TIME-MEAN VELOCITY MEASUREMENTS IN SUDDEN EXPANSION CONFINED FLOW WITH TANGENTIAL INJECTION

By

WOON DON CHAI

Bachelor of Science in Mechanical Engineering

Sung Kyun Kwan University

Seoul, Korea

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Thesis Approved:

David G. Lilley.
Thesis Adviser

A. J. Ghajar

P. M. Moretti

Norman N. Durham
Dean of the Graduate College

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NOMENCLATURE

D	test section diameter
d	axial air inlet diameter
m	mass flow rate
P	time-mean pressure
Re	Reynolds number
u	axial velocity
v	radial velocity
w	tangential velocity
x, r, Θ	axial, radial, azimuthal cylindrical polar coordinates
β	yaw angle of probe = $\tan^{-1}(w/u)$
δ	pitch angle probe = $\tan^{-1}[v/(u^2 + w^2)^{1/2}]$
ρ	density
ψ	probe rotation angle

Subscripts

a	relating to axial flow at inlet
C	central location
av	average in the large test section
N,S,E,W	north, south, east, west locations
p	probe sensing tip
t	relating to tangential flow at inlet

Superscripts

$\overline{\quad}$	time-mean average
$'$	fluctuating quantity

CHAPTER I

INTRODUCTION

1.1 The Phenomenon

Vortex phenomena are described by scientists as one of the most important subjects of research in fluid motion. Today, there has been much interest in the study of swirling flows because numerous application utilizing this phenomenon have been evolved in such specialized fields as heat transfer, gas turbines, swirl atomizers, nuclear reactors, and meteorology.

Swirl flows (1,2) occur in a very wide range of application. In combustion systems, the strong favorable effects of applying swirl to injected air and fuel are extensively used as an aid to stabilization of high intensity combustion process and efficient clean combustion in a variety of practical situation.

Recently, concentrated research effort has been expended on understanding and characterizing the combustion aerodynamics of swirl flow burning processes of gaseous, liquid, and solid fuels. Economical design and operation of practical combustion equipment can be facilitated greatly by estimates made from complementary experimental and modeling studies.

Swirl flows result from the application of a spiraling motion, with a swirl velocity component (also known as a tangential velocity component) being imparted to the flow by the use of swirl vanes, by the use of axial-plus-tangential entry swirl generators or by direct tangential entry into the chambers (3).

A major outcome of the current study is the experimental characterization of the flowfield inside the cyclone chamber for seven basic flowfields. Parameter variations investigated are the ratio of the tangential air mass flow rate to the axial air mass flow rate (m_t/m_a) and the ratio of the tangential air velocity to the mean velocity at the cyclone exit flow (w_t/u_{av}). In the absence of particles, measurements of time-mean velocity components using a five-hole pitot probe characterized the air flow patterns.

1.2 The Problem

The cyclone mixer provides a means to inject solid fuel particles into furnaces for subsequent combustion. Many factors affect the particle distribution and velocity inside the cyclone chamber (4). In design situations, the engineer has to seek an optimum path between alternatives of, for example, efficiency and pollution. Figure 1 shows different cyclone-furnace arrangements:

1. Horizontal cyclone-furnace (or slightly slanting at an angle of 5-20 degrees).
2. Vertical cyclone-furnace not concentric with the furnace.

3. Vertical cyclone-furnace concentric.

There are many advantages of the cyclone combustion in comparison to conventional combustion chambers. They arise mainly on a unique flow pattern produced by the dominant circumference velocity component. The strong centrifugal field, created by the tangential inlet, alters the two-dimensional radial-axial flow and aids the combustion processes in several ways. The spiral fluid motion enhances the residence of solid fuel in the chamber, and provides adequate time even for the most "difficult" fuel to be completely burned (5-9).

Many instruments (10) are used for separately measuring the magnitude and direction of fluid velocity. However, there are only a few instruments capable of simultaneously sensing both magnitude and direction. The simplest of these senses pressure at certain location on the surface of a sphere, hemisphere, or some other shape of probe.

The five-hole pressure probe is recommended by Beer and Chigier (3) for mean velocity measurements in turbulent swirling flows and several investigations have successfully used it. The main technique of the five-hole probe depends on the fact that the three pressure measurements on a great circle of a sphere unequal determine the velocity component in that plane (11).

1.3 Previous Studies

Three-dimensional spherical pitot probe has been developed and calibrated by Lee and Ash (12) to measure static pressure and the magnitude and direction of the velocity vector for any arbitrary flow angle without adjustment of the probe.

Time-mean and turbulent flow quantities downstream of pipe expansions with 15, 30, 45, and 90 degrees for non-swirling flow were measured by Chaturvedi (13). The expansion diameter ratio was 2. Measurements of velocity in regions of high turbulence intensity and where the direction of the velocity vector was unknown were made with a 2.5 mm diameter pitot tube. Mean velocity was also measured with a constant temperature hot-wire anemometer using a single wire. A cross-wire used to measure all the Reynolds stresses.

Ustimenko and Bukham (14) carried out the measurement of fluctuating velocity components by a hot-wire anemometer in a cyclone chamber with four tangential inlets positioned equidistant over the circumference. They showed that symmetry in the cyclone flowfield is obtained not only for the time-mean values but for the turbulent characteristics of the flow.

The experiments of Vatistas el al (15) found the dimensionless core size, pressure drop, and radial pressure distribution depend solely upon the geometrical parameters of cyclone chamber from the analytical model with potential flow assumption and confirmed their findings with experiment.

The detailed experimental measurements on a multi-inlet cyclone combustion under both isothermal and combustion conditions have been done by Styles et al (16). Pressure drop and processing vortex core frequency were measured for a fuel gas/air mixture model under both conditions using a pressure transducer. Temperature measurements were also obtained in the downstream region of the exit on combustion condition by thermocouples.

The research of Lilley (17) was concerned with experimental and theoretical studies on 2-D axisymmetric geometries under low speed nonreacting, turbulent, swirling flow conditions typical of gas turbine and ramjet combustion chambers. They included recirculation zone characterization, time-mean and turbulence simulation in swirling recirculating flow, sudden and gradual expansion flowfields, and further complexities and parameter influences. The study included the investigations: a complete range of swirl strength; swirler performance; downstream contraction nozzle sizes and combined effects on the test section flowfield were observed, measured and characterized. In addition to hot-wire experiments and theoretical studies, one Ph.D. thesis (18) and two M.S. theses (19,21) evolved during the comprehensive study.

In experiments of Rhode (18), he utilized the five-hole pitot probe technique to measure time-mean velocities u, v, w in the large diameter test section with D/d = 2, low swirl strengths ϕ = 0, 38 and 45 degrees, and no downstream nozzles. Later, Yoon (19) excreted the study to higher swirl strengths ϕ = 60 and 70 degrees, and downstream nozzle effects with both weak and strong nozzles of area ratios A/a = 2 and 4 located at x/D = 1 and 2. The results show that the presence of a swirler shortens the corner recirculation zone and generates a central recirculation zone followed by a precessing vortex core. The effect of a gradual inlet expansion is to encourage the flow to remain close to the sidewall and shorted the extent of the corner recirculation zone in all cases investigated. And the time-mean and turbulence properties of a confined swirling jet using the six-orientation, single hot-wire technique were obtained by Jackson (20). The test section with expansion ratios D/d = 1 and 2 was equipped with a strong contraction nozzle of area ratio 4 at x/D = 2. The effect of swirl on time-mean velocities, complete Reynolds stress tensor and dissipation rates were measured.

More recently, Scharrer (21) used the same measurement technique with smaller test section tubes with D/d = 1.5 and 1, again with downstream nozzles and a full range of swirl strengths. Findings included that the corner recirculation zone is prominent in nonswirling expanding flows, but it decreases when swirl is introduced. The presence of swirl results in the formation of a central recirculation zone. Initially increases in inlet swirl strength result in an increase in length of this zone. However, increasing to very high swirl strengths results in a shortening and widening of this zone.

The exit velocities of a cyclone chamber which had axial and tangential inlets with D/d = 4.5 and downstream nozzle at x/D = 2 were measured by Khalil and Lilley (22). And they visualized the particle distribution at the cyclone exit.

They also measured the concentration of particles in a mixed air-particle flow by a direct probe sampling method. Findings included that extreme high level of swirl reduces the efficiency of the cyclone as a mixing device.

The present study used same facility but without nozzle and extends this earlier study (22) by investigating in detailed the flow development after injection. The earlier thesis work at O.S.U. described in Reference 17 was presented in research papers (23-26).

1.4 Objectives

The present paper describes a logical sequence of experiments which were undertaken to establish the effects on the flowfield of the cyclone chamber with axial and tangential inlets and no downstream nozzle for sudden expansion into large plexiglass pipe D/d = 4.5 for seven basic flowfields.

The parameters to be studied are the ratio of the tangential air mass flow rate to the axial air mass flow rate (m_t/m_a) and the ratio of the tangential air velocity to the mean velocity at the cyclone exit flow (w_t/u_{av}).
A five-hole pitot probe was used to measure the magnitude and direction of the time-mean velocity.

The experimental research included in this study concentrated on:

(a) measurements of the magnitude and direction of the flow velocity.

(b) The effects on geometric parameters on the flow-field in the cyclone chamber.

1.5 Outline of the Thesis

In the Section I, the significance and scope of this study are introduced. Section II describes facilities used in the investigation. This section also explains the operation of the five-hole pitot probe which was used to measure the magnitude and direction of the time-mean velocity.

Section III describes the procedures of data measurements and reduction. The raw data measured by a five-hole pitot probe are reduced by a Fortran computer program which was made by Rhode (18). A detailed description of the data reduction computer program is listed in Appendix C. And Reference 19 explains the instruction for its use.

Section IV contains the results obtained for different boundary conditions. Finally Section V summarizes these results and suggests further research.

CHAPTER II

EXPERIMENTAL FACILITIES

A complete test facility has been built in the Mechanical Engineering Laboratory at Oklahoma State University by Khalil, and it is described in detail in Reference 22. The major features are recalled here.

A schematic of the overall facility is shown in Figure 2. The test facility consists of a cyclone mixer test section which has two inlets; axial and tangential, air blowing and stilling chamber for the tangential inlet and exhaust system.

2.1 Test Section

The test section is composed of a cyclone mixer assembly. The general arrangement of this is given in Figure 3. According to manufacturing consideration the test section was constructed from different parts and materials, nine inch internal diameter plexiglass tube with 1/8" (0.32 cm) thickness was used. The tangential inlet was made of a box according to the required dimensions and was fixed to an opening made in the 9" (22.86 cm) tube.

Great attention was made in using the different machines to get the same centerline for different concentric parts within an accuracy 0.01 mm. And two wooden cradle which are mounted on a table supports the test section.

2.2 Tangential Inlet Arrangements

The tangential air was supplied by a centrifugal blower directly coupled to a 1.5 horse power motor. The maximum output of this blower is 200 CFM and to control the rate of air volume a system of two coaxial orifices with slots was used to partially block the blower intake.

Next is the stilling chamber. It consists of: jet facing plate; followed by two fine mesh screens. Next is the area reduction section which was designed by the method of Morel (27) to produce a minimum adverse pressure gradient on the boundary layer to avoid the flow unsteadiness phenomenon associated with local separation regions. The slope angle was 5 degrees. The final reduced cross-sectional area was the same like that of the rectangular tangential inlet of the cyclone mixer. Figure 4 illustrated the design of this stilling chamber which ensure the supply of a uniform air velocity to the tangential air inlet of the cyclone.

The dynamic pressure from which the air velocity can be calculated and also the air volume flow rate was measured by a two-hole pitot static pressure probe which had been embedded in the rectangular section just before the cyclone inlet.

2.3 Axial Air Arrangements

Air volume flow rate is controlled by a pressure regulator and measured by a calibrated rotameter. And compressed air is supplied to 2" diameter tube.

A 25 liter pressurized air tank is used to damp any pressure fluctuation in the compressed air line before the pressure regulator. The static pressure is measured by a pressure manometer.

2.4 Five-Hole Pitot Probe Instrumentation

A five-hole pitot probe has been used for instruments capable of measuring both the magnitude and the direction of fluid velocity simultaneously. The five-hole pitot probe used in this study is a model DC-125-12-CD manufactured by United Sensor and Control Corp. The accuracy of this particular probe is well documented in Reference 18 and 19. It is shown schematically in Figure 5 and has a 3.2 mm diameter steel sensing tip and shaft containing five tubes. The sensing head is hook-shaped to allow for probe shaft rotation without altering the probe tip location.

There are three standard method of operating the five-hole pitot probe:

1. To adjust the orientation of the probe in both pitch and yaw so that the probe is aligned with the local flow direction.
2. To determine the flow direction from the calibration relationship between probe pressures and flow direction while maintaining a fixed probe orientation.
3. To align the probe yaw angle with the flow yaw angle

while deducing the pitch angle and total velocity coefficient calibration characteristics.

The third method was employed in this study because it used readily available orientation equipment and relatively simple data reduction procedures.

The five-hole pitot probe is accurate within the approximately 5 percent for most of the measurements (24). This value may increase to 10 percent as the velocity magnitude falls below approximately 2.0 m/s because of the insensitivity of the probe to low dynamic pressure.

The instrumentation assembly, in addition to the five-hole pitot probe, consists of a manual traverse mechanism, two five-way ball valves, a differential pressure traduce, a power supply, and an integrating digital voltmeter. The probe is mounted vertically on the test chamber, as shown in Figure 6, using a manual traverse mechanism, model C 1000-18 from United Sensor and Control Corp. This mechanism, shown in Figure 7, is made entirely of steel with a linear vernier accurately readable within ±0.25 mm. This allows the probe to vertically traverse across the chamber radius with the capability of manually rotating the probe about its axis to null the yaw angle felt by the pressure sensing tip. This yaw angle is read from the rotary vernier of the traverse unit which is accurately readable within ±0.2 degree. The differential pressure traduce is model 590D from Datametrics, Inc. It has a differential pressure range of from 0 to 1.3 x 10^3 N/m^2. The pressure transducer output is read as the d.c. signal from the TSI model 1076 integrating voltmeter. Use of an integrating voltmeter removes pressure fluctuations from the vibrating tygon tubing connecting the probe to the valves and transducer.

Finally, auxiliary equipment is used, including a barometer/thermometer unit from Cenco Corp. for local pressure and temperature readings.

CHAPTER III

MEASUREMENT AND REDUCTION OF DATA

3.1 Measurement Procedures

The basic measurement technique entails aerodynamically nulling the yaw in the horizontal plane by rotation of the probe about its vertical shaft and then reading two differential pressures (p_N - p_S and p_C - p_W). These pressures along with the yaw angle β are used to obtain the pitch angle δ in the vertical plane and the magnitude of total velocity vector from the calibration characteristics. The data reduction employs two calibration curves which were obtained for a single calibration velocity. The underlying principle is that the calibration is independent of probe Reynolds number Re_p, which is based on probe tip diameter (18).

Calibration experiments of Rhode et al (22) reveal that this condition exists for $Re_p \geq 1090$, or a local velocity of 5.4 m/s. Hence measurements of such low velocities suffer from a necessary calibration error. However, the investigation also shows that this calibration error affects the velocity measurements typically by less than 6 percent for $Re_p \geq 400$, corresponding to a local velocity greater than 2.0 m/s. In this study, all calibrations are conducted at air velocity of 6.01 m/s.

Before the production measurements, five-hole pitot rotary vernier must be zeroed for yaw so that the x and Θ axis of the measurement coordinate frame coincide with those of the test section, which are illustrated in Figure 6. This is accomplished by rotating the probe until the yaw is aerodynamically nulled near the center of the test section inlet for nonswirling flow. The radial axes of the probe and the test section coincide since the traverse unit base has been carefully machined to mount vertically on the plexiglass tube. The pressure and yaw angle data are read at 0.3 inch increments up to 3.9 inches in the upper half from the centerline and 4.2 inches in the lower half from the centerline.

After the pressure transducer is zeroed, the measurement procedure for each location within a traverse begins with rotation of the probe until the yaw is aerodynamically nulled. This is indicated by a zero reading for p_W-p_E, where the pressures are identified in Figure 5. The resulting probe rotation angle is read from the rotary vernier. Then the five-way switching valves are set so that p_N - p_S is sensed by transducer. Finally, the reading of p_C -p_W is similarly obtained.

The quantity of air mass flow rate has been previously obtained as illustrated in Section 2.2, 2.3 of the discussion about test facilities. The ambient pressure and temperature were monitored near the facility for the determination of air density.

3.2 Data Reduction

The differential pressure reading from the five-hole pitot probe are utilized directly to obtain the square of the vector velocity. The vector velocity of turbulent flow consists of a time-mean velocity and a fluctuating velocity component. Since

$$\overline{V^2} = \overline{V}^2 + \overline{V'^2} \qquad (3.1)$$

where V' is the fluctuating portion of the velocity magnitude and the overbar denote time-averaging, it is slightly incorrect to infer that $\overline{V^2}$ is equal to the square of the magnitude of the time-mean velocity vector $\overline{V}^2$. However, the fluctuation term $\overline{V'^2}$ is not known and very little information is available for the effect of turbulence in swirl flows on pressure probes, which is probably considerable for the effect of turbulence in swirl flows on pressure probes, which is probably considerable for turbulence intensities greater than about 20 percent (1). Furthermore, the procedures for making corrections for turbulence levels are long and tedious, and even then the confidence in their applicability is unknown. Therefore, no attempt is presently made to incorporate such corrections, and the deduced velocity is taken to be the time-mean velocity magnitude $\overline{V}$ which is written without the overbar from here onward.

All data used in this investigation were reduced with a Fortran computer program which is similar to that developed by Rhode (18) by first calculating the pitch coefficient (p_N

$-p_S)/(p_C - p_W)$. From this value a cubic spline interpolation technique (28) is used to obtain the pitch angle δ in the vertical plane from the calibration characteristic presented in Figure 8. The resulting value of δ is similarly utilized to determine the velocity coefficient $\rho V^2/[(p_C - p_W)]$ from the calibration characteristic given in Figure 9.

Values for V as well as the axial, radial, and swirl velocity components u, v, and w, shown in Figure 10, are easily calculated from the velocity coefficient, pitch angle, and yaw angle β, which is in the horizontal plane. The latter angle is given by

$$\beta = 360^\circ - \psi \qquad (3.2)$$

where ψ is the probe rotation angle read on the rotary vernier of the traverse mechanism. The magnitude of the velocity vector is given by

$$V = \left[\frac{2}{\rho} \frac{\rho V^2}{2(p_C - p_W)} (p_C - p_W)\right]^{1/2} \qquad (3.3)$$

and the velocity components are obtained from

$$u = V \cos\delta \cos\beta \qquad (3.4)$$

$$v = V \sin\delta \qquad (3.5)$$

and

$$w = V \cos\delta \sin\beta \qquad (3.6)$$

3.3 Calibration

A five-hole pitot probe must be calibrated carefully to translate the measured quantities β, $(p_N - p_S)$, and $(p_C - p_W)$ into a velocity magnitude and a direction. The calibration equipment consists of a small air jet, a rotary table, a probe mounting bracket, and the instrumentation system previously described. The calibration jet supply line consists of a compressed air line, which delivers the desired flow rate through a small pressure regulator and a Fischer and Porter model 10A1735A rotameter. The jet housing consists of an effective flow management section followed by a contoured nozzle with a 3.5 cm diameter throat.

The five-hole pitot probe is rotated by the rotary table model BH-9 from Troyke Manufacturing Co., whose rotary vernier is readable within ± 0.5 minutes. As shown in Figure 11, the aluminum probe mounting bracket is secured to the rotary table, and it supports the probe which rests in a cylindrical steel collect.

The motion of the rotary table orients the probe at the desired pitch angle, whereas the yaw is aerodynamically nulled. The probe sensing tip remains at the centerline within the potential core of the jet and less than one throat diameter downstream of the nozzle discharge plane. The pitch angle is zeroed by very carefully aligning the probe shaft in a plane parallel to that of the nozzle throat.

The operation of calibration consists of recording the voltage output from the pressure transducer for differential pressure $p_N - p_S$ and $p_C - p_W$, where these pressures are identified in Figure 5. These data are measured at 5 degrees increments in δ over the range $-58° \le \delta \le 58°$. The measurement technique requires the entire calibration to be conducted at a constant jet velocity. This is permitted since the dimensionless calibration coefficients are independent of Re_p for $Re_p \geq 1090$ (5.4 m/s) determined by careful calibration experiments (18).

As shown in Figures 8 and 9, the calibration characteristics from which δ and velocity coefficient $\rho V^2/[2(p_c - p_w)]$ are obtained, respectively. Both curves exhibit considerable symmetry, as the five pressure sensing holes are almost symmetrical about the probe tip axis.

CHAPTER IV

RESULTS

A number of experiments have been done on the sudden expansion cyclone facility without exit nozzle so as to investigate the flow patterns and velocity distribution inside the flow domain. The geometry of the facility was detailed in Chapter II. Velocity measurements were made with the five-hole pitot probe as described in Chapter III. The effects of two inlet flow parameters on the flowfield were investigated: the ratio of the tangential inlet air mass flow rate to the axial inlet mass flow rate ($\dot{m}_t/\dot{m}_a$ = 2, 4, 8, and 0) with two values of the tangential inlet velocity in each of the swirling cases. With the lower inlet tangential velocity, Cases 1, 3, and 5 were obtained as the mass flow ratio increased (equal to 2, 4, and 8, respectively). Cases 2, 4, and 6 were corresponding cases with the higher tangential velocity, obtained by blocking half the area of the tangential inlet, so doubling the inlet tangential velocity. Case 7 was for nonswirling flow conditions with no tangential injection. These seven flowfields have ratio of tangential inlet velocity to mean axial velocity (in the downstream region) of w_t/u_{av} = 2.83, 5.64, 3.39, 6.78, 3.77, 7.51, and 0. Seven axial measurement stations were chosen:

x/D = 0.25, 0.75, 1.25, 1.75, 2.25, 2.75 and 3.75, each with up to 27 measurements points across the vertical plane. Table I illustrates the different parameters investigated for the seven cases covered in the study.

Flow characteristics are tabulated in terms of normalized time-mean u, v, and w velocity components, yaw angle β and pitch angle δ in Tables II through VIII. Axial and swirl velocity profiles for all flowfields are shown in Figures 12 through 18 to illustrate the main findings of the experiments.

All the figures show time-mean velocity measurements at the axial locations x/D = 0.25, 0.75, 1.25, 1.75, 2.25, 2.75 and 3.75 respectively. Full traverses were made at the first 5 measurement locations, but because of near axisymmetry, only half traverses were needed at the two furthest downstream locations. Part a of the figures gives the normalized time-mean axial velocity u; it presents measurements of u/u_{av} (time-mean axial velocity normalized by division with the cross-sectional averaged time-mean axial velocity at the test section exit). Part b shows the normalized time-mean swirl velocity w; it presents measurements of w/u_{av} (time-mean swirl velocity normalized by division with the cross-sectional averaged time-mean axial velocity at the test section exist. Radial velocities were consistently much smaller than the axial and swirl components, and are not plotted. These values are available in the tabulated data.

The near-axisymmetry assumption was verified by additional measurements in the lower half of the tube, with + marking these values on the figures.

4.1 Case 1 ($m_t/m_a = 2$ and $w_t/u_{av} = 2.83$)

Figure 12 shows normalized axial and swirl velocity measurements for Case 1. As can be seen from Figure 12(a), the maximum axial velocity occurs close to the centerline at the first upstream location. At x/D = 0 the average inflow has a normalized velocity magnitude of $u_a/u_{av} = 6.74$ across the central region (r/D = less than 0.11). In fact this inflow is not of constant velocity, because of the build up of the wall boundary layer will have caused a rounded or peaked velocity profile. The additional mass flow of the tangential injection and other geometric and flow changes causes a normalized velocity magnitude of 8.63 to occur at the first measurement station at x/D = 0.25. Further, the maximum axial velocity shifts towards the outer boundaries as the flow proceeds in the downstream direction. The negative axial velocities seen at the first station (x/D = 0.25) in the lower part of the tube are explained on the basis of the tangential inflow suddenly sensing an area increase on entering the large flow. This is amalgamated with the effects of the axial flow, also tending to recirculate after entry to the large tube (at x/D = 0). This nonsymmetrical phenomenon at the upstream station is observed in all the swirl flow cases investigated. It is seen clearly in part a of Figures 12 through 17.

In a similar flow situation with weak swirl strength, Rhode (18) found the central recirculation zone ending at x/D = 1.5 with swirl vane angle ϕ = 38 degrees and D/d = 2 which is smaller than this study (D/d = 4.5). The central recirculation zone is caused by a swirl velocity being imparted to the flow via use of swirl vane. The central recirculation zone is defined as the wide reverse flow region encountered near the inlet.

As shown in Figure 12(b), the radial location where the maximum swirl velocity occurs increases in the downstream direction. But the maximum velocities in Rhode (18) exist near the centerline. The swirl velocity along the axis as shown in Figure 12(b) is found to be zero as expected because of symmetry. And the profiles of swirl velocity are beginning to be symmetric starting at location x/D = 2.25.

4.2 Case 2 (m_t/m_a = 2 and w_t/u_{av} = 5.64)

Case 2 was conducted in the same condition to the Case 1 except that the ratio of the inlet tangential velocity to the mean axial velocity of the cyclone exit flow (w_t/u_{av}) was twice that of Case 1.

The corner recirculation zone near the upper and lower half at the location x/D = 0.25 provoked by the rather sudden enlargement of the cross-sectional area and increasing of swirl velocity. It can be seen from the Figure 13(a) that the velocity profiles are changed dramatically at the three upstream locations. This is because the upstream locations are close to the tangential air inlet and the swirl velocity increases.

In Figure 13(a) back flow is seen to occur at three upstream locations ($x/D = 0.25, 0.75, 1.25$) instead of occurring at only one location as in Case 1. Also axial velocity profiles are a symmetric in early upstream locations whereas the maximum axial velocities occur near the wall and centerline in the downstream locations as inlet swirl velocity increases as compared to Case 1.

The swirl velocities are minimal in a large region (almost half the tube width) near the centerline at the three upstream locations because incoming axial velocity is larger than the incoming tangential velocity, see part b of Figure 13. The maximum swirl velocities occur close to the wall since strong centrifugal forces are present in the incoming tangential inlet flow. In a similar flow situation, measurements of Scharrer and Lilley (25) with expansion ratio $\alpha = 90$ degrees, swirl vane angle $\phi = 45$ and 70 degrees, and $D/d = 1.5$ shows the swirl velocity profiles are nearly uniform in the near-wall region and the radial location of the maximum swirl velocity moves outward for the strong swirl case due to centrifugal effects. As compared to Case 1, the difference is that the symmetry of the axial velocity profiles is destroyed by the increased swirl velocity.

4.3 Case 3 ($m_t/m_a = 4$ and $w_t/u_{av} = 3.39$)

In this case, the ratio of the tangential inlet mass flow rate to the axial inlet mass flow rate was twice that of Case 1. All axial velocities except the first location are positive like Case 1. Therefore increasing the mass flow rate promotes a very large forward velocity. By looking at the Figure 14(a) one can see that the maximum axial velocities occur near the wall and the minimum occur near the centerline. Further, the profiles of the axial velocity are visibly changing in the downstream locations as compared to Case 1.

Yoon and Lilley (24) with expansion angle α = 90 degrees, D/d = 2, and swirl vane angle ϕ = 45 degrees found a considerable back flow around the hub. However, in this case the back flow did not occur except at the first location, which is caused by increasing the tangential inlet mass flow rate. As shown in Figure 14(a) the profiles of the axial velocities are not symmetric like Case 1. This implies that increasing tangential mass flow ratio does not affect the symmetry of axial velocity profiles.

Swirl velocity profiles are almost similar to those in Case 1. Like Case 1, the maximum swirl velocities are observed close to the wall and the minimum occur near the centerline. Also the profiles of the swirl velocity start being symmetric from location x/D = 2.25. Hence the symmetry of swirl velocity profile is not affected by increasing tangential mass flow ratio.

4.4 Case 4 (m_t/m_a = 4 and w_t/u_{av} = 6.78)

The tangential air inlet was partially blocked so that the mass flow rate remains the same with the tangential velocity doubled. As shown in Figure 15(a), the reverse flow occurs much more than Case 2 and 3. This means that back flow increases as the swirl velocity increases. In contrast to Case 2, the locations of the maximum axial velocity moves from the centerline to the wall as one goes in the downstream direction. This effect results from the stronger centrifugal forces present now as compared to Case 2. Also the minimum velocities exist near the r/D = 0.3 like Cases 2 and 3. Rhode and Lilley (23) measured time-mean velocity in the test section with D/d = 2 as the swirl vane angle increase. In their results, the maximum axial velocity occurs near the wall and minimum velocity occurs at the centerline because the large central recirculation region cause the downstream flow to accelerate near the wall. It may be seen that the profiles of the axial velocity are more symmetric than Case 3, which means that the higher inlet swirl velocity affects the axial velocity profile considerably.

Figure 15(b) reveals that this stronger swirl velocity case provides much more symmetric profiles of swirl velocities which is caused by even stronger centrifugal forces. Like other cases, the maximum swirl velocity occurs near the wall and the minimum velocity is zero near the centerline because of symmetry. Rhode and Lilley's (23) results give that the swirl velocities are maximum in a large region from r/D = 0.2 to the wall and the minimum exists near the centerline as the swirl vane angle increases. As illustrated in Figure 15(b) the profiles of the swirl velocity are symmetric in early locations as the swirl velocity increases as compared to the Case 3.

4.5 Case 5 (m_t/m_a = 8 and w_t/u_{av} = 3.77)

This case considers the largest mass flow ratio. Back flows occur in the lower part at the first station and r/D = 0.25 at x/D = 1.75 as shown in Figure 16(a). The maximum axial velocities exist near the outer boundaries. Therefore increasing the tangential inflow keeps the flow near the boundaries with large forward velocities.

The profiles of the axial velocity are not symmetric, see Figure 16(a). Hence increasing of the mass flow ratio does not affect the axial velocity profile and promotes the high positive axial velocity near the wall.

The profiles of the swirl velocity in Figure 16(b) are very symmetric as compared to Case 1 and Case 3. So the mass flow ratio influences the swirl velocity profile very much. It may be seen that the location of the maximum swirl velocity occurs near the wall through all cases, which is caused by large tangential inlet mass flow ratio. Also as shown in Figure 16(b), the swirl velocity along the axis is found to be zero as expected because of symmetry.

4.6 Case 6 (m_t/m_a = 8 and w_t/u_{av} = 7.51)

Here, the strongest inlet swirl velocity was considered. As illustrated in Figure 17(a) a lot of back flow around r/D = 0.3 is observed in the lower half of the domain. But Scharrer (21) with D/d = 1.5 gives a considerable reverse flow near the axis as the largest swirl vane angle ϕ = 70 degrees. This difference results from the different inlet swirl velocity position. However, the maximum axial velocity is observed close to the wall in both cases because of the strong centrifugal forces present in the incoming swirling flow. These keep the majority of the flow near the confining walls with resulting higher velocities.

As shown in Figure 17(a) the symmetry is much more prevalent than the previous cases which leads to the conclusion that profiles get increasingly symmetric with the increasing swirl velocity. Yoon and Lilley's (24) results (with D/d = 2 which is also smaller than this case) show that the radial location where the maximum swirl velocity occurs goes up as the swirl vane angle increases. Figure 17(b) shows that the maximum swirl velocity occurs near the wall, which are caused by the increase of the centrifugal effects. As shown in Figure 17(b), the swirl velocity near the axis is zero because of symmetry like other cases.

The above observances are summarized as follows. It may be seen in Figure 12(b) through 17(b) that the profiles of the normalized swirl velocity become symmetric in early axial locations as the inlet mass flow ratio and swirl velocity increase. And the effect of the increase of the swirl velocity generates a considerable back flow and promotes the symmetry of the normalized axial velocity profiles. However, normalized axial velocity profiles are unaffected by the inlet mass flow ratio (m_t/m_a). All axial velocities at the centerline are positive for all cases. And maximum swirl velocities occur near the outer boundaries in all cases.

4.7 Case 7 ($m_t/m_a = 0$ and $w_t/u_{av} = 0$)

Figure 18 shows normalized axial velocity for nonswirling flow for comparison with all the other cases which contained swirl. A nearly flat axial velocity profile is seen in the entrance region of the test section. As expected, there was no measurable swirl velocity and it is therefore not plotted. The corner recirculation zone extends to about x/D = 0.75, which is about two step-heights downstream of the inlet expansion. Yoon and Lilley (24) measured the reattachment point in a test section with an expansion ratio D/d = 2, which is different from the present study (with = 4.5). The result yields a value of x/D = 2 as a reattachment point, which corresponds to an attachment point approximately eight step-heights downstream. This is much greater than the present study. Therefore large expansion ratio shortens step-heights toward upstream direction.

Although a corner recirculation zone is present, there is no evidence of a central torridly recirculation zone. Indeed there is no swirl-induced centrifugal force to encourage its formation. As shown in Figure 18(a), the axial velocity profiles are almost symmetric.

4.8 Recirculation Zones

General observations of recirculation zones in the test section are given in Figure 19 for all cases. As shown in

Figure 19, recirculation zones are generally more prominent in the lower part of domain than the top part. This is because of greater centrifugal effects near the lower part of the tube close to the incoming tangential flow.

The recirculation zones of Cases 1, 3, and 5 appear only in the bottom of the tube. However Cases 2, 4, and 6 with stronger incoming swirl velocity provide additional recirculation zones in the half of the tube, and larger zones in the lower half.

CHAPTER V

CLOSURE

5.1 Conclusions

The present research is concerned with the time-mean velocity measurements of a nonreacting, swirling flowfields. Three velocity components normalized with the average axial velocity at the test section exit are tabulated along with yaw and pitch angles.

Many factors affect the velocity distribution in cyclone chamber such as degree of inlet swirl and choice of geometric parameters. A major outcome of the current study is the experimental characterization of these factors for seven basic flowfields. Parameter variations which define these flow conditions are the ratio of the tangential air mass flow rate to the axial mass flow rate (m_t/m_a) and the ratio of the tangential inlet air velocity to the mean velocity of the test section exit (w_t/u_{av}).

The detailed experiment involved of the measurement of time-mean velocity components using a five-hole pitot probe. These measurements provided a complete understanding of each flowfield and an extensive data base for latter verification of a theoretical simulation of the complex turbulent flow.

Recirculation increases for a fixed ratio of the tangential inlet mass flow rate to axial inlet mass flow rate (m_t/m_a) as tangential inlet velocity increases. All axial velocities at the centerline are positive for all cases. The normalized axial velocity profile become more uniform in the downstream direction. And normalized axial velocity profiles were unaffected by the inlet mass flow ratio (m_t/m_a). On the other hand, the normalized swirl velocity profiles are almost unaffected by downstream locations, or inlet mass flow ratio, or magnitude of inlet swirl velocity. Maximum swirl velocities occurred near the outer boundary in all cases.

5.2 Recommendations for Further Work

Fundamental research should be continued in swirling flows in several areas. First, additional flow visualization and computational studies would be useful in helping to understand the flowfield. Second, more realistic geometry could be achieved by changing the sudden expansion to gradual expansion and putting a downstream contraction nozzle in place. Third, further details of the flowfields are needed to allow a more complete fundamental understanding. These should consist of turbulence quantity measurements, including all of the Reynolds stresses. This would allow the deduction of more sophisticated turbulence models relating turbulent shear stresses with time-mean velocity gradients and useful for prediction study.

