

# Operating Limitations

## SECTION V

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**INSTRUMENT MARKINGS.**

Careful attention must be given to the instrument markings (figure 5-1), because the limitations shown on these instruments and noted in the captions are not necessarily repeated in the text of this or any other section.

**ENGINE LIMITATIONS.**

All normal engine limitations are shown in figure 5-1 and are based on the use of oxidizer and fuel specified in figure 1-16.

**CAPTIVE FLIGHT LIMITATIONS.**

Control surfaces may be deflected only individually. Full throw of the vertical stabilizer or flaps is permissible up to 300 knots EAS. The horizontal stabilizer may be deflected full throw at 200 knots EAS, decreasing linearly to one-half throw at 300 knots EAS. To avoid possible buffet on both the X-15 and carrier airplane, the speed brakes should not be extended beyond 10 degrees.

**LAUNCH LIMITATIONS.**

Launch from the carrier airplane should be made under the following conditions:

- a. Mach .75 at 35,000 feet to Mach .82 at 45,000 feet.
- b. Carrier airplane in 1 G symmetrical flight.
- c. X-15 control surfaces as follows:  
Vertical stabilizer-ventral neutral.

Horizontal stabilizer neutral in roll and 0 degrees to -2 degrees (leading edge down) in pitch. The setting of -2 degrees should not be used until some familiarity with launch characteristics has been gained at the 0-degree setting.

- d. Launch should not be made with the ventral jettisoned or not installed, except when the scheduled mission specifically requires it.

**AIRSPPEED LIMITATIONS.**

**MAXIMUM ALLOWABLE AIRSPEEDS.**

The maximum allowable Mach number for varying flight altitudes is shown in figure 5-2. The maximum q (dynamic pressure) is 2200 psf with modified movable vertical stabilizer (Part No. 240-23001-201) and ventral (Part No. 240-23501-101 or 240-23502-201).



Because of the exploratory nature of the X-15 research program, limitations for all flights beyond 3.5 Mach number will be based on separate mission analysis.

**LANDING GEAR AND WING FLAP LOWERING SPEED.**

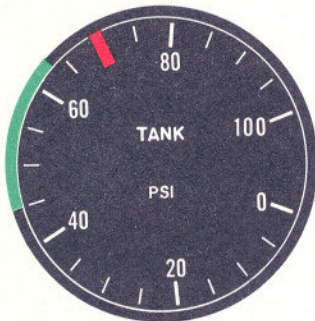
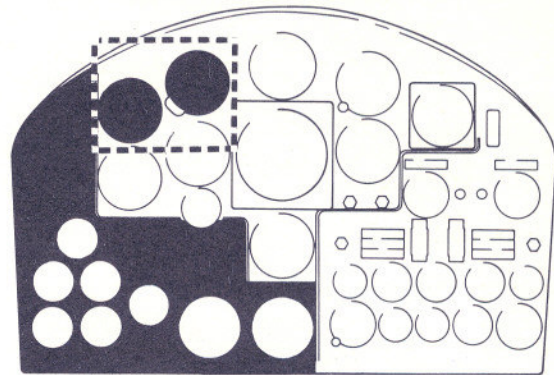
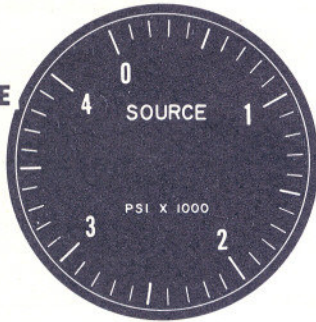
Maximum allowable airspeed for extending the landing gear and wing flaps, or for flight with the landing gear\* and wing flaps fully extended, is 300 knots IAS. Flight with the landing gear and flaps extended at speeds above 300 knots IAS may cause structural damage.

# INSTRUMENT MARKINGS

## ENGINE INSTRUMENTS, AIRSPEED INDICATOR, AND ACCELEROMETER

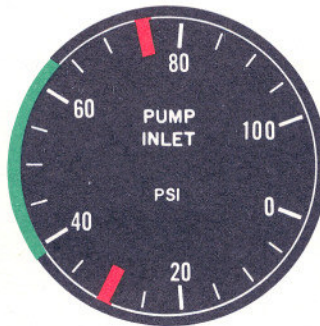
### PROPELLANT SOURCE PRESSURE GAGE

NO MARKINGS



### PROPELLANT TANK PRESSURE GAGE

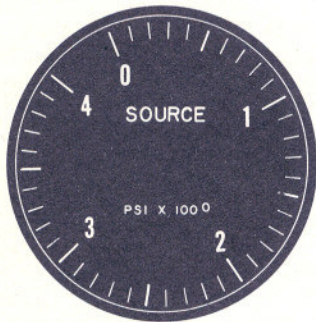
45-63 psi Normal  
70 psi Maximum



### PROPELLANT PUMP INLET PRESSURE GAGE

30 psi Minimum  
Ammonia pressure below 30 psi will require engine operation at reduced thrust. [Refer to "Fuel Line Pressure Low (XLR99 Engine)" in Section III.]

39-63 psi Normal  
75 psi Maximum



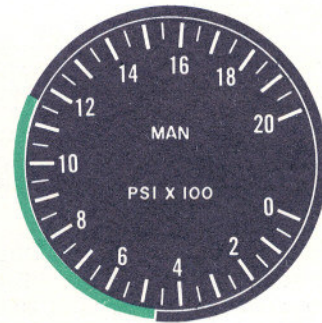
### H<sub>2</sub>O<sub>2</sub> SOURCE AND PURGE PRESSURE GAGE

