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OFF-DESIGN LOSS MEASUREMENTS IN A COMPRESSOR CASCADE

by

Michael A. Classick

September 1989

Thesis Advisor:

Raymond P. Shreeve

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OFF-DESIGN LOSS MEASUREMENTS
IN A COMPRESSOR CASCADE

by

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Submitted in partial fulfillment
of the requirements for the degree of
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ABSTRACT

Data acquisition software was written to recover the ability to make loss measurements using a five-hole pneumatic probe in a wind tunnel facility currently containing a modeled subsonic cascade of controlled diffusion (CD) stator blades. Acquisition, reduction and ancillary programs were written for a Hewlett Packard 9000 Series 300 computer/HP 3052 Data Acquisition System in HP BASIC 5.0. The new software was demonstrated and validated by conducting a set of surveys at the (near to stall) air inlet flow angle of 48 degrees. The survey results showed a diminishing core of two-dimensional flow through the blading due to side wall boundary layer effects, and integration of upstream and downstream measurements gave an axial velocity-density ratio of 1.108 and a NASA loss coefficient of 0.097. Prior to the surveys, the probe was calibrated in a free jet facility, thus also revalidating the calibration software. It was concluded that the facility instrumentation and procedures were now in place for making accurate off-design loss measurements on a routine basis.

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The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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LIST OF SYMBOLS

English Letter Symbols

AVDR	Axial Velocity Density Ratio
C_p	Pressure coefficient
$\overline{C_p}$	Mass averaged coefficient of pressure from instrumented blade
C_{p2}	Static pressure rise coefficient
c	Chord
c_p	Specific heat at a constant pressure
h	Span-wise depth of control volume
M	Mach number
n	Number of scans
P	Pressure
Q	Dynamic pressure ($1/2 \rho V^2$)
s	Blade spacing
T	Temperature
V	Velocity
X	Nondimensional velocity
x	Position of probe in blade-to-blade direction

Greek Letter Symbols

β	Flow angle
γ	Ratio of specific heats
ω	Loss coefficient
ρ	Density

Subscripts

1	Upstream survey station
2	Downstream survey station
a	Atmospheric
l	Local
p	Measured in the plenum
ref	Reference value derived from plenum stagnation pressure
s	Static
t	Stagnation or total

Superscripts

^	Ensemble average of values during a survey
---	--

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I. INTRODUCTION

Off-design compressor performance is becoming more important as future engine design goals involve higher thrust-to-weight ratios, lower specific fuel consumption, and smaller size. Currently, great demands on the engine are made during high angle-of-attack flight by fighter aircraft and by VSTOL and rotorcraft operating in flight conditions that greatly distort the flow to the compressor. Design goals and extreme operating conditions push the compressor operating point towards the stall boundary. Thus, it is vitally important to have methods for predicting stall margin in the process of design.

The modeling of compressor flows using computational fluid dynamic (CFD) codes is the key to such a development, and cascade data on flow structure and blade element behavior are required to validate the codes. While flow structure of the velocity field can be mapped using a laser doppler velocimeter (LDV) system, it is the loss coefficient (introduced in Chapter VI of Ref. 1) which is the essential integral measure of the blade element performance. The focus of the present work was to recover the ability to make loss measurements using a pressure probe in the Naval Postgraduate School's (NPS) cascade facility.

In the present study, the cascade was configured with the mid section of a controlled diffusion (CD) stator blade designed by Sanger [Ref. 2] at NASA Lewis Research Center.

Previous studies using CD blading in this facility include the work of Koyuncu [Ref. 3], who conducted fourteen tests at air inlet angles from 24.3 degrees to 47.2 degrees to measure blade performance using pressure probes. Dreon [Ref. 4] followed with probe studies at air inlet angles of 40.3 degrees and 43.4 degrees, concentrating on verifying the accuracy of the loss measurements. Dreon's work is cited frequently throughout the present report since much of what he did, in principle, was used to guide the present work. Elazar [Ref. 5] performed detailed measurements of inviscid flow in the passage between two adjacent blades, the boundary layer development on the blade surfaces and the early wake development using a two-component LDV system. Baydar [Ref. 6] made wake measurements using hot wires to verify the LDV wake measurements made by Elazar. In these earlier studies, the cascade flow was found to be acceptably uniform and periodic (each blade passage the same), and showed good span-wise independence. Cascade flow quality was initially analyzed by NACA [Ref. 7] and first addressed at NPS by Duval [Ref. 8].

The necessity for the present work arose when an obsolete and unsupported computer was replaced by a Hewlett Packard 300 PC in an upgrade of the facility's data acquisition system. Entirely new software was required to be written (using HP BASIC 5.0) to replace the many previous programs. A simple translation of the previous software was not attempted in view of the undocumented

modifications generated by a series of previous investigators. The new software is described fully in Appendix B.

Overall, recovering the ability to make loss measurements involved first, the calibration of a five-hole conical pressure probe (Appendix A), second, developing the required acquisition and reduction software and third, obtaining a complete set of preliminary measurements at an air inlet angle of 48 degrees to demonstrate and validate all aspects of the procedure. The conclusion of the study was that the calibrated probe and data acquisition system are indeed operational, and ready to be used to make surveys and loss measurements in the cascade.

Section II of this report describes the experimental apparatus, namely the cascade facility, instrumentation and the data system. Section III addresses the test conditions, calibration, procedures, method of referencing, and outlines the measurements that were made. The results are presented and discussed in Section IV followed by conclusions and recommendations in Section V. Appendix A contains the details of the probe calibration. Appendix B contains a complete discription of the new software, with listings of all programs and samples of the printed output tables. Appendix B is intended to serve as a description and user guide to the software. Finally, Appendix C outlines procedures for referencing the probe yaw angle.

II. EXPERIMENTAL APPARATUS

A. CASCADE WIND TUNNEL

The NPGS cascade facility is shown in Fig. 1. Figure 2 shows the test section. A detailed description of the facility, test section and CD blading is contained in Ref. 9.

B. CONTROLLED DIFFUSION BLADING

Reference 2 describes the CD blading in detail. A profile of blade and pressure tap locations on instrumented blades are shown in Fig. 3.

C. INSTRUMENTATION

The five-hole conical probe used and described by Dreon [Ref. 4] was calibrated and used for the probe measurements. Appendix A contains the calibration details.

The iron-constantan thermocouple, plenum pressure probe and instrumented CD blade were used as described by Dreon. Wall static pressure was measured from a centrally located tap upstream of the blades. A Prandtl probe was installed approximately midway between the inlet guide vanes and the test blading. The probe was located at mid span between blades 15 and 16, well clear of the probe survey locations. The Prandtl probe measurements provided an additional measure of tunnel conditions. The cone probe, plenum, wall static and Prandtl probe pressures were connected to a 48-port Scanivalve. A second Scanivalve sampled pressures

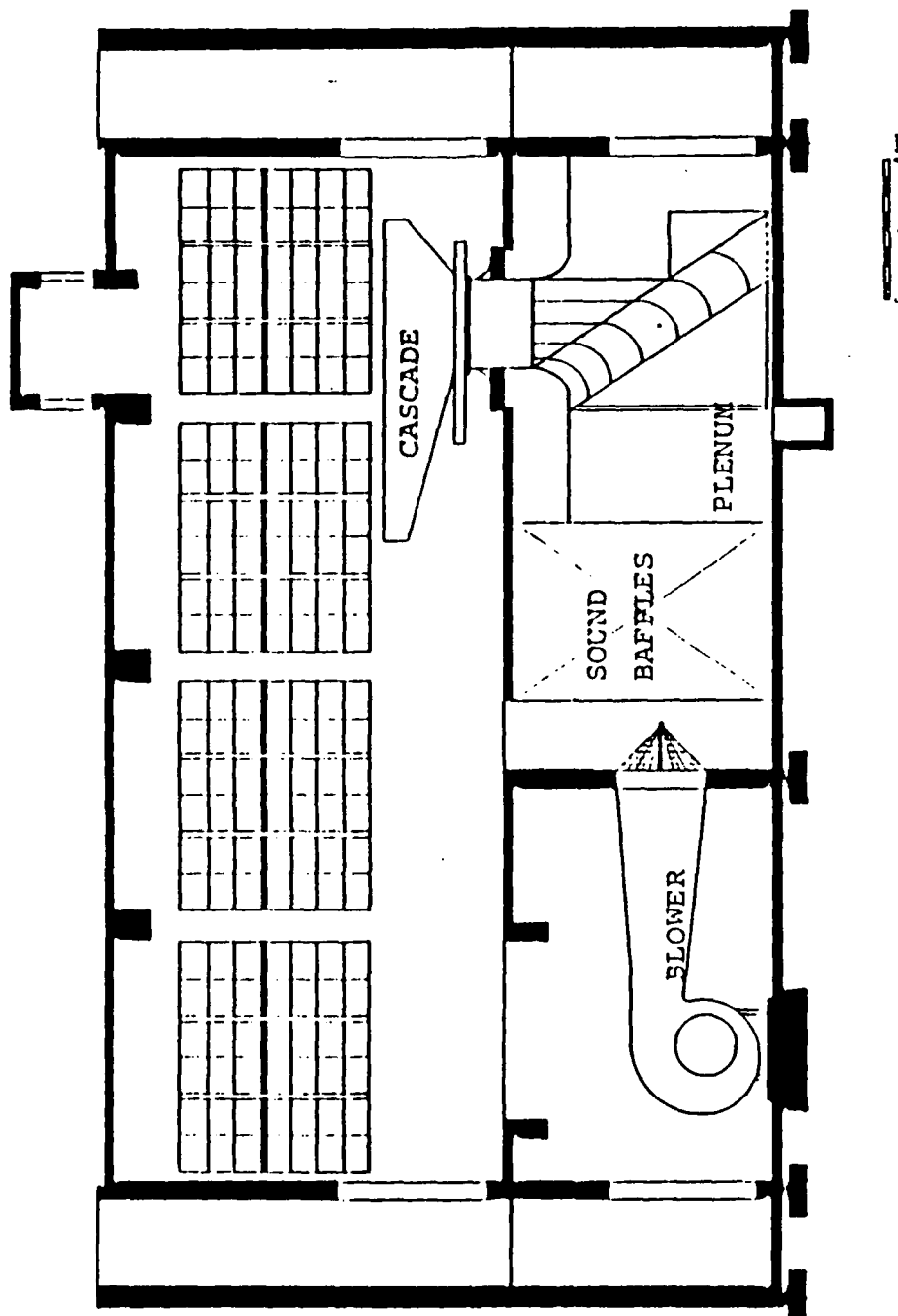


Figure 1. Cascade Wind Tunnel Test Facility

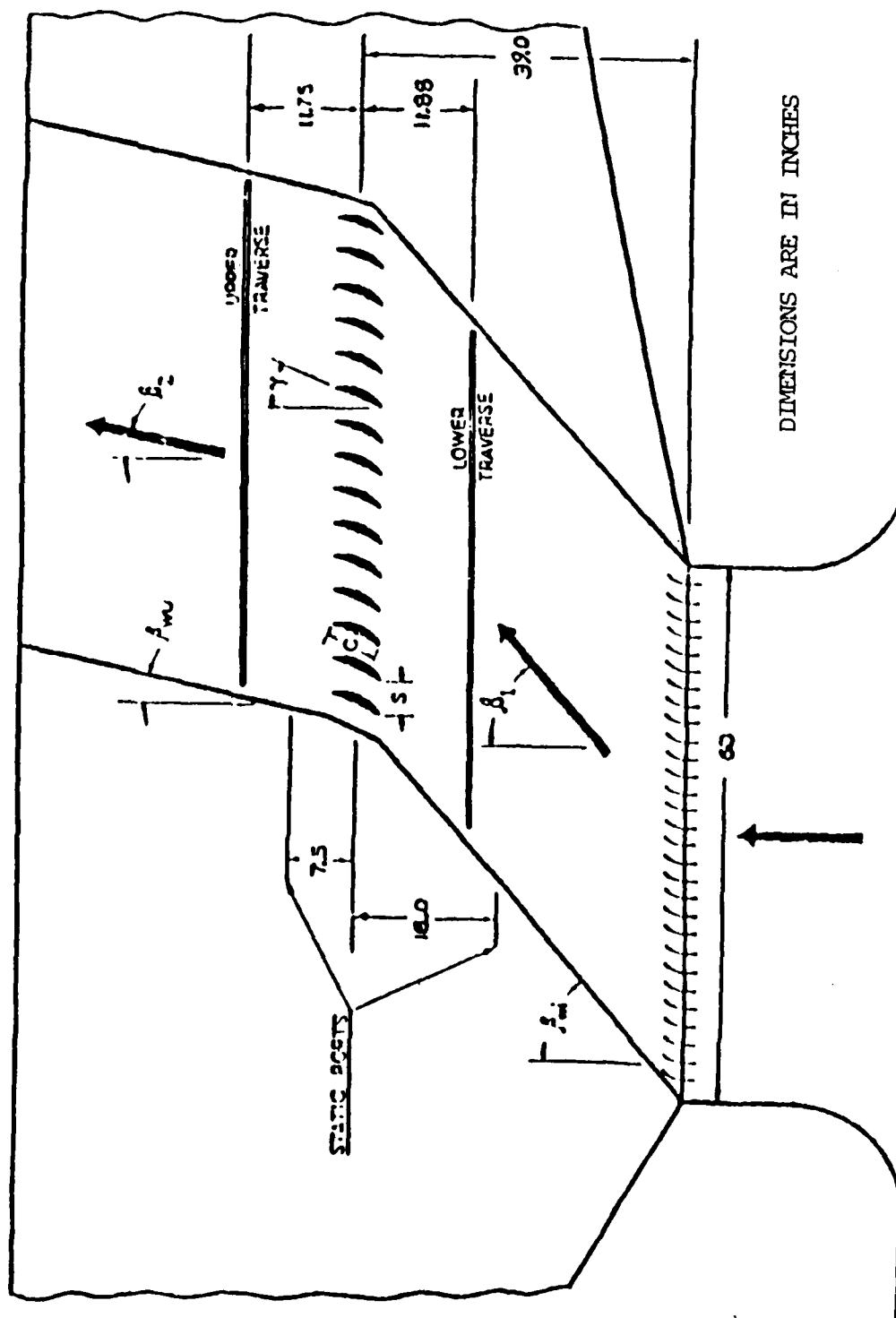


Figure 2. Cascade Test Section Schematic

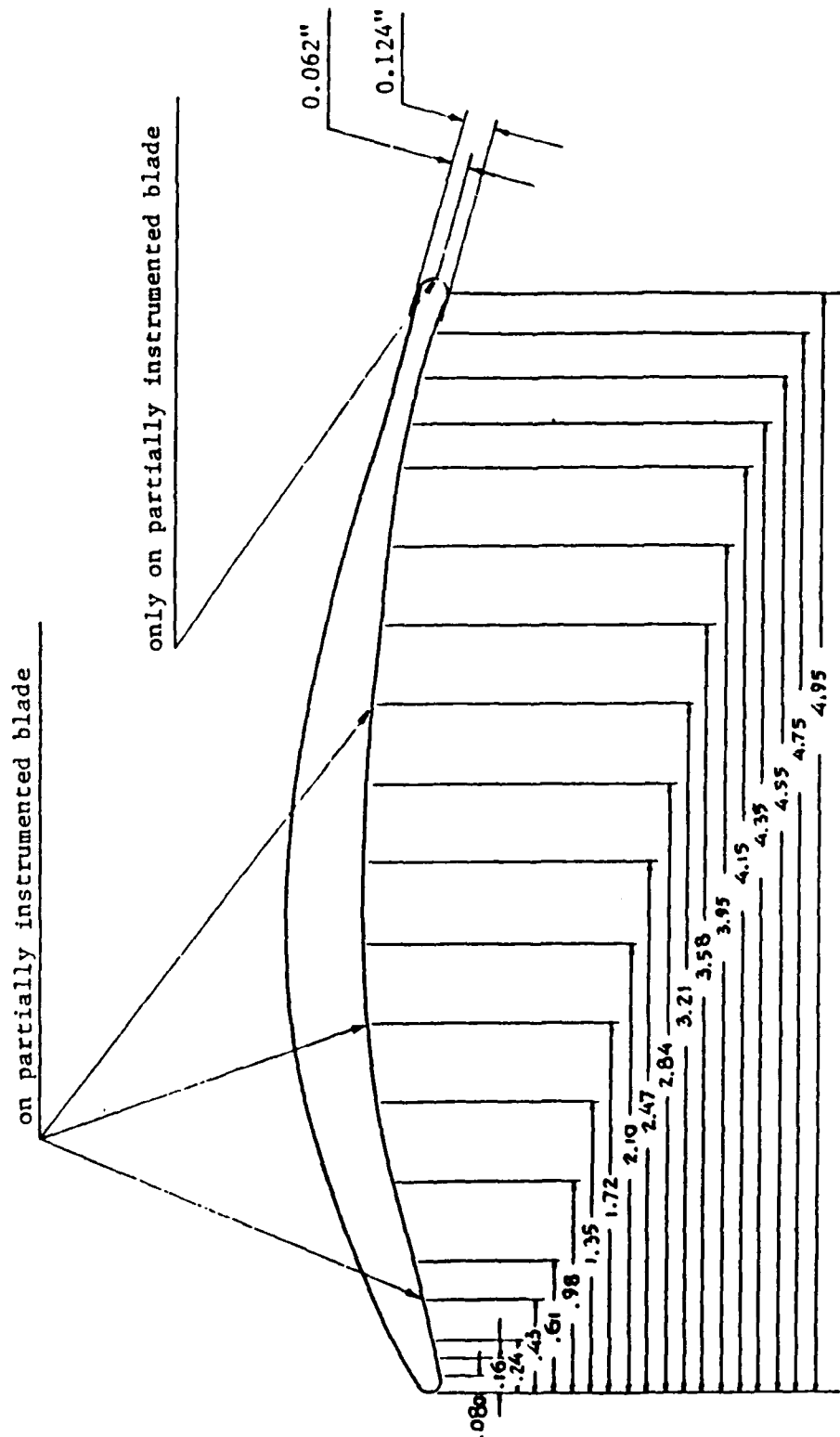


Figure 3. CD Blade Pressure Tap Locations

from the fully (blade 10) and one partially instrumented blade (blade 11), and from the plenum.

A yaw transducer on the conical probe, linear over the range used, provided the means to record inlet and outlet flow angles.

Probe displacement in the blade-to-blade direction was determined by a turn counter on the motor-driven traverse mechanism.

Span-wise displacement was recorded manually from a vernier scale attached to the probe.

D. DATA ACQUISITION SYSTEM

1. Hardware

A simplified schematic of the data acquisition system is shown in Fig. 4.

The data were collected using the Hewlett Packard Data Acquisition System (HP-3052) with instruments connected through an Interface Bus (HP-98034, HP-IB). The HG-78K Scanivalve controller, which controlled the selection and positioning of the Scanivalves is described by Geopfarth [Ref. 10]. A Hewlett Packard 900 series 300 computer controlled the system. The instrumentation channel assignments are given in Table B1.

2. Software

Three programs comprise the data acquisition software. Program "ACQUIRE" controls the acquisition and stores the collected data. Program "CALC" reduces the data to commonly used engineering quantities and "LOSS" computes

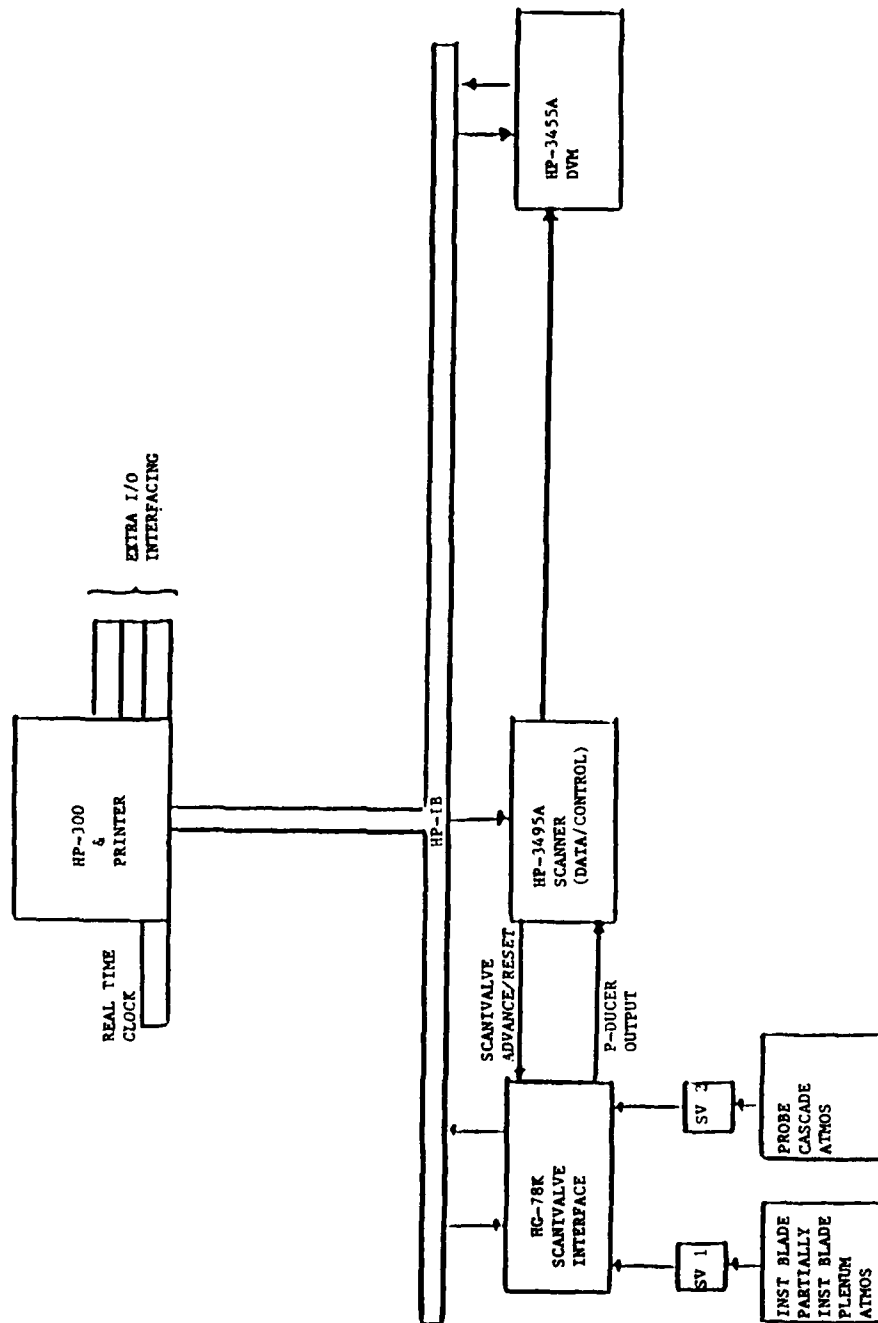


Figure 4. Data Acquisition System Block Diagram

the static pressure rise coefficient, axial velocity density ratio (AVDR) and loss coefficient. Software details are contained in Appendix B.

III. TEST PROCEDURES AND PROGRAM OF MEASUREMENTS

A. TEST PROCEDURES

1. Setting Test Conditions

Murray [Ref. 11], in a recently completed study, set the wall angle to 48 degrees for LDV measurements. A complete account of the angle setting procedure is given in Appendix A, Section VI of Ref. 11. All tests in the present study were conducted at a wall angle setting of 48 degrees and an inlet dynamic pressure (Q) of $17'' \text{ H}_2\text{O}$. Atmospheric pressure was taken to be constant over the survey period of approximately two hours.

2. Calibration

The Scanivalves were calibrated prior to each test using shop air and a water manometer. The probe yaw transducer was scaled at two limiting settings prior to each test, having been shown previously to be linear to within 0.2 degrees—the resolution of the yaw vernier scale on the probe.

3. Referencing

Pressure and velocity values obtained by reducing probe test data at each probe position were referenced to the tunnel conditions at the time of the recording. This eliminated the effects that small changes in the tunnel supply conditions might have had on the calculation of the loss coefficient.

4. Data Points

The probe surveys consisted of a series of individual measurements at intervals ranging from .05 - .5 inches. At each interval, the probe was balanced in yaw (Appendix A) and measurements taken—defining a data point. The data collected were reduced using the equations given in Table I.

B. PROGRAM OF MEASUREMENTS

A summary of the probe surveys conducted in the present study is contained in Table II. First, a set of probe surveys was conducted to establish the flow quality into the cascade test section. Second, an inlet survey in the blade-to-blade direction was conducted to examine inlet uniformity. Span-wise surveys upstream and downstream of the blades were then made to examine two-dimensionality. Finally, detailed blade-to-blade, mid-span surveys over one blade passage were made upstream and downstream in order to compute the loss coefficient.

Upstream and downstream surveys were made at the traverse locations indicated in Fig. 2. Intervals between data points were decreased when a change in flow conditions was evident. Downstream span-wise surveys were located ± 1.2 inches from a vertical extension of the trailing edge of blade 9. Surface tap pressures were recorded from the instrumented blade after the last probe data point was recorded for the upstream blade-to-blade survey. Additionally, pressures were recorded from the partially

TABLE I. DATA REDUCTION FORMULAE

PARAMETER	EXPRESSION	PROGRAMMED EXPRESSION
X	$\left[\frac{\frac{\gamma-1}{2} M^2}{1 + \frac{\gamma-1}{2} M^2} \right]^{\frac{1}{2}}$	same
P _s	$P_t (1-X^2)^{\frac{\gamma}{\gamma-1}}$	same
V	$X [2 c_p T_p]^{\frac{1}{2}}$	$X [2 c_p (778 \times 32.174) T_p]^{\frac{1}{2}}$
Q	$P_t \left(\frac{\gamma}{\gamma-1} \right) X^2 (1-X^2)^{\frac{1}{\gamma-1}}$	same
$\hat{P}_p$	$\frac{1}{n} \sum_{p=1}^n P_p$	same
$\hat{T}_p$	$\frac{1}{n} \sum_{p=1}^n T_p$	same
X _{ref}	$\left[1 - \left(\frac{P_s}{P_t} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{1}{2}}$	same
V _{ref}	$X_{ref} [2 c_p T_p]^{\frac{1}{2}}$	$X_{ref} [2 c_p (778 \times 32.174) T_p]^{\frac{1}{2}}$
Q _{ref}	$P_p \left(\frac{\gamma}{\gamma-1} \right) X_{ref}^2 (1-X_{ref}^2)^{\frac{1}{\gamma-1}}$	same
$\hat{X}_{ref}$	$\left[1 - \left(\frac{P_s}{P_t} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{1}{2}}$	same
$\hat{V}_{ref}$	$\hat{X}_{ref} [2 c_p \hat{T}_p]^{\frac{1}{2}}$	$\hat{X}_{ref} [2 c_p (778 \times 32.179) \hat{T}_p]^{\frac{1}{2}}$

TABLE I. DATA REDUCTION FORMULAE (CONT.)

PARAMETER	EXPRESSION	PROGRAMMED EXPRESSION
$\hat{Q}_{ref}$	$\hat{P}_p \left(\frac{\gamma}{\gamma-1} \right) \hat{X}_{ref}^2 (1 - \hat{X}_{ref}^2)^{\frac{1}{\gamma-1}}$	same
* K		$\frac{P_t}{P_p} \frac{X}{X_{ref}} \left[\frac{1-X^2}{1-X_{ref}^2} \right]^{\frac{1}{\gamma-1}} \cos \beta$
* AVDR	$\frac{h_1}{h_2}$	$\frac{\int_0^1 K_2 dx}{\int_0^1 K_1 dx}$
C_{Pt}	$\frac{P_t}{P_p}$	same
C_{Ps}	$\frac{P_s}{P_p}$	same
* $\bar{\omega}$	$\frac{(\bar{C}_{Pt1} - \bar{C}_{Pt2})}{(\bar{C}_{Pt1} - \bar{C}_{Ps1})}$	$\frac{\int_0^1 C_{Pt1} K_1 dx - \frac{1}{AVDR} \int_0^1 C_{Pt2} K_2 dx}{\int_0^1 C_{Pt1} K_1 dx - \int_0^1 C_{Ps1} K_1 dx}$
$\bar{C}_P$	$\left[\frac{P_1 \cdot P_2}{P_p \cdot P_s} \right] \left(\frac{P_p \cdot P_s}{Q} \right) + \left(\frac{P_s \cdot P_s}{Q} \right)$	$\left(\frac{P_1 \cdot P_2}{P_p \cdot P_s} \right) \frac{\int_0^1 \frac{P_p \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx} + \frac{\int_0^1 \frac{P_s \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx}$
C_{P2}	$\left(\frac{P_{s2} \cdot P_s}{Q} \right) + \left(\frac{P_s \cdot P_s}{Q} \right)$	$\frac{\int_0^1 \frac{P_{s2} \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx} + \frac{\int_0^1 \frac{P_s \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx}$

* Derivation given in Ref. 8

TABLE II - PROBE SURVEYS

<u>SURVEY #</u>	<u>LOCATION</u>	<u>DIRECTION</u> (Length)	<u>NOMINAL</u> <u>INTERVAL</u> (in.)
1	UPSTREAM	BLADE-TO-BLADE (20 Blade Spaces)	.5
2	UPSTREAM	SPAN-WISE	.05 - .1
3	DOWNSTREAM (Pressure Side, 1.2")	SPAN-WISE	.05 - .1
4	DOWNSTREAM (Suction Side, 1.2")	SPAN-WISE	.05 - .1
5	UPSTREAM	BLADE-TO-BLADE (1 Blade Space)	.1
6	DOWNSTREAM	BLADE-TO-BLADE (1 Blade Space)	.05 - .1

instrumented blade to aid in establishing periodicity. Three data points were collected from the suction side and two from the pressure side. Further, a trailing edge tap on this blade provided base pressure.

IV. RESULTS AND DISCUSSION

A. FLOW FIELD

The probe surveys were considered to be preliminary and were conducted primarily to demonstrate and validate the new data acquisition software. The results were interesting, however, since they were the first to be obtained at an inlet angle of 48 degrees with the CD blading. Survey results are presented in Figs. 5-22 and tabulations of the detailed blade-to-blade and instrumented blade data are given in Appendix B, Tables B2 - B7.

1. Inlet Flow Field

The inlet flow field was seen to be acceptably uniform. Deviations from a fully uniform velocity were due to inlet guide vane wakes and non-uniformity in vane geometry. A non-uniform migration of the guide vane wakes is thought to explain the irregular profile of the inlet flow angle across the span, seen in Fig. 10.

2. Two-Dimensionality and Periodicity

Downstream span-wise surveys, located one inch to both the pressure and suction sides of the blade, show a diminishing core of two-dimensional flow. This was the result of side-wall boundary layer build-up through the test section. Flow properties were independent of span only over a limited displacement to the pressure side of the blade. The significant difference between the pressure

and suction side span-wise profiles was due, in part, to the probe being in the blade wake on the suction side.

Periodicity cannot be shown with results obtained over only one blade passage. However, the first and last points in the downstream survey over one blade passage in Fig. 20 can be seen to be in good agreement, which is required if the flow is truly periodic over successive passages. The degree to which periodicity was manifested was also seen in Fig. 23. Three values of the coefficient of pressure for the partially instrumented blade are shown plotted with the distribution of values for the fully instrumented blade. Values for two other taps, towards the leading and trailing edge on the suction surface, were omitted due to partial blockage of the pneumatic lines leading from these taps to the Scanivalve; otherwise, good agreement was noted.

B. BLADE ELEMENT PERFORMANCE

In the distribution of pressure shown in Fig. 23, a strong adverse pressure gradient is clearly indicated over the first ten percent of the blade chord on the suction side. The profile was similar in shape to those recorded in Dreon's [Ref. 4] and Elazar's [Ref. 5] work at inlet angles of 43.7 degrees and 46 degrees respectively. It is noted that the trailing edge (base) pressure on the partially instrumented blade gave $C_p = 0.253$.

From an integration of the data obtained in surveys 5 and 6 (Table II) using program "LOSS" (Appendix B), the AVDR was calculated to be 1.108 and the loss coefficient

was 0.097. The loss coefficient value is shown plotted in Fig. 24 where it can be seen in relation to Dreon's and Koyuncu's [Ref. 3] losses.

C. MEASUREMENT UNCERTAINTIES

All measurement uncertainties listed in Table I of Ref. 4 were the same for the present study except those for the inlet and outlet flow angles. The absolute values of the flow angle for the present data were not known to better than an uncertainty ± 2 degrees. The means to establish a pneumatic axis referenced to a precisely measured horizontal or vertical axis on the cascade was not available at the time of the measurements. The probe yaw angle readout was set to zero when the probe tip was judged to be pointing vertically downward. The inlet angle was subsequently observed to indicate approximately 48 degrees at the inlet station, consistent with Murray's [Ref. 11] observations. The yaw angles recorded during the tests were uncertain on an absolute basis; however, the relative flow angles recorded from the yaw transducer during the surveys were accurate to within 0.2 degrees.

The proposed method for obtaining absolute accuracy in the yaw angle measurements, using the optical accuracy of the LDV system for referencing, is given in Appendix C.

D. TABULATED AND PLOTTED QUANTITIES

The data from surveys 5 and 6 (Table II) are shown in Tables B2 - B5. The tables include values of the

Scanivalve gauge pressures, yaw transducer reading, plenum temperature (total temperature) and atmospheric pressure. Pressures are given in inches of water. Table B1 will aid in interpreting the scaled probe data.

Appendix B defines and describes the quantities Beta, Gamma and Phi which are listed in Tables B3 and B5. The ensemble averages given at the end of Tables B3 and B5 represent the nominal (ensemble averaged) test conditions for the survey. All other quantities can be interpreted using the List of Symbols and Table I.