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APPENDIX A

TABLES

TABLE I TEST CASES

Investigated Case	m_t/m_a	w_t/u_{av}	m_t (CFM)	m_a (CFM)	w_t (m/s)	u_a (m/s)	u_{av} (m/s)
Case 1	2	2.82	70	35	3.41	8.15	1.21
Case 2	2	5.64	70	35	6.82	8.15	1.21
Case 3	4	3.39	80	20	3.90	4.66	1.15
Case 4	4	6.78	80	20	7.80	4.66	1.15
Case 5	8	3.77	144	18	7.01	4.19	1.86
Case 6	8	7.51	128	16	12.47	3.73	1.66
Case 7	0	0	0	38.5	0	6.99	0.44

TABLE II

VELOCITY DATA FOR CASE 1

J	Y \ I = / X =	1 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	0.273E+03	0.294E+03	0.302E+03	0.307E+03	0.302E+03	0.290E+03	0.299E+03
26	0.0838	0.277E+03	0.302E+03	0.303E+03	0.305E+03	0.303E+03	0.290E+03	0.298E+03
25	0.0762	0.278E+03	0.311E+03	0.305E+03	0.303E+03	0.303E+03	0.291E+03	0.298E+03
24	0.0686	0.280E+03	0.324E+03	0.309E+03	0.301E+03	0.302E+03	0.292E+03	0.297E+03
23	0.0610	0.285E+03	0.335E+03	0.315E+03	0.301E+03	0.304E+03	0.294E+03	0.297E+03
22	0.0533	0.300E+03	0.344E+03	0.322E+03	0.302E+03	0.305E+03	0.296E+03	0.298E+03
21	0.0457	0.330E+03	0.347E+03	0.327E+03	0.302E+03	0.307E+03	0.300E+03	0.302E+03
20	0.0381	0.356E+03	0.349E+03	0.330E+03	0.304E+03	0.310E+03	0.311E+03	0.308E+03
19	0.0305	0.220E+01	0.350E+03	0.332E+03	0.310E+03	0.316E+03	0.325E+03	0.317E+03
18	0.0229	0.380E+01	0.350E+03	0.332E+03	0.318E+03	0.324E+03	0.340E+03	0.330E+03
17	0.0152	0.300E+01	0.351E+03	0.332E+03	0.335E+03	0.336E+03	0.357E+03	0.350E+03
16	0.0076	0.300E+01	0.351E+03	0.332E+03	0.353E+03	0.350E+03	0.110E+02	0.100E+02
15	0.0000	0.400E+00	0.351E+03	0.334E+03	0.000E+00	0.360E+03	0.200E+02	0.240E+02
14	-0.0076	0.000E+00	0.200E+01	0.334E+03	0.160E+02	0.340E+02		
13	-0.0152	0.200E+01	0.360E+02	0.334E+03	0.300E+02	0.450E+02		
12	-0.0229	0.450E+02	0.750E+02	0.134E+03	0.420E+02	0.500E+02		
11	-0.0305	0.106E+03	0.860E+02	0.000E+00	0.440E+02	0.600E+02		
10	-0.0381	0.102E+03	0.820E+02	0.860E+02	0.490E+02	0.660E+02		
9	-0.0457	0.990E+02	0.780E+02	0.778E+02	0.520E+02	0.680E+02	0.570E+02	0.620E+02
8	-0.0533	0.960E+02	0.750E+02	0.870E+02	0.530E+02	0.700E+02		
7	-0.0610	0.960E+02	0.736E+02	0.840E+02	0.560E+02	0.700E+02		
6	-0.0686	0.959E+02	0.736E+02	0.856E+02	0.580E+02	0.660E+02		
5	-0.0762	0.959E+02	0.760E+02	0.856E+02	0.620E+02	0.656E+02		
4	-0.0838	0.970E+02	0.800E+02	0.842E+02	0.650E+02	0.630E+02		
3	-0.0914	0.976E+02	0.800E+02	0.842E+02	0.680E+02	0.600E+02	0.590E+02	0.600E+02
2	-0.0991	0.980E+02	0.806E+02	0.856E+02	0.690E+02	0.590E+02		
1	-0.1067	0.960E+02	0.808E+02	0.856E+02	0.698E+02	0.580E+02		

(a) Yaw Angle

TABLE II (Continued)

J	Y	I = 1 X = 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	-0.770E+01	-0.561E+00	-0.128E+02	-0.481E+01	-0.195E+02	-0.707E+01	-0.645E+01
26	0.0838	-0.773E+01	0.378E+01	-0.181E+02	-0.439E+01	-0.238E+02	-0.725E+01	-0.605E+01
25	0.0762	-0.853E+01	0.858E+01	-0.205E+02	-0.382E+01	-0.273E+02	-0.957E+01	-0.248E+01
24	0.0686	-0.101E+02	0.149E+02	-0.267E+02	-0.332E+01	-0.330E+02	-0.129E+02	-0.147E+01
23	0.0610	-0.100E+02	0.147E+02	-0.367E+02	-0.254E+01	-0.346E+02	-0.132E+02	0.000E+00
22	0.0533	-0.465E+01	0.161E+02	-0.419E+02	-0.295E+01	-0.378E+02	-0.188E+02	0.194E+01
21	0.0457	0.384E+02	0.122E+02	-0.388E+02	-0.479E+01	-0.433E+02	-0.286E+02	0.249E+01
20	0.0381	0.306E+02	0.854E+01	-0.413E+02	-0.628E+01	-0.485E+02	-0.393E+02	0.912E+01
19	0.0305	0.220E+02	0.673E+01	-0.402E+02	-0.636E+01	-0.510E+02	-0.478E+02	0.211E+02
18	0.0229	0.136E+02	0.362E+01	-0.433E+02	-0.147E+02	-0.525E+02	0.000E+00	0.341E+02
17	0.0152	0.121E+02	0.257E+01	-0.483E+02	-0.165E+02	-0.549E+02	0.000E+00	0.428E+02
16	0.0076	0.112E+02	0.585E+00	-0.489E+02	-0.165E+02	-0.510E+02	-0.465E+02	0.527E+02
15	0.0000	0.889E+01	0.000E+00	-0.496E+02	-0.315E+02	-0.478E+02	-0.433E+02	0.560E+02
14	-0.0076	0.542E+01	0.000E+00	-0.510E+02	-0.218E+02	-0.147E+02		
13	-0.0152	0.177E+01	0.000E+00	0.000E+00	-0.188E+02	-0.100E+02		
12	-0.0229	0.161E+02	0.102E+02	0.000E+00	-0.218E+02	-0.605E+01		
11	-0.0305	0.147E+02	0.912E+01	0.000E+00	-0.210E+02	-0.266E+01		
10	-0.0381	0.102E+02	0.673E+01	0.264E+02	-0.212E+02	0.000E+00		
9	-0.0457	0.783E+01	0.585E+01	0.211E+02	-0.228E+02	0.000E+00	-0.110E+02	0.178E+02
8	-0.0533	0.766E+01	0.498E+01	0.217E+02	-0.192E+02	0.000E+00		
7	-0.0610	0.676E+01	0.447E+01	0.200E+02	-0.189E+02	-0.107E+01		
6	-0.0686	0.726E+01	0.409E+01	0.144E+02	-0.165E+02	-0.930E+00		
5	-0.0762	0.720E+01	0.384E+01	0.102E+02	-0.134E+02	-0.185E+01		
4	-0.0838	0.720E+01	0.415E+01	0.736E+01	-0.105E+02	-0.237E+01		
3	-0.0914	0.619E+01	0.354E+01	0.423E+01	-0.721E+01	-0.287E+01	-0.906E+00	0.947E+00
2	-0.0991	0.533E+01	0.306E+01	0.650E+00	-0.499E+01	-0.387E+01		
1	-0.1067	0.306E+01	0.188E+01	-0.693E+00	-0.188E+01	-0.340E+01		

(b) Pitch Angle

TABLE II (Continued)

J	I = / Y	1	2	3	4	5	6	7
	X =	0.0278	0.0833	0.1389	0.1944	0.2500	0.3056	0.4167
27	0.4000	0.206E+00	0.129E+01	0.145E+01	0.173E+01	0.125E+01	0.855E+00	0.118E+01
26	0.3667	0.516E+00	0.161E+01	0.127E+01	0.161E+01	0.125E+01	0.773E+00	0.110E+01
25	0.3333	0.544E+00	0.191E+01	0.117E+01	0.150E+01	0.118E+01	0.722E+00	0.997E+00
24	0.3000	0.620E+00	0.245E+01	0.106E+01	0.136E+01	0.103E+01	0.672E+00	0.898E+00
23	0.2667	0.760E+00	0.318E+01	0.986E+00	0.135E+01	0.103E+01	0.680E+00	0.829E+00
22	0.2333	0.110E+01	0.380E+01	0.978E+00	0.129E+01	0.956E+00	0.600E+00	0.771E+00
21	0.2000	0.161E+01	0.420E+01	0.108E+01	0.115E+01	0.827E+00	0.517E+00	0.760E+00
20	0.1667	0.378E+01	0.467E+01	0.112E+01	0.104E+01	0.756E+00	0.516E+00	0.779E+00
19	0.1333	0.632E+01	0.459E+01	0.122E+01	0.103E+01	0.720E+00	0.497E+00	0.821E+00
18	0.1000	0.823E+01	0.417E+01	0.115E+01	0.829E+00	0.681E+00	0.530E+00	0.794E+00
17	0.0667	0.863E+01	0.368E+01	0.998E+00	0.821E+00	0.646E+00	0.563E+00	0.776E+00
16	0.0333	0.858E+01	0.300E+01	0.925E+00	0.734E+00	0.664E+00	0.514E+00	0.661E+00
15	0.0000	0.820E+01	0.204E+01	0.815E+00	0.339E+00	0.607E+00	0.577E+00	0.603E+00
14	-0.0333	0.624E+01	0.125E+01	0.661E+00	0.602E+00	0.925E+00		
13	-0.0667	0.344E+01	0.000E+00	0.619E+00	0.838E+00	0.849E+00		
12	-0.1000	0.556E+00	0.251E+00	0.000E+00	0.806E+00	0.867E+00		
11	-0.1333	-0.393E+00	0.124E+00	0.000E+00	0.976E+00	0.738E+00		
10	-0.1667	-0.474E+00	0.335E+00	0.538E-01	0.981E+00	0.688E+00		
9	-0.2000	-0.479E+00	0.600E+00	0.236E+00	0.991E+00	0.701E+00	0.101E+01	0.870E+00
8	-0.2333	-0.374E+00	0.888E+00	0.686E-01	0.108E+01	0.735E+00		
7	-0.2667	-0.408E+00	0.107E+01	0.160E+00	0.104E+01	0.791E+00		
6	-0.3000	-0.414E+00	0.112E+01	0.141E+00	0.104E+01	0.101E+01		
5	-0.3333	-0.424E+00	0.992E+00	0.166E+00	0.993E+00	0.103E+01		
4	-0.3667	-0.502E+00	0.709E+00	0.247E+00	0.987E+00	0.123E+01		
3	-0.4000	-0.527E+00	0.684E+00	0.267E+00	0.963E+00	0.142E+01	0.129E+01	0.119E+01
2	-0.4333	-0.518E+00	0.630E+00	0.221E+00	0.101E+01	0.154E+01		
1	-0.4667	-0.357E+00	0.595E+00	0.219E+00	0.105E+01	0.155E+01		

(c) u/u_{av}

TABLE II (Continued)

J	Y \ I =	1	2	3	4	5	6	7
	X =	0.0278	0.0833	0.1389	0.1944	0.2500	0.3056	0.4167
27	0.4000	-0.531E+00	-0.309E-01	-0.623E+00	-0.242E+00	-0.838E+00	-0.304E+00	-0.274E+00
26	0.3667	-0.544E+00	0.201E+00	-0.754E+00	-0.215E+00	-0.101E+01	-0.287E+00	-0.247E+00
25	0.3333	-0.586E+00	0.439E+00	-0.763E+00	-0.184E+00	-0.112E+01	-0.340E+00	-0.935E-01
24	0.3000	-0.637E+00	0.806E+00	-0.840E+00	-0.153E+00	-0.125E+01	-0.411E+00	-0.506E-01
23	0.2667	-0.518E+00	0.921E+00	-0.104E+01	-0.116E+00	-0.127E+01	-0.392E+00	0.000E+00
22	0.2333	-0.180E+00	0.114E+01	-0.112E+01	-0.125E+00	-0.129E+01	-0.465E+00	0.557E-01
21	0.2000	0.147E+01	0.933E+00	-0.104E+01	-0.182E+00	-0.130E+01	-0.563E+00	0.627E-01
20	0.1667	0.224E+01	0.715E+00	-0.113E+01	-0.205E+00	-0.133E+01	-0.644E+00	0.203E+00
19	0.1333	0.256E+01	0.550E+00	-0.116E+01	-0.179E+00	-0.124E+01	-0.670E+00	0.434E+00
18	0.1000	0.200E+01	0.268E+00	-0.122E+01	-0.292E+00	-0.110E+01	0.000E+00	0.620E+00
17	0.0667	0.184E+01	0.167E+00	-0.127E+01	-0.268E+00	-0.101E+01	0.000E+00	0.731E+00
16	0.0333	0.171E+01	0.311E-01	-0.120E+01	-0.219E+00	-0.833E+00	-0.553E+00	0.881E+00
15	0.0000	0.128E+01	0.000E+00	-0.107E+01	-0.208E+00	-0.670E+00	-0.579E+00	0.978E+00
14	-0.0333	0.593E+00	0.000E+00	-0.907E+00	-0.250E+00	-0.292E+00		
13	-0.0667	0.106E+00	0.000E+00	0.000E+00	-0.329E+00	-0.212E+00		
12	-0.1000	0.227E+00	0.174E+00	0.000E+00	-0.434E+00	-0.143E+00		
11	-0.1333	0.372E+00	0.286E+00	0.000E+00	-0.522E+00	-0.686E-01		
10	-0.1667	0.411E+00	0.284E+00	0.383E+00	-0.579E+00	0.000E+00		
9	-0.2000	0.421E+00	0.296E+00	0.433E+00	-0.677E+00	0.000E+00	-0.360E+00	0.593E+00
8	-0.2333	0.481E+00	0.299E+00	0.521E+00	-0.621E+00	0.000E+00		
7	-0.2667	0.463E+00	0.296E+00	0.556E+00	-0.640E+00	-0.432E-01		
6	-0.3000	0.513E+00	0.284E+00	0.474E+00	-0.578E+00	-0.402E-01		
5	-0.3333	0.521E+00	0.275E+00	0.390E+00	-0.503E+00	-0.806E-01		
4	-0.3667	0.521E+00	0.296E+00	0.315E+00	-0.432E+00	-0.112E+00		
3	-0.4000	0.432E+00	0.244E+00	0.196E+00	-0.325E+00	-0.143E+00	-0.397E-01	0.395E-01
2	-0.4333	0.347E+00	0.206E+00	0.327E-01	-0.245E+00	-0.202E+00		
1	-0.4667	0.183E+00	0.122E+00	-0.345E-01	-0.996E-01	-0.173E+00		

(d) v/u_{av}

TABLE II (Continued)

J	Y \ I =	1	2	3	4	5	6	7
	X =	0.0278	0.0833	0.1389	0.1944	0.2500	0.3056	0.4167
27	0.4000	-0.393E+01	-0.289E+01	-0.232E+01	-0.229E+01	-0.200E+01	-0.230E+01	-0.212E+01
26	0.3667	-0.397E+01	-0.257E+01	-0.193E+01	-0.229E+01	-0.192E+01	-0.212E+01	-0.206E+01
25	0.3333	-0.387E+01	-0.219E+01	-0.167E+01	-0.231E+01	-0.182E+01	-0.188E+01	-0.192E+01
24	0.3000	-0.352E+01	-0.179E+01	-0.129E+01	-0.226E+01	-0.164E+01	-0.166E+01	-0.176E+01
23	0.2667	-0.284E+01	-0.148E+01	-0.986E+00	-0.224E+01	-0.152E+01	-0.153E+01	-0.163E+01
22	0.2333	-0.191E+01	-0.112E+01	-0.770E+00	-0.206E+01	-0.137E+01	-0.123E+01	-0.145E+01
21	0.2000	-0.928E+00	-0.984E+00	-0.693E+00	-0.185E+01	-0.110E+01	-0.895E+00	-0.122E+01
20	0.1667	-0.264E+00	-0.892E+00	-0.647E+00	-0.155E+01	-0.902E+00	-0.593E+00	-0.997E+00
19	0.1333	0.243E+00	-0.809E+00	-0.646E+00	-0.123E+01	-0.695E+00	-0.348E+00	-0.766E+00
18	0.1000	0.547E+00	-0.735E+00	-0.601E+00	-0.747E+00	-0.495E+00	-0.193E+00	-0.458E+00
17	0.0667	0.452E+00	-0.596E+00	-0.531E+00	-0.383E+00	-0.288E+00	-0.295E-01	-0.137E+00
16	0.0333	0.449E+00	-0.476E+00	-0.492E+00	-0.901E-01	-0.117E+00	0.100E+00	0.117E+00
15	0.0000	0.572E-01	-0.308E+00	-0.397E+00	0.000E+00	-0.106E-02	0.210E+00	0.268E+00
14	-0.0333	0.000E+00	0.438E-01	-0.322E+00	0.173E+00	0.624E+00		
13	-0.0667	0.120E+00	0.000E+00	-0.299E+00	0.484E+00	0.849E+00		
12	-0.1000	0.556E+00	0.936E+00	0.000E+00	0.726E+00	0.103E+01		
11	-0.1333	0.136E+01	0.178E+01	0.000E+00	0.943E+00	0.128E+01		
10	-0.1667	0.223E+01	0.238E+01	0.770E+00	0.113E+01	0.155E+01		
9	-0.2000	0.302E+01	0.282E+01	0.109E+01	0.127E+01	0.173E+01	0.155E+01	0.164E+01
8	-0.2333	0.355E+01	0.331E+01	0.131E+01	0.143E+01	0.202E+01		
7	-0.2667	0.388E+01	0.363E+01	0.152E+01	0.155E+01	0.217E+01		
6	-0.3000	0.400E+01	0.381E+01	0.183E+01	0.166E+01	0.226E+01		
5	-0.3333	0.410E+01	0.398E+01	0.216E+01	0.187E+01	0.228E+01		
4	-0.3667	0.409E+01	0.402E+01	0.243E+01	0.212E+01	0.241E+01		
3	-0.4000	0.395E+01	0.388E+01	0.263E+01	0.238E+01	0.246E+01	0.215E+01	0.207E+01
2	-0.4333	0.368E+01	0.380E+01	0.288E+01	0.263E+01	0.256E+01		
1	-0.4667	0.340E+01	0.367E+01	0.284E+01	0.285E+01	0.248E+01		

(e) w/u_{av}

TABLE III

VELOCITY DATA FOR CASE 2

J	Y	1	2	3	4	5	6	7
	I =	1	2	3	4	5	6	7
	X =	0.0063	0.0190	0.0318	0.0444	0.0572	0.0698	0.0952
27	0.0914	0.278E+03	0.280E+03	0.280E+03	0.289E+03	0.282E+03	0.280E+03	0.285E+03
26	0.0838	0.280E+03	0.277E+03	0.277E+03	0.283E+03	0.280E+03	0.280E+03	0.282E+03
25	0.0762	0.278E+03	0.272E+03	0.276E+03	0.278E+03	0.280E+03	0.285E+03	0.280E+03
24	0.0686	0.272E+03	0.271E+03	0.289E+03	0.274E+03	0.282E+03	0.291E+03	0.279E+03
23	0.0610	0.264E+03	0.307E+03	0.314E+03	0.272E+03	0.287E+03	0.300E+03	0.281E+03
22	0.0533	0.261E+03	0.344E+03	0.340E+03	0.275E+03	0.297E+03	0.310E+03	0.290E+03
21	0.0457	0.283E+03	0.352E+03	0.350E+03	0.299E+03	0.316E+03	0.320E+03	0.301E+03
20	0.0381	0.338E+03	0.355E+03	0.354E+03	0.340E+03	0.332E+03	0.326E+03	0.317E+03
19	0.0305	0.100E+00	0.356E+03	0.356E+03	0.359E+03	0.342E+03	0.329E+03	0.336E+03
18	0.0229	0.380E+01	0.356E+03	0.356E+03	0.700E+01	0.350E+03	0.335E+03	0.349E+03
17	0.0152	0.300E+01	0.356E+03	0.355E+03	0.800E+01	0.352E+03	0.339E+03	0.359E+03
16	0.0076	0.240E+01	0.356E+03	0.354E+03	0.100E+02	0.355E+03	0.343E+03	0.600E+01
15	0.0000	0.200E+01	0.354E+03	0.353E+03	0.120E+02	0.356E+03	0.345E+03	0.700E+01
14	-0.0076	0.200E+01	0.152E+03	0.353E+03	0.160E+02	0.400E+01		
13	-0.0152	0.300E+01	0.146E+03	0.354E+03	0.180E+02	0.700E+01		
12	-0.0229	0.110E+02	0.126E+03	0.100E+00	0.220E+02	0.110E+02		
11	-0.0305	0.890E+02	0.200E+03	0.260E+02	0.280E+02	0.180E+02		
10	-0.0381	0.107E+03	0.138E+03	0.170E+03	0.340E+02	0.350E+02		
9	-0.0457	0.970E+02	0.110E+03	0.150E+03	0.470E+02	0.550E+02	0.778E+02	0.620E+02
8	-0.0533	0.940E+02	0.970E+02	0.125E+03	0.560E+02	0.780E+02		
7	-0.0610	0.920E+02	0.899E+02	0.112E+03	0.690E+02	0.870E+02		
6	-0.0686	0.920E+02	0.850E+02	0.102E+03	0.800E+02	0.890E+02		
5	-0.0762	0.921E+02	0.802E+02	0.950E+02	0.850E+02	0.870E+02		
4	-0.0838	0.930E+02	0.782E+02	0.890E+02	0.870E+02	0.830E+02		
3	-0.0914	0.103E+03	0.800E+02	0.840E+02	0.850E+02	0.790E+02	0.720E+02	0.768E+02
2	-0.0991	0.945E+02	0.860E+02	0.790E+02	0.810E+02	0.740E+02		
1	-0.1067	0.940E+02	0.880E+02	0.758E+02	0.780E+02	0.710E+02		

(a) Yaw Angle

TABLE III (Continued)

	I =	1	2	3	4	5	6	7
	X =	0.0063	0.0190	0.0318	0.0444	0.0572	0.0698	0.0952
J	Y							
27	0.0914	-0.680E+01	-0.857E+01	-0.750E+01	-0.594E+01	-0.152E+02	-0.112E+02	-0.801E+01
26	0.0838	-0.863E+01	-0.109E+02	-0.913E+01	-0.657E+01	-0.181E+02	-0.116E+02	-0.843E+01
25	0.0762	-0.107E+02	-0.150E+02	-0.110E+02	-0.707E+01	-0.202E+02	-0.105E+02	-0.919E+01
24	0.0686	-0.122E+02	-0.171E+02	-0.137E+02	-0.817E+01	-0.214E+02	-0.107E+02	-0.978E+01
23	0.0610	-0.139E+02	0.000E+00	-0.150E+02	-0.982E+01	-0.200E+02	-0.788E+01	-0.122E+02
22	0.0533	-0.132E+02	0.607E+01	-0.325E+01	-0.141E+02	-0.132E+02	-0.739E+01	-0.891E+01
21	0.0457	0.233E+01	0.391E+01	-0.682E+01	0.000E+00	-0.465E+01	-0.605E+01	-0.605E+01
20	0.0381	0.344E+02	0.368E+01	-0.734E+01	-0.165E+02	0.442E+01	-0.439E+01	-0.415E+01
19	0.0305	0.203E+02	0.235E+01	-0.878E+01	-0.110E+02	0.756E+01	-0.232E+01	0.000E+00
18	0.0229	0.109E+02	0.143E+01	-0.106E+02	-0.144E+02	0.756E+01	-0.232E+01	0.391E+01
17	0.0152	0.741E+01	0.143E+00	-0.133E+02	-0.124E+02	0.867E+01	-0.248E+01	0.391E+01
16	0.0076	0.617E+01	-0.140E+01	-0.163E+02	-0.141E+02	0.842E+01	-0.266E+01	0.673E+01
15	0.0000	0.461E+01	-0.366E+01	-0.196E+02	-0.136E+02	0.712E+01	-0.652E+01	0.116E+02
14	-0.0076	0.316E+01	0.310E+02	-0.255E+02	-0.195E+02	0.146E+01		
13	-0.0152	0.127E+00	-0.433E+02	-0.343E+02	-0.209E+02	0.000E+00		
12	-0.0229	-0.465E+01	-0.244E+02	-0.451E+02	-0.221E+02	-0.195E+01		
11	-0.0305	0.545E+02	0.000E+00	-0.465E+02	-0.226E+02	-0.494E+01		
10	-0.0381	0.112E+02	0.135E+02	-0.259E+02	-0.262E+02	-0.340E+01		
9	-0.0457	0.564E+01	0.658E+01	-0.141E+02	-0.197E+02	-0.415E+01	-0.853E+01	-0.185E+01
8	-0.0533	0.451E+01	0.536E+01	-0.494E+01	-0.173E+02	0.000E+00		
7	-0.0610	0.395E+01	0.469E+01	0.000E+00	-0.141E+02	0.152E+01		
6	-0.0686	0.489E+01	0.354E+01	0.198E+01	-0.989E+01	0.855E+00		
5	-0.0762	0.554E+01	0.291E+01	0.322E+01	-0.539E+01	0.541E+00		
4	-0.0838	0.528E+01	0.256E+01	0.280E+01	-0.283E+01	0.391E+00		
3	-0.0914	0.511E+01	0.256E+01	0.188E+01	-0.107E+01	0.296E+00	-0.403E+01	-0.143E+01
2	-0.0991	0.435E+01	0.268E+01	0.376E+00	-0.757E+00	-0.240E+00		
1	-0.1067	0.301E+01	0.203E+01	-0.102E+01	-0.889E+00	-0.721E+00		

(b) Pitch Angle

TABLE III (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.850E+00	0.914E+00	0.781E+00	0.155E+01	0.748E+00	0.557E+00	0.905E+00
26	0.3667	0.965E+00	0.461E+00	0.432E+00	0.965E+00	0.532E+00	0.485E+00	0.670E+00
25	0.3333	0.689E+00	0.964E-01	0.302E+00	0.516E+00	0.435E+00	0.610E+00	0.502E+00
24	0.3000	0.162E+00	0.322E-01	0.599E+00	0.208E+00	0.408E+00	0.724E+00	0.386E+00
23	0.2667	-0.394E+00	0.241E+00	0.861E+00	0.779E-01	0.453E+00	0.913E+00	0.373E+00
22	0.2333	-0.470E+00	0.194E+01	0.178E+01	0.122E+00	0.540E+00	0.109E+01	0.566E+00
21	0.2000	0.477E+00	0.356E+01	0.264E+01	0.195E+00	0.800E+00	0.128E+01	0.696E+00
20	0.1667	0.214E+01	0.482E+01	0.317E+01	0.495E+00	0.943E+00	0.135E+01	0.862E+00
19	0.1333	0.519E+01	0.576E+01	0.363E+01	0.114E+01	0.109E+01	0.137E+01	0.103E+01
18	0.1000	0.795E+01	0.611E+01	0.380E+01	0.149E+01	0.138E+01	0.144E+01	0.111E+01
17	0.0667	0.894E+01	0.626E+01	0.369E+01	0.183E+01	0.150E+01	0.144E+01	0.114E+01
16	0.0333	0.901E+01	0.574E+01	0.337E+01	0.196E+01	0.171E+01	0.142E+01	0.121E+01
15	0.0000	0.889E+01	0.469E+01	0.286E+01	0.215E+01	0.167E+01	0.126E+01	0.111E+01
14	-0.0333	0.854E+01	-0.336E+00	0.228E+01	0.215E+01	0.192E+01		
13	-0.0667	0.664E+01	-0.361E+00	0.168E+01	0.208E+01	0.182E+01		
12	-0.1000	0.267E+01	-0.419E+00	0.105E+01	0.188E+01	0.170E+01		
11	-0.1333	0.577E-02	0.000E+00	0.670E+00	0.163E+01	0.145E+01		
10	-0.1667	-0.386E+00	-0.778E+00	-0.778E+00	0.134E+01	0.108E+01		
9	-0.2000	-0.256E+00	-0.663E+00	-0.859E+00	0.112E+01	0.679E+00	0.284E+00	0.831E+00
8	-0.2333	-0.195E+00	-0.371E+00	-0.872E+00	0.904E+00	0.301E+00		
7	-0.2667	-0.125E+00	0.721E-02	-0.809E+00	0.616E+00	0.984E-01		
6	-0.3000	-0.161E+00	0.455E+00	-0.590E+00	0.345E+00	0.442E-01		
5	-0.3333	-0.214E+00	0.104E+01	-0.312E+00	0.219E+00	0.168E+00		
4	-0.3667	-0.348E+00	0.137E+01	0.753E-01	0.169E+00	0.461E+00		
3	-0.4000	-0.159E+01	0.119E+01	0.527E+00	0.351E+00	0.831E+00	0.124E+01	0.794E+00
2	-0.4333	-0.607E+00	0.513E+00	0.104E+01	0.748E+00	0.134E+01		
1	-0.4667	-0.533E+00	0.257E+00	0.131E+01	0.106E+01	0.159E+01		

(c) u/u_{av}

TABLE III (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	-0.729E+00	-0.794E+00	-0.575E+00	-0.495E+00	-0.981E+00	-0.634E+00	-0.492E+00
26	0.3667	-0.861E+00	-0.764E+00	-0.570E+00	-0.494E+00	-0.100E+01	-0.574E+00	-0.474E+00
25	0.3333	-0.962E+00	-0.739E+00	-0.528E+00	-0.460E+00	-0.922E+00	-0.436E+00	-0.459E+00
24	0.3000	-0.955E+00	-0.569E+00	-0.449E+00	-0.427E+00	-0.769E+00	-0.380E+00	-0.421E+00
23	0.2667	-0.901E+00	0.000E+00	-0.332E+00	-0.387E+00	-0.565E+00	-0.253E+00	-0.423E+00
22	0.2333	-0.681E+00	0.215E+00	-0.108E+00	-0.353E+00	-0.279E+00	-0.221E+00	-0.262E+00
21	0.2000	0.862E-01	0.246E+00	-0.320E+00	0.000E+00	-0.905E-01	-0.177E+00	-0.143E+00
20	0.1667	0.158E+01	0.312E+00	-0.411E+00	-0.156E+00	0.825E-01	-0.125E+00	-0.855E-01
19	0.1333	0.192E+01	0.237E+00	-0.562E+00	-0.222E+00	0.152E+00	-0.646E-01	0.000E+00
18	0.1000	0.153E+01	0.153E+00	-0.713E+00	-0.386E+00	0.186E+00	-0.646E-01	0.776E-01
17	0.0667	0.116E+01	0.156E-01	-0.872E+00	-0.406E+00	0.230E+00	-0.668E-01	0.776E-01
16	0.0333	0.974E+00	-0.140E+00	-0.989E+00	-0.500E+00	0.254E+00	-0.693E-01	0.143E+00
15	0.0000	0.718E+00	-0.302E+00	-0.103E+01	-0.529E+00	0.209E+00	-0.149E+00	0.231E+00
14	-0.0333	0.472E+00	0.228E+00	-0.109E+01	-0.791E+00	0.489E-01		
13	-0.0667	0.148E-01	-0.411E+00	-0.115E+01	-0.837E+00	0.000E+00		
12	-0.1000	-0.221E+00	-0.323E+00	-0.105E+01	-0.823E+00	-0.589E-01		
11	-0.1333	0.463E+00	0.000E+00	-0.786E+00	-0.769E+00	-0.131E+00		
10	-0.1667	0.262E+00	0.252E+00	-0.384E+00	-0.797E+00	-0.780E-01		
9	-0.2000	0.207E+00	0.224E+00	-0.250E+00	-0.587E+00	-0.859E-01	-0.201E+00	-0.571E-01
8	-0.2333	0.220E+00	0.285E+00	-0.131E+00	-0.504E+00	0.000E+00		
7	-0.2667	0.247E+00	0.339E+00	0.000E+00	-0.433E+00	0.499E-01		
6	-0.3000	0.395E+00	0.323E+00	0.979E-01	-0.347E+00	0.378E-01		
5	-0.3333	0.566E+00	0.310E+00	0.201E+00	-0.237E+00	0.302E-01		
4	-0.3667	0.615E+00	0.299E+00	0.211E+00	-0.159E+00	0.258E-01		
3	-0.4000	0.623E+00	0.305E+00	0.166E+00	-0.753E-01	0.225E-01	-0.282E+00	-0.867E-01
2	-0.4333	0.590E+00	0.344E+00	0.358E-01	-0.632E-01	-0.204E-01		
1	-0.4667	0.402E+00	0.262E+00	-0.948E-01	-0.792E-01	-0.616E-01		

(d) v/u_{av}

TABLE III (Continued)

J	Y \ I =	1	2	3	4	5	6	7
	X =	0.0278	0.0833	0.1389	0.1944	0.2500	0.3056	0.4167
27	0.4000	-0.605E+01	-0.518E+01	-0.430E+01	-0.450E+01	-0.352E+01	-0.316E+01	-0.338E+01
26	0.3667	-0.559E+01	-0.393E+01	-0.352E+01	-0.418E+01	-0.302E+01	-0.275E+01	-0.313E+01
25	0.3333	-0.503E+01	-0.276E+01	-0.269E+01	-0.367E+01	-0.247E+01	-0.228E+01	-0.279E+01
24	0.3000	-0.442E+01	-0.185E+01	-0.174E+01	-0.297E+01	-0.192E+01	-0.189E+01	-0.241E+01
23	0.2667	-0.363E+01	-0.319E+00	-0.891E+00	-0.223E+01	-0.148E+01	-0.158E+01	-0.192E+01
22	0.2333	-0.287E+01	-0.557E+00	-0.650E+00	-0.140E+01	-0.106E+01	-0.130E+01	-0.157E+01
21	0.2000	-0.206E+01	-0.500E+00	-0.451E+00	-0.351E+00	-0.773E+00	-0.107E+01	-0.116E+01
20	0.1667	-0.866E+00	-0.422E+00	-0.333E+00	-0.180E+00	-0.501E+00	-0.911E+00	-0.804E+00
19	0.1333	0.907E-02	-0.403E+00	-0.285E+00	-0.199E-01	-0.354E+00	-0.821E+00	-0.460E+00
18	0.1000	0.528E+00	-0.427E+00	-0.279E+00	0.183E+00	-0.244E+00	-0.674E+00	-0.217E+00
17	0.0667	0.469E+00	-0.405E+00	-0.323E+00	0.258E+00	-0.200E+00	-0.553E+00	-0.198E-01
16	0.0333	0.377E+00	-0.381E+00	-0.354E+00	0.345E+00	-0.149E+00	-0.436E+00	0.127E+00
15	0.0000	0.310E+00	-0.477E+00	-0.352E+00	0.456E+00	-0.117E+00	-0.337E+00	0.137E+00
14	-0.0333	0.298E+00	0.178E+00	-0.280E+00	0.615E+00	0.134E+00		
13	-0.0667	0.348E+00	0.244E+00	-0.176E+00	0.677E+00	0.224E+00		
12	-0.1000	0.519E+00	0.576E+00	0.183E-02	0.758E+00	0.331E+00		
11	-0.1333	0.331E+00	0.000E+00	0.327E+00	0.868E+00	0.470E+00		
10	-0.1667	0.126E+01	0.700E+00	0.137E+00	0.906E+00	0.753E+00		
9	-0.2000	0.208E+01	0.182E+01	0.496E+00	0.120E+01	0.969E+00	0.131E+01	0.156E+01
8	-0.2333	0.278E+01	0.302E+01	0.124E+01	0.134E+01	0.141E+01		
7	-0.2667	0.357E+01	0.412E+01	0.200E+01	0.161E+01	0.188E+01		
6	-0.3000	0.462E+01	0.520E+01	0.277E+01	0.196E+01	0.253E+01		
5	-0.3333	0.583E+01	0.601E+01	0.356E+01	0.251E+01	0.320E+01		
4	-0.3667	0.664E+01	0.654E+01	0.431E+01	0.322E+01	0.375E+01		
3	-0.4000	0.679E+01	0.673E+01	0.501E+01	0.402E+01	0.427E+01	0.380E+01	0.339E+01
2	-0.4333	0.772E+01	0.734E+01	0.535E+01	0.472E+01	0.468E+01		
1	-0.4667	0.763E+01	0.737E+01	0.516E+01	0.499E+01	0.462E+01		

(e) w/u_{av}

TABLE IV

VELOCITY DATA FOR CASE 3

	I =	1	2	3	4	5	6	7
	X =	0.0063	0.0190	0.0318	0.0444	0.0572	0.0698	0.0952
J	Y							
27	0.0914	0.282E+03	0.290E+03	0.290E+03	0.295E+03	0.290E+03	0.297E+03	0.298E+03
26	0.0838	0.283E+03	0.291E+03	0.284E+03	0.292E+03	0.290E+03	0.293E+03	0.297E+03
25	0.0762	0.284E+03	0.290E+03	0.278E+03	0.290E+03	0.290E+03	0.288E+03	0.294E+03
24	0.0686	0.284E+03	0.291E+03	0.273E+03	0.287E+03	0.290E+03	0.284E+03	0.292E+03
23	0.0610	0.292E+03	0.292E+03	0.270E+03	0.286E+03	0.291E+03	0.279E+03	0.289E+03
22	0.0533	0.308E+03	0.296E+03	0.267E+03	0.290E+03	0.292E+03	0.277E+03	0.287E+03
21	0.0457	0.330E+03	0.312E+03	0.270E+03	0.295E+03	0.294E+03	0.277E+03	0.287E+03
20	0.0381	0.344E+03	0.335E+03	0.277E+03	0.302E+03	0.297E+03	0.280E+03	0.288E+03
19	0.0305	0.350E+03	0.356E+03	0.295E+03	0.310E+03	0.300E+03	0.287E+03	0.291E+03
18	0.0229	0.352E+03	0.800E+01	0.322E+03	0.314E+03	0.308E+03	0.300E+03	0.295E+03
17	0.0152	0.352E+03	0.800E+01	0.358E+03	0.317E+03	0.317E+03	0.322E+03	0.305E+03
16	0.0076	0.352E+03	0.800E+01	0.200E+02	0.322E+03	0.332E+03	0.357E+03	0.317E+03
15	0.0000	0.348E+03	0.800E+01	0.375E+02	0.328E+03	0.351E+03	0.250E+02	0.351E+03
14	-0.0076	0.000E+00	0.300E+02	0.430E+02	0.345E+03	0.700E+01		
13	-0.0152	0.122E+03	0.450E+02	0.430E+02	0.200E+02	0.360E+02		
12	-0.0229	0.122E+03	0.800E+02	0.480E+02	0.600E+02	0.530E+02		
11	-0.0305	0.104E+03	0.924E+02	0.490E+02	0.780E+02	0.650E+02		
10	-0.0381	0.997E+02	0.890E+02	0.520E+02	0.840E+02	0.750E+02		
9	-0.0457	0.960E+02	0.870E+02	0.560E+02	0.840E+02	0.800E+02	0.702E+02	0.838E+02
8	-0.0533	0.960E+02	0.830E+02	0.600E+02	0.840E+02	0.860E+02		
7	-0.0610	0.960E+02	0.797E+02	0.650E+02	0.802E+02	0.890E+02		
6	-0.0686	0.962E+02	0.787E+02	0.710E+02	0.770E+02	0.880E+02		
5	-0.0762	0.970E+02	0.820E+02	0.740E+02	0.735E+02	0.840E+02		
4	-0.0838	0.962E+02	0.822E+02	0.760E+02	0.700E+02	0.800E+02		
3	-0.0914	0.958E+02	0.830E+02	0.770E+02	0.670E+02	0.750E+02	0.660E+02	0.600E+02
2	-0.0991	0.940E+02	0.840E+02	0.760E+02	0.640E+02	0.700E+02		
1	-0.1067	0.938E+02	0.840E+02	0.760E+02	0.630E+02	0.670E+02		