NO MARKINGS



### H<sub>2</sub>O<sub>2</sub> TANK AND ENGINE CONTROL LINE PRESSURE GAGE

445-psi Minimum  
550-615 psi Normal  
775 psi Maximum

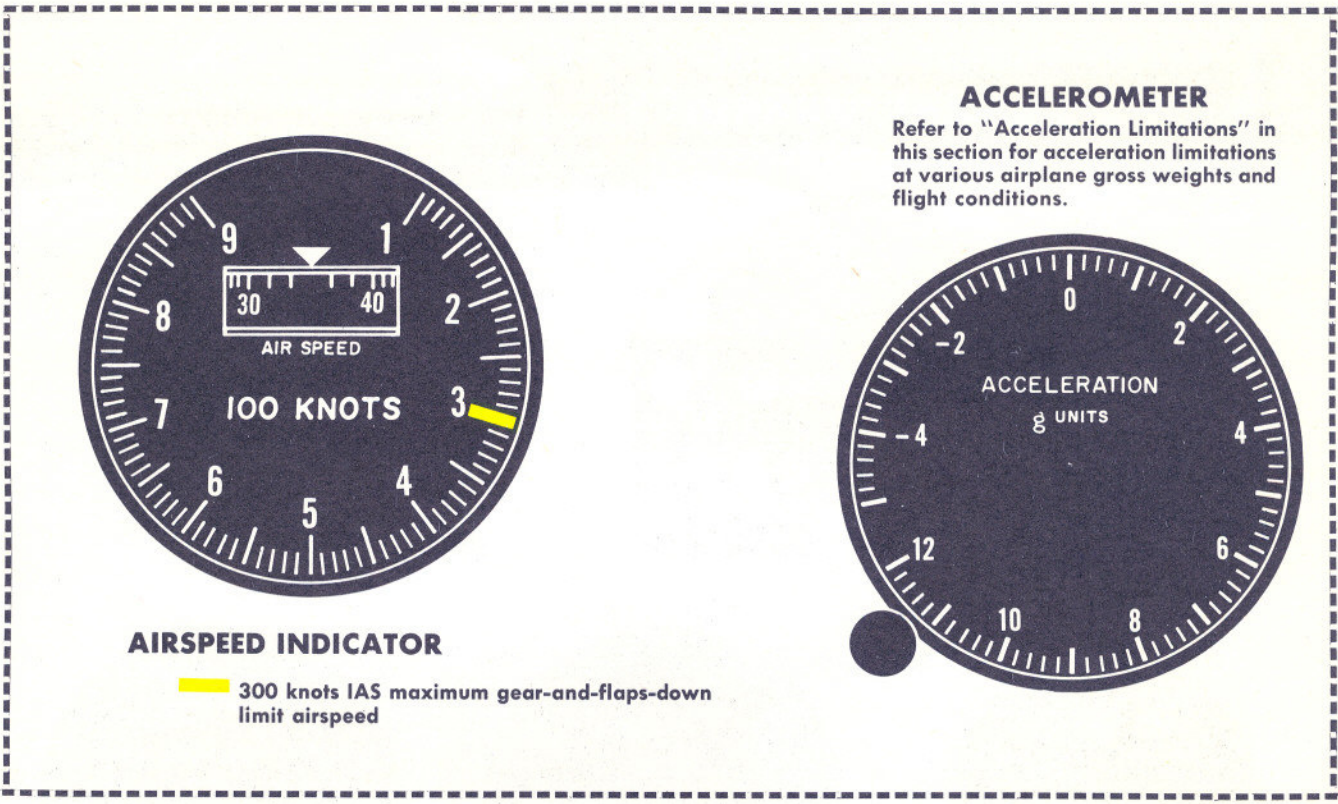


### PROPELLANT MANIFOLD PRESSURE GAGE

455-1155 psi Normal

X-15-1-51-7C

Figure 5-1. (Sheet 1 of 4)



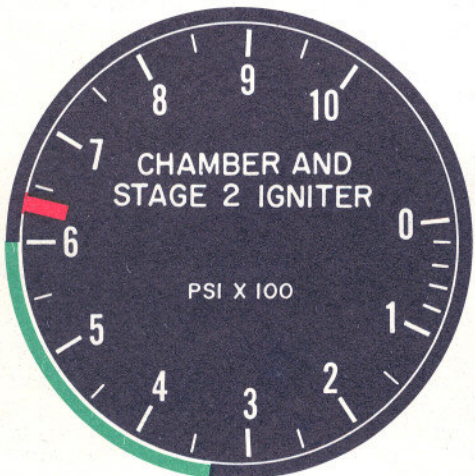
**AIRSPED INDICATOR**

300 knots IAS maximum gear-and-flaps-down limit airspeed

**LIQUID OXYGEN BEARING TEMPERATURE GAGE**

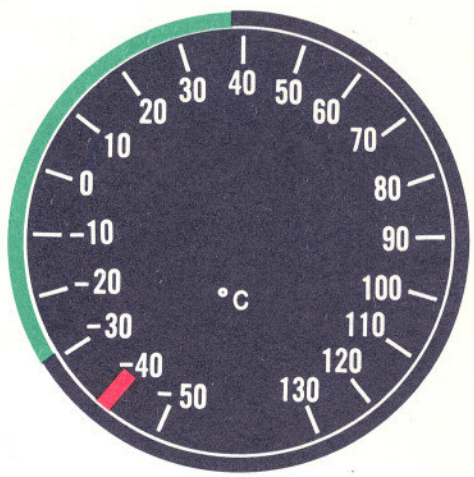
**Red** -40°C Minimum If bearing temperature is below this value, launch must be aborted.

**Green** -29°C to 38°C Normal



**CHAMBER AND STAGE 2 IGNITER PRESSURE GAGE**  
MAIN CHAMBER (LONG POINTER)

**Green** 335-600psi Normal  
**Red** 630 psi Maximum

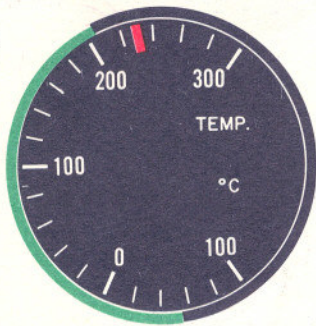
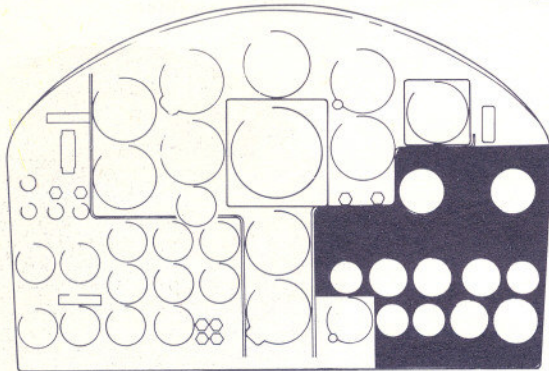


X-15-1-51-8C

Figure 5-1. (Sheet 2 of 4)

