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AERODYNAMIC CHARACTERISTICS OF A SERIES OF AIRBREATHING MISSILE--ETC(U)
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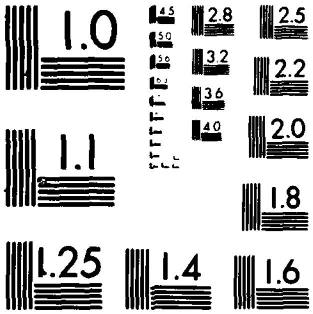

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AERODYNAMIC CHARACTERISTICS OF A SERIES OF AIRBREATHING MISSILE CONFIGURATIONS

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ABSTRACT

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Due to the interest in the application of airbreathing propulsion to missiles and the lack of a suitable data base, an experimental program has been conducted to contribute to such a data base. The configurations investigated were with twin-inlets, either two-dimensional or axisymmetric, each located at three circumferential locations. The effects of a wing located above the inlets and of tail configuration were investigated. Longitudinal stability and control and lateral-directional stability were included in the data obtained.

This paper will present a summary of the program and some of the results obtained. Certain trends of the data, as well as problem areas, will be discussed. Due to the large volume of data obtained, a detailed analysis will not be presented.

INTRODUCTION

Since 1972, the National Aeronautics and Space Administration has participated in several airbreathing missile research programs. These programs have included the MORASS[1], ALRAAM[2], SASS[3], AIAAM[4-5], and the ASALM[6] configurations. The results from these studies indicated that a more comprehensive data base would be required to advance and develop new design techniques for airbreathing missile configurations.

In 1977, Langley Research Center developed a parametric model series that could be configured to cover a wide range of airbreathing missile configurations (figure 1). The model components, shown schematically in figure 1, included single and twin axisymmetric and two-dimensional inlets. The twin-inlets could be rotated about half the body centerline from 0° to 45° from horizontal. Various wing and tail configurations could be installed.

This model series has been tested with internal flow in the Langley Unitary Plan Wind Tunnel and in the David W. Taylor Naval Ship Research & Development Center (DTNSRDC) 7' x 10' Transonic Tunnel without internal flow. Figure 2 shows the extent of this investigation. In addition to the variables shown in figure 2, a series of tests at both Langley and DTNSRDC have been run with single tail surfaces deflected for pitch, yaw, and roll control.

This paper will present only a small portion of the findings of this investigation. A comparison will be shown between the twin axisymmetrical and two-dimensional inlet configuration, and the effect of various variables in the twin axisymmetric inlet configuration.

SYMBOLS

The aerodynamic characteristics are referred to the body axis system. The moment reference center was located at 50.0 percent of the body length.

A	maximum cross-sectional area of body
$C_{l\beta}$	effective dihedral parameter (roll stability), $\left(\frac{\Delta C_l}{\Delta \beta}\right)_{\beta = 0^\circ, 3^\circ}$, where $C_l = \frac{\text{rolling moment}}{qAd}$
C_{n_β}	directional-stability parameter, $\left(\frac{\Delta C_n}{\Delta \beta}\right)_{\beta = 0^\circ, 3^\circ}$, where $C_n = \frac{\text{yawing moment}}{qA}$
d	maximum body diameter
M	free-stream Mach number
q	free-stream dynamic pressure
α	angle of attack
β	angle of sideslip
ϕ_I	angle of inlet orientation

DISCUSSION

The twin-inlet configurations are shown in figure 3. The geometries of the axisymmetric and two-dimensional configuration are compared and the wing and tail arrangements are shown. The wing could not be attached to the model when the inlets were located at $\phi_I = 90^\circ$. Two vertical wing locations are shown for the two circumferential positions for which the wing was used. A tri-tail configuration was used for all the inlet circumferential positions. For inlets in the 45° position, in addition to the tri-tail, an x-tail and inverted tri-tail configuration were tested and are shown in figure 4.

