(NASA-CR-164684) A PROGRAM TO EVALUATE A
CONTROL SYSTEM BASED ON FEEDBACK OF
AERODYNAMIC PRESSURE DIFFERENTIALS, PART 1
Interim Report (Kansas Univ. Center for
Research, Inc.) 213 p HC A10/MF A01

N81-30134

Unclas
G3/06 27182

ESTABLISHED 1865

THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.
2291 Irving Hill Drive—Campus West
Lawrence, Kansas 66045

Prepared under
NASA Grant No. NAG 4-5

# Interim Report
for
# A PROGRAM TO EVALUATE A CONTROL SYSTEM BASED ON FEEDBACK OF AERODYNAMIC PRESSURE DIFFERENTIALS

KU-FRL-490-1

Part I

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August 1981

# ABSTRACT

This report describes work done under a program to evaluate the use of pressure differentials in a flight control system.

The first part of the program consists of a study to determine the pressure profile around the test surface. This study was performed using two techniques:

1) Windtunnel Data (Actual)
2) NASA/Langley Single Element Airfoil Computer Program (Theoretical).

The system designed to evaluate the concept of using pressure differentials is composed of a sensor drive and power amplifiers, actuator, position potentiometer, and a control surface.

The second part of this program consists of determining the characteristics (both desired and actual) of the system and each individual component. This report, however, terminates with the desired characteristics of the system as a whole. The actual frequency response of the system could not be obtained due to the use of an inappropriate sensor.

This report describes the flight control system developed, the testing procedures and data reduction methods used, and theoretical frequency response analysis.

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# LIST OF SYMBOLS AND ACRONYMS

| Symbol | Definition | Dimension |
|---|---|---|
| $C_p$ | Pressure coefficient | |
| q | Dynamic pressure | lbs, ft$^{-2}$ |
| $\alpha$ | Angle of attack | deg |
| $\theta$ | Euler pitch angle | deg |
| $\delta_E$ | Elevator angle | deg |
| $\omega_{n_{sp}}$ | Undamped natural frequency of the short period mode | Hz |
| $\omega_{n_p}$ | Undamped natural frequency of the dutch roll mode | |
| $\Delta P$ | Change in pressure between lower and upper surface | lbs, ft$^{-2}$ |

## Acronyms

| | |
|---|---|
| DAS | Data Acquisition System |
| AFCS | Automatic Flight Control System |
| SEAP | Single Element Airfoil Program |
| SSSA | Separate Surface Stability Augmentation |

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# 1. INTRODUCTION

## 1.1 PURPOSE

The purpose of this study is to provide information leading to determining the feasibility of using a differential pressure feedback signal in an airplane's flight control system.

## 1.2 BACKGROUND

In nearly all airplanes equipped with automatic flight controls (AFC), the control surfaces are positioned via a feedback loop with a feedback gain proportional to control surface position. Since in many instances control surface position is linearly related to the differential pressure created by a control surface deflection, this type of feedback works well.

However, in many systems, it is found necessary to schedule the feedback gain as a function of flight attitude, Mach number, dynamic pressure, or a combination thereof. (At this point in time, Mach number is not included.)

Since the purpose of any control motion is to create a certain pressure differential, it is logical to consider a system whereby control surface motion is signalled by a gain directly proportional to the pressure differential. The differential itself would then have to be sensed by a suitable pressure sensor.

This method of control surface signalling may simplify control law requirements. It may also allow for the direct control of airplane attitude relative to the total velocity vector of an airplane. This is because such attitudes are themselves proportional to pressure differentials across lifting surfaces (Reference 1).

## 1.3 METHODOLOGY

This study was performed using the following three phases:

1) Pressure profile study
2) Sensor calibration
3) Frequency response and transfer function determination.

The pressure profile study is used to determine the range and characteristics of the test surface. The sensor calibration phase is needed to obtain the sensor's physical characteristics. (The actual work of this study terminated at this phase.) A theoretical frequency response analysis has been conducted; but at the time of this report, the physical testing of this phase has not begun, due to the results of Phase II.

# 2. SYSTEM DESCRIPTION

## 2.1 OVERALL SYSTEM THEORY

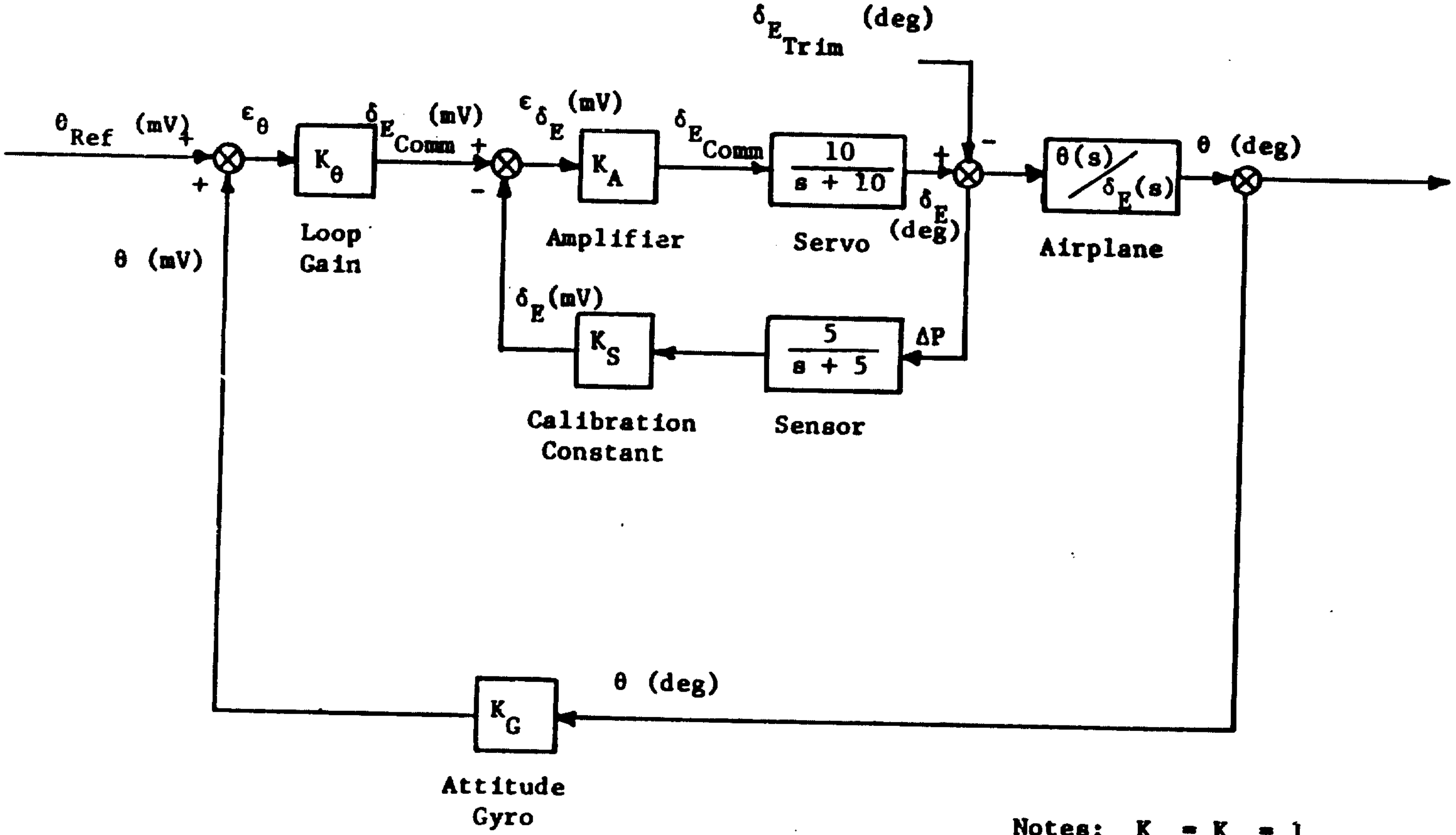
The flight control system which was designed to test the use of a differential pressure sensor is illustrated in Figure 2.1. The block diagram is a pitch attitude hold system with the differential pressure feedback for the $\delta_{E_{COMM.}}$ loop. The flow diagram of the inner loop is illustrated in Figure 2.2.

## 2.2 COMPONENT BREAKDOWN

The components used in the testing are listed in the flow diagram of Figure 2.2 and can be found in the appropriate drawings according to Table 2.1.

Table 2.1 Guide to Delta P Drawings

| Drawing No.(s) | Component |
|---|---|
| DP-0105 | Sensor |
| DP-0204 | Sensor Circuit Schematic |
| DP-0204 | Sensor Wiring Diagram and Layout |
| DP-0301 | Signal Conditioner (Control Box) |
| DP-0204 | Signal Conditioner Schematic |
| DP-0204 | Signal Conditioner Wiring Diagram and Layout |
| DP-0301 | Drive Amplifier |
| DP-0301 DP-0203 | Power Amplifier |
| DP-0203 | Power Amplifier Schematic |
| DP-0101 | Actuator (Assembly View) |
| DP-0101 | Position Potentiometer (Assembly View) |
| DP-0101 | Delta P Test Surface (Assembly View) |



Notes: $K_A = K_G = 1$

$K_S = .047\ q$

Figure 2.1 System Block Diagram

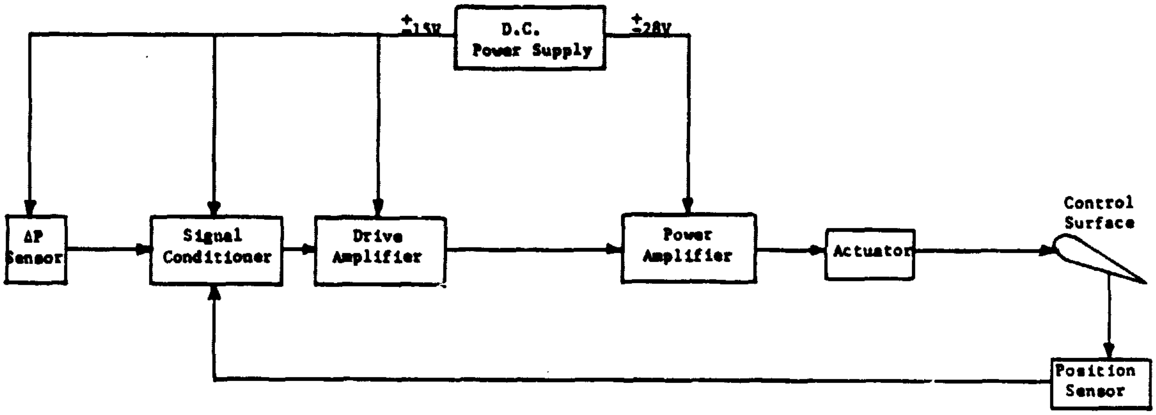


Figure 2.2 System Flow Diagram

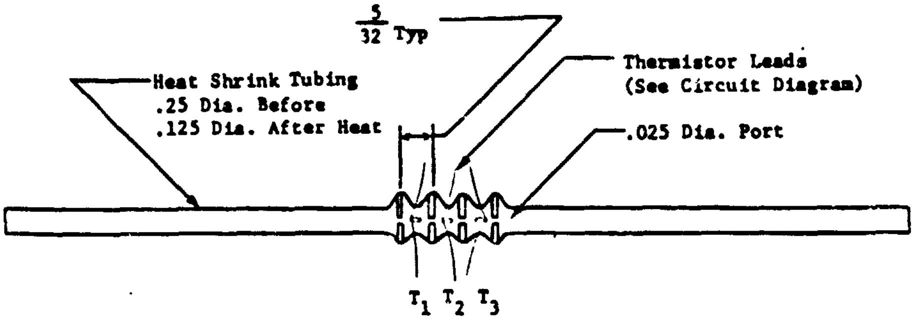


Figure 2.3 Differential Pressure Sensor

### 2.2.1 SENSOR

The sensor used in this study was designed by Jim Black, NASA DFRC Engineer. The sensor uses three thermistors to measure the differential pressure between the two ports. Figure 2.3 illustrates the sensor's components. The circuit diagram for the sensor is found in Figure 2.4.

The sensor, designed to be used in a wing-leveler autopilot system, operates by keeping the middle thermistor at a constant temperature. As the air flows past the front thermistor (a flow due to differential pressure), it is cooled. After passing the middle thermistor, the air is heated, thus causing the rear thermistor to be at a different temperature. This temperature difference results in a voltage difference within the sensor circuit. This difference, again, is the result of a pressure differential.

### 2.2.2 SIGNAL CONDITIONER

The signal conditioner in the flow diagram performs the following tasks:

1) Reads the differential pressure signal from the sensor-circuit combination
2) Monitors the position of the control surface.

The signal conditioner uses the signal from the position potentiometer to prevent a hardover condition.

The circuit diagram for the signal conditioner is given in Figure 2.5. The signal conditioner (designed by Dr. D. G. Daugherty,

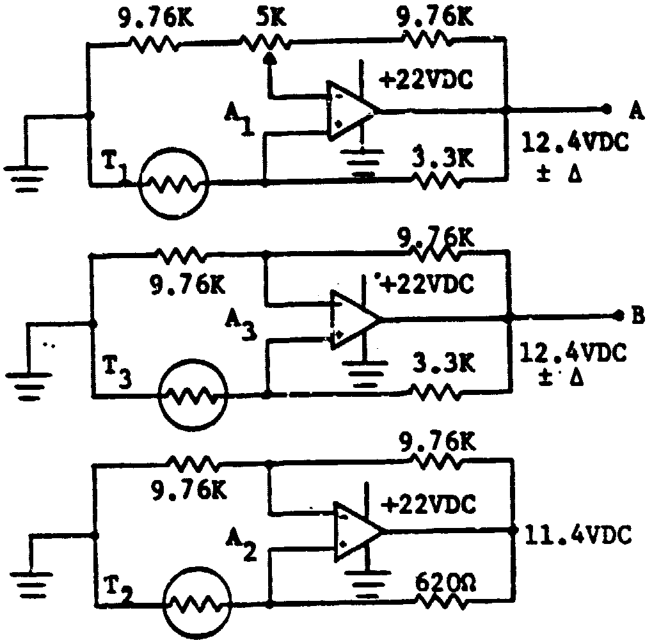
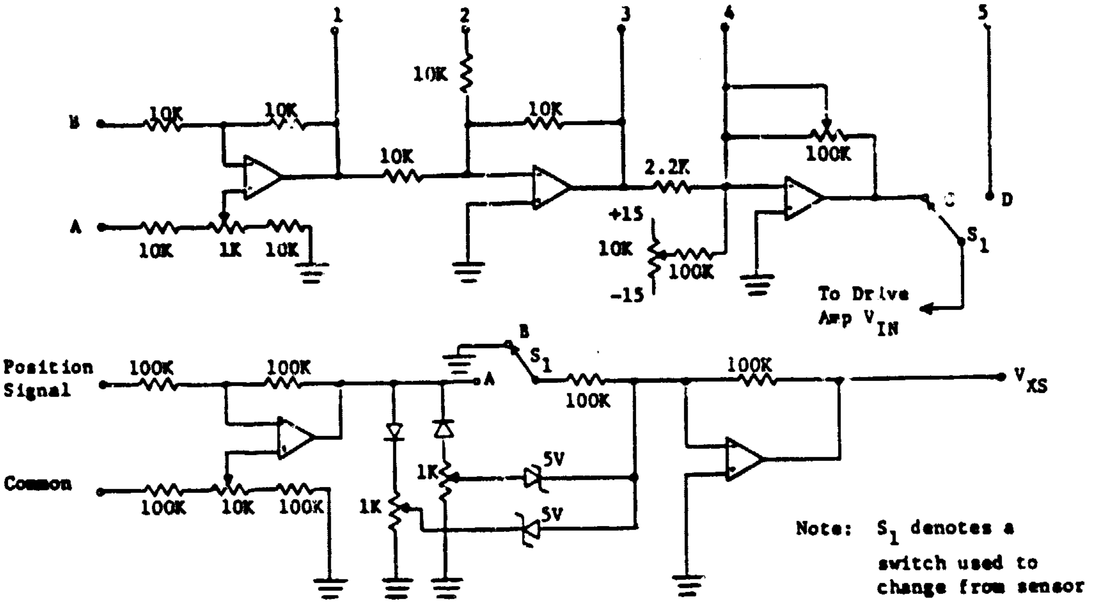


Figure 2.4  Sensor Circuit Schematic



Note: $S_1$ denotes a switch used to change from sensor command to position command

Figure 2.5  Signal Conditioner Schematic

KU Electrical Engineering Professor) was also designed to aid the frequency response testing of Phase III. To do this, test points and input terminals were included; their functions are listed in Table 2.2.

Table 2.2 Signal Conditioner Test Points and Input Terminals

| Circuit Point No. | Symbol | Function |
|---|---|---|
| 1 | +P (OUT) | Differential Pressure Output Signal |
| 2 | $-P_c$ (IN) | Frequency Response Signal Input |
| 3 | $P_c-P = \varepsilon$ | Error Signal |
| 4 | Comp. | Compensating Circuit Signal (if Required) |
| 5 | P.C. | Position Command Signal-Sensor can be bypassed and surface controlled using position potentiometer (LVDT) |

### 2.2.3 DRIVE AMPLIFIER

The drive amplifier used in this study is from the NASA M99 separate Surface Stability Augmentation (SSSA) Project. The schematic of the drive amplifier may be found in Figure 2.6.

The drive amplifier uses standard op-amp methods for developing opposite phase drive signals required by the power amplifier. Discrete transistors connected as complementary emitter-followers provide the necessary drive current for the power amplifier inputs. Small (56 Ω) resistors are included in the collector circuits of

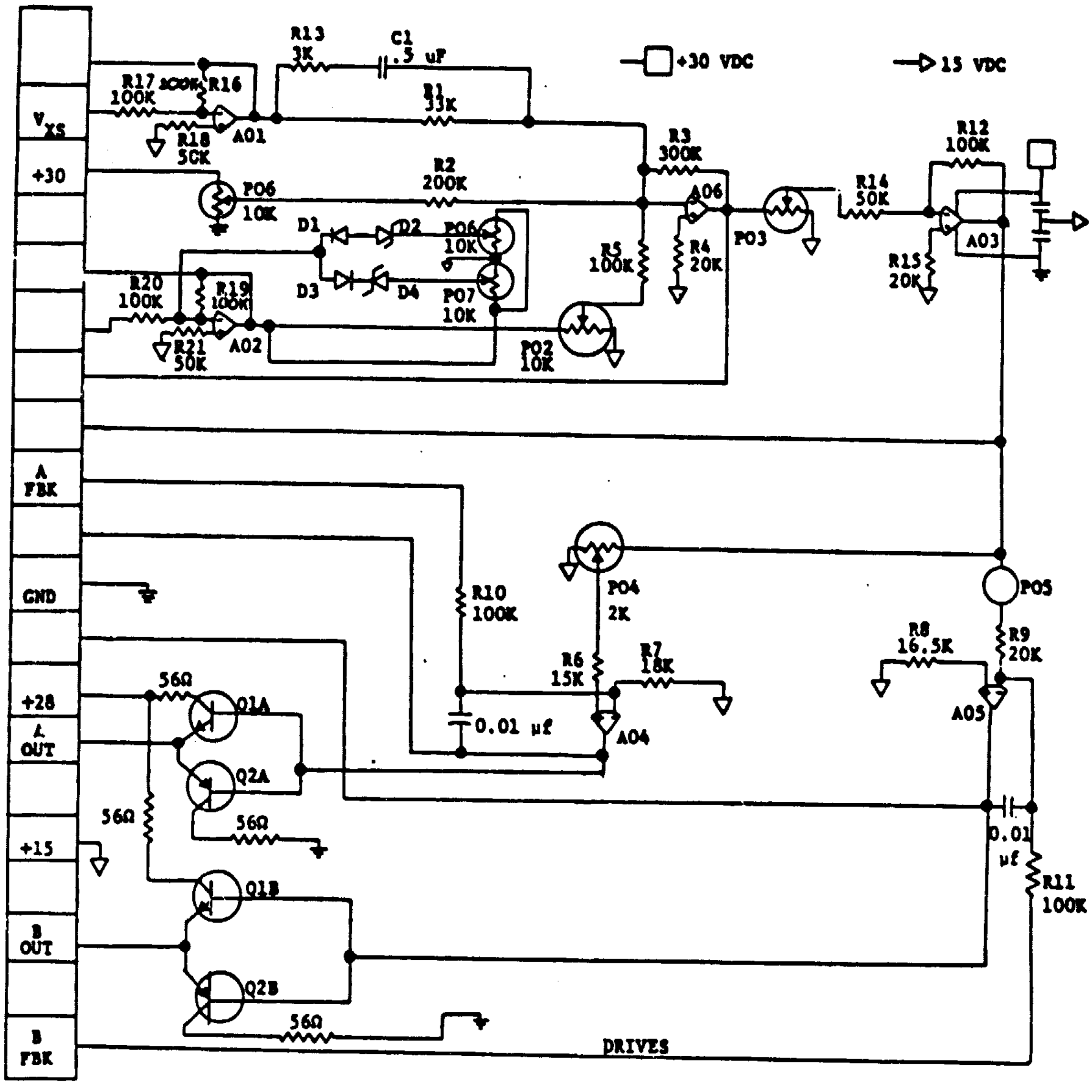


Figure 2.6 Drive Amplifier Schematic (Reference 2)

these emitter-followers as protection against mishaps during circuit testing. In normal circuit operation their function is inconsequential (Reference 2).

The drive amplifier receives the $V_{IN}$ signal from the signal conditioner, while also monitoring the position of the surface through the $V_{XS}$ terminal. The output then goes to the power amplifier.

### 2.2.4 POWER AMPLIFIER

The power amplifier used in this study is also from the SSSA project. The schematic of the power amplifier is given in Figure 2.7.

The power amplifier is a Class-B push-pull bridge configuration. This configuration was used in order to attain actuator voltages approaching ±28 volts (56 volts, peak-to-peak). Diodes are included for protecting the power transistors against inductive spikes from the actuator (Reference 2).

The power amplifier receives four (4) signals from the drive amplifier:

1) A FDBK
2) A IN
3) B FDBK
4) B IN

The A and B FDBK signals are transmitted directly to the actuator. It is these signals which drive the actuator. The A and B IN signals originate at the drive amplifier. The A and B IN signals are connected to the drive amplifiers A and B OUT terminals, respectively.

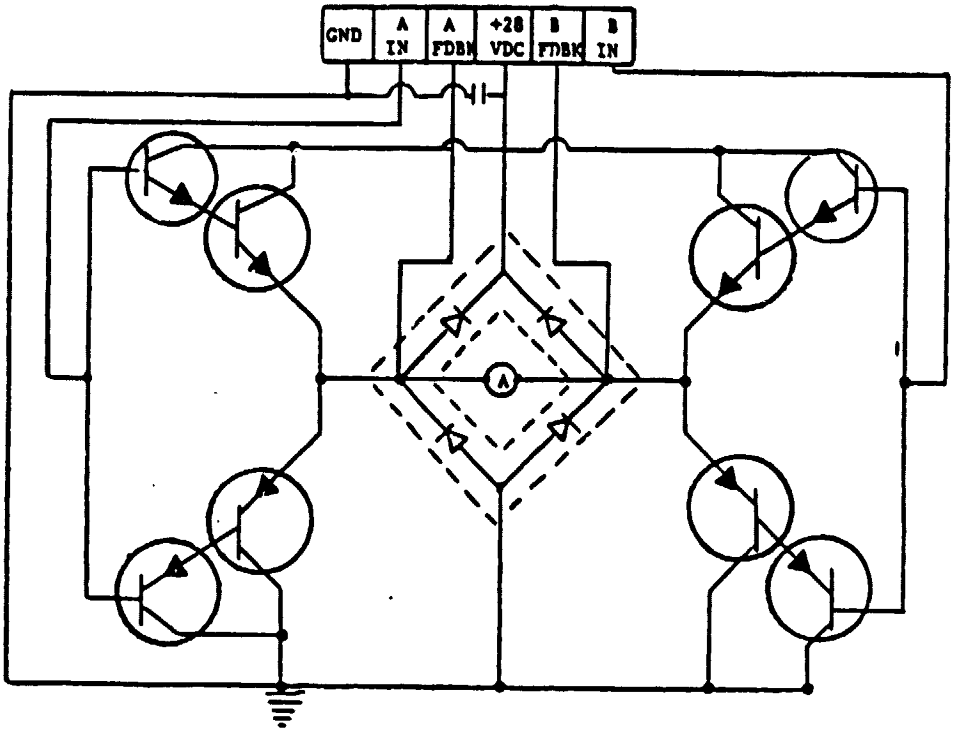
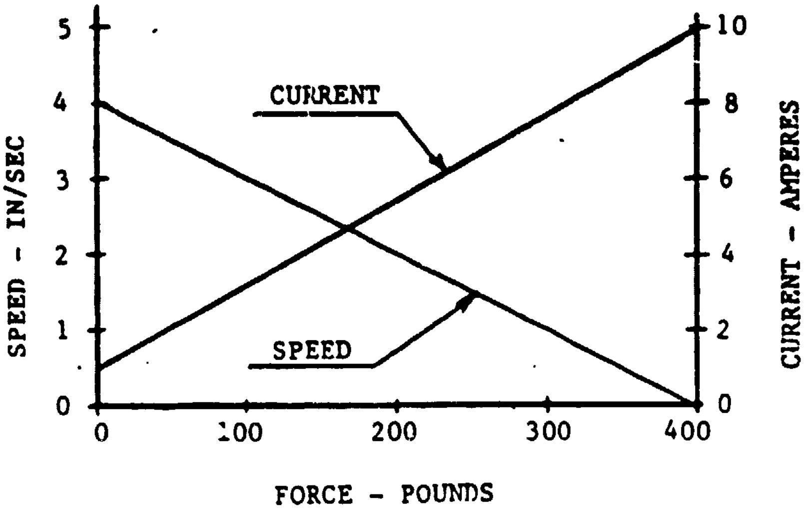


Figure 2.7 Power Amplifier Schematic



NOTE: 28 VDC OPERATION, 25°C

Figure 2.8 Solactor Actuator Properties

### 2.2.5 ACTUATOR

The actuator used in this study is the McDonnell Douglas "Solactor," Model 6023 A, also used in the SSSA project. The properties of the actuator are given in Figure 2.8.

### 2.2.6 POSITION POTENTIOMETER

The position potentiometer (L.V.D.T.) used in this study has the following characteristics:

1) Type: III
2) Resistance: 2K Ω ± 10%
3) Range: 3" linear: 1%

### 2.2.7 SURFACE AND MOUNTING HARDWARE

The test surface used in this study is the Beech, Model 60 (DUKE), elevator-trim tab assembly. The surface was obtained through the Aerospace Engineering Department at the University of Kansas. The surface and mounting hardware are illustrated in Figures 2.9 and 2.10. Also included in these figures are the actuator and L.V.D.T. Table 2.3 gives a listing of the detailed drawings of the surface and mounting hardware which are available through the Flight Research Lab, at the University of Kansas Center for Research, Inc.

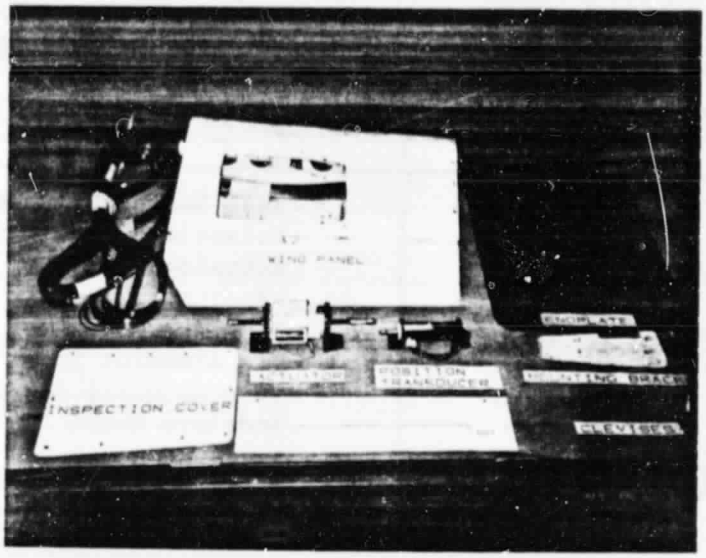


Figure 2.9 Test Surface and Mounting Hardware

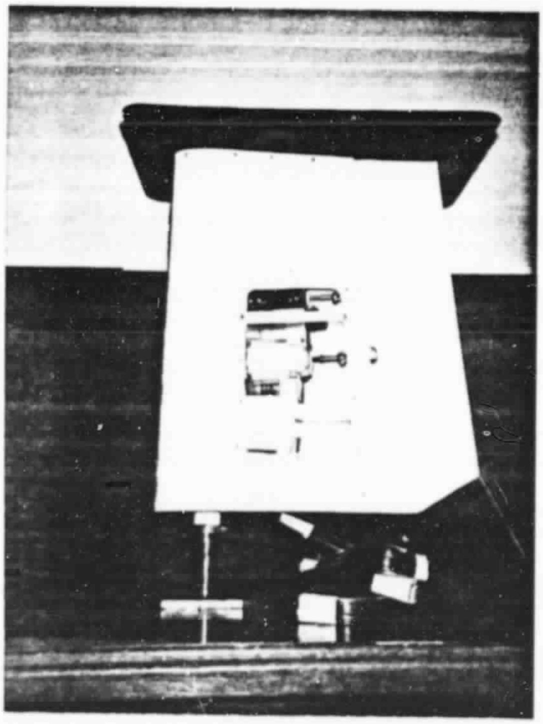


Figure 2.10 Test Surface (Assembly View)

## Table 2.3 Delta P Surface and Hardware Drawings

| Drawing No. | Item |
|---|---|
| DP-0101 | Test Surface (Assembly View) |
| DP-0102 | Potentiometer Clevis |
| DP-0102 | Actuator Clevis |
| DP-0102 | Windtunnel Mount |
| DP-0102 | Mounting Rib |
| DP-0103 | Aft Actuator Mount |
| DP-0103 | Fore Actuator Mount |
| DP-0104 | Endplate Mount |
| DP-0104 | Endplate |

# 3. PHASE I: PRESSURE PROFILE STUDY

## 3.1 PURPOSE

### 3.1.1 BASELINE DATA ON PRESSURE DISTRIBUTION

Because of the uniqueness of the airfoil used, a pressure profile study is necessary to obtain baseline data on the pressure distribution at specific angles of attack and flap deflections. The data obtained during this study are used against the theoretical analysis of Section 6.1. If the pressure distribution can be predicted, then a windtunnel pressure profile study can be eliminated.

### 3.1.2 SENSOR LOCATION

The major objective of the pressure profile study is to determine the location of the differential pressure sensor.

The control system illustrated in Figure 2.2 is designed primarily for flap deflection sensitivity; however, provisions have been made in the signal conditioner control box for angle of attack sensitivity. The selection can be made through a switch mounted on the control box.

The locations of the sensors are determined using the results of the data reduction. These results are best summarized using the graphs found in the data presentation of this report. These graphs show how the change in the pressure coefficient, $\Delta C_p = C_{p_{LOWER}} - C_{p_{UPPER}}$, changes with angle of attack and flap deflections for 13 chordwise locations.

The criteria for selection are as follows:

Sensor No. 1: a) Sensitivity to angle of attack
b) Least sensitivity to flap deflection
c) Consistent linearity

Sensor No. 2: a) Least sensitivity to angle of attack
b) Sensitivity to flap deflection
c) Consistent linearity

With sensors at these two locations, both angle of attack and flap deflection can be sensed separately and accurately within the range of linear aerodynamics.

### 3.1.3 SENSOR RANGE

Results from the pressure profile study are also used to determine the range of pressure required to be sensed by the sensor. It is this characteristic which the sensor does not have.

## 3.2 FACILITIIES AND HARDWARE

### 3.2.1 WINDTUNNEL

All testing of the surface was performed at the University of Kansas Aerospace Engineering Department's 3' x 4' subsonic windtunnel. Facilities include a 60 tube manometer, 26 of which were used for this study. The manometer may be seen in Figure 3.1. Figure 3.2 views the test surface before a run.

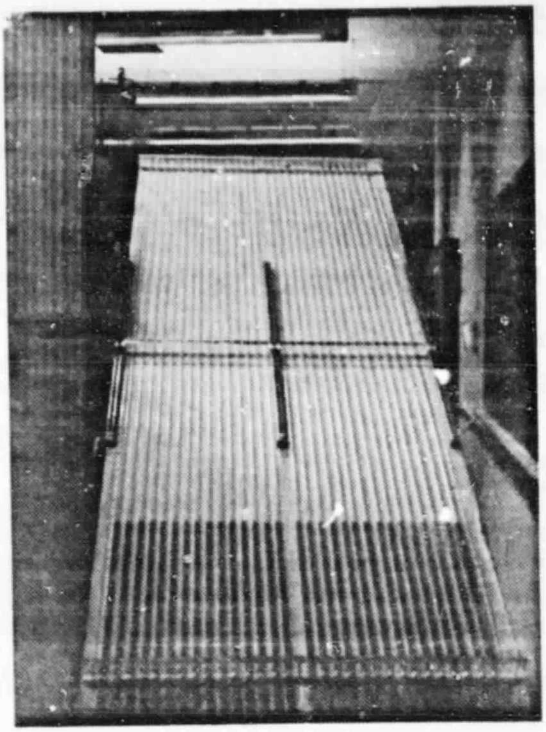


Figure 3.1 Manometer Board

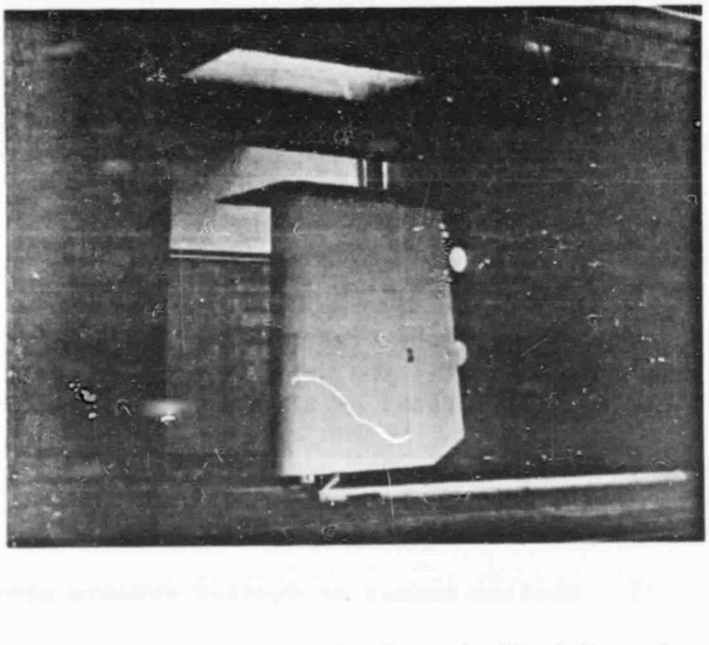


Figure 3.2 Test Surface in Wind Tunnel

### 3.2.2 TEST SURFACE

Provisions were made on the test surface of Figure 3.2 to measure the pressure profile at 13 different locations, on each side of the surface. All static ports were connected to the manometer board using 1/16" I.D. pressure tubing. All connections were made airtight using a polyurethane spray lacquer.

## 3.3 TEST SET-UP

The test set-up consisted of installing the surface in the windtunnel, and connecting the pressure lines to the appropriate connectors on the manometer board. Each pressure line was tested for blockages and leaks. When all lines were determined to be clear and airtight, the testing began. The manometer board was tilted at a 30° angle to match the inclination of the tunnel pitot-static manometer; this simplifies the data reduction.

A static pressure port was installed in the tunnel test section. The port was used for a reference static pressure on the manometer board. Corrections due to position are outlined in Subsection 3.5.1.

## 3.4 PROCEDURES

The procedures for the pressure profile testing followed the items of Table 3.1. A total of nine runs were performed. Each run consisted of the following steps:

1) Setting flap at desired deflection
2) Setting tunnel at desired dynamic pressure

3) Obtaining equilibrium condition in manometer board tubes

4) Setting surface at minimum angle of attack (-8°)

5) Reading manometer board pressure tubes

6) Repeating Steps (3) and (5) for angles of attack -8° to +8° by increments of 2.

Table 3.1 Pressure Profile Run Log

| Run No. | $\alpha$ | $\delta_F$ (deg) |
|---|---|---|
| 1 | $\alpha_{SWEEP}^{*}$ | - 20 |
| 2 | | - 15 |
| 3 | | - 10 |
| 4 | | - 5 |
| 5 | | 0 |
| 6 | | + 5 |
| 7 | | + 10 |
| 8 | | + 15 |
| 9 | | + 20 |

$^{*}\alpha_{SWEEP}$: -8,-6,-4,-2,0,+2,+4,+6,+8 (degrees)

Note: All testing was performed for a tunnel dynamic pressure of 25.6 psf.

## 3.5 DATA PROCESSING

### 3.5.1 DATA CORRECTIONS

The raw data obtained from the Phase I testing includes:

1) Static pressure at the 26 locations along the test surface ($P_s$)

2) Static pressure in the test section ($P_\infty$)

3) Dynamic pressure at the test section (q)

These values, in centimeters of alcohol, are read from the manometer board, inclined to 30°. Before the data can be reduced, two corrections must be made. First, the dynamic pressure must also be corrected for tunnel blockage. The procedure of Pope (Reference 3) is followed. Second, the test section static pressure port (see Figure 3.3), being located forward of the test surface leading edge, reads slightly high due to the increase in dynamic pressure over the surface from tunnel blockage. The incompressible Bernoulli equation is used to calculate the true reference static pressure from the change in dynamic pressure due to blockage.

The corrections are detailed in Part II of this report, which contains all the data obtained from the pressure profile study. Included in Part II are sample calculations, computer program listings, and presentations (tabular and graphical) of the data.

### 3.5.2 DATA REDUCTION

Since the inclination of the manometer board (used to measure the test surface's static pressure) is identical to the dynamic pressure manometer tube, the coefficient of pressure is calculated directly from:

$$C_p = \frac{P_s - P_\infty}{q} \tag{3.1}$$

where the pressures have been corrected as per Subsection 3.5.1. Since differential pressure is the quantity to be investigated, the difference between the lower and upper coefficients is calculated. However, the lower and upper pressure tap locations are not the same. Therefore, the lower surface pressure coefficients are linearly interpolated to the upper surface tap locations.

It is desired to find the chordwise locations that satisfy the criteria specified in Subsection 3.1.2. Toward this end, the change in pressure coefficient, $C_{p_{LOWER}} - C_{p_{UPPER}}$, is plotted against flap deflection and angle of attack for each of the 13 chordwise tap locations. (These graphs are located in Appendix A and in Part II.) This facilitates inspection and interpretation of the data. A numerical regression of the data is performed to quantify the slopes of these graphs. This augments the interpretation of the figures and is used in the theoretical analysis of Section 6.2.

## 3.6 RESULTS AND DISCUSSION

Based on the figures of Appendix A, tap number (13) (x/c = .766) has the best combination of linear sensitivity to flap deflection, and insensitivity to angle of attack. One pressure sensor, located here, can sense flap position with little error to angle of attack. The location of tap number (1) is best for angle of attack sensitivity, but is not used for the purpose of this study.

The required range of the sensor is best put in terms of pressure coefficient:

$$-1.2 \leq \Delta C_p \leq 1.2 \tag{3.2}$$

This is the nondimensional differential pressure occurring at the largest angle of attack and flap deflection tested. At a dynamic pressure of $q = 25$ psf, the required range is:

$$-30 \leq \Delta P \leq +30 \text{ psf} \tag{3.3}$$

If this study is to be repeated, it is recommended that a more common airfoil, with a known, experimental pressure distribution be used. For example, a NACA 0012 would be a good choice because of its wide use in horizontal tails.

# 4. PHASE II: SENSOR CALIBRATION

## 4.1 PURPOSE

The sensor calibration process is performed to determine the relationship between the differential pressure acting on the sensor, and its output. From this process the drive amplifier's gain value is determined.

## 4.2 FACILITIES AND HARDWARE

### 4.2.1 FACILITIES

The calibration tests were performed using the windtunnel facilities previously mentioned in Section 3.2. Also included in the facilities is the Hewlett Packard (HP) 2012 Data Acquisition System (DAS), HP9825 micro-minicomputer, and the HP9872 X-Y plotter, all shown in Figures 4.1 and 4.2. A schematic of the entire data acquisition system is illustrated in Figure 4.3.

### 4.2.2 HARDWARE

The hardware and components used for the calibration tests included:

1) Differential pressure sensor
2) Sensor calibration mount
3) Signal conditioner

The calibration mount is shown in Figure 4.4. The mount provides a pitot-static pressure differential across the sensor which is

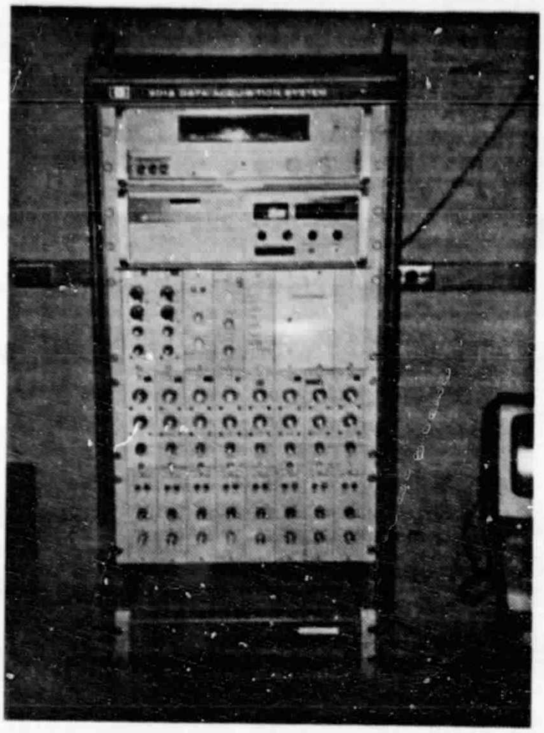


Figure 4.1 2012 Data Acquisition System

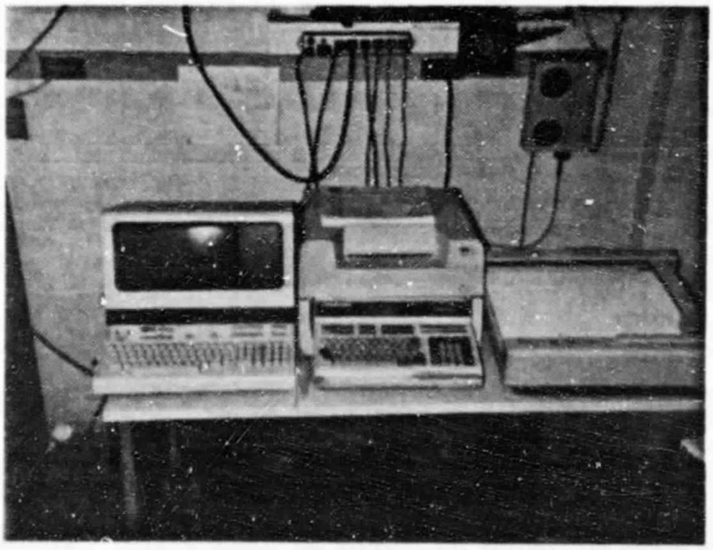
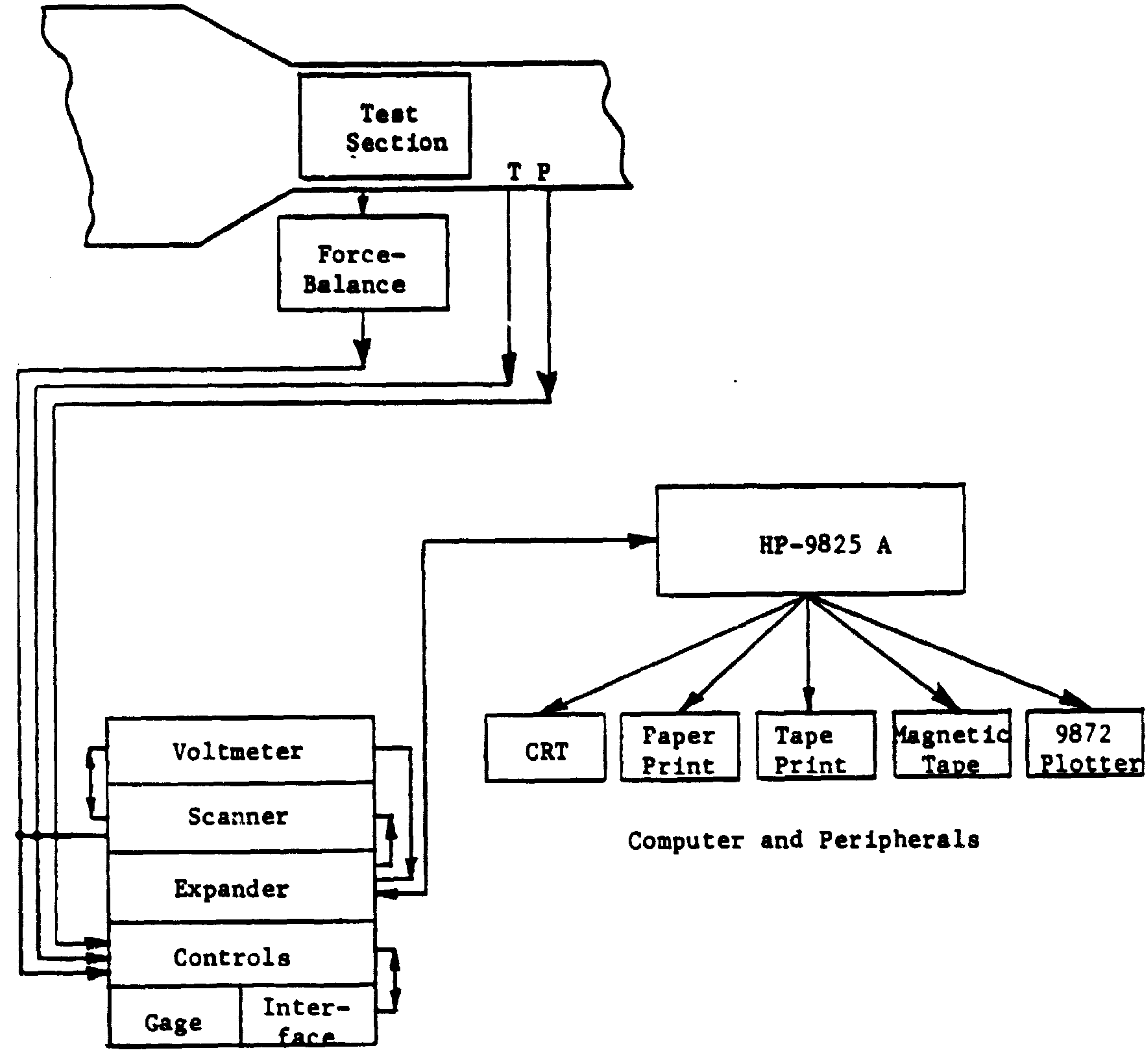


Figure 4.2 HP9825 A Computer and 9872 Plotter



HP-2012 Data Acquisition System

Computer and Peripherals

Figure 4.3 Data Acquisition System Schematic

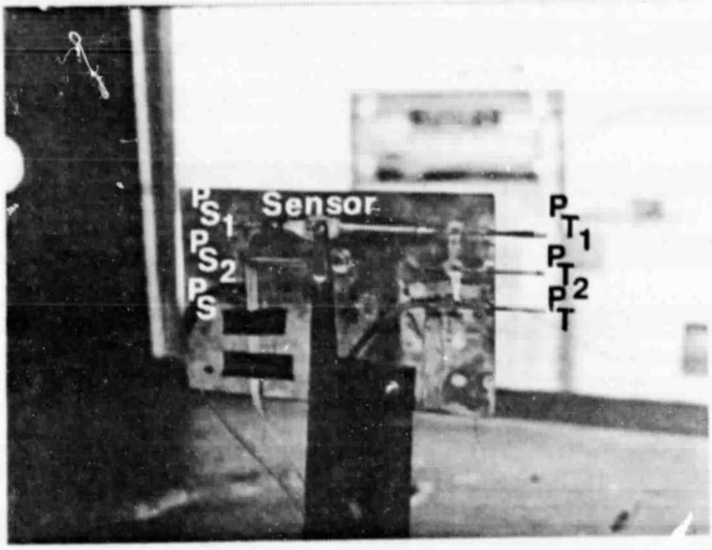


Figure 4.4 Pressure Sensor Calibration Mount

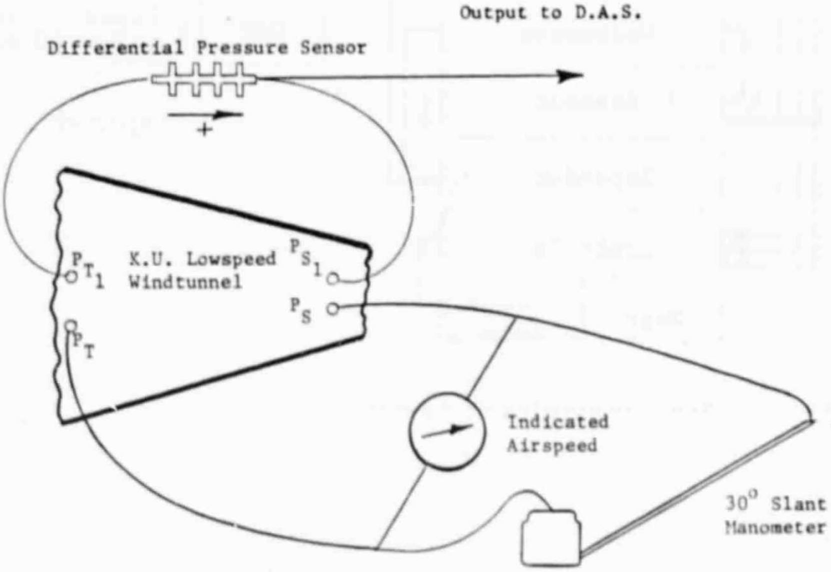


Figure 4.5 Calibration Schematic

calibrated against the tunnel manometer. The apparatus utilizes a "u" shaped windtunnel mount to secure it in the tunnel.

## 4.3 TEST SET-UP

The schematic of Figure 4.5 illustrates the uses of the components for the calibration process. The set-up consists of securing the sensor on the calibration mount and checking the side-slip angle (β) of the plate so the flow becomes just attached.

Channels 12 and 13 of the DAS are then zeroed. This is done using the 5K Ω potentiometer of Figure 2.4. In effect, this is causing the output of the fore and aft thermistors to equal, negatively. Once initialized, the calibration process can begin.

## 4.4 PROCEDURES

The calibration procedures follow the computer listing of Appendix B on Page 81. Once initialized, the computer asks for the tunnel dynamic pressure, which is the differential pressure of the sensor. As the desired tunnel dynamic pressure is attained, the DAS takes 10 sampled values and obtains the average. This average is then used in the output and for plotting purposes. Table 4.1 gives the output of a typical calibration run. The output is then plotted in Figure 4.6. As indicated in the output, the tunnel dynamic pressure range is from 0 to 35 cm of alcohol, or 0 to 27.2 psf.