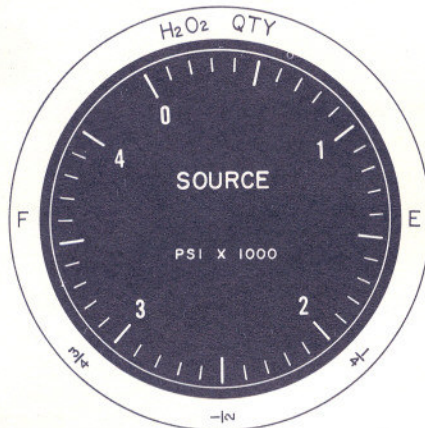
# INSTRUMENT MARKINGS

## ELECTRICAL, HYDRAULIC, AND COCKPIT INSTRUMENTS



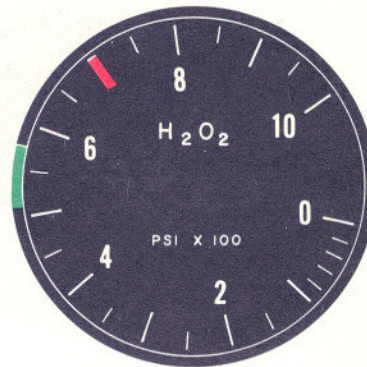
**HYDRAULIC SYSTEM  
NO. 1 TEMPERATURE  
GAGE**

—54°C TO +204°C  
NORMAL  
— 230°C MAXIMUM



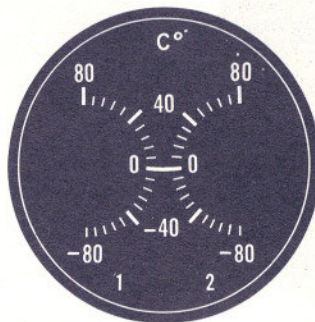
**APU SOURCE  
PRESSURE  
GAGE**

NO MARKINGS



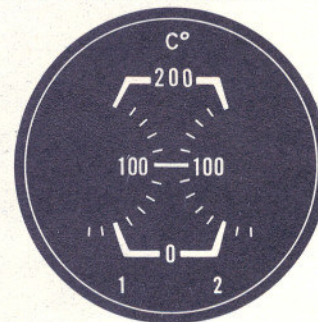
**APU HYDROGEN  
PEROXIDE TANK  
PRESSURE  
GAGE**

— 510-575 PSI NORMAL  
— 700 PSI MAXIMUM



**MIXING CHAMBER  
TEMPERATURE  
GAGE**

NO MARKINGS

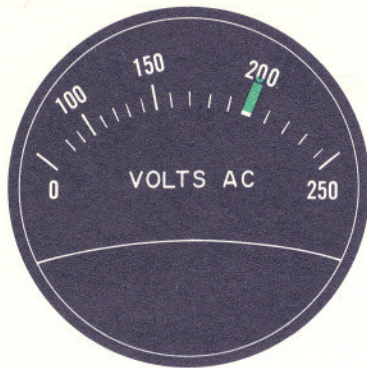


**APU BEARING  
TEMPERATURE  
GAGE**

NO MARKINGS

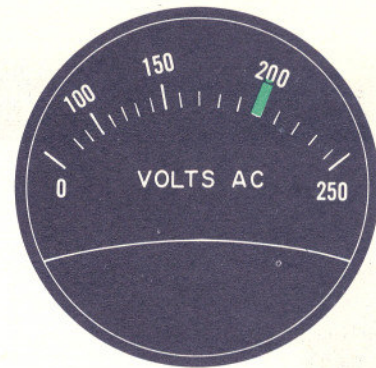
X-15-1-51-3C

Figure 5-1. (Sheet 3 of 4)



**NO. 1 GENERATOR  
VOLTMETER**

200 VOLTS NORMAL



**NO. 2 GENERATOR  
VOLTMETER**

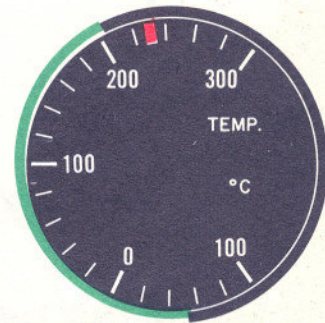
200 VOLTS NORMAL



**HYDRAULIC  
PRESSURE  
GAGE**

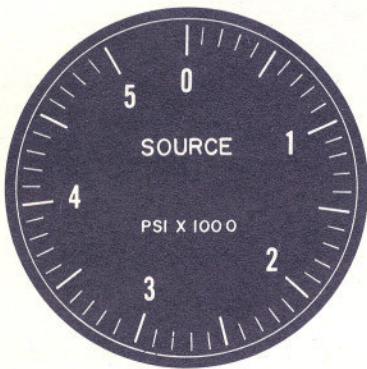
2900-3400 PSI NORMAL  
3500 PSI MAXIMUM  
NOTE

For a period not to exceed 30 seconds  
after APU start, pressure exceeding  
4000 is permissible.