Figure 5 shows the effect of inlet orientation angle on the longitudinal aerodynamics for both the axisymmetric and two-dimensional inlets. The body-inlet-tail (tri-tail) configuration shows a variation of pitching moment with angle of attack that tends to be a characteristic of this type of configuration--very stable at high angles of attack with little or no margin of stability near 0° angle of attack. The effect of inlet orientation was to decrease the longitudinal stability as the inlets were rotated downward. The difference between the two inlet types was generally an overall lower stability level for the two-dimensional inlet as compared to the axisymmetric inlet. The effect of the decrease in stability as the inlets were rotated downward is due largely to the decrease in planform area at the aft end of the model. This should also affect the directional stability, since the lateral area of the model at the aft end is also changed.

Figure 6 shows the affect on the directional stability to be about as expected at low angle of attack (up to about $\alpha = 6°$). It should be noted that the change of inlet orientation angle from 90° to 115° showed little affect on pitching moment with a large change between 115° and 135°, while the variation of directional stability varied more directly with inlet orientation angle. Above about $\alpha = 6°$, the vertical tail surface becomes ineffective and the model is directionally unstable at angle of attack above about 12°. The change in lateral area also affects the lateral stability and the model was laterally unstable with the 135° inlet orientation angle.

Figure 7 shows the longitudinal aerodynamic characteristics of the body-inlet-tail and body-inlet-wing-tail compared for three different tail configurations. These configurations are with the axisymmetric inlets at 135° orientation angle. While the configuration with the tri-tail shows rather nonlinear pitching moment characteristics, the x-tail configuration provides a much more linear variation, in fact, without the wing the curve is essentially a straight line for the range of angle of attack of the tests. With the wing added, the curve is somewhat less linear, but the configuration remained stable for the range of angle of attack. The third tail configuration, an inverted tri-tail has unsatisfactory stability characteristics.

Figure 8 shows the effect of pitch control deflection for the winged configuration. The left half of the figure is from the previous figure. The right side shows the effect of -10° pitch control deflection. The tri-tail configuration would trim at an angle of attack above 20°, but has an unstable range of angle of attack. The x-tail, despite its stability level, trims at 20° angle of attack and has a more linear pitching-moment variation. The inverted tri-tail shows a straightening of the pitching-moment curve apparently due to the loss of effectiveness at high angle of attack.

Figure 9 shows the lateral-directional stability of the tail winged configuration. Generally, the x-tail and inverted tri-tail show lateral-directional stability throughout the angle-of-attack range. The tri-tail became laterally unstable at high angles of attack and was generally unstable laterally throughout the angle-of-attack range.

CONCLUDING REMARKS

Due to the interest in the application of airbreathing propulsion to missiles and the lack of a suitable data base, an experimental program has been conducted to contribute to such a data base. The configurations investigated were with twin-inlets, either two-dimensional or axisymmetric, each located at three circumferential locations. The effects [illegible]ing located above the inlets and of tail configurations were also investigated. Longitudinal stability and control and lateral-directional stability characteristics were obtained as part of the experimental program. Some of the more general observations regarding the aerodynamic characterisics of the model can be made:

(1) The configuration tested showed a trend which consisted of a variation of pitching moment with angle of attack, that the model was very stable at high angles of attack and with little or no margin of stability near 0° angle of attack.

(2) Rotating the inlets downward tended to decrease the longitudinal stability, while increasing the directional stability, and decreasing the lateral stabilty.

(3) Of the three tails tested, the x-tail configuration provided the best performance, the most linear pitching-moment curve, sufficient pitch control effectiveness and positive lateral-directional stability.

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1. Hayes, Clyde, and Monta, William J.: Aerodynamic Characteristics of a 1/4-Scale Model of MORASS Missile Configurations at Supersonic Speeds. NASA TM X-3354, 1976.

2. Hayes, Clyde: Aerodynamic Characteristics of 1/4-Scale Model of ALRAAM Missile Configuration at Supersonic Speeds. NASA TM 74075, 1977.

3. Hayes, Clyde; and Sawyer, Wallace C.: Aerodynamic Characteristics of a Series of Air-Breathing Missile Configurations Investigated as Part of the SASS Program. NASA TM 80139, 1979.

