Speakers; Weil + Sleeman 7X10

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1. Basic force and moment data and control effectiveness have been obtained through the transonic speed range on the series of wing and wing-fuselage combinations described by Mr. . The flow field in regions of probable tail locations was also studied. Effective downwash angles were measured with the aid of a series of free-floating tails such as the one shown mounted on this fuselage. The ratio of wake dynamic pressure to free-stream dynamic pressure was determined by the use of a survey rake. As an example of the type of data obtained we have prepared a chart illustrating the manner in which sweepback affects the wing lift-curve slope in the transonic range.

2. The solid lines represent the experimental lift slope variation with Mach number. Note that as the sweep angle is increased, the Mach number for peak lift-curve slope becomes higher, until for the wing of 60° sweepback, the lift-curve slope is practically invariant with Mach number in the range investigated. The theoretical values of lift-curve slope obtained at zero Mach number by use of the Weissinger lifting-line theory extended by the three-dimensional Prandtl-Glauert transformation are

shown by the dashed lines. The degree of correlation between theory and experiment is reasonably good and gives us a certain amount of confidence when interpreting bump data at transonic speeds.

3. Systematic data such as are obtained in these investigations will enable the designer to study various configurations and select one which will have the most satisfactory stability and control characteristics in the transonic range.

4. The next chart illustrates the results of one such study. This chart shows the elevator deflection required to trim an airplane through the speed range in steady level flight at an altitude of 36,000 feet for a hypothetical airplane with a wing loading of 60 pounds per square foot for two stabilizer settings. The airplane had a wing with 35° sweepback and a tail with 45° sweepback. An arbitrary tail height of 0.4 semispan above the chordline extended was assumed. It can be seen from the variation of elevator angle with Mach number that increasing trailing edge up elevator is required for trim as the Mach number is increased above .87 for the stabilizer setting used for the upper curve. These control position characteristics are associated with airplanes that tend to tuck under or

nose down, sometimes dangerously. The steeper the slope of this curve the more pronounced this nosing down tendency will be. A more desirable variation of elevator for trim with Mach number was obtained with the trailing edge up stabilizer setting used for the lower curve. It is apparent from these results that the elevator trim characteristics may be critically dependent on stabilizer setting at transonic speeds.

5. In view of this fact it may prove desirable on some airplanes to utilize an all movable tail as the means of longitudinal control. Trim characteristics were estimated for an airplane with such a control and the results are shown on the next chart. The same flight condition and airplane configuration that were assumed for the elevator calculations were used to make these estimations. Trim characteristics were investigated for four tail heights ranging from 0.4 semispan above the chordline extended to 0.2 semispan below the chordline extended. The assumed airplane center-of-gravity for these tail configurations was adjusted so that all configurations had the same stability at Mach number of .6 as indicated by the parallel curves of stabilizer deflection for trim against Mach number. The variation of stabilizer angle for trim with Mach number indicates that increasing

trailing edge up stabilizer is needed for trim as the speed is increased in the Mach number range near .9 for all tail positions investigated. These control position characteristics again indicate a nosing down tendency which would appear to be minimized with the tail located at the highest positions investigated but the trim changes shown for the unaccelerated flight condition assumed are reasonably small for all tail heights.

6. Apart from transonic considerations the problem in determining the horizontal tail location may be critically dependent on the low speed and landing characteristics.

7. The effect of tail height at low speed is illustrated in the next chart. The variation of pitching-moment coefficient with lift coefficient obtained from a systematic program at high Reynolds numbers in the 19-foot pressure tunnel is presented for a complete model incorporating an aspect ratio 4 mid-wing with quarter chordline sweptback 40°. Both with flap neutral and flap down and slots extended the tail off pitching moment curves show the characteristic unstable trend at stall. With the hroizontal tail on and located about 0.4 semispan above the chordline

extended, the curves still indicate an undesirable stall for both flap up and down conditions. Lowering the tail to slightly below the chordline extended, however, results in satisfactory pitching moment characteristics at stall especially with flaps deflected.