$V1/V_{ref}$ VS PROBE DISPLACEMENT

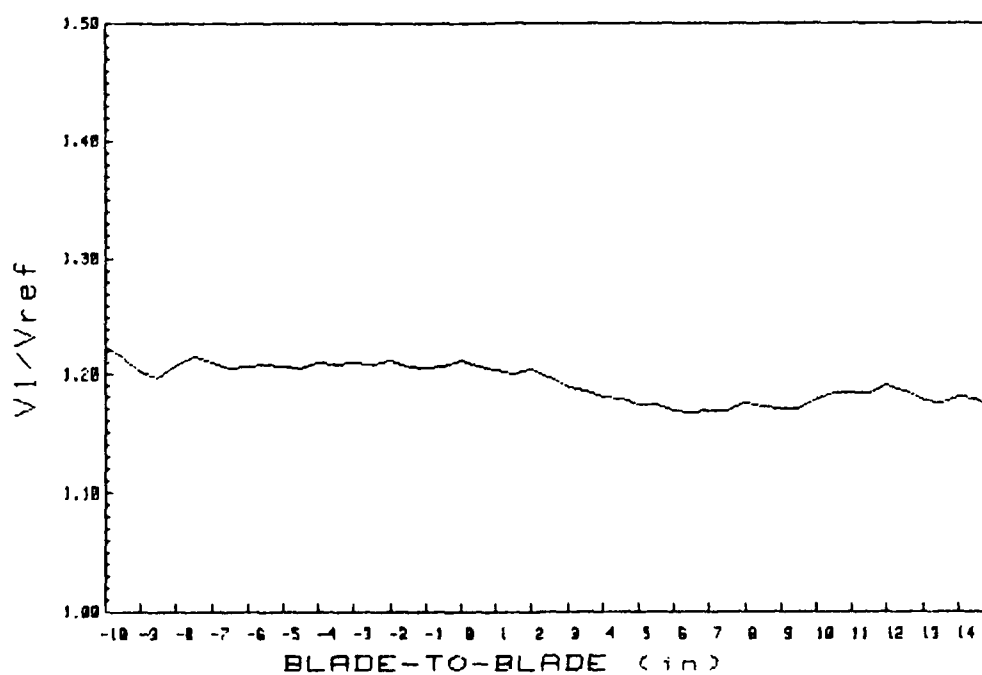


Figure 5. Inlet Survey: $V1/V_{ref}$ vs. Probe Displacement, Blade-to-Blade

Pref-Pt1/Qref VS PROBE DISPLACEMENT

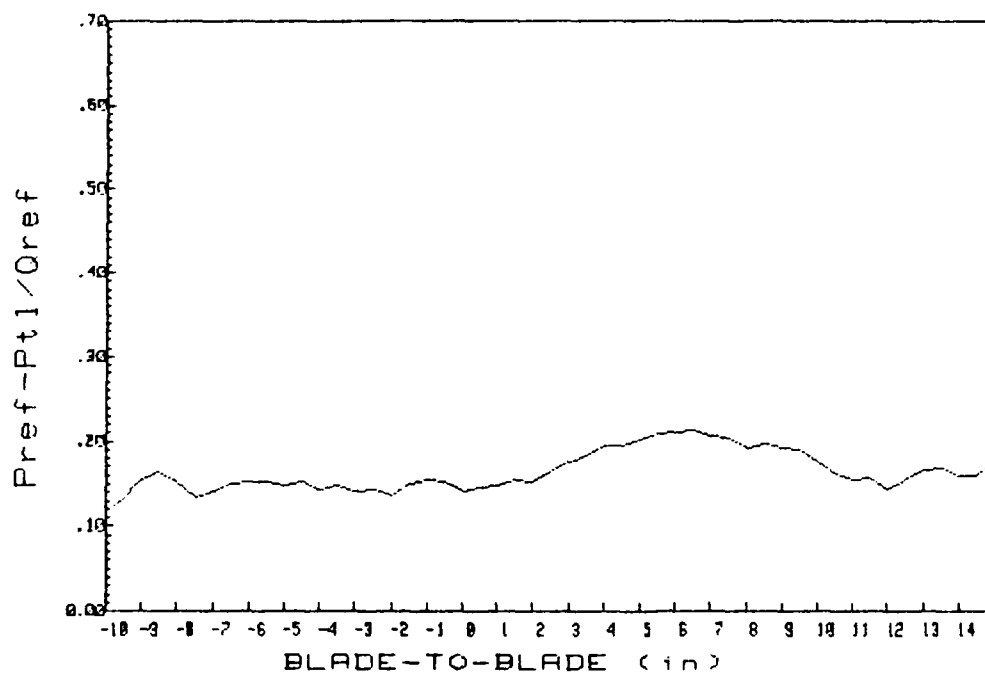


Figure 6. Inlet Survey: Pref-Pt1/Qref vs.
Probe Displacement, Blade-to-Blade

BETA1 VS PROBE DISPLACEMENT

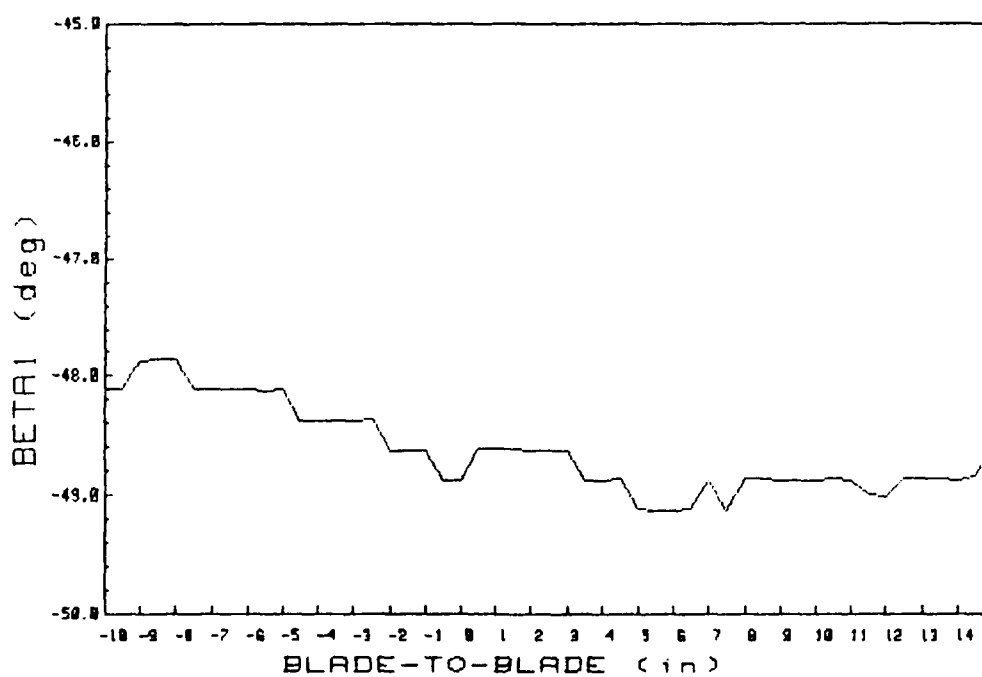


Figure 7. Inlet Survey: Beta1 vs. Probe Displacement, Blade-to-Blade

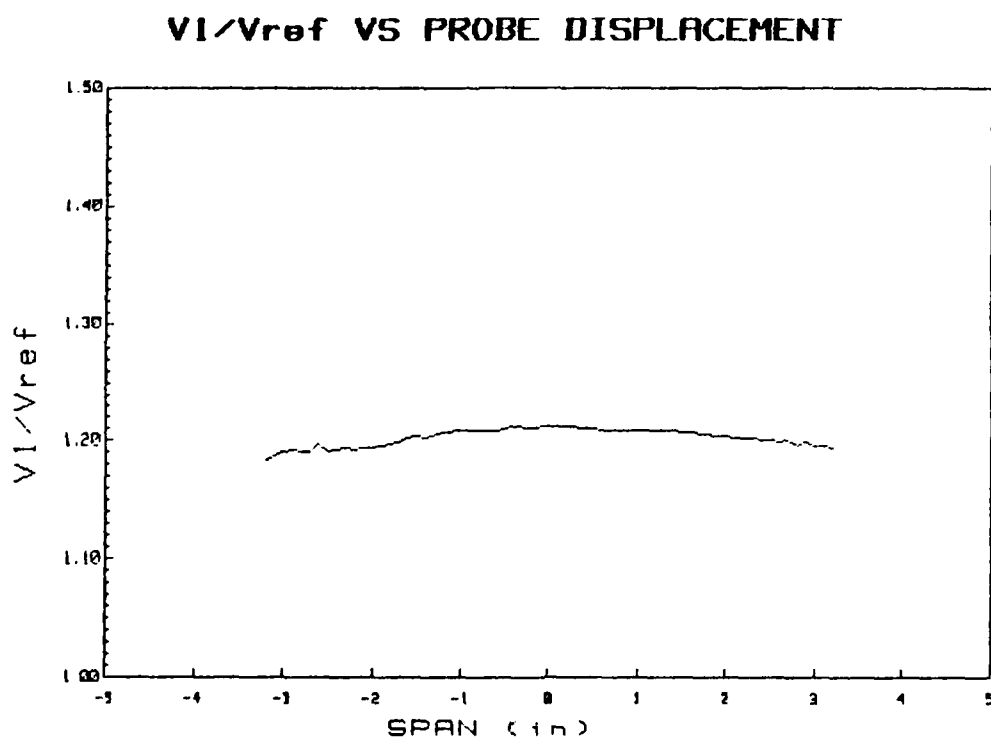


Figure 8. Inlet Survey: V_1/V_{ref} vs. Probe Displacement, Spanwise

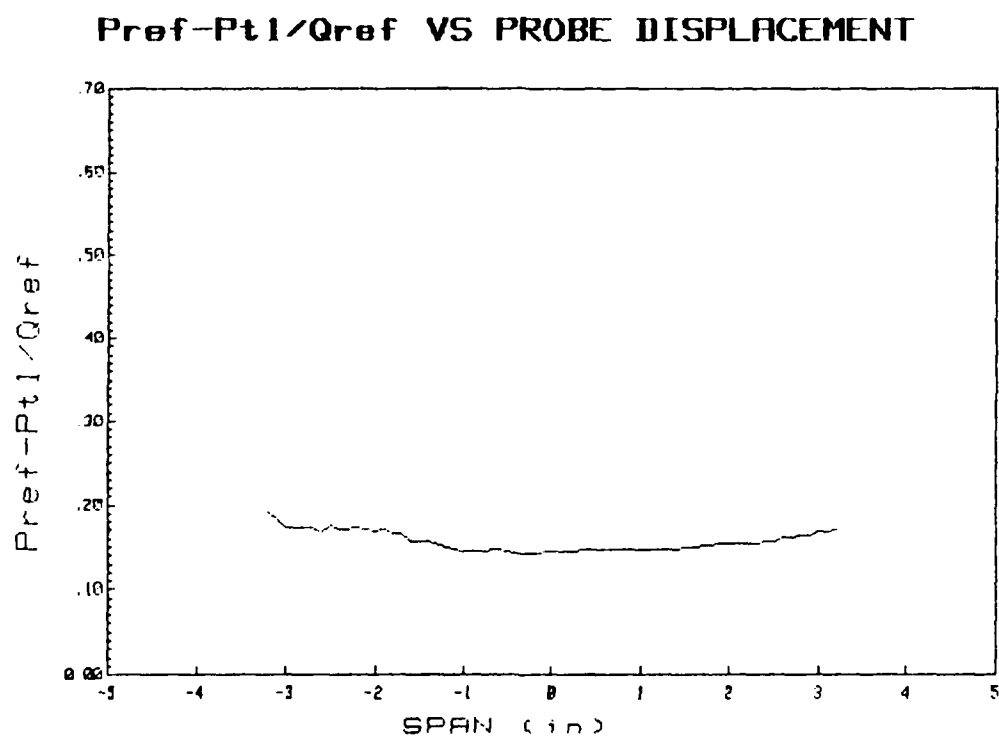


Figure 9. Inlet Survey: Pref-Pt1/Qref vs.
Probe Displacement, Spanwise

BETA1 VS PROBE DISPLACEMENT

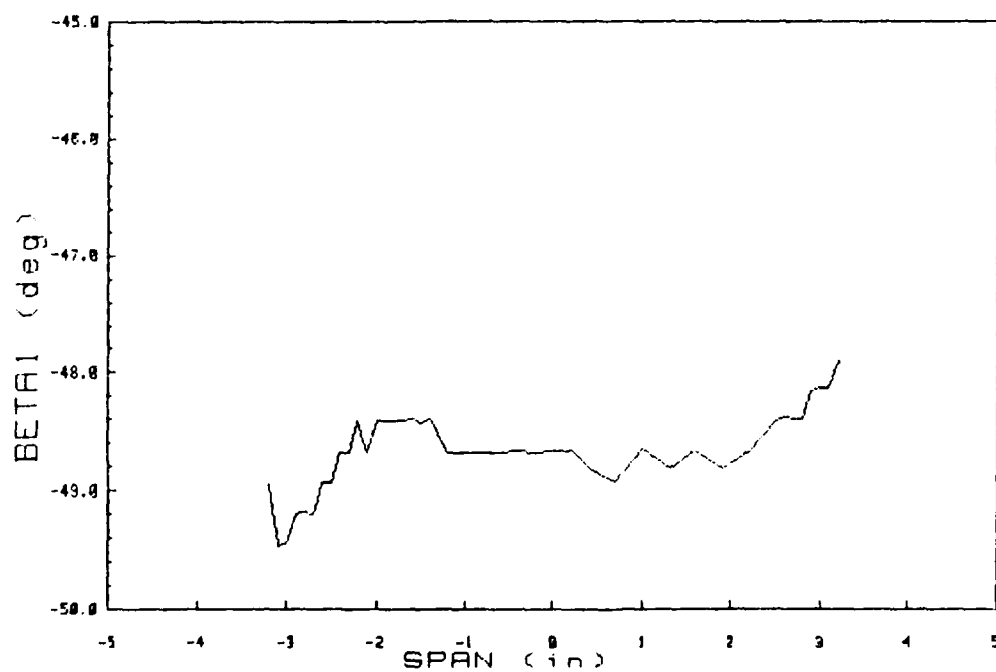


Figure 10. Inlet Survey: Beta1 vs. Probe Displacement, Spanwise

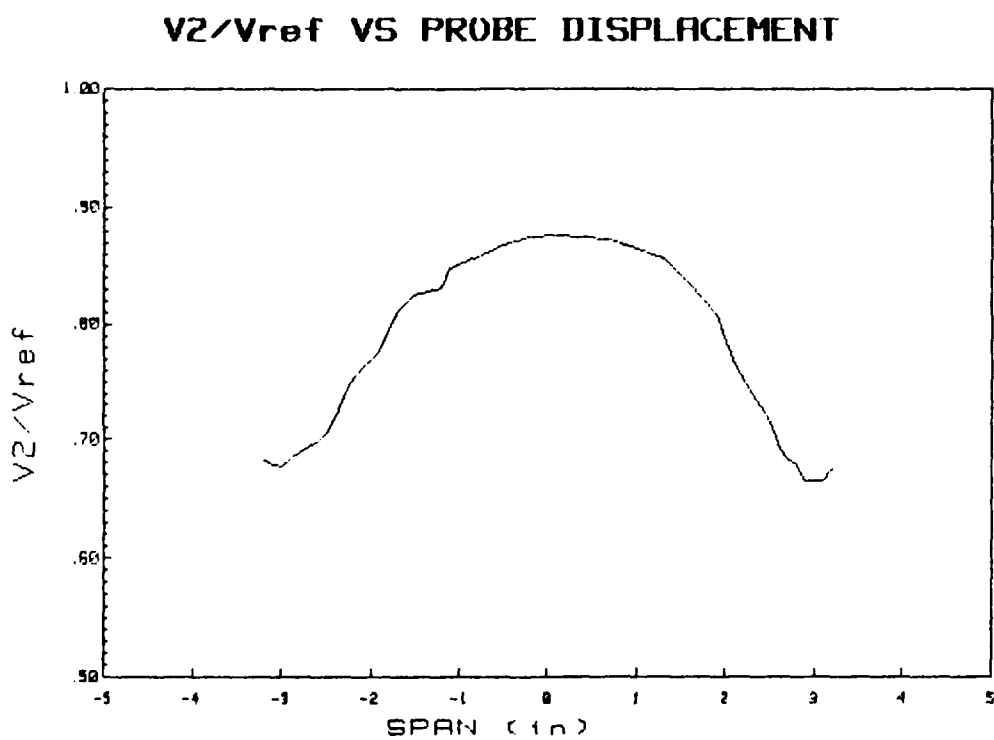


Figure 11. Outlet Survey: V2/Vref vs. Probe Displacement, Spanwise (Pressure Side)

Pref-Pt2/Qref VS PROBE DISPLACEMENT

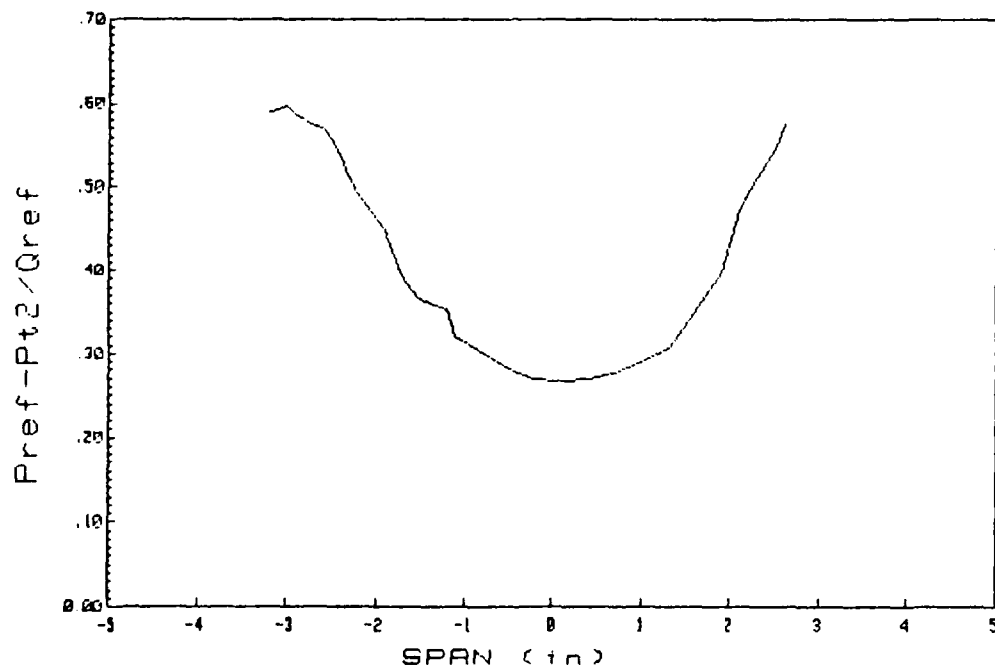


Figure 12. Outlet Survey: Pref-Pt2/Qref vs. Probe Displacement, Spanwise (Pressure Side)

BETA2 VS PROBE DISPLACEMENT

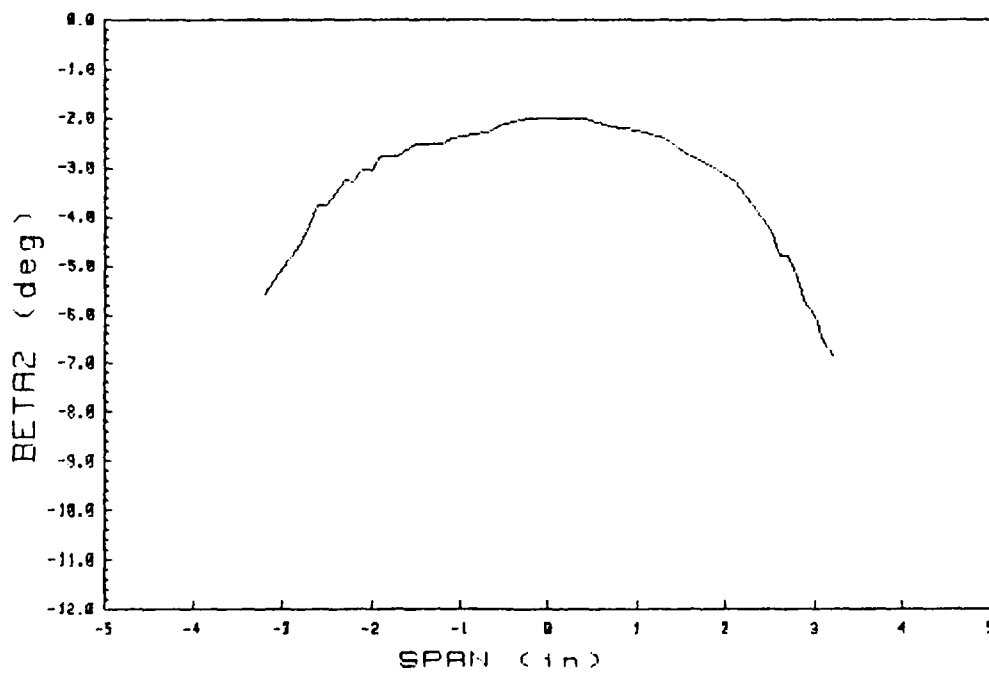


Figure 13. Outlet Survey: Beta2 vs. Probe Displacement, Spanwise (Pressure Side)

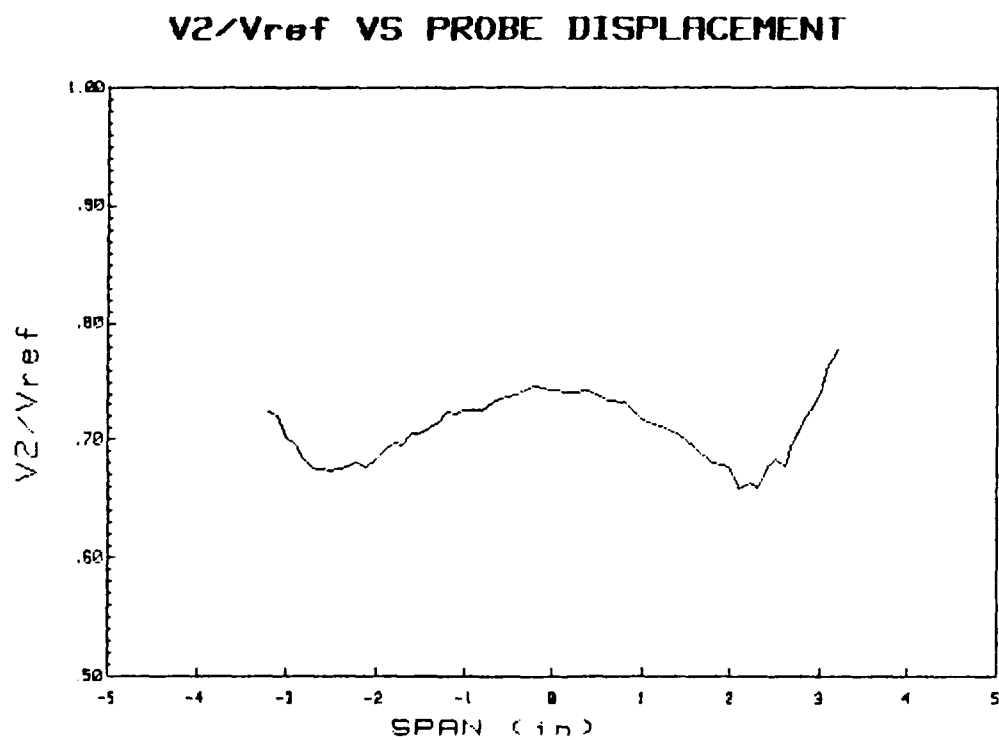


Figure 14. Outlet Survey: $V2/V_{ref}$ vs. Probe Displacement, Spanwise (Suction Side)

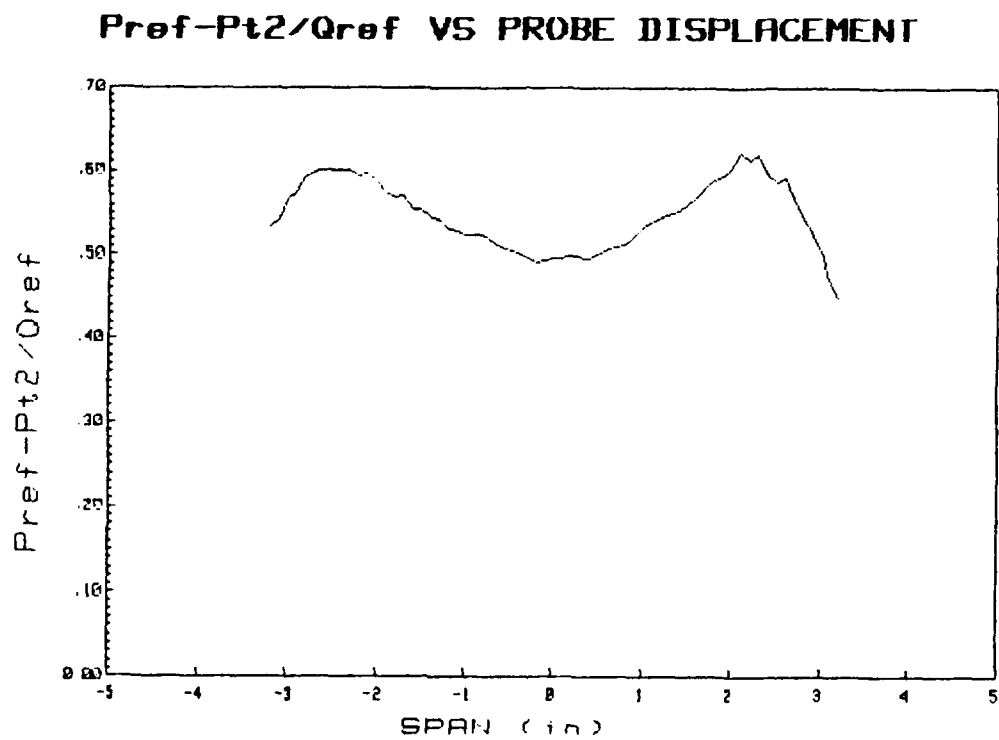


Figure 15. Outlet Survey: Pref-Pt2/Qref vs. Probe Displacement, Spanwise (Suction Side)

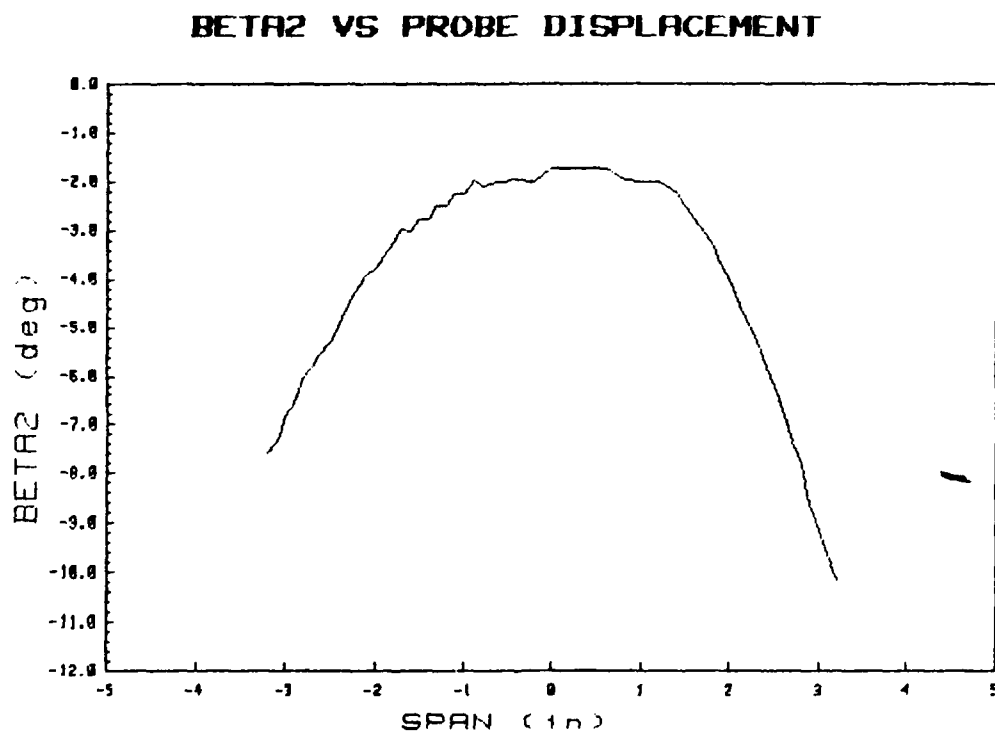


Figure 16. Outlet Survey: Beta2 vs. Probe Displacement Spanwise (Suction Side)

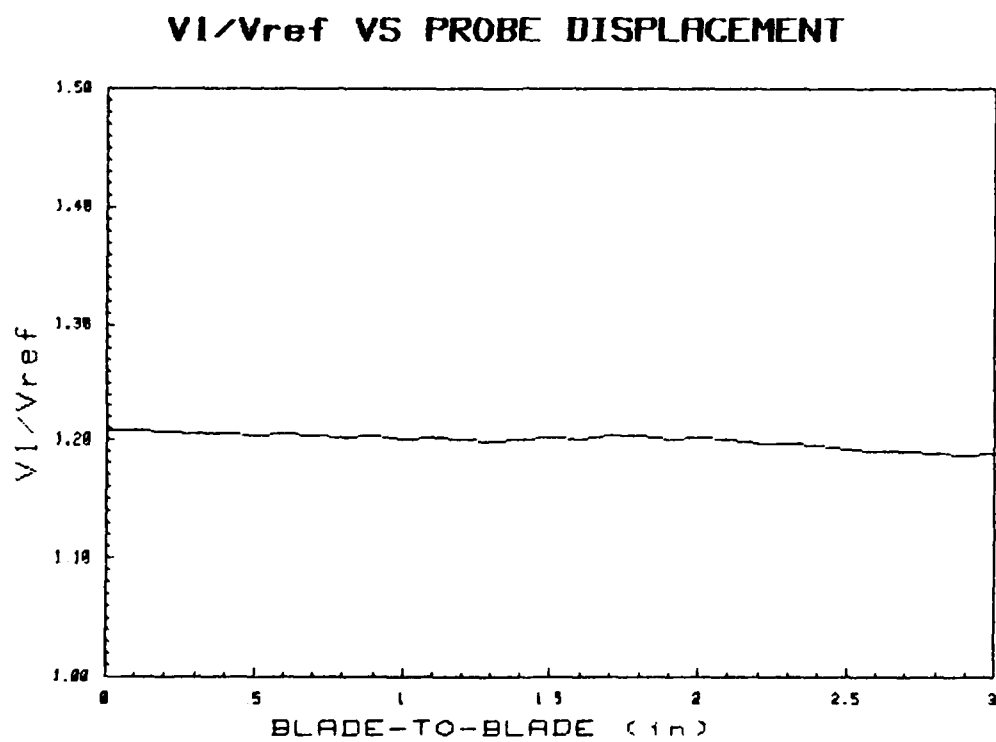


Figure 17. Loss Survey: V_1/V_{ref} vs. Probe Displacement, Blade-to-Blade

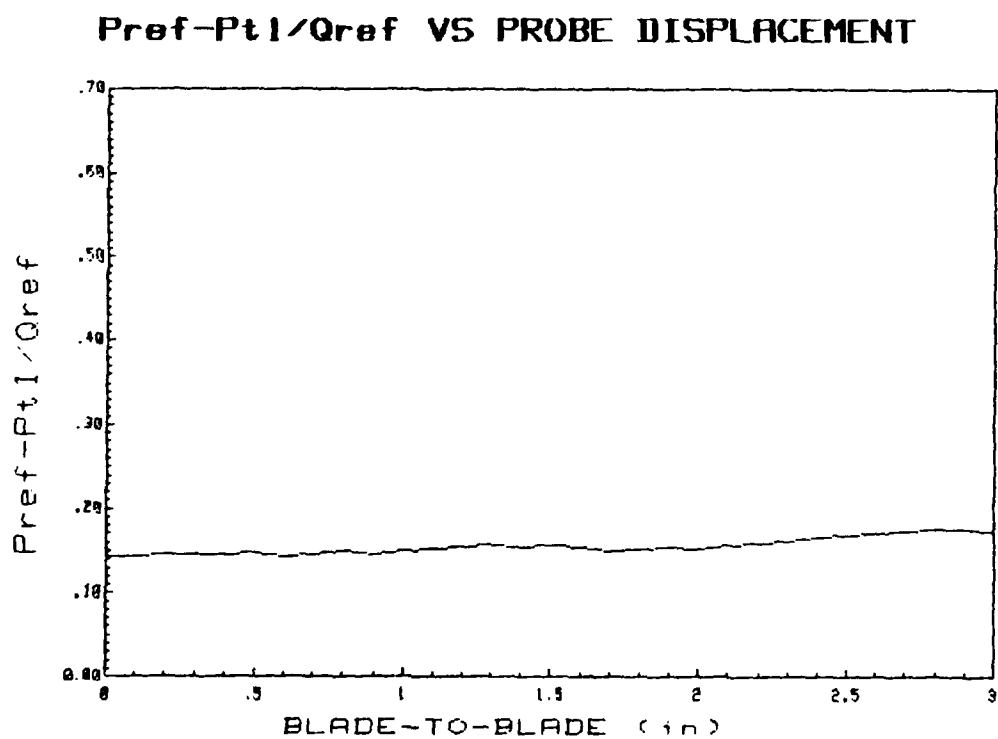


Figure 18. Loss Survey: Pref-Pt1/Qref vs. Probe Displacement, Blade-to-Blade

BETA1 VS PROBE DISPLACEMENT

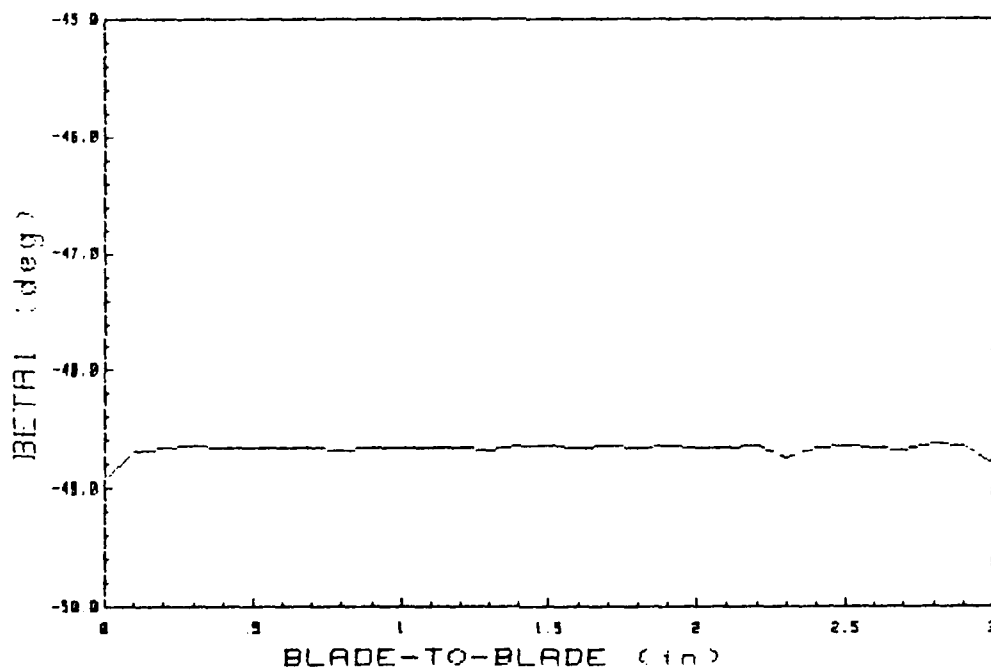


Figure 19. Loss Survey: Beta1 vs. Probe Displacement, Blade-to-Blade

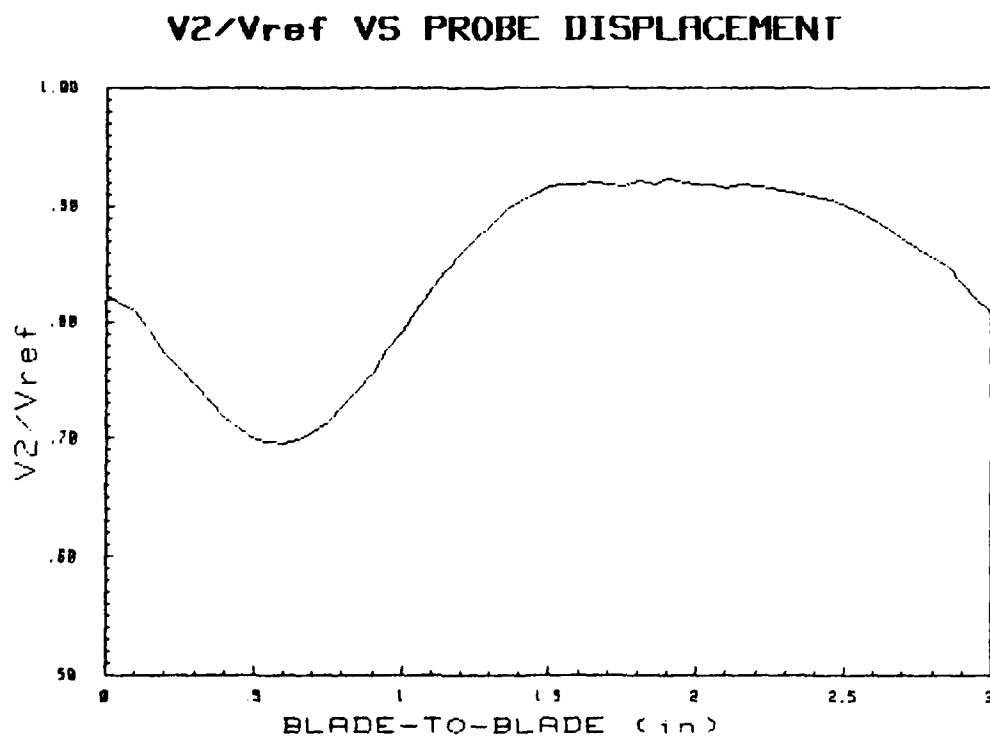


Figure 20. Loss Survey: $V2/V_{ref}$ vs. Probe Displacement, Blade-to-Blade

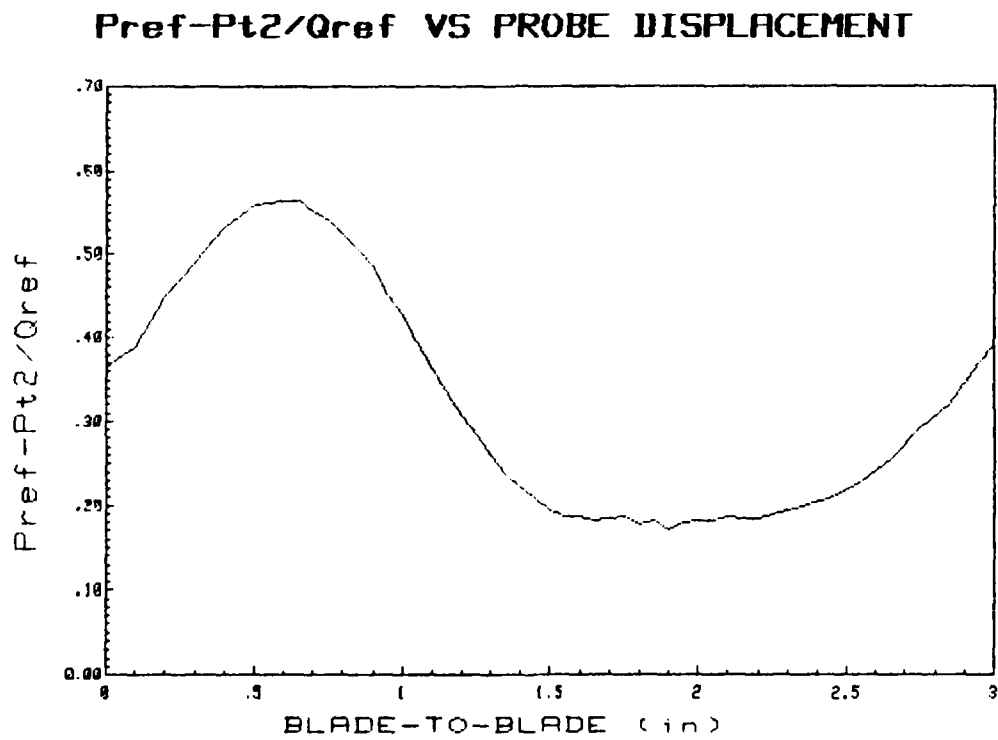


Figure 21. Loss Survey: Pref-Pt2/Qref vs. Probe Displacement, Blade-to-Blade

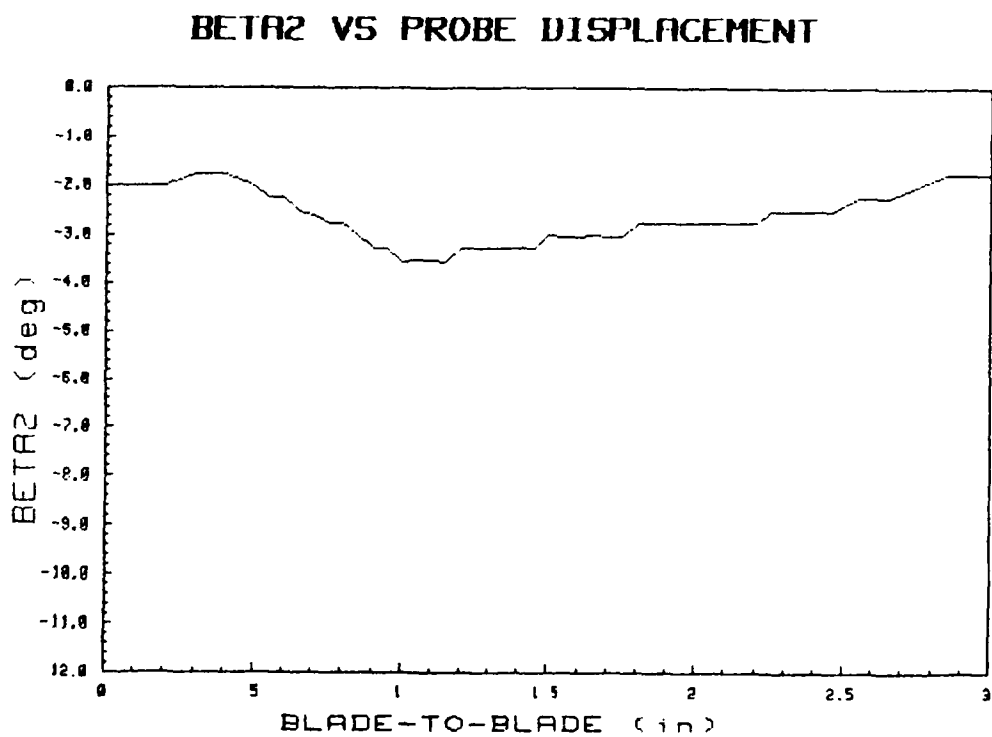


Figure 22. Loss Survey: Beta2 vs. Probe
Displacement, Blade-to-Blade

C_p VS PERCENT CHORD

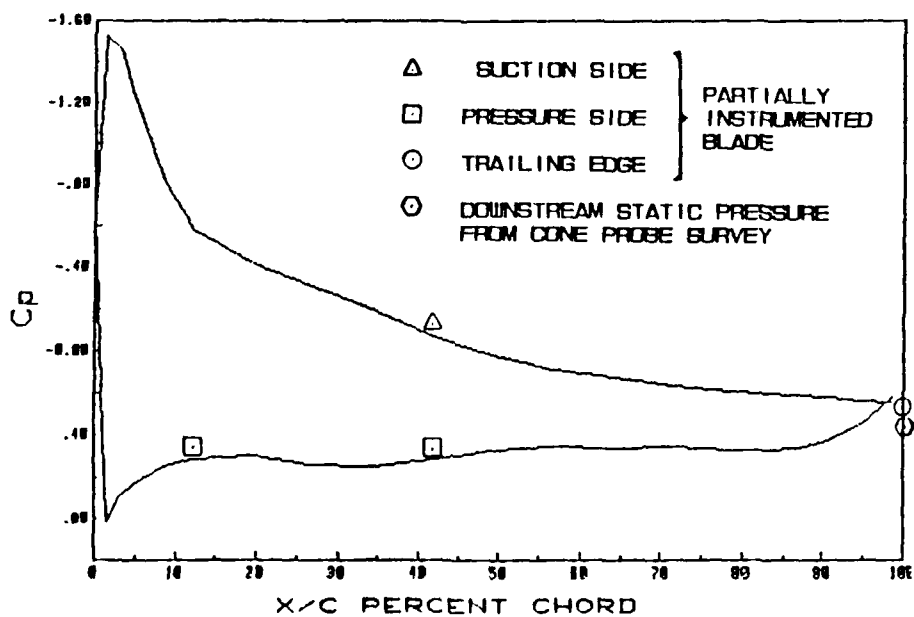


Figure 23. Surface Pressure Distribution:
 C_p vs. X/C

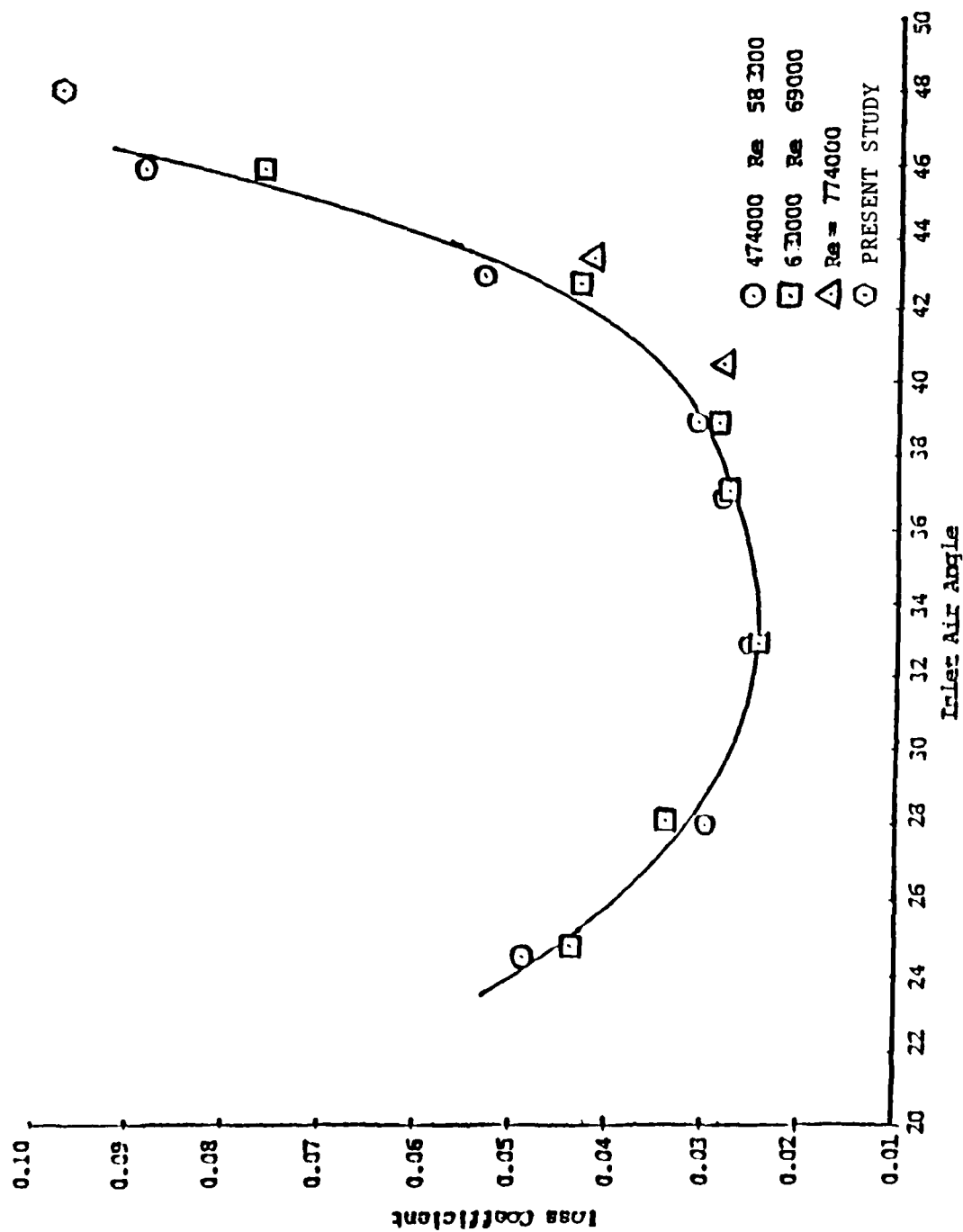


Figure 24. Loss Coefficient vs. Inlet Air Angle

V. CONCLUSIONS AND RECOMMENDATIONS

Preliminary probe surveys were conducted at an inlet flow angle of 48 degrees using data acquisition software specifically written for the Hewlett Packard 300 PC and associated acquisition hardware. From the study, the following conclusions were drawn:

1. At an inlet flow angle of 48 degrees, there was a vanishing core of two-dimensional flow at the downstream survey station.
2. The blade-element performance quantities derived from the measurements were consistent with previous results at lower angle settings.
3. Software for calibrating five-hole pneumatic probes was revalidated and made available for use.
4. New software, for acquiring and reducing probe survey data to obtain the AVDR and loss coefficient, was written and verified.
5. The facility, instrumentation and procedures are available for making accurate off-design loss measurements on a routine basis.

Recommendations focus on improving results which can be obtained using pressure probe surveys in this facility.

(Recommendations concerning the software are given separately in Appendix B.) The recommendations are:

1. Make probe surveys closer to the trailing edge of the blade to reduce the effects of side-wall boundary layer buildup on the two-dimensionality of the flow.
2. Redesign the front wall of the cascade tunnel to be made of lighter materials and of modular construction. The present facility requires a high capacity overhead hoist to remove the wall to modify the cascade geometry. The modular construction would provide the means to expand the coverage of pneumatic and hot-wire probe surveys without sacrificing the quality of the flow through the test section. A design with interchangeable window and survey panels would provide greater access for the LDV.
3. Dreon's [Ref. 4] recommendations concerning calibrating the probe in yaw and automating the probe traverses are reiterated.
4. Incorporate the use of highly accurate linear variable displacement transducers (LVDT) in implementing item 3.
5. Consideration should be given to using two probes simultaneously to conduct the survey (the software has this provision) to avoid the danger of damaging the

probe during transfer to and from the upper and lower traverse slots.

6. Use the LDV system to obtain an accurate probe angle reference as shown in Appendix C.

7. At the present and any higher inlet angle settings, fully map the downstream flow field to better establish flow quality and degree of two-dimensionality.

8. Extend the blade-to-blade surveys to conclusively establish periodicity.

9. Employ the cascade's boundary layer suction provision to extend the range of two-dimensional flow at high inlet flow angles.

APPENDIX A
PROBE CALIBRATION

A1. INTRODUCTION

A five-hole conical probe was calibrated in a 7" free jet facility. The calibration process involved acquiring the data necessary to calculate the probe coefficients, beta and gamma, for various probe pitch angles and free jet flow velocities. Beta and gamma can be shown (Appendix A, Ref. 12) to be functions of Mach number and pitch angle (ϕ) when the probe is balanced (no yaw). The values of beta and gamma over the range of flow velocities and pitch angles tested are, in turn, used to determine a set of probe calibration coefficients for polynomial expressions for Mach number and ϕ in terms of beta and gamma [Ref. 12]. From the polynomial expressions, the Mach number and pitch angle can be determined when the five-hole pneumatic probe is immersed and balanced in an unknown flow.

In the reduction program "CALC" [Appendix B], beta and gamma are calculated from the pressures sensed by the probe. The files containing the probe calibration coefficients are accessed by "CALC" and the coefficients are made available to the subprogram Xphicalc where the non-dimensional velocity X and pitch angle ϕ are calculated. The relation between X , Mach number and other quantities involved in the calculation of the loss coefficient can be seen in Table I.

Section A2 describes the calibration apparatus. The calibration test program is addressed in Section A3. Results and discussion in Section A4 are followed by Recommendations in Section A5. Tables of data produced during the calibration of the cone probe used in the present study are contained in Section A6.

The following is a list of symbols used in Appendix A:

PA	Atmospheric Pressure
PK	Total pressure as sensed by the Kiel probe.
P1 - P5	Probe pressure parts as shown in Fig. A2.
P23	$(P2 + P3)/2$

A2. PROBE CALIBRATION APPARATUS

A2.1 Hardware

An illustration of the probe calibration apparatus and picture of the probe are shown in Fig. A1 and Fig. A2 respectively. The probe port numbering is also shown in Fig. A2. The 7 inch diameter free jet receives air from the Allis Chalmers compressor. Flow rate is controlled by a hand operated valve near the free jet attachment to the settling chamber. Honeycomb flow straighteners remove swirl and the nozzle acceleration generates a nearly uniform velocity profile at the probe.