4. Hayes, Clyde: Aerodynamic Characteristics of Twin-Inlet Missile Configurations Tested as Part of the AIAAM Program. Proposed NASA TM.

5. Hayes, Clyde: Aerodynamic Characteristics of a Single-Inlet Missile Configuration Tested as Part of the AIAAM Program. Proposed NASA TM.

6. Sawyer, Wallace C.; and Hayes, Clyde: Stability and Control Characterisitcs of an Air-Breathing Missile Configuration Having a Forward Located Inlet. NASA TM X-3391, 1976.

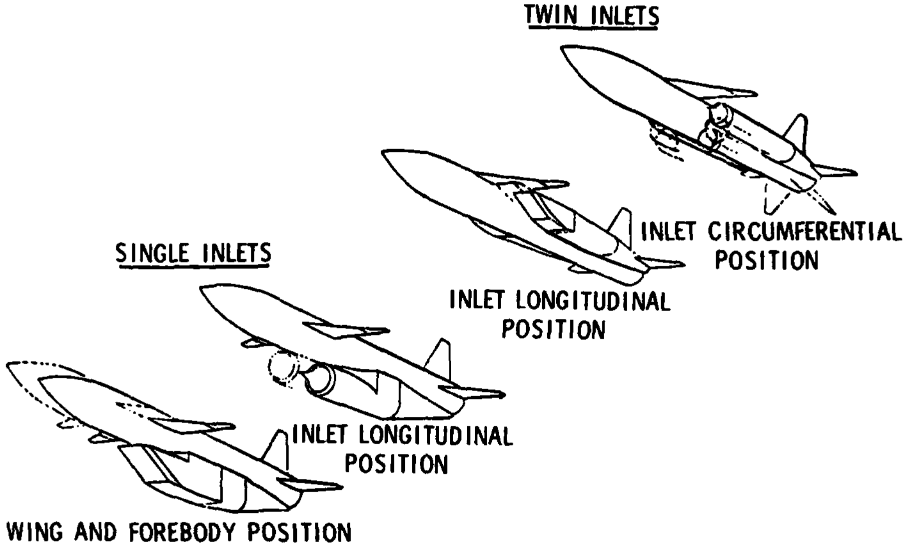


Figure 1. - Configuration variables.

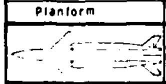
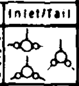
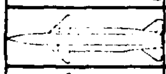
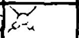
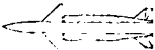
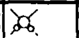
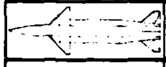
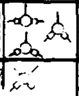
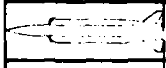
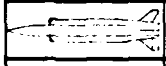
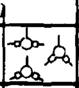
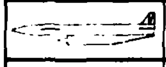
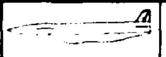
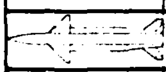
Model Drawing		Angle Of Attack		Mach Number		Control Deflection		Configuration Inlets Included			
Planform	Inlet/Tail	α	β	Subsonic	Supersonic	δ_{pitch}	δ_{yaw}	Body	Body-Wing	Body-Tail	Body-Wing-Tail
		-2°to12°	0°, 5°	.60, .80, .95		-10° 0° +10°		90° 115° 135°	115° 135°	90° 115° 135°	115° 135°
		-5° to 20°	0°, 3°		2.50, 2.95 3.50, 3.95	0° -10° -20°		90° 115° 135°	115° 135°	90° 115° 135°	115° 135°
		-2° to 12°	0°, 5°	.60, .80, .95		-10° 0° +10°		135°	135°	135°	135°
		-5°to20°	0°, 3°		2.50, 2.95, 3.50, 3.95	+10° 0° -10° -20°		135°	135°	135°	135°
		-2° to 12°	0°, 5°	.60, .80, .95		0° +10°		135°	135°	135°	135°
		-5°to20°	0°, 3°		2.50, 2.95, 3.50, 3.95	0° -10° -20°		135°	135°	135°	135°
		-2° to 12°	0°, 5°	.60, .80, .95		0° +10° -10°		90° 115° 135°	115° 135°	90° 115° 135°	115° 135°
		-5°to20°	0°, 3°		2.50, 2.95, 3.50, 3.95	0° -10° -20°		90° 115° 135°	115° 135°	90° 115° 135°	115° 135°
				.60, .80, .95		0°		135°		135	
		-5°to20°	0°, 3°		2.50, 2.95, 3.50, 3.95	0° -10° -20°		135°		135°	
				.60, .80, .95		0°				90° 115° 135	
		-5°to20°	0°, 3°		2.50, 2.95 3.50, 3.95	0° -10° -20°		90° 115° 135°		90° 115° 135°	
				.60, .80, .95		0° +10° -10°		Tested	Tested	T_1 T_2	T_1 T_2
		-5°to20°	0°, 3°		2.50, 2.95 3.50, 3.95	0° -10° -20°		Tested	Tested	T_1 T_2	T_1 T_2
				.60, .80, .95		0° +10° -10°		Tested	Tested	T_1	T_1
		-5°to20°	0°, 3°		2.50, 2.95, 3.50, 3.95	0° -10° -20°		Tested	Tested	T_1 T_2	T_1 T_2
											
