutoff valve.

Turn the affected side refrigeration switch OFF if necessary (such as for smoke entering the cockpit).

* (11) Chine bay equipment (except MRS) -Off.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

* 12. C.G. - Forward of 22%.

Transfer fuel to maintain c.g. within subsonic limits. Monitor tank 1 quantity while transferring fuel.

* 13. Cockpit temperature control rheostat - COLD, if necessary.

Approximately 75% of the normal flow of cooling air to the cockpits remains available.

Below Mach 1.7:

14. Pitot heat switch - ON.

15. Exterior lights - On.

Below Mach 1.3:

* 16. Restart switch - ON.

Set the restart switch ON and reposition the aft bypass (when necessary) to minimize roughness.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

17. IGV switches - NORMAL.

    Deenergizing the IGV Lockout System restores the engine to maximum thrust capability. The IGV should shift to axial and IGV lights illuminate if RPM is above 5500-6000 rpm.

When subsonic:

*18. C.G. - Monitor and control.

    Press crossfeed OPEN when tanks 5 and 6 are empty.

*19. SAS - Appropriate channels off.

    Review SAS and hydraulic systems available. Refer to procedures for SAS and hydraulic system emergencies.

*20. Land as soon as possible.

*21. Complete the Single-Engine Penetration and Landing procedure.

SINGLE-ENGINE FLIGHT CHARACTERISTICS

The loss of one engine will not result in loss of all hydraulic or electrical systems. If an engine fails just after takeoff, the large amount of asymmetric thrust will require bank toward the good engine and may require full rudder for directional control. Refer to Figure 3-2 for minimum single-engine control speeds. After regaining directional control, 7° to 9° rudder trim with bank and sideslip toward the good engine provide minimum drag during acceleration to climb speed. Charts showing single-engine climb capabilities are included in the performance data appendix. Acceleration to climb speed and climb to landing pattern altitude must be accomplished with Maximum thrust on the operating engine. During single-engine cruise, or after climb, reduction to zero rudder trim and use of bank and sideslip to maintain course provides minimum drag. A bank of up to 10 degrees is recommended, using no more than enough rudder trim to maintain course.

NOTE

During single-engine operation at low speed, a large rudder input may be required to maintain directional control under high asymmetric thrust conditions. A yaw toward the failed engine will cause a SAS correction proportional to the yaw rate up to 8 degrees maximum. Once the sum of the rudder and SAS inputs reaches 20 degrees maximum rudder displacement, any additional Yaw SAS input feeds back through the servo's internal linkage moving the rudder pedal suddenly back toward neutral an amount up to approximately one-half of the full pedal authority. In this case, the sum of the rudder and yaw SAS inputs remains 20 degrees, and no actual change in rudder position occurs even though the rudder pedal position has moved. As the yaw SAS input washes out (approximately 12 seconds), the pilot must continue to apply rudder pressure to compensate for the loss in SAS authority, or rudder deflection will decrease.

Trim Changes

Pitch trim changes can be expected while dumping fuel, due to shifting center of gravity. Directional trim is quite sensitive to changes in airspeed and power during landing

SINGLE-ENGINE AIR REFUELING

ACTUAL	SIMULATED
Receiver weight and altitude variations may result in conditions where military power is inadequate and afterburning power is excessive. Single engine rendezvous and refueling can be accomplished satisfactorily with approximately 10,000 pounds of fuel and 27,000 feet aircraft altitude. Approximately the same control trim and forces as for single engine cruise may be used with bank angles up to 10 degrees. After completing rendezvous:	Practice of single-engine refueling techniques can be accomplished at normal refueling altitudes with a fuel load of 25,000 - 30,000 pounds, one engine in IDLE, and one engine in afterburner:
1. Adjust throttles (and EGT trim if necessary) to stabilize behind tanker in mid-afterburner.	1. Same as "ACTUAL".
2. Turn both roll SAS channels off.	2. Same as "ACTUAL".
3. Trim roll and yaw axes to reduce effects of asymmetric thrust on stick pressures.	3. Same as "ACTUAL".
4. Turn forward transfer on if left engine is being used. Select crossfeed OPEN if right engine is being used.	4. Same as "ACTUAL".
5. Set brake switch to operate refueling system with appropriate L or R hydraulic system, then establish tanker contact.	5. Brake switch - ANTI-SKID ON.
6. If EGT is manually downtrimmed, uptrim EGT to nominal AUTO band or return EGT trim to AUTO as fuel is being transferred. Trimming beyond nominal band exposes the engine to stall.	6. Same as "ACTUAL".
7. Initiate a toboggan maneuver prior to reaching maximum afterburner.	7. Same as "ACTUAL" or: Initiate disconnect when power is limited at maximum afterburner. Do not intentionally exercise an outer limit disconnect.
	8. Reestablish normal 2-engine refuel operations if desired.

Figure 3-9

pattern operation. At high speed, engine failure or engine flameout could cause yaw angle to become critical if an effective damper were not operating. Temporary thrust reduction on the good engine helps to counteract the asymmetric thrust. Follow-up rudder action is necessary. If large yaw angles develop, inlet duct airflow disturbances may cause the other engine to stall or flame out.

Fuel System Management

Fuel system management during protracted engine-out operation should consider maintaining center of gravity, making all of the fuel available to the operating engine and, when possible, continuing the fuel cooling of necessary systems. Refer to Fuel System Management with Engine Shutdown, this section.

Single-Engine Air Refueling

Single-engine air refueling procedures for actual and simulated operation are provided by Figure 3-9.

WARNING

> Do not air refuel or land with only one roll SAS servo engaged.

Single-Engine Cruise

Conservative single-engine cruise performance data for Military, Minimum A/B, and Maximum A/B thrust are in Figure 3-10.

The cruise altitudes in Figure 3-10 are also the aircraft constant throttle single-engine ceiling capability. An altitude capability lower than shown on the charts must be expected on a hot day.

Minimum A/B thrust and Military thrust provide the best single-engine cruise options. Military provides the best range performance, but penalizes altitude capability especially at heavy gross weights. Minimum A/B provides good range performance with an ample altitude capability.

Maximum A/B single-engine cruise has poor range performance and should only be used when the required cruise altitude is higher than the minimum A/B cruise altitude capability. At least two fuel tank boost pumps are required for maximum afterburning fuel flow. If bus tie split occurs, manual selection of an additional fuel tank may be required. Simultaneous forward transfer and fuel dump should be avoided.

AFTERBURNER FLAMEOUT

Afterburner flameout can result from engine stall, abnormal inlet operation, or insufficient airspeed at altitude. Afterburner flameout may be detected by a loss of thrust and by comparison of nozzle position indicators. The flamed-out afterburner nozzle will be noticeably more closed. Fuel continues to flow from the spray bars until the throttle is retarded to Military. A fuel vapor trail may be observed through the periscope. Correct the inlet, engine, or airspeed and altitude condition before attempting afterburner relight. At high Mach, the minimum airspeed necessary for afterburner operation is lower with spike scheduling than with spike forward.

Affected engine:

1. Throttle - Military.

2. Nozzle - Check proper operation.

   Retard the throttle below Military momentarily and observe ENP moves toward open.

3. Throttle - A/B midrange.

   Note fuel flow increase.

4. Nozzle position - Checked.

   Check for more-open nozzle position when A/B relights.

SINGLE-ENGINE CRUISE PERFORMANCE

DATA BASIS: FLIGHT TEST

1 - ENGINE CRUISE

Fuel Remain Lb	TDI Alt.	TDI KEAS	TDI MACH	Fuel Flow Lb/Hr	NMI K Lb	TAS Knots	Time to 5K Lb HR:MIN	Range to 5K Lb N. MI
				MAX A/B THRUST				
80 K	19.2M	362	0.80	56.9K	9.0	490	1:55	953
70	21.1	358	0.82	51.8	9.8	501	1:44	859
60	23.2	347	0.83	47.5	10.6	504	1:32	757
50	25.3	332		43.4	11.5	499	1:19	647
45	26.4	324		41.4	12.0	497	1:12	588
40	27.6	316		39.5	12.5	494	1:05	527
35	28.7	308		37.6	13.1	492	:57	463
30	29.9	300		35.7	13.7	490	:49	396
25	31.0		0.85	34.7	14.4	501	:36	311
20	31.9		0.87	33.9	15 0	510	:28	238
15	32.8		0.89	33.2	15.6	518	:18	162
10	33.5		0.90	32.3	16.2	524	:09	82
5	34.2		0.92	31.9	16.6	530	0	0
				MIN A/B THRUST				
80 K	11.5M	380	0.71	38.3K	11.8	453	2:50	1316
70	14.1	364	0.72	34.9	12.9	452	2:33	1192
60	16.9	351	0.74	32.2	14.2	457	2:15	1057
50	19.5	350	0.77	30.4	15.7	476	1:56	907
45	20.7	344	0.78	29.0	16.5	478	1:46	827
40	21.8	337		27.4	17.4	476	1:35	743
35	22.9	329		26.0	18.2	474	1:24	654
30	24.0	320		24.5	19.2	472	1:12	560
25	25.2	312		23.0	20.4	469	1:00	461
20	26.5	303		21.6	21.6	467	:46	356
15	27.7	300	0.79	20.6	22.8	471	:30	240
10	28.8		0.81	20.0	24.0	480	:15	123
5	29.8		0.83	19.5	25.0	488	0	0
				MILITARY THRUST				
60K	7.8M	359	0.62	22.3K	18.0	402	3:19	1379
50	10.9	348	0.64	20.5	20.0	410	2:51	1189
40	14.5	335	0.67	18.6	22.4	418	2:21	978
30	17.5	321	0.68	16.8	25.2	422	1:47	740
25	18.8	313		15.7	26.7	420	1:28	611
20	20.2	304		14.7	28.3	418	1:09	473
15	21.5	300	0.69	14.0	30.3	423	:45	323
10	22.9		0.71	13.4	32.3	432	:23	167
5	24.1		0.73	12.9	34.4	442	0	0

Set zero rudder trim.
Use bank & sideslip to hold course.
Restart ON. Set aft bypass for smoothness.

Figure 3-10

If relight not successful:

5. EGT - Increase trim.

For CIT above 40°C, trim toward 845°C EGT (emergency limit).

For CIT below 40°C, trim toward 865°C EGT (emergency limit). Switch the FUEL DERICH to OFF when approaching 860°C EGT.

CAUTION

Uptrim toward 865°C EGT carefully due to possibility of engine surge (compressor stall).

If relight not successful:

6. Throttle - Military.

AFTERBURNER CUTOFF FAILURE

If the afterburner does not cut off when the throttle is retarded to Military, attempt to vary the thrust by retarding the throttle below Military. The engine should be shut down if thrust cannot be modulated satisfactorily. After shutdown, the respective emergency fuel shutoff switch should be activated if the fuel flow and/or periscope observation indicates that the afterburner is dumping fuel.

AFTERBURNER NOZZLE FAILURE

Nozzle malfunctions are indicated by the exhaust nozzle position (ENP) indicator and either excessive rpm fluctuations or rpm deviation from the scheduled speed. This may be accompanied by compressor stall and exhaust gas overtemperature. Precautionary engine shut down may be necessary.

NOTE

Since nozzle failure will affect engine rpm, and rpm, in turn, affects automatic forward bypass door operation (supersonic), abnormal forward bypass door indications can result from nozzle failure.

Afterburner nozzle malfunctions may result from an exhaust nozzle control (ENC) failure, nozzle actuator failure, fuel-hydraulic pump failure, or a ruptured fuel-hydraulic line. A ruptured fuel-hydraulic line can be identified by excessively high fuel flow. It may not be possible to identify which one of the other causes of nozzle failure is responsible by using cockpit instruments. Therefore, the procedures address the nozzle position indication rather than the cause of the malfunction.

Nozzle Failed Open

A nozzle full open failure can be verified by failure of the nozzle to respond to throttle changes, and by abnormally high rpm at high power settings. If accompanied by excessively high fuel flow indications, the condition could indicate rupture of a nozzle actuator line in the engine fuel-hydraulic system. With nozzle failure, the main fuel control limits engine overspeed to approximately 350 rpm above the normal schedule; however, the actual overspeed rpm varies significantly with power setting. For example, at high altitude and maximum afterburner, the normal nozzle position is 80% to 100% open. A nozzle failure to full open results in a slight to moderate overspeed. As the throttle is retarded while in afterburner, the nozzle will normally close to approximately 60% open at minimum afterburner. A full open nozzle failure in this case would result in an overspeed approaching 350 rpm over the normal schedule. At military power, the nozzle would normally be almost closed to maintain the scheduled rpm and a full open failure would result in maximum overspeed. The accompanying EGT would be abnormally low and unresponsive to EGT trim inputs, as the fuel control will schedule fuel flow to restrict the overspeed. It is unlikely that the afterburner could be lighted while at such a high rpm and low EGT condition. At idle power, engine operation would be normal, as the nozzle would ordinarily be full open at that power setting.

Engine overspeed can be reduced while in afterburner by setting maximum thrust and downtrimming EGT. Overspeed while in non-afterburning conditions can be eliminated by throttle reduction below military.

NOTE

> If the thrust required is critical with the nozzle failed open, as during takeoff, it may be practical to retain maximum thrust - -even with engine overspeed - - until safe airspeed and altitude are attained.

NOZZLE FAILED OPEN PROCEDURE

NOTE

> If subsonic, accomplish only * items.

For high altitude cruise, affected engine:

1. Throttle - Set maximum afterburner position.

2. EGT - Downtrim to keep engine below 7250 rpm at cruise speed.

   Downtrim EGT to maintain engine speed within 200 rpm of the normal schedule. Refer to Figure 5-2.

   The main fuel control fuel flow schedule limits engine overspeed to approximately 350 rpm above the normal schedule at all power settings. Engine overspeed may be much less while at maximum afterburner and high Mach, since normal nozzle scheduling positions the nozzle nearly full open at these conditions.

   Some rpm control can be achieved at maximum afterburner by downtrimming EGT.

If rpm at cruise cannot be kept below 7300 with CIT above 300° or below 7450 with CIT below 300°:

3. Begin normal descent immediately.

   An immediate descent is not required if rpm can be controlled.

*4. Check for abnormally high fuel flow.

*5. Check visually for streaming fuel.

   Check through the periscope for a fuel trail.

If high fuel flow or streaming fuel observed:

*6. Proceed with Fuel-Hydraulic Line Leak procedure at step 3.

For descent:

7. Throttle, affected side - Match opposite engine rpm.

   EGT will be much lower than the opposite engine.

At Mach 2.5:

8. Throttles - Set 6900 rpm.

9. Throttle, affected side - Maintain at least 6100 rpm.

   Maintain engine speed above 6100 rpm, particularly while at low subsonic speeds and low altitudes, until operation of the fuel-hydraulic system is confirmed to be normal.

   Continued engine operation is permissible with a failed afterburner nozzle if maximum limits for engine rpm are observed.

   Land as soon as possible.

Below Mach 1.3, or subsonic:

*10. IGV - Check operation, if desired.

If decelerating from supersonic speeds with the IGV cambered, select IGV NORM. Check IGV light on. Slowly reduce engine speed toward 5500 rpm to extinguish the IGV light. If engine operation becomes unstable, or the IGV light remains on at 5500 rpm, increase engine speed above 6100 rpm. With IGV light off, increase engine speed toward Military to illuminate the IGV light. If the IGV fails to cycle properly, or engine instability prevented completion of the IGV operational check, fuel hydraulic pump failure is indicated.

If the IGV is inoperative or not checked:

*11. Complete the Fuel-Hydraulic System Pump Failure procedure.

For confirmed nozzle failure:

*12. Land as soon as possible.

*13. Throttle, affected side - Match opposite engine rpm.

Match opposite engine rpm for subsonic cruise, penetration, approach and landing, but keep rpm within limits.

NOTE

With a nozzle failed open and a normally operating fuel-hydraulic system, operation at any rpm within rpm limits (including idle) is permissible.

*14. Use single-engine airspeeds for approach and landing, holding 200 KIAS minimum on final approach.

Nozzle Failed Closed or Toward Closed

A nozzle failed closed or toward closed condition can be verified by failure of the nozzle to respond to throttle setting changes, and by high EGT and engine stalls if in afterburner, or near idle power. Engine operation will be normal only near military power. If the nozzle failure occurs while in afterburner, immediate rpm suppression and engine stall will result – with a very high probability of engine flameout. If engine speed is allowed to decrease below 6100 rpm, the engine will normally experience a compressor stall and may flame out. If compressor stall is encountered, immediately advance throttle to increase engine speed above 6100 rpm. If subsonic, it may be possible to clear the stall by increasing airspeed above 400 KEAS and slowly advancing the throttle. If the stall cannot be cleared, the engine should be shut down. After engine shutdown or flameout, the restart possibilities with a closed nozzle are poor.

NOZZLE FAILED CLOSED OR TOWARD CLOSED PROCEDURE

NOTE

If subsonic, accomplish only * items.

Affected engine:

*1. Throttle - Military.

Engine stall and afterburner blow-out are probable at the onset of nozzle failure if supersonic with the afterburner on. Retard the throttle to Military. RPM suppression due to a closed nozzle is minimized at Military power.

Do not attempt to light the afterburner, as an unrecoverable engine stall and flameout may result.

* 2. Derich switch - Recycle to ARM as necessary.

If the fuel derich light is on, move the fuel derich switch to REARM, then back to ARM.

* 3. EGT - Maintain within limits.

Adjust the throttle to maintain EGT within limits; however, avoid power settings below 6100 rpm as the engine may experience compressor stall or flame out.

For nozzle failure while supersonic:

4. Begin normal descent.

At Mach 2.5:

5. Throttles - set 6900 rpm.

* 6. Throttle, affected side - Maintain at least 6100 rpm.

Land as soon as possible.

* 7. Check for abnormally high fuel flow.

* 8. Check visually for streaming fuel.

Check through the periscope for a fuel trail.

If high fuel flow or streaming fuel observed:

* 9. Proceed with Fuel-Hydraulic Line Leak procedure at step 7.

If neither high fuel flow nor streaming fuel:

*10. Complete Fuel-Hydraulic System Pump Failure procedure.

NOTE

Engine considerations for a nozzle failed closed with functioning fuel-hydraulic pump are the same as for a failed fuel-hydraulic pump.

FUEL-HYDRAULIC SYSTEM MALFUNCTION

Fuel-hydraulic system malfunction usually results from engine fuel-hydraulic system pump failure or leakage from a broken fuel-hydraulic system line, connector, or actuator. If a rupture occurs, pressure at the actuators may remain high enough for near-normal operation of the nozzle, bleed, and IGV systems. Complete system failure renders the engine nozzle, compressor bleeds, and variable inlet guide vane system inoperative. The nozzle may remain stationary or it may drift full open or closed, depending on internal nozzle pressure and external air loads; however, if the fuel hydraulic pump shaft shears, the engine nozzle will move to the 60% open position via the pressure fuel servo in the exhaust nozzle control unit.

The initial indications of fuel-hydraulic system failure are similar to those for afterburner nozzle failure, i.e. a lack of nozzle response to changes in throttle position <u>and</u> either excessive rpm fluctuations or rpm deviation from the scheduled speed.

A fuel-hydraulic system leak is indicated by a sudden step increase in total fuel flow indication as much as 25,000 pph and fuel streaming from the engine (or an engine fire). Engine rpm response and nozzle function may appear normal with persistent high fuel flow indications.

For fuel-hydraulic system pump failure, fuel flow response to throttle, airspeed, and altitude will be near normal. In afterburner cruise, the nozzle will eventually move to full open. However, during subsonic cruise with the throttle below the afterburner range, the nozzle will normally remain in the failed position.

The main fuel control fuel flow schedule limits engine overspeed at all power settings to approximately 350 rpm above the normal military schedule. Engine overspeed may not be nearly this great while at maximum afterburning and high Mach, since normal nozzle scheduling is nearly full open at these conditions. Some rpm control can be achieved by downtrimming EGT while in maximum afterburner.

Inlet guide vane position does not drift with engine fuel-hydraulic system failure. The vanes maintain their settings, either axial or cambered, regardless of the existing IGV Lockout switch position, CIT, or engine rpm. If cambered, the guide vanes are held in this position by the latching feature of the IGV Lockout system. Fuel-hydraulic system pressure is required to overpower this latch,

DIAGNOSTIC FLOW CHART EXHAUST NOZZLE/FUEL HYDRAULIC FAILURES

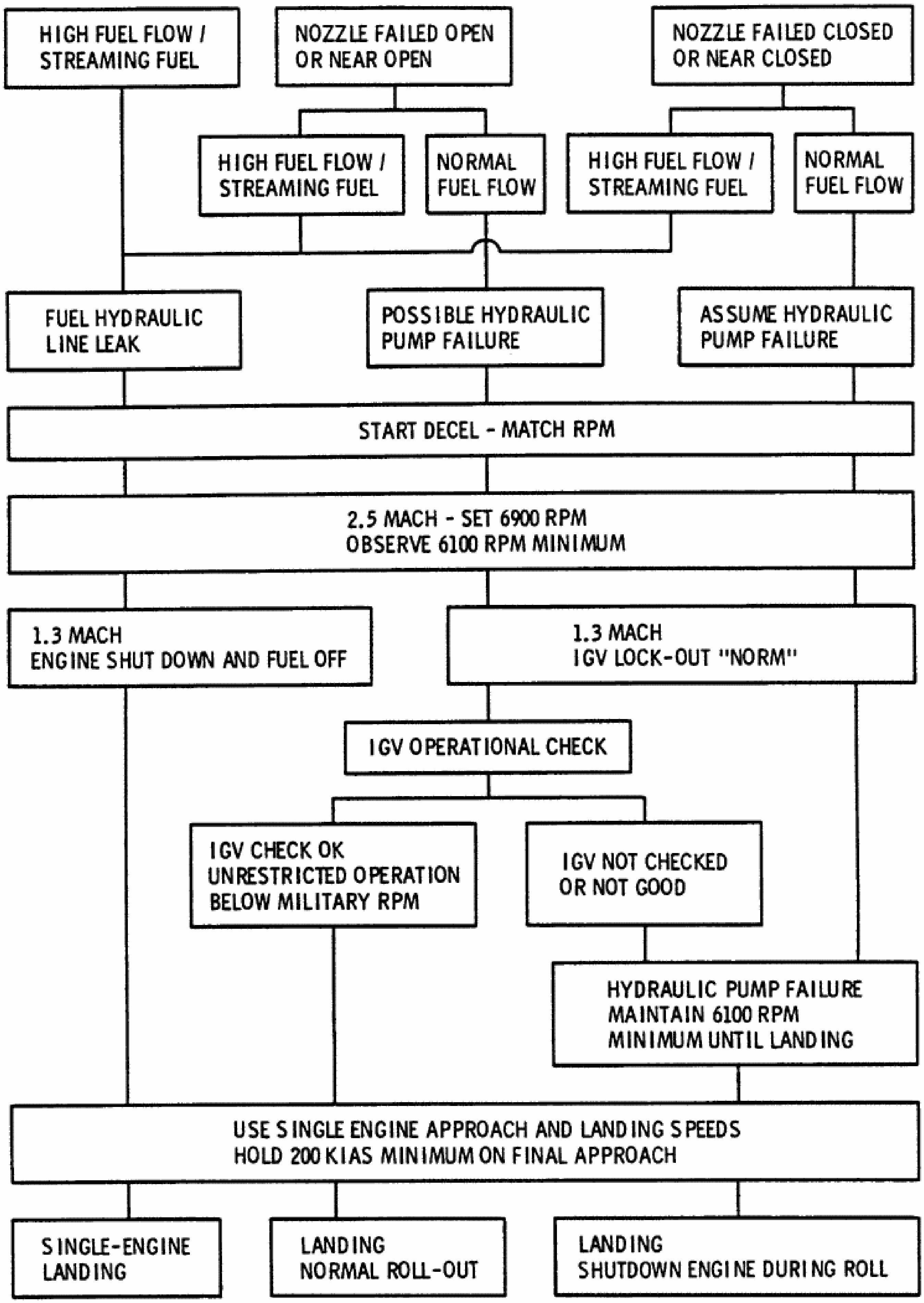


Figure 3-11

but the latch is ineffective if the IGV actuator line ruptures. If in the axial position, the IGV position light will remain on, and CIT must be maintained below CIT limits listed in Section V to avoid engine stalls and/or IGV blade flutter.

The engine internal (bypass) bleeds tend to open or remain open if engine fuel-hydraulic system failure occurs.

The external (start) bleeds are normally closed for all flight conditions (except when windmilling and, possibly, when idling at low airspeed). See Figure 1-11. They can be expected to remain closed with the fuel-hydraulic system failed. The closed condition may result in engine stall and flameout when at idle or at low rpm and airspeed, and airstart attempts after flameout for this condition would probably be unsuccessful. If the start bleeds remain closed during landing, rpm may "collapse" during the roll-out, and a damaging overtemperature will occur if the engine is not shutdown immediately.

Continued engine operation is permissible with a failed hydraulic pump if engine speed is maintained above 6100 rpm and if maximum limits for rpm and EGT and the existing IGV positions are observed; however, land as soon as possible.

FUEL-HYDRAULIC LINE LEAK

NOTE

If subsonic, accomplish only * items.

For a ruptured or leaking fuel-hydraulic line:

* 1. Check for abnormally high fuel flow.

Expect fuel flow to be 8,000 to 25,000 pounds per hour above normal with a fuel-hydraulic line rupture.

If abnormally high fuel flow indications are accompanied by open nozzle and rpm overspeed indications, a fuel-hydraulic system line rupture or leakage is confirmed. However, engine nozzle functioning can be near normal. If below Mach 1.3, shutdown the engine and activate the emergency fuel shutoff switch to isolate the fuel system of the affected engine. If at higher supersonic speeds, delay shutdown and fuel shut-off until below Mach 1.3, if practicable, to avoid engine damage.

* 2. Check visually for streaming fuel.

Check through the periscope for a fuel trail.

If a ruptured fuel-hydraulic line is confirmed:

3. Begin a normal descent.

4. Throttle, affected side - Match opposite engine rpm.

At Mach 2.5:

5. Throttles - Set 6900 rpm.

6. Throttle, affected side - Maintain at least 6100 rpm.

Below Mach 1.3:

* 7. Throttle, affected side - OFF.

* 8. Emergency fuel shutoff - Fuel off.

This switch operates the emergency fuel shutoff valve and closes the fuel heatsink crossfeed valve for that engine, isolating the nacelle from the ship's fuel supply system.

* 9. Complete Engine Shutdown and Descent procedure.

FUEL-HYDRAULIC SYSTEM PUMP FAILURE

For fuel-hydraulic system pump failure (nozzle failed, IGV inoperative, <u>no</u> excessive fuel flow or streaming fuel):

* 1. Throttle, affected side - Maintain at least 6100 rpm until landing.

Continued engine operation is permissible with a failed hydraulic pump if engine speed is maintained above 6100 rpm and if maximum limits for rpm, EGT, and CIT (for the existing IGV position) are observed.

Maintain at least 6100 rpm and minimize throttle movement. This eliminates the need for IGV and bleed shift. The engine may experience compressor stall and flameout if rpm decreases below 6100.

* 2. Land as soon as possible.

* 3. Plan for an extended enroute descent, or lower the landing gear for penetration.

* 4. Brakes & Anti-skid - Set.

a. For left engine pump failed - ALT STEER & BRAKES.

b. For right engine pump failed -ANTI-SKID ON.

(T) c. Brake switch - OFF.

* 5. Use single-engine airspeeds for approach and landing, holding 200 KIAS minimum on final approach.

The external (start) bleeds are normally closed for all flight conditions (except when windmilling and, possibly, when idling at low airspeed). See Figure 1-11. They can be expected to remain closed with the fuel-hydraulic system failed. The closed condition may result in engine stall and flameout when at idle or at low rpm and airspeed. Airstart attempts after flameout for this condition would probably be unsuccessful.

NOTE

If IGV and/or nozzle position indications are abnormal, set the throttle to military when starting if an airstart attempt is necessary. An airstart attempt may result in further engine damage. Engine stalls are likely following light-off, but it may be possible to accelerate and obtain stall-free operation at military power.

* 6. Affected engine condition - Monitor.

CAUTION

Shutdown the engine if overtemperature or flameout occurs due to engine compressor stall or rpm rollback. The EGT limit at idle rpm is 565°C.

During the landing roll:

* 7. Throttle - OFF.

Shutdown the engine as a precaution to avoid EGT overtemperature. The affected engine will probably flameout when the throttles are retarded for touchdown. If rpm "collapse" occurs without flameout during the landing roll, a damaging overtemperature will occur if the engine is not shutdown immediately. The engine EGT limit at or below idle rpm is 565°C.

Anticipate loss of the affected engine and its associated hydraulic, generator, and refrigeration systems.

* 8. Retain drag chute after landing, if practical.

After engine stops windmilling:

* 9. Emergency fuel shutoff (affected engine) - Fuel off.

Shutoff fuel to isolate the nacelle from the ship's fuel supply system. Delay fuel shutoff until after windmilling stops to avoid unnecessarily cavitating fuel lines.

ABNORMAL EGT INDICATIONS

EGT Overtemperature

EGT overtemperature may be caused by intentional or inadvertent uptrimming, failure of the main fuel control to regulate EGT, malfunction of the automatic EGT trim system, nozzle failure, or airflow transients during engine stall or inlet unstart. EGT indication over 860°C illuminates the EGT gage red warning light. If the fuel derich system is armed, the Fuel Derich light also illuminates when EGT indication exceeds 860°C. The fuel derich light remains on until the derich switch is cycled to REARM (or OFF) even if EGT returns below 860°C. A relatively small rpm and/or fuel flow increase may be observed when the fuel derich is rearmed.

Downtrimming EGT or throttle repositioning below Military will usually correct overtemperature unless the condition is caused by inlet airflow disturbances. In this case, use the appropriate compressor stall or inlet unstart procedures.

The Derich system reduces EGT by decreasing fuel flow to the affected engine(s) if 860°C is exceeded while the system is armed. The Fuel Derich system should be rearmed only <u>after</u> normal inlet or engine operation has been restored and EGT is within normal limits.

Overtemperature is usually more extreme at high altitude and/or low KEAS. EGT may become uncontrollable when near maximum altitude and Mach if the overtemperature is associated with compressor stall or unstart and if the Derich system is not sufficiently effective.

Inlet airflow is severly reduced during unstarts or compressor stalls, causing the main fuel control to operate on its minimum fixed fuel flow schedule. Consequently, manual or automatic trimming and throttle reduction to IDLE have no effect. The fuel flow reduction accomplished by the Derich System may not be sufficient to reduce EGT while at extreme altitudes. It may be necessary to shut down the engine to control EGT if there is insufficient time to clear the compressor stall or inlet unstart by increasing airflow (increasing KEAS/decreasing altitude). Refer to Engine Operating Limits, In-Flight Shutdown, Section V.

WARNING

Shutdown the affected engine for EGT:

- Above emergency EGT limit (845° C above 40°C CIT; 865°C below 40°C CIT) and below 900°C for 2 minutes.
- Between 900°C and 950°C for 15 seconds.
- Over 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

The airstart procedure can be initiated as soon as flight conditions are suitable.

Auto EGT System - Malfunctioning Permission Circuit

The Auto EGT Trim System is operative if the EXHAUST GAS TEMP switch is in AUTO and the permission circuit is off (throttle at or above the military position and Derich not actuated). The Auto EGT Trim System is disabled by a solenoid-operated interlock switch which is powered when the permission circuit is on (throttle position below military or Derich System actuated). If the permission circuit malfunctions on (energized), only manual EGT downtrim is available.

EGT Gage Malfunction

If an EGT gage malfunctions, the indication may stick, fluctuate, operate erratically, or slew to zero or to the maximum indication of 1198°C. If the indication exceeds 860°C, the gage warning light illuminates and derichment occurs if the Derich system is armed. If EGT gage malfunction is confirmed, pull the respective L or R FUEL DERICH circuit breaker to return the deriched engine to normal.

If the EGT gage temperature display malfunctions, the HOT and COLD condition flags should continue to operate normally.

The flags should not be displayed persistently. Their operation is controlled by the Auto EGT Vernier Temperature Control rather than by the gage temperature display. Occasional temporary appearance of a flag while at or above Military indicates normal automatic trim system operation. EGT may be downtrimmed manually to test that the COLD flag will appear on return to automatic trimming while at or above Military.

If only the EGT gage digital indication malfunctions, the Auto EGT system should be left on. Attempt to match nozzle positions

and to minimize sideslip if using less than military power. If the afterburners are on, attempt to match fuel flow indications and minimize sideslip. The EGT condition flags (HOT and COLD flags) will operate normally.

EGT Harness Malfunction

The automatic EGT system (vernier control of HOT and COLD flags) and the EGT gage digital indication provide separate cockpit indications of EGT. The EGT is sensed by nine temperature probes arranged concentrically about the engine, aft of the second stage turbine. The nine probes are linked together by the EGT harness. The harness combines the individual signals from the probes into a single, averaged value which is sent to the automatic EGT control system and the EGT gage digital indication.

A malfunction which causes varying resistance within the harness appears as an erratic and/or wandering EGT gage digital indication with associated HOT and COLD flag activity.

Degraded power or loss of signal from a temperature probe causes erroneously low temperature indication from that probe. This lowers the average signal to both the EGT gage digital indication and the automatic EGT system. If the automatic EGT system is operating, initial cockpit indications are low EGT gage digital reading with the COLD flag in view. As the engine uptrims, EGT and fuel flow will increase, the nozzle will move toward closed, and the turn-and-slip ball will move toward the uptrimming engine. This type of harness malfunction could be insidious and is potentially dangerous. Severe engine damage caused by EGT overtemperature is possible.

The automatic EGT system will continue to respond to an erroneous signal from the harness and will uptrim/downtrim the engine as long as the respective EGT switch is in AUTO. Discontinue automatic EGT operation, downtrim to assure that actual EGT is within operating limits, and control EGT by reference to fuel flow, nozzle position, and turn-and-slip ball position.

ABNORMAL EGT PROCEDURE

Initiate this procedure if the EGT system has malfunctioned while operating in afterburner with Auto EGT on.

Accomplish those steps necessary to assure that EGT is controllable within the normal limit (805°C above 40°C CIT) and to identify the cause of the EGT malfunction. Then, either continue the Abnormal EGT Procedure or complete the appropriate procedure for that specific malfunction (EGT Gage Malfunction, EGT Harness Malfunction, or Permission Switch Stuck On procedure).

If an abnormal EGT condition occurs while the throttle is in Military, retard the throttle and downtrim EGT. With the EGT switch in manual, cautiously readvance throttle to Military (if continued operation with the throttle at or above Military is desired) and then initiate the Abnormal EGT Procedure.

The Abnormal EGT Procedure is complete when a decision is made concerning further flight operations: continue with no in-flight restrictions, land when practical, or land as soon as possible. If EGT remained below the emergency limit (845°C above 40°C CIT; 865°C below 40°C CIT) and manual EGT trim is operative, continue unrestricted. If EGT trimmed above the emergency limit but remained below 900°C, or if the EGT harness is inoperative, land when practical. If EGT was above 900°C, land as soon as possible.

In all circumstances, if EGT exceeded the normal limits (805°C above 40°C CIT; 830°C below 40°C CIT), record peak EGT and write up the magnitude and duration of the overtemperature.

WARNING

Shutdown the affected engine for EGT:

- Above the emergency EGT limit (845°C above 40°C CIT; 865°C below 40°C CIT), and below 900°C for 2 minutes.
- Between 900°C and 950°C for 15 seconds.
- Above 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

NOTE

Where the phrase "throttles matched" appears in the Abnormal EGT Procedure, it means: move the throttles to a position which provided equal thrust (turn-and-slip ball centered with matched fuel flow indications) before the abnormal EGT condition occurred. Refer to Cruise, Optimizing Trim, Section II.

Affected engine:

1. Downtrim EGT.

   If a HOT or COLD flag was present, it should dispappear when the EGT trim switch is out of AUTO.

   Hold the EGT trim switch in DECR for at least 3 seconds and until EGT is below the normal limit (805°C above 40°C CIT). EGT indication should decrease 8°C per second when downtrimming.

   Confirm effective downtrimming by observing EGT digital indication decreasing, fuel flow decreasing, ENP moving toward open, and the turn-and-slip ball moving away from the downtrimming engine.

   CAUTION

   Downtrim EGT immediately for at least 10 seconds if the affected engine is deriched or appears to have higher EGT than the normal engine.

   This should reduce EGT approximately 80°C, about half the trim range available. The trim motor may have reached full uptrim while in Auto EGT.

   CAUTION

   Stop downtrimming if rpm decreases, as some rpm suppression can be expected if EGT is actually approaching the bottom of the trim band and the nozzle is full open.

2. If downtrim has no effect - Check EGT TRIM ac circuit breaker.

   If a HOT or COLD condition flag was present when the EGT trim switch was in AUTO, the EGT vernier was receiving power through the EGT TRIM ac circuit breaker.

   If there is no response to downtrim with the EGT TRIM ac circuit breaker in, the trim motor may be at the bottom of its trim range.

3. With throttles matched, can downtrim achieve normal or low thrust?

   To confirm low thrust, check for turn-and-slip ball away from the affected engine, lower EGT digital indication, lower fuel flow, and ENP more open. The fuel flow check may not be conclusive if the normal fuel flow was below 15,000 pounds per hour. Compare readings with the other engine. This analysis of the engines' instruments, and the cross-check of engine parameters and aircraft performance will assist in determining which system(s) and/or indicator(s) are abnormal.

   Yes: (Continue step 4)

   No: Retard throttle below Military. (Go to step 8)

   If manual EGT downtrim does not reduce thrust to normal, the EGT gage digital indication is probably accurate and runaway EGT uptrim may exist. Retard the throttle below Military until EGT is within the normal range; throttle movement in the afterburner range has no effect on EGT control.

4. Cautiously check EGT uptrim from a low-thrust condition.

WARNING

Do not attempt uptrim or return to Auto EGT unless, with throttles matched, a low thrust condition is readily apparent on the suspected engine.

With throttles matched, cautiously uptrim toward equal thrust (turn-and-slip ball toward center, but do not go beyond center). It may be necessary to tap the turn-and-slip indicator to prevent the ball sticking. Cross-check EGT gage digitial indication, fuel flow, and ENP with the other engine. Manual EGT uptrim rate is 8°C per second.

5. Is EGT uptrim effective?

Yes: Recheck EGT downtrim to a low-thrust condition. (Continue step 6)

If the trim motor was at the bottom of its trim range when downtrim was previously attempted, downtrim effectiveness can be evaluated after uptrim.

No: Complete Permission Switch Stuck On procedure.

6. Is manual EGT trim effective?

Yes: Check EGT dc circuit breaker. (Continue step 7)

Without EGT dc circuit breaker power to the Auto EGT power interlock, Auto EGT is disabled and the HOT and COLD flags will not appear (see Figure 1-8). Since dc power for the EGT permission circuit goes through the EGT circuit breaker, the permission circuit is off when the circuit breaker is open; therefore, manual EGT downtrim <u>and</u> uptrim are available (regardless of throttle position).

No: Monitor EGT and land when practical; if EGT exceeded 900°C, land as soon as possible. (Checklist complete)

If EGT does not follow trim switch operation, the trim circuit, vernier temperature control, or trim motor may have failed. Also, trim motor switching may fail in a manner which prevents travel in one direction only. In these cases, the EGT gage digital indication should still be accurate. With throttles matched, monitor EGT digital indication, fuel flow, ENP, and the turn-and-slip ball to ensure EGT remains within normal limits.

7. Does EGT digital indication appear accurate?

Yes: Use manual EGT trim and continue unrestricted. (Auto EGT trim malfunction)

If manual EGT trim is effective and the EGT gage digital indication is accurate, it is probable that the Auto EGT trim system malfunctioned and that manual control will be satisfactory. Continue unrestricted operations, using manual EGT trim, if engine response and EGT indications appear normal and if the EGT emergency limit was not exceeded.

a. If EGT trimmed above the emergency limit (845°C above 40°C CIT) but remained below 900°C, land when practical.

b. If EGT exceeded 900°C, land as soon as possible. (Checklist complete)

No: Complete EGT Gage Malfunction procedure.

If throttle is retarded below Military (from step 3):

8. Is EGT controllable below the emergency limit (845°C above 40°C CIT; 865°C below 40°C CIT)?

   Yes: Downtrim EGT for at least 10 seconds. (Continue step 9)

   Auto EGT trim and manual uptrim are disabled by the permission switch when the throttle is below Military (or when deriched). Manual downtrim should always be available if ac power is supplied.

   No: Shut down the affected engine. Complete the Engine Fire/Shutdown & Descent procedure.

WARNING

Shutdown the affected engine for EGT:

- Above the emergency EGT limit (845°C above 40°C CIT; 865°C below 40°C CIT), and below 900°C for 2 minutes.
- Between 900°C and 950°C for 15 seconds.
- Above 950°C for 3 seconds.

EGT over 950°C for more than 3 seconds or between 900°C and 950°C for more than 15 seconds results in severe turbine damage.

Lack of EGT response to throttle movement below Military indicates a fuel control failure. If throttle control cannot keep EGT within normal parameters, engine shutdown is necessary.

9. Pull appropriate EGT TRIM ac circuit breaker.

10. Cautiously check EGT in Military, if desired.

   The effectiveness of downtrimming cannot be determined while the throttle is below Military. Actual EGT downtrim can be confirmed by readvancing the throttle to Military and cross-checking performance and engine parameters.

   a. Afterburner operation is not recommended but is permitted.

   b. If downtrimming is required, the throttle must be retarded below Military and the EGT TRIM ac circuit breaker reset.

   c. Ensure the EGT TRIM ac circuit breaker is pulled before readvancing the throttle to Military.

   With runaway EGT uptrim, the EGT gage digital indication is probably accurate, but check thrust with throttles matched to be sure.

11. Land when practical; if EGT exceeded 900°C, land as soon as possible.

<u>EGT Gage Malfunction Procedure</u>

With low thrust confirmed, if the EGT digital indication is not accurate:

1. Pull and reset appropriate EGT IND ac circuit breaker.

   Pulling and resetting the EGT IND ac circuit breaker may free a sticking digital indicator.

If EGT gage is still <u>not</u> accurate:

2. Pull appropriate FUEL DERICH dc circuit breaker.

   Maximum altitude: 75,000 feet.

   Pull the FUEL DERICH dc circuit breaker for the affected engine so that false EGT digital indications above 860°C will not derich the engine. Maximum altitude with derich inoperative is 75,000 feet.

NOTE

Pulling one FUEL DERICH dc circuit breaker does not disable the Fuel Derich System for the other engine.

3. Check COLD flag response.

ABNORMAL EGT
Logic Diagram

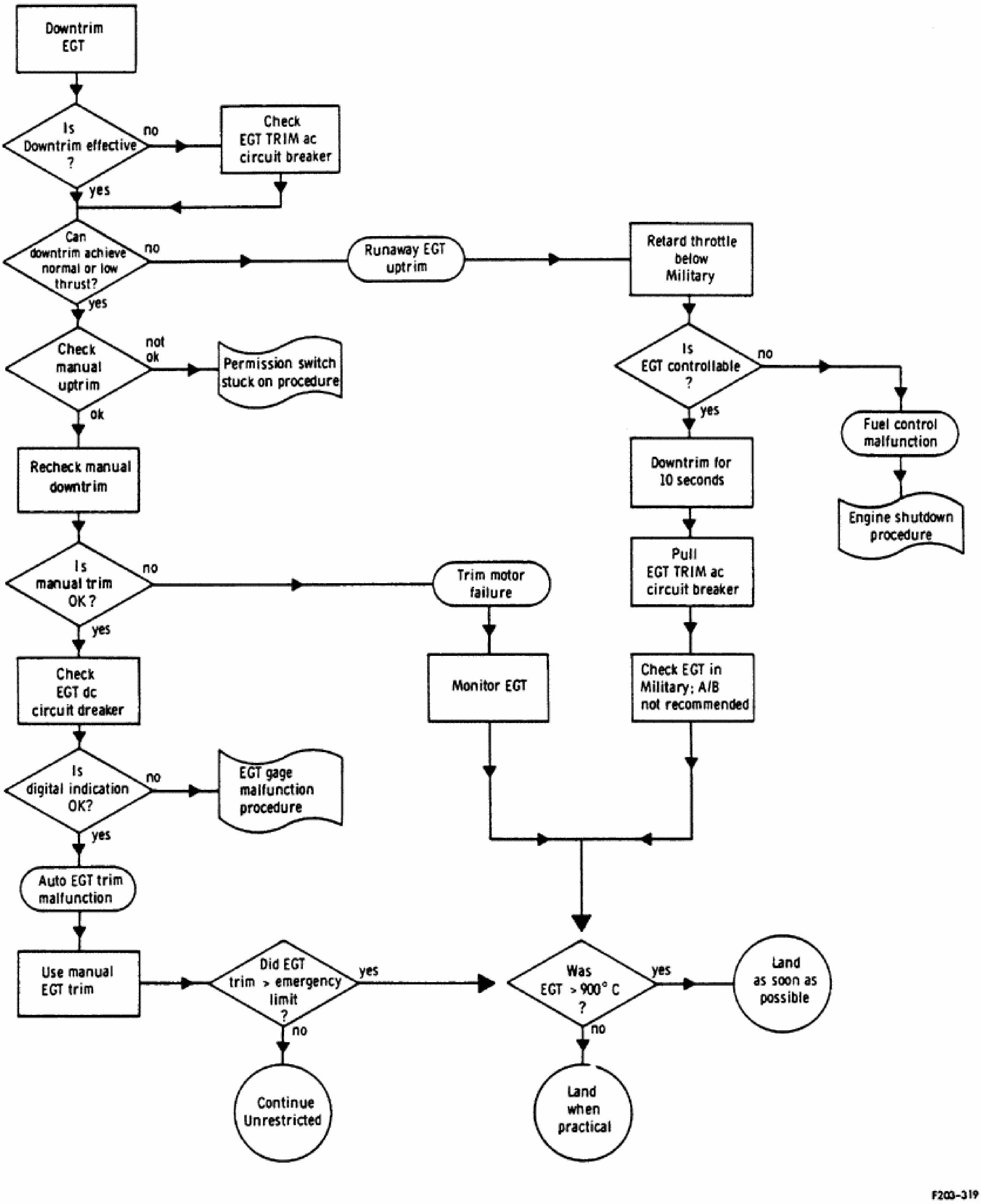
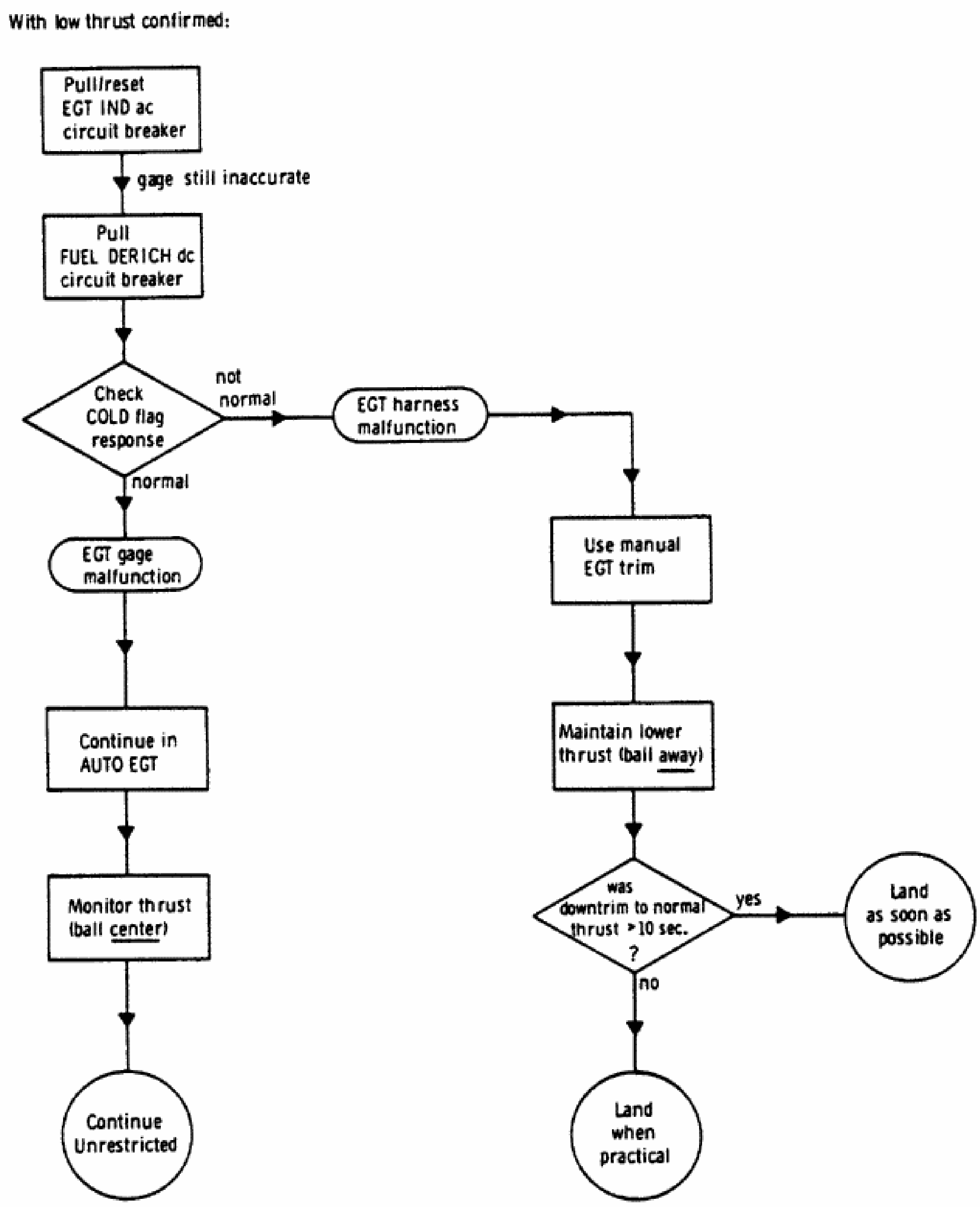


Figure 3-12 (Sheet 1 of 3)

EGT GAGE/HARNESS MALFUNCTION
Logic Diagram

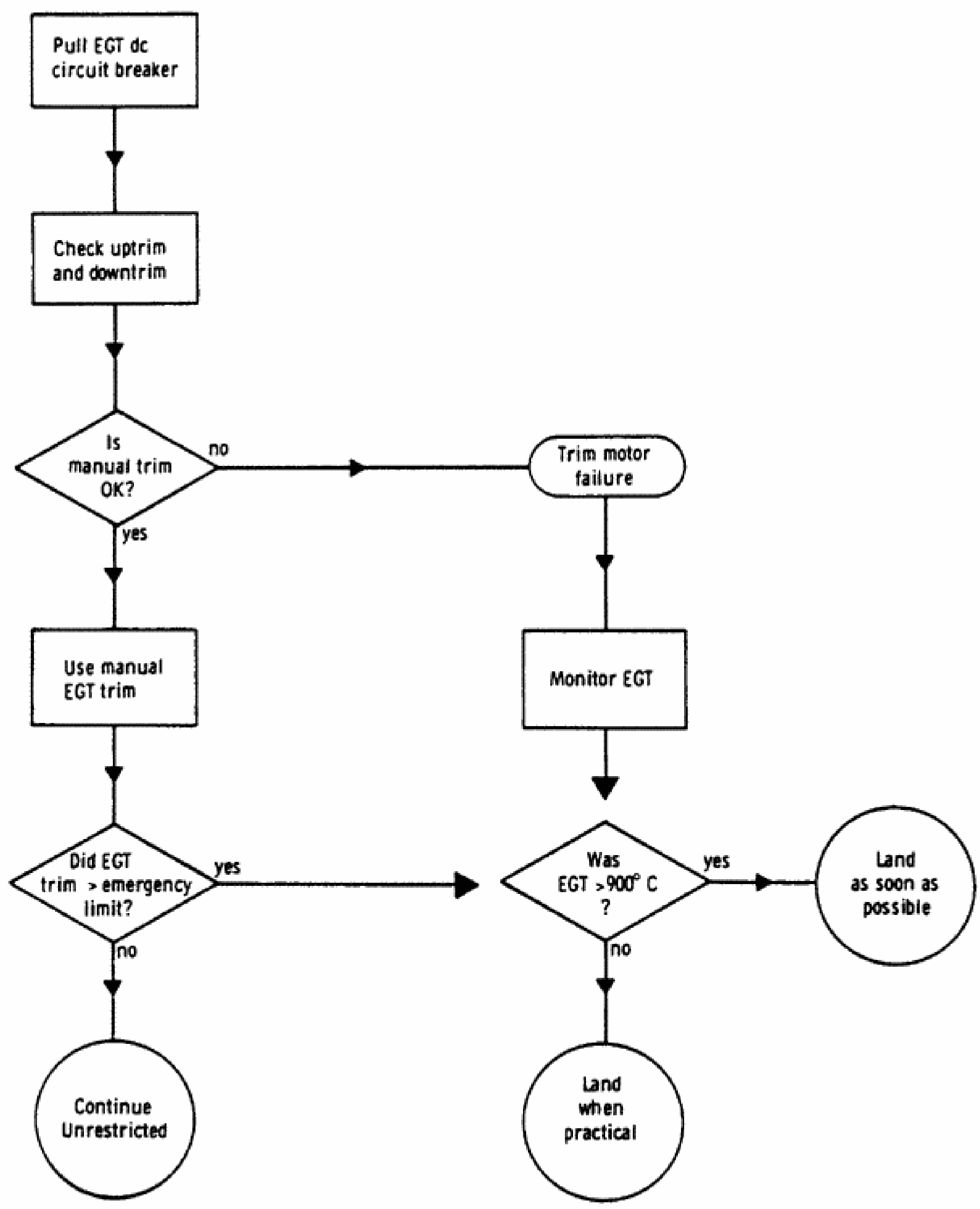


F203-320

Figure 3-12 (Sheet 2 of 3)

PERMISSION SWITCH STUCK ON
Logic Diagram

With low thrust confirmed:



F203-321

Figure 3-12 (Sheet 3 of 3)

ABNORMAL EGT INDICATIONS - Auto EGT on Initially

Indication EGT	Flag	First Actions	Typical Response	Possible Cause	Follow-up actions
Low	COLD	Trim EGT Down	Ball remains toward eng.	False EGT indication (harness malfunction)	Downtrim at least 10 sec. Land when practical or ASAP.
		Check Thrust	Ball in center No trim	Trim motor failure	Monitor EGT, land when practical.
			Ball away from engine	Auto trim malfunction	Cross-check thrust, & uptrim. If EGT appears accurate, continue in manual EGT trim.
Low or High	HOT or COLD	Trim EGT Down Check Thrust	EGT follows manual trim	Auto trim malfunction	Trim EGT in manual. Continue if engine parameters are normal.
High	HOT	Trim EGT Down	EGT follows manual trim	Auto trim malfunction	Trim EGT in manual. Continue if engine parameters are normal.
		Check Thrust	None	Runaway EGT uptrim	Set throttle below Military. Downtrim EGT & pull EGT TRIM c/b. Check in Military. A/B not recommended. Land when practical or ASAP.
				Fuel control	If EGT does not respond to throttle, shut down affected engine.
High or Low	None	Trim EGT Down	EGT follows manual trim down & up	Auto trim failed	Check EGT TRIM and EGT c/b's. Trim EGT in manual.
			EGT only follows man. downtrim	Permission switch stuck on	Pull EGT dc c/b and use manual EGT trim.
		Check EGT TRIM c/b	COLD Flag appears in AUTO but EGT doesn't follow	EGT gage digital indication has failed	Pull FUEL DERICH c/b. Use Auto EGT & monitor flags. Max altitude 75,000 ft.
		Check Thrust	No flag in AUTO, or no EGT change	Trim ckt, trim motor fuel control	Check EGT TRIM & EGT c/b's. Set throttle below Mil to control high EGT. If EGT does not respond to throttle, shut down affected engine.
With throttle below MIL: Low	Cold	Trim EGT Down	No flag in man EGT, man trim usable.	Auto EGT Permission circuit inoperative	Use manual EGT trim when increasing pwr to Mil. Do not use AUTO EGT while below Mil.

[redacted]

a. With throttles matched, confirm low-thrust condition.

b. EGT trim switch — AUTO.

c. Monitor engine parameters for normal uptrim.

With throttles matched, check for COLD flag appearance and Auto EGT uptrim. Cross-check performance and engine parameters with the other engine: the fuel flow should increase, the ENP should move toward closed, and the turn-and-slip ball should move toward the affected engine (do not go beyond center). The initial uptrim rate is 1°C per second if EGT is more than 10°C below the EGT trim deadband. The COLD flag should retract and uptrim continue at 1/3°C per second when EGT is within 10°C of the nominal deadband.

If COLD flag response is normal (fuel flow, ENP, and turn-and-slip ball indicate normal Auto EGT operation), an EGT gage digital indication malfunction is confirmed.

Discontinue check and manually downtrim EGT if fuel flow, ENP, and/or turn-and-slip ball indicate Auto EGT uptrim above normal limits.

Nonappearance of the COLD flag confirms either an Auto EGT system malfunction (harness malfunction if the EGT digital indication is also inaccurate) or an electrical supply malfunction. The COLD flag will not appear if either the EGT TRIM ac or the EGT dc circuit breaker is out.

NOTE

Auto EGT trimming (including the HOT and COLD condition flags) and the EGT digital indicator operate independently; however, they receive a common electrical signal from the EGT harness.

If COLD flag response is not normal:

4. Complete EGT Harness Malfunction Procedure.

If COLD flag response is normal:

5. Continue in Auto EGT trim.

6. Monitor engine for normal thrust by reference to fuel flow, ENP, turn-and-slip ball, and EGT condition flags.

   Monitor HOT and COLD flags (periodic appearance is normal) and with throttles matched, correlate fuel flow and ENP with the other engine; the turn-and-slip ball should remain in the center.

7. Continue unrestricted.

   With only an EGT gage digital indication malfunction, EGT should never have exceeded the normal automatic trim band.

If downtrim is required to achieve normal thrust:

8. Complete the EGT Harness Malfunction procedure.

EGT Harness Malfunction Procedure

With low thrust confirmed, if EGT digital indication is not accurate and Auto EGT trim is not normal:

1. Use manual EGT trim.

WARNING

If the EGT harness has malfunctioned, operating EGT in AUTO could result in severe engine overtemperature.

2. With throttles matched, maintain lower fuel flow, ENP more-open, turn-and-slip ball away from affected engine.

If both the EGT digital indicator and the Auto EGT system are not operating normally, the EGT harness has malfunctioned and attempting to control EGT near normal thrust is not recommended; therefore, with throttles matched, use manual EGT trim to maintain the affected engine's thrust below the thrust of the other engine (turn-and-slip ball away from the affected engine).

3. Pull appropriate FUEL DERICH dc circuit breaker.

   Maximum altitude: 75,000 feet.

   Pull the FUEL DERICH dc circuit breaker for the affected engine so that false EGT digital indications above 860°C will not derich the engine. Maximum altitude with derich inoperative is 75,000 feet.

   NOTE

   Pulling one FUEL DERICH dc circuit breaker does not disable the Fuel Derich System for the other engine.

4. Land when practical.

If total downtrim time to normal thrust was greater than 10 seconds:

5. Land as soon as possible.

   With a lower-than-actual EGT indication (low digital reading and the COLD flag in view), severe engine damage may have been sustained due to actual high EGT from automatic uptrim. The rate of manual downtrim is 8° per second. If harness failure was detected by a continuous COLD flag (continuous uptrim) and normal thrust was achieved within 10 seconds of downtrim, severe turbine damage is unlikely. If downtrim to normal thrust exceeded 10 seconds or the pilot is unsure of the duration of excessive EGT, land as soon as possible since severe engine damage may have been sustained.

Permission Switch Stuck On Procedure

With low thrust confirmed, if uptrim is not effective:

1. Pull appropriate EGT dc circuit breaker.

   If the permission switch is stuck on, the COLD flag would have been disabled when the EGT trim switch was in AUTO and uptrim (manual and Auto) is inhibited. Pulling the EGT dc circuit breaker disables the permission circuit, and manual uptrim (and downtrim) should be possible regardless of throttle position; Auto EGT is disabled since power is removed from the Auto EGT power interlock (see Figure 1-8). Manual EGT trim must be used for the remainder of the flight.

2. Check EGT uptrim and downtrim.

If manual EGT trim is effective:

3. Use manual EGT trim and continue unrestricted.

   a. If EGT trimmed above the emergency limit (845°C above 40°C CIT) but remained below 900°C, land when practical.

   b. If EGT exceeded 900°C, land as soon as possible.

If manual EGT trim is not effective:

4. Monitor EGT and land when practical; if EGT exceeded 900°C, land as soon as possible.

   If EGT does not follow trim switch operation, the trim circuit, vernier temperature control, or trim motor may have failed. Also, trim motor switching may fail in a manner which prevents travel in one direction only. In these cases, the EGT gage digital indication should still be accurate. With throttles matched, monitor EGT digital indication, fuel flow, ENP, and the turn-and-slip ball to ensure EGT remains within normal limits.

EGT GAGE COLD FLAG VISIBLE WHILE THROTTLE BELOW MILITARY POSITION (PERMISSION SWITCH OFF)

Appearance of an EGT gage COLD flag while the corresponding engine throttle is below Military indicates that its Auto EGT permission circuit is stuck off or inoperative. EGT will automatically uptrim while the throttle is below Military with this condition. EGT overtemperature is possible when the throttle is advanced to Military if the uptrim condition is not corrected.

For COLD flag indication with throttle below Military (permission switch off):

1. Downtrim EGT.

   The COLD flag should disappear.

   Downtrim for the same length of time that the COLD flag was in view. If in doubt as to the time, downtrim for at least ten seconds.

   The effectiveness of downtrimming cannot be determined while the throttle is below Military. Actual EGT downtrim can only be confirmed by advancing the throttle to Military.

2. Cautiously check EGT at Military.

   Downtrim as necessary to keep EGT within limits while advancing the throttle.

With the throttle at or above Military:

3. EGT manual downtrim and uptrim - Check.

If manual EGT trim and EGT indications are normal:

4. Use manual EGT trim.

   Unless manual trim is used, Auto EGT will uptrim the engine while operating below Military.

   When the throttle is at or above Military, Auto EGT remains usable with the permission circuit failed, although its use is not recommended. If Auto EGT is used, Auto EGT should be disengaged before operating below Military. Check EGT while advancing power from below Military.

ACCESSORY DRIVE SYSTEM (ADS) FAILURE

An accessory drive system (ADS) failure is indicated by progressive loss of the associated generator and the corresponding A and L or B and R hydraulic systems. The rpm, oil pressure, fuel flow, and nozzle position indications should also be monitored in case ADS failure is a symptom of or is followed by engine failure. The roll SAS servos will probably disengage.

Hydraulic, electrical, and environmental control system emergency procedures are incorporated in the ADS failure procedure. Steps for an immediate descent to subsonic speed are also incorporated. Do not reset the remaining roll SAS servo immediately after identifying an ADS failure. Shut down the affected engine if there is an indication of fire or for excessive vibration; otherwise, operate the affected engine as required.

With ADS failure at high speed, loss of the associated flight control and utility hydraulic system on that side can lead to difficulty in maintaining control of aircraft attitude. The affected inlet will unstart if hydraulic pressure is lost before corrective action is taken, as its forward bypass will not open when aerodynamic pressure moves the spike forward. The unstart cannot be cleared in this case until low supersonic speeds are reached. Actuation of the throttle restart switch immediately after recognizing ADS failure is of particular importance, especially if turning and if the failed ADS is on the down-wing side, even though the restart switch for the affected inlet may have been operated previously as part of the utility hydraulic system emergency procedure. Use of the throttle restart switch while reducing to minimum afterburning or military power produces a symmetrical thrust and drag configuration in the least time. This minimizes control problems and starts a deceleration. When adequate control has been established, the operative inlet may be returned to normal operation and up to maximum power may be set on both engines if it is necessary to delay further descent; however, land as soon as possible.

If both roll SAS servos are engaged initially, both will disengage immediately after loss of one primary hydraulic system if the aircraft has any appreciable rolling motion. This is due to servo logic which operates automatically when a difference in roll servo positions is detected. If there is any appreciable motion in the pitch and/or yaw axis, the corresponding SAS servo(s) for the affected side also disengages when the A or B system hydraulic pressure decreases below 1500 to 1300 psi. Refer to the SAS descriptions in Section I.

The usable roll SAS servo should not be re-engaged while banking, as roll coupling will disturb control in the pitch axis. Refer to Roll Axis Failure, this section.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

The circulating fuel pump which is driven by the malfunctioning ADS will also be inoperative. This affects items in the fuel heat sink system which are listed on Figure 1-34. Fuel flow through the primary and secondary air conditioning heat exchangers is lost. If the left ADS has failed, fuel cooling flow to the pitch and yaw SAS gyros (supplied from the left heat sink system only) is reduced. (Since gyro cooling fuel is discharged into tank 2 from the gyro cans, boost pump pressure can maintain some cooling flow.) Also refer to the Environmental Control System schematic diagram, Figure 1-80.

ACCESSORY DRIVE SYSTEM FAILURE PROCEDURE

For a combined left or right GEN OUT caution plus the corresponding A HYD and L HYD or B HYD and R HYD annunciator panel warnings or decreasing hydraulic pressure indications.

NOTE

If subsonic, accomplish only * items.

* 1. **THROTTLE RESTART ON.**

Immediately select the full aft position of the throttle restart switch. Opening the forward bypass in each inlet while hydraulic pressure remains on the affected side and starting both spikes forward in the least possible time is necessary to maintain a symmetrical inlet configuration. A symmetrical inlet configuration minimizes attitude control difficulties at high speed.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

NOTE

If the forward bypass does not open and the spike moves to its forward position while supersonic, expect unstarts, compressor stalls, and/or flameout on the affected side. Engine restart is unlikely above Mach 1.3.

Normally, the spikes are automatically locked forward while below 30,000 feet. If the affected spike is not locked <u>and</u> its forward bypass is closed, the inlet will become "choked" if the spike is sucked aft by engine airflow requirements. If this should happen at low altitude, a combination of high rpm and low airspeed might collapse the duct due to a critical differential between ambient air pressure and pressure within the duct. If the spike is aft and the forward door is closed while subsonic, use minimum required power when above 5000 feet, and IDLE below 5000 feet.

2. Airspeed - 350 KEAS.

* a. If subsonic, under 350 KEAS.

Reduce power immediately and until wings-level.

Subsonic operation and a landing as soon as possible are recommended. Operational restrictions are 350 KEAS and Mach 2.8. Use the manual inlet descent schedule while in restart.

In restart:

Set the throttle at 720°C to Military above Mach 2.5. Set 6500 rpm at Mach 2.5, and let rpm decrease. Throttle setting is optional below Mach 1.3.

NOTE

Expect roll SAS disengagement. Leaving the roll SAS OFF for turns will avoid coupling into the pitch axis.

The available roll SAS servo may be reengaged after attitude is stabilized, wings level.

3. Aft bypass - CLOSE.

Set both aft bypass controls to CLOSE. The control switch on the affected side may be ineffective unless sufficient residual hydraulic pressure remains; if so, note the bypass position. If the bypass is not closed, anticipate compressor stalls on the affected side while decelerating near Mach 2.

4. IGV switches - LOCKOUT checked.

Operation may be continued at intermediate supersonic speeds, if necessary, if an aft-bypass-closed and forward-bypass-open configuration can be obtained and the engine inlet guide vanes are maintained cambered. Sustained operation at airspeeds which result in engine internal bleed shifting should be avoided.

5. LN_2 quantity - Check.

On the affected side (steps 6, 7):

* 6. Engine instruments - Check.

Check rpm, oil pressure, fuel flow, and nozzle indications for evidence of engine failure.

Shut down the affected engine for fire or excessive vibration.

* 7. Restart switch - ON.

* 8. Throttle restart switch - OFF.

On the unaffected side, resume normal rpm and inlet schedules.

For normal side with restart off:

Set 720°C EGT to Military above Mach 2.5. Set 6900 rpm at Mach 2.5, and as required below Mach 1.3.

AUTO spike and forward bypass

Afterburner is permissible to reduce rate of descent for tactical considerations. It should be possible to maintain Mach 2.4 to 2.6 with one inlet in restart and one inlet in automatic operation with full power on both engines.

* 9. Affected SAS servos - Off.

Set the affected pitch, roll, and yaw SAS servo engage switches off.

* 10. Operational roll servo - Cycle off, then ON.

Recycle the operating roll SAS servo to regain roll damping.

* 11. Affected generator switch - OFF.

12. C.G. - forward of 22%.

Transfer fuel to maintain c.g. within subsonic limits.

* 13. Bay Air switch - OFF.

This closes the bay and nose air valves to make the maximum amount of cooling air available to the cockpits.

* (14.) Chine Bay equipment (except MRS) - OFF.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

* 15. Cockpit temperature control rheostat- COLD, if necessary.

Approximately 75% of the normal flow of cooling air to the cockpits remains available.

At Mach 2.5:

16. Throttles - Set.

Set the affected engine at 6500 rpm to conform with the manual inlet schedule. Let rpm decrease and retard the throttle if compressor stall occurs. Set 6900 rpm on the unaffected side.

At FL 600:

(T17.) IFF Mode C - Set.

(18.) DEF Systems - As required.

Below Mach 1.7:

19. Pitot heat switch - ON.

20. Exterior lights - ON.

Below Mach 1.3:

* 21. Inlets - Check.

a. Both spikes forward.

b. Affected side, forward bypass open.

c. Normal side, forward bypass closed.

22. IGV switches - NORMAL.

* 23. Throttles - As required.

Reduce rate of descent, if necessary, to avoid low fuel tank pressure below FL 400.

When c.g. is forward of 20%:

* 24. Fuel forward transfer switch -OFF.

* 25. C.G. - Maintain forward of 20%.

* 26. Crossfeed - Set.

* 27. Land as soon as possible.

350 KEAS is the maximum airspeed.

CAUTION

- Monitor spike and forward bypass positions.
- If the forward bypass remains closed and the spike is not locked forward, fly approach at single-engine approach speed with idle power on the affected inlet.

* 28. Accomplish Single-Engine Penetration and Landing Procedure, except use normal approach speed.

Loss of Liquid Nitrogen Supply

Loss of LN_2 supply to the ADS does not affect ADS operation during flight, as contamination of the ADS by oxygen does not occur until the ADS is completely cooled. However, loss of LN_2 must be reported following flight.

OIL PRESSURE ABNORMAL

Refer to Oil Pressure limits, Section V. Although not desirable, operation may be continued with oil pressure above the normal pressure range. Operation may also be continued with oil pressure in the 35 to 40 psi range; however, engine operation should be monitored for indications of failure, which include engine roughness or rapidly increasing vibration. Oil pressure below 35 psi is unsafe and requires that a landing be made as soon as possible using the minimum thrust required to sustain flight. The engine may have to be shut down.

OIL QUANTITY LOW

Cross-check oil pressure indication when low oil quantity is indicated by illumination of either L or R OIL QTY warning light.

Disregard intermittent illumination of the L or R OIL QTY warning light if accompanied by normal oil pressure. Flickering of the light may occur, particularly during climb, if foaming or out-gassing of the engine oil reduces relative bouyancy of the tank float, resulting in a false indication of fluid surface.

If a L or R OIL QTY warning light illuminates continuously, or if intermittent illumination is accompanied by low or fluctuating oil pressure indication for the corresponding engine:

1. Begin normal descent.
2. Oil pressure - Monitor.
3. Land as soon as possible.

NOTE

Monitor engine operation for oil pressure fluctuations, high temperature, vibration, or other indications of imminent engine failure. Be prepared to shutdown the engine.

Oil Temperature Abnormal

The L and R OIL TEMP annunciator lights are not functional. The OIL TEMP light only illuminates when the IND & LT TEST button is depressed.

FUEL CONTROL FAILURE

If a fuel control malfunction is suspected:

1. Minimize throttle movements.
2. Monitor RPM and EGT.

If unable to keep RPM and EGT within limits:

3. Complete Engine Shutdown and Descent procedure.

ENGINE INSTABILITY DURING SUPERSONIC DESCENT

Hot fuel (greater than 300°F) may cause engine instability during the first few minutes of the descent when using the normal descent procedure. RPM, ENP, and EGT fluctuations may occur shortly after A/B cutoff. These fluctuations can result in an inlet unstart, derichment, and possibly flame-out on the affected engine. With derichment, the nozzle will fully open and the RPM and EGT fluctuations will be reduced or eliminated. Recycling the derich switch will restore nozzle scheduling and another unstart, derichment, and flameout may result.

To reduce engine instability, retard the throttle on the affected engine until the nozzle is fully open, when RPM, ENP, and EGT fluctuations are recognized. Some intermittent engine roughness may be encountered which requires no corrective action. With automatic inlet scheduling, maintain RPM above 6500 to avoid inlet unstart. Normal descent procedures can be reestablished at Mach 2.5.

If RPM, ENP, and EGT fluctuations occur after A/B cutoff:

1. Crossfeed - OPEN.
2. Throttle, affected engine - Retard toward 6500 rpm. Maintain 6500 rpm minimum.

   Retard throttle until the nozzle is fully open but not below 6500 rpm.

3. ENP, affected engine - Checked 100% open.

At Mach 2.5:

4. Resume normal Descent procedure.

If compressor stalls develop:

5. Complete Compressor Stall in Descent procedure.

AIRCRAFT SYSTEM EMERGENCIES

FUEL SYSTEM

Automatic operation of the fuel system provides center of gravity and trim drag control in addition to furnishing fuel to the engines. Fuel is also used to cool cockpit air, engine and accessory drive system oil, hydraulic fluid, and the SAS gyros. Abnormal operating conditions or emergencies affecting fuel system operation (such as generator failure) may affect c.g. control and operation of the fuel-cooled systems in addition to engine operation.

Fuel System Manual Operation

Manual control of the fuel system is accomplished through: the fuel panel crossfeed, tank pump and, pump release switches; the forward and aft transfer switches; and the essential dc bus circuit breakers for the automatic aft transfer and ullage systems. Manual control, manual pump selection, crossfeed, and/or fuel transfer is necessary for low fuel pressure, abnormal c.g. condition or c.g. trend, incorrect boost pump sequencing, single engine operation, or if using the emergency mode of the generators.

NOTE

> Manual operation supplements, but does not terminate, automatic fuel sequencing.

Crossfeed During Forward Transfer

Forward transfer is less efficient with XFEED OPEN when fuel remains in tanks 5 or 6. During cruise, most of the fuel transferred would come from the operating tank(s) of group 2, 3 or 4 because of the aircraft nose-up attitude and the lower fuel pressure head that these forward tank pumps would have to overcome. Only a small forward c.g. shift would result.

FUEL QUANTITY LOW CAUTION

Illumination of the FUEL QTY LOW caution light indicates that fuel is below the low-level float switches in both tanks 1 and 4. At 6.2 degrees pitch angle, the caution light indicates less than 5400 pounds in tank 1 and less than 4050 pounds in tank 4. As the caution may indicate premature depletion of tanks 1 and 4 with ample fuel remaining in other tanks, confirm remaining total fuel from individual tank quantity indications. (TOTAL and individual tank quantity indications are affected to some degree by pitch attitude and accelerations.) If the quantity in either tank 1 or 4 is above the low-level float switch, the caution light can be extinguished by cycling the air refuel switch to AIR REFUEL and OFF. Proceed as described under Fuel Sequencing Incorrect if tanks 1 and 4 deplete prematurely.

Fuel Quantity Low Condition

Confirm crossfeed open. Monitor total fuel quantity and land with at least 5000 pounds if possible. If immediate landing is not possible and a tanker aircraft is available, accomplish air refueling with any JP-type fuel. Subsequent operation, should be restricted below Mach 1.5 if refueled with other than standard JP-7 fuel. Flight operations may be continued with a FUEL QTY LOW caution light if the total fuel remaining will allow air refueling or landing with an adequate fuel reserve.

FUEL PRESSURE LOW WARNING

If one or both FUEL PRESS warning lights illuminate:

1. **X-FEED OPEN.**

   Press the crossfeed control switch to illuminate XFEED. The OPEN portion of the switch illuminates when the crossfeed valve is fully open.

2. **PRESS TANK 4 ON.**

   Fuel pressure should be restored with crossfeed and tank 4 on. Analyze the difficulty and attempt to resume sequencing. The warning could be caused by dumping fuel or selecting forward or aft manual fuel transfer at high power without selecting an extra boost pump.

3. Check tank quantities, proper sequencing, FWD TRANSFER OFF and no streaming fuel.

   The L or R FUEL PRESS warning light may illuminate due to: a weak or inoperative fuel boost pump in a tank supplying fuel to an engine; a fuel manifold or fuel-hydraulic system leak; the use of afterburner at low altitude without additional boost pumps selected; the use of forward transfer when in afterburner without additional boost pumps selected; or fuel dumping when engine fuel demands are high. If appropriate, complete the Fuel Sequencing Incorrect procedure or the Fuel-Hydraulic Line Leak procedure.

To restore automatic sequencing:

4. Pump release - Press.

5. Crossfeed - Press closed.

If pressure cannot be restored:

6. Land as soon as possible.

FUEL TANK PRESSURIZATION FAILURE

Fuel tank pressurization failure is indicated by the tank pressure gage and illumination of the TANK PRESS annunciator panel warning light. Liquid nitrogen quantity gages should indicate empty if the TANK PRESS warning light illuminates. Impending tank pressurization failure may be indicated by illumination of both the SYS 1 and SYS 2 N QTY LOW caution lights.

NOTE

Do not continue flight above Mach 2.6 without nitrogen inerting of the fuel system.

No corrective action is possible after all liquid nitrogen systems deplete, except to limit maximum speed to Mach 2.6 and to reduce rates of descent to minimize the difference between fuel tank and ambient pressures. In descent, the fuel tank suction relief valve in the nosewheel well opens when slightly negative tank pressures occur. Limit rate of descent so that tank pressure does not become less than -0.5 psi to maintain normal maneuvering capability and structural safety factor.

Air refueling and normal climb may be accomplished without nitrogen inerting of the fuel system. In climbs, the fuel tank vent relieves internal pressure when the tank-to-ambient differential pressure reaches 3.0 to 3.5 psi. Mach 2.6 must not be exceeded.

WARNING

Limit tank pressures are -0.5 and +5.0 psi. The limits are based on structural capabilities of the fuselage tanks with design limit load factors.

1. Cruise at or below Mach 2.6.

To descend with fuel tank pressurization failure:

2. Descend within tank pressure limit (-0.5 psi).

   Adjust rate of descent as required.

After cruise over Mach 2.6 (steps 3 - 9):

3. Adjust descent to allow subsonic cruise between FL 400 and FL 350 for 10 minutes, if possible.

   An early on-course descent to allow a 100 mile subsonic cruise between FL 400 and FL 350 uses about 1400 pounds more fuel than supersonic cruise, descent, and no subsonic cruise.

At Mach 1.3:

4. Inlet controls - Checked.

5. IGV switches - NORMAL.

6. Maintain c.g. forward of 22% for subsonic loiter.

7. Below FL 400, maintain altitude and slow to 275 KEAS (250 KEAS Min).

   Do not slow to subsonic flight until c.g. is forward of 22%.

   During descent from flight above Mach 2.6 with fuel tank pressurization failure, 250 KEAS minimum airspeed is permissible below FL 400.

8. Throttles - Military.

9. Loiter subsonic at 275 KEAS between FL 400 to FL 350 for 10 minutes, if possible. Descend from FL 400 to FL 350 as slowly as practical.

WARNING

After flight above Mach 2.6 with fuel tank pressurization failure, remain subsonic above FL 350 for 10 minutes to cool tank structure and prevent autogenous ignition of fuel vapor and vent air.

For supersonic flight after refueling:

10. Do not exceed Mach 2.6.

For penetration (steps 11 & 12):

11. Maintain tank pressure above -0.5 psi. Plan slowest descent at low altitude where pressure gradient is highest. Descend at about 1500 fpm at low altitude.

    Figure A1-9 shows that the atmospheric pressure gradient is about .05 psi/1000 ft at FL 600, .25 psi/1000 ft at FL 240 and .50 psi/1000 ft near sea level.

12. Landing gear - Down, if desired.

NOTE

- o Cooling will be accelerated and pressure may be relieved faster when subsonic if the nose gear is extended.
- o If the suction relief valve has stuck and a tanker is available, it may be possible to relieve negative pressure by insertion of the tanker IFR probe into the air refueling receptacle.

FUEL SYSTEM MANAGEMENT WITH ENGINE SHUTDOWN

Although automatic fuel sequencing continues during single-engine operation, manual control of the fuel system is necessary. With the right engine operating, the crossfeed valve should be opened as soon as tanks 5 and 6 are empty. Forward transfer as necessary to obtain a c.g. for subsonic operation. If the right engine has failed, tanks 5 and 6 may be emptied by successive forward transfer, leaving the crossfeed valve closed. This maintains c.g. properly and makes the maximum quantity of fuel available to the operating engine in case of subsequent loss of ac power.

NOTE

When operating on battery power, fuel transfer capability is lost and the crossfeed valve position cannot be changed. An aft c.g. condition can be expected as forward fuel is consumed unless tanks 5 and 6 are empty.

Fuel cooling will continue automatically and there will be an indication of fuel flow to the inoperative engine, if it is windmilling, unless its emergency fuel shutoff switch is actuated. This heat sink system fuel is either supplied automatically to the opposite engine's mixing valve, if the crossfeed and fuel shut off valves are open, or returned to tank 4.

FUEL SEQUENCING INCORRECT

Incorrect automatic fuel sequencing is indicated primarily by the fuel boost pump lights. (A light may illuminate out of normal sequence, or fail to illuminate on schedule.) In this event, control the boost pumps manually until correct automatic sequencing resumes. Faulty fuel sequencing may cause a fuel EMPTY light to illuminate prematurely, or cause an abnormal pitch trim requirement (due to c.g. change by faulty fuel distribution). Forward c.g. requires increased power to maintain speed and altitude due to trim drag. If normal sequencing does not resume and manual sequencing is not practical, press XFEED OPEN (and transfer fuel as necessary) so that any available fuel feeds the engines.

CAUTION

Do not permit a manually selected fuel boost pump to continue running in an empty fuel tank. The boost pump will be damaged.

NOTE

Crossfeed OPEN may be required to provide fuel to both engines during fuel sequence malfunctions.

PARTIAL LOSS OF BOOST PUMPS

Partial loss of boost pumps may result from individual pump failure, sequencing failure, or loss of ac power at the generator bus. Partial boost pump failure may not be indicated by the fuel pressure low (L or R FUEL PRESS) warning lights unless the condition is associated with some other system emergency (such as generator failure with bus tie split).

NOTE

- o Loss of pump 5-1 and either pump in tank 6 may trap fuel in tank 6A when fuel dump and/or forward transfer are on.

- o Loss of pump 1-3 will temporarily trap approximately 2500 lbs of fuel in tank 1 while supersonic. When tank 4 has 3600 lb remaining, pump 1-4 is started. Manual selection of tank 1 pumps to obtain feed from pump 1-4 is not recommended since forward pumps 1-1 and 1-2 would be operating dry. Continuation of cruise with automatic sequencing could result in c.g. of 22% at end of cruise. Early selection of tank 2 plus use of manual aft transfer results in near-normal c.g. position in supersonic cruise.

Incorrect fuel sequencing and center of gravity shift may be the first indication. Proceed as directed for Fuel Sequencing Incorrect.

COMPLETE LOSS OF BOOST PUMPS

Use this procedure if both generators will not operate in NORM or EMER.

Loss of all boost pumps can only result from multiple failures such as loss of both generators. The condition is indicated by illumination of the L and R FUEL PRESS warning lights, probably in conjunction with the L and R GEN OUT caution lights. If this occurs during takeoff, ground test shows that fuel tank pressurization will supply sufficient fuel to the engine-driven pumps to maintain engine and afterburner operation if all tanks are nearly full. Abort the takeoff if speed and runway length permit; otherwise, continue takeoff and land as soon as possible.

WARNING

Fuel cannot be dumped with complete boost pump failure. Observe operating limits of Section V if a heavy weight landing is required.

Maintain a higher power setting on the right engine than the left engine to minimize aft c.g. shift as fuel is used.

Fuel Management Prior to Complete Pump Failure

When there is a possibility of complete pump failure; e.g., after loss of one generator, make successive forward transfers to obtain and maintain a c.g. of at least 22% (17% is preferable) until tanks 5 and 6 are empty. Crossfeed should remain closed until tanks 5 and 6 are empty, then press XFEED OPEN to minimize tank 4 usage.

Subsonic Cruise Capability Without Boost Pumps

The cruise capability remaining with boost pumps inoperative depends on fuel quantity remaining in tanks 1, 2, 4, and 5 prior to complete failure. Tanks 3 and 6 should not be expected to feed. Fuel can flow from tanks 1, 2, 4, and 5 as long as individual quantities remain above the minimums described below.

The engines can draw fuel from tanks 2 and 4 with all other tanks empty if low power settings are used and a level or nose-up attitude is maintained. Since multiple failures are involved in loss of all boost pumps, it should be possible to transfer fuel prior to loss of all pumps and to continue operation of both engines for a "reasonable" time without pumps, using subsonic loiter power, speed and altitude schedules. The time available depends on location and quantity of usable fuel and the c.g. developed as the fuel is used. Full scale mock-up simulations indicate the following unusable quantities when operating at loiter speeds without boost pumps. (Values are approximate.)

Tank 1	2300 lb.
Tank 2	3400 lb.
Tank 4	1200 lb.
Tank 5	1900 lb.

Tank 4 quantity is critical. Both engines will probably be lost when the unusable quantity is reached in this tank, regardless of crossfeed position or quantities remaining in other tanks. The minimum value may be higher with XFEED OPEN. With crossfeed closed, the left engine will probably flameout when tank 2 reaches 3400 to 2800 pounds unless tank 4 reaches 1200 pounds remaining first.

NOTE

- Fuel quantity indications are inoperative without ac power. Quantities remaining must be estimated.
- Except where specifically noted otherwise, fuel system operating characteristics with boost pumps off are based on ground tests with a full scale mock-up of the fuel system. The tests simulated engine flow requirements, expected tank environments, pitch attitudes, and stable flight conditions. Fuel sloshing due to aircraft motion was not simulated.

A gradual aft c.g. shift toward 22% can be expected, using symmetrical power settings, if tank 6 is emptied and a c.g. of approximately 17% attained prior to loss of pumps. If near 25% c.g. it will be necessary to advance right engine power to Military to maintain that c.g.; with symmetrical power settings, the c.g. will travel aft rapidly and the aircraft may become uncontrollable.

Without generator or battery power, the inlet spikes remain locked forward.

WARNING

If the boost pumps are inoperative, there is no assurance of continued engine operation if one or more fuel tanks are empty. If one of the tanks serving an engine is empty, engine flameout can occur at any time if flight attitude, engine flow requirements, and/or fuel level in the associated tank(s) is such that the remaining head of fuel in the supply tank(s) cannot keep that manifold clear of fuel vapor or nitrogen gas.

Supersonic Descent

Use normal descent speed and Military power to minimize the rate of descent and maintain a positive deck angle. If the inlets are in restart, use the manual inlet descent procedure. At some point, probably below 60,000 feet, the engines will be receiving insufficient fuel flow to maintain full power. The engines may surge. If this occurs, reduce the throttle setting to eliminate "chugging".

Subsonic Cruise

Loiter speed and altitude schedules are recommended to minimize engine fuel flow requirements. The optimum loiter altitude is approximately 7000 feet below the altitude for long range cruise; Mach 0.75 to 0.80 is suggested.

Landing Approach

A straight-in landing approach without abrupt nose-over should be started approximately 20 minutes prior to intended landing, using approximately 250 KIAS to maintain a level or nose-up deck angle. The probability of engine failure during approach is increased if rpm is advanced during approach.

WARNING

Bailout if a complete flameout occurs. Do not attempt a dead-stick landing.

ELECTRICAL SYSTEM

Either generator is capable of supplying all electrical system power requirements.

SINGLE GENERATOR FAILURE

Illumination of an L or R GEN OUT caution light indicates that the respective generator has been disconnected. The GEN BUS TIE OPEN light may illuminate also. This procedure allows for either situation. A combined generator out and bus-tie open condition is confirmed by illumination of the corresponding XFMR RECT OUT caution light.

NOTE

> If a split-bus condition is <u>not</u> indicated, do not press the BUS TIE switch; this would split the left and right generator buses for the remainder of the flight.

With an L or R GEN OUT caution light illuminated (alone or with the GEN BUS TIE OPEN light on):

1. Affected generator switch - OFF, then NORM.

   If the fault was momentary, the generator will be reconnected to the system, and the caution light will extinguish.

NOTE

> Monitor hydraulic system warning lights and pressure instruments for indication of ADS failure.

A generator reset is required after an engine is windmilled at subsonic speed and restarted if the generator disconnected automatically.

WARNING

> Do not recycle the generator switch more than twice during an attempt to reset an automatically disengaged generator. If a fault in the generator feeder system exists, multiple cycling of its generator switch could cause repeated momentary short circuits each time while the protective system is operating to disconnect the generator.

NOTE

> It may be possible to accomplish generator reset after attaining subsonic temperatures.

If the L or R GEN OUT light remains on after 1 minute (steps 2 and 3):

2. If the GEN BUS TIE OPEN light is also illuminated - Depress BUS TIE switch momentarily.

   The bus tie will close if the fault is not in a generator ac bus and the generator switch of the affected generator is in NORM.

   The GEN BUS TIE OPEN and L or R XFMR RECT OUT caution lights may extinguish. With the GEN BUS TIE OPEN caution light extinguished, all ac and dc systems are powered by the operating generator.

   If the GEN BUS TIE OPEN light remains illuminated with L or R GEN OUT light on, the essential ac bus is powered by the operating generator regardless of whether the inoperative generator can then be reset or not. Refer to GEN BUS TIE OPEN Light On, this section.

   If the inoperative generator is reset later and either generator subsequently fails, the essential ac bus will be powered automatically by the operating generator.

3. Affected generator switch - OFF.

With one generator inoperative:

4. Speed - Subsonic recommended. Operational restrictions are Mach 2.8 and 350 KEAS while supersonic.

NOTE

All flight control trim systems will be inoperative if the remaining generator fails unless power is available from the EMER function of a generator to power pitch and yaw trim through the ac hot bus.

5. C.G. - forward of 22%.

Transfer fuel to maintain c.g. within subsonic limit.

When subsonic:

6. Affected generator - Attempt to reset.

If the L or R GEN OUT Light remains on after 1 minute:

7. C.G. - Maintain forward of 20%.

8. Land as soon as possible.

If both generators reset in NORM, land when practical.

DOUBLE GENERATOR FAILURE

If both generators disengage automatically (L and R GEN OUT and L and R XFMR RECT OUT caution lights illuminated), the essential dc busses and the emergency ac bus are powered by the battery. Attempt to provide ac power to the boost pumps and the ac hot bus by placing both generator switches in EMER. If a generator in EMER is turning at sufficient speed and its windings are intact, the ac hot bus and half the fuel boost pumps are energized with power of unregulated frequency and voltage and the corresponding L or R GEN OUT light extinguishes. If both generators are operating in EMER, all fuel boost pumps are energized with unregulated power. The GEN BUS TIE OPEN light illuminates if either generator switch is in EMER.

If a generator is operating in EMER (corresponding L or R GEN OUT caution light extinguished) and there is sufficient voltage, the transformer-rectifier on that generator bus will power the essential dc buses (corresponding L or R XFMR RECT OUT caution light extinguished and EMER BAT ON caution light extinguished); otherwise, dc buses will be powered by the batteries (L and R XFMR RECT OUT caution lights both illuminated and EMER BAT ON caution light illuminated). The dc monitored bus is locked-out in either case, by loss of transformer-rectifier power or by placing a generator switch in EMER.

When regulated ac power cannot be obtained from the generators, the emergency ac bus is powered from the No. 1 essential dc bus through the instrument inverter (whether the No. 1 essential bus is powered by the No. 1 battery or an operating transformer-rectifier). The emergency ac bus never receives power directly from a generator in EMER (see Figure 1-45). The instrument inverter should automatically start if either generator is not operating in NORM and should automatically power the emergency ac bus (INSTR INVERTER ON caution light illuminated) if neither generator is operating in NORM. If the emergency ac bus does not receive power, place the emergency ac bus switch to EMER AC BUS (up) and check that the INSTR INVERTER ON caution light illuminates.

The batteries will last approximately 40 minutes with reduced usage. Battery power is in use when the EMER BAT ON and the L and R XFMR RECT OUT caution lights illuminate. Systems not essential for flight or not usable on battery power alone should be turned off to minimize battery drain (see Figure 1-43).

The essential ac bus is never powered with double generator failure, even with generator(s) operating in EMER.

Fuel System Remaining Capability

Boost pumps are powered by the left and right generator busses. If neither generator will operate in NORM or EMER, the fuel boost pumps will be inoperative. The ac hot bus, including the fuel quantity indicators and c.g. indicators, will also be inoperative. Refer to Complete Loss of Boost Pumps, this section.

If only one generator is operating in EMER (corresponding L or R GEN OUT caution light extinguished) half the fuel boost pumps are energized.

When the generators are operating in EMER, the boost pumps must be manually selected.

WARNING

With double engine flameout, if both generators trip off, perform the Double Generator Failure boldface procedures to regain boost pump pressure before attempting airstart.

Flight Control System Capability Remaining

With at least one generator operating in EMER (corresponding L or R GEN OUT caution light extinguished), ac hot bus power is available to the pitch and yaw trim motors. The pitch trim indicator, powered by the emergency ac bus, should be operative. The yaw trim indicator, powered by the essential ac bus, is inoperative.

DOUBLE GENERATOR FAILURE PROCEDURE

Failure or disengagement of both generators is indicated by illumination of both L and R GEN OUT caution lights. In addition, some or all of the following lights may be expected to form a massive display on the annunciator panel:

L/R FUEL PRESS	INSTR INVERTER ON
L/R XFMR RECT OUT	AUTO PILOT OFF
GEN BUS TIE OPEN	ANS REF
EMER BAT ON	

The A and L, or B and R HYD lights will also illuminate if a generator disengagement is due to ADS failure.

With both L and R GEN OUT lights on:

▲1. **ATTITUDE REFERENCE INS.**

Select the INS to maintain a primary attitude reference.

The ANS reference platform is inoperative without both essential ac and dc power. The pilot's ANS REF and the RSO's ANS FAIL caution lights illuminate. The pilot's INS REF caution light should remain off.

NOTE

The INS will continue to operate normally as long as emergency ac bus power is available.

PVD operation should resume when the ATT REF SELECT switch is in INS.

The standby attitude indicator remains operative. If power to the standby attitude indicator is lost (emergency ac power for the 2 inch standby attitude indicator; essential dc power for the 3 inch standby attitude indicator), the standby attitude indicator will continue to display usable pitch and roll information for at least nine minutes.

2. **BOTH GENS EMER.**

   Set both generator switches to EMER and check the annunciator panel lights.

   With double generator failure, placing both generator switches in EMER offers the best chance of restoring power to boost pumps and to the ac hot bus.

   Check both L and R GEN OUT caution lights. If at least one generator resets, fuel manifold pressure can be restored to both engines by manually selecting Tank 4. The pilot's and RSO's fuel quantity and c.g. instruments and manual pitch and yaw trim will be available with ac hot bus power.

   Check the L and R XFMR RECT OUT and EMER BAT ON caution lights. A generator operating in EMER may provide sufficient voltage to operate its transformer-rectifier and supply the essential dc bus. The corresponding L or R XFMR RECT OUT light and the EMER BAT ON light will extinguish in this case. Monitor the dc loads as necessary.

3. **PRESS TANK 4 ON**

   Manually selecting Tank 4 should restore fuel manifold pressure to both engines.

   Check both L and R FUEL PRESS lights extinguish. Manually select fuel boost pumps and/or XFEED OPEN as required to maintain fuel pressure in both manifolds.

The emergency ac bus should remain on, powered by the instrument inverter.

If the emergency ac bus is not powered, the A, B, and M CMPTR OUT lights illuminate immediately and the INS REF light illuminates 10 seconds later. (Without emergency ac bus power, the INS remains operational for 10 seconds, powered by its self-contained battery.)

The INSTR INVERTER ON light should remain on, as the emergency ac bus never receives ac power directly from a generator(s) in EMER.

4. If the INSTR INVERTER ON light is <u>not</u> illuminated, emergency ac bus switch - EMER AC BUS (up).

   If the instrument inverter did not energize automatically, positioning the emergency ac bus switch to EMER AC BUS (up), energizes the inverter <u>and</u> mechanically latches the emergency ac bus to the instrument inverter.

5. DAFICS Computers and SAS - Check.

   If emergency ac power is interrupted, DAFICS computers and SAS should automatically reset when power is restored to the emergency ac bus. If necessary, reset DAFICS computers and SAS sensors/servos. If all SAS is lost near maximum Mach, pitch axis stability may be marginal and there is little damping of yaw oscillations. Refer to DAFICS Computer Failures and Stability Augmentation System, this section.

If either generator resets with EMER selected:

6. Boost pumps, and crossfeed - Control manually.

   Do not deplete tank 4 prematurely.

   The automatic fuel sequencing system is inoperative. Use manual control to schedule the boost pumps, and forward and aft transfer to adjust c.g.

   Only one tank of tank group 1, 2, 3 and one tank of tank group 4, 5, 6 can be manually selected at the same time. XFEED OPEN may assist maintaining fuel pressure in both manifolds.

7. C.G. - forward of 24% for continued supersonic operation; forward of 22% for subsonic operation.

T 8. Display mode select switch - Other than ANS.

HSI compass card will be frozen if the display mode select switch remains in ANS with the ANS not powered.

9. Airspeed - Subsonic recommended.

Operational restrictions are 350 KEAS while supersonic and Mach 2.8 with one generator functioning.

When appropriate:

10. Generator switches - Attempt to reset NORM.

Attempt to reset the generators individually. If only one generator will operate in EMER, that generator is more likely to reset in NORM.

Select an appropriate time considering speed, altitude, and location. An attempt to restore normal power will result in temporary loss of the only operating generator if the opposite generator is inoperative both in NORM and EMER. This may result in complete loss of generator power if NORM reset attempts are not successful and service in EMER cannot be regained.

WARNING

Do not recycle the generator switch more than twice during an attempt to reset an automatically disengaged generator. If a fault in the generator feeder system exists, multiple cycling of its generator switch could cause repeated momentary short circuits each time while the protective system is operating to disconnect the generator.

NOTE

It may be possible to accomplish generator reset after attaining subsonic temperatures.

If one generator resets in NORM:

11. Failed generator - Off.

CAUTION

Inflight, do not operate either generator in EMER unless both generators have failed.

NOTE

One generator switch in EMER will cause loss of power to the monitored dc bus even if the other generator is operating in NORM.

(12.) MRS - Recycle to ON.

Cycle the MRS power switch to restore normal operation.

13. Emergency ac bus switch -NORM.

A, B, and M CMPTR OUT lights may blink on then off during power transfer. INSTR INVERTER ON light will extinguish.

14. C.G. - Maintain forward of 20% (subsonic).

15. Land as soon as possible.

If both generators reset in NORM, land when practical.

If both generators remain inoperative:

16. Control c.g.

WARNING

The c.g. will tend to shift aft as fuel is used. If possible, use a higher power setting on the right engine to maintain c.g. position.

▲17. Conserve battery.

One pitch and yaw SAS servo and both roll SAS servos may be disengaged while supersonic. Turn off the UHF, VHF, IFF, TACAN, and other nonessential systems where possible.

When subsonic, select spikes forward and forward bypass doors open, aft bypass doors closed, and then pull the following inlet circuit breakers: L & R SPIKE, L & R SOL, and AFT BYPASS circuit breakers on the pilot's left console; and the L & R SPIKE AND DOOR circuit breakers on the pilot's right console.

Battery loads may be reduced further when subsonic by disengaging all SAS and pulling circuit breakers for nonessential systems and by turning the battery OFF if flying VFR. The EMER BAT ON light may extinguish if dc load is reduced below 10 amperes.

CAUTION

Computer circuit breakers in the aft cockpit should not be pulled. The gyros should remain operating in case SAS reengagement is desired. Single channel pitch SAS reengagement may be required if a subsonic c.g. has not been attained.

The maximum duration of the dual-battery power system is approximately 40 minutes if unnecessary equipment is turned off. Figure 1-43 lists power requirements of equipment energized from the essential dc buses.

WARNING

If the boost pumps are inoperative, there is no assurance of continued engine operation if one or more fuel tanks are empty. If one of the tanks serving an engine is empty, engine flameout can occur at any time if flight attitude, engine flow requirements, and/or fuel level in the associated tank(s) is such that the remaining head of fuel in the supply tank(s) cannot keep that manifold clear of fuel vapor or nitrogen gas.

By airspeed control, attempt to maintain level to nose-up fuselage attitude during descent.

Just before landing:

18. Pitch SAS - Attempt servo engagement.

Equipment available with at least one generator operating in EMER:	
Boost pumps, ac hot bus (crossfeed, fuel quantity and c.g. indicators, pitch & yaw trim, forward cockpit instrument lights). Emergency ac bus & essential dc bus available from battery (or from transformer-rectifier(s) if generator(s) in EMER has sufficient voltage).	
Equipment available with only battery power:	
Attitude indicators	*Pitch trim ind
* ADI	*Fire warning
* RSO attitude ind	Fuel dump & transfer valves
* 2 inch standby	Hydro sys crossover
3 inch standby	IFF (Except Mode 4)
Cockpit lighting	Igniter purge
*DAFICS	ILS
* Air data (& PTAs)	*Inlet controls & ind
* α indicator	Inph & (T) Emer ICS
* APW	*INS
* High-α warning	Landing gear, brakes & steering
* Auto inlets	Manual air-cond control
* Roll Autopilot	Rain remvr & deice
* SAS	Rudder limiter
* Both TDIs	Seat adjust
* Unstart lights	*Turn and slip
Drag chute	VHF radio
Face Heat	
*HSI	
*PVD	
*Equipment on emergency ac bus powered by the inverter.	

Rain removal is deleted after S/B R-2674.

GENERATOR BUS TIE OPEN LIGHT ON

All electrical busses are still powered if the bus tie splits (GEN BUS TIE OPEN caution light illuminates); however, be prepared for the possibility of a generator or constant speed drive system malfunction. If either generator subsequently trips, the essential ac, emergency ac, and ac hot bus will automatically be powered by the remaining generator. DAFICS computers should automatically reset if power is momentarily interrupted during transfer to battery power; however, reset the affected DAFICS computer(s) and/or SAS sensors and servos if they do not automatically reset.

Do not take action if the GEN BUS TIE OPEN caution light illuminates unless the condition is followed by erratic ac power system indications (such as abnormally fluctuating lights and/or ac instrument indications). In this case, an abnormality in the right generator or its control or drive system is indicated. Cycle the right generator control switch to OFF momentarily, then back to NORM. This transfers the essential and emergency bus loads to the left generator. If either generator should subsequently fail, all loads (except its boost pumps and transformer rectifier) will transfer to the remaining generator in the least required time. Otherwise, a transfer time of up to seven seconds could be required if the right generator should fail with the buses split. The appearances of electrical failure during this transfer delay are similar to simultaneous double generator failure indications.

TRANSFORMER-RECTIFIER FAILURE

One transformer-rectifier can supply the normal electrical demands. If a single transformer-rectifier fails, no action is required.

A double failure of the transformer-rectifiers is indicated by illumination of both L and R XFMR RECT OUT caution lights. Generator power is removed from all of the dc buses, but the batteries automatically supply power to the essential dc buses (indicated when EMER BAT ON caution light illuminates). DAFICS computers should automatically reset if power is momentarily interrupted during transfer to battery power; however, the affected DAFICS computer(s) and/or SAS sensors/servos should be reset if they do not automatically reset.

With both L and R XFMR RECT OUT caution lights on:

1. EMER BAT ON caution light - Check on.
2. Complete Double Generator Failure Procedure, steps 13 through 18.

EMERGENCY AC BUS POWER LOSS

Loss of emergency ac bus power is indicated by loss of the A, B and M computers and, after ten seconds, the INS. The following power OFF warning flags should appear: INS, TDI, ADI, Angle of Attack Indicator and the 2 inch Standby Attitude Indicator. (The 3 inch Standby Attitude Indicator is powered by dc power and is not affected.)

WARNING

> With emergency ac bus failure, second condition SAS failure limits apply.

Power may be restored by moving the emergency ac bus switch to the EMER AC BUS (up) position. Actuation of the emergency ac bus switch may be accompanied by heading and attitude indication transients. The DAFICS computers reset automatically within one second.

Expect loss of all DAFICS computers and INS until EMER AC BUS is selected. All DAFICS computers should automatically reset when emergency ac power is restored; however, any disengaged computers or SAS sensors/servos should be reset if they do not automatically reset.

If emergency ac power is not restored to the INS within 10 seconds, the INS platform may be lost. In this case, use the Standby Attitude Indicator and complete an INS inflight alignment.

HYDRAULIC SYSTEM

With both engines out, the hydraulic pumps provide sufficient flow for satisfactory flight control system operation at windmilling speeds above 3000 rpm. Reduced control system capability is available down to a windmilling speed of approximately 1500 rpm. With one engine windmilling, all flight control and most utility services are supplied by the operating engine hydraulic systems. The windmilling engine utility system pressure and flow may be sufficient to supply service until the engine is almost stopped.

ABNORMAL HYDRAULIC PRESSURE

Steady hydraulic system pressures between 2200 and 3000 psi, and above 3500 psi, are considered abnormal. An abnormal pressure should be corrected before flight. Although not desirable, unrestricted operation may be continued if abnormal pressure is observed during flight; however, system operation should be monitored for indications of low quantity or degraded performance and the condition must be reported after landing. Transient pressure fluctuations are not considered abnormal when they can be associated with system demand.

L & R (UTILITY) HYDRAULIC SYSTEMS

Illumination of an L or R HYD warning light indicates low fluid quantity for that system (not low quantity and/or low pressure as the A and B HYD warning lights). Low pressure is indicated by the corresponding hand of the L and R hydraulic system (SPIKE) pressure gage. If L system pressure becomes less than 2200 psi during gear retraction, an automatic crossover to the R system continues until retraction is completed. If L system has failed, the Emergency Gear Extension procedure must be used to lower the landing gear.

L AND/OR R HYDRAULIC SYSTEM FAILED

Assume that an L or R hydraulic system has failed when its pressure indication remains below 2200 psi or its L or R HYD annunciator warning light remains illuminated. If at high Mach, a descent should be started in either case. Subsonic operating speeds are recommended; however, operation may be continued at intermediate supersonic speeds, when necessary, if an aft-bypass-closed and restart configuration is achieved and the engine inlet guide vanes maintained in the cambered position (IGV LOCKOUT). Sustained operation at speeds which result in engine internal bleed shifting should be avoided. Refer to Figures 3-4 and 3-7 for Unstart and Compressor Stall Boundary conditions for various inlet configurations.

NOTE

If subsonic, accomplish only * items.

With a low quantity warning or if pressure remains below 2200 psi, affected inlet:

* 1. **RESTART ON.**

Check the spike indicates full forward and the forward bypass indicates 100% open.

If supersonic, the spike will move forward because of air pressure in the inlet, regardless of hydraulic pressure available. However, some hydraulic pressure must be available to open the forward bypass.

NOTE

Without residual hydraulic pressure, the affected aft bypass will remain in the last selected position.

WARNING

If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

NOTE

If the forward bypass does not open and the spike moves to its forward position while supersonic, expect unstarts, compressor stalls, and/or flameout on the affected side. Engine restart is unlikely above Mach 1.3.

2. Aft Bypass - CLOSE.

3. Begin normal descent.

On the affected side:

4. Throttle - Set.

   - o 720° EGT to Military above Mach 2.5.
   - o 6500 rpm at Mach 2.5, let rpm decrease.
   - o Retard throttle if compressor stalls.

NOTE

Use the normal Descent procedure for the good inlet. If desired, afterburner can be used on the unaffected side to reduce the rate of deceleration while above Mach 2.0.

CAUTION

Monitor spike and forward bypass positions.

If the forward bypass is closed and the spike free to move, the inlet will become "choked" if the spike is sucked aft by engine airflow requirements. If this should happen at low altitude, a combination of high rpm and low airspeed might collapse the duct due to a critical differential between ambient air pressure and pressure within the duct. If the spike is aft and the forward door is closed while subsonic, use minimum required power when above 5000 feet and IDLE below 5000 feet.

CAUTION

If the forward bypass remains closed and the spike is not locked forward, fly approach at single-engine approach speed with idle power on the affected inlet.

If the forward bypass is open and the spike is aft (or free to move), duct collapse is not likely; however, to minimize the possiblity of compressor stalls, avoid using afterburner and avoid full military power. With IGVs cambered (locked out), compressor stalls are unlikely up to full military power.

* 5. Land when practical.

Refueling is not recommended if the L hydraulic system has failed; however, R system pressure may be used for refueling by moving the brake switch to ALT STEER & BRAKE. Do not leave the brake switch in ALT STEER & BRAKE after refueling.

WARNING

With both the L and R systems failed, wheel brakes may not be available and steering will not be available. Ejection may be necessary if a suitable landing area cannot be reached.

With the L system failed:

* 6. Brakes and antiskid - DRY/WET, ALT STEER & BRAKE.

CAUTION

R hydraulic pressure may be lost also if L system fluid loss is due to a malfunction of the steering or refueling system.

* 7. If L HYD Pressure is insufficient to lower the gear, complete Gear Emergency Extension procedure.

Allow additional time to lower the gear. At least 90 seconds must be allowed if Gear Emergency Extension, is required.

* 8. Retain drag chute after landing, if practical.

Jettison the drag chute for directional control, if required.

A AND B HYDRAULIC SYSTEMS

The loss of either A or B hydraulic system fluid quantity or pressure illuminates the corresponding A or B HYD annunciator warning light. The A and B hydraulic pressure gage will indicate complete failure of a system. If the A or B hydraulic system fails, the control forces will not change. Either system will operate the control surfaces, but at a slower rate and with some reduction in available control at higher KEAS and Mach. Airspeed reduction with a single hydraulic system is a precaution which allows for the reduction in available hinge moment capability. The APW system stick pusher is inoperative if the A system fails. Monitor system operation closely and attempt to determine if complete failure is imminent. Prepare for ejection prior to complete failure.

Effect of System Loss on SAS

Manual disengagement of the failed A or B hydraulic system SAS servos is necessary to regain normal SAS damping capability in all channels, as a hydraulic system failure is not sensed directly by DAFICS. The signal gain of the operating yaw servo is doubled automatically by disengagement of the servo for the failed hydraulic system.

It is necessary to recycle the operating roll SAS servo to regain damping in roll. The useable roll SAS servo should not be reengaged while banking, as roll coupling will disturb control in the pitch axis. Refer to Roll Axis Failures, this section.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

A OR B HYD LIGHT ON

NOTE

If subsonic, accomplish only * items.

If an A or B HYD warning light illuminates:

*1. A and B hydraulic systems -Check for normal pressure indication.

2. Begin normal descent.

*3. Land as soon as possible.

A OR B HYDRAULIC SYSTEM FAILED

If an A or B hydraulic system fails, as indicated by illumination of the A or B HYD warning light and confirmed by indication of the hydraulic pressure gage:

NOTE

If subsonic, accomplish only * items.

*1. Airspeed - 350 KEAS or less.

CAUTION

Do not exceed 350 KEAS (subsonic or supersonic) with only one A or B hydraulic system operative. If either system fails above this speed, reduce airspeed immediately. Set Idle power if transonic with higher KEAS.

*2. SAS - Affected servos off.

*3. Roll SAS - Cycle operating servo off, then ON, if roll SAS desired.

The roll SAS may be left off, if desired, to avoid pitch coupling.

4. Make normal descent at 350 KEAS to subsonic speed.

*5. Land as soon as possible.

A AND B HYDRAULIC SYSTEMS FAILED

If both the A and B hydraulic systems fail as indicated by illumination of the A HYD and B HYD warning lights and confirmed by loss of A and B hydraulic pressure and deteriorating control effectiveness:

▲1. Eject.

WARNING

All control will be lost if both the A and B hydraulic systems fail.

FLIGHT CONTROL SYSTEM

AIRCRAFT CONTROL ABNORMAL

If unusual aircraft control is encountered:

1. A and B hydraulic systems - Check for normal pressure indications.

2. Autopilot - Disengage and check control.

▲3. Electrical system - Check warning lights off and circuit breakers normal.

NOTE

Do not pull and reset DAFICS computer ac circuit breakers not already out; otherwise, DAFICS will detect multiple computer/sensor power supply failures.

4. DAFICS Computers/SAS - Check caution lights.

If failure has occurred, refer to DAFICS Computer Failures and/or SAS Emergency Operation, this section.

If unable to determine cause of malfunction:

5. Proceed at subsonic speeds (recommended) and land when practical.

TRIM FAILURES

Pitch, yaw or roll trim may fail inoperative or may runaway. Runaway trim failures in pitch may occur at the slow rate (0.113°/sec) if due to a runaway automatic trim motor, or at fast rate (1.13°/sec) if due to a runaway manual trim motor. A slow rate runaway malfunction will be manifest by the need for constant manual pitch trimming. A fast rate runaway pitch trim will result in a moderately rapid change in pitch attitude or stick forces. If the cause is a sticky manual pitch trim switch, a rapid oscillation may develop if the pilot applies corrective pitch trim inputs. The possibility of manual trim runaway can be minimized by manually centering the trim switch following each trim application. The runaway yaw trim rate is 0.90°/sec. The roll trim rate is .96°/sec. Runaway yaw trim will be accompanied by rudder pedal deflections as the surfaces move. Runaway pitch or roll trim will not be accompanied by stick movement with surface movement.

If runaway trim is suspected:

1. **TRIGGER HOLD.**

   Depress the control stick trigger switch to disengage the autopilot, pitch and yaw trim, and to disable the APW stick pusher. Keep the trigger depressed until trim power switch is OFF.

2. Trim power switch - OFF.

   All manual and automatic trim are inoperative with the Trim Power switch OFF.

When circumstances permit:

3. Reduce supersonic speed below 350 KEAS and Mach 2.5.

With runaway nose-up trim:

4. Transfer fuel forward to reduce forward stick requirement.

With runaway nose-down trim:

5. Do not transfer fuel aft of normal c.g. limits in an attempt to reduce aft stick requirements.

6. Affected trim circuit breaker(s) - Pull.

NOTE

The manual pitch and yaw trim motors are powered from the same circuit breaker.

Trim Malfunctions:

a. If runaway slow rate pitch trim - Pull the AUTO PITCH trim circuit breaker.

b. If runaway high rate pitch trim -Pull the PITCH AND YAW trim circuit breaker.

c. If runaway roll or yaw trim - Pull the ROLL trim or PITCH AND YAW trim circuit breaker.

7. Trim power switch - ON.

With manual pitch trim inoperative and autotrim available, engagement of the pitch autopilot will gradually correct an out-of-pitch-trim condition. This will relieve the pilot from maintaining stick deflection to maintain attitude. The pitch autopilot will not remain engaged when the auto trim motor is inoperative because DAFICS will disengage the autopilot when autotrim does not follow autopilot inputs.

If the trim malfunction is a runaway in the roll axis, right or left stick deflection will be required for the rest of the flight, but stick force will not be more than normally required for the same amount of deflection. If the malfunction was a runaway in the yaw axis, rudder pedal force will be required to maintain neutral rudder pedal position.

STABILITY AUGMENTATION SYSTEM (SAS)

SAS disengagements may result from failures of: servo(s), multiple sensors, multiple DAFICS computer failures, or electrical power fluctuations and failures. Disengagement or loss of effectiveness may also occur as a result of complete or partial loss of A or B system hydraulic power. Failure of SAS sensors and servos is indicated by illumination of the master caution light, the SAS OUT annunciator caution light, and one or more of the indicator lights on the SAS control panel.

A steady YAW SENSOR light indicates a yaw rate gyro failure. A flashing YAW SENSOR light indicates failure of a lateral accelerometer. If both the yaw rate gyro and lateral accelerometer in the same yaw sensor fail, that YAW SENSOR light will illuminate steady. DAFICS provides analytical redundancy for yaw rate, but not for lateral acceleration.

No SAS capability is lost as a result of a single DAFICS computer failure. SAS sensor redundancy is reduced in pitch and yaw by any dual computer failure. Also, SAS channel A is lost in pitch and yaw due to servo disengagements if the A and M computers fail. SAS channel B is lost in pitch and yaw due to servo disengagements if the B and M computers fail. All roll SAS is lost if A and B computers fail. Refer to DAFICS Computer Failures, this section.

All SAS is disengaged if all three DAFICS computers fail. SAS is functionally inoperative while DAFICS is in the ground test mode (DAFICS preflight BIT TEST or FAIL light illuminated steady).

WARNING

Only the master caution and the A, B, and M CMPTR OUT lights illuminate if all three DAFICS computers fail.

NOTE

Computer failures are indicated by illumination of the A, B, and/or M CMPTR OUT annunciator caution lights. SAS disengagement due to multiple computer failures is not indicated by lights on the SAS control panel.

SAS EMERGENCY OPERATION

When any SAS SERVO or SENSOR light illuminates:

1. A and B hydraulic systems - Check for normal pressure indications.

   If hydraulic pressure failure is indicated, follow A or B Hydraulic System Failed procedure, this section.

▲2. Electrical system - Check warning lights off and circuit breakers normal.

NOTE

Do not pull and reset DAFICS computer ac circuit breakers not already popped; otherwise, DAFICS might detect multiple computer/sensor power supply failures.

3. Recycle appropriate SENSOR/SERVO lights.

   a. Single sensor or servo failure:

   For pitch or yaw SAS, press any recycle light (A, B, or M SENSOR/SERVO light-switch) in that axis. For roll SAS, cycle either A or B ROLL channel engage switch off, then ON. If the malfunction was a transient condition, the sensor/servo monitor will reset.

   b. Multiple sensor failures in one axis:

   Multiple lateral accelerometer failures (flashing A, B, and M YAW SENSOR lights) cannot be reset.

   If more than one SAS rate-gyro fails in the pitch or yaw axis, press any recycle light (A, B, or M SENSOR/SERVO light-switch) in that axis. Pressing a recycle light resets only one sensor. The DAFICS computers determine which sensor resets regardless of which recycle light is pressed. If the malfunction was a transient condition, a sensor will reset. If no SENSOR light extinguishes, press a recycle light again to attempt reset of another sensor. After one sensor resets (one SENSOR light extinguishes), DAFICS will not allow reset of another sensor in the same axis until the pilot pulses the aircraft in both directions in that axis to assure that the sensor is tracking.

   If both roll SAS sensors fail, cycle either A or B ROLL channel engage switch off, then ON. Cycling an engage switch resets only one sensor. The DAFICS computers determine which sensor resets regardless of which switch is cycled. If the malfunction was a transient condition, a sensor will reset. Since one sensor is still failed, the ROLL SENSOR light remains illuminated. The pilot must pulse the airplane in roll to determine if a sensor has reset. If a sensor resets, DAFICS will not allow reset of the other roll sensor until the pilot rolls the aircraft both left and right to assure that the sensor is tracking.

If more than one rate-gyro SAS sensor fails in an axis, DAFICS compares the first sensor reset in that axis to analytical redundancy (ANR). Therefore, recycling of multiple sensor failures in an axis is only possible when the attitude source (ANS or INS) selected by the pilot's ATT REF SELECT switch is reliable.

c. Dual servo failure in one axis:

For dual SAS servo failures in the pitch or yaw axis, press any recycle light (A, B, or M SENSOR/SERVO light-switch) in that axis. Pressing a recycle light once resets servos in only one channel. The DAFICS computers determine which servos reset regardless of which recycle light is pressed. Press a recycle light again to reset the servos in the other channel. If the malfunction was a transient condition, both servo monitors will reset.

For dual roll SAS servo failure, cycling either A or B ROLL channel engage switch off, then ON reengages servos in both channels.

4. Pulse the aircraft in the appropriate axis.

Pulsing the aircraft checks for a dead or sticking sensor. Although this check is desirable, it is not conclusive. If the SENSOR/SERVO light remains extinguished, assume no failure. If the light reilluminates during movement (active trip) or will not recycle (passive trip), assume a failure.

Pulse the aircraft both directions in the appropriate axis, i.e. generate up and down movement after resets in pitch, left and right movement (with rudder) after resets in yaw, and left and right roll rates after resets in roll.

NOTE

Consider that no failure exists if all pitch, yaw, and roll recycle lights extinguish. Normal operation of the recycle lights is verified by depressing the SAS LITE TEST button.

5. For multiple sensor failures in the same axis, repeat steps 3 and 4 as required.

With multiple rate-gyro failures, after one sensor resets, DAFICS will not allow reset of another sensor in the same axis until the pilot pulses the aircraft in both directions in that axis to assure that the sensor is tracking.

If the A, B, and/or M CMPTR OUT, the 2 PTA CHAN OUT or the ANR (flashing DAFICS PREFLIGHT BIT FAIL light) caution lights illuminate, refer to the appropriate procedure.

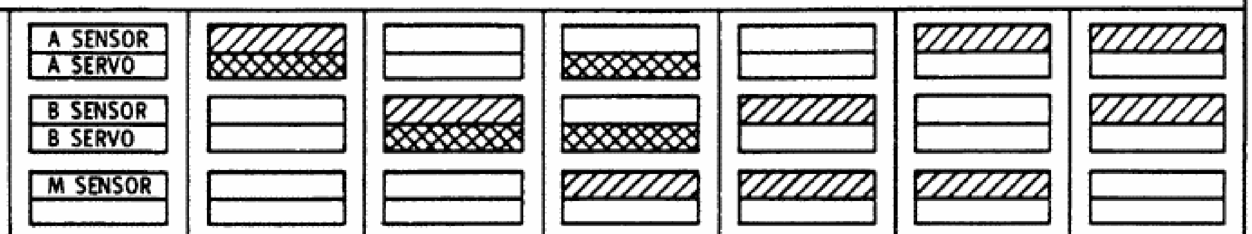
The SAS Warning Lights charts, Figure 3-14, illustrate the probable causes of failure, indications, remaining capabilities, procedures and limits which apply after channel disengagement.

SAS WARNING LIGHTS CHART

PITCH SENSOR/SERVO FAILURES

FUNCTION SELECTOR

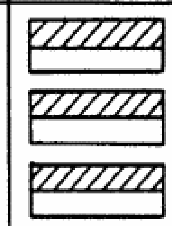
Recycle Lights Illuminated Steady



Operable Channels – SENSOR FAILURES	(sensor symbol)	A & B	A & B	A & B	A & B	A & B	A & B
Operable Channels – SERVO FAILURES	(servo symbol)	B	A	NONE			

ACTION: Check Hydro Press, Electrical Sys. Then try to press lights off.

Then: If servo light remains on, turn failed servo off. If pitch axis failed while supersonic move c. g. forward.



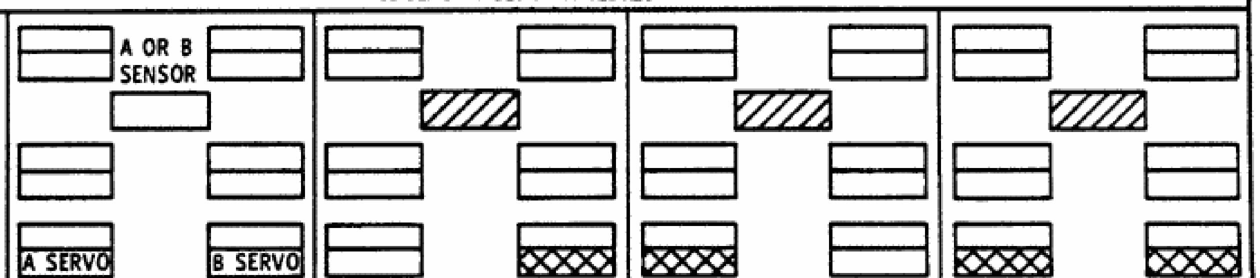
NOTE
1. Without analytical redundancy:
   a. Treat the loss of one sensor as a "first" condition SAS failure.
   b. Two sensor failures will result in "second" condition SAS failure.
   c. A sensor failure coupled with dual computer failure can result in "second" condition SAS failure.
2. Servo failure coupled with dual computer failure can result in "second" condition SAS failure.
3. Dual sensor failure coupled with dual computer failure can result in "second" condition SAS failure.

LIMITS: For Single Servo, Single Sensor w/o ANR, or Dual Sensor Failure	Max Supersonic speed:	Mach 3.0, 400 KEAS. Intermediate Altitude profile recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical. Land when practical.
LIMITS: For Dual Channel Out ("SECOND CONDITION")	Max Supersonic speed:	Mach 2.0, 350 KEAS. Subsonic c.g. limits required. Subsonic Operation recommended. Land when practical

ROLL SENSOR/SERVO FAILURES

FUNCTION SELECTOR

Recycle Lights Illuminated Steady



Operable Channels – SENSOR FAILURES	(sensor symbol)	A AND B OR NONE	A AND B OR NONE	A AND B OR NONE
Operable Channels – SERVO FAILURES	(servo symbol)	A OR NONE *	B OR NONE *	NONE **

ACTION: Check Hydro Press, Electrical Sys. Then try to reset (Either Roll Engage Switch off and ON)

Then: If servo light(s) stay on:

Turn off failed servo switch and recycle good servo switch.

If second failure is detected by loss of damping, disengage remaining servo switch.

LIMITS: Single or Dual Channel Out	Single servo not to be used during refueling or landings. No restriction on operation without roll SAS	* Servo light indication does not change for a second servo failure, both roll servos disengage with first servo failure. A subsequent failure in the re-engaged good channel will neither disengage the servo nor illuminate the servo light in that channel. ** Illumination of both servo lights results from intentional disengagement of both channels, or in infrequent occasions when system comparison of servos against model does not yield a positive identification of the servo which has failed.

F203-219(h)

Figure 3-14 (Sheet 1 of 2)

SAS WARNING LIGHTS CHART

YAW AXIS RATE-GYRO/SERVO FAILURES

FUNCTION SELECTOR Recycle Lights Illuminated Steady	A SENSOR A SERVO B SENSOR B SERVO M SENSOR						
Operable Channels } SENSOR FAILURES		A & B	A & B	A & B	A & B	A & B	A & B
Operable Channels } SERVO FAILURES		B	A	NONE			
							NONE

ACTION: Check Hydro Press, Electrical Sys. Then try to press lights OFF

Then: If servo light remains on, turn failed servo OFF. If both yaw servos failed while at cruise, decel by symmetric use of RESTART switches.

NOTE

1 Without analytical redundancy:
- a. Treat the loss of one sensor as a "first" condition SAS failure.
- b. Two sensor failures will result in "second" condition SAS failure.
- c. A sensor failure coupled with dual computer failure can result in "second" condition SAS failure.

2 Servo failure coupled with dual computer failure can result in "second" condition SAS failure.

3 Dual sensor failure coupled with dual computer failure can result in "second" condition SAS failure.

LIMITS: For Single Servo, Single Sensor w/o ANR, or Dual Sensor Failure	Max Supersonic speed:	Mach 3.0, 400 KEAS. Intermediate Altitude profile recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical. Land when practical.
LIMITS: For Dual Channel Out ("SECOND CONDITION")	Max Supersonic speed:	Mach 2.0, 350 KEAS. Subsonic c.g. limits required. Subsonic Operation recommended. Land when practical

YAW AXIS LATERAL ACCELEROMETER FAILURES

FUNCTION SELECTOR Recycle Lights Illuminated Flashing	A SENSOR B SENSOR M SENSOR				1ST 2ND 2ND	2ND 1ST 2ND	2ND 2ND 1ST
Operable Channels } SENSOR FAILURES		A & B	A & B	A & B	NONE	NONE	NONE

ACTION: Check Hydro Press, Electrical Sys. Then try to press lights off.

Then: If light(s) stay ON: Land when practical. For complete yaw axis failure while at cruise, decel by symmetric use of RESTART switches.

NOTE

1 If a lateral accelerometer and YAW rate gyro fail in the same sensor, the YAW sensor light will illuminate steady.

2 Sensor failure coupled with dual computer failures can result in "second" condition SAS failure.

LIMITS: For Dual Channel Out ("SECOND CONDITION")	Max Supersonic Speed:	Mach 2.0, 350 KEAS. Subsonic c.g limits required. Subsonic Operation recommended. Land when practical

F203-220(h)

Figure 3-14 (Sheet 2 of 2)

PITCH OR YAW AXIS "FIRST" CONDITION FAILURE

A "first" condition failure exists after the SAS Emergency Operation procedure has been accomplished and either an A or B SAS servo is inoperative in the pitch and/or yaw axis. "First" condition failure limitations are also observed for: dual pitch sensor or dual yaw rate gyro failures; and single pitch sensor or single yaw rate gyro failure with ANR failure (DAFICS Preflight BIT red FAIL light flashing).

Sensors

There is no combination of pitch or yaw sensor failures that can fail only one channel in either axis. Both SAS channels operate if one sensor is available in that axis. No SAS channel is lost in pitch or yaw as a result of a single sensor failure; however, "first" condition failure limitations should be observed for single pitch sensor or yaw-rate gyro failure with ANR failure. If analytical redundancy is operative, no pitch or yaw SAS channel is lost if two pitch sensors or two yaw rate gyros are lost; however, "first" condition failure limitations should be observed for dual pitch sensor or dual yaw rate gyro failures.

Servos

A "first" condition failure exists after the SAS Emergency Operation procedure has been accomplished and one servo light remains on (A PITCH SERVO, B PITCH SERVO, A YAW SERVO, or B YAW SERVO) or one servo light remains on in each axis (any combination of one PITCH SERVO and one YAW SERVO light). Aircraft flight characteristics do not change as a result of a failure or combination of failures which leaves one A or B servo operating in each axis.

Computers

No SAS capability is lost as a result of a single computer failure. SAS channel A is lost in pitch and yaw due to servo disengagement if the A and M computers fail. SAS channel B is lost in pitch and yaw due to servo disengagement if the B and M computers fail.

NOTE

> Computer failures are indicated by illumination of the A, B, and/or M CMPTR OUT annunciator caution lights. SAS disengagement due to multiple computer failures is not indicated by lights on the SAS control panel.

Appropriate SAS emergency procedures are incorporated in multiple computer failure procedures. Refer to DAFICS Computer Failures, this section.

PITCH OR YAW AXIS "FIRST" CONDITION FAILURE PROCEDURE

This procedure is only initiated after the SAS Emergency Operation procedure is complete.

NOTE

> If subsonic, accomplish only * items.

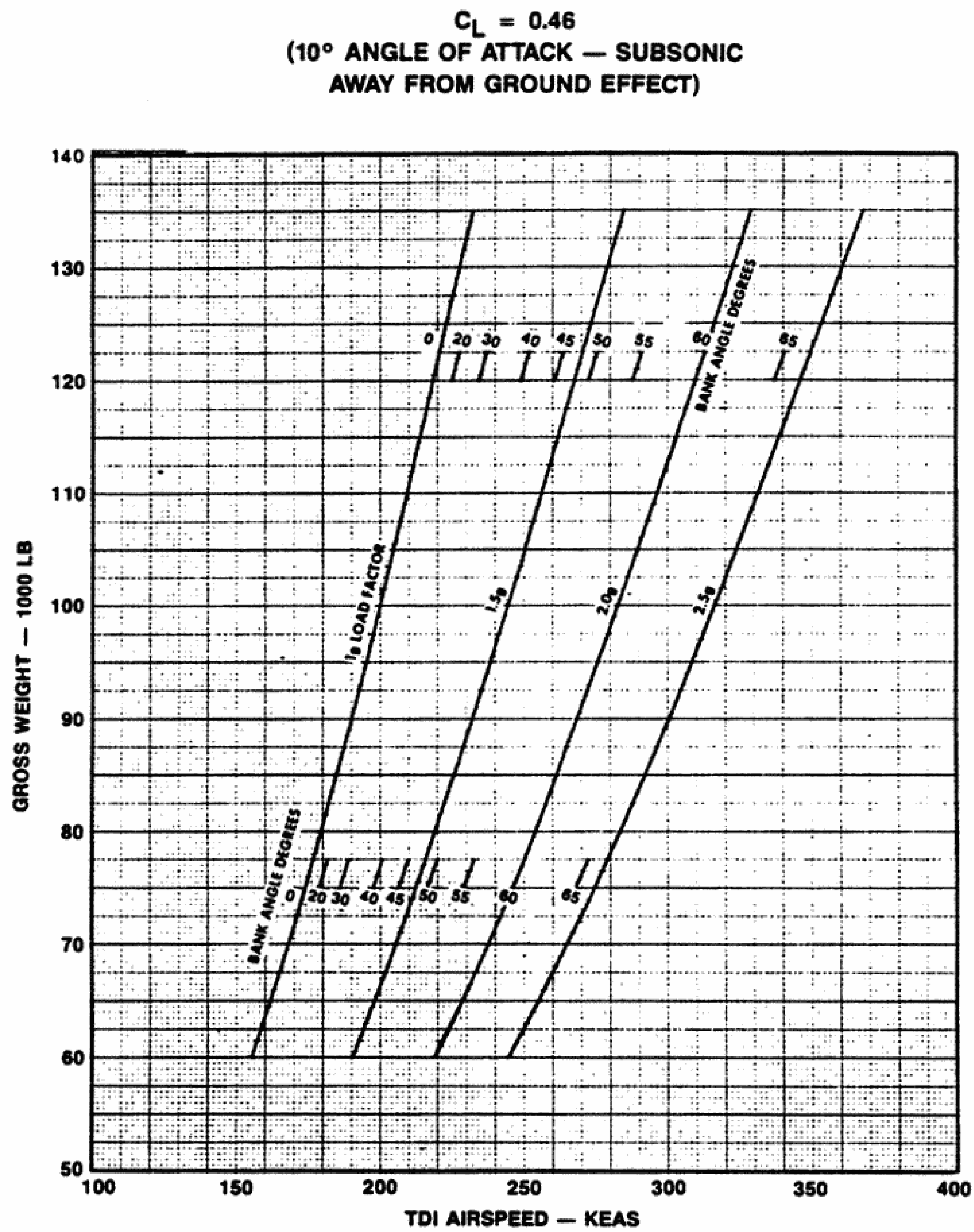
Sensor

No action is required for a single sensor failure in the pitch and/or yaw axis (A PITCH SENSOR, B PITCH SENSOR, M PITCH SENSOR, A YAW SENSOR, B YAW SENSOR, or M YAW SENSOR light or any combination of one PITCH SENSOR light and one YAW SENSOR light) unless ANR failure is also indicated. No action is required for two sensor lights in the yaw axis if one light is a yaw rate gyro (steady) and the other is a lateral accelerometer (flashing) unless ANR failure is also indicated.

Servo, Dual Pitch Sensor or Dual Yaw Rate Gyro, Single Pitch Sensor With ANR Failure, or Single Yaw Rate Gyro With ANR Failure

When A PITCH, B PITCH, A YAW or B YAW SERVO light is on; one PITCH SERVO and one YAW SERVO light is on; dual PITCH SENSOR lights or steady dual YAW SENSOR lights are on; a single PITCH SENSOR light is

MINIMUM RECOMMENDED SUBSONIC AIRSPEED WITH PITCH SAS INOPERATIVE



Refer to Section V for listing of airspeed restrictions.

Figure 3-15

on with ANR failure; or a single steady YAW SENSOR light is on with ANR failure:

1. Maximum supersonic speed - Mach 3.0, 400 KEAS.

   Intermediate Altitude profile is recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical.

* 2. For servo failure, failed servo switch - Off.

* 3. For first condition pitch failure, C.G. - Forward of 24% for continued supersonic operation; forward of 22% for subsonic operation.

* 4. Land when practical.

NOTE

With dual PITCH SENSOR lights or dual steady YAW SENSOR lights, changing the position of the pilot's attitude reference switch will not illuminate an ANR light or SENSOR light but will momentarily disengage all SAS in that axis until analytical redundancy is restored.

PITCH OR YAW AXIS "SECOND" CONDITION FAILURE

A "second" condition failure exists when both SAS servos disengage in the same axis.

Pitch SAS Disengaged Characteristics

Normally, pitch SAS opposes pitch rates that result from control stick inputs. Without pitch SAS, the aircraft pitch rate and load factor response to a pilot input is greater than the response to the same stick movement or stick force when pitch SAS is operating. With pitch SAS off, longitudinal overcontrol is likely, particularly at high Mach (where static margin is low and normal pitch SAS gain is high). Observance of "second" failure limits is required, and descent to subsonic speed is recommended when practical. Air refueling and landing may present difficulties in maintaining precise attitude control. With SAS off, divergent speed and attitude tendencies occur slowly enough to be controllable. Stability improves when the c.g. is moved forward (see Stability Characteristics, Sec. VI). Minimum airspeed at or above normal pattern speeds (i.e. angle of attack at or below 10°) is recommended until landing. See Figure 3-15.

Pitch Sensors

Due to analytical redundancy models in the DAFICS computers, neither pitch SAS channel is lost until all three pitch sensors fail, or two pitch sensors and analytical redundancy fail. These triple failures will cause the A, B, and M PITCH SENSOR lights to illuminate and both pitch SAS channels to disengage. In this case, the pitch servo lights on the SAS control panel will not illuminate.

Pitch Servos

A failure of both pitch servos (A PITCH SERVO and B PITCH SERVO lights on) will cause both pitch SAS channels to disengage.

Yaw SAS Disengaged Characteristics

At high Mach, neutral to slightly positive stability exists and there is little damping of yaw oscillations after they commence. Above Mach 2.8, automatic scheduling of the inlets may induce neutrally damped directional oscillations. Directional and roll control could become difficult (as a result of large bank angles generated by yawing motion) if an unstart or flameout occurs above Mach 2.9. Pilot rudder inputs usually aggravate this condition. These conditions could also result in excessive rudder surface loads above 400 KEAS. Use of both restart switches is recommended while decelerating to avoid asymmetric nacelle drag or unstarts.

Yaw Sensors

Due to yaw rate analytical redundancy models in the DAFICS computers, neither yaw SAS channel is lost until all three yaw rate gyros fail or two yaw rate gyros and analytical redundancy fail. These triple failures will cause the A, B, and M YAW

SENSOR lights to illuminate steady and both yaw SAS channels to disengage. Because analytical redundancy is not provided for lateral accelerometers, the failure of any two lateral accelerometers will cause the A, B, and M YAW SENSOR lights to illuminate flashing and both yaw channels to disengage. In either case, the YAW SERVO lights on the SAS control panel will not illuminate.

Yaw Servos

Failure of both yaw servos (A YAW SERVO and B YAW SERVO lights on) will cause both yaw SAS channels to disengage.

Computers

If all three DAFICS computers fail, all SAS channels will disengage. In this case, all SAS capability is lost and the A CMPTR OUT, B CMPTR OUT and M CMPTR OUT annunciator lights illuminate. SAS disengagement will not be indicated by lights on the SAS control panel. Refer to the A, B, and M Computers Out procedure, this section, which incorporates appropriate SAS emergency actions.

If two DAFICS computers are inoperative, SAS redundancy is degraded. The loss of a servo or sensor in combination with a dual computer failure may result in a "second" condition SAS failure. Appropriate SAS emergency procedures are incorporated in computer-out procedures. Refer to A and B, (A and M) or (B and M) Computers Out procedure as appropriate.

PITCH OR YAW AXIS "SECOND" CONDITION FAILURE PROCEDURE

When triple PITCH SENSOR, triple YAW SENSOR (steady or flashing), both PITCH SERVO, or both YAW SERVO lights are on:

NOTE

If subsonic, accomplish only * items.

The maximum supersonic speed restrictions are 350 KEAS and Mach 2.0. Subsonic operation is recommended.

1. Restarts ON simultaneously.

   The throttle restart switch will expeditiously put both inlets in restart.

   WARNING

   If the L and/or R SPIKE SOL dc circuit breaker(s) are open, the respective spike will move only 15 inches forward of the auto inlet schedule when restart ON is selected or the throttle restart switch is set to the aft position. Without SPIKE SOL power, the first detent (center position) of the throttle restart switch for the respective inlet is inoperative. Without SPIKE SOL power, if manual spike is selected, all normal restart capability for the respective inlet is lost.

2. Maintain 350 KEAS.
3. Aft bypass - CLOSE.

Above Mach 2.5:

4. Throttles - 720°C EGT to Military.
5. IGV switches - LOCKOUT.
6. C. G. - Forward of 22%.

At Mach 2.5:

7. Throttles - Set 6500 rpm.

To cruise at Mach 2.0:

8. Restart switches - Off.
9. Aft bypass controls - Normal schedule.
10. Throttles - As required.

At Mach 2.0, to continue deceleration:

* 11. C.G. - Forward of 20%.

12. Resume normal checklist procedures.

* 13. Land when practical.

ROLL AXIS FAILURES

With one ROLL SERVO failed, some undesirable cross-coupling may occur during single roll SAS channel operation, particularly during turns. This appears as small amplitude oscillations in the pitch and yaw axes. Roll coupling occurs because the A and B roll SAS servos only operate through their left and right side elevons. With the "A" roll servo off, for example, the "B" servo only supplies stability augmentation through the right side elevons. However, the pitch axis SAS channel which remains will continue to operate through the elevons on both sides of the aircraft. A disturbance in the roll axis which is resisted by the B roll SAS servo results in a nose-up or nose-down pitch signal to the right side elevons. There is no balancing roll signal to the left side elevons if the A roll SAS servo is off, and a pitch transient is introduced. When this happens, the pitch SAS will immediately resist any disturbance in the longitudinal axis which is introduced by the right side elevons. It reacts against the roll SAS command, and deflects the elevons on both sides toward the opposite direction. The result is a pitch transient in the opposite direction to that of the original roll SAS input. The magnitude of the transient and the number of resultant transients depends largely on the strength of the original disturbance.

Roll coupling can occur in wings-level or turning flight. The effect is not unduly hazardous unless compounded by other abnormal or emergency situations - - such as an unstart. Therefore, the usable roll SAS servo can be reengaged when level, if desired, and autopilot AUTO NAV can be engaged. As a precaution, the roll SAS can be disengaged before turns.

Scheduled activity may be continued for the remainder of the flight with a single roll SAS channel operating. The roll autopilot may be engaged and AUTO NAV used as desired.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

NOTE

- Operation with both roll channels disengaged is permitted without limitation.
- With an engine failure at low speed or while reducing airspeed, loss of hydraulic power from the windmilling engine may cause failure of that roll SAS channel and simultaneous automatic disengagement of the other roll channel.

Use of Roll SAS for Single-Engine Landing

To avoid changes in pitch control characteristics at a critical time during single-engine landings, make the approach and landing with all roll SAS off. With both roll channels off, roll response is increased and the airplane feels lighter in roll. Therefore, the roll channels should be turned off early enough to allow the pilot to become accustomed to the new feel prior to landing.

Roll SAS Failure at High Speed

A second roll SAS failure while at high speed will probably be indicated by loss of roll damping or possibly illumination of both roll servo lights.

Loss of ANR (DAFICS Preflight BIT light flashing red) with a single roll sensor failure causes loss of all roll SAS.

Operation with Roll SAS Disengaged

Failure or intentional disengagement of both roll SAS channels is expected to increase pilot fatigue, reduce mission effectiveness, and will disable the roll autopilot and AUTO NAV; however, no hazard to safety should result and there are no flight restrictions for continued operation.

ROLL SAS FAILURE PROCEDURE

This procedure is only initiated after the SAS Emergency Operation procedure is complete.

NOTE

> With A and B CMPTR OUT lights illuminated, roll A & B SENSOR and SERVO lights and roll A & B channels are inoperative.

With A or B ROLL SERVO light illuminated:

1. A and B roll servo switches - Off.
2. Operative roll servo switch - ON.

   A SERVO failed, engage channel B,
   or
   B SERVO failed, engage channel A.

With both ROLL SERVO lights illuminated:

3. A and B roll servo switches - Off.
4. A roll servo switch - ON.

If a hard-over obtained or if no improvement:

5. A roll servo switch - Off.
6. B roll servo switch - ON.

If a hard-over obtained or if no improvement:

7. A and B roll servo switches - Off.

For ROLL SENSOR light illuminated:

8. Check for normal roll damping.

   If normal, a single ROLL SENSOR has failed. Single sensor failure will not disengage or degrade roll SAS.

If abnormal:

9. A and B roll SAS servo switches - Off.

   Both ROLL SENSORS have failed and both roll SAS servos have disengaged.

With ROLL SENSOR light illuminated and ANR failure (DAFICS Preflight BIT light flashing):

10. A and B roll SAS servo switches - Off.

    Roll SAS cannot operate on one sensor unless ANR is available.

ANALYTICAL REDUNDANCY FAILURE

If the BIT FAIL light illuminates flashing, analytical redundancy for pitch, roll, and/or yaw SAS sensors has failed. DAFICS fails ANR if pitch, yaw, or roll rates derived from movement of the inertial platform selected by the pilot (ANS or INS) do not compare with SAS rate gyros in an axis when two SAS rate gyros are operating in that axis. In effect, the two rate gyros are voting out the inertial platform. Because a platform error may be present, the PVD is inhibited when ANR failure is indicated.

Without analytical redundancy, two sensor failures in the pitch and the yaw axis and a single sensor failure in the roll axis will result in loss of all SAS in that axis ("second" condition SAS failure).

A transient failure of analytical redundancy may be cleared by cycling the ATT REF SELECT switch. If the BIT FAIL light continues to flash after cycling the ATT REF SELECT switch, the selected attitude reference may be marginally degraded or unreliable. Analytical redundancy for SAS may be regained by setting the ATT REF SELECT switch to the opposite source, if desired.

ANALYTICAL REDUNDANCY FAILURE PROCEDURE

If the BIT FAIL light illuminates flashing:

▲1. Attitude indicators and annunciator lights - Check.

   Check attitude indicators and the annunciator panel caution lights (ANS REF/INS REF).

2. ATT REF SELECT switch - Cycle.

   Cycling the switch to the other attitude source and back will recycle a transient failure.

If the BIT FAIL light continues to flash:

3. ATT REF SELECT switch - Select other attitude source, if desired.

AUTOPILOT FAILURE

If the pitch axis and/or the roll axis of the autopilot will not engage, the ATT REF SELECT switch must be cycled to reset the DAFICS software; otherwise, the autopilot cannot be reengaged.

If the autopilot will not engage:

▲1. Attitude indicators and annunciator lights - Check.

   Check attitude indicators and the annunciator panel caution lights (ANS REF/INS REF).

2. ATT REF SELECT switch - Cycle.

   Cycling the switch to the other attitude source and back will reset the DAFICS software and permit reengagement.

3. Autopilot - Engage.

DAFICS COMPUTER FAILURES

The A CMPTR OUT, B CMPTR OUT, and M CMPTR OUT caution lights on the pilot's annunciator panel indicate DAFICS computer failures. To reset a computer, momentarily position the corresponding CMPTR RESET switch up and release it. The up position interrupts power to the computer. Releasing the switch restores power and reinitiates computer self-test; the computer will not reset if a fault is detected.

Report all computer failures even if reset was successful.

SINGLE COMPUTER OUT

If the A or B CMPTR OUT annunciator caution light illuminates, computer system redundancy is lost; however, no DAFICS systems are degraded.

With A, B, or M DAFICS computer failed, the forward bypass door duct pressure ratio (DPR) schedule for automatic inlet operation is biased slightly lower on both inlets. The lower DPR schedule causes the forward bypass doors to open slightly and provides increased margin from unstart. The DPR schedule returns to normal if the computer resets.

If the M CMPTR OUT annunciator caution light illuminates, M PTA inputs are lost and the beta (sideslip) value will go to zero. Auto inlet scheduling will not be biased for sideslip and unstarts are likely if the aircraft is yawed. Also, the computer input to the CIP barber pole is disabled and the reference needle displays zero. Altitude change is disabled and IFF MODE C will continue to report the altitude at the time of failure. TAS to the Pilot's & RSO's map projector automatic map rate at the time of failure will continue to be used. DAFICS related signals to the DMRS are disabled. The altitude and TAS values at the time of failure will continue to be sent to the ANS and affects the following:

1) DEAD RECKON MODE (TAS to ANS computer).
2) NAV V/H source (altitude from ANS to V/H).
3) RADAR ALTITUDE (altitude from ANS to CAPRE SLR).

Single Computer Out Procedure

If the A <u>or</u> B <u>or</u> M CMPTR OUT caution light illuminates:

1. Appropriate CMPTR RESET switch - Reset.

If an A or B CMPTR OUT light remains illuminated, no further action is required.

If M CMPTR OUT caution light remains illuminated:

▲2. Use manual map rate.

3. V/H SOURCE selector switch - VWSGT or MAN.

T4. IFF MODE C switch - OUT.

A AND B COMPUTERS OUT, M COMPUTER OPERATIVE

If only the A and B CMPTR OUT lights illuminate, only the M computer is operating. If the A or B computer cannot be reset, revert to use of pitot-static instruments. If A and B CMPTR OUT caution lights illuminate, both inlets revert to restart unless in manual control. Use the Schedule For Manual Inlet Control, Figure 3-5, for supersonic cruise & descent, and subsonic operation. Refer to Figure 3-16 for the list of operative equipment.

NOTE

The following are inoperative if only the M computer remains.

- TDI (front and rear)
- Auto Inlet
- PITCH & YAW A SENSOR caution lights
- ROLL A & B SENSOR & SERVO caution lights
- ROLL A & B engage switches
- A/P panel controls and indicators
- APW & High Alpha Warning System
- AOA Indicator
- KEAS Warning System
- SURFACE LIMITER annunciator light

NOTE

Since each PTA only sends information to its respective computer, only one PTA remains when two computers are out.

<u>A and B Computers Out Procedure</u>

NOTE

If subsonic, accomplish only * items.

If the A <u>and</u> B CMPTR OUT lights illuminate (M CMPTR OUT <u>not</u> illuminated):

* 1. A CMPTR RESET switch - Reset.

* 2. B CMPTR RESET switch - Reset.

If at least one computer resets, no further action is required.

If both the A and B CMPTR OUT lights remain illuminated:

* 3. Use pitot-static instruments.

4. Use the Schedule For Manual Inlet Control, Figure 3-5.

* 5. A and B ROLL servo switches - Off.

* 6. APW switch - OFF.

If aircraft control difficulties are encountered:

* 7. Complete the SAS Emergency Operation procedure.

If aircraft control does not improve:

* 8. Complete the Pitch or Yaw Axis "Second" Failure procedure.

With A and B computers failed, Pitch A and Yaw A sensors are not available; however, the respective sensor indicator lights on the SAS control panel do <u>not</u> illuminate. Failure of Pitch B and M sensor, or failure of analytical redundancy plus Pitch B or M sensor results in loss of all pitch SAS. Failure of Yaw B and M rate-gyro, failure of analytical redundancy plus Yaw B or M rate-gyro, or failure of Yaw B or M lateral-accelerometer results in loss of all yaw SAS.

(A AND M) OR (B AND M) COMPUTERS OUT

If only the (A and M) or (B and M) CMPTR OUT annunciator panel lights illuminate, most DAFICS functions will remain operating. Aircraft control and performance will not be degraded under this condition; however, either A or B Pitch and Yaw SAS will be inoperative. Although the single operative computer is capable of driving the DAFICS system, there is no longer protection for erroneous outputs from the system. The APW stick pusher is disabled.

The forward bypass door duct pressure ratio (DPR) schedule for automatic inlet operation is biased slightly lower on both inlets. The lower DPR schedule causes the forward bypass doors to open slightly and provides increased margin from unstart. The DPR schedule returns to normal if both computers reset.

NOTE

> Since each PTA only sends information to its respective computer, only one PTA remains when two computers are out.

The TDI's may be inaccurate and inlet unstarts could occur above Mach 1.6, if the operating computer/PTA is supplying unreliable information. See Single Computer Out, this section, for additional equipment disabled due to M computer out.

(A and M) or (B and M) Computers Out Procedure

NOTE

> If subsonic, accomplish only * items.

If only the (A and M) or (B and M) CMPTR OUT lights illuminate:

* 1. A or B CMPTR RESET switch - Reset.

Attempt to reset the failed computer.

* 2. M CMPTR RESET switch - Reset.

If the M computer resets and only the A or B computer cannot be reset, no further action is required. If only the M computer cannot be reset, complete Single Computer Out procedure, this section.

If both the (A and M) or (B and M) CMPTR OUT lights remain illuminated:

3. Maximum supersonic speed - Mach 3.0, 400 KEAS.

Intermediate Altitude profile is recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical.

* 4. Failed pitch and yaw servo switches - Off.

a. If the A and M computers fail, pitch A and yaw A servos are inoperative.

Also, the following SENSOR/SERVO lights are inoperative:
- M PITCH SENSOR light
- M YAW SENSOR light
- A PITCH SERVO light
- A YAW SERVO light

b. If the B and M computers fail, pitch B and yaw B servos are inoperative.

Also, the following SENSOR/SERVO lights are inoperative:
- B PITCH SENSOR light
- B YAW SENSOR light
- B PITCH SERVO light
- B YAW SERVO light

NOTE

> Roll SAS is not degraded with either (A and M) or (B and M) computer failures.

*▲5. Use manual map rate.

*(6) V/H SOURCE selector switch VWSGT or MAN

*(7) IFF MODE C switch - OUT.

* 8. Land when practical.

* 9. C.G. - Forward of 24% for continued supersonic operation; forward of 22% for subsonic operation.

* 10. Check TDI against airspeed and altimeter.

If TDI inaccurate (steps 11, 12, and 13):

*11. Use pitot-static instruments.

*12. Autopilot - Off.

*13. AUTO PITCH TRIM ac c/b - Pull.

If inlets unstart repeatedly or schedule abnormally:

14. Use the schedule for Manual Inlet Control.

If aircraft control difficulties are encountered:

*15. Complete the SAS Emergency Operation procedure.

If aircraft control does not improve:

*16. Complete the Pitch or Yaw Axis "Second" Condition Failure procedure.

With A and M computers failed, Pitch M and Yaw M sensors are not available and Pitch A and Yaw A servos are inoperative; however, the respective sensor and servo indicator lights on the SAS control panel do not illuminate. Failure of Pitch A and B sensors, failure of analytical redundancy plus Pitch A or B sensor, or failure of Pitch B servo results in loss of all pitch SAS. Failure of Yaw A and B rate-gyros, failure of analytical redundancy plus Yaw A or B rate-gyro, failure of Yaw A or B lateral-accelerometer or failure of Yaw B servo results in loss of all yaw SAS.

With B and M computers failed, Pitch B and Yaw B sensors are not available and Pitch B and Yaw B servos are inoperative; however, the respective sensor and servo indicator lights on the SAS control panel do not illuminate. Failure of Pitch A and M sensors, failure of analytical redundancy plus Pitch A or M sensor, or failure of Pitch A servo results in loss of all pitch SAS. Failure of Yaw A and M rate-gyros, failure of analytical redundancy plus Yaw A or M rate-gyro, failure of Yaw A or M lateral-accelerometer, or failure of Yaw A servo results in loss of all yaw SAS.

A, B AND M COMPUTERS OUT

If the A, B, and M CMPTR OUT caution lights illuminate, both inlets revert to restart unless in manual control. Use pitot-static instruments.

NOTE

The following systems or items are inoperative if all three DAFICS computers fail.

- TDI (front and rear)
- Auto Inlet
- Manual Inlet (If M computer loses A and C or B and C phase power)
- SAS
- Autopilot
- Mach Trim
- APW & High Alpha Warning
- AOA Indicator
- KEAS Warning
- CIP Barber Pole
- IFF Mode C
- Automatic Map Rate
- Altitude from ANS to V/H and RADAR
- TAS to ANS
- MRS (DAFICS related portions)
- All warning, caution, and condition lights on the main annunciator panel and system panels, associated with the above systems, will not illuminate.
- SURFACE LIMITER annunciator panel light will not illuminate.

WARNING

Only A, B, and M CMPTR OUT lights illuminate if all three DAFICS computers fail.

EQUIPMENT AVAILABLE WITH DAFICS COMPUTER(S) OUT

COMPUTER(S) OUT					
None or A or B	M	A and M	B and M	A and B	A, B and M
Auto Inlets	X	X	X		
Manual Inlets (See NOTE)	X	X	X	X	X
A Pitch Servo	X		X	X	
B Pitch Servo	X	X		X	
A Yaw Servo	X		X	X	
B Yaw Servo	X	X		X	
A Roll Servo	X	X	X		
B Roll Servo	X	X	X		
Mach Trim	X	X	X	X	
Autopilot	X	X	X		
APW & High Alpha Warning	X	X	X		
KEAS Warning	X	X	X		
AOA Indicator	X	X	X		
TDI (Pilot's & RSO's)	X	X	X		
Surface Limiter Caution Light	X	X	X		
DMRS (DAFICS Portions)				X	
CIP Barber Pole				X	
Altitude Reporting				X	
Altitude & TAS to ANS				X	
TAS to Auto Map Rate				X	
X Indicates Equipment Available					

NOTE: Manual Inlet control is disabled if the M computer loses A and C phase or B and C phase power.

Figure 3-16

A, B and M Computers Out Procedure

NOTE

If subsonic, accomplish only * items.

* 1. A CMPTR RESET switch - Reset.
* 2. B CMPTR RESET switch - Reset.
* 3. M CMPTR RESET switch - Reset.

If any of the computers reset, refer to the appropriate procedure for the computers which remain out.

If none of the computers reset:

4. Emergency ac bus switch -EMER AC BUS (up).

If any of the computers reset, refer to the appropriate procedure for the computers which remain out.

If none of the computers reset:

5. Restarts ON simultaneously.

   The throttle restart switch will expeditiously put both inlets in restart.

6. Maintain 350 KEAS.
7. Aft bypass - CLOSE.

Above Mach 2.5:

8. Throttles - 720° to Military.
9. IGV switches - LOCKOUT.
10. C. G. - Forward of 22%.

At Mach 2.5:

11. Throttles - Set 6500 rpm.

At Mach 2.0:

*12. C.G. - Forward of 20%.

*▲13. Use manual map rate.

*14. V/H SOURCE selector switch - VWSGT or MAN.

*T15. IFF MODE C switch - Out.

*16. Resume normal checklist procedures.

*17. Land when practical.

APW and HIGH ALPHA WARNING SYSTEMS

NOTE

- o With A and B CMPTR OUT lights illuminated, both the APW and High Alpha Warning systems are inoperative, but the APW annunciator light will not illuminate.
- o The APW stick shaker and pusher are disabled while the APW annunciator light is on.
- o The APW stick pusher is disabled when any two DAFICS computers are inoperative.

If DAFICS detects a 2 PTA failure, both the 2 PTA CHAN OUT and the APW annunciator caution lights illuminate. Refer to the 2 PTA Channels Out procedure, this section.

If the APW switch is OFF, the High Angle of Attack Warning system stick shaker will continue to operate. The High Alpha Warning system shaker limits are 14° when below Mach 1.55, and 8° when above Mach 1.55. The High Alpha Warning system may be unreliable if the 2 PTA CHAN OUT annunciator light illuminates.

The ADI pitch boundary indication continues to operate with the APW switch OFF. However, it should be considered unreliable if the APW light was illuminated before the APW switch was OFF or any of the following caution light combinations exist:

- 2 PTA CHAN OUT
- A and B CMPTR OUT
- PITCH SENSOR A, B and M

NOTE

Hydraulic power for APW stick pusher is lost if the A Hydraulic system fails.

The stick pusher assembly is a hydraulically powered piston. A solenoid valve on the assembly allows A hydro pressure to extend the piston when it receives an electrical signal from DAFICS. It is possible, through a series of failures in DAFICS, to have the stick pusher assembly extend. With an additional failure to retract, it would require 30 to 35 pounds pull force on the control stick to overpower the stick pusher spring; the control stick trigger and APW control switch would be ineffective. Inadvertent pusher activation could be particularly hazardous when supersonic or near the ground.

If the APW pusher extends, the elevons deflect 1.7° down from the trimmed position and the control stick moves 2.5° (1.5 inches) forward of neutral. A pull force on the stick of 30 to 35 pounds will be required to overpower the forward stick displacement. Pitch trim capability remains and can be used to retrim the elevons and relieve the stick force; however, the stick will remain approximately 2.5° (1.5 inches) forward of the original neutral position unless the pilot pulls aft with 30 to 35 pounds in addition to the normal stick force gradient. No abnormal force is required to move the stick forward of the new neutral position.

With trim indication at zero, the maximum manual up-elevon deflection is 10° (11.7° up from the new neutral position) with the APW pusher extended. This is due to mechanical limits in the mixer assembly. When the pusher is extended, the manual down-elevon deflection available, with trim indication at zero, remains 10° (8.3° down from the new neutral position).

WARNING

Immediately depress and hold the control stick trigger switch to deactivate the APW stick pusher if a false stick pusher activation occurs while close to the ground. If the stick pusher is not deactivated by the trigger, use a pull force of 30 to 35 pounds, in addition to normal stick forces, to overcome the stick pusher. Use pitch trim to relieve stick force.

For false stick pusher:

1. **TRIGGER HOLD.**

   Depress and hold the control stick trigger switch until the APW switch is turned off.

For continuous stick shaker operation, or false pusher warnings:

2. Pitch attitude - Keep within limits.
3. APW switch - OFF.

   Trim as required. Trim position affects up-elevon authority.

NOTE

If the stick trigger or APW switch do not deactivate the stick pusher, use a pull force of 30 to 35 pounds, in addition to normal stick forces, to overcome the stick pusher spring. Use control stick pitch trim to relieve stick force.

If shaker continues:

4. STALL WARN dc circuit breaker - Pull.

If false pusher continues:

5. Speed - A maximum speed of Mach 3.0 is recommended.

If higher speed must be maintained, the maximum recommended bank angle is 35°.

WARNING

Keep at least one hand on the control stick and monitor the ADI and stick position for any tendency of the aircraft to increase nose-up attitude in response to release of the stick pusher actuator.

NOTE

- Unless absolutely necessary, air refueling is not recommended because of the reduced elevon deflection available with the APW pusher extended.
- A c.g. aft of 19% is recommended for landing, to reduce elevon requirements.
- Trim position effects up-elevon authority. Use nose-up trim if increased elevon deflection is required for refueling or landing.

With an unreliable alpha indication:

6. Land when practical.

TWO PTA CHANNELS OUT

If the 2 PTA CHAN OUT annunciator caution light illuminates, air data functions may be unreliable although they will continue to operate.

If DAFICS detects a 2 PTA failure, both the 2 PTA CHAN OUT and the APW annunciator caution lights illuminate. The APW stick shaker and pusher are inoperative while the APW annunciator light is illuminated. The APW light may subsequently extinguish, but the 2 PTA CHAN OUT light will remain on until reset by maintenance personnel.

TDI and alpha indications should be cross-checked against the pitot-static operated airspeed and altitude instruments. If the cross-check shows the TDI to be inaccurate, revert to pitot-static operated airspeed and altitude instruments for aircraft control. Inlet unstarts can be expected above Mach 1.6 if TDI and alpha information is unreliable; the AUTO PITCH TRIM essential ac circuit breaker should be pulled and the autopilot should be turned off. SAS gain schedules may be in error and could result in poor aircraft damping in all three aircraft axes. Caution should be exercised about magnitude of rudder motion and angle of attack excursions induced. If inlets unstart, use manual control, referring to the pitot-static Mach and altitude instruments. If inlets do not clear, use the Inlet Unstart procedure, this section.

If all PTA self-check signals to the DAFICS computers fail, OFF flags appear in both TDIs. Air data functions are unreliable, although they may continue to operate.

2 PTA CHANNELS OUT PROCEDURE

If the 2 PTA CHAN OUT light illuminates, it will remain on until reset by maintenance personnel.

1. Check TDI against airspeed and altimeter.

If TDI inaccurate:

2. Use pitot-static operated instruments.
3. Autopilot - OFF.
4. AUTO PITCH TRIM ac c/b - Pull.

If inlets unstart repeatedly or schedule abnormally:

5. Complete the Inlet Unstart procedure.
6. AOA - Check Accuracy.

AIR DATA MALFUNCTION

Each PTA (A, B, M) is powered by its respective (A, B, M) computer. When the M CMPTR OUT annunciator caution light illuminates, the M PTA is not powered and the beta (sideslip) value goes to zero. Appropriate procedures are included in DAFICS Computer Failure procedures, this section.

Sideslip angle data is only provided by the M PTA. If sideslip data is erroneous, spike and door scheduling on both inlets will be biased excessively and may cause an unacceptable degradation in performance. If required, refer to Inlet Malfunction, this section.

If DAFICS is not receiving sideslip angle data from the M PTA (as determined by PTA self test), or the sideslip angle from the M PTA is unreasonably high (as determined by comparison with the yaw SAS lateral accelerometers), the angle of sideslip used for automatic inlet operation computations is zero and the DPR schedules for both inlets are biased slightly lower. Auto inlet scheduling will not be biased for sideslips, and unstarts are likely if the aircraft is yawed significantly. If unstarts occur, refer to Inlet Unstart and Inlet Malfunction, this section.

If air data malfunctions are not associated with DAFICS computer failures, refer to Two PTA Channels Out procedure, this section.

If accuracy of air data is suspect:

1. Cross-check TDI against pitot-static airspeed, Mach and altimeter.

If cross-check shows both TDI and pitot-static indications to be suspect:

2. Complete the Pitot-Static System Malfunction procedure.

If cross-check shows only TDI to be inaccurate:

3. Complete the 2 PTA Channels Out procedure.

PITOT-STATIC SYSTEM MALFUNCTION

The pitot and static pressure sources for the TDI are separate from the pitot and static sources for the pilot's airspeed, altimeter and inertial-lead vertical speed indicator; however, both pitot and static pressures are sensed in the nose boom. Both of the pitot-static sources may become inaccurate or inoperative from a common malfunction. In icing conditions, failure of the pitot heater may affect both systems (and angle of attack indication). The pitot probe also could be plugged by a foreign body.

If both TDI and pilot's direct pitot-static instruments are unreliable:

1. Maintain aircraft control by use of attitude and power.
2. Check pitot heat switch and circuit breaker.
3. Request chase aircraft for letdown and landing.

NAVIGATION SYSTEMS

Refer to Section IV for ANS and INS warning indications.

ANS MALFUNCTION

If the ANS REF annunciator caution light illuminates in either cockpit:

▲1. ATT REF SELECT switch - INS.

T 2. DISPLAY MODE SEL switch - Other than ANS.

(3.) BDHI HDG SELECT switch - INS.

(T4.) ANS circuit breakers - Check.

(T5.) Follow MAL light procedures.

INS MALFUNCTION

▲1. ATT REF SELECT switch - ANS.

T 2. DISPLAY MODE SEL switch - ANS.

(3.) BDHI HDG SELECT switch - ANS.

(T4) If the INS attitude appears reasonable, set the INS FUNCTION switch to ATT, BDHI HDG SELECT to INS, and set heading with HEADING SLEW knob.

▲5. ATT REF SELECT switch - As desired.

6. DISPLAY MODE SEL switch - As desired.

(T7) Cross-check and reset INS heading as required.

(T8) If the INS attitude is in error, perform the INS Airborne Attitude Alignment procedure.

ENVIRONMENTAL CONTROL SYSTEM

L OR R AIR SYSTEM OUT

If one air conditioning system fails or if the L or R AIR SYS OUT annunciator caution light illuminates:

1. Bay Air switch - OFF.

   This makes the maximum amount of cooling air available to the cockpits and closes the nose air shutoff valve.

(2.) Chine bay equipment (except MRS) - OFF.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

If supersonic:

3. Cockpit temperature control rheostat - COLD, if necessary.

   Approximately 75% of the normal flow of cooling air to the cockpits remains available.

4. Descend when practical.

   Supersonic cruise can be maintained indefinitely at reduced cooling if the power to the mission equipment is turned off.

5. Monitor E and R bay temperatures for indication of overheat.

COCKPIT OVERTEMPERATURE

High cockpit temperatures can result from failure of the cockpit air mixing valve, manifold temperature control valve, or hot air bypass valve. They can also result from malfunction of the cold air manifold, or cockpit air automatic or manual temperature controls, or if operation of an air cycle machine cooling turbine is marginal. High temperatures can also result from high fuel temperatures in the heat sink system, or if high back-pressure at the cooling turbines prevents effective operation.

With abnormally high cockpit air temperatures, check E and R Bay temperature. Suspect the cockpit temperature control system if E and R Bay and suit vent temperatures are normal.

1. Defog switch - Check CLOSED.

▲2. Cabin pressure select switch - 26,000 FT.

If automatic temperature control is not effective and cockpit temperature remains too high:

3. Cockpit temperature override switch - Hold in COLD.

NOTE

The motor driven valve takes from 7 to 13 seconds to travel from full hot to full cold.

4. Check E and R Bay temperature.

If there is no decrease in cockpit temperature in 30 seconds, or if the E and R Bay are also hot:

5. Manifold temperature switch - FULL COLD.

If there is no decrease in cockpit temperature in 30 seconds:

6. MANF TEMP dc circuit breaker - Pull.

   This deenergizes the hot air bypass solenoids, closes the hot air bypass valves (if open), and results in maximum available air-to-air and air-to-fuel cooling.

7. Bay Air switch - OFF.

   This makes the maximum amount of cooling air available to the cockpits and closes the nose air shutoff valve.

(8.) Chine bay equipment (except MRS) -Off.

CAUTION

+ The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

If supersonic:

9. Descend as soon as possible.

If below 25,000 feet MSL and temperature remains too hot:

(T10.) Cockpit air shutoff control - OFF (forward).

COCKPIT TOO COLD

Cockpit air and suit vent air temperatures may become unbearably low, even when cruising at high Mach, with some types of air conditioning system malfunctions or if the FULL COLD position of the manifold temperature control switch is selected inadvertently. Temperatures may be substantially below -30°F. A landing may be necessary if the condition cannot be corrected. In general, the aft cockpit will be colder. If the automatic and manual temperature controls are ineffective with AUTO manifold temperature selected, attempt to minimize suit vent air flow and increase suit air temperature. The pilot can use defog air to heat the forward cockpit. If these actions are not sufficient, shut off an air conditioning unit. Positioning the cockpit air handle OFF shuts off the cockpit air supply but does not shut off suit vent air flow.

1. Manifold temperature switch - Check in AUTO.

If in AUTO or no response:

2. Cockpit temperature override switch - Hold in HOT.

▲3. Suit Air Vent - As required.

4. Suit heat - Increase.

If cockpit temperature remains uncomfortably cold:

T 5. Defog switch - OPEN

   Defog air will only heat the pilot's cockpit.

If temperature remains uncomfortably cold:

6. One refrigeration switch - OFF.

▲7. Cabin pressure select switch - 10,000 FT.

If below 25,000 feet MSL and temperature remains too cold:

(T8) Cockpit air shutoff control - OFF (forward).

COCKPIT DEPRESSURIZATION

If the cockpit pressure is above 35,000 feet, the pressure suits will inflate.

1. Cockpit altitude - Check.

▲2. Canopy seal levers - Check ON.

3. Cockpit pressure dump switch - Check OFF.

   If all cockpit pressure has been lost (cockpit pressure equals ambient pressure), cycle the cockpit pressure dump switch, if desired.

(T4) Cockpit air shutoff control - Check on (aft).

WARNING

During this time, the crew members will be depending on the pressure suit for altitude protection.

If cockpit does not repressurize:

5. Descend as soon as possible.

CAUTION

Loss of cockpit pressurization, or cockpit air off at supersonic cruise will cause overheat and subsequent failure of the PTAs if a descent is not begun within 15 minutes.

SUIT OVERTEMPERATURE

1. Suit heat rheostat - OFF (full counterclockwise).

If tank 3 is near empty:

2. Press tank 2 on.

   At high Mach, as tank 3 nears empty, the temperature of tank fuel supplied to the fuel manifold and the fuel-air heat exchangers increases due to high skin temperature.

3. SUIT HTR ac c/b - Pull.

▲4. Suit vent flow - Restrict.

5. L and R AIR SYS OUT lights - Check.

6. Cockpit temperature - Check.

   If cockpit temperature is excessive, complete the Cockpit Overtemperature procedure, this section.

If overtemperature persists:

7. Descend as soon as possible.

E OR R BAY OVERHEAT

If E or R BAY OVERHEAT caution light illuminates:

1. Bay air temperature - Check.

   An indication in excess of 150°F confirms the overheat warning.

2. Manifold temperature switch - FULL COLD.

NOTE

An ANS undertemperature condition (ANS steady TOLR light indication) may eventually result from selecting FULL COLD.

▲3. Nonessential bay equipment (except MRS) - Off.

If overtemperature continues:

4. Descend when practical.

When overtemperature corrected:

5. Manifold temperature switch - AUTO.

LIFE SUPPORT SYSTEMS

NOTE

Steps with a # apply to the crewmember with a life support system malfunction.

BREATHING OR SUIT PRESSURIZATION DIFFICULTY PROCEDURE

\# 1. Advise other crewmember.

WARNING

If a breathing difficulty is experienced, immediately notify the other crewmember and check personal equipment and oxygen system controls, lights, and quantity and pressure indications.

For a suit or helmet leak, or if No. 1 <u>and</u> No. 2 oxygen systems are lost:

2. Begin normal descent.

For oxygen system or breathing difficulty, if using the emergency oxygen system, or for a helmet leak, descend below 10,000 feet cabin altitude (10,000 feet aircraft altitude, terrain and range permitting). Monitor oxygen system pressure and quantity.

With loss of Number 1 and 2 systems, the integrity of the standby system is suspect, as failures within Number 1 and 2 systems could result in loss of the standby system when it is selected. Be prepared to use the emergency oxygen supply.

For a leak in the pressure suit, descend below FL 350.

If either crewmember experiences continued difficulty in breathing or maintaining oxygen flow:

3. Make emergency descent.

\# 4. Emergency oxygen - Pull GREEN APPLE.

The dual emergency oxygen system provides sufficient duration for a normal descent if the helmet and emergency systems are intact.

▲5. Cockpit pressure select switch - 10,000 FT.

As the aircraft descends (with 10,000 FT selected), cockpit altitude will decrease toward the 5.0 psi differential pressure schedule shown by Figure 1-81. At 45,000 feet, for example, the cockpit altitude will be less than 19,000 feet.

For suit inflation:

6. Bay Air switch - OFF.

With partial suit inflation, cockpit pressure may be restored by turning bay air off. This also reduces cockpit out-flow by closing the nose air shutoff valve. With the bay air and nose air valves closed, there is sufficient engine bleed air pressure to maintain cockpit pressurization until engine speeds approach windmilling rpm.

▲7. Non-essential bay equipment (except MRS) - Off.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

8. Land when practical.

If either crewmember experiences abnormal psysiological symptoms or decompression sickness, land as soon as possible.

USE OF STANDBY OXYGEN SYSTEM

If one or both normal oxygen systems fail:

1. Standby oxygen system - ON, to failed system.

▲2. Standby system quantity and pressure - Monitor.

Switch liquid oxygen system quantity switch as necessary to monitor both systems.

If standby system quantity or pressure is depleting rapidly:

3. Standby oxygen system - ON, to other ship system.

4. Standby oxygen system - OFF, to failed system.

▲5. Monitor quantity and pressure of the remaining oxygen supply.

Be prepared to activate emergency oxygen (GREEN APPLE).

USE OF EMERGENCY OXYGEN

With loss of all three aircraft oxygen systems due to failures other than separation at the seat connection point, the individual crewmember's emergency oxygen should be available. Emergency oxygen duration is approximately 15 minutes.

#1. Pull GREEN APPLE.

CONTAMINATED OXYGEN

▲1. Pull GREEN APPLE.

▲2. No. 1 and/or No. 2 Oxygen supply levers - OFF.

Because emergency oxygen system regulated pressure is lower than the aircraft system pressure, turn the normal oxygen system supply lever(s) to OFF after actuating emergency oxygen if contamination of the aircraft system is suspected. Emergency oxygen duration is approximately 15 minutes.

USE OF PRESSURE SUIT AIR WITH ALL OXYGEN LOST

Aircraft ventilation air is capable of increasing suit pressure approximately 2.35 psi above cabin pressure. If all oxygen supplies are lost, it may be possible to establish ventilation airflow into the oral nasal cavity of the helmet by inflating the suit and loosening the face seal.

#1. Suit controller valve - Close.

NOTE

Tighten the helmet tie-down strap.

#2. Suit vent air valve - Open.

#3. Face seal - Loosen.

Loosen the face seal with the barrier control knob to aid airflow from the suit into the face area of the helmet.

4. Bay Air switch - OFF.

Shut off the bay air supply to make the most air pressure available to the cockpit and suit while descending. Make emergency descent.

(5.) Chine bay equipment (except (MRS) - OFF.

CAUTION

The chine bay equipment will overheat during subsonic or supersonic flight if electrical power to the equipment is not turned off. If supersonic, the E and/or R BAY OVERHEAT caution lights may illuminate even with the equipment off.

▲6. Cockpit pressure select switch - 10,000 FT.

7. Autopilot - KEAS HOLD and AUTO NAV, as desired.

   Consider using the autopilot with KEAS HOLD and AUTO NAV engaged to assist a safe descent.

(8.) RSO be prepared to eject.

   If the pilot has lost oxygen, the RSO must closely monitor attitude and speed, and evaluate the pilot's capability of making a successful recovery. If the pilot does not respond, and if aircraft control is obviously lost, the RSO should eject.

LOSS OF VISOR HEAT

Without visor heat, moisture could condense in the helmet and cause the oxygen controller to freeze during bailout.

#1. Check FACE HTR dc circuit breaker and communication cord.

2. Cockpit temperature - Increase near 100°F.

   Increase cockpit air temperature by use of automatic or manual air temperature controls. Defog air may also be used.

   Loss of visor heat can be a minor discrepancy if visor fogging and moisture condensation are controlled by increasing cockpit temperature and use of defog air.

If visor fogging begins to block vision:

#3. Insert feeding/drinking probe into helmet feeding port.

   This will help clear the visor by allowing a continuous flow of oxygen.

4. Descend below 10,000 foot cabin altitude, terrain and range permitting.

5. Autopilot - KEAS HOLD and AUTO NAV, as desired.

   Consider using the autopilot with KEAS HOLD and AUTO NAV engaged to assist a safe descent.

#6. Raise visor.

LOSS OF SUIT VENT AIR

#1. Check vent hose connection.

If affected crewmember perspires excessively:

2. Adjust cockpit temperature.

DRAG CHUTE SYSTEM

DRAG CHUTE UNSAFE WARNING

If the DRAG CHUTE UNSAFE annunciator caution light illuminates because of power loss to both actuator motors, the chute could still be in a safe condition and would not have to be deployed. However, to verify that loss of power to the actuator motors has occurred and that the chute mechanism is safe (will not deploy inadvertently):

While subsonic:

1. Airspeed - Establish 275-295 KEAS

   Speeds between 275 and 295 KEAS assure failure of the chute canopy, panel and/or shroud lines. Deploying the chute at lower speeds (255 KEAS or less) may result in a successful (unwanted) deployment. Maximum power would be insufficient to overcome the drag and break away the chute.

   WARNING

   Do not deploy the chute while supersonic.

2. Drag chute handle - Pull to deploy position then push to jettison position.

   Break away is accompanied by a slight nose-up pitching motion and a momentary shock. The pilot may hear a loud noise as chute separation or failure occurs. Depending on the nature of the break away, shroud lines may remain attached and stream behind the aircraft.

If the chute does not deploy and break away, assume that the chute mechanism is safe. Use emergency (mechanical) deployment after landing.

NOTE

The DRAG CHUTE circuit breakers on the pilot's essential dc circuit breaker panel may be pulled, if desired.

3. Land when practical.

After landing, if drag chute did not deploy and breakaway:

4. Drag chute - Deploy mechanically.

   Emergency chute deployment will be necessary after landing. A suitable base with a dry or grooved runway is preferred.

NOTE

If the light illuminates when committed to a landing, land and be prepared to deploy the chute mechanically.

LANDING EMERGENCIES

SINGLE-ENGINE PENETRATION & LANDING

This procedure may be used in lieu of the normal Before Penetration, Penetration, Before Landing and After Touchdown procedures when one engine is inoperative and the Engine Shutdown & Descent procedure has been completed. In addition, refer to All Weather Operation procedures, Section VII, when applicable.

1. Display mode selector switch - Set.

T 2. Defog switch - Set.

T 3. Altimeter - Set.

(4.) DEF systems power - OFF.

(5.) Sensor operate switches - STP.

(6.) Sensor power switches - Off.

(7.) V/H power switch - OFF.

(8.) Exposure power switch - OFF.

NOTE

Do not shut down the MRS.

(9.) G-Band Beacon switch - OFF.

(T10.) INS altitude - Update.

Update the INS altitude to field elevation.

11. Gross Weight & c.g. - Dump & transfer fuel as required.

When time and conditions permit, dump fuel to obtain normal landing weight. Monitor c.g. Transfer fuel as necessary to maintain subsonic c.g. limits (17-22%). If c.g. is between 14.5% and 17% no more than half the remaining fuel may be transferred to tank 1; otherwise, the reduced load factor limits shown by sheet 3 of Figure 5-5 are not valid.

12. Crossfeed switch - Pressed OPEN.

CAUTION

Leave crossfeed open to assure fuel supply to the engine(s) during landing and possible use of afterburner.

13. SAS channels - Set.

a. Operative engine pitch and yaw SAS - ON.

b. Inoperative engine SAS servos - Off.

b. Both roll SAS servos - Off.

WARNING

Do not air refuel or land with only one roll SAS servo engaged.

Below Mach 0.5:

14. Brakes & antiskid - Set.

a. For left engine failed - ALT STEER & BRAKES.

b. For right engine failed - ANTI-SKID ON.

(T) c. Brake switch - OFF.

d. Set antiskid - DRY/WET.

Use the DRY antiskid position for a RCR of 21 or more. Wet runway conditions shall be assumed to exist and the WET position used if RCR is less than 21. If RCR is not available, assume that a wet runway condition exists if moisture is visible on the runway, particularly as evidenced by glare or reflections.

15. Surface limiter control handle - Pulled, light off.

Pull and rotate the surface limiter handle 90 degrees to disengage the surface limiters, lock the handle, and extinguish the SURFACE LIMITER caution light.

▲16. UHF power selector - Set.

Set power 4 or lower if making ILS approach.

T 17. Defog switch - Set.

18. Landing light switch - Set.

▲19. Approach and landing speeds - Compute.

The minimum approach speed is 200 KIAS. If it is necessary to land with more than 35,000 pounds of fuel remaining, add 1 knot for each additional 1000 pounds.

A single-engine landing is basically the same as normal landing. Expand the pattern to avoid steep turns. Establish a steeper than normal final approach. A rate of descent of 1500 fpm is recommended.

Attempt to dump fuel and avoid a heavy weight landing if an instrument approach is required. When landing at heavy weight, the single-engine performance available with maximum power may not be sufficient to maintain a 2.5° glide path with the gear down.

At heavy weights, increase airspeed as necessary to maintain angle of attack less than 8 degrees for turns to base leg and 9 degrees for turns to final approach.

The APW stick pusher is inoperative if the A hydraulic system has failed.

20. Landing gear lever - DOWN and checked.

Check gear warning lights.

a. For left engine failed, put landing gear handle DOWN. If L HYD pressure is insufficient to lower the gear, use Gear Emergency Extension procedure, this section.

Allow additional time to lower the gear if the left engine is windmilling and normal gear extension is attempted.

At least 90 seconds must be allowed for gear emergency extension if the L hydraulic system is inoperative.

b. For right engine failed (if the left hydraulic system is operating), the landing gear may be lowered on final approach. Normal gear extension time is 12 to 16 seconds.

21. Hydraulic pressure - Checked.

With both engines operating (simulated single-engine, ADS failure, etc):

22. Right refrigeration switch - OFF.

(T23.) Cockpit air handle - OFF.

Place the cockpit air handle in the forward (valve closed) position to preclude cockpit fogging. The pilot's CKPT AIR OFF caution light should illuminate.

24. Annunciator panel - Checked.

NOTE

Lowering the vision splitter during night landings will reduce the glare caused by reflections off the inside of the windshield.

25. Rudder trim - Neutral.

During single-engine approach, the required rudder and bank compensation changes as thrust is varied. Set the rudder trim indication to neutral before landing so that, after power is reduced to idle in the flare, rudder position will be normal for landing.

When landing is assured, retard throttle smoothly and make a normal landing.

After touchdown:

26. Drag chute - Deploy

27. Nosewheel steering - Engage

28. Brakes - Checked

29. Retain drag chute, if practical.

    Jettison the drag chute for directional control, if required.

    Retain the drag chute, if practical, to reduce demand on the operative brake system.

    If the antiskid system relieves brake pressure and wheel rpm does not increase within 2.7 seconds: the antiskid fail-safe circuit should deactivate antiskid and illuminate the ANTI SKID OUT annunciator caution light; and braking without antiskid protection should become available.

    The L hydraulic system accumulator may provide up to 3 brake applications; however, the brake accumulator is not required to hold a charge after L hydraulic system failure.

With loss of L hydraulic pressure:

30. Stop straight ahead, have downlocks installed before clearing runway.

After landing, continue to monitor the ANS temperature lights.

CAUTION

Shut down the ANS after landing if the TEMP TOLR light flashes. This minimizes the possibility of ANS damage due to high internal temperatures.

SIMULATED SINGLE-ENGINE LANDING

Directional trim changes are more pronounced during an actual single-engine approach with one engine windmilling.

1. Retard one throttle to IDLE.

2. Follow Single-Engine Penetration & Landing procedure.

SINGLE-ENGINE GO-AROUND

Make decision to go-around as soon as possible and definitely prior to flare.

1. Throttle - As required.

2. Leave gear down until go-around is assured.

3. Landing gear lever - UP, as appropriate.

   Delay gear retraction until there is no possibility of contacting the runway.

4. Accelerate to 275 KIAS.

LANDING GEAR SYSTEM EMERGENCIES

GEAR UNSAFE INDICATION

An unsafe indication could be caused by low L hydraulic system pressure or malfunction within the landing gear extension or indicating system. With unsafe gear indication:

1. Landing gear CONT dc and landing gear IND dc circuit breakers - Check.

(T) 2. Landing gear switch - DOWN.

3. L hydraulic pressure - Check.

4. IND & LT TEST Push-button - Press.

   If a landing gear indicator light does not illuminate, either the indicator light circuit is faulty or the light bulb is burned out. Switching light bulbs with one known to be operative may restore a gear safe indication.

5. Recycle landing gear lever to down position, repeat as required.

If landing gear still indicates unsafe:

6. Accomplish Gear Emergency Extension procedure.

GEAR EMERGENCY EXTENSION

The landing gear emergency extension system unlocks the landing gear uplocks and allows the landing gear to free-fall to the down-and-locked position. The landing gear handle should be placed in the DOWN position and the landing gear control circuit breaker should be pulled to permit emergency gear extension. If the landing gear handle cannot be placed DOWN and the landing gear CONT circuit breaker is not pulled, the landing gear will retract if there is pressure in the R hydraulic system. The time required for emergency gear extension is 60 to 90 seconds. The emergency landing gear release handle must be pulled approximately 9 inches for full actuation. If it is not fully actuated, one or more gear may fail to extend. Up to 65 pounds of force is required.

If inability to extend the gear is due to a failure in the plastic knob on the landing gear control handle, slide the pin forward 1/4 inch to release a catch within the control handle mechanism, then push the gear handle down. Refer to Figure 3-17.

If normal gear extension is unsuccessful:

1. Landing gear handle - DOWN.

(T) 2. Landing gear switch - DOWN.

3. Landing gear CONT dc circuit breaker - Pull. (For SR-71B, also pull landing gear WARN dc circuit breaker).

4. Emergency landing gear release handle - Pull.

   Pull the GEAR RELEASE handle approximately 9-1/3 inch. Up to 65 pounds of force is required.

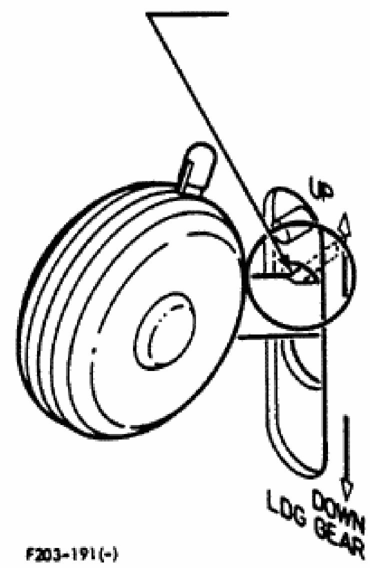


Figure 3-17

CAUTION

The landing gear must not be retracted while the emergency gear release handle is pulled as damage to the system can result. The GEAR RELEASE handle must be stowed before attempting to retract the gear.

If gear is down and locked and R hydraulic pressure is normal:

5. Brake switch - ALT STEER & BRAKE.

   With the landing gear CONT dc circuit breaker open, selecting ALT STEER & BRAKE restores nosewheel steering. Hydraulic power for nosewheel steering is automatically supplied by the L system if its pressure remains above 2200 psi; otherwise, the R system will provide hydraulic power. Power for the brake system will be supplied by the R hydraulic system and the antiskid system will be operative.

   The landing gear strut dampers will be inoperative unless L system hydraulic pressure remains available. The normal brake system accumulator pressure is isolated so that its pressure is not dumped when ALT STEER & BRAKE is selected; however, the brake accumulator is not required to hold a charge after L hydraulic system failure.

6. Retain the drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

7. Stop straight ahead, have downlocks installed before taxiing.

If gear still indicates unsafe:

8. Increasing airspeed and pitch pulses may lock a partially extended nose gear.

9. Yawing aircraft may lock a partially extended main landing gear.

If gear appears down, but still indicates unsafe:

10. Igniter purge switch - Dump during approach.

    Holding the spring-loaded switch up for 40 seconds will dump a full load of TEB.

11. Battery switch - OFF.

▲12. Shoulder harness - Manually LOCK.

13. Make normal landing on side of runway away from unsafe gear.

14. Hold weight off unsafe gear, lower nose at 130 KIAS.

15. Retain the drag chute after landing, if practical.

    Jettison the drag chute for directional control, if required.

16. Stop straight ahead, have downlocks installed before taxiing.

If gear is definitely not down and locked:

17. Accomplish Partial Gear Landing procedure.

PARTIAL GEAR LANDING

A landing with the nose gear retracted or with all gear up should not be attempted. Under ideal circumstances, a landing with the nose gear extended and both main wheels retracted may be possible. If this configuration can be accomplished, base a decision to land or eject on whether or not other factors are favorable.

If a decision is made to land, conventional final approach and landing speeds and attitudes are recommended. This will result in the tail touching while the nose height is less than normal. An attempt to hold the aircraft off by using a higher pitch angle is not recommended because of the greater possibility of high impact loads as the nose gear slaps down. Tank 1 should be empty, if possible.

1. Acccomplish nose-gear-only configuration, as follows:

   a. Landing gear CONT dc circuit breaker - Push in.

   b. Landing gear lever - Up.

   c. Landing gear CONT dc circuit breaker - Pull.

   d. Emergency gear release handle -Pull to release nose gear only (first lock releases nose gear). Check nose gear down light - ON.

2. Do not transfer fuel forward.

3. Fuel dump switch - DUMP, if necessary.

4. Igniter purge switch - Dump during approach.

   Holding the spring-loaded switch up for 40 seconds will dump a full tank of TEB.

5. Battery switch - OFF.

▲6. Shoulder harness - Manually LOCK.

▲7. Canopy jettison handle - Pull, if desired.

NOTE

If the canopy is not jettisoned prior to landing, it should not be unlocked until the aircraft has stopped.

8. Make normal approach and landing.

9. Drag chute - Deploy.

(T) a. Drag chute switch - OFF.

10. Use rudders for directional control.

11. Retain the drag chute after landing, if practical.

Jettison the drag chute for directional control, if required.

12. Throttles - OFF, when directional control is no longer possible.

NOTE

Interphone will not be powered.

▲13. Abandon aircraft.

MAIN GEAR FLAT TIRE LANDING

For a landing with one or more flat tires, turn the antiskid system off to obtain effective braking. With antiskid on, the brake system prevents spin-down of the inboard and outboard wheels of each truck. If either or both of these tires has failed, normal runway contact is not made and they tend to lock-up when braking is attempted. The antiskid system defeats the braking attempt by releasing brake pressure as soon as the wheel starts to spin down.

Plan the landing for minimum gross weight, and touchdown on the good truck first on the side of the runway away from the flat tire(s). Little danger exists when landing at light weight if only one tire on a truck has failed, as the remaining tires have sufficient strength to support the aircraft. If two tires on a truck have failed, the third may fail during the roll-out because of the overload.

When all tires on a truck are known to have failed, apply enough brake pressure to lock all three wheels on that side. Maintain the pressure to prevent spin-up and the tire/wheel fragmentation that might result with rolling wheels. Use asymmetric braking (modulating the opposite side), nosewheel steering, and rudder and elevon roll inputs for directional control and stopping.

Engine shutdown is not recommended unless critical for stopping. Do not shut down the engine on the downwind side if an appreciable crosswind exists. Left engine shutdown would require selection of the alternate brake system. Therefore, if a choice exists, landing into the wind or at least with the right engine into the crosswind is preferable. After S/B R-2695, if the left engine must be shut down, select the alternate brake system then depress and hold the trigger switch to disable antiskid.

With all tires failed on both trucks, lock the wheels and skid to a stop rather than risk wheel fragmentation. Use the nosewheel and aerodynamic steering for directional control.

1. Gross weight - Dump fuel to obtain minimum gross weight.

2. Antiskid - OFF.

3. Make normal landing on side of runway away from flat tire(s).

4. Touch down on good tires.

5. Hold weight off bad side as long as possible using full aileron.

6. Drag chute - Deploy, as soon as possible.

(T) a. Drag chute switch - OFF.

7. Nosewheel - Lower.

8. Nosewheel steering - Engage.

9. Brakes - Apply cautiously.

   Refer to Abort procedure, this section.

10. Use nosewheel steering and differential braking for directional control.

11. Retain drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

WARNING

If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

BLOWN MAIN GEAR TIRE AFTER LANDING

If main gear tire failure is suspected or occurs after touchdown and braking is abnormal:

1. **ANTISKID OFF.**

   Set the brake switch to OFF or, after S/B R-2695, depress and hold the trigger switch.

   Tire failure may be heard or felt by the crew; however, the primary indication of failure is ineffective braking on one side with antiskid braking selected. Refer to the Main Gear Flat Tire Landing procedure.

CAUTION

- If antiskid OFF is selected, R system hydraulic power is not available for braking or steering.
- The antiskid brakes are disabled if the landing gear BRK & SKD dc circuit breaker is opened. The alternate brake and the alternate nosewheel steering systems are also disabled.

2. Brakes - Apply cautiously.

   If tire failure occurs, increased brake pressure will be required to maintain braking force on the remaining tires. Moderate to heavy brake pressure may be required to prevent spin-up of wheels with failed tires and wheel and/or tire disintegration at high rotational speeds. Refer to Abort and Main Gear Flat Tire Landing, this section.

3. Nosewheel steering - Check engaged.

   Check for illumination of the STEER ON light.

4. Use nosewheel steering and differential braking for directional control.

5. Retain drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

WARNING

If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

NOSE GEAR FLAT TIRE LANDING

If it is necessary to land with a flat nosewheel tire(s), avoid c.g. forward of 20% if possible.

1. C.G. - 20% to 22%.

After normal touchdown:

2. Drag chute - Deploy.

   (T) a. Drag chute switch - OFF.

3. Nose gear - Hold off to 130 knots, then lower gently.

4. Use nosewheel steering and differential braking for directional control.

5. Retain the drag chute after landing, if practical.

   Jettison the drag chute for directional control, if required.

After stop, before shutdown:

6. C.G. - Forward of 17%.

LANDING WITHOUT NOSEWHEEL STEERING

It should be possible to stop safely without nosewheel steering when landing on a dry or grooved runway with crosswind components within recommended values. However, crosswinds combined with a slippery runway or damaged tire can be hazardous.

NOTE

> Do not overcontrol the aircraft on a slippery runway and start a lateral skid. The reduced side reaction force capability of the main gear tires may result in a "break out" and slide.

Distinguish between aircraft heading and ground track. A lateral skid can develop if the main gear loses traction because of a slippery runway and/or damaged main gear tires. The ground track will probably diverge downwind. First, attempt to regain traction by steering into the skid. If this is successful, bring the heading back parallel to the runway centerline, then steer to the upwind side of the runway. Steer by applying roll control first. After full elevon deflection is reached, use rudder as necessary. Lateral stick deflection toward the desired direction of heading change should start a turn, but without the side force in the opposite direction which the rudders produce. Upwind rudder deflection produces a turn, but also results in a downwind rudder force which compounds the downwind skid problem.

Jettison the drag chute if roll control and use of the rudders fails to correct the ground track and it appears that the aircraft may slide off the runway. Otherwise, retain the drag chute.

If traction cannot be regained by turning into the skid, and if the ground track continues to diverge, try bringing the aircraft heading around so that it is well upwind of the ground track direction. This moves the relative wind to the other side of the nose, and puts the upwind weathercock force in the direction of the ground track. The thrust component of the idling engines tends to correct the track. If the aircraft continues to slide, the weathercock force will tend to rotate the heading back into the relative wind. Use roll control first, then the rudders, to keep the heading upwind and maintain a track on the runway. Use differential braking whenever main gear traction can be regained.

NOTE

> Assymmetric thrust is not recommended for directional control because of the difficulty expected in obtaining a controlled and timely response. Lateral stick and rudder steering should be adequate to control aircraft heading. However, if an otherwise irretrievable drift has developed, short bursts of equal thrust on both engines may correct the ground track to stay on the runway for barrier engagement. Thrust is in the proper direction to help regain runway position.

The effects of the weathercock force and aerodynamic steering with the elevons and rudders is shown by Figure 3-18 for a heavy crosswind combined with a slippery runway and ineffective nosewheel steering.

FLAT STRUT LANDING

The initial indication of a flat strut on landing is a 5° - 10° wing low condition after touchdown, and a directional control characteristic similar to that for crosswinds. Directional control may be difficult. The wings-not-level attitude is similar to that for all tires blown on one side and causes uneven loading of the inboard and outboard tires on each truck. This may result in wheel spin-down for the more lightly loaded tires during braking. Protracted cycling of the antiskid

EFFECTS OF WEATHERCOCK FORCE AND AERODYNAMIC STEERING ON CROSSWIND LANDING WITHOUT NOSEWHEEL STEERING

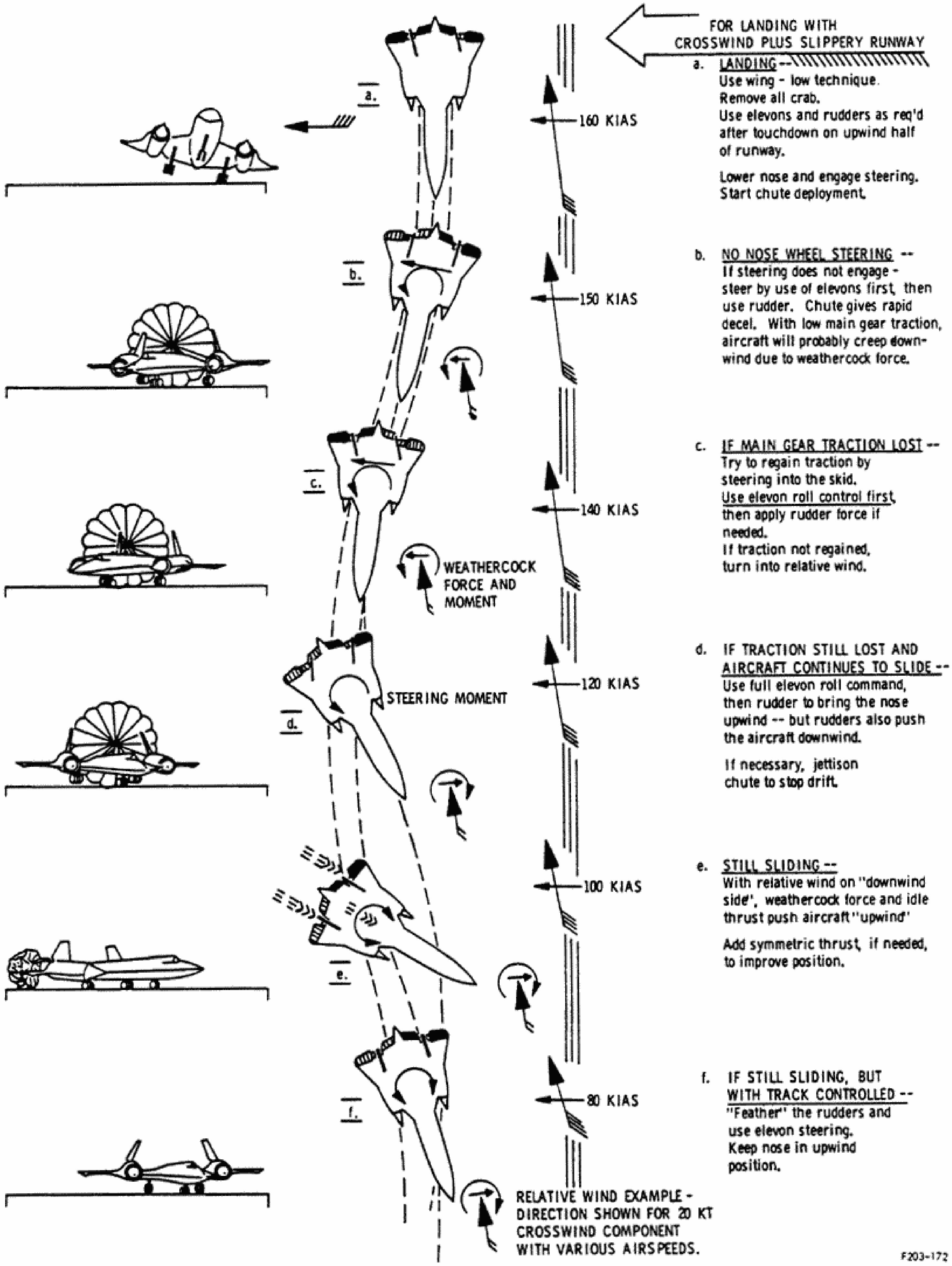


Figure 3-18

[redacted]

system can occur and result in reduced braking effectiveness if the antiskid system is not turned off. When brakes are applied, the lightly loaded tires may blow out.

After stop, clear the runway and wait for assistance. If inflation of the strut is not possible, the other strut should be deflated to 1" clearance to reduce side loads during aircraft movement. Slow taxiing is permitted; however, towing is recommended.

FLAT STRUT LANDING PROCEDURE

1. Antiskid - OFF.

After landing:

2. Drag chute - Deploy.

   (T)a. Drag chute switch - Off.

3. Lower nose immediately.

4. Nosewheel steering - Engage.

5. Brakes - Apply cautiously.

6. Use nosewheel steering and differential braking for directional control.

7. Retain the drag chute, if practical.

   Jettison the drag chute for directional control, if required.

   WARNING

   If there is no fire, do not shutdown until fire-fighting equipment arrives. Engine shutdown vents fuel in the wheel brake area, thus creating a fire hazard.

<u>GEAR DOWN AIR REFUELING</u>

During air refueling rendezvous, airspeed must be monitored to prevent exceeding landing gear limits. Engine response is very rapid; therefore, throttle movements just prior to and during contact should be less than those used at normal refueling altitudes.

<u>COCKPIT FOG</u>

COCKPIT DEFOGGING

The possibility of cockpit fogging exists when ambient humidity is high. When the ambient air is cooled below its dew point temperature, moisture condenses into fog. Fogging will be most noticeable near sea level when near Military rpm. Under these conditions, the rate of airflow into the cockpit is greatest and the air may be cooled to as low as 37°F.

<u>Cockpit Temperature Control</u>

To eliminate cockpit fog, raise the temperature of the cockpit air to evaporate the moisture. This can be accomplished by either manual or automatic control of cockpit temperature.

<u>AUTO TEMP Control Positioning</u>

If cockpit fog is anticipated due to high ambient humidity, attempt to set the automatic temperature control to maintain cockpit temperature at or slightly above ambient temperature while the engines are at a high rpm. A little experimenting should establish a position on the AUTO TEMP selector that prevents excessive fogging. After takeoff, readjust the control for comfort. The same control position may be reestablished prior to landing to prevent fogging.

<u>Water Separators</u>

To minimize system pressure drop and to maintain maximum refrigeration capacity, the aircraft is not provided with a water separator in the cockpit air supply duct. A water separator in the cockpit system would cause considerable back-pressure at the cooling turbines. Water separators provided in the supply ducting to the ANS and mission equipment do not affect the overall refrigeration system performance. The equipment bays are not pressurized and additional pressure drop at these points does not raise the cooling turbine discharge pressure.

If fogging is encountered and increasing cockpit temperature is not practical:

(T1.) COCKPIT AIR OFF.

Position the cockpit air handle off (forward).

2. Right refrigeration switch - OFF.

Turn both refrigeration switches off if the cockpit air handle is inoperative; however, this will result in loss of cooling air to the ANS and requires ANS shutdown.

If cockpit fog persists:

3. Defog switch - OPEN, then HOLD.

Defog hot air is available to raise the cockpit air temperature and evaporate the moisture, unless both refrigerators are turned off.

4. Bay air switch - OFF.

5. Cockpit temperature override switch - COLD 10 sec, then HOLD.

This causes the cockpit temperature control valve to close and prevents excessive hot air from entering the cold air manifold.

DAMAGED AIR REFUELING RECEPTACLE

If the air refueling receptacle is damaged, or if streaming fuel is reported after landing, make a complete stop on the runway and attempt to obtain precautionary assistance from fire fighting personnel and equipment before taxiing. If immediate taxiing is necessary to clear the runway, accomplish the turn at slow speed to minimize fuel spillage. Fuel sloshing from a damaged receptacle can be ingested by an inlet if taxi speed is not minimized while turning.

WARNING LIGHTS SYSTEM

Illumination of any light(s) on the annunciator panels indicates an abnormal or emergency operating condition, or a situation deserving special attention. A summary of the lights and recommended actions is provided in Figure 3-19.

TACTICAL LIMITS

Normal Restrictions vs Tactical Limits

If the crew finds the normal operating restrictions unacceptable because of operations in a hostile area, the pilot is authorized to use the tactical limits listed in Figure 3-20 to exit the hostile area by the most expeditious means.

The margin of safety provided by the tactical limits is substantially reduced and exposure to such limits must be as brief as possible. They are to be used only when adherence to the normal/emergency restrictions would place the aircraft in a more hazardous situation because of probable hostile actions. Subsequent reentry into situations which rely on use of these limits is NOT authorized.

Figure 3-20 summarizes the existing operating restrictions and the tactical limits which are authorized with various malfunctioning systems. The term "tactical limits" is NOT synonymous with aircraft limits provided in Section V.

WARNING

The use of tactical limits is not authorized for training conditions, or for operational missions outside a hostile area.

EMERGENCY ENTRANCE

If qualified ground personnel are not available, use the procedures illustrated in Figure 3-21 for emergency access to the cockpits and crew.

ANNUNCIATOR PANEL LIGHTS ANALYSIS CHART

LIGHT	CONDITION	RECOMMEMDED ACTION
	RED WARNINGS	
C.G.	c.g. aft 25.3% or fwd of 17%	Correct c.g. Transfer fuel or manually select tanks.
FUEL PRESS	Pressure to engine below 7 psi	Open crossfeed and press tank 4 on.
A or B HYD	Quan below 1-1/4 gal or press below 2200 psi	Descend if supersonic. If pressure low, stay below 350 KEAS, check SAS, & land.
L or R HYD	Quan below 1-1/4 gal	Restart on and begin descent to subsonic speed.
OIL QTY	Eng quan below 2-1/4 gal	Descend if supersonic. Monitor pressure.
OIL TEMP		Not functionally operating. Will only illuminate when the IND & TEST button is depressed.
TANK PRESS	Tank press below 0.25 psi	Check LN_2 quan. Decrease rate of descent.
	AMBER CAUTIONS	
A CMPTR OUT	No degradation of DAFICS for single failure.	Reset A computer. Redundancy is lost if computer does not reset.
AIR SYS OUT	Air cond sys off or failed	Bay air off. Chine eqpt off (except MRS). Temp control to COLD. Monitor bay temps.
ANS FAIL ANS REF	ANS hdg & attitude ref lost. RSO's MAL or TEMP LIMIT warning on, or nav sys not ready.	Set attitude ref to INS. RSO check ANS for MAL or TEMP LIMIT. Shutdown ANS if req'd.
ANTI-SKID OUT	Anti skid braking inop	Recycle anti-skid or set anti-skid off. If L HYD light on, set alt steer & brake.
AUTO NAV OUT	Autopilot Auto Nav mode disengaged	RSO confirm that AutoNav off desired.
APW	Auto pitch warn sys off	Monitor α . Check ADI pitch boundary ind. High α system still operates stick shaker.
AUTO PILOT OFF	Autopilot disengaged or will not engage	Check attitude reference. Cycle ATT REF SE-LECT switch. Reengage autopilot if desired.
BAY AIR OFF	Bay Air switch off	Turn Bay Air switch on. If no result, mainten-ance action required before flight.
BAY OVERHEAT	Bay temp over 150° F	Set manifold temp FULL COLD. Turn non-essential bay equipment off.
B CMPTR OUT	No degradation of DAFICS for single failure	Reset B computer. Redundancy is lost if computer does not reset.
CANOPY UNSAFE	Canopy not locked, or seal not inflated	Check latches, handles fwd & locked, seal pressure on. Land if canopy unsafe.
CKPT AIR OFF	RSO's cockpit air handle off (fwd)	If landing: turn R refrig off. If temp high: use cockpit o'temp procedure.
DRAG CHUTE UNSAFE	Mechanism unsafe, or pwr lost to both chute motors	In flt, try norm deploy at safe alt & 275-295 KEAS subsonic. Use emer deploy after landing.
EMER BAT ON	Ess dc on battery pwr. Both gens or T/R's off	Attitude ref to INS, check instr inv & SAS. Try to reset gens if out. If no result, control c.g., conserve batteries, and land.

Figure 3-19 (Sheet 1 of 2)

ANNUNCIATOR PANEL LIGHTS ANALYSIS CHART

LIGHT	CONDITION	RECOMMENDED ACTION
FUEL QTY LOW	At $6^{\circ}\alpha$, tank 1 below 5400 lb. and tank 4 below 4050 lb.	Xfeed open. Check fuel sequencing. If total fuel qty is low, land or refuel. If low qty not confirmed in tank 1 or 4, cycle A/R switch.
GEN BUS TIE OPEN	ac buses are split	No action unless ac power erratic;, then cycle the right gen to OFF and NORM.
GEN OUT	Respective generator is disconnected.	Recycle gen, check bus tie light, land ASAP. 350 KEAS & Mach 2.8 are limits with one gen.
INS REF	INS hdg inaccurate, cmptr or platform failed.	Select ANS attitude reference. RSO check INS heading and attitude.
INSTR INVERTER ON	Both gens out. Emer ac on inverter pwr.	If gen power cannot be restored to dc bus, conserve batteries and land.
MANUAL INLET	Restart on, or spike/door controls not all in auto.	If manual op not desired, turn restart off or turn spike & fwd door controls to Auto.
M CMPTR OUT	Inop: CIP-barber pole, automatic map rate, RADAR ALTITUDE, TAS to the ANS, and IFF Mode C.	Reset M computer. If computer does not reset, refer to SINGLE COMPUTER OUT.
N QTY LOW	Respective LN_2 sys quan below 3 liters.	Monitor fuel tank pressure. Limit speed is Mach 2.6 if all LN_2 low.
OXY PRESS LOW	Respective oxy sys press below 50 psi.	Use standby oxygen system.
OXY QTY LOW	Respective oxy sys quan below 1 liter.	Use standby oxygen system.
PITOT HEAT	Pitot heat switch in wrong position.	Check altitude. Change pitot heat switch position.
SAS OUT	Flight Mode	Try to recycle failed sensor or servo. Refer to SAS Lights Chart.
	Ground Test Mode	If BIT TEST light is flashing, press one of the six recycle switches.
SENSOR FAIL	Sensor malfunction	RSO check PWR & Sensor panel for fail indication.
SURFACE LIMITER	Surface limiter position not correct	Engage or release limiter handle.
2 PTA CHAN OUT	Air data may be unreliable	Check pitot-static instruments. Turn Autopilot Off. Pull AUTO PITCH TRIM ac c/b. If inlets unstart use manual inlet control & schedule.
WINDSHIELD DEICE ON	Windshield hot air on.	Monitor need for hot air de-icing.
XFMR RECT OUT	Respective transformer-rectifier not supplying pwr	For both lights on, check battery & SAS on. Land as soon as possible.

Figure 3-19 (Sheet 2 of 2)

TACTICAL LIMITS

Condition	Present Limit or Restriction	Tactical Limit
Limit Mach, Speed and Altitude Schedule -- With automatic inlets	Mach 3.2, aft c.g. limit = 25% MAC. Min airspeed = 310 KEAS unless restricted by 8° α or APW boundary. 85,000 ft max altitude. 45° max bank angle.	Mach 3.3 permitted with aft c.g. limit = 24.3% MAC when authorized by the commander.
With manual inlet control	Mach 3.0, aft c.g. limit = 25% MAC. Min airspeed = 310 KEAS unless restricted by 6° α or APW boundary. 400 KEAS max above FL 700. 80,000 ft max altitude. 20° max bank above FL 750, 35° max bank above FL 700.	Mach 3.2 permitted with aft c.g. limit = 24% MAC.
With loss of LN_2	Mach 2.6 maximum. −0.5 psi min tank pressure.	If in climb or cruise, Mach 3.2 and 85,000 ft max. Decel to Mach 2.6 10 minutes before descent and deceleration to subsonic speed and altitude conditions. Loiter 10 minutes between FL 400 and 350 at 0.9 Mach (above 250 KEAS) before refueling or landing if LN_2 is lost above Mach 2.6 while descending.
Single generator failure	Mach 2.8, 350 KEAS maximum.	Mach 3.2, 400 KEAS maximum.
SAS pitch or yaw, first failure	Mach 3.0, 400 KEAS. Intermediate Altitude profile recommended for cruise until below 350 KEAS. Avoid high-bank turns if practical.	Mach 3.2 permitted with aft c.g. limit = 24% MAC. 400 KEAS maximum.
SAS pitch or yaw, second failure	Mach 2.0, 350 KEAS maximum Aft c.g. limit = 22% MAC.	Speed available with both restart switches on, maximum afterburner, aft c.g. limit = 22% MAC.
L <u>or</u> R hydro system failed, or L <u>and</u> R hydro systems failed	Mach 2.3 maximum.	Speed available with one or both restart switches on, maximum afterburner.
A <u>or</u> B hydro system failed	Subsonic Mach required, 350 KEAS maximum.	Mach 3.2 permitted, 350 KEAS maximum.
High compressor inlet temperature	427° C CIT maximum	450° C CIT permitted with rpm within normal limits and Mach number within tactical limit. Report maximum CIT and time above 427° C. One hour total accumulated time allowed per engine.
High engine rpm	7450 rpm below 300° C CIT and 7300 rpm above 300° C CIT. Report maximum rpm and time above limit rpm if overspeed occurs.	7500 rpm permitted below 300° C CIT and 7350 rpm above 300° C CIT. Report maximum rpm and time above normal rpm limit if overspeed occurs.

F203-197(b)

Figure 3-20

CRASH RESCUE PROCEDURES

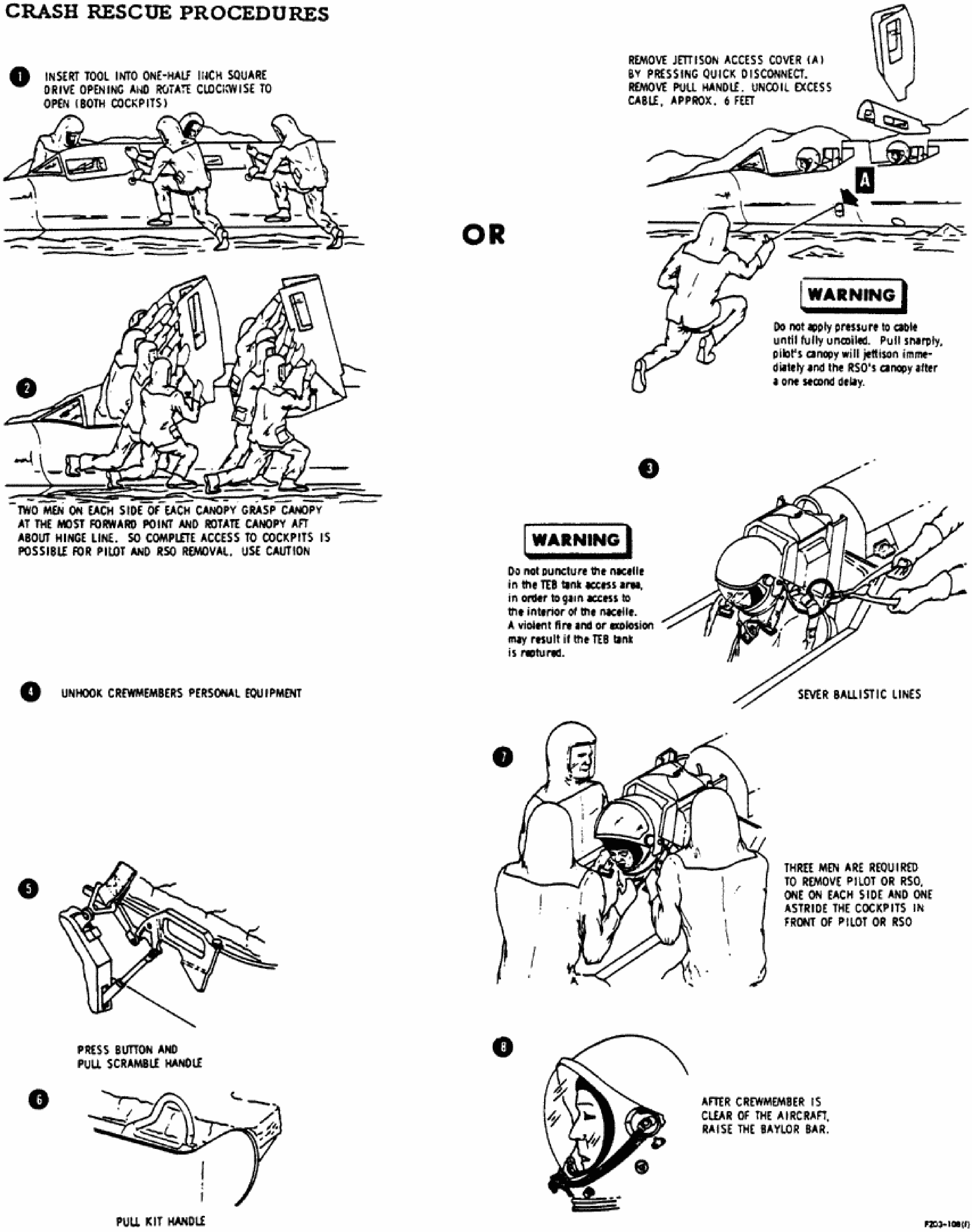


Figure 3-21

ASTROINERTIAL NAVIGATION SYSTEM (ANS) TAPE 12

The ANS is an inertial navigation system employing a star tracker to eliminate gyro drift and to limit position error. The system provides a steering signal to the autopilot for guiding the aircraft automatically along a predetermined flight path. It provides heading, attitude, and position information to cockpit displays. The ANS can control the CAPRE side-looking radar and technical objective cameras for imaging operations. The ANS supplies navigational data to the electromagnetic - reconnaissance sensor and mission data to the mission recorder system. See Figure 4-1 for an ANS functional diagram.