A United Sensor 5-hole conical probe, #DC-125-24-F-22-065-4" was mounted vertically on top of the free jet frame. A special mount allowed the probe to be yawed, pitched and translated i.e., the immersion distance

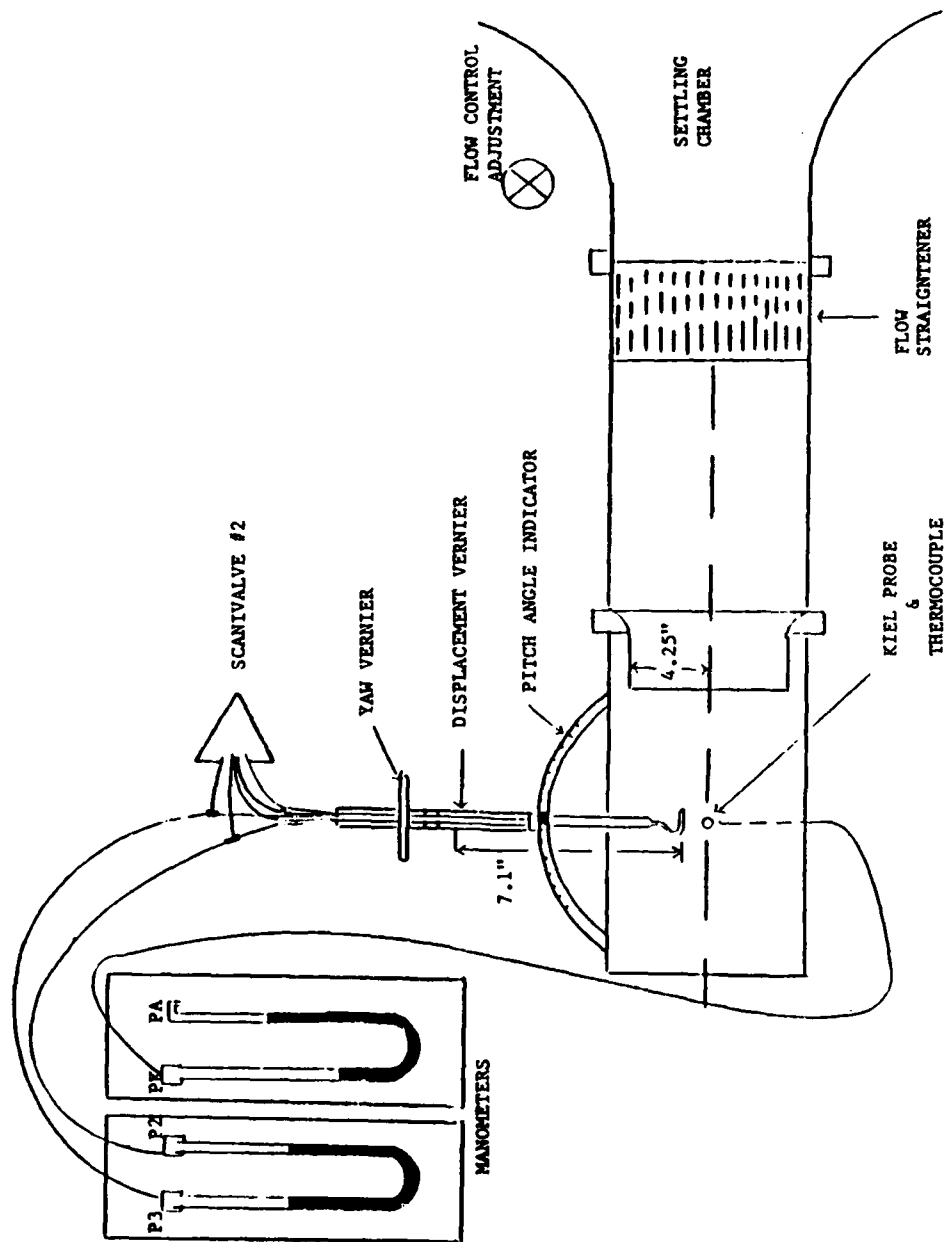


Figure A1. Probe Calibration Apparatus

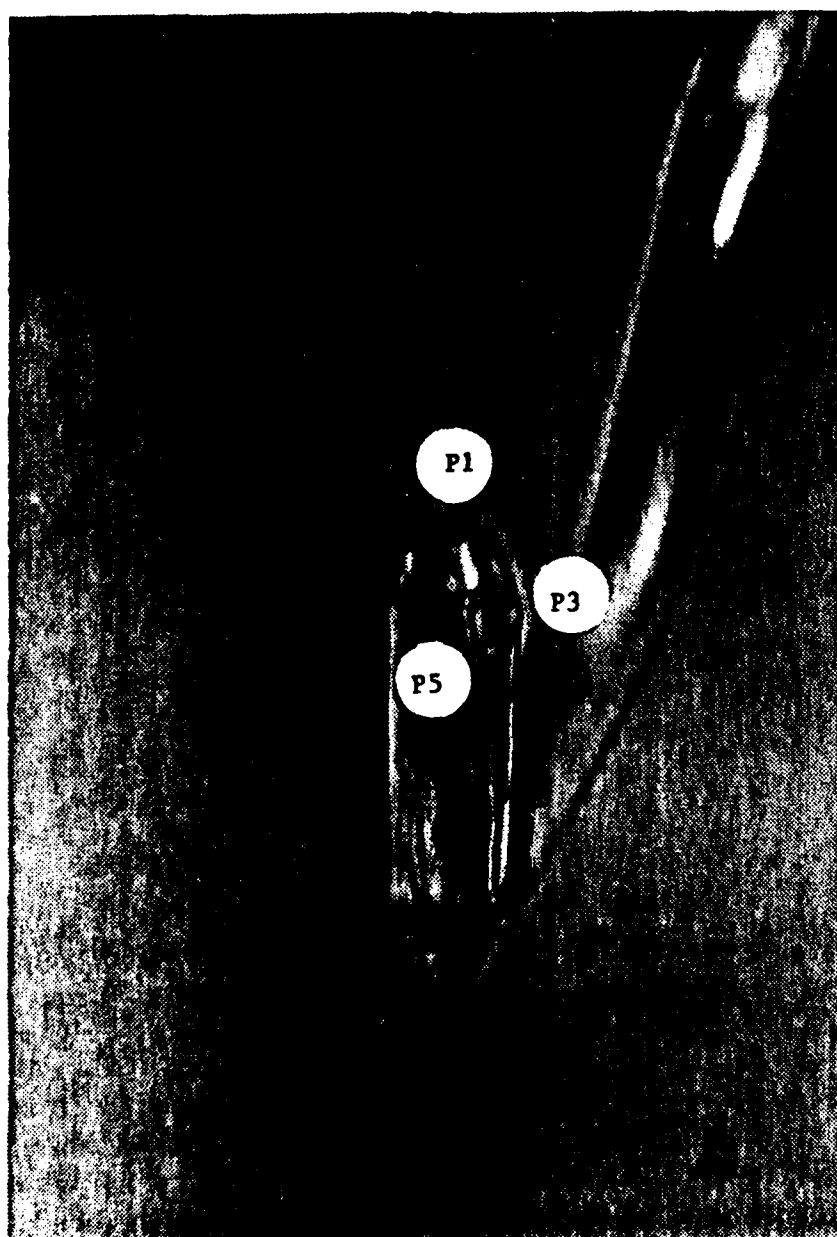


Figure A2. Five-Hole Conical Probe

could be varied. In this case, the immersion distance was fixed to read 7.1 on the vernier, allowing the probe to be rotated about its tip.

A combination Kiel and thermocouple probe was mounted horizontally and positioned into the flow to read total pressure and temperature.

Two water manometers were mounted next to the free jet. Pressures from conical probe ports 2 & 3 were fed to each side of one manometer, thus allowing the probe to be balanced in yaw. Total pressure as sensed by the Kiel probe (PK) was fed to the other manometer to allow the total flow of the free jet to be adjusted and monitored.

A Scanivalve rated at 2.5 psid sampled the conical probe pressures in addition to the Kiel probe and atmospheric pressures. A scanner, Scanivalve controller, and digital voltmeter (DVM) were used in conjunction with the Scanivalve to convert the pressures to digital form for subsequent storage and reduction.

Data acquisition software was run on the Hewlett Packard 9830 computer and associated peripheral components. The HP 9830 system primarily was used to record, store, and reduce the Scanivalve and thermocouple output while the HP 21MX system performed the calculations to generate the probe calibration coefficients.

A2.2 Software

The primary acquisition program was PRBCAL. Entries consisted of atmospheric pressure in inches Hg, number of

separate probe pitch angles (maximum of 12), Scanivalve number, temperature channel and number of samples to average (normally five). The program acquired the data for each probe pitch setting, then stopped to allow the user to change the pitch setting and balance the probe before data was again acquired. After all pitch settings had been sampled, the program prompted the user for a six element alphanumeric file name for the data to be stored. This file had to be opened prior to running PRBCAL. After the file name was entered in response to the prompt, the reduced data was printed in the form of Tables A1 - A3.

The program PRBRED generated probe coefficients and other parameters from the PRBCAL data files. PRBRED, used in conjunction with the "KEY" program PLOTK, allowed probe coefficients to be plotted against pitch angles. The PLOTK program required some familiarity with Hewlett Packard plotting procedures.

CALI2 provided the means to transfer data files from the HP 9830 system to the HP 21MX system. This was required since the 9830 system does not have the capability to generate the calibration coefficients. PRBCAL, PRBRED, PLOTK & CALI2 were on disc SHREEVE P007.

A data transfer program, also named CALI2, was loaded and run on the HP 21MX when CALI2 was run on the HP 9830. The raw data files were transferred and probe calibration quantities were calculated by the HP 21MX programs as shown in Tables A4 and A5. The program JOHN3 combined the

TABLE A1. TABULATED SCALED DATA OUTPUT BY
PRBCAL (DATAFILES CV = 100; CV = 150)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA ** PHI
-0.0040	34.518 **	2.4020	-0.1630	0.2420	-0.4740	2.336 ** -6.0
-0.0240	34.468 **	2.4120	-0.1430	0.1180	-0.3980	2.340 ** -4.0
-0.0400	-0.048 **	2.3260	-0.1270	0.0820	-0.3580	2.316 ** -3.0
-0.0240	-0.030 **	2.3370	-0.1270	0.0540	-0.3180	2.354 ** -2.0
-0.0520	-0.044 **	2.3130	-0.1180	0.0120	-0.2500	2.326 ** -1.0
-0.0360	-0.036 **	2.3320	-0.1240	-0.0320	-0.2100	2.342 ** 0.0
-0.0440	-0.058 **	2.2780	-0.1380	-0.1266	-0.1980	2.306 ** 1.0
-0.0500	-0.020 **	2.3280	-0.1160	-0.1140	-0.1220	2.338 ** 2.0
-0.0340	-0.054 **	2.2980	-0.1270	-0.1720	-0.0980	2.318 ** 3.0
-0.0480	-0.050 **	2.3180	-0.1290	-0.2300	-0.0260	2.320 ** 4.0
-0.0420	-0.046 **	2.2960	-0.1100	-0.2560	0.0200	2.344 ** 6.0

ATMOS. PRESS. (IN.HG)

30.06
30.06
30.06
30.06
30.06
30.06
30.06
30.06
30.06
30.06
30.06
30.06

TEMPERATURE (F)

98.61
99.43
100.07
100.58
100.92
101.29
101.32
101.60
101.76
101.76
101.93
102.27

DATA STORED IN CV=100

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA ** PHI
0.0540	32.900 **	5.3300	-0.3430	0.5460	-1.0200	5.326 ** -6.0
0.0200	32.924 **	5.3360	-0.3010	0.3300	-0.8540	5.284 ** -4.0
0.0760	-0.032 **	5.2540	-0.2820	0.1760	-0.8115	5.292 ** -3.0
-0.0260	-0.012 **	5.2580	-0.2680	0.1040	-0.6980	5.320 ** -2.0
-0.0040	-0.010 **	5.2560	-0.2680	0.0100	-0.6220	5.292 ** -1.0
-0.0360	-0.028 **	5.2520	-0.2480	-0.0820	-0.5320	5.306 ** 0.0
-0.0600	-0.072 **	5.2940	-0.2330	-0.1640	-0.4160	5.314 ** 1.0
-0.0640	-0.066 **	5.2740	-0.2270	-0.2380	-0.2920	5.338 ** 2.0
-0.0900	-0.086 **	5.2940	-0.2120	-0.3200	-0.1940	5.340 ** 3.0
-0.0740	-0.064 **	5.2260	-0.2410	-0.4380	-0.1140	5.276 ** 4.0
-0.1000	-0.038 **	5.2560	-0.2630	-0.6000	0.1060	5.332 ** 6.0

ATMOS. PRESS. (IN.HG)

30.09
30.09
30.09
30.09
30.09
30.09
30.09
30.09
30.09
30.09
30.09
30.09

TEMPERATURE (F)

109.50
109.70
109.70
109.73
109.70
109.77
109.70
109.77
109.77
109.80
109.77
109.84

DATA STORED IN CV=150

TABLE A2. TABULATED SCALED DATA OUTPUT BY
PRBCAL (DATA FILES CV = 200, CV = 250)

PAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0100	0.014 **	9.1650	-0.6360	0.9560	-1.8500	9.350 **	-6.0
-0.0160	-0.014 **	9.2660	-0.5700	0.5690	-1.5600	9.364 **	-4.0
-0.0520	-0.062 **	9.2540	-0.5410	0.3980	-1.4320	9.348 **	-3.0
-0.0700	-0.070 **	9.3000	-0.5010	0.1730	-1.2740	9.380 **	-2.0
-0.0400	-0.030 **	9.3100	-0.4610	0.0500	-1.0940	9.372 **	-1.0
-0.0160	-0.020 **	9.3000	-0.4860	-0.3420	-0.7820	9.352 **	1.0
-0.0200	-0.024 **	9.2560	-0.4690	-0.4860	-0.6080	9.344 **	2.0
-0.0380	-0.044 **	9.2840	-0.4530	-0.6240	-0.4380	9.364 **	3.0
-0.0320	-0.032 **	9.2140	-0.4670	-0.7720	-0.2440	9.326 **	4.0
-0.0300	-0.024 **	9.2360	-0.5190	-1.1000	0.1280	9.334 **	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.10	108.45
30.10	108.38
30.10	108.24
30.10	108.34
30.10	108.55
30.10	108.75
30.10	108.72
30.10	108.72
30.10	108.75
30.10	108.85
30.10	108.99

DATA STORED IN CV=200

PAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.1040	32.980 **	14.4320	-1.1430	1.1300	-3.1100	14.550 **	-6.0
-0.3100	32.978 **	14.6340	-0.8610	0.8980	-2.5020	14.650 **	-4.0
-0.0160	32.970 **	14.5880	-0.8090	0.6160	-2.2320	14.660 **	-3.0
-0.0460	32.884 **	14.7120	-0.7780	0.3180	-1.9940	14.688 **	-2.0
-0.0140	32.648 **	14.6840	-0.7630	0.0380	-1.7480	14.644 **	-1.0
-0.0320	-0.024 **	14.6080	-0.7250	-0.3260	-1.4980	14.764 **	0.0
-0.0620	-0.050 **	14.6960	-0.6750	-0.4500	-1.2160	14.782 **	1.0
-0.2620	-0.258 **	14.7620	-0.4910	-0.4380	-0.7800	14.880 **	2.0
-0.0400	-0.050 **	14.5180	-0.7320	-1.0340	-0.7520	14.622 **	3.0
-0.0720	-0.060 **	14.5300	-0.7760	-1.2980	-0.4720	14.684 **	4.0
-0.0580	-0.056 **	14.6380	-0.8880	-1.2160	0.0960	14.750 **	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.11	107.26
30.11	107.12
30.11	107.12
30.11	107.12
30.11	107.09
30.11	107.19
30.11	107.26
30.11	107.26
30.11	107.29
30.11	107.16
30.11	107.33

DATA STORED IN CV=250

TABLE A3. TABULATED SCALED DATA OUTPUT BY
PRBCAL (DATA FILES CV = 300)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0320	30.956 **	21.1960	-1.5050	2.2300	-4.3800	21.458 **	-6.0
-0.0080	30.188 **	21.3360	-1.2700	1.3200	-3.6400	21.480 **	-4.0
-0.0140	29.022 **	21.4420	-1.1880	0.9380	-3.3260	21.524 **	-3.0
0.0040	28.518 **	21.5880	-1.1510	0.4780	-2.9640	21.612 **	-2.0
-0.0280	27.730 **	21.4020	-1.1010	0.1000	-2.5800	21.448 **	-1.0
0.0040	27.048 **	21.3080	-1.0380	-0.2920	-2.2020	21.334 **	0.0
-0.0120	26.554 **	21.3020	-1.0220	-0.7100	-1.7840	21.352 **	1.0
-0.0260	25.724 **	21.3680	-1.0270	-1.1540	-1.4600	21.538 **	2.0
-0.0480	25.240 **	21.5420	-1.0680	-1.5440	-1.0620	21.664 **	3.0
-0.0160	24.756 **	21.4160	-1.1220	-1.9900	-0.6700	21.542 **	4.0
-0.0040	24.156 **	21.4520	-1.3430	-2.1100	0.1400	21.656 **	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.12	107.50
30.12	107.56
30.12	107.50
30.12	107.36
30.12	107.46
30.12	107.70
30.12	107.80
30.12	107.80
30.12	107.77
30.12	107.77
30.12	107.80

DATA STOPED IN CV=300

TABLE A4. TABULATED REDUCED DATA OUTPUT BY CALI2
(DATA FILES CV = 100, CV = 150, CV = 200)

THE DATA FROM DATA SET # 1 OF FILE CV=100 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.006250	.272442	.001745	.040043	.009655	-6.000000	98.611176
.006255	.281957	.001257	.040069	.020118	-4.000000	99.427018
.006270	.179372	.001072	.040458	.020541	-3.000000	100.069310
.006007	.150913	.000907	.040307	.020383	-2.000000	100.578000
.005936	.107553	.000638	.040392	.020393	-1.000000	100.917100
.005943	.076669	.000453	.040390	.020309	0.000000	101.270100
.005888	.029801	.000175	.040154	.020058	1.000000	101.324010
.005956	.003273	.000019	.040476	.020581	2.000000	101.595310
.005940	-.030515	-.000180	.040168	.020892	3.000000	101.764000
.005963	-.083367	-.000497	.040306	.020201	4.000000	101.934100
.005864	-.114713	-.000673	.040458	.020541	6.000000	102.273500

THE DATA FROM DATA SET # 1 OF FILE CV=150 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.013211	.276044	.003785	.060200	.136127	-6.000000	109.426310
.013625	.210041	.002862	.060359	.135212	-4.000000	109.697000
.013303	.128180	.002387	.060430	.135390	-3.000000	109.699000
.013359	.145132	.001939	.060595	.135744	-2.000000	109.732700
.013355	.114410	.001520	.060312	.135108	-1.000000	109.699000
.013296	.081818	.001080	.060573	.135696	0.000000	109.767500
.013359	.045594	.000609	.060754	.136102	1.000000	109.699000
.013296	.002816	.000131	.060511	.136455	2.000000	109.767500
.013307	-.022894	-.000305	.061103	.136885	3.000000	109.801500
.013215	-.059265	-.000703	.060620	.135799	4.000000	109.767500
.013339	-.127922	-.001706	.061080	.136835	6.000000	109.835400

THE DATA FROM DATA SET # 1 OF FILE CV=200 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.023160	.286268	.006718	.099003	.179242	-6.000000	108.441100
.023542	.216340	.005093	.099072	.179624	-4.000000	108.377300
.023443	.186830	.004300	.099158	.179817	-3.000000	108.241500
.023454	.146108	.003427	.099369	.180293	-2.000000	108.343400
.023383	.117801	.002738	.099208	.179931	-1.000000	108.546800
.023077	.078780	.001824	.079624	.178612	0.000000	108.750310
.023421	.044962	.001053	.099022	.179511	1.000000	108.716400
.023277	.012545	.000292	.099005	.179172	2.000000	108.716400
.023303	-.019102	-.000445	.099166	.179835	3.000000	108.750310
.023173	-.054540	-.001264	.079981	.179417	4.000000	108.812010
.023349	-.125881	-.002939	.099086	.179474	6.000000	108.982500

TABLE A5. TABULATED REDUCED DATA OUTPUT BY CALI2
(DATA FILES CV = 250, CV = 300)

THE DATA FROM DATA SET # 1 OF FILE CV=250 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.036822	.272231	.010024	.090882	.222196	-6.000000	107.258190
.036603	.219426	.008032	.092707	.224068	-4.000000	107.122600
.036375	.184971	.006728	.099734	.224129	-3.000000	107.122600
.036504	.149250	.005460	.099826	.224339	-2.000000	107.122600
.036487	.115621	.004219	.092573	.223764	-1.000000	107.088700
.036223	.082306	.002981	.100031	.224804	0.000000	107.130400
.036303	.049444	.001795	.100191	.225166	1.000000	107.258190
.036001	.018488	.000666	.101176	.227402	2.000000	107.258190
.036034	-.018492	-.000666	.099587	.223796	3.000000	107.258190
.036163	-.053966	-.001952	.099900	.224507	4.000000	107.156490
.036674	-.129589	-.004753	.100071	.224896	6.000000	107.326100

THE DATA FROM DATA SET # 1 OF FILE CV=300 ARE

.052799	.221177	.015374	.120103	.270974	-6.000000	
.052556	.219411	.011531	.120471	.271359	-4.000000	107.563200
.052520	.189422	.009911	.120607	.271660	-3.000000	107.495610
.052836	.151370	.007998	.120796	.272101	-2.000000	107.360000
.052306	.119095	.006229	.120439	.271284	-1.000000	107.461700
.051956	.085474	.004441	.120042	.270377	0.000000	107.622100
.051904	.048110	.002497	.120135	.270589	1.000000	107.800800
.052059	.013664	.000711	.120678	.271830	2.000000	107.800900
.052535	-.021318	-.001120	.121078	.272744	3.000000	107.766910
.052387	-.050390	-.003059	.120661	.271793	4.000000	107.766910
.052981	-.142575	-.007554	.120937	.272423	6.000000	107.800800

separate files generated during CALI2 execution into a single file consistent with the format required for the JOHN4 program. (A tabulation of JOHN3 data is not included since the quantities are the same as those listed in the separate files of CALI2.) JOHN4 produced a surface plot of the data (Figs. A3 and A4) and generated a matrix of the probe calibration coefficients (Table A6). Figures A3 and A4 are plots of the actual data generated from the probe calibration process, while the ERRORS (%) at each point in Table A6 quantitatively show the difference between the data points in Figures A3 and A4 and the "best fit" surface at the given values of beta and gamma. The "best fit" surface was given by the polynomial expressions previously cited [Ref. 12] using the matrix of calibration coefficients produced by JOHN4, and tabulated in Table A6. JOHN4 produced a matrix of coefficients and also associated tabulation of errors at each point for increasingly higher order polynomials. The user was required to make the choice of what order polynomial gave the best fit to the actual data by an examination of the errors at each point, associated with the use of polynomials of different orders. It is noted that the program prompts the user for the M and N order of the "best fit" polynomial. The coefficients are presented in an M by N matrix where M represents column values and N represents row values. The polynomial order entered is thus, M-1 and N-1, since the polynomial order is one less than the number of coefficients that it requires.

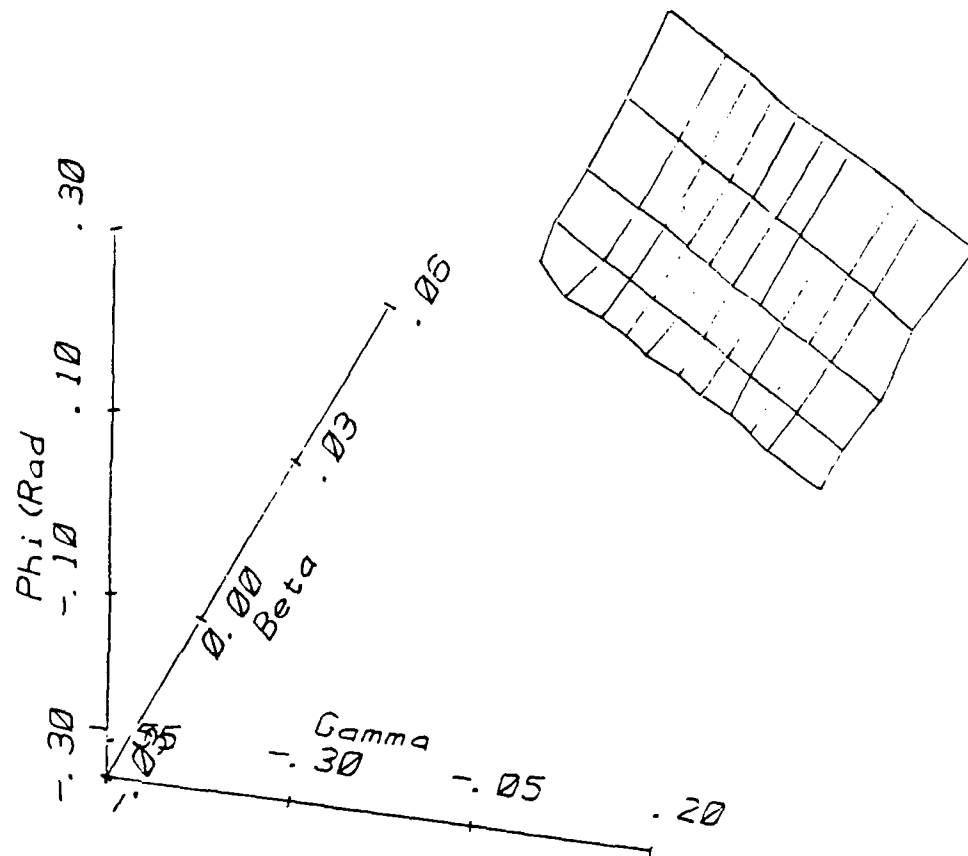


Figure A3. Surface Plot of Phi. vs. Gamma and Beta

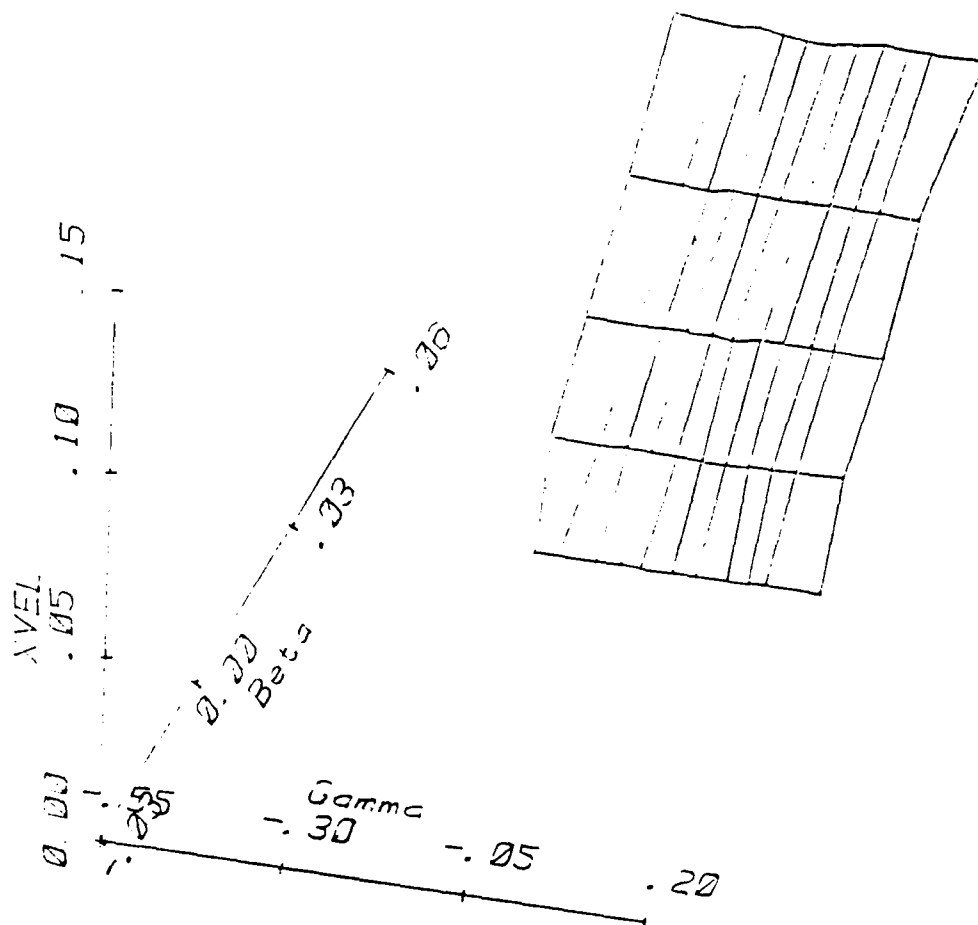


Figure A4. Surface Plot of X (velocity)
vs. Gamma and Beta

TABLE A6. BEST FIT CALIBRATION COEFFICIENTS
SELECTED USING JOHN4 WITH ASSOCIATED
ERRORS

COEFFICIENTS FOR THE CALIBRATION SURFACE STORED IN FILE IMKEC3

	1	2	3	4	5
1	.015976	4.932133	-153.668740	3137.961400	-24299.0050
2	-.000363	.699505	-62.977264	2068.372100	-20872.1400
3	.000098	-24.844173	1988.495400	-57799.7030	541835.5000
	1	2	3	4	5

ERRORS(Z) AT EACH POINT

	1	2	3	4	5	6	7	8	9	10	11
1	-.556	-1.098	1.832	.319	.522	.499	-.135	-.007	-.467	-.575	.644
2	1.001	-.463	.161	.114	-.650	-.257	-.411	-.051	.173	-.252	.307
3	-.418	-.264	.076	.329	.273	.110	-.092	.137	.285	.101	-.359
4	.137	.325	.198	-.392	-.785	-.114	-.180	1.225	-.346	-.005	-.024
5	-.064	.139	.092	-.050	-.077	-.212	-.172	.166	.233	.024	-.007
	1	2	3	4	5	6	7	8	9	10	11

COEFFICIENTS FOR THE CALIBRATION SURFACE STORED IN FILE IMKEC2

	1	2	3	4	5
1	.023535	3.178730	-199.593870	5134.302700	-45091.8980
2	-.557400	11.194368	-778.272950	21622.69100	-180536.340
3	.758150	-183.145780	12999.86900	-351917.690	3136833.000
	1	2	3	4	5

ERRORS(DEGREES) AT EACH POINT

	1	2	3	4	5	6	7	8	9	10	11
1	-.071	-.258	.097	.288	.049	.158	-.205	.010	.013	-.569	.486
2	.084	-.017	-.004	-.032	.030	.049	-.028	-.075	-.018	-.051	.041
3	-.049	-.056	.094	-.083	.075	-.034	-.026	.025	.096	.053	-.056
4	-.079	.176	.071	-.047	-.080	-.078	-.050	.059	.006	.016	-.008
5	.060	-.054	.019	-.069	-.000	.008	-.053	.006	.097	.102	-.084
	1	2	3	4	5	6	7	8	9	10	11

A3. TEST PROGRAM AND RESULTS

The calibration was conducted at five flow velocities: nominally 100, 150, 200, 250 and 300 ft/sec. At each velocity, the probe was moved to -6, -4, -3, -2, -1, 0, 1, 2, 3, 4, 6 degrees of pitch (ϕ) and balanced so probe port P2 and P3 pressures were equal on the manometer. The data were stored in files CV=100 to CV=300 on disc SHREEVE P007.

Prior to the calibration, a survey of the free jet was conducted at a flow of approximately 200 ft/sec to determine the velocity profile. The survey was conducted from top to bottom and, with the probe mounted on the underside, from bottom to top. There was some overlap in the survey, which in principle, would allow the departure of the jet flow direction from true axial to be resolved by the pitch angle indicated from the two sides.

Data collected in files CV=100, CV=200 and CV=300 and subsequently reduced by PRBRED were handplotted to show the effect of pitch angle on the coefficients. Fig. A5 shows ϕ vs. β , where $\beta = (P1-P23)/P1$. Fig. A6 is a plot of ϕ vs. $\bar{\beta}$, where $\bar{\beta} = \beta/(PK-PA)/PK$. ϕ vs γ ($P1-P4/P1-P23$) is shown in Fig. A7 and ϕ vs. $(P1-PK)/(PK-PA)$ is plotted in Fig. A8. Free jet survey results are shown in Fig. A9.

A4. DISCUSSION

The probe calibration data presented in Figs. A3-A9 are well-behaved and qualitatively consistent with the