		-5° to 20°	0°, 3°		2.50, 2.95, 3.50, 3.95	0° -10° -20°				135°	135°

Figure 2. - Test matrix of UPWT airbreathing missile model tests.

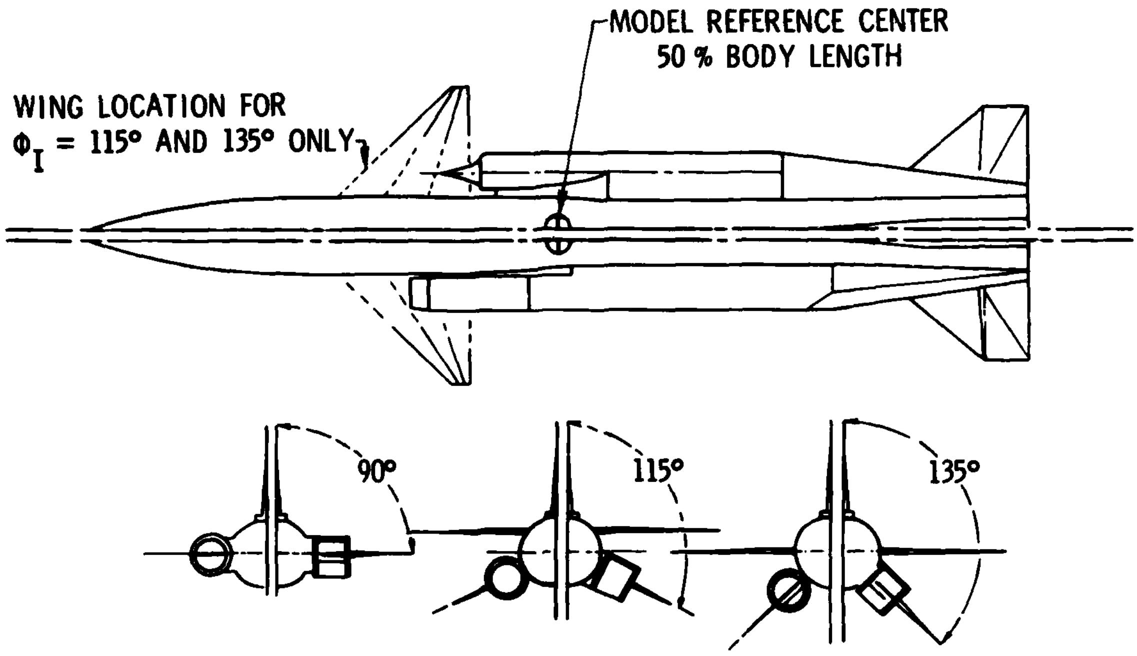


Figure 3. - Twin-inlet model configurations.