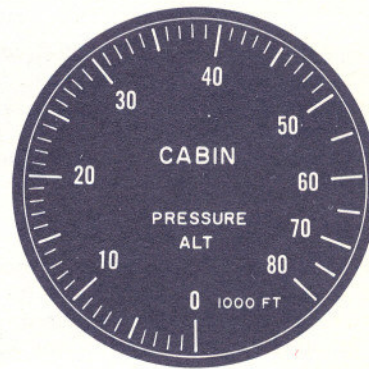


**HYDRAULIC SYSTEM  
NO. 2 TEMPERATURE  
GAGE**

-54°C TO +204°C  
NORMAL  
230°C MAXIMUM



**CABIN HELIUM SOURCE  
PRESSURE GAGE**  
NO MARKINGS

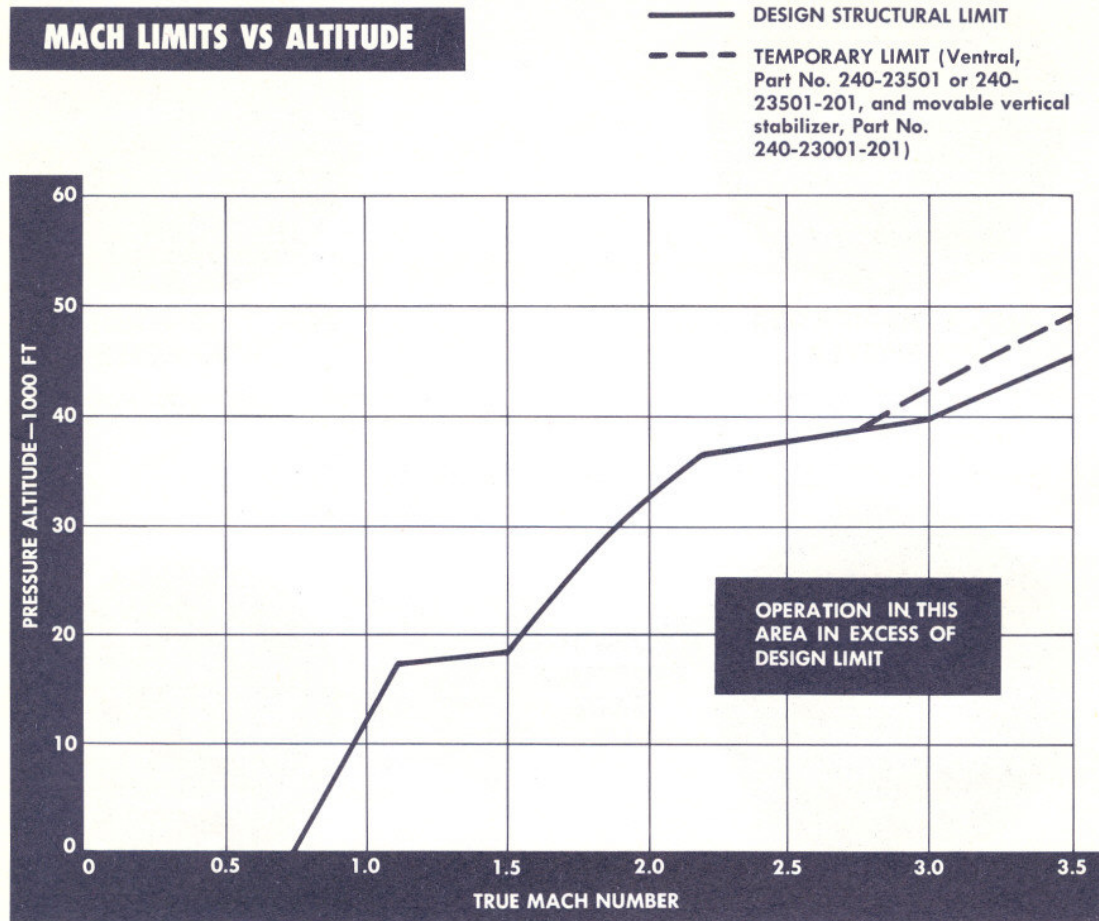


**CABIN PRESSURE  
ALTIMETER**  
NO MARKINGS

X-15-1-51-4E

Figure 5-1. (Sheet 4 of 4)

## MACH LIMITS VS ALTITUDE



X-15-1-93-6

Figure 5-2.

### VENTRAL JETTISON LIMITATIONS.

For all flights where the ventral is installed for launch, the ventral should not be jettisoned at speeds above 300 knots IAS or Mach 3.5, whichever is lower. Under normal flight conditions, with the SAS functioning properly, the ventral should not be jettisoned except during the landing approach.

#### NOTE

In the event of controllability problems arising from the loss of various SAS modes (primarily loss of the SAS roll mode), jettisoning of the ventral greatly improves airplane handling characteristics in the Mach number range of 2.0 to 3.5.

With the ventral jettisoned, the following limits apply:

Maximum angle of attack, 16 degrees

Maximum rate of roll, 30 degrees per second

Maximum Mach number, 3.5

### SPEED BRAKE OPERATION.

The upper and lower speed brakes must be operated simultaneously and symmetrically. This restriction is imposed because no analysis has been conducted to determine limitations required for asymmetrical operation of the speed brakes.

#### CAUTION

Be cautious when using speed brakes for approach control, because rate of descent approximately doubles with the speed brakes open.

#### NOTE

Normally, the speed brake handles are mechanically interconnected to ensure simultaneous and symmetrical operation of the speed brakes.

STABILITY AUGMENTATION SYSTEM LIMITATIONS.

For normal flight operations, SAS gain settings should be:

Ventral on - pitch, 8; roll, 6; yaw, 8.

Ventral off - pitch, 8; roll, 4; yaw, 8.

Under conditions of a single system APU failure or failure of either the roll or yaw functions, lateral-directional control problems can be encountered in the speed range of Mach 2.5 to 6.0 and at angles of attack in excess of 8 degrees nose up with the ventral installed. Should control problems be encountered under these conditions, the following recovery techniques should be employed:

1. Reduce angle of attack.
2. Extend speed brakes.
3. Jettison ventral if below the airspeed limit for jettisoning the ventral.

NOTE

If the ventral is not installed, the failures noted previously will not seriously affect airplane controllability.

ACCELERATION LIMITATIONS.

In order to ensure correct interpretation of the two basic types of acceleration limitations imposed on this airplane, the following definitions apply:

- a. Symmetrical flight is that where airplane bank angle is constant.
- b. Asymmetrical flight is that involving a bank angle change rate, i. e., rolling flight.

SYMMETRICAL.

Acceleration limitations for symmetrical flight at various gross weights are shown graphically in figure 5-3.

**CAUTION**

Negative G imposed at low engine propellant levels may result in premature main chamber burnout.

ASYMMETRICAL.

Acceleration limitations for various gross weights from 33,000 to 19,000 pounds are shown in figure 5-4. At burnout gross weight (15,119 pounds), asymmetrical limitations are 5.2 G and 0 G.

ROLL LIMITATIONS.

The maximum allowable rate of roll is 100 degrees per second. Roll coupling can be encountered at the higher

Mach numbers and angles of attack. Abrupt aileron rolls under these conditions should be simulator-tested before flight.

YAW (SIDESLIP) LIMITATIONS.

Abrupt yawing maneuvers utilizing maximum rudder rate and deflection should not be performed. Yaw maneuvers exceeding one half of the maximum rudder deflection in one direction, followed immediately by a similar deflection in the opposite direction should not be performed. The maximum permissible yaw (side-slip) angles at varying Mach numbers and altitudes are shown in figure 5-5.

PROHIBITED MANEUVERS.

The airplane is restricted from performing the following maneuvers:

- a. Spins.
- b. Snap rolls or snap maneuvers.

BALLISTIC CONTROL SYSTEM LIMITATIONS.

To conserve catalyst bed life, continuous operation of the ballistic rocket motors should be limited to 3 seconds for ground or captive flight tests.

LANDING LIMITATIONS.

Information on sink speed - angle-of-attack limits for touchdown will be supplied when available.