SYSTEM INTERFACES

The ANS provides signals for aircraft sytems as seen in Figure 4-1. The following equipment is either controlled by or receives inputs from the ANS:

1. DAFICS (for Autopilot and SAS analytical redundancy (ANR)).
2. Attitude Indicators (Pilot and RSO).
3. Flight Director Computer.
4. Horizontal Situation Indicator (Pilot).
5. Bearing, Distance, Heading Indicator (RSO).
6. Mission Recorder System.
7. EIP.
8. Technical Objective Cameras (in AUTO).
9. Optical Bar Camera
10. V/H System.
11. Viewsight.
12. Radar, including the RCD (controlled when in AUTO).
13. RSO Annunciator Panel.
14. Pilot Annunciator Panel.
15. Sensor time counter driver.
16. Peripheral Vision Display (PVD).

MODES OF OPERATION

The navigation system has four navigation modes: (1) astro inertial, (2) inertial only, (3) airstart (airspeed-damped astro inertial), and (4) dead reckoning. Figure 4-2 summarizes the navigational errors expected in each mode. The mode to be employed depends on the time for activation and alignment, and whether the aircraft is on the ground or airborne when the ANS is turned on. Astro inertial is the preferred mode.

ASTRO INERTIAL Mode

In this mode, navigation errors will be relatively small, depending on the alignment method, and do not increase with mission duration. As soon as the system begins navigating the star tracker automatically begins to search for stars. Stars are normally tracked at night and during the day provided good sky conditions exist. A 61 star catalog is stored in the ANS computer. Either normal or special coverage for the SR-71B trainer can be provided. The sun, moon and planets, are not used by the star-tracker. At least two different stars must be tracked for optimum performance. The star tracker measures the difference between the inertial platform orientation and celestial computed position. Data derived from stars is used to correct true heading, computed position, computed velocity, platform tilt, and gyro drift rates. Measured gyro drift rates are stored in the computer memory and are used to improve any subsequent inertial only navigation. This sequence eliminates the unbounded position error growth characteristic of pure inertial systems.

In a normal mission, either a rapid or gyro compassing alignment is performed prior to navigation. These alignments require 18 minutes and 36 minutes respectively, exclusive

NAVIGATION AND SENSOR CONTROL SYSTEM

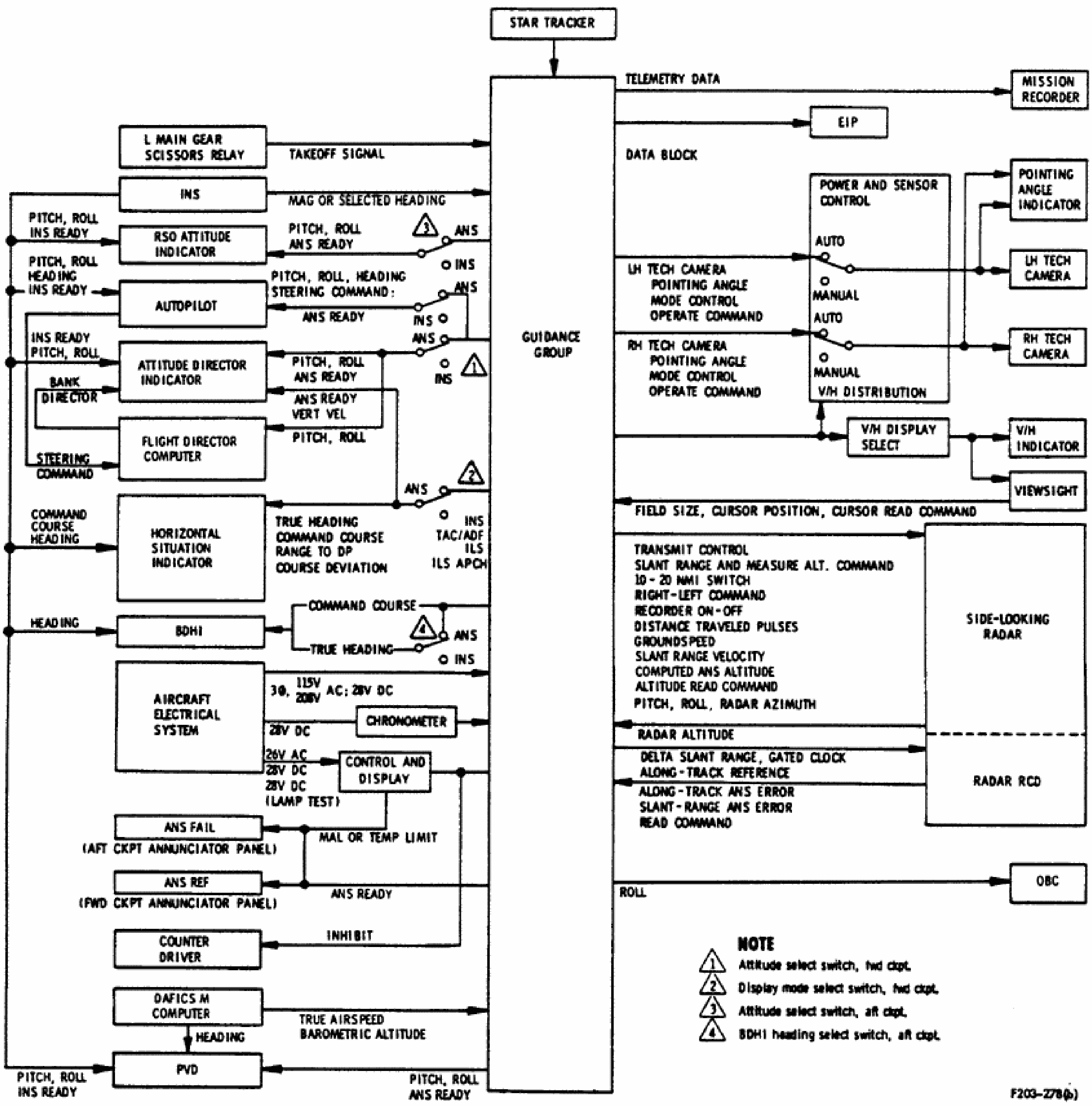


Figure 4-1

of warmup time. A ground hot start can be performed on a system previously aligned and shut down or on a system which has been shut down after operation in the astro inertial or inertial-only mode, provided the aircraft has not been moved. A runway heading alignment is recommended after a rapid alignment or a ground hot start. A heading update may or may not be required.

INERTIAL-ONLY Mode

INERTIAL-ONLY mode, in which only the inertial portion of the astroinertial system is employed, is recommended when the star-tracking capability of the navigation system is impaired. In this mode, navigation errors are unbounded.

AIRSTART Mode

The airspeed-damped, astro inertial (airstart) mode, which uses both the inertial platform and star tracker, is intended for: (1) scramble-initiated flights when the system is not prepared for a ground hot start, and (2) restart in flight. In this mode, errors can be large at first but should damp down with time to the values in Figure 4-2. Dead reckoning data are used for present position until three different stars have been acquired (steady illumination of the star ON light). Star acquisition is critical for accurate navigation.

Dead Reckon Mode (DR)

If the ANS inertial platform fails, navigation may continue using dead reckoning. In DEAD RECKON mode the ANS computer navigates using heading from the INS, true airspeed from the DAFICS (M computer) and inflight winds filled by the RSO. Position error increases proportional to errors in these inputs.

SYSTEM ERRORS

Error values in Figure 4-2 are based on the high altitude flight profiles. Abnormal flight profiles (low-altitude, race-track, touch-and-go, etc.,) may result in errors in excess of the listed values. The error values listed are probable radial errors (CEP's); therefore, under normal system operation, the listed errors will be exceeded about half the time. When star tracking is lost, a residual position error may develop that will not be totally eliminated when star tracking resumes. It might take as many as 3 navigation position updates (depending on Schuler cycle period) and a steady C star light to eliminate the total residual error.

SYSTEM COMPONENTS

The navigation system has three major assemblies: the control and display panel, the portable chronometer, and the guidance group. The control and display panel (Figure 4-3), located on the aft cockpit right console, is used to activate the system, select modes of operation, insert and monitor navigational data, modify the mission flight plan, and observe operating status.

A portable chronometer, in the aft cockpit supplies Greenwich Mean Time (GMT) (accurate to one-hundredth of a second) and the Julian date to establish the orientation of the Earth in inertial space for astro-inertial operations. The chronometer is set in the base shop, using a time standard set up to receive WWV time signals. Day can be set up to 511, thus allowing use of the computer star catalog into the next calendar year. A fully-charged, self-contained battery permits timekeeping for up to 24 hours without other power. Chronometer outputs are enabled only when aircraft power is applied. There is a GO, NO-GO indicator on the chronometer. GO indicates that either external or battery power is available and that the chronometer is operable, but does not indicate that the correct day and time is set. NO-GO indicates that chronometer outputs are unreliable.

The guidance group contains the electronic and optical-mechanical equipment for navigation and avionics subsystems control. The guidance group is mounted in the fuselage aft of the rear cockpit to provide an upward 78-degree cone of vision for the star-tracking telescope. The axis of the cone is vertical

NAVIGATION MODE PROBABLE RADIAL ERROR

NAVIGATION MODE	ALIGNMENT METHOD			
	GRD HOT START	RAPID	AIRSTART	GYROCOMPASS
ASTRO INERTIAL (4) (3)	1.0 nmi	0.3 nmi (up to 10 hrs) (5)	—	0.3 nmi (up to 10 hrs)
INERTIAL ONLY (1) (with fixpoints every hour)	5.0 nmi/hr	2 nmi/hr 1.28 nmi	—	2 nmi/hr 1.28 nmi
AIRSTART (without fixpoints) (with 2 fixpoints in first hr 20±5 min apart) (1)	— —	— —	after 2 hrs: 1.75 nmi after 1 hr: 1.25 nmi	
DEAD RECKONING	(2) 55 nmi/hr (Depends on INS and DAFICS accuracy)			

(1) Using fixpoints ascertained to 1-nmi accuracy
(2) No alignment required - Accuracy only as good as inputs (W/V, Hdg, MV, TAS)
(3) Without continuous star tracking, errors approaching inertial operation can develop
(4) With current accelerometer null bias calibration
(5) With heading entry accurate to 0.1 degree

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Figure 4-2

when the aircraft pitch angle is 7-1/2 degrees. The guidance group includes an inertially stabilized platform and associated electronic and electromechanical components required to control (1) its attitude, (2) a star-tracking telescope, and (3) the electronic and electromechanical components for pointing, servo-controlling, and discrimination of telescope photo-detections. A digital computer computes auto-navigation, guidance and avionics control, and maintains a continuously updated account of navigational status and coordinate values. The computer also stores instrument and mathematical coefficients, predetermined data references that define stars, and the mission flight plan. The computer initiates and evaluates self-tests periodically throughout the operating interval. Software corrections to the star data are provided for: (1) the shock wave over the window that refracts the star light and (2) pressure and temperature gradients (differentials) acting on the window causing optical lens effects.

NAVIGATION CONTROL AND DISPLAY PANEL (NCD)

The NCD (Figure 4-3) on the aft cockpit right console controls the ANS.

NOTE

> The positions of the ANS controls and the last pushbutton operations are recorded once each 0.832 seconds by the MRS. Events can be marked by using the ANS keyboard.

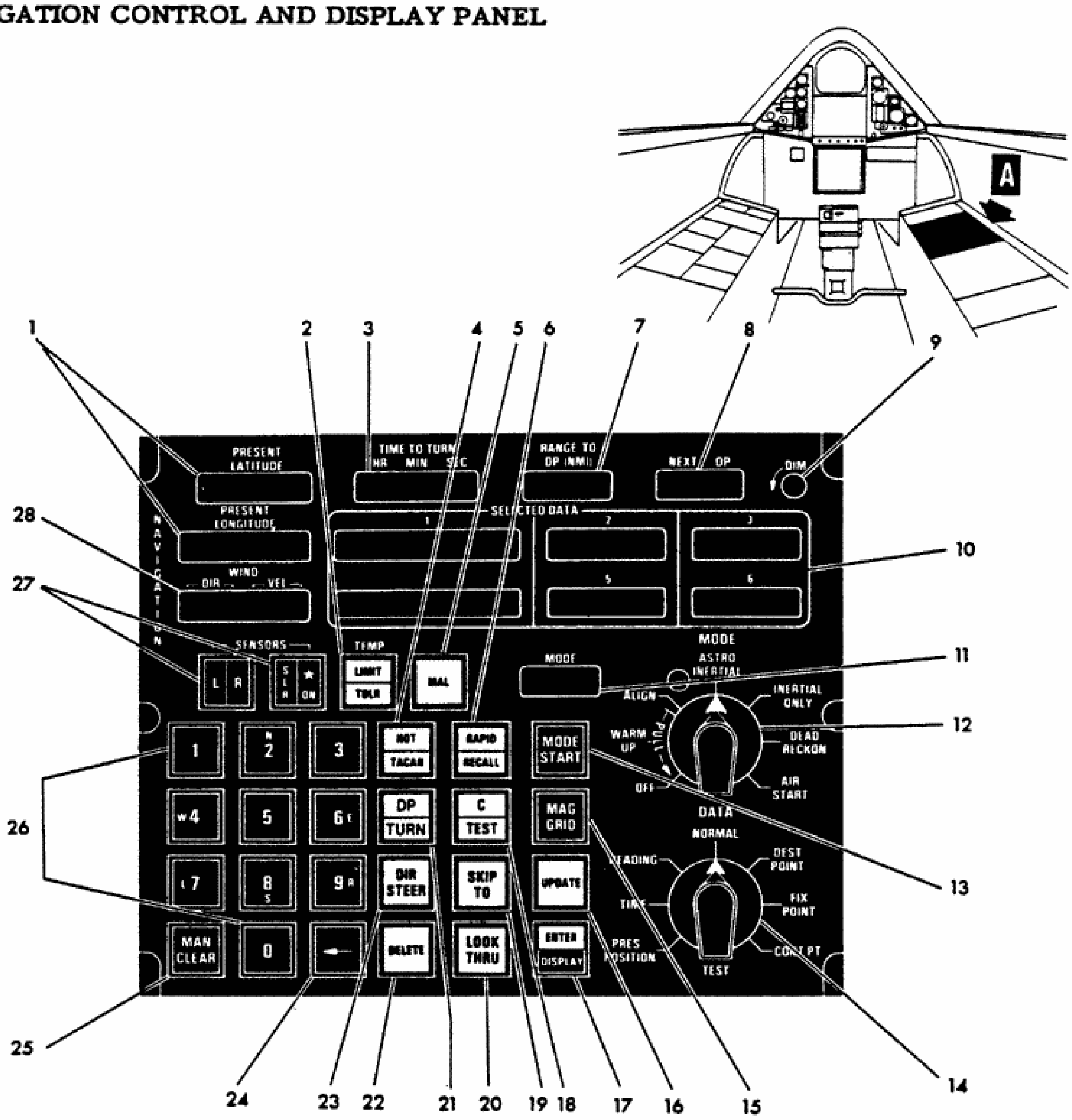
MODE Switch

The rotary MODE switch has seven positions:

OFF — Power is off except illumination power and chronometer power.

WARM UP — Power to temperature control circuitry and the computer.

NAVIGATION CONTROL AND DISPLAY PANEL



1 PRESENT POSITION WINDOWS
2 TEMPERATURE MONITOR LIGHTS
3 TIME-TO-TURN WINDOW
4 HOT/TACAN SWITCH
5 MALFUNCTION LIGHT
6 RAPID/RECALL SWITCH
7 RANGE TO DESTINATION POINT WINDOW
8 NEXT DESTINATION POINT WINDOW
9 DIM SWITCH
10 SELECTED DATA WINDOWS
11 MODE WINDOW
12 MODE SWITCH
13 MODE START SWITCH
14 DATA SWITCH
15 MAG/GRID SWITCH
16 UPDATE SWITCH
17 ENTER/DISPLAY SWITCH
18 C/TEST SWITCH
19 SKIP TO SWITCH
20 LOOK THRU SWITCH
21 DP/TURN SWITCH
22 DELETE SWITCH
23 DIRECT STEER SWITCH
24 BACK SPACE SWITCH
25 MANUAL CLEAR SWITCH
26 MANUAL KEYBOARD AND POSITION PREFIX REFERENCE SWITCHES
27 SENSOR OPERATION INDICATOR LIGHTS
28 WIND DIRECTION AND WIND VELOCITY WINDOWS

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Figure 4-3

The following five modes are called "operate" modes, since power is applied to the entire ANS. Operation begins only after the MODE START, RAPID, or HOT switch is pressed.

ALIGN	Used on the ground to remain in fine alignment or for ground alignment correct procedure.
ASTRO INERTIAL	Selects astro-inertial navigation.
INERTIAL ONLY	Selects inertial-only navigation.
DEAD RECKON	Selects dead-reckon navigation.
AIRSTART	Used to perform a cold airstart (in-flight alignment) which results in airspeed damped, astro inertial navigation.

The MODE switch has a detent that prevents switching to OFF or WARM UP from an "operate" mode without lifting the switch. A detent prevents moving the switch clockwise past AIRSTART.

MODE START Switch

After power on, pressing MODE START initiates a gyrocompass or cold airstart alignment. After alignment, pressing the self-illuminated switch enables the mode selected by the MODE and MAG/GRID switches.

MAG/GRID Switch

The MAG/Grid switch is an alternate-action switch. Either the MAG or GRID half of the switch is lighted at all times. The ANS computer interrogates this switch each time the MODE START switch is pressed.

Set the switch to MAG. There is no useable grid heading available to either cockpit with the SKN-2417 INS in normal operation. The ANS computer interprets the INS heading input as MAG heading and makes appropriate computations to provide a true heading value for the dead-reckoning reference frame.

DATA Switch

The rotary DATA switch is used to select a panel fill, update, display, or mission modification procedure. The position of the switch determines the first character (always alphabetical) of the SELECTED DATA (SD) window that expects data. The eight DATA switch positions are PRES POSITION, TIME, HEADING, NORMAL, DEST POINT, FIX POINT, CONT PT, and TEST.

Keyboard Switches

The ten numerical keyboard switches, labeled 0 through 9, are used to enter data into the ANS or to command display of ANS data.

MAN CLEAR Switch

Used to clear the SELECTED DATA windows if an error is made during a panel-initiated procedure, and to not use an ANS position, altitude, or runway-heading alignment update. It is also used in the ANS malfunction routines.

ARROW (Backspace) Switch

Used to erase filled data one digit at a time in reverse order prior to actuating an action switch such as ENTER.

LOOK THRU Switch

Used to display data pertaining to the destination point (DP) after the DP now approaching.

SKIP TO Switch

Used to command the ANS to skip to a selected DP from the current next DP.

RAPID/RECALL Switch

Used to select rapid ground alignment or to recall data for display of the previously panel-filled TACAN point.

DELETE Switch

Used to delete a particular panel-filled mission point from the 40-List of panel-filled points or the entire 40-List.

DIR STEER Switch

Used to make an immediate change in destination (direct steer) to a selected DP or to any panel-entered latitude and longitude.

HOT/TACAN Switch

Used to mark the time of reading current TACAN data and to freeze the ANS computed values of range and bearing or to select air or ground hot starts.

ENTER/DISPLAY Switch

Used to command the ANS computer to accept panel-filled data or to display selected data.

UPDATE Switch

Commands the ANS to correct computed position, heading, reinitialize the star tracker, or change the current track leg.

DP/TURN Switch

This push-button switch selects the source for the pilot's HSI range indicator. The DP/TURN switch is enabled when the ANS DATA switch is in TEST; pressing ENTER/DISPLAY will then illuminate the "DP" or "TURN" legend in the switch (corresponding to the mode presently selected); pressing the DP/TURN switch will change the mode and illuminate the other legend. When "DP" is illuminated, the pilot's HSI range indicator will read distance to the ANS destination point (DP); when "TURN" is illuminated, the pilot's HSI range indicator will read distance to the ANS-computed turn point. Refer to Horizontal Situation Indicator, Range Indicator, Section I.

C/TEST Switch

Used to perform a panel light test and to display ANS tape data and internal ANS conditions when used in conjunction with the TEST position of the DATA switch.

SELECTED DATA Indicators

The indicators or windows consist of six separate sets of digital displays. Various operating parameters are displayed in the indicators during the panel fill, mission modification, update, and alignment routines as shown in Figure 4-4.

Present Data Indicators

The PRESENT LATITUDE and PRESENT LONGITUDE windows show the present position coordinates in degrees and minutes. During ground alignment, the coordinates are blank until fine alignment is completed.

The WIND DIR and WIND VEL window displays the wind direction in degrees and the wind velocity in knots. The window displays zeros until airborne.

The TIME-TO-TURN window displays the time-to-turn in hours, minutes, and seconds. The window is blank until the aircraft is moving.

The RANGE TO DP window displays the range to the DP in nautical miles. The window is blank until present position coordinates are entered.

The NEXT DP window displays the next destination point number. The window is blank until the present position coordinates are entered.

Sensor Indicators

The TECH L and R, and SLR indicator lights illuminate during display of control points or fix points to indicate programmed sensor activity at the selected point. The SLR light is not illuminated during display of viewsight fixpoints. During NORMAL display, these lights illuminate during actual ANS on-time commands and are extinguished by standby control point commands. The lights do not illuminate during manual sensor operation.

These lights also illuminate to verify sensor selection when adding or replacing control points.

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES

SELECTED DATA WINDOW / PANEL ROUTINE	RUNWAY HEADING ALIGNMENT	FILL PRESENT POSITION AND INITIAL ALTITUDE	FILL WIND	FILL DAY AND TIME	FILL MAGNETIC VARIATION	FILL CHART CONVERGENCE FACTOR	UPDATE HEADING	UPDATE PRESENT POSITION, USING REMOTE SOURCE DATA	UPDATE PRESENT POSITION USING RADAR	UPDATE PRESENT POSITION, USING VIEWSIGHT	UPDATE PRESENT POSITION USING TACAN	UPDATE TRACK LEG
1	Computed runway true heading, XXX°XX.X'	Latitude, N/S XX XX.XX'		GMT, XX hours XX minutes XX seconds				North-South error, nautical miles, N/S 00XX.XX	North-South error, nautical miles, N/S XX.XX	North-South error, nautical miles, N/S XX.XX	North-South error, in nautical miles, N/S XX.XX	
2												
3		Altitude in hundreds of feet, XXX										
4	Filled runway true heading, XXX° XX.X'	Longitude E/W XXX° XX.XX'			Magnetic variation, E/W XXX° XX.X'		Heading XXX°XX.X'	East-West error, nautical miles, E/W 000 XX.XX	East-West error, nautical miles, E/W XX.XX	East-West error, in nautical miles, E/W XX.XX	East-West error, in nautical miles, E/W XX.XX	
5			Wind direction XXX°									
6			Wind speed in Knots, XXX	Julian day, XXX		Chart convergence factor X.XXX°						All five digits of point - ID code, D XXXX

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Figure 4-4 (Sheet 1 of 2)

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES

PANEL ROUTINE / SELECTED DATA WINDOW	DIRECT STEER	SKIP TO DP	DELETE FP, CP, DP	ADD OR REPLACE FP, CP, DP	NORMAL DISPLAY	DISPLAY NEXT FP, CP, DP	DISPLAY SELECTED FP, CP, DP	DISPLAY HEADING	DISPLAY DAY OF YEAR/STAR DATA	DISPLAY PRESENT POSITION	DISPLAY LOOK THRU	DISPLAY TAPE NUMBERS/ TEST
1	Latitude if new point is filled, N/S XX° XX.XX'			Latitude, N/S XX° XX.XX'	GMT in XX hours, XX mins, XX seconds	Latitude, N/S XX° XX.XX'	Latitude N/S XX° XX XX'	Velocity vector heading VXXX° XX.X'	GMT in XX hours, XX mins, XX seconds	Latitude of alternate present position frame, N/S XX° XX.XX'	Latitude of DP+1 N/SXX° XX.XX'	I TTMMCC T - Tape M - Mod C - Corr
2					True airspeed in knots TXXXX	Range to DP RXXX.X nmi slant range if TACAN FP SXXX.X nmi along track range to CP/FP AXXX.X nmi	Great circle range for CP, DP, FP AXXX.X nmi slant range if TACAN FP SXXX.X nmi	Grid heading GXXX.X°	Star number SXX		Along track range to DP +1 R XXXX nmi	Mission tape No. 0XXX 0 - * or A thru Z or a thru e
3				Terrain elevation in hundreds of feet for CP's or FP's XXX. Turn radius in nmi for DP's.	Next FP No. F/F1 XXXX	Turn radius to DP KXXX nmi terrain elev for CP, FP hundreds of feet XXX	Turn radius if DP KXXX nmi terrain elev if CP, FP, hundreds of feet EXXX	Chart convergence factor CX.XXX	Scan Rate Code R X	Nav altitude in hundreds of feet, AXXX	Turn radius of DP +1 K XXX nml	General Instrument constants tape NO. GXXX
4	Longitude if new point is filled, E/W XXX XX.XX'			Longitude E/W XXX° XX.XX'	Aircraft cross track position, nautical miles L/R XXX.X	Longitude E/W XXX° XX.XX'	Longitude E/W XXX° XX.XX'	Aircraft true heading TXXX° XX.X'	Time in this star search T XX:XX min : sec	Longitude of alternate present position frame, E/W XXX° XX.XX'	Longitude of DP +1 E/W XXX° XX.XX'	
5				L/R XX.0 S1R code or L/R00.0 for CP, FP or E/W XX.X° mag var for TACAN FP's	Aircraft Ground Speed in Knots GXXXX	Relative bearing to DP, CP, FP L/R XXX.X° TACAN bearing to TACAN FP BXXX.X°	Relative bearing to point L/R XXX.X° Magnetic bearing if TACAN FP BXXX.X°	Magnetic variation E/W XXX.X°	Number of stars acquired AXXXX	Sun angle in degrees, (if positive) SXX.X°	Time to DP +1 TXXX.X min	TYY1 (Normal) TYY2 (Trainer) Where YY=year
6	All five digits of point - ID code if DP in memory is selected, D XXXX	All five digits of point - ID code, D XXXX	All five digits of point deleted D XXXX C/C1XXXX F/F1XXXX	Point ID Code D XXXX C/C1XXXX F/F1XXXX	Next CP No. C/C1XXXX	ID code of next point, D XXXX C/C1XXXX F/F1XXXX	Selected point ID code D XXXX C/C1XXXX F/F1XXXX	Magnetic heading MXXX°	Julian day of year DXXX (1-511)		DP + 1 ID No. D XXXX	Test 0 Indication T 0

Figure 4-4 (Sheet 2 of 2)

Star ON Indicator Light

The light indicates the status of star tracking as described in the Computer Program section. Steady illumination of the light indicates that a minimum of two different stars have been tracked within the last 5 minutes.

MODE Window

The MODE window displays a legend which shows the operating phase of the ANS. The MODE window also displays an error message in the event of an operator error and may indicate recommended action in case of system malfunction. The malfunction indications are described in the Malfunction Indicator and the ANS MALFUNCTION PROCEDURES paragraphs. The MODE window indications are:

Indication	Operating Phase	Definition
C/A	COARSE ALIGN	Initial phase of ground or air start alignment.
F/A	FINE ALIGN	Final phase ground alignment.
RES	RE-START	Second phase of air-start or ground hot start alignment.
A-I	ASTRO INERTIAL	Astro inertial navigation.
I/O	INERTIAL ONLY	Inertial-only navigation.
D/R	DEAD RECKON	Dead-reckon navigation.
ENT		Coarse align complete. Enter present position or heading.
ERR		An operator error in panel operation has been committed.
ENC		Encoding failure.
DP*		Mission tape program sequence in error.
BLANK	WARM UP	Mode switch is in WARM UP and 28 volts dc is present.

Temperature Limit/Tolerance Indicator

The temperature limit and tolerance indicator, labeled TEMP LIMIT/TOLR is a split-function indicator which displays monitored cooling air flow and system internal temperatures. The top half of the indicator is red with the LIMIT legend visible when lighted. The bottom half of the indicator is amber, with the TOLR legend (tolerance) visible when lighted. (Refer to ANS MALFUNCTION PROCEDURES.)

Malfunction Indicator

The ANS malfunction indicator, labeled MAL, is a red panel light that can be off, on-steady, or on-flashing. Generally, the MAL light is off during normal operation, on-steady when the ANS is in the WARM UP mode, and on-flashing when a system self test has failed. (Refer to ANS MALFUNCTION PROCEDURES for detailed description.)

COMPUTER PROGRAM

The basic instructions and constants for computer operation are contained in the main program tape which is loaded into the computer permanent memory. The computer program is loaded in two parts, a basic main program tape and a correction tape (if needed). In addition, a general instrument constant (GIC) tape, star catalog (SYY1, SYY2) tape, and mission tape are loaded. Each ASTRO INERTIAL (A-I) unit has its own GIC tape which defines gyro, accelerometer, resolver, etc. parameters unique to the respective A-I unit. Annual revisions are made to the star catalog tapes. The main program tape currently used is Tape 10639512 (Tape 12).

STAR DATA USAGE

STAR	DEFINITION	DATA USAGE
A	First star tracked after a hot or cold airstart, ground hot start, or after changing from A-I to I/O and back to the A-I mode.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
B	Second star tracked after an A star, or	Computational triad and platform are corrected and now in coincidence. Latitude, longitude and auto nav adjustments occur.
	First star tracked after a ground alignment.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
C	First and subsequent star tracked after B star.	Platform and computational triad are corrected. Auto-Nav transients are allowed on first star C but suppressed on subsequent ones until a bank angle exceeds 5° or position fix inserted

Figure 4-5

Astro Inertial Navigation

The ANS operates in typical inertial navigation fashion. Outputs from two 2-axis gyros drive the platform gimbals to isolate three orthogonally mounted accelerometers from changes in aircraft attitude. The gyros and accelerometers are mounted on the platform's azimuth gimbal (stable element). The accelerometer outputs are components of aircraft velocity change. If the azimuth gimbal is not kept level, the accelerometers also measure a component of acceleration due to gravity and position errors are produced.

In INERTIAL ONLY, the computer uses the accelerometer outputs to calculate aircraft velocity and change in position, and gyro torquing rates. The gyro torquing rates (signals proportional to aircraft velocity plus earth's rate) are applied to the gyros to maintain the azimuth gimbal (and thus the accelerometers) level with respect to the earth. The success of inertial navigation is due to the fact that any system error eventually causes the accelerometers to go off level and measure a component of gravity which introduces an error that tends to cancel the original error. For example, if an accelerometer develops a null shift that appears to be an aircraft acceleration to the north, the platform will be torqued to keep up with the apparent aircraft motion over the earth's surface. Thus if the platform were level, it becomes tipped off level resulting in accelerometer measurement of gravity which looks like aircraft acceleration to the south. This characteristic of inertial systems is called Schuler tuning.

The star tracking function improves knowledge of accelerometer orientation in azimuth and eliminates the effects of gyro drift. Star search is initiated when astro-inertial mode is selected after completion of alignment. Selection of the star is made by the computer as a function of latitude, longitude, day of year, time of day, aircraft pitch and roll, and location of the sun. Aircraft pitch and roll determine the orientation of the star tracker window. For a given latitude, longitude, time of day and year, a particular star should be at a particular azimuth and elevation. If the star tracker measurements show that the star is not at the expected azimuth and elevation, there is an error in computed latitude and longitude and/or an error in platform orientation. Since the telescope is mounted on the platform, the star tracker measures the angular difference between the physical triad formed by the platform axes and the computational triad formed by the vertical through the computed position and the calculated orientation of the platform in azimuth. Thus the system cannot directly distinguish between a computed position error and a platform orientation error but, based on statistical probabilities determined by prestored error models and flight dynamics preceding the measurement, (as modeled by a Kalman filter, described later) it will attempt to optimally adjust the various navigational parameters.

To aid in describing star tracker logic, stars are given arbitrary labels depending on if they are the first, second, or third star tracked after the beginning of an operation. These are listed in Figure 4-5 with definitions and a summary of the usage of star tracker measured errors. In all cases, the end result of tracking two different stars is to align the computational triad with the platform triad or vice versa. A single star cannot be used to correct all errors since errors about the axis from the platform through that star are not measured. After the initial two stars are acquired, the normal interval between loss of track from one star to tracking the next star is about 30 seconds at altitude. Since the platform is almost continually brought into alignment with the computational triad, gyro errors have an almost negligible effect. The predominant ANS errors are those due to gyro drift that develop before stars are acquired and when star tracking is interrupted such as during aerial refueling. The star tracking data is used to update computed values of gyro drift to minimize error growth during any subsequent lapses in star tracking.

Star selection, tracker scan rate, and search patterns depend on many factors and are all under computer control. The computer selects a star by going through the star catalog which is arranged in order of decreasing star brightness until it finds a star that is within the window aperture, not within 10° of zenith (not within 5° of zenith for trainer aircraft), and not within 12-1/2° of the sun. The tracker telescope is commanded to search for the selected star using a variable sized pattern which is symmetrical about the computed star position.

The star search pattern is an expanding rectangular spiral which starts at the side of the pattern and then passes across the computed star postion. See Figure 4-6. Maximum A star pattern size is a function of search rate so that all A star searches are completed within 23 minutes.

If the star is detected during this search, confirmation and reconfirmation patterns are made. If these are successful, the star is considered tracked, and elevation and azimuth errors are determined by the star actual position relative to its computed position. Search and track operations are discontinued if the star moves out of the window, the sky is too bright, or a position update is performed. The computer then goes to the next brightest star available, except that when a position update is performed, star search begins at the top of the star list (brightest star).

There are four scan rates which can be used in star search. Scan rate depends on star magnitude and sky brightness. The fastest is used on a bright star in a dim background while the slowest is used on a dim star in a bright background.

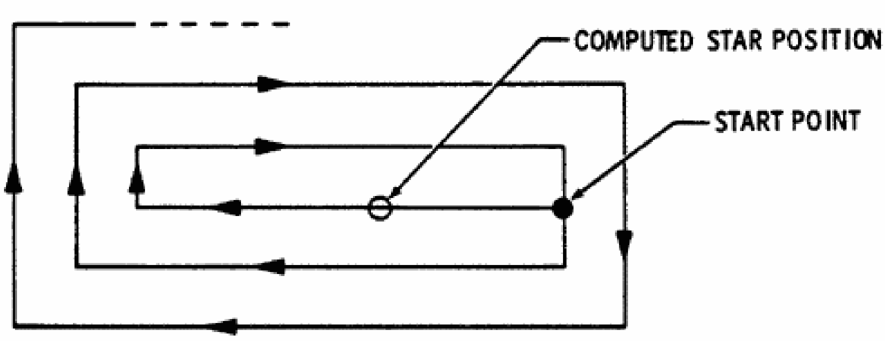
The search patterns are chosen as a function of the type of alignment and whether an A, B, or C star is being searched. See Figure 4-6. This table also lists the star ON light activity during star tracking operations.

Star Tracking Techniques

The star ON light provides the RSO with a guide for actions (listed in Figure 4-7) to optimize star tracking. Star tracking is automatic but the operator can assist the system in overcoming conditions such as overcasts, changes of sky background brightness, long

SEARCH PATTERNS AND STAR-ON LIGHT INDICATIONS

TYPES OF ALIGNMENT	STAR	SCAN RATE arc sec/sec	SEARCH AZIMUTH	SEARCH ELEVA-TION	MAXIMUM TIME REQUIRED TO COMPLETE SEARCH	AFTER TRACKING ★ LIGHT WILL
Hot or cold airstart or when search unsuccessfully completed for - A after ground hot start or INERTIAL ONLY navigation.	A	1250	3°	1°	17.3 min.	Flash at 1 second intervals.
	A	703	2.3°	.8°	18.1 min.	Flash at 1 second intervals.
	A	395.5	1.9°	.6°	20.8 min.	Flash at 1 second intervals.
	A	222.5	1.4°	.48°	22.7 min.	Flash at 1 second intervals.
	B	all	3°12'	6'	10.0 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Ground hot start or when changing mode from INERTIAL ONLY to ASTRO INERTIAL	A	all	36'	12'	3.9 min.	Flash at 1 second intervals.
	B	all	36'	12'	3.9 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
When INERTIAL ONLY was selected after ground alignment	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Rapid, gyro compass or runway heading alignment.	B	all	36'	12'	3.9 min.	Stay off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)



NOTE

1. All search patterns are expanding rectangular spirals with the first beginning at one side and passing horizontally across the computed star position.
2. Star B' (re-tracking of star B) is performed only if the azimuth error measured with star B is greater than 5.27 arc-minutes.
3. After tracking star C, the star light remains on until mode is changed to INERTIAL ONLY or five minutes have elapsed without tracking two different stars.

F203-253(b)

Figure 4-6

periods of ground time after system initialization to A-I mode, refueling, and periods when tracking is not being accomplished. The operator should attempt to commence tracking stars as soon as possible to prevent or eliminate position error growth.

Improving Star Tracker Scan Rates

The ANS uses different scan rates for the star tracker depending upon the lightness of the sky background around the computed star position. This sampling of background conditions is accomplished automatically prior to beginning each star search. The time it takes the ANS to acquire a star depends on the magnitude of ANS errors. In extreme cases approximately twenty minutes could be required to acquire an A star.

An active (optimum signal-to-noise) filter to the ANS increases the probability of star detection, improves the accuracy of angle measurement, reduces the time devoted to detection and tracking of each star, and increases position and heading accuracy.

By using position fixes or remote updates, the RSO can reinitialize star search at the top of the star list (brightest star). This provides a new sky background lightness measurement and a change in scan rate if sky background lightness has changed. The RSO should use this procedure when there is a noticeable improvement in background conditions and the star ON light is not illuminated.

The RSO should periodically note the star tracking performance as indicated by the star light and star data in the Time display. If star tracking performance is less than expected (intermittent or no star light) for the existing sky conditions, the RSO should display day of year and note star number and scan rate. He should perform a zero remote update or command A, B, C Star Search to select the brightest star available (indicated by a number equal to or less than that previously indicated in SELECTED DATA window 2). This action will match the scan rate to the current sky background condition. A slower scan rate than that previously observed indicates less than optimum sky background conditions. If a star is not acquired, a repeat of these routines when the sky background improves could increase the scan rate thus improving the probability of star acquisition. The scan rates are selected by the computer based on sky background measurements in the vicinity of the star. There are four scan rates available and the one in current use is indicated in SELECTED DATA window 3 as a code R1 (1250), R2 (703), R3 (395) or R4 (222) (arc sec/sec) when using the Time display routine. A dark sky background increases the likelihood of tracking stars and induces a fast scan rate. Conversely, a bright sky back ground decreases the likelihood of tracking stars and induces a slow scan rate.

CREW ACTIONS TO OPTIMIZE STAR TRACKING

CONDITION	ACTION
Search underway for A or B star.	Maintain straight and level flight.
Star ON light out.	Make maximum number of position checks.
Star ON light out after entering a good sky situation.	Restart star search by using zero remote update procedure.
Star ON light out more than 15 minutes after zero remote update procedure has been performed and good sky conditions prevail throughout.	Command star A tracking by changing mode to INERTIAL ONLY, then change back to ASTRO INERTIAL to increase search pattern size.
Preflight in hangar.	Select INERTIAL ONLY to terminate fine alignment. Select ASTRO INERTIAL after clearing hangar or cloud cover.

Figure 4-7

An example of when this procedure could assist star acquisition is: the system is put in A-I mode after completing ground alignment with haze or thin cirrus clouds; after takeoff and leveloff at 25,000 feet, the star ON indicator is not illuminated but the aircraft is now above all haze and cirrus. A zero remote update routine should cause the system to select a faster scan rate as a result of the darker sky background. In most cases, this will speed up star acquisition.

Commanding A and B Mode Stars

If a preflight alignment is performed while under cover, such as in a hangar, select the INERTIAL ONLY mode at the completion of fine alignment and remain in INERTIAL ONLY until clear of the covered area. This prevents false star acquisitions due to ceiling lights, etc. In this case the first star tracked after selecting ASTRO INERTIAL will be a B mode star.

The nominal error growth of the ANS in INERTIAL ONLY is based on pure inertial operation; that is, MODE in INERTIAL ONLY, disabling the tracker from star searching. The tracker slewing on top of the platform in search operation can induce further position error growth. Because of this, the operator should avoid leaving the ANS in the ASTRO INERTIAL mode when star tracking is not expected for 25 minutes or longer. Put the system in INERTIAL ONLY mode when star tracking is lost or is not expected for at least 25 minutes (e.g. during overcast conditions or operation behind a tanker.) Once INERTIAL ONLY has been selected, operation in this mode should be continued until suitable tracking conditions are encountered.

Above 60,000 feet, with nominal star availability and sun angle, the crew can expect A/B mode star acquisition in a few minutes after returning to the ASTRO INERTIAL mode.

NOTE

- o Return the ANS to INERTIAL ONLY mode prior to entering a critical sensor "take" area if the star ON indicator has not indicated A/B star acquisition. This will inhibit A/B star updates which would cause auto nav roll transients.
- o Although a star light generally indicates a bounded error of less than 1 nm, greater errors are possible. Computer and/or chronometer malflunctions have resulted in the star light being on when position error exceeded 10 miles.

Kalman Filter

The system employs a Kalman filter to optimally incorporate measurements from the star tracker, DAFICS M computer, and fixpoints to correct inertial system errors. The filter continually estimates the error state of 16 parameters:

1. Platform azimuth
2. Platform tilt axis 2
3. Platform tilt axis 3
4. Position error axis 2
5. Position error axis 3
6. Velocity error axis 2
7. Velocity error axis 3
8. Azimuth gyro drift rate
9. 2 axis gyro drift rate
10. 3 axis gyro drift rate
11. 2 axis accelerometer bias
12. 3 axis accelerometer bias
13. Telescope elevation bias
14. True airspeed scale factor
15. Axis 2 Wind
16. Axis 3 Wind

Each of these parameters has a calculated error probability which is initialized as a function of the type of alignment accomplished. During a ground alignment system position is monitored to detect deviations from the entered coordinates. These deviations are fed as measurements to the filter which utilizes them to refine the first ten listed parameters. When star measurements are obtained, the first thirteen parameters are refined, and when airborne, all sixteen elements are estimated and continually refined. Because of wind variability and the accuracy (±30 knots) of True Air Speed, the airspeed measurement has essentially zero influence on the first thirteen parameters except in the case of a cold and hot airstart. When fixpoint measurements are inserted by the operator, the filter adjusts the 16 parameters according to the ratio of their current estimated error state to the programmed accuracy of the fixpoint device (.25 n.m. for SLR, .5 n.m, for Viewsight, and 1.0 n.m. for TACAN). The system incorporates 100 percent of a fixpoint if the correction is more than 5.0 n.m..

Dead Reckoning

Dead reckoning is performed simultaneously and separately from inertial navigation. During normal operation in ASTRO INERTIAL or INERTIAL ONLY, the dead reckoning latitude and longitude do not appear to the RSO unless the display Present Position routine is performed. However, prior to continuous star tracking in a cold or hot air start, or when DEAD RECKON is selected, dead reckon data is used as the source of present position and heading for all displays, great circle navigation and guidance, and sensor control. DEAD RECKON is the only mode in which present position can be entered after navigation is started; this may be done as often as desired. When DEAD RECKON is selected, the ANS generates all its normal outputs and continues astroinertial or inertial only navigation so that the DEAD RECKON mode can be selected for training while permitting return to ASTRO INERTIAL or INERTIAL ONLY modes. In normal operation, when dead reckon data is not used for ANS outputs, the dead reckoned latitude, longitude, and difference between INS heading and ANS true heading (magnetic variation), if applicable, are updated every four minutes using inertial data.

Dead reckoning is the process of computing change in position using heading, speed, and elapsed time. True airspeed from DAFICS (M computer) is used with RSO entered values of wind speed and direction to approximate ground speed. Heading is provided from the INS and is magnetic heading except that ANS inertial heading is used following coarse alignment in a hot or cold air start.

When INS mag heading is being used, the RSO must periodically fill local magnetic variation so that computed true heading will have minimum error. When dead reckon data is not being used, magnetic variation need not be filled since the ANS itself computes a new magnetic variation every four minutes.

MISSION TAPE PROGRAM

The mission profile is defined in terms of destination points (DP), control points (CP), and fix points (FP), and the sensor operations associated with these points. Destination points delineate the prescribed mission track; they are intersections of the intended great-circle legs. Control points and fix points permit automatic activation of imaging sensors, and fix points define preferred navigational references. The mission plan is loaded into the computer memory on a mission tape prior to preflight operations. The mission tape can be programmed to hold up to 127 DP, 127 FP, and 127 CP (381 total). Additional temporary memory is provided for 40 point modification operations, known as the "40-List". The modifications may be performed using the Control and Display panel anytime power is supplied to the panel. Up to 40 add and/or replace operations and unlimited skip-to operations, are provided. In addition, there are special Anytime and Opportunity fix point procedures which do not use the 40-List. The mission tape may include a primary flight plan with one or more alternate routes that the crew may elect to follow by exercising the skip-to, direct steer, or track leg update options. The add and replace options of the 40-List permit additional alternate paths to be formulated, and allow last-minute changes to sensor activity on programmed legs.

The data loaded into specified cells of the computer memory are identified by function and order of use in the mission plan (D00003, C00007, F00021, etc.). Each point is further defined by its coordinates, its sensor-usage, applicable pointing parameters, and reference to the next consecutive point or points. The destination points reference the next point of all three classes. The information programmed for each type of point is listed in Figure 4-11.

Great-Circle Steering

The mission path is a sequence of great-circle legs computed on the basis of DP coordinates. The ANS supplies a steering (bank angle) command to the autopilot in all ANS navigation modes but it is usable only when all requirements for a "nav-ready" condition are present. In the autopilot AUTO-NAV mode, bank angle is commanded by the ANS to automatically guide the aircraft onto and along the preprogrammed flight path. The bank angle steering command is computed from aircraft cross-track position and velocity relative to the desired course. If the planner has scheduled a bank angle of 35° or less, the ANS will not command a bank greater than 35°, even if a higher bank is required to keep the aircraft on course. If the turn is planned above 35° (up to 42°) the ANS will command up to 45° to keep the aircraft on course.

If the AUTO NAV mode is engaged when the aircraft is considerably off track, the ANS will steer towards the desired track at a 30° intercept angle. Depending on current groundspeed, the ANS will compute where to initiate a turn to discontinue the intercept course and smoothly fair onto track. During supersonic cruise this point is approximately 20 nm off course.

Once on course, the aircraft should usually be within 300 feet of the commanded course, except in turns. Actual position of the track is dependent on ANS navigation accuracy.

ANS Steering Turn Modes

The mission planner can choose one of two different turn modes at each DP. These modes determine where the turn start to the next great circle leg will occur and the amount of bank angle commanded during the turn.

Auto-Range-To-Turn

The system computes the turn radius based on a 32° bank angle and the groundspeed at the start turn point. Once the turn is initiated, it is identical to the turn described in the Fixed-Range-To-Turn paragraphs.

Auto-Range-To-Turn should be used for subsonic turns to prevent high bank angles at heavy weights. Current groundspeed and the heading change from present course to next are used to compute and initiate an automatic turn (termed by the mission planners as Turn Start Automatic, or TSA). The TSA point varies since it depends on groundspeed. If actual groundspeed is different from planned groundspeed, the TSA will not occur where planned and the aircraft will not follow the turn line depicted on the strip map. However, if there are no other disturbances, the aircraft should make the turn at a 32° bank angle.

Fixed-Range-To-Turn

Fixed-Range-To-Turn is used by the mission planners for turns that indicate critical sensor legs and turns where strict adherence to the planned turn line is required. In this mode, the mission planner specifies a constant turn radius at a particular DP. The TSA point is a fixed distance plus a variable distance from the DP. The fixed distance is determined by the programmed turn radius and the change in course; it would be equal to turn radius on a 90° turn. The variable distance ranges from 0 to 4.5 nm, depending on groundspeed, and compensates for the distance required to roll into the turn. During the turn, commanded bank angle is the sum of two components. One component is the nominal bank required to achieve the programmed turn radius at the current

TYPICAL DESTINATION-POINT PLAN

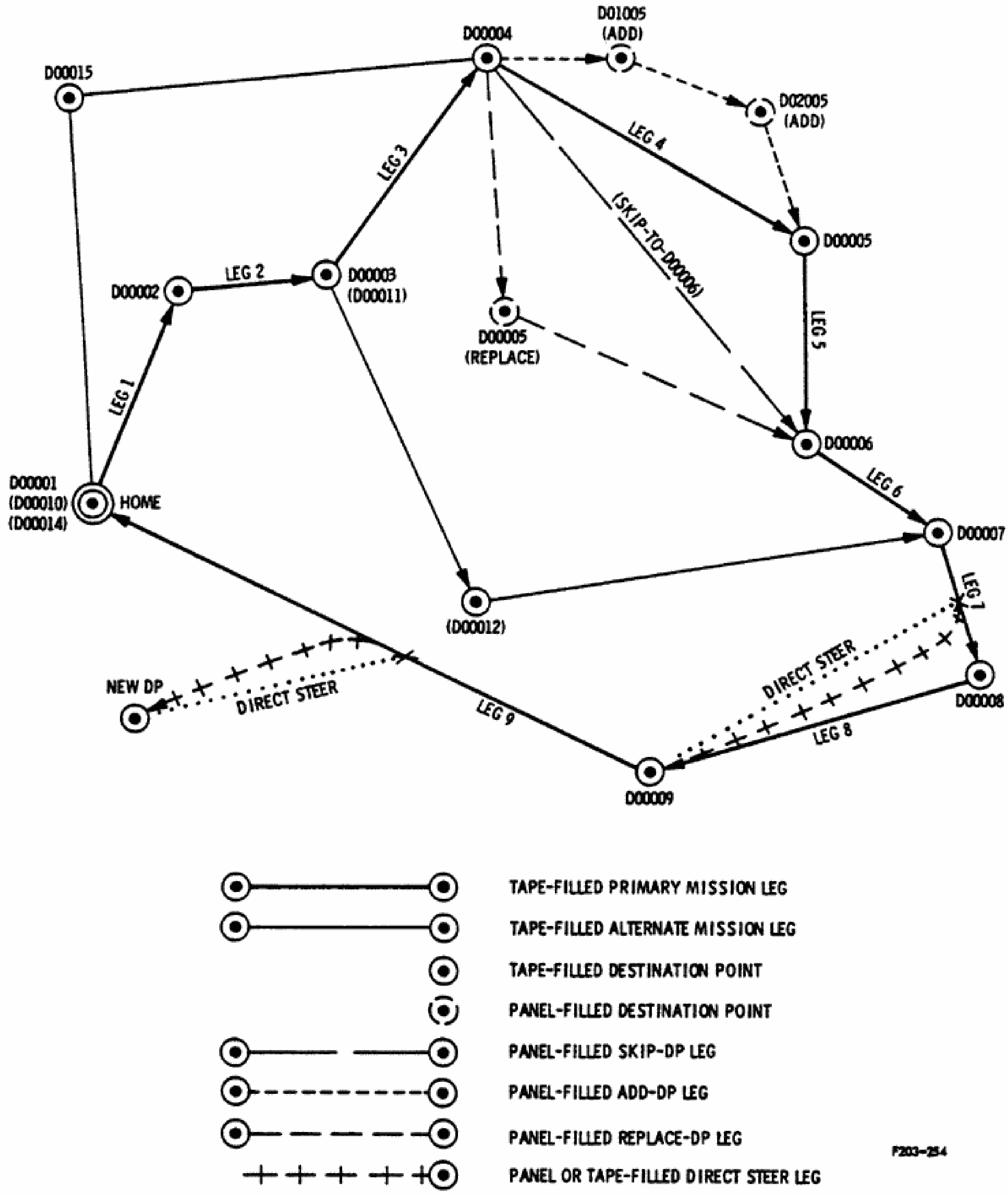


Figure 4-8

ground speed. The second component trims bank angle trim as a function of the radial speed and position relative to the programmed radius so that the aircraft follows the planned turn line throughout the turn. If a transient causes the aircraft to deviate from the turn line, bank angle trim varies within $\pm 10^{\circ}$ to return to the turn line.

Range to destination as displayed on the HSI and the NCD includes distance around a turn rather than the length of the great circle from present position to destination. This distance around the turn is also used in computing time to turn for the NORMAL display.

Turn steering automatically terminates when aircraft track is within 2° of the command course, the new track is crossed, or the theoretical tangency point is passed.

The sum of the nominal commanded bank angle and the bank angle trim is limited to the ANS maximum bank angle command of 45 degrees. Refer to Figures 4-14 and 4-15 for bank angle vs speed and turn radius information.

NOTE

> During preflight planning, do not schedule any turns above Mach 2.9 which have a radius smaller than can be maintained using a 42° bank angle.

Turns should be planned to require at least three degrees less than the planned bank angles limits. This provides a margin to accommodate aircraft trim requirements and/or greater ground speed than expected. However, when below Mach 2.9, bank angles of up to 44 degrees may be scheduled if justified by operational requirements. Crews should monitor ANS groundspeed prior to and during turns and prevent ground speed from exceeding the maximum value at which the planned track can be accomplished within bank angle limits.

When scheduling turns with greater than 35° bank angle, allow for expected altitude loss if maximum power will not maintain level flight. Refer to Parts V & VI of the Performance Data appendix and to the ceiling altitude data, Figure 6-8, in Section VI. When scheduling turns requiring 42° bank angle at speeds above Mach 3.0, consider the altitude at the turn (which is a function of weight) and the programmed Mach. For a given weight and bank angle it may be necessary to decrease altitude, which at a given Mach may increase the KEAS to the KEAS limit. Turns at maximum scheduled bank angles must not be programmed for such heavy weights that the maximum KEAS limit for normal operation would be exceeded. A descent of approximately 2500 to 3000 feet below the maximum range altitude may have to be made before entering a 42° bank turn.

In normal operation, the aircraft will follow the turn line and roll out onto the next leg within 0.2 nm. Overshoots and undershoots will degrade sensor performance if the maneuver to get onto track is outside sensor stabilization limits. For the TECH camera(s), roll and pitch rate should be less than 0.3° per second for good photography.

With the CAPRE radar, cross track velocity must be less than 35 fps in the programmed mode or 20 fps in the auto mode for good mapping. Figure 4-9 shows distances required to obtain cross track velocities within limits at standard cruise conditions. During most of the settle out distance, roll rates will be slight and suitable for good photography.

During a SKIP TO operation, the same fixed turn radius is used, but a different TSA and turn line will result if the next leg is different from the planned leg.

Manual Steering

The ANS provides navigation information so the pilot can manually steer the aircraft. The bank steering bar on the ADI indicates the error between aircraft roll angle and ANS bank angle command and centers when the two are equal. Centering the bar steers the aircraft on the same path as AUTONAV steering.

The pitch steering bar of the ADI indicates altitude rate (0 to ±3484 fpm) and is used to maintain altitude.

The HSI displays true heading, command course, range to next DP, and cross track deviation (0 to ± 1 nm). These displays are relative to the turn line during turns or the great circle leg following turns; the range value represents the distance around the turn plus distance along the next leg.

Control Points (CPs)

The technical objective cameras (TECHs) are turned on or off and pointed as the aircraft's along-track range to the next destination

DISTANCE TO OBTAIN STABLE CROSS TRACK VELOCITIES

Peak Overshoot in NM	Additional Settle Out Distance in NM		Additional Settle Out Time in Minutes and Seconds	
	20 fps	35 fps	20 fps	35 fps
0.2	14	0	0:28	0:00
0.5	36	2	1:11	0:01
1.0	46	31	1:32	1:02
2.0	56	44	1:52	1:28
4.0	65	54	2:10	1:48
8.0	82	70	2:44	2:20

Figure 4-9

point coincides with the CP's along-track range to the next destination point. CPs bracket the target, with the turn-on control point at the same cross-track range as the target. The ANS computes the camera pointing angle required to cover the CP, and thus the target. (Actual target coordinates are not stored in the computer.) Camera CPs can be programmed along the turn line in Fixed-Range-To-Turn turns. Here the CP is located at the same radial distance from the turn line as the target.

The CAPRE side-looking radar (SLR) is controlled similarly to the cameras. In addition to the mode and range commands, the navigation system supplies altitude, groundspeed, cross track, vertical velocity, and aircraft attitude to the radar. These parameters permit compensation for aircraft motion while mapping. Programmed map swath, and a mapping progression marker transmitted every 2.5 n.m. are also supplied.

The mode commands to the TECH(s) and the SLR are updated at each CP and FP so that more than one sensor can be turned on or off at a single point. All CP's and FP's on a leg are processed on that leg, even if a mission planning error or a panel filled change puts a CP or FP past the start turn point at the end of a leg.

Fix Points (FPs)

FPs are accurately known and readily identifiable points along the mission path that are used in measuring ANS position error with the SLR and RCD (Radar Correlator Display), viewsight or TACAN. FPs are used to determine ANS error at the time of the fix. The ANS can be corrected by depressing the UPDATE button, or the routine can be terminated without updating the ANS by depressing the MAN CLEAR pushbutton.

The SLR is automatically turned on and pointed a prescribed distance in advance of the FP as determined by the mission planner. When the aircraft passes the FP, a MARK light appears at the bottom center of the RCD, the display stops moving, and the ANS transmits the computed fixpoint slant range to the radar. A right-angle "L" mark appears on the RCD 50 seconds later. The RSO measures ANS position error by first zeroing on the "L" mark and then moving the crosshairs to the actual fixpoint.

The MARK light extinguishes when the "L" mark moves into view. ANS errors appear as north-south and east-west values on the NCD after the radar READ ERR switch is pressed.

TYPICAL ADD/REPLACE PLAN FOR FIX AND CONTROL POINTS

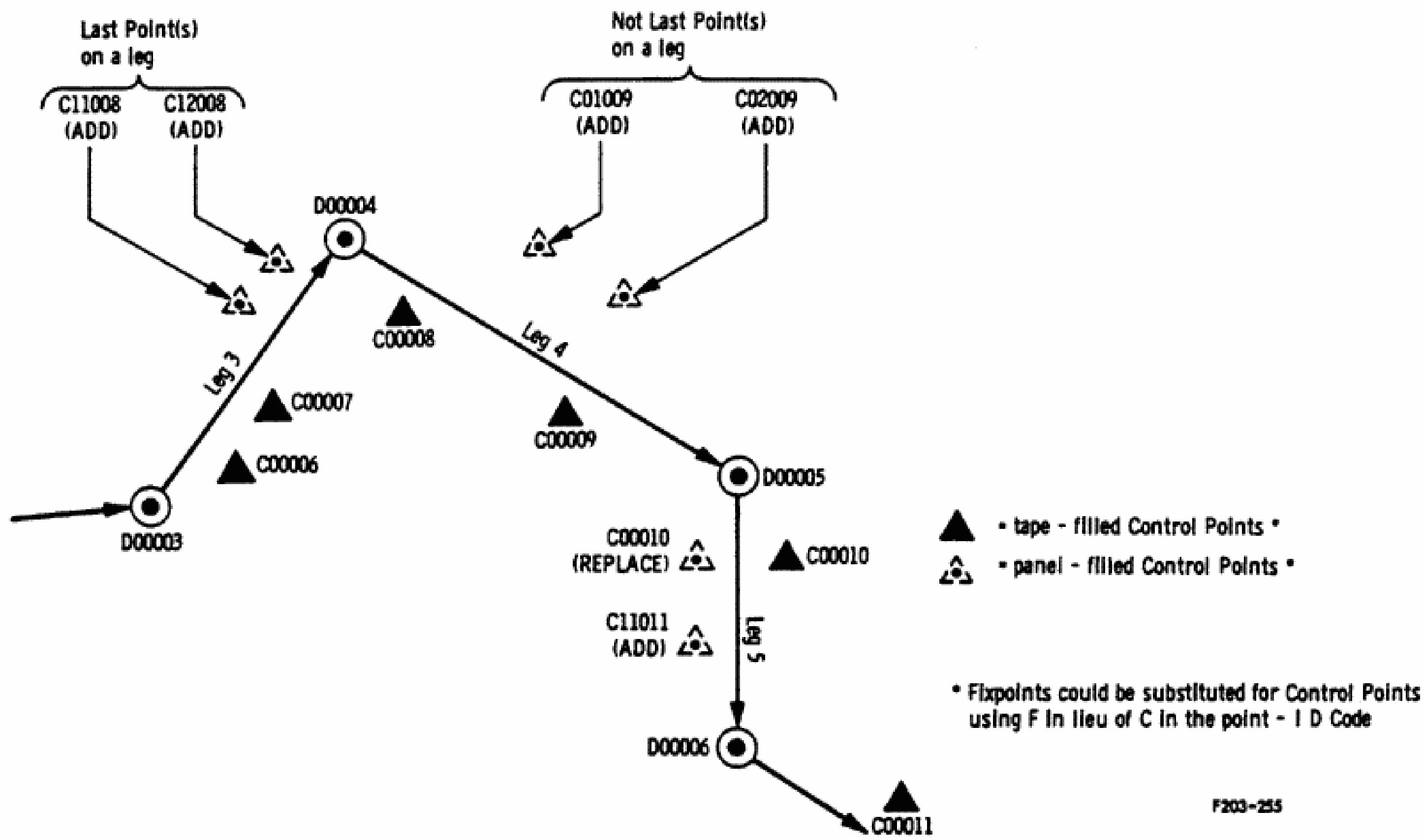


Figure 4-10

The radar remains on until a CP or FP commanding turn off occurs. RCD fixes are accurate to about 0.25 nm CEP.

For viewsight FPs, the RSO normally uses wide angle view to search for the FP as it approaches. After identifying the FP, select narrow view, if possible, for maximum accuracy. As the FP passes down the viewsight screen, move the cursor to intercept the FP as it passes under the nadir line. At that instant, press the viewsight READ switch. This provides the ANS with the location of the FP relative to the aircraft and allows measurement of ANS computed position error. Again, the errors appear in north-south, east-west values on the NCD after the READ switch is pressed. Viewsight fixes are accurate to about 0.5 nm CEP.

At TACAN FPs, ANS computed values of slant range and bearing to a TACAN station are displayed on the NCD for comparison with TACAN data observed on the BDHI. When a TACAN fix is desired, depress the TACAN switch, then enter the TACAN values of magnetic bearing (xxx°) and slant range (xxx nm) at the time the TACAN button was actuated. The ANS will then display the north-south and east-west errors.

MISSION POINT DATA

	Dest. Point		Control Point		Viewsight or SLR FP		TACAN FP (1)
	Tape Filled	40-List	Tape Filled	40-List	Tape Filled	40-List	Tape Filled
Latitude	x	x	x	x	x	x	x
Longitude	x	x	x	x	x	x	x
Turn radius	(2)	(2)					
Next DP No.	x	(3)					
Next FP No.	x				x	(3)	x
Next FP on Track (yes/no)	x				x		x
Next CP No.	x		x	(3)			
Next CP on Track (yes/no)	x		x	x			
Left TEOC Mode			x	(4)			
Right TEOC Mode			x	(4)			
Camera/Radar			x	(5)			
Left TEOC (on/off)			x	x	x		x
Right TEOC (on/off)			x	x	x		x
Radar (on/off)			x	x	x		x
Left/Right TEOC			x	(6)			
Terrain Altitude			x	x	x	x	x
Radar Range Code			x	(5)	x	(7)	
Radar (narrow/wide)			x	(8)	x	(8)	
Radar (left/right)			x	(6)	x	(7)	
Radar to Radar FP					x	(9)	x
Radar/Viewsight FP					x	(7)	
TACAN/Not-TACAN FP					x		x
Magnetic Variation							x

NOTE:
An "x" in a column indicates that the corresponding parameter is programmed for that type of point.

(1) There are no 40-list TACAN fix points. TACAN fix points are panel-filled as Anytime fix points which are not included on this chart.

(2) Tape filled points: Zero turn radius used for auto-range-to-turn.

40-list points: No turn radius filled for auto-range-to-turn.

(3) Point ID code is the 40-list equivalent to next point number. No point ID code entered for Anytime fixpoints or Opportunity Viewsight fix points.

(4) Mode 3 is automatically used for 40-list camera points.

(5) Camera/radar CP designation made by filling zero slant range code for camera points.

(6) 40-list marker designates left/right camera for camera CP's, radar left/right for radar CP's.

(7) Slant range code and left/right are not filled for viewsight FP's.

(8) Only narrow modes can be used for panel-filled points.

(9) 60 nm. is used automatically.

Figure 4-11

TACAN fixes are accurate to 2 to 3 nm at slant ranges from 20 to 200 nm. Accuracy is degraded at less than 20 nm and greater than 200 nm. The range data can generally be accepted, but TACAN bearing information may be somewhat inaccurate. When the INS is in the ATT mode, the TACAN mag bearing is correct, but the relative bearing may be in error.

If desired, the ANS computed position can be corrected by pressing the UPDATE switch; otherwise, press the MAN CLEAR switch to clear the measurement data. If FPs are used for updating, the ANS adjusts position, platform level, velocity, and heading based on the Kalman filter weighing matrices. The amounts applied to each of these parameters are optimized for the existing mode. Generally, corrections will not be necessary in the ASTRO INERTIAL mode although the measurement should be made to check the system.

Sensor operation may also be commanded at FPs. The point of execution will be at the along track position determined by the FP abeam point plus the range-to-turn-on value in the FP data of the mission tape. The TECH(s) may be turned on or off at any tape-filled FP. The camera(s) will be pointed and have the modes programmed at previous CPs. The SLR may be turned on or off at any tape-filled FP and may be repointed if the FP is not a TACAN FP.

MISSION MODIFICATION

The tape-filled mission program can be modified through the NCD panel. Up to 40 sets of data (40-List) may be entered to replace or add to previously stored mission points. In addition, the operator can skip any number of tape-filled or panel-filled destination points, or change destination. There are also special panel-filled fixpoints called Anytime or Opportunity fixpoints that are exclusive of the 40-List.

Add or Replace CP-FP-DP Routine

The mission tape is stored in the tape-filled memory of the computer. Panel-filled data for mission modification is stored in the panel-filled memory of the computer. Only Add or Replace modifications use the 40 panel-filled memory cells. Data required for each type of point, both panel-filled 40 List and tape-filled points, is listed in Figure 4-11. If necessary, the RSO can clear any or all of the mission modification data entered into the panel-filled memory and enter new data in the same 40 memory spaces. Detailed knowledge of the tape-filled mission is required to modify that mission, especially when control points or fixpoints are added or replaced.

Point-ID Code

Every tape-filled or 40-List mission point has an identification code. The code consists of a letter and five digits, referred to in the following text as digits 1, 2, 3, 4, and 5, counting from the left. This is the order in which the point-ID code is entered in the NCD panel. A letter C/C1, F/F1 or D designates the point as a control point, fixpoint, or destination point, respectively, and appears in the left-most display of the SELECTED DATA 6 window when a mission point is selected for display. When modifying a mission, this part of the ID code is entered by selecting FIXPOINT, CONT PT, or DEST POINT on the DATA switch.

Digits 3 thru 5 of the ID code denote the number assigned to each tape-filled CP, FP, and DP. Tape-filled points are numbered from 001 for the first CP, FP, and DP, to 127. In general, the points on the primary mission are numbered in sequence followed by the points on alternate legs. However, the sequence is not really important since the next point number of each type is listed with each tape-filled mission point; i.e., the data for DP 002 can define DP013 as the next DP, or vice versa. The same applies to CP's and FP's.

As shown on Figure 4-8, DP's which are the start points for alternate legs are doubly defined. This means that the same geographic point is contained in two different locations with different number and different next-point numbers (example: D00003 and

D00011). The alternate leg is selected by skipping to D00011 when on leg 1. Note that the alternate path rejoins the primary mission at D00007; thus, both D00006 and D00012 list D00007 as the next DP. 40-List (ADD or REPLACE) points are defined relative to tape-filled points; digits 3 thru 5 define the tape-filled point to be replaced, or the tape-filled or panel-replaced point following the point(s) to be added.

Digit 2 is the "add" number for panel-filled ADD points. Digit 2 can range from 1 to 7 for the first through seventh points to be added ahead of the tape-filled or panel-replaced point of the same type defined by digits 3 thru 5, where add point X10YZ is the first add point encountered in the mission, ahead of point 000YZ with add point X20YZ the second, etc. Digit 2 is zero for tape-filled points or replaced points. Digit 2 is the left-most digit in the SELECTED DATA window 6 when a mission modification is performed or a mission point is displayed.

Digit 1 is a zero for all tape-filled points, replaced control or fix points, and 40-list destination points. When adding fix or control points, however, digit 1 is used by the computer to determine the track leg location of the new added point. If the add point is after the last tape-filled point of its type on its track leg, this digit is 1; if the add point is before the last tape-filled point of its type on its track leg, then the digit is a zero. Digit 1 appears as C1 or F1 in the letter position of the SELECTED DATA 6 counter during a mission modification or mission point display operation (when ID code is entered). It also appears when a point is displayed.

Sensor Selection Code

The three-digit sensor selection code designates which sensor shall be turned on and/or remain on, at a panel-filled control point.

When control points are added or replaced, take care not to disrupt prior turn-on commands to the TECH cameras or SLR system. If, for example, the L TECH was automatically turned on 50 nm prior to an add R TECH control point, and the mission planner intended it to remain on for a total 100 nm swath, the add-control point sensor assignment code would be 110. This would tell the computer to leave the L TECH on at the new control point and that the R TECH will be turned on. This is necessary because each CP will turn sensors off without an "on" marker in the sensor code.

SENSOR SELECTION CODE

SENSOR	CODE		
L TECH	1	0	0
R TECH	0	1	0
SLR	0	0	1
Verify code insertion on panel by illumination of appropriate sensor indicator.			

Figure 4-12

Left-Right Start Range Code

The left-right marker and start range code (three digits in the range code column of Figure 4-13) designate which side of the aircraft to point and the distance from nadir to the area to be mapped (near edge of the radar beam, when the SLR is selected for use with fix-points or control points). The panel-filled start range code is limited to the SLR five-mile recorder strip width noted in the first column of the table. When adding or replacing TECH camera control points, insert L00.0 or R00.0 for control points to the left or right of course respectively. Verify code insertion in the SELECTED DATA window 5 (R or L plus three numeric digits).

40-List Add/Replace FP-CP-DP Limitations

Add/replace can be performed in any ANS mode except OFF or WARM UP. Add/replace alters the tape-filled mission. If the added point is located before the "next point" of each type on the current leg, or the replaced point is the current "next point" of

START RANGE CODE
-Capre Radar-

Ground Range Mapped (nm)	Range Code	Start Range (Cross Track Range to Near Edge of Beam (nm))
(Illegal Code)	L/R* 05	5
10 - 15	10	10
15 - 20	15	15
20 - 25	20	20
25 - 30	25	25
30 - 35	30	30
35 - 40	35	35
40 - 45	40	40
45 - 50	45	45
50 - 55	50	50
55 - 60	55	55
60 - 65	60	60
65 - 70	65	65
70 - 75	70	70

*L or R, depending on whether CP or FP is to the left or right of course.

Figure 4-13

each type, then the RSO must fill the new points into the 40-List and then perform a Track Leg Update. This will cause the ANS computer to recognize and use these new 40-List points. For example, if the first tape-filled leg is changed by replacing or adding DP's, a Track Leg Update will reinitialize the computer to the new first leg.

Any filled 40-List points located after the current "next tape-filled point" of each type will be utilized in the normal ANS sequence and no Track Leg Update is required (see Figure 4-10).

NOTE

> A FP/CP/DP in the 40-List must be deleted before a correction/modification can be made to that numbered point.

Points may be added before replaced tape-filled DP's. A maximum of seven points of one type can be added in between two tape-filled points of that type. Points cannot be added after the last tape-filled point of that type. FP's and CP's cannot be added into track legs that contain no tape-filled FPs or CPs except an Anytime Fixpoint (described later) can be added to a leg that has no tape-filled FPs. If a FP is replaced, any sensor activity programmed at the original tape filled-point is negated, that is, will not occur. For example, if a camera was to be turned on at a radar FP or turned off, and that FP is replaced, the programmed camera activity will not take place. The sensors should then be operated in the Manual Mode. If a FP is added, there is no effect on the programmed camera activity. Adding a viewsight FP does not affect programmed radar activity.

The ANS does not automatically stop processing CP's and FP's on the original tape-filled leg when navigating on a leg from a tape-filled DP to an added or replaced DP; or from a replaced DP to any type of DP. In these cases, the CP's and FP's on the original leg are processed relative to the new leg. In general, pointing and mapping commands will be incorrect, and unless all CP's and FP's can be projected on to the new leg, a sensor could be commanded on but not off. Therefore, the sensors should be operated in their manual modes or tape-filled CP's and FP's should be replaced. No CP's and FP's are processed when navigating from an added DP to any type of DP.

After a power dropout, pressing RAPID or MODE START on the ground with the MAL light flashing will erase the 40-List. Anytime a rapid or gyro-compass ground alignment is performed, 40-List data must be re-entered. 40-List data is not deleted if the HOT switch is pressed with the MAL light flashing or a cold airstart is performed. Therefore, 40-List data is retained for a ground hot start, cold airstart, or a hot airstart. Pressing the MODE START switch without the MAL light flashing has no effect on the 40-List.

Turn Radius For Panel-Filled DPs

A turn radius can be filled with any panel-filled DP to get a fixed-range-to-turn at that DP. This data is filled in nautical miles with three digits and appears in the SELECTED DATA window 3. If no turn radius is filled, the system calculates the turn radius based on current groundspeed and a 32° bank angle. Figure 4-14 lists turn radius values for various Mach numbers and bank angles.

NOTE

> A turn radius for a bank angle greater than 35° will only be commanded by the autopilot if the original programmed bank angle for that turn start point (TSP) was greater than 35°. The autopilot will otherwise be limited to 35°.

Delete DP/FP/CP Procedure

The DELETE procedure can erase a panel-filled DP, FP, or CP from the 40-List so that the memory space can be re-used, or that a mistake in manually entering a point can be rectified without clearing the entire 40-List. Tape-filled points cannot be deleted.

Add FP Anytime Procedure

The ADD FP ANYTIME procedure is identical with the ADD-FP procedure except that no ID code is entered and the entry does not go into the 40-List. The procedure allows the RSO to add fixpoints on legs that have no tape-filled FPs (during critical phases of hot or cold airstarts; on skip-to or direct-steer legs; or any time).

The Anytime FP can only be entered when on the great-circle leg on which it is to be used. Actuation of the viewsight READ switch deletes either a viewsight or radar Anytime FP. A TRACK LEG UPDATE or DIRECT STEER procedure also deletes an Anytime fix point.

When a viewsight Anytime FP is inserted, no tape-filled or panel-filled fixpoints on that track leg are processed until the RSO presses the viewsight READ switch. Camera and radar control points are not affected by the viewsight Anytime FP routine.

When a radar Anytime FP is inserted, the radar is commanded to operate 60 nm ahead of the Anytime point. Any tape-filled or panel-filled radar commands (CP's or FP) are inhibited and will not take place until 24 nm past the "Anytime" point. The radar remains on and pointed at the "Anytime" fix point until subsequent tape-filled or panel-filled radar commands turn the radar off or re-points it. Camera control points are not affected by the Radar Anytime FP routine.

TACAN Anytime FP's do not affect sensor programming at tape-filled control points or fixpoints. Therefore, for a confidence check on sensor "take" legs, it is better to use the Anytime TACAN or viewsight fix than the Anytime radar fix.

Opportunity Viewsight Fix

The Opportunity viewsight fix allows the RSO to update ANS present position using a visually identified point which has not been tape or panel-filled into the ANS. In this procedure the RSO aligns the cursor and presses the READ switch as in a normal viewsight fix routine. As the coordinates of the opportunity point are not previously stored in the computer, the initial display of ANS corrections is meaningless. However, these initial corrections are cleared when the RSO fills the latitude, longitude, and elevation of the opportunity point. When the ENTER/DISPLAY switch is pressed after coordinate entry, new errors are displayed. The RSO can then either clear the errors or enter the corrections.

The RSO can repeat the coordinate entry if an error is made in the initial entry by pressing the ENTER/DISPLAY switch and re-entering all data required. However, if ERR is displayed in the MODE window, MAN CLEAR must be pressed to terminate the routine and no update is possible.

Skip to DP Routine

The following examples refer to Figure 4-8.

When the skip-to routine is performed, the following DP number associated with the current next DP is replaced with the skipped-to DP number. This procedure can be used to select an alternate route in flight. For example, perform skip to D00011 while en-route from D00001 to D00002 and before reaching the range-to-turn to D00003, to select the alternate route from D00002 to D00011 to D00012, etc. This procedure could also be used to skip any portion of the programmed mission. For example, to skip from D00004 to D00006, perform a "skip to D00006" while enroute from D00003 to D00004 and before reaching the range-to-turn to D00005. Do not perform a skip from a doubly defined destination to its alternate destination since this creates a zero-length leg and unpredictable navigation results. For example, do not perform a "skip to D00011" after reaching the range-to-turn to D00003 and enroute to D00003 since the leg from D00003 to D00011 has zero length.

Skipping to a DP after starting great-circle navigation does not erase CP or FP operation on the original programmed leg following the current next DP. Consequently, skipping to D00011 to select the alternate route does not eliminate the sensor operation on the leg from D00002 to D00003. On the other hand, skipping to D00006 while enroute to D00004 will not eliminate the CP's and FP's along the original leg from D00004 to D00005, and the system will process these points. In this case, the sensors should be operated in their manual modes until back on the programmed mission course.

Direct Steer

The direct-steer procedure results in an immediate change in destination. When commanded, the ANS computes a new great-circle course from the present position to the destination point selected or coordinates entered by the RSO. The aircraft turns to the new course immediately after the DIR STEER switch is pressed. The ANS computes new great-circle courses to the selected DP or coordinates until the aircraft has turned to within 2 degrees relative bearing to the destination. This results in the most direct path to the destination. If aircraft track subsequently deviates more than 2 degrees from command course, the direct steer is automatically restarted. When the DIRECT STEER procedure is performed, ANS operate commands to the sensors are turned off. The ADD ANYTIME FP and OPPORTUNITY Viewsight Fix procedures are usable while in DIRECT STEER if the aircraft track remains within 2 degrees of the bearing to the DP during the Fix procedure.

Track Leg Update

The Track Leg Update procedure allows the RSO to change the current ANS track leg. Any track leg segment in the mission may be selected. The RSO fills the ID code number of the beginning DP of the leg he desires. The ANS then initializes to the leg from that DP to the next sequential tape-filled or 40-List DP. Great-circle navigation and sensor control are immediately conducted relative to this new leg. The ANS sequences through all FP's and CP's on the new leg up to the current computed along-track position, where sensor commands will be as programmed for that point on the track; normal auto-nav steering is performed, using a 30-degree approach to the new track, if necessary.

The RSO should perform a track leg update during a Hot or Cold Airstart and Ground Hot Start since the computer automatically re-initializes to the first track leg segment on the mission tape at system turn-on.

NOTE

If the current groundspeed and/or present position satisfy turn start criteria to the next leg, then the ANS will accept the updated track leg and immediately "index" to that next track leg.

ANS BANK ANGLE VS TURN RADIUS FOR VARIOUS MACH NUMBERS

FAT = -56°

Mach No. KTAS*	2.80 1606	2.85 1635	2.90 1664	2.95 1693	3.00 1721	3.05 1750	3.10 1779	3.15 1807	3.20 1836	3.25 1865
Bank Angle	Turn Radius (KR) - NM									
Deg.										
20	105	109	113	117	121	125	129	133	137	142
21	100	103	107	111	114	118	122	126	130	134
22	95	98	102	105	109	112	116	120	124	127
23	90	93	97	100	103	107	110	114	118	121
24	86	89	92	95	99	102	105	109	112	116
25	82	85	88	91	94	97	101	104	107	111
26	78	81	84	87	90	93	96	99	102	106
27	75	78	80	83	86	89	92	95	98	101
28	72	75	77	80	83	85	88	91	94	97
29	69	72	74	77	79	82	85	87	90	93
30	66	69	71	74	76	79	81	84	87	89
31	64	66	68	71	73	76	78	81	83	86
32	61	63	66	68	70	73	75	77	80	82
33	59	61	63	65	68	70	72	75	77	79
34	57	59	61	63	65	67	69	72	74	76
35	55	57	59	61	63	65	67	69	71	74
36	53	55	56	58	60	62	65	67	69	71
37	51	53	54	56	58	60	62	64	66	68
38	49	51	52	54	56	58	60	62	64	66
39	47	49	51	52	54	56	58	60	62	64
40	46	47	49	51	52	54	56	58	60	61
41	44	46	47	49	50	52	54	56	57	59
42	42	44	46	47	49	50	52	54	55	57
43	41	42	44	46	47	49	50	52	54	55
44	40	41	42	44	45	47	49	50	52	53
45	38	40	41	42	44	45	47	48	50	52

*KTAS based on Mach 1.0 = 573.6 knots at $-56.5^{\circ}C$ ambient air temperature.

KR = $14.815 (V/1000)^2/\tan \phi$ for ANS System turn; where V = KTAS, ϕ = bank angle.

Figure 4-14

ANS OPERATION

The ANS must be warmed up and aligned before flight. The methods for ground and air alignment and their association with various navigation modes is outlined in Figure 4-16.

Prior to ground alignment, verify that the prescribed mission program is in the computer and that the portable chronometer is installed and operating. Power and cooling air are required continuously through warm-up, alignment, and navigation. Once alignment has started, a power interruption of

ANS TURN RADIUS VS. TRUE AIRSPEED & BANK ANGLE

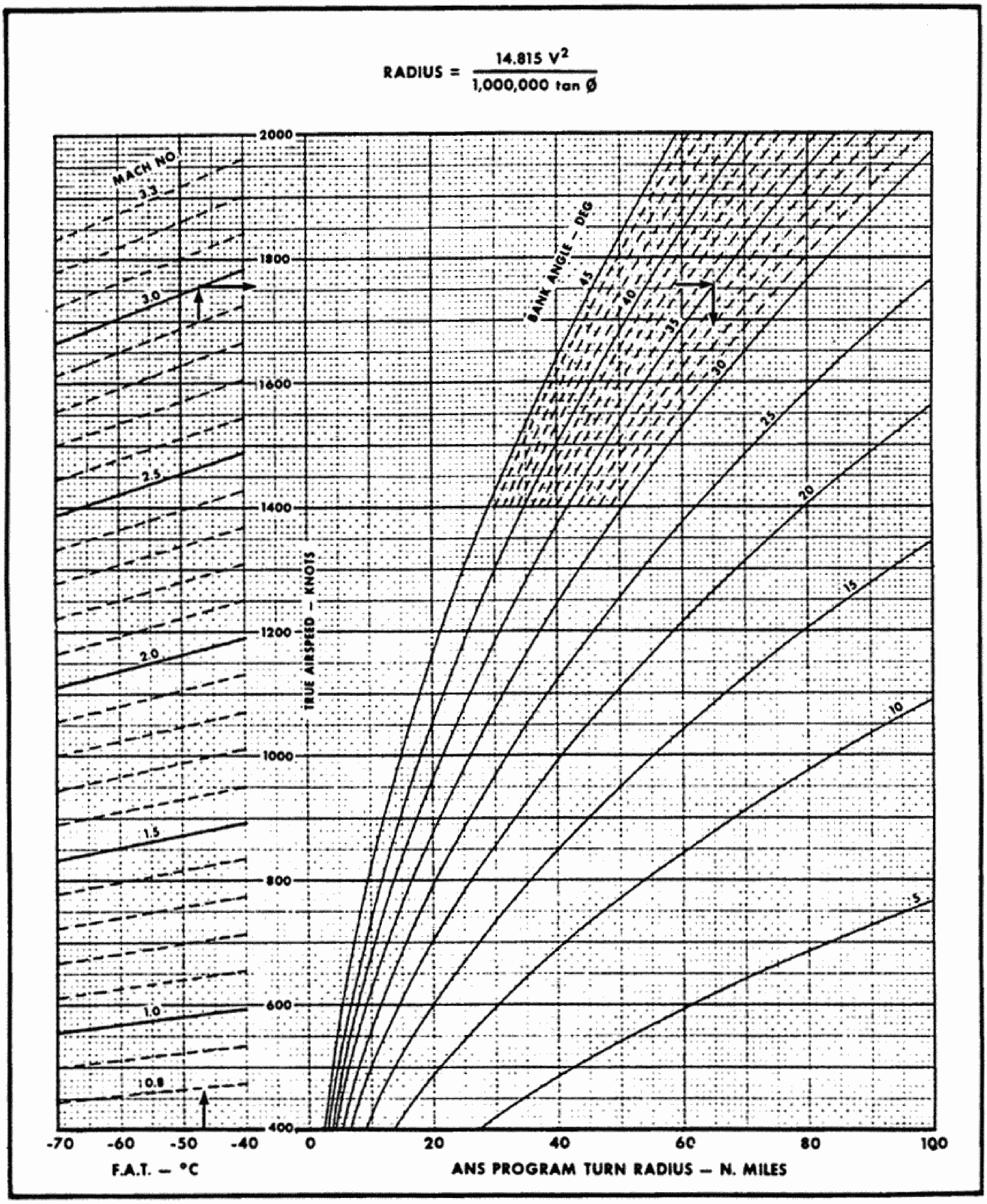


Figure 4-15

NAVIGATION MODES VS ALIGNMENT METHODS

	NAVIGATION MODE	ALIGNMENT METHOD WITH NDC -1070 COMPUTER
GROUND ACTIVATION	ASTRO INERTIAL INERTIAL ONLY	**GYROCOMPASSING** - Warm up 60 min - Coarse align 6 min - Fine align 29 min 55 sec 1st align - 12 min 15 sec slew 90° - 1 min 30 sec 2nd align- 16 min 10 sec (Coarse align through 2nd align: 95 min 55 sec) **RAPID** - Warmup 60 min - Coarse align 6 min - Fine align 12 min (78 min 15 sec) **GROUND HOT START** - Coarse align 50 sec - Restart 30 sec (90 sec)
INFLIGHT ACTIVATION	AIRSTART	**AIRSTART** - Coarse Align Phase: Until platform is rough leveled (< 40 arc min) - Restart: Until platform is leveled (< 21 arc min) - Navigate Phase: Continuous after platform leveling Dead Reckon: Continuous from FILL PP (during coarse align) to ★ ON (steady) Search for Star A & B: Continuous from platform leveling + 5 min to ★ ON illumination (steady) Airmass-damped, astro inertial navigation: Continuous after ★ ON illumination (steady)

Figure 4-16

F203-256(a)

more than 1 second will require realignment. Normally, warmup and alignment are performed on ground power and cooling air with transfer to aircraft power and cooling air after engine start, but can be performed on aircraft power and cooling air after engine start.

When operating from an alternate base without ANS support personnel, the chronometer day/time accuracy must be checked. If a flight with an accurate chronometer installed terminates at an alternate base, the chronometer can be (a) maintained indefinitely in an accurate GO state by connecting ground power and cooling to the aircraft with the MODE switch OFF and the aft cockpit ANS essential DC circuit breaker in, or (b) left in the aircraft after normal shutdown procedures are completed. In the latter case, if the battery ON/OFF switch is left in the ON position, the chronometer battery will run down in approximately 24 hours and the chronometer will stop. After power is reapplied to the aircraft and the battery ON/OFF switch is in the ON position, the chronometer should display a GO status and begin to charge its internal battery. If the chronometer is in a GO status, but merely incorrectly set, fill DAY/TIME during C/A and operate in the ASTRO INERTIAL mode. (In a ground hot start, the C/A mode lasts only 60 seconds.) After filling DAY/TIME, the difference between RSO filled values and chronometer values is retained as a bias term to update the computer time following power dropouts of less than 1 second. Thus, astro inertial navigation should function normally. Power dropouts that exceed 1 second will not be compensated for.

After filling DAY/TIME a Hot Airstart cannot be performed and a new ground alignment or Cold Airstart is required. Chronometer options are listed in Figure 4-17.

(Note: 4-32A/([redacted] Blank) deleted

CHRONOMETER/OPERATION OPTIONS

Status of Chronometer Installed	RSO Mode Options	Hot Start Program Retained
A. Accurate, GO	Any	Yes
B. Inaccurate, GO	Do not fill DAY/TIME. INERTIAL ONLY selected after align.	Yes, no star tracking possible.
C. Inaccurate, GO	Fill DAY/TIME - ASTRO INERTIAL selected after align.	No, star tracking available. (Recommended procedure.)
D. NO/GO or Chronometer disconnected or not installed.	Any. But <u>any</u> power dropout of <u>any</u> duration will cause drop out of ANS. New alignment or Cold Airstart will be required. This situation very undesireable and ANS dropout is highly probable in flight due to electrical system interruption or transient below 103 volts.	No.

Figure 4-17

NOTE

Takeoff without a chronometer or with a NO/GO is permitted but not recommended. ANS mode options are the same for any of these conditions, but are subject to conditions discussed under Power Dropout and Chronometer Failure in this section under <u>Malfunction Indicator</u>. Also refer to <u>Flashing MAL Light On During Ground Operation</u> and <u>Flashing MAL Light On In Flight</u>, this section.

Warmup

Turn the MODE switch from OFF to WARM UP. The MAL light will illuminate steady. Monitor the TEMP LIMIT light. If the light remains out, the MODE switch can be moved to an "operate" position. If the TEMP LIMIT light is on steady or flashing, immediately turn the MODE switch to OFF and check ANS cooling. The MODE window display is blank in the WARM UP mode.

Ground Alignment

When the MODE switch is moved from WARM UP to ALIGN or an "operate" mode, full operating power is applied to the entire system and alignment begins. The MODE window indicates the current phase of alignment. Initially, the MODE window reads C/A, and the computer starts the self and system test routines. A flashing MAL light comes on when full operating power comes on and is reset by pressing the MODE START, or RAPID, or HOT switch; it will relight if the computer test routines detect a malfunction or power dropout.

Upon successful completion of the test routines, the computer automatically starts alignment beginning with the coarse phase. Coarse alignment time (5 to 6 minutes) is the same for all ground-start cases except ground hot start.

Except for hot starts, fine alignment begins after completion of coarse alignment if present position coordinates have been entered. Do not enter present position until the TEMP TOLR light extinguishes.

NOTE

> Except for hot starts, enter either magnetic variation or true heading prior to entering present position and field elevation.

The optimum method of alignment is gyrocompassing. The 30-minute fine-alignment phase includes gyrocompassing. Gyro compassing determines the orientation of the platform relative to true north. Fine alignment accurately levels the platform to the local vertical.

An alternate method of ground alignment is the rapid alignment. In this mode, the system automatically goes directly to a 12-minute fine-align period from coarse align. During fine align, the gyros are rated and the platform is leveled. Since gyrocompassing is not performed, a runway heading alignment should be performed during takeoff following a rapid alignment unless the aircraft true heading in the parking location is known within 0.1 degree or the star ON light illuminates before flight.

Completion of fine alignment (and gyrocompassing) is indicated by display of present position coordinates in the PRESENT LATITUDE/LONGITUDE windows. For optimum navigation performance, remain in fine-alignment until just before taxi. If the aircraft will be stationary for 5 minutes or more after a navigation mode has been initiated, use the Ground Alignment Correct procedure. This procedure puts the system back into fine align and removes any velocity error induced by taxiing. Star tracking will continue during the alignment if it was in progress.

Alignment Mode Selection

The ANS is aligned by setting the MODE switch to ALIGN, ASTRO INERTIAL or INERTIAL ONLY and pressing either the MODE START switch or the RAPID switch.

For a gyrocompassing alignment, set the MODE switch to ALIGN, ASTRO INERTIAL or INERTIAL ONLY and press the MODE START switch. At the completion of Fine Align the ANS automatically enters the mode selected with the MODE switch. If ALIGN was selected the ANS remains in Fine Align until a navigation mode is selected or the aircraft is moved (in which case the system automatically enters the ASTRO INERTIAL mode).

For a rapid alignment, set the MODE switch to ALIGN, ASTRO INERTIAL or INERTIAL ONLY and press the RAPID switch. At the completion of Fine Align the ANS remains in Fine Align until a navigation mode is selected or aircraft motion causes the system to enter the ASTRO INERTIAL mode.

Navigation cannot start until the minimum fine-alignment time has elapsed as indicated by display of the present position coordinates in the PRESENT LATITUDE/LONGITUDE windows.

NOTE

The alignment mode cannot be changed subsequent to the first MODE START or RAPID switch operation without turning the MODE switch to OFF or WARM UP and back to the desired mode. Merely moving the MODE switch to the alternate mode and pressing the MODE START switch does not change the mode of alignment.

Ground Hot Start

An abbreviated ground alignment is provided when the aircraft has not moved since the ANS was turned off following a normal ground alignment or operation in an operate mode. In this mode the RSO presses the HOT switch after power and cooling air are on. The ANS uses the true heading and present position stored in memory at the end of the previous operation. The ground hot start alignment consists of a variable time coarse alignment followed by a 30 second leveling period during which RESTART (RES) is displayed. The time in C/A should not exceed 90 seconds from the time HOT is pressed. Platform leveling is inhibited until 45 seconds after power is applied, then coarse alignment begins if HOT has been pressed. If HOT is not pressed, platform leveling is inhibited. When the platform tilt error is less than 10 arc minutes, the ANS enters the RES mode for 30 seconds of fine alignment. Failure to enter the RES mode means that the platform was unable to level to less than 10 arc minutes. The platform cannot recover from greater than $2\text{-}1/2^{\circ}$ of tilt during a ground hot start. If the ANS will not come out of C/A, a rapid or gyro compass alignment must be performed. Completion of a ground hot start alignment is indicated by the appearance of F/A in the MODE window.

NOTE

If star tracking is not possible due to aircraft location or sky conditions, leave the system in F/A. Otherwise place the system in ASTRO INERTIAL mode by setting the MODE switch to ASTRO INERTIAL and press MODE START. When A-I appears in the MODE window, inertial data is used for all ANS updates and displays and the star tracker will start searching for an "A" star.

The ANS uses the landing gear switch to distinguish between a ground hot start and a hot air start. Air mass damping is not performed following a ground hot start. Before a ground hot start, ground cooling air should be provided at $75^{\circ}F$ if possible. Loading a new mission tape destroys the stored values of position and heading. If the stored heading is not accurate within 0.1° and the star ON light is off, a runway heading alignment should be performed following the ground hot start.

Takeoff

If the runway heading alignment routine is used, maintain takeoff roll parallel to runway centerline. This alignment is automatically terminated at lift-off by a switch on the left main landing gear strut. The RSO must press the UPDATE or MAN CLEAR pushbutton to end the procedure.

In-Flight

After takeoff, the tape-filled mission plan will be followed automatically except as modified by panel-filled inputs. Generally, the autopilot is engaged in the auto-nav mode to simplify flying the mission. Refer to Mission Tape Program and Mission Modification, this section, for a more complete discussion of navigation and sensor control.

Position fixes, using the TACAN, SLR, and viewsight should be made at frequent intervals to verify and, if necessary, refine computed position. The ANS errors measured by these systems are displayed on the NCD panel and may be cleared or entered into the ANS to correct present position. This is especially important in the alternate navigation modes.

TACAN FP accuracy is inherently worse than the viewsight, radar, or ANS fixes, so updates of the ANS by TACAN should only be entered when the ANS is positively known to have large errors.

The ANS software will weight the correction according to prestored accuracy estimates for the type of fixpoint and its current estimate of ANS accuracy. Hence the update command by the RSO will result in only a portion of the displayed error being accepted. The Remote Update routine will, however, always make a total position update by the amount commanded. On other types of fix updates, if either the latitude or longitude correction requested is greater than 5 nautical miles, the total amount will be accepted.

The NCD panel star ON light is an important indicator during astro-inertial and airstart operation. If the star ON light is out during astro-inertial operation, system error will increase at the inertial-only rate and extra effort should be made to check computed position. If the star ON light is on, astro-inertial performance will generally be good. Refer to Astro-Inertial Navigation, this section.

Airstart Alignment

Should there be an airborne power interruption or temporary malfunction, it may be possible to realign the ANS using the airstart procedure. A period of coarse alignment to level the platform is followed by a period when it may be possible to accurately level the platform for precision navigation by performing a series of fixes.

Present position can be entered any time after initiating the airstart procedure and is updated continuously thereafter by dead-reckoning computations. If present position has not been filled by the time the coarse align phase has been completed, the MODE window will indicate ENT (Enter data).

The system also commences great-circle navigation and sensor control using dead reckoning position as a reference in computing steering commands, true heading, range and bearing to points of interest, NORMAL display data, etc. True heading must be checked for accuracy and updated as required. Magnetic variation may be used to correct true heading when the ANS is in the C/A mode. Afterwards the TRUE HEADING UPDATE routine must be performed. Also, if accurate navigation is desired prior to star ON light illumination, the FILL WIND procedure should be used initially in the coarse align mode and repeated as wind conditions change until star ON steady illumination. Position fixes (TACAN, viewsight, or radar) may be used to update the dead reckon frame during this period. Remote updates may be used to update the inertial frame.

After coarse alignment is completed, the MODE window display changes to RES and the system commences internal airspeed-damped navigation using dead-reckon data as a starting point. In one minute the first airmass damping correction is made and corrections of diminishing magnitude are made every minute for the duration of the flight. These corrections do not cause autonav steering transients. Inertial present position can be displayed and compared with dead-reckon present position by using the DISPLAY PRESENT POS procedure. Star search begins when A-I appears in the MODE window. To optimize star acquisition, the aircraft should be flown straight and level.

Acquisition of star A is indicated by flashing of the star ON indicator. When B star is acquired the star ON light goes out.

When the star ON indicator goes on steady, indicating that continuous star tracking is in progress, inertial data is used to update all ANS outputs and internal dead-reckon computations. If the autopilot is engaged in the auto-nav mode, an aircraft maneuver will occur. Position fixes should be made and the system updated as required.

ANS NORMAL PROCEDURES

The following ANS Tape 12 operating procedures are divided into the general categories of alignment, fill, update, change and display.

NOTE

In these procedures, only the indications that change as a result of procedural steps are listed. Assume that the display does not change if the indication of a particular display is not listed.

The L and R TECH and SLR NCD indicators will be off unless otherwise specified.

The MAL indicator must be off at all times except: it must be on steady while in the WARM UP mode and flash when the MODE switch has been turned from OFF or WARM UP to ALIGN, ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART; and must extinguish after the MODE START, HOT, or RAPID switch is pressed. Refer to the Emergency Procedures paragraph if the MAL light illuminates under any other circumstances.

"Operate" positions of the MODE switch means ALIGN, ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART.

If ERR is indicated in the MODE window, press the MAN CLEAR switch and restart the procedure.

ENT is displayed following the minimum coarse alignment period when present position/heading has not been filled.

When the MAN CLEAR switch is pressed (or the first keyboard switch is pressed after a panel routine is completed in a sequence of routines) the SELECTED DATA counters blank with the exception of a cue letter in one of the windows which will indicate the first data to be entered. The exact letter and window will depend on the DATA switch position. The PRESENT LATITUDE/LONGITUDE/WIND/NEXT DP/TIME TO TURN displays and the star ON, TEMP LIMIT, and TEMP TOLR indicator lights are not affected.

GROUND ALIGNMENT

Prior to ground alignment, an operating chronometer must be installed, the aircraft must be stationary, and the MODE switch must be OFF. Heading must be supplied within ±28 degrees for gyrocompassing alignments, or ±2 degrees for rapid alignment by the INS or TRUE HEADING UPDATE procedure.

1. MODE switch - WARM UP.
   a. MAL light - On steady.
   b. MODE window - Blank.
   c. TEMP LIMIT light - Off.

      Turn MODE switch to OFF if TEMP LIMIT light illuminates.
   d. TEMP TOLR light - Off, on, or flashing.
2. MAG/GRID switch - MAG illuminated.
3. MODE switch - ALIGN, ASTRO INERTIAL, or INERTIAL ONLY.

   Allow 5 minutes in WARM-UP before selecting an alignment mode.

a. MAL light - Flashing

b. MODE window - C/A.

c. PRESENT LATITUDE and LONGITUDE windows - Blank.

d. SELECTED DATA windows - Blank.

4. Check GMT and Julian Day using TIME Display.

If either GMT or Julian Day are in error replace the chronometer and restart the alignment. If a chronometer replacement is not available, fill DAY and TIME as accurately as possible. Time error greater than 2 seconds may result in star tracking but with erroneous ANS updating. If accurate star tracking cannot be accomplished, the ANS may be operated in the INERTIAL ONLY Mode.

NOTE

The ANS may be initialized without TIME only if INERTIAL ONLY is selected and MODE START is depressed.

5. For GYROCOMPASS alignment: MODE START - Press or

For RAPID alignment: RAPID Switch - Press

a. MAL light - Off.

b. Star ON light - Flashing when artificial internal star is tracked.

If coarse alignment is completed before steps 6 through 8 are completed, MODE window will display ENT.

Perform step 6 or 7:

6. Use aircraft heading for TRUE HEADING UPDATE.

Enter known, accurate aircraft true heading, using the TRUE HEADING UPDATE procedure.

7. Use INS true heading for TRUE HEADING UPDATE.

Verify the INS is aligned and operating in NORM or NAV mode. Display INS true heading and insert these values into the ANS using the TRUE HEADING UPDATE routine.

NOTE

If the TRUE HEADING UPDATE routine is performed in coarse align or enter data, the updated true heading is used but will not be displayed until the ANS enters the fine align (F/A) mode.

When TEMP TOLR light off:

8. Fill present position and initial altitude (field elevation).

When coarse alignment is complete:

a. For gyrocompassing alignment, MODE window displays F/A for at least 30 minutes.

b. For rapid alignment, MODE window displays F/A for at least 12 minutes.

When the minimum alignment time has elapsed, present position is displayed in the PRESENT LATITUDE and LONGITUDE counters. After this occurs, and just before taxi, start navigation by performing steps 9 and 10.

Before taxiing:

9. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

10. MODE START - Press.

a. MODE window - A-I or I/O.

NOTE

> If ASTRO INERTIAL or INERTIAL ONLY mode was selected in step 3, the system automatically starts astro inertial or inertial only navigation, and the MODE window indicates A-I or I/O when the minimum alignment time has elapsed.

If rapid alignment used and star light off:

11. Do a RUNWAY HEADING ALIGNMENT.

NOTE

> This step is not required if at least one star has been tracked (B star), however, this might not be evident unless the DATA switch was placed to TIME. In any case, the star on light (C star) indicates at least two different stars have been tracked within the past 5 minutes.

GROUND ALIGNMENT CORRECT

The GROUND ALIGNMENT CORRECT routine torques the platform to earth rate at the local latitude and thus removes any velocity errors that may have built up during taxi. If it is expected that the aircraft will remain stationary for at least four minutes after the star ON light has illuminated, this procedure should be used. Since star tracking continues during ground align correct, star tracking data is used to correct heading and recompute the accelerometer null bias point. This procedure is normally performed after engine runup and before taxiing to the runway. If the ANS is in the ALIGN mode during engine runs, inertial errors may result from inadvertant aircraft movement. A ground alignment correct need not be performed if the ANS is not tracking stars unless a long mission delay occurs. Although any built-up velocity errors will be removed, the accelerometer null bias point is not recomputed. Returning to ALIGN under this circumstance prevents further platform deterioration by retorqueing it to local latitude earth rate, but any errors present will continue to affect the platform after this procedure until star tracking occurs. If ALIGN is selected from the INERTIAL ONLY mode and if INERTIAL ONLY is reselected after ground align correct, the first star tracked after ASTRO INERTIAL is selected will be an A-star.

1. MODE switch - ALIGN.
2. MODE START - Press.
   a. MODE window - F/A.

Prior to start of taxi, initiate navigation by performing steps 3 and 4.

3. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.
4. MODE START - Press.
   a. MODE window - A-I or I/O.

NOTE

> If the ground-alignment-correct time is less than 10 seconds, no alignment correction is made.

GROUND HOT START ALIGNMENT

A ground hot start must be preceded by a ground alignment or navigation operation so that an accurate present position, altitude, and heading are stored in the computer. Following the previous operation, the aircraft must be stationary, no tape-fill operations can be performed, and the MODE switch must be in OFF or WARMUP. Prior to the hot start cooling air should be available (75°F) and an operating chronometer should be installed. If the system has not been turned OFF, skip to step 2.

1. MODE switch - WARM UP.
   a. MAL light - On steady.

b. MODE window - Blank.

c. TEMP LIMIT light - Off.

Turn MODE switch to OFF if TEMP LIMIT light illuminates.

d. TEMP TOLR light - Off, on, or flashing.

2. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

a. MAL light - Flashing.

b. MODE window - C/A.

c. PRESENT LATITUDE and LONGITUDE windows - Blank.

d. SELECTED DATA - Blank.

3. Check GMT & Julian Day using TIME display.

If either GMT or Julian Day are in error, replace the chronometer and realign the ANS. If a chronometer replacement is not available, fill DAY and TIME as accurately as possible. TIME error greater than 2 seconds may result in star tracking but with erroneus ANS updating. If accurate star tracking cannot be accomplished, the ANS may be operated in the INERTIAL ONLY mode.

4. HOT switch - Press.

5. Check True Heading and present position.

NOTE

If true heading and/or present position are changed (or not accurate) since previous shutdown, turn system OFF and perform a Rapid or Gyrocompass alignment.

6. Use TRACK LEG UPDATE for initial DP.

7. MODE window - RES.

8. MODE window - F/A.

Before taxiing:

9. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

10. MODE START - Press.

a. MODE window - A-I or I/O.

When aligned on runway and no "A" star:

11. Do RUNWAY HEADING ALIGNMENT.

Not required if at least one star has been tracked (flashing star ON light).

COLD AIRSTART ALIGNMENT

NOTE

If a power dropout has occured, skip to step 3 if HOT or MODE START has not been pressed after power returns.

1. MODE switch - OFF.

a. All NCD panel lights & windows - Extinguished/Blank.

2. MODE switch - WARM UP.

a. MAL light - On steady.

b. MODE window - Blank.

c. TEMP LIMIT light - Off.

Turn MODE switch to OFF if TEMP LIMIT light illuminates.

d. TEMP TOLR light - Off, on, or flashing.

3. Adjust to straight and level flight.

Make necessary heading, altitude, and airspeed changes before continuing since the aircraft should be maintained as steady as possible throughout the airstart until the star ON illuminates, especially during C/A.

4. MODE switch - AIRSTART.

   a. MAL light - Flashing.

   b. MODE window - C/A.

NOTE

I/O appears in the MODE window if chronometer time and day are not available.

   c. PRESENT LATITUDE & LONGITUDE windows - Blank.

   d. SELECTED DATA windows - Blank.

5. MODE START - Press.

   a. MAL light - Off.

6. Check GMT & Julian Day using TIME Display.

If either time or day are in error, fill as accurately as possible. Time error greater than 2 seconds may result in star tracking but with erroneous ANS updating.

NOTE

If an error is made filling TIME and DAY, the routine may be repeated as long as the system is in C/A or ENT and the correct number of digits and ENTER/DISPLAY have been pressed first.

If accurate star tracking cannot be accomplished, select INERTIAL ONLY and press MODE START after the MODE window changes to A-I. If INERTIAL ONLY Mode is selected before C-star tracking, ANS present latitude and longitude will be DEAD RECKON coordinates. Monitor ANS attitude.

7. Check True Heading and Update if required.

An accurate True Heading should be displayed during C/A since the ANS uses the current INS magnetic heading and the last computed value of ΔPSIM, (this value normally equates to magnetic variation since it is the difference between the ANS inertial true heading and INS magnetic heading). If a heading error exists in the INS, ΔPSIM will be MAG VAR plus or minus INS heading error. ΔPSIM is updated every 4 minutes along with the DR position update and is also computed whenever ANS power is lost. If the aircraft does not fly through more than 1-1/2° of variation from the time this value is computed until RES appears in the MODE window, the ANS heading should be accurate enough to track stars. If MAG VAR is filled, the computed value of MAG VAR (ΔPSIM) is superseded. A true heading error could result from adding a geographically accurate MAG VAR to an inaccurate INS magnetic heading. In any case filling MAG VAR will only change true heading and true heading display when in C/A. Fill MAG VAR has no effect on heading or heading display in RES or A-I. If a true heading update routine is performed during C/A or ENT, the updated true heading will not be displayed until RES. True heading may be updated and displayed in RES or A-I. The TRUE HEADING UPDATE routine will override the fill MAG VAR routine regardless of their sequence. The inertial frame uses the true heading at the end of C/A to begin inertial navigation.

The RSO has three options for true heading in the ANS: do nothing and let the last computed value of the MAG VAR (Δ PSIM) determine the true heading; fill a true heading (using tanker heading for example); or fill MAG VAR. If INS heading appears normal, the first option is recommended.

8. Fill Lat/Long of point ahead.

Insert latitude and longitude of a point to be overflown at a convenient distance ahead, using FILL PP procedure, but do not press ENTER switch until step 9.

9. ENTER switch - Press when over selected point.

PRESENT LATITUDE and LONGITUDE windows continually update, using dead-reckon data. Dead reckon data is used for great-circle navigation, sensor control, and all ANS outputs except pitch and roll which are not functional until the completion of coarse alignment.

10. Use TRACK LEG UPDATE or DIRECT STEER as required.

11. MODE window - Check for RES.

When MODE window changes to RES, C/A is complete.

a. ANS pitch, roll, and heading outputs are now functional and reflect inertial data.

b. Internal inertial navigation begins and inertial heading used for DR and heading.

c. Auto-Nav usable, aircraft straight and level.

The autopilot can now be engaged, using ANS attitude reference. Any turns or attitude changes made during the RES mode will affect platform leveling and may prevent subsequent star tracking when the ANS goes into the A-I mode. Avoid engaging Auto-Nav in RES unless necessary.

12. Use DISPLAY PRESENT POSITION procedure to compare inertial and dead-reckoning computations. Update dead-reckon present position using TACAN, viewsight, radar or PRESENT POSITION FILL procedures.

13. MODE window - Check for A-I.

MODE window display changes to A-I to indicate completion of true airspeed coarse leveling, beginning of star search, and the beginning of air-mass damping.

14. FILL WIND, as necessary.

NOTE

Wind can be filled for use in dead-reckoning navigation either in an airstart or when dead-reckon has been selected. Filling wind does not affect inertial navigation.

Perform FILL WIND procedure, as necessary, until star ON illuminates to keep the D.R. position accurate.

Use the REMOTE UPDATE routine to correct inertial position and re-initialize star search if inertial errors exceed 10 NM.

15. Check star ON light.

Acquisition of star A is indicated by flashing of the star ON light. When star B is acquired, the star ON light goes out. After the star ON light illuminates steady, inertial data is used to update all ANS outputs and internal dead-reckon data. If the autopilot is engaged in AUTO-NAV an aircraft maneuver will occur.

16. Update Present Position as required.

All inertial position error may not be yet removed even though the star light is illuminated.

HOT AIRSTART ALIGNMENT

NOTE

If system has not been turned OFF, skip to Step 2.

1. MODE Switch - WARM UP.
   a. MAL light - On steady.
   b. MODE window - Blank.
   c. TEMP LIMIT light - Off.

      Turn MODE switch to OFF if TEMP LIMIT light illuminates.

   d. TEMP TOLR light - Off, on, or flashing.

2. MODE switch - ALIGN, ASTRO INERTIAL, INERTIAL ONLY, or AIRSTART.
   a. MAL light - Flashing.

      NOTE

      The flashing MAL light after a power dropout indicates power restoration and inertial position extrapolation occurs. Inertial position at the time power was removed is moved at TAS rate along the inertial heading at the time power was lost for a time interval equal to the period from power off to power on. This position extrapolation has nothing to do with when the RSO presses HOT. For 45-50 seconds after the MAL light begins flashing, nothing is done with the platform. At the end of this period, platform leveling begins if HOT has been pressed.

   b. MODE window - C/A. (If I/O, perform a COLD AIRSTART)

      NOTE

      If the MODE window display is I/O, turn the system off and perform a COLD AIRSTART. I/O appears in the MODE window if chronometer time and day are not available.

   c. PRESENT LATITUDE & LONGITUDE windows - Blank.
   d. Selected data windows - Blank.

3. Check GMT & Julian Day using TIME Display. If in error, perform a COLD AIRSTART.

   If either time or day are in error, turn the MODE switch OFF and perform a COLD AIRSTART. Accurate position extrapolation cannot occur with erroneous time.

4. Adjust to straight and level flight.

   Make necessary heading, altitude, and airspeed changes before continuing since the aircraft should be maintained as steady as possible throughout the airstart until the star ON light illuminates, especially during C/A.

5. HOT switch - Press.
   a. MAL light - Off.
   b. Present position windows - DR data.
   c. Platform leveling is enabled.

6. FILL WIND, as necessary.

   NOTE

   Wind can be filled for use in dead-reckoning navigation either in an airstart or when DEAD-RECKON has been selected. Filling wind does not affect inertial navigation.

Perform FILL WIND procedures as necessary until the star light illuminates to keep DR position as accurate as possible.

7. Check True Heading and Update if required.

   True Heading during C/A is INS heading and the last computed value of magnetic variation (△PSIM). This heading is used to drive the extrapolated Inertial position as well as the Dead Reckon position. Operation, display, and update of True Heading during C/A, RES, and A-I is identical to that during the COLD AIRSTART.

8. Check current track leg - Perform TRACK LEG UPDATE <u>or</u> DIRECT STEER, if required.

   NOTE

   An Auto Track Leg Update is initiated to the track leg on which the hot airstart is performed. If a direct steer had been performed on the leg on which the airstart is attempted then initialization will be to DP 1. SKIP TO operations initiated before a hot airstart are not retained.

9. MODE window - Check for RES.

   When MODE window display changes to RES, C/A is complete.

   a. ANS pitch, roll, and heading outputs are now functional and reflect Inertial data.

   b. Internal inertial navigation begins and inertial heading used for DR and heading.

   c. Auto-nav usable, aircraft straight & level.

      The autopilot can now be engaged, using ANS attitude reference. Any turns or attitude changes made during the RES mode will affect platform leveling and may prevent subsequent star tracking when the ANS goes into the A-I mode. Avoid engaging Auto-Nav in RES unless necessary.

   NOTE

   If the platform precesses beyond 2-1/2° of tilt from the time power is removed until the time platform leveling is enabled, the ANS will probably not come out of. C/A into RES mode in a reasonable period of time and a COLD AIRSTART will have to be performed to level the platform.

10. MODE window - A-I.

    MODE window display changes to A-I to indicate completion of true airspeed coarse leveling, and the beginning of star search, and air-mass damping.

    NOTE

    Even if the MODE switch is in ALIGN, INERTIAL ONLY, or AIR-START when HOT is pressed, the system will automatically go into ASTRO INERTIAL mode during a HOT AIRSTART.

11. Check star ON light.

    Acquisition of star A is indicated by flashing of the star ON light. When star B is acquired, the star ON light goes out. After the star ON light illuminates steady, inertial data is used to update all ANS outputs and internal dead-reckon data. If the autopilot is engaged in AUTO-NAV, an aircraft maneuver will occur.

SELECT DEAD RECKON MODE

The DEAD RECKON mode can be selected any time in flight.

1. MODE switch - DEAD RECKON.

2. MAG/GRID switch - MAG.

3. MODE START - Press.

   a. MAL light - Off.

      If on, refer to Emergency Procedures paragraph.

   b. MODE window - D/R.

4. True Heading - Check, fill Mag Var as required.

   Check true heading. Fill MAG VAR as required to keep the true heading as accurate as possible. When the DEAD RECKON mode is initially entered, magnetic variation should not have to be filled since the true heading will be the last computed value of △PSIM (the difference between the ANS inertial true heading and INS magnetic heading).

5. Fix and Update Present Position as required.

   Fill present position if DEAD RECKON is selected from OFF or WARM UP.

6. FILL WIND, as necessary.

NOTE

Wind can be filled for use in dead-reckoning navigation either in an air start or when dead-reckon has been selected. Filling wind does not affect inertial navigation.

PRESENT LATITUDE and LONGITUDE windows are clear until filled if DEAD RECKON is selected from OFF or WARM UP, or during a "cold" airstart. Otherwise, the PRESENT LATITUDE and LONGITUDE counters are continuously updated from their initial reading as soon as MODE START is pressed.

The ANS assumes 0 degrees roll and 6 degrees pitch when VIEWSIGHT PP UPDATE procedure is performed in the DEAD RECKON mode; therefore, the aircraft should be straight-and-level for viewsight fixpoints. If another operate mode is selected from DEAD RECKON, even prior to star ON light illumination in a "cold" or "hot" airstart, dead-reckon position and magnetic variation are updated to inertial data at 4-minute intervals in the new mode.

RUNWAY HEADING ALIGNMENT

The aircraft should be aligned with runway centerline. MODE switch must be in ASTRO INERTIAL or INERTIAL ONLY position. MODE window display must match MODE switch position. A heading correction will be inhibited if star B was successfully acquired as the first star after ground alignment.

1. DATA switch - HEADING.

2. Runway True Heading - Enter (XXX° XX.X').

   Enter known runway true heading in degrees (three digits), minutes (two digits), and tenths of minutes (one digit). Entered data appears in SELECTED DATA 4 window.

3. MODE START - Press.

   Press just before takeoff roll.

At liftoff:

4. Check ANS computed True Heading in SD-1 window.

   At aircraft lift-off, average ANS heading appears in degrees (three digits), minutes (two digits), and tenths of minutes (one digit).

Perform step 5 <u>or</u> 6:

5. UPDATE switch - Press.

Press to incorporate difference between average ANS and runway headings.

6. MAN CLEAR switch - Press.

NOTE

If computed runway heading does not appear in SD-1 window at lift-off, the takeoff switch has probably failed; in this case, press MAN CLEAR to terminate the procedure.

FILL PRESENT POSITION AND INITIAL ALTITUDE

In any "operate" mode, when MODE window displays C/A, ENT, RES, A-I or D/R for other than initial fill for ground align.

NOTE

Either magnetic variation or true heading must be entered for ground alignment prior to FILL PRESENT POSITION and INITIAL ALTITUDE or an ERR indication will appear after ENTER is pressed.

If present position is filled in flight, position coordinates should be those that will exist when ENTER is pressed. Any present position filled after the COARSE ALIGN (C/A) phase will be entered into the dead reckon reference frame.

If not a ground Alignment, do steps 1, 2, 3, & 5:

1. DATA switch - PRES POSITION.
2. Fill Latitude (N/S XX°XX.XX')

   Enter N or S position latitude in degrees (two digits), minutes (two digits), and hundredths of minutes (two digits). Entered data appears in SD-1 window.

3. Fill Longitude (E/W XXX°XX.XX')

   Enter E or W position longitude in degrees (three digits), minutes (two digits), and hundredths of minutes (two digits). Entered data appears in SD-4 window.

4. Local Field Elevation - Enter (XXX) in hundred feet.

   Entered data appears in SD-3 window.

5. ENTER switch - Press.

FILL WIND

MODE switch in any "operate" mode. MODE window displays any mode.

1. DATA switch - TEST.
2. Wind direction - Enter (XXX°).

   Entered data appears in SD-5 window.

3. Wind speed - Enter (XXX).

   Enter wind speed in knots (three digits). Entered data appears in SD-6 window.

4. ENTER switch - Press.

FILL DAY AND TIME

Day and time may be filled only when the ANS is in COARSE ALIGN. Attempting to enter day/time in any other mode will result in ERR in the MODE window.

NOTE

The MODE window normally reads C/A or ENT when the ANS is in the C/A mode. Whenever the ANS has power restored after a power loss and chronometer day and time are not available, the ANS will be in the C/A mode although the MODE window will read I/O and the MAL light will be flashing.

1. DATA switch - TIME.

2. Julian Day - Enter (ØXXX)

   Enter Julian day of year (four digits). Entered data appears in SD-6 window.

   NOTE

   Fill Julian day to correspond with GMT.

3. GMT - Enter (XX hr, XX min, XX sec).

   Entered data appears in SD-1 window.

4. ENTER switch - Press & release at time hack.

   Filled day and time are entered when the ENTER switch is released.

   NOTE

   If an error is made in filling day and time the routine may be repeated as long as the correct number of digits and ENTER have been pressed first. If the MAL light is flashing in C/A and an error is made in filling day and time which results in ERR in the MODE window, press MAN CLEAR and reenter data.

FILL DAY

If a chronometer has the correct time but the wrong Julian Day, then a FILL DAY routine will be required during COARSE ALIGN to permit accurate star tracking.

1. DATA switch - TIME.
2. Julian Day - Enter (ØXXX).
3. ENTER switch - Press.

FILL MAGNETIC VARIATION

In any "operate" mode:

1. DATA switch - HEADING.

2. Variation - Enter (E/W XXX°XX.X').

   Entered data appears in SD-4 window.

3. ENTER switch - Press.

   NOTE

   This routine is only functional if the system is in the MAG mode.

HEADING UPDATE

In any "operate" MODE:

1. DATA switch - HEADING.

2. True Heading - Enter (XXX°XX.X').

   Entered data appears in SD-4 window.

3. UPDATE switch - Press.

If this procedure is performed during the coarse align mode, entered value of heading will be used to initialize system true heading. If performed during fine align or any navigate mode, entered value will replace existing true heading.

NOTE

Unless the system is in C/A, the ANS will accept a maximum heading update change of 28°. For an update change greater than 28° the routine will have to be repeated until the desired heading to be updated is within 28° of the system's last known heading.

PRESENT POSITION UPDATE, USING REMOTE SOURCE DATA (REMOTE UPDATE)

The maximum allowable correction is 90 nautical miles. The correction always goes to the inertial frame regardless of system mode. A dead-reckoned position cannot be updated by this procedure. The correction moves the inertial frame by the desired amount, i.e., if the aircraft is 0.5 nm south of the known location, a remote update of N0000.50 should be performed.

In any "operate" mode:

1. DATA switch - PRES POSITION.
2. N or S Correction - Enter (N/S 00XX.XX nm).

   Entered data appears in SD-1 window.
3. E or W Correction - Enter (E/W 000XX.XX nm).

   Entered data appears in SD-4 window.
4. UPDATE switch - Press.

PRESENT POSITION UPDATE, USING RADAR WITH RCD

MODE: ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART; MODE window displays any mode except F/A or ENT.

1. MOT switch - Press, S light On.
2. Radar crosshair - Place over ANS L mark intersection.

NOTE

> As the aircraft passes abeam the programmed fixpoint, the MARK light appears at the bottom center of the RCD screen. This alerts the RSO of the impending L-mark. The light will remain illuminated for approximately 50 seconds after marker appearance. The light goes out when the L-mark is in the approximate center of the screen.

3. RCD Zero Control - Press, WAIT illuminated.

   WAIT illuminates for 5 seconds. During this time do not move crosshair controls.

When WAIT extinguished:

4. Radar crosshair - Place over fixpoint.
5. READ ERR switch - Press.
   a. North or south ANS-computed error in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-1 window.
   b. East or west ANS-computed error in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-4 window.
6. MOT switch - Press, R light On.

Do step 7 <u>or</u> 8:

7. UPDATE switch - Press.

   Automatically updates present position.

8. MAN CLEAR switch - Press.

Bypasses updating of present position.

NOTE

The ANS automatically sequences to the following FP when the L mark is sent to the RCD, except on Anytime radar FPs when the sequencing occurs 24 nm past the FP.

PRESENT POSITION UPDATE, USING VIEWSIGHT

MODE: ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART; MODE window displays any mode except F/A or ENT.

1. Magnification - Select desired field of view.

2. Viewsight Cursor - Align with fixpoint.

When fixpoint under nadir:

3. READ switch - Press.

   a. North or south ANS-computed error in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-1 window.

   b. East or west ANS-computed error in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-4 window.

Do step 4 or 5.

4. UPDATE switch - Press.

   Automatically corrects present position.

5. MAN CLEAR switch - Press.

   Bypasses updating of present position.

The ANS automatically sequences to the following FP 17.25 nm past a viewsight FP.

PRESENT POSITION UPDATE, USING TACAN (TAPE FILLED POINT)

In any "operate" mode:

1. BDHI HDG Select switch - INS.

2. BDHI No. 1 needle select switch - TACAN.

3. Use Display Next FP, or Display Selected FP procedure.

4. TACAN switch - Press.

   Press when TACAN system values have been noted on BDHI. All SELECTED DATA displays will clear.

5. TACAN mag bearing value - Enter (XXX°).

   Enter TACAN value of magnetic bearing from aircraft to station in degrees (three digits). Entered data appears in SD-5 window.

6. TACAN slant range value - Enter (XXX nm).

   Entered data appears in SD-6 window.

7. ENTER switch - Press.

   a. SD-1 window displays north or south ANS computed error in nm and hundredths of miles.

   b. SD-4 window displays east or west computed error in nm and hundredths of miles.

Do step 8 or 9:

8. UPDATE switch - Press.

   Automatically updates present position.

9. MAN CLEAR switch - Press.

Bypasses updating of present position.

The ANS automatically sequences to the next FP when 17.25 nm past a TACAN FP.

PRESENT POSITION UPDATE, USING TACAN (ANYTIME TACAN FP)

In any "operate" mode:

1. BDHI HDG select switch - INS.
2. BDHI No. 1 needle select switch - TACAN.
3. DATA switch - FIX POINT.
4. Fixpoint Latitude - Enter (N/S XX°XX.XX')

   Enter N or S and latitude of fixpoint in degrees (two digits), minutes (two digits), and hundredths of minutes (two digits). Entered data appears in SD-1 window. If any of the sensor operation indicator lights are illuminated, they extinguish when N or S is pressed. The automatic sensors continue to operate normally during the add anytime TACAN fixpoint routine.

5. Fixpoint Longitude - Enter (E/W XXX°XX.XX')

   Enter E or W and longitude of fixpoint in degrees (three digits), minutes (two digits) and hundredths of minutes (two digits). Entered data appears in SD-4 window.

6. Fixpoint Elevation - Enter (XXX).

   Enter elevation of fixpoint in hundreds of feet (three digits). Entered data appears in SD-3 window.

7. Variation - Enter (E/W XX.XX°).

   Enter E or W magnetic variation of TACAN station in degrees and tenths of degrees of arc as follows: E or WXX.XX°. Entered data will appear as follows:

   a. E/W in SD-5 window.
   b. Tens, units, and tenths of degrees in SD-5 window following E/W. Hundredths of degrees <u>is not displayed</u>.

   NOTE

   The maximum value of magnetic variation which can be <u>entered</u> is 99.99°. ANYTIME TACAN fixpoints cannot be used if actual magnetic variation exceeds this value.

8. ENTER switch - Press.

   a. SD-2 window displays computed TACAN slant range.
   b. SD-5 window displays computed TACAN bearing.

9. TACAN switch - Press.

   Press when TACAN system values have been noted on BDHI. All SELECTED DATA displays will clear.

10. TACAN mag bearing value - Enter (XXX°)

    Enter TACAN value of magnetic bearing from aircraft to station in degrees (three digits). Entered data appears in SD-5 window.

11. TACAN slant range value - Enter (XXX nm).

    Entered data appears in SD-6 window.

12. ENTER switch - Press.

    a. SD-1 window displays north or south ANS computed error in nm and hundredths of miles.

b. SD-4 window displays east or west ANS computed error in nm and hundredths of miles.

Do step 13 <u>or</u> 14:

13. UPDATE switch - Press.

Automatically updates present position.

14. MAN CLEAR switch - Press.

Bypasses updating of present position.

The ANS automatically sequences to the next FP when 17.25 nm past a TACAN FP.

RECALL ANYTIME TACAN FIXPOINT

MODE in any "operate" mode; an ANYTIME TACAN FIXPOINT must have been previously entered using the TACAN (ANYTIME TACAN FP) procedure. If more than one ANYTIME TACAN FIXPOINT has been entered, the last entered fixpoint will be recalled. Verify that the proper TACAN station is selected and that the TACAN T/R mode is set.

1. BDHI HDG select switch - INS.
2. BDHI No. 1 needle select switch - TACAN.
3. DATA switch - FIX POINT.
4. RECALL switch - Press.

NOTE

Step 4 will recall the last entered ANYTIME TACAN FIXPOINT. If there is none, the MODE window indicates ERR.

5. TACAN switch - Press.

Press when TACAN system values have been noted on BDHI. All SELECTED DATA displays clear.

6. TACAN mag bearing value - Enter (XXX°).

Enter TACAN value of magnetic bearing from aircraft to station in degrees (three digits). Entered data appears in SD-5 window.

7. TACAN slant range value - Enter (XXX nm).

Entered data appears in SD-6 window.

8. ENTER switch - Press.

a. SD-1 window displays north or south ANS computed error in nm and hundredths of miles.

b. SD-4 window displays east or west computed error in nm and hundredths of miles.

Do step 9 <u>or</u> 10:

9. UPDATE switch - Press.

Automatically corrects present position.

10. MAN CLEAR switch - Press.

Bypasses updating of present position.

The ANS automatically sequences to the next FP when 17.25 nm past a TACAN FP.

PRESENT POSITION UPDATE, USING OPPORTUNITY VIEWSIGHT FIXPOINT

MODE in any "operate" mode; MODE window indicates any mode except C/A, F/A, or ENT.

1. Magnification - Set desired field of view.
2. Viewsight cursor - Align with fixpoint.

When Fixpoint under nadir:

3. READ switch - Press.

a. SD-1 window - Meaningless number.

b. SD-4 window - Meaningless number.

4. Fixpoint Latitude - Enter (N/S XX°XX.XX').

Entered data appears in SD-1 window.

5. Fixpoint longitude - Enter (E/W XXX°XX.XX')

Entered data appears in SD-4 window.

6. Fixpoint Elevation - Enter (XXX) in hundreds of feet.

Entered data appears in SD-3 window.

7. ENTER switch - Press.

a. North or south ANS computed error in nautical miles (two digits) and hundredths of miles (two digits) appears in SD-1 window.

b. East or West ANS computed error in nautical miles (two digits) and hundredths of miles (two digits) appears in SD-4 window.

NOTE

If an error is made when entering data (other than entering too many digits) press ENTER pushbutton and re-enter all data. If MODE window displays ERR press MAN CLEAR to terminate procedure and bypass present position update.

Do step 8 <u>or</u> 9:

8. UPDATE switch - Press.

Automatically updates present position.

9. MAN CLEAR switch - Press.

Bypasses updating of present position.

TRACK LEG UPDATE

MODE switch in ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIR START position; MODE window displays any mode.

1. DATA switch - DEST POINT or NORMAL.

2. Enter point - ID code (five digits) of start DP on desired track leg. Last four entered digits appear in SD-6 window, (first digit, always zero, replaces letter P with D).

3. UPDATE switch - Press.

DIRECT STEER

In any "operate" mode:

1. DATA switch - DEST POINT or NORMAL.

For direct steer to tape-filled or panel-filled DP:

2. Enter five digit ID code of DP in memory (tape-filled or panel-filled). Last four entered digits appear in SD-6 window.

3. DIR STEER switch - Press.

For direct steer to new DP:

4. Enter latitude of new DP in degrees (two digits), minutes (two digits), and hundredths (two digits). Entered data appears in SD-1 window.

5. Enter longitude of new DP in degrees (three digits) minutes (two digits), and hundredths (two digits). Entered data appears in SD-4 window.

6. DIR STEER switch - Press.

The ANS automatically proceeds to the next great-circle leg if Direct Steer DP is in memory. The ANS commands a constant 35 degree, right wing down turn upon passing a new Direct Steer DP, or a DP with no next leg.

SKIP TO DP

In any "operate" mode:

1. DATA switch - DEST POINT or NORMAL.
2. Enter five digit ID code of DP to be skipped to. Last four digits appear in SD-6 window.
3. SKIP TO switch - Press.

DELETE FP, CP, AND DP (40-LIST)/CLEAR 40 LIST

This procedure permits deleting points from the 40-List (panel-filled Add/Replace points). After a point is deleted the vacated space may be reused. In any "operate" mode:

Do steps 1, 2, & 4 for single point deletion. Do steps 1, 3, & 4 to clear entire 40-list.

1. DATA switch - DEST POINT, FIX POINT, CONT PT.
2. Enter ID code (five digits) of FP, CP or DP to be deleted. All digits appear in SD-6 window.
3. ID CODE 99999 - Enter.
4. DELETE switch - Press.

ADD ANYTIME FIXPOINT

Normally, this procedure is followed closely by a Present Position Update procedure, using the Radar or Viewsight. It can only be used on the existing leg, as no ID code is established for the Anytime Fixpoint.

In any "operate" mode:

1. DATA switch - FIX POINT.
2. Fixpoint Latitude - Enter (N/S XX°XX.XX').

   Entered data appears in the SD-1 window.

NOTE

If any of the sensor operation indicator lights are illuminated, they extinguish when N or S is pressed. The automatic sensors continue to operate normally during the add Anytime Fixpoint routine. The SLR light illuminates if an add Anytime radar fix is displayed after all data is entered (After step 6). None of the sensor operation indicator lights illuminate if an add anytime viewsight fix is displayed.

3. Fixpoint Longitude - Enter (E/W XXX°XX.XX').

   Entered data appears in SD-4 window.

4. Fixpoint Elevation - Enter (XXX).

   Enter the terrain elevation of the fixpoint in hundreds of feet (three digits). For example, 12,500 feet is entered as 125. Entered data appears in the SD-3 window.

For Radar Fixpoint, do steps 5 and 6: for Viewsight Fixpoint, skip to step 6.

5. SLR code - Enter near edge range (L/R XX.0).

   Last entry must be zero. Entered data appears in SD-5 window.

6. ENTER switch - Press.

NOTE

The DATA switch may now be used to display other than fixpoint data. If returned to FIXPOINT and ENTER before the fixpoint, anytime fixpoint data will be retained and displayed. The fix may be taken with the DATA switch in NORMAL. The viewsight or radar opportunity fix must still be taken on the leg during which it was entered. Existing FPs will be inhibited until the Anytime FP is passed.

ADD OR REPLACE FP, CP, DP

NOTE

- For DP's perform steps 1 through 4, then 9 and 10.
- For CP's, perform steps 1 through 5, then 6, 7, 8 and 10.
- For FP's, perform steps 1 through 5, and 10. Also do step 6 for radar FP's.

In any "operate" mode:

1. DATA switch - DEST POINT, FIX POINT, or CONT PT.
2. Enter ID code (five digits) of FP, CP, or DP to be added or replaced. All entered digits appear in SD-6 window.

NOTE

- 0XXXX Point No. displays DXXXX, FXXXX, or CXXXX, 1XXXX Point No. displays F1XXXX or C1XXXX. Only zero allowed for first digit of DP.
- If a FP is added to be used immediately (Add-Anytime FP) do not enter an ID code number. All other FPs in memory will be inhibited until the added FP is passed.

3. Enter N or S and latitude of added or replaced point in degrees (two digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-1 window.
4. Enter E or W and longitude of added or replaced point in degrees (three digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-4 window.

Skip to step 9 if entered point is a DP; continue with step 5 if point is CP or FP.

5. Enter terrain elevation of FP or CP in hundreds of feet (three digits). Entered data appears in SD-3 window.

Skip to step 10 for viewsight FPs. Perform step 6 for radar FPs and CPs or step 7 for camera CPs.

6. SLR code - Enter near edge Range (L/R XX.0).

   Last entry must be zero. Entered data appears in SD-5 window.

7. Press RIGHT or LEFT pushbutton and enter camera CP code (L/R plus 000). Entered data appears in SD-5 window.

Skip to step 10 for radar FP's.

8. For all CPs enter sensors on-off code (three digits). First entered digit is LH TECH camera, second is RH TECH camera, and third digit is SLR. Enter 0 for off at CP, and 1 for on at CP. Corresponding sensor operation indicators illuminate to indicate sensor selection for the CP.

If a Fixed-Range-To-Turn is desired:

9. Enter turn radius of added or replaced DP in nm (three digits). Entered data appears in SD-3 window.
10. ENTER switch - Press.

NORMAL DISPLAY

In any "operate" mode:

1. DATA switch - NORMAL.
2. DISPLAY switch - Press.
   a. SD-1 window displays letter Z and GMT in hours (two digits), minutes (two digits), and seconds (two digits).
   b. SD-2 window displays letter T and true airspeed in knots (XXXX).
   c. SD-3 window displays letter F or F1 and next FP (four digits).
   d. SD-4 window displays R or L and cross track error in nautical miles (XXX.X).
   e. SD-5 window displays letter G and ground speed in knots (XXXX).
   f. SD-6 window displays letter C or C1 and next CP number (four digits).
   g. Sensor indication lights illuminate when the associated sensor is programmed on.

DISPLAY SELECTED FP, CP, DP

In any "operate" mode:

1. DATA switch - DEST POINT, FIX POINT, or CONT PT.
2. Enter ID code (five digits) of desired FP, CP, or DP.

   SD-6 window displays all entered digits (except first digit).
3. DISPLAY switch - Press.
   a. SD-1 window displays latitude of selected point.
   b. SD-2 window displays letter R and slant range to selected point if TACAN, great circle range to CP or FP, or great circle range to DP.
   c. SD-3 window displays letter E and terrain elevation of selected FP or CP. For DP, letter K and turn radius is displayed (255 nm max).
   d. SD-4 window displays longitude of selected point.
   e. SD-5 window displays L or R and relative bearing (four digits) to a selected CP or DP; or letter B and magnetic bearing in degrees (four digits), to TACAN FP.
   f. SD-6 window displays data code of selected point.
   g. L/R TECH and SLR lights illuminate to indicate sensor activity at selected FP or CP. The SLR light is not illuminated during display of viewsight fixpoints.

DISPLAY NEXT FP, CP, DP

MODE switch in ASTRO-INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIR START position; MODE window displays any mode.

1. DATA switch - DEST POINT, FIX POINT, or CONT PT.
2. DISPLAY switch - Press.
   a. SD-1 window displays latitude of next FP, CP, or DP.
   b. SD-2 window displays letter R and slant range to TACAN FP, along track range for radar or viewsight FP or CP and along track range to turn start point (TSP) for DP (which includes the computed range around a closed loop turn).

c. SD-3 window displays letter E and terrain elevation of next FP or CP, in hundreds of feet. For DP, letter K and turn radius is displayed (255 NM max).

d. SD-4 window displays longitude of next FP, CP, or DP.

e. SD-5 window displays L or R and relative bearing in degrees (four digits) to next viewsight or radar FP, CP, DP, or letter B and magnetic bearing in degrees (four digits) to next TACAN FP.

f. SD-6 window displays data code of next FP, CP, or DP.

g. L/R TECH and SLR lights illuminate to indicate sensor activity at next FP or CP. The SLR light is not illuminated during display of viewsight fixpoints.

NOTE

- If there is no next FP or CP on the current leg, SD-2 window displays zero range and other displayed data will be for the preceding FP or CP. If there was no preceding FP or CP, all SELECTED DATA windows except 5 display all zeros. The SD-5 window displays bearing to zero latitude and longitude coordinates.
- If DATA switch is in DEST POINT and LOOK THRU switch is pressed:

  1) SD-1 window displays latitude of DP after next DP.

  2) SD-2 window displays range to DP after next DP.

  3) SD-3 window displays turn radius of DP after next DP.

  4) SD-4 window displays longitude of DP after next DP.

  5) SD-5 window displays time to DP after next DP (four digits) in minutes and tenths.

  6) SD-6 window displays the DP number after next DP. If no DP exists after next DP, SD-6 window displays D0000 and all other SELECTED DATA windows are blank.

DISPLAY DAY OF YEAR/STAR DATA

In any "operate" mode:

1. DATA switch - TIME.

2. DISPLAY switch - Press.

   a. SD-1 window displays letter Z and GMT in hr., min, sec.

   b. SD-2 window displays letter S and star number.

   c. SD-3 window displays the scan rate code of the star-tracking telescope (R1, R2, R3 or R4).

   d. SD-4 window displays letter T and time in star search in min. and sec.

   e. SD-5 window displays letter A and number of stars acquired.

   f. SD-6 window displays letter D and Julian date.

NOTE

Julian day Display changes after 2400 GMT and may read any value from 0 to 511. Day values greater than 365 allow next calendar year usage of the star catalog in the computer.

DISPLAY HEADING

In any "operate mode":

1. DATA switch - HEADING.
2. DISPLAY switch - Press.
   a. SD-1 window displays letter V and ground track in degrees (three digits), minutes (two digits), and tenths of minutes (one digit).
   b. SD-2 window displays letter G and computed grid heading in degrees and tenths of degrees (four digits).
   c. SD-3 window displays letter C and the chart convergence factor (four digits) (1.000 max).
   d. SD-4 window displays letter T and true heading in degrees (three digits), minutes (two digits), and tenths of minutes (one digit).

NOTE

Displayed true heading is ANS inertial data except that INS data is used in dead-reckon mode and in ground and cold airstart coarse alignments until a heading update is performed.

   e. SD-5 window displays E/W magnetic variation (four digits).
   f. SD-6 window displays letter M and magnetic heading (three digits).

DISPLAY PRESENT POSITION

MODE switch: ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIR START; MODE window displays any mode.

1. DATA switch - PRES POSITION.
2. DISPLAY switch - Press.
   a. SD-1 window displays N or S latitude of alternate frame in degrees (two digits), minutes (two digits), and hundredths of minutes (two digits).
   b. SD-2 window is blank.
   c. SD-3 window displays letter A and ANS altitude (three digits) (flight level).
   d. SD-4 window displays E or W longitude of alternate frame in degrees (three digits), minutes (two digits), and hundredths of minutes (two digits).
   e. SD-5 window displays letter S and sun angle in degrees and tenths (three digits).
   f. SD-6 window is blank.

PRESENT DISPLAY

A. PRESENT LATITUDE window displays present N/S latitude in degrees and minutes (four digits).

B. PRESENT LONGITUDE window displays present E/W longitude in degrees and minutes (five digits).

NOTE

Window displays are blank until completion of F/A, at which time primary coordinates are displayed depending on MODE switch position.

C. WIND DIR window displays present wind direction in degrees (three digits). While on the ground with ANS operating but not calculating, and if wind direction is not filled, the WIND DIR counter displays 000.

D. WIND VEL window displays present wind velocity in knots (three digits). While on the ground with ANS operating but not calculating, the WIND VEL counter displays 0.

E. TIME-TO-TURN window displays the time to turn in hours, minutes, and seconds (five digits). The TIME-TO-TURN window displays 0 until the aircraft moves.

F. RANGE TO DP (NM) window displays the range to the next destination point, shown in the NEXT DP window (four digits). Until the present position has been filled, the RANGE TO DP (NM) window will be blank.

G. NEXT DP window displays the next destination point identification number (four digits). The first (left) digit is blank if the DP is not an added point, or the actual ADD NUMBER (1 thru 7) if the DP is an added point. Until present position has been filled, the NEXT DP window will be blank.

DISPLAY TAPE NUMBERS

In any "operate" mode:

1. DATA switch - TEST.

2. DISPLAY switch - Press.

   a. SD-1 window displays letter I and main program tape number, (six digits) representing tape number, mod number, and correction number.

   b. SD-2 window displays * or A thru Z or a thru e and mission tape number (three digits).

   c. SD-3 window displays letter G and general instrument constants tape number (three digits).

   d. SD-4 window is blank.

   e. SD-5 window displays letter S and star catalog type as follows:

      SYY1 - Normal (worldwide)
      SYY2 - Trainer
      Where YY=last two digits of the year.

   f. SD-6 window displays letter T (test) and 0.

ANS MALFUNCTION PROCEDURES

The ANS provides warning indications of some malfunctions or conditions external to the ANS that could lead to an ANS malfunction. All malfunctions are not detected, so the crew should not depend entirely on warning indications.

Temperature Limit/Tolerance Indicator

The LIMIT portion of the indicator is unlighted when temperatures within the ANS are normal. The red LIMIT can illuminate either steady or flashing. A steady light indicates that the temperature of the astro-inertial instrument housing or the cooling air at the computer inlet is above nominal limits. Steady illumination after initial turn-on is caused by system over-temperature. A flashing light indicates that ANS cooling airflow is less then 2.5 pounds per minute. To prevent damage, turn the ANS off when the temperature LIMIT indicator comes on.

When the LIMIT light illuminates, the RSO's annunciator panel ANS FAIL light, and the pilot's annunciator panel ANS REF caution light illuminate.

When the TEMP TOLR light is unlighted, the platform temperature is in the range for optimum system performance. The amber TOLR light illuminates either steady or flashing. Steady illumination signifies that platform temperature is below normal. A flashing light signifies that temperature is above normal.

Figure 4-18 lists ANS temperature warning indications, conditions and recommended actions.

TEMP LIMIT Light Illuminates

1. Check ECS system.

   If L or R air system failed:

   a. Complete L or R Air System Out procedure.

   If L or R air system off for landing:

   b. Check cockpit air off (forward).

If TEMP LIMIT light remains illuminated:

▲2. ATT REF switch - INS.

T 3. DISPLAY MODE SEL switch - Other than ANS.

(4.) BDHI HDG SELECT switch - INS.

(5.) MODE switch - OFF.

CAUTION

If the TEMP LIMIT light cannot be extinguished, turn the MODE switch OFF to avoid damage to the ANS.

TEMP TOLR Light Illuminates in Flight

Make as many position checks as practical since navigation accuracy may degrade in a TEMP TOLR condition. Be alert for a possible TEMP LIMIT light.

NOTE

If the TEMP TOLR light illuminates in flight, do not turn the ANS off unless the TEMP LIMIT light illuminates.

Malfunction Indicator (MAL Light)

The MODE window usually indicates action to be taken when the MAL light is flashing. Several of the conditions for a MAL light are synonymous with conditions for nav-not-ready indications described under the Warning Indication section. Figure 4-19 lists general ANS malfunction and nav-not-ready conditions.

NOTE

When the MAL light illuminates, the RSO's annunciator panel ANS FAIL light, and the pilot's annunciator panel ANS REF caution light illuminate.

Power Dropout

A decrease of the ANS ac supply voltage to less than 103 volts per phase causes the computer to stop operating regardless of mode. Voltage drop can be caused by a primary power transient, opening of the ANS 3-phase essential ac or essential dc circuit breaker(s), or turning the MODE switch to OFF or WARM UP. When power returns, the computer determines power dropout duration by comparing chronometer day and time with the day and time stored in memory at power loss.

If the power dropout is less than one second, operation resumes as though nothing occurred except star tracking is suspended for 70-seconds.

If the power dropout is greater than one second, the system returns to C/A, the MAL light illuminates, the MODE window indicates C/A, and all display counters clear. If the RSO presses the HOT switch, the system proceeds with an automatic restart (hot airstart or ground hot start). If, instead, the RSO selects AIRSTART with the MODE switch and presses the MODE START switch, the system starts a COLD airstart. Refer to COLD Airstart Alignment, this section.

(Note: 4-60A/4-60B Blank deleted)

ANS TEMPERATURE WARNINGS

INDICATOR	STATE	ANS CONDITION	ACTION
Red TEMP LIMIT Light	Off	Within safe limits	————
	Steady	Air inlet housing or cooling air at computer inlet above design limits.	Turn MODE switch OFF.
	Flashing	Cooling air flow less than 2.5 lb/min.	Turn MODE switch OFF.
Amber TEMP TOLR Light	Off	Within tolerance for optimum accuracy	————
	Steady	Platform temp below normal.	Check ANS accuracy
	Flashing	Platform temp above normal	Be alert for TEMP LIMIT. Check ANS accuracy. Keep rpm up if warning on due to hot fuel in flight.

Figure 4-18

NOTE

If the system is HOT started and then a COLD airstart is desired, return the MODE switch to OFF. If the MODE START switch is pressed in any MODE other than AIRSTART, the system must be turned off to initiate a COLD airstart.

NOTE

After a power dropout, pressing MODE START on the ground with the MAL light flashing (initiating a ground alignment) erases the 40-List. Anytime a rapid or a gyro-compass ground alignment is performed, 40-List data must be reentered. 40-List data is not deleted if HOT is pressed with the MAL light flashing or if a cold or hot airstart is performed. Therefore, 40-List data is retained for a ground hot start, cold airstart, or a hot airstart. Pressing the MODE START switch with a steady MAL light has no effect on the 40-List.

ANS WARNING INDICATIONS

PROBLEM CAUSE		COCKPIT INDICATIONS: PILOT — AUTO PILOT DISENGAGE	ADI PWR OFF FLAG IN VIEW	ADI VERTICAL STEERING BAR FLAG IN VIEW	ANS REF AND CAUTION ON	HSI RANGE SHUTTER CLOSED	RSO — ATTITUDE IND OFF FLAG IN VIEW	MAL LIGHT ON	ANS FAIL AND CAUTION	MODE WINDOW	PRESENT LAT/LONG DISPLAY	TEMP LIMIT LIGHT	TEMP TOLR LIGHT
MODE CONTROL IN	OFF	■	■	■	■		■	■	■				
	WARM UP	■	■	■	■		■	■ STEADY	■				
ANS ESS DC C/B OUT		■	■	■	■	■	■		■				
ANS 3 PHASE C/B OUT		■	■	■	■		■		■				
AC PWR LESS THAN 60 V DC PWR LESS THAN 20V		■	■	■	■		■	■ FLASH	■	■ FROZEN	■ FROZEN		
PWR ON AFTER ONE SEC OR MORE INTERRUPT (1) (2)		■	■	■	■		■	■ FLASH	■	■ C/A	■ BLANK		
PLATFORM FAIL, GROUND SPEED EXCESSIVE, OR PLATFORM SELF TEST FAIL (4)		■	■	■	■		■	■ FLASH	■	■ D/R			
CHRONOMETER INPUT OFF		■	■	■	■		■	■ FLASH	■	■ I/O	■ BLANK		
ENCODING FAILURE					■			■ FLASH	■	■ ENC			
COMPUTER FAILURE		■	■	■	■		■	■ FLASH	■	■ FROZEN	■ FROZEN		
INTERNAL STAR MISSED BY STAR TRACKER (3) AND (1)					■			■ FLASH	■	■ I/O			
TEMP LIMIT CONDITION					■				■			■	
TEMP TOLR CONDITION													■
MISSION TAPE DP ERROR										■ DP ##			

NAV NOT READY in heavy bordered area -- ANS outputs not valid

Squares are shaded where warning is given. Squares are clear where no warning given

NOTE

(1) Warnings not repeated if CLEAR is depressed

(2) Coarse alignment is starting, ground or air start required

(3) Internal star only tracked from approximately one minute into COARSE ALIGN until end of COARSE ALIGN

(4) Platform self test failure

F203-247(c)

Figure 4-19

NOTE

> Complete loss of ac or dc power to the guidance group will cause all ANS NCD panel lights and windows to extinguish/go blank.

Chronometer Failure

The system checks the chronometer day and time inputs when the MODE switch is turned to an "operate" mode and after a power dropout. If the chronometer inputs are not present, a chronometer failure has occurred. This is indicated by a flashing MAL light, clearing of the present position display, and I/O in the MODE window. The system will return to a coarse align condition. The MAL light will not clear without corrective action. On the ground, the alternatives are to replace the chronometer, perform the fill Day and Time routine, or to select INERTIAL ONLY. A Hot Airstart may be possible after a chronometer failure if the Fill Day and Time procedure is used.

Incorrect chronometer day or time does not result in a chronometer malfunction, only incorrect inputs. With a chronometer failure, in the event of any power dropout (even less than one second), the MAL light will illuminate since the system cannot determine dropout duration.

NOTE

> If the chronometer fails after the ANS is in ASTRO INERTIAL, the failure will not be apparent unless the ANS must be restarted. The ANS only interrogates the chronometer when it is initially activated.

Star Tracker Failure (During Ground Alignment)

Forty five seconds after initiation of C/A (for rapid and gyrocompassing ground alignments) the star tracker searches for the artificial star within the astroinertial instrument.

If the artificial star is tracked, the star light on the ANS NCD panel flashes until the system enters F/A. If the artificial star is not acquired and the alignment was initiated by pressing MODE START or RAPID, the MAL light flashes at the end of C/A and the MODE window indicates I/O. If the MAN CLEAR switch is pressed, the MAL light extinguishes and the MODE window will change to F/A. The alignment in progress proceeds normally. Since the most common cause of this malfunction indication is a burned out artifical star bulb rather than an actual tracker malfunction, an attempt should be made to track stars. If stars cannot be tracked, the ANS should be operated in INERTIAL ONLY. Other alternatives are to repeat the alignment or replace the guidance group and realign. There is no star tracker malfunction indication in flight.

Platform Failure

During F/A or A-I, the system checks groundspeed and horizontal speed perpendicular to keel line; if this speed is greater than 2150 and 300 knots, respectively, the MAL light flashes, the MODE window indicates D/R, and the nav-not-ready warning legends and flags are activated. This malfunction cannot be cleared unless DEAD RECKON is selected or the measured speed drops below the prescribed limits. This test will not rapidly detect all platform failures. To get an early indication of ANS or INS failure, the RSO should compare true airspeed with ground speed and INS pitch and roll with ANS pitch and roll throughout the flight; especially in IFR conditions.

NOTE

- o The ANS failure indications may not be energized for several minutes if the platform fails while subsonic.
- o If DEAD RECKON is selected for training, there is no MAL light warning in case of platform failure; the only indications are the nav-not-ready warnings on other cockpit indicators and annunciator panels.

Platform Self-Test Failure (Platform Disable)

During all modes of operation, the platform BIT (BUILT-IN-TEST) monitors circuit parameters which may indicate saturation of the platform servo loops. If saturation is detected, the loops are disabled momentarily. Re-establishment is attempted every five seconds until successful.

If a platform disable occurs, the MAL light flashes, the RSO's ANS FAIL annunciator light illuminates, and the pilot's ANS REF annunciator caution light illuminates. If the pilot has ANS platform selected, the autopilot disengages, an OFF flag appears in the ADI, the ANR warning illuminates (flashing red DAFICS PREFLIGHT BIT FAIL light) and the PVD is inhibited. If the RSO has ANS platform selected, an OFF flag appears in the attitude indicator. All ANS displays change to DEAD RECKON updating, "A" star tracking is commanded, and airspeed damping is increased.

There is a good probability that the platform will recover, and ANS performance should be approximately equivalent to that of a Hot Airstart. To engage the system and remove the NAV-NOT-READY flags, the RSO must place the MODE switch to DEAD RECKON, press the MODE START switch, then place the MODE switch to ASTRO INERTIAL or INERTIAL ONLY position, and press the MODE START switch again.

Computer Failure

The MAL light illumination circuitry is such that the computer must supply a periodic signal to keep the MAL light out. If a computer failure occurs which prevents proper sequencing of the computer program, the MAL light does not receive the periodic signal and illuminates. In general, no MODE window indication is provided, since the computer is no longer operating; however, the computer could cause random control panel display changes while coming to a stop. No RSO operation will extinguish the MAL light, once on, except possibly moving the MODE switch to OFF and restarting. In most cases, the ANS will be unusable until the computer is replaced.

Yaw Encoding Failure

If the ANS computer self test routine detects a failure in the Yaw Gimbal Angle encoding function, the NCD panel Mode window changes to ENC, the MAL light flashes, and the synthesized heading back-up mode activates. Pressing MAN CLEAR extinguishes the flashing MAL light and removes the ENC indication but does not remove the malfunction. "Synthesized heading" is true ground track and is output to the HSI and BDHI compass cards and NCD panel as true heading. Aircraft drift/sideslip results in true heading error. ANS navigation capability is not affected by this failure, nor are auto-nav operation, normal ANS displays or panel routines. INS magnetic heading displayed on the NCD panel is not affected. Radar system imaging may be degraded. Other sensor systems are not affected.

Mission Tape Destination Point Error

If the aircraft is at index (turn start) and a destination point is specified which does not exist in the mission tape, the next destination point in the normal mission tape sequence is assumed and the aircraft is automatically directed to that point. The MODE window displays DP * and the SELECTED DATA windows flash their contents at a one and a half second rate. MAN CLEAR and DISPLAY must be pressed to restore normal NCD panel operation and to verify correct navigation. If not on the correct track, DIR STEER or Track Leg Update as required.

Warning Indications

The ANS uses a variety of cockpit warnings. Figure 4-19 lists these displays. In some cases, these displays alert the RSO to problems that may affect eventual mission success. In other cases, however, these display indicators warn the crew that ANS outputs are inaccurate and/or unsafe. NAV-NOT-READY indicators must be recognized and responded to instinctively by the flight crew.

The ANS warnings are:

1. MAL, TEMP LIMIT, and TEMP TOLR warnings are on the NCD panel.

2. The RSO's ANS FAIL annunciator panel light and the pilot's ANS REF annunciator caution light illuminate when a MAL or TEMP LIMIT light illuminates on the NCD panel or if there is a loss of ac or dc power.

3. A nav-ready output is provided by the ANS to:

   a. ADI vertical steering bar flag when the pilot's display mode select switch is in ANS.

   b. ADI power-off flag when the pilot's attitude reference select switch is in ANS.

   c. RSO attitude indicator power-off flag when the RSO's attitude reference select switch is in ANS.

   d. DAFICS when the pilot's attitude reference select switch is in ANS. The autopilot will disengage, the ANR light illuminates (flashing DAFICS PREFLIGHT BIT red FAIL light), and the PVD is inhibited if the NAV-READY signal is not present.

   e. ANS REF caution light on the pilot's annunciator panel.

   f. ANS FAIL light on the RSO's annunciator panel.

With ANS reference selected, the warning shutters and flags are withdrawn from view, the autopilot can be engaged, and the caution lights are extinguished when the nav-ready signal path exists.

Nav-Not-Ready Indications

The ANS REF and ANS FAIL lights illuminate, the warning flags appear, the autopilot disengages, the ANR light illuminates and the PVD is inhibited when the nav-ready output is in the not-ready state. The conditions for a nav-not-ready signal are:

1. MODE switch in OFF or WARM UP.

2. MODE window displays C/A or ENT.

3. AC or DC power to the ANS is interrupted for more than 1 second. An interruption of less than 1 second may cause a momentary not-ready output.

4. Platform failure.

5. Computer failure.

Attitude Outputs

The source of ANS attitude information is the inertial platform. Resolvers on the platform gimbals provide: pitch and roll to the attitude indicators and the PVD; yaw, pitch and roll to the ANS digital computer; and heading, yaw, pitch and roll to DAFICS.

The analog-to-analog follow-up servos are not rate limited and can follow aircraft attitude changes at rates above 60 degrees per second. These servos do not automatically stop during a power transient; however, response does decrease and the servos freeze when ac voltage drops to approximately 60 volts. Failures of these follow-up servos could cause frozen attitude displays (including inputs to DAFICS), rapidly changing attitude values, or gradually increasing attitude errors. This is particularly dangerous at night or in IFR conditions, especially if the pilot's attitude reference select switch is in ANS and the autopilot is engaged. An ANR light (flashing DAFICS PREFLIGHT BIT red FAIL light) could indicate that the selected attitude reference is erroneous. Monitor other attitude references (INS platform and pilot's standby attitude indicator) to detect ANS attitude errors as soon as possible.

Flashing MAL Light During Ground Operation

It is normal for the MAL light to flash when the MODE switch is moved from OFF or WARM UP to ALIGN, ASTRO INERTIAL, or INERTIAL ONLY. The MODE window reads C/A if the system has a DAY and TIME, or I/O if a DAY and TIME are not available from the chronometer. The MAL light will go out after DAY and TIME are filled, MODE START is pressed and MAN CLEAR is pressed.

If the MAL light flashes during any ground operation after either MODE START or RAPID is pressed to start an alignment, observe the MODE window and SELECTED DATA (SD) windows.

1. If the MODE window display has not changed and the SD windows are frozen, a computer malfunction has occurred. Turn the MODE switch to OFF and restart the alignment. If the malfunction repeats, replace the ANS guidance group.

2. If the MODE window has changed to C/A and the SD windows are cleared, a power dropout in excess of 1 second has occurred. If a GROUND HOT START is desired, complete the GROUND HOT START checklist. If a GROUND HOT START is not desired, turn the MODE switch to OFF and perform another ground alignment.

3. If the mode window has changed to ENC and the SD true heading is in question, the yaw encoding has malfunctioned. "Synthesized heading" (true ground track output to the HSI and BDHI compass cards and NCD panel) cannot be accurately calculated when not moving. Pressing MAN clear extinguishes the flashing MAL light and removes the ENC indication but does not remove the malfunction. Replace the ANS guidance group. Refer to YAW Encoding Failure this section.

4. If the MODE window has changed to I/O and the SD windows are not affected, the platform collimator light (artificial star) has not been tracked. This is most likely due to the platform collimator bulb being burned out. Otherwise it is a tracker malfunction. This malfunction only occurs at the end of C/A or ENT. If the ANS guidance group cannot be replaced, press the MAN CLEAR switch to extinguish the MAL light. The MODE window will initialize normally. Attempt to track stars in ASTRO INERTIAL. If stars cannot be tracked, fly in INERTIAL ONLY.

5. If the MODE window has changed to I/O and the SD windows are cleared, a power dropout with no DAY and/or TIME available from the chronometer is indicated. This would also happen if no chronometer were available. Turn the MODE switch to OFF, replace the chronometer, and perform another alignment. If a chronometer is not available:

   a. If a correct DAY and TIME are available, insure MODE switch is set to desired type alignment, fill day and time, press MODE START or RAPID and continue with GROUND ALIGNMENT checklist.

   b. If correct DAY and TIME are not available insure MODE switch is set to desired type alignment, and press MODE START or RAPID. If RAPID was selected, then turn the MODE switch to INERTIAL ONLY and MODE START. This extinguishes the flashing MAL light and a RAPID alignment will continue. Perform the Ground Alignment Correct procedure if desired.

NOTE

The first MODE START or RAPID start selects the type alignment. But INERTIAL ONLY has to be MODE started to clear the flashing MAL Light if DAY and/or TIME are not available, either from the chronometer or fill routine.

6. If the MODE window has changed to D/R, a platform failure or platform disable is indicated. Confirm by pressing MAN CLEAR switch while observing the MODE window and the MAL Light.

   a. If the MODE window then changes to A-I or I/O, and the MAL light goes off, a platform failure is indicated. The SD windows will not be affected. If the ANS guidance group can be replaced, turn the MODE switch to OFF, replace the group and realign. If the group cannot be replaced, select DEAD RECKON with the MODE switch, and complete DEAD RECKON MODE checklist.

NOTE

The MODE window change and MAL light extinguishing could be momentary. The light will go out when the window reverts to A-I or I/O. The window may eventually revert back to D/R with a flashing MAL light.

   b. If the MODE window <u>remains</u> D/R and the MAL light goes out, a platform disable is indicated. The counters will be referenced to the DEAD RECKON frame. Select DEAD RECKON with the MODE switch and press MODE START. Then select ASTRO INERTIAL or INERTIAL ONLY and press MODE START again. The NAV-READY functions will now resume and the system will operate normally.

<u>**Flashing MAL Light In Flight**</u>

It is normal for the MAL light to flash when the MODE switch is moved from OFF or WARMUP to ASTRO INERTIAL, INERTIAL ONLY, or AIR START. The MODE window will read C/A if the system has a day and time or I/O if a day and time are not available from the chronometer. The MAL light will go out after DAY and TIME are filled, MODE START is pressed and MAN CLEAR is pressed.

If the MAL light flashes during airborne operation, observe the MODE window and SELECTED DATA windows.

1. If the MODE window display has not changed and the SD windows are frozen, a computer malfunction has occurred. Turn the MODE switch to OFF and attempt a COLD AIRSTART.

2. If the MODE window has changed to C/A and the SD windows are cleared, a power dropout in excess of 1 second has occurred. Attempt a HOT AIRSTART procedure. Otherwise press MAN CLEAR, select DEAD RECKON with the MODE switch, and complete DEAD RECKON mode checklist. A COLD AIRSTART may then be performed. The COLD AIRSTART is also necessary if the HOT AIRSTART is unsuccessful.

3. If the mode window has changed to ENC and the SD windows are not affected, the yaw encoding has malfunctioned. "Synthesized heading" (true ground track) is output to the HSI and BDHI compass cards and NCD panel as true heading. Pressing MAN clear extinguishes the flashing MAL light and removes the ENC indication but does not remove the malfunction. Refer to Yaw Encoding Failure this section.

4. If the MODE window has changed to I/O and the SD windows are cleared, a power dropout with no day and/or time avail-

able from the chronometer is indicated. Turn the MODE switch OFF and perform a COLD AIRSTART. If DEAD RECKON mode is preferable to a COLD AIRSTART, press MAN CLEAR to initialize the system. Select INERTIAL ONLY and MODE START to extinguish the flashing MAL Light. Then select DEAD RECKON and complete the DEAD RECKON checklist.

NOTE

The initial position error will probably be very large due to no time reference when the system is initialized after pressing MAN CLEAR. Fill present position or update by fixing.

5. If the MODE window has changed to D/R, a platform failure or platform disable is indicated. Confirm by pressing the MAN CLEAR switch, while observing the MODE window and the MAL light.

    a. If the MODE window then changes to A-I or I/O and the MAL light goes off, a platform failure is indicated. To confirm platform failure, check ANS attitude, heading, and groundspeed displays. The SD displays will not be affected. Turn the MODE switch to DEAD RECKON and complete the DEAD RECKON mode checklist, or turn the MODE switch to OFF and attempt a COLD AIRSTART.

    NOTE

    The MODE window change and MAL light extinguishing may be momentary in the event of a platform failure. The light will go out when the MODE window reverts to A-I or I/O. But the window will eventually revert back to D/R and the MAL light will flash again.

    b. If the MODE window remains D/R and the MAL light goes out, a platform disable is indicated. The SD displays will be referenced to the DEAD RECKON frame. Select DEAD RECKON with the MODE switch and press MODE START. Then select either ASTRO INERTIAL or INERTIAL ONLY with the MODE switch and press MODE START again. The NAV-READY functions will now resume and the system will operate normally.

All NCD Panel Windows Blank

If all NCD panel lights and windows go blank it indicates loss of ac or dc power to the ANS. Check the ANS essential dc and ANS 3 phase ac circuit breakers and the position of the MODE switch. When power is restored, as indicated by the MAL light flashing, follow the procedures listed under Flashing MAL Light During Ground Operation or Flashing MAL Light In Flight.

INERTIAL NAVIGATION SYSTEM (INS)

The SKN-2417 INS is the source of inertially derived magnetic reference for the basic flight instruments and radio navigation aids. It also provides aircraft attitude and navigation information. The INS consists of the inertial navigation unit (INU), the inertial control panel (ICP) and the INU battery.

The system provides present position, groundspeed and steering, distance, and enroute time to 10 destinations and 3 mark points. Destination points may be entered or changed any time the system has power applied and are retained in the computer memory after power is removed. Mark points are entered in memory by a panel routine which allows sequential and repetitive marking of present position in the 3 mark points A, B and C.

Heading information is furnished to the:

1. DAFICS for autopilot, PVD heading input, and SAS analytical redundancy (ANR) when the pilot's attitude reference select switch is in INS.

NOTE

The auto-nav feature of the autopilot is disengaged and cannot be used when INS is selected.

2. Pilot's HSI.

3. BDHI when the BDHI heading select switch is in INS.

Attitude information is furnished to the:

1. Autopilot when the pilot's attitude reference select switch is in INS.

2. ADI when the pilot's attitude reference select switch is in INS.

3. Peripheral Vision Display (PVD) when the pilot's attitude reference switch is in INS.

4. Attitude Indicator when the RSO's attitude indicator select switch is in INS.

NOTE

Heading information is not provided in either alignment mode. The INS must be in the NAV mode before a valid heading display is available on the compass cards. With a computer failure, which causes the system to revert to the attitude mode (ATT), or with the FUNCTION switch set to ATT, the RSO controls compass card orientation with the heading slew knob.

INS OPERATION

The INS is programmed with global magnetic variation to 78 degrees north latitude and 65 degrees south latitude. During the NAV mode of operation the INS does not have an enterable grid navigation capability. A free gyro capability is available with the INS operating in the ATT mode with the limitation that once this mode is selected all computer and navigation functions are terminated leaving only attitude and heading available for the remainder of the flight. In the ATT mode the HSI and BDHI heading must be set using the heading slew knob.

The NAV mode cannot be reentered from the ATT mode. The INS does not have an air alignment function to restore full navigation capability.

ANS grid mode navigation should not be used since there is no useable grid heading display available to either cockpit in NAV mode and the ANS dead reckon (DR) frame does not receive correct heading information to maintain accurate navigation.

Waypoint to waypoint navigation with the INS, as with the ANS, is via great circle steering. With either system apparent heading change on a given leg is not obvious at lower latitudes, whereas at higher latitudes large apparent heading change is evident.

When in the NAV mode and within the latitude limits, (between 78N and 65S) the INS operates in the automatic mag var mode (MODE SEL light off). This will allow magnetic headings to be flown and maintains correct TACAN relative bearing. The pilot's standby compass can be used to cross-check heading. When crossing the automatic mag var latitude limit of the INS (steering toward a pole) the mag var is maintained at the last computed value until recrossing the latitude limit (steering toward the equator).

If zero MAG VAR is manually set when north of 78 degrees North latitude or south of 65 degrees South latitude (MODE SEL light on), the INS provides a true heading readout to the compass cards, which can be cross

INERTIAL CONTROL PANEL (ICP)

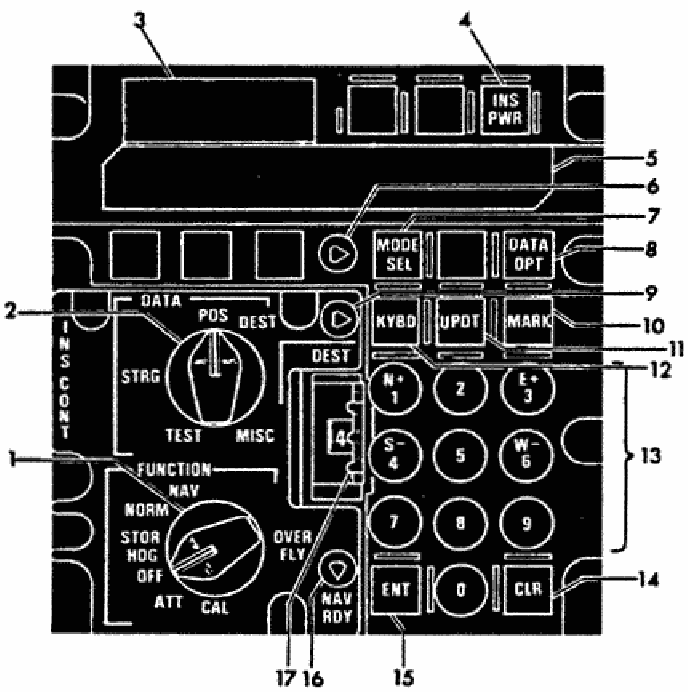


Figure 4-20

checked with the ANS. In this case the magnetic bearing to a TACAN station will be correctly displayed but the relative bearing will be in error.

INERTIAL CONTROL PANEL (ICP)

The ICP (Figure 4-20) is on the aft cockpit left console.

FUNCTION Switch

Selects the INS operating modes. The switch must be pushed down to rotate into or out of positions OFF, STOR HDG, NORM and ATT; it cannot be rotated directly from OFF to ATT or from ATT to OFF.

OFF	INS operation is disabled.
STOR HDG	Selects quick reaction alignment if aircraft has not moved since last alignment.
NORM	Selects normal alignment.
NAV	Selects inertial navigation.
OVERFLY	Selects inertial navigation and allows overfly update.
CAL	A ground maintenance function used to recalibrate INS gyros.
ATT	Selects inertial attitude and heading without navigation or computer correction for apparent precession.

The INS remains in inertial navigation at all switch positions between NAV and ATT.

DATA Switch

Used in conjunction with the DATA OPT pushbutton to establish what data is called

INERTIAL CONTROL PANEL DATA DISPLAYS

DATA SWITCH	DATA OPT PUSHBUTTON	ALPHA DISPLAY	LEFT DISPLAY	RIGHT DISPLAY
POS		L/L	Present Position latitude (to nearest tenth of an arc minute).	Present Position longitude (to nearest tenth of an arc minute).
	First press	V/T	Groundspeed (to nearest knot).	Aircraft true ground track (to nearest tenth of a degree).
	Second press	H/M	True Heading (to nearest tenth of a degree).	Computed or manually entered mag var (to nearest tenth of a degree (1)
	Third press	IS	Time in alignment (to nearest tenth of a minute).	Alignment status (50, 40, 30, etc.).
DEST		L/L	Latitude of DP on DEST wheel (to nearest tenth of an arc minute).	Longitude of DP on DEST wheel (to nearest tenth of an arc minute).
	First press	E/T	BLANK	Time to DP on DEST wheel (hour(s) and minute(s)). (Groundspeed more than 75 knots).
	Second press	D/C	Distance to DP on DEST wheel (to nearest nautical mile).	Computed true ground track to DP on DEST wheel from Present Position (to nearest tenth of a degree).
STRG		G/C	Distance to DP on DEST wheel (to nearest nautical mile).	Time to DP on DEST wheel (hour(s) and minute(s)). (Groundspeed more than 75 knots).
	First press	HDG (2)	0	0
TEST		INS (3)	0, FAIL 1 or FAIL 2	Failure indication.
	First press	PNL	0	0
			Lamp test available by depressing MODE SEL/MODE SEL light on. Terminate lamp test by depressing MODE SEL/MODE SEL light out.	
	Second press		Blank	Blank
MISC	The MISC position is used to display and/or enter various INS parameters. Of primary interest to the operator (RSO) is the entry of altitude into the system at various points in the mission in order to prevent degradation of system navigation performance. Refer to Altitude Update.			

(1) With MODE SEL light on, computed mag var is removed from HSI and BDHI, heading displayed on instruments is true heading plus or minus manually entered mag var. If E or W "0" mag var is displayed then heading displayed on instruments is true heading.

(2) No meaningful data is presented with this display option selected.

(3) If Fail 1 or Fail 2 appears refer to INS Fault Indication Clearing.

F203-291

Figure 4-21

from the computer for display, or what data may be keyed for entry into the computer. Refer to Figure 4-21 for data options.

ALPHA Display

Provides a three character label identifying the information being displayed in the left and right data displays, or the information to be entered into the system.

INS PWR Pushbutton

Pushbutton switch used in conjunction with the FUNCTION switch to turn the INS on or off. When aircraft power is removed, the INU battery will discharge unless the INS PWR switch is off.

Left and Right Data Displays

The left and right alphanumeric data displays display readouts or show values keyed for entry.

MODE SEL Pushbutton

Used in conjunction with the DATA selector switch to enable automatically computed or manually entered magnetic variation. It is used to initiate self test (TEST position of the DATA switch) during the first 2 minutes of a normal (NORM) alignment. It is also used to clear INS fault indications.

MODE SEL Light

The light illuminates when manual magnetic variation is selected. It illuminates during a maintenance self-test and extinguishes after 5 minutes when the test is complete.

DATA OPT Pushbutton

Used in conjunction with the DATA switch to select the displays available at each DATA switch position. See Figure 4-21.

MARK Pushbutton

Enters present position into computer memory for recall as a point of interest. After 3 sequential MARK points have been accomplished (A, B and C) subsequent marking erases the previous point(s) in order (A, B, C).

UPDT Pushbutton

Used when the FUNCTION switch is in OVERFLY to update INS present position.

KYBD Pushbutton

Enables or disenables the keyboard buttons.

Keyboard Light

The light is on when the keyboard is enabled and off when keyboard is disenabled.

Keyboard Pushbuttons

When enabled, used to select codes and numerical data for display and entry.

CLR Pushbutton

Used to clear the displays if an error is made during keyboard inputs.

ENT Pushbutton

Used to enter data into the computer upon completion and validation of keyboard inputs.

NAV RDY Light

The light illuminates steady at the completion of fast alignment; the light flashes at the completion of full alignment. The light goes out when the FUNCTION switch is set to NAV.

DEST Wheel

Used to select destinations (0 - 9) for computer entry via the keyboard and to select the desired destination or mark point (A, B or C) to steer to. The mark point selected for display by the DEST wheel cannot be changed by the marking routine when it is being displayed. Mark points D, E and F are not used.

Heading Slew Knob

A heading slew knob is on the RSO's instrument panel adjacent to the BDHI switches. The knob sets HSI and BDHI heading if the INS enters ATT mode (either automatically by computer failure or selected by the RSO). The best known heading reference should be set.

INS Segment Lights Control

A light control labeled INS SEG LTS on the left aft console varies the intensity of the INS segment lights (Alpha, left and right data displays). The light control is powered by the emergency ac bus through the INS PRIME circuit breaker on the pilot's right console.

INS Panel Lights

INS panel lighting is controlled by the L CONSOLE light control.

INU Battery

A self-contained battery on the INU mount provides continued INS operation for up to 10 seconds in the event of aircraft or ground power transients. The battery charges when the FUNCTION switch is not OFF and the INS PWR switch is ON.

NOTE

> Continued INS operation after loss of power discharges the INU Battery.

INS PROCEDURES

Normal Alignment

Normal alignment (NORM) is a gyrocompass alignment which requires only correct present positon and is completed in less than 8 minutes at temperatures above 40°F. For temperature less than 40°F the alignment time will be increased to 9 minutes at 0°F and 12 minutes at -40°F. Six minutes into the alignment, fast ready is indicated by steady illumination of the NAV RDY light. The NAV RDY lamp flashes at the completion of alignment.

A fast ready capability is available from normal alignment by selecting NAV mode with the FUNCTION switch after steady illumination of the NAV RDY light. Attitude information and navigation capability are available, however, navigation accuracy will be degraded.

With the DATA switch in POS, the third press of the DATA OPT pushbutton will allow inertial alignment status (IS) to be monitored. Prior to fast ready (NAV RDY steady light at six minutes) the status indicates "99" (course alignment in progress) or "90" (fine alignment in progress). After fast ready (NAV RDY light steady) and before ready (NAV RDY light flashing) inertial status (IS) decreases in units of 10 (60, 50, 40, 30, 20) to indicate improving CEP (error probable) as alignment improves. When "10" is displayed, specification performance is available, the NAV RDY light flashes, and alignment is complete; however INS accuracy may improve beyond specification requirements if alignment is continued in NORM. During self test, the align status indicates "80" from 4 to 6 minutes in self test.

1. INS PWR pushbutton - Press.
2. FUNCTION switch - NORM.
3. DATA switch - POS, alpha display is L/L.

   If left and right data displays indicate correct position continue to step 4, otherwise perform the following:

   a. KYBD pushbutton - Press, keyboard light on.
   b. Enter latitude - N or S XX°XX.X'
   c. ENT pushbutton - Press. Check latitude in left display.

d. Enter longitude - E or W XXX°XX.X'

e. ENT pushbutton - Press. Check longitude in right display.

4. DATA OPT pushbutton - Press three times, alpha display is IS (Inertial Status). Right display counts down from 99 to 10 indicating alignment status. Left display counts up indicating time in alignment.

NOTE

Other ICP activity, such as entry or verification of destination coordinates or altitude entry may be accomplished during alignment. Entry of system latitude or heading will reinitialize alignment.

5. DATA switch - MISC, enter field elevation.

a. KYBD pushbutton - Press, keyboard light on.

b. Altitude address - Enter 1138.

c. CLR pushbutton - Press

d. +(3) keyboard pushbutton - Press.

e. Enter field elevation - XX,XXX ft.

f. ENT pushbutton - Press. Check altitude in right display.

g. DATA switch - POS.

When NAV RDY light flashes:

6. FUNCTION switch - NAV.

NAV RDY light illuminates steady after 6 minutes. Select NAV mode if fast ready (minimum time) alignment is required.

NOTE

Setting the FUNCTION switch to NAV from STOR HDG, NORM or CAL prior to steady illumination of the NAV RDY light will transfer the INS to the ATT mode and alignment must be reinitialized.

At 8 minutes, NAV RDY light flashes indicating full alignment is complete.

NOTE

- The FUNCTION switch <u>must</u> be in NAV prior to taxiing the aircraft, or realignment will be required.

- When the NAV mode is selected after alignment the INS remains in the navigate mode until the FUNCTION switch is set to OFF or ATT, or a computer failure occurs. There is no capability to reenter an alignment mode after the NAV mode has been selected. If short delays occur before takeoff maintain the INS in the NAV mode. For prolonged delays it may be desirable to turn the INS off and perform another alignment.

- The FUNCTION switch must remain off for 2 minutes before reinitiating alignment to optimize system accuracy during the new alignment.

<u>**Stored Heading Alignment**</u>

The stored heading alignment provides a quick reaction capability and can only be accomplished if the aircraft has not been moved after previous INS shutdown. Stored heading (STOR HDG) alignment is normally completed in less than 4 minutes at temperatures above 60°F. For temperature less than 60°F, the alignment time increases to 5 minutes at 0°F and 6 minutes at -40°F.

When the absolute minimum alignment is completed, (about one minute above 25°F and 2 minutes at -40°F) fast ready (steady NAV RDY light) is indicated with a fine alignment in process status ("90"). At alignment complete (NAV RDY flashing) status "30" is displayed. This occurs at 1-1/2 minutes above 40°F. The status is then decremented (30 to 29 to 28, etc.) every fifteen seconds until status "20" is displayed.

1. INS PWR pushbutton - Press.

2. FUNCTION switch - STOR HDG.

   If the aircraft has not been moved since the last INS shutdown, skip to step 3, otherwise perform the following:

   a. DATA switch - POS, alpha display is L/L. Check present latitude and longitude in left and right displays.

   b. DATA OPT pushbutton - Press twice, alpha display is H/M. Check magnetic variation in right display.

   c. DATA switch - STRG, alpha display is G/C.

   d. DATA OPT pushbutton - Press, alpha display is HDG.

   e. KYBD pushbutton - Press, keyboard light on.

   f. "1" keyboard pushbutton - Press, left display blanks.

   g. Enter true heading - XXX.X°

   h. ENT pushbutton - Press. Check heading in left display.

When NAV RDY light flashes:

3. FUNCTION switch - NAV.

NOTE

Minimum fine alignment is complete in 1-1/2 minutes (NAV RDY light flashing and status IS 30). Specification performance is not available until status IS 20 appears (2-1/2 minutes after NAV RDY light flashing).

Airborne Attitude Alignment

Should the INS fail completely in flight, it may be possible to reestablish the platform in the attitude (ATT) mode. This will not provide navigation capability, but will provide pitch, roll and heading to the cockpit displays. The RSO can use the heading slew knob to establish a heading reference.

1. FUNCTION switch - OFF.

   Flags will appear on the attitude instruments with INS attitude source selected.

After 2 minutes:

2. FUNCTION switch - ATT.

3. Maintain straight and level flight.

At the end of the 36 second coarse alignment phase, the flags will disappear from the attitude instruments. INS pitch and roll attitude displays are now available. The INS heading display will be the platform azimuth angle.

After 36 seconds <u>and</u> OFF Flags out of view:

4. Heading Slew Knob - Set desired heading.

5. Monitor INS pitch and roll displays.

WARNING

INS attitude accuracy may degrade over a period of time after the airborne attitude alignment. Attitude displays should be monitored closely. If attitude precesses excessively additional airborne alignments may be performed.

Destination Point Entry

Destination points may be entered or changed at any time with the FUNCTION switch in STOR HDG, NORM, NAV, or OVERFLY.

1. DATA switch - DEST, alpha display is L/L.
2. DEST wheel - Set DP (0 to 9).
3. Enter destination position.
   a. KYBD pushbutton - Press, keyboard light on.
   b. Enter latitude - N or S XX° XX.X'.
   c. ENT pushbutton - Press. Check latitude in left display.
   d. Enter longitude - E or W XXX °XX.X'.
   e. ENT pushbutton - Press. Check longitude in right display.

NOTE

With the DEST wheel in A, B, or C position previous MARK points may be observed but not entered.

Altitude Update

The INS is a stand alone system and does not receive altitude inputs. Altitude updating will prevent system accuracy from degrading due to large altitude transients. Altitude may be updated at the discretion of the operator. Suggested points for altitude updates based on normal mission profiles are incorporated in aircrew checklists.

1. DATA switch - MISC, alpha display is M/L.
2. KYBD pushbutton - Press, keyboard light on.
3. Altitude address - enter 1138.

   138 appears in left display. Right display is last entered altitude.
4. CLR pushbutton - Press.

   Displays blank then last entered altitude reappears in right display.
5. +(3) keyboard pushbutton - Press.
6. Enter altitude - XX,XXX Ft.
7. ENT pushbutton - Press. Check altitude in right display.

Position Update

The RSO can update the INS present position by overflying a known point which has been previously entered as a destination point.

The RSO should occasionally cross check the INS position with the ANS by noting the ANS position and "marking" the INS position. The marked position can be displayed on the ICP and compared with the noted ANS position. If update is necessary, select a point on track such as an IKP or the point of crossing an even line of latitude or longitude. Enter the point into the INS as a destination point and set the FUNCTION switch to OVERFLY. When the point is reached as determined by the ANS position, press the UPDT push-button.

The viewsight can also be used for updating if an identifiable point is to be overflown. The point is entered into the INS as a DP, then set the FUNCTION switch to OVERFLY.

When the point reaches the intersection of the viewsight groundtrack reference line and nadir depress the INS UPDT pushbutton.

1. DATA switch - DEST.

2. DEST wheel - Set DP (0-9).

3. Enter latitude - N or S XX °XX.X'.

   Enter latitude of point to be used for postion update.

4. ENT pushbutton - Press. Check latitude in left display.

5. Enter longitude - E or W XXX °XX.X'.

   Enter longitude of point to be used for position update.

6. ENT pushbutton - Press. Check longitude in right display.

7. FUNCTION switch - OVERFLY.

8. UPDT pushbutton - Depress when point is reached.

9. FUNCTION switch - NAV.

Marking Procedure

Any point overflown may be "marked" for subsequent use or reference. Depressing the MARK pushbutton will cause MKA, MKB or MKC to appear in the Alpha display. The left and right displays continue to display present position. After 10 seconds the Alpha display returns to normal operation. The marked point can then be displayed by setting the destination wheel to A, B, or C and the DATA switch to DEST. The system will maintain three points at any time. Repetitive marking erases the previously marked points in order.

DATA Displays

Data is displayed using the DATA switch and DATA OPT pushbutton. Repositioning the DATA switch selects the first display of that position. Remaining displays for a given DATA switch position are selected by depressing the DATA OPT pushbutton. See Figure 4-21 for data displays available.

Attitude Mode (ATT)

In ATT mode the INS operates as an inertial attitude and heading reference platform. The ATT mode is entered automatically in the event of computer failure or may be selected by the operator.

The ATT mode is entered by rotating the FUNCTION switch clockwise and pressing before reaching the ATT position. The INS remains in ATT mode until the FUNCTION switch is OFF.

NOTE

> NAV mode cannot be reentered from the ATT mode. Once ATT mode is entered all INS navigation capability is lost.

Failure Indications

The INS REF caution light on the pilot's annunciator panel is illuminated by a computer failure or heading failure (INS automatically in ATT mode), FUNCTION switch in ATT mode, or platform failure.

If the pilot's attitude reference select switch is in INS and the INS is in ATT mode (automatically or by setting the FUNCTION switch in ATT) a course warning flag appears on the pilot's ADI to indicate heading is not reliable. When the INS is operating in ATT mode, DAFICS analytical redundancy, autopilot operation, and PVD operation are not affected.

If the pilot's attitude reference select switch is in INS and the INS platform fails (attitude malfunction), an OFF flag appears on the pilot's ADI in addition to the course warning flag. A DAFICS analytical redundancy failure is indicated (flashing red DAFICS PREFLIGHT BIT FAIL light), the autopilot will not engage, and PVD operation is inhibited. If the RSO selects INS attitude reference the RSO's attitude indicator displays an OFF flag.

INS "NO WARNING" MALFUNCTIONS

DISPLAY		MALFUNCTION	EFFECT
LEFT	RIGHT		
FAIL 1	000002	BITE ON BITE	NO INTERNAL TEST
FAIL 1	000100	VERTICAL VELOCITY	GRADUAL NAV DEGRADATION
FAIL 1	000200	REDUNDANT LOOP	GRADUAL NAV DEGRADATION
FAIL 2	002000	INU BATTERY FAILED	NO AIRCRAFT POWER LOSS PROTECTION
FAIL 2	004000	MUX 1	ERRONEOUS, BLANK OR FROZEN DISPLAYS
FAIL 2	010000	MUX 1	
FAIL 2	020000	MUX 2	

Figure 4-22

Therefore, if the pilot is using the ANS as the attitude source and the INS REF annunciator light illuminates, the RSO should check the aft cockpit attitude indicator (INS attitude reference). If the power OFF flag is not in view the INS is operating in ATT; if the power OFF flag is in view there is an INS platform (attitude) malfunction.

An INS malfunction that illuminates the INS REF annunciator caution light can be considered a hard failure. There is a remote possiblity of clearing a malfunction inflight by attempting the INS Fault Indication Clearing Procedure. There are seven additional malfunctions that could occur which do not illuminate the INS REF light. Two cause degraded accuracy, three cause erroneous, blank or frozen ICP displays, and the remaining two do not affect system performance. None of the seven are evident through the aircraft warning system, but they can be viewed on the ICP with the DATA switch set to TEST. See Figure 4-21.

INS Fault Indication Clearing Procedure

1. DATA switch - TEST, Alpha display reads INS.
   a. If Left and Right displays read "O" - No action required.
   b. If Left display reads FAIL 1 or FAIL 2 (Figure 4-22) - Perform steps 2 through 4.
2. DATA OPT - Press twice, Alpha display reads CLR.
3. MODE SEL - Press, MODE SEL light ON.
4. DATA OPT - Press, Alpha display reads INS, MODE SEL light OFF. If FAIL 1 or FAIL 2 reoccurs, notify maintenance.

Attitude Outputs

Failures of INS attitude output servos could cause frozen attitude displays (including inputs to DAFICS), rapidly changing attitude values, or gradually increasing attitude errors. This is particularly dangerous at night or in IFR conditions, especially if the pilot's attitude reference select switch is in INS and the auto pilot is engaged. An ANR light (flashing DAFICS PREFLIGHT red FAIL light) could indicate that the selected attitude reference is erroneous. Monitor other attitude references (ANS platform and pilot's standby attitude indicator) to detect INS attitude errors as soon as possible.

SENSOR SYSTEMS

The following sensor systems are available:

1. Two high-resolution, narrow field technical objective cameras (TECH).
2. Advanced Synthetic Aperture Radar System (ASARS).
3. High resolution, side-looking radar (SLR) for mapping (CAPRE).
4. ELINT Improvement Program/Electromagnetic Reconnaissance (EIP).
5. Optical bar camera (OBC).

The following equipment complements the sensor systems:

1. V/H system.
2. Viewsight.
3. Map projectors (two). (Refer to Section I).
4. Exposure control system.
5. Mission Recorder System (MRS).

SENSOR COMPARISON CHART.

		TECHNICAL CAMERA	ASARS	CAPRE	EIP	OBC
V/H RANGE		21-45				35-45
STABILIZATION AND LIMITS		NOT STABILIZED	PITCH ROLL YAW TILT	PITCH ROLL YAW TILT	NOT STABILIZED	NOT STABILIZED
FAIL LIGHTS		CONNECTED TO SENSOR FAIL	CONNECTED TO SENSOR FAIL	CONNECTED TO SENSOR FAIL	CONNECTED TO SENSOR FAIL	CONNECTED TO SENSOR FAIL
IMAGE MOTION COMPENSATION		MIRROR ROTATION AND EXPOSURE RATE				NODDING FMC
OPERATION		MANUAL OR AUTOMATIC	MANUAL OR AUTOMATIC	MANUAL OR AUTOMATIC	MANUAL	MANUAL
FILM TAPE CAPACITY		FILM 9-1/2 x 9-1/2 IN. [redacted]	TAPE 9200 FT (2)	FILM - 1300 FT	TAPE (2)	[redacted] 5" FILM [redacted]
WARMUP TIME		20-40 SEC	6 MIN	6 MIN	2 MIN	PREFLIGHT
POWER TURN	ON	AFTER TAKEOFF	AFTER TAKEOFF	AFTER TAKEOFF	AFTER TAKEOFF	AFTER ENGINE START
	OFF	PRIOR TO LANDING	PRIOR TO LANDING	PRIOR TO LANDING	PRIOR TO LANDING	AFTER LANDING

F203-103(1)(KA)

Figure 4-23

[redacted]

SENSOR COMPONENT AND DEF EQUIPMENT LOCATIONS

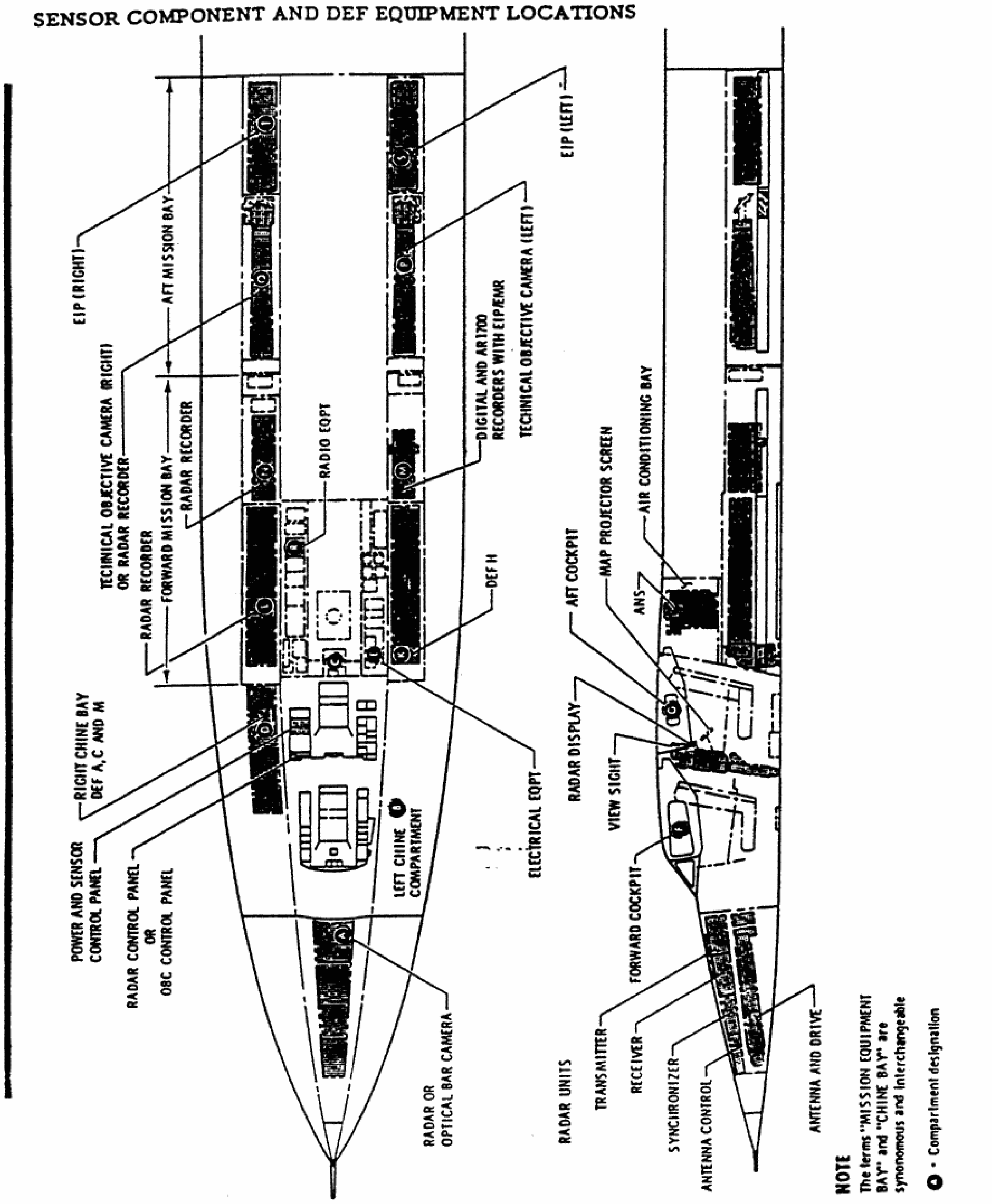


Figure 4-24

F200-49(m)

[redacted]

POWER AND SENSOR CONTROL PANEL

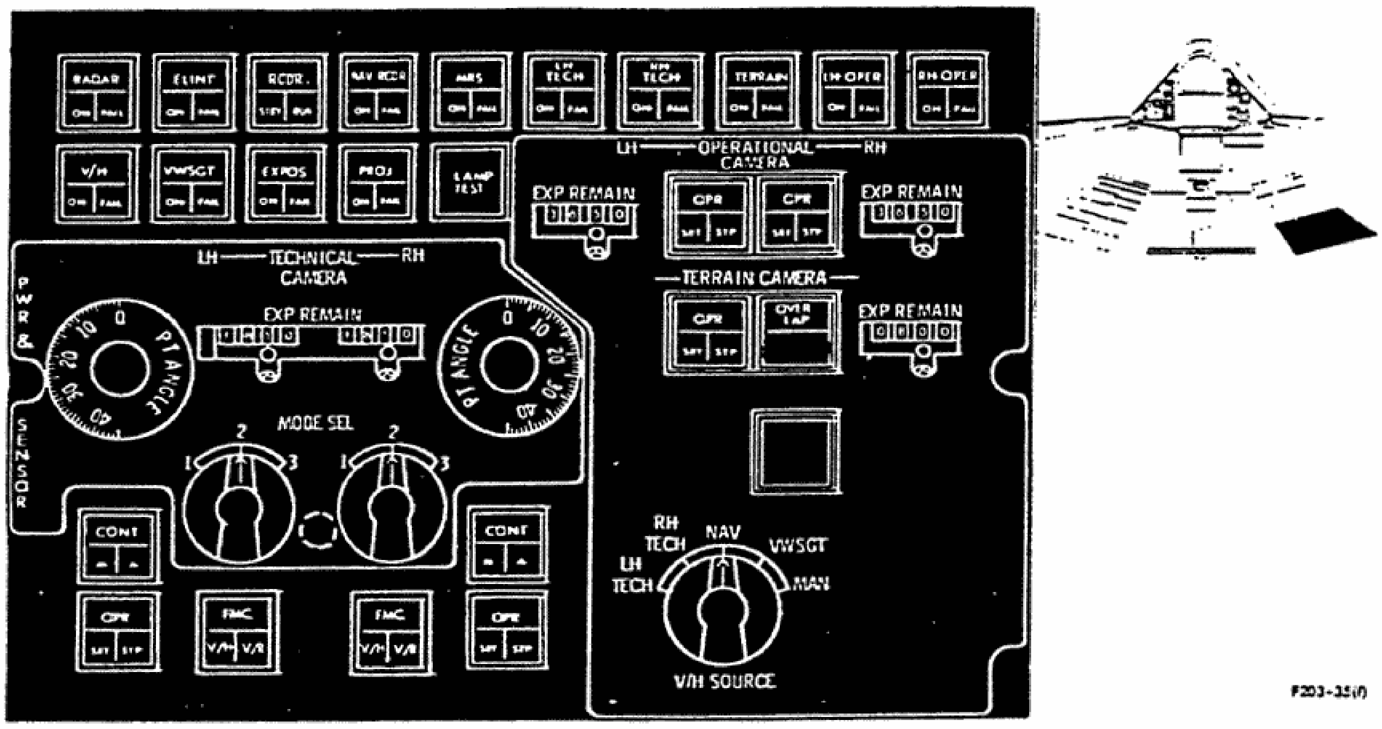


Figure 4-25

POWER AND SENSOR CONTROL PANEL

The power and sensor control panel, labeled PWR & SENSOR, is on the RSO's right console. It contains power switches for all of the sensors, and the control switches for the cameras and the V/H system. For information concerning switch operation, refer to the individual sensor description(s).

The Terrain Objective Camera System (TROC) and Operational Objective Camera System (OOC) are no longer available. The seven alternate action switches and three film counters (on the upper right portion of the panel) that were associated with these systems are no longer used.

NOTE

- **Application or reapplication of electrical power to the aircraft electrical system while a sensor power switch is ON requires the sensor power switch to be cycled OFF and then ON to reapply power to the sensor.**
- **Set each sensor operation switch to STP or STBY before moving its power switch to OFF.**

TECHNICAL OBJECTIVE CAMERA SYSTEM (TECH)

Two TECH cameras mounted in the left and right aft mission equipment bays, are used for obtaining detailed photographic imagery. These cameras are often referred to as TEOC cameras. TEOC and TECH are synonomous. They are variable pointing angle, high-resolution, narrow field cameras that produce overlapping exposures of the terrain below or to the side of the flight path. The cameras are either automatically controlled by the ANS, or manually controlled by the RSO. Camera controls are on the power and sensor control panel. The lateral pointing angle of each camera is read on an indicator on the left side of the RSO's instrument panel. The exposure-remaining counters, failure indication, and pointing-angle indicator are used to monitor camera operation.

There are two camera models; the HR-308B and the HR-308C. There are two versions of the HR-308B, the -11 and the -21. The HR-308B is unstabilized (except for passive vibration isolation) while the HR-308C is actively stabilized in pitch, roll, and, at higher look angles, yaw. Another difference is the source of forward motion compensation (FMC), although FMC is mechanized similarly in all cameras by rocking the oblique mirror in the camera head at a variable rate determined by V/R (velocity divided by slant range).

Camera field of view (FOV) is [redacted] Each camera may be pointed laterally [redacted] degrees (aircraft nadir) [redacted] outboard on its side of the aircraft. The stabilized look angle is the sum of the aircraft bank angle and camera pointing angle, thus with the aircraft [redacted] bank the look angle could vary from [redacted] degrees. Terrain coverage in a single frame from operational altitude typically varies from a [redacted] square [redacted] look angle to a [redacted] area with the center of the field of view approximately [redacted]

The cameras are normally operated automatically by depressing the CONT A pushbutton on the PWR & SENSOR control panel, selecting NAV V/H source, and setting the FMC to V/R.

NOTE

FMC for the -11 HR-308B must be set to V/H during turns where that camera is the upwing camera.

Should manual camera operation be required, the RSO must set the mode and pointing angle controls to prebriefed settings. The cameras are switched to manual mode by depressing the CONT pushbutton on the PWR & SENSOR control panel to illuminate the M legend. The NAV V/H source may still be used if the ANS is in operation, but for manual operation the FMC setting will depend upon the model and version of the camera in use. The -11 HR-308B and HR-308C require the same FMC setting and will provide the same FMC accuracy in manual or automatic operation. For -21 HR-308B manual operation, FMC should be set to V/H, which provides accurate FMC in level flight only (image degradation can be expected in turns).

The pointing angle and overlap coverage for the different manual modes of camera operation vary with the model and version of the camera in use.

Mode Selector

Two rotary mode selector (MODE SEL) switches on the PWR & SENSOR control panel, one for each camera, select the desired mode during manual operation. The switch is effective only when the respective CONT switch illuminates M and has three operating mode positions, labeled 1, 2, or 3:

MODE 1 (all):
Single exposures at 1.1 per second at the selected pointing angle.

MODE 2
-11 HR-308B:
Single exposures at a V/R controlled rate which provides [redacted] overlap between successive exposures at the selected pointing angle.

-21 HR-308B and HR-308C:
Single exposures every 1.25 seconds alternating between 4 degrees greater and 4 degrees less than the selected pointing angle.

MODE 3 (all):
Single exposures at a V/R controlled rate which provides [redacted] overlap between successive exposures alternating between 4 degrees greater and 4 degrees less than the selected pointing angle.

TECH Camera Power Switches

A self-illuminated pushbutton power switch for each camera is located on the forward edge of the PWR & SENSOR control panel. The switches are labeled LH TECH and RH TECH. Operation of either switch illuminates ON and applies power to the camera but does not initiate operation. (Camera temperature control circuitry is not controlled by this switch.) The FAIL portion of the switch illuminates to indicate a malfunction within the respective camera and the camera will be simultaneously deactivated. The SENSOR FAIL annunciator and RSO master CAUTION lights illuminate when the FAIL portion of either switch illuminates.

TECH Camera Mode Control Switch

A self-illuminated pushbutton-switch, labeled CONT, M, A, is located on the lower left of the PWR & SENSOR control panel.

The CONT portion of the switch illuminates when the tech camera power switches illuminate ON. The lower left quarter of each switch is labeled M (manual) and the lower right quarter is labeled A (automatic). The A and M portions illuminate alternately when the control switch is pressed. When the A portion is illuminated, the camera is controlled by the ANS. When the M portion is illuminated the OPR switch, MODE SEL switch, and PT ANGLE switches control the cameras.

TECH Camera Operate Switches

A self-illuminated camera operate pushbutton switch, labeled OPR in the top half, is provided for each camera. The lower left quarter of the switch is labeled SRT (start) and the lower right quarter STP (stop); SRT and STP illuminate alternately as the pushbutton is pressed. The switch is effective only when its related control switch is in manual (M) position. The OPR portion of the switch illuminates immediately for the -21 HR-308B and HR-308C, or in approximately 30 seconds for the -11 HR-308B after the power switch is actuated to ON. Either version of HR-308B camera can operate as soon as power is on with no image degradation. Due to stabilization delay the HR-308C should not be operated until 15 seconds after OPR illuminates. If the CONT switch is in M (manual), verify that the OPR switch is in STP until camera operation is desired.

FMC Selector Switch

Self-illuminated FMC selector pushbutton switches, one for each camera, select the signal source for forward motion compensation. The top half of the pushbutton is labeled FMC and the legend illuminates when its respective camera power switch is on. The lower left quarter of the switch is labeled V/H and the lower right quarter is labeled V/R. The V/H and V/R legends illuminate alternately when the pushbutton is actuated. When the V/R legend illuminates, the camera is using the primary source of FMC input. When the V/H legend illuminates, the camera is using an alternate source of FMC input. The signals selected as primary and alternate sources are:

-11 HR-308B Normal Operation:

a. FMC switch - V/R; V/H source switch - NAV.

   This is used for straight and level flight.

   When V/R is selected, the Bus V/H is fed into and modified in the camera for head position only.

b. FMC switch - V/H; V/H source switch - NAV.

   V/H is used for the upwing camera during operation in turns with bank angles of 30 or 45 degrees.

When V/H is selected, the Bus V/H is fed into and modified in the camera head for mirror position and a preset bank angle of 30° or 45°. This preset bank angle is set in the camera and cannot be changed by the RSO.

NOTE

In both cases (above), camera uses Bus V/H so if NAV V/H source fails the RSO must switch to VWSGT or MAN source.

-21 HR-308B Normal Operation:

a. FMC switch - V/R; V/H source switch - NAV.

This setting is used for straight and level or turning flight.

When FMC - V/R is selected, NAV V/R, which takes into account aircraft bank angle and commanded pointing angle, is fed directly to the camera IMC and Film Drive circuits.

If NAV V/R fails:

b. FMC switch - V/H; V/H source switch - NAV.

When FMC - V/H is selected, the V/H bus is fed to and modified in the camera head by mirror position only and does not take into account aircraft bank angle. It can be used in straight and level flight only.

If NAV V/H source fails:

c. Set V/H source switch to VWSGT or MAN.

HR-308C Normal Operation:

a. FMC switch - V/R; V/H source switch - NAV.

When FMC - V/R is selected, the voltage on the bus is fed to the camera where it is modified by the aircraft bank angle, camera head mirror position and camera roll position. This modified signal is then fed to the IMC and Film Drive circuits.

If NAV V/H source fails:

b. Set source switch to VWSGT or MAN.

If Bus fails in all positions:

c. FMC switch - V/H.

When FMC-V/H is selected, NAV V/R voltage is fed directly to the IMC and Film Drive circuits. (NAV V/R takes aircraft bank angle and commanded pointing angle into account but not actual camera head mirror position or camera roll position.)

Image degradation as a result of using V/H in lieu of V/R can be slight to moderate depending on the stability of the aircraft.

Pointing Angle Selectors

Rotary PT ANGLE controls, on the PWR & SENSOR control panel, one for each camera, position the camera pointing angle during manual operation. The pointing range extends from zero to 45 degrees from aircraft vertical. The control is effective only when the respective CONT switch illuminates M.

Exposures Remaining Counters

Four-digit EXP REMAIN counters, on the PWR & SENSOR control panel indicate exposures remaining for each camera. When the camera is freshly loaded each counter indicates [redacted] exposures. Camera cycling decreases the respective counter.

NOTE

There is a remote possibility that the counter(s) may stick and not drive. Assume normal automatic camera operation if the respective sensor light on the ANS NCD panel illuminates, pointing angle and V/H (V/R) indicators appear reasonable, and the respective FAIL light is not illuminated.

Camera Pointing Angle Indicator

A circular CAMERA PT ANGLE indicator is on the RSO's left instrument panel. The indicator has two pointers (L, R) indicating respective camera pointing angle from 0 to 45 degrees, left and right of the aircraft vertical axis. In the manual mode, the indicator is a repeater for the pointing angle controls on the PWR & SENSOR control panel and indicates the manually selected angle. In the automatic mode, the indicator displays ANS pointing commands to the cameras.

TECH NORMAL PROCEDURES

For automatic camera operation:

1. LH(RH) TECH power switch -ON.
2. Mode control (CONT) switch - A.
3. FMC selector switch - As required.

For manual camera operation:

1. LH(RH) TECH power switch -ON.
2. Mode control (CONT) switch -M.
3. OPR switch - STP.
4. FMC Selector switch - As required.
5. MODE SEL switch - As briefed (1, 2, or 3).
6. PT ANGLE control knob - As briefed.
7. OPR switch - SRT/STP as briefed when appropriate.

TECH MALFUNCTION PROCEDURES

For EXP REMAIN counter not decreasing in AUTO continue normal operation if:

a. TECH L and/or R sensor light is on.
b. Pointing angle indicator responds to control point commands.
c. FMC is valid.
d. FAIL indicator and SENSOR FAIL lights are not on.

NOTE

A TECH camera FAIL indication may result from a camera malfunction or from a loss of V/H (V/R) signal input. Only the latter case can be corrected by the RSO.

If the FAIL indicator is on use the following procedure to determine if the FAIL is due to a camera malfunction or a V/H (V/R) failure:

1. Mode Control (CONT) switch - M.
2. OPR switch - STP.
3. MODE SEL switch - Mode 3.
4. V/H - Check.

   With V/H SOURCE selector switch in NAV and V/H MONITOR switch in BUS, check that the A needle on the V/H indicator indicates correctly. If indication appears accurate go to step 9.

If NAV V/H appears inaccurate:

5. V/H - Select an alternate V/H source.

If alternate V/H source appears accurate:

6. OPR switch - SRT.

NOTE

Loss of V/H signal to the -11 HR-308B or loss of both V/H and V/R signals to the -21 HR-308B or HR-308C makes camera inoperative in Mode 3. Manual operation in Modes 1 or 2, with grossly degraded FMC is possible in 20 second bursts. The FAIL indicator illuminates and the OPR switch must be cycled to STP then SRT every 20 seconds.

7. EXP REMAIN counter - Note normal operation for 30 seconds.

If FAIL does not illuminate, Automatic or Manual operation is available.

If FAIL illuminates (for -21 HR-308B camera):

8. OPR switch - STP.

9. FMC switch - Set alternate signal if using -21 HR-308B camera.

10. OPR switch - SRT.

11. EXP REMAIN counter - Note normal operation for 30 seconds.

If FAIL does not illuminate Automatic or Manual operation is available.

If FAIL illuminates:

12. OPR switch - STP.

13. TECH power switch - OFF.

SIDE-LOOKING RADAR (CAPRE) SYSTEM

The CAPRE System is a side-looking synthetic aperture radar. When installed, it replaces the Optical Bar Camera System.The Radar Correlator Display (RCD) can be operated with the CAPRE SLR System to produce an in-flight display for navigation. However, the main function of the SLR is to expose a film strip which records reflected radar signals. Range marks and data block information are automatically superimposed on the film. The radar can cover a strip 10 or 20 nm wide, on either side of the aircraft with the near edge of the swath between 10 and 70 nm from the aircraft. The CAPRE can only image during non-turning flight. The ANS provides automatic stabilization to allow operation during limited drift angles. Mapping information received by the antenna in the aircraft nose section is recorded on film on two recorders in the aft portion of the right forward mission bay.

Automatic and manual operating modes are provided. In the automatic mode, system operation is controlled by the ANS. In the manual mode, the RSO controls operation.

Except for the power switch on the PWR & SENSOR control panel, controls and indicator lights for the SLR are located on the radar control panel on the RSO's right console. A display of radar altitude is also provided by a digital indication on the radar control panel. Power for the SLR is furnished by the essential ac and monitored dc buses through circuit breakers in the C-bay.

Radar Power Control Switch

The self-illuminated radar pushbutton power switch has a white illuminated RADAR legend in the top half and is located on the PWR & SENSOR control panel. The ON portion of the pushbutton alternately illuminates and extinguishes as the pushbutton is depressed. The FAIL portion of the pushbutton illuminates when the SLR fails self-test. Illumination of the FAIL light illuminates the SENSOR FAIL light on the RSO annunciator panel. Removing RADAR power or a successful SLR self-test extinguishes the FAIL light.

RADAR CONTROL PANEL

The radar control panel on the RSO's right console controls the SLR. See Figure 4-26.

CAPRE SLR CONTROL PANEL

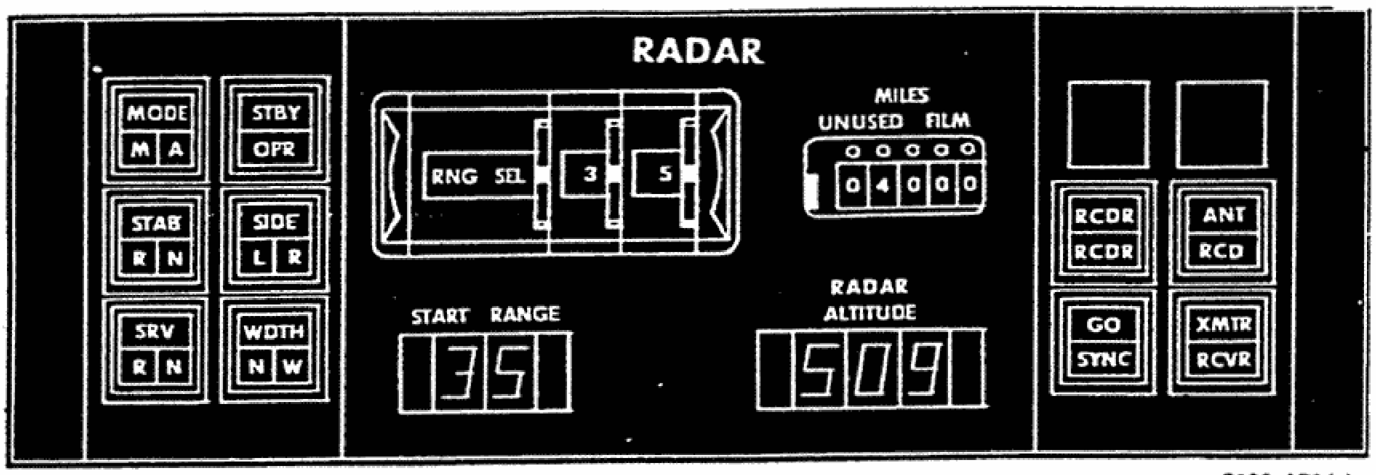


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Figure 4-26

Mode Selector Switch

A self-illuminated mode selector pushbutton switch displays an illuminated MODE legend in the top half when power is applied to the radar. The bottom half of the switch has two legends, A (automatic), and M (manual) which illuminate alternately as the pushbutton is depressed. A indicates automatic SLR operation. M illuminates during manual operation and during normal system shutdown.

Standby-Operate Switch

The self-illuminated standby (STBY)/operate (OPR) pushbutton switch illuminates when the radar system warm-up period is completed (approximately 6 minutes after power has been applied). In the manual mode, the STBY na dOPR light illuminate alternately when the pushbutton is depressed. In the automatic mode, the light indicates operate/standby commands received from the ANS.

STAB Selector Switch

Not functional. Stabilization is provided automatically by the ANS at all times.

SIDE Selector Switch

The self-illumininated SIDE selector pushbutton switch illuminates in either the manual or auto mode. The bottom quarters of the pushbutton have legends L (left) and R (right) which alternately illuminate when the push-button is depressed. In automatic mode, the legend indicates the antenna position command received from the ANS.

SRV Selector Switch

Not functional. The slant range velocity signal, utilized for motion compensation, is provided automatically by the ANS at all times.

Width Selector Switch

A radar mapping swath width selector switch is on the left side of the radar control panel. A WDTH legend is displayed in the top half of the switch. Either N (narrow) or W (wide) appears in the bottom half.

When start ranges of 20, 35, 40, 50 or 60 miles are selected in a manual mode, a choice of either a 10 or 20 mile swath width may be made by alternately depressing the WDTH switch to illuminate either N (narrow, 10 mile) or W (wide, 20 mile) coverage. The WDTH switch is electrically interlocked to illuminate only N for all other start ranges. Better radar image resolution will be obtained in the N position, and should be used unless mission requirements dictate a wider swath coverage. The RCD swath coverage and resolution are unaffected by the WDTH switch. In the automatic mode, the legend indicates the width command received from the ANS.

Start Range Selector Switches

Two thumb-wheel type start range selector switches, labeled RNG SEL are in the center of the radar control panel. The switches select the ground range at which mapping starts in manual mode. Start ranges of 10 through 70 nautical miles may be selected in five mile increments. (Selection of the ambiguous 75 miles start range is electrically interlocked to provide 70 miles, as indicated on the START RANGE indicator). The RNG SEL legend and the numbers illuminate only when the mode switch is in M.

Start Range Indicator

A start range indicator, labeled START RANGE, is on the left side of the radar control panel. The indicator displays the ground range in nautical miles from nadir to the start of the swath being mapped. The indication should agree with the RNG SEL switch setting during manual mode operation. During automatic mode operation, the indicator indicates the mapping range command received from the ANS.