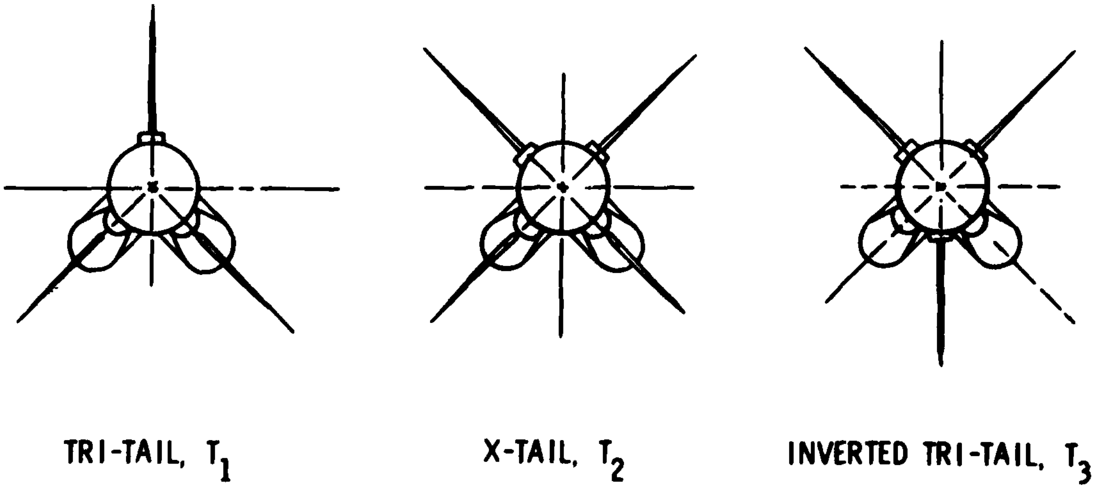


Figure 4. - Tail configurations.

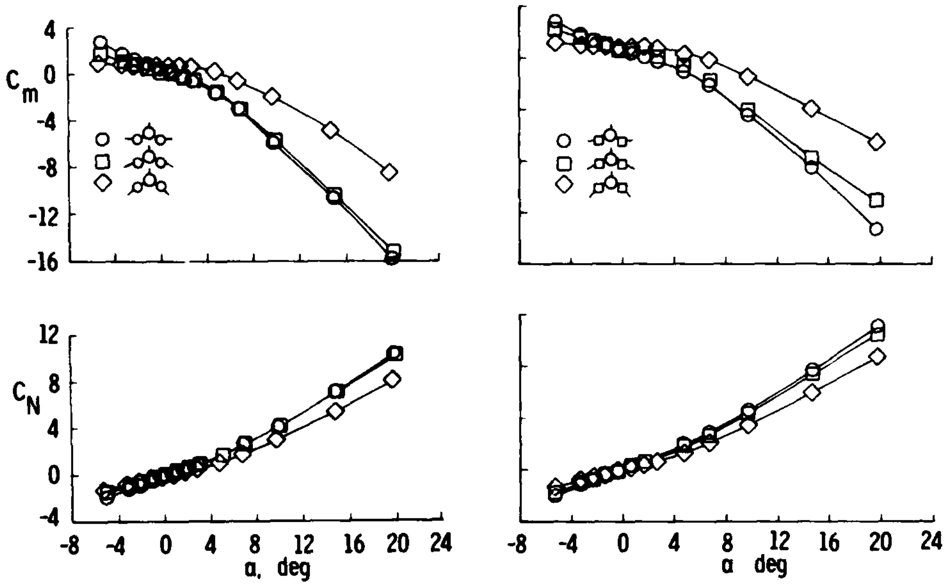


Figure 5. - Effect of inlet orientation on longitudinal aerodynamic characteristics. M = 2.95.