CENTER-OF-GRAVITY LIMITATIONS.

Since the in-flight horizontal and vertical centers of gravity are automatically controlled as a result of the design of the engine and engine turbopump propellant systems, the horizontal CG normally is maintained within the forward and aft aerodynamic limits. The vertical CG will be within the engine adjustment provisions if all of the design equipment is installed. The engine and engine turbopump propellant jettison rate is automatically controlled to prevent an unsatisfactory CG condition. If airplane response during jettisoning indicates an unsatisfactory trim condition, selective jettisoning of the engine propellants should be accomplished.

WEIGHT LIMITATIONS.

The design of the airplane precludes the possibility of overloading at launch. The structural design weight for landing does not include engine propellants or engine turbopump monopropellant; therefore, they must be jettisoned before landing.

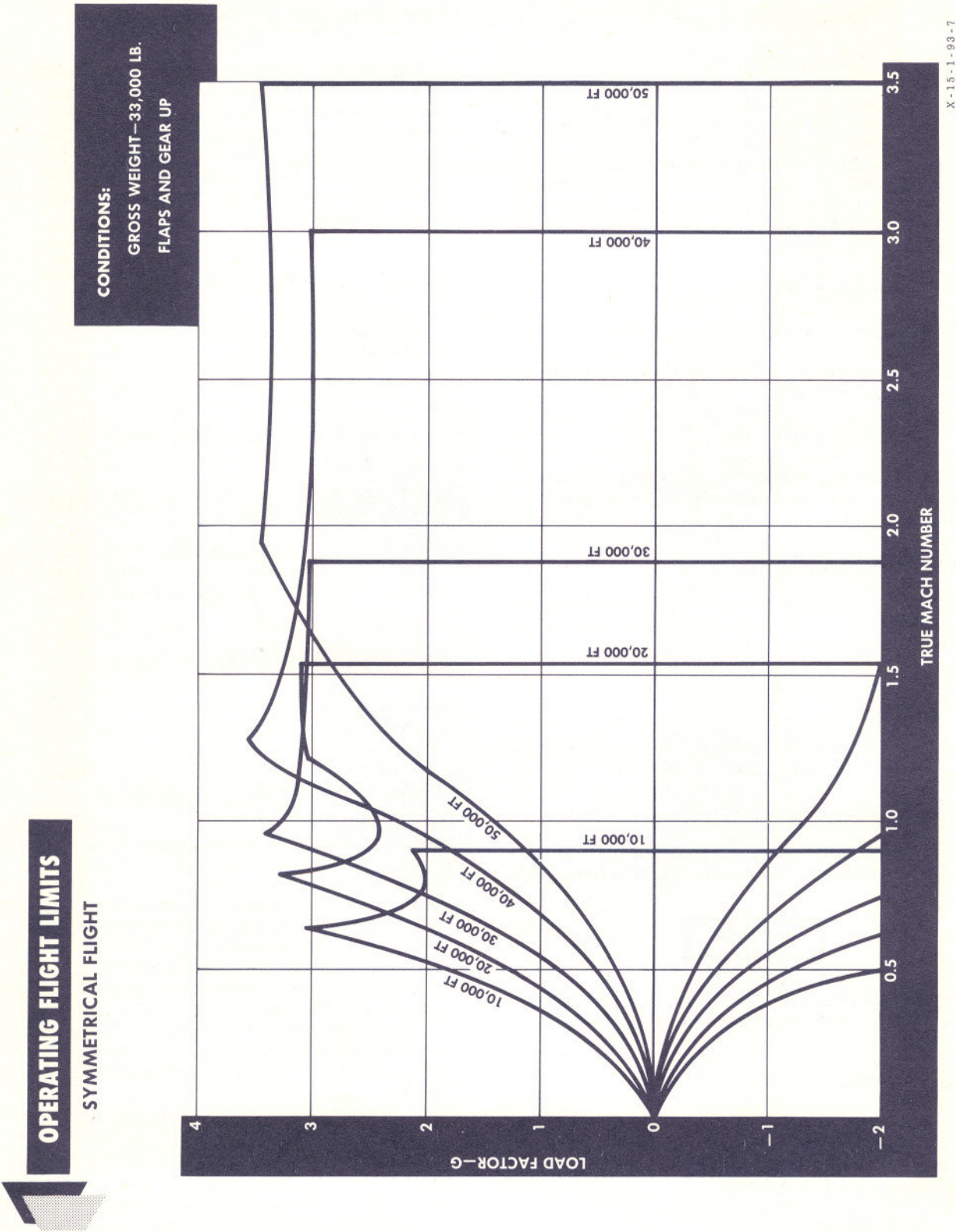
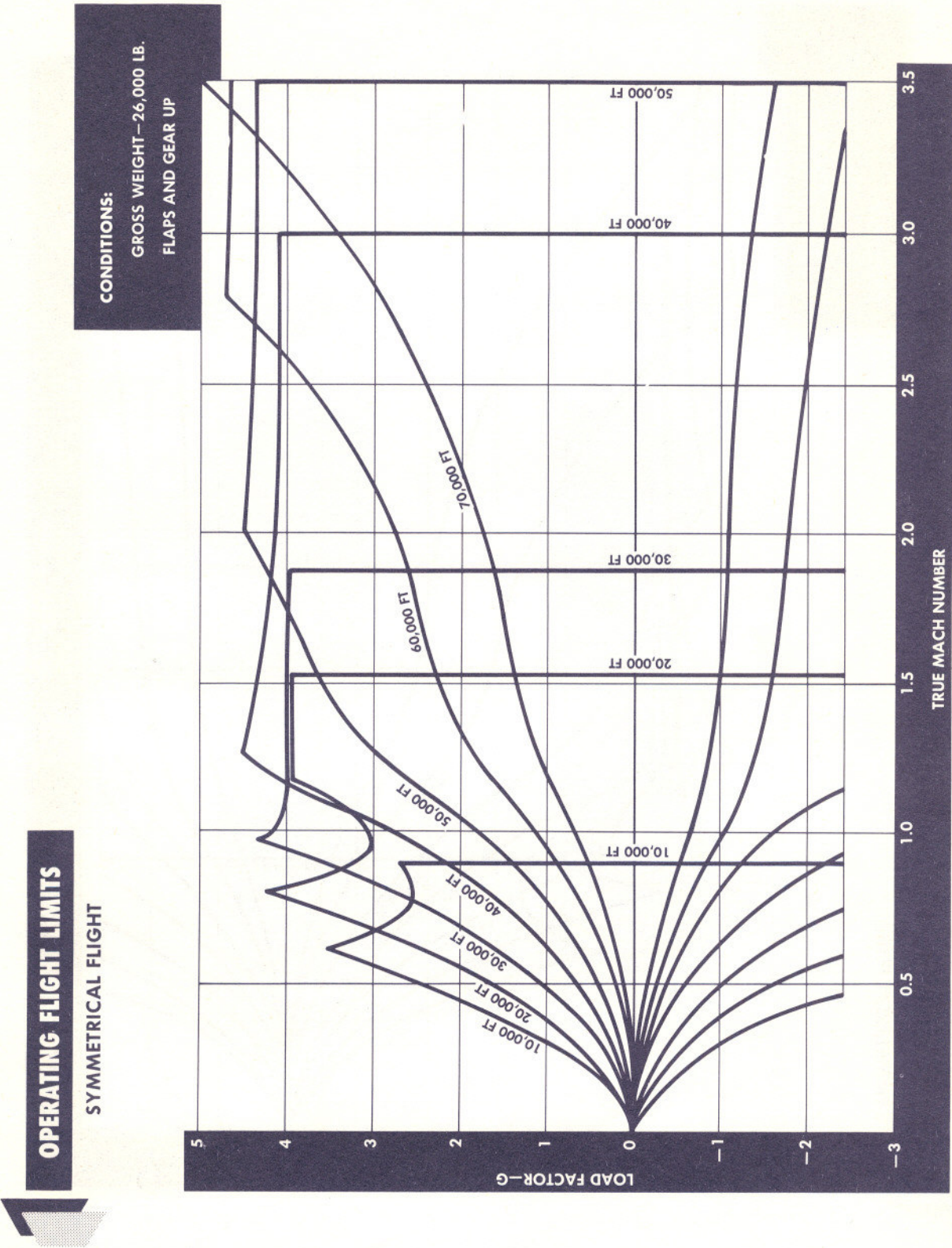