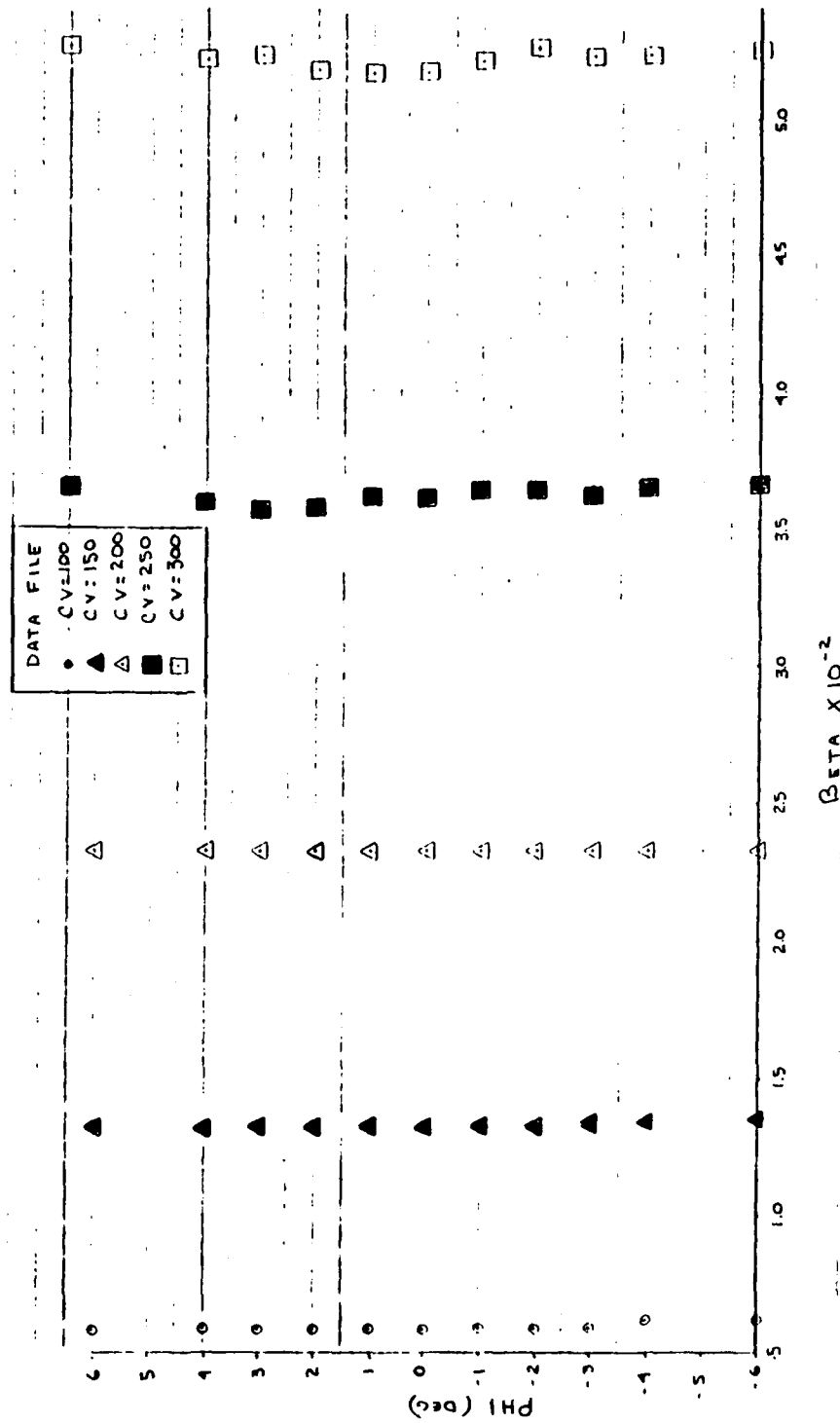


Figure A5. Phi vs. Beta

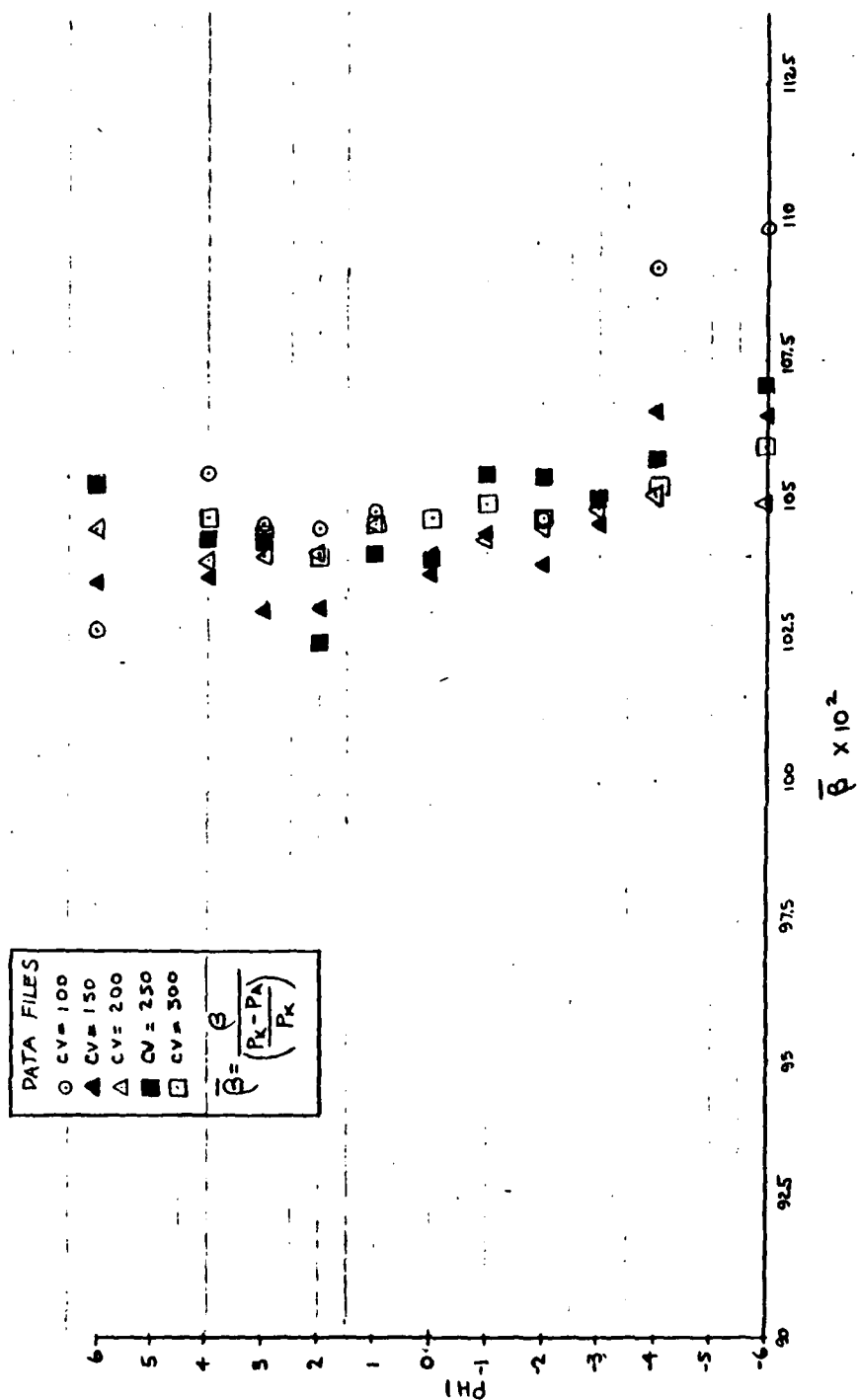


Figure A6. Phi vs. Betabar

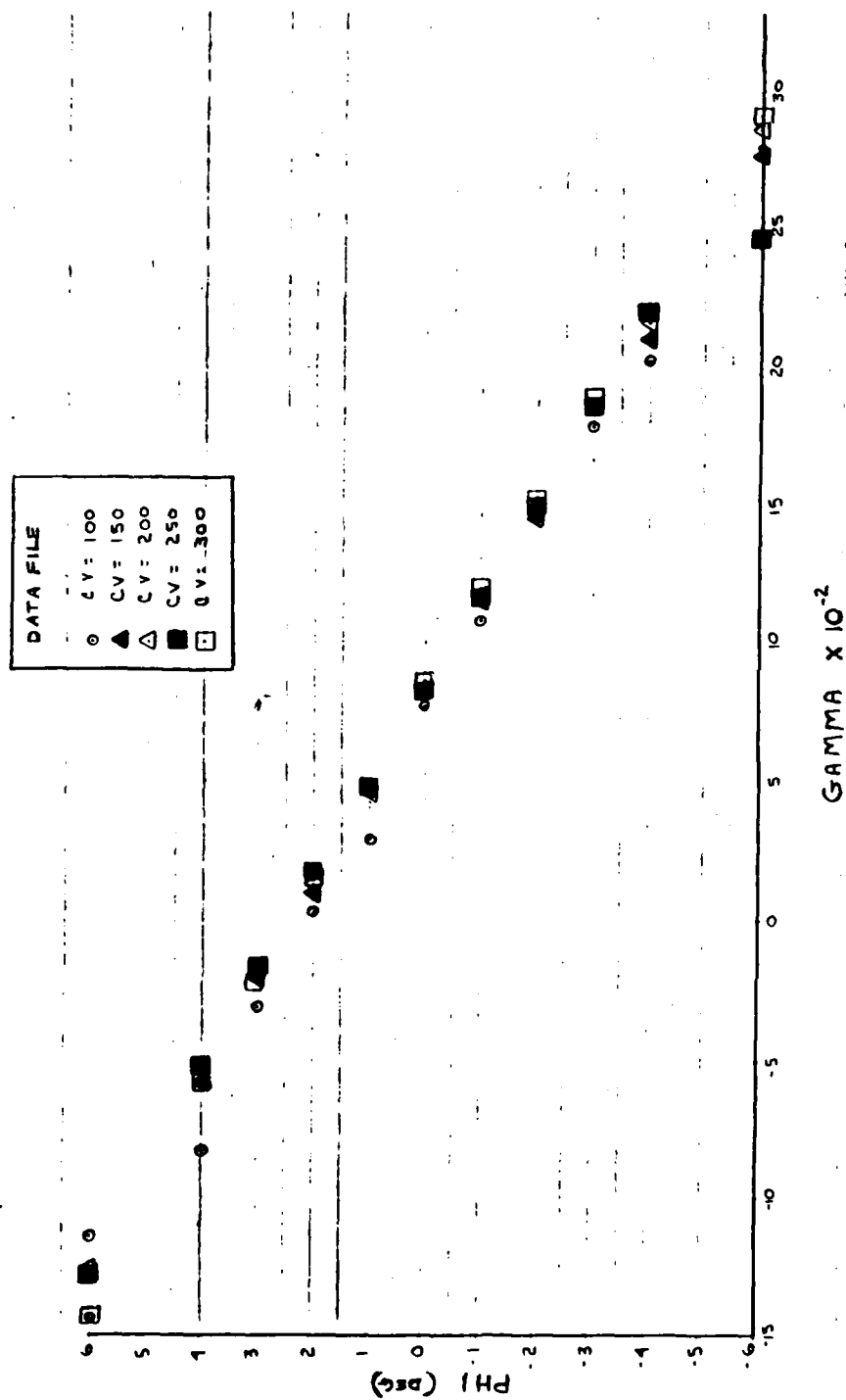


Figure A7. Phi vs. Gamma

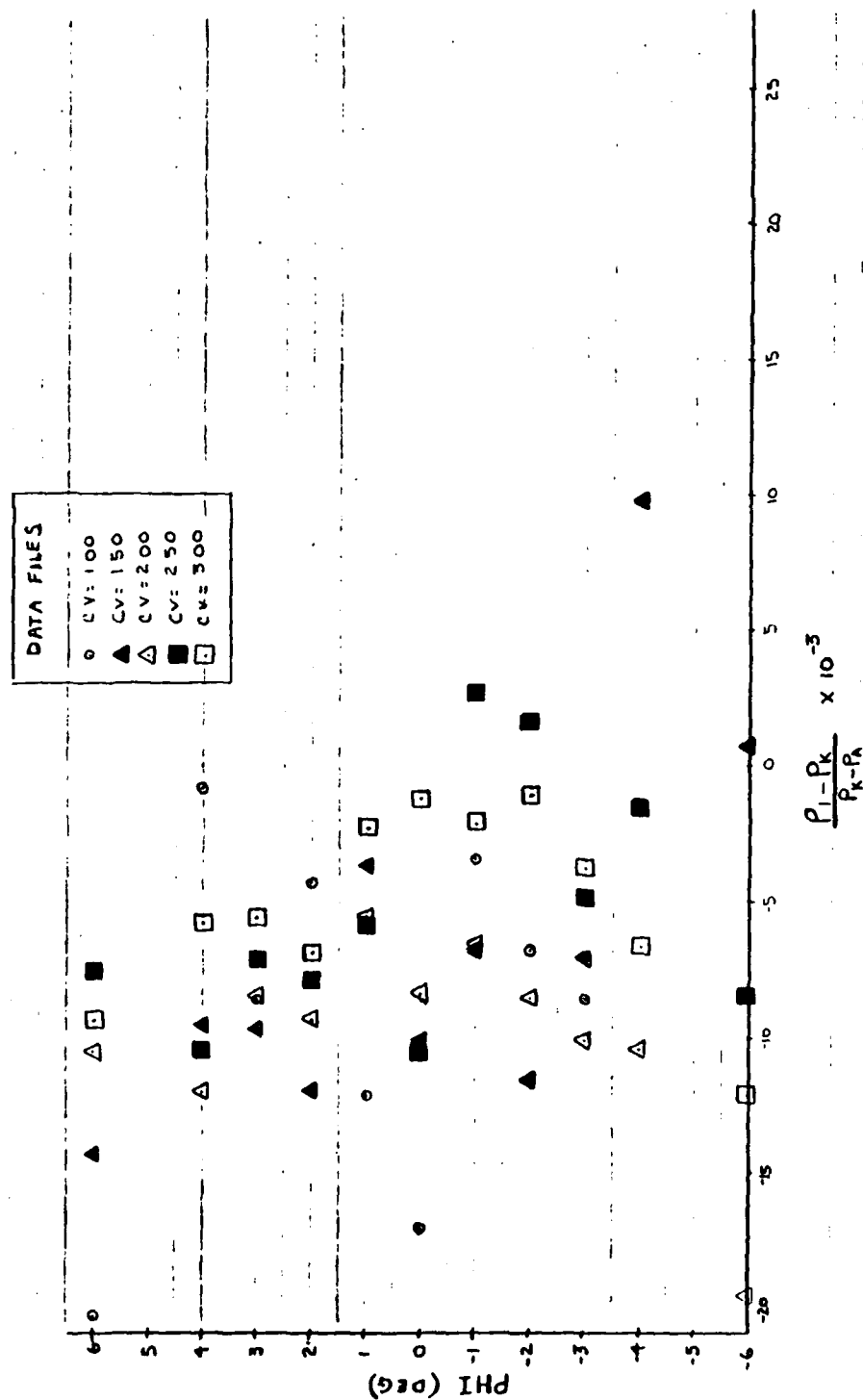


Figure A8. Phi vs. $(P_1 - PK)/(PK - PA)$

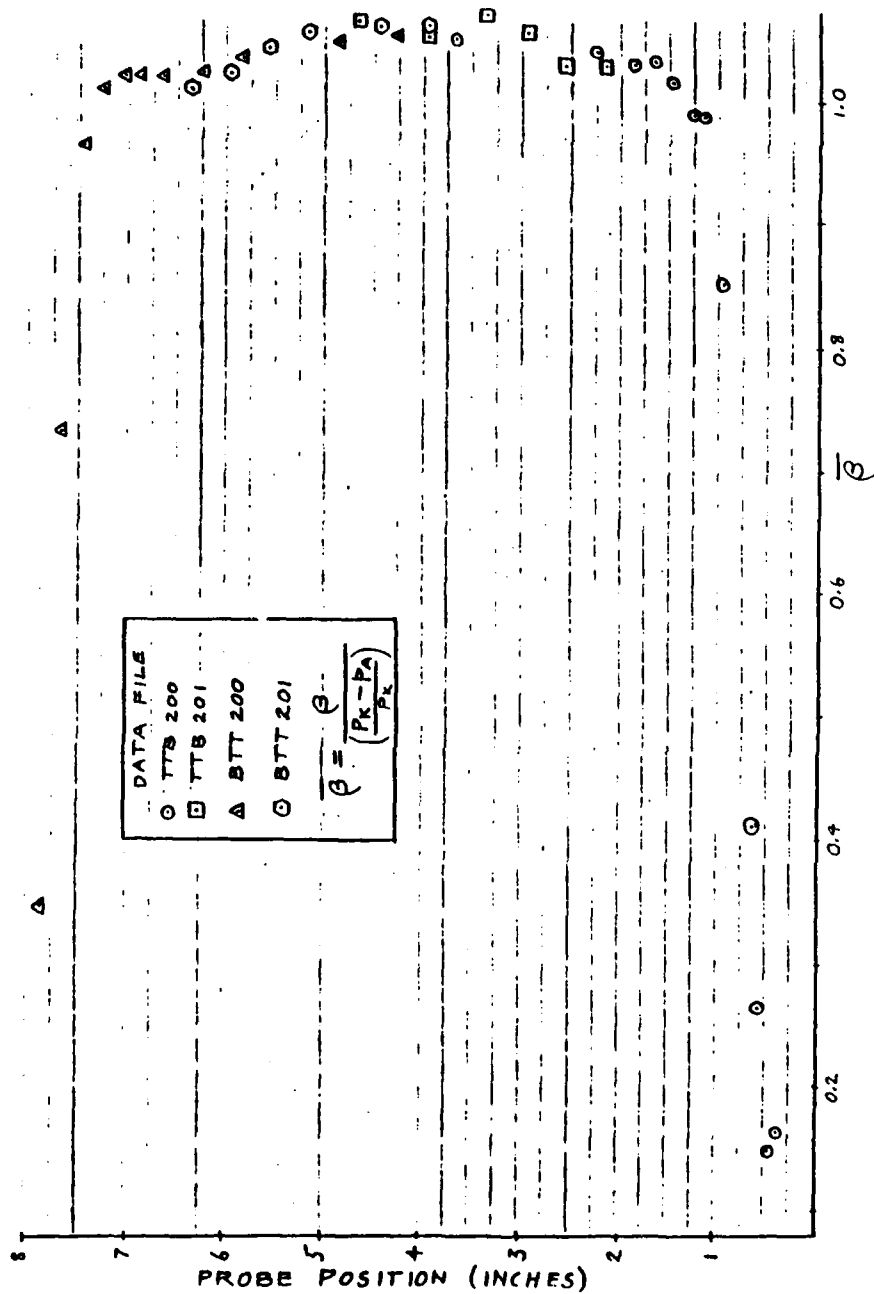


Figure A9. Free Jet Survey: Probe Position vs. Betabar

experience of previous investigators [Ref. 4 and Ref. 12]. Data quality and probe characteristics can be determined from the quantities plotted in these figures. A discussion of the results in each plot follows.

Appendix A of Ref. 12 shows that beta is a function of the non-dimensional velocity X and ϕ with strongest dependence on X ; gamma is a function of X and ϕ but most strongly dependent on ϕ . Fig. A5 shows that as the pitch angle was changed, there was very little change in beta for a given flow velocity. Since beta is related to velocity as developed in Appendix A, Ref. 12, the plot implies that there was a very small change in the measured velocity by the probe with pitch variation, or that beta is slightly sensitive to pitch. The greatest variation in beta is seen in the data from file CV = 300. Beta varied by about 1.3% which equates to about a 1.1% possible variation in velocity. (Change in beta equals change in velocity squared.)

To remove the variations in beta due to changes in the free jet flow, ϕ was plotted against betabar (Fig. A6). By dividing beta by $(PK-PA)/PA$, the effect of the changes in flow through the jet are removed. The plot shows only those changes in beta which are due strictly to pitch angle variation. Ideally, all points for each ϕ should coincide. Some variation is seen at the extreme ϕ values; however, the betabar scale is over expanded by a factor of two compared to a scale appropriate to the

ability to resolve the measurements, and the differences are therefore unnecessarily exaggerated.

Figure A7 clearly shows the strong dependence gamma has on phi. The data points tend to be more closely grouped in the -2 to +2 deg. range with the lower velocity points slightly more separated from the higher velocity points. Part of the reason for this difference may be due to pressure errors at the lower jet velocities having a larger relative effect on the accuracy of the data points.

Total pressure at the conical probe (P1) and total pressure at the Kiel probe (PK) should be nearly identical when phi equals zero. One would expect that the plot in Fig. A8 would reflect this, however it does not. It would be expected that P1 and PK would differ with pitch change, accompanied by some movement of the data points away from zero, but the dispersion of the data in this plot is difficult to explain. The general trend is that nearly all points are less than zero, implying that PK is generally higher than P1. This is corroborated by the free jet survey which shows that the Kiel probe was immersed in a slightly higher velocity region than was the conical probe (see Fig. A9). Note that JOHN4 corrects for this difference when calculating the coefficients. Additionally, it is pointed out by Dreon [Ref. 4] that the core of the free jet has a 0.05 degree pitch to it. The combination of a nonuniform velocity profile and

unsteadiness at low flow velocities might explain some of the observed scatter.

A5. RECOMMENDATIONS

The recommendations presented here focus on software and hardware improvements. The recommendations are:

1. Restore the capability to generate surface plots of the X and phi functional relationship with beta and gamma using the "best fit" polynomial and calibration coefficients. This would provide a visual qualitative check of the fit to the calibration data (Figs. A3 and A4).
2. Modify the HP-9830 based program PRBRED to include the computation of beta bar.
3. Create specific plotting programs on the HP-9830 to plot the quantities in Figs. A5 - A8.
4. Repair or service the printer that supports the HP-21MX system. Frequent malfunctions dramatically slowed the execution of HP-21MX programs.
5. Investigate the feasibility of replacing the HP-9830 with an HP-300 system for probe calibration and related work.

APPENDIX B

SOFTWARE

B1. INTRODUCTION

The software consists of three programs; namely, "ACQUIRE," "CALC," and "LOSS." An in-depth knowledge of computer programming is not required to run the programs; however, some knowledge of programming in Hewlett Packard BASIC 5.0 would be required in order to plot results or make corrections to data files. A rudimentary knowledge of computers by the user is presumed. The main references for the programs are Ref. 13 - 17.

The programs were written to be understandable and flexible. To facilitate understanding program flow, emphasis was placed on clear logic rather than sophistication. To this end, subroutines were called from a library to perform all calculations and repetitive operations. In addition to providing for one or two probe surveys, modifications to hardware addresses on the interface bus or changes to scanner channel assignments can be made easily at the beginning of the program.

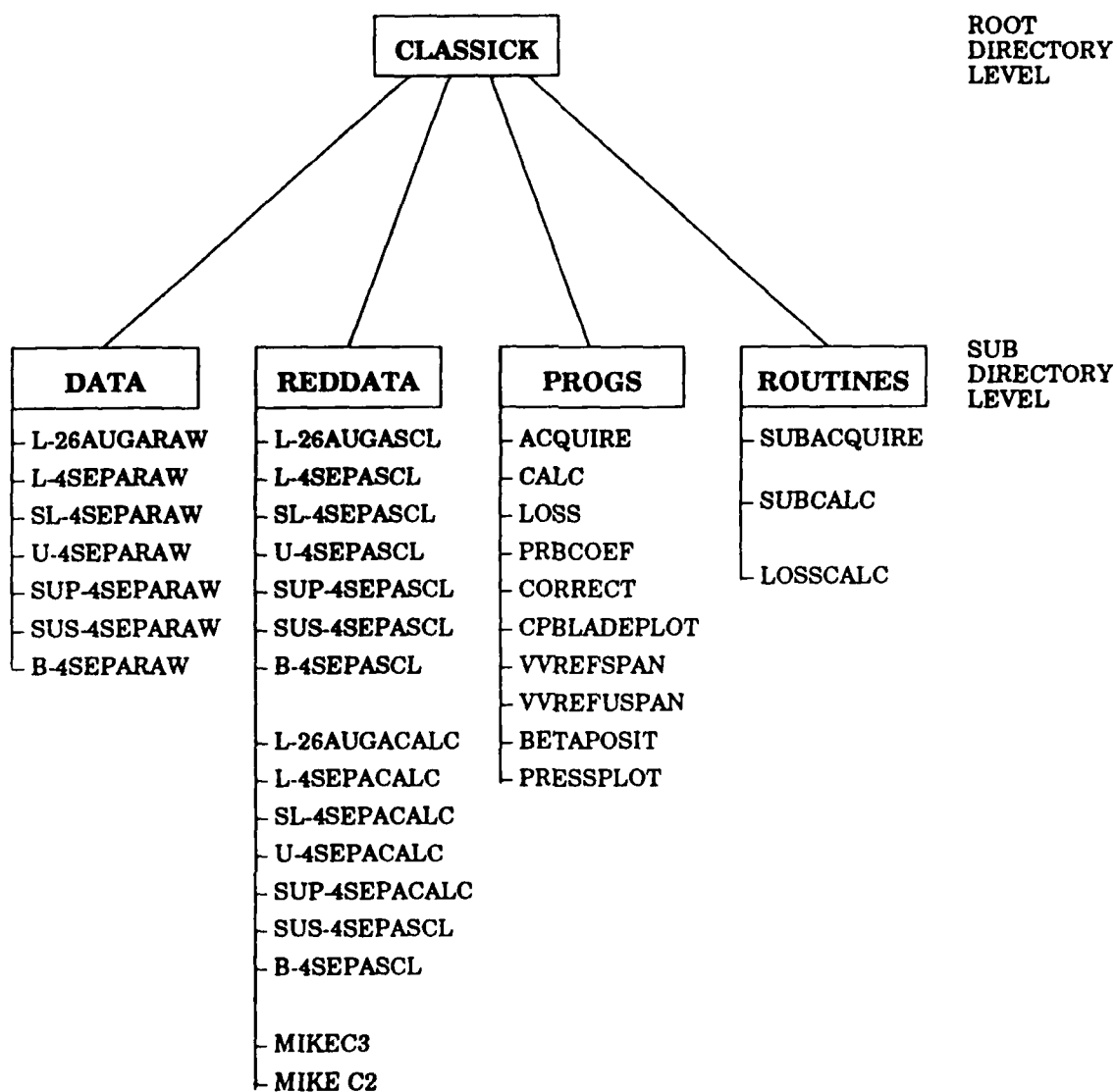
An overview of the file system and program flow is given in sections B2 and B3 respectively, and the step-by-step procedures required to run the programs are given in Section B4, Program Execution. Common errors and recovery steps are addressed in Section B5, and common modifications are discussed in Section B6. Copies of the three main

programs are contained in Section B7 along with examples of the plotting and data file correction programs. Examples of output tables of scaled and reduced data for both detailed blade-to-blade surveys are also contained in this section. Initialization of flexible discs and backing up files to flexible discs is addressed in Section B8. Recommendations to improve the software are presented in Section B9. Finally, for the user, a summary of the steps involved in running the program is given in Section B10.

B2. FILE SYSTEM

Chapter 3 and 10 of Ref. 13 cover mass storage concepts (how the computer's hard disk can be divided up for storage space) and the use of files and directories respectively. The current directory and file system is shown in Fig. B1. Four subdirectories were created under CLASSICK in the root directory. The sub directory DATA contains all the digital voltmeter (DVM) readings during the survey. Scaled data, or raw data that has been scaled in engineering units, e.g., pressure, degrees, etc., are stored in REDDATA, along with the scaled data reduced to useful calculated quantities. The probe calibration coefficients are also stored in REDDATA. The main and ancillary programs are contained under PROGS. ROUTINES contains all the subroutines called by the main programs.

When conducting a probe survey, files need to be created to store the data. Data can be collected from blade-to-blade or span-wise probe surveys or from a scan of



PREFIX

L Lower Traverse
 SL Span Lower Traverse
 U Upper Traverse
 SUP Span Upper Traverse Pressure
 SUS Span Upper Traverse Suction
 B Blade

SUFFIX

RAW Raw Voltage Readings
 SCL Scaled
 CALC Calculated (reduced)

Figure B1. File System

the instrumented blade surface pressures. For each survey, raw data, scaled data and reduced data files are created as the user progresses through the programs. The file names are arbitrary but should be descriptive in the interests of identification and kept to a maximum of twelve characters. The file names in this report consisted of a prefix to designate the survey type, followed by the date, run and data type. The prefix and suffix meanings are given in Fig. B1. As an example, the raw data acquired from the lower traverse blade-to-blade probe survey which was conducted on 4 Sept., was named "L-4SEPARAW." If, for some reason, this survey were repeated the same day and the previous survey results were saved, the new file would be named "L-4SEPRAW." The user should define the file names for the proposed surveys before executing the program.

B3. PROGRAM FLOW

The program flow from the user's perspective is shown in Fig. B2(a)-(d). The figures show, verbatim, the prompts the user will see on the screen and the effects that options will have when selected. The selection of options will be addressed in the following section.

B4. PROGRAM EXECUTION

In this section the procedures to power up the system and run the programs will be spelled out. (A summary of the steps for the user to run the programs is given in Section B10.) The intent here is to provide the user with

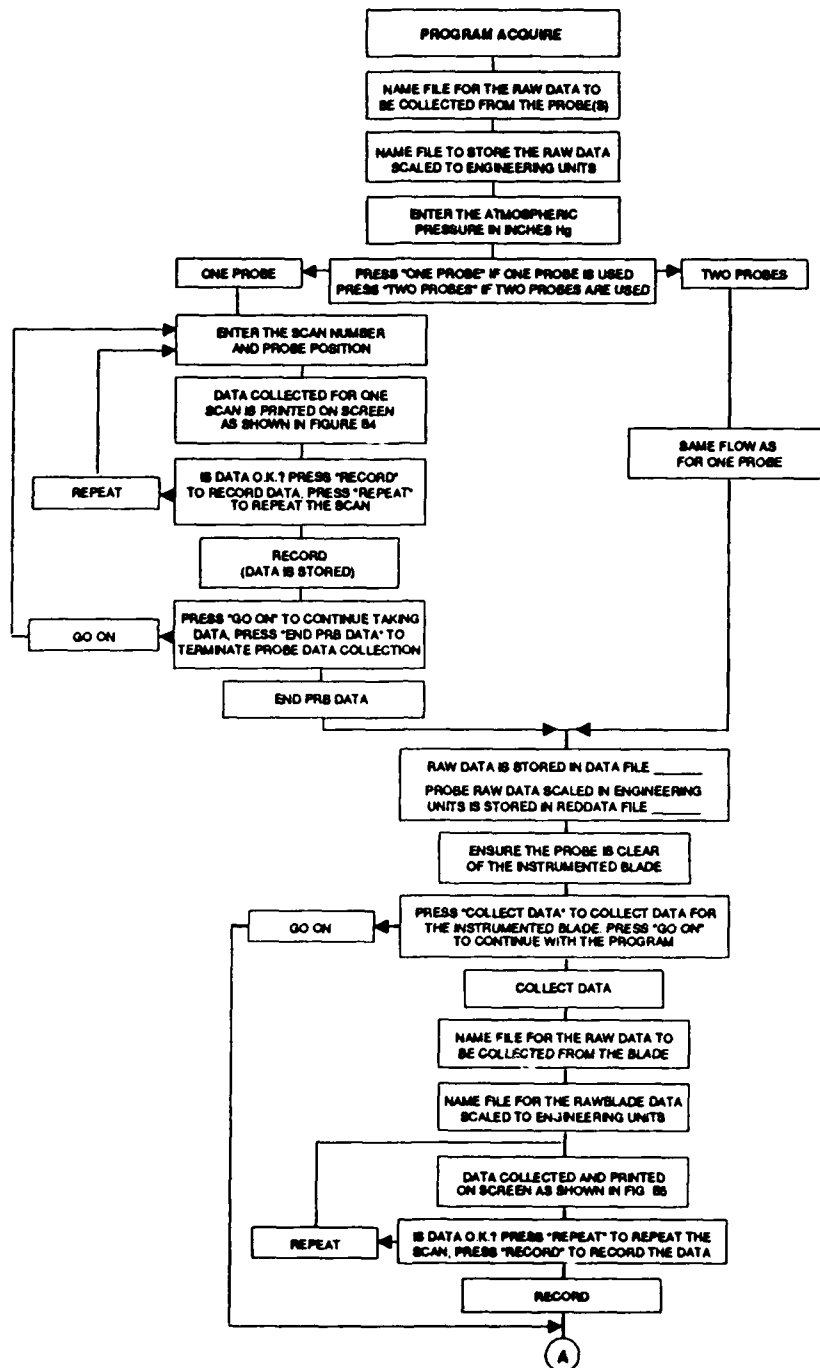


Figure B2(a) Program Flow Chart - ACQUIRE

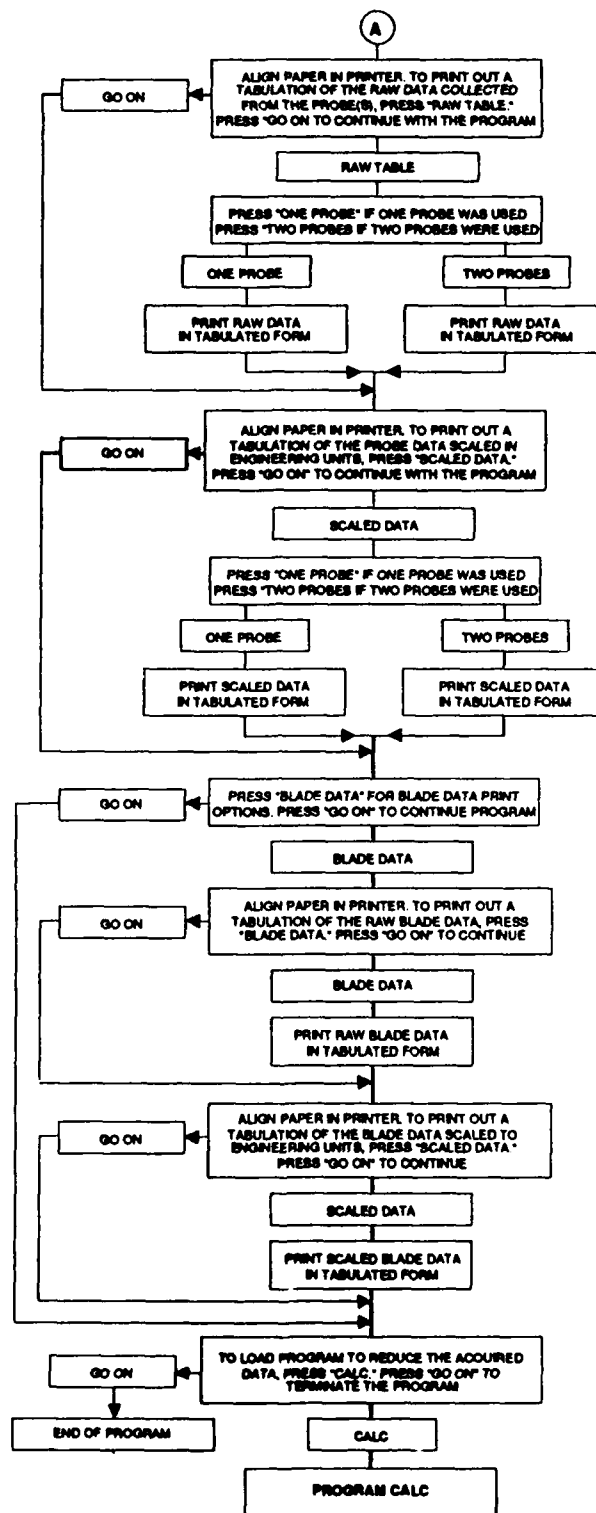


Figure B2(b) Program Flow Chart -
ACQUIRE (cont.)

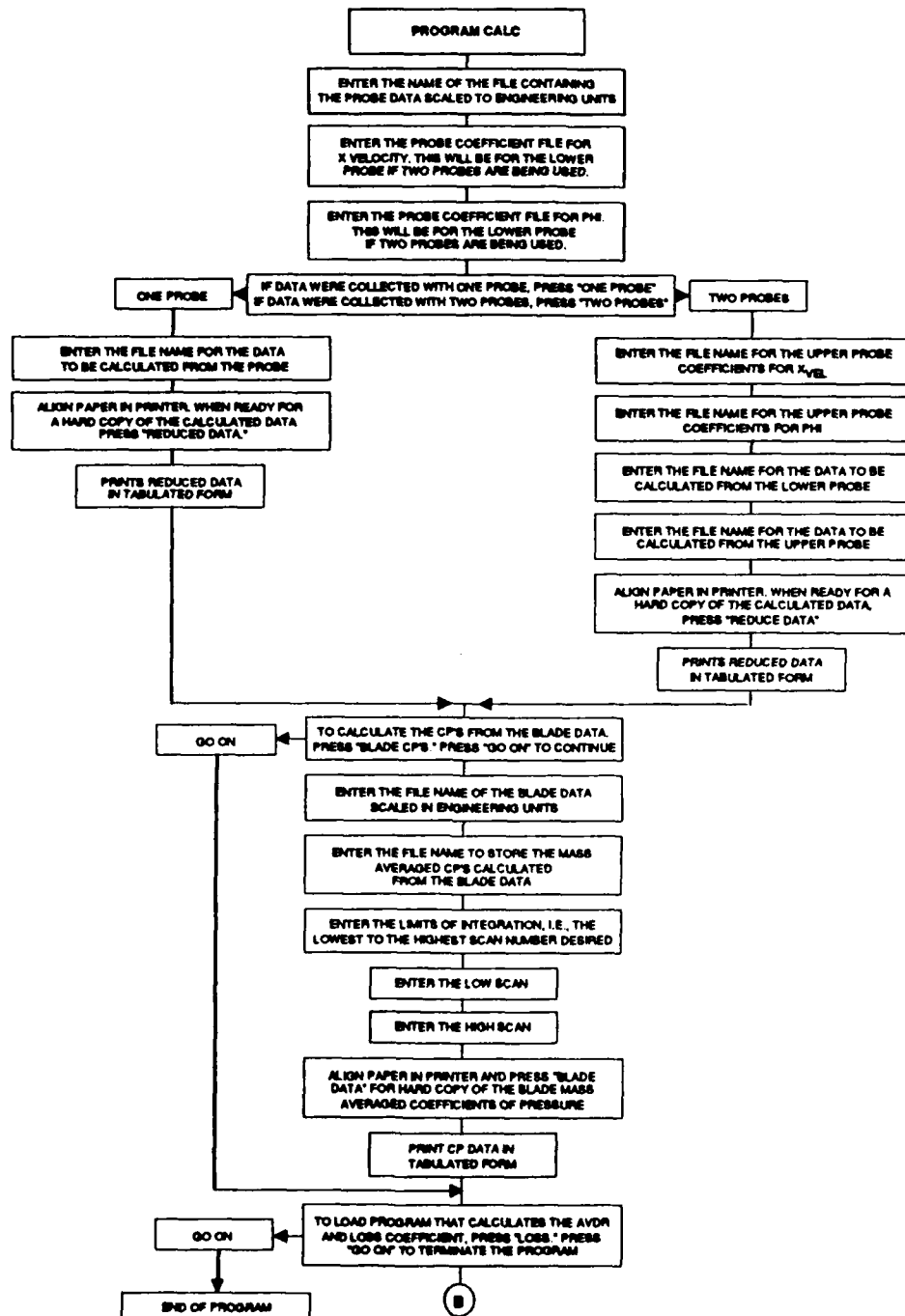


Figure B2(c) Program Flow Chart -
CALC

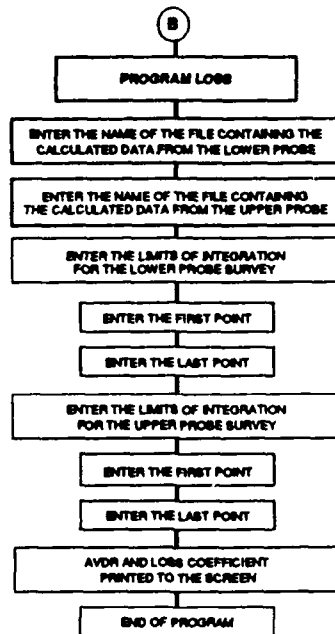


Figure B2(d) Program Flow Chart -
LOSS

the necessary information to acquire and reduce the data in order to obtain the loss coefficient from a set of probe surveys. The program flow chart should be referred to as the program steps are briefly explained.

1. Turn on the DVM, scanner and Scanivalve controller. The computer will not boot-up unless the DVM or scanner is on, however, all of these components must be on before starting the survey.

2. Turn the disk drive on and wait for the self test to complete (two amber lights below the flex disc access extinguish).

3. Turn on the computer, monitor and printer. The printer power switch is located behind the unit.

4. The system will boot up the HP BASIC 5.0 resident on the hard disc and go through a series of self tests. In less than a minute, the Hewlett Packard copywrite statements will appear on the monitor. Soft key labels appear along the bottom of the screen; these correspond to the top row of keys on the keyboard labeled f1 - f8. The key board and an example of what the soft key labels look like for step 12 is shown in Fig. B3.

5. Press f5 corresponding to the soft key label LOAD.

6. Type /CLASSICK/PROGS/ACQUIRE between the quotation marks. Press RETURN. This establishes the path from

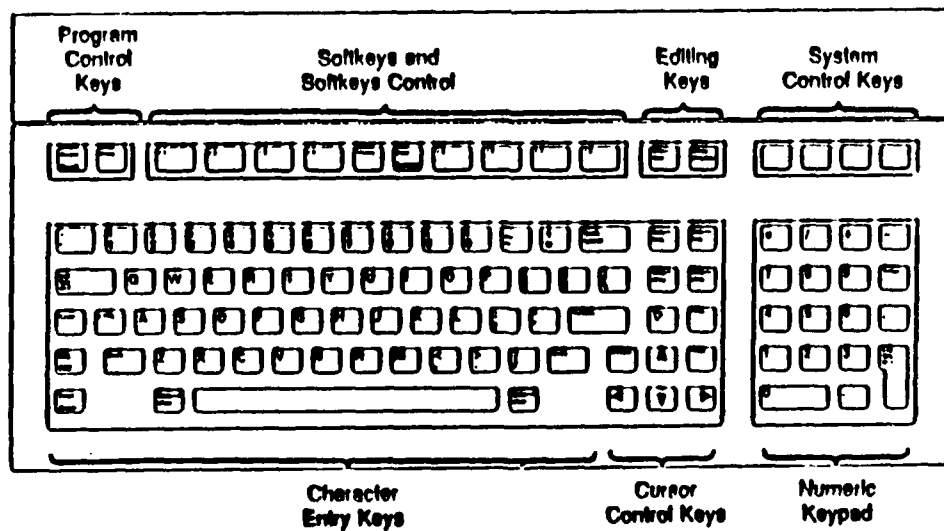
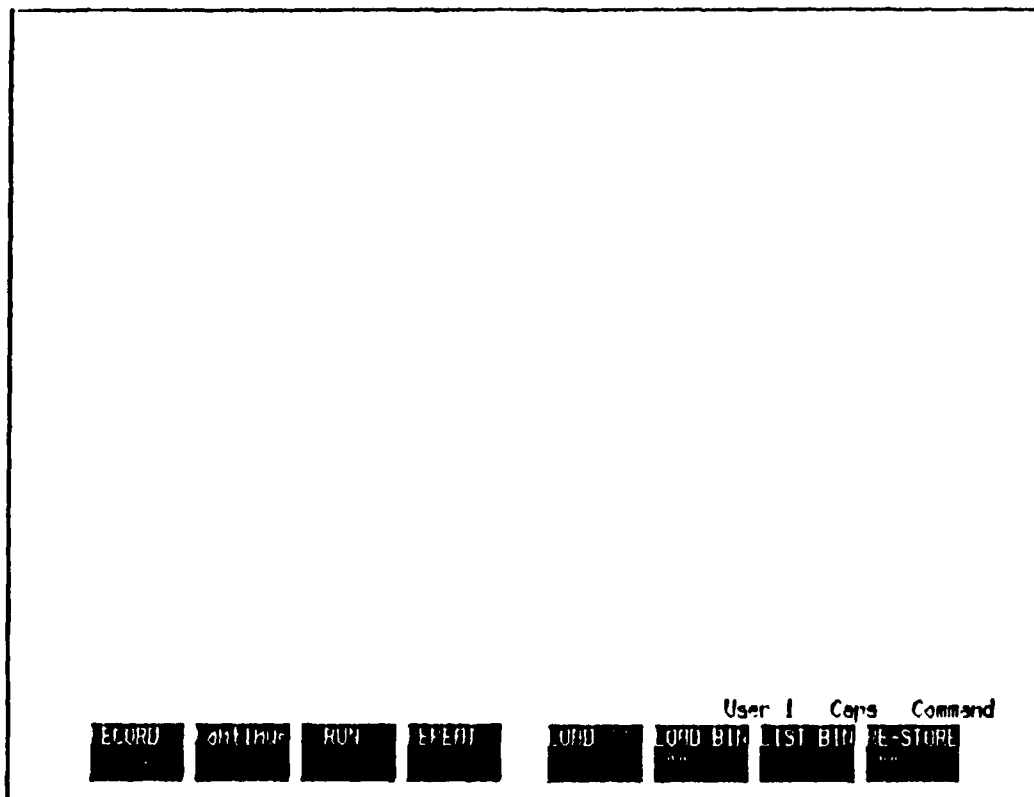


Figure B3. Keyboard and Softkey Labels

the root directory where the CLASSICK directory is located to the file ACQUIRE via the subdirectory PROGS. An alternate way of doing this would be to type in at the blinking cursor the word LOAD followed by "/CLASSICK/PROGS/ACQUIRE." Press RETURN.

7. Press f3 corresponding to the soft key label RUN. The first prompt in the ACQUIRE program will appear. From the program flow chart, it can be determined that the prompt will read "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE PROBE(S)." The file name is typed in directly without quotation marks, e.g., L-2SEPARAW. Press ENTER.

8. At the next prompt, type in the scaled data file, e.g., L-4SEPASCL. Press RETURN.

9. Type in the atmospheric pressure in inches of mercury, e.g., 29.92. Press RETURN. In the program this defines the variable Pbaro as equal to 29.92. This will normally be constant throughout the duration of a survey, however, in the rare event of a weather front passing through, the barometric pressure can change during the survey. If the change is significant, the variable Pbaro can be redefined while the program is running by performing the following steps:

- a. Press the STOP key next to key f1.
- b. Type Pbaro 30.00 to change from 29.92 to 30.00.
- c. Press RETURN.
- c. Press f2 corresponding to soft key label CONTINUE.

10. Once step 9 has been completed, the one or two probe option prompt appears, and the soft key labels EDIT and SCRATCH corresponding to keys f1 and f4 respectively are replaced by ONE PROBE and TWO PROBES. Press the appropriate key. Note that the only soft keys the user will press during normal program execution will be those corresponding to keys f1 and f4. It will be assumed in the following steps that the one probe option was used - the only difference in procedure will be an additional position that the user must enter for the second probe.

11. The scan number and position are typed in and separated by a comma, e.g., 43, 2.55. Press RETURN. The scan number can be up to four characters and the position, seven characters - four to the left and two to the right of a decimal.

12. The scan begins after RETURN is pressed for step 11. All the data for the scan will print to the screen for the user to evaluate. An example of the screen presentation is given in Fig. B4. If the data is unsatisfactory, press f4 corresponding to soft key

```

*****
SCAN NUMBER 2
PROBE POSITION 200
PORT      VOLTAGE      GUAGE PRESSURE(INCHES H2o)
1          4.000E-07      4.000E-03
2          9.052E-04      9.048E+00
3          1.182E-03      1.182E+01
4          -6.170E-04      -6.174E+00
5          5.254E-04      5.250E+00
6          -6.560E-05      -6.600E-01
7          -6.380E-05      -6.420E-01
8          -3.060E-05      -3.100E-01
9          -1.106E-04      -1.110E+00
10         1.016E-03      1.016E+01
11         -6.790E-04      -6.794E+00
12         4.000E-07      0.000E+00
13         -2.600E-06      -3.000E-02
14         6.000E-07      2.000E-03
*****
YAW CHAN READING      .0023624
YAW (DEGREES)         2.3624
TEMP CHAN READING     -.0012328
TEMPERATURE (DEGREES R) 452.445752
ATMOSPHERIC PRESS (INCHES) 30.00 (Hg)      407.10(H2o)
*****

IS DATA OK? PRESS "RECORD" TO RECORD DATA, PRESS "REPEAT" TO
REPEAT THE SCAN.

*****

```

Figure B4. Data Printed on the Screen -
One Probe Scan

label REPEAT. This will return the program to step 11. If the data is satisfactory, press f1 corresponding to soft key label RECORD. The disc drive amber light will flash momentarily as the data is stored on the disk.

13. Press GO ON to continue taking more data. This will return the program to step 11 again and the cycle repeats until the survey is terminated by pressing END PRB DATA.

14. A statement appears informing the user what file names the raw and scaled data files are under. This is just a reminder and requires no action.

15. The next statement is a reminder to clear the probe away from the instrumented blade before collecting a blade surface pressure distribution.

16. Options appear to either collect the blade data or by-pass this operation and go on to the print options.

17. The collect option requires file names for the raw and scaled data. Type the names as was done in steps 7 and 8.

18. The scan begins after RETURN is pressed for step 17. The blade data will be printed on the screen. As in step 12, the scan can be repeated if the data is unsatisfactory. An example of the screen presentation

is given in Fig. B5. Similarly, the data is stored when RECORD is pressed.

19. After recording blade data, there follows a series of print options for the stored probe and blade data. The steps are readily apparent from the program flow chart. Note that this is the only time to obtain a hard copy of the raw and scaled probe and blade data. Currently a program does not exist to print the data from an arbitrary file in the tabulated format produced by the ACQUIRE program.

20. The last step in program "ACQUIRE" is the option of terminating the program by pressing GO ON or loading the reduction program "CALC" by pressing CALC. If the data collected is to be reduced at a later time, then GO ON is the correct choice. Later, when the user is ready to reduce the data, program "CALC" is executed by following steps 5 and 6 except type /CLASSICK/PROGS/CALC; press RETURN, then press soft key RUN.

21. Once "CALC" is executed, the first prompt that appears is "ENTER THE NAME OF THE FILE CONTAINING THE PROBE DATA SCALED TO ENGINEERING UNITS." This is the scaled data file produced during the execution of "ACQUIRE." A new file is not being created at this time - the entry allows "CALC" to reduce the data in

SCAN NUMBER	VOLTAGE	GUAGE PRESS(INCHES H2o)
1	1.000E-06	1.000E-02
2	9.008E-04	8.998E+00
3	1.206E-03	1.205E+01
4	-3.380E-04	-3.390E+00
5	-1.048E-04	-1.058E+00
6	2.380E-05	2.280E-01
7	8.000E-05	7.900E-01
8	9.780E-05	9.680E-01
9	8.300E-05	8.200E-01
10	6.240E-05	6.140E-01
11	8.260E-05	8.160E-01
12	7.260E-05	7.160E-01
13	8.500E-05	8.400E-01
14	1.712E-04	1.702E+00
15	2.334E-04	2.324E+00
16	2.144E-04	2.134E+00
17	1.334E-04	1.324E+00
18	1.728E-04	1.718E+00
19	2.270E-04	2.260E+00
20	3.804E-04	3.794E+00
21	4.674E-04	4.664E+00
22	6.896E-04	6.886E+00
23	-1.709E-03	-1.710E+01
24	-3.333E-03	-3.334E+01
25	-3.202E-03	-3.203E+01
26	-2.779E-03	-2.780E+01
SAMPLE EXCEEDED MAXIMUM DEVIATION ALLOWED-SAMPLE RETAKEN		
27	-2.068E-03	-2.069E+01
28	-1.631E-03	-1.632E+01
29	-1.411E-03	-1.412E+01
30	-1.238E-03	-1.239E+01
31	-1.043E-03	-1.044E+01
32	-8.212E-04	-8.222E+00
33	-6.908E-04	-6.918E+00
34	-5.584E-04	-5.594E+00
35	-4.712E-04	-4.722E+00
36	-4.158E-04	-4.168E+00
37	-3.784E-04	-3.794E+00
38	-3.608E-04	-3.618E+00
39	-3.350E-04	-3.360E+00
40	-3.232E-04	-3.242E+00
41	-3.068E-04	-3.078E+00
42	-2.922E-04	-2.932E+00
43	3.334E-04	3.324E+00
44	-9.170E-04	-9.180E+00
45	-3.214E-04	-3.224E+00
46	1.446E-04	1.436E+00
47	9.420E-05	9.320E-01
48	-2.656E-04	-2.666E+00

.....

IS DATA OK? PRESS "REPEAT" TO REPEAT THE SCAN, PRESS "RECORD" TO RECORD THE DATA.

.....

Figure B5. Data Printed on the Screen -
Instrumented Blade Scan

the scaled data file to useful engineering quantities. Type the file name, e.g., L-4SEPASCL. Press RETURN.

22. The next two prompts are to allow "CALC" access to the probe calibration coefficient file - one for X and one for Phi. For this study the X file was MIKEC3 and the Phi file was MIKEC2. Type these file names in at the prompt followed by RETURN.

23. The one or two probe option appears next. The difference between the two choices, is in the prompts displayed. Two probes require two additional calibration coefficient files to be accessed - hence the prompts for the upper probe coefficient file for X and Phi.

24. The prompt "ENTER THE FILE NAME FOR THE DATA TO BE CALCULATED FROM THE PROBE," requires the user to create a new file for the data about to be reduced from the scaled data file. Type the file name, e.g., L-4SEPCALC. Press RETURN. Note that for the two-probe survey, an additional file must be created for the second probe, even though only one scaled data file was created in "ACQUIRE" for either a one or two-probe survey.

25. The next prompt will remain on the screen until the REDUCED DATA soft key is pressed. It is assumed that the "CALC" program would not be executed unless a

hard copy of the reduced data were desired, hence, no other options are available.

26. The option to calculate the mass averaged coefficient of pressure from the instrumented blade data appears next. Pressing GO ON bypasses this calculation. Pressing BLADE CP'S prompts the user for additional information.