(a) Yaw Angle

TABLE IV (Continued)

J	Y	I = 1 X = 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	0.577E+01	-0.618E+01	-0.384E+00	-0.798E+01	-0.362E+01	-0.769E+01	-0.707E+01
26	0.0838	0.595E+01	-0.752E+01	-0.852E+00	-0.845E+01	-0.465E+01	-0.938E+01	-0.783E+01
25	0.0762	0.660E+01	-0.916E+01	-0.139E+01	-0.890E+01	-0.594E+01	-0.109E+02	-0.853E+01
24	0.0686	0.100E+02	-0.118E+02	-0.110E+01	-0.977E+01	-0.665E+01	-0.127E+02	-0.973E+01
23	0.0610	0.273E+02	-0.186E+02	-0.311E+01	-0.914E+01	-0.853E+01	-0.145E+02	-0.104E+02
22	0.0533	0.380E+02	-0.333E+02	-0.122E+01	-0.773E+01	-0.110E+02	-0.165E+02	-0.121E+02
21	0.0457	0.364E+02	0.000E+00	0.000E+00	-0.400E+01	-0.158E+02	-0.160E+02	-0.122E+02
20	0.0381	0.319E+02	0.000E+00	0.318E+01	-0.176E+01	-0.197E+02	-0.186E+02	-0.136E+02
19	0.0305	0.263E+02	0.000E+00	0.277E+02	0.000E+00	-0.277E+02	-0.218E+02	-0.165E+02
18	0.0229	0.206E+02	0.000E+00	0.506E+02	0.194E+01	-0.362E+02	-0.252E+02	-0.174E+02
17	0.0152	0.176E+02	0.000E+00	0.000E+00	0.269E+01	-0.448E+02	-0.393E+02	-0.208E+02
16	0.0076	0.157E+02	0.000E+00	0.520E+02	0.673E+01	-0.540E+02	-0.315E+02	-0.269E+02
15	0.0000	0.104E+02	0.000E+00	0.336E+02	0.125E+02	0.000E+00	-0.165E+02	-0.315E+02
14	-0.0076	0.000E+00	-0.565E+02	0.175E+02	0.310E+02	-0.549E+02		
13	-0.0152	-0.510E+02	0.000E+00	0.129E+02	0.545E+02	-0.373E+02		
12	-0.0229	0.000E+00	-0.605E+01	0.720E+01	0.355E+02	-0.218E+02		
11	-0.0305	0.000E+00	0.116E+02	0.140E+01	0.246E+02	-0.147E+02		
10	-0.0381	0.295E+02	0.922E+01	-0.136E+01	0.161E+02	-0.110E+02		
9	-0.0457	0.228E+02	0.100E+02	-0.257E+01	0.116E+02	-0.415E+01	-0.981E+00	0.189E+01
8	-0.0533	0.149E+02	0.820E+01	-0.374E+01	0.803E+01	-0.153E+01		
7	-0.0610	0.130E+02	0.584E+01	-0.340E+01	0.526E+01	-0.107E+01		
6	-0.0686	0.125E+02	0.472E+01	-0.185E+01	0.363E+01	-0.768E+00		
5	-0.0762	0.105E+02	0.494E+01	-0.153E+01	0.149E+01	0.000E+00		
4	-0.0838	0.912E+01	0.475E+01	-0.579E+00	0.359E+00	-0.459E+00		
3	-0.0914	0.744E+01	0.426E+01	0.000E+00	-0.109E+01	-0.426E+00	-0.478E+00	-0.981E+00
2	-0.0991	0.569E+01	0.269E+01	-0.388E+00	-0.195E+01	-0.126E+01		
1	-0.1067	0.252E+01	0.119E+01	-0.384E+00	-0.169E+01	-0.137E+01		

(b) Pitch Angle

TABLE IV (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.851E+00	0.151E+01	0.139E+01	0.165E+01	0.114E+01	0.173E+01	0.150E+01
26	0.3667	0.907E+00	0.147E+01	0.939E+00	0.145E+01	0.108E+01	0.147E+01	0.147E+01
25	0.3333	0.899E+00	0.123E+01	0.519E+00	0.124E+01	0.100E+01	0.113E+01	0.130E+01
24	0.3000	0.765E+00	0.106E+01	0.179E+00	0.955E+00	0.938E+00	0.796E+00	0.113E+01
23	0.2667	0.978E+00	0.786E+00	-0.138E-04	0.777E+00	0.880E+00	0.468E+00	0.912E+00
22	0.2333	0.143E+01	0.557E+00	-0.120E+00	0.844E+00	0.825E+00	0.305E+00	0.750E+00
21	0.2000	0.241E+01	0.559E+00	-0.830E-05	0.935E+00	0.770E+00	0.276E+00	0.693E+00
20	0.1667	0.333E+01	0.378E+00	0.164E+00	0.102E+01	0.788E+00	0.325E+00	0.663E+00
19	0.1333	0.413E+01	0.931E+00	0.386E+00	0.119E+01	0.692E+00	0.436E+00	0.662E+00
18	0.1000	0.439E+01	0.131E+01	0.399E+00	0.122E+01	0.688E+00	0.563E+00	0.684E+00
17	0.0667	0.444E+01	0.137E+01	0.423E+00	0.108E+01	0.620E+00	0.467E+00	0.736E+00
16	0.0333	0.399E+01	0.131E+01	0.582E+00	0.102E+01	0.551E+00	0.509E+00	0.667E+00
15	0.0000	0.304E+01	0.101E+01	0.836E+00	0.798E+00	0.727E+00	0.504E+00	0.357E+00
14	-0.0333	0.000E+00	0.644E+00	0.111E+01	0.675E+00	0.529E+00		
13	-0.0667	-0.167E+00	0.417E+00	0.126E+01	0.330E+00	0.566E+00		
12	-0.1000	-0.221E+00	0.173E+00	0.131E+01	0.396E+00	0.568E+00		
11	-0.1333	-0.142E+00	-0.695E-01	0.136E+01	0.274E+00	0.502E+00		
10	-0.1667	-0.307E+00	0.420E-01	0.134E+01	0.196E+00	0.361E+00		
9	-0.2000	-0.314E+00	0.170E+00	0.126E+01	0.250E+00	0.308E+00	0.870E+00	0.272E+00
8	-0.2333	-0.417E+00	0.503E+00	0.114E+01	0.314E+00	0.144E+00		
7	-0.2667	-0.478E+00	0.842E+00	0.101E+01	0.583E+00	0.430E-01		
6	-0.3000	-0.512E+00	0.963E+00	0.864E+00	0.847E+00	0.101E+00		
5	-0.3333	-0.598E+00	0.699E+00	0.802E+00	0.114E+01	0.350E+00		
4	-0.3667	-0.515E+00	0.665E+00	0.803E+00	0.143E+01	0.650E+00		
3	-0.4000	-0.470E+00	0.570E+00	0.857E+00	0.165E+01	0.101E+01	0.149E+01	0.182E+01
2	-0.4333	-0.303E+00	0.479E+00	0.979E+00	0.180E+01	0.135E+01		
1	-0.4667	-0.263E+00	0.465E+00	0.984E+00	0.178E+01	0.147E+01		

(c) u/u_{av}

TABLE IV (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.414E+00	-0.478E+00	-0.273E-01	-0.549E+00	-0.209E+00	-0.515E+00	-0.398E+00
26	0.3667	0.420E+00	-0.552E+00	-0.577E-01	-0.573E+00	-0.254E+00	-0.622E+00	-0.446E+00
25	0.3333	0.430E+00	-0.580E+00	-0.906E-01	-0.571E+00	-0.302E+00	-0.701E+00	-0.476E+00
24	0.3000	0.559E+00	-0.614E+00	-0.658E-01	-0.562E+00	-0.317E+00	-0.753E+00	-0.516E+00
23	0.2667	0.135E+01	-0.707E+00	-0.158E+00	-0.453E+00	-0.368E+00	-0.771E+00	-0.513E+00
22	0.2333	0.182E+01	-0.835E+00	-0.489E-01	-0.335E+00	-0.429E+00	-0.772E+00	-0.548E+00
21	0.2000	0.205E+01	0.000E+00	0.000E+00	-0.155E+00	-0.534E+00	-0.648E+00	-0.514E+00
20	0.1667	0.216E+01	0.000E+00	0.746E-01	-0.591E-01	-0.621E+00	-0.628E+00	-0.520E+00
19	0.1333	0.207E+01	0.000E+00	0.479E+00	0.000E+00	-0.726E+00	-0.596E+00	-0.547E+00
18	0.1000	0.167E+01	0.000E+00	0.616E+00	0.593E-01	-0.817E+00	-0.531E+00	-0.508E+00
17	0.0667	0.142E+01	0.000E+00	0.000E+00	0.692E-01	-0.842E+00	-0.485E+00	-0.488E+00
16	0.0333	0.113E+01	0.000E+00	0.793E+00	0.152E+00	-0.858E+00	-0.313E+00	-0.464E+00
15	0.0000	0.571E+00	0.000E+00	0.701E+00	0.209E+00	0.000E+00	-0.164E+00	-0.221E+00
14	-0.0333	0.000E+00	-0.112E+01	0.476E+00	0.420E+00	-0.758E+00		
13	-0.0667	-0.389E+00	0.000E+00	0.396E+00	0.491E+00	-0.534E+00		
12	-0.1000	0.000E+00	-0.106E+00	0.248E+00	0.564E+00	-0.377E+00		
11	-0.1333	0.000E+00	0.342E+00	0.506E-01	0.603E+00	-0.311E+00		
10	-0.1667	0.103E+01	0.390E+00	-0.516E-01	0.541E+00	-0.272E+00		
9	-0.2000	0.127E+01	0.575E+00	-0.101E+00	0.492E+00	-0.129E+00	-0.440E-01	0.830E-01
8	-0.2333	0.106E+01	0.595E+00	-0.149E+00	0.423E+00	-0.552E-01		
7	-0.2667	0.106E+01	0.482E+00	-0.142E+00	0.315E+00	-0.460E-01		
6	-0.3000	0.106E+01	0.406E+00	-0.855E-01	0.239E+00	-0.389E-01		
5	-0.3333	0.913E+00	0.434E+00	-0.777E-01	0.105E+00	0.000E+00		
4	-0.3667	0.765E+00	0.407E+00	-0.336E-01	0.262E-01	-0.300E-01		
3	-0.4000	0.607E+00	0.348E+00	0.000E+00	-0.804E-01	-0.289E-01	-0.306E-01	-0.623E-01
2	-0.4333	0.433E+00	0.215E+00	-0.274E-01	-0.139E+00	-0.866E-01		
1	-0.4667	0.175E+00	0.922E-01	-0.273E-01	-0.116E+00	-0.905E-01		

(d) v/u_{av}

TABLE IV (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	-0.401E+01	-0.414E+01	-0.382E+01	-0.355E+01	-0.310E+01	-0.340E+01	-0.283E+01
26	0.3667	-0.393E+01	-0.392E+01	-0.377E+01	-0.358E+01	-0.293E+01	-0.347E+01	-0.289E+01
25	0.3333	-0.361E+01	-0.338E+01	-0.370E+01	-0.343E+01	-0.273E+01	-0.346E+01	-0.289E+01
24	0.3000	-0.307E+01	-0.275E+01	-0.341E+01	-0.312E+01	-0.255E+01	-0.324E+01	-0.279E+01
23	0.2667	-0.242E+01	-0.195E+01	-0.290E+01	-0.271E+01	-0.229E+01	-0.296E+01	-0.265E+01
22	0.2333	-0.183E+01	-0.114E+01	-0.230E+01	-0.232E+01	-0.204E+01	-0.259E+01	-0.245E+01
21	0.2000	-0.139E+01	-0.620E+00	-0.174E+01	-0.200E+01	-0.173E+01	-0.225E+01	-0.227E+01
20	0.1667	-0.954E+00	-0.176E+00	-0.133E+01	-0.164E+01	-0.155E+01	-0.184E+01	-0.204E+01
19	0.1333	-0.727E+00	-0.651E-01	-0.828E+00	-0.142E+01	-0.120E+01	-0.143E+01	-0.173E+01
18	0.1000	-0.601E+00	0.184E+00	-0.311E+00	-0.126E+01	-0.881E+00	-0.975E+00	-0.147E+01
17	0.0667	-0.608E+00	0.193E+00	-0.148E-01	-0.101E+01	-0.578E+00	-0.365E+00	-0.105E+01
16	0.0333	-0.568E+00	0.184E+00	0.212E+00	-0.793E+00	-0.293E+00	-0.267E-01	-0.622E+00
15	0.0000	-0.646E+00	0.142E+00	0.642E+00	-0.499E+00	-0.115E+00	0.235E+00	-0.565E-01
14	-0.0333	0.000E+00	0.372E+00	0.103E+01	-0.181E+00	0.649E-01		
13	-0.0667	0.267E+00	0.417E+00	0.118E+01	0.120E+00	0.411E+00		
12	-0.1000	0.353E+00	0.983E+00	0.146E+01	0.686E+00	0.754E+00		
11	-0.1333	0.571E+00	0.166E+01	0.156E+01	0.129E+01	0.108E+01		
10	-0.1667	0.180E+01	0.241E+01	0.172E+01	0.187E+01	0.135E+01		
9	-0.2000	0.299E+01	0.325E+01	0.187E+01	0.237E+01	0.175E+01	0.242E+01	0.250E+01
8	-0.2333	0.397E+01	0.409E+01	0.198E+01	0.298E+01	0.206E+01		
7	-0.2667	0.454E+01	0.464E+01	0.217E+01	0.337E+01	0.246E+01		
6	-0.3000	0.471E+01	0.482E+01	0.251E+01	0.367E+01	0.290E+01		
5	-0.3333	0.487E+01	0.497E+01	0.280E+01	0.386E+01	0.333E+01		
4	-0.3667	0.474E+01	0.485E+01	0.322E+01	0.393E+01	0.369E+01		
3	-0.4000	0.462E+01	0.464E+01	0.371E+01	0.388E+01	0.375E+01	0.335E+01	0.315E+01
2	-0.4333	0.433E+01	0.456E+01	0.393E+01	0.369E+01	0.370E+01		
1	-0.4667	0.396E+01	0.443E+01	0.395E+01	0.350E+01	0.347E+01		

(e) w/u_{av}

TABLE V

VELOCITY DATA FOR CASE 4

J	Y	1	2	3	4	5	6	7
	X =	0.0063	0.0190	0.0318	0.0444	0.0572	0.0698	0.0952
27	0.0914	0.280E+03	0.282E+03	0.276E+03	0.282E+03	0.282E+03	0.282E+03	0.282E+03
26	0.0838	0.282E+03	0.279E+03	0.270E+03	0.278E+03	0.278E+03	0.278E+03	0.278E+03
25	0.0762	0.280E+03	0.276E+03	0.266E+03	0.277E+03	0.274E+03	0.274E+03	0.274E+03
24	0.0686	0.276E+03	0.272E+03	0.262E+03	0.276E+03	0.272E+03	0.272E+03	0.272E+03
23	0.0610	0.272E+03	0.272E+03	0.260E+03	0.278E+03	0.270E+03	0.270E+03	0.270E+03
22	0.0533	0.270E+03	0.276E+03	0.264E+03	0.283E+03	0.270E+03	0.270E+03	0.270E+03
21	0.0457	0.283E+03	0.294E+03	0.284E+03	0.290E+03	0.272E+03	0.274E+03	0.272E+03
20	0.0381	0.336E+03	0.323E+03	0.312E+03	0.302E+03	0.280E+03	0.280E+03	0.276E+03
19	0.0305	0.355E+03	0.352E+03	0.341E+03	0.313E+03	0.300E+03	0.294E+03	0.284E+03
18	0.0229	0.359E+03	0.359E+03	0.354E+03	0.324E+03	0.327E+03	0.310E+03	0.293E+03
17	0.0152	0.359E+03	0.180E+01	0.400E+01	0.327E+03	0.347E+03	0.323E+03	0.313E+03
16	0.0076	0.358E+03	0.200E+01	0.800E+01	0.333E+03	0.400E+01	0.342E+03	0.346E+03
15	0.0000	0.356E+03	0.300E+01	0.140E+02	0.338E+03	0.100E+02	0.360E+03	0.700E+01
14	-0.0076	0.356E+03	0.180E+01	0.190E+02	0.345E+03	0.200E+02		
13	-0.0152	0.353E+03	0.180E+01	0.250E+02	0.353E+03	0.310E+02		
12	-0.0229	0.351E+03	0.800E+01	0.350E+02	0.100E+02	0.400E+02		
11	-0.0305	0.351E+03	0.240E+02	0.450E+02	0.460E+02	0.510E+02		
10	-0.0381	0.112E+03	0.900E+02	0.570E+02	0.770E+02	0.650E+02		
9	-0.0457	0.104E+03	0.101E+03	0.670E+02	0.910E+02	0.760E+02	0.800E+02	0.800E+02
8	-0.0533	0.102E+03	0.990E+02	0.750E+02	0.970E+02	0.830E+02		
7	-0.0610	0.972E+02	0.950E+02	0.810E+02	0.960E+02	0.870E+02		
6	-0.0686	0.940E+02	0.902E+02	0.830E+02	0.937E+02	0.870E+02		
5	-0.0762	0.923E+02	0.859E+02	0.840E+02	0.893E+02	0.835E+02		
4	-0.0838	0.937E+02	0.822E+02	0.830E+02	0.843E+02	0.810E+02		
3	-0.0914	0.941E+02	0.827E+02	0.807E+02	0.790E+02	0.767E+02	0.761E+02	0.730E+02
2	-0.0991	0.939E+02	0.870E+02	0.780E+02	0.737E+02	0.727E+02		
1	-0.1067	0.100E+03	0.880E+02	0.760E+02	0.688E+02	0.700E+02		

(a) Yaw Angle

TABLE V (Continued)

J	Y	I = 1 X = 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	-0.564E+01	-0.605E+01	-0.388E+01	-0.666E+01	-0.555E+01	-0.794E+01	-0.493E+01
26	0.0838	-0.698E+01	-0.786E+01	-0.465E+01	-0.775E+01	-0.646E+01	-0.955E+01	-0.641E+01
25	0.0762	-0.757E+01	-0.100E+02	-0.523E+01	-0.793E+01	-0.794E+01	-0.105E+02	-0.739E+01
24	0.0686	-0.729E+01	-0.129E+02	-0.521E+01	-0.720E+01	-0.937E+01	-0.114E+02	-0.853E+01
23	0.0610	-0.605E+01	-0.190E+02	-0.356E+01	-0.672E+01	-0.111E+02	-0.119E+02	-0.996E+01
22	0.0533	0.000E+00	-0.280E+02	0.000E+00	-0.640E+01	-0.145E+02	-0.115E+02	-0.114E+02
21	0.0457	0.231E+02	-0.465E+02	0.351E+01	-0.374E+01	-0.184E+02	-0.957E+01	-0.147E+02
20	0.0381	0.455E+02	-0.549E+02	0.231E+02	-0.356E+01	-0.252E+02	-0.563E+01	-0.158E+02
19	0.0305	0.318E+02	-0.359E+02	0.287E+02	-0.415E+01	-0.404E+02	-0.465E+01	-0.192E+02
18	0.0229	0.204E+02	-0.297E+02	0.333E+02	-0.439E+01	-0.354E+02	0.000E+00	-0.244E+02
17	0.0152	0.150E+02	-0.275E+02	0.310E+02	-0.527E+01	-0.315E+02	0.000E+00	-0.315E+02
16	0.0076	0.120E+02	-0.256E+02	0.231E+02	-0.798E+01	-0.218E+02	0.161E+02	-0.315E+02
15	0.0000	0.958E+01	-0.288E+02	0.212E+02	-0.707E+01	-0.110E+02	0.310E+02	-0.315E+02
14	-0.0076	0.436E+01	-0.315E+02	0.151E+02	-0.465E+01	-0.773E+01		
13	-0.0152	0.103E+01	-0.445E+02	0.121E+02	-0.132E+02	-0.100E+02		
12	-0.0229	0.000E+00	0.000E+00	0.796E+01	-0.165E+02	-0.652E+01		
11	-0.0305	0.000E+00	0.000E+00	0.579E+01	0.000E+00	-0.563E+01		
10	-0.0381	0.410E+02	0.000E+00	0.391E+01	0.102E+02	-0.605E+01		
9	-0.0457	0.141E+02	0.474E+01	0.205E+01	0.125E+02	-0.430E+01	0.108E+02	0.269E+01
8	-0.0533	0.875E+01	0.479E+01	0.731E+00	0.879E+01	-0.254E+01		
7	-0.0610	0.710E+01	0.506E+01	0.000E+00	0.682E+01	-0.107E+01		
6	-0.0686	0.648E+01	0.462E+01	0.000E+00	0.548E+01	-0.357E+00		
5	-0.0762	0.614E+01	0.388E+01	-0.264E+00	0.459E+01	-0.752E+00		
4	-0.0838	0.570E+01	0.300E+01	-0.200E+00	0.343E+01	-0.386E+00		
3	-0.0914	0.542E+01	0.262E+01	-0.151E+00	0.235E+01	-0.333E+00	0.132E+01	0.256E+01
2	-0.0991	0.426E+01	0.263E+01	-0.244E+00	0.130E+01	-0.652E+00		
1	-0.1067	0.266E+01	0.153E+01	0.000E+00	0.766E+00	-0.536E+00		

(b) Pitch Angle

TABLE V (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.124E+01	0.150E+01	0.722E+00	0.125E+01	0.128E+01	0.114E+01	0.103E+01
26	0.3667	0.137E+01	0.960E+00	0.210E-01	0.786E+00	0.791E+00	0.725E+00	0.614E+00
25	0.3333	0.105E+01	0.473E+00	-0.372E+00	0.574E+00	0.376E+00	0.356E+00	0.315E+00
24	0.3000	0.515E+00	0.139E+00	-0.535E+00	0.428E+00	0.133E+00	0.143E+00	0.140E+00
23	0.2667	0.129E+00	0.915E-01	-0.474E+00	0.479E+00	-0.180E-04	-0.161E-04	0.124E-01
22	0.2333	-0.121E-04	0.186E+00	-0.194E+00	0.626E+00	-0.144E-04	-0.129E-04	-0.142E-04
21	0.2000	0.287E+00	0.395E+00	0.311E+00	0.785E+00	0.792E-01	0.150E+00	0.829E-01
20	0.1667	0.113E+01	0.604E+00	0.693E+00	0.102E+01	0.276E+00	0.260E+00	0.198E+00
19	0.1333	0.278E+01	0.141E+01	0.102E+01	0.121E+01	0.477E+00	0.479E+00	0.326E+00
18	0.1000	0.420E+01	0.193E+01	0.113E+01	0.139E+01	0.728E+00	0.668E+00	0.296E+00
17	0.0667	0.458E+01	0.217E+01	0.134E+01	0.130E+01	0.784E+00	0.587E+00	0.348E+00
16	0.0333	0.464E+01	0.232E+01	0.162E+01	0.132E+01	0.939E+00	0.564E+00	0.350E+00
15	0.0000	0.439E+01	0.198E+01	0.165E+01	0.121E+01	0.968E+00	0.571E+00	0.358E+00
14	-0.0333	0.362E+01	0.162E+01	0.174E+01	0.114E+01	0.116E+01		
13	-0.0667	0.244E+01	0.969E+00	0.163E+01	0.885E+00	0.109E+01		
12	-0.1000	0.127E+01	0.597E+00	0.154E+01	0.549E+00	0.105E+01		
11	-0.1333	0.000E+00	0.000E+00	0.140E+01	0.512E+00	0.940E+00		
10	-0.1667	-0.249E+00	0.135E-05	0.114E+01	0.234E+00	0.742E+00		
9	-0.2000	-0.444E+00	-0.295E+00	0.944E+00	-0.285E-01	0.514E+00	0.447E+00	0.512E+00
8	-0.2333	-0.647E+00	-0.450E+00	0.756E+00	-0.321E+00	0.339E+00		
7	-0.2667	-0.538E+00	-0.380E+00	0.559E+00	-0.379E+00	0.182E+00		
6	-0.3000	-0.398E+00	-0.205E-01	0.517E+00	-0.299E+00	0.221E+00		
5	-0.3333	-0.287E+00	0.515E+00	0.517E+00	0.678E-01	0.573E+00		
4	-0.3667	-0.532E+00	0.114E+01	0.693E+00	0.630E+00	0.899E+00		
3	-0.4000	-0.635E+00	0.113E+01	0.106E+01	0.132E+01	0.142E+01	0.136E+01	0.147E+01
2	-0.4333	-0.667E+00	0.502E+00	0.151E+01	0.201E+01	0.187E+01		
1	-0.4667	-0.170E+01	0.333E+00	0.179E+01	0.252E+01	0.205E+01		

(c) u/u_{av}

TABLE V (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	-0.708E+00	-0.765E+00	-0.468E+00	-0.718E+00	-0.595E+00	-0.775E+00	-0.428E+00
26	0.3667	-0.806E+00	-0.812E+00	-0.491E+00	-0.741E+00	-0.644E+00	-0.876E+00	-0.529E+00
25	0.3333	-0.787E+00	-0.828E+00	-0.454E+00	-0.655E+00	-0.716E+00	-0.881E+00	-0.571E+00
24	0.3000	-0.630E+00	-0.828E+00	-0.351E+00	-0.516E+00	-0.739E+00	-0.827E+00	-0.601E+00
23	0.2667	-0.392E+00	-0.901E+00	-0.170E+00	-0.406E+00	-0.745E+00	-0.716E+00	-0.623E+00
22	0.2333	0.000E+00	-0.945E+00	0.000E+00	-0.312E+00	-0.787E+00	-0.552E+00	-0.601E+00
21	0.2000	0.544E+00	-0.102E+01	0.788E-01	-0.150E+00	-0.754E+00	-0.362E+00	-0.621E+00
20	0.1667	0.125E+01	-0.108E+01	0.442E+00	-0.120E+00	-0.749E+00	-0.148E+00	-0.534E+00
19	0.1333	0.173E+01	-0.103E+01	0.594E+00	-0.129E+00	-0.810E+00	-0.957E-01	-0.468E+00
18	0.1000	0.156E+01	-0.110E+01	0.748E+00	-0.132E+00	-0.616E+00	0.000E+00	-0.343E+00
17	0.0667	0.123E+01	-0.113E+01	0.808E+00	-0.143E+00	-0.493E+00	0.000E+00	-0.313E+00
16	0.0333	0.990E+00	-0.111E+01	0.699E+00	-0.208E+00	-0.376E+00	0.171E+00	-0.221E+00
15	0.0000	0.742E+00	-0.109E+01	0.658E+00	-0.162E+00	-0.191E+00	0.343E+00	-0.221E+00
14	-0.0333	0.277E+00	-0.994E+00	0.497E+00	-0.959E-01	-0.167E+00		
13	-0.0667	0.442E-01	-0.953E+00	0.386E+00	-0.209E+00	-0.225E+00		
12	-0.1000	0.000E+00	0.000E+00	0.263E+00	-0.165E+00	-0.157E+00		
11	-0.1333	0.000E+00	0.000E+00	0.200E+00	0.000E+00	-0.147E+00		
10	-0.1667	0.578E+00	0.000E+00	0.144E+00	0.187E+00	-0.186E+00		
9	-0.2000	0.451E+00	0.128E+00	0.866E-01	0.362E+00	-0.160E+00	0.492E+00	0.138E+00
8	-0.2333	0.479E+00	0.241E+00	0.373E-01	0.408E+00	-0.123E+00		
7	-0.2667	0.535E+00	0.386E+00	0.000E+00	0.433E+00	-0.649E-01		
6	-0.3000	0.648E+00	0.474E+00	0.000E+00	0.445E+00	-0.263E-01		
5	-0.3333	0.768E+00	0.489E+00	-0.228E-01	0.445E+00	-0.664E-01		
4	-0.3667	0.823E+00	0.439E+00	-0.198E-01	0.381E+00	-0.388E-01		
3	-0.4000	0.843E+00	0.407E+00	-0.172E-01	0.284E+00	-0.360E-01	0.131E+00	0.224E+00
2	-0.4333	0.730E+00	0.441E+00	-0.309E-01	0.163E+00	-0.714E-01		
1	-0.4667	0.446E+00	0.255E+00	0.000E+00	0.931E-01	-0.560E-01		

(d) v/u_{av}

TABLE V (Continued)

J	I = / Y \ X =	1 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	-0.705E+01	-0.706E+01	-0.687E+01	-0.602E+01	-0.598E+01	-0.543E+01	-0.486E+01
26	0.3667	-0.644E+01	-0.580E+01	-0.603E+01	-0.539E+01	-0.563E+01	-0.516E+01	-0.467E+01
25	0.3333	-0.583E+01	-0.466E+01	-0.494E+01	-0.467E+01	-0.512E+01	-0.474E+01	-0.439E+01
24	0.3000	-0.490E+01	-0.362E+01	-0.381E+01	-0.407E+01	-0.448E+01	-0.409E+01	-0.400E+01
23	0.2667	-0.370E+01	-0.262E+01	-0.269E+01	-0.341E+01	-0.378E+01	-0.339E+01	-0.355E+01
22	0.2333	-0.254E+01	-0.177E+01	-0.185E+01	-0.271E+01	-0.304E+01	-0.272E+01	-0.298E+01
21	0.2000	-0.124E+01	-0.887E+00	-0.125E+01	-0.216E+01	-0.227E+01	-0.214E+01	-0.237E+01
20	0.1667	-0.502E+00	-0.455E+00	-0.770E+00	-0.163E+01	-0.156E+01	-0.147E+01	-0.188E+01
19	0.1333	-0.243E+00	-0.198E+00	-0.353E+00	-0.130E+01	-0.826E+00	-0.108E+01	-0.131E+01
18	0.1000	-0.734E-01	-0.338E-01	-0.119E+00	-0.101E+01	-0.473E+00	-0.796E+00	-0.696E+00
17	0.0667	-0.800E-01	0.681E-01	0.938E-01	-0.847E+00	-0.181E+00	-0.442E+00	-0.373E+00
16	0.0333	-0.162E+00	0.810E-01	0.228E+00	-0.673E+00	0.656E-01	-0.183E+00	-0.872E-01
15	0.0000	-0.307E+00	0.104E+00	0.412E+00	-0.490E+00	0.171E+00	-0.344E-05	0.439E-01
14	-0.0333	-0.253E+00	0.509E-01	0.598E+00	-0.305E+00	0.421E+00		
13	-0.0667	-0.300E+00	0.305E-01	0.760E+00	-0.109E+00	0.657E+00		
12	-0.1000	-0.201E+00	0.840E-01	0.108E+01	0.967E-01	0.881E+00		
11	-0.1333	0.000E+00	0.000E+00	0.140E+01	0.530E+00	0.116E+01		
10	-0.1667	0.616E+00	0.427E+00	0.176E+01	0.101E+01	0.159E+01		
9	-0.2000	0.174E+01	0.152E+01	0.222E+01	0.163E+01	0.206E+01	0.253E+01	0.290E+01
8	-0.2333	0.304E+01	0.284E+01	0.282E+01	0.262E+01	0.276E+01		
7	-0.2667	0.426E+01	0.434E+01	0.353E+01	0.360E+01	0.347E+01		
6	-0.3000	0.569E+01	0.587E+01	0.421E+01	0.463E+01	0.422E+01		
5	-0.3333	0.714E+01	0.718E+01	0.492E+01	0.554E+01	0.503E+01		
4	-0.3667	0.823E+01	0.831E+01	0.564E+01	0.632E+01	0.568E+01		
3	-0.4000	0.886E+01	0.880E+01	0.645E+01	0.678E+01	0.602E+01	0.549E+01	0.480E+01
2	-0.4333	0.979E+01	0.957E+01	0.712E+01	0.688E+01	0.599E+01		
1	-0.4667	0.947E+01	0.955E+01	0.717E+01	0.649E+01	0.563E+01		

(e) W/u_{av}

TABLE VI

VELOCITY DATA FOR CASE 5

J	Y	I = 1 X = 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	0.283E+03	0.288E+03	0.290E+03	0.289E+03	0.291E+03	0.277E+03	0.290E+03
26	0.0838	0.286E+03	0.288E+03	0.285E+03	0.286E+03	0.286E+03	0.282E+03	0.285E+03
25	0.0762	0.288E+03	0.288E+03	0.280E+03	0.284E+03	0.282E+03	0.278E+03	0.280E+03
24	0.0686	0.290E+03	0.285E+03	0.276E+03	0.282E+03	0.277E+03	0.275E+03	0.276E+03
23	0.0610	0.293E+03	0.282E+03	0.273E+03	0.281E+03	0.274E+03	0.272E+03	0.273E+03
22	0.0533	0.303E+03	0.279E+03	0.274E+03	0.281E+03	0.272E+03	0.272E+03	0.272E+03
21	0.0457	0.316E+03	0.278E+03	0.278E+03	0.282E+03	0.272E+03	0.274E+03	0.273E+03
20	0.0381	0.328E+03	0.278E+03	0.286E+03	0.282E+03	0.274E+03	0.276E+03	0.276E+03
19	0.0305	0.334E+03	0.284E+03	0.295E+03	0.285E+03	0.278E+03	0.280E+03	0.280E+03
18	0.0229	0.336E+03	0.310E+03	0.305E+03	0.288E+03	0.288E+03	0.289E+03	0.286E+03
17	0.0152	0.336E+03	0.358E+03	0.320E+03	0.295E+03	0.305E+03	0.300E+03	0.295E+03
16	0.0076	0.336E+03	0.300E+02	0.344E+03	0.306E+03	0.329E+03	0.324E+03	0.318E+03
15	0.0000	0.348E+03	0.420E+02	0.200E+01	0.327E+03	0.000E+00	0.600E+01	0.700E+01
14	-0.0076	0.718E+02	0.500E+02	0.360E+02	0.355E+03	0.300E+02		
13	-0.0152	0.102E+03	0.567E+02	0.570E+02	0.360E+02	0.540E+02		
12	-0.0229	0.102E+03	0.630E+02	0.680E+02	0.620E+02	0.650E+02		
11	-0.0305	0.100E+03	0.710E+02	0.750E+02	0.760E+02	0.737E+02		
10	-0.0381	0.980E+02	0.800E+02	0.800E+02	0.840E+02	0.783E+02		
9	-0.0457	0.960E+02	0.870E+02	0.820E+02	0.900E+02	0.810E+02	0.822E+02	0.822E+02
8	-0.0533	0.956E+02	0.890E+02	0.830E+02	0.920E+02	0.810E+02		
7	-0.0610	0.960E+02	0.870E+02	0.820E+02	0.917E+02	0.803E+02		
6	-0.0686	0.982E+02	0.859E+02	0.810E+02	0.880E+02	0.790E+02		
5	-0.0762	0.999E+02	0.863E+02	0.797E+02	0.815E+02	0.762E+02		
4	-0.0838	0.980E+02	0.879E+02	0.780E+02	0.760E+02	0.732E+02		
3	-0.0914	0.940E+02	0.870E+02	0.758E+02	0.714E+02	0.700E+02	0.769E+02	0.659E+02
2	-0.0991	0.900E+02	0.860E+02	0.743E+02	0.675E+02	0.670E+02		
1	-0.1067	0.879E+02	0.860E+02	0.738E+02	0.650E+02	0.650E+02		

(a) Yaw Angle

TABLE VI (Continued)