Figure 5-3. (Sheet 1 of 4)





X-15-1-98-8

Figure 5-3. (Sheet 2 of 4)

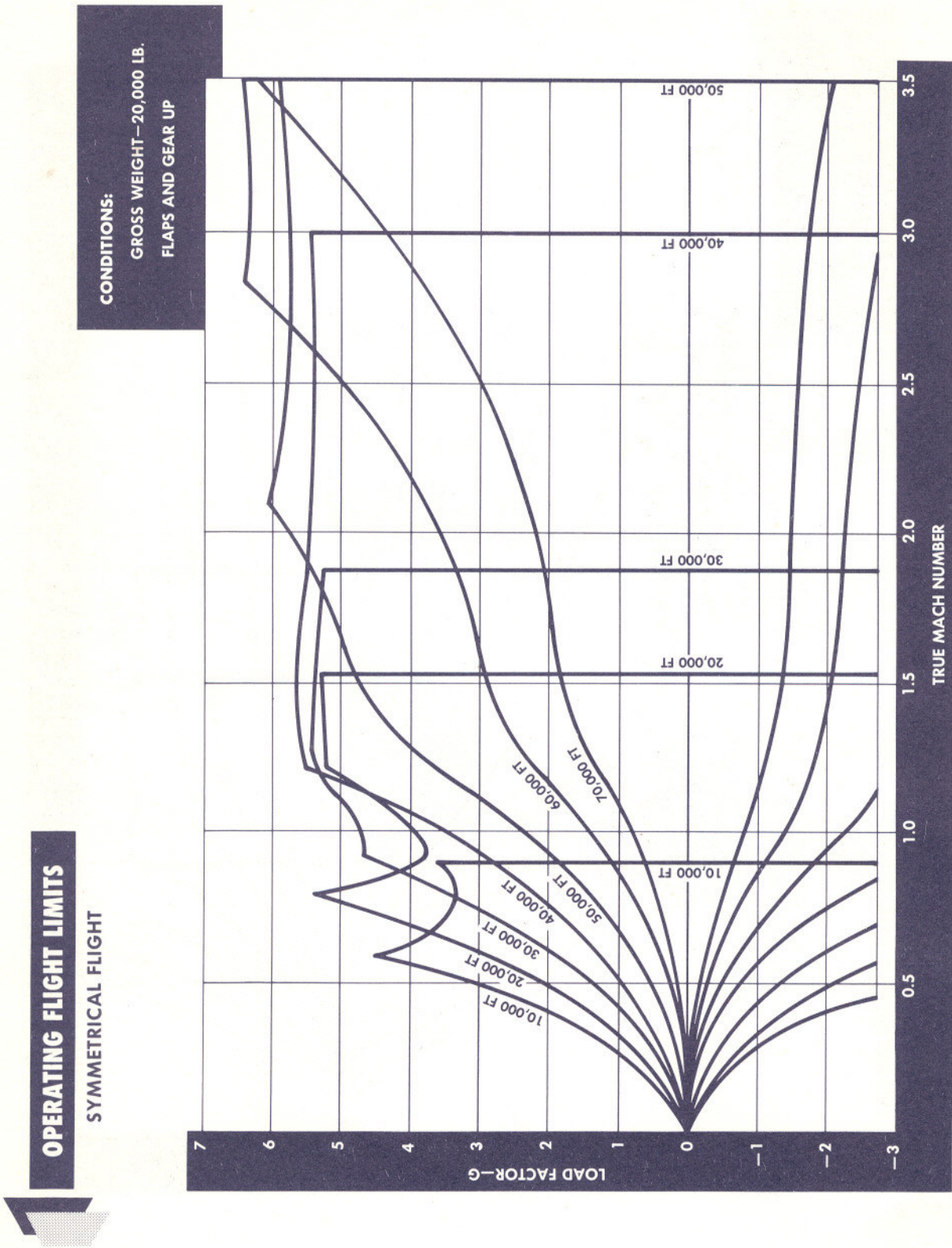


Figure 5-3. (Sheet 3 of 4)