8. It should be emphasized that these low-speed characteristics were obtained for the particular arrangements shown. Designs have been investigated, for example, where high tail positions have been found satisfactory at low speeds, also; on other designs, tail position may have a large effect at high speeds. The main point that should be made is that systematic design studies for both high and low speed flight are necessary to assure the attainment of satisfactory longitudinal stability and control throughout the speed range.

9. Mr.   will now discuss some aspects of dynamic lateral stability.

Speakers: Toll, Bird, Stanfield, & Gates

Stab anal. Stab tunnel

In considering the disturbed lateral motions of an airplane the effects of the rolling motion and yawing motion on the aerodynamic forces and moments acting on the airplane are very important. These aerodynamic forces and moments due to the rolling and yawing motions are known as rotary stability derivatives. As will be emphasized later, knowledge of their magnitudes is essential in the prediction of dynamic stability characteristics. During the last inspection held at this labofatory, experimental results on some of the rotary stability derivatives of airplane wings were presented. It was also shown at the last inspection that the potential-flow theory is inadequate for the prediction of some of the rotary derivatives of swept wings. In some instances, the experimental values actually had the opposite sign of the theoretical values.

During the past two years, research on this problem has continued. Systematic series' of airplane configurations have been tested, and the results have been utilized in the development of improved methods for estimating the rotary derivatives. In general, the methods involve modifications to the theory by means of empirical corrections, which are a function of measured lift and drag data. This procedure has been applied to several of the rotary stability derivatives. I will illustrate its application to the derivative of yawing moment in roll, which is usually referred to by the symbol C_{n_p} , but first I will demonstrate by means of this model the meaning of this derivative. The derivative C_{n_p} is a measure of the tendency of a rolling motion to produce a change in heading of an airplane. For the usual case, C_{n_p} is negative and a rolling motion causes the downgoing wing to be pulled forward. When C_{n_p} is positive, a rolling motion causes a moment tending to pull the downgoing wing rearward. This latter tendency has been encountered rarely in the past, but it seems to be inherent in many current high-speed airplane designs.

The first chart compares measured and predicted values of C_{n_p} for a 45° sweptback wing of aspect ratio 4. Potential-flow theory predicts negative values at positive lift coefficients. You will note that for the test conditions the experimental values of C_{n_p} are positive over the greater part of the lift-coefficient range. At a higher Reynolds number the positive values of C_{n_p} might be confined to a smaller range of lift coefficients, but the general shape of the curve would not be appreciably altered. The fact that positive values are obtained is attributed to the high drag of outboard sections of the wing, resulting from partial stalling at the higher lift coefficients. The empirical method, which is based on the lift and drag characteristics of the wing, is in reasonably good agreement with experiment.

The vertical fin of an airplane usually contributes a positive increment of C_{n_p} at low lift coefficients. The magnitude of this contribution varies widely with different airplane configurations. The triangular-wing type of airplane for which test results are presented on the next chart, is a rather extreme case. For this configuration, with fins off, C_{n_p} increases positively from zero, at zero lift, as the lift coefficient is increased. When a single large central fin is used, C_{n_p} is found to be positive over the test range of lift coefficients, which extended from 0 to 0.8. With twin vertical fins, located near the wing tips, C_{n_p} has a positive value of approximately 0.1 at zero lift, but becomes negative at high lift coefficients.