MILES UNUSED FILM Counter

A MILES UNUSED FILM digital counter shows the nautical miles of film remaining in SLR recorder number one. It has a five-digit range of 0 to 4999. 4000 appears when the adjacent reset button is pressed. The initial indication is preset on the ground and the counter should not be readjusted in flight. Recorder number two has no associated digital counter.

Radar Altitude Indicator

A radar altitude indicator is on the right side of the radar control panel. The indicator displays radar altitude above the terrain when the SLR is operating.

The SLR will not update altitude if there is a difference of more than 5,000 feet between SLR and ANS altitude. If ten consecutive measurements are not valid, the altitude validity signal will be set to not valid. This signal is transmitted to the ANS to prevent ANS altitude update and turns off the SLR altitude display illumination. This also occurs if the SLR is turned off, placed in standby or if there is an SLR failure.

NOTE

> The indicator lights could give erroneous readings if the aircraft is overflying heavy cloud concentrations. The indicator will provide normal readings when clear of these areas unless a radar altitude malfunction is present.

BIT Test Indicators

The BIT (Built-In-Test) indicator lights are on the right side of the radar control panel. The BIT is automatically activated approximately six minutes after the SLR is turned on and remains activated until the SLR is turned off. If the tests are satisfactory, the green GO legend illuminates and remains on. If the radar malfunctions, the faulty radar component (XMTR, RCVR, SYNC, ANT, RCD, RCDR) indicator light(s) illuminate red. There is a possiblility of a momentary RCDR or XMTR fail indication during initial turn-on or when OPR is selected. This condition should self clear.

NOTE

> If any BIT indicator lights illuminate, the SENSOR FAIL light and RADAR power switch FAIL light also illuminate.

SLR NORMAL OPERATION

CAUTION

> The radar power switch must not be ON when the airplane is on the ground unless cooling air is supplied.

For automatic mode operation:

1. RADAR power switch - ON.
2. MODE switch - A.

For manual mode operation:

1. RADAR power switch - ON.
2. MODE switch - M.
3. SIDE switch - As required.
4. START RANGE switch - As required.
5. WIDTH switch - As required.
6. STBY/OPR switch - OPR, when required.

SLR MALFUNCTION PROCEDURES

The annunciator panel SENSOR FAIL light and the FAIL light on the power and sensor control panel illuminate for any failure. If no BIT malfunction is indicated and the FAIL lights remain illuminated, SLR operation is permissible.

If a BIT light illuminates:

XMTR - If the XMTR light is cycling on and off, shut the radar off using the normal shutdown procedure. If the light remains on steady, the system can still be used and operation with or without an RCD picture should be continued.

CAUTION

> Failure to turn the radar off when the XMTR light is cycling on and off can damage the radar transmitter.

RCVR - SLR operation is permissible. If a malfunction exists, it may clear later.

ANT - SLR operation is permissible. Malfunction may be due to "G" forces.

RCD - SLR operation is permissible. Recycle RCD power switch. RCD use is doubtful if RCD BIT fail light stays on. RCD fail does not affect recorded signal.

SYNC - SLR operation is permissible.

RCDR - SLR operation is permissible. If the film counter is not moving, use of recorder(s) is doubtful. RCD may be used. Note RCDR number for maintenance information.

NOTE

> The top portion of this dual RCDR light reflects RCDR number one and the bottom RCDR number two when two recorders are loaded.

For normal shutdown (during straight and level flight):

1. Mode switch - M.

2. STBY/OPR switch - STBY.

After 30 seconds:

3. RADAR power switch - ON extinguished.

For emergency shutdown:

1. RADAR power switch - ON extinguished.

RECORDER CORRELATOR DISPLAY (RCD)

The RCD is a self-contained unit in the forward portion of the aft cockpit. It operates in conjunction with, but is independent of the radar recorder(s). The RCD operates when RCD power is applied and only when the SLR is in operation since it uses SLR doppler phase history video to produce an inflight display for navigation. The display moves downward at a rate proportional to ground speed and is normally 50 seconds (25 nautical miles at cruise speed and altitude) behind aircraft position. The RCD map display is 15 nautical miles wide. This display must be stopped for target evaluation and navigation fixpoint error determination.

RCD Control Panel

The RCD control panel (figure 4-27) is below and to the right of the radar map display. At the left of the panel is a crosshair control. In the center are error readout position counters. There are six display indicator and control switches on the right side of the panel.

Crosshair Control

The CROSSHAIR control moves in all directions but is spring-loaded to return to the center neutral position. When the control is moved from the neutral position, the crosshairs on the radar map display move in the direction of control movement at a rate proportional to the displacement.

Slant-Range Error Readout

A three-digit counter, labeled SLANT RANGE - NMI, indicates lateral error to the nearest one-tenth nm between predicted ANS fixpoint location, as indicated by the illuminated "L" marker on the radar display, and the actual location of the fix on the radar. An adjacent indicator displays LEFT or RIGHT to indicate direction of crosshair displacement from the ANS computed position. Although the maximum counter indication is 99.9 nautical miles, the system will only display an error up to 15 nm.

Along-Track Error Readout

A three-digit ALONG TRACK - NMI counter indicates distance to the nearest one-tenth nm along track between predicted fixpoint location, as indicated by the "L" marker on the radar display, and actual fixpoint location on the radar. An adjacent indicator shows the direction of crosshair displacement, FWD or AFT, from the ANS computed position. The maximum error displayed is 12 nm, although the counters go up to 99.9 nm.

Read Error Control Switch (READ ERR)

This pushbutton switch transmits position error information from the RCD to the ANS. Depressing the switch during tape-filled Radar fixing causes the error data, generated by the position of the crosshairs on the RCD radar display, to appear in SELECTED DATA windows one and four on the ANS NCD panel. The error is displayed as N/S and E/W components in nautical miles and tenths of nautical miles. The READ ERR legend illuminates when the SLR begins manual or automatic operation.

Map Storage Control Switch

This pushbutton switch labeled HOLD/FULL is disabled.

RCD Power Switch

The RCD pushbutton power switch is labeled PWR in the top half, OFF and ON in the bottom half. The switch should be left in the

ON position if operation of the RCD is desired. The OFF position is used only for emergency removal of RCD power or recycling the RCD in specific RCD BIT-Light malfunctions.

Crosshair Readout Zero Control Switch

The crosshair readout zero control pushbutton switch, labeled ZERO in the top and WAIT in the lower half, electrically zeros the crosshair position on the radar display during position error determination. The ZERO legend illuminates when the SLR begins manual or automatic operation. Depressing the pushbutton when the RCD crosshairs are positioned over the intersection of the horizontal and vertical traces of the "L" on the radar display provides an electrical zero reference point for subsequent crosshair movement. WAIT illuminates when the pushbutton is depressed, and stays on for five seconds. This provides time for the SLANT RANGE and ALONG TRACK counters to go to zero. The crosshairs can be positioned on the precise radar fix aimpoint after the WAIT light is off.

Display Motion Control Switch

The display motion control pushbutton switch, labeled MOT (motion) in the top half, R (run) in the lower right quarter, and S (stop) in the lower left quarter, stops the radar map display motion (as required for fix taking) during SLR operation. The legends R and S illuminate alternately as the pushbutton is depressed to start or stop radar map travel. The MOT legend illuminates when the SLR begins manual or automatic operation.

RCD Operate Control Switch

The self-illuminated, operate control pushbutton switch is labeled RCD in the top half, R (run) in the lower right quarter, and S (standby) in the lower left quarter. When power is applied to the SLR with ON illuminated on the RCD power switch, the RCD and S legends illuminate. When the SLR receives a continuous operate command (in automatic or manual mode), the R legend illuminates, the RCD starts to run, and imagery becomes visible in 50 seconds. While the SLR <u>operate</u> command is present (initiated by either the ANS or the RSO), the switch is functional and may be operated to illuminate S or R. Once the SLR <u>operate</u> command is removed, the RCD goes to the standby status (S illuminated), and operating the switch has no effect. When a radar operate command is removed, the RCD does not immediately stop, but requires approximately 50 seconds for the S legend to illuminate and imagery on the radar screen to cease before going into standby mode.

Video Gain Control

This thumbwheel on the right side of the RCD control panel is disabled.

<u>Film Remaining Counter</u>

A four-digit, decreasing, RCD film remaining counter, labeled N MILES of FILM REMAIN, is located on a small panel to the left of the navigation map projector screen. The counter is preset to 3000 by pushing a reset button above the panel when the RCD film magazine is loaded. It continuously displays the amount of RCD film remaining in nautical miles.

<u>Display Brightness Control</u>

A display brightness control located at the top of the recess provided for the film remaining counter is used to control RCD display brightness.

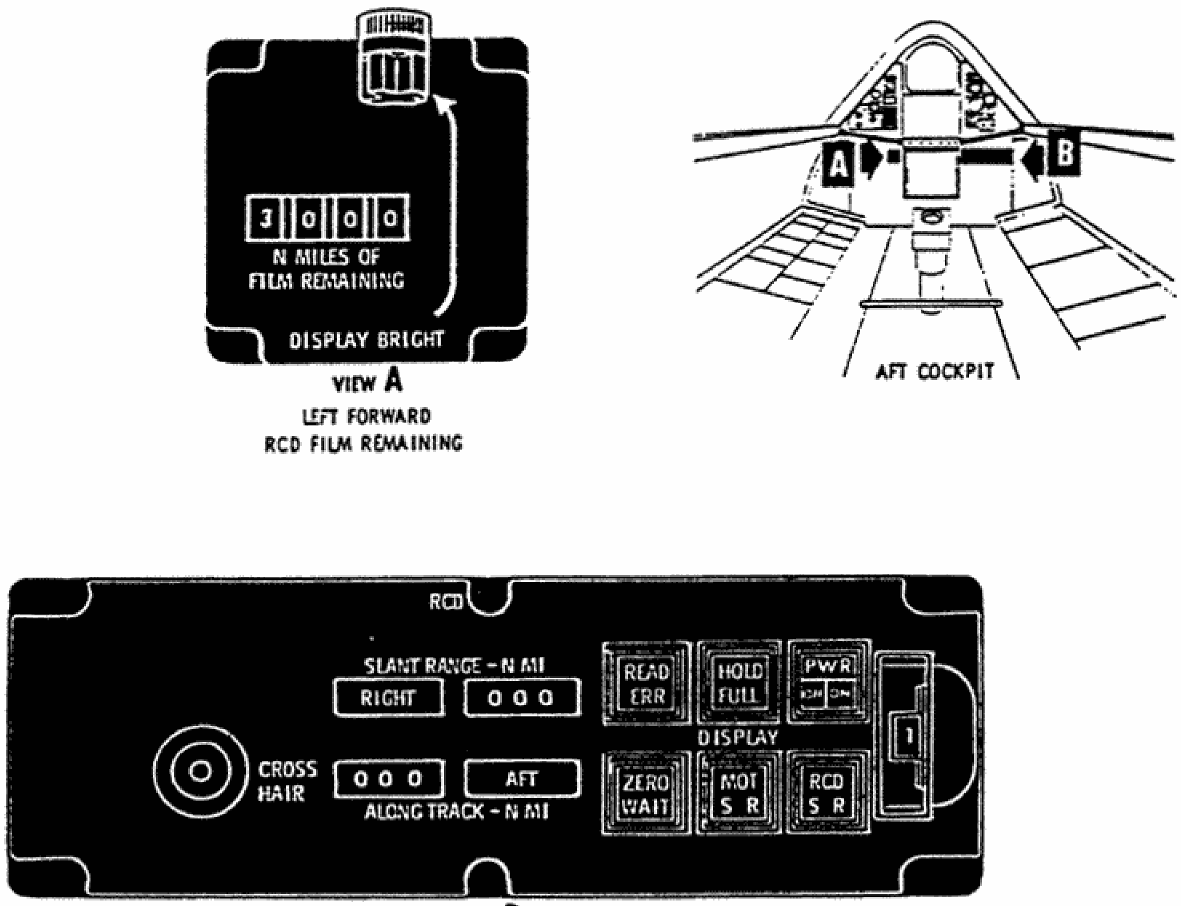
RCD PROCEDURES

Power to the RCD is controlled by the RADAR power switch and by the RCD PWR switch. With the RCD power switch ON, the RCD and S legends on the RCD Operate Control Switch illuminate when power is applied to the SLR system.

NOTE

> The RCD will operate only when the SLR is operating.

RCD CONTROL PANELS



VIEW B
RCD CONTROL PANEL
RIGHT FORWARD

Figure 4-27

F203-25(g)

1. Radar power control switch - ON.

2. RCD power switch - ON.

When the SLR is in an operate mode:

3. RCD switch - R

4. MOT switch - R.

   If the RCD does not drive and the RCD switch is in R (Run), this switch (MOT) is most likely in S (Stop).

5. Display brightness - As desired.

To stop display motion:

1. MOT switch - S.

To measure ANS fixpoint error with motion stopped:

1. CROSSHAIR control - Position radar map display crosshairs over the intersection of the horizontal and vertical trace of the ANS "L" marker on radar display.

NOTE

As the aircraft passes abeam the programmed fixpoint, a MARK light appears at the bottom center of the RCD screen. This alerts the RSO of an impending "L" marker. The MARK light remains illuminated for approximately 50 seconds until the "L"-mark appears on the display. The light goes out when the "L" mark is in the approximate center of the screen.

2. Crosshair readout zero control switch - Depress. WAIT illuminated, then off.

   The slant-range and along-track counters on the RCD control panel go to all zeros.

3. CROSSHAIR control - Position radar map display crosshairs over desired fixpoint on radar display.

   The values of slant and along-track range errors appear in the respective counters on the RCD control panel.

To transmit measured error data to the ANS;

4. READ ERR pushbutton - READ ERR.

5. MOT switch - R.

OPTICAL BAR CAMERA

The Optical Bar Camera (OBC) is a high resolution panoramic camera with a "folded" [redacted] "-lens system. It provides continuous [redacted] or [redacted] coverage along the flight track through an angle of 70 degrees on each side of the aircraft.

The camera is mounted on a hatch in an OBC nose. The nose is interchangeable with the SLR nose. Camera controls are on the RSO's right console. Camera temperature is maintained automatically. The film is supported by air through the canopy seal supply line.

The camera is not stabilized, but it has a vibration isolation and damping system which is compatible with its environment in the nose.

An interlock is installed to prevent film damage. Even though the heaters remain energized, the interlock prevents power application to the camera whenever the skew bar and air cage are not receiving air.

CAUTION

The OBC must be off unless both canopies are closed and the canopy seals are on.

The lens system has a fixed relative aperture of [redacted] It is mounted on an "optical bar" which accommodates the lens and two mirror assemblies used to create the folded optical path. The optical bar revolves continuously around its longitudinal axis whenever power is applied. Film exposure is accomplished through a scanning slit shutter while the bar and film are in motion. Width of the slit is adjusted automatically to allow for differences in scene brightness and V/H ratio. Full [redacted] coverage is provided through a scan angle of 140 degrees, with a field angle along the flight path of approximately 8 degrees. Aircraft forward motion compensation is provided during frame exposure when the V/H ratio is between 35 and 45 milliradians (mr) per second; otherwise, the forward motion compensation is automatically set to 40 mr/sec if the applied signal is outside this range.

Image format is nominally [redacted] inches. [redacted]. A data block in each frame records mission information, frame number, and camera fore and aft or (vertical) orientation.

Cyclic rate of the camera is controlled automatically by the frame overlap requirement of the mode selected, and by V/H forward motion compensation.

OBC FILM SIZE AND EXPOSURES

Film No.	3414	1414
Thickness Width	3.0 MIL 5 IN.	1.5 MIL 5 IN.
Maximum Load Length No. of Exposures	[redacted]	[redacted]
Standard Load Length No. of Exposures	[redacted]	
Center Core Length No. of Exposures	[redacted]	

F203-199(b)

Figure 4-28

Three operating modes can be selected in flight. Two [redacted], which result in [redacted] provide either [redacted] of successive frames. In the [redacted] is automatic. The nominal convergence angle is twelve degrees (approximately six degrees fore and aft tilt angle) in the [redacted] mode.

Control and operating power for the camera is provided from the monitored dc bus. Three phase ac power for the shroud, camera heaters and thermal control system is provided from the essential ac bus. Circuit breakers are located in the C-Bay.

OBC Air Supply and Temperature Control

Camera temperature in flight is controlled automatically by cockpit exhaust air and cold air from the air conditioning system. In addition, electrically operated heaters are provided for the lens system and in the camera shroud.

Air for the skew bar and air cage is obtained from the canopy seal supply line (upstream from the canopy seal control valves) and operates as a cushion to separate the film from the surface of the skew bars where the film path changes direction. Figure 1-71 depicts airflow to the OBC system.

Refrigerated air for the OBC is supplied by an extension of the cold air supply manifold in the forward chine bay. It is normally directed into a shroud above and on each side of the rotating lens system. It then exhausts into the nose compartment. Flow from the supply manifold is filtered and controlled by a barometrically sensitive valve which is open above approximately 45,000 feet. Flow into the lens shroud is also controlled by a diverter valve which opens into the nose compartment and reduces flow to the lens shroud when the camera lens system temperature decreases to a pre-set value. Air supplied from the chine bay manifold is capable of over-cooling the OBC lens system to some extent. This is overcome by electric heaters which maintain the optical bar temperature at approximately 105°F.

Conditioned air exhausted from the cockpit through the nose air shutoff valve is ducted to the top, front, and back of the nose compartment. From the front, it is directed aft to a shroud around the camera hatch windows. A T-bar outlet supplies cool air to the space near the top of the camera electronics compartment and film transport shroud. Air is also directed toward each side of the camera shroud. Another source of cockpit exhaust air is provided by a small sonic venturi. This air is ducted to the camera power transistor locations at each side of the aft end of the camera assembly. These OBC compartment air supply ducts can also be supplied through a ground air connection located under the air exit louvers on the left side of the nose.

CAUTION

- Interruption of cooling air from the chine bay and cockpit while at supersonic cruise speed can damage the camera.
- The OBC must be off unless both canopies are closed and the canopy seals are on.

NOTE

- The camera is normally preheated before nose compartment loading. Warm air is then supplied to maintain the lens system at 105°F ± 2°.
- Cockpit exhaust air is not available unless both canopies are closed, the RSO's cockpit air shutoff handle is on (aft), and the Bay Air switch is ON.
- Interruption of camera air supplies during the ground stabilization period or during subsonic flight will not damage the camera; however imagery may be degraded.

OPTICAL BAR CAMERA CONTROL PANEL

An optical bar camera control panel, labeled NOSE OBC, replaces the radar control panel on the right console in the aft cockpit. See Figure 4-29.

Power Control Switch & Indicator Light

An alternate action pushbutton POWER switch (guarded) controls ac and dc power to the OBC System, and indicates a failure condition. A white OBC legend is illuminated in the upper half of the switch. Operation of this switch alternately applies standby power to the OBC or de-energizes the system.

A green ON legend illuminates in the lower left quadrant of the switch when the OBC System is energized. In the standby condition, the lens drive and heater circuits are energized and the film supply spool is under partial power to retain film tension.

A red FAIL legend in the lower right quarter of the POWER switch illuminates to indicate failure during self test or while operating. The FAIL indication can occur as a result of film depletion or improper skew bar air supply. In these cases, the camera reverts to the standby condition if in an operating mode. A FAIL indication can also be caused by abnormal forward motion compensaton (FMC), improper film advance, center of format signal malfunction, malfunction of the capping shutter or if the film has jammed and the film remaining counter is not cycling. In cases where the film has not jammed, the camera will continue to operate.

NOTE

Air for the skew bar and air cage system is obtained from the canopy seal pressure line. The camera will not operate without this supply, and a FAIL indication will occur if a self test is attempted.

The SENSOR FAIL caution light on the RSO's annunciator panel illuminates if a FAIL indication appears on the NOSE OBC panel.

Operate Switch

An alternate action pushbutton OPERATE switch starts and stops the film transport mechanism. After the first successful self test of the OBC system, a white OPR legend illuminates in the upper half of the switch while OBC power is on. Regardless of whether the OPR light is on or off, either a green SRT or an amber STP legend illuminates in the lower left and right quarters of the switch if the power switch is on. The STP legend indicates standby mode. [redacted]

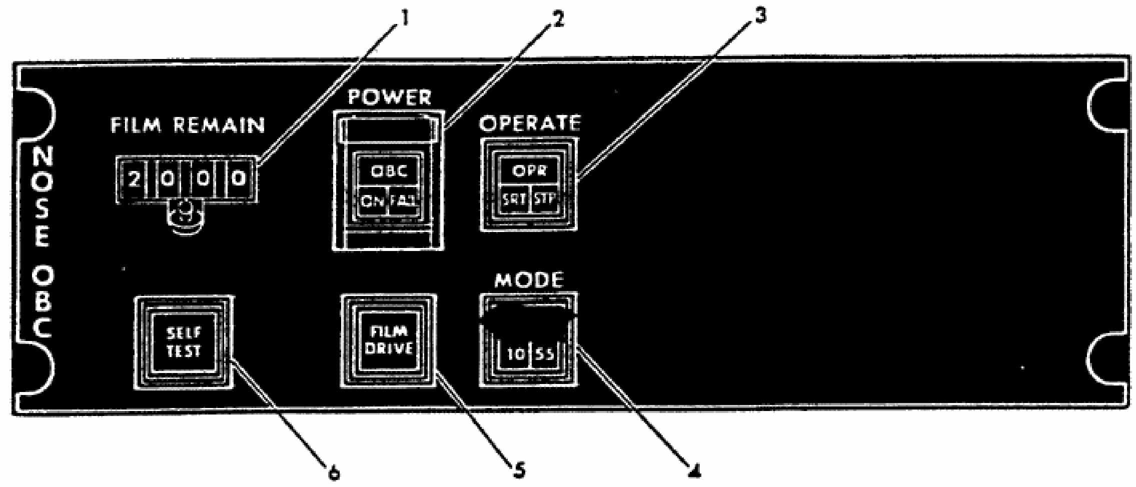
NOTE

The OPERATE switch should be checked as soon as the power switch is ON. The STP legend should be illuminated. Actuate the OPERATE switch to illuminate STP, if necessary.

Mode Control Switch

A triple action pushbutton MODE switch selects the [redacted] operating mode, and the percentage of frame overlap in

OPTICAL BAR CAMERA CONTROL PANEL



1 EXPOSURE REMAINING COUNTER AND COUNTER RESET BUTTON
2 CAMERA POWER CONTROL SWITCH AND INDICATOR LIGHT (GUARDED) (WHITE/GREEN/RED)
3 FILM DRIVE CONTROL SWITCH AND INDICATOR LIGHT (WHITE/GREEN/AMBER)
4 MODE CONTROL SWITCH AND OVERLAP INDICATOR LIGHT (LEGENDS WHITE)
5 FILM DRIVE INDICATOR LIGHT (WHITE)
6 SELF TEST CONTROL SWITCH AND INDICATOR LIGHT (WHITE)

NOTE
Replaces SLR control panel when operating with the OBC.

F203-177(a)

Figure 4-29

the [redacted] Illumination of the white [redacted] legend indicates [redacted] Illumination of the white 10 or 55 legend indicates that a [redacted] been selected with [redacted] frame overlap, respectively. The selection sequence repeats from [redacted]

Film Counter

The FILM REMAIN counter indicates the number of exposures remaining. At typical cruise conditions, the counter decreases approximately one unit per 1 3/4 seconds of camera operation [redacted] is selected. The interval is approximately 3 1/2 seconds in the [redacted]

A spring loaded reset button is below the indicator window. The counter rotates to [redacted] when the button is pressed. The counter is reset to [redacted] or [redacted] by the ground crew before flight. The indication should not be readjusted by the RSO. Refer to Figure 4-28 for the number of exposures vs film load. Counter progression beyond 0000 results in decreasing numbers from 9999.

Film Drive Light

An indicator light displays a white FILM DRIVE legend while the camera is operating. The light is extinguished with the OPERATE switch indicating OPR/STP.

With the OPERATE switch indicating OPR/SRT, the light is turned on by the FILM REMAIN counter. A holding circuit holds the light on for six seconds after the counter is pulsed. Receipt of another impulse during this period resets the light time interval. Since it is controlled by the FILM REMAIN counter pulses, the light will not illuminate or extinguish immediately when the OPERATE switch is actuated.

NOTE

It may be possible to continue operation after a FAIL indication, although degraded imagery is probable. Continued operation of the film transport is indicated by the film drive light and continued cycling of the film counter.

Self Test Switch

The legend in the SELF TEST switch illuminates while the Power Control switch is on. The SELF TEST switch initiates a self test sequence for the OBC System. The test must be initiated while in the standby condition, and 17 to 35 seconds should be allowed for test completion. The camera will not begin self-test without skew bar air. During self test, the camera operates at half the normal speed.

The FILM REMAIN counter indication should decrease five frames during the test, and the FAIL light should remain off. The FILM DRIVE light should not illuminate during self-test. The OPR legend in the operate switch will appear after satisfactory completion of the self-test. FAIL light illumination with termination of camera cycling indicates:

a. Capping shutter not operating.

b. Film supply depleted.

c. Abnormal FMC condition.

d. Film center of format signal malfunction.

e. Improper film advance.

OBC NORMAL PROCEDURES

Preflight Check

The preflight procedures will normally be completed by the ground crew.

With aircraft electrical or camera power off:

1. OBC nose air supply - Warm air on.

The camera is normally pre-heated in the shop before installation in the nose. After loading, a warm external air supply must provide a stable temperature environment of approximately 105° in the nose.

CAUTION

The camera must not be placed in operation with heated air supplied to the nose. The camera electronic controls and/or power transistors may be damaged.

2. OBC Power switch - Off.

Interior Check

a. OBC Power switch - Off, (ON and FAIL lights off).

Before Taxiing

With the engines started, canopies closed, canopy seals on, and ground air disconnected:

1. OBC Power switch - ON.

CAUTION

The OBC must be off unless both canopies are closed and the canopy seals are on.

2. Operate switch - STP ON.

3. OBC Self Test - Completed, OPR/STP lights on.

The self test is accomplished as follows:

a. Operate switch - STP ON.

b. Mode switch - "10".

c. FILM REMAIN counter - Check.

[redacted] or [redacted] are the normal indications. Do not reset the counter without the concurrence of the crew chief.

d. SELF TEST switch - Press.

The OPR legend of the operate switch extinguishes immediately, and the FILM REMAIN counter indication decreases five units in approximately forty seconds. The FILM DRIVE light will not illuminate.

The SELF TEST light remains on. Confirm illumination of the operate switch OPR legend, indicating satisfactory conclusion of the test. The power switch FAIL legend should remain off unless a malfunction occurs.

In-Flight

To initiate photography:

1. V/H SOURCE switch - Set.

The OBC normally uses the ship V/H signal selected with the V/H source selector switch. An internally generated value of 40 mr/sec is provided if the signal is not between 35 to 45 mr/sec.

2. Exposure control system - Set.

Refer to Exposure Control Normal Procedures, this section.

3. OBC Mode switch - As briefed.

4. OBC Operate switch - Check OPR/STP.

5. OBC Operate switch - OPR/SRT.

6. FILM REMAIN counter and FILM DRIVE light - Monitor.

NOTE

There is a 5 to 10 second delay after SRT illuminates before the FILM DRIVE light and FILM REMAIN counter indicate film transport. Steady illumination of the FILM DRIVE light and decreasing FILM REMAIN counter indicate proper camera cycling.

To terminate photography:

1. OBC Operate switch - OPR/STP.

CAUTION

After selecting the standby mode do not reselect SRT for a minimum of ten seconds to avoid film transport damage.

2. FILM REMAIN counter and FILM DRIVE light - Confirm stopped/extinguished.

Confirm that the counter stops cycling and that the FILM DRIVE light extinguishes six seconds after the last counter indication change.

NOTE

Depending on the optical bar position when STP is selected, camera operation may continue for one or two frames before reverting to standby.

Engine Shutdown

1. OBC Power Control switch - Off.

CAUTION

The OBC System is not normally shut down in flight.

OBC MALFUNCTION PROCEDURES

For-FAIL indication during ground self test:

1. SELF TEST switch - Recycle when camera cycling stops.

   After camera cycling stops, wait ten seconds and then recycle the SELF TEST switch. If the FAIL indication remains on after two attempts to clear the malfunction, consider the camera inoperative. Notify the crew chief.

For FILM REMAIN counter not decreasing in flight (FILM DRIVE light on or off):

1. OBC Operate switch - STP.

After 10 seconds:

2. OBC Operate switch - SRT. If FILM REMAIN counter is still not decreasing operate OBC normally.

For FAIL light on in flight:

1. OPR/SRT - Check illuminated.

If FILM REMAIN counter is decreasing operate the OBC normally.

If FILM REMAIN counter is not decreasing:

2. OBC Operate switch - STP.

After 10 seconds:

3. OBC Operate switch - SRT.

If FILM REMAIN counter is still not decreasing:

4. OBC Operate switch - STP.

After 10 seconds:

5. OBC POWER switch - Off for 2 seconds (ON extinguished).

6. OBC POWER switch - ON.

   Cycling the power switch allows the OBC logic to recycle and go into the correct standby mode if the film has jammed.

7. OBC Operate switch - SRT.

   If FILM REMAIN counter decreasing with FAIL light on, operate the OBC normally. Degraded imagery is probable.

If FAIL light on and FILM REMAIN counter is not decreasing:

8. OBC Operate switch - STP for remainder of flight.

If smoke, fire or vibration is apparent from the nose compartment:

9. OBC POWER switch - Off.

CAUTION

The OBC system is not normally shut down in flight.

ELINT IMPROVEMENT PROGRAM (EIP)

The EIP system is comprised of the ELINT (electronic intelligence) equipment in the aft of the left and right aft mission bays. The control switch for the EIP is on the PWR & SENSOR panel on the RSO's right console. The recorder assembly, consisting of a digital recorder and a continuous analog recorder, is in the aft of the left forward mission bay. The ELINT system covers a wide range of frequencies, detecting and recording on magnetic tape information used to determine the operation and location of radiating transmitters within a wide area along the aircraft track. The EIP system is passive, emitting no radiation. It is entirely automatic, and after turn on requires no further adjustment. The system is interfaced with the ANS and MRS for data collection, and with the IFF, TACAN, SLR and DEF to prevent received intelligence from being

[redacted]

masked by transmissions of those aircraft systems. The ANS must be operating for the EIP to furnish meaningful data; however, the system operates independently of the ANS.

The ELINT system performs two search functions simultaneously: special search, and general search. Special search is based on preflight instructions in the EIP computer, which designate emitters of special interest. Special search function can search the frequency spectrum from [redacted] When a received signal matches the designated emitter, a monitor receiver is automatically tuned to this signal for a pre-programmed period, and the signal pulses are passed to special detectors and recorded on tracks of the continuous analog recorder as video signals to be evaluated with special equipment after landing.

The general search function searches the frequency spectrum from [redacted] This spectrum is divided into 6 bands, all of which are searched simultaneously. Every emitter signal received in the bands is recorded on the digital recorder as to time, frequency, direction, pulse width, and amplitude.

Operating power for the left and right EIP units and the digital recorder is provided by the essential ac bus through circuit breakers in the C-bay. Operating power for the continuous analog recorder is furnished by the 28V monitored dc bus through a circuit breaker in the C-bay.

DIGITAL RECORDER

The digital recorder records general search signals. It is enabled by the ELINT pushbutton switch on the PWR & SENSOR Control Panel and controlled by the ANS program. The maximum recording time is three hours.

If desired, maintenance can program the RCDR pushbutton switch on the PWR & SENSOR Control Panel to control the digital recorder instead of the analog recorder.

CONTINUOUS ANALOG RECORDER

The continuous analog recorder, a 14-channel Ampex Model AR-1700 wide band magnetic tape recorder, records special search signals, ELINT data from the on-board DEF systems, and maintenance data. The recorder can be operated automatically by the EIP system and/or manually by the RCDR pushbutton switch on the PWR & SENSOR Control Panel.

The tape transport operates at 60 or 120 inches per second. A 14-inch reel which supplies 9200 feet of one-inch magnetic tape provides 30 or 15 minutes of recording time per flight. There is no cockpit display of the tape remaining. If the recorder is operated manually, the RSO should log accumulated operating time.

When recorder operation is commanded by the EIP system, recording of ELINT analog data is continuous. This capability permits more comprehensive collection and analysis of ELINT signals.

EIP System Control Switch

The EIP system and the digital recorder are controlled by the ELINT power switch on the PWR & SENSOR control panel. The switch has a white illuminated ELINT legend, a green ON light that illuminates alternately as the switch is depressed, and a red FAIL light that illuminates to indicate failure of the digital recorder. The RSO's master caution light and the SENSOR FAIL annunciator light illuminate if the ELINT FAIL light illuminates.

Recorder Control Switch

The continuous analog recorder (or, if programmed by maintenance, the digital recorder) is controlled by an alternate action RCDR pushbutton switch on the PWR & SENSOR Control Panel. Illumination of its white RCDR legend is controlled by the right console lights rheostat. A green STBY legend illuminates when the ELINT power switch is ON and the continuous analog recorder is in

[redacted]

tandby. A green RUN legend illuminates and STBY is extinguished when the recorder switch is pressed. The RUN legend indicates a manual-run command, it is not a positive indication that the recorder is operating. STBY illuminates and RUN extinguishes when the RCDR switch is pressed again. Any interruption of power to the recorder, such as pressing the ELINT switch off, will automatically cause it to revert to standby.

NOTE

The RUN legend will not illuminate when the continuous analog recorder is turned on by the automatic mode.

When operating the recorder allow 9 seconds for the tape transport mechanism to reach a stable speed of 120 ips. A maximum of 10 seconds is required to stop from this speed.

EIP PROCEDURES

To turn the EIP on:

1. ELINT switch - ON.

   The system is operational immediately. The continuous analog recorder STBY light illuminates when the ELINT switch is ON.

If ELINT FAIL light illuminates:

2. ELINT switch - Off/After FAIL light off (approx. 15 seconds) - ON.

NOTE

- A 15 second delay is recommended after a power interruption before the system is turned ON.
- If FAIL light reilluminates, the digital recorder is inoperative. The EIP system is operative and the analog recorder can be operated automatically or manually.

If the RCDR STBY light does not illuminate:

3. RCDR switch - Press to illuminate STBY for automatic operation of the continuous analog recorder.

For manual operation of the analog recorder:

4. RCDR switch - RUN.

NOTE

- A maximum of 30 or 15 minutes (60 or 120 inches per second) of recording is available.
- Allow 9 seconds for the tape transport to reach operating speed. A maximum of 10 seconds is required to stop from operating speed.

5. Time - Record.

To stop manual recording:

6. RCDR switch - STBY.
7. Time - Record.

For EIP shutdown:

8. ELINT switch - Off.

V/H (FMC) SYSTEM

The V/H (Velocity/Height ratio) or FMC (Forward Motion Compensation) system provides dc voltage signals through the V/H bus to the cameras to improve photographic resolution. These signals cause the camera mirror or film platen to move in such a way that the terrain image remains stationary on the film during exposure while the aircraft moves forward. The voltages are scaled to represent the angular rate of aircraft forward motion relative to the terrain. The units of motion used are milliradians per second (mr/-sec).

Two types of signals can be developed. V/H is provided when the signal represents movement of the aircraft relative to a point directly beneath the aircraft (its nadir point). V/H is approximately the same as true airspeed divided by aircraft altitude. The signal can be generated by the ANS computer, from the optical viewsight system, or by manual inputs using a control on the V/H indicator. At 1835 KTAS and 77,500 feet elevation, V/H = 40 mr/sec. This is illustrated by Figure 4-30. V/R (velocity/range ratio) allows photographic reconnaissance while turning; that is, when the desired ratio is that of aircraft speed relative to a surface point on the aircraft vertical axis. This is approximately the same as true airspeed divided by (altitude/cosine of the bank angle). V/H and V/R are the same at zero bank angle for vertically oriented cameras.

Both signals can be modified automatically for camera pointing angle commands and aircraft rate of turn to assure optimum FMC. In some cases, the camera using the signal makes an internally computed adjustment. In others, depending on the type of camera, the ANS computer adjusts the signal.

With an optical viewsight installed, four controls operate the V/H system: the V/H Power and V/H Source switches on the Power and Sensor panel, the V/H Monitor switch on the viewsight control panel, and the manual control knob on the V/H indicator on the instrument panel. The traveling grid on the viewsight can be used to check the V/H signal when the viewsight is in wide angle. The Viewsight Rate control can be used to adjust the speed at which the traveling grid moves across the viewsight screen if the grid motion does not correspond exactly to motion of the terrain display.

With a video viewsight installed (S/B R-2538), three controls operate the V/H system: the V/H Power and V/H Source switches on the Power and Sensor panel, and the manual control knob on the V/H indicator on the instrument panel.

Operating power for the V/H system is provided from the essential ac bus through a V/H circuit breaker in the C-Bay.

V/H Power Control Switch

The V/H Power control switch is an internally illuminated pushbutton on the PWR & SENSOR control panel. A white V/H legend is illuminated in the top half of the switch. Green ON and red FAIL legends are in the lower left and right quarters of the switch. Actuation of the switch to illuminate ON indicates that the system is energized and that power is being supplied to the V/H indicator and V/H amplifier. The system is de-energized when ON is extinguished. The FAIL light is not functional.

NOTE

> FAIL legends illuminate in the TECH power switches if the V/H system is de-energized while the cameras are operating. (The OBC power switch does not indicate fail if the V/H system is de-energized.) Monitor film counter cycling as a positive indication of normal operation.

V/H SOURCE Selector Switch

A five-position V/H SOURCE selector switch is on the PWR & SENSOR control panel. It selects the V/H source signal for the V/H bus. V/H bus voltage is regulated by the ANS computer when NAV is selected. Before S/B R-2538, viewsight signals are provided when the switch is in VWSGT. In MAN, the RSO regulates the signal using the manual control knob on the V/H indicator. The LH TECH and RH TECH positions are not functional.

V/H MONITOR Switch

With an optical viewsight installed, a five position V/H MONITOR switch is on the viewsight control panel. It controls the display shown by the V/H indicator A-needle. In NAV, the A-needle displays V/H signals from the ANS. In VS, the A-needle displays V/H signals from the viewsight. In BUS, the A-needle displays the V/H bus signal supplied to the camera(s). The LH and RH TECH positions are not functional.

V/H CHART

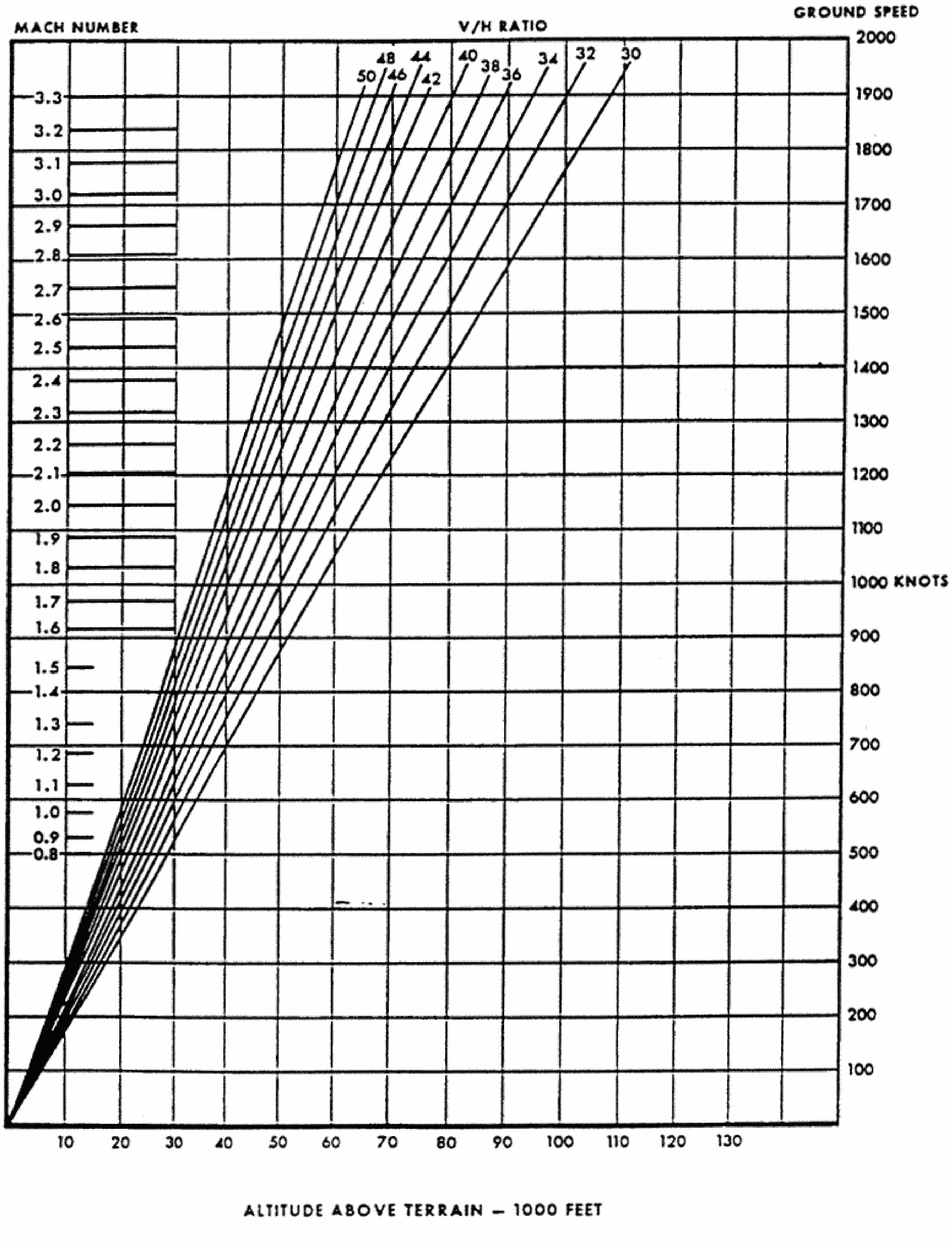


Figure 4-30

With a video viewsight installed (S/B R-2538), the A-needle always displays the V/H bus signal. No V/H monitor switch is provided.

V/H Indicator and Manual V/H Selector Knob

A V/H indicator and manual V/H selector knob are located together on the RSO's instrument panel. The range of the indicator is from 30 to 50 milliradians per second. With an optical viewsight installed, the A-needle indicates the V/H signal obtained from the ANS, the optical viewsight, or the V/H bus as selected by the V/H MONITOR switch on the optical viewsight control panel. With a video viewsight installed (S/B R-2538) the A-needle indicates V/H bus signal. Position of the M-needle is manually controlled by the V/H selector knob in the lower right corner of the V/H instrument bezel. M-needle voltage is supplied to the V/H bus when the V/H source switch is in MAN.

V/H SYSTEM PROCEDURES

The V/H system should operate normally when speed and altitude conditions are such that the aircraft V/H ratio is between 30 and 50 milliradians per second.

To self test V/H:

With optical viewsight:

1. V/H MONITOR switch - BUS.

   With the video viewsight, the A-needle always displays the V/H bus signal.

2. V/H SOURCE switch - MAN.
3. Rotate V/H M-needle. Check A-needle follows.

   Check that the A and M-needles of the V/H indicator coincide. As the M-needle is moved by turning the manual V/H control knob on the indicator, the A-needle should follow and again coincide with the M-needle.

For normal operation:

1. V/H power switch - ON.
2. V/H SOURCE switch - NAV.

With optical viewsight installed:

3. V/H MONITOR switch - BUS, then as desired.

For V/H system malfunction:

1. V/H SOURCE switch - Set.

   With video viewsight:

   a. MAN.

   With optical viewsight:

   b. VWSGT or MAN.

      Determine a valid source.

With video viewsight installed:

2. Monitor V/H A-needle.

   The A-needle indicates V/H bus signal. Check signal validity and stability.

With optical viewsight installed:

2. V/H MONITOR switch - BUS. Monitor A-needle. If the V/H SOURCE switch is in VWSGT, monitor performance of the viewsight traveling grid.

NOTE

- A V/H bus or V/H amplifier failure will cause the A-needle indication to be in error.
- V/H indicator A-needle failure can be confirmed by monitoring the optical viewsight traveling grid.

OPTICAL VIEWSIGHT

Without S/B R-2538, the viewsight in the aft cockpit has a 9-inch diameter optical display at the top of the instrument panel. This ground viewing optical instrument allows the RSO to obtain visual fixes to update the ANS present position, measure V/H, and obtain data for manual operation of the camera systems.

Two fields of view can be used. If the wide angle 136° field is selected, a demagnification ratio of 6:1 occurs and the on-axis resolution at the nadir is approximately 149 feet at normal cruising altitude. The viewsight display is centered at an angle approximately 14-1/2 degrees forward of the nadir. See Figure 4-31. The narrow angle selection provides a demagnification ratio of 2:1 and an on-axis resolution of approximately 46 feet at nadir at cruise altitudes.

The viewsight controls are located on the Power and Sensor control panel, the optical viewsight control panel, and on the bezel of the viewsight display. Short, traveling grid lines across the longitudinal center line of the optical display are used for V/H monitoring and adjustment. The grid lines are displayed only when the wide angle field of view is selected.

The viewsight is unstabilized and will reflect all pitch and roll excursions of the aircraft; however, the ANS compensates for these excursions during automatic viewsight fixing operations.

Viewsight Power Switch

The viewsight power switch on the PWR & SENSOR control panel has a white VWSGT legend illuminated on the top half of the switch. A green ON legend in the lower left quarter illuminates alternately when the pushbutton is depressed. The red FAIL legend in the lower right quarter is not functional.

Viewsight Display Control Knob

A two-position, push-pull knob, labeled MAGNIF, is on the right side of the viewsight bezel. Pushing the knob in provides a 136-degree field of view; pulling the knob out provides 56-degree field of view. The readable scale, reticle image, and nadir line change when the field of view is changed. The traveling grid lines are displayed only when the 136-degree field of view is selected.

CAUTION

The MAGNIF control knob must be moved cautiously when changing the field of view to prevent damage to the optical components.

Cursor Control Knob

A knurled wheel, on the left side of the display case, moves the cursor laterally for locating fix displacement along the nadir line. This control may be used during updating of the ANS.

Cursor Illumination Control

A rotary cursor illumination control knob, labeled CURSOR ILLUM, is located on the left bezel of the viewsight. Clockwise rotation increases cursor illumination.

Read Button

A READ push-button is located on the left side of the display bezel. The pushbutton is depressed to insert a cursor displacement signal into the ANS for error readout when a fix crosses the nadir line.

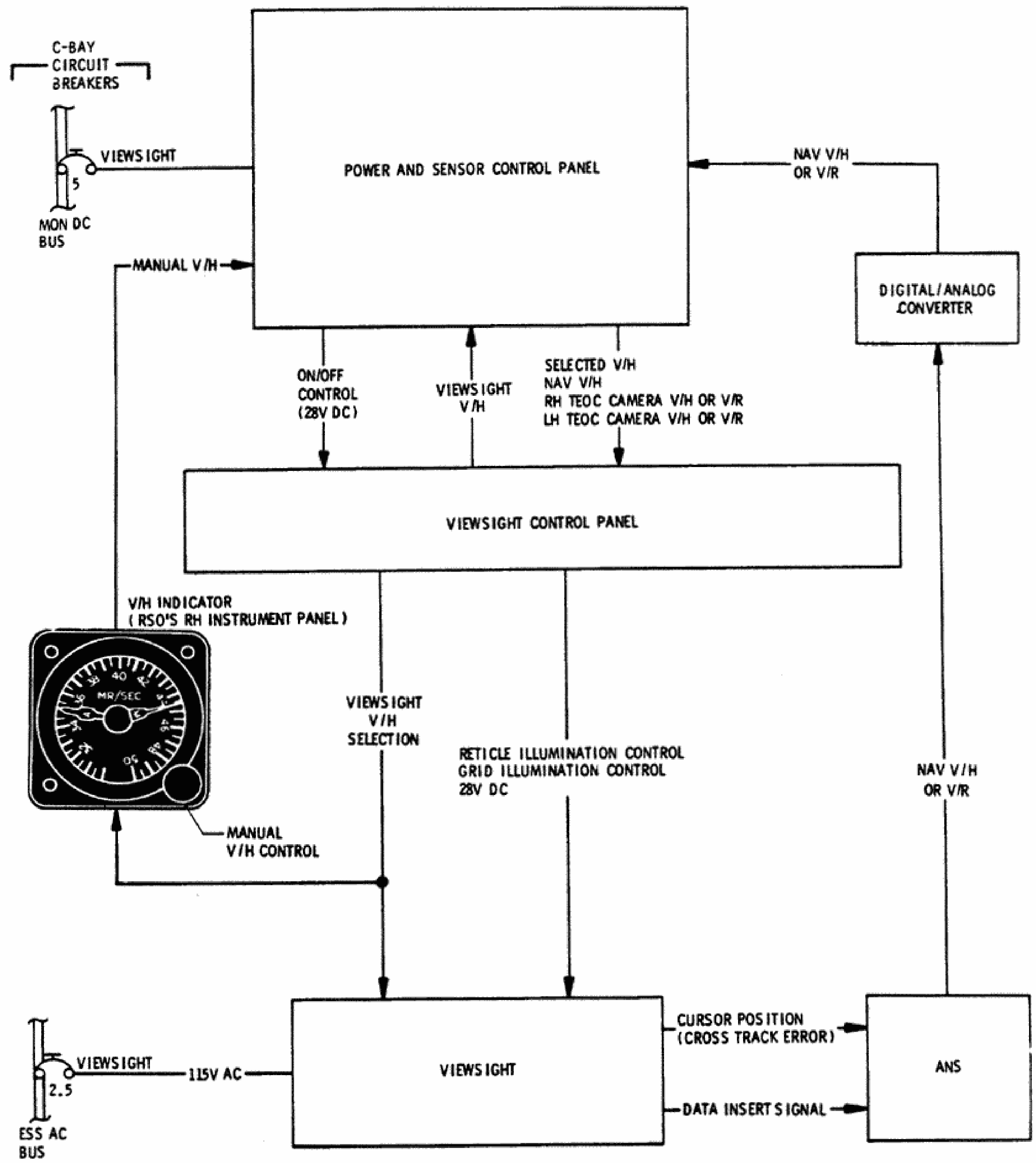
Reticle Illumination Control

A VIEWSIGHT RETICLE illumination control on the viewsight control panel varies the intensity of reticle illumination.

OPTICAL VIEWSIGHT CONTROL PANEL

An optical viewsight control panel (Figure 4-33) is located in the center of the aft cockpit

OPTICAL VIEWSIGHT INTERFACE DIAGRAM



F203-51(F)

Figure 4-31

OPTICAL VIEWSIGHT DISPLAYS

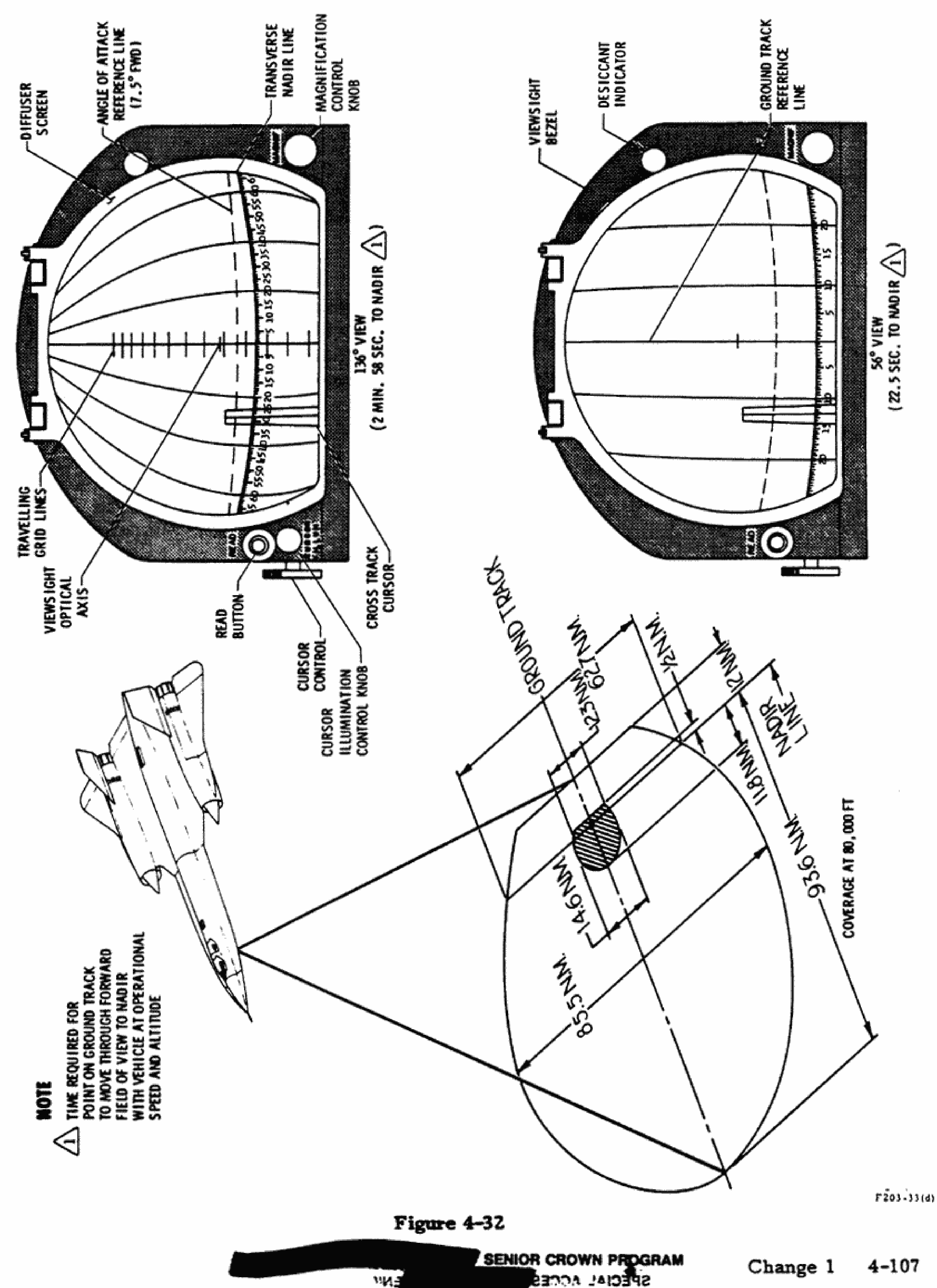
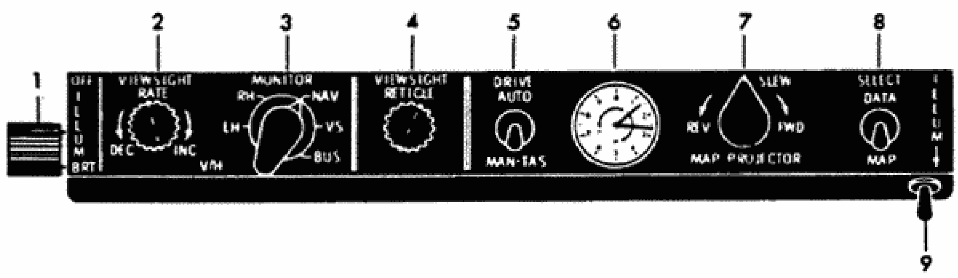


Figure 4-32

SECTION IV
OPTICAL VIEWSIGHT CONTROL PANEL



1 GRID ILLUMINATION CONTROL
2 VIEWSIGHT RATE CONTROL
3 V/H MONITOR SWITCH
4 VIEWSIGHT RETICLE ILLUM CONTROL
5 MAP DRIVE SWITCH
6 MAP RATE CONTROL AND IND
7 SLEW CONTROL SWITCH
8 FILM SELECT SWITCH
9 PROJECTOR ILLUMINATION SWITCH

F203-118(a)

Figure 4-33

instrument panel. The panel contains controls and indicators which are a part of the V/H and nav map projection systems, and are described with those systems.

Viewsight Grid Illumination Control

A viewsight grid illumination control on the left end of the viewsight control panel controls grid illumination. Full counterclockwise is off.

VIEWSIGHT RATE Control Knob

This rotary variable control synchronizes the traveling grid to correspond with terrain view travel across the viewsight display, when VS is selected with the MONITOR switch.

Viewsight Diffuser Screen

The diffuser screen has a vertical grid surface, and is hinged at the top with a detent latch to hold it in a stowed position. Without the diffuser the full screen image is visible only when the eye is 20 inches from the screen, and within 3/4 inches of the optical axis. As the eye is brought closer to the screen, the visible image disc diameter becomes smaller. When the diffuser is used, the viewer has two eye position capabilities in which lateral eye position is not critical. (Although the vertical dimension will vary when the eye is brought closer than 20 inches to the screen, the visible image will now be rectangular, having a constant, full horizontal dimension.)

OPTICAL VIEWSIGHT PROCEDURES

1. VWSGT power switch - ON.
2. MAGNIF knob - Wide or narrow field, as desired.
3. RETICLE illumination - As desired.
4. Grid ILLUM - As desired.

To use the viewsight V/H signal:

5. V/H power switch - ON.

6. MONITOR switch - VS.

7. MAGNIF knob - WIDE.

8. VIEWSIGHT RATE - DEC or INC to match V/H grid with terrain movement.

9. V/H SOURCE switch - VWSGT.

To use viewsight for ANS updating:

10. MAGNIF knob - Wide or narrow field.

11. Cursor illumination - As desired.

12. Cursor Control - Align cursor with fix point.

13. READ push-button - Depress when fix point is at nadir.

Do step 14 <u>or</u> 15:

14. UPDATE switch - Press.

    Updates present position.

15. MAN CLEAR - Press.

    Bypasses updating of present position.

VIDEO VIEWSIGHT (S/B R-2538)

The video viewsight is an electro-optical system in the aft cockpit used for vertical viewing and ANS position fixing. The optics and heat exchanger from the visual viewsight are integrated with a black and white (B&W) video camera, a processor and a 5-inch CRT cockpit display. Power is furnished by the essential ac and monitored dc buses through circuit breakers in the C-bay.

There are two fields of view (FOV). The wide angle FOV is 114 degrees (one-fifth minification) with image resolution of approximately 450 feet at cruise altitudes. The narrow angle FOV is 44 degrees (one-half minification) with image resolution of approximately 225 feet at cruise altitudes.

At a 7.5 degree aircraft deck angle the video imagery is centered about a point 14.5 degrees forward of nadir.

In wide angle FOV the viewed angle is 79.7 degrees forward and 31.9 degrees aft of nadir. In narrow FOV the viewed angle is 39.8 degrees forward and 2.2 degrees aft of nadir.

The viewsight display is at top center of the RSO instrument panel (Figure 4-33A) with system controls to the left of the display on the VIEWSIGHT CONT panel.

The viewsight is unstabilized and will reflect all pitch and roll excursions of the aircraft; however, the ANS compensates for these excursions during automatic viewsight fixing operations.

VIDEO VIEWSIGHT CONTROLS

Viewsight Power Switch

The alternate action push-button power switch is on the PWR & SENSOR control panel. A green ON legend illuminates when power is applied to the viewsight. The FAIL portion of the switch is not functional.

Viewsight Control Panel

Field of View Switch

The two-position FIELD OF VIEW switch selects either wide (up) or narrow (down) FOV. See Figure 4-33D.

Reticle Illumination Switch

The rotary RETICLE ILLUM control varies the reticle intensity independently of the display controls.

VIDEO VIEWSIGHT DISPLAY CONTROLS

Video Control Switches

There are four rocker switches on the display perimeter, one at each corner. The top left switch is not functional.

Symbology Switch (SYM)

The SYM switch at the top right corner adjusts the intensity of the cursor and legends.

Contrast Switch (CON)

The CON switch at the bottom right corner adjusts video contrast.

Brightness Switch (BRT)

The BRT switch at the bottom left corner adjusts video brightness.

Viewsight Bezel Switches

There are 20 unmarked push-button bezel switches (five on each side of the display). The switches are numbered clockwise starting with switch number 1 on the bottom left-hand side. Only eight switches are active. Except for switches 19 and 20, all are alternate action switches. See Figure 4-33A.

Ambient Brightness Sensors

Two light sensors on the bottom edge of the video display housing automatically vary the display gain for changing cockpit light conditions.

VIDEO VIEWSIGHT DISPLAYS

Bezel pushbutton switch functions and legends change with each of the three viewsight pages (Figure 4-33C).

Menu Page

When power is first applied to the viewsight system the MENU page is displayed.

Bezel 5 - VIEWSIGHT CAL - OK legend
or VIEWSIGHT CAL - NEED legend

Pressing bezel 5 selects the calibration page

Bezel 4 - VIEWSIGHT OPR legend

Pressing bezel 4 displays the viewsight operate page.

Bezel 3 - SELF TEST legend

Pressing and holding bezel 3 displays a six color test pattern with six brightness levels.

Operate Page

Bezel 11 - EXIT legend

Pressing bezel 11 displays the menu page.

Bezel 4 - CURSOR ON legend
or CURSOR OFF legend

If CURSOR ON is displayed, pressing bezel 4 will activate the cursor and associated functions (READ, L, R, and CURSOR OFF legends illuminate). If CURSOR OFF is displayed, pressing the same bezel removes the cursor and associated functions.

Bezel 1 - READ legend

Pressing bezel 1 inserts a cursor displacement signal into the ANS for error readout. The RSO should press this bezel as the fix crosses the nadir line.

Bezel 19 - R legend

Pressing and holding bezel 19 provides slow cursor movement to the right for 3 seconds followed by rapid movement. Cursor movement stops when the bezel is released.

Bezel 20 - L legend

Pressing and holding bezel 20 provides slow cursor movement to the left for 3 seconds followed by rapid movement. Cursor movement stops when the bezel is released.

Viewsight Calibration Page

Bezel 11 - EXIT legend

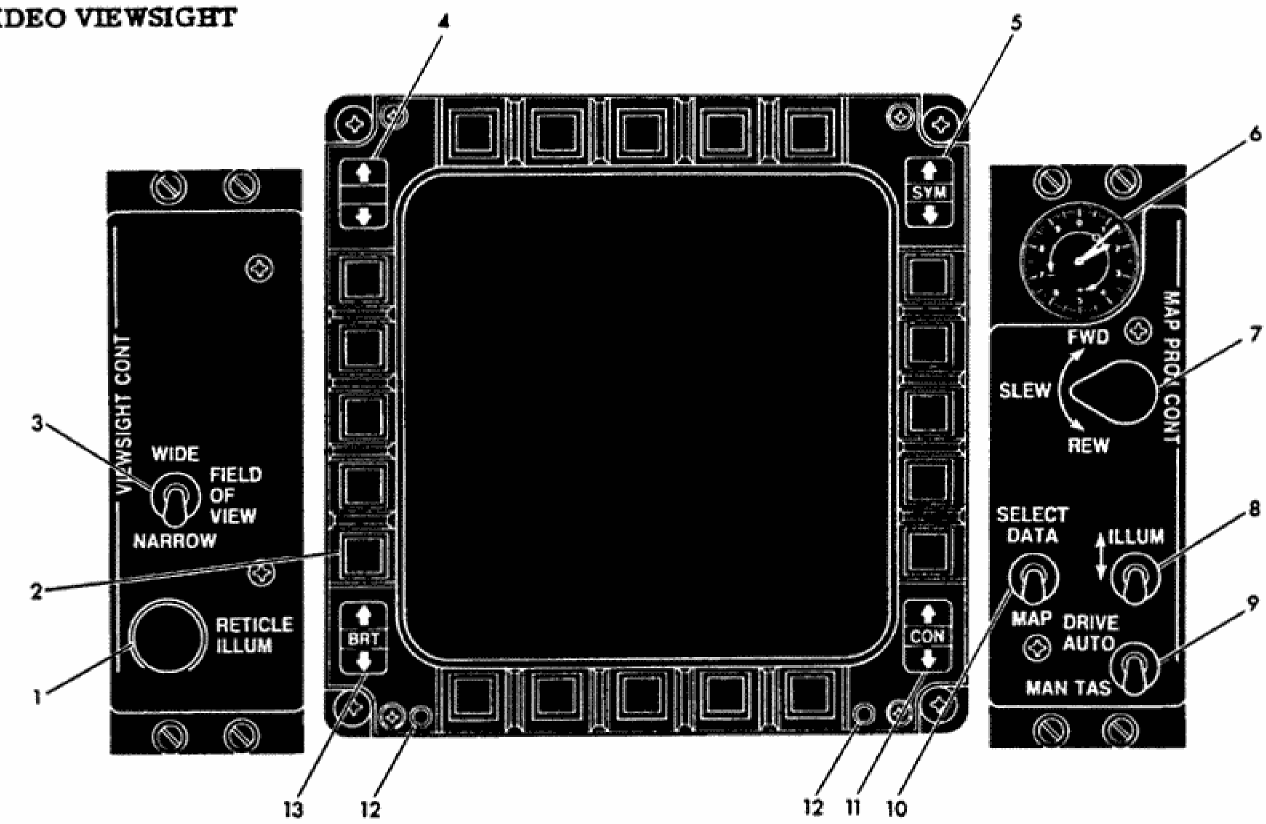
Pressing bezel 11 displays the menu page

Bezel 12 - CAL DELETE legend (Red)

Pressing and holding bezel 12 for five seconds deletes the existing calibration from memory

(Note: 4-110A thru 4-110G/4-110H Blank deleted)

VIDEO VIEWSIGHT



1 RETICLE ILLUMINATION SWITCH
2 BEZEL PUSHBUTTON SWITCH
3 FIELD OF VIEW (FOV) SWITCH
4 UNUSED
5 SYMBOLOGY BRIGHTNESS SWITCH
6 MAP RATE CONTROL
7 SLEW CONTROL SWITCH
8 PROJECTOR ILLUMINATION SWITCH
9 MAP DRIVE SWITCH
10 FILM SELECT SWITCH
11 VIDEO CONTRAST SWITCH
12 AMBIENT BRIGHTNESS SENSOR
13 VIDEO BRIGHTNESS SWITCH

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Figure 4-33A

and activates the calibration functions (L, R, CAL ENT, and first calibration instruction legends illuminate).

Bezel 5

Calibration instructions appear one at a time in the following sequence after each step is correctly completed and CAL ENT is pressed:

BW-W-CUR 0° (wide FOV, cursor at 0°)

BW-N-CUR 0° (narrow FOV, cursor at 0°)

BW-N-CUR 20° (narrow FOV, cursor at 20° left or right)

BW-W-CUR 40° (wide FOV, cursor at 40° left or right)

Bezel 4

To enter a correctly completed calibration step into memory, press bezel 4 (CAL ENT legend). CAL OK appears for 2 seconds, then CAL ENT reappears along with the next calibration instruction.

CAL ERROR flashes after CAL ENT is pressed if FOV switch is not set per instruction, CAL ERROR goes off when switch setting is corrected. CAL IN MEM comes on when all calibration steps are entered in memory.

VIDEO VIEWSIGHT PROCEDURES

1. VWSGT power switch - ON.

VIDEO VIEWSIGHT INTERFACE DIAGRAM

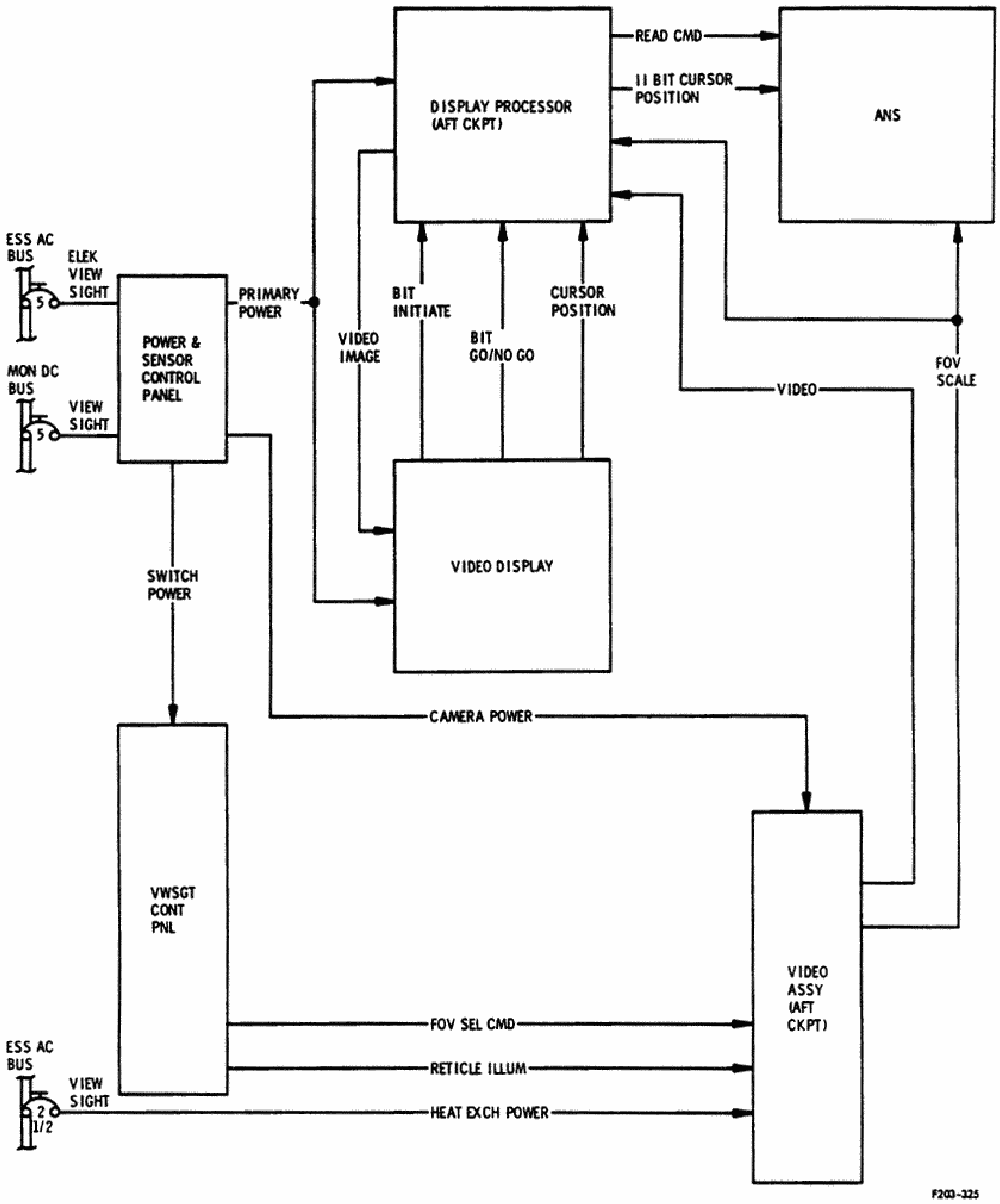
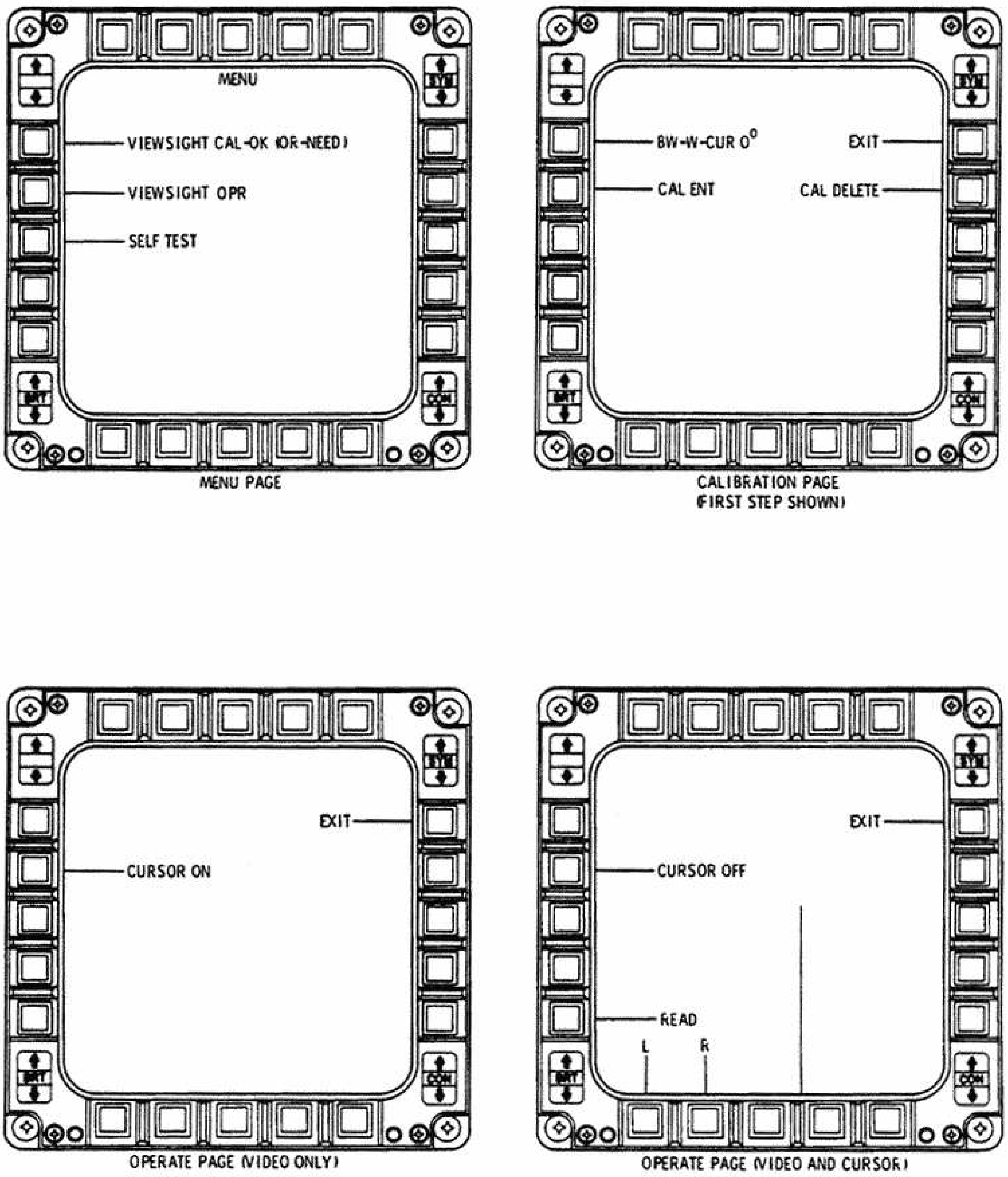


Figure 4-33B

VIDEO DISPLAYS



F203-323

Figure 4-33C

VIDEO FIELDS OF VIEW (FOV)

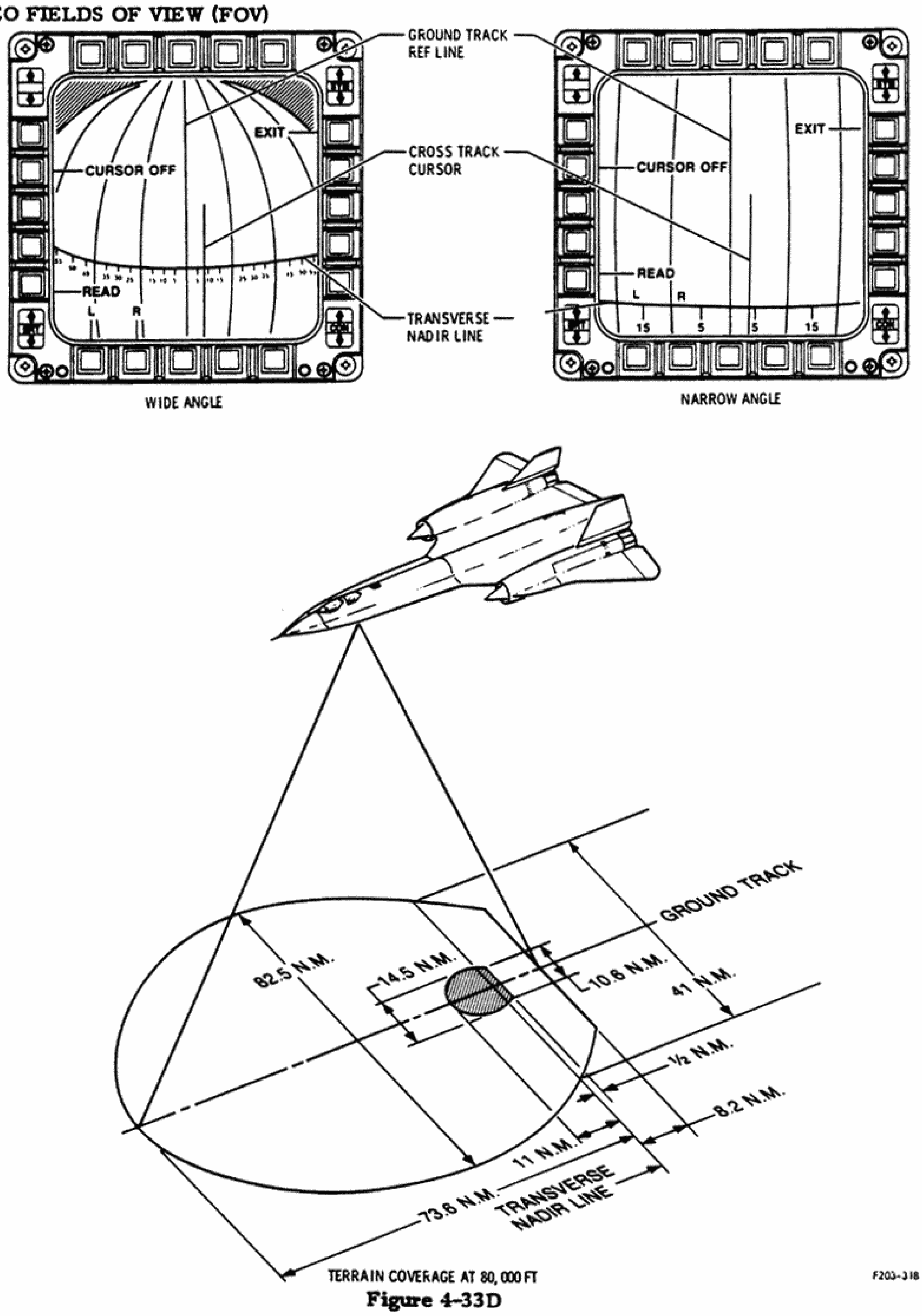


Figure 4-33D

2. Video controls - As desired.

3. FOV switch - WIDE or NARROW.

4. RETICLE ILLUM - As desired.

To use viewsight for ANS updating:

1. FOV switch - WIDE or NARROW.

2. CURSOR ON - Press.

3. Align cursor over fixpoint.

4. READ - Press when fixpoint crosses nadir.

Do step 5 or 6:

5. UPDATE switch - Press.
Updates present position.

6. MAN CLEAR switch - Press.
Bypasses updating of present position.

Viewsight Calibration

A calibration may be performed on the ground or inflight in any aircraft attitude. The viewsight reticle must be visible. Calibration is normally accomplished by maintenance.

With viewsight power ON and the MENU page displayed; if VIEWSIGHT CAL-NEED is in view, a calibration is required.

With VIEWSIGHT CAL-NEED on menu page:

1. VIEWSIGHT CAL-NEED - Press.

   Calibration page replaces menu page (Figure 4-32B). If CAL IN MEM in view press and hold CAL DELETE for 5 seconds.

With BW-W-CUR 0° displayed:

2. FIELD OF VIEW switch - WIDE.

3. CURSOR - Set 0 degrees.

4. CAL ENT - Press.

   Press CAL ENT to enter preceding step in memory. CAL OK will appear for 2 seconds, then CAL ENT will reappear along with the next calibration instruction.

With BW-N-CUR 0° displayed:

5. FIELD OF VIEW switch - NARROW.

6. CURSOR - Set 0 degrees.

7. CAL ENT - Press.

With BW-N-CUR 20° displayed:

8. Cursor - Set 20 degrees (L or R).

9. CAL ENT - Press.

With BW-W-CUR 40° displayed:

10. FIELD OF VIEW switch - WIDE.

11. CURSOR - Set 40 degrees (L or R).

12. CAL ENT - Press.

CAL IN MEM will appear indicating calibration is complete.

13. EXIT - Press.

EXPOSURE CONTROL SYSTEM

An exposure control system provides a scaled voltage signal to the cameras to control the exposure for different conditions of sun angle and terrain brightness. Sun angle, measured from the horizon, is the basic reference for the exposure setting. The rotary selector has 10 sun angle values between 5 and 90, and is set manually by the RSO. Each increment equals one-half stop of exposure setting. In most cases, mission planners will determine correct exposure settings. When mission planning data is not available or is invalid due to a delay in takeoff, the ANS sun angle display and RSO observations of terrain reflectivity can be used to set the CAMERA EXPOS control.

<u>Exposure System Control Switch</u>

A self-illuminated exposure system control pushbutton switch on the PWR & SENSOR control panel has a white-illuminated EXPOS legend, in the upper half of the pushbutton. A green-illuminated ON legend, in the lower left portion of the switch, illuminates alternately when the pushbutton is depressed. The exposure control system is energized when ON is illuminated. A red-illuminated FAIL legend in the lower right portion of the switch illuminates to indicate loss of power to, or within the exposure control unit. When the FAIL legend illuminates, and the pushbutton is depressed to extinguish the ON and FAIL legends, a voltage corresponding to nominal exposure (approximately 25-degree sun angle) will be supplied to the cameras from the PWR & SENSOR control panel.

<u>Exposure Control Knob</u>

The exposure control knob (figure 4-34) is on the left instrument panel. The control is set to a sun angle determined from mission planning data. A triangular index is provided for setting the control. The LOW REFL and HIGH REFL index dots are not used. Setting this knob accurately provides correctly scaled voltage to each type of camera for proper exposure control.

EXPOSURE CONTROL

Figure 4-34

EXPOSURE CONTROL NORMAL PROCEDURES

To operate the exposure control system:

1. EXPOS power switch - ON.

2. SUN ANGLE knob - Set.

3. If mission planning data on CAMERA EXPOS setting is not available or is invalid, display sun angle on the ANS NCD panel, and set the CAMERA EXPOS control as follows:

ANS Sun Angle	Camera Expos	ANS Sun Angle	Camera Expos
57 - 90	65	14.5 - 20.4	20
40.5 - 56.9	50	10.7 - 14.4	15
28.8 - 40.4	37	7.3 - 10.6	10
20.5 - 28.7	25	5.2 - 7.2	8

NOTE

Position 90 is not normally used except for camera resolution ranges having very high reflectance. Over resolution ranges, set CAMERA EXPOS two positions higher than normal. For example, if sun angle is 55 degrees, set CAMERA EXPOS to 50 for intelligence photography, but change to 90 for a resolution range.

EXPOSURE CONTROL EMERGENCY PROCEDURE

If FAIL light illuminates:

1. EXPOS power switch - Off.

   A voltage corresponding to a 25-degree sun angle will be supplied to the camera(s) when the EXPOS power switch is off.

MISSION RECORDER SYSTEM (MRS)

The MRS records signals from various aircraft data sources, including analog transducer outputs, digital information sources, voice communications, DEF system, and event information sources. The information is recorded on magnetic tapes.

Power Control Switch

A self-illuminated mission recorder power control pushbutton switch, labeled MRS in the top half, is on the PWR & SENSOR control panel. The switch contains the legends ON in the lower left quarter and FAIL in the lower right quarter. When the switch is depressed the ON legend illuminates to indicate that power is being applied to the recorder. The FAIL legend illuminates to indicate malfunction of the recorder, such as temporary power failure, broken tape, or end of tape.

MRS control power is supplied from the monitored dc bus.

115 volt/400 cycle ac operating power is normally supplied from the No. 1 essential dc bus through a special MRS inverter. Operating power is automatically switched to the essential ac bus to provide continuous recording if the MRS inverter fails. In the event of a double generator failure, a time delay relay (associated with the generator line contactors) allows the inverter to continue for one minute after the second failure. Then inverter operation is terminated automatically to minimize dc loads on the No. 1 battery.

NOTE

After an interruption of power, the MRS switch ON light comes on again when power is restored, but the recorder remains inoperative. To restart the recorder, recycle the switch to extinguish FAIL, then again to illuminate ON.

MISSION RECORDER MALFUNCTION

FAIL light on:

1. Recycle MRS switch.

If the FAIL light remains on:

2. Disregard failure indication.

CENTER OF GRAVITY CALCULATOR

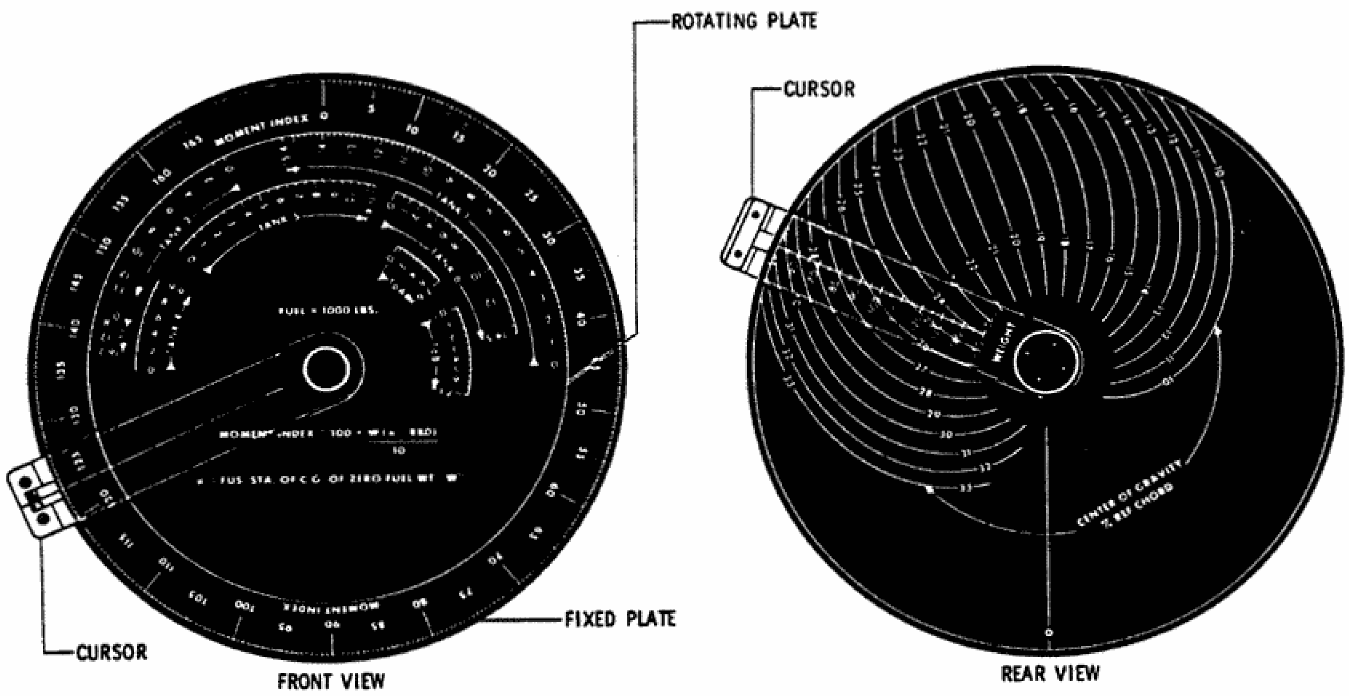


Figure 4-35

F203-115(A)

ANS/MRS Dual Format Processor and ANS Recorder

The ANS/MRS dual format processor provides the signals necessary for recording 128 and 32 word ANS telemetry simultaneously. The 128 word format is recorded on the ANS (NAV) recorder and the 32 word format is recorded on the MRS. The essential ac (3Ø) and monitored dc busses provide power for the signal formatter and ANS recorder through circuit breakers in the C-bay. Recording time available with the ANS recorder is approximately eight hours. System control is accomplished by use of the NAV RCDR switch on the PWR & SENSOR panel. ON must be illuminated in the switch to record 32 and 128 word format recordings.

Illumination of the FAIL legend in the NAV RCDR power switch after an ON condition indicates that the ANS recorder is not operating. The ANS recorder is inoperable if recycling the power switch to a NAV RCDR ON condition does not extinguish the FAIL light; however, MRS recording can continue.

CENTER OF GRAVITY (CG) CALCULATOR

The c.g. calculator is a circular slide rule designed to determine aircraft c.g.. The calculator consists of a fixed plate, a rotating plate, and a cursor. The front of the fixed plate has a graduated moment index scale. The rear of the fixed plate has constant c.g. lines in percent reference chord. The rotating plate has individual fuel tank moments, graduated to the same angular moment scale as the front fixed scale, however, these moment scales are labeled in increments of pounds from zero to full quantity. The cursor rotates about the center of the fixed and rotating plates. The front of the cursor has a hairline and the back of the cursor has a weight scale in addition to a matching hairline.

Operation of the C.G. Calculator

a. Set front cursor hairline to calculator moment index (from aircraft load sheet).

b. Hold cursor against fixed plate and turn rotating plate until zero for desired tank is under hairline.

c. Hold rotating plate against fixed plate and move cursor to quantity in that tank.

d. Repeat steps b and c for each tank until all fuel is loaded or all fuel remaining has been accounted for.

e. Hold cursor in last position for fuel load, turn calculator over, and read c.g. in percent reference chord opposite gross weight on cursor hairline.

NOTE

- While on the ground, c.g. computed using the manual c.g. computer should be corrected to allow for the effect of level rather than flight attitude. Refer to Section II, Starting Engines.
- On the ground, when tank 6 is not full, use tank 6A and 6B scale. Fuel distribution must be obtained from mission loading form.

DEFENSIVE (DEF) SYSTEMS

The DEF systems defend the aircraft by electronic means. Arbitrarily assigned letters designate and identify the systems. Systems A2, C2, H and M are currently operational. The DEF equipment installed varies. DEF systems are controlled and monitored by the RSO, using the DEF control panel, on the left console. In addition to the advisory light display on the DEF control panel, a series of DEF advisory lights are arranged on the DEF warning panel, located to the right of the radar RCD display. There are no DEF controls or displays in the forward cockpit.

DEF CONTROL PANEL

The controls and displays needed to operate all DEF systems are consolidated on a single panel on the RSO's left console. Power control switches, threat warning lights, and status and activity indicators for each system are arranged in rows on the right side of the panel. The rotary controls and lights on the left side are used for fail indications, system reset, testing, and operating mode selection. Two projection displays at the forward edge of the left side provide "GO" and "FAIL" condition advisory information. Refer to Figure 4-36.

Go and Fail Displays

The Go and Fail displays are forward of the mode switches. Go and Fail condition information and DEF system designations are projected on the face of the two displays. The displays indicate results of operator-initiated tests and failures detected during system self-monitor tests. The following legends are provided:

A		LO
C	M	HI
	GO	

Go Display

A		LO
	M	HI
FAIL	COMP	HOT

Fail Display

(FAIL, COMP, and HOT indications appear in the same position)

LO and HI legends both refer to DEF H. The FAIL, COMP (computer), and HOT legends are red; all others are white. During the warning and control panel lamp test, GO should appear on the Go display and A, LO and HI should appear on the Fail display. There is no DEF C2 designator in the Fail display.

DEF CONTROL PANEL

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The Go display shows the system selected by the SYSTEM SELECT switch (unless the system is not installed in the aircraft). The system designation remains illuminated until repositioning the SYSTEM SELECT switch extinguishes the designator. The word GO does not appear in the Go display until a self-test is satisfactory. A failure condition after self-test will not extinguish the GO.

Normally, the Fail display is blank. FAIL and the corresponding system designator illuminate if a system malfunction is detected. HOT or COMP (computer) also can appear instead of FAIL. The HOT display applies to DEF A2 and H systems. COMP applies only to DEF H. More than one legend can be displayed simultaneously. In this event, it is possible for the FAIL, HOT, and/or COMP legends to be superimposed.

GO and FAIL can illuminate almost simultaneously during system tests. Except for self-tests of the DEF H and M systems, a GO display is locked in when it appears. It stays illuminated until the SYSTEM SELECT switch is repositioned. FAIL can appear as a result of a subsequent failure during the self-test sequence, or as a result of a failure of another system while the self-test is in progress. (In this latter case, another legend would appear in the Fail display.)

With DEF H, a HI FAIL erases a LO GO display, and A LO FAIL erases a HI GO. In DEF H, the self-test is a single function. That is, a GO is a GO, and a FAIL is a F'"
for the entire system.

DEF Power Switches

Three alternate action pushbutton switches (labeled A, F/H, and M) control power for the DEF systems. White legends in the upper half of these switches illuminate to display the designations of the systems installed. When DEF H is installed, the F/H power switch may illuminate F for semi-automatic or H for fully automatic state. The DEF C2 system is turned on when the A, M, or F/H power switches are ON, and is turned off when the A, M, and F/H power switches are off. If no other system is installed, DEF C2 may be turned on (self-test, for example) by pressing one of the power switches. However, the switch must be held pressed as there is no interlock signal present to hold the switch in ON. When the A, F/H, and/or M, power switches are first pressed, the green ON and amber W (warm-up) legends illuminate in the lower left and right quarters of the switches. The system legends, inscribed in the corresponding status switches, also illuminate when their systems are turned on. When the system warm-up is completed, the power switch W legend extinguishes, and the amber S (standby) legend illuminates in the system status switch.

Interlocks prevent the systems from being turned on accidentally when the electrical system is turned on. If a system is not installed, the ON and W legends cannot be illuminated by power switch actuation.

The normal initial warm-up periods are:

DEF System	Time (min)
A2	3
C2	0
H	5
M	3

NOTE

- If system H does not go to standby after six minutes from system turn-on, the probable cause is an open circuit breaker in the C-bay.
- If system H is in standby, then goes to warmup without any crew action the probable cause is an open circuit breaker in the C-bay. Any threat indications that were illuminated will extinguish.

The left console light control rheostat regulates the intensity of the power and status switch legends, but not the intensity of the colored lights.

Threat Warning and Activity Indicators

The threat warning light legends, directly associated systems, and corresponding activity indicator lights are discussed under the descriptions of the associated DEF systems.

Status Switches

Seven alternate action switches are provided to control the standby (S)/operate (O) state of the DEF systems installed. Only those five switches associated with DEF A2, H, and M systems are functional. DEF C2B does not have a standby state; it is either on or off as determined by pressing a DEF power switch (A, M, or F/H). The status switch system designation legend illuminates when the associated power switch is ON. The status switch S legend illuminates at the end of system warm-up, as the W legend on the associated power switch extinguishes, to indicate that the associated system is in a standby state. Pressing the status switch extinguishes the S legend and illuminates the O legend and begins system operation. Pressing the status switch alternately shifts the system to operate (O) or standby (S). The DEF H system [redacted] S/O switch will not function like the other status switches until the HI operate status switch is on.

Auto/Manual Mode Switches

The SYSTEM SELECT switch and three 3-position, self-centering AUTO/MAN mode switches control the operating modes of the DEF H system in the low and high frequency ranges. The mode selection in effect is indicated by illumination of the corresponding numbered automatic (A) or manual (M) mode indicator lights located in two rows along the bottom edge of the control panel.

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Mode selection is accomplished by positioning the SYSTEM SELECT switch to H LO or to H HI, and then momentarily turning the numbered AUTO/MAN mode switches to the required AUTO or MAN position. The switches are spring-loaded to the neutral position. Mode selection can be made while in either S or O.

To cancel a mode selection, make the same selection again. The LO and HI band mode indicator lights confirm the settings in effect. Manual mode selections override the corresponding automatic settings. However, when the manual mode is cancelled, the system reverts to the previously selected automatic mode unless it also has been cancelled.

NOTE

Jamming is inhibited if all modes are cancelled, but the threat warning indicators remain operative.

Fail/Reset Switch

A single action switch, inscribed with a white RESET legend is right of the SYSTEM SELECT switch. When illuminated, a red FAIL legend is visible in the upper half of this switch. The FAIL legend will illuminate simultaneously with the FAIL, HOT, or COMP legend and the system designator in the Fail display if the system malfunction is a type which can be reset; for example, a power transient during turn-on. Press the RESET switch to initiate reset. It is not necessary to set the SYSTEM SELECT switch to the corresponding system. The system designator and the FAIL, HOT, or COMP legends extinguish when the system returns to normal operation.

NOTE

The Fail/Reset switch only applies to DEF H. Systems A2, C2, and M have no Fail/Reset indications.

Test Switch

An alternate action switch, with a wh TEST legend, is below the RESET swit When illuminated, a green ON legend is visible in the lower half of the switch. It is used with the SYSTEM SELECT switch to start or stop the self-test for individual systems. To start a test, set the SYSTEM SELECT switch to the desired system and press the TEST switch. Illumination of GO in the Go display during the sequence indicates a satisfactory self-test unless a Fail display indication also appears for that system. (See Fail Indications/Malfunction Procedures for the individual systems.) The self-test ON legend will extinguish automatically after a self-test is started (10 seconds for A2; 12 seconds for C2; 26 seconds for H; and 5 seconds for M). A self-test can be terminated during the sequence by repositioning the SYSTEM SELECT switch or by pressing the TEST switch again to extinguish ON. However, a self-test of the same system or of another system cannot be started until completion of the self-test time-out period for the interrupted system; for example, 12 seconds for DEF C2.

The DEF A2 system must be tested in tl mode; therefore an external transmission occurs. DEF H can be tested in either the S or O mode. The choice is dependent on whether an external transmission legends illuminated) is desired.

System Select Switch

A five-position rotary SYSTEM SELECT switch enables self-testing the individual systems, and selects DEF H AUTO/MAN operating • mode indicators. The corresponding system legend (A, C, M, or LO/HI for H) in the Go display illuminates when an installed system is selected with the SYSTEM SELECT switch. System selection must be made before initiating mode selection or a self-test. Selecting OFF, or repositioning of the switch while a self-test is in progress terminates the self-test. Do not initiate self-test of another system until completion of the full time programmed for the first self-test.

NOTE

> The low and high bands for DEF H cannot be self-tested independently. Selection of either F/H LO or F/H HI automatically results in consecutive self-testing of both low and high bands. The FAIL legend can be displayed for either band. A GO legend will be shown only for the selected band. Lack of a FAIL legend for the band not selected implies a GO.

Control Panel Lighting

The GO display, FAIL display, threat warning indicators, and H LO and H HI . activity indicators are powered by the 28 V monitored dc bus through the DEF CONT circuit breaker on the RSO's right console. Panel and title lights for the DEF power switches, the RESET switch, and the TEST switch are powered by essential ac bus power through the L console PNL circuit breaker on the RSO's left console. All other lights on the DEF panel are powered by the essential ac bus through the L console LGD circuit breaker on the RSO's left console.

Lamp test for the DEF control panel is accomplished by pressing the LAMP TEST switch on the PWR & SENSOR control panel. This tests all indicators on the DEF warning panel and all lights and displays on the DEF control panel except the Go and Fail displays. Only the GO will illuminate in the Go display (A, C, M, LO, and HI will not illuminate), and only the A, M, LO, and HI will illuminate in the Fail display (FAIL, HOT and COMP will not illuminate).

DEF WARNING PANEL

The DEF warning panel is on the RSO's instrument panel, right of the viewsight. It directs the RSO's attention to the DEF control panel if a threat or failure involves the DEF systems. See Figure 4-37. Seven red or amber warning legends are on the panel: these are [redacted] DEF FAIL illuminates when FAIL, HOT, or COMP is displayed in the Fail display on the DEF control panel. The other warning indicators repeat like indicators on the DEF panel, and therefore illuminate simultaneously with those indicators. [redacted]

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[redacted] The significance of the various warnings is discussed under the descriptions of the associated DEF systems. Power for indicators on the warning panel is supplied by the monitored dc bus through the DEF CONT circuit breaker on the RSO's right console.

DEF A2 SYSTEM

DEF A2 is a [redacted] jammer ECM system with two sets of receive and transmit antennas, and a gaseous nitrogen system to pressurize the transmit waveguides. DEF A2 can respond to signals typical of [redacted] radars in the [redacted] band-frequency ranges of [redacted] The antennas receive signals from emitters below the aircraft. The system identifies threat aircraft in the left or right forward quadrants.

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DEF A2 can be installed in the forward right chine bay (Compartment D). See Figure 4-37. The antennas and waveguides are permanently installed. The left and right transmit antennas protrude slightly from the lower surfaces of the chines, opposite the pilot's cockpit. The receive antennas are located aft of cut-outs on the left and right sides of the nose chines. The DEF A2 system is interfaced with the MRS, the Radar, and the EMR system.

DEF A2 signals are applied to the AR-1700 recorder when mission requirements dictate. DEF A2 operation, indication, and control data is recorded by MRS.

Electrical power to DEF A2 is supplied from the essential ac bus and the monitored dc bus through circuit breakers in the C-bay. See Figure 4-38.

Cooling air is supplied directly to the DEF A2 repeater through an air duct and hose, which are connected to the aircraft cooling air duct during DEF A2 installation. Air flow is from the right mission bay air manifold and is controlled by the right mission bay air shutoff valve.

DEF A2 Threat Warning & Activity Indicators

Threat warning indications are provided by the [redacted] and LT/RT legends on the DEF control panel and LEFT/RIGHT legends on the DEF warning panel. These indicators are operable in either the standby (S) or operate (O) mode. The [redacted] legend indicates [redacted] threat signal which exceeds the threshold setting of the system. The RT(RIGHT) and LT(LEFT) legends indicate receipt of a threat signal from either the forward right or forward left quadrant. Only one legend illuminates at a time, indicating the side with the greatest threat.

Jamming [redacted] activity is indicated by the [redacted] and [redacted] legends on the DEF control panel. Illumination of [redacted] indicates adequate transmitter output power. Illumination of [redacted] indicates transmission of a [redacted] signal. If both [redacted] threat signals are received, DEF A determines which signal represents the most significant threat and responds accordingly.

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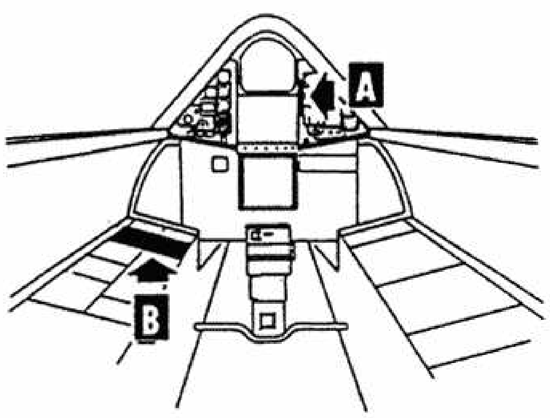
DEF A2 Operation

DEF A2 is turned on and off using the DEF A power switch. Pressing this switch to illuminate ON supplies power to the DEF A to place it in a warm-up state, and illuminates the W legend on the power switch and the A legend on the DEF A status switch. Pressing the power switch to ON also turns on the DEF C2 system (not a part of DEF A2). Approximately three minutes after power is applied, the W legend extinguishes and the S legend on the status switch illuminates. This indicates warm-up is complete and the system is in S (standby).

In the S mode, DEF A2 threat recognition and signal source direction circuitry are active. The [redacted] /LT/RT threat warning indicators on the DEF control panel and the [redacted] LEFT/RIGHT indicators on the warning panel may illuminate; how , jamming is inhibited.

DEF EQUIPMENT LOCATION



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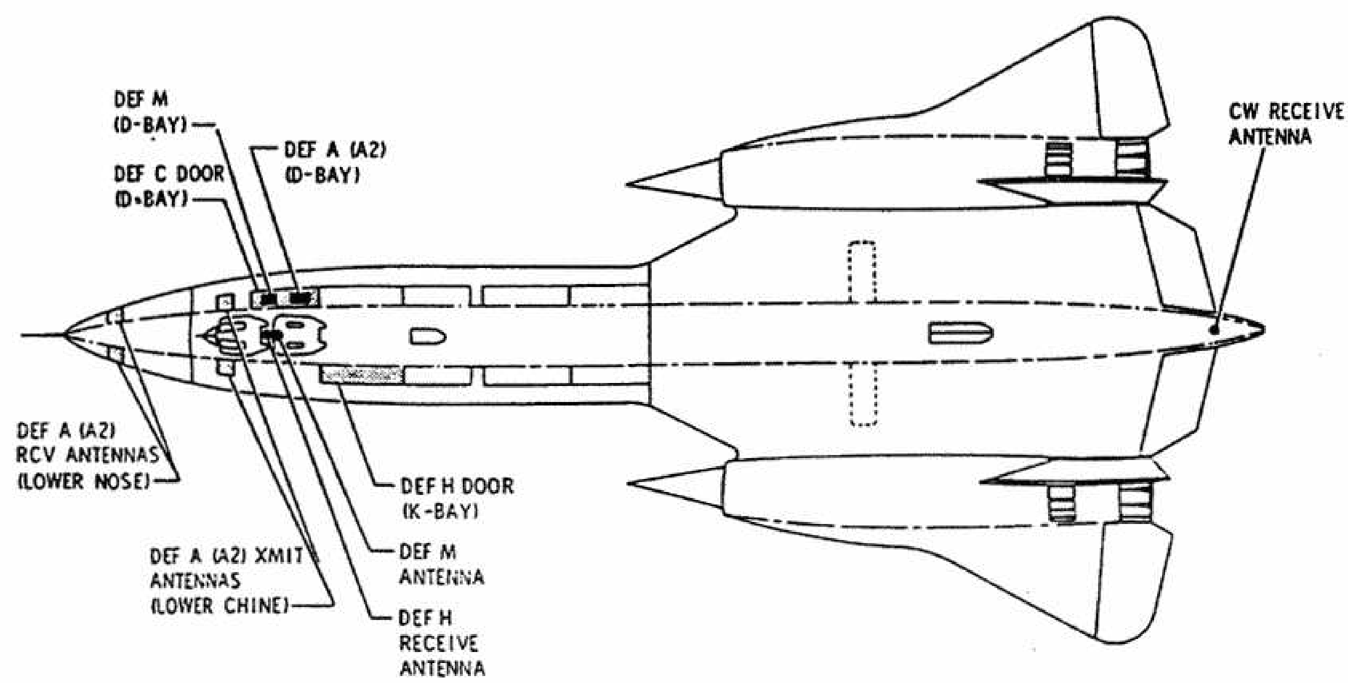

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Figure 4-37

DEF A2 SYSTEM SIGNAL FLOW

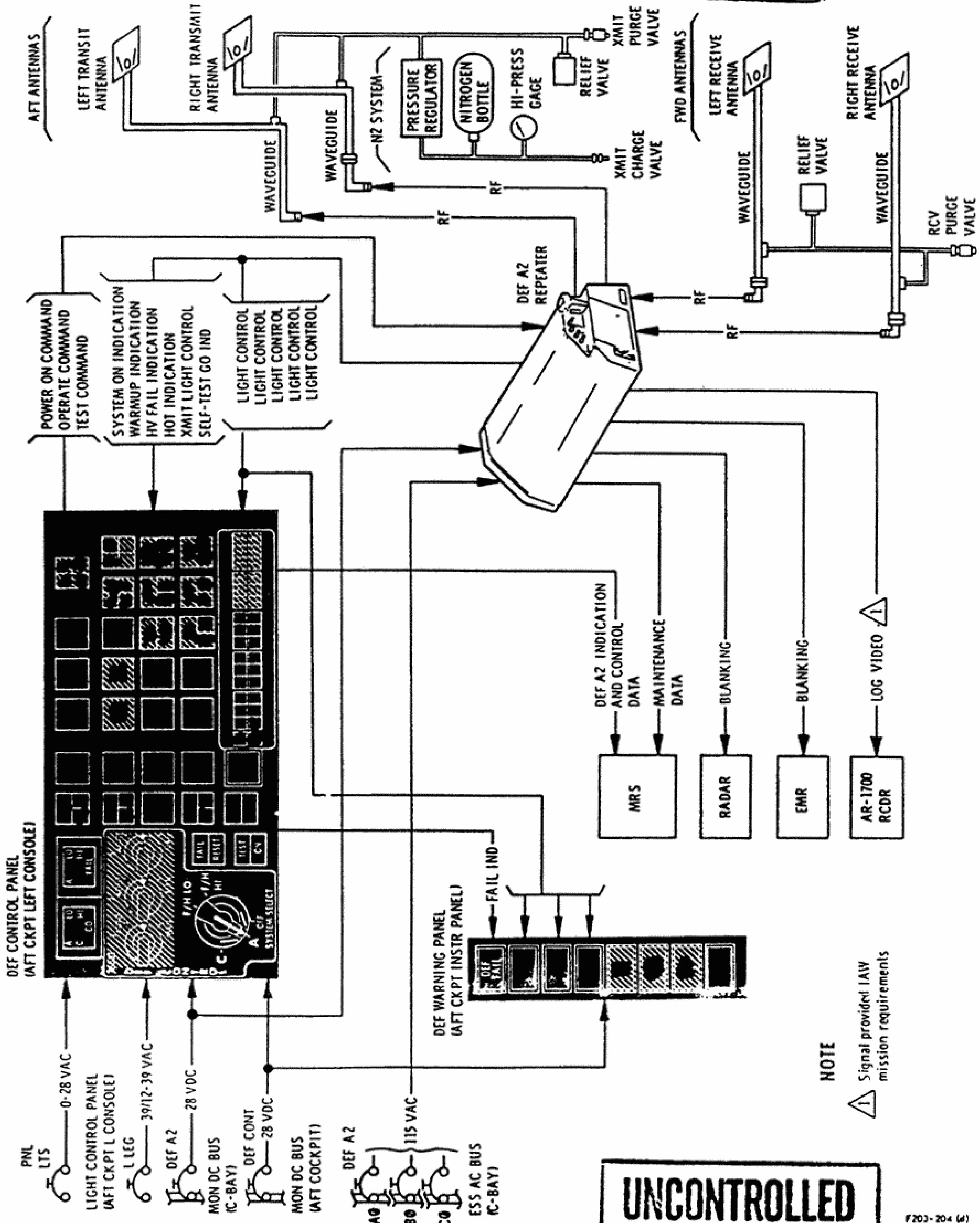

Figure 4-38

DEF A2 is in the operate mode when the A status switch is pressed to illuminate the O legend. In this mode, DEF A2 automatically changes from passive receiving to [redacted] jamming. Illumination of the [redacted] legend indicates that DEF A2 is [redacted] (jamming) received rf threat signals.

DEF A2 Normal Procedures

To turn on DEF A2:

1. A power switch - Press to illuminate ON.

   The ON and W (warm-up) legends illuminate. If the SYSTEM SELECT switch is in A, A illuminates in the Go display. In approximately three minutes, the W legend extinguishes and the S (standby) legend in the status switch illuminates.

   NOTE

   Jamming is inhibited in the S mode, but the threat warning lights are operative.

After warm-up is complete:

2. A status switch - Press to illuminate O.

   The S legend extinguishes and the O (operate) legend illuminates. Jamming operations are automatic in the O mode.

3. Self-test - Complete.

   Refer to DEF A2 Self-Test.

To return to the S mode:

1. A status switch - Press to illuminate S.

   The O legend extinguishes and the S legend illuminates.

To turn off DEF A2:

Ensure that the system is in the S mode before turning off power.

1. A power switch - Press to extinguish ON.

NOTE

Remain in the S mode after descent if it is desired to retain an immediate response capability.

DEF A2 Self-Test

Self-tests must be accomplished in the operate mode with the SYSTEM SELECT switch in A. During self-test, a self-generated pulse signal is introduced into the left channel to check the [redacted] mode, and a self-generated [redacted] signal is introduced into the right channel to check the mode. The test takes ten seconds.

WARNING

Due to the [redacted] radiation levels generated by a DEF external transmission, set DEF systems to standby and do not conduct self-test during air refueling.

NOTE

Illumination of the [redacted] legend during any self-test indicates an actual external transmission.

To self-test DEF A2:

1. A status switch - O illuminated.

2. SYSTEM SELECT switch - A.

   The A legend appears in the Go display.

3. Test switch - Press to illuminate ON.

   Check for the following light indications:

   a. Test switch ON legend remains illuminated for 10 seconds.

   b. The following legends illuminate for the first five seconds and then extinguish:
      legends on the DEF control panel; [redacted] legends on the DEF warning panel.

c. For the next five seconds, the following legends illuminate and then extinguish:
legends on the DEF control panel;
legends on the DEF warning panel.

d. The GO legend in the Go display illuminates immediately and stays illuminated until the SYSTEM SELECT switch is repositioned.

If any of the above indications do not appear and/or the FAIL/HOT legend illuminates, refer to DEF A2 Malfunction Procedures.

NOTE

> Any self-test can be terminated while the test is in progress by repositioning the SYSTEM SELECT switch. However, a self-test of the same system or another system cannot be started until completion of the original test duration period.

4. A status switch - Press to illuminate S.

Return the system to S unless operational conditions dictate otherwise.

DEF A2 Malfunction Procedures

NOTE

> The control panel RESET switch will not reset DEF A2.

1. Electrical Fault

In the operate mode, the [redacted] high voltage supplies and the pulser circuit are monitored. If any of these circuits fail, the A and FAIL legends on the control panel Fail display and the DEF FAIL legend on the DEF warning panel illuminate.

If the above conditions are present and the XMIT light does not illuminate during self-test or in response to a threat while in operate, an under/over voltage condition or tube ionizat... could be present. In this case, remain ... O (S extinguished) for no more than twenty seconds after completion of the DEF A2 System Self-Test before returning to the S mode. Remaining in operate after the System Self-Test is complete will enable the system Fault Generator. The generator monitors various fault signals and system current levels. If a fault is detected, the Fault indicator is enabled and the appropriate MRS signal is generated. A 4-6 second timer is then allowed to check fault processing circuits. In essence, the system will attempt to correct the malfunction and return to normal fault-free operation. Fault Generator activation should clear any transitory fault condition. If corrected, the system will be reset and provide normal Self-Test indications on subsequent Self-Tests.

If the system fault is not corrected by Fault Generator activation, attempt to reset the system by recycling the power switch off for 10 seconds t... ON.

If the XMIT portion of the system is disabled, remain in the S mode to receive threat warning indications observed to be operable during the Self-Test.

CAUTION

> If the following indications are present during the DEF A2 System Self-Test, do not allow the system to remain in O (Self-Test completed) more than 20 seconds to prevent equipment damage: XMIT Light extinguished, A and FAIL legends on the control panel Fail Display and DEF FAIL legend on the DEF Warning Panel illuminated.

NOTE

Either [redacted] side can cause a FAIL indication. The [redacted] side will operate normally if the [redacted] side fails; however, if the [redacted] high voltage power supply fails, the system will return automatically to the S condition, and attempt to update the operate condition at six-second intervals. The FAIL legend will blink at six-second intervals. For operational missions, leave the system in O; otherwise, return to S.

2. Low RF Power

Low rf power is indicated by the [redacted] XMIT legend being extinguished when the [redacted] legend is illuminated in operate. No FAIL legends will be illuminated.

Recycling the system power probably will not correct the malfunction. If time and conditions permit, leave the power off for a period of time and then reattempt normal operation. If the conditon was transitory in nature, the system may later operate normally.

3. Overheat Fault

A temperature switch on the DEF A2 main chassis monitors the system for an over-temperature condition. The signal provided by this switch illuminates the A and HOT legends on the DEF control panel Fail display and the DEF FAIL legend on the DEF warning panel.

In this event, the system should be placed to S then turned off. If may be possible to operate the system again after a cool down period. The system may be operated in a tactical threat situation, even with the HOT legend illuminated. In this case, the receiver may operate normally, but the transmitter will operate at reduced power until FAIL illuminates.

CAUTION

If the DEF A2 HOT legend illuminates, the system shall be turned off as soon as possible to minimize damage to the sytem. However, the system can be left in the operate mode until FAIL appears, if an appropriate threat condition exists.

DEF C2 SYSTEM

The DEF C2 system receives and processes [redacted] signals in the [redacted] frequency band of [redacted] The DEF C2 receiver is associated with [redacted]: operation of the DEF H system.

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When installed, DEF C2 system components are on the forward right chine bay door (Compartment D). See Figure 4-37. Components include the DEF C2 receiver, band antenna, band-pass filter, DEF C2 power relay, and electrical and coaxial cables. DEF C2 operates in conjunction with DEF H and the MRS.

Electrical power to DEF C2 is supplied from the monitored dc bus through a circuit breaker in the C-bay. See Figure 4-39.

Cooling air is supplied to the components on the DEF C2 door by air supplied to the right chine bay from the right mission bay cooling air manifold.

DEF C2 Threat Warning & Activity Indicators

Since DEF C2 does not require a warm-up period, its threat warning / legends are operational as soon as DEF A, DEF M, or DEF H power is on.

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Analysis and display characteristics of DEF C2 are independent of other systems' operation. [redacted] threat warning legends are provided on the DEF control and warning panels. [redacted] the [redacted]egends on the DEF control panel and on the DEF warning panel illuminate steady. [redacted]

On receipt of an [redacted] legend signal from DEF C2, the DEF H system is triggered into operation, provided it is set to the proper operating status.

NOTE

- [redacted] DEF H will not transmit [redacted] upon display of a DEF C2 [redacted] In this case, the DEF H [redacted] legend also will be illuminated. However, the legend is associated with the DEF C2 receiver, and will not illuminate unless an associated [redacted] legend is illuminated.
- In [redacted] the [redacted] mode, DEF H will transmit [redacted] when an [redacted] legend illuminates if the proper modes are selected.
- During refueling rendezvous, the UHF may cause erroneous [redacted] indications if operated in the external mode, [redacted] and approximately [redacted] higher in frequency.

DEF C2 Operation

DEF C2 is turned on by pressing the DEF A, DEF M, or DEF F/H power switch (provided one of these systems is aboard the aircraft). DEF C2 is operational as soon as the DEF A, DEF M, or DEF F/H power switch is ON. To turn off DEF C2, the DEF A, DEF M, and DEF F/H power switches must be off.

DEF C2 Normal Procedures

To turn on DEF C2:

1. A, M, or F/H power switch - Press to illuminate ON.

   The [redacted] threat legends are now operative (no warm up is required).

2. System self-test - Complete.

   Refer to DEF C2 Self-Test procedures.

DEF C2 SYSTEM SIGNAL FLOW

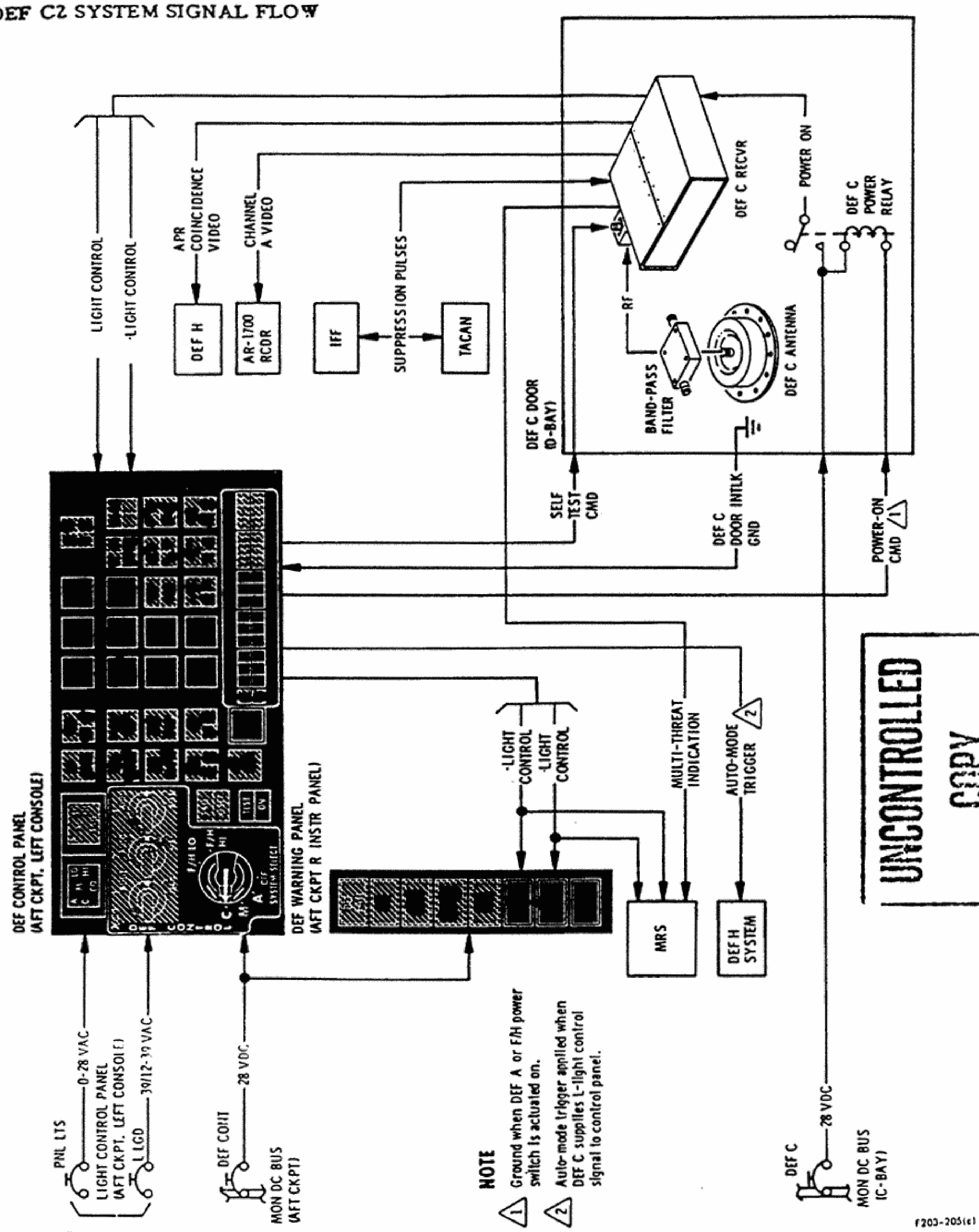

Figure 4-39

To turn off DEF ~~C2:~~

1. A, M, and F/H power switches - Off.

   System C2 remains on if A, M, or F/H power is ON.

DEF C2 Self-Test

DEF C2 must be tested independently, as self-tests of DEF A2, DEF M, or DEF H do not include DEF C2. The test takes 12 seconds.

To self-test DEF C2:

1. A, M, or F/H power switch - ON illuminated.

2. SYSTEM SELECT switch - C.

   The C legend appears in the Go display.

3. TEST switch - Press to illuminate ON.

Check for the following indications:

a. Test switch ON legend remains illuminated for 12 seconds.

b. The legend illuminates steady for one second and then begins flashing. The legend illuminates steady concurrently with the flashing legend.

c. The GO legend in the Go display illuminates immediately and stays illuminated until the SYSTEM SELECT switch is repositioned.

If any of the above indications do not appear, refer to the DEF C2 Malfunction Procedures.

NOTE

> Any self-test can be terminated by repositioning the SYSTEM SELECT switch during the test or by pressing the TEST switch again to extinguish ON. However, a self-test of the same system or of another system cannot be started until completion of the original test duration period.

DEF C2 Malfunction Procedures

There is no direct indication of a DEF C2 failure. Indirect indications are the absence of a GO legend in the Go display and/or no illumination of the [redacted] warning legends during a self-test.

Additionally, a DEF C2 failure <u>might</u> be indicated in a tactical situation by continuous illumination or rapid flashing activity indicator lights on the DEF control panel (in addition to a legend for DEF H) without illumination of the legends. A quick DEF C2 self-test can be initiated for verification. If the legends illuminate, terminate the self-test immediately by repositioning the SYSTEM SELECT switch and continue monitoring the DEF panel.

The only possible method of correcting a DEF C2 failure is recycling the system by simultaneously recycling the A, M, and F/H power switches to off and back to ON.

WARNING

> If DEF C2 has failed, and the aircraft is under a threat condition do not recycle DEF A, DEF M, or DEF F/H power switches. DEF A and DEF M are independent of DEF C2 and DEF H can be activated manually in conjunction with the legends.

DEF H SYSTEM

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DEF H is a [redacted] jamming system

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DEF H includes a transceiver, two transmitting systems, an interface unit (IU), a data processor, and an evaporative cooler. Radar signals received by the forward centerline receive antenna are sent to the transceiver,

Signals associated with the which are received by an aft centerline antenna, are routed to the DEF H system through a band pass filter and pre-amplifier in the S-bay. The DEF H system then processes these signals if the status switches are in operate (O).

NOTE

The HI band status switch must be in O before the status switch can be set to O.

and provides an output to the AR-1700 recorder of the EIP system. The IU then controls the jamming pulses generated by the transmitting systems. The transmitting systems are designated as low-band and high band coverage). Each consists of

During manual operation, each band can be driven by commands from the DEF control panel to three modes).

During operation, except for system transmit functions, the DEF H operates identically to operation. Upon receiving information from DEF C2, DEF H will transmit predetermined frequencies as determined by the LO and HI Mode selections. The jamming in the state is either computer controlled or predetermined broad band depending on whether is selected. If either of these modes is selected, jamming is in the corresponding band.

The threat recognition characteristics and DEF H transmitted output characteristics are programmed in the computer prior to flight. See Figure 4-41.

DEF H is installed in the forward left bay (K Bay). See Figure 4-38. DEF H operates in conjunction with the DEF C2 receiver system and the EIP AR-1700 recorder. It also supplies transmit, self-test results, mode select, system status, and fault data to the MRS.

Electrical power to DEF H is supplied from the left generator ac bus through the 3-phase circuit breaker in the C-bay and from the monitored dc bus through the DEF F circuit breaker on the RSO's right console. See Figure 4-40.

Cooling air is supplied directly to the DEF H unit through an air inlet opening which mates with the airplane cooling air duct during DEF H installation in the aircraft. Air flow is controlled by the left mission bay air shutoff valve. The evaporative cooler acts as a heat sink for coolant fluid after it is heated.

DEF H Threat Warning & Activity Indicators

Threat warning is provided by the DEF H system

Illumination of these legends reflect receipt of radar threats meeting preprogrammed parameters.

LEGEND/RADAR MATRIX

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(jamming) is indicated by the continuous illumination of the associated

correspond to the azimuth and elevation antennas for each band and illumination signifies rf power is being radiated.

NOTE

- Due to the low power of jamming, the HI-band legends may not illuminate when rf power is being radiated. Illumination of the legend is a valid indication of jamming.
- DEF H threat warning indicators remain illuminated during jamming

  Illumination of DEF H threat warning indicators

  jamming has been activated in either high or low band.

The legend illuminates steady when DEF C2 receives a signal. The legend flashes and the legend illuminates steady when DEF C2 receives a signal. If DEF H interprets the threat to be genuine, the Legend will also illuminate. With illumination of the legends, and with operation selected for either low band and/or high band trasmitters, jamming begins as evidenced by the low and/or high band legends illuminating.

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DEF H SYSTEM SIGNAL FLOW

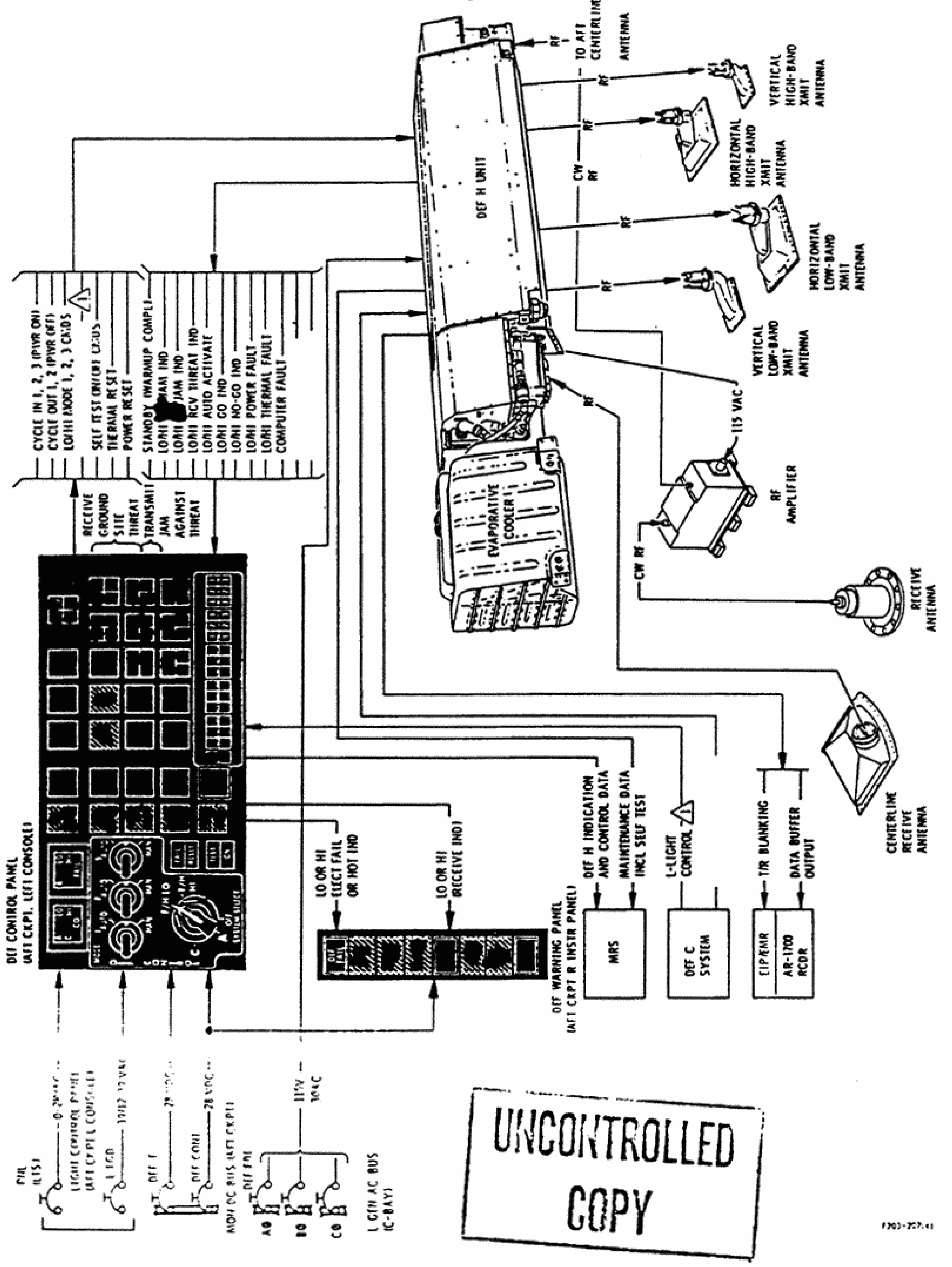

Figure 4-40

DEF C - H INTERFACES
JAMMING ONLY)

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5271 SCG
23 Sept 96.

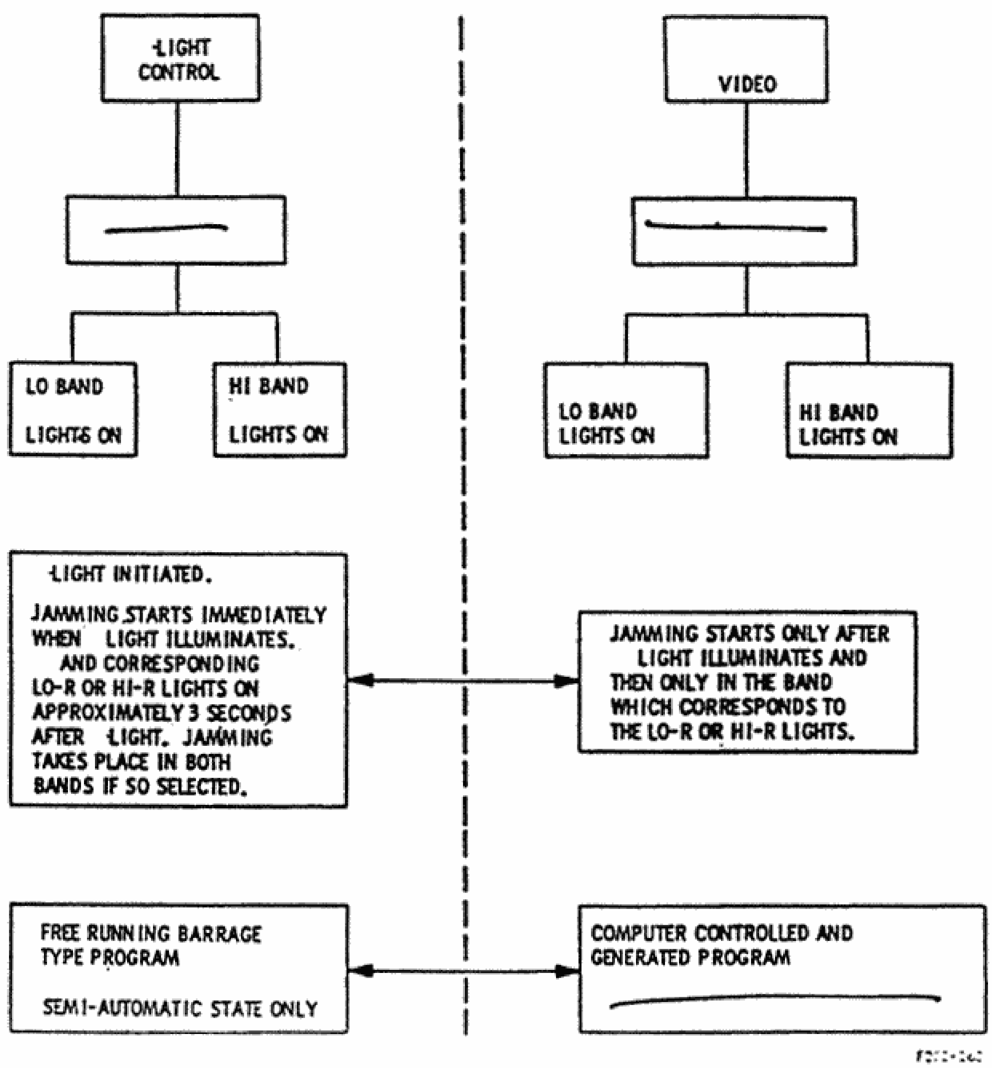

Figure 4-41

DEF H is turned on and off by pressing the F/H power switch. The system operational state is indicated by illumination of the F or H legend.

Pressing the switch to illuminate ON places DEF H in a warm-up state, and illuminates the W legend on the power switch and the LO, and HI legends on the DEF H status switches. Pressing the power switch to illuminate ON also turns on DEF C2. At turn on, the DEF H receiver is activated immediately; thus, threat warning indicators are enabled.

WARNING

Because of the dangerous radio frequency radiation levels, do not turn on the DEF H system transmitters while on the ground unless all four antennas are covered with hoods, and maintenance personnel are on interphone.

Following system turn-on, the data processor performs a self-test and loads all tables.

Approximately five minutes after the power switch is ON, the W legend extinguishes and the S legends on the LO-band HI-band and status switches illuminate, indicating warm-up is completed and the system is in a standby state (S) ready for operation (O).

DEF H is turned off by pressing the F/H power switch on the control panel to extinguish the ON legend. This action initiates a three-minute cycle-out period. After three minutes, power is removed and the system shuts down.

NOTE

If DEF H is turned off inadvertently it can be reactivated at any time during the three minute cycle-out period. Otherwise, a full five minute warm-up is required.

System operating states are selected by using switches on the DEF control panel. The F and H legends on the F/H power switch, in conjunction with the A and M mode lights, indicate the existing operational state.

During operation, only mode lights illuminate. If jamming is desired in both low and high bands, at least one mode light must be illuminated in each band.

Manual operation can be selected when the

Manual is indicated by illumination of either the F or H legend, and at least one M mode light. If jamming is desired in both the low and high bands, at least one M mode light must be illuminated in each band.

the alternate state can be selected using the following procedure.

Deleted IAW SR-71 SLC 23 Sept 78.

a. SYSTEM SELECT switch - F/H LO or F/H HI

b. TEST switch - On.

NOTE

If a FAIL legend illuminates, the system will default to

Deleted IAW SR71 SCG 23 Sept 96.

After test completion (26 sec):

c. TEST Legend - Extinguishes and the threat warning indicators flash for 5 seconds.

During this 5 second period:

d. Test switch - On, then Off.

Mode selection is accomplished by setting the SYSTEM SELECT switch to the appropriate position (F/H LO or F/H HI), and then momentarily turning the numbered

Selection of operating modes can be made while the system is either in S or O. Refer to the Mode Switches under the DEF Control Panel, this section.

NOTE

It is not necessary that any of the six mode selections be in effect at a given time. Jamming is inhibited if all modes are cancelled, but the threat warning indicators remain operative.

operation by the low or high band transmitters is established when any one of the modes in that band has been selected, the H legend is illuminated in the power switch and the O legend is illuminated in the associated status switch.

Jamming is indicated by the legend illuminating, or the appropriate (LO and/or HI-band) legends illuminating. operation is initiated either by the DEF H computer or by DEF C2.

When DEF H recognizes a radar threat and the corresponding legends illuminate, the associated threat warning indicator illuminates and the jamming legends illuminate.

DEF C2 can also initiate operation. The legend illuminates when the DEF C2 receiver recognizes a DEF H interprets video signals received from DEF C2 thereby illuminating the legend, the and/or legends will illuminate (if not already), and jamming will commence in the appropriate band. Once started, jamming is continous while the legend is illuminated. Jamming ceases when the threat terminates As the number of radars received by DEF . C2 increases, jamming takes priority over jamming of other radars.

NOTE

- The legend is associated with the DEF C2 receiver and will not illuminate unless an associated legend also illuminates.
- Even though the legend is located on the LO-band side of the control panel, it can be associated with either LO or HI band as indicated by the or light.

operation (jamming) by the LO and/or HI band transmitters is established when one or more modes in that band has been selected, the F legend is illuminated in the power switch and the O legend is illuminated in the associated status switch.

Jamming is indicated by the legend illuminating, or the appropriate (LO and/or HI-band) legends illuminating. Illumination of the mode indicator light(s) indicates the modes in which jamming will take place. operation is initiated at pre-programmed threat frequencies upon receipt of a valid signal by DEF C2

In operation when the legend is extinguished (DEF H not jamming), the DEF H receiver recognizes a radar threat. Corresponding and associated threat warning legends illuminate immediately. If DEF C2 receives a valid threat legend illuminates), DEF H jamming is initiated. All warning indicators except are inhibited. The legends are illuminated by the DEF H computer as the computer defines and tests the validity of the mission threat. DEF H jamming continues as long as the legend is illuminated. The legend is illuminated by the upon receipt of a valid threat and the legend will illuminate indicating jamming as long as the legend is illuminated.

During semi-automatic operation, upon receiving information from DEF C, DEF H will transmit predetermined broad band frequencies.

NOTE

- The legend is associated with the DEF C receiver and will not illuminate unless an associated legend is also illuminated.
- Even though the legend is located on the Lo-band side of the control panel, it can be associated with either LO or HI band.

Manual Operation

Manual operation (jamming) by the LO and/or Hi-band transmitters is initiated when one or more manual modes has been selected for that transmitting system and the O legend is illuminated in the associated status switch. Jamming is indicated by the appropriate legends illuminating. Illumination of the mode indicator light(s) indicates the modes in which jamming will take place. Manual operation in either low or high band inhibits illumination of the threat warning legends and inhibits operation in both bands.

jamming (with illumination of the legend) in a band set up for jamming, even if the other band was manual jamming. Manual jamming is terminated by pressing the status switch to illuminate the S legend or by cancelling all manual mode selections in that band.

jamming can be initiated from each of the DEF H system operational states. The must be set to operate by setting the HI status switch to illuminate the O legend, then pressing the status switch to illuminate the O legend.

is received, the RF is within the subsystem filter limits, and the RF is above the preset minimum threshold level, the DEF H system responds with a

jamming program.

Receipt of a valid threat is indicated by the legend illuminating. DEF H jamming of the threat is indicated by JAM illuminating on the acitivity indicator.

NOTE

> Depending on incoming signal levels and system gain, the may or may not illuminate during jamming.

DEF H Normal Procedures

WARNING

> Because of the dangerous rf radiation levels, do not turn on the DEF H system transmitters while on the ground unless all four antennas are covered with hoods, and maintenance personnel are on interphone.

To turn on DEF H;

1. F/H power switch - Press to illuminate ON.

   The ON and W (warm-up) legends will illuminate and either the F or H legend will illuminate, dependent upon the system operational status; The LO, and HI legends of the status switches will illuminate and, if the SYSTEM SELECT switch is positioned to F/H LO or F/H HI, LO or HI will illuminate in the Go display. In approximately five minutes, the W legend will extinguish and the S (standby) legends in the LO, HI, and status switches will illuminate.

After warm-up is completed:

2. Mode indicator lights - Check off.

   The mode indicator lights should be extinguished during the initial warm-up. If not, set the SYSTEM SELECT switch to H LO or H HI as required, and turn the AUTO/MAN switches to cancel the mode(s) in effect.

3. LO, HI, and status switches - Press to illuminate O.

   CAUTION

   - Except for tests or where tactical situations dictate, DEF H should remain in S while below FL 500. This avoids transmitter operation causing a thermal malfunction due to decreased cooling at lower altitudes.
   - DEF H transmissions may cause erroneous [redacted]

4. Mode selection - Complete.

   Using the SYSTEM SELECT switch and the switches, set at least one mode for both LO and HI-band systems. Ensure that the corresponding mode indicator lights illuminate.

   NOTE

   > Transmitter operation for each band is inhibited if a transmit mode is not selected for the respective band.

5. Self-test - Complete.

   Refer to DEF H Self-Test.

To return to standby:

1. LO, HI, and status switches - Press to illuminate S.

To turn off DEF H:

Ensure that the system is in S before turning power off.

1. F/H power switch - Press to extinguish ON.

NOTE

- If DEF H is turned off inadvertently it can be reactivated at any time during the three minute cycle-out period. Otherwise, a full five minute warm-up is required.
- Remain in S if it is desired to retain an immediate response capability.

DEF H Self-Test

DEF H self-test permits a quick check of the system operating condition. Although the visual indications last 31 seconds, the actual self-test requires approximately five seconds. During self-test all threat indicator legends, illuminate steady for 26 seconds.

Other indications are illumination of the GO legend, approximate ten second illumination of the LO and HI-band legends, and a one-second illumination of warning and JAM legends. The self-test can be accomplished either in standby or operate, with or without an selected. However, the transmit portions cannot be tested unless the system is in operate with an selected for the band to be tested.

NOTE

In standby (S), all functions are tested except for the actual transmit output.

During self-test, the SYSTEM SELECT switch can be in either H LO or H HL. Acceptable performance of the system is indicated by the illumination of the GO legend. In addition, either the LO or HI legend illuminates, dependent upon the SYSTEM SELECT switch position. (It does not mean that only that band has passed the self-test). GO will remain illuminated until the SYSTEM SELECT switch is repositioned.

Self test is performed in the state even though operation has been manually selected before the test. If the F legend on the F/H power switch is illuminated at the beginning of the test, the F legend extinguishes and the H legend illuminates. At the end of self-test, the H legend extinguishes and the F legend illuminates.

A self-test failure will illuminate the HI, LO, COMP, and FAIL legends in the FAIL display, the FAIL legend on the RESET switch illuminates, and the DEF FAIL legend illuminates on the DEF warning panel. Also all threat warning indicators go out. The system is automatically placed in legend on). The computer will stop and a reset must be initiated before system operation can be continued.

WARNING

Due to the rf radiation levels generated by a DEF external transmission, set DEF systems to standby and do not conduct self-test during air refueling.

NOTE

Illumination of legends during any self-test indicates an actual external transmission.

To self-test DEF H:

1. LO, HI, and status switches - O legends illuminated.
2. Mode selection - Complete.

   Ensure that an mode for both LO and HI band is set and their corresponding indicator lights are illuminated.

NOTE

Transmitter operation for each band is inhibited if a transmit mode is not selected for the respective band.

3. SYSTEM SELECT switch - H LO or H HI.

The corresponding LO or HI legend appears in the Go display.

4. TEST switch - Press to illuminate ON.

Check for the following indications:

a. TEST switch ON legend appears immediately and remains illuminated for 26 seconds.

b. If not already on, the H legend illuminates on the F/H power switch.

c.

legends illuminate for 26 seconds. The TEST switch ON legend then extinguishes, the LO-R and HI-R lights remain illuminated. If in the remaining indicators flash on and off for five seconds before extinguishing. All indicators then extinguish.

d. Approximately three seconds after test initiation the warning and lights flash on for approximately one second, and the LO-band and HI-band legends illuminate for 10 seconds.

e. The GO legend illuminates after approximately three seconds, and remains illuminated until the SYSTEM SELECT switch is repositioned.

f. At the conclusion of the self-test, the F or H legend illuminates, indicating the state.

If any of the above indications do not appear and/or the FAIL/HOT/COMP legend illuminates, refer to the DEF H Malfunction Procedures.

NOTE

Any self-test can be terminated by repositioning the SYSTEM SELECT switch during the test or by depressing the TEST switch again to extinguish ON. A self-test of the same system or of another system can not be started until completion of the original test duration period.

5. LO, HI, and status switches - Press to illuminate S.

Return the system to S unless operational conditions dictate otherwise.

DEF C2 interface with DEF H
operational states can be verified during a DEF C2 self-test.

To test C2 interface with DEF H:

1. F/H power switch - F illuminated.
2. SYSTEM SELECT switch - H LO.
3. MODE switch momentarily.
4. Low-band A3 mode light - Check on.
5. SYSTEM SELECT switch - H HI.
6. MODE switch momentarily.
7. High-band A2 mode light - Check on.
8. LO and HI status switches - On, O light on.
9. SYSTEM SELECT switch - C.
10. TEST switch - Press momentarily.
11.

lights on -Check.

12. LO and HI status switches - Press to illuminate S.
13. MODE selections - Cancel all.

The following test sequentially tests each mode for 10 seconds.

To test DEF H manual transmit modes:

1. LO and HI status switches - O illuminated.

2. SYSTEM SELECT switch - H LO.

   The LO legend will appear in the Go display.

NOTE

This test involves sequentially testing each of the modes for 10 seconds. To minimize transmitter cycling shocks, the next mode is selected before de-selecting the previous mode.

3. mode switch - Select MAN mode 1.

   Confirm that the LO band M1 indicator light illuminates. The LO band legends will illuminate and remain illuminated as long as a MAN position is commanded.

After ten seconds:

4. mode switch - Select MAN mode 2.

   Confirm that the LO band M2 indicator light illuminates.

5. mode switch - Deselect MAN mode 1.

   Confirm that the LO band M1 indicator light extinguishes and the M2 indicator light is still illuminated. (If mode 1 had been selected previously as the light will illuminate.) The legends will still be illuminated.

After ten seconds:

6. mode switch -Select MAN mode 3.

   Confirm that the LO band M3 indicator light illuminates.

7. mode switch - Deselect MAN mode 2.

   Confirm that the LO band M2 indicator light extinguishes and the M3 indicator light is still illuminated. (If mode 2 had been selected previously as the light will illuminate). The legends will still be illuminated.

After ten seconds:

8. mode switch - Deselect MAN mode 3.

   Confirm that the LO band M3 indicator light and the legends extinguish. (If mode 3 had been selected previously as the light illuminates).

9. SYSTEM SELECT switch - H HI.

   The HI legend will appear in the Go display.

10. Repeat steps 3 through 8 for the HI band.

    No lights will illuminate for HI mode 3.

    If any of the above indications do not appear and/or the FAIL/HOT/COMP legend illuminates, refer to the DEF H Malfunction Procedures.

11. LO and HI status switches - Press to illuminate S.

    Return the system to standby (s) unless operational conditions dictate otherwise.

<u>DEF H Malfunction Procedures</u>

DEF H failures are indicated by illumination of the FAIL, HOT, or COMP legends on the Fail display, illumination of the FAIL legend on the FAIL RESET switch, non-illumination or extinguishing of the legends (when jamming should occur), or a combination thereof. In most cases, a return to normal operation is accomplished by pressing the FAIL RESET switch (hereafter referred to as the RESET switch) after the TEST switch ON legend extinguishes.

NOTE

The DEF FAIL legend on the DEF Warning Panel illuminates whenever a FAIL, HOT or COMP legend is illuminated on the DEF control panel Fail display.

1. Electrical Power Failure

This type of failure affects the and TWT power supplies. It is indicated by illumination of the HI and/or LO and the FAIL legend on the control panel Fail display and the absence of legends under jamming conditions (threat or self-test) for the associated HI and/or LO-band.

Press the RESET switch. If this does not correct the fault and, if time and conditions permit, turn power OFF for 3 minutes, then back ON. The system will come back on in the warm-up mode if the system has completed the cycle-out phase. Then perform the normal operating procedures. If the system comes back on in the standby mode (S), the system did not complete the cycle-out phase, the fault remains, and the power will have to be recycled again.

2.

Unfaulted transmitter(s) continue to operate normally. This fault is indicated by the system (LO or HI band) legends being extinguished

The control panel FAIL legends blink o momentarily if only one channel is disconnected (either legend extinguished), but illuminate steady if both channels are disconnected legends extinguished). A disconnect of only one channel is referred to as a disconnect while disconnect of both channels is a complete disconnect.

If either fault occurs, press the RESET switch. If the fault does not clear, return the system to standby, press the RESET switch, and return the system to operate. If the corrective action does not correct the fault, and if time and conditions permit, turn power OFF for 3 minutes, then back ON. The system will come back on in the warm-up mode if the system has completed the cycle-out phase. Then perform the normal operating procedures. If the system comes back on in the standby mode (S), the system did not complete the cycle-o phase. The fault remains, and the pow will have to be recycled again.

3. Thermal Failure

This failure is caused by several faults; over/under voltage, high oil pressure, high oil temperature, low oil flow or high temperature in the IU. A thermal fault is indicated by a (LO and HI band) HOT indication on the DEF control panel Fail display and by both systems' legends, if illuminated, extinguishing.

With a HOT indication in either band, both bands return automatically to standby (S) until the fault clears or a manual RESET is performed. If the fault is transient, the system will clear itself, and both systems will return from S to O. With a HOT legend illuminated, DEF H should be turned off if continued operation is not essential. If time perm allow a five to ten-minute coold period with power off and th reattempt normal operation. (The coolant pumps continue to operate for three minutes during the cycle-out phase.) In an emergency, the RESET switch may be pressed and jamming will resume after 60 seconds. If the fault has cleared within that time, jamming continues. If the fault is still present after 60 seconds, both systems return to standby (S) and must again be reset manually to resume jamming. If the tactical situation warrants, this action can be repeated as required but may cause permanent damage.

CAUTION

The RESET switch should not be used in training situations to clear a thermal failure. It is reserved for tactical situations.

NOTE

A thermal failure in the IU results in the HOT legend illuminating. This failure cannot be overridden and manual mode must be selected. When the manual mode is selected, the HOT legend extinguishes.

4. Low RF Output Power

If an antenna does not receive adequate power from its transmitter, the associated legend does not illuminate during jamming.

Return the system to standby, press the RESET switch, and return the system to operate. If this does not correct the fault, and if time and conditions permit, turn power OFF for 3 minutes, then back ON. The system will come back on in the warm-up mode if the system has completed the cycle-out phase. Then perform the normal operating procedures. If the system comes back on in the standby mode, the system did not complete the cycle-out phase. The fault remains, and the power will have to be recycled again. In a tactical situation, do not recycle power if one antenna is jamming. FAIL legends are not associated with this malfunction and it is doubtful that it can be cleared.

5. Computer Failure

A failure which causes the data processor (computer) to cease operation is indicated by HI, LO, and COMP legends illuminating on the DEF control panel Fail display and all automatic operation ceasing.

Press the RESET switch. If this does not correct the fault, and if time and conditions permit, turn power OFF for 3 minutes, then back ON. The system will come back on in the warm-up mode if it has completed the cycle-out phase. Then perform the normal operating procedures. If the system comes back on in the standby mode, the system did not complete the cycle-out phase, the fault remains, and the power will have to be recycled again.

If the failure persists, manual jamming is available and the only warning indications would be the legends.

The computer conducts a diagnostic self-test at system turn-on. If a computer fault occurs, a reset may be attempted. If the fault clears, operation can be continued. If the fault does not clear, manual operation is the only state available.

6. DEF C2 Interface Defect

An interface defect between DEF C2 and DEF H could result in DEF H not responding automatically when a signal is received by DEF C2. Since neither system recognizes this failure, FAIL legends would not illuminate. The only indication would be illumination of the legends without corresponding or jamming of the LO and/or HI band. (An legend without an legend would indicate optical guidance.)

If the legends illuminate, but the legend does not illuminate, initiate manual jamming as long as the legends are illuminated.

WARNING

Continuous illumination of the DEF C2 legend, without a corresponding legend, could indicate a

threat and/or interface failure between DEF C2 and DEF H.

DEF M SYSTEM

DEF M is a deceptive repeater jammer ECM system that reacts against

Deleted DAW SR71 SCG 23 Sep 96.

DEF M indications on the DEF control panel are provided to the MRS for postflight analysis. Except for electrical power and cooling requirements, DEF M does not interface with any other aircraft or DEF systems.

The DEF M unit, located on a rack in the D-bay, is ground programmable through the User Data Memory module (UDM). Programs are selected in

bands; each band center is programmable in The bands may overlap, be adjacent or non-adjacent, in any combination.

DEF M uses a single antenna

and is time-shared between the receive and transmit functions. The antenna is located on the fuselage bottom centerline at FS 315, forward of the viewsight window and is protected by a slightly protruding fiberglass radome.

Electrical power is supplied to DEF M from the essential ac and monitored dc busses through circuit breakers in the C-bay. See Figure 4-42.

Cooling air is supplied to the DEF M unit through an inlet plenum and hose connected to the D-bay cooling air duct. Air flow is from the right mission bay air manifold which is controlled by the right bay air shut-off valve.

DEF M Threat Warning & Activity Indicators

Threat warning indications are provided by the legend on the DEF control panel a the legend on the DEF warning panel. T indications are operative in the standby (S) and operate (O) modes.

In standby, the legend may flicker when the received signal strength is near the preset threshold. In operate, the indication will only illuminate in a steady state, indicating a designated threat signal has been received and countermeasures are to be taken. Illumination of the legend indicates the system is responding to the threat. Jamming continues for 5 seconds after a threat is no longer present. The and legends will then extinguish simultaneously.

DEF M Operation

DEF M is turned on and off using the M power switch. Pressing this switch to illuminate ON places the DEF M unit in a three minute warm-up state indicated by illumination of the power switch W legend and the status switch M legend. At completion of warm-up the W extingui

DEF M SYSTEM SIGNAL FLOW

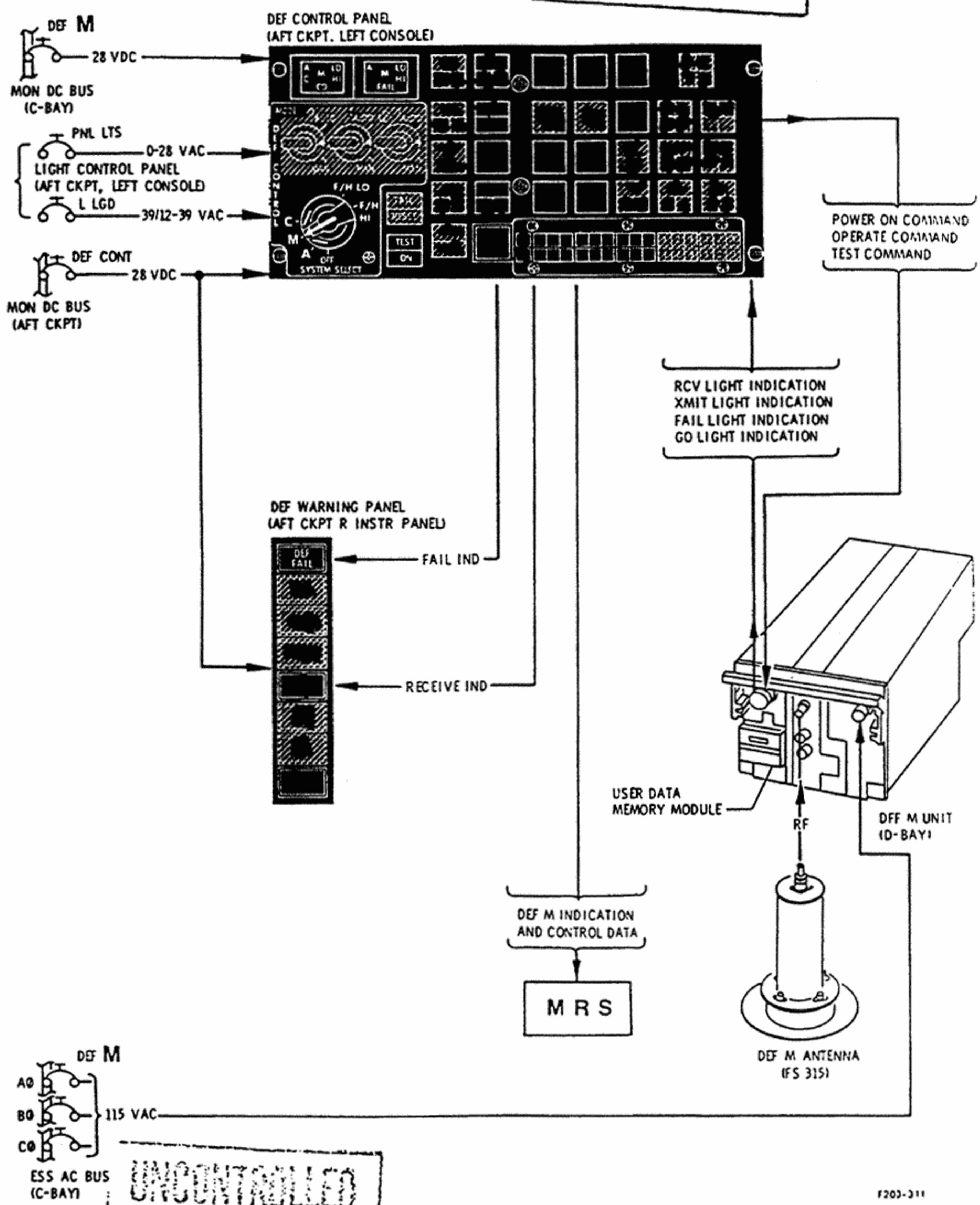

Figure 4-42

and the M status switch S legend illuminates. In standby (S illuminated) DEF M is capable of threat detection and warning but, countermeasures are inhibited until the system is set to operate (O illuminated) by pressing the M status switch.

DEF M Normal Procedures

To turn on DEF M:

1. M power switch - Press on.

   ON and W legends illuminate. With SYSTEM SELECT switch set to M the M legend illuminates in the GO display. In approximately 3 minutes the W legend extinguishes and the status switch S (standby) legend illuminates.

NOTE

Threat warning lights are operative.

After warm-up:

2. M status switch - Press to illuminate O.

   The S legend extinguishes and the O (operate) legend illuminates. Jamming is automatic in operate.

3. Self-test - Complete.

   Refer to DEF M Self-Test.

To return to standby:

1. M status switch - Press to illuminate S.

To turn off DEF M:

Ensure S illuminated before removing power.

1. M power switch - Off (ON extinguished).

NOTE

If immediate system availability is desired maintain DEF M in S mode.

DEF M Self-Test

Self-test may be accomplished in standby or operate. A self-test in standby can produce a GO indication, but the system jamming capability will not have been tested. Therefore, self-test is normally accomplished in operate.

Self-tests are performed with the SYSTEM SELECT switch set to M. A self-test requires 5 seconds although all checks are completed within the first 1.5 seconds. During self-test in operate a transmission of less than 1 second will occur.

WARNING

Do not perform self-test during air refueling.

NOTE

The self-test cannot be reinitiated until the five seconds have elapsed.

To self-test DEF M:

1. M status switch - O illuminated.
2. SYSTEM SELECT switch - M.

   M legend appears in the GO display.

3. TEST switch - Press to illuminate ON.

   Check the following indications:

   a. Test ON illuminates immediately and remains for 5 seconds.
   b. The following DEF control panel legends illuminate for 1 second; M XMIT, FAIL/RCV, GO in GO display, and M and FAIL in the FAIL display.
   c. After 1 second, the GO display GO legend remains on until self-test is complete then it and the TEST switch ON legend extinguish.

4. SYSTEM SELECT switch - OFF.

   GO display M legend extinguishes.

5. M status switch - O or S, as required.

DEF M Malfunction Procedures

For a FAIL indication attempt to reset DEF M by ensuring the system is in standby and then cycling the power switch off and back on. If the system is off for less than 10 seconds the warm-up period is reduced to 45 seconds.

NOTE

DEF M cannot be reset with the DEF control panel RESET switch.

DEF SYSTEMS INTERFACE/ RELIABILITY CHECKS

The following tests of systems interface and reliability should be initiated as soon after takeoff as convenient. They should be accomplished before acceleration to supersonic speeds but can be finished after transonic acceleration if required. The checks performed will depend on the actual combination of systems aboard the aircraft. See the respective Self-Test discussions for each DEF system.

WARNING

Due to the rf radiation levels generated by a DEF external transmission, set DEF systems to standby and do not conduct self-test during air refueling.

CAUTION

To avoid DEF H damage due to overheating, do not exceed the transmission time periods scheduled for the reliability checks while testing in the manual modes below FL 500.

NOTE

- Any self-test can be terminated while the test is in progress by repositioning the SYSTEM SELECT switch. However, a self-test of the same system or of another system cannot be started until completion of the original test duration period.
- For training missions, perform several self-tests of each system during flight. For operational missions, perform another DEF A2 self-test prior to final descent; whether or not self-test of DEF H will be performed prior to descent varies for operating locations and will be briefed.

1. DEF A2 - Self-test.

2. DEF H - Self-test.

3. DEF C2 (With DEF H installed) - Self-test DEF C2 and DEF H interface.

   DEF C2 (Without DEF H installed) -Self-test.

4. DEF H - Test the manual transmit modes.

5. DEF M - Self-test.

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ASTROINERTIAL NAVIGATION SYSTEM (ANS) TAPE 13

The ANS is an inertial navigation system employing a star tracker to eliminate gyro drift and to limit position error. The system provides a steering signal to the autopilot for guiding the aircraft automatically along a predetermined flight path. It provides heading, attitude, and position information to cockpit displays. The ANS can control the Advanced Synthetic Aperture Radar System (ASARS) and technical objective cameras (TECH) for imaging operations. The ANS supplies navigational data to the electromagnetic - reconnaissance (EIP) sensor and mission data to the mission recorder system (MRS). See Figure 4-47 for an ANS functional diagram.

SYSTEM INTERFACES

The ANS provides signals for aircraft sytems as seen in Figure 4-47. The following equipment is either controlled by or receives inputs from the ANS:

1. DAFICS (for Autopilot and SAS analytical redundancy (ANR)).
2. Attitude Indicators (Pilot and RSO).
3. Flight Director Computer.
4. Horizontal Situation Indicator (Pilot).
5. Bearing, Distance, Heading Indicator (RSO).
6. MRS.
7. EIP.
8. TECH Cameras (in AUTO).
9. Optical Bar Camera
10. V/H System.
11. Viewsight.
12. ASARS
13. RSO Annunciator Panel.
14. Pilot Annunciator Panel.
15. Sensor time counter driver.
16. Peripheral Vision Display (PVD).

MODES OF OPERATION

The navigation system has four navigation modes: (1) astro inertial, (2) inertial only, (3) airstart (airspeed-damped astro inertial), and (4) dead reckoning. Figure 4-48 summarizes the navigational errors expected in each mode. The mode to be employed depends on the time for activation and alignment, and whether the aircraft is on the ground or airborne when the ANS is turned on. Astro inertial is the preferred mode.

ASTRO INERTIAL Mode

In this mode, navigation errors will be relatively small, depending on the alignment method, and do not increase with mission duration. As soon as the system begins navigating the star tracker automatically begins to search for stars. Stars are normally tracked at night and during the day provided good sky conditions exist. A 61 star catalog is stored in the ANS computer. Either normal or special coverage for the SR-71B trainer can be provided. The sun, moon and planets, are not used by the star-tracker. At least two different stars must be tracked for optimum performance. The star tracker measures the difference between the inertial platform orientation and celestial computed position. Data derived from stars is used to correct true heading, computed position, computed velocity, platform tilt, and gyro drift rates. Measured gyro drift rates are stored in the computer memory and are used to improve any subsequent inertial only navigation. This sequence eliminates the unbounded position error growth characteristic of pure inertial systems.

In a normal mission, either a rapid or gyro compassing alignment is performed prior to navigation. These alignments require 18 minutes and 36 minutes respectively, exclusive

SECTION IV

NAVIGATION AND SENSOR CONTROL SYSTEM

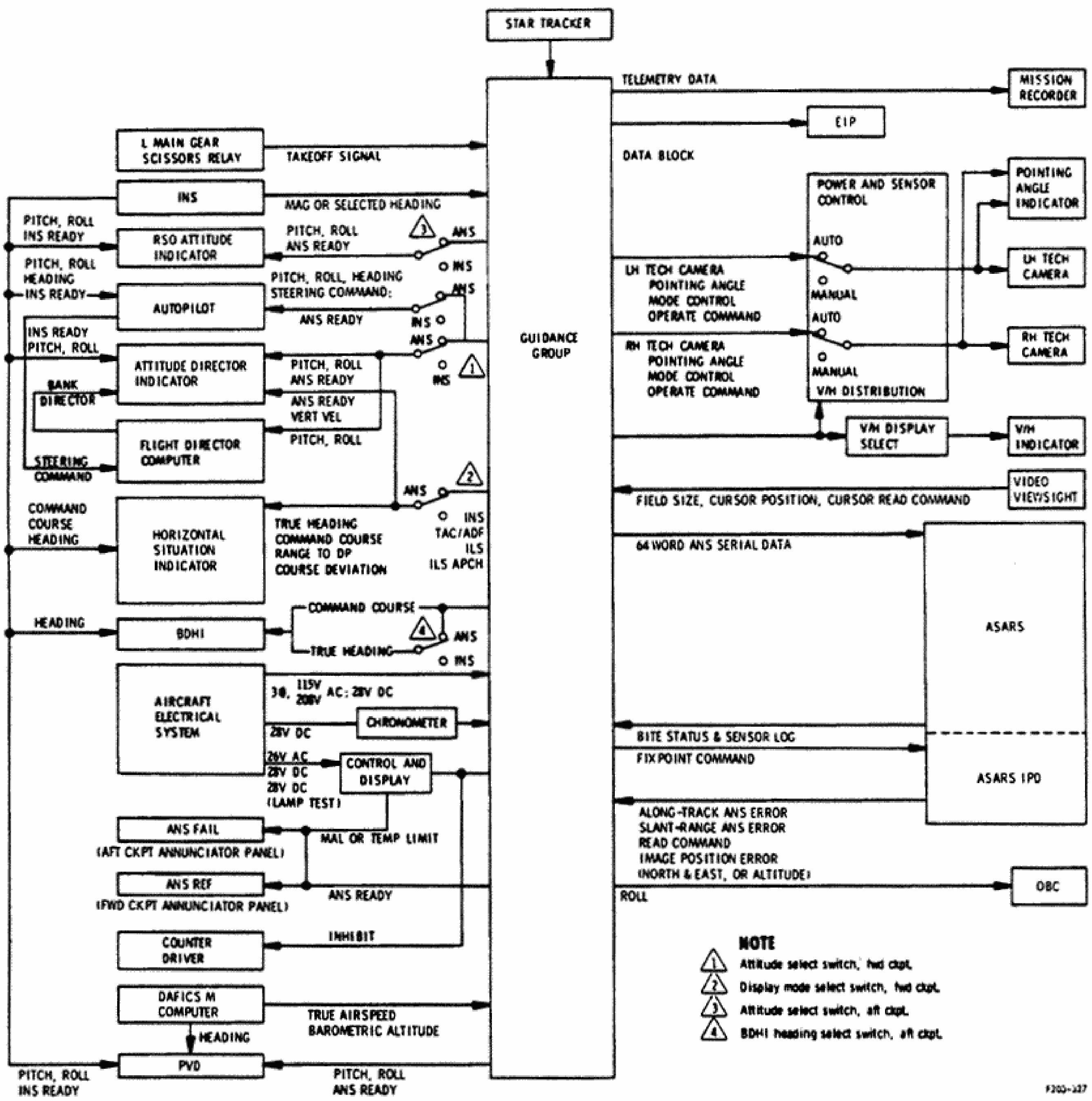

Figure 4-47

of warmup time. A ground hot start can be performed on a system previously aligned and shut down or on a system which has been shut down after operation in the astro inertial or inertial-only mode, provided the aircraft has not been moved. A runway heading alignment is recommended after a rapid alignment or a ground hot start. A heading update may or may not be required.

INERTIAL-ONLY Mode

INERTIAL-ONLY mode, in which only the inertial portion of the astroinertial system is employed, is recommended when the star-tracking capability of the navigation system is impaired. In this mode, navigation errors are unbounded.

AIRSTART Mode

The airspeed-damped, astro inertial (airstart) mode, which uses both the inertial platform and star tracker, is intended for: (1) scramble-initiated flights when the system is not prepared for a ground hot start, and (2) restart in flight. In this mode, errors can be large at first but should damp down with time to the values in Figure 4-48. Dead reckoning data are used for present position until three different stars have been acquired (steady illumination of the star ON light). Star acquisition is critical for accurate navigation.

Dead Reckon Mode (DR)

If the ANS inertial platform fails, navigation may continue using dead reckoning. In DEAD RECKON mode the ANS computer navigates using heading from the INS, true airspeed from the DAFICS (M computer) and inflight winds filled by the RSO. Position error increases proportional to errors in these inputs.

SYSTEM ERRORS

Error values in Figure 4-48 are based on the high altitude flight profiles. Abnormal flight profiles (low-altitude, race-track, touch-and-go, etc.,) may result in errors in excess of the listed values. The error values listed are probable radial errors (CEP's); therefore, under normal system operation, the listed errors will be exceeded about half the time. When star tracking is lost, a residual position error may develop that will not be totally eliminated when star tracking resumes. It might take as many as 3 navigation position updates (depending on Schuler cycle period) and a steady C star light to eliminate the total residual error.

SYSTEM COMPONENTS

The navigation system has three major assemblies: the control and display panel, the portable chronometer, and the guidance group. The control and display panel (Figure 4-49), located on the aft cockpit right console, is used to activate the system, select modes of operation, insert and monitor navigational data, modify the mission flight plan, and observe operating status.

A portable chronometer, in the aft cockpit supplies Greenwich Mean Time (GMT) (accurate to one-hundredth of a second) and the Julian date to establish the orientation of the Earth in inertial space for astro-inertial operations. The chronometer is set in the base shop, using a time standard set up to receive WWV time signals. Day can be set up to 511, thus allowing use of the computer star catalog into the next calendar year. A fully-charged, self-contained battery permits timekeeping for up to 24 hours without other power. Chronometer outputs are enabled only when aircraft power is applied. There is a GO, NO-GO indicator on the chronometer. GO indicates that either external or battery power is available and that the chronometer is operable, but does not indicate that the correct day and time is set. NO-GO indicates that chronometer outputs are unreliable.

The guidance group contains the electronic and optical-mechanical equipment for navigation and avionics subsystems control. The guidance group is mounted in the fuselage aft of the rear cockpit to provide an upward 78-degree cone of vision for the star-tracking telescope. The axis of the cone is vertical

NAVIGATION MODE PROBABLE RADIAL ERROR

NAVIGATION MODE	ALIGNMENT METHOD			
	GRD HOT START	RAPID	AIRSTART	GYROCOMPASS
ASTRO INERTIAL △4 △3	1.0 nmi	0.3 nmi (up to 10 hrs) △5	—	0.3 nmi (up to 10 hrs)
INERTIAL ONLY △1 (with fixpoints every hour)	5.0 nmi/hr	2 nmi/hr 1.28 nmi	—	2 nmi/hr 1.28 nmi
AIRSTART (without fixpoints)	—	—	after 2 hrs: 1.75 nmi	
(with 2 fixpoints in first hr 20±5 min apart) △1	—	—	after 1 hr: 1.25 nmi	
DEAD RECKONING	△2 55 nmi/hr (Depends on INS and DAFICS accuracy)			

△1 Using fixpoints ascertained to 1-nmi accuracy
△2 No alignment required - Accuracy only as good as inputs (W/V, Hdg, MV, TAS)
△3 Without continuous star tracking, errors approaching inertial operation can develop
△4 With current accelerometer null bias calibration
△5 With heading entry accurate to 0.1 degree

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Figure 4-48

when the aircraft pitch angle is 7-1/2 degrees. The guidance group includes an inertially stabilized platform and associated electronic and electromechanical components required to control (1) its attitude, (2) a star-tracking telescope, and (3) the electronic and electromechanical components for pointing, servo-controlling, and discrimination of telescope photo-detections. A digital computer computes auto-navigation, guidance and avionics control, and maintains a continuously updated account of navigational status and coordinate values. The computer also stores instrument and mathematical coefficients, predetermined data references that define stars, and the mission flight plan. The computer initiates and evaluates self-tests periodically throughout the operating interval. Software corrections to the star data are provided for: (1) the shock wave over the window that refracts the star light and (2) pressure and temperature gradients (differentials) acting on the window causing optical lens effects.

NAVIGATION CONTROL AND DISPLAY PANEL (NCD)

The NCD (Figure 4-49) on the aft cockpit right console controls the ANS.

NOTE

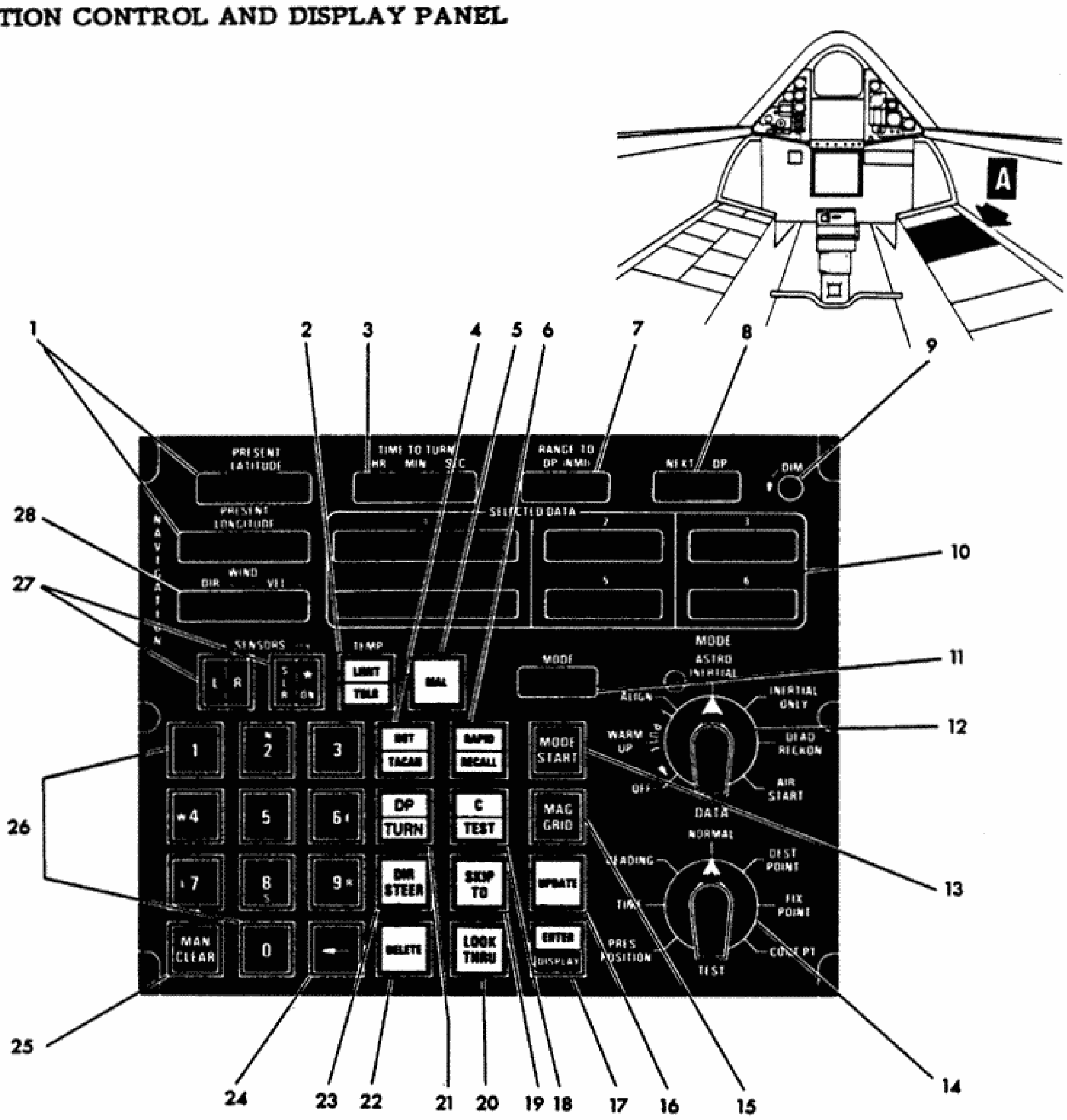
> The positions of the ANS controls and the last pushbutton operations are recorded once each 0.832 seconds by the MRS. Events can be marked by using the ANS keyboard.

MODE Switch

The rotary MODE switch has seven positions:

OFF	Power is off except illumination power and chronometer power.
WARM UP	Power to temperature control circuitry and the computer.

NAVIGATION CONTROL AND DISPLAY PANEL



1 PRESENT POSITION WINDOWS
2 TEMPERATURE MONITOR LIGHTS
3 TIME-TO-TURN WINDOW
4 HOT/TACAN SWITCH
5 MALFUNCTION LIGHT
6 RAPID/RECALL SWITCH
7 RANGE TO DESTINATION POINT WINDOW
8 NEXT DESTINATION POINT WINDOW
9 DIM SWITCH
10 SELECTED DATA WINDOWS
11 MODE WINDOW
12 MODE SWITCH
13 MODE START SWITCH
14 DATA SWITCH
15 MAG/GRID SWITCH
16 UPDATE SWITCH
17 ENTER/DISPLAY SWITCH
18 C/TEST SWITCH
19 SKIP TO SWITCH
20 LOOK THRU SWITCH
21 DP/TURN SWITCH
22 DELETE SWITCH
23 DIRECT STEER SWITCH
24 BACK SPACE SWITCH
25 MANUAL CLEAR SWITCH
26 MANUAL KEYBOARD AND POSITION PREFIX REFERENCE SWITCHES
27 SENSOR OPERATION INDICATOR LIGHTS
28 WIND DIRECTION AND WIND VELOCITY WINDOWS

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Figure 4-49

The following five modes are called "operate" modes, since power is applied to the entire ANS. Operation begins only after the MODE START, RAPID, or HOT switch is pressed.

ALIGN	Used on the ground to remain in fine alignment or for ground alignment correct procedure.
ASTRO INERTIAL	Selects astro-inertial navigation.
INERTIAL ONLY	Selects inertial-only navigation.
DEAD RECKON	Selects dead-reckon navigation.
AIRSTART	Used to perform a cold airstart (in-flight alignment) which results in airspeed damped, astro inertial navigation.

The MODE switch has a detent that prevents switching to OFF or WARM UP from an "operate" mode without lifting the switch. A detent prevents moving the switch clockwise past AIRSTART.

MODE START Switch

After power on, pressing MODE START initiates a gyrocompass or cold airstart alignment. After alignment, pressing the self-illuminated switch enables the mode selected by the MODE and MAG/GRID switches.

MAG/GRID Switch

The MAG/Grid switch is an alternate-action switch. Either the MAG or GRID half of the switch is lighted at all times. The ANS computer interrogates this switch each time the MODE START switch is pressed.

Set the switch to MAG. There is no useable grid heading available to either cockpit with the SKN-2417 INS in normal operation. The ANS computer interprets the INS heading input as MAG heading and makes appropriate computations to provide a true heading value for the dead-reckoning reference frame.

DATA Switch

The rotary DATA switch is used to select a panel fill, update, display, or mission modification procedure. The position of the switch determines the first character (always alphabetical) of the SELECTED DATA (SD) window that expects data. The eight DATA switch positions are PRES POSITION, TIME, HEADING, NORMAL, DEST POINT, FIX POINT, CONT PT, and TEST.

Keyboard Switches

The ten numerical keyboard switches, labeled 0 through 9, are used to enter data into the ANS or to command display of ANS data.

MAN CLEAR Switch

Used to clear the SELECTED DATA windows if an error is made during a panel-initiated procedure, and to not use an ANS position, altitude, or runway-heading alignment update. It is also used in the ANS malfunction routines.

ARROW (Backspace) Switch

Used to erase filled data one digit at a time in reverse order prior to actuating an action switch such as ENTER.

LOOK THRU Switch

Used to display data pertaining to the destination point (DP) after the DP now approaching.

SKIP TO Switch

Used to command the ANS to skip to a selected DP from the current next DP.

RAPID/RECALL Switch

Used to select rapid ground alignment or to recall data for display of the previously panel-filled TACAN point.

DELETE Switch

Used to delete a particular panel-filled mission point from the 40-List of panel-filled points or the entire 40-List.

DIR STEER Switch

Used to make an immediate change in destination (direct steer) to a selected DP or to any panel-entered latitude and longitude.

HOT/TACAN Switch

Used to mark the time of reading current TACAN data and to freeze the ANS computed values of range and bearing or to select air or ground hot starts.

ENTER/DISPLAY Switch

Used to command the ANS computer to accept panel-filled data or to display selected data.

UPDATE Switch

Commands the ANS to correct computed position, heading, reinitialize the star tracker, or change the current track leg.

DP/TURN Switch

This push-button switch selects the source for the pilot's HSI range indicator. The DP/TURN switch is enabled when the ANS DATA switch is in TEST; pressing ENTER/DISPLAY will then illuminate the "DP" or "TURN" legend in the switch (corresponding to the mode presently selected); pressing the DP/TURN switch will change the mode and illuminate the other legend. When "DP" is illuminated, the pilot's HSI range indicator will read distance to the ANS destination point (DP); when "TURN" is illuminated, the pilot's HSI range indicator will read distance to the ANS-computed turn point. Refer to Horizontal Situation Indicator, Range Indicator, Section I.

C/TEST Switch

Used to perform a panel light test and to display ANS tape data and internal ANS conditions when used in conjunction with the TEST position of the DATA switch.

SELECTED DATA Indicators

The indicators or windows consist of six separate sets of digital displays. Various operating parameters are displayed in the indicators during the panel fill, mission modification, update, and alignment routines as shown in Figure 4-50.

Present Data Indicators

The PRESENT LATITUDE and PRESENT LONGITUDE windows show the present position coordinates in degrees and minutes. During ground alignment, the coordinates are blank until fine alignment is completed.

The WIND DIR and WIND VEL window displays the wind direction in degrees and the wind velocity in knots. The window displays zeros until airborne.

The TIME-TO-TURN window displays the time-to-turn in hours, minutes, and seconds. The window is blank until the aircraft is moving.

The RANGE TO DP window displays the range to the DP in nautical miles. The window is blank until present position coordinates are entered.

The NEXT DP window displays the next destination point number. The window is blank until the present position coordinates are entered.

Sensor Indicators

The TECH L and R, and SLR indicator lights illuminate during display of control points or fix points to indicate programmed sensor activity at the selected point. The SLR light is not illuminated during display of viewsight fixpoints. During NORMAL display, these lights illuminate during actual ANS on-time commands and are extinguished by standby control point commands. The lights do not illuminate during manual sensor operation.

These lights also illuminate to verify sensor selection when adding or replacing control points.

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES (TAPE 13)

PANEL ROUTINE / SEL-ECTED DATA WINDOW	RUNWAY HEADING ALIGNMENT	FILL PRESENT POSITION AND INITIAL ALTITUDE	FILL WIND	FILL DAY AND TIME	FILL MAGNETIC VARIATION	FILL CHART CONVER-GENCE FACTOR	UPDATE HEADING	UPDATE PRESENT POSITION, USING REMOTE SOURCE DATA	UPDATE PRESENT POSITION USING ASARS	UPDATE PRESENT POSITION, USING VIEWSIGHT	UPDATE PRESENT POSITION USING TACAN	UPDATE TRACK LEG
1	Computed runway true heading, XXX°XX.X'	Latitude, N/S XX XX.XX'		GMT, XX hours XX minutes XX seconds				North-South error, nautical miles, N/S 00XX.XX	Cumulative North-South error, nautical miles, N/S XX.XX	North-South error, nautical miles, N/S XX.XX	North-South error, in nautical miles, N/S XX.XX	
2									North-South error, nautical miles, N/S XX.X			
3		Altitude in hundreds of feet, XXX										
4	Filled runway true heading, XXX° XX.X'	Longitude E/W XXX° XX.XX'			Magnetic variation, E/W XXX° XX.X'		Heading XXX°XX.X'	East-West error, nautical miles, E/W 000 XX.XX	Cumulative East-West error, nautical miles, E/W XX.XX	East-West error, in nautical miles, E/W XX.XX	East-West error, in nautical miles, E/W XX.XX	
5			Wind direction XXX°						East-West error, nautical miles, E/W XX.X			
6			Wind speed in Knots, XXX	Julian day, XXX		Chart convergence factor X.XXX°						All five digits of point - ID code, D XXXX

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Figure 4-50 (Sheet 1 of 3)

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES (TAPE 13)

PANEL ROUTINE / SELECTED DATA WINDOW	DIRECT STEER	SKIP TO DP	DELETE FP, CP, DP	ADD OR REPLACE FP, CP, DP	NORMAL DISPLAY	DISPLAY NEXT FP, CP, DP	DISPLAY SELECTED FP, CP, DP	DISPLAY HEADING	DISPLAY DAY OF YEAR/STAR DATA	DISPLAY PRESENT POSITION	DISPLAY LOOK THRU	DISPLAY TAPE NUMBERS/ TEST
1	Latitude if new point is filled, N/S XX° XX.XX'			Latitude, N/S XX° XX.XX'	GMT in XX hours, XX mins, XX seconds	Latitude, N/S XX° XX.XX'	Latitude, N/S XX° XX.XX'	Velocity vector heading VXXX° XX.X'	GMT in XX hours, XX mins, XX seconds	Latitude of alternate present position frame, N/S XX° XX.XX'	Latitude of DP+1 N/SXX° XX.XX'	I TTMMCC T - Tape M - Mod C - Corr
2					True airspeed in knots TXXXX	Range to DP RXXX.X nmi slant range if TACAN FP SXXX.X nmi along track range to CP/FP AXXX.X nmi	Great circle range for CP, DP, FP AXXX.X nmi slant range if TACAN FP SXXX.X nmi	Grid heading GXXX.X°	Star number SXX		Along track range to DP +1 R XXXX nmi	Mission tape No. OXXX O•* or A thru Z or a thru e
3				Terrain elevation in hundreds of feet for CP's or FP's XXX. Turn radius in nmi for DP's.	Next FP No. F/F1 XXXX	Turn radius to DP KXXX nmi terrain elev for CP, FP hundreds of feet XXX	Turn radius if DP KXXX nmi terrain elev if CP, FP, hundreds of feet EXXX	Chart convergence factor CX.XXX	Scan Rate Code R X	Nav altitude in hundreds of feet, AXXX	Turn radius of DP +1 K XXX nml	General instrument constants tape NO. GXXX
4	Longitude if new point is filled, E/W XXX° XX.XX'			Longitude E/W XXX° XX.XX'	Aircraft cross track position, nautical miles L/R XXX.X	Longitude E/W XXX° XX.XX'	Longitude E/W XXX° XX.XX'	Aircraft true heading TXXX° XX.X'	Time in this star search T XX:XX min : sec	Longitude of alternate present position frame, E/W XXX° XX.XX'	Longitude of DP +1 E/W XXX° XX.XX'	
5				L/R XX.0 SLR code or L/R00.0 for CP, FP or E/W XX.X° mag var for TACAN FP's	Aircraft Ground Speed in Knots GXXXX	Relative bearing to DP, CP, FP L/R XXX.X° TACAN bearing to TACAN FP BXXX.X°	Relative bearing to point L/R XXX.X° Magnetic bearing if TACAN FP BXXX.X°	Magnetic variation E/W XXX.X°	Number of stars acquired AXXXX	Sun angle in degrees, (if positive) SXX.X°	Time to DP +1 TXXX.X min	TYY1 (Normal) TYY2 (Trainer) Where YY-year
6	All five digits of point - ID code if DP in memory is selected, D XXXX	All five digits of point - ID code, D XXXX	All five digits of point deleted D XXXX C/C1XXXX F/F1XXXX	Point ID Code D XXXX C/C1XXXX F/F1XXXX	Next CP No. C/C1XXXX	ID code of next point, D XXXX C/C1XXXX F/F1XXXX	Selected point ID code D XXXX C/C1XXXX F/F1XXXX	Magnetic heading MXXX°	Julian day of year DXXX (1-511)		DP + 1 ID No. D XXXX	Test O Indication T O

Figure 4-50 (Sheet 2 of 3)

DATA IN SELECTED DATA WINDOWS FOR PANEL ROUTINES (TAPE 13)

PANEL ROUTINE / SELECTED DATA WINDOW	ADD OR REPLACE ASARS CP	REPLACE ASARS FP	DISPLAY SELECTED ASARS FP, CP
1	Latitude N/S XX° XX.XX'	Latitude N/S XX° XX.XX'	Latitude N/S XX° XX.XX'
2			
3	Terrain elevation in hundreds of feet	Terrain elevation in hundreds of feet	ASARS mode AXXXX if CP Terrain elevation in hundreds of feet for FP
4	Longitude E/W XXX° XX.XX'	Longitude E/W XXX° XX.XX'	Longitude E/W XXX° XX.XX'
5	ASARS code XXXXX		Relative Bearing to point L/R XXX.X°
6	Point ID code C/C1 XXXX	Point ID code C/C1 XXXX	Selected point ID code C/C1 XXXX

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Figure 4-50 (Sheet 3 of 3)

Star ON Indicator Light

The light indicates the status of star tracking as described in the Computer Program section. Steady illumination of the light indicates that a minimum of two different stars have been tracked within the last 5 minutes.

MODE Window

The MODE window displays a legend which shows the operating phase of the ANS. The MODE window also displays an error message in the event of an operator error and may indicate recommended action in case of system malfunction. The malfunction indications are described in the Malfunction Indicator and the ANS MALFUNCTION PROCEDURES paragraphs. The MODE window indications are:

Indication	Operating Phase	Definition
C/A	COARSE ALIGN	Initial phase of ground or air start alignment.
F/A	FINE ALIGN	Final phase ground alignment.
RES	RE-START	Second phase of air-start or ground hot start alignment.
A-I	ASTRO INERTIAL	Astro inertial navigation.
I/O	INERTIAL ONLY	Inertial-only navigation.
D/R	DEAD RECKON	Dead-reckon navigation.
ENT		Coarse align complete. Enter present position or heading.
ERR		An operator error in panel operation has been committed.
ENC		Encoding failure.
DP*		Mission tape program sequence in error.
BLANK	WARM UP	Mode switch is in WARM UP and 28 volts dc is present.

Temperature Limit/Tolerance Indicator

The temperature limit and tolerance indicator, labeled TEMP LIMIT/TOLR is a split-function indicator which displays monitored cooling air flow and system internal temperatures. The top half of the indicator is red with the LIMIT legend visible when lighted. The bottom half of the indicator is amber, with the TOLR legend (tolerance) visible when lighted. (Refer to ANS MALFUNCTION PROCEDURES.)

Malfunction Indicator

The ANS malfunction indicator, labeled MAL, is a red panel light that can be off, on-steady, or on-flashing. Generally, the MAL light is off during normal operation, on-steady when the ANS is in the WARM UP mode, and on-flashing when a system self test has failed. (Refer to ANS MALFUNCTION PROCEDURES for detailed description.)

COMPUTER PROGRAM

The basic instructions and constants for computer operation are contained in the main program tape which is loaded into the computer permanent memory. The computer program is loaded in two parts, a basic main program tape and a correction tape (if needed). In addition, a general instrument constant (GIC) tape, star catalog (SYY1, SYY2) tape, and mission tape are loaded. Each ASTRO INERTIAL (A-I) unit has its own GIC tape which defines gyro, accelerometer, resolver, etc. parameters unique to the respective A-I unit. Annual revisions are made to the star catalog tapes.

STAR DATA USAGE

STAR	DEFINITION	DATA USAGE
A	First star tracked after a hot or cold airstart, ground hot start, or after changing from A-I to I/O and back to the A-I mode.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
B	Second star tracked after an A star, or	Computational triad and platform are corrected and now in coincidence. Latitude, longitude and auto nav adjustments occur.
	First star tracked after a ground alignment.	Computational triad and platform are corrected but present position is not changed, so there is no perturbation in latitude, longitude, or auto nav.
C	First and subsequent star tracked after B star.	Platform and computational triad are corrected. Auto-Nav transients are allowed on first star C but suppressed on subsequent ones until a bank angle exceeds 5° or position fix inserted

Figure 4-51

Astro Inertial Navigation

The ANS operates in typical inertial navigation fashion. Outputs from two 2-axis gyros drive the platform gimbals to isolate three orthogonally mounted accelerometers from changes in aircraft attitude. The gyros and accelerometers are mounted on the platform's azimuth gimbal (stable element). The accelerometer outputs are components of aircraft velocity change. If the azimuth gimbal is not kept level, the accelerometers also measure a component of acceleration due to gravity and position errors are produced.

In INERTIAL ONLY, the computer uses the accelerometer outputs to calculate aircraft velocity and change in position, and gyro torquing rates. The gyro torquing rates (signals proportional to aircraft velocity plus earth's rate) are applied to the gyros to maintain the azimuth gimbal (and thus the accelerometers) level with respect to the earth. The success of inertial navigation is due to the fact that any system error eventually causes the accelerometers to go off level and measure a component of gravity which introduces an error that tends to cancel the original error. For example, if an accelerometer develops a null shift that appears to be an aircraft acceleration to the north, the platform will be torqued to keep up with the apparent aircraft motion over the earth's surface. Thus if the platform were level, it becomes tipped off level resulting in accelerometer measurement of gravity which looks like aircraft acceleration to the south. This characteristic of inertial systems is called Schuler tuning.

The star tracking function improves knowledge of accelerometer orientation in azimuth and eliminates the effects of gyro drift. Star search is initiated when astro-inertial mode is selected after completion of alignment. Selection of the star is made by the computer as a function of latitude, longitude, day of year, time of day, aircraft pitch and roll, and location of the sun. Aircraft pitch and roll determine the orientation of the star tracker window. For a given latitude, longitude, time of day and year, a particular star should be at a particular azimuth and elevation. If the star tracker measurements show that the star is not at the expected azimuth and elevation, there is an error in computed latitude and longitude and/or an error in platform orientation. Since the telescope is mounted on the platform, the star tracker measures the angular difference between the physical triad formed by the platform axes and the computational triad formed by the vertical through the computed position and the calculated orientation of the platform in azimuth. Thus the system cannot directly distinguish between a computed position error and a platform orientation error but, based on statistical probabilities determined by prestored error models and flight dynamics preceding the measurement, (as modeled by a Kalman filter, described later) it will attempt to optimally adjust the various navigational parameters.

To aid in describing star tracker logic, stars are given arbitrary labels depending on if they are the first, second, or third star tracked after the beginning of an operation. These are listed in Figure 4-51 with definitions and a summary of the usage of star tracker measured errors. In all cases, the end result of tracking two different stars is to align the computational triad with the platform triad or vice versa. A single star cannot be used to correct all errors since errors about the axis from the platform through that star are not measured. After the initial two stars are acquired, the normal interval between loss of track from one star to tracking the next star is about 30 seconds at altitude. Since the platform is almost continually brought into alignment with the computational triad, gyro errors have an almost negligible effect. The predominant ANS errors are those due to gyro drift that develop before stars are acquired and when star tracking is interrupted such as during aerial refueling. The star tracking data is used to update computed values of gyro drift to minimize error growth during any subsequent lapses in star tracking.

Star selection, tracker scan rate, and search patterns depend on many factors and are all under computer control. The computer selects a star by going through the star catalog which is arranged in order of decreasing star brightness until it finds a star that is within the window aperture, not within 10° of zenith (not within 5° of zenith for trainer aircraft), and not within $12\text{-}1/2^{\circ}$ of the sun. The tracker telescope is commanded to search for the selected star using a variable sized pattern which is symmetrical about the computed star position.

The star search pattern is an expanding rectangular spiral which starts at the side of the pattern and then passes across the computed star postion. See Figure 4-52. Maximum A star pattern size is a function of search rate so that all A star searches are completed within 23 minutes.

If the star is detected during this search, confirmation and reconfirmation patterns are made. If these are successful, the star is considered tracked, and elevation and azimuth errors are determined by the star actual position relative to its computed position. Search and track operations are discontinued if the star moves out of the window, the sky is too bright, or a position update is performed. The computer then goes to the next brightest star available, except that when a position update is performed, star search begins at the top of the star list (brightest star).

There are four scan rates which can be used in star search. Scan rate depends on star magnitude and sky brightness. The fastest is used on a bright star in a dim background while the slowest is used on a dim star in a bright background.

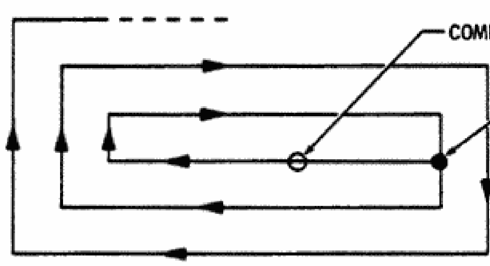
The search patterns are chosen as a function of the type of alignment and whether an A, B, or C star is being searched. See Figure 4-52. This table also lists the star ON light activity during star tracking operations.

Star Tracking Techniques

The star ON light provides the RSO with a guide for actions (listed in Figure 4-53) to optimize star tracking. Star tracking is automatic but the operator can assist the system in overcoming conditions such as overcasts, changes of sky background brightness, long

SEARCH PATTERNS AND STAR-ON LIGHT INDICATIONS

TYPES OF ALIGNMENT	STAR	SCAN RATE arc sec/sec	SEARCH AZIMUTH	SEARCH ELEVA-TION	MAXIMUM TIME REQUIRED TO COMPLETE SEARCH	AFTER TRACKING ★ LIGHT WILL:
Hot or cold airstart or when search unsuccessfully completed for - A after ground hot start or INERTIAL ONLY navigation.	A	1250	3^{0}	1^{0}	17.3 min.	Flash at 1 second intervals.
	A	703	2.3^{0}	$.8^{0}$	18.1 min.	Flash at 1 second intervals.
	A	395.5	1.9^{0}	$.6^{0}$	20.8 min.	Flash at 1 second intervals.
	A	222.5	1.4^{0}	$.48^{0}$	22.7 min.	Flash at 1 second intervals.
	B	all	$3^{0}12'$	6'	10.0 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Ground hot start or when changing mode from INERTIAL ONLY to ASTRO INERTIAL	A	all	36'	12'	3.9 min.	Flash at 1 second intervals.
	B	all	36'	12'	3.9 min.	Go off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
When INERTIAL ONLY was selected after ground alignment	C	all	12'	6'	0.6 min.	Go on steady (see note 3)
Rapid, gyro compass or runway heading alignment.	B	all	36'	12'	3.9 min.	Stay off
	B'	all	12'	6'	0.6 min.	Stay off (see note 2)
	C	all	12'	6'	0.6 min.	Go on steady (see note 3)



NOTE

1 All search patterns are expanding rectangular spirals with the first beginning at one side and passing horizontally across the computed star position.

2 Star B' (re-tracking of star B) is performed only if the azimuth error measured with star B is greater than 5.27 arc-minutes.

3 After tracking star C, the star light remains on until mode is changed to INERTIAL ONLY or five minutes have elapsed without tracking two different stars.

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Figure 4-52

periods of ground time after system initialization to A-I mode, refueling, and periods when tracking is not being accomplished. The operator should attempt to commence tracking stars as soon as possible to prevent or eliminate position error growth.

Improving Star Tracker Scan Rates

The ANS uses different scan rates for the star tracker depending upon the lightness of the sky background around the computed star position. This sampling of background conditions is accomplished automatically prior to beginning each star search. The time it takes the ANS to acquire a star depends on the magnitude of ANS errors. In extreme cases approximately twenty minutes could be required to acquire an A star.

An active (optimum signal-to-noise) filter to the ANS increases the probability of star detection, improves the accuracy of angle measurement, reduces the time devoted to detection and tracking of each star, and increases position and heading accuracy.

By using position fixes or remote updates, the RSO can reinitialize star search at the top of the star list (brightest star). This provides a new sky background lightness measurement and a change in scan rate if sky background lightness has changed. The RSO should use this procedure when there is a noticeable improvement in background conditions and the star ON light is not illuminated.

The RSO should periodically note the star tracking performance as indicated by the star light and star data in the Time display. If star tracking performance is less than expected (intermittent or no star light) for the existing sky conditions, the RSO should display day of year and note star number and scan rate. He should perform a zero remote update or command A, B, C Star Search to select the brightest star available (indicated by a number equal to or less than that previously indicated in SELECTED DATA window 2). This action will match the scan rate to the current sky background condition. A slower scan rate than that previously observed indicates less than optimum sky

CREW ACTIONS TO OPTIMIZE STAR TRACKING

CONDITION	ACTION
Search underway for A or B star.	Maintain straight and level flight.
Star ON light out.	Make maximum number of position checks.
Star ON light out after entering a good sky situation.	Restart star search by using zero remote update procedure.
Star ON light out more than 15 minutes after zero remote update procedure has been performed and good sky conditions prevail throughout.	Command star A tracking by changing mode to INERTIAL ONLY, then change back to ASTRO INERTIAL to increase search pattern size.
Preflight in hangar.	Select INERTIAL ONLY to terminate fine alignment. Select ASTRO INERTIAL after clearing hangar or cloud cover.

Figure 4-53

background conditions. If a star is not acquired, a repeat of these routines when the sky background improves could increase the scan rate thus improving the probability of star acquisition. The scan rates are selected by the computer based on sky background measurements in the vicinity of the star. There are four scan rates available and the one in current use is indicated in SELECTED DATA window 3 as a code R1 (1250), R2 (703), R3 (395) or R4 (222) (arc sec/sec) when using the Time display routine. A dark sky background increases the likelihood of tracking stars and induces a fast scan rate. Conversely, a bright sky background decreases the likelihood of tracking stars and induces a slow scan rate.

An example of when this procedure could assist star acquisition is: the system is put in A-I mode after completing ground alignment with haze or thin cirrus clouds; after takeoff and leveloff at 25,000 feet, the star ON indicator is not illuminated but the aircraft is now above all haze and cirrus. A zero remote update routine should cause the system to select a faster scan rate as a result of the darker sky background. In most cases, this will speed up star acquisition.

Commanding A and B Mode Stars

If a preflight alignment is performed while under cover, such as in a hangar, select the INERTIAL ONLY mode at the completion of fine alignment and remain in INERTIAL ONLY until clear of the covered area. This prevents false star acquisitions due to ceiling lights, etc. In this case the first star tracked after selecting ASTRO INERTIAL will be a B mode star.

The nominal error growth of the ANS in INERTIAL ONLY is based on pure inertial operation; that is, MODE in INERTIAL ONLY, disabling the tracker from star searching. The tracker slewing on top of the platform in search operation can induce further position error growth. Because of this, the operator should avoid leaving the ANS in the ASTRO INERTIAL mode when star tracking is not expected for 25 minutes or longer. Put the system in INERTIAL ONLY mode when star tracking is lost or is not expected for at least 25 minutes (e.g. during overcast conditions or operation behind a tanker.) Once INERTIAL ONLY has been selected, operation in this mode should be continued until suitable tracking conditions are encountered.

Above 60,000 feet, with nominal star availability and sun angle, the crew can expect A/B mode star acquisition in a few minutes after returning to the ASTRO INERTIAL mode.

NOTE

- Return the ANS to INERTIAL ONLY mode prior to entering a critical sensor "take" area if the star ON indicator has not indicated A/B star acquisition. This will inhibit A/B star updates which would cause auto nav roll transients.
- Although a star light generally indicates a bounded error of less than 1 nm, greater errors are possible. Computer and/or chronometer malflunctions have resulted in the star light being on when position error exceeded 10 miles.

Kalman Filter

The system employs a Kalman filter to optimally incorporate measurements from the star tracker, DAFICS M computer, and fixpoints to correct inertial system errors. The filter continually estimates the error state of 16 parameters:

1. Platform azimuth
2. Platform tilt axis 2
3. Platform tilt axis 3
4. Position error axis 2
5. Position error axis 3
6. Velocity error axis 2
7. Velocity error axis 3
8. Azimuth gyro drift rate
9. 2 axis gyro drift rate
10. 3 axis gyro drift rate
11. 2 axis accelerometer bias
12. 3 axis accelerometer bias
13. Telescope elevation bias
14. True airspeed scale factor
15. Axis 2 Wind
16. Axis 3 Wind

Each of these parameters has a calculated error probability which is initialized as a function of the type of alignment accomplished. During a ground alignment system position is monitored to detect deviations from the entered coordinates. These deviations are fed as measurements to the filter which utilizes them to refine the first ten listed parameters. When star measurements are obtained, the first thirteen parameters are refined, and when airborne, all sixteen elements are estimated and continually refined. Because of wind variability and the accuracy (±30 knots) of True Air Speed, the airspeed measurement has essentially zero influence on the first thirteen parameters except in the case of a cold and hot airstart. When fixpoint measurements are inserted by the operator, the filter adjusts the 16 parameters according to the ratio of their current estimated error state to the programmed accuracy of the fixpoint device (.05 nm for ASARS, .5 nm, for Viewsight, and 1.0 nm for TACAN). The system incorporates 100 percent of a fixpoint if the correction is more than 5.0 nm.

Dead Reckoning

Dead reckoning is performed simultaneously and separately from inertial navigation. During normal operation in ASTRO INERTIAL or INERTIAL ONLY, the dead reckoning latitude and longitude do not appear to the RSO unless the display Present Position routine is performed. However, prior to continuous star tracking in a cold or hot air start, or when DEAD RECKON is selected, dead reckon data is used as the source of present position and heading for all displays, great circle navigation and guidance, and sensor control. DEAD RECKON is the only mode in which present position can be entered after navigation is started; this may be done as often as desired. When DEAD RECKON is selected, the ANS generates all its normal outputs and continues astroinertial or inertial only navigation so that the DEAD RECKON mode can be selected for training while permitting return to ASTRO INERTIAL or INERTIAL ONLY modes. In normal operation, when dead reckon data is not used for ANS outputs, the dead reckoned latitude, longitude, and difference between INS heading and ANS true heading (magnetic variation), if applicable, are updated every four minutes using inertial data.

Dead reckoning is the process of computing change in position using heading, speed, and elapsed time. True airspeed from DAFICS (M computer) is used with RSO entered values of wind speed and direction to approximate ground speed. Heading is provided from the INS and is magnetic heading except that ANS inertial heading is used following coarse alignment in a hot or cold air start.

When INS mag heading is being used, the RSO must periodically fill local magnetic variation so that computed true heading will have minimum error. When dead reckon data is not being used, magnetic variation need not be filled since the ANS itself computes a new magnetic variation every four minutes.

MISSION TAPE PROGRAM

The mission profile is defined in terms of destination points (DP), control points (CP), and fix points (FP), and the sensor operations associated with these points. Destination points delineate the prescribed mission track; they are intersections of the intended great-circle legs. Control points and fix points permit automatic activation of imaging sensors, and fix points define preferred navigational references. The mission plan is loaded into the computer memory on a mission tape prior to preflight operations. The mission tape can be programmed to hold up to 256 DP, 256 FP, and 1023 CP (1535 total). Additional temporary memory is provided for 40 point modification operations, known as the "40-List". The modifications may be performed using the Control and Display panel anytime power is supplied to the panel. Up to 40 add and/or replace operations and unlimited skip-to operations, are provided. In addition, there are special Anytime and Opportunity fix point procedures which do not use the 40-List. The mission tape may include a primary flight plan with one or more alternate routes that the crew may elect to follow by exercising the skip-to, direct steer, or track leg update options. The add and replace options of the 40-List permit additional alternate paths to be formulated, and allow last-minute changes to sensor activity on programmed legs.

The data loaded into specified cells of the computer memory are identified by function and order of use in the mission plan (D00003, C00007, F00021, etc.). Each point is further defined by its coordinates, its sensor-usage, applicable pointing parameters, and reference to the next consecutive point or points. The destination points reference the next point of all three classes.

Great-Circle Steering

The mission path is a sequence of great-circle legs computed on the basis of DP coordinates. The ANS supplies a steering (bank angle) command to the autopilot in all ANS navigation modes but it is usable only when all requirements for a "nav-ready" condition are present. In the autopilot AUTO-NAV mode, bank angle is commanded by the ANS to automatically guide the aircraft onto and along the preprogrammed flight path. The bank angle steering command is computed from aircraft cross-track position and velocity relative to the desired course. If the planner has scheduled a bank angle of 35° or less, the ANS will not command a bank greater than 35°, even if a higher bank is required to keep the aircraft on course. If the turn is planned above 35° (up to 42°) the ANS will command up to 45° to keep the aircraft on course.

If the AUTO NAV mode is engaged when the aircraft is considerably off track, the ANS will steer towards the desired track at a 30° intercept angle. Depending on current groundspeed, the ANS will compute where to initiate a turn to discontinue the intercept course and smoothly fair onto track. During supersonic cruise this point is approximately 20 nm off course.

Once on course, the aircraft should usually be within 300 feet of the commanded course, except in turns. Actual position of the track is dependent on ANS navigation accuracy.

ANS Steering Turn Modes

The mission planner can choose one of two different turn modes at each DP. These modes determine where the turn start to the next great circle leg will occur and the amount of bank angle commanded during the turn.

Auto-Range-To-Turn

The system computes the turn radius based on a 32° bank angle and the groundspeed at the start turn point. Once the turn is initiated, it is identical to the turn described in the Fixed-Range-To-Turn paragraphs.

Auto-Range-To-Turn should be used for subsonic turns to prevent high bank angles at heavy weights. Current groundspeed and the heading change from present course to next are used to compute and initiate an automatic turn (termed by the mission planners as Turn Start Automatic, or TSA). The TSA point varies since it depends on groundspeed. If actual groundspeed is different from planned groundspeed, the TSA will not occur where planned and the aircraft will not follow the turn line depicted on the strip map. However, if there are no other disturbances, the aircraft should make the turn at a 32° bank angle.

Fixed-Range-To-Turn

Fixed-Range-To-Turn is used by the mission planners for turns that indicate critical sensor legs and turns where strict adherence to the planned turn line is required. In this mode, the mission planner specifies a constant turn radius at a particular DP. The TSA point is a fixed distance plus a variable distance from the DP. The fixed distance is determined by the programmed turn radius and the change in course; it would be equal to turn radius on a 90° turn. The variable distance ranges from 0 to 4.5 nm, depending on groundspeed, and compensates for the distance required to roll into the turn. During the turn, commanded bank angle is the sum of two components. One component is the nominal bank required to achieve the programmed turn radius at the current

TYPICAL DESTINATION-POINT PLAN

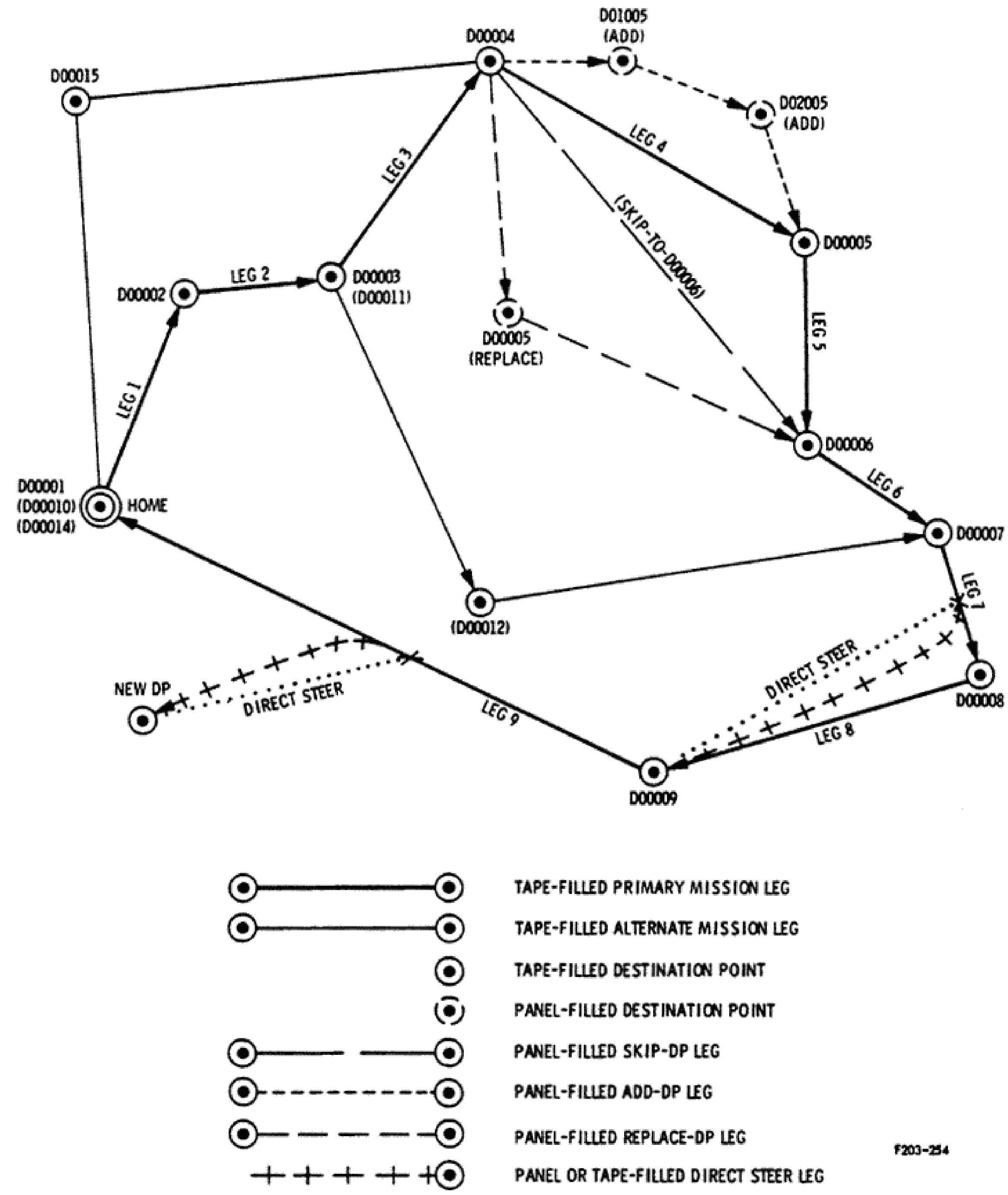


Figure 4-54

ground speed. The second component trims bank angle trim as a function of the radial speed and position relative to the programmed radius so that the aircraft follows the planned turn line throughout the turn. If a transient causes the aircraft to deviate from the turn line, bank angle trim varies within $\pm 10^\circ$ to return to the turn line.

Range to destination as displayed on the HSI and the NCD includes distance around a turn rather than the length of the great circle from present position to destination. This distance around the turn is also used in computing time to turn for the NORMAL display.

Turn steering automatically terminates when aircraft track is within 2° of the command course, the new track is crossed, or the theoretical tangency point is passed.

The sum of the nominal commanded bank angle and the bank angle trim is limited to the ANS maximum bank angle command of 45 degrees. Refer to Figures 4-14 and 4-15 for bank angle vs speed and turn radius information.

NOTE

> During preflight planning, do not schedule any turns above Mach 2.9 which have a radius smaller than can be maintained using a 42° bank angle.

Turns should be planned to require at least three degrees less than the planned bank angles limits. This provides a margin to accommodate aircraft trim requirements and/or greater ground speed than expected. However, when below Mach 2.9, bank angles of up to 44 degrees may be scheduled if justified by operational requirements. Crews should monitor ANS groundspeed prior to and during turns and prevent ground speed from exceeding the maximum value at which the planned track can be accomplished within bank angle limits.

When scheduling turns with greater than 35° bank angle, allow for expected altitude loss if maximum power will not maintain level flight. Refer to Parts V & VI of the Performance Data appendix and to the ceiling altitude data, Figure 6-8, in Section VI. When scheduling turns requiring 42° bank angle at speeds above Mach 3.0, consider the altitude at the turn (which is a function of weight) and the programmed Mach. For a given weight and bank angle it may be necessary to decrease altitude, which at a given Mach may increase the KEAS to the KEAS limit. Turns at maximum scheduled bank angles must not be programmed for such heavy weights that the maximum KEAS limit for normal operation would be exceeded. A descent of approximately 2500 to 3000 feet below the maximum range altitude may have to be made before entering a 42° bank turn.

In normal operation, the aircraft will follow the turn line and roll out onto the next leg within 0.2 nm. ASARS will be unaffected by maneuvering. For the TECH camera(s), roll and pitch rate should be less than 0.3° per second for good photography. During most of the settle out distance, roll rates will be slight and suitable for good photography.

During a SKIP TO operation, the same fixed turn radius is used, but a different TSA and turn line will result if the next leg is different from the planned leg.

Manual Steering

The ANS provides navigation information so the pilot can manually steer the aircraft. The bank steering bar on the ADI indicates the error between aircraft roll angle and ANS bank angle command and centers when the two are equal. Centering the bar steers the aircraft on the same path as AUTONAV steering.

The pitch steering bar of the ADI indicates altitude rate (0 to $\pm$3484 fpm) and is used to maintain altitude.

The HSI displays true heading, command course, range to next DP, and cross track deviation (0 to $\pm$ 1 nm). These displays are relative to the turn line during turns or the great circle leg following turns; the range value represents the distance around the turn plus distance along the next leg.

Control Points (CPs)

The technical objective cameras (TECHs) are turned on or off and pointed as the aircraft's along-track range to the next destination point coincides with the CP's along-track range to the next destination point. CPs bracket the target, with the turn-on control point at the same cross-track range as the target. The ANS computes the camera pointing angle required to cover the CP, and thus the target. (Actual target coordinates are not stored in the computer.) Camera CPs can be programmed along the turn line in Fixed-Range-To-Turn turns. Here the CP is located at the same radial distance from the turn line as the target.

The ASARS utilizes control point information to generate required parameters which are sent via a 64 word serial data bus. It contains such items as: aircraft velocities, target vectors, gravity anomaly values and radar operating modes. This information allows the ASARS computer to generate the desired imaging commands.

The mode commands to the TECH(s) are updated at each CP so that more than one sensor can be turned on or off at a single point. Dedicated CP's are required for ASARS operation. All CP's and FP's on a leg are processed on that leg, even if a mission planning error or a panel-filled change puts a CP or FP past the start turn point at the end of a leg.