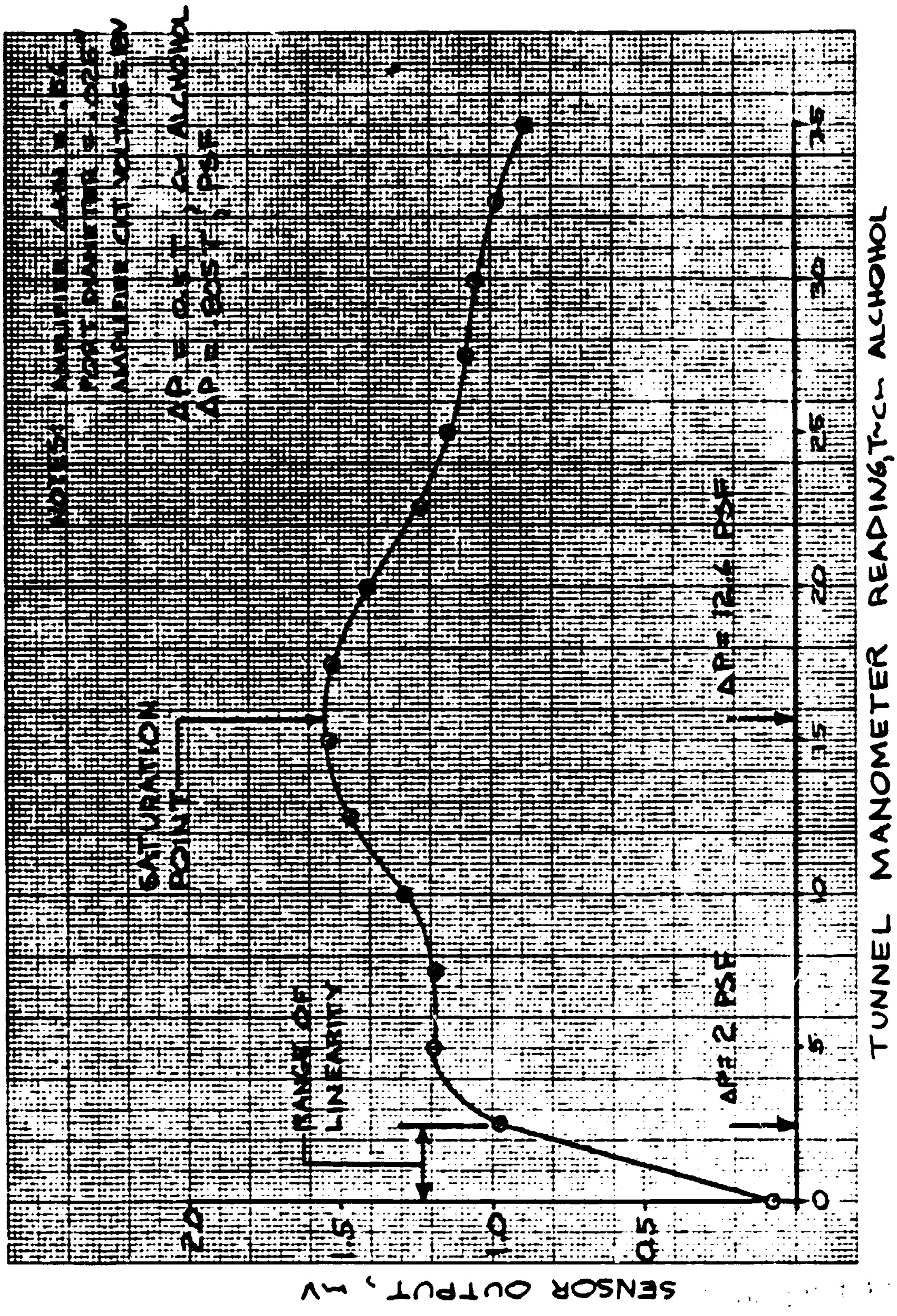


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Figure 4.6 Sensor Calibration Curve

Table 4.1 Calibration Run Data

| Manometer Dynamic Pressure (cm. of alcohol) | Transducer Output (mVolts) |
|---|---|
| 0 | - 0.080 |
| 2.5 | - 0.982 |
| 5.0 | - 1.185 |
| 7.5 | - 1.183 |
| 10.0 | - 1.290 |
| 12.5 | - 1.464 |
| 15.0 | - 1.538 |
| 17.5 | - 1.525 |
| 20.0 | - 1.410 |
| 22.5 | - 1.225 |
| 25.0 | - 1.140 |
| 27.5 | - 1.083 |
| 30.0 | - 1.049 |
| 32.5 | - 0.982 |
| 35.0 | - 0.889 |

## 4.5 RESULTS AND DISCUSSION

The results of the calibration tests indicate that for this type of application, the sensor is not adequate due to shortcomings in two areas:

1) Sensor range
2) Dynamic response.

It was found that the sensor produced a linear output only up to approximately 2 psf. In addition, the sensor became completely saturated at values up to 13 psf. As outlined in Section 3.6, the required linear range of the sensor is ±30 psf.

A pressure sensor can usually be mathematically modelled by a pure lag. Although specific dynamic response tests were not performed, it was observed that approximately 10 seconds was required for the sensor output to return to zero after a pressure differential was removed. This type of response is unacceptable in a feedback control system.

## 4.6 MODIFICATIONS AND SUBSEQUENT RESULTS

Various methods were tried to obtain different sensor characteristics. The following methods were suggested by Jim Black, designer of the sensor:

1) Change sensor port diameter
2) Change amplifier gain.

### 4.6.1 SENSOR PORT DIAMETER

The sensor port diameter was changed from the original diameter of .025" to a diameter of .0135". This was done by plugging both ports on the calibration mount with epoxy. The epoxy was ther drilled out to a .0135" diameter (#80 drill).

The calibration process was then repeated. It was found that while the sensor range was slightly increased, the dynamic response characterictics were degraded.

### 4.6.2 AMPLIFIER GAIN

The amplifier (sensor) was altered by changing the resistance of the input resistor to the amplifier of Figure 2.4. The amplifier gain was changed to values of .01, .10, and .50. Again, the saturation point remained unchanged.

### 4.6.3 AMPLIFIER VOLTAGE

The sensor circuit of Figure 2.4 defines the input voltage to the amplifier as +22 volts d.c. The amplifier voltage used in the testing was set at 15 volts d.c. To see if any difference would result, the voltage was increased to 18 volts d.c. (the limit voltage for the LM 324N OP AMP). This tended to increase the saturation point, but still not to the required value. The linear range appeared to be unchanged.

### 4.6.4 MIDDLE THERMISTOR

A sensor thermistor profile was conducted to determine how the voltage, current, and resistance of each thermistor in the sensor was changing as the pressure differential increased. It was concluded that the middle thermistor was not able to increase its power output after a relatively low pressure was applied to the sensor. Four (4) different thermistors replaced the middle thermistor to check this theory. Using values of 5K, 10K, 50K, and 100K Ω, the power output of the middle thermistor was increased. The results were encouraging but still saturated out before maximum estimated pressure differential occurred.

### 4.7 CONCLUSIONS AND RECOMMENDATIONS

The sensor is not suitable for the purpose of this study. There are two types of pressure sensors available today that meet the needs of the project.

Conventional diaphragm pressure sensors have the range, accuracy, and dynamic response required but are relatively expensive.

A Piezoresistive sensor offers the same qualities for a reasonable cost. A brief literature search is recommended before final selection is made.

## 5. PHASE III: FREQUENCY RESPONSE

Phase III of this study is designed to determine the transfer function for the system, actuator, and sensor. The circuit can be either assumed to be a pure gain, or determined analytically. Once these transfer functions are known, a closed loop analysis of a typical feedback control system can be performed, and the stability determined. A theoretical analysis of a typical control system is included in Section 6.2.

Phase III is composed of Parts A, B, and C. The objective of Part A is to obtain standard lift, drag, and pitching moment coefficients and their variations with $\alpha$ and $\delta_F$. The run schedule for Part A is given in Table 5.1.

Table 5.1 Part A Run Schedule

| Run No. | $\alpha$ | $\delta_F$ (degrees) | q (psf) |
|---|---|---|---|
| 1 | ① | - 20 | 25 |
| 2 | | - 15 | |
| 3 | | - 10 | |
| 4 | | - 5 | |
| 5 | | 0 | |
| 6 | | + 5 | |
| 7 | | + 10 | |
| 8 | | + 15 | |
| 9 | ↓ | + 20 | ↓ |

Note: ① $\alpha = -8, -6, -4, -2, 0, +2, +4, +6, +8$ (degrees)

Part B of Phase III is designed to obtain preliminary data on system performance at various angles of attack and initial flap positions. (Several of the runs may be deleted if the initial indications are promising.) This is accomplished by applying a step input to the pressure sensor via the signal conditioner control box. The run schedule for Part B is given in Table 5.2.

Table 5.2 Part B Run Schedule

| Run No. | α (deg) | $\Delta P_{COMMAND}$* | $\delta_{F_{INITIAL}}$ (deg) | q (psf) |
|---|---|---|---|---|
| 1 | - 8 | ② ↓ | - 10 | 25 ↓ |
| 2 | - 8 | | 0 | |
| 3 | - 4 | | - 10 | |
| 4 | - 4 | | 0 | |
| 5 | 0 | | - 10 | |
| 6 | 0 | | 0 | |
| 7 | + 4 | | - 10 | |
| 8 | + 4 | | 0 | |
| 9 | + 8 | | - 10 | |
| 10 | + 8 | | 0 | |

Note: ② $\Delta C_p = 0.1, 0.3, 0.5, 1.0$ or

$\Delta P = 2.5, 7.5, 12.5, 25$ psf at $q = 25$psf

The data obtained will be presented as illustrated in Figure 5.1.

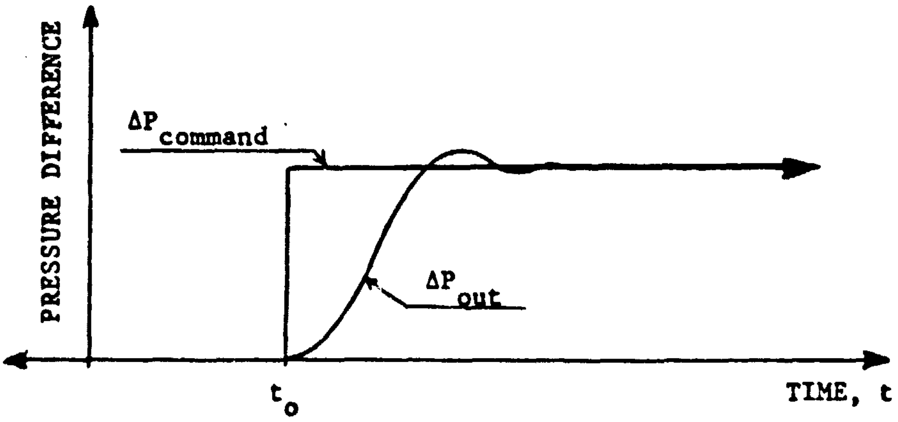

Figure 5.1 Response to a Step Input

Part C will be used to determine the necessary frequency response characteristics of the system. A total of 18 windtunnel runs will be used to obtain the data, each containing the following:

| INPUTS | OUTPUTS |
|---|---|
| $\delta_{F_{IN}}(t) = \lvert\delta_{F_{IN}}\rvert\cos\omega t$ | $\delta_{F_{OUT}}(t) = \lvert\delta_{F_{OUT}}\rvert\cos(\omega t + \phi_1)$ |
|  | $\Delta P_{OUT}(t) = \lvert\Delta P_{OUT}\rvert\cos(\omega t + \phi_2)$ |
| $\Delta P_{IN}(t) = \lvert\Delta P_{IN}\rvert\cos\omega t$ | $\delta_{F_{OUT}}(t) = \lvert\delta_{F_{OUT}}\rvert\cos(\omega t + \phi_3)$ |
|  | $\Delta P_{OUT}(t) = \lvert\Delta P_{OUT}\rvert\cos(\omega t + \phi_4)$ |

The reader should note the following:

1) $\delta_F$ inputs directly into the actuator.
2) $\Delta P$ inputs into the control circuit.
3) Frequency range: $.01 < \omega < 1000$ rad/sec.

Tables 5.3 (a) and (b) give the run schedules for this part of the frequency response testing. The sinusoidal inputs to the actuator and sensor will be accomplished by connecting a function generator to the appropriate inputs on the signal conditioner. A two-channel strip chart recorder will be used to monitor the outputs of the sensor and L.V.D.T.

The data obtained during this phase of the study would be presented in the form of a standard bode plot. It will be from these plots that a transfer function will be derived. These transfer functions will then be tested against those used in the theoretical analysis of Section 6.2.

**Table 5.3(a) Frequency Response Test Runs - Position**

| Run No. | $\alpha$ (deg) | $\lvert \delta_{F_{IN}} \rvert$ | $\lvert \Delta P_{IN} \rvert$ | q (psf) |
|---|---|---|---|---|
| 1 | - 8° | ③ ↓ | - | 25 ↓ |
| 2 | - 6 | | - | |
| 3 | - 4 | | - | |
| 4 | - 2 | | - | |
| 5 | 0 | | - | |
| 6 | + 2 | | - | |
| 7 | + 4 | | - | |
| 8 | + 6 | | - | |
| 9 | + 8 | | - | |

**Table 5.3(b) Frequency Response Test Runs - Pressure**

| Run No. | $\alpha$ (deg) | $\lvert \delta_{F_{IN}} \rvert$ | $\lvert \Delta P_{IN} \rvert$ | q (psf) |
|---|---|---|---|---|
| 1 | - 8 | - | ② ↓ | 25 ↓ |
| 2 | - 6 | - | | |
| 3 | - 4 | - | | |
| 4 | - 2 | - | | |
| 5 | 0 | - | | |
| 6 | + 2 | - | | |
| 7 | + 4 | - | | |
| 8 | + 6 | - | | |
| 9 | + 8 | - | | |

Note: ② $\lvert \Delta P_{IN} \rvert$ = 2.5, 7.5, 12.5, 25 psf at q = 25 psf

③ $\lvert \delta_{F_{IN}} \rvert$ = 5, 10, 15, 20 degrees

# 6. THEORETICAL ANALYSIS

## 6.1 THEORETICAL PRESSURE DISTRIBUTION

The windtunnel test described in Chapter 3 required significant amounts of time, manpower, and hardware development. It is desirable to find a way to bypass the need for this test. If a commonly used airfoil with the necessary testing already performed (e.g., NACA 4 and 5 digit airfoils) is chosen, then the published results can be used instead of repeating the test. However, the test surface employed for this study incorporated a unique airfoil (see Figure 6.1) with an unknown pressure distribution. Therefore, to avoid windtunnel testing, numerical methods must be used. The method used for this study was the NASA/Langley Single Element Airfoil Program (SEAP), which was stored on the University of Kansas Honeywell 66/60.

The program requires, as input, the airfoil coordinates listed in Table 6.1. Mach number and Reynolds number inputs are the same as in the Phase I testing. Included in the output is a listing of the pressure coefficients at chordwise stations along the airfoil (see Appendix B for sample output).

A total of 16 cases were input to the program—four angles of attack ($\alpha = 0, 3, 6, 9°$) and four flap deflections ($\delta_F = 0, 5, 10, 15°$). It is assumed that symmetry holds with respect to angle of attack and flap deflections. Flap deflections are input to the program by altering the airfoil coordinates aft of the hingeline (see Figure 6.2 and Table 6.2). Due to difficulties with software, results were not obtained for the case of $\alpha = 9°$, $\delta_F = 0°$.

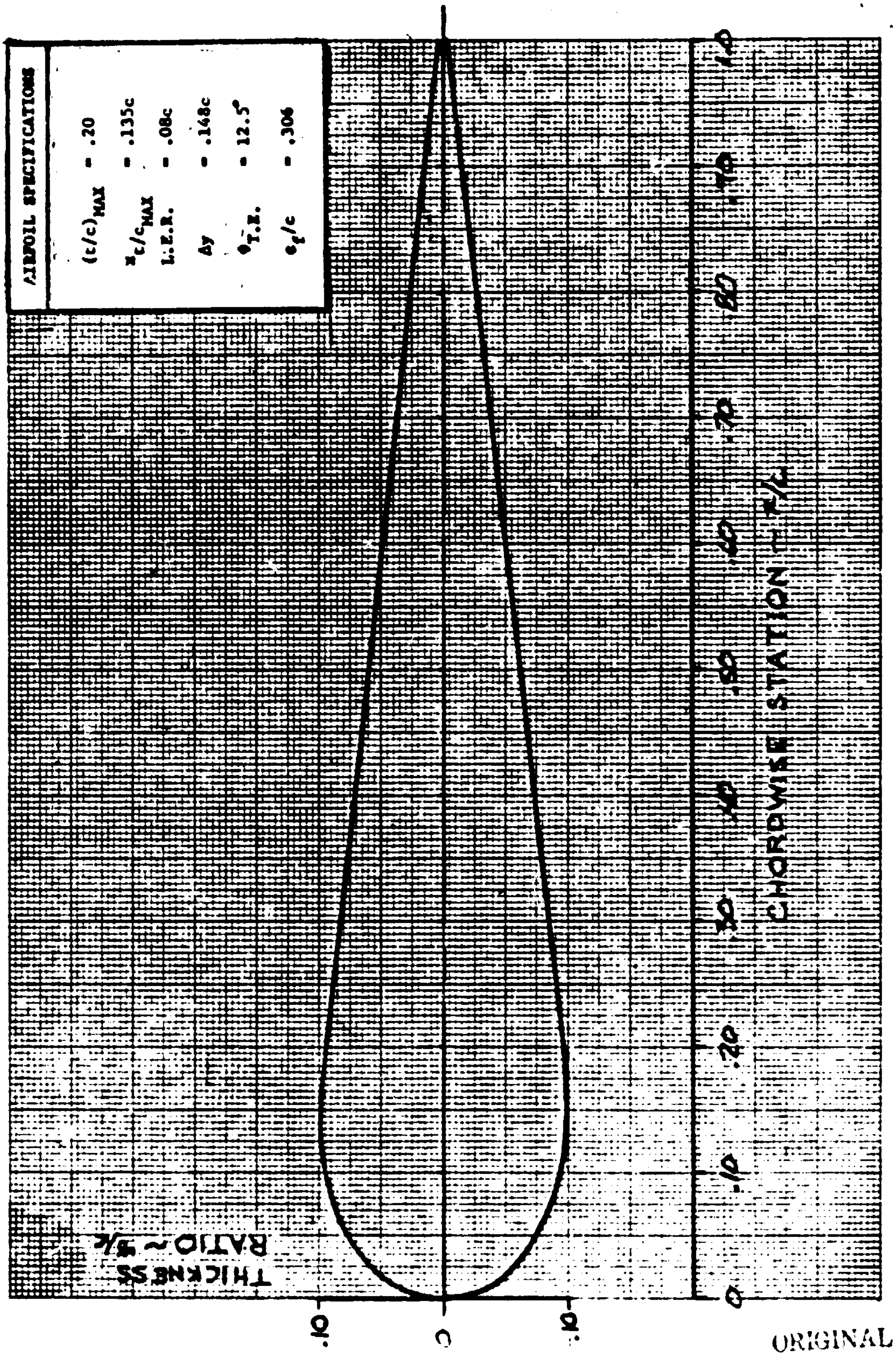

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Figure 6.1 Delta P Airfoil Section

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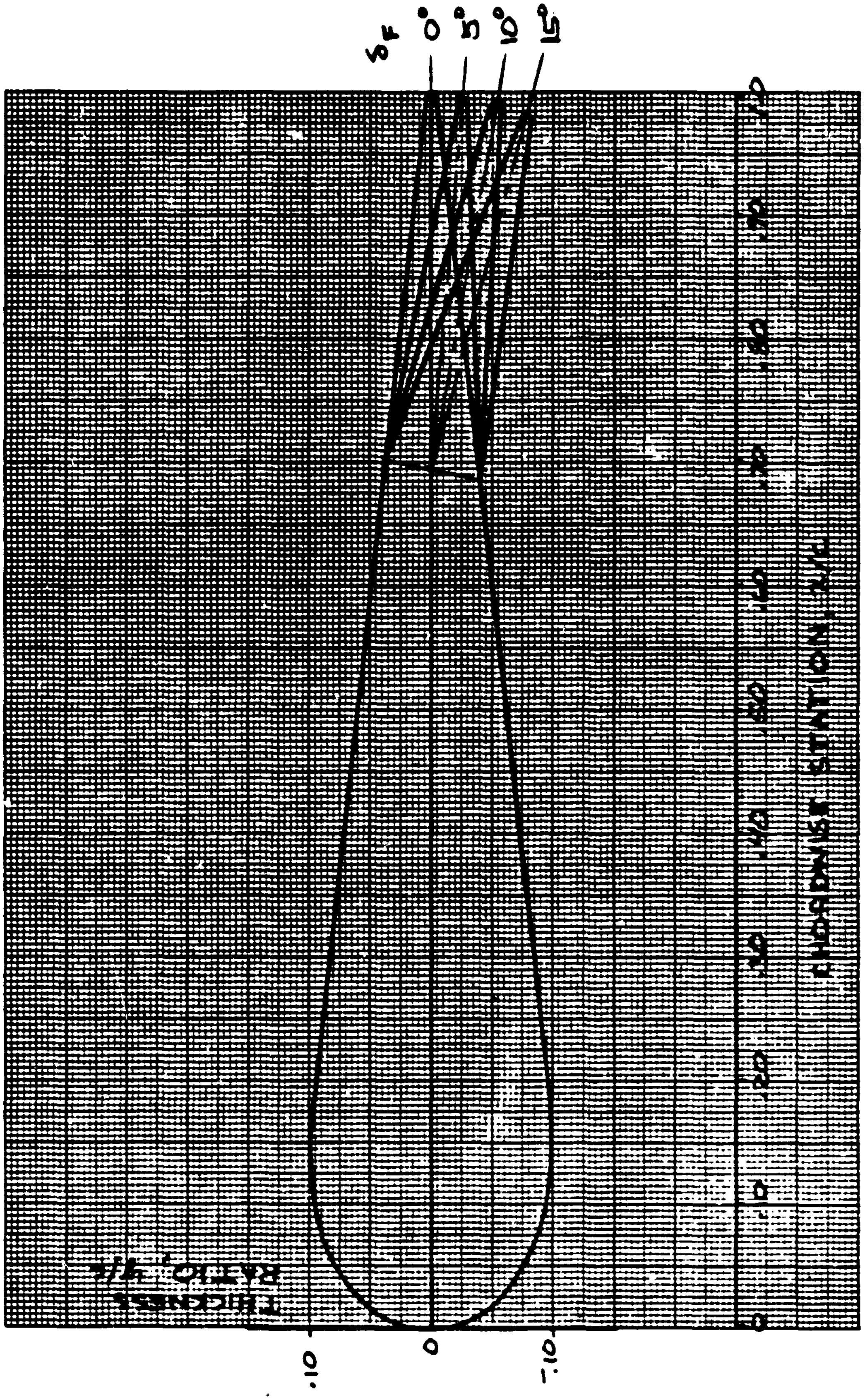

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Figure 6.2 Airfoil with Flap Deflections

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## Table 6.1 Delta P Airfoil Coordinates - Zero Flap Deflection

| XU (=XL) | ZU (= -ZL) | XU (=XL) | ZU (= -ZL) |
|---|---|---|---|
| 0 | 0 | .325 | .080 |
| .00625 | .032 | .350 | .077 |
| .0125 | .043 | .375 | .074 |
| .01875 | .052 | .400 | .071 |
| .0250 | .057 | .425 | .06825 |
| .03125 | .064 | .450 | .0655 |
| .0375 | .069 | .475 | .06275 |
| .04375 | .073 | .500 | .060 |
| .0500 | .077 | .525 | .05725 |
| .05625 | .081 | .550 | .0545 |
| .0625 | .083 | .575 | .05175 |
| .06875 | .085 | .600 | .049 |
| .0750 | .087 | .625 | .04625 |
| .08125 | .090 | .650 | .0435 |
| .0875 | .092 | .675 | .04075 |
| .09375 | .093 | .700 | .038 |
| .100 | .094 | .725 | .035 |
| .1125 | .0965 | .750 | .032 |
| .125 | .098 | .775 | .029 |
| .1375 | .100 | .800 | .026 |
| .150 | .099 | .825 | .02325 |
| .1625 | .0985 | .858 | .0205 |
| .175 | .097 | .875 | .01775 |
| .1875 | .096 | .900 | .015 |
| .200 | .095 | .925 | .01225 |
| .225 | .092 | .950 | .0095 |
| .250 | .089 | .975 | .00675 |
| .275 | .086 | 1.000 | .004 |
| .300 | .083 | | |

## Table 6.2 Delta P Airfoil Coordinates - Flap Deflection = 5, 10, 15 (degrees)

Substitute into Table 6.1 for $.70 \leq XU \leq 1.00$

| XU (=XL) | $\delta_F = 5^\circ$ | | $\delta_F = 10^\circ$ | | $\delta_F = 15^\circ$ * | |
|---|---|---|---|---|---|---|
| | ZU | ZL | ZU | ZL | ZU | ZL |
| .700 | .038 | -.040 | .038 | -.041 | .037 | -.043 |
| .725 | .032 | -.039 | .0305 | -.0425 | - | - |
| .750 | .027 | -.038 | .023 | -.044 | .017 | -.050 |
| .775 | .022 | -.037 | .0155 | -.0455 | - | - |
| .800 | .017 | -.036 | .008 | -.047 | -.003 | -.057 |
| .825 | .012 | -.0355 | .0005 | -.0485 | - | - |
| .850 | .007 | -.035 | -.007 | -.050 | -.023 | -.064 |
| .875 | .002 | -.034 | -.0145 | -.051 | - | - |
| .900 | -.003 | -.033 | -.022 | -.052 | -.043 | -.071 |
| .925 | -.008 | -.032 | -.0295 | -.0535 | - | - |
| .950 | -.013 | -.031 | -.037 | -.055 | -.063 | -.078 |
| .975 | -.018 | -.030 | -.0445 | -.0565 | - | - |
| 1.000 | -.023 | -.029 | -.052 | -.058 | -.083 | -.083 |

* For the $\delta_F = 15^\circ$ case, it was necessary to input a slightly fewer number of coordinates. Since the aft portion of the surface is essentially flat, this is considered to make little, if any, difference.

The $C_p$ values generated are at distributed points (chosen by the computer) along the airfoil. Consequently, for comparison with the windtunnel data, the pressure coefficients are interpolated to the 13 chordwise locations of the test surface. Then the same data reduction process outlined in Subsection 3.5.2 is performed on the data. The results are tabulated and plotted in Appendix C.

From Figures C.1 through C.26 it is seen that the general sensitivity trends follow those of the windtunnel data. However, contrary to the experimental data, the pressure differential, at all locations, is sensitive to flap deflection. In addition, the results are somewhat nonlinear--especially at the five degree flap deflection case. The maximum $C_p$ predicted by the SEAP at $x/c = .766$ agrees reasonably well with the experimental data, but this is not the case at the forward tap locations.

There are a few explanations for the discrepancies between the experimental and theoretical data. First, the large thickness ratio (t/c) and extreme forward location of the maximum t/c might not lend itself to accurate analysis by the SEAP. Second, since the program is not specifically designed to handle flap deflections, the method of doing so could lead to errors. Finally, the program utilizes a two-dimensional analysis technique,while the windtunnel test is three dimensional.

While the results of the theoretical analysis do not correlate exactly with the experimental data, they are promising enough to prompt further study. Analysis of other airfoils, perhaps with another computer program more suited to the specific needs of the project, is recommended before discounting the theoretical approach.

## 6.2 CLOSED LOOP DYNAMIC STABILITY ANALYSIS

A study has been performed to see what the closed loop performance of a system is (or should be) that incorporates differential pressure command as opposed to elevator position command. In analyzing the system, the block diagram of Figure 6.3 is used. The system illustrated is a pitch attitude hold loop which uses pressure as the feedback quantity in the $\delta_{E_{COMMAND}}$ inner loop. As a control a conventional pitch attitude hold system which incorporates elevator position command (of Figure 6.4) was also analyzed.

For simplification, the amplifier of the inner loop has been assumed to be a pure gain, equal to unity:

$$K_{AMP} = 1 \tag{6.1}$$

The elevator servo is assumed to be a first order lag:

$$\frac{\delta_E(s)}{\delta_{E_{OUT}}(s)} = \frac{10}{s + 10} \tag{6.2}$$

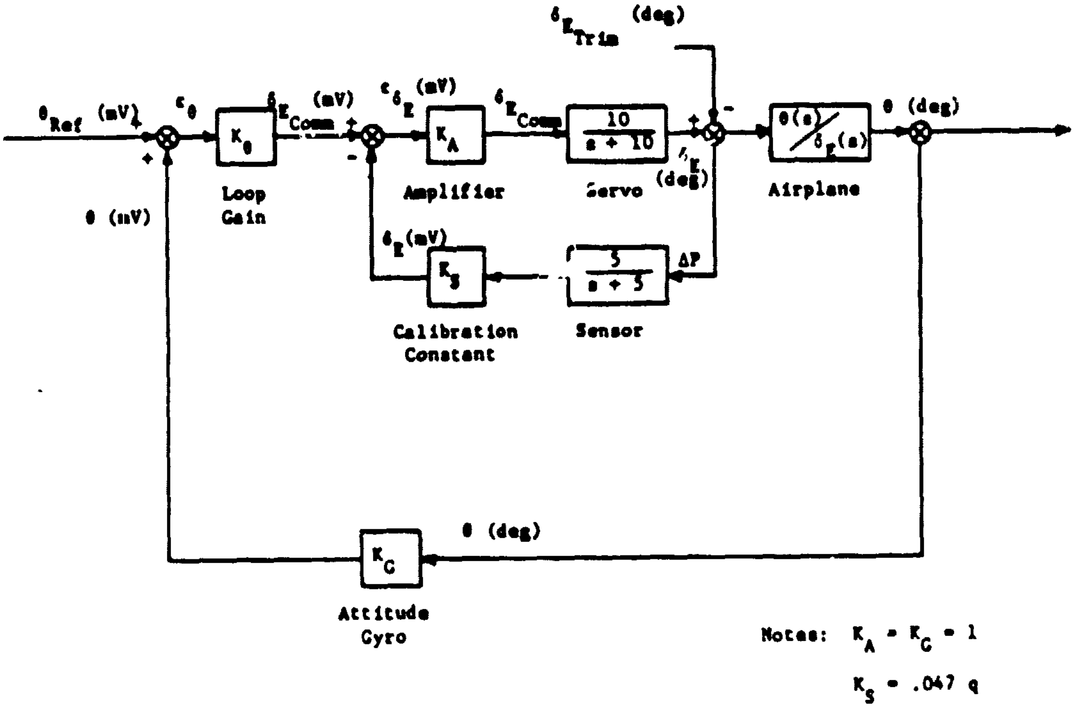
The break frequency of 10 rad/sec is representative of a reasonably fast, general aviation actuator.

The sensor calibration constant, or position command gain, is a function of dynamic pressure and is obtained from the numerical regression of Chapter 10, Part II, of this report:

$$\frac{\partial \Delta C_P}{\partial \delta_F} = .047 \tag{6.3}$$

or:

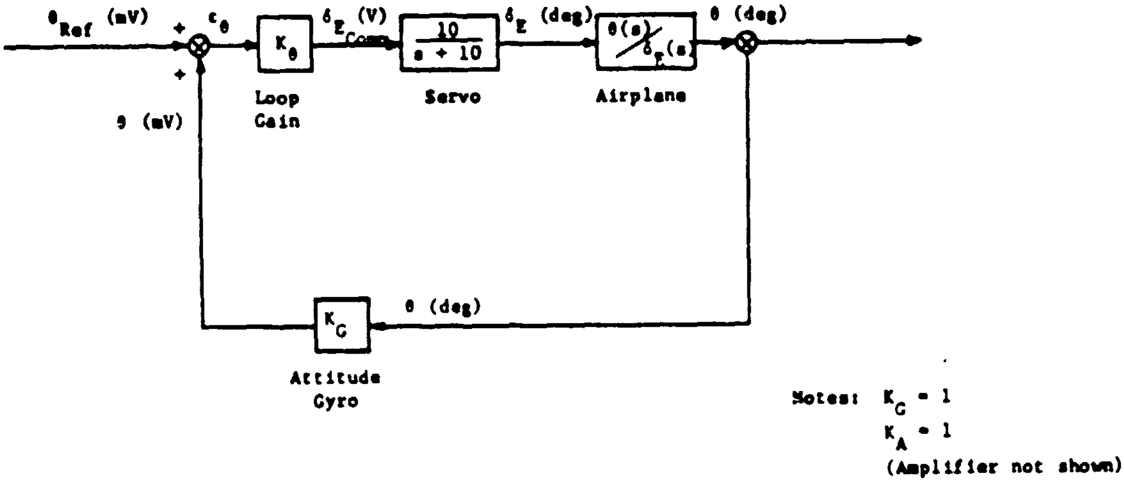
$$\frac{\partial \Delta P}{\partial \delta_F} = K_{\substack{SENSOR \\ \& \ CIRCUIT}} = .047q \tag{6.4}$$



Notes: $K_A = K_G = 1$

$K_S = .047\ q$

Figure 6.3 System Block Diagram (Pressure Command)



Notes: $K_G = 1$

$K_A = 1$

(Amplifier not shown)

Figure 6.4 System Block Diagram (Position Command)

The aerodynamic lag[*] and the sensor lag are combined into one first order transfer function:

$$\frac{\delta_{E_{IN}}(s)}{\Delta P_{OUT}(s)} = \frac{a}{s + a} = \frac{5}{s + 5} \tag{6.5}$$

The break frequency of 5 rad/sec has been assumed as "reasonable." The experimental determination of this lag is one of the major purposes of the Phase III windtunnel test.

The airplane $\frac{\theta(s)}{\delta_E(s)}$ transfer function is derived using data obtained from Appendix B of Reference 4 for a typical general aviation airplane. To investigate the effect of dynamic pressure on system performance, high and low values were used:

Case 1: $q = 8.47$ psf ($K_s = .40$)

Case 2: $q = 76.28$ psf ($K_s = 3.59$)

Using Reference 5 in conjunction with the University of Kansas Aerospace Engineering Departmen's HP9825A micro-minicomputer, the airplane $\frac{\theta(s)}{\delta_E(s)}$ transfer function was derived for each case; and the root loci of Figures 6.5 through 6.8 were generated. The computer output used to construct the root loci is located in Appendix D. Notice that with the inner loop pressure command, the sensor and actuator combine to form an oscillatory pair. In fact, Figure 6.6 shows that it is these poles which go unstable at high dynamic pressure.

It can be seen from the figures that a loop gain equal to

$$K_\theta = 1.0 \tag{6.6}$$

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[*] The aerodynamic lag represents the lag between a change in $\delta_E$ and the resulting pressure change at the sensor.

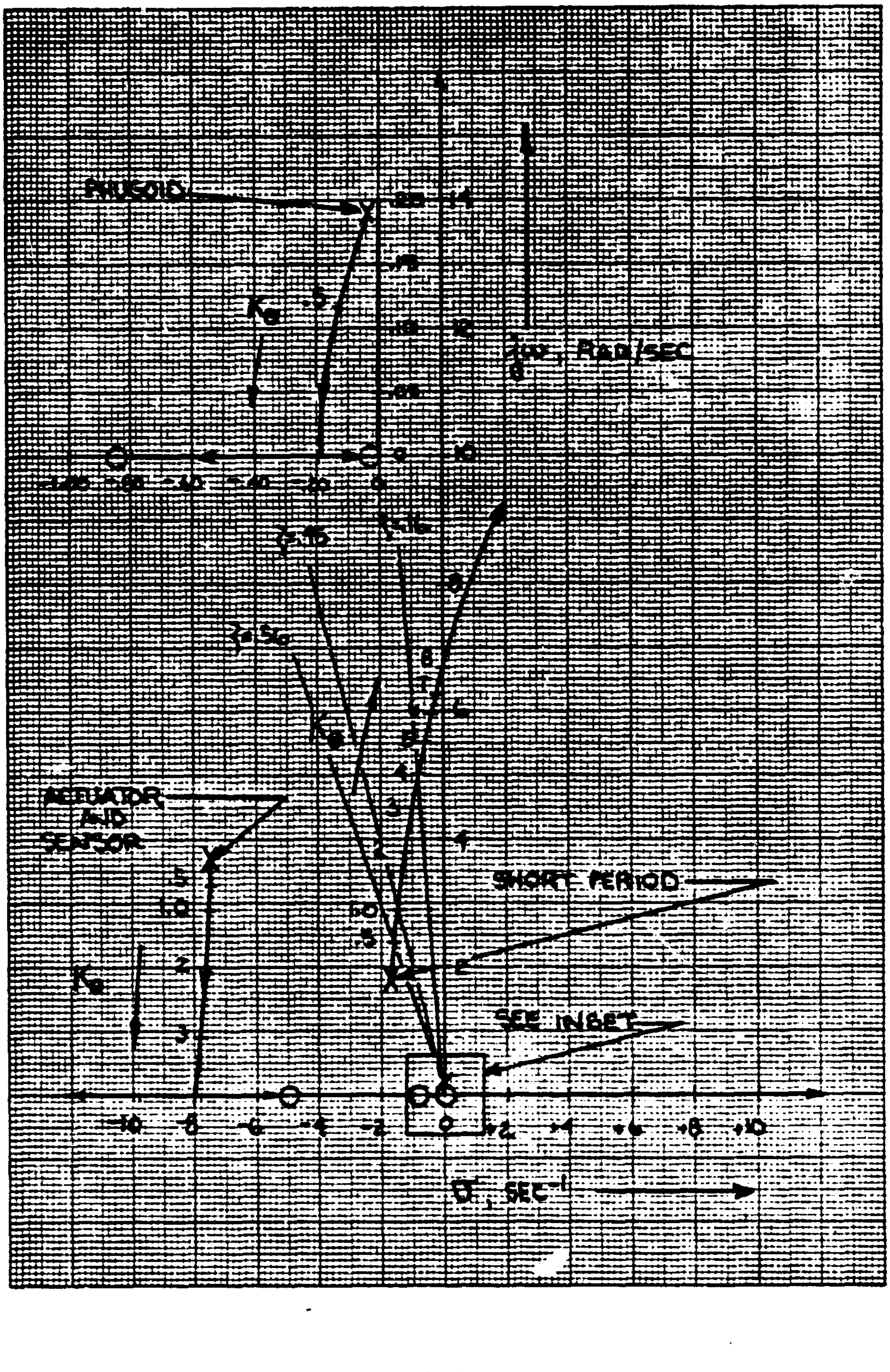

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Figure 6.5 Pitch Attitude Hold for Airplane A (App. C, Ref 4) with Pressure Sensor ($q = 8.5$ psf)

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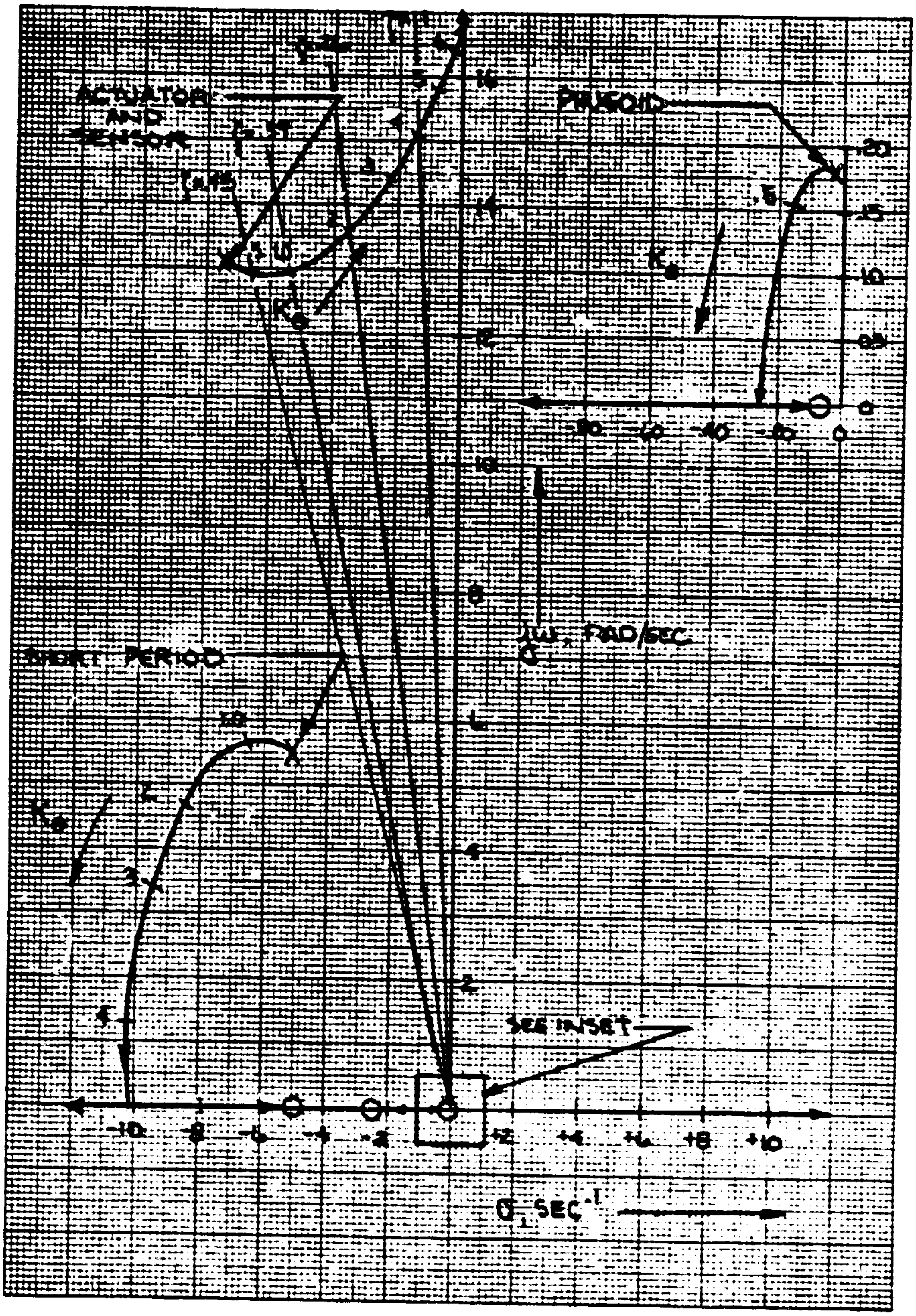

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Figure 6.6 Pitch Attitude Hold for Airplane A (App. C, Ref 4) with Pressure Sensor (q= 76.3 psf)

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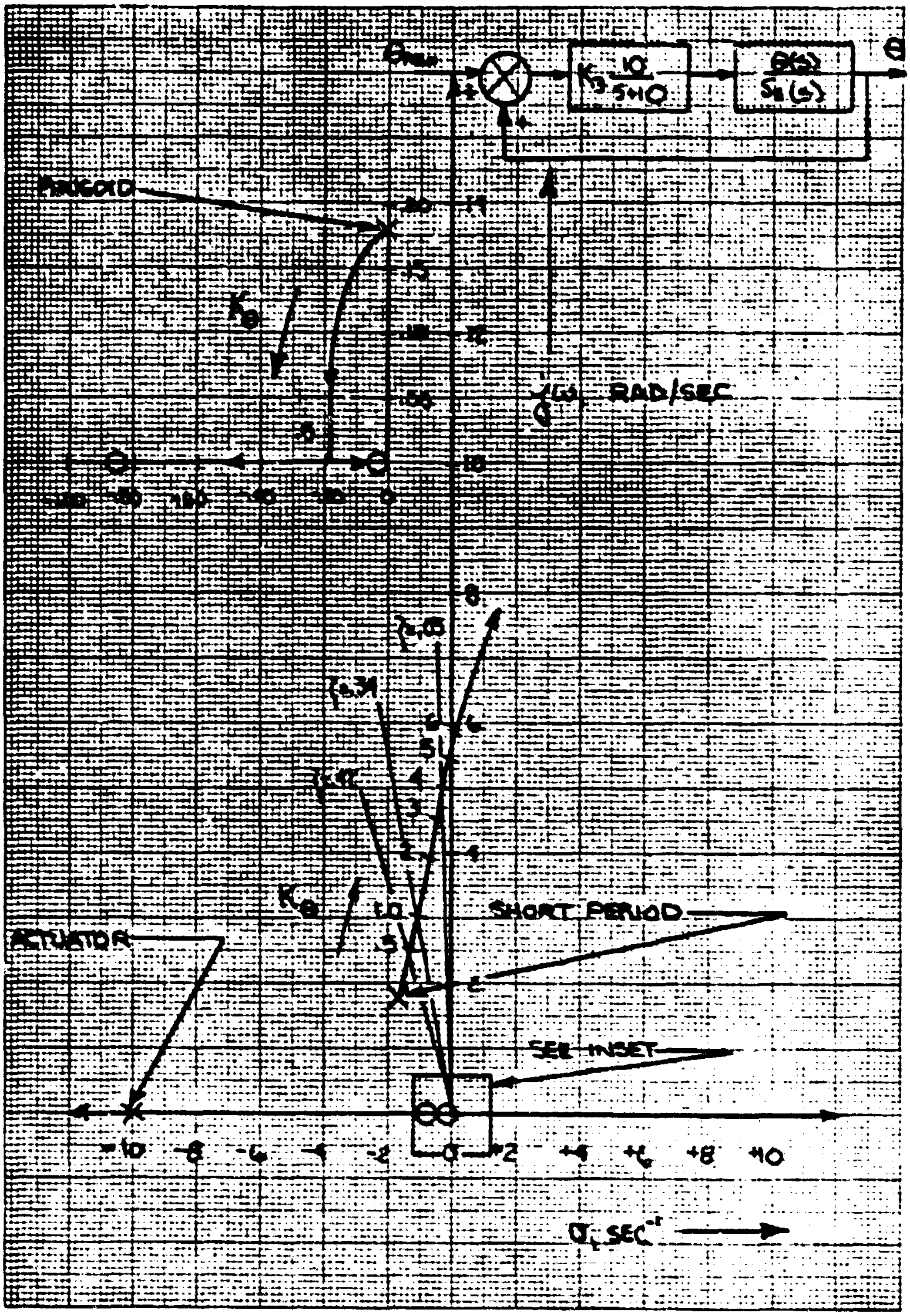

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| CALC | R. Hoesak | | REVISED | DATE | Figure 6.7 Pitch Attitude Hold for Airplane A (App. C, Ref 4) (q= 8.5 psf) |
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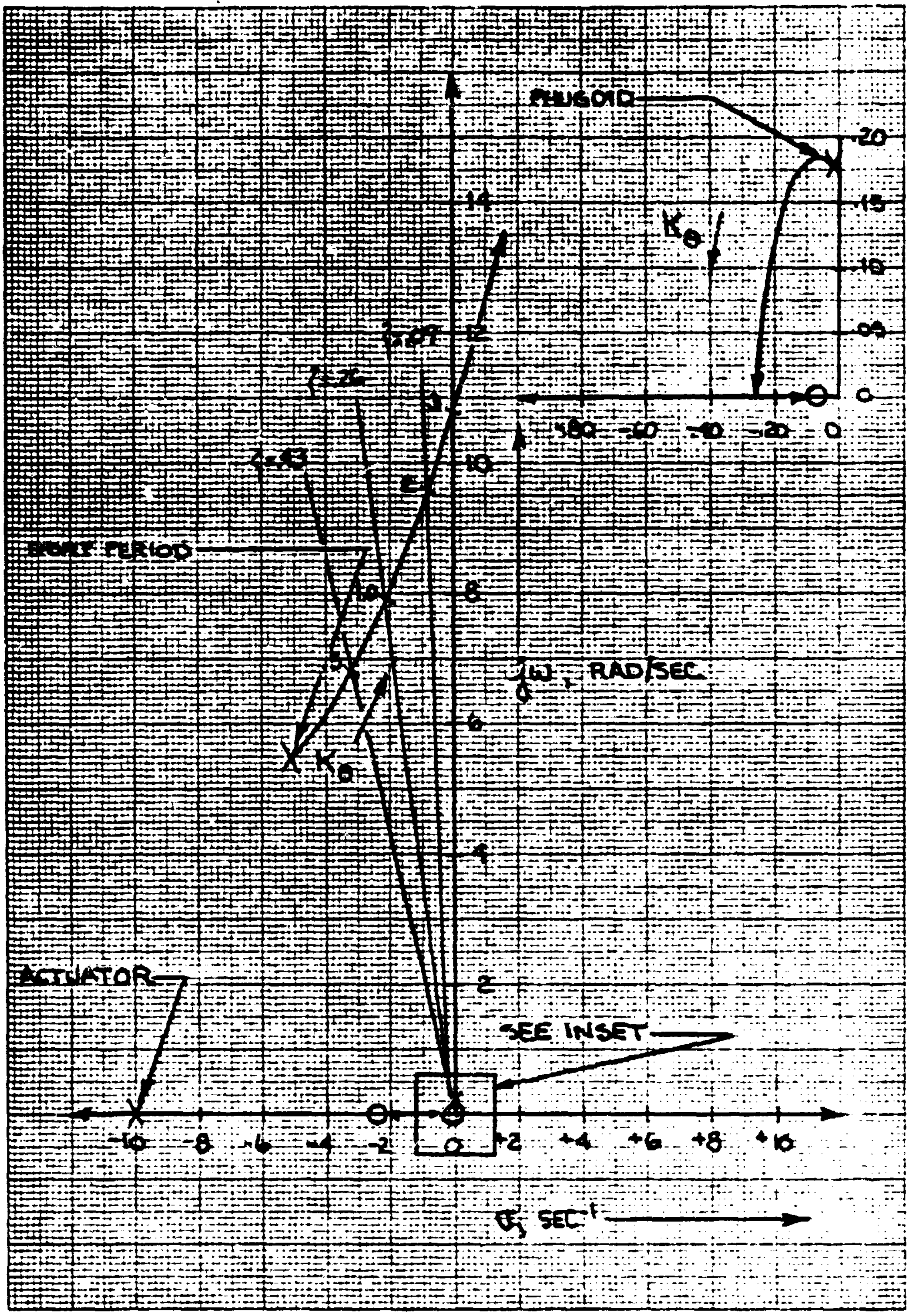

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yields reasonable damping ratios and natural frequencies for the pressure sensor pitch attitude hold system. It is also observed that in the system with the pressure sensor, the gain margin remains relatively constant with dynamic pressure as compared to the conventional system. It appears that gain scheduling with dynamic pressure can be avoided without a compensator or inner loop pitch damping.

Again it should be noted that the sensor properties have not been determined. The frequency response data obtained during Phase III will yield the necessary information for a more detailed study. This analysis is merelv a preliminary investigation of the closed loop characteristics of the pressure feedback system.

# 7. CONCLUSIONS AND RECOMMENDATIONS

The sensor used in this study does not have the qualities required to determine the feasibility of differential pressure feedback in a flight control system. Of available sensors, the piezoresistive has the characteristics most suited for this type of application.

Once this concept has been proven feasible, a follow-up program is recommended which will include the use of a more conventional airfoil. Within this program, both theoretical and experimental pressure distributions should be investigated.

# 8. REFERENCES

1. Proposal for a Program to Evaluate a Control System Based on Feedback of Aerodynamic Pressure Differentials; Submitted to NASA Dryden Flight Research Center, July 1980; University of Kansas Center for Research, Inc., Flight Research Lab.
2. Daugherty, D. G.; A Critical Review of an Automatic Attitude Command Control System Electronics Design; Flight Research Laboratory Report FRL 325, The University of Kansas, Lawrence, Kansas, November 1974.
3. Pope, A.: Lowspeed Wind Tunnel Testing; John Wiley and Sons, 1966.
4. Roskam, J.; Airplane Flight Dynamics and Automatic Flight Controls, Part II; Published by the Author, Ottawa, Kansas, 1979.
5. Clarke, Robert; A Computer Program for Determining Open and Closed Loop Dynamics of Airplanes; The University of Kansas, Lawrence, Kansas, May 1980.