The significance of a change in C_{n_p} from negative to positive, insofar as lateral stability is concerned is shown on the next chart. This chart shows the desired period-damping criterion designated by both the Navy and the Air Force in their most recent flying qualities specifications. This criterion gives a particular relationship between period and time to damp for a lateral oscillation and divides the quadrant into a satisfactory and an unsatisfactory region. The results for an airplane with a wing loading of 50 pounds per square foot flying at 500 miles per hour at 20,000 feet altitude indicate that when C_{n_p} is negative this particular airplane has a period-damping relationship, which is located in the unsatisfactory region well away from the criterion, at this point on the chart. A change to a positive value of about .06 results in a large improvement in the damping of the lateral oscillation without changing the period, and shifts the point into the satisfactory region on the chart. Although the effect of a change in C_{n_p} from negative to positive was very beneficial in this case, it should be noted that a sufficiently large positive value of C_{n_p} which might be obtained with an auto pilot will result in an undesirable divergence. This example indicates that the character of the lateral motion is strongly influenced by the value of C_{n_p}. Experience has shown that all the stability derivatives, as well as the mass characteristics, must be accurately known in order to estimate correctly the airplane motions.

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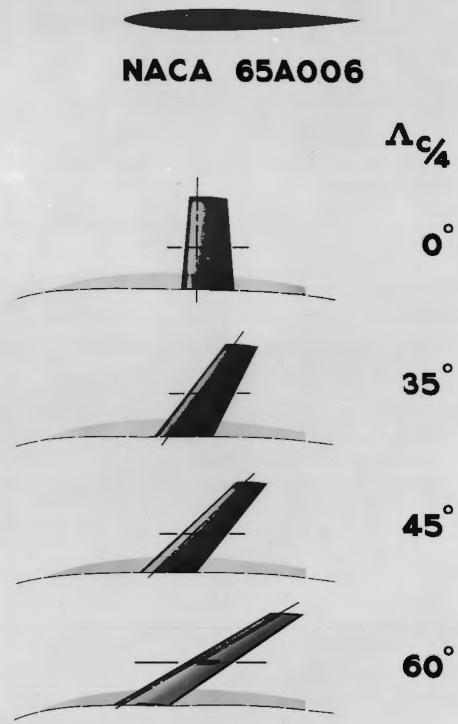
THE 7-BY 10-FOOT WIND TUNNELS

WING CONFIGURATIONS

ASPECT RATIO 4 TAPER RATIO .6



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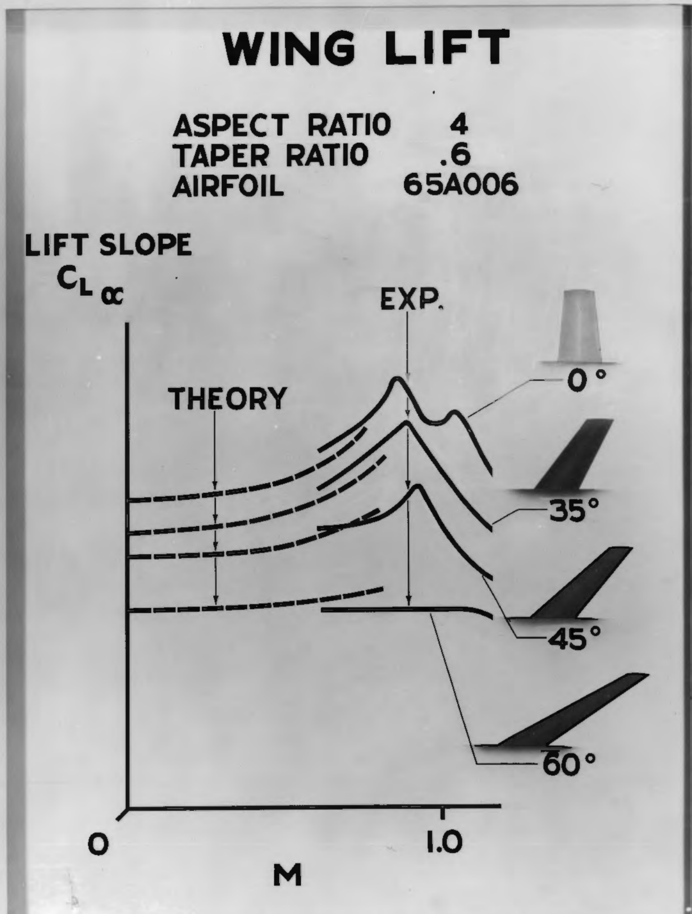