ASARS Control Point MODE

Digit 1:	Always M
Digit 2:	0 = Normal 1 = Dual Spot (Not available) 2 = Measure Altitude
Digit 3:	0 = Neither Set 2 = Rewind 4 = Down Link (Not available) 6 = Both Set (Not available)
Digit 4:	0 = Frequency F1, Low Resolution 1 = Frequency F1, High Resolution 2 = Frequency F2, Low Resolution 3 = Frequency F2, High Resolution 4 = Frequency F3, Low Resolution 5 = Frequency F3, High Resolution 6 = Frequency F4, Low Resolution 7 = Frequency F4, High Resolution
Digit 5:	0 = Standby 1 = Acquisition/Measure Altitude 2 = Search 4 = Spot
SENSOR "L" On =	Leave recorder on after this swath
SENSOR "L" Off =	Turn recorder off after this swath

Figure 4-55

Control point information is displayed on the NCD panel. With the DATA SELECT switch in NORMAL the NCD can display either ASARS or non-ASARS fixpoint and control point ID's in SELECTED DATA window numbers 3 and 6. ASARS or non-ASARS information is alternately selectable via the ENTER/DISPLAY switch. ASARS control points in NORMAL are designated by AXXXX vice CXXXX for non-ASARS control points.

ASARS control point mode information can be displayed on the NCD panel. This information is displayed in SELECTED DATA window number 3 with the DATA SELECT switch in CONT PT. ASARS control point mode information is shown in Figure 4-55.

Fix Points (FPs)

FPs are accurately known and readily identifiable points along the mission path that are used in measuring ANS position error with the ASARS and Inflight Processor Display (IPD), viewsight or TACAN. FPs are used to determine ANS error at the time of the fix. The ANS can be corrected by depressing the UPDATE button, or the routine can be terminated without updating the ANS by depressing the MAN CLEAR pushbutton. FPs using ASARS can be used to improve ASARS pointing information without updating the ANS by pressing READ ERROR on the Radar Control panel but not pressing UPDATE.

The ASARS is automatically turned on prior to a planned fixpoint. Fixpoints define the end of an acquisition swath and may also be planned during a search swath. When a fixpoint is approaching, the IPD FIX legend appears and flashes. At the planned fixpoint the FIX legend will go steady, the moving imagery display freezes and crosshairs appear. At this time the IPD RUN/HOLD button indicates HOLD. The RSO uses the joystick to position the crosshairs over the fixpoint. Depressing the IPD READ ERROR button sends north-south and east-west errors

TYPICAL ADD/REPLACE PLAN FOR FIX AND CONTROL POINTS

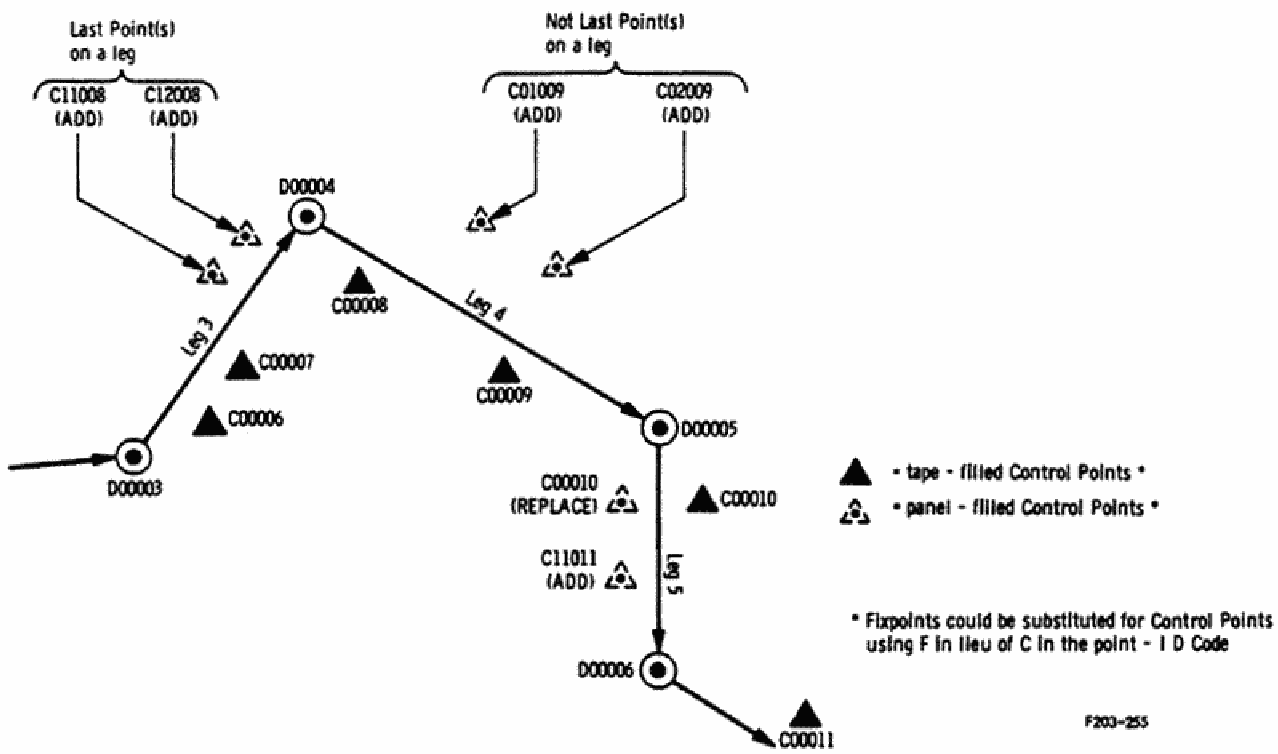


Figure 4-56

to the ANS and pointing information is corrected and used for all subsequent ASARS operations. The ASARS IPD will then resume preplanned operations and the RSO has the option of updating the ANS or clearing the errors. Clearing the ANS errors does not remove the ASARS pointing information correction.

ASARS fixes are accurate to about .050 nm CEP.

For viewsight FPs, the RSO normally uses wide angle view to search for the FP as it approaches. After identifying the FP, select narrow view, if possible, for maximum accuracy. As the FP passes down the viewsight screen, move the cursor to intercept the FP as it passes under the nadir line. At that instant, press the viewsight READ switch. This provides the ANS with the location of the FP relative to the aircraft and allows measurement of ANS computed position error. Again, the errors appear in north-south, east-west values on the NCD after the READ switch is pressed. Viewsight fixes are accurate to about 0.5 nm CEP.

At TACAN FPs, ANS computed values of slant range and bearing to a TACAN station are displayed on the NCD for comparison with TACAN data observed on the BDHI. When a TACAN fix is desired, depress the TACAN switch, then enter the TACAN values of magnetic bearing (xxx°) and slant range (xxx nm) at the time the TACAN button was actuated. The ANS will then display the north-south and east-west errors. TACAN fixes are accurate to 2 to 3 nm at slant ranges from 20 to 200 nm. Accuracy is degraded at less than 20 nm and greater than 200 nm. The range data can generally be accepted, but TACAN bearing information may be somewhat inaccurate. When the INS is in the ATT mode, the TACAN mag bearing is correct, but the relative bearing may be in error.

If desired, the ANS computed position can be corrected by pressing the UPDATE switch; otherwise, press the MAN CLEAR switch to clear the measurement data. If FPs are used for updating, the ANS adjusts position, platform level, velocity, and heading based on the Kalman filter weighing matrices. The amounts applied to each of these parameters are optimized for the existing mode. Generally, corrections will not be necessary in the ASTRO INERTIAL mode although the measurement should be made to check the system.

Non-ASARS sensor operation may also be planned and commanded at FPs. The point of execution will be at the along track position determined by the FP abeam point plus the range-to-turn-on value in the FP data of the mission tape. The TECH(s) may be turned on or off at any tape-filled FP. The camera(s) will be pointed and have the modes programmed at previous CPs. ASARS does not utilize a non-ASARS CP or FP.

MISSION MODIFICATION

The tape-filled mission program can be modified through the NCD panel. Up to 40 sets of data (40-List) may be entered to replace or add to previously stored mission points. In addition, the operator can skip any number of tape-filled or panel-filled destination points, or change destination. There are also special panel-filled fixpoints called Anytime or Opportunity fixpoints that are exclusive of the 40-List.

Add or Replace CP-FP-DP Routine

The mission tape is stored in the tape-filled memory of the computer. Panel-filled data for mission modification is stored in the panel-filled memory of the computer. Only Add or Replace modifications use the 40 panel-filled memory cells. Data required for each type of point, both panel-filled 40 List and tape-filled points, is listed in Figure 4-11 (non-ASARS). If necessary, the RSO can clear any or all of the mission modification data entered into the panel-filled memory and enter new data in the same 40 memory spaces. Detailed knowledge of the tape-filled mission is required to modify that mission, especially when control points or fixpoints are added or replaced.

Point-ID Code (Non-ASARS)

Every tape-filled or 40-List mission point has an identification code. The code consists of a letter and five digits, referred to in the following text as digits 1, 2, 3, 4, and 5, counting from the left. This is the order in which the point-ID code is entered in the NCD panel. A letter C/C1, F/F1 or D designates the point as a control point, fixpoint, or destination point, respectively, and appears in the left-most display of the SELECTED DATA window 6 when a mission point is selected for display. When modifying a mission, this part of the ID code is entered by selecting FIXPOINT, CONT PT, or DEST POINT on the DATA switch.

Digits 3 thru 5 of the ID code denote the number assigned to each tape-filled CP, FP, and DP. Tape-filled points are numbered starting with 001 for the first CP, FP, and DP. In general, the points on the primary mission are numbered in sequence followed by the points on alternate legs. However, the sequence is not really important since the next point number of each type is listed with each tape-filled mission point; i.e., the data for DP 002 can define DP013 as the next DP, or vice versa. The same applies to CP's and FP's.

As shown on Figure 4-54, DP's which are the start points for alternate legs are doubly defined. This means that the same geographic point is contained in two different locations with different number and different next-point numbers (example: D00003 and D00011). The alternate leg is selected by skipping to D00011 when on leg 1. Note that the alternate path rejoins the primary mission at D00007; thus, both D00006 and D00012 list D00007 as the next DP. 40-List (ADD or REPLACE) points are defined relative to tape-filled points; digits 3 thru 5 define the tape-filled point to be replaced, or the tape-filled or panel-replaced point following the point(s) to be added.

Digit 2 is the "add" number for panel-filled ADD points. Digit 2 can range from 1 to 7 for the first through seventh points to be added ahead of the tape-filled or panel-replaced point of the same type defined by digits 3 thru 5, where add point X10YZ is the first add point encountered in the mission, ahead of point 000YZ with add point X20YZ the second, etc. Digit 2 is zero for tape-filled points or replaced points. Digit 2 is the left-most digit in the SELECTED DATA window 6 when a mission modification is performed or a mission point is displayed.

Digit 1 is a zero for all tape-filled points, replaced control or fix points, and 40-list destination points. When adding fix or control points, however, digit 1 is used by the computer to determine the track leg location of the new added point. If the add point is after the last tape-filled point of its type on its track leg, this digit is 1; if the add point is before the last tape-filled point of its type on its track leg, then the digit is a zero. Digit 1 appears as C1 or F1 in the letter position of the SELECTED DATA window 6 during a mission modification or mission point display operation (when ID code is entered). It also appears when a point is displayed.

Point ID Code (ASARS)

Like non-ASARS points every 40-List mission point has an identification code. The code consists of a letter and five digits, referred to in the following text as digits 1, 2, 3, 4 and 5, counting from the left. This is the order in which the point-ID code is entered in the NCD panel. A letter C or F designates the ASARS point as a control point or fixpoint.

Digits 2 through 5 are the same as the corresponding digits of the non-ASARS Point-ID code. Digit 1 is always zero for all replaced ASARS Fixpoints and added or replaced ASARS control points. No ASARS control or fixpoints can be added after the last tape-filled point of its type on a track leg.

Sensor Selection Code (Non-ASARS)

The three-digit sensor selection code designates which sensor shall be turned on and/or remain on, at a panel-filled control point.

The first and second digits control L and R TECH camera operation. The third digit is always zero. When control points are added or replaced, take care not to disrupt prior turn-on commands to the TECH cameras. If, for example, the L TECH was automatically turned on 50 nm prior to an add R TECH control point, and the mission planner intended it to remain on for a total 100 nm swath, the add-control point sensor assignment code would be 110. This would tell the computer to leave the L TECH on at the new control point and that the R TECH will be turned on. This is necessary because each CP will turn sensors off without an "on" marker in the sensor code.

Left-Right Camera Pointing Code

The left-right marker designates which TECH camera to operate. When adding or replacing

SENSOR SELECTION CODE

SENSOR	CODE		
L TECH	1	0	0
R TECH	0	1	0
Verify code insertion on panel by illumination of appropriate sensor indicator.			

Figure 4-57

TECH camera control points, insert L000 or R000 for control points to the left or right of course respectively. Verify code insertion in the SELECTED DATA window 5 (R or L plus three numeric digits).

ASARS Control Point Code

A five digit code designates which feature of the ASARS will be activated at a panel-filled control point.

Digit 1 is used to select the dual spot mode. Digit 2 selects rewind and/or downlink options. Digit 3 specifies resolution and frequency characteristics. Digit 4 defines the mode and Digit 5 controls the recorder status. Digits 1 thru 4 are displayed in SELECTED DATA window 5 as they are entered. Selection of 1 for Digit number 5 will be indicated by illumination of the TECH L light. These codes are shown in Figure 4-58.

ASARS Fix Point Code

ASARS Fixpoints cannot be added. Fixpoints can be replaced by entering the new latitude, longitude, and terrain elevation.

40-List Add/Replace FP-CP-DP Limitations

Add/replace can be performed in any ANS mode except OFF or WARM UP. Add/replace alters the tape-filled mission. If the added point is located before the "next point" of each type on the current leg, or the replaced point is the current "next point" of each type, then the RSO must fill the new points into the 40-List and then perform a Track Leg Update. This will cause the ANS computer to recognize and use these new 40-List points. For example, if the first tape-filled leg is changed by replacing or adding DPs, a Track Leg Update will reinitialize the computer to the new first leg.

Any filled 40-List points located after the current "next tape-filled point" of each type will be utilized in the normal ANS sequence and no Track Leg Update is required (see Figure 4-56).

ASARS Control Point CODE

Digit 1:	L = Dual Spot (Not available) R = Normal
Digit 2:	0 = Neither Set 2 = Rewind 4 = Down link (Not available) 6 = Both Set (Not available)
NOTE:	Selection of 4 or 6 will result in no ASARS imagery being recorded.
Digit 3:	0 = F1, Low Resolution (Spot only) 1 = F1, High Resolution (Spot only) 2 = F2, Low Resolution (Acquisition and Search only) 3 = F2, High Resolution (Not available) 4 = F3, Low Resolution (Spot only) 5 = F3, High Resolution (Not available) 6 = F4, Low Resolution (Acquisition and Search only) 7 = F4, High Resolution (Not available)
NOTE:	Extreme care must be exercised in selecting resolution and frequency. Non-available combinations of mode (Digit 4) and Resolution/-Mode may be selected resulting in no ASARS activity.
Digit 4:	0 = Standby 1 = Acquisition 2 = Search 4 = Spot
Digit 5:	0 = Turn recorder off after this swath 1 = Leave recorder on after this swath

Figure 4-58

NOTE

A FP/CP/DP in the 40-List must be deleted before a correction/modification can be made to that numbered point.

Points may be added before replaced tape-filled DPs. A maximum of seven points of one type can be added in between two tape-filled points of that type. Points cannot be added after the last tape-filled point of that type. FPs and CPs cannot be added into track legs that contain no tape-filled FPs or CPs except an Anytime Fixpoint (described later) can be added to a leg that has no tape-filled FPs. If a FP is replaced, any sensor activity programmed at the original tape filled-point is negated, that is, will not occur. The sensors should then be operated in the Manual Mode. If a FP is added, there is no effect on the programmed camera activity. Adding a viewsight FP does not affect programmed radar activity.

ASARS Acquisition Mode CPs cannot be added or replaced. Acquisition Mode FPs may be replaced. ASARS Search Mode CPs may be added in pairs preceeding other ASARS CPs but no FPs can be placed on a newly created swath. Search mode CPs can be replaced, but will result in FPs on that swath not being processed. Spotlight or standby ASARS CPs may be replaced or added to existing ASARS CPs. ASARS CPs and FPs may only be added to the same leg as the referenced point, not to the preceeding leg. Measure Altitude CPs and FPs cannot be added or replaced.

The ANS does not automatically stop processing CPs and FPs on the original tape-filled leg when navigating on a leg from a tape-filled DP to an added or replaced DP; or from a replaced DP to any type of DP. In these cases, the CPs and FPs on the original leg are processed relative to the new leg. In general, pointing and mapping commands will be incorrect, and unless all CPs and FPs can be projected on to the new leg, a sensor could be commanded on but not off. Therefore, the sensors should be operated in their manual modes or tape-filled CPs and FPs should be replaced. No CPs and FPs are processed when navigating from an added DP to any type of DP.

After a power dropout, pressing RAPID or MODE START on the ground with the MAL light flashing will erase the 40-List. Anytime a rapid or gyro-compass ground alignment is performed, 40-List data must be re-entered. 40-List data is not deleted if the HOT switch is pressed with the MAL light flashing or a cold airstart is performed. Therefore, 40-List data is retained for a ground hot start, cold airstart, or a hot airstart. Pressing the MODE START switch without the MAL light flashing has no effect on the 40-List.

Turn Radius For Panel-Filled DPs

A turn radius can be filled with any panel-filled DP to get a fixed-range-to-turn at that DP. This data is filled in nautical miles with three digits and appears in the SELECTED DATA window 3. If no turn radius is filled, the system calculates the turn radius based on current groundspeed and a 32° bank angle. Figure 4-59 lists turn radius values for various Mach numbers and bank angles.

NOTE

> A turn radius for a bank angle greater than 35° will only be commanded by the autopilot if the original programmed bank angle for that turn start point (TSP) was greater than 35°. The autopilot will otherwise be limited to 35°.

Delete DP/FP/CP Procedure

The DELETE procedure can erase a panel-filled DP, FP, or CP from the 40-List so that the memory space can be re-used, or that a mistake in manually entering a point can be rectified without clearing the entire 40-List. Tape-filled points cannot be deleted.

Add FP Anytime Procedure

The ADD FP ANYTIME procedure is identical with the ADD-FP procedure except that no ID code is entered and the entry does not go into the 40-List. The procedure allows the RSO to add viewsight or TACAN fixpoints on legs that have no tape-filled FPs (during critical phases of hot or cold airstarts; on skip-to or direct-steer legs; or any time).

The Anytime FP can only be entered when on the great-circle leg on which it is to be used.

Actuation of the viewsight READ switch deletes a viewsight FP. A TRACK LEG UPDATE or DIRECT STEER procedure also deletes an Anytime FP. There is no provision for ASARS Anytime FPs.

When a viewsight Anytime FP is inserted, no tape-filled or panel-filled fixpoints on that track leg are processed until the RSO presses the viewsight READ switch. Camera and ASARS control points are not affected by the viewsight Anytime FP routine.

TACAN Anytime FPs do not affect sensor programming at tape-filled control points or fixpoints.

Opportunity Viewsight Fix

The Opportunity viewsight fix allows the RSO to update ANS present position using a visually identified point which has not been tape or panel-filled into the ANS. In this procedure the RSO aligns the cursor and presses the READ switch as in a normal viewsight fix routine. As the coordinates of the opportunity point are not previously stored in the computer, the initial display of ANS corrections is meaningless. However, these initial corrections are cleared when the RSO fills the latitude, longitude, and elevation of the opportunity point. When the ENTER/DISPLAY switch is pressed after coordinate entry, new errors are displayed. The RSO can then either clear the errors or enter the corrections.

The RSO can repeat the coordinate entry if an error is made in the initial entry by pressing the ENTER/DISPLAY switch and reentering all data required. However, if ERR is displayed in the MODE window, MAN CLEAR must be pressed to terminate the routine and no update is possible.

Skip to DP Routine

The following examples refer to Figure 4-54.

When the skip-to routine is performed, the following DP number associated with the current next DP is replaced with the skipped-to DP number. This procedure can be used to select an alternate route in flight. For example, perform skip to D00011 while enroute from D00001 to D00002 and before reaching the range-to-turn to D00003, to select the alternate route from D00002 to D00011 to D00012, etc. This procedure could also be used to skip any portion of the programmed mission. For example, to skip from D00004 to D00006, perform a "skip to D00006" while enroute from D00003 to D00004 and before reaching the range-to-turn to D00005. Do not perform a skip from a doubly defined destination to its alternate destination since this creates a zero-length leg and unpredictable navigation results. For example, do not perform a "skip to D00011" after reaching the range-to-turn to D00003 and enroute to D00003 since the leg from D00003 to D00011 has zero length.

Skipping to a DP after starting great-circle navigation does not erase CP or FP operation on the original programmed leg following the current next DP. Consequently, skipping to D00011 to select the alternate route does not eliminate the sensor operation on the leg from D00002 to D00003. On the other hand, skipping to D00006 while enroute to D00004 will not eliminate the CP's and FP's along the original leg from D00004 to D00005, and the system will process these points. In this case, the sensors could be operated in their manual modes until back on the programmed mission course.

Direct Steer

The direct-steer procedure results in an immediate change in destination. When commanded, the ANS computes a new great-circle course from the present position to the destination point selected or coordinates entered by the RSO. The aircraft turns to the new course immediately after the DIR STEER switch is pressed. The ANS computes new great-circle courses to the selected DP or coordinates until the aircraft has turned to within 2 degrees relative bearing to the destination. This results in the most direct path to the destination. If aircraft track subsequently deviates more than 2 degrees from command course, the direct steer is

ANS BANK ANGLE VS TURN RADIUS FOR VARIOUS MACH NUMBERS

FAT = -56^{o}

Mach No. KTAS*	2.80 1606	2.85 1635	2.90 1664	2.95 1693	3.00 1721	3.05 1750	3.10 1779	3.15 1807	3.20 1836	3.25 1865
Bank Angle	Turn Radius (KR) - NM									
Deg.										
20	105	109	113	117	121	125	129	133	137	142
21	100	103	107	111	114	118	122	126	130	134
22	95	98	102	105	109	112	116	120	124	127
23	90	93	97	100	103	107	110	114	118	121
24	86	89	92	95	99	102	105	109	112	116
25	82	85	88	91	94	97	101	104	107	111
26	78	81	84	87	90	93	96	99	102	106
27	75	78	80	83	86	89	92	95	98	101
28	72	75	77	80	83	85	88	91	94	97
29	69	72	74	77	79	82	85	87	90	93
30	66	69	71	74	76	79	81	84	87	89
31	64	66	68	71	73	76	78	81	83	86
32	61	63	66	68	70	73	75	77	80	82
33	59	61	63	65	68	70	72	75	77	79
34	57	59	61	63	65	67	69	72	74	76
35	55	57	59	61	63	65	67	69	71	74
36	53	55	56	58	60	62	65	67	69	71
37	51	53	54	56	58	60	62	64	66	68
38	49	51	52	54	56	58	60	62	64	66
39	47	49	51	52	54	56	58	60	62	64
40	46	47	49	51	52	54	56	58	60	61
41	44	46	47	49	50	52	54	56	57	59
42	42	44	46	47	49	50	52	54	55	57
43	41	42	44	46	47	49	50	52	54	55
44	40	41	42	44	45	47	49	50	52	53
45	38	40	41	42	44	45	47	48	50	52

*KTAS based on Mach 1.0 = 573.6 knots at $-56.5^{o}C$ ambient air temperature.

KR = 14.815 $(V/1000)^2/\tan \phi$ for ANS System turn; where V = KTAS, ϕ = bank angle.

Figure 4-59

automatically restarted. When the DIRECT STEER procedure is performed, ANS operate commands to the sensors are turned off. The ADD ANYTIME FP and OPPORTUNITY Viewsight Fix procedures are usable while in DIRECT STEER if the aircraft track remains within 2 degrees of the bearing to the DP during the Fix procedure.

Track Leg Update

The Track Leg Update procedure allows the RSO to change the current ANS track leg. Any track leg segment in the mission may be selected. The RSO fills the ID code number of the beginning DP of the leg he desires.

ANS TURN RADIUS VS. TRUE AIRSPEED & BANK ANGLE

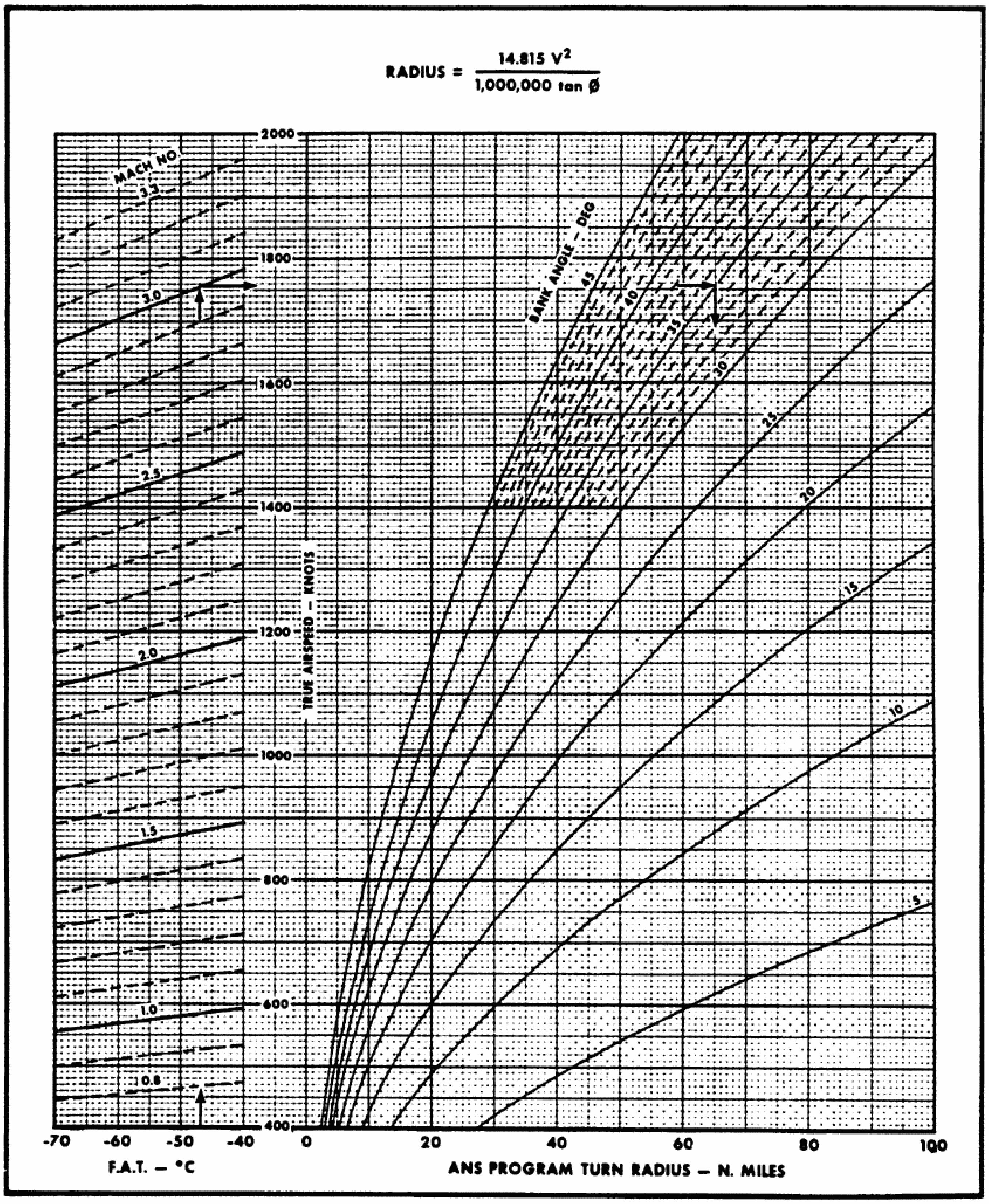


Figure 4-60

NAVIGATION MODES VS ALIGNMENT METHODS

	NAVIGATION MODE	ALIGNMENT METHOD WITH NDC -1070 COMPUTER		
GROUND ACTIVATION	ASTRO INERTIAL INERTIAL ONLY	**GYROCOMPASSING**		
		- Warm up	60 min	95 min 55 sec
		- Coarse align	6 min	
		- Fine align	29 min 55 sec	
		1st align -	12 min 15 sec	
		slew 90° -	1 min 30 sec	
		2nd align -	16 min 10 sec	
		RAPID		
		- Warmup	60 min	78 min 15 sec
		- Coarse align	6 min	
		- Fine align	12 min	
		GROUND HOT START		
		- Coarse align	50 sec	90 sec
		- Restart	30 sec	
INFLIGHT ACTIVATION	AIRSTART	**AIRSTART**		
		- Coarse Align Phase	Until platform is rough leveled (< 40 arc min)	
		- Restart	Until platform is leveled (< 21 arc min)	
		- Navigate Phase	Continuous after platform leveling	
		Dead Reckon	Continuous from FILL PP (during coarse align) to ★ ON (steady)	
		Search for Star A & B	Continuous from platform leveling + 5 min to ★ ON illumination (steady)	
		Airmass-damped, astro inertial navigation	Continuous after ★ ON illumination (steady)	

F203-256(o)

Figure 4-61

The ANS then initializes to the leg from that DP to the next sequential tape-filled or 40-List DP. Great-circle navigation and sensor control are immediately conducted relative to this new leg. The ANS sequences through all FP's and CP's on the new leg up to the current computed along-track position, where sensor commands will be as programmed for that point on the track; normal auto-nav steering is performed, using a 30-degree approach to the new track, if necessary.

The RSO should perform a track leg update during a Hot or Cold Airstart and Ground Hot Start since the computer automatically re-initializes to the first track leg segment on the mission tape at system turn-on.

NOTE

If the current groundspeed and/or present position satisfy turn start criteria to the next leg, then the ANS will accept the updated track leg and immediately "index" to that next track leg.

ANS OPERATION

The ANS must be warmed up and aligned before flight. The methods for ground and air alignment and their association with various navigation modes is outlined in Figure 4-61.

CHRONOMETER/OPERATION OPTIONS

Status of Chronometer Installed	RSO Mode Options	Hot Start Program Retained
A. Accurate, GO	Any	Yes
B. Inaccurate, GO	Do not fill DAY/TIME. INERTIAL ONLY selected after align.	Yes, no star tracking possible.
C. Inaccurate, GO	Fill DAY/TIME - ASTRO INERTIAL selected after align.	No, star tracking available. (Recommended procedure.)
D. NO/GO or Chronometer disconnected or not installed.	Any. But any power dropout of any duration will cause drop out of ANS. New alignment or Cold Airstart will be required. This situation very undesireable and ANS dropout is highly probable in flight due to electrical system interruption or transient below 103 volts.	No.

Figure 4-62

Prior to ground alignment, verify that the prescribed mission program is in the computer and that the portable chronometer is installed and operating. Power and cooling air are required continuously through warmup, alignment, and navigation. Once alignment has started, a power interruption of more than 1 second will require realignment. Normally, warmup and alignment are performed on ground power and cooling air with transfer to aircraft power and cooling air after engine start, but can be performed on aircraft power and cooling air after engine start.

Tape 13 is compatible with increased altitude resolution from DAFICS. This feature requires hardware changes to DAFICS. To verify correct system configuration the RSO must check proper altitude scaling by performing the Altitude Scaling Test routine. This routine compares the ANS altitude to the TDI. The altitude readings must agree, otherwise, notify maintenance.

When operating from an alternate base without ANS support personnel, the chronometer day/time accuracy must be checked. If a flight with an accurate chronometer installed terminates at an alternate base, the chronometer can be (a) maintained indefinitely in an accurate GO state by connecting ground power and cooling to the aircraft with the MODE switch OFF and the aft cockpit ANS essential DC circuit breaker in, or (b) left in the aircraft after normal shutdown procedures are completed. In the latter case, if the battery ON/OFF switch is left in the ON position, the chronometer battery will run down in approximately 24 hours and the chronometer will stop. After power is reapplied to the aircraft and the battery ON/OFF switch is in the ON position, the chronometer should display a GO status and begin to charge its internal battery. If the chronometer is in a GO status, but merely incorrectly set, fill DAY/TIME during C/A and operate in the ASTRO INERTIAL mode. (In a ground hot start, the C/A mode lasts only 60 seconds.) After filling DAY/TIME, the difference between RSO filled values and chronometer values is retained as a bias term to update the computer time following power dropouts of less than 1 second. Thus, astro inertial navigation should function normally. Power dropouts that exceed 1 second will not be compensated for.

After filling DAY/TIME a Hot Airstart cannot be performed and a new ground alignment or Cold Airstart is required. Chronometer options are listed in Figure 4-62.

NOTE

> Takeoff without a chronometer or with a NO/GO is permitted but not recommended. ANS mode options are the same for any of these conditions, but are subject to conditions discussed under Power Dropout and Chronometer Failure in this section under Malfunction Indicator. Also refer to Flashing MAL Light On During Ground Operation and Flashing MAL Light On In Flight, this section.

Warmup

Turn the MODE switch from OFF to WARM UP. The MAL light will illuminate steady. Monitor the TEMP LIMIT light. If the light remains out, the MODE switch can be moved to an "operate" position. If the TEMP LIMIT light is on steady or flashing, immediately turn the MODE switch to OFF and check ANS cooling. The MODE window display is blank in the WARM UP mode.

Ground Alignment

When the MODE switch is moved from WARM UP to ALIGN or an "operate" mode, full operating power is applied to the entire system and alignment begins. The MODE window indicates the current phase of alignment. Initially, the MODE window reads C/A, and the computer starts the self and system test routines. A flashing MAL light comes on when full operating power comes on and is reset by pressing the MODE START, or RAPID, or HOT switch; it will relight if the computer test routines detect a malfunction or power dropout.

Upon successful completion of the test routines, the computer automatically starts alignment beginning with the coarse phase. Coarse alignment time (5 to 6 minutes) is the same for all ground-start cases except ground hot start.

Except for hot starts, fine alignment begins after completion of coarse alignment if present position coordinates have been entered. Do not enter present position until the TEMP TOLR light extinguishes.

NOTE

> Except for hot starts, enter either magnetic variation or true heading prior to entering present position and field elevation.

The optimum method of alignment is gyrocompassing. The 30-minute fine-alignment phase includes gyrocompassing. Gyro compassing determines the orientation of the platform relative to true north. Fine alignment accurately levels the platform to the local vertical.

An alternate method of ground alignment is the rapid alignment. In this mode, the system automatically goes directly to a 12-minute fine-align period from coarse align. During fine align, the gyros are rated and the platform is leveled. Since gyrocompassing is not performed, a runway heading alignment should be performed during takeoff following a rapid alignment unless the aircraft true heading in the parking location is known within 0.1 degree or the star ON light illuminates before flight.

Completion of fine alignment (and gyrocompassing) is indicated by display of present position coordinates in the PRESENT LATITUDE/LONGITUDE windows. For optimum navigation performance, remain in fine-alignment until just before taxi. If the aircraft will be stationary for 5 minutes or more after a navigation mode has been initiated, use the Ground Alignment Correct procedure. This procedure puts the system back into fine align and removes any velocity error induced by taxiing. Star tracking will continue during the alignment if it was in progress.

Alignment Mode Selection

The ANS is aligned by setting the MODE switch to ALIGN, ASTRO INERTIAL or INERTIAL ONLY and pressing either the MODE START switch or the RAPID switch.

For a gyrocompassing alignment, set the MODE switch to ALIGN, ASTRO INERTIAL or INERTIAL ONLY and press the MODE START switch. At the completion of Fine Align the ANS automatically enters the mode selected with the MODE switch. If ALIGN was selected the ANS remains in Fine Align until a navigation mode is selected or the aircraft is moved (in which case the system automatically enters the ASTRO INERTIAL mode).

For a rapid alignment, set the MODE switch to ALIGN, ASTRO INERTIAL or INERTIAL ONLY and press the RAPID switch. At the completion of Fine Align the ANS remains in Fine Align until a navigation mode is selected or aircraft motion causes the system to enter the ASTRO INERTIAL mode.

Navigation cannot start until the minimum fine-alignment time has elapsed as indicated by display of the present position coordinates in the PRESENT LATITUDE/LONGITUDE windows.

NOTE

The alignment mode cannot be changed subsequent to the first MODE START or RAPID switch operation without turning the MODE switch to OFF or WARM UP and back to the desired mode. Merely moving the MODE switch to the alternate mode and pressing the MODE START switch does not change the mode of alignment.

Ground Hot Start

An abbreviated ground alignment is provided when the aircraft has not moved since the ANS was turned off following a normal ground alignment or operation in an operate mode. In this mode the RSO presses the HOT switch after power and cooling air are on. The ANS uses the true heading and present position stored in memory at the end of the previous operation. The ground hot start alignment consists of a variable time coarse alignment followed by a 30 second leveling period during which RESTART (RES) is displayed. The time in C/A should not exceed 90 seconds from the time HOT is pressed. Platform leveling is inhibited until 45 seconds after power is applied, then coarse alignment begins if HOT has been pressed. If HOT is not pressed, platform leveling is inhibited. When the platform tilt error is less than 10 arc minutes, the ANS enters the RES mode for 30 seconds of fine alignment. Failure to enter the RES mode means that the platform was unable to level to less than 10 arc minutes. The platform cannot recover from greater than $2\text{-}1/2^{\circ}$ of tilt during a ground hot start. If the ANS will not come out of C/A, a rapid or gyro compass alignment must be performed. Completion of a ground hot start alignment is indicated by the appearance of F/A in the MODE window.

NOTE

> If star tracking is not possible due to aircraft location or sky conditions, leave the system in F/A. Otherwise place the system in ASTRO INERTIAL mode by setting the MODE switch to ASTRO INERTIAL and press MODE START. When A-I appears in the MODE window, inertial data is used for all ANS updates and displays and the star tracker will start searching for an "A" star.

The ANS uses the landing gear switch to distinguish between a ground hot start and a hot air start. Air mass damping is not performed following a ground hot start. Before a ground hot start, ground cooling air should be provided at 75°F if possible. Loading a new mission tape destroys the stored values of position and heading. If the stored heading is not accurate within 0.1° and the star ON light is off, a runway heading alignment should be performed following the ground hot start.

Takeoff

If the runway heading alignment routine is used, maintain takeoff roll parallel to runway centerline. This alignment is automatically terminated at lift-off by a switch on the left main landing gear strut. The RSO must press the UPDATE or MAN CLEAR pushbutton to end the procedure.

In-Flight

After takeoff, the tape-filled mission plan will be followed automatically except as modified by panel-filled inputs. Generally, the autopilot is engaged in the auto-nav mode to simplify flying the mission. Refer to Mission Tape Program and Mission Modification, this section, for a more complete discussion of navigation and sensor control.

Position fixes, using the TACAN, ASARS, and viewsight should be made at frequent intervals to verify and, if necessary, refine computed position. The ANS errors measured by these systems are displayed on the NCD panel and may be cleared or entered into the ANS to correct present position. This is especially important in the alternate navigation modes.

TACAN FP accuracy is inherently worse than the viewsight, ASARS, or ANS fixes, so updates of the ANS by TACAN should only be entered when the ANS is positively known to have large errors.

The ANS software will weight the correction according to prestored accuracy estimates for the type of fixpoint and its current estimate of ANS accuracy. Hence the update command by the RSO will result in only a portion of the displayed error being accepted. The Remote Update routine will, however, always make a total position update by the amount commanded. On other types of fix updates, if either the latitude or longitude correction requested is greater than 5 nautical miles, the total amount will be accepted.

The NCD panel star ON light is an important indicator during astro-inertial and airstart operation. If the star ON light is out during astro-inertial operation, system error will increase at the inertial-only rate and extra effort should be made to check computed position. If the star ON light is on, astro-inertial performance will generally be good. Refer to Astro-Inertial Navigation, this section.

Airstart Alignment

Should there be an airborne power interruption or temporary malfunction, it may be possible to realign the ANS using the airstart procedure. A period of coarse alignment to level the platform is followed by a period when it may be possible to accurately level the platform for precision navigation by performing a series of fixes.

Present position can be entered any time after initiating the airstart procedure and is updated continuously thereafter by dead-reckoning computations. If present position has not been filled by the time the coarse align phase has been completed, the MODE window will indicate ENT (Enter data).

The system also commences great-circle navigation and sensor control using dead reckoning position as a reference in computing steering commands, true heading, range and bearing to points of interest, NORMAL display data, etc. True heading must be checked for accuracy and updated as required. Magnetic variation may be used to correct true heading when the ANS is in the C/A mode. Afterwards the TRUE HEADING UPDATE routine must be performed. Also, if accurate navigation is desired prior to star ON light illumination, the FILL WIND procedure should be used initially in the coarse align mode and repeated as wind conditions change until star ON steady illumination. Position fixes (TACAN, viewsight, or ASARS) may be used to update the dead reckon frame during this period. Remote updates may be used to update the inertial frame.

After coarse alignment is completed, the MODE window display changes to RES and the system commences internal airspeed-damped navigation using dead-reckon data as a starting point. In one minute the first airmass damping correction is made and corrections of diminishing magnitude are made every minute for the duration of the flight. These corrections do not cause auto-nav steering transients. Inertial present position can be displayed and compared with dead-reckon present position by using the DISPLAY PRESENT POS procedure. Star search begins when A-I appears in the MODE window. To optimize star acquisition, the aircraft should be flown straight and level.

Acquisition of star A is indicated by flashing of the star ON indicator. When B star is acquired the star ON light goes out.

When the star ON indicator goes on steady, indicating that continuous star tracking is in progress, inertial data is used to update all ANS outputs and internal dead-reckon computations. If the autopilot is engaged in the auto-nav mode, an aircraft maneuver will occur. Position fixes should be made and the system updated as required.

ANS NORMAL PROCEDURES

The following ANS Tape 13 operating procedures are divided into the general categories of alignment, fill, update, change and display.

NOTE

In these procedures, only the indications that change as a result of procedural steps are listed. Assume that the display does not change if the indication of a particular display is not listed.

The L and R TECH and SLR NCD indicators will be off unless otherwise specified.

The MAL indicator must be off at all times except: it must be on steady while in the WARM UP mode and flash when the MODE switch has been turned from OFF or WARM UP to ALIGN, ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART; and must extinguish after the MODE START, HOT, or RAPID switch is pressed. Refer to the Emergency Procedures paragraph if the MAL light illuminates under any other circumstances.

"Operate" positions of the MODE switch means ALIGN, ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART.

If ERR is indicated in the MODE window, press the MAN CLEAR switch and restart the procedure.

ENT is displayed following the minimum coarse alignment period when present position/heading has not been filled.

When the MAN CLEAR switch is pressed (or the first keyboard switch is pressed after a panel routine is completed in a sequence of routines) the SELECTED DATA counters blank with the exception of a cue letter in one of the windows which will indicate the first data to be entered. The exact letter and window will depend on the DATA switch position. The PRESENT LATITUDE/LONGITUDE/WIND/NEXT DP/TIME TO TURN displays and the star ON, TEMP LIMIT, and TEMP TOLR indicator lights are not affected.

GROUND ALIGNMENT

Prior to ground alignment, an operating chronometer must be installed, the aircraft must be stationary, and the MODE switch must be OFF. Heading must be supplied within ±28 degrees for gyrocompassing alignments, or ±2 degrees for rapid alignment by the INS or TRUE HEADING UPDATE procedure.

1. MODE switch - WARM UP.
   a. MAL light - On steady.
   b. MODE window - Blank.
   c. TEMP LIMIT light - Off.

      Turn MODE switch to OFF if TEMP LIMIT light illuminates.
   d. TEMP TOLR light - Off, on, or flashing.
2. MAG/GRID switch - MAG illuminated.
3. MODE switch - ALIGN, ASTRO INERTIAL, or INERTIAL ONLY.

   Allow 5 minutes in WARM-UP before selecting an alignment mode.

a. MAL light - Flashing.

b. MODE window - C/A.

c. PRESENT LATITUDE and LONGITUDE windows - Blank.

d. SELECTED DATA windows - Blank.

4. Check GMT and Julian Day using TIME Display.

If either GMT or Julian Day are in error replace the chronometer and restart the alignment. If a chronometer replacement is not available, fill DAY and TIME as accurately as possible. Time error greater than 2 seconds may result in star tracking but with erroneous ANS updating. If accurate star tracking cannot be accomplished, the ANS may be operated in the INERTIAL ONLY Mode.

NOTE

The ANS may be initialized without TIME only if INERTIAL ONLY is selected and MODE START is depressed.

5. For <u>GYROCOMPASS</u> alignment: MODE START - Press <u>or</u>

For <u>RAPID</u> alignment: RAPID Switch - Press.

a. MAL light - Off.

b. Star ON light - Flashing when artificial internal star is tracked.

If coarse alignment is completed before steps 6 through 8 are completed, MODE window will display ENT.

Perform step 6 <u>or</u> 7:

6. Use aircraft heading for TRUE HEADING UPDATE.

Enter known, accurate aircraft true heading, using the TRUE HEADING UPDATE procedure.

7. Use INS true heading for TRUE HEADING UPDATE.

Verify the INS is aligned and operating in NORM or NAV mode. Display INS true heading and insert these values into the ANS using the TRUE HEADING UPDATE routine.

NOTE

If the TRUE HEADING UPDATE routine is performed in coarse align or enter data, the updated true heading is used but will not be displayed until the ANS enters the fine align (F/A) mode.

When TEMP TOLR light off:

8. Fill present position and initial altitude (field elevation).

When coarse alignment is complete:

a. For gyrocompassing alignment, MODE window displays F/A for at least 30 minutes.

b. For rapid alignment, MODE window displays F/A for at least 12 minutes.

When the minimum alignment time has elapsed, present position is displayed in the PRESENT LATITUDE and LONGITUDE counters. After this occurs, and just before taxi, start navigation by performing steps 9 and 10.

Before taxiing:

9. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

10. MODE START - Press.

a. MODE window - A-I or I/O.

NOTE

If ASTRO INERTIAL or INERTIAL ONLY mode was selected in step 3, the system automatically starts astro inertial or inertial only navigation, and the MODE window indicates A-I or I/O when the minimum alignment time has elapsed.

If rapid alignment used and star light off:

11. Do a RUNWAY HEADING ALIGNMENT.

NOTE

This step is not required if at least one star has been tracked (B star), however, this might not be evident unless the DATA switch was placed to TIME. In any case, the star on light (C star) indicates at least two different stars have been tracked within the past 5 minutes.

GROUND ALIGNMENT CORRECT

The GROUND ALIGNMENT CORRECT routine torques the platform to earth rate at the local latitude and thus removes any velocity errors that may have built up during taxi. If it is expected that the aircraft will remain stationary for at least four minutes after the star ON light has illuminated, this procedure should be used. Since star tracking continues during ground align correct, star tracking data is used to correct heading and recompute the accelerometer null bias point. This procedure is normally performed after engine runup and before taxiing to the runway. If the ANS is in the ALIGN mode during engine runs, inertial errors may result from inadvertant aircraft movement. A ground alignment correct need not be performed if the ANS is not tracking stars unless a long mission delay occurs. Although any built-up velocity errors will be removed, the accelerometer null bias point is not recomputed. Returning to ALIGN under this circumstance prevents further platform deterioration by retorqueing it to local latitude earth rate, but any errors present will continue to affect the platform after this procedure until star tracking occurs. If ALIGN is selected from the INERTIAL ONLY mode and if INERTIAL ONLY is reselected after ground align correct, the first star tracked after ASTRO INERTIAL is selected will be an A-star.

1. MODE switch - ALIGN.

2. MODE START - Press.

   a. MODE window - F/A.

Prior to start of taxi, initiate navigation by performing steps 3 and 4.

3. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

4. MODE START - Press.

   a. MODE window - A-I or I/O.

NOTE

If the ground-alignment-correct time is less than 10 seconds, no alignment correction is made.

GROUND HOT START ALIGNMENT

A ground hot start must be preceded by a ground alignment or navigation operation so that an accurate present position, altitude, and heading are stored in the computer. Following the previous operation, the aircraft must be stationary, no tape-fill operations can be performed, and the MODE switch must be in OFF or WARMUP. Prior to the hot start cooling air should be available (75°F) and an operating chronometer should be installed. If the system has not been turned OFF, skip to step 2.

1. MODE switch - WARM UP.

   a. MAL light - On steady.

b. MODE window - Blank.

c. TEMP LIMIT light - Off.

Turn MODE switch to OFF if TEMP LIMIT light illuminates.

d. TEMP TOLR light - Off, on, or flashing.

2. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

a. MAL light - Flashing.

b. MODE window - C/A.

c. PRESENT LATITUDE and LONGITUDE windows - Blank.

d. SELECTED DATA - Blank.

3. Check GMT & Julian Day using TIME display.

If either GMT or Julian Day are in error, replace the chronometer and realign the ANS. If a chronometer replacement is not available, fill DAY and TIME as accurately as possible. TIME error greater than 2 seconds may result in star tracking but with erroneus ANS updating. If accurate star tracking cannot be accomplished, the ANS may be operated in the INERTIAL ONLY mode.

4. HOT switch - Press.

5. Check True Heading and present position.

NOTE

If true heading and/or present position are changed (or not accurate) since previous shutdown, turn system OFF and perform a Rapid or Gyrocompass alignment.

6. Use TRACK LEG UPDATE for initial DP.

7. MODE window - RES.

8. MODE window - F/A.

Before taxiing:

9. MODE switch - ASTRO INERTIAL or INERTIAL ONLY.

10. MODE START - Press.

a. MODE window - A-I or I/O.

When aligned on runway and no "A" star:

11. Do RUNWAY HEADING ALIGNMENT.

Not required if at least one star has been tracked (flashing star ON light).

COLD AIRSTART ALIGNMENT

NOTE

If a power dropout has occured, skip to step 3 if HOT or MODE START has not been pressed after power returns.

1. MODE switch - OFF.

a. All NCD panel lights & windows - Extinguished/Blank.

2. MODE switch - WARM UP.

a. MAL light - On steady.

b. MODE window - Blank.

c. TEMP LIMIT light - Off.

Turn MODE switch to OFF if TEMP LIMIT light illuminates.

d. TEMP TOLR light - Off, on, or flashing.

3. Adjust to straight and level flight.

Make necessary heading, altitude, and airspeed changes before continuing since the aircraft should be maintained as steady as possible throughout the airstart until the star ON illuminates, especially during C/A.

4. MODE switch - AIRSTART.

   a. MAL light - Flashing.

   b. MODE window - C/A.

NOTE

I/O appears in the MODE window if chronometer time and day are not available.

   c. PRESENT LATITUDE & LONGITUDE windows - Blank.

   d. SELECTED DATA windows - Blank.

5. MODE START - Press.

   a. MAL light - Off.

6. Check GMT & Julian Day using TIME Display.

   If either time or day are in error, fill as accurately as possible. Time error greater than 2 seconds may result in star tracking but with erroneous ANS updating.

NOTE

If an error is made filling TIME and DAY, the routine may be repeated as long as the system is in C/A or ENT and the correct number of digits and ENTER/DISPLAY have been pressed first.

If accurate star tracking cannot be accomplished, select INERTIAL ONLY and press MODE START after the MODE window changes to A-L If INERTIAL ONLY Mode is selected before C-star tracking, ANS present latitude and longitude will be DEAD RECKON coordinates. Monitor ANS attitude.

7. Check True Heading and Update if required.

   An accurate True Heading should be displayed during C/A since the ANS uses the current INS magnetic heading and the last computed value of △PSIM, (this value normally equates to magnetic variation since it is the difference between the ANS inertial true heading and INS magnetic heading). If a heading error exists in the INS, △PSIM will be MAG VAR plus or minus INS heading error. △ PSIM is updated every 4 minutes along with the DR position update and is also computed whenever ANS power is lost. If the aircraft does not fly through more than 1-1/2° of variation from the time this value is computed until RES appears in the MODE window, the ANS heading should be accurate enough to track stars. If MAG VAR is filled, the computed value of MAG VAR (△PSIM) is superseded. A true heading error could result from adding a geographically accurate MAG VAR to an inaccurate INS magnetic heading. In any case filling MAG VAR will only change true heading and true heading display when in C/A. Fill MAG VAR has no effect on heading or heading display in RES or A-L. If a true heading update routine is performed during C/A or ENT, the updated true heading will not be displayed until RES. True heading may be updated and displayed in RES or A-L. The TRUE HEADING UPDATE routine will override the fill MAG VAR routine regardless of their sequence. The inertial frame uses the true heading at the end of C/A to begin inertial navigation.

   The RSO has three options for true heading in the ANS: do nothing and let the last computed value of the MAG VAR (△ PSIM) determine the true heading; fill a true heading (using tanker heading for example); or fill MAG VAR. If INS heading appears normal, the first option is recommended.

8. Fill Lat/Long of point ahead.

Insert latitude and longitude of a point to be overflown at a convenient distance ahead, using FILL PP procedure, but do not press ENTER switch until step 9.

9. ENTER switch - Press when over selected point.

PRESENT LATITUDE and LONGITUDE windows continually update, using dead-reckon data. Dead reckon data is used for great-circle navigation, sensor control, and all ANS outputs except pitch and roll which are not functional until the completion of coarse alignment.

10. Use TRACK LEG UPDATE or DIRECT STEER as required.

11. MODE window - Check for RES.

When MODE window changes to RES, C/A is complete.

a. ANS pitch, roll, and heading outputs are now functional and reflect inertial data.

b. Internal inertial navigation begins and inertial heading used for DR and heading.

c. Auto-Nav usable, aircraft straight and level.

The autopilot can now be engaged, using ANS attitude reference. Any turns or attitude changes made during the RES mode will affect platform leveling and may prevent subsequent star tracking when the ANS goes into the A-I mode. Avoid engaging Auto-Nav in RES unless necessary.

12. Use DISPLAY PRESENT POSITION procedure to compare inertial and dead-reckoning computations. Update dead-reckon present position using TACAN, viewsight, radar or PRESENT POSITION FILL procedures.

13. MODE window - Check for A-I.

MODE window display changes to A-I to indicate completion of true airspeed coarse leveling, beginning of star search, and the beginning of air-mass damping.

14. FILL WIND, as necessary.

NOTE

Wind can be filled for use in dead-reckoning navigation either in an airstart or when dead-reckon has been selected. Filling wind does not affect inertial navigation.

Perform FILL WIND procedure, as necessary, until star ON illuminates to keep the D.R. position accurate.

Use the REMOTE UPDATE routine to correct inertial position and re-initialize star search if inertial errors exceed 10 NM.

15. Check star ON light.

Acquisition of star A is indicated by flashing of the star ON light. When star B is acquired, the star ON light goes out. After the star ON light illuminates steady, inertial data is used to update all ANS outputs and internal dead-reckon data. If the autopilot is engaged in AUTO-NAV an aircraft maneuver will occur.

16. Update Present Position as required.

All inertial position error may not be yet removed even though the star light is illuminated.

HOT AIRSTART ALIGNMENT

NOTE

If system has <u>not</u> been turned OFF, skip to Step 2.

1. MODE Switch - WARM UP.

   a. MAL light - On steady.

   b. MODE window - Blank.

   c. TEMP LIMIT light - Off.

   Turn MODE switch to OFF if TEMP LIMIT light illuminates.

   d. TEMP TOLR light - Off, on, or flashing.

2. MODE switch - ALIGN, ASTRO INERTIAL, INERTIAL ONLY, or AIRSTART.

   a. MAL light - Flashing.

   NOTE

   The flashing MAL light after a power dropout indicates power restoration and inertial position extrapolation occurs. Inertial position at the time power was removed is moved at TAS rate along the inertial heading at the time power was lost for a time interval equal to the period from power off to power on. This position extrapolation has nothing to do with when the RSO presses HOT. For 45-50 seconds after the MAL light begins flashing, nothing is done with the platform. At the end of this period, platform leveling begins if HOT has been pressed.

   b. MODE window - C/A. (If I/O, perform a COLD AIRSTART)

   NOTE

   If the MODE window display is I/O, turn the system off and perform a COLD AIRSTART. I/O appears in the MODE window if chronometer time and day are not available.

   c. PRESENT LATITUDE & LONGITUDE windows - Blank.

   d. Selected data windows - Blank.

3. Check GMT & Julian Day using TIME Display. If in error, perform a COLD AIRSTART.

   If either time or day are in error, turn the MODE switch OFF and perform a COLD AIRSTART. Accurate position extrapolation cannot occur with erroneous time.

4. Adjust to straight and level flight.

   Make necessary heading, altitude, and airspeed changes before continuing since the aircraft should be maintained as steady as possible throughout the airstart until the star ON light illuminates, especially during C/A.

5. HOT switch - Press.

   a. MAL light - Off.

   b. Present position windows - DR data.

   c. Platform leveling is enabled.

6. FILL WIND, as necessary.

   NOTE

   Wind can be filled for use in dead-reckoning navigation either in an airstart or when DEAD-RECKON has been selected. Filling wind does not affect inertial navigation.

Perform FILL WIND procedures as necessary until the star light illuminates to keep DR position as accurate as possible.

7. Check True Heading and Update if required.

   True Heading during C/A is INS heading and the last computed value of magnetic variation (△PSIM). This heading is used to drive the extrapolated Inertial position as well as the Dead Reckon position. Operation, display, and update of True Heading during C/A, RES, and A-I is identical to that during the COLD AIRSTART.

8. Check current track leg - Perform TRACK LEG UPDATE <u>or</u> DIRECT STEER, if required.

   NOTE

   An Auto Track Leg Update is initiated to the track leg on which the hot airstart is performed. If a direct steer had been performed on the leg on which the airstart is attempted then initialization will be to DP 1. SKIP TO operations initiated before a hot airstart are not retained.

9. MODE window - Check for RES.

   When MODE window display changes to RES, C/A is complete.

   a. ANS pitch, roll, and heading outputs are now functional and reflect Inertial data.

   b. Internal inertial navigation begins and inertial heading used for DR and heading.

   c. Auto-nav usable, aircraft straight & level.

      The autopilot can now be engaged, using ANS attitude reference. Any turns or attitude changes made during the RES mode will affect platform leveling and may prevent subsequent star tracking when the ANS goes into the A-I mode. Avoid engaging Auto-Nav in RES unless necessary.

   NOTE

   If the platform precesses beyond 2-1/2° of tilt from the time power is removed until the time platform leveling is enabled, the ANS will probably not come out of C/A into RES mode in a reasonable period of time and a COLD AIRSTART will have to be performed to level the platform.

10. MODE window - A-I.

    MODE window display changes to A-I to indicate completion of true airspeed coarse leveling, and the beginning of star search, and air-mass damping.

    NOTE

    Even if the MODE switch is in ALIGN, INERTIAL ONLY, or AIRSTART when HOT is pressed, the system will automatically go into ASTRO INERTIAL mode during a HOT AIRSTART.

11. Check star ON light.

    Acquisition of star A is indicated by flashing of the star ON light. When star B is acquired, the star ON light goes out. After the star ON light illuminates steady, inertial data is used to update all ANS outputs and internal dead-reckon data. If the autopilot is engaged in AUTO-NAV, an aircraft maneuver will occur.

SELECT DEAD RECKON MODE

The DEAD RECKON mode can be selected any time in flight.

1. MODE switch - DEAD RECKON.

2. MAG/GRID switch - MAG.

3. MODE START - Press.

   a. MAL light - Off.

      If on, refer to Emergency Procedures paragraph.

   b. MODE window - D/R.

4. True Heading - Check, fill Mag Var as required.

   Check true heading. Fill MAG VAR as required to keep the true heading as accurate as possible. When the DEAD RECKON mode is initially entered, magnetic variation should not have to be filled since the true heading will be the last computed value of ΔPSIM (the difference between the ANS inertial true heading and INS magnetic heading).

5. Fix and Update Present Position as required.

   Fill present position if DEAD RECKON is selected from OFF or WARM UP.

6. FILL WIND, as necessary.

NOTE

Wind can be filled for use in dead-reckoning navigation either in an air start or when dead-reckon has been selected. Filling wind does not affect inertial navigation.

PRESENT LATITUDE and LONGITUDE windows are clear until filled if DEAD RECKON is selected from OFF or WARM UP, or during a "cold" airstart. Otherwise, the PRESENT LATITUDE and LONGITUDE counters are continuously updated from their initial reading as soon as MODE START is pressed.

The ANS assumes 0 degrees roll and 6 degrees pitch when VIEWSIGHT PP UPDATE procedure is performed in the DEAD RECKON mode; therefore, the aircraft should be straight-and-level for viewsight fixpoints. If another operate mode is selected from DEAD RECKON, even prior to star ON light illumination in a "cold" or "hot" airstart, dead-reckon position and magnetic variation are updated to inertial data at 4-minute intervals in the new mode.

RUNWAY HEADING ALIGNMENT

The aircraft should be aligned with runway centerline. MODE switch must be in ASTRO INERTIAL or INERTIAL ONLY position. MODE window display must match MODE switch position. A heading correction will be inhibited if star B was successfully acquired as the first star after ground alignment.

1. DATA switch - HEADING.

2. Runway True Heading - Enter (XXX$^{\circ}$ XX.X').

   Enter known runway true heading in degrees (three digits), minutes (two digits), and tenths of minutes (one digit). Entered data appears in SELECTED DATA 4 window.

3. MODE START - Press.

   Press just before takeoff roll.

At liftoff:

4. Check ANS computed True Heading in SD-1 window.

   At aircraft lift-off, average ANS heading appears in degrees (three digits), minutes (two digits), and tenths of minutes (one digit).

Perform step 5 <u>or</u> 6:

5. UPDATE switch - Press.

   Press to incorporate difference between average ANS and runway headings.

6. MAN CLEAR switch - Press.

NOTE

> If computed runway heading does not appear in SD-1 window at lift-off, the takeoff switch has probably failed; in this case, press MAN CLEAR to terminate the procedure.

FILL PRESENT POSITION AND INITIAL ALTITUDE

In any "operate" mode, when MODE window displays C/A, ENT, RES, A-I or D/R for other than initial fill for ground align.

NOTE

> Either magnetic variation or true heading must be entered for ground alignment prior to FILL PRESENT POSITION and INITIAL ALTITUDE or an ERR indication will appear after ENTER is pressed.

If present position is filled in flight, position coordinates should be those that will exist when ENTER is pressed. Any present position filled after the COARSE ALIGN (C/A) phase will be entered into the dead reckon reference frame.

If not a ground Alignment, do steps 1, 2, 3, & 5:

1. DATA switch - PRES POSITION.

2. Fill Latitude (N/S XX°XX.XX').

   Enter N or S position latitude in degrees (two digits), minutes (two digits), and hundredths of minutes (two digits). Entered data appears in SD-1 window.

3. Fill Longitude (E/W XXX°XX.XX').

   Enter E or W position longitude in degrees (three digits), minutes (two digits), and hundredths of minutes (two digits). Entered data appears in SD-4 window.

4. Local Field Elevation - Enter (XXX) in hundred feet.

   Entered data appears in SD-3 window.

5. ENTER switch - Press.

FILL WIND

MODE switch in any "operate" mode. MODE window displays any mode.

1. DATA switch - TEST.

2. Wind direction - Enter (XXX°).

   Entered data appears in SD-5 window.

3. Wind speed - Enter (XXX).

   Enter wind speed in knots (three digits). Entered data appears in SD-6 window.

4. ENTER switch - Press.

FILL DAY AND TIME

Day and time may be filled only when the ANS is in COARSE ALIGN. Attempting to enter day/time in any other mode will result in ERR in the MODE window.

NOTE

> The MODE window normally reads C/A or ENT when the ANS is in the C/A mode. Whenever the ANS has power restored after a power loss and chronometer day and time are not available, the ANS will be in the C/A mode although the MODE window will read I/O and the MAL light will be flashing.

1. DATA switch - TIME.

2. Julian Day - Enter (ØXXX).

   Enter Julian day of year (four digits). Entered data appears in SD-6 window.

NOTE

Fill Julian day to correspond with GMT.

3. GMT - Enter (XX hr, XX min, XX sec).

Entered data appears in SD-1 window.

4. ENTER switch - Press & release at time hack.

Filled day and time are entered when the ENTER switch is released.

NOTE

If an error is made in filling day and time the routine may be repeated as long as the correct number of digits and ENTER have been pressed first. If the MAL light is flashing in C/A and an error is made in filling day and time which results in ERR in the MODE window, press MAN CLEAR and reenter data.

FILL DAY

If a chronometer has the correct time but the wrong Julian Day, then a FILL DAY routine will be required during COARSE ALIGN to permit accurate star tracking.

1. DATA switch - TIME.

2. Julian Day - Enter (ØXXX).

3. ENTER switch - Press.

FILL MAGNETIC VARIATION

In any "operate" mode:

1. DATA switch - HEADING.

2. Variation - Enter (E/W $XXX^{\circ}XX.X'$).

Entered data appears in SD-4 window.

3. ENTER switch - Press.

NOTE

This routine is only functional if the system is in the MAG mode.

HEADING UPDATE

In any "operate" MODE:

1. DATA switch - HEADING.

2. True Heading - Enter ($XXX^{\circ}XX.X'$).

Entered data appears in SD-4 window.

3. UPDATE switch - Press.

If this procedure is performed during the coarse align mode, entered value of heading will be used to initialize system true heading. If performed during fine align or any navigate mode, entered value will replace existing true heading.

NOTE

Unless the system is in C/A, the ANS will accept a maximum heading update change of 28°. For an update change greater than 28° the routine will have to be repeated until the desired heading to be updated is within 28° of the system's last known heading.

PRESENT POSITION UPDATE, USING REMOTE SOURCE DATA (REMOTE UPDATE)

The maximum allowable correction is 90 nautical miles. The correction always goes to the inertial frame regardless of system mode. A dead-reckoned position cannot be updated by this procedure. The correction moves the inertial frame by the desired amount, i.e., if the aircraft is 0.5 nm south of the known location, a remote update of N0000.50 should be performed.

In any "operate" mode:

1. DATA switch - PRES POSITION.

2. N or S Correction - Enter (N/S 00XX.XX nm).

   Entered data appears in SD-1 window.

3. E or W Correction - Enter (E/W 000XX.XX nm).

   Entered data appears in SD-4 window.

4. UPDATE switch - Press.

PRESENT POSITION UPDATE, USING ASARS WITH IPD

MODE: ASTRO INERTIAL, INERTIAL ONLY, or AIRSTART; MODE window displays any mode except F/A or ENT.

1. Mode M/A switch - A.

2. Fix warning - Flashing.

When imagery stops scrolling:

3. RUN/HOLD switch - HOLD illuminated.

4. Radar crosshair - Place over fixpoint.

5. READ ERR switch - Press.

   Changes ASARS Pointing Information.

   a. Cumulative north or south ANS-computed error (sum of all radar fixes since NAV update) in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-1 window.

   b. Cumulative east or west ANS-computed error (sum of all radar fixes since NAV update) in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-4 window.

   c. Fixpoint north or south ANS-computed error in nautical miles (two digits), and tenths of miles (one digit) appears in SD-2 window.

   d. Fixpoint east or west ANS-computed error in nautical miles (two digits), and tenths of miles (one digit) appears in SD-5 window.

Do step 6 <u>or</u> 7:

6. UPDATE switch - Press.

   Automatically updates ANS present position.

7. MAN CLEAR switch - Press.

   Bypasses updating of ANS present position.

MEASURE ALTITUDE UPDATE, USING ASARS WITH IPD

MODE: ASTRO INERTIAL, INERTIAL ONLY, or AIRSTART; MODE window displays any mode except F/A or ENT.

1. MODE M/A switch - A.

2. FIX warning - Flashing.

When imagery stops scrolling:

3. RUN/HOLD switch - HOLD illuminated.

4. Radar crosshair - Align with left edge of return.

5. READ ERR switch - Press.

   Changes ANS NAV altitude.

PRESENT POSITION UPDATE, USING VIEWSIGHT

MODE: ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIRSTART; MODE window displays any mode except F/A or ENT.

1. FOV switch - Select desired field of view.

2. Viewsight Cursor - Align with fixpoint.

When fixpoint under nadir:

3. READ switch - Press.

a. North or south ANS-computed error in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-1 window.

b. East or west ANS-computed error in nautical miles (two digits), and hundredths of miles (two digits) appears in SD-4 window.

Do step 4 <u>or</u> 5.

4. UPDATE switch - Press.

   Automatically corrects ANS present position.

5. MAN CLEAR switch - Press.

   Bypasses updating of ANS present position.

The ANS automatically sequences to the following FP 17.25 nm past a viewsight FP.

PRESENT POSITION UPDATE, USING TACAN (TAPE FILLED POINT)

In any "operate" mode:

1. BDHI HDG select switch - INS.

2. BDHI No. 1 needle select switch - TACAN.

3. Use Display Next FP, <u>or</u> Display Selected FP procedure.

4. TACAN switch - Press.

   Press when TACAN system values have been noted on BDHI. All SELECTED DATA displays will clear.

5. TACAN mag bearing value - Enter (XXX°).

   Enter TACAN value of magnetic bearing from aircraft to station in degrees (three digits). Entered data appears in SD-5 window.

6. TACAN slant range value - Enter (XXX nm).

   Entered data appears in SD-6 window.

7. ENTER switch - Press.

   a. SD-1 window displays north or south ANS computed error in nm and hundredths of miles.

   b. SD-4 window displays east or west computed error in nm and hundredths of miles.

Do step 8 <u>or</u> 9:

8. UPDATE switch - Press.

   Automatically updates ANS present position.

9. MAN CLEAR switch - Press.

   Bypasses updating of ANS present position.

   The ANS automatically sequences to the next FP when 17.25 nm past a TACAN FP.

PRESENT POSITION UPDATE, USING TACAN (ANYTIME TACAN FP)

In any "operate" mode:

1. BDHI HDG select switch - INS.

2. BDHI No. 1 needle select switch - TACAN.

3. DATA switch - FIX POINT.

4. Fixpoint Latitude - Enter (N/S XX°XX.XX').

   Enter N or S and latitude of fixpoint in degrees (two digits), minutes (two digits), and hundredths of minutes (two digits). Entered data appears in SD-1 window. If any of the sensor operation indicator lights are illuminated, they extinguish when N or S is pressed. The automatic sensors continue to operate normally during the add anytime TACAN fixpoint routine.

5. Fixpoint Longitude - Enter (E/W XXX°XX.XX').

   Enter E or W and longitude of fixpoint in degrees (three digits), minutes (two digits) and hundredths of minutes (two digits). Entered data appears in SD-4 window.

6. Fixpoint Elevation - Enter (XXX).

   Enter elevation of fixpoint in hundreds of feet (three digits). Entered data appears in SD-3 window.

7. Variation - Enter (E/W XX.XX°).

   Enter E or W magnetic variation of TACAN station in degrees and tenths of degrees of arc as follows: E or WXX.XX°. Entered data will appear as follows:

   a. E/W in SD-5 window.

   b. Tens, units, and tenths of degrees in SD-5 window following E/W. Hundredths of degrees <u>is not displayed</u>.

NOTE

The maximum value of magnetic variation which can be <u>entered</u> is 99.99°. ANYTIME <u>TACAN fixpoints</u> cannot be used if actual magnetic variation exceeds this value.

8. ENTER switch - Press.

   a. SD-2 window displays computed TACAN slant range.

   b. SD-5 window displays computed TACAN bearing.

9. TACAN switch - Press.

   Press when TACAN system values have been noted on BDHI. All SELECTED DATA displays will clear.

10. TACAN mag bearing value - Enter (XXX°).

   Enter TACAN value of magnetic bearing from aircraft to station in degrees (three digits). Entered data appears in SD-5 window.

11. TACAN slant range value - Enter (XXX nm).

   Entered data appears in SD-6 window.

12. ENTER switch - Press.

   a. SD-1 window displays north or south ANS computed error in nm and hundredths of miles.

   b. SD-4 window displays east or west ANS computed error in nm and hundredths of miles.

Do step 13 <u>or</u> 14:

13. UPDATE switch - Press.

   Automatically updates ANS present position.

14. MAN CLEAR switch - Press.

   Bypasses updating of ANS present position.

   The ANS automatically sequences to the next FP when 17.25 nm past a TACAN FP.

RECALL ANYTIME TACAN FIXPOINT

MODE in any "operate" mode; an ANYTIME TACAN FIXPOINT must have been previously entered using the TACAN (ANYTIME TACAN FP) procedure. If more than one ANYTIME TACAN FIXPOINT has been entered, the last entered fixpoint will be recalled. Verify that the proper TACAN station is selected and that the TACAN T/R mode is set.

1. BDHI HDG select switch - INS.

2. BDHI No. 1 needle select switch - TACAN.

3. DATA switch - FIX POINT.

4. RECALL switch - Press.

   NOTE

   Step 4 will recall the last entered ANYTIME TACAN FIXPOINT. If there is none, the MODE window indicates ERR.

5. TACAN switch - Press.

   Press when TACAN system values have been noted on BDHI. All SELECTED DATA displays clear.

6. TACAN mag bearing value - Enter (XXX°).

   Enter TACAN value of magnetic bearing from aircraft to station in degrees (three digits). Entered data appears in SD-5 window.

7. TACAN slant range value - Enter (XXX nm).

   Entered data appears in SD-6 window.

8. ENTER switch - Press.

   a. SD-1 window displays north or south ANS computed error in nm and hundredths of miles.

   b. SD-4 window displays east or west computed error in nm and hundredths of miles.

Do step 9 <u>or</u> 10:

9. UPDATE switch - Press.

   Automatically corrects ANS present position.

10. MAN CLEAR switch - Press.

    Bypasses updating of ANS present position.

    The ANS automatically sequences to the next FP when 17.25 nm past a TACAN FP.

PRESENT POSITION UPDATE, USING OPPORTUNITY VIEWSIGHT FIXPOINT

MODE in any "operate" mode; MODE window indicates any mode except C/A, F/A, or ENT.

1. Magnification - Set desired field of view.

2. Viewsight cursor - Align with fixpoint.

When Fixpoint under nadir:

3. READ switch - Press.

   a. SD-1 window - Meaningless number.

   b. SD-4 window - Meaningless number.

4. Fixpoint Latitude - Enter (N/S XX°XX.XX').

   Entered data appears in SD-1 window.

5. Fixpoint Longitude - Enter (E/W XXX°XX.XX').

   Entered data appears in SD-4 window.

6. Fixpoint Elevation - Enter (XXX) in hundreds of feet.

   Entered data appears in SD-3 window.

7. ENTER switch - Press.

   a. North or south ANS computed error in nautical miles (two digits) and hundredths of miles (two digits) appears in SD-1 window.

   b. East or West ANS computed error in nautical miles (two digits) and hundredths of miles (two digits) appears in SD-4 window.

NOTE

If an error is made when entering data (other than entering too many digits) press ENTER pushbutton and re-enter all data. If MODE window displays ERR press MAN CLEAR to terminate procedure and bypass present position update.

Do step 8 or 9:

8. UPDATE switch - Press.

   Automatically updates ANS present position.

9. MAN CLEAR switch - Press.

   Bypasses updating of ANS present position.

TRACK LEG UPDATE

MODE switch in ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIR START position; MODE window displays any mode.

1. DATA switch - DEST POINT or NORMAL.

2. Enter point - ID code (five digits) of start DP on desired track leg. Last four entered digits appear in SD-6 window, (first digit, always zero, replaces letter P with D).

3. UPDATE switch - Press.

DIRECT STEER

In any "operate" mode:

1. DATA switch - DEST POINT or NORMAL.

For direct steer to tape-filled or panel-filled DP:

2. Enter five digit ID code of DP in memory (tape-filled or panel-filled). Last four entered digits appear in SD-6 window.

3. DIR STEER switch - Press.

For direct steer to new DP:

4. Enter latitude of new DP in degrees (two digits), minutes (two digits), and hundredths (two digits). Entered data appears in SD-1 window.

5. Enter longitude of new DP in degrees (three digits) minutes (two digits), and hundredths (two digits). Entered data appears in SD-4 window.

6. DIR STEER switch - Press.

The ANS automatically proceeds to the next great-circle leg if Direct Steer DP is in memory. The ANS commands a constant 35 degree, right wing down turn upon passing a new Direct Steer DP, or a DP with no next leg.

SKIP TO DP

In any "operate" mode:

1. DATA switch - DEST POINT or NORMAL.

2. Enter five digit ID code of DP to be skipped to. Last four digits appear in SD-6 window.

3. SKIP TO switch - Press.

DELETE FP, CP, AND DP (40-LIST)/CLEAR 40 LIST

This procedure permits deleting points from the 40-List (panel-filled Add/Replace points). After a point is deleted the vacated space may be reused. In any "operate" mode:

Do steps 1, 2, & 4 for single point deletion. Do steps 1, 3, & 4 to clear entire 40-list.

1. DATA switch - DEST POINT, FIX POINT, CONT PT.

2. Enter ID code (five digits) of FP, CP or DP to be deleted. All digits appear in SD-6 window.

3. ID CODE 99999 - Enter.

4. DELETE switch - Press.

ADD ANYTIME FIXPOINT

Normally, this procedure is followed closely by a Present Position Update procedure, using the ASARS or Viewsight. It can only be used on the existing leg, as no ID code is established for the Anytime Fixpoint.

In any "operate" mode:

1. DATA switch - FIX POINT.

2. Fixpoint Latitude - Enter (N/S XX°XX.XX').

   Entered data appears in the SD-1 window.

NOTE

If any of the sensor operation indicator lights are illuminated, they extinguish when N or S is pressed. The automatic sensors continue to operate normally during the add Anytime Fixpoint routine.

3. Fixpoint Longitude - Enter (E/W XXX°XX.XX').

   Entered data appears in SD-4 window.

4. Fixpoint Elevation - Enter (XXX).

   Enter the terrain elevation of the fixpoint in hundreds of feet (three digits). For example, 12,500 feet is entered as 125. Entered data appears in the SD-3 window.

5. ENTER switch - Press.

NOTE

The DATA switch may now be used to display other than fixpoint data. If returned to FIXPOINT and ENTER before the fixpoint, anytime fixpoint data will be retained and displayed. The fix may be taken with the DATA switch in NORMAL. The viewsight opportunity fix must still be taken on the leg during which it was entered. Existing FPs will be inhibited until the Anytime FP is passed.

ADD OR REPLACE (NON ASARS) FP, CP, DP

NOTE

- For DPs perform steps 1 through 4, then 9 and 10.
- For CPs, perform steps 1 through 5, then 6, 7, 8 and 10.
- For FPs, perform steps 1 through 5, and 10.

In any "operate" mode:

1. DATA switch - DEST POINT, FIX POINT, or CONT PT.
2. Enter ID code (five digits) of FP, CP, or DP to be added or replaced. All entered digits appear in SD-6 window.

NOTE

- 0XXXX Point No. displays DXXXX, FXXXX, or CXXXX, 1XXXX Point No. displays F1XXXX or C1XXXX. Only zero allowed for first digit of DP.
- If a FP is added to be used immediately (Add-Anytime FP) do not enter an ID code number. All other FPs in memory will be inhibited until the added FP is passed.

3. Enter N or S and latitude of added or replaced point in degrees (two digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-1 window.
4. Enter E or W and longitude of added or replaced point in degrees (three digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-4 window.

Skip to step 8 if entered point is a DP; continue with step 5 if point is CP or FP.

5. Enter terrain elevation of FP or CP in hundreds of feet (three digits). Entered data appears in SD-3 window.

Skip to step 9 for viewsight FPs. Perform step 6 for camera CPs.

6. Press RIGHT or LEFT pushbutton and enter camera CP code (L/R plus 000). Entered data appears in SD-5 window.
7. For all CPs enter sensors on-off code (three digits). First entered digit is LH

TECH camera, second is RH TECH camera. Enter 0 for off at CP, and 1 for on at CP. Corresponding sensor operation indicators illuminate to indicate sensor selection for the CP.

If a Fixed-Range-To-Turn is desired:

8. Enter turn radius of added or replaced DP in nm (three digits). Entered data appears in SD-3 window.

9. ENTER switch - Press.

REPLACE ASARS FP

In any "operate" mode:

1. DATA switch - FIX POINT.

2. Enter ID code (five digits) of FP to be replaced. ALL entered digits appear in SD-6 window.

NOTE

0XXXX Point No. displays FXXXX.

3. Enter N or S and latitude of added or replaced point in degrees (two digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-1 window.

4. Enter E or W and longitude of added or replaced point in degrees (three digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-4 window.

5. Enter terrain elevation of FP in hundreds of feet (three digits). Entered data appears in SD-3 window.

6. ENTER switch - Press.

ADD OR REPLACE ASARS CP

In any "operate" mode:

1. DATA switch - CONT PT.

2. Enter ID code (five digits) of CP to be added or replaced. All entered digits appear in SD-6 window.

NOTE

0XXXX Point No. displays CXXXX.

3. Enter N or S and latitude of added or replaced point in degrees (two digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-1 window.

4. Enter E or W and longitude of added or replaced point in degrees (three digits), minutes (two digits), and hundredths minutes (two digits). Entered data appears in SD-4 window.

5. Enter terrain elevation of CP in hundreds of feet (three digits). Entered data appears in SD-3 window.

6. ASARS control point code -Enter (R0XXX). Entered data for first 4 digits appears in SD-5 window. Digit 5 indicated by illumination of sensor "L" light if value is 1.

ASARS Control Point CODE

Digit 1:
- L = Dual Spot (Not Available)
- R = Normal

Digit 2:
- 0 = Neither Set
- 2 = Rewind
- 4 = Down link (Not Available)
- 6 = Both Set (Not Available)

NOTE: Selection of 4 or 6 will result in no ASARS imagery being recorded.

Digit 3:
- 0 = F1, Low Resolution (Spot only)
- 1 = F1, High Resolution (Spot only)
- 2 = F2, Low Resolution (Acquisition and Search only)
- 3 = F2, High Resolution (Not available)
- 4 = F3, Low Resolution (Spot only)
- 5 = F3, High Resolution (Not available)
- 6 = F4, Low Resolution (Acquisition and Search only)
- 7 = F4, High Resolution (Not available)

NOTE: Extreme care must be exercised in selecting resolution and frequency. Non available combinations of mode (Digit 4) and Resolution/Mode may be selected resulting in no ASARS activity.

Digit 4:
- 0 = Standby
- 1 = Acquisition
- 2 = Search
- 4 = Spot

Digit 5:
- 0 = Turn recorder off after this swath
- 1 = Leave recorder on after this swath

7. ENTER switch - Press.

NORMAL DISPLAY

In any "operate" mode:

1. DATA switch - NORMAL.
2. DISPLAY switch - Press.
   a. SD-1 window displays letter Z and GMT in hours (two digits), minutes (two digits), and seconds (two digits).
   b. SD-2 window displays letter T and true airspeed in knots (XXXX).
   c. SD-3 window displays letter F or F1 and next FP (four digits).
   d. SD-4 window displays R or L and cross track error in nautical miles (XXX.X).
   e. SD-5 window displays letter G and ground speed in knots (XXXX).
   f. SD-6 window displays letter C, C1, or A and next CP number (four digits). The ENTER/DISPLAY switch alternately selects ASARS or non-ASARS CP information.
   g. Sensor indication lights illuminate when the associated sensor is programmed on.

DISPLAY SELECTED FP, CP, DP

In any "operate" mode:

1. DATA switch - DEST POINT, FIX POINT, or CONT PT.
2. Enter ID code (five digits) of desired FP, CP, or DP.

   SD-6 window displays all entered digits (except first digit).
3. DISPLAY switch - Press.
   a. SD-1 window displays latitude of selected point.
   b. SD-2 window displays letter R and slant range to selected point if

TACAN, great circle range to CP or FP, or great circle range to DP.

c. SD-3 window displays letter E and terrain elevation of selected FP or non-ASARS CP. For ASARS CP, letter M and ASARS mode information displayed. Sensor "L" light on or off also used in conjunction with ASARS mode. For DP, letter K and turn radius is displayed (255 nm max).

d. SD-4 window displays longitude of selected point.

e. SD-5 window displays L or R and relative bearing (four digits) to a selected CP or DP; or letter B and magnetic bearing in degrees (four digits), to TACAN FP.

f. SD-6 window displays data code of selected point.

g. L/R TECH and SLR lights illuminate to indicate sensor activity at selected FP or CP. The SLR light is not illuminated during display of viewsight fixpoints.

DISPLAY NEXT NON-ASARS FP, CP, DP

MODE switch in ASTRO-INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIR START position; MODE window displays any mode.

1. DATA switch - DEST POINT, FIX POINT, or CONT PT.

2. DISPLAY switch - Press.

   a. SD-1 window displays latitude of next FP, CP, or DP.

   b. SD-2 window displays letter R and slant range to TACAN FP, along track range for radar or viewsight FP or CP and along track range to turn start point (TSP) for DP (which includes the computed range around a closed loop turn).

   c. SD-3 window displays letter E and terrain elevation of next FP or CP, in hundreds of feet. For DP, letter K and turn radius is displayed (255 NM max).

   d. SD-4 window displays longitude of next FP, CP, or DP.

   e. SD-5 window displays L or R and relative bearing in degrees (four digits) to next viewsight or radar FP, CP, DP, or letter B and magnetic bearing in degrees (four digits) to next TACAN FP.

   f. SD-6 window displays data code of next FP, CP, or DP.

   g. L/R TECH and SLR lights illuminate to indicate sensor activity at next FP or CP. The SLR light is not illuminated during display of viewsight fixpoints.

NOTE

- If there is no next FP or CP on the current leg, SD-2 window displays zero range and other displayed data will be for the preceding FP or CP. If there was no preceding FP or CP, all SELECTED DATA windows except 5 display all zeros. The SD-5 window displays bearing to zero latitude and longitude coordinates.

- If DATA switch is in DEST POINT and LOOK THRU switch is pressed:

  1) SD-1 window displays latitude of DP after next DP.

  2) SD-2 window displays range to DP after next DP.

3) SD-3 window displays turn radius of DP after next DP.

4) SD-4 window displays longitude of DP after next DP.

5) SD-5 window displays time to DP after next DP (four digits) in minutes and tenths.

6) SD-6 window displays the DP number after next DP. If no DP exists after next DP, SD-6 window displays D0000 and all other SELECTED DATA windows are blank.

DISPLAY DAY OF YEAR/STAR DATA

In any "operate" mode:

1. DATA switch - TIME.

2. DISPLAY switch - Press.

   a. SD-1 window displays letter Z and GMT in hr., min, sec.

   b. SD-2 window displays letter S and star number.

   c. SD-3 window displays the scan rate code of the star-tracking telescope (R1, R2, R3 or R4).

   d. SD-4 window displays letter T and time in star search in min. and sec.

   e. SD-5 window displays letter A and number of stars acquired.

   f. SD-6 window displays letter D and Julian date.

NOTE

Julian day Display changes after 2400 GMT and may read any value from 0 to 511. Day values greater than 365 allow next calendar year usage of the star catalog in the computer.

DISPLAY HEADING

In any "operate mode":

1. DATA switch - HEADING.

2. DISPLAY switch - Press.

   a. SD-1 window displays letter V and ground track in degrees (three digits), minutes (two digits), and tenths of minutes (one digit).

   b. SD-2 window displays letter G and computed grid heading in degrees and tenths of degrees (four digits).

   c. SD-3 window displays letter C and the chart convergence factor (four digits) (1.000 max).

   d. SD-4 window displays letter T and true heading in degrees (three digits), minutes (two digits), and tenths of minutes (one digit).

NOTE

Displayed true heading is ANS inertial data except that INS data is used in dead-reckon mode and in ground and cold airstart coarse alignments until a heading update is performed.

   e. SD-5 window displays E/W magnetic variation (four digits).

   f. SD-6 window displays letter M and magnetic heading (three digits).

DISPLAY PRESENT POSITION

MODE switch: ASTRO INERTIAL, INERTIAL ONLY, DEAD RECKON, or AIR START; MODE window displays any mode.

1. DATA switch - PRES POSITION.

2. DISPLAY switch - Press.

a. SD-1 window displays N or S latitude of alternate frame in degrees (two digits), minutes (two digits), and hundredths of minutes (two digits).

b. SD-2 window is blank.

c. SD-3 window displays letter A and ANS altitude (three digits) (flight level).

d. SD-4 window displays E or W longitude of alternate frame in degrees (three digits), minutes (two digits), and hundredths of minutes (two digits).

e. SD-5 window displays letter S and sun angle in degrees and tenths (three digits).

f. SD-6 window is blank.

PRESENT DISPLAY

A. PRESENT LATITUDE window displays present N/S latitude in degrees and minutes (four digits).

B. PRESENT LONGITUDE window displays present E/W longitude in degrees and minutes (five digits).

NOTE

Window displays are blank until completion of F/A, at which time primary coordinates are displayed depending on MODE switch position.

C. WIND DIR window displays present wind direction in degrees (three digits). While on the ground with ANS operating but not calculating, and if wind direction is not filled, the WIND DIR counter displays 000.

D. WIND VEL window displays present wind velocity in knots (three digits). While on the ground with ANS operating but not calculating, the WIND VEL counter displays 0.

E. TIME-TO-TURN window displays the time to turn in hours, minutes, and seconds (five digits). The TIME-TO-TURN window displays 0 until the aircraft moves.

F. RANGE TO DP (NM) window displays the range to the next destination point, shown in the NEXT DP window (four digits). Until the present position has been filled, the RANGE TO DP (NM) window will be blank.

G. NEXT DP window displays the next destination point identification number (four digits). The first (left) digit is blank if the DP is not an added point, or the actual ADD NUMBER (1 thru 7) if the DP is an added point. Until present position has been filled, the NEXT DP window will be blank.

DISPLAY TAPE NUMBERS

In any "operate" mode:

1. DATA switch - TEST.

2. DISPLAY switch - Press.

a. SD-1 window displays letter I and main program tape number, (six digits) representing tape number, mod number, and correction number.

b. SD-2 window displays * or A thru Z or a thru e and mission tape number (three digits).

c. SD-3 window displays letter G and general instrument constants tape number (three digits).

d. SD-4 window is blank.

e. SD-5 window displays letter S and star catalog type as follows:

SYY1 - Normal (worldwide)
SYY2 - Trainer
Where YY=last two digits of the year.

f. SD-6 window displays letter T (test) and 0.

ANS MALFUNCTION PROCEDURES

The ANS provides warning indications of some malfunctions or conditions external to the ANS that could lead to an ANS malfunction. All malfunctions are not detected, so the crew should not depend entirely on warning indications.

Temperature Limit/Tolerance Indicator

The LIMIT portion of the indicator is unlighted when temperatures within the ANS are normal. The red LIMIT can illuminate either steady or flashing. A steady light indicates that the temperature of the astroinertial instrument housing or the cooling air at the computer inlet is above nominal limits. Steady illumination after initial turn-on is caused by system over-temperature. A flashing light indicates that ANS cooling airflow is less then 2.5 pounds per minute. To prevent damage, turn the ANS off when the temperature LIMIT indicator comes on.

When the LIMIT light illuminates, the RSO's annunciator panel ANS FAIL light, and the pilot's annunciator panel ANS REF caution light illuminate.

When the TEMP TOLR light is unlighted, the platform temperature is in the range for optimum system performance. The amber TOLR light illuminates either steady or flashing. Steady illumination signifies that platform temperature is below normal. A flashing light signifies that temperature is above normal.

Figure 4-18 lists ANS temperature warning indications, conditions and recommended actions.

TEMP LIMIT Light Illuminates

1. Check ECS system.

   If L or R air system failed:

   a. Complete L or R Air System Out procedure.

   If L or R air system off for landing:

   b. Check cockpit air off (forward).

If TEMP LIMIT light remains illuminated:

▲2. ATT REF switch - INS.

T 3. DISPLAY MODE SEL switch - Other than ANS.

(4.) BDHI HDG SELECT switch - INS.

(5.) MODE switch - OFF.

CAUTION

If the TEMP LIMIT light cannot be extinguished, turn the MODE switch OFF to avoid damage to the ANS.

TEMP TOLR Light Illuminates in Flight

Make as many position checks as practical since navigation accuracy may degrade in a TEMP TOLR condition. Be alert for a possible TEMP LIMIT light.

NOTE

> If the TEMP TOLR light illuminates in flight, do not turn the ANS off unless the TEMP LIMIT light illuminates.

Malfunction Indicator (MAL Light)

The MODE window usually indicates action to be taken when the MAL light is flashing. Several of the conditions for a MAL light are synonymous with conditions for nav-not-ready indications described under the Warning Indication section. Figure 4-19 lists general ANS malfunction and nav-not-ready conditions.

NOTE

> When the MAL light illuminates, the RSO's annunciator panel ANS FAIL light, and the pilot's annunciator panel ANS REF caution light illuminate.

Power Dropout

A decrease of the ANS ac supply voltage to less than 103 volts per phase causes the computer to stop operating regardless of mode. Voltage drop can be caused by a primary power transient, opening of the ANS 3-phase essential ac or essential dc circuit breaker(s), or turning the MODE switch to OFF or WARM UP. When power returns, the computer determines power dropout duration by comparing chronometer day and time with the day and time stored in memory at power loss.

If the power dropout is less than one second, operation resumes as though nothing occurred except star tracking is suspended for 70-seconds.

If the power dropout is greater than one second, the system returns to C/A, the MAL light illuminates, the MODE window indicates C/A, and all display counters clear. If the RSO presses the HOT switch, the system proceeds with an automatic restart (hot airstart or ground hot start). If, instead, the RSO selects AIRSTART with the MODE switch and presses the MODE START switch, the system starts a COLD airstart. Refer to COLD Airstart Alignment, this section.

NOTE

- If the system is HOT started and then a COLD airstart is desired, return the MODE switch to OFF. If the MODE START switch is pressed in any MODE other than AIRSTART, the system must be turned off to initiate a COLD airstart.
- After a power dropout, pressing MODE START on the ground with the MAL light flashing (initiating a ground alignment) erases the 40-List. Anytime a rapid or a gyro-compass ground alignment is performed, 40-List data must be reentered. 40-List data is not deleted if HOT is pressed with the MAL light flashing or if a cold or hot airstart is performed. Therefore, 40-List data is retained for a ground hot start, cold airstart, or a hot airstart. Pressing the MODE START switch with a steady MAL light has no effect on the 40-List.
- Complete loss of ac or dc power to the guidance group will cause all ANS NCD panel lights and windows to extinguish/go blank.

Chronometer Failure

The system checks the chronometer day and time inputs when the MODE switch is turned to an "operate" mode and after a power dropout. If the chronometer inputs are not present, a chronometer failure has occurred. This is indicated by a flashing MAL light, clearing of the present position display, and I/O in the MODE window. The system will return to a coarse align condition. The MAL light will not clear without corrective action. On the ground, the alternatives are to

ANS TEMPERATURE WARNINGS

INDICATOR	STATE	ANS CONDITION	ACTION
Red TEMP LIMIT Light	Off	Within safe limits.	————
	Steady	Air inlet housing or cooling air at computer inlet above design limits.	Turn MODE switch OFF.
	Flashing	Cooling air flow less than 2.5 lb/min.	Turn MODE switch OFF.
Amber TEMP TOLR Light	Off	Within tolerance for optimum accuracy.	————
	Steady	Platform temp below normal.	Check ANS accuracy.
	Flashing	Platform temp above normal.	Be alert for TEMP LIMIT. Check ANS accuracy. Keep rpm up if warning on due to hot fuel in flight.

Figure 4-60

replace the chronometer, perform the fill Day and Time routine, or to select INERTIAL ONLY. A Hot Airstart may be possible after a chronometer failure if the Fill Day and Time procedure is used.

Incorrect chronometer day or time does not result in a chronometer malfunction, only incorrect inputs. With a chronometer failure, in the event of any power dropout (even less than one second), the MAL light will illuminate since the system cannot determine dropout duration.

NOTE

> If the chronometer fails after the ANS is in ASTRO INERTIAL, the failure will not be apparent unless the ANS must be restarted. The ANS only interrogates the chronometer when it is initially activated.

Star Tracker Failure (During Ground Alignment)

Forty five seconds after initiation of C/A (for rapid and gyrocompassing ground alignments) the star tracker searches for the artificial star within the astroinertial instrument.

If the artificial star is tracked, the star light on the ANS NCD panel flashes until the system enters F/A. If the artificial star is not acquired and the alignment was initiated by pressing MODE START or RAPID, the MAL light flashes at the end of C/A and the MODE window indicates I/O. If the MAN CLEAR switch is pressed, the MAL light extinguishes and the MODE window will change to F/A. The alignment in progress proceeds normally. Since the most common cause of this malfunction indication is a

ANS WARNING INDICATIONS

PROBLEM CAUSE	COCKPIT INDICATIONS: PILOT					RSO								
	AUTO PILOT DISENGAGE	ADI PWR OFF FLAG IN VIEW	ADI VERTICAL STEERING BAR FLAG IN VIEW	ANS REF AND CAUTION ON	HSI RANGE SHUTTER CLOSED	ATTITUDE IND OFF FLAG IN VIEW	MAL LIGHT ON	ANS FAIL AND CAUTION	MODE WINDOW	PRESENT LAT/LONG DISPLAY	TEMP LIMIT LIGHT	TEMP TOLR LIGHT
MODE CONTROL IN — OFF												
MODE CONTROL IN — WARM UP							STEADY					
ANS ESS DC C/B OUT												
ANS 3 PHASE C/B OUT												
AC PWR LESS THAN 60 V DC PWR LESS THAN 20V							FLASH		FROZEN	FROZEN		
PWR ON AFTER ONE SEC OR MORE INTERRUPT (1) (2)							FLASH		C/A	BLANK		
PLATFORM FAIL. GROUND SPEED EXCESSIVE, OR PLATFORM SELF TEST FAIL (4)							FLASH		D/R			
CHRONOMETER INPUT OFF							FLASH		I/O	BLANK		
ENCODING FAILURE							FLASH		ENC			
COMPUTER FAILURE							FLASH		FROZEN	FROZEN		
INTERNAL STAR MISSED BY STAR TRACKER (3) AND (1)							FLASH		I/O			
TEMP LIMIT CONDITION												
TEMP TOLR CONDITION												
MISSION TAPE DP ERROR									DP **			

NAV NOT READY in heavy bordered area -- ANS outputs not valid

Squares are shaded where warning is given. Squares are clear where no warning given

NOTE

(1) Warnings not repeated if CLEAR is depressed

(2) Coarse alignment is starting, ground or air start required

(3) Internal star only tracked from approximately one minute into COARSE ALIGN until end of COARSE ALIGN

(4) Platform self test failure

F203-247(c)

Figure 4-61

burned out artifical star bulb rather than an actual tracker malfunction, an attempt should be made to track stars. If stars cannot be tracked, the ANS should be operated in INERTIAL ONLY. Other alternatives are to repeat the alignment or replace the guidance group and realign. There is no star tracker malfunction indication in flight.

Platform Failure

During F/A or A-I, the system checks groundspeed and horizontal speed perpendicular to keel line; if this speed is greater than 2150 and 300 knots, respectively, the MAL light flashes, the MODE window indicates D/R, and the nav-not-ready warning legends and flags are activated. This malfunction cannot be cleared unless DEAD RECKON is selected or the measured speed drops below the prescribed limits. This test will not rapidly detect all platform failures. To get an early indication of ANS or INS failure, the RSO should compare true airspeed with ground speed and INS pitch and roll with ANS pitch and roll throughout the flight; especially in IFR conditions.

NOTE

- The ANS failure indications may not be energized for several minutes if the platform fails while subsonic.
- If DEAD RECKON is selected for training, there is no MAL light warning in case of platform failure; the only indications are the nav-not-ready warnings on other cockpit indicators and annunciator panels.

Platform Self-Test Failure (Platform Disable)

During all modes of operation, the platform BIT (BUILT-IN-TEST) monitors circuit parameters which may indicate saturation of the platform servo loops. If saturation is detected, the loops are disabled momentarily. Re-establishment is attempted every five seconds until successful.

If a platform disable occurs, the MAL light flashes, the RSO's ANS FAIL annunciator light illuminates, and the pilot's ANS REF annunciator caution light illuminates. If the pilot has ANS platform selected, the autopilot disengages, an OFF flag appears in the ADI, the ANR warning illuminates (flashing red DAFICS PREFLIGHT BIT FAIL light) and the PVD is inhibited. If the RSO has ANS platform selected, an OFF flag appears in the attitude indicator. All ANS displays change to DEAD RECKON updating, "A" star tracking is commanded, and airspeed damping is increased.

There is a good probability that the platform will recover, and ANS performance should be approximately equivalent to that of a Hot Airstart. To engage the system and remove the NAV-NOT-READY flags, the RSO must place the MODE switch to DEAD RECKON, press the MODE START switch, then place the MODE switch to ASTRO INERTIAL or INERTIAL ONLY position, and press the MODE START switch again.

Computer Failure

The MAL light illumination circuitry is such that the computer must supply a periodic signal to keep the MAL light out. If a computer failure occurs which prevents proper sequencing of the computer program, the MAL light does not receive the periodic signal and illuminates. In general, no MODE window indication is provided, since the computer is no longer operating; however, the computer could cause random control panel display changes while coming to a stop. No RSO operation will extinguish the MAL light, once on, except possibly moving the MODE switch to OFF and restarting. In most cases, the ANS will be unusable until the computer is replaced.

Yaw Encoding Failure

If the ANS computer self test routine detects a failure in the Yaw Gimbal Angle encoding function, the NCD panel Mode window changes to ENC, the MAL light flashes, and the synthesized heading back-up mode activates. Pressing MAN CLEAR extinguishes the flashing MAL light and removes the ENC indication but does not remove the malfunction. "Synthesized heading" is true ground track and is output to the HSI and BDHI compass cards and NCD panel as true heading. Aircraft drift/sideslip results in true heading error. ANS navigation capability is not affected by this failure, nor are auto-nav operation, normal ANS displays or panel routines. INS magnetic heading displayed on the NCD panel is not affected. ASARS and other sensor systems are not affected.

Mission Tape Destination Point Error

If the aircraft is at index (turn start) and a destination point is specified which does not exist in the mission tape, the next destination point in the normal mission tape sequence is assumed and the aircraft is automatically directed to that point. The MODE window displays DP * and the SELECTED DATA windows flash their contents at a one and a half second rate. MAN CLEAR and DISPLAY must be pressed to restore normal NCD panel operation and to verify correct navigation. If not on the correct track, DIR STEER or Track Leg Update as required.

Warning Indications

The ANS uses a variety of cockpit warnings. Figure 4-19 lists these displays. In some cases, these displays alert the RSO to problems that may affect eventual mission success. In other cases, however, these display indicators warn the crew that ANS outputs are inaccurate and/or unsafe. NAV-NOT-READY indicators must be recognized and responded to instinctively by the flight crew.

The ANS warnings are:

1. MAL, TEMP LIMIT, and TEMP TOLR warnings are on the NCD panel.

2. The RSO's ANS FAIL annunciator panel light and the pilot's ANS REF annunciator caution light illuminate when a MAL or TEMP LIMIT light illuminates on the NCD panel or if there is a loss of ac or dc power.

3. A nav-ready output is provided by the ANS to:

   a. ADI vertical steering bar flag when the pilot's display mode select switch is in ANS.

   b. ADI power-off flag when the pilot's attitude reference select switch is in ANS.

   c. RSO attitude indicator power-off flag when the RSO's attitude reference select switch is in ANS.

   d. DAFICS when the pilot's attitude reference select switch is in ANS. The autopilot will disengage, the ANR light illuminates (flashing DAFICS PREFLIGHT BIT red FAIL light), and the PVD is inhibited if the NAV-READY signal is not present.

   e. ANS REF caution light on the pilot's annunciator panel.

   f. ANS FAIL light on the RSO's annunciator panel.

With ANS reference selected, the warning shutters and flags are withdrawn from view, the autopilot can be engaged, and the caution lights are extinguished when the nav-ready signal path exists.

Nav-Not-Ready Indications

The ANS REF and ANS FAIL lights illuminate, the warning flags appear, the autopilot disengages, the ANR light illuminates and the PVD is inhibited when the nav-ready output is in the not-ready state. The conditions for a nav-not-ready signal are:

1. MODE switch in OFF or WARM UP.

2. MODE window displays C/A or ENT.

3. AC or DC power to the ANS is interrupted for more than 1 second. An interruption of less than 1 second may cause a momentary not-ready output.

4. Platform failure.

5. Computer failure.

Attitude Outputs

The source of ANS attitude information is the inertial platform. Resolvers on the platform gimbals provide: pitch and roll to the attitude indicators and the PVD; yaw, pitch and roll to the ANS digital computer; and heading, yaw, pitch and roll to DAFICS.

The analog-to-analog follow-up servos are not rate limited and can follow aircraft attitude changes at rates above 60 degrees per second. These servos do not automatically stop during a power transient; however, response does decrease and the servos freeze when ac voltage drops to approximately 60 volts. Failures of these follow-up servos could cause frozen attitude displays (including inputs to DAFICS), rapidly changing attitude values, or gradually increasing attitude errors. This is particularly dangerous at night or in IFR conditions, especially if the pilot's attitude reference select switch is in ANS and the autopilot is engaged. An ANR light (flashing DAFICS PREFLIGHT BIT red FAIL light) could indicate that the selected attitude reference is erroneous. Monitor other attitude references (INS platform and pilot's standby attitude indicator) to detect ANS attitude errors as soon as possible.

Flashing MAL Light During Ground Operation

It is normal for the MAL light to flash when the MODE switch is moved from OFF or WARM UP to ALIGN, ASTRO INERTIAL, or INERTIAL ONLY. The MODE window reads C/A if the system has a DAY and TIME, or I/O if a DAY and TIME are not available from the chronometer. The MAL light will go out after DAY and TIME are filled, MODE START is pressed and MAN CLEAR is pressed.

If the MAL light flashes during any ground operation after either MODE START or RAPID is pressed to start an alignment, observe the MODE window and SELECTED DATA (SD) windows.

1. If the MODE window display has not changed and the SD windows are frozen, a computer malfunction has occurred. Turn the MODE switch to OFF and restart the alignment. If the malfunction repeats, replace the ANS guidance group.

2. If the MODE window has changed to C/A and the SD windows are cleared, a power dropout in excess of 1 second has occurred. If a GROUND HOT START is desired, complete the GROUND HOT START checklist. If a GROUND HOT START is not desired, turn the MODE switch to OFF and perform another ground alignment.

3. If the mode window has changed to ENC and the SD true heading is in question, the yaw encoding has malfunctioned. "Synthesized heading" (true ground track output to the HSI and BDHI compass cards and NCD panel) cannot be accurately calculated when not moving. Pressing MAN clear extinguishes the flashing MAL light and removes the ENC indication but does not remove the malfunction. Replace the ANS guidance group. Refer to YAW Encoding Failure this section.

4. If the MODE window has changed to I/O and the SD windows are not affected, the platform collimator light (artificial star) has not been tracked. This is most likely due to the platform collimator bulb being burned out. Otherwise it is a tracker malfunction. This malfunction only occurs at the end of C/A or ENT. If the ANS guidance group cannot be replaced, press the MAN CLEAR switch to extinguish the MAL light. The MODE window will initialize normally. Attempt to track stars in ASTRO INERTIAL. If stars cannot be tracked, fly in INERTIAL ONLY.

5. If the MODE window has changed to I/O and the SD windows are cleared, a power dropout with no DAY and/or TIME available from the chronometer is indicated. This would also happen if no chronometer were available. Turn the MODE switch to OFF, replace the chronometer, and perform another alignment. If a chronometer is not available:

    a. If a correct DAY and TIME are available, insure MODE switch is set to desired type alignment, fill day and time, press MODE START or RAPID and continue with GROUND ALIGNMENT checklist.

    b. If correct DAY and TIME are not available insure MODE switch is set to desired type alignment, and press MODE START or RAPID. If RAPID was selected, then turn the MODE switch to INERTIAL ONLY and MODE START. This extinguishes the flashing MAL light and a RAPID alignment will continue. Perform the Ground Alignment Correct procedure if desired.

    NOTE

    The first MODE START or RAPID start selects the type alignment. But INERTIAL ONLY has to be MODE started to clear the flashing MAL Light if DAY and/or TIME are not available, either from the chronometer or fill routine.

6. If the MODE window has changed to D/R, a platform failure or platform disable is indicated. Confirm by pressing MAN CLEAR switch while observing the MODE window and the MAL Light.

    a. If the MODE window then changes to A-I or I/O, and the MAL light goes off, a platform failure is indicated. The SD windows will not be affected. If the ANS guidance group can be replaced, turn the MODE switch to OFF, replace the group and realign. If the group cannot be replaced, select DEAD RECKON with the MODE switch, and complete DEAD RECKON MODE checklist.

    NOTE

    The MODE window change and MAL light extinguishing could be momentary. The light will go out when the window reverts to A-I or I/O. The window may eventually revert back to D/R with a flashing MAL light.

    b. If the MODE window <u>remains</u> D/R and the MAL light goes out, a platform disable is indicated. The counters will be referenced to the DEAD RECKON frame. Select DEAD RECKON with the MODE switch and press MODE START. Then select ASTRO INERTIAL or INERTIAL ONLY and press MODE START again. The NAV-READY functions will now resume and the system will operate normally.

<u>Flashing MAL Light In Flight</u>

It is normal for the MAL light to flash when the MODE switch is moved from OFF or WARMUP to ASTRO INERTIAL, INERTIAL ONLY, or AIR START. The MODE window will read C/A if the system has a day and time or I/O if a day and time are not available from the chronometer. The MAL light will go out after DAY and TIME are filled, MODE START is pressed and MAN CLEAR is pressed.

If the MAL light flashes during airborne operation, observe the MODE window and SELECTED DATA windows.

1. If the MODE window display has not changed and the SD windows are frozen, a computer malfunction has occurred. Turn the MODE switch to OFF and attempt a COLD AIRSTART.

2. If the MODE window has changed to C/A and the SD windows are cleared, a power dropout in excess of 1 second has

occurred. Attempt a HOT AIRSTART procedure. Otherwise press MAN CLEAR, select DEAD RECKON with the MODE switch, and complete DEAD RECKON mode checklist. A COLD AIRSTART may then be performed. The COLD AIRSTART is also necessary if the HOT AIRSTART is unsuccessful.

3. If the mode window has changed to ENC and the SD windows are not affected, the yaw encoding has malfunctioned. "Synthesized heading" (true ground track) is output to the HSI and BDHI compass cards and NCD panel as true heading. Pressing MAN clear extinguishes the flashing MAL light and removes the ENC indication but does not remove the malfunction. Refer to Yaw Encoding Failure this section.

4. If the MODE window has changed to I/O and the SD windows are cleared, a power dropout with no day and/or time available from the chronometer is indicated. Turn the MODE switch OFF and perform a COLD AIRSTART. If DEAD RECKON mode is preferable to a COLD AIRSTART, press MAN CLEAR to initialize the system. Select INERTIAL ONLY and MODE START to extinguish the flashing MAL Light. Then select DEAD RECKON and complete the DEAD RECKON checklist.

NOTE

The initial position error will probably be very large due to no time reference when the system is initialized after pressing MAN CLEAR. Fill present position or update by fixing.

5. If the MODE window has changed to D/R, a platform failure or platform disable is indicated. Confirm by pressing the MAN CLEAR switch, while observing the MODE window and the MAL light.

a. If the MODE window then changes to A-I or I/O and the MAL light goes off, a platform failure is indicated. To confirm platform failure, check ANS attitude, heading, and groundspeed displays. The SD windows will not be affected. Turn the MODE switch to DEAD RECKON and complete the DEAD RECKON mode checklist, or turn the MODE switch to OFF and attempt a COLD AIRSTART.

NOTE

The MODE window change and MAL light extinguishing may be momentary in the event of a platform failure. The light will go out when the MODE window reverts to A-I or I/O. But the window will eventually revert back to D/R and the MAL light will flash again.

b. If the MODE window <u>remains</u> D/R and the MAL light goes out, a platform disable is indicated. The SD displays will be referenced to the DEAD RECKON frame. Select DEAD RECKON with the MODE switch and press MODE START. Then select either ASTRO INERTIAL or INERTIAL ONLY with the MODE switch and press MODE START again. The NAV-READY functions will now resume and the system will operate normally.

<u>All NCD Panel Windows Blank</u>

If all NCD panel lights and windows go blank it indicates loss of ac or dc power to the ANS. Check the ANS essential dc and ANS 3 phase ac circuit breakers and the position of the MODE switch. When power is restored, as indicated by the MAL light flashing, follow the procedures listed under <u>Flashing MAL Light During Ground Operation</u> or <u>Flashing MAL Light In Flight</u>.

INTRODUCTION

This section provides operating limits and restrictions for normal operation of the SR-71A and SR-71B.

MINIMUM CREW

The aircraft may be flown solo.

INSTRUMENT MARKINGS

The instrument markings shown in Figure 5-1 are not necessarily repeated elsewhere in this section.

Airspeed-Mach Meter

The limit hand of the airspeed-mach meter is set to indicate 460 KIAS at sea level.

FUEL

The only approved fuel is JP-7.

EMERGENCY FUELS

Any fuel other than JP-7 (such as JP-4, JP-5, or JP-8) is considered an emergency fuel and may be used only when refueling must be accomplished to avoid loss of the aircraft. Operation with emergency fuels is restricted to speeds below Mach 1.5. Rate of climb is not restricted. If fuels other than JP-7 are used, record it as a discrepancy in AFTO Form 781.

ENGINE OPERATING LIMITS

IN-FLIGHT SHUTDOWN

After any in-flight shutdown, a report must be made if the fuel shut-off valve was operated and/or if windmilling speeds less than 3400 rpm were experienced.

While in-flight, intentional engine shutdown is not permitted during normal operation unless specifically authorized.

EXHAUST GAS TEMPERATURE (EGT)

The nominal operating bands, limits for continuous operation, and emergency operating zones are a function of compressor inlet temperature (CIT) as shown in Figure 5-2.

Ground Operation

The EGT limit for starting and for all ground operations with the RPM at or below idle is 565°C.

Start

Shut down the engine if EGT exceeds 565°C during start. If EGT exceeds 565° but is less than 649°C record in the AFTO Form 781 the number of excursions and peak EGTs. The engine is limited to five excursions between 565°C and 649°C before it must be removed and inspected.

If EGT exceeds 649°C during engine start, do not attempt additional starts; an engine inspection must be made.

Engine Surge

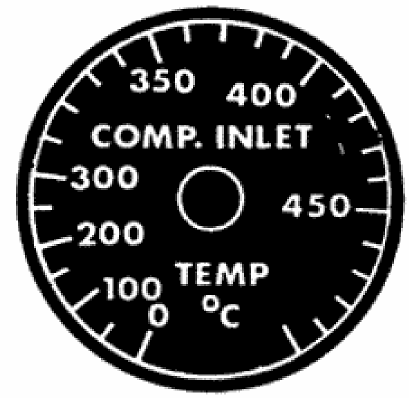
If an engine surges (compressor stalls) during pretakeoff trimming, downtrim to eliminate the surge, but do not trim lower than 60°C below the desired trim point for the ambient temperature. After takeoff, engines downtrimmed for surge protection should be uptrimmed to 775°C EGT when CIT has reached 0°C if automatic EGT trimming is not employed.

NOTE

When EGT is not above the nominal operating band, Figure 5-2, surging is only a problem during ground operations.

INSTRUMENT MARKINGS

TACHOMETER



COMPRESSOR INLET TEMPERATURE GAGE

COMPRESSOR INLET PRESSURE GAGE
7 psi-Minimum for air start

FUEL TANK PRESSURE GAGE

ANGLE OF ATTACK INDICATOR

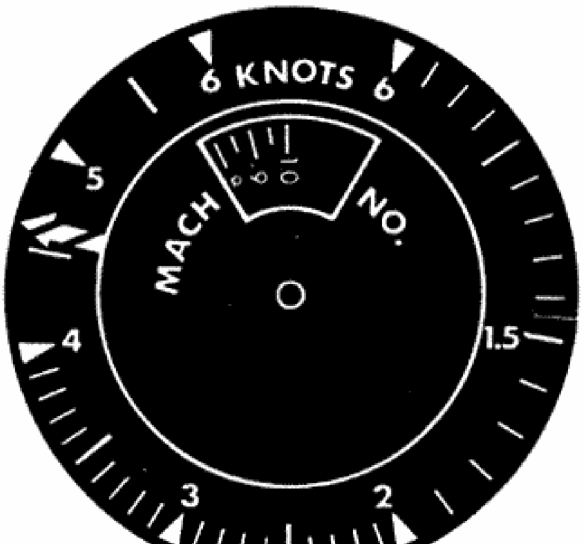
OIL PRESSURE GAGE

NOTE
LIMIT VALUE DENOTED BY EDGE OF RED LINE SO THAT INDICATION WITHIN MARKED RED RANGE EXCEEDS LIMIT VALUE

F203-30(1)(1)

Figure 5-1 (Sheet 1 of 2)

INSTRUMENT MARKINGS



MACH-AIRSPEED INDICATOR

NOTE
LIMIT VALUE DENOTED BY EDGE OF RED LINE SO THAT INDICATION WITHIN MARKED RED RANGE EXCEEDS LIMIT VALUE

C. G. INDICATOR

HYDRAULIC SYSTEM PRESSURE GAGES
(A AND B-L AND R)

F203-30(2)(h)

Figure 5-1 (Sheet 2 of 2)

Emergency Operation

Report EGT's experienced and the time involved any time EGT in or above the emergency operating zone is experienced (EGT above 830°C below 40°C CIT; EGT above 805°C above 40°C CIT), as a special post flight inspection is required.

Continuous or accumulated operating time in the emergency EGT operating zone for more than 15 minutes may require engine removal. No more than one hour may be accumulated with EGT in excess of the normal limit schedules.

EGT must be reduced immediately if an emergency limit temperature is exceeded.

WARNING

Shutdown the affected engine for EGT:

- Above emergency EGT limit (845° C above 40°C CIT; 865°C below 40°C CIT) and below 900°C for 2 minutes.
- between 900°C and 950°C for 15 seconds.
- over 950°C for 3 seconds.

CAUTION

At low CIT, EGT above the nominal trim band may cause engine surge (compressor stall).

COMPRESSOR INLET TEMPERATURE (CIT)

With both inlet guide vanes (IGVs) cambered, the maximum allowable compressor inlet temperature is 427°C.

With an IGV in axial (IGV light illuminated), 150°C must not be exceeded, and continued operation with CIT above 125°C is not permitted (approximately Mach 2.0).

ENGINE SPEED (RPM)

Engine speed should not exceed the higher value shown by Figure 5-2 for the nominal operating band. Report engine speeds above 7450 rpm below 300°C CIT, and 7300 rpm above 300°C CIT as an engine overspeed. Include maximum rpm attained, CIT, and accumulated time above the limit.

The allowable rpm fluctuation is ±1%.

OIL PRESSURE

35 psi is the minimum oil pressure permitted at idle rpm. Oil pressure below 35 psi is unsafe and requires that a landing be made as soon as possible using the minimum thrust required to sustain flight. The engine may have to be shut down.

In-flight oil pressures between 35 and 40 psi are undesirable but acceptable.

The normal pressure is 40 to 55 psi while rpm is in the nominal operating band. Gradually increasing oil pressure up to 60 psi is acceptable at high Mach provided the indication returns to normal values after deceleration to subsonic speeds.

The allowable oil pressure fluctuation is ±3 psi.

EXHAUST NOZZLE POSITION (ENP)

Random ENP fluctuations of ±4% are acceptable in-flight (if rpm is within limits). Cyclic ENP fluctuations should be reported.

MAXIMUM WEIGHT

The maximum gross weight for takeoff and landing is not limited; however, when feasible, routine full-stop landings should be made with no more than 10,000 pounds of fuel. The maximum fuel load recommended for touch-and-go landings is 25,000 pounds remaining.

SECTION V

ENGINE OPERATING SCHEDULES AND LIMITS

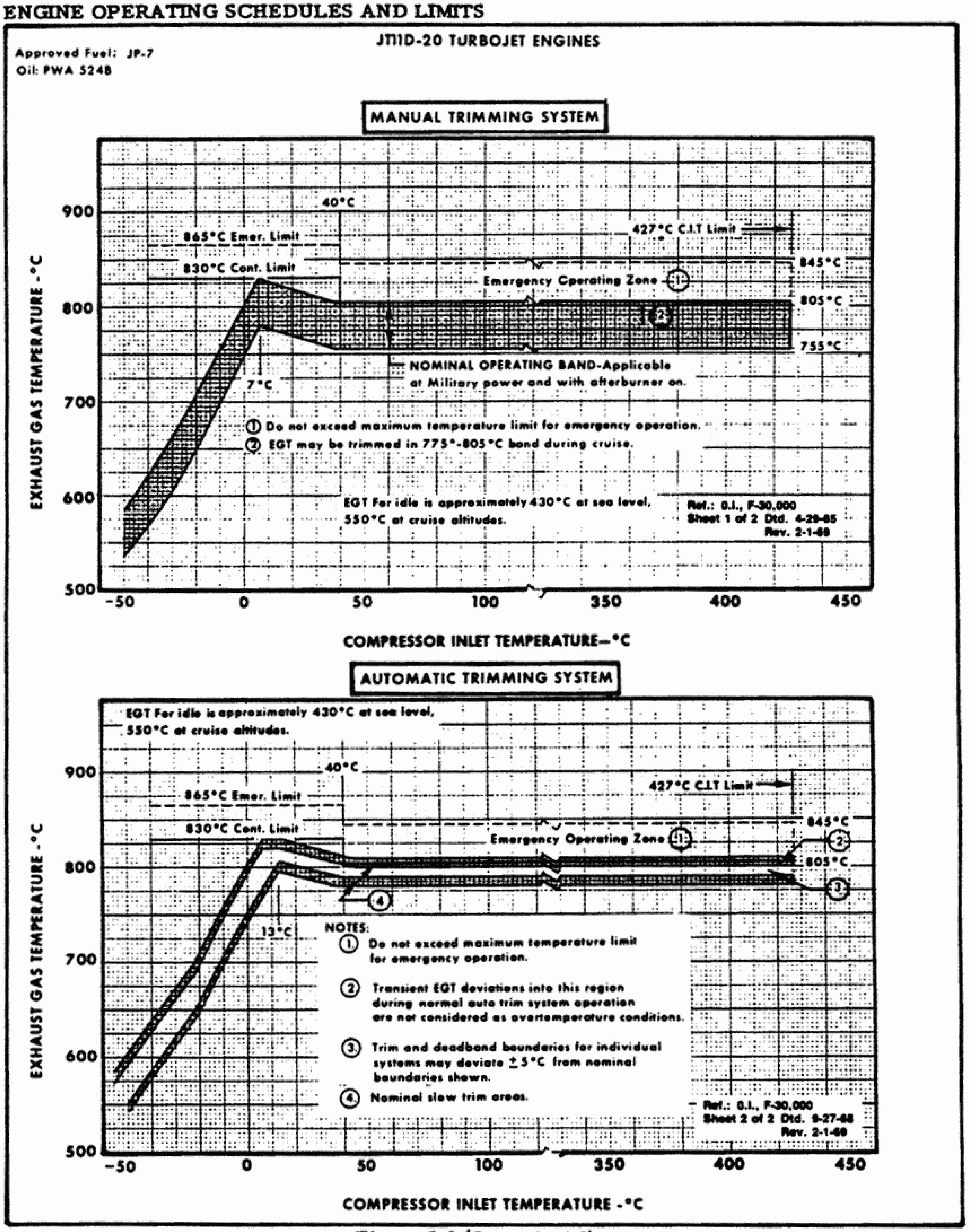


Figure 5-2 (Sheet 1 of 2)

ENGINE OPERATING SCHEDULES AND LIMITS

Approved Fuel : JP-7
Oil: PWA 524B

JT11D-20 TURBOJET ENGINES

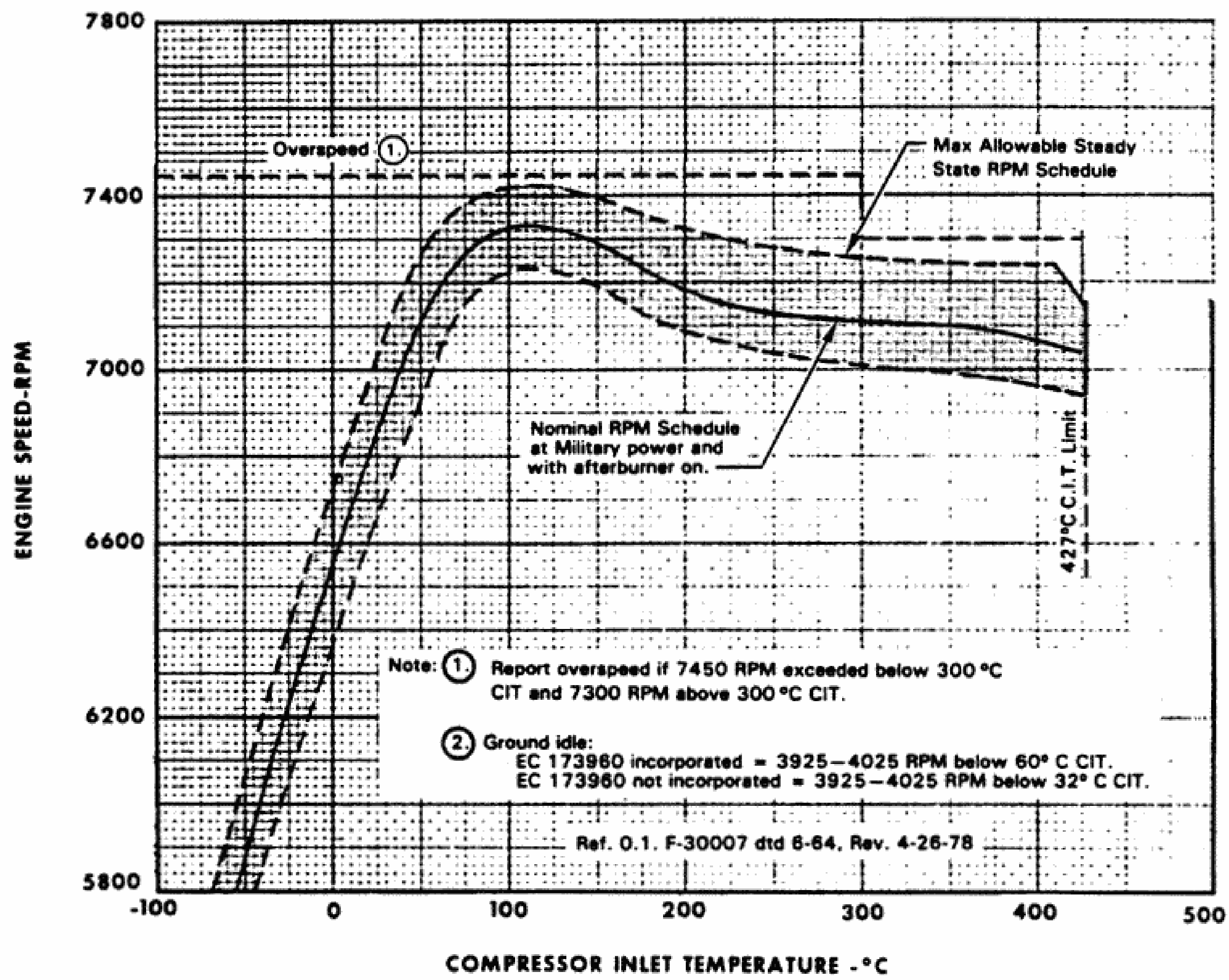


Figure 5-2 (Sheet 2 of 2)

The maximum gross weight capability for single-engine flight is presented in Part II of the Appendix.

LOAD FACTOR LIMITS

Limit load factors are shown by Figure 5-5. The diagrams presented for symmetrical flight are also applicable to entry into turns with normal bank angles. Allowable load factors applicable to rolling flight (abrupt maneuvers as a result of rapid control displacement) are especially identified and have a minimum limit of 1 g. Specific limits are shown for flight at Mach 3.2, 2.6, and at Mach 2.0 or less and for subsonic cruise and transonic penetration at forward c.g. Limit speeds and load factors applicable to operation at intermediate speeds above Mach 2.0 are obtained from sheets 4 and 5 of Figure 5-5.

The following rule of thumb may be used for operational limit load factors for symmetrical flight:

Mn 2.0 or less:	
65,000 to 124,000 lb	-.2 to 2.5 g
124,000 to 143,000 lb	-.2 to 2.0 g
80,000 to 90,000 lb	
below 50,000 ft	-.2 to 3.5 g
above 50,000 ft	-.2 to 2.5 g
Mn 2.0 to 2.6	
all weights	-.1 to 2.0 g
Mn 2.6 to 3.2	
all weights	-.1 to 1.5 g

FLIGHT ENVELOPE LIMITS

Refer to Figures 5-3 and 5-4 for summarized Mach, airspeed, angle of attack, altitude and bank angle limits and restrictions. Refer to Center of Gravity Limits, this section, for speed limits with c.g. forward of 17%.

MAXIMUM MACH

Mach 3.2 is the design Mach number. Mach 3.17 is the maximum scheduled cruise speed recommended for normal operations. However, when authorized by the Commander, speeds up to Mach 3.3 may be flown if the limit CIT of 427°C is not exceeded.

WARNING

Mach excursions when using Mach Hold may be severe during turns or while flying through rapid temperature changes at altitude. Use the basic pitch autopilot instead of Mach Hold if speed and altitude excursions are excessive.

Without Inert Tank Atmosphere

Mach 2.6 is the maximum speed without an inert atmosphere in the fuel tanks. To achieve an inert atmosphere in the tanks, LN_2 must be available and fueling to the ground shutoff level must be accomplished prior to flight or aerial refueling must be accomplished to a minimum level of 65,000 lb.

During descent from flight above Mach 2.6 with fuel tank pressurization failure, 250 KEAS minimum airspeed is permissible during subsonic loiter between FL 400 and FL 350.

AIRSPEED

WARNING

Monitor flight instruments during autopilot operation. Assure that speed does not exceed the normal operating envelope.

Refer to Figure 5-3. The minimum airspeed restrictions are 310 KEAS when supersonic, 300 KEAS when subsonic above FL 250, and 145 KIAS below FL 250 unless angle of attack limits would be exceeded.

LIMIT SPEED AND ALTITUDE ENVELOPE

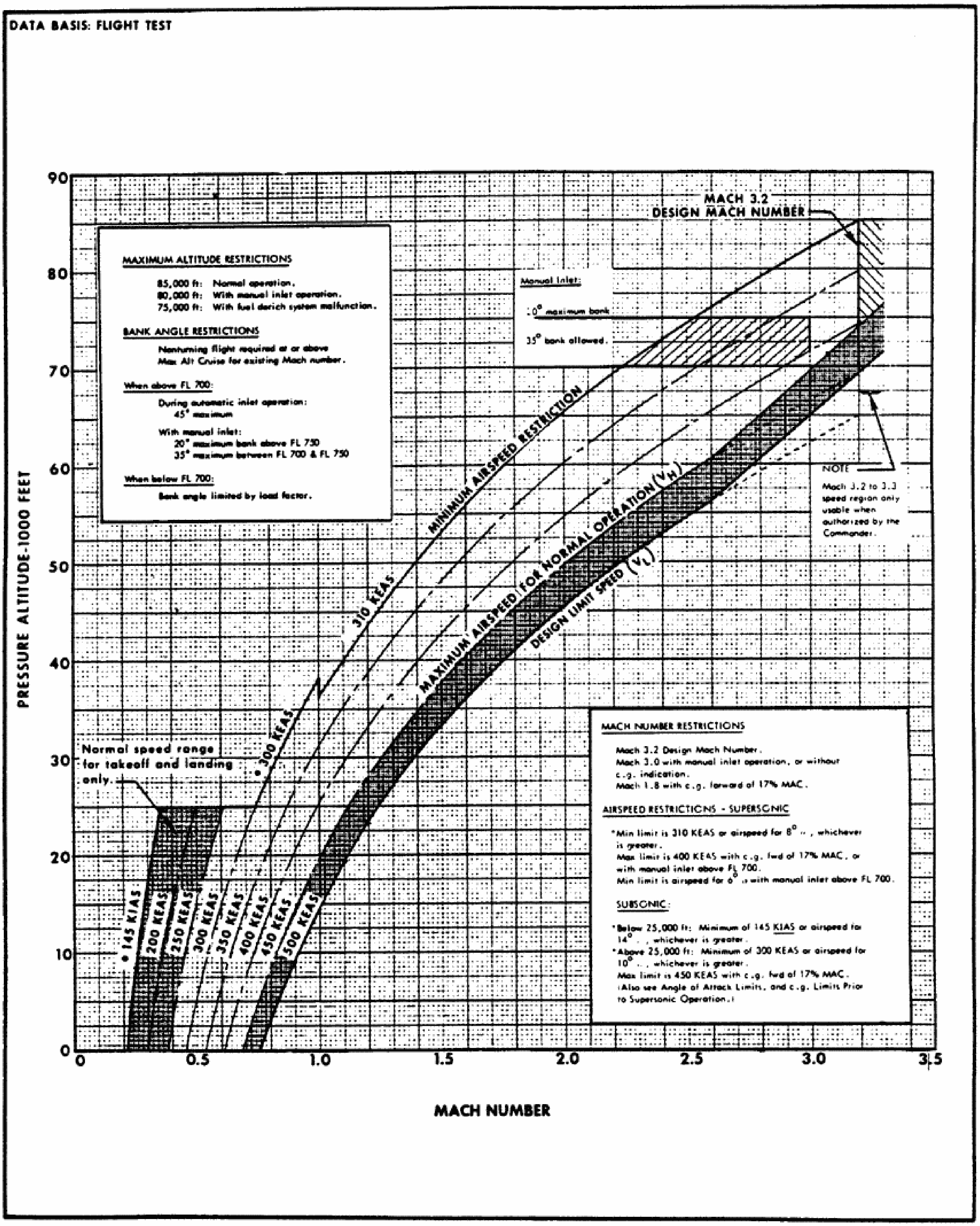


Figure 5-3

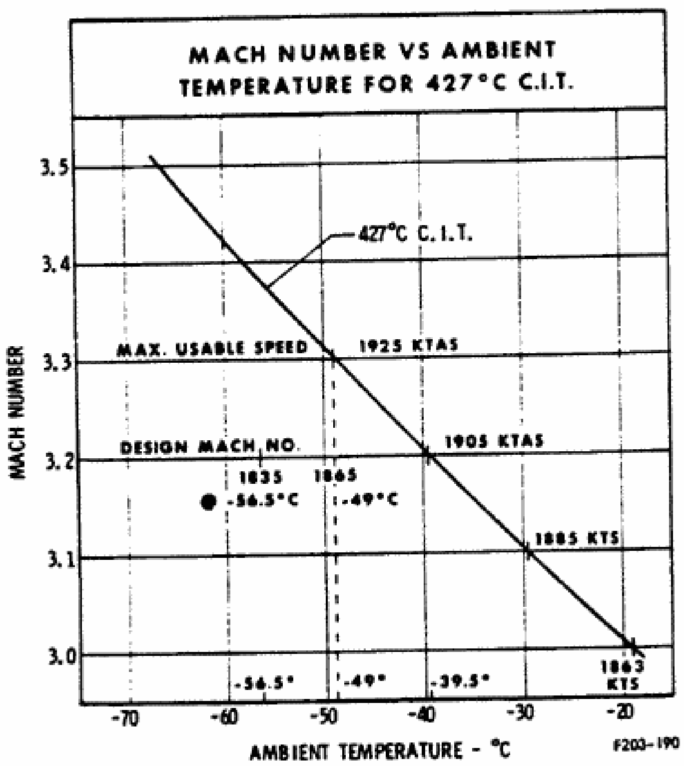


Figure 5-4

ANGLE OF ATTACK

The maximum angle of attack limit is the stick shaker boundary or the following (whichever occurs first):

> 6° with manual inlet above 70,000 feet.
>
> 8° supersonic
>
> 10° subsonic, above FL 250.
>
> 14° below FL 250.

Angle of attack limits are valid only if airspeed and c.g. limits specified in this section are observed.

With a normally operating automatic pitch warning system, do not position the APW (pusher/shaker) switch to OFF.

If either the stick shaker or pusher/shaker warning is activated, reduce angle of attack immediately. Operation in flight conditions such that the shaker warning is on continuously is not permitted. The pitch boundary indicator (PBI) should be cross-checked with the angle of attack when operating near the angle of attack limits or PBI shaker boundary.

WARNING

> Avoidance of the stick shaker or pusher/shaker warning boundaries does not, by itself, assure that load factor or angle of attack limits will be observed.

ALTITUDE

The maximum altitude limit is 85,000 feet unless higher altitude is specifically authorized.

Do not exceed 80,000 feet with an inlet in manual operation.

Do not exceed 75,000 feet with either fuel derichment system inoperative.

HIGH ALTITUDE TURNS

Flight at or above the Maximum Altitude Cruise profile (for the existing Mach, gross weight, and ambient temperature) is restricted to nonturning flight. A descent of approximately 2000 feet below the Maximum Altitude Cruise profile (i.e. to the Intermediate Altitude Cruise Profile) prior to turn entry is recommended. Refer to Maximum Afterburner Ceiling Profile and Maximum Altitude Cruise Profile, Section VI.

PROHIBITED MANEUVERS

Stalls, spins, inverted flight, and intentional inlet unstarts are prohibited.

SIMULATED SINGLE-ENGINE FLIGHT

Simulated single-engine approaches at less than 200 KIAS or with more than 25,000 pounds of fuel remaining are prohibited. Planned single-engine missed approaches/go-arounds will be initiated not lower than 300 feet above the ground.

LIMIT LOAD FACTOR DIAGRAM

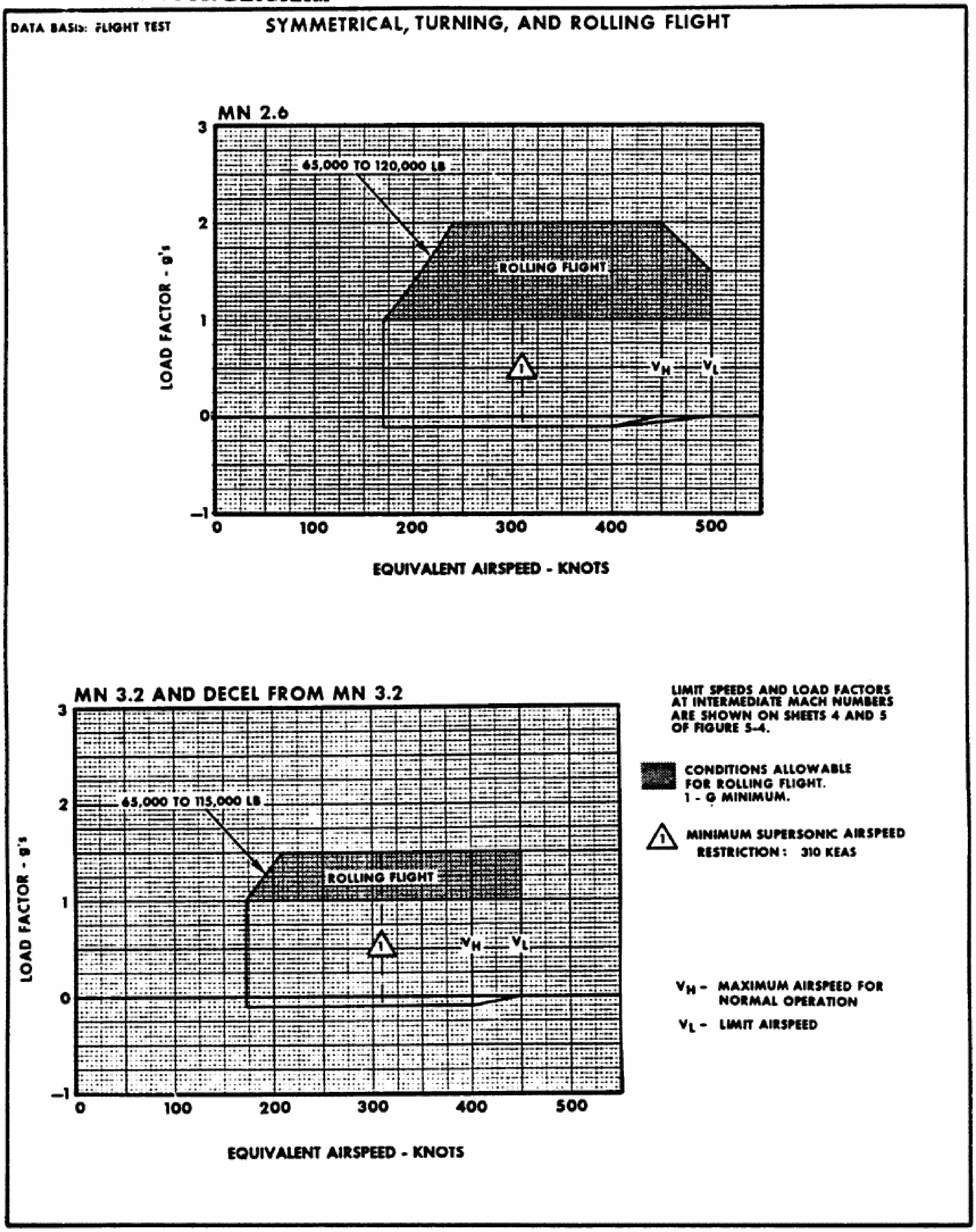


Figure 5-5 (Sheet 1 of 5)

LIMIT LOAD FACTOR DIAGRAM

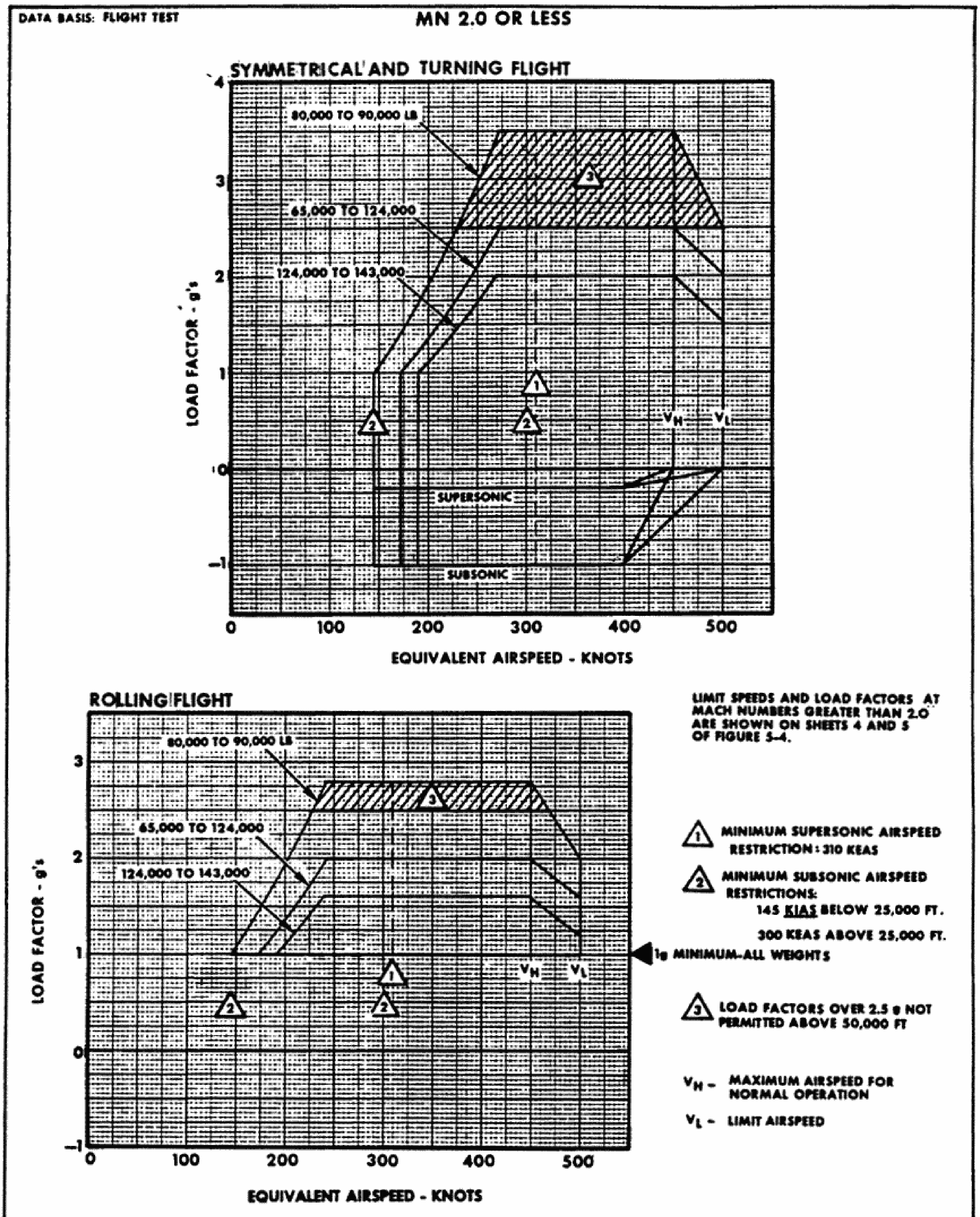


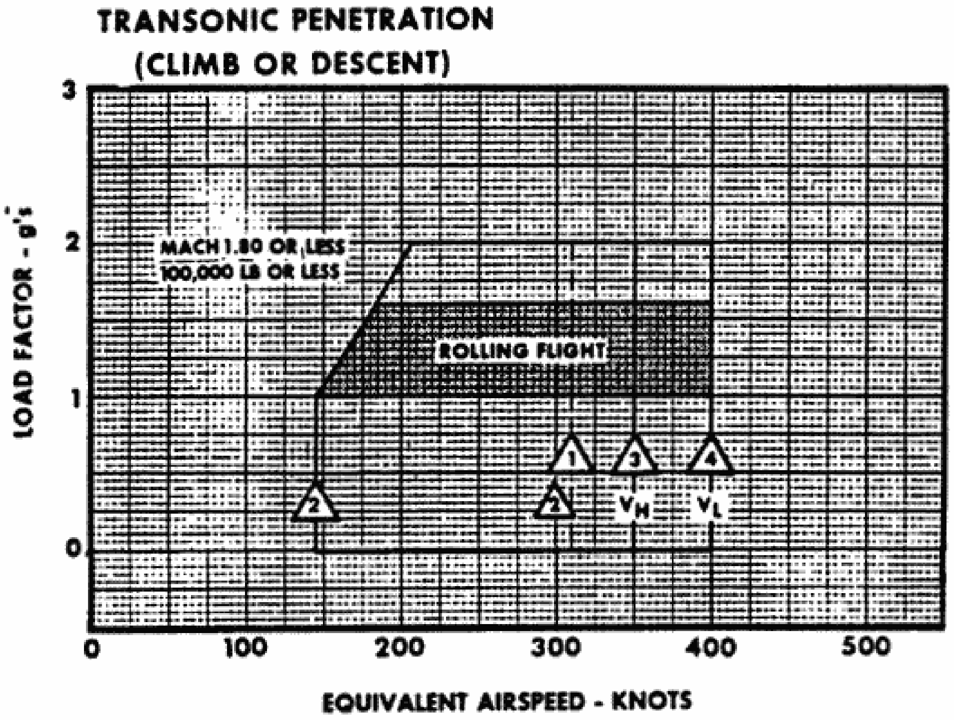
Figure 5-5 (Sheet 2 of 5)

LIMIT LOAD FACTOR DIAGRAM

DATA BASIS: ESTIMATED

SYMMETRICAL, TURNING, AND ROLLING FLIGHT

C.G. 14.5% TO 17% MAC



NOTES: WITH C.G. FORWARD OF 17% MAC,

1. STRUCTURAL CAPABILITY IS LESS THAN FOR NORMAL OPERATION.
2. SEE SHEET 1 AND 2 OF FIG 5-4 FOR NORMAL OPERATING LIMITS.
3. TANK 1 MAY CONTAIN UP TO 50% OF FUEL ON BOARD.

⚠1 MINIMUM SUPERSONIC AIRSPEED RESTRICTION: 310 KEAS

⚠2 MINIMUM SUBSONIC AIRSPEED RESTRICTIONS:
145 KIAS BELOW 25,000 FT.
300 KEAS ABOVE 25,000 FT.

⚠3 MAXIMUM AIRSPEED FOR NORMAL OPERATION (V_H): 350 KEAS

⚠4 LIMIT AIRSPEED (V_L): 400 KEAS

⚠5 MAXIMUM AIRSPEED FOR NORMAL OPERATION (V_H): 400 KEAS

⚠6 LIMIT AIRSPEED (V_L): 450 KEAS

CONDITIONS ALLOWABLE FOR ROLLING FLIGHT. 1 - G MINIMUM.

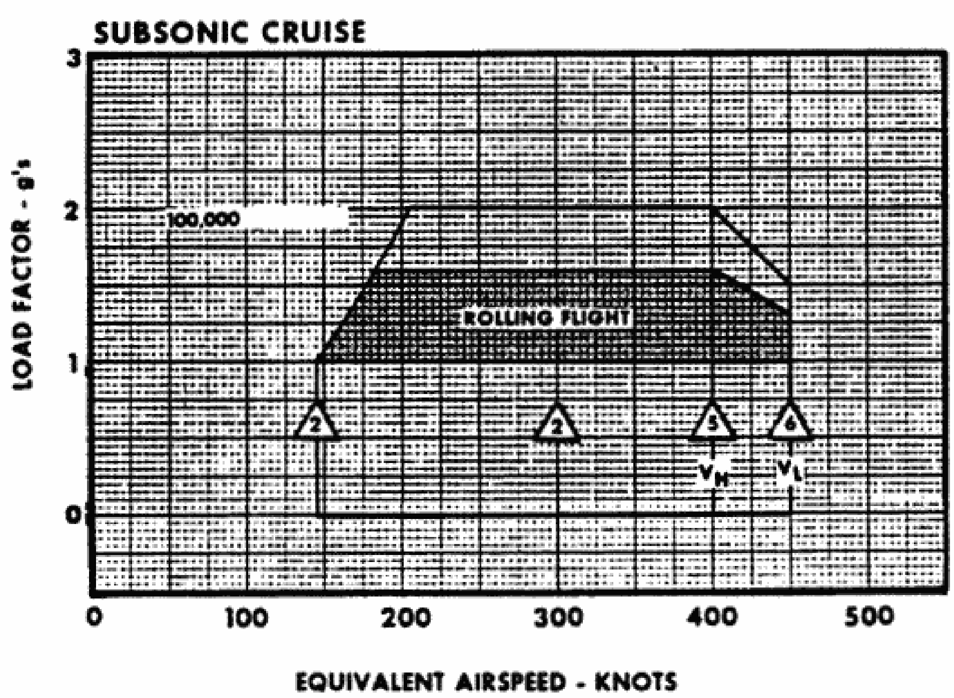


Figure 5-5 (Sheet 3 of 5)

LIMIT LOAD FACTOR DIAGRAM

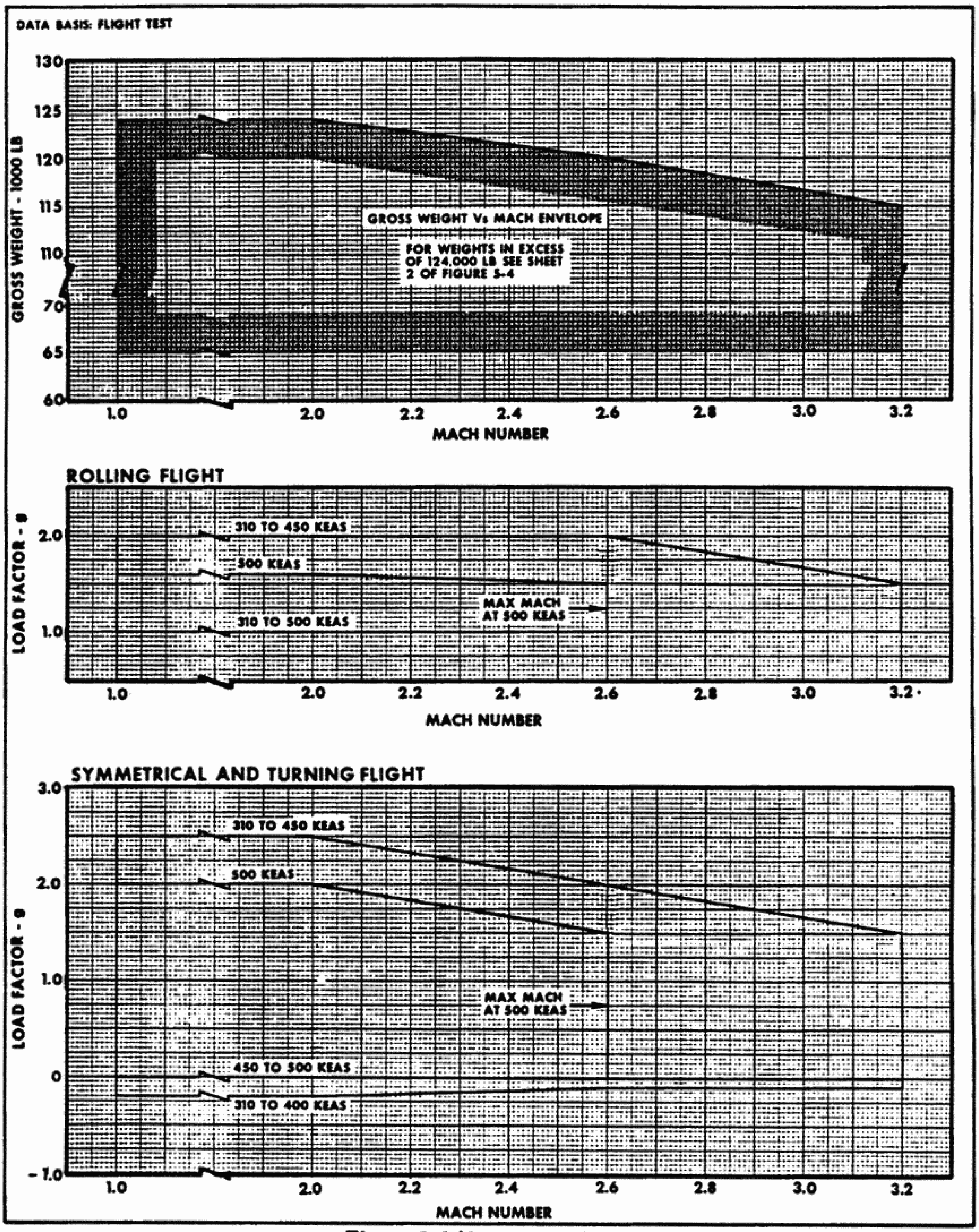


Figure 5-5 (Sheet 4 of 5)

LIMIT LOAD FACTOR DIAGRAM

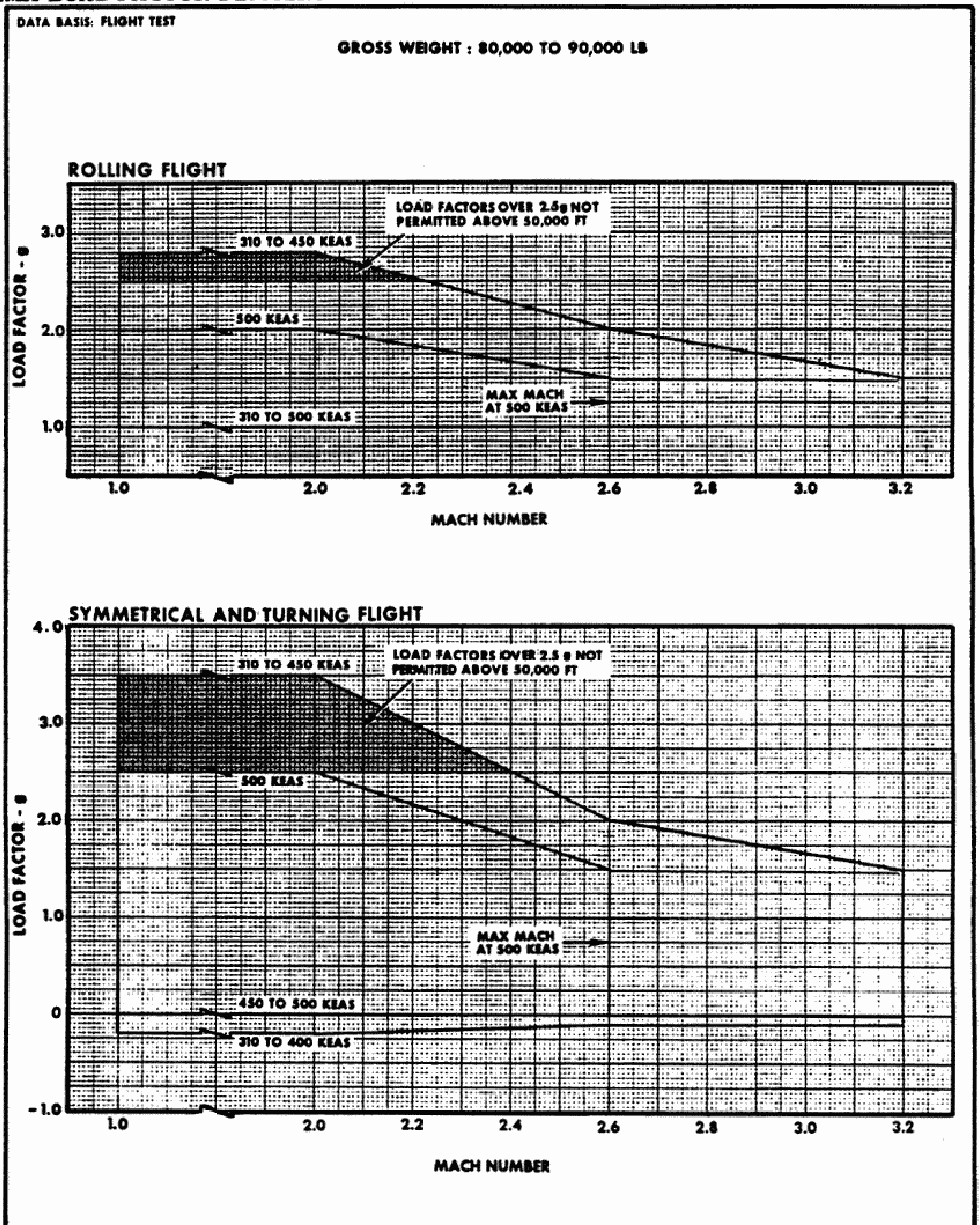


Figure 5-5 (Sheet 5 of 5)

RATE OF DESCENT

Rate of descent must be limited so as to maintain positive fuel tank pressure when sustained speeds have exceeded Mach 2.6.

While above Mach 1.8, the maximum rate of descent should be such that rate of deceleration does not exceed 1.0 Mach number in 3 minutes. There is no limitation on rate of deceleration while below Mach 1.8.

CENTER OF GRAVITY

Use the c.g. indicator and pitch trim to determine center of gravity location. However, both systems are subject to indicator and system tolerance. Computed and indicated c.g. should agree within 0.5% during stabilized cruise conditions and on the ground (after allowing for the effect of the three-point attitude on the computed c.g. value). When supersonic, pitch trim indications should conform with values derived from Figure 6-7 within 1°. If c.g. is suspected to be aft of the prescribed limit, correct the condition with fuel forward transfer.

Subsonic Operation

The c.g. must be forward of 22% for takeoff. The unrestricted c.g. range is from 17% to 22% during sustained subsonic operation within the airspeed and load factor limits provided by sheet 2 of Figure 5-5.

When gross weight is below 100,000 pounds and speed is below Mach 1.8, operation with c.g. from 14.5% to 17% is permitted within reduced airspeed and load factor limits. For the reduced airspeed and load factor limits shown by sheet 3 of Figure 5-5 to be valid, tank 1 must contain no more than half the fuel remaining. Note that limit airspeeds are 450 KEAS while subsonic and 400 KEAS while supersonic, and that the maximum airspeeds recommended are 50 KEAS less than these limit values.

Prior to Supersonic Operation

After takeoff or air refueling, c.g. as far aft as 24% is permitted while subsonic when normal climb and supersonic acceleration procedures have been initated.

Similarly, the subsonic aft c.g. limit is 24% when a short period of subsonic cruise is necessary prior to initiating normal supersonic acceleration procedures if:

a. Speed is at least 0.90 Mach and 325 KEAS.

b. All pitch SAS is operating.

Supersonic Operation

Below Mach 3.2, the supersonic aft c.g. limit is 25%. If speed exceeds Mach 3.2, the c.g. must be positioned forward of 25% by 0.7% per 0.1 Mach number increase in speed; e.g., to 24.3% at Mach 3.30.

C.G. Forward of 17%

When gross weight is below 100,000 pounds, operation with c.g. from 14.5% to 17% is permitted while below Mach 1.8 if tank 1 contains no more than half the fuel remaining and the reduced airspeed and load factor limits shown by sheet 3 of Figure 5-5 are observed. Note that limit airspeeds are 450 KEAS while subsonic and 400 KEAS while supersonic, and that the maximum airspeeds recommended are 50 KEAS less than these limit values.

PITCH TRIM INDICATIONS WHILE SUBSONIC

In trimmed flight (autopilot on or off), no more than 1.5° nose-down trim is permitted when subsonic with c.g. at or forward of 22%, and no more than 2.5° nose-down trim is permitted if operating in accordance with the special conditions when the 24% aft c.g. limit applies.

PITCH TRIM INDICATIONS WHILE SUPERSONIC

Refer to Figure 6-7 for the normal variation of pitch trim indications with Mach. When supersonic, steady-state trim indications should agree within $\pm 1^{\circ}$ of values derived from this figure when trimmed at 1-g load factor.

NOTE

> The minimum pitch trim indication to be expected at Mach 2.6 is $+0.5^{\circ}$. At higher Mach, the minimum limit depends on KEAS, aircraft weight, and c.g. Assure trim is at or above 0° except for the specific high Mach, high KEAS conditions at 25% c.g. depicted on Figure 6-7. Check the c.g. if less nose-up trim is indicated.

In trimmed flight (autopilot on or off) at 25% c.g., no more than 1.5° nose-down trim is permitted when supersonic.

While supersonic, trim indication should increase about 1° per 50 KEAS decrease in trimmed speed, and 1° for each 1% forward c.g. shift from 25%.

Excessive nose-down trim indicates a potentially hazardous situation and the possibility of a fuel system or c.g. indicating system malfunction.

AIRCRAFT SYSTEMS LIMITATIONS

SURFACE LIMITER

The control surface limiter shall be engaged whenever speed exceeds either 330 KEAS or 0.7 Mach.

STABILITY AUGMENTATION SYSTEM

The SAS shall be on for all takeoffs. Landings with normally functioning SAS channels intentionally disengaged are not permitted except that the roll SAS may be disengaged prior to simulated and actual single-engine landings.

Normal operation with all pitch and yaw SAS intentionally disengaged is not permitted; however, they may be disengaged for training demonstrations provided Mach 1.0 is not exceeded and gross maneuvers are not attempted.

Operation with both roll channels disengaged is permitted without limitation.

AUTOPILOT

Do not use the pitch autopilot with bank angles exceeding 45°.

FUEL SYSTEM

Use Of Forward Transfer

In-flight, with c.g. between 14.5% and 17%, no more than half of the remaining fuel may be transferred to tank 1; otherwise, the load factor limits shown by sheet 3 of Figure 5-5 are not valid.

Refueling Door

If the air-refueling door is open while supersonic, write up in AFTO 781 the temperature encountered and duration of exposure.

ANTICOLLISION LIGHTS

If the anticollision lights are not retracted before high-temperature flight, write up in AFTO 781 the temperature encountered and duration of exposure.

CANOPY

The canopy shall be opened or closed only when the aircraft is stationary. Maximum taxi speed with a canopy open is 40 knots. Gusts or strong winds should be considered as a portion of the 40-knot speed limit.

LANDING GEAR

Touchdown Sink Rates

The main landing gear is designed for landing sink speeds at touchdown which decrease from 600 feet per minute at 68,000 pounds to 360 feet per minute at 125,000 pounds gross weight. Landing at gross weights above 125,000 lb is not recommended. However, if a landing must be accomplished before weight can be reduced to this value, the sink rate at touchdown should not exceed 300 feet per minute. Side loads during takeoff, landing, and taxiing must be kept to a minimum, as landing gear side-load strength is critical during ground maneuvering.

Maximum Speed

In-flight, gear door strength limits the airspeed with gear down to 300 KEAS or Mach 0.7, whichever is less, with a maximum permissible sideslip angle of 10°. Maximum permissible speeds are 300 KEAS or Mach 0.9, whichever is less, with gear down when sideslip does not exceed 5°.

Crosswind Limits

Because of the loads imposed on the landing gear system, operation with crosswind components above 30 knots is not recommended.

Crosswind components between 25 and 30 knots represent a cautionary area. See Appendix Figure A2-1. A decision to land with winds of this magnitude should consider all related factors, i.e., weather, runway surface condition, airdrome facilities, and availability of a suitable alternate.

The maximum recommended crosswind components are:

> 25 knots with a grooved runway (wet or dry) or with a dry, nongrooved runway.
>
> 20 knots with a nongrooved, wet runway.

Retraction-Extension Cycles

Do not extend the landing gear more than 10 times each flight.

TIRES

The maximum ground speed rating of the tires is 239 knots. The conversion from 239 knots to KIAS with various combinations of temperature and altitude is shown by Figure 5-6.

A cooling period between the end of taxi and start of takeoff may be required. Figure 5-7 provides recommended cooling time vs taxi distance.

If a tire and/or brake cooling period is necessary, it should be continued until each individual tire and wheel is relatively tolerable to touch.

A check of tires, wheels and brakes is required when clear of the runway after an aborted takeoff or a heavy weight landing.

Takeoff after an abort is not permitted until maintenance has inspected the tires.

WARNING

Extreme caution should be exercised when making the tire and wheel check after a heavy weight landing, an aborted takeoff, or after any heavy braking. Overheated tires may explode and cause injury or loss of life. The check should be delayed until reasonable cooling has been accomplished if there is evidence of an overheated condition.

CAUTION

After an abort, brakes must be cooled to approximately ambient temperature before attempting another takeoff.

RATED TIRE SPEED

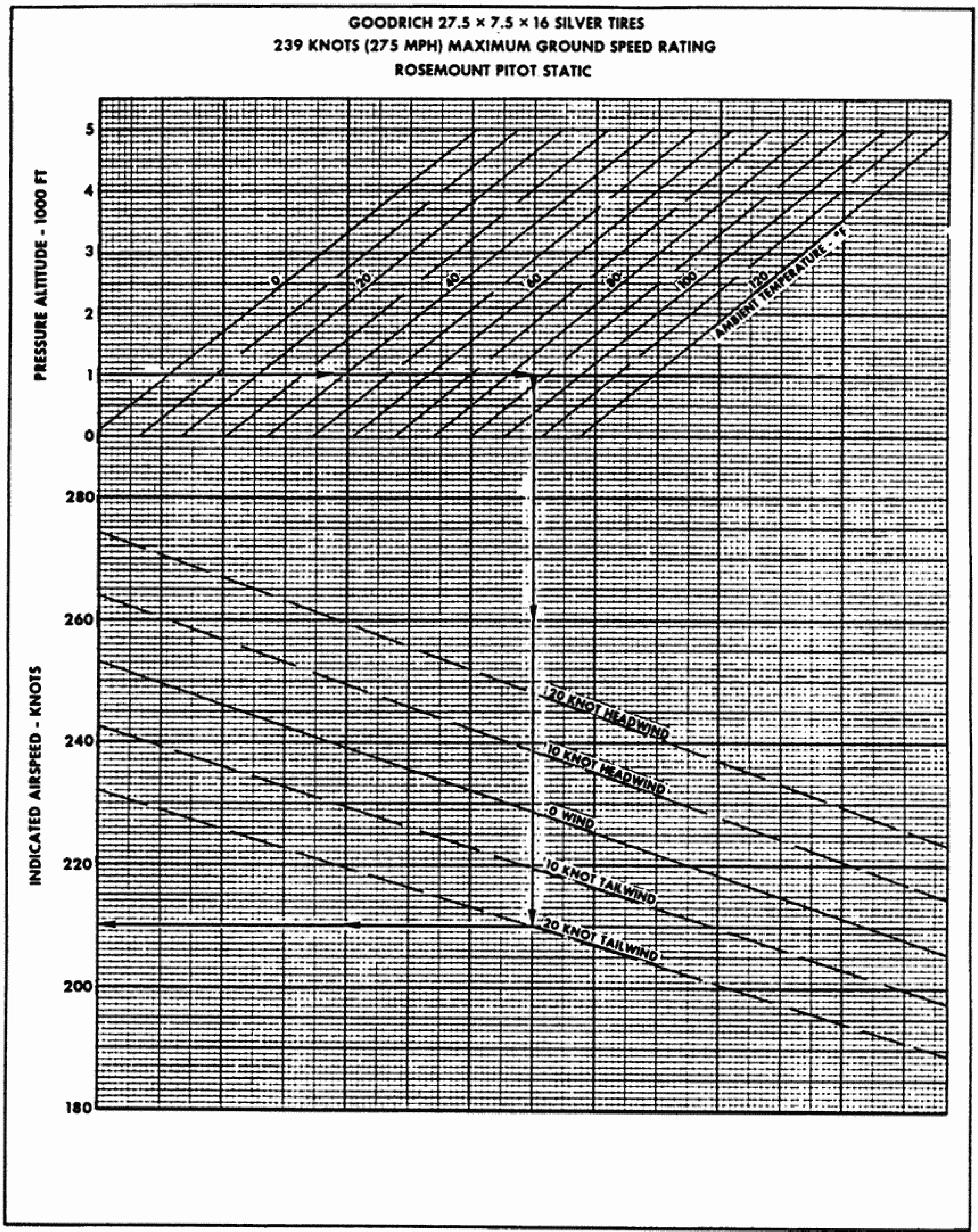
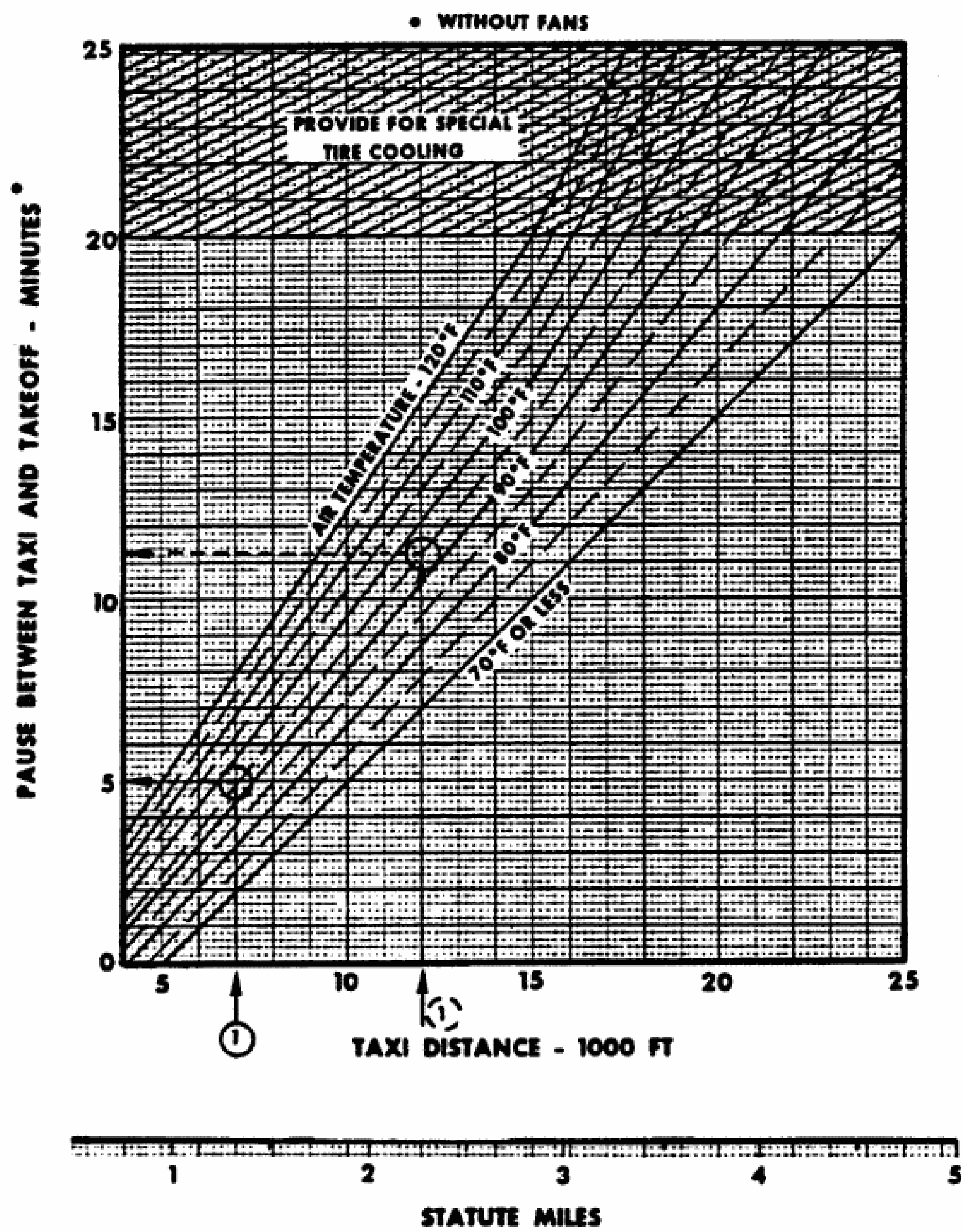


Figure 5-6

ESTIMATED TIRE COOLING PERIOD FOR FULL RTO CAPABILITY

Data Basis: REPORT NO.SP 1331

31% TIRE DEFLECTION
(140,000 LB AND 400 PSI PRESSURE)
(120,000 LB AND 310 PSI PRESSURE)



Conditions:
60 MPH - Maximum Taxi Speed.
(40 MPH - Maximum Speed Recommended)

Examples:
7000 ft Taxi-out, 95°F, 31% Deflection.

(1) 5 Minute pause before Takeoff required for full RTO capability (Cooling time after 12,000 ft RTO = 11.3 minutes if no heavy braking).

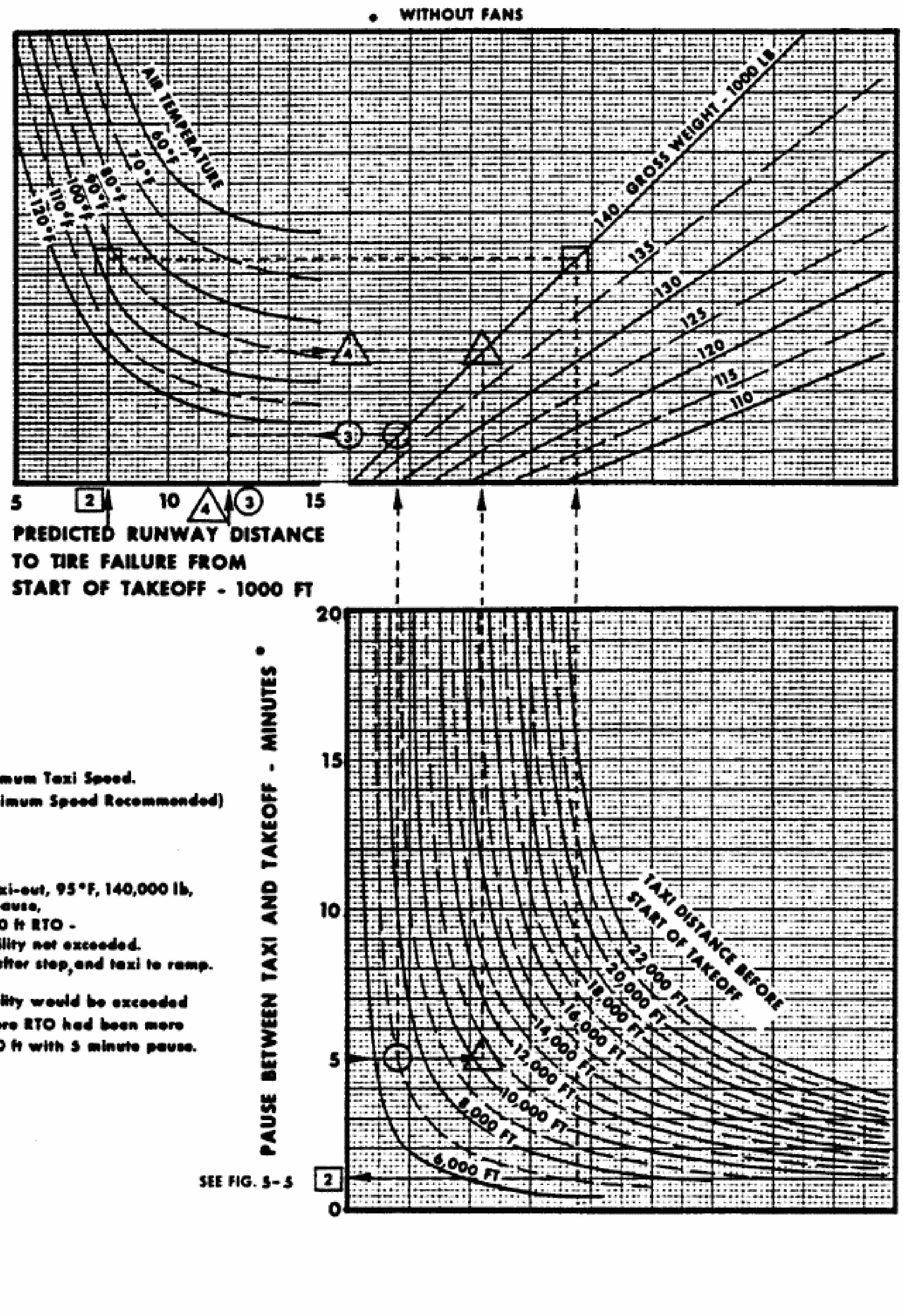
[2] (Refer to Figure 5-6))[for 140,000 lb, and EWO Takeoff Run = 8000 ft, Tire limit capability reached before Takeoff if pause time is less than 1.0 minutes.

Figure 5-7

TIRE LIMIT CAPABILITY

Data Basis: REPORT NO. SP 1331

400 PSI TIRE PRESSURE
AT ALL GROSS WEIGHTS



Conditions:
60 MPH - Maximum Taxi Speed.
(40 MPH - Maximum Speed Recommended)

Examples:

(3) 7000 ft Taxi-out, 95°F, 140,000 lb,
5 minute pause,
then 12,000 ft RTO -
Tire capability not exceeded.
Cool tires after stop, and taxi to ramp.

(4) Tire capability would be exceeded
if Taxi before RTO had been more
than 10,500 ft with 5 minute pause.

Figure 5-8

MAXIMUM INITIAL BRAKING SPEED FOR STOP USING RATED BRAKE CAPACITY

ONE STOP CAPABILITY

(4x7) + (2x5) ROTOR BRAKES
198,700,000 FOOT - POUND CAPACITY
ROSEMOUNT PITOT STATIC

WITHOUT DRAG CHUTE
NOSE DOWN
DRY AND HARD RUNWAY
ZERO WIND, ZERO SLOPE

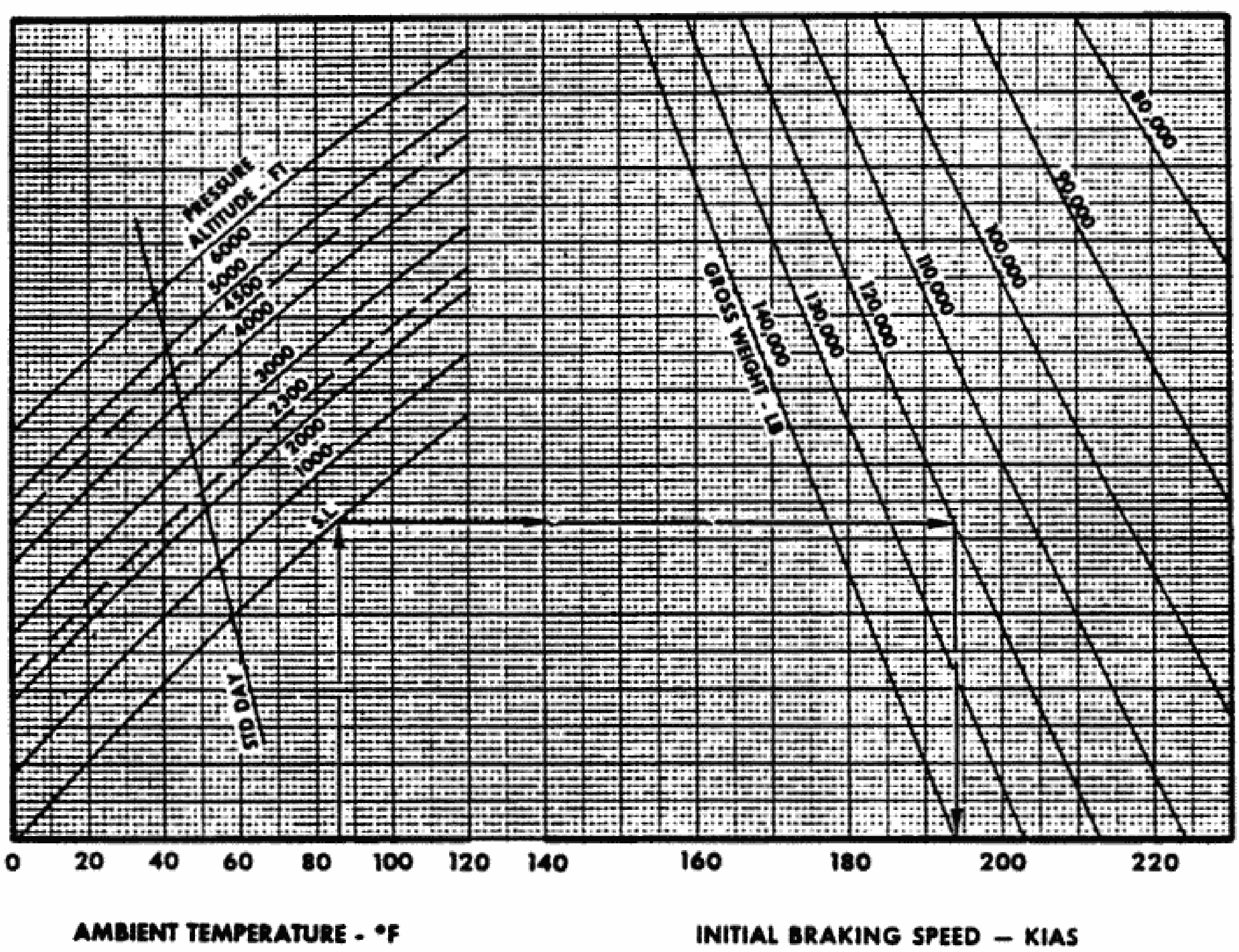


Figure 5-9

Taxiing or landing across exposed arresting gear cables (e.g. BAK-9, BAK-12 systems) is not recommended. Such action could damage the tires and/or wheels.

BRAKES

Maximum initial KIAS for a one-time stop using the maximum brake energy is shown in Figure 5-9. Headwind components may be added to values shown, and tailwind components must be subtracted. Refer to Part II of the Appendix for information on maximum refusal speeds and heavy-weight landings.

DRAG CHUTE

The maximum airspeed for drag chute deployment is 210 KIAS. The drag chute shall not be deployed in-flight except for a drag chute unsafe indication.

The maximum crosswind component for jettisoning the drag chute is 12 knots. The minimum airspeed for jettisoning the drag chute is 55 KIAS.

FLIGHT WITHOUT PRESSURE SUIT

Flight without pressure suits is restricted to below 50,000 feet.

INTRODUCTION

SR-71 aircraft operate in an exceptionally large Mach and altitude envelope, but the equivalent airspeed, angle of attack, and load factor envelope is narrow. Typical takeoff and landing airspeeds are 210 and 155 knots, respectively; climbs are at 400 to 450 KEAS, and normal supersonic cruise is from 310 to 400 KEAS. These aircraft obtain maximum cruise performance near Mach 3.2 at altitudes from 74,000 to 85,000 feet. The external configuration, air inlet system, power plant, and fuel sequencing are optimized for Mach 3.20. True airspeeds attained are near 1850 knots. For stability considerations, a three-axis stability augmentation system (SAS) is an integral part of the aircraft control system and is normally used for all flight conditions. The normal flight characteristics discussed in this section assume proper SAS operation, unless specified otherwise, and observance of limits specified in Section V.

CONFIGURATION EFFECTS

External configuration features which affect flight characteristics include the delta wing, fuselage chines and the engine nacelle location.

Delta Wing

The SR-71 has normal delta wing characteristics. There is a large increase in drag as limit angle of attack is approached. This delta wing characteristic can cause very high rates of sink to develop if the aircraft is flown too slow. Dihedral effect is positive, but diminishes at higher Mach. Roll damping is relatively low over the entire speed range and lateral-directional qualities are poor with SAS off.

The outboard portion of the wing's leading edge has negative conical camber. This moves the center of lift inboard to relieve loading on the nacelle carry-through structure. It also improves the maximum lift characteristics of the outboard wing at high angles of attack, and enhances crosswind landing capability.

Chines

The SR-71 has a blended forward wing (chine) which extends from the fuselage nose to the wing leading edge. This chined forebody is approximately 40% of the aircraft length. The chines improve directional stability with increasing angle of attack at all speeds. However, their primary purpose is to provide a substantial portion of the total lift at high supersonic speeds and eliminate a need for canard surfaces or special nose-up trimming devices.

A large rearward shift in the aerodynamic center of lift occurs when the aircraft transitions from subsonic to supersonic flight. Without chines, the center of lift would shift aft while in the transonic region and remain between 40% to 45% mean aerodynamic chord (MAC) at all speeds above Mach 1.4. A large elevon deflection would be required for trimming, and the resultant drag would be unacceptable. A similar shift of the aerodynamic center occurs at transonic speeds with chines, but the initial displacement is to a position between 35% to 40% MAC. As Mach increases, the center of lift moves forward until a position slightly aft of 25% MAC is reached at the design speed. The result is that the static stability margin is maintained at desirable levels and trim drag due to elevon position is reduced to a minimum at design speed. The SAS provides satisfactory handling qualities.

Automatic fuel tank sequencing shifts the c.g. aft to approximately 25% MAC while the fuel in tank 1 is being reduced to the right-hand shut-off level. This normally occurs during acceleration to supersonic cruise and conforms with the aft shift of the aerodynamic center.

NOTE

> Because of chine effectiveness, c.g. must be moved forward of 25% if design speed is exceeded. Refer to Center of Gravity, Section V.

Nacelle Location

The mid-span location of the engines minimizes drag and interference effects of the fuselage. The inboard cant and droop of the nacelles gives maximum pressure recovery at normal angle of attack for high altitude supersonic cruise. However, the nacelle location makes the aircraft sensitive to asymmetric thrust conditions. During afterburner cruise, match fuel flows to minimize thrust differences. During subsonic cruise, match engine EGT's and nozzle positions (instead of fuel flows) since heat sink system requirements are an appreciable portion of indicated fuel flows during non-afterburning operation.

ANGLE OF ATTACK

Angle of attack indications range from 8° to 12° for takeoff (depending on weight and procedure used), 3° to 5° during climb, and 4° to 7° during cruise. Angle of attack at optimum supersonic cruise altitudes is about 5° to 6° for all gross weights. The indication is approximately 10.5° during final approach at recommended airspeeds; although, during landing approach in gusty conditions, the indication will oscillate. The indicated angle of attack is approximately equal to the true angle of attack.

Definitions of Longitudinal Reference Angles

Angle of Attack

Angle of attack is the angle between the wing chord plane at the mean aerodynamic chord and the relative wind. When not turning, this angle is also equal to the difference between the pitch angle of the fuselage reference line (FRL) and the airplane flight path (measured relative to horizontal) minus 1.2° (the wing angle of incidence relative to the FRL is 1.2° negative). See Figure 6-1. The pilot's instrument provides wing angle of attack.

Relative Wind

Relative wind is the apparent speed and direction of air passing the aircraft parallel to the aircraft flight path. The speed of the relative wind is equal to the airplane's true airspeed.

Flight Path Angle

The flight path angle is the angle between the relative wind and the horizontal plane. It can be determined from true airspeed and rate of climb or descent.

Deck Angle or Pitch Angle

Pitch angle (deck angle) is the angle between the fuselage reference line and horizontal. It is associated with, but not necessarily the same as, the pitch attitude indication. The attitude instruments would indicate true pitch angle if set at 0° with the airplane FRL level (for example, while on the ground) and not reset, and if no precession error occurs in pitch.

Angle of Attack As A Flight Parameter

Lift is a function of airspeed and angle of attack. Assuming weight does not change appreciably, the lift required for straight and level flight is constant. To maintain straight and level flight: if KEAS increase, alpha must decrease; and if KEAS decrease, alpha must increase. This direct relationship of angle of attack and KEAS with lift allows angle of attack to be used in place of airspeed, if necessary. If the airspeed systems malfunction and angle of attack remains, angle of attack can be held constant to hold relatively constant equivalent airspeed conditions.

HIGH ANGLE OF ATTACK CONDITIONS

In-flight minimum airspeed restrictions and maximum angle of attack limits are imposed to prevent approach to pitch-up conditions.

LONGITUDINAL REFERENCE ANGLES

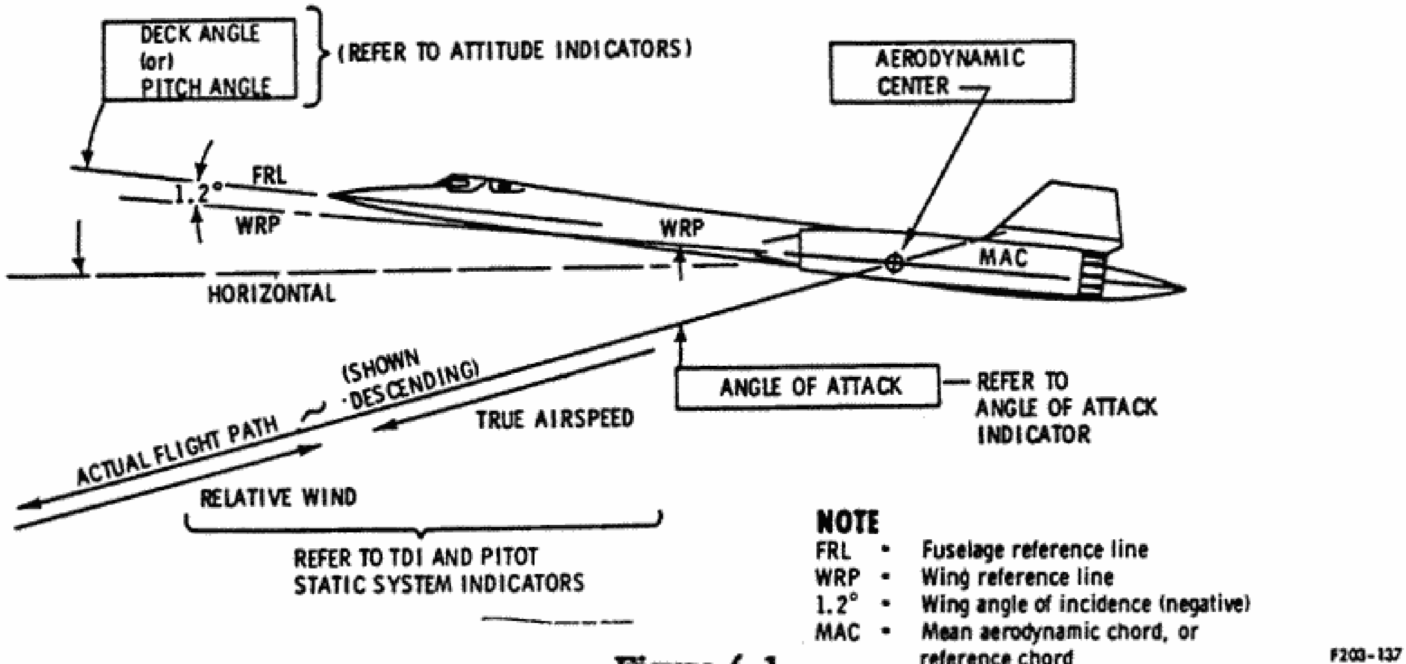


Figure 6-1

There is no stall in the classic sense where an abrupt loss in lift would occur at a critical angle of attack. (See Figure 6-2, Lift vs Angle of Attack.) Instead, a nose-up pitching moment develops as angle of attack increases, which becomes uncontrollable (even with full nose-down elevon) as the critical angle of attack boundary is reached. (See Figure 6-3, Subsonic Critical Angle of Attack Boundary.) An uncontrollable pitch-up will not occur until after limit angle of attack as given in Section V is reached. The SAS will tend to maintain apparent stability about all three axes until pitch-up occurs, then aircraft control is lost with little or no warning.

WARNING

Reduce angle of attack and adjust attitude nose-down if a high angle of attack warning occurs or if an alpha limit is approached. Do not confuse angle of attack with flight attitude. A dangerously high angle of attack can be reached while flight attitude is relatively level if the aircraft is descending or sinking. See Figure 6-1.

WARNING

Nose-up pitch trim above zero indication reduces down elevon authority. If full forward stick is not sufficient to control angle of attack and pitch rate, trim nose down.

At subsonic speeds, engine stalls may occur when at angles of attack above 10°, with more susceptibility existing while at airspeeds below 300 KEAS and altitudes above 25,000 feet. In such a condition, loss of thrust due to the stalls requires that angle of attack be reduced immediately and KEAS increased if pitch-up is to be avoided.

Note that the critical angle of attack for pitch-up is approximately 18° when subsonic and at the aft c.g. limit of 22%. The critical angle of attack is slightly higher if at a more forward c.g. The angle is less when supersonic, and varies with Mach. Center of gravity aft of the limit materially reduces the margin between the limit alpha and the critical angle of attack for pitch-up. When near the limit angle of attack, recovery from a rapid nose-up pitch rate may not be possible.

WING LIFT VS ANGLE OF ATTACK

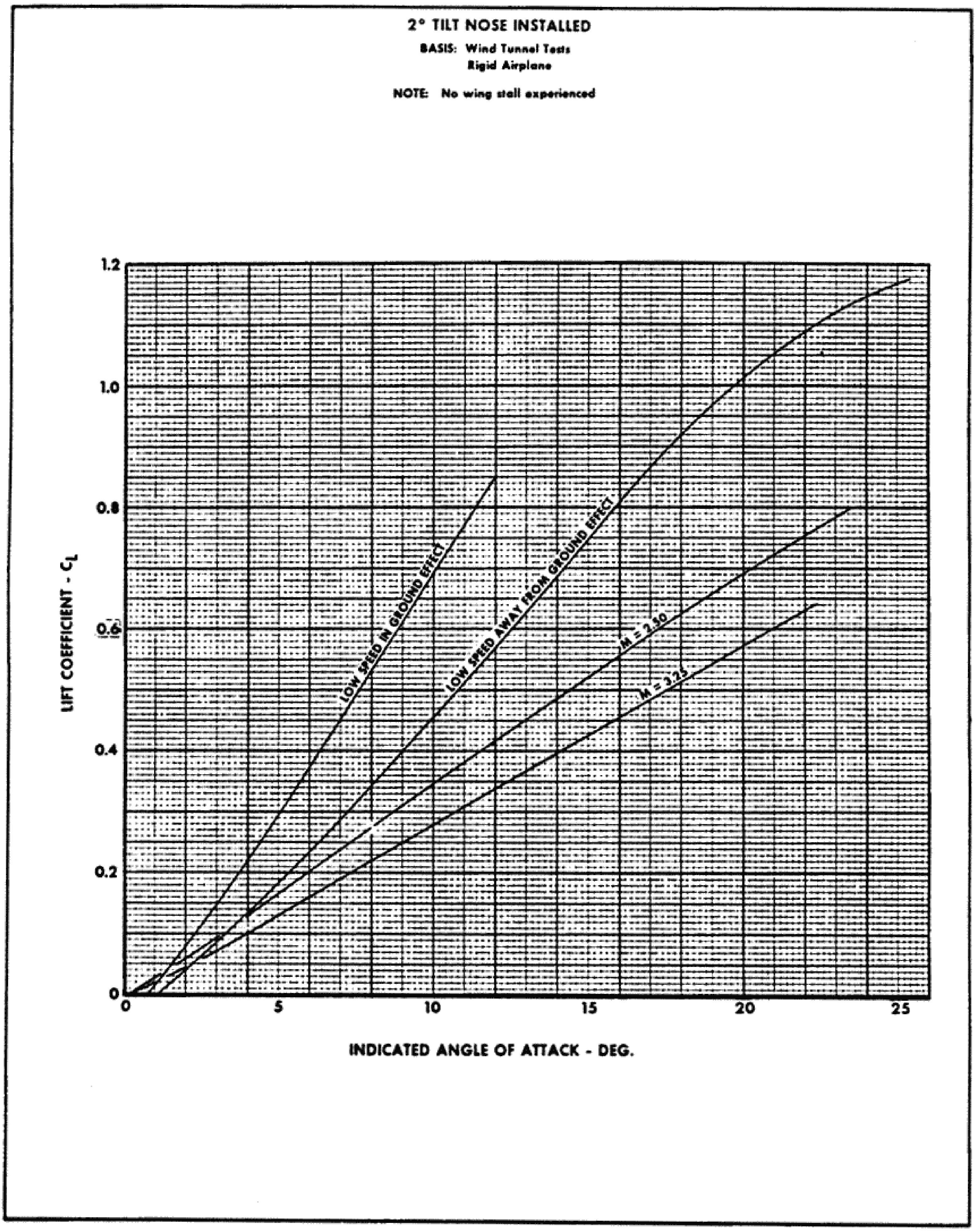


Figure 6-2

SUBSONIC - CRITICAL ANGLE OF ATTACK BOUNDARY

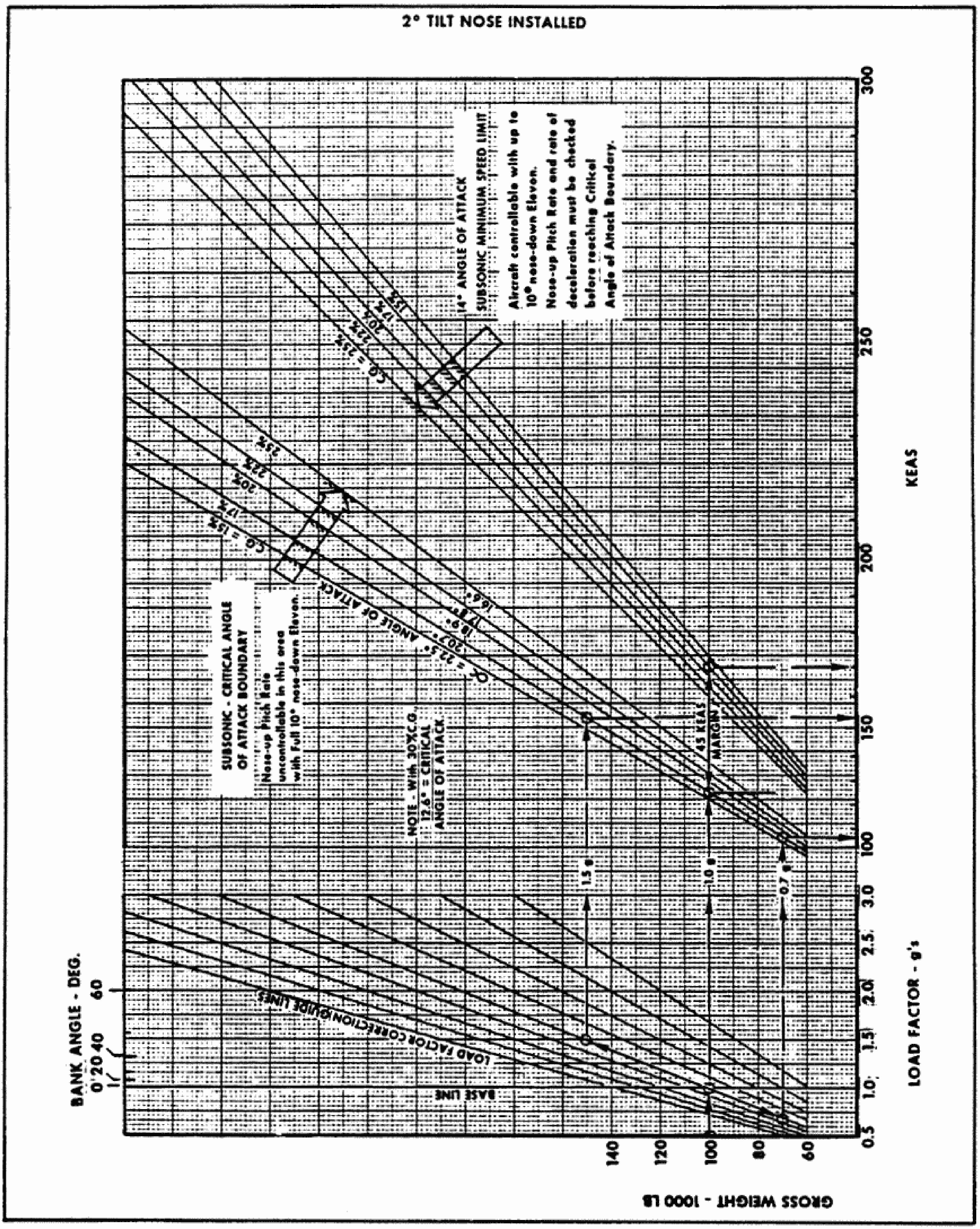


Figure 6-3

WARNING

Uncontrollable pitch-up occurs at the critical angle of attack boundary. Recovery from this condition is extremely unlikely. Attempted recovery must not be continued to the point where insufficient altitude for recovery or ejection exists.

Pitch rates which accompany increasing angles of attack must be checked and load factor relieved at a sufficient rate to increase airspeed when the critical angle of attack boundary is approached. Recovery should be controlled by cross-referencing pitch rate, angle of attack, airspeed, and attitude. Airspeed must be allowed to increase, but not to extremes, so that recovery load factors will neither cause limit angle of attack to recur or impose loads beyond allowable values. During subsonic recovery, use cruise angle of attack as the basic reference while accelerating to 300-350 KIAS. When near limit Mach number, it may be necessary to reduce power and/or increase drag while recovering so that limit Mach number is not exceeded while airspeed is increasing.

WARNING

Extreme caution is necessary while turning at altitudes above those for optimum supersonic cruise. The angle of attack may exceed 7^{o} to 8^{o}, and any transients caused by unstarts, increased bank angles, etc., may lead to pitch-up.

SPINS

Intentional spins are prohibited. The following technique is suggested if an inadvertent spin occurs; however, ejection may be the best course of action because spin recovery has not been demonstrated and is considered extremely unlikely. At the pilot's discretion:

1. Center controls, disengage surface limiters, and determine the direction of rotation from the turn indicator.
2. Apply forward stick and full roll control into the direction of spin (into the turn needle) as the nose drops.
3. Apply opposite rudder to stop rotation.
4. Center the rudder and roll control as rotation stops.
5. Start pull-out at 300 to 350 KIAS.
6. If possible, avoid exceeding 450 KIAS and limit load factor during recovery.

WARNING

If uncontrollable, eject at least 15,000 feet above the terrain.

STABILITY CHARACTERISTICS

The augmented (SAS on) dynamic stability is positive and dynamic damping is essentially deadbeat. Static stability is positive when operating within the c.g. and angle of attack limits. Positive static stability continues when c.g. is somewhat aft of the limit while at intermediate supersonic speeds (from Mach 1.2 to at least Mach 2.6.) However, if the aft c.g. limit is violated while near the design cruise Mach number, a static instability in pitch may result. If pitch rates are then generated and not arrested within the angle of attack limit, a pitch-up can develop and result in structural failure of the aircraft.

EFFECTS OF C.G. LOCATION

To fully understand the effects of center of gravity location on longitudinal flight characteristics, it is necessary to be familiar with the following terms:

Static Stability

Static stability is the initial tendency of an airplane to return to "one-g" flight after being disturbed from its trimmed attitude. An example of a statically stable system is shown in Figure 6-4. In the example, if the angle of attack is increased by an upward gust or outside disturbance, the increased lift created causes a nose-down moment about the center of gravity which tends to return the airplane to its trimmed angle of attack.

Static Margin

Static margin is the distance between the aerodynamic center of the aircraft and its center of gravity. Static margin determines the degree of static stability of an aircraft. This margin can be changed by shifting the center of gravity or by varying the airspeed to shift the aerodynamic center. As static margin increases, small disturbances from the trimmed attitude of the aircraft result in larger restoring moments. As static margin decreases, stability of the aircraft decreases accordingly to a point where an outside disturbance could cause a divergence (either up or down) that the pilot could not control.

Dynamic Stability

Dynamic stability is the tendency of an airplane to overcome a disturbance from its trimmed condition, dampen out the resulting oscillations, and return to its original angle of attack. The degree of dynamic stability is indicated by the number of cycles (of decreasing amplitude) required to dampen the oscillations. For a system to be dynamically stable, it must be statically stable. Examples of a statically stable system depicting dynamic stability, dynamic neutral stability, and dynamic instability are shown in Figure 6-5. An example of a statically unstable system showing pure divergence or loss of control is also shown.

Effect of C.G. On Control Characteristics

The relation of center of gravity and aerodynamic center location (static margin) determines the static stability of the airplane. If the center of gravity is forward of the aerodynamic center, the airplane has static stability. Moving the c.g. further forward increases static stability. Moving the c.g. aft decreases static margin and decreases static stability accordingly. Static instability results if the center of gravity is aft of the aerodynamic center. SAS operation tends to overcome a small degree of static instability; however, a disturbance could cause the airplane to diverge beyond pilot control, even with full application of control stick and pitch trim.

EXAMPLE OF STATICALLY STABLE SYSTEM

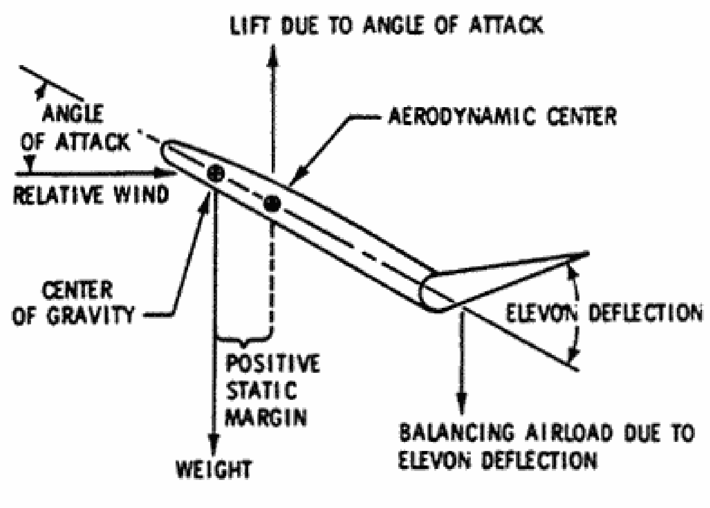


Figure 6-4

NOTE

As the center of gravity moves aft and static margin decreases, less elevon deflection is required to maneuver. Neutral stability is approached if the aft c.g. limit is exceeded.

EXAMPLES OF ANGLE OF ATTACK VS TIME WITH VARIOUS DYNAMIC STABILITY CONDITIONS

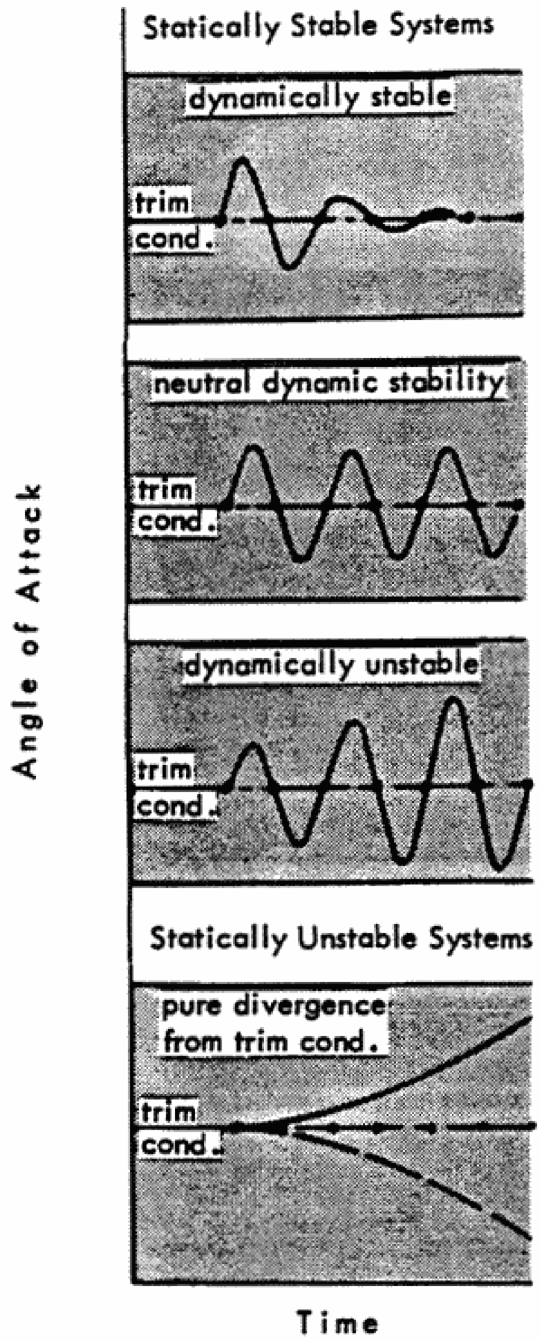


Figure 6-5

The supersonic aft center of gravity limit insures acceptable SAS-on stability and handling qualities commensurate with performance objectives. At forward center of gravity locations, large elevon deflections are required to trim and maneuver the airplane. The center of gravity should be maintained near the aft center of gravity limit, when range is a consideration, to mimimize elevon deflection and reduce drag. Normally, this is accomplished automatically by the fuel sequencing system.

Short Period Longitudinal Oscillation

Short period longitudinal oscillation means the relatively short-time pitching motions of an airplane after being disturbed in pitch. With the pitch SAS on, the longitudinal short period motion is so heavily damped that the pilot is not aware of any oscillatory motion. With the pitch SAS turned off, however, a disturbance of the aircraft results in oscillatory motion (nose-up, nose-down, nose-up) that persists for several cycles before the motion subsides (damps out). The effect of pitch SAS and center of gravity position on this motion is illustrated by Figure 6-6. Note that moving the center of gravity forward shortens the time for each cycle of motion, and moving the center of gravity aft increases the time for each cycle. If the center of gravity is moved progressively farther aft, the static margin approaches zero and the time-per-cycle for the short period oscillation becomes increasingly longer. At zero static margin (center of gravity behind the aft limit), SAS operation tends to dampen the oscillations and mask the condition. If the center of gravity is moved still farther aft (to a negative static margin) the SAS becomes ineffective and the airplane may exhibit dynamic instability without damping. With extreme aft c.g. position, the aircraft will exhibit a pure divergence; that is, the airplane will continue to pitch in the same direction at an increasing rate upon being disturbed from trim. The pilot can correct pitch motion using elevon control if the amount of instability (negative static margin) is small and if he applies correction control as soon as he recognizes any divergent pitching motion. If he allows the motions to become large, however, the pitching moment will exceed the corrective moment that he can supply with elevon and loss of control results.

EXAMPLES OF ANGLE OF ATTACK VS TIME

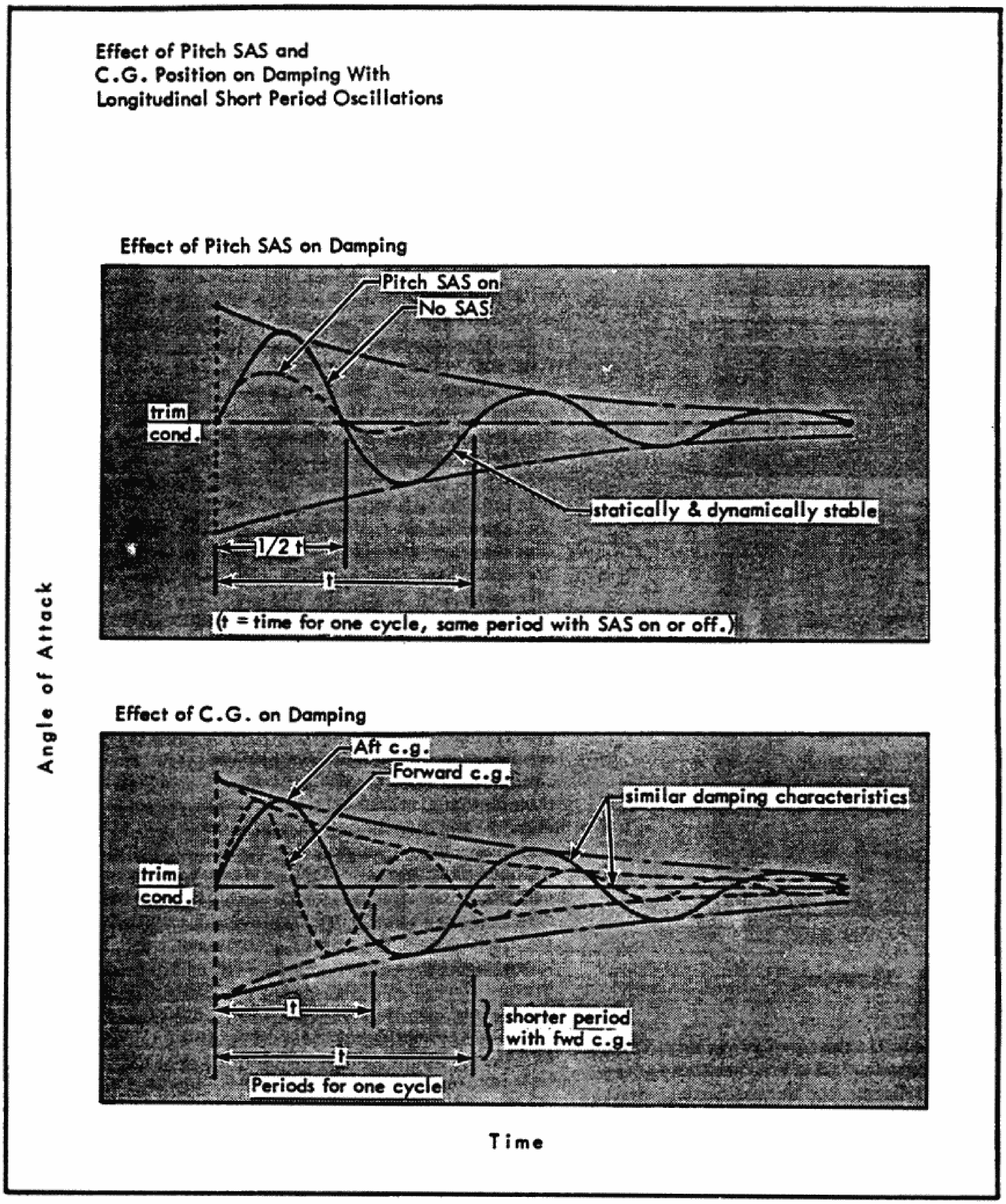


Figure 6-6

Stability With SAS Off

Aircraft controllability without stability augmentation has been demonstrated to Mach 3.20. SAS off flight tests have also demonstrated controllability in climb and descent, during inlet unstart at Mach 2.8 and 430 KEAS, during unstart and engine flameout at Mach 2.5, and during twenty degree bank turns in heavy turbulence at low supersonic and transonic Mach numbers. However, control with SAS off is sensitive and control movement should be kept to the necessary minimum. Thrust asymmetry should be minimized, particularly at high Mach. Sustained cruise or maneuvering without pitch and yaw SAS is not recommended near design speed. Refer to Stability Augmentation System, Section III.

Pitch Stability at High Speeds

At cruise Mach, the pitch stability is only slightly positive and disturbances are only lightly damped. Sudden loss of all pitch SAS while maneuvering causes a pitch transient that momentarily increases the load factor for the same stick position.

Yaw Stability

SAS-off yaw stability varies from positive to very slowly divergent. Response of the automatic air inlet system to yaw oscillation has a pronounced effect on directional motion. Unless controlled by the pilot, phasing of the spikes and forward bypass doors may either drive or damp the yaw oscillations.

Single-Engine Operation - Low Speeds

The yawing moment from asymmetric thrust is large if an engine fails just after takeoff or a single-engine go-around is necessary. Approximately 2/3 to full rudder deflection and 10 degrees (or more) bank into the good engine is necessary to maintain control immediately after loss of power. Drag can then be minimized by reducing pedal force and trimming to 7° to 9° rudder position indication, while using bank and sideslip toward the operating engine to maintain the desired flight path. The SAS automatically responds with corrective control at the time of engine failure or go-around power application, and its response rate is faster than pilot reaction time. However, rudder control follow-up by the pilot is necessary as the yaw SAS authority is limited to 8 degrees rudder deflection. The SAS continues to apply rudder deflection as long as a sideslip is maintained, but this deflection is not indicated by pedal position or by the rudder trim indicator.

Single-Engine Operation - Subsonic Speeds

The rudder deflection required during single-engine operation decreases as airspeed increases. During single-engine cruise at 0.5 to 0.85 Mach number, the aircraft can maintain course with surface limiters engaged. Optimum rudder deflections are maintained by the SAS without using rudder trim when bank and sideslip toward the operating engine are used to maintain course. The bank angles required approach 10°.

Single-Engine Operation - High Speeds

Above Mach 2.8, engine failure or inlet unstart may require yaw axis stability augmentation to avoid excessive sideslip and bank angles which could cause the other inlet to unstart. Inlet unstarts while at 450 KEAS and maximum power are quite severe. In these cases, unassisted pilot reaction is too slow to provide all the control immediately required. Pilot follow-up is necessary after the initial SAS corrections.

NOTE

Before retarding the throttle to shutdown an engine, be careful to properly identify the side with the malfunction. There have been cases where an operating engine was shut-down.

NORMAL OPERATING CHARACTERISTICS

See Appendix I for performance information.

TAKEOFF

The aircraft accelerates rapidly to rotation speed once maximum thrust is set during takeoff. The nosewheel can be lifted 50 to 60 knots below takeoff speed, but this is not advised because the drag that is created decreases the acceleration and extends the takeoff run. With zero degrees pitch trim, a stick force of approximately 25 pounds is required to lift the nosewheel at rotation speed. Stick force must be relaxed during rotation to check the nose-up pitch rate. Forward stick may be necessary if a high rate of rotation is developed or if c.g. is aft of 22%. During maximum performance takeoffs, speed and attitude must be monitored carefully to avoid overrotating and striking the tail.