# APPENDIX A

# PRESSURE PROFILE SENSITIVITY PLOTS

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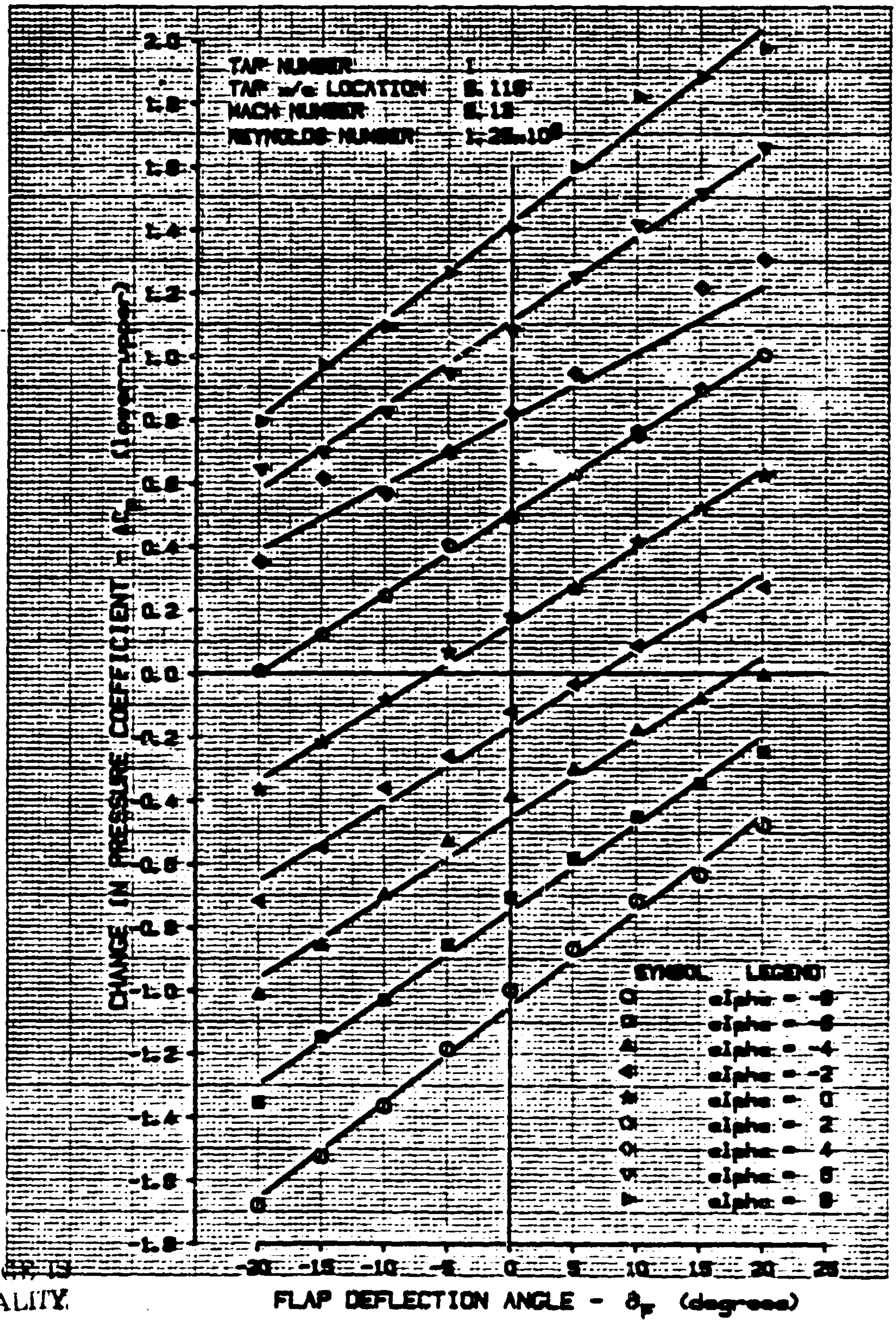
## A.1 FLAP DEFLECTION

NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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| CALC | P. FINN | 5-81 | REVISED | DATE | FIGURE A.1.1 EXPERIMENTAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY |
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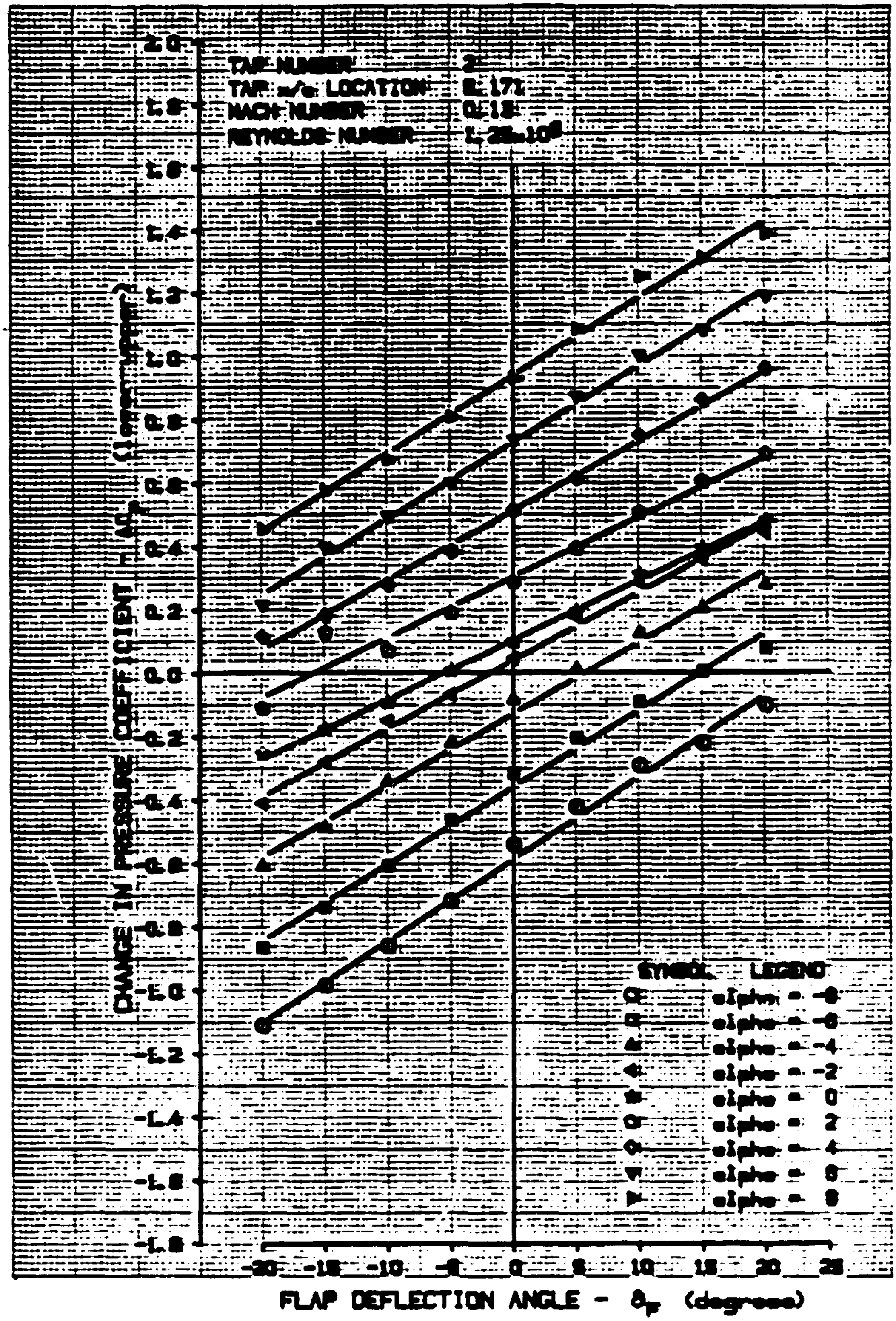
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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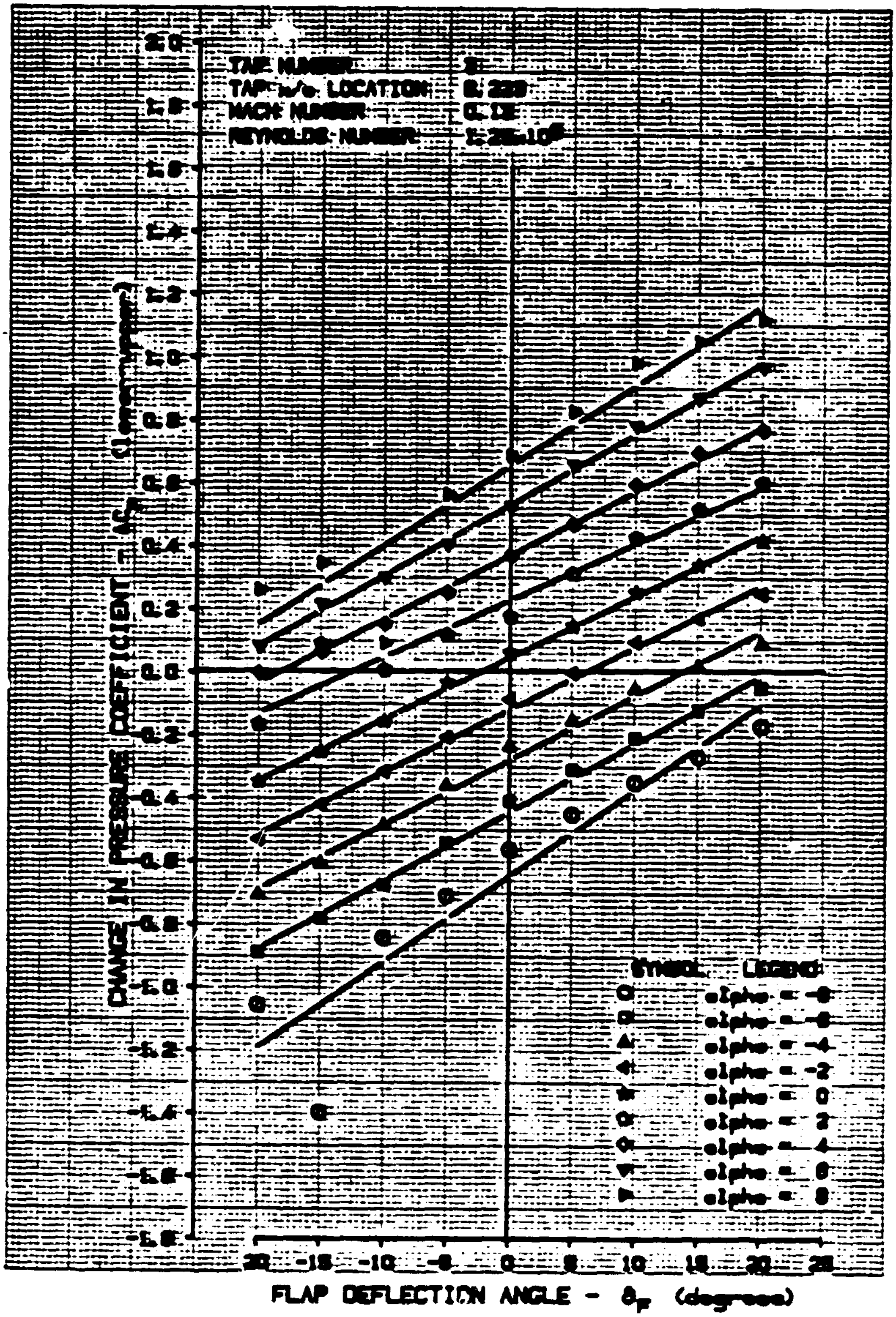
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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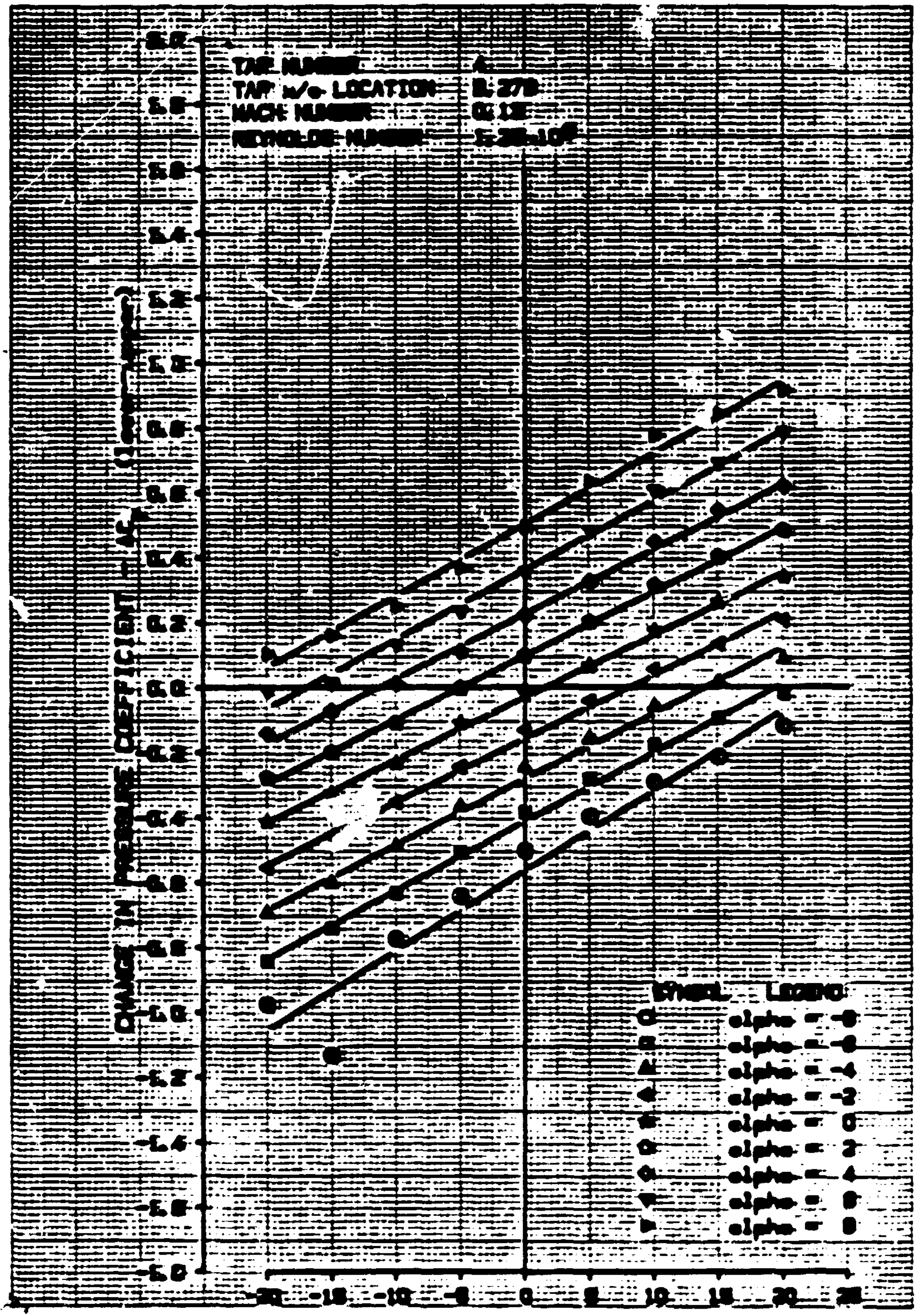
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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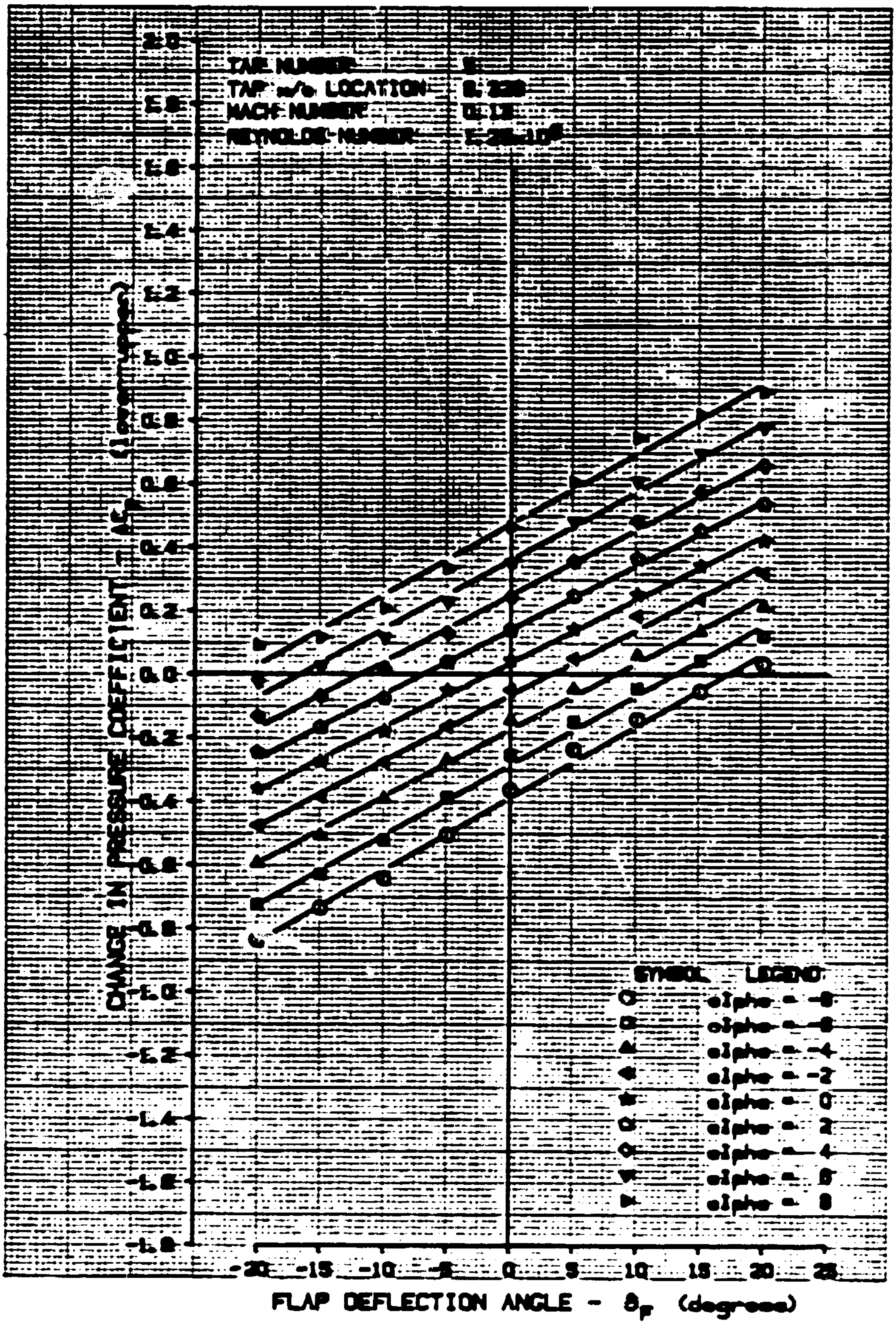
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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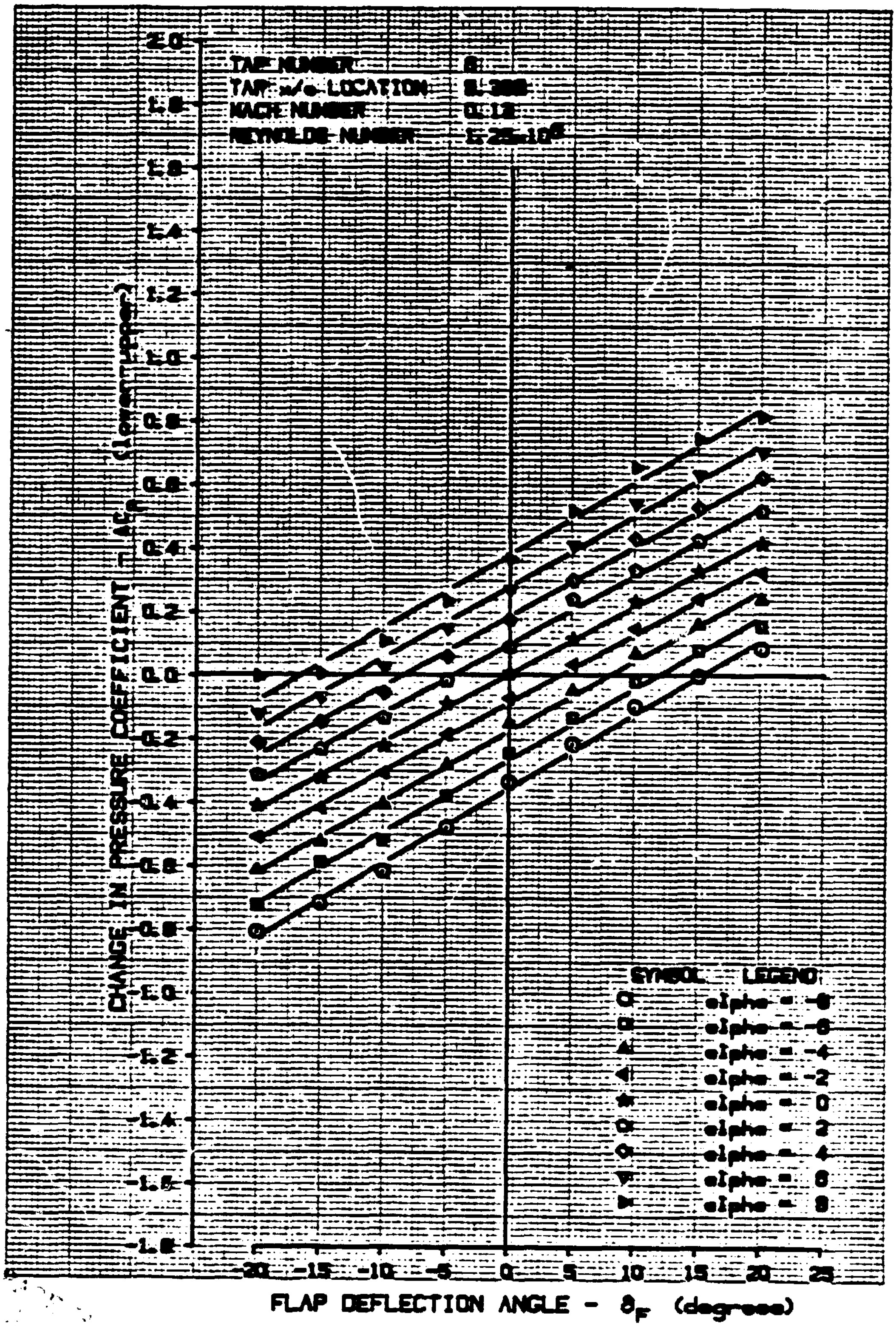
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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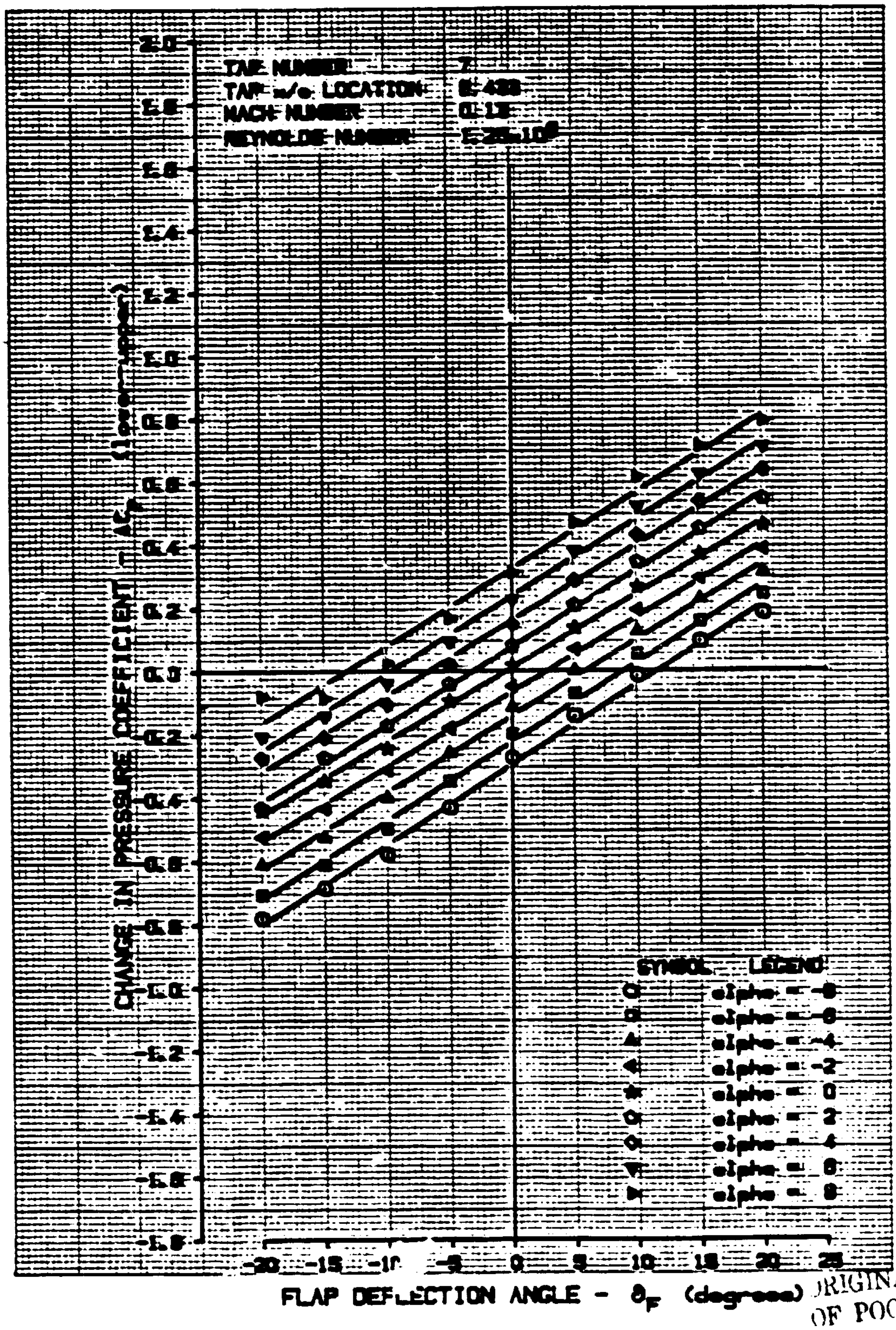
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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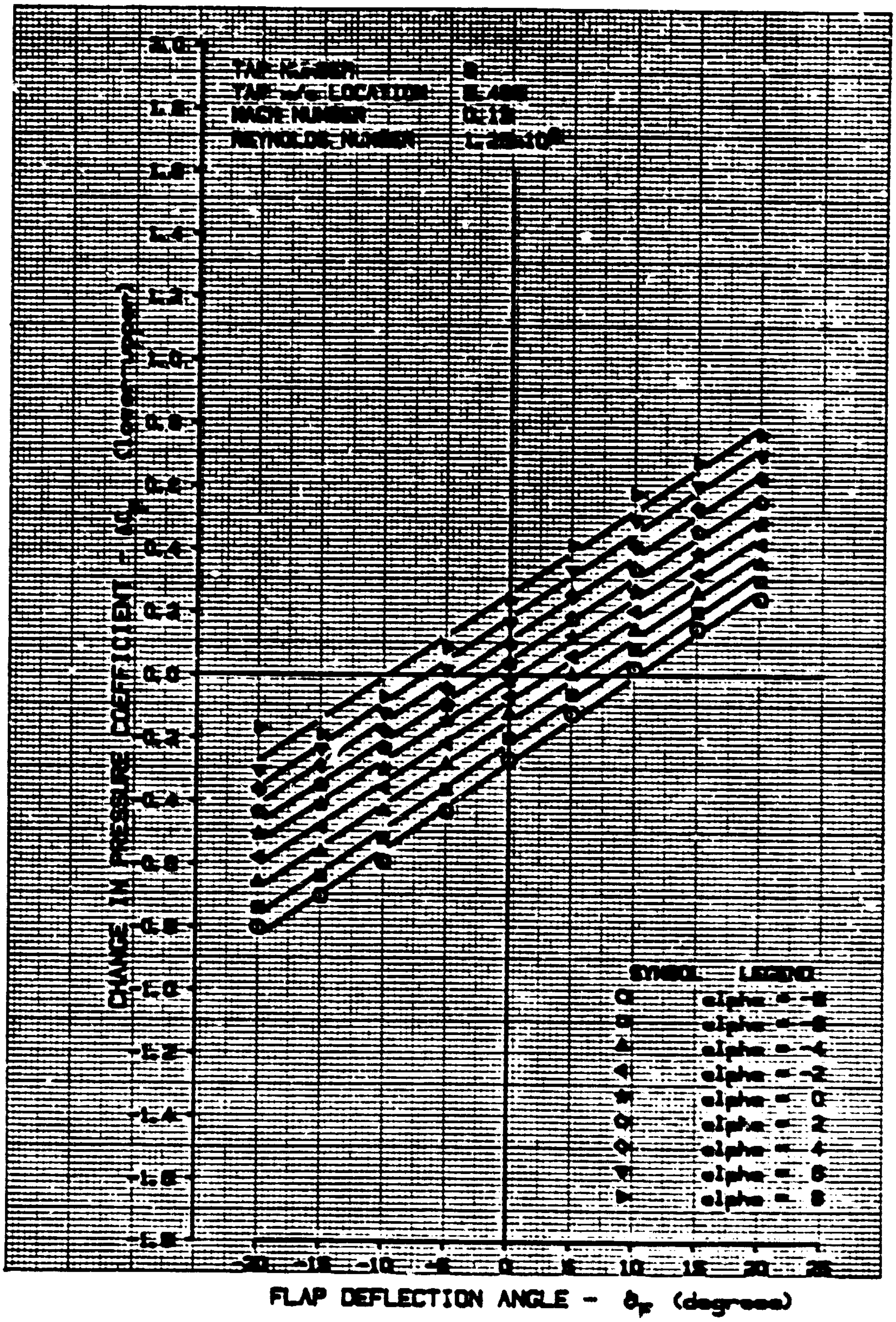
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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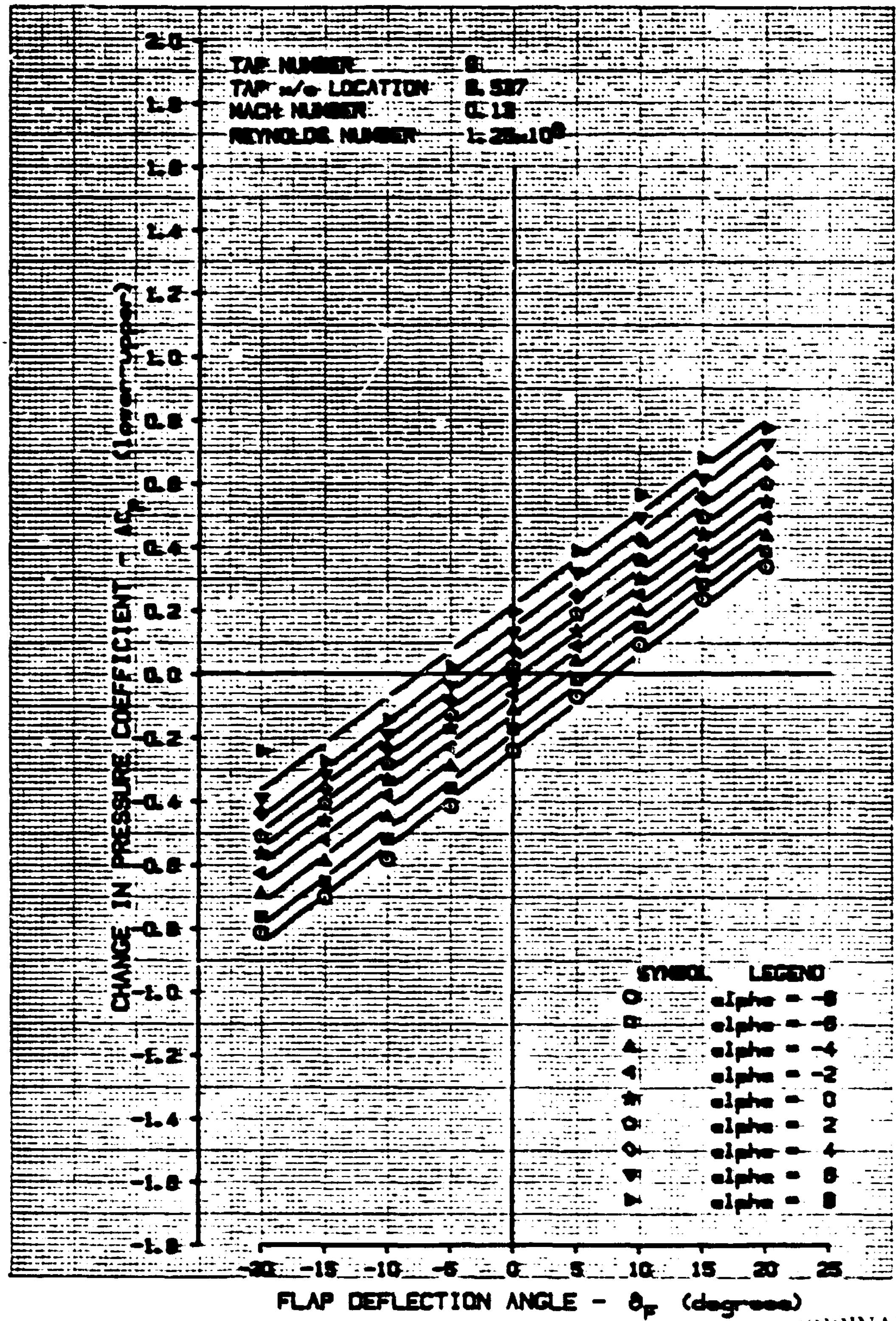
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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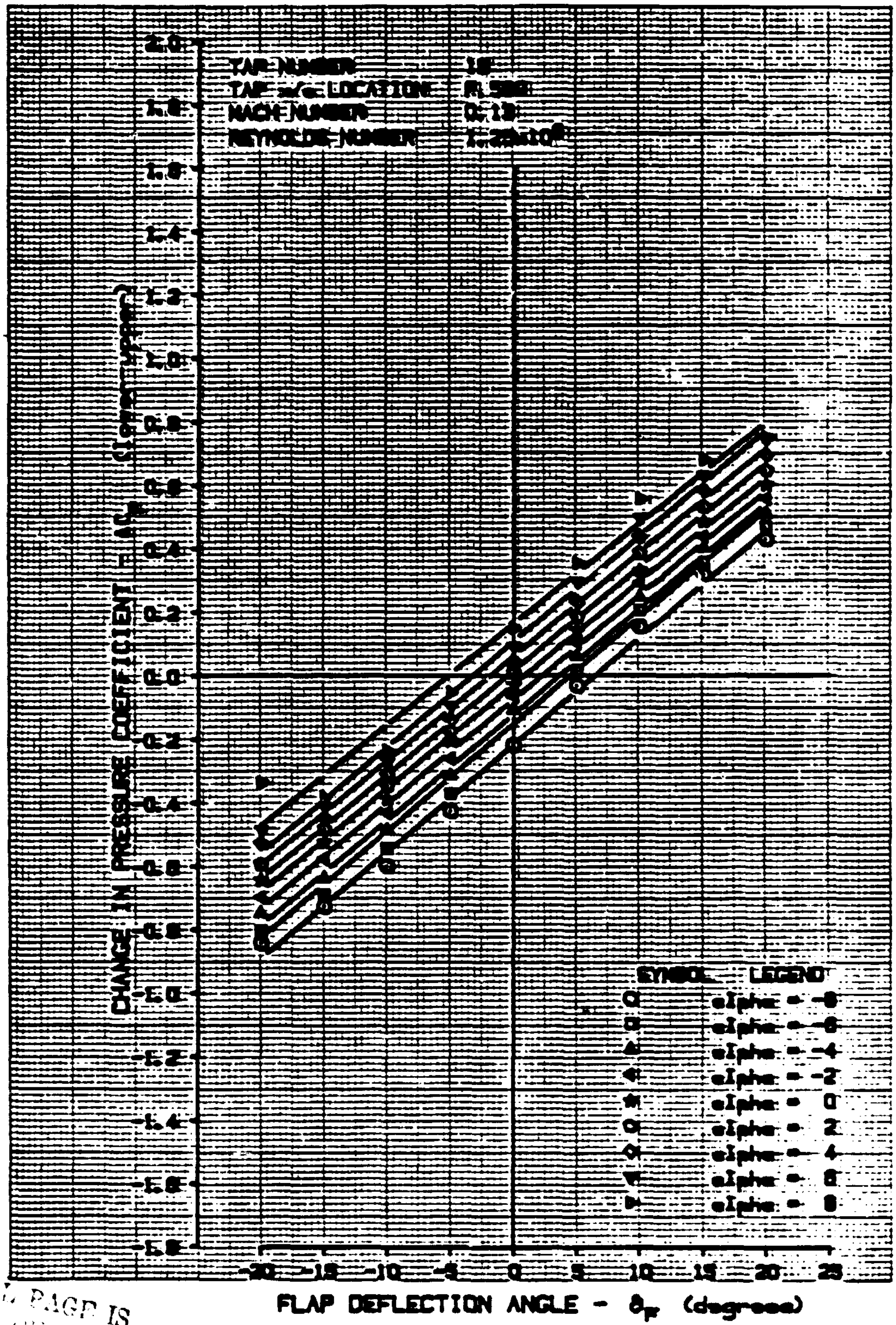
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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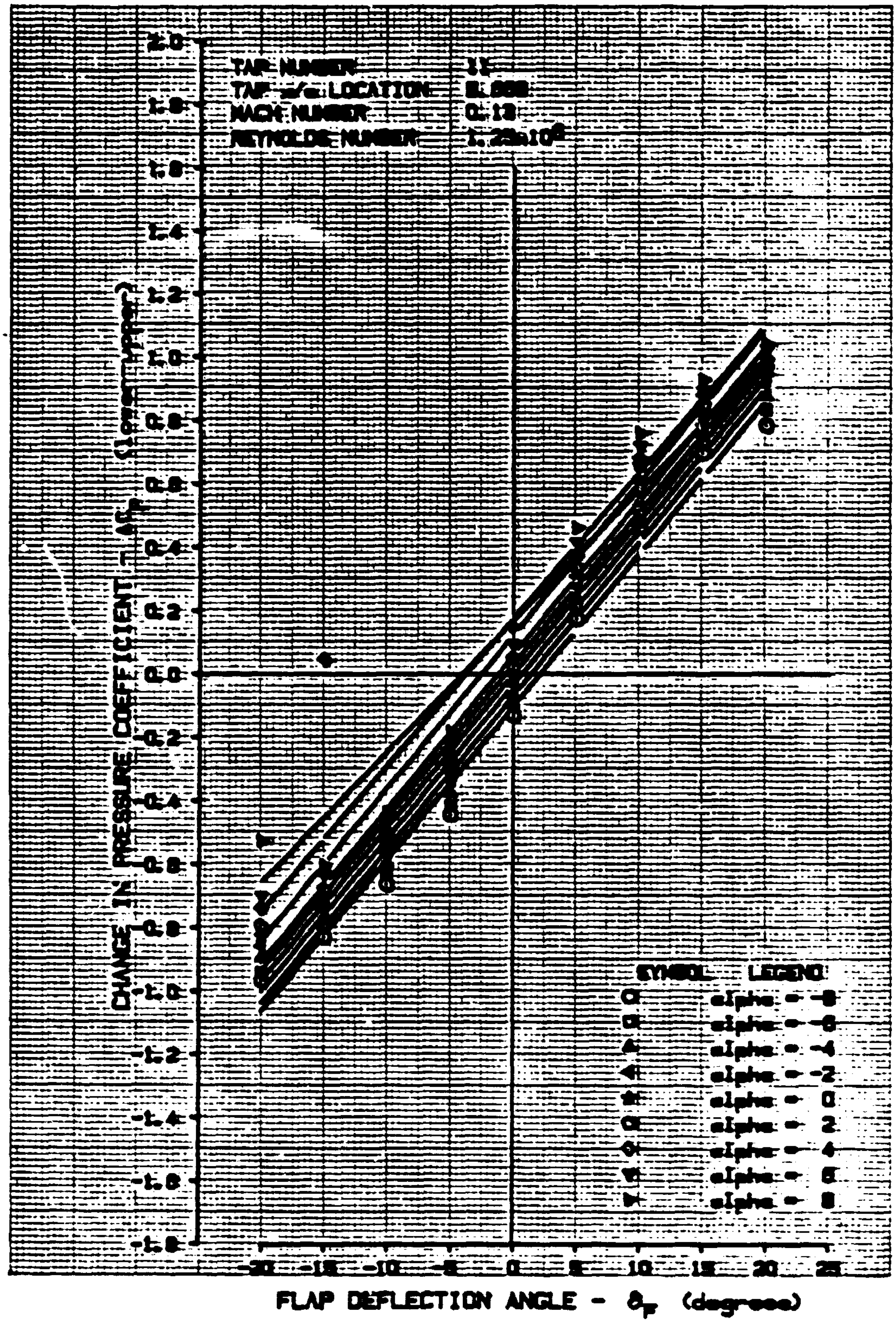
NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



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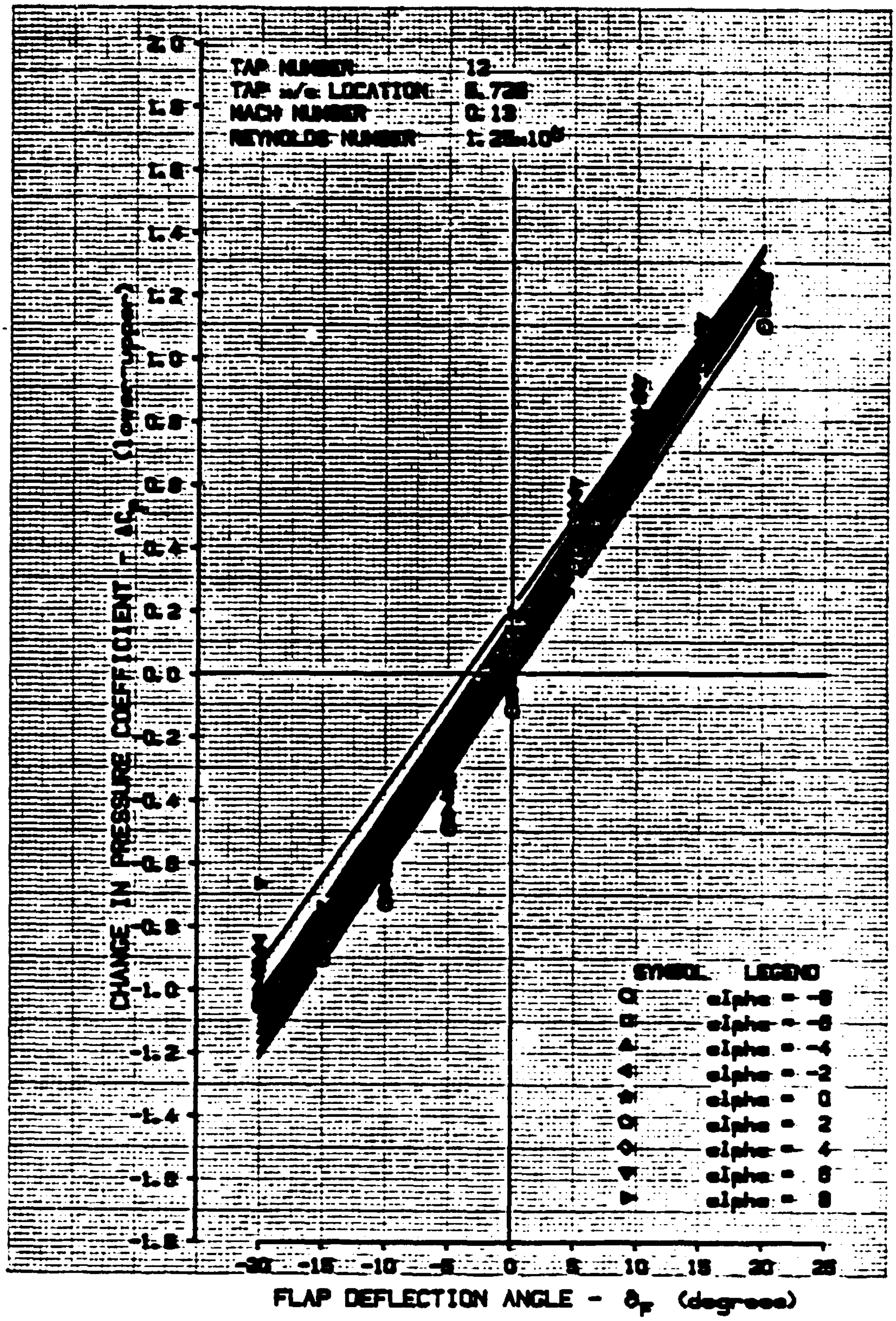
NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



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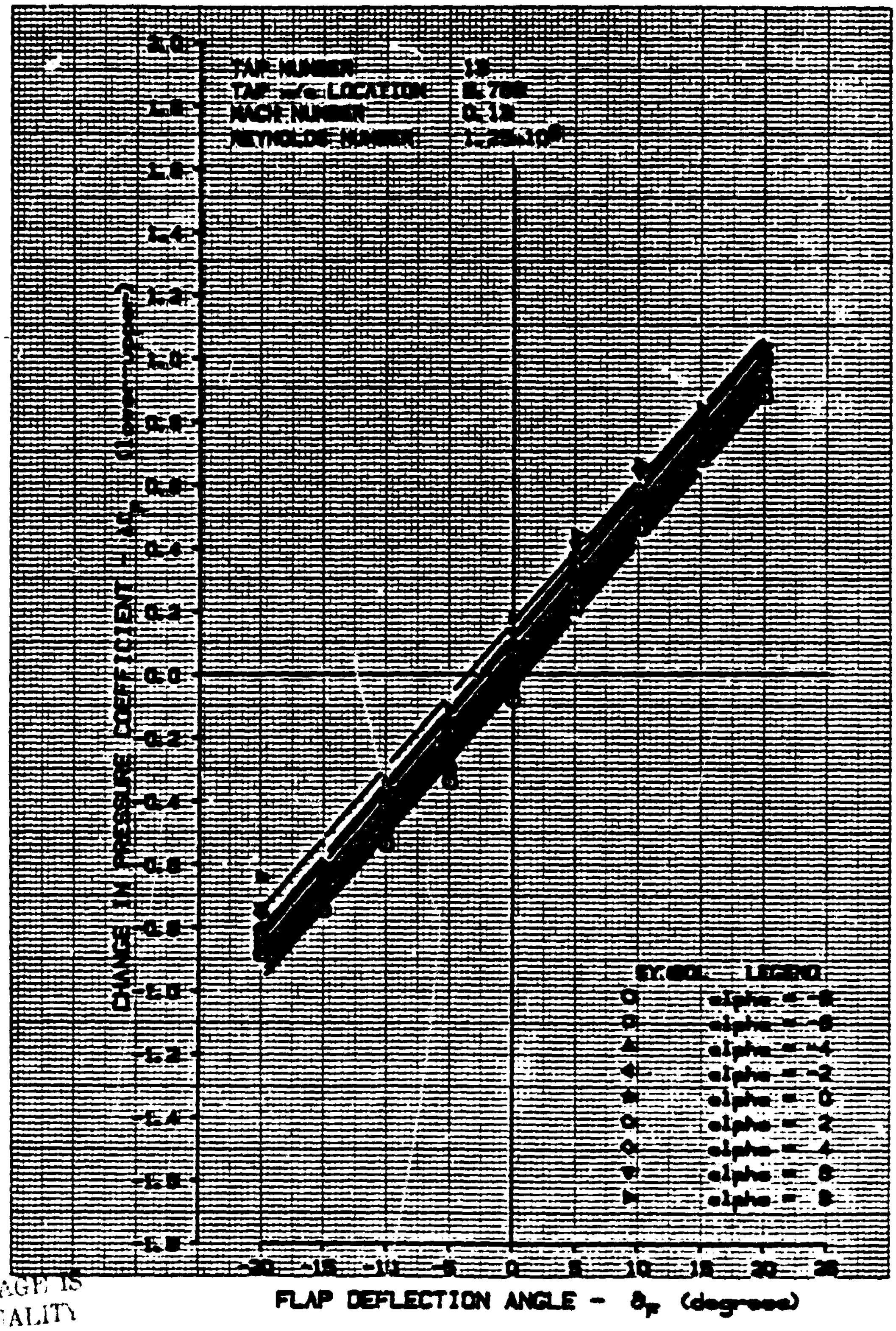
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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## A.2 ANGLE OF ATTACK

NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION

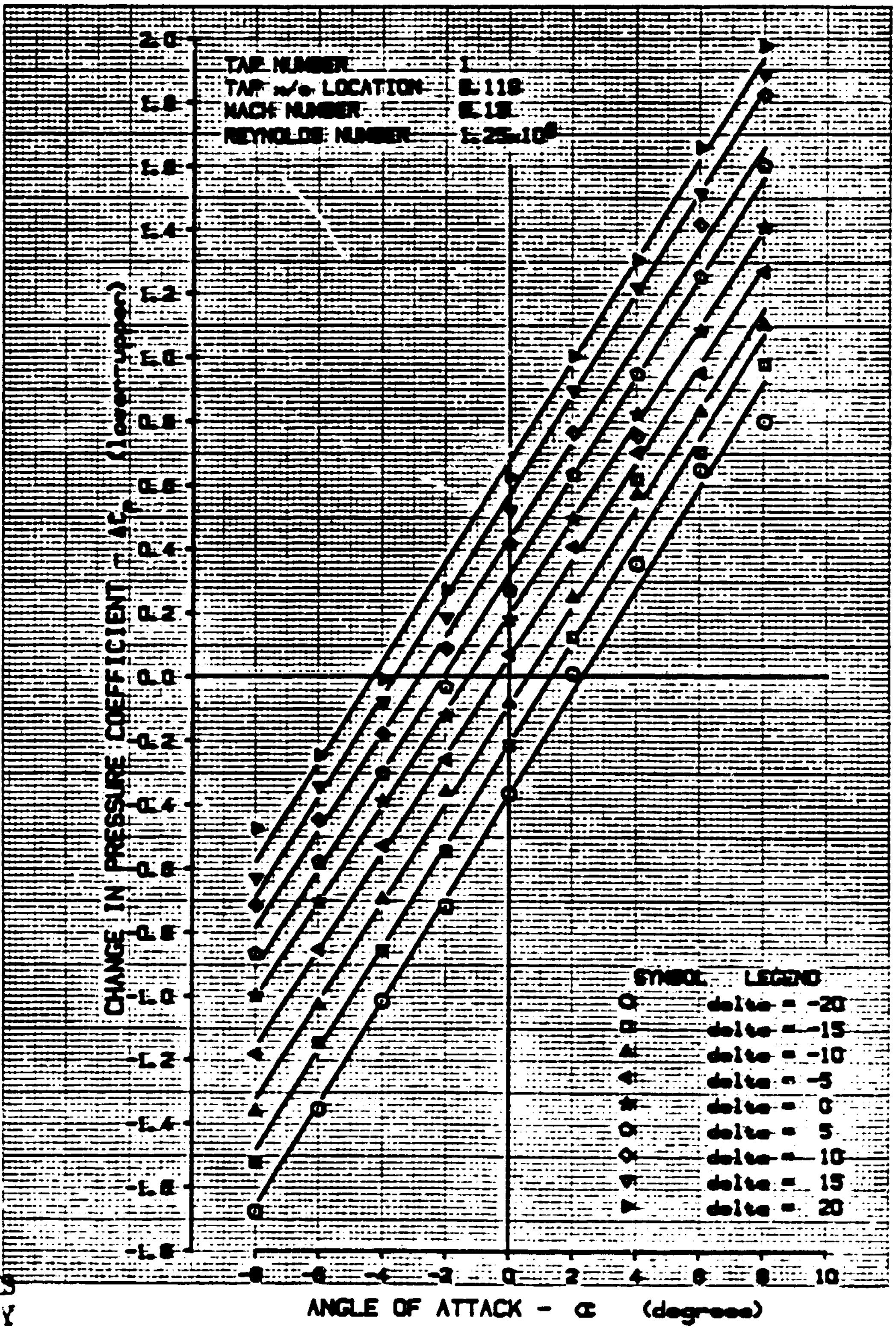

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FIGURE A.2.1 EXPERIMENTAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY

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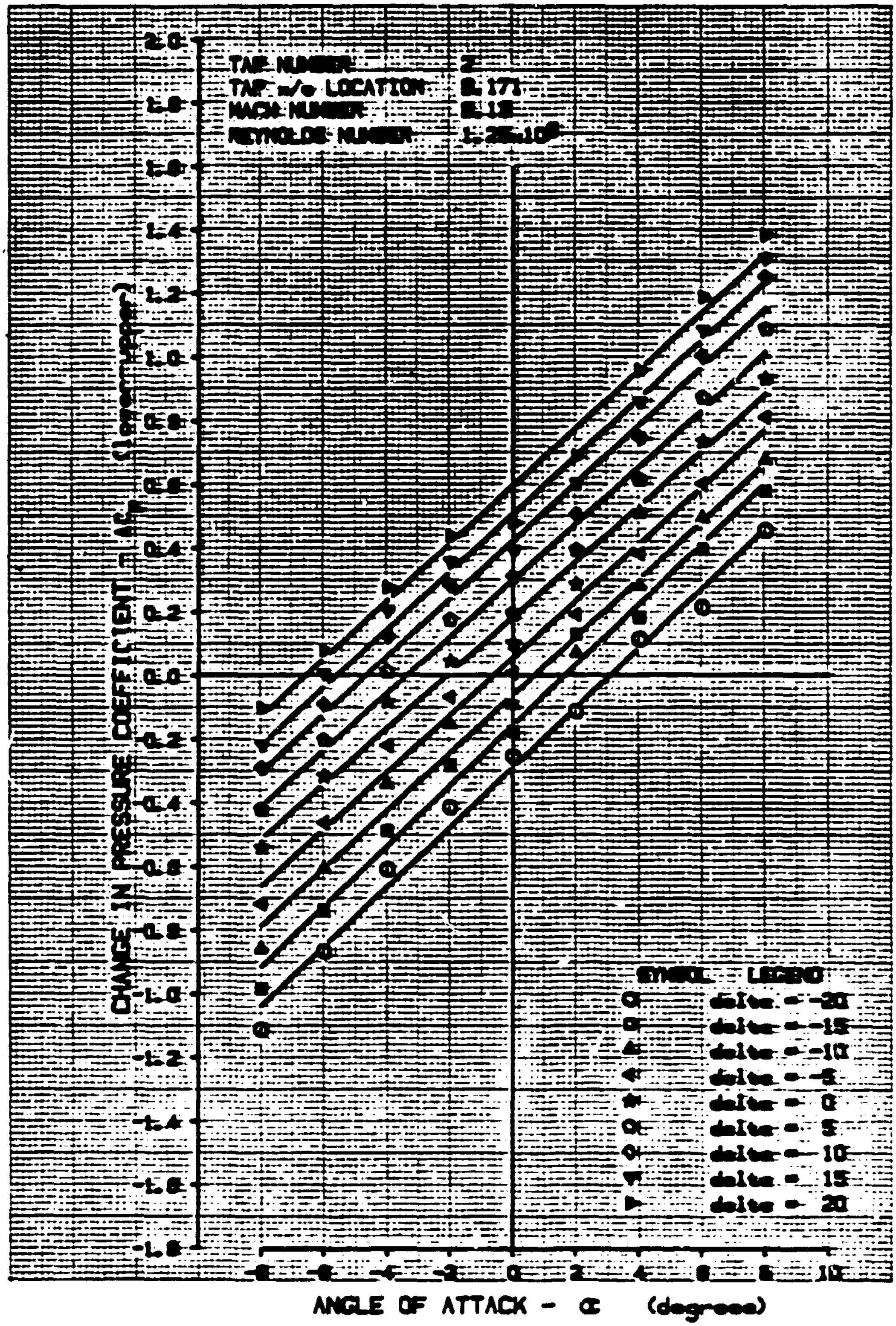
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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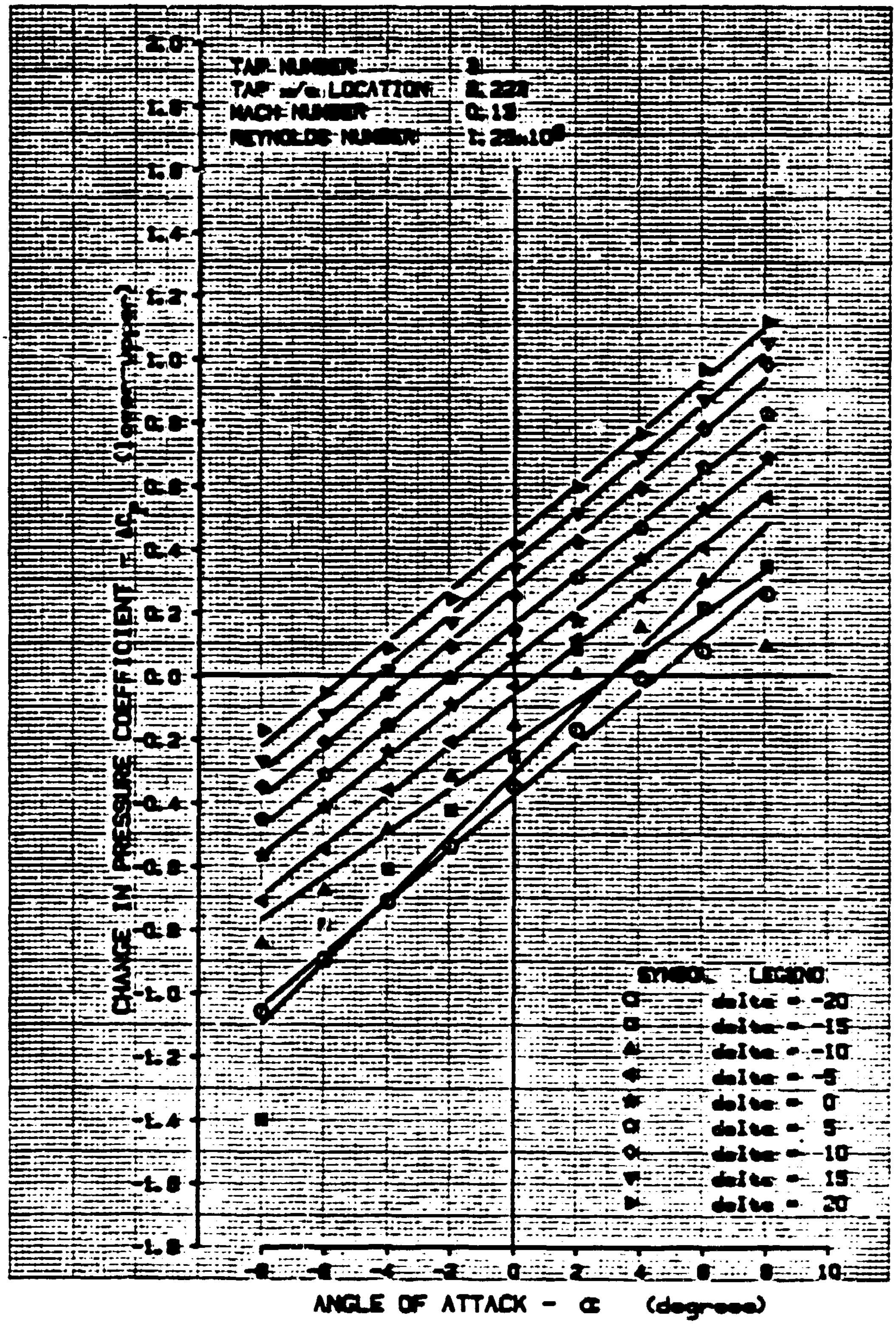
NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



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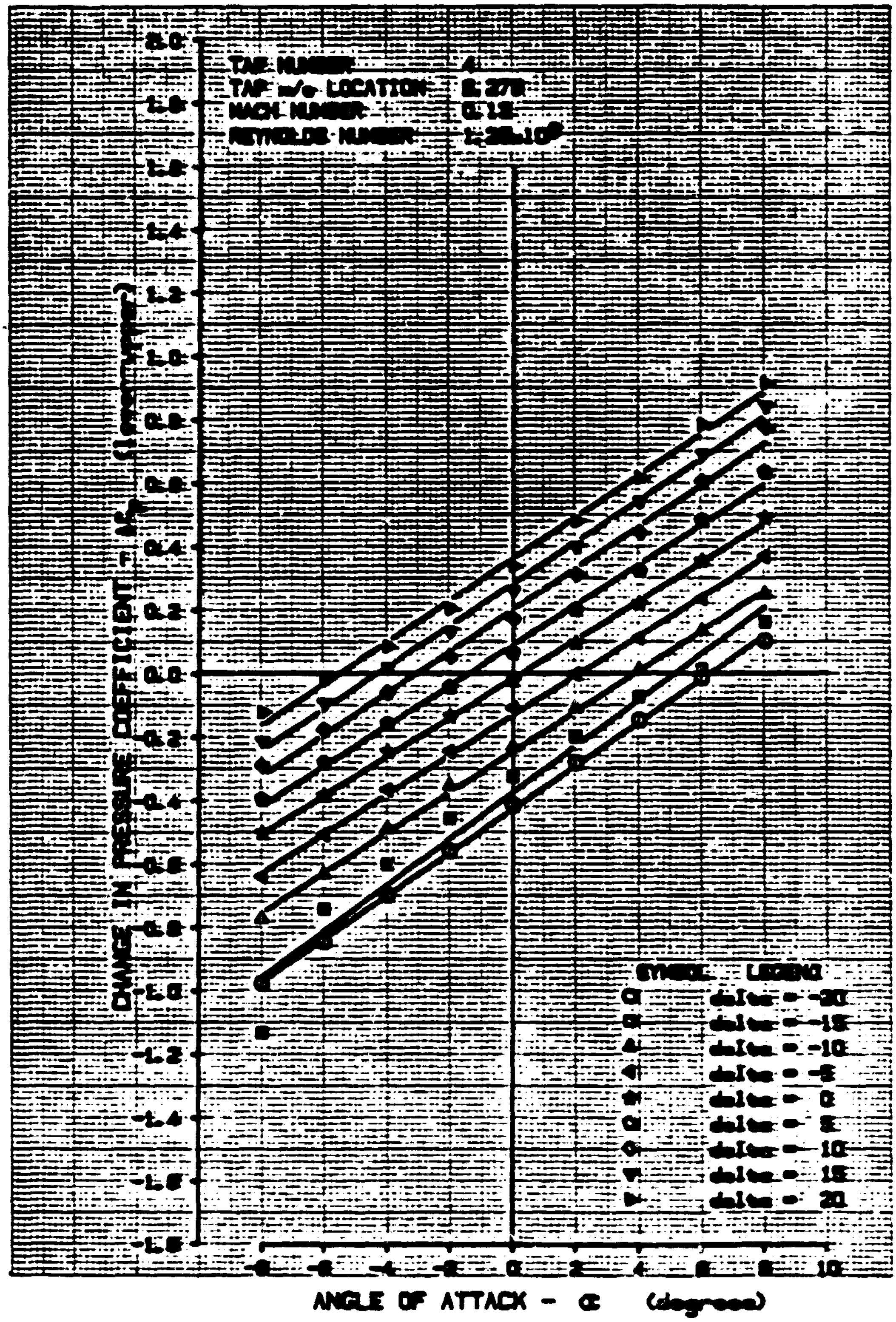
NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



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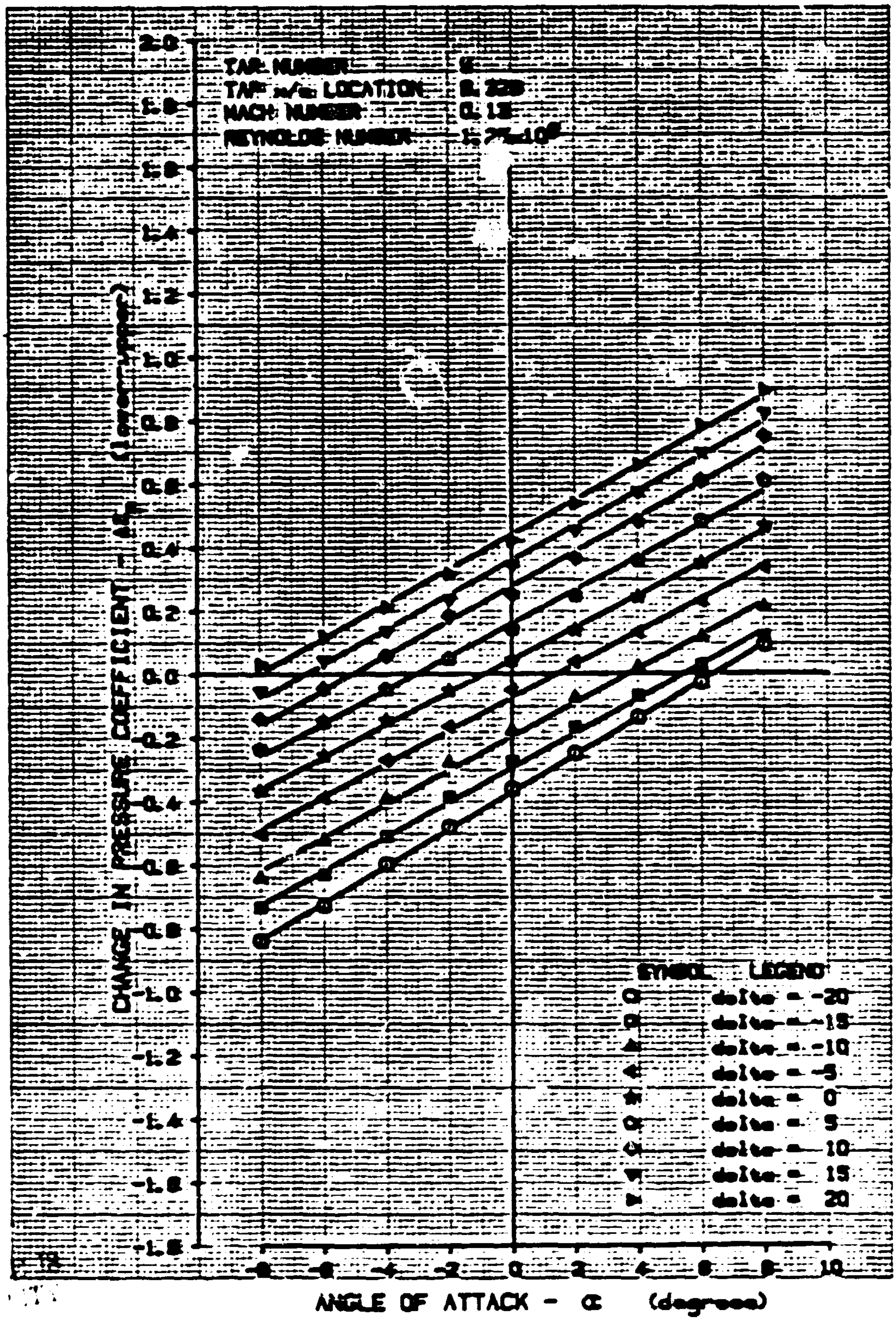
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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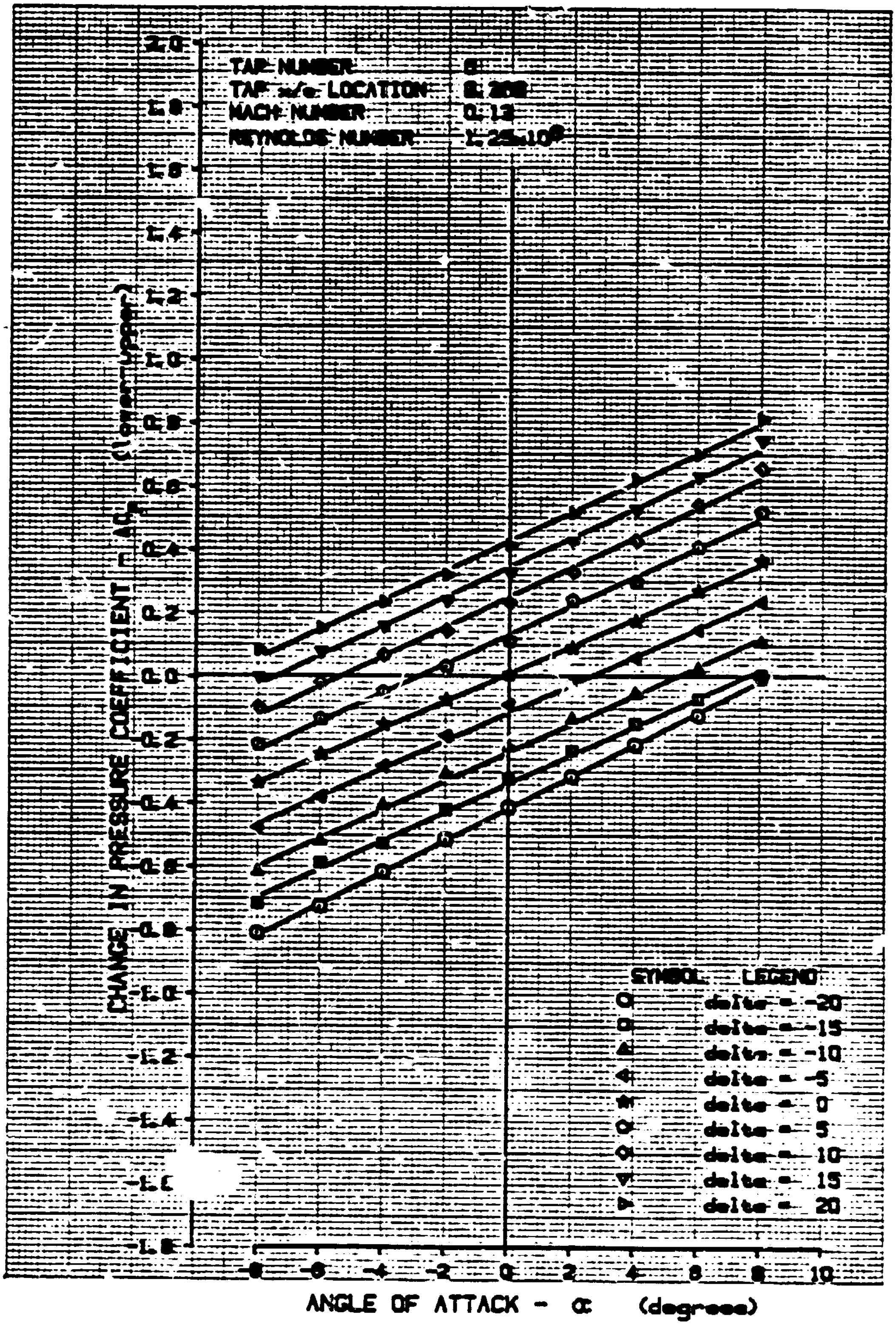
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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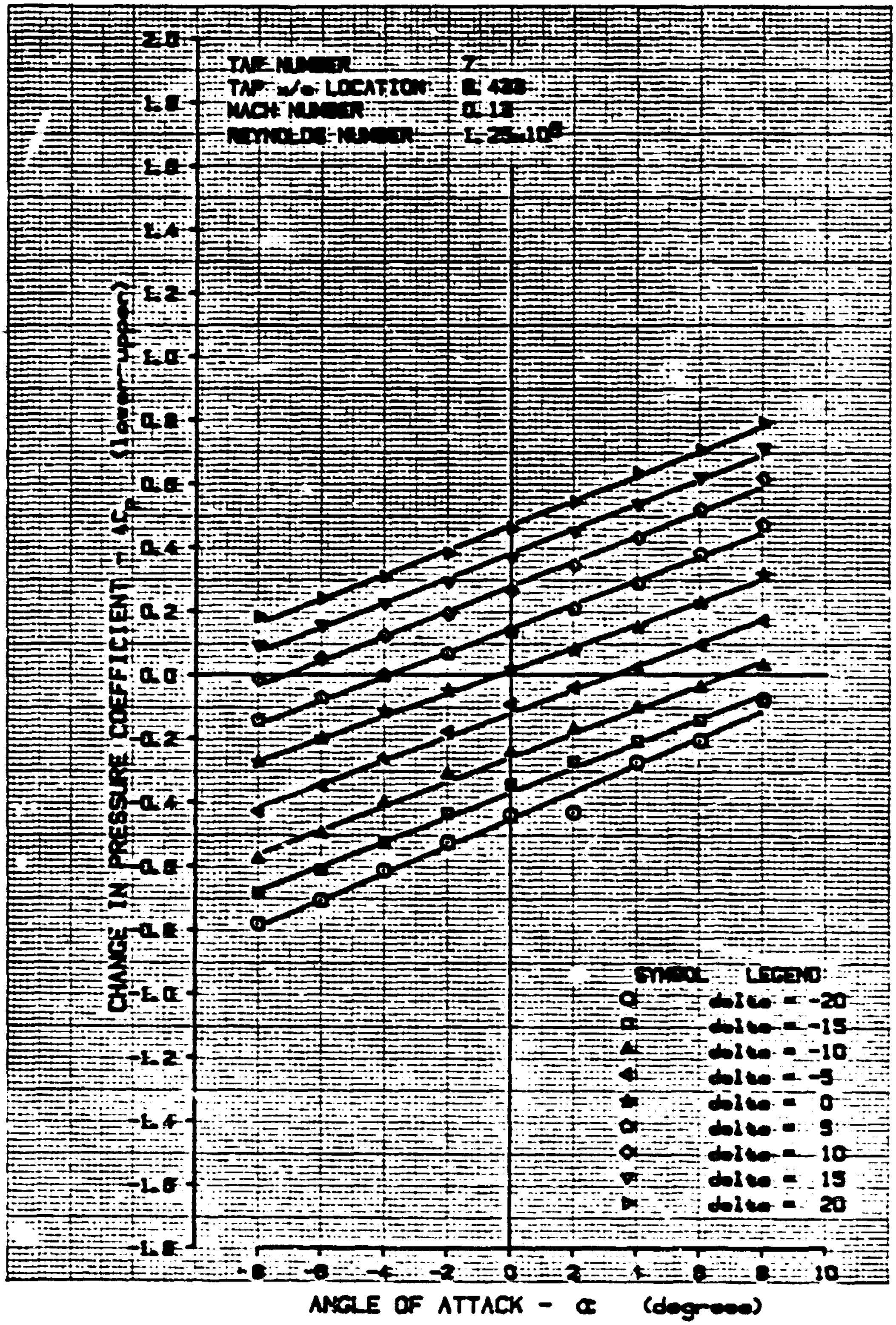
NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



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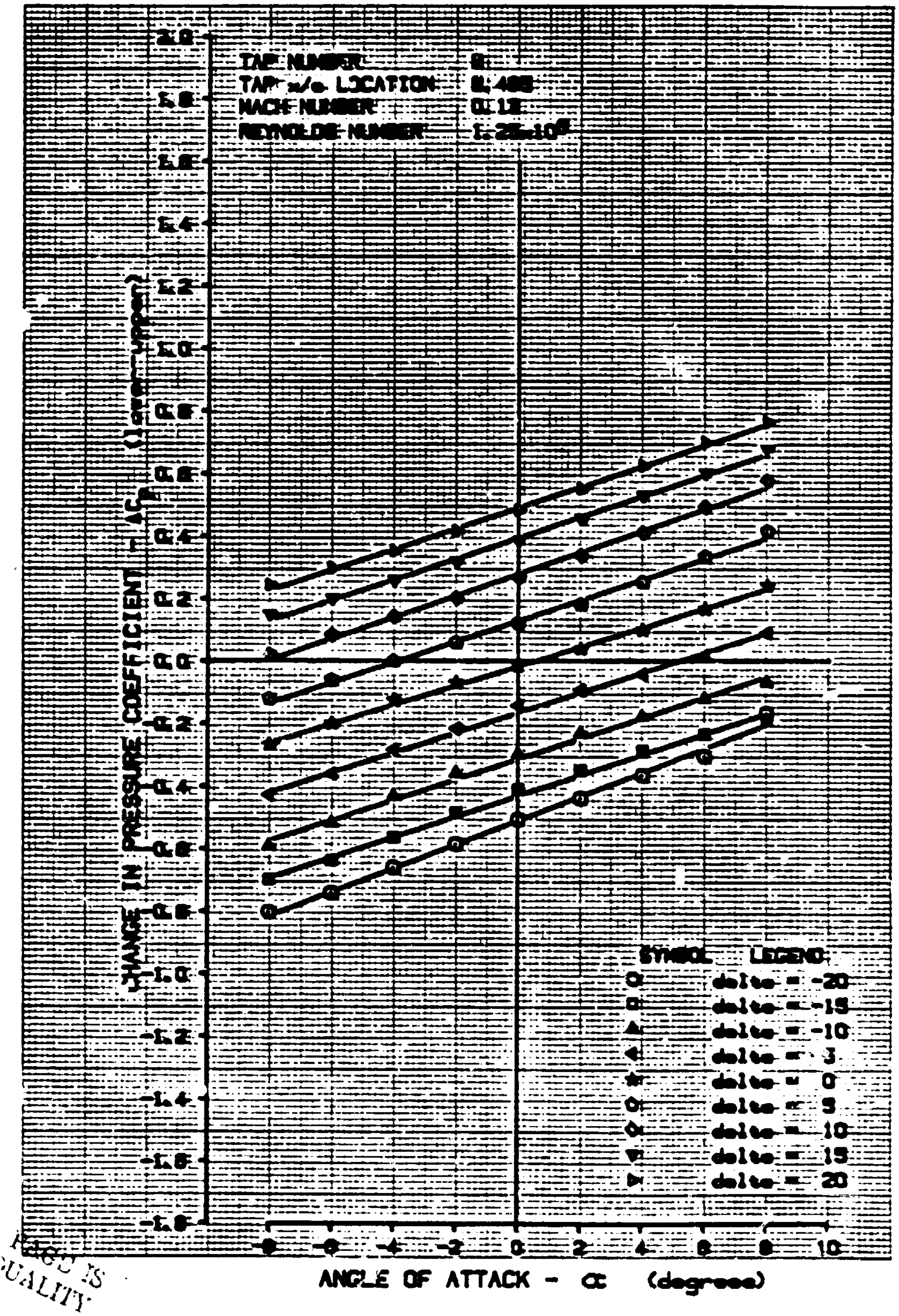
NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



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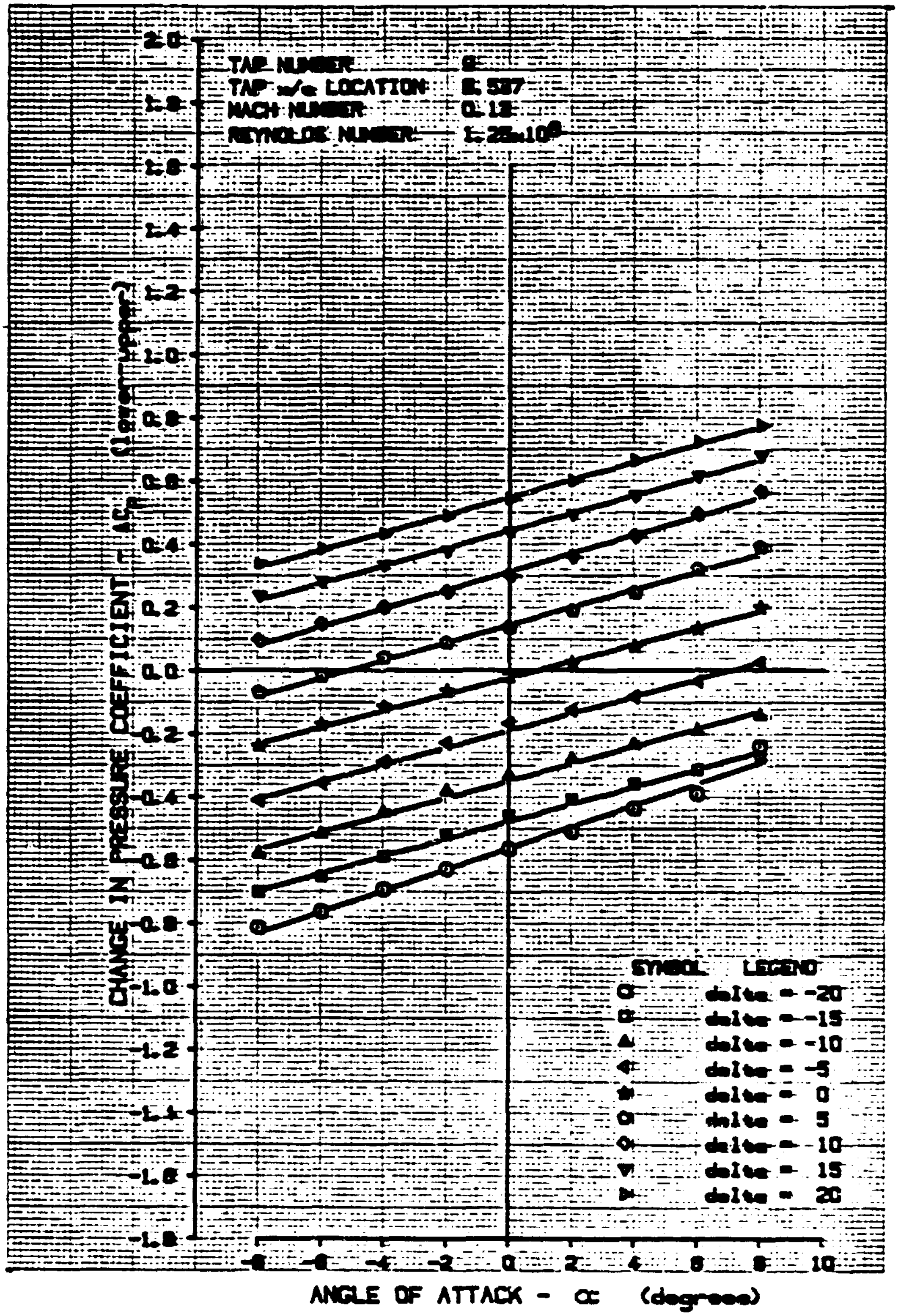
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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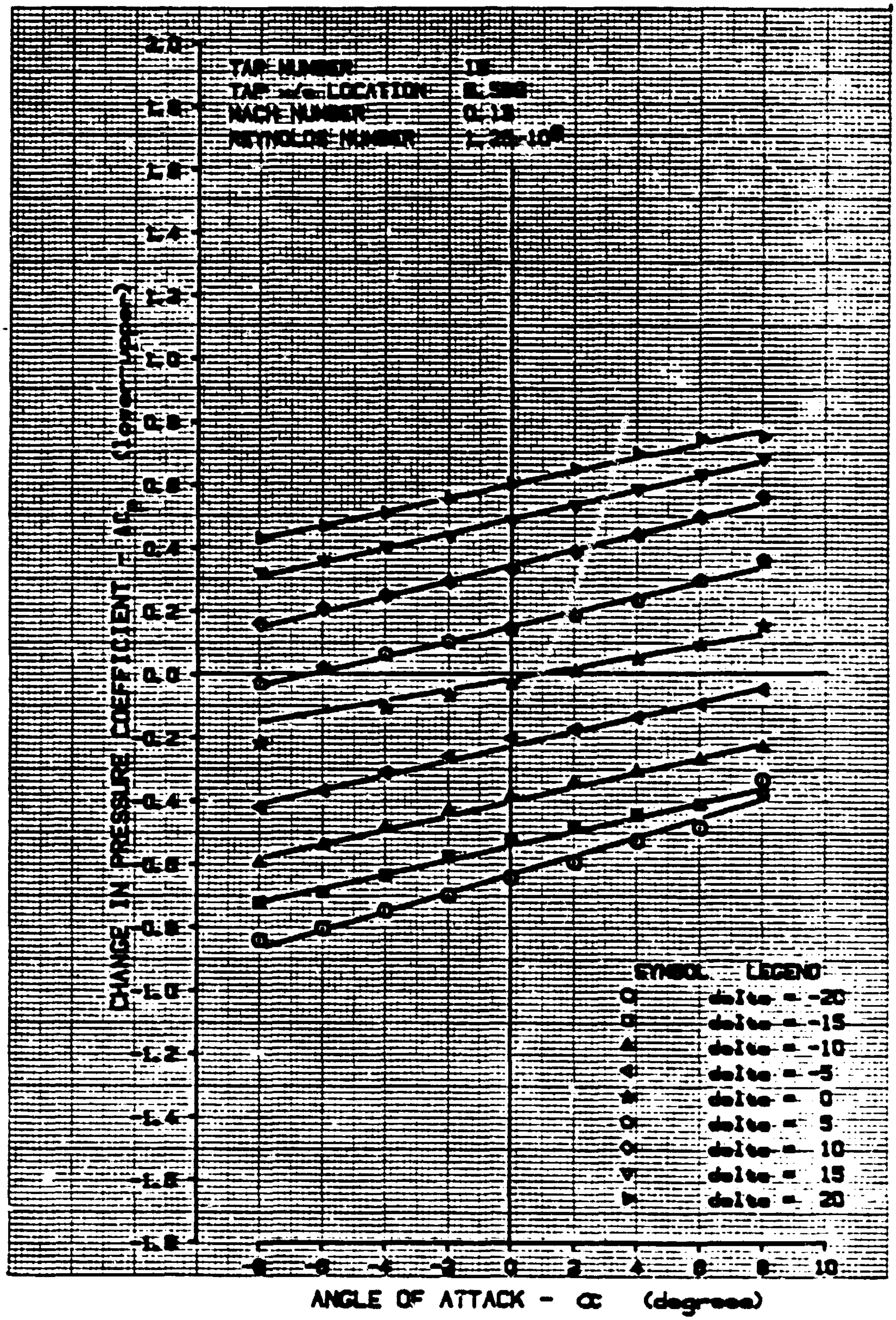
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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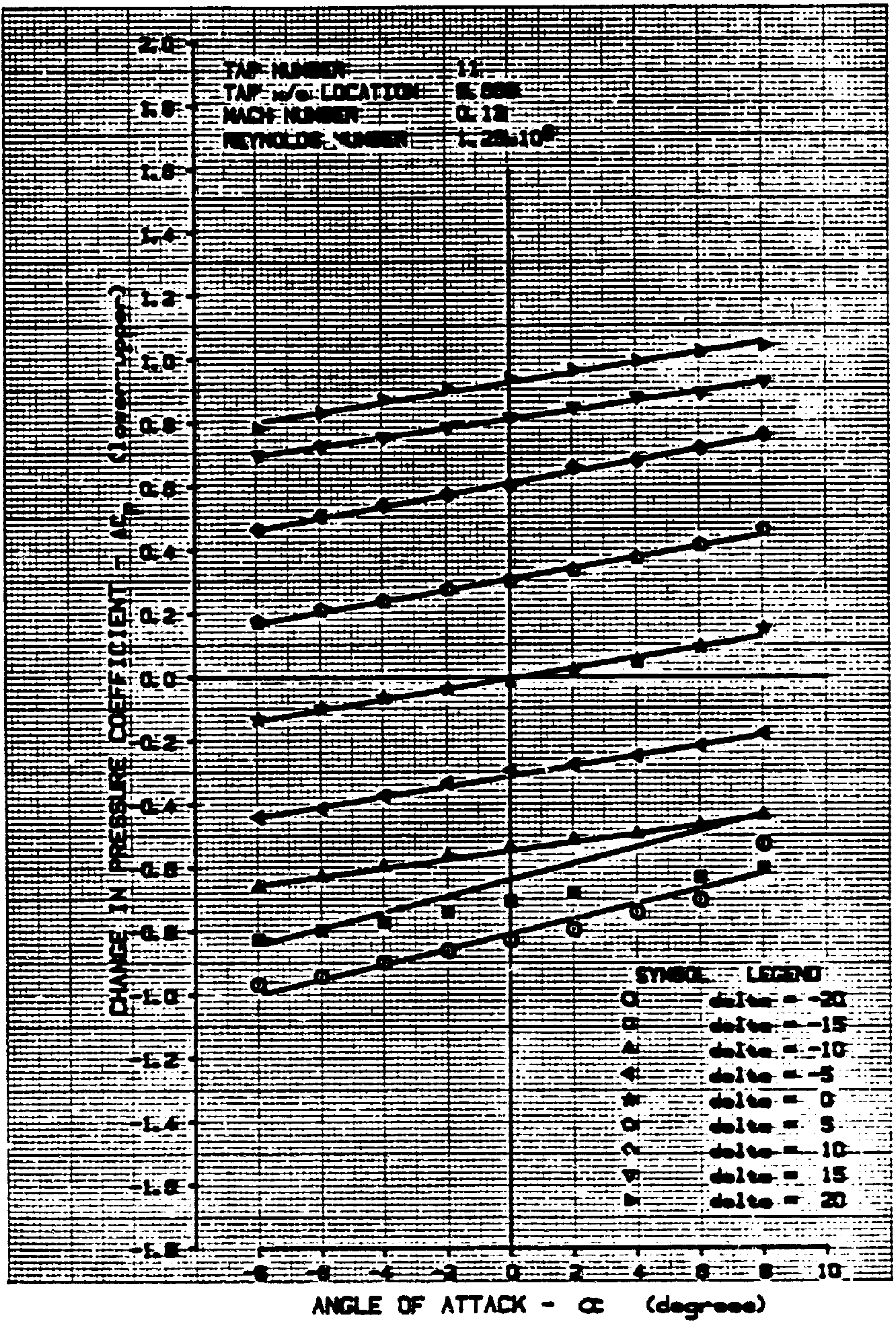
NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



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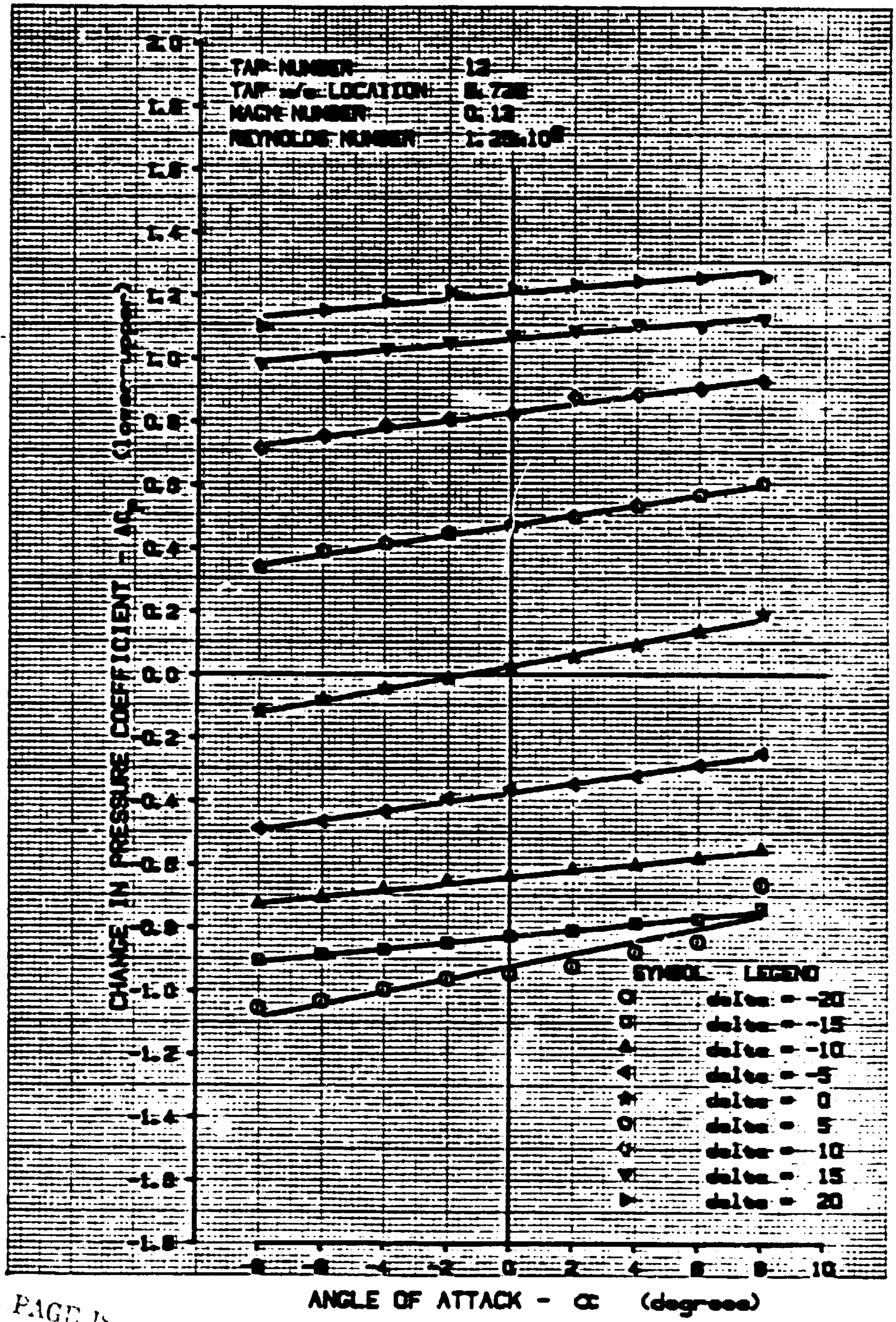
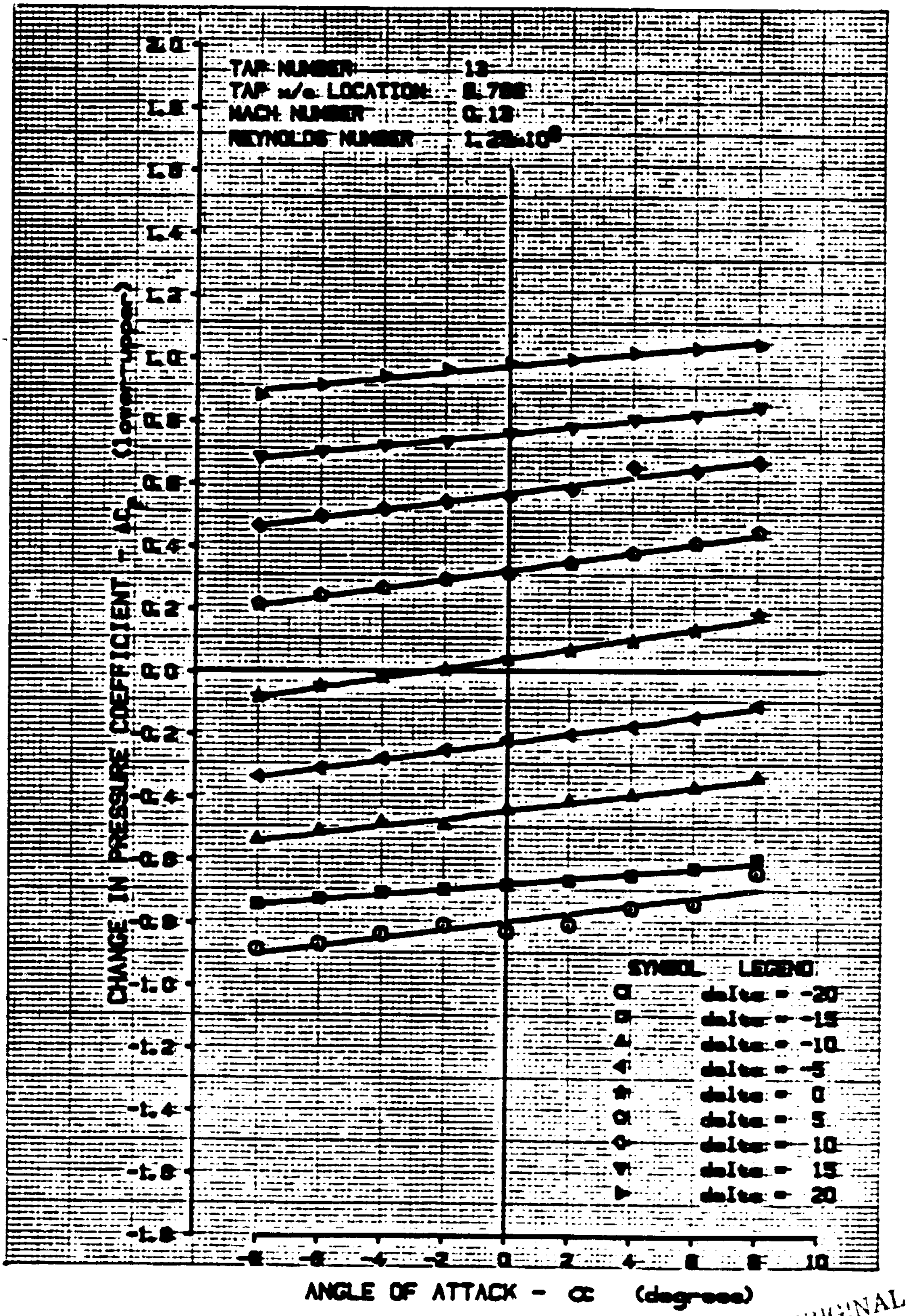
| APPD | | | | | UNIVERSITY OF KANSAS | | PAGE 82 |

NOTE: LOWER SURFACE Cp INTERPOLATED TO UPPER SURFACE TAP LOCATION



| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 5-81 | REVISED | DATE | FIGURE A. 2. 12 EXPERIMENTAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 21-5-81 |
| CHECK | D. LEVY | 5/25/81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 83 |

NOTE: LOWER SURFACE $C_p$ INTERPOLATED TO UPPER SURFACE TAP LOCATION



| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 5-81 | REVISED | DATE | FIGURE A. 2. 13 EXPERIMENTAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE<br>21-5-81 |
| CHECK | D. LEVY | 5/25/81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 84 |

## APPENDIX B.  PRESSURE TRANSDUCER CALIBRATION PROGRAM

```
240: wrt 4
241: wrt 4,"          DELTA P  PRESSURE TRANSDUCER CALIBRATION"
242: wrt 4
243: wrt 4,"  THE PRESSURE TRANSDUCER WILL BE CALIBRATED AGAINST THE TUNNEL"
244: wrt 4," MANOMETER BOARD LOCATED ON THE NORTH SIDE OF THE TUNNEL BELL"
245: wrt 4,"   THE TRANSDUCER MUST BE HOOKED TO CHANNEL 12 OF THE DAS"
246: wrt 4
247: wrt 4
248: wrt 4,"PROCEEDURE:"
249: wrt 4
250: wrt 4," TO CALIBRATE, THE TUNNEL WILL BE RUN AT VARIOUS ASSIGNED SPEEDS."
251: wrt 4," THE hp 9825 WILL RECORD THE PRESSURE TRANSDUCER OUTPUT AND "
252: wrt 4," THE OPERATOR WILL ADJUST THE TUNNEL SPEED TO THE MANOMETER VALUE"
253: wrt 4," REQUESTED BY THE CALCULATOR DISPLAY"
254: wrt 4;wrt 4
255: ent "DATE   TRANSDUCER NUMBER",D$
256: wtb 5,12+6
257: wrt 6;wrt 6;wrt 6;wrt 6,"           PRESSURE TRANSDUCER CALIBRATION  ",D$
258: wrt 6,"   ",G$
259: wrt 6,"    MANOMETER Q              TRANSDUCER OUTPUT"
260: csiz 2,2,1,0
261: ent "DO YOU WISH A GRAPH ?  Y or N",A$
262: if cap(A$)="Y";csiz 2,2,1,0
263: if cap(A$)="Y";fxd 0;scl 0,35,0,2;yax 0,.5,0,2,2;xax 0,5,0,35,1
264: if cap(A$)="Y";plt 8,-.5,-1;csiz 2,2,1,0
265: if cap(A$)="Y";lbl " TUNNEL DYNAMIC PRESSURE - Q (cm Al)"
266: if cap(A$)="Y";plt -5,.6,-1;csiz 2,2,1,90
267: if cap(A$)="Y";lbl " TRANSDUCER OUTPUT - Q1 (mV)"
268: if cap(A$)="Y";csiz 2.5,2,1,0;plt 5,-.8,-1
269: if cap(A$)="Y";lbl " PRESSURE TRANSDUCER CALIBRATION  ",D$
270: if cap(A$)="Y";plt 2.5,2.4,-1;csiz 2,2,1,0
271: lbl "Q = (TUNNEL MANOMETER * SIN30)"
272: for Q=0 to 35 by 5
273: fxd 0;0→S
274: dsp "TUNNEL Q (cmAl)",Q,"CONT W/RDY";stp
275: for I=1 to 50
276: red 3,A,B
277: if B>1;-A→A
278: A+S→S
279: next I
280: fmt 4,2x,f4.0,20x,f10.3
281: wrt 6.4,Q,20S
282: if cap(A$)="Y";plt Q,-20S;pen;cplt -.165,-.05;lbl "*"
283: next Q
```

# APPENDIX C

## THEORETICAL PRESSURE PROFILE DATA

## C.1 SAMPLE LISTING OF SEAP OUTPUT

```
                              LOAD SUMMARY SHEET--ITERATION NUMBER 4
                   [illegible] THEORETICAL PRESSURE DISTRIBUTION

MACH NUMBER        =  0.13000           REFERENCE CHORD (BASIS FOR ALL COEFFICIENT NORMALIZATION) =   1.38300 FT.
REYNOLDS NO.       =  1.25030 MILLION   ANGLE OF ATTACK (VALUE OF (ALPHA = 0)                     =   3.00000 DEG.
LONGEST CHORDLINE  =  1.38353 FEET          ((ALPHA0--ANGLE DEFINED W.R.T. REFERENCE LINE)
                                            ((ALPHA1--ANGLE DEFINED W.R.T. LONGEST CHORDLINE)

ANGLE BETWEEN LONGEST CHORDLINE AND REFERENCE LINE =  1.48935 DEG. (POSITIVE FOR REFERENCE LINE BELOW THE LONGEST CHORDLINE)
                                                      ...........................................
NORMAL FORCE COEFFICIENTS                             . LIFT COEFFICIENTS                       .
              ((CN)PRESS. =  0.15716                  .               ((CL)PRESS. =  0.15716    .
              ((CN)SHEAR  = -0.00003                  .               ((CL)SHEAR  = -0.00078    .
               CN         =  0.15713                  .                 CL        =  0.15638    .
                                                      .                                         .
AXIAL FORCE COEFFICIENTS                              . DRAG COEFFICIENTS                       .
              ((CA)PRESS. = -0.00455                  .               ((CD)PRESS. =  0.00368    .
              ((CA)SHEAR  =  0.01468                  .               ((CD)SHEAR  =  0.01468    .
               CA         =  0.01014                  .                 CD        =  0.01836    .
                                                      .                                         .
MOMENT COEFFICIENTS                                   . MOMENT COEFFICIENTS                     .
 (ABOUT NOSE)  ((CM)PRESS. = -0.00833                 .       ((CM)ABOUT NOSE     = -0.00763    .
               ((CM)SHEAR  =  0.00070                 .       ((CM)QUARTER CHORD  =  0.03163    .
                CM         = -0.00763                 .                                         .
                                                      ...........................................
DRAG COEFFICIENT COMPUTED BY SQUIRE-YOUNG FORMULA =  0.01595

ZEROTH ITERATION PRESSURE DRAG = -0.01341

TRANSITION POINTS:  X/C(LOWER) =  0.14532          X/C(UPPER) =  0.09327

 LONGEST CHORDLINE SYSTEM    BASIC REFERENCE SYSTEM
     X/C         Z/C            X/C         Z/C          S/C        CP         CF       DSTAR/C     V/V0
[illegible]
```

