Introduction

In order to extend the effectiveness of the transonic area rule of ref. 1 into the supersonic speed range, a supersonic area rule was developed (ref. 2). Since most aircraft manufacturers find it impossible to apply the symmetrical method of body indentation used in the greater part of the development of the area rule, an attempt has been made to indent the body in a more usable manner—side indentation. Through use of the supersonic area rule, a side indentation was...
arrived at which gave a reasonable area distribution for $M = 1.8$ (Fig. 2).

This indentation was tested at speeds considerably below its design speed, but the results tended to justify their publication before experimental results for the complete design speed range could be obtained.

It may be seen from references 3 & 4 that leading-edge droop tends to increase the maximum lift-drag ratio for swept-back wings. It was felt that this
could be used to advantage with a thin delta wing. The droop was not that needed for maximum effect at the design speed for the body indentation, but that which it was felt would give the best results throughout the Mach number range.

Wing incidence was tested because of its increasing use on present-day aircraft. It is used to give the necessary ground clearance and it was deemed advisable to determine the
effects, beneficial or adverse, throughout the entire Mach number range. These three modifications were tested in combination as well as separately through a Mach number range from .80 to 1.15. The wing angle of attack varied from 0° to 120°.
Symbols

\( \bar{c} \) \hspace{1cm} \text{mean aerodynamic chord}

\( C_D \) \hspace{1cm} \text{drag coefficient}

\( C_{D_0} \) \hspace{1cm} \text{zero-lift drag coefficient}

\( \Delta C_D \) \hspace{1cm} \text{zero-lift drag-rise coefficient}

\( C_{D_{\alpha=0}} - C_{D_{\alpha=0}} \) \hspace{1cm} \text{incremental drag coefficient between lift coefficients of 0 and 0.3}

\( C_L \) \hspace{1cm} \text{lift coefficient}

\( C_{m\alpha} \) \hspace{1cm} \text{slope of the lift curve}

\( C_{m1} \) \hspace{1cm} \text{pitching-moment coefficient about the 0.25-chord point at } \alpha

\( C_{m2} \) \hspace{1cm} \text{slope of pitching-moment curve}

\( D \) \hspace{1cm} \text{Drag, lb}

\( L \) \hspace{1cm} \text{Lift, lb}

\( \left( \frac{L}{D} \right)_{\text{max}} \) \hspace{1cm} \text{maximum lift-drag ratio}

\( M \) \hspace{1cm} \text{Mach number}

\( \alpha \) \hspace{1cm} \text{angle of attack}
Apparatus and Methods

Tunnel

The subject tests were conducted in the Langley 8-foot transonic tunnel which is a dodecagonal, single-return, slotted wind tunnel designed to obtain aerodynamic data through the speed of sound without the usual choking and blockage effects associated with a conventional closed-throat type of wind tunnel. The tunnel operates at atmospheric stagnation pressures.

A more detailed tunnel description may be found in reference 5.
Configurations

The wing used in this investigation was a plane delta wing with 60° sweep-back at the leading edge, and NACA 65-2023 airfoil section parallel to the model plane of symmetry. This wing is of stainless steel construction. In order to investigate the effects of leading-edge droop, the forward 1.2 inches of the delta wing was drooped along the camber line shown in Figure 3. The wing was tested as a mid-wing configuration.
The basic body used in this investigation is the same as the one used in ref. 2. This body was indented for a Mach number of 1.8 according to the supersonic area rule of reference 2. In Figure 2 can be seen the area distribution of the indented coordinate both for the design Mach number and for a Mach number of 1.0 which is in the region of our maximum test Mach number. The model was attached to the
forward end of an internal strain-gage balance. This balance was attached, by means of a sting, to the tunnel central support system.

Measurements and Accuracy

The average free-stream Mach number was determined to within ±0.003 from a calibration with respect to the pressure in the chamber surrounding the slotted test section.

The accuracy of the lift, drag, and pitching-moment coefficients, based
on calibration and reproducibility of the data, is believed to be within \( \pm 0.01 \), \( \pm 0.001 \), and \( \pm 0.002 \) respectively.

The drag data have been adjusted for base pressure such that the drag corresponds to conditions for which the body base pressure would be equal to free-stream static pressure.

Data have not been presented between Mach numbers of 1.03 and 1.15 because of tunnel-wall shock-reflection effects (Ref. 6).

Unpresented schlieren data from other tests
of this same body indicate that there would be little effect of tunnel-wall shock reflection on the drag data at \( M = 1.15 \). On all cross-plotted data, however, Mach numbers from 1.03 to 1.15 were connected with an arbitrary fairing.

The angle of attack of the model was measured through the use of a pendulum-type accelerometer mounted in the model nose. This instrument was kept at a constant temperature throughout the test.
Mach number range by the use of an electric heater. The overall accuracy of this device was ±0.10.
Presentation of Results

The variation of angle of attack, drag coefficient, and pitching-moment coefficient with lift coefficient for all of the wing-body configuration of the subject investigation are presented in Figures 4 through 9. Typical base pressure coefficients for the subject investigation may be found in Figure 10. The effects of supersonic body indentation and wing leading-edge droop on the variations of drag, incremental drag-rise coefficient, drag due to lift, and maximum
Lift-drag ratio with Mach number are found in Figures 11 through 13. Figures 14 through 16 show the effect of wing incidence and wing leading-edge drop on these parameters. The variations of lift-curve slope and pitching-moment curve slope with Mach number for all configurations are shown in Figures 17 and 18.

In order to facilitate presentation of the data, staggered scales have been used in some figures, and therefore care should be taken in identifying the
zero axis for each curve
Discussion

Drag Characteristics

Indentation effects. - The variations of drag coefficient with Mach number for both the basic body and the indented body in combination with the plane delta wing may be found in Figure 11. The indented configuration has a slightly higher zero-lift drag coefficient value throughout the entire test Mach number range. This figure also shows that the drag coefficients for the 0.3
Lift coefficient condition for the two combinations are the same up to a Mach number of 0.95. Above this Mach number, the indentation effect is greater for the 0.3 lift coefficient condition than for the zero-lift condition.

Figure 12 shows that the basic configuration has a lower incremental drag coefficient above a Mach number of 0.93 than does the indented body. It would be expected that the effect...
of the indented configuration would be detrimental since the area distribution for this indentation around sonic speeds (figure 2) is so far from the distribution desired—that is, the distribution of the body alone. Reference 1 indicates that an area distribution as abrupt as this combination has a Mach number of 1.00 would have a detrimental effect on drag.

The incremental-drag coefficient values between lift coefficients of 0
and 0.3 (figure 12) show that the basic configuration is slightly better below $M=1.00$ but the indented is better above this point. It should be stated, however, that most of the difference in the two configurations is within the accuracy of the test data.

The maximum lift-drag ratios (figure 13) are better for the basic configuration throughout the Mach number range.