J	Y	I = 1 X = 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	0.333E+01	-0.312E+01	-0.203E+01	-0.605E+01	-0.790E+01	-0.703E+01	-0.360E+01
26	0.0838	0.360E+01	-0.359E+01	-0.280E+01	-0.674E+01	-0.956E+01	-0.840E+01	-0.480E+01
25	0.0762	0.434E+01	-0.460E+01	-0.345E+01	-0.692E+01	-0.114E+02	-0.920E+01	-0.577E+01
24	0.0686	0.583E+01	-0.630E+01	-0.276E+01	-0.751E+01	-0.135E+02	-0.102E+02	-0.667E+01
23	0.0610	0.807E+01	-0.857E+01	-0.206E+01	-0.741E+01	-0.156E+02	-0.102E+02	-0.727E+01
22	0.0533	0.128E+02	-0.137E+02	-0.271E+01	-0.790E+01	-0.185E+02	-0.110E+02	-0.849E+01
21	0.0457	0.218E+02	-0.208E+02	-0.173E+01	-0.865E+01	-0.212E+02	-0.131E+02	-0.108E+02
20	0.0381	0.240E+02	-0.348E+02	-0.599E+00	-0.105E+02	-0.249E+02	-0.144E+02	-0.112E+02
19	0.0305	0.220E+02	-0.568E+02	0.835E+00	-0.125E+02	-0.311E+02	-0.168E+02	-0.141E+02
18	0.0229	0.249E+02	0.000E+00	0.607E+01	-0.178E+02	-0.411E+02	-0.183E+02	-0.184E+02
17	0.0152	0.304E+02	0.000E+00	0.179E+02	-0.225E+02	-0.518E+02	-0.248E+02	-0.297E+02
16	0.0076	0.406E+02	-0.524E+02	0.287E+02	-0.239E+02	0.000E+00	-0.957E+01	-0.565E+02
15	0.0000	0.000E+00	-0.328E+02	0.491E+02	-0.165E+02	-0.565E+02	0.756E+01	-0.315E+02
14	-0.0076	0.000E+00	-0.221E+02	0.431E+02	-0.110E+02	-0.165E+02		
13	-0.0152	0.000E+00	-0.169E+02	0.326E+02	0.391E+01	-0.340E+01		
12	-0.0229	0.373E+02	-0.129E+02	0.269E+02	0.712E+01	-0.906E+00		
11	-0.0305	0.289E+02	-0.652E+01	0.176E+02	0.431E+01	0.000E+00		
10	-0.0381	0.207E+02	-0.968E+00	0.119E+02	0.550E+01	0.391E+00		
9	-0.0457	0.158E+02	0.335E+01	0.717E+01	0.582E+01	0.306E+00	0.355E+01	0.383E+01
8	-0.0533	0.135E+02	0.549E+01	0.428E+01	0.521E+01	0.251E+00		
7	-0.0610	0.123E+02	0.586E+01	0.227E+01	0.479E+01	0.213E+00		
6	-0.0686	0.111E+02	0.543E+01	0.129E+01	0.394E+01	0.178E+00		
5	-0.0762	0.973E+01	0.547E+01	0.560E+00	0.244E+01	0.000E+00		
4	-0.0838	0.833E+01	0.531E+01	0.125E+00	0.160E+01	-0.136E+00		
3	-0.0914	0.668E+01	0.474E+01	-0.348E+00	0.103E+01	-0.532E+00	-0.178E+01	0.109E+01
2	-0.0991	0.458E+01	0.395E+01	-0.461E+00	0.640E+00	-0.140E+01		
1	-0.1067	0.183E+01	0.157E+01	-0.127E+00	0.704E+00	-0.109E+01		

(b) Pitch Angle

TABLE VI (Continued)

	I =	1	2	3	4	5	6	7
	X =	0.0278	0.0833	0.1389	0.1944	0.2500	0.3056	0.4167
J	Y							
27	0.4000	0.108E+01	0.158E+01	0.162E+01	0.136E+01	0.154E+01	0.469E+00	0.135E+01
26	0.3667	0.131E+01	0.158E+01	0.125E+01	0.114E+01	0.116E+01	0.864E+00	0.102E+01
25	0.3333	0.138E+01	0.148E+01	0.832E+00	0.938E+00	0.802E+00	0.537E+00	0.674E+00
24	0.3000	0.132E+01	0.111E+01	0.434E+00	0.749E+00	0.454E+00	0.290E+00	0.371E+00
23	0.2667	0.120E+01	0.733E+00	0.200E+00	0.618E+00	0.229E+00	0.139E+00	0.174E+00
22	0.2333	0.119E+01	0.407E+00	0.201E+00	0.569E+00	0.887E-01	0.103E+00	0.117E+00
21	0.2000	0.128E+01	0.268E+00	0.333E+00	0.559E+00	0.851E-01	0.171E+00	0.138E+00
20	0.1667	0.156E+01	0.170E+00	0.557E+00	0.507E+00	0.148E+00	0.225E+00	0.211E+00
19	0.1333	0.175E+01	0.166E+00	0.707E+00	0.532E+00	0.230E+00	0.308E+00	0.316E+00
18	0.1000	0.162E+01	0.238E+00	0.831E+00	0.512E+00	0.358E+00	0.469E+00	0.385E+00
17	0.0667	0.122E+01	0.524E+00	0.890E+00	0.539E+00	0.447E+00	0.477E+00	0.353E+00
16	0.0333	0.710E+00	0.510E+00	0.904E+00	0.529E+00	0.628E+00	0.533E+00	0.199E+00
15	0.0000	0.256E+00	0.718E+00	0.545E+00	0.494E+00	0.377E+00	0.524E+00	0.219E+00
14	-0.0333	0.141E+00	0.850E+00	0.620E+00	0.424E+00	0.588E+00		
13	-0.0667	-0.163E+00	0.832E+00	0.647E+00	0.597E+00	0.705E+00		
12	-0.1000	-0.334E+00	0.758E+00	0.594E+00	0.508E+00	0.689E+00		
11	-0.1333	-0.448E+00	0.618E+00	0.516E+00	0.379E+00	0.586E+00		
10	-0.1667	-0.527E+00	0.392E+00	0.419E+00	0.214E+00	0.495E+00		
9	-0.2000	-0.485E+00	0.153E+00	0.393E+00	0.806E-05	0.433E+00	0.410E+00	0.419E+00
8	-0.2333	-0.502E+00	0.671E-01	0.386E+00	-0.106E+00	0.478E+00		
7	-0.2667	-0.556E+00	0.253E+00	0.479E+00	-0.104E+00	0.559E+00		
6	-0.3000	-0.774E+00	0.398E+00	0.591E+00	0.138E+00	0.694E+00		
5	-0.3333	-0.935E+00	0.367E+00	0.734E+00	0.641E+00	0.940E+00		
4	-0.3667	-0.734E+00	0.205E+00	0.913E+00	0.111E+01	0.121E+01		
3	-0.4000	-0.353E+00	0.279E+00	0.112E+01	0.150E+01	0.145E+01	0.923E+00	0.157E+01
2	-0.4333	0.152E-04	0.359E+00	0.124E+01	0.178E+01	0.163E+01		
1	-0.4667	0.164E+00	0.347E+00	0.122E+01	0.187E+01	0.166E+01		

(c) u/u_{av}

TABLE VI (Continued)

J	Y \ I = / X =	1 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.279E+00	-0.277E+00	-0.166E+00	-0.456E+00	-0.601E+00	-0.511E+00	-0.250E+00
26	0.3667	0.301E+00	-0.319E+00	-0.235E+00	-0.491E+00	-0.711E+00	-0.609E+00	-0.332E+00
25	0.3333	0.341E+00	-0.386E+00	-0.281E+00	-0.471E+00	-0.810E+00	-0.625E+00	-0.388E+00
24	0.3000	0.399E+00	-0.468E+00	-0.200E+00	-0.475E+00	-0.898E+00	-0.634E+00	-0.429E+00
23	0.2667	0.435E+00	-0.531E+00	-0.125E+00	-0.433E+00	-0.944E+00	-0.598E+00	-0.438E+00
22	0.2333	0.496E+00	-0.657E+00	-0.136E+00	-0.425E+00	-0.100E+01	-0.578E+00	-0.457E+00
21	0.2000	0.713E+00	-0.779E+00	-0.724E-01	-0.419E+00	-0.995E+00	-0.584E+00	-0.500E+00
20	0.1667	0.820E+00	-0.906E+00	-0.211E-01	-0.444E+00	-0.988E+00	-0.551E+00	-0.435E+00
19	0.1333	0.787E+00	-0.105E+01	0.244E-01	-0.457E+00	-0.994E+00	-0.530E+00	-0.458E+00
18	0.1000	0.824E+00	0.000E+00	0.154E+00	-0.532E+00	-0.101E+01	-0.475E+00	-0.463E+00
17	0.0667	0.787E+00	0.000E+00	0.376E+00	-0.523E+00	-0.989E+00	-0.441E+00	-0.476E+00
16	0.0333	0.666E+00	-0.763E+00	0.515E+00	-0.398E+00	0.000E+00	-0.111E+00	-0.404E+00
15	0.0000	0.000E+00	-0.622E+00	0.629E+00	-0.174E+00	-0.569E+00	0.700E-01	-0.135E+00
14	-0.0333	0.000E+00	-0.537E+00	0.717E+00	-0.829E-01	-0.201E+00		
13	-0.0667	0.000E+00	-0.460E+00	0.759E+00	0.504E-01	-0.713E-01		
12	-0.1000	0.120E+01	-0.382E+00	0.805E+00	0.135E+00	-0.258E-01		
11	-0.1333	0.143E+01	-0.217E+00	0.633E+00	0.118E+00	0.000E+00		
10	-0.1667	0.143E+01	-0.382E-01	0.509E+00	0.197E+00	0.167E-01		
9	-0.2000	0.131E+01	0.171E+00	0.355E+00	0.259E+00	0.148E-01	0.188E+00	0.207E+00
8	-0.2333	0.124E+01	0.370E+00	0.237E+00	0.277E+00	0.134E-01		
7	-0.2667	0.115E+01	0.495E+00	0.136E+00	0.293E+00	0.124E-01		
6	-0.3000	0.107E+01	0.530E+00	0.851E-01	0.272E+00	0.113E-01		
5	-0.3333	0.932E+00	0.545E+00	0.401E-01	0.185E+00	0.000E+00		
4	-0.3667	0.772E+00	0.520E+00	0.955E-02	0.128E+00	-0.993E-02		
3	-0.4000	0.593E+00	0.443E+00	-0.278E-01	0.848E-01	-0.394E-01	-0.127E+00	0.730E-01
2	-0.4333	0.383E+00	0.355E+00	-0.370E-01	0.521E-01	-0.102E+00		
1	-0.4667	0.143E+00	0.137E+00	-0.966E-02	0.545E-01	-0.750E-01		

(d) v/u_{av}

TABLE VI (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	-0.467E+01	-0.482E+01	-0.441E+01	-0.408E+01	-0.405E+01	-0.412E+01	-0.373E+01
26	0.3667	-0.460E+01	-0.482E+01	-0.465E+01	-0.399E+01	-0.406E+01	-0.403E+01	-0.382E+01
25	0.3333	-0.429E+01	-0.456E+01	-0.458E+01	-0.376E+01	-0.394E+01	-0.382E+01	-0.378E+01
24	0.3000	-0.368E+01	-0.410E+01	-0.413E+01	-0.352E+01	-0.370E+01	-0.352E+01	-0.365E+01
23	0.2667	-0.282E+01	-0.345E+01	-0.347E+01	-0.327E+01	-0.336E+01	-0.332E+01	-0.343E+01
22	0.2333	-0.183E+01	-0.266E+01	-0.287E+01	-0.301E+01	-0.299E+01	-0.296E+01	-0.306E+01
21	0.2000	-0.124E+01	-0.203E+01	-0.237E+01	-0.270E+01	-0.257E+01	-0.251E+01	-0.263E+01
20	0.1667	-0.975E+00	-0.129E+01	-0.194E+01	-0.235E+01	-0.212E+01	-0.214E+01	-0.219E+01
19	0.1333	-0.854E+00	-0.668E+00	-0.152E+01	-0.198E+01	-0.163E+01	-0.173E+01	-0.179E+01
18	0.1000	-0.720E+00	-0.284E+00	-0.119E+01	-0.157E+01	-0.110E+01	-0.136E+01	-0.134E+01
17	0.0667	-0.545E+00	-0.183E-01	-0.746E+00	-0.114E+01	-0.638E+00	-0.826E+00	-0.757E+00
16	0.0333	-0.316E+00	0.294E+00	-0.259E+00	-0.727E+00	-0.378E+00	-0.388E+00	-0.179E+00
15	0.0000	-0.544E-01	0.647E+00	0.190E-01	-0.321E+00	0.000E+00	0.551E-01	0.269E-01
14	-0.0333	0.430E+00	0.101E+01	0.450E+00	-0.371E-01	0.340E+00		
13	-0.0667	0.767E+00	0.127E+01	0.996E+00	0.434E+00	0.970E+00		
12	-0.1000	0.155E+01	0.149E+01	0.147E+01	0.955E+00	0.148E+01		
11	-0.1333	0.254E+01	0.179E+01	0.193E+01	0.152E+01	0.201E+01		
10	-0.1667	0.375E+01	0.222E+01	0.237E+01	0.203E+01	0.239E+01		
9	-0.2000	0.462E+01	0.292E+01	0.280E+01	0.254E+01	0.273E+01	0.299E+01	0.306E+01
8	-0.2333	0.512E+01	0.384E+01	0.315E+01	0.303E+01	0.302E+01		
7	-0.2667	0.529E+01	0.482E+01	0.341E+01	0.350E+01	0.327E+01		
6	-0.3000	0.537E+01	0.556E+01	0.373E+01	0.395E+01	0.357E+01		
5	-0.3333	0.536E+01	0.568E+01	0.404E+01	0.429E+01	0.383E+01		
4	-0.3667	0.522E+01	0.560E+01	0.430E+01	0.445E+01	0.400E+01		
3	-0.4000	0.505E+01	0.533E+01	0.444E+01	0.445E+01	0.399E+01	0.397E+01	0.351E+01
2	-0.4333	0.478E+01	0.513E+01	0.443E+01	0.430E+01	0.383E+01		
1	-0.4667	0.446E+01	0.497E+01	0.420E+01	0.402E+01	0.356E+01		

(e) w/u_{av}

TABLE VII

VELOCITY DATA FOR CASE 6

J	Y	I = 1 X = 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	0.276E+03	0.275E+03	0.274E+03	0.279E+03	0.281E+03	0.282E+03	0.282E+03
26	0.0838	0.278E+03	0.272E+03	0.269E+03	0.276E+03	0.277E+03	0.279E+03	0.278E+03
25	0.0762	0.279E+03	0.268E+03	0.266E+03	0.274E+03	0.273E+03	0.276E+03	0.274E+03
24	0.0686	0.278E+03	0.263E+03	0.263E+03	0.273E+03	0.270E+03	0.273E+03	0.270E+03
23	0.0610	0.278E+03	0.260E+03	0.262E+03	0.272E+03	0.268E+03	0.272E+03	0.268E+03
22	0.0533	0.280E+03	0.260E+03	0.265E+03	0.272E+03	0.266E+03	0.272E+03	0.268E+03
21	0.0457	0.288E+03	0.262E+03	0.272E+03	0.274E+03	0.267E+03	0.272E+03	0.268E+03
20	0.0381	0.307E+03	0.268E+03	0.285E+03	0.276E+03	0.270E+03	0.275E+03	0.268E+03
19	0.0305	0.326E+03	0.284E+03	0.297E+03	0.281E+03	0.276E+03	0.277E+03	0.269E+03
18	0.0229	0.337E+03	0.310E+03	0.308E+03	0.290E+03	0.287E+03	0.281E+03	0.271E+03
17	0.0152	0.342E+03	0.337E+03	0.320E+03	0.303E+03	0.303E+03	0.288E+03	0.278E+03
16	0.0076	0.344E+03	0.358E+03	0.333E+03	0.318E+03	0.324E+03	0.298E+03	0.280E+03
15	0.0000	0.345E+03	0.120E+02	0.350E+03	0.337E+03	0.200E+01	0.320E+03	0.400E+02
14	-0.0076	0.350E+03	0.220E+02	0.900E+01	0.800E+00	0.370E+02		
13	-0.0152	0.358E+03	0.300E+02	0.362E+02	0.300E+02	0.550E+02		
12	-0.0229	0.460E+02	0.400E+02	0.567E+02	0.500E+02	0.680E+02		
11	-0.0305	0.840E+02	0.520E+02	0.700E+02	0.680E+02	0.770E+02		
10	-0.0381	0.980E+02	0.680E+02	0.780E+02	0.820E+02	0.827E+02		
9	-0.0457	0.987E+02	0.810E+02	0.820E+02	0.890E+02	0.850E+02	0.890E+02	0.860E+02
8	-0.0533	0.962E+02	0.865E+02	0.850E+02	0.920E+02	0.874E+02		
7	-0.0610	0.940E+02	0.872E+02	0.858E+02	0.925E+02	0.880E+02		
6	-0.0686	0.902E+02	0.857E+02	0.847E+02	0.908E+02	0.877E+02		
5	-0.0762	0.889E+02	0.820E+02	0.828E+02	0.880E+02	0.860E+02		
4	-0.0838	0.900E+02	0.790E+02	0.801E+02	0.840E+02	0.830E+02		
3	-0.0914	0.925E+02	0.785E+02	0.773E+02	0.795E+02	0.800E+02	0.784E+02	0.743E+02
2	-0.0991	0.920E+02	0.825E+02	0.740E+02	0.740E+02	0.774E+02		
1	-0.1067	0.893E+02	0.830E+02	0.721E+02	0.688E+02	0.760E+02		

(a) Yaw Angle

TABLE VII (Continued)

J	I =	1	2	3	4	5	6	7
	X =	0.0063	0.0190	0.0318	0.0444	0.0572	0.0698	0.0952
	Y							
27	0.0914	-0.137E+01	-0.569E+01	-0.774E+01	-0.472E+01	-0.754E+01	-0.701E+01	-0.455E+01
26	0.0838	-0.234E+01	-0.730E+01	-0.840E+01	-0.550E+01	-0.874E+01	-0.812E+01	-0.545E+01
25	0.0762	-0.276E+01	-0.917E+01	-0.848E+01	-0.649E+01	-0.102E+02	-0.927E+01	-0.599E+01
24	0.0686	-0.162E+00	-0.119E+02	-0.809E+01	-0.761E+01	-0.110E+02	-0.990E+01	-0.647E+01
23	0.0610	0.143E+01	-0.151E+02	-0.755E+01	-0.853E+01	-0.127E+02	-0.927E+01	-0.641E+01
22	0.0533	0.260E+01	-0.198E+02	-0.661E+01	-0.979E+01	-0.143E+02	-0.976E+01	-0.727E+01
21	0.0457	0.573E+01	-0.267E+02	-0.517E+01	-0.109E+02	-0.184E+02	-0.109E+02	-0.663E+01
20	0.0381	0.989E+01	-0.424E+02	-0.114E+01	-0.135E+02	-0.212E+02	-0.115E+02	-0.692E+01
19	0.0305	0.736E+01	-0.552E+02	0.000E+00	-0.165E+02	-0.296E+02	-0.128E+02	-0.883E+01
18	0.0229	0.653E+01	0.000E+00	0.184E+01	-0.137E+02	-0.401E+02	-0.121E+02	-0.539E+01
17	0.0152	0.588E+01	-0.454E+02	0.269E+01	-0.218E+02	-0.465E+02	-0.155E+02	-0.218E+01
16	0.0076	0.456E+01	-0.346E+02	0.756E+01	-0.269E+02	-0.565E+02	-0.110E+02	-0.316E+02
15	0.0000	0.491E+01	-0.213E+02	0.389E+02	-0.510E+02	-0.315E+02	-0.316E+02	0.000E+00
14	-0.0076	0.548E+01	-0.165E+02	0.520E+02	-0.315E+02	0.510E+01		
13	-0.0152	0.125E+02	-0.150E+02	0.382E+02	0.607E+01	0.442E+01		
12	-0.0229	0.478E+02	-0.124E+02	0.320E+02	0.269E+01	0.328E+01		
11	-0.0305	0.418E+02	-0.107E+02	0.248E+02	0.607E+01	0.259E+01		
10	-0.0381	0.257E+02	-0.605E+01	0.153E+02	0.665E+01	0.194E+01		
9	-0.0457	0.118E+02	-0.484E+00	0.111E+02	0.578E+01	0.179E+01	0.560E+01	0.505E+01
8	-0.0533	0.752E+01	0.112E+01	0.532E+01	0.480E+01	0.123E+01		
7	-0.0610	0.589E+01	0.297E+01	0.387E+01	0.446E+01	0.803E+00		
6	-0.0686	0.512E+01	0.384E+01	0.218E+01	0.426E+01	0.219E+00		
5	-0.0762	0.486E+01	0.404E+01	0.814E+00	0.345E+01	0.179E+00		
4	-0.0838	0.466E+01	0.351E+01	-0.619E-01	0.261E+01	0.744E-01		
3	-0.0914	0.457E+01	0.295E+01	-0.415E+00	0.184E+01	-0.646E-01	0.126E+01	0.103E+01
2	-0.0991	0.336E+01	0.172E+01	-0.507E+00	0.111E+01	-0.563E+00		
1	-0.1067	0.110E+01	0.113E+01	-0.462E-01	0.639E+00	-0.538E+00		

(b) Pitch Angle

TABLE VII (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.861E+00	0.700E+00	0.459E+00	0.115E+01	0.125E+01	0.130E+01	0.122E+01
26	0.3667	0.108E+01	0.239E+00	-0.116E+00	0.689E+00	0.770E+00	0.892E+00	0.778E+00
25	0.3333	0.107E+01	-0.209E+00	-0.439E+00	0.418E+00	0.313E+00	0.549E+00	0.330E+00
24	0.3000	0.855E+00	-0.584E+00	-0.560E+00	0.269E+00	0.181E-01	0.295E+00	0.345E-01
23	0.2667	0.676E+00	-0.639E+00	-0.494E+00	0.154E+00	-0.162E+00	0.165E+00	-0.136E+00
22	0.2333	0.592E+00	-0.513E+00	-0.221E+00	0.130E+00	-0.240E+00	0.139E+00	-0.165E+00
21	0.2000	0.761E+00	-0.285E+00	0.712E-01	0.213E+00	-0.143E+00	0.139E+00	-0.139E+00
20	0.1667	0.103E+01	-0.408E-01	0.435E+00	0.260E+00	-0.961E-05	0.230E+00	-0.119E+00
19	0.1333	0.150E+01	0.171E+00	0.628E+00	0.339E+00	0.137E+00	0.275E+00	-0.420E-01
18	0.1000	0.195E+01	0.501E+00	0.771E+00	0.464E+00	0.228E+00	0.325E+00	0.320E-01
17	0.0667	0.222E+01	0.646E+00	0.785E+00	0.507E+00	0.298E+00	0.347E+00	0.166E+00
16	0.0333	0.222E+01	0.957E+00	0.752E+00	0.472E+00	0.245E+00	0.319E+00	0.432E-01
15	0.0000	0.202E+01	0.125E+01	0.529E+00	0.292E+00	0.250E+00	0.191E+00	0.317E+00
14	-0.0333	0.182E+01	0.143E+01	0.427E+00	0.251E+00	0.580E+00		
13	-0.0667	0.113E+01	0.136E+01	0.655E+00	0.579E+00	0.636E+00		
12	-0.1000	0.391E+00	0.120E+01	0.652E+00	0.661E+00	0.596E+00		
11	-0.1333	0.906E-01	0.100E+01	0.576E+00	0.501E+00	0.469E+00		
10	-0.1667	-0.242E+00	0.698E+00	0.496E+00	0.267E+00	0.345E+00		
9	-0.2000	-0.423E+00	0.395E+00	0.431E+00	0.464E-01	0.293E+00	0.603E-01	0.277E+00
8	-0.2333	-0.426E+00	0.221E+00	0.346E+00	-0.123E+00	0.185E+00		
7	-0.2667	-0.367E+00	0.241E+00	0.350E+00	-0.203E+00	0.164E+00		
6	-0.3000	-0.232E-01	0.474E+00	0.518E+00	-0.786E-01	0.211E+00		
5	-0.3333	0.158E+00	0.108E+01	0.795E+00	0.229E+00	0.406E+00		
4	-0.3667	0.296E-04	0.173E+01	0.121E+01	0.757E+00	0.781E+00		
3	-0.4000	-0.423E+00	0.194E+01	0.170E+01	0.141E+01	0.120E+01	0.133E+01	0.158E+01
2	-0.4333	-0.367E+00	0.136E+01	0.226E+01	0.221E+01	0.153E+01		
1	-0.4667	0.126E+00	0.126E+01	0.251E+01	0.283E+01	0.164E+01		

(c) u/u_{av}

TABLE VII (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	-0.198E+00	-0.800E+00	-0.102E+01	-0.586E+00	-0.884E+00	-0.765E+00	-0.467E+00
26	0.3667	-0.314E+00	-0.877E+00	-0.978E+00	-0.624E+00	-0.971E+00	-0.841E+00	-0.540E+00
25	0.3333	-0.337E+00	-0.920E+00	-0.834E+00	-0.665E+00	-0.104E+01	-0.887E+00	-0.568E+00
24	0.3000	-0.173E-01	-0.985E+00	-0.653E+00	-0.687E+00	-0.101E+01	-0.868E+00	-0.561E+00
23	0.2667	0.123E+00	-0.100E+01	-0.483E+00	-0.663E+00	-0.100E+01	-0.736E+00	-0.516E+00
22	0.2333	0.163E+00	-0.103E+01	-0.320E+00	-0.643E+00	-0.921E+00	-0.684E+00	-0.524E+00
21	0.2000	0.247E+00	-0.103E+01	-0.185E+00	-0.589E+00	-0.908E+00	-0.666E+00	-0.422E+00
20	0.1667	0.298E+00	-0.107E+01	-0.330E-01	-0.571E+00	-0.785E+00	-0.574E+00	-0.376E+00
19	0.1333	0.233E+00	-0.102E+01	0.000E+00	-0.526E+00	-0.746E+00	-0.512E+00	-0.373E+00
18	0.1000	0.243E+00	0.000E+00	0.402E-01	-0.332E+00	-0.655E+00	-0.367E+00	-0.173E+00
17	0.0667	0.241E+00	-0.711E+00	0.481E-01	-0.372E+00	-0.578E+00	-0.312E+00	-0.456E-01
16	0.0333	0.184E+00	-0.661E+00	0.112E+00	-0.323E+00	-0.457E+00	-0.133E+00	-0.153E+00
15	0.0000	0.180E+00	-0.501E+00	0.433E+00	-0.391E+00	-0.153E+00	-0.153E+00	0.000E+00
14	-0.0333	0.177E+00	-0.456E+00	0.553E+00	-0.154E+00	0.649E-01		
13	-0.0667	0.250E+00	-0.422E+00	0.638E+00	0.712E-01	0.857E-01		
12	-0.1000	0.620E+00	-0.343E+00	0.741E+00	0.482E-01	0.913E-01		
11	-0.1333	0.776E+00	-0.308E+00	0.780E+00	0.142E+00	0.943E-01		
10	-0.1667	0.839E+00	-0.197E+00	0.652E+00	0.223E+00	0.920E-01		
9	-0.2000	0.586E+00	-0.213E-01	0.609E+00	0.269E+00	0.105E+00	0.339E+00	0.352E+00
8	-0.2333	0.521E+00	0.708E-01	0.370E+00	0.297E+00	0.874E-01		
7	-0.2667	0.543E+00	0.256E+00	0.323E+00	0.362E+00	0.660E-01		
6	-0.3000	0.597E+00	0.424E+00	0.214E+00	0.419E+00	0.201E-01		
5	-0.3333	0.701E+00	0.548E+00	0.901E-01	0.395E+00	0.182E-01		
4	-0.3667	0.761E+00	0.557E+00	-0.762E-02	0.330E+00	0.831E-02		
3	-0.4000	0.776E+00	0.501E+00	-0.559E-01	0.249E+00	-0.777E-02	0.145E+00	0.105E+00
2	-0.4333	0.617E+00	0.313E+00	-0.726E-01	0.155E+00	-0.691E-01		
1	-0.4667	0.198E+00	0.203E+00	-0.658E-02	0.874E-01	-0.636E-01		

(d) v/u_{av}

TABLE VII (Continued)

J	I = / X = / Y	1 / 0.0278	2 / 0.0833	3 / 0.1389	4 / 0.1944	5 / 0.2500	6 / 0.3056	7 / 0.4167
27	0.4000	-0.819E+01	-0.800E+01	-0.750E+01	-0.700E+01	-0.656E+01	-0.608E+01	-0.574E+01
26	0.3667	-0.761E+01	-0.684E+01	-0.662E+01	-0.645E+01	-0.627E+01	-0.583E+01	-0.561E+01
25	0.3333	-0.691E+01	-0.569E+01	-0.557E+01	-0.583E+01	-0.579E+01	-0.540E+01	-0.540E+01
24	0.3000	-0.608E+01	-0.462E+01	-0.456E+01	-0.514E+01	-0.519E+01	-0.497E+01	-0.495E+01
23	0.2667	-0.487E+01	-0.366E+01	-0.361E+01	-0.441E+01	-0.442E+01	-0.451E+01	-0.459E+01
22	0.2333	-0.354E+01	-0.282E+01	-0.275E+01	-0.372E+01	-0.361E+01	-0.398E+01	-0.410E+01
21	0.2000	-0.234E+01	-0.203E+01	-0.204E+01	-0.304E+01	-0.273E+01	-0.346E+01	-0.363E+01
20	0.1667	-0.136E+01	-0.117E+01	-0.160E+01	-0.235E+01	-0.202E+01	-0.280E+01	-0.309E+01
19	0.1333	-0.101E+01	-0.686E+00	-0.123E+01	-0.175E+01	-0.131E+01	-0.224E+01	-0.240E+01
18	0.1000	-0.835E+00	-0.597E+00	-0.987E+00	-0.128E+01	-0.744E+00	-0.167E+01	-0.183E+01
17	0.0667	-0.721E+00	-0.274E+00	-0.658E+00	-0.780E+00	-0.459E+00	-0.107E+01	-0.118E+01
16	0.0333	-0.636E+00	-0.334E-01	-0.383E+00	-0.425E+00	-0.178E+00	-0.601E+00	-0.245E+00
15	0.0000	-0.541E+00	0.267E+00	-0.933E-01	-0.124E+00	0.873E-02	-0.160E+00	0.266E+00
14	-0.0333	-0.321E+00	0.578E+00	0.676E-01	0.351E-02	0.437E+00		
13	-0.0667	-0.393E-01	0.787E+00	0.479E+00	0.335E+00	0.908E+00		
12	-0.1000	0.405E+00	0.101E+01	0.992E+00	0.788E+00	0.148E+01		
11	-0.1333	0.862E+00	0.128E+01	0.158E+01	0.124E+01	0.203E+01		
10	-0.1667	0.172E+01	0.173E+01	0.233E+01	0.190E+01	0.269E+01		
9	-0.2000	0.277E+01	0.249E+01	0.307E+01	0.266E+01	0.334E+01	0.345E+01	0.397E+01
8	-0.2333	0.392E+01	0.361E+01	0.395E+01	0.354E+01	0.408E+01		
7	-0.2667	0.525E+01	0.493E+01	0.476E+01	0.464E+01	0.470E+01		
6	-0.3000	0.666E+01	0.631E+01	0.558E+01	0.563E+01	0.525E+01		
5	-0.3333	0.823E+01	0.768E+01	0.629E+01	0.655E+01	0.581E+01		
4	-0.3667	0.934E+01	0.891E+01	0.694E+01	0.720E+01	0.636E+01		
3	-0.4000	0.970E+01	0.953E+01	0.754E+01	0.760E+01	0.678E+01	0.648E+01	0.561E+01
2	-0.4333	0.105E+02	0.104E+02	0.789E+01	0.769E+01	0.686E+01		
1	-0.4667	0.103E+02	0.102E+02	0.777E+01	0.730E+01	0.658E+01		

(e) w/u_{av}

TABLE VIII

VELOCITY DATA FOR CASE 7

	I =	1	2	3	4	5	6	7
	X =	0.0063	0.0190	0.0318	0.0444	0.0572	0.0698	0.0952
J	Y							
27	0.0914	0.250E+03	0.000E+00	0.895E+02	0.230E+02	0.360E+03	0.340E+02	0.360E+03
26	0.0838	0.234E+03	0.000E+00	0.895E+02	0.330E+02	0.000E+00	0.340E+02	0.360E+03
25	0.0762	0.234E+03	0.200E+00	0.895E+02	0.540E+01	0.360E+03	0.340E+02	0.360E+03
24	0.0686	0.229E+03	0.000E+00	0.395E+02	0.350E+01	0.360E+03	0.260E+02	0.360E+03
23	0.0610	0.210E+03	0.000E+00	0.400E+01	0.350E+01	0.360E+03	0.260E+02	0.000E+00
22	0.0533	0.204E+03	0.000E+00	0.400E+01	0.140E+01	0.360E+03	0.800E+01	0.360E+03
21	0.0457	0.100E+02	0.000E+00	0.100E+01	0.140E+01	0.360E+03	0.800E+01	0.360E+03
20	0.0381	0.400E+01	0.200E+00	0.100E+01	0.360E+03	0.360E+03	0.800E+01	0.360E+03
19	0.0305	0.400E+01	0.200E+00	0.100E+01	0.360E+03	0.360E+03	0.800E+01	0.360E+03
18	0.0229	0.200E+01	0.360E+03	0.100E+01	0.360E+03	0.360E+03	0.360E+03	0.360E+03
17	0.0152	0.200E+00	0.360E+03	0.360E+03	0.360E+03	0.360E+03	0.360E+03	0.360E+03
16	0.0076	0.100E+00	0.100E+00	0.360E+03	0.360E+03	0.360E+03	0.360E+03	0.360E+03
15	0.0000	0.360E+03	0.360E+03	0.360E+03	0.360E+03	0.360E+03	0.360E+03	0.360E+03
14	-0.0076	0.000E+00	0.360E+03	0.360E+03	0.360E+03	0.360E+03		
13	-0.0152	0.000E+00	0.360E+03	0.360E+03	0.359E+03	0.360E+03		
12	-0.0229	0.000E+00	0.360E+03	0.360E+03	0.359E+03	0.360E+03		
11	-0.0305	0.100E+01	0.360E+03	0.360E+03	0.359E+03	0.360E+03		
10	-0.0381	0.200E+01	0.360E+03	0.360E+03	0.359E+03	0.360E+03		
9	-0.0457	0.000E+00	0.360E+03	0.360E+03	0.359E+03	0.360E+03	0.800E+01	0.360E+03
8	-0.0533	0.152E+03	0.170E+01	0.100E+01	0.359E+03	0.360E+03		
7	-0.0610	0.161E+03	0.000E+00	0.100E+01	0.359E+03	0.360E+03		
6	-0.0686	0.161E+03	0.100E+03	0.100E+01	0.359E+03	0.360E+03		
5	-0.0762	0.000E+00	0.138E+03	0.100E+01	0.000E+00	0.360E+03		
4	-0.0838	0.161E+03	0.138E+03	0.100E+01	0.000E+00	0.360E+03		
3	-0.0914	0.161E+03	0.138E+03	0.200E+01	0.000E+00	0.360E+03	0.800E+01	0.360E+03
2	-0.0991	0.161E+03	0.138E+03	0.110E+02	0.000E+00	0.360E+03		
1	-0.1067	0.161E+03	0.138E+03	0.110E+02	0.000E+00	0.360E+03		

(a) Yaw Angle

TABLE VIII (Continued)