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## C.2 PRESSURE DISTRIBUTION DATA AS INPUT TO HP9825 A

```
          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0           FLAP DEFLECTION ANGLE =    0
FILE NUMBER  34

*************************************************************

                     RESULTS OF SEAP DATA

*************************************************************
  TAP   *           x/c             Cp             Cp
 NUMBER *        location         upper          lower
*************************************************************
        *
   1    *          0.060         -1.198         -1.198
   2    *          0.076         -1.135         -1.135
   3    *          0.084         -1.396         -1.396
   4    *          0.094         -1.354         -1.354
   5    *          0.108         -1.216         -1.216
        *
   6    *          0.121         -1.277         -1.277
   7    *          0.133         -1.450         -1.450
   8    *          0.143         -1.365         -1.365
   9    *          0.155         -1.081         -1.081
  10    *          0.169         -0.881         -0.881
        *
  11    *          0.184         -0.743         -0.743
  12    *          0.205         -0.648         -0.648
  13    *          0.228         -0.572         -0.572
  14    *          0.250         -0.334         -0.334
  15    *          0.381         -0.264         -0.264
        *
  16    *          0.416         -0.136         -0.136
  17    *          0.480         -0.115         -0.115
  18    *          0.680         -0.103         -0.103
  19    *          0.715         -0.076         -0.076
  20    *          0.750         -0.070         -0.070
        *
  21    *          0.785         -0.042         -0.042
  22    *          0.820         -0.029         -0.029
  23    *          1.000          0.634          0.634
        *
*************************************************************
```

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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    3         FLAP DEFLECTION ANGLE =    0
FILE NUMBER  35

************************************************************

                  RESULTS OF SEAP DATA

************************************************************
 TAP    *          x/c             Cp              Cp
NUMBER  *        location         upper           lower
************************************************************
        *
  1     *          0.060          -1.860          -0.612
  2     *          0.076          -1.728          -0.603
  3     *          0.084          -1.989          -0.849
  4     *          0.094          -1.877          -0.854
  5     *          0.108          -1.665          -0.777
        *
  6     *          0.121          -1.702          -0.855
  7     *          0.133          -1.887          -1.019
  8     *          0.143          -1.786          -0.965
  9     *          0.155          -1.445          -0.744
 10     *          0.169          -1.192          -0.591
        *
 11     *          0.184          -1.009          -0.490
 12     *          0.205          -0.881          -0.423
 13     *          0.228          -0.788          -0.364
 14     *          0.250          -0.476          -0.193
 15     *          0.381          -0.381          -0.145
        *
 16     *          0.416          -0.209          -0.057
 17     *          0.480          -0.177          -0.050
 18     *          0.680          -0.159          -0.045
 19     *          0.715          -0.119          -0.035
 20     *          0.750          -0.115          -0.028
        *
 21     *          0.785          -0.080          -0.006
 22     *          0.820          -0.063          -0.002
 23     *          1.000           0.630           0.630
        *
************************************************************
```

C - 2

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                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                    DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     6          FLAP DEFLECTION ANGLE =    0
FILE NUMBER  36

************************************************************

                      RESULTS OF SEAP DATA

************************************************************
  TAP     *           x/c             Cp             Cp
 NUMBER   *        location          upper          lower
************************************************************
          *
   1      *          0.060          -2.624         -0.093
   2      *          0.076          -2.407         -0.124
   3      *          0.084          -2.670         -0.345
   4      *          0.094          -2.489         -0.382
   5      *          0.108          -2.190         -0.355
          *
   6      *          0.121          -2.194         -0.444
   7      *          0.133          -2.383         -0.598
   8      *          0.143          -2.240         -0.578
   9      *          0.155          -1.822         -0.418
  10      *          0.169          -1.512         -0.308
          *
  11      *          0.184          -1.283         -0.240
  12      *          0.205          -1.121         -0.198
  13      *          0.228          -1.008         -0.156
  14      *          0.250          -0.626         -0.047
  15      *          0.381          -0.510         -0.018
          *
  16      *          0.416          -0.298          0.033
  17      *          0.480          -0.248          0.026
  18      *          0.680          -0.221          0.022
  19      *          0.715          -0.163          0.016
  20      *          0.750          -0.162          0.024
          *
  21      *          0.785          -0.119          0.039
  22      *          0.820          -0.096          0.036
  23      *          1.000           0.624          0.624
          *
************************************************************
```

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              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                   DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0          FLAP DEFLECTION ANGLE =    5
FILE NUMBER  37

************************************************************

                     RESULTS OF SEAP DATA

************************************************************
  TAP    *          x/c              Cp              Cp
 NUMBER  *        location          upper           lower
************************************************************
         *
   1     *          0.062          -1.340          -1.022
   2     *          0.073          -1.285          -0.949
   3     *          0.083          -1.572          -1.148
   4     *          0.094          -1.501          -1.202
   5     *          0.107          -1.359          -1.063
         *
   6     *          0.123          -1.486          -1.116
   7     *          0.135          -1.627          -1.266
   8     *          0.148          -1.324          -1.146
   9     *          0.163          -1.032          -0.886
  10     *          0.181          -0.903          -0.714
         *
  11     *          0.293          -0.596          -0.436
  12     *          0.296          -0.418          -0.275
  13     *          0.404          -0.214          -0.076
  14     *          0.652          -0.158          -0.008
  15     *          0.671          -0.027           0.215
         *
  16     *          0.688          -0.060           0.157
  17     *          0.704          -0.039           0.144
  18     *          0.720           0.020           0.124
  19     *          0.741          -0.022           0.068
  20     *          0.795          -0.067           0.033
         *
  21     *          0.824          -0.043           0.008
  22     *          0.852          -0.102          -0.088
  23     *          1.000           0.760           0.760
         *
************************************************************
```

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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    3          FLAP DEFLECTION ANGLE =    5
FILE NUMBER  38

************************************************************

                     RESULTS OF SEAP DATA

************************************************************
  TAP   *           x/c            Cp             Cp
 NUMBER *        location         upper          lower
************************************************************
        *
   1    *          0.062         -1.607         -0.748
   2    *          0.073         -1.513         -0.712
   3    *          0.083         -1.803         -0.912
   4    *          0.094         -1.703         -0.984
   5    *          0.107         -1.524         -0.881
        *
   6    *          0.123         -1.632         -0.951
   7    *          0.135         -1.767         -1.107
   8    *          0.148         -1.452         -1.006
   9    *          0.163         -1.141         -0.773
  10    *          0.181         -1.001         -0.619
        *
  11    *          0.203         -0.644         -0.384
  12    *          0.296         -0.438         -0.250
  13    *          0.404         -0.178         -0.105
  14    *          0.652         -0.097         -0.060
  15    *          0.671          0.122          0.078
        *
  16    *          0.688          0.091          0.009
  17    *          0.704          0.123         -0.020
  18    *          0.720          0.158         -0.022
  19    *          0.741          0.080         -0.039
  20    *          0.795          0.017         -0.053
        *
  21    *          0.824          0.039         -0.077
  22    *          0.852         -0.024         -0.174
  23    *          1.000          0.750          0.750
        *
************************************************************
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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    6          FLAP DEFLECTION ANGLE =    5
FILE NUMBER  39

***********************************************************

                     RESULTS OF SEAP DATA

***********************************************************
  TAP   *           x/c            Cp             Cp
 NUMBER *        location         upper          lower
***********************************************************
        *
   1    *          0.062         -1.905         -0.469
   2    *          0.073         -1.773         -0.464
   3    *          0.083         -2.063         -0.661
   4    *          0.094         -1.925         -0.748
   5    *          0.107         -1.707         -0.680
        *
   6    *          0.123         -1.798         -0.764
   7    *          0.135         -1.914         -0.932
   8    *          0.148         -1.563         -0.860
   9    *          0.163         -1.230         -0.652
  10    *          0.181         -1.083         -0.512
        *
  11    *          0.203         -0.688         -0.318
  12    *          0.296         -0.456         -0.209
  13    *          0.404         -0.140         -0.119
  14    *          0.652         -0.035         -0.098
  15    *          0.671          0.261         -0.040
        *
  16    *          0.688          0.254         -0.145
  17    *          0.704          0.307         -0.209
  18    *          0.720          0.319         -0.192
  19    *          0.741          0.199         -0.158
  20    *          0.795          0.113         -0.150
        *
  21    *          0.824          0.130         -0.168
  22    *          0.852          0.045         -0.281
  23    *          1.000          0.725          0.725
        *
***********************************************************
```

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              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                   DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    9          FLAP DEFLECTION ANGLE =    5
FILE NUMBER  48

*************************************************************

                      RESULTS OF SEAP DATA

*************************************************************
 TAP    *         x/c            Cp              Cp
NUMBER  *       location        upper           lower
*************************************************************
        *
  1     *        0.062          -2.268          -0.158
  2     *        0.073          -2.088          -0.183
  3     *        0.083          -2.376          -0.372
  4     *        0.094          -2.194          -0.471
  5     *        0.107          -1.928          -0.438
        *
  6     *        0.123          -1.997          -0.533
  7     *        0.135          -2.091          -0.701
  8     *        0.148          -1.699          -0.658
  9     *        0.163          -1.338          -0.488
 10     *        0.181          -1.185          -0.369
        *
 11     *        0.203          -0.754          -0.215
 12     *        0.295          -0.498          -0.132
 13     *        0.404          -0.126          -0.091
 14     *        0.652          -0.002          -0.081
 15     *        0.671           0.322          -0.017
        *
 16     *        0.688           0.384          -0.286
 17     *        0.704           0.488          -0.503
 18     *        0.720           0.482          -0.472
 19     *        0.741           0.316          -0.327
 20     *        0.795           0.205          -0.276
        *
 21     *        0.824           0.214          -0.275
 22     *        0.852           0.096          -0.407
 23     *        1.000           0.683           0.683
        *
*************************************************************
```

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             KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                  DELTA P PROJECT - PHASE I

             SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     0         FLAP DEFLECTION ANGLE =   10
FILE NUMBER  40

************************************************************

                      RESULTS OF SEAP DATA

************************************************************
  TAP    *          x/c            Cp             Cp
 NUMBER  *        location        upper          lower
************************************************************
         *
   1     *         0.060         -1.945         -0.541
   2     *         0.071         -1.856         -0.493
   3     *         0.081         -2.166         -0.534
   4     *         0.091         -2.055         -0.747
   5     *         0.102         -1.832         -0.725
         *
   6     *         0.116         -1.928         -0.668
   7     *         0.128         -2.110         -0.767
   8     *         0.140         -1.960         -0.887
   9     *         0.151         -1.613         -0.771
  10     *         0.165         -1.370         -0.562
         *
  11     *         0.180         -1.263         -0.444
  12     *         0.199         -0.932         -0.241
  13     *         0.278         -0.683         -0.101
  14     *         0.399         -0.469          0.068
  15     *         0.649         -0.428          0.141
         *
  16     *         0.672         -0.527          0.364
  17     *         0.688         -0.622          0.331
  18     *         0.704         -0.685  ?       0.317 ?
  19     *         0.720         -0.294          0.188
  20     *         0.844         -0.213          0.158
         *
  21     *         0.873         -0.072          0.127
  22     *         0.901          0.027          0.105
  23     *         1.001          0.170          0.170
         *
************************************************************
```

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           KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

           SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    3          FLAP DEFLECTION ANGLE =   10
FILE NUMBER  41

************************************************************

                  RESULTS OF SEAP DATA

************************************************************
 TAP    *          x/c           Cp            Cp
 NUMBER *        location       upper         lower
************************************************************
        *
   1    *         0.060        -2.761         0.020
   2    *         0.071        -2.588         0.006
   3    *         0.081        -2.922        -0.063
   4    *         0.091        -2.744        -0.245
   5    *         0.102        -2.430        -0.265
        *
   6    *         0.116        -2.507        -0.252
   7    *         0.128        -2.685        -0.353
   8    *         0.140        -2.476        -0.469
   9    *         0.151        -2.048        -0.400
  10    *         0.165        -1.748        -0.252
        *
  11    *         0.180        -1.617        -0.168
  12    *         0.199        -1.200        -0.033
  13    *         0.278        -0.883         0.057
  14    *         0.399        -0.588         0.165
  15    *         0.649        -0.519         0.215
        *
  16    *         0.672        -0.566         0.400
  17    *         0.688        -0.671         0.377
  18    *         0.704        -0.730 ?       0.361 ?
  19    *         0.720        -0.331         0.230
  20    *         0.844        -0.247         0.199
        *
  21    *         0.873        -0.096         0.159
  22    *         0.901         0.010         0.128
  23    *         1.001         0.165         0.165
        *
************************************************************
```

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              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                    DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    6          FLAP DEFLECTION ANGLE =   10
FILE NUMBER  42

************************************************************

                      RESULTS OF SEAP DATA

************************************************************
 TAP    *         x/c            Cp             Cp
 NUMBER *       location        upper          lower
************************************************************
        *
   1    *        0.060         -3.655          0.459
   2    *        0.071         -3.384          0.409
   3    *        0.081         -3.737          0.327
   4    *        0.091         -3.476          0.178
   5    *        0.102         -3.060          0.130
        *
   6    *        0.116         -3.111          0.112
   7    *        0.128         -3.279          0.014
   8    *        0.140         -2.999         -0.100
   9    *        0.151         -2.483         -0.072
  10    *        0.165         -2.128          0.028
        *
  11    *        0.180         -1.979          0.084
  12    *        0.199         -1.476          0.160
  13    *        0.278         -1.090          0.209
  14    *        0.399         -0.707          0.262
  15    *        0.649         -0.606          0.291
        *
  16    *        0.672         -0.600          0.437
  17    *        0.688         -0.717          0.424
  18    *        0.704         -0.771          0.407
  19    *        0.720         -0.364          0.276
  20    *        0.844         -0.277          0.242
        *
  21    *        0.873         -0.116          0.194
  22    *        0.901         -0.003          0.153
  23    *        1.001          0.163          0.163
        *
************************************************************
```

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              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                   DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     9           FLAP DEFLECTION ANGLE =   10
FILE NUMBER  46

************************************************************

                     RESULTS OF SEAP DATA

************************************************************
  TAP    *         x/c             Cp              Cp
 NUMBER  *       location         upper           lower
************************************************************
         *
   1     *        0.060          -4.614          0.771
   2     *        0.071          -4.232          0.711
   3     *        0.081          -4.594          0.632
   4     *        0.091          -4.240          0.517
   5     *        0.102          -3.708          0.456
         *
   6     *        0.116          -3.724          0.417
   7     *        0.128          -3.871          0.327
   8     *        0.140          -3.518          0.225
   9     *        0.151          -2.909          0.221
  10     *        0.165          -2.492          0.272
         *
  11     *        0.180          -2.326          0.301
  12     *        0.199          -1.753          0.334
  13     *        0.278          -1.301          0.349
  14     *        0.399          -0.833          0.359
  15     *        0.650          -0.704          0.372
         *
  16     *        0.672          -0.668          0.488
  17     *        0.688          -0.776          0.483
  18     *        0.764          -0.816          0.467
  19     *        0.720          -0.398          0.330
  20     *        0.844          -0.308          0.294
         *
  21     *        0.873          -0.135          0.237
  22     *        0.901          -0.016          0.185
  23     *        1.001           0.160          0.160
         *
************************************************************
```

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                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                       DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  43

************************************************************

                       RESULTS OF SEAP DATA

************************************************************
  TAP    *          x/c             Cp              Cp
 NUMBER  *        location         upper           lower
************************************************************
         *
   1     *         0.073          -2.507          -0.227
   2     *         0.085          -2.529          -0.298
   3     *         0.098          -2.256          -0.423
   4     *         0.114          -2.350          -0.409
   5     *         0.128          -2.522          -0.477
         *
   6     *         0.142          -2.133          -0.584
   7     *         0.157          -1.715          -0.457
   8     *         0.175          -1.479          -0.288
   9     *         0.197          -1.357          -0.214
  10     *         0.222          -0.903           0.011
         *
  11     *         0.367          -0.781           0.073
  12     *         0.416          -0.608           0.217
  13     *         0.607          -0.616           0.254
  14     *         0.632          -0.718           0.406
  15     *         0.6[illegible]          -0.750           0.418
         *
  16     *         0.674          -0.945           0.444
  17     *         0.695          -1.061           0.449
  18     *         0.715          -0.913           0.449
  19     *         0.735          -0.269           0.248
  20     *         0.916          -0.157           0.201
         *
  21     *         0.947           0.152           0.079
  22     *         0.977           0.247           0.083
  23     *         1.003           0.151           0.151
         *
************************************************************
```

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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    3        FLAP DEFLECTION ANGLE =   15
FILE NUMBER  44

**************************************************************

                     RESULTS OF SEAP DATA

**************************************************************
  TAP   *           x/c             Cp              Cp
 NUMBER *        location          upper           lower
**************************************************************
        *
   1    *          0.073          -3.224           0.190
   2    *          0.085          -3.193           0.103
   3    *          0.098          -2.815          -0.025
   4    *          0.114          -2.874          -0.048
   5    *          0.128          -3.036          -0.129
        *
   6    *          0.142          -2.586          -0.235
   7    *          0.157          -2.103          -0.156
   8    *          0.175          -1.819          -0.041
   9    *          0.197          -1.687           0.009
  10    *          0.222          -1.114           0.154
        *
  11    *          0.367          -0.959           0.193
  12    *          0.416          -0.711           0.288
  13    *          0.607          -0.703           0.315
  14    *          0.631          -0.762           0.439
  15    *          0.654          -0.787           0.454
        *
  16    *          0.674          -0.960           0.477
  17    *          0.695          -1.061           0.481
  18    *          0.715          -0.913           0.482
  19    *          0.735          -0.280           0.275
  20    *          0.916          -0.166           0.224
        *
  21    *          0.947           0.150           0.079
  22    *          0.977           0.241           0.070
  23    *          1.003           0.143           0.143
        *
**************************************************************
```

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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    6          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  45

************************************************************

                   RESULTS OF SEAP DATA

************************************************************
 TAP    *          x/c            Cp              Cp
NUMBER  *       location        upper           lower
************************************************************
        *
   1    *         0.073         -4.040          0.539
   2    *         0.085         -3.951          0.448
   3    *         0.098         -3.454          0.328
   4    *         0.114         -3.475          0.280
   5    *         0.128         -3.614          0.193
        *
   6    *         0.142         -3.061          0.087
   7    *         0.157         -2.491          0.121
   8    *         0.175         -2.160          0.193
   9    *         0.197         -2.017          0.224
  10    *         0.222         -1.329          0.296
        *
  11    *         0.327         -1.144          0.316
  12    *         0.416         -0.819          0.364
  13    *         0.607         -0.792          0.382
  14    *         0.631         -0.812          0.479
  15    *         0.655         -0.840          0.497
        *
  16    *         0.674         -0.997          0.518
  17    *         0.695         -1.087          0.521
  18    *         0.715         -0.936          0.524
  19    *         0.735         -0.292          0.311
  20    *         0.916         -0.175          0.257
        *
  21    *         0.947          0.155          0.992
  22    *         0.977          0.246          0.069
  23    *         1.003          0.145          0.145
        *
************************************************************
```

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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    9          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  47

*************************************************************

                     RESULTS OF SEAP DATA

*************************************************************
  TAP   *            x/c             Cp              Cp
 NUMBER *          location         upper           lower
*************************************************************
        *
   1    *           0.073          -4.897          0.791
   2    *           0.085          -4.740          0.711
   3    *           0.098          -4.113          0.608
   4    *           0.114          -4.090          0.548
   5    *           0.128          -4.203          0.464
        *
   6    *           0.142          -3.550          0.367
   7    *           0.157          -2.891          0.365
   8    *           0.175          -2.504          0.394
   9    *           0.970          -2.343          0.405
  10    *           0.222          -1.530          0.424
        *
  11    *           0.367          -1.310          0.427
  12    *           0.416          -0.912          0.439
  13    *           0.607          -0.874          0.450
  14    *           0.632          -0.869          0.531
  15    *           0.655          -0.898          0.554
        *
  16    *           0.674          -1.044          0.574
  17    *           0.695          -1.123          0.574
  18    *           0.715          -0.967          0.577
  19    *           0.735          -0.304          0.356
  20    *           0.916          -0.181          0.297
        *
  21    *           0.947           0.163          0.109
  22    *           0.977           0.253          0.070
  23    *           1.003           0.146          0.146
        *
*************************************************************
```

```
0: "DELTA P THEORETICAL PRESSURE DISTRIBUTION DATA STORER":
1: dim X[3,3,33],U[3,3,33],L[3,3,33],N$[1],Y$[1]
2: fmt 1,z,2x,f8.5
3: for I=1 to 3
4: for J=1 to 3
5: wrt 4,"ANGLE OF ATTACK=",3(J-1),"DEG"
6: wrt 4,"FLAP DEFLECTION=",5(I-1),"DEG"
7: for K=1 to 33
8: ent "X/C?",X[I,J,K]
9: wrt 4,K,X[I,J,K]
10: next K
11: ent "CHANGES?",N$
12: if cap(N$)="Y";cll 'changes'(1)
13: for K=1 to 33
14: wrt 4.1,K,X[I,J,K]
15: ent "Cp UPPER?",U[I,J,K]
16: wrt 4.1,U[I,J,K];wrt 4
17: next K
18: ent "CHANGES?",N$
19: if cap(N$)="Y";cll 'changes'(2)
20: for K=1 to 33
21: wrt 4.1,K,X[I,J,K],U[I,J,K]
22: ent "Cp LOWER?",L[I,J,K]
23: wrt 4.1,L[I,J,K];wrt 4
24: next K
25: ent "CHANGES?",N$
26: if cap(N$)="Y";cll 'changes'(3)
27: 4→r1
28: wrt r1,"ALPHA=",3(J-1),"DEG"
29: wrt r1,"DELTA FLAP=",5(I-1),"DEG"
30: wrt r1,"     X/C     Cp UPPER     Cp LOWER";wrt r1
31: for K=1 to 33
32: if cap(N$)="Y";wrt 6.1,K,X[I,J,K],U[I,J,K],L[I,J,K];wrt r1;jmp 2
33: wrt 4.1,K,X[I,J,K],U[I,J,K],L[I,J,K];wrt r1
34: next K
35: ent "GENERAL CHANGES?",Y$
36: if cap(Y$)="Y";gsb "GC"
37: if cap(N$)="Y";jmp 4
38: ent "HARD COPY OF THIS?",N$
39: if cap(N$)#"Y";jmp 3
40: 6→r1;gto 28
41: "N"→N$
42: next J
43: next I
44: trk 1;fdf 33;rcf 33,X[*],U[*],L[*]
45: stp
46: "GC":
47: "N"→Y$
48: ent "CHANGE 1) X/C? 2) Cp UPPER? 3) Cp LOWER?",A
49: cll 'changes'(A)
50: ent "MORE?",Y$
51: if cap(Y$)#"Y";ret
52: gto 47
53: "changes":
54: "N"→N$
55: ent "NUMBER?",K
56: if p1=1;ent "X/C?",X[I,J,K]
57: if p1=2;ent "Cp UPPER?",U[I,J,K]
58: if p1=3;ent "Cp LOWER?",L[I,J,K]
59: ent "MORE?",N$
60: if cap(N$)#"Y";ret
61: gto 54
*1442
```

```
0: "SEAP -  C SUB P OUTPUTTING PROGRAM      files 34→49":
1: dim L$[80],P$[3],Y$[80],S$[10];for S=1 to 60;"*"→L$[S];next S;fxd 1
2: dim X[23],U[23],L[23],A,D;"            "&L$→L$
3: "          "→S$
4: fmt 1,10x,f3.0,4x,"*",3f15.3
5: fmt 2,9x,"ANGLE OF ATTACK = ",f4.0,10x,"FLAP DEFLECTION ANGLE = ",f4.0
6: fmt 3,9x,"FILE NUMBER  ",f2.0
7: "PCL":ent "FILE NUMBER?",F;if F<34 or F>49;beep;gto +0
8: trk 1;fdf F;ldf F,X[*],U[*],L[*],A,D
9: "STR":wrt 6,"                     ------------------";for S=1 to 5;wrt 6;next S
10: wrt 6,"                      KANSAS UNIVERSITY FLIGHT RESEARCH LAB";wrt 6
11: wrt 6,"                             DELTA P PROJECT - PHASE I"
12: wrt 6
13: wrt 6,"                      SINGLE ELEMENT AIRFOIL PROGRAM RESULTS"
14: wrt 6;wrt 6;wrt 6;wrt 6.2,A,D;wrt 6.3,F;wrt 6;wrt 6,L$;wrt 6
15: wrt 6,S$&S$&S$&"RESULTS OF SEAP DATA"
16: wrt 6;wrt 6,L$
17: wrt 6,S$&" TAP    *"&S$&" x/c            Cp             Cp"
18: wrt 6,S$&"NUMBER *        location          upper           lower"
19: wrt 6,L$
20: wrt 6,"                *";0→B;for S=1 to 23
21: wrt 6.1,S,X[S],U[S],L[S];B+1→B
22: if B=5;0→B;wrt 6,"              *"
23: next S;wrt 6,"              *"
24: wrt 6,L$;wrt 6;wrt 6;wrt 6
25: for S=1 to 12;wrt 6;next S
26: ent "ANOTHER FILE?",P$;if cap(P$)="Y";gto "PCL"
27: stp
*8319
```

# C.3 INTERPOLATED CHANGE IN $C_p$ BY ANGLE OF ATTACK AND FLAP DEFLECTION

```
                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                       DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0          FLAP DEFLECTION ANGLE =    0
FILE NUMBER  50

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *        x/c        Cp           Cp        change in
 NUMBER  *     location     upper        lower         Cp
************************************************************
   1     *       0.119      -1.267       -1.267       0.000
         *
   2     *       0.171      -0.859       -0.859       0.000
         *
   3     *       0.223      -0.588       -0.588       0.000
         *
   4     *       0.276      -0.320       -0.320       0.000
         *
   5     *       0.328      -0.292       -0.292       0.000
         *
   6     *       0.380      -0.264       -0.264       0.000
         *
   7     *       0.433      -0.130       -0.130       0.000
         *
   8     *       0.485      -0.114       -0.114       0.000
         *
   9     *       0.537      -0.111       -0.111       0.000
         *
  10     *       0.589      -0.108       -0.108       0.000
         *
  11     *       0.668      -0.103       -0.103       0.000
         *
  12     *       0.720      -0.075       -0.075       0.000
         *
  13     *       0.766      -0.058       -0.058       0.000
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
            KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                 DELTA P PROJECT - PHASE I

            SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    3          FLAP DEFLECTION ANGLE =    0
FILE NUMBER  51

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *       x/c          Cp          Cp       change in
 NUMBER  *     location      upper       lower         Cp
************************************************************
   1     *      0.119       -1.695      -0.841       0.854
         *
   2     *      0.171       -1.162      -0.574       0.587
         *
   3     *      0.223       -0.807      -0.376       0.431
         *
   4     *      0.276       -0.457      -0.184       0.273
         *
   5     *      0.328       -0.419      -0.164       0.255
         *
   6     *      0.380       -0.382      -0.145       0.237
         *
   7     *      0.433       -0.201      -0.055       0.145
         *
   8     *      0.485       -0.177      -0.049       0.127
         *
   9     *      0.537       -0.172      -0.048       0.124
         *
  10     *      0.589       -0.167      -0.047       0.120
         *
  11     *      0.668       -0.160      -0.045       0.115
         *
  12     *      0.720       -0.118      -0.034       0.084
         *
  13     *      0.766       -0.100      -0.018       0.082
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
            KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                  DELTA P PROJECT - PHASE I

            SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    6          FLAP DEFLECTION ANGLE =    0
FILE NUMBER  52

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *        x/c          Cp          Cp        change in
 NUMBER  *     location      upper       lower         Cp
************************************************************
   1     *       0.119      -2.193      -0.429        1.764
         *
   2     *       0.171      -1.474      -0.297        1.177
         *
   3     *       0.223      -1.031      -0.165        0.866
         *
   4     *       0.276      -0.602      -0.041        0.561
         *
   5     *       0.328      -0.557      -0.029        0.527
         *
   6     *       0.380      -0.511      -0.018        0.493
         *
   7     *       0.433      -0.285       0.031        0.316
         *
   8     *       0.485      -0.248       0.026        0.273
         *
   9     *       0.537      -0.240       0.025        0.265
         *
  10     *       0.589      -0.233       0.024        0.257
         *
  11     *       0.668      -0.222       0.022        0.245
         *
  12     *       0.720      -0.163       0.017        0.180
         *
  13     *       0.766      -0.143       0.031        0.174
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                       DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0          FLAP DEFLECTION ANGLE =    5
FILE NUMBER  53

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP   *       x/c         Cp          Cp        change in
 NUMBER *    location      upper       lower         Cp
************************************************************
    1   *      0.119      -1.455      -1.104       0.352
        *
    2   *      0.171      -0.973      -0.809       0.165
        *
    3   *      0.223      -0.558      -0.401       0.156
        *
    4   *      0.276      -0.456      -0.310       0.147
        *
    5   *      0.328      -0.358      -0.216       0.142
        *
    6   *      0.380      -0.259      -0.120       0.139
        *
    7   *      0.433      -0.208      -0.068       0.140
        *
    8   *      0.485      -0.196      -0.054       0.142
        *
    9   *      0.537      -0.184      -0.040       0.144
        *
   10   *      0.589      -0.172      -0.025       0.147
        *
   11   *      0.668      -0.049       0.177       0.226
        *
   12   *      0.720       0.018       0.125       0.107
        *
   13   *      0.766      -0.043       0.052       0.094
        *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                   DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    3          FLAP DEFLECTION ANGLE =    5
FILE NUMBER  54

**************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

**************************************************************
  TAP    *       x/c          Cp          Cp        change in
 NUMBER  *     location      upper       lower         Cp
**************************************************************
   1     *       0.119      -1.606      -0.934       0.672
         *
   2     *       0.171      -1.078      -0.704       0.374
         *
   3     *       0.223      -0.600      -0.355       0.245
         *
   4     *       0.276      -0.482      -0.279       0.203
         *
   5     *       0.328      -0.360      -0.207       0.154
         *
   6     *       0.380      -0.236      -0.137       0.099
         *
   7     *       0.433      -0.169      -0.100       0.069
         *
   8     *       0.485      -0.152      -0.090       0.061
         *
   9     *       0.537      -0.135      -0.081       0.054
         *
  10     *       0.589      -0.118      -0.072       0.046
         *
  11     *       0.668       0.085       0.055      -0.030
         *
  12     *       0.720       0.156      -0.022      -0.178
         *
  13     *       0.766       0.052      -0.046      -0.097
         *
**************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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           KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                DELTA P PROJECT - PHASE I

           SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     6           FLAP DEFLECTION ANGLE =     5
FILE NUMBER  55

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
 TAP    *       x/c          Cp          Cp        change in
 NUMBER *     location      upper       lower         Cp
************************************************************
   1    *      0.119       -1.777      -0.744       1.033
        *
   2    *      0.171       -1.164      -0.589       0.575
        *
   3    *      0.223       -0.638      -0.295       0.343
        *
   4    *      0.276       -0.506      -0.233       0.273
        *
   5    *      0.328       -0.362      -0.182       0.180
        *
   6    *      0.380       -0.210      -0.139       0.071
        *
   7    *      0.433       -0.128      -0.116       0.012
        *
   8    *      0.485       -0.106      -0.112      -0.006
        *
   9    *      0.537       -0.084      -0.108      -0.024
        *
  10    *      0.589       -0.062      -0.103      -0.042
        *
  11    *      0.668        0.211      -0.050      -0.261
        *
  12    *      0.720        0.319      -0.192      -0.511
        *
  13    *      0.766        0.160      -0.154      -0.314
        *
************************************************************


 *   Change in pressure coefficient represents the difference
     between lower and upper surface pressure coefficients
```

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          KANSAS UNIVERSITY FLIGHT RESEARCH LAB

               DELTA P PROJECT - PHASE I

          SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0          FLAP DEFLECTION ANGLE =   10
FILE NUMBER  56

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP   *       x/c         Cp          Cp        change in
 NUMBER *     location     upper       lower         Cp
************************************************************
   1    *      0.119      -1.977      -0.695       1.282
        *
   2    *      0.171      -1.328      -0.515       0.812
        *
   3    *      0.223      -0.856      -0.198       0.658
        *
   4    *      0.276      -0.690      -0.106       0.585
        *
   5    *      0.328      -0.595      -0.031       0.563
        *
   6    *      0.380      -0.503       0.042       0.545
        *
   7    *      0.433      -0.464       0.078       0.542
        *
   8    *      0.485      -0.455       0.093       0.548
        *
   9    *      0.537      -0.447       0.108       0.555
        *
  10    *      0.589      -0.438       0.123       0.561
        *
  11    *      0.668      -0.511       0.328       0.839
        *
  12    *      0.720      -0.294       0.188       0.482
        *
  13    *      0.766      -0.264       0.177       0.441
        *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                  DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     3          FLAP DEFLECTION ANGLE =   10
FILE NUMBER  57

*************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

*************************************************************
  TAP    *       x/c          Cp          Cp        change in
 NUMBER  *     location      upper       lower         Cp
*************************************************************
   1     *       0.119      -2.555      -0.279        2.276
         *
   2     *       0.171      -1.697      -0.219        1.478
         *
   3     *       0.223      -1.104      -0.006        1.098
         *
   4     *       0.276      -0.893       0.054        0.947
         *
   5     *       0.328      -0.762       0.102        0.864
         *
   6     *       0.380      -0.635       0.149        0.783
         *
   7     *       0.433      -0.579       0.172        0.751
         *
   8     *       0.485      -0.564       0.183        0.747
         *
   9     *       0.537      -0.550       0.193        0.743
         *
  10     *       0.589      -0.535       0.203        0.739
         *
  11     *       0.668      -0.558       0.370        0.928
         *
  12     *       0.720      -0.331       0.231        0.562
         *
  13     *       0.766      -0.300       0.219        0.519
         *
*************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
               KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                  DELTA P PROJECT - PHASE I

               SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     6          FLAP DEFLECTION ANGLE =   10
FILE NUMBER  58

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *       x/c         Cp          Cp        change in
 NUMBER  *     location     upper       lower         Cp
************************************************************
   1     *      0.119      -3.156       0.086        3.242
         *
   2     *      0.171      -2.070       0.050        2.119
         *
   3     *      0.223      -1.359       0.175        1.533
         *
   4     *      0.276      -1.101       0.207        1.308
         *
   5     *      0.328      -0.932       0.230        1.162
         *
   6     *      0.380      -0.767       0.253        1.020
         *
   7     *      0.433      -0.693       0.266        0.959
         *
   8     *      0.485      -0.672       0.272        0.944
         *
   9     *      0.537      -0.651       0.278        0.929
         *
  10     *      0.589      -0.630       0.284        0.914
         *
  11     *      0.668      -0.601       0.413        1.014
         *
  12     *      0.720      -0.364       0.276        0.640
         *
  13     *      0.766      -0.332       0.263        0.595
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                   DELTA F PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    0          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  59

*************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

*************************************************************
  TAP    *       x/c          Cp          Cp        change in
 NUMBER  *     location      upper       lower         Cp
*************************************************************
   1     *       0.119      -2.411      -0.433       1.978
         *
   2     *       0.171      -1.526      -0.322       1.204
         *
   3     *       0.223      -0.902       0.011       0.914
         *
   4     *       0.276      -0.858       0.034       0.892
         *
   5     *       0.328      -0.814       0.056       0.870
         *
   6     *       0.380      -0.736       0.111       0.846
         *
   7     *       0.433      -0.609       0.220       0.829
         *
   8     *       0.485      -0.611       0.230       0.841
         *
   9     *       0.537      -0.613       0.240       0.853
         *
  10     *       0.589      -0.615       0.250       0.866
         *
  11     *       0.668      -0.882       0.436       1.318
         *
  12     *       0.720      -0.751       0.399       1.150
         *
  13     *       0.766      -0.250       0.240       0.490
         *
*************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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               KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                     DELTA P PROJECT - PHASE I

               SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =     3          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  60

*************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

*************************************************************
 TAP    *          x/c          Cp           Cp         change in
 NUMBER *        location      upper        lower          Cp
*************************************************************
   1    *         0.119       -2.932       -0.077        2.855
        *
   2    *         0.171       -1.882       -0.067        1.816
        *
   3    *         0.223       -1.113        0.154        1.267
        *
   4    *         0.276       -1.056        0.169        1.225
        *
   5    *         0.328       -1.001        0.183        1.183
        *
   6    *         0.380       -0.893        0.218        1.111
        *
   7    *         0.433       -0.710        0.290        1.001
        *
   8    *         0.485       -0.708        0.298        1.006
        *
   9    *         0.537       -0.706        0.305        1.011
        *
  10    *         0.589       -0.704        0.312        1.016
        *
  11    *         0.668       -0.908        0.470        1.378
        *
  12    *         0.720       -0.755        0.430        1.185
        *
  13    *         0.766       -0.260        0.266        0.527
        *
*************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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                   DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    6          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  61

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *         x/c         Cp          Cp       change in
 NUMBER  *      location     upper       lower         Cp
************************************************************
   1     *        0.119      -3.525      0.249       3.774
         *
   2     *        0.171      -2.234      0.177       2.411
         *
   3     *        0.223      -1.327      0.296       1.623
         *
   4     *        0.276      -1.234      0.306       1.540
         *
   5     *        0.328      -1.140      0.317       1.457
         *
   6     *        0.380      -0.950      0.345       1.295
         *
   7     *        0.433      -0.817      0.366       1.182
         *
   8     *        0.485      -0.809      0.371       1.180
         *
   9     *        0.537      -0.802      0.375       1.177
         *
  10     *        0.589      -0.795      0.380       1.175
         *
  11     *        0.668      -0.947      0.511       1.459
         *
  12     *        0.720      -0.775      0.471       1.246
         *
  13     *        0.766      -0.272      0.302       0.574
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                     DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    9          FLAP DEFLECTION ANGLE =   10
FILE NUMBER  62

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP   *        x/c         Cp          Cp       change in
 NUMBER *      location     upper       lower        Cp
************************************************************
   1    *       0.119      -3.761       0.395       4.155
        *
   2    *       0.171      -2.426       0.284       2.709
        *
   3    *       0.223      -1.616       0.339       1.954
        *
   4    *       0.276      -1.312       0.349       1.661
        *
   5    *       0.328      -1.108       0.353       1.461
        *
   6    *       0.380      -0.906       0.357       1.264
        *
   7    *       0.433      -0.816       0.361       1.176
        *
   8    *       0.485      -0.789       0.363       1.152
        *
   9    *       0.537      -0.762       0.366       1.128
        *
  10    *       0.589      -0.735       0.369       1.104
        *
  11    *       0.668      -0.675       0.467       1.141
        *
  12    *       0.720      -0.398       0.330       0.728
        *
  13    *       0.766      -0.365       0.317       0.681
        *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

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                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                     DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    9          FLAP DEFLECTION ANGLE =   15
FILE NUMBER  63

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *       x/c          Cp          Cp       change in
 NUMBER  *     location      upper       lower        Cp
************************************************************
   1     *       0.119      -4.130       0.518       4.648
         *
   2     *       0.171      -2.590       0.388       2.978
         *
   3     *       0.223      -1.528       0.424       1.953
         *
   4     *       0.276      -1.448       0.425       1.873
         *
   5     *       0.328      -1.369       0.426       1.795
         *
   6     *       0.380      -1.204       0.430       1.635
         *
   7     *       0.433      -0.909       0.440       1.349
         *
   8     *       0.485      -0.898       0.443       1.341
         *
   9     *       0.537      -0.888       0.446       1.334
         *
  10     *       0.589      -0.878       0.449       1.327
         *
  11     *       0.668      -0.998       0.568       1.566
         *
  12     *       0.720      -0.801       0.522       1.323
         *
  13     *       0.766      -0.283       0.346       0.629
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
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                 DELTA P PROJECT - PHASE I

            SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


ANGLE OF ATTACK =    9           FLAP DEFLECTION ANGLE =    5
FILE NUMBER  64

************************************************************

 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS

************************************************************
  TAP    *       x/c          Cp          Cp        change in
 NUMBER  *     location      upper       lower         Cp
************************************************************
    1    *       0.119      -1.980      -0.509       1.471
         *
    2    *       0.171      -1.270      -0.435       0.835
         *
    3    *       0.223      -0.698      -0.197       0.501
         *
    4    *       0.276      -0.551      -0.149       0.402
         *
    5    *       0.328      -0.385      -0.120       0.266
         *
    6    *       0.380      -0.208      -0.100       0.108
         *
    7    *       0.433      -0.112      -0.090       0.022
         *
    8    *       0.485      -0.086      -0.088      -0.002
         *
    9    *       0.537      -0.060      -0.086      -0.026
         *
   10    *       0.589      -0.034      -0.084      -0.050
         *
   11    *       0.668       0.271      -0.027      -0.298
         *
   12    *       0.720       0.482      -0.472      -0.954
         *
   13    *       0.766       0.265      -0.303      -0.568
         *
************************************************************


 *  Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients
```

```
0: "SEAP INTERPOL. PROG.":
1: dim X[13],U[13],L[13],C[13],A,D;dim G[23],H[23],I[23],O,Q
2: dim E[13,16],A[16],D[16];dim B[4,4],P,X
3: .119→X[1];.171→X[2];.223→X[3];.276→X[4];.328→X[5];.38→X[6];.433→X[7]
4: .485→X[8];.537→X[9];.589→X[10];.668→X[11];.72→X[12];.766→X[13]
5: trk 1;for F=34 to 48
6: ldf F,G[*],H[*],I[*],O,Q
7: for I=1 to 13
8: for J=1 to 22
9: if X[I]#G[J];gto 11
10: H[J]→U[I];I[J]→L[I];gto 15
11: if not (X[I]>G[J] and X[I]<G[J+1]);gto 16
12: (X[I]-G[J])/(G[J+1]-G[J])→Z
13: Z(H[J+1]-H[J])+H[J]→U[I]
14: Z(I[J+1]-I[J])+I[J]→L[I]
15: L[I]-U[I]→C[I]→E[I,F-33]
16: next J
17: next I
18: O→A[F-33]→A;Q→D[F-33]→D
19: rcf F+16,X[*],U[*],L[*],C[*],A,D
20: next F
21: for T=1 to 13;T→P;X[T]→X
22: for S=1 to 16
23: E[T,S]→B[D[S]/5+1,A[S]/3+1]
24: next S
25: fdf T+65;rcf T+65,B[*],P,X
26: next T
*24010
```

```
0: "SEAP - DELTA C SUB P OUTPUTTING PROGRAM      files 50→65":
1: dim L$[80],P$[3],Y$[80],S$[10];for S=1 to 60;"*"→L$[S];next S;fxd 1
2: dim X[13],U[13],L[13],C[13],A,D;"           "&L$→L$
3: "             "→S$
4: fmt 1,10x,f3.0,4x,"*",4f12.3
5: fmt 2,9x,"ANGLE OF ATTACK = ",f4.0,10x,"FLAP DEFLECTION ANGLE = ",f4.0
6: fmt 3,9x,"FILE NUMBER  ",f2.0
7: "PCL":ent "FILE NUMBER?",F;if F>65 or F<50;gto +0
8: trk 1;fdf F;ldf F,X[*],U[*],L[*],C[*],A,D
9: "STR":wrt 6,"                    ------------------";for S=1 to 5;wrt 6;next S
10: wrt 6,"                    KANSAS UNIVERSITY FLIGHT RESEARCH LAB";wrt 6
11: wrt 6,"                           DELTA P PROJECT - PHASE I"
12: wrt 6
13: wrt 6,"                    SINGLE ELEMENT AIRFOIL PROGRAM RESULTS"
14: wrt 6;wrt 6;wrt 6;wrt 6.2,A,D;wrt 6.3,F;wrt 6;wrt 6,L$;wrt 6
15: wrt 6,S$&"RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS"
16: wrt 6;wrt 6,L$
17: wrt 6,S$&" TAP    *         x/c          Cp           Cp       change in"
18: wrt 6,S$&"NUMBER *      location       upper        lower         Cp"
19: wrt 6,L$
20: for S=1 to 13
21: wrt 6.1,S,X[S],U[S],L[S],C[S];wrt 6,"                       *";next S
22: wrt 6,L$;wrt 6;wrt 6;wrt 6
23: wrt 6,S$&"*  Change in pressure coefficient represents the difference"
24: wrt 6,S$&"   between lower and upper surface pressure coefficients"
25: for S=1 to 12;wrt 6;next S
26: ent "another file?",P$;if cap(P$)#"N";gto "PCL"
27: stp
*13077
```

## C.4 INTERPOLATED CHANGE IN $C_p$ BY TAP LOCATION

```
              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                    DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER  1                                  FILE NUMBER  66

  TAP x/c LOCATION  0.119



***************************************************************************

                    CHANGE IN PRESSURE COEFFICIENT
                             INTERPOLATED

***************************************************************************
   FLAP    *              ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*             0              3              6              9
***************************************************************************
           *
     0.0   *        0.000          0.854          1.764          0.000
           *
     5.0   *        0.352          0.672          1.033          1.471
           *
    10.0   *        1.282          2.276          3.242          4.155
           *
    15.0   *        1.978          2.855          3.774          4.648
           *
***************************************************************************



       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

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                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                      DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER  2                                        FILE NUMBER  67

  TAP x/c LOCATION  0.171



*************************************************************************

                    CHANGE IN PRESSURE COEFFICIENT
                             INTERPOLATED

*************************************************************************
   FLAP    *              ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*               0             3             6             9
*************************************************************************
           *
     0.0   *          0.000         0.587         1.177         0.000
           *
     5.0   *          0.165         0.374         0.575         0.835
           *
    10.0   *          0.812         1.478         2.119         2.709
           *
    15.0   *          1.204         1.816         2.411         2.978
           *
*************************************************************************
```

*   Results of SEAP data interpolated to phase I tap locations

*   Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

```
                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                      DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER  3                                   FILE NUMBER  68

  TAP x/c LOCATION  0.223



***************************************************************************

                      CHANGE IN PRESSURE COEFFICIENT
                               INTERPOLATED

***************************************************************************
   FLAP   *             ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*            0             3            6              9
***************************************************************************
          *
     0.0  *         0.000         0.431         0.866         0.000
          *
     5.0  *         0.156         0.245         0.343         0.501
          *
    10.0  *         0.658         1.098         1.533         1.954
          *
    15.0  *         0.914         1.267         1.623         1.953
          *
***************************************************************************



       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

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                    KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                         DELTA P PROJECT - PHASE I

                    SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



   TAP NUMBER  4                                          FILE NUMBER  69

   TAP x/c LOCATION  0.276



*************************************************************************

                         CHANGE IN PRESSURE COEFFICIENT
                                  INTERPOLATED

*************************************************************************
   FLAP    *              ALPHA-ANGLE OF ATTACK (degrees)
 DEFLECTION*                 0             3             6             9
*************************************************************************
           *
    0.0    *               0.000         0.273         0.561         0.000
           *
    5.0    *               0.147         0.203         0.273         0.402
           *
   10.0    *               0.585         0.947         1.308         1.661
           *
   15.0    *               0.892         1.225         1.540         1.873
           *
*************************************************************************



       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

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                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                    DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


   TAP NUMBER  5                                   FILE NUMBER  70

   TAP x/c LOCATION  0.328


*************************************************************************

                  CHANGE IN PRESSURE COEFFICIENT
                          INTERPOLATED

*************************************************************************
   FLAP    *            ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*            0              3              6              9
*************************************************************************
           *
     0.0   *         0.000          0.255          0.527          0.000
           *
     5.0   *         0.142          0.154          0.180          0.266
           *
    10.0   *         0.563          0.864          1.162          1.461
           *
    15.0   *         0.870          1.183          1.457          1.795
           *
*************************************************************************


      *   Results of SEAP data interpolated to phase I tap locations

      *   Change in pressure coefficient represents the difference
          between lower and upper surface pressure coefficients
```

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                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                      DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER  6                                        FILE NUMBER  71

  TAP x/c LOCATION  0.380



*********************************************************************

                   CHANGE IN PRESSURE COEFFICIENT
                            INTERPOLATED

*********************************************************************
   FLAP    *            ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*               0             3             6             9
*********************************************************************
           *
    0.0    *            0.000         0.237         0.493         0.000
           *
    5.0    *            0.139         0.099         0.071         0.108
           *
   10.0    *            0.545         0.783         1.020         1.264
           *
   15.0    *            0.846         1.111         1.295         1.635
           *
*********************************************************************



        *   Results of SEAP data interpolated to phase I tap locations

        *   Change in pressure coefficient represents the difference
            between lower and upper surface pressure coefficients
```

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                      DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER  7                                     FILE NUMBER  72

  TAP x/c LOCATION  0.433



***************************************************************************

                      CHANGE IN PRESSURE COEFFICIENT
                               INTERPOLATED

***************************************************************************
   FLAP    *            ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*            0             3            6             9
***************************************************************************
          *
     0.0  *          0.000         0.145         0.316         0.000
          *
     5.0  *          0.140         0.069         0.012         0.022
          *
    10.0  *          0.542         0.751         0.959         1.176
          *
    15.0  *          0.829         1.001         1.182         1.349
          *
***************************************************************************



       *  Results of SEAP data interpolated to phase I tap locations

       *  Change in pressure coefficient represents the difference
          between lower and upper surface pressure coefficients
```

```
              KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                   DELTA P PROJECT - PHASE I

              SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



 TAP NUMBER  8                                 FILE NUMBER  73

 TAP x/c LOCATION  0.485



****************************************************************************

                  CHANGE IN PRESSURE COEFFICIENT
                           INTERPOLATED

****************************************************************************
   FLAP    *           ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*           0             3             6             9
****************************************************************************
           *
    0.0    *        0.000         0.127         0.273         0.000
           *
    5.0    *        0.142         0.061        -0.006        -0.002
           *
   10.0    *        0.548         0.747         0.944         1.152
           *
   15.0    *        0.841         1.006         1.180         1.341
           *
****************************************************************************



      *   Results of SEAP data interpolated to phase I tap locations

      *   Change in pressure coefficient represents the difference
          between lower and upper surface pressure coefficients
```

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                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                      DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER  9                                     FILE NUMBER  74