CLIMB

Normal climbs to supersonic cruise speeds involve three phases of operation: a subsonic climb, a transonic acceleration to the supersonic climb schedule, and a supersonic climbing acceleration. Subsonic climb is normal except that a light airframe buffet may be felt near 0.9 Mach number as airflow conditions near the tertiary doors and ejector flap areas change.

Transonic Operation

A Mach jump on the TDI occurs between Mach 0.98 and 1.03 during transition to the supersonic climb schedule. There is an area of decreased excess thrust from Mach 1.05 to Mach 1.15. A descent technique is used to improve acceleration through this speed range. The transition should be made without other maneuvering, if possible, as even shallow turns increase drag sufficiently to decrease acceleration and increase fuel consumption considerably. A noticeable increase in acceleration occurs after passing Mach 1.15. The pull-up to establish climb attitude should be started in sufficient time to prevent overshooting climb speed.

Supersonic Operation

The supersonic climb is initiated when climb airspeed is established at approximately 30,000 feet. Maintain the schedule accurately to achieve best climb performance. Avoid speeds above the climb schedule because limit airspeed can be inadvertently approached quickly.

Pitch Axis Stability In Climb

The aircraft does not respond immediately to small pitch commands. This characteristic makes precise airspeed control difficult. If significant overspeed occurs, reduce power until climb speed can be reestablished rather than pull up sharply and impose load factors.

Pitch Trim

A continual variation in nose-up trim is required during the acceleration to cruise speed, with the 400 KEAS schedule requiring more trim than the normal 450 KEAS schedule. The variation of elevon angle and pitch trim indication for the trimmed condition is illustrated by Figure 6-7 for c.g. positions of 22% and 25%. The figure also shows the variation of trim required with airspeed and the effect of weight decrease during cruise when operating near the aft c.g. limits.

Inlet Operation

Occasional periods of inlet roughness may be encountered between Mach 2.5 and 2.8. It may also be encountered at climb speeds above Mach 3.0 if the forward bypass is hard closed. The roughness normally diminishes at cruising altitudes with equivalent airspeed reduced from the climb speed schedule. However, during cold operation, some roughness may continue if the forward bypass is hard closed (i.e., no modulation of the bypass position occurs) so that the inlet normal shock is positioned aft of the desired location.

Level Off

Ideally, the transition to cruise altitude and speed would be accomplished at constant Mach number with power being reduced upon reaching the initial cruise altitude. In practice, however, this usually results in a pronounced altitude overshoot and subsequent difficulty in stabilizing at the desired cruise condition. The following describes three distinct level off situations.

Cruise Mach and Altitude Attained Simultaneously

For the maximum range cruise profile, the initial cruising altitude is close to the altitude at which the cruise Mach is attained using the normal climb procedure. Stabilization at the desired altitude is expedited by reducing power to approximately 3/4 of the afterburner throttle range and by decreasing the climb angle slightly when 0.10 to 0.05 Mach below the desired cruise speed. Then adjust pitch attitude so that Mach increases slowly to the desired value, while the rate of climb decreases to arrive at the cruise Mach and altitude simultaneously. At the desired cruise speed and altitude, reduce power to the estimated initial fuel flow setting, and make small adjustments in both pitch attitude and power setting until cruise is stabilized.

Intermediate to High Altitude Cruise

When the initial cruise altitude is above the altitude at which cruise Mach is attained using normal climb procedure, use a constant Mach climb to cruise altitude. Increase the climb angle to decrease the rate of acceleration when 0.10 to 0.05 Mach below the desired cruise Mach and continue climbing toward the desired altitude. If acceleration rate is still excessive when approaching the desired speed, momentarily retard the throttles slightly to break the rate. With Mach stable, begin reducing climb angle when approximately 1000 to 2000 feet below the desired level-off altitude. Reduce power to maintain Mach, and slowly reduce the rate of climb as the desired cruise altitude is reached. Maintain Mach by power adjustments. Make small adjustments in pitch attitude and power setting until stabilized at cruise.

Level Off from Reduced KEAS Climb

Level-off altitude may be reached before the desired Mach is attained when climbing at 400 KEAS prior to cruise at 2.8 or 3.0 Mach. In this case (when airspeeds above 400 KEAS are permissible) reduce the climb angle to allow a gradual transition to level flight when approximately 1000 to 2000 feet below the level-off altitude. Mach and airspeed will increase more rapidly than during the previous portion of the climb. When approximately 0.03 Mach below the desired cruise speed, retard the throttles to the estimated initial fuel flow setting. Make small adjustments in pitch attitude and power setting to stabilize at the cruise condition. Mach number is quite responsive to throttle adjustment.

CRUISE

Supersonic cruising requires an awareness of high altitude techniques.

Types of Cruise Profiles

Cruise profile parameters are: desired Mach, aircraft weight (fuel remaining), and ambient temperature (CIT). The following definitions categorize several types of profiles.

a. Minimum afterburner cruise - This profile yields the lowest cruise altitude for the Mach scheduled, and usually results in less than maximum range.

b. Maximum range (optimum) cruise - This profile yields maximum range for the Mach specified. Power settings used are in the lower portion of the afterburner range.

c. Intermediate altitude cruise - This profile yields altitude schedules below the maximum altitude cruise profile, but

CHARACTERISTIC PITCH TRIM INDICATIONS

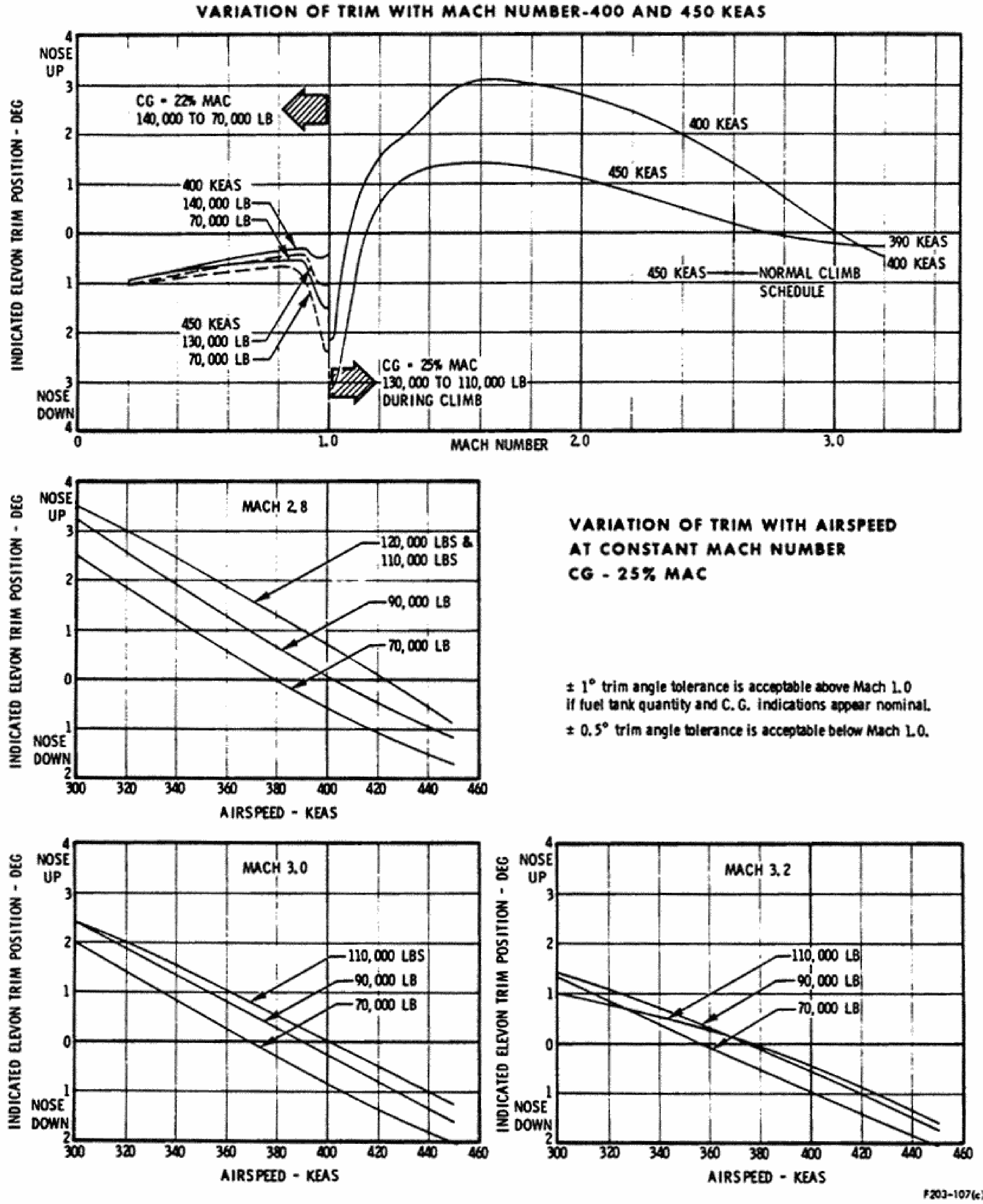


Figure 6-7

above the maximum range profile. Specific range is less than optimum, but reasonably efficient.

d. Maximum altitude cruise - This profile results in altitudes approximately 1000 feet below the maximum afterburner ceiling for the Mach specified.

e. Maximum afterburner ceiling - This profile requires continuous operation at maximum afterburner and the Mach specified.

These profiles employ a cruise climb that requires a gradual but continuous increase in altitude as fuel is consumed. As altitude increases during constant Mach cruise, KEAS decreases. For a given profile, gross weight and ambient temperature (ambient temperature and Mach influence CIT) determine the desired altitude for cruise at constant Mach number.

NOTE

Do not allow airspeed to decrease below 310 KEAS in cruise climb. See Limit Speed and Altitude Envelope, Section V.

Refer to Figure 6-8 for a summary of maximum range and ceiling altitudes for various Mach numbers, gross weights, and ambient temperatures.

Mach, KEAS, Altitude Relationship

The selection of values for any two of the Mach, KEAS, or altitude variables automatically defines the value of the third, regardless of ambient temperature. For instance, if cruise is scheduled for Mach 3.0 and the desired initial cruise altitude is 72,000 feet, the KEAS must be 396 knots.

Effects of Changing Air Temperatures

Because of the high true airspeed at cruise, ambient air temperature may change abruptly as different air masses are encountered. Initially, if a constant altitude is maintained, flight into a warmer air mass will cause a decrease in Mach and KEAS, and the true airspeed (TAS) and compressor inlet temperature (CIT) will remain constant. A higher TAS and CIT will result as the desired Mach is reestablished. The opposite would occur as a result of flying into a colder air mass. New cruise altitudes or speeds may be required to compensate for effects of variations in ambient air temperature.

Effect Of Mach Number

For any given gross weight and ambient temperature, the altitudes for maximum range and maximum altitude cruise profiles increase with Mach. This increase is approximately 1000 feet per 0.05 Mach number. A related characteristic is that if Mach increases slightly above that desired and the throttles are not retarded, excess thrust increases. It is easy to exceed target Mach inadvertently.

MAXIMUM RANGE (OPTIMUM) CRUISE-PROFILE

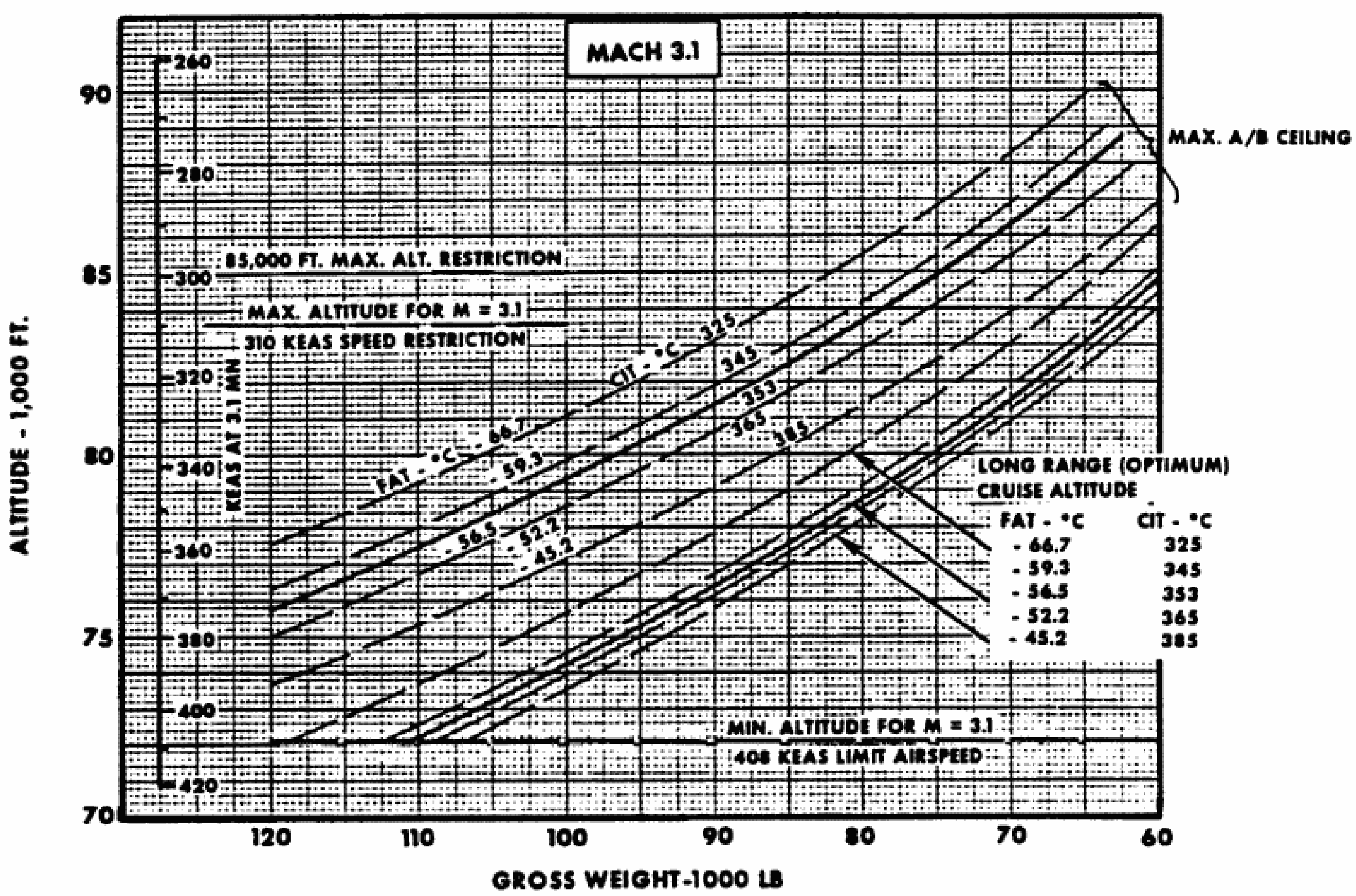
At high Mach, the maximum range (optimum) profile is a continuous cruise climb at substantially constant angle of attack with the throttles in the afterburner range (approximately 1/3 forward of the minimum afterburner stop). Relatively high KEAS are required when at heavy weight. It may be necessary to fly this profile at a constant altitude for a short period, slightly higher than the altitude for best specific range, to maintain KEAS at or below the KEAS bleed schedule. In this case, the initial cruise altitude remains above the optimum until gross weight is reduced sufficiently to fly the cruise climb profile.

NORMAL AND STEEP TURNS

Constant altitude turns of up to 35° of bank can normally be made at optimum cruise altitudes by increasing thrust. Angle of attack and required fuel flow increase approximately in proportion to load factor. It is more desirable from an operational standpoint to make constant altitude turns

MAXIMUM RANGE AND CEILING ALTITUDES

2° TILTED NOSE   C.G. AT 25% MAC   K ENGINES



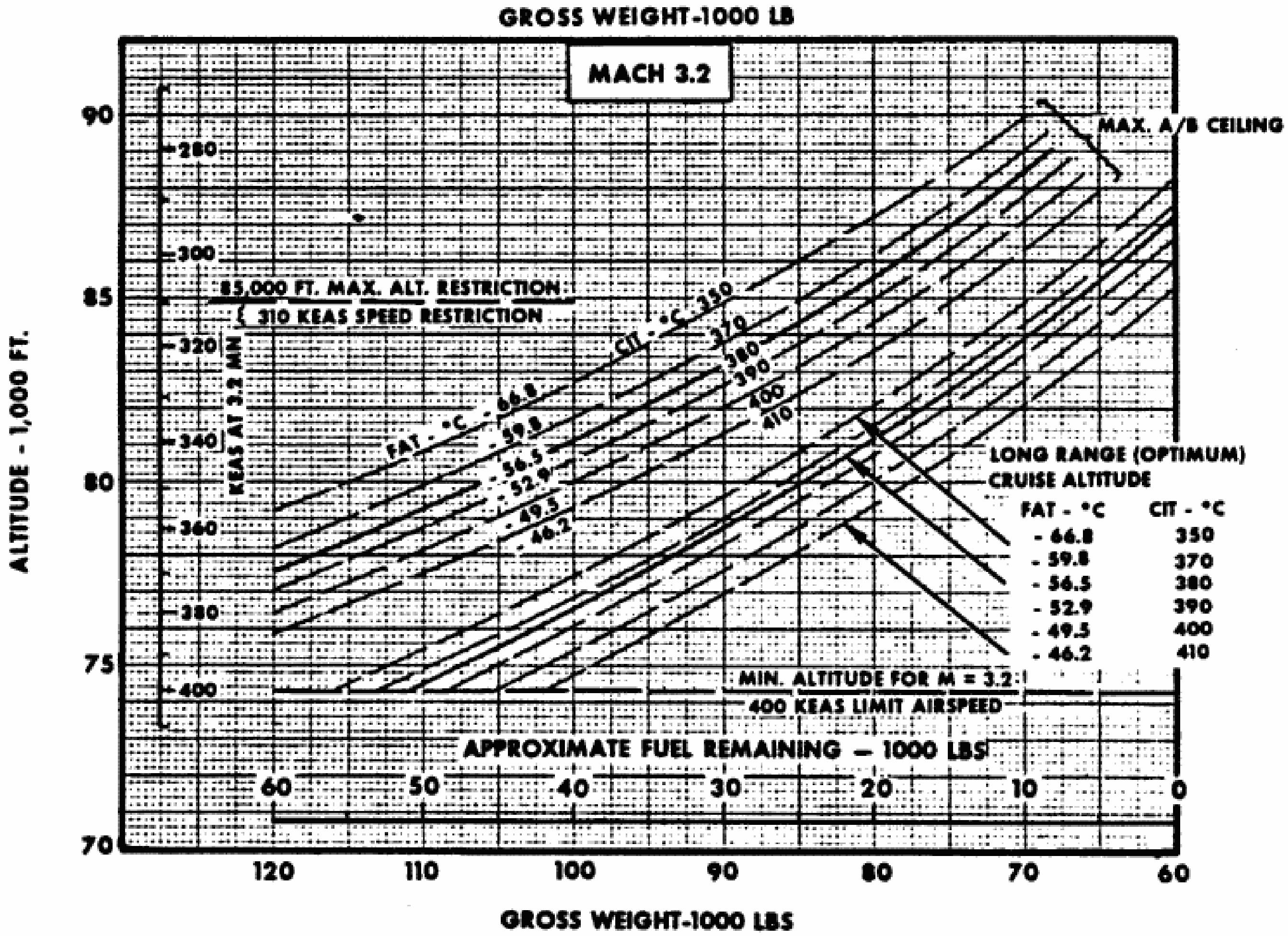


Figure 6-8 (Sheet 1 of 2)

MAXIMUM RANGE AND CEILING ALTITUDES

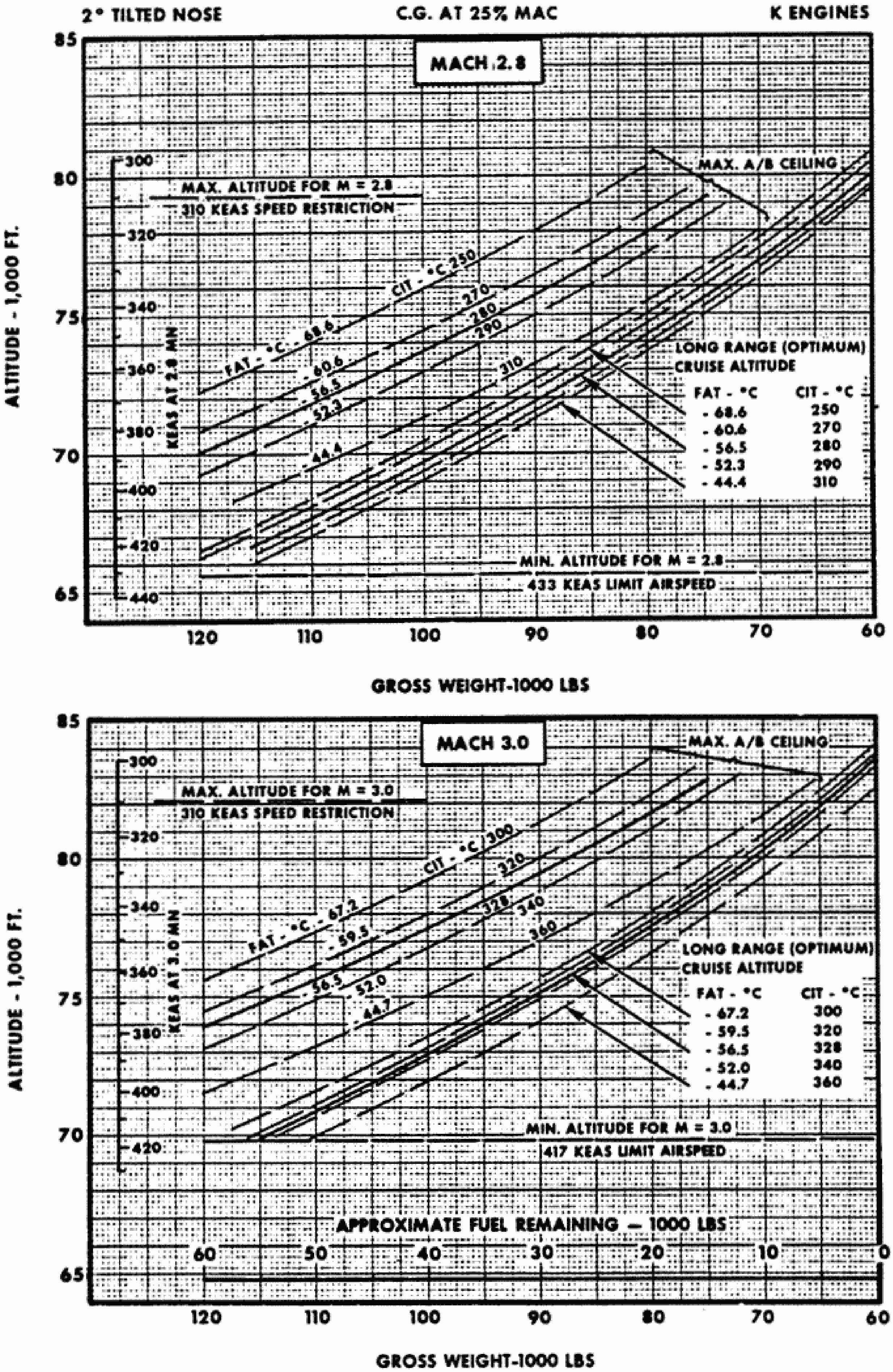


Figure 6-8 (Sheet 2 of 2)

than to maintain constant throttle setting and descend after roll in. It is slightly more economical to allow altitude to decrease while turning, maintaining constant power setting and Mach number during the turn; however, the difference in overall range due to technique is negligible. But there is always a range loss associated with turning, using either technique, of approximately 2.5 miles per 10° of turn when using normal bank angles. It may not be possible to maintain the cruise altitude schedule during steep turns (more than 35°). Whenever the aircraft is power limited in a turn, it is better to lose altitude to maintain Mach than to lose Mach and maintain altitude. An altitude loss below the maximum range cruise schedule should be anticipated for 45° bank-angle turns. A greater loss in altitude may be required for turns on hot days. Refer to Parts V and VI of the Performance Data Appendix.

NOTE

> During descending turns, KEAS must not be allowed to increase above the limit value for the Mach number. Lower bank angles (with increased turn radius) are necessary if the maximum KEAS/minimum altitude schedule can not be maintained by use of power.

Bank angles of up to 45° may be used with the roll autopilot AUTO NAV engaged. Bank angles of 45° are not recommended during climb, except as an operational necessity, due to the reduction in climb performance.

Dihedral Effect At High Speed

A characteristic difference in dihedral effect between the SR-71A and the SR-71B aircraft exists at low angles of attack, above Mach 2.8. The SR-71A aircraft exhibit a normal (positive) dihedral effect; that is, a right yaw produces right roll. Because of the ventral fins, the trainer exhibits a negative dihedral effect; that is, a right yaw produces left roll.

Elevon Positioning In Supersonic Turns

Figure 6-9 illustrates typical elevon positions required to maintain wings level and bank angles of 32° and 42° at speeds above Mach 2.75. Data are provided for airspeeds of 350 and 400 KEAS and c.g. conditions aft of 24% while at 90,000 pounds gross weight. Trends for other airspeeds and weights can be determined from Figure 6-7. Note that nose-up elevon positions are always required when operating within the normal c.g. range. Nose-down positions could occur with c.g. aft of the supersonic limit of 25%. Approximate elevon positions are provided by the pitch trim indicator in the cockpit when the autopilot is engaged and the aircraft is in nonturning 1-g flight. The same indications are obtained when flying manually with the aircraft trimmed to zero stick force (hands-off trim) with wings level. 32° and 42° lines show elevon positions for turns at these bank angles. Note that the control deflection adjustments are relatively small, usually less than one degree. Also note that a reduction in nose-up deflection is typical when near the limit Mach and that nose-down deflection is required if c.g. is aft of the limit. These changes in elevon deflection are not reflected by the pitch trim indication while turning, because of the manner in which trim position indications are affected by operation of the SAS.

Effect of Lagged Yaw Rate (LYR) on Pitch Trim Indications

The pitch trim indicator shows the additive effects of manual trimming and Mach Trim system inputs before autopilot engagement, and the effect of trim inputs due to operation of the autopilot. The trim gage can not reflect control system input signals which result from SAS activity; therefore, the trim gage indication can not represent trimmed elevon positions while in turns. The pitch SAS introduces a nose-down elevon deflection signal to counter the steady state pitch-up rate sensed when the aircraft is in a pull-up or a turn. Without LYR all of the additional trimming necessary to overcome the pitch SAS input in turns must be accomplished by the pitch autopilot or by the pilot through trim and/or control stick adjustments. With the autopilot in control, or when the pilot manually trims out stick force, the pitch trim indicator shows the net requirement needed to overcome the SAS activity and to position the elevons for the desired turn. Figure 6-10 shows typical trim indications for trimmed flight with LYR (roll autopilot on) and without LYR (roll autopilot off) for wings-level and at 32° and 42° bank angles. Flight conditions of weight, Mach, and airspeed are the same as for Figure 6-9.

With LYR, pitch trim values in turns are as much as 2.3 degrees lower than for the same flight conditions without LYR. This occurs because the LYR signal, which is derived from bank angle and the sustained yaw rate sensed by the SAS in a turn, is applied as a nose-up signal to oppose the nose-down signal obtained from the sustained pitch rate sensed by the SAS in a turn. The trim requirements in a turn are reduced by an amount which equals the control signal provided by the LYR, and Figure 6-10 illustrates how the nose-up indicated trim change is smaller than without the LYR. Without LYR the amount of uptrimming required by the pitch autopilot in a turn would increase and could exceed autopilot pitch authority (2.3 degrees δ e) until the slow trim motor could trim out the difference. In some cases with LYR, the indicated trim change from the wings-level condition is almost nil or slightly nose-down. Normal trim positions should reappear on roll out at the conclusion of a turn.

MAXIMUM AFTERBURNER CEILING PROFILE

In the Mach 2.8 to 3.2 range, the maximum afterburner ceiling profile is 4000 to 5000 feet above the altitude schedule for maximum range. The pilot maintains this schedule primarily by small pitch adjustments after the profile is established. The maximum altitude cruise profile (1000 feet lower) is recommended except where maximum altitude is essential.

MAXIMUM ALTITUDE CRUISE PROFILE

The maximum altitude cruise profile is 1000 feet below the maximum afterburner ceiling. Continuous use of maximum afterburner should not be required.

Effect of Mach Decrease

The Mach must not decrease appreciably below the desired cruise Mach. A small decrease in Mach at constant altitude will cause the aircraft to intercept the maximum afterburner ceiling for that speed and become thrust limited. A descent of several thousand feet may be required to reestablish the desired Mach.

Turn Restrictions

NOTE

> Turns must be anticipated when flying near maximum altitudes. A descent of approximately 2000 feet should be completed prior to turn entry.

Use of the maximum altitude cruise and maximum afterburning ceiling profiles is restricted to nonturning flight. If 35° bank turns are attempted at these altitude schedules, the angle of attack will exceed 8°. Inlet angle of attack biasing will cause compressor inlet pressure to decrease as much as 2 to 3 psi.

Due allowances must be made for the expected altitude loss if maximum power will not be sufficient to maintain level flight. Refer to Figure 6-8 and the Performance Data Appendix, Parts V and VI.

ELEVON POSITIONS - WINGS LEVEL AND IN TURNS

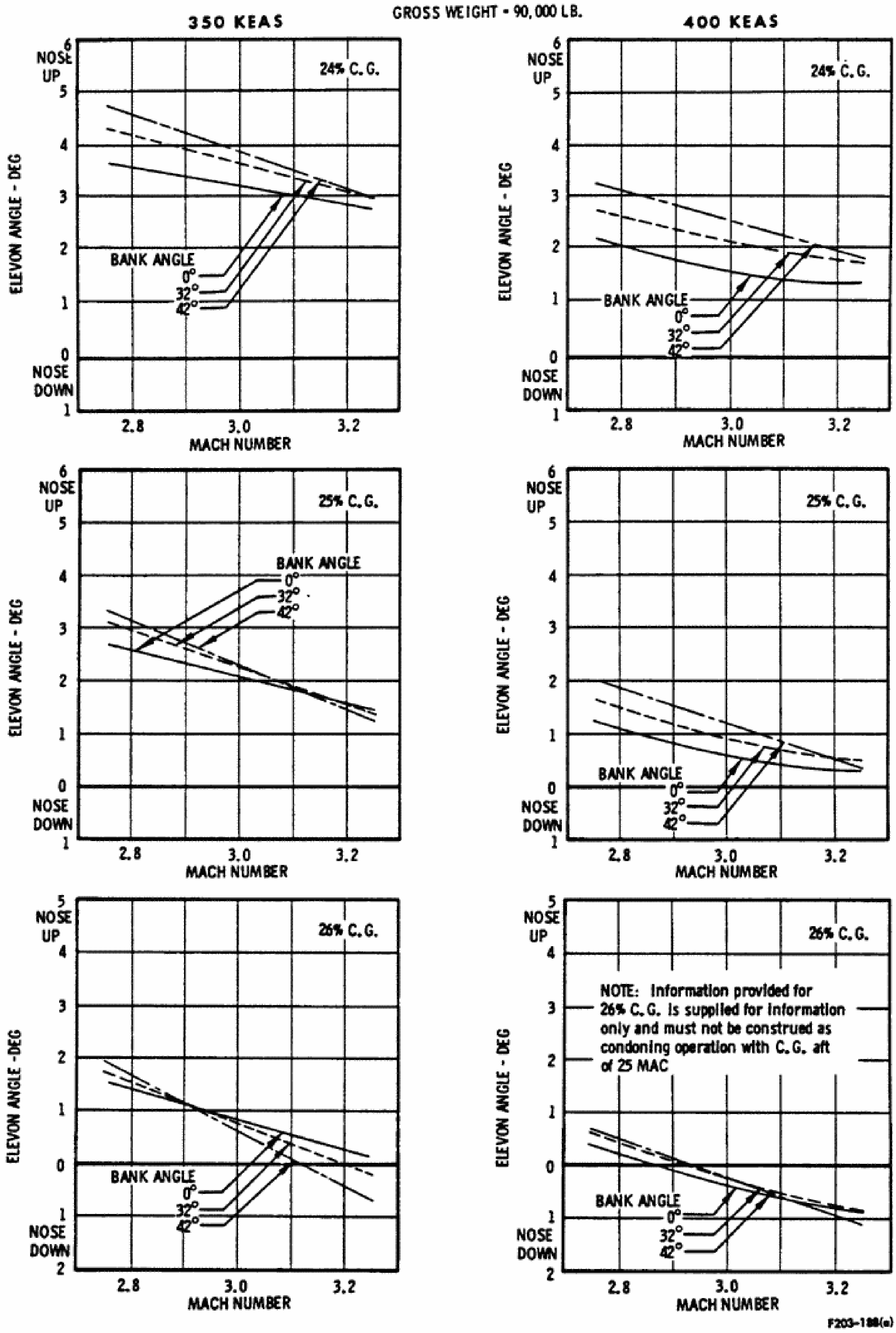


Figure 6-9

ELEVON TRIM INDICATION – WITH LYR (ROLL AUTOPILOT ON) AND WITHOUT LYR (ROLL AUTOPILOT OFF)

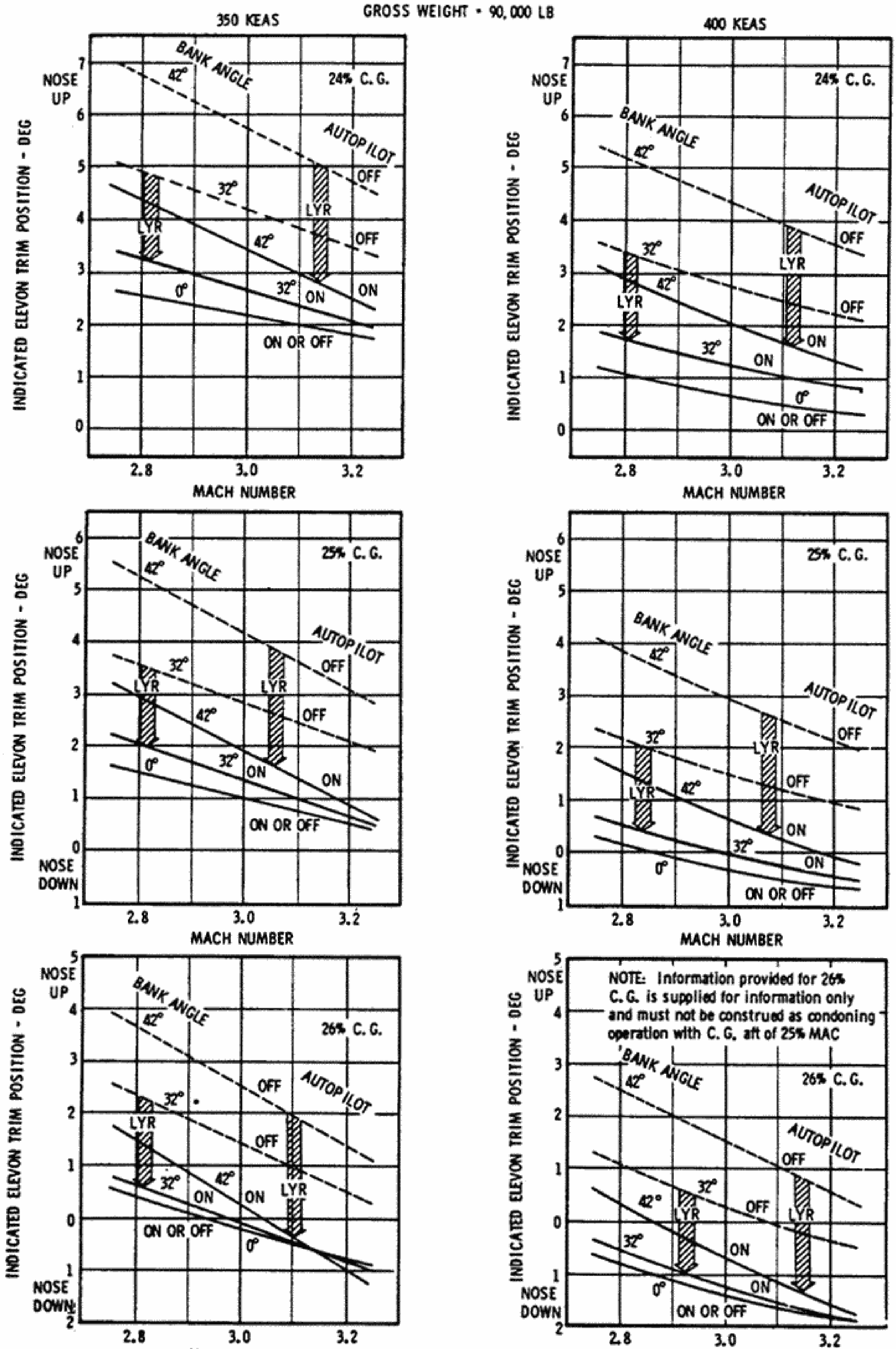


Figure 6-10

When scheduling turns requiring 42° bank angle at speeds above Mach 3.0, the initial weight must be such that the aircraft can stabilize at least 2500 feet above the altitude at which 400 KEAS would be intercepted. Turns at this bank angle must not be planned for such heavy weights that altitude loss would result in exceeding 400 KEAS. In such cases, select a turning radius which requires less bank angle. When planning 42° bank-angle turns at speeds above Mach 3.1, it is also recommended that a distance allowance be included for a descent of 2500 to 3000 feet below the maximum range altitude to be completed and level off accomplished before starting the turn. Maximum thrust may not be sufficient to maintain the maximum range cruise altitude schedule at such high bank angles. The specific range curves in Part V, and the Maximum A/B Constant Mach/Altitude Turn Capability curves in Part VI of the Performance Data Appendix can be used for predicting turning performance and for planning the flight profile required before turn entry.

HIGH ALTITUDE TURN TECHNIQUE

NOTE

Heavy weight turns at maximum cruise speed should be avoided (if possible) by preflight planning or by turning during the climb, before reaching cruise altitude. Bank-angle turns of 45° are not recommended during climb except as an operational necessity.

Anticipate turns during cruise at the maximum altitude cruise profile or higher, and descend approximately 2000 feet before reaching the turn point. Use minimum A/B, (or a power setting slightly higher, if exhaust nozzle instability is encountered at minimum A/B) when at maximum altitudes. Maintain cruise Mach during the descent, and reset level-flight power before turning. Advance the throttles slowly to maximum afterburner, either after the bank is established or as the turn is entered, considering:

1. A nose-up pitch rate develops during the roll in. Setting maximum afterburner power during the roll in could aggravate control problems if an unstart occurs.
2. A delay in advancing power increases the possibility of altitude loss, but reduces the problem of attitude control if an unstart occurs.

NOTE

Anticipate a slight increase in indicated TDI Mach as the aircraft rolls into the turn. This does not reflect an actual increase in speed or a need for immediate correction. It is characteristic of the airspeed system at high speed.

Maintain Mach, using pitch attitude adjustment, when turning with maximum afterburner.

WARNING

Do not make abrupt pitch attitude changes while turning.

Maximum power may also be required to maintain Mach during level turns at the maximum range altitude schedule when using high bank angles. Refer to the Turn Restrictions paragraph for turns above 35° when at the maximum range altitude.

NOTE

Use of the pitch autopilot with Mach Hold off is recommended for high altitude turns. Use the pitch trim adjustment wheel to control attitude, but do not make abrupt pitch changes.

The pitch autopilot can be used with bank angles up to 45° at all speeds.

DESCENT

Descent characteristics are not unusual except for the variation in flight path angle encountered during the supersonic deceleration. For start of descent, either a constant altitude deceleration is made to 365 KEAS or a constant Mach number descent is made until 350 to 365 KEAS is intercepted. The choice depends on whether airspeed is above or below 350 to 365 KEAS at end of cruise. Then 365 KEAS is maintained. When 350 KEAS is intercepted near Mach 3.2 with military power, the angle of descent is approximately 1^o. As speed is reduced and power reduced to near idle thrust, the descent angle increases until over 7^o is reached just above Mach 1.0.

AIR REFUELING

Air refueling with the flying boom system of the KC-10 or KC-135 tankers poses no problem of compatability and is normally accomplished between 25,000 and 30,000 feet. The aircraft provides a stable platform with the SAS on. Without afterburning, the aircraft may become power limited at the higher refueling altitudes before a maximum onload can be completed. This requires using either a toboggan technique or completing the refueling with one afterburner on.

Forward visibility in the observation and precontact positions is excellent, but upward, lower, and aft visibility is restricted. Rendezvous is easiest from a slightly low position with the tanker within 60^o either side of the nose. The pilot's refueling visibility is optimized by lowering his seat prior to contact. Depth perception through the vee windshield is slightly impaired, and some pilots prefer to use one side of the windshield during contact.

A slight buffet will be felt as the contact position is reached. This is tanker downwash and has no effect on the receiver except for a slight decelerating effect. Acceleration response of the engines is excellent and aircraft drag at refueling speeds produces good deceleration response.

Avoid overcontrolling the engines, while gaining and holding position, due to nonlinearity of throttle position vs engine thrust. A given throttle angle change near military power yields more thrust change than a similar change in the throttle midrange.

The aircraft may become power limited, if the afterburner-on technique is not used, and tobogganing descents of up to 1000 feet per minute can be requested as the military power throttle position is approached. Asymmetric thrust is easily controlled with one afterburner on.

Turbulence encountered while in contact poses no particular problem with SAS operating normally and shallow turns can be made without difficulty. However, if all pitch SAS is inoperative, refueling is not recommended except in an emergency. The aircraft is poorly damped without any pitch SAS, but control can be maintained under favorable conditions with a forward c.g.

After disconnect, movement relative to the tanker should be rearward and slightly downward with wings level. This insures a straight line force separation of the boom from the receptacle.

During night refueling, added caution and effort is required to avoid overshoot, and the tendency toward throttle overcontrol while in contact increases.

The angle of attack is approximately 3^o for a lightweight hookup and increases to approximately 6^o for full tanks.

APPROACH AND LANDING

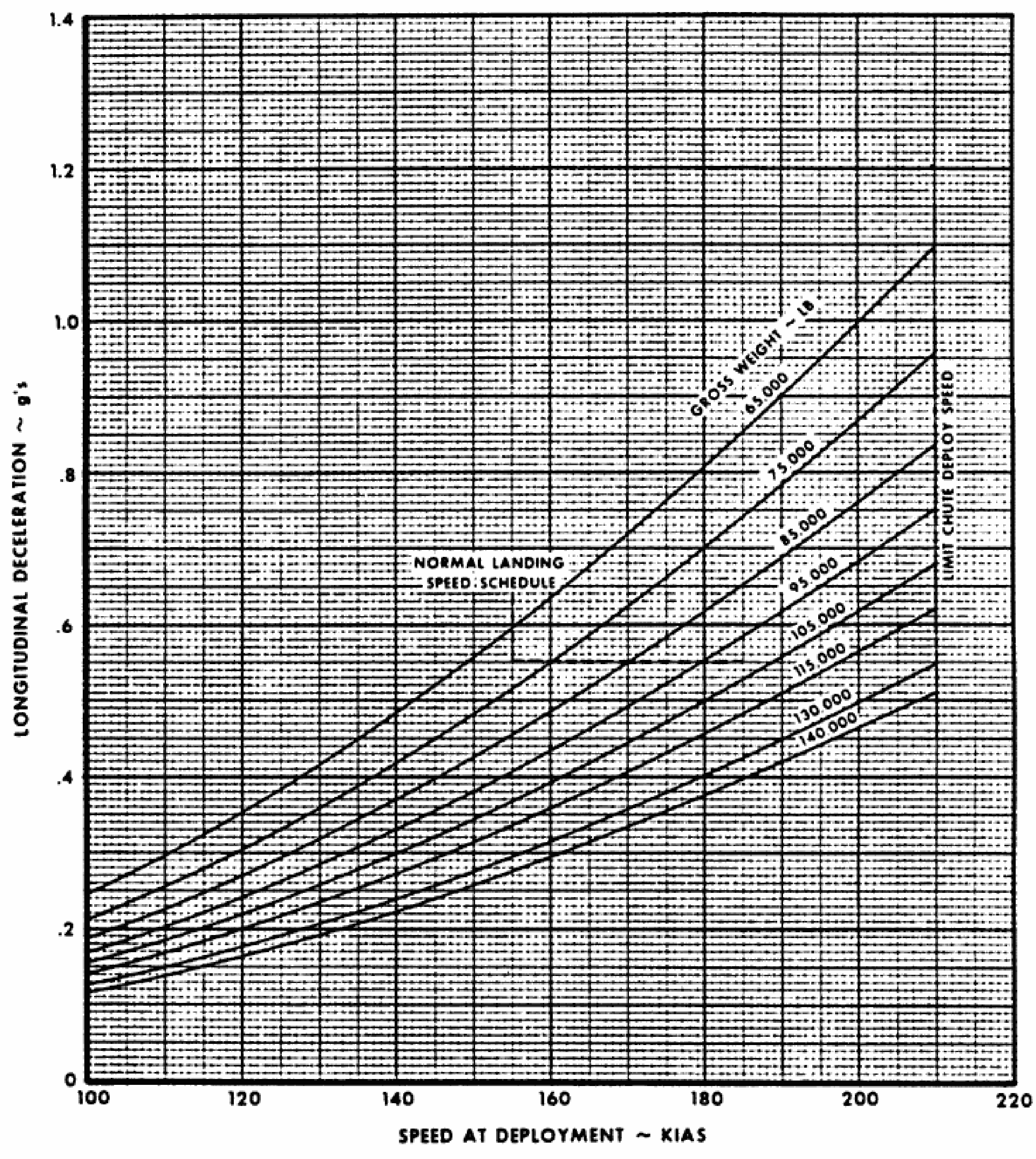
Handling characteristics during approach and landing with SAS operative are good. Short period disturbances are well damped, and available roll rates are adequate. The aircraft can be held off the runway to speeds much lower than recommended landing speed. Normal touchdown angle of attack is from 10° to 12°. There is a risk of damage to the aft fuselage if the touchdown angle of attack exceeds 14°.

Normally the aircraft is flown directly to touchdown rather than attempting to hold just off the runway with subsequent settling at too high an attitude. Prompt chute deployment will result in momentary deceleration loads of about 1/2 g. The chute should not be deployed in the air because of the rapid deceleration and rate of sink that could develop, but it can be actuated before nosewheel contact without any unusual pitching tendencies. During crosswind landings, however, chute deployment should be delayed until the nosewheel is on the runway and steering engaged. Refer to Crosswind Landing, Section II and Landing Gear Limits, Section V.

The initial loads which occur when the drag chute deploys are illustrated by Figure 6-11. Note that approximately 1/2 g initial deceleration can be expected at deployment speeds for normal landings. The initial shock can be much greater during high-speed deployments at light to moderate weights. The load at which the drag chute attachment link is designed to fail is 110,000 pounds.

Practice landings with pitch and/or yaw SAS off are not permitted. The roll SAS may be disengaged prior to simulated and actual single-engine landings. Control during emergency landings with all pitch SAS off is increasingly more difficult if c.g. approaches or exceeds the aft limit.

INITIAL DECELERATION VS CHUTE DEPLOY SPEED



REFERENCE DATE: SEPTEMBER 1972

Figure 6-11

INSTRUMENT FLIGHT PROCEDURES

SPATIAL DISORIENTATION

Spatial disorientation is possible if the pilot is not concentrating on attitude instruments, particularly if a true visual horizon is not available. During constant acceleration there is susceptibility to a phenomenon known as somatogravic illusion. This illusion causes the crewmember to falsely perceive increasing pitch attitude when the aircraft is in a constant flight path acceleration, or to falsely perceive decreasing pitch attitude when the aircraft is in a constant flight path deceleration. The magnitude of this illusion is exacerbated by the high rates and durations of acceleration and deceleration within the capabilities of the SR-71. The instinctive response, without reference to flight instruments, would normally be opposite to the actions required to recover to the desired attitude. The effects of this illusion can be minimized by vigilant monitoring of attitude instruments when a true visual horizon is not available.

PITOT-STATIC SYSTEMS

The pitot-static operated flight instruments are used for subsonic flight. The TDI should be used for acceleration to, during, and for deceleration from supersonic flight. Equivalent airspeeds (KEAS) and altitude information from the TDI can be used when subsonic, however, TDI response may not be as rapid as the ship system indication.

Angle of Attack Indication

The angle of attack indication is referenced to pitot total pressure and to the attitude probe on the Rosemount pitot-static boom. It is independent of static pressure. Pitot heat should be sufficient to keep both the pitot-static head and the angle of attack probe operating during icing conditions. If the pitot tube is completely blocked, both airspeed systems are unreliable and angle of attack may also be unreliable. Check for reasonable angle of attack indication by cross reference to the attitude gyros during turns.

BEFORE INSTRUMENT TAKEOFF

Set the pilot's ATT REF SELECT switch to INS, the DISPLAY MODE SEL switch as desired, and the ADI from 3 to 5 degrees nose low.

INSTRUMENT TAKEOFF AND CLIMB

Takeoff and climb under instrument conditions are identical to normal Takeoff and Climb procedures in Section II.

STEEP TURNS

Any bank angle 35° or greater is considered a steep turn. The aircraft is easily controlled on instruments in banks up to 60°; however, due to structural load restrictions, avoid bank angles in excess of 45°.

HOLDING

Holding patterns and descents between holding levels should be flown at 275 KIAS. Approximately 6400 rpm is required at FL 200 with normal conditions and 15,000 pounds of fuel remaining.

JET PENETRATION

Penetrations are flown at 275 KIAS with power set at approximately 5500 rpm. Initial rate of descent will be 3000 to 4000 fpm.

The landing gear may be used for additional drag during the penetration. Landing gear should be extended prior to the final approach fix. At normal approach gross weights, maintain 230 to 250 KIAS until final approach.

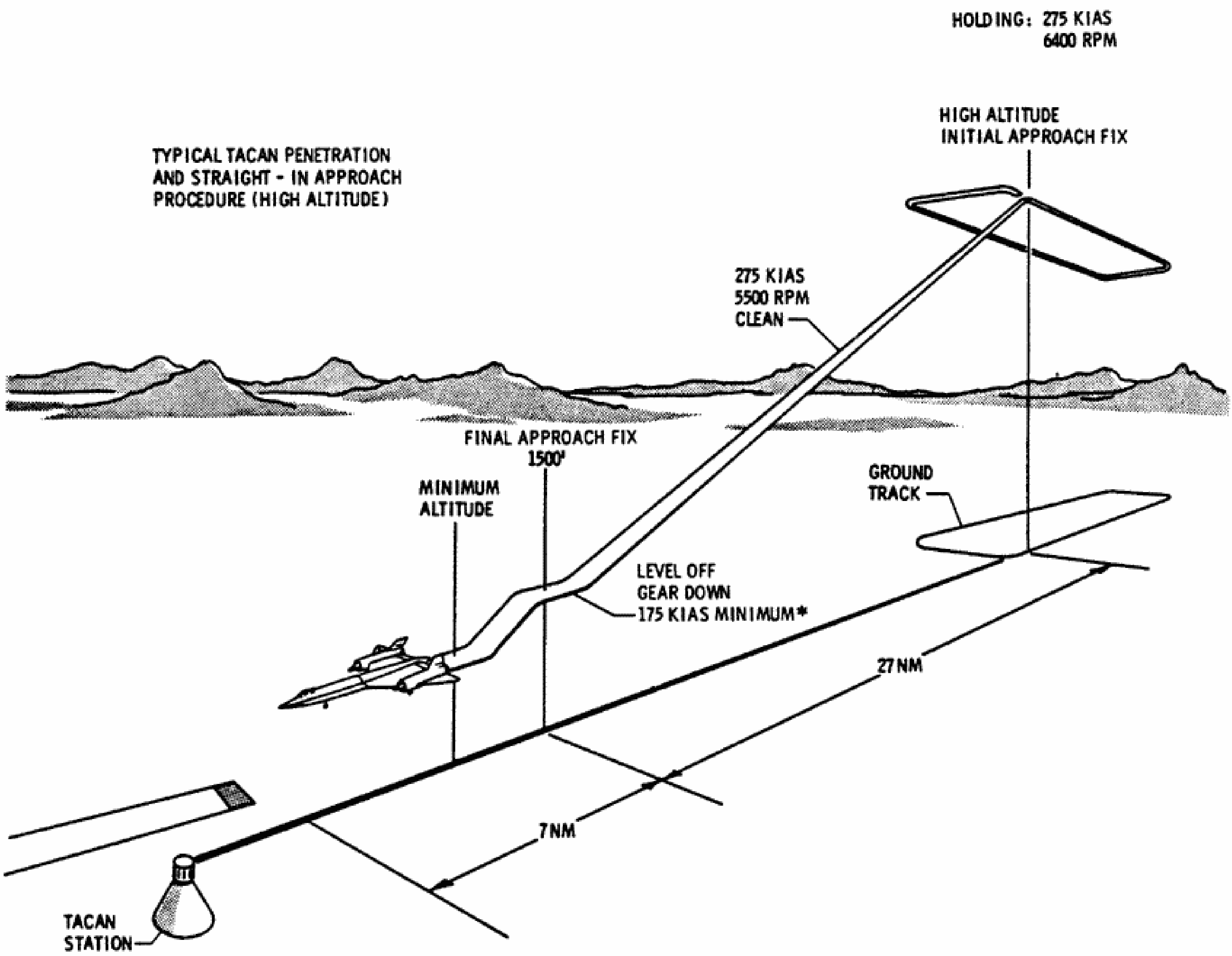
NOTE

> Fuel required for a typical jet penetration is 1000 to 1700 pounds.

INSTRUMENT APPROACHES

Use normal traffic pattern airspeeds; refer to Section II, Before Landing.

JET PENETRATION



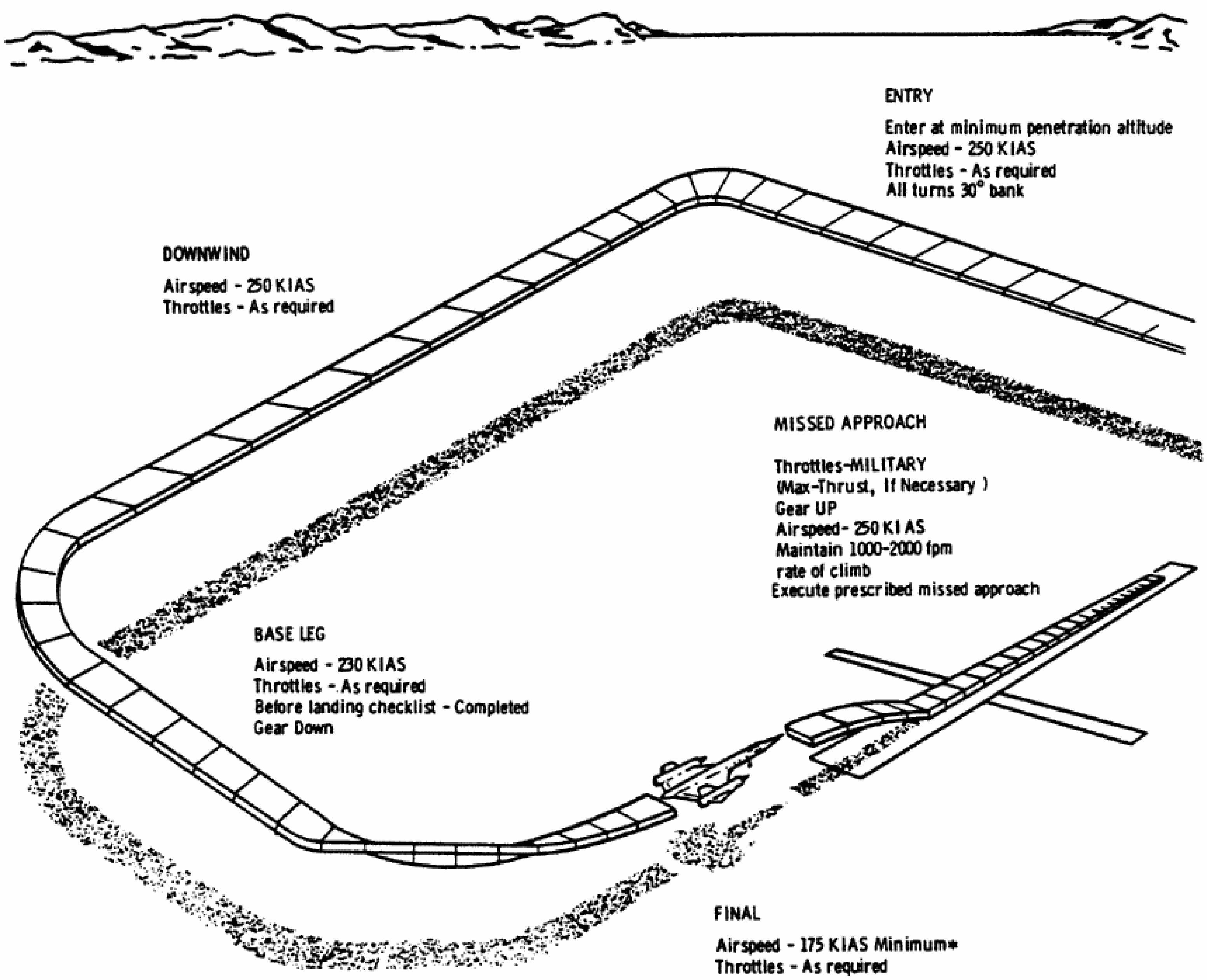
NOTE

* Increase final approach speed 1 knot for each 1000 lbs. over 10,000 lbs. fuel remaining.

F203-31(c)

Figure 7-1

PRECISION RADAR APPROACH



NOTE

* Increase final approach speed 1 knot for each 1000 lbs. over 10,000 lbs. fuel remaining.

For aircraft over 100,000 lbs. (over 40,000 lbs. fuel remaining), maintain 275 KIAS on downwind leg and 250 KIAS on base leg. Use approximately 10.5 degrees angle of attack for final approach and landing.

F203-32(c)

Figure 7-2

NOTE

Altimeter position error corrections at instrument approach speeds are negligible.

For an ILS approach, set UHF radio power to 4 or lower. Set the inbound localizer course in the HSI, select ILS on the DISPLAY MODE SEL switch until the aircraft is established on the localizer, then select ILS APPROACH. The ADI bank and pitch steering bars (front-course ILS only), and the HSI course deviation bar will provide correct steering directions.

WARNING

ILS reception can be affected by UHF transmission at high power settings.

MISSED APPROACH AND GO-AROUND

Apply Military thrust as soon as it is determined that a go-around is necessary. Use afterburner if necessary. Raise the landing gear after a climb has been established, and climb to the missed approach altitude at 250 KIAS. When a positive rate of climb has been established, adjust power as necessary to maintain 250 KIAS and approximately 1000 to 2000 feet per minute rate of climb.

NOTE

Fuel required for a missed approach and instrument go-around (typical GCA pattern) is approximately 3000 pounds. A closed pattern go-around requires approximately 1000 pounds.

SINGLE-ENGINE OPERATION

Refer to Section III, Single-Engine Penetration and Landing. Hold gear extension until final approach and maintain a minimum final approach speed of 200 KIAS. For single-engine missed approach, follow the Single Engine Go-Around procedures in Section III and observe the single-engine minimum control speed.

ICE AND RAIN

Flight in areas where moderate or heavy icing is present or forecast is prohibited. Extended flight in any icing is also prohibited. Ice will build up on the spikes at penetration and approach speeds and enter the engine as it breaks off. Engine damage due to ice ingestion is not normally severe enough to cause engine shutdown and can be minimized by reducing rpm.

Extended flight in heavy rain is prohibited. If heavy rain is encountered while subsonic, maintain below 350 KEAS. When climbing at supersonic speeds, reduce to 400 KEAS. If the climb can not be continued, decelerate at 350 KEAS.

If icing or heavy rain at near freezing temperatures is encountered, make an entry in Form 781 so that the engines will be examined for damage.

WINDSHIELD ICING

Without hot air deicing, forward visibility is unsatisfactory under all icing conditions. Ice build up occurs very rapidly and dissipates very slowly, even after descent to lower, warmer altitudes. Hot air flow on the windshield is satisfactory for inhibiting ice build up if used prior to encountering icing conditions.

VISIBILITY IN RAIN

In rain, forward visibility is obscured by a water film which extends over almost all of the windshield area. Hot air deicing is useful for improving visibility through the left windshield while taxiing or flying in rain. Use of windshield hot air deicing or the rain remover liquid (before S/B R-2674) during light and moderate rain conditions improves visibility to a usable condition at approach speeds; however, windshield deicing should not be used simultaneously with rain remover fluid. Visibility is momentarily obscured as the rain remover liquid is applied, then the windshield clears and beads of water form which stream across the glass. Rain remover application is needed at ten to fifteen second intervals for best effectiveness. Approximately 30 applications of the rain remover fluid are available. The rain remover system is not effective with very heavy rain conditions and although hot air deicing provides very slight improvement, visibility remains obscured. After S/B R-2674, the rain removal system is deactivated.

__Rain Removal__

NOTE

Reduce speed below 250 __KIAS__ before applying rain remover fluid.

CAUTION

Do not apply rain repellent on a dry windshield. Prolonged obscuration may result.

Residual rain remover fluid can be baked in the spray bars during high speed (hot flight), causing subsequent stoppage of fluid flow. Therefore, the rain removal system should not be used prior to hot flight unless essential. After S/B R-2674, the rain removal system is deactivated.

1. Windshield deicing switch - RAIN REMOVAL ARM ON.

2. Rain removal button - PUSH.

NOTE

Momentary cloudiness will occur.

CAUTION

Do not apply removal liquid after passing approach minimums.

3. Repeat as required when visibility deteriorates.

NOTE

Make an entry in Form 781 if the rain removal system has been used.

HIGH HUMIDITY CONDITIONS

If condensation forms on the inner or outer windshield glass:

1. Cockpit defog switch - Set.

   Hold the defog switch OPEN, then select HOLD or CLOSED as required to keep the inner windshield canopy glass clear.

2. Windshield deicing switch - ON DE-ICE.

   Selection of the ON DE-ICE. position directs hot air to the left windshield outer panel and causes the WINDSHIELD DE-ICE ON caution light on the pilot's annunciator panel to illuminate.

NOTE

Windshield deicing can be used with other normal procedures for management of the environmental control system; however, this diversion of air may reduce the supply to the cockpits and bay areas when operating at low engine rpm. Windshield deicing should not be used simultaneously with rain removal.

If fog emanates from the cockpit air distribution ducts:

3. Cockpit temperature control rheostat - Increase as required.

   Light to moderate cockpit fogging can be eliminated immediately by moving the cockpit temperature control and override switch to manual WARM. In automatic operation, moving the cockpit temperature control rheostat to a warmer setting (clockwise) also eliminates fog.

If fogging persists:

4. Use the Cockpit Fog emergency procedure.

STRUCTURAL CAPABILITY IN GUSTS

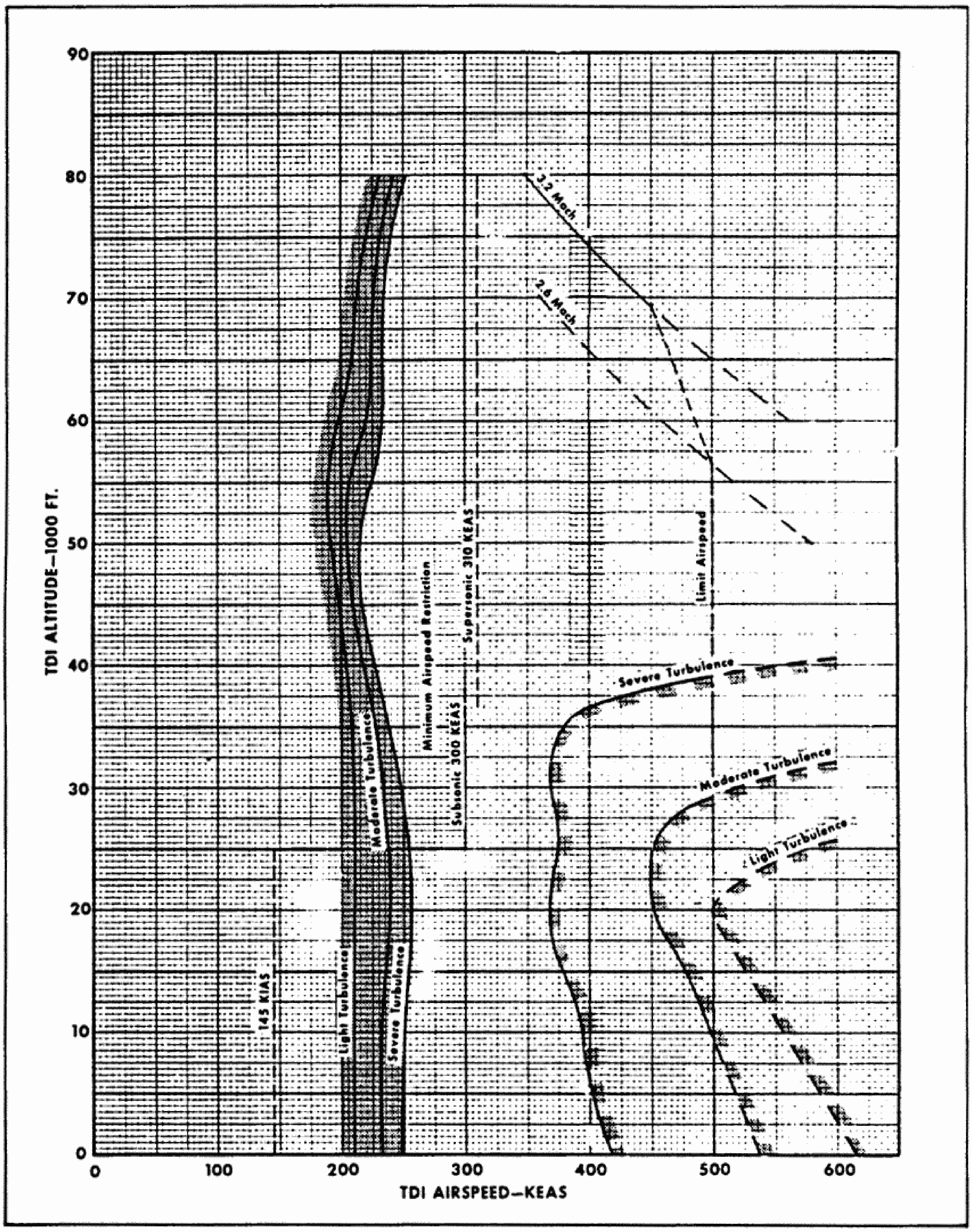


Figure 7-3

Before the cockpit air handle is returned to the open position, the cockpit temperature control and override switch should be moved to manual WARM long enough to assure that fog will not recur.

TURBULENCE AND THUNDERSTORMS

Flight should not be scheduled through areas where moderate or severe turbulence is forecast. If such conditions are encountered while subsonic, maintain 300 to 350 KEAS. When climbing at supersonic speeds, reduce to 400 KEAS. If the climb can not be continued, decelerate at 350 KEAS. Refer to the Structural Capability in Gusts chart, Figure 7-3.

OPERATION IN TURBULENCE

The inlets may not operate normally if severe turbulence is encountered at high speed: flameout may occur.

Stick shaker can occur while in turbulence; however, the APW pusher/shaker switch should not be turned OFF unless a definite malfunction of the APW system is identified. Reduce load factor and increase KEAS, if practicable, to avoid shaker operation.

Jet Penetration

The normal penetration speed of 275 KIAS is compatible with operation in turbulence.

Landing Approach

The normal turn to final approach speed may be increased to 250 KIAS to avoid control difficulty.

COLD AND HOT WEATHER PROCEDURES

Detailed cold and hot weather procedures have not been established. The pilot must be aware of the effects of nonstandard temperatures on takeoff and landing distances and minimum single-engine control speeds. The pilot should also be aware of the effects of wet, icy, and slush covered runways on takeoff and landing distances and on ground handling characteristics.

COLD DAY GROUND OPERATION

After start during cold weather, the DAFICS Preflight BIT may fail until hydraulic fluid in the servos warms sufficiently to provide normal servo response. Repeat the Preflight BIT until it is successful.

Taxi speeds tend to increase during cold weather. Restrict taxiing to low speeds when on wet or icy surfaces. Braking must be accomplished carefully to avoid skidding when below 12 mph, as antiskid protection is not available. Shut down of the right engine during taxi-in after landing may be necessary to reduce braking requirements; however, taxiing with one engine shut down is not recommended.

Painted Areas

Painted areas are significantly more slippery than unpainted areas when wet. Painted areas serve as condensation surfaces and it is possible to have icy conditions on these areas when the overall surface condition is dry.

HOT DAY GROUND OPERATION

Sunshades over the cockpits are advisable before the crew boards when the aircraft is directly exposed to the sun.

NIGHT FLYING

Interior Light Reflections

The combined reflective qualities of the canopy and cockpit instruments can create reflection problems at night from cockpit lights. A reduction of canopy reflections is realized if the front cockpit sunshades are joined and positioned as an extension of the glare shield. Open the face plate (below 10,000 feet) and/or lower the front windshield vision splitter for night landings to reduce reflections.

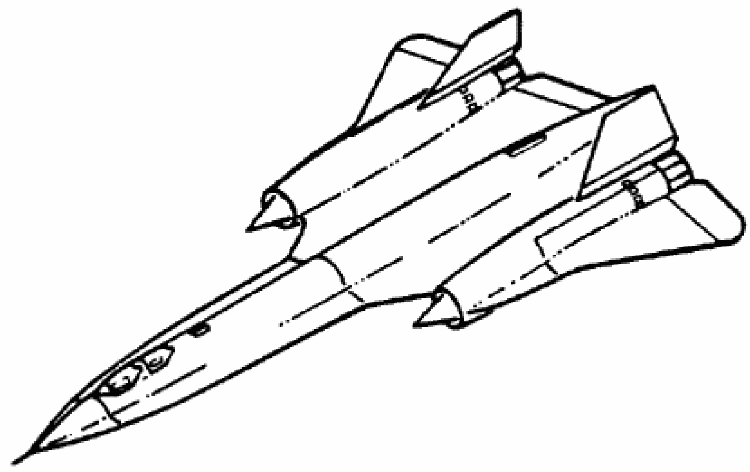
Interior Lighting

Except for the pilot's attitude indicator and map projector, lighting balance between individual cockpit instruments is preset. Deficiencies in lighting balance should be reported. A reduction in the interior lighting level to reduce glare and reflections, plus the encumbrance of the pressure suit gloves, requires that crew members have an intimate knowledge of switch positions and functions.

Supersonic Operation

Precise altitude and speed control is more difficult while supersonic at night because of the lack of outside reference. The pilot is dependent on cockpit instrumentation only, for all attitude changes. Vigilantly monitor attitude references and frequently cross-check aircraft performance indications such as Mach, altitude, IAS, and heading.

Appendix I



Performance Data

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ABBREVIATIONS AND SYMBOLS

Abbreviations	Definitions
AA	Air to Air
A/B	Afterburner
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
ADS	Accessory Drive System
ANS	Astroinertial Navigation System
APW	Automatic Pitch Warning
AR	Air Refueling
ARCP	Air Refueling Control Point
ARCT	Air Refueling Control Time
BDHI	Bearing Distance Heading Indicator
BIT	Built-in Test
BO	Boom Operator
CB	Circuit Breaker
CCF	Chart Convergence Factor
CCW	Counterclockwise
CDI	Course Deviation Indicator
CEP	Circular Error Probability
CG	Center of Gravity
CIP	Compressor Inlet Pressure
CIT	Compressor Inlet Temperature
COMINT	Communication Intelligence
CSC	Control Stick Command
CP	Control Point
DAFICS	Digital Automatic Flight and Inlet Control System
DEF	Defense System
DP	Destination Point
DPR	Duct Pressure Ratio
EGT	Exhaust Gas Temperature
ELINT	Electronic Intelligence
EMF	Electromotive Force
EMR	Electromagnetic Reconnaissance
ENP	Exhaust Nozzle Position
ETA	Estimated Time of Arrival
EWS	Electronic Warfare System
FAT	Free Air Temperature
FDC	Flight Director Computer
FP	Fix Point
FRL	Fuselage Reference Line
GSE	Ground Support Equipment
GW	Gross Weight
HF	High Frequency
HSI	Horizontal Situation Indicator
IAF	Initial Approach Fix
ICS	Inter-Communications System
IFF	Identification Friend or Foe
IGV	Inlet Guide Vanes
ILS	Instrument Landing System
INS	Inertial Navigation System
IR	Infrared
IVSI	Inertial-Lead Vertical Speed Indicator
KHz	Kilo-hertz
KCAS	Knots Calibrated Air Speed
KEAS	Knots Equivalent Air Speed
KIAS	Knots Indicator Air Speed
KTAS	Knots True Air Speed
LN2	Liquid Nitrogen
LOX	Liquid Oxygen
MAC	Mean Aerodynamic Chord
MAG	Magnetic
MAL	Malfunction
MHz	Mega-hertz
MRS	Mission Recorder System
NCD	Navigation Control Panel
NDRO	Non-Destructive Readout
NM	Nautical Mile
NWS	Nose Wheel Steering
OBC	Optical Bar Camera
PP	Present Position
PRF	Pulse Repetition Frequency
PVD	Peripheral Vision Display

ABBREVIATIONS AND SYMBOLS

Abbreviations	Definitions
R/C	Rate of Climb
RCD	Recorder Correlator Display
RCR	Runway Condition Reading
R/D	Rate of Descent
RSC	Runway Surface Covering
RSO	Reconnaissance Systems Operator
SAS	Stability Augmentation System
SES	Shock Expulsion Sensor
SLR	Side Looking Radar
TACAN	Tactical Air Navigation
TDI	Triple Display Indicator
TEB	Triethylborane
TECH	
TEOC	Technical Objective Camera
TGS	Takeoff Ground Speed
TOL	Takeoff and Landing
TOLR	Tolerance
TROC	Terrain Objective Camera
T/R	Transmit - Receive
TSA	Turn Start Automatic
UHF	Ultra High Frequency
V/H	Velocity/Height
WRP	Wing Reference Plane
W/δ	Cruise Parameter
XFMR	Transformer
ZFW	Zero Fuel Weight
α	Angle of Attack
$\dot{\theta}$	Pitch Rate
ϕ	Bank Angle
θ	Pitch Angle

PART I

INTRODUCTION

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SCOPE AND ARRANGEMENT

This appendix contains performance data in chart form to aid flight planning. The material is grouped into phases of flight. Descriptive text explains the use of the charts. Profile charts are included for subsonic and supersonic cruise missions.

PERFORMANCE DATA BASIS

This performance data is based on USAF Category II and Contractor flight tests of aircraft equipped with J-58 (JT11D-20) engines rated at 34,000 pounds maximum sea level static thrust. The basic material is presented for standard atmospheric conditions as defined by the 1956 ARDC Standard Atmosphere. Corrections for nonstandard temperature have been included when possible.

FUEL AND FUEL DENSITY

Performance and operating weight are based on JP-7 (PWA-535) fuel at a fuel density of 6.57 pounds per gallon. The effect on operational capabilities must be considered if fuel density is different from this nominal value. Typical variation of JP-7 fuel density with temperature is shown in Figure A1-11. With full fuel tanks, the fuel load varies 1220 pounds for each 0.1 pound per gallon change in fuel density.

AIRSPEED SYSTEMS

Airspeed, altitude, and Mach are available from both the pitot-static instruments (airspeed indicator and altimeter) and from the triple display indicator (TDI). The pitot-static instruments provide conventional pressure altitude and indicated airspeed-Mach indications. The TDI provides digitial values of equivalent airspeed (KEAS), corrected pressure altitude, and true Mach number. The difference between indicated airspeed (KIAS) and KEAS is a function of speed, altitude, and position error.

NOTE

Sections II and VII designate which of the systems should normally be used for the various phases of flight.

POSITION ERROR CORRECTIONS

Pitot-Static Instruments

Figures A1-1 and A1-2 supply position error corrections for the altimeter and airspeed indicator. Subsonic corrections were obtained from inflight and ground run calibrations. Supersonic corrections were obtained from wind tunnel calibrations.

Triple Display Indicator (TDI)

The TDI is almost completely compensated for position error and compressibility effects. However, the TDI may lag slightly during takeoff.

COMPRESSIBILITY CORRECTIONS

Standard corrections for compressibility effects on KIAS are provided by Figure A1-3. To obtain KEAS, subtract these corrections from KIAS after the position error corrections have been made.

A comparison of KEAS from the TDI and KIAS from the normal ship system is shown on Figure A1-4. This Figure is the basis for the normal climb and descent and limit indicated airspeed values provided by the placard on the TDI. For example, at 400 KEAS, the normal ship system indicates 422 KIAS at 20,000 feet indicated pressure altitude and 476 KIAS at 50,000 feet indicated pressure altitude. Other combinations of indicated altitude and KIAS can be determined from Figure A1-4 and used to determine KEAS if the TDI fails.

TRUE MACH NUMBER VS EQUIVALENT AIRSPEED

Figures A1-5 and A1-6 show the relationship between true Mach number, pressure altitude, and equivalent airspeed (KEAS), based on a "gamma" of 1.4. ($\gamma = 1.4$ is the standard specific heat ratio for air below 350°C. It decreases slightly at higher temperatures.) Figure A1-6 is a rearrangement and expansion of part of the material on sheet 3 of Figure A1-5. It is applicable between FL 650 and FL 860 from Mach 2.55 to Mach 3.35. It is also reproduced in the pilot's and RSO's checklists. In flight, it can be used to check the TDI Mach-KEAS-Altitude display.

MACH-AIRSPEED-TEMPERATURE RELATIONSHIP

Ambient air temperature and true airspeed can be obtained from CIT and TDI Mach as shown on the Mach-Airspeed-Temperature charts, Figures A1-7 and A1-8. For example, as shown on Figure A1-7, at a TDI Mach of 3.05 and CIT of 300°C the ambient temperature is -072°C and the true airspeed is 1686 knots. The effect of adiabatic compression and temperature rise on atmospheric characteristics has been included by using a variable γ parameter.

Figure A1-8 is a rearrangement and expansion of Figure A1-7 between Mach 2.55 and 3.35. Special emphasis is given to the CIT range above 300°C to provide increased reading accuracy for true airspeeds encountered at normal cruise speeds. This chart is also reproduced in the pilot's and RSO's checklists. In flight, it can be used with the ANS true airspeed output to cross-check the TDI and pitot-static system Mach displays at normal cruise speeds. It can also be used to check ambient temperature so that the effects of FAT on cruise and maneuvering capability can be anticipated.

STANDARD ATMOSPHERE

The 1956 ARDC standard atmosphere table, Figure A1-9, provides reference temperature, pressure, air density, and sonic speed information which may be of assistance in flight planning. Figure A1-10 compares the 1956 ARDC standard atmosphere and the MIL-STD-210A tropic atmosphere temperature vs altitude schedules.

STANDARD UNITS CONVERSION

The standard units conversion chart, Figure A1-11, provides a means for conversion of temperature, distance, and speed between English and metric units.

W/δ AS A FUNCTION OF GROSS WEIGHT AND ALTITUDE

Figure A1-12 presents the relationship between the cruise parameter W/δ and airplane gross weight and altitude.

BANK ANGLE vs LOAD FACTOR

The following table provides the load factors associated with bank angles up to 70° during coordinated level turns. (Refer to Section V for load factor limits.)

Bank Angle Deg.	Load Factor "g's"	Bank Angle Deg.	Load Factor "g's"
0	1.000	40	1.305
5	1.004	45	1.414
10	1.015	50	1.556
15	1.035	55	1.743
20	1.064	60	2.000
25	1.103	65	2.366
30	1.155	70	2.924
35	1.211		

POSITION ERROR CORRECTIONS VS MACH

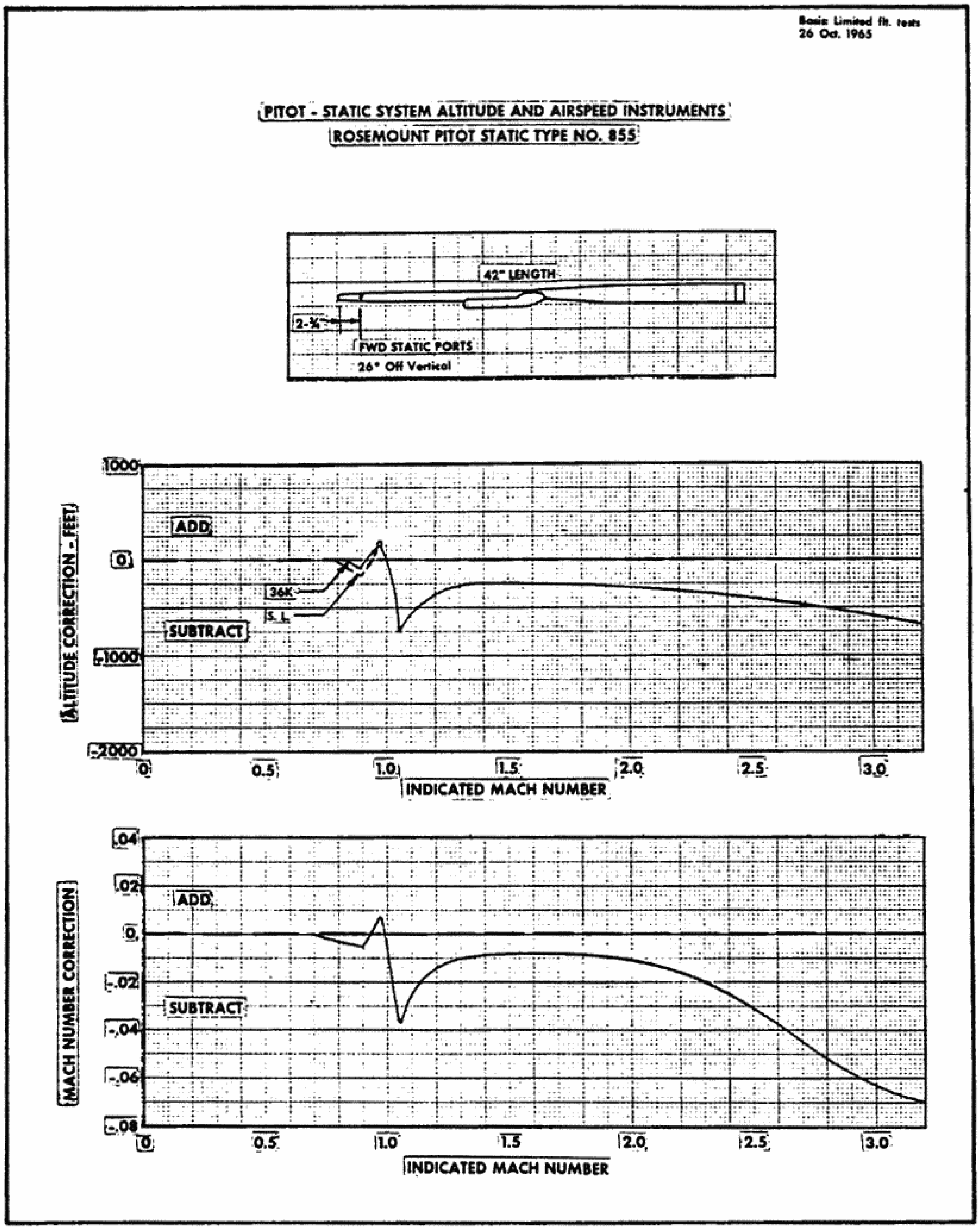


Figure A1-1

POSITION ERROR CORRECTIONS VS IAS

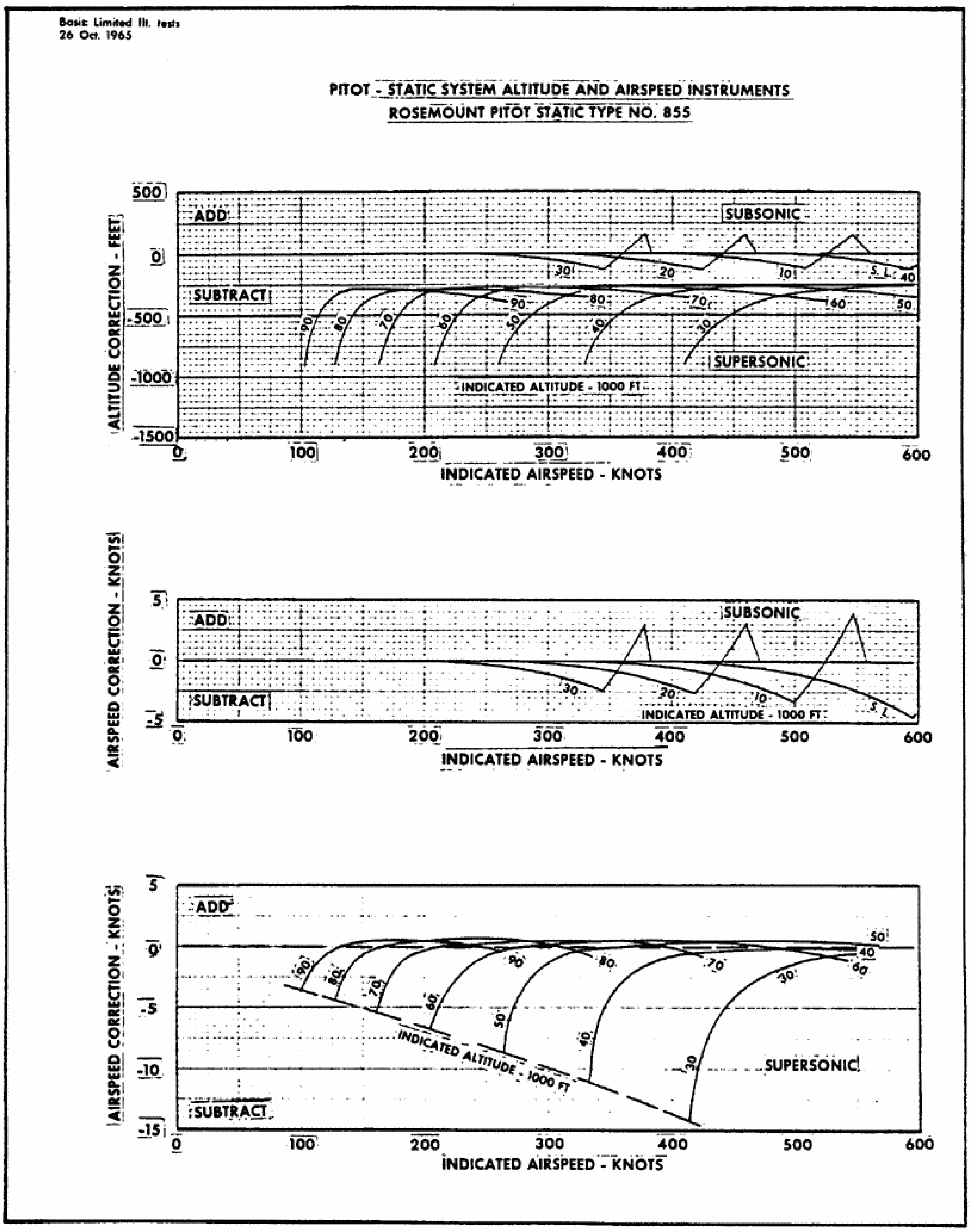


Figure A1-2

AIRSPEED COMPRESSIBILITY CORRECTION CHART
(APPLICABLE AFTER POSITION ERROR CORRECTION)

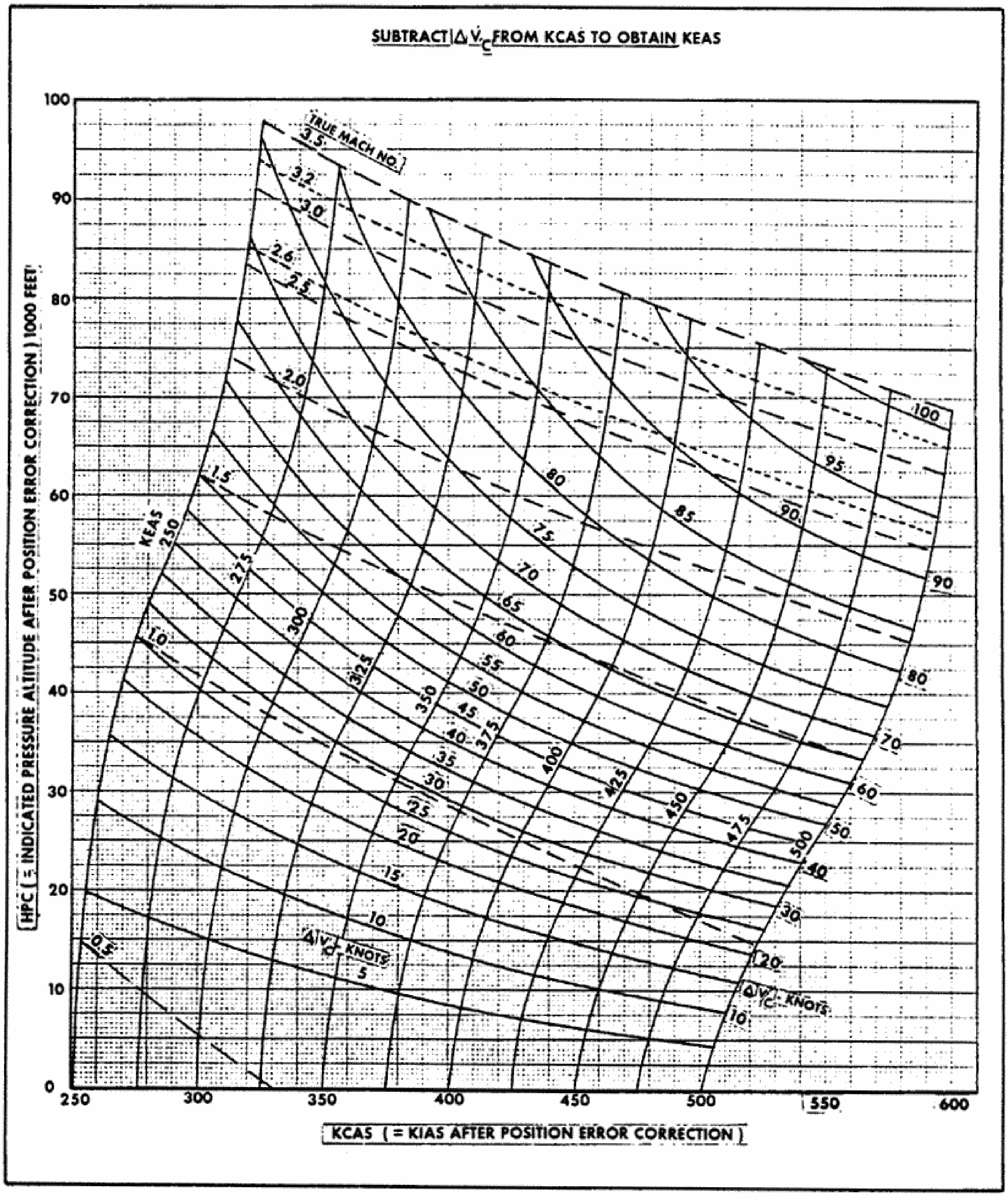


Figure A1-3
[redacted]

APPROXIMATE DIFFERENCES BETWEEN IAS AND EAS INDICATIONS

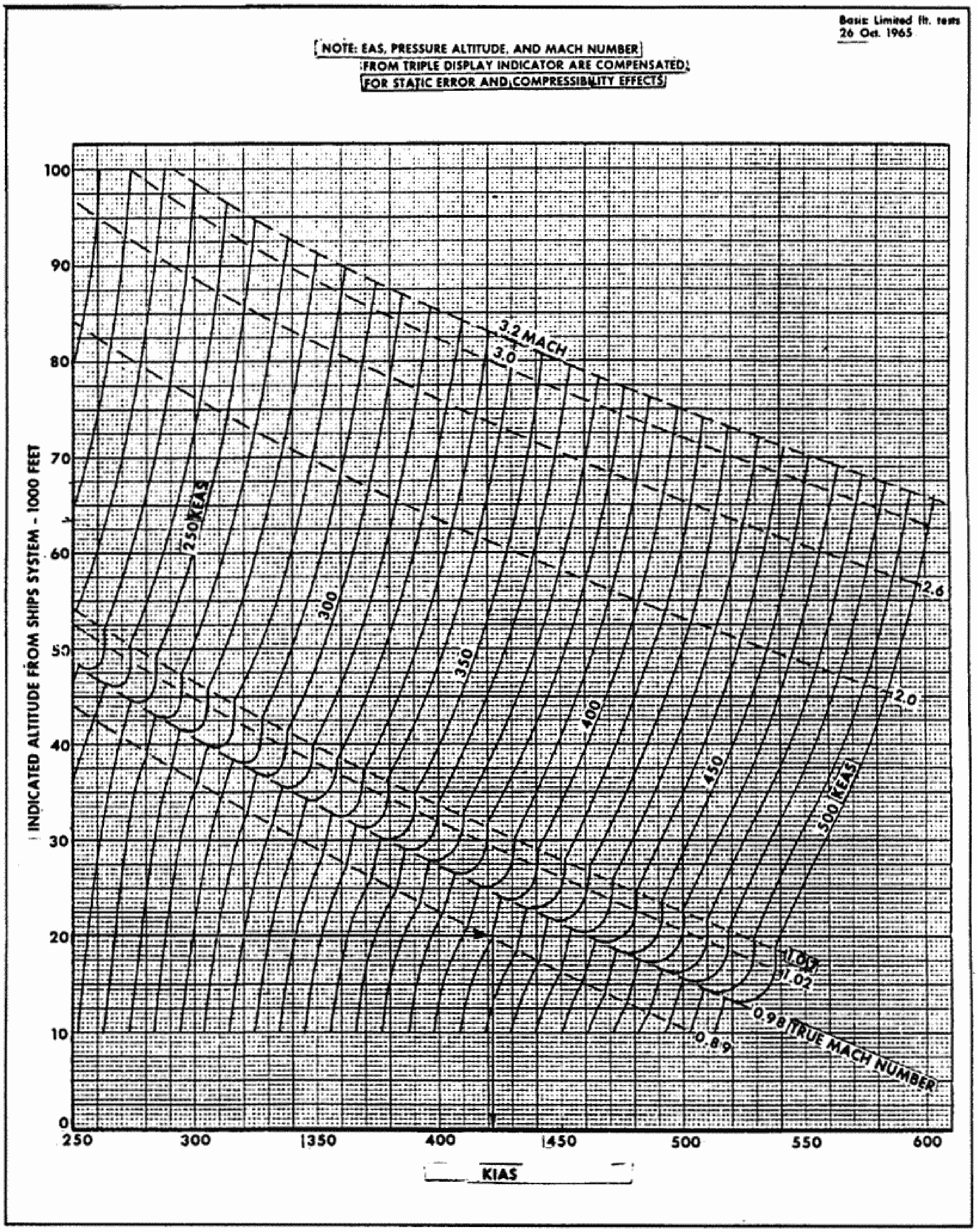


Figure A1-4

TRUE MACH NUMBER VS EQUIVALENT AIRSPEED

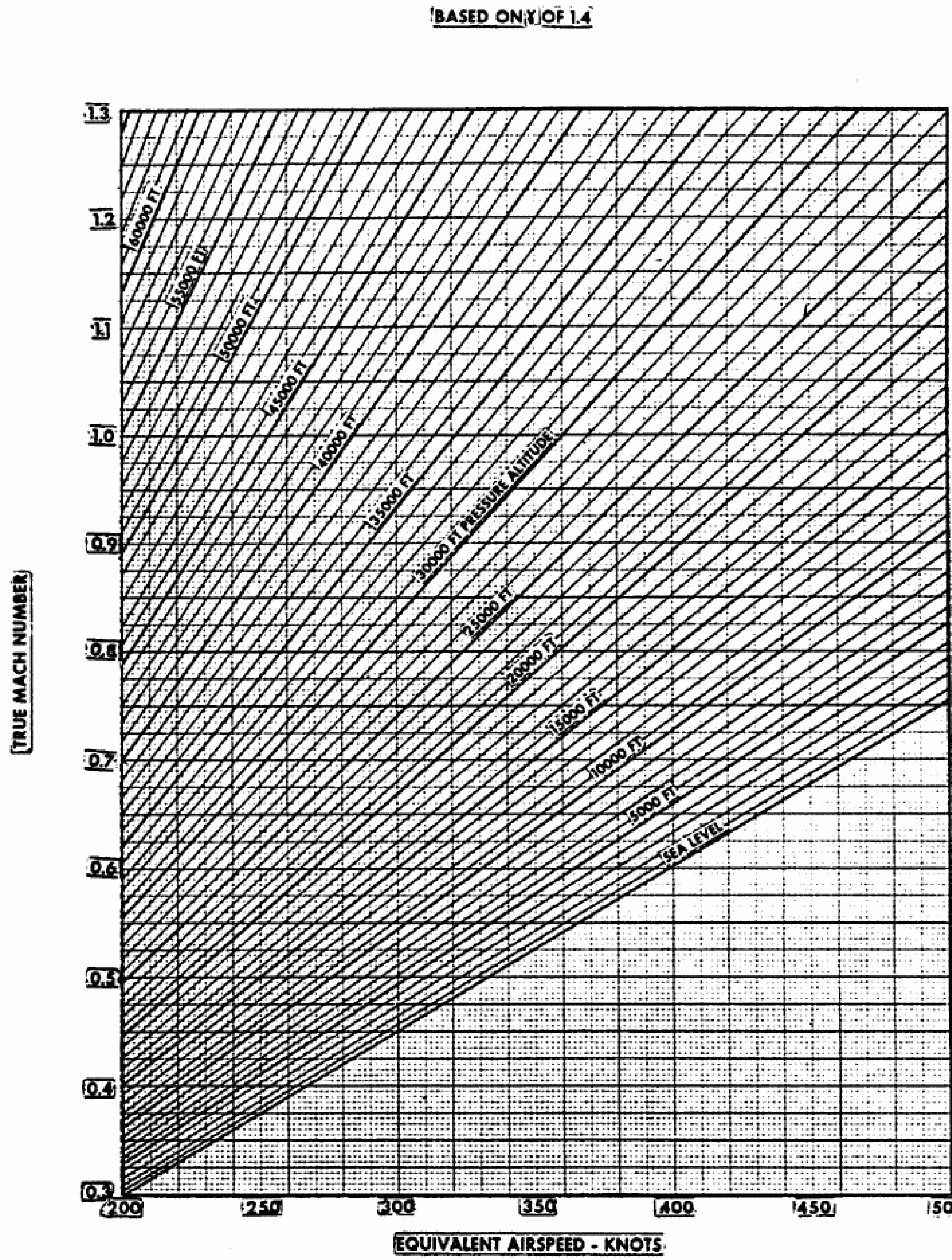


Figure A1-5 (Sheet 1 of 3)

[redacted]

TRUE MACH NUMBER VS EQUIVALENT AIRSPEED

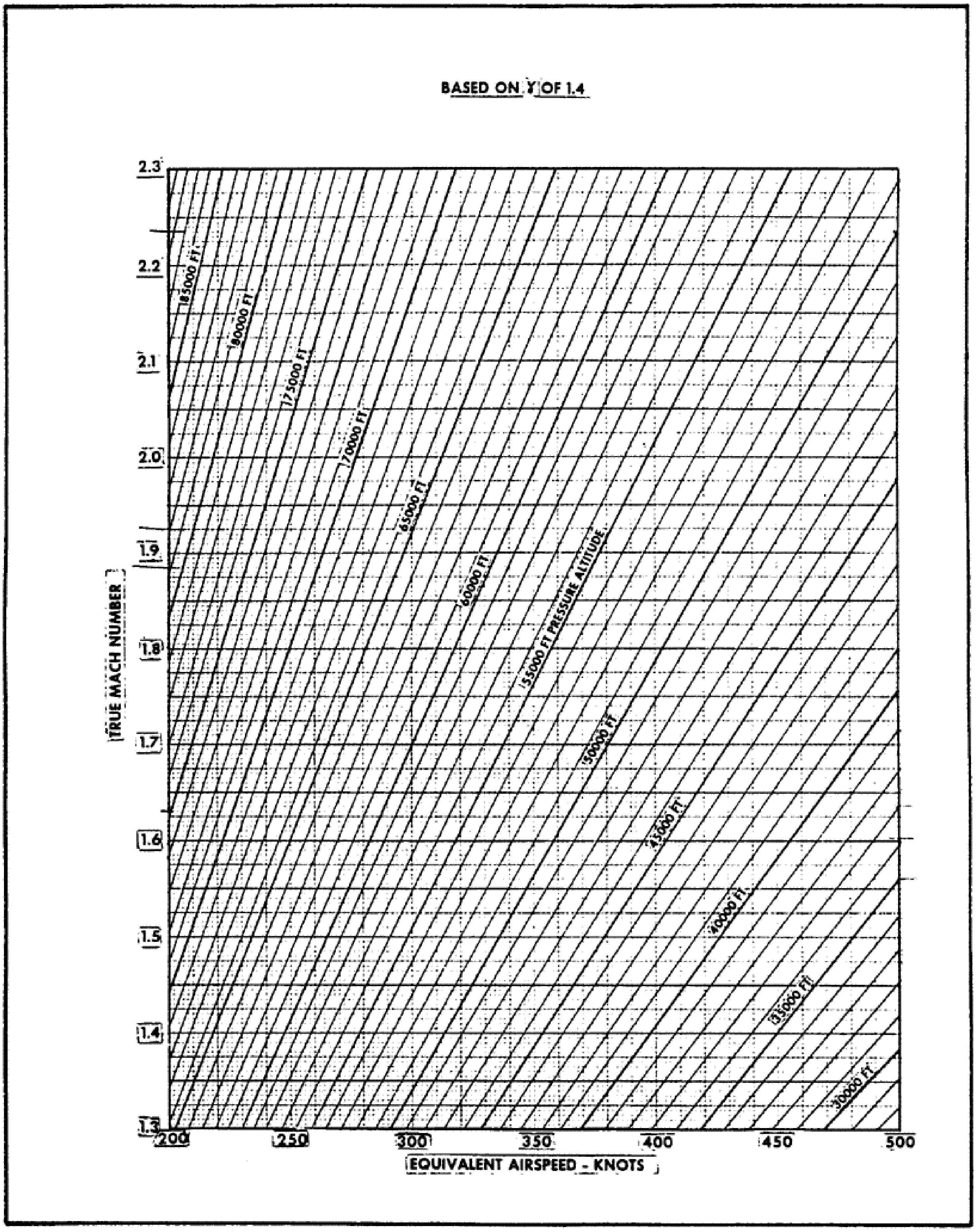


Figure A1-5 (Sheet 2 of 3)

TRUE MACH NUMBER VS EQUIVALENT AIRSPEED

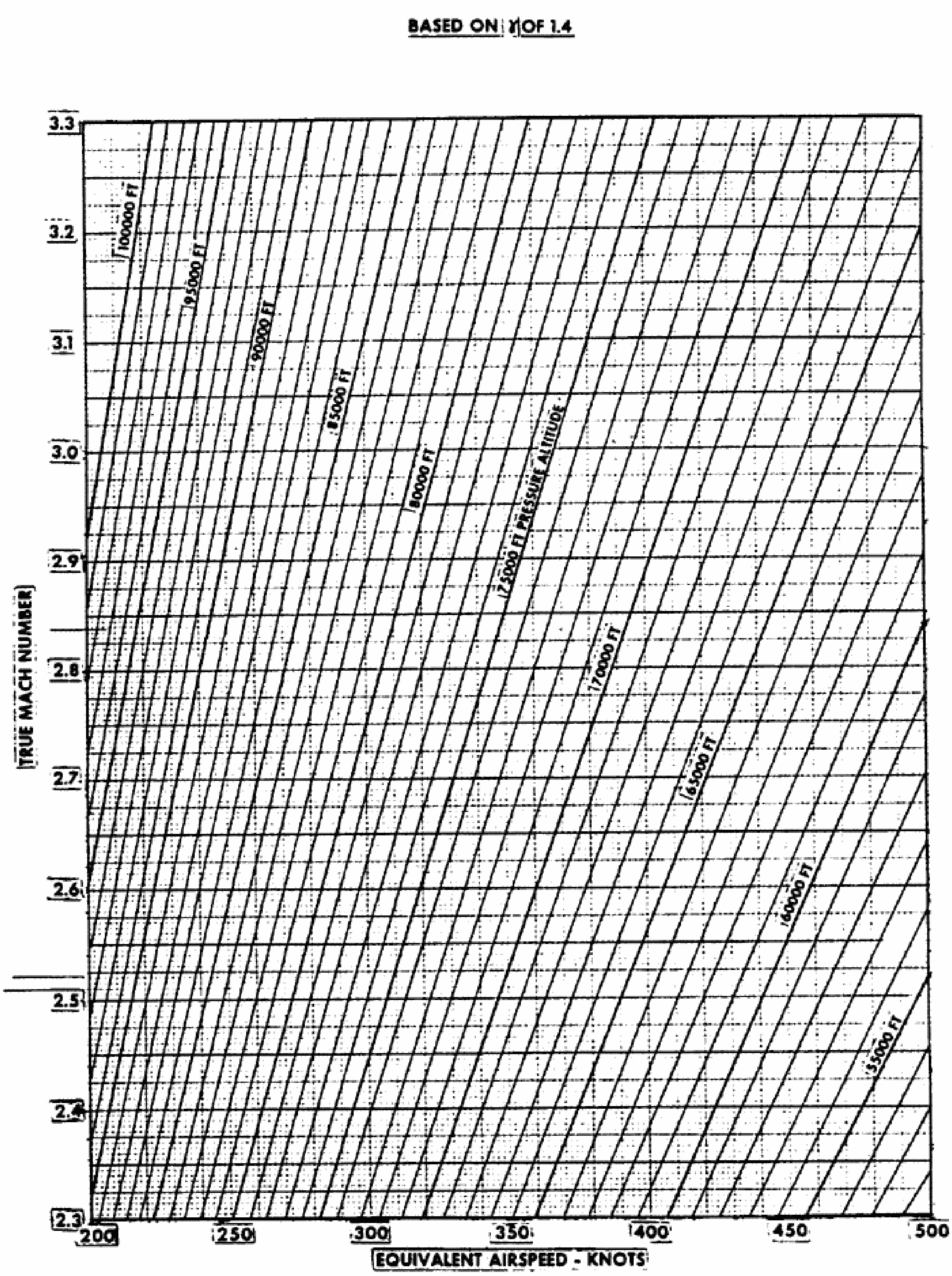


Figure A1-5 (Sheet 3 of 3)

TDI MACH-KEAS-ALTITUDE RELATIONSHIP ABOVE FL 650

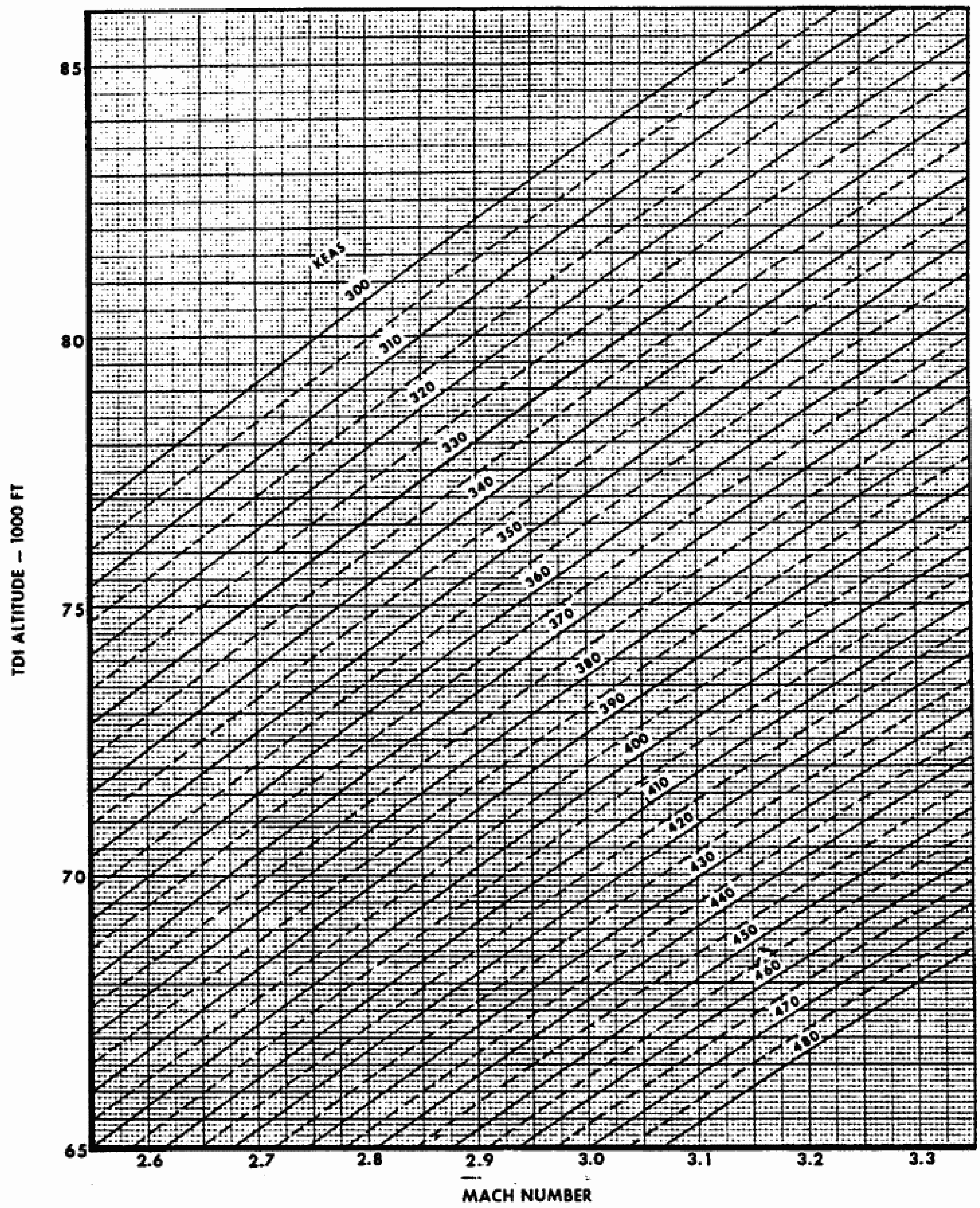


Figure A1-6

MACH-AIRSPEED-TEMPERATURE CONVERSION

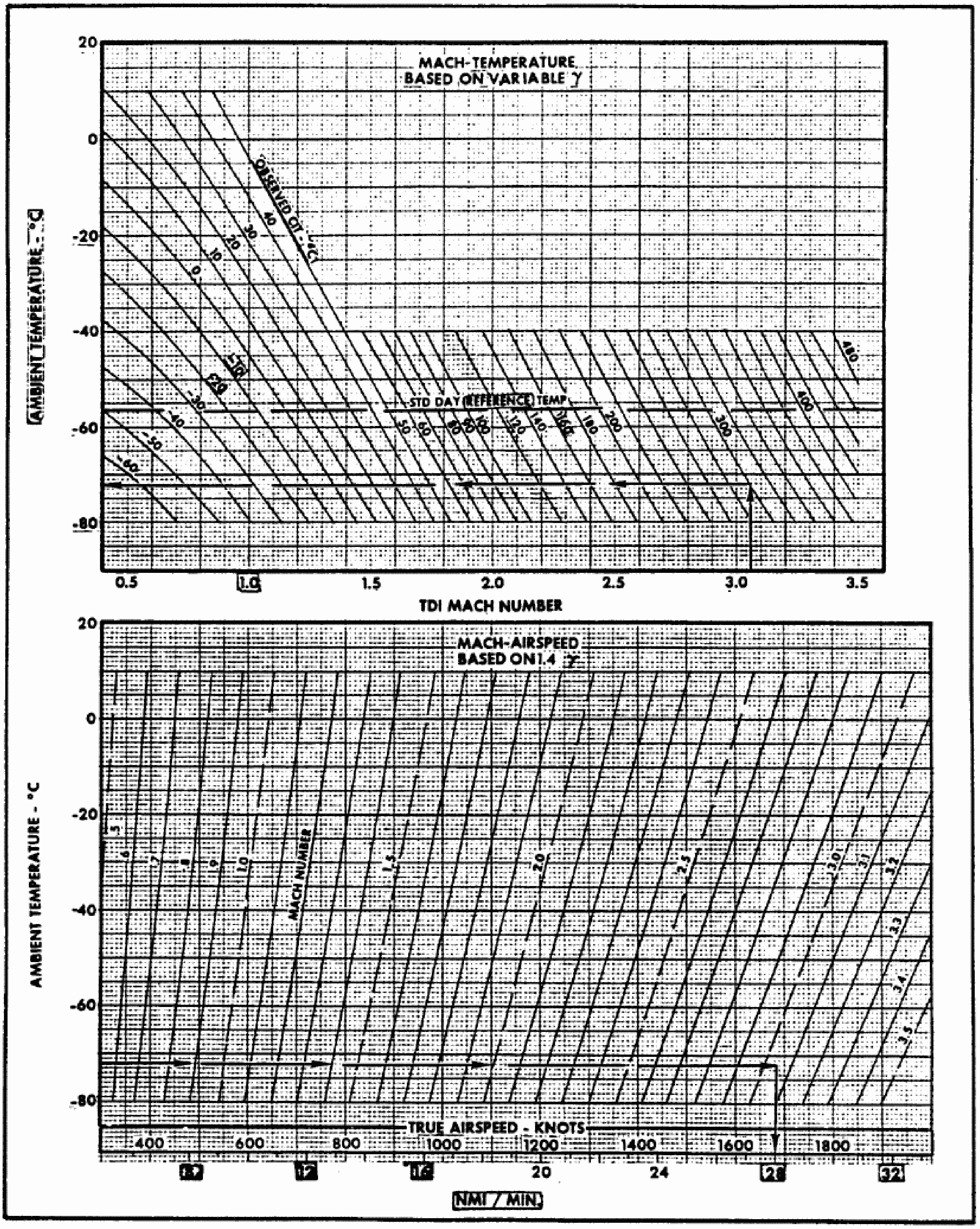


Figure A1-7
[redacted]

MACH-AIRSPEED-TEMPERATURE CONVERSIONS ABOVE MACH 2.6

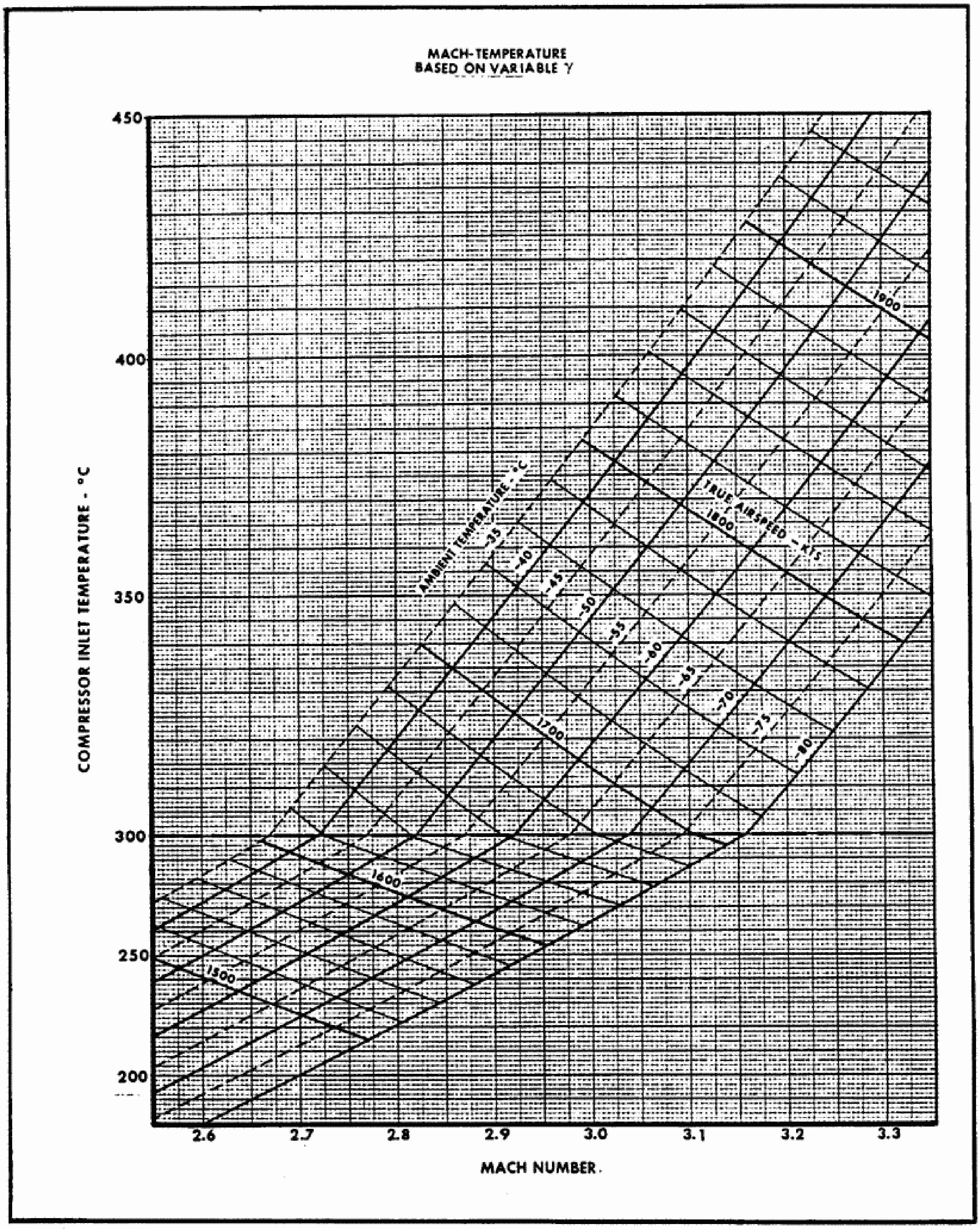


Figure A1-8

STANDARD ATMOSPHERE TABLE

ARDC MODEL ATMOSPHERE – 1956

Alt ft	Temp. t °F	Temp. t °C	Press. P in. Hg	Press. P lb/ft²	$\frac{\rho}{\rho_o} = \sigma$	$\sqrt{\frac{\rho}{\rho_o}}$	$\frac{P}{P_o} = \delta$	$\frac{T}{T_o} = \theta$	$\sqrt{\frac{T}{T_o}}$	$\frac{P}{P_o}\sqrt{\frac{T}{T_o}}$	c ft/sec	Alt ft
0	59.0	15.0	29.92	2116	1.000	1.000	1.000	1.000	1.000	1.000	1117	0
1000	55.4	13.0	28.86	2041	.9711	.9854	.9644	.9931	.9965	.9610	1113	1000
2000	51.9	11.0	27.82	1968	.9428	.9710	.9298	.9862	.9931	.9234	1109	2000
3000	48.3	9.1	26.82	1897	.9151	.9566	.8962	.9794	.9896	.8869	1105	3000
4000	44.7	7.1	25.84	1828	.8881	.9424	.8637	.9725	.9862	.8518	1101	4000
5000	41.2	5.1	24.90	1761	.8617	.9283	.8320	.9656	.9826	.8175	1098	5000
6000	37.6	3.1	23.98	1696	.8359	.9143	.8014	.9587	.9791	.7847	1094	6000
7000	34.0	+1.1	23.09	1633	.8106	.9003	.7716	.9519	.9757	.7529	1090	7000
8000	30.5	–0.8	22.22	1572	.7860	.8866	.7428	.9450	.9721	.7221	1086	8000
9000	26.9	–2.8	21.39	1513	.7620	.8729	.7148	.9381	.9686	.6924	1082	9000
10000	23.3	–4.8	20.58	1455	.7385	.8594	.6877	.9312	.9650	.6636	1078	10000
11000	19.8	–6.8	19.79	1400	.7156	.8459	.6614	.9244	.9615	.6360	1074	11000
12000	16.2	–8.8	19.03	1346	.6932	.8326	.6360	.9175	.9579	.6092	1070	12000
13000	12.6	–10.8	18.29	1294	.6713	.8193	.6113	.9106	.9543	.5834	1066	13000
14000	9.1	–12.7	17.58	1243	.6500	.8062	.5875	.9037	.9506	.5585	1062	14000
15000	5.5	–14.7	16.89	1194	.6292	.7932	.5643	.8969	.9470	.5344	1058	15000
16000	+1.9	–16.7	16.22	1147	.6090	.7804	.5420	.8900	.9434	.5113	1054	16000
17000	–1.6	–18.7	15.57	1101	.5892	.7676	.5203	.8831	.9397	.4889	1050	17000
18000	–5.2	–20.7	14.94	1057	.5699	.7549	.4994	.8762	.9361	.4675	1045	18000
19000	–8.8	–22.6	14.34	1014	.5511	.7424	.4791	.8694	.9324	.4467	1041	19000
20000	–12.3	–24.6	13.75	972.5	.5328	.7299	.4595	.8625	.9287	.4267	1037	20000
21000	–15.9	–26.6	13.18	932.4	.5150	.7176	.4406	.8556	.9250	.4076	1033	21000
22000	–19.5	–28.6	12.64	893.7	.4976	.7054	.4223	.8487	.9212	.3890	1029	22000
23000	–23.0	–30.6	12.11	856.3	.4806	.6933	.4046	.8419	.9176	.3713	1025	23000
24000	–26.6	–32.5	11.60	820.2	.4642	.6813	.3876	.8350	.9138	.3542	1021	24000
25000	–30.2	–34.5	11.10	785.3	.4481	.6694	.3711	.8281	.9100	.3377	1016	25000
26000	–33.7	–36.5	10.63	751.6	.4325	.6576	.3552	.8212	.9062	.3219	1012	26000
27000	–37.3	–38.5	10.17	719.1	.4173	.6460	.3398	.8144	.9024	.3066	1008	27000
28000	–40.9	–40.5	9.725	687.8	.4025	.6344	.3250	.8075	.8986	.2920	1004	28000
29000	–44.4	–42.5	9.297	657.6	.3881	.6230	.3107	.8006	.8948	.2780	999.4	29000
30000	–48.0	–44.4	8.885	628.4	.3741	.6116	.2970	.7937	.8909	.2646	995.1	30000
31000	–51.6	–46.4	8.488	600.3	.3605	.6004	.2837	.7869	.8871	.2517	990.7	31000
32000	–55.1	–48.4	8.106	573.3	.3473	.5893	.2709	.7800	.8832	.2393	986.4	32000
33000	–58.7	–50.4	7.737	547.2	.3345	.5784	.2586	.7731	.8793	.2274	982.0	33000
34000	–62.2	–52.4	7.382	522.1	.3220	.5675	.2467	.7662	.8753	.2159	977.7	34000
35000	–65.8	–54.3	7.041	498.0	.3099	.5568	.2353	.7594	.8714	.2050	973.3	35000
36089	–69.7	–56.5	6.683	472.7	.2971	.5450	.2234	.7519	.8671	.1937	968.5	36089
37000	–69.7	–56.5	6.397	452.4	.2844	.5333	.2138	.7519	.8671	.1854	968.5	37000
38000	–69.7	–56.5	6.097	431.2	.2710	.5206	.2038	.7519	.8671	.1767	968.5	38000
39000	–69.7	–56.5	5.811	411.0	.2583	.5082	.1942	.7519	.8671	.1684	968.5	39000
40000	–69.7	–56.5	5.538	391.7	.2462	.4962	.1851	.7519	.8671	.1605	968.5	40000
41000	–69.7	–56.5	5.278	373.3	.2346	.4844	.1764	.7519	.8671	.1530	968.5	41000
42000	–69.7	–56.5	5.030	355.8	.2236	.4729	.1681	.7519	.8671	.1458	968.5	42000
43000	–69.7	–56.5	4.794	339.1	.2131	.4616	.1602	.7519	.8671	.1389	968.5	43000
44000	–69.7	–56.5	4.569	323.2	.2031	.4507	.1527	.7519	.8671	.1324	968.5	44000
45000	–69.7	–56.5	4.355	308.0	.1936	.4400	.1455	.7519	.8671	.1262	968.5	45000
46000	–69.7	–56.5	4.151	293.6	.1845	.4295	.1387	.7519	.8671	.1203	968.5	46000
47000	–69.7	–56.5	3.956	279.8	.1758	.4193	.1322	.7519	.8671	.1146	968.5	47000
48000	–69.7	–56.5	3.770	266.7	.1676	.4094	.1260	.7519	.8671	.1093	968.5	48000
49000	–69.7	–56.5	3.593	254.1	.1597	.3996	.1201	.7519	.8671	.1041	968.5	49000
50000	–69.7	–56.5	3.425	242.2	.1522	.3901	.1145	.7519	.8671	.09928	968.5	50000
51000	–69.7	–56.5	3.264	230.8	.1451	.3809	.1091	.7519	.8671	.09460	968.5	51000
52000	–69.7	–56.5	3.111	220.0	.1383	.3719	.1040	.7519	.8671	.09018	968.5	52000
53000	–69.7	–56.5	2.965	209.7	.1318	.3630	.09909	.7519	.8671	.08592	968.5	53000
54000	–69.7	–56.5	2.826	199.8	.1256	.3544	.09444	.7519	.8671	.08189	968.5	54000
55000	–69.7	–56.5	2.693	190.5	.1197	.3460	.09001	.7519	.8671	.07805	968.5	55000
56000	–69.7	–56.5	2.567	181.5	.1141	.3378	.08578	.7519	.8671	.07438	968.5	56000
57000	–69.7	–56.5	2.446	173.0	.1087	.3297	.08176	.7519	.8671	.07089	968.5	57000
58000	–69.7	–56.5	2.331	164.9	.1036	.3219	.07792	.7519	.8671	.06756	968.5	58000
59000	–69.7	–56.5	2.222	157.2	.09877	.3143	.07426	.7519	.8671	.06439	968.5	59000
60000	–69.7	–56.5	2.118	149.8	.09414	.3068	.07078	.7519	.8671	.06137	968.5	60000
61000	–69.7	–56.5	2.018	142.8	.08972	.2995	.06746	.7519	.8671	.05849	968.5	61000
62000	–69.7	–56.5	1.924	136.1	.08551	.2924	.06429	.7519	.8671	.05575	968.5	62000
63000	–69.7	–56.5	1.833	129.7	.08150	.2855	.06127	.7519	.8671	.05313	968.5	63000
64000	–69.7	–56.5	1.747	123.6	.07767	.2787	.05840	.7519	.8671	.05064	968.5	64000
65000	–69.7	–56.5	1.665	117.8	.07403	.2721	.05566	.7519	.8671	.04826	968.5	65000
66000	–69.7	–56.5	1.587	112.3	.07055	.2656	.05306	.7519	.8671	.04600	968.5	66000
67000	–69.7	–56.5	1.513	107.0	.06724	.2593	.05056	.7519	.8671	.04384	968.5	67000
68000	–69.7	–56.5	1.442	102.0	.06409	.2532	.04819	.7519	.8671	.04179	968.5	68000
69000	–69.7	–56.5	1.374	97.19	.06108	.2471	.04592	.7519	.8671	.03982	968.5	69000
70000	–69.7	–56.5	1.310	92.63	.05821	.2413	.04377	.7519	.8671	.03795	968.5	70000

Figure A1-9 (Sheet 1 of 2)

STANDARD ATMOSPHERE TABLE

ARDC MODEL ATMOSPHERE – 1956

Alt ft	Temp. t °F	Temp. t °C	Press. P in. Hg	Press. P lb/ft²	$\frac{\rho}{\rho_0} = \sigma$	$\sqrt{\frac{\rho}{\rho_0}}$	$\frac{P}{P_0} = \delta$	$\frac{T}{T_0} = \theta$	$\sqrt{\frac{T}{T_0}}$	$\frac{P}{P_0}\sqrt{\frac{T}{T_0}}$	c ft/sec	Alt ft
71000	−69.7	−56.5	1.248	88.28	.05548	.2355	.04172	.7519	.8671	.03618	968.5	71000
72000	−69.7	−56.5	1.190	84.14	.05288	.2300	.03976	.7519	.8671	.03448	968.5	72000
73000	−69.7	−56.5	1.134	80.19	.05040	.2245	.03789	.7519	.8671	.03285	968.5	73000
74000	−69.7	−56.5	1.081	76.43	.04803	.2192	.03611	.7519	.8671	.03131	968.5	74000
75000	−69.7	−56.5	1.030	72.84	.04578	.2140	.03442	.7519	.8671	.02985	968.5	75000
76000	−69.7	−56.5	.9815	69.42	.04363	.2089	.03280	.7519	.8671	.02844	968.5	76000
77000	−69.7	−56.5	.9355	66.16	.04158	.2039	.03127	.7519	.8671	.02711	968.5	77000
78000	−69.7	−56.5	.8916	63.06	.03963	.1991	.02980	.7519	.8671	.02584	968.5	78000
79000	−69.7	−56.5	.8497	60.10	.03777	.1943	.02840	.7519	.8671	.02463	968.5	79000
80000	−69.7	−56.5	.8099	57.28	.03600	.1897	.02707	.7519	.8671	.02347	968.5	80000
81000	−69.7	−56.5	.7718	54.59	.03431	.1852	.02580	.7519	.8671	.02237	968.5	81000
82021	−69.7	−56.5	.7349	51.98	.03267	.1807	.02456	.7519	.8671	.02130	968.5	82021
83000	−68.1	−55.6	.7012	49.59	.03104	.1762	.02343	.7550	.8689	.02036	970.5	83000
84000	−66.4	−54.7	.6685	47.28	.02947	.1717	.02234	.7582	.8607	.01923	972.5	84000
85000	−64.8	−53.8	.6374	45.08	.02798	.1673	.02130	.7613	.8725	.01858	974.5	85000
86000	−63.2	−52.9	.6079	43.00	.02658	.1630	.02032	.7645	.8744	.01777	976.6	86000
87000	−61.5	−51.9	.5799	41.02	.02525	.1589	.01938	.7677	.8762	.01698	978.6	87000
88000	−59.9	−51.1	.5533	39.13	.02399	.1549	.01849	.7708	.8780	.01623	980.6	88000
89000	−58.2	−50.1	.5280	37.45	.02280	.1510	.01765	.7740	.8798	.01553	982.6	89000
90000	−56.6	−49.2	.5040	35.65	.02167	.1472	.01684	.7772	.8816	.01485	984.6	90000
91000	−54.9	−48.3	.4811	34.03	.02061	.1436	.01608	.7804	.8834	.01421	986.6	91000
92000	−53.3	−47.4	.4594	32.49	.01960	.1400	.01535	.7835	.8852	.01359	988.6	92000
93000	−51.6	−46.4	.4387	31.03	.01864	.1365	.01466	.7867	.8870	.01300	990.6	93000
94000	−50.0	−45.6	.4191	29.64	.01773	.1332	.01401	.7899	.8888	.01245	992.6	94000
95000	−48.3	−44.6	.4004	28.32	.01687	.1299	.01338	.7931	.8906	.01192	994.6	95000
96000	−46.7	−43.7	.3826	27.06	.01606	.1267	.01279	.7962	.8923	.01141	996.6	96000
97000	−45.1	−42.8	.3656	25.86	.01529	.1236	.01222	.7994	.8941	.01093	998.6	97000
98000	−43.4	−41.9	.3495	24.72	.01455	.1206	.01168	.8026	.8959	.01046	1001	98000
99000	−41.8	−41.0	.3341	23.63	.01386	.1177	.01117	.8058	.8977	.01003	1003	99000
100000	−40.1	−40.1	.3195	22.60	.01320	.1149	.01068	.8089	.8994	.009606	1005	100000
110000	−23.7	−30.9	.2062	14.58	.008196	.09053	.006890	.8407	.9170	.006318	1024	110000
120000	−7.19	−21.8	.1352	9.561	.005179	.07197	.004518	.8724	.9340	.004220	1043	120000
130000	+9.27	−12.6	.09000	6.365	.003327	.05768	.003008	.9041	.9508	.002860	1062	130000
140000	25.7	−3.50	.06076	4.297	.002170	.04658	.002031	.9359	.9674	.001965	1081	140000
150000	42.2	+5.67	.04156	2.940	.001436	.03789	.001389	.9676	.9837	.001366	1099	150000
200000	−6.78	−21.5	.00621	0.440	.000238	.01542	.000208	.8732	.9345	.000194	1044	200000

ATMOSPHERIC STANDARDS

	English	Metric
Gravity	32.17405 ft/sec²	9.80665 m/sec²
Absolute zero	−459.688°F	−273.16°C
Standard Values at Sea Level		
Pressure	29.92 in. Hg	760 mm Hg
Pressure	2116 lb/ft²	10332 kg/m²
Temp	59°F	15°C
Abs temp	518.688°R	288.16°K
Specific wt $g\rho_0$	0.076475 lb/ft³	1.2250 kg/m³
Density	0.0023769 lb sec²/ft⁴	0.12492 kg sec²/m⁴
Standard Values at Altitude		
Isothermal alt H	36,089.2 ft	11,000 m
Isothermal temp	−69.7°F	−56.5°C

GENERAL PROPERTIES OF GASES

$Pv = RT$ or $P = \rho gRT$ or $PV = mRT$

Constant Volume $P_1/P_2 = T_1/T_2$

Constant Pressure $V_1/V_2 = T_1/T_2$

Constant Temperature $P_1/P_2 = V_2/V_1$

Reversible Adiabatic $\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{\gamma}$

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}}$$

Polytropic $P_1V_1^n = P_2V_2^n$

$$\frac{T_1}{T_2} = \left(\frac{V_1}{V_2}\right)^{1-n} = \left(\frac{P_1}{P_2}\right)^{\frac{n-1}{n}}$$

Figure A1-9 (Sheet 2 of 2)

FREE AIR TEMPERATURE VARIATION WITH ALTITUDE

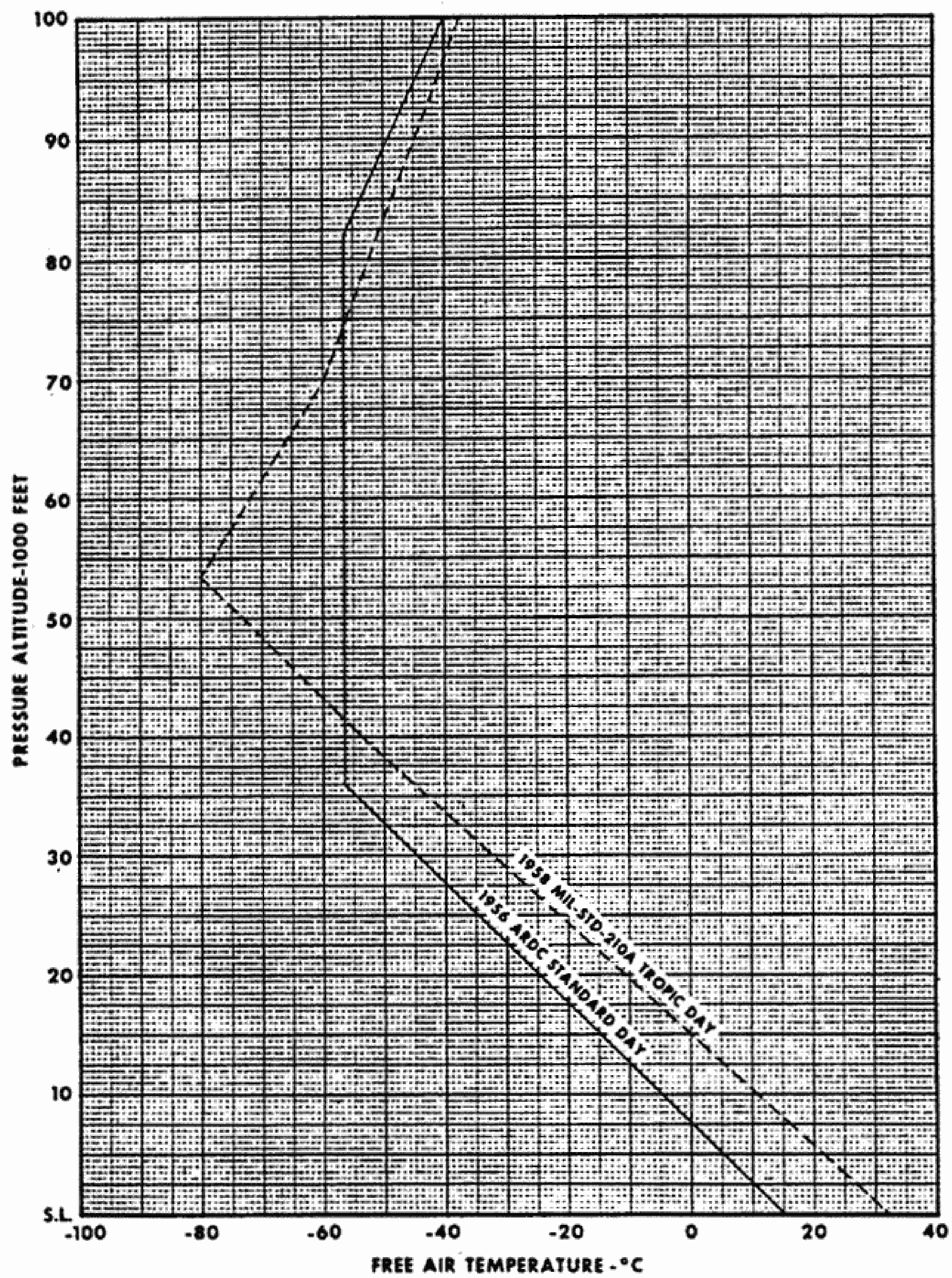
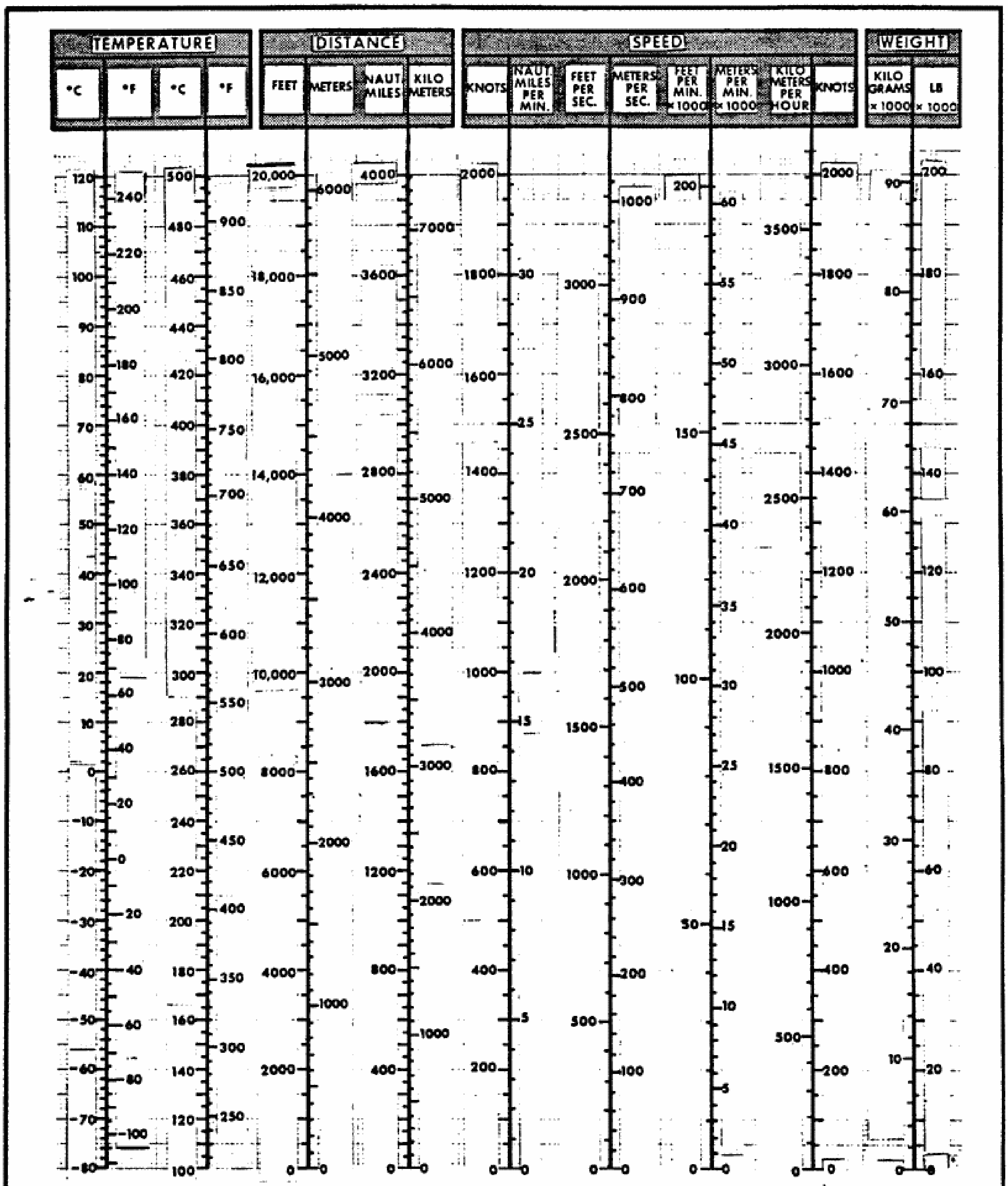


Figure A1-10

STANDARD UNITS CONVERSION CHART



NOTE: U. S. GALLON = LITER × 0.264
IMP. GALLON = LITER × 0.220
IN. MERCURY = MILIBAR × 0.0295

Figure A1-11

[redacted]

W/δ AS A FUNCTION OF GROSS WEIGHT AND ALTITUDE

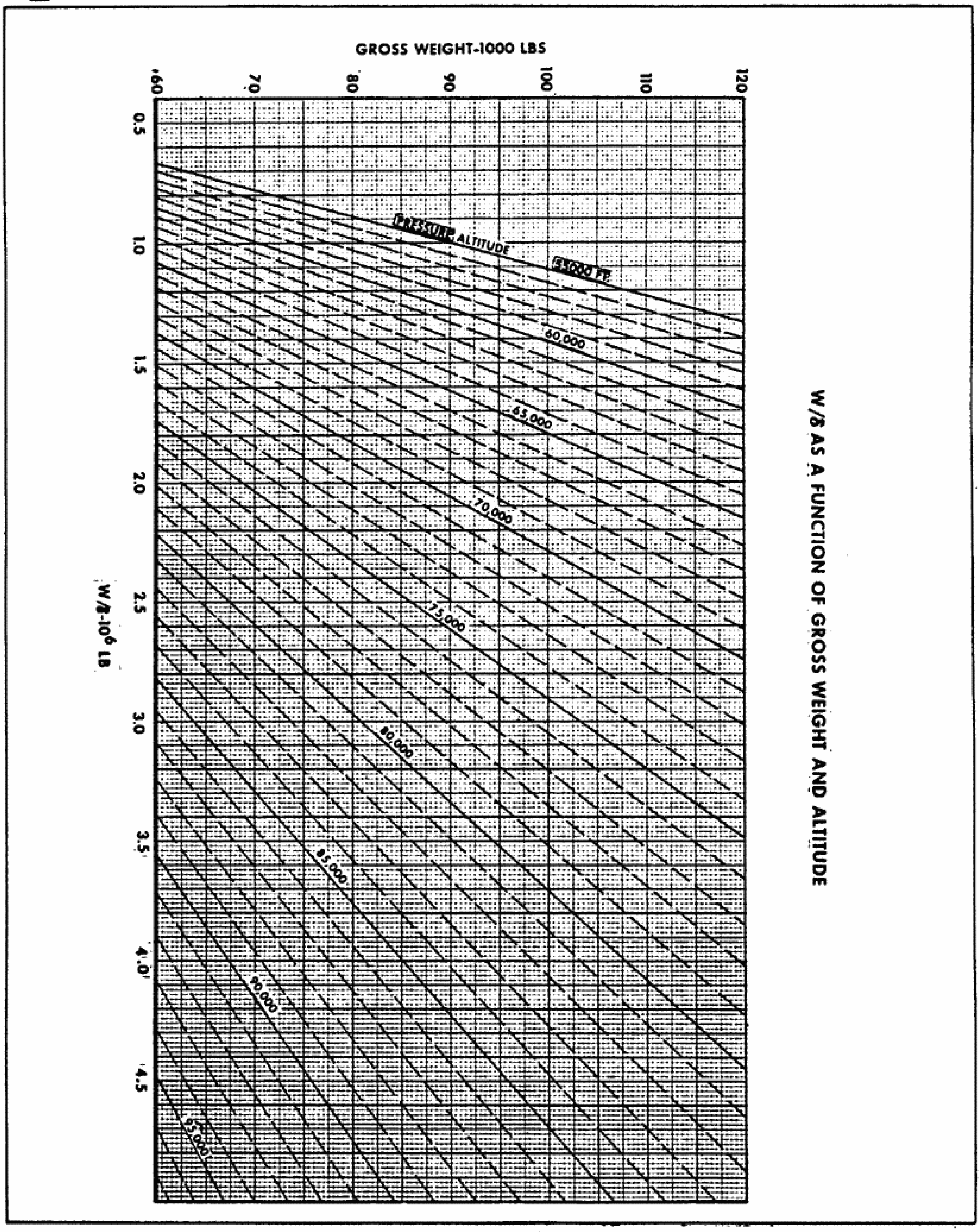


Figure A1-12

TYPICAL VARIATION OF FUEL DENSITY WITH TEMPERATURE

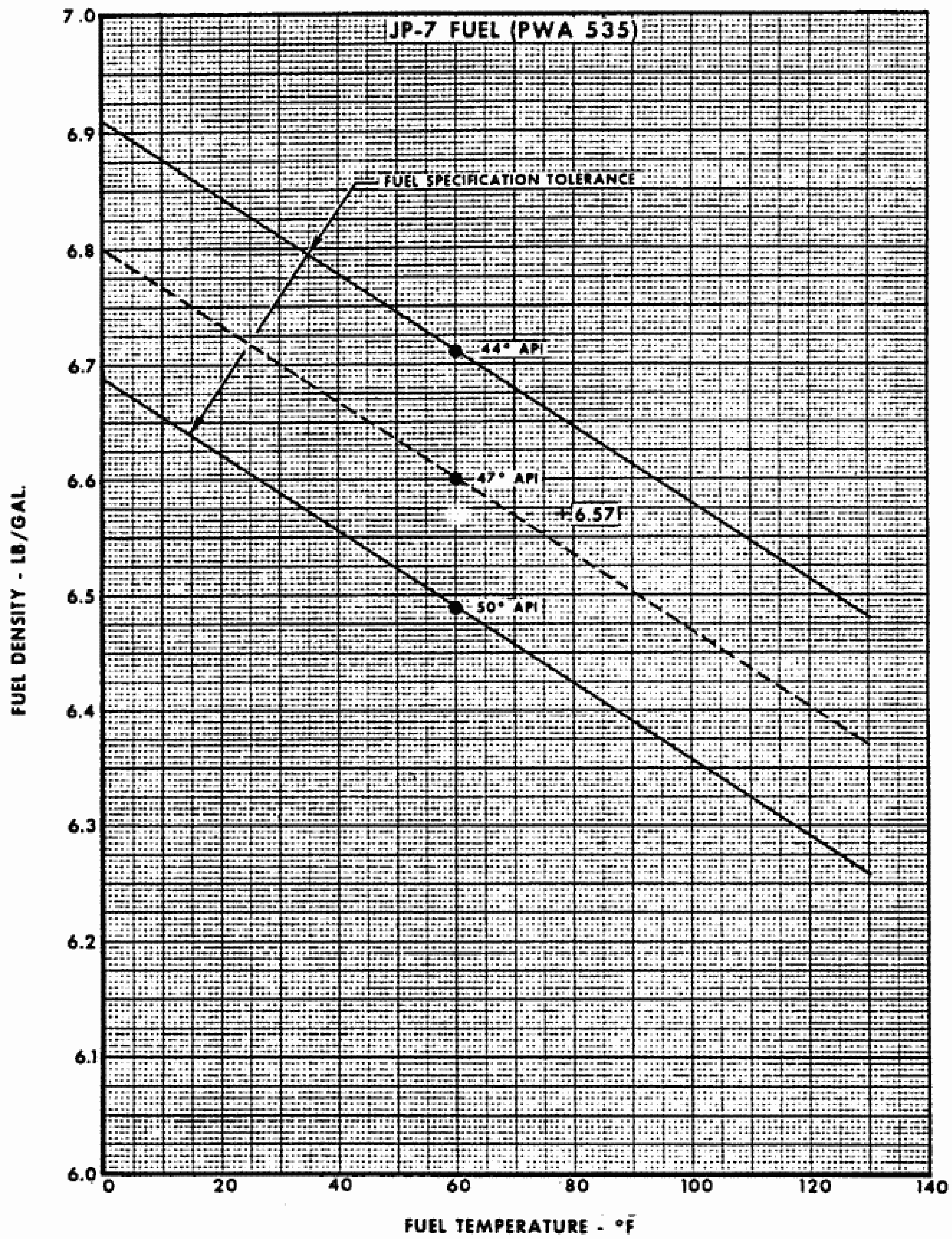


Figure A1-13

PART II

TAKEOFF AND LANDING PERFORMANCE

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FIELD LENGTH REQUIREMENTS

This part of the appendix contains data for determining takeoff and landing field length requirements. Charts are also included for computing takeoff acceleration check speed, refusal speed, single-engine climbout capability, and final approach and touchdown speeds. Temperature, altitude, gross weight, wind, and runway slope corrections are included. Braking performance on dry or wet, grooved or ungrooved runways is provided.

NOTE

> Refusal speed and landing distance information is conservative when the ambient temperature is hotter than 32°C (90°F) because it does not reflect Pratt and Whitney EC 173960 which decreased J-58 idle rpm to 3975 above 32°C.

Crosswind Component & Rated Tire Speed Chart

The upper part of Figure A2-1 is used to convert wind velocity and direction into runway and crosswind components. The lower portion of the chart is used to determine whether takeoff and landing speeds will exceed rated tire speed.

TAKEOFF PERFORMANCE

Charts are furnished for normal, alternate (maximum speed), and maximum performance (minimum distance) takeoff procedures. Takeoff climbout distances are included for normal performance takeoffs. The information supplied by the charts is supplied in the Pilot's and RSO's checklists.

Normal Performance Takeoff

Normal peformance takeoff distances are based on rotation at 180 KIAS and liftoff at 210 KIAS. Rotation at speeds slightly less than 180 KIAS have no appreciable effect on takeoff distance. However, at light weights the 210 KIAS takeoff speed may be exceeded if rotation is not begun before 180 KIAS.

NOTE

> Do not exceed this alternate takeoff speed schedule (tire speed limitation).

When the normal performance takeoff procedure requires excessive runway length, rotation and takeoff speeds may be reduced equally by one knot for each percent reduction in takeoff distance desired. Reduce takeoff distance 1% for each knot reduction in takeoff speed.

NOTE

> Do not reduce takeoff speed below the maximum performance takeoff speed schedule.

Figure A2-2 shows the ground run distance associated with the normal performance takeoff speed.

Takeoff Climbout Distance

Figure A2-3 shows the distance from liftoff to heights of 50 feet and 200 feet above the runway when using the normal performance takeoff procedure.

Example:

For a field pressure altitude of sea level, ambient temperature of 86°F (30°C), and a takeoff gross weight of 120,000 lb, determine the normal performance takeoff distance with a 10 knot headwind and 1% downhill runway slope. Refer to Figures A2-2 and A2-3. (Takeoff distance with predicted wind and slope is 4800 feet. The distances from liftoff to 50 feet and 200 feet above the runway are 3050 feet and 5500 feet, respectively. Total distance to 50 feet is 7850 feet, and to 200 feet is 10,300 feet.)

Alternate (Maximum Speed) Takeoff

The alternate (maximum speed) takeoff procedure provides a takeoff speed schedule which will not exceed rated tire speed under high altitude, high temperature conditions and/or with tailwinds. The normal rotation speed (180 KIAS) is not changed but liftoff speed corresponds to 234 knots groundspeed (rated tire speed minus 5 knots).

NOTE

> When using this procedure it is important to unload the main gear tires by starting rotation at the normal schedule.

Local altitude, temperature, and steady headwind component or gusting tailwind component should be considered when using this procedure.

Example:

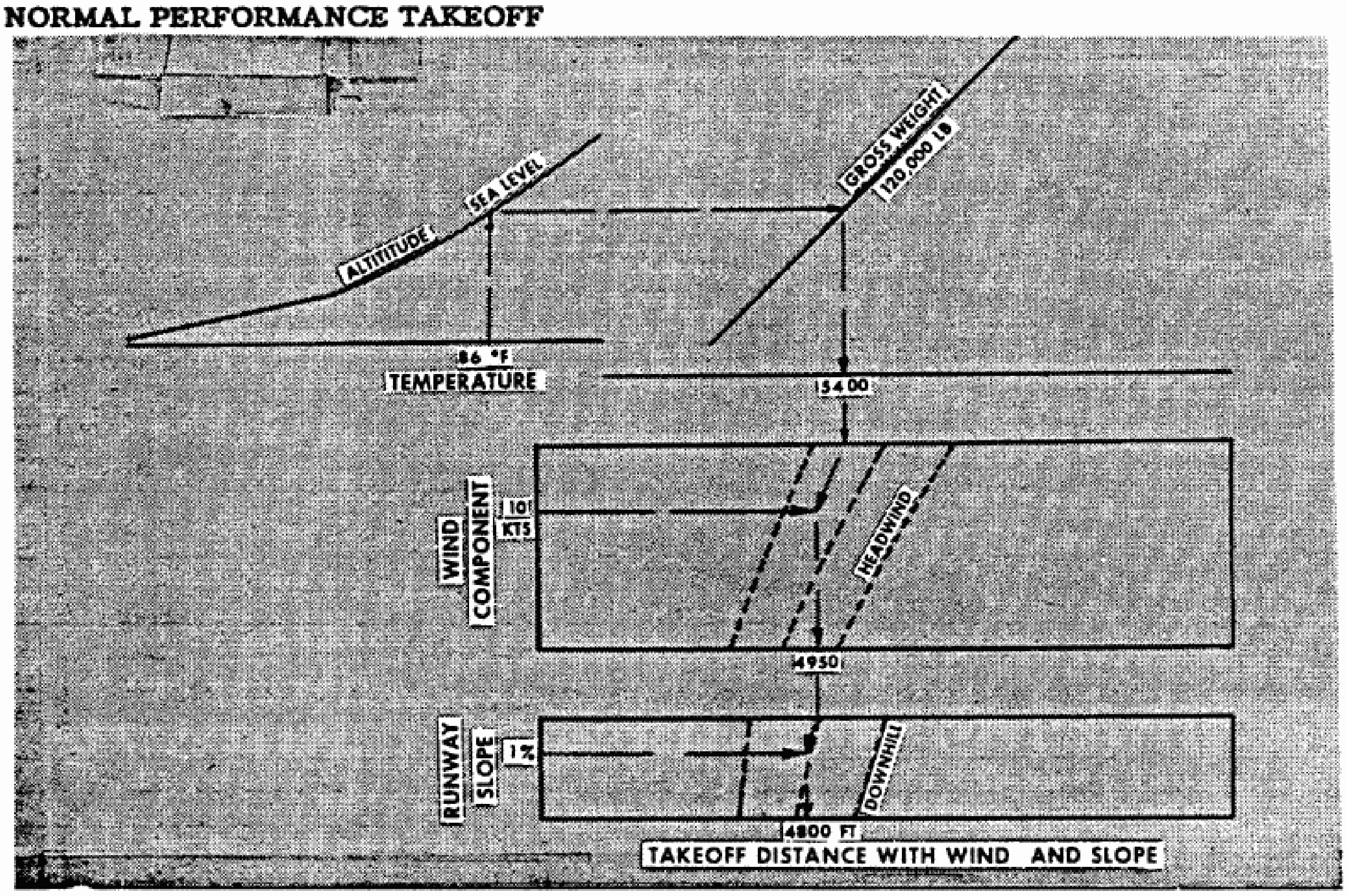
For the normal performance takeoff example, find the takeoff speed and distance for an alternate procedure takeoff. Refer to Figure A2-4. (Takeoff speed is 237 KIAS. Takeoff distance is 6250 feet.)

Maximum Performance (Minimum Distance) Takeoff

For the maximum performance (minimum distance) takeoff procedure, takeoff speed is scheduled according to gross weight and corresponds to a lift coefficient of 0.60. Since tail clearance at lift-off will be at a minimum, this procedure is recommended only when required by field length and/or tailwind conditions.

Figure A2-5 presents maximum performance takeoff distances. Takeoff speeds are listed with the corresponding gross weights. Rotation speeds are also shown, based on 4.5 seconds from rotation to lift-off.

NORMAL PERFORMANCE TAKEOFF



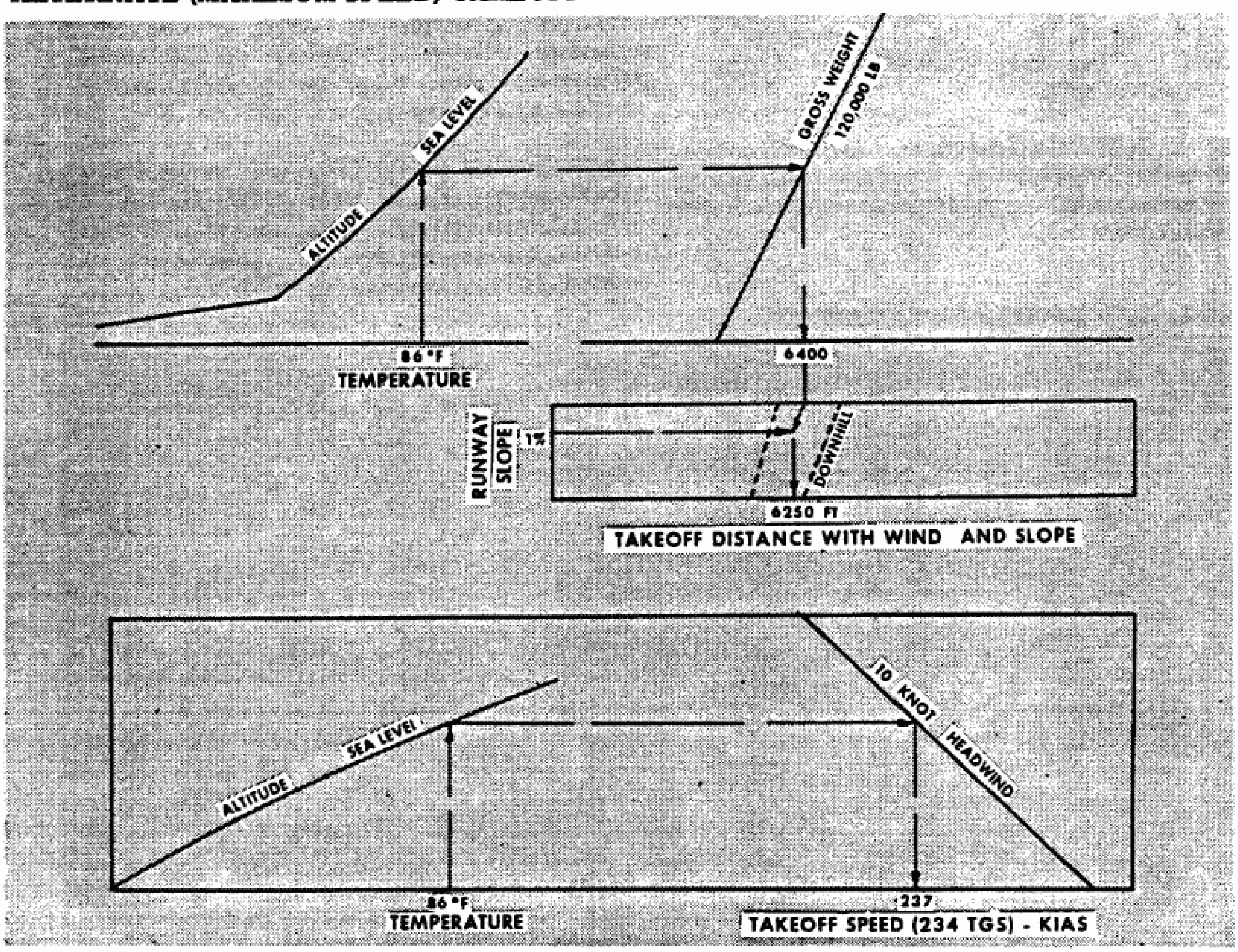
Example:

For a field pressure altitude of sea level, ambient temperature of 86°F (30°C), and a takeoff gross weight of 120,000 lb, determine the maximum performance takeoff distance, rotation speed, and takeoff speed with a 10 knot headwind and 1% downhill runway slope. Refer to Figure A2-5. (Rotation speed is 160 KIAS. Takeoff speed is 192 KIAS. Takeoff distance is 3950 feet.)

TAKEOFF FUEL ALLOWANCE

Fuel load at engine start should be adjusted to allow for fuel consumption prior to takeoff. Use 150 lb per minute for planning purposes. Fuel consumption during the takeoff run is approximately 1000 pounds. Refer to the subsonic climb performance charts, Figures A3-1 and A3-2 for fuel planning data.

ALTERNATE (MAXIMUM SPEED) TAKEOFF



ACCELERATION CHECK

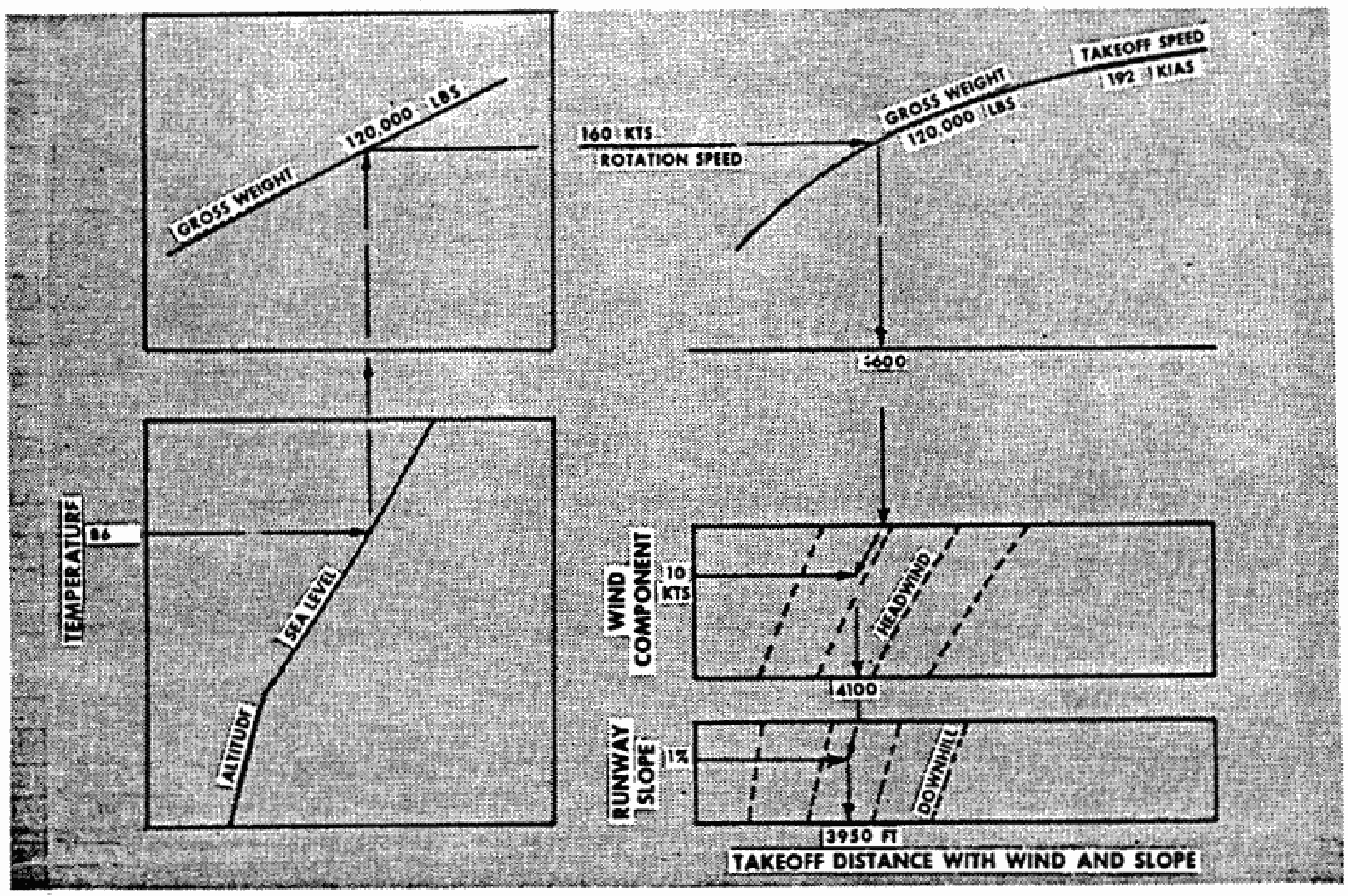
Figure A2-6 provides a means of checking takeoff acceleration performance during the first part of the takeoff ground run. Normally the check is indicated airspeed reached at the 3000 foot marker. However, any combination of speed and acceleration check distance can be used. The acceleration check should be accomplished below 165 KIAS and the acceleration check distance reduced, if necessary, to achieve this speed.

Takeoff speed and takeoff distance are used to establish a guide line on the acceleration check speed chart. The acceleration check speed corresponding to the desired check distance is read at the bottom of the chart. (A 5 knot negative tolerance has been included to provide an acceleration margin.)

Example:

For the normal performance takeoff example, i.e., sea level altitude, 86°F temperature, 120,000 lb gross weight, 10 knot headwind, and 1% downhill runway slope, find the acceleration check speed corresponding to 2800 feet during the takeoff run. (3000 foot marker less 200 feet lineup allowance.) Refer to Figure A2-6. (Acceleration check speed is 156 KIAS.)

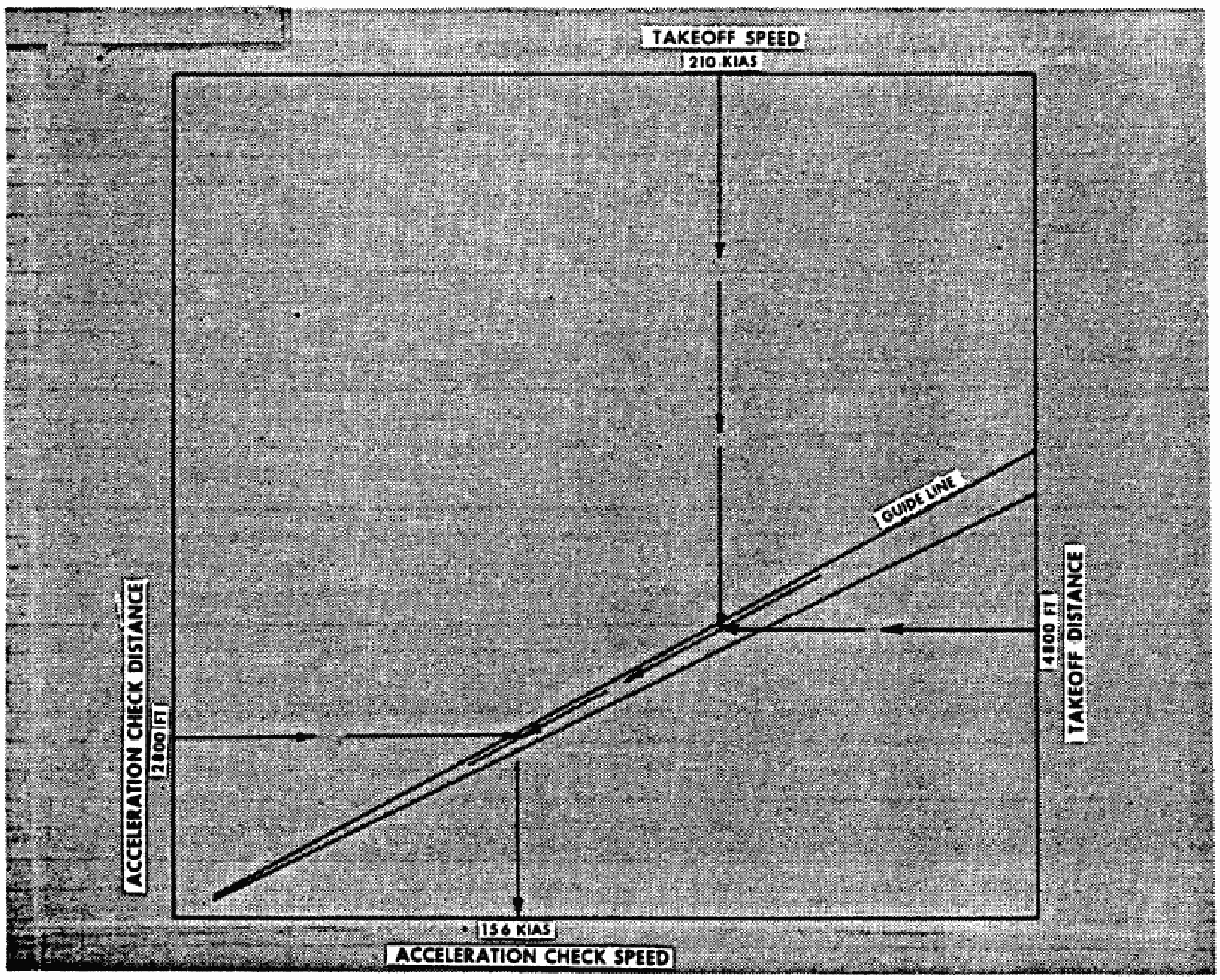
MAXIMUM PERFORMANCE (MINIMUM DISTANCE) TAKEOFF



REFUSAL SPEED

Refusal speed is the maximum speed from which the aircraft can be brought to a stop in a given accelerate-stop distance, usually the available runway length. Maximum refusal speed is the maximum speed from which the aircraft can be brought to a stop without exceeding the energy capacity of the brakes. Either the scheduled rotation speed or the refusal speed with drag chute can be listed on the TOL data card. Refusal speeds on dry and wet runways, with and without drag chute, may be obtained from Figures A2-7, A2-9, and A2-10. Maximum refusal speeds when brake energy is limited, for dry and wet runways, with and without drag chute, may be obtained from Figures A2-8 and A2-11. (On a wet runway, with WET selected and drag chute deployed, the brakes do not absorb enough energy to exceed the brake energy rating. Therefore no data is presented for this condition.) Refusal speeds are given as a function of RCR, ambient temperature, pressure altitude, and gross weight. Brake energy capacity is assumed to be 90% of full rated one-stop capability, thus allowing some normal use prior to a refused takeoff. It is also assumed that brake application is not delayed when airspeed is above the rated

ACCELERATION CHECK



brake energy speed (Figure 5-8, Section V). Therefore, the maximum refusal speed (brake energy limited) charts should always be used with the refusal speed charts to ensure that brake energy capacity is not exceeded.

NOTE

> Brake application should not be delayed when the abort speed is greater than the rated brake energy speed. The increased distance travelled at high speed will increase the risk of tire failure, which in turn will decrease the brake energy capacity available for stopping.

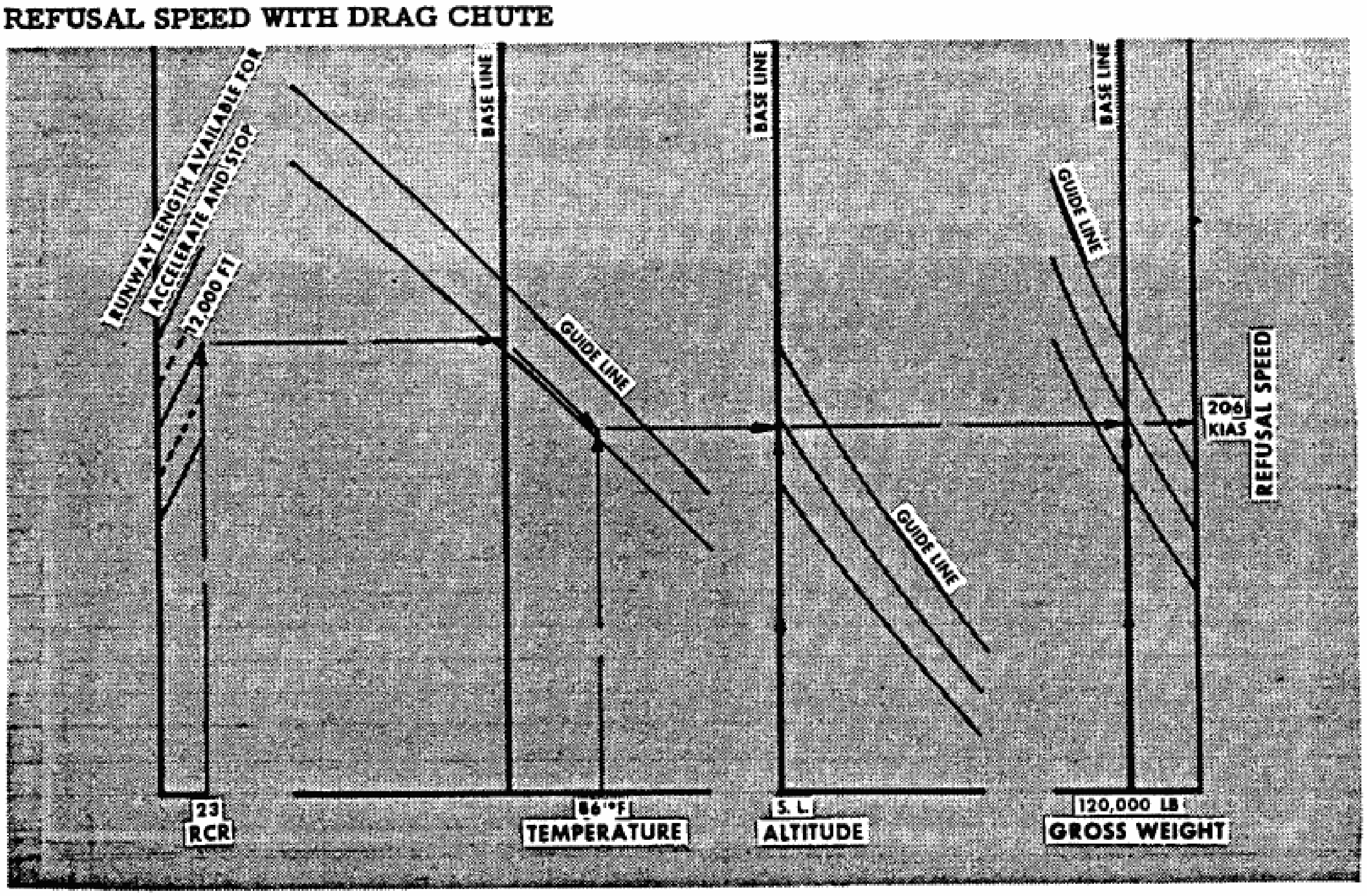
For abort conditions where brake burn-out will occur before a stop can be made, either the takeoff should be continued, if possible, or a barrier engagement should be anticipated. Various factors may contribute to less than optimum performance, such as blown tires, delayed drag chute deployment, etc.

Refusal Speed With Drag Chute

The assumptions made in calculating refusal speeds with drag chute are:

1. Normal rate of acceleration is continued to the refusal speed. At that point, complete and instantaneous loss of one engine occurs. (If the abort is not due to engine failure, one engine must be shutdown to realize calculated performance.

REFUSAL SPEED WITH DRAG CHUTE



2. Maximum afterburning thrust is continued on the operating engine for three seconds, at which time the throttle is retarded to idle and brake application is initiated. Rotation is not attempted when an emergency occurs before reaching rotation speed, even though rotation speed may be exceeded during the recognition and action period.

3. One second after brake application, drag chute deployment is initiated and brake torque is obtained. (Chute deployment time is 4.75 seconds.)

4. Optimum wheel braking, with continuous antiskid cycling, is used until the aircraft is stopped.

5. The drag chute is jettisoned at 60 knots on a dry runway, and is retained to full stop on a wet runway. (However, the drag chute should always be retained for aborts unless directional control problems require jettison.)

6. Hard surface runway with zero wind and zero slope.

Example:

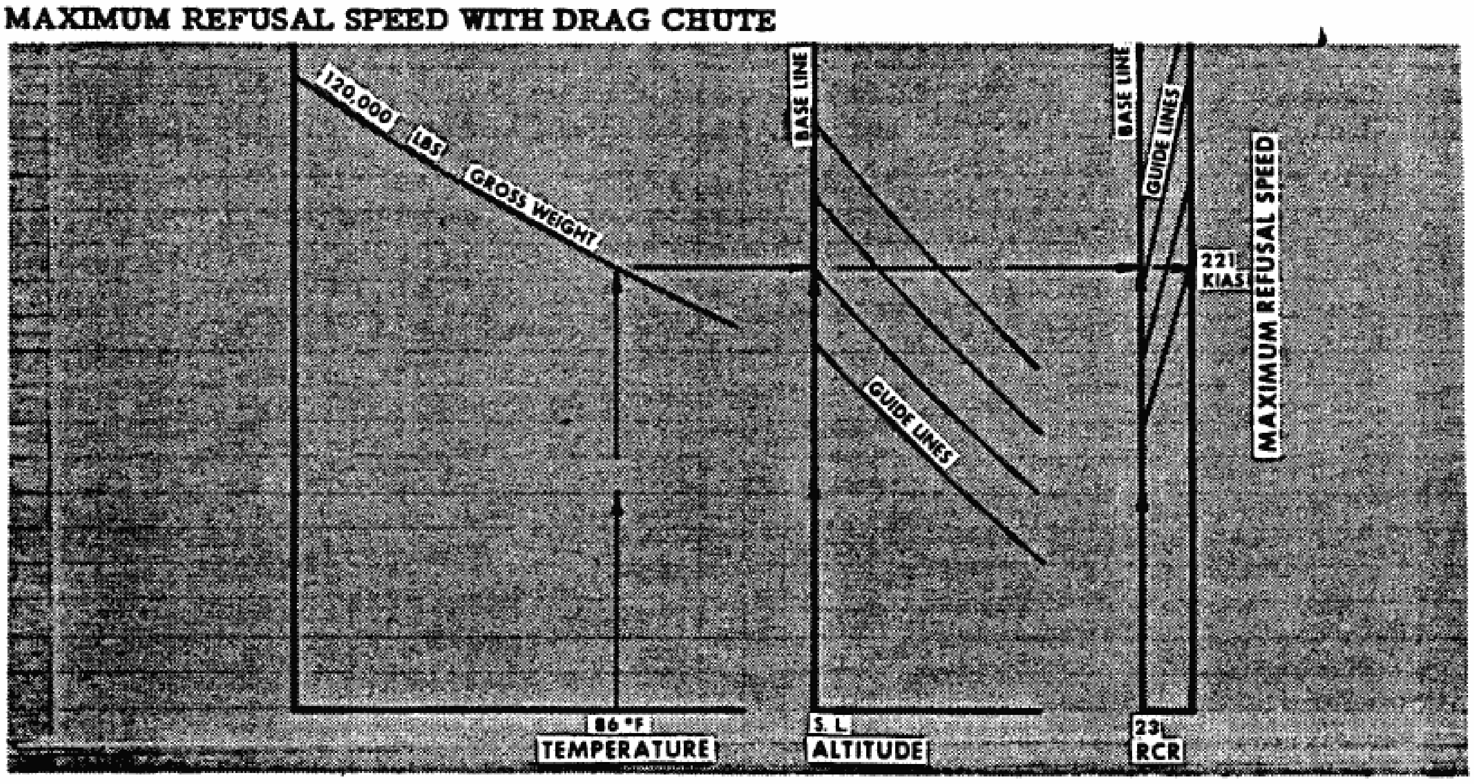
For a field pressure altitude of sea level, temperature of 86°F, and gross weight of 120,000 lb find the refusal speed with drag chute for a 12,000 ft accelerate and stop distance. The runway is dry (RCR=23). Refer to Figures A2-7 and A2-8. (Refusal speed from Figure A2-7 is 206 KIAS. Maximum refusal speed, brake energy limited, from figure A2-8, is 221 KIAS.)

Refusal Speed Without Drag Chute

The assumptions made in calculating refusal speeds without drag chute are the same as above.

When on a wet runway, up-elevon should be used to increase drag after recognition of chute failure, although not assumed in the calculations. (Nosedown attitude must be maintained.)

MAXIMUM REFUSAL SPEED WITH DRAG CHUTE



Example:

Find the refusal speed without drag chute for the conditions of the previous example. Refer to Figures A2-10 and A2-11. (Refusal speed from Figure A2-10 is 188 KIAS. Maximum refusal speed, brake energy limited, is 179 KIAS.)

SINGLE-ENGINE CLIMB CAPABILITY

In the event of engine failure after lift-off, marginal control during climbout will be available even if immediate corrective action is taken. Takeoff speeds are normally higher than minimum single-engine control speeds for steady flight. (Refer to Takeoff Emergencies, Section III.)

Figures A2-12 and A2-13 show single-engine level flight speeds and minimum aerodynamic control speeds, in and out of ground effect, with the gear down or retracted. ("In ground effect" refers to operation as close to the ground as airplane geometry will permit.) Ground effect diminishes rapidly as height increases and the aircraft is essentially out of ground effect at heights above one-half wing span (approximately 30 feet above the ground).

The charts include the effects of pressure altitude, temperature, and gross weight. One engine is assumed to be windmilling and the other engine developing maximum afterburning thrust. The single-engine level flight speed data out of ground effect are based on flight tests with full rudder deflection and the c.g. at 20% MAC.

For performance at other c.g. positions the gross weight should be increased/decreased 1500 lbs for each percent the c.g. is forward/aft of 20% MAC, i.e.

120,000 lb, 20% c.g., enter at 120,000 lb.
120,000 lb, 18% c.g., enter at 123,000 lb.
120,000 lb, 22% c.g., enter at 117,000 lb.

SINGLE-ENGINE LEVEL FLIGHT SPEEDS IN GROUND EFFECT GEAR DOWN

APPENDIX I
PART II

Example:

Determine the minimum control speeds and minimum speed for single engine flight under the following conditions:

Altitude	-	Sea Level
Temperature	-	86°F
Gross Weight	-	120,000 lb
C.G.	-	20% MAC

Refer to Figures 3-2, A2-12, and A2-13.

With the gear up or down, the minimum control speed is 209 KIAS with 0° sideslip and angle of attack from 6° to 10°. In a 5° sideslip with the gear up, the minimum control speeds are 177 KIAS and 170 KIAS at 6° and 10° angle of attack, respectively. In a 5° sideslip with the gear down, the minimum control speeds are 180 KIAS and 173 KIAS at 6° and 10° angle of attack, respectively.

Refer to Figure A2-12.

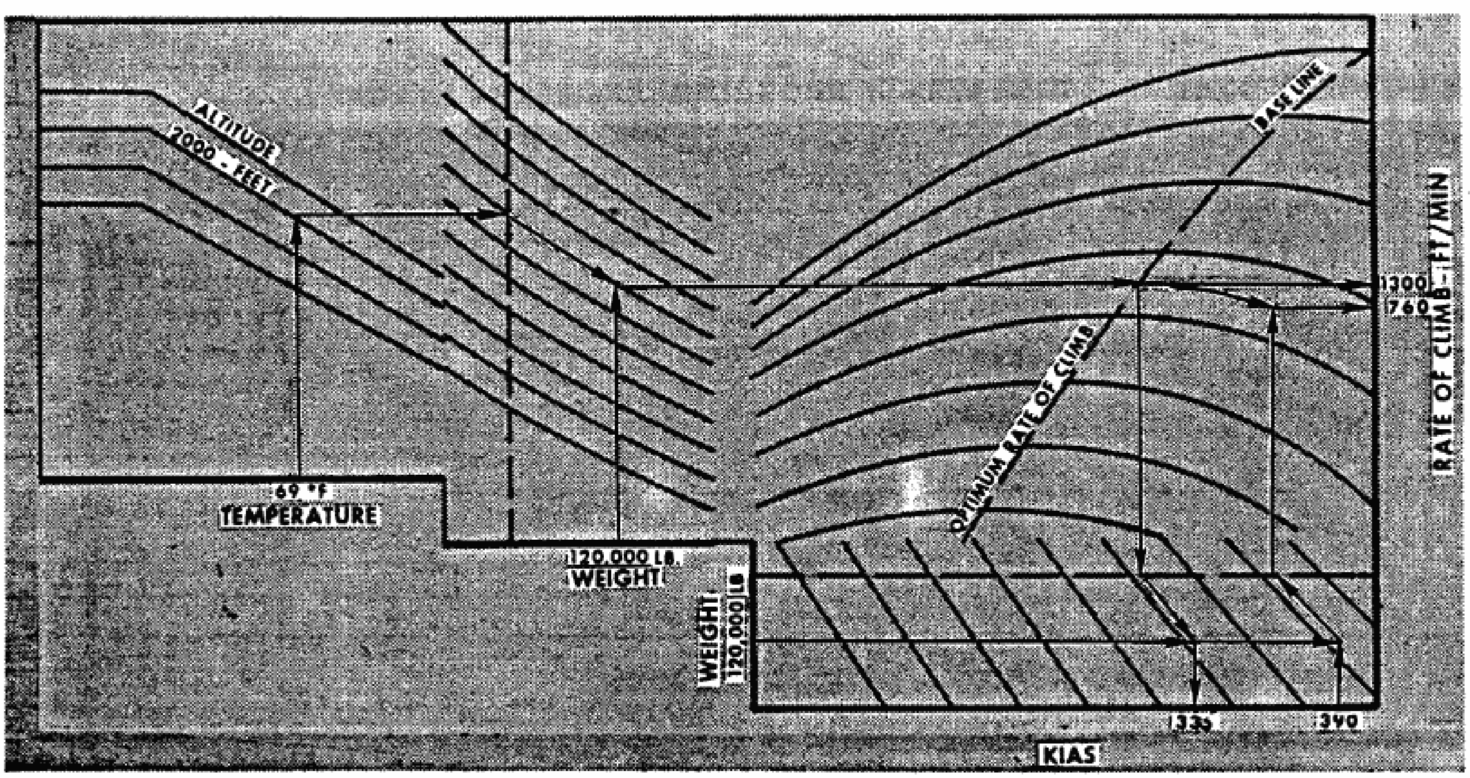
With the gear down, in ground effect, level flight can not be maintained under these ambient conditions at a gross weight of 120,000 lb. The maximum gross weight would be 116,500 lb and 248 KIAS would be required.

With the gear up, in ground effect, level flight can be maintained at 120,000 lb at a speed of 197 KIAS.

Refer to Figure A2-13.

With the gear down, out of ground effect, level flight can not be maintained under these conditions. The maximum gross weight would be 103,500 lb and 247 KIAS would be required. With the gear up, out of ground effect, level flight can be maintained at 120,000 lb at a speed of 226 KIAS.

SINGLE-ENGINE MAXIMUM THRUST RATE OF CLIMB



If operating at less than the maximum weight for single-engine flight, the available excess thrust can be used for acceleration instead of climbing. For example, at the same ambient conditions as the preceding problem, except at 115,000 lbs, the minimum speed is 233 KIAS and the maximum speed is 262 KIAS. The best single-engine climb speed with the gear down near the ground is approximately 250 KIAS. Since the gear would ordinarily be retracting during acceleration, this value represents a target speed for transition to a shallow climb. The best single-engine climb speed with gear up, out of ground effect, is shown on Figure A2-14. This chart also presents rate of climb information for off-optimum climb speeds.

Example:

Determine the optimum climb speed and rate of climb for the following conditions:

Altitude	-	2000 Ft.
Temperature	-	69°F
Gross Weight	-	120,000 lb
C.G.	-	20% MAC

Refer to Figure A2-14.

The optimum climb speed is 335 KIAS and the rate of climb is 1300 feet per minute.

With the above conditions and a climb speed of 390 KIAS the rate of climb would be 760 feet per minute.

LANDING PERFORMANCE

Landing speed schedules and landing distance information are provided for normal and for maximum performance landing procedures. (Normal performance landing charts are supplied for dry runway only.) The charts show landing temperature, pressure altitude, gross weight, Runway Condition Reading (RCR), wind, and runway slope. The data is applicable to grooved or ungrooved runways. Landing air distance from a height of 50 feet to touchdown is also presented.

Approach and Landing Speed Schedules

Final approach and landing speed schedules are shown on Figure A2-15. Normal performance final approach and landing speeds are 175 KIAS and 155 KIAS respectively at gross weights of 70,000 lb or less. At gross weights in excess of 70,000 lb, increase final approach and touchdown speeds 1 knot per 1000 lb. Maximum performance touchdown speeds are 10 knots less than those for normal performance. When landing at gross weights of more than 100,000 lb, and for all wet runway landings, use the maximum performance touchdown speed schedule.

Example:

Determine the final approach and landing speeds for a landing at 80,000 lb gross weight. Refer to Figure A2-15. (Final approach speed is 185 KIAS. Landing speed is 165 KIAS.)

Determine the final approach and landing speeds for a landing at 116,000 lb gross weight. Refer to Figure A2-15. (Note that this is a heavyweight condition and the maximum performance landing speed schedule must be used. Final approach speed is 221 KIAS. Landing speed is 191 KIAS.)

Normal Performance Landing Distances

Normal performance landing procedures assume that drag chute deployment is initiated 1.25 seconds after touchdown and the drag chute is fully deployed 4.75 seconds later (6 seconds after touchdown). Braking is delayed until 120 KIAS is reached. An additional one-second delay is included to allow development of full braking pressure. The drag chute is jettisoned at 60 knots. (The drag chute should always be retained until a stop is assured.)

Normal performance landing procedures without drag chute assume that a normal drag chute deployment is attempted. Brakes are applied at 120 KIAS as with the drag chute case. (Enough up-elevon should be used to increase drag without lifting the nose wheel, although this is not included in the calculations.)

Examples:

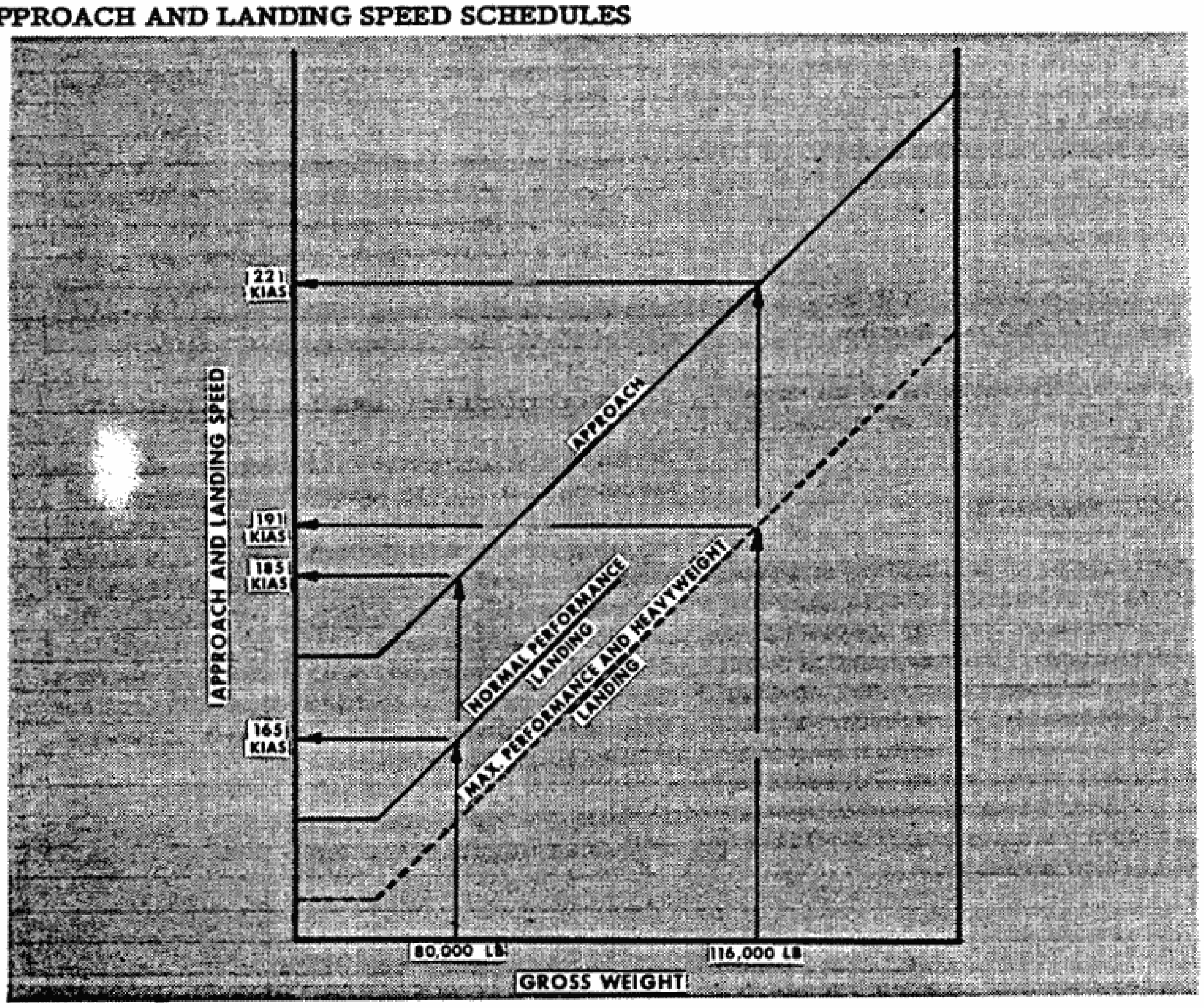
For a field pressure altitude of sea level, ambient temperature of 86°F (30°C), and a gross weight of 80,000 lb, find the normal performance landing ground roll distance, with drag chute, with a 10 knot headwind and 1% downhill runway slope. The runway is dry. (RCR=23.) Refer to Figure A2-16. (Landing ground roll distance is 4100 feet.)

For the same conditions as the previous example, find the Normal Performance landing ground roll distance without drag chute. Refer to Figure A2-17. (Note that runway slope must be corrected by gross weight rather than RCR. Landing ground roll distance is 6900 feet.)

Maximum Performance Landing Distances

The maximum performance landing procedure should be used when operating conditions require the shortest possible landing distance. Landings at gross weights in excess of 100,000 lb, and all wet runway landings, require use of the maximum performance procedure.

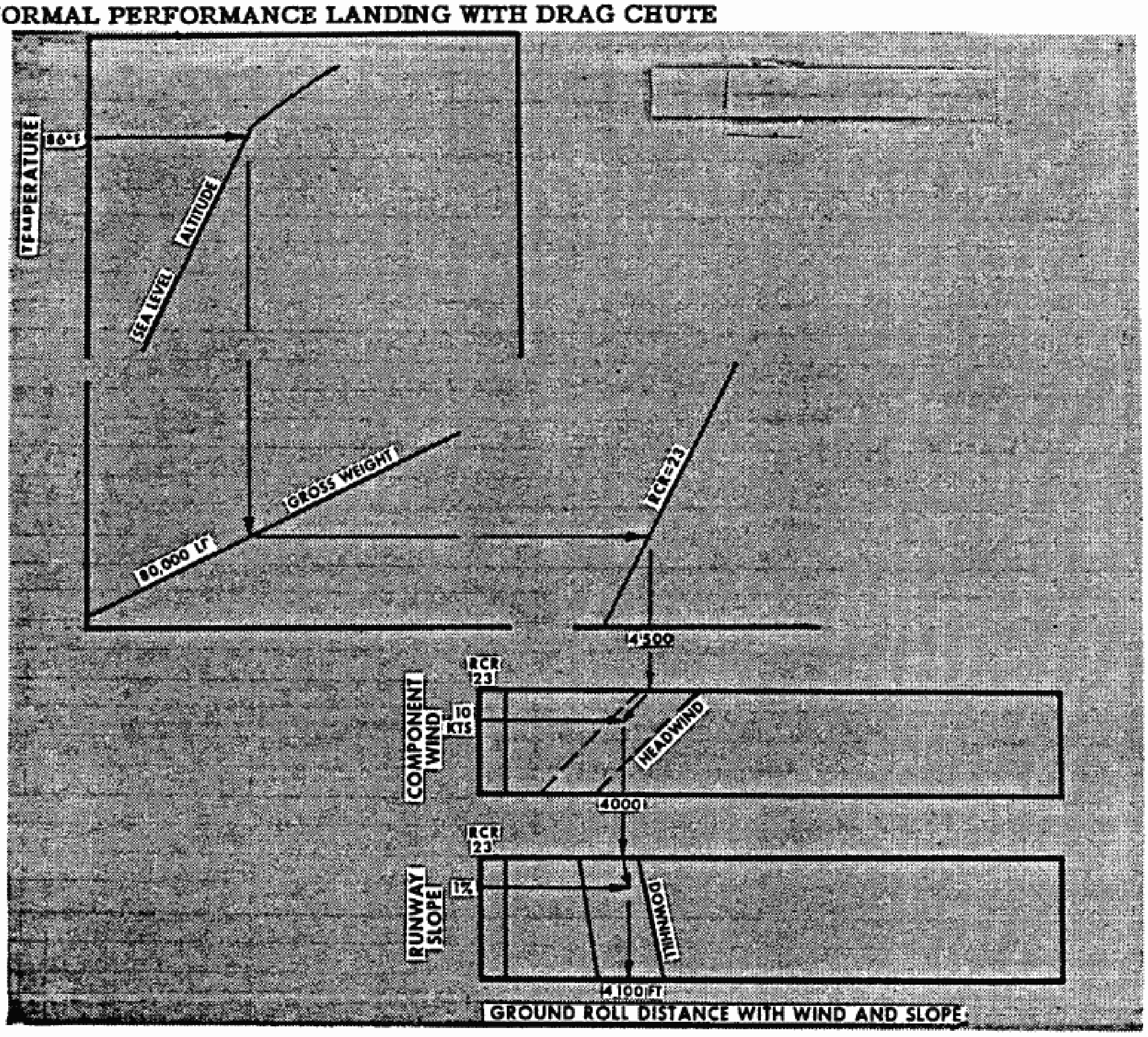
APPROACH AND LANDING SPEED SCHEDULES



Maximum performance landing procedures assume that drag chute deployment is initiated 1.25 seconds after touchdown. The nose gear is lowered 3 seconds after touchdown and the brakes are applied. Braking torque is obtained one second after brake application. The drag chute is fully deployed 4.75 seconds after actuation. Calculations assume that the drag chute is jettisoned at 60 knots on a dry runway and retained until full stop on a wet runway. (However, the drag chute should always be retained for heavyweight or short field landings.)

Maximum performance landing procedures without drag chute assume that a normal drag chute deployment attempt is made. The nose gear is lowered and braking initiated as for landings with normal drag chute operation. (Brakes are applied without regard to brake energy rating.) A three second period after the normal 4.75 second drag chute deployment is included for recognition of drag chute failure. One engine is shut down at this time. (Enough up elevon should be used to increase drag without lifting the nosewheel, although not included in the calculations.)

NORMAL PERFORMANCE LANDING WITH DRAG CHUTE



Example:

For a field pressure altitude of sea level, ambient temperature of 86°F (30°C), and a gross weight of 80,000 lb, find the maximum performance landing ground roll distance, without drag chute, with a 10 knot headwind and 1% downhill runway slope. The runway is wet and ungrooved. (RCR=14.) Refer to Figure A2-21. (Landing ground roll distance is 9250 feet.)

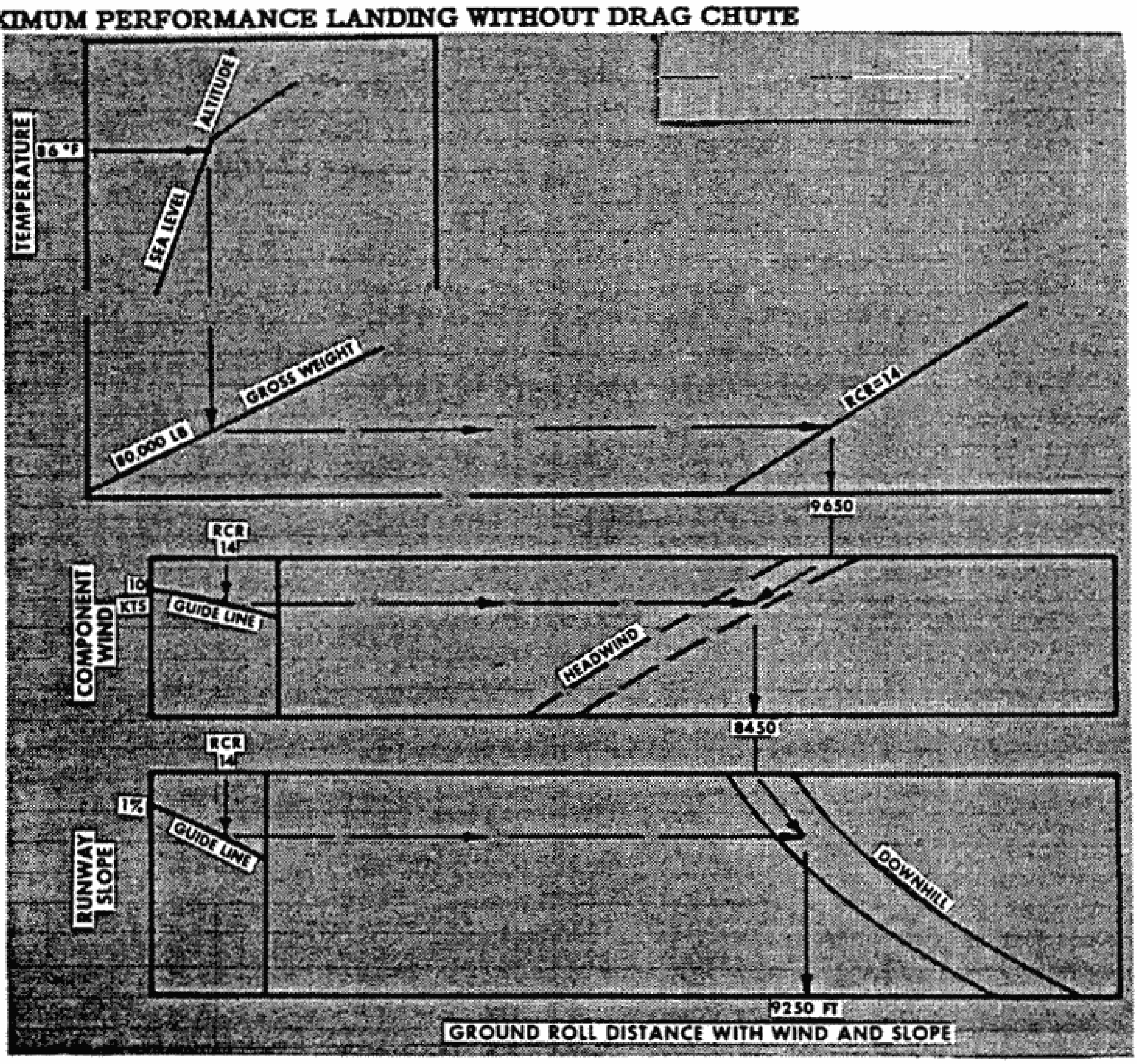
Landing Air Distance

Figure A2-22 shows the distance travelled during landing flare from a height of 50 feet to touchdown. The chart can be used for either normal or maximum performance landing procedures.

Example:

For a field pressure altitude of sea level, ambient temperature of 86°F (30°C), and a gross weight of 80,000 lb, find the landing air distance for a normal performance landing with a 10 knot headwind. Refer to Figure A2-22. (Landing air distance is 2750 feet.)

MAXIMUM PERFORMANCE LANDING WITHOUT DRAG CHUTE



TAKEOFF PLANNING

Information obtained from the takeoff and landing distance charts should be summarized on the checklist Takeoff and Landing Data Card prior to flight. The following card form is used.

CONFIDENTIAL
(When Filled Out)

TAKEOFF AND LANDING DATA CARD

TAKEOFF: (Norm) (~~Incr Speed~~) (~~Int Speed~~) (~~Max Perf~~)

Weight/C.G.	120,000/22	RCR	23
Press. Alt.	S.L. ft	Temp	86 °F
Wind (H) (T)	10 Kn	Gradient	-1 %
Trim EGT	804 °C	R.P.M.	6870

Acceleration check speed:

@ 2800 ft (3000ft. marker)	156 Kn
Rotation Speed	180 Kn
Refusal speed w/chute	180 Kn
Takeoff speed	210 Kn
Ground run	4800 ft
S.E. Speed (Out of ground effect) — Gear Up	226 Kn
Gear Dn	- Kn

Increase Takeoff Distance 1% Per Knot of Headwind Reduction

LANDING: (~~Norm~~) (Max Perf)

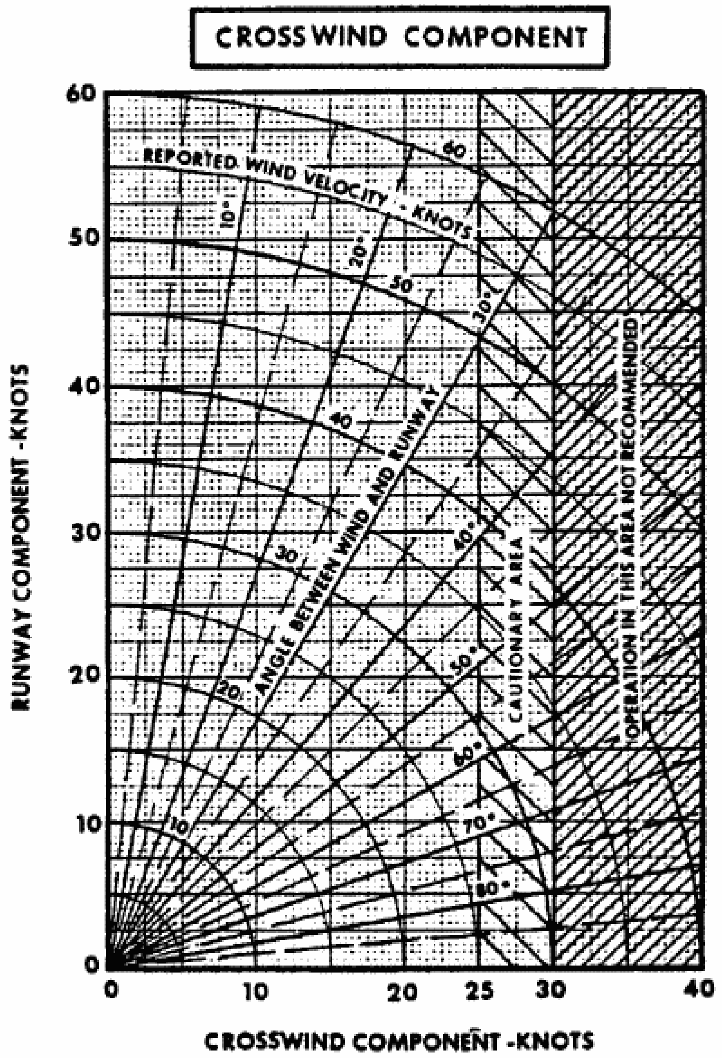
Landing immediately after T.O. w/chute:

Wt 116,000# Dist 5250 ft (0 wind, 0 slope)

Final speed 221 Kn Land speed 191 Kn

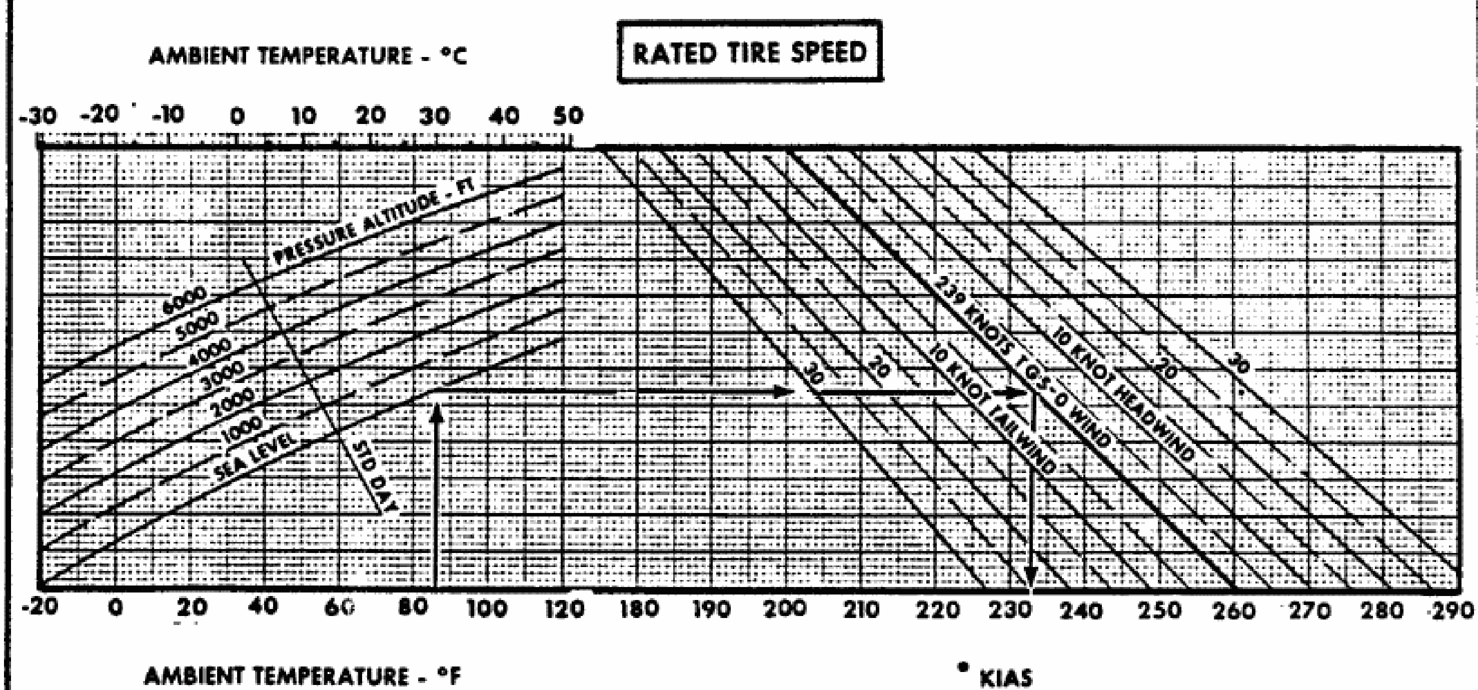
CONFIDENTIAL

CROSSWIND COMPONENT AND RATED TIRE SPEED CONVERSION CHARTS



NOTE:

30 KNOTS = MAXIMUM RECOMMENDED
25-30 KNOTS = CAUTIONARY AREA
25 KNOTS = MAXIMUM FOR NORMAL OPERATION ON GROOVED RUNWAY, OR DRY NON-GROOVED RUNWAY
20 KNOTS = MAXIMUM FOR NORMAL OPERATION ON WET, NON-GROOVED RUNWAY



* SUBTRACT 5 KNOTS TO OBTAIN MAXIMUM RECOMMENDED TAKEOFF SPEED (ALTERNATE TAKEOFF PERFORMANCE SCHEDULE)

REFERENCE DATE: SEPTEMBER 1972

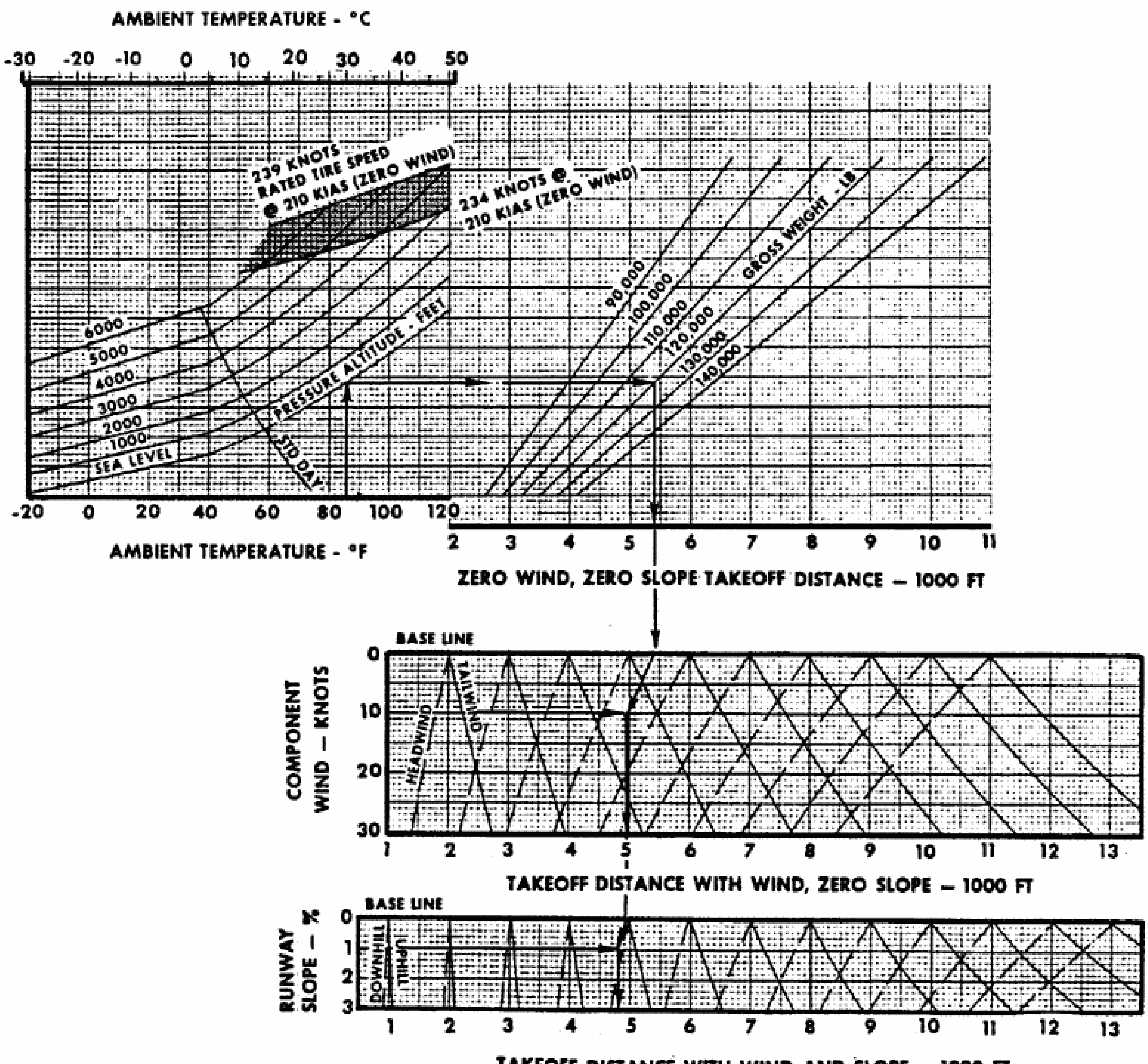
Figure A2-1

NORMAL PERFORMANCE TAKEOFF

DATA BASIS : FLIGHT TEST

180 KIAS ROTATION SPEED
210 KIAS TAKEOFF SPEED

REFER TO FIGURE A2-1 FOR RATED TIRE SPEED. IF TAKEOFF SPEED WOULD BE WITHIN 5 KNOTS OF RATED TIRE SPEED, USE ALTERNATE PERFORMANCE TAKEOFF PROCEDURE, FIG. A2-4, OR MAXIMUM PERFORMANCE TAKEOFFF PROCEDURE, FIG. A2-5.