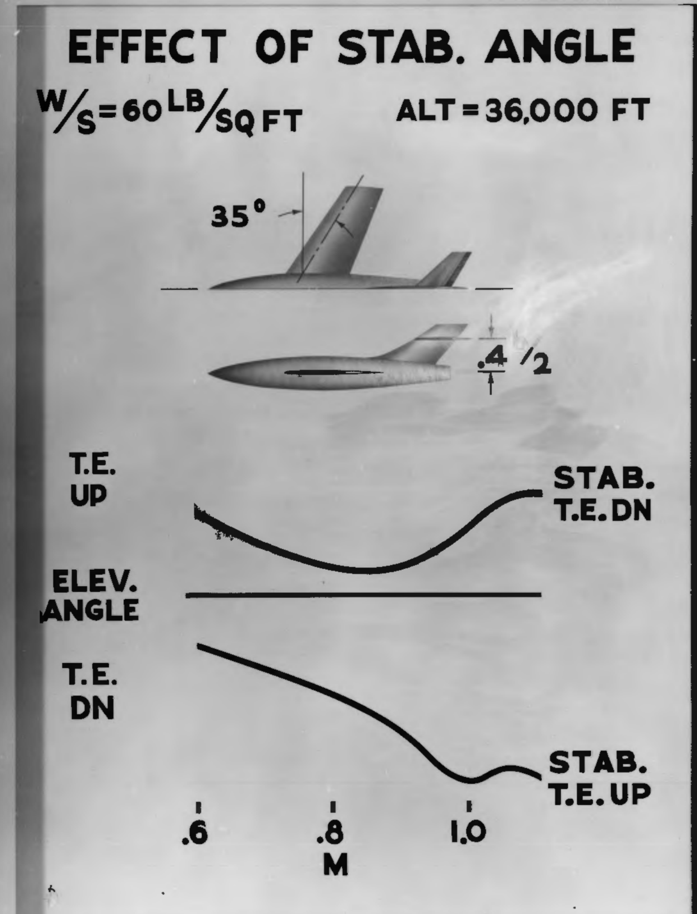

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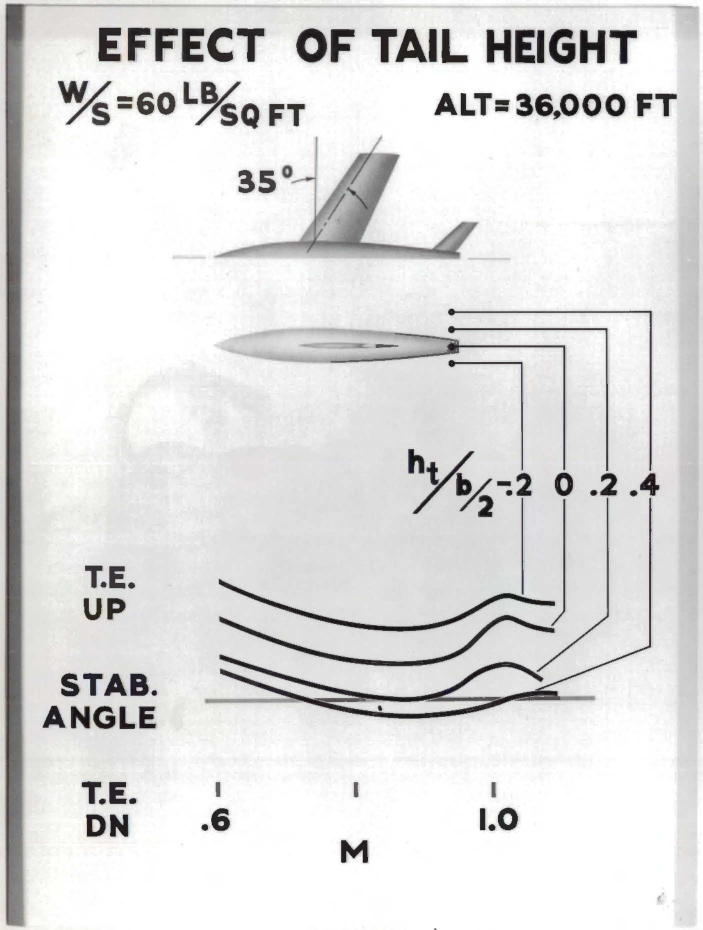