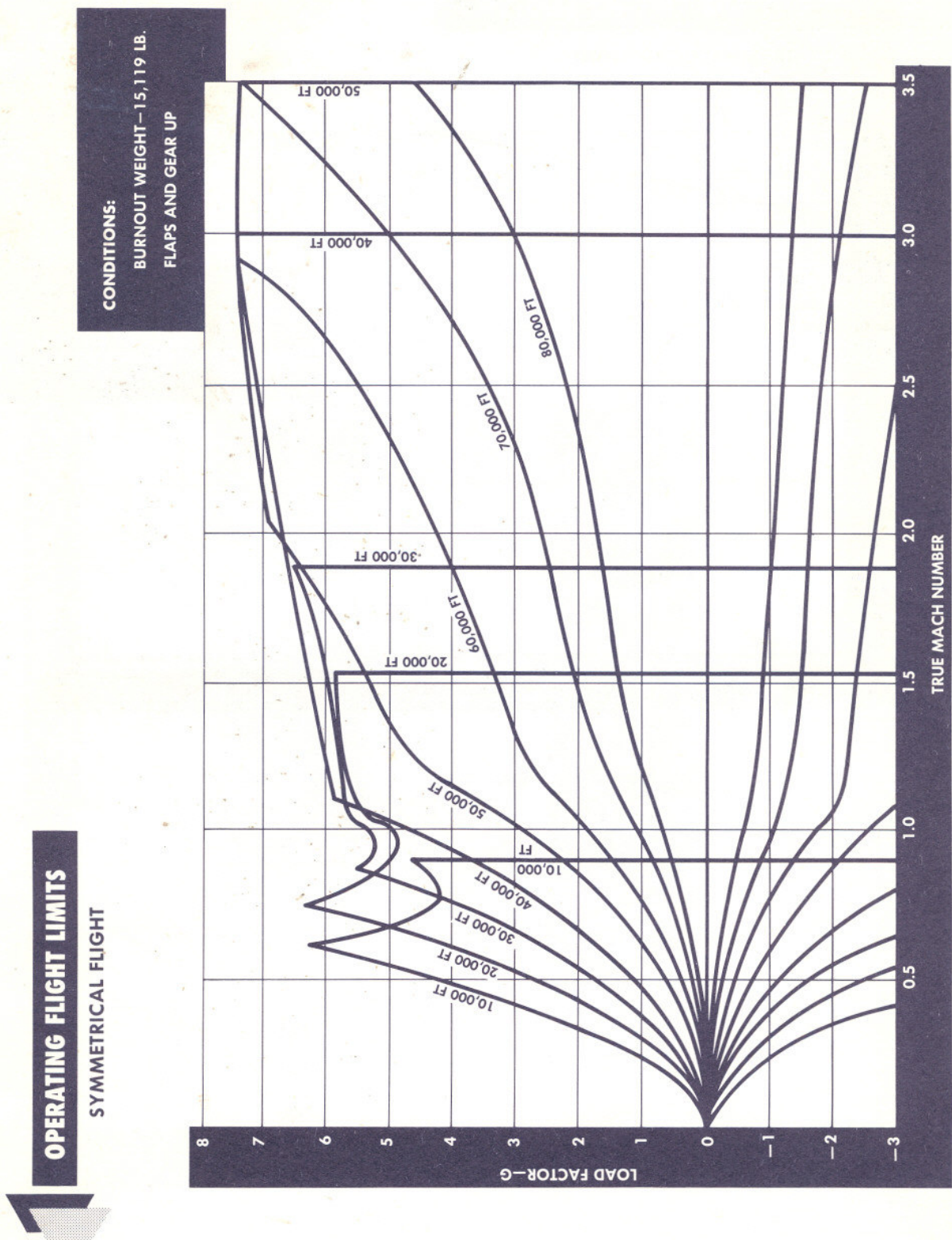
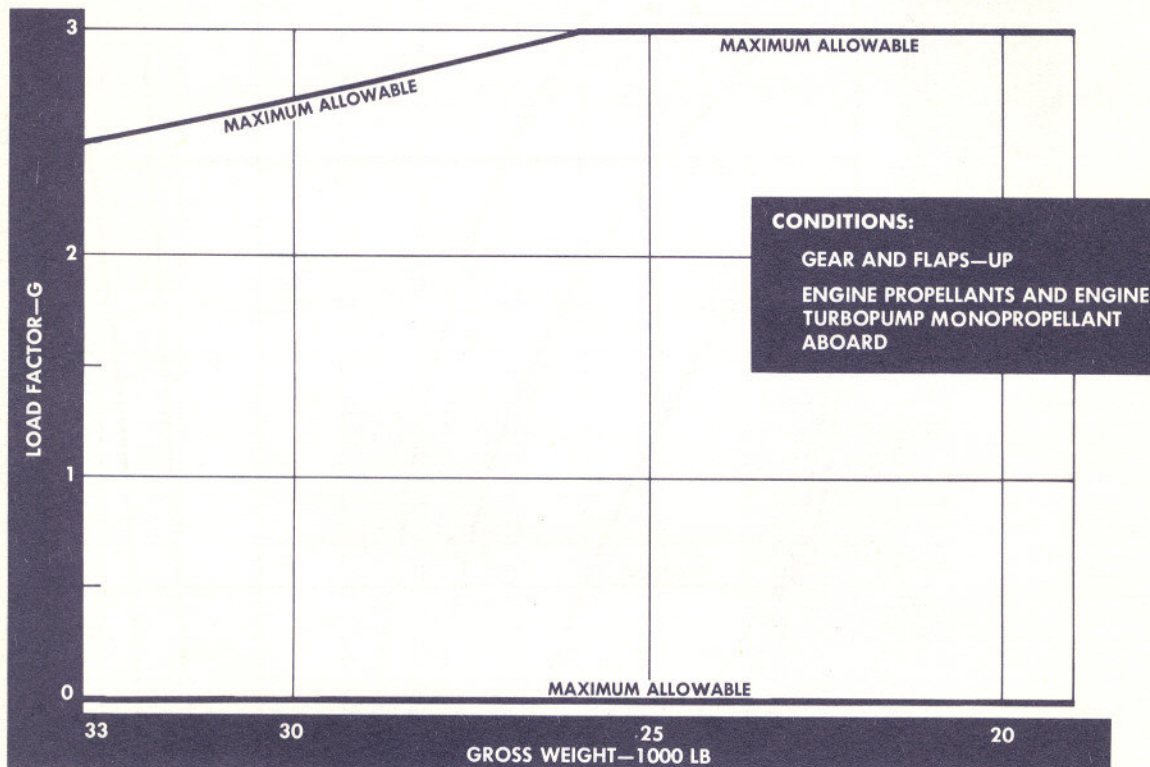


Figure 5-3. (Sheet 4 of 4)