J	I = / X = Y	1 0.0063	2 0.0190	3 0.0318	4 0.0444	5 0.0572	6 0.0698	7 0.0952
27	0.0914	0.000E+00	0.000E+00	-0.433E+02	-0.165E+02	0.000E+00	-0.315E+02	0.000E+00
26	0.0838	0.000E+00	0.000E+00	-0.510E+02	-0.165E+02	0.000E+00	-0.218E+02	0.000E+00
25	0.0762	-0.510E+02	0.000E+00	0.000E+00	0.000E+00	0.310E+02	-0.165E+02	0.000E+00
24	0.0686	-0.510E+02	0.000E+00	-0.707E+01	0.351E+01	0.161E+02	-0.132E+02	0.000E+00
23	0.0610	-0.510E+02	0.000E+00	-0.287E+01	0.474E+01	0.756E+01	-0.527E+01	0.000E+00
22	0.0533	-0.315E+02	0.000E+00	0.318E+01	0.280E+01	0.116E+02	0.000E+00	0.000E+00
21	0.0457	0.000E+00	0.000E+00	0.463E+01	0.420E+01	0.102E+02	0.000E+00	0.000E+00
20	0.0381	0.000E+00	0.607E+01	0.415E+01	0.391E+01	0.756E+01	0.000E+00	0.000E+00
19	0.0305	0.867E+01	0.607E+01	0.341E+01	0.238E+01	0.511E+01	0.000E+00	0.000E+00
18	0.0229	0.339E+01	0.318E+01	0.235E+01	0.152E+01	0.366E+01	0.000E+00	0.000E+00
17	0.0152	0.512E+00	0.820E+00	-0.235E+01	-0.248E+01	0.198E+01	0.000E+00	0.000E+00
16	0.0076	-0.860E+00	-0.853E+00	0.512E+00	0.275E+00	0.558E+00	0.000E+00	0.000E+00
15	0.0000	-0.204E+01	-0.403E+01	-0.768E+00	-0.774E+00	0.000E+00	0.000E+00	0.000E+00
14	-0.0076	-0.299E+01	-0.289E+01	-0.304E+01	-0.432E+01	-0.170E+01		
13	-0.0152	-0.357E+01	-0.567E+01	-0.588E+01	-0.652E+01	-0.359E+01		
12	-0.0229	-0.581E+01	-0.758E+01	-0.805E+01	-0.773E+01	-0.494E+01		
11	-0.0305	-0.125E+02	-0.107E+02	-0.113E+02	-0.957E+01	-0.682E+01		
10	-0.0381	0.000E+00	-0.807E+01	-0.100E+02	-0.128E+02	-0.107E+02		
9	-0.0457	0.000E+00	-0.152E+02	-0.165E+02	-0.150E+02	-0.119E+02	-0.179E+02	-0.315E+02
8	-0.0533	0.000E+00	-0.315E+02	-0.315E+02	-0.197E+02	-0.116E+02		
7	-0.0610	0.000E+00	0.000E+00	-0.315E+02	0.000E+00	-0.197E+02		
6	-0.0686	0.000E+00	0.000E+00	-0.510E+02	-0.315E+02	-0.315E+02		
5	-0.0762	0.000E+00	0.000E+00	-0.315E+02	0.000E+00	-0.244E+02		
4	-0.0838	-0.315E+02	0.000E+00	0.000E+00	0.000E+00	-0.315E+02		
3	-0.0914	0.000E+00	0.000E+00	-0.315E+02	0.000E+00	-0.315E+02	-0.315E+02	0.000E+00
2	-0.0991	0.000E+00	0.000E+00	-0.315E+02	0.000E+00	0.000E+00		
1	-0.1067	0.000E+00	0.000E+00	-0.315E+02	0.000E+00	0.000E+00		

(b) Pitch Angle

TABLE VIII (Continued)

J	I = / X = / Y	1 / 0.0278	2 / 0.0833	3 / 0.1389	4 / 0.1944	5 / 0.2500	6 / 0.3056	7 / 0.4167
27	0.4000	0.000E+00	0.000E+00	0.132E+01	0.132E+01	0.109E+01	0.109E+01	0.109E+01
26	0.3667	-0.644E+00	0.000E+00	0.120E+01	0.120E+01	0.000E+00	0.142E+01	0.109E+01
25	0.3333	-0.487E+00	0.000E+00	0.218E+01	0.218E+01	0.104E+01	0.168E+01	0.109E+01
24	0.3000	-0.544E+00	0.000E+00	0.329E+01	0.329E+01	0.153E+01	0.206E+01	0.109E+01
23	0.2667	-0.718E+00	0.000E+00	0.396E+01	0.396E+01	0.221E+01	0.254E+01	0.000E+00
22	0.2333	-0.850E+00	0.000E+00	0.525E+01	0.526E+01	0.308E+01	0.324E+01	0.109E+01
21	0.2000	0.000E+00	0.000E+00	0.668E+01	0.669E+01	0.378E+01	0.342E+01	0.109E+01
20	0.1667	0.000E+00	0.247E+01	0.822E+01	0.823E+01	0.494E+01	0.389E+01	0.109E+01
19	0.1333	0.291E+01	0.494E+01	0.991E+01	0.992E+01	0.603E+01	0.389E+01	0.109E+01
18	0.1000	0.130E+02	0.917E+01	0.115E+02	0.115E+02	0.721E+01	0.450E+01	0.109E+01
17	0.0667	0.201E+02	0.141E+02	0.122E+02	0.122E+02	0.774E+01	0.475E+01	0.155E+01
16	0.0333	0.212E+02	0.187E+02	0.123E+02	0.123E+02	0.860E+01	0.463E+01	0.109E+01
15	0.0000	0.222E+02	0.215E+02	0.129E+02	0.129E+02	0.902E+01	0.488E+01	0.155E+01
14	-0.0333	0.217E+02	0.209E+02	0.105E+02	0.105E+02	0.875E+01		
13	-0.0667	0.213E+02	0.198E+02	0.866E+01	0.866E+01	0.922E+01		
12	-0.1000	0.176E+02	0.162E+02	0.710E+01	0.710E+01	0.829E+01		
11	-0.1333	0.728E+01	0.999E+01	0.552E+01	0.553E+01	0.730E+01		
10	-0.1667	0.000E+00	0.724E+01	0.435E+01	0.436E+01	0.577E+01		
9	-0.2000	0.000E+00	0.367E+01	0.337E+01	0.338E+01	0.515E+01	0.330E+01	0.929E+00
8	-0.2333	-0.968E+00	0.131E+01	0.223E+01	0.223E+01	0.462E+01		
7	-0.2667	-0.104E+01	0.000E+00	0.000E+00	0.000E+00	0.316E+01		
6	-0.3000	-0.104E+01	0.000E+00	0.928E+00	0.928E+00	0.227E+01		
5	-0.3333	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.195E+01		
4	-0.3667	-0.880E+00	0.000E+00	0.000E+00	0.000E+00	0.131E+01		
3	-0.4000	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.929E+00	0.130E+01	0.109E+01
2	-0.4333	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		
1	-0.4667	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		

(c) u/u_{av}

TABLE VIII (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.000E+00	0.000E+00	-0.423E+00	-0.423E+00	0.000E+00	-0.803E+00	0.000E+00
26	0.3667	0.000E+00	0.000E+00	-0.423E+00	-0.423E+00	0.000E+00	-0.684E+00	0.000E+00
25	0.3333	-0.102E+01	0.000E+00	0.000E+00	0.000E+00	0.624E+00	-0.597E+00	0.000E+00
24	0.3000	-0.102E+01	0.000E+00	0.202E+00	0.202E+00	0.440E+00	-0.535E+00	0.000E+00
23	0.2667	-0.102E+01	0.000E+00	0.329E+00	0.329E+00	0.293E+00	-0.260E+00	0.000E+00
22	0.2333	-0.570E+00	0.000E+00	0.257E+00	0.257E+00	0.633E+00	0.000E+00	0.000E+00
21	0.2000	0.000E+00	0.000E+00	0.491E+00	0.491E+00	0.681E+00	0.000E+00	0.000E+00
20	0.1667	0.000E+00	0.263E+00	0.562E+00	0.562E+00	0.656E+00	0.000E+00	0.000E+00
19	0.1333	0.445E+00	0.525E+00	0.412E+00	0.412E+00	0.539E+00	0.000E+00	0.000E+00
18	0.1000	0.771E+00	0.510E+00	0.304E+00	0.304E+00	0.460E+00	0.000E+00	0.000E+00
17	0.0667	0.180E+00	0.202E+00	-0.498E+00	-0.499E+00	0.267E+00	0.000E+00	0.000E+00
16	0.0333	-0.318E+00	-0.279E+00	0.591E-01	0.591E-01	0.837E-01	0.000E+00	0.000E+00
15	0.0000	-0.790E+00	-0.151E+01	-0.174E+00	-0.174E+00	0.000E+00	0.000E+00	0.000E+00
14	-0.0333	-0.113E+01	-0.105E+01	-0.791E+00	-0.791E+00	-0.260E+00		
13	-0.0667	-0.133E+01	-0.196E+01	-0.990E+00	-0.991E+00	-0.578E+00		
12	-0.1000	-0.179E+01	-0.216E+01	-0.964E+00	-0.964E+00	-0.717E+00		
11	-0.1333	-0.162E+01	-0.189E+01	-0.932E+00	-0.932E+00	-0.873E+00		
10	-0.1667	0.000E+00	-0.103E+01	-0.991E+00	-0.991E+00	-0.109E+01		
9	-0.2000	0.000E+00	-0.997E+00	-0.903E+00	-0.904E+00	-0.108E+01	-0.108E+01	-0.569E+00
8	-0.2333	0.000E+00	-0.804E+00	-0.798E+00	-0.798E+00	-0.944E+00		
7	-0.2667	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-0.113E+01		
6	-0.3000	0.000E+00	0.000E+00	-0.569E+00	-0.569E+00	-0.140E+01		
5	-0.3333	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-0.883E+00		0.000E+00
4	-0.3667	-0.570E+00	0.000E+00	0.000E+00	0.000E+00	-0.805E+00		
3	-0.4000	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-0.569E+00	-0.803E+00	0.000E+00
2	-0.4333	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		
1	-0.4667	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		

(d) v/u_{av}

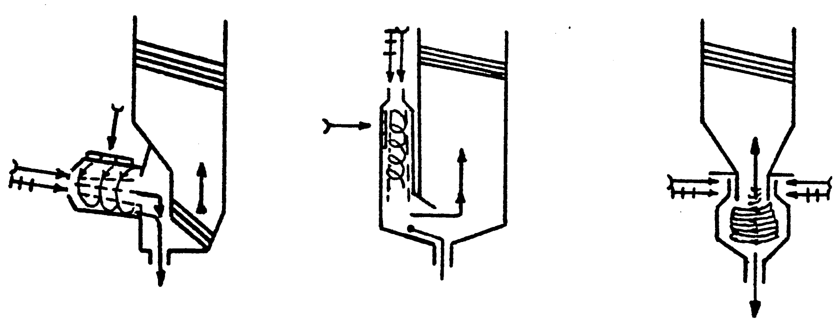
TABLE VIII (Continued)

J	Y	I = 1 X = 0.0278	2 0.0833	3 0.1389	4 0.1944	5 0.2500	6 0.3056	7 0.4167
27	0.4000	0.000E+00	0.000E+00	0.560E+00	0.560E+00	-0.659E-05	0.732E+00	-0.659E-05
26	0.3667	-0.887E+00	0.000E+00	0.780E+00	0.780E+00	0.000E+00	0.958E+00	-0.659E-05
25	0.3333	-0.671E+00	0.000E+00	0.206E+00	0.206E+00	-0.626E-05	0.113E+01	-0.659E-05
24	0.3000	-0.626E+00	0.000E+00	0.201E+00	0.201E+00	-0.921E-05	0.100E+01	-0.659E-05
23	0.2667	-0.414E+00	0.000E+00	0.242E+00	0.242E+00	-0.133E-04	0.124E+01	0.000E+00
22	0.2333	-0.378E+00	0.000E+00	0.128E+00	0.128E+00	-0.185E-04	0.455E+00	-0.659E-05
21	0.2000	0.000E+00	0.000E+00	0.163E+00	0.163E+00	-0.228E-04	0.480E+00	-0.659E-05
20	0.1667	0.000E+00	0.862E-02	-0.495E-04	-0.496E-04	-0.298E-04	0.547E+00	-0.659E-05
19	0.1333	0.204E+00	0.172E-01	-0.597E-04	-0.597E-04	-0.363E-04	0.547E+00	-0.659E-05
18	0.1000	0.454E+00	-0.553E-04	-0.690E-04	-0.691E-04	-0.434E-04	-0.271E-04	-0.659E-05
17	0.0667	0.702E-01	-0.850E-04	-0.735E-04	-0.735E-04	-0.466E-04	-0.286E-04	-0.932E-05
16	0.0333	0.371E-01	0.327E-01	-0.742E-04	-0.742E-04	-0.518E-04	-0.279E-04	-0.659E-05
15	0.0000	-0.134E-03	-0.129E-03	-0.775E-04	-0.776E-04	-0.543E-04	-0.294E-04	-0.932E-05
14	-0.0333	-0.130E-03	-0.126E-03	-0.631E-04	-0.631E-04	-0.527E-04		
13	-0.0667	0.000E+00	-0.119E-03	-0.151E+00	-0.151E+00	-0.555E-04		
12	-0.1000	0.000E+00	-0.568E-01	-0.124E+00	-0.124E+00	-0.499E-04		
11	-0.1333	0.127E+00	-0.350E-01	-0.964E-01	-0.965E-01	-0.440E-04		
10	-0.1667	0.000E+00	-0.253E-01	-0.760E-01	-0.761E-01	-0.348E-04		
9	-0.2000	0.000E+00	-0.128E-01	-0.589E-01	-0.590E-01	-0.311E-04	0.464E+00	-0.560E-05
8	-0.2333	0.515E+00	0.389E-01	-0.389E-01	-0.390E-01	-0.278E-04		
7	-0.2667	0.357E+00	0.000E+00	0.000E+00	0.000E+00	-0.190E-04		
6	-0.3000	0.357E+00	0.000E+00	-0.162E-01	-0.162E-01	-0.137E-04		
5	-0.3333	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-0.117E-04		
4	-0.3667	0.303E+00	0.000E+00	0.000E+00	0.000E+00	-0.791E-05		
3	-0.4000	0.000E+00	0.000E+00	0.000E+00	0.000E+00	-0.559E-05	0.182E+00	-0.659E-05
2	-0.4333	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		
1	-0.4667	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00		

(e) w/u_{av}

APPENDIX B

FIGURES



(a) (b) (c)

Air	Burned gases
Fuel	Liquid cinders

Figure 1. The Cyclone Furnace

(a) Horizontal (or slightly inclined by 5-20°)
(b) Vertical VTJ (USSR)
(c) Vertcal KSG

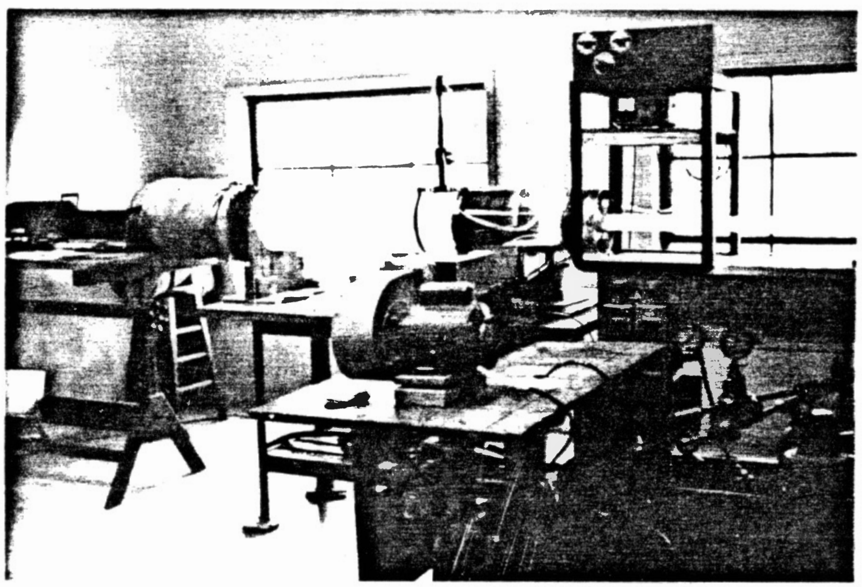


Figure 2. Photograph of the Overall Facility

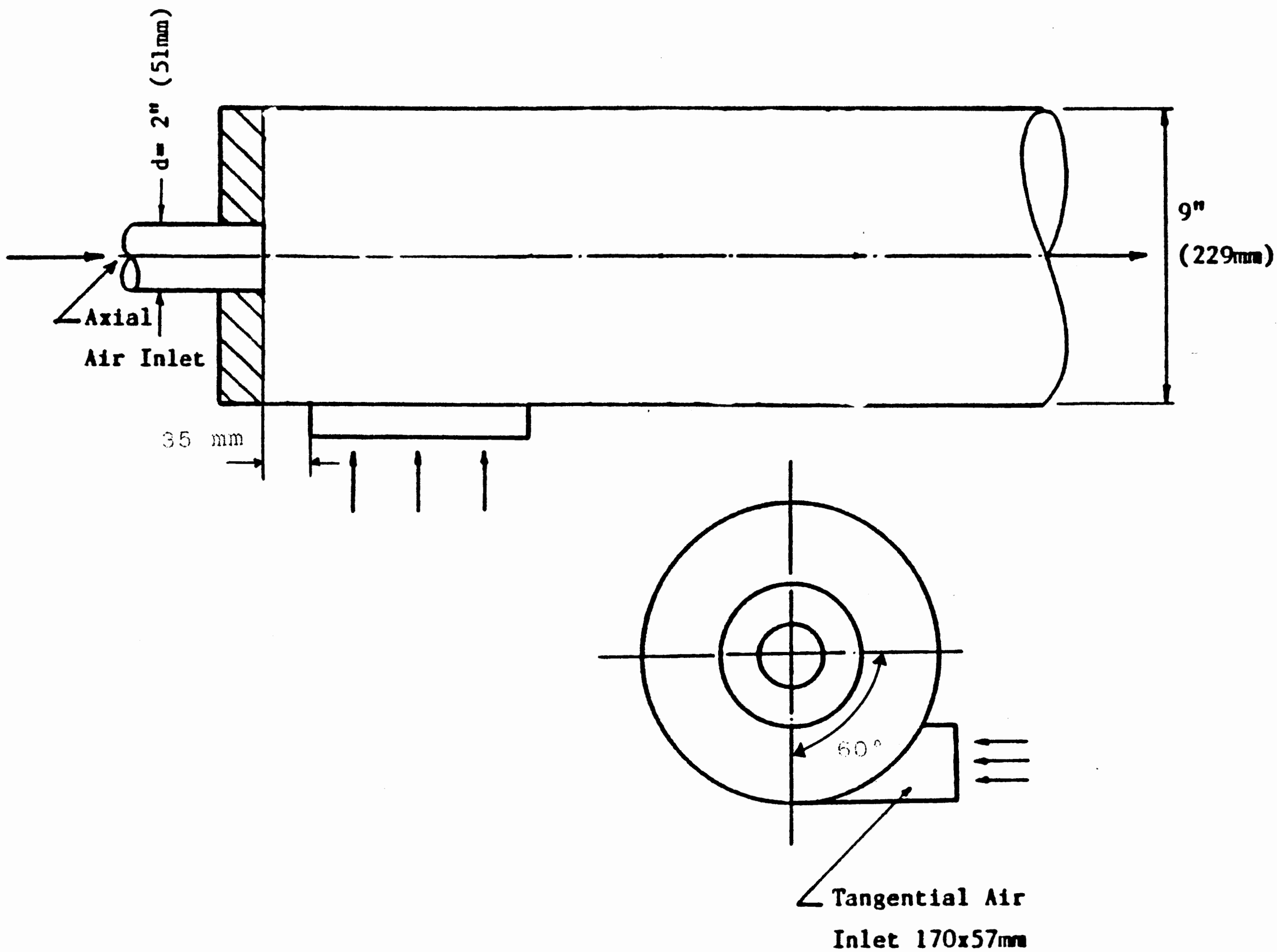
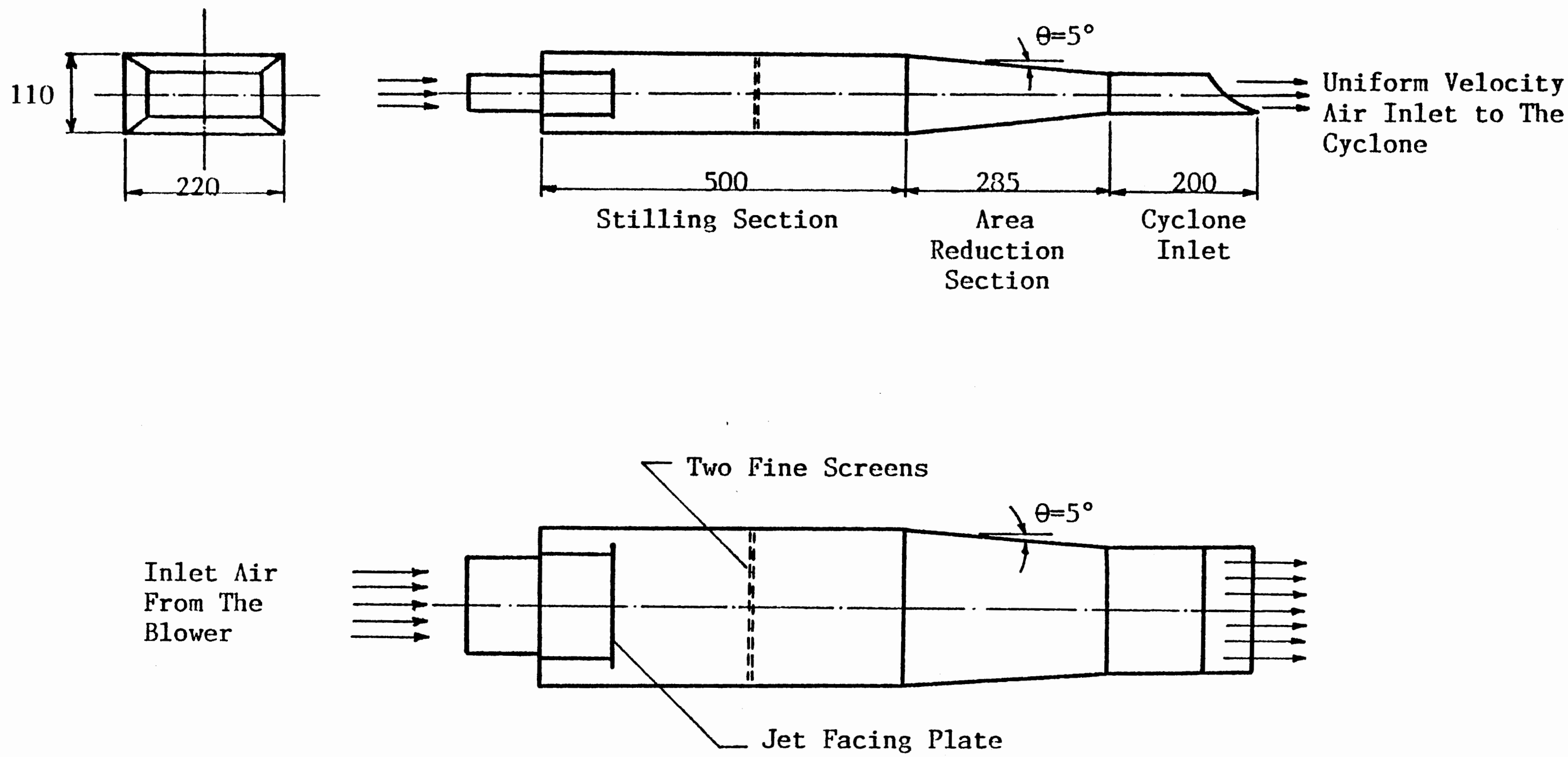


Figure 3. Geometry of strongly Swirling Flow Facility



All Dimensions in mm

Scale 1 : 10

Figure 4. Tangential Inlet Stilling Chamber

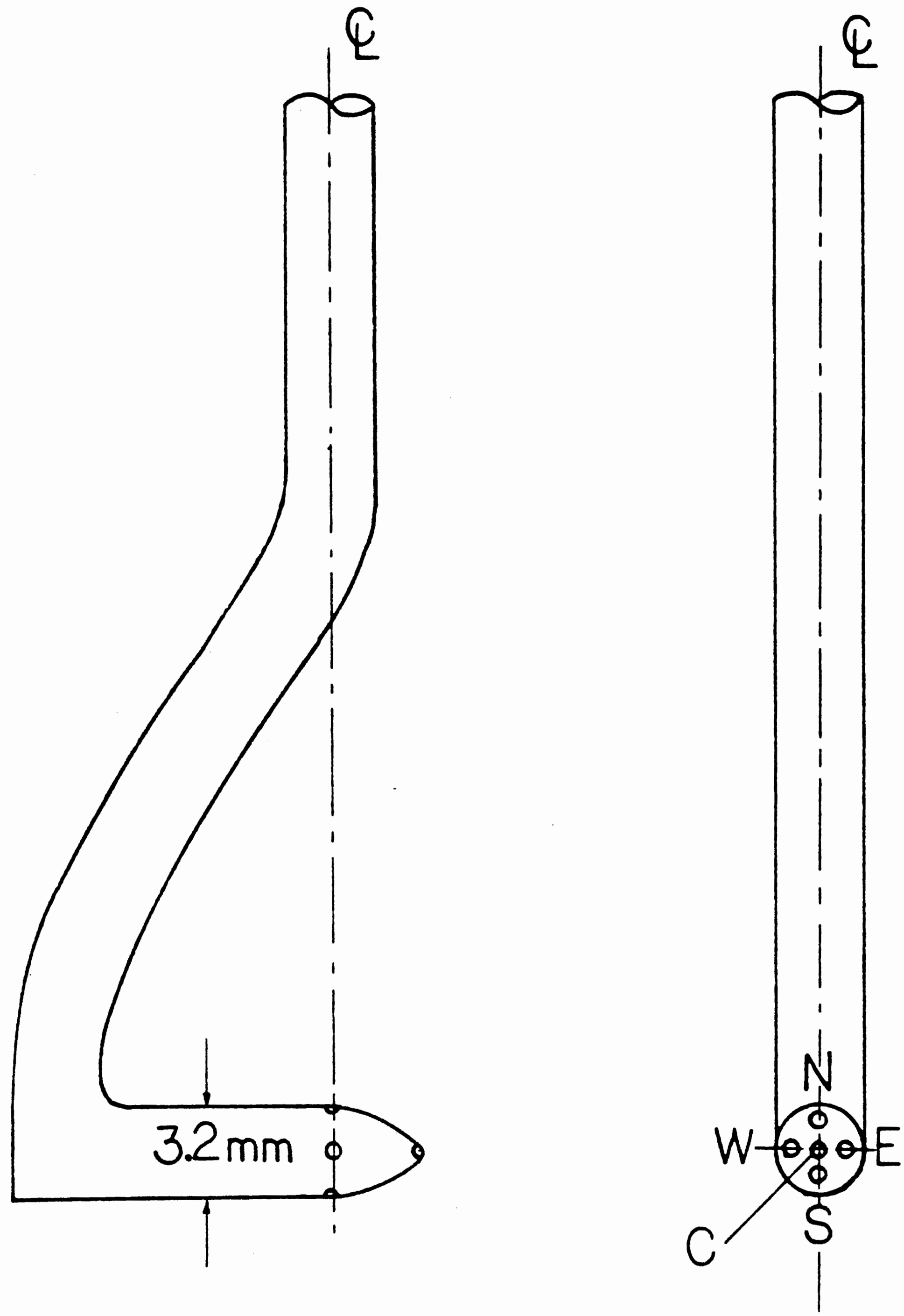


Figure 5. Five-Hole Pitot Probe

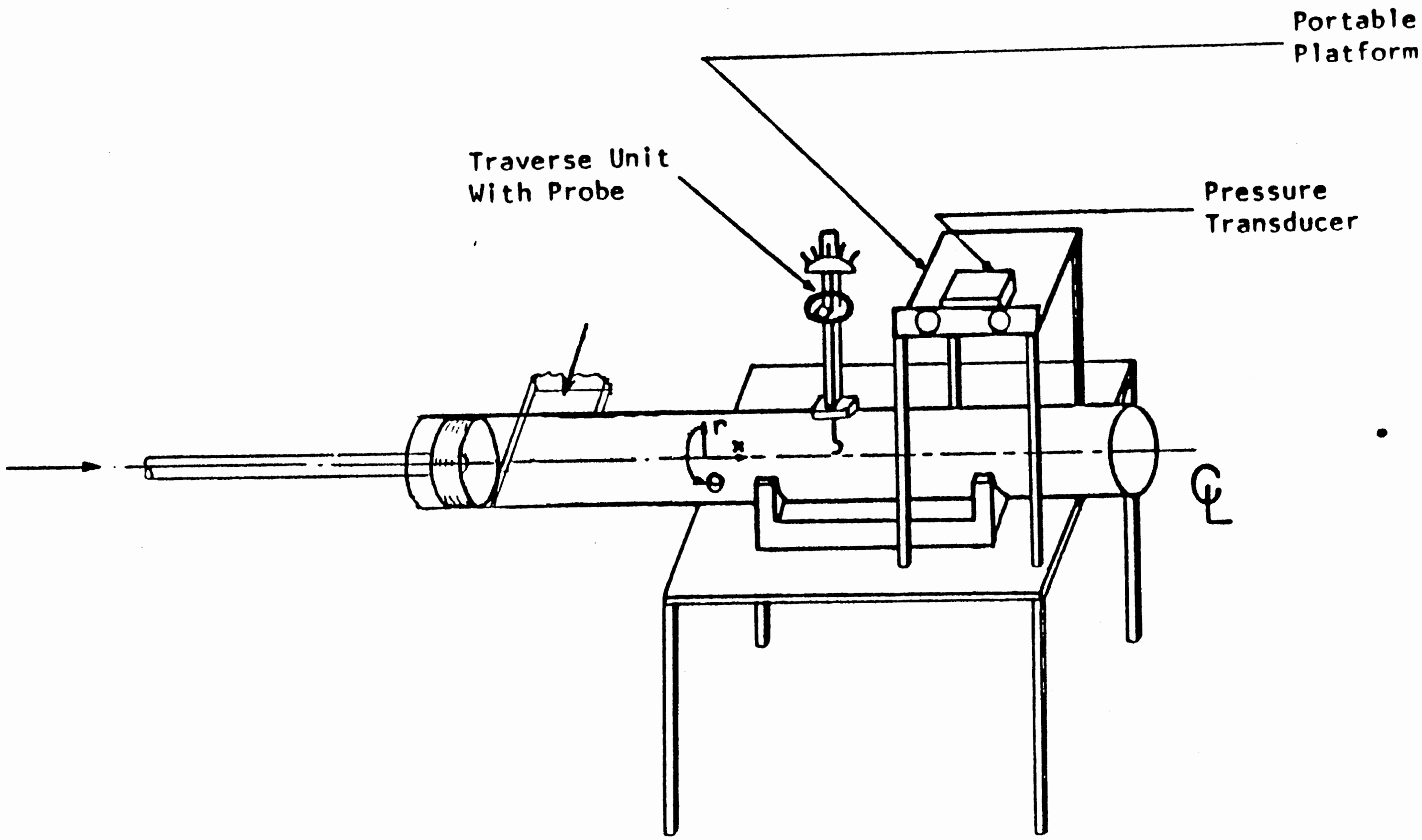


Figure 6. Apparatus for Time-Mean Velocity Measurements Using a Five-Hole Pitot Probe

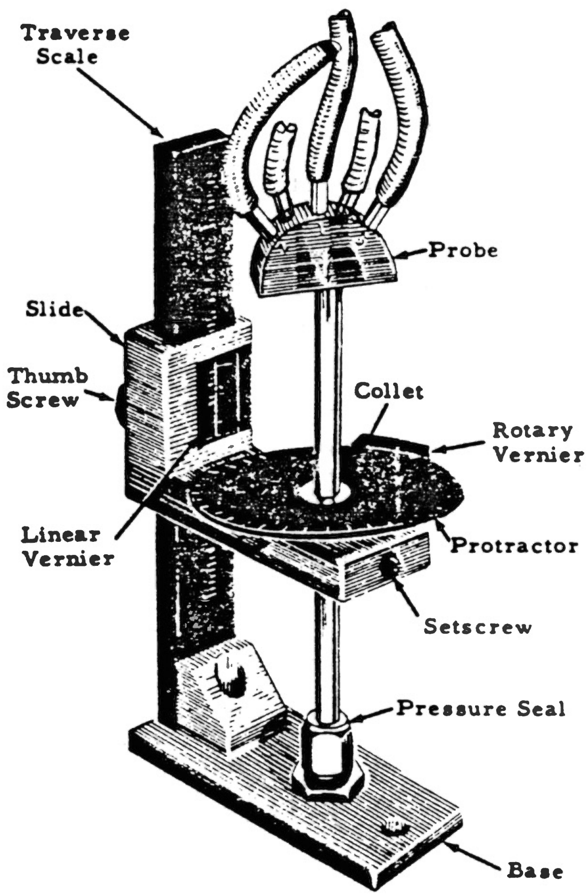


Figure 7. Manual Traverse Mechanism used for Five-Hole Pitot Probe Measurements

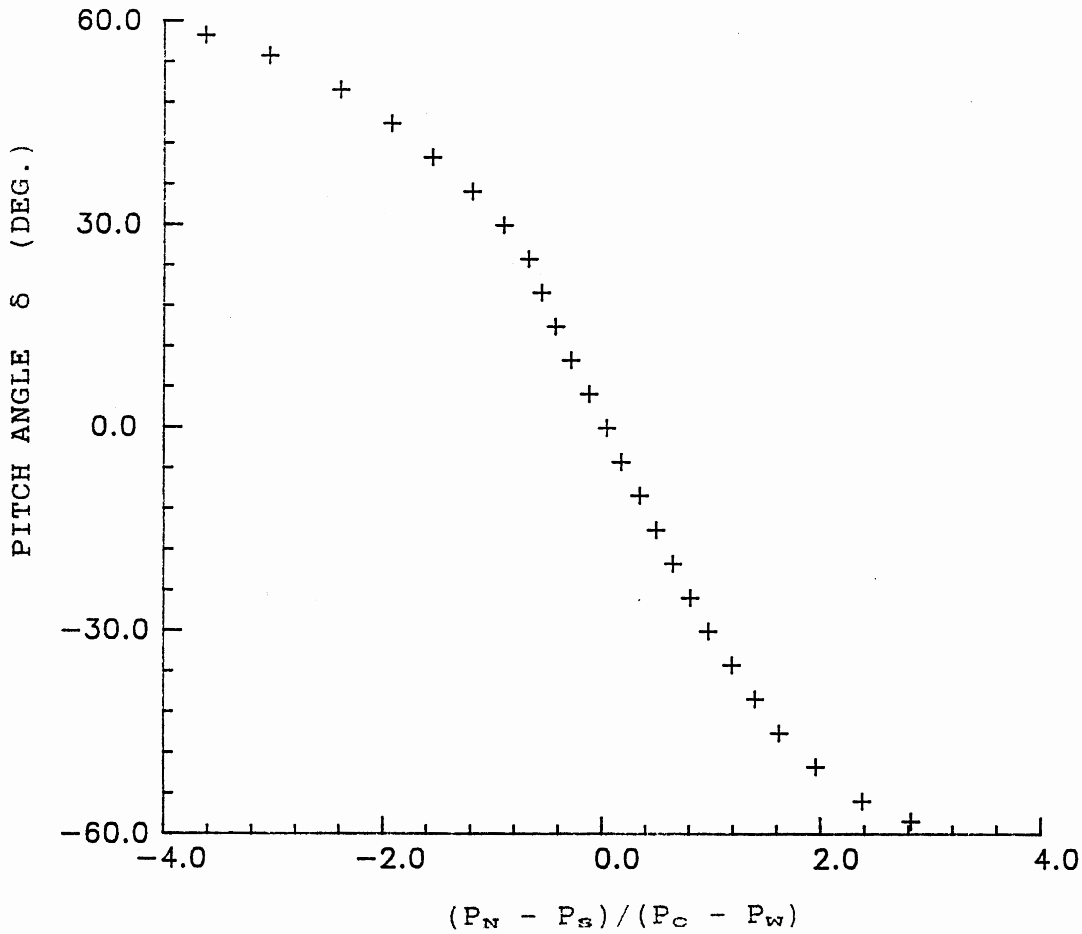


Figure 8. Pitch Angle Calibration Characteristic for Five-Hole Pitot Probe

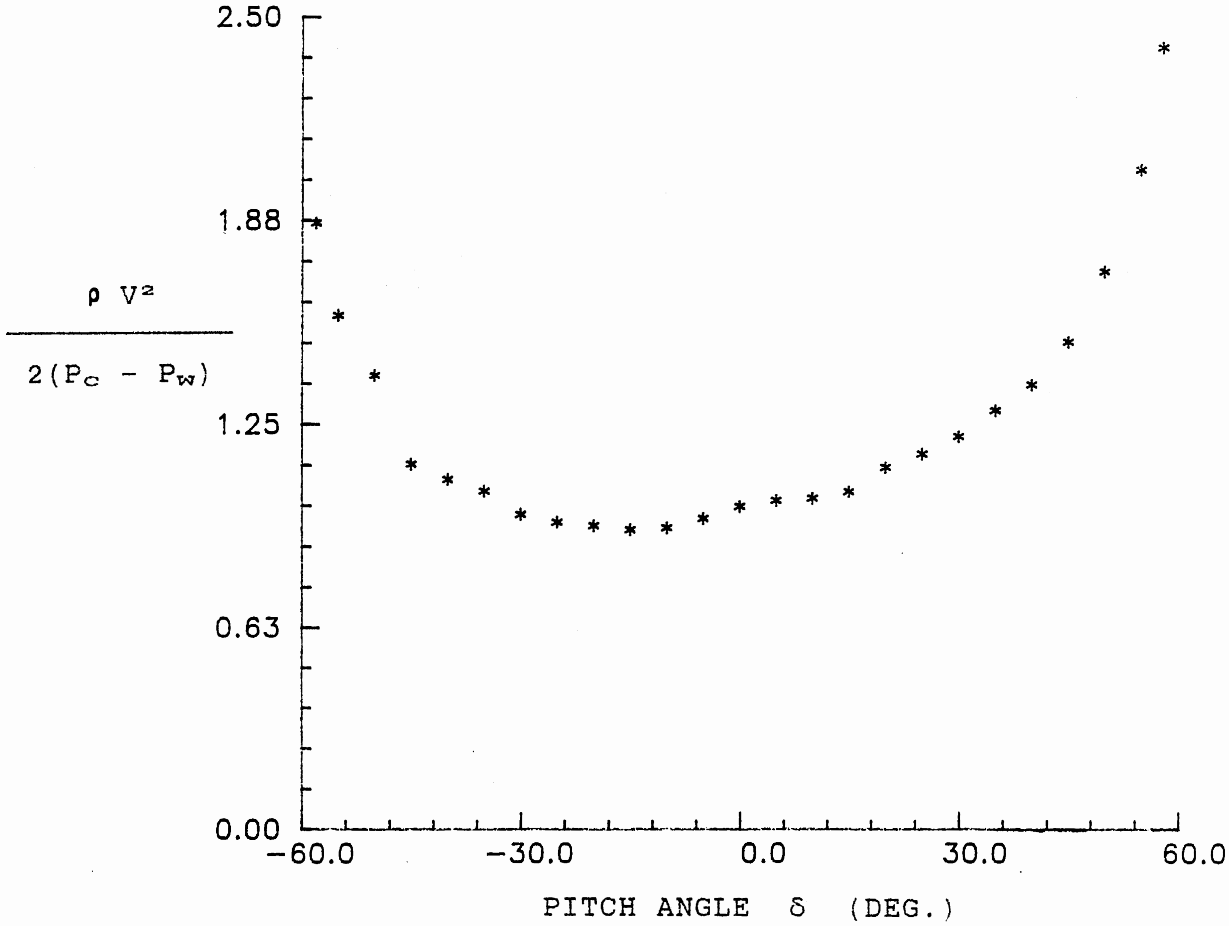


Figure 9. Velocity Coefficient Calibration Characteristic for Five-Hole Pitot Probe