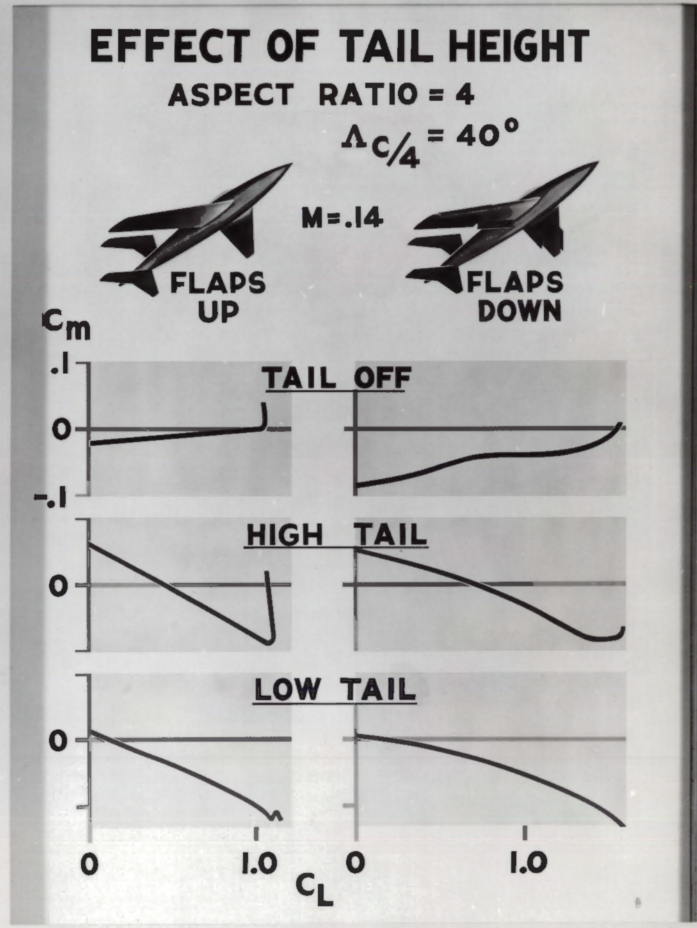

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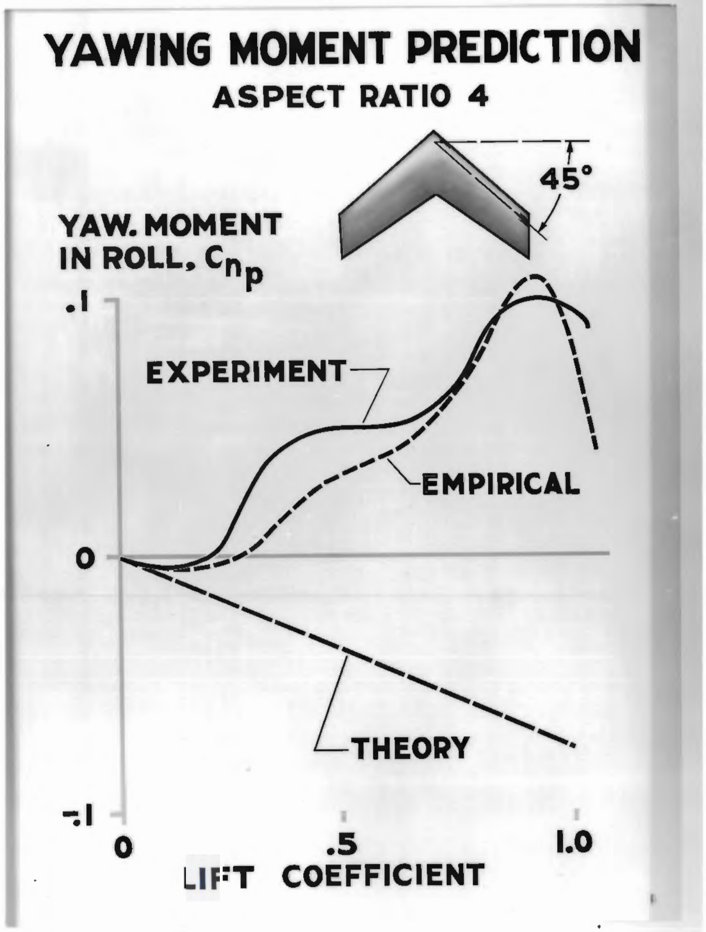