  TAP x/c LOCATION  0.537



*********************************************************************

                  CHANGE IN PRESSURE COEFFICIENT
                           INTERPOLATED

*********************************************************************
   FLAP     *              ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*             0             3             6             9
*********************************************************************
            *
     0.0    *         0.000         0.124         0.265         0.000
            *
     5.0    *         0.144         0.054        -0.024        -0.026
            *
    10.0    *         0.555         0.743         0.929         1.128
            *
    15.0    *         0.853         1.011         1.177         1.334
            *
*********************************************************************



       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

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                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                       DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER 10                                    FILE NUMBER  75

  TAP x/c LOCATION  0.589



*****************************************************************************

                      CHANGE IN PRESSURE COEFFICIENT
                                INTERPOLATED

*****************************************************************************
   FLAP    *                ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*              0              3             6              9
*****************************************************************************
          *
     0.0  *           0.000          0.120         0.257          0.000
          *
     5.0  *           0.147          0.046        -0.042         -0.050
          *
    10.0  *           0.561          0.739         0.914          1.104
          *
    15.0  *           0.866          1.016         1.175          1.327
          *
*****************************************************************************



       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

```
                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                       DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


  TAP NUMBER 11                                   FILE NUMBER  76

  TAP x/c LOCATION  0.668


****************************************************************************

                       CHANGE IN PRESSURE COEFFICIENT
                                INTERPOLATED

****************************************************************************
   FLAP   *             ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*            0             3            6             9
****************************************************************************
          *
     0.0  *          0.000         0.115        0.245         0.000
          *
     5.0  *          0.226        -0.030       -0.261        -0.298
          *
    10.0  *          0.839         0.928        1.014         1.141
          *
    15.0  *          1.318         1.378        1.459         1.566
          *
****************************************************************************


       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

```
                KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                      DELTA P PROJECT - PHASE I

                SINGLE ELEMENT AIRFOIL PROGRAM RESULTS


  TAP NUMBER 12                                    FILE NUMBER  77

  TAP x/c LOCATION  0.720


****************************************************************************

                      CHANGE IN PRESSURE COEFFICIENT
                               INTERPOLATED

****************************************************************************
   FLAP   *             ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*             0             3            6              9
****************************************************************************
          *
     0.0  *         0.000         0.084          0.180         0.000
          *
     5.0  *         0.107        -0.178         -0.511        -0.954
          *
    10.0  *         0.482         0.562          0.640         0.728
          *
    15.0  *         1.150         1.185          1.246         1.323
          *
****************************************************************************



       *   Results of SEAP data interpolated to phase I tap locations

       *   Change in pressure coefficient represents the difference
           between lower and upper surface pressure coefficients
```

```
                 KANSAS UNIVERSITY FLIGHT RESEARCH LAB

                      DELTA P PROJECT - PHASE I

                 SINGLE ELEMENT AIRFOIL PROGRAM RESULTS



  TAP NUMBER 13                                     FILE NUMBER  78

  TAP x/c LOCATION  0.766



*********************************************************************

                    CHANGE IN PRESSURE COEFFICIENT
                             INTERPOLATED

*********************************************************************
   FLAP    *            ALPHA-ANGLE OF ATTACK (degrees)
DEFLECTION*             0            3            6             9
*********************************************************************
           *
    0.0    *          0.000        0.082        0.174         0.000
           *
    5.0    *          0.094       -0.097       -0.314        -0.568
           *
   10.0    *          0.441        0.519        0.595         0.681
           *
   15.0    *          0.490        0.527        0.574         0.629
           *
*********************************************************************
```

*   Results of SEAP data interpolated to phase 1 tap locations

*   Change in pressure coefficient represents the difference
    between lower and upper surface pressure coefficients