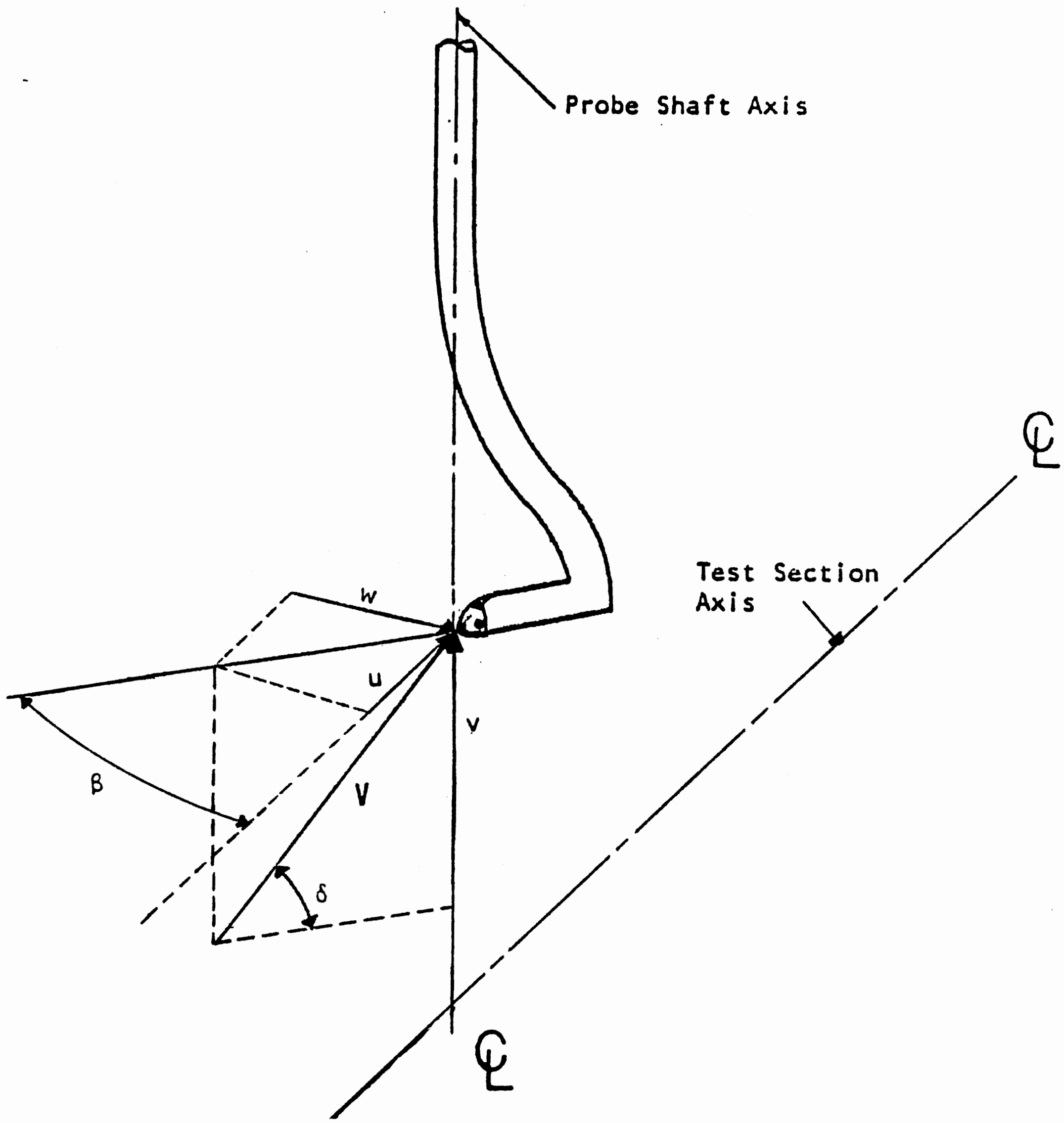


Figure 10. Velocity Components and Flow Direction Angles Associated with Five-Hole Pitot Probe Measurements

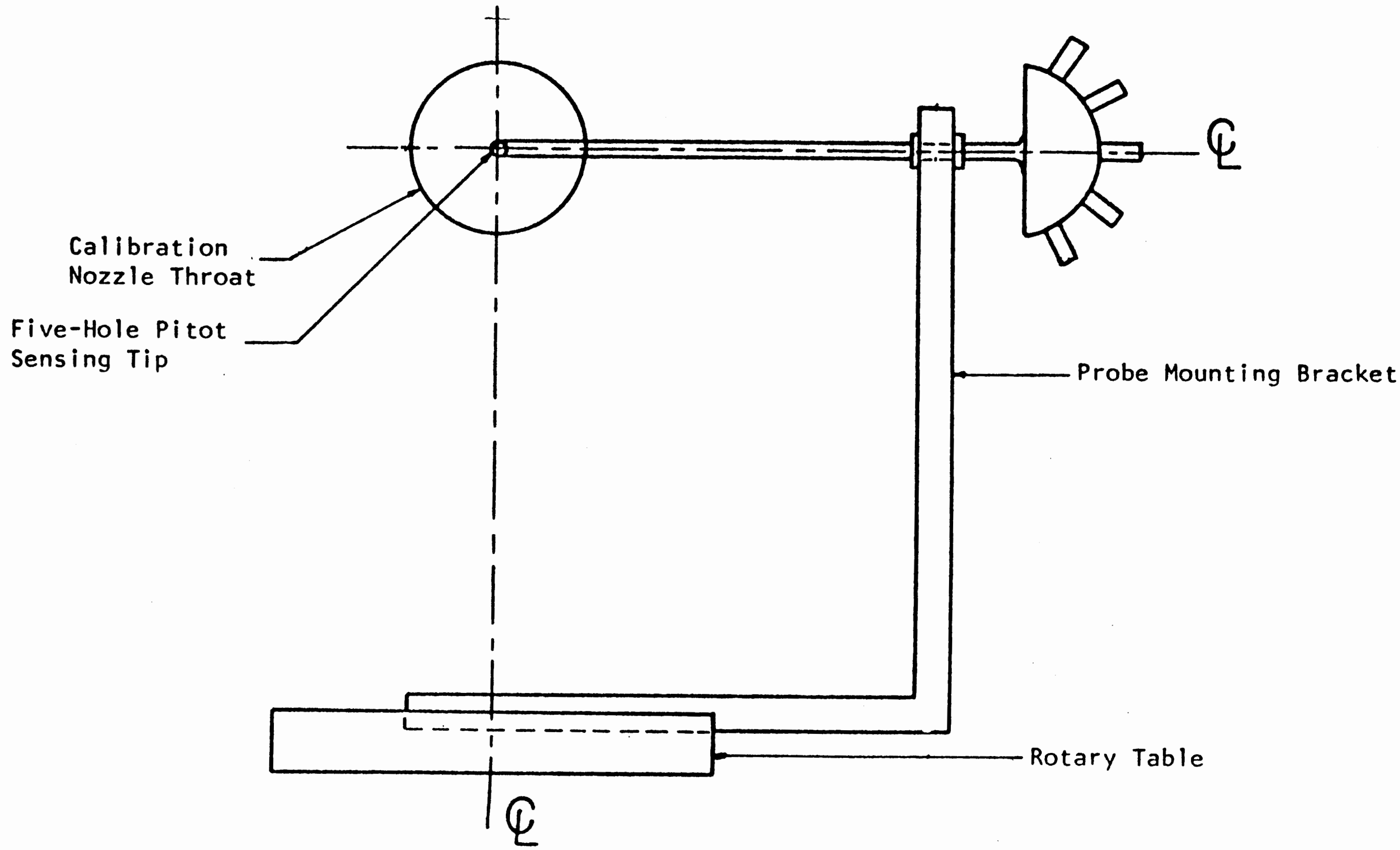


Figure 11. Calibration Apparatus with Five-Hole Pitot Probe

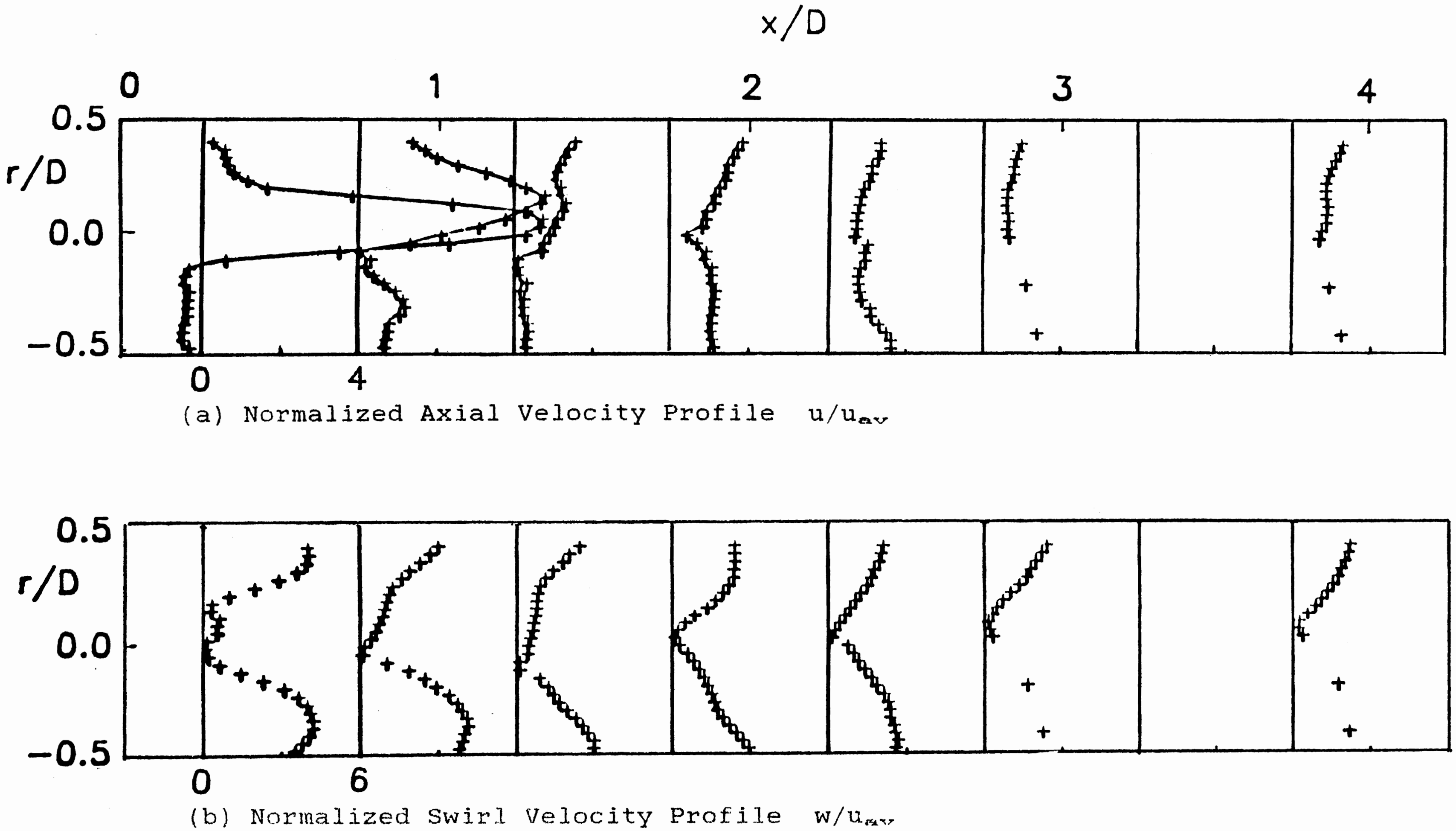
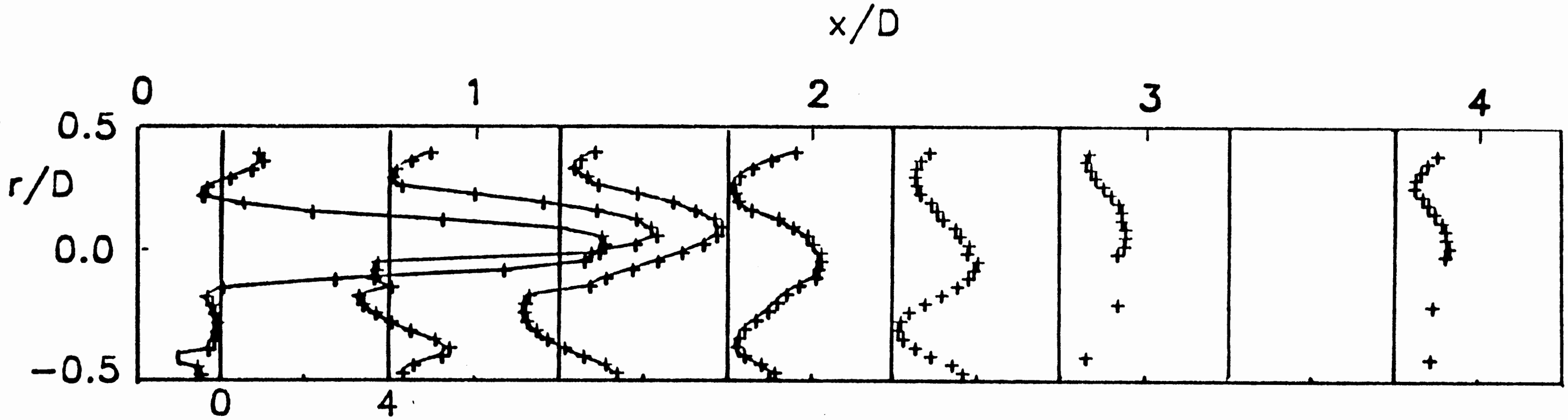
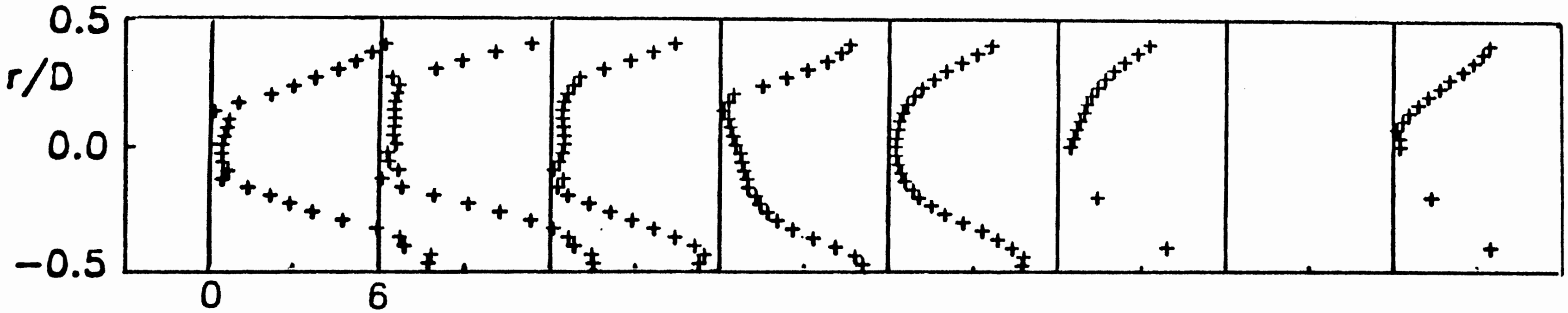


Figure 12. Case 1 ($m_t/m_a = 2$ and $w_t/u_{av} = 2.83$)

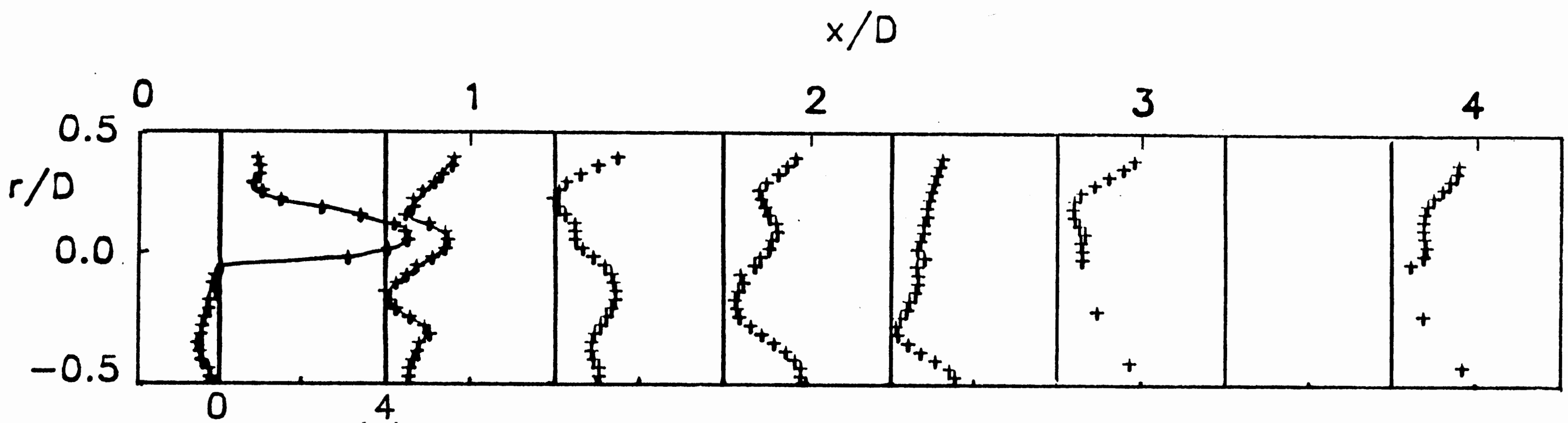


(a) Normalized Axial Velocity Profile u/u_{av}

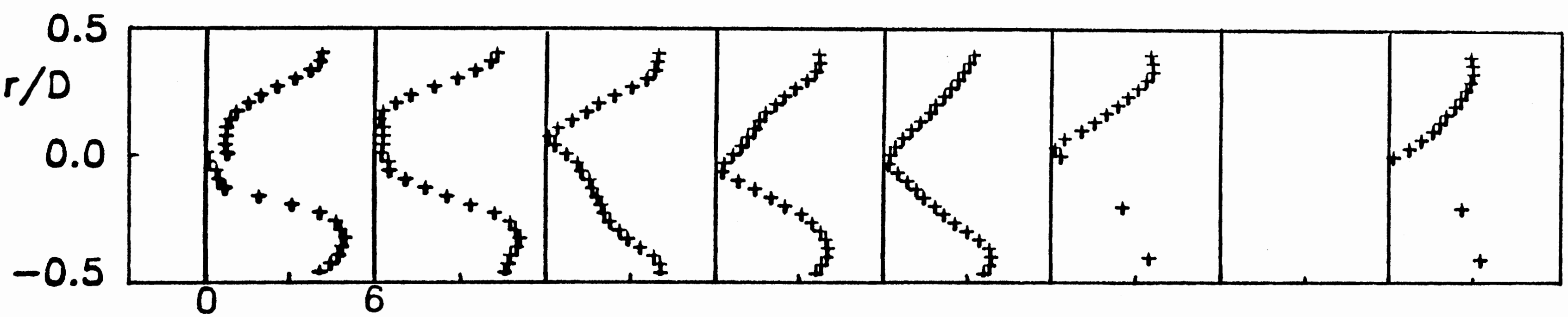


(b) Normalized Swirl Velocity Profile w/u_{av}

Figure 13. Case 2 ($m_t/m_a = 2$ and $w_t/u_{av} = 5.64$)

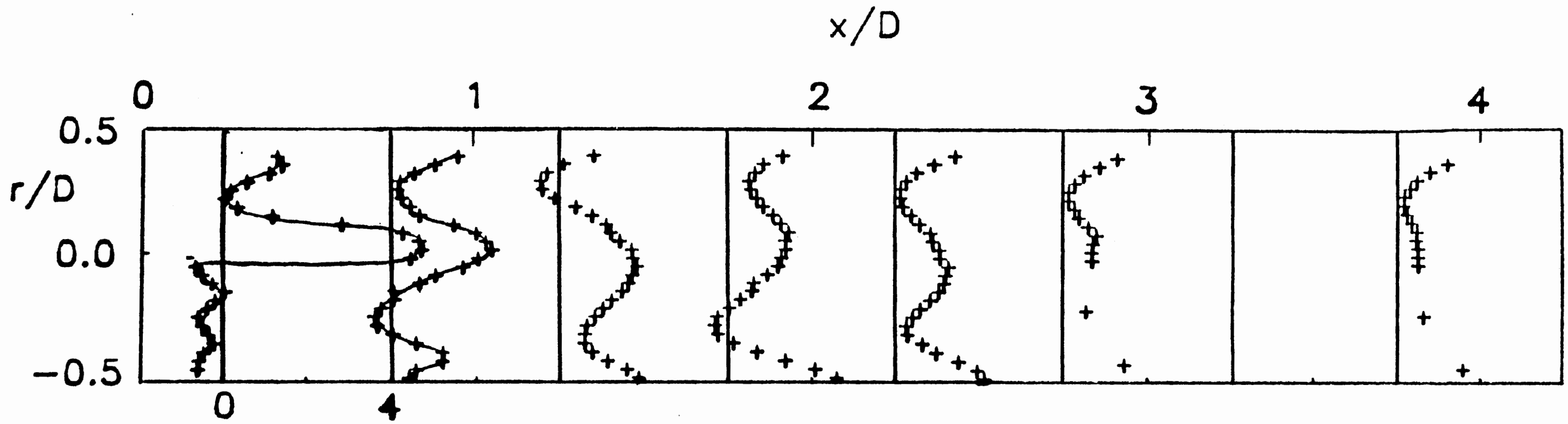


(a) Normalized Axial Velocity Profile u/u_{av}

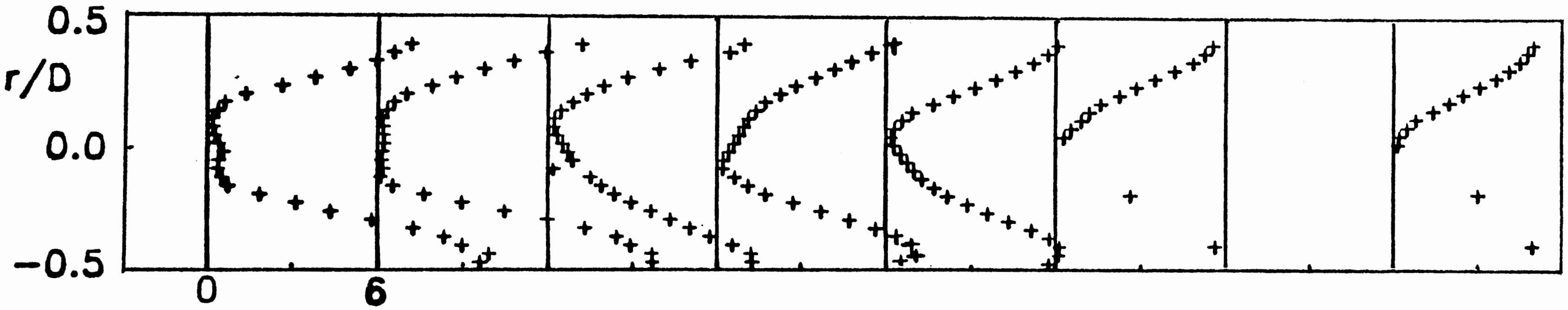


(b) Normalized Swirl Velocity Profile w/u_{av}

Figure 14. Case 3 (m_t/m_a = 4 and w_t/u_{av} = 3.39)

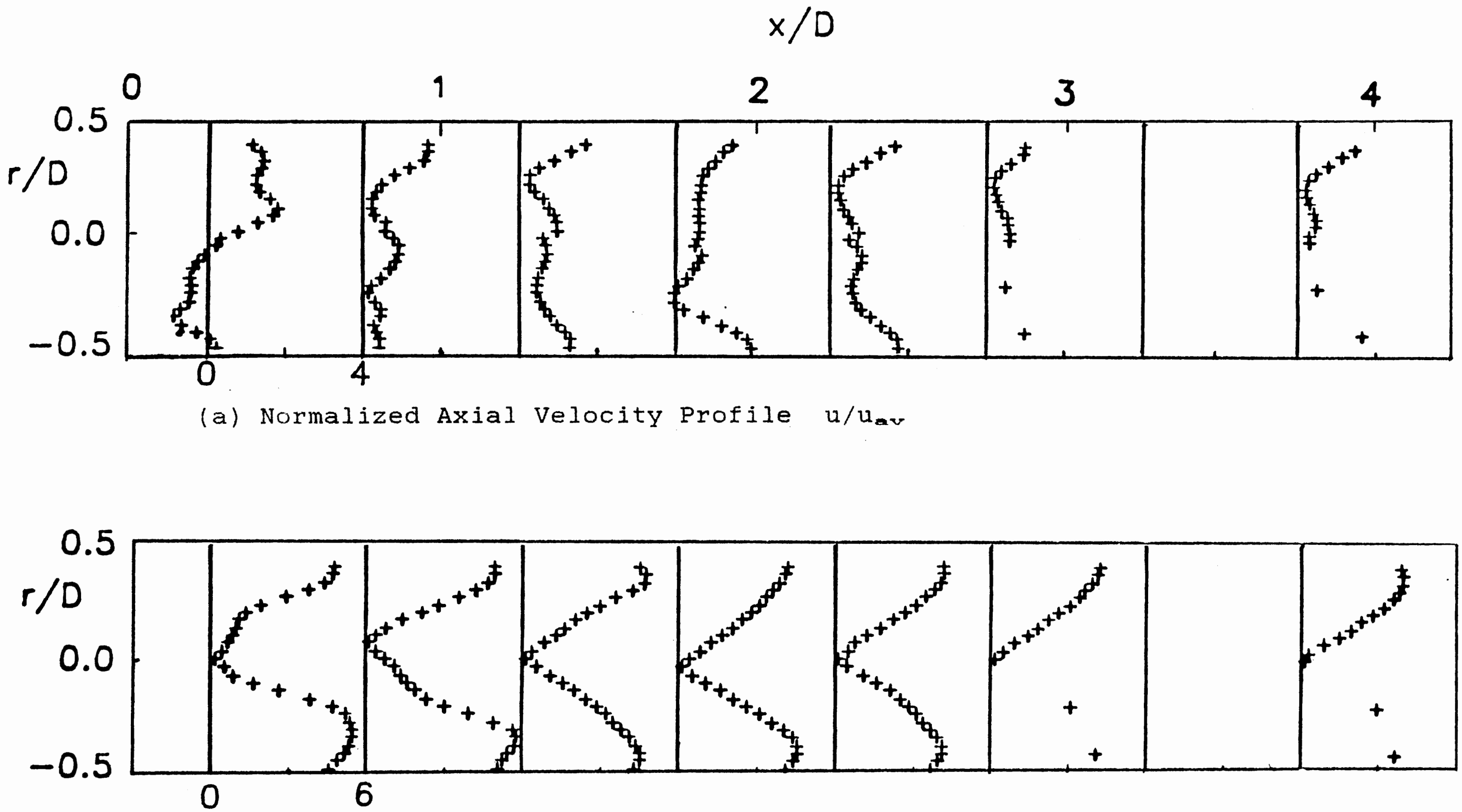


(a) Normalized Axial Velocity Profile u/u_{av}



(b) Normalized Swirl Velocity Profile w/u_{av}

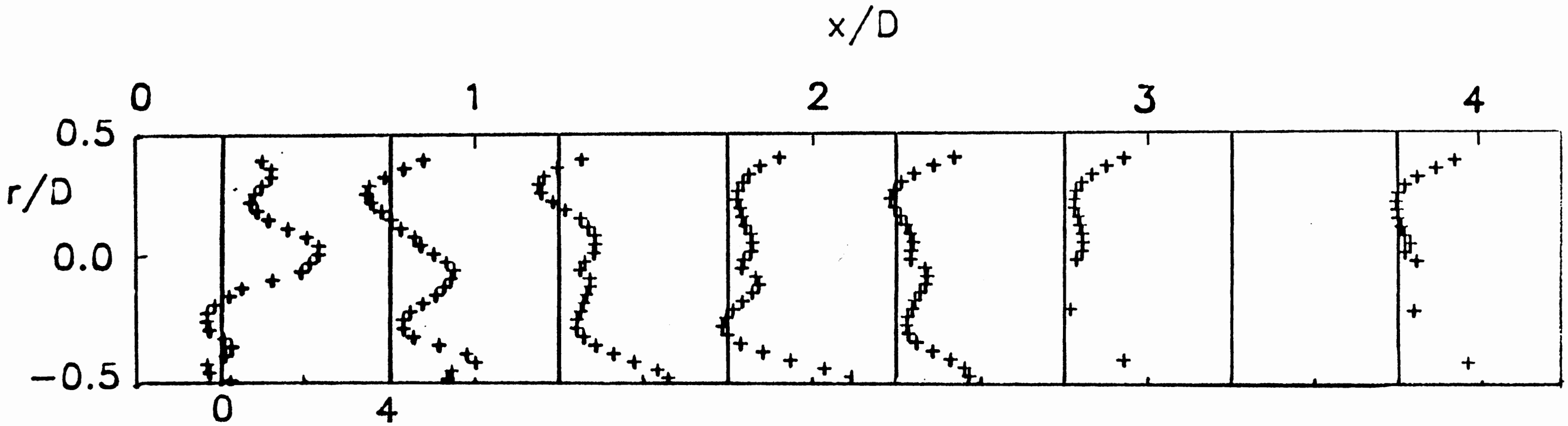
Figure 15. Case 4 (m_t/m_a = 4 and w_t/u_{av} = 6.78)



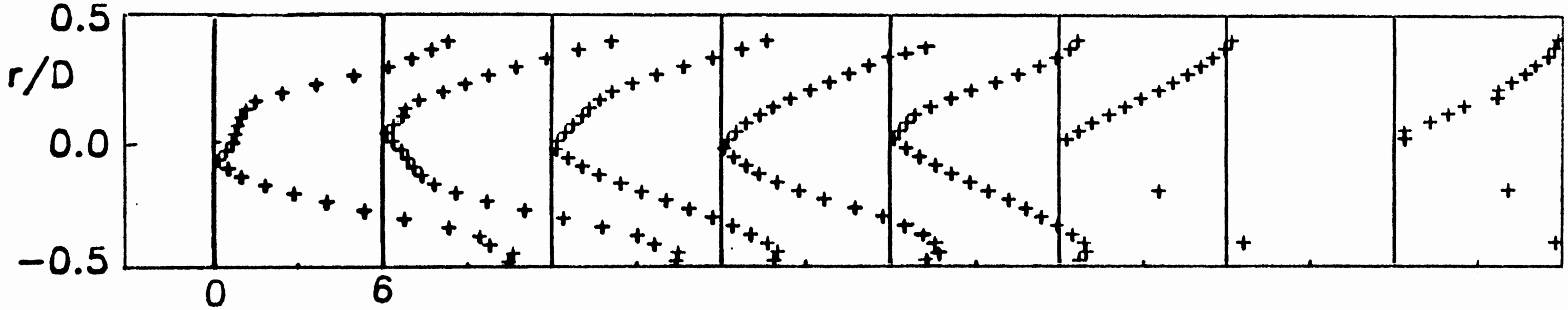
(a) Normalized Axial Velocity Profile u/u_{av}

(b) Normalized Swirl Velocity Profile w/u_{av}

Figure 16. Case 5 (m_t/m_a = 8 and w_t/u_{av} = 3.77)

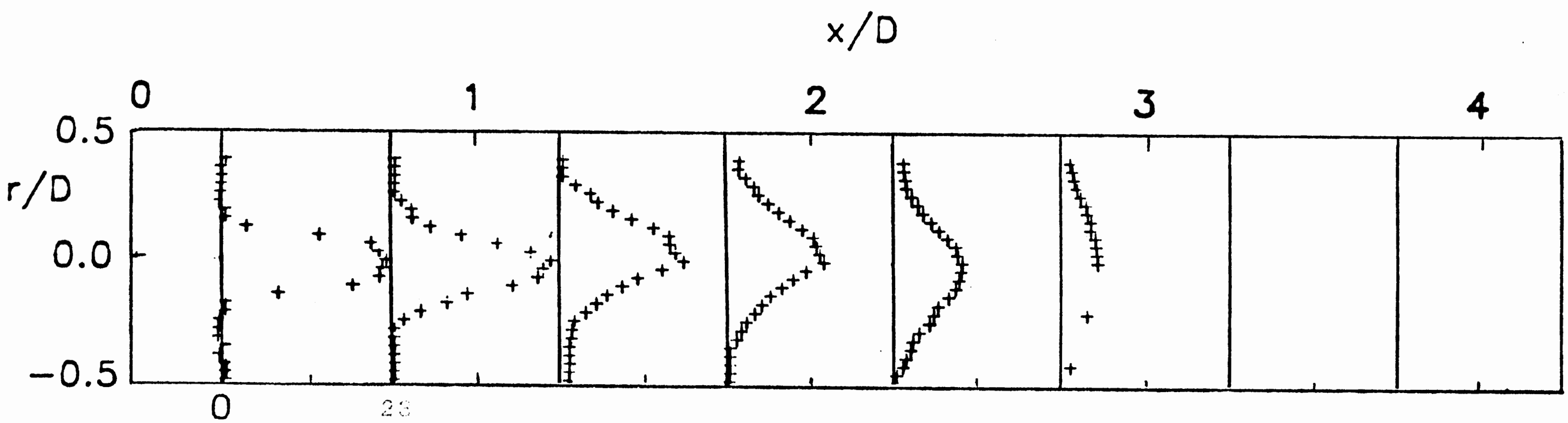


(a) Normalized Axial Velocity Profile u/u_{av}

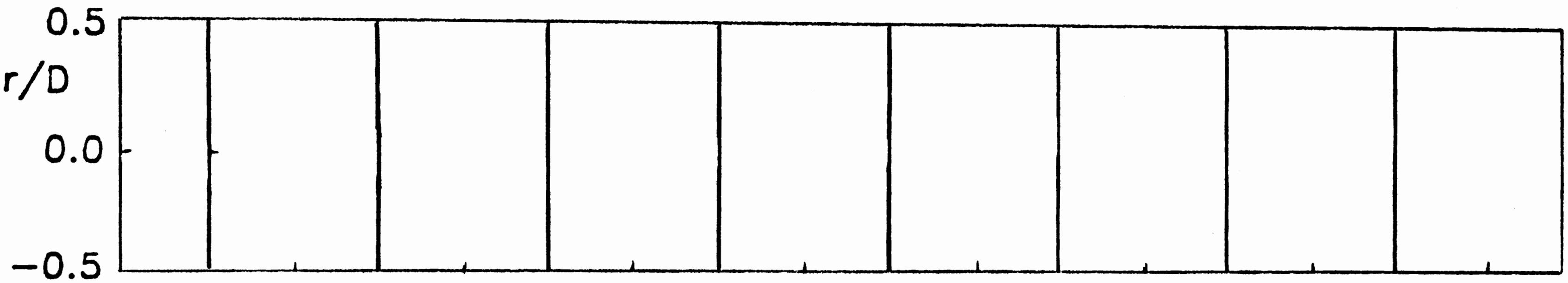


(b) Normalized Swirl Velocity Profile w/u_{av}

Figure 17. Case 6 (m_t/m_a = 8 and w_t/u_{av} = 7.51)