27. As in step 21, type in the scaled blade data file, e.g., B-4SEPASCL. Press RETURN.

28. As in step 24, type in the name of the file to be created for the blade C_p 's, e.g., B-4SEPACALC. Press RETURN.

29. The next prompt requires the user to supply the limits of integration for the probe survey file entered in at the beginning of "CALC" e.g., L-4SEPASCL. This file contains data for the blade-to-blade survey upstream at midspan, which is the inlet condition to the instrumented blade. (The taps are located at midspan.) Quantities obtained from the blade-to-blade scaled file and reduced file are mass averaged for the C_p calculation as shown in Table I. The limits of integration are determined by noting what the beginning and ending scan numbers are. In the case of L-4SEPASCL, the first scan was 1 and the last scan, 31. For "ENTER THE LOW SCAN", type 1. Press RETURN. For

"ENTER THE HIGH SCAN", type 31. Press RETURN. Note that it is not the position that is entered, but the scan number corresponding to the position that is entered. Additionally, the integration limits can be over a shorter interval than the entire length of the survey if desired.

30. The prompt to print the blade C_p 's appears once the computer completes the C_p calculations.

31. The final prompt in "CALC" allows the user to terminate the program by pressing GO ON or to execute program "LOSS" by pressing LOSS. To calculate the AVDR and loss coefficient, requires an upper and a lower blade-to-blade survey. The execution of "LOSS" at this point would not be appropriate unless the user has a reduced file for an upper and lower blade-to-blade probe survey.

32. If program "LOSS" was not executed by pressing the LOSS soft key in step 31, then it can be executed by pressing the LOAD soft key and typing /CLASSICK/PROGS/LOSS between the quotation marks and pressing RETURN. Press the RUN soft key.

The static pressure rise coefficient, AVDR and loss coefficient are calculated from quantities contained in the reduced files of the upper and lower blade-to-blade surveys as shown in Table I. The

entries for the prompts provide the program access to the reduced data files.

33. The prompt "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE LOWER PROBE" requires the user to enter the file name for the lower probe blade-to-blade survey data that was reduced in "CALC" e.g., L-4SEPACALC. Press RETURN.

34. The next prompt pertains to the upper probe blade-to-blade survey reduced data e.g., U-4SEPACALC. Press RETURN.

35. Integration limits for the lower probe blade-to-blade survey are requested next. As noted in step 29, it is the scan number corresponding to the lower limit of the integration interval that is entered for "ENTER THE FIRST POINT." Likewise, the scan number for the upper limit of the integration interval is entered for "ENTER THE LAST POINT."

36. Limits of integration, in terms of scan number, are requested again for the upper probe blade-to-blade survey.

Note that the upper and lower integrations must be the same, exact, integral number of blade spaces (usually one), but the number of scans to cover the same distance will probably be different. It is vitally important to ensure that correct scan numbers,

match desired integration limits when the integration interval is something other than the beginning and ending of a blade-to-blade survey.

37. The calculations are performed and the static pressure rise coefficient, AVDR and loss coefficient are printed on the screen; the program then terminates.

B5. COMMON ERRORS AND RECOVERY STEPS

B5.1 Introduction

Common errors germane to the program execution are outlined in this section. Errors for each program are covered rather than broad categories of errors. Specific recovery steps are given which, in some cases, require knowledge of the program structure. Since probe surveys are time consuming, it behooves the investigator to be familiar with the program. A mistake in many cases may be rectified by stopping the program, then continuing at a specific line in the program. To this end, a copy of the three main programs should be available during a survey. A listing of the programs may be obtained by following the steps outlined in Section B6. In those cases where a specific recovery step cannot be made, the user is referred to Ref. 13-17. A complete listing and description of system errors can be found in Ref. 16.

While not specifically an error associated with program execution, the new user may become lost in the directory. The Mass Storage Is or MSI command (addressed in Ref. 13),

in conjunction with a path name, allows the user to move through the directory levels. The command `MSI"/` places the system in the root directory while the command `MSI"/CLASSICK`, places the system in the CLASSICK directory which is subordinate to the root directory. Executing any of the three main programs by following the steps in Section B4 will initially place the system in the PROGS subdirectory. As the program runs, the subdirectory will change to facilitate entry of the various file names. In all cases when the programs have terminated, the system is in the REDDATA subdirectory. The program can be repeated even from this subdirectory by pressing RUN. However, if the user decides to move somewhere else in the directory, the MSI command and path name must be used. As an example, upon "CALC" termination it is desired to execute "ACQUIRE." The command `MSI "/CLASSICK/PROGS` puts the system in the PROGS subdirectory. "ACQUIRE" can then be loaded from the subdirectory PROGS by pressing LOAD and typing ACQUIRE between the quotation marks.

Alternatively, "ACQUIRE" could have been loaded from subdirectory REDDATA by pressing LOAD followed by typing `"/CLASSICK/PROGS/ACQUIRE`.

B5.2 ACQUIRE

1. Errors Involving File Names

These errors will most likely be the result of either attempting to enter a file name which exceeds twelve characters or entering an undesired file name. If a

system error is returned while attempting to enter a file name and it is suspected that the name exceeded twelve characters, reenter the file name using twelve characters or less. Refer to Ref. 16 for other system errors.

Undesired file names which have been entered into the system i.e., the file was created, can be handled in different ways. Assuming no data had been collected, the program could be aborted, the undesired file name purged and the program reexecuted. The steps for this would be:

- a. Press STOP (This is a labeled key on the top row).
- b. Type MSI "/CLASSICK/SUBDIRECTORY NAME" (subdirectory name is either DATA for rawdata files or REDDATA for scaled or reduced data files).
- c. RETURN
- d. Type PURGE "UNDESIRE FILE NAME" (include quotation marks).
- e. RETURN
- f. Press LOAD
- g. Type /CLASSICK/PROGS/ACQUIRE between quotation marks.
- h. RETURN
- i. Press RUN

Alternatively, the program could be run with the undesired file name and the name changed after terminating "ACQUIRE." The steps for this would involve writing a short program.

2. Incorrect Atmospheric Pressure Entry

The required steps are as follows:

- a. Press STOP
- b. Type Pbaro = CORRECT VALUE
- c. RETURN
- d. Press CONTINUE

3. Incorrect Probe Option Selected

The required steps are as follows:

- a. Press STOP
- b. Type CONT 145

[Line 145 is the line number which the program would have to return to in order to generate the probe option prompt again.]

- c. RETURN

4. Incorrect Scan Number or Probe Position Entered

Upon pressing RECORD, an error statement will be returned if the scan number was entered out of sequence. This will prevent the data from being stored. Take the following steps:

- a. Press STOP
- b. Type CONT 162 for a one probe survey
- c. Type CONT 160 for a two probe survey

[These are the line numbers in the program that return the prompt for entering the scan number and position.]

- d. RETURN

An incorrect position entry will not return an error statement. A correction to position can be done using a version of program "correct" after completion of the survey.

5. Premature Termination of Data Collection

If END PRB DATA was mistakenly pressed, the ability to continue with probe data collection can be regained by these steps:

- a. Press STOP
- b. Type CONT 162 for a one probe survey
- c. Type CONT 160 for a two probe survey
- d. RETURN

6. By-passed Collecting Blade Data Mistakenly

The required steps are as follows:

- a. Press STOP
- b. Type CONT 357. [This line number returns the blade data collection option prompt.]
- c. RETURN

7. By-passed Hard Copy Print Options Mistakenly

The required steps are as follows:

- a. Press STOP
- b. Type CONT 408. [Line 408 is the beginning of the hard copy option prompts.]
- c. RETURN

B5.3 CALC

1. Incorrect File Entered

The "CALC" program will reduce any scaled data file obtained from "ACQUIRE." If an undesired file name was entered, abort the program then reexecute it using the following steps:

- a. Press STOP
- b. Press RUN

2. Incorrect Probe Coefficient File Entered

The required steps are as follows:

- a. Press STOP
- b. Type CONT 144. [Line 144 will return the prompt for entering the X velocity coefficient file.]
- c. RETURN

3. Incorrect Probe Option Selected

The required steps are as follows:

- a. Press STOP
- b. Type CONT 200 [Line 200 returns the probe option prompt.]
- c. RETURN

4. Incorrect Reduced Data File Name Entered

"CALC" is short enough to allow termination and reexecution of the program in order to enter the correct desired file name for the reduced data. The steps to do this are:

- a. Press STOP
- b. Press RUN

The undesired file name can be purged from the REDDATA subdirectory by following the steps in paragraph "1" of Section B5.2. If "CALC" is to be executed after the purge operation, press LOAD and type /CLASSICK/PROGS/CALC between the quotation marks. Press RETURN followed by pressing RUN.

5. By-passed Blade C_p Calculations Mistakenly

The required steps are as follows:

- a. Press STOP
- b. Type CONT 736. [Line 736 returns the blade C_p calculation option.]
- c. RETURN

6. Incorrect Limits of Integration Entered

Unless the limits entered are non existent, no error will be returned--only erroneous data if the limits are wrong. If the C_p values do not look correct, the calculation can be repeated if the integration limits are suspected to be in error. Perform the following:

- a. Press STOP
- b. Type CONT 736. [This will return the blade C_p calculation option. A new reduced blade data file name will have to be entered since the previous file name contains the suspect C_p reduced data. This suspect file can be purged following the steps in paragraph 1, Section B5.2.]
- c. RETURN

B5.4 LOSS

"LOSS" is a short program; any errors in entering the prompted entries can be handled by terminating the program and starting again. The steps are:

- a. Press STOP
- b. Press RUN

B6. MODIFICATIONS

B6.1 Introduction

The programs were written to accomodate changes that might be expected to occur in the equipment set-up of the cascade facility. Variables defining scanner channel assignments, HP-IB equipment addresses and other variables that might change as the investigations are modified were placed at the beginning of the program. Thus, all such changes are made in one section of the code. Those variables embedded in the program such as temperature, yaw and position are cited by line number to allow modifications to be made in the way they are evaluated. Array elements were redefined when necessary. Changes to array elements require familiarization with the program structure. All changes should be followed up with a revalidation of the modified code prior to acquiring new survey data.

Program modifications are made and their effects evaluated best by examining a hard copy of the program.

Obtain a copy of any program in the PROGS subdirectory by performing the following steps:

- a. Type MSI"/CLASSICK/PROGS"
- b. RETURN
- c. Type CAT [This will list all the programs or files in the PROGS subdirectory. After identifying the desired program, proceed with the next step.]
- d. Type PRINTER IS 701 [Output is now directed to the printer.]
- e. RETURN
- f. LOAD "DESIRED PROGRAM"
- g. RETURN
- h. Type LIST
- i. RETURN [The program will now be printed.]

Note that after the program is printed, return the system to print on the screen by typing PRINTER IS 1, followed by RETURN.

Once the changes have been identified, refer to Chapter 11, of Ref. 13 to edit and store the modified program.

B6.2 Common Changes

In "ACQUIRE" the common variables that might be changed are listed in the front of the program along with a plain language description of what the variable represents. It is assumed the user will understand the rudiments of the acquisition system prior to making any variable changes.

B6.3 Temperature, Yaw and Position Changes

The variable Temp on line 245 of "ACQUIRE" is defined by an equation that represents the characteristics of the iron-constantan thermocouple used in the present work. This equation will change if the thermocouple changes. Edit this line with appropriate changes to account for a thermocouple change.

Referencing the yaw angle to a precisely known horizontal or vertical axis as outlined in Appendix C requires a correction to the yaw transducer output. This correction can be made in "ACQUIRE" by modifying line 240 for a one probe survey or lines 207 and 212 for a two probe survey. An alternative to this would be to modify "CALC". Change line 626 for a one probe survey; change lines 359 and 491 for a two probe survey.

Incorporating the use of linear potentiometers for probe position read-out is a more extensive modification to "ACQUIRE" which will be briefly summarized for a one probe survey. A scanner channel for the potentiometer transducer must be assigned and this channel defined by a variable name. The variable must be included in the COM statement on line 169 and in line 754 of the subprogram "Readdvm". A CALL statement similar to that listed for the Yaw and Temp channel readings on lines 238 and 242, is required. A statement allowing the transducer channel to be read by the DVM must be included in the IF-ELSE structure of "Readdvm". Array elements presently defining

probe position must be modified if necessary and traced through "CALC".

B6.4 Array Elements Changes

In "ACQUIRE," Scanivalve port readings, in addition to other quantities are assigned an array element. A change in an array element assignment may require a change in the formatted print statements and headings. Additionally, since array elements are redefined during the execution of the three main programs, a trace through those programs is necessary to ensure that any changes in array element assignments are consistent.

B.7 PROGRAMS AND DATA

A complete listing of the program and data files is given in the Table of Contents for Appendix B. The three main programs have been previously explained. The listed subprograms are called by the main programs from the ROUTINES subdirectory during execution. The plot programs are specifically those used to plot some of the data in the present study. The following is a list of the figures corresponding to the plot program written for it:

<u>Program</u>	<u>Figure</u>
PREFPQREF	18
BETAPOSIT	19
VVREFSPAN	8
VVREFUSPAN	11
CPBLADEPLOT	23

Plots are printed to the printer by pressing DUMP GRAPHICS. Samples of the programs to correct erroneous data points or to rereference the probe-displacement are included. "CORRECT A" (Section B7.12) was used to extrapolate the recorded data to add an additional scan. This was done to enable data to be integrated over exactly one blade space. The artificially generated scan does not appear in Table B4 but does appear in Table B5. "CORRECT B" (Section B7.13) provided the means to correct an incorrect value of probe position entered during a scan. The corrected value then appears in Table B5. "CORRECT C" (Section B7.14) was used to rereference displacement values of file SUS-4SEPASCL (example not included) to make the midspan position equal to zero.

The probe calibration coefficients were stored in a file using "PRBCOEF" (Section B7.15) with actual coefficients in the DATA statement in lieu of those in the example. Note that the DATA statement must contain 36 entries to be consistent with the way the file is used in the program "CALC."

The remainder of the tables have been previously addressed.

B7.1 Acquisition Program ACQUIRE

[illegible]

```

127                                INUMBERS 8X105-848.
128    ASSIGN @Path1 TO Rawfile$    IASSIGNS A PATH NAME TO THE RAW FILE JUST
129                                ICREATED FOR ENTER AND OUTPUT STATEMENTS.
130    MASS STORAGE IS "/CLASSICK/REDDATA"
132    PRINT "....."
133    PRINT ""
134    PRINT "NAME FILE TO STORE THE RAW DATA SCALED TO ENGINEERING UNITS"
135    INPUT Scffile$
136    CREATE BDATA Scffile$,100,848
137    ASSIGN @Path2 TO Scffile$
138    PRINT "....."
139    PRINT ""
140    PRINT "ENTER THE ATMOSPHERIC PRESURE IN INCHES Hg"
141    INPUT Pbaro
142    PRINT ""
143    PRINT "....."
144    PRINT ""
145    PRINT "PRESS "ONE PROBE" IF ONE PROBE IS USED."
146    PRINT "PRESS "TWO PROBES" IF TWO PROBES ARE USED."
147    PRINT ""
148    PRINT "....."
149    PRINT ""
150    ON KEY 1 LABEL "ONE      PROBE" GOTO Numberprbs1 ICODING FOR SOFT KEYS
151    ON KEY 4 LABEL "TWO      PROBES" GOTO Numberprbs2
152    Spin1:    GOTO Spin1    IKEEPS SOFT KEY LABELS ON SCREEN UNTIL
153                                IEITHER SOFT KEY IS PRESSED.
154    Numberprbs1: Noofprbs=1    INUMBER OF PROBES DETERMINES WHERE TO
155                                IGO IN THE PROGRAM.
156    GOTO Checknoofprbs
157    Numberprbs2: Noofprbs=2
158    Checknoofprbs: IF Noofprbs=2 THEN
159    Start2prbs: INPUT "ENTER THE SCAN NUMBER, LOWER PROBE POSITION AND UPPER P
160    ROBE POSITION",Scan,Posit1,Positu
161    ELSE
162    Start1prb:INPUT "ENTER THE SCAN NUMBER AND PROBE POSITION",Scan,Posit
163    PRINT ""
164    PRINT "....."
165    END IF
166    COM /Positvrbls/ Svc,Scn    ICOMMON BLOCK VARIABLES USED IN POSITIONING
167                                ITHE SCANIVALVE PORTS.
168    COM /Readvrbls/ Scan,Dvm,Scanvb(1,48),Tempchnrd,Yawchnrd,Scnyawchn,Scntemp
169    chn,Scnrdsvc,Scanva(1,48),Scnrdsavc,Noofprbs,Yawchnrd,Scnrdsavc
170    COM /Readvrbls/ Yawchnrd1,Scnyawchnu,Scnyawchn1,Maxdif
171                                IABOVE COMMON BLOCK VARIABLES USED IN
172                                IOBTAINING DVM READINGS.
173    IF Noofprbs=2 THEN
174    GOTO Read2prbs
175    ELSE
176    GOTO Read1prb
177    END IF
178    Read2prbs:PRINT "SCAN NUMBER",Scan
179    PRINT "LOWER PROBE POSITION",Posit1
180    PRINT "UPPER PROBE POSITION",Positu
181    PRINT "PORT          VOLTAGE          GAUGE PRESS(INCHES H2o) "
182    MAT Scanvb= (0)
183    FOR Db=Dportb TO Hportb
184    CALL Scnvportposit(Scnvb,Db,Scnhmsvc,Scnstpsvc) ICALLS SUBROUTINE
185                                ITO POSITION SCANIVALVE PORTS. INITIALLY IT WILL
186                                IPOSITION SCANIVALVE TO PORT 1.
187    CALL Readdvm(Db,Scnrdsavc) ICALLS SUBROUTINE TO READ THE
188                                ITHE SCANIVALVE PORT READINGS ON
189                                ITHE DVM.
190    Prntdatb(1,1)=Scanvb(1,1)*10000 ICONVERTS DVM READINGS TO PRESSURE
191                                IVALUES.
192    IF Db>1 THEN Prntdatb(1,Db)=Scanvb(1,Db)*10000-Prntdatb(1,1) IALLWS
193                                IPORT 1 READING TO BE SUBTRACTED
194

```

```

198                                FROM OTHER READINGS.
200 PRINT USING "00,10X,MD.3DE,10X,MD.3DE" iDb,Scanvb(1,Db),Prntdatb(1,Db)
201 NEXT Db
202 CALL Readdvm(Db,Scnyawchn)      IDb IN THIS CONTEXT ACTS AS A DUMMY
203                                I VARIABLE. DVM READS THE LOWER PROBE YAW TRANSDUCER.
204 CALL Readdvm(Db,Scnyawchnu)    I UPPER PROBE YAW TRANSDUCER IS READ.
205 PRINT "....."
206 PRINT "LOWER PROBE YAW CHAN READING"      iYawchnrdl
207 Yawl=Yauchnrdl*1000                    I THIS IS WHERE THE REFERENCING
208                                I CORRECTION FOR THE YAW ANGLE IS MADE
209 PRINT "LOWER PROBE YAW (DEGREES)"      iYawl
210 PRINT "UPPER PROBE YAW CHAN READING"    iYawchnrdu
211 Yawu=Yauchnrdu*1000                    I MAKE THE REFERENCING CORRECTION FOR
212                                I UPPER PROBE YAW ANGLE HERE.
213 PRINT "UPPER PROBE YAW (DEGREES)"      iYawu
214 GOTO Continue
215 Readlprb:PRINT "SCAN NUMBER" iScan      ICODING FOR READING ONE PROBE BEGINS
216 PRINT "PROBE POSITION" iPosit
217 PRINT "PORT" VOLTAGE GUAGE PRESSURE(INCHES H2o)"
218 MAT Scanvb= (0)
219 FOR D=Dport TO Hport
220 CALL Scnvpportposit(iScnvd,D,Scnhmavcb,Scnstpsvcb) ICALLS SUBROUTINE TO
221                                I POSITION SCANIVALVE PORT.
222 CALL Readdvm(D,Scnrdsvc) ICALLS SUBROUTINE TO READ SCANIVALVE PORTS
223                                I ON THE DVM.
224 Prntdatb(1,1)=Scanvb(1,1)*10000 I SCALES DVM READINGS TO
225                                I TO ENGINEERING UNITS.
226 IF D>1 THEN Prntdatb(1,D)=Scanvb(1,D)*10000-Prntdatb(1,1) IPORT 1
227                                I READING SUBTRACTED OFF THE SCANIVALVE
228                                I PORT READINGS.
229 PRINT USING "00,10X,MD.3DE,10X,MD.3DE" iD,Scanvb(1,D),Prntdatb(1,D)
230 NEXT D
231 PRINT "....."
232 CALL Readdvm(D,Scnyawchn)
233 PRINT "YAW CHAN READING"      iYawchnrd
234 Yaw=Yauchnrd*1000 I THIS IS WHERE TO CORRECT FOR PROBE YAW REFERENCING
235 PRINT "YAW (DEGREES)"      iYaw
236 Continue:CALL Readdvm(Db,Scntempchn)
237 PRINT "TEMP CHAN READING"      iTempchnrd
238 T=Tempchnrd*1000
239 Temp=33.91+T+34.25+460 I IRON CONSTANTAN THERMOCOUPLE EQUATION
240                                I SAME ONE USED BY DREON.
241 PRINT "TEMPERATURE (DEGREES R)"      iTemp
242 Pa=Pbaro*13.57 I ATMOSPHERIC PRESS CONVERTED TO INCHES H2o
243 PRINT USING "26A,4X,2D.2D,X,4A,5X,3D.2D,5A" i"ATMOSPHERIC PRESS (INCHES)",P
244 baro,"(Hg)",Pa,"(H2o)"
245 PRINT ""
246 PRINT "....."
247 PRINT ""
248 PRINT "IS DATA OK? PRESS ""RECORD"" TO RECORD DATA, PRESS ""REPEAT"" TO"
249 PRINT "REPEAT THE SCAN."
250 PRINT ""
251 PRINT "....."
252 ON KEY 1 LABEL "RECORD" GOTO Storerawdata
253 ON KEY 4 LABEL "REPEAT" GOTO Repeatscan
254 Spin2: GOTO Spin2
255 Repeatscan: IF Noofprbs=2 THEN
256 GOTO Start2prbs
257 ELSE
258 GOTO Start1prb
259 END IF
260 Storerawdata: I STORE RAWDATA TO RAWDATA FILE
261 IF Noofprbs=2 THEN
262 MAT Rawdat= (0)
263 FOR K=1 TO 19
264 Rawdat(1,K)=Scanvb(1,K) I ASSIGN ALL THE SCANIVALVE READINGS IN THE

```

```

271                                     !SCANVB ARRAY TO THE RAWDAT ARRAY ELEMENT
272                                     !BY ELEMENT
274     NEXT K
275     Rawdat(1,20)=Posit1
276     Rawdat(1,21)=Positu
277     Rawdat(1,22)=Yawchnrd1
278     Rawdat(1,23)=Yawchnrdu
279     Rawdat(1,24)=Tempchnrd
280     Rawdat(1,25)=Pa
281     OUTPUT @Path1,Scan1Rawdat(*)
282                                     !THE DATA IS STORED IN THE RAW DATA
283                                     !FILE WHICH WAS PREVIOUSLY CREATED.
284                                     !THIS IS A RANDOM OUTPUT STATEMENT.
285     MAT Scaled= (0)
286     FOR K=1 TO 19
287     Scaled(1,K)=Prntdatb(1,K)
288                                     !SAME METHOD HERE EXCEPT SCALED DATA
289                                     !IS REASSIGNED.
290     NEXT K
291     Scaled(1,20)=Posit1
292     Scaled(1,21)=Positu
293     Scaled(1,22)=Yaw1
294     Scaled(1,23)=Yawu
295     Scaled(1,24)=Temp
296     Scaled(1,25)=Pa
297     OUTPUT @Path2,Scan1Scaled(*)
298     ELSE
299     MAT Rawdat= (0)
300     FOR K=1 TO 14
301                                     !FOR THE ONE PROBE OPTION, ASSIGNS
302                                     !ALL THE SCANIVALVE READINGS IN THE
303                                     !ARRAY TO THE RAWDAT ARRAY ELEMENT
304                                     !BY ELEMENT.
305     Rawdat(1,K)=Scanvb(1,K)
306     NEXT K
307     Rawdat(1,15)=Posit
308     Rawdat(1,16)=Yawchnrd
309     Rawdat(1,17)=Tempchnrd
310     Rawdat(1,18)=Pa
311     OUTPUT @Path1,Scan1Rawdat(*)
312                                     !THE DATA IS STORED IN THE RAW DATA
313                                     !WHICH WAS PREVIOUSLY CREATED. THIS
314                                     !IS A RANDOM OUTPUT STATEMENT.
315     MAT Scaled= (0)
316     FOR K=1 TO 14
317     Scaled(1,K)=Prntdatb(1,K)
318                                     !SAME METHOD HERE EXCEPT SCALED DATA
319                                     !IS REASSIGNED.
320     NEXT K
321     Scaled(1,15)=Posit
322     Scaled(1,16)=Yaw
323     Scaled(1,17)=Temp
324     Scaled(1,18)=Pa
325     OUTPUT @Path2,Scan1Scaled(*)
326     END IF
327     PRINT "....."
328     PRINT ""
329     PRINT "PRESS ""GO ON"" TO CONTINUE TAKING DATA, PRESS ""END PRB DATA""
330     PRINT "TO TERMINATE PROBE DATA COLLECTION."
331     PRINT ""
332     PRINT "....."
333     ON KEY 1 LABEL "END PRB DATA" GOTO Printfilename
334     ON KEY 4 LABEL "GO ON" GOTO Collectdata
335     Spin3: GOTO Spin3
336     Collectdata: IF Noofprbs=2 THEN
337         GOTO Start2prbs
338     ELSE
339         GOTO Start1prb
340     END IF
341     PRINT "....."
342     PRINT ""

```

```

343 Printfilename: PRINT "RAW PROBE DATA IS STORED "
344 PRINT "IN DATA FILE",Rawfiles
345 PRINT ""
346 PRINT "....."
347 PRINT ""
348 PRINT "PROBE RAW DATA SCALED TO ENGINEERING UNITS"
349 PRINT "IS STORED IN REDDATA FILE",Scifiles
350 PRINT ""
351 PRINT "....."
352 PRINT ""
353 PRINT "ENSURE THE PROBE IS CLEAR OF THE INSTRUMENTED BLADE."
354 PRINT ""
355 PRINT "....."
356 PRINT ""
357 PRINT "PRESS "COLLECT DATA" TO COLLECT DATA FOR THE INSTRUMENTED BLADE"
358 PRINT "PRESS "GO ON" TO CONTINUE WITH THE PROGRAM."
359 PRINT ""
360 ON KEY 4 LABEL "GO ON" GOTO Printoption1
361 ON KEY 1 LABEL "COLLECT DATA" GOTO Namefile
362 Spin4: GOTO Spin4
363 Namefile: MASS STORAGE IS "/CLASSICK/DATA" (CODING FOR INSTRUMENTED
364 IBLADE SECTION OF PROGRAM IS SAME AS FOR
I PROBE SECTION.

366 PRINT "....."
367 PRINT ""
368 PRINT "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE BLADE."
369 INPUT Rawbladfiles
370 CREATE BDAT Rawbladfiles,100,384 1100 RECORDS, EACH RECORD CAN CONTAIN
371 148 REAL NUMBERS 8X48=384.
373 ASSIGN @Path3 TO Rawbladfiles
374 MASS STORAGE IS "/CLASSICK/REDDATA"
375 PRINT "....."
376 PRINT ""
377 PRINT "NAME FILE FOR THE RAW BLADE DATA SCALED TO ENGINEERING UNITS."
378 INPUT Scibladfiles
379 PRINT ""
380 PRINT "....."
381 CREATE BDAT Scibladfiles,100,384
382 ASSIGN @Path4 TO Scibladfiles
383 Bladeread: MAT Scanva= (0)
384 PRINT "SCAN NUMBER",Scan
385 PRINT "PORT VOLTAGE GUAGE PRESS(INCHES H2o)"
386 FOR Da=Dporta TO Hporta
387 CALL Scnvportposit(Scnva,Da,Scnhsvca,Scnstpsvca)
388 CALL Readddm(Da,Scnrdsvca)
389 Prntdata(1,Da)=Scanva(1,Da)*10000
390 IF Da>1 THEN Prntdata(1,Da)=Scanva(1,Da)*10000-Prntdata(1,1)
391 PRINT USING "DD,10X,MD.3DE,10X,MD.3DE",Da,Scanva(1,Da),Prntdata(1,Da)
392 NEXT Da
393 PRINT "....."
394 PRINT ""
395 PRINT "IS DATA OK? PRESS "REPEAT" TO REPEAT THE SCAN, PRESS "RECORD""
396 PRINT "TO RECORD THE DATA."
397 PRINT ""
398 PRINT "....."
399 ON KEY 1 LABEL "RECORD" GOTO Storedata
400 ON KEY 4 LABEL "REPEAT" GOTO Bladeread
401 Spin5: GOTO Spin5
402 Storedata: OUTPUT @Path3;Scanva(*)
403 OUTPUT @Path4;Prntdata(*)
404 PRINT "THIS DATA IS ASSOCIATED WITH THE LAST SCAN OF FILE ".Scifiles
405 PRINT ""
406 Printoption1: PRINT "....."
407 PRINT ""
408 PRINT "ALIGN PAPER IN PRINTER. "
409 PRINT ""

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410 PRINT "TO PRINT OUT A TABULATION OF THE RAW DATA COLLECTED FROM"
411 PRINT ""
412 PRINT "THE PROBE(S), PRESS "RAW TABLE". PRESS "60 ON""
413 PRINT ""
414 PRINT "TO CONTINUE WITH THE PROGRAM."
415 PRINT ""
416 PRINT "....."
417 ON KEY 1 LABEL "RAW TABLE" GOTO Printrawtable
418 ON KEY 4 LABEL "60 ON" GOTO Printoption2
419 Spin6: GOTO Spin6
420 Printrawtable: MASS STORAGE IS "/CLASSICK/DATA"
421 ASSIGN @Path1 TO Rawfile$ ISTATEMENT PUTS FILE POINTER AT BEGINING
422 IOF FILE.
424 PRINT ""
425 PRINT "PRESS "ONE PROBE" IF ONE PROBE WAS USED."
426 PRINT "PRESS "TWO PROBES" IF TWO PROBES WERE USED."
427 PRINT ""
428 PRINT "....."
429 ON KEY 1 LABEL "ONE PROBE" GOTO Numberofprbs1
430 ON KEY 4 LABEL "TWO PROBES" GOTO Numberofprbs2
431 Spin7: GOTO Spin7
432 Numberofprbs1: Noofprbs=1
433 GOTO Howmanyprbs
434 Numberofprbs2: Noofprbs=2
435 Howmanyprbs: IF Noofprbs=2 THEN
436 PRINTER IS Prnter ISENDS PRINT STATEMENTS TO THE PRINTER.
437 PRINT "....."
438 PRINT "PROBE RAW DATA FILE ",Rawfile$
439 PRINT "....."
440 PRINT "SCAN L PRB 1 2 3 4
5"
441 PRINT " FOSIT"
442 FOR N=1 TO 100
443 ENTER @Path1,NiRawdat(*) ISTATEMENT ACCESSES THE RAW DATA FILE IN
444 IRANDOM MODE.
445 ON END @Path1 GOTO Twoprintrawl ISINCE ALL RECORDS OF A FILE MAY
446 INOT BE FILLED (RECALL 100 RECORDS WERE
447 IRESERVED FOR 100 DATA POINTS), THE ON
448 IEND STATEMENT ALLOWS THE PROGRAM TO
449 ICONTINUE AT THE Twoprintrawl LINE WHEN
450 IAN END OF FILE CONDITION OCCURS.
451
453 Posit1=Rawdat(1,20)
454 Port1=Rawdat(1,1)
455 Port2=Rawdat(1,2)
456 Port3=Rawdat(1,3)
457 Port4=Rawdat(1,4)
458 Port5=Rawdat(1,5)
459 PRINT USING "40,3X,40.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE"
iN,Posit1,Port1,Port2,Port3,Port4,Port5
460 NEXT N
461 Twoprintrawl: PRINT "....."
462 PRINT "SCAN 6 7 8 9 10
11"
463 FOR N=1 TO 100
464 ENTER @Path1,NiRawdat(*)
465 ON END @Path1 GOTO Twoprintraw2
466 Port6=Rawdat(1,6)
467 Port7=Rawdat(1,7)
468 Port8=Rawdat(1,8)
469 Port9=Rawdat(1,9)
470 Port10=Rawdat(1,10)
471 Port11=Rawdat(1,11)
472 PRINT USING "40,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3DE"
iN,Port6,Port7,Port8,Port9,Port10,Port11
473 NEXT N

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474 Twoprintraw2: PRINT "....."
....."
475 PRINT "SCAN   U PR8      12      13      -      14      15
16"
476 PRINT "      POSIT"
477 FOR N=1 TO 100
478 ENTER @Path1,NiRawdat(*)
479 ON END @Path1 GOTO Twoprintraw3
480 Positu=Rawdat(1,21)
481 Port12=Rawdat(1,12)
482 Port13=Rawdat(1,13)
483 Port14=Rawdat(1,14)
484 Port15=Rawdat(1,15)
485 Port16=Rawdat(1,16)
486 PRINT USING "4D,3X,4D,2D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE"
iN,Positu,Port12,Port13,Port14,Port15,Port16
487 NEXT N
488 Twoprintraw3: PRINT "....."
....."
489 PRINT "SCAN      17      18      19 "
490 FOR N=1 TO 100
491 ENTER @Path1,NiRawdat(*)
492 ON END @Path1 GOTO Twoprintraw4
493 Port17=Rawdat(1,17)
494 Port18=Rawdat(1,18)
495 Port19=Rawdat(1,19)
496 Pa=Rawdat(1,25)
497 PRINT USING "4D,3X,MD,3DE,4X,MD,3DE,4X,MD,3DE"iN,Port17,Port18,Port19
498 NEXT N
499 Twoprintraw4: PRINT "....."
....."
500 PRINT "SCAN   YAW L      YAW U      TEMPCHN      ATMOS"
501 PRINT "      VOLT      VOLT      VOLT      PRESSURE"
502 FOR N=1 TO 100
503 ENTER @Path1,NiRawdat(*)
504 ON END @Path1 GOTO Twoprintraw5
505 Yawchnrd1=Rawdat(1,22)
506 Yawchnrd2=Rawdat(1,23)
507 Tempchnrd=Rawdat(1,24)
508 Pa=Rawdat(1,25)
509 PRINT USING "4D,3X,MD,3DE,4X,MD,3DE,4X,MD,3DE,4X,3D,2D"iN,Yawchnrd1,Yawchnr
du,Tempchnrd,Pa
510 NEXT N
511 Twoprintraw5: OFF END @Path1      I TERMINATES THE ON END COMMAND
512 ELSE
513 PRINTER IS Prnter
514 PRINT "....."
515 PRINT "PROBE RAW DATA FILE  ",Rawfile$
516 PRINT "....."
517 PRINT "SCAN PROBE      1      2      3      4      5"
518 PRINT "      POSIT"
519 FOR N=1 TO 100
520 ENTER @Path1,NiRawdat(*)      I STATEMENT ACCESSES THE RAW DATA FILE IN
521                                I RANDOM MODE
523 ON END @Path1 GOTO Printraw1    I SINCE ALL RECORDS OF A FILE MAY NOT BE
524                                I FILLED (RECALL 100 WERE USED FOR 100
525                                I DATA POINTS), ON END STATEMENT ALLOWS THE
526                                I PROGRAM TO CONTINUE AT THE Printraw1 LINE
528 Posit=Rawdat(1,15)
529 Port1=Rawdat(1,1)
530 Port2=Rawdat(1,2)
531 Port3=Rawdat(1,3)
532 Port4=Rawdat(1,4)
533 Port5=Rawdat(1,5)
534 PRINT USING "4D,2X,4D,2D,2X,MD,3DE,2X,MD,3DE,2X,MD,3DE,2X,MD,3DE,2X,MD,3DE"
iN,Posit,Port1,Port2,Port3,Port4,Port5

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535 NEXT N
536 Printraw1: PRINT "....."
537 PRINT "SCAN 6      7      8      9      10      11"
538 FOR N=1 TO 100
539 ENTER @Path1,NiRawdat(0)
540 ON END @Path1 GOTO Printraw2
541 Port6=Rawdat(1,6)
542 Port7=Rawdat(1,7)
543 Port8=Rawdat(1,8)
544 Port9=Rawdat(1,9)
545 Port10=Rawdat(1,10)
546 Port11=Rawdat(1,11)
547 PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE"
    iN,Port6,Port7,Port8,Port9,Port10,Port11
548 NEXT N
549 Printraw2: PRINT "....."
550 PRINT "SCAN 12      13      14      YAWCHAN      TEMPCHAN      AT"
551 PRINT "      MOS"
552 PRINT "      VOLTAGE      VOLTAGE      FR"
553 PRINT "      ESSURE"
554 FOR N=1 TO 100
555 ENTER @Path1,NiRawdat(0)
556 ON END @Path1 GOTO Printraw3
557 Port12=Rawdat(1,12)
558 Port13=Rawdat(1,13)
559 Port14=Rawdat(1,14)
560 Yawchnrd=Rawdat(1,15)
561 Tempchnrd=Rawdat(1,17)
562 Pa=Rawdat(1,18)
563 PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,3D.2D"
    iN,Port12,Port13,Port14,Yawchnrd,Tempchnrd,Pa
564 NEXT N
565 Printraw3: PRINT "....."
566 PRINT "....."
567 OFF END @Path1      ITERMINATES ON END STATEMENT
568 END IF
569 PRINTER IS Screen      IRETURNS PRINT STATEMENTS TO MONITOR.
570 PRINT "....."
571 PRINT "....."
572 Printoption2: PRINT "ALIGN PAPER IN PRINTER."
573 PRINT "....."
574 PRINT "TO PRINTOUT A TABULATION OF THE PROBE DATA SCALED IN"
575 PRINT "....."
576 PRINT "ENGINEERING UNITS, PRESS ""SCALED DATA""."
577 PRINT "....."
578 PRINT "PRESS ""GO ON"" TO CONTINUE WITH THE PROGRAM."
579 PRINT "....."
580 PRINT "....."
581 ON KEY 1 LABEL " SCALED DATA" GOTO Printscaledtable
582 ON KEY 4 LABEL "GO ON" GOTO Printoption3
583 Spin8: GOTO Spin8
584 Printscaledtable: MASS STORAGE IS "/CLASSICK/REDDATA"
585 ASSIGN @Path2 TO Scifile8
586 PRINT "....."
587 PRINT "PRESS ""ONE PROBE"" IF ONE PROBE WAS USED."
588 PRINT "PRESS ""TWO PROBES"" IF TWO PROBES WERE USED."
589 PRINT "....."
590 PRINT "....."
591 ON KEY 1 LABEL "ONE      PROBE" GOTO Numberprobes1
592 ON KEY 4 LABEL "TWO      PROBES" GOTO Numberprobes2
593 Spin9: GOTO Spin9
594 Numberprobes1: Noofprbs=1
595 GOTO Howmanyprobes

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593 Numberprobes2: Noofprbs=2
594 Howmanypbes: IF Noofprbs=2 THEN
595 PRINTER IS Prnter
596 PRINT "*****"
597 PRINT "PROBE SCALED DATA FILE ",Scifiles
598 PRINT "*****"
599 PRINT "SCAN L PRB 1 2 3 4
5"
600 PRINT " POSIT"
601 FOR N=1 TO 100
602 ENTER @Fath2,NiScaled(*)
603 ON END @Fath2 GOTO Twoprintsc11
604 Posit1=Scaled(1,20)
605 Port1=Scaled(1,1)
606 Port2=Scaled(1,2)
607 Port3=Scaled(1,3)
608 Port4=Scaled(1,4)
609 Port5=Scaled(1,5)
610 PRINT USING "4D,3X,4D,2D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE"
iN,Posit1,Port1,Port2,Port3,Port4,Port5
611 NEXT N
612 Twoprintsc11: PRINT "*****"
*****"
613 PRINT "SCAN 5 7 8 9 10
11"
614 FOR N=1 TO 100
615 ENTER @Fath2,NiScaled(*)
616 ON END @Fath2 GOTO Twoprintsc12
617 Port6=Scaled(1,6)
618 Port7=Scaled(1,7)
619 Port8=Scaled(1,8)
620 Port9=Scaled(1,9)
621 Port10=Scaled(1,10)
622 Port11=Scaled(1,11)
623 PRINT USING "4D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,2X,MD,3DE,2X,MD,3DE"
iN,Port6,Port7,Port8,Port9,Port10,Port11
624 NEXT N
625 Twoprintsc12: PRINT "*****"
*****"
626 PRINT "SCAN U FRB 12 13 14 15
16"
627 PRINT " POSIT"
628 FOR N=1 TO 100
629 ENTER @Fath2,NiScaled(*)
630 ON END @Fath2 GOTO Twoprintsc13
631 Positu=Scaled(1,21)
632 Port12=Scaled(1,12)
633 Port13=Scaled(1,13)
634 Port14=Scaled(1,14)
635 Port15=Scaled(1,15)
636 Port16=Scaled(1,16)
637 PRINT USING "4D,3X,4D,2D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE"
iN,Positu,Port12,Port13,Port14,Port15,Port16
638 NEXT N
639 Twoprintsc13: PRINT "*****"
*****"
640 PRINT "SCAN 17 18 19 "
641 FOR N=1 TO 100
642 ENTER @Fath2,NiScaled(*)
643 ON END @Fath2 GOTO Twoprintsc14
644 Port17=Scaled(1,17)
645 Port18=Scaled(1,18)
646 Port19=Scaled(1,19)
647 PRINT USING "4D,3X,MD,3DE,4X,MD,3DE,4X,MD,3DE"iN,Port17,Port18,Port19
648 NEXT N
649 Twoprintsc14: PRINT "*****"
*****"

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650 PRINT "SCAN   YAW L       YAW U       TEMP       ATMOS"
651 PRINT "      DEG        DEG        (R)      PRESSURE"
652 FOR N=1 TO 100
653 ENTER @Path2,NiScaled(*)
654 ON END @Path2 GOTO Twoprintsc15
655 YawL=Scaled(1,22)
656 YawU=Scaled(1,23)
657 Temp=Scaled(1,24)
658 Pa=Scaled(1,25)
659 PRINT USING "4D,3X,MD.3DE,4X,MD.3DE,4X,MD.3DE,4X,3D.2D" iN,YawL,YawU,Temp,Pa
660 NEXT N
661 Twoprintsc15: OFF END @Path2
662 ELSE
663 1 END IF
664 PRINTER IS Prnter
665 PRINT "....."
666 PRINT "PROBE SCALED DATA FILE ",Sc1file$
667 PRINT "....."
668 PRINT "SCAN   PROBE      1          2          3          4
5"
669 PRINT "      POSIT"
670 FOR N=1 TO 100
671 ENTER @Path2,NiScaled(*)
672 ON END @Path2 GOTO Printsc11
673 Posit=Scaled(1,15)
674 Port1=Scaled(1,1)
675 Port2=Scaled(1,2)
676 Port3=Scaled(1,3)
677 Port4=Scaled(1,4)
678 Port5=Scaled(1,5)
679 PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE
iN,Posit,Port1,Port2,Port3,Port4,Port5
680 NEXT N
681 Printsc11: PRINT "....."
....."
682 PRINT "SCAN 6          7          8          9          10          11
"
683 FOR N=1 TO 100
684 ENTER @Path2,NiScaled(*)
685 ON END @Path2 GOTO Printsc12
686 Port6=Scaled(1,6)
687 Port7=Scaled(1,7)
688 Port8=Scaled(1,8)
689 Port9=Scaled(1,9)
690 Port10=Scaled(1,10)
691 Port11=Scaled(1,11)
692 PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE
iN,Port6,Port7,Port8,Port9,Port10,Port11
693 NEXT N
694 Printsc12: PRINT "....."
....."
695 PRINT "SCAN 12          13          14          YAW       TEMP       AT
MOS"
696 PRINT "      DEG        (R)        PR
ESS"
697 FOR N=1 TO 100
698 ENTER @Path2,NiScaled(*)
699 ON END @Path2 GOTO Printsc13
700 Port12=Scaled(1,12)
701 Port13=Scaled(1,13)
702 Port14=Scaled(1,14)
703 Yaw=Scaled(1,16)
704 Temp=Scaled(1,17)
705 Pa=Scaled(1,18)
706 PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,3D.2D"

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iN,Port12,Port13,Port14,Yaw,Temp,Pa
707 NEXT N
708 Printsc13: PRINT "....."
709 OFF END @Path2
710 END IF
711 PRINTER IS Screen
712 PRINT "....."
713 PRINT ""
714 Printoption3: PRINT "PRESS ""BLADE DATA"" FOR BLADE DATA PRINT OPTIONS."
715 PRINT ""
716 PRINT "PRESS ""GO ON"" TO CONTINUE PROGRAM."
717 PRINT ""
718 PRINT "....."

719 ON KEY 1 LABEL "BLADE DATA" GOTO Printoption4
720 ON KEY 4 LABEL "GO ON" GOTO Loadoption1
721 Spin10: GOTO Spin10
722 Printoption4: PRINT ""
723 PRINT "ALIGN PAPER IN PRINTER."
724 PRINT ""
725 PRINT "TO PRINT OUT A TABULATION OF THE RAW BLADE DATA"
726 PRINT ""
727 PRINT "PRESS ""BLADE DATA"", PRESS ""GO ON"" TO CONTINUE."
728 PRINT ""
729 PRINT "....."

730 ON KEY 1 LABEL "BLADE DATA" GOTO Prntbladedata
731 ON KEY 4 LABEL "GO ON" GOTO Printoption5
732 Spin11: GOTO Spin11
733 Prntbladedata: MASS STORAGE IS "/CLASSICK/DATA"
734 ASSIGN @Path3 TO Rawbladfile$
735 PRINTER IS Prnter
736 PRINT "....."
737 PRINT "BLADE RAW DATA FILE ",Rawbladfile$
738 PRINT "....."
739 PRINT ""
740 PRINT "PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED"
741 PRINT "IN FILE: ",Rawfile$
742 PRINT "SCAN:",Scan
743 PRINT "SCANIVALVE VOLTAGE"
744 PRINT "PORT READING"
745 FOR N=1 TO 48
746 ENTER @Path3,Scanva(1,N)
747 PRINT USING "DD,20X,MD.3DE"iN,Scanva(1,N)
748 NEXT N
749 PRINTER IS Screen
750 Printoption5: PRINT "....."
751 PRINT ""
752 PRINT "ALIGN PAPER IN PRINTER."
753 PRINT ""
754 PRINT "TO PRINT OUT A TABULATION OF THE BLADE DATA SCALED TO "
755 PRINT ""
756 PRINT "ENGINEERING UNITS, PRESS ""SCALED DATA""."
757 PRINT ""
758 PRINT "PRESS ""GO ON"" TO TERMINATE PROGRAM."
759 PRINT ""
760 ON KEY 1 LABEL "SCALED DATA" GOTO Prntscldbladdat
761 ON KEY 4 LABEL "GO ON" GOTO Loadoption1
762 Spin12: GOTO Spin12
763 Prntscldbladdat: MASS STORAGE IS "/CLASSICK/REDDATA"
764 ASSIGN @Path4 TO Scbladfile$
765 PRINTER IS Prnter
766 PRINT "....."
767 PRINT "BLADE SCALED DATA FILE ",Scbladfile$
768 PRINT "....."