REFERENCE DATE: JULY 1969

Figure A2-2

TAKEOFF CLIMB OUT DISTANCE

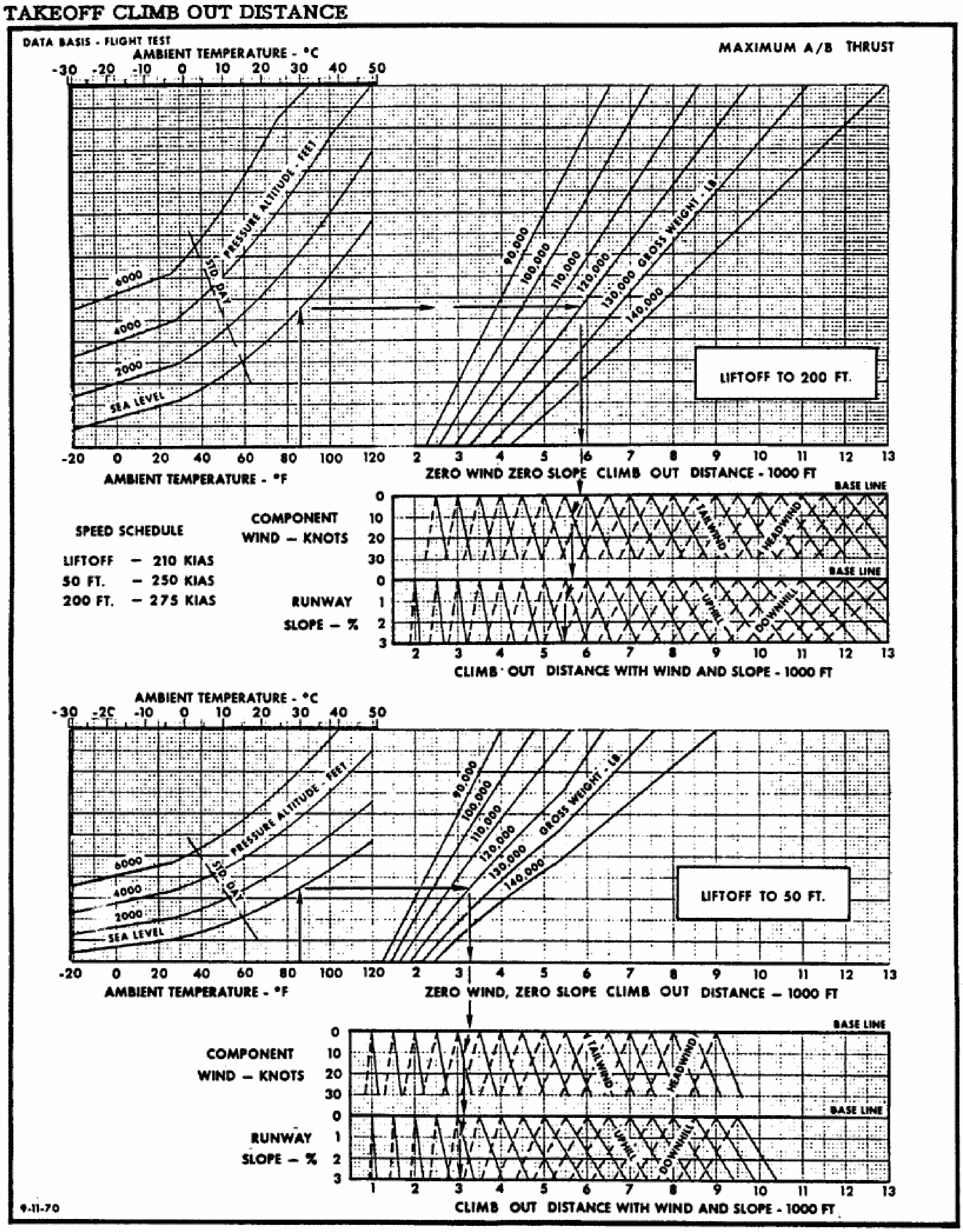


Figure A2-3

ALTERNATE (MAXIMUM SPEED) TAKEOFF PERFORMANCE

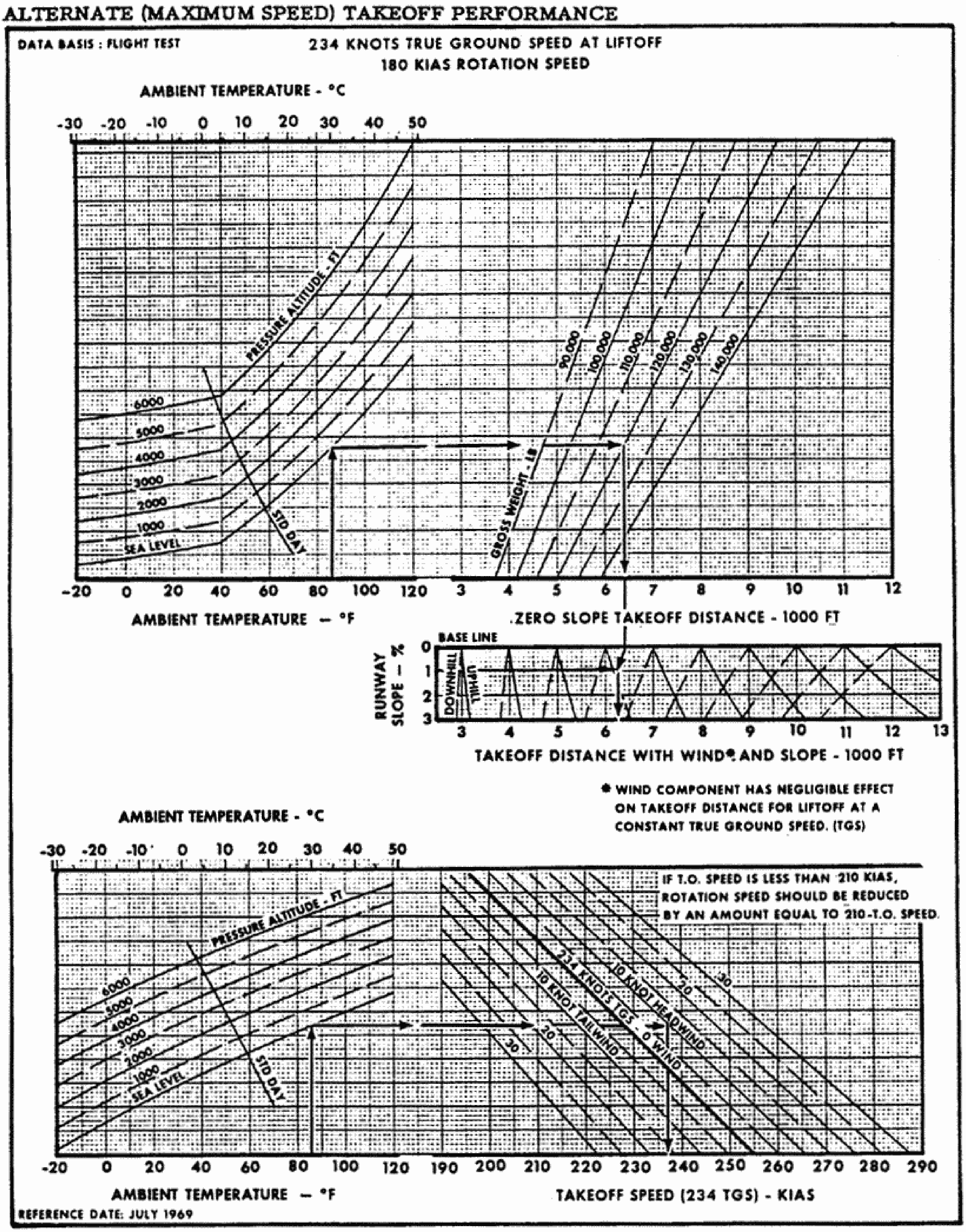
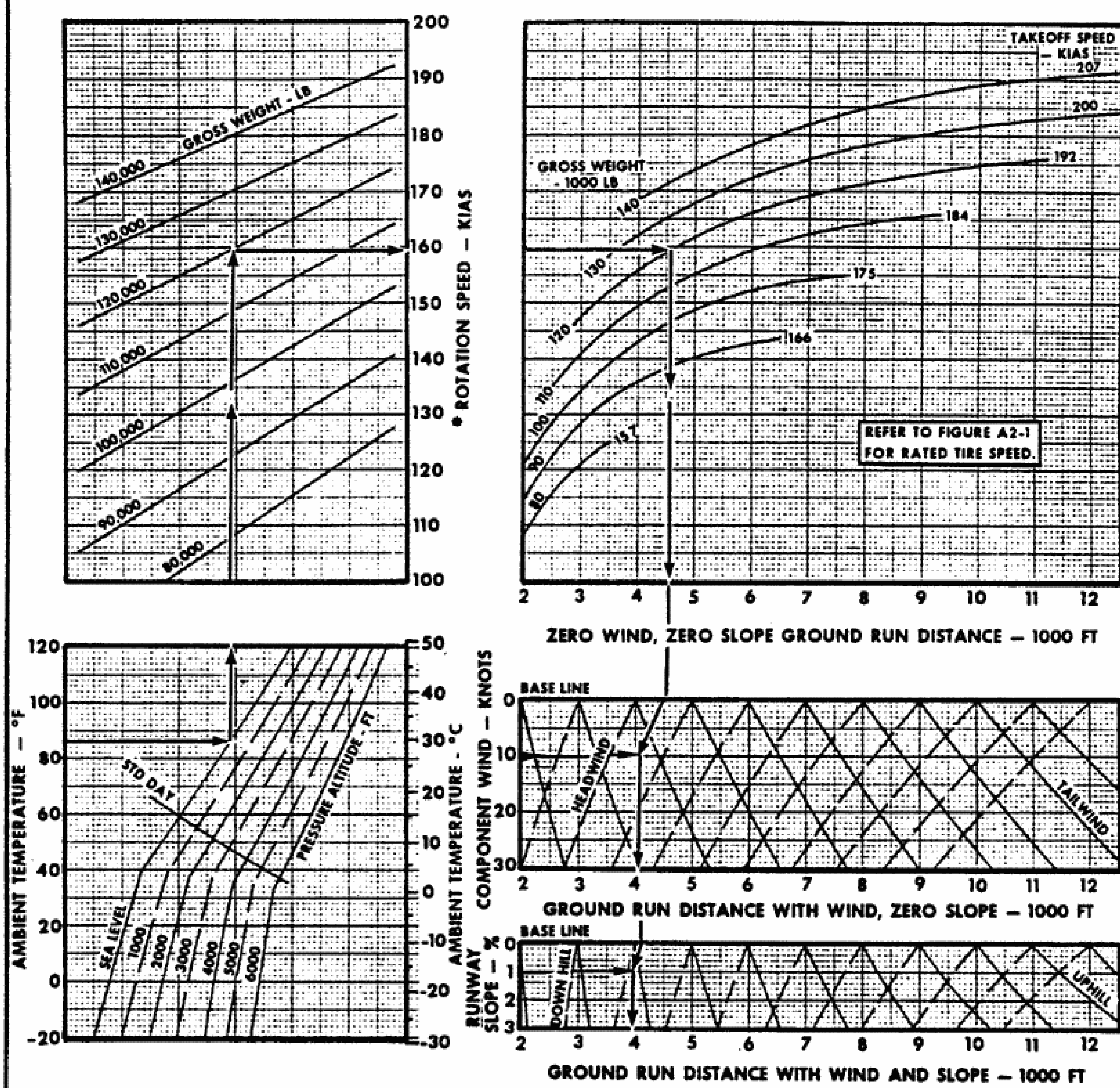


Figure A2-4

MAXIMUM PERFORMANCE (MINIMUM DISTANCE) TAKEOFF

DATA BASIS: FLIGHT TEST



* NOTE: INCREASE ROTATION SPEED 1 KNOT PER 1% UPHILL SLOPE. DECREASE 1 KNOT PER 1% DOWNHILL SLOPE.

IF RATED TIRE SPEED WILL BE EXCEEDED, USE 234 KNOT GROUNDSPEED TAKEOFF.

REFERENCE DATE: JULY 1969

Figure A2-5.

ACCELERATION CHECK

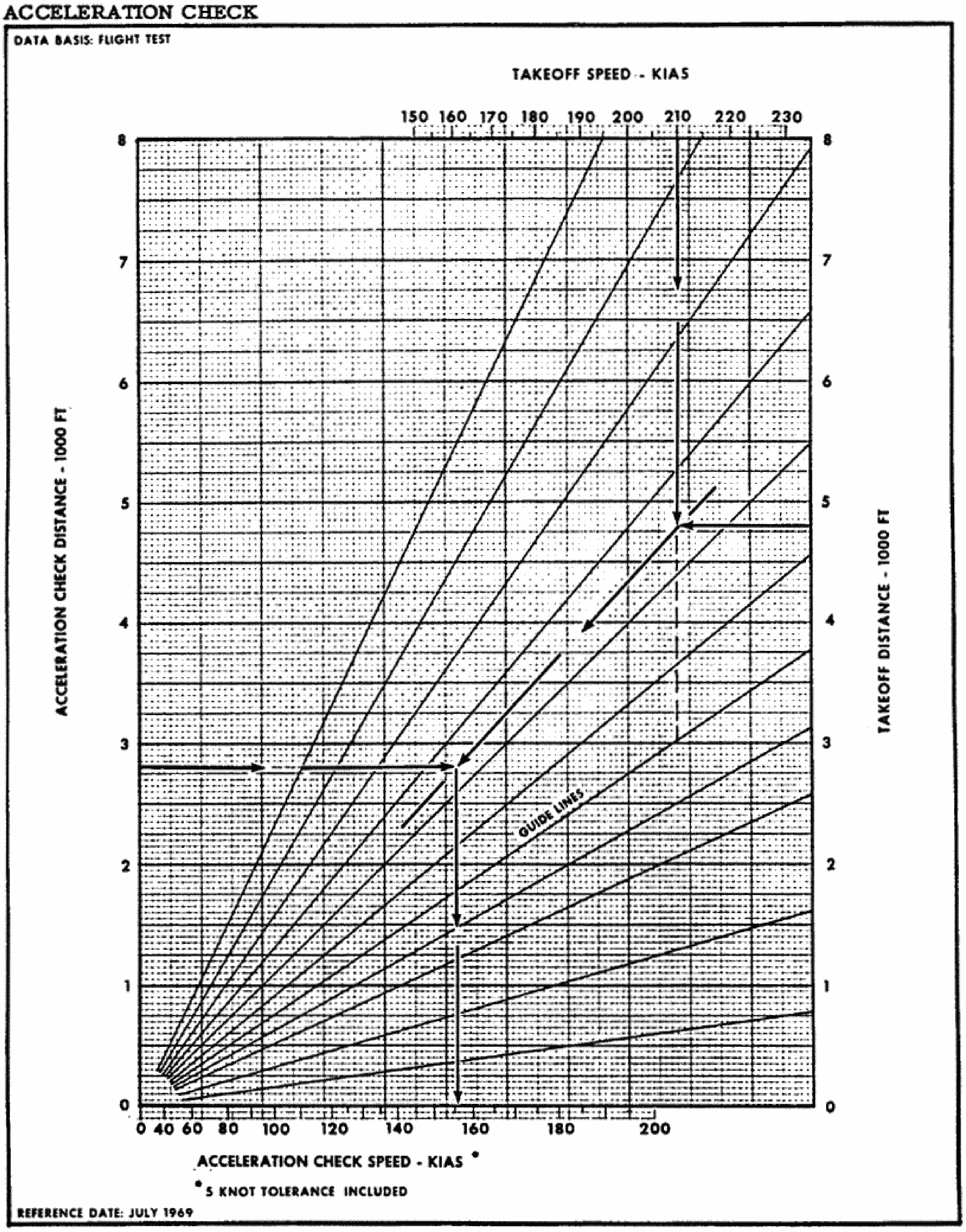
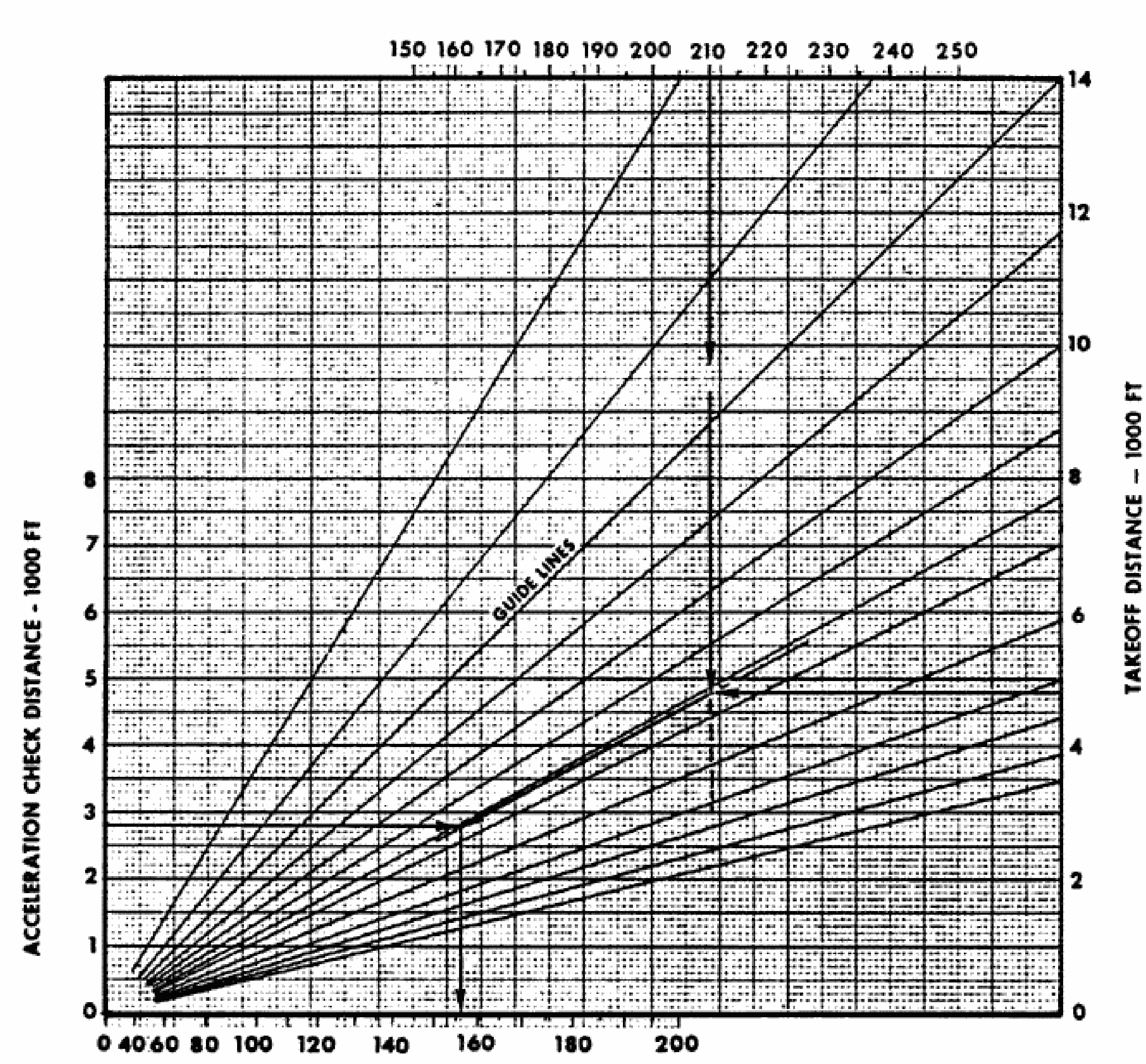


Figure A2-6 (Sheet 1 of 2)

ACCELERATION CHECK

DATA BASIS : FLIGHT TEST



* 5 KNOT TOLERANCE INCLUDED

REFERENCE DATE: JULY 1969

Figure A2-6 (Sheet 2 of 2)

REFUSAL SPEED

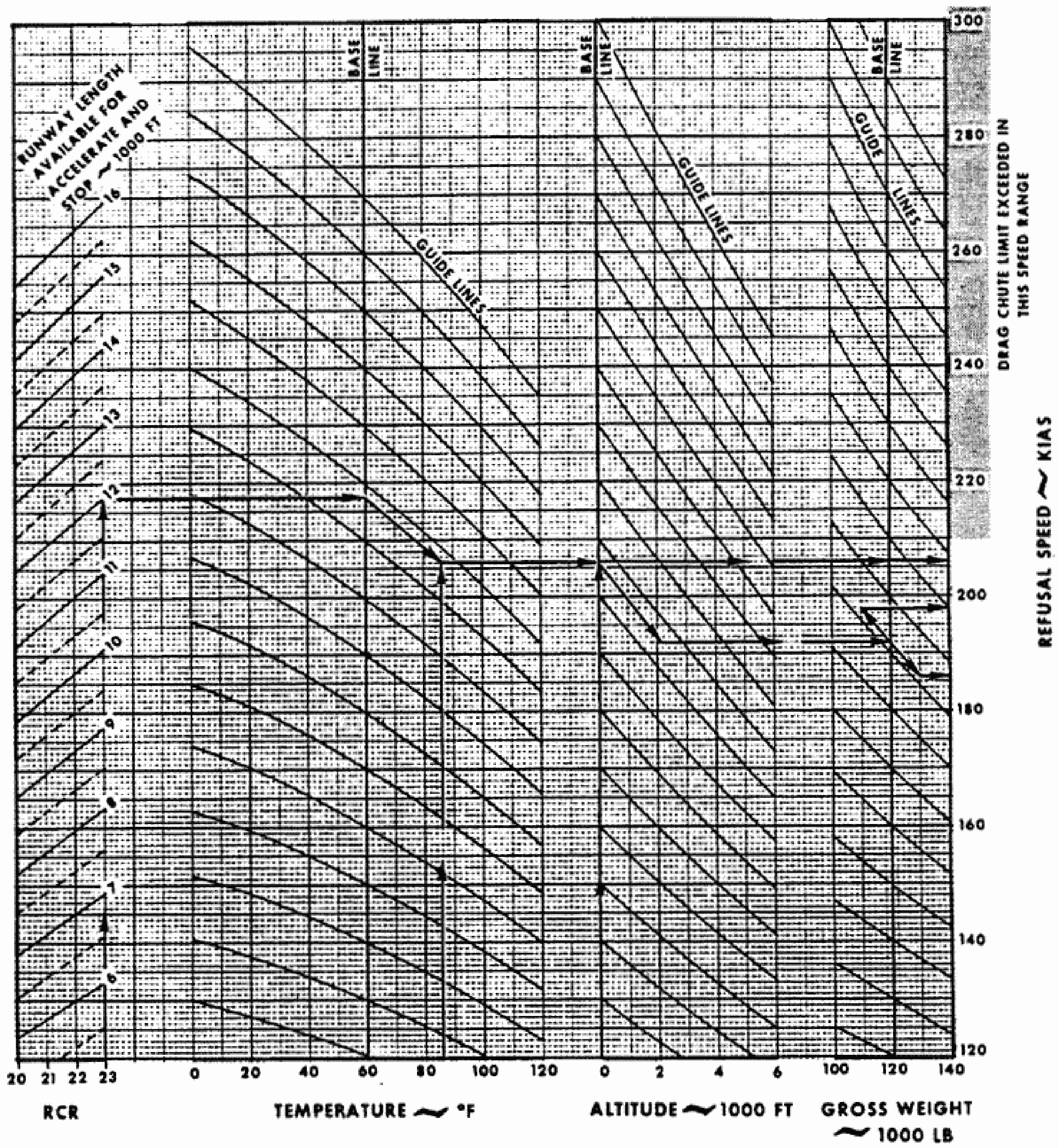
DATA BASIS: FLIGHT TEST

WITH DRAG CHUTE

DRY RUNWAY VARIABLE RCR

IMPROVED ANTI-SKID SYSTEM
(4×7) + (2×5) ROTOR BRAKES
ZERO WIND, ZERO SLOPE

SEE FIGURE A2-8 FOR MAXIMUM REFUSAL
SPEED LIMITED BY BRAKE ENERGY CAPABILITY



REFERENCE DATE: MARCH 1974

Figure A2-7

MAXIMUM REFUSAL SPEED - BRAKE ENERGY LIMITED*

DATA BASIS : FLIGHT TEST

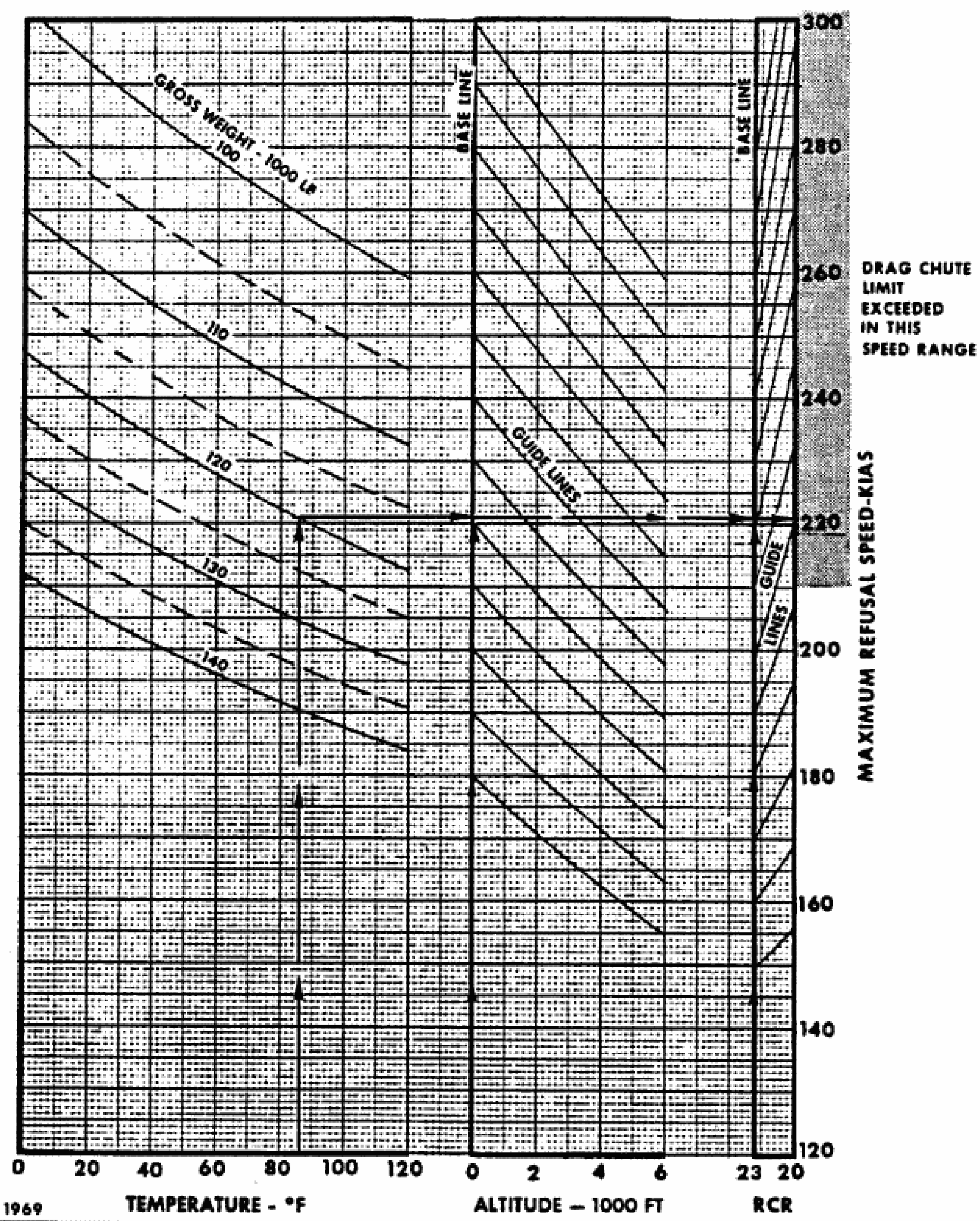
WITH (-501) DRAG CHUTE

DRY RUNWAY   VARIABLE RCR

IMPROVED ANTI-SKID SYSTEM
(4×7) + (2×5) ROTOR BRAKES

ONE STOP CAPABILITY

*MAXIMUM REFUSAL SPEED IS THE MAXIMUM SPEED FROM WHICH THE AIRCRAFT CAN BE BROUGHT TO A STOP WITHOUT BARRIER ENGAGEMENT USING 90% OF THE ONE-STOP BRAKE ENERGY RATING OF 198,700,000 FT LB.



REFERENCE DATE: JULY 1969

Figure A2-8

REFUSAL SPEED

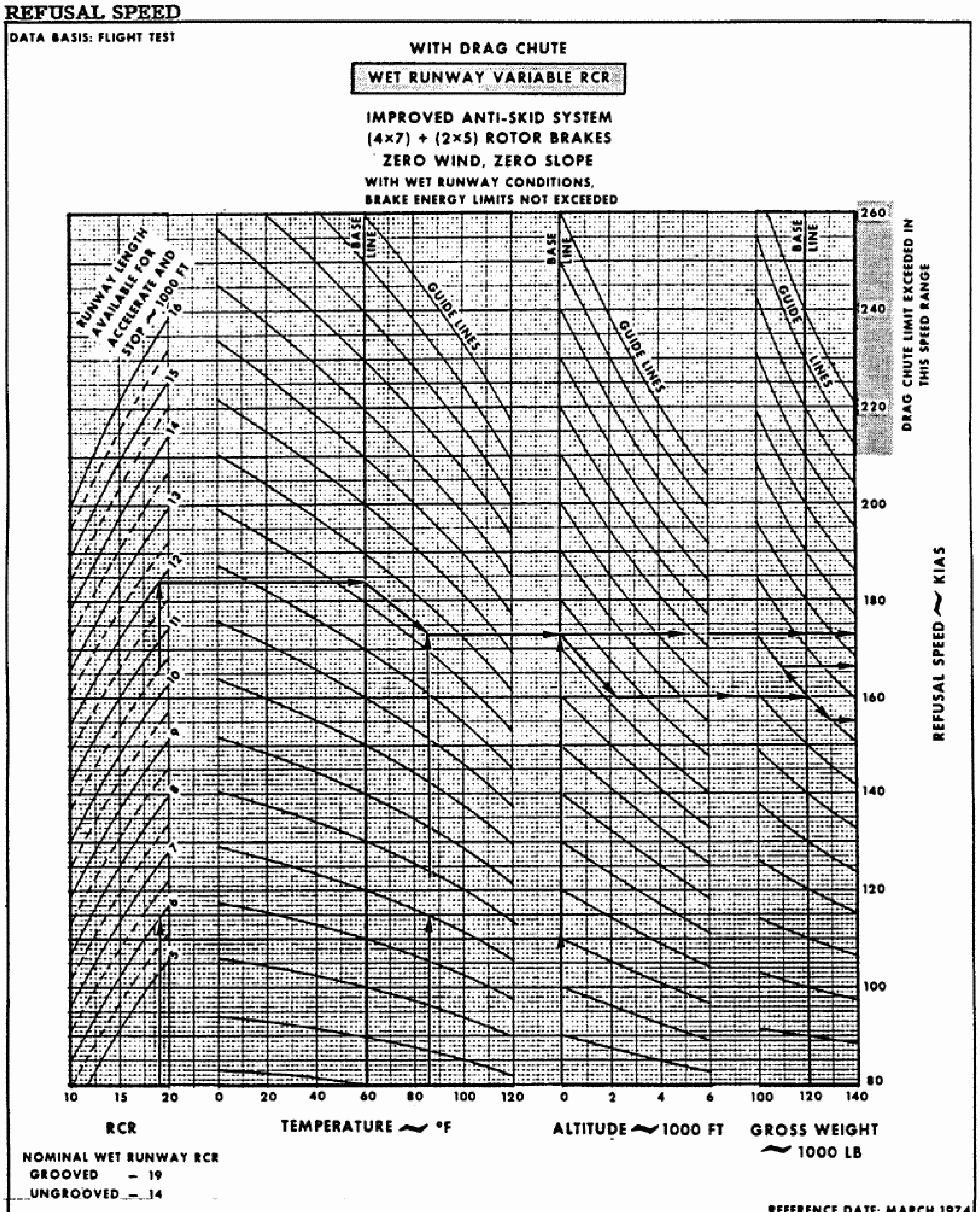


Figure A2-9

REFUSAL SPEED

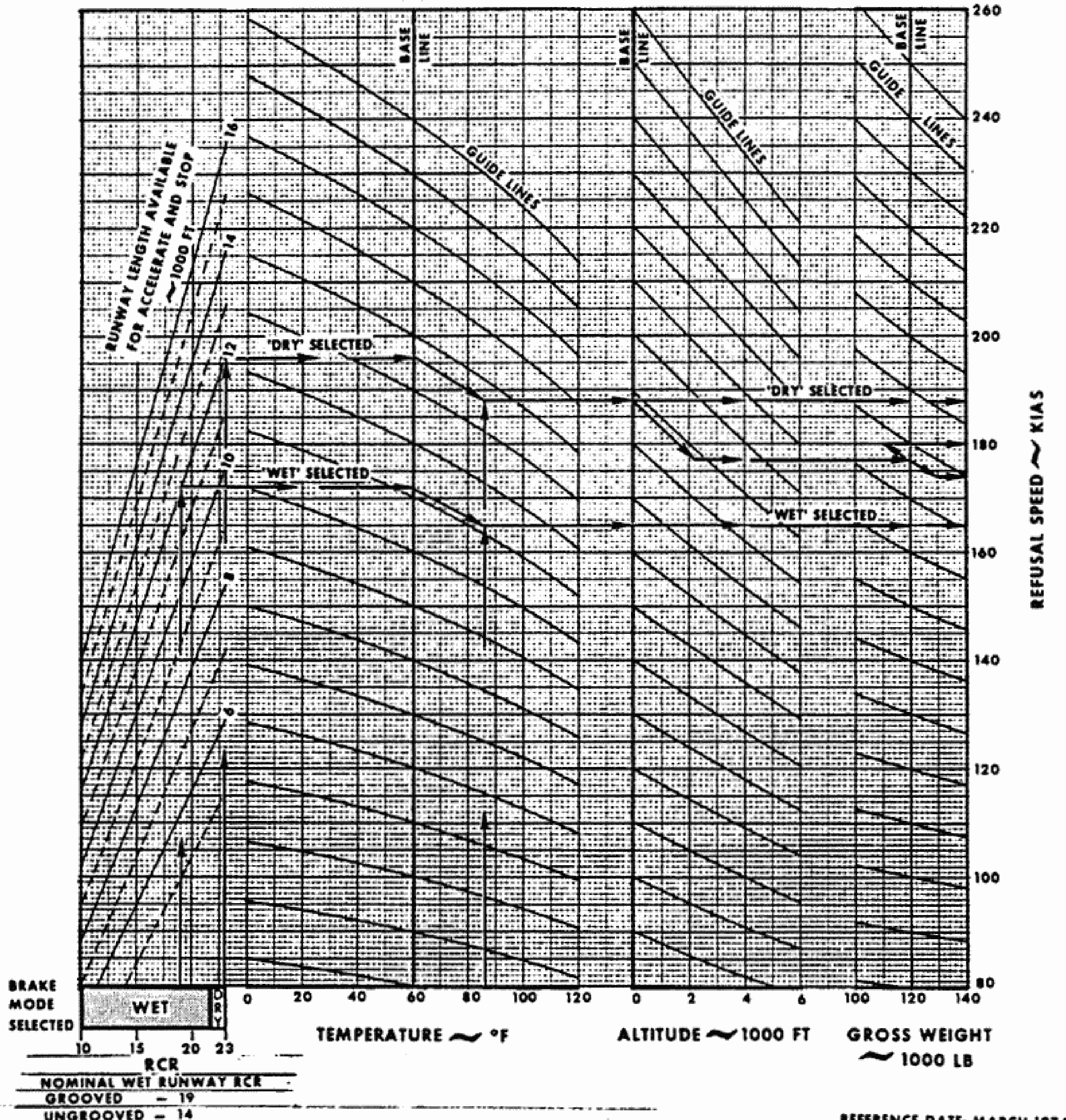
DATA BASIS: FLIGHT TEST

WITHOUT DRAG CHUTE

DRY OR WET RUNWAY VARIABLE RCR

IMPROVED ANTI-SKID SYSTEM
(4×7) + (2×5) ROTOR BRAKES
ZERO WIND, ZERO SLOPE

SEE FIGURE A2-11 FOR MAXIMUM REFUSAL SPEED LIMITED BY BRAKE ENERGY CAPABILITY



REFERENCE DATE: MARCH 1974

Figure A2-10

MAXIMUM REFUSAL SPEED – BRAKE ENERGY LIMITED*

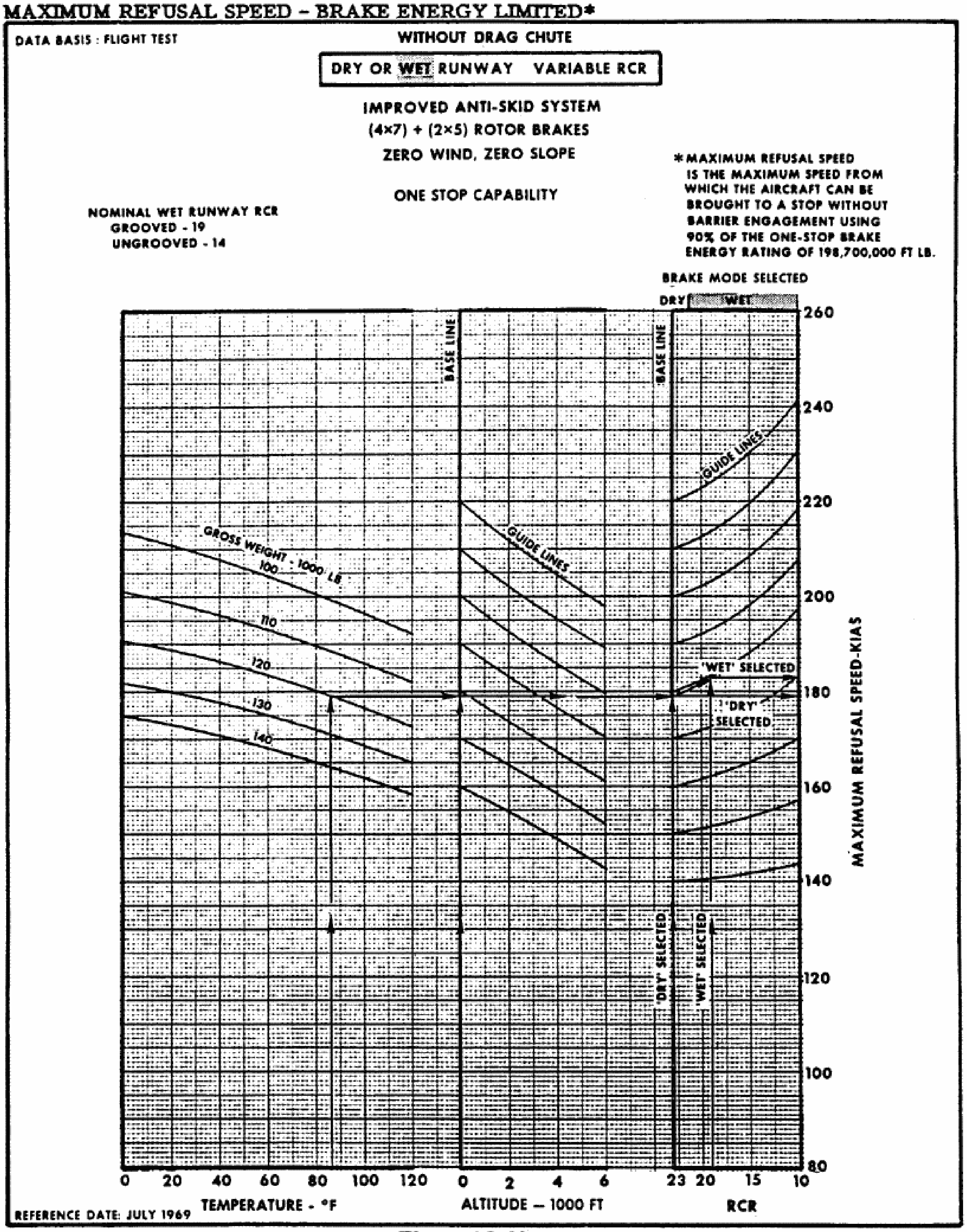


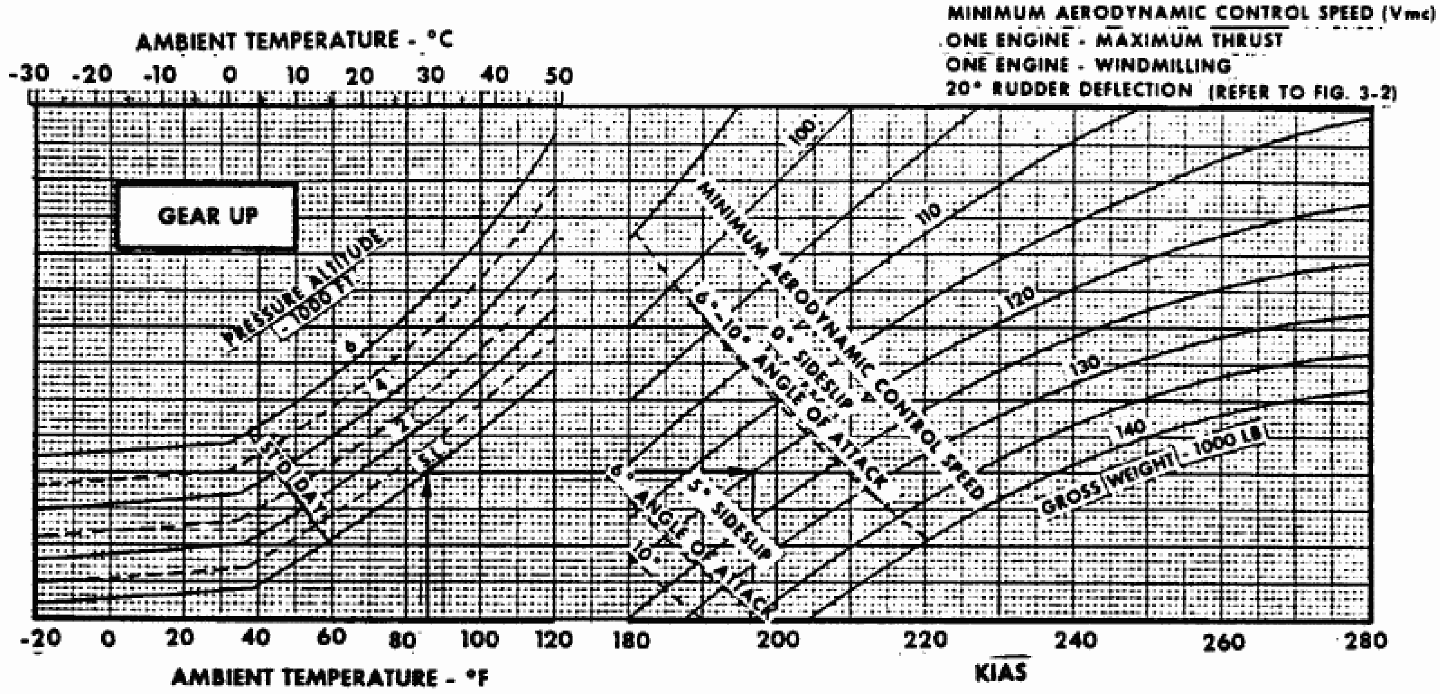
Figure A2-11

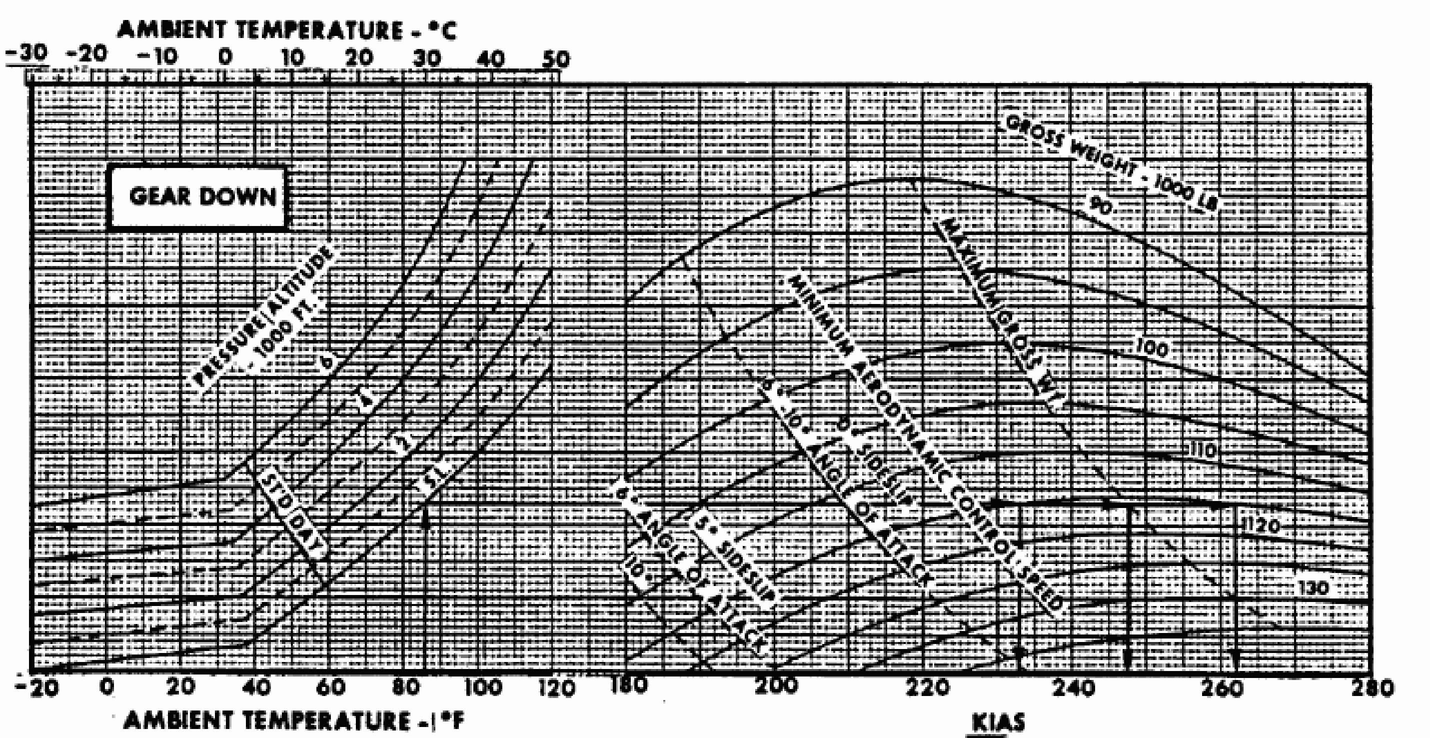
SINGLE-ENGINE LEVEL FLIGHT SPEEDS

DATA BASIS: ESTIMATED

IN GROUND EFFECT

20% C.G.
ONE ENGINE AT MAXIMUM THRUST - ONE ENGINE WINDMILLING
RUDDER DEFLECTION AND BANK TO MAINTAIN FLIGHT TRACK (SIDESLIP LESS THAN 5°)





*AT MAXIMUM GROUND EFFECT (AS CLOSE TO THE GROUND AS POSSIBLE WITHOUT MAKING CONTACT.)

Figure A2-12

SINGLE-ENGINE LEVEL FLIGHT SPEEDS

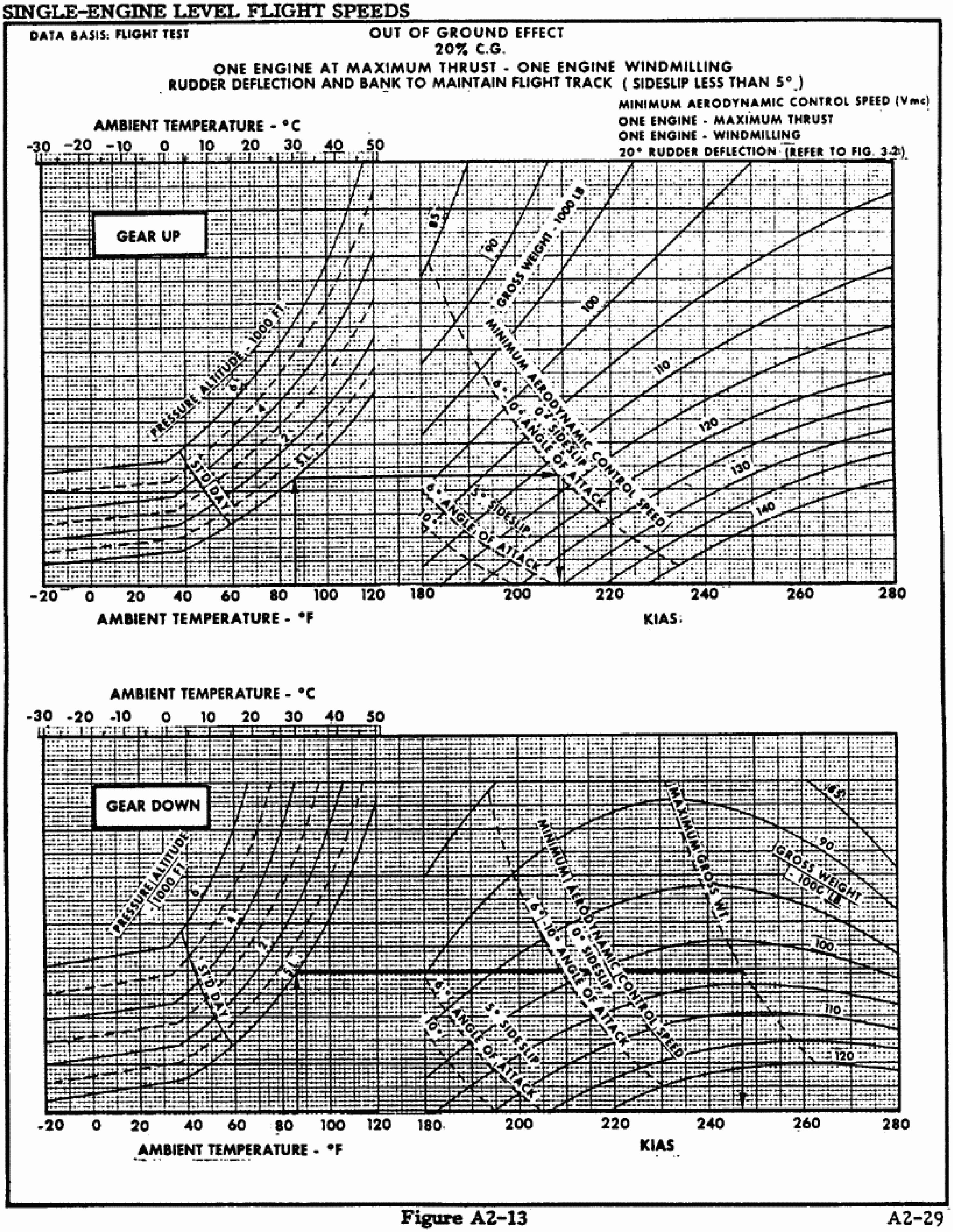


Figure A2-13

[redacted]

SINGLE-ENGINE MAXIMUM THRUST RATE OF CLIMB

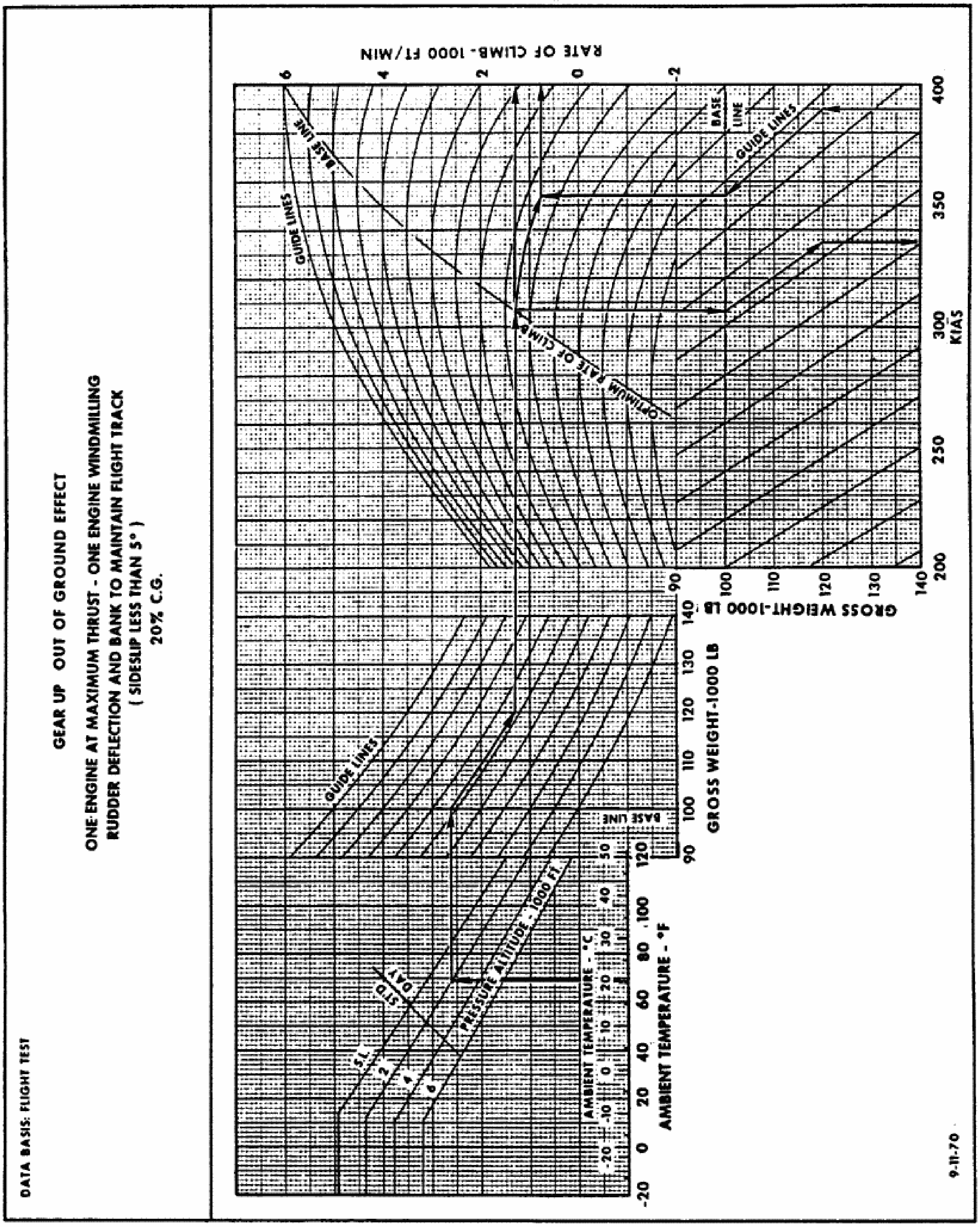
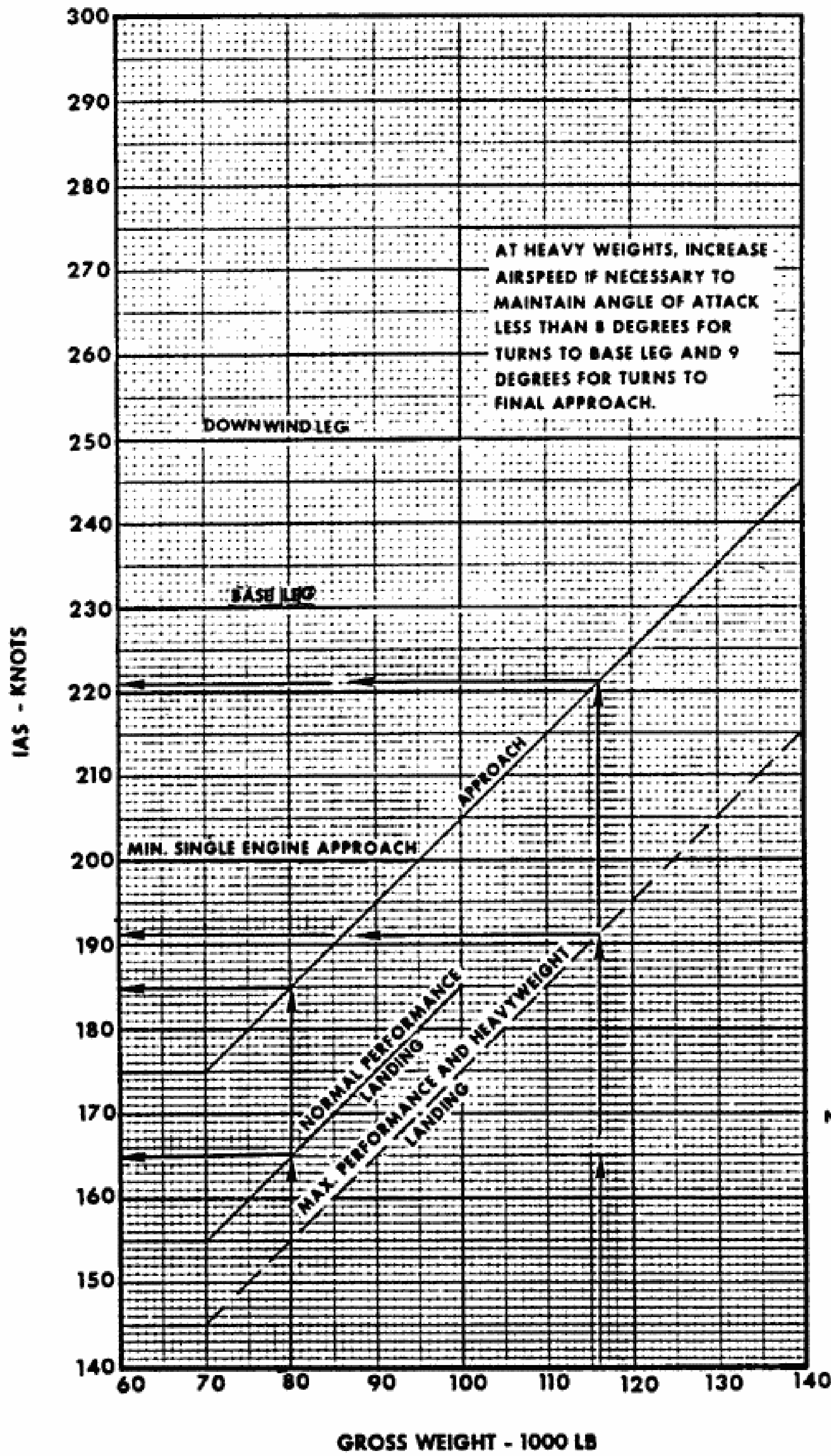


Figure A2-14

[redacted]

NORMAL PATTERN AND LANDING SPEED SCHEDULES

DATA BASIS : FLIGHT TEST



NOTE: USE MAXIMUM PERFORMANCE AND HEAVY WEIGHT LANDING SPEED SCHEDULE FOR LANDINGS AT GROSS WEIGHTS IN EXCESS OF 100,000 LB AND FOR ALL WET RUNWAY LANDINGS.

Figure A2-15

LANDING DISTANCE

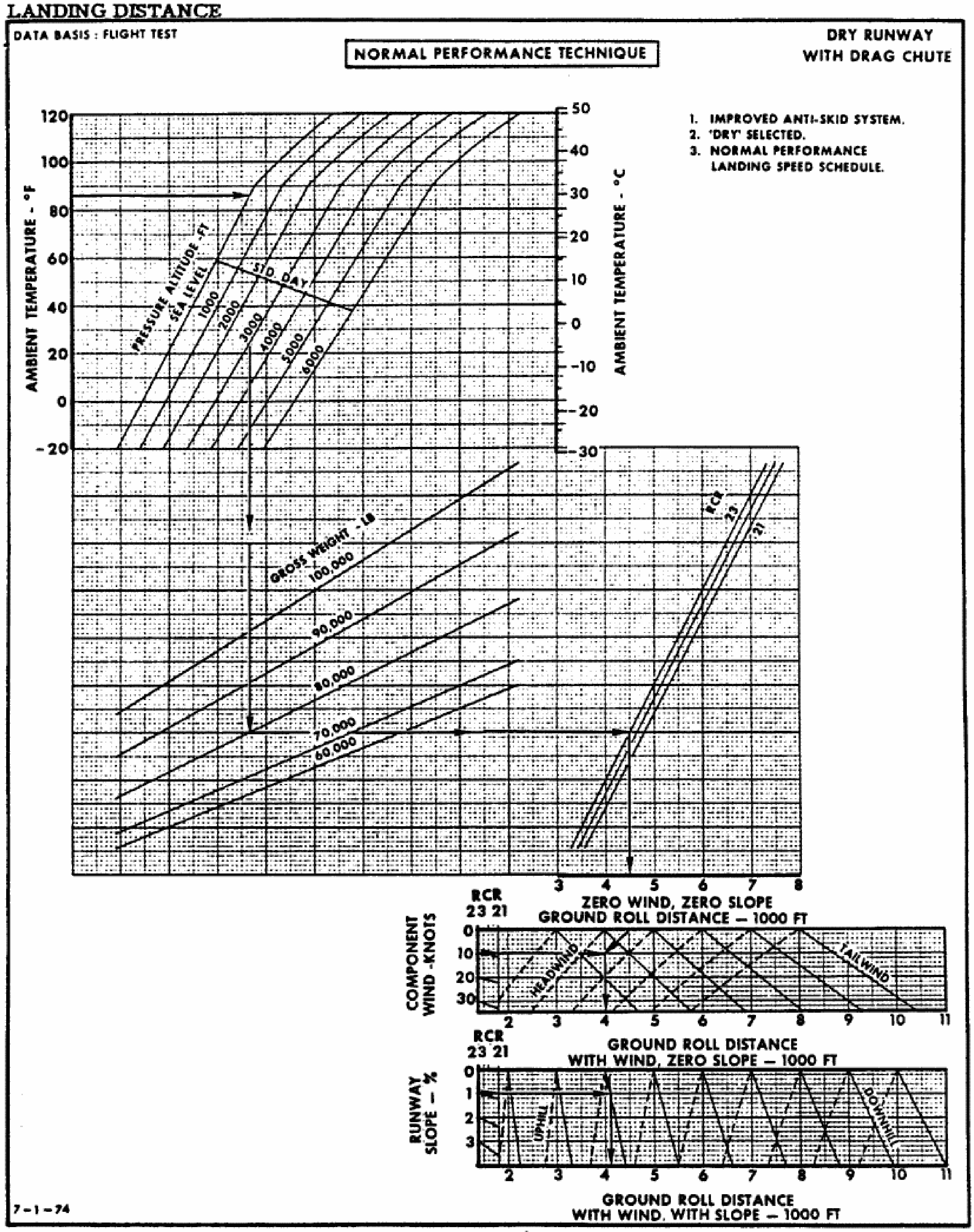


Figure A2-16

LANDING DISTANCE

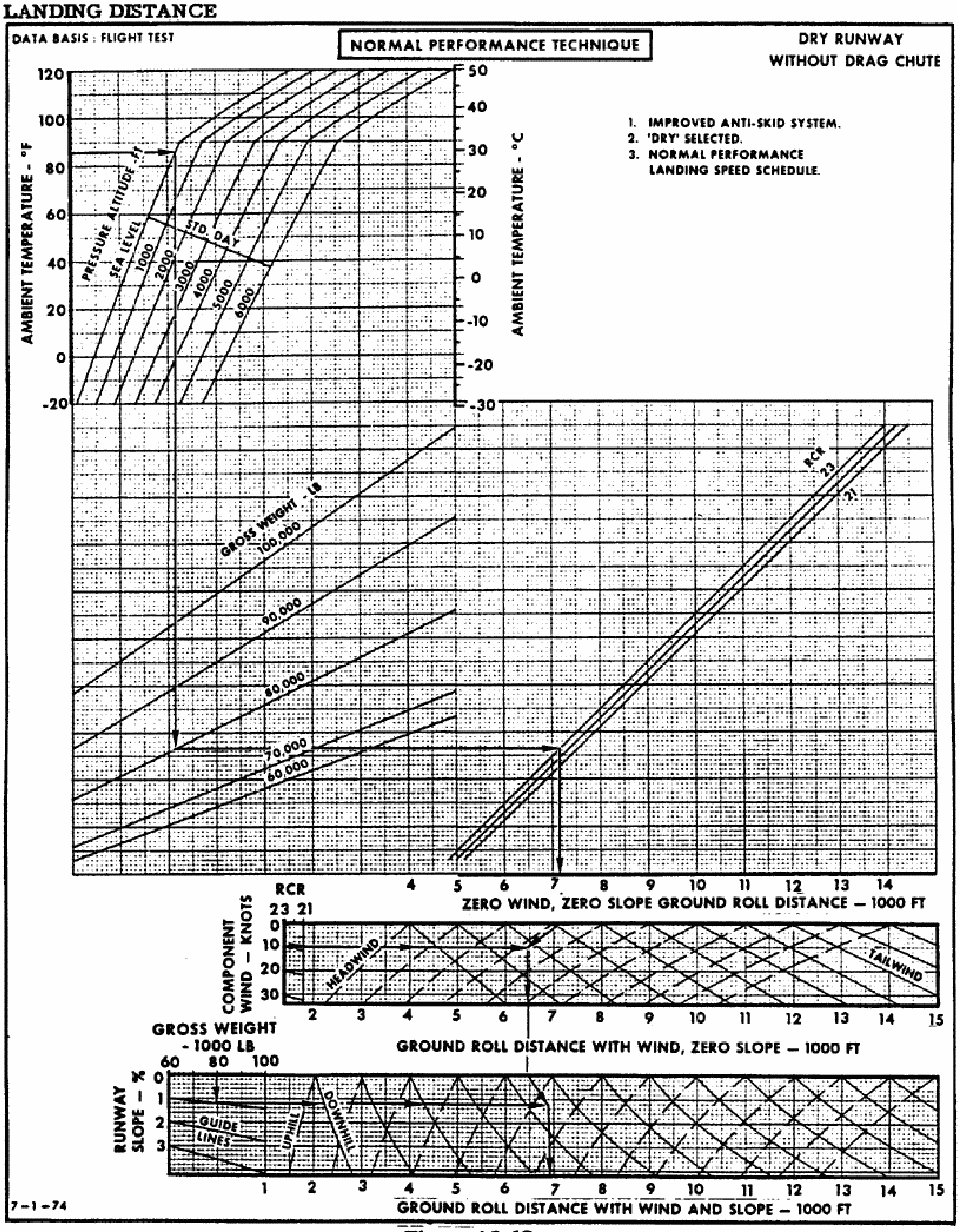


Figure A2-17

LANDING DISTANCE

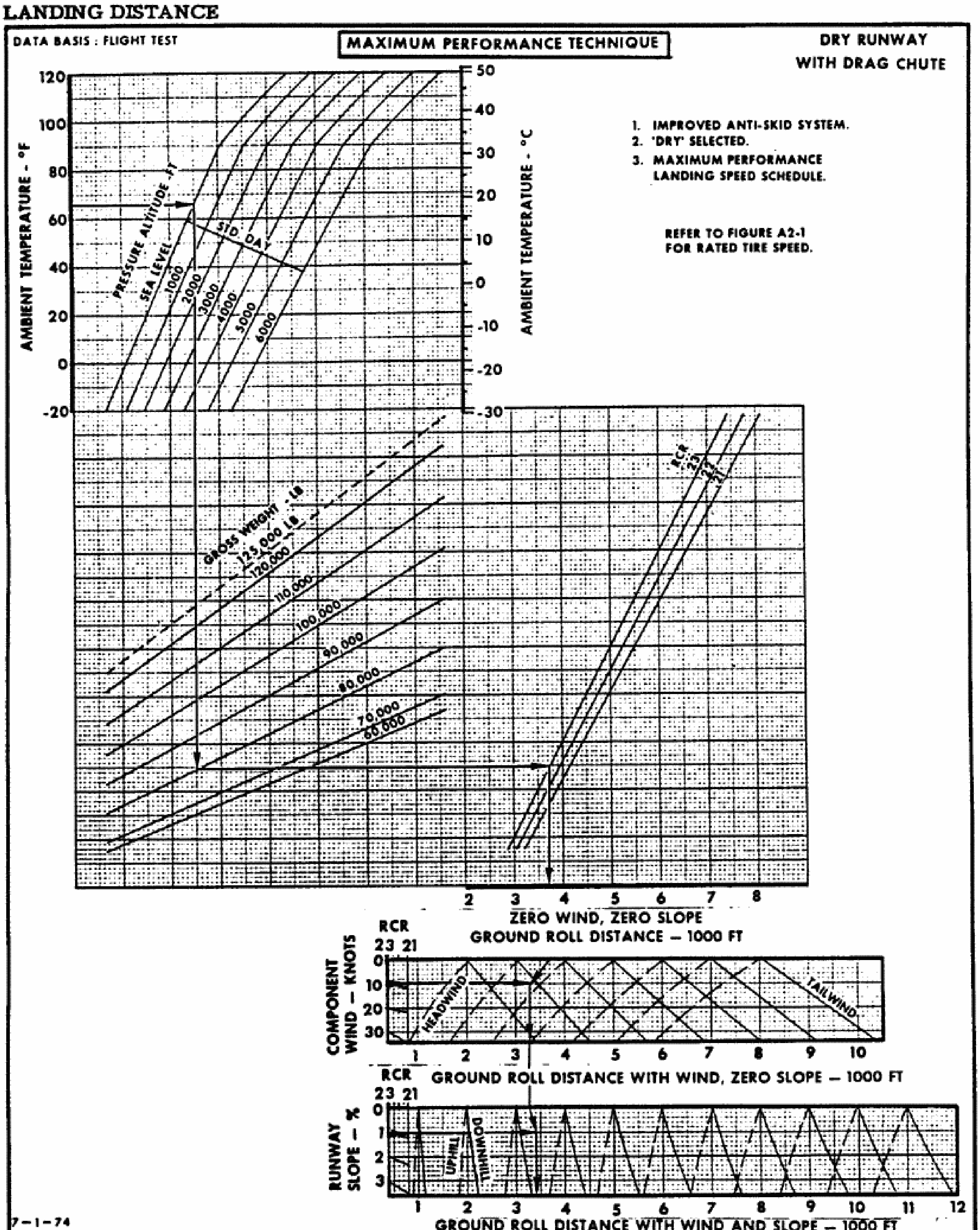


Figure A2-18

LANDING DISTANCE

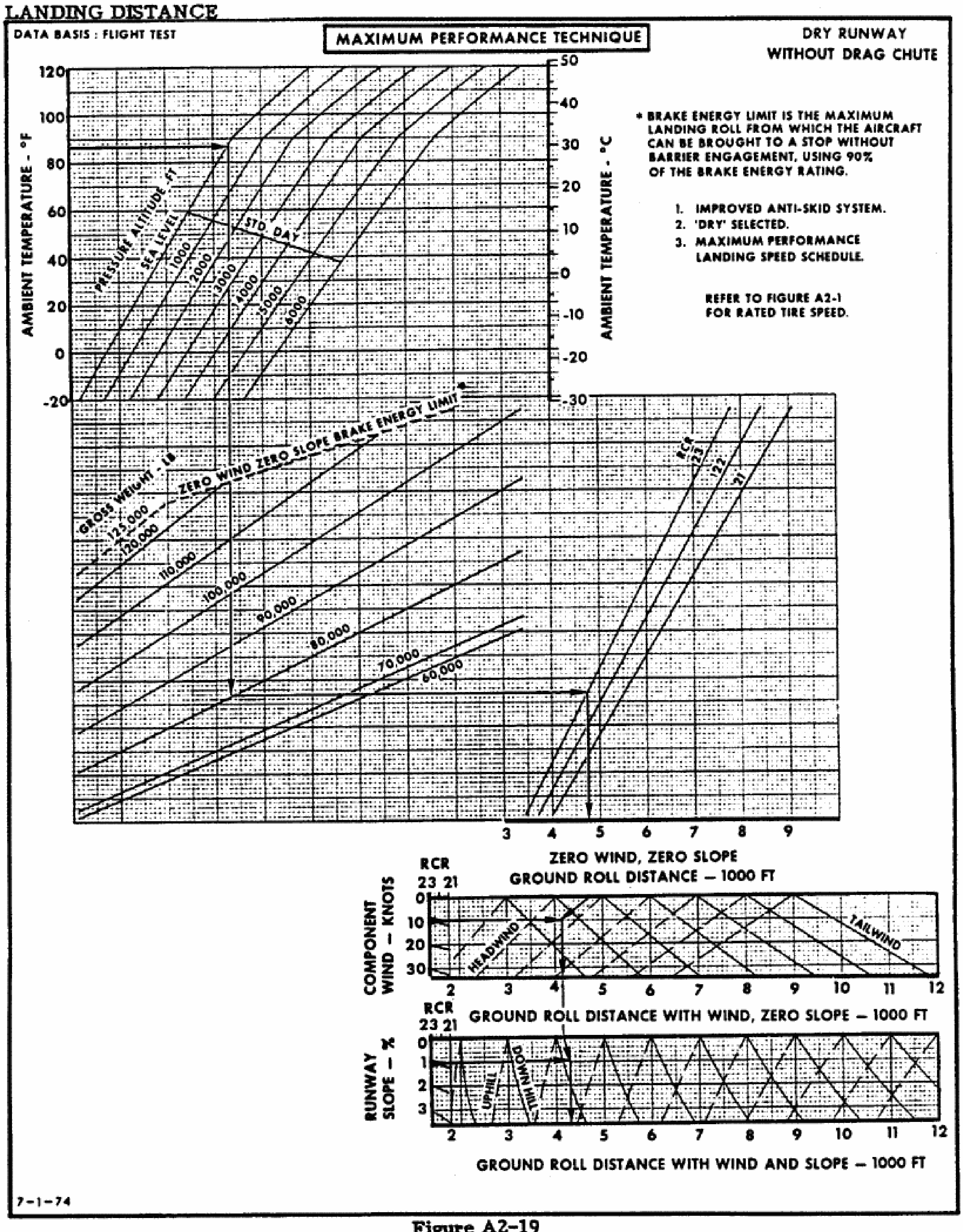


Figure A2-19

LANDING DISTANCE

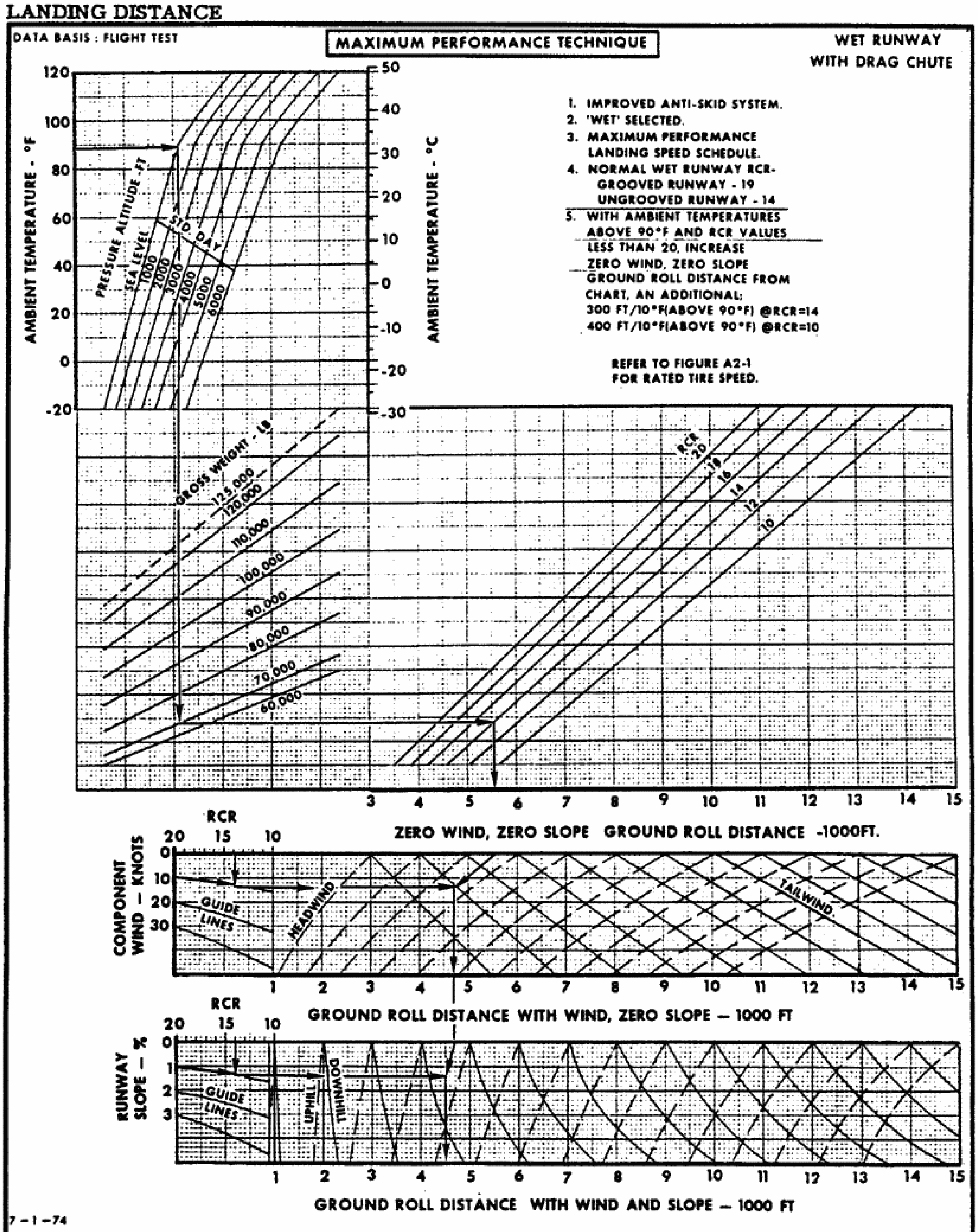


Figure A2-20

LANDING DISTANCE

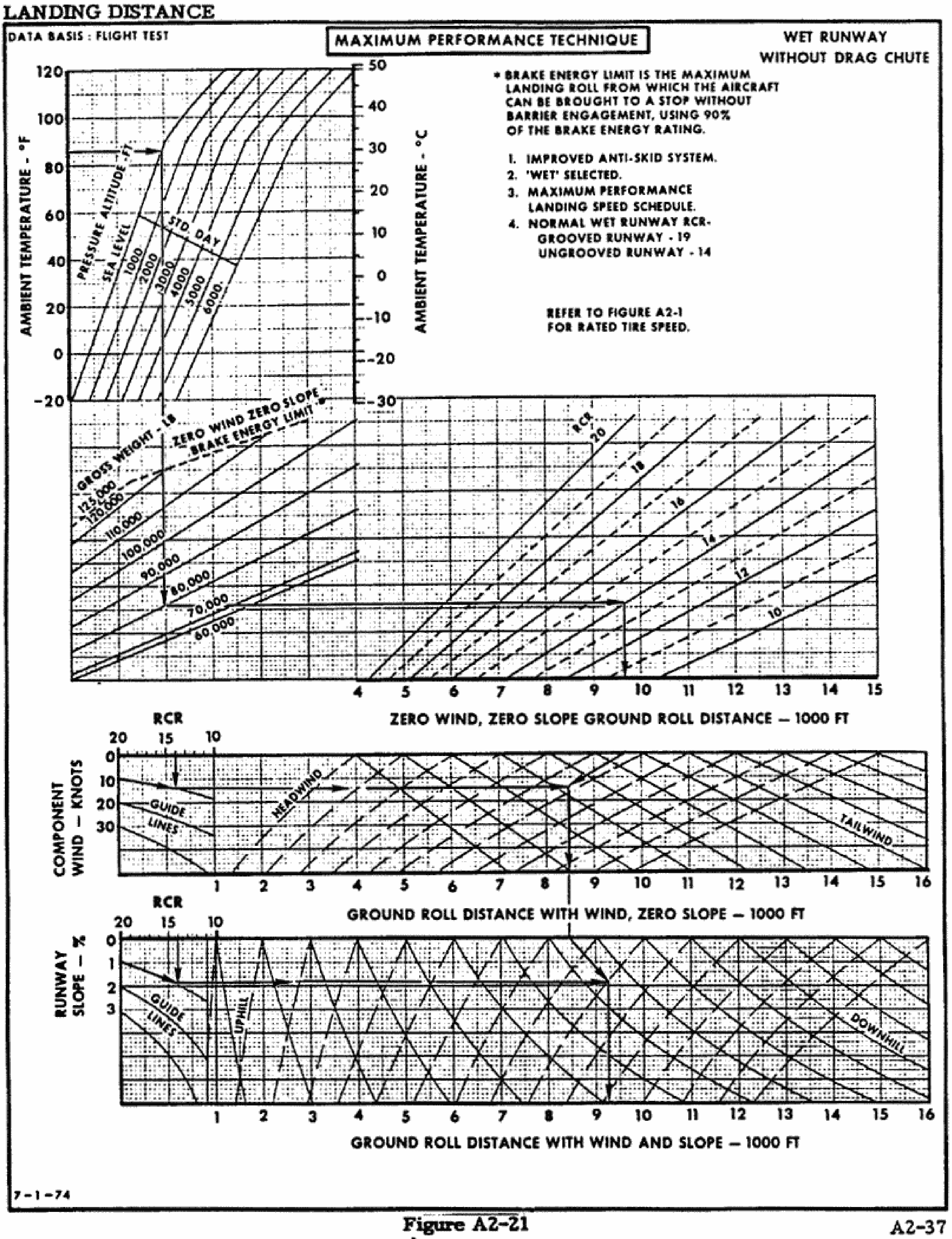


Figure A2-21

LANDING AIR DISTANCE

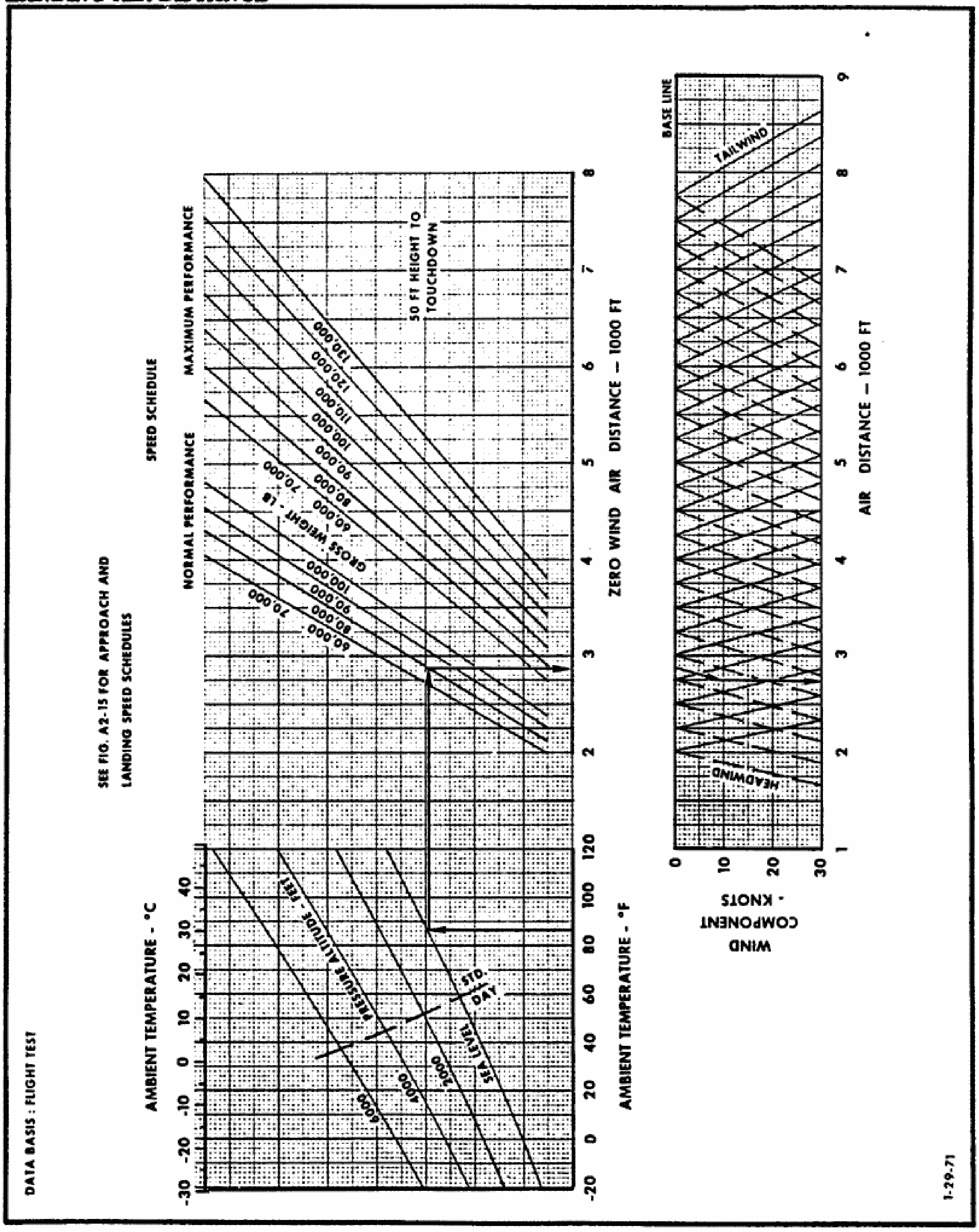


Figure A2-22

[redacted]

PART III

CLIMB AND DESCENT PERFORMANCE

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

CLIMB AND DESCENT DATA

This part of the appendix contains planning information for the climb and descent portions of a mission. Charts are provided for the normal 450 KEAS supersonic climb schedule and for the 350 KEAS descent. Additional information is provided for an alternate 400 KEAS supersonic climb, for single engine subsonic climbs, and for single engine supersonic descents.

NORMAL CLIMB

Time, fuel and distance requirements for the normal 450 KEAS climb schedule are shown in Figures A3-1 through A3-16. Allowances are tabulated on Figure A3-1 and A3-2 for ground operation, for takeoff at altitudes other than Sea Level, and for climb after refueling. Figures A3-9 and A3-10 summarize normal climb acceleration performance from brake release for a standard day and tropic day, respectively. A normal operating range of gross weights is presented.

Subsonic Climb Performance

Figures A3-1 and A3-2 provide two engine climb performance from brake release at Sea Level to Mach 0.90 at 30,000 feet for standard and tropic atmospheres, respectively. The data can be used on an incremental basis for climbs between other altitudes in this range. Performance is supplied for initial gross weights from 90,000 pounds to 140,000 pounds. Correction grids are provided for temperature deviations of $\pm 10^{\circ}C$.

Transonic Acceleration Performance

Figures A3-2 through A3-8 show the time, distance, and fuel required for transonic acceleration. Performance is supplied for initial gross weights from 90,000 pounds to 140,000 pounds at temperatures ranging $\pm 10^{\circ}C$ from the standard and tropic atmospheres. The charts also provide total time, distance and fuel required to accelerate to Mach 1.25 at 30,000 feet after

Sample Use of Charts

Determine the time, fuel, and distance required for a standard day climb from sea level takeoff to Mach 3.0 at 70,600 feet. Gross weight at engine start is 136,800 pounds.

Segment	Time	Fuel Used	Distance	End Weight
Start Engines	0	0	0	136,800
Ground Maneuver (150 lb/min)	(0:20)	3,000 3,000	0	133,800
Climb to 30,000 feet (Figure A3-1) Std Day	0:04.6 0:04.6	6,400 9,400	34 34	127,400
Accel to Mach 1.25 (Figure A3-5) Std Day	0:02.2 0:06.8	3,000 12,400	22 56	124,400
Climb to 70,600 feet (Mach 3.0, 410 KEAS (Figure A3-11)	0:13.1 0:19.9	17,300 29,700	272 328	107,100
	Min.	Lb.	NMi	Lb.

refueling at Mach 0.75 and 25,000 feet. The added allowances are based on the use of minimum afterburner for the subsonic acceleration, or for acceleration and climb to the initiation of maximum afterburner power at Mach 0.90.

Performance charts are included for three types of maximum power acceleration techniques.

1. Climb-and-descent: Climb at Mach 0.90 from 30,000 feet to 33,000 feet, and then descend at 3000 fpm to Mach 1.25 at 30,000 feet. (See Figure A3-5.)

2. Level acceleration: Accelerate from Mach 0.90 to Mach 1.25 at 30,000 feet. (See Figure A3-6.)

3. Level acceleration and climb: Accelerate from Mach 0.90 to 450 KEAS at 25,000 feet and climb at 450 KEAS to Mach 1.25 at 30,000 feet. (See Figure A3-7.)

Figure A3-8 presents a performance comparison of the transonic acceleration techniques for an initial gross weight of 140,000 pounds at Mach 0.75 and 25,000 feet. The chart illustrates the effect of ambient temperature and shows that at ambient temperatures below standard, all three techniques have similar fuel consumption but the climb-and-descent technique improves range since more distance is covered for the same fuel consumption. At temperatures hotter than standard, the climb-and-descent technique reduces fuel consumed 700 to 900 pounds in a tropic atmosphere (approximately 13°C hotter than standard between 25,000 feet and 30,000 feet), and as much as 1300 to 1900 pounds at a temperature deviation 22°C hotter than standard.

Any necessary heading changes should be made prior to the transonic acceleration, as turns would seriously degrade performance during this phase. A 32° banked turn at 25,000 feet, initiated between Mach 0.75 and 0.80 at 140,000 pounds will increase time, distance, and fuel used by 0.5 minutes, 5 nautical miles, and 500 pounds, respectively, for a ninety degree change in aircraft heading.

__Supersonic Acceleration & Climb__

Performance for the supersonic climbing acceleration is provided by Figures A3-11 through A3-16. Data is provided for standard and tropic atmospheres including temperature deviations of ± 10°C. Enter the chart with the end-of-transonic acceleration weight determined from Figures A3-5 through A3-8.

When a constant Mach climb is required to reach cruise altitude after attaining the desired Mach, climb at Maximum afterburning power. For planning purposes, 4000 ft/min rate of climb and 900 pounds/minute fuel flow.

400 KEAS CLIMB

Figure A3-17 summarizes time, fuel, and distance required from takeoff for an alternate, 400 KEAS supersonic climb schedule at a nominal takeoff gross weight of 130,000 lb.

SINGLE-ENGINE CLIMB

Figures A3-3 and A3-4 show the time, fuel, and distance requirements for single engine climb from sea level to the altitudes at which 300 ft/min rate of climb is reached. Performance is shown for Standard and Tropic days, respectively. These charts can be used on an incremental basis to determine requirements for climbing to single engine cruise altitudes. (See Part IV of this appendix and Section III.) The data are based on Maximum afterburning climb at 400 KEAS to Mach 0.85, then Mach 0.85 to the 300 ft/min ceiling. (If the climb is continued above this ceiling, a cruise-climb at 200-250 ft/min rate of climb will result.)

Example

Find the time, distance and fuel required for a single engine climb from sea level to 20,000 feet. The initial climb gross weight is 115,000 pounds and the forecast ambient temperature for the climb is approximately 10°C hotter than a Tropic atmosphere. Enter Figure A3-4 at a gross weight of 115,000 pounds, follow the temperature guide lines at 10°C hot. Proceed to a pressure altitude of 20,000 feet and read distance travelled as 98 nautical miles, time of 12.2 minutes and 13,100 pounds of fuel used. Rate of climb at an average altitude of 10,000 feet is 1600 feet per minute.

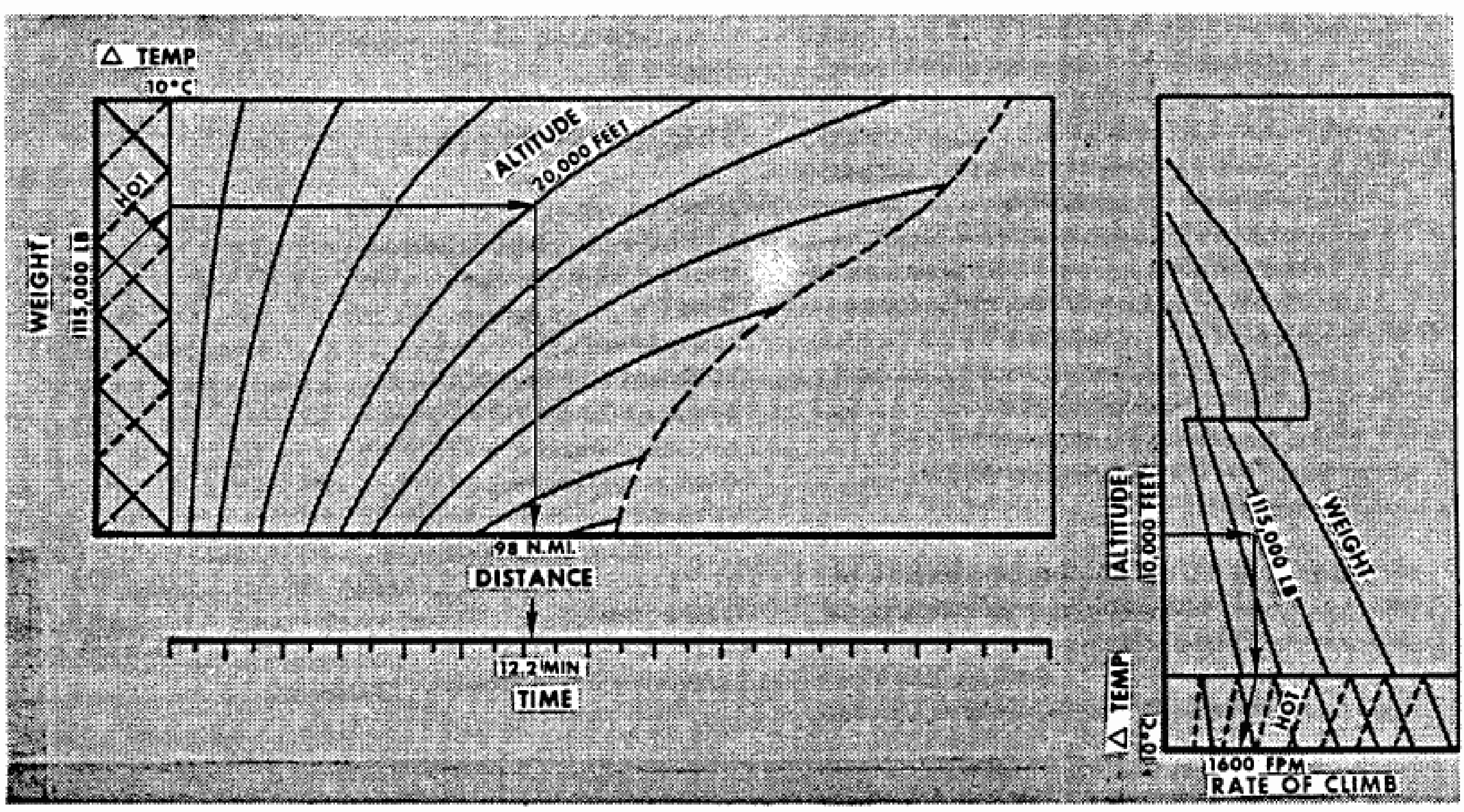
NORMAL DESCENT

Time, fuel, and distance requirements for 350 KEAS descents are shown in Figures A3-18 thru A3-21. Figure A3-18 applies to on course descents when 720°C EGT is set at the start of descent and 6900 RPM is set at Mach 2.5. Ambient temperature has very little effect on the performance shown. (On a Tropic day, total distance from start of descent increases 10 nautical miles and time increases 0.5 minutes.) Figure A3-21 shows the performance which would result for the same power schedule when a 180° turn is required. Figure A3-19 shows performance for on-course descents when Military thrust is set at the start of descent and 6900 RPM is set at Mach 2.5. This power schedule results in a total distance increase of approximately 10 nautical miles over the 720°C EGT descent schedule. Figure A3-20 shows performance for on-course descents when Military thrust is set at the start of descent and 720°C EGT is set at Mach 2.5. This power schedule results in a total distance increase of approximately 70 nautical miles over the 720°C EGT descent schedule, but uses approximately 1700 lb. more fuel.

Example

Find the time, distance and fuel required for a two engine on course descent from

SINGLE ENGINE CLIMB



Mach 3.10 at 80,000 feet, descending at 350 KEAS to 15,000 feet. EGT is set at 720°C at the start of the descent, 6900 RPM at Mach 2.5 and 6100 RPM below 31,300 feet. Enter Figure A3-18 at 80,000 feet and Mach 3.10 and read 8.5 minutes, 168 nautical miles and 1190 pounds of fuel for the descent to 31,300 feet. Re-enter at the final altitude of 15,000 feet and the 6100 RPM line and read 4.8 minutes, 39 nautical miles and 1100 pounds of fuel. Total time, distance and fuel are 13.3 minutes, 207 nautical miles and 2290 pounds.

Example

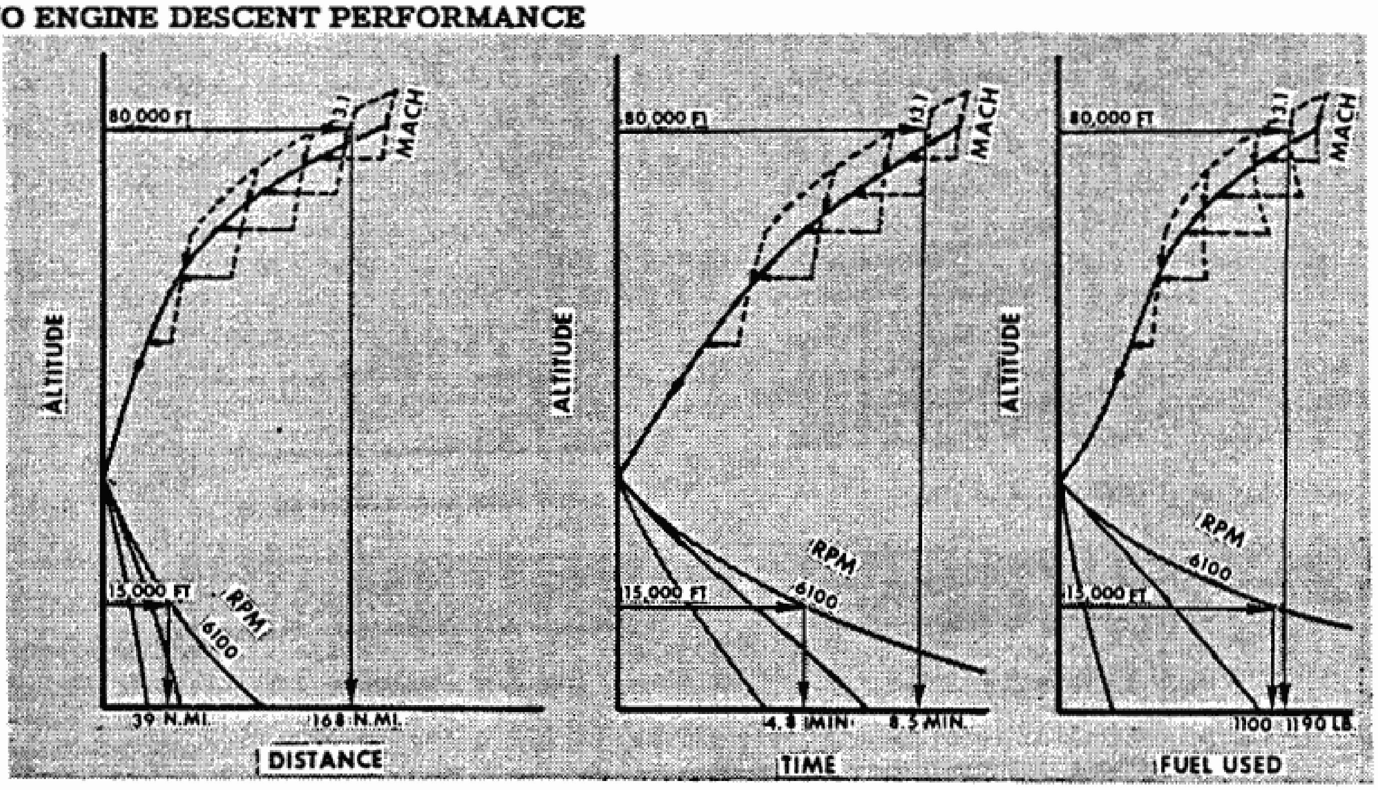
Find the track time, distance and fuel required for a two engine descent from Mach 3.20 at 79,800 feet descending at 350 KEAS to 25,000 feet. A 120 degree turn is to be completed above 50,000 feet. EGT is set at 720°C at the start of the descent, 6900 RPM at Mach 2.5 and 6100 RPM below 31,300 feet. Enter figure A3-21 at 120 degrees of turn and note that the turn is completed at an altitude of 59,500 feet. Read time in the descending turn to that altitude as 4.1 minutes, penetration distance as 58 nautical miles and 560 pounds of fuel used. Enter the ground track profile at the 58 nautical mile penetration distance and read 100 nautical miles travelled at a course offset distance of 60 nautical miles. Enter Figure A3-18 at 59,500 feet (end of turn altitude) and read time, distance and fuel required in the descent to Mach 1.0 at 31,300 feet as 3.8 minutes, 52 nautical miles and 540 pounds. Re-enter at the final altitude of 25,000 feet on the 6100 RPM line and read time, distance and fuel required as 1.3 minutes, 13 nautical miles and 260 pounds. Total time, distance and fuel for the turning descent is 9.2 minutes, 165 nautical miles and 1360 pounds.

SINGLE-ENGINE DESCENT

Figures A3-22 and A3-23 show performance requirements for on-course, single engine supersonic descents with Maximum and Minimum afterburning power, respectively, selected at the start of descent. The charts are indexed to an altitude of 50,000 feet and show the effects of operating at reduced power below that altitude.

Figure A3-24 shows the performance to be expected at Maximum afterburning power when a 180° turn is required. (A turning descent at less than Maximum afterburning power may result in exceeding the rate of descent limitations in Section V.)

TWO ENGINE DESCENT PERFORMANCE

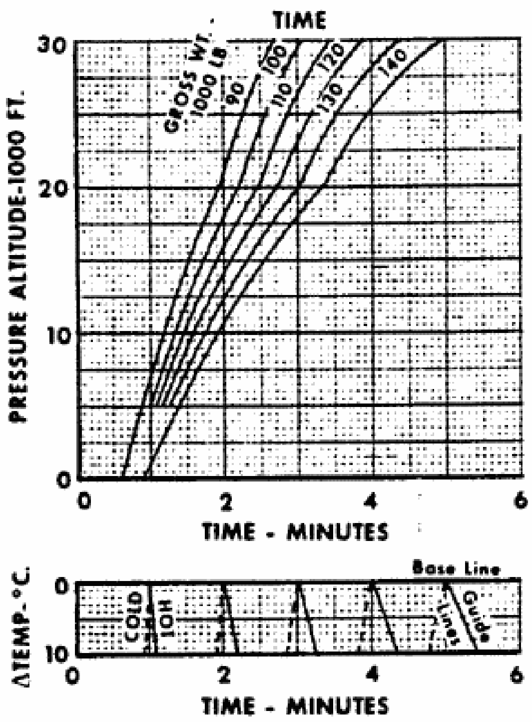


[redacted]

SUBSONIC CLIMB PERFORMANCE

DATA BASIS: FLIGHT TEST

BRAKE RELEASE AT S.L. TO 0.90 MACH AT 30,000 FT.
NORMAL PROCEDURE CLIMB
1956 ARDC STANDARD DAY



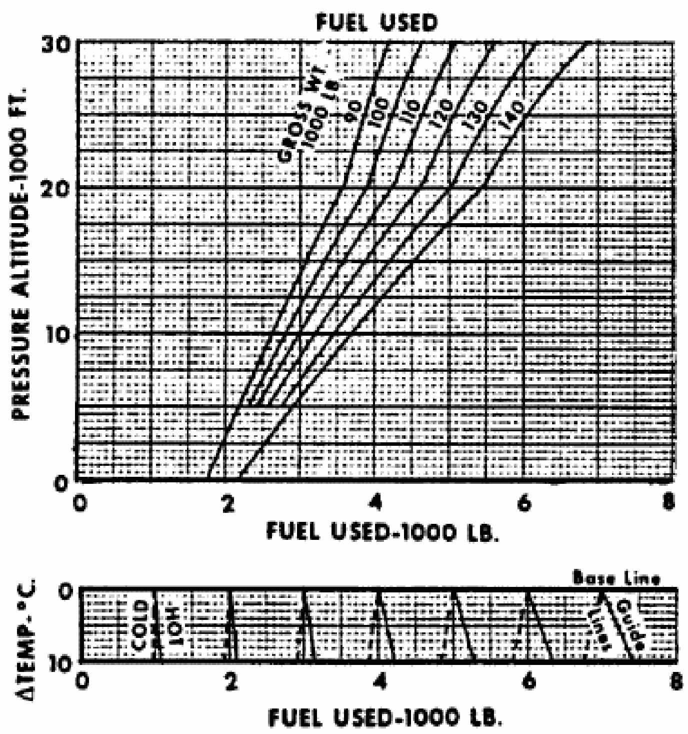
GROUND MANEUVER FUEL - 150 LB/MIN.

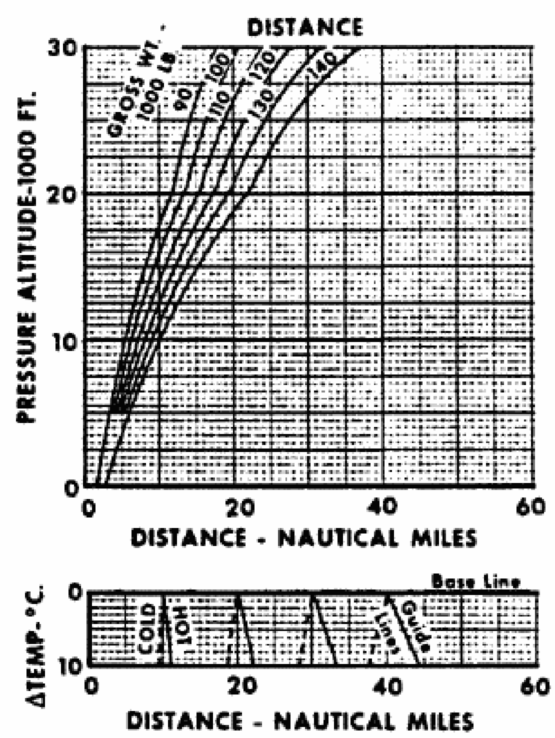
MAX. A/B TAKEOFF
MIN. A/B WHEN GEAR IS UP
CLIMB AT 400 KEAS TO 0.90 MACH NO.
CLIMB AT 0.90 MACH NO. TO 30,000 FT.

TIME, FUEL, AND DISTANCE CORRECTIONS FOR TAKEOFF AT FIELD ELEVATIONS OTHER THAN SEA LEVEL:

ΔTIME = 0.1 MIN./1000 FT.
ΔFUEL = 200 LB/1000 FT.
ΔDIST. = 1.0 N.MI./1000 FT.
SUBTRACT FROM CHART VALUES

AIR REFUELING CLIMB - 300 KEAS AT 24,000 FT. TO 0.90 MACH NO. AT 30,000 FT.
TIME = 1.6 MIN.
FUEL = 1200 LB.
DIST. = 14 N.MI.





8-2-71

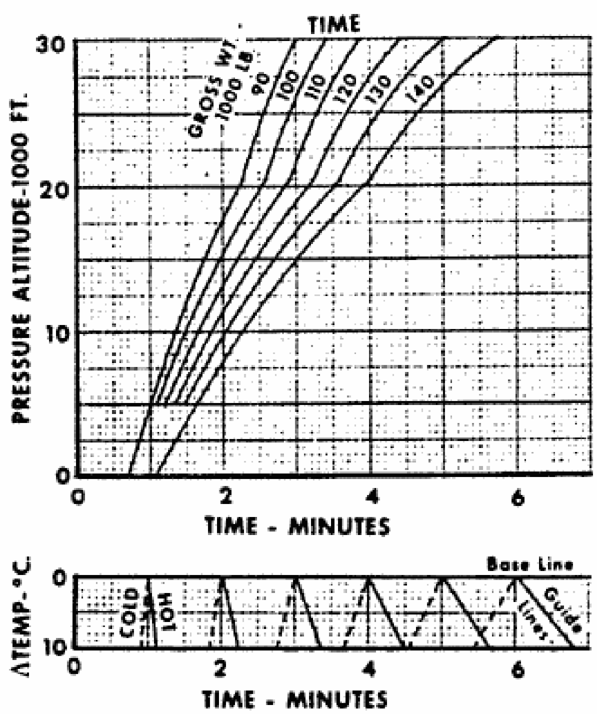
Figure A3-1

SUBSONIC CLIMB PERFORMANCE

DATA BASIS: FLIGHT TEST

BRAKE RELEASE AT S.L. TO 0.90 MACH AT 30,000 FT.

NORMAL PROCEDURE CLIMB
MIL-STD-210A TROPIC DAY



GROUND MANEUVER FUEL - 150 LB/MIN.

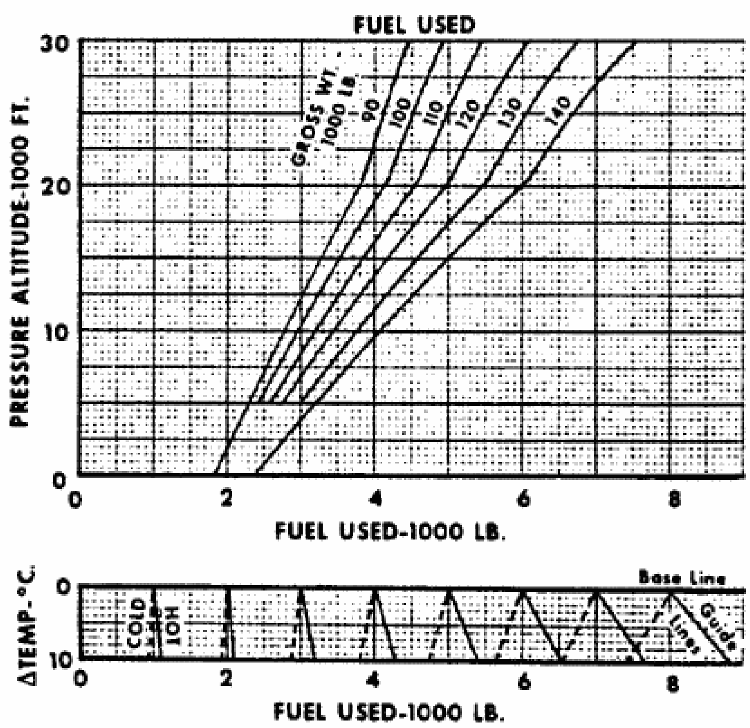
MAX. A/B TAKEOFF
MIN. A/B WHEN GEAR IS UP
CLIMB AT 400 KEAS TO 0.90 MACH NO.
CLIMB AT 0.90 MACH NO. TO 30,000 FT.

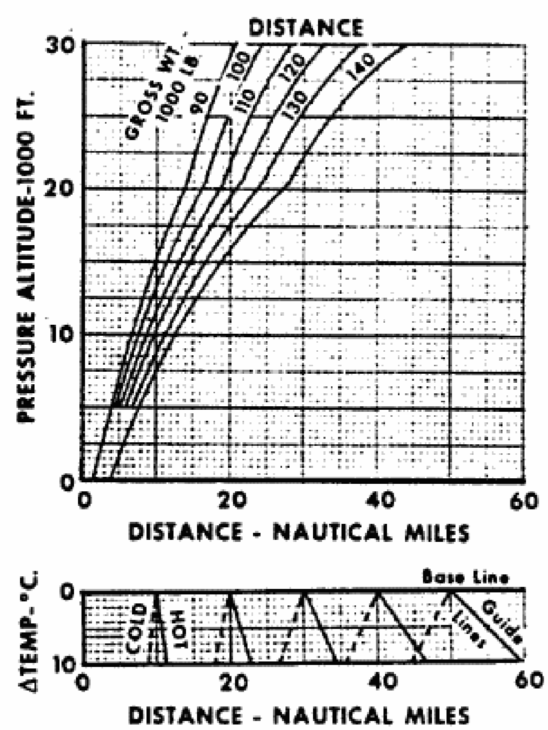
TIME, FUEL, AND DISTANCE CORRECTIONS FOR TAKEOFF AT FIELD ELEVATIONS OTHER THAN SEA LEVEL:

ΔTIME = 0.1 MIN./1000 FT.
ΔFUEL = 200 LB/1000 FT.
ΔDIST. = 1.0 N.MI./1000 FT.
SUBTRACT FROM CHART VALUES

AIR REFUELING CLIMB - 300 KEAS AT 24,000 FT. TO 0.90 MACH NO. AT 30,000 FT.

TIME = 1.6 MIN.
FUEL = 1200 LB.
DIST. = 14 N.MI.





8-2-71

Figure A3-2

SINGLE-ENGINE CLIMB

DATA BASIS: FLIGHT TEST

ARDC STANDARD DAY

22% MAC C.G.

ONE ENGINE MAX. A/B
ONE ENGINE WINDMILLING

CLIMB SCHEDULE: 400 KEAS-0.85MN

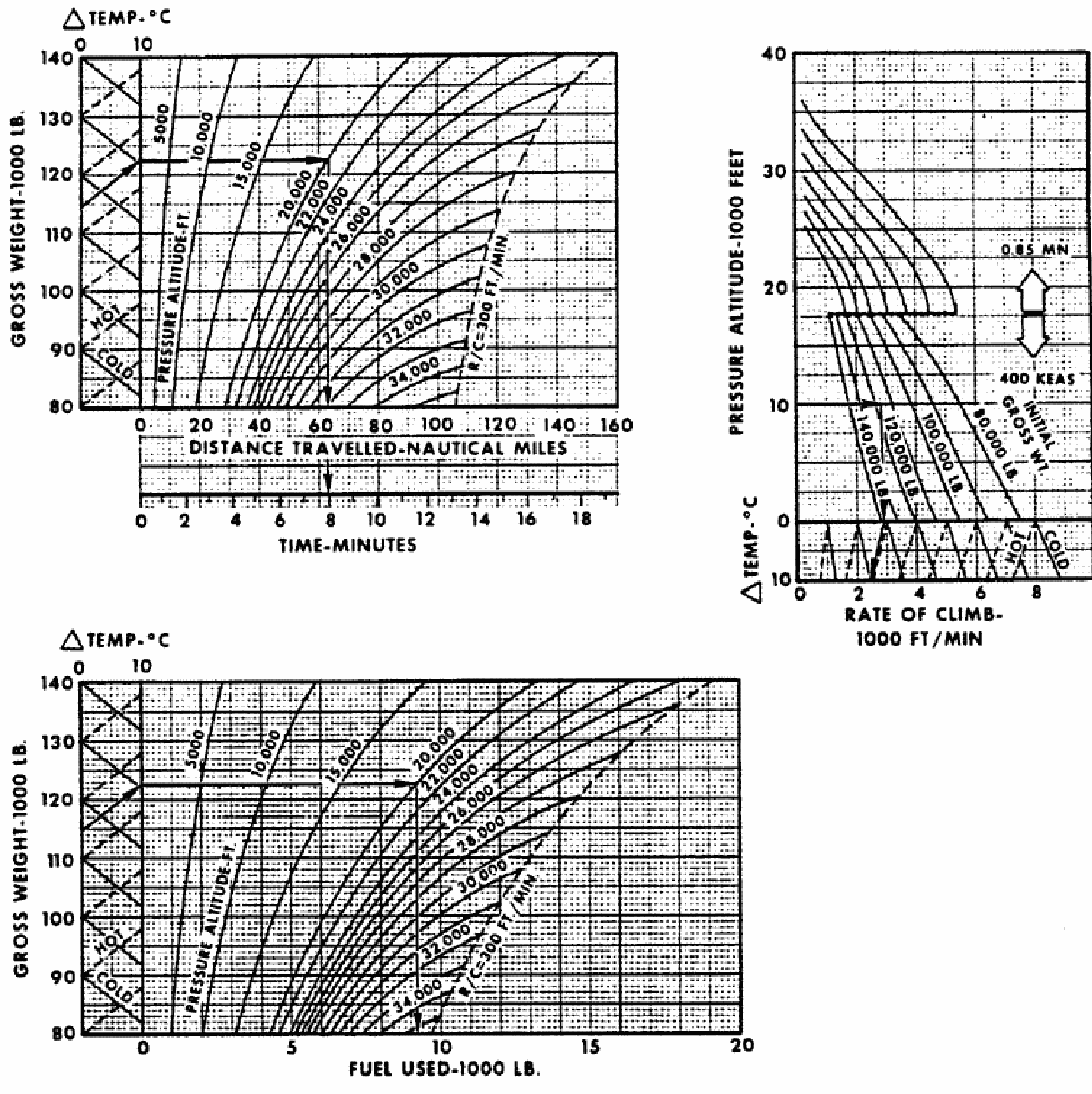


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Figure A3-3

SINGLE-ENGINE CLIMB

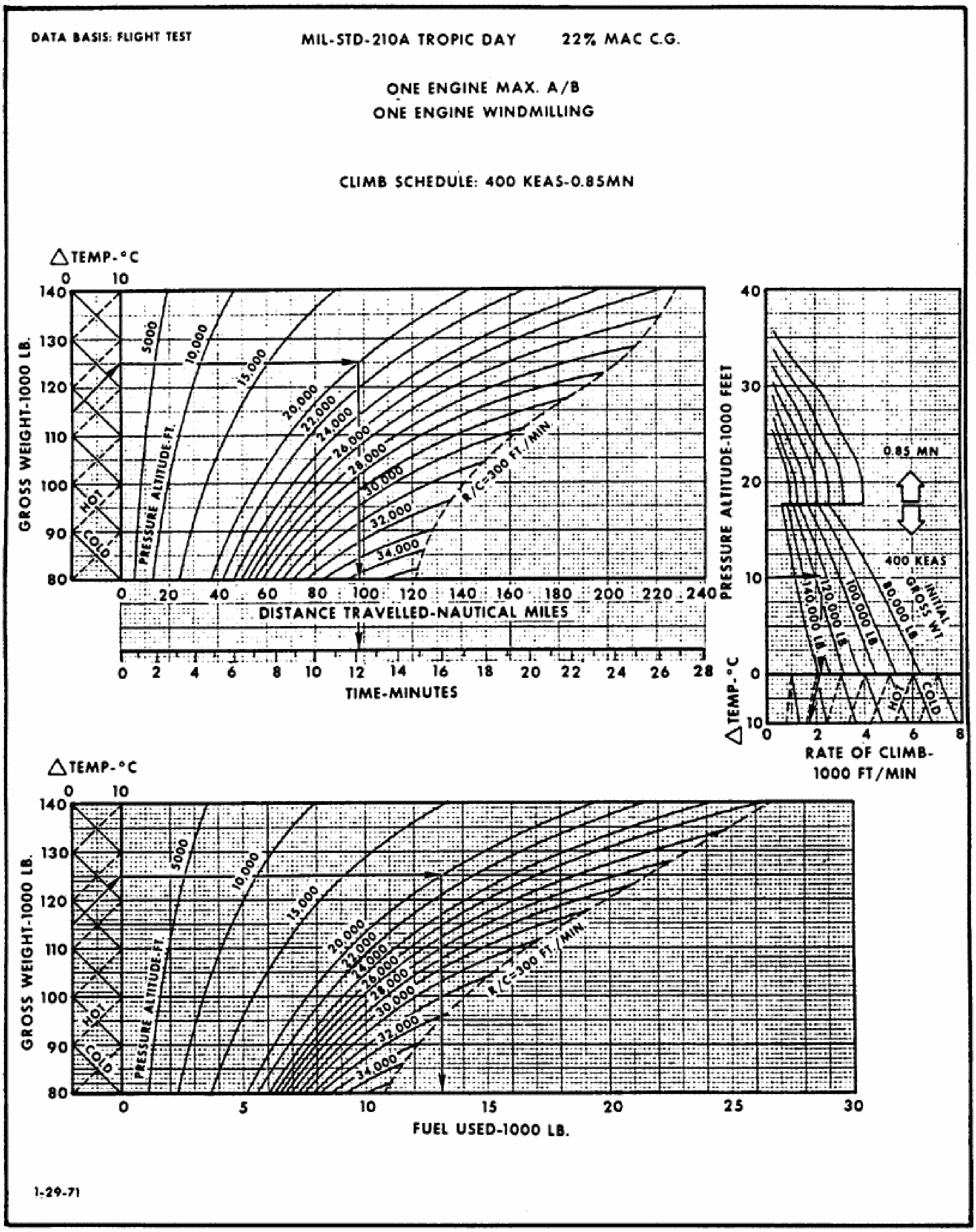


Figure A3-4

TRANSONIC ACCLERATION PERFORMANCE

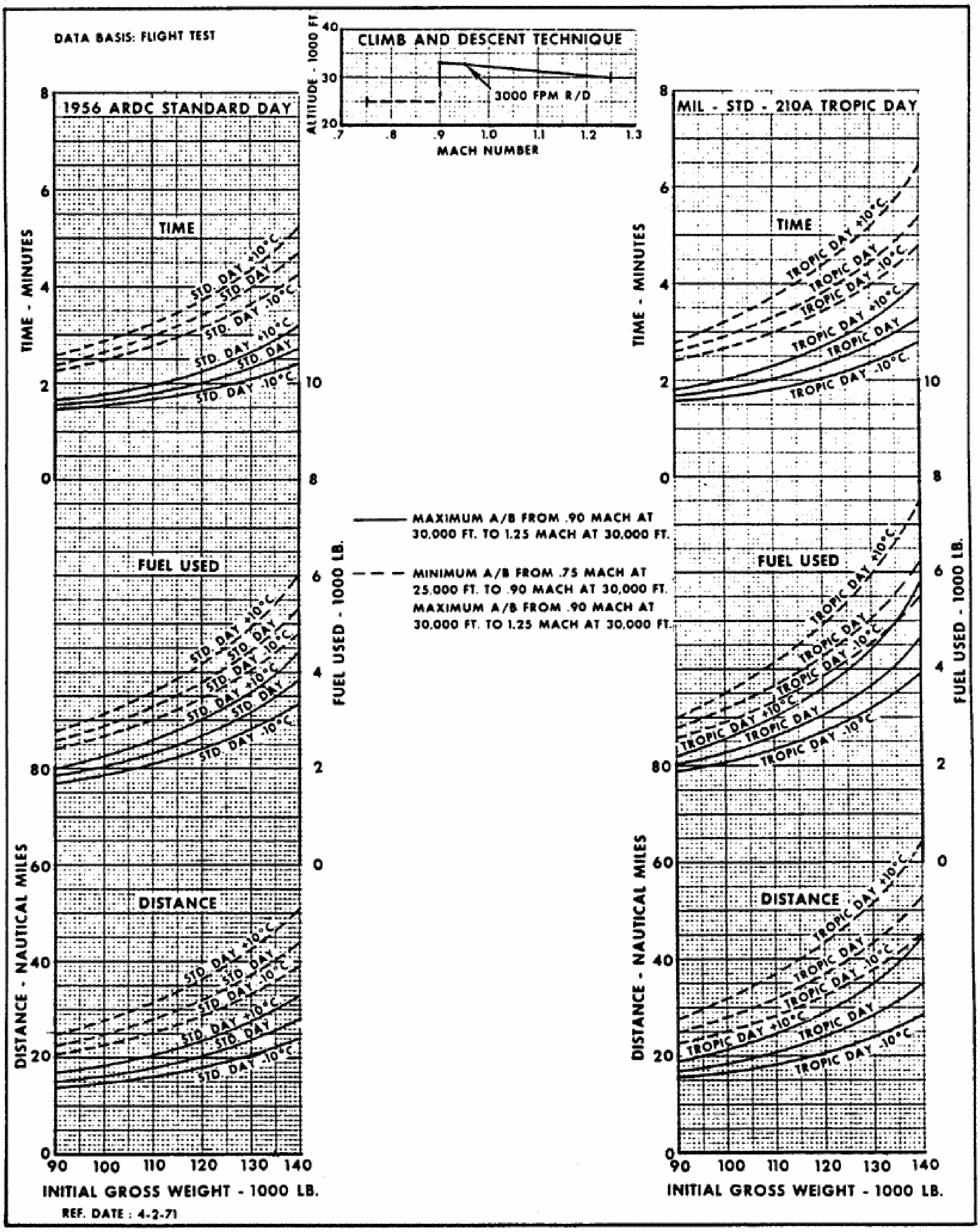


Figure A3-5

TRANSONIC ACCELERATION PERFORMANCE

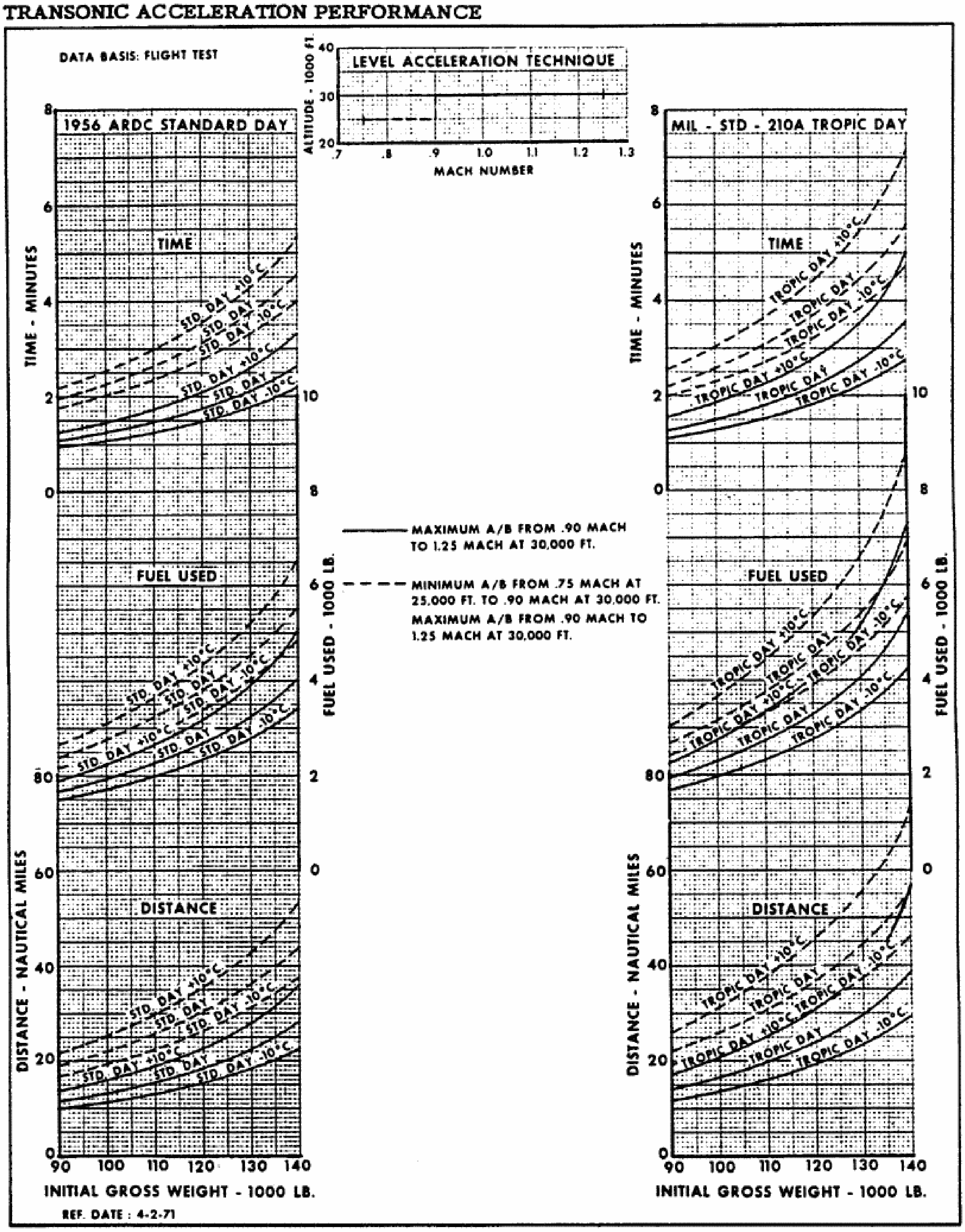


Figure A3-6

TRANSONIC ACCELERATION PERFORMANCE

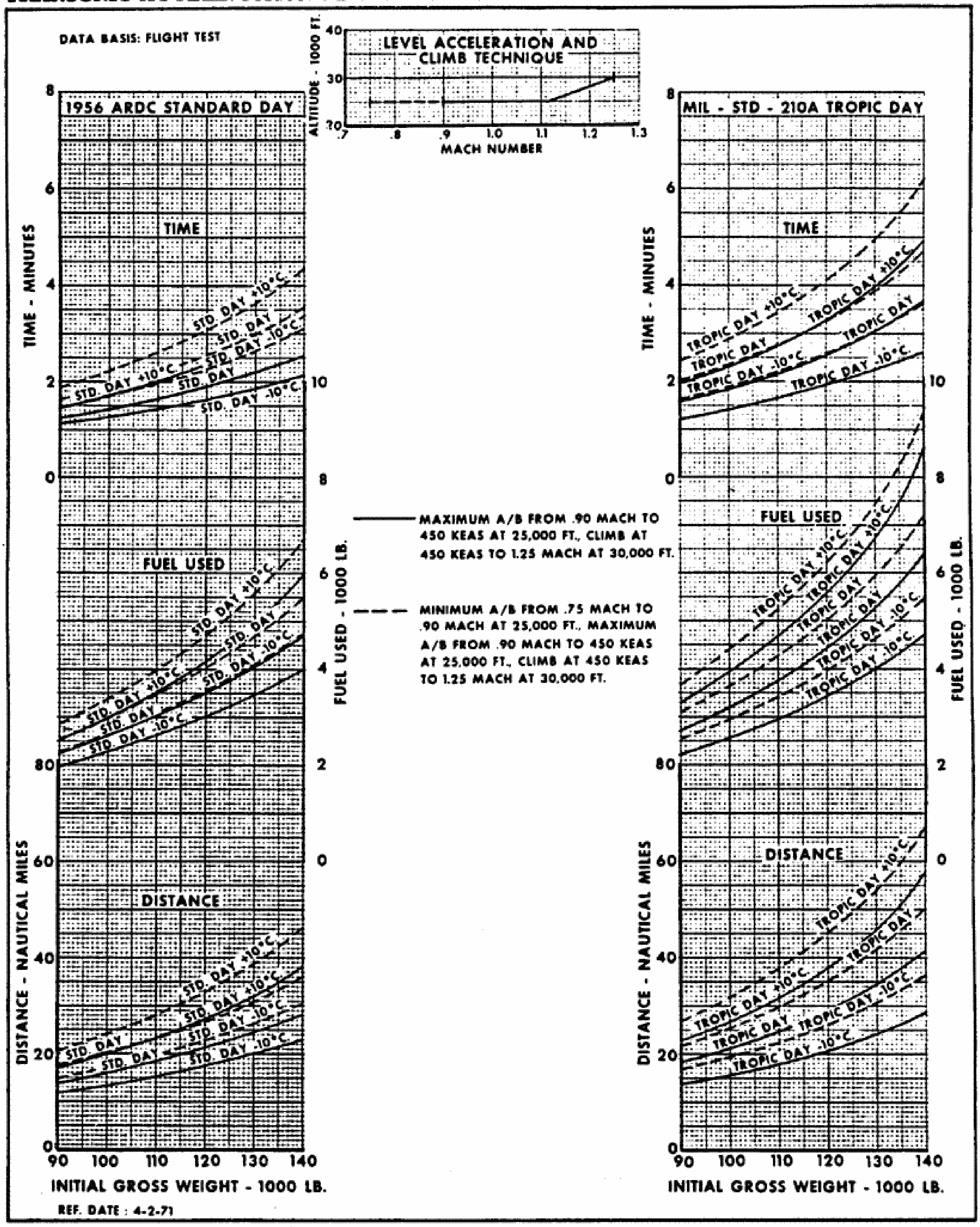
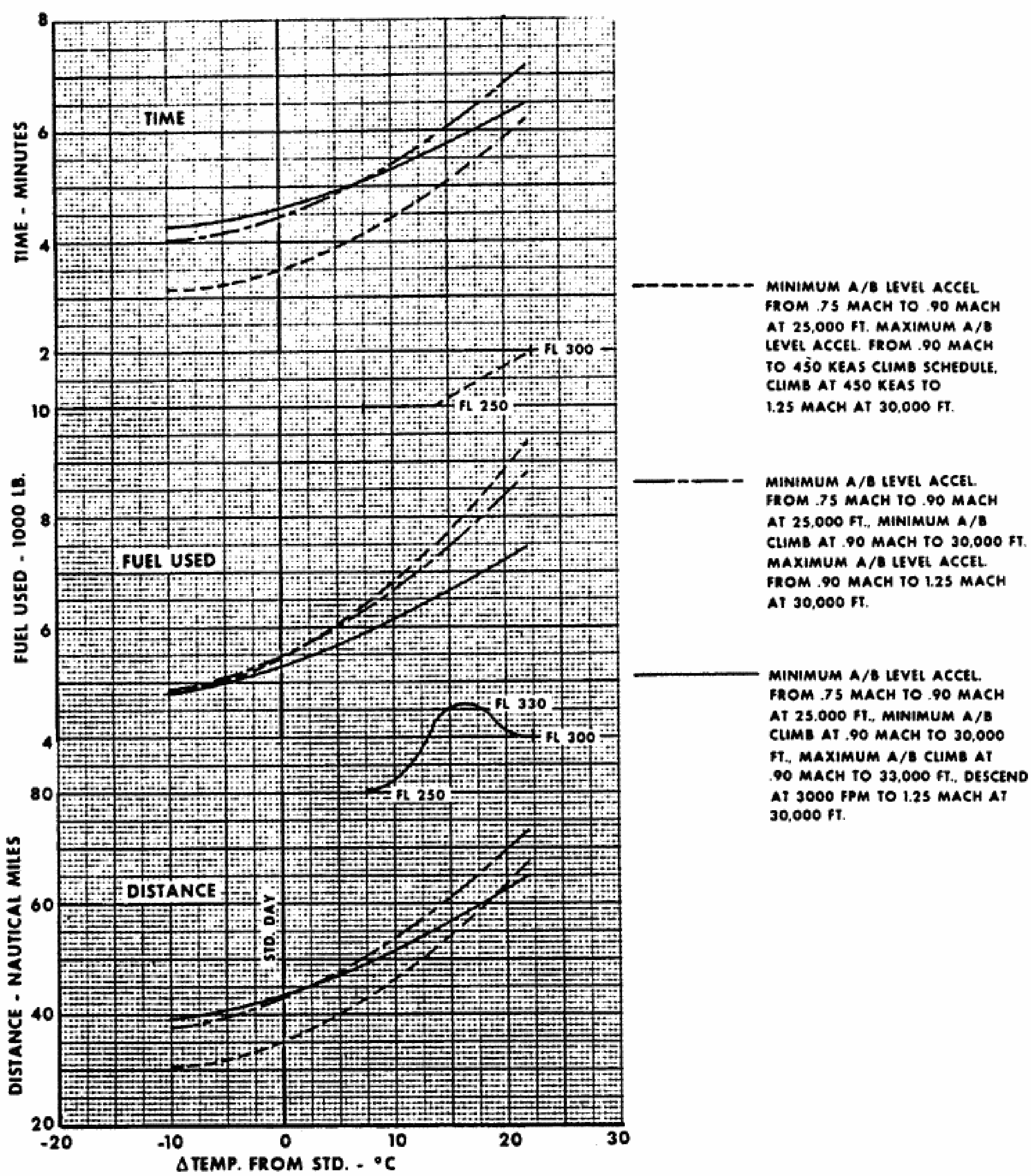


Figure A3-7

TRANSONIC ACCELERATION PERFORMANCE

DATA BASIS: FLIGHT TEST .75 MACH AT 25,000 FT. TO 1.25 MACH AT 30,000 FT.

140,000 LB. INITIAL GROSS WEIGHT AT .75 MACH AND 25,000 FT.



REF. DATE : 4-2-71

Figure A3-8

NORMAL PROCEDURE CLIMB

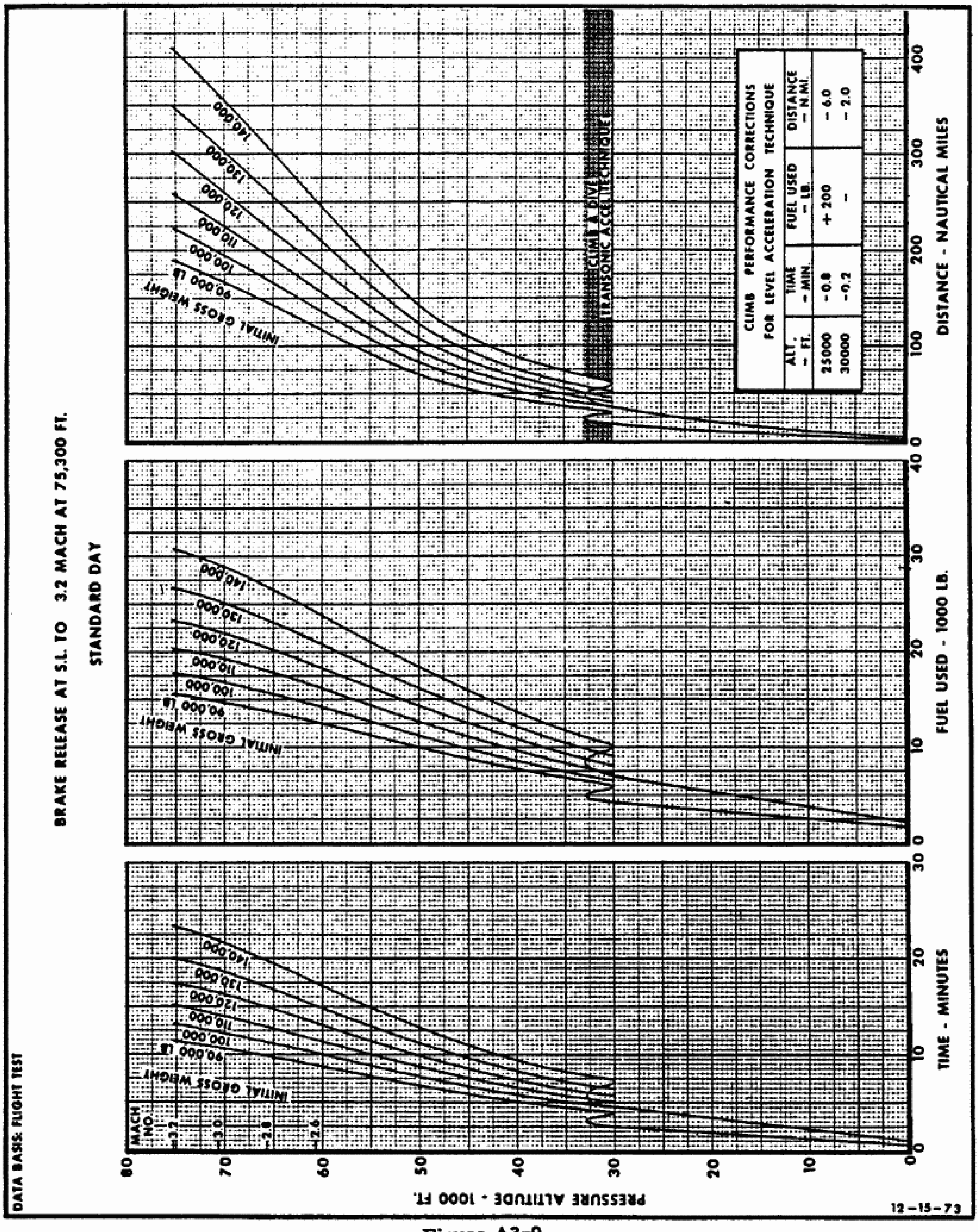
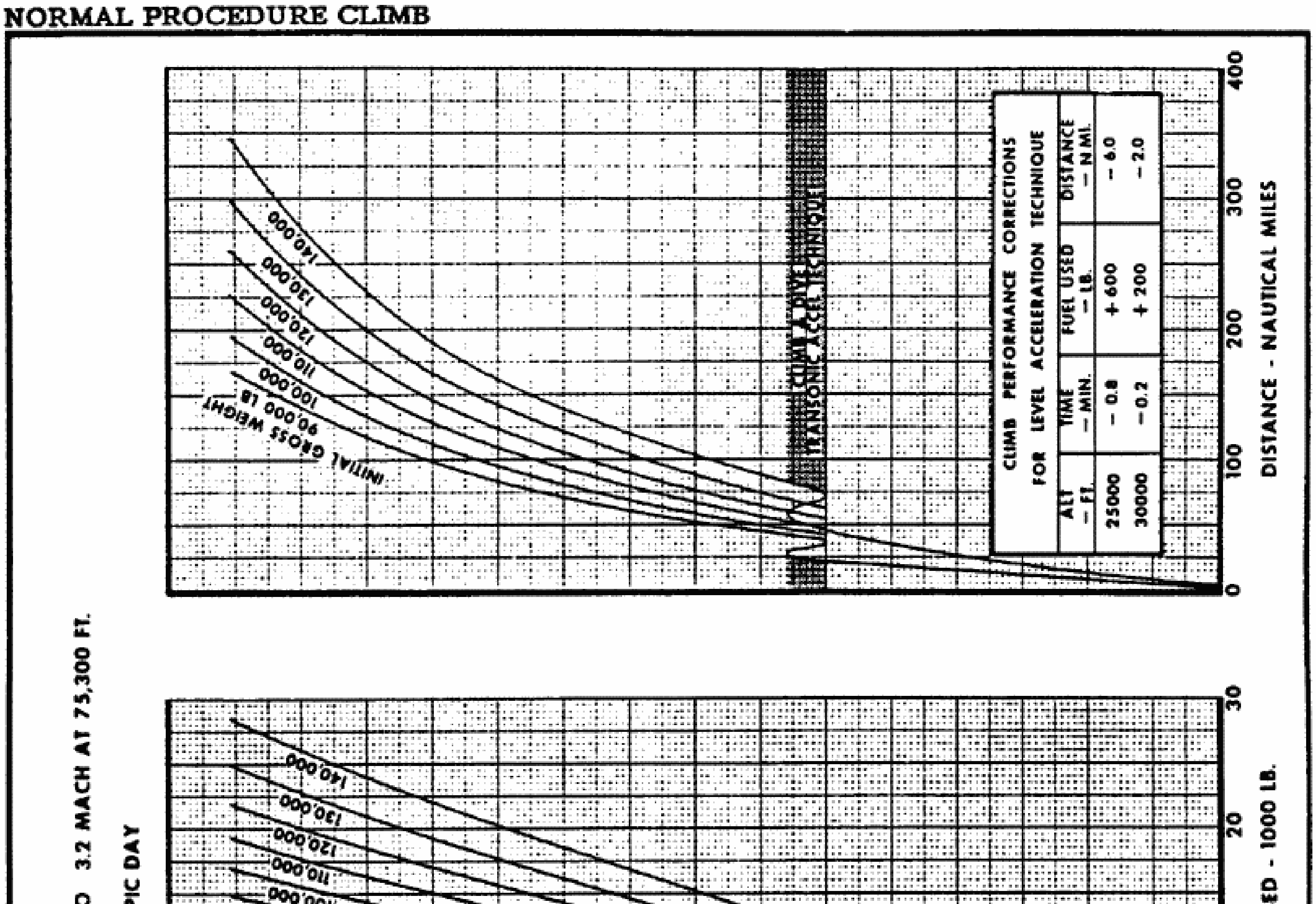


Figure A3-9

NORMAL PROCEDURE CLIMB



CLIMB PERFORMANCE CORRECTIONS FOR LEVEL ACCELERATION TECHNIQUE

ALT – FT.	TIME – MIN.	FUEL USED – LB.	DISTANCE – N MI.
25000	– 0.8	+ 600	– 6.0
30000	– 0.2	+ 200	– 2.0

Figure A3-10

SUPERSONIC CLIMB PERFORMANCE – NORMAL PROCEDURE CLIMB

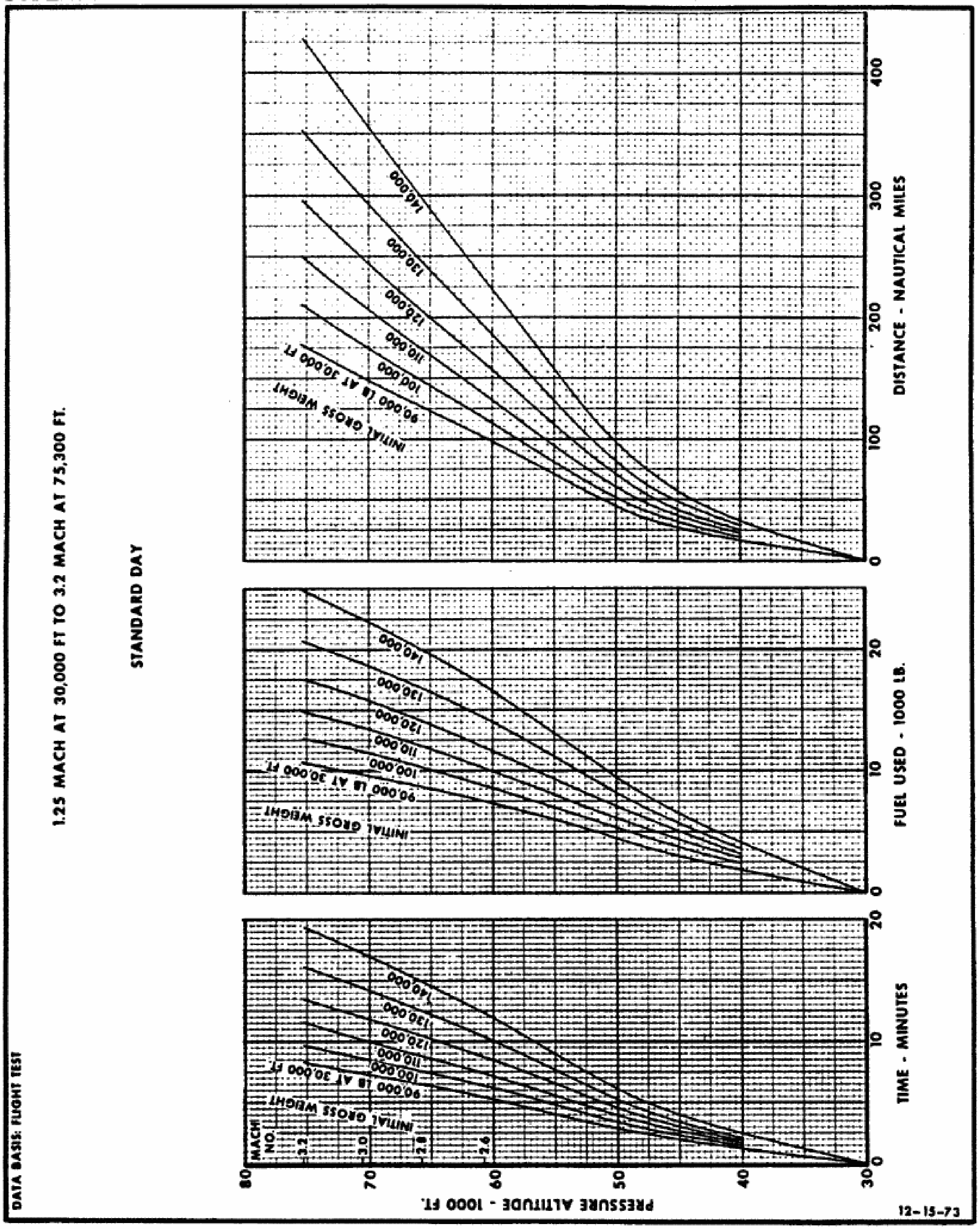


Figure A3-11

SUPERSONIC CLIMB PERFORMANCE – NORMAL PROCEDURE CLIMB

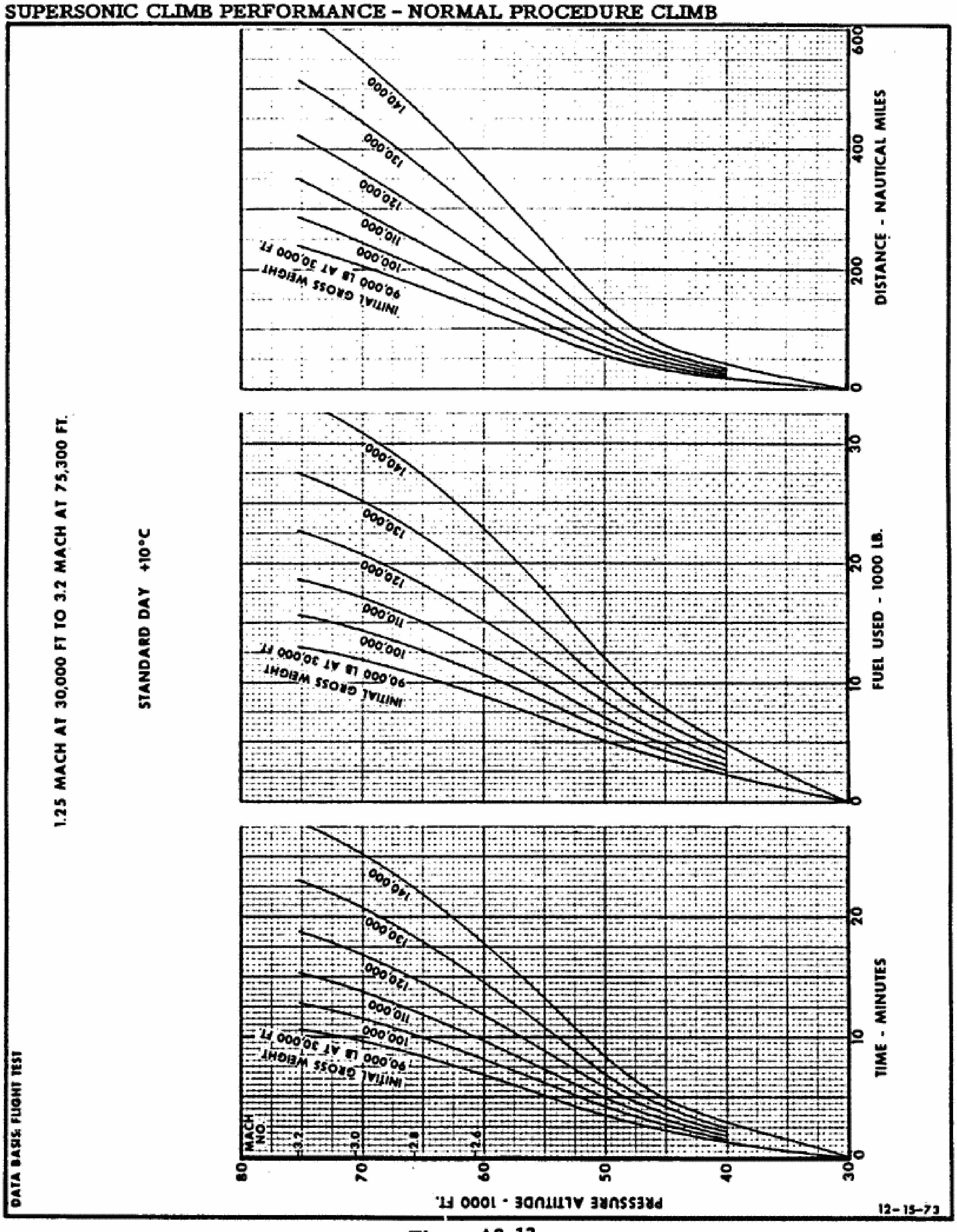


Figure A3-12

SUPERSONIC CLIMB PERFORMANCE – NORMAL PROCEDURE CLIMB

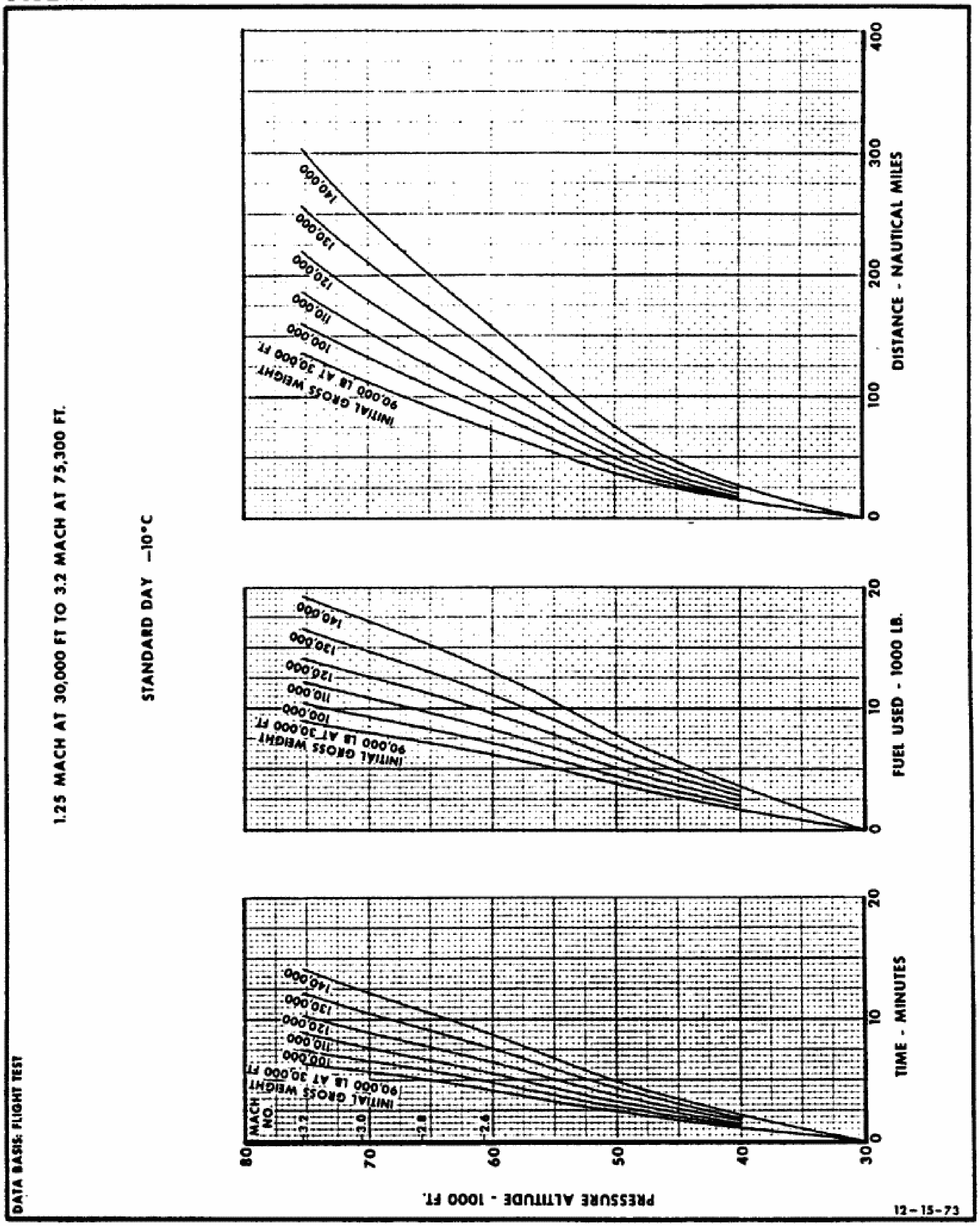


Figure A3-13

SUPERSONIC CLIMB PERFORMANCE – NORMAL PROCEDURE CLIMB

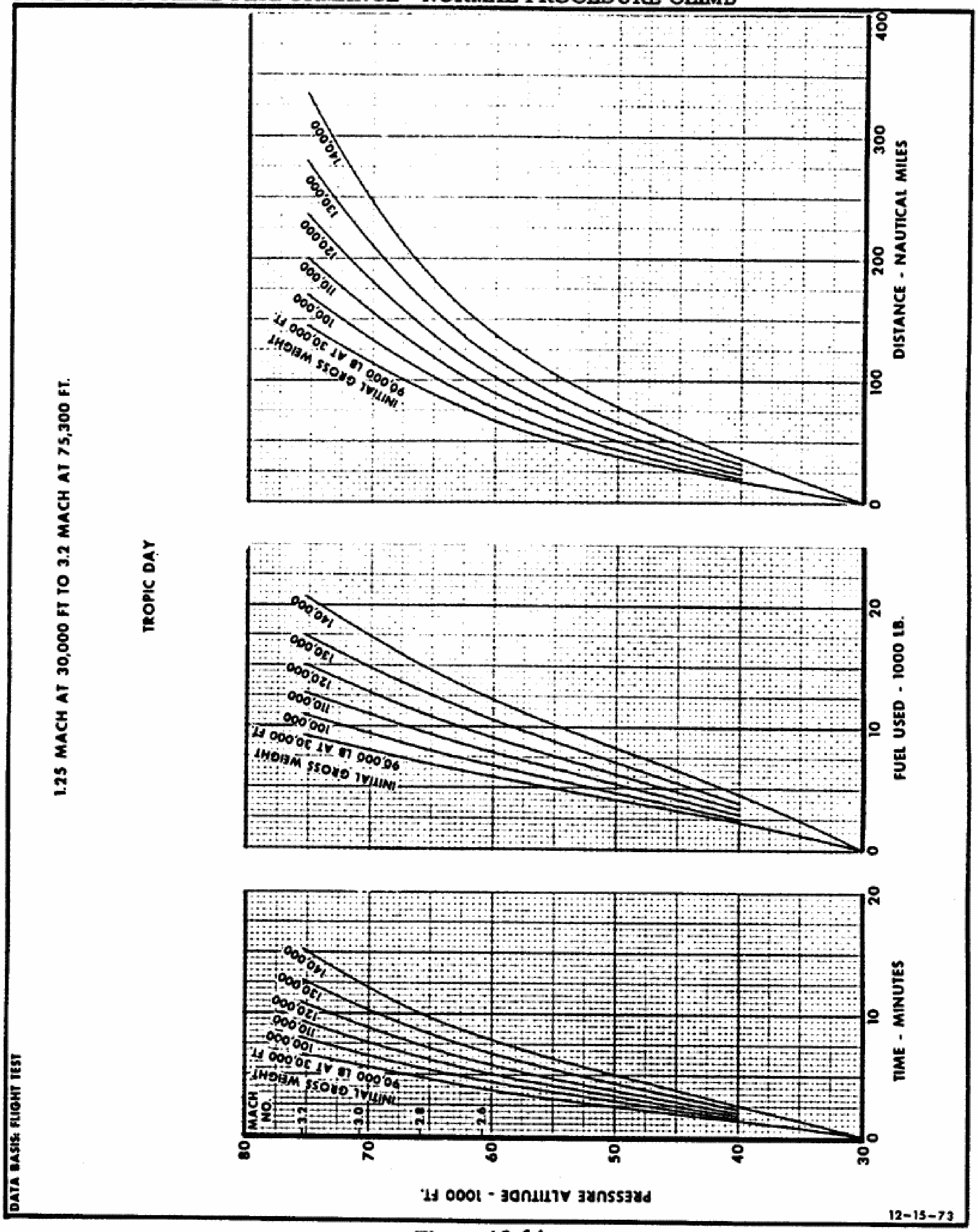


Figure A3-14

SUPERSONIC CLIMB PERFORMANCE – NORMAL PROCEDURE CLIMB

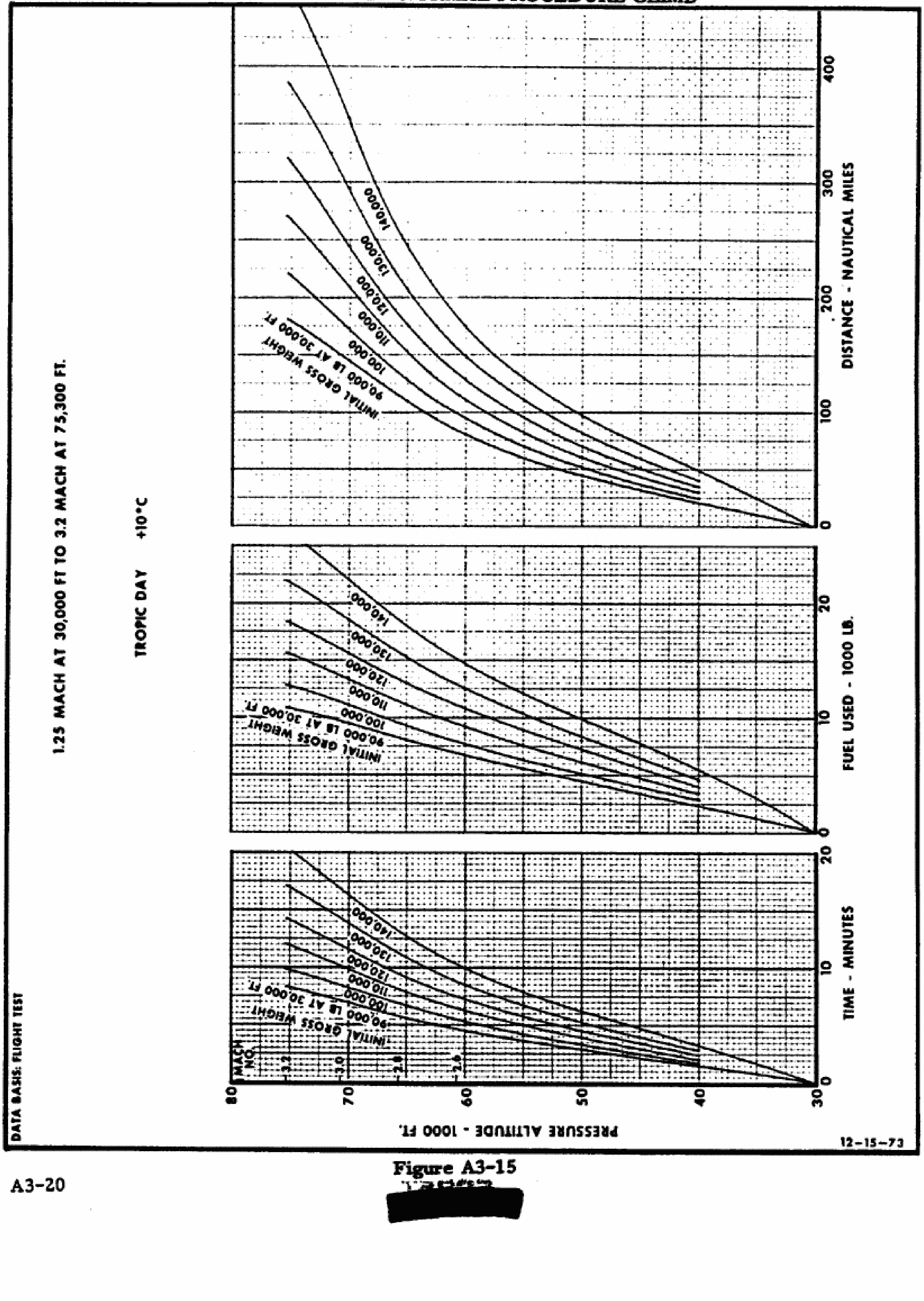


Figure A3-15

SUPERSONIC CLIMB PERFORMANCE – NORMAL PROCEDURE CLIMB

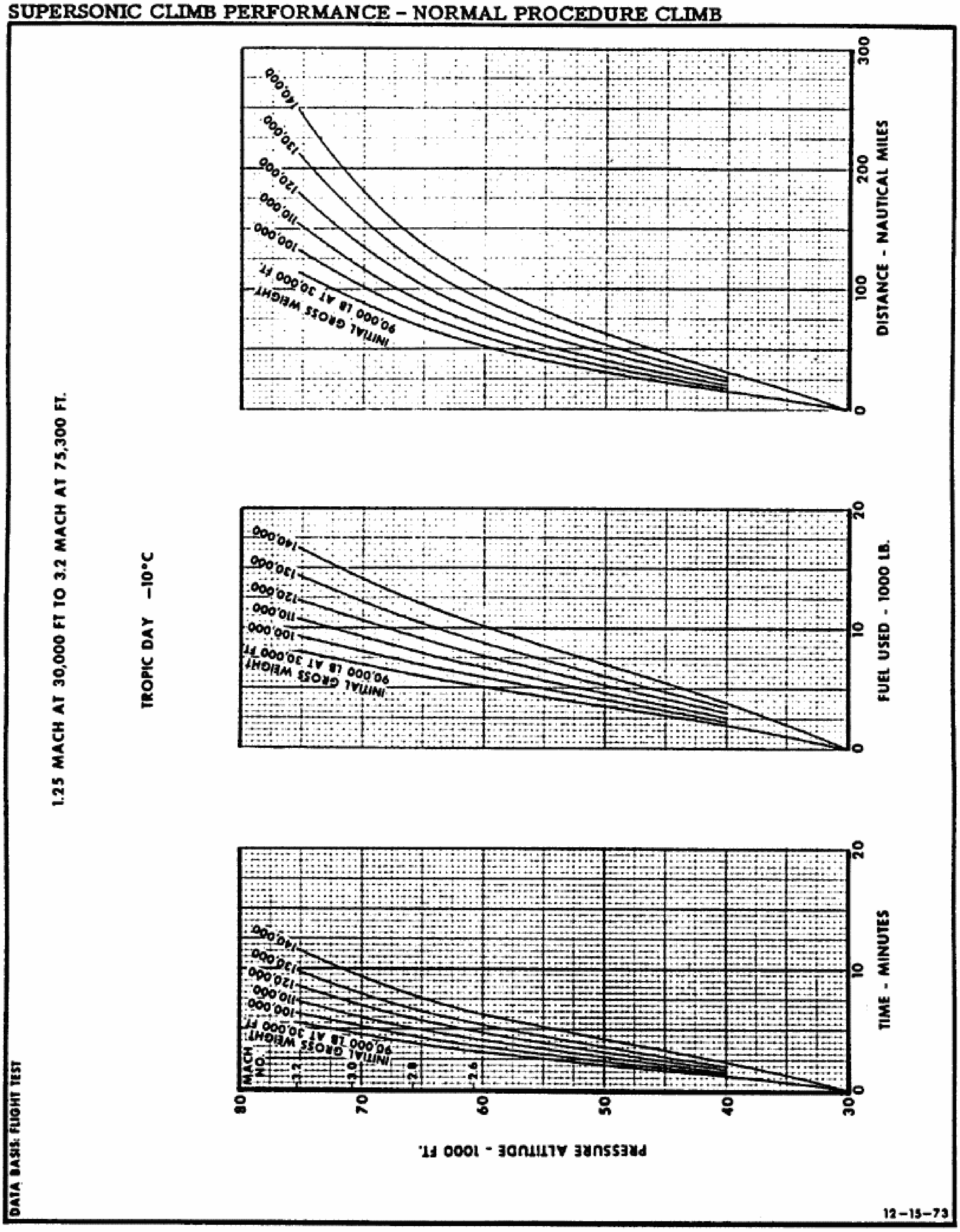


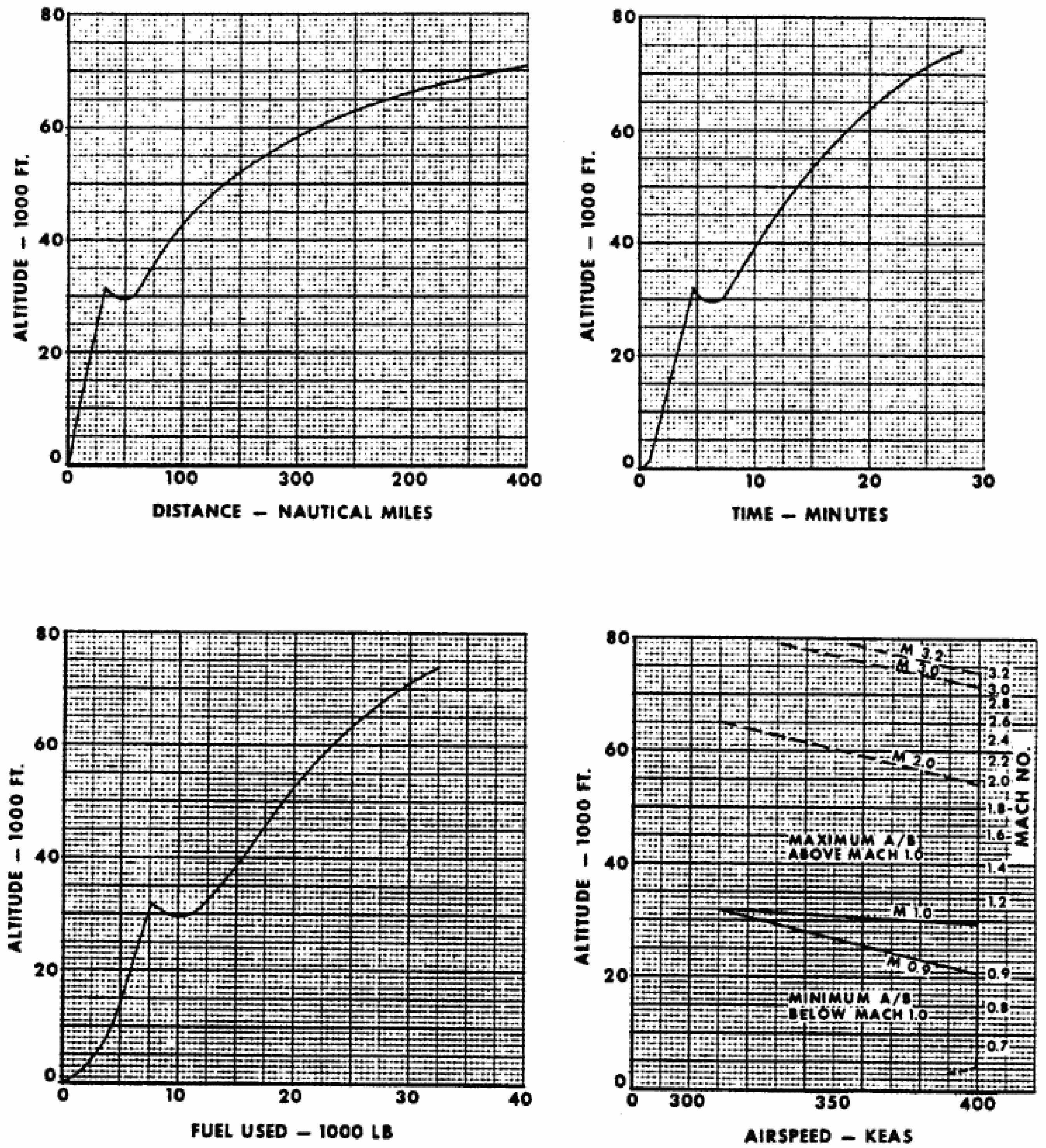
Figure A3-16

PROFILE CLIMB PERFORMANCE - 400 KEAS

DATA BASIS: PRELIM. FLT. TEST

APPROX. STD. DAY TEMPERATURES
NOMINAL GROSS WEIGHT = 130,000 LB
NOMINAL FUEL SEQUENCE & C.G. LOCATION

NOTE: CLIMB PERFORMANCE INCLUDES 1200 LB FUEL USED AND 0.5 MINUTES FOR TAKEOFF GROUND RUN.



REF. DATE: 4-15-67

Figure A3-17

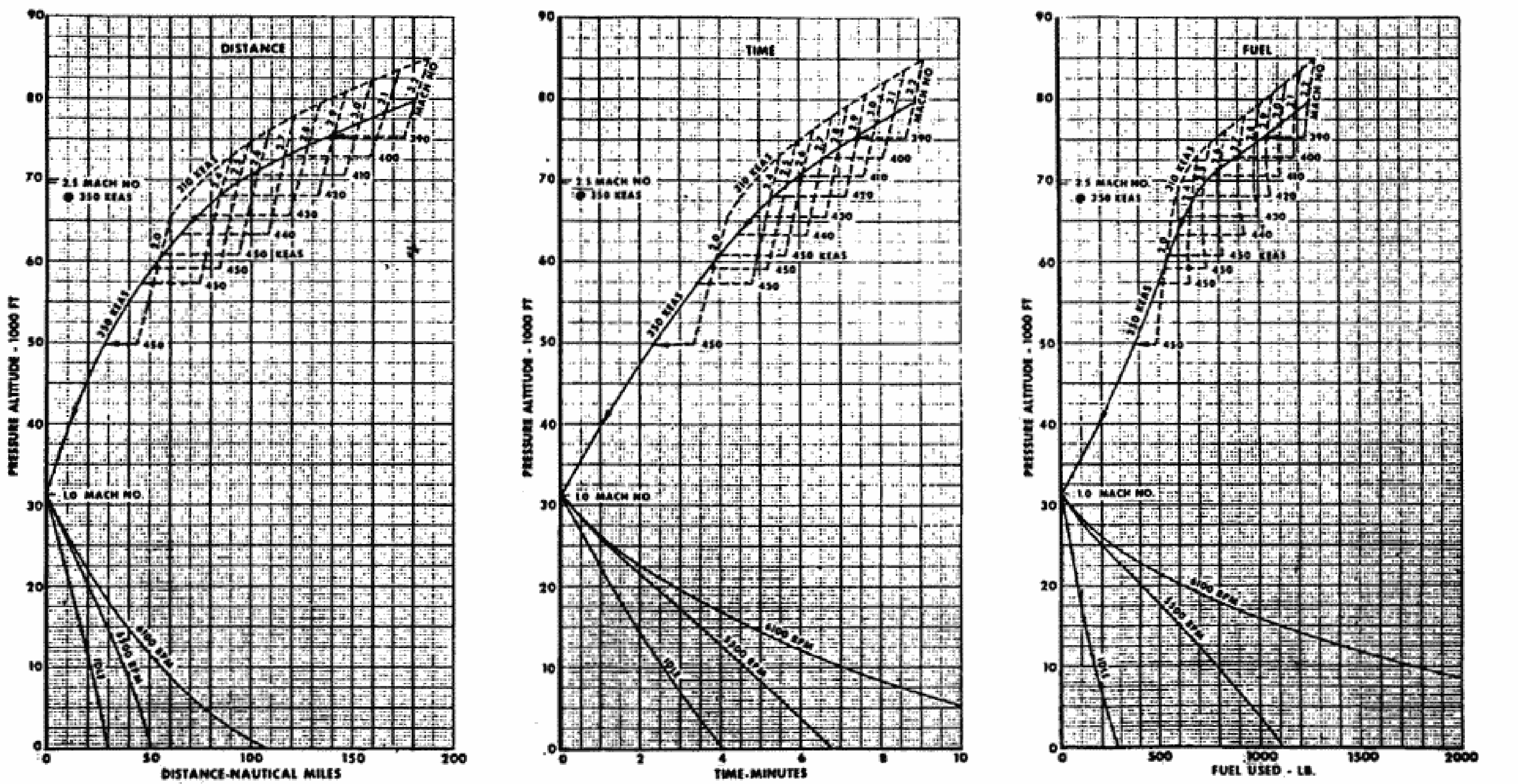
TWO ENGINE DESCENT PERFORMANCE

DATA BASIS: FLIGHT TEST

INLET CONFIGURATION	
SPIKE	AUTO
FWD B/P	AUTO
AFT B/P	CLOSED

720°C. EGT TO MACH 2.5 6900 RPM AT MACH 2.5

STANDARD DAY 350 KEAS 22% C.G.



1-29-71

Figure A3-18

TWO ENGINE DESCENT PERFORMANCE

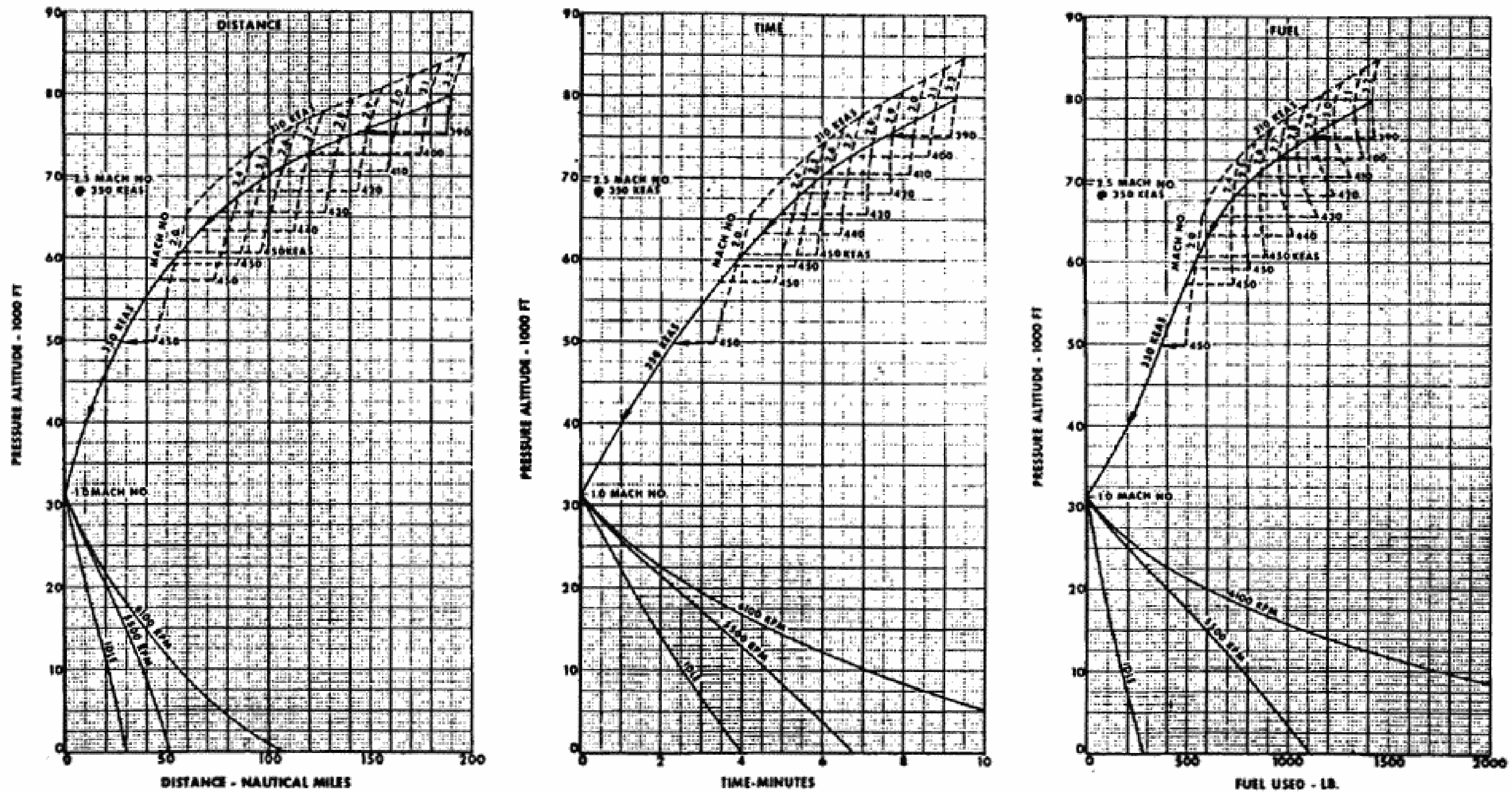
DATA BASIS: FLIGHT TEST

INLET CONFIGURATION	
SPIKE	AUTO
FWD B/P	AUTO
AFT B/P	CLOSED

MILITARY THRUST TO 6900 RPM AT 2.5 MACH NO.

STANDARD DAY 350 KEAS 22% C.G.

80,000 LB. INITIAL GROSS WEIGHT



1-29-71

Figure A3-19

TWO ENGINE DESCENT PERFORMANCE

DATA BASIS: FLIGHT TEST

INLET CONFIGURATION	
SPIKE	AUTO
FWD B/P	AUTO
AFT B/P	CLOSED

MILITARY THRUST TO 720° … AT MACH 2.5

STANDARD DAY   350 KEAS   22% C.G.

80,000 LB. INITIAL GROSS WEIGHT

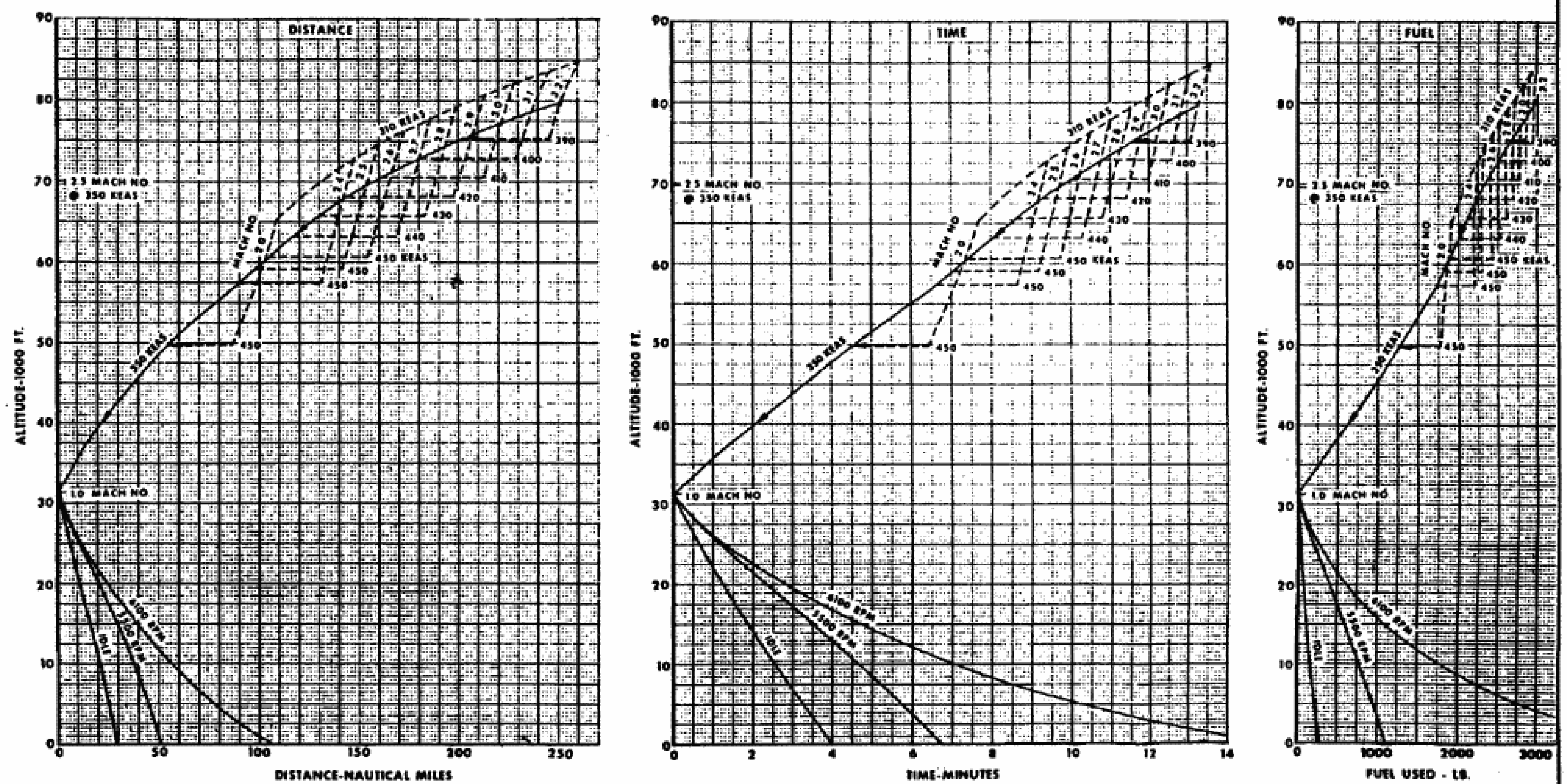


Figure A3-20

TWO ENGINE TURNING DESCENT

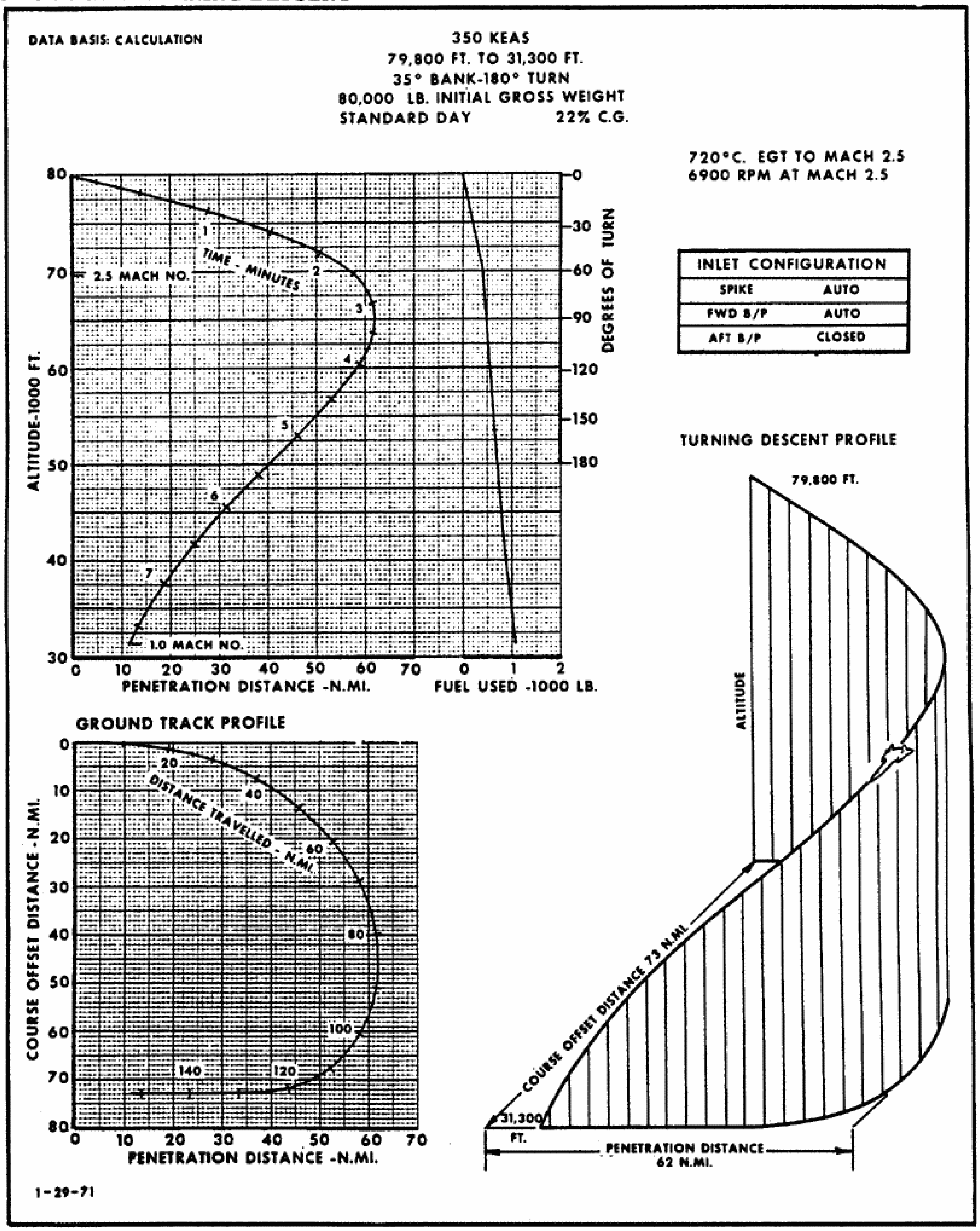


Figure A3-21

SINGLE-ENGINE DESCENT PERFORMANCE

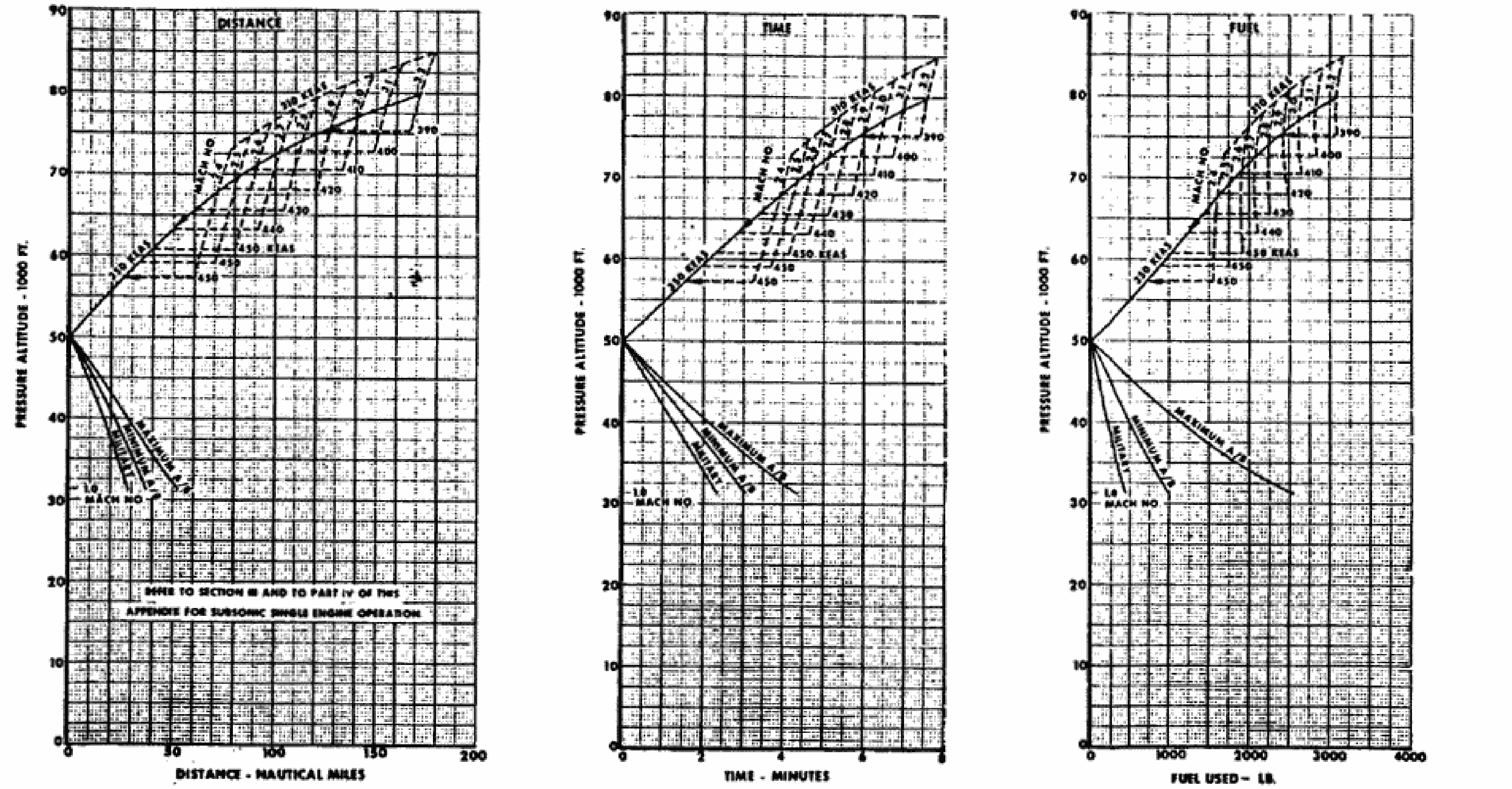
DATA BASIS: FLIGHT TEST

MAXIMUM A/B [illegible] TO 50,000 FT.

STANDARD DAY 350 KEAS 22% C.G.

80,000 LB. INITIAL GROSS WEIGHT

INLET CONFIGURATION			
ENGINE	SPIKE	FWD B/P	AFT B/P
OPERATING	AUTO	AUTO	CLOSED
WINDMILLING	FWD TO M 2.8, AFT M2.8 TO M 1.5, FWD AT 1.5	FULL OPEN	FULL OPEN



3-29-71

Figure A3-22
[redacted]

SINGLE-ENGINE DESCENT PERFORMANCE

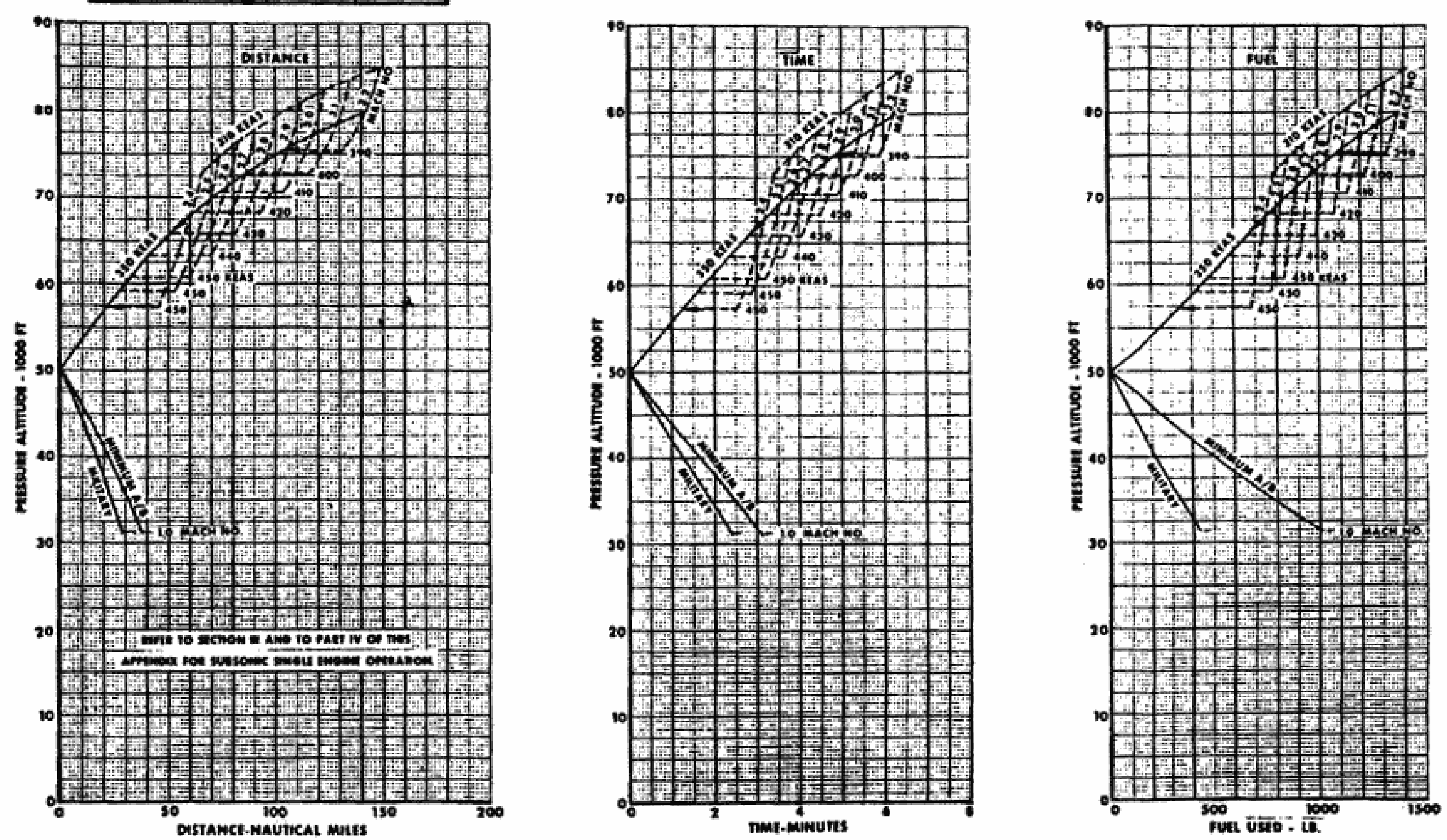
DATA BASIS: FLIGHT TEST

MINIMUM A/B THRUST TO 50,000 FT.

STANDARD DAY 350 KEAS 22% C.G.

80,000 LB. INITIAL GROSS WEIGHT

INLET CONFIGURATION			
ENGINE	SPIKE	FWD B/P	AFT B/P
OPERATING	AUTO	AUTO	CLOSED
WINDMILLING	FWD TO M 2.8, AFT M 2.8 TO M 1.5 FWD AT 1.5	FULL OPEN	FULL OPEN



1-29-71

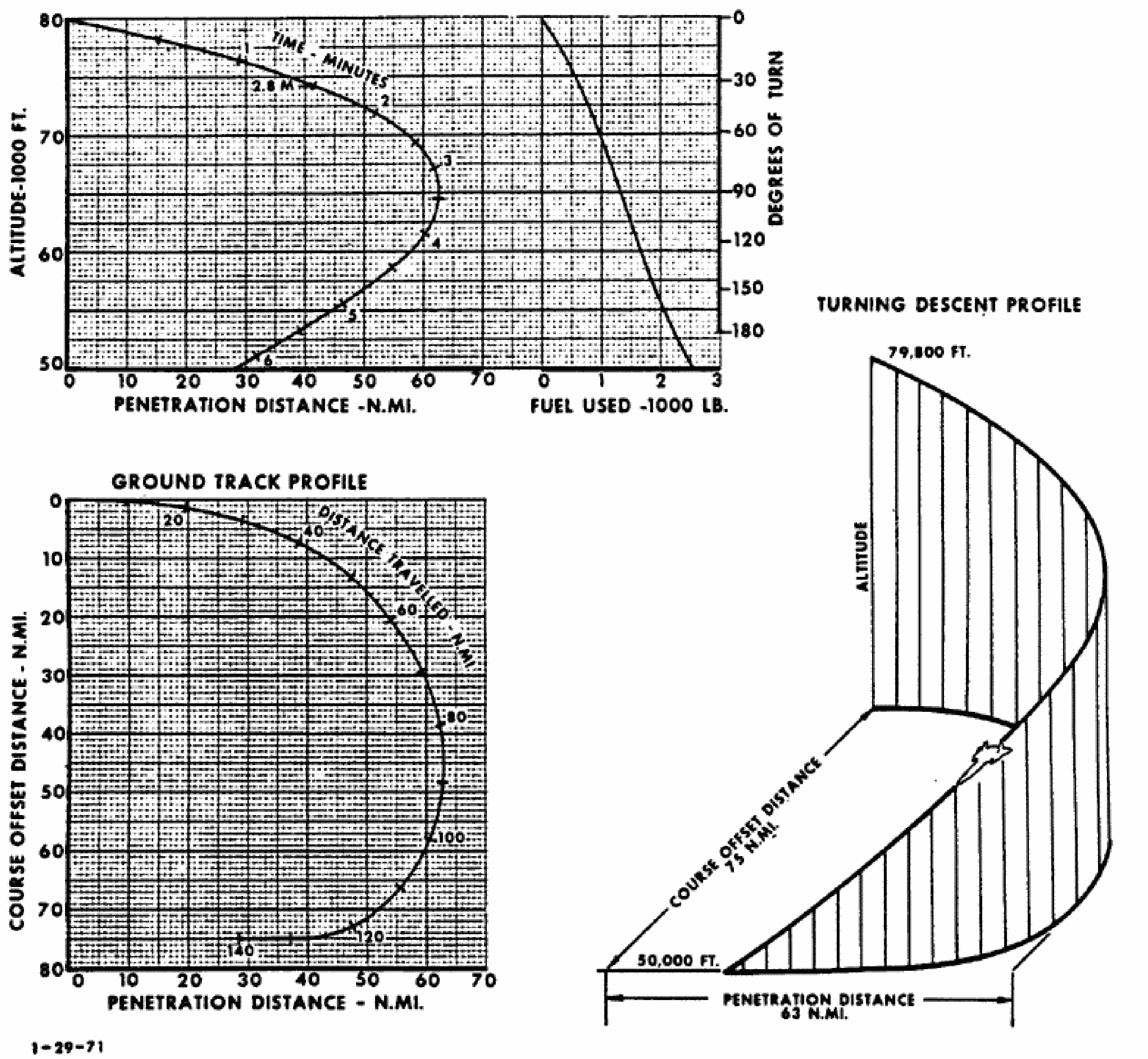
Figure A3-23

SINGLE-ENGINE TURNING DESCENT

DATA BASIS: CALCULATION

350 KEAS
MAXIMUM A/B
79,800 FT. TO 50,000 FT.
35°BANK-180° TURN
80,000 LB. INITIAL GROSS WEIGHT
STANDARD DAY 22% C.G.

INLET CONFIGURATION			
ENGINE	SPIKE	FWD B/P	AFT B/P
OPERATING	AUTO	AUTO	CLOSED
WINDMILLING	FWD TO M 2.8, AFT M2.8 TO M 1.5	FULL OPEN	FULL OPEN



1-29-71

Figure A3-24

PART IV

SUBSONIC CRUISE PERFORMANCE

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SPECIFIC RANGE - TWO ENGINE

Specific Range vs Mach for two engine operation is shown in Figures A4-1 thru A4-17 for altitudes from Sea Level to 40,000 ft. All performance information has been corrected to a c.g. of 22% MAC. Operation at c.g. positions forward of 22% reduces range approximately 1% for each percent c.g. shift, as noted on the specific range curves. The curves show performance for the operational range of gross weights at each altitude and cover the speed range from maximum endurance to Military thrust. Subscales of equivalent airspeed and calibrated airspeed are provided. The recommended loiter speed schedule is included for each altitude.

NOTE

> The subsonic minimum airspeed restriction of 300 KEAS above 25,000 feet has been observed in all performance presented except the specific range curves.

SUBSONIC MAXIMUM RANGE CRUISE-CLIMB

Figure A4-18 shows the range available by cruise-climbing at Mach 0.88 and at 380,000 lb W/δ . The curve is indexed to an end-of-cruise gross weight of 70,000 lbs (approximately 10,000 lb of fuel remaining) as a convenience in flight planning. (10,000 lbs is an arbitrary fuel remaining value and is not mandatory for termination of cruise.) The curve can also be used on an incremental basis for any desired start and end cruise condition.

Example:

For a gross weight of 90,000 lbs (approx. 30,000 lbs of fuel remaining) determine the distance remaining to 70,000 lbs gross weight and distance flown between 90,000 lbs gross weight and 80,000 lbs gross weight. Enter Figure A4-18 at 90,000 lbs gross weight and read the distance to 70,000 lbs directly as 725 nautical miles. At 80,000 lbs read the distance to 70,000 lbs as 375 nautical miles. The distance flown between 90,000 lbs and 80,00 lbs is (725-375) or 350 nautical miles. Cruise at 32,400 feet.

An additional 190 nautical miles is available by ending cruise at 65,000 lbs gross weight (approximately 5000 lbs of fuel remaining).

RANGE FACTOR SUMMARY

The Range Factor Summary shown in Figure A4-19 defines the maximum specific range capability in terms of the gross weight/altitude parameter, W/δ . The Mach schedule required to obtain this performance is shown on the lower portion of the curve. The curve covers the complete operating weight and power range of the airplane, up to and including Military thrust. Maximum range capability (cruise-climb) is obtained at a W/δ of 380,000 lb and at Mach 0.88.

Figure A4-20 depicts the information given by the Range Factor Summary in terms of Maximum Specific Range as a function of gross weight and altitude.

BUDDY MISSION AT MACH 0.75

The buddy mission schedule, Mach 0.75, is based on performance compatibility with KC-135 tanker aircraft. Figure A4-21 shows the specific range available in cruise-climb or at constant altitude with constant Mach 0.75 cruise speed. Greater range capability is obtained by cruise-climbing.

Example:

Determine the range available at 24,000 ft at an initial gross weight of 90,000 lb if 10,000 lbs of fuel is to be consumed. Enter Figure A4-21 at 90,000 lbs at 24,000 ft and read the specific range available as 28.5 nautical miles per 1000 lbs of fuel. At 80,000 lb and 24,000 ft read the specific range as 29.7 nautical miles per 1000 lbs of fuel. The average specific range is 29.1 nautical miles per 1000 lbs and the range available for 10,000 lbs of fuel consumed is 291 nautical miles.

LOITER PERFORMANCE

Figure A4-22 presents loiter performance in terms of minutes per 1000 lbs of fuel consumed. A loiter profile in Figure A4-23 provides time available from various initial fuel remaining values to 10,000 pounds remaining. (70,000 lb gross weight). The profile is keyed to the same speed schedule as the specific endurance chart.

Example:

Determine the loiter time available at 20,000 ft at an initial gross weight of 90,000 lbs if 10,000 lbs of fuel is to be consumed. Enter Figure A4-22 at 90,000 lbs gross weight and 20,000 ft and read loiter time available as 3.75 minutes per 1000 lbs of fuel. At 80,000 lbs and 20,000 ft read 4.01 minutes per 1000 lbs of fuel. The average loiter time available is 3.9 minutes per 1000 lbs of fuel or 39 minutes for 10,000 lbs of fuel.

SUBSONIC MISSION PROFILE

Figure A4-24 presents the constant altitude, cruise climb, and Military thrust range in terms of distance to go to 70,000 lbs gross weight (approximately 10,000 lbs of fuel remaining). The curve may also be used on an incremental basis.

Cruise speeds for constant altitude cruise are tabulated on the chart. Climb performance tables are also provided which apply to takeoff (brake release) at nominal gross weights of 140,000, 120,000, and 100,000 lb. The climb data are based on Maximum thrust takeoff with power reduction to Minimum afterburning following gear retraction.

Example:

Determine the range available at an initial gross weight of 125,000 lbs if cruise is to be terminated at 10,000 lbs remaining (approximately 70,000 lbs gross weight). Figure A4-24 shows that by cruising at 25,000 feet at an initial gross weight of 125,000 lbs the range will be 1554 nautical miles to 10,000 lbs of fuel remaining. This range increases to 1703 nautical miles by cruising at 30,000 feet. Maximum range is available by cruise climbing at Mach 0.88. Under this condition cruise would be initiated at 27,700 feet to 300 KEAS at 32,400 feet and constant altitude cruise to 10,000 lbs remaining. Distance traveled would be 1746 nautical miles.

SINGLE-ENGINE SPECIFIC RANGE

Specific range vs Mach for one engine operation at Military, Minimum A/B and Maximum A/B thrust is presented in Figures A4-25 through A4-27. The cruise altitudes are single engine ceiling capabilities with corresponding nautical miles per 1000 pounds of fuel. The optimum cruise Mach is included for each thrust setting.

Refer to Section III, Emergency Procedures, for single engine maximum range capabilities at each throttle setting to 5000 pounds of fuel remaining.