(a) Normalized Axial Velocity Profile u/u_{av}



(b) Normalized Swirl Velocity Profile w/u_{av}

Figure 18. Case 7 (m_t/m_a = 0 and w_t/u_{av} = 0)

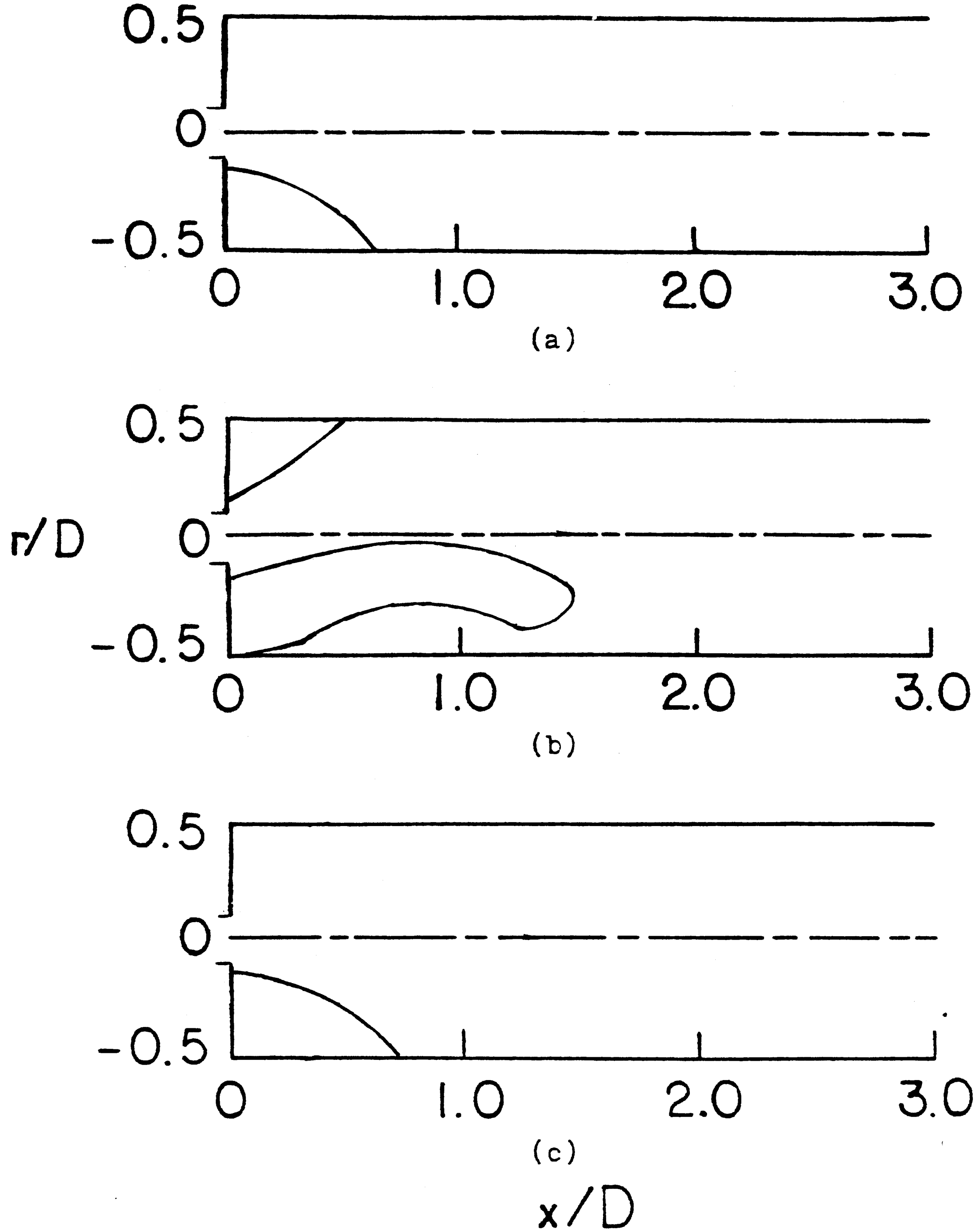


Figure 19. Sketch of Recirculation Zones: (a) Case 1 (b) Case 2 (c) Case 3

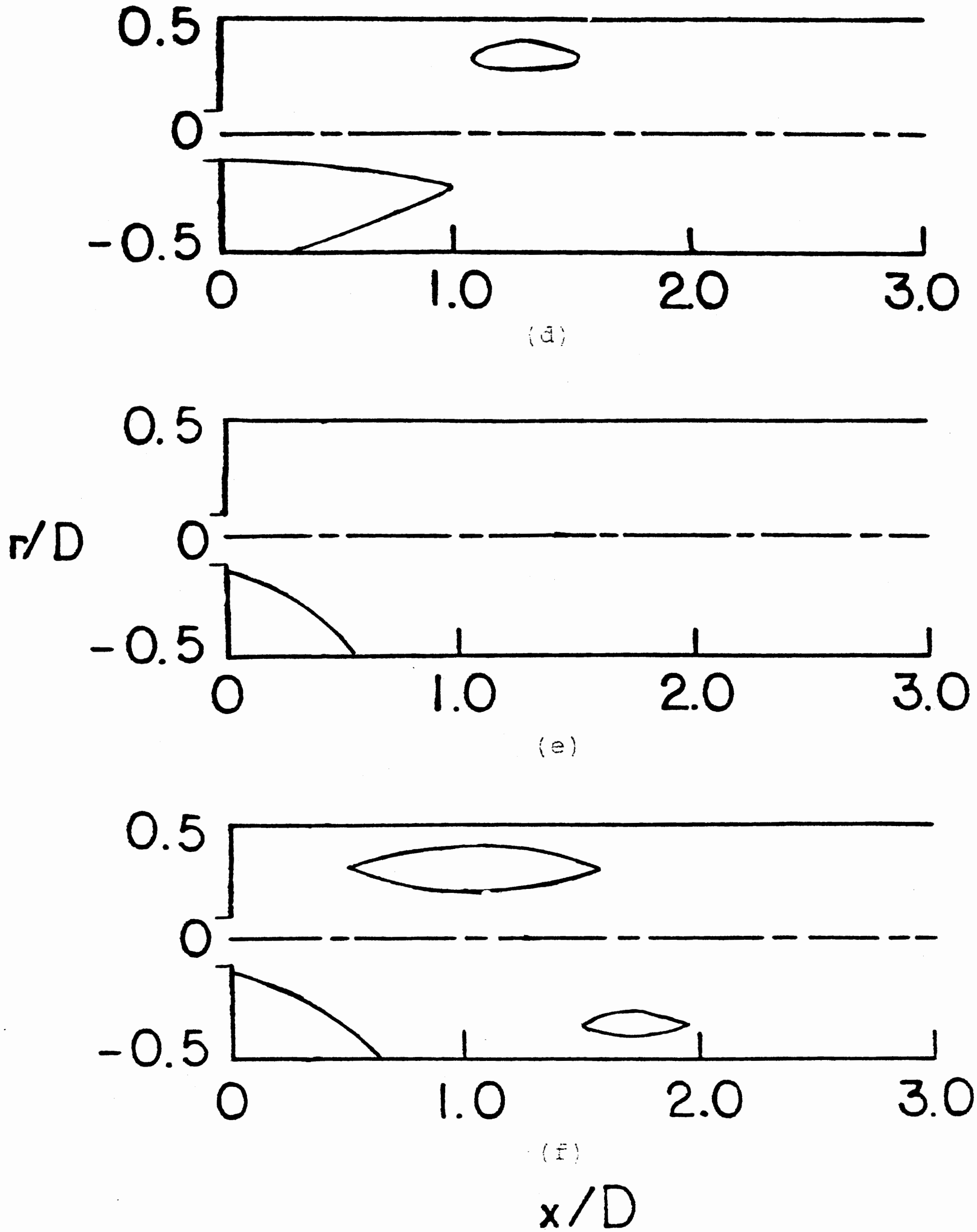


Figure 19. Continued: (d) Case 4 (e) Case 5
(f) Case 6

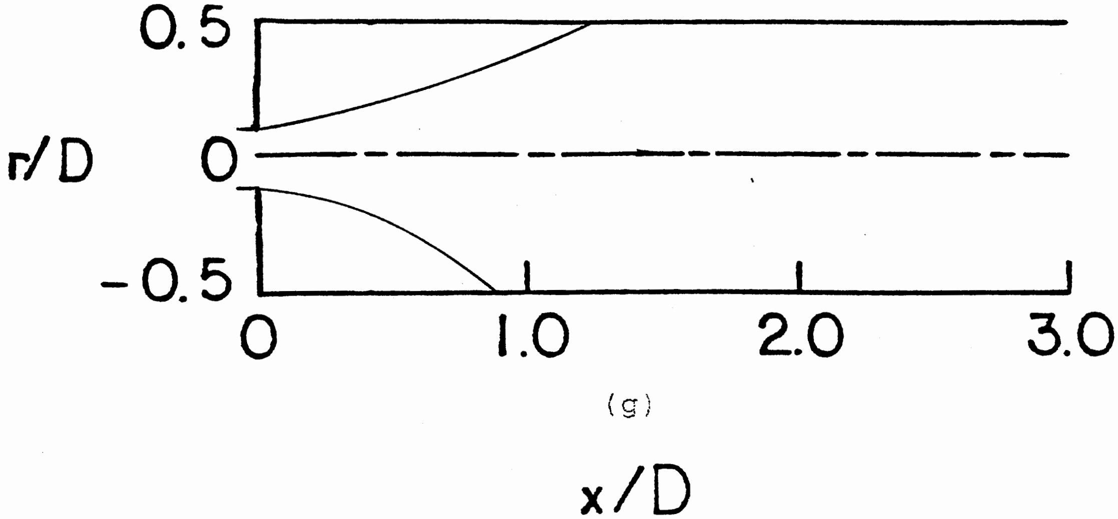


Figure 19. Continued: (g) Case 7

APPENDIX C

DATA REDUCTION COMPUTER PROGRAM AND CALIBRATION DATA FOR FIVE-HOLE PITOT PROBE MEASUREMENTS

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U12107A.TEST1.FORT

C      SUBROUTINE MAIN                                                  0000000
C                                                                       0000000
C***********************************************************************0000000
C                                                                       0000000
C                                                                       0000000
C      A COMPUTER PROGRAM FOR DATA REDUCTION OF FIVE-HOLE PITOT         0000000
C      MEASUREMENTS IN TURBULENT, SWIRLING, RECIRCULATING FLOW          0000000
C      IN COMBUSTOR GEOMETRIES                                          0000000
C                                                                       0000000
C      MODIFIED VERSION FOR INTERACTIVE USE ON CYCLONE FACILITY         0000000
C      MAY, 1988                                                        0000000
C                                                                       0000000
C      MODIFICATIONS INCLUDE COMBINED RADIAL AND AZIMUTHAL CAPA-        0000000
C      BILITY, REDUCTION OF STATIC PRESSURE DATA, AND CALCULATION       0000000
C      OF MOMENTUM FLUXES AND SWIRL NUMBERS FOR RADIAL PROFILES.        0000000
C                                                                       0000000
C      BASED ON A PROGRAM BY D. L. RHODE (PHD THESIS, OSU, 1981)        0000000
C                                                                       0000000
C                                                                       0000000
C      FIRST MODIFICATION    : G. F. SANDER  (MS THESIS, OSU, 1983)     0000000
C      SECOND MODIFICATION   : L. H. ONG     (MS THESIS, OSU, 1985)     0000000
C      THIRD MODIFICATION    : C. B. MCMURRY (MS THESIS, OSU, 1985)     0000000
C      FORTH MODIFICATION    : W. D. CHAI AND G. EGHNEIM                0000000
C                                            (MS THESIS, OSU, 1988)     0000000
C                                                                       0000000
C      MECHANICAL AND AEROSPACE ENGINEERING                             0000000
C      OKLAHOMA STATE UNIVERSITY                                        0000000
C      STILLWATER, OK      74078                                        0000000
C                                                                       0000000
C***********************************************************************0000000
C                                                                       0000000
C---MAJOR FORTRAN VARIABLES IN MAIN PROGRAM (LISTED IN ORDER            0000000
C           OF FIRST OCCURRENCE IN THE PROGRAM):                        0000000
C                                                                       0000000
C IWRITE - LOGICAL FLAG FOR WRITING INTO OUTPUT DATASET (UNFORMATTED)   0000000
C DIAGNS - FLAG FOR DIAGNOSTIC OUTPUT                                   0000000
C IT     - MAX NO. OF TRAVERSES ALLOWED; DIMENSION VALUE IN SUBROUTINES 0000000
C JT     - MAX NO. OF POINTS ALLOWED PER TRAVERSE; ALSO DIMENSION VALUE 0000000
C HEDM ETC. - ALL VARIABLES STARTING WITH "HED" ARE ALPHANUMERIC ARRAYS 0000000
C              FOR OUTPUT HEADINGS                                      0000000
C NCAL   - NO. OF CALIBRATION DATA POINTS                               0000000
C CPITCH - CALIBRATION PITCH COEFF. -- (PN-PS)/(PC-PW)                  0000000
C CDELTA - CAL. PITCH ANGLE -- STANDARD RANGE -58 TO +58 DEG.           0000000
C CVELCF - CAL. VELOCITY COEFF. -- (CAL. DYN. PRESS.)/(PC-PW)           0000000
C CPSTCF - CAL. STATIC PRESSURE COEFF. -- (PC-PA)/(PC-PW)               0000000
C HEDID1,HEDID2 - USER HEADINGS TO IDENTIFY THE RUN BEING REDUCED       0000000
C ALPHA  - INLET SIDEWALL EXPANSION ANGLE                               0000000
C PHI    - SWIRL VANE ANGLE SETTING                                     0000000
C DSINCH - INLET NOZZLE OR SWIRLER DIAMETER, DSMALL, IN INCHES          0000000
C DLINCH - TEST SECTION DIAMETER, DLARGE, INCHES                        0000000
C AAFR   - AXIAL AIR FLOW RATE,CFM                                      0000000
C TAFR   - TANGENTIAL AIR FLOW RATE,CFM                                 0000000
C KRADTR - INTEGER FLAG FOR TRAVERSE TYPE -- 1 FOR RADIAL, 0 FOR AZIM.  0000000
C NSTATN - NO. OF TRAVERSES TO BE REDUCES                               0000000
C MAXJPT - MAX NO. OF POINTS IN ANY OF THE TRAVERSES BEING REDUCED      0000000
C XINCHS - AXIAL POSITION OF EACH TRAVERSE, INCHES                      0000000
C NDATA  - NO. OF DATAPOINTS IN EACH TRAVERSE                           0000000
C RDNPRS - INLET DYNAMIC PRESSURE (UPSTREAM OF SWIRLER), TORR           0000000
C PREF   - REF. PRESS. USED TO CALC. PDIFF FOR SWIRL NUMBER, TORR       0000000
```

```
C FANSPD - FAN SPEED, RPM                                                0000000
C TFLOW  - TEMPERATURE OF AIR IN TEST SECTION, DEG. CELSIUS               0000000
C PATM   - ATMOSPHERIC PRESSURE, TORR                                     0000000
C BZOFF  - BETA ZERO-OFFSET FOR YAW ANGLE READINGS                        0000000
C RINCHS - RADIAL POS. OF DATAPOINT, INCHES (THETA FOR AZIM. TRAVERSES) 0000000
C RBETA  - RAW VALUE OF YAW ANGLE BETA, DEG.                              0000000
C RPNMPS - MEAS. VALUE OF PNORTH - PSOUTH PRESS. DIFF, TORR               0000000
C RPCMPW - MEAS. VALUE OF PCENTER - PWEST, TORR                           0000000
C RPCMPA - MEAS. VALUE OF PCENTER - PATMOSPHERE, TORR                     0000000
C RSMALL - INLET NOZZLE OR SWIRLER RADIUS, METERS                         0000000
C RLARGE - TEST SECTION RADIUS, METERS                                    0000000
C X      - AXIAL POSITION OF TRAVERSE, METERS                             0000000
C R      - RADIAL POSITION OF DATAPOINT, METERS                           0000000
C IDID   - FLAG TO USE ENTRY POINT SP IN SPLINE INTERPOLATION ROUTINE     0000000
C PICHCF - REDUCED PITCH COEFF. FOR EACH DATAPOINT                        0000000
C DELTA  - REDUCED PITCH ANGLE FOUND BY INTERPOLATION USING PICHCF        0000000
C VELCF  - REDUCED VELOCITY COEFF. FROM INTERPOLATION USING DELTA         0000000
C PSTCF  - REDUCED STATIC PRESS. COEFF. FROM INTERPOLATION USING DELTA    0000000
C RHO    - DENSITY FOR EACH TRAVERSE, FROM IDEAL-GAS LAW                  0000000
C BETA   - REDUCED VALUE FOR PROBE YAW ANGLE, DEG.                        0000000
C VTOTAL - TOTAL VELOCITY VECTOR MAGNITUDE, M/S                           0000000
C U      - AXIAL COMPONENT OF VELOCITY, M/S                               0000000
C V      - RADIAL COMP. OF VELOCITY, M/S                                  0000000
C W      - TANGENTIAL (SWIRL) VELOCITY, M/S                               0000000
C P      - REDUCED VALUE OF STATIC PRESSURE, N/SQ. M (GAGE)               0000000
C XND    - NONDIMENSIONAL AXIAL POSITION, X/DLARGE                        0000000
C UIN    - INLET REFERENCE VELOCITY (CALC. FROM RDNPRS), M/S              0000000
C MASFLO - INLET MASS FLOW RATE (ASSUMING UNIFORM AXIAL VELOCITY), KG/S 0000000
C VTSTAR - NONDIM. TOTAL VELOCITY MAGNITUDE, VTOTAL/UIN                   0000000
C USTAR  - NONDIM. AXIAL VELOCITY, U/UIN                                  0000000
C VSTAR  - NONDIM. RADIAL VELOCITY, V/UIN                                 0000000
C WSTAR  - NONDIM. TANGENTIAL VEL., W/UIN                                 0000000
C PSTAR  - NONDIM. STATIC PRESSURE, P/RDNPRS                              0000000
C RND    - NONDIM. RADIAL POS., R/DLARGE; ALSO THETA FOR AZIM. TRAVERSES0000000
C DYPS   - "DELTA-Y, POINT-SOUTH" (FOR RADIAL INTEGRATION; FROM STARPIC)0000000
C DYNP   - "DELTA-Y, NORTH-POINT" (SIM. TO DYPS)                          0000000
C SNS    - "SMALL NORTH-SOUTH" FROM STARPIC; USED AS DELTA-R FOR INTEGR.0000000
C PDIFF  - PRESS. DIFF. P - PREF USED TO CALCULATE SWIRL NUMBER, N/SQ. M0000000
C AREA1  - AREA OF DISC ELEMENT AT CENTER OF INTEGRATION REGION           0000000
C FLOW   - SUMMATION FOR MASS FLOW THROUGH RING ELEMENTS                  0000000
C WMOM   - SUMMATION FOR ANGULAR MOMENTUM FLUX                            0000000
C UMOM   - SUMMATION FOR DYNAMIC AXIAL MOM. FLUX (NEGL. PRESS. TERM)      0000000
C UMOMP  - SUMMATION FOR AXIAL MOMENTUM FLUX, INCL. PRESSURE DIFF. TERM 0000000
C AREAJ  - AREA OF EACH RING ELEMENT, SQ. M                               0000000
C MASS   - INTEGRATED MASS FLOW RATE, KG/S                                0000000
C UMEAN  - INTEGRATED MEAN AXIAL VELOCITY, M/S                            0000000
C ANGMOM - INTEGRATED AXIAL FLUX OF ANGULAR MOMENTUM, N-M                 0000000
C AXMOM  - INT. AXIAL FLUX OF DYNAMIC AXIAL MOM., N (NEGL. PRESS. TERM) 0000000
C AXMOMP - INT. AXIAL FLUX OF AXIAL MOMENTUM, N (INCL. PRESSURE TERM)     0000000
C SPRIME - SWIRL NUMBER CALC. USING DYNAMIC AXIAL MOMENTUM FLUX           0000000
C S      - SWIRL NUMBER CALC. USING FULL AXIAL MOM. FLUX (INCL. PRESS.) 0000000
C USTAVG - AVERAGE OF USTAR VALUES FOR AZIM. TRAV., OVER ONE BLADE SPACE0000000
C VSTAVG - AVG. OF VSTAR VALUES                                           0000000
C WSTAVG - AVG. OF WSTAR VALUES                                           0000000
C PDFAVG - AVG. OF PDIFF VALUES                                           0000000
C VISCOS - LAMINAR ABS. VISCOSITY CALCULATED FOR EACH TRAVERSE, KG/M*S    0000000
C REDIN  - INLET REYNOLDS NUMBER, CALC. USING VISCOSITY FOR EACH TRAV.    0000000
C                                                                         0000000
C                                                                         0000000
C***********************************************************************0000000
CHAPTER O O O O O O O O O PRELIMINARIES O O O O O O O O O O 0000000
C                                                                         0000000
      DIMENSION HEDM(9),HEDUMN(9),HEDNMS(9),HEDCMW(9),HEDCMA(9),          0000000
     #HEDU(9),HEDV(9),HEDW(9),HEDVT(9),HEDUST(9),                         0000000
     #HEDVST(9),HEDWST(9),HEDPST(9),HEDDEL(9),HEDBET(9),                  0000000
     #HEDMMF(9),HEDMIV(9),HEDMIP(9),HEDAM(9),                             0000000
```

```
     #HEDAX(9),HEDAXP(9),HEDSPR(9),HEDS(9),HEDP(9),HEDPDF(9),HEDRED(9), 0000000
     #HEDID1(18),HEDID2(18),HEDUSA(9),HEDVSA(9),HEDWSA(9),HEDPDA(9),    0000000
     #HEDFAN(9),HEDTFL(9),HEDPAT(9),HEDRHO(9),HEDVIS(9),HEDCAL(9)        0000000
C                                                                         0000000
C                                                                         0000000
      COMMON                                                              0000000
     #/CALIB/CPITCH(26),CDELTA(26),CVELCF(26),CPSTCF(26)                 0000000
     #/MEASUR/RBETA(8,24),RPNMPS(8,24),RPCMPW(8,24),RPCMPA(8,24),       0000000
     #     NDATA(8),MAXJPT,RDNPRS(8),                                    0000000
     #     FANSPD(8),TFLOW(8),PATM(8),BZOFF(8)                           0000000
     #/GEOM/X(8),R(24),XND(8),RND(24),DYPS(24),DYNP(24),                0000000
     #     SNS(24),NSTATN,XINCHS(8),RINCHS(24)                           0000000
     #/CALC/VTOTAL(8,24),U(8,24),V(8,24),W(8,24),P(8,24),               0000000
     #     VTSTAR(8,24),USTAR(8,24),VSTAR(8,24),WSTAR(8,24),             0000000
     #     PICHCF(8,24),VELCF(8,24),DELTA(8,24),BETA(8,24),              0000000
     #     ANGMOM(8),UMEAN(8),UIN(8),RMASS(8),RMASFL(8),                 0000000
     #     PSTAR(8,24),PSTCF(8,24),AXMOM(8),AXMOMP(8),                   0000000
     #     SPRIME(8),S(8),REDIN(8),PREF(8),RHO(8),VISCOS(8),             0000000
     #     USTAVG(8,24),VSTAVG(8,24),WSTAVG(8,24),PSTAVG(8,24)           0000000
     #/OUTPUT/STORE(8)                                                    0000000
C                                                                         0000000
      LOGICAL IWRITE,DIAGNS                                               0000000
C                                                                         0000000
C---SET IWRITE=.TRUE. FOR WRITING SOLN. ON DISK STORAGE;                 0000000
C   SET DIAGNS=.TRUE. TO ACTIVATE DIAGNOSTIC WRITE STATEMENTS            0000000
C                                                                         0000000
      IWRITE=.TRUE.                                                       0000000
      DIAGNS=.TRUE.                                                       0000000
      IT=8                                                                0000000
      JT=24                                                               0000000
C                                                                         0000000
C---READ CHARACTER DATA FOR HEADINGS USED BY SUBROUTINES                 0000000
C   WRITE AND PRINT (ALSO CALIBRATION HEADING)                           0000000
C                                                                         0000000
      READ(7,205) HEDM,HEDUMN,HEDU,HEDV,HEDW,                             0000000
     #     HEDVT,HEDUST,HEDVST,HEDWST,HEDPST,HEDDEL,HEDBET,              0000000
     #     HEDNMS,HEDCMW,HEDCMA,HEDMMF,HEDMIV,HEDMIP,HEDAM,              0000000
     #     HEDAX,HEDAXP,HEDSPR,HEDS,HEDP,HEDPDF,HEDRED,                  0000000
     #     HEDFAN,HEDTFL,HEDPAT,HEDRHO,HEDVIS,                           0000000
     #     HEDUSA,HEDVSA,HEDWSA,HEDPDA,HEDCAL                            0000000
  205 FORMAT(9A4)                                                         0000000
C                                                                         0000000
C---------INITIALIZE VARIABLES TO ZERO                                    0000000
C                                                                         0000000
      CALL INIT                                                           0000000
C                                                                         0000000
C---------READ FIVE-HOLE PITOT CALIBRATION DATA                           0000000
C                                                                         0000000
      NCAL=25                                                             0000000
      DO 10 I=1,NCAL                                                      0000000
        READ(7,210) CPITCH(I),CDELTA(I),CVELCF(I),CPSTCF(I)               0000000
   10 CONTINUE                                                            0000000
  210 FORMAT(4F10.5)                                                      0000000
      IF(DIAGNS) WRITE(8,400) (CPITCH(I),I=1,25)                          0000000
      IF(DIAGNS) WRITE(8,400) (CDELTA(I),I=1,25)                          0000000
      IF(DIAGNS) WRITE(8,400) (CVELCF(I),I=1,25)                          0000000
      IF(DIAGNS) WRITE(8,400) (CPSTCF(I),I=1,25)                          0000000
  400 FORMAT(///,1X,13(F8.4,1X),//,5X,12(F8.4))                          0000000
C                                                                         0000000
C---READ RAW MEASURED DATA TO BE REDUCED                                 0000000
C                                                                         0000000
      READ(7,215) HEDID1,HEDID2                                           0000000
  215 FORMAT(18A4)                                                        0000000
      READ(7,216) ALPHA,PHI,DSINCH,DLINCH,AAFR,TAFR                       0000000
  216 FORMAT(6F10.5)                                                      0000000
      READ(7,217) KRADTR,NSTATN,MAXJPT                                    0000000
```

```
  217 FORMAT(3I10)                                                          0000000
      DO 30 I=1,NSTATN                                                      0000000
        READ(7,230) XINCHS(I),NDATA(I),RDNPRS(I),PREF(I)                    0000000
        READ(7,216) FANSPD(I),TFLOW(I),PATM(I),BZOFF(I)                     0000000
        JPTS=NDATA(I)                                                       0000000
        DO 20 J=1,JPTS                                                      0000000
          READ(7,220) RINCHS(J),RBETA(I,J),RPNMPS(I,J),RPCMPW(I,J),         0000000
     #        RPCMPA(I,J)                                                   0000000
   20   CONTINUE                                                            0000000
   30   CONTINUE                                                            0000000
C                                                                           0000000
C---------CONVERT X'S AND R'S FROM INCHES TO METERS                         0000000
C                                                                           0000000
      RSMALL=DSINCH*0.0254/2.0                                              0000000
      RLARGE=DLINCH*0.0254/2.0                                              0000000
      DO 35 I=1,NSTATN                                                      0000000
        X(I)=XINCHS(I)*0.0254                                               0000000
        JPTS=NDATA(I)                                                       0000000
        DO 32 J=1,JPTS                                                      0000000
          R(J)=RINCHS(J)*0.0254                                             0000000
   32   CONTINUE                                                            0000000
   35 CONTINUE                                                              0000000
  220 FORMAT(7F10.5)                                                        0000000
  230 FORMAT(1F10.5,1I10,2F10.5)                                            0000000
      IF(DIAGNS) WRITE(8,470) (NDATA(I),I=1,NSTATN)                         0000000
      IF(DIAGNS) WRITE(8,450) (X(I),I=1,NSTATN)                             0000000
      IF(DIAGNS) WRITE(8,500) (R(J),J=1,JPTS)                               0000000
      DO 37 I=1,NSTATN                                                      0000000
        IF(DIAGNS) WRITE(8,500) (RBETA(I,J),J=1,JPTS)                       0000000
        IF(DIAGNS) WRITE(8,500) (RPNMPS(I,J),J=1,JPTS)                      0000000
        IF(DIAGNS) WRITE(8,500) (RPCMPW(I,J),J=1,JPTS)                      0000000
        IF(DIAGNS) WRITE(8,500) (RPCMPA(I,J),J=1,JPTS)                      0000000
   37 CONTINUE                                                              0000000
  450 FORMAT(/,40X,1(F8.4,1X))                                              0000000
  470 FORMAT(///,40X,1(I8,1X))                                              0000000
  500 FORMAT(///,20X,10(F8.4))                                              0000000
C                                                                           0000000
CHAPTER  1  1  1  1  1  DATA REDUCTION  1  1  1  1  1  1                    0000000
C                                                                           0000000
C---------CALC PICHCF AND INTERPOLATE FOR DELTA FROM                        0000000
C---------    PITOT CALIBRATION CURVE                                       0000000
C                                                                           0000000
      IDID=0                                                                0000000
      DO 50 I=1,NSTATN                                                      0000000
        JPTS=NDATA(I)                                                       0000000
        DO 40 J=1,JPTS                                                      0000000
          IF((RPCMPW(I,J).EQ.0.0).AND.(RPNMPS(I,J).EQ.0.0)) GO TO 38        0000000
          PICHCF(I,J)=RPNMPS(I,J)/(RPCMPW(I,J)+1.E-6)                       0000000
          IF((PICHCF(I,J).GT.2.544).OR.(PICHCF(I,J).LT.-3.769)) GO TO 380000000
          IF(IDID .EQ. 0) DELTA(I,J)=SPLINE(CPITCH,                         0000000
     #      CDELTA,NCAL,PICHCF(I,J),IDID)                                   0000000
          IF(IDID .GT. 0) DELTA(I,J)=SPLINE(CPITCH,CDELTA,                  0000000
     #      NCAL,PICHCF(I,J),IDID)                                          0000000
          IDID=1                                                            0000000
          GO TO 40                                                          0000000
   38     CONTINUE                                                          0000000
          DELTA(I,J)=0.0                                                    0000000
          WRITE(8,850) I,J                                                  0000000
  850     FORMAT(20X,'PICHCF IS OUT OF RANGE OF CALIBRATION AT I=           0000000
     #           ',I3,' AND J=',I3)                                         0000000
   40   CONTINUE                                                            0000000
   50 CONTINUE                                                              0000000
C                                                                           0000000
C---------INTERPOLATE FOR VELCF AND PSTCF FROM PITOT CALIBRATION DATA       0000000
C                                                                           0000000
      IDID=0                                                                0000000
```

```
      DO 80 I=1,NSTATN
        JPTS=NDATA(I)
        DO 70 J=1,JPTS
          IF((RPCMPW(I,J).EQ.0.0).AND.(RPNMPS(I,J).EQ.0.0)) GO TO 65
          IF((ABS(DELTA(I,J))) .GT. 58.0) GO TO 65
          IF(IDID .EQ. 0) VELCF(I,J)=SPLINE(CDELTA,
     #      CVELCF,NCAL,DELTA(I,J),IDID)
          IF(IDID .GT. 0) VELCF(I,J)=SPLINE(CDELTA,CVELCF,
     #      NCAL,DELTA(I,J),IDID)
          IF(IDID .EQ. 0) PSTCF(I,J)=SPLINE(CDELTA,
     #      CPSTCF,NCAL,DELTA(I,J),IDID)
          IF(IDID .GT. 0) PSTCF(I,J)=SPLINE(CDELTA,CPSTCF,
     #      NCAL,DELTA(I,J),IDID)
          IDID=1
          GO TO 70
   65     CONTINUE
          VELCF(I,J)=0.0
          PSTCF(I,J)=0.0
          WRITE(8,890) I,J
  890     FORMAT(20X,'DELTA IS OUT OF RANGE OF CALIBRATION DATA
     #           AT I=',I3,' AND J=',I3)
   70   CONTINUE
   80 CONTINUE
C
      DO 85 I=1,NSTATN
        IF(DIAGNS) WRITE(8,500) (PICHCF(I,J),J=1,JPTS)
        IF(DIAGNS) WRITE(8,500) (DELTA(I,J),J=1,JPTS)
        IF(DIAGNS) WRITE(8,500) (VELCF(I,J),J=1,JPTS)
        IF(DIAGNS) WRITE(8,500) (PSTCF(I,J),J=1,JPTS)
   85 CONTINUE
C
C---------CALC MAGNITUDE OF TOTAL MEAN VELOCITY VECTOR,
C---------    U, V, & W COMPONENTS, AND STATIC PRESSURE
C
      PI=3.14159
      DO 100 I=1,NSTATN
        RHO(I)=PATM(I)*(133.33)/(286.94*(TFLOW(I)+273.15))
        JPTS=NDATA(I)
        DO 90 J=1,JPTS
          BETA(I,J)=360.+BZOFF(I)-RBETA(I,J)
          IF((RPCMPW(I,J).EQ.0.0).AND.(RPNMPS(I,J).EQ.0.0))BETA(I,J)=0.0
          VTOTAL(I,J)=SQRT(ABS(2.0/RHO(I)*VELCF(I,J)*RPCMPW(I,J)*133.9))
          U(I,J)=VTOTAL(I,J) * COS(DELTA(I,J)*PI/180.0) *
     #      COS(BETA(I,J)*PI/180.0)
          V(I,J)=VTOTAL(I,J) * SIN(DELTA(I,J)*PI/180.0)
          W(I,J)=VTOTAL(I,J) * COS(DELTA(I,J)*PI/180.0) *
     #      SIN(BETA(I,J)*PI/180.0)
          P(I,J)=(RPCMPA(I,J)-PSTCF(I,J)*RPCMPW(I,J))*133.33
   90   CONTINUE
  100 CONTINUE
      IF(DIAGNS) WRITE(8,500)(VTOTAL(I,J),J=1,JPTS)
      IF(DIAGNS) WRITE(8,500)(U(I,J),J=1,JPTS)
      IF(DIAGNS) WRITE(8,500)(V(I,J),J=1,JPTS)
      IF(DIAGNS) WRITE(8,500)(W(I,J),J=1,JPTS)
      IF(DIAGNS) WRITE(8,500)(P(I,J),J=1,JPTS)
C
CHAPTER  2  2  2  2  2  2  AUXILIARY CALCULATIONS  2  2  2  2  2
C
C----------NONDIMENSIONALIZE LENGTHS AND VELOCITIES
C
       DO 150 I=1,NSTATN
        XND(I)=X(I)/(2.0*RLARGE)
        JPTS=NDATA(I)
        UIN(I)=AAFR*4.7195/(10000.0 * PI * RSMALL**2)
        UAV=(AAFR+TAFR)*4.7195/(10000.0 * PI *RLARGE**2)
        RMASFL(I)=PI*RHO(I)*UIN(I)*RSMALL**2
```