```
0: "SEAP DATA OUTPUTTING PROGRAM   specific x/c files 66→78":
1: dim L$[80],P$[3],Y$[80],S$[5],T$[10];for S=1 to 75;"*"→L$[S];next S;fxd 1
2: dim B[4,4],P,X;"     "→S$;"          "→T$
3: fmt 3,z,f12.2,2x;fmt 5,5x,"TAP NUMBER ",f2.0,35x,"FILE NUMBER ",f3.0
4: fmt 4,z,6x,f5.1,2x,"*",2x;fmt 6,5x,"TAP x/c LOCATION ",f6.3
5: T$&"0"&T$&"   3"&T$&"  6"&T$&"   9"→Y$
6: "PCL":ent "FILE NUMBER?",F;if F>78 or F<66;gto +0
7: trk 1;rdf F;ldf F,B[*],P,X
8: "STR":wrt 6,T$&T$&T$&"------------------";for S=1 to 3;wrt 6;next S
9: wrt 6,T$&"          KANSAS UNIVERSITY FLIGHT RESEARCH LAB";wrt 6
10: wrt 6,T$&T$&"     DELTA P PROJECT - PHASE I"
11: wrt 6
12: wrt 6,T$&"           SINGLE ELEMENT AIRFOIL PROGRAM RESULTS"
13: wrt 6;wrt 6;wrt 6;wrt 6;wrt 6.5,P,F;wrt 6;wrt 6.6,X;wrt 6;wrt 6;wrt 6
14: wrt 6;wrt 6,S$&L$;wrt 6
15: wrt 6,T$&T$&"     CHANGE IN PRESSURE COEFFICIENT"
16: wrt 6,T$&T$&T$&"   INTERPOLATED"
17: wrt 6;wrt 6,S$&L$
18: wrt 6,"     FLAP    *             ALPHA-ANGLE OF ATTACK (degrees)"
19: wrt 6,"   DEFLECTION*  ",Y$
20: wrt 6,S$&L$;wrt 6,T$&"   *"
21: for I=1 to 4;(I-1)5→C;wrt 6.4,C;for J=1 to 4
22: wrt 6.3,B[I,J];next J;wrt 6;wrt 6,T$&"   *"
23: next I
24: wrt 6,S$&L$;wrt 6;wrt 6;wrt 6;wrt 6;wrt 6
25: wrt 6,T$&"*  Results of SEAP data interpolated to phase I tap lacations"
26: wrt 6
27: wrt 6,T$&"*  Change in pressure coefficient represents the difference"
28: wrt 6,T$&"   between lower and upper surface pressure coefficients"
29: for S=1 to 16
30: wrt 6;next S;ent "ANOTHER FILE?",P$;if cap(P$)="Y";gto "PCL"
31: end
*8226
```

## C.5 GRAPHICAL OUTPUT--FLAP DEFLECTION SENSITIVITY

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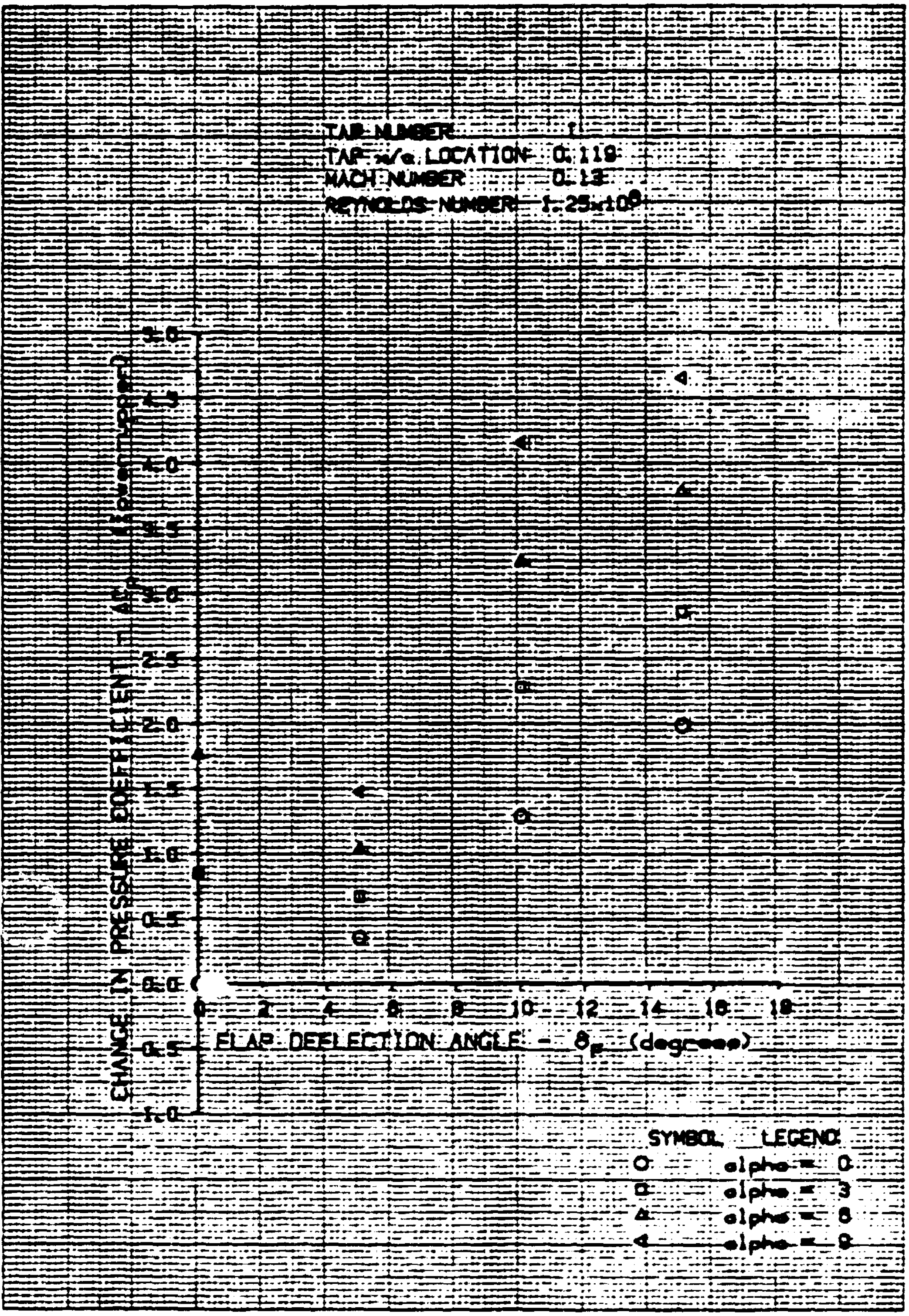
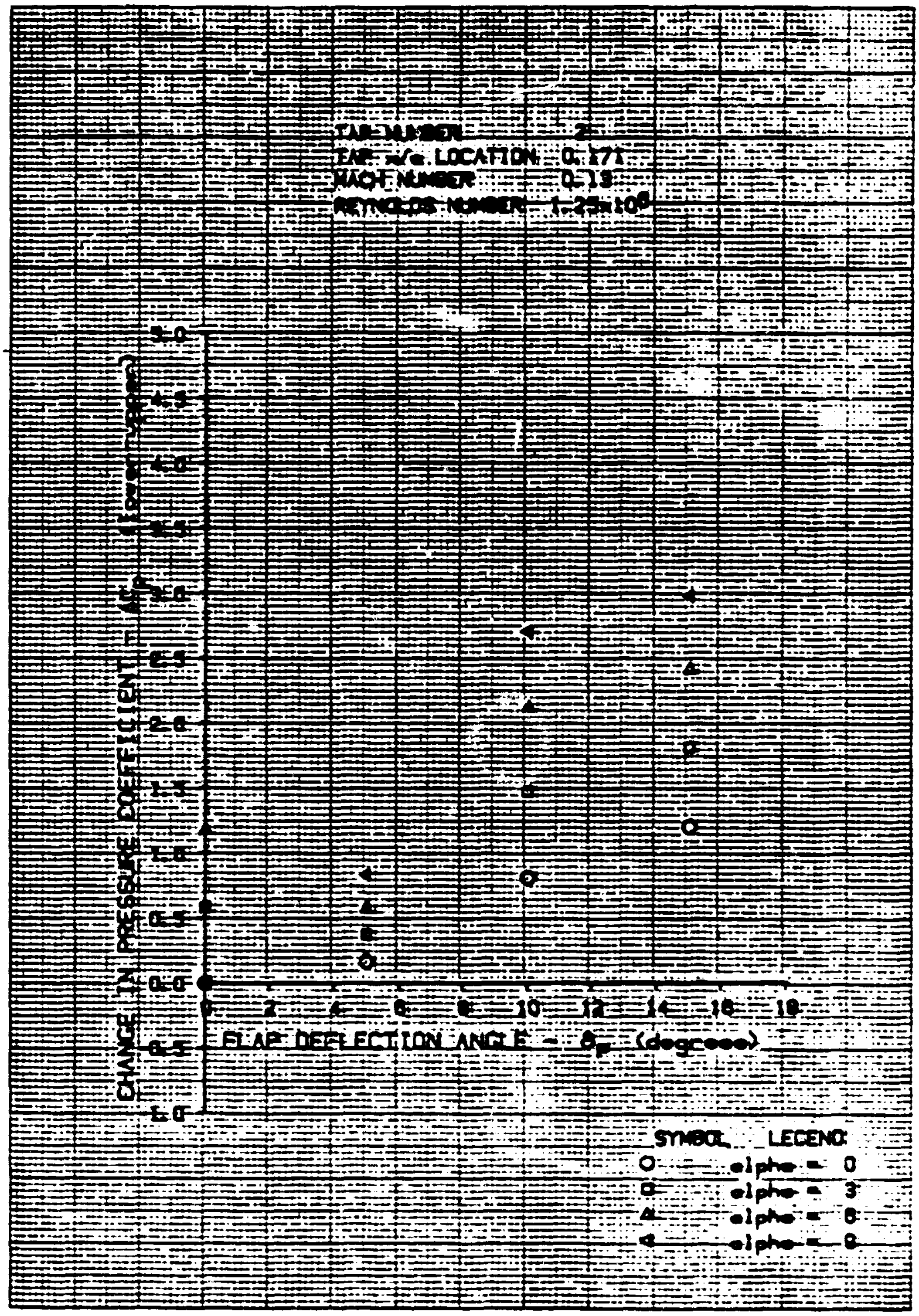
NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



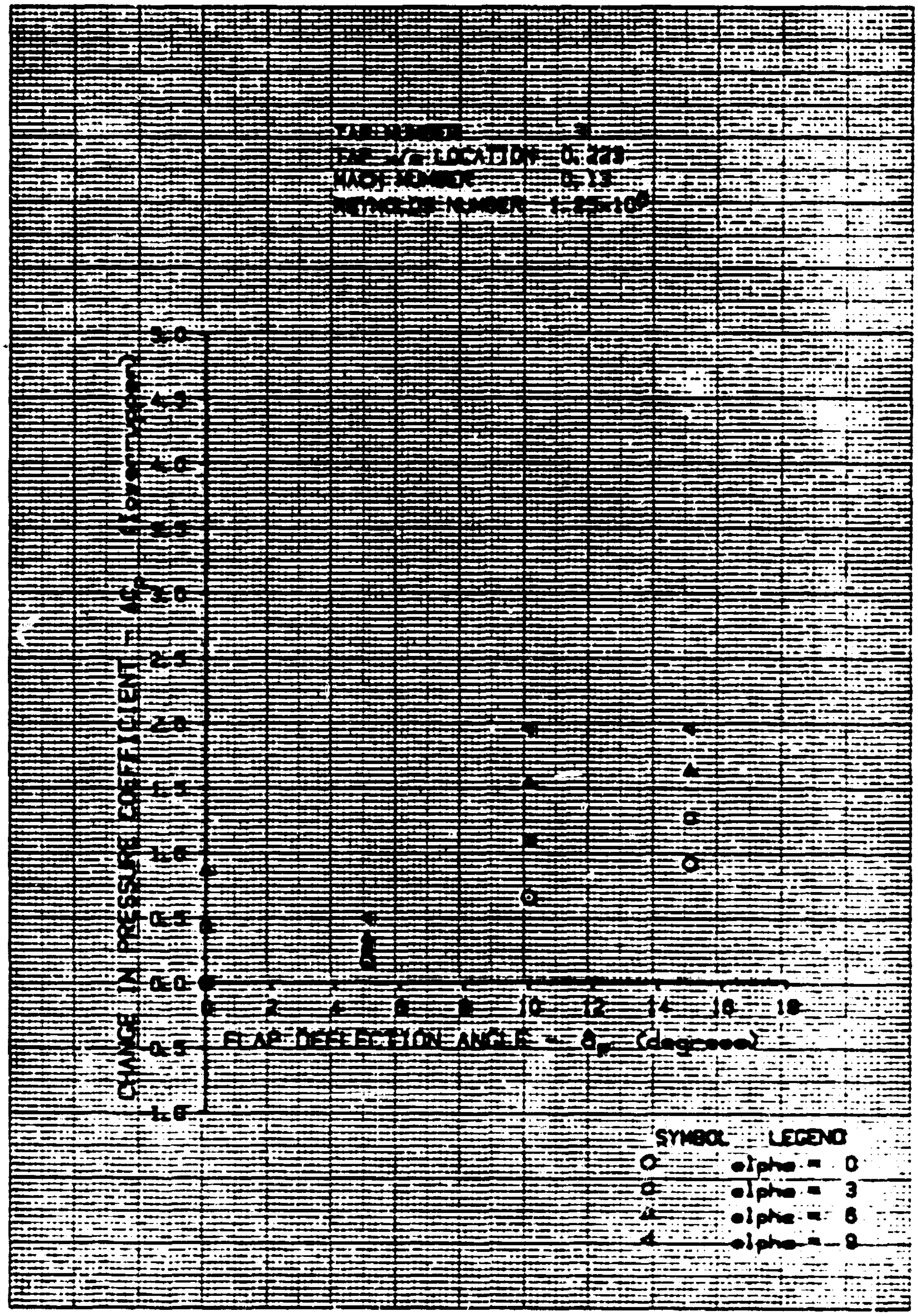
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.1 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 146 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



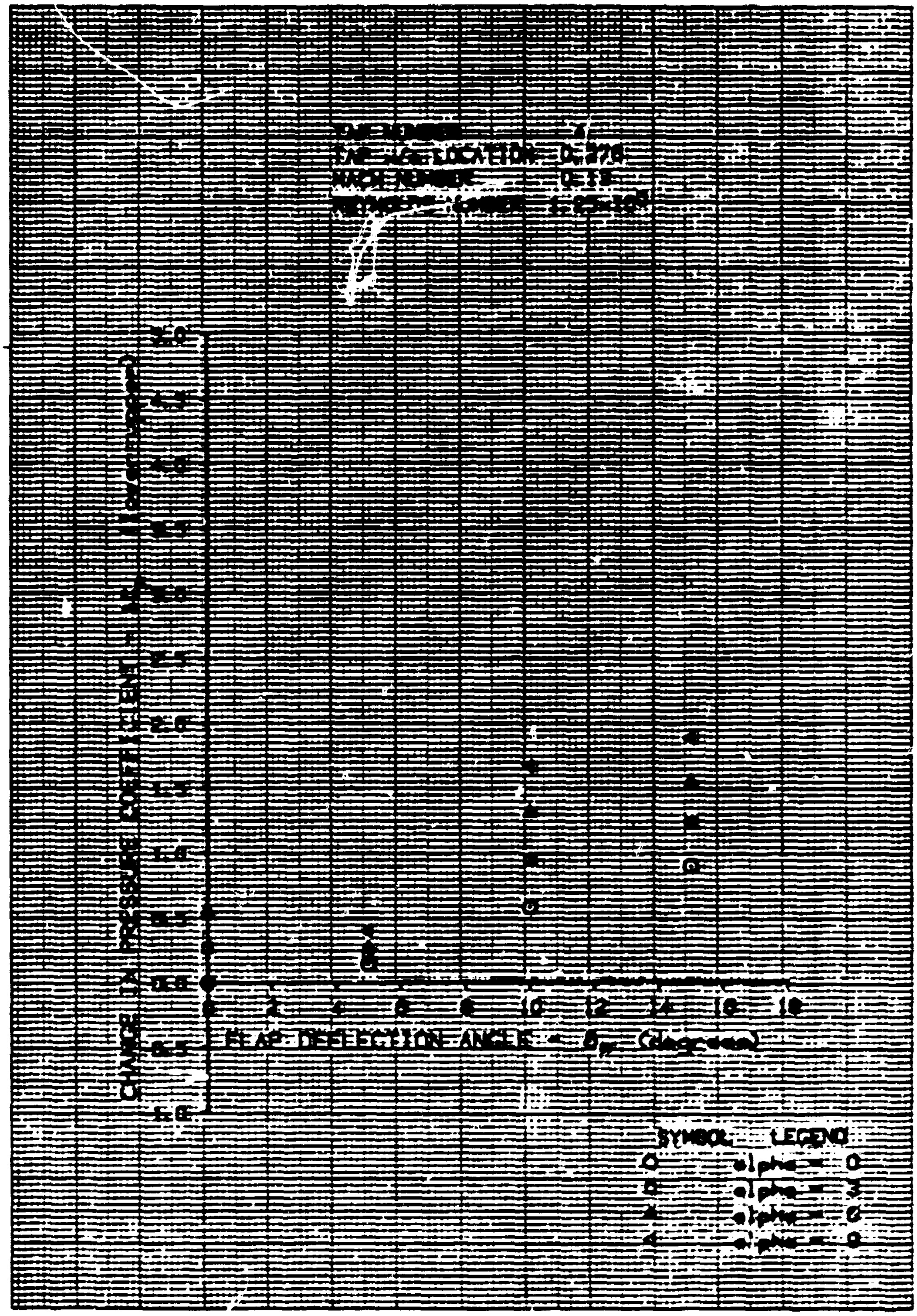
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.2 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 147 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



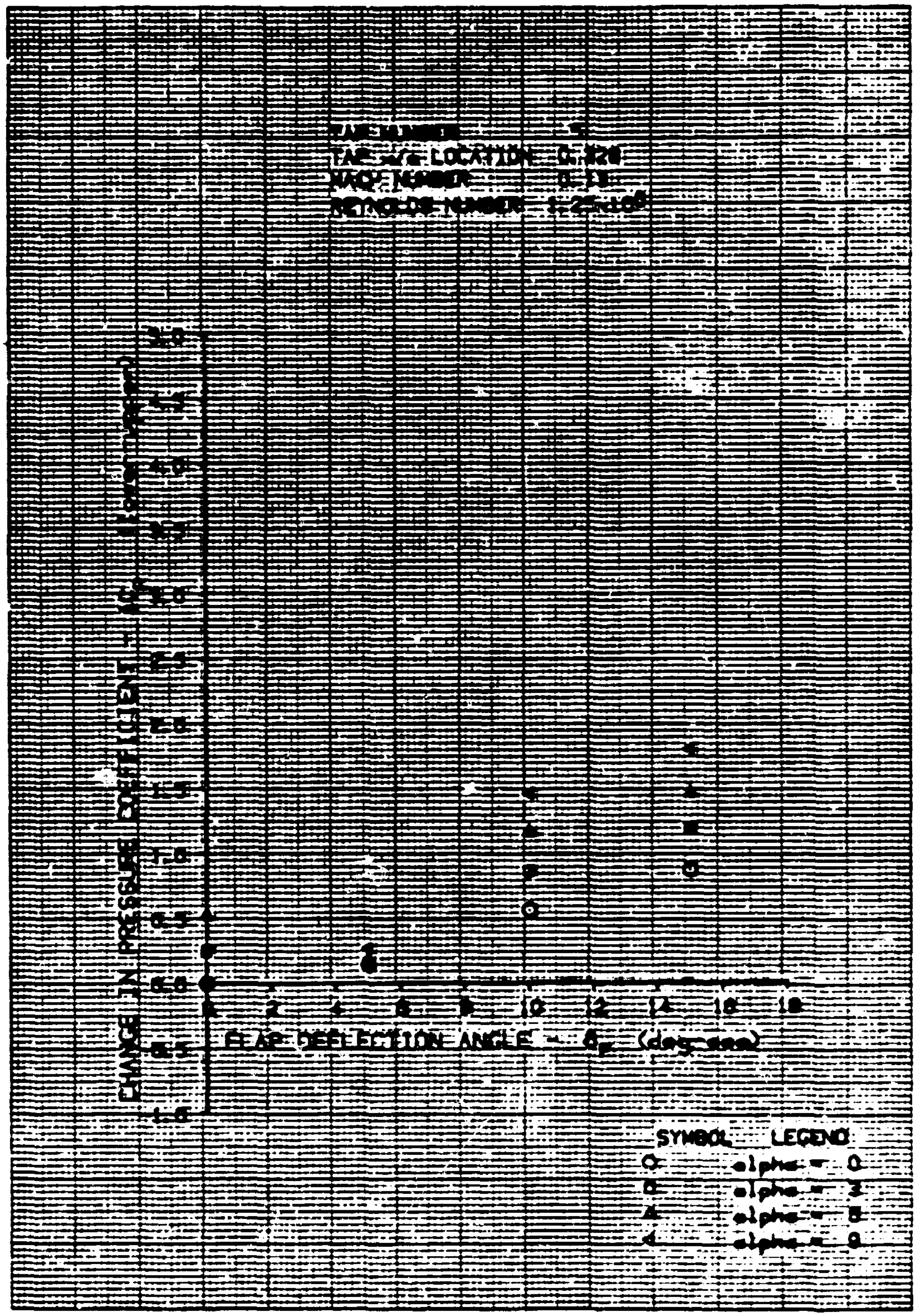
|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.3 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 |  |  |  |  |
| APPD |  |  |  |  |  |  |
| APPD |  |  |  |  |  |  |
|  |  |  |  |  | UNIVERSITY OF KANSAS | PAGE 148 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



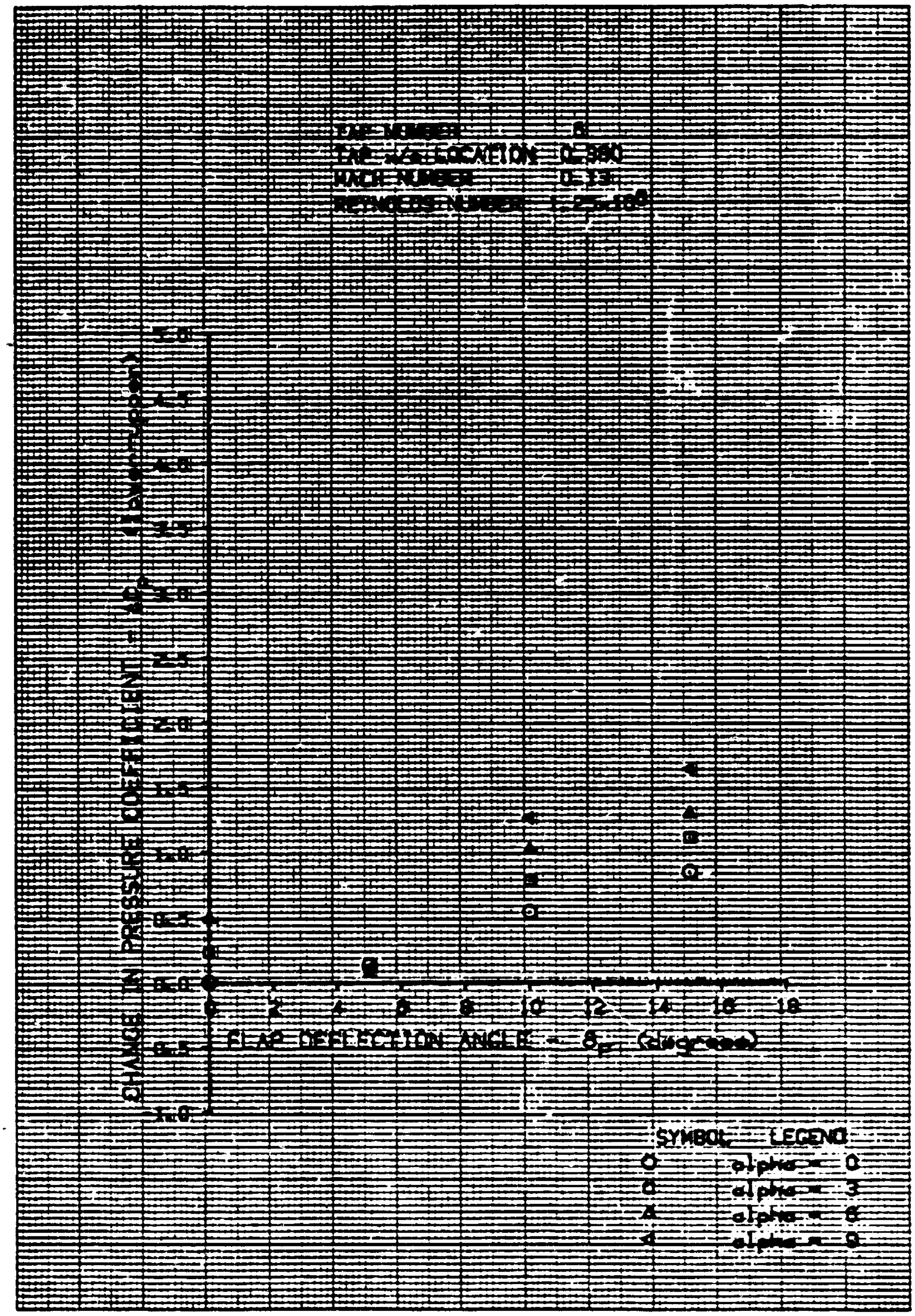
|  |  |  |  |  | FIGURE C. 4 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE |  |  |
| CHECK | R HRABAK | 8-81 |  |  |  |  |
| APPD |  |  |  |  |  |  |
| APPD |  |  |  |  |  |  |
|  |  |  |  |  | UNIVERSITY OF KANSAS | PAGE 149 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



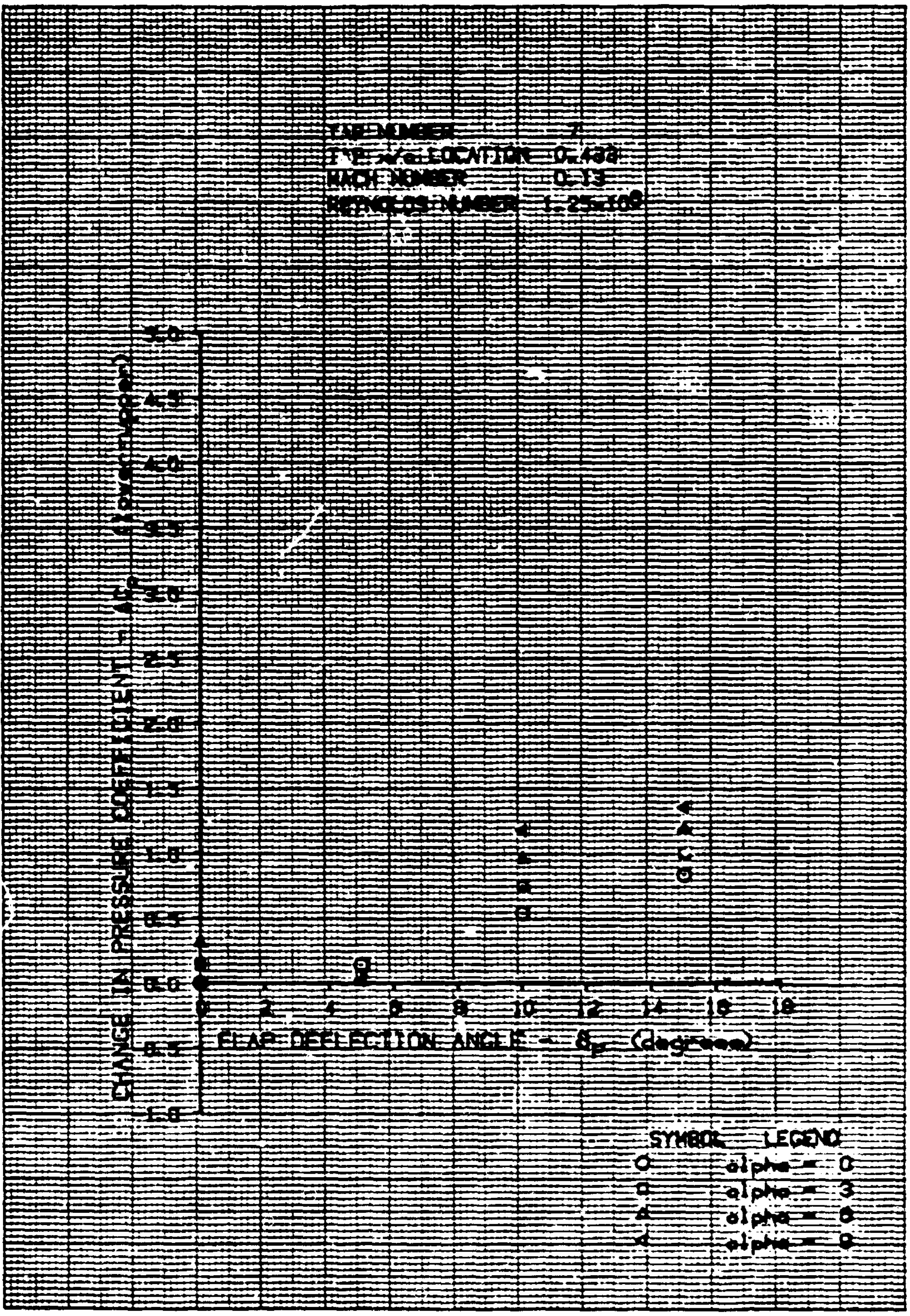
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.5 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRADAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 150 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



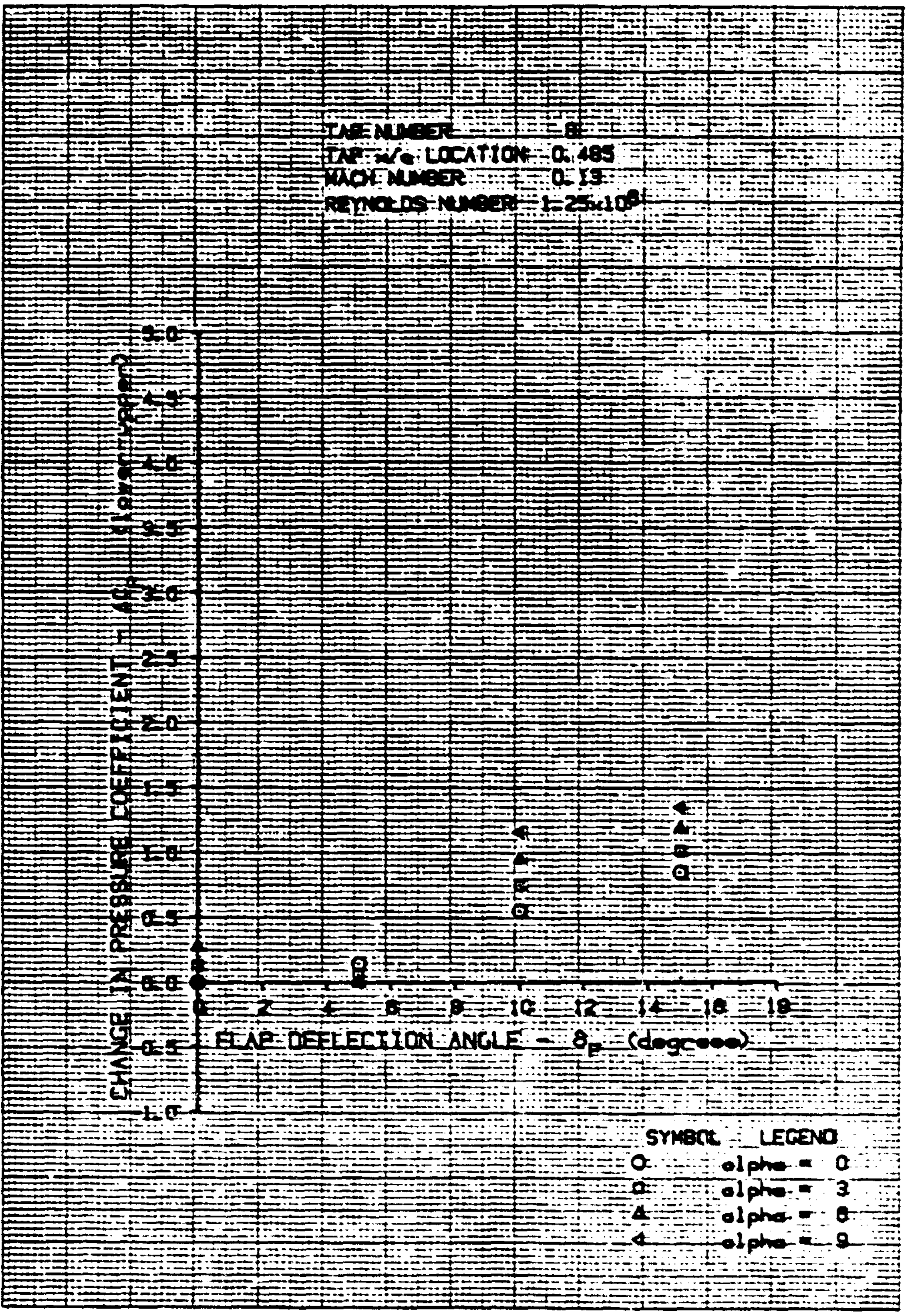
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.6 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE<br>5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 151 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



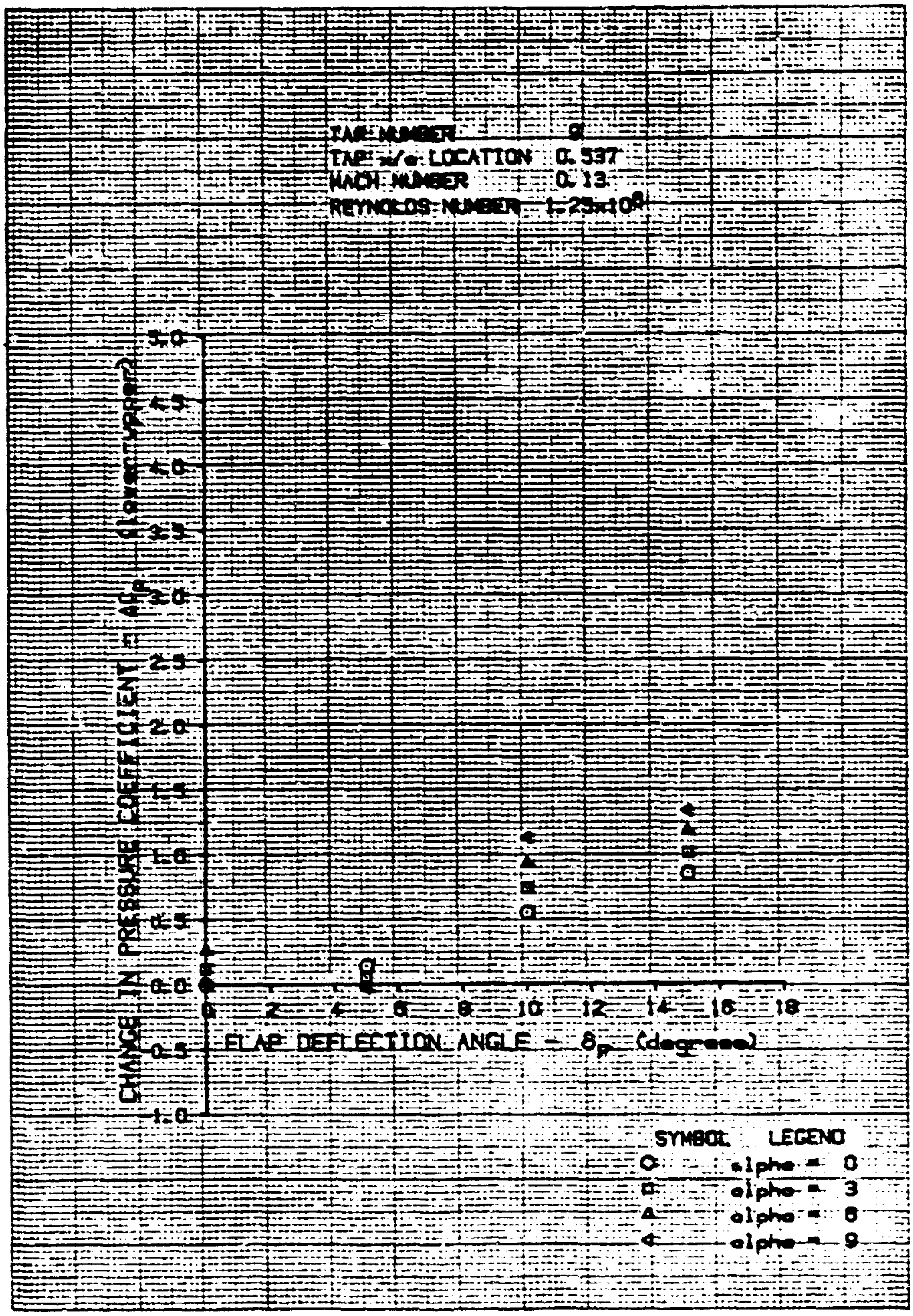
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.7 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 152 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



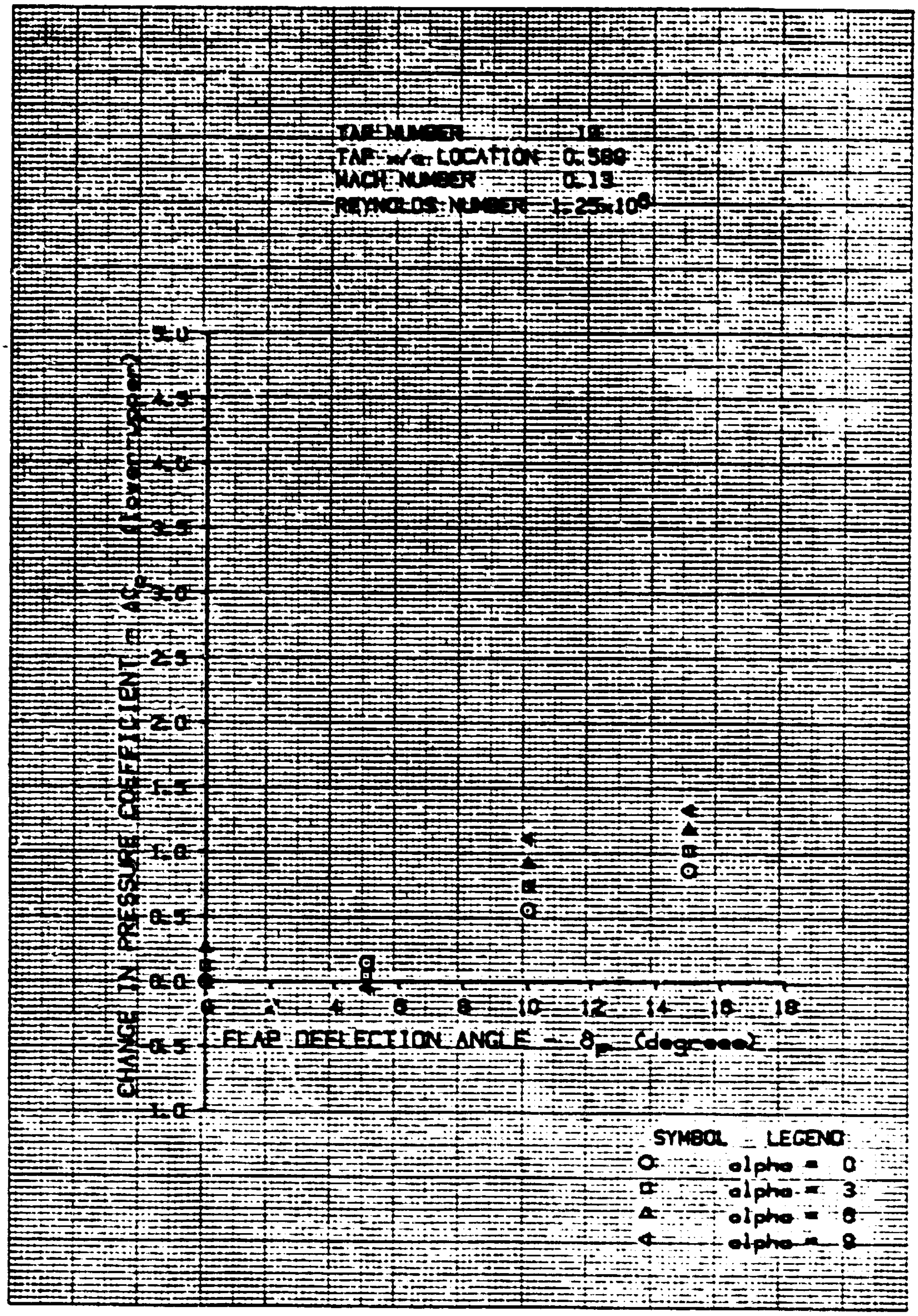
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.8 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HAAGAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 153 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



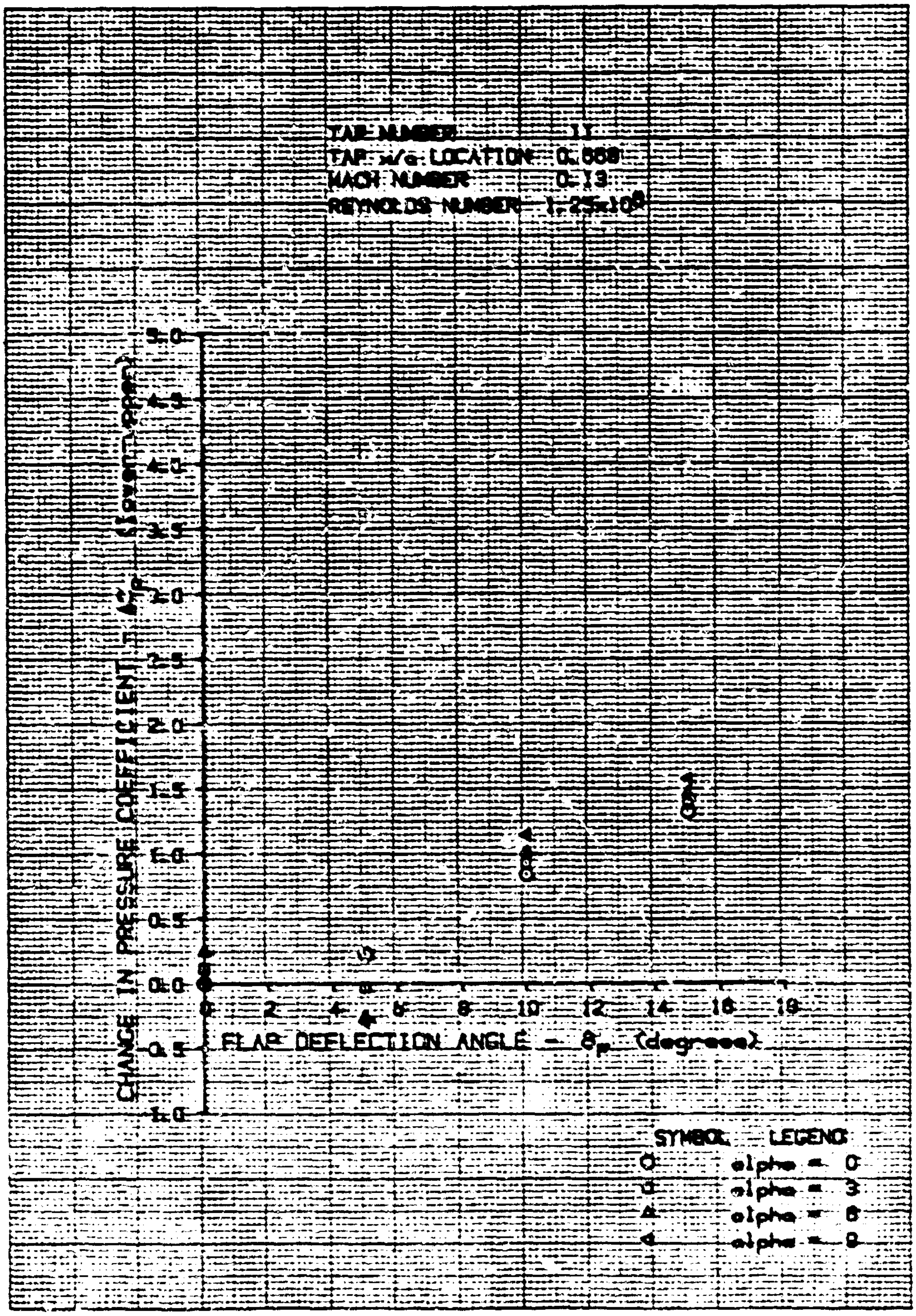
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.9 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
|---|---|---|---|---|---|---|
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 154 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



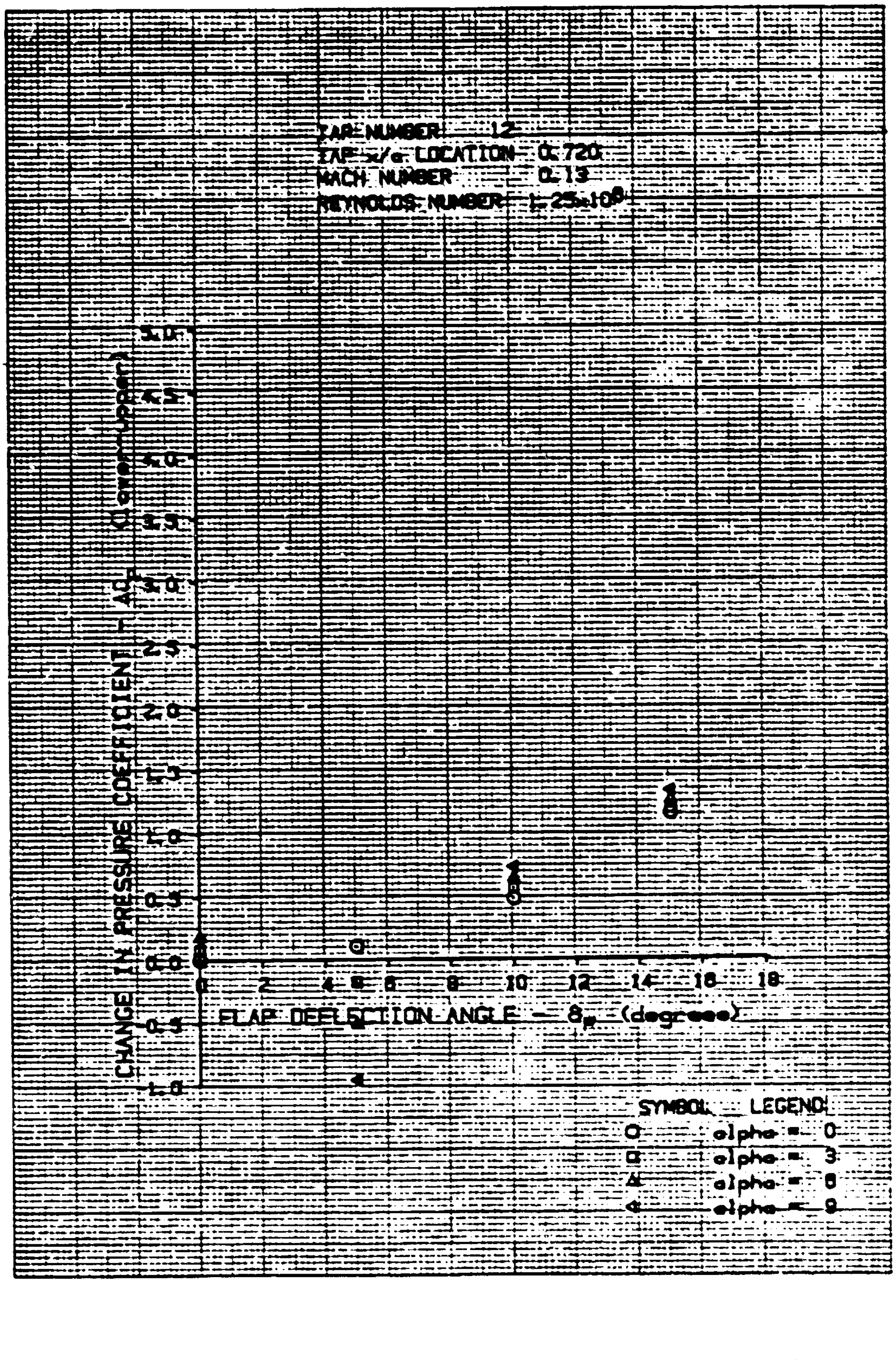
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.10 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | | DATE<br>5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | | |
| APPD | | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | | PAGE 155 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



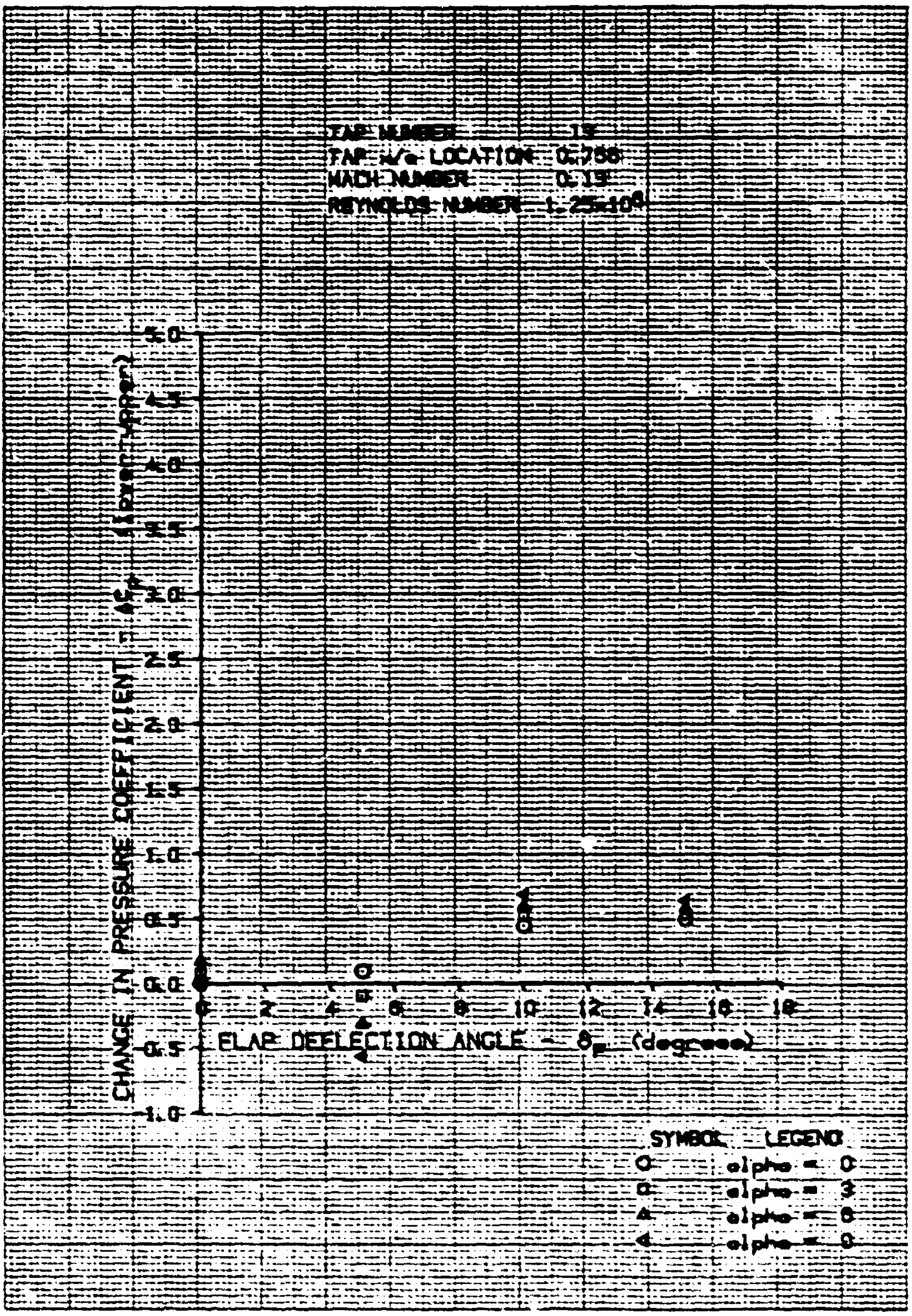
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.11 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE<br>5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 156 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C. 12 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS – FLAP DEFLECTION SENSITIVITY | DATE 7-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 157 |

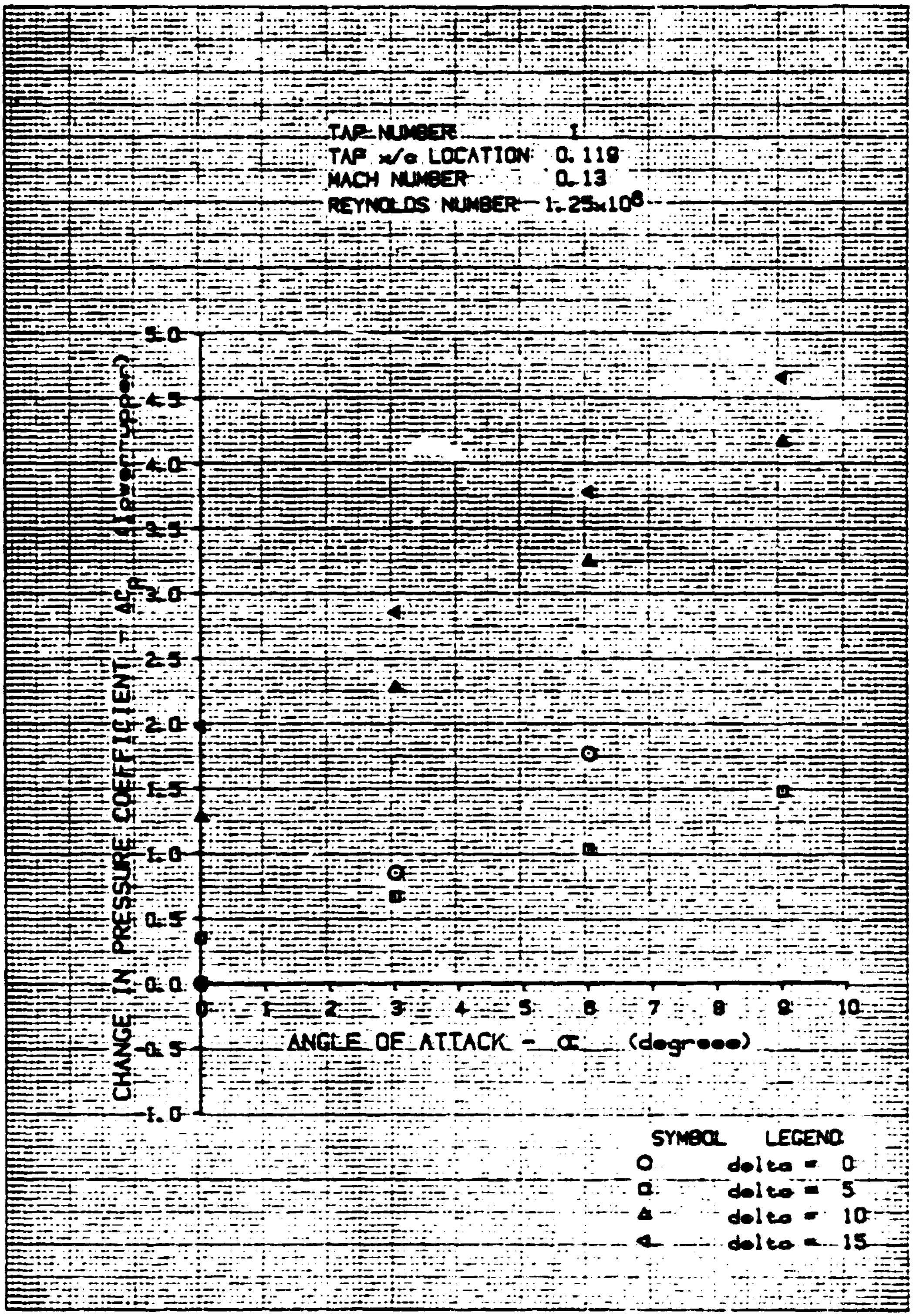
NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.13 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - FLAP DEFLECTION SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 158 |

## C.6 GRAPHICAL OUTPUT--ANGLE OF ATTACK SENSITIVITY

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



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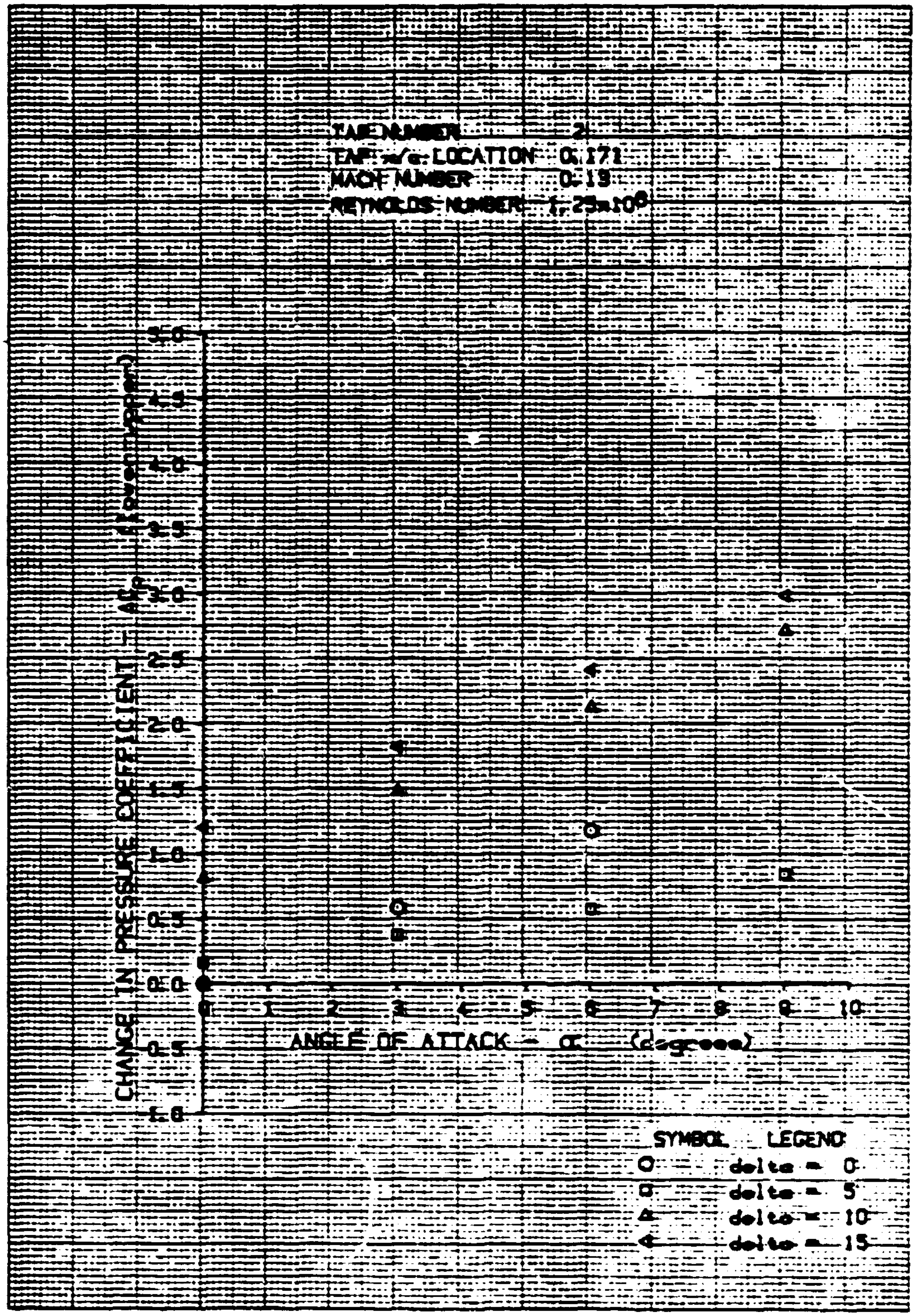
OF POOR QUALITY

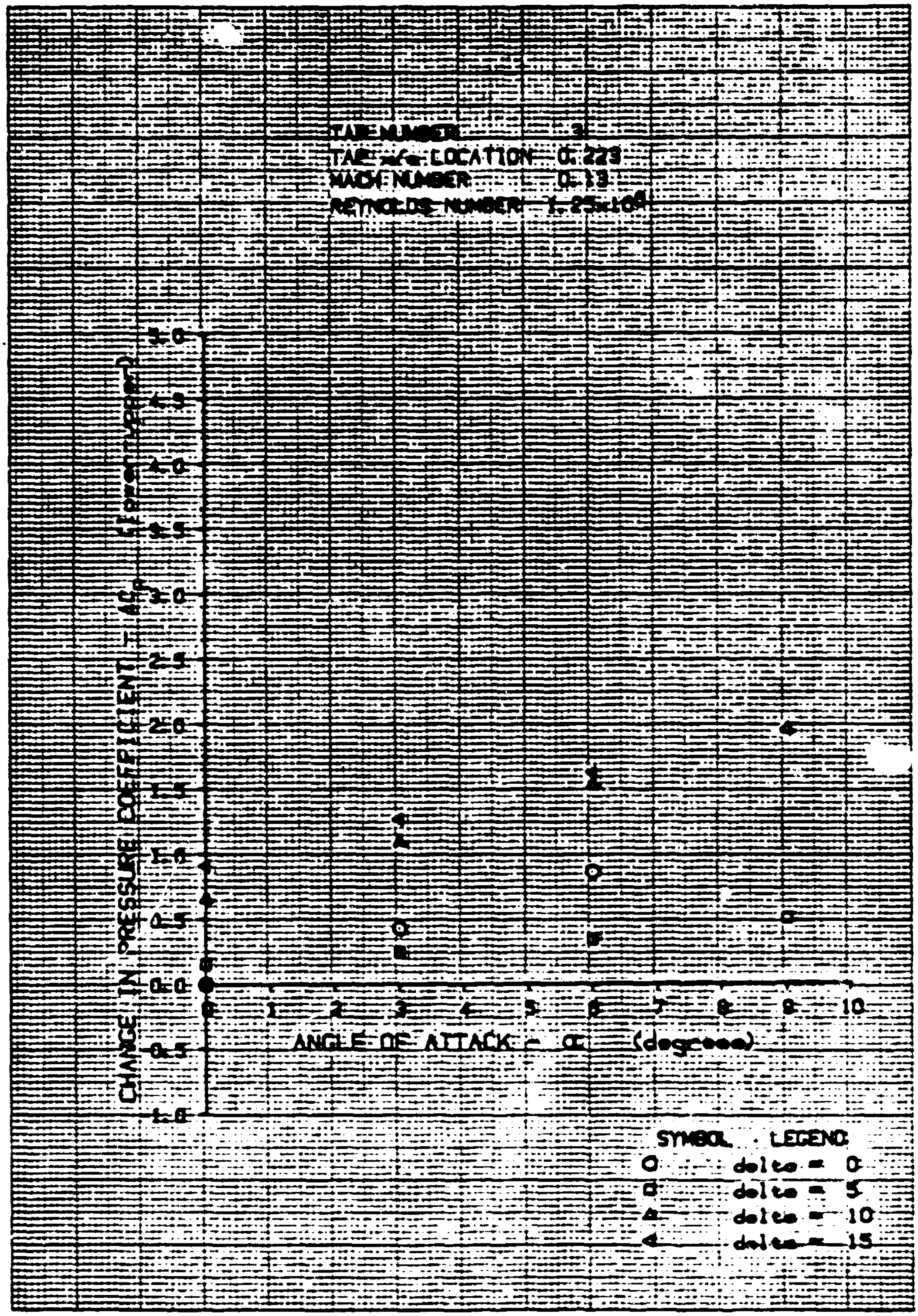
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.14 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE<br>5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 160 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



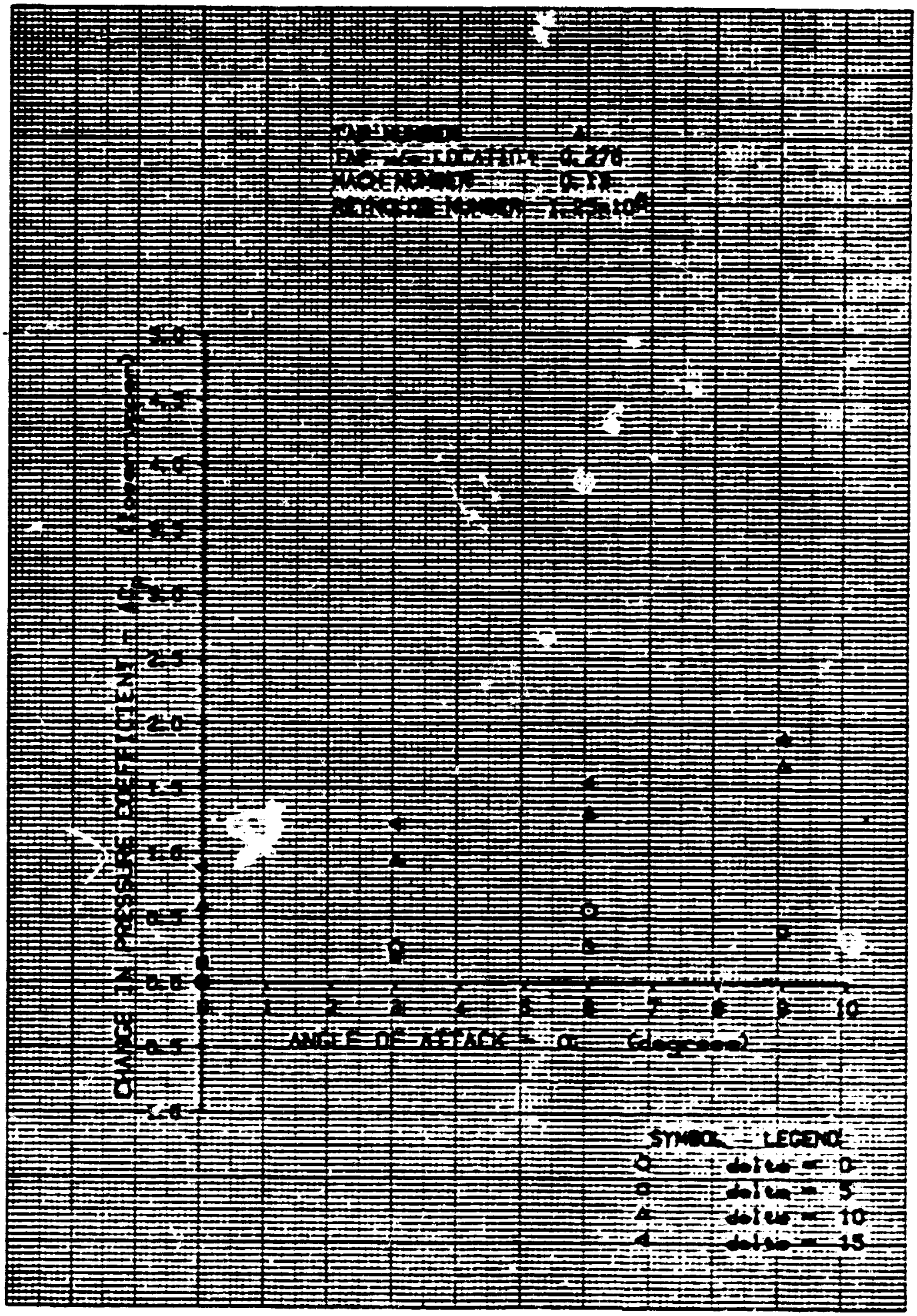
|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.13 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R. WRABAK | 8-81 |  |  |  |  |
| APPD |  |  |  |  |  |  |
| APPD |  |  |  |  | UNIVERSITY OF KANSAS | PAGE 161 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



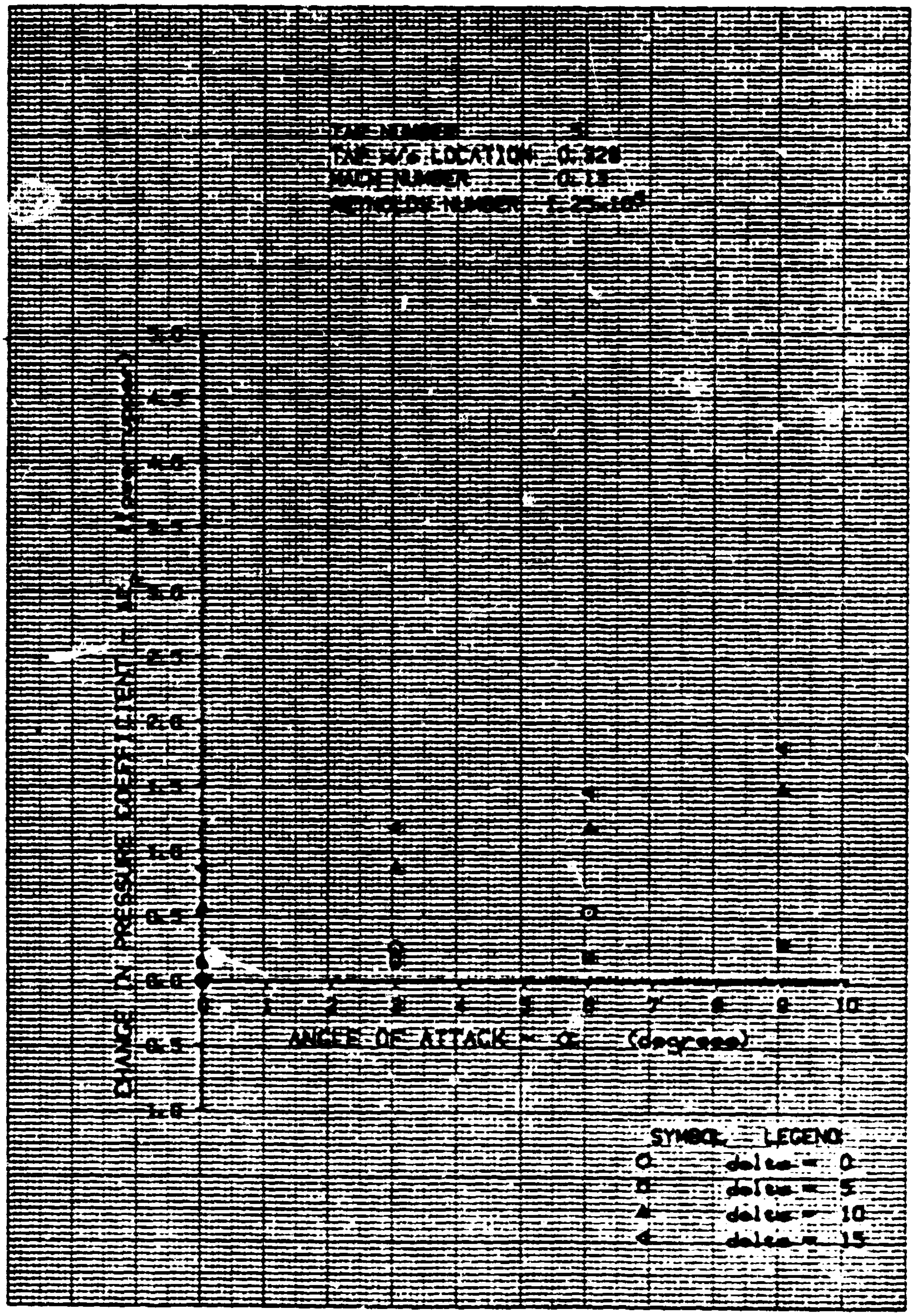
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.18 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 162 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



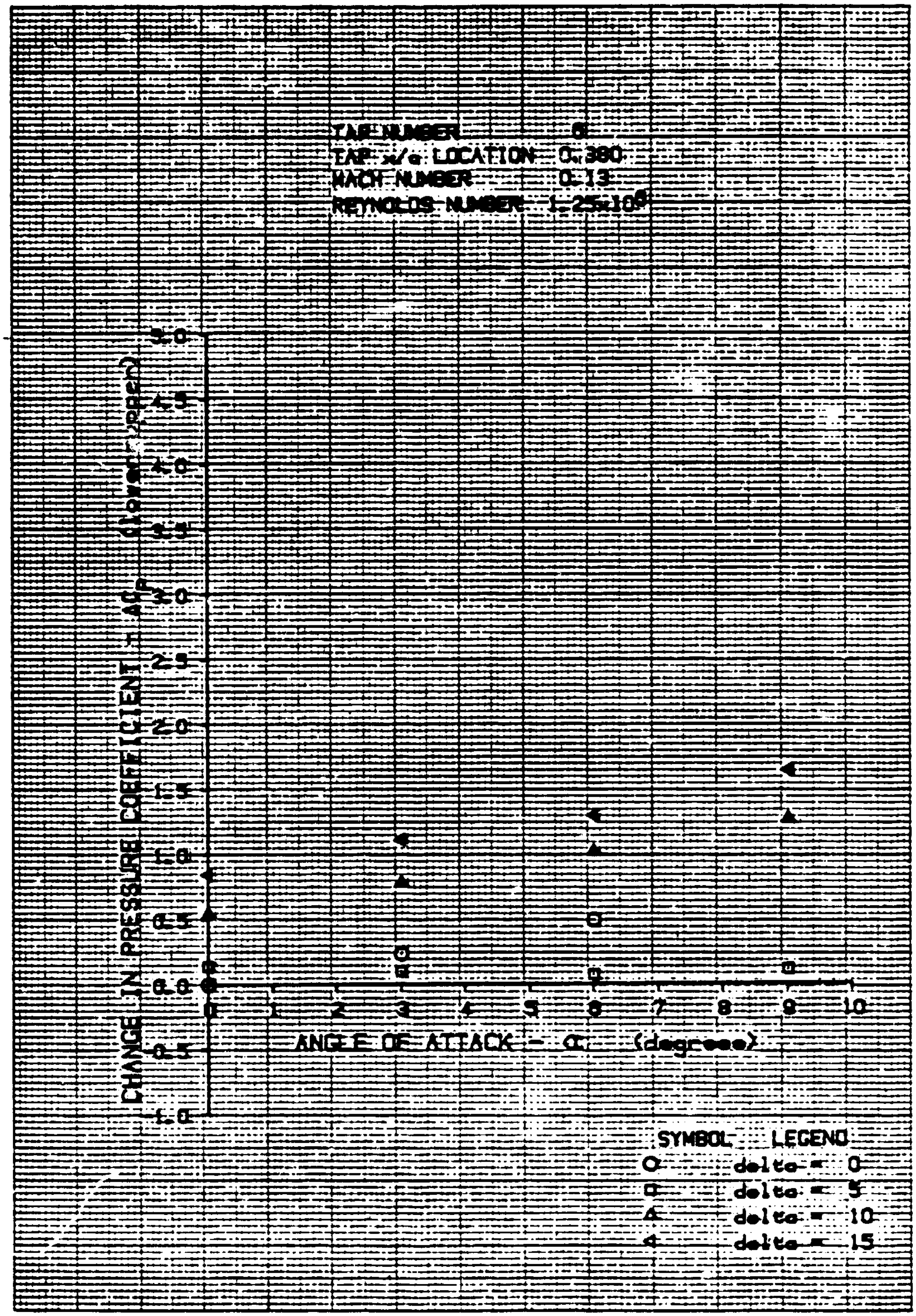
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C. 17 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HAABAK | 8.81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 163 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.18 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
|---|---|---|---|---|---|---|
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 164 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



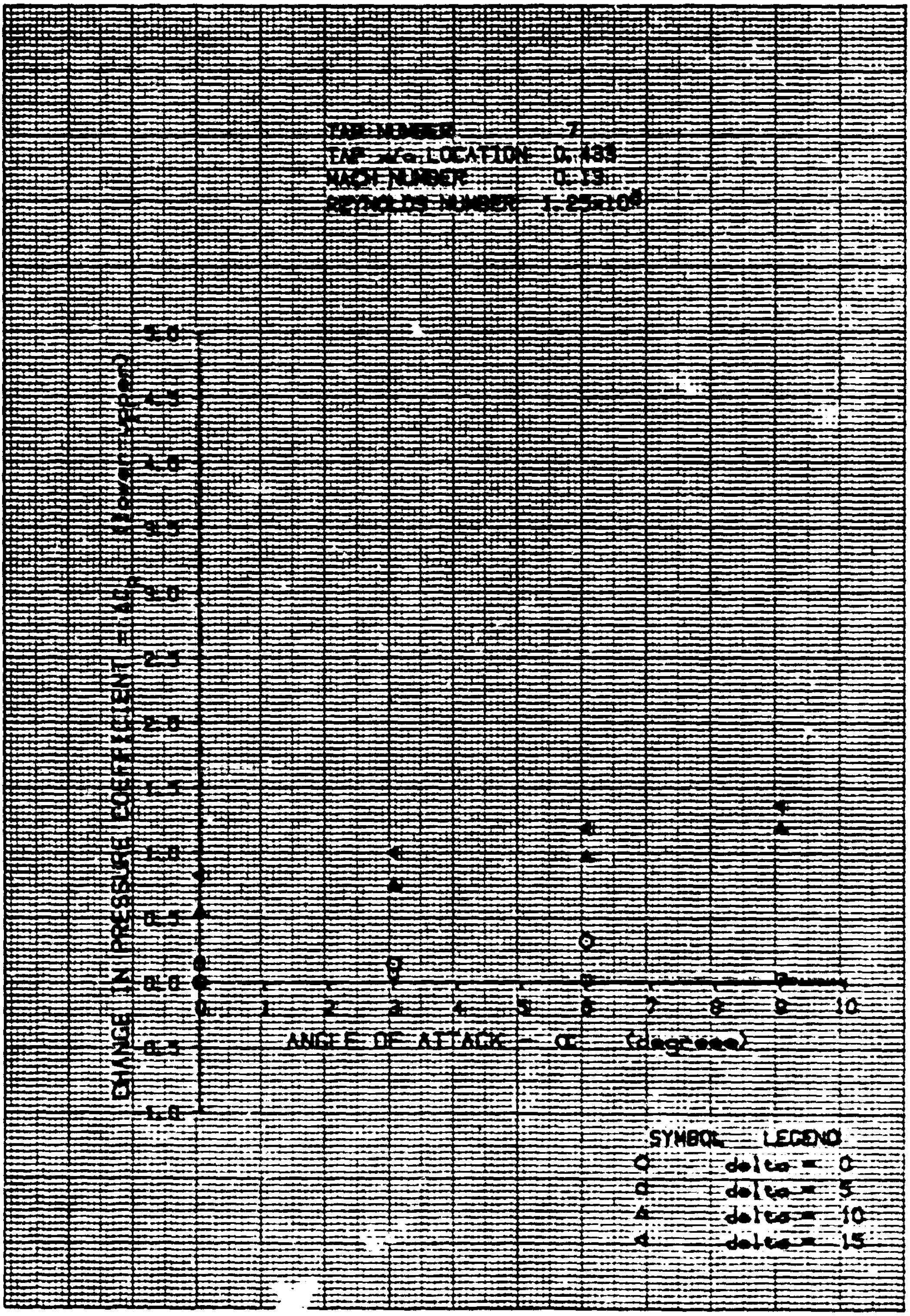
| | | | | |
|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE |
| CHECK | R. URABAK | 8-81 | | |
| APD | | | | |
| APPD | | | | |

FIGURE C.19 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY

DATE 5-8-81

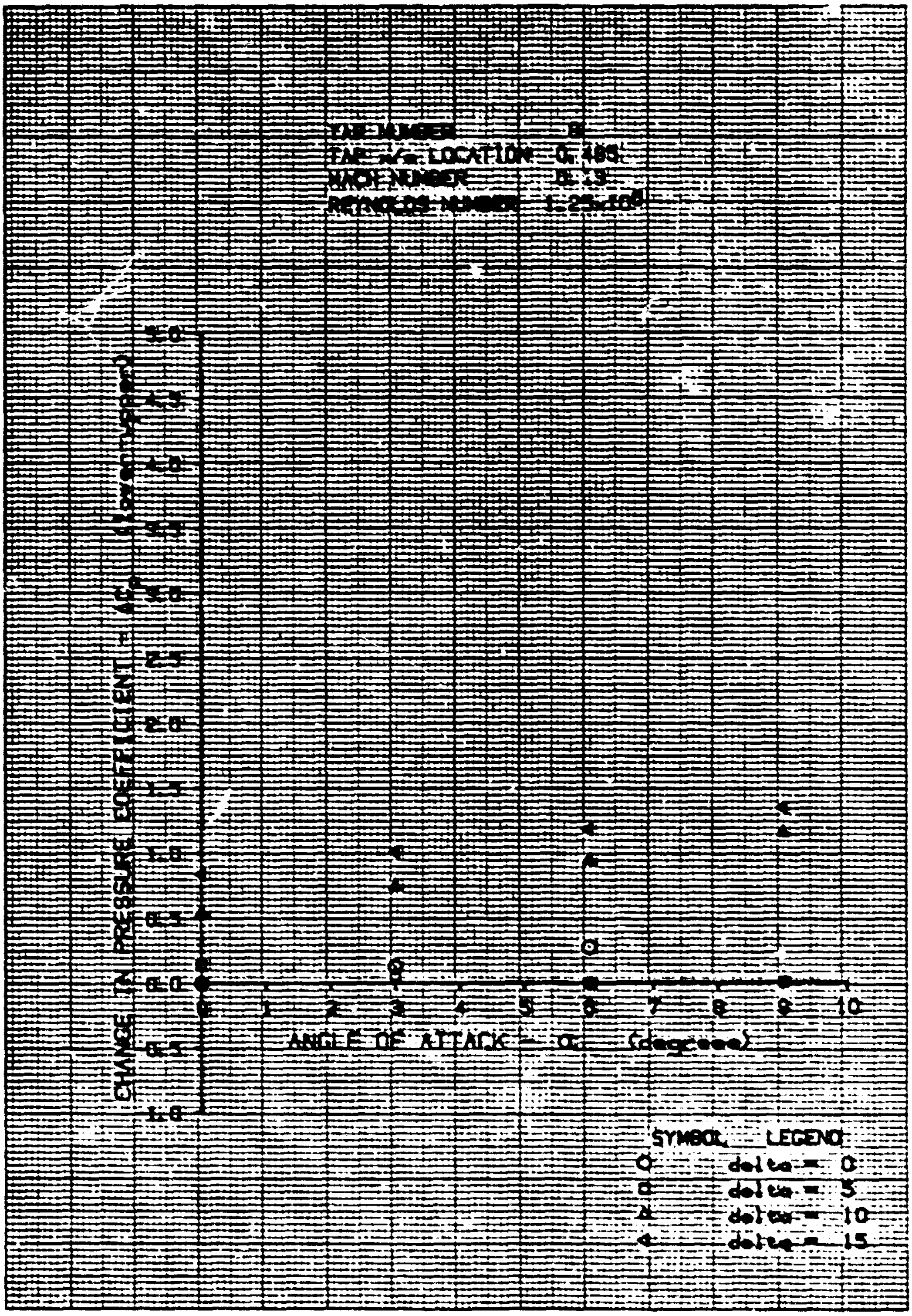
UNIVERSITY OF KANSAS

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



|  |  |  |  |  |  |
|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.20 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY |
| CHECK | R. HRABAK | 8-81 |  |  | DATE 5-8-81 |
| APPD |  |  |  |  |  |
| APPD |  |  |  |  | UNIVERSITY OF KANSAS |

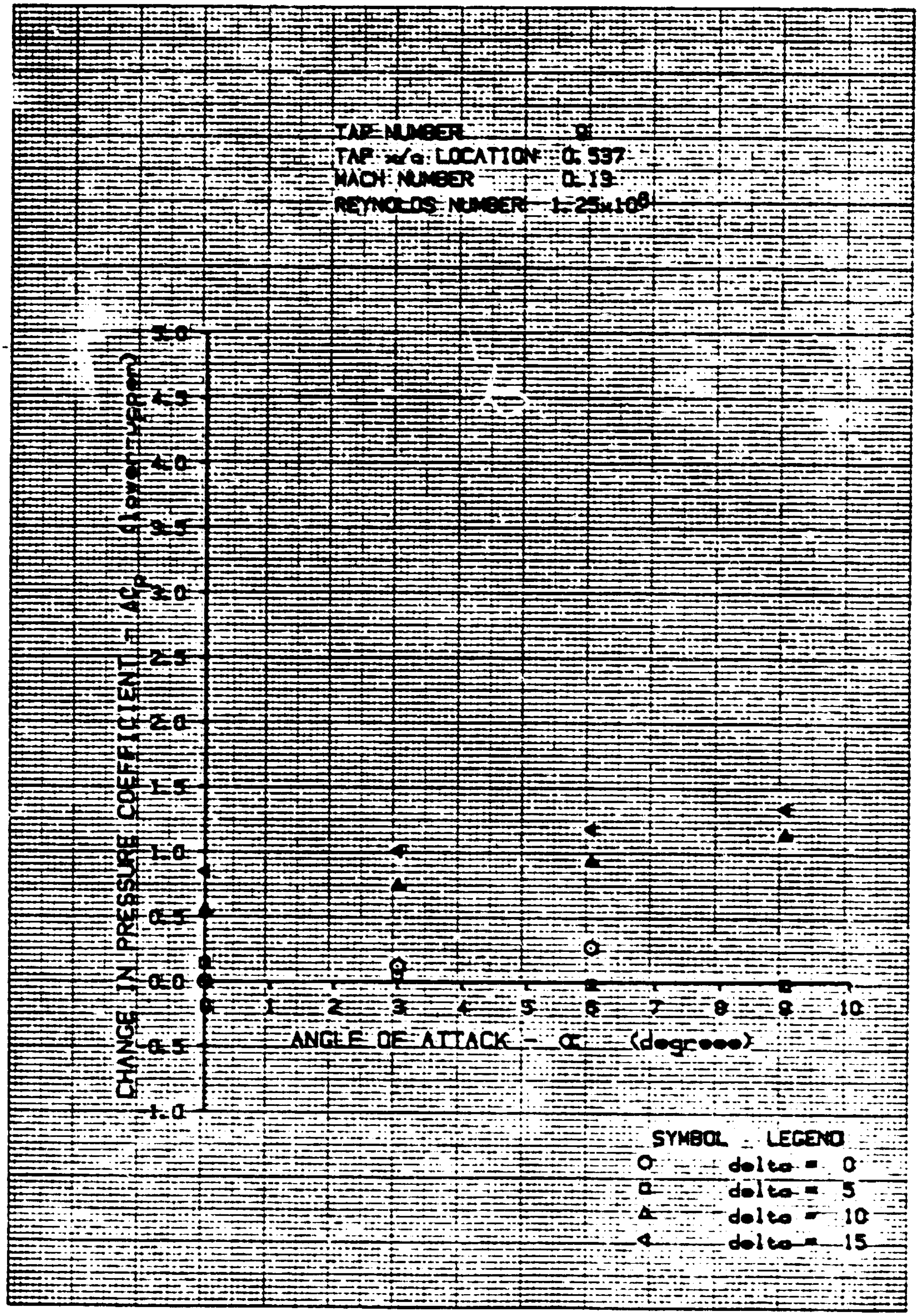
NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



ORIGINAL PAGE IS OF POOR QUALITY

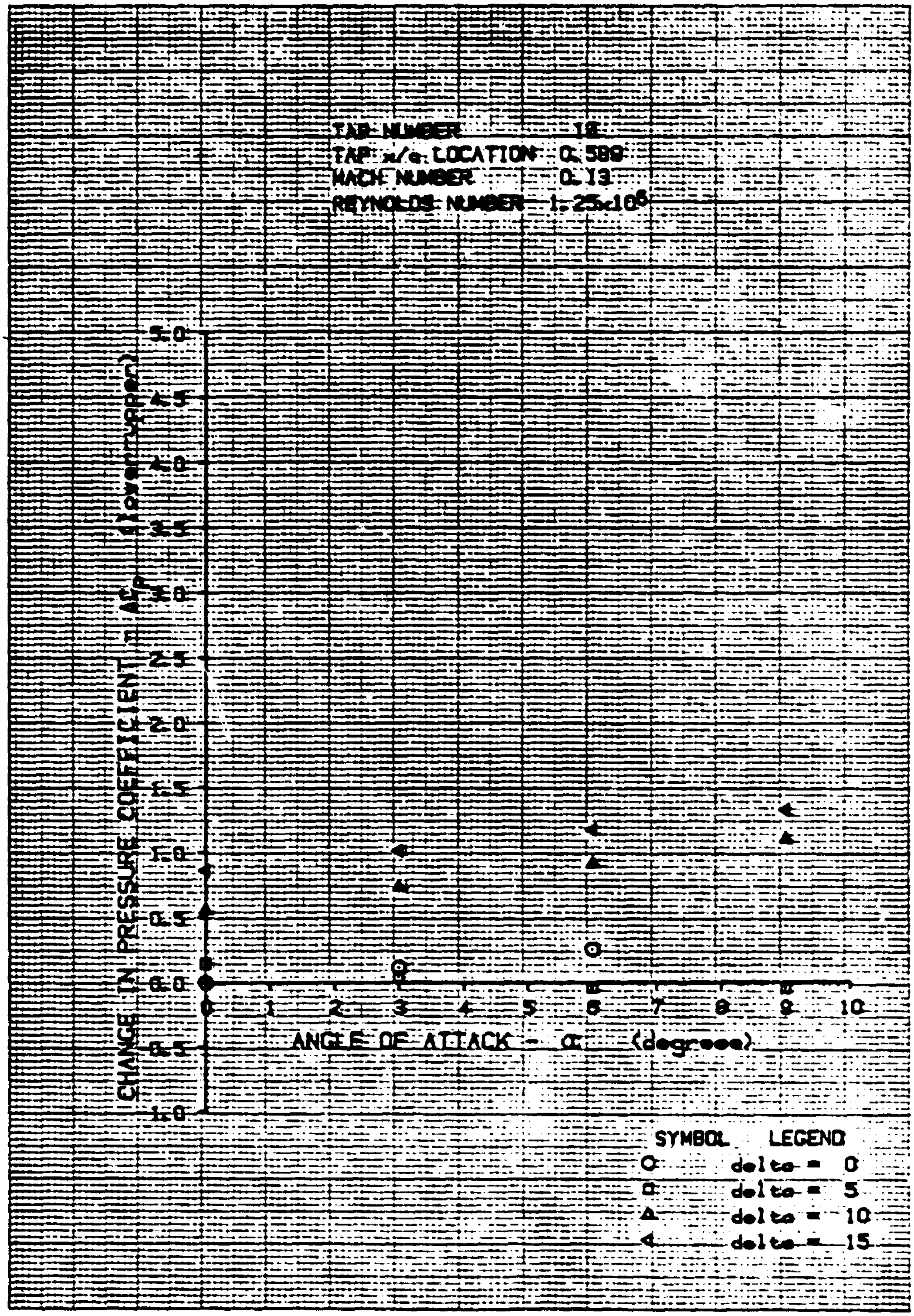
|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.21 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE<br>5-8-81 |
| CHECK | R.HAABAK | 8-81 |  |  |  |  |
| APPD |  |  |  |  |  |  |
| APPD |  |  |  |  | UNIVERSITY OF KANSAS | PAGE 167 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



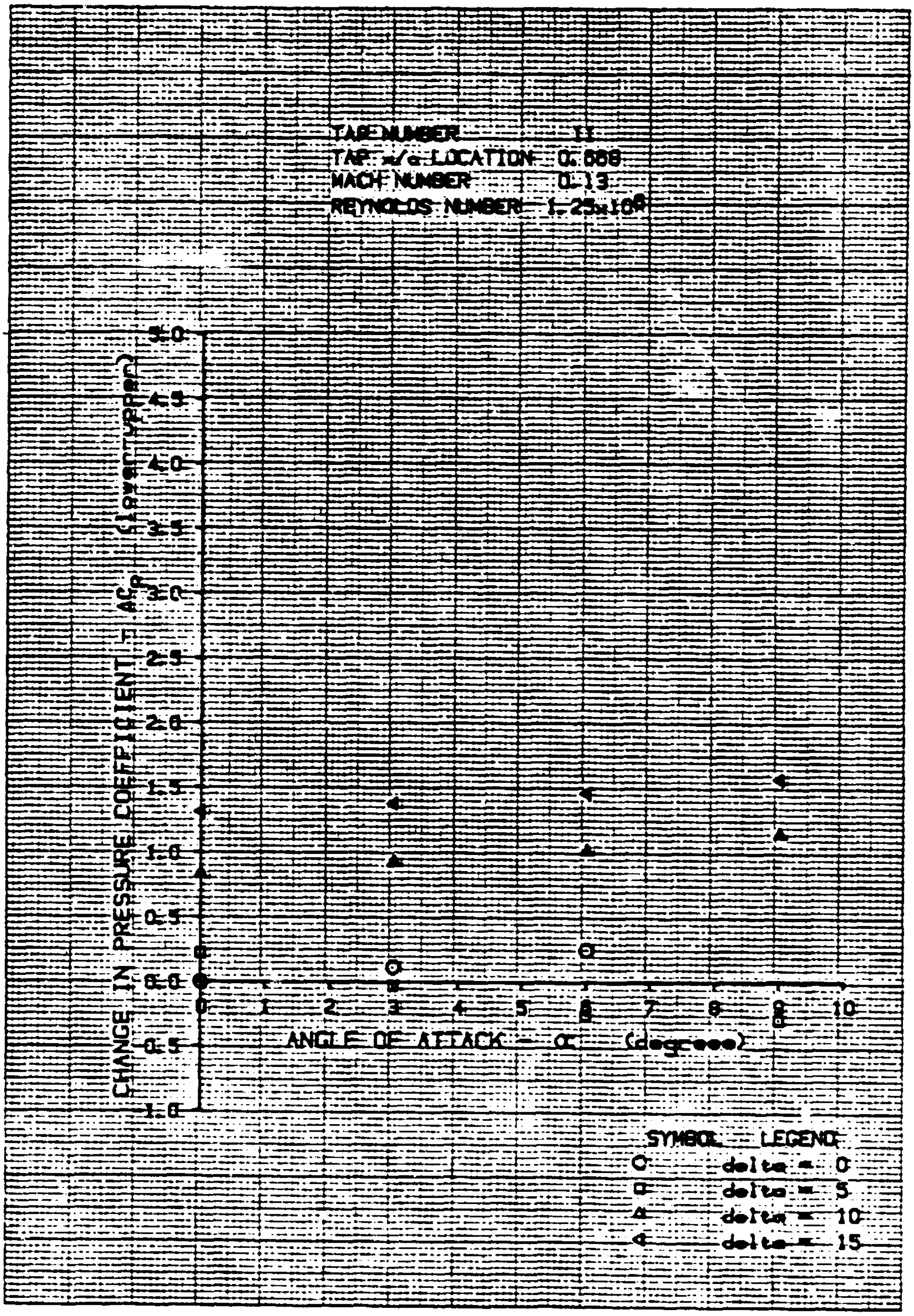
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.22 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | | |
| | | | | | UNIVERSITY OF KANSAS | PAGE 168 |

NOTE: THEORETICAL DATA INTERPOLATED TO : ECIFIC TAP LOCATIONS



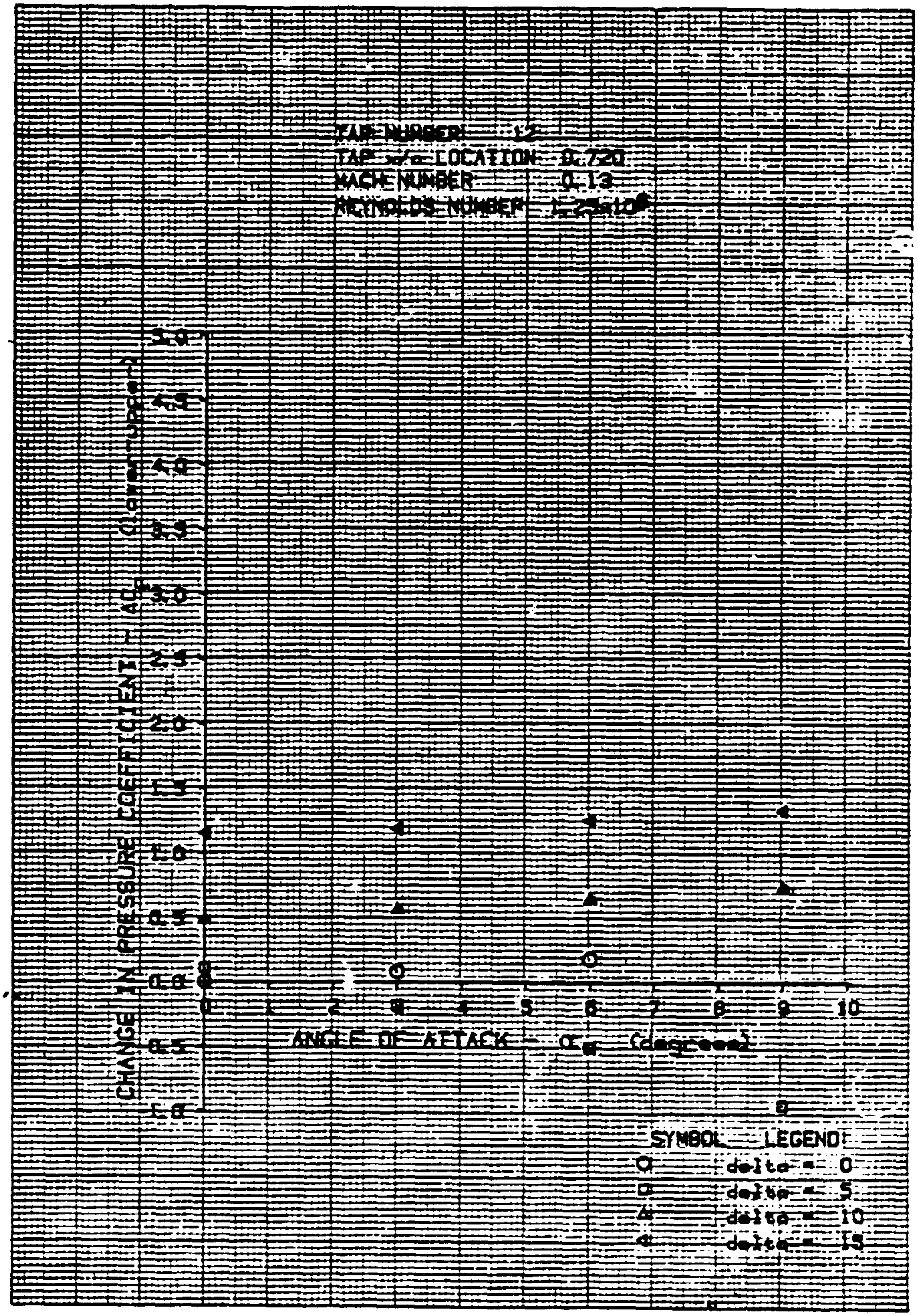
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.23 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HAABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 169 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



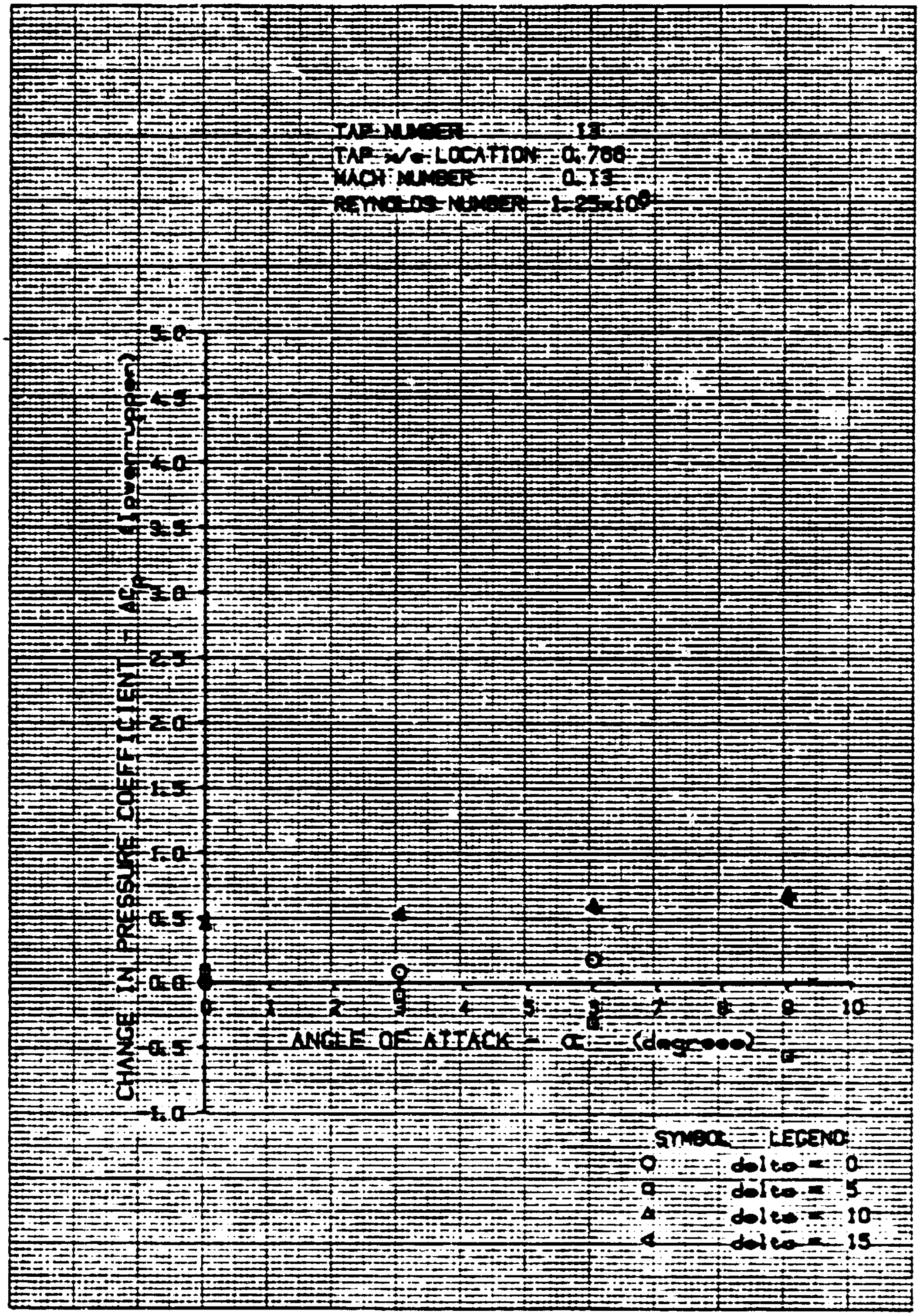
| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.24 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | | |
| | | | | | UNIVERSITY OF KANSAS | PAGE 170 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.25 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | | DATE<br>7-8-81 |
| CHECK | R. HRABAK | 8-81 | | | | | |
| APPD | | | | | | | |
| APPD | | | | | | | |
| | | | | | UNIVERSITY OF KANSAS | | PAGE 171 |

NOTE: THEORETICAL DATA INTERPOLATED TO SPECIFIC TAP LOCATIONS



| | | | | | | |
|---|---|---|---|---|---|---|
| CALC | P. FINN | 8-81 | REVISED | DATE | FIGURE C.28 SEAP THEORETICAL CHANGE IN PRESSURE COEFFICIENTS - ANGLE OF ATTACK SENSITIVITY | DATE 5-8-81 |
| CHECK | R HRABAK | 8-81 | | | | |
| APPD | | | | | | |
| APPD | | | | | UNIVERSITY OF KANSAS | PAGE 172 |

## C.7 NUMERICAL REGRESSION DATA

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## RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 66          TAP NUMBER  1

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT  ANGLES ANGLES OF ATTACK (alpha)