SUBSONIC SPECIFIC RANGE - TWO ENGINES, SEA LEVEL

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC

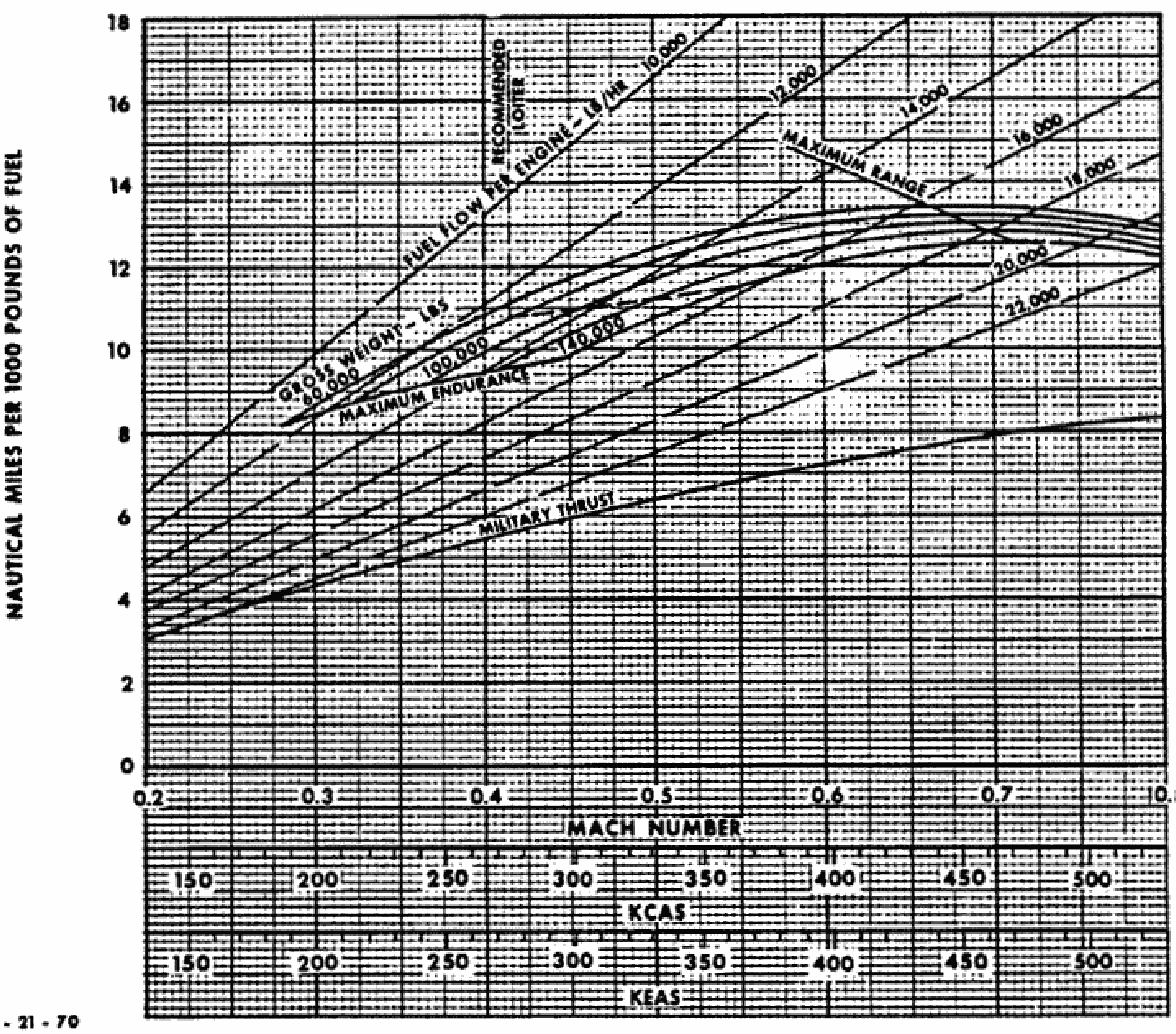


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Figure A4-1

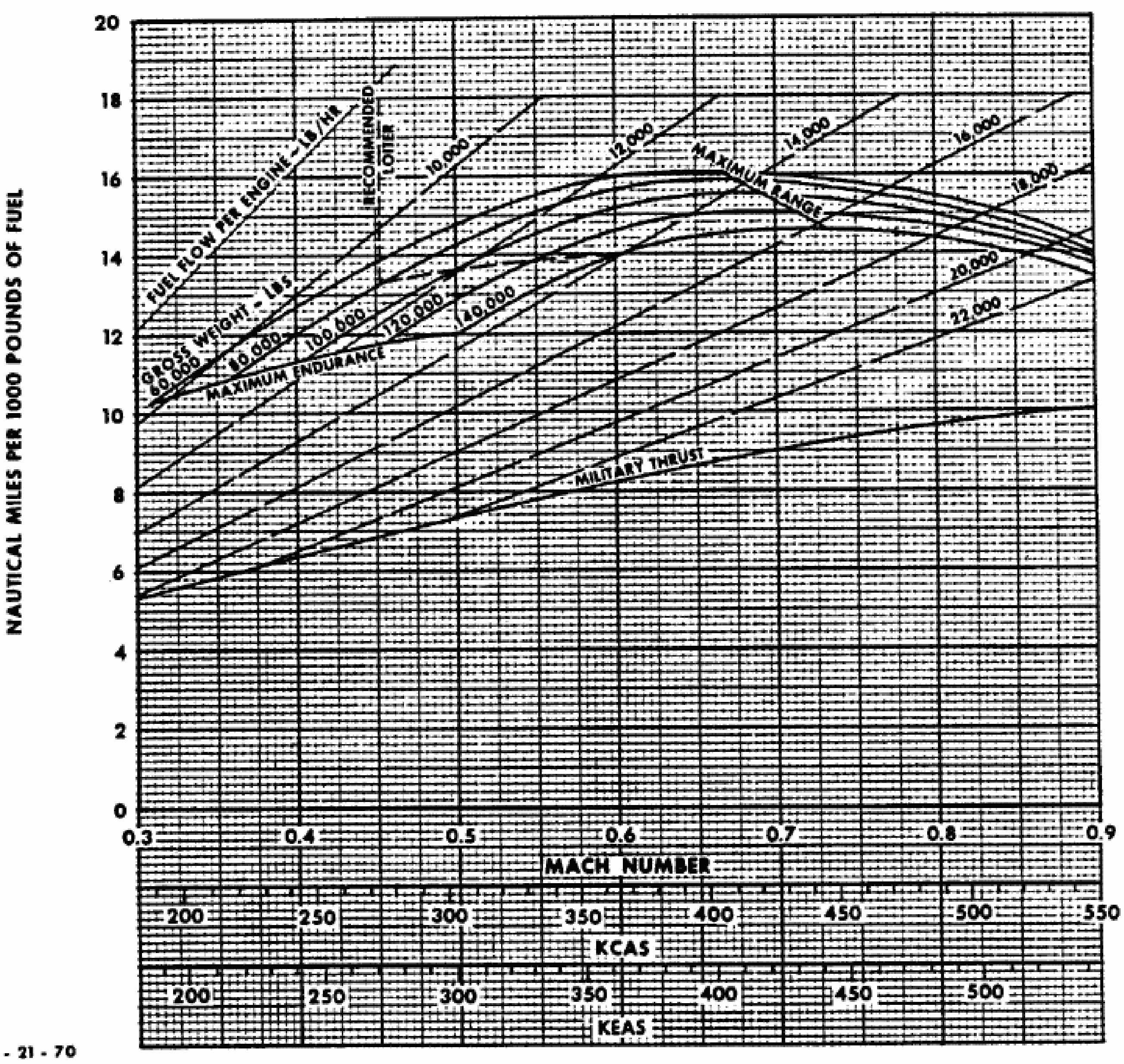
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 5000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-2

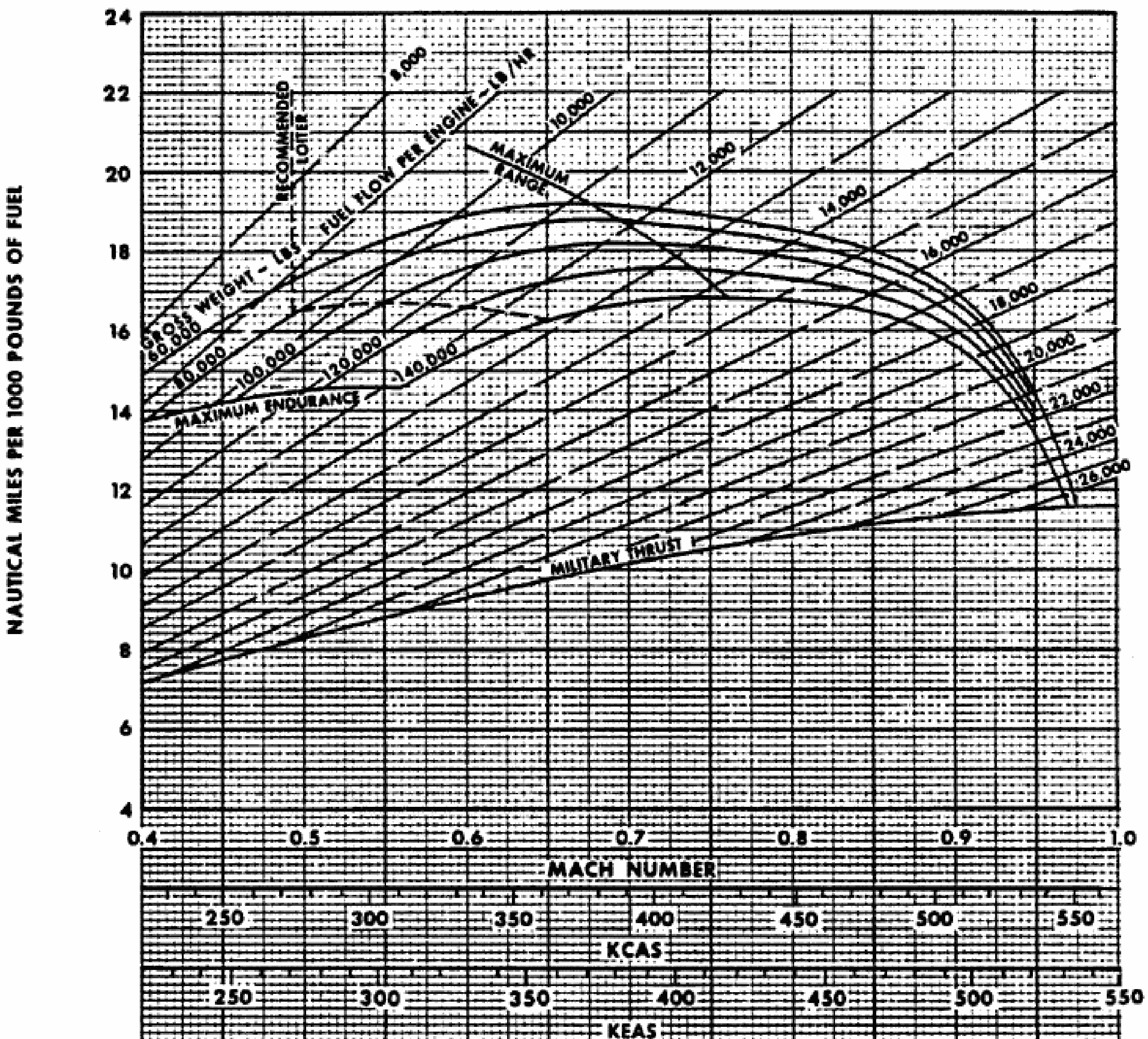
SUBSONIC SPECIFIC RANGE – TWO ENGINES, 10,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-3

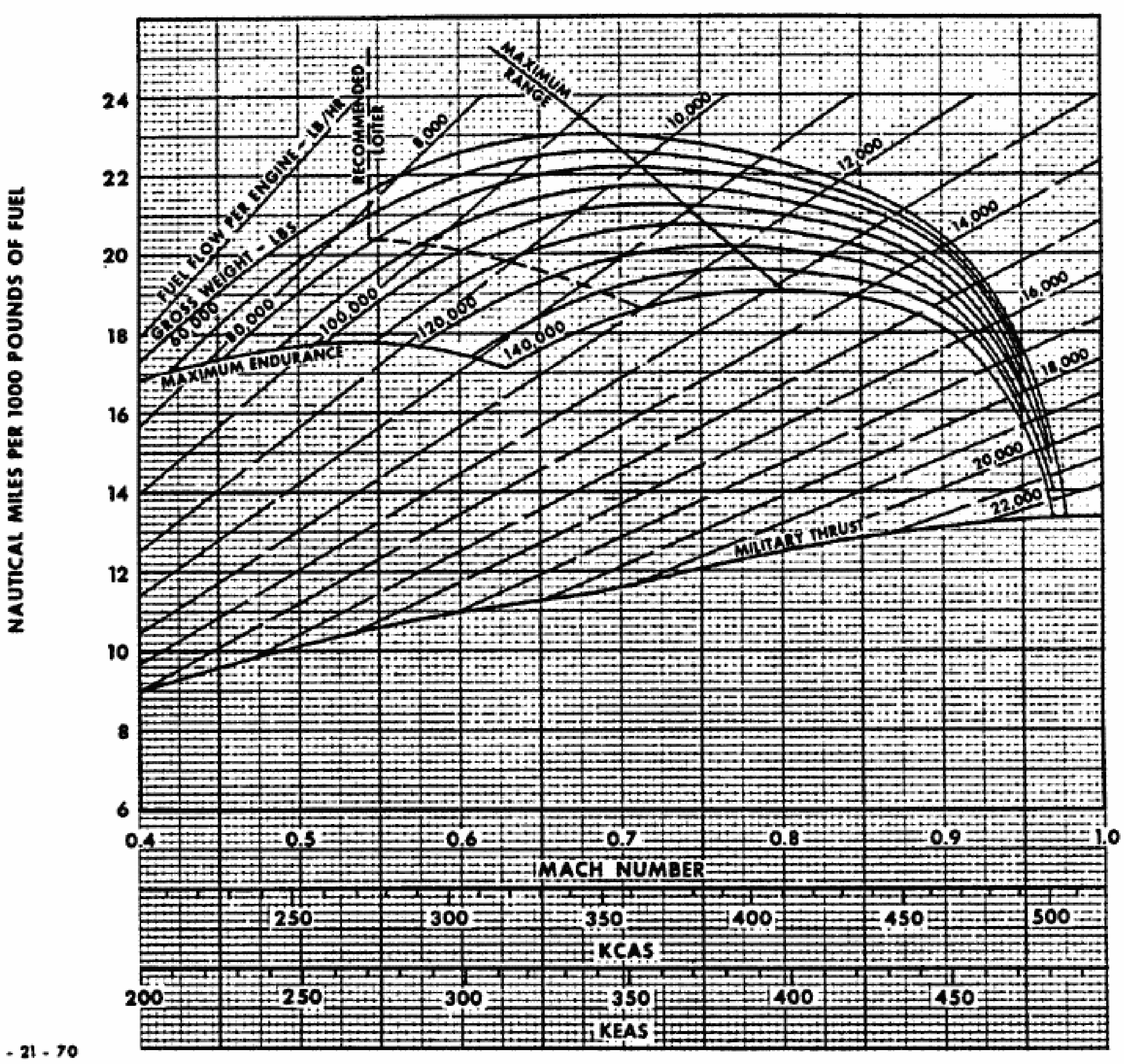
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 15,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-4

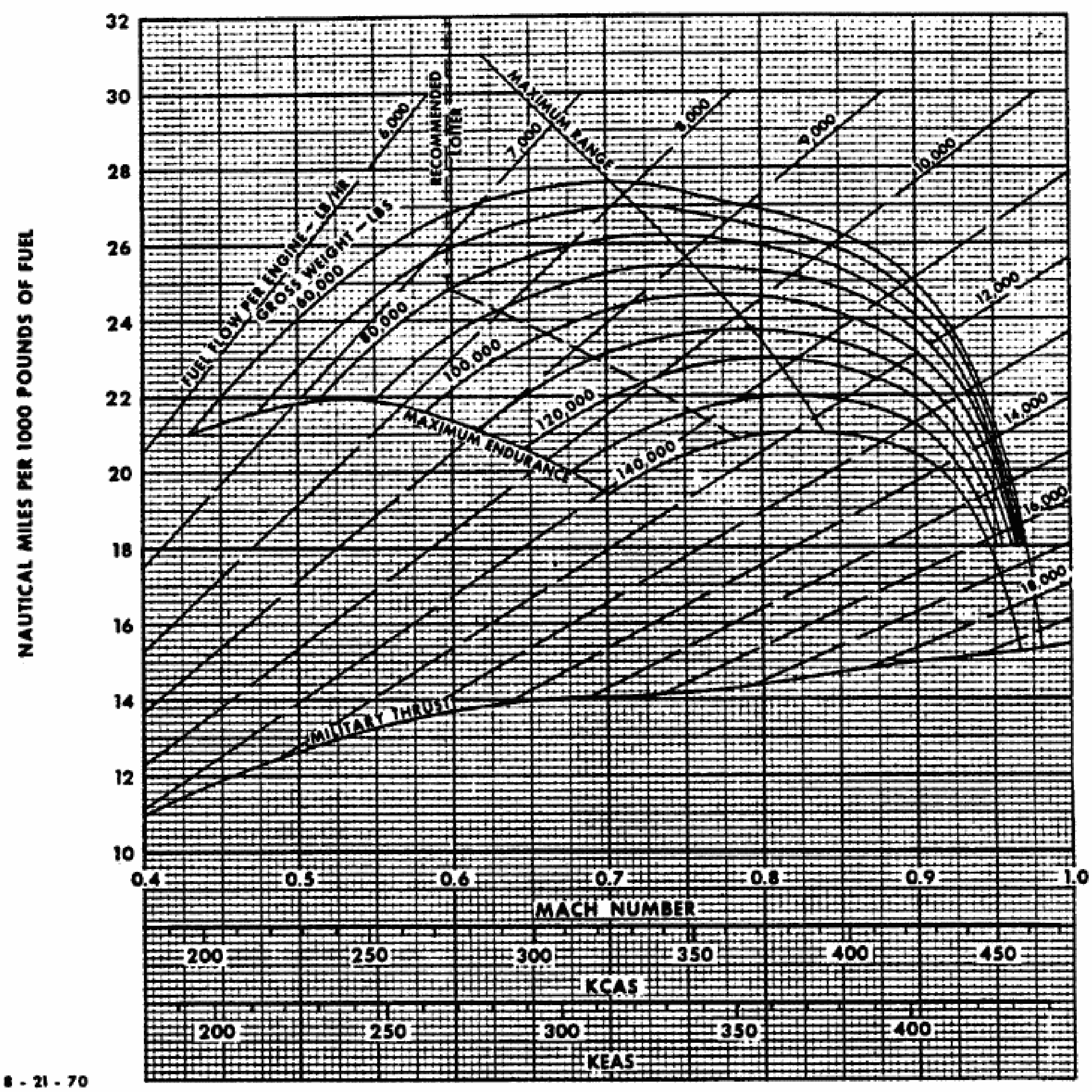
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 20,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-5

SUBSONIC SPECIFIC RANGE - TWO ENGINES, 22,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC

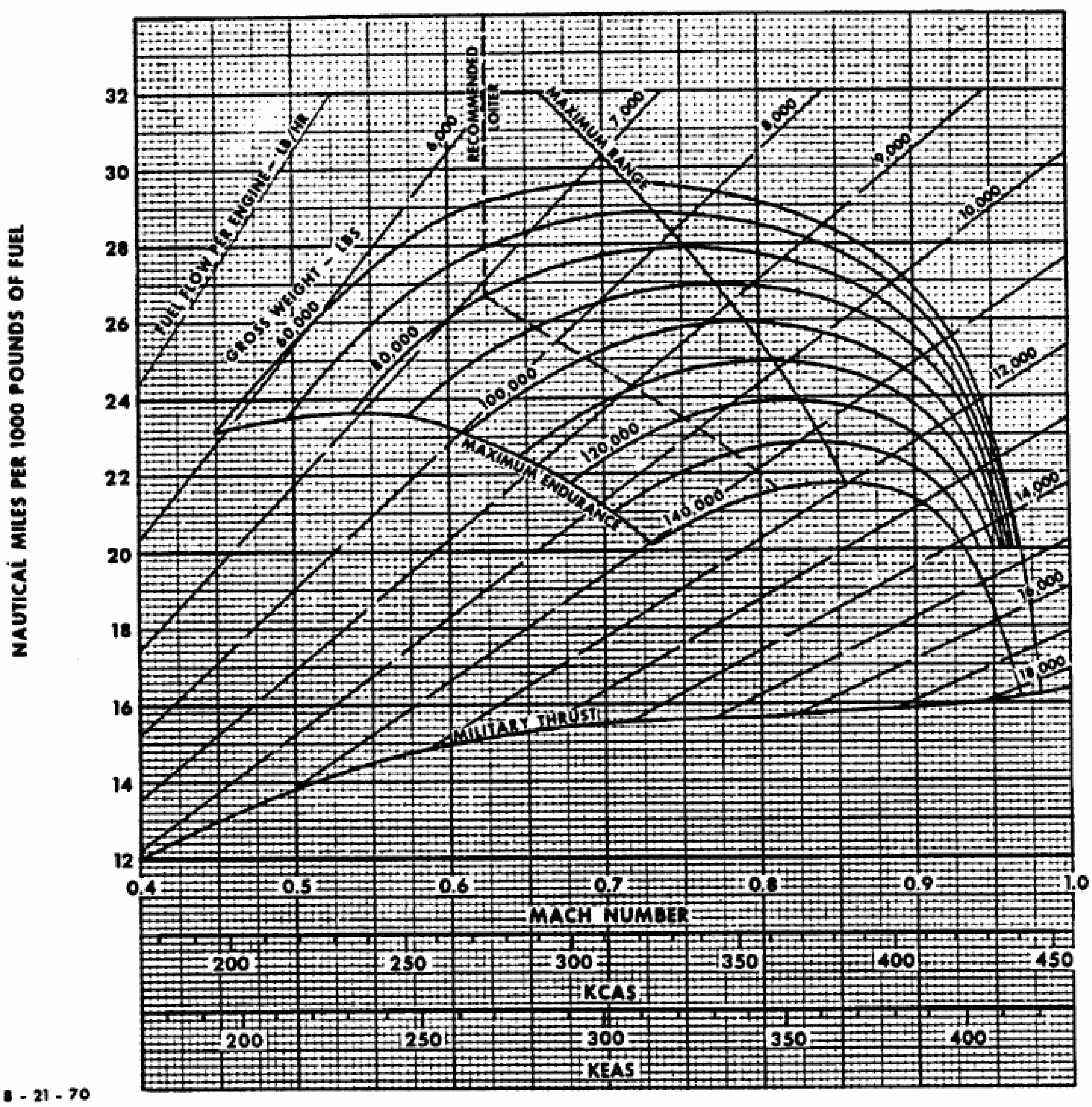


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Figure A4-6

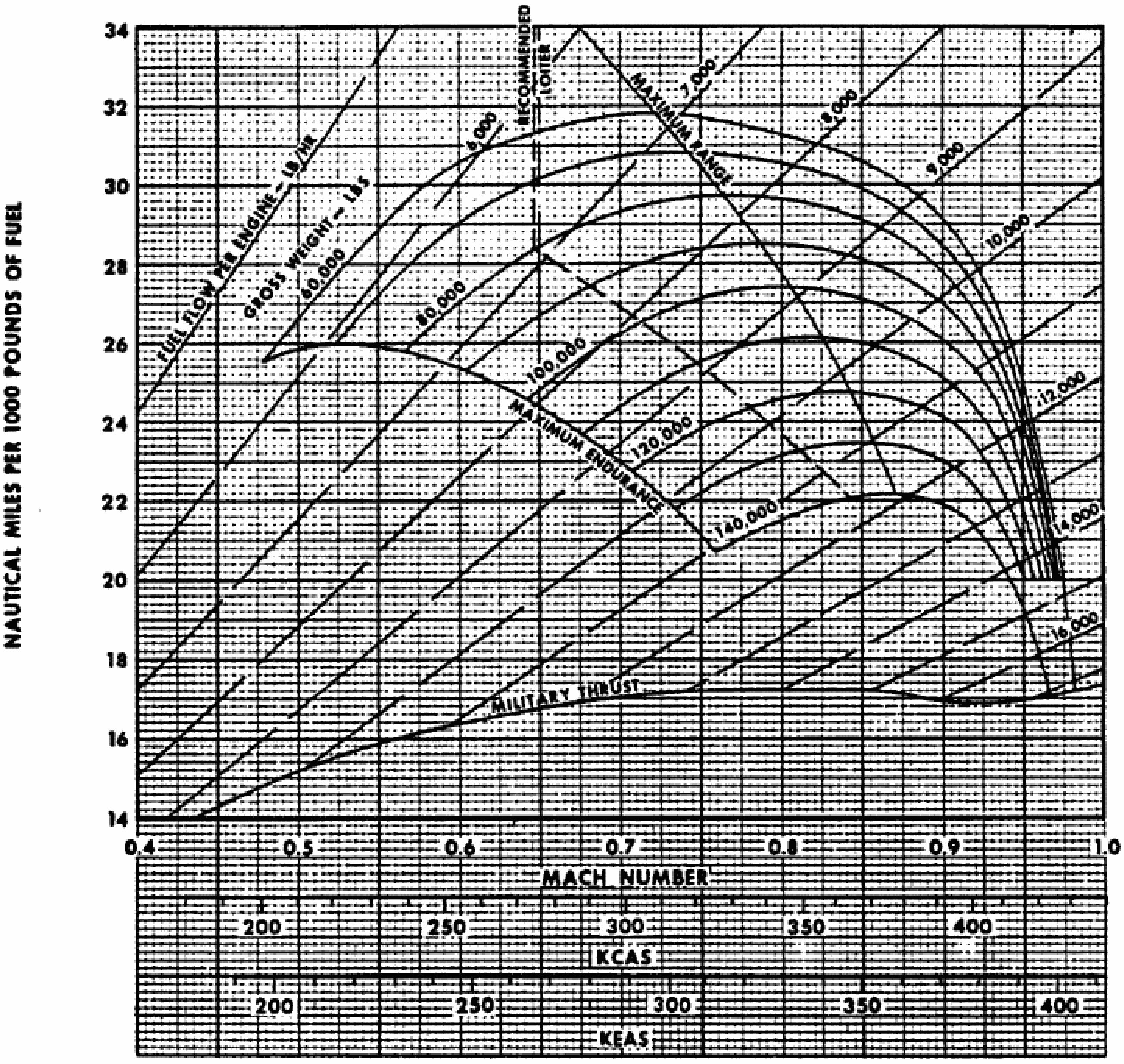
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 24,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-7
[redacted]

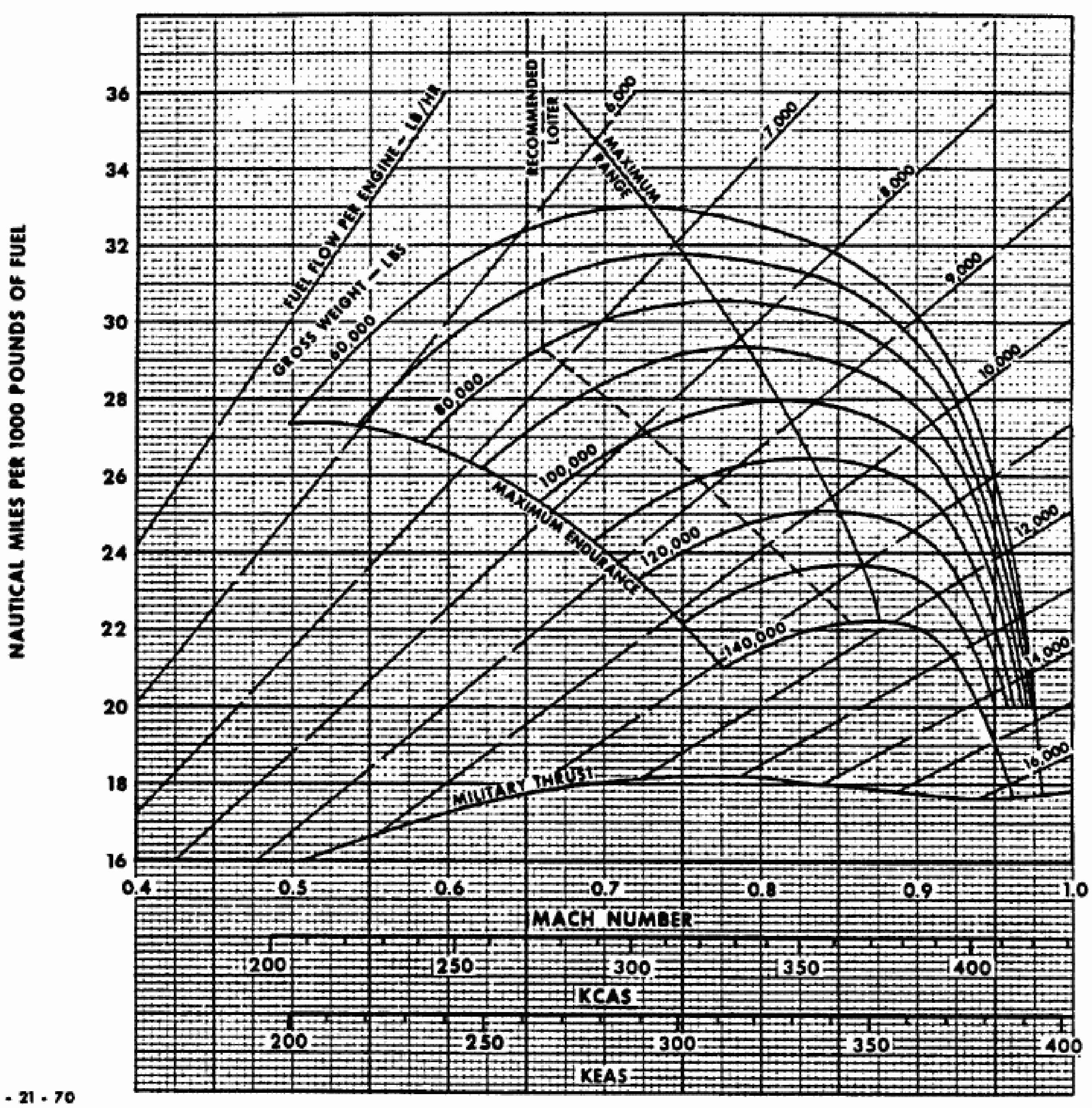
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 25,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-8

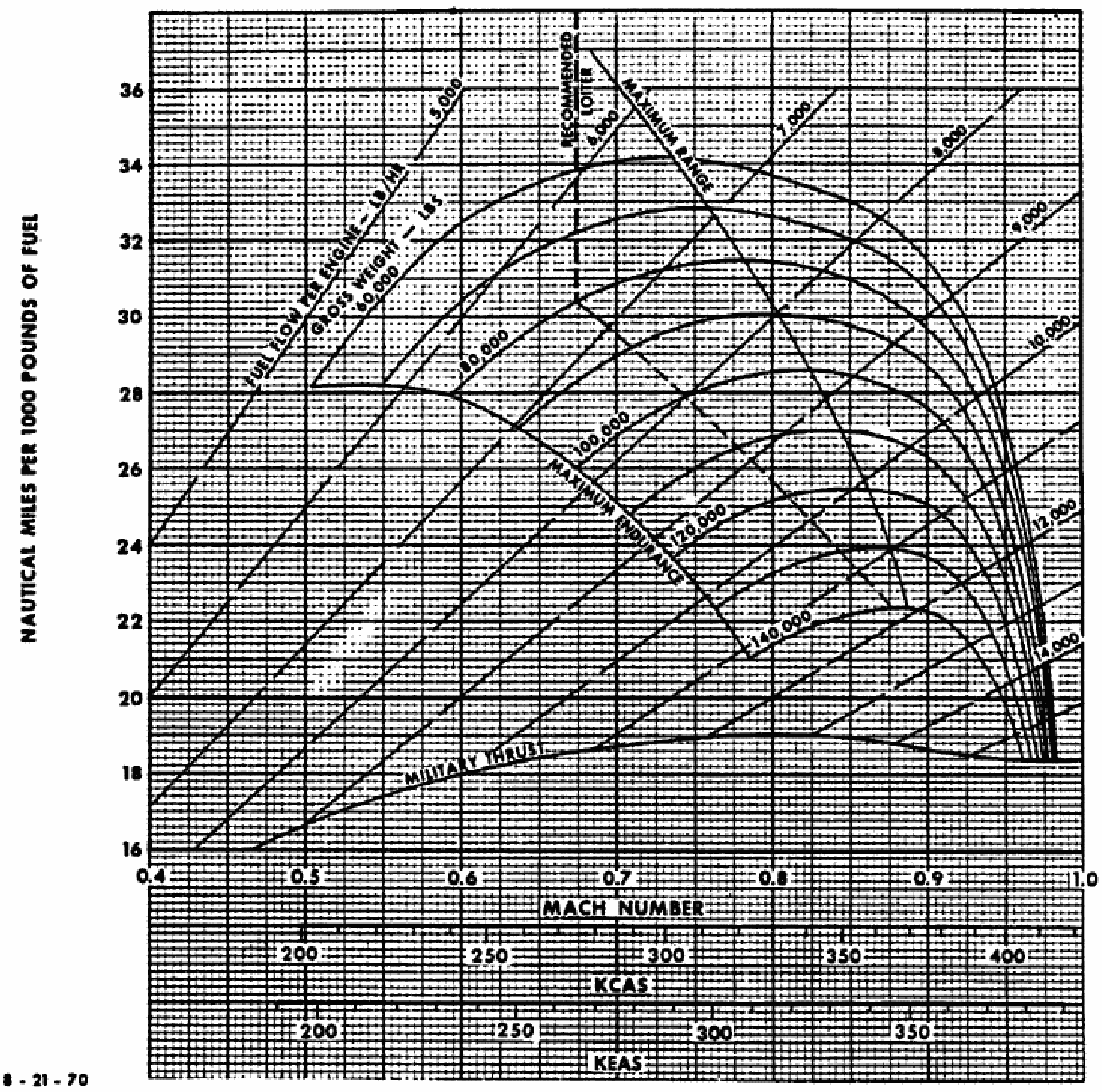
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 26,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-9

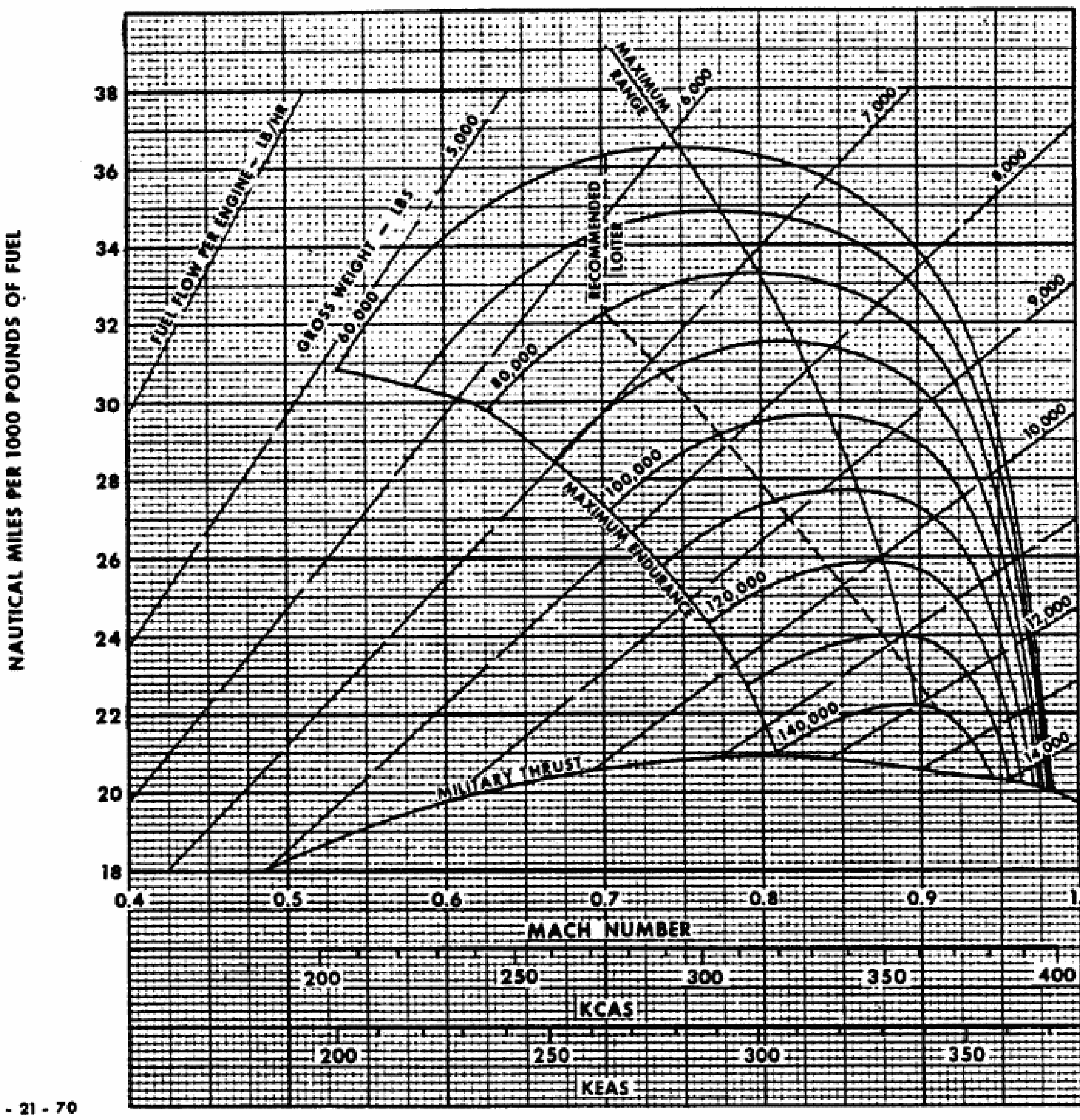
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 28,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-10

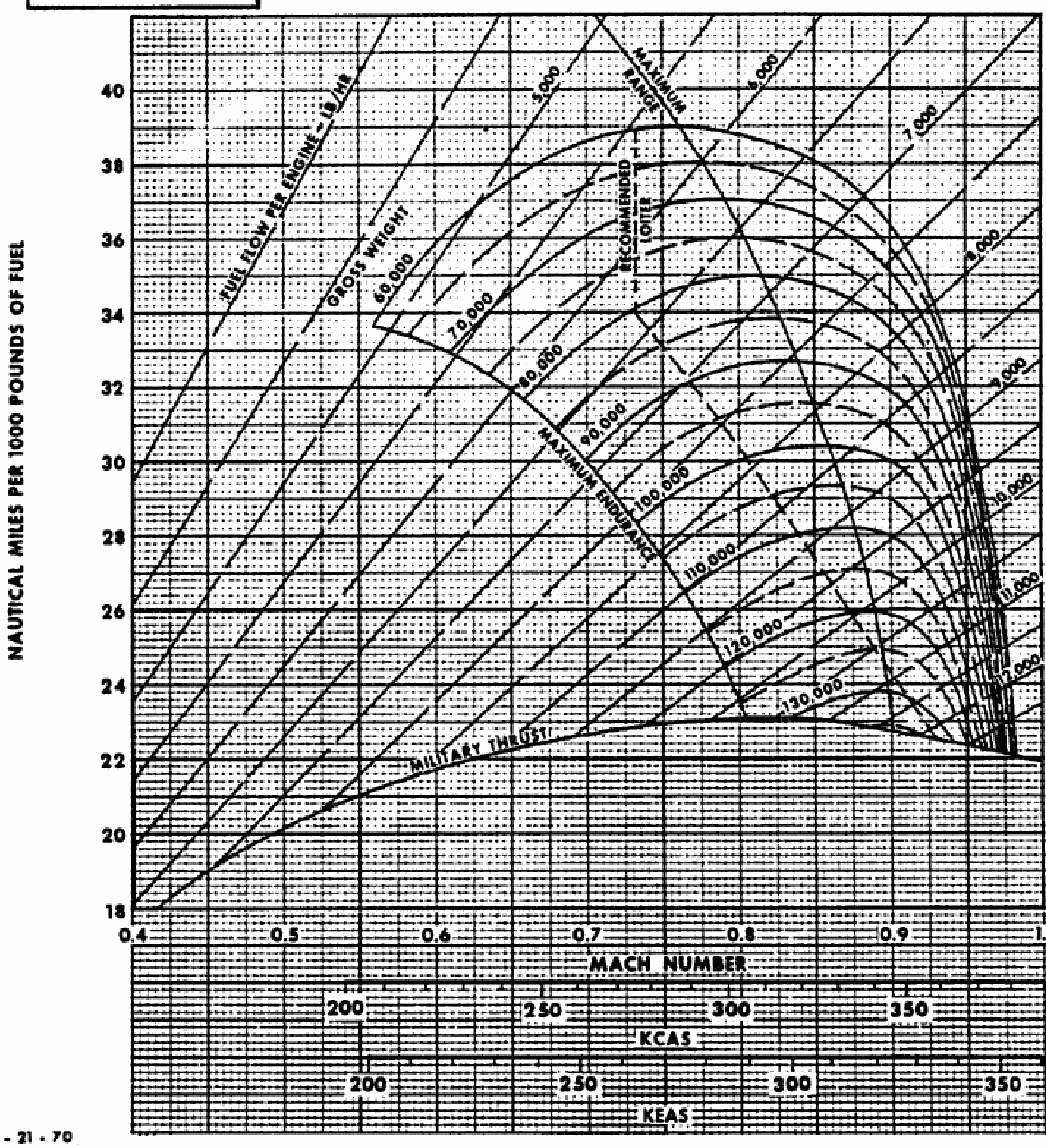
SUBSONIC SPECIFIC RANGE – TWO ENGINES, 30,000 FT. ALTITUDE

Data Basis: Flight Test

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

STANDARD DAY 22% MAC C.G.

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-11

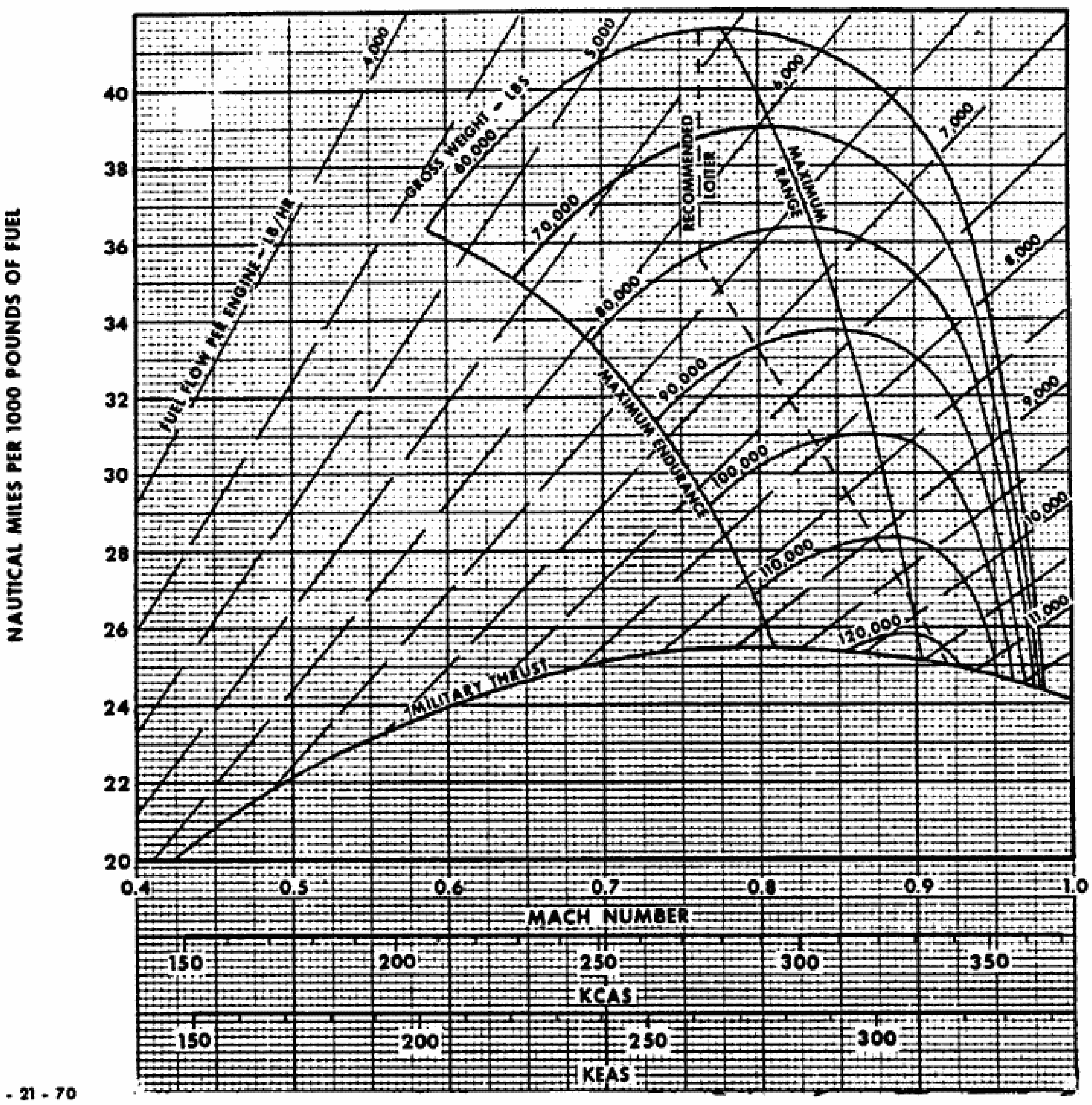
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 32,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-12

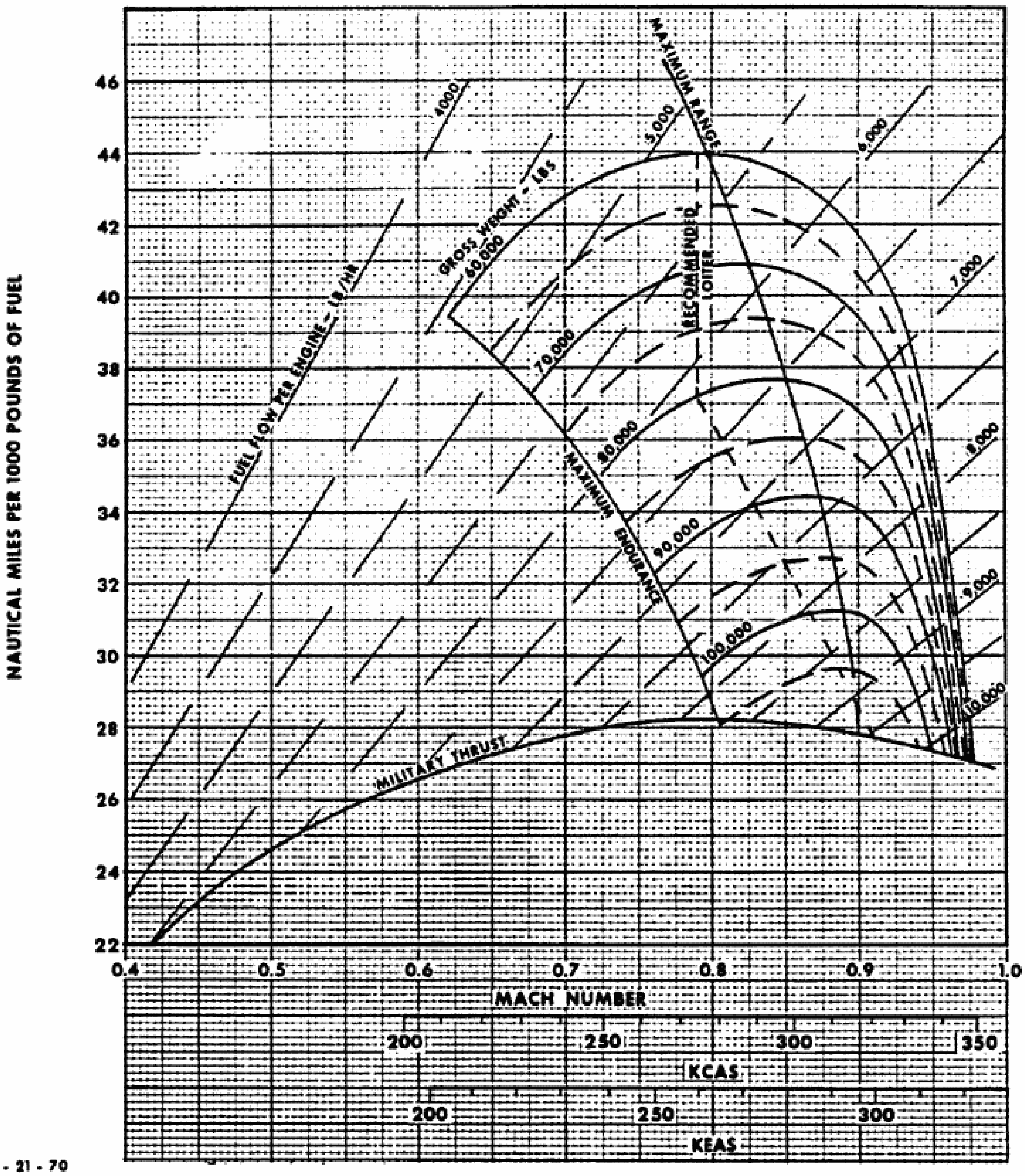
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 34,000 FT. ALTITUDE

Data Basis: Flight Test

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335

STANDARD DAY   22% MAC C.G.

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-13

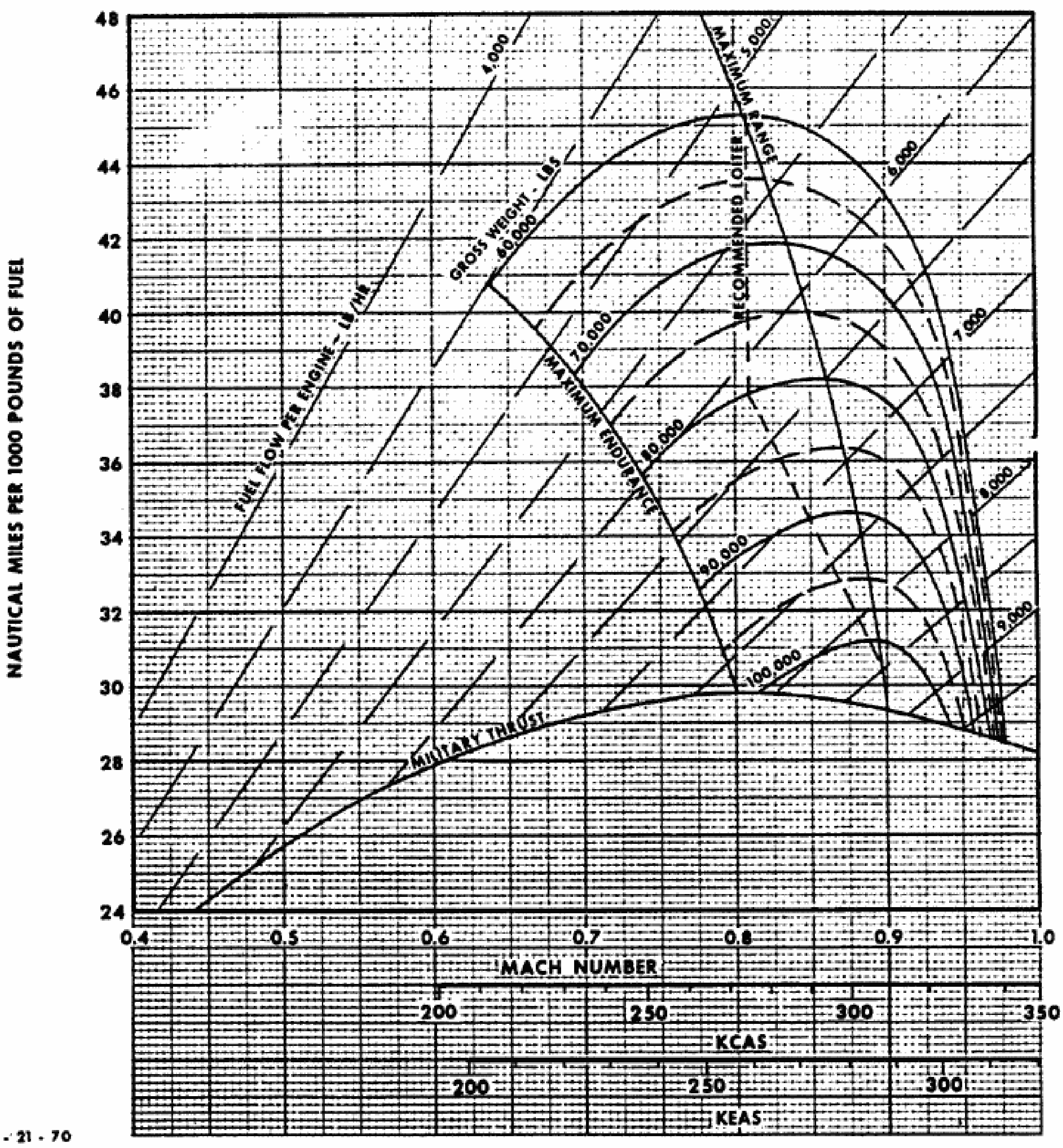
SUBSONIC SPECIFIC RANGE - TWO ENGINES, 35,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC



8 - 21 - 70

Figure A4-14

SUBSONIC SPECIFIC RANGE - TWO ENGINES, 36,000 FT. ALTITUDE

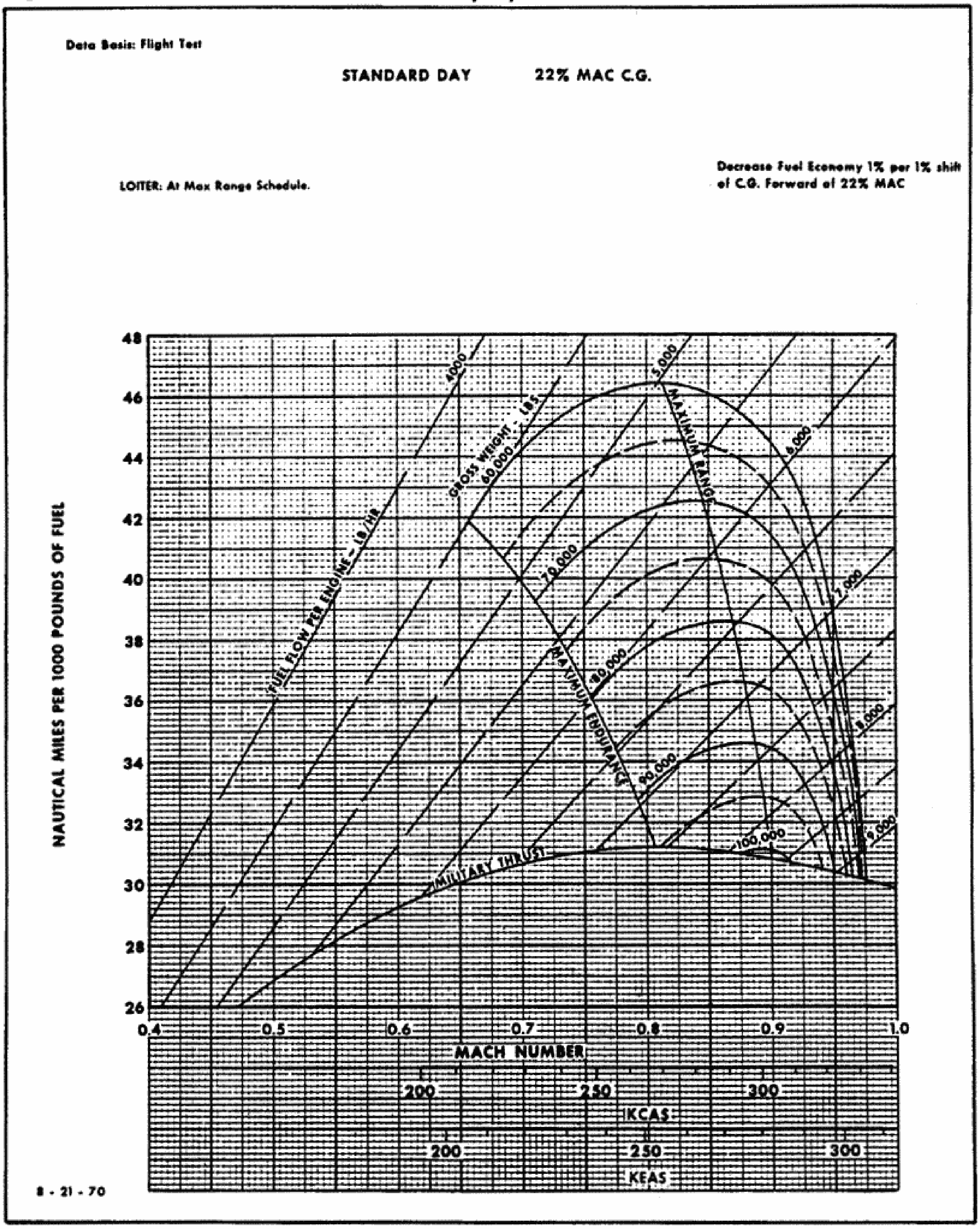


Figure A4-15

SUBSONIC SPECIFIC RANGE - TWO ENGINES, 38,000 FT. ALTITUDE

Data Basis: Flight Test

STANDARD DAY 22% MAC C.G.

LOITER: At Max Range Schedule.

Decrease Fuel Economy 1% per 1% shift of C.G. Forward of 22% MAC

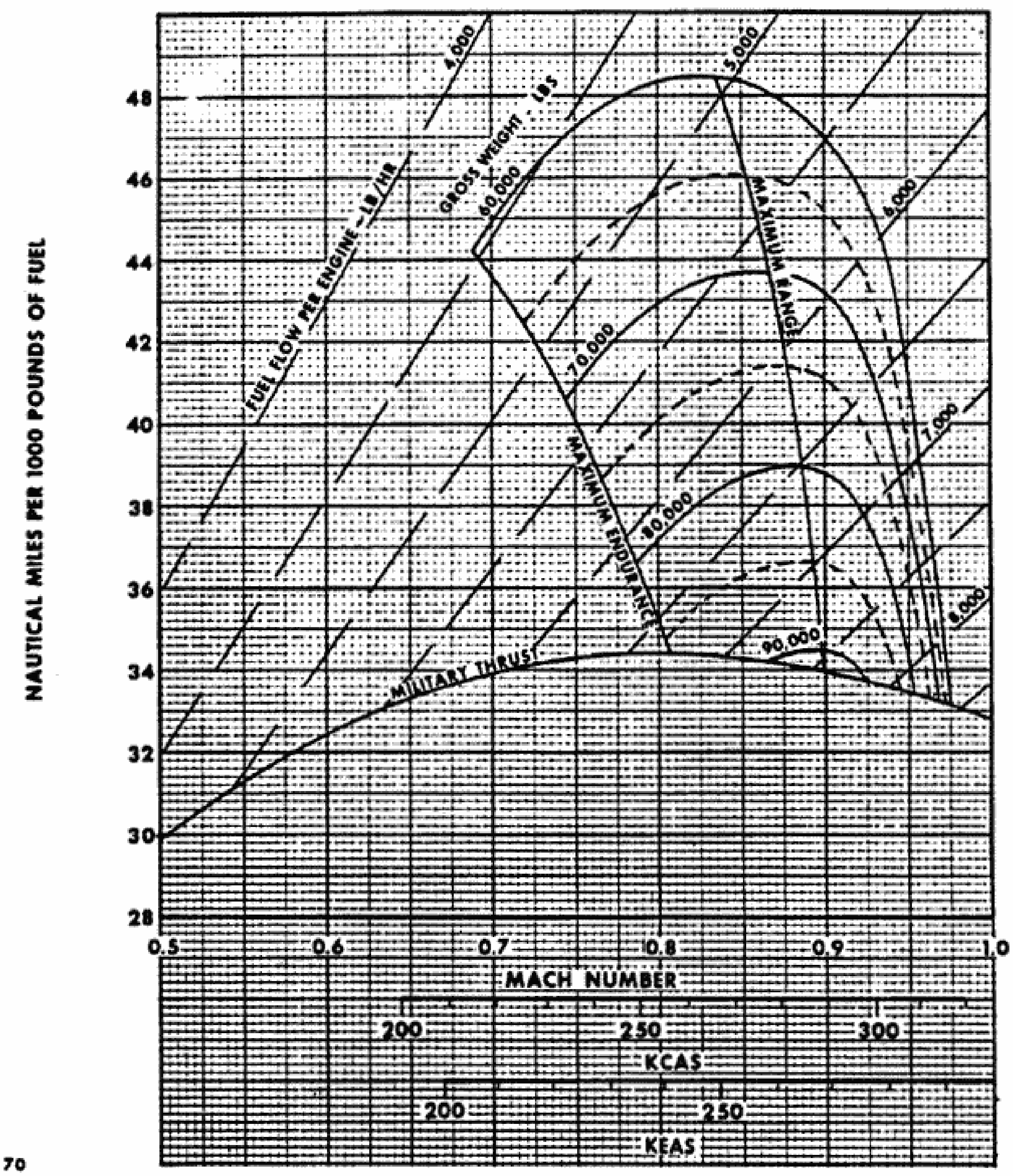


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Figure A4-16

SUBSONIC SPECIFIC RANGE – TWO ENGINES, 40,000 FT. ALTITUDE

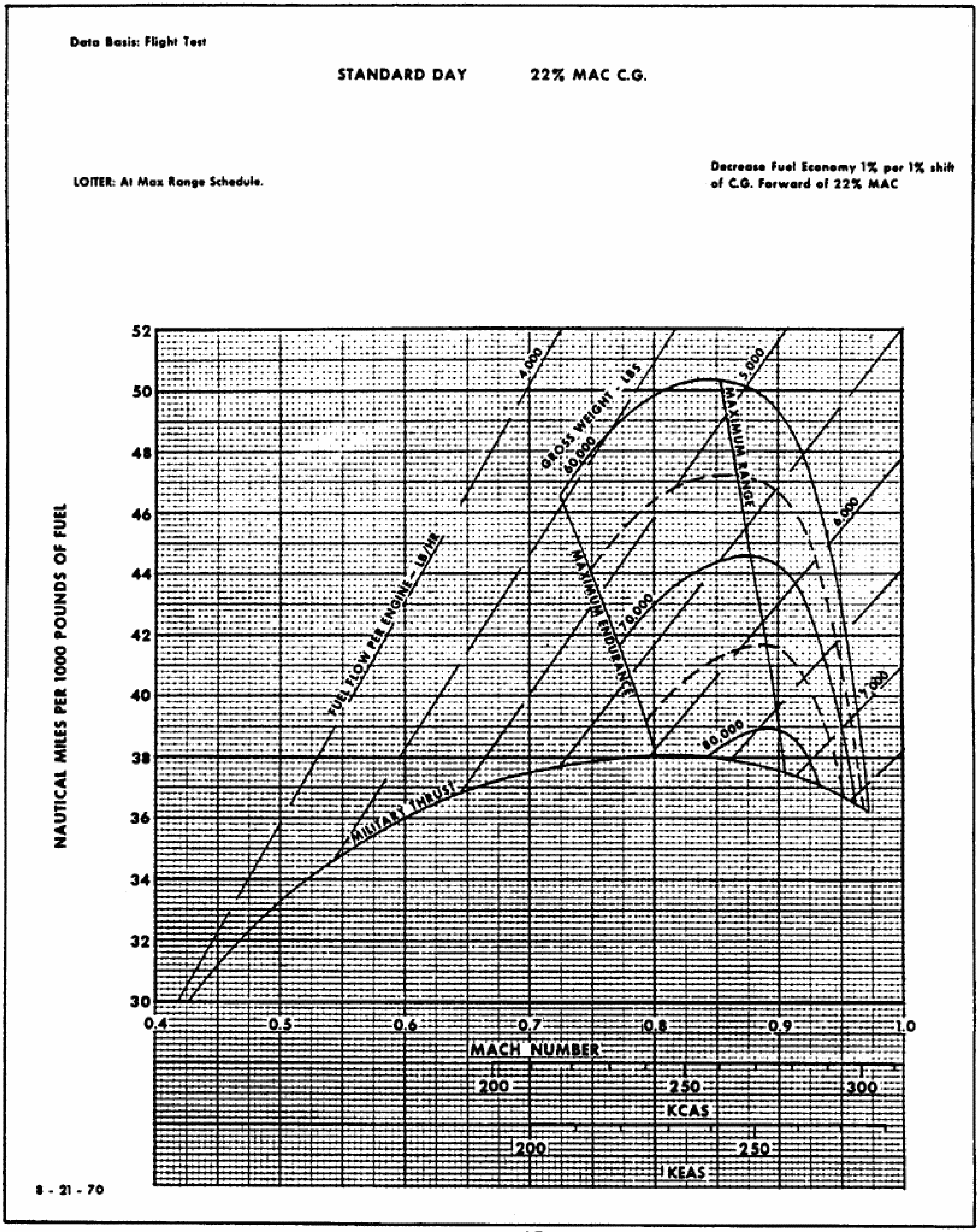


Figure A4-17

SUBSONIC MAXIMUM RANGE; .88 MACH CRUISE-CLIMB TO 300 KEAS

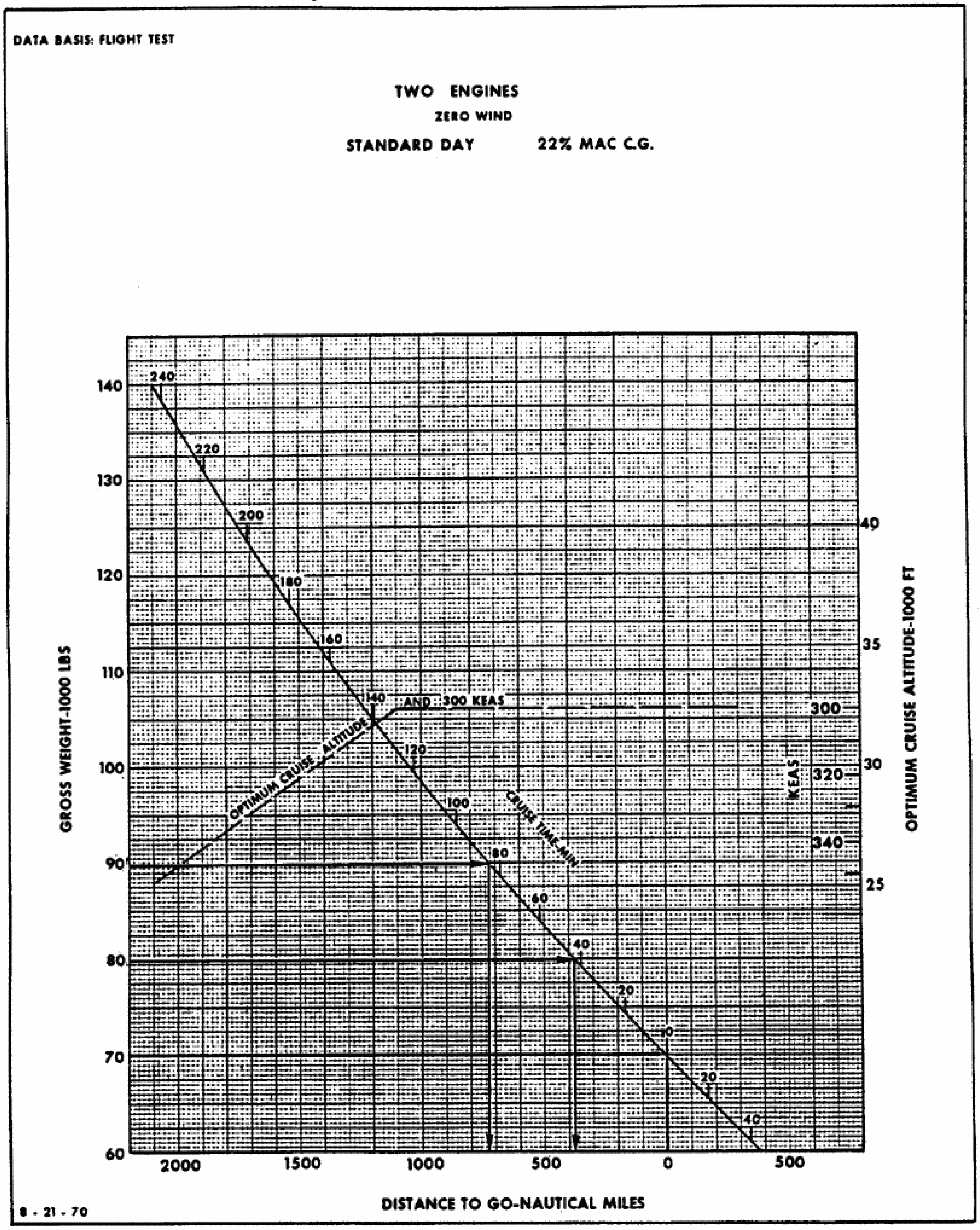


Figure A4-18

APPENDIX I
PART IV

SUBSONIC RANGE FACTOR

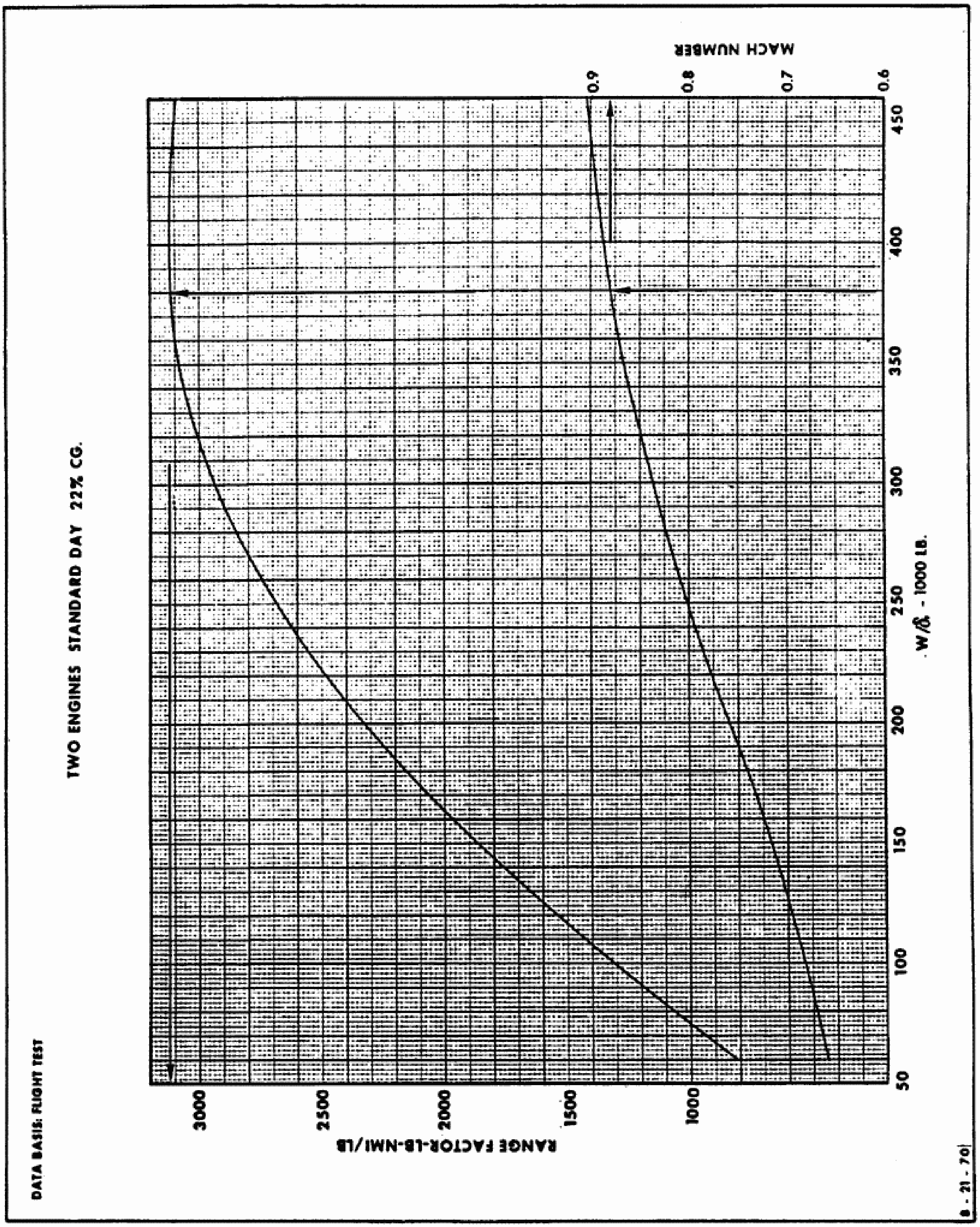


Figure A4-19

MAXIMUM SPECIFIC RANGE

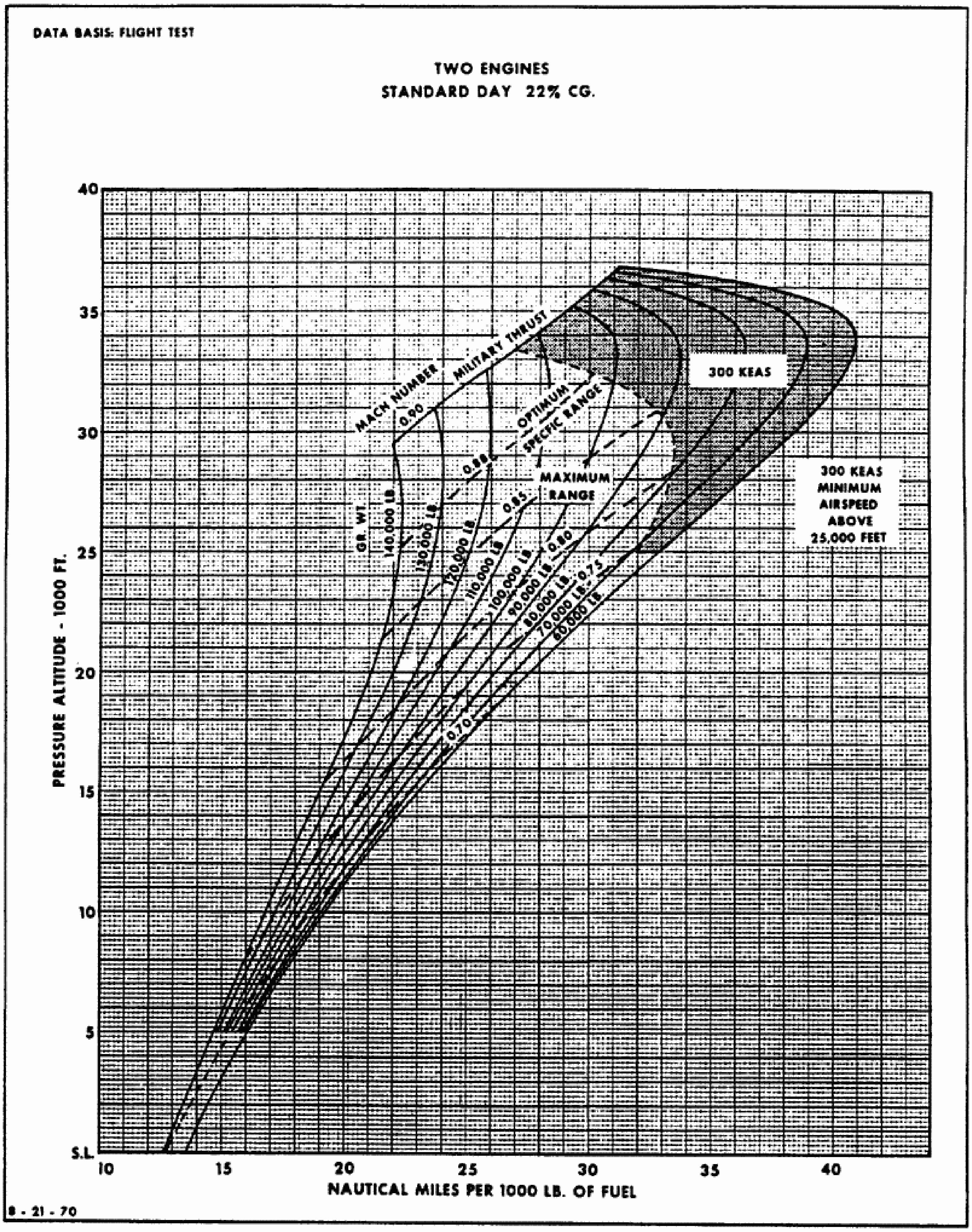


Figure A4-20

CONSTANT MACH CRUISE AT 0.75 MACH

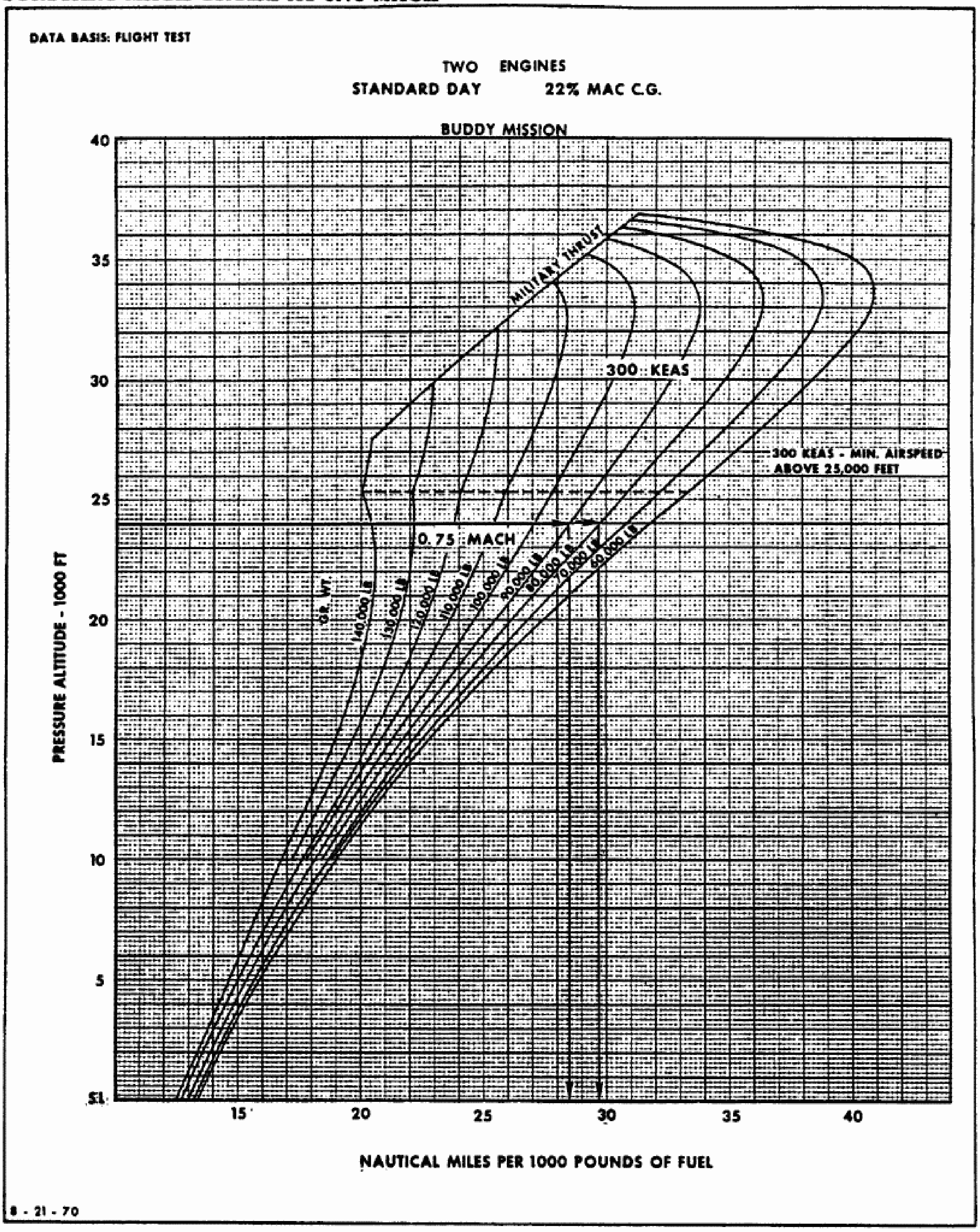


Figure A4-21

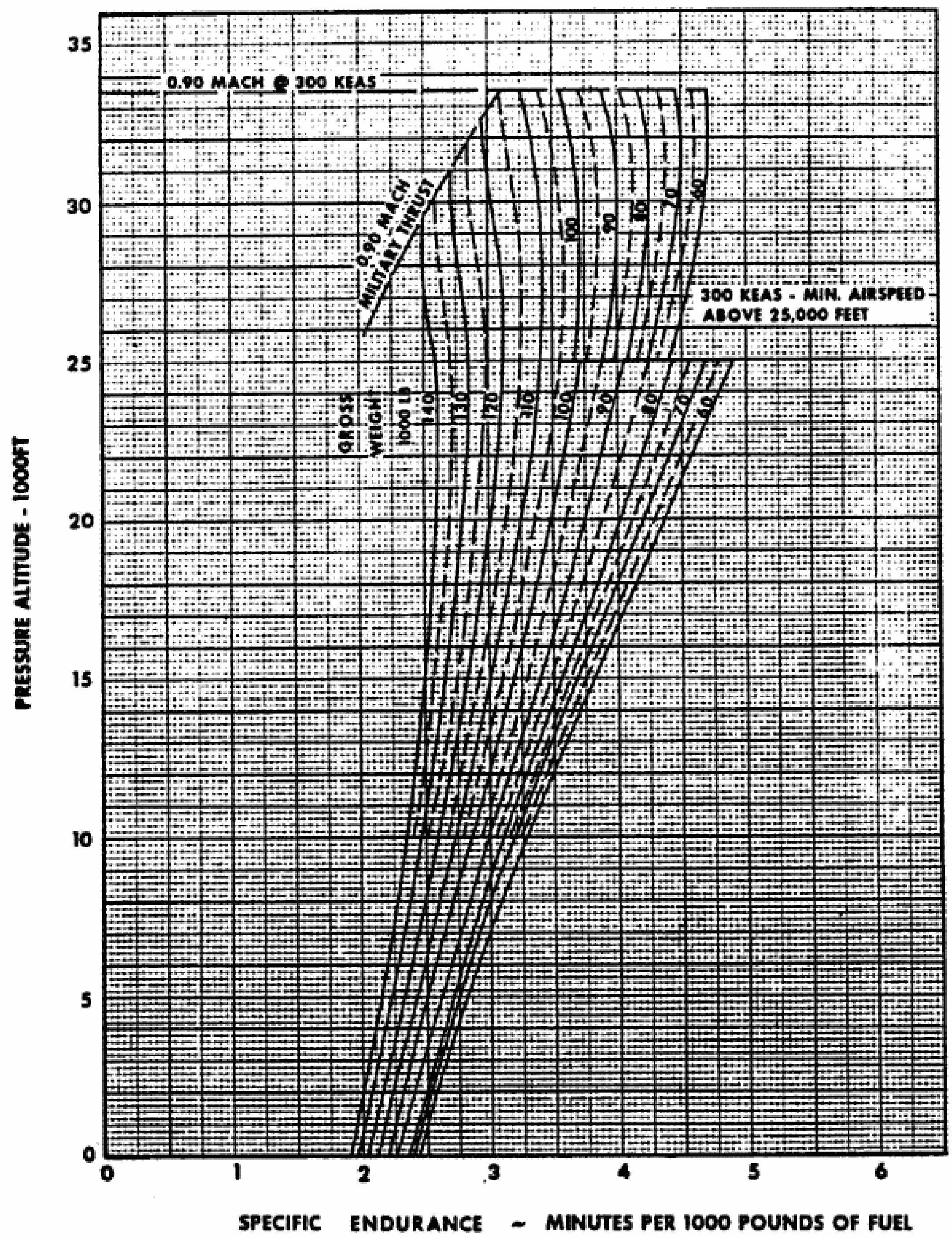
SPECIFIC ENDURANCE

DATA BASIS: FLIGHT TEST

TWO ENGINES

STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365



8 - 21 - 70

Figure A4-22

LOITER PROFILE

DATA BASIS: FLIGHT TEST

TWO ENGINES
STANDARD DAY 22% MAC C.G.

FUEL REMAINING	LOITER KIAS
20,000 lb. or less	275
30,000 lb.	290
40,000 lb.	305
50,000 lb.	320
60,000 lb.	335
70,000 lb.	350
80,000 lb.	365

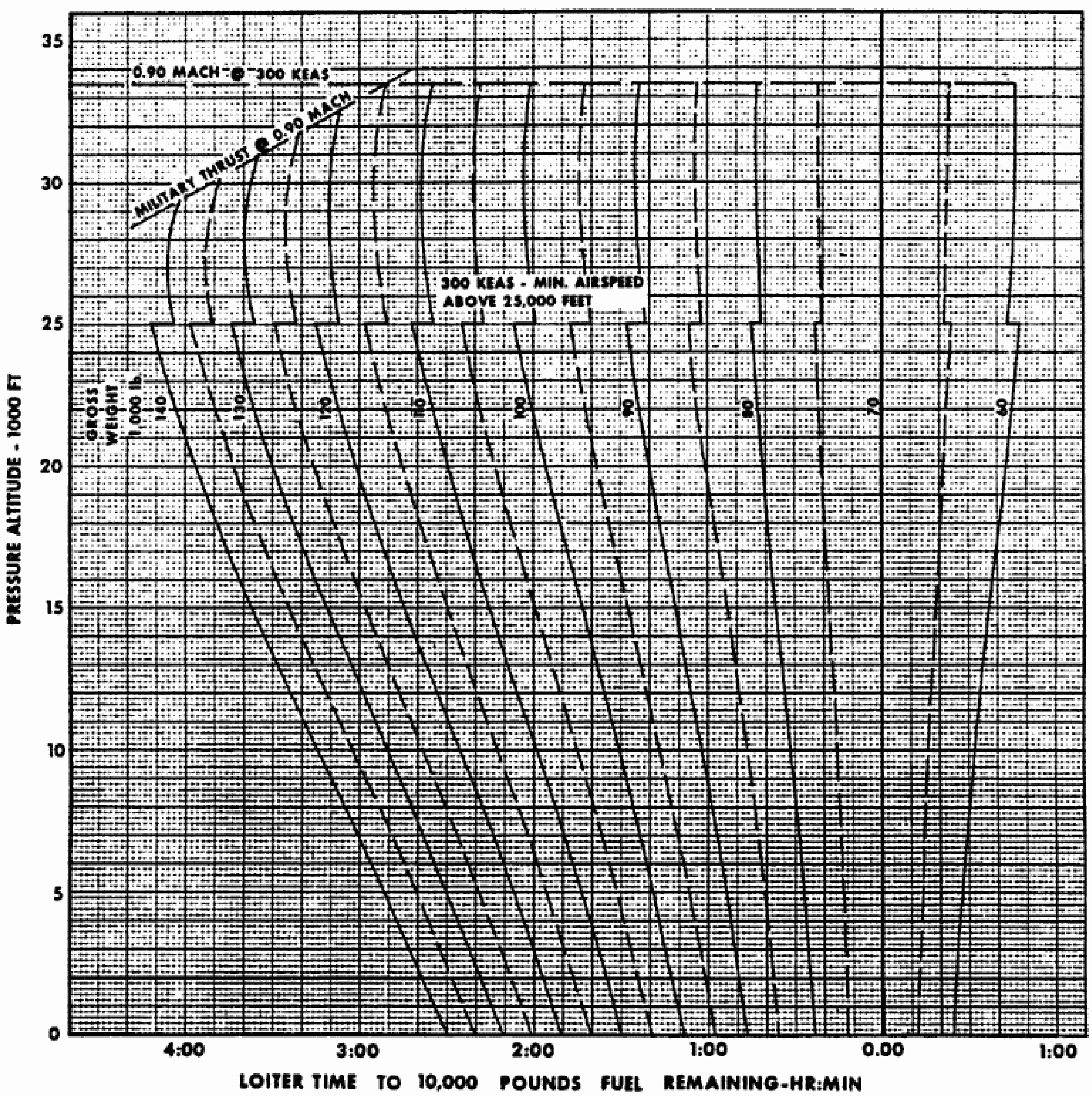


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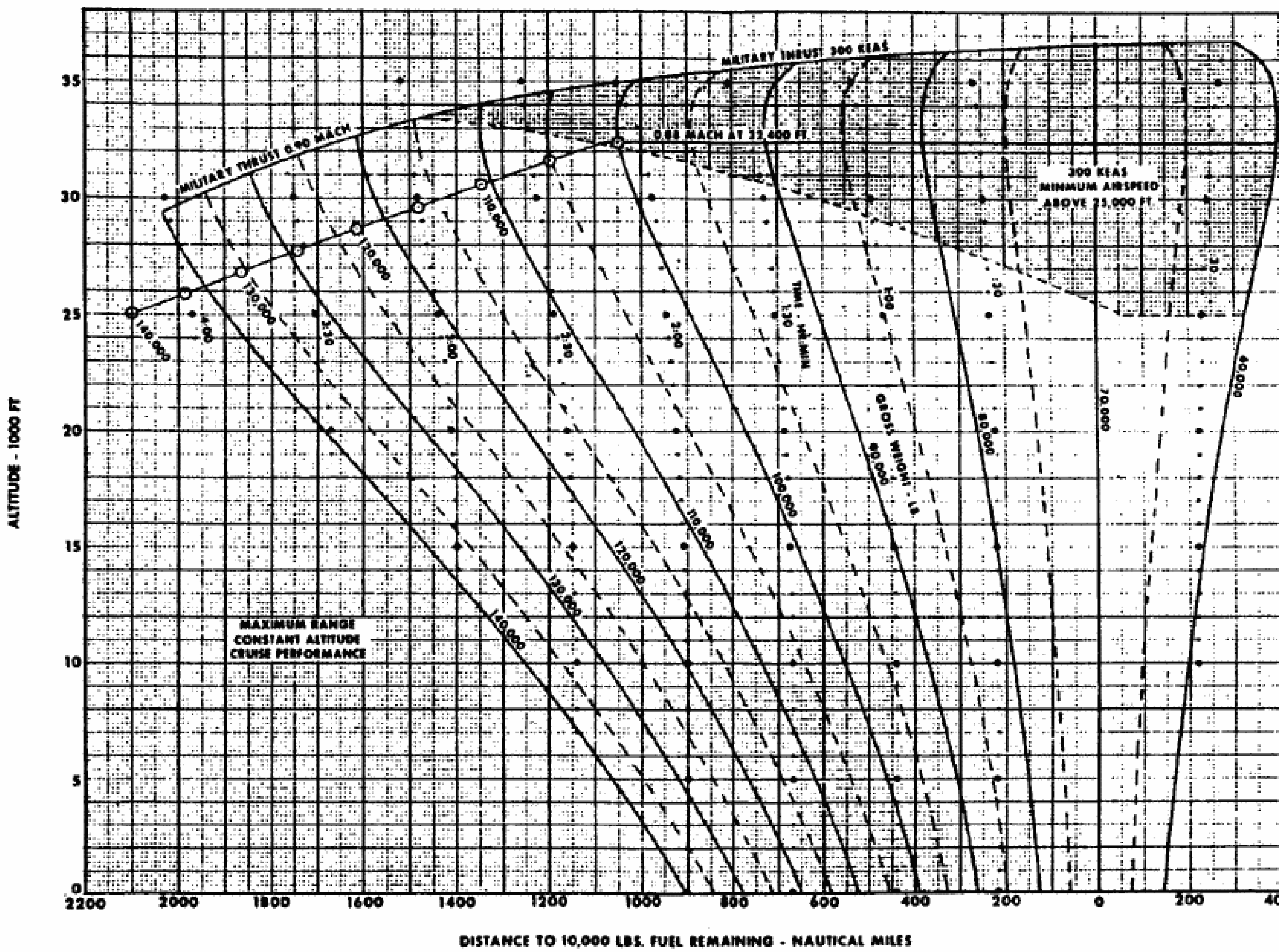
Figure A4-23

SUBSONIC MISSION PROFILE

DATA BASIS - FLIGHT TEST

TWO ENGINES
ZERO WIND   STANDARD DAY

AIR REFUEL (FULL) TO 140,000 LBS.
AT TANKER DISCONNECT THE
AIRCRAFT WILL BE NEAR OPTIMUM
CRUISE ALTITUDE



CLIMB DATA
400 KEAS TO .90 MACH AT 30,000 FT. - MINIMUM A/B

FLIGHT DATA	PRESSURE ALTITUDE - 1000 FT.							
	S.L.	5	10	15	20	25	30	OPTIMUM CRUISE
B.R. GR. WT.	140,000 LB.							(26,300 FT.)
INITIAL CRUISE GR. WT. - 1000 LB.	137.8	137.1	136.3	135.5	134.6	134.0		133.8
FUEL USED - LB	2200	2900	3700	4500	5400	6000		6200
TIME - MIN	0.9	1.6	1.9	2.5	3.3	3.9		4.7
DIST. - N.M.	3.0	6.0	10.0	15.0	21.8	27.4		29.5
B.R. GR. WT.	120,000 LB.							(29,800 FT.)
INITIAL CRUISE GR. WT. - 1000 LB.	118.0	117.4	116.8	116.1	115.4	114.9		114.4
FUEL USED - LB	2000	2600	3200	3900	4600	5100		5600
TIME - MIN	0.8	1.2	1.6	2.1	2.7	3.2		3.8
DIST. - N.M.	2.6	5.0	8.0	12.2	17.2	21.4		27.5
B.R. GR. WT.	100,000 LB.							(33,450 FT.)
INITIAL CRUISE GR. WT. - 1000 LB.	98.2	97.7	97.2	96.7	96.1	95.8	95.4	95.0
FUEL USED - LB	1800	2300	2800	3300	3900	4200	4600	5000
TIME - MIN	0.7	1.0	1.3	1.7	2.2	2.6	3.0	3.5
DIST. - N.M.	2.0	3.9	6.2	9.3	13.3	16.2	20.5	25.0

CRUISE DATA

FLIGHT DATA	PRESSURE ALTITUDE - 1000 FT.									
	S.L.	5	10	15	20	25	30	35	OPTIMUM CRUISE	
GR. WT.	140,000 TO 120,000 LB.								CRUISE CLIMB 25,100 TO 28,600 FT.	
MACH	.70	.73	.75	.79	.83	.87			.88	
KEAS	463	442	412	393	372	350			362-328	
KCAS	463	445	420	405	389	371			383-348	
KTAS	463	475	480	495	510	524			532-523	
GR. WT.	120,000 TO 100,000 LB.								CRUISE CLIMB 28,600 TO 32,400 FT.	
MACH	.69	.71	.73	.75	.79	.83	.88		.88	
KEAS	457	430	401	373	354	334	317		328-300	
KCAS	457	433	408	383	369	352	338		348-319	
KTAS	457	462	466	470	486	500	519		523-515	
GR. WT.	100,000 TO 80,000 LB.								CONSTANT ALTITUDE 32,400 FT.	CONSTANT ALTITUDE 33,450 FT.
MACH	.68	.69	.71	.73	.76	.80	.84	.935	.88	.90
KEAS	450	418	390	363	340	322	307	300	300	300
KCAS	450	420	397	373	353	338	321	324	320	321
KTAS	450	449	454	457	467	482	495	539	513	523
GR. WT.	80,000 TO 60,000 LB.								CONSTANT ALTITUDE 32,400 FT.	CONSTANT ALTITUDE 33,450 FT.
MACH	.67	.68	.69	.70	.72	.75	.833	.935	.88	.90
KEAS	443	412	379	349	323	302	300	300	300	300
KCAS	443	414	386	358	334	315	318	324	320	321
KTAS	443	443	441	439	443	452	491	539	513	523

NOTE:
1. CLIMB DATA TABLE INCLUDES TIME AND FUEL USED FROM BRAKE RELEASE TO 400 KEAS AT SEA LEVEL. DISTANCE INCLUDES ACCELERATION FROM 225 KEAS TO 400 KEAS AT SEA LEVEL.
2. CRUISE DATA TABLE MAXIMUM RANGE SPEED SCHEDULE BASED ON AVERAGE GROSS WEIGHT.

Figure A4-24

SUBSONIC SINGLE-ENGINE SPECIFIC RANGE - MILITARY

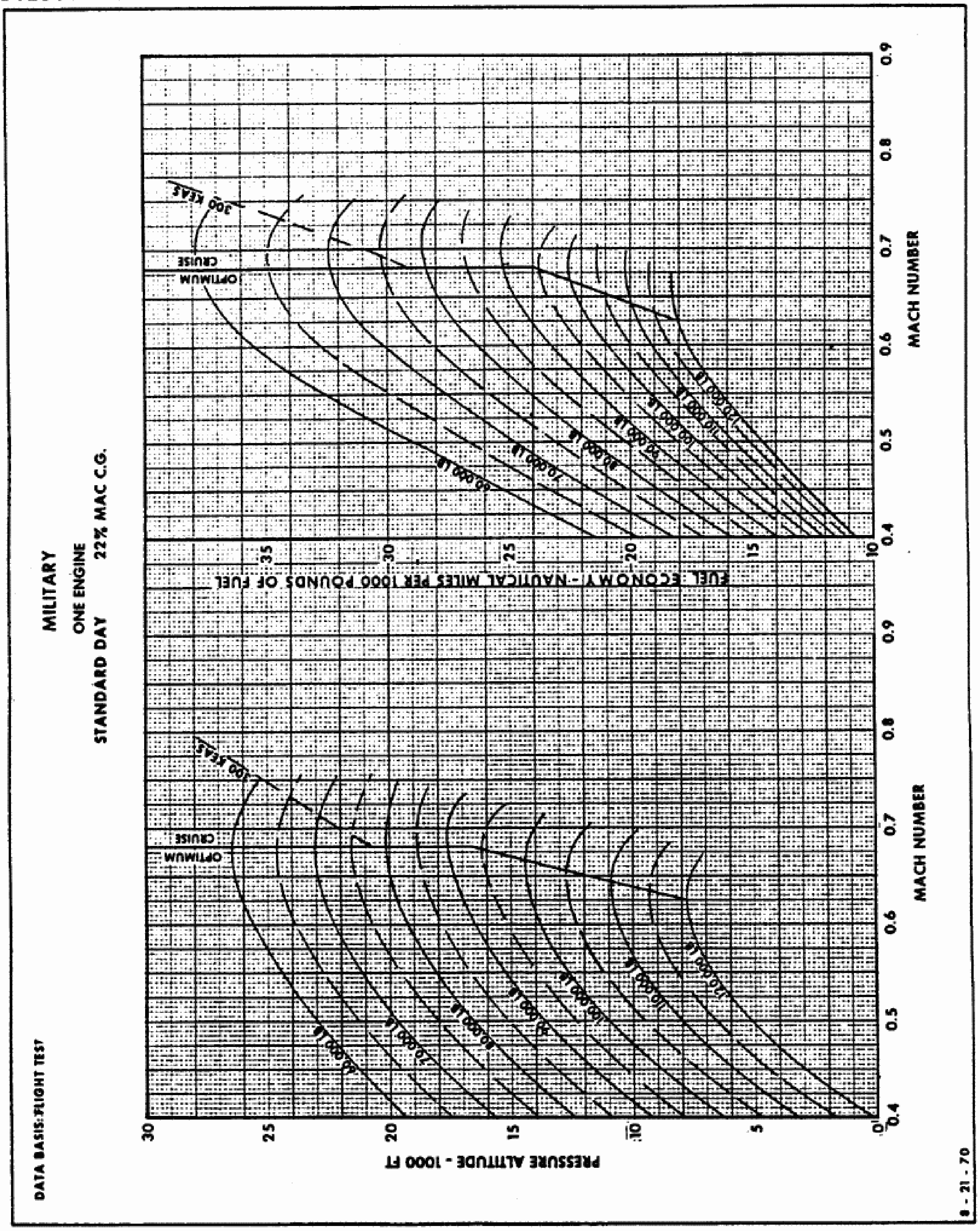


Figure A4-25

SUBSONIC SINGLE-ENGINE SPECIFIC RANGE – MINIMUM A/B

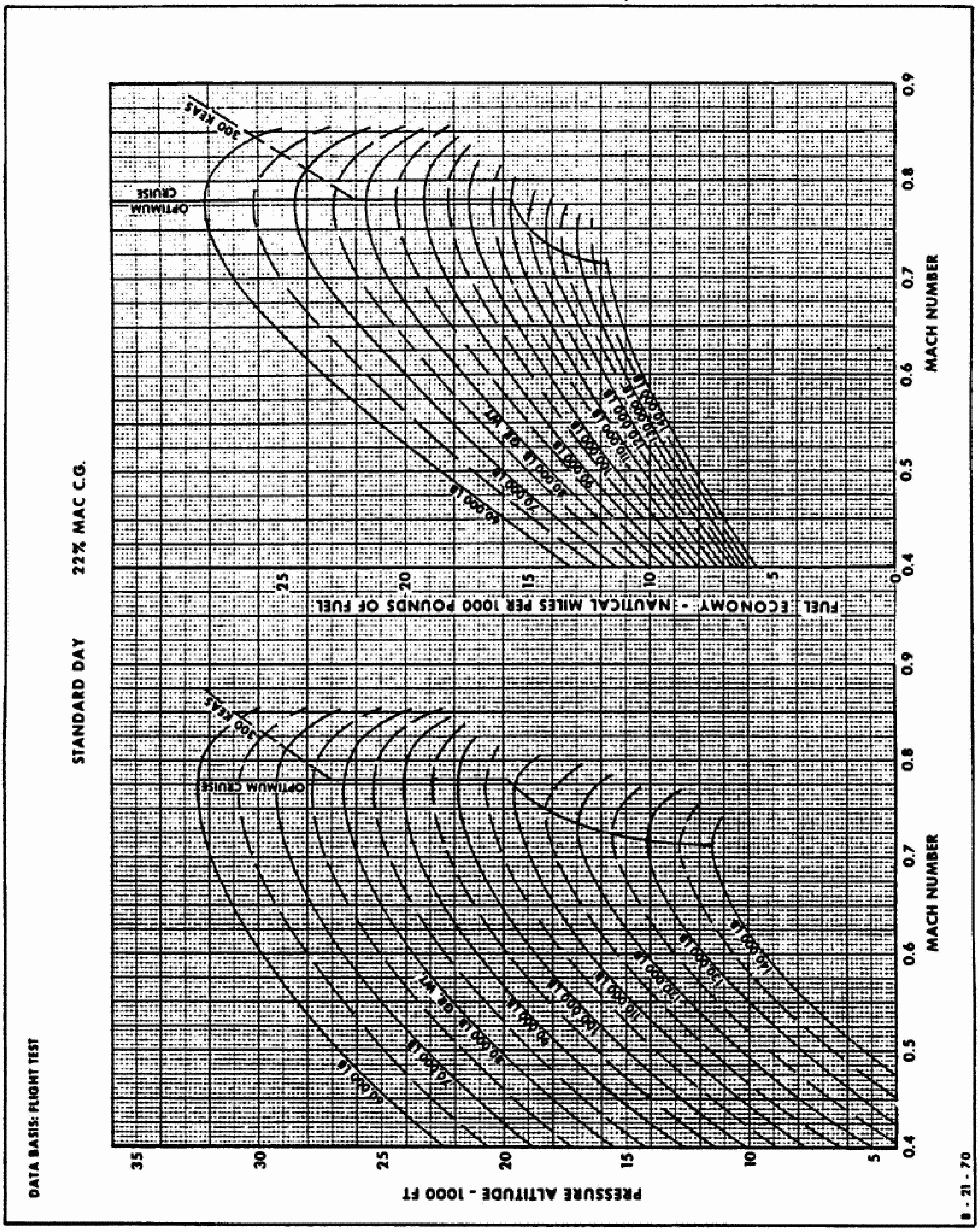


Figure A4-26

SUBSONIC SINGLE-ENGINE SPECIFIC RANGE - MAXIMUM A/B

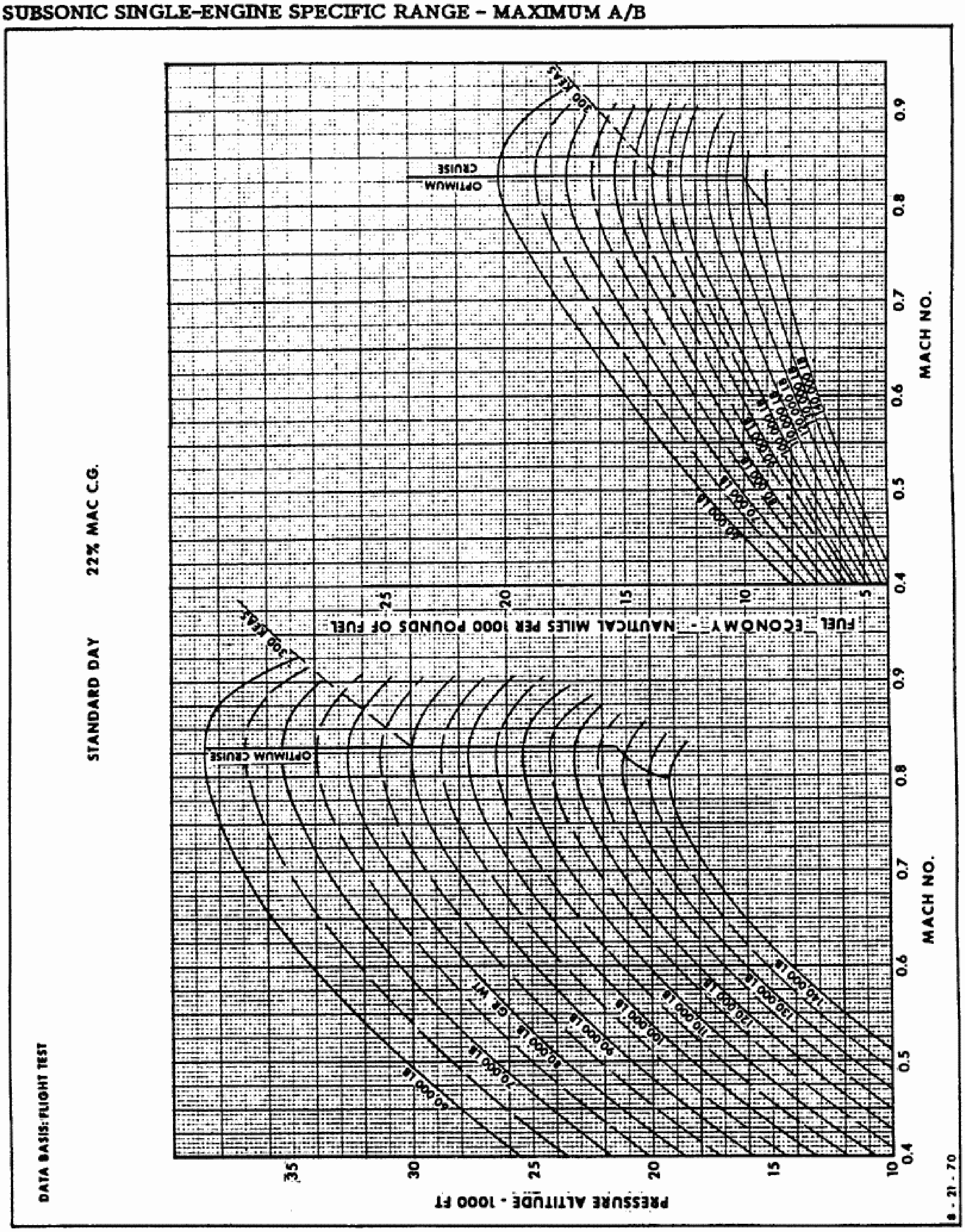


Figure A4-27

[redacted]

PART V

SUPERSONIC SPECIFIC RANGE DATA

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SPECIFIC RANGE

Specific range curves are provided for cruise speeds of Mach 3.20, 3.15, 3.10, 3.00, 2.80 and 2.40 and for a range of temperatures at each cruise speed except Mach 2.40. Data is presented for the operational range of gross weights and altitudes available at afterburning power settings, including Maximum afterburning. Correction grids show the effects of bank angle on specific range and altitude during turns at constant power settings. Supplemental scales provide KEAS-altitude information and convert nautical miles per 1000 lb (nmi/1000 lb) to fuel flow.

Example:

At Mach 3.20, with a CIT of 380°C (-56.5°C FAT) (Figure A5-5), the maximum specific range at a gross weight of 90,000 lb is 54.1 nm/1000 lb of fuel at an altitude of 78,700 feet. For a 30° banked turn, maximum range altitude decreases to 75,700 feet and specific range decreases to 46.8 nm/1000 lb of fuel. Fuel flow per engine is 16,900 lb/hr at maximum range and increases to 19,700 lb/hr in a 30° banked turn at the lower altitude. For the same gross weight at a CIT of 370°C (Figure A5-3) the maximum specific range is 55.0 nm/1000 lb of fuel at an altitude of 79,000 feet while an increase in CIT to 390°C (Figure A5-8) only decreases specific range to 54.0 nm/1000 lb but altitude decreases to 78,400 feet.

RANGE FACTOR PARAMETER

The Range Factor Parameter curves show the range capability of the aircraft in terms of Range Factor and the weight/altitude parameter, W/δ . The W/δ for maximum range is noted on the upper portion of the curves, while the lower portion of the curves provides the corresponding gross weight-altitude-KEAS relationship. A correction grid is supplied for determining Range Factor at c.g. positions other than 25%.

Range Factor is a measure of cruise performance. Range Factor is defined as

Range Factor = (gross weight) x (specific range)

The specific range at any point during cruising flight may be determined by using the definition of range factor, since

$$\text{nm/1000 lb} = \frac{\text{R.F.}}{\text{G.W.}} \times 1000$$

Range Factor does not change as rapidly as specific range during cruising flight. Typical range factors for a particular flight schedule can be used during flight to forecast miles per pound as fuel is used. Since specific range is also defined as

$$\text{Specific Range} = \frac{\text{KTAS}}{\text{Total fuel flow}}$$

then, during cruising flight, the fuel flow per engine at any given moment is

$$\text{Fuel flow/engine} = \frac{\text{KTAS x gross wt}}{2 \times \text{R.F.}}$$

Example:

At Mach 3.20, with 1835 KTAS, 100,000 lb gross weight, and 4940 R.F.

$$\text{Specific Range} = \frac{4940}{100{,}000} \times 1000 =$$

49.4 nm/1000 lb.

$$\text{Fuel flow/engine} = \frac{1835 \times 100{,}000}{2 \times 4940} =$$

18,600 lb/hr.

For a gross weight of 80,000 lb and 4810 R.F.

$$\text{Specific Range} = \frac{4810}{80{,}000} \times 1000 =$$

60.1 nm/1000 lb

$$\text{Fuel flow/engine} = \frac{1835 \times 80{,}000}{2 \times 4810} =$$

15,250 Lb/hr.

SPECIFIC RANGE AT MACH 3.20

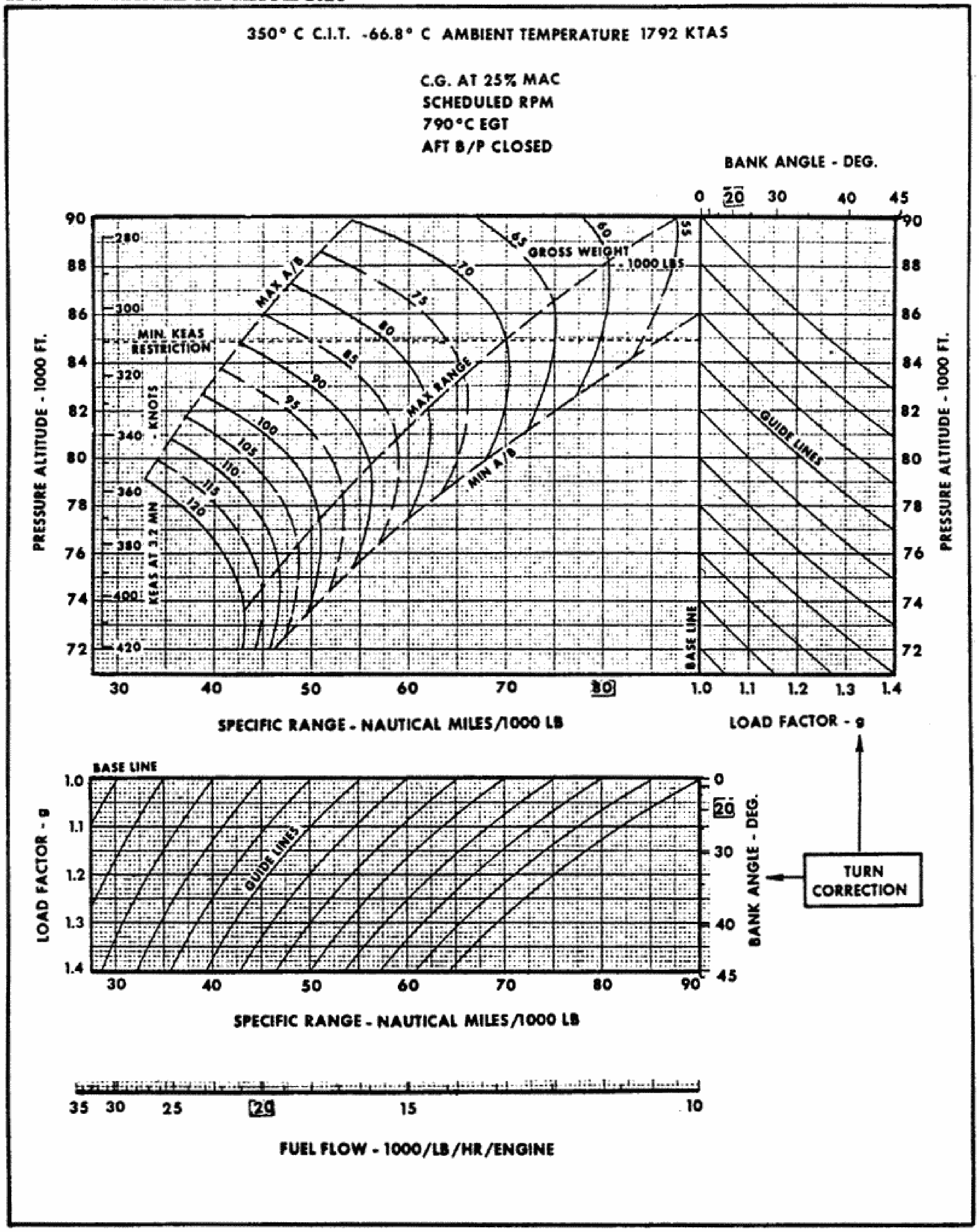


Figure A5-1

MACH 3.20 RANGE FACTOR PARAMETER

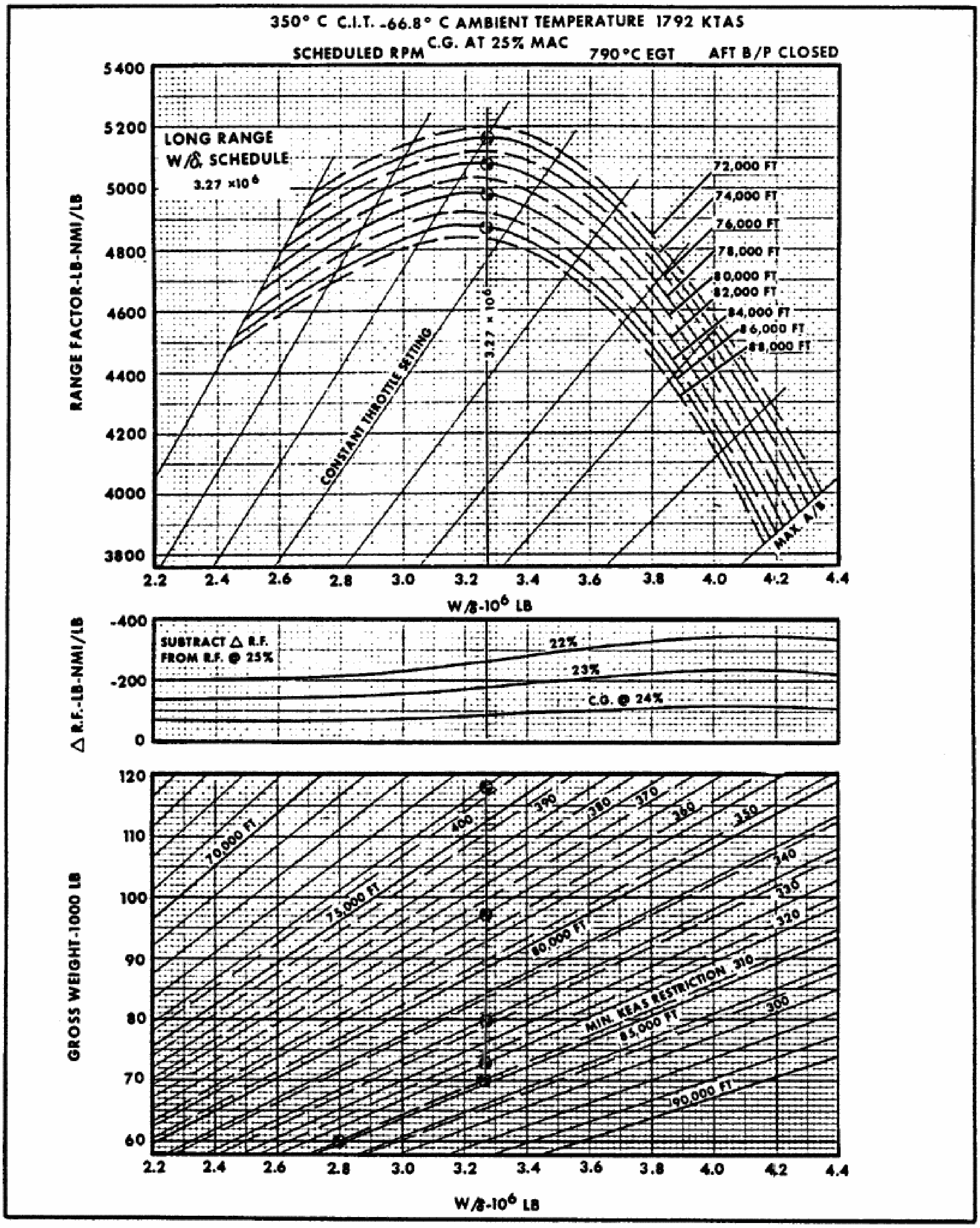


Figure A5-2

SPECIFIC RANGE AT MACH 3.20

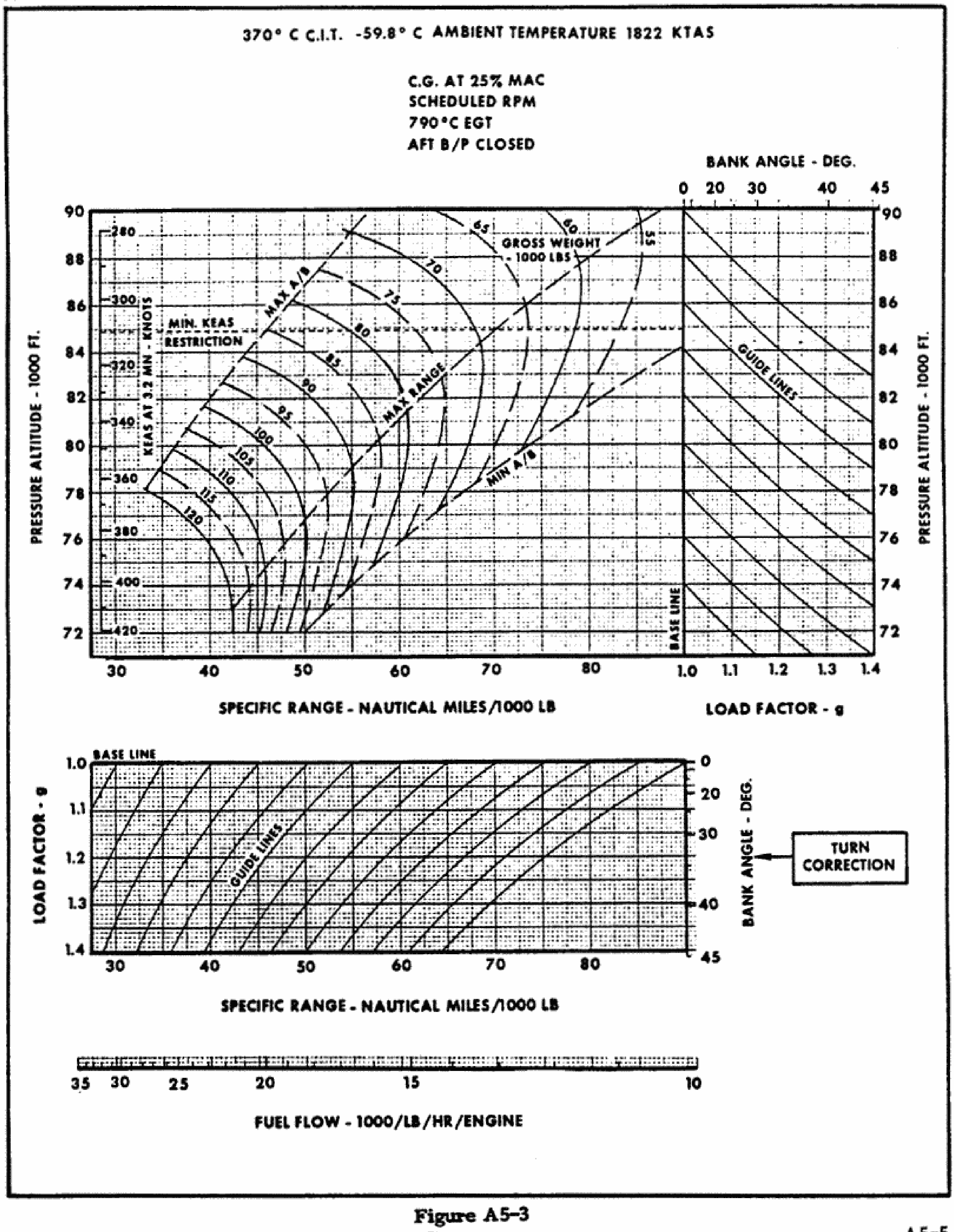


Figure A5-3

MACH 3.20 RANGE FACTOR PARAMETER

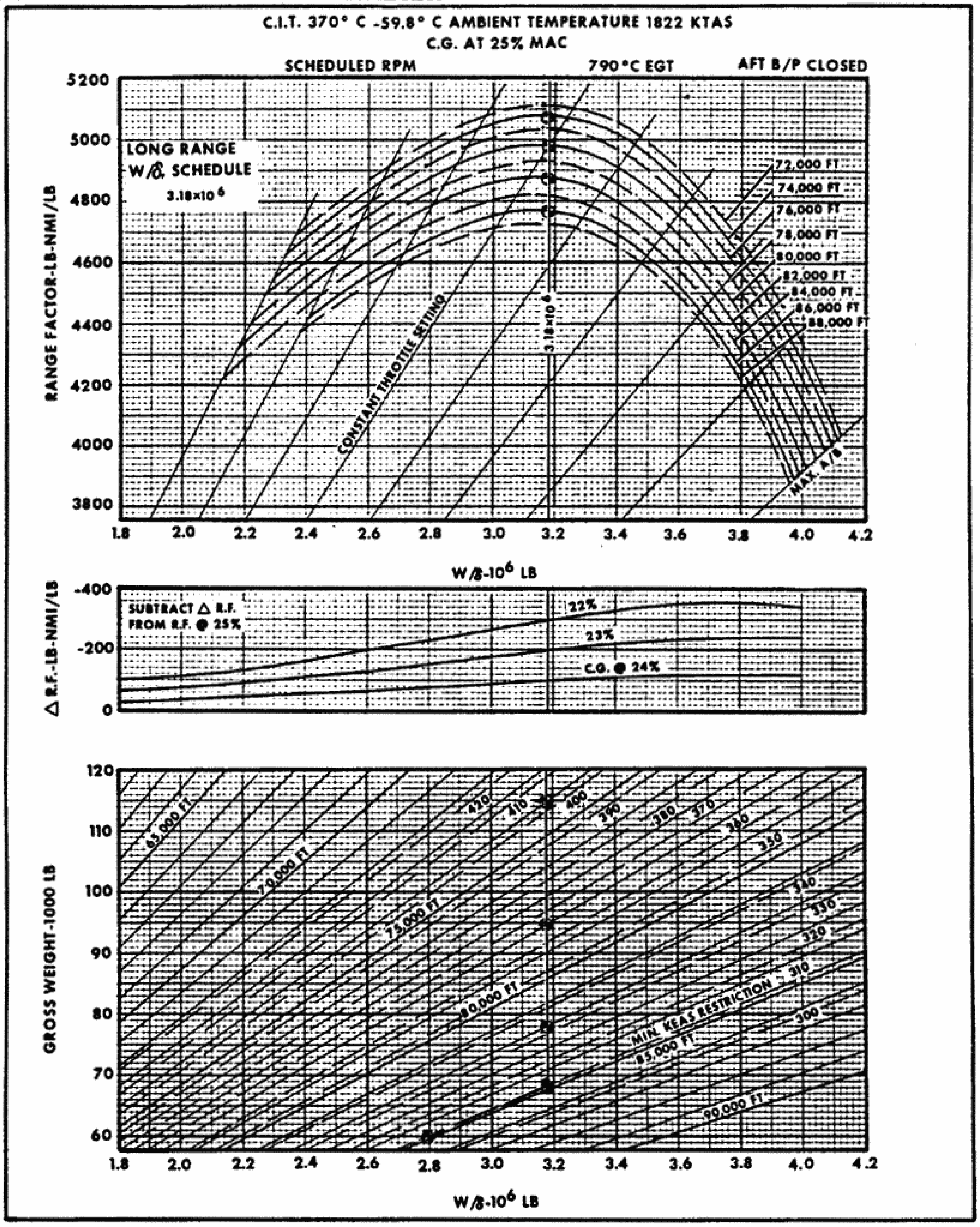


Figure A5-4

SPECIFIC RANGE AT MACH 3.20

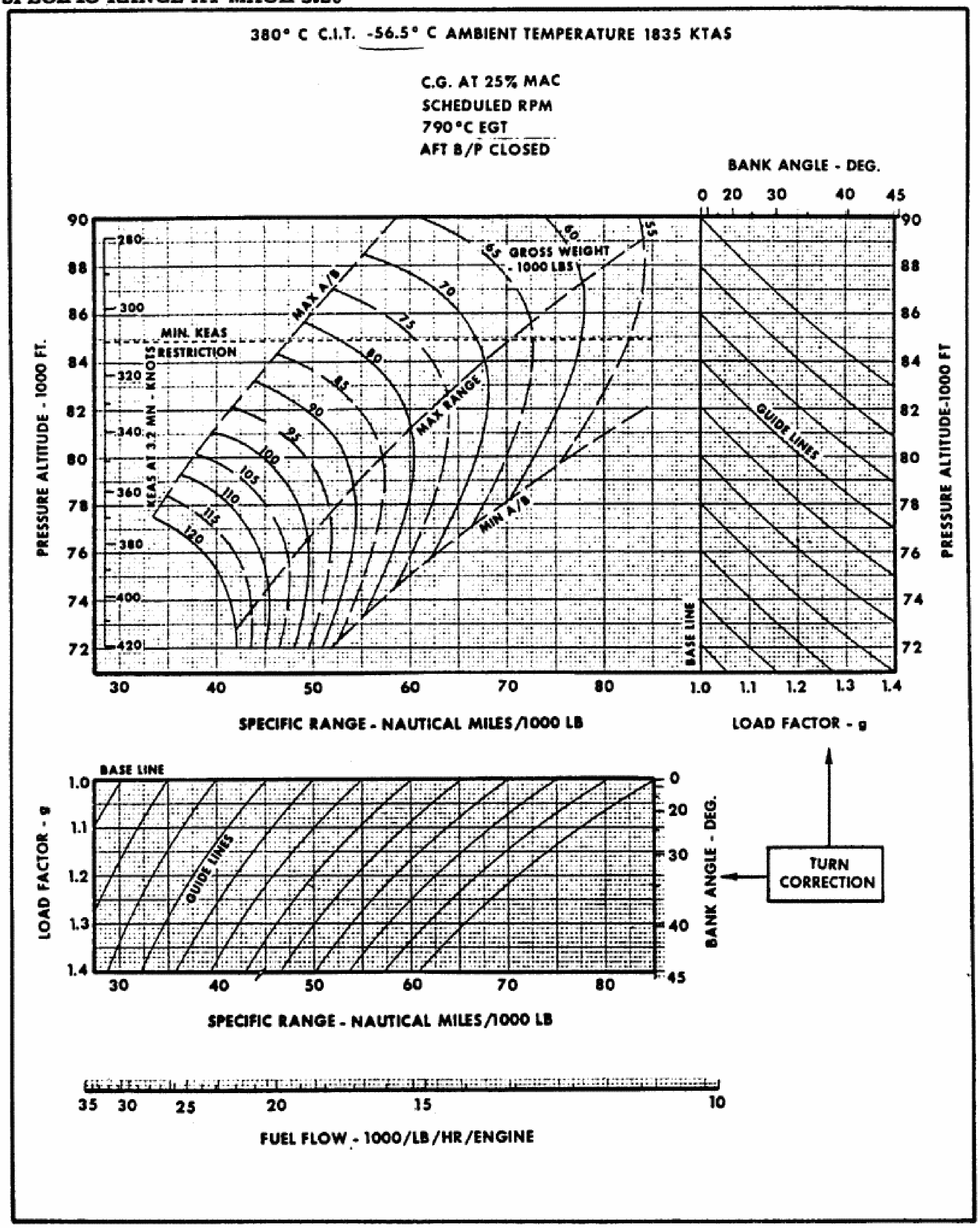


Figure A5-5

[redacted]

MACH 3.20 RANGE FACTOR PARAMETER

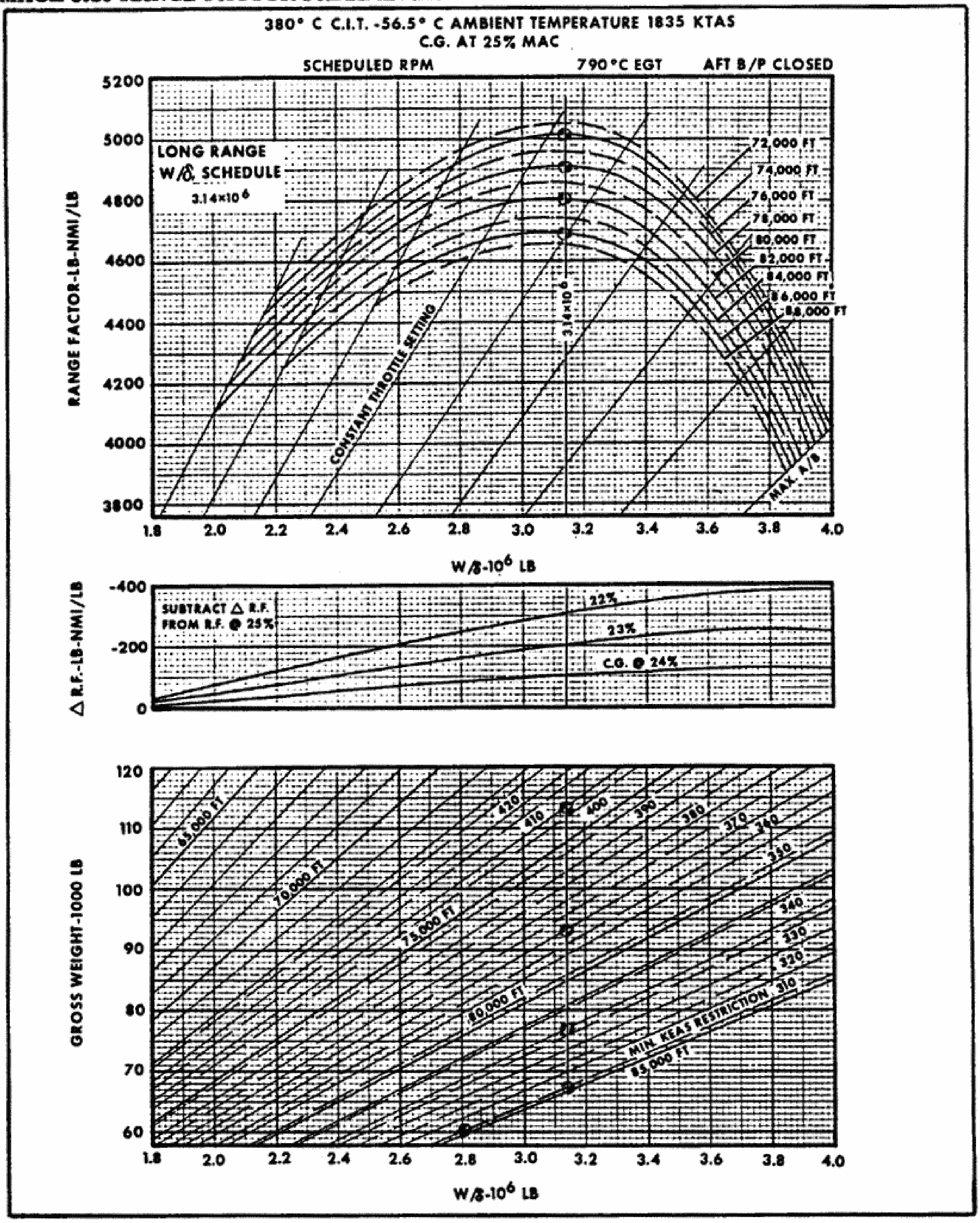


Figure A5-6

SPECIFIC RANGE AT MACH 3.20

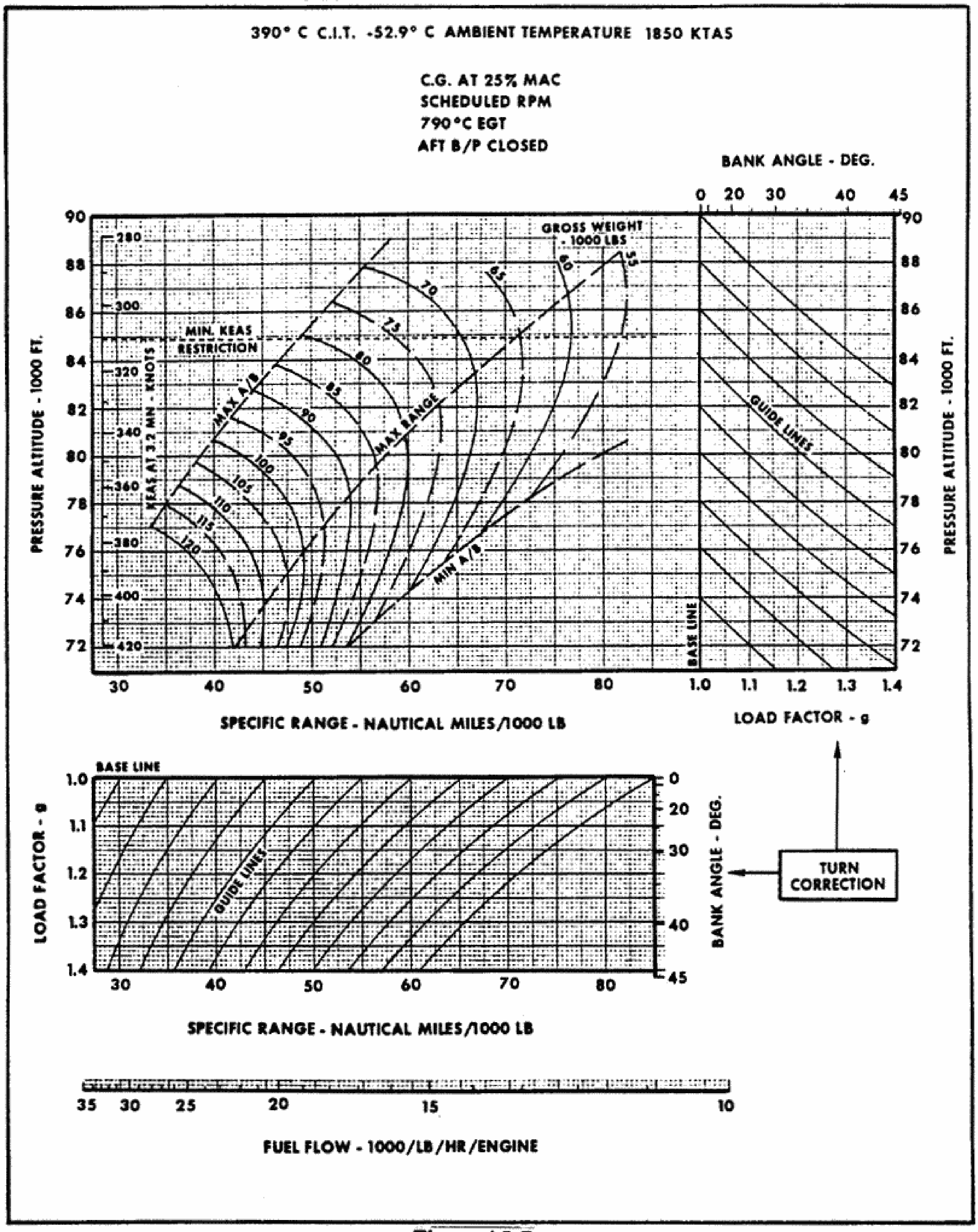


Figure A5-7

MACH 3.20 RANGE FACTOR PARAMETER

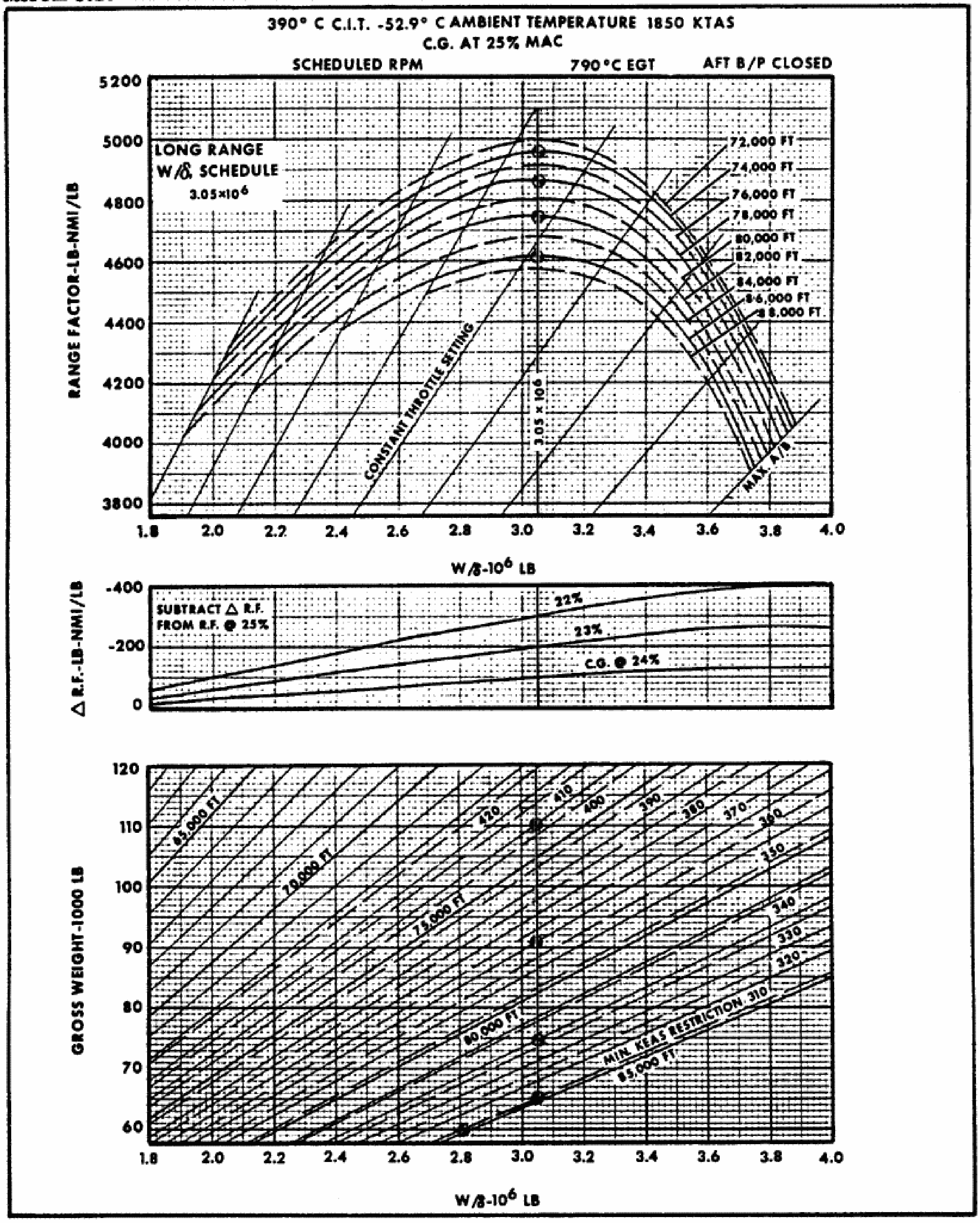


Figure A5-8

[redacted]

SPECIFIC RANGE AT MACH 3.20

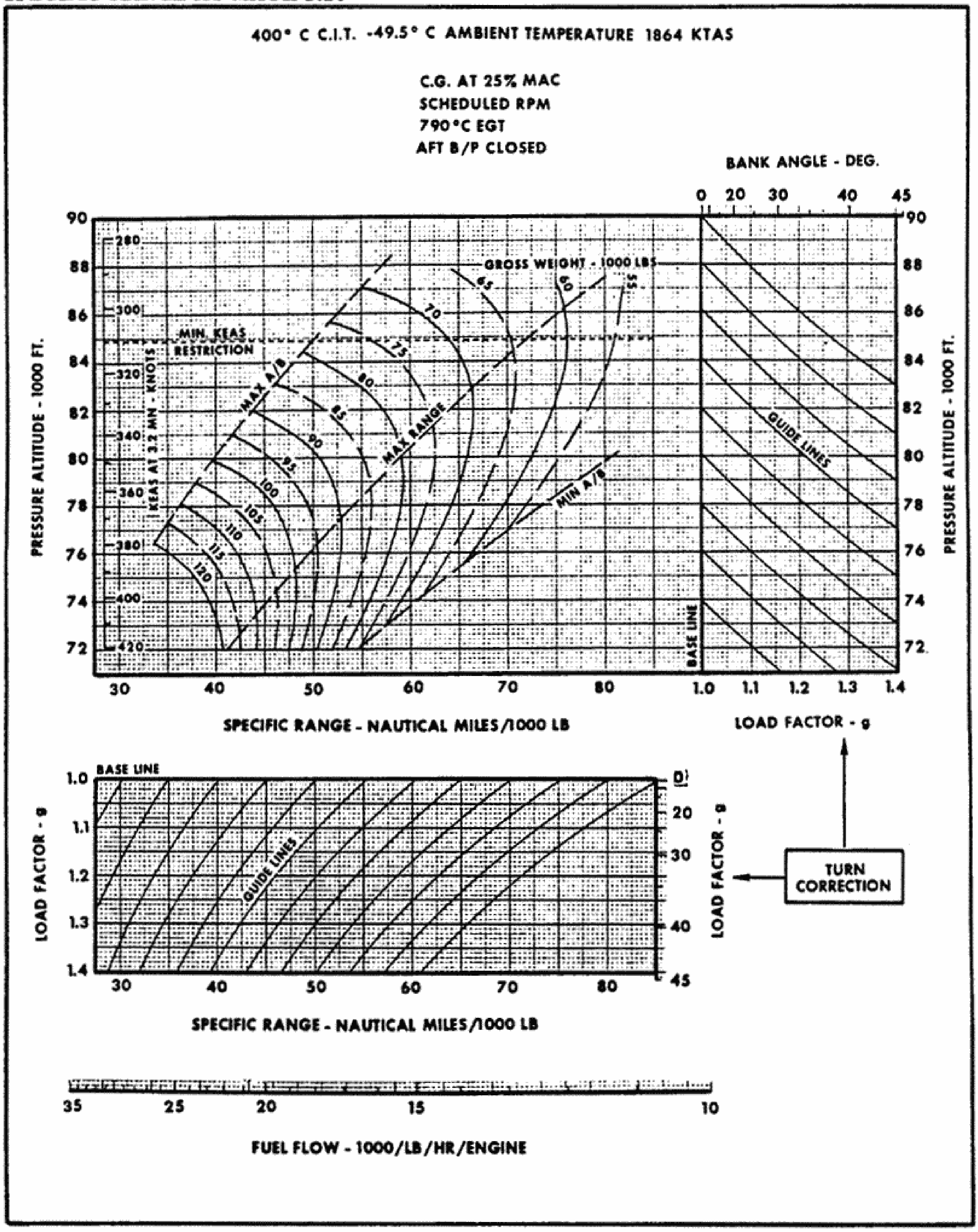


Figure A5-9

MACH 3.20 RANGE FACTOR PARAMETER

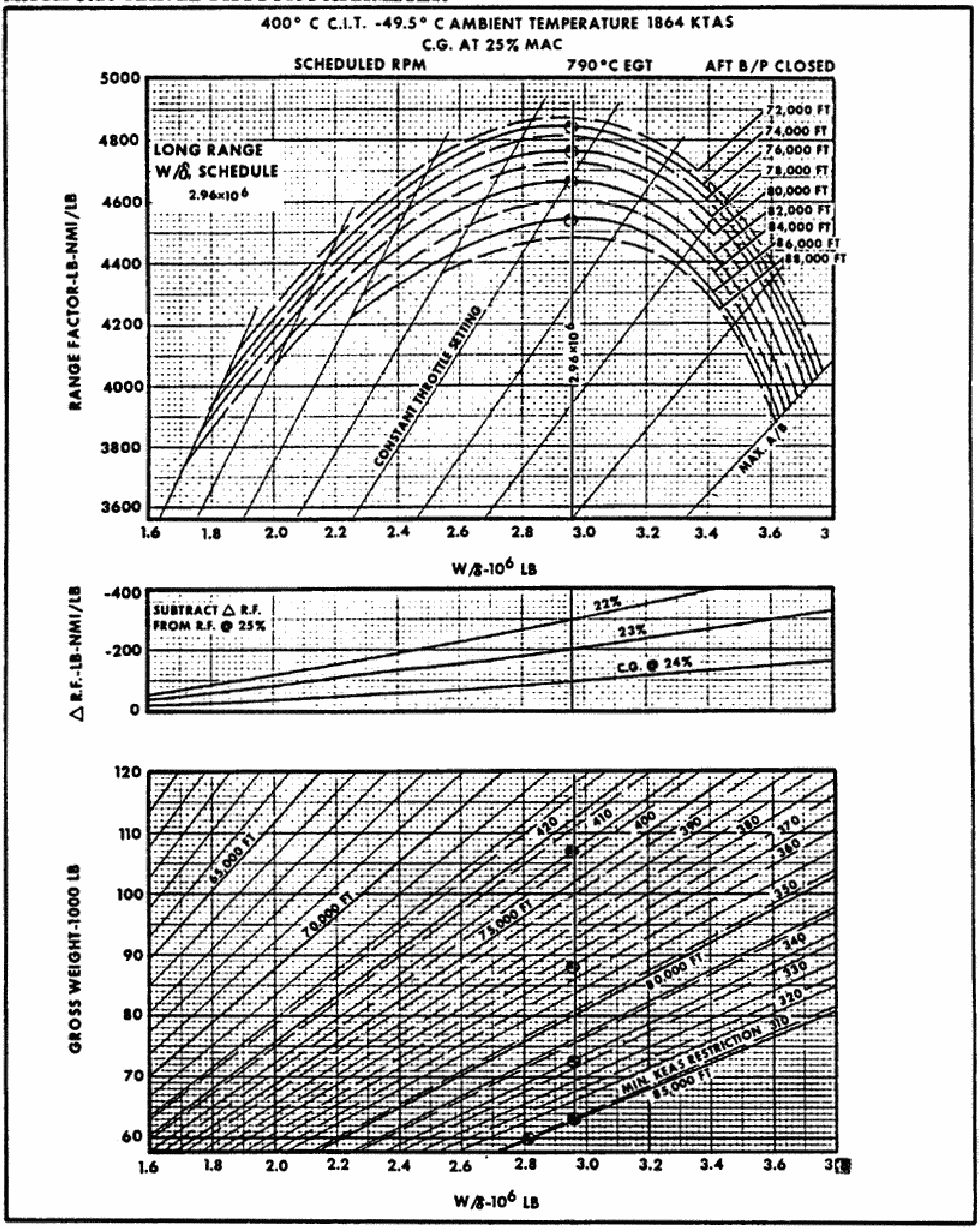


Figure A5-10

SPECIFIC RANGE AT MACH 3.20

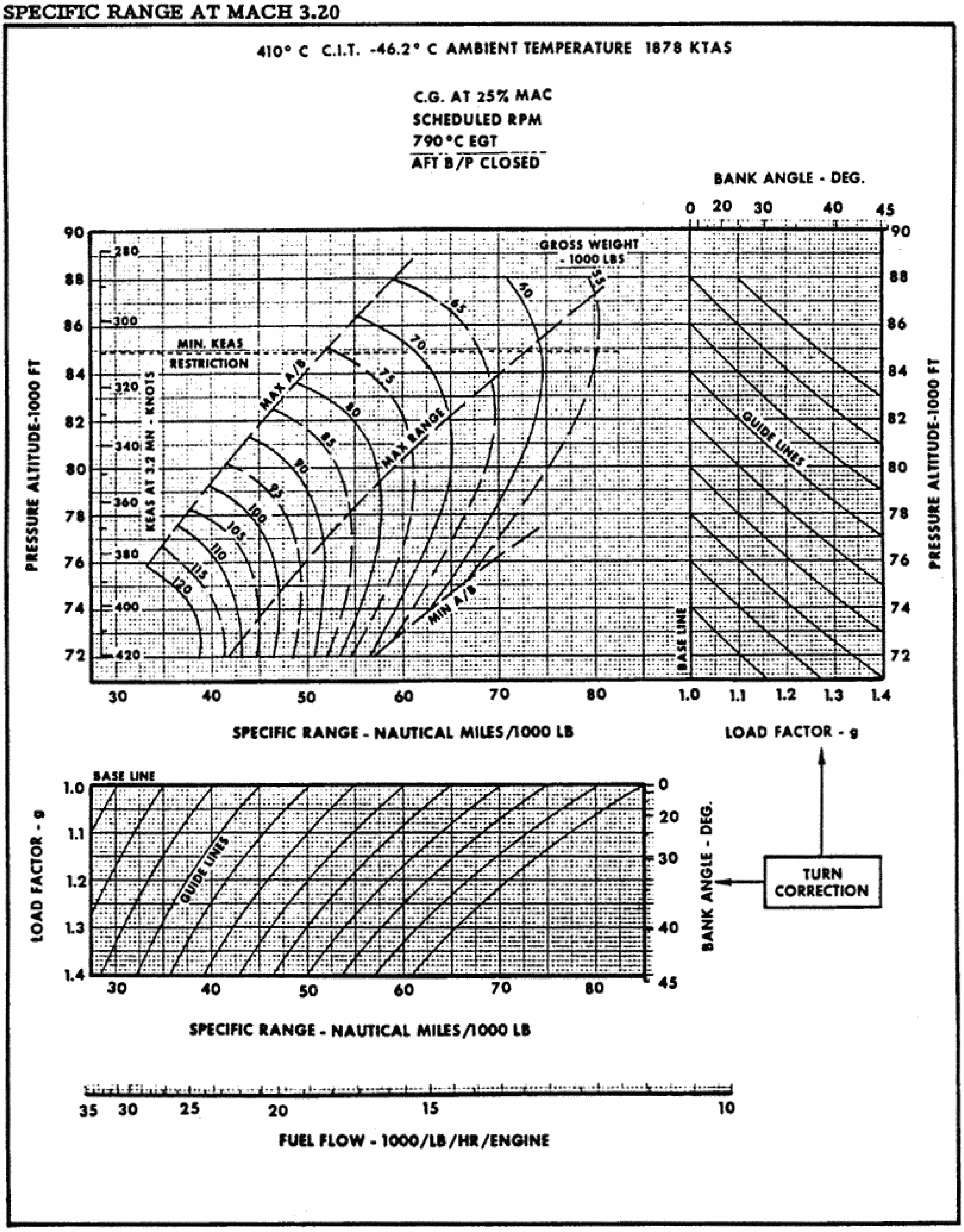


Figure A5-11

MACH 3.20 RANGE FACTOR PARAMETER

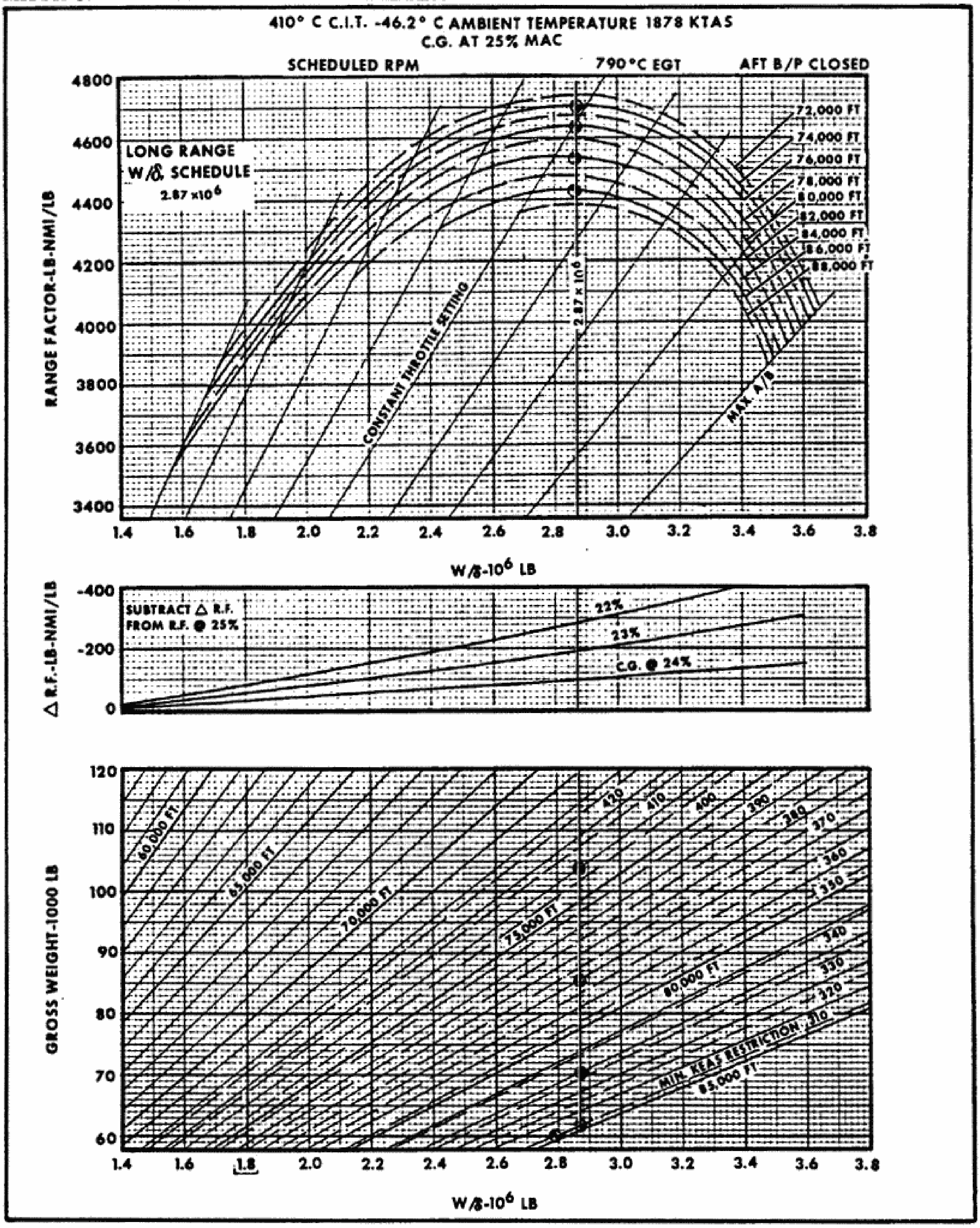


Figure A5-12

[redacted]

SPECIFIC RANGE AT MACH 3.15

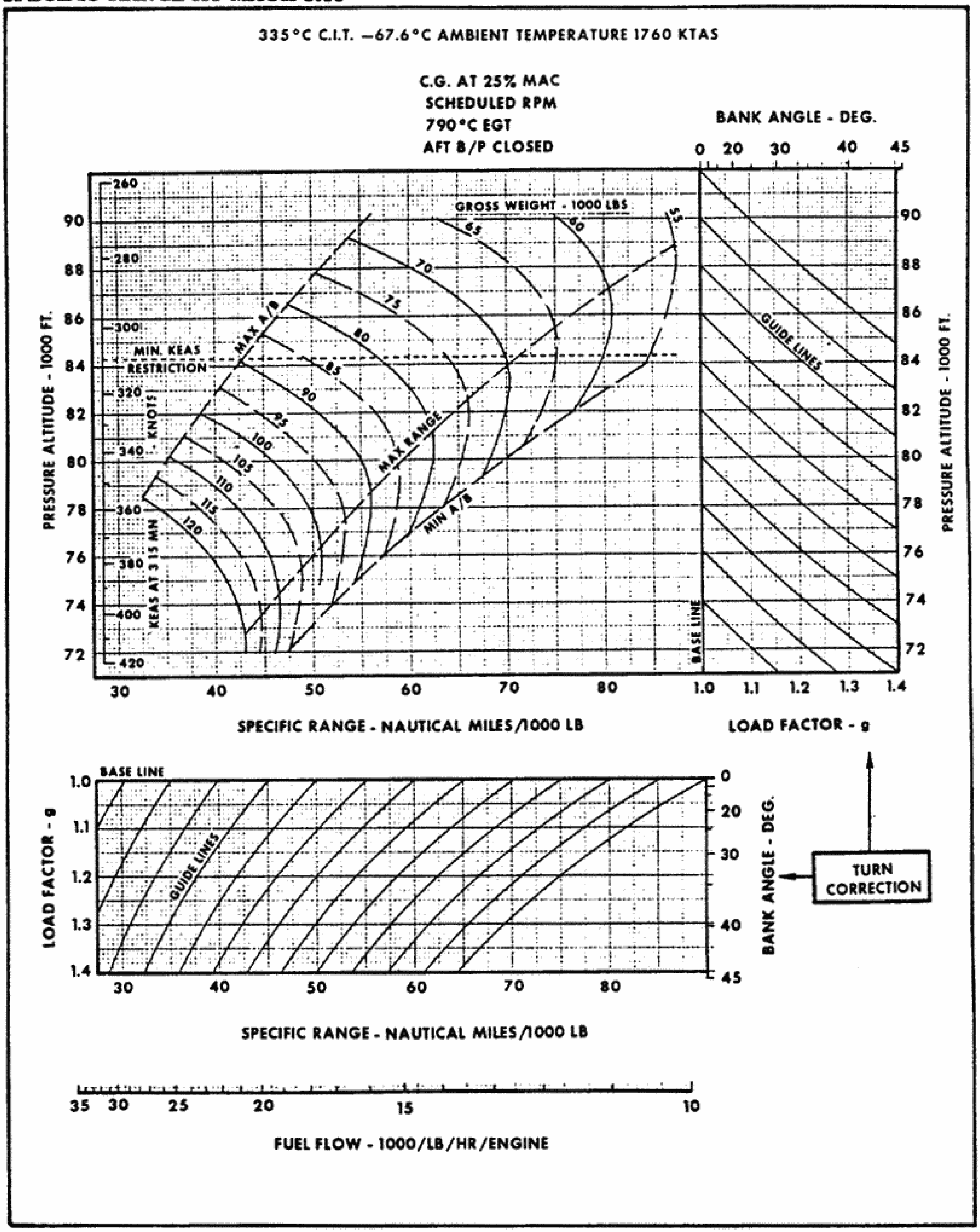


Figure A5-13

[redacted]