```

```

769     PRINT ""
770     PRINT "PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED"
771     PRINT "IN FILE: ",Scifile$
772     PRINT "SCAN:",Scan
773     PRINT "SCANIVALVE          PRESS (INCHES H2o)"
774     PRINT "PORT"
775     FOR N=1 TO 48
776         ENTER @Path4;Prntdata(1,N)
777         PRINT USING "DD,20X,MD.3DE";N,Prntdata(1,N)
778     NEXT N
779 Loadoption1:  PRINTER IS Screen
780     PRINT "....."
781     PRINT ""
782     PRINT "TO LOAD PROGRAM TO REDUCE THE ACQUIRED DATA"
783     PRINT ""
784     PRINT "PRESS ""CALC"".  PRESS ""GO ON"" TO TERMINATE THE PROGRAM"
785     PRINT ""
786     PRINT "....."
787     ON KEY 1 LABEL "CALC" GOTO Loadup1
788     ON KEY 4 LABEL "GO ON" GOTO Fin
789 Spin13:      GOTO Spin13
790 Loadup1: MASS STORAGE IS "/CLASSICK/PROGS"
791     LOAD "CALC",10
792 Fin: PRINT "....."
793     PRINT "....."
794     PRINT ""
795     PRINT "          END OF PROGRAM"
796     PRINT ""
797     PRINT "....."
798     PRINT "....."
799     END

```

B7.2 Reduction Program CALC

```

10  IPROGRAM CALC
20  I THIS PROGRAM TAKES THE FILES OF DATA COLLECTED FROM THE PROBE(S)
30  I AND REDUCES THE DATA TO  USEFUL ENGINEERING QUANTITIES THESE
40  I VALUES ARE PRINTED IN TABLE FORM.
41  IMUCH OF THE CODING IN THIS PROGRAM HAS BEEN PREVIOUSLY COMMENTED ON
42  IIN PROGRAM ACQUIRE.
50  OPTION BASE 1
70  DIM Reddat(1,105)          !AN ARRAY FOR THE SCALED DATA FROM ACQUIRE.
71                                !RECALL THAT THE SCALED DATA WAS STORED BY
72                                !A RANDOM OUTPUT STATEMENT.
80  DIM P(6,6)                !THE ARRAY FOR THE PHI COEFFICIENTS.
90  DIM X(6,6)                !THE ARRAY FOR THE X VELOCITY COEFFICIENTS.
91  DIM Pu(6,6)               !IF 2 PROBES USED THEN THE PHI ARRAY FOR
92                                !THE UPPER PROBE.
94  DIM Xu(6,6)
95  DIM Kneray(100)            !KN VALUES STORED IN AN ARRAY.Kn=K IN TABLE
96                                !I OF CLASSICK THESIS.
98  DIM Prbpos(100)
99  DIM Aeray(100)            !AN ARRAY OF VALUES USED IN THE CALCULATION
100  DIM Baray(100)            !OF BLADE CP'S.
102  MAT Reddat= (0)
103  MAT Kneray= (0)
104  MAT Prbpos= (0)
105  MAT Aeray= (0)
106  MAT Baray= (0)
107  DEG                      !ALL ANGLES WILL BE IN DEGREES.
108  Prnter=701
109  Scree=1
110  Firstbladeprt=4          !FIRST SCANIVALUE PORT ASSIGNED TO THE
111                                !INSTRUMENTED BLADE THAT IS OF INTEREST
112                                !IN THE CP CALCULATION.
114  Lastbladeprt=48          !LAST " " "ect.
115  G=1.4
116  Cp=.24
120  LOADSUB ALL FROM "/CLASSICK/ROUTINES/SUBCALC"
130  MASS STORAGE IS "/CLASSICK/REDDATA"
131  PRINT "....."
132  PRINT ""
134  PRINT "ENTER THE NAME OF THE FILE CONTAINING THE PROBE DATA SCALED"
135  PRINT "TO ENGINEERING UNITS"
136  INPUT Scf1file$
140  ASSIGN @Path1 TO Scf1file$
141  PRINT "....."
142  PRINT ""
144  PRINT "ENTER THE PROBE COEFFICIENT FILE FOR X VELOCITY. THIS WILL BE "
145  PRINT ""
146  PRINT "FOR THE LOWER PROBE IF TWO PROBES ARE BEING USED."
148  INPUT Readx$
151  ASSIGN @Path2 TO Readx$
160  ENTER @Path2,X(0)
161  PRINT "....."
162  PRINT ""
170  PRINT "ENTER THE NAME OF THE COEFFICIENT FILE FOR PHI. THIS WILL BE "
171  PRINT ""
172  PRINT "FOR THE LOWER PROBE IF TWO PROBES ARE BEING USED."
174  INPUT Readp$
180  ASSIGN @Path3 TO Readp$
190  ENTER @Path3,P(0)
191  PRINT "....."
192  PRINT ""
200  PRINT "IF DATA WERE COLLECTED WITH ONE PROBE, PRESS "" ONE PROBE""
201  PRINT ""
220  PRINT "IF DATA WERE COLLECTED WITH TWO PROBES, PRESS ""TWO PROBES""
221  PRINT ""

```

```

224 PRINT "....."
225 ON KEY 1 LABEL "ONE" PROBE" GOTO Numberprbs1
226 ON KEY 4 LABEL "TWO" PROBES" GOTO Numberprbs2
227 Spin1: GOTO Spin1
228 Numberprbs1: Noofprbs=1
229 GOTO Checknoofprbs
231 Numberprbs2: Noofprbs=2
240 Checknoofprbs: IF Noofprbs=2 THEN
250 MASS STORAGE IS "/CLASSICK/REDDATA"
251 PRINT "....."
252 PRINT ""
253 PRINT "ENTER THE FILE NAME FOR THE UPPER PROBE COEFFICIENTS FOR Xvel."
254 INPUT Readxu$
255 ASSIGN @Path2u TO Readxu$
256 ENTER @Path2u: Xu(*)
259 PRINT "....."
260 PRINT ""
261 PRINT "ENTER THE FILE NAME FOR THE UPPER PROBE COEFFICIENTS FOR PHI."
262 INPUT Readpu$
263 ASSIGN @Path3u TO Readpu$
264 ENTER @Path3u: Pu(*)
267 PRINT "....."
268 PRINT ""
269 PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED FROM LOWER PROBE "
270 INPUT Calc1file$
273 CREATE BDAT Calc1file$,100
274 ASSIGN @Path4 TO Calc1file$
275 PRINT "....."
276 PRINT ""
277 PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED FROM UPPER PROBE"
278 INPUT Calcufile$
281 CREATE BDAT Calcufile$,100
282 ASSIGN @Path5 TO Calcufile$
283 !.....
284 !* NOTE: THE SCANIVALVE SENSES THE PRESSURE DIFFERENTIAL FROM *
285 !* ATMOS. THE SCANIVALVE IS CALIBRATED SO ATMOS PRESS(Pa) *
286 !* READS ZERO. THE PRESS SENSED AT A PORT IS THE PORT *
287 !* PRESS MINUS Pa i.e., GAGE PRESS. TO ELIMINATE ERRORS DUE *
288 !* TO DVM DRIFT, THE PRESS SENSED BY PORT 1 OF THE *
289 !* SCANIVALVE (Ptare=Pa-Pa) IS SUBTRACTED FROM EACH *
290 !* SCANIVALVE PORT READING. *
291 !*
292 !..... TWO PROBES .....
293 !.....SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENT.....
294 !*
295 !*
296 !* VARIABLE VARIABLE PORT/CHANNEL DATA ARRAY
297 !* REPRESENTS
298 !*
299 !* Ptare Pa-Pa PORT 1 Reddat(1,1)
300 !* Pcel Pcel-Ptare PORT 2 Reddat(1,2)
301 !* Pp Pplenom-Ptare PORT 3 Reddat(1,3)
302 !* Pa Pwallstatic-Ptare PORT 4 Reddat(1,4)
303 !* P1 P1-Ptare PORT 5 Reddat(1,5)
304 !* P2 P2-Ptare PORT 6 Reddat(1,6)
305 !* P3 P3-Ptare PORT 7 Reddat(1,7)
306 !* P23 (P2+P3)/2
307 !* P4 P4-Ptare PORT 8 Reddat(1,8)
308 !* P5 P5-Ptare PORT 9 Reddat(1,9)
309 !* Ptp Ptotalprndtl-Ptare PORT 10 Reddat(1,10)
310 !* Psp Pstatprndtl-Ptare PORT 11 Reddat(1,11)
311 !* BLANK PORT 12 Reddat(1,12)
312 !* Plu Plu-Ptare PORT 13 Reddat(1,13)
313 !* P2u P2u-Ptare PORT 14 Reddat(1,14)
314 !* P3u P3u-Ptare PORT 15 Reddat(1,15)
315 !* P23u (P2u+P3u)/2

```

```

316 I* P4u      P4u-Ptare      PORT 16      Reddat(1,16)      *
317 I* P5u      P5u-Ptare      PORT 17      Reddat(1,17)      *
318 I*          BLANK          PORT 18      Reddat(1,18)      *
319 I*          BLANK          PORT 19      Reddat(1,19)      *
320 I* Posit    L PRB POSIT    INPUT      Reddat(1,20)      *
321 I* Positu   U PRB POSIT    INPUT      Reddat(1,21)      *
322 I* Yaw      LOWER PRB YAW   24         Reddat(1,22)      *
323 I* Yawu     UPPER PRB YAW   21         Reddat(1,23)      *
324 I* Temp     TOTAL TEMP(PLENUM) CHAN 10   Reddat(1,24)      *
325 I* Pa       ATMOSPHERIC PRESS INPUT      Reddat(1,25)      *
326 I*                                     *
327 I*                                     *
328 I*.....*
329 I*.....DATA REDUCTION*.....*
330 DIM Calc1(100,25)
331 MAT Calc1= (0)
332 Pinitial=0                                IINITIALIZES THE CONDITIONS TO CALCULATE
333                                     IENSEMBLE VALUES IN SUBROUTINE ENSEMBLE
335 Tinitial=0
336 Pinitial=0
337 FOR N=1 TO 100
338 ENTER @Path1,N,Reddat(*)                ITHE ARRAY IS ENTERED WITH A RANDOM
339                                     ISTATEMENT.
341 ON END @Path1 GO TO Twoprintcalc1
342 Ptare=Reddat(1,1)                        IREASSIGNMENT OF ARRAY ELEMENTS TO
343                                     IIDENTIFIABLE QUANTITIES TO BE USED IN
344                                     IIN SUBROUTINE CALCULATIONS.
346 Pcel=Reddat(1,2)
347 Pp=Reddat(1,3)
348 Ps=Reddat(1,4)
349 P1=Reddat(1,5)
350 P2=Reddat(1,6)
351 P3=Reddat(1,7)
352 P23=(P2+P3)/2
353 P4=Reddat(1,8)
354 P5=Reddat(1,9)
355 Ptp=Reddat(1,10)
356 Psp=Reddat(1,11)
357 IBLANK=Reddat(1,12)
358 Posit=Reddat(1,20)
359 Yaw=Reddat(1,22)                        IYAW ANGLE CORRECTION COULD BE MADE
360                                     IHERE IF NOT ALREADY DONE IN ACQUIRE.
362 Temp=Reddat(1,24)
363 Pa=Reddat(1,25)
364 I CALCULATE BETA AND GAMMA COEFFICIENTS
365 CALL Bgcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
366 I CALCULATE THE ENSEMBLE REFERENCE VALUES OF PLENUM PRESS,PLENUM TEMP AND PA
367 CALL Ensemble(Pp,Pinitial,Pa,Pinitial,Temp,Tinitial,Ppavg,Ppavg,Tempavg,N)
368 I CALCULATE Xvel AND Phi
369 CALL Xphicalc(Beta,Gamma,Xvel,X(*),Phi,P(*))
370 I CALCULATE Xref
371 CALL Xrefcalc(Pa,Pp,6,Xref)
372 I CALCULATE QREF AND UREF
373 CALL Qvrefcalc(Xref,Cp,Temp,6,Pp,Pa,Qref,Uref)
374 I CALCULATE VELOCITY AND MACH # AND Q
375 CALL Vmcalc(Xvel,Cp,Temp,6,Vel,Mach,P1,Pa,Q)
376 I CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
377 CALL Kncalc(Pa,P1,Pp,Xvel,Xref,6,Yaw,Kn)
378 I CALCULATE THE COEFFICIENT OF PRESSURE TERM TO BE MASS AVERAGED.
379 I THESE TERMS ARE USED IN THE CALCULATION OF THE LOSS COEFFICIENT.
380 CALL Coefpress(P1,Pp,Pa,Xvel,6,Cps,Cpt)
381 I CALCULATE THE QUANTITIES TO BE MASS AVERAGED. MULTIPLY THESE VALUES
382 I BY Kn TO GET THE INTEGRAND REQUIRED TO CALCULATE THE MASS AVERAGED CP'S
383 CALL Cpintegrand(Pp,P1,Pa,6,Xvel,A,B,Kn)
384 I CALCULATE Pp-P1/Qref FOR PLOTS
385 CALL Prefqref(Pp,P1,Qref,Pq)

```

```

386 1 CALCULATE STATIC PRESSURE UPSTREAM
387 CALL Staticpress(P1,Pa,Xvel,G,Ps)
389 1DEFINE AN ARRAY TO STORE CALCULATED VALUES
390 Calc1(N,1)=Posit
391 Calc1(N,2)=Beta
392 Calc1(N,3)=Gamma
393 Calc1(N,4)=Phi
394 Calc1(N,5)=Xvel
395 Calc1(N,6)=Xref
396 Calc1(N,7)=Vel
397 Calc1(N,8)=Mach
398 Calc1(N,9)=Yaw
399 Calc1(N,10)=Kn
400 Calc1(N,11)=Cpt
401 Calc1(N,12)=Cps
402 Calc1(N,13)=Qref
403 Calc1(N,14)=Uref
404 Calc1(N,15)=Q
405 Calc1(N,16)=A
406 Calc1(N,17)=B
407 Calc1(N,18)=Fq
408 Calc1(N,19)=Pa
409
411 Calc1(N,20)=Ps
412 Knarray(N)=Calc1(N,10)
413
414
415 Prbpos(N)=Calc1(N,1)
416 Aarray(N)=Calc1(N,16)
417 Barray(N)=Calc1(N,17)
418 Scan=N
419 NEXT N
420 Twoprintcalcl: OFF END @Path1
421 1CALCULATE ENSEMBLE AVERAGE OF XREF
422 CALL Xrefensemble(Pavg,Ppavg,G,Xrefavg)
423 1CALCULATE ENSEMBLE AVERAGE OF UREF
424 CALL Urefensemble(Xrefavg,Cp,Tempavg,Urefavg)
425 1CALCULATE ENSEMBLE AVERAGE OF QREF
426 CALL Qrefensemble(Pavg,Ppavg,G,Xrefavg,Qrefavg)
427 PRINT "*****"
428 PRINT ""
429 PRINT "ALIGN PAPER IN PRINTER. WHEN READY FOR A HARDCOPY OF THE "
430 PRINT "CALCULATED DATA, PRESS ""REDUCED DATA""."
431 PRINT ""
432 PRINT "*****"
433 ON KEY 1 LABEL "REDUCED DATA" GOTO Prntdata2
434 Spin2: GOTO Spin2
435 Prntdata2: PRINTER IS Prnter
436 PRINT "*****"
437 PRINT "FILE ",Calc1file$
438 PRINT "*****"
439 PRINT "*****"
440 PRINT ""
441 PRINT "SCAN L PRB BETA GAMMA PHI Xvel
Xref "
442 PRINT " POSIT"
443 FOR N=1 TO Scan
444 PRINT USING "4D,3X,4D,2D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,2X,MD,3DE,2X,MD,3DE
",N,Calc1(N,1),Calc1(N,2),Calc1(N,3),Calc1(N,4),Calc1(N,5),Calc1(N,6)
445 NEXT N
446 PRINT ""
447 PRINT "*****"
448 PRINT ""
449 PRINT "SCAN VEL UREF Q QREF MACH

```

IFa & Ps ARE USED FOR STATIC PRESS
 IRISE CALCULATION IN PROGRAM LOSS.
 ITHESE VALUES ARE NOT PRINTED.
 IWANT TO STORE MORE THAN JUST ONE
 IKn VALUE FOR MASS AVERAGING
 I CALCULATIONS.
 I"" ""
 I"" ""
 I"" ""

```

YAW"
450 PRINT "
DEG "
451 FOR N=1 TO Scan
452 PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3D
E"iN,Calcl(N,7),Calcl(N,14),Calcl(N,15),Calcl(N,13),Calcl(N,8),Calcl(N,9)
453 NEXT N
454 PRINT ""
455 PRINT "....."
....."
456 PRINT ""
457 PRINT "....."
....."
458 PRINT ""
459 PRINT "SCAN Pref-Pt1/Qref"
460 FOR N=1 TO Scan
461 PRINT USING "4D,3X,MD.3DE"iN,Calcl(N,18)
462 NEXT N
463 PRINT ""
464 PRINT "....."
....."
465 PRINT ""
466 PRINT "ENSEMBLE AVERAGES"
467 PRINT ""
468 PRINT "PPAUG          PAAUG          TEMPAUG          XREFAUG          UREFAUG
QREFAUG "
469 PRINT USING "MD.3DE,5X,M3D.2DE,5X,3D.2D,5X,MD.3DE,5X MD.3DE,3X,MD.3DE"iPpa
vg,Paeavg,Tempavg,Xrefavg,Urefavg,Qrefavg
470 OUTPUT @Path4;Calcl(*)          !OUTPUT STATEMENT IS SERIAL.
471 DIM Calcu(100,25)          !SEPARATE CALC ARRAY FOR REDUCED
472          !DATA FROM UPPER SURVEY STATION.
473 MAT Calcu= (0)
474 FOR N=1 TO 100
475 ENTER @Path1,N;Reddat(*)          !ENTER STATEMENT IS RANDOM.
476 ON END @Path1 GOTO Twoprintcalc2
477 P1ere=Reddat(1,1)
478 Pp=Reddat(1,3)
479 Ps=Reddat(1,4)
480 Ptp=Reddat(1,10)
481 Psp=Reddat(1,11)
482 Plu=Reddat(1,13)
483 P2u=Reddat(1,14)
484 P3u=Reddat(1,15)
485 P2u3u=(P2u+P3u)/2
486 P4u=Reddat(1,16)
487 PSu=Reddat(1,17)
488 !BLANK=REDDAT(1,18)
489 !BLANK=REDDAT(1,19)
490 Positu=Reddat(1,21)
491 Yawu=Reddat(1,23)
492 Temp=Reddat(1,24)
493 Pa=Reddat(1,25)
494 !CALCULATE BETA AND GAMMA COEFFICIENTS
495 CALL Bgcalc(Pa,Plu,P2u3u,P4u,PSu,Betau,Gammau)
496 !CALCULATE Xvelu AND Phiu
497 CALL Xphicalc(Betau,Gammau,Xvelu,Xu(*),Phiu,Pu(*))
498 !CALCULATE Xrefu
499 CALL Xrefcalc(Pa,Pp,6,Xrefu)
500 !CALCULATE QREF AND UREF
501 CALL Qvrefcalc(Xref,Cp,Temp,6,Pp,Pa,Qref,Uref)
502 !CALCULATE VELOCITYu AND MACHu & AND Qu
503 CALL Vmcalc(Xvelu,Cp,Temp,6,Velu,Machu,Plu,Pa,Qu)
504 ! CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
505 CALL Kncalc(Pa,Plu,Pp,Xvelu,Xrefu,6,Yawu,Knu)
506 ! CALCULATE THE COEFFICIENT OF PRESSURE FOR THE UPPER PROBE.
507 ! THIS TERM WILL BE MASS AVERAGED AND USED IN THE CALCULATION OF THE

```

```

508  ! LOSS COEFFICIENT. THE Cpsu TERM IS NOT USED IN THE LOSS COEFFICIENT
509  ! CALCULATION.
510  CALL Coefpress(Plu,Pp,Pa,Xvelu,6,Cpsu,Cptu)
511  ! CALCULATE Pp-P1/Qref FOR PLOTS
512  CALL Prefaref(Pp,P1,Qref,Pqu)
513  ! CALCULATE THE DOWNSTREAM STATIC PRESSURE
514  CALL Staticpress(Plu,Pa,Xvelu,6,Psu)
515  Calcu(N,1)=Positu
516  Calcu(N,2)=Betau
517  Calcu(N,3)=Gammau
518  Calcu(N,4)=Phiu
519  Calcu(N,5)=Xvelu
520  Calcu(N,6)=Xrefu
521  Calcu(N,7)=Velu
522  Calcu(N,8)=Machu
523  Calcu(N,9)=Yawu
524  Calcu(N,10)=Knu
525  Calcu(N,11)=Cptu
526  Calcu(N,12)=Cpsu
527  Calcu(N,13)=Qu
528  Calcu(N,14)=Pqu
529  Calcu(N,15)=Pa
530  Calcu(N,16)=Psu
531  Calcu(N,17)=Pa
532  Calcu(N,18)=Psu
533
534  Scan=N
535  NEXT N
536  Twoprintcalc2: OFF END @Path1
537  PRINT "....."
538  PRINT "....."
539  PRINT "....."
540  PRINT "....."
541  PRINT "FILE ",Calcufile$
542  PRINT "....."
543  PRINT "....."
544  PRINT "....."
545  PRINT "SCAN U PRB BETAU GAMMAU PHIU Xvelu "
546  PRINT " POSIT"
547  FOR N=1 TO Scan
548  PRINT USING "40,2X,40,20,3X,MD,30E,3X,MD,30E,3X,MD,30E,3X,MD,30E"iN,Calcu(
N,1),Calcu(N,2),Calcu(N,3),Calcu(N,4),Calcu(N,5)
549  NEXT N
550  PRINT "....."
551  PRINT "....."
552  PRINT "SCAN VELU QU Pref-Ptu/Qref MACHU YAWU"
553  PRINT " DEG"
554  FOR N=1 TO Scan
555  PRINT USING "40,3X,MD,30E,3X,MD,30E,3X,MD,30E,3X,MD,30E,3X,MD,30E"iN,Calcu
(N,7),Calcu(N,13),Calcu(N,14),Calcu(N,8),Calcu(N,9)
556  NEXT N
557  PRINT "....."
558  PRINTER IS ScreeN
559  OUTPUT @Path5:Calcu(*)
560  ELSE
561  MASS STORAGE IS "/CLASSICK/REDDATA"
562  PRINT "....."
563  PRINT "....."
564  PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED FROM THE PROBE "
565  INPUT Calcufile$
566  CREATE BOAT Calcufile$,100
567  ASSIGN @Path4 TO Calcufile$
568  !.....

```

!Calcu(N,15) TO Calcu(N,18) WILL HAVE
!ZEROS. ARRAY ELEMENT ASSIGNMENT IS
!CONSISTENT WITH LOSS PROGRAM AND
!ONE PROBE SURVEY.

```

569 ..... ONE PROBE .....
570 .....SCANIVALUE PORT AND SCANNER CHANNEL ASSIGNMENT.....
571 .....
572 .....
573 VARIABLE      VARIABLE      PORT/CHANNEL  DATA ARRAY
574 REPRESENTS
575 .....
576 Ptare         Pa-Pa         PORT 1        Reddat(1,1)
577 Pcal          Pcal-Ptare    PORT 2        Reddat(1,2)
578 Pp            Pplenum-Ptare PORT 3        Reddat(1,3)
579 Ps            Pwallstatic-Ptare PORT 4        Reddat(1,4)
580 P1            P1-Ptare      PORT 5        Reddat(1,5)
581 P2            P2-Ptare      PORT 6        Reddat(1,6)
582 P3            P3-Ptare      PORT 7        Reddat(1,7)
583 P23           (P2+P3)/2
584 P4            P4-Ptare      PORT 8        Reddat(1,8)
585 P5            P5-Ptare      PORT 9        Reddat(1,9)
586 Ptp          Ptotalprndtl-Ptare PORT 10       Reddat(1,10)
587 Psp          Pstatprndtl-Ptare PORT 11       Reddat(1,11)
588 BLANK
589 BLANK
590 BLANK
591 Posit        PRB POSIT      INPUT          Reddat(1,15)
592 Yaw          PRB YAW        CHAN 24          Reddat(1,16)
593 Temp         TOTAL TEMP(PLENUM) CHAN 10      Reddat(1,17)
594 Pa           ATMOSPHERIC PRESS INPUT        Reddat(1,18)
595 .....
596 .....
597 .....
598 .....DATA REDUCTION.....
599 DIM Calc(100,25)
600 MAT Calc= (0)
601 Pinitial=0
602 .....
603 Tinitial=0
604 Pinitial=0
605 FOR I=1 TO 100
606 ENTER @Path1,N1Reddat(*)
607 ON END @Path1 GOTO Printcalcl
608 Ptare=Reddat(1,1)
609 .....
610 .....
611 Pcal=Reddat(1,2)
612 Pp=Reddat(1,3)
613 Ps=Reddat(1,4)
614 P1=Reddat(1,5)
615 P2=Reddat(1,6)
616 P3=Reddat(1,7)
617 P23=(P2+P3)/2
618 P4=Reddat(1,8)
619 P5=Reddat(1,9)
620 Ptp=Reddat(1,10)
621 Psp=Reddat(1,11)
622 IBLANK=Reddat(1,12)
623 IBLANK=Reddat(1,13)
624 IBLANK=Reddat(1,14)
625 Posit=Reddat(1,15)
626 Yaw=Reddat(1,16)
627 Temp=Reddat(1,17)
628 Pa=Reddat(1,18)
629 I CALCULATE BETA AND GAMMA COEFFICIENTS
630 CALL Bpcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
631 I CALCULATE THE ENSEMBLE REFERENCE VALUES OF PPLENUM,PLENUM TEMP AND PA.
632 CALL Ensemble(Pp,Pinitial,Pa,Pinitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
633 I CALCULATE Xvel AND Phi
634 CALL Xphicalc(Beta,Gamma,Xvel,X(0),Phi,P(0))

```

```

635  I CALCULATE Xref
636  CALL Xrefcalc(Pa,Pp,G,Xref)
637  I CALCULATE QREF AND UREF
638  CALL Qvrefcalc(Xref,Cp,Temp,G,Pp,Pa,Qref,Uref)
639  I CALCULATE VELOCITY AND MACH # AND Q
640  CALL Vmncalc(Xvel,Cp,Temp,G,Vel,Mach,P1,Pa,Q)
641  I CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
642  CALL Kncalc(Pa,P1,Pp,Xvel,Xref,G,Yaw,Kn)
643  I CALCULATE THE COEFFICIENT OF PRESSURE TERMS TO BE MASS AVERAGED.
644  I THESE TERMS ARE USED IN THE CALCULATION OF THE LOSS COEFFICIENT.
645  CALL Coefpress(P1,Pp,Pa,Xvel,G,Cps,Cpt)
646  I CALCULATE THE QUANTITIES TO BE MASS AVERAGED. MULTIPLY THESE VALUES
647  I BY Kn TO GET THE INTEGRAND REQUIRED TO CALCULATE THE MASS AVERAGED CP'S
648  CALL Cpintegrand(Pa,P1,Pa,G,Xvel,A,B,Kn)
649  I CALCULATE Pp-P1/Qref FOR PLOTS
650  CALL Prefqref(Pp,P1,Qref,Pq)
651  I CALCULATE STATIC PRESSURE
652  CALL Staticpress(P1,Pa,Xvel,G,Ps)
653  I DEFINE AN ARRAY TO STORE CALCULATED VALUES
654  Calc(N,1)=Posit
655  Calc(N,2)=Beta
656  Calc(N,3)=Gamma
657  Calc(N,4)=Phi
658  Calc(N,5)=Xvel
659  Calc(N,6)=Xref
660  Calc(N,7)=Vel
661  Calc(N,8)=Mach
662  Calc(N,9)=Yaw
663  Calc(N,10)=Kn
664  Calc(N,11)=Cpt
665  Calc(N,12)=Cps
666  Calc(N,13)=Qref
667  Calc(N,14)=Uref
668  Calc(N,15)=Q
669  Calc(N,16)=A
670  Calc(N,17)=B
671  Calc(N,18)=Fq
672  Calc(N,19)=Pa
673  Calc(N,20)=Ps
674  Kncarray(N)=Calc(N,10)          IWANT TO STORE THE Kn VALUE IN AN
675                                     IARRAY FOR MASS AVERAGING CALCULATIONS
676  Prbpos(N)=Calc(N,1)             I"" ""
677  Aarray(N)=Calc(N,16)            I"" ""
678  Barray(N)=Calc(N,17)            I"" ""
679  Scan=N
680  NEXT N
681  Printcalcl:  OFF END @Pathl
682  I CALCULATE ENSEMBLE AVERAGE OF XREF
683  CALL Xrefensemble(Pavg,Ppavg,G,Xrefavg)
684  I CALCULATE ENSEMBLE AVERAGE OF UREF
685  CALL Urefensemble(Xrefavg,Cp,Tempavg,Urefavg)
686  I CALCULATE ENSEMBLE AVERAGE OF QREF
687  CALL Qrefensemble(Pavg,Ppavg,G,Xrefavg,Qrefavg)
688  PRINT "....."
689  PRINT ""
690  PRINT "ALIGN PAPER IN THE PRINTER. WHEN READY FOR A HARDCOPY OF THE "
691  PRINT ""
692  PRINT "CALCULATED DATA, PRESS ""REDUCED DATA"" ."
693  PRINT ""
694  PRINT "....."
695  ON KEY 4 LABEL "REDUCED DATA" GOTO Prntdata1
696  Spin3:  GOTO Spin3
697  Prntdata1:  PRINTER IS Prnter
698  PRINT "....."
699  PRINT "FILE ",Calcfile$
700  PRINT "....."

```

```

701 PRINT ""
702 PRINT "....."
703 PRINT ""
704 PRINT "SCAN   PRB       BETA       GAMMA       PHI       Xvel
      xref"
705 PRINT "      POSIT"
706 FOR N=1 TO Scan
707 PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE
      "iN,Calc(N,1),Calc(N,2),Calc(N,3),Calc(N,4),Calc(N,5),Calc(N,6)
708 NEXT N
709 PRINT ""
710 PRINT "....."
711 PRINT ""
712 PRINT "SCAN   Vel       Vref       Q       Qref       MACH
      YAW"
713 PRINT "
      DEG "
714 FOR N=1 TO Scan
715 PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3D
      E"iN,Calc(N,7),Calc(N,14),Calc(N,15),Calc(N,13),Calc(N,8),Calc(N,9)
716 NEXT N
717 PRINT ""
718 PRINT "....."
719 PRINT ""
720 PRINT "SCAN   Pref-Pt/Qref"
721 FOR N=1 TO Scan
722 PRINT USING "4D,3X,MD.3DE"iN,Calc(N,18)
723 NEXT N
724 PRINT ""
725 PRINT "....."
726 PRINT ""
727 PRINT " ENSEMBLE AVERAGES"
728 PRINT ""
729 PRINT "PPAVG       PAAVG       TEMPAVG       XREFAVG       UREFAVG
      QREFAVG"
730 PRINT USING "MD.3DE,5X,M3D.2DE,5X,3D.2D,5X,MD.3DE,5X,MD.3DE,3X,MD.3DE"iPpa
      vg,Pavg,Tempavg,Xrefavg,Qrefavg,Qrefavg
731 PRINTER IS Screen
732 OUTPUT @Path4;Calc(*)          ISERIAL OUTPUT STATEMENT.
733 END IF
734 PRINT "....."
735 PRINT ""
736 PRINT "TO CALCULATE THE CP'S FOR THE BLADE DATA, PRESS ""BLADE CP'S""
737 PRINT " PRESS ""GO ON"" TO CONTINUE."
738 PRINT ""
739 PRINT "....."
740 ON KEY 1 LABEL "BLADE   CP'S" GOTO Calculatecp
741 ON KEY 4 LABEL "GO ON" GOTO Loadoption2
742 Spin4:  GOTO Spin4
743 Calculatecp:  MASS STORAGE IS "/CLASSICK/REDDATA"
744 PRINT ""
745 PRINT "....."
746 PRINT ""
747 PRINT "ENTER THE FILE NAME OF THE BLADE DATA SCALED IN ENGINEERING UNITS"
748 INPUT Scibladfile$
749 PRINT "....."
750 ASSIGN @Path5 TO Scibladfile$
751 PRINT ""
752 PRINT "ENTER THE FILE NAME TO STORE THE MASS AVERAGED CP'S CALCULATED"
753 PRINT "FROM THE BLADE DATA."
754 INPUT Bladcalc$

```

```

755 CREATE BDAT Bladcalc$,100
756 ASSIGN @Path6 TO Bladcalc$
757 DIM Prntdata(1,48)          !DIMENSION STATEMENTS FOR BLADE ARRAYS
758                               !ARE HERE SO ARRAY SPACE IS ONLY ASSIGNED
759                               !IF BLADE OPTION IS SELECTED.
760 DIM Cpmassavg(48)
761 MAT Cpmassavg= (0)
762 MAT Prntdata= (0)
763 PRINT "....."
764 PRINT ""
765 PRINT "ENTER THE LIMITS OF INTEGRATION i.e., THE LOWEST TO THE "
766 PRINT "HIGHEST SCAN NUMBER DESIRED."
767 PRINT ""
768 PRINT "....."
769 PRINT ""
770 PRINT "....."
771 PRINT ""
772 PRINT "ENTER THE LOW SCAN"
773 INPUT Lowpoint
774 PRINT "....."
775 PRINT ""
776 PRINT "ENTER THE HIGH SCAN"
777 INPUT Hpoint
778 LOADSUB ALL FROM "/CLASSICK/ROUTINES/LOSSCALC"
779 !INTEGRATE A
780 CALL Datint(Lowpoint,Hpoint,Aarray(*),Prbpos(*),Aintg)
781 !INTEGRATE B
782 CALL Datint(Lowpoint,Hpoint,Barray(*),Prbpos(*),Bintg)
783 !INTEGRATE Kn
784 CALL Datint(Lowpoint,Hpoint,Karray(*),Prbpos(*),Knintg)
785 A1=Aintg/Knintg
786 B1=Bintg/Knintg
787 ENTER @Fath5;Prntdata(*)
788 Pp=Prntdata(1,3)
789 FOR N=Firstbladeprt TO Lastbladeprt !OBTAINED FROM PORT ASSIGNMENT SHEET
790 Plocal=Prntdata(1,N)
791 CALL Cpcalc(A1,B1,Pp,Plocal,C)
792 Cpmassavg(N)=C
793 NEXT N
794 PRINT "....."
795 PRINT ""
796 PRINT "ALIGN PAPER IN PRINTER AND PRESS ""BLADE DATA"" FOR HARD COPY"
797 PRINT " OF BLADE MASS AVERAGED COEFFICIENTS OF PRESSURE."
798 PRINT ""
799 PRINT "....."
800 ON KEY 1 LABEL "BLADE DATA" GOTO Prntbladedata
801 Spin5: GOTO Spin5
802 Prntbladedata: PRINTER IS Prnter
803 PRINT "....."
804 PRINT "BLADE CP FILE ",Bladcalc$
805 PRINT "....."
806 PRINT ""
807 PRINT "SCANIVALVE          MASS AVERAGED COEFFICIENT"
808 PRINT "PORT                OF PRESSURE          "
809 FOR N=Firstbladeprt TO Lastbladeprt
810 PRINT USING "2D,15X,MD.3DE"IN,Cpmassavg(N)
811 NEXT N
812 OUTPUT @Path6;Cpmassavg(*)          !SERIAL OUTPUT STATEMENT
813 Loadoption2: PRINTER IS Scran
814 PRINT "....."
815 PRINT ""
816 PRINT "TO LOAD PROGRAM THAT CALCULATES THE AVDR AND LOSS COEFFICIENT,"
817 PRINT ""
818 PRINT "PRESS ""LOSS"". PRESS ""GO ON"" TO TERMINATE THE PROGRAM."
819 PRINT ""

```

```

820 PRINT "....."
821 ON KEY 1 LABEL "LOSS" GOTO Loadup2
822 ON KEY 4 LABEL "GO ON" GOTO Fin
823 Spin6: GOTO Spin6
824 Loadup2: MASS STORAGE IS "/CLASSICK/PROGS"
825 LOAD "LOSS",10
826 Fin: PRINT ""
827 PRINT "....."
828 PRINT ""
829 PRINT "                END OF PROGRAM"
830 PRINT ""
831 PRINT "....."
832 END

```

B7.3 Reduction Program LOSS

```

10  IPROGRAM LOSS
20  ITHIS PROGRAM USES VALUES FROM THE CALC ARRAYS GENERATED BY REDUCING
30  ISCALED DATA IN PROGRAM CALC. SUBROUTINES INTEGRATE THESE VALUES AND A
50  ISTATIC PRESSURE RISE COEFFICIENT,AVDR & LOSS COEFFICIENT IS CALCULATED.
51  IMUCH OF THE CODING WAS PREVIOUSLY COMMENTED ON IN PROGRAM ACQUIRE AND
52  IPROGRAM CALC.
60  OPTION BASE 1
70  DIM Calc1(100,25)          INOTE THAT u AND I DESIGNATORS DISTINGUISH
71                               ITHOSE VALUES FROM UPPER SURVEY AND LOWER
72                               ISURVEY STATIONS RESPECTIVELY.
80  DIM Calcu(100,25)
90  DIM Posit(100)
100 DIM Positu(100)
110 DIM Kn(100)                ISEE TABLE 1 OF CLASSICK THESIS Kn=K.
120 DIM Knu(100)
121 DIM Cpt(100)               ITHese VALUES PREVIOUSLY DEFINED IN "CALC"
122 DIM Cptu(100)
123 DIM Cps(100)
124 DIM Y(100)                 IAN INTERMEDIATE QUANTITY IN THE STATIC
125                               IPRESSURE RISE COEFFICIENT CALCULATION.
129 DIM Z(100)                 I"
131 DIM Cptxkn(100)            ICOMBINED VALUES TO MAKE THE INTEGRATIONS
132 DIM Cptuxknu(100)          IMORE EXPLICIT TO THE PROGRAMMER.
133 DIM Cpsxkn(100)
134 DIM Yxkn(100)
135 DIM Zxknu(100)
136 MAT Calc1= (0)
137 MAT Calcu= (0)
138 MAT Posit= (0)
139 MAT Positu= (0)
140 MAT Kn= (0)
141 MAT Knu= (0)
142 MAT Cpt= (0)
143 MAT Cptu= (0)
144 MAT Cps= (0)
145 MAT Cptxkn= (0)
146 MAT Cptuxknu= (0)
147 MAT Cpsxkn= (0)
148 MAT Yxkn= (0)
149 MAT Zxknu= (0)
150 LOADSUB ALL FROM "/CLASSICK/ROUTINES/LOSSCALC"
151 MASS STORAGE IS "/CLASSICK/REDDATA"
152 PRINT "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE"
153 PRINT "LOWER PROBE"
154 PRINT "....."
155 INPUT Calc1file$
156 ASSIGN @Path1 TO Calc1file$
157 ENTER @Path1:Calc1(*)
158 FOR N=1 TO 100
159   Posit(N)=Calc1(N,1)
212   Kn(N)=Calc1(N,10)
213   Cpt(N)=Calc1(N,11)
214   Cps(N)=Calc1(N,12)
215   Pal=Calc1(N,19)
216   Psi=Calc1(N,20)
217   Q1=Calc1(N,15)
218   IF Q1=0 THEN Skipy          IPREVENTS A DIVISION BY ZERO IF THE
219                               IARRAY IS NOT ENTIRELY FILLED WITH
220                               INONZERO VALUES I.e., TOTAL DATA POINTS
221                               ITAKEN DID NOT EQUAL 100.
222   Y(N)=(Pal-Psi)/Q1
224   Cptxkn(N)=Cpt(N)*Kn(N)
225   Cpsxkn(N)=Cps(N)*Kn(N)
226   Yxkn(N)=Y(N)*Kn(N)
227 NEXT N