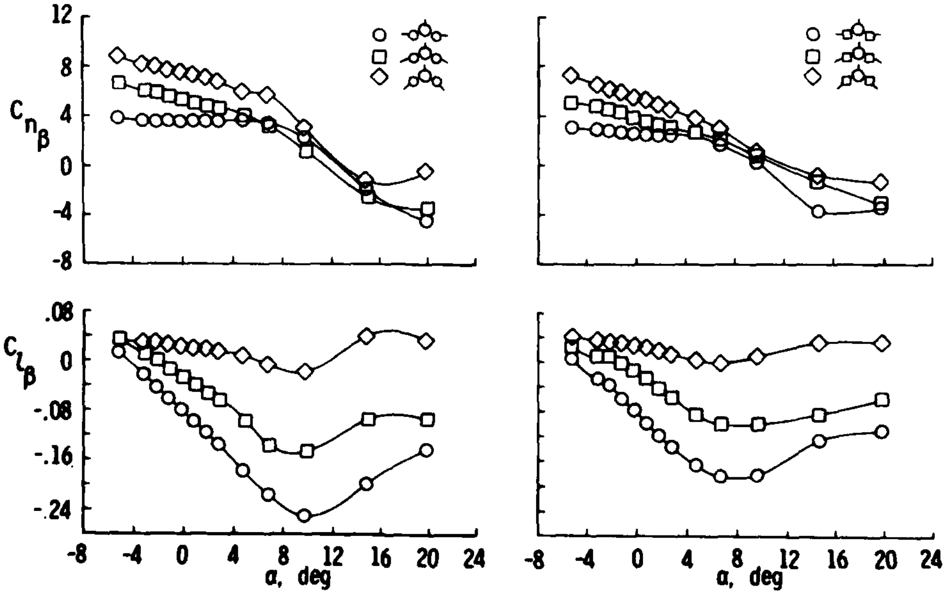


Figure 6. - Effect of inlet orientation on lateral-directional stability. M = 2.95

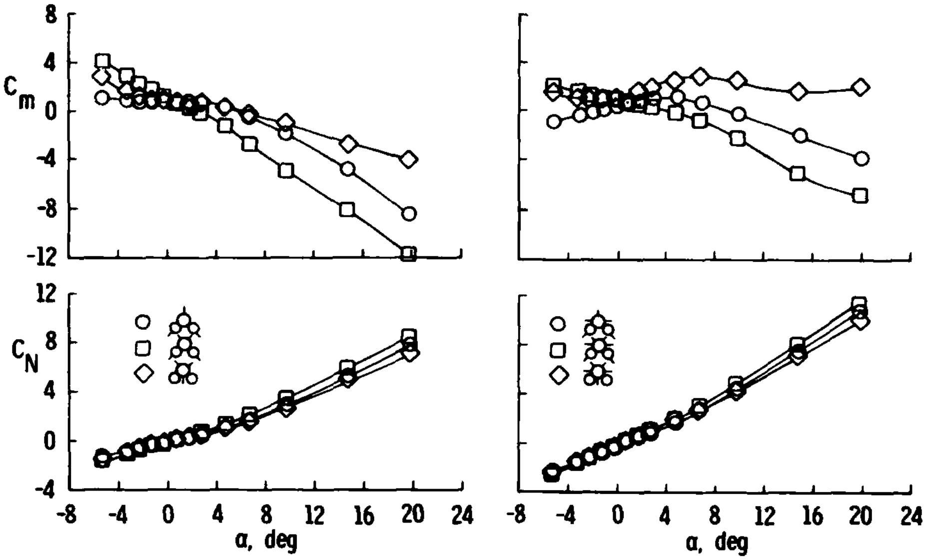


Figure 7. - Effect of tail configuration on longitudinal aerodynamic characteristics with and without wing. M = 2.95.