MACH 3.15 RANGE FACTOR PARAMETER

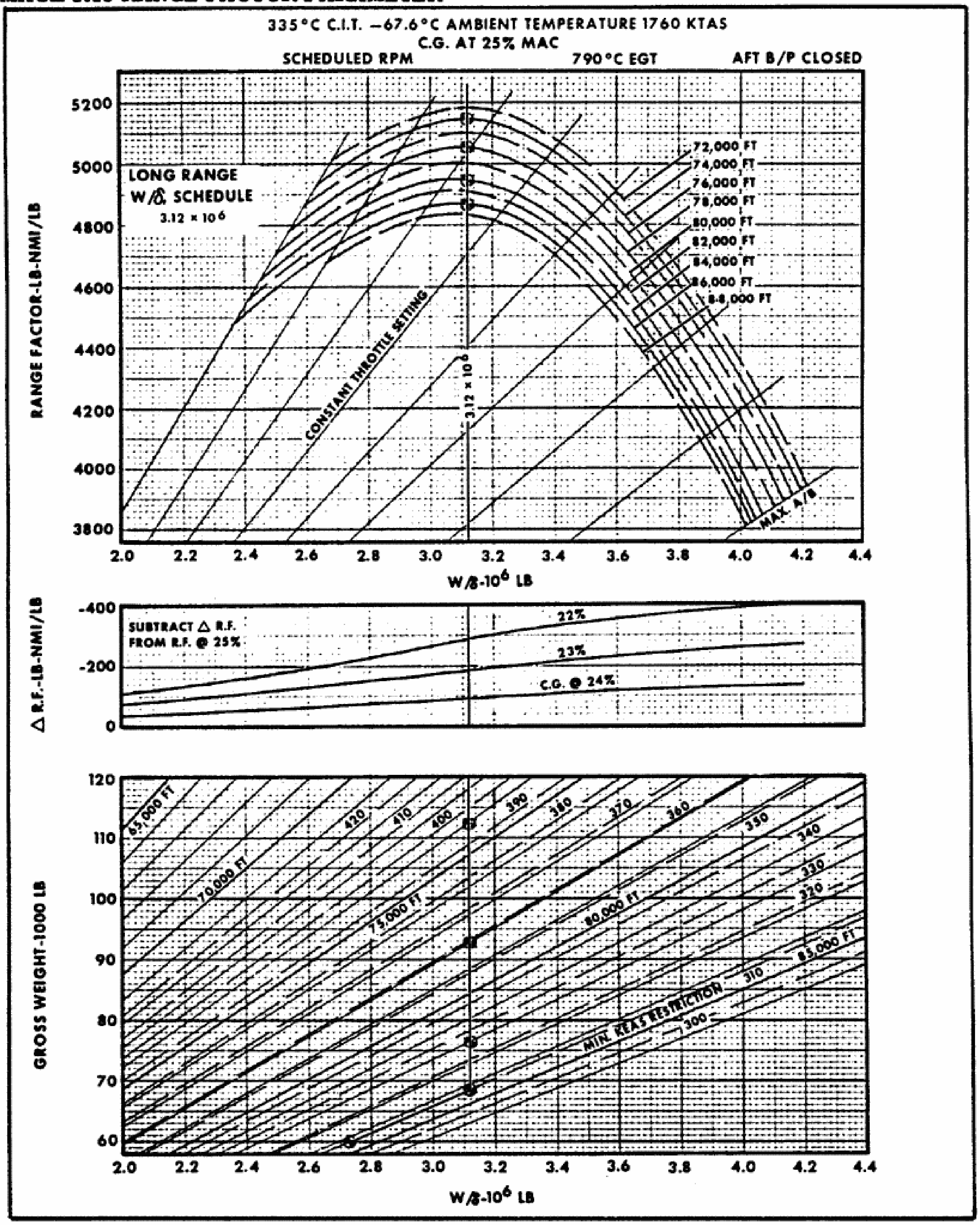


Figure A5-14

SPECIFIC RANGE AT MACH 3.15

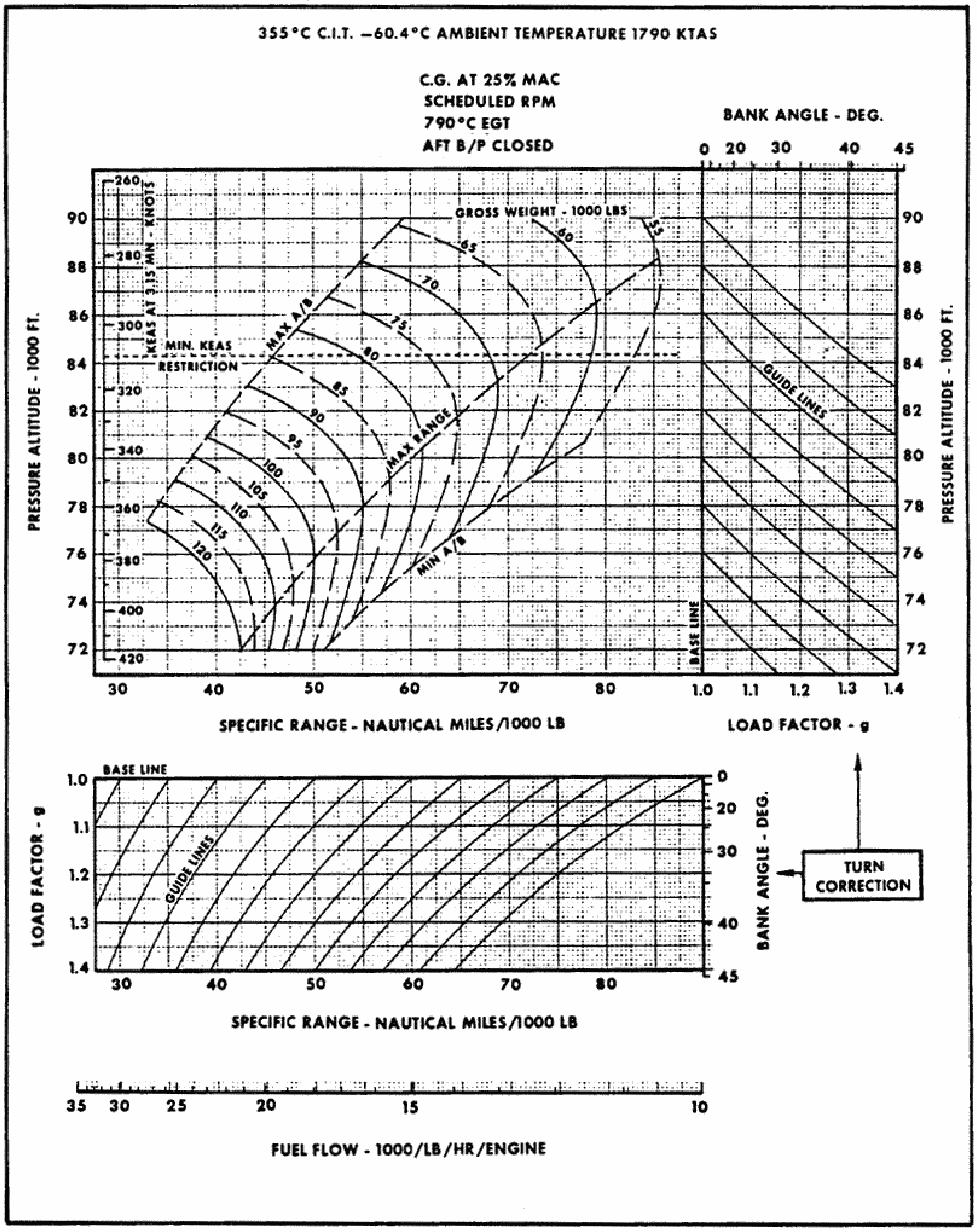


Figure A5-15

MACH 3.15 RANGE FACTOR PARAMETER

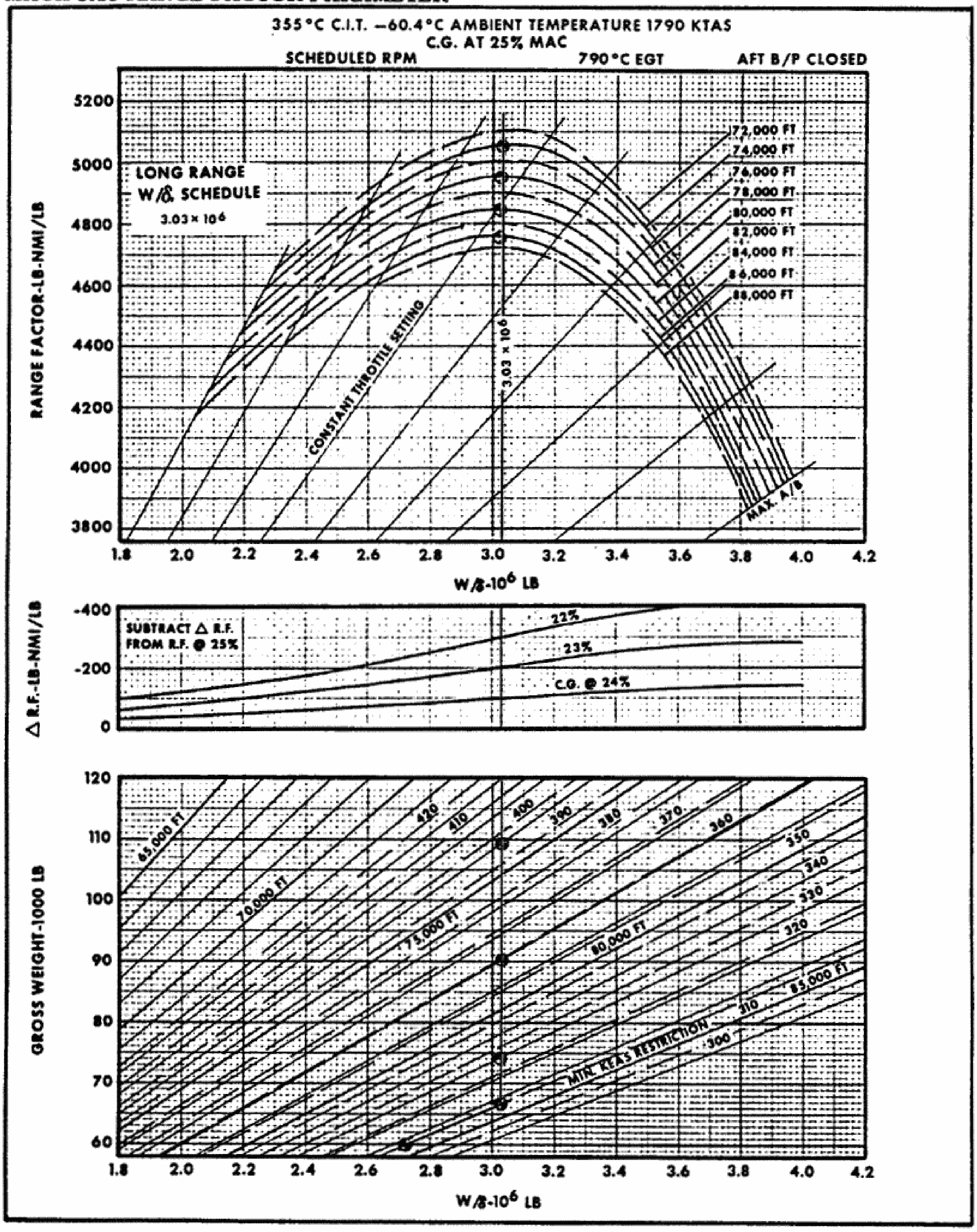


Figure A5-16

SPECIFIC RANGE AT MACH 3.15

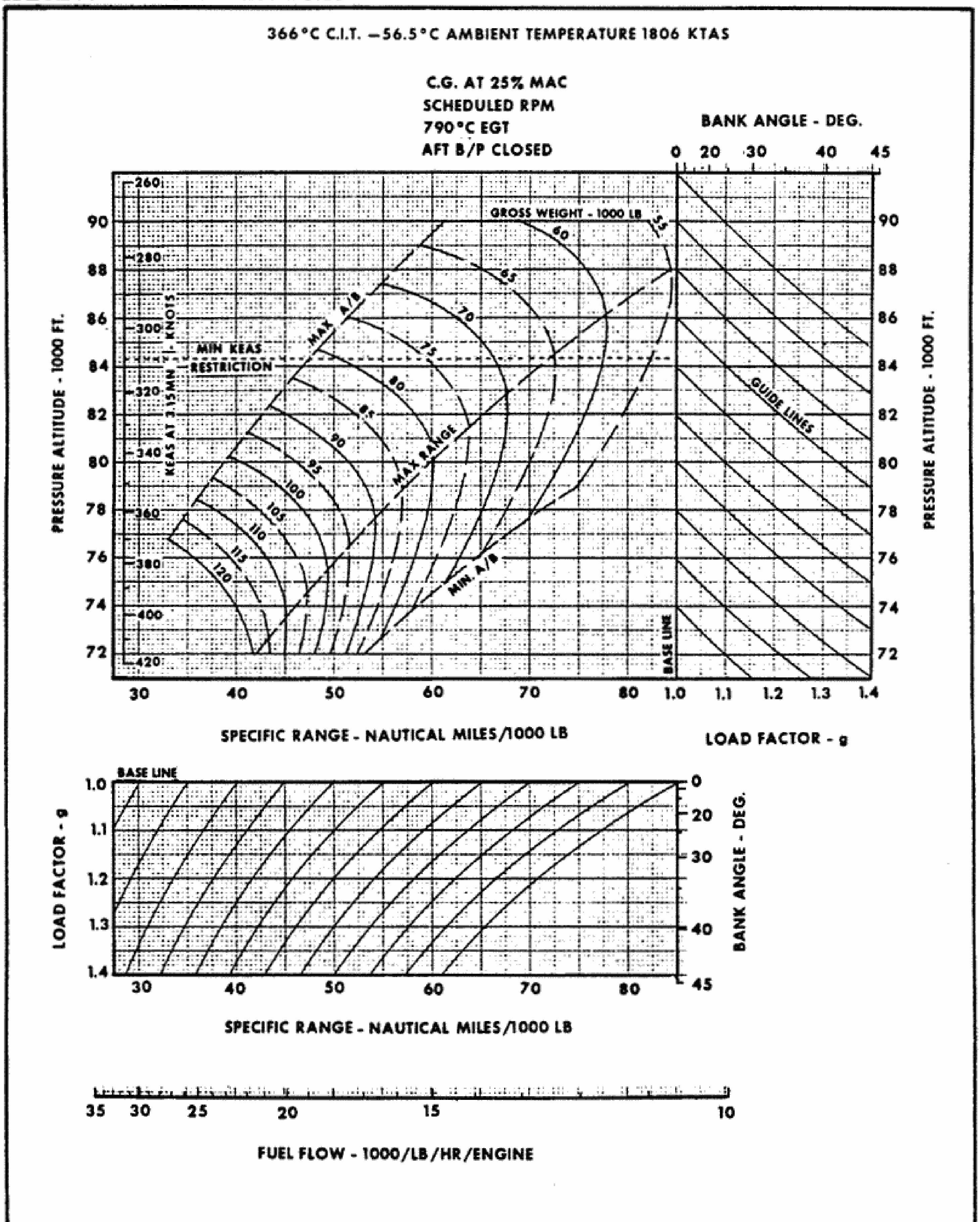


Figure A5-17

MACH 3.15 RANGE FACTOR PARAMETER

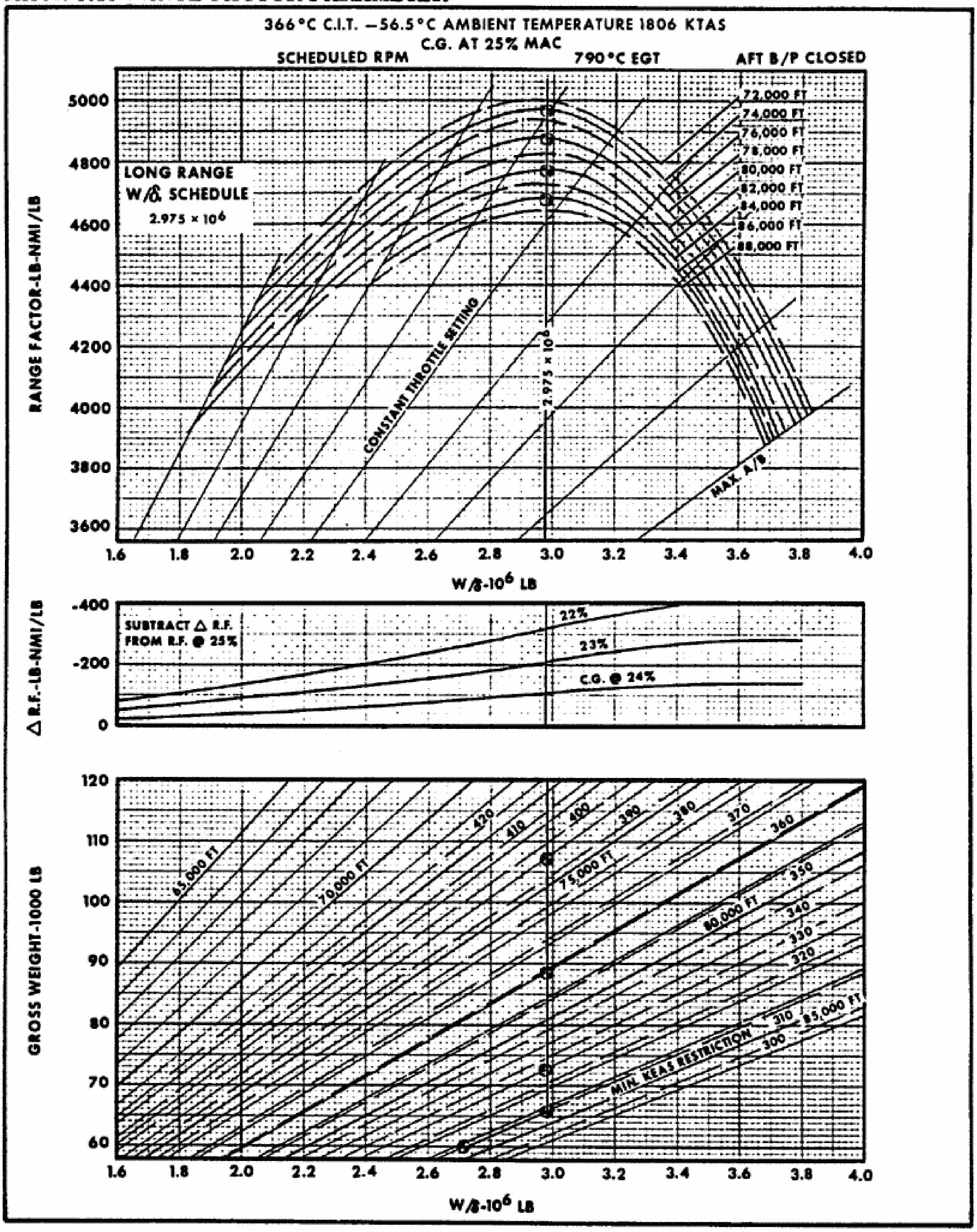


Figure A5-18

SPECIFIC RANGE AT MACH 3.15

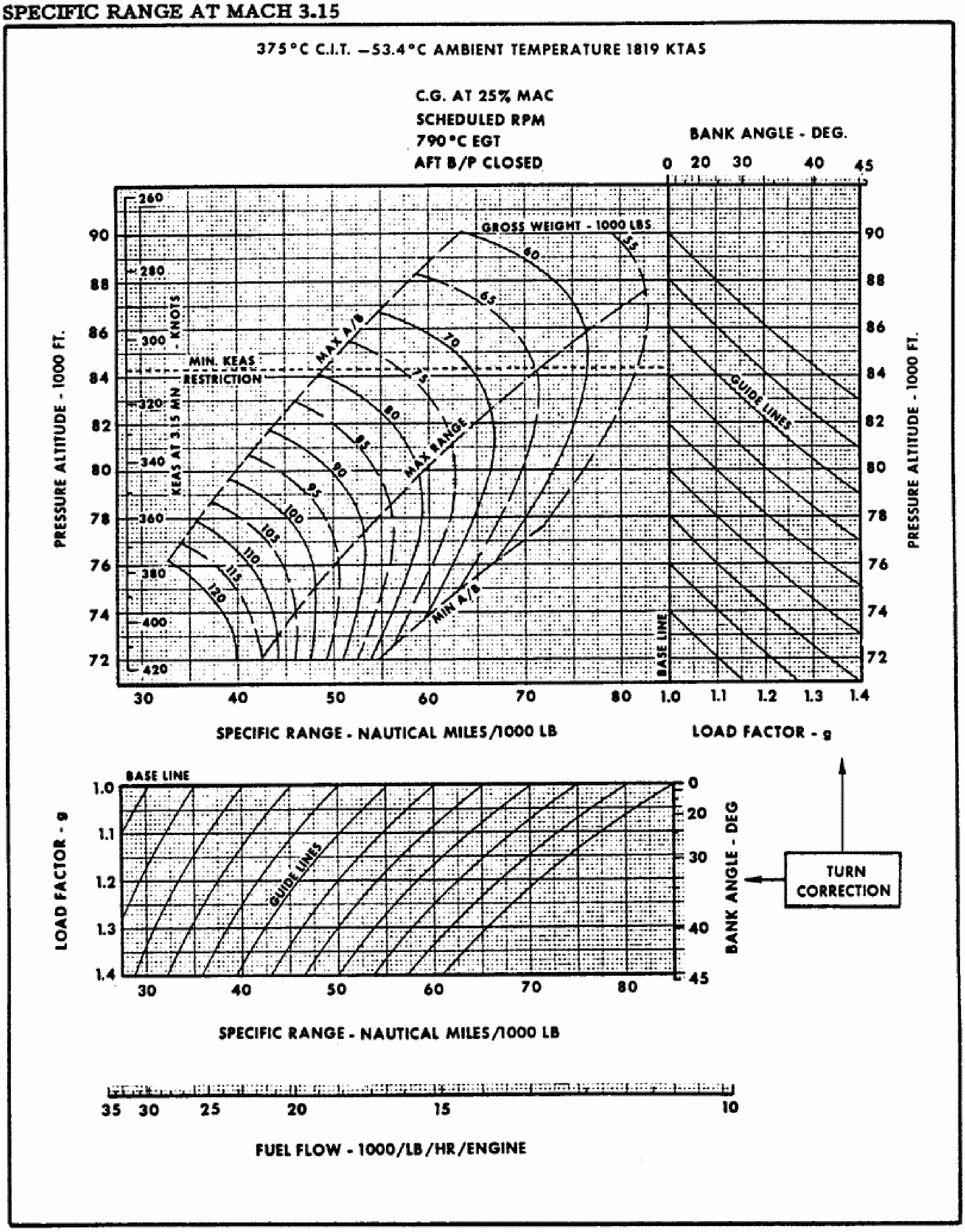


Figure A5-19

MACH 3.15 RANGE FACTOR PARAMETER

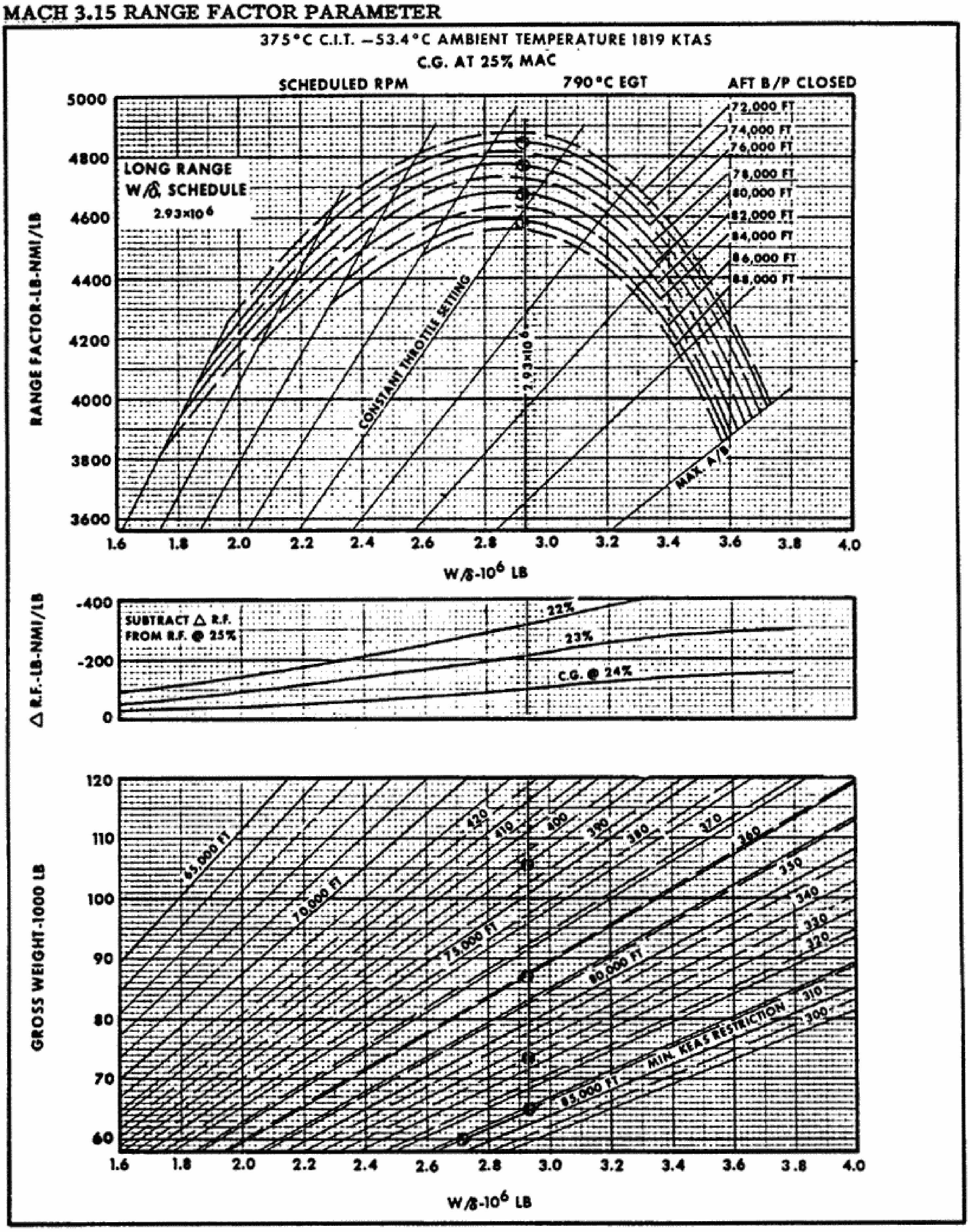


Figure A5-20

SPECIFIC RANGE AT MACH 3.15

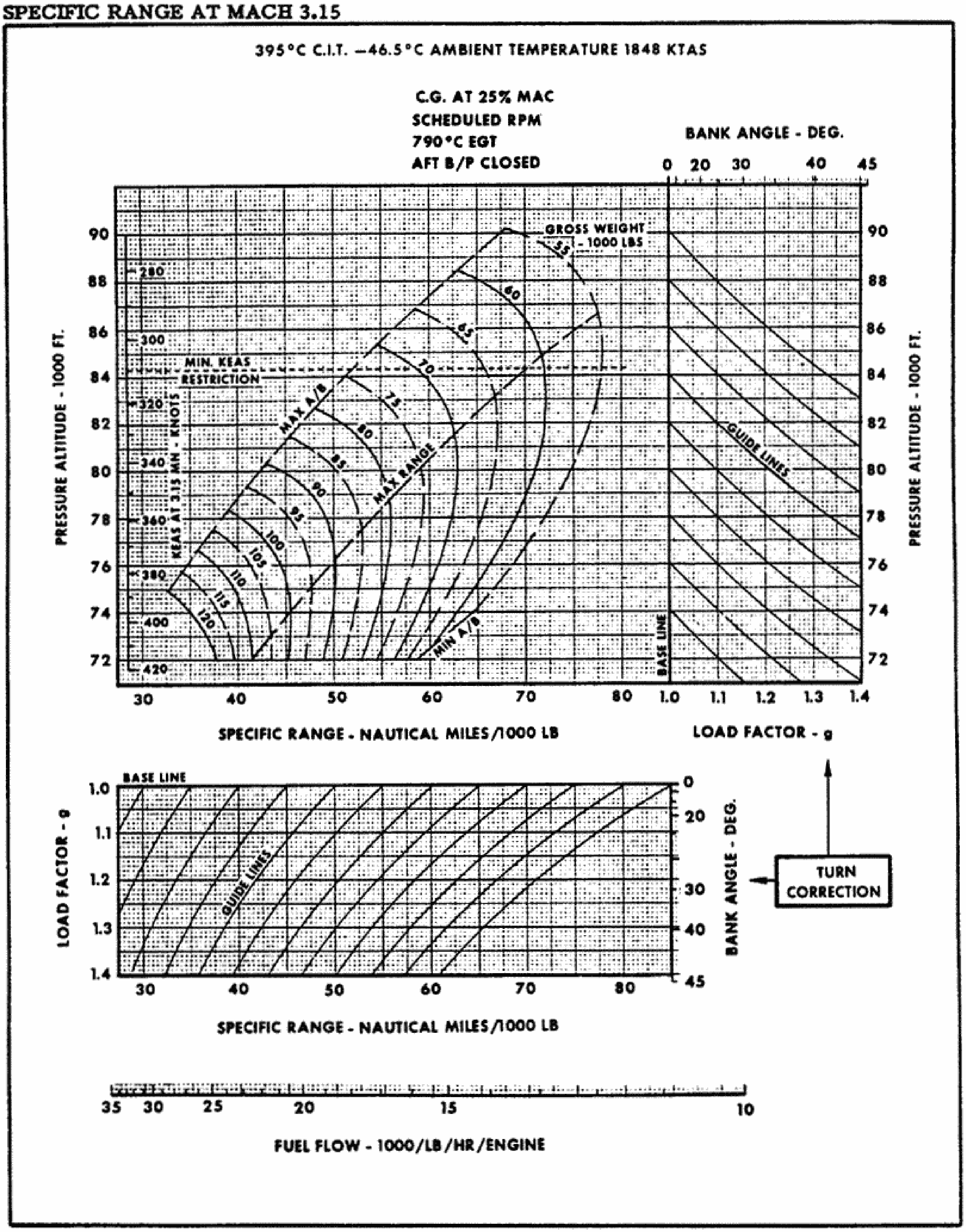


Figure A5-21

MACH 3.15 RANGE FACTOR PARAMETER

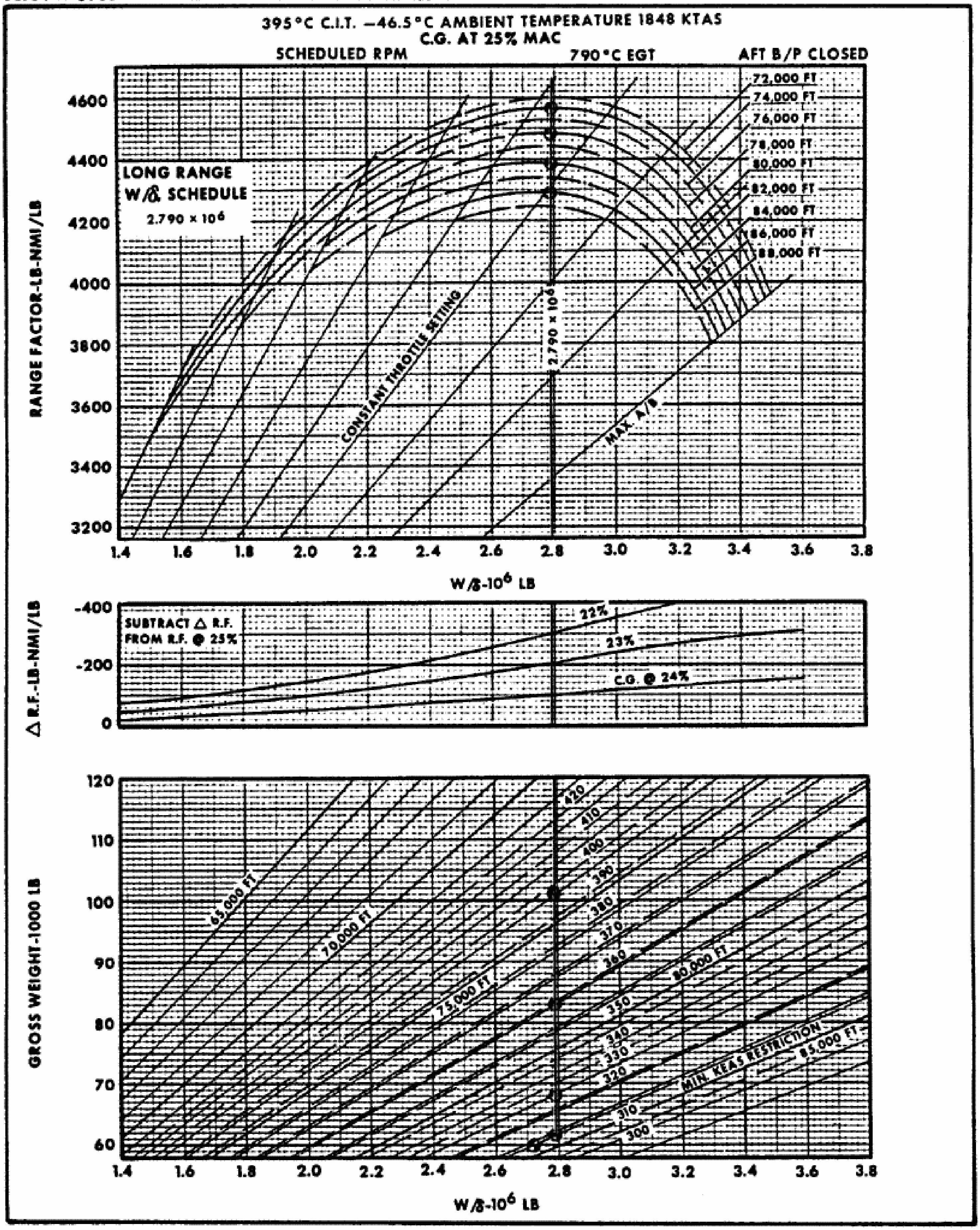


Figure A5-22

SPECIFIC RANGE AT MACH 3.15

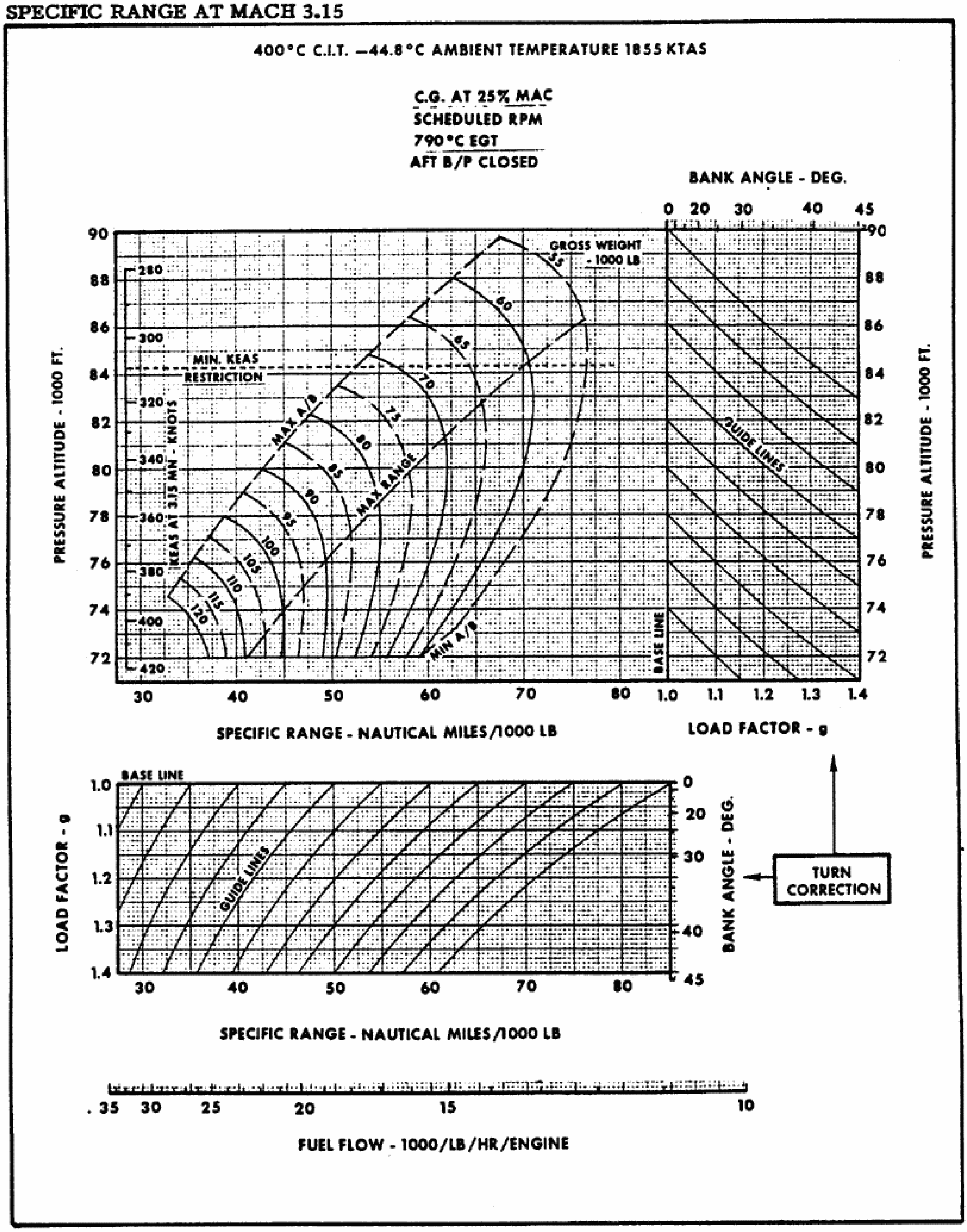


Figure A5-23

MACH 3.15 RANGE FACTOR PARAMETER

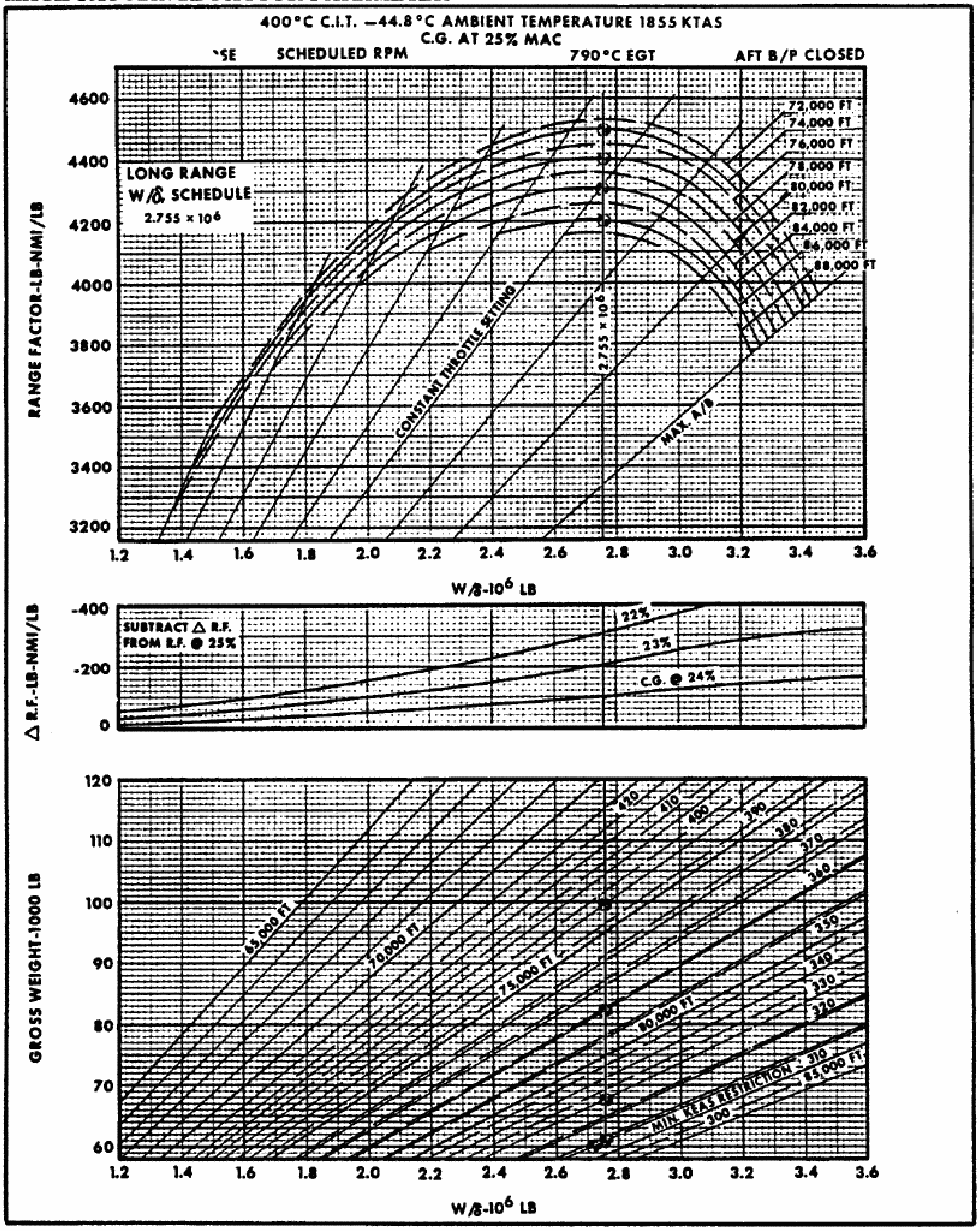


Figure A5-24

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SPECIFIC RANGE AT MACH 3.15

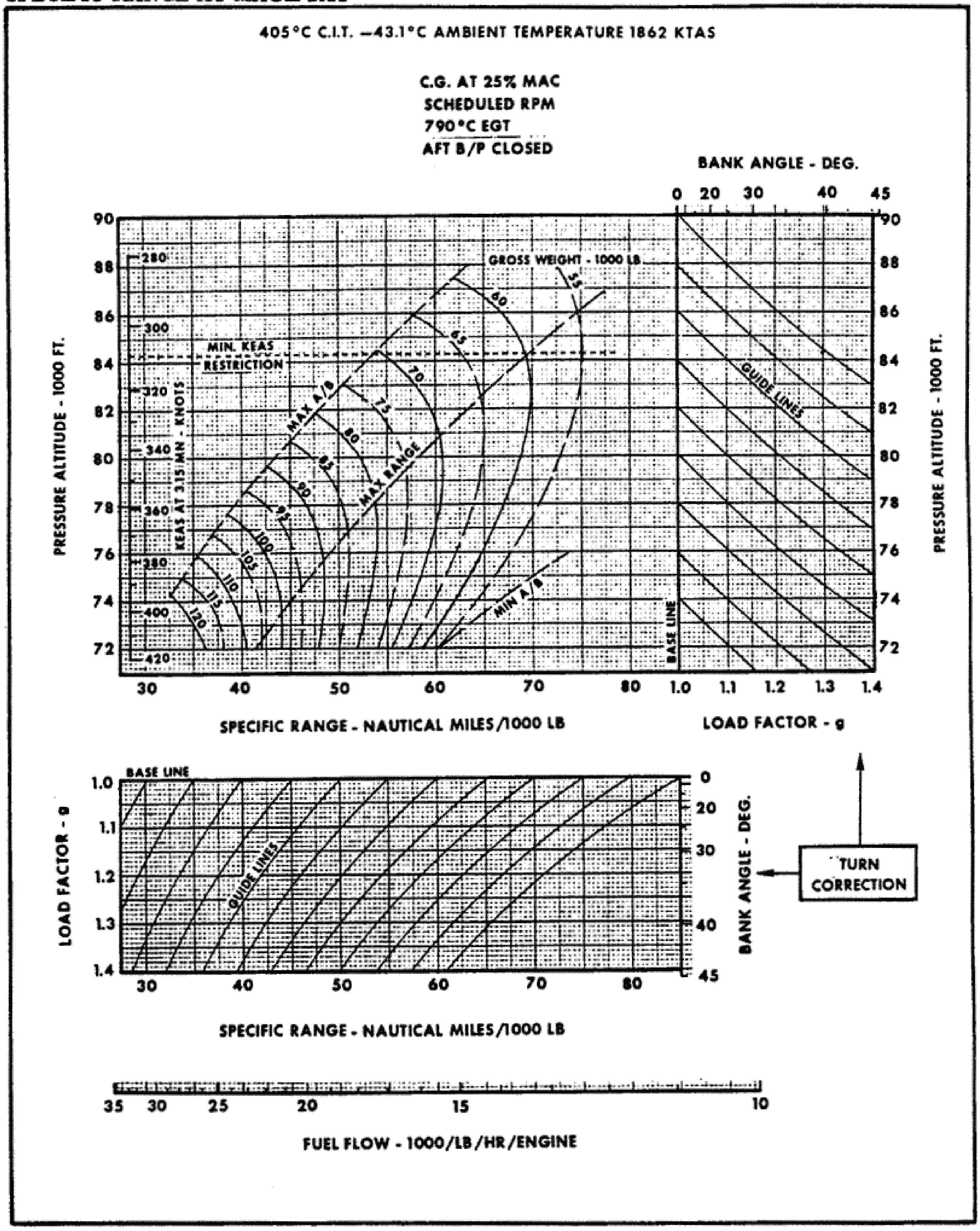

Figure A5-25

MACH 3.15 RANGE FACTOR PARAMETER

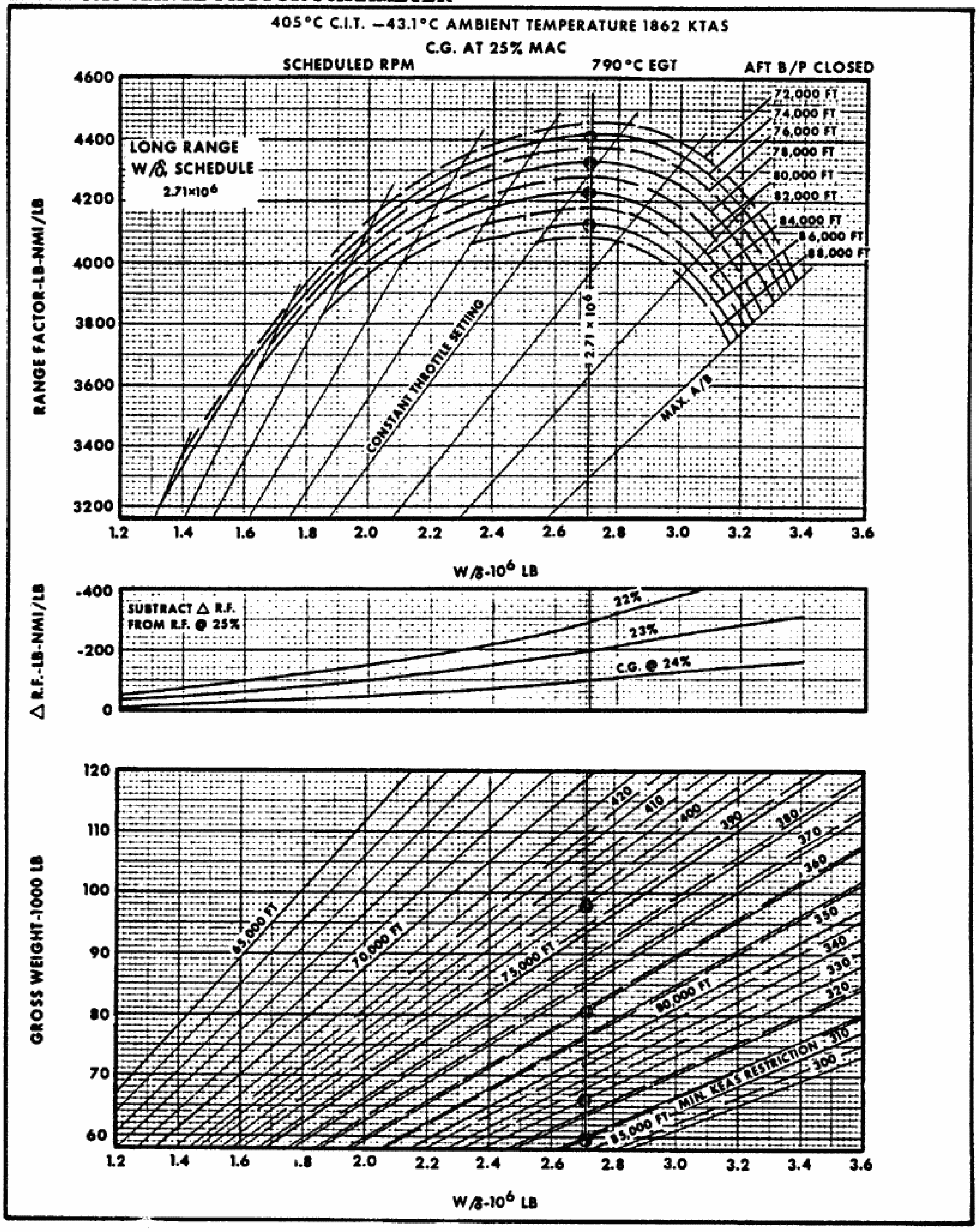

Figure A5-26

SPECIFIC RANGE AT MACH 3.10

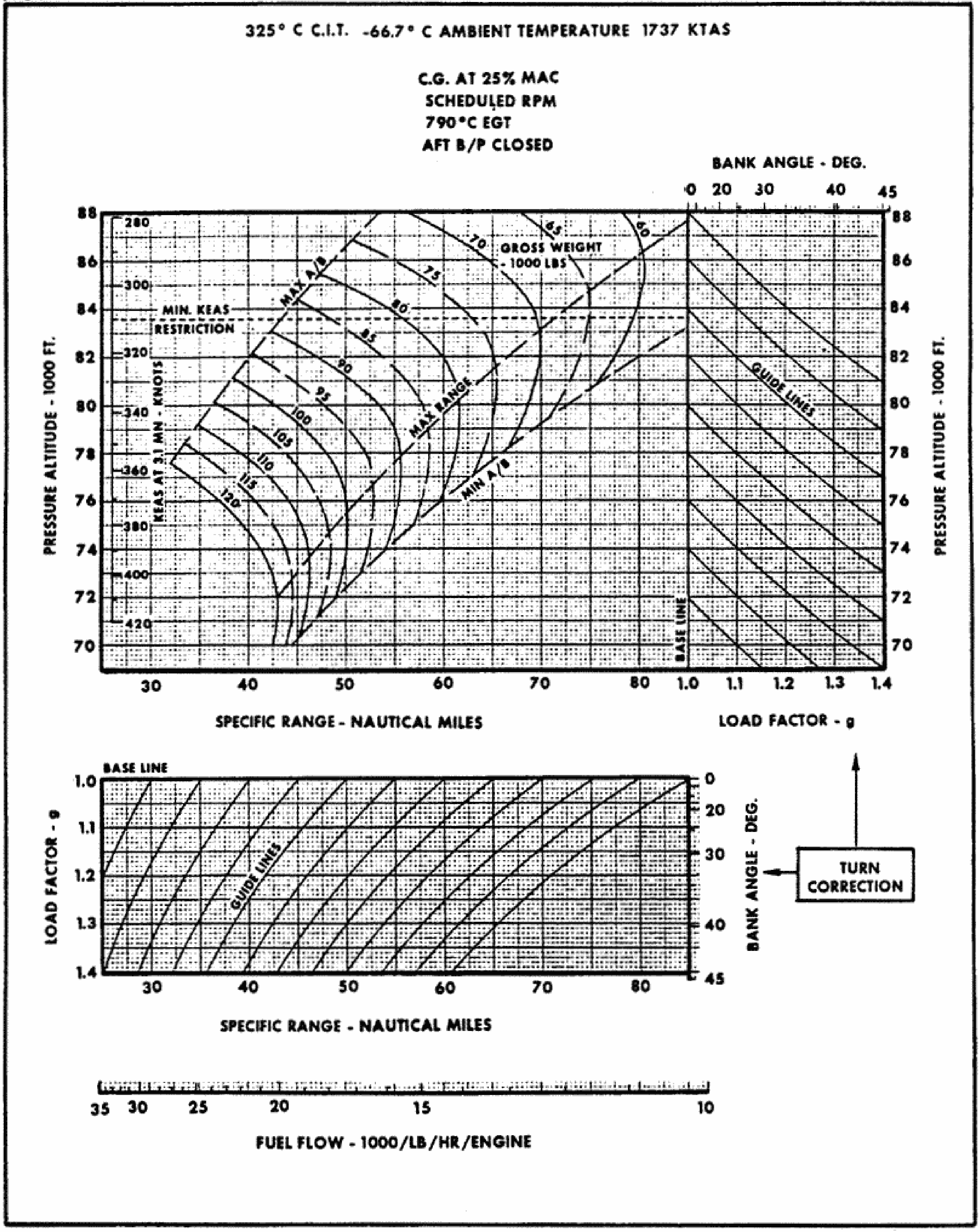

Figure A5-27

MACH 3.10 RANGE FACTOR PARAMETER

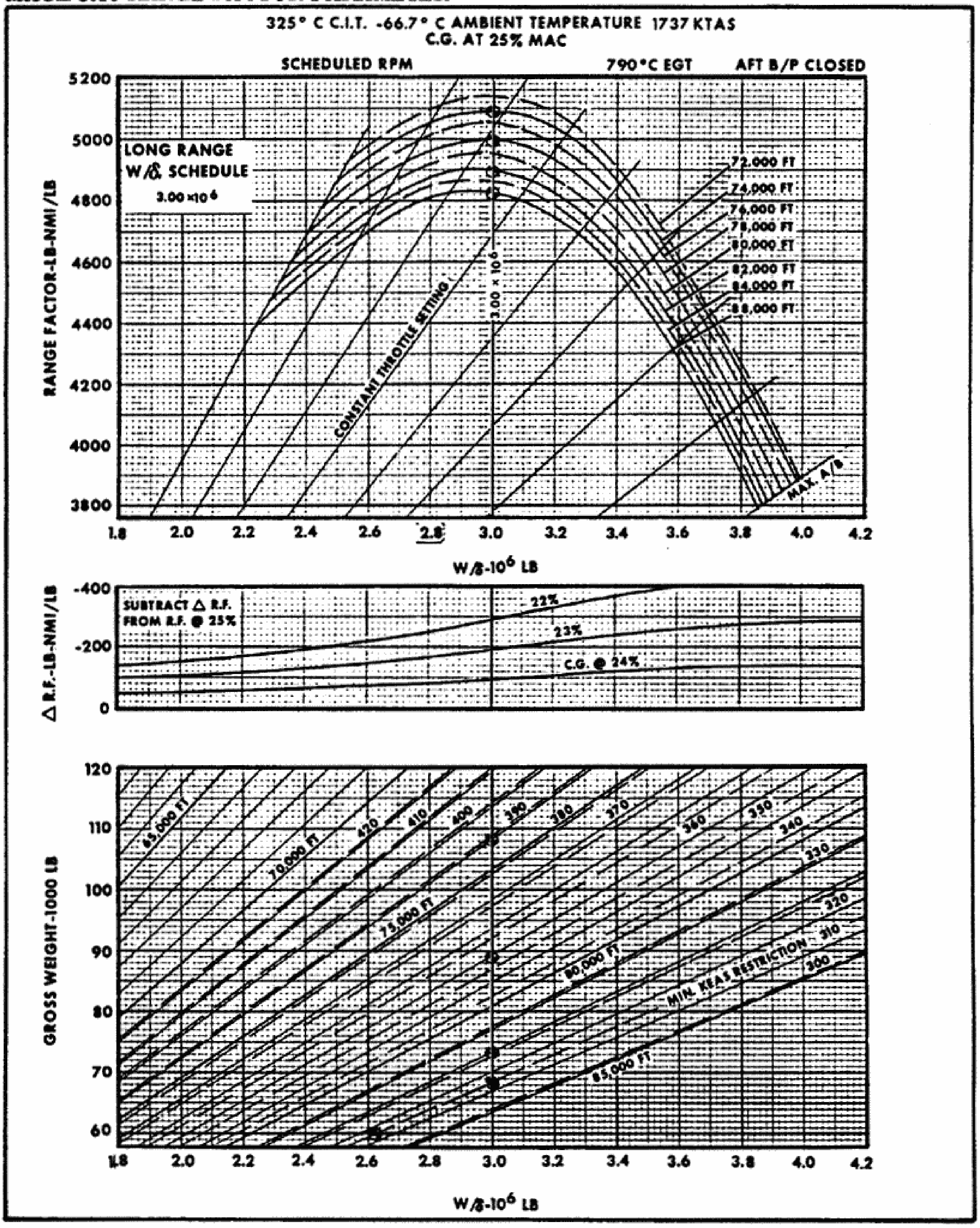

Figure A5-28

SPECIFIC RANGE AT MACH 3.10

345° C C.I.T. -59.3° C AMBIENT TEMPERATURE 1767 KTAS

C.G. AT 25% MAC
SCHEDULED RPM
790°C EGT
AFT B/P CLOSED

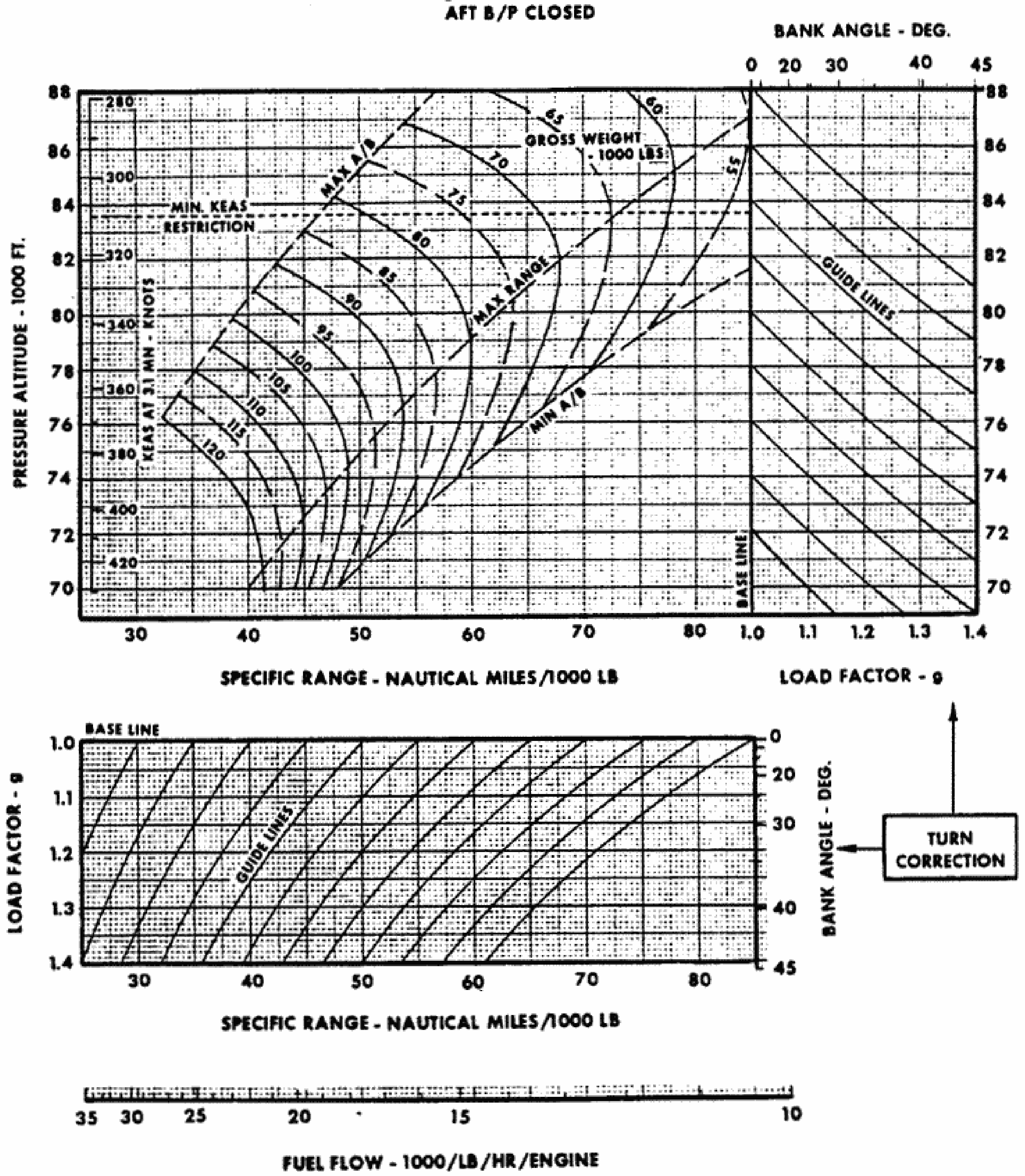

Figure A5-29

MACH 3.10 RANGE FACTOR PARAMETER

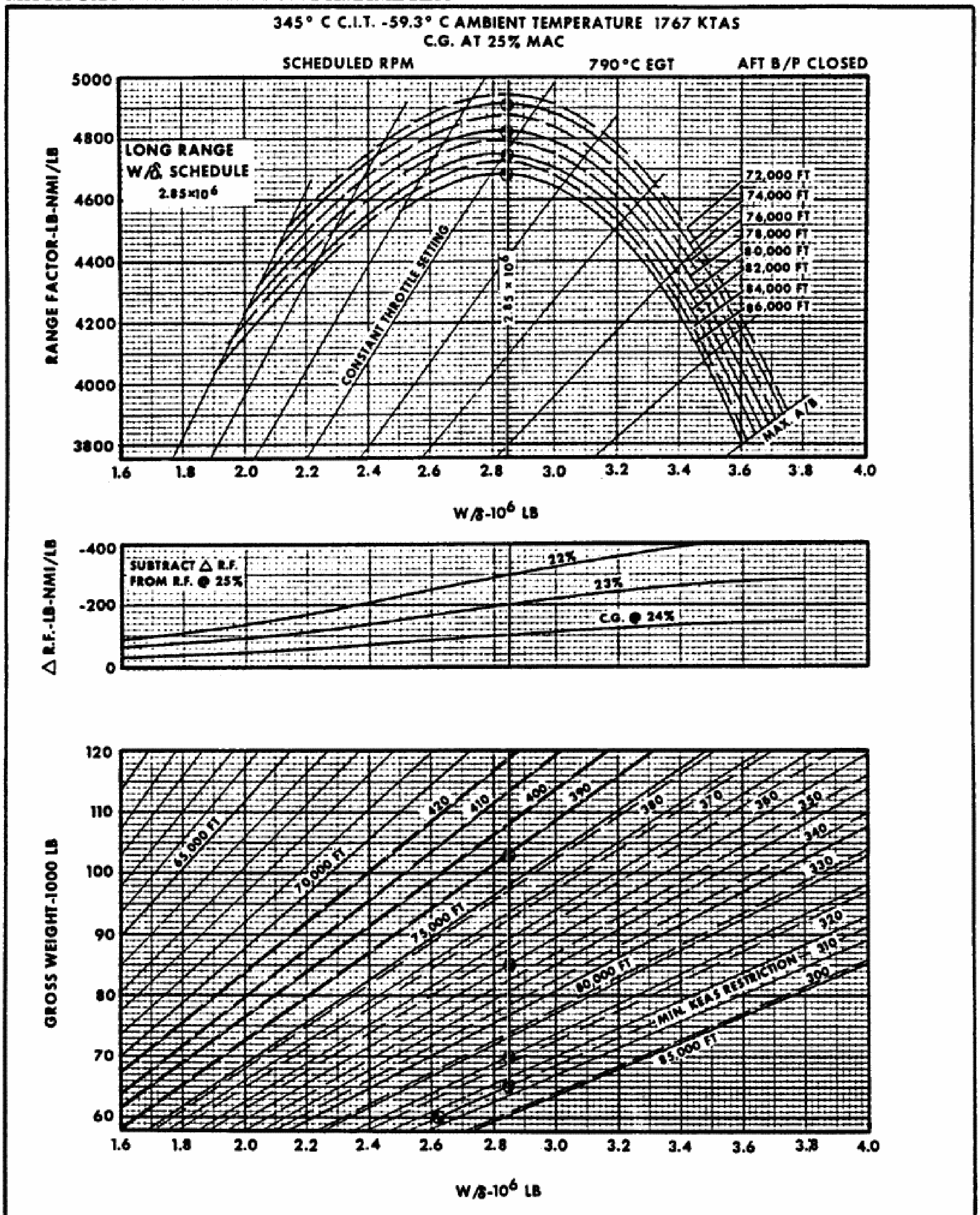

Figure A5-30

SPECIFIC RANGE AT MACH 3.10

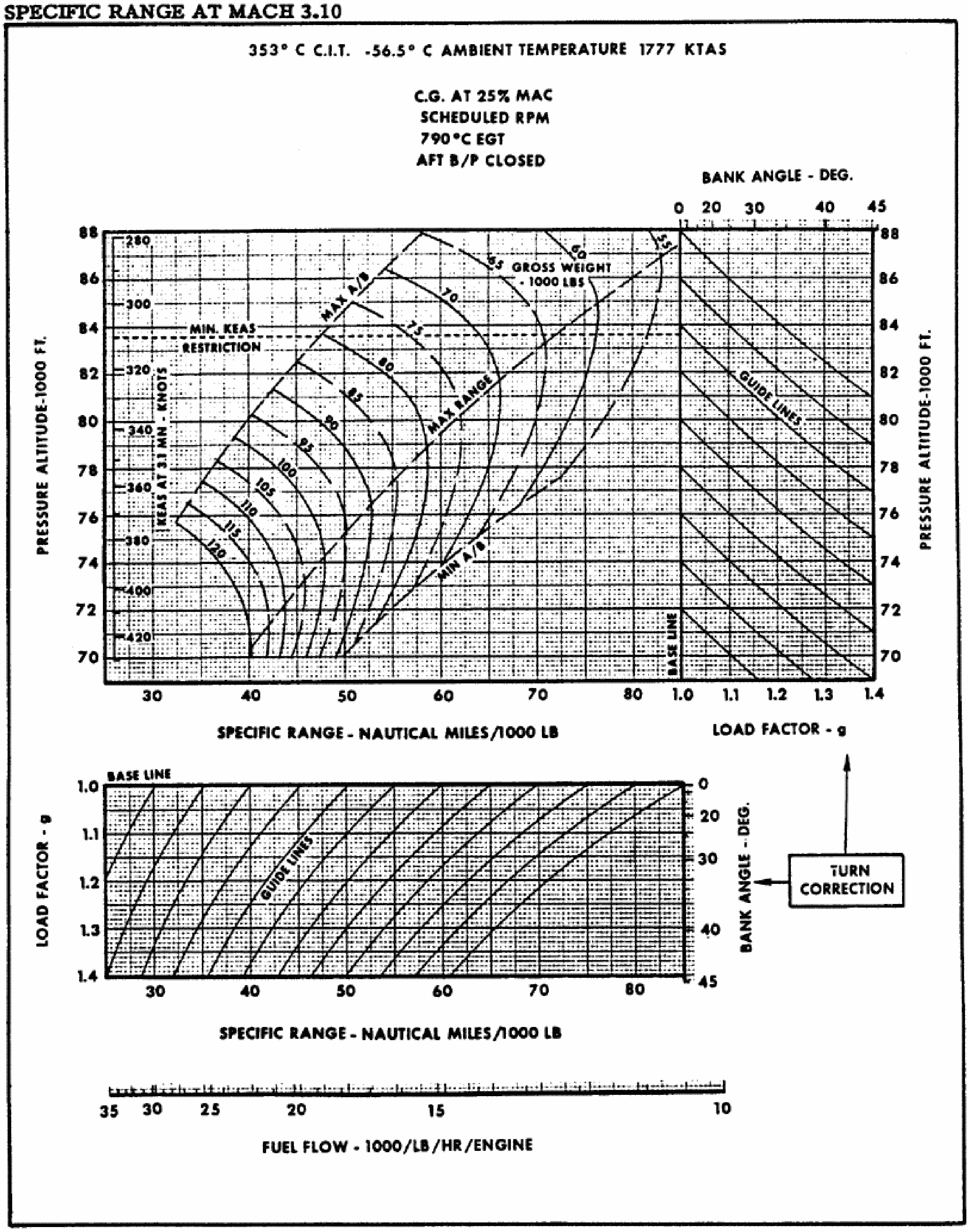

Figure A5-31

MACH 3.10 RANGE FACTOR PARAMETER

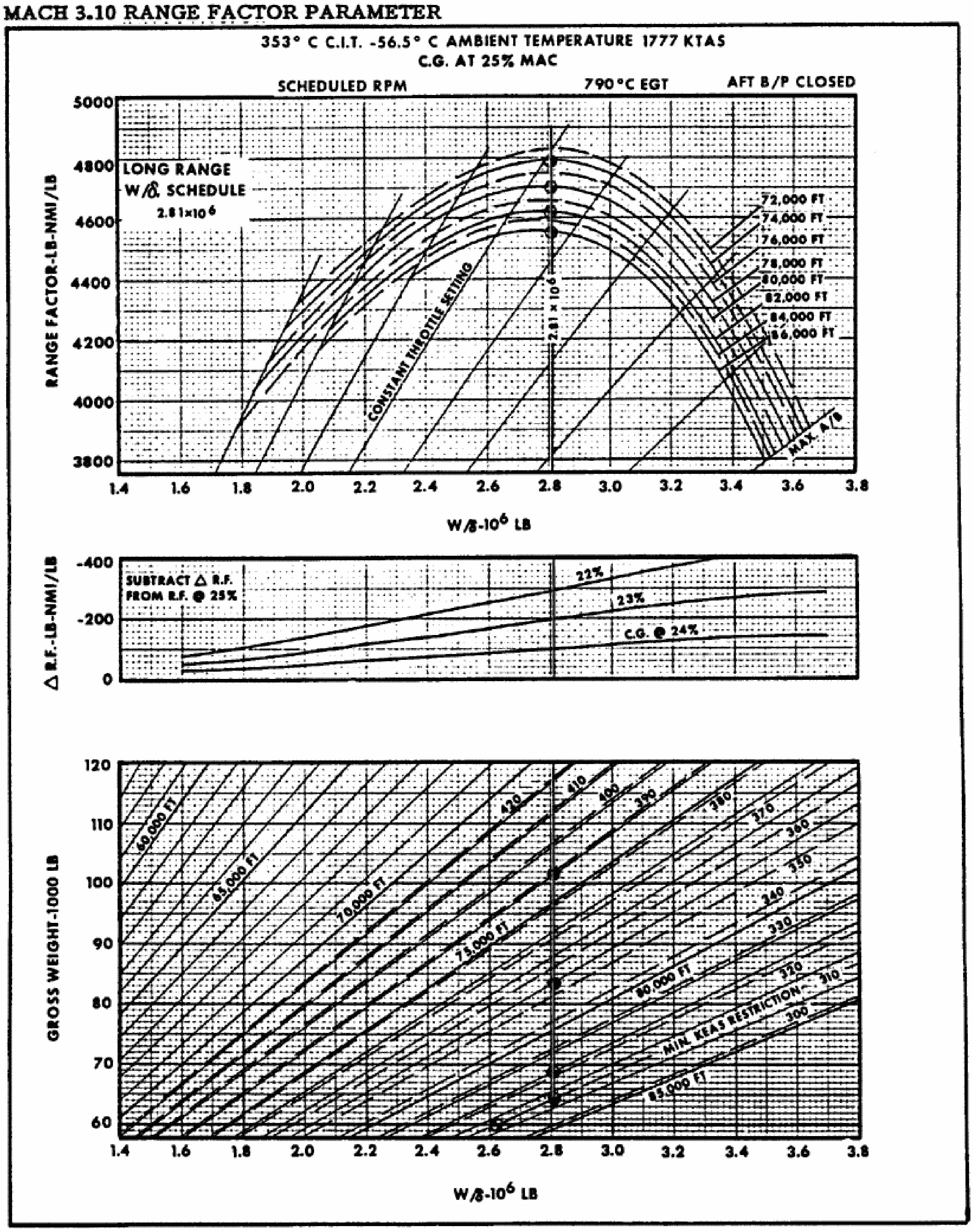

Figure A5-32

SPECIFIC RANGE AT MACH 3.10

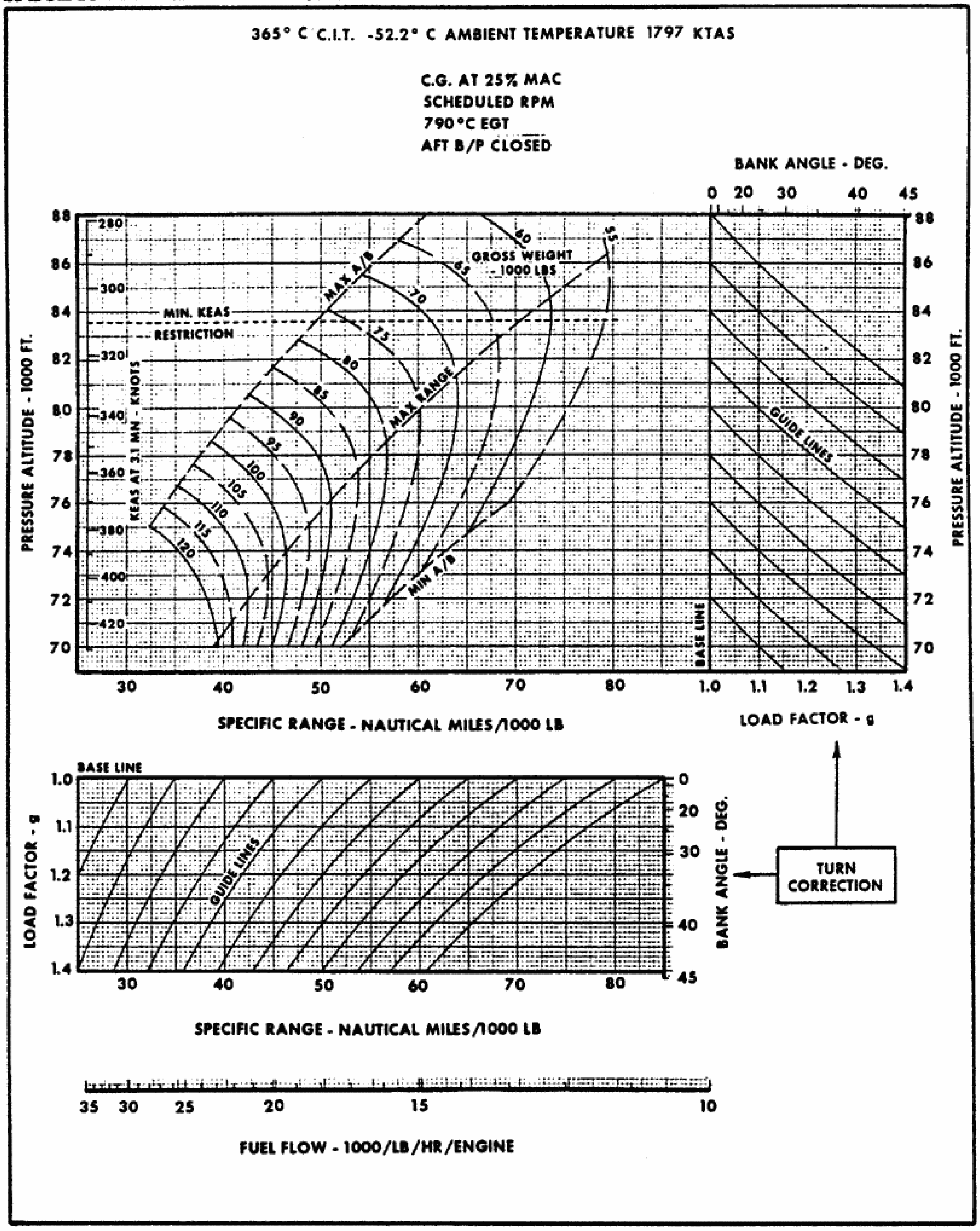

Figure A5-33

MACH 3.10 RANGE FACTOR PARAMETER

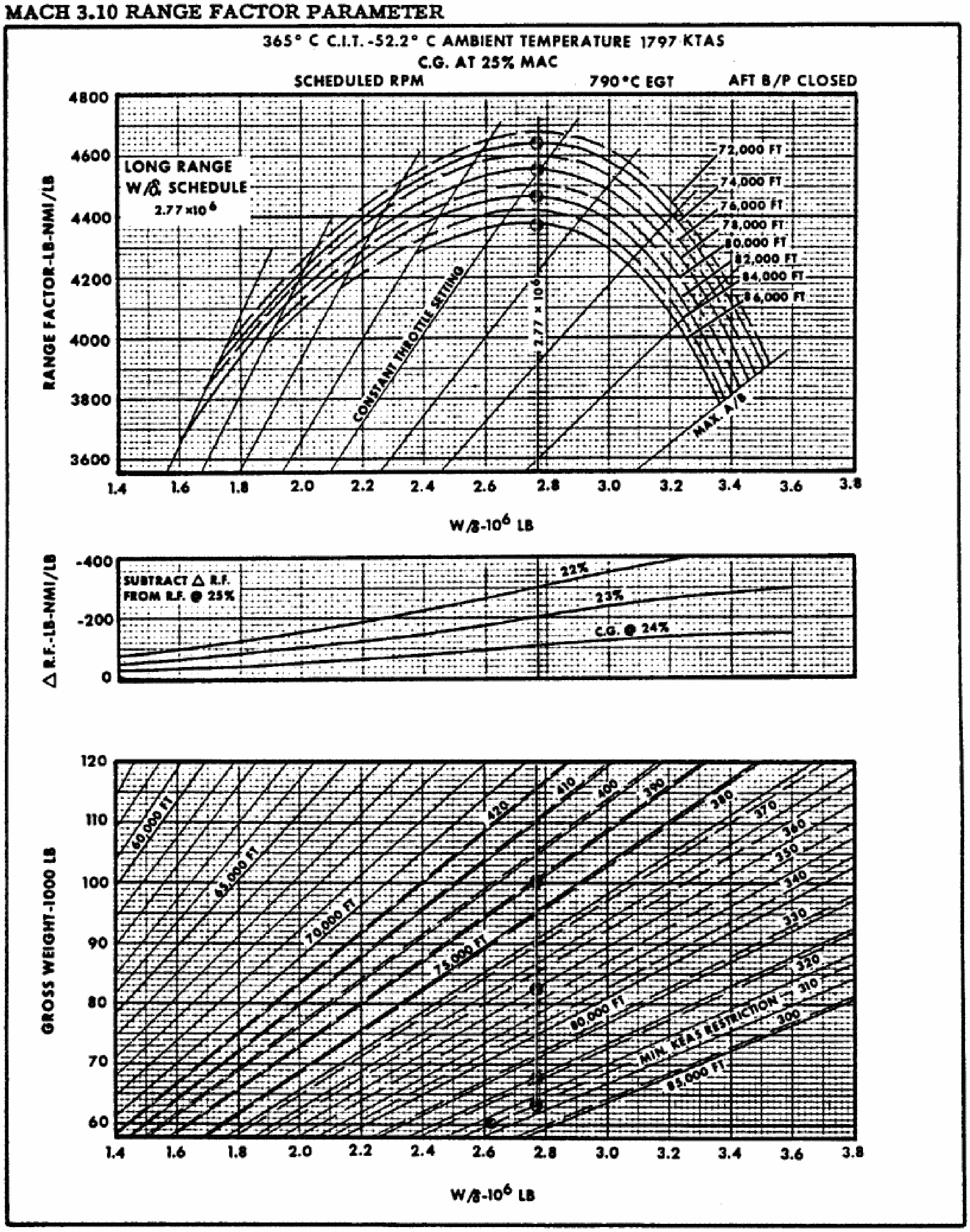

Figure A5-34

SPECIFIC RANGE AT MACH 3.10

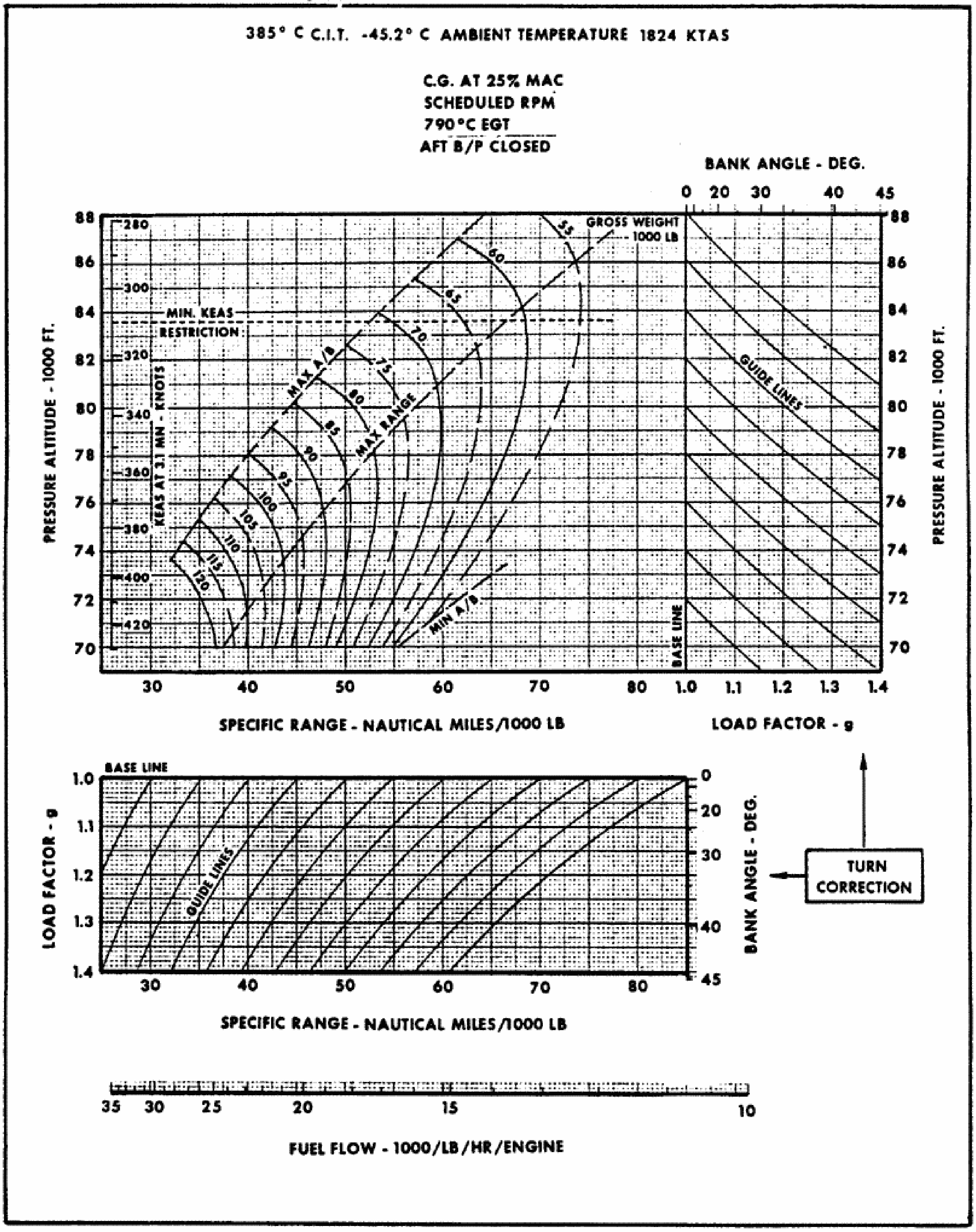

Figure A5-35

MACH 3.10 RANGE FACTOR PARAMETER

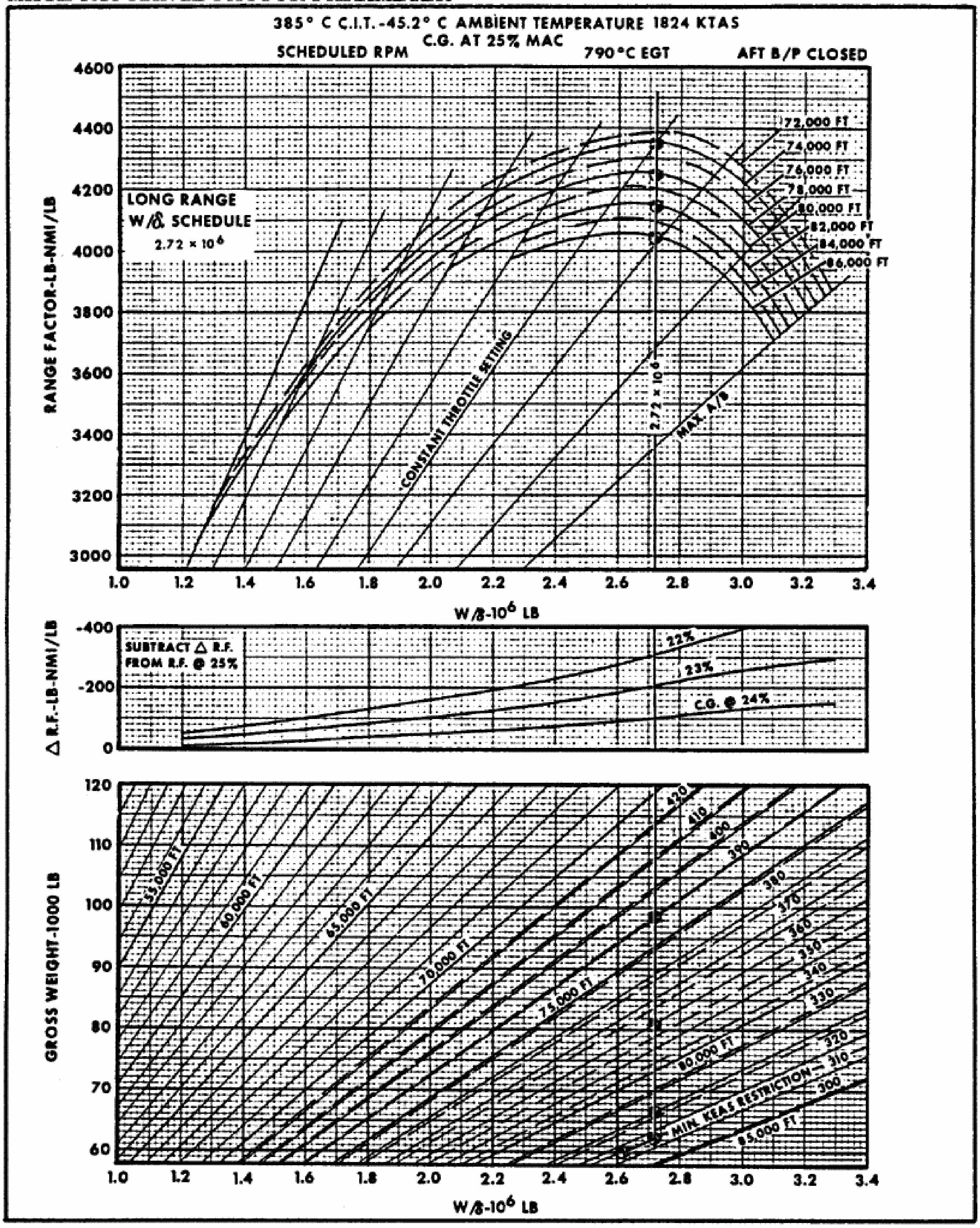

Figure A5-36

SPECIFIC RANGE AT MACH 3.0

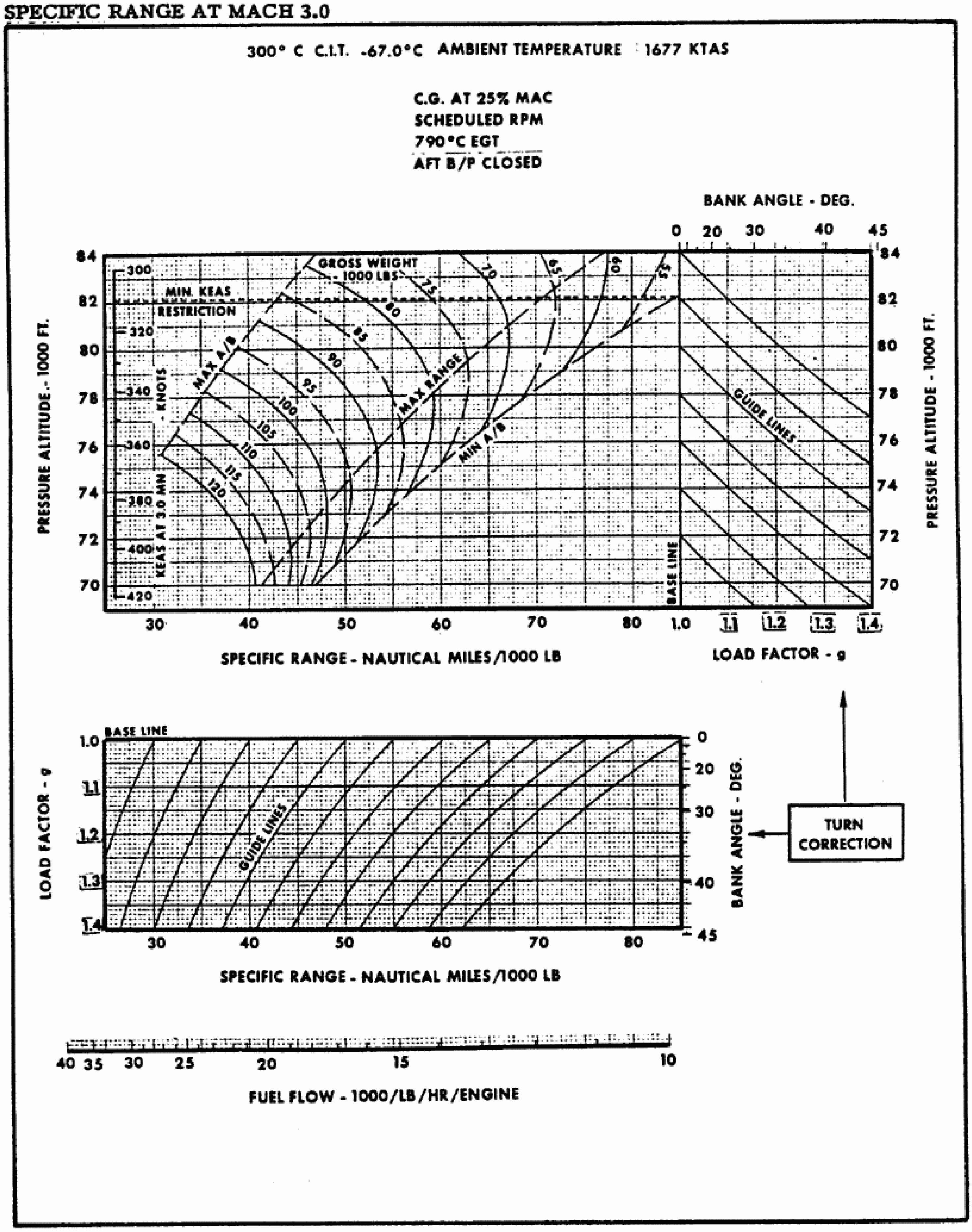

Figure A5-37

MACH 3.0 RANGE FACTOR PARAMETER

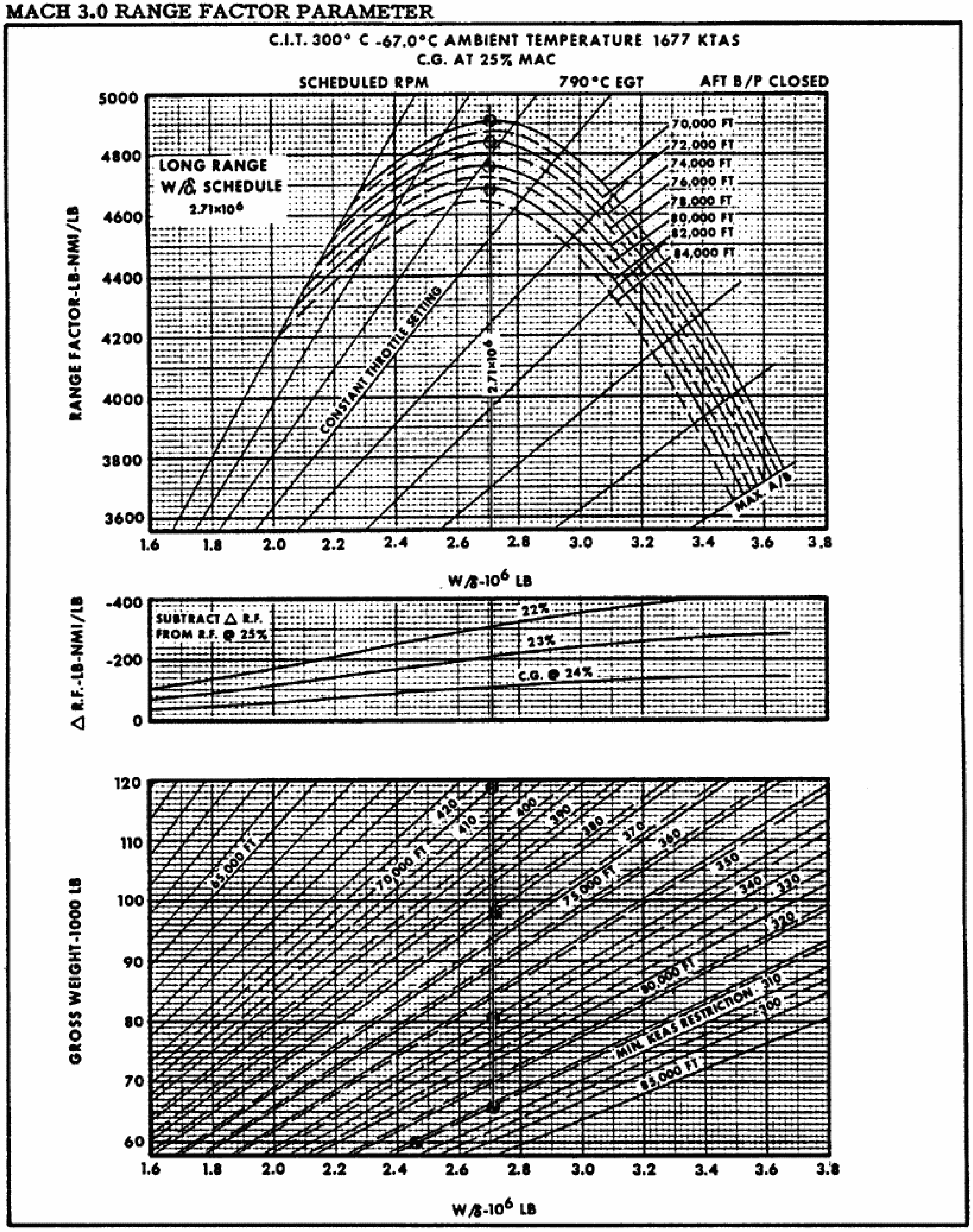

Figure A5-38

SPECIFIC RANGE AT MACH 3.0

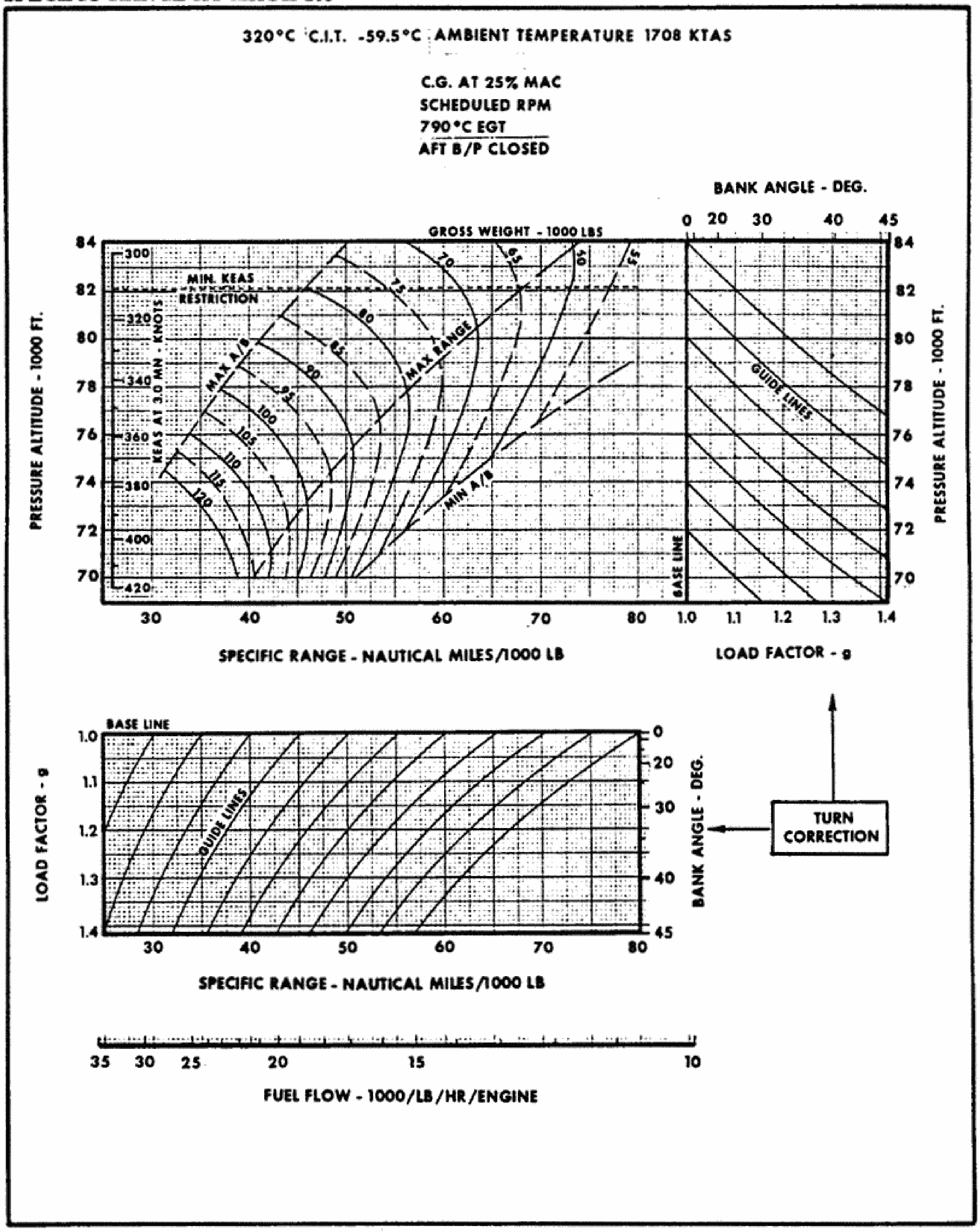

Figure A5-39

MACH 3.0 RANGE FACTOR PARAMETER

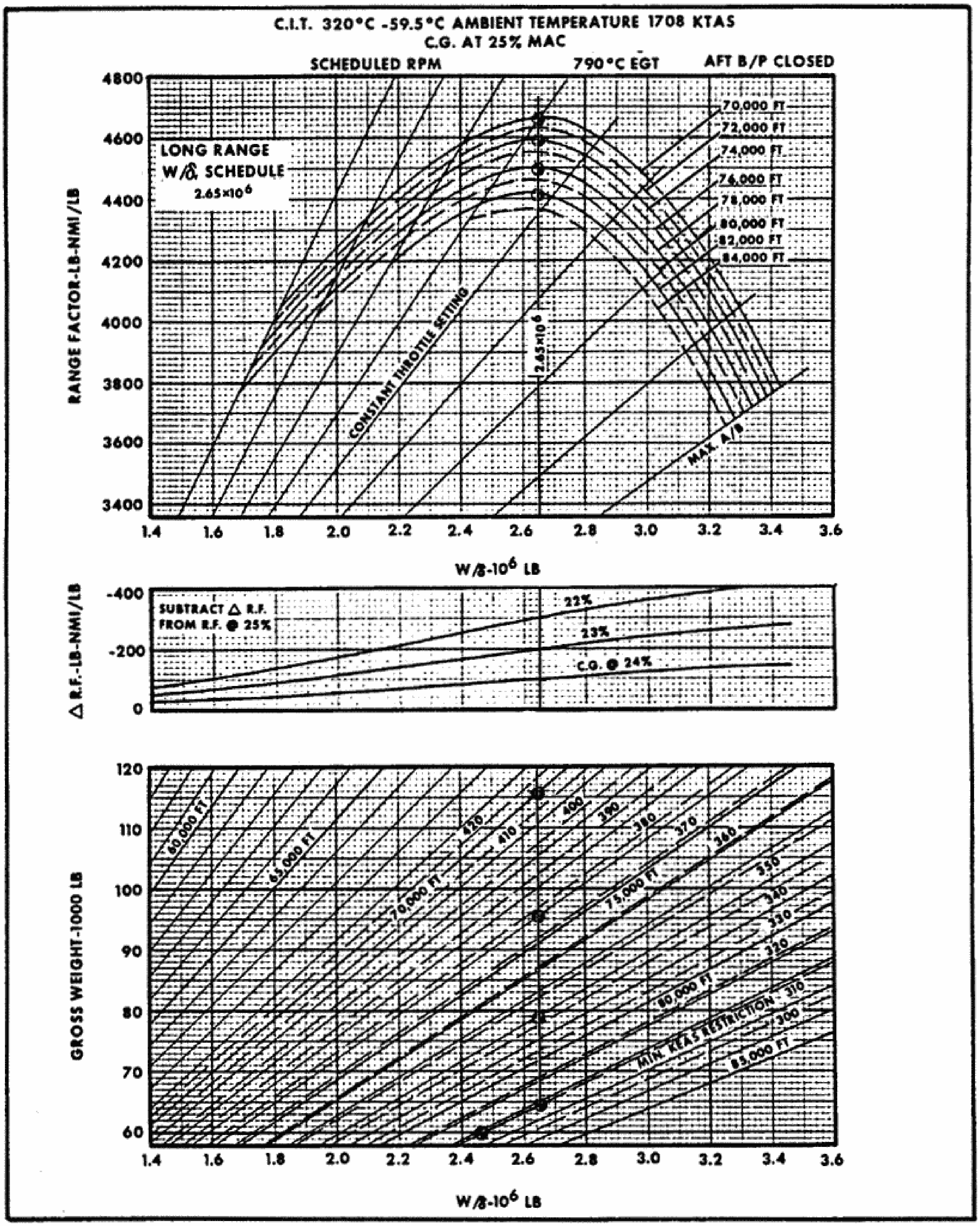

Figure A5-40

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SPECIFIC RANGE AT MACH 3.0

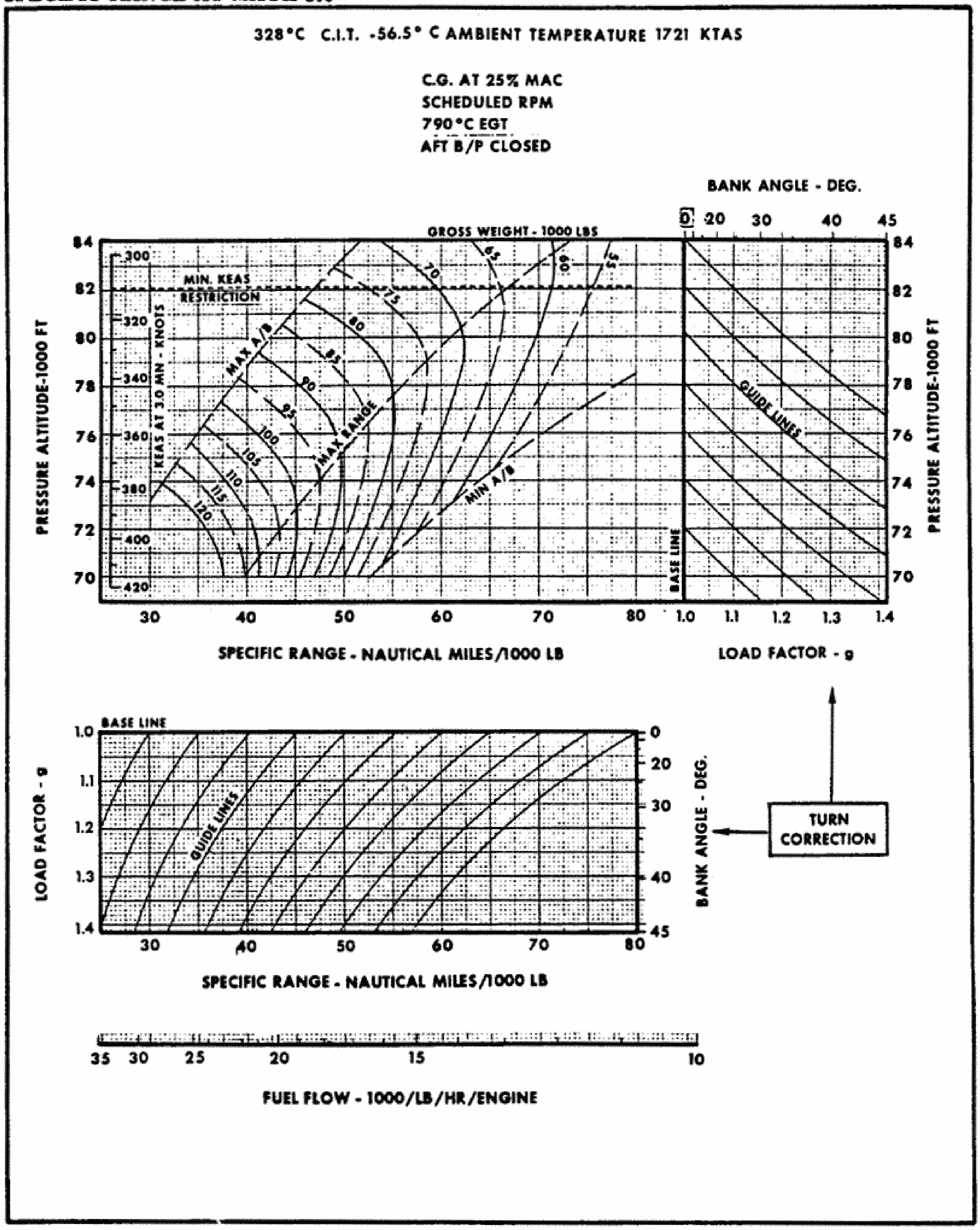

Figure A5-41

MACH 3.0 RANGE FACTOR PARAMETER

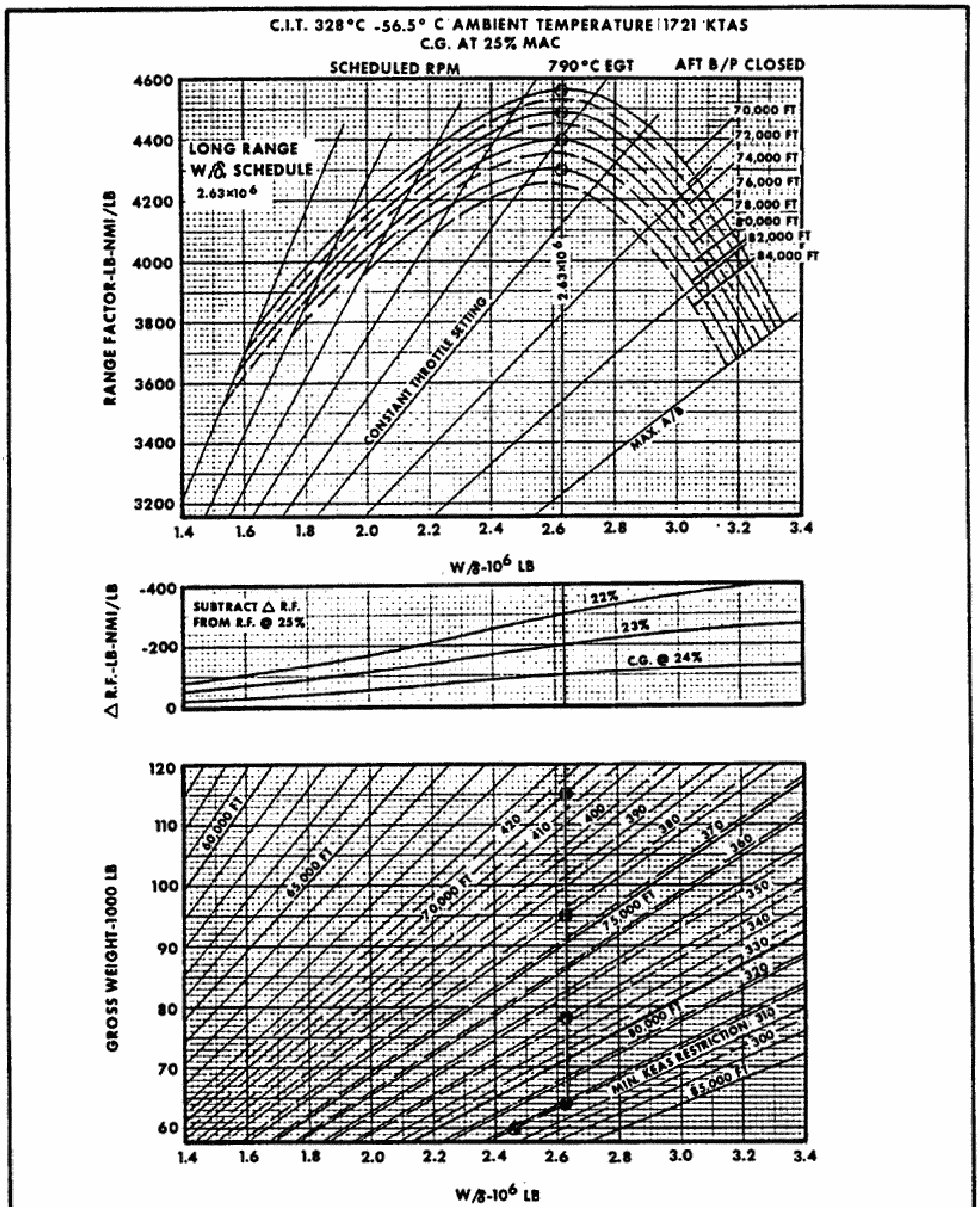

Figure A5-42

SPECIFIC RANGE AT MACH 3.0

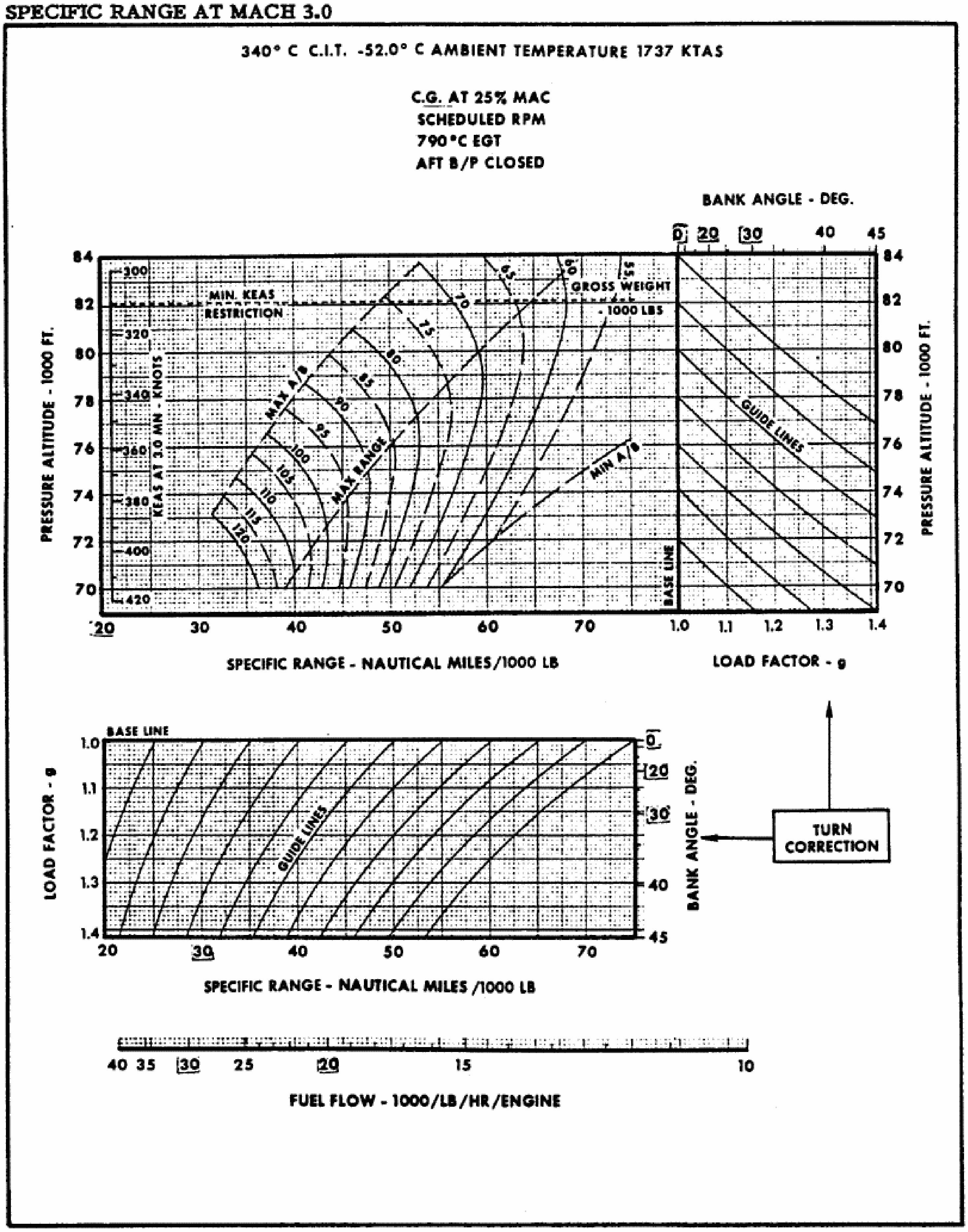

Figure A5-43

MACH 3.0 RANGE FACTOR PARAMETER

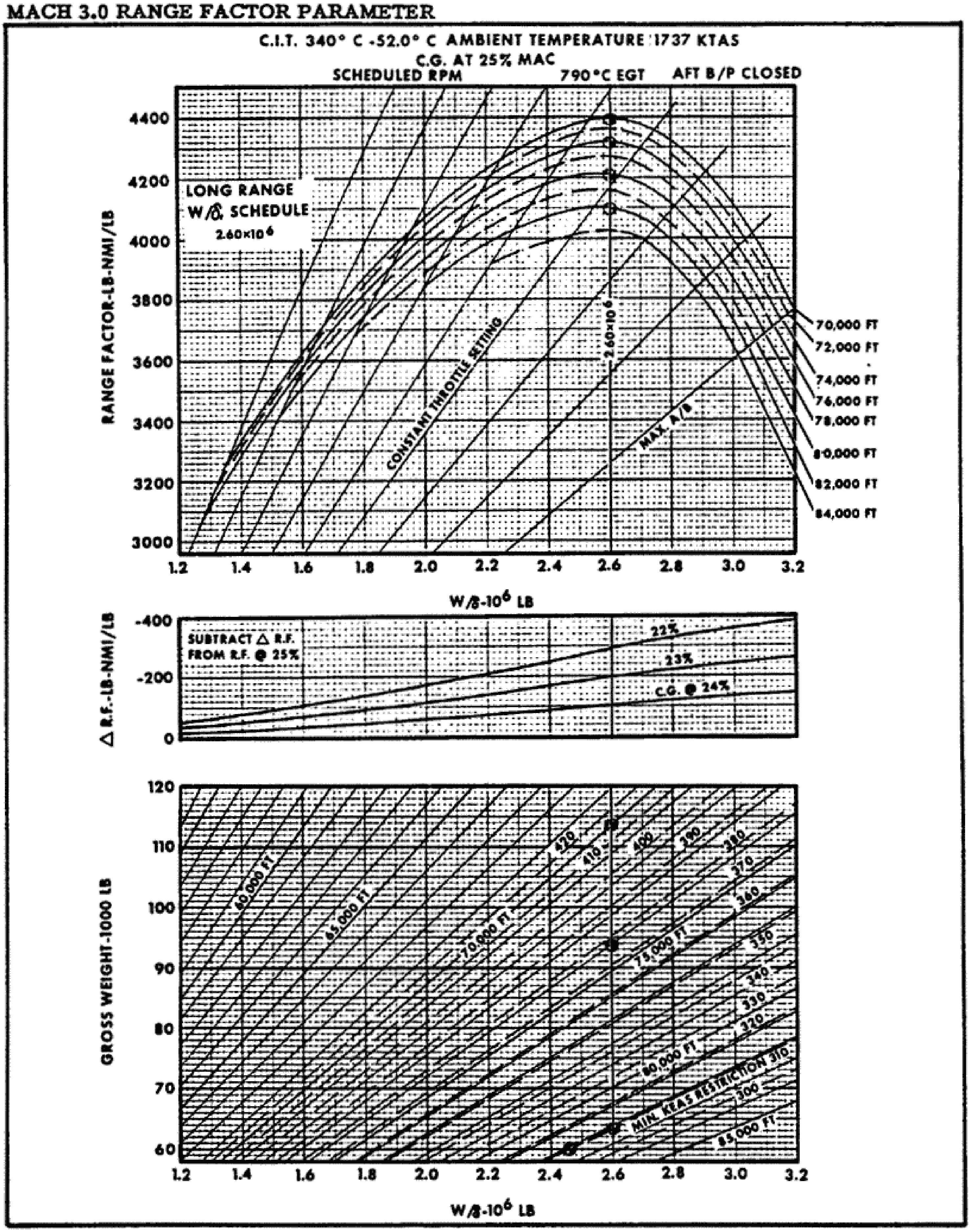

Figure A5-44

SPECIFIC RANGE AT MACH 3.0

360° C C.I.T. -44.5°C AMBIENT TEMPERATURE 1666 KTAS

C.G. AT 25% MAC
SCHEDULED RPM
790°C EGT
AFT B/P CLOSED

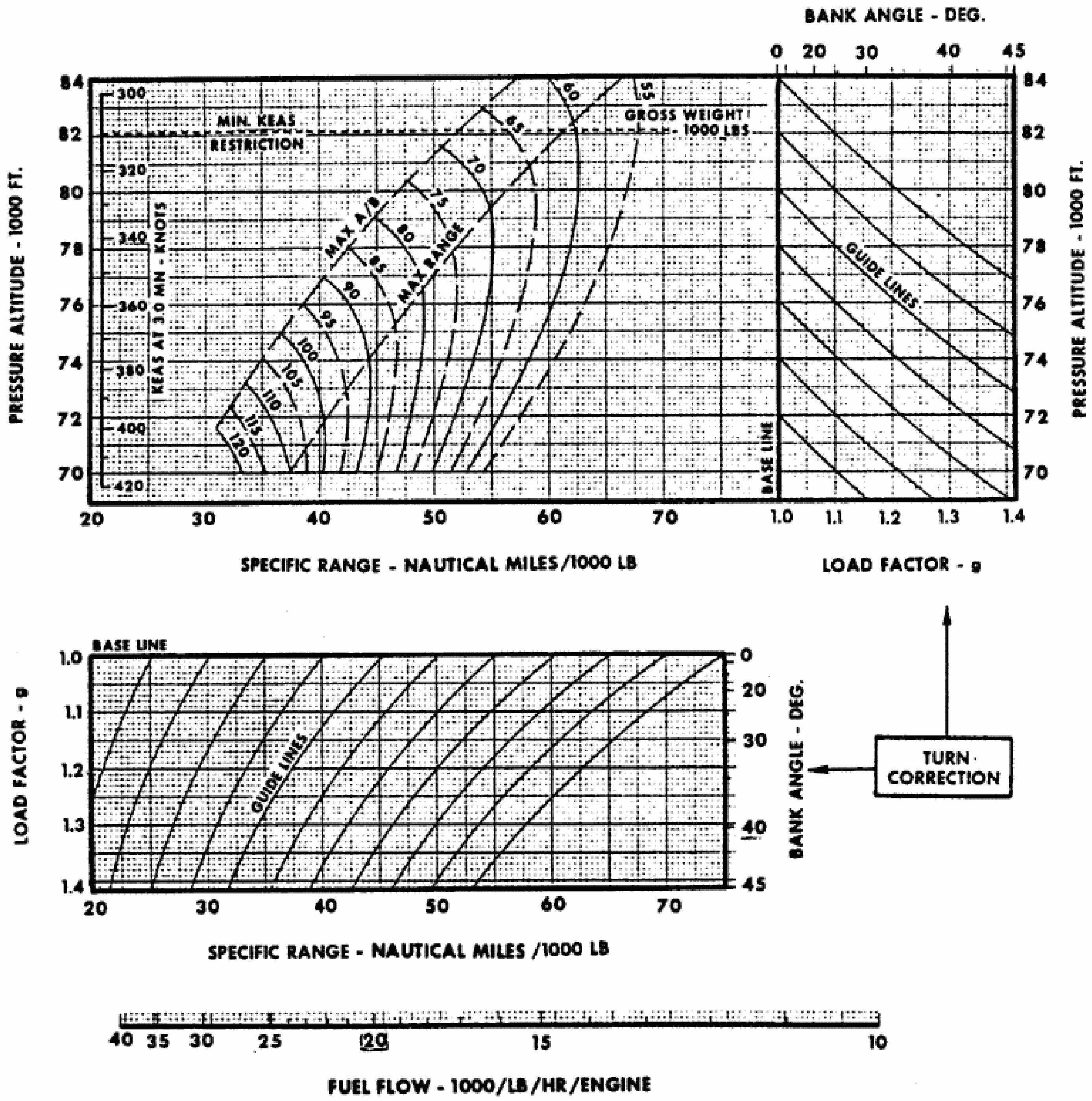

Figure A5-45

MACH 3.0 RANGE FACTOR PARAMETER

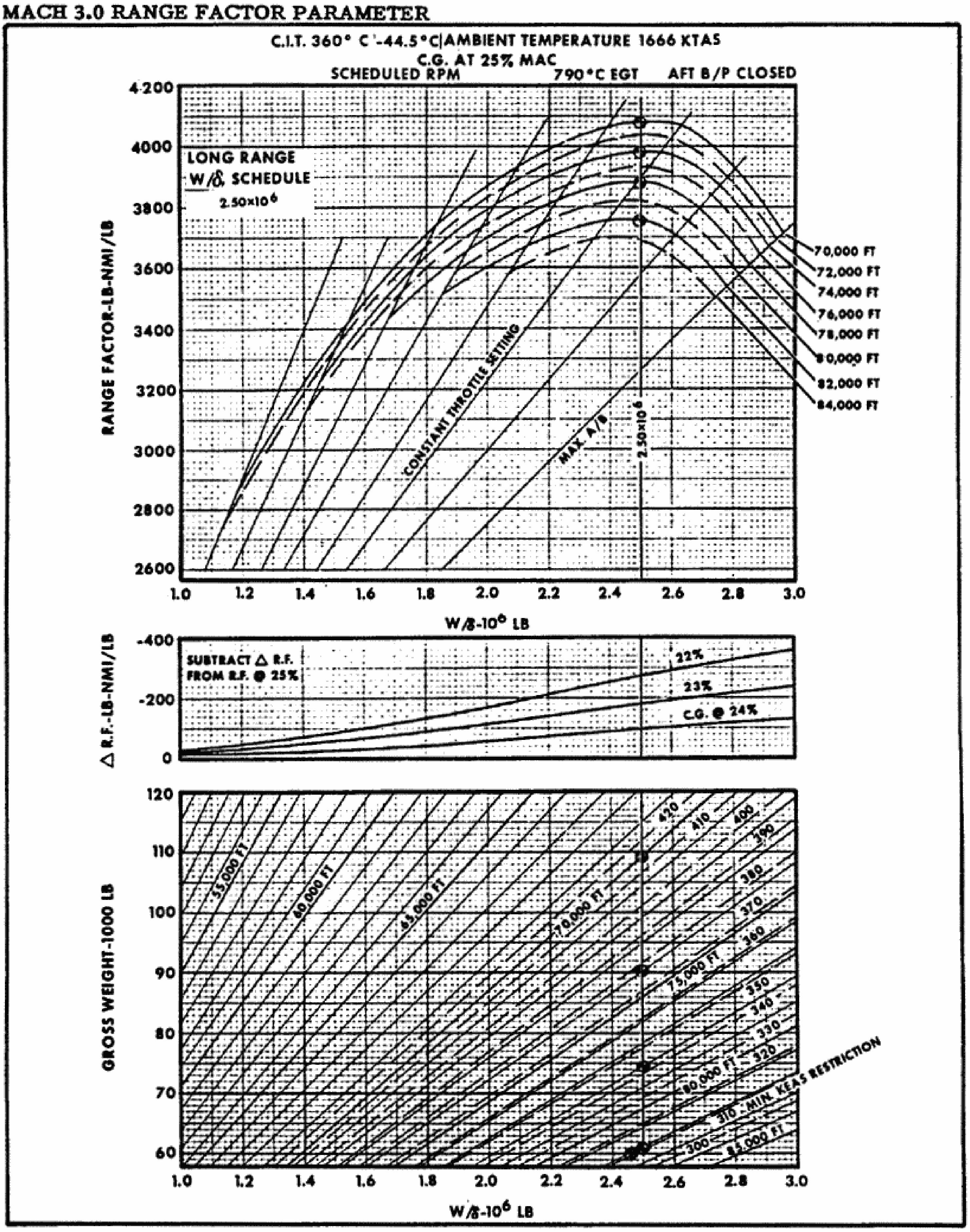

Figure A5-46

SPECIFIC RANGE AT MACH 2.80

250° C C.I.T. -68.6° C AMBIENT TEMPERATURE 1560 KTAS

C.G. AT 25% MAC
SCHEDULED RPM
790°C EGT
AFT B/P "A" POSITION

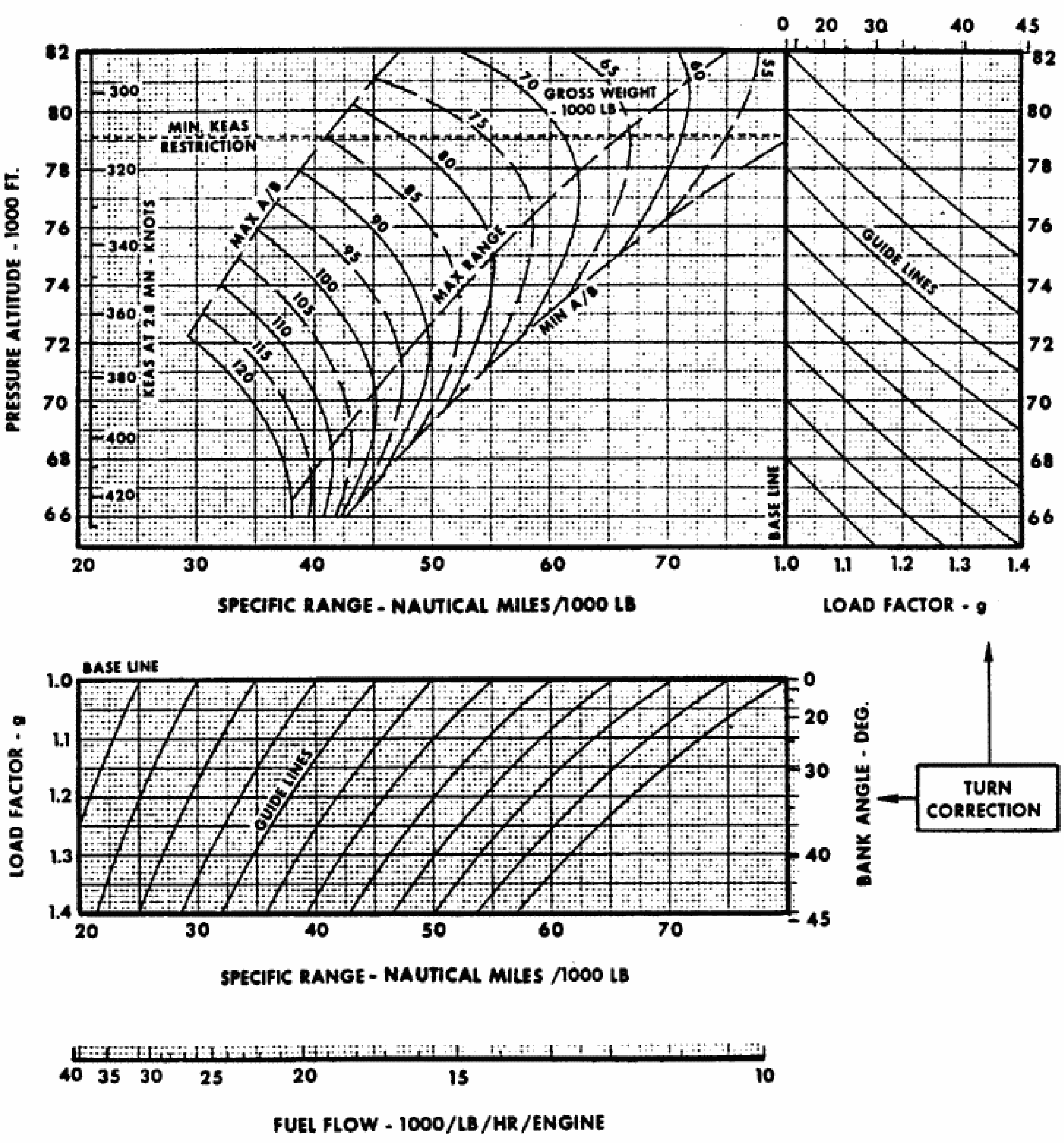

Figure A5-47

MACH 2.8 RANGE FACTOR PARAMETER

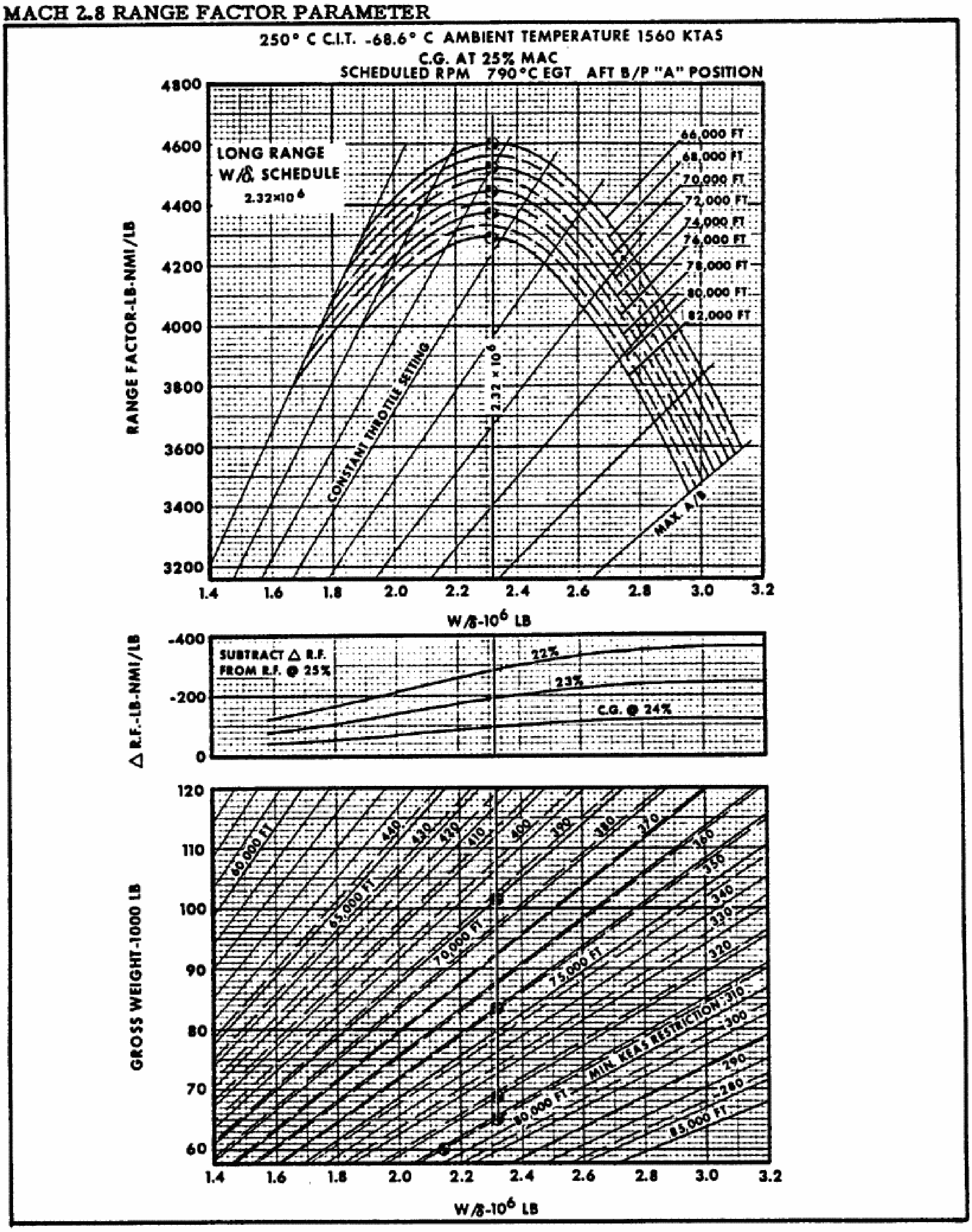

Figure A5-48

SPECIFIC RANGE AT MACH 2.80

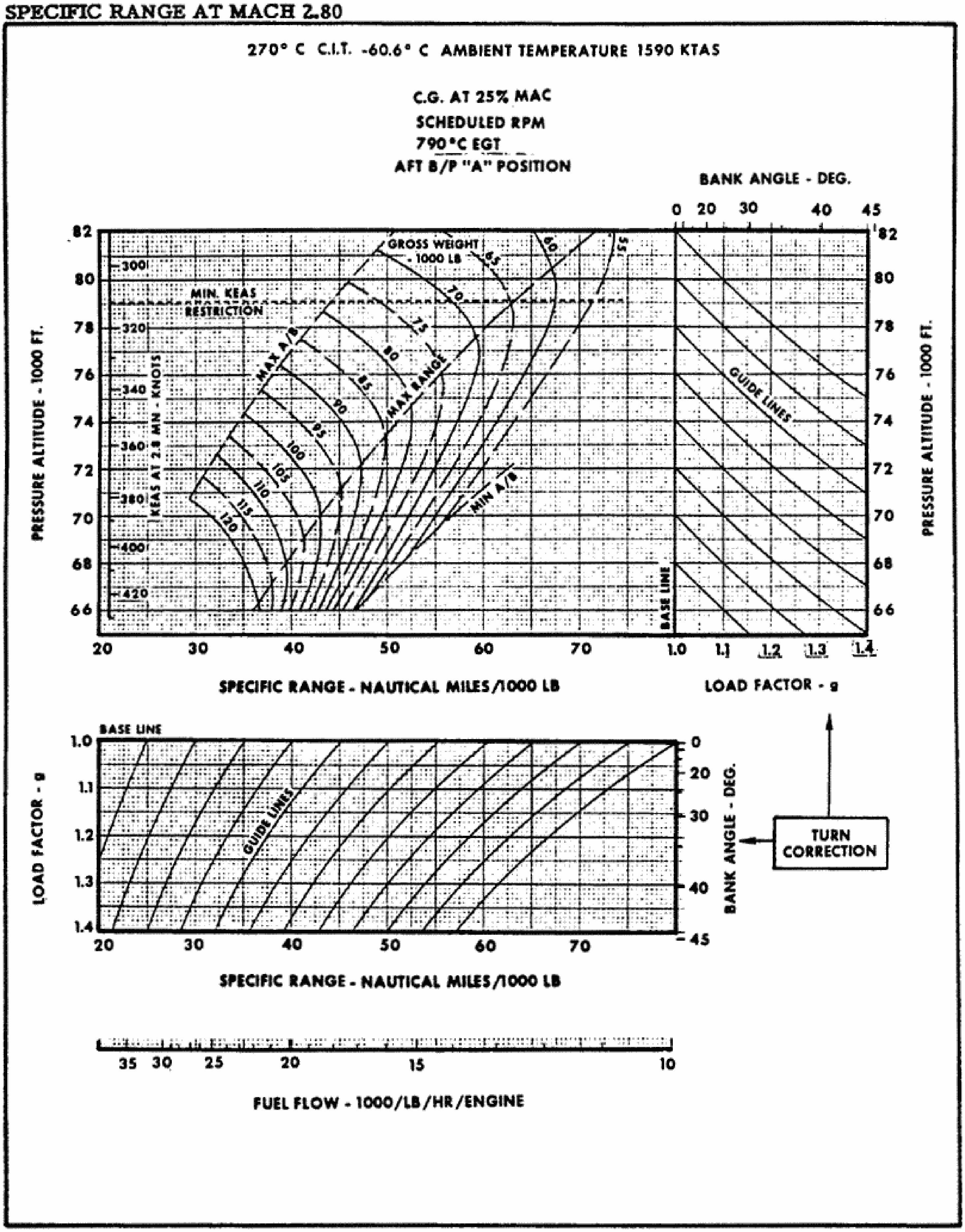

Figure A5-49

MACH 2.8 RANGE FACTOR PARAMETER

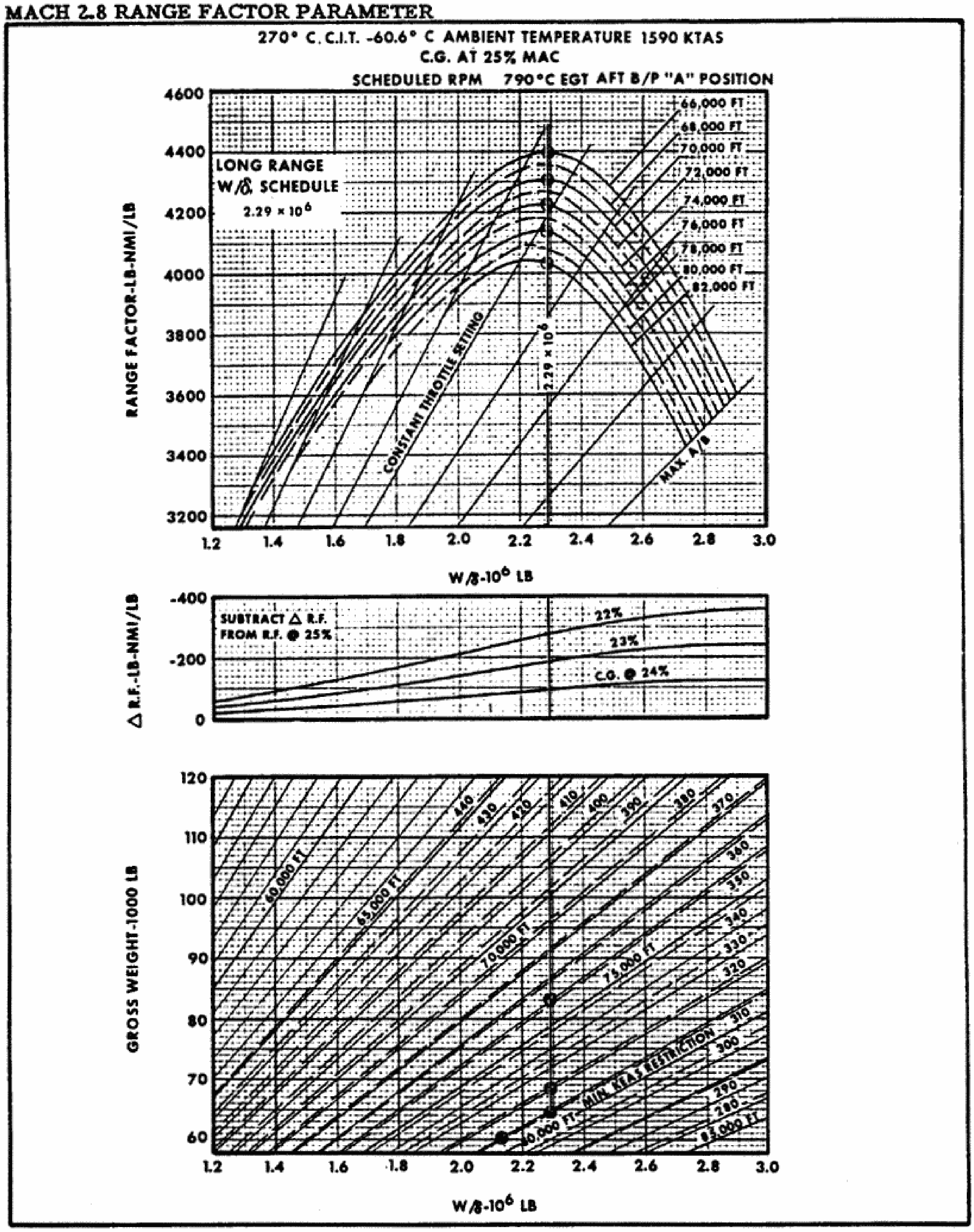

Figure A5-50

SPECIFIC RANGE AT MACH 2.80

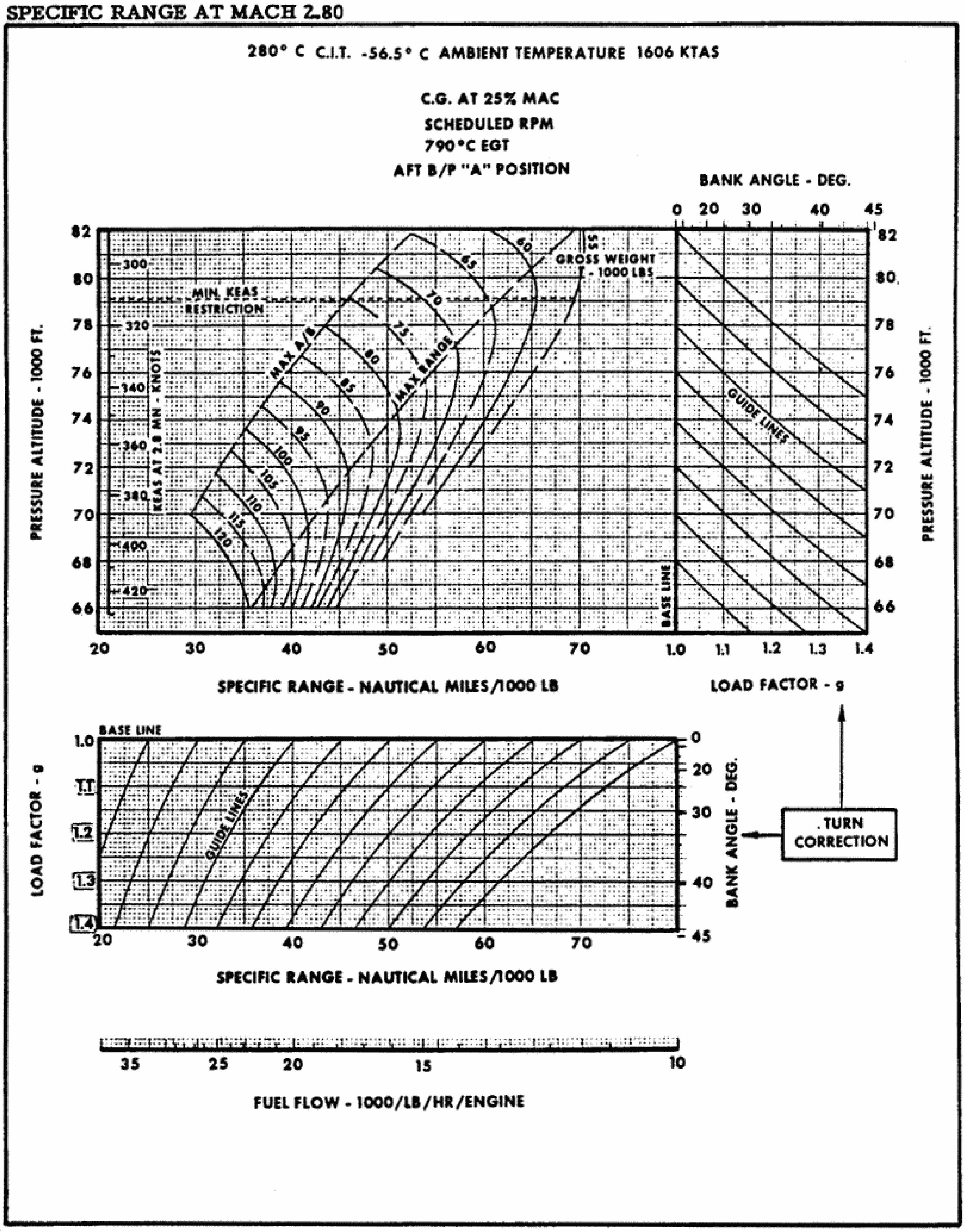

Figure A5-51

MACH 2.8 RANGE FACTOR PARAMETER

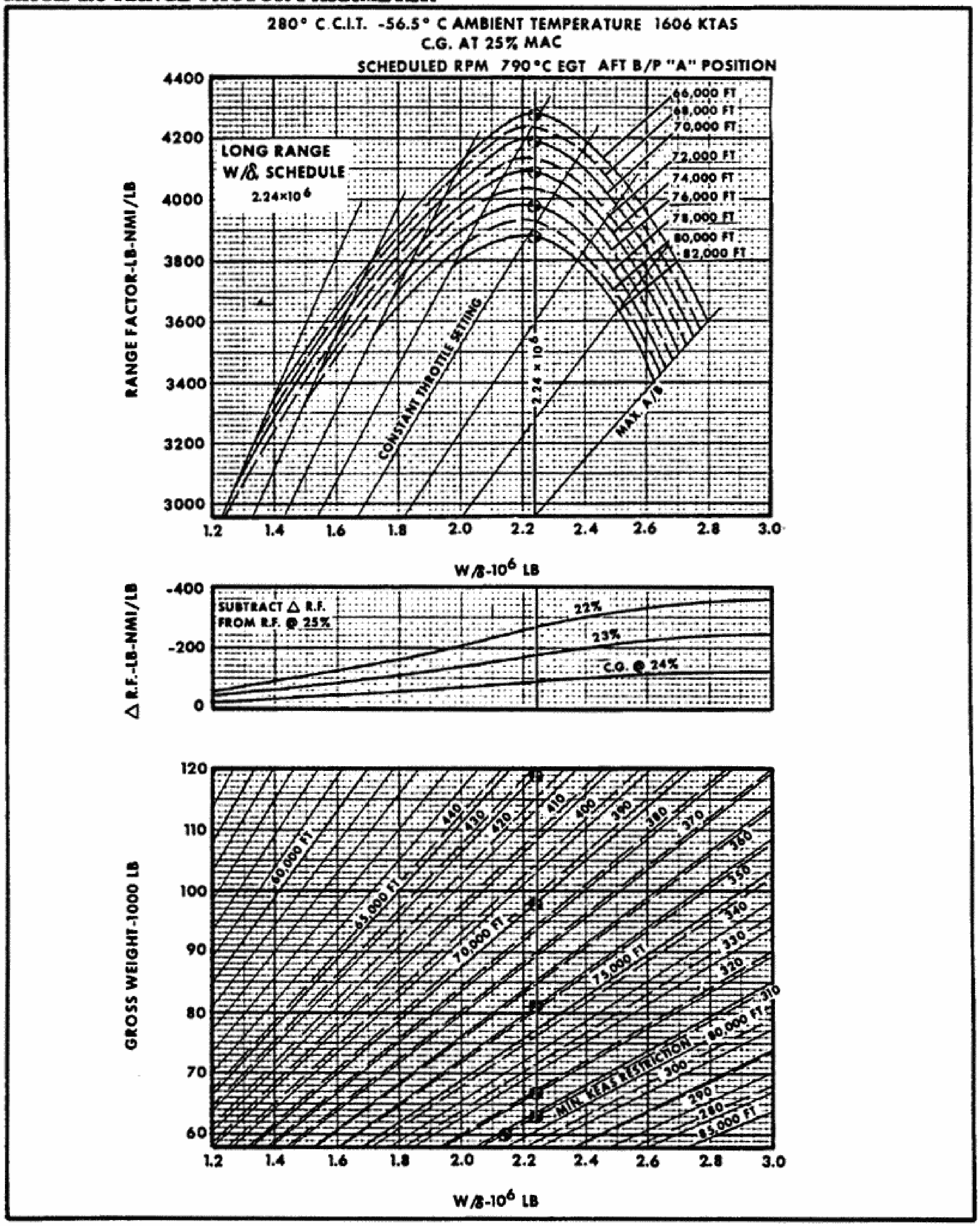

Figure A5-52

SPECIFIC RANGE AT MACH 2.80

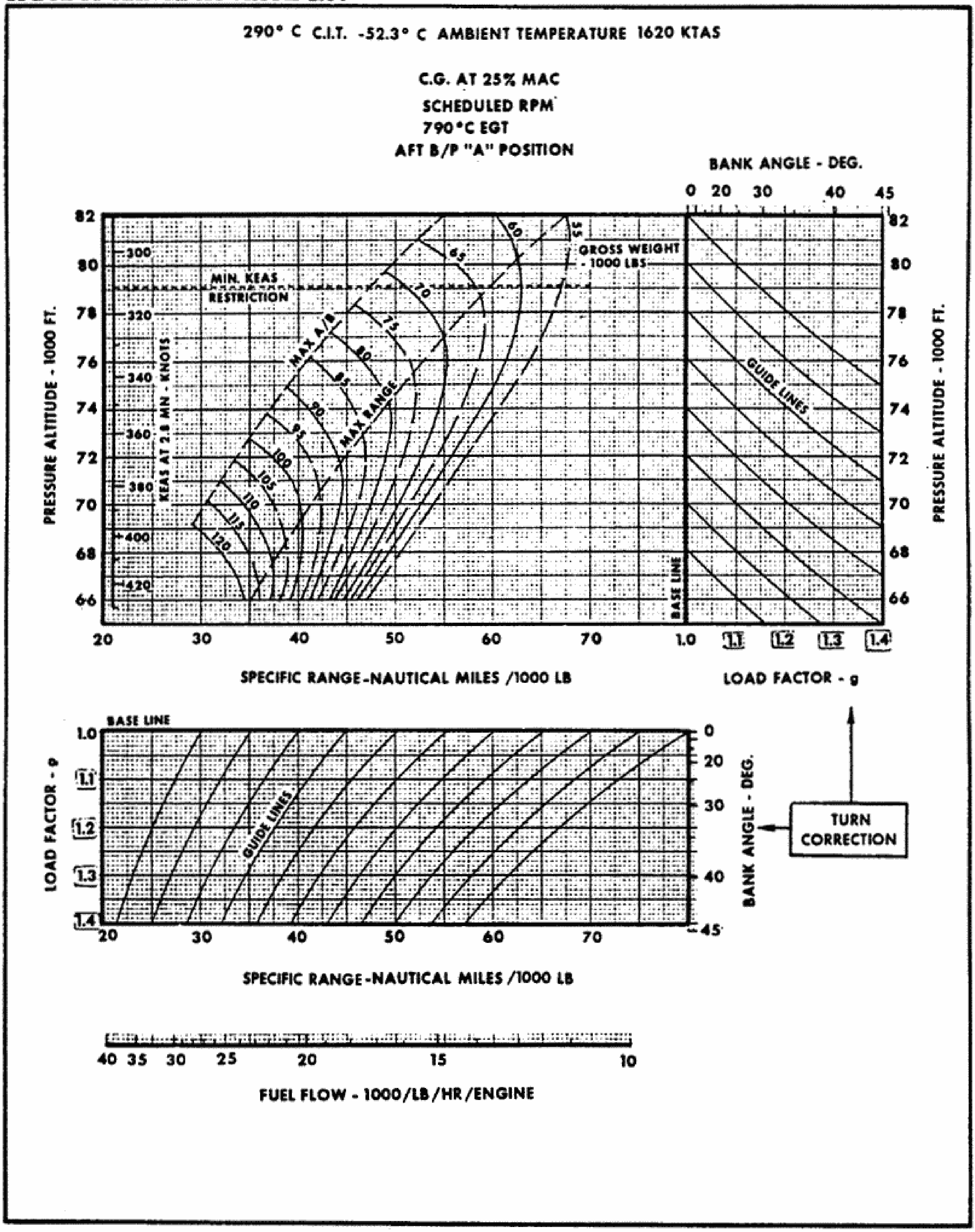

Figure A5-53

MACH 2.8 RANGE FACTOR PARAMETER

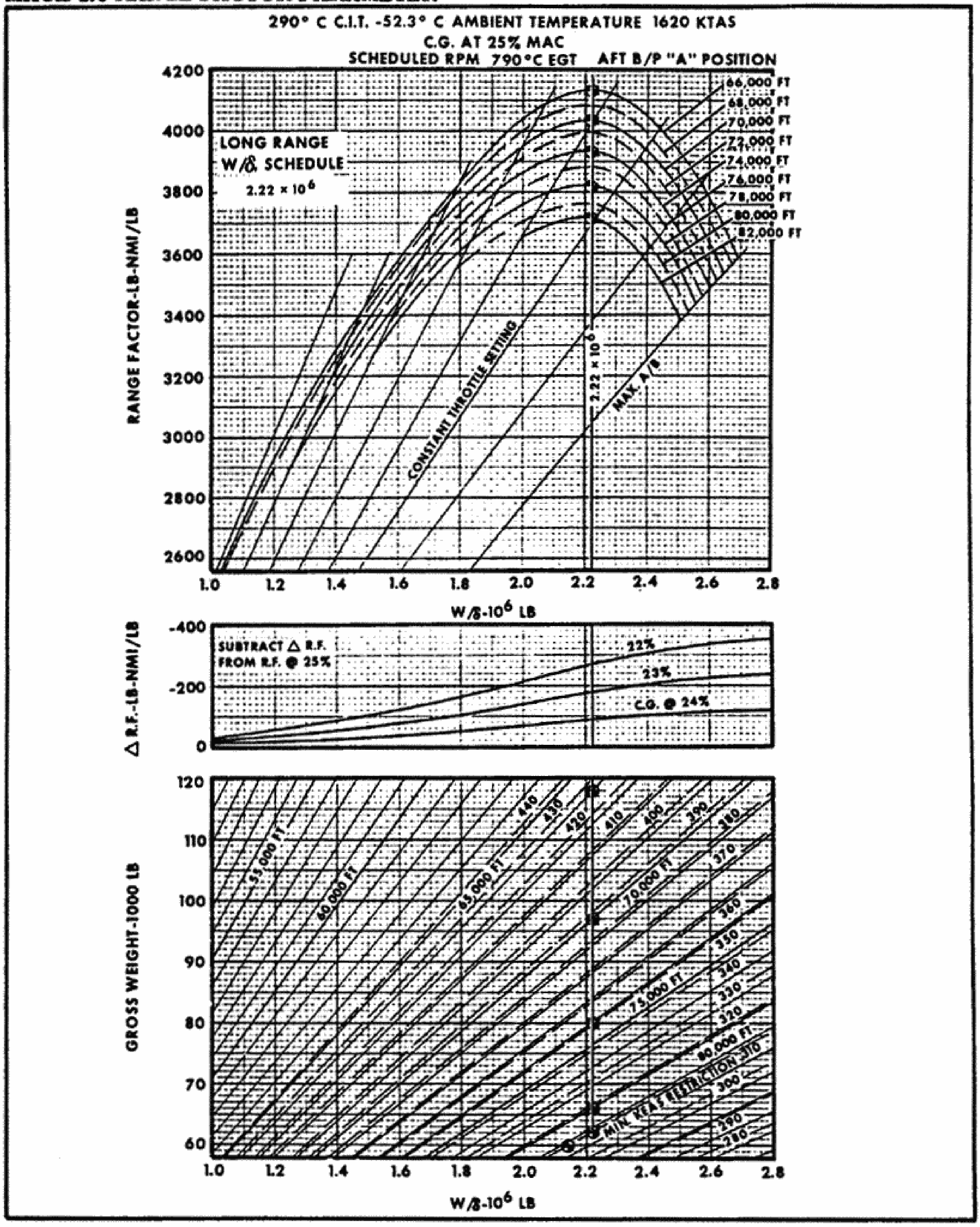

Figure A5-54

SPECIFIC RANGE AT MACH 2.80

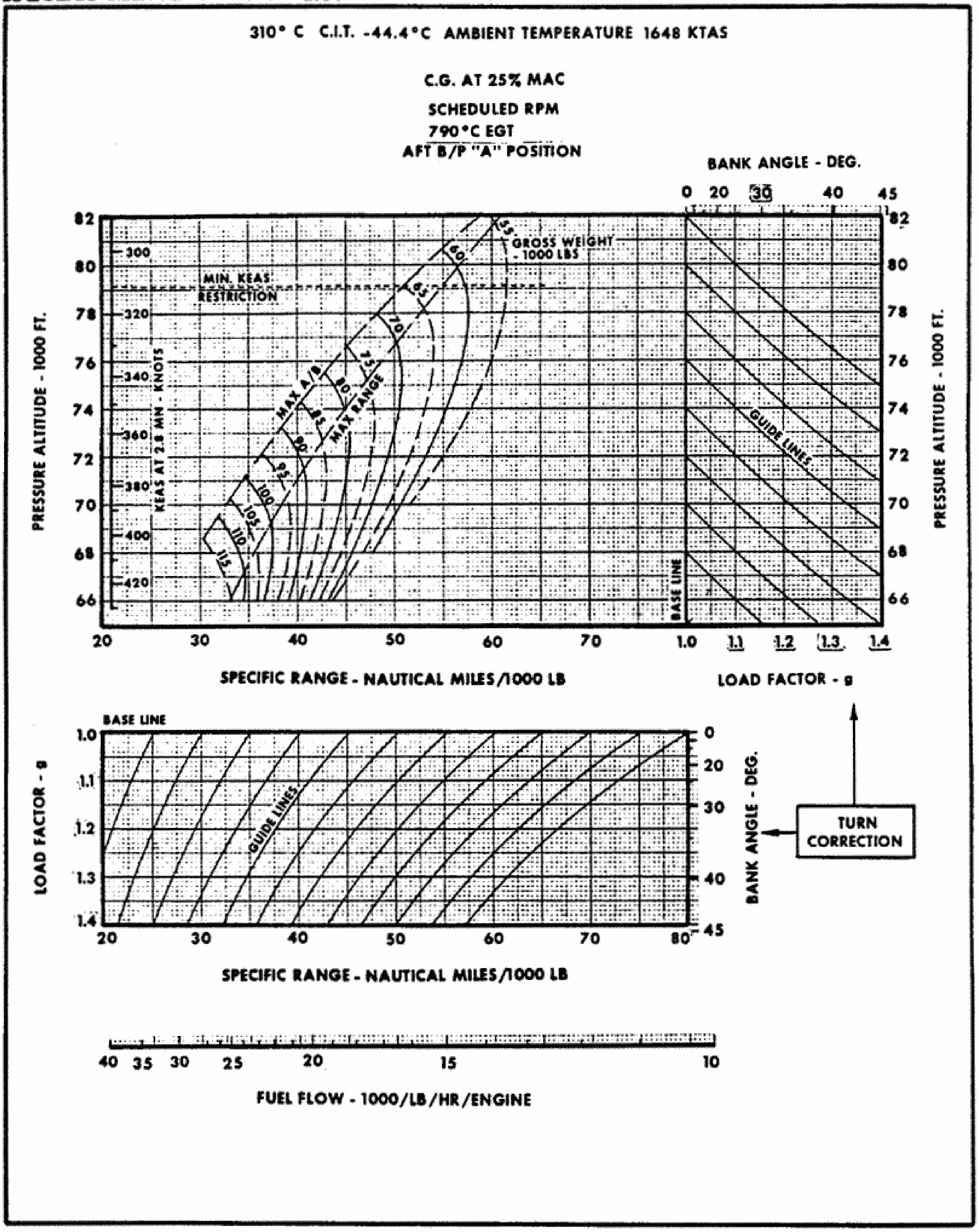

Figure A5-55

MACH 2.8 RANGE FACTOR PARAMETER

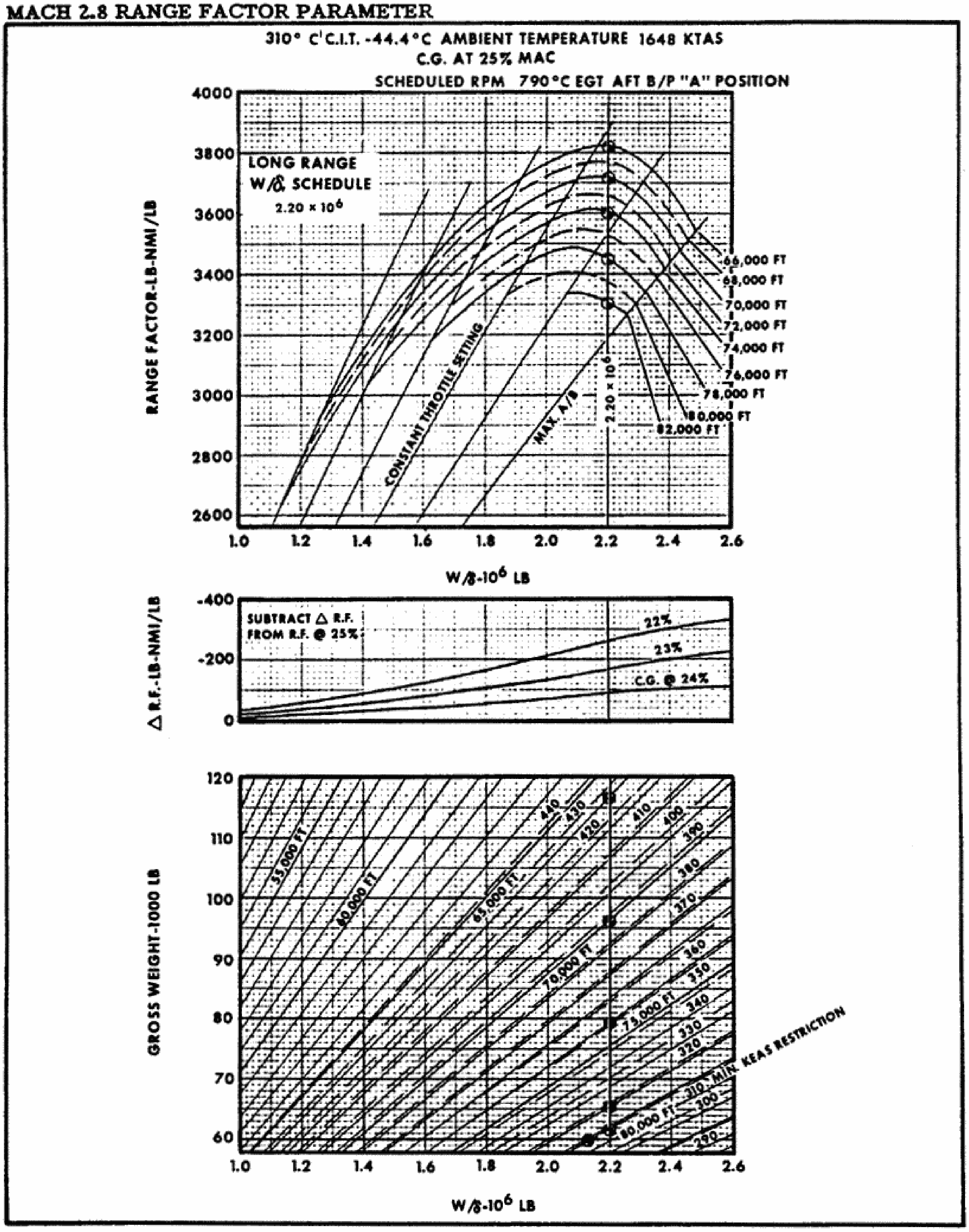

Figure A5-56

SPECIFIC RANGE AT MACH 2.40

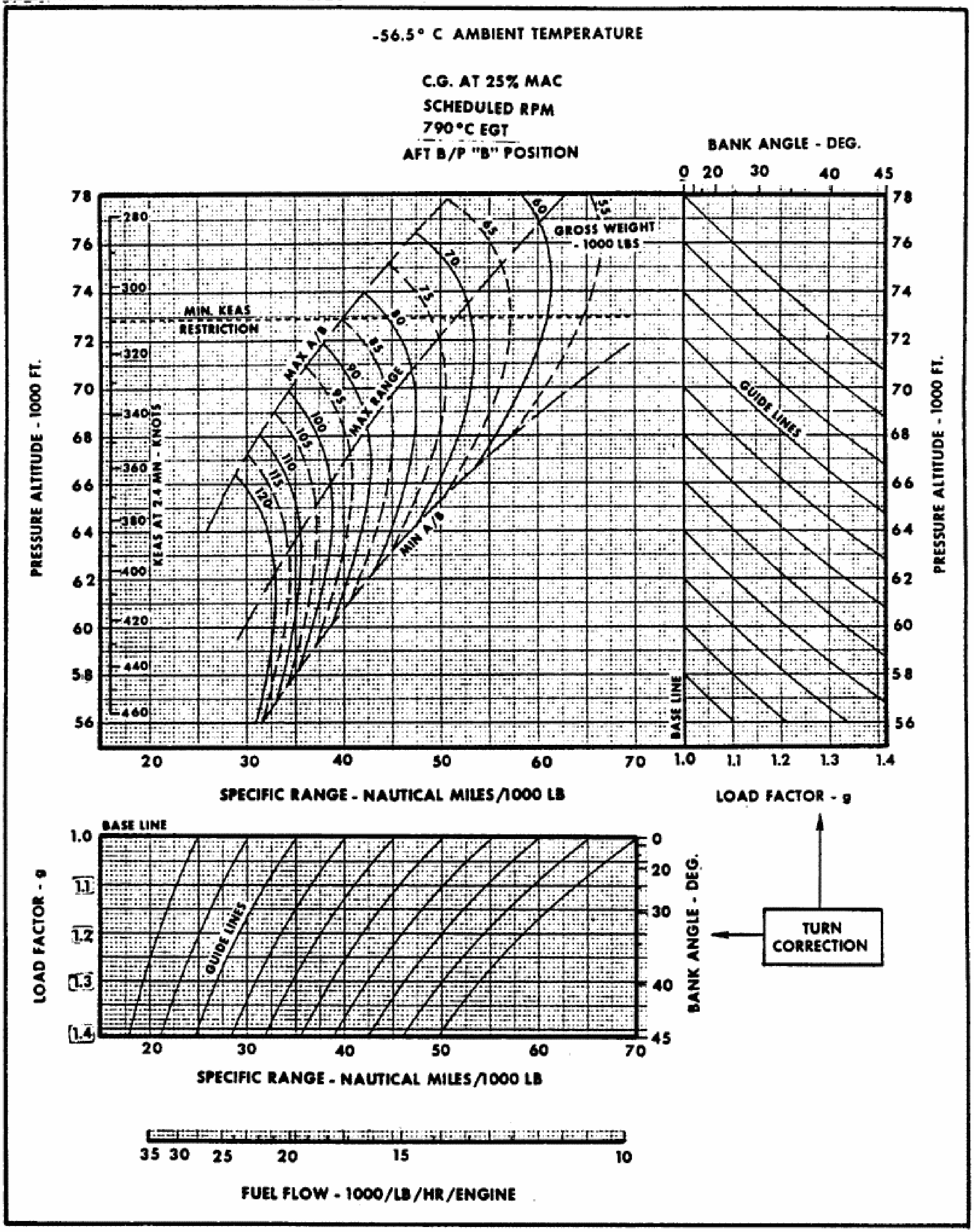

Figure A5-57

MACH 2.4 RANGE FACTOR PARAMETER

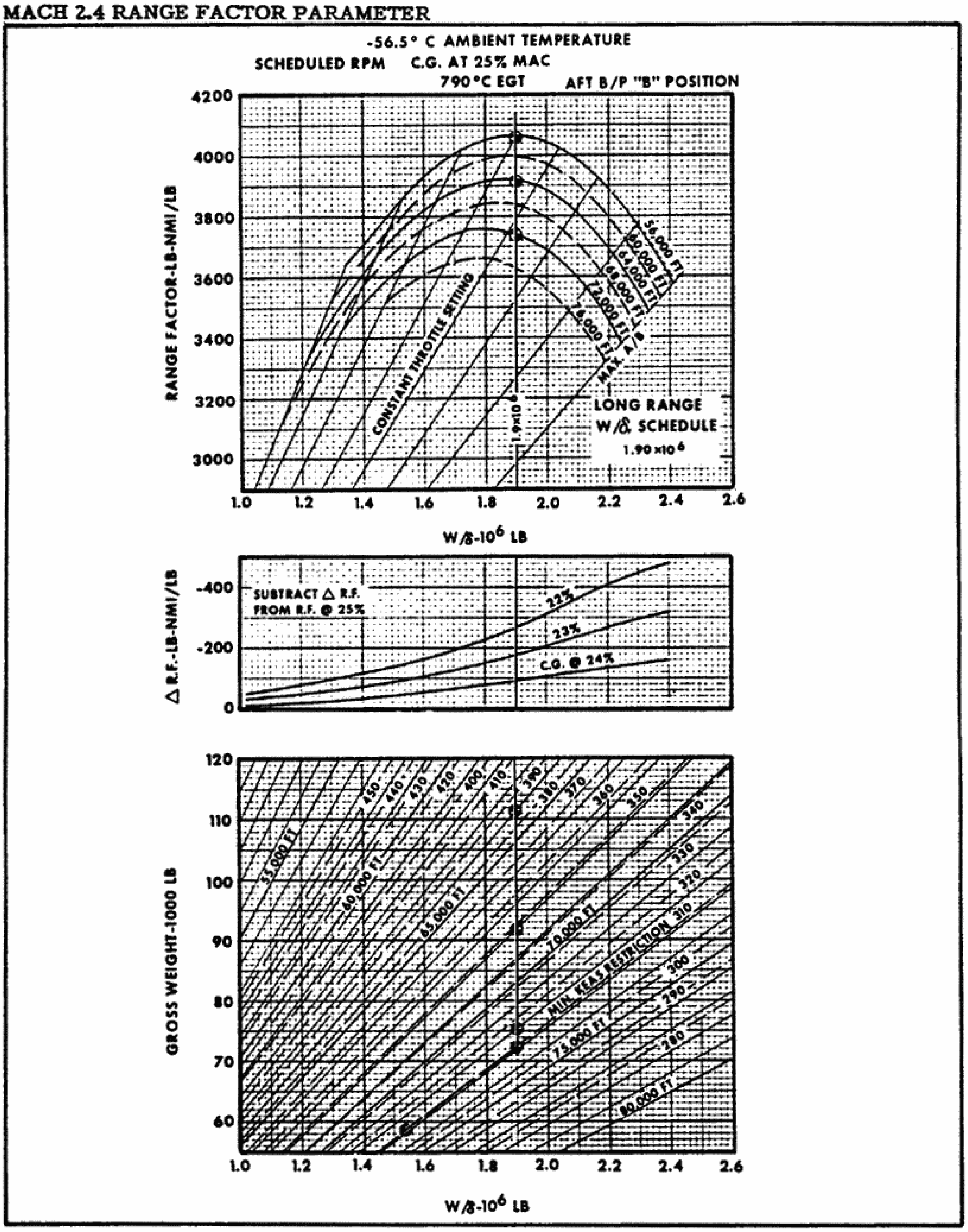

Figure A5-58

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PART VI

MISSION PLANNING

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

MISSION PLANNING

The cruise speeds, altitudes and flight distances associated with the operation of this aircraft require careful planning when operating near maximum mission capability. The charts presented in parts III through V of this appendix provide the necessary performance information for many types of missions.

Several mission profiles are included to assist in mission planning. These include Maximum Range Cruise profiles for Mach 3.20, 3.15, 3.10, 3.00, 2.80, and 2.40; and Maximum Altitude and Intermediate Altitude Cruise profiles for Mach 3.20, 3.15, 3.10, and 3.00. With the exception of Mach 2.40 cruise, the effect of other than standard temperatures on cruise performance is included. The climb and descent performance shown is test performance at or near standard temperatures.

There are two sheets for each figure. The first sheet is a cruise summary of fuel and time remaining vs flight distance. These charts are indexed to 10,000 lb fuel remaining at cruise altitudes (zero distance and time).

The second sheet is a mission profile which includes climb and descent flight paths. The initial conditions are based on end AR with 78,200 lb of fuel, and brake release with either 75,200 lb or 60,000 lb fuel remaining. Plots of cruise fuel and cruise time remaining are provided. Distance and time for descent, starting at 10,000, 7500 and 5000 lb remaining, are also shown. To obtain the total distance flown from end AR or brake release to a specific fuel reserve condition, add the distances and times read from each side of the index mark for the desired profile.

Example:

Refer to Figure A6-4, sheet 2 of 2. Find the total distance and time for a 3.15 Mach long range cruise at a forecast ambient temperature of -56°C at cruise. A profile is planned consisting of a heavy weight takeoff at sea level, normal performance climb, cruise without turns, and descent to 20,000 ft starting at 7500 lb fuel remaining. Planned fuel load at brake release is 75,200 lb fuel remaining and read distance and time as 2361 nmi, and 1 hr. 28 min. Re-enter on the 7500 lb remaining descent line at 20,000 feet and read distance and time as 442 nmi, and 21.2 min. Add the distances and times and obtain 2803 nmi and 1 hr, 49.2 min.

If forecast temperatures indicate cold day cruise conditions the distance will be increased by two increments. The cruise distance will be longer due to the colder temperature, and the climb distance will be longer due to the climb to higher altitude. Referring again to Figure A6-4, sheet 2 of 2, the shaded diamonds show where the climb intercepts the four cruise lines. For the heavy weight takeoff case the cold day intercept shows a distance of 2062 nm for a cruise at -67.5°C. Extend the climb curve (constant Mach climb) to the altitude where the cold day cruise begins and read a distance of 1999 nm. The difference between these distances (2062 - 1999 = 63) is the increase in range due to cold day cruise conditions. The corresponding time increment is 2.2 minutes for the additional 63 nm of cruise. This results in a total range and time of 2866 nm and 1 hr, 51.4 min.

TURNING PERFORMANCE

A generalized supersonic turn performance chart is presented in Figure A6-15. Turn radius is provided for bank angles from 10° to 45° at true airspeeds (knots) that include Mach from 2.0 to 3.2 at ambient temperatures from -40°C to -70°C. Turn distance and time are plotted for various turn radii and degrees of turn.

Maximum afterburner turn capabilities for constant Mach and altitude are presented in Figures A6-16 through A6-20. Performance is shown for various Mach, compressor inlet temperatures and bank angles from 30° to 45°. The charts also include the minimum gross weight for pre-planning turns (various bank angles) so that the cruise Mach can be maintained without exceeding the maximum air speeds for normal operation (V_H).

These data, in conjunction with the specific range data presented in Part V of this appendix, provide sufficient information to include various turns in the mission plan.

__Example:__

For a turn of 180° at Mach 3.00 a forecast ambient temperature of -56.5°C and a bank angle of 30° find the turn radius, distance, and time. Enter Figure A6-15 at Mach 3.00 and -56.5°C ambient temperature and note that true airspeed is 1720 knots. Proceed horizontally to 30°C bank angle and read turn radius as 74.5 nautical miles. Proceed downward to 180° of turn and read turn distance as 235 nautical miles flown. Proceed horizontally to 1720 KTAS and read the turn time as 8.1 minutes.

LN_2 CONSUMPTION

The following table presents nominal values of LN_2 consumption which can be used for mission planning. The information is based on flight tests. In using the information for planning and for in-flight monitoring of LN_2 consumption, it should be recognized that variations from nominal values must be expected. In addition to other factors, this would be due to differences in individual flight plans and overall aircraft condition. It is suggested that the crew maintain a "how-goes-it" chart in flight to check actual LN_2 consumption against predicted consumption and to forecast LN_2 required for successive legs. It may be necessary to alter flight plans if in-flight quantity indications show premature depletion of LN_2.

NOMINAL LN_2 CONSUMPTION SCHEDULE

Boil-off before engine start	7 liters per hour
From engine start until takeoff	2 liters
For takeoff and climb to subsonic cruise altitude	1 liter
Subsonic cruise, approximately 25,000 to 30,000 feet	1/2 liter per minute
Air refueling near 25,000 feet	5 liters
Climb to supersonic cruise altitude after refueling	4 liters
Supersonic cruise, 70,000 to 85,000 feet	2 liters
Descent from supersonic cruise altitude to A/R altitude near 25,000 feet, including tanker rendezvous	16 liters
Descent from supersonic cruise altitude to approximately 20,000 feet prior to penetration	15 liters
Descent from penetration altitude to landing	34 liters
From landing to engine shutdown	13 liters

[redacted]

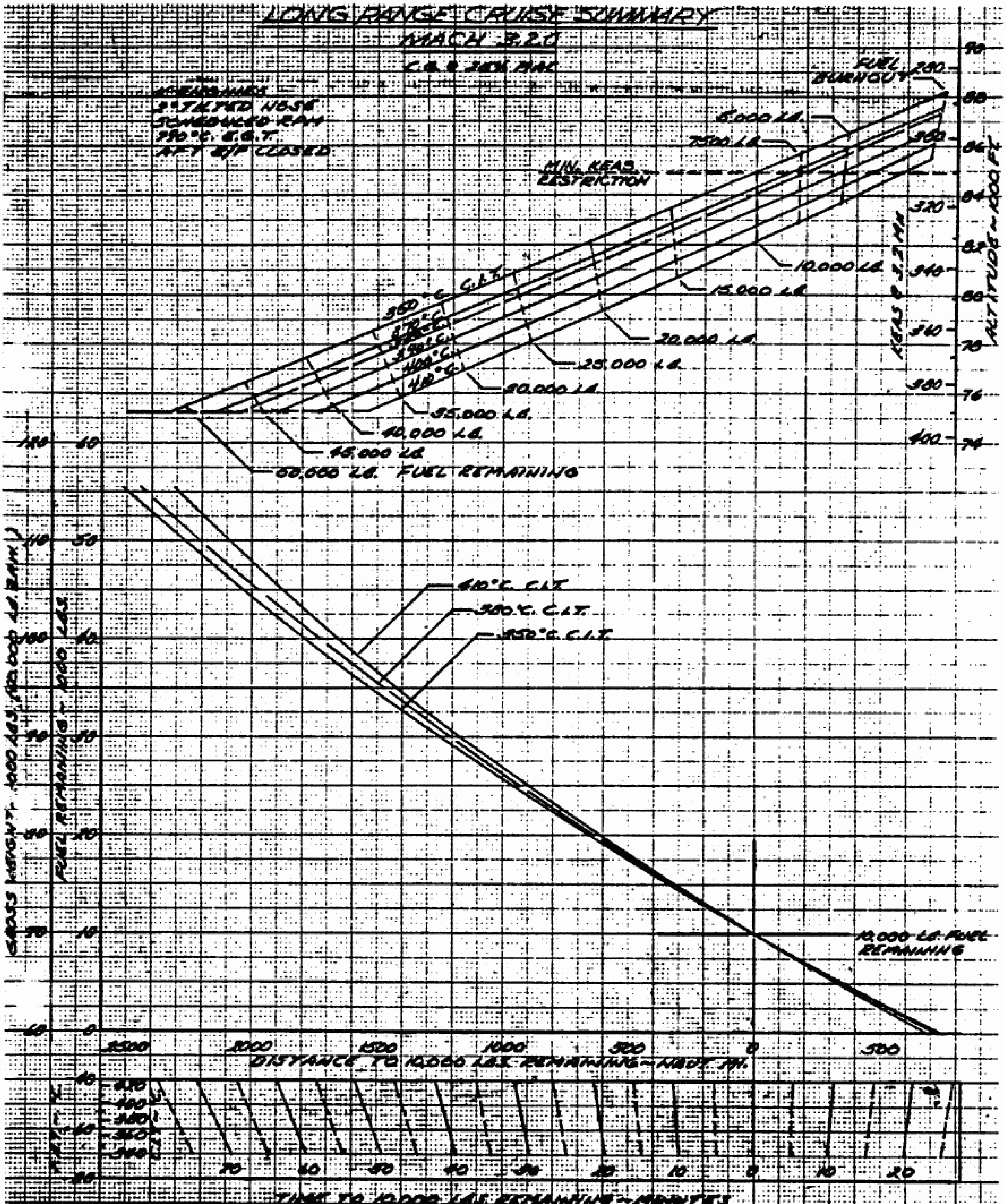

Figure A6-1 (Sheet 1 of 2)

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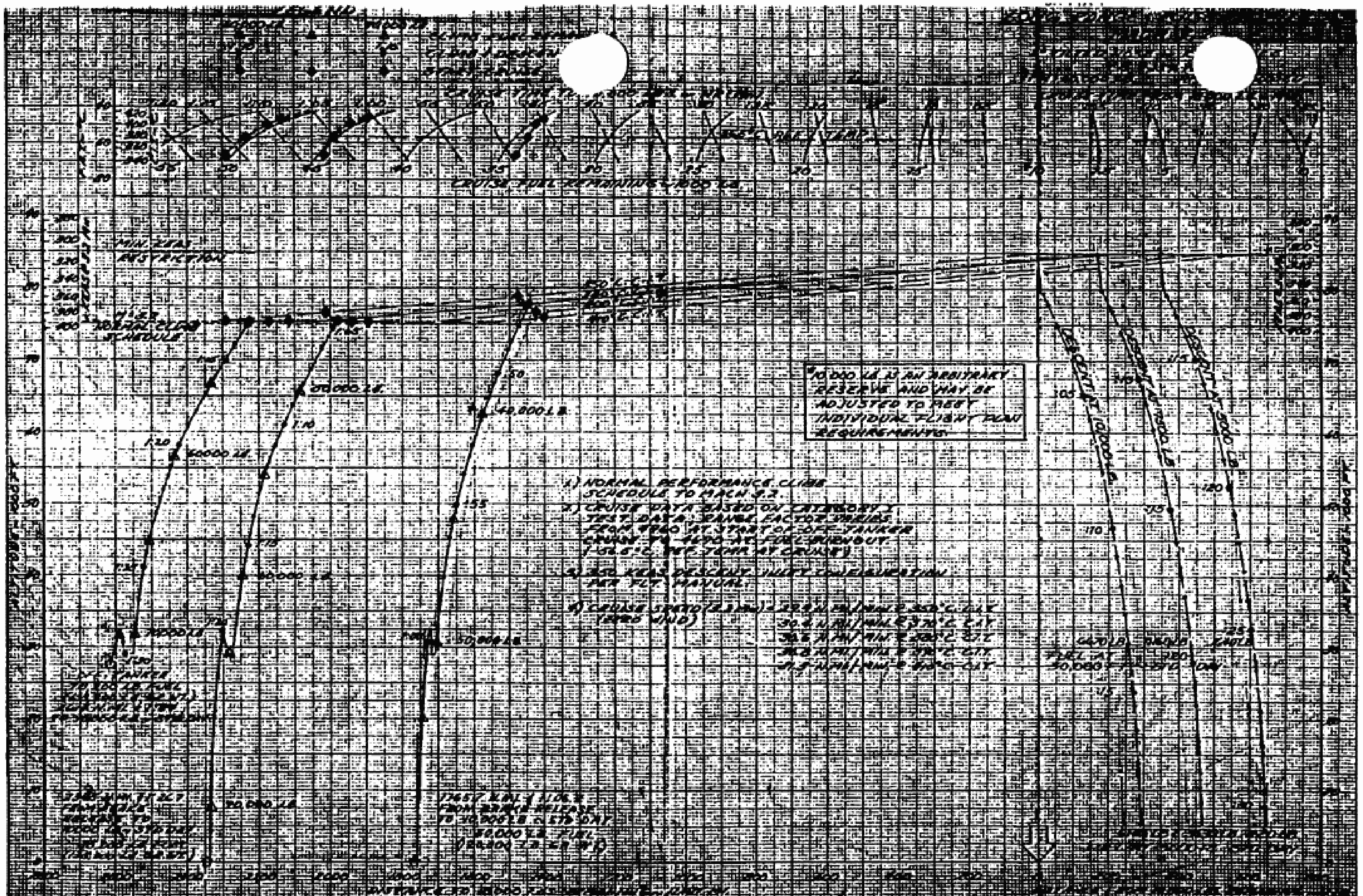

Figure A6-1 (Sheet 2 of 2)

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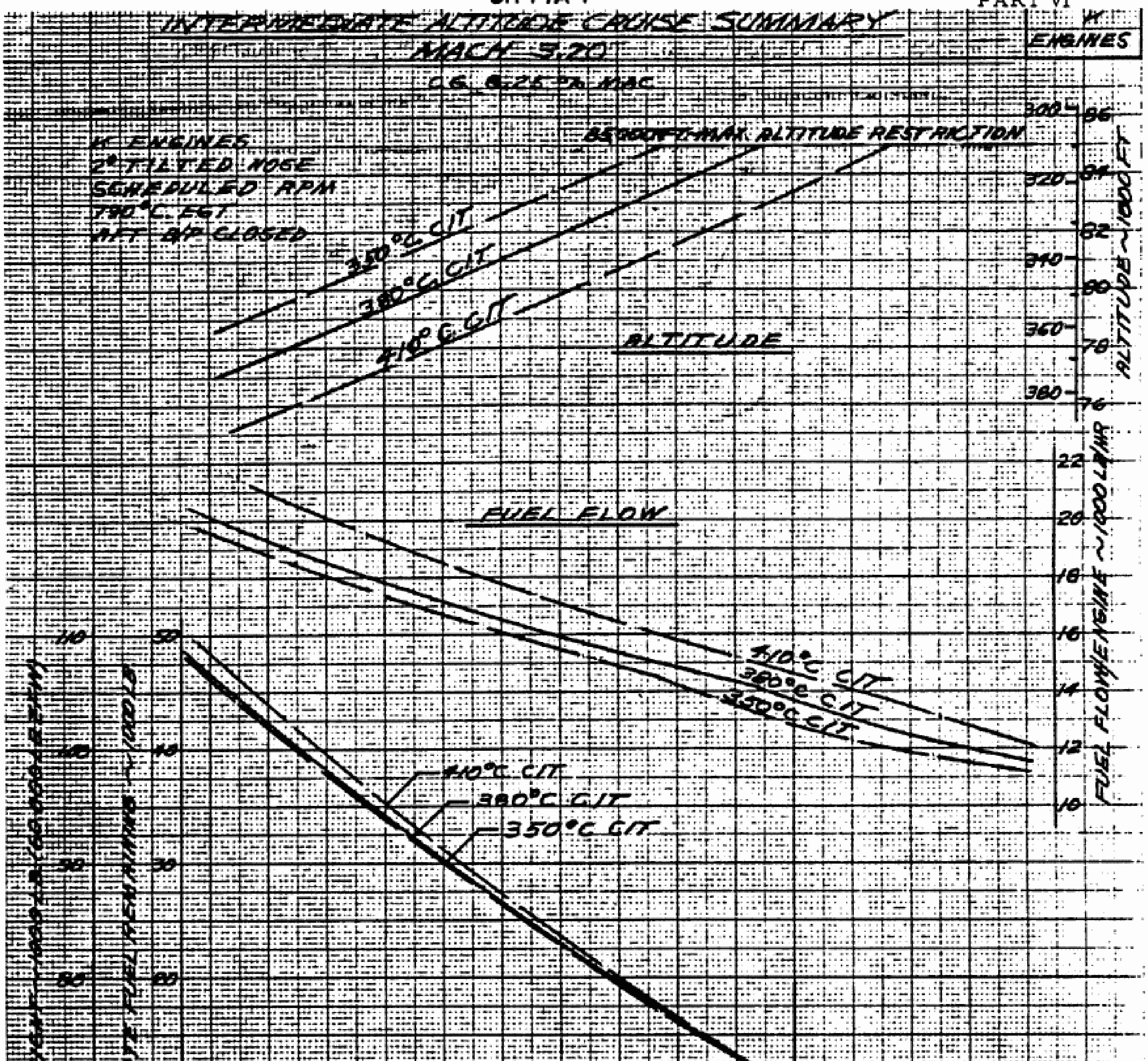

Figure A6-2 (Sheet 1 of 2)

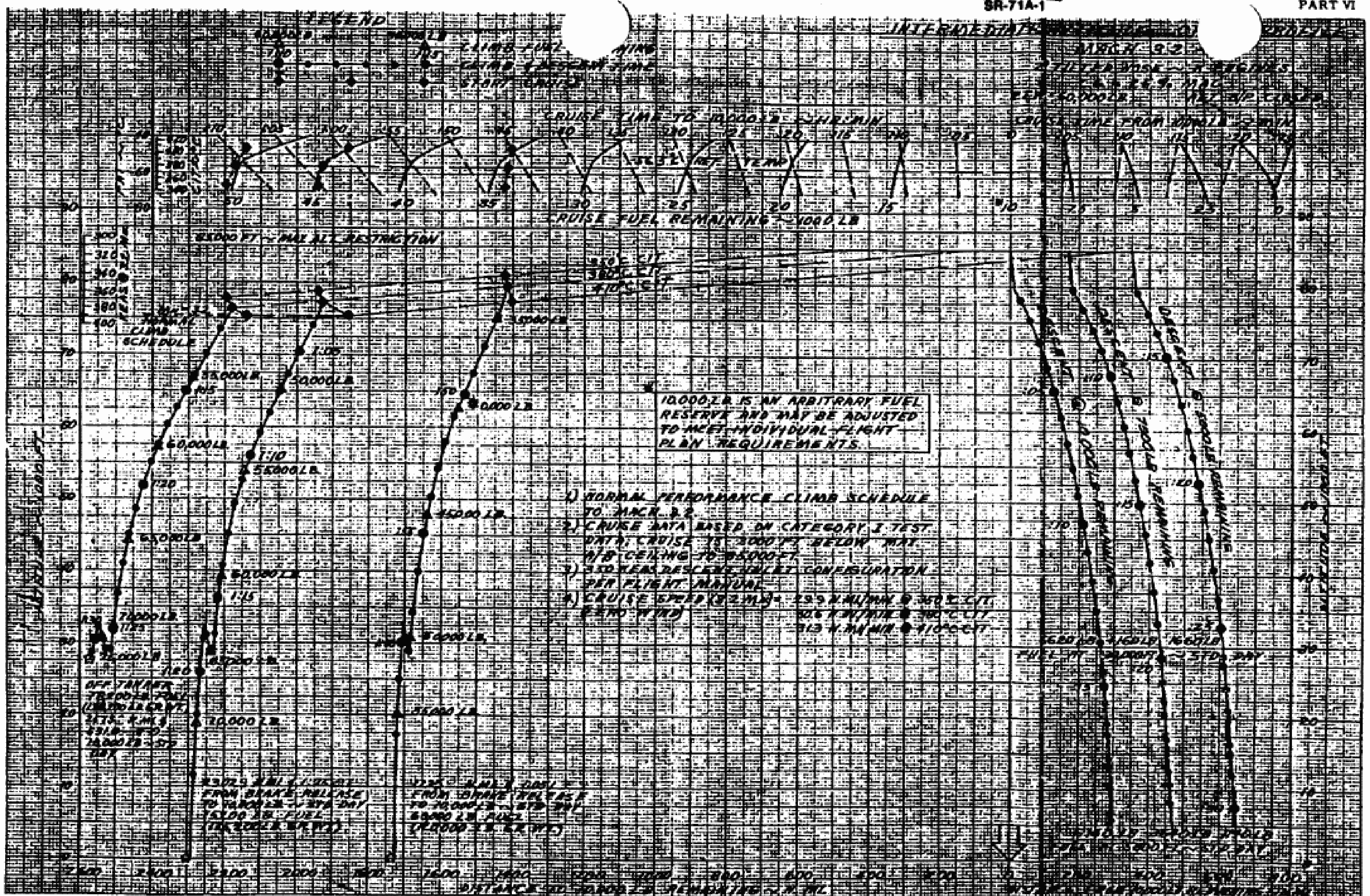

Figure A6-2 (Sheet 2 of 2)

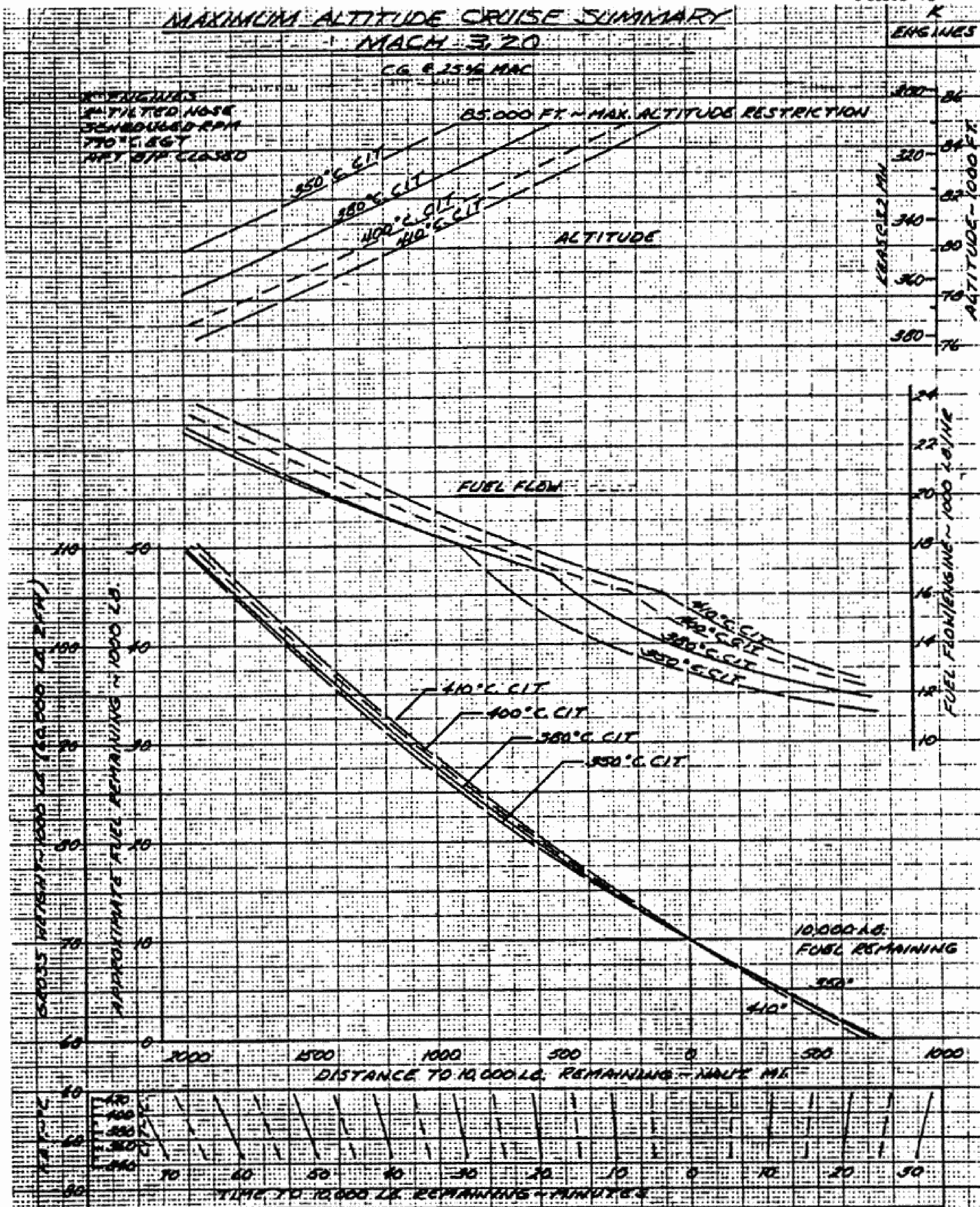

Figure A6-3 (Sheet 1 of 2)

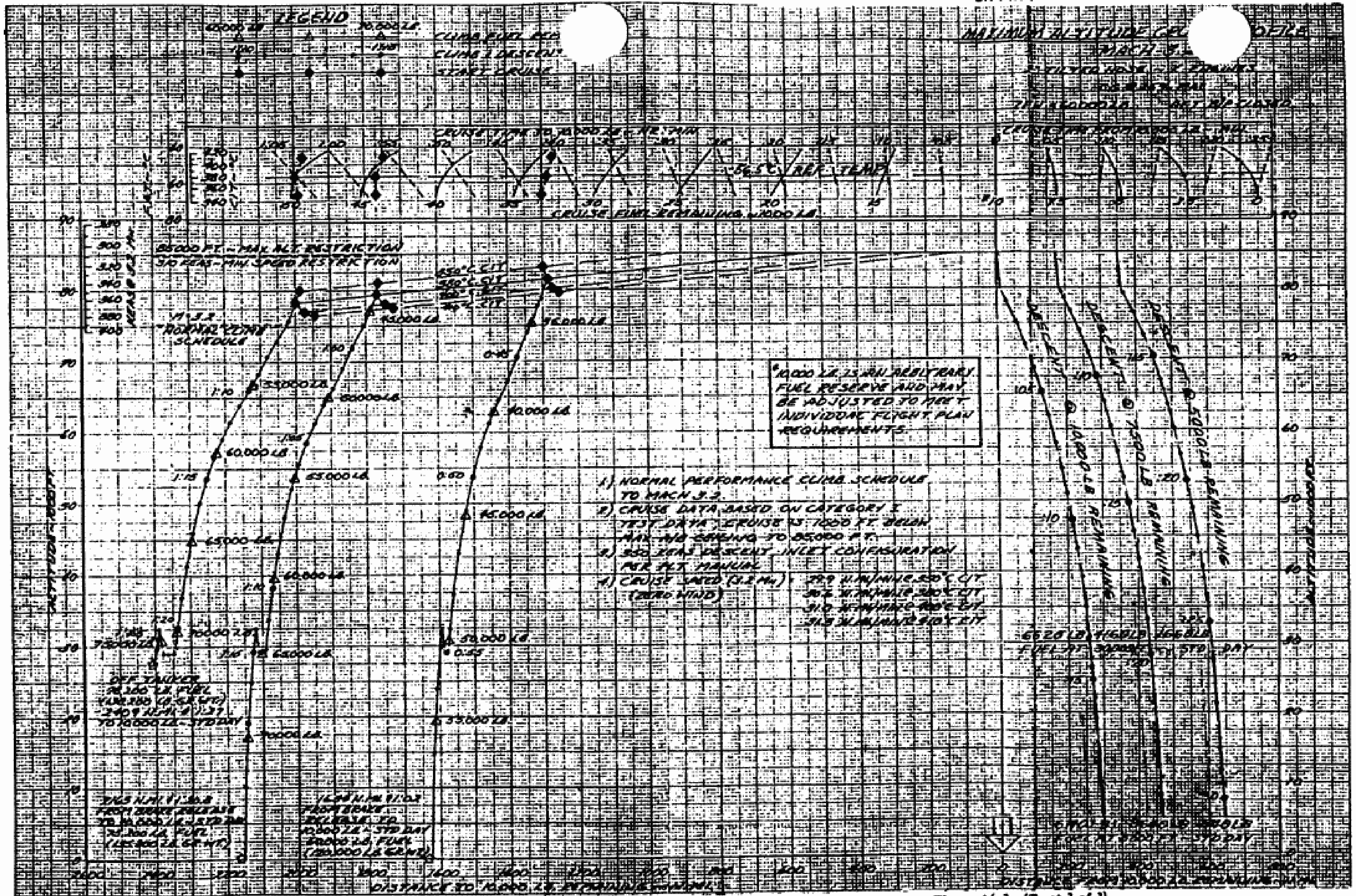

Figure A6-3 (Sheet 2 of 2)

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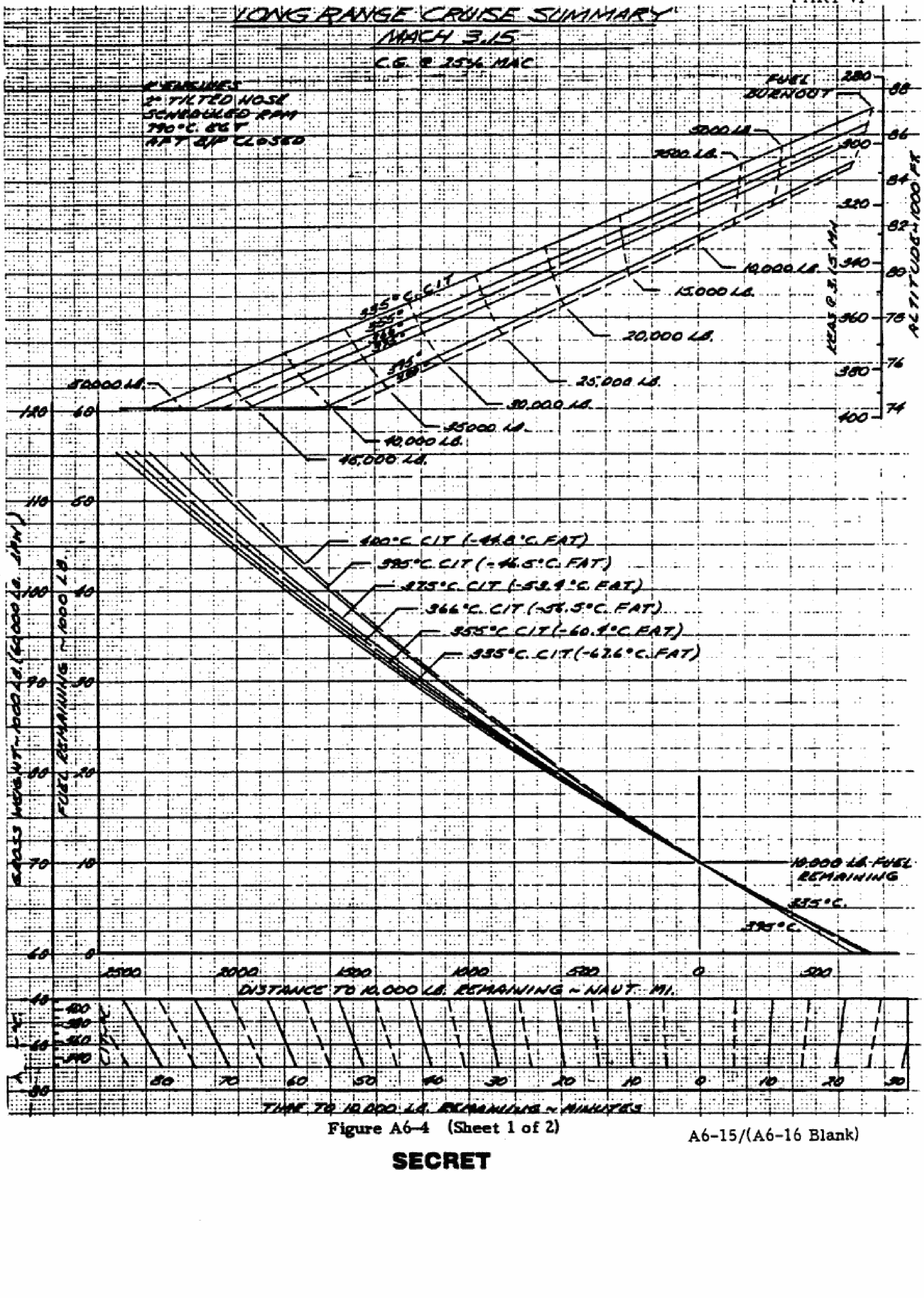


Figure A6-4 (Sheet 1 of 2)

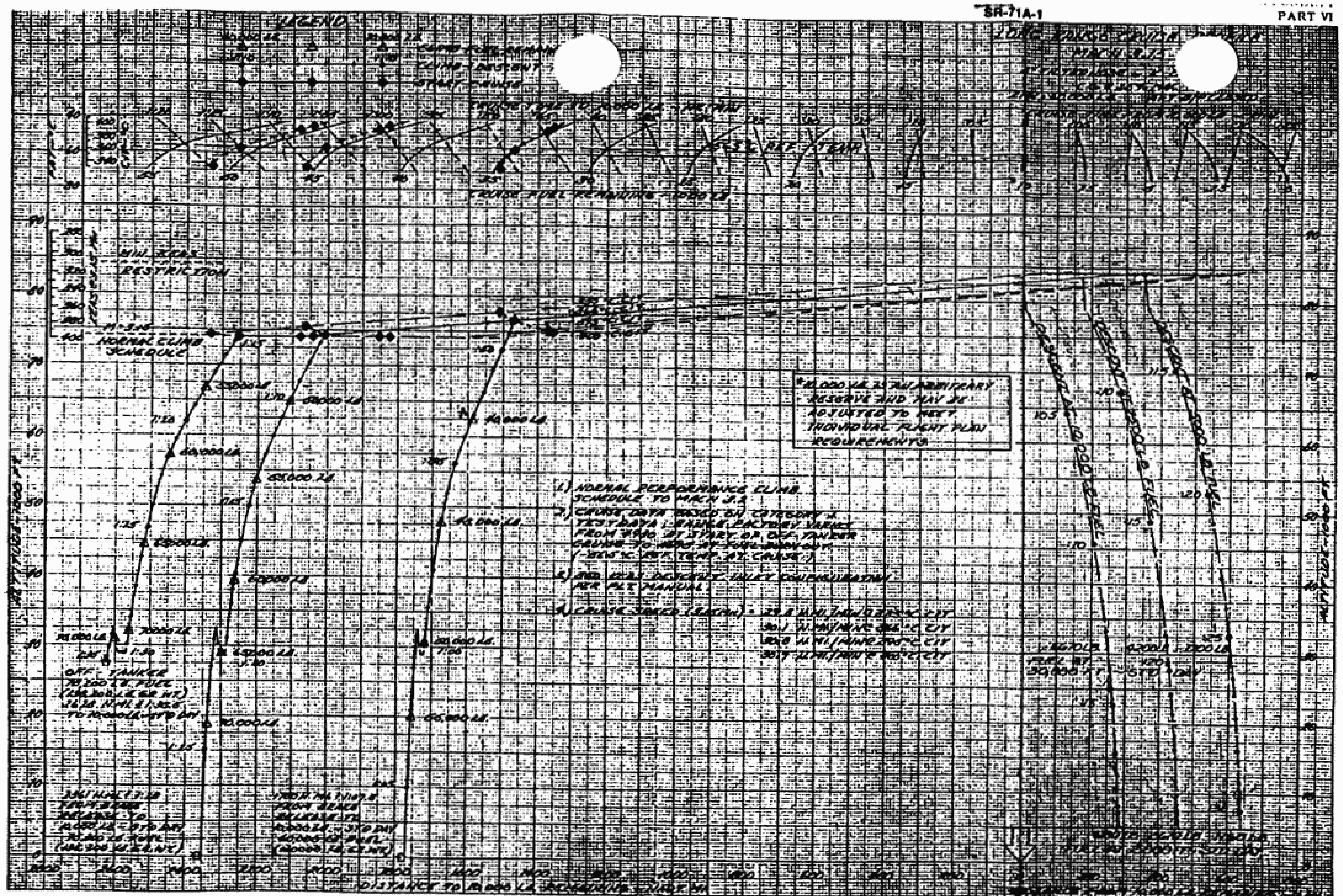


Figure A6-4 (Sheet 2 of 2)

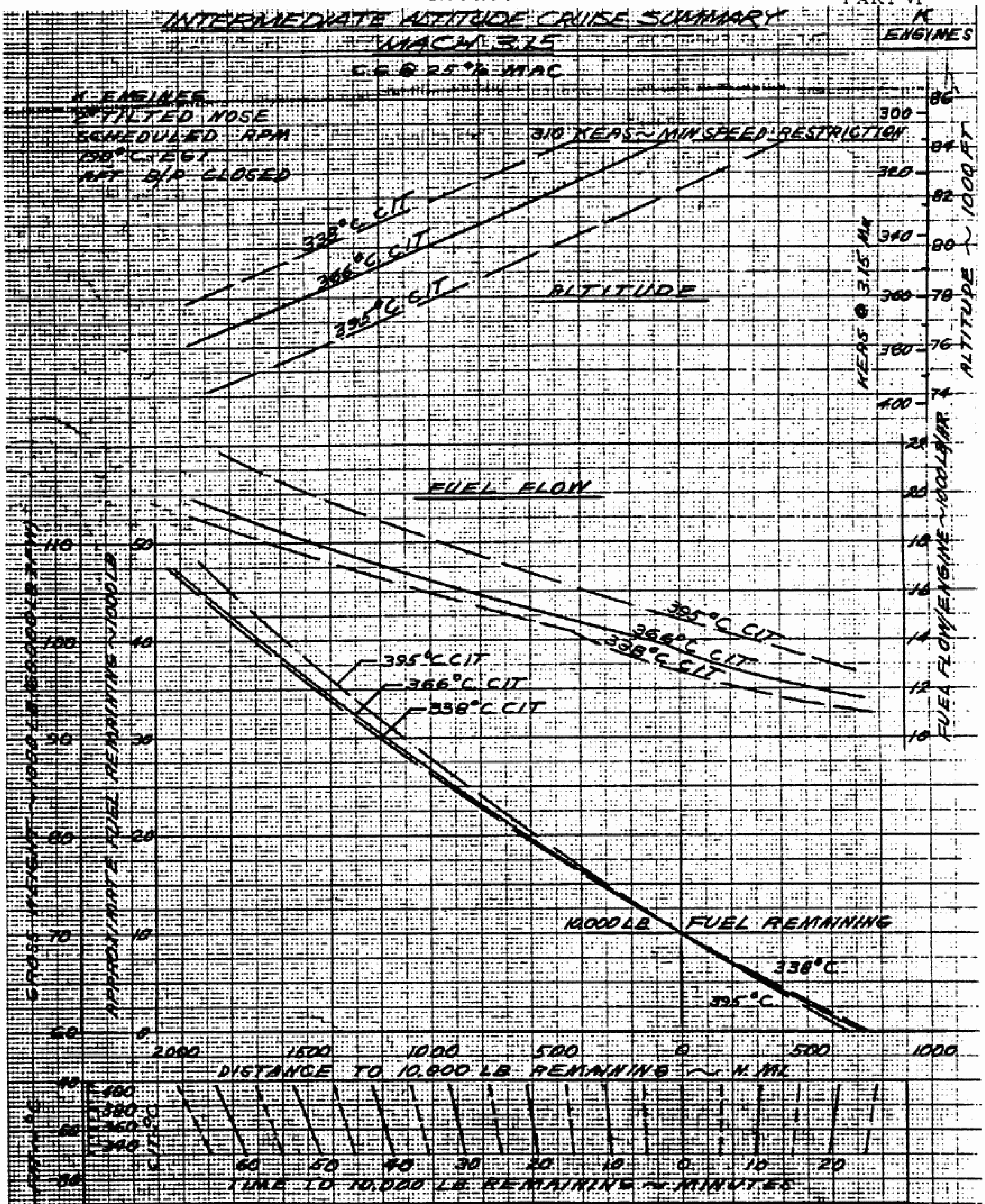
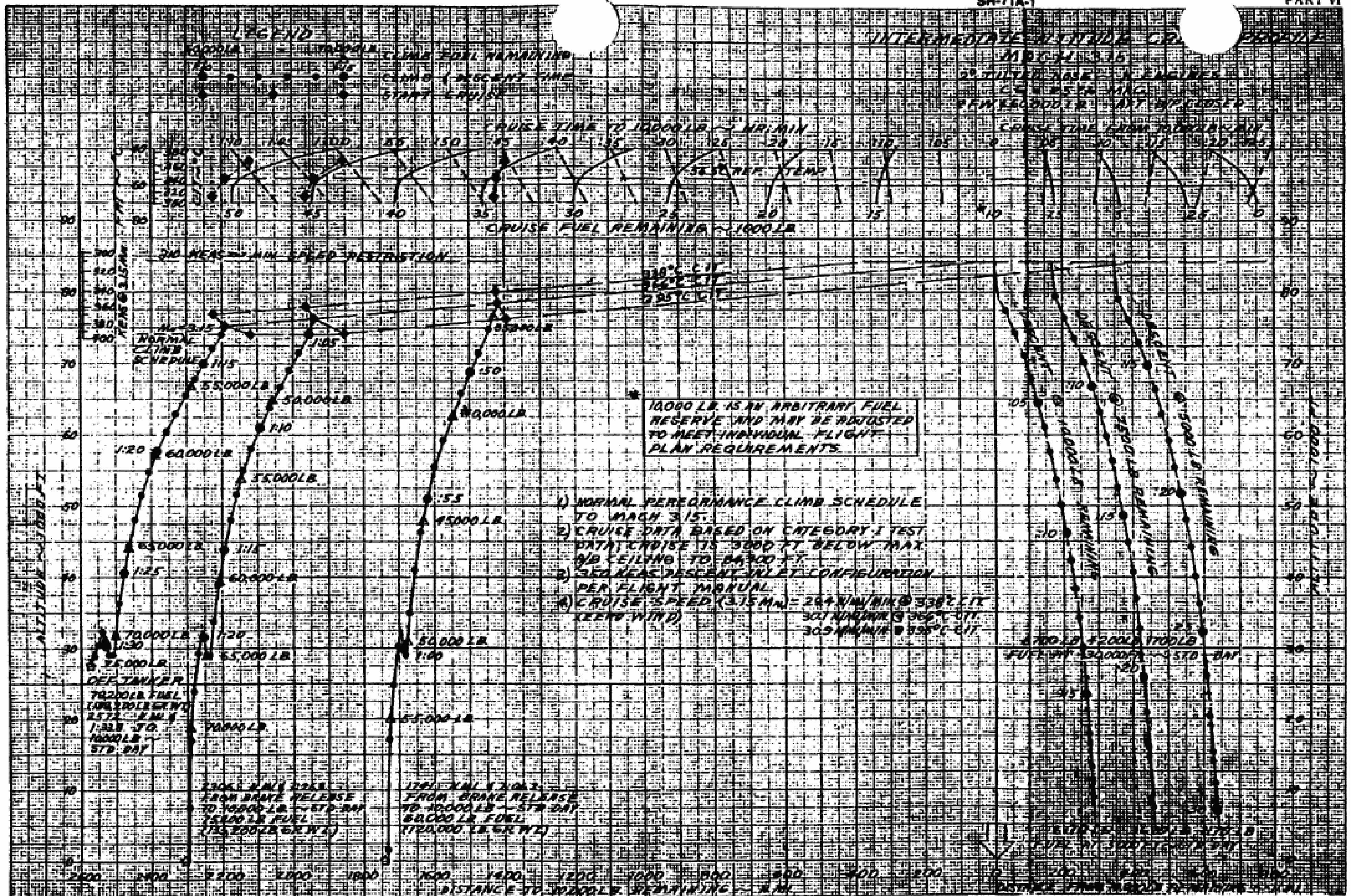


Figure A6-5 (Sheet 1 of 2)



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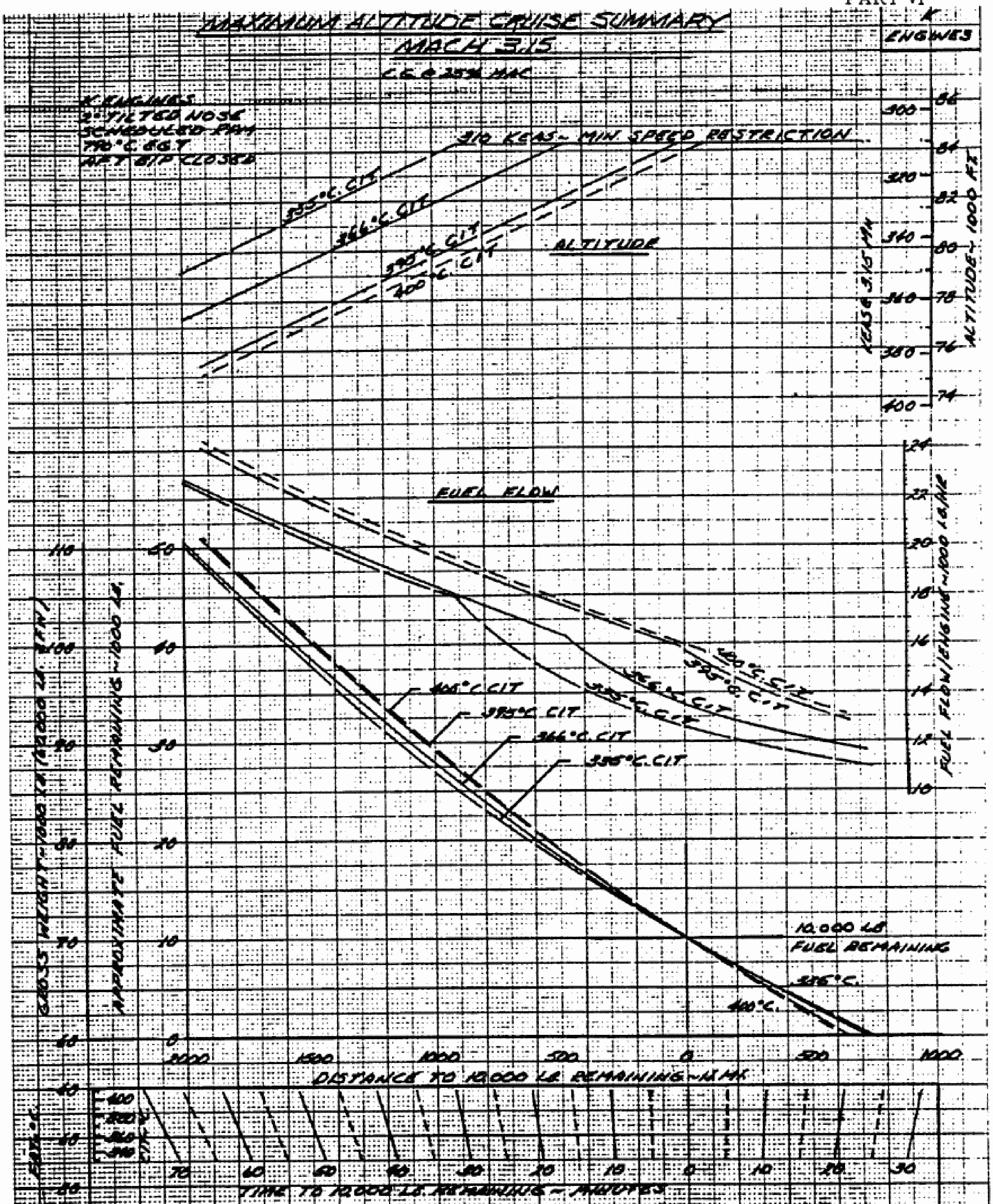

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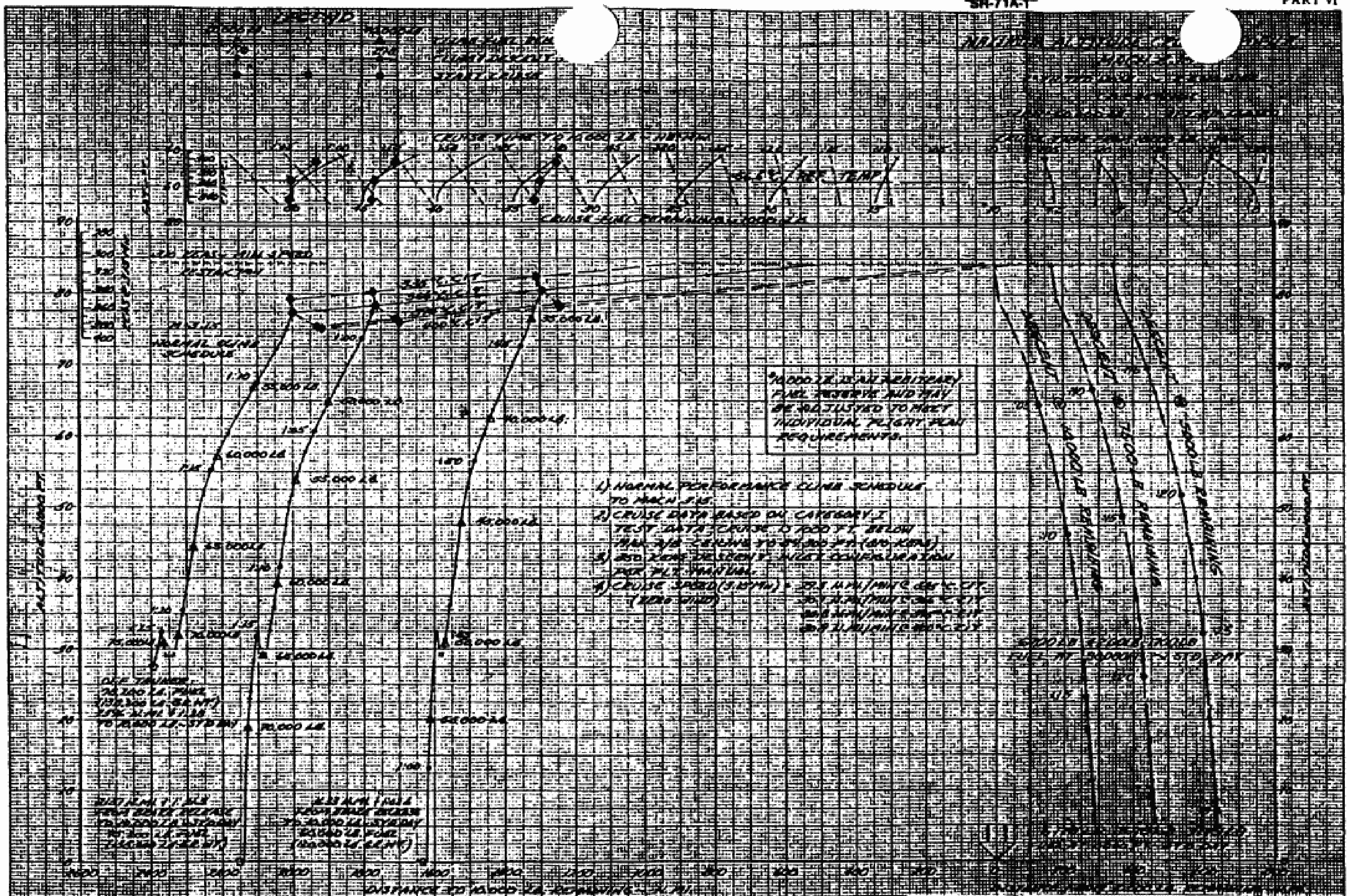

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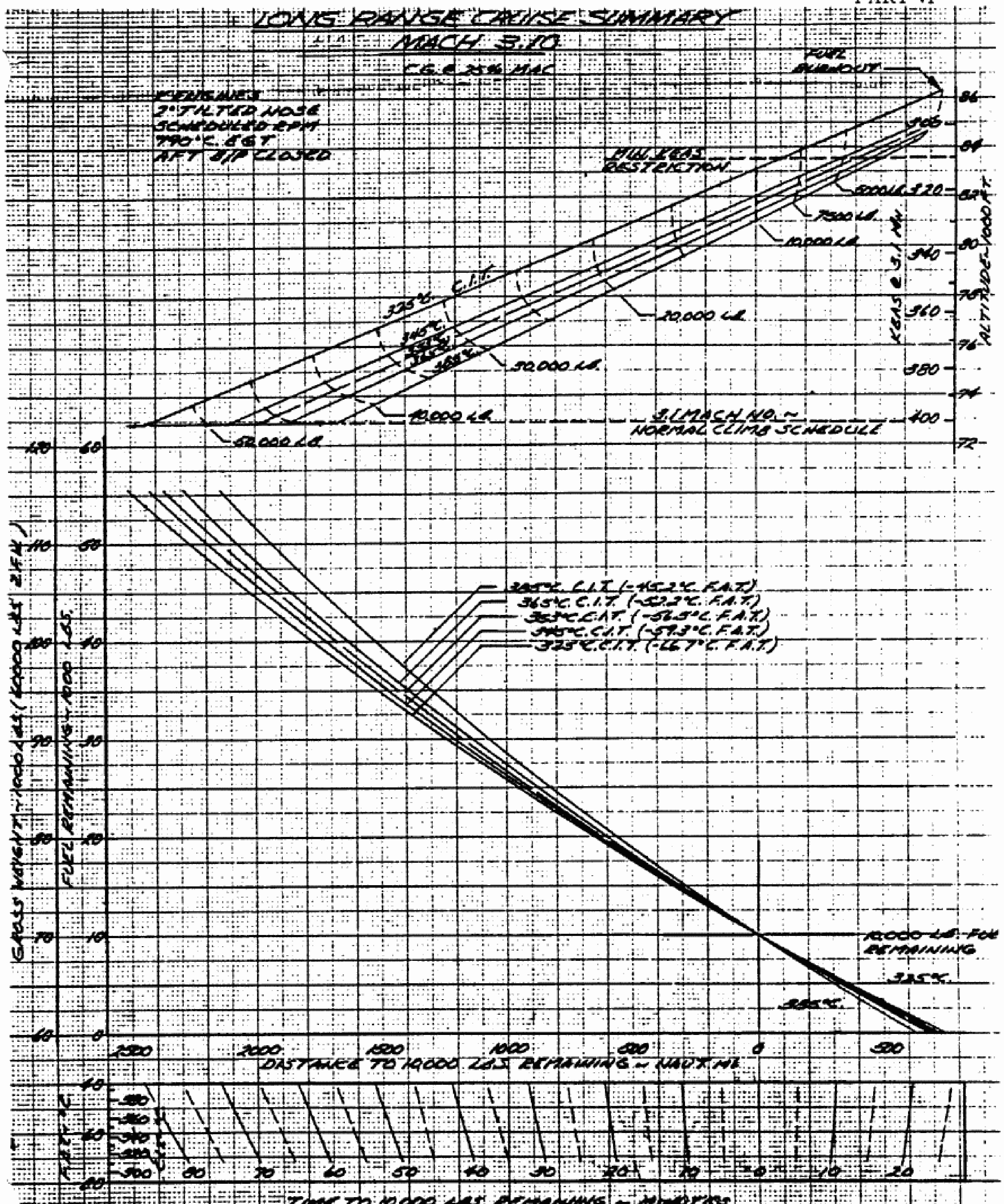

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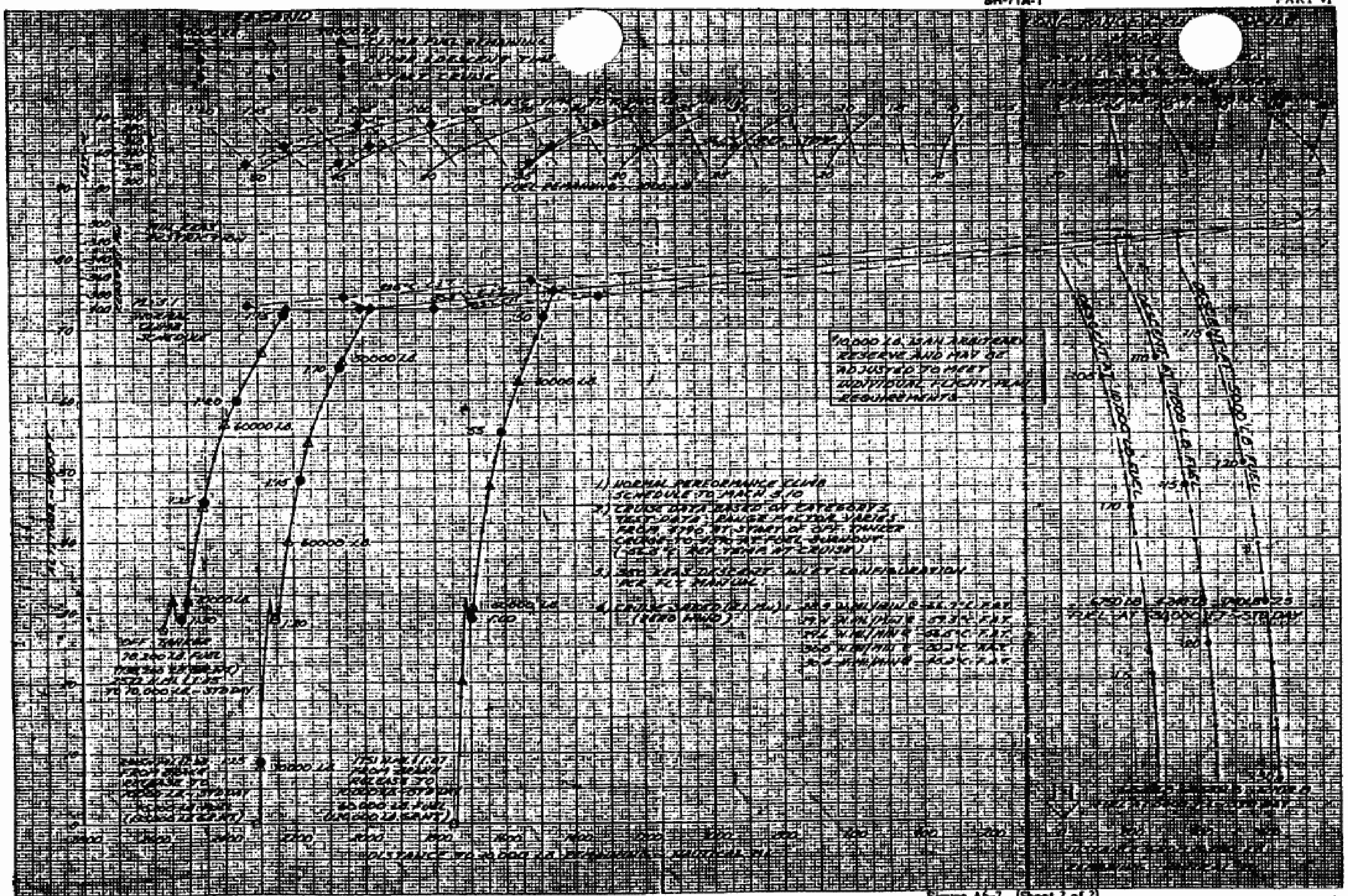

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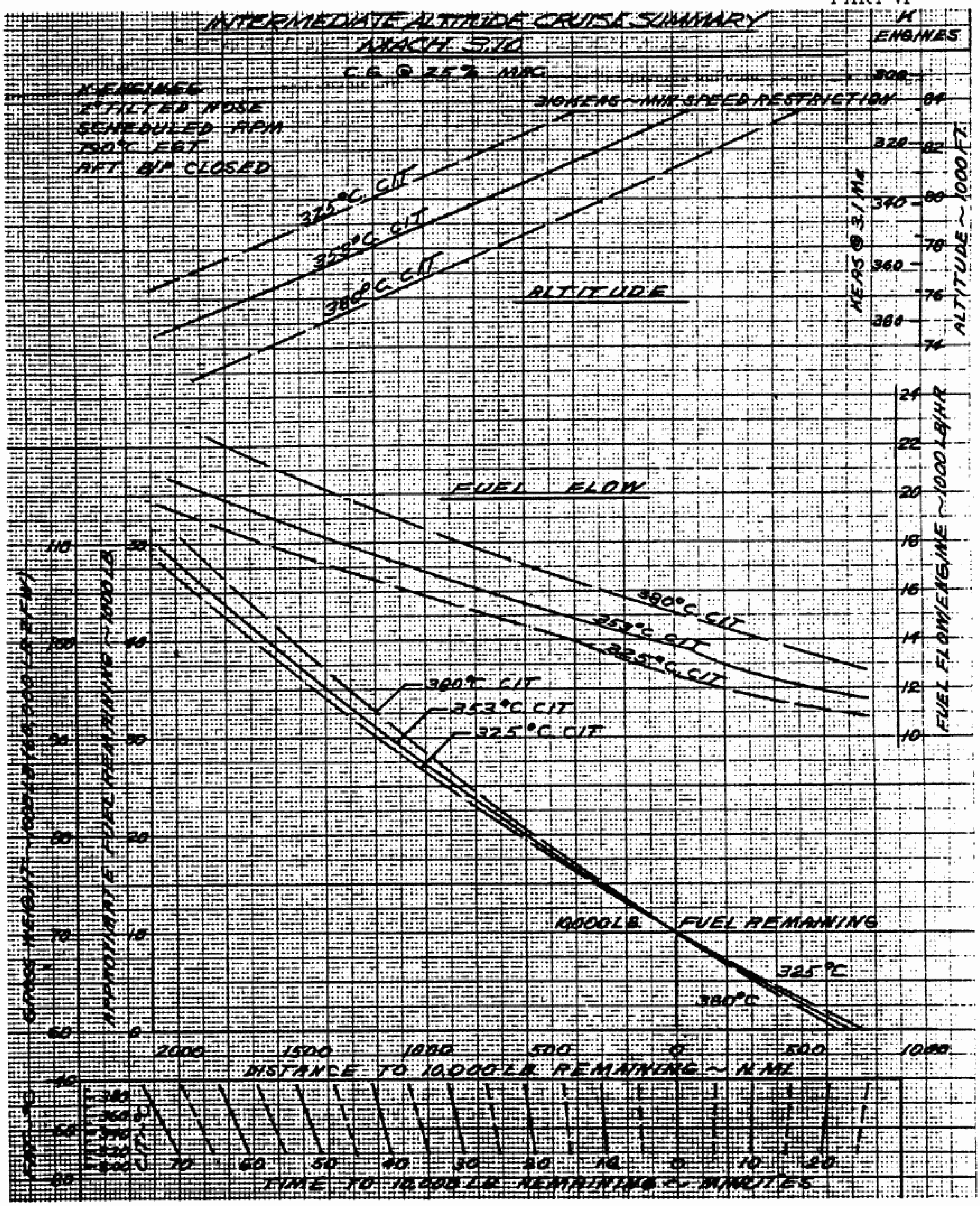

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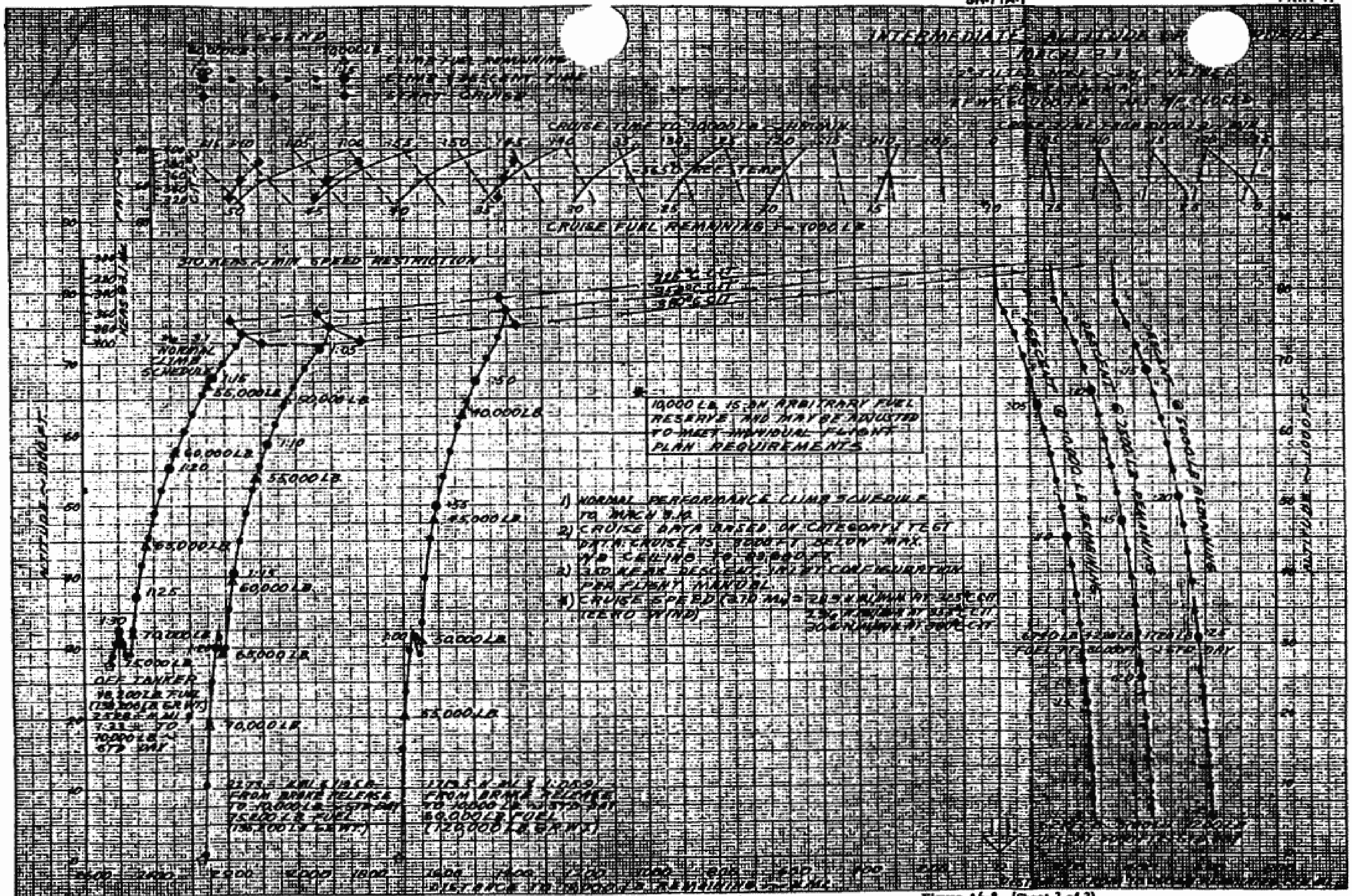

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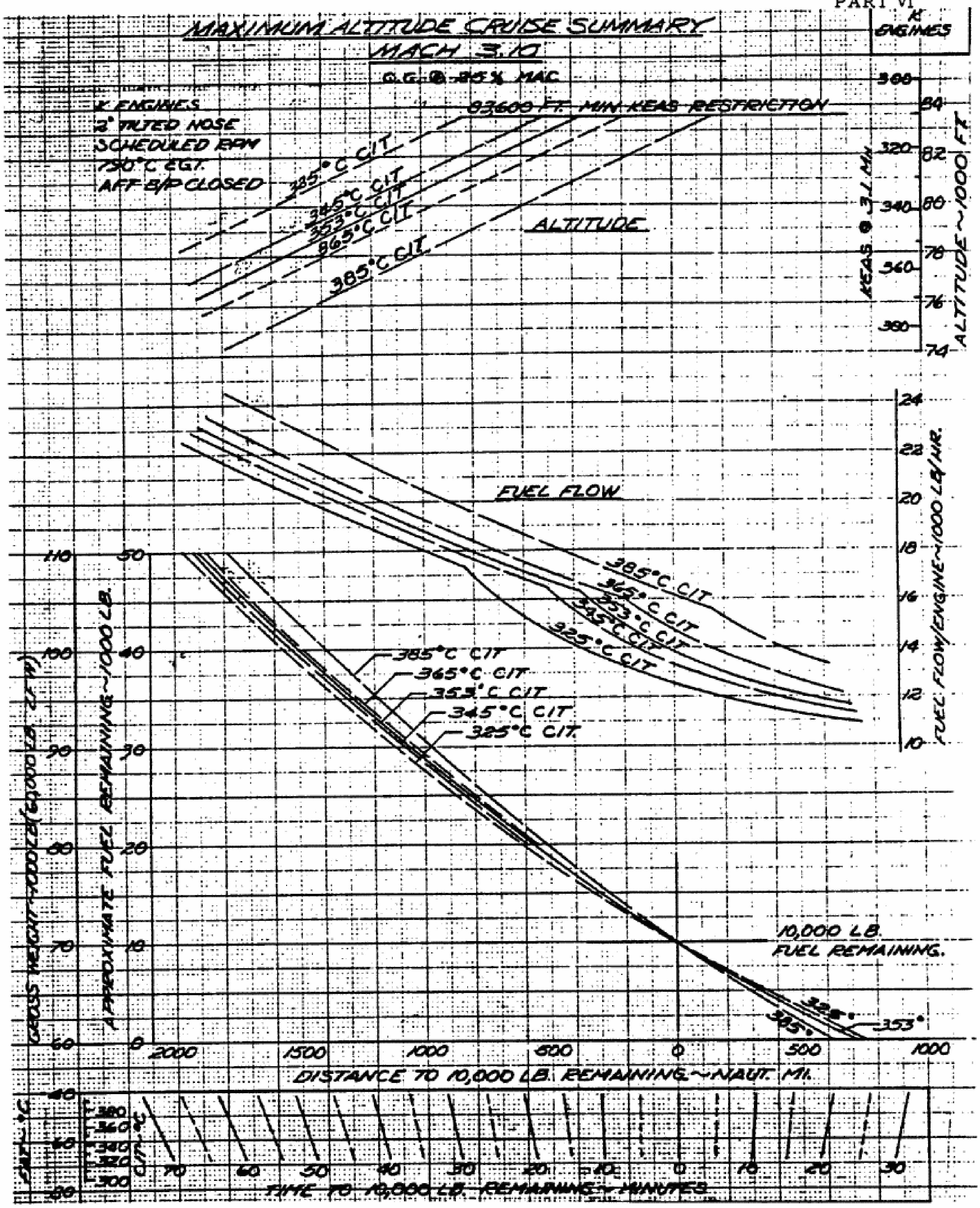

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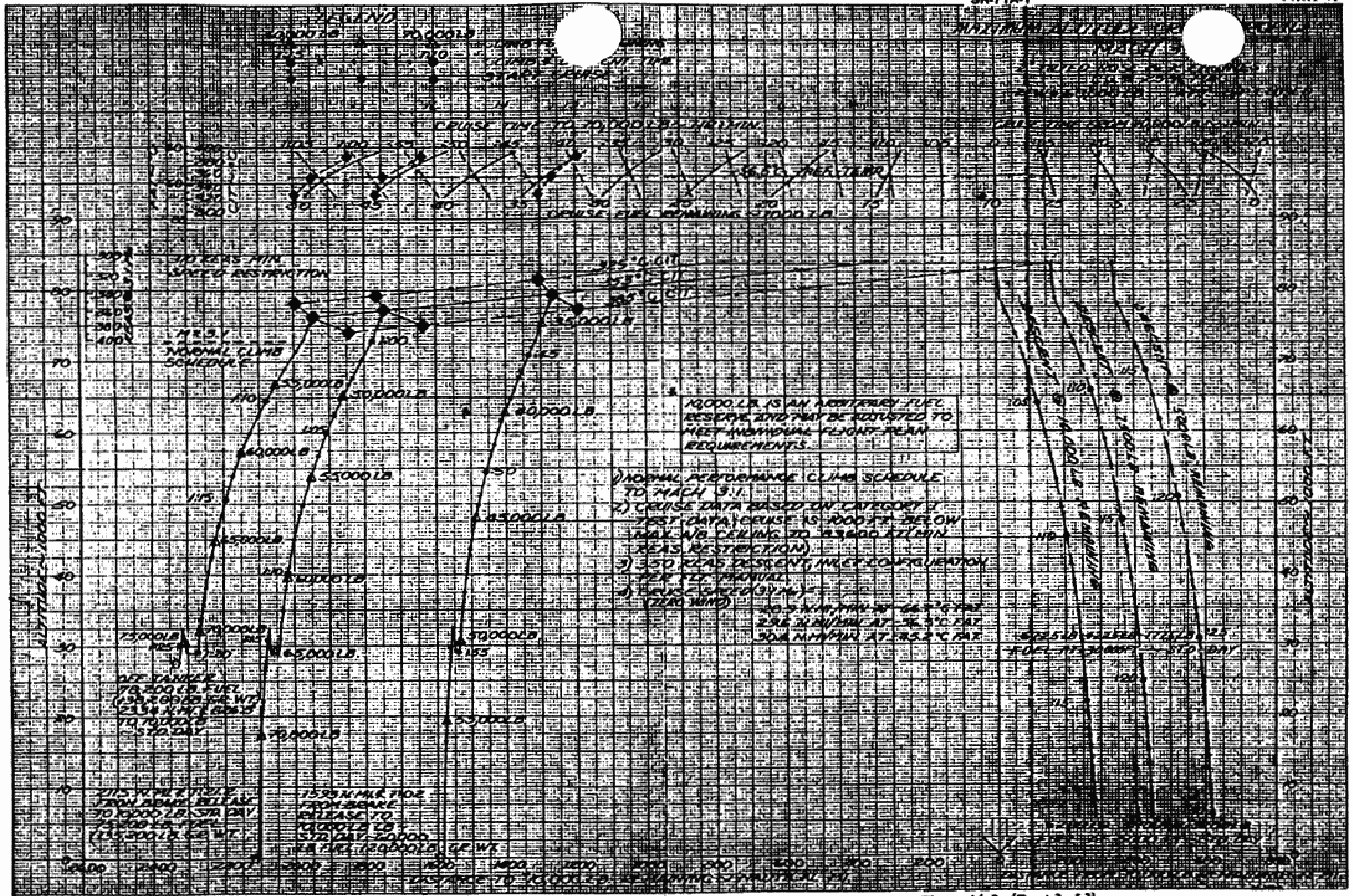

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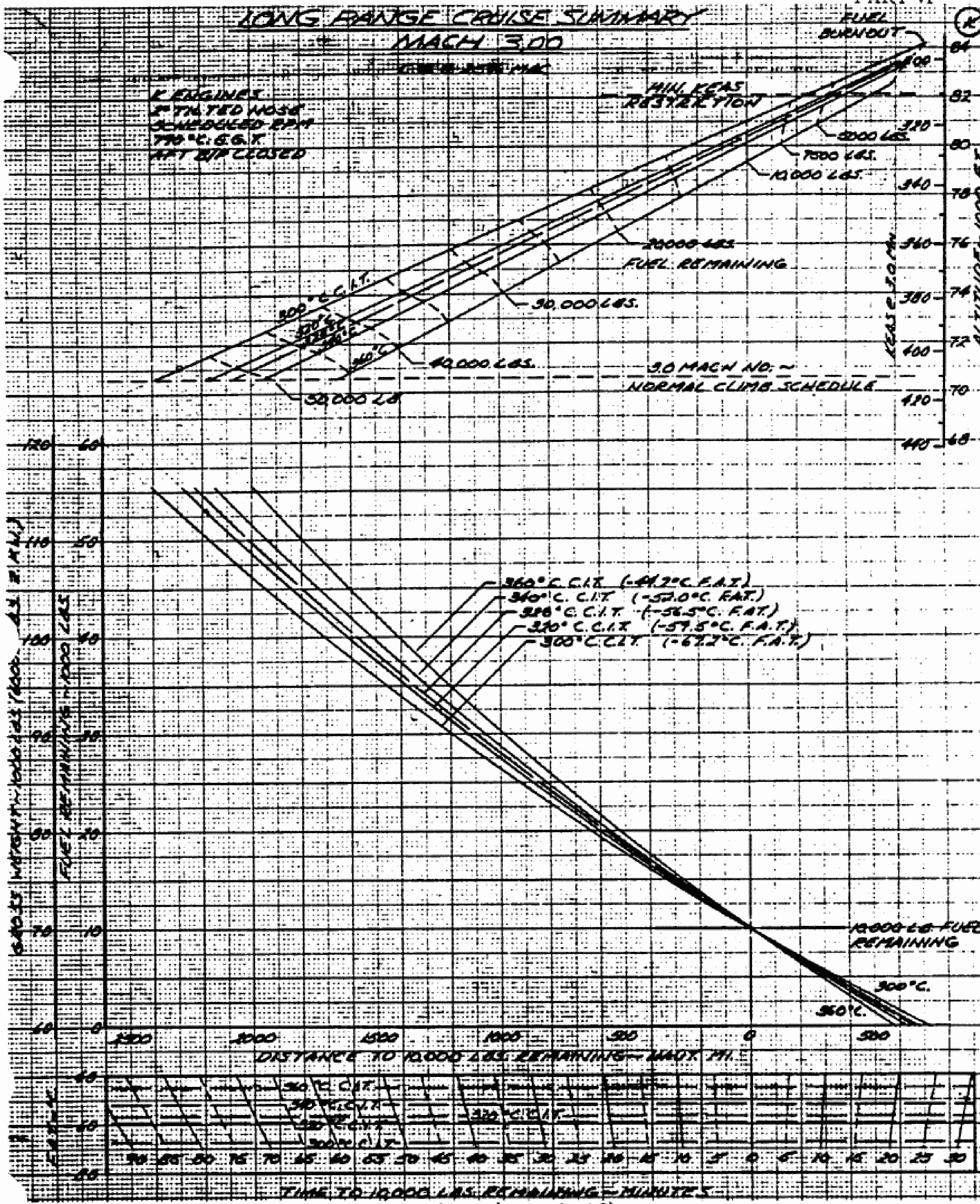

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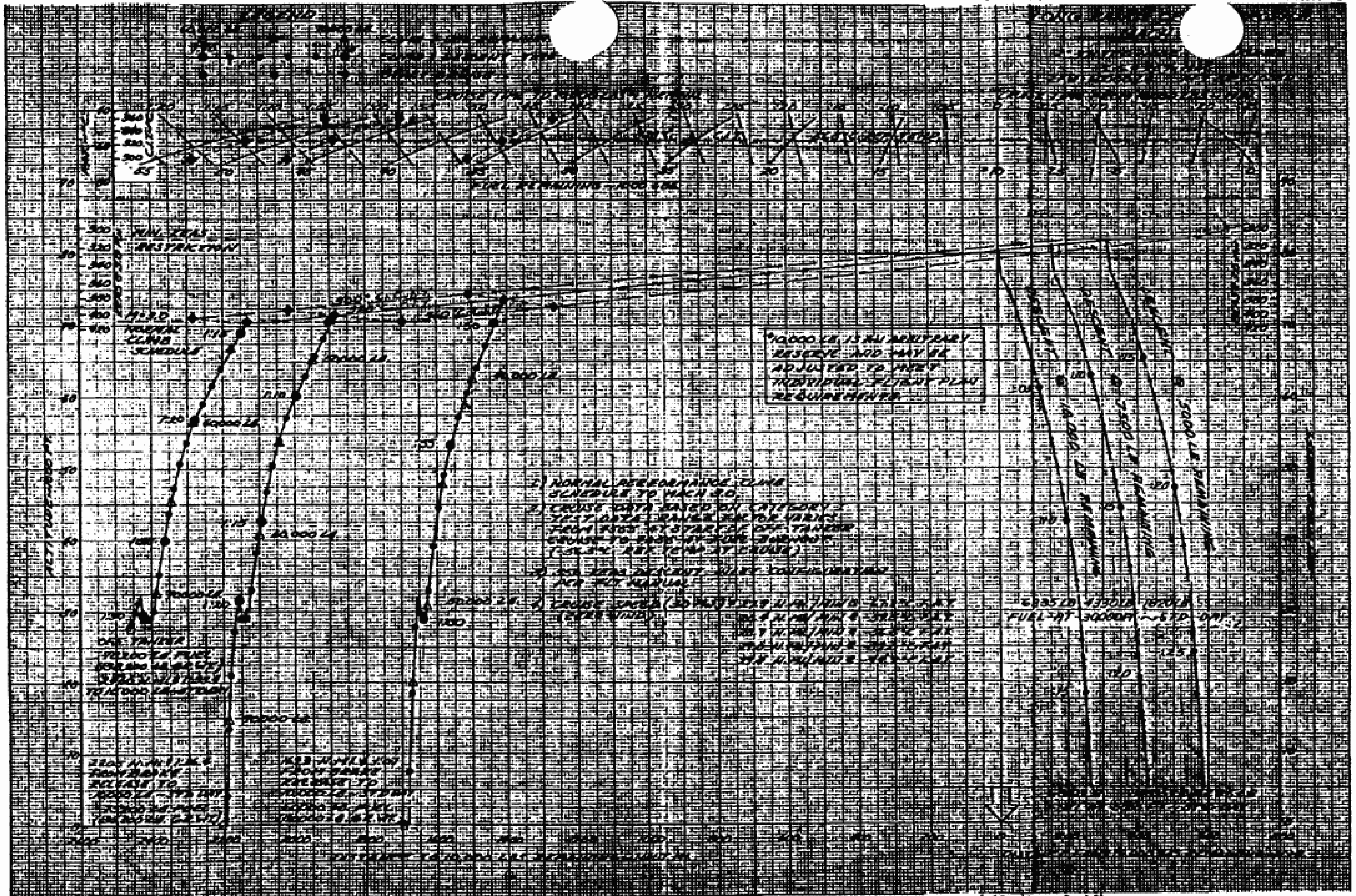

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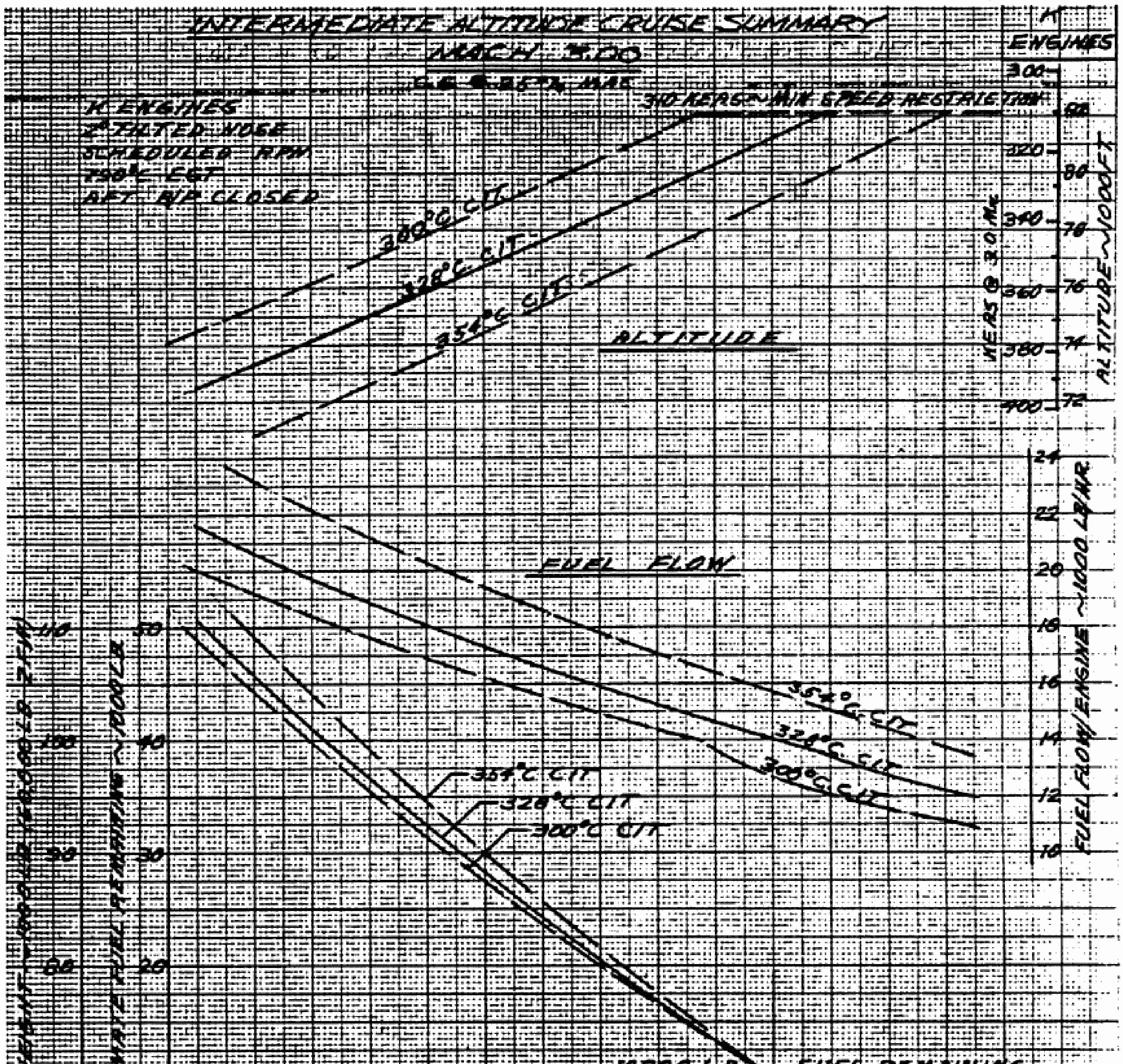

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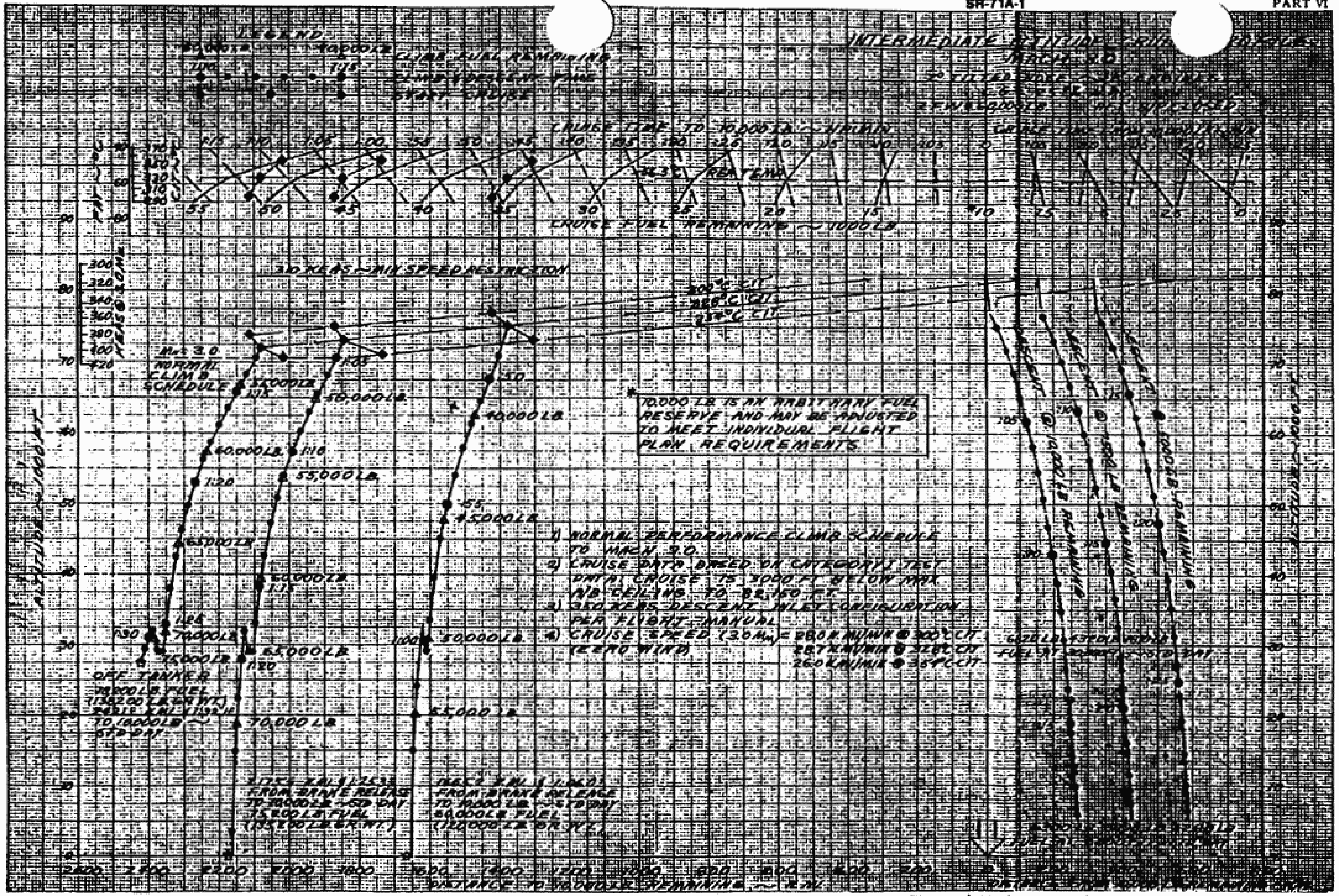

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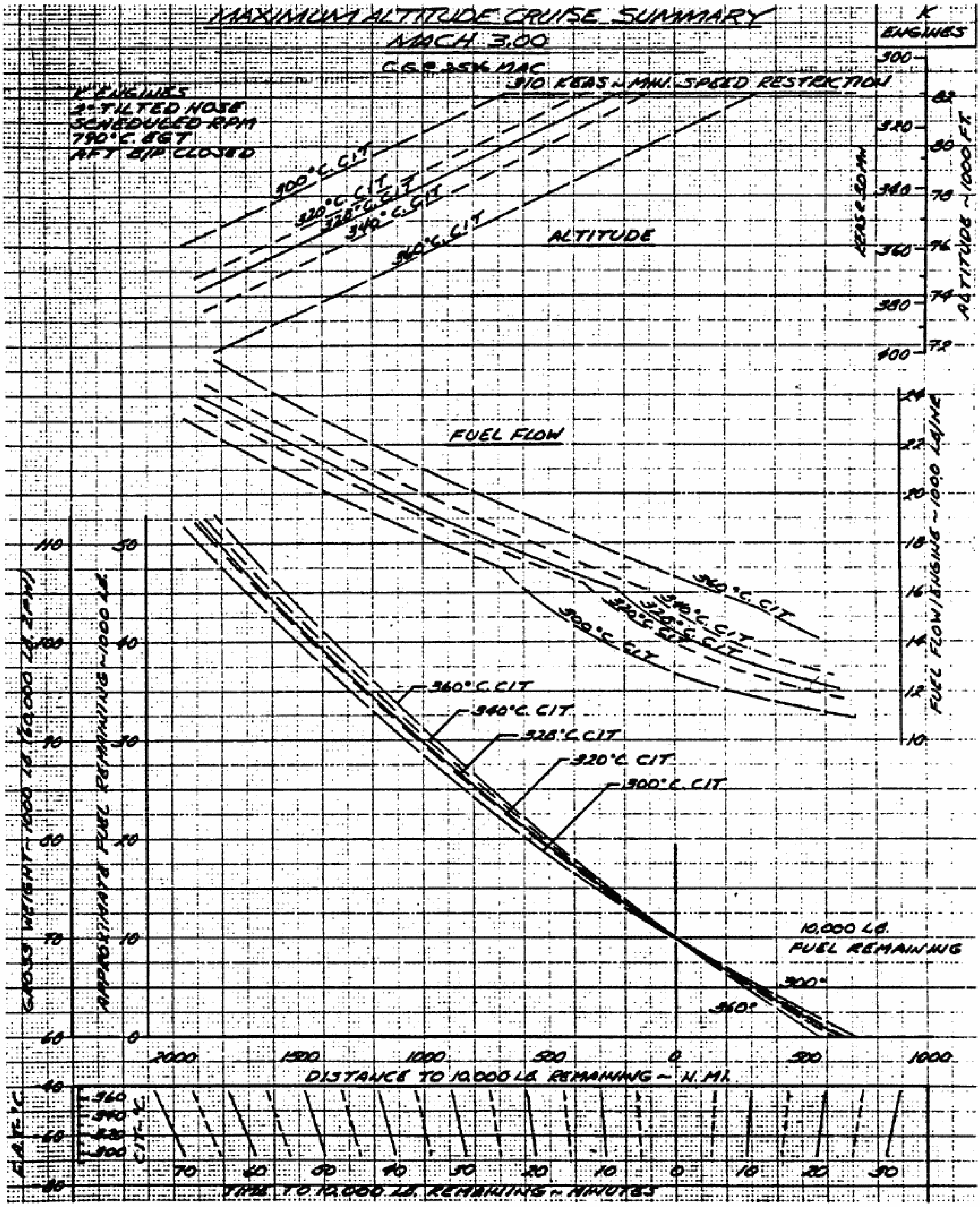

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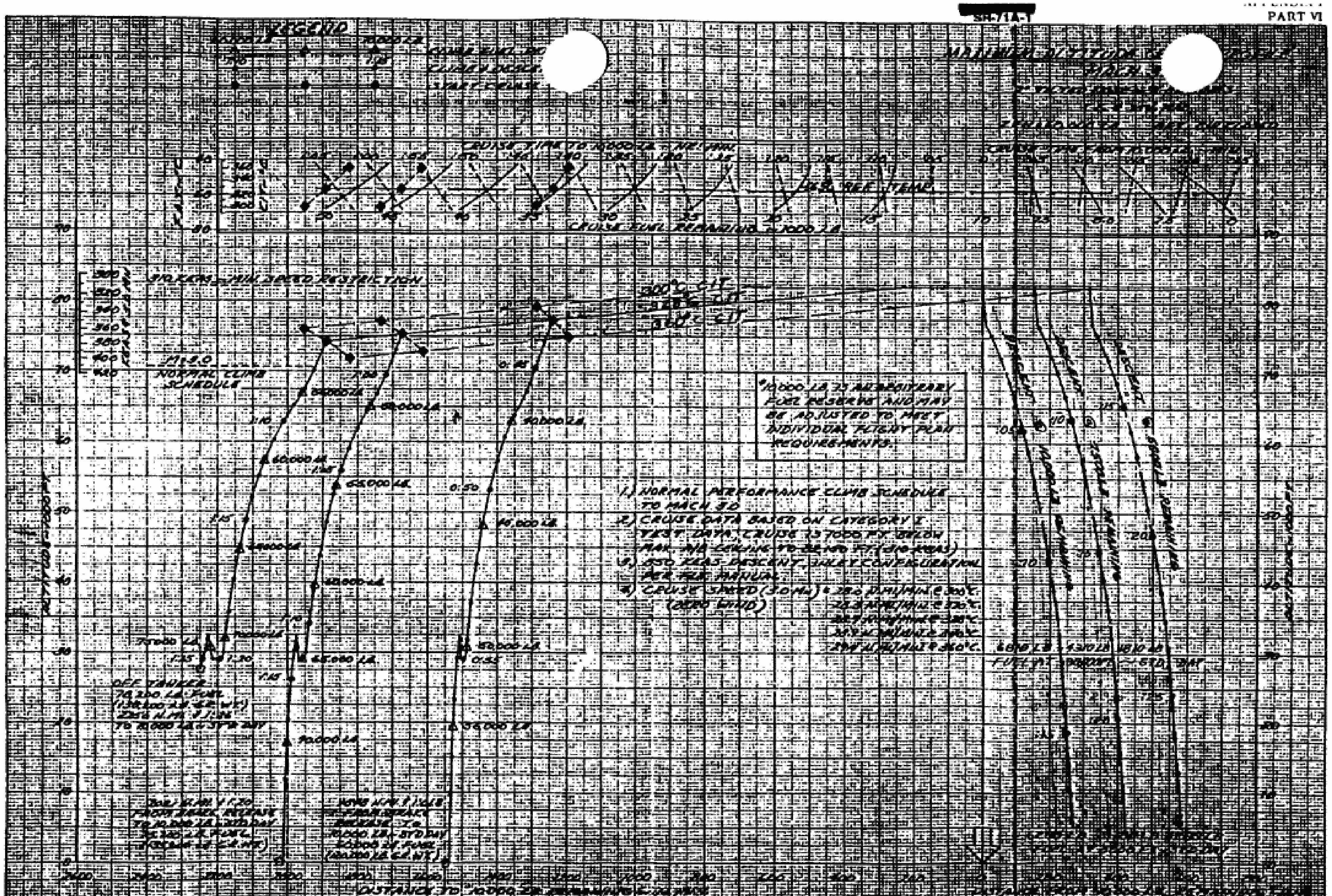

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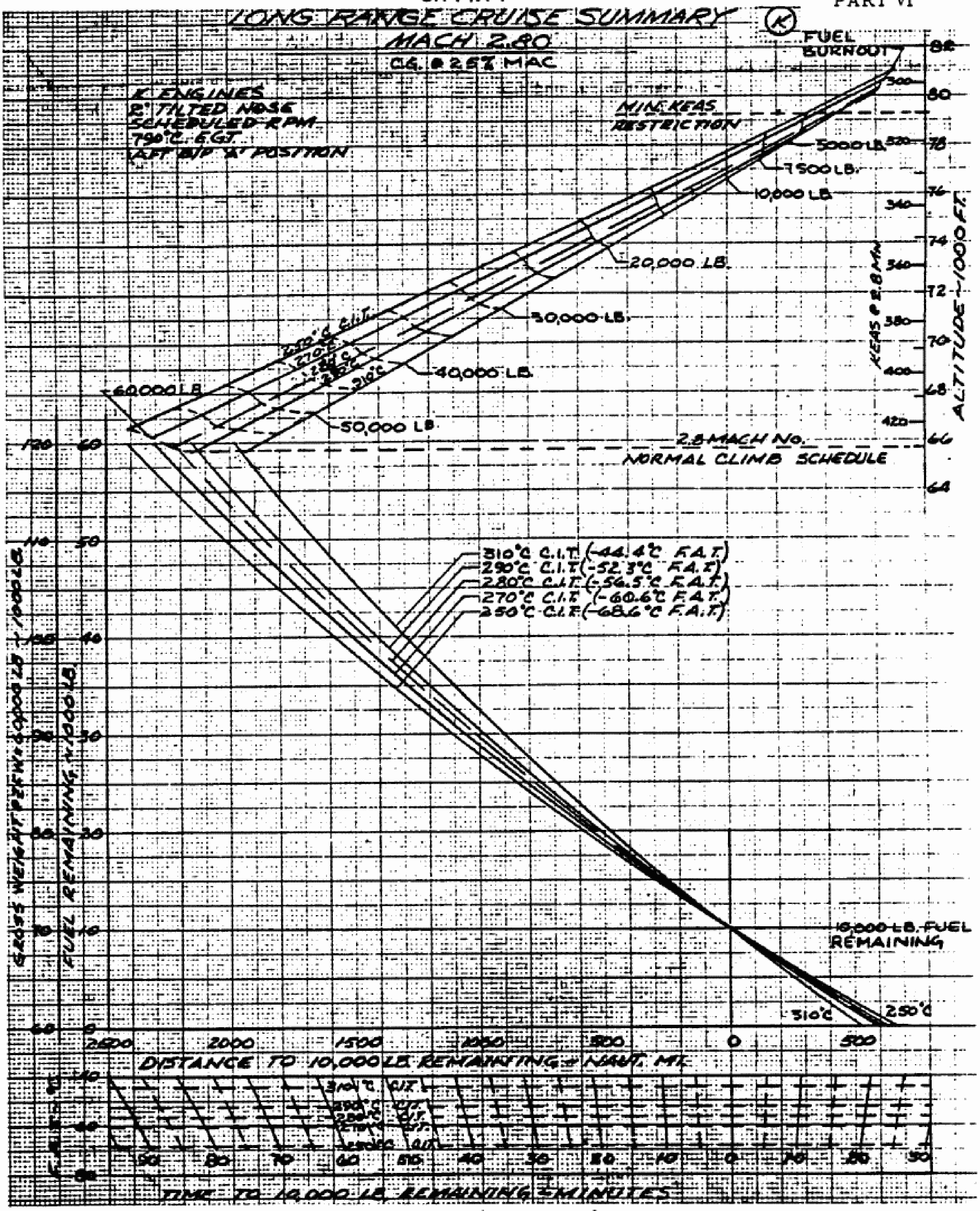

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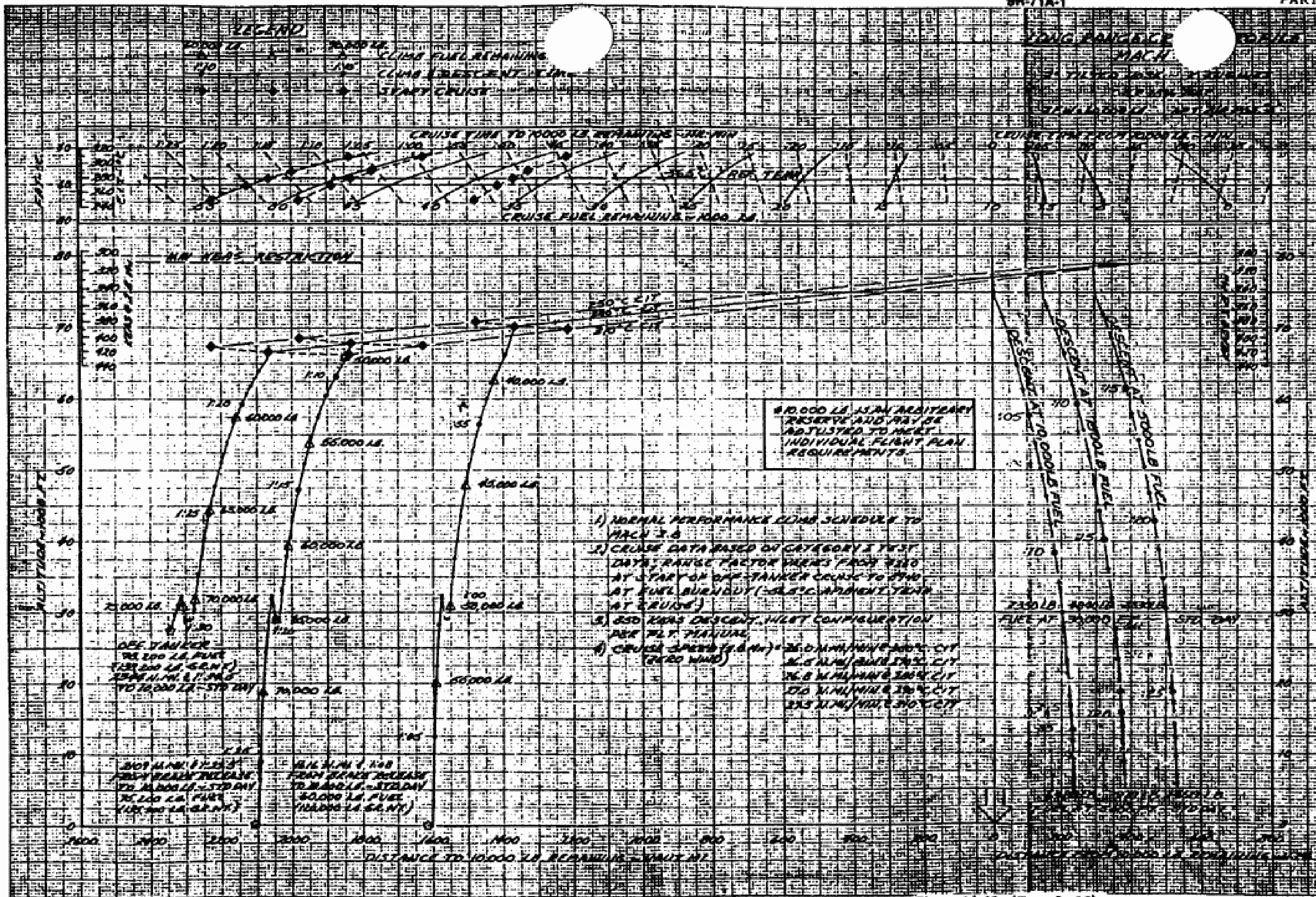

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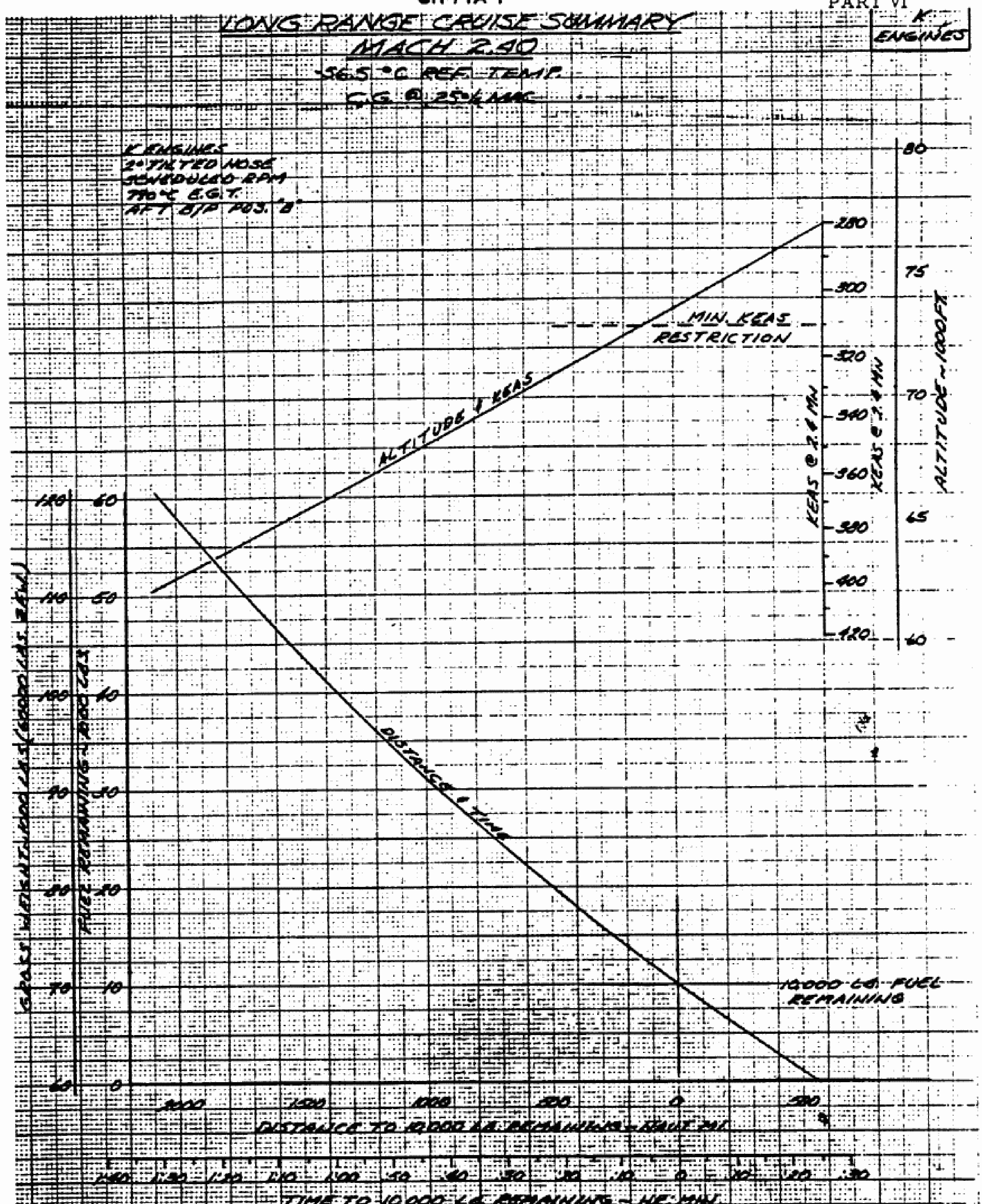

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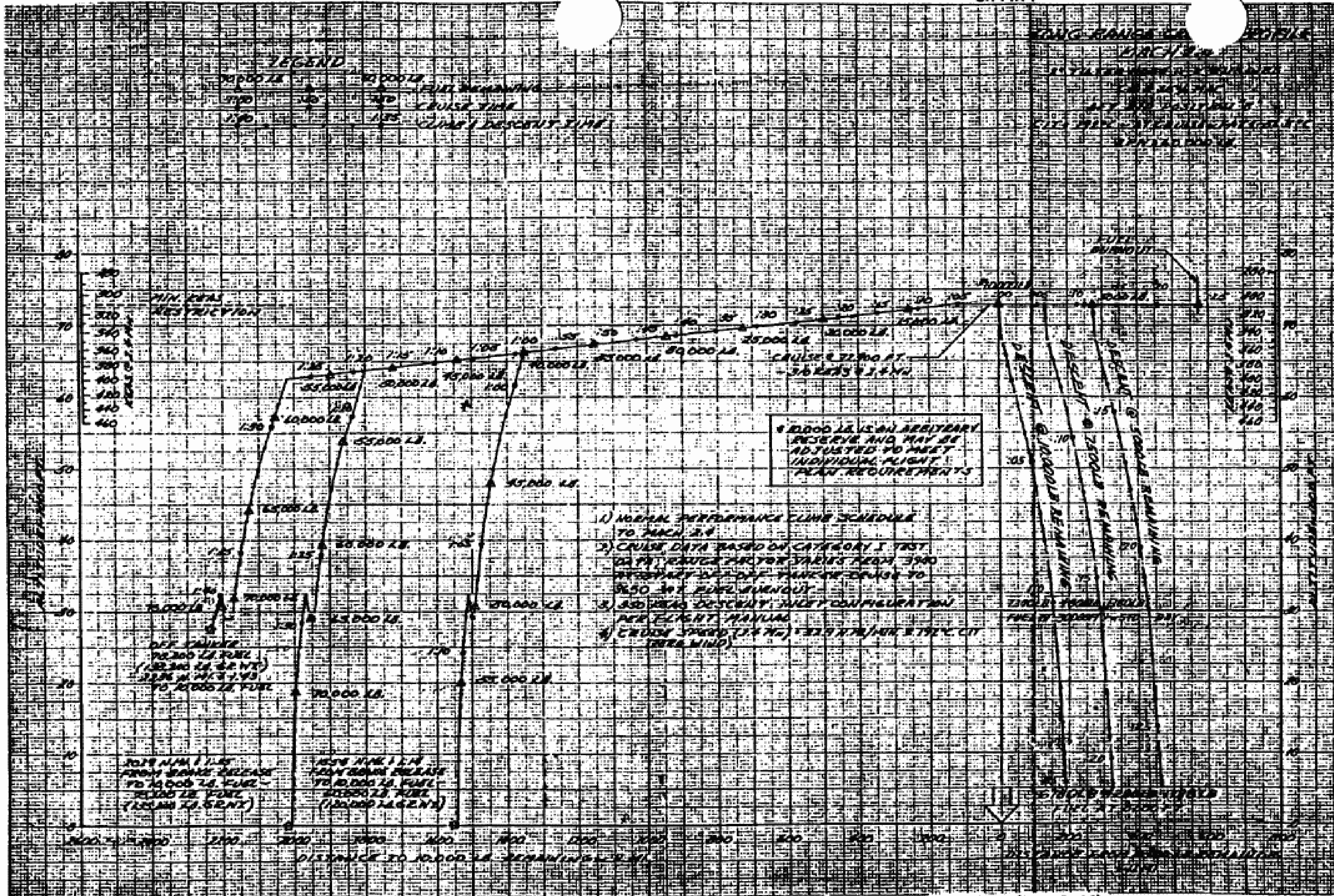

Figure A6-14 (Sheet 2 of 2)

TURNING PERFORMANCE

AT CONSTANT MACH, TEMPERATURE, AND BANK ANGLE

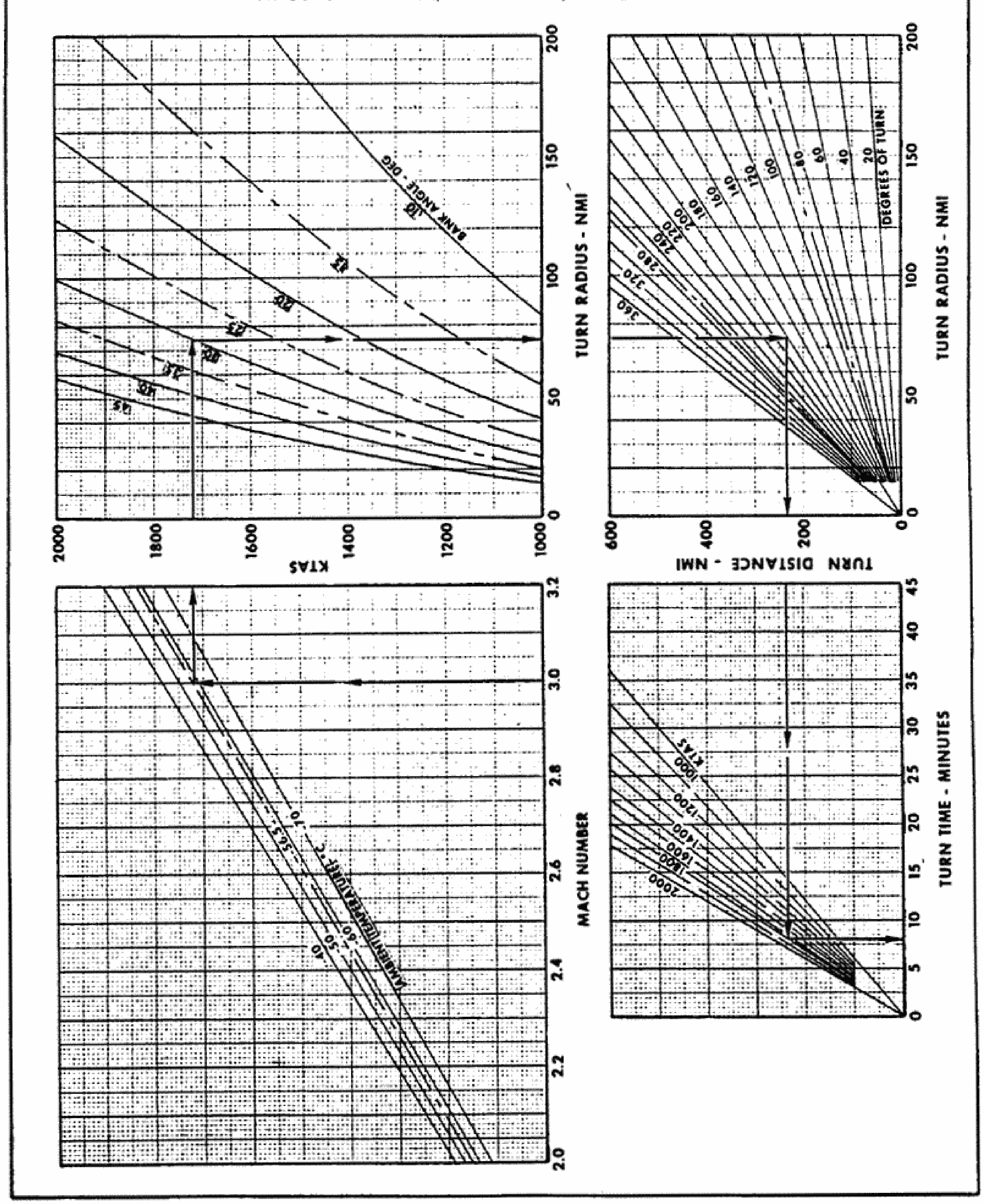

Figure A6-15

MAXIMUM A/B TURN CAPABILITY AT MACH 3.15

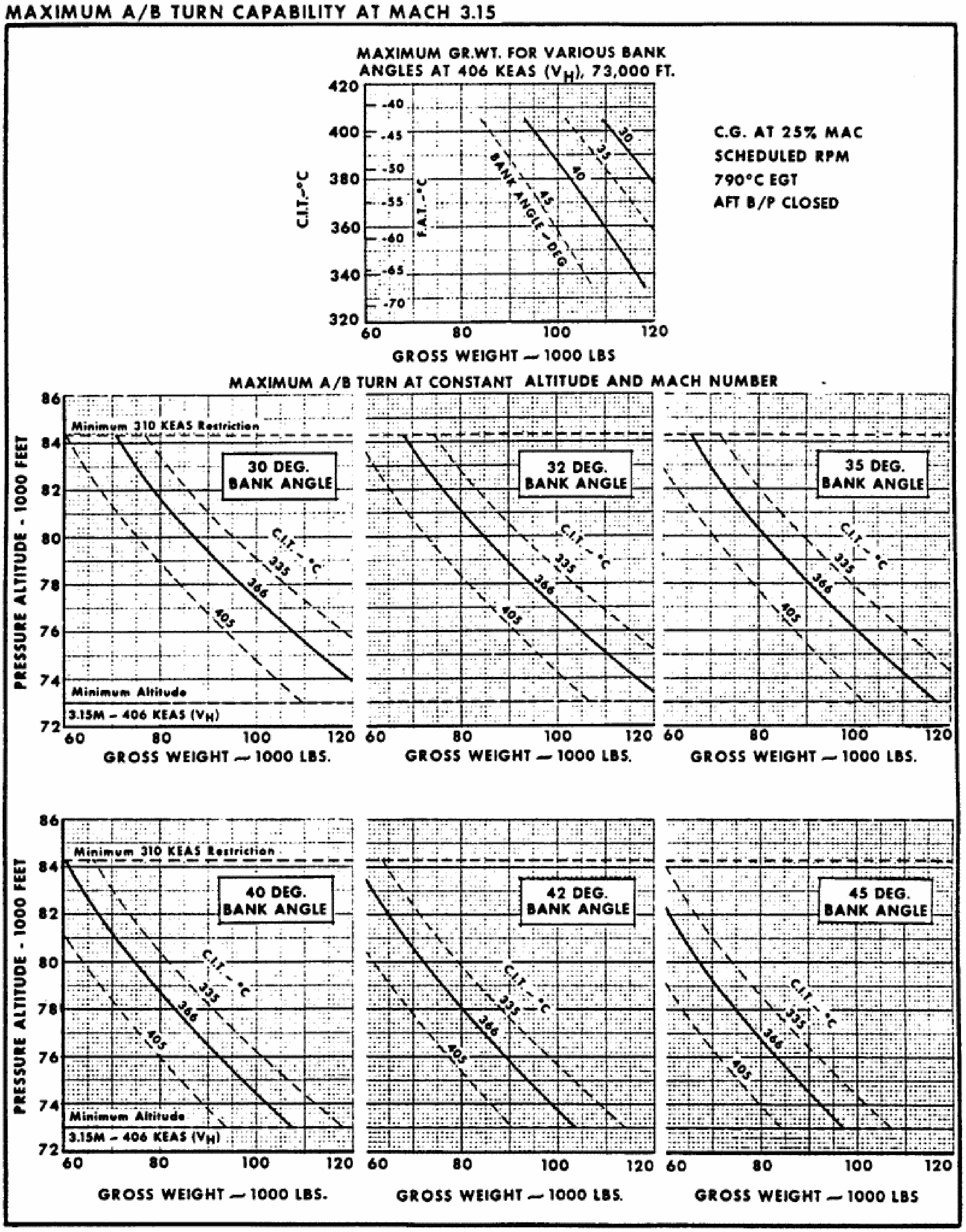

Figure A6-17

MAXIMUM A/B TURN CAPABILITY AT MACH 3.00

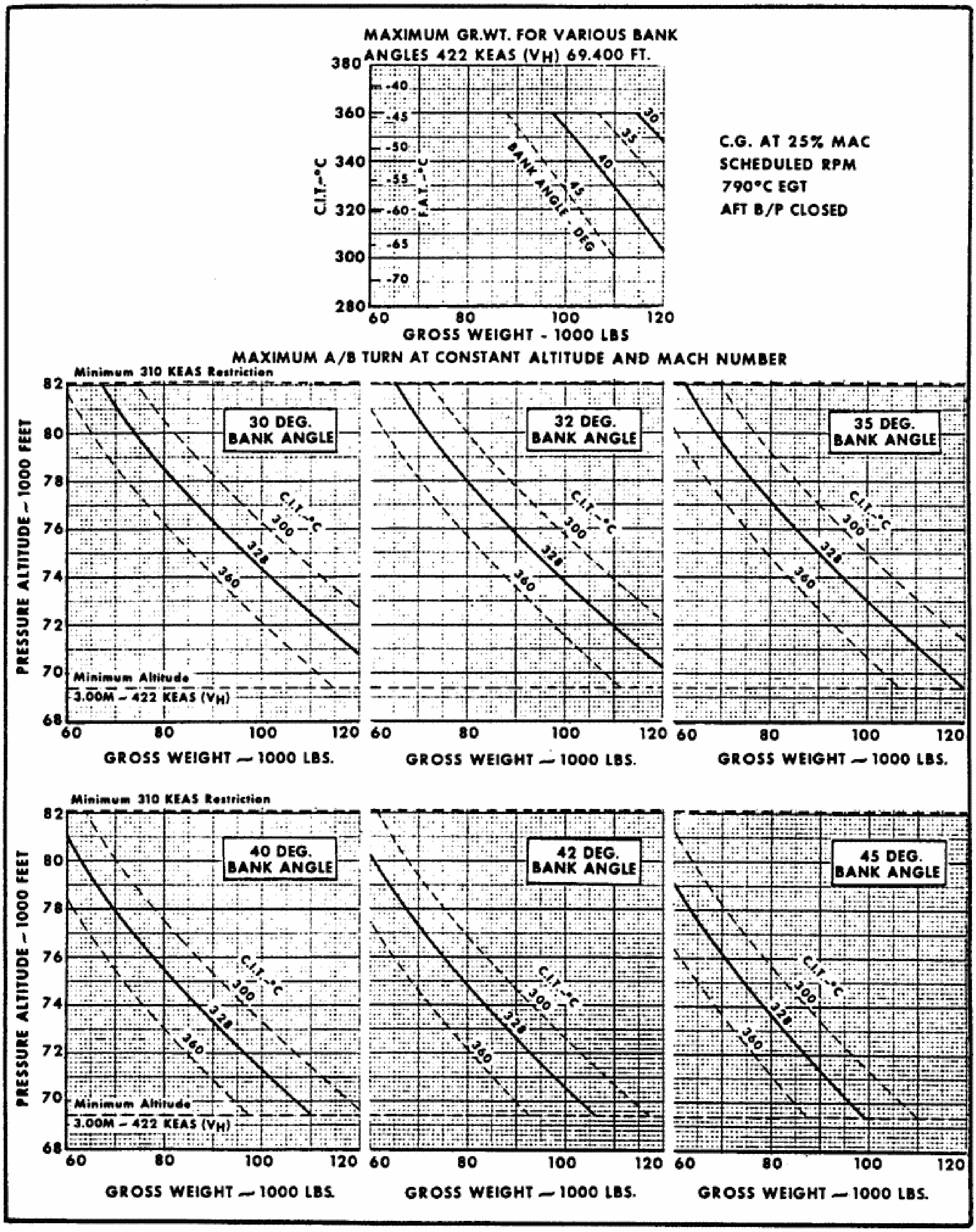

Figure A6-19

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