```

```

231 Skipy: PRINT "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE"
232 PRINT "UPPER PROBE"
233 PRINT "*****"
234 INPUT Calcufile$
235 ASSIGN @Path2 TO Calcufile$
236 ENTER @Path2:Calcu(*)
237 FOR N=1 TO 100
238   Positu(N)=Calcu(N,1)
239   Knu(N)=Calcu(N,10)
240   Cptu(N)=Calcu(N,11)
241   Pau=Calcu(N,19)
242   Zxknu(N)=Calcu(N,20)
243   Qu=Calcu(N,15)
244   IF Qu=0 THEN Skipz
245   Z(N)=(Pau-Pau)/Qu
246   Cptuxknu(N)=Cptu(N)*Knu(N)
247   Zxknu(N)=Z(N)*Knu(N)
248 NEXT N
249 Skipz: PRINT ""
250 PRINT "ENTER THE LIMITS OF INTEGRATION FOR THE LOWER PROBE SURVEY"
251 PRINT ""
252 PRINT "*****"
253 INPUT "ENTER THE FIRST POINT",Lowpoint
254 INPUT "ENTER THE LAST POINT",Hipoint
255 I CALL THE INTEGRATION ROUTINE
256 CALL Datint(Lowpoint,Hipoint,Kn(*),Posit(*),Denominator)
257 CALL Datint(Lowpoint,Hipoint,Cptuxkn(*),Posit(*),Intega)
258 CALL Datint(Lowpoint,Hipoint,Cpsxkn(*),Posit(*),Integc)
259 CALL Datint(Lowpoint,Hipoint,Yxkn(*),Posit(*),Integy)
260 PRINT ""
261 PRINT "ENTER THE LIMITS OF INTEGRATION FOR THE UPPER PROBE SURVEY"
262 PRINT ""
263 PRINT "*****"
264 INPUT "ENTER THE FIRST POINT",Lowpoint
265 INPUT "ENTER THE LAST POINT",Hipoint
266 CALL Datint(Lowpoint,Hipoint,Knu(*),Positu(*),Numerator)
267 CALL Datint(Lowpoint,Hipoint,Cptuxknu(*),Positu(*),Integb)
268 CALL Datint(Lowpoint,Hipoint,Zxknu(*),Positu(*),Integz)
269 Cp2=(Integz/Denominator)/(Integy/Denominator)
270 Avdr=Numerator/Denominator
271 PRINT "STATIC PRESSURE RISE COEFFICIENT"
272 PRINT USING "MD.3DE" Cp2
273 PRINT ""
274 PRINT "AVDR"
275 PRINT USING "MD.3DE" Avdr
276 PRINT ""
277 W=(Intega-(1/Avdr)*(Integb))/(Intega-Integc)
278 PRINT "LOSS COEFFICIENT"
279 PRINT USING "MD.3DE" W
280 PRINT "*****"
281 PRINT ""
282 PRINT "END OF PROGRAM"
283 PRINT ""
284 PRINT "*****"
285 END

```

B7.4 Subprogram SUBACQUIRE

```

1   IFILE SUBACQUIRE
10  ITHIS FILE CONTAINS THE SUBPROGRAMS FOR POSITIONING THE SCANIVALVE
20  IPORTS AND READING THE DVM.
720 SUB Scnvpportposit(Scnv,Dp,Scnhmsvc,Scnstpsvc) ITHE STRUCTURE OF THIS
721 I SUBPROGRAM IS SIMILAR TO PREVIOUS
722 I ACQUISITION PROGRAMS WRITTEN AT THE
723 I TPL. SEE GEOPFARTH THESIS.
725   OPTION BASE 1
726   COM /Positvrbls/ Svc,Scn
727 Posit:OUTPUT Svc USING "%,K":Scnv
728   Z=SPOLL(Svc)
729   U=BINAND(Z,15)
730   V=SHIF1(Z,4)
731   T=BINAND(V,7)
732   P=10*T+U
733   IP IS THE PRESENT PORT THAT THE
       ISCANIVALVE IS ON.
735   CLEAR Svc
736   IF P=Dp THEN Retrn
737   IF P>Dp THEN
738     OUTPUT Scn USING "ZZ":Scnhmsvc IHOME THE SCANIVALVE
739     CLEAR Scn
740     WAIT 4
741     IALLOW 4 SECONDS FOR THE HOME TO
       ICOMPLETE.
743     GOTO Posit
744   ELSE
745     OUTPUT Scn USING "ZZ":Scnstpsvc ISTEP THE SCANIVALVE
746     CLEAR Scn
747     WAIT .1
748     IWAIT 1/10 SEC BETWEEN STEPS
749     GOTO Posit
749   END IF
750 Retrn: SUBEND
751 SUB Readvbm(Dp,Chanlassign)
752   OPTION BASE 1
753   COM /Positvrbls/ Svc,Scn
754   COM /Readvrbls/ Scn,Dvm,Scanvb(1,48),Tempchnrd,Yawchnrd,Scnyawchn,Scnto
mpchn,Scnrdsvcb,Scanva(1,48),Scnrdsvc,Noofprbs,Yawchnrdu,Scnrdsvc
755   COM /Readvrbls/ Yawchnrd1,Scnyawchnu,Scnyawchnl,Maxdif
756   OUTPUT Scn USING "ZZ":Chanlassign ICHANLASIGN TAKES ON THE VALUE
757   IASSIGNED TO IT BY THE CALLING
758   ISTATEMENT IN THE MAIN PROGRAM.
760   OUTPUT Dvm:Fir7m3a0h0t3
761   I STANDARD SETTING FOR THE DVM.
762   ISETS THE FUNCTIONS ON THE PANEL.
763 Sample: DIM A(5)
764   MAT A= (0)
765   FOR I=1 TO 5
766     ITAKE 5 READINGS AND STORE IN THE
       I"A" ARRAY
768   TRIGGER Dvm
769   ENTER Dvm:A(I)
770   Avg=SUM(A)/I
771   Dev=A(I)-Avg
772   I AVERAGE THE 5 READINGS
773   IF Dev>Maxdif THEN
774     IERROR TRAP FOR SPURIOUS DVM READINGS
775     PRINT "SAMPLE EXCEEDED MAXIMUM DEVIATION ALLOWED-SAMPLE RETAKEN"
776     GOTO Sample
777   END IF
778   WAIT .3
779   NEXT I
780   IF Noofprbs=1 THEN Readone
781   IF Chanlassign=Scnrdsvcb THEN
782     Scanvb(1,Dp)=SUM(A)/5
783   ELSE
784     IF Chanlassign=Scnyawchnl THEN
785       Yawchnrd1=SUM(A)/5
786     ELSE
787       IF Chanlassign=Scnyawchnu THEN
788         Yawchnrdu=SUM(A)/5

```

```

787         ELSE
788             GOTO Tempread
789         END IF
790     END IF
791 END IF
792 Readone: IF Chanlsgn=Scnrdsve THEN
793     Scnvb(1,Dp)=SUM(A)/5
794 ELSE
795     IF Chanlsgn=Scnyauchn THEN
796         Yawchnrd=SUM(A)/5
797     ELSE
798         Tempread: Tempchnrd=SUM(A)/5
799     END IF
800 END IF
801 IF Chanlsgn=Scnrdsve THEN Scnva(1,Dp)=SUM(A)/5
802 Retrn: CLEAR Scn
803 SUBEND

```

B7.5 Subprogram SUBCALC

```

1  IFILE SURCALC
10  ITHIS FILE CONTAINS ALL THE CALCULATION SUBROUTINES CALLED BY THE
20  IDATA REDUCTION PROGRAM CALC.
798  SUB Bpccalc(Pa,P1,P23,P4,P5,Beta,Gamma)
799  Beta=(P1-P23)/(P1+Pa)
800  Gamma=(P4-P5)/(P1-P23)
801  SUBEND
802  SUB Xphicalc(Beta,Gamma,Xvel,X( ),Phi,P( ))
803  OPTION BASE 1
804  DIM E(6)
805  DIM F(6)
806  MAT E= (0)
807  MAT F= (0)
808  FOR J=1 TO 6
809  E(J)=X(1,J)+X(2,J)*Gamma+X(3,J)*Gamma^2+X(4,J)*Gamma^3+X(5,J)*Gamma^4+X(6,
J)*Gamma^5
810  F(J)=P(1,J)+P(2,J)*Gamma+P(3,J)*Gamma^2+P(4,J)*Gamma^3+P(5,J)*Gamma^4+P(6,
J)*Gamma^5
811  NEXT J
812  Xvel=E(1)+E(2)*Beta+E(3)*Beta^2+E(4)*Beta^3+E(5)*Beta^4+E(6)*Beta^5
813  Phi=F(1)+F(2)*Beta+F(3)*Beta^2+F(4)*Beta^3+F(5)*Beta^4+F(6)*Beta^5
814  SUBEND
815  SUB Vmccalc(Xvel,Cp,Temp,G,Vel,Mach,P1,Pa,Q)
816  Vel=Xvel*(2+Cp*778*32.174*Temp)^.5
817  Mach=((Xvel^2)/(1-Xvel^2))^(2/(G-1))^.5
818  Q=(P1+Pa)*(G/(G-1))*Xvel^2*((1-Xvel^2)^(1/(G-1)))
819  SUBEND
820  SUB Xrefcalc(Pa,Fp,G,Xref)
821  Xref=((1-(Pa/(Pp+Pa)))^(G-1)/G)^.5
822  SUBEND
823  SUB Kncalc(Pa,P1,Pp,Xvel,Xref,G,Yaw,Kn)
824  Kn=((P1+Pa)/(Pp+Pa))*(Xvel/Xref)*(((1-Xvel^2)/(1-Xref^2))^(1/(G-1)))
* COS(Yaw)
825  SUBEND
826  SUB Coefpress(P1,Pp,Pa,Xvel,G,Cps,Cpt)
827  Cpt=(P1+Pa)/(Pp+Pa)
828  Cps=((P1+Pa)*((1-Xvel^2)^(G/(G-1))))/(Pp+Pa)
829  SUBEND
830  SUB Ensemble(Pp,Pinitial,Pa,Painitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
831  Ppe=Pp+Pinitial
832  Ppavg=Ppe/N
833  Pinitial=Ppe
834  Te=Temp+Tinitial
835  Tempavg=Te/N
836  Tinitial=Te
837  Pee=Pa+Painitial
838  Paavg=Pee/N
839  Painitial=Pee
840  SUBEND

```

```

867 SUB Xrefensemble(Pavg,Ppavg,6,Xrefavg)
868 Xrefavg=(1-((Pavg)/(Ppavg+Pavg))^(6-1)/6)^(.5)
869 SUBEND
870 SUB Urefensemble(Xrefavg,Cp,Tempavg,Urefavg)
871 Urefavg=Xrefavg*(2*Cp*Tempavg+778+32.174)^(.5)
872 SUBEND
873 SUB Qrefensemble(Pavg,Ppavg,6,Xrefavg,Qrefavg)
874 Qrefavg=(Ppavg+Pavg)*(6/(6-1))*Xrefavg^2*(1-Xrefavg^2)^(1/(6-1))
875 SUBEND
876 SUB Qvrefcalc(Xref,Cp,Temp,6,Pp,Pa,Qref,Uref)
877 Uref=Xref*(2*Cp*778+32.174*Temp)^(.5)
878 Qref=(Pa+Pp)*(6/(6-1))*(Xref^2)*((1-Xref^2)^(1/(6-1)))
879 SUBEND
880 SUB Cpintegrand(Pp,P1,Pa,6,Xvel,A,B,Kn)
881 M=Pp/((P1+Pa)*(6/(6-1))*Xvel^2*((1-Xvel^2)^(1/(6-1))))
882 N1=(Pa/(P1+Pa))-((1-Xvel^2)^(6/(6-1)))
883 N2=(6/(6-1))*Xvel^2*((1-Xvel^2)^(1/(6-1)))
884 N=N1/N2
885 A=M*Kn
886 B=N*Kn
887 SUBEND
888 SUB Cpcalc(A1,B1,Pp,Plocal,C)
889 C=((Plocal/Pp)*A1)+B1
890 SUBEND
900 SUB Staticpress(P1,Pa,Xvel,6,Pa)
910 Pa=(P1+Pa)*(1-Xvel^2)^(6/(6-1))
920 SUBEND
930 SUB Prefqref(Pp,P1,Qref,Pq)
940 Pq=(Pp-P1)/Qref
950 SUBEND

```

B7.6 Subprogram LOSSCALC

```
1   IFILE LOSSCALC
10  ITHIS SUBPROGRAM IS AN ADAPTATION OF SHREEVE'S INTEGRATION ROUTINE
20  I GIVEN IN APPENDIX B OF NPS-575F73071A
272 SUB Datint(Lowpoint,Hipoint,D(*),Posit(*),Datint)
277 OPTION BASE 1
287 DIM A(100)
297 DIM B(100)
307 DIM C(100)
317 DIM Dint(100)
321 MAT A= (0)
322 MAT B= (0)
323 MAT C= (0)
324 MAT Dint= (0)
325 N=Hipoint-1
326 Nml=N-1
327 FOR I=Lowpoint+1 TO N
337 A(I)=(1/(Posit(I+1)-Posit(I-1)))*(((D(I+1)-D(I))/(Posit(I+1)-Posit(I)))-((
D(I)-D(I-1))/(Posit(I)-Posit(I-1))))
347 B(I)=((D(I)-D(I-1))/(Posit(I)-Posit(I-1)))-((Posit(I)+Posit(I-1))*A(I))
357 C(I)=D(I)-(A(I)*Posit(I)^2)-(B(I)*Posit(I))
360 NEXT I
361 Datint=0
362 FOR J=Lowpoint+1 TO Nml
363 Dint(J)=(A(J)+A(J+1))*(Posit(J+1)^3-Posit(J)^3)/6+(B(J)+B(J+1))*(Posit(J+1)
)^2-Posit(J)^2)/4+(C(J)+C(J+1))*(Posit(J+1)-Posit(J))/2
364 Datint=Datint+Dint(J)
367 NEXT J
377 Dint(1)=A(2)*(Posit(2)^3-Posit(1)^3)/3+B(2)*(Posit(2)^2-Posit(1)^2)/2+C(2)
*(Posit(2)-Posit(1))
387 Dint(N)=A(N)*(Posit(N+1)^3-Posit(N)^3)/3+B(N)*(Posit(N+1)^2-Posit(N)^2)/2+
C(N)*(Posit(N+1)-Posit(N))
397 Datint=Datint+Dint(1)+Dint(N)
407 SUBEND
```

B7.7 Plot Program PREFPOREF

```
1  IPROGRAM PREFPOREF
2  IPROGRAM PLOTS PREF-PT/QREF VS PROBE POSITION
4  MASS STORAGE IS "/CLASSICK/REDDATA"
7  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
10 ASSIGN @Path1 TO Calcdat$
11 OPTION BASE 1
12 DIM Calc(100,25)
17 MAT Calc= (0)
20 Scan=31
26 ENTER @Path1:Calc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LORG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+1,Y_gdu_max
78 LABEL "Pref-Pt1/Qref VS PROBE DISPLACEMENT"
79 NEXT I
83 DEG
84 LDIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "Pref-Pt1/Qref"
87 LDIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "BLADE-TO-BLADE (in)"
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW 0,3,0,.7
96 AXES .1,.01,0,0,5,10,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LORG 6
100 FOR I=0 TO 3 STEP .5
101 MOVE I,-.01
102 LABEL USING "%,K",I
103 NEXT I
104 LORG 8
105 FOR I=1.0 TO 0 STEP -.1
106 MOVE -.01,I
107 LABEL USING "DD.DD",I
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT Calc(K,1),Calc(K,18)
114 NEXT K
117 END
```

B7.8 Plot Program BETAPOSIT

```
1  IPROGRAM BETAPOSIT
2  IPROGRAM PLOTS BETA VS PROBE POSITION
4  MASS STORAGE IS "/CLASSICK/REDDATA"
7  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat#
10 ASSIGN @Path1 TO Calcdat#
11 OPTION BASE 1
12 DIM Calc(100,25)
17 MAT Calc= (0)
20 Scan=31
26 ENTER @Path1;Calc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LORG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "BETA1 VS PROBE DISPLACEMENT"
79 NEXT I
83 DEG
84 LDIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "BETA1 (deg)"
87 LDIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "BLADE-TO-BLADE (in)"
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW 0,3,-50,-45
96 AXES .1,.2,0,-50,5,5,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LORG 6
100 FOR I=0 TO 3 STEP .5
101 MOVE I,-50.2
102 LABEL USING "#,K":I
103 NEXT I
104 LORG 8
105 FOR I=-50.0 TO -45.0 STEP 1
106 MOVE -.01,I
107 LABEL USING "DDD.D":I
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT Calc(K,1),-Calc(K,9)
114 NEXT K
117 END
```

B7.9 Plot Program VVREFSPAN

```
1  IPROGRAM VVREFSPAN
2  IPROGRAM PLOTS V1/VREF VS PROBE POSITION FOR A SPAN-WISE SURVEY
4  MASS STORAGE IS "/CLASSICK/REDDATA"
5  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
6  ASSIGN @Path2 TO Calcdat$
9  OPTION BASE 1
10 DIM Calc(:20,25)
11 MAT Calc= (0)
12 Scan=42
14 ENTER @Path2;Calc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LOG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "V1/Vref VS PROBE DISPLACEMENT"
79 NEXT I
83 DEG
84 LDIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "V1/Vref"
87 LDIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "SPAN (in) "
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW -5,5,1,1.5
96 AXES 1,.01,-5,1.0,1,10,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LOG 6
100 FOR I=5 TO -5 STEP -1
101 MOVE I,.99
102 LABEL USING "#,K":I
103 NEXT I
104 LOG 8
105 FOR I=15 TO 1.0 STEP -.1
106 MOVE -5.05,I
107 LABEL USING "DD.DD":I
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT Calc(K,1),Calc(K,7)/Calc(K,14)
114 NEXT K
117 END
```

B7.10 Plot Program VVREFUSPAN

```
1  IPROGRAM VVREFUSPAN
2  IPROGRAM PLOTS V2/VREF VS PROBE POSITION FOR UPPER TRAVERSE SPAN-WISE
3  I SURVEYS
4  MASS STORAGE IS "/CLASSICK/REDDATA"
5  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
6  ASSIGN @Path2 TO Calcdat$
7  OPTION BASE 1
8  DIM Calc(100,25)
9  MAT Calc= (0)
10 Scan=38
11 ENTER @Path2;Calc(0)
12 GINIT
13 PLOTTER IS CRT,"INTERNAL"
14 GRAPHICS ON
15 X_gdu_max=100*MAX(1,RATIO)
16 Y_gdu_max=100*MAX(1,1/RATIO)
17 LOG 6
18 FOR I=-.3 TO .3 STEP .1
19   MOVE X_gdu_max/2+I,Y_gdu_max
20   LABEL "V2/Vref VS PROBE DISPLACEMENT"
21   NEXT I
22 DEG
23 LDIR 90
24 MOVE 0,Y_gdu_max/2
25 LABEL "V2/Vref"
26 LDIR 0
27 MOVE X_gdu_max/2,.1*Y_gdu_max
28 CSIZE 3,1
29 LABEL "SPAN (in)"
30 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
31 FRAME
32 WINDOW -5,5,.5,1.0
33 AXES 1,.01,-5,.5,1,10,2
34 CLIP OFF
35 CSIZE 2.5,.5
36 LOG 6
37 FOR I=5 TO -5 STEP -1
38   MOVE I,.49
39   LABEL USING "%,K",I
40   NEXT I
41 LOG 8
42 FOR I=1.0 TO .5 STEP -.1
43   MOVE -5.05,I
44   LABEL USING "00.00",I
45   NEXT I
46 FOR K=1 TO Scan
47   PLOT Calc(K,1),Calc(K,7)/Calc(K,14)
48   NEXT K
49 END
```

B7.11 Plot Program CPBLADEPLOT

```

1  IPROGRAM CPBLADEPLOT
2  IPROGRAM PLOTS MASS AVERAGED BLADE COEFFICIENT OF PRESSURE AGAINST
3  ITHE FRACTION OF CORD X/C FROM THE LEADING EDGE.
5  MASS STORAGE IS "/CLASSICK/REDDATA"
7  INPUT "ENTER THE NAME OF THE FILE CONTAINING THE BLADE CP'S",Cpfile$
10 ASSIGN @Path1 TO Cpfile$
11 OPTION BASE 1
12 DIM Cpmassavg(40)
15 DIM Xoc(20)
16 MAT Cpmassavg= (0)
19 DATA 98.8,94.8,90.8,86.8,82.8,78.8,71.5,64.1,56.7,49.3,41.9,34.3,26.9,19.6
,12.2,8.6,4.8,3.2,1.6,0
20 READ Xoc(*)
26 ENTER @Path1:Cpmassavg(*)
54 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LONG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "Cp VS PERCENT CHORD"
79 NEXT I
83 DEG
84 LDIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "Cp"
87 LDIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "X/C PERCENT CHORD"
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW 0,100,1.0,-1.6
96 AXES S,.2,0,1.0,2,2,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LONG 6
100 FOR I=0 TO 100 STEP 10
101 MOVE I,1.02
102 LABEL USING "8,K",I
103 NEXT I
104 LONG 8
105 FOR I=-1.6 TO 1.0 STEP .4
106 MOVE -.6,I
107 LABEL USING "00.00",I
108 NEXT I
109 FOR N=1 TO 20
113 PLOT Xoc(N),Cpmassavg(N+3)
114 NEXT N
115 FOR N=1 TO 20
116 PLOT Xoc(21-N),Cpmassavg(22+N)
117 NEXT N
119 END

```

B7.12 Program CORRECT A

```
10  IPROGRAM CORRECT A
11  OPTION BASE 1
20  DIM Scldata(1,106)
30  DIM Correctaray(1,106)
35  MAT Correctaray= (0)
40  MAT Scldata= (0)
80  MASS STORAGE IS "/CLASSICK/REDDATA"
90  INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Scfile$
100 INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfile$
110 CREATE BDAT Correctfile$,500,848
120 ASSIGN @Path1 TO Scfile$
130 ASSIGN @Path2 TO Correctfile$
140 FOR N=1 TO 49
150 ENTER @Path1,N,Scldata(*)
151 ON END @Path1 GOTO Adddata
153 Adddata: IF N=49 THEN
154   Scldata(1,1)=2.000E-2
155   Scldata(1,2)=1.494E+1
156   Scldata(1,3)=1.256E+1
157   Scldata(1,4)=-6.520E+0
158   Scldata(1,5)=7.700E+0
159   Scldata(1,6)=-8.160E-1
160   Scldata(1,7)=-8.280E-1
161   Scldata(1,8)=-3.280E-1
162   Scldata(1,9)=-1.270E+0
163   Scldata(1,10)=1.075E+1
164   Scldata(1,11)=-7.200E+0
165   Scldata(1,12)=1.000E-2
166   Scldata(1,13)=-2.000E-3
167   Scldata(1,14)=-6.000E-3
168   Scldata(1,16)=1.770E+0
169   Scldata(1,15)=3.0
170   Scldata(1,17)=4.561E+2
171   Scldata(1,18)=405.20
172 END IF
173 MAT Correctaray= Scldata
174 OUTPUT @Path2,N,Correctaray(*)
175 NEXT N
192 ASSIGN @Path2 TO Correctfile$
194 FOR N=1 TO 49
195 ENTER @Path2,N,Correctaray(*)
197 PRINT "*****"
198 PRINT "SCAN",N
200 PRINT Correctaray(*)
201 PRINT "*****"
203 NEXT N
210 END
```

B7.13 Program CORRECT B

```
10  PROGRAM CORRECT B
11  OPTION PAGE 1
20  DIM Sdata(1,100)
30  DIM Correctaray(1,100)
45  NAT Correctaray= (0)
48  DIM Sldata= (0)
80  MASS STORAGE IS "/CLASSICK/REUDATA"
82  INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",ScfFile$
100 INPUT "ENTER THE NAME OF THE CORRECTED FILE",CorrectFile$
110 CREATE DATA CorrectFile$,600,840
120 ASSIGN @Path1 TO ScfFile$
130 ASSIGN @Path2 TO CorrectFile$
140 FOR N=1 TO 40
150 ENTER @Path1,HSldata(*)
151 IF N=35 THEN Sldata(1,15)=1.95
163 NAT Correctaray= Sldata
164 OUTPUT @Path2,NiCorrectaray(*)
166 NEXT N
172 ASSIGN @Path2 TO CorrectFile$
181 FOR N=1 TO 40
195 ENTER @Path2,NiCorrectaray(*)
197 PRINT "*****"
199 PRINT "SCAN",N
200 PRINT Correctaray(*)
201 PRINT "*****"
203 NEXT N
210 END
```

B7.14 Program CORRECT C

```
10  IF PROGRAM CORRECT C
11  OPTION BASE 1
20  DIM Sdata(1,100)
30  DIM Correctaray(1,100)
31  DIM Correctdata(30)
35  MAT Correctaray = 10
40  MAT Sdata = 0
50  DATA -3.2,-3.1,-3.0,-2.9,-2.8,-2.7,-2.6,-2.5,-2.4,-2.3,-2.2,-2.1,-2.0,-1.9
,-1.7, 1.5,-1.2,-1.1,-.7,-.5,-.2,-.1,.4,.7,1.0,1.3,1.6,1.9,2.1,2.3,2.5,2.6,2.7
70  DATA 2.8,2.9,3.0,3.1,3.2
71  READ Correctdata(*)
80  MASS STORAGE IS "/CLASSICK/REDATA"
90  INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Scifiles
100 INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfiles
110 OPEN DATA Correctfiles,500,848
120 ASSIGN #Path1 TO Scifiles
130 ASSIGN #Path2 TO Correctfiles
140 FOR N=1 TO 30
150 ENTER #Path1,HiSdata(*)
151 Sdata(1,15)=Correctdata(N)
163 MAT Correctaray = Sdata
164 OUTPUT #Path2,HiCorrectaray(*)
165 NEXT N
170 ASSIGN #Path2 TO Correctfiles
180 FOR N=1 TO 30
195 ENTER #Path2,HiCorrectaray(*)
197 PRINT "*****"
198 PRINT "SCAN",N
200 PRINT Correctaray(*)
201 PRINT "*****"
203 NEXT N
210 END
```

B7.15 Program PRBCOEF

[illegible]

B7.18 Examples of Acquired and Reduced Data

The Scanivalve port and scanner channel assignments for data acquired using program ACQUIRE are shown in Table B1.

An example of the table of survey data output by program ACQUIRE in engineering units ('scaled') is given in Table B2, and the corresponding reduced data output by program CALC is given in Table B3 for an upstream probe survey. Similar results for the downstream survey [survey # in Table II] are given in Table B4 and Table B5 respectively.

An example of scaled data output by program ACQUIRE for a surface pressure scan is given in Table B6. The corresponding table of pressure coefficients calculated by program CALC is given in Table B7.

B8. FLEXIBLE DISC INITIALIZATION AND FILE BACKUP

Flexible discs are used to backup the files stored on the computer's hard disc. The file structure used for the present work was designed to allow the contents of each subdirectory to be stored separately from the other subdirectories. Backing up the file system therefore requires separate flexible discs for each subdirectory. Blank discs must be formatted first, using the following steps:

1. Type MSI "/" [Puts system in root directory if not already there.]

TABLE B1. SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENTS

5-Hole Probe		SCANNER #2		SCANNER #2	
S.V. # 2	S.V. # 1	ch		ch	
1 P atmospheric	P atmospheric	0	SV1 READ DATA	40	SV1 ADVANCE(step)
2 P calibration	P calibration	1	SV2 " "	41	SV2 "
3 P plenum	P plenum	2		42	
4 P wall static	20B blade(press)	3		43	
5 P1 (probe)	19B	4		44	
6 P2 "	18B	5		45	SV1 RESET(home)
7 P3 "	17B	6		46	SV2 "
8 P4 "	16B	7		47	
9 P5 "	15B	8		48	
10 Ptp Prandtl(total)	14B	9		49	
11 Psp Prandtl(static)	13B	10	Tt(plenum)	50	
12 BLANK	12B	11		51	
13 "	11B	12		52	
14 "	10B	13		53	
15	9B	14		54	
16	8B	15		55	
17	7B	16		56	
18	6B	17		57	
19	5B	18		58	
20	4B	19		59	
21	3B	20		60	
22	2B	21		61	
23	1	22		62	
24	2T(suction side)	23		63	
25	3T	24	YAW XDUCER	64	
26	4T	25		65	
27	5T	26		66	
28	6T	27		67	
29	7T	28		68	
30	8T	29		69	
31	9T	30		70	
32	10T	31		71	
33	11T	32		72	
34	12T	33		73	
35	13T	34		74	
36	14T	35		75	
37	15T	36		76	
38	16T	37		77	
39	17T	38		78	
40	18T	39		79	
41	19T				
42	20T				
43	S1 (partial inst)				
44	S2 (suction side)				
45	S3				
46	P2 (press side)				
47	P3				
48	TRAILING EDGE				

TABLE B2. UPSTREAM BLADE-TO-BLADE SCALED PROBE
DATA FILE L-4SEPASCL

SCAN	PROBE POSIT	1	2	3	4	5
1	0.00	2.800E-02	1.475E+01	1.177E+01	-6.012E+00	1.010E+01
2	.10	3.400E-02	1.476E+01	1.182E+01	-6.052E+00	1.014E+01
3	.20	2.600E-02	1.478E+01	1.189E+01	-6.146E+00	1.015E+01
4	.30	2.600E-02	1.460E+01	1.187E+01	-6.104E+00	1.017E+01
5	.40	3.200E-02	1.479E+01	1.186E+01	-6.154E+00	1.015E+01
6	.50	2.400E-02	1.464E+01	1.195E+01	-6.112E+00	1.021E+01
7	.60	3.600E-02	1.482E+01	1.197E+01	-6.134E+00	1.027E+01
8	.70	2.400E-02	1.483E+01	1.200E+01	-6.156E+00	1.026E+01
9	.80	2.600E-02	1.484E+01	1.203E+01	-6.166E+00	1.025E+01
10	.90	4.200E-02	1.485E+01	1.201E+01	-6.216E+00	1.026E+01
11	1.00	3.400E-02	1.487E+01	1.203E+01	-6.180E+00	1.024E+01
12	1.10	3.600E-02	1.486E+01	1.209E+01	-6.246E+00	1.026E+01
13	1.20	4.600E-02	1.490E+01	1.212E+01	-6.282E+00	1.025E+01
14	1.30	3.400E-02	1.491E+01	1.215E+01	-6.284E+00	1.027E+01
15	1.40	3.200E-02	1.489E+01	1.219E+01	-6.334E+00	1.032E+01
16	1.50	3.600E-02	1.492E+01	1.225E+01	-6.266E+00	1.036E+01
17	1.60	3.600E-02	1.491E+01	1.225E+01	-6.358E+00	1.037E+01
18	1.70	3.400E-02	1.494E+01	1.230E+01	-6.280E+00	1.047E+01
19	1.80	3.600E-02	1.493E+01	1.233E+01	-6.356E+00	1.048E+01
20	1.90	4.200E-02	1.493E+01	1.232E+01	-6.368E+00	1.044E+01
21	2.00	4.400E-02	1.492E+01	1.235E+01	-6.374E+00	1.049E+01
22	2.10	4.000E-02	1.492E+01	1.247E+01	-6.490E+00	1.052E+01
23	2.20	4.200E-02	1.493E+01	1.249E+01	-6.420E+00	1.051E+01
24	2.30	3.400E-02	1.492E+01	1.262E+01	-6.516E+00	1.059E+01
25	2.40	4.600E-02	1.489E+01	1.266E+01	-6.574E+00	1.059E+01
26	2.50	3.600E-02	1.490E+01	1.273E+01	-6.588E+00	1.059E+01
27	2.60	4.000E-02	1.466E+01	1.276E+01	-6.582E+00	1.060E+01
28	2.70	4.200E-02	1.490E+01	1.276E+01	-6.586E+00	1.058E+01
29	2.80	4.600E-02	1.490E+01	1.278E+01	-6.620E+00	1.056E+01
30	2.90	4.600E-02	1.486E+01	1.277E+01	-6.632E+00	1.055E+01
31	3.00	4.600E-02	1.489E+01	1.279E+01	-6.680E+00	1.059E+01

SCAN	6	7	8	9	10	11
1	-7.456E+00	-7.542E+00	-6.816E+00	-8.432E+00	1.014E+01	-6.746E+00
2	-7.516E+00	-7.542E+00	-6.816E+00	-8.500E+00	1.021E+01	-6.796E+00
3	-7.576E+00	-7.602E+00	-6.750E+00	-8.578E+00	1.029E+01	-6.794E+00
4	-7.558E+00	-7.542E+00	-6.706E+00	-8.612E+00	1.025E+01	-6.782E+00
5	-7.566E+00	-7.578E+00	-6.620E+00	-8.680E+00	1.025E+01	-6.814E+00
6	-7.592E+00	-7.596E+00	-6.662E+00	-8.714E+00	1.026E+01	-6.820E+00
7	-7.594E+00	-7.612E+00	-6.650E+00	-8.816E+00	1.032E+01	-6.822E+00
8	-7.626E+00	-7.626E+00	-6.596E+00	-8.880E+00	1.036E+01	-6.816E+00
9	-7.630E+00	-7.640E+00	-6.562E+00	-8.862E+00	1.035E+01	-6.860E+00
10	-7.640E+00	-7.662E+00	-6.586E+00	-8.862E+00	1.034E+01	-6.850E+00
11	-7.670E+00	-7.626E+00	-6.592E+00	-8.920E+00	1.042E+01	-6.904E+00
12	-7.656E+00	-7.696E+00	-6.684E+00	-8.914E+00	1.044E+01	-6.898E+00
13	-7.682E+00	-7.696E+00	-6.670E+00	-8.870E+00	1.043E+01	-6.922E+00
14	-7.674E+00	-7.686E+00	-6.694E+00	-8.834E+00	1.046E+01	-6.924E+00
15	-7.714E+00	-7.706E+00	-6.764E+00	-8.816E+00	1.053E+01	-6.974E+00
16	-7.766E+00	-7.758E+00	-6.834E+00	-8.804E+00	1.055E+01	-7.008E+00
17	-7.726E+00	-7.726E+00	-6.892E+00	-8.842E+00	1.057E+01	-7.050E+00
18	-7.744E+00	-7.772E+00	-6.896E+00	-8.870E+00	1.060E+01	-7.042E+00
19	-7.788E+00	-7.772E+00	-6.970E+00	-8.826E+00	1.062E+01	-7.056E+00
20	-7.732E+00	-7.776E+00	-6.920E+00	-8.822E+00	1.061E+01	-7.102E+00
21	-7.788E+00	-7.776E+00	-6.950E+00	-8.886E+00	1.065E+01	-7.076E+00
22	-7.816E+00	-7.840E+00	-6.984E+00	-8.876E+00	1.073E+01	-7.146E+00
23	-7.842E+00	-7.842E+00	-6.970E+00	-8.978E+00	1.079E+01	-7.172E+00
24	-7.914E+00	-7.930E+00	-7.062E+00	-9.066E+00	1.092E+01	-7.250E+00
25	-7.960E+00	-7.932E+00	-7.040E+00	-9.140E+00	1.092E+01	-7.220E+00
26	-7.946E+00	-7.958E+00	-6.974E+00	-9.158E+00	1.096E+01	-7.284E+00
27	-7.976E+00	-7.988E+00	-6.912E+00	-9.220E+00	1.096E+01	-7.310E+00
28	-7.988E+00	-7.990E+00	-6.936E+00	-9.256E+00	1.099E+01	-7.304E+00
29	-7.936E+00	-8.006E+00	-6.852E+00	-9.274E+00	1.103E+01	-7.316E+00
30	-7.964E+00	-7.976E+00	-6.830E+00	-9.326E+00	1.098E+01	-7.324E+00
31	-7.986E+00	-8.004E+00	-6.886E+00	-9.336E+00	1.107E+01	-7.366E+00

TABLE B2 (CONT.). UPSTREAM BLADE-TO-BLADE SCALED
PROBE DATA FILE L-4SEPASCL

SCAN	12	13	14	YAW DEG	TEMP (R)	ATMOS PRESS
1	-8.000E-03	-1.660E-01	-2.460E-01	4.892E+01	4.607E+02	405.47
2	0.000E+00	-1.680E-01	-2.620E-01	4.876E+01	4.603E+02	405.47
3	0.000E+00	-1.680E-01	-2.620E-01	4.867E+01	4.602E+02	405.47
4	2.000E-03	-1.800E-01	-2.620E-01	4.865E+01	4.600E+02	405.47
5	6.000E-03	-1.840E-01	-2.580E-01	4.866E+01	4.596E+02	405.47
6	-4.000E-03	-1.660E-01	-2.600E-01	4.867E+01	4.597E+02	405.47
7	-8.000E-03	-1.660E-01	-2.560E-01	4.866E+01	4.596E+02	405.47
8	1.600E-02	-1.760E-01	-2.480E-01	4.866E+01	4.594E+02	405.47
9	1.600E-02	-1.500E-01	-2.520E-01	4.867E+01	4.595E+02	405.47
10	-1.400E-02	-1.840E-01	-2.620E-01	4.866E+01	4.596E+02	405.47
11	2.000E-03	-1.660E-01	-2.520E-01	4.866E+01	4.595E+02	405.47
12	-2.000E-03	-1.760E-01	-2.620E-01	4.865E+01	4.594E+02	405.47
13	-1.600E-02	-2.020E-01	-2.840E-01	4.867E+01	4.593E+02	405.47
14	-1.600E-02	-1.760E-01	-2.580E-01	4.867E+01	4.595E+02	405.47
15	4.000E-03	-1.900E-01	-2.420E-01	4.865E+01	4.593E+02	405.47
16	2.000E-03	-1.960E-01	-2.620E-01	4.865E+01	4.592E+02	405.47
17	8.000E-03	-1.660E-01	-2.660E-01	4.867E+01	4.593E+02	405.47
18	1.200E-02	-1.620E-01	-2.680E-01	4.864E+01	4.593E+02	405.47
19	4.000E-03	-1.780E-01	-2.580E-01	4.866E+01	4.590E+02	405.47
20	6.000E+00	-1.780E-01	-2.660E-01	4.890E+01	4.594E+02	405.47
21	4.000E-03	-1.840E-01	-2.740E-01	4.865E+01	4.594E+02	405.47
22	1.600E-02	-1.700E-01	-2.500E-01	4.866E+01	4.595E+02	405.47
23	4.000E-03	-1.920E-01	-2.760E-01	4.864E+01	4.596E+02	405.47
24	2.000E-03	-1.620E-01	-2.540E-01	4.875E+01	4.601E+02	405.47
25	6.939E-10	-1.720E-01	-2.620E-01	4.866E+01	4.603E+02	405.47
26	1.400E-02	-1.820E-01	-2.480E-01	4.865E+01	4.603E+02	405.47
27	6.000E-03	-1.740E-01	-2.400E-01	4.865E+01	4.603E+02	405.47
28	2.000E-03	-1.860E-01	-2.560E-01	4.867E+01	4.602E+02	405.47
29	0.000E+00	-1.740E-01	-2.500E-01	4.863E+01	4.604E+02	405.47
30	2.000E-03	-1.960E-01	-2.700E-01	4.864E+01	4.607E+02	405.47
31	-2.000E-03	-1.860E-01	-2.560E-01	4.879E+01	4.606E+02	405.47

TABLE B3. UPSTREAM BLADE-TO-BLADE REDUCED PROBE
DATA FILE L-4SEPCALC

SCAN	PRB POSIT	BETA	GAMMA	PHI	Xvel	Xref
1	0.00	4.240E-02	9.172E-02	-1.550E-03	1.092E-01	9.023E-02
2	.10	4.252E-02	9.529E-02	-3.445E-03	1.093E-01	9.044E-02
3	.20	4.277E-02	1.028E-01	-7.483E-03	1.096E-01	9.068E-02
4	.30	4.263E-02	1.076E-01	-1.012E-02	1.093E-01	9.061E-02
5	.40	4.263E-02	1.163E-01	-1.492E-02	1.092E-01	9.057E-02
6	.50	4.283E-02	1.153E-01	-1.433E-02	1.095E-01	9.091E-02
7	.60	4.299E-02	1.212E-01	-1.759E-02	1.096E-01	9.098E-02
8	.70	4.306E-02	1.276E-01	-2.116E-02	1.097E-01	9.108E-02
9	.80	4.303E-02	1.275E-01	-2.111E-02	1.096E-01	9.119E-02
10	.90	4.312E-02	1.270E-01	-2.081E-02	1.097E-01	9.113E-02
11	1.00	4.304E-02	1.301E-01	-2.260E-02	1.096E-01	9.121E-02
12	1.10	4.320E-02	1.242E-01	-1.923E-02	1.099E-01	9.145E-02
13	1.20	4.316E-02	1.226E-01	-1.836E-02	1.099E-01	9.153E-02
14	1.30	4.318E-02	1.192E-01	-1.646E-02	1.099E-01	9.164E-02
15	1.40	4.335E-02	1.139E-01	-1.345E-02	1.102E-01	9.182E-02
16	1.50	4.358E-02	1.087E-01	-1.056E-02	1.106E-01	9.203E-02
17	1.60	4.353E-02	1.077E-01	-1.003E-02	1.105E-01	9.203E-02
18	1.70	4.383E-02	1.083E-01	-1.029E-02	1.109E-01	9.219E-02
19	1.80	4.389E-02	1.017E-01	-6.635E-03	1.111E-01	9.233E-02
20	1.90	4.375E-02	1.045E-01	-8.234E-03	1.109E-01	9.229E-02
21	2.00	4.394E-02	1.060E-01	-9.034E-03	1.111E-01	9.240E-02
22	2.10	4.411E-02	1.031E-01	-7.393E-03	1.114E-01	9.283E-02
23	2.20	4.412E-02	1.094E-01	-1.087E-02	1.113E-01	9.291E-02
24	2.30	4.450E-02	1.093E-01	-1.077E-02	1.118E-01	9.338E-02
25	2.40	4.455E-02	1.133E-01	-1.297E-02	1.118E-01	9.352E-02
26	2.50	4.457E-02	1.178E-01	-1.546E-02	1.118E-01	9.377E-02
27	2.60	4.466E-02	1.242E-01	-1.905E-02	1.118E-01	9.388E-02
28	2.70	4.462E-02	1.250E-01	-1.949E-02	1.118E-01	9.388E-02
29	2.80	4.461E-02	1.305E-01	-2.263E-02	1.117E-01	9.397E-02
30	2.90	4.451E-02	1.348E-01	-2.507E-02	1.115E-01	9.391E-02
31	3.00	4.467E-02	1.318E-01	-2.336E-02	1.117E-01	9.400E-02
SCAN	Vel	Vref	Q	Qref	MACH	YAW DEG
1	2.568E+02	2.123E+02	1.682E+01	1.165E+01	2.455E-01	4.892E+01
2	2.570E+02	2.127E+02	1.686E+01	1.170E+01	2.459E-01	4.870E+01
3	2.576E+02	2.132E+02	1.695E+01	1.177E+01	2.465E-01	4.867E+01
4	2.570E+02	2.130E+02	1.687E+01	1.175E+01	2.459E-01	4.865E+01
5	2.566E+02	2.128E+02	1.684E+01	1.174E+01	2.457E-01	4.866E+01
6	2.573E+02	2.136E+02	1.692E+01	1.183E+01	2.463E-01	4.867E+01
7	2.576E+02	2.138E+02	1.697E+01	1.185E+01	2.467E-01	4.866E+01
8	2.576E+02	2.140E+02	1.697E+01	1.187E+01	2.467E-01	4.866E+01
9	2.575E+02	2.143E+02	1.696E+01	1.190E+01	2.466E-01	4.867E+01
10	2.579E+02	2.142E+02	1.700E+01	1.189E+01	2.469E-01	4.866E+01
11	2.575E+02	2.143E+02	1.695E+01	1.191E+01	2.465E-01	4.866E+01
12	2.581E+02	2.148E+02	1.704E+01	1.197E+01	2.472E-01	4.865E+01
13	2.581E+02	2.150E+02	1.703E+01	1.199E+01	2.471E-01	4.867E+01
14	2.583E+02	2.153E+02	1.705E+01	1.202E+01	2.473E-01	4.867E+01
15	2.589E+02	2.157E+02	1.715E+01	1.207E+01	2.480E-01	4.865E+01
16	2.598E+02	2.162E+02	1.727E+01	1.212E+01	2.488E-01	4.865E+01
17	2.597E+02	2.162E+02	1.725E+01	1.212E+01	2.487E-01	4.867E+01
18	2.606E+02	2.166E+02	1.737E+01	1.217E+01	2.496E-01	4.864E+01
19	2.609E+02	2.168E+02	1.742E+01	1.220E+01	2.500E-01	4.866E+01
20	2.605E+02	2.168E+02	1.735E+01	1.219E+01	2.495E-01	4.865E+01
21	2.611E+02	2.171E+02	1.743E+01	1.222E+01	2.500E-01	4.865E+01
22	2.617E+02	2.181E+02	1.751E+01	1.234E+01	2.506E-01	4.866E+01
23	2.616E+02	2.184E+02	1.749E+01	1.236E+01	2.505E-01	4.864E+01
24	2.629E+02	2.196E+02	1.765E+01	1.248E+01	2.516E-01	4.875E+01
25	2.630E+02	2.199E+02	1.765E+01	1.252E+01	2.517E-01	4.866E+01
26	2.629E+02	2.205E+02	1.764E+01	1.259E+01	2.516E-01	4.865E+01
27	2.630E+02	2.208E+02	1.765E+01	1.262E+01	2.517E-01	4.865E+01
28	2.628E+02	2.207E+02	1.763E+01	1.262E+01	2.515E-01	4.867E+01
29	2.626E+02	2.210E+02	1.760E+01	1.264E+01	2.513E-01	4.863E+01
30	2.623E+02	2.209E+02	1.754E+01	1.263E+01	2.508E-01	4.864E+01
31	2.629E+02	2.211E+02	1.762E+01	1.265E+01	2.514E-01	4.879E+01