# OPERATING FLIGHT LIMITS

## ASYMMETRICAL FLIGHT



X-15-1-93-11

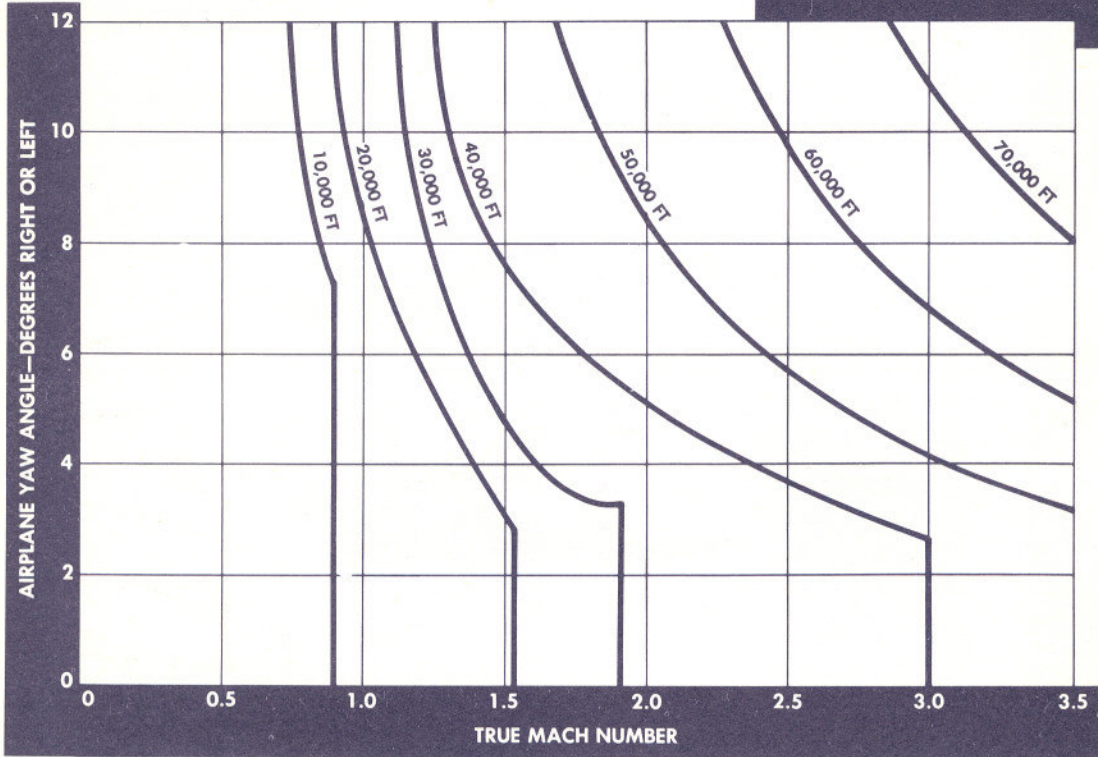
Figure 5-4.

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# MAXIMUM ALLOWABLE YAW ANGLES

## CONDITIONS:

VENTRAL—ON OR OFF  
LOAD FACTOR—1 G  
SPEED BRAKES—OPEN OR CLOSED  
VERTICAL STABILIZER ANGLE—0 DEG



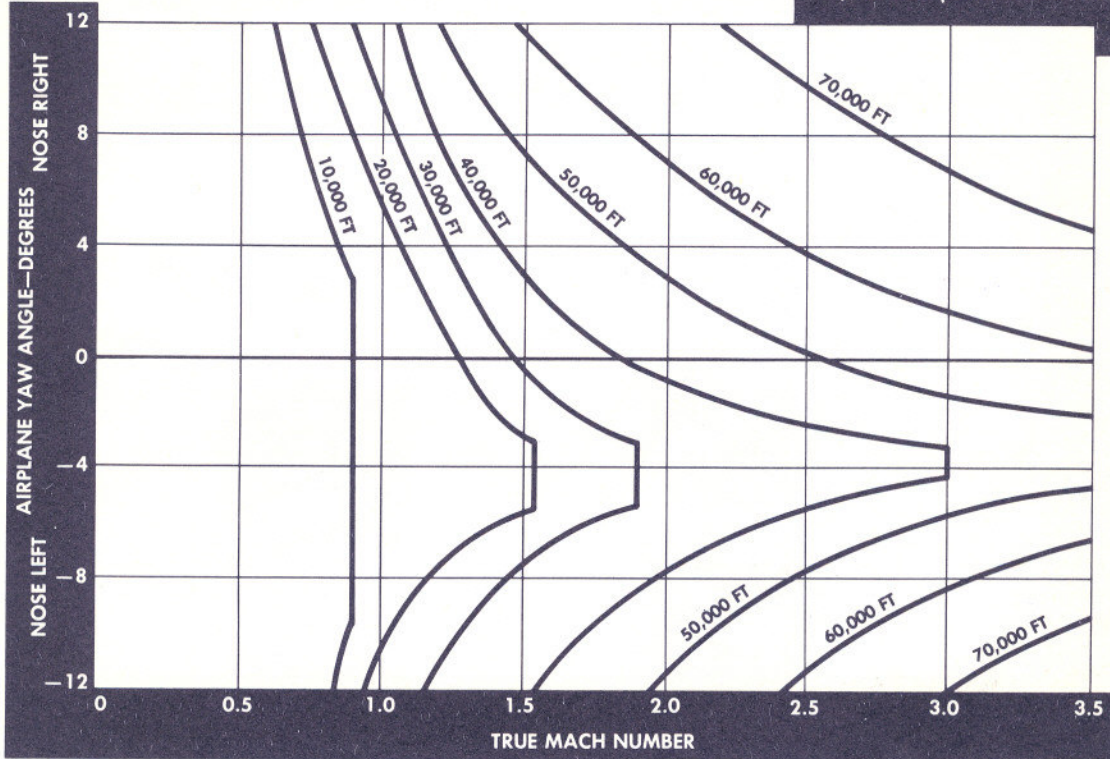
X-15-1-93-12

Figure 5-5.

# MAXIMUM ALLOWABLE YAW ANGLES

## CONDITIONS:

VENTRAL—ON OR OFF  
LOAD FACTOR—1 G  
SPEED BRAKES—OPEN OR CLOSED  
VERTICAL STABILIZER ANGLE—  
+7.5 DEG (LEADING EDGE RIGHT)



X-15-1-93-13

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