```
*************************************************
*       *           *           *               *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION *
*       *           *           *               *
*************************************************
*       *           *           *               *
*    0  *   0.137   *  -0.127   *      0.97     *
*    3  *   0.152   *   0.523   *      0.84     *
*    6  *   0.165   *   1.218   *      0.70     *
*    9  *   0.318   *   0.247   *      0.86     *
*       *           *           *               *
*************************************************
```

ALPHA (angle of attack) VERSES CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION ANGLES (delta)

```
*************************************************
*       *           *           *               *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION *
*       *           *           *               *
*************************************************
*       *           *           *               *
*    0  *   0.294   *  -0.009   *      1.00     *
*    5  *   0.124   *   0.324   *      0.99     *
*   10  *   0.319   *   1.301   *      1.00     *
*   15  *   0.298   *   1.974   *      1.00     *
*       *           *           *               *
*************************************************
```

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FILE NUMBER 67          TAP NUMBER  2

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


**************************************************
*       *           *           *                *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *   0.085   *  -0.094   *      0.96      *
*    3  *   0.096   *   0.346   *      0.80      *
*    6  *   0.105   *   0.784   *      0.64      *
*    9  *   0.214   *   0.031   *      0.84      *
*       *           *           *                *
**************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


**************************************************
*       *           *           *                *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *   0.196   *  -0.000   *      1.00      *
*    5  *   0.074   *   0.155   *      1.00      *
*   10  *   0.211   *   0.830   *      1.00      *
*   15  *   0.197   *   1.215   *      1.00      *
*       *           *           *                *
**************************************************
```

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            RESULTS OF LINEAR CURVE FITTING


FILE NUMBER 68            TAP NUMBER  3

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


**************************************************
*       *           *           *                *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *  0.065    *  -0.054   *      0.96      *
*    3  *  0.067    *   0.256   *      0.76      *
*    6  *  0.069    *   0.572   *      0.55      *
*    9  *  0.145    *   0.018   *      0.75      *
*       *           *           *                *
**************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


**************************************************
*       *           *           *                *
* delta *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *  0.144    *  -0.001   *      1.00      *
*    5  *  0.038    *   0.141   *      0.98      *
*   10  *  0.144    *   0.662   *      1.00      *
*   15  *  0.116    *   0.918   *      1.00      *
*       *           *           *                *
**************************************************
```

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            RESULTS OF LINEAR CURVE FITTING


FILE NUMBER 69            TAP NUMBER  4

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


*************************************************
*       *           *           *               *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION *
*       *           *           *               *
*************************************************
*       *           *           *               *
*    0  *   0.062   *  -0.061   *      0.97     *
*    3  *   0.072   *   0.122   *      0.85     *
*    6  *   0.079   *   0.325   *      0.73     *
*    9  *   0.147   *  -0.159   *      0.86     *
*       *           *           *               *
*************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


*************************************************
*       *           *           *               *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION *
*       *           *           *               *
*************************************************
*       *           *           *               *
*    0  *   0.094   *  -0.003   *      1.00     *
*    5  *   0.028   *   0.131   *      0.96     *
*   10  *   0.120   *   0.587   *      1.00     *
*   15  *   0.109   *   0.893   *      1.00     *
*       *           *           *               *
*************************************************
```

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              RESULTS OF LINEAR CURVE FITTING


FILE NUMBER 70           TAP NUMBER  5

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


************************************************
*       *          *           *               *
* alpha *   SLOPE  * INTERCEPT * COEFFICIENT OF*
*       *          *           * DETERMINATION *
*       *          *           *               *
************************************************
*       *          *           *               *
*    0  *  0.061   *  -0.061   *      0.97     *
*    3  *  0.070   *   0.090   *      0.84     *
*    6  *  0.075   *   0.266   *      0.70     *
*    9  *  0.153   *  -0.356   *      0.90     *
*       *          *           *               *
************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


************************************************
*       *          *           *               *
* delta *  SLOPE   * INTERCEPT * COEFFICIENT OF*
*       *          *           * DETERMINATION *
*       *          *           *               *
************************************************
*       *          *           *               *
*    0  *  0.088   *  -0.003   *      1.00     *
*    5  *  0.013   *   0.125   *      0.84     *
*   10  *  0.100   *   0.564   *      1.00     *
*   15  *  0.102   *   0.869   *      1.00     *
*       *          *           *               *
************************************************
```

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RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 71          TAP NUMBER  6

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)

```
*********************************************
*       *          *           *               *
* alpha *   SLOPE  * INTERCEPT * COEFFICIENT OF *
*       *          *           * DETERMINATION  *
*       *          *           *               *
*********************************************
*       *          *           *               *
*    0  *   0.059  *  -0.059   *      0.97     *
*    3  *   0.066  *   0.061   *      0.82     *
*    6  *   0.067  *   0.216   *      0.63     *
*    9  *   0.153  *  -0.525   *      0.92     *
*       *          *           *               *
*********************************************
```

ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)

```
*********************************************
*       *          *           *               *
* delta *  SLOPE   * INTERCEPT * COEFFICIENT OF
*       *          *           * DETERMINATION  *
*       *          *           *               *
*********************************************
*       *          *           *               *
*    0  *   0.082  *  -0.003   *      1.00     *
*    5  *  -0.004  *   0.122   *      0.31     *
*   10  *   0.080  *   0.544   *      1.00     *
*   15  *   0.085  *   0.840   *      0.99     *
*       *          *           *               *
*********************************************
```

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## RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 72              TAP NUMBER  7

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)

```
*************************************************
*       *           *           *               *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION *
*       *           *           *               *
*************************************************
*       *           *           *               *
*    0  *   0.058   *  -0.056   *     0.97      *
*    3  *   0.065   *   0.004   *     0.84      *
*    6  *   0.071   *   0.085   *     0.70      *
*    9  *   0.133   *  -0.478   *     0.85      *
*       *           *           *               *
*************************************************
```

ALPHA (angle of attack) VERS¯S CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)

```
*************************************************
*       *           *           *               *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION *
*       *           *           *               *
*************************************************
*       *           *           *               *
*    0  *   0.053   *  -0.004   *     1.00      *
*    5  *  -0.014   *   0.122   *     0.83      *
*   10  *   0.070   *   0.540   *     1.00      *
*   15  *   0.058   *   0.829   *     1.00      *
*       *           *           *               *
*************************************************
```

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               RESULTS OF LINEAR CURVE FITTING


FILE NUMBER 73          TAP NUMBER  8

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


**************************************************
*       *           *           *                *
* alpha *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *  0.059    *  -0.057   *      0.97      *
*    3  *  0.066    *  -0.013   *      0.85      *
*    6  *  0.073    *   0.047   *      0.73      *
*    9  *  0.134    *  -0.513   *      0.85      *
*       *           *           *                *
**************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


**************************************************
*       *           *           *                *
* delta * SLOPE     * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *  0.046    *  -0.003   *      1.00      *
*    5  * -0.017    *   0.124   *      0.86      *
*   10  *  0.067    *   0.547   *      1.00      *
*   15  *  0.056    *   0.841   *      1.00      *
*       *           *           *                *
**************************************************
```

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RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 74 TAP NUMBER 9

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT ANGLES
ANGLES OF ATTACK (alpha)

```
***************************************************
*       *            *           *                *
* alpha *   SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *            *           * DETERMINATION  *
*       *            *           *                *
***************************************************
*       *            *           *                *
*     0 *   0.059    *  -0.057   *      0.97      *
*     3 *   0.067    *  -0.020   *      0.85      *
*     6 *   0.074    *   0.034   *      0.72      *
*     9 *   0.136    *  -0.548   *      0.86      *
*       *            *           *                *
***************************************************
```

ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)

```
***************************************************
*       *            *           *                *
* delta *   SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *            *           * DETERMINATION  *
*       *            *           *                *
***************************************************
*       *            *           *                *
*     0 *   0.044    *  -0.003   *      1.00      *
*     5 *  -0.020    *   0.125   *      0.89      *
*    10 *   0.064    *   0.553   *      1.00      *
*    15 *   0.054    *   0.853   *      1.00      *
*       *            *           *                *
***************************************************
```

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FILE NUMBER 75 TAP NUMBER 10

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

| alpha | SLOPE | INTERCEPT | COEFFICIENT OF DETERMINATION |
|---|---|---|---|
| 0 | 0.060 | -0.058 | 0.97 |
| 3 | 0.068 | -0.027 | 0.85 |
| 6 | 0.074 | 0.020 | 0.72 |
| 9 | 0.138 | -0.583 | 0.87 |

ALPHA (angle of attack) VERSES CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION ANGLES (delta)

| delta | SLOPE | INTERCEPT | COEFFICIENT OF DETERMINATION |
|---|---|---|---|
| 0 | 0.043 | -0.003 | 1.00 |
| 5 | -0.023 | 0.127 | 0.91 |
| 10 | 0.060 | 0.559 | 1.00 |
| 15 | 0.051 | 0.865 | 1.00 |

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FILE NUMBER 76             TAP NUMBER 11

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


**************************************************
*       *           *           *                *
* alpha *    SLOPE  * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*     0 *    0.091  *   -0.089  *      0.97      *
*     3 *    0.095  *   -0.115  *      0.84      *
*     6 *    0.098  *   -0.123  *      0.68      *
*     9 *    0.186  *   -1.060  *      0.91      *
*       *           *           *                *
**************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


**************************************************
*       *           *           *                *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*     0 *   0.041   *  -0.003   *      1.00      *
*     5 *  -0.060   *   0.180   *      0.92      *
*    10 *   0.033   *   0.831   *      0.99      *
*    15 *   0.027   *   1.306   *      0.98      *
*       *           *           *                *
**************************************************
```

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FILE NUMBER 77          TAP NUMBER 12

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


**************************************************
*       *           *           *                *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *   0.076   *  -0.139   *      0.90      *
*    3  *   0.081   *  -0.193   *      0.76      *
*    6  *   0.087   *  -0.264   *      0.57      *
*    9  *   0.228   *  -1.911   *      0.93      *
*       *           *           *                *
**************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


**************************************************
*       *           *           *                *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF *
*       *           *           * DETERMINATION  *
*       *           *           *                *
**************************************************
*       *           *           *                *
*    0  *   0.030   *  -0.002   *      1.00      *
*    5  *  -0.117   *   0.143   *      0.99      *
*   10  *   0.027   *   0.480   *      1.00      *
*   15  *   0.019   *   1.135   *      0.97      *
*       *           *           *                *
**************************************************
```

```
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FILE NUMBER 78          TAP NUMBER 13

DELTA (flap deflection angle) versus CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT  ANGLES
ANGLES OF ATTACK (alpha)


***************************************************
*       *           *           *                 *
* alpha *   SLOPE   * INTERCEPT * COEFFICIENT OF  *
*       *           *           * DETERMINATION   *
*       *           *           *                 *
***************************************************
*       *           *           *                 *
*    0  *   0.036   *  -0.016   *      0.91       *
*    3  *   0.039   *  -0.035   *      0.64       *
*    6  *   0.042   *  -0.059   *      0.41       *
*    9  *   0.120   *  -0.949   *      0.72       *
*       *           *           *                 *
***************************************************


ALPHA (angle of attack) VERSES CHANGE IN
PRESSURE COEFFICIENT AT DIFFERENT FLAP DEFLECTION
ANGLES (delta)


***************************************************
*       *           *           *                 *
* delta *  SLOPE    * INTERCEPT * COEFFICIENT OF  *
*       *           *           * DETERMINATION   *
*       *           *           *                 *
***************************************************
*       *           *           *                 *
*    0  *   0.029   *  -0.002   *      1.00       *
*    5  *  -0.073   *   0.109   *      1.00       *
*   10  *   0.027   *   0.439   *      1.00       *
*   15  *   0.015   *   0.485   *      0.99       *
*       *           *           *                 *
***************************************************
```

# APPENDIX D

## THEORETICAL FREQUENCY ANALYSIS DATA

## D.1 LOW DYNAMIC PRESSURE

```
**********************************************************
                DELTA P FREQUENCY ANALYSIS FC1
**********************************************************

                        INPUT DATA

  Wing Area (D[80],ft↑2)                         174.0000000
  Weight (D[71],lb)                             2645.0000000
  Wing Span (D[72],ft)                            35.8000000
  MAC (D[73],ft)                                   4.9000000
  Airspeed (D[74],ft/s)                           90.9000000
  Density (D[75],slugs/ft↑3)                       0.0020500
  Angle of attack (D[76],rad)                      0.0000000
  Theta initial (D[77],rad)                        0.0000000
  Iyyb (D[81],slugs-ft↑2)                       1346.0000000
  CL1 (D[95])                                      0.3100000
  CD1 (D[96])                                      0.0310000
  CXT1 (D[97])                                     0.0310000
  CM1 (D[88])                                      0.0000000
  CMT1 (D[89])                                     0.0000000

  Nondimensional derivatives        Dimensional derivatives

                  LONGITUDINAL DERIVATIVES

   CDU (D[1])        0.0000        XU (1/s)          -0.0122
   CXTU (D[2])      -0.0930        XTU (1/s)         -0.0061
   CDA (D[3])        0.1300        XA (ft/s↑2)        3.2267
   CDDE (D[4])       0.0600        XDE (ft/s↑2)      -1.0756
   CLU (D[6])        0.0000        ZU (1/s)          -0.1223
   CLA (D[7])        4.6000        ZA (ft/s↑2)      -83.0147
   CLAD (D[8])       1.7000        ZAD (ft/s)        -0.8214
   CLQ (D[9])        3.9000        ZQ (ft/s)         -1.8843
   CLDE (D[10])      0.4300        ZDE (ft/s↑2)      -7.7081
   CMU (D[12])       0.0000        MU (1/ft s)        0.0000
   CMTU (D[13])      0.0000        MTU (1/ft s)       0.0000
            4])     -0.8900        MA (1/s↑2)        -4.7747
            5])      0.0000        MTA (1/s↑2)        0.0000
           16])     -5.2000        MAD (1/s)         -0.7519
   CMQ (D[17])     -12.4000        MQ (1/s)          -1.7930
   CMDE (D[18])     -1.2800        MDE (1/s↑2)       -6.8669
```

```
**************************************************************
                DELTA P FREQUENCY ANALYSIS FC1
**************************************************************

       TRANSFER FUNCTION POLYNOMIAL COEFFICIENTS

     THE COEFFICIENTS OF THE LONGITUDINAL CHARACTERISTIC EQUATION ARE:
   A=         91.72136   B=       316.08207   C=        580.02367
   D=         14.18981   E=        18.78257

            THE COEFFICIENTS OF THE NUMERATOR U(S) ARE:
               0.00000   AU=      -98.65111   BU=      -363.02499
  CU=      17443.94743   DU=    17156.83612

           THE COEFFICIENTS OF THE NUMERATOR ALPHA(S) ARE:
               0.00000   AA=       -7.70812   BA=      -625.09400
  CA=        -11.22826   DA=      -27.01314

          THE COEFFICIENTS OF THE NUMERATOR THETA(S) ARE:
               0.00000              0.00000   AT=      -624.04734
  BT=       -544.79548   CT=      -13.11681

STANDARD FORMAT FOR LONGITUDINAL TRANSFER FUNCTIONS


 U(S)/DELTA-E(S) COEFFICIENTS ARE:

         KUDE      913.44451
          TU1        1.03184
          TU2        0.06748
          TU3       -0.08258
      OMN SP         2.50357
       ZT SP         0.68689
       OMN P         0.18075
        ZT P         0.01869

 ALPHA(S)/DELTA-E(S) COEFFICIENTS ARE:

     KALPHADE       -1.43820
      TALPHA1        0.01233
    OMN ALPHA        0.20790
     ZT ALPHA        0.04193
       OMN SP        2.50357
        ZT SP        0.68689
        OMN P        0.18075
         ZT P        0.01869

 THETA(S)/DELTA-E(S) COEFFICIENTS ARE:

     KTHETADE       -0.69835
      TTHETA1       40.35522
      TTHETA2        1.17893
       OMN SP        2.50357
        ZT SP        0.68689
        OMN P        0.18075
         ZT P        0.01869
```

## D.1.1 WITH PRESSURE SENSOR (PRESSURE COMMAND)

```
*****************************************************
                    DELTA P FREQUENCY ANALYSIS FC1
*****************************************************


NO(S) COEFFICIENTS
  1.000E 01  5.000E 01
DO(S) COEFFICIENTS
  1.000E 00  1.500E 01  7.000E 01
N1(S) COEFFICIENTS
  6.240E 02  5.448E 02  1.310E 01
D1(S) COEFFICIENTS
  9.170E 01  3.161E 02  5.800E 02  1.420E 01  1.330E 01
N2(S) COEFFICIENTS
  1.000E 00
D2(S) COEFFICIENTS
  1.000E 00



NC0]NC1]DC2]=

  6.240E 03  3.665E 04  2.737E 04  6.550E 02
NC0]NC1]NC2]=

  6.240E 03  3.665E 04  2.737E 04  6.550E 02
                 Real     Imaginary                        Real      Imaginary
ROOT NO. 3    -0.025      0.000          ROOT NO. 2    -5.000      0.000
ROOT NO. 1    -0.348      0.000

K=     0.000
   DC0]DC1]DC2]+KNC0]NC1]NC2]=

    9.170E 01   1.692E 03   1.174E 04   3.084E 04   4.083E 04   1.2[illegible]E
    1.316E 03
                 Real     Imaginary                        Real      Imaginary
ROOT NO. 6    -7.500     -3.709          ROOT NO. 5    -7.500      3.709
ROOT NO. 4    -1.720     -1.819          ROOT NO. 3    -0.003     -0.111
ROOT NO. 2    -1.720      1.819          ROOT NO. 1    -0.003      0.111

K=     0.200
   DC0]DC1]DC2]+KNC0]NC1]NC2]=

    9.170E 01   1.692E 03   1.174E 04   3.209E 04   4.816E 04   6.750E 03
    1.447E 03
                 Real     Imaginary                        Real      Imaginary
ROOT NO. 6    -7.495     -3.553          ROOT NO. 5    -7.495      3.553
ROOT NO. 4    -1.663     -2.043          ROOT NO. 3    -0.066     -0.170
ROOT NO. 2    -1.663      2.043          ROOT NO. 1    -0.066      0.170

K=     0.500
   DC0]DC1]DC2]+KNC0]NC1]NC2]=

    9.170E 01   1.692E 03   1.174E 04   3.396E 04   5.916E 04   1.496E 04
    1.644E 03
                 Real     Imaginary                        Real      Imaginary
ROOT NO. 6    -7.497     -3.314          ROOT NO. 5    -7.497      3.314
ROOT NO. 4    -1.588     -2.374          ROOT NO. 3    -0.119     -0.116
ROOT NO. 2    -1.588      2.374          ROOT NO. 1    -0.119      0.116

K=     0.800
   DC0]DC1]DC2]+KNC0]NC1]NC2]=

    9.170E 01   1.692E 03   1.174E 04   3.583E 04   7.[illegible]15E 04   [illegible]17E 04
    1.840E 03
                 Real     Imaginary                        Real      Imaginary
ROOT NO. 6    -7.512     -3.068          ROOT NO. 5    -7.512      3.068
ROOT NO. 4    -1.520     -2.692          ROOT NO. 3    -0.1[illegible]1      0.000
ROOT NO. 2    -1.520      2.692          ROOT NO. 1    -0.2[illegible]3      0.000
```

```
K=      1.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  3.708E 04  7.741E 04  2.865E 04
      1.971E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -7.528    -2.902          ROOT NO. 5    -1.476    -2.894
  ROOT NO. 4    -7.528     2.902          ROOT NO. 3    -0.060    -0.000
  ROOT NO. 2    -1.476     2.894          ROOT NO. 1    -0.344     0.000

K=      2.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  4.332E 04  1.141E 05  5.602E 04
      2.625E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -1.253    -3.784          ROOT NO. 5    -7.671     2.031
  ROOT NO. 4    -7.671    -2.031          ROOT NO. 3    -0.052     0.000
  ROOT NO. 2    -1.253     3.784          ROOT NO. 1    -0.547     0.000

K=      3.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 0'  1.692E 03  1.174E 04   .956E 04  1.508E 05  8.339E 04
      3.281E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -1.021    -4.491          ROOT NO. 5    -7.865     0.902
  ROOT NO. 4    -7.865    -0.902          ROOT NO. 3    -0.043    -0.000
  ROOT NO. 2    -1.021     4.491          ROOT NO. 1    -0.632     0.000

K=      4.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  5.580E 04  1.874E 05  1.108E 05
      3.936E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -0.797    -5.067          ROOT NO. 5    -9.423     0.000
  ROOT NO. 4    -6.712     0.000          ROOT NO. 3    -0.038    -0.000
  ROOT NO. 2    -0.797     5.067          ROOT NO. 1    -0.680     0.000

K=      5.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  6.204E 04  2.241E 05  1.381E 05
      4.591E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -0.589    -5.551          ROOT NO. 5   -10.280     0.000
  ROOT NO. 4    -6.244    -0.000          ROOT NO. 3    -0.035    -0.000
  ROOT NO. 2    -0.589     5.551          ROOT NO. 1    -0.710     0.000

K=      6.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  6.828E 04  2.607E 05  1.655E 05
      5.246E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -0.396    -5.971          ROOT NO. 5   -10.901     0.000
  ROOT NO. 4    -5.989     0.000          ROOT NO. 3    -0.033     0.000
  ROOT NO. 2    -0.396     5.971          ROOT NO. 1    -0.732    -0.000

K=      7.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  7.452E 04  2.974E 05  1.929E 05
      5.901E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -0.213    -6.344          ROOT NO. 5   -11.403    -0.000
  ROOT NO. 4    -5.323    -0.000          ROOT NO. 3    -0.032     0.000
  ROOT NO. 2    -0.218     6.344          ROOT NO. 1    -0.747     0.000

K=      8.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174F 04  8.076E 04  3.340E 05  2.203E 05
      6.556E 03
                   Real     Imaginary                          Real     Imaginary
  ROOT NO. 6    -0.050    -6.679          ROOT NO. 5   -11.345     0.000
  ROOT NO. 4    -5.706     0.000          ROOT NO. 3    -0.031    -0.000
  ROOT NO. 2    -0.050     6.679          ROOT NO. 1    -0.758    -0.000
```

```
K=      7.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  7.452E 04  2.974E 05  1.928E 05
      5.901E 03
                  Real     Imaginary                         Real     Imaginary
  ROOT NO. 6    -0.218    -6.344           ROOT NO. 5  -11.408    -0.000
  ROOT NO. 4    -5.823    -0.000           ROOT NO. 3   -0.032     0.000
  ROOT NO. 2    -0.218     6.344           ROOT NO. 1   -0.747     0.000

K=      8.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  8.076E 04  3.340E 05  2.202E 05
 -    6.556E 03
                  Real     Imaginary                         Real     Imaginary
  ROOT NO. 6    -0.053    -6.679           ROOT NO. 5  -11.845     0.000
  ROOT NO. 4    -5.706     0.000           ROOT NO. 3   -0.031    -0.000
  ROOT NO. 2    -0.053     6.679           ROOT NO. 1   -0.759    -0.000


K=      9.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  8.700E 04  3.707E 05  2.476E 05
      7.211E 03
                  Real     Imaginary                         Real     Imaginary
  ROOT NO. 6     0.102    -6.986           ROOT NO. 5  -12.233    -0.000
  ROOT NO. 4    -0.031     0.000           ROOT NO. 3    0.102     6.986
  ROOT NO. 2    -5.618     0.000           ROOT NO. 1   -0.768    -0.000

K=     10.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01  1.692E 03  1.174E 04  9.324E 04  4.073E 05  2.750E 05
      7.866E 03
                  Real     Imaginary                         Real     Imaginary
  ROOT NO. 6     0.247    -7.268           ROOT NO. 5  -12.584    -0.000
  ROOT NO. 4    -0.030     0.000           ROOT NO. 3    0.247     7.268
  ROOT NO. 2    -5.550    -0.000           ROOT NO. 1   -0.776    -0.000
```

## D.1.2 WITHOUT PRESSURE SENSOR (POSITION COMMAND)

```
******************************************************
                      DELTA P THEORETICAL ANALYSIS
******************************************************


N0(S) COEFFICIENTS
  1.000E 01
D0(S) COEFFICIENTS
  1.000E 00  1.000E 01
N1(S) COEFFICIENTS
  6.240E 02  5.448E 02  1.310E 01
D1(S) COEFFICIENTS
  9.170E 01  3.161E 02  5.800E 02  1.420E 01  1.880E 01
N2(S) COEFFICIENTS
  1.000E 00
D2(S) COEFFICIENTS
  1.000E 00



N[0]N[1]D[2]=

  6.240E 03  5.448E 03  1.310E 02
N[0]N[1]N[2]=

  6.240E 03  5.448E 03  1.310E 02
             Real    Imaginary                      Real    Imaginary
ROOT NO. 2  -0.025    0.000          ROOT NO. 1   -0.848    0.000

K=     0.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01  1.233E 03  3.741E 03  5.814E 03  1.608E 02  1.880E 02
                 Real    Imaginary                      Real    Imaginary
    ROOT NO. 5  -1.720   -1.819          ROOT NO. 4  -10.000   -0.000
    ROOT NO. 3  -0.003   -0.181          ROOT NO. 2   -1.720    1.819
    ROOT NO. 1  -0.003    0.181


K=     0.200
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01  1.233E 03  3.741E 03  7.062E 03  1.250E 03  2.142E 02
                 Real    Imaginary                      Real    Imaginary
    ROOT NO. 5  -1.552   -2.111          ROOT NO. 4  -10.167    0.000
    ROOT NO. 3  -0.089   -0.160          ROOT NO. 2   -1.552    2.111
    ROOT NO. 1  -0.089    0.160

K=     0.500
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01  1.233E 03  3.741E 03  8.934E 03  2.885E 03  2.535E 02
                 Real    Imaginary                      Real    Imaginary
    ROOT NO. 5  -1.345   -2.504          ROOT NO. 4  -10.397    0.000
    ROOT NO. 3  -0.180   -0.021          ROOT NO. 2   -1.345    2.504
    ROOT NO. 1  -0.180    0.021

K=     0.800
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01  1.233E 03  3.741E 03  1.081E 04  4.519E 03  2.928E 02
                 Real    Imaginary                      Real    Imaginary
    ROOT NO. 5  -1.181   -2.849          ROOT NO. 4  -10.607    0.000
    ROOT NO. 3  -0.079    0.000          ROOT NO. 2   -1.181    2.849
    ROOT NO. 1  -0.398    0.000
```

C-3

```
K=      1.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   1.205E 04   5.609E 03   3.190E 02
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5     -1.088      -3.056          ROOT NO. 4  -10.739    -0.000
  ROOT NO. 3     -0.066       0.000          ROOT NO. 2   -1.088     3.056
  ROOT NO. 1     -0.466       0.000

K=      2.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   1.829E 04   1.106E 04   4.500E 02
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5     -0.728      -3.892          ROOT NO. 4  -11.317     0.000
  ROOT NO. 3     -0.044       0.000          ROOT NO. 2   -0.728     3.892
  ROOT NO. 1     -0.631      -0.000


K=      3.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   2.453E 04   1.650E 04   5.810E 02
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5     -0.456      -4.525          ROOT NO. 4  -11.802    -0.000
  ROOT NO. 3     -0.037      -0.000          ROOT NO. 2   -0.456     4.525
  ROOT NO. 1     -0.697      -0.000

K=      4.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   3.077E 04   2.195E 04   7.120E 02
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5     -0.228      -5.043          ROOT NO. 4  -12.225    -0.000
  ROOT NO. 3     -0.034      -0.000          ROOT NO. 2   -0.228     5.043
  ROOT NO. 1     -0.732      -0.000

K=      5.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   3.701E 04   2.740E 04   8.430E 02
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5     -0.029      -5.485          ROOT NO. 4  -12.603     0.000
  ROOT NO. 3     -0.032       0.000          ROOT NO. 2   -0.029     5.485
  ROOT NO. 1     -0.754       0.000

K=      6.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   4.325E 04   3.285E 04   9.740E 02
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5      0.149      -5.873          ROOT NO. 4  -12.946     0.000
  ROOT NO. 3     -0.031       0.000          ROOT NO. 2    0.149     5.873
  ROOT NO. 1     -0.769      -0.000

K=      7.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   4.949E 04   3.830E 04   1.105E 03
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5      0.312      -6.222          ROOT NO. 4  -13.261     0.000
  ROOT NO. 3     -0.030       0.000          ROOT NO. 2    0.312     6.222
  ROOT NO. 1     -0.780      -0.000

K=      8.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      9.170E 01   1.233E 03   3.741E 03   5.573E 04   4.374E 04   1.236E 03
                   Real       Imaginary                  Real      Imaginary
  ROOT NO. 5      0.462      -6.540          ROOT NO. 4  -13.554     0.000
  ROOT NO. 3     -0.029       0.000          ROOT NO. 2    0.462     6.540
  ROOT NO. 1     -0.788       0.000
```

```
K=      9.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01   1.233E 03   3.741E 03   6.197E 04   4.919E 04   1.367E 03
                   Real     Imaginary                              Real     Imaginary
  ROOT NO. 5      0.603     -6.332           ROOT NO. 4    -13.829     -0.000
  ROOT NO. 3     -0.029      0.000           ROOT NO. 2      0.603      6.832
  ROOT NO. 1     -0.795     -0.000

K=     10.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

      9.170E 01   1.233E 03   3.741E 03   6.821E 04   5.464E 04   1.498E 03
                   Real     Imaginary                              Real     Imaginary
  ROOT NO. 5      0.734     -7.104           ROOT NO. 4    -14.087     -0.000
  ROOT NO. 3     -0.028     -0.000           ROOT NO. 2      0.734      7.104
  ROOT NO. 1     -0.800      0.000
```

## D.2 HIGH DYNAMIC PRESSURE

```
**********************************************************
               DELTA P FREQUENCY ANALYSIS FC1
**********************************************************

                        INPUT DATA

   Wing Area (D[80],ft↑2)                        174.0000000
   Weight (D[71],lb)                            2645.0000000
   Wing Span (D[72],ft)                           35.0000000
   MAC (D[73],ft)                                  4.9000000
   Airspeed (D[74],ft/s)                         272.0000000
   Density (D[75],slugs/ft↑3)                      0.0020500
   Angle of attack (D[76],rad)                     0.0000000
   Theta initial (D[77],rad)                       0.0000000
   Iyb (D[81],slugs-ft↑2)                       1346.0000000
   CL1 (D[95])                                     0.3100000
   CD1 (D[96])                                     0.0310000
   CXT1 (D[97])                                    0.0310000
   CM1 (D[88])                                     0.0000000
   CMT1 (D[89])                                    0.0000000

   Nondimensional derivatives       Dimensional derivatives

                  LONGITUDINAL DERIVATIVES

    CDU (D[1])       0.0000        XU (1/s)          -0.0367
    CXTU (D[2])     -0.0930        XTU (1/s)         -0.0183
    CDA (D[3])       0.1300        XA (ft/s↑2)       29.0612
    CDDE (D[4])      0.0600        XDE (ft/s↑2)      -9.6871
    CLU (D[6])       0.0000        ZU (1/s)          -0.3669
    CLA (D[7])       4.6000        ZA (ft/s↑2)     -747.6804
    CLAD (D[8])      1.7000        ZAD (ft/s)        -2.4650
    CLQ (D[9])       3.9000        ZQ (ft/s)         -5.6549
    CLDE (D[10])     0.4300        ZDE (ft/s↑2)     -69.4240
    CMU (D[12])      0.0000        MU (1/ft s)        0.0000
    CMTU (D[13])     0.0000        MTU (1/ft s)       0.0000
    CMA (D[14])     -0.8900        MA (1/s↑2)       -43.0034
    CMTA (D[15])     0.0000        MTA (1/s↑2)        0.0000
    CMAD (D[16])    -5.2000        MAD (1/s)         -2.3565
    CMQ (D[17])    -12.4000        MQ (1/s)          -5.3809
    CMDE (D[18])    -1.2800        MDE (1/s↑2)      -61.8476
```

```
           ************************************************************
                              DELTA P FREQUENCY ANALYSIS FC1
           ************************************************************

                  TRANSFER FUNCTION POLYNOMIAL COEFFICIENTS

                THE COEFFICIENTS OF THE LONGITUDINAL CHARACTERISTIC EQUATION ARE:
 --   A=        275.26497   B=       2846.82537   C=     15677.67370
      D=        937.76723   E=        507.68751

                       THE COEFFICIENTS OF THE NUMERATOR U(S) ARE:
                         0.00000  AU=     -2666.51129  BU=    -29448.17973
     CU=    -98568.06981  DU=  1391743.28340

                      THE COEFFICIENTS OF THE NUMERATOR ALPHA(S) ARE:
                         0.00000  AA=        -69.42401  BA=    -16896.11195
     CA=       -910.82371  DA=       -730.15732

                     THE COEFFICIENTS OF THE NUMERATOR THETA(S) ARE:
                         0.00000              0.00000  AT=    -16367.82100
     BT=    -44193.19758  CT=      -3193.23231

STANDARD FORMAT FOR LONGITUDINAL TRANSFER FUNCTIONS


 U(S)/DELTA-E(S) COEFFICIENTS ARE:

          KUDE      2741.33843
           TU1        -0.21267
        OMN U        10.53575
          ZT U         0.74725
        OMN SP         7.50749
         ZT SP         0.68516
         OMN P         0.18090
          ZT P         0.15056

 ALFHA(S)/DELTA-E(S) COEFFICIENTS ARE:

      KALPHADE        -1.43820
       TALPHA1         0.00411
     OMN ALPHA         0.20790
      ZT ALPHA         0.12923
        OMN SP         7.50749
         ZT SP         0.68516
         OMN P         0.18090
          ZT P         0.15056

 THETA(S)/DELTA-E(S) COEFFICIENTS ARE:

      KTHETADE        -6.28976
       TTHETA1        13.44681
       TTHETA2         0.39283
        OMN SP         7.50749
         ZT SP         0.68516
         OMN P         0.18090
          ZT P         0.15056
```

## D.2.1 WITH PRESSURE SENSOR (PRESSURE COMMAND)

```
     ******************************************************
                         DELTA P FREQUENCY ANALYSIS FC1
     ******************************************************


     N0(S) COEFFICIENTS
       1.000E 01  5.000E 01
     D0(S) COEFFICIENTS
       1.000E 00  1.500E 01  2.295E 02
     N1(S) COEFFICIENTS
       1.687E 04  4.419E 04  3.193E 03
     D1(S) COEFFICIENTS
       2.753E 02  2.847E 03  1.568E 04  9.378E 02  5.077E 02
     N2(S) COEFFICIENTS
       1.000E 00
     D2(S) COEFFICIENTS
       1.000E 00



     N[0]N[1]D[2]=

       1.687E 05  1.285E 06  2.242E 06  1.597E 05
     N[0]N[1]N[2]=

       1.687E 05  1.285E 06  2.242E 06  1.597E 05
                   Real    Imaginary                        Real    Imaginary
   ROOT NO. 3    -0.074     0.000          ROOT NO. 2     -5.000     0.000
   ROOT NO. 1    -2.546     0.000

 K=      0.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

       2.753E 02  6.976E 03  1.216E 05  8.894E 05  3.613E 06  2.228E 05
       1.165E 05
                   Real    Imaginary                        Real    Imaginary
   ROOT NO. 6    -7.500   -13.162          ROOT NO. 5     -5.143    -5.468
   ROOT NO. 4    -7.500    13.162          ROOT NO. 3     -5.143     5.468
   ROOT NO. 2    -0.027    -0.179          ROOT NO. 1     -0.027     0.179

 K=      0.200
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

       2.753E 02  6.976E 03  1.216E 05  9.232E 05  3.870E 06  6.712E 05
       1.484E 05
                   Real    Imaginary                        Real    Imaginary
   ROOT NO. 6    -7.129   -13.026          ROOT NO. 5     -7.129    13.026
   ROOT NO. 4    -5.455    -5.600          ROOT NO. 3     -5.455     5.600
   ROOT NO. 2    -0.086    -0.181          ROOT NO. 1     -0.086     0.181

 K=      0.500
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

       2.753E 02  6.976E 03  1.216E 05  9.738E 05  4.255E 06  1.344E 06
       1.963E 05
                   Real    Imaginary                        Real    Imaginary
   ROOT NO. 6    -6.513   -12.886          ROOT NO. 5     -5.993    -5.725
   ROOT NO. 4    -6.513    12.886          ROOT NO. 3     -5.993     5.725
   ROOT NO. 2    -0.165    -0.151          ROOT NO. 1     -0.165     0.151

 K=      0.800
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

       2.753E 02  6.976E 03  1.216E 05  1.024E 06  4.641E 06  2.016E 06
       2.442E 05
                   Real    Imaginary                        Real    Imaginary
   ROOT NO. 6    -5.857   -12.859          ROOT NO. 5     -6.579    -5.723
   ROOT NO. 4    -5.857    12.859          ROOT NO. 3     -0.234    -0.059
   ROOT NO. 2    -6.579     5.723          ROOT NO. 1     -0.234     0.059
```

```
K=      1.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  1.058E 06  4.898E 06  2.464E 06
        2.762E 05
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6    -5.428  -12.910            ROOT NO. 5   -6.966   -5.646
  ROOT NO. 4    -5.428   12.910            ROOT NO. 3   -0.163   -0.000
  ROOT NO. 2    -6.966    5.646            ROOT NO. 1   -0.390    0.000

K=      2.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  1.227E 06  6.183E 06  4.706E 06
        4.358E 05
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6    -3.720  -13.588            ROOT NO. 5   -3.720   13.588
  ROOT NO. 4    -8.505   -4.726            ROOT NO. 3   -0.107    0.000
  ROOT NO. 2    -8.505    4.726            ROOT NO. 1   -0.784    0.000


K=      3.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  1.395E 06  7.469E 06  6.948E 06
        5.955E 05
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6    -2.572  -14.384            ROOT NO. 5   -9.533   -3.408
  ROOT NO. 4    -2.572   14.384            ROOT NO. 3   -0.095   -0.000
  ROOT NO. 2    -9.533    3.408            ROOT NO. 1   -1.037   -0.000

K=      4.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  1.564E 06  8.754E 06  9.189E 06
        7.552E 05
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6    -1.707  -15.119            ROOT NO. 5   -1.707   15.119
  ROOT NO. 4   -10.307   -1.336            ROOT NO. 3   -0.090   -0.000
  ROOT NO. 2   -10.307    1.336            ROOT NO. 1   -1.223   -0.000

K=      5.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  1.733E 06  1.004E 07  1.143E 07
        9.148E 05
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6    -1.007  -15.788            ROOT NO. 5  -13.618   -0.000
  ROOT NO. 4    -0.087    0.000            ROOT NO. 3   -1.007   15.788
  ROOT NO. 2    -8.258   -0.000            ROOT NO. 1   -1.365    0.000

K=      6.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  1.902E 06  1.132E 07  1.367E 07
        1.074E 06
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6    -0.412  -16.399            ROOT NO. 5  -15.408    0.000
  ROOT NO. 4    -0.084   -0.000            ROOT NO. 3   -0.412   16.399
  ROOT NO. 2    -7.546    0.000            ROOT NO. 1   -1.478   -0.000

K=      7.000
     D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  6.976E 03  1.216E 05  2.070E 06  1.261E 07  1.591E 07
        1.234E 06
                      Real    Imaginary                            Real    Imaginary
  ROOT NO. 6     0.107  -16.962            ROOT NO. 5  -16.765   -0.000
  ROOT NO. 4    -0.083   -0.000            ROOT NO. 3    0.107   16.962
  ROOT NO. 2    -7.136    0.000            ROOT NO. 1   -1.570   -0.000
```

```
K=      8.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      2.753E 02  6.976E 03  1.216E 05  2.239E 06  1.390E 07  1.816E 07
      1.394E 06
                 Real    Imaginary                        Real    Imaginary
  ROOT NO. 6    0.570  -17.487           ROOT NO. 5  -17.894    0.000
  ROOT NO. 4   -0.082   -0.000           ROOT NO. 3    0.570   17.487
  ROOT NO. 2   -6.857    0.000           ROOT NO. 1   -1.647    0.000

K=      9.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      2.753E 02  6.976E 03  1.216E 05  2.408E 06  1.518E 07  2.040E 07
      1.553E 06
                 Real    Imaginary                        Real    Imaginary
  ROOT NO. 6    0.989  -17.977           ROOT NO. 5  -18.875    0.000
  ROOT NO. 4   -0.081   -0.000           ROOT NO. 3    0.989   17.977
  ROOT NO. 2   -6.651    0.000           ROOT NO. 1   -1.712   -0.000

K=     10.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      2.753E 02  6.976E 03  1.216E 05  2.576E 06  1.647E 07  2.264E 07
      1.713E 06
                 Real    Imaginary                        Real    Imaginary
  ROOT NO. 6    1.373  -18.439           ROOT NO. 5  -19.749    0.000
  ROOT NO. 4   -0.080    0.000           ROOT NO. 3    1.373   18.439
  ROOT NO. 2   -6.490   -0.000           ROOT NO. 1   -1.768    0.000
```

### D.2.2 WITHOUT PRESSURE SENSOR (POSITION COMMAND)

```
        ****************************************************
                                   DELTA P FREQUENCY ANALYSIS
        ****************************************************


       NO(S) COEFFICIENTS
         1.000E 01
       DO(S) COEFFICIENTS
         1.000E 00  1.000E 01
       N1(S) COEFFICIENTS
         1.687E 04  4.419E 04  3.193E 03
       D1(S) COEFFICIENTS
         2.753E 02  2.847E 03  1.568E 04  9.378E 02  5.077E 02
       N2(S) COEFFICIENTS
         1.000E 00
       D2(S) COEFFICIENTS
         1.000E 00



       N[0]N[1]D[2]=

         1.687E 05  4.419E 05  3.193E 04
       N[0]N[1]N[2]=

         1.687E 05  4.419E 05  3.193E 04
                      Real    Imaginary                           Real     Imaginary
    ROOT NO. 2    -0.074      0.000           ROOT NO. 1    -2.546      0.000

  K=      0.000
      D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  5.600E 03  4.415E 04  1.577E 05  9.886E 03  5.077E 03
                      Real    Imaginary                           Real     Imaginary
    ROOT NO. 5    -5.143    -5.468            ROOT NO. 4   -10.000      0.000
    ROOT NO. 3    -5.143     5.468            ROOT NO. 2    -0.027     -0.179
    ROOT NO. 1    -0.027     0.179


  K=      0.200
      D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  5.600E 03  4.415E 04  1.915E 05  9.827E 04  1.146E 04
                      Real    Imaginary                           Real     Imaginary
    ROOT NO. 5    -4.196    -5.994            ROOT NO. 4   -11.380      0.000
    ROOT NO. 3    -0.172     0.000            ROOT NO. 2    -4.196      5.994
    ROOT NO. 1    -0.397     0.000

  K=      0.500
      D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  5.600E 03  4.415E 04  2.421E 05  2.309E 05  2.104E 04
                      Real    Imaginary                           Real     Imaginary
    ROOT NO. 5    -3.209    -6.779            ROOT NO. 4   -12.777     -0.000
    ROOT NO. 3    -0.102    -0.000            ROOT NO. 2    -3.209      6.779
    ROOT NO. 1    -1.044     0.000

  K=      0.800
      D[0]D[1]D[2]+KN[0]N[1]N[2]=

        2.753E 02  5.600E 03  4.415E 04  2.927E 05  3.634E 05  3.062E 04
                      Real    Imaginary                           Real     Imaginary
    ROOT NO. 5    -2.512    -7.489            ROOT NO. 4   -13.804     -0.000
    ROOT NO. 3    -0.091    -0.000            ROOT NO. 2    -2.512      7.489
    ROOT NO. 1    -1.422    -0.000
```

```
K=     1.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  3.264E 05  4.518E 05  3.701E 04
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5   -2.144    -7.915          ROOT NO. 4  -14.374    0.000
  ROOT NO. 3   -0.087     0.000          ROOT NO. 2   -2.144    7.915
  ROOT NO. 1   -1.592     0.000

K=     2.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  4.951E 05  8.937E 05  6.894E 04
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5   -0.869    -9.619          ROOT NO. 4  -16.508    0.000
  POOT NO. 3   -0.869     9.619          ROOT NO. 2   -0.081    0.000
  ROOT NO. 1   -2.015     0.000



K=     3.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  6.638E 05  1.336E 06  1.009E 05
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5   -0.022   -10.888          ROOT NO. 4  -18.038   -0.000
  ROOT NO. 3   -0.079     0.000          ROOT NO. 2   -0.022   10.888
  ROOT NO. 1   -2.181     0.000

K=     4.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  8.324E 05  1.778E 06  1.328E 05
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5    0.635   -11.917          ROOT NO. 4  -19.265   -0.000
  ROOT NO. 3   -0.078     0.000          ROOT NO. 2    0.635   11.917
  ROOT NO. 1   -2.268     0.000

K=     5.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  1.001E 06  2.220E 06  1.647E 05
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5    1.181   -12.795          ROOT NO. 4  -20.304   -0.000
  ROOT NO. 3   -0.077     0.000          ROOT NO. 2    1.181   12.795
  ROOT NO. 1   -2.322     0.000

K=     6.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  1.170E 06  2.661E 06  1.967E 05
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5    1.654   -13.566          ROOT NO. 4  -21.214   -0.000
  ROOT NO. 3   -0.076     0.000          ROOT NO. 2    1.654   13.566
  ROOT NO. 1   -2.358     0.000

K=     7.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  1.338E 06  3.103E 06  2.286E 05
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5    2.074   -14.257          ROOT NO. 4  -22.029   -0.000
  ROOT NO. 3   -0.076     0.000          ROOT NO. 2    2.074   14.257
  ROOT NO. 1   -2.384     0.000

K=     8.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=

     2.753E 02  5.600E 03  4.415E 04  1.507E 06  3.545E 06  2.605E 05
                  Real     Imaginary                  Real     Imaginary
  ROOT NO. 5    2.455   -14.888          ROOT NO. 4  -23.770    0.000
  ROOT NO. 3   -0.076     0.000          ROOT NO. 2    2.455   14.888
  ROOT NO. 1   -2.404     0.000
```

```
K=      9.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      2.753E 02  5.600E 03  4.415E 04  1.676E 06  3.997E 06  2.925E 05
                    Real    Imaginary                    Real    Imaginary
  ROOT NO. 5     2.803  -15.468          ROOT NO. 4  -23.452   -0.000
  ROOT NO. 3    -0.076    0.000          ROOT NO. 2    2.803   15.468
  ROOT NO. 1    -2.420    0.000

K=     10.000
    D[0]D[1]D[2]+KN[0]N[1]N[2]=

      2.753E 02  5.600E 03  4.415E 04  1.844E 06  4.429E 06  3.244E 05
                    Real    Imaginary                    Real    Imaginary
  ROOT NO. 5     3.126  -16.008          FOOT NO. 4  -24.085   -0.000
  FOOT NO. 3    -0.076    0.000          FOOT NO. 2    3.126   16.008
  FOOT NO. 1    -2.432    0.000
```