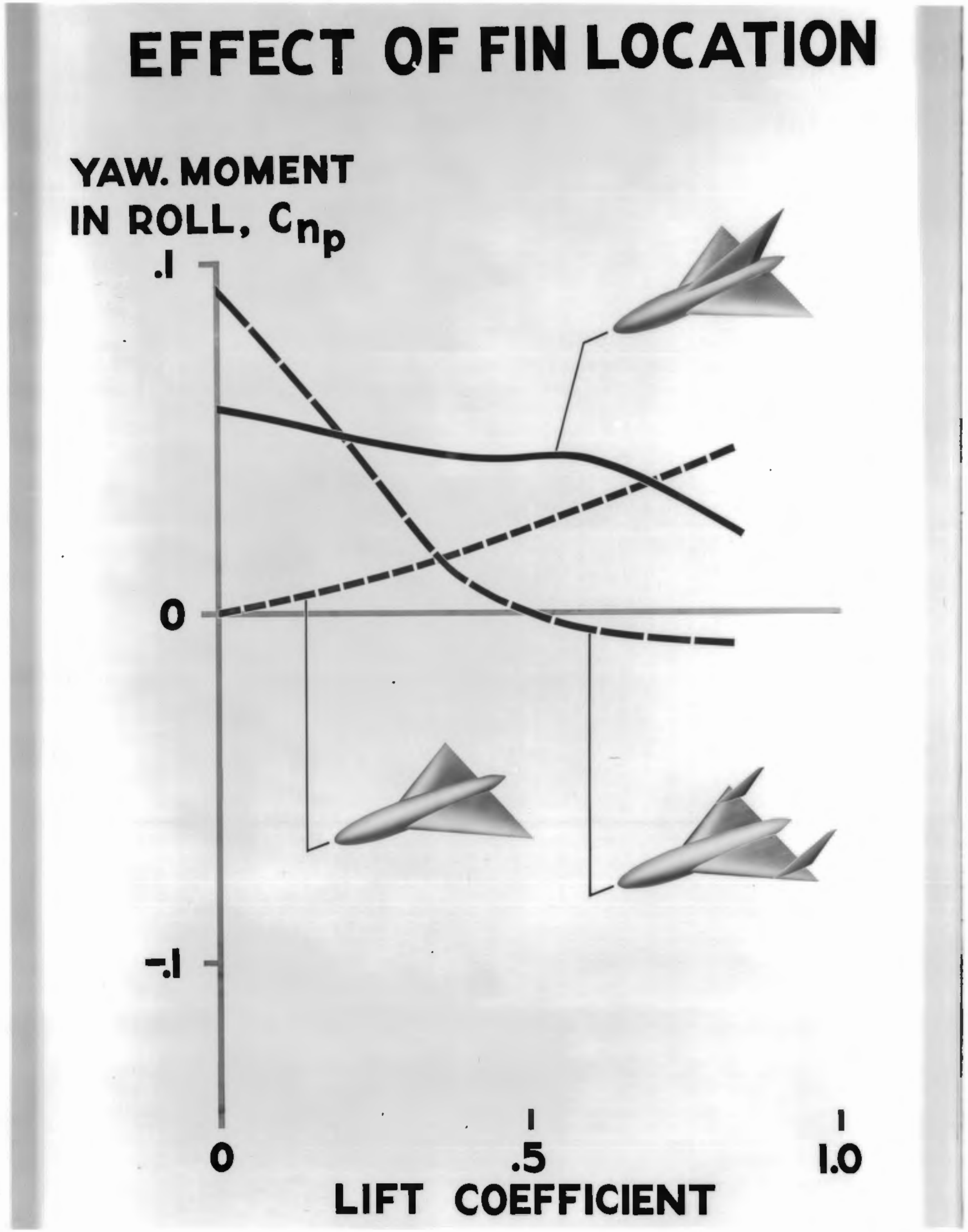

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