TABLE B3 (CONT.). UPSTREAM BLADE-TO-BLADE REDUCED
PROBE DATA FILE L-4SEPACALC

SCAN	Pref-Pt/Qref
1	1.432E-01
2	1.436E-01
3	1.445E-01
4	1.449E-01
5	1.459E-01
6	1.473E-01
7	1.435E-01
8	1.447E-01
9	1.491E-01
10	1.459E-01
11	1.502E-01
12	1.514E-01
13	1.553E-01
14	1.561E-01
15	1.557E-01
16	1.561E-01
17	1.549E-01
18	1.499E-01
19	1.521E-01
20	1.544E-01
21	1.522E-01
22	1.579E-01
23	1.604E-01
24	1.626E-01
25	1.655E-01
26	1.698E-01
27	1.712E-01
28	1.731E-01
29	1.762E-01
30	1.758E-01
31	1.742E-01

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ENSEMBLE AVERAGES

PPAVG	PAAVG	TEMPAVG	XREFAVG	VREFAVG	QREFAVG
1.227E+01	405.47E+00	459.78	9.210E-02	2.165E+02	1.214E+01

TABLE B4. DOWNSTREAM BLADE-TO-BLADE SCALED
PROBE DATA FILE U-SEPASCL

SCAN	PROBE POSIT	1	2	3	4	5	6	7
1	0.00	3.200E-02	1.498E+01	1.088E+01	-5.584E+00	6.946E+00	-6.880E-01	-6.920E-01
2	.10	2.600E-02	1.501E+01	1.081E+01	-5.626E+00	6.648E+00	-6.700E-01	-6.840E-01
3	.20	3.800E-02	1.499E+01	1.074E+01	-5.614E+00	5.954E+00	-6.440E-01	-6.680E-01
4	.30	3.000E-02	1.501E+01	1.074E+01	-5.602E+00	5.504E+00	-6.280E-01	-6.280E-01
5	.40	3.800E-02	1.498E+01	1.072E+01	-5.576E+00	5.058E+00	-6.080E-01	-6.080E-01
6	.50	4.200E-02	1.499E+01	1.072E+01	-5.568E+00	4.788E+00	-5.940E-01	-5.940E-01
7	.55	4.400E-02	1.497E+01	1.071E+01	-5.550E+00	4.738E+00	-6.020E-01	-6.120E-01
8	.60	3.600E-02	1.500E+01	1.070E+01	-5.576E+00	4.728E+00	-6.000E-01	-6.120E-01
9	.65	4.800E-02	1.501E+01	1.068E+01	-5.548E+00	4.720E+00	-6.340E-01	-6.400E-01
10	.70	4.400E-02	1.500E+01	1.069E+01	-5.490E+00	4.836E+00	-6.300E-01	-6.520E-01
11	.75	3.600E-02	1.500E+01	1.072E+01	-5.574E+00	4.968E+00	-6.300E-01	-6.560E-01
12	.80	4.400E-02	1.498E+01	1.073E+01	-5.588E+00	5.160E+00	-6.880E-01	-6.740E-01
13	.85	4.000E-02	1.501E+01	1.105E+01	-5.784E+00	5.512E+00	-7.200E-01	-7.300E-01
14	.90	4.000E-02	1.499E+01	1.128E+01	-5.824E+00	5.878E+00	-7.780E-01	-7.580E-01
15	.95	3.400E-02	1.502E+01	1.138E+01	-5.926E+00	6.276E+00	-8.020E-01	-7.960E-01
16	1.00	3.200E-02	1.500E+01	1.156E+01	-6.006E+00	6.660E+00	-8.020E-01	-8.260E-01
17	1.05	2.800E-02	1.508E+01	1.163E+01	-5.972E+00	7.066E+00	-8.220E-01	-8.300E-01
18	1.10	4.200E-02	1.509E+01	1.170E+01	-6.064E+00	7.492E+00	-8.680E-01	-8.760E-01
19	1.15	4.000E-02	1.507E+01	1.174E+01	-6.108E+00	7.822E+00	-8.720E-01	-8.900E-01
20	1.20	4.400E-02	1.505E+01	1.180E+01	-6.116E+00	8.214E+00	-8.760E-01	-8.880E-01
21	1.25	3.400E-02	1.504E+01	1.187E+01	-6.118E+00	8.550E+00	-9.020E-01	-8.840E-01
22	1.30	3.800E-02	1.503E+01	1.190E+01	-6.180E+00	8.828E+00	-8.820E-01	-8.860E-01
23	1.35	4.800E-02	1.503E+01	1.191E+01	-6.176E+00	9.130E+00	-8.880E-01	-8.960E-01
24	1.40	5.600E-02	1.499E+01	1.186E+01	-6.156E+00	9.238E+00	-8.900E-01	-8.820E-01
25	1.45	4.200E-02	1.500E+01	1.192E+01	-6.154E+00	9.468E+00	-8.640E-01	-8.740E-01
26	1.50	4.600E-02	1.498E+01	1.191E+01	-6.172E+00	9.624E+00	-8.540E-01	-8.680E-01
27	1.55	3.600E-02	1.501E+01	1.197E+01	-6.208E+00	9.748E+00	-8.480E-01	-8.420E-01
28	1.60	5.200E-02	1.495E+01	1.201E+01	-6.230E+00	9.790E+00	-8.500E-01	-8.560E-01
29	1.65	4.000E-02	1.497E+01	1.199E+01	-6.200E+00	9.838E+00	-8.100E-01	-8.300E-01
30	1.70	4.000E-02	1.497E+01	1.207E+01	-6.264E+00	9.852E+00	-8.240E-01	-8.400E-01
31	1.75	4.200E-02	1.498E+01	1.206E+01	-6.230E+00	9.836E+00	-8.140E-01	-8.460E-01
32	1.80	4.600E-02	1.497E+01	1.207E+01	-6.334E+00	9.958E+00	-8.220E-01	-8.160E-01
33	1.85	4.000E-02	1.499E+01	1.212E+01	-6.320E+00	9.920E+00	-8.100E-01	-8.040E-01
34	1.90	2.600E-02	1.500E+01	1.215E+01	-6.376E+00	1.009E+01	-8.180E-01	-8.120E-01
35	2.00	4.400E-02	1.497E+01	1.216E+01	-6.338E+00	9.996E+00	-8.180E-01	-8.400E-01
36	2.00	4.600E-02	1.495E+01	1.221E+01	-6.366E+00	9.988E+00	-8.200E-01	-8.480E-01
37	2.05	4.000E-02	1.497E+01	1.226E+01	-6.368E+00	1.004E+01	-8.180E-01	-8.420E-01
38	2.10	4.000E-02	1.496E+01	1.226E+01	-6.348E+00	9.976E+00	-8.160E-01	-8.160E-01
39	2.15	4.400E-02	1.496E+01	1.228E+01	-6.386E+00	1.005E+01	-8.120E-01	-8.320E-01
40	2.20	3.600E-02	1.496E+01	1.230E+01	-6.442E+00	1.004E+01	-7.980E-01	-8.180E-01
41	2.25	3.800E-02	1.495E+01	1.230E+01	-6.458E+00	9.982E+00	-8.300E-01	-8.220E-01
42	2.35	3.000E-02	1.497E+01	1.238E+01	-6.432E+00	9.952E+00	-8.280E-01	-8.340E-01
43	2.45	4.800E-02	1.494E+01	1.239E+01	-6.456E+00	9.812E+00	-8.360E-01	-8.600E-01
44	2.55	3.800E-02	1.495E+01	1.240E+01	-6.512E+00	9.568E+00	-8.300E-01	-8.360E-01
45	2.65	2.800E-02	1.496E+01	1.246E+01	-6.480E+00	9.304E+00	-8.120E-01	-8.160E-01
46	2.75	3.600E-02	1.496E+01	1.246E+01	-6.508E+00	8.848E+00	-8.500E-01	-8.740E-01
47	2.85	4.000E-02	1.493E+01	1.248E+01	-6.506E+00	8.528E+00	-8.600E-01	-8.280E-01
48	2.95	2.800E-02	1.495E+01	1.254E+01	-6.528E+00	7.950E+00	-8.160E-01	-8.280E-01

TABLE B4 (CONT.). DOWNSTREAM BLADE-TO-BLADE SCALED
PROBE DATA FILE U-4SEPASCL

SCAN	9	10	11	12	13	14	YAW DEG	TEMP (IN)	ATMOS PRESS
1	-3.500E-01	-1.026E+00	9.332E+00	-0.200E+00	0.000E+00	-0.000E-03	0.000E+00	2.007E+00	4.557E+02
2	-3.100E-01	-9.600E-01	9.310E+00	-0.170E+00	-1.200E-02	1.000E-02	0.000E-03	2.010E+00	4.556E+02
3	-3.040E-01	-9.700E-01	9.202E+00	-0.166E+00	-1.000E-02	-0.000E-03	-1.000E-02	2.007E+00	4.555E+02
4	-3.400E-01	-0.240E+01	9.270E+00	-0.170E+00	4.000E-03	0.000E-03	1.400E-02	1.763E+00	4.556E+02
5	-3.240E-01	-0.920E-01	9.230E+00	-0.184E+00	-1.000E-02	2.000E-03	-2.000E-03	1.757E+00	4.556E+02
6	-3.140E-01	-0.900E-01	9.210E+00	-0.154E+00	-1.200E-02	-0.000E-03	-3.000E-02	2.004E+00	4.556E+02
7	-3.050E-01	-0.020E+01	9.230E+00	-0.170E+00	-1.200E-02	-1.000E-02	-1.000E-02	2.264E+00	4.556E+02
8	-3.360E-01	-0.900E-01	9.236E+00	-0.124E+00	0.000E+00	0.000E-03	-1.000E-02	2.250E+00	4.555E+02
9	-3.520E-01	-0.100E+01	9.202E+00	-0.136E+00	-1.200E-02	-2.000E-02	-2.200E-02	2.531E+00	4.556E+02
10	-3.500E-01	-0.540E-01	9.100E+00	-0.106E+00	-1.000E-02	-4.000E-03	0.000E+00	2.624E+00	4.556E+02
11	-3.040E-01	-0.420E-01	9.240E+00	-0.116E+00	-1.000E-02	2.000E-03	4.000E-03	2.700E+00	4.556E+02
12	-3.020E-01	-0.020E+01	9.254E+00	-0.160E+00	-1.000E-02	-1.400E-02	-0.000E-03	2.700E+00	4.557E+02
13	-4.040E-01	-1.036E+00	9.654E+00	-0.310E+00	-0.000E-03	-1.000E-02	-1.400E-02	3.026E+00	4.557E+02
14	-4.260E-01	-1.074E+00	9.692E+00	-0.442E+00	-1.200E-02	-6.000E-03	-2.000E-03	3.296E+00	4.557E+02
15	-4.360E-01	-1.100E+00	9.702E+00	-0.520E+00	-0.000E-03	-4.000E-03	-0.000E-03	3.275E+00	4.557E+02
16	-4.400E-01	-1.170E+00	9.952E+00	-0.600E+00	-4.000E-03	4.000E-03	-0.000E-03	3.554E+00	4.558E+02
17	-4.260E-01	-1.110E+00	9.894E+00	-0.840E+00	-1.400E-02	0.000E-03	2.000E-03	3.550E+00	4.558E+02
18	-4.320E-01	-1.102E+00	1.007E+01	-0.714E+00	-0.000E-03	-2.000E-03	-0.000E-03	3.540E+00	4.558E+02
19	-4.460E-01	-1.202E+00	1.013E+01	-0.722E+00	-2.000E-02	-1.400E-02	-1.200E-02	3.556E+00	4.557E+02
20	-4.460E-01	-1.104E+00	1.010E+01	-0.604E+00	-1.400E-02	-4.000E-03	2.000E-03	3.294E+00	4.558E+02
21	-4.360E-01	-1.370E+00	1.022E+01	-0.802E+00	0.000E-03	4.000E-03	-4.000E-03	3.201E+00	4.557E+02
22	-4.100E-01	-1.214E+00	1.026E+01	-0.732E+00	2.000E-03	4.000E-03	-0.000E-03	3.204E+00	4.558E+02
23	-3.940E-01	-1.226E+00	1.027E+01	-0.704E+00	-2.200E-02	-0.000E-03	-4.000E-03	3.296E+00	4.558E+02
24	-3.920E-01	-1.174E+00	1.022E+01	-0.772E+00	-2.400E-02	-1.600E-02	-1.200E-02	3.205E+00	4.559E+02
25	-3.700E-01	-1.170E+00	1.027E+01	-0.820E+00	-1.000E-02	-2.000E-03	0.000E-03	3.296E+00	4.559E+02
26	-3.500E-01	-1.100E+00	1.031E+01	-0.060E+00	-1.000E-02	-1.600E-02	-1.200E-02	3.023E+00	4.559E+02
27	-3.400E-01	-1.104E+00	1.035E+01	-0.026E+00	-4.000E-03	-0.000E-03	0.000E+00	3.039E+00	4.559E+02
28	-3.340E-01	-1.210E+00	1.034E+01	-0.030E+00	-6.000E-03	-1.200E-02	-1.200E-02	3.041E+00	4.558E+02
29	-3.300E-01	-1.202E+00	1.037E+01	-0.954E+00	-0.000E-03	-1.200E-02	-0.000E-03	3.024E+00	4.560E+02
30	-5.950E-01	-1.370E+00	1.039E+01	-0.092E+00	-2.200E-02	-0.000E-03	-0.000E-03	3.036E+00	4.559E+02
31	-2.040E-01	-1.552E+00	1.036E+01	-0.910E+00	-2.400E-02	-1.200E-02	-1.200E-02	3.036E+00	4.558E+02
32	-3.740E-01	-1.306E+00	1.040E+01	-0.976E+00	4.000E-03	-4.000E-03	-1.600E-02	2.776E+00	4.558E+02
33	-2.940E-01	-1.210E+00	1.043E+01	-7.012E+00	2.000E-03	-2.000E-03	0.000E+00	2.772E+00	4.558E+02
34	-1.040E-01	-1.544E+00	1.044E+01	-0.942E+00	1.000E-02	1.400E-02	0.000E+00	2.702E+00	4.558E+02
35	-1.600E-01	-1.566E+00	1.040E+01	-0.990E+00	-1.000E-02	-1.400E-02	-1.200E-02	2.778E+00	4.559E+02
36	-1.060E-01	-1.504E+00	1.047E+01	-7.040E+00	-1.000E-02	-3.200E-02	-0.000E-03	2.773E+00	4.561E+02
37	-3.560E-01	-1.370E+00	1.052E+01	-7.044E+00	2.000E-03	-1.400E-02	-3.200E-02	2.701E+00	4.562E+02
38	-4.160E-01	-1.406E+00	1.053E+01	-7.052E+00	0.039E+00	-4.000E-03	2.000E-03	2.707E+00	4.562E+02
39	-2.700E-01	-1.262E+00	1.054E+01	-7.060E+00	-1.600E-02	-1.200E-02	-1.000E-02	2.771E+00	4.561E+02
40	-3.450E-01	-1.390E+00	1.060E+01	-7.060E+00	0.000E-03	-0.000E-03	-0.000E-03	2.704E+00	4.560E+02
41	-2.540E-01	-1.240E+00	1.062E+01	-7.000E+00	4.000E-03	-2.000E-03	-4.000E-03	2.536E+00	4.561E+02
42	-9.200E-02	-1.602E+00	1.064E+01	-7.100E+00	-0.000E-03	-4.000E-03	-4.000E-03	2.527E+00	4.561E+02
43	-1.220E-01	-1.642E+00	1.066E+01	-7.122E+00	-1.400E-02	-1.400E-02	-1.600E-02	2.537E+00	4.560E+02
44	-5.300E-01	-1.472E+00	1.060E+01	-7.150E+00	-1.000E-02	-4.000E-03	-2.000E-03	2.257E+00	4.561E+02
45	-2.620E-01	-1.396E+00	1.069E+01	-7.106E+00	-4.000E-03	-2.000E-03	-4.000E-03	2.270E+00	4.560E+02
46	-3.340E-01	-1.400E+00	1.075E+01	-7.200E+00	-4.000E-03	-6.000E-03	-1.400E-02	2.023E+00	4.561E+02
47	-3.240E-01	-1.294E+00	1.071E+01	-7.164E+00	-4.000E-03	-6.000E-03	-4.000E-03	1.751E+00	4.561E+02
48	-3.300E-01	-1.270E+00	1.070E+01	-7.190E+00	1.000E-02	-2.000E-03	-0.000E-03	1.700E+00	4.561E+02

TABLE B5. DOWNSTREAM BLADE-TO-BLADE REDUCED PROBE
DATA FILE U-4SEPACALC

SCAN	Vel	Vref	Q	Qref	MACH	YAW DEG
1	1.673E+02	2.032E+02	7.277E+00	1.078E+01	1.603E-01	2.007E+00
2	1.640E+02	2.026E+02	6.992E+00	1.071E+01	1.571E-01	2.010E+00
3	1.560E+02	2.019E+02	6.332E+00	1.064E+01	1.495E-01	2.007E+00
4	1.504E+02	2.019E+02	5.880E+00	1.064E+01	1.440E-01	1.763E+00
5	1.446E+02	2.017E+02	5.434E+00	1.062E+01	1.385E-01	1.757E+00
6	1.409E+02	2.017E+02	5.157E+00	1.062E+01	1.349E-01	2.004E+00
7	1.405E+02	2.016E+02	5.130E+00	1.061E+01	1.346E-01	2.264E+00
8	1.403E+02	2.015E+02	5.112E+00	1.060E+01	1.343E-01	2.258E+00
9	1.406E+02	2.013E+02	5.135E+00	1.058E+01	1.346E-01	2.531E+00
10	1.423E+02	2.014E+02	5.260E+00	1.059E+01	1.363E-01	2.624E+00
11	1.440E+02	2.017E+02	5.384E+00	1.062E+01	1.379E-01	2.788E+00
12	1.468E+02	2.018E+02	5.598E+00	1.063E+01	1.406E-01	2.780E+00
13	1.516E+02	2.048E+02	5.974E+00	1.095E+01	1.452E-01	3.026E+00
14	1.564E+02	2.068E+02	6.359E+00	1.117E+01	1.498E-01	3.296E+00
15	1.613E+02	2.077E+02	6.759E+00	1.127E+01	1.545E-01	3.275E+00
16	1.656E+02	2.094E+02	7.125E+00	1.144E+01	1.586E-01	3.554E+00
17	1.700E+02	2.100E+02	7.511E+00	1.151E+01	1.628E-01	3.550E+00
18	1.747E+02	2.106E+02	7.939E+00	1.158E+01	1.674E-01	3.540E+00
19	1.780E+02	2.110E+02	8.245E+00	1.162E+01	1.706E-01	3.556E+00
20	1.818E+02	2.115E+02	8.601E+00	1.168E+01	1.742E-01	3.294E+00
21	1.850E+02	2.121E+02	8.911E+00	1.175E+01	1.773E-01	3.281E+00
22	1.875E+02	2.123E+02	9.155E+00	1.177E+01	1.797E-01	3.284E+00
23	1.903E+02	2.125E+02	9.435E+00	1.179E+01	1.825E-01	3.296E+00
24	1.913E+02	2.120E+02	9.528E+00	1.174E+01	1.834E-01	3.285E+00
25	1.932E+02	2.125E+02	9.721E+00	1.179E+01	1.852E-01	3.296E+00
26	1.945E+02	2.125E+02	9.855E+00	1.178E+01	1.865E-01	3.023E+00
27	1.954E+02	2.130E+02	9.953E+00	1.185E+01	1.874E-01	3.039E+00
28	1.959E+02	2.134E+02	9.998E+00	1.189E+01	1.878E-01	3.041E+00
29	1.960E+02	2.132E+02	1.000E+01	1.187E+01	1.879E-01	3.024E+00
30	1.963E+02	2.139E+02	1.004E+01	1.195E+01	1.882E-01	3.036E+00
31	1.961E+02	2.138E+02	1.002E+01	1.194E+01	1.880E-01	3.036E+00
32	1.970E+02	2.139E+02	1.012E+01	1.195E+01	1.889E-01	2.776E+00
33	1.966E+02	2.143E+02	1.007E+01	1.199E+01	1.885E-01	2.772E+00
34	1.981E+02	2.146E+02	1.023E+01	1.203E+01	1.900E-01	2.782E+00
35	1.975E+02	2.147E+02	1.016E+01	1.203E+01	1.893E-01	2.778E+00
36	1.975E+02	2.151E+02	1.016E+01	1.208E+01	1.893E-01	2.773E+00
37	1.979E+02	2.156E+02	1.020E+01	1.213E+01	1.897E-01	2.781E+00
38	1.973E+02	2.156E+02	1.013E+01	1.213E+01	1.891E-01	2.787E+00
39	1.979E+02	2.158E+02	1.020E+01	1.215E+01	1.897E-01	2.771E+00
40	1.977E+02	2.159E+02	1.019E+01	1.217E+01	1.896E-01	2.784E+00
41	1.974E+02	2.159E+02	1.015E+01	1.217E+01	1.892E-01	2.536E+00
42	1.971E+02	2.166E+02	1.012E+01	1.225E+01	1.890E-01	2.527E+00
43	1.960E+02	2.166E+02	1.001E+01	1.225E+01	1.880E-01	2.537E+00
44	1.938E+02	2.167E+02	9.778E+00	1.226E+01	1.857E-01	2.257E+00
45	1.912E+02	2.173E+02	9.520E+00	1.232E+01	1.833E-01	2.270E+00
46	1.875E+02	2.173E+02	9.151E+00	1.233E+01	1.797E-01	2.023E+00
47	1.844E+02	2.175E+02	8.846E+00	1.235E+01	1.767E-01	1.751E+00
48	1.787E+02	2.180E+02	8.302E+00	1.240E+01	1.712E-01	1.768E+00
49	1.762E+02	2.181E+02	8.075E+00	1.242E+01	1.688E-01	1.770E+00

TABLE B5 (CONT.). DOWNSTREAM BLADE-TO-BLADE REDUCED
PROBE DATA FILE U-4SEPACALC

SCAN	PRB POSIT	BETA	GAMMA	PHI	Xval	Xref
1	0.00	1.853E-02	8.853E-02	-4.111E-03	7.148E-02	8.684E-02
2	.10	1.779E-02	8.983E-02	-4.764E-03	7.008E-02	8.658E-02
3	.20	1.610E-02	1.018E-01	-1.102E-02	6.671E-02	8.630E-02
4	.30	1.493E-02	9.524E-02	-7.663E-03	6.429E-02	8.628E-02
5	.40	1.381E-02	1.002E-01	-1.043E-02	6.181E-02	8.621E-02
6	.50	1.313E-02	1.070E-01	-1.413E-02	6.022E-02	8.620E-02
7	.55	1.304E-02	9.654E-02	-8.619E-03	6.007E-02	8.617E-02
8	.60	1.301E-02	1.054E-01	-1.327E-02	5.996E-02	8.613E-02
9	.65	1.307E-02	1.042E-01	-1.263E-02	6.010E-02	8.605E-02
10	.70	1.336E-02	9.202E-02	-6.184E-03	6.082E-02	8.610E-02
11	.75	1.369E-02	1.029E-01	-1.186E-02	6.153E-02	8.622E-02
12	.80	1.423E-02	1.027E-01	-1.167E-02	6.274E-02	8.624E-02
13	.85	1.519E-02	1.013E-01	-1.083E-02	6.480E-02	8.752E-02
14	.90	1.617E-02	9.750E-02	-8.767E-03	6.686E-02	8.838E-02
15	.95	1.719E-02	9.498E-02	-7.432E-03	6.892E-02	8.878E-02
16	1.00	1.815E-02	9.660E-02	-8.275E-03	7.075E-02	8.947E-02
17	1.05	1.914E-02	8.667E-02	-3.176E-03	7.263E-02	8.973E-02
18	1.10	2.027E-02	8.728E-02	-3.539E-03	7.466E-02	8.999E-02
19	1.15	2.107E-02	8.687E-02	-3.363E-03	7.607E-02	9.017E-02
20	1.20	2.200E-02	7.894E-02	6.477E-04	7.768E-02	9.036E-02
21	1.25	2.282E-02	9.446E-02	-7.283E-03	7.906E-02	9.065E-02
22	1.30	2.346E-02	8.278E-02	-1.351E-03	8.013E-02	9.074E-02
23	1.35	2.419E-02	8.302E-02	-1.469E-03	8.133E-02	9.080E-02
24	1.40	2.443E-02	7.724E-02	1.466E-03	8.173E-02	9.059E-02
25	1.45	2.493E-02	7.817E-02	1.007E-03	8.254E-02	9.081E-02
26	1.50	2.528E-02	7.916E-02	5.131E-04	8.310E-02	9.077E-02
27	1.55	2.553E-02	7.892E-02	6.459E-04	8.351E-02	9.103E-02
28	1.60	2.565E-02	8.306E-02	-1.447E-03	8.370E-02	9.118E-02
29	1.65	2.566E-02	8.188E-02	-8.475E-04	8.372E-02	9.110E-02
30	1.70	2.574E-02	7.319E-02	3.562E-03	8.386E-02	9.140E-02
31	1.75	2.570E-02	1.264E-01	-2.334E-02	8.378E-02	9.136E-02
32	1.80	2.596E-02	9.390E-02	-6.922E-03	8.420E-02	9.139E-02
33	1.85	2.584E-02	8.539E-02	-2.619E-03	8.401E-02	9.156E-02
34	1.90	2.625E-02	1.247E-01	-2.247E-02	8.467E-02	9.170E-02
35	1.95	2.607E-02	1.291E-01	-2.471E-02	8.438E-02	9.172E-02
36	2.00	2.607E-02	1.292E-01	-2.473E-02	8.437E-02	9.189E-02
37	2.05	2.617E-02	9.404E-02	-6.975E-03	8.454E-02	9.208E-02
38	2.10	2.599E-02	9.173E-02	-5.821E-03	8.426E-02	9.209E-02
39	2.15	2.618E-02	9.126E-02	-5.569E-03	8.455E-02	9.218E-02
40	2.20	2.613E-02	9.622E-02	-8.083E-03	8.447E-02	9.224E-02
41	2.25	2.603E-02	9.197E-02	-5.938E-03	8.432E-02	9.222E-02
42	2.35	2.597E-02	1.400E-01	-3.020E-02	8.422E-02	9.252E-02
43	2.45	2.569E-02	1.426E-01	-3.151E-02	8.376E-02	9.255E-02
44	2.55	2.508E-02	9.057E-02	-5.278E-03	8.278E-02	9.259E-02
45	2.65	2.441E-02	1.121E-01	-1.619E-02	8.169E-02	9.282E-02
46	2.75	2.345E-02	1.098E-01	-1.506E-02	8.010E-02	9.282E-02
47	2.85	2.265E-02	1.035E-01	-1.188E-02	7.877E-02	9.290E-02
48	2.95	2.123E-02	1.072E-01	-1.374E-02	7.633E-02	9.311E-02
49	3.00	2.064E-02	1.105E-01	-1.547E-02	7.528E-02	9.319E-02

TABLE B5 (CONT.). DOWNSTREAM BLADE-TO-BLADE REDUCED
PROBE DATA FILE U-4SEPACALC

SCAN	Pref-Pt/Qref
1	3.650E-01
2	3.889E-01
3	4.490E-01
4	4.559E-01
5	5.331E-01
6	5.584E-01
7	5.628E-01
8	5.633E-01
9	5.632E-01
10	5.527E-01
11	5.417E-01
12	5.238E-01
13	5.062E-01
14	4.834E-01
15	4.529E-01
16	4.282E-01
17	3.963E-01
18	3.631E-01
19	3.374E-01
20	3.068E-01
21	2.827E-01
22	2.606E-01
23	2.361E-01
24	2.232E-01
25	2.076E-01
26	1.937E-01
27	1.879E-01
28	1.871E-01
29	1.822E-01
30	1.860E-01
31	1.865E-01
32	1.770E-01
33	1.833E-01
34	1.718E-01
35	1.799E-01
36	1.837E-01
37	1.831E-01
38	1.883E-01
39	1.840E-01
40	1.856E-01
41	1.902E-01
42	1.981E-01
43	2.101E-01
44	2.306E-01
45	2.559E-01
46	2.931E-01
47	3.201E-01
48	3.700E-01
49	3.912E-01

.....

ENSEMBLE AVERAGES

PAAVG	PAAVG	TEMPAVG	XREFAVG	VREFAVG	QREFAVG
1.172E+01	405.20E+00	455.84	9.007E-02	2.108E+02	1.160E+01

TABLE B6. BLADE SCALED DATA FILE B-4SEPASCL

PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED
IN FILE: L-4SEFASCL

SCAN: 31

SCANIVALVE PRESS (INCHES H₂O)
PORT

1	8.000E-03
2	1.487E+01
3	1.284E+01
4	-3.614E+00
5	-1.134E+00
6	2.300E-01
7	8.600E-01
8	9.520E-01
9	3.200E-01
10	6.640E-01
11	9.020E-01
12	6.600E-01
13	1.002E+00
14	1.846E+00
15	2.428E+00
16	2.182E+00
17	1.482E+00
18	1.812E+00
19	2.356E+00
20	4.026E+00
21	4.906E+00
22	7.336E+00
23	-1.924E+01
24	-3.458E+01
25	-3.382E+01
26	-2.966E+01
27	-2.221E+01
28	-1.806E+01
29	-1.436E+01
30	-1.304E+01
31	-1.105E+01
32	-8.656E+00
33	-7.204E+00
34	-5.974E+00
35	-5.214E+00
36	-4.570E+00
37	-4.060E+00
38	-3.906E+00
39	-3.716E+00
40	-3.502E+00
41	-3.254E+00
42	-3.156E+00
43	-7.160E-01
44	-9.750E+00
45	-3.586E+00
46	1.612E+00
47	9.860E-01
48	-2.836E+00

TABLE B7. BLADE REDUCED DATA FILE B-4SEPACALC

SCANIVALVE PORT	MASS AVERAGED COEFFICIENT OF PRESSURE
4	2.133E-01
5	3.507E-01
6	4.263E-01
7	4.612E-01
8	4.663E-01
9	4.646E-01
10	4.515E-01
11	4.636E-01
12	4.513E-01
13	4.691E-01
14	5.160E-01
15	5.481E-01
16	5.345E-01
17	4.957E-01
18	5.140E-01
19	5.463E-01
20	6.367E-01
21	6.854E-01
22	8.201E-01
23	-6.524E-01
24	-1.525E+00
25	-1.460E+00
26	-1.230E+00
27	-8.171E-01
28	-5.869E-01
29	-4.153E-01
30	-3.092E-01
31	-1.986E-01
32	-6.606E-02
33	1.440E-02
34	8.255E-02
35	1.247E-01
36	1.604E-01
37	1.886E-01
38	1.971E-01
39	2.077E-01
40	2.195E-01
41	2.333E-01
42	2.386E-01
43	3.739E-01
44	-1.267E-01
45	2.149E-01
46	5.029E-01
47	4.682E-01
48	2.531E-01

2. RETURN
3. Press LOAD
4. Type INITFLEX between quotation marks. [The root directory based INITFLEX program formats the disc.]
5. RETURN
6. Press RUN
7. Follow the prompts--the process takes a few minutes.

Once the disc is formatted, it can be used to back up files. To load the root directory-based BACKUP program, use the following steps:

1. Type MSI"/"
2. RETURN
3. Press LOAD
4. Type BACKUP between quotation marks
5. RETURN
6. Press RUN
7. Press SELECT. [The arrow indicator will be at the desired position i.e., "Backup selected files."]
8. Type /CLASSICK/DESIRED SUBDIRECTORY/=CS80,700
9. RETURN
10. Press PROCEED. [Use arrow keys to move indicator to flexible disc option.]
11. Press SELECT
12. Press YES. [Note the caution]

The backup process proceeds to completion, displaying each file transferred to the flexible disc. If there are too many files for one disc, a prompt for an additional disc

will be displayed. Note that the files generated by "CALC" consume a lot of disc space. Upon completion,

13. Press UNLDTAPE

14. Press DONE

B.9 RECOMMENDATIONS

The method of obtaining probe survey data can be improved upon by making changes to the three main programs and including software additions. Changes to the programs will provide higher quality data, reduce the chance of erroneous entries and make computations more efficient. Software additions will enhance data recovery and reduce the chance of mistakenly deleting data files. Specific recommendations are:

1. Improve the existing DVM error trap. Occasional surges in the facilities' power supply cause spurious DVM readings. Spurious DVM readings are trapped by the Maxdif variable on line 91 of "ACQUIRE" and the IF-THEN structure in the subprogram "Readdvm". The existing trap is adequate for Scanivalve port readings but not for yaw transducer readings. A separate Maxdif value, and incorporation into "Readdvm", is required for the yaw transducer. Alternately, a subroutine to statistically analyze and reject spurious DVM readings could be added to "Readdvm", [A more extensive but permanent solution is to rectify the power surge problem.]

2. Dynamically size the CALC array in program "CALC." This is done in "ACQUIRE" with the Rawdat and Scaled arrays. Dynamic sizing would reduce the amount of disc space the reduced data files from "CALC" consume.

3. Eliminate the need in "ACQUIRE" for scan number and position entries by the user for each data point. For repetitive surveys with a known number of data points and probe displacement interval, a data file could be used to supply those values.

4. Combine "CALC" and "LOSS." The AVDR and loss coefficient could be calculated within the structure that calculates C_p . While this would eliminate one program, it would complicate the structure of "CALC" somewhat and make the structure more difficult for a new user to grasp.

5. Create a subdirectory for the scaled data files from "ACQUIRE." This would eliminate the clutter of files in the REDDATA subdirectory, and make the file system consistent with the distinction that program "CALC" makes between scaled and reduced data files. A cluttered file system increases the chances of losing a valuable file during a purge. This addition would require change to the MSI statements on lines 130, 374, 581 and 763 in "ACQUIRE" and line 130 in "CALC." A MSI "CLASSICK/REDDATA" would have to be inserted before

line 134 to allow access to the probe coefficients file stored in the subdirectory READDATA.

6. Develop a program to print a tabulation of the data stored in the scaled data files. This tabulation should duplicate the format in "ACQUIRE." The program can be produced by appropriate additions and deletions to "ACQUIRE" since the formatted print statements already exist. [See Chapter 11, Ref. 13.]

B10. FOR THE USER - SUMMARY OF PROGRAM STEPS

All commands except RETURN are executed by pressing the set of keys f1 - f8 corresponding to the soft key labels appearing at the bottom of the screen. RETURN is the key found on the main keyboard.

The following is a summary of program steps:

1. DVM, Scanner and Scanivalve Controller--ON
2. Disc Drive--ON
3. Disc Drive Amber Lights--EXTINGUISHED
4. Computer, Monitor and Printer--ON
5. LOAD "/CLASSICK/PROGS/ACQUIRE"
6. RETURN
7. RUN
8. Type raw data file name for probe survey without quotation marks.
9. RETURN
10. Type scaled data file name for probe survey.
11. RETURN

12. Type atmospheric pressure in inches Hg.

13. RETURN

14. Press ONE PROBE or TWO PROBES

15. Type scan number and probe position. For two probe option, type scan number, lower probe position and upper probe position.

16. RETURN

17. Press REPEAT or RECORD

[REPEAT returns prompt for scan number and position of data point to be repeated. Record stores data to the file.]

18. Press GO ON or END PRB DATA

[GO ON, returns prompt for scan number and probe position of next data point. END PRB DATA terminates probe data collection.]

19. Press GO ON or COLLECT

[GO ON, by-passes blade data collection and returns print option prompts (Step 20). COLLECT, returns prompt for raw blade data file name.]

a. Type raw blade data file name

b. RETURN

c. Type scaled blade data file name

d. RETURN

e. Press REPEAT or RECORD

[REPEAT, repeats the blade pressure scan. RECORD, stores data to the file.]

20. Follow the print option prompts

Note that this is the only time to obtain a hard copy of the raw and scaled probe and blade data.

21. Press GO ON or CALC

[GO ON, Terminates "ACQUIRE"]

Note that "CALC" can be executed later by the command: LOAD "/CLASSICK/PROGS/CALC" CALC, Loads and executes "CALC"]

22. Type the scaled probe data file name created in "ACQUIRE."

23. RETURN

24. Type the probe calibration coefficient file for X (velocity).

25. RETURN

26. Type the probe calibration coefficient file for Pni (pitch).

27. RETURN

28. Press ONE PROBE or TWO PROBES

TWO PROBES, will prompt the user for the upper probe calibration coefficient files for X and Pni

29. Type the file name for the data to be reduced from the scaled data file. For two probes, a second scaled data file name is required.

30. RETURN

31. Press REDUCE DATA after amber light quits blinking.

32. Press GO ON or BLADE Cp's.

GO ON, returns prompt to load "LOSS" (step 33)
BLADE Cp's, prompts for scaled blade data file name.

a. Type blade scaled data file name

b. RETURN

c. Type the file name for the data to be reduced from the scaled data file.

d. RETURN

e. Type scan number associated with lower limit of integration of probe lower blade-to-blade survey.

f. RETURN

- g. Type scan number associated with higher limit of integration of probe lower blade-to-blade survey.
 - h. RETURN
 - i. Press BLADE DATA after amber light quits blinking.
- 33. Press GO ON or LOSS
 - a. GO ON terminates "CALC". Note that "LOSS" can be executed later by the command:
 - 1. LOAD "/CLASSICK/PROGS/LOSS"
 - 2. LOSS, loads and executes "LOSS"
 - b. Note that "LOSS" requires upper and lower probe blade-to-blade survey reduced data file names.]
- 34. Type the lower probe blade-to-blade survey reduced data file name.
- 35. RETURN
- 36. Type the upper probe blade-to-blade survey reduced data file name.
- 37. RETURN
- 38. Type the scan number corresponding to the lower limit of integration for the lower probe survey.
- 39. RETURN
- 40. Type the scan number corresponding to the higher limit of integration for the lower probe survey.
- 41. RETURN
- 42. Repeat for upper probe survey.
 - [Note that integration interval for both upper and lower probes must be exactly equal even though the scan number entries may not be the same.]
- 43. Program "LOSS" terminates after static pressure rise coefficient, AVDR and loss coefficient are printed to the screen.

APPENDIX C

PROBE YAW ANGLE REFERENCING

Two methods can be used to relate yaw angle measured using the angle vernier (or electrical equivalent), to the locus of the leading edges of the cascade. Both make use of a digital precision inclinometer which measures angles to the horizontal with a resolution of 0.1° . A flat bar must be attached firmly to the probe shaft.

C.1 FREE-JET METHOD

Step 1 Mount the probe in the free-jet from the N side as shown in Figure C1(a).

Balance the probe pneumatically.

Read the angle of the bar (to horizontal) using the inclinometer (Δ_1).

Step 2 Mount the probe in the free-jet from the S side as shown in Figure C1(b).

Balance the probe pneumatically.

Read the angle of the bar (to horizontal) using the inclinometer (Δ_2).

Step 3 If Δ_0 is the angle of the probe pneumatic axis (P.A.) to the surface of the bar, and δ_j is the inclination of the free-jet to the horizontal, then

$$\Delta_1 = \Delta_0 - \delta_j$$

and

$$\Delta_2 = \Delta_0 + \delta_j.$$

Hence

$$\Delta_0 = \left(\frac{\Delta_1 + \Delta_2}{2} \right)$$

$$\delta_J = \left(\frac{\Delta_1 - \Delta_2}{2} \right)$$

Step 4 Mount the probe on the cascade on the N side as shown in Figure C1(c).

Read the vernier when the bar is horizontal (β_H).

Then, the angle of the pneumatic axis to the vertical

$$\beta_{PA} = 90 - \Delta_0 .$$

Angle of the pneumatic axis to the normal to the locus of the leading edges

$$\beta'_{PA} = \beta_{PA} - \delta_B = 90 - \Delta_0 - \delta_B .$$

Rotate probe to balance in the flow. Read the vernier (β_F).

The flow angle, related correctly to the normal to the locus of the leading edges, is given by

$$\begin{aligned} \beta &= \beta'_{PA} + (\beta_F - \beta_H) \\ &= 90^\circ - \Delta_0 - \delta_B + (\beta_F - \beta_H) \end{aligned}$$

C.2 LDV (IN SITU) METHOD

Mount the probe and balance at a point where β_1 is known from LDV measurements. Read the vernier (β_{F1}). Turn the bar to horizontal. Read the vernier (β_H)

then $\beta'_{PA} = \beta_1 - (\beta_{F1} - \beta_H) = (\beta_1 - \beta_{F1}) + \beta_H$

At any other condition, the inlet air angle is given by

$$\begin{aligned} \beta &= \beta'_{PA} + (\beta_F - \beta_H) \\ &= (\beta_1 - \beta_{F1}) + \beta_F . \end{aligned}$$

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