```
      IF(DIAGNS) WRITE(8,450) (UIN(II),II=1,NSTATN)                     0000000
      IF(DIAGNS) WRITE(8,450) (RMASFL(II),II=1,NSTATN)                  0000000
        DO 140 J=1,JPTS                                                 0000000
          VTSTAR(I,J)=VTOTAL(I,J)/UAV                                   0000000
          USTAR(I,J)=U(I,J)/UAV                                         0000000
          VSTAR(I,J)=V(I,J)/UAV                                         0000000
          WSTAR(I,J)=W(I,J)/UAV                                         0000000
          PSTAR(I,J)=P(I,J)/(RDNPRS(I)*133.33)                          0000000
  140   CONTINUE                                                        0000000
  150 CONTINUE                                                          0000000
      DO 160 J=1,MAXJPT                                                 0000000
        RND(J)=R(J)/(2.0*RLARGE)                                        0000000
        IF(KRADTR.EQ.0) RND(J)=RINCHS(J)                                0000000
        IF(KRADTR.EQ.0) R(J)=RINCHS(J)                                  0000000
  160 CONTINUE                                                          0000000
C                                                                       0000000
      IF(KRADTR.EQ.0) GO TO 135                                         0000000
C                                                                       0000000
C---FOR RADIAL PROFILES:  NUMERICAL INTEGRATION TO CALC. MASS           0000000
C   FLOW AND MOMENTUM FLUXES FOR SWIRL NUMBER                           0000000
C                                                                       0000000
C   FOR PROFILES AT AND UPSTREAM OF EXPANSION CORNER, RSMALL            0000000
C   IS USED IN EXPRESSIONS FOR DYNP AND UMEAN; DOWNSTREAM OF            0000000
C   EXPANSION, RLARGE IS USED.                                          0000000
C                                                                       0000000
      DO 130 I=1,NSTATN                                                 0000000
        JPTS=NDATA(I)                                                   0000000
        JPTSM1=JPTS-1                                                   0000000
        PREF(I)=P(I,JPTS)                                               0000000
        DYPS(1)=0.0                                                     0000000
        DYNP(JPTS)=2.0*(RSMALL-R(JPTS))                                 0000000
C                                                                       0000000
        DO 110 J=1,JPTSM1                                               0000000
          DYNP(J)=R(J+1)-R(J)                                           0000000
          DYPS(J+1)=DYNP(J)                                             0000000
  110   CONTINUE                                                        0000000
        DO 115 J=1,JPTS                                                 0000000
          SNS(J)=0.5*(DYNP(J)+DYPS(J))                                  0000000
          PSTAR(I,J)=P(I,J)-PREF(I)                                     0000000
  115   CONTINUE                                                        0000000
C                                                                       0000000
C----INNER 3 (HUB) VALUES OF PSTAR SET TO ZERO FOR SWIRLER              0000000
C    EXIT-PLANE PROFILES:  FOR DOWNSTREAM PROFILES, MAKE THESE          0000000
C    STATEMENTS COMMENTS.                                               0000000
C                                                                       0000000
C         PSTAR(I,1)=0.0                                                0000000
C         PSTAR(I,2)=0.0                                                0000000
C         PSTAR(I,3)=0.0                                                0000000
C                                                                       0000000
        IF(DIAGNS) WRITE(8,500) (DYNP(J),J=1,JPTS)                      0000000
        IF(DIAGNS) WRITE(8,500) (SNS(J),J=1,JPTS)                       0000000
        AREA1=PI*SNS(1)**2                                              0000000
        ARSUM=AREA1                                                     0000000
        FLOW=RHO(I)*U(I,1)*AREA1                                        0000000
        WMOM=W(I,1)*R(2)/4.*FLOW                                        0000000
        UMOM=U(I,1)*FLOW                                                0000000
        UMOMP=(RHO(I)*U(I,1)**2+PSTAR(I,1))*AREA1                       0000000
        IF(DIAGNS) WRITE(8,2030) AREA1,ARSUM,FLOW,WMOM,UMOM,UMOMP       0000000
        DO 120 J=2,JPTS                                                 0000000
          AREAJ=2.*PI*R(J)*SNS(J)                                       0000000
          ARSUM=ARSUM+AREAJ                                             0000000
          FLOW=FLOW+RHO(I)*U(I,J)*AREAJ                                 0000000
          UMOM=UMOM+RHO(I)*U(I,J)**2*AREAJ                              0000000
          UMOMP=UMOMP+(RHO(I)*U(I,J)**2+PSTAR(I,J))*AREAJ               0000000
          WMOM=WMOM+RHO(I)*U(I,J)*W(I,J)*R(J)*AREAJ                     0000000
          IF(DIAGNS) WRITE(8,2040) AREAJ,ARSUM,FLOW,WMOM,UMOM,UMOMP     0000000
```

```
  120    CONTINUE                                                       0000000
         RMASS(I)=FLOW                                                  0000000
         UMEAN(I)=RMASS(I)/(RHO(I)*PI*RSMALL**2)                        0000000
         ANGMOM(I)=WMOM                                                 0000000
         AXMOM(I)=UMOM                                                  0000000
         AXMOMP(I)=UMOMP                                                0000000
         IF(DIAGNS) WRITE(8,2050) UMEAN(I),RMASS(I),ANGMOM(I),AXMOM(I), 0000000
     #           AXMOMP(I)                                              0000000
C                                                                       0000000
 2030 FORMAT(//4X,'AREAJ',5X,'ARSUM',5X,'FLOW',6X,'WMOM',6X,            0000000
     #        'UMOM',6X,'UMOMP'//' ',6E10.3)                            0000000
 2040 FORMAT(' ',6E10.3)                                                0000000
 2050 FORMAT(/14X,'UMEAN',5X,'MASS',6X,'ANGMOM',4X,'AXMOM',             0000000
     #        5X,'AXMOMP'//11X,5E10.3)                                  0000000
C                                                                       0000000
         SPRIME(I)=ANGMOM(I)/(AXMOM(I)*RSMALL)                          0000000
         S(I)=ANGMOM(I)/(AXMOMP(I)*RSMALL)                              0000000
  130 CONTINUE                                                          0000000
      IF(DIAGNS) WRITE(8,450) (UMEAN(I),I=1,NSTATN)                     0000000
      IF(DIAGNS) WRITE(8,450) (RMASS(I),I=1,NSTATN)                     0000000
      IF(DIAGNS) WRITE(8,450) (ANGMOM(I),I=1,NSTATN)                    0000000
      IF(DIAGNS) WRITE(8,450) (AXMOM(I),I=1,NSTATN)                     0000000
      IF(DIAGNS) WRITE(8,450) (AXMOMP(I),I=1,NSTATN)                    0000000
      IF(DIAGNS) WRITE(8,450) (SPRIME(I),I=1,NSTATN)                    0000000
      IF(DIAGNS) WRITE(8,450) (S(I),I=1,NSTATN)                         0000000
  135 CONTINUE                                                          0000000
C                                                                       0000000
      IF(KRADTR.EQ.1) GO TO 180                                         0000000
C---FOR AZIMUTHAL TRAVERSES:  CALC. PSTAR=(P-PREF) USING SUPPLIED       0000000
C   VALUES OF PREF(I).                                                  0000000
C                                                                       0000000
      DO 178 I=1,NSTATN                                                 0000000
        JPTS=NDATA(I)                                                   0000000
        DO 177 J=1,JPTS                                                 0000000
          PSTAR(I,J)=P(I,J)-PREF(I)*133.33                              0000000
  177   CONTINUE                                                        0000000
  178 CONTINUE                                                          0000000
C                                                                       0000000
C---CALC. AVERAGE VALUES FOR AZIMUTHAL TRAVERSES -- NREP IS NO. OF      0000000
C   POINTS IN REPEATING CYCLE ACROSS ONE BLADE; NAVE IS NO. OF          0000000
C   AVERAGES POSSIBLE CONTAINING NREP CONSECUTIVE POINTS.               0000000
C                                                                       0000000
      NREP=6                                                            0000000
      DO 180 I=1,NSTATN                                                 0000000
        NAVE=NDATA(I)-NREP+1                                            0000000
        DO 175 K=1,NAVE                                                 0000000
          NAVEND=K+NREP-1                                               0000000
          USUM=0.                                                       0000000
          VSUM=0.                                                       0000000
          WSUM=0.                                                       0000000
          PSUM=0.                                                       0000000
          DO 174 J=K,NAVEND                                             0000000
            USUM=USUM+USTAR(I,J)                                        0000000
            VSUM=VSUM+VSTAR(I,J)                                        0000000
            WSUM=WSUM+WSTAR(I,J)                                        0000000
            PSUM=PSUM+PSTAR(I,J)                                        0000000
  174     CONTINUE                                                      0000000
          USTAVG(I,K)=USUM/NREP                                         0000000
          VSTAVG(I,K)=VSUM/NREP                                         0000000
          WSTAVG(I,K)=WSUM/NREP                                         0000000
          PSTAVG(I,K)=PSUM/NREP                                         0000000
  175   CONTINUE                                                        0000000
  180 CONTINUE                                                          0000000
C                                                                       0000000
C---CALCULATE VISCOSITY AND INLET REYNOLDS NUMBER (BOTH TRAVERSE TYPES) 0000000
C                                                                       0000000
```

```
C---VISCOSITY FORMULA FROM LAN & ROSKAM, AIRPLANE AERODYNAMICS
C   & PERFORMANCE, P.42.
C
      DO 162 I=1,NSTATN
        DENOM=TFLOW(I)+273.15+110.4
        VISCOS(I)=(1.458E-06)*(TFLOW(I)+273.15)**1.5/DENOM
        REDIN(I)=UIN(I)*2.*RSMALL*RHO(I)/VISCOS(I)
  162 CONTINUE
C
CHAPTER  3  3  3  3  3  OUTPUT  3  3  3  3  3  3  3
C
      IF(.NOT. IWRITE) GO TO 165
      DO 168 I=1,NSTATN
      WRITE(11,163) XINCHS(I)
      WRITE(11,163) UIN(I)
      WRITE(11,163) PREF(I)
      DO 168 J=1,MAXJPT
      WRITE(11,166) RINCHS(J), USTAR(I,J), VSTAR(I,J), WSTAR(I,J),
     &              BETA(I,J), DELTA(I,J), PSTAR(I,J)
C     WRITE(11,163) RINCHS
C     WRITE(11,163) USTAR
C     WRITE(11,163) VSTAR
C     WRITE(11,163) WSTAR
C     WRITE(11,163) BETA
C     WRITE(11,163) DELTA
C     WRITE(11,163) PSTAR
  163 FORMAT(E10.3)
  166 FORMAT(7E10.3)
  168 CONTINUE
C
  165 CONTINUE
      WRITE(8,311)
      WRITE(8,312) HEDID1,HEDID2,HEDCAL
      WRITE(8,325) ALPHA
      WRITE(8,330) PHI
      WRITE(8,335) RSMALL
      WRITE(8,340) RLARGE
      CALL WRITE(1,1,NSTATN,1,IT,JT,XINCHS,RINCHS,FANSPD,HEDFAN)
      CALL WRITE(1,1,NSTATN,1,IT,JT,XINCHS,RINCHS,TFLOW,HEDTFL)
      CALL WRITE(1,1,NSTATN,1,IT,JT,XINCHS,RINCHS,PATM,HEDPAT)
      CALL WRITE(1,1,NSTATN,1,IT,JT,XINCHS,RINCHS,RHO,HEDRHO)
      CALL WRITE(1,1,NSTATN,1,IT,JT,XINCHS,RINCHS,VISCOS,HEDVIS)
      CALL WRITE(1,1,NSTATN,1,IT,JT,XINCHS,RINCHS,RDNPRS,HEDMIP)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,UIN,HEDMIV)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,RMASFL,HEDMMF)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,REDIN,HEDRED)
C
      IF(KRADTR.EQ.O) GO TO 170
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,RMASS,HEDM)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,UMEAN,HEDUMN)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,ANGMOM,HEDAM)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,AXMOMP,HEDAXP)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,AXMOM,HEDAX)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,S,HEDS)
      CALL WRITE(1,1,NSTATN,1,IT,JT,X,R,SPRIME,HEDSPR)
C
  170 CONTINUE
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,U,HEDU)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,V,HEDV)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,W,HEDW)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,P,HEDP)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,DELTA,HEDDEL)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,BETA,HEDBET)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,X,R,VTOTAL,HEDVT)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XND,RND,USTAR,HEDUST)
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XND,RND,VSTAR,HEDVST)
```

```
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XND,RND,WSTAR,HEDWST)          0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XND,RND,PSTAR,HEDPST)          0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XND,RND,VTSTAR,HEDPDF)         0000000
C                                                                       0000000
      IF(KRADTR.EQ.1) GO TO 172                                         0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,USTAVG,HEDUSA)   0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,VSTAVG,HEDVSA)   0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,WSTAVG,HEDWSA)   0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,PSTAVG,HEDPDA)   0000000
  172 CONTINUE                                                          0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,RPNMPS,HEDNMS)   0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,RPCMPW,HEDCMW)   0000000
      CALL PRINT(1,1,NSTATN,MAXJPT,IT,JT,XINCHS,RINCHS,RPCMPA,HEDCMA)   0000000
      STOP                                                              0000000
C                                                                       0000000
C---------FORMAT STATEMENTS                                             0000000
C                                                                       0000000
  311 FORMAT(1H1,T37,'AXISYMMETRIC,ISOTHERMAL, GT COMBUSTOR FLOWFIELD ',0000000
     #'MEASUREMENTS',//,T53,'USING A FIVE-HOLE PITOT PROBE')            0000000
  312 FORMAT(//T10,18A4/T10,18A4//T10,9A4)                              0000000
  325 FORMAT(/T10,'EXPANSION ANGLE(DEG.) =',T50,1PE13.3)                0000000
  330 FORMAT(/T10,'SWIRL VANE ANGLE(DEG.) =',T50,1PE13.3)               0000000
  335 FORMAT (/T10,'INLET RADIUS(M) =',T50,1PE13.3)                     0000000
  340 FORMAT(/T10,'COMBUSTOR RADIUS(M) =',T50,1PE13.3)                  0000000
      END                                                               0000000
C                                                                       0000000
      SUBROUTINE INIT                                                   0000000
C*****************************************************************      0000000
C                                                                       0000000
      COMMON                                                            0000000
     #/MEASUR/RBETA(8,24),RPNMPS(8,24),RPCMPW(8,24),RPCMPA(8,24),       0000000
     #     NDATA(8),MAXJPT,RDNPRS(8),                                   0000000
     #     FANSPD(8),TFLOW(8),PATM(8),BZOFF(8)                          0000000
     #/GEOM/X(8),R(24),XND(8),RND(24),DYPS(24),DYNP(24),                0000000
     #     SNS(24),NSTATN,XINCHS(8),RINCHS(24)                          0000000
     #/CALC/VTOTAL(8,24),U(8,24),V(8,24),W(8,24),P(8,24),               0000000
     #     VTSTAR(8,24),USTAR(8,24),VSTAR(8,24),WSTAR(8,24),            0000000
     #     PICHCF(8,24),VELCF(8,24),DELTA(8,24),BETA(8,24),             0000000
     #     ANGMOM(8),UMEAN(8),RMASS(8),RMASFL(8),UIN(8),                0000000
     #     PSTAR(8,24),PSTCF(8,24),AXMOM(8),AXMOMP(8),                  0000000
     #     SPRIME(8),S(8),REDIN(8),PREF(8),RHO(8),VISCOS(8),            0000000
     #     USTAVG(8,24),VSTAVG(8,24),WSTAVG(8,24),PSTAVG(8,24)          0000000
C                                                                       0000000
C                                                                       0000000
      DO 20 I=1,NSTATN                                                  0000000
        RMASFL(I)=0.0                                                   0000000
        RMASS(I)=0.0                                                    0000000
        ANGMOM(I)=0.0                                                   0000000
        AXMOM(I)=0.0                                                    0000000
        AXMOMP(I)=0.0                                                   0000000
        SPRIME(I)=0.0                                                   0000000
        S(I)=0.0                                                        0000000
        UMEAN(I)=0.0                                                    0000000
        UIN(I)=0.0                                                      0000000
        DO 10 J=1,MAXJPT                                                0000000
          VTOTAL(I,J)=0.0                                               0000000
          U(I,J)=0.0                                                    0000000
          V(I,J)=0.0                                                    0000000
          W(I,J)=0.0                                                    0000000
          P(I,J)=0.0                                                    0000000
          VTSTAR(I,J)=0.0                                               0000000
          USTAR(I,J)=0.0                                                0000000
          VSTAR(I,J)=0.0                                                0000000
          PSTAR(I,J)=0.0                                                0000000
          RBETA(I,J)=0.0                                                0000000
          BETA(I,J)=0.0                                                 0000000
```

```
          RPNMPS(I,J)=0.0                                               0000000
          RPCMPW(I,J)=0.0                                               0000000
          RPCMPA(I,J)=0.0                                               0000000
          PICHCF(I,J)=0.0                                               0000000
          VELCF(I,J)=0.0                                                0000000
          PSTCF(I,J)=0.0                                                0000000
          DELTA(I,J)=0.0                                                0000000
          USTAVG(I,J)=0.0                                               0000000
          VSTAVG(I,J)=0.0                                               0000000
          WSTAVG(I,J)=0.0                                               0000000
          PSTAVG(I,J)=0.0                                               0000000
   10   CONTINUE                                                        0000000
   20 CONTINUE                                                          0000000
      RETURN                                                            0000000
      END                                                               0000000
C                                                                       0000000
      FUNCTION SPLINE(X, FX, N, X1, IDID)                               0000000
C*****************************************************************      0000000
                                                                        0000000
C     CUBIC SPLINE CURVE FITTING IN 2 DIMENSIONAL DATA PLANE            0000000
C     INPUT VALUES :                                                    0000000
C     X, FX      DATA ARRAYS, ONE DIMENSIONAL, X IN INCREASING ORDER    0000000
C     N          NUMBER OF DATA POINTS IN X, MAX 26                     0000000
C     X1         POINT OF INTEREST, WHERE F(X1) IS TO BE FOUND          0000000
C                                                                       0000000
C     RETURN VALUE :                                                    0000000
C     SPLINE = F(X1)                                                    0000000
C     THIS ROUTINE ACTIVATES ROUTINE ABUILD, H, AND GAUSS.              0000000
C     FOR INTERPOLATION OF A LARGE NUMBER OF DATA POINTS, FUNCTION      0000000
C     SPLINE MAY BE CALLED ONLY ONCE , AND SUBSEQUENT CALLS MAY USE     0000000
C     ENTRY POINT AT STATEMENT 36.                                      0000000
C***********************************************************************0000000
      DIMENSION X(1), FX(1), A(26,27)                                   0000000
C                                                                       0000000
C---------CONSTRUCT SPLINE MATRIX                                       0000000
C                                                                       0000000
      IF (IDID .GT. 0)GO TO 36                                          0000000
      N1=N+1                                                            0000000
      DO 10  I=1, N                                                     0000000
        DO 10  J=1, N1                                                  0000000
   10     A(I,J)=0.                                                     0000000
      M1=N-1                                                            0000000
      DO 20  I=2, M1                                                    0000000
   20   CALL ABUILD(X, FX, A, N, I)                                     0000000
      A(1,1)=H(X,2)                                                     0000000
      A(1,2)=-H(X,1)-H(X,2)                                             0000000
      A(1,3)=H(X,1)                                                     0000000
      M2=N-2                                                            0000000
      A(N,M2)=H(X,M1)                                                   0000000
      A(N,M1)=-H(X,M2)-H(X,M1)                                          0000000
      A(N,N)=H(X,M2)                                                    0000000
C                                                                       0000000
C---------FIND SECOND DERIVATIVES                                       0000000
C                                                                       0000000
      CALL GAUSS(A, N, N1)                                              0000000
C                                                                       0000000
C---------FIND F(X1)                                                    0000000
C                                                                       0000000
   36   CONTINUE                                                        0000000
        DO 40  I=1, M1                                                  0000000
        I1=I+1                                                          0000000
        IF(X1 .EQ. X(I)) GO TO 50                                       0000000
        IF(X1 .LT. X(I) .AND. X1 .GT. X(I1)) GO TO 41                   0000000
        IF(X1 .GT. X(I) .AND. X1 .LT. X(I1) ) GO TO 41                  0000000
40    CONTINUE                                                          0000000
      IF(X1 .EQ. X(N)) GO TO 60                                         0000000
```

```
      WRITE(8, 42) X1                                                   0000000
42    FORMAT(' X1=', G14.7, ' OUT OF INTERPOLATION RANGE, RETURNED VALUE0000000
     *=0')                                                              0000000
      SPLINE=0.                                                         0000000
      STOP                                                              0000000
C                                                                       0000000
41    CONTINUE                                                          0000000
      I1=I+1                                                            0000000
      HI=H(X,I)                                                         0000000
      HX=X(I1)-X1                                                       0000000
      HX2=X1-X(I)                                                       0000000
      FX1=HX**3/HI-HI*HX                                                0000000
      FX1=FX1*A(I,N1)                                                   0000000
      STO=HX2**3/HI - HI*HX2                                            0000000
      FX1=(FX1+STO*A(I1,N1) )/6.                                        0000000
      SPLINE=(FX(I)*HX+FX(I1)*HX2)/HI+FX1                               0000000
      RETURN                                                            0000000
C                                                                       0000000
50    CONTINUE                                                          0000000
      SPLINE=FX(I)                                                      0000000
      RETURN                                                            0000000
C                                                                       0000000
60    CONTINUE                                                          0000000
      SPLINE=FX(N)                                                      0000000
      RETURN                                                            0000000
      END                                                               0000000
C                                                                       0000000
      FUNCTION H(X,I)                                                   0000000
C***********************************************************************0000000
C     CALCULATE DELTA X WHICH IS USUALLY CALLED H.                      0000000
C***********************************************************************0000000
      DIMENSION X(1)                                                    0000000
      I1=I+1                                                            0000000
      H=X(I1)-X(I)                                                      0000000
      RETURN                                                            0000000
      END                                                               0000000
C                                                                       0000000
      SUBROUTINE ABUILD(X, F, A, N, I)                                  0000000
C***********************************************************************0000000
C     CONSTRUCT  SPLINE MATRIX FOR FINDING 2ND DERIVATIVES.             0000000
C***********************************************************************0000000
      DIMENSION X(1), F(1), A(26,27)                                    0000000
      IM1=I-1                                                           0000000
      I1=I+1                                                            0000000
      N1=N+1                                                            0000000
      STO=H(X,I)                                                        0000000
      HIM1=H(X,IM1)                                                     0000000
      A(I,IM1)=HIM1                                                     0000000
      A(I,I)=2.*(HIM1+STO)                                              0000000
      A(I,I1)=STO                                                       0000000
      A(I,N1)=( (F(I1)-F(I))/STO - (F(I)-F(IM1))/HIM1 )*6.              0000000
      RETURN                                                            0000000
      END                                                               0000000
C                                                                       0000000
      SUBROUTINE GAUSS(A, K, M)                                         0000000
C***********************************************************************0000000
C     GAUSS-JORDAN ELIMINATION                                          0000000
C***********************************************************************0000000
      DIMENSION A(26,27)                                                0000000
      M1=M-1                                                            0000000
      K1=K-1                                                            0000000
      DO 3  L=1, K1                                                     0000000
        L1=L+1                                                          0000000
        DO 3  I=L1, K                                                   0000000
          CONST=A(I,L)/A(L,L)                                           0000000
          DO 3  J=L, M                                                  0000000
```

```
    3       A(I,J)=A(I,J)-CONST*A(L,J)                                  0000000
      DO 6 I=1, K1                                                      0000000
        I1=I+1                                                          0000000
        DO 6  L=I1, M1                                                  0000000
          CONST=A(I,L)/A(L,L)                                           0000000
          DO 6  J=I, M                                                  0000000
6           A(I,J)=A(I,J)-CONST*A(L,J)                                  0000000
      DO 10  I=1, K                                                     0000000
        A(I,M)=A(I,M)/A(I,I)                                            0000000
   10   A(I,I)=1.                                                       0000000
      RETURN                                                            0000000
      END                                                               0000000
C                                                                       0000000
      SUBROUTINE PRINT(ISTART,JSTART,NI,NJ,IT,JT,X,Y,PHI,HEAD)          0000000
C***********************************************************************0000000
C                                                                       0000000
      DIMENSION PHI(IT,JT),X(IT),Y(JT),HEAD(9)                          0000000
      COMMON /OUTPUT/ STORE(8)                                          0000000
      ISKIP=1                                                           0000000
      JSKIP=1                                                           0000000
      WRITE(8,110)HEAD                                                  0000000
      ISTA=ISTART-10                                                    0000000
  100 CONTINUE                                                          0000000
      ISTA=ISTA+10                                                      0000000
      IEND=ISTA+9                                                       0000000
      IF(NI.LT.IEND)IEND=NI                                             0000000
      WRITE(8,111)(I,I=ISTA,IEND,ISKIP)                                 0000000
      WRITE(8,114)(X(I),I=ISTA,IEND,ISKIP)                              0000000
      WRITE(8,112)                                                      0000000
      DO 101 JJ=JSTART,NJ,JSKIP                                         0000000
        J=JSTART+NJ-JJ                                                  0000000
        DO 120 I=ISTA,IEND                                              0000000
          A=PHI(I,J)                                                    0000000
          IF(ABS(A).LT.1.E-20) A=0.0                                    0000000
  120     STORE(I)=A                                                    0000000
  101   WRITE(8,113)J,Y(J),(STORE(I),I=ISTA,IEND,ISKIP)                 0000000
      IF(IEND.LT.NI)GO TO 100                                           0000000
      RETURN                                                            0000000
  110 FORMAT(1HO,17(2H*-),7X,9A4,7X,17(2H-*))                           0000000
  111 FORMAT(1HO,15H          I =    ,I2,9I11)                          0000000
  112 FORMAT(8HO J     Y)                                               0000000
  113 FORMAT(I3,OPF8.4,1X,10(1X,E10.3))                                 0000000
  114 FORMAT(13H          X = ,F8.4,9F11.4)                             0000000
      END                                                               0000000
C                                                                       0000000
      SUBROUTINE WRITE(ISTART,JSTART,NI,NJ,IT,JT,X,Y,PHI,HEAD)          0000000
C                                                                       0000000
      COMMON /OUTPUT/ STORE(8)                                          0000000
      DIMENSION PHI(IT),X(IT),Y(JT),HEAD(9)                             0000000
      ISKIP=1                                                           0000000
      JSKIP=1                                                           0000000
      WRITE(8,110)HEAD                                                  0000000
      ISTA=ISTART-12                                                    0000000
  100 CONTINUE                                                          0000000
      ISTA=ISTA+12                                                      0000000
      IEND=ISTA+11                                                      0000000
      IF(NI.LT.IEND)IEND=NI                                             0000000
      WRITE(8,111)(I,I=ISTA,IEND,ISKIP)                                 0000000
      WRITE(8,114)(X(I),I=ISTA,IEND,ISKIP)                              0000000
      DO 101 JJ=JSTART,NJ,JSKIP                                         0000000
        J=JSTART+NJ-JJ                                                  0000000
        DO 120 I=ISTA,IEND                                              0000000
          A=PHI(I)                                                      0000000
          IF(ABS(A).LT.1.E-20) A=0.0                                    0000000
  120     STORE(I)=A                                                    0000000
  101   WRITE(8,113) (STORE(I),I=ISTA,IEND,ISKIP)                       0000000
```

```
      IF(IEND.LT.NI)GO TO 100                                              0000000
      RETURN                                                               0000000
  110 FORMAT(1HO,17(2H*-),7X,9A4,7X,17(2H-*))                              0000000
  111 FORMAT(1HO,15H          I =     ,I2,9I11)                            0000000
  113 FORMAT(/12X,1P10E11.3)                                               0000000
  114 FORMAT(13H          X = ,F8.4,9F11.4)                                0000000
      END                                                                  0000000
```

**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11316A.PI4126.DATA

COMPUTED MASS FLOW RATE (KG/S)
COMPUTED MEAN AXIAL VELOCITY (M/S)
U VELOCITY (M/S)
V VELOCITY (M/S)
W VELOCITY (M/S)
TOTAL VELOCITY MAGNITUDE (M/S)
DIMENSIONLESS U VELOCITY
DIMENSIONLESS V VELOCITY
DIMENSIONLESS W VELOCITY
DIMENSIONLESS STATIC PRESS. P/RDNPRS
PROBE PITCH ANGLE (DEG.)
PROBE YAW ANGLE (DEG.)
P(NORTH) - P(SOUTH) (VOLTS)
P(CENTER) - P(WEST) (VOLTS)
P(CENTER) - P(ATM.) (VOLTS)
MEAS. INLET MASS FLOW RATE (KG/S)
MEAS. INLET AXIAL VELOCITY (M/S)
MEAS. INLET DYNAMIC PRESS. (TORR)
AXIAL FLUX OF ANGULAR MOMENTUM (N-M)
AXIAL FLUX OF AXIAL MOM. (NEGL. PST)
AXIAL FLUX OF AXIAL MOM. (INCL. PST)
SWIRL NO. S-PRIME (NEGL. PST)
SWIRL NO. S (INCL. PST)
STATIC PRESSURE, GAGE (N/SQ. M)
STAT. PRESS. DIFF., P-PREF (N/SQ.M)
INLET REYNOLDS NUMBER
FAN SPEED (RPM)
REP. FLOW TEMP. (DEG CELSIUS)
ATMOSPHERIC PRESSURE (TORR)
DENSITY (KG/CU. M)
ABS. (LAM.) VISCOSITY (KG/M-S)
AVERAGES OF NONDIM. U-VELOCITY
AVERAGES OF NONDIM. V-VELOCITY
AVERAGES OF NONDIM. W-VELOCITY
AVERAGES OF STATIC PRESS. DIFFERENCE

CALIBRATION DATA FOR FIVE-HOLE PITOT PROBE

(PN-PS) / (PC-PW)	PITCH ANGLE	VELOCITY COEFFICIENT	PC-PA / PC-PW
2.780	-58.0	1.869	-0.655
2.343	-55.0	1.586	-0.414
1.920	-50.0	1.402	-0.125
1.580	-45.0	1.130	0.129
1.360	-40.0	1.083	0.345
1.150	-35.0	1.047	0.480
0.940	-30.0	0.975	0.590
0.770	-25.0	0.952	0.745
0.610	-20.0	0.940	0.814
0.455	-15.0	0.929	0.850
0.300	-10.0	0.935	0.893
0.135	-5.0	0.963	0.957
0.000	0.0	1.000	0.930
-0.163	5.0	1.020	0.993
-0.327	10.0	1.026	0.980
-0.470	15.0	1.047	0.900

```
-0.600      20.0      1.121       0.910                                      00000530
-0.710      25.0      1.163       0.844                                      00000540
-0.940      30.0      1.212       0.698                                      00000550
-1.220      35.0      1.298       0.570                                      00000560
-1.590      40.0      1.377       0.351                                      00000570
-1.960      45.0      1.510       0.086                                      00000580
-2.430      50.0      1.725      -0.176                                      00000590
-3.080      55.0      2.039      -0.532                                      00000600
-3.700      58.0      2.416      -0.985                                      00000610
RAD TRAV. AT X/D=2.25 FOR PHI=0, EXIT PLANE(NO NOZZLE)                       00000620
MEAS.11/8/87 BY CHAI DATAFILE NAME 'PI4225'                                  00000630
90.0        0.0       2.0         9.0       20.0        80.0                 00000640
         1            1         12                                           00000650
     2.25            12       0.068       746.0                              00000660
     0000.         15.0       746.0        0.0                               00000670
 0.0        320.0     -3.000      0.520     -0.220                           00000680
 0.3        307.0     -0.293      0.450     -0.205                           00001100
 0.6        300.2     -0.231      0.570      0.220                           00001200
 0.9        291.5     -0.148      0.478      0.370                           00001300
 1.2        281.5     -0.087      0.390      0.484                           00001400
 1.5        275.0     -0.056      0.348      0.555                           00001500
 1.8        274.0     -0.038      0.289      0.583                           00001600
 2.1        275.5     -0.021      0.236      0.600                           00001700
 2.4        275.5     -0.014      0.198      0.606                           00001800
 2.7        275.5     -0.005      0.170      0.610                           00001900
 3.0        278.2     -0.003      0.147      0.613                           00002000
 3.3        282.0      0.000      0.132      0.617                           00002100
```

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U11316A.B.DATA

O      U VELOCITY (M/S)
O
O          I =      1
           X =    0.0572
O J     Y
 12   0.0838    0.113E+01
 11   0.0762    0.815E+00
 10   0.0686    0.589E+00
  9   0.0610    0.637E+00
  8   0.0533    0.696E+00
  7   0.0457    0.563E+00
  6   0.0381    0.772E+00
  5   0.0305    0.188E+01
  4   0.0229    0.379E+01
  3   0.0152    0.561E+01
  2   0.0076    0.599E+01
  1   0.0000    0.824E+01
O
O      V VELOCITY (M/S)
O
O          I =      1
           X =    0.0572
O J     Y
 12   0.0838    0.000E+00
 11   0.0762    0.700E-01
 10   0.0686    0.107E+00
  9   0.0610    0.268E+00
  8   0.0533    0.362E+00
  7   0.0457    0.577E+00
  6   0.0381    0.765E+00
  5   0.0305    0.112E+01
  4   0.0229    0.172E+01
  3   0.0152    0.251E+01
  2   0.0076    0.410E+01
  1   0.0000    0.000E+00
O
O      W VELOCITY (M/S)
O
O          I =      1
           X =    0.0572
O J     Y
 12   0.0838    0.530E+01
 11   0.0762    0.566E+01
 10   0.0686    0.612E+01
  9   0.0610    0.661E+01
  8   0.0533    0.723E+01
  7   0.0457    0.805E+01
  6   0.0381    0.882E+01
  5   0.0305    0.923E+01
  4   0.0229    0.962E+01
  3   0.0152    0.965E+01
  2   0.0076    0.795E+01
  1   0.0000    0.692E+01
O
O      STATIC PRESSURE, GAGE (N/SQ. M)
O
O          I =      1
           X =    0.0572
O J     Y
```

```
 12  0.0838   0.659E+02
 11  0.0762   0.634E+02
 10  0.0686   0.601E+02
  9  0.0610   0.556E+02
  8  0.0533   0.497E+02
  7  0.0457   0.399E+02
  6  0.0381   0.280E+02
  5  0.0305   0.124E+02
  4  0.0229  -0.136E+02
  3  0.0152  -0.414E+02
  2  0.0076  -0.810E+02
  1  0.0000  -0.938E+02
0
0      PROBE PITCH ANGLE (DEG.)
0
0          I =      1
           X =    0.0572
0 J      Y
 12  0.0838   0.000E+00
 11  0.0762   0.702E+00
 10  0.0686   0.100E+01
  9  0.0610   0.231E+01
  8  0.0533   0.286E+01
  7  0.0457   0.409E+01
  6  0.0381   0.494E+01
  5  0.0305   0.675E+01
  4  0.0229   0.943E+01
  3  0.0152   0.127E+02
  2  0.0076   0.224E+02
  1  0.0000   0.000E+00
0
0      PROBE YAW ANGLE (DEG.)
0
0          I =      1
           X =    0.0572
0 J      Y
 12  0.0838   0.780E+02
 11  0.0762   0.818E+02
 10  0.0686   0.845E+02
  9  0.0610   0.845E+02
  8  0.0533   0.845E+02
  7  0.0457   0.860E+02
  6  0.0381   0.850E+02
  5  0.0305   0.785E+02
  4  0.0229   0.685E+02
  3  0.0152   0.598E+02
  2  0.0076   0.530E+02
  1  0.0000   0.400E+02
0
0      TOTAL VELOCITY MAGNITUDE (M/S)
0
0          I =      1
           X =    0.0572
0 J      Y
 12  0.0838   0.542E+01
 11  0.0762   0.571E+01
 10  0.0686   0.614E+01
  9  0.0610   0.665E+01
  8  0.0533   0.728E+01
  7  0.0457   0.809E+01
  6  0.0381   0.889E+01
  5  0.0305   0.949E+01
  4  0.0229   0.105E+02
  3  0.0152   0.114E+02
  2  0.0076   0.108E+02
  1  0.0000   0.108E+02
```

```
0
0     DIMENSIONLESS U VELOCITY
0
0          I =       1
           X =    0.2500
0 J      Y
 12   0.3667    0.980E+00
 11   0.3333    0.709E+00
 10   0.3000    0.512E+00
  9   0.2667    0.554E+00
  8   0.2333    0.606E+00
  7   0.2000    0.489E+00
  6   0.1667    0.671E+00
  5   0.1333    0.163E+01
  4   0.1000    0.329E+01
  3   0.0667    0.488E+01
  2   0.0333    0.521E+01
  1   0.0000    0.717E+01
0
0     DIMENSION V VELOCITY
0
0          I =       1
           X =    0.2500
0 J      Y
 12   0.3667    0.000E+00
 11   0.3333    0.609E-01
 10   0.3000    0.934E-01
  9   0.2667    0.233E+00
  8   0.2333    0.315E+00
  7   0.2000    0.502E+00
  6   0.1667    0.666E+00
  5   0.1333    0.970E+00
  4   0.1000    0.149E+01
  3   0.0667    0.219E+01
  2   0.0333    0.357E+01
  1   0.0000    0.000E+00
0
0     DIMENSION W VELOCITY
0
0          I =       1
           X =    0.2500
0 J      Y
 12   0.3667    0.461E+01
 11   0.3333    0.492E+01
 10   0.3000    0.532E+01
  9   0.2667    0.575E+01
  8   0.2333    0.629E+01
  7   0.2000    0.700E+01
  6   0.1667    0.767E+01
  5   0.1333    0.803E+01
  4   0.1000    0.836E+01
  3   0.0667    0.839E+01
  2   0.0333    0.691E+01
  1   0.0000    0.601E+01
END
```

VITA 2

Woon Don Chai

Candidate for the Degree of

Master of Science

Thesis: TIME-MEAN VELOCITY MEASUREMENTS IN SUDDEN EXPANSION CONFINED FLOW WITH TANGENTIAL INJECTION

Major Field: Mechanical Engineering

Biographical:

Personal Data: Born in Seoul, Korea, May 13, 1962, the son of the Mr. and Mrs. Chang S. Chae.

Education: Graduated from Han Sung High School, Seoul, Korea, in March 1981; received Bachelor of Science degree in Mechanical Engineering from Sung Kyun Kwan University, February, 1985; completed requirements for the Master of Science degree at Oklahoma State University in May, 1988.

Professional Experience: Research Assistant, School of Mechanical Engineering, Oklahoma State University, Stillwater, Oklahoma, 1987

Professional Society: AIAA