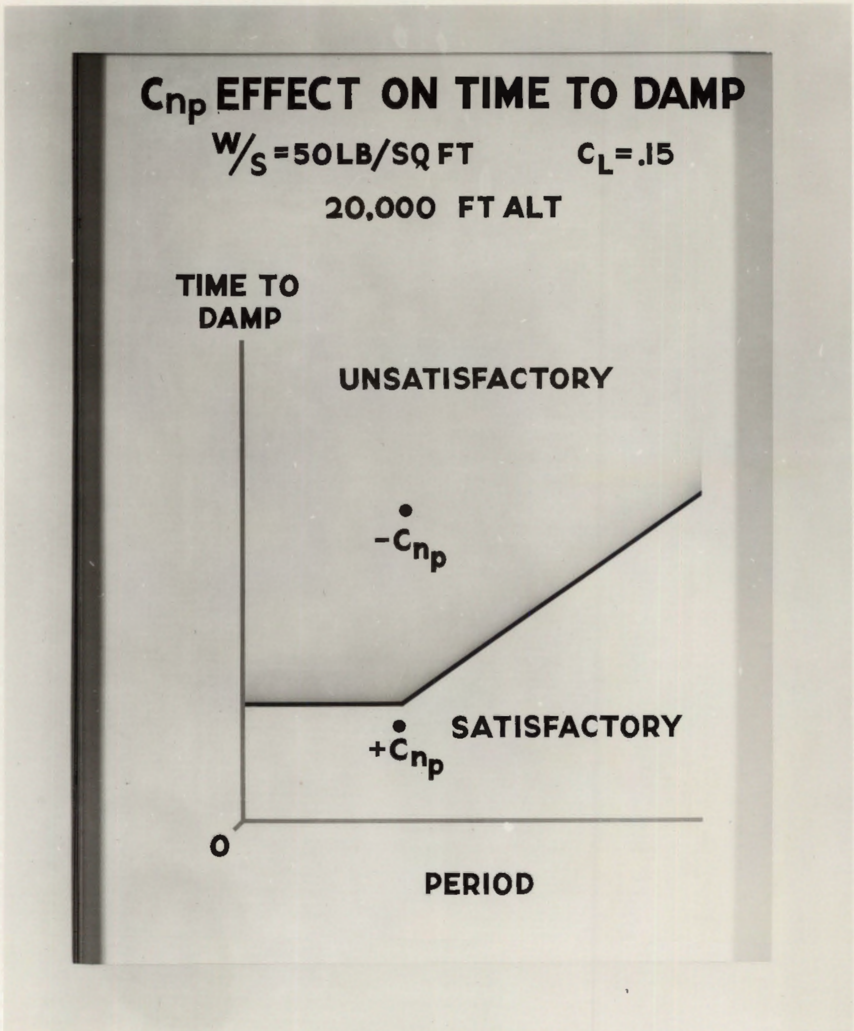

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