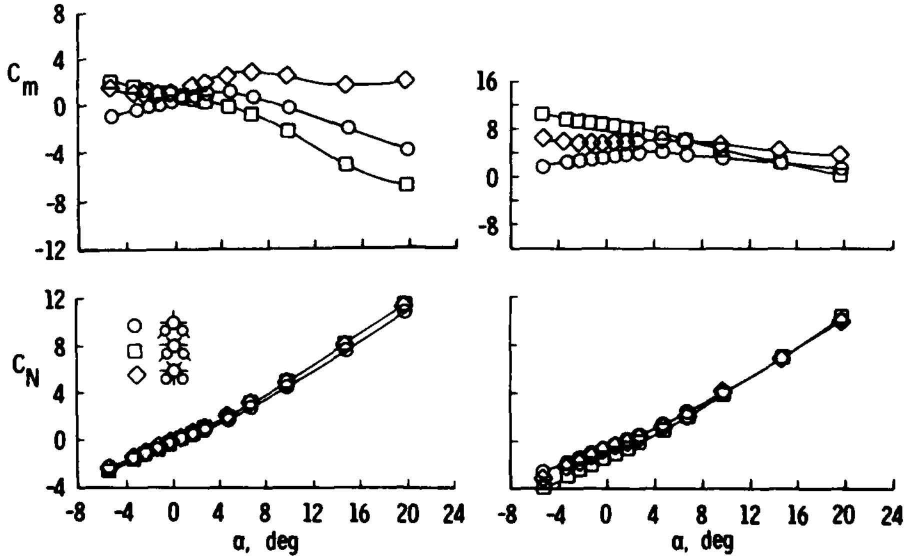


Figure 8. - Effect of -10^{o} pitch control deflection on three tail configurations. M = 2.95.

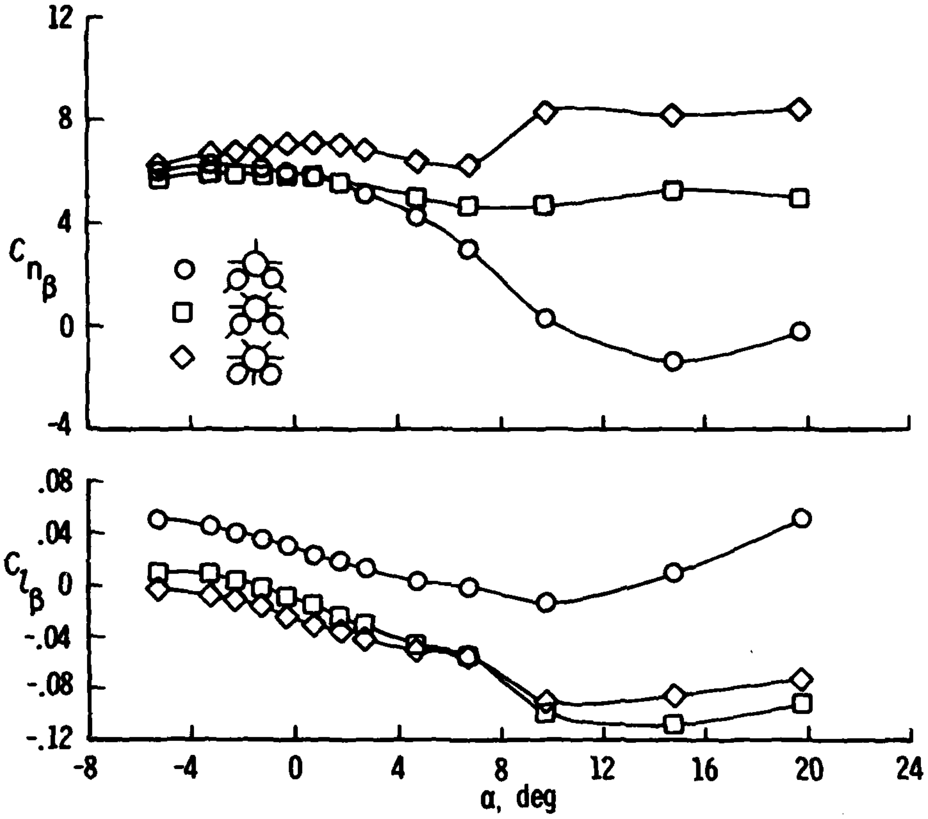


Figure 9. - Effect of tail configuration on lateral-directional stability